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(54) Cooling of critical parts of the turbo-blower compressor stage

(57) The compressor stage of the turbo-blower consists of suction **(13),** a compressor wheel **(1)** attached to a shaft to which the compressor insert **(5)** is adjoined, installed into a spiral casing **(4)** (the insert may be an integral part of casing 4), whereby the compressor wheel **(1),** equipped with a greater number of blades is further linked to a bladeless part **(2)** of the diffuser followed by a bladed part **(3)** of the diffuser, where the compressor stage has a separated space for the passage of compressed gas and a space for the coolant, limited by the left side wall **(6)** and the right side wall **(7)** of the bladeless part (2) as well as of the bladed part (3) of the diffuser, followed by the right and left chambers (**9** and **10**), which are designed for the passage of the coolant fed or drained by the respective supply and drain connections (**11** and **12**) of the coolant in the respective supply and drain, whereby in this construction both the left and right chambers (**9** and **10**) are equipped with one respective supply and drain connection (**11** and **12**) of the respective supply and drain of the coolant.

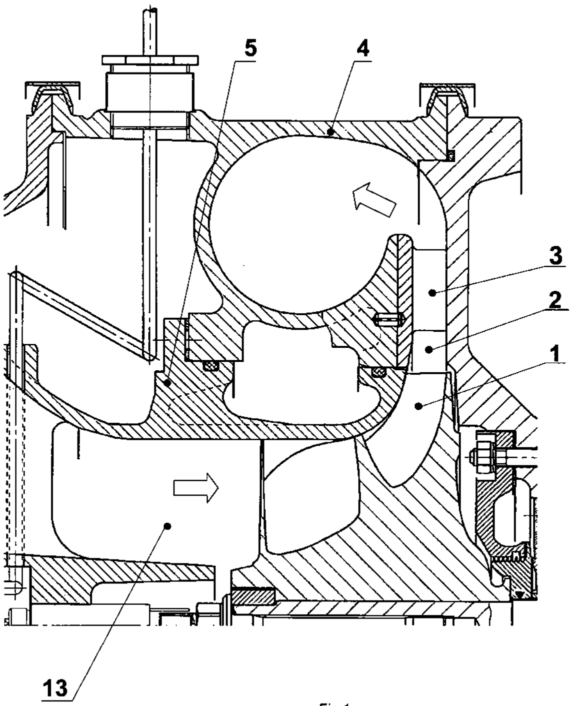

Fig.1

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Description

Technical Field

[0001] This invention concerns the cooling of critical parts of a turbo-blower's compressor stage; consisting of suction, a compressor wheel attached to a shaft to which the compressor insert is adjoined, installed into a spiral casing, whereby the compressor wheel that is equipped with a greater number of blades is further linked to the bladeless part of the diffuser and then a diffuser part equipped with blades.

Background Art

[0002] The intake turbo-blower device is a jet device, utilizing the energy contained in the exhaust fumes for its propulsion. It facilitates the compression of air which is, after its cooling, conveyed into the cylinder of the combustion piston engine. It is comprised of two main parts - the compressor and the turbine parts. The compressor compresses the air admitted into the motor and thereby significantly increases its volume efficiency in comparison with the standard un-supercharged engine. The kinetic energy of the gas is transmitted to the turbine propelling the compressor. The turbine is opened by exhaust fumes coming out of the engine and is situated along a common shaft together with the compressor. The expansion of specific output develops along with the requirements for proportional air compression in the compressor of the turbo-blower. In proportion with the compression, the temperature of the compressed air increases as well, which is a drawback. In engines, the increasing temperature of the intake air results in a decrease in engine efficiency. This problem is generally overcome by using an intercooler of compressed air that lowers the temperature once more. The compression of the intake air leads to increases in air density, cylinder mass charge, an improvement in the temperature operating schedule, a decrease in the production of nitrogen oxides, improvements in conditions for cylinder lubrication and a decrease in the temperature of the exhaust fumes. From the standpoint of the construction of the turbo-blower, the increase in compression and output temperature meant, until now, only some modification of the material of the impeller wheel, of the casing and of the bladed diffuser - if it was used in the respective assembly. In the more recent turbo-blower construction, a radial compressor wheel is utilized, mounted on a shaft and set in bearings. At the other end of the shaft, an impeller wheel of either axial or radial construction is mounted. The impeller wheel of the compressor is, on the outer edge, surrounded by a stator part so that the clearance between the impeller wheel and the stator is as small as possible, whilst maintaining the necessary operational safety and reliability parameters. After passing through the compressor impeller wheel, the compressed and heated air enters the diffuser, which usually consists of a wall of the compressor casing and a counter-wall belonging to the journal box (bearing casing). In some cases, a bladed diffuser is also incorporated into the assembly. After passing the diffuser, the air enters the spiral of the compressor box with a short diffuser and it passes to an output flange, to which an inter-cooler and the filling piping of the combustion engine are attached. The compressor box is usually made as a single-layer casting. Sometimes, a double-layer casing is also used so that the external surface temperatures do not exceed the allowed limit (e.g. see the article "MTU's powerful single-stage performer for four-strokes", Worldwide Turbocharger Guide, August/September 2007).

[0003] The fact that a turbo-blower's compressor stage sucks air largely from the area of the engine where fumes of mainly petroleum products occur is seen as a problem. In many cases, suction into the compressor is accompanied by some venting of the motor crankcase where, despite the integration of a separator, oil fumes occur as well. These products through compression, influenced by increasing temperatures, modify their structure and especially cling to the output of the impeller wheel, the walls of the bladeless diffuser and to the blades of the bladed diffuser. This negative impact mainly arises at high pressures that are common in advanced turbo-blowers. Over time, the clinging particles form a continuous layer which has a number of negative effects:

- They modify the cross-section of the areas of passage
- They build up unevenly and increase the residual imbalance of rotating parts and the stress of the profiles
- They increase surface abrasion
- They worsen heat transfer

As a result of these effects, the deterioration of efficiency and operational characteristics of the compressor occur. The afore-mentioned negative effects were resolved by shortening the time between maintenance and by mechanically cleaning the parts, by dismantling the rotor and repeatedly balancing it with all the associated consequences.

[0004] For the radial compressor stages, there are diverse types of diffusers commonly used, e. g. bladeless diffusers, or diffusers with blades or with drilled channels etc. Fig. 1 depicts an example of a compressor stage equipped with a bladed diffuser. Next to the impeller wheel of the compressor stage a diffuser is set, which comprises a short bladeless part and a bladed part from which the gas enters the spiral casing. The work is transferred in the impeller wheel of the compressor stage, leading to increase of the internal energy of gas. This is externally manifest by an increase in pressure and temperature. In the stator of the compressor stage, the kinetic energy is transformed into pressure energy (potential energy). The overall gas temperature does not, in principle, change any further. The temperature of the bladeless part and of the bladed part of the diffuser and of the spiral casing is close to the overall gas temperature, which can lead, at high compression rates where the temperatures are high, to the following technical problems:

- deterioration of the mechanical characteristics of the materials
- lost tension
- deformation
- parts getting choked by material contained in the air that modify their structure at higher temperatures, and thus reducing efficiency

Disclosure of the Invention

[0005] The aim of the invention is to reduce the temperature in the critical parts of the compressor stage, especially in the location of the compressor impeller wheel as well as the diffuser, regardless of their construction, and, in addition, in their adjacent parts, via the delivery of coolants to those parts.

[0006] According to this invention, this aim is achieved by the compressor stage of the turbo-blower, consisting of suction, a compressor wheel attached to a shaft to which the compressor insert is adjoined, installed into a spiral casing; or the insert is an integral part of the spiral casing, whereby the compressor wheel that is equipped with a greater number of blades is further linked to the bladeless part of the diffuser and then a diffuser part equipped with blades. The substance of the invention is the fact that the area of the compressor stage with the highest temperatures has a separate space for the passage of compressed gas and a space for coolants, limited by the left side wall and the right side wall of the bladeless part as well as of the bladed part of the diffuser, and by the adjoining left and right chambers which are designed for the passage of coolants fed or drained by the respective supply and drain connections of the coolant, whereby in this construction both the left and right chambers are equipped with one respective supply and drain connection of the coolant.

[0007] External medium that is mostly at the disposal of the engine is used for cooling - such things as water, oil or air. This may also include solutions not connected with the engine and having their own circuit. In order to have a sufficiently cooling effect, the coolant circulates forcibly. Liquids or gases developed specially for cooling purposes may be used as well.

[0008] At stator parts, the coolant washes the walls of the blade and bladeless diffuser, thereby lowering their temperature. The temperature of blades and of their adjacent parts is lowered by the heat transfer of metallic parts, the conductivity of which is significantly lower than the heat transfer from the compressed air into the cooled parts of the compressor. In the case of a bladed diffuser, the efficiency of heat drain may be increased by directly cooling the blades, by transferring the coolant through openings made in the blades.

[0009] In order to decrease the surface temperature of the parts and to lower the deposit of substances, leading to a reduction in efficiency, the left side wall and the right side wall and the adjoining left and right chamber are mutually interconnected by at least one opening for the passage of coolant made in the blades of the bladed part of the diffuser. The coolant, passing forcibly through the channels that have been constructed for this purpose, draws off heat.

[0010] When cooling the diffuser and its adjoining parts it is advantageous to use an additional coolant such as, for example, water. The coolant withdraws the heat from the material of the diffuser and its attached elements, thereby lowering the temperature of the diffuser material as well as that of the adjoining parts and the gas temperature. Additional cooling of the afore-mentioned parts has the following advantages:

- The temperature of the diffuser and its adjoined components is lowered
- Complications associated with the high temperature of the parts are reduced or even eliminated
- The lifetime of the diffuser and its adjoining parts is prolonged
- The temperature of substances being compressed is decreased (seemingly increasing compression efficiency)
- A reduction in the temperature peak after the machine is shutdown as the cooled parts accommodate more heat and the coolant may usually flow by itself even after shutdown
- The procedure also decreases the thermal stress of the impeller wheel of the compressor stage at return flow (surging).

Brief Description of the Drawings

[0011] The invention will become clear with the assistance of the pictures. Fig. 1 is the partial longitudinal section of the compressor stage with the diffuser equipped with blades. Fig. 2 depicts the partial longitudinal section of the compressor stage in the area of the diffuser, where only the walls adjoined to the bladed and bladeless parts of the diffuser are cooled. Fig. 3a is a longitudinal cross-section of the compressor stage showing the second example of construction in the area of bladed diffuser, the stator part of which is cooled by the flow of coolant along the diffuser walls and through the blades of the bladed diffuser. Fig. 3b illustrates a transverse cross-section of the diffuser across the blade.

[0012] The pictures show only those parts of the compressor stage that are essential in order to understand the invention. The circulation of the coolant and of the working gas is illustrated by arrows.

Examples of the Embodiments of the Invention

[0013] The principle of the construction of cooling for the turbo-blower diffuser and of its associated parts in the context of this invention will be explained further by, but not limited to the following examples.

[0014] The turbo-blower consists of the compressor stage and of (not depicted in the drawing) flue turbines. The basic arrangement of the compressor stage of the turbo-blower is partially illustrated in Fig. 1. The arrangement represents a complex of parts that allows gas suction and compression. In this arrangement, the compressor stage consists of suction **13,** an impeller (compressor) wheel **1** a compressor stage, to which a compressor insert **5** is attached, installed into the spiral casing **4.** The impeller (compressor) wheel **1** of the compressor stage equipped with a higher number of blades and attached to the shaft, is further followed by a bladeless part **2** of the diffuser, to which the bladed part **3** of the diffuser is adjoined. This bladed part **3** of the diffuser disembogues into the spiral casing **4**, to which the output diffuser with an attachment flange is mostly linked (not depicted in drawing No. 1).

[0015] An example of the realization of the cooling of the diffuser and the associated parts of the compressor stage, where only the walls adjacent to the bladeless and bladed parts of the diffuser are cooled is shown in Fig. 2. The construction for the cooling of the diffuser in this arrangement consists of the compressor impeller wheel **1,** to which the compressor insert **5** is attached, installed into the spiral casing **4.** To the impeller wheel **1** of the compressor stage the bladeless part **2** of the diffuser is also adjoined, followed by the bladed part **3** of the diffuser. The drawing shows that at the bladeless part **2** as well as at the bladed part **3** of the diffuser, at the left and right side walls **6** and **7** the left and right chambers **9** and **10** were created through which the coolant is supplied/drained by connections **11** and **12** of the respective supply and drain of the coolant. In this arrangement, the left and right chambers **9** and **10** have one connection each, **11** and **12,** of the respective supply and drain of the coolant.

[0016] During the operation of the compressor stage, the coolant having a significantly lower temperature than the temperature of the structural modification of the vapour contained in the gas being compressed, is supplied into the left chamber **9** and the right chamber **10** through the openings **111** and **121** of the respective supply and drain connections **11** and **12** of the coolant. The left side wall **6** and the right side wall **7** of the diffuser are washed by the compressed gas. The blades **31** of the diffuser are attached to the left side wall **6** and the right side wall **7** of the diffuser in a way that allows heat to be drawn off from the flowing compressed gas by conduction through the left and right side walls **6** and **7** of the diffuser into the coolant. The coolant is drawn off from the left and right chambers **9** and **10** through connections **11, 12** of the respective supply and drain of the coolant. The coolant is further drained through openings **111, 121** of the connections **11, 12** of the respective supply and drain of the coolant away from the compressor stage into the cooler (not depicted in the drawing).

[0017] Another variant of the configuration of the compressor stage, designed in a way similar to that described above, with the difference that the coolant passes the openings **8**, which are created in the blades **31** of the bladed part **3** of the diffuser, is shown in Fig. 3a and Fig. 3b. In this arrangement, the construction consists of the impeller wheel **1** of the compressor stage, followed by the bladeless part **2** of the diffuser and the bladed part **3** of the diffuser, into the right side wall **7** of the diffuser the right chamber **10** for the coolant encroaches, as well as into the left side wall **6** of the diffuser encroaching the left chamber **9** for the coolant, whereby the left and right chambers 9 and **10** are mutually interconnected by the openings **8** created in the blades **31** of the bladed part **3** of the diffuser.

[0018] During the operation of the compressor stage, is the coolant having a significantly lower temperature than the temperature of the structural modification of the vapours contained in the gas being compressed, e. g. supplied through the openings **111** of the connection **11** (not depicted in the drawing) into the left chamber **9** and from there through the openings **8** created in the blades **31** into the right chamber **10.** Through those chambers, **9** and **10,** as well as through the openings **8** the heat is drained by the flowing coolant from the left wall **6**, the right wall **7** and from the diffuser blades **31**; thereby also cooling the gas being compressed, which washes those parts. The blades **31** of the diffuser, equipped with openings **8** are attached to the left wall **6** and the right wall **7** of the diffuser in a way that allows heat to be drawn off from the flowing compressed gas by conduction through the left and right side walls **6** and **7** of the diffuser into the coolant, which is further drained through the opening **121** of the respective supply and drain connection **12** of the coolant away from the compressor stage into the cooler (not depicted in the drawing). The flow of the coolant through the left and right chambers **9** and **10** and through the openings **8** may be also achieved in another way, for example: by splitting the right chamber **10** in two halves. Into one half, through the connection **11** the coolant is admitted which, via the openings **8** in the respective half of the blades **31,** passes through into the left chamber **9** and, via the openings **8** in the other half of the blades, it returns to the other half of the right chamber **10** from which it is drained through connection **12.**

Industrial Applicability

[0019] With this invention, the construction cooling the critical parts of the turbo-blower can be especially utilized in compressors of turbo-blowers and flue turbines and the like, operating with gas containing vapors of substances that, in the course of compression and due to changes in pressure and temperature, modify their structure and cling to the parts of the compressor stage, thereby degrading its thermodynamic and operating parameters.

List of the reference symbols

[0020]

1. impeller (compressor) wheel of the compressor stage
2. bladeless part of the diffuser
3. bladed part of the diffuser
31. diffuser blades
4. spiral of the compressor casing - spiral casing
5. compressor insert
6. left side wall of the diffuser
7. right side wall of the diffuser
8. opening in the diffuser blade
9. left chamber for the coolant
10. right chamber for the coolant
11. connection of the respective supply and drain of the coolant
111 supply (inlet) orifice
12. connection of the respective supply and drain of the coolant
121 drain orifice
13 suction of the compressor wheel

Claims

1. Cooling of critical parts of the turbo-blower compressor stage consisting of a suction **(13),** compressor wheel (**1**) attached to a shaft, to which a compressor insert **(5)** is adjoined, installed into a spiral casing **(4)** (the insert can be an integral part of the casing **4),** whereby the compressor wheel **(1),** equipped with a greater number of blades is further linked to a bladeless part **(2)** of the diffuser followed by a bladed part **(3)** of the diffuser, **characterized in, that** it has a separate space for the passage of compressed gas and a space for coolant, that is limited by a left side wall **(6)** and a right side wall **(7)** of both, the bladeless **(2)** and the bladed part **(3)** of the diffuser, followed by the left and right chambers **(9** and **10),** that are designed for the passage of the coolant fed or drained by the respective supply and drain connections **(11** and **12)** of the coolant in the respective supply and drain, whereby in this construction both the left and right chambers **(9** and **10)** are equipped with one respective supply and drain connection **(11** and **12)** of the respective supply and drain of the coolant.

2. The cooling of critical parts of the turbo-blower compressor stage according to the claim 1, **characterized in, that** by both connections **(11** and **12)** can be equipped only one of the chambers **(9** and **10).**

3. The cooling of critical parts of the turbo-blower compressor stage according to the claim 1, **characterized in, that** the left side wall **(6)** and the right side wall **(7)** adjoining left and right chambers **(9** and **10)** are mutually interconnected by at least one opening **(8)** made in the blades **(31)** of the bladed part **(3)** of the diffuser.

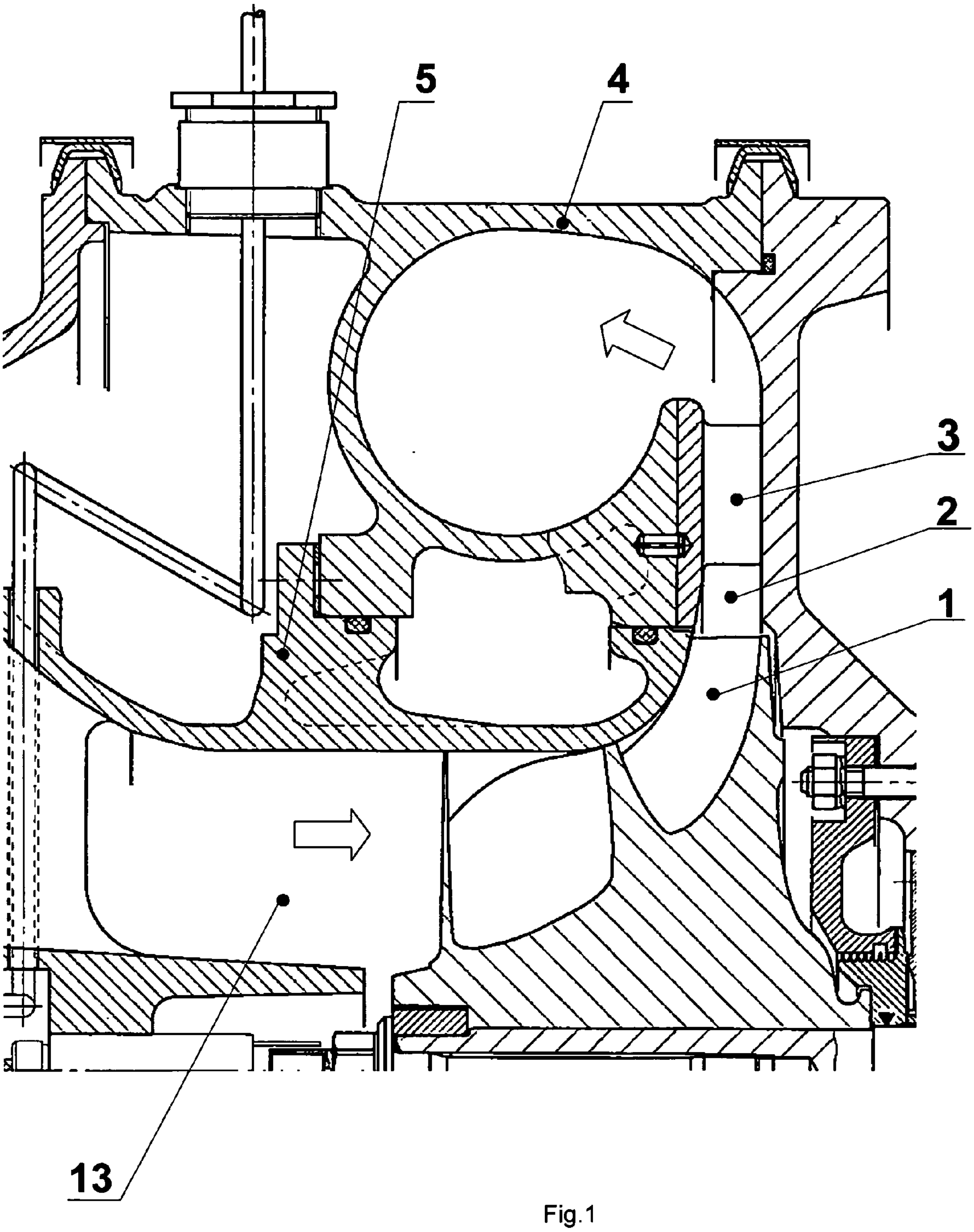

Fig.1

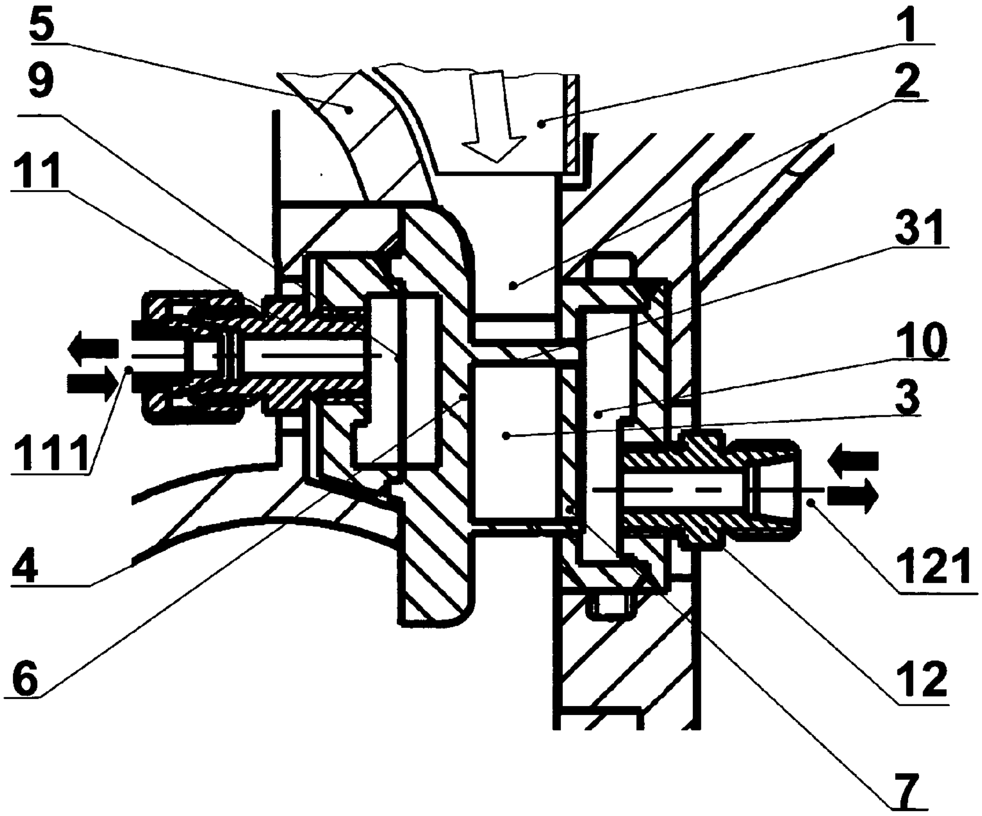

Fig.2

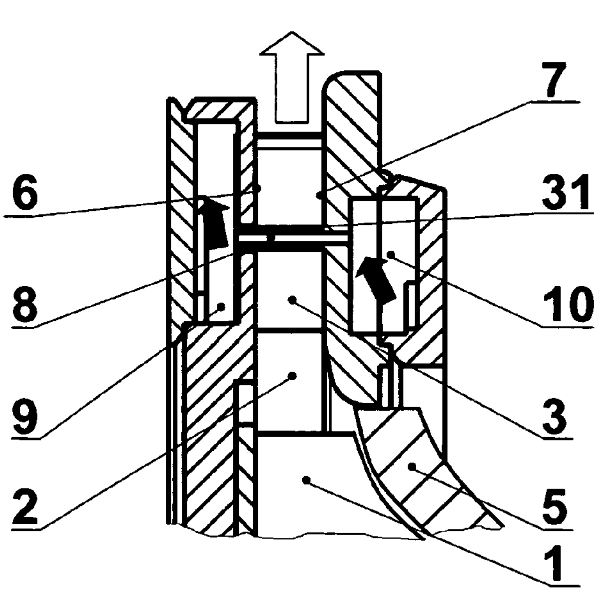

Fig.3a

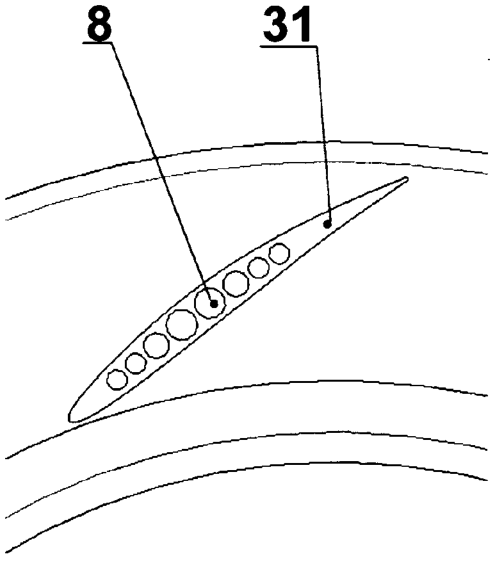

Fig.3b

REFERENCES CITED IN THE DESCRIPTION

Non-patent literature cited in the description

- MTU's powerful single-stage performer for four-strokes. *Worldwide Turbocharger Guide,* August 2007 **[0002]**