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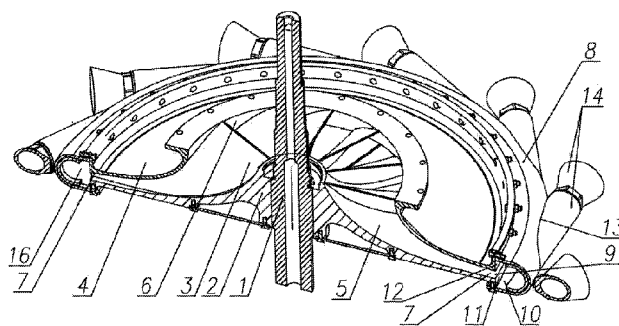
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BINE, AND TURBO-JET APPARATUS THEREFOR

FIG. 2

(57) **Abstract:** The invention relates to mechanical engineering, in particular to air-driven, gas-driven and steam-driven turbines for driving electrical power generators, propulsion systems, refrigeration compressors, heat pumps and the like. According to the invention, a method for generating mechanical energy in a jet turbine includes the steps of supplying a working medium into a centrifugal impulse wheel thereof, wherein the wheel is provided with centrifugal passages, compressing the working medium in the centrifugal passages of the wheel, outputting the working medium into a toroid collector having jet nozzles, to decrease the flow speed and increase the flow pressure so as to cause the working medium to be accelerated in the jet nozzles and to exit into the surrounding space at supersonic speed, thus forming a propelling force pulse providing rotation of the impulse wheel of the jet turbine. The invention provides an increase in efficiency of generating mechanical energy with an increase in power and efficiency and decrease in weight and dimensions at a given power requirement. According to the invention, a method for generating mechanical energy can be employed in a single-flow jet turbine, a double-flow jet turbine, and a turbo-jet apparatus based thereon.

**METHOD FOR PRODUCING MECHANICAL ENERGY, SINGLE-
FLOW TURBINE AND DOUBLE-FLOW TURBINE, AND TURBO-JET
5 APPARATUS THEREFOR**

The invention relates to mechanical engineering, in particular to air-driven, gas-driven and steam-driven turbines for driving electrical power generators, propulsion systems, refrigeration compressors, and heat
10 pumps.

Utility model patent RU99540 discloses a turbine comprising a rotor with nozzles arranged in an equally spaced manner around the circumference, a stator with blades, and a supercharger located at the
15 inlet into the turbine body; said elements being provided in order to increase the turbine efficiency.

The primary disadvantage of such turbine is low efficiency due to significant pressure loss in both the working medium flow entering the
20 turbine (due to complicated and suboptimal flow duct configuration at a section including an inlet, output and passages of a centrifugal supercharger, passages and blades of stationary distributor, and passages and blades of rotating distributor) which fails to provide sufficient working medium compression in the rotor pocket, and in the working medium flow
25 exiting the turbine (due to simplified and suboptimal nozzle configuration, since the nozzles are tapered, sonic and reducing, thus failing to expel the working medium from the turbine at supersonic rate).

The working medium flow entering the turbine flows around the
30 rotating outer surface of the supercharger, thus changing direction at an angle close to 180°, which leads to a significant pressure loss in the flow. The working medium flow exits the supercharger along the rotational axis

of the supercharger, rather than radially, which also leads to a substantial decrease in working medium flow compression therein. The blades of the stationary distributor and the blades of the rotating distributor further contribute to pressure loss in the working medium flow. Therefore, considering relatively narrow diameter of the supercharger, the compression rate of the working medium flow in the turbine is low.

Furthermore, the simplified and suboptimal configuration of flat tapered sonic nozzles, formed as reducing nozzles, fails to provide high operational efficiency of the turbine due to the fact that when the working medium flow reaches sonic speed, the flow exits the nozzle throat, thus exiting the turbine with substantially high flow pressure. Pressure loss, and subsequently, loss of output pulse of the working medium jet can reach about 30-35%.

15

Further disadvantages of such turbine include: complexity of manufacturing a turbine rotor with nozzles, high metal consumption and high mass-dimensional characteristics of the turbine in general.

The closest prior art for the present invention is a method for producing mechanical energy in a turbine, and a turbine therefor (RU 2200848, F01D1/32, 11.03.2002).

The prior art method for producing mechanical energy in a turbine comprising a Segner wheel includes supplying a working medium into passages of a turbine rotor and then accelerating the working medium exiting from the passages in one direction perpendicular to the rotor radius so as to rotate the rotor. The working medium is expelled from these passages into the space around the rotor, wherein the space is defined by a jacket. The working medium frictionally interacts with the jacket, and exits through openings in the jacket so as the working medium is accelerated in one direction to rotate the jacket. The space around the rotor as defined by the jacket is enclosed circumferentially along the outlet

30

openings of the rotor passages. While exiting through the openings in the jacket, the working medium is accelerated along the circumference, in a direction perpendicular to the jacket radius and opposite relative to the rotor output. The aforementioned patent can be considered as the closest
5 prior art technical solution for the present invention.

According to RU 2200848, a turbine comprises

a Segner wheel formed by a tube with a closed end attached to a shaft in a coaxial manner, wherein the turbine is adapted to rotate on the
10 tube,

at least one pair of tube assemblies with open ends deflected in opposite directions with respect to axis thereof, radially attached to the opposite sides of the turbine,

wherein axes of deflected open ends of tube assemblies are arranged
15 perpendicularly to a plane passing through axes of tube assemblies and the axis of the tube, and openings aligned with the tube assemblies are provided in the tube wall;

a jacket attached to the shaft in a coaxial manner and enclosing the Segner wheel, wherein the shaft is adapted to rotate,

20 a housing enclosing the Segner wheel and the jacket, said housing provided with openings for installing the Segner wheel tube, Segner tube shafts and the jacket with a fitting for providing working medium exit therein, wherein

the jacket is formed as a cylindrical barrel, the cylindrical barrel band
25 being arranged adjacently to the deflected ends of the Segner wheel tube assemblies forming a gap,

at least one pair of tube assemblies with open ends deflected in different directions with respect to axis thereof is radially attached to the cylindrical barrel band, said directions being opposite to the sides of the
30 Segner wheel tube assemblies,

wherein axes of deflected open ends of barrel tube assemblies are arranged perpendicularly to a plane passing through axes of barrel tube

assemblies and the axis of the tube, and openings aligned with the tube assemblies are provided in the band wall.

The main disadvantages of the method and turbine as described in
5 RU2200848, are the low efficiency of mechanical energy production, in particular due to non-optimal structure of the known turbine which results in low flow rates, the substantial pressure changes, the high working medium exit speeds, and consequently, the low efficiency of generating mechanical energy in the above described open-ended Segner wheel tube
10 assemblies and open-ended cylindrical barrel tube assemblies.

The thorough analysis and research made by the Inventors of the present invention has shown that these and other drawbacks of the construction of the turbine can be significantly improved.

15

In particular, though, to effectively expel working medium from the inner chamber of barrel through tube assemblies, the pressure in the inner chamber of the barrel must be sufficiently high. The high pressure in the inner chamber of the barrel does not allow the working medium to
20 effectively exit from the tube assemblies into the chamber of the barrel. Thus, the barrel significantly decreases efficiency of producing mechanical energy in the turbine, makes the turbine unreasonably heavy and large, and can be omitted.

25 Furthermore, the contribution of friction force between the working medium and the inner walls of the barrel in the known method is insignificant, as thickness and mass of the "boundary layer" of the working medium involved in said process constitutes only a small part of the overall working medium flow rate through tube assemblies and can be
30 neglected.

Furthermore, the research made by the Inventors has shown that when the barrel 5 is rotated, the working medium is unaffected by centrifugal forces whose centrifugal pressure drives the working medium out from the open ends of the barrel and creates further rotation torque combining with the friction torque, due to the fact that a small portion of working medium in the inner chamber of the barrel forms a thin "boundary layer" adjacent to the inner wall of the barrel rotates together with the barrel in the same direction, while the other portion of the working medium rotates in the opposite direction by eddy flows formed by the Segner wheel. The speed of said portion of the working medium depends on the distance to the rotational center of the barrel. As the result, a third portion of the working medium, in which the working medium is practically still, is formed within the barrel between two portions of working medium rotating in opposite directions.

Taking into account the above, as well as the fact that the overall mass of working medium in the inner chamber of the barrel is insignificant, the Inventors of the present invention suggested a novel and inventive construction of a turbine.

Without wishing to be bound by a particular theory, the Inventors believe that the effect of centrifugal forces on increase in turbine efficiency is negligible. Furthermore, due to the non-stationary, discrete character of working medium flow at the inlet to tube assemblies caused by a narrow gap between the Segner wheel and the inlet to the tube assembly and due to the rotational speed of a Segner wheel, the efficiency of working medium exiting through the tube assemblies decreases, respectively lowering the propelling force and reducing the operational efficiency factor of the turbine.

The object of the present invention is to eliminate, or at least alleviate, the above and other drawbacks of the prior art and to provide a highly efficient method of producing mechanical energy in a jet turbine, a

single-flow jet turbine, a double-flow jet turbine, and a turbo-jet apparatus based thereon with a high operational efficiency factor.

The above and other objects of the present invention are achieved in
5 a single-flow jet turbine having increased efficiency of producing energy, such as mechanical energy, electrical energy or the same and decreased mass –dimensional properties.

The object of the present invention is achieved by modifying the
10 operational thermodynamic cycle of the jet turbine so as to achieve an increase in power and efficiency and a decrease in the mass-dimensional characteristics of a single-flow or double-flow jet turbine and a turbo-jet apparatus comprising thereof at a given power requirement. In one aspect of the invention, a method for producing mechanical energy in a jet
15 turbine is provided, the method comprising

supplying a working medium into the centrifugal impulse wheel of the jet turbine;

compressing the working medium in the passages of the wheel to increase temperature and speed of the working medium,

20 discharging a flow of working medium into a collector having nozzles, further compressing the flow of the working medium inside the collector to decrease the flow speed and increase the pressure so as to accelerate the working medium in the nozzles; and

expelling the flow of working medium out of the nozzles and into the
25 surrounding space, thus forming a propelling force pulse providing rotation of the impulse wheel.

In another aspect of the invention, a single-flow jet turbine is provided, comprising

30 a single-flow centrifugal impulse wheel having blades and rotatably mounted on a shaft, the wheel being adapted to compress a working medium entering the wheel, and covered with a cowl along upper side

edges of the blades to form centrifugal passages having outlet openings, and

a hollow toroid-shaped collector having a circular opening extending along the inner circumference of the collector,

5 wherein the collector is rigidly fixed and sealingly attached to the single-flow centrifugal impulse wheel so as to provide the outlet openings of the centrifugal passages with a fluid connection to the inner chamber of the toroid-shape collector,

10 wherein the collector has exhaust openings with jet nozzles mounted therein, the exhaust openings being arranged substantially along the outer circumference of the toroid-shaped collector.

The technical effect of the invention is the increased efficiency of producing energy, such as mechanical energy, in turbine, such as a single-
15 flow jet turbine, or a double-flow jet turbine, and a turbo-jet apparatus based thereon. Further, the invention provides higher power and efficiency of producing mechanical energy whilst reducing the weight and dimensions of a jet turbine at a given power value. In addition, the invention provides a thermodynamic cycle in which working medium flow is compressed
20 directly in the flow part of the gas-dynamic tract of a turbine. The flow part comprises passages formed by the cowl of the wheel and the blades, a collector chamber and nozzles.

In one embodiment of the invention, a centrifugal impulse wheel of
25 the jet turbine can be implemented as an impulse wheel of a single-flow centrifugal compressor.

In one embodiment of the invention, blades of a single-flow centrifugal impulse wheel are radial.

In one embodiment of the invention, blades of a single-flow centrifugal impulse wheel have a shaped deflection angle at the outlet directed against the direction of rotation.

5 In one embodiments the toroid-shaped collector is formed integral with inlet portions of the jet nozzles.

In one embodiment of the invention, an opening extending along the inner circumference of the toroid-shaped collector is continuous or, in
10 some other particular embodiments, multiple openings can be formed by installing dividers.

In one embodiment of the invention, the width of an opening extending along the inner circumference of the collector is preferably not
15 less than the blade height in outlet cross-section of centrifugal passages of a single-flow centrifugal impulse wheel. Without being bound by a particular theory, the inventors believe that this design reduces pressure loss in the working medium when it enters the toroid-shaped collector.

20 In one embodiment of the invention, jet nozzles are supersonic, to achieve maximum working medium exit speed from the jet turbine.

In one embodiment of the invention, jet nozzles are mounted into the toroid-shaped collector of the jet turbine tangentially, in a plane
25 perpendicular to the rotation axis of the single-flow centrifugal impulse wheel.

In some particular embodiments, the jet nozzles are mounted into the toroid-shaped collector tangentially, wherein some of the jet nozzles
30 are mounted in a plane perpendicular to the rotation axis of the single-flow centrifugal impulse wheel, while some other jet nozzles are mounted at an

angle to the plane perpendicular to the rotation axis of the single-flow centrifugal impulse wheel.

In one embodiment of the invention, some of the jet nozzles have an
5 elongated inlet section, wherein a side cut is made in the elongated inlet section to supply the working medium through said cut.

In one embodiment of the invention, the jet nozzles are provided with a fixedly secured bottom on the side of inlet section end, wherein the
10 dimensions of said bottom correspond to cross-sectional dimensions of the toroid-shaped collector. Without being bound to a particular theory, the inventors believe that this design increases the propelling force pulse transmitted from a jet nozzle to a single-flow centrifugal impulse wheel.

15 In some particular embodiments, the toroid-shaped collector of the jet turbine is provided with dividers extending in a cross-section plane of the collector, wherein said dividers are fixedly secured generally in the vicinity of the inlet section end of each of the jet nozzles.

20 In some embodiments of the invention, the number of the jet nozzles does not exceed the number of the centrifugal passages in the single-flow centrifugal impulse wheel. Without being bound to a particular theory, the inventors believe that this increases efficiency of each jet nozzle.

25 In another aspect of the invention, a double-flow jet turbine is provided, comprising

a double-flow centrifugal impulse wheel having blades and rotatably mounted on a shaft, the wheel being adapted to compress a working
30 medium entering the wheel, wherein said double-flow impulse wheel comprises

two single-flow centrifugal impulse wheels securely and sealingly connected to each other in a coaxial manner or formed as a single integral element,

wherein said wheels are arranged such that shape of the blades in
5 one of said wheels mirrors the shape of the blades in the other of said wheels, and

said impulse wheels are covered with cowls along upper side edges of the blades to form centrifugal passages having outlet openings, and,

at least one hollow toroid-shaped collector having an opening
10 extending along the inner circumference of the collector,

wherein the collector is securely and sealingly attached to the double-flow centrifugal impulse wheel in such manner that the outlet openings of the centrifugal passages are in a fluid connection and open into the inner chamber of the toroid-shaped collector,

15 wherein the collector further has exhaust openings with jet nozzles mounted therein, the exhaust openings being arranged substantially along the outer circumference of the toroid-shaped collector.

In some embodiments of the invention, single-flow impulse wheels
20 forming the double-flow impulse wheel or formed as a single integral element are generally implemented each as an impulse wheel of a single-flow centrifugal compressor.

In some embodiments of the invention, blades of a double-flow
25 centrifugal impulse wheel are radial.

In some particular embodiments, blades of a double-flow centrifugal impulse wheel are formed to define a deflection angle at the outlet, wherein the angle is directed against the direction of rotation.

30

In some embodiments of the invention, the toroid-shaped collector is formed integral with inlet portions of the jet nozzles.

In some embodiments of the invention, an opening extending along the inner circumference of the toroid-shaped collector is continuous.

5 In some embodiments of the invention, an opening extending along the inner circumference of the toroid-shaped collector is provided with dividers.

10 In some embodiments of the invention, the width of an opening around the circumference defined by said inner diameter is generally at least equal to the total blade height in outlet cross-section of passages of the double-flow centrifugal impulse wheel. Without being bound to a particular theory, the inventors believe that this reduces pressure loss in the working medium when it enters the toroid-shaped collector.

15 In some embodiments of the invention, to achieve maximum working medium exit speed from the jet turbine, the jet nozzles are supersonic.

20 In some embodiments of the invention, jet nozzles are mounted into the toroid-shaped collector of the jet turbine tangentially, in a plane perpendicular to the rotation axis of the double-flow centrifugal impulse wheel.

25 In some particular embodiments, jet nozzles are mounted into the toroid-shape collector of the jet turbine tangentially, wherein some of the jet nozzles are mounted in a plane perpendicular to the rotation axis of the double-flow centrifugal impulse wheel, while some other jet nozzles are mounted at an angle to the plane perpendicular to the rotation axis of the
30 double-flow centrifugal impulse wheel.

In some embodiments of the invention, jet nozzles are provided with an elongated inlet section, wherein a side cut is made in the elongated inlet section to supply the working medium through said cut.

5 In some embodiments of the invention, jet nozzles are provided with a fixedly secured bottom on the side of inlet section end, wherein the dimensions of said bottom correspond to cross-sectional dimensions of the toroid-shaped collector. Without being bound to a particular theory, the inventors believe that this increases the propelling force pulse transmitted
10 from the jet nozzle to the double-flow centrifugal impulse wheel.

In particular embodiments, the toroid-shaped collector is provided with dividers extending across the collector in cross-section plane, wherein said dividers are fixedly secured generally in the vicinity of the inlet section
15 end of each jet nozzle.

In one embodiment of the invention, the number of jet nozzles does not generally exceed half of the number of the centrifugal passages in the double-flow centrifugal impulse wheel when utilizing one toroid-shaped
20 collector, and is preferably equal to the number of passages when utilising two toroid-shaped collectors. Without being bound to a particular theory, the inventors believe that this increases efficiency of each jet nozzle.

According to yet another aspect of the present invention a turbo-jet
25 apparatus is provided, comprising

a shaft with bearing supports, wherein at least two single-flow and/or double-flow jet turbines as described above are mounted thereon in a spaced manner and adapted to rotate in one direction,

inlet collectors for supplying a working medium, the collectors being
30 fixedly mounted around the shaft and connected to inlet openings of impulse wheels by means of tube assemblies, wherein

the tube assemblies are arranged around the shaft, the tube assemblies being fixedly connected to the collectors, and moveably connected to the inlet openings of the impulse wheels of the turbines in a sealed manner.

5

In particular embodiments, the single-flow turbines comprise impulse wheels arranged such that shape of the blades in one of said wheels mirrors the shape of the blades in some other of said wheels, wherein the jet nozzles are directed in oppositely mirrored directions.

10

The present invention can be further described in more detail with reference to accompanying illustrating drawings, which shall not be considered as limiting the scope of the present invention, but merely illustrating some particular embodiments of the invention.

15

Fig. 1 shows an axonometric view of a single-flow jet turbine according to one embodiment of the present invention.

Fig. 2 shows an axonometric cross-sectional view of a single-flow jet turbine according to one embodiment of the present invention.

20

Fig. 3 shows an axonometric view of a single-flow centrifugal impulse wheel according to one embodiment of the present invention.

Fig. 4 shows an axonometric view of an embodiment of a toroid-shaped collector according to one embodiment of the present invention .

25

Fig. 5 shows an axonometric view of an embodiment of a jet nozzle with an elongated inlet section according to one embodiment of the present invention.

Fig. 6 shows an axonometric view of an embodiment of a toroid-shaped collector formed integrally with the inlet sections of a jet nozzle according to one embodiment of the present invention.

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Fig. 7 shows an axonometric view of an embodiment of a jet nozzle with a threaded apparatus according to one embodiment of the present invention.

Fig. 8 shows an axonometric cross-sectional view of a double-flow jet turbine according to one embodiment of the present invention.

Fig. 9 shows an axonometric view of a double-flow jet turbine according to one embodiment of the present invention.

5 Fig. 10 shows an axonometric view of a double-flow centrifugal impulse wheel according to one embodiment of the present invention.

Fig. 11 shows an axonometric view of a turbo-jet apparatus with two double-flow jet turbines according to one embodiment of the present invention.

10 Fig. 12 shows an axonometric cross-sectional view of a turbo-jet apparatus with two double-flow jet turbines according to one embodiment of the present invention.

Fig. 13 shows the results of analysis of operational characteristics of a single-flow jet turbine with different working medium compression values according to one embodiment of the present invention.

A single-flow jet turbine (Fig. 1 and Fig. 2) according to one embodiment of the present invention comprises a shaft 1 with single-flow centrifugal impulse wheel 2 comprising blades 3 fixedly mounted thereon (e.g. by means of splines). The impulse wheel 2 is covered with a cowl 4 along the upper side edge of blades 3 to form closed centrifugal passages 5 comprising inlet openings 6, which function as an inlet for the impulse wheel 2 of the jet turbine, and outlet openings 7, which function as an outlet from the impulse wheel 2.

25

In the illustrated embodiment of a jet turbine (Fig. 3), the impulse wheel 2 is provided with radial blades 3.

In particular embodiments, blades of the impulse wheel can have a shaped form, for example, they can be profiled, with a deflection angle at the outlet directed against the direction of rotation of the impulse wheel.

30

Cowl 4 is generally attached to the upper side edge of the blades 3 in a fixed and rigid manner, e.g. via welding.

The cowl can be mounted fixedly with respect to the impulse wheel 2
5 with a gap therebetween to provide rotation thereof, and is attached to a stationary base which can be specifically formed therefore.

The single-flow centrifugal impulse wheel 2 is adapted to compress the working medium entering the wheel by means of centrifugal forces
10 acting upon the working medium and due to geometry of the flow duct formed by centrifugal passages 5. Single-flow impulse wheel 2 can be implemented for example, as an impulse wheel of a single-flow centrifugal compressor, in particular, an impulse wheel similar to the prior art solution (N. Kampsti, "Compressor Aerodynamics", chapter 2.2, Moscow, Mir
15 Publishing, 2000). Parameters of a single-flow impulse wheel and operational characteristics thereof including its geometrical parameters are determined based on requirements for the jet turbine in accordance with methods and calculations provided, for instance, in the aforementioned publication.

20

Blades 3 of the centrifugal impulse wheel 2 can be curved such that they interact with the encircling flow of a working medium and force on particles of the working medium when the impulse wheel 2 is rotated. Consequently, centrifugal forces are generated in the particles of the
25 working medium, and the working medium is thrown back with a high speed to an exterior of the impulse wheel 2, in particular, to the outlet openings 7 of the centrifugal passages 5, where the working medium has an increased pressure. Thus, blades 3 form geometry of the flow duct of centrifugal passages 5, and blades 3 compress the working medium in
30 centrifugal passages 5 together with centrifugal forces.

Compression of a medium flow in the single-flow jet turbine according to the present invention depends partly on rotation speed of the impulse wheel 2 which can be increased in the single-flow jet turbine due to its construction.

5

A single-flow impulse wheel 2 is in a fluid connection with a collector 8. According to one embodiment of the present invention, the collector 8 is implemented as a toroid provided with an opening 9 extending along the inner circumference of the collector. The opening 9 can be continuous or
10 provided with dividers. The width of the opening 9 is at least equal to the blade 3 height in cross-section of opening 7 of centrifugal passages 5 of the impulse wheel 2, which provides unimpeded inlet of working medium into the toroid-shaped collector 8 without pressure loss in the working medium. The toroid-shaped collector 8 is attached to the impulse wheel 2
15 in such manner that outlet openings 7 of the centrifugal passages 5 are in fluid communication with the inner chamber 10 of the toroid-shaped collector 8.

20 According to one embodiment of the present invention, the toroid-shaped collector 8 can be formed with different cross-sections, e.g. square, rectangular, circular or other shape. In the illustrated embodiment of the jet turbine, the toroid-shaped collector 8 is provided with a circular cross-section in order to minimize mass-dimensional properties thereof.
25 The width of the opening 9 is practically identical to the cross-sectional diameter of the toroid-shaped collector 8.

The toroid-shaped collector 8 is fixedly and hermetically sealed to the impulse wheel 2 from the side of opening 9.

30

To provide attachment, the toroid-shaped collector 8 can be provided with specific attachment points, by which it is connected (generally by

means of bolted connection providing a hermetic seal, e.g. using a washer or a sealant) to the impulse wheel 2 and the cowl 4, which can be provided with cylindrical flanges 11 and 12 respectively for said purpose. Such arrangement provides secure attachment of the toroid-shaped collector 8 to the impulse wheel 2, as well as the ability to assembly and disassembly the jet turbine.

Collector 3 performs the following functions:

- collector 3 connects together the impulse wheel 2 and the jet nozzles 14 by a rigid, hermetic, and compact connection providing their effective joint and providing outflow of working medium through the outlet openings 7 of the closed centrifugal passages 5 in the chamber 10;
- collector 3 stores working medium in the chamber 10 and provides increase of the working medium's pressure;
- collector 3 facilitates fitting of thermodynamic parameters in working medium prior to its expelling out of the jet nozzles 14.

Openings 13, in which the jet nozzles 14 are installed, are arranged around the outer circumference of the toroid-shaped collector 8 (Fig. 4).

20

According to one embodiment of the present invention, jet nozzles 14 are generally supersonic, e.g. formed by convergent-divergent nozzles (A. A. Dorofeev, "Basic thermal rocket engine theory", chapters 3 and 5, Bauman MHTS, Moscow, 1999), with flow duct sections thereof in serial arrangement: the inlet section, the convergent section, and the divergent section respectively.

In order to provide maximum rotational torque of the impulse wheel 2, the jet nozzles 14 are mounted with inlet section thereof into the toroid-shaped collector 8 tangentially and uniformly directed along the circumference, generally perpendicular to the impulse wheel 2.

30

In particular embodiments, in order to provide necessary balance of axial load on the shaft 1 of the jet turbine, said load exerted by both centrifugal passages 5 and jet nozzles 14, the axis of symmetry of at least some jet nozzles 14 can be arranged at an angle with respect to the plane perpendicular to the axis of rotation of impulse wheel 2 by forming openings 13 in the toroid-shaped collector 8 at different angles with respect to the plane perpendicular to the axis of rotation of impulse wheel 2, and by providing curvilinear jet nozzles 14.

10 Jet nozzles 14 can be mounted by means of a threaded connection and/or by welding.

In the illustrated embodiment of the jet turbine, the inlet section of the jet nozzle 14 is elongated (Fig. 5) to provide the possibility of installing said section into the toroid-shaped collector 8, e.g. by welding.

Another method of installing jet nozzles can be realized by forming the toroid-shaped collector integrally with the inlet sections of jet nozzles (Fig. 6). Jet nozzles can thus be installed into the toroid-shaped collector by means of a threaded connection and/or by welding (Fig. 7).

In the preferred embodiment, the toroid-shaped collector is formed integrally with the inlet section of jet nozzles. This allows to significantly increase the strength of attachment in such jet nozzle collector, which consequently results in that the rotational speed of the impulse wheel can be substantially increased, in particular up to 680-700 m/s or more, and therefore, that the compression of working medium flow in the jet turbine can be increased. An increase in working medium compression in the flow channel of the jet turbine's gas-dynamic tract results in an increase in efficiency of producing mechanical energy and, correspondingly, in jet turbine output.

In the elongated inlet section of the jet nozzle 14, a side cut 15 is formed. Side cut 15 is open towards outlet openings 7 and provides supply of working medium therethrough, from chamber 10 of the toroid-shaped collector 8 into jet nozzle 14.

5

In order to increase the propelling force pulse value, said pulse transmitted from the jet nozzle 14 to the impulse wheel 2, jet nozzles 14 can be provided on the inlet side with a fixedly secured (e.g. by welding) bottom 16, wherein the dimensions of said bottom correspond to cross-sectional dimensions of the toroid-shaped collector 8, with said bottom bridging said collector.

10

In a particular embodiment, the inlet section of each jet nozzle 14 can be tightly covered from the inlet side thereof with a divider fixedly secured (e.g. by welding) in the collector 8, wherein the dimensions of said divider correspond to cross-sectional dimensions of the toroid-shaped collector 8, with said divider bridging said collector.

15

In particular embodiments, jet nozzles can be mounted tangentially on the openings of the toroid-shaped collector. In this case, in order to transfer said propelling force pulse from the jet nozzle to the impulse wheel, jet nozzles are formed with a bottom fixedly secured on the side of inlet section end, wherein the dimensions of said bottom correspond to cross-sectional dimensions of the inlet section of the jet nozzle.

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Jet nozzles 14 can be formed with different cross-sections, e.g. square, rectangular, circular or other shape. In the illustrated embodiments of jet turbines, jet nozzles 14 are formed with a circular cross-section in order to minimize mass-dimensional properties thereof.

30

In one embodiment, jet nozzles 14 are integral with the collector to provide a high strength of the turbine structure. In another embodiment,

jet nozzles 14 are dismountable to allow for easier manufacturing, repair and/or replacement during maintenance.

In the illustrated embodiment of jet turbines, axes of symmetry of
5 jet nozzles 14 are arranged substantially perpendicular to the outlet profile of radial blades 3 in cross-section of outlet openings 7 of the impulse wheel 2.

When the blades of the impulse wheel are shaped, the direction of
10 mounting jet nozzles 14 generally coincides with the deflection angle of blades 3 in cross-section of outlet openings 7 in order to reduce working medium pressure loss in the jet turbine.

In order to provide a steady working medium flow over the whole
15 length of the flow duct of a single-flow jet turbine, the number of jet nozzles 14 generally does not exceed the number of centrifugal passages 5.

In order to achieve maximum performance, all elements of the
20 single-flow jet turbine are made of a high-strength construction-grade titanium alloy BT6.

The experiments performed by the inventors of the present invention have shown that rotation speed of the impulse wheel 2 can be increased in
25 the single-flow jet turbine by selecting design parameters, which result in increase of the working medium pressure and/or reduction of the working medium pressure losses, which include:

- width of the opening 9 which is at least equal to the blade 3 height in cross-section of opening 7 of centrifugal passages 5 of the impulse
30 wheel 2;

- direction of mounting jet nozzles 14 which generally coincides with the deflection angle of blades 3 in cross-section of outlet openings 7;

- bottoms 16 provided in jet nozzles 14;
- forming the collector 8 integrally with inlet sections of jet nozzles 14.

The design parameters as selected above are also applicable to a double-flow jet turbine and a turbo-jet apparatus according to
5 embodiments of the present disclosure in order to increase the working medium pressure and/or reduce the working medium pressure losses.

A double-flow jet turbine (Fig. 8 and Fig. 9) comprises a double-flow
10 centrifugal impulse wheel 22 with blades 23 rotatably mounted on a shaft 21, adapted to compress the working medium entering the wheel.

The double-flow impulse wheel 22 is formed of two single-flow impulse wheels arranged in a coaxial manner and fixedly secured to each
15 other, or formed integrally. Single-flow impulse wheels similar to the wheel described herein for a single-flow jet turbine can be used, wherein one wheel is formed with a mirrored (opposite) direction of blade shape with respect to the other.

20 The secure coaxial connection between the single-flow impulse wheels can be formed, e.g. by means of a fixed bolted connection or by welding.

In the illustrated embodiment of a double-flow jet turbine, the
25 double-flow impulse wheel 22 (Fig. 10) is formed integrally from one piece by milling the blades on each side of the piece using specialized multi-axis machining tools. The blade shapes are milled in a mirrored (opposite) direction on each side.

30 The double-flow impulse wheel 22 is covered with cowls 24 along the upper side edge of blades 23. In this arrangement, centrifugal passages 25 are formed, comprising inlet openings 26, which function as inlets for the

double-flow impulse wheel 22 , and outlet openings 27, which function as outlets from the double-flow impulse wheel 22.

Cowls 24 is generally attached to the upper side edges of the blades
5 23 in a fixed and rigid manner, e.g. via welding.

The cowls 24 can be mounted fixedly with respect to the double-flow impulse wheel 22 with a gap therebetween to provide rotation thereof, and are attached to a specifically formed stationary base.

10

In the illustrated embodiment of the double-flow jet turbine, in order to minimize mass and simplify manufacturing, the double-flow impulse wheel 22 is rigidly and sealedly connected to one (common for both single-flow wheels) toroid-shaped collector 28, wherein inlet openings 27 of
15 centrifugal passages 25 are open into the collector chamber 29.

An opening 30, which can be continuous or provided with dividers, is formed to extend along the circumference of the inner diameter of the toroid-shaped collector 28. Width of the opening 30 is at least equal to the
20 total height of blades 23 in cross-section of outlet openings 27 of centrifugal passages 25 of the impulse wheel 22.

The toroid-shaped collector 28 can be attached to the double-flow impulse wheel 22 similarly to the attachment of the toroid-shaped collector
25 in a single-flow jet turbine described herein.

Openings 31, in which the jet nozzles 32 are installed, are arranged around the outer circumference of the toroid-shaped collector 28.

30 Jet nozzles 32 are formed and mounted into the toroid-shaped collector 30 of the double-flow jet turbine similarly to the process described herein with respect to the single-flow jet turbine.

In case when inlet sections of jet nozzles are formed integrally with the toroid-shaped collector 28, the collector can be provided with fixedly attached dividers 33 placed in front of the inlet section of each jet nozzle
5 32.

The double-flow jet turbine can also be provided with two identical toroid-shaped collectors mounted in a coaxial manner and securely connected to each other with side surfaces thereof, e.g., by means of bolts
10 or by welding. Jet nozzles can thus be rigidly mounted along the outer circumference of each collector by means of a threaded connection and/or by welding.

In particular embodiments, two toroid-shaped collectors can be
15 formed by installing an inner medial divider in a common toroid-shaped collector for both single-flow wheels, wherein said divider is placed perpendicularly to the axis of rotation of the collector and dividing the inner chamber thereof into two (generally equal) parts. Jet nozzles can thus be rigidly mounted along the outer circumference of each part of the
20 collector by means of a threaded connection and/or by welding.

At identical power values of jet turbines, mass-dimensional properties of a double-flow jet turbine provided with one toroid-shaped collector display a near 20% improvement over similar combined
25 properties of two single-flow jet turbines combined.

A turbo-jet apparatus (Fig. 11 and Fig. 12) comprises a shaft 41 with bearing supports 42, with at least two double-flow jet turbines 43 fixedly mounted thereon in a spaced manner and adapted to rotate in one
30 direction.

Several single-flow and/or double-flow turbines as disclosed in claims 2 and 17 can be mounted on the shaft 41 at the same time. In this case, single-flow turbines can be mounted in the same way, or they can be arranged facing each other or in opposite directions with respect to the inlets thereof. Double-flow turbines can be mounted on the shaft 41 facing in one direction only.

When two single-flow turbines with inlets thereof facing each other or in opposite directions are mounted on the shaft 41, single-flow jet turbines with impulse wheels formed with mirrored (opposite) directions of blade shape and mirrored (opposite) direction of mounting jet nozzles must be used.

Inlet collectors 44 for supplying working medium are generally fixedly mounted around the shaft 41. Connection between the inlet collectors 44 and inlet openings of impulse wheels of the turbines 43 is formed by means of tube assemblies 45 arranged around the shaft 41 with inlet collectors 44, wherein said tube assemblies are sealedly and moveably connected with inlet openings of impulse wheels of the turbines 43 by means of end seals and/or labyrinth seals. Tube assemblies 45 are rigidly connected with inlet collectors 44, e.g. by means of flanges, thread or by welding.

The use of turbo-jet apparatuses with several single-flow or double-flow jet turbines results in a manifold increase in power of turbo-jet apparatuses with only a slight increase in mass-dimensional properties thereof.

The method for producing mechanical energy in a single-flow jet turbine is carried out as follows.

In the initial position, the single-flow centrifugal impulse wheel 2 of a single-flow jet turbine is in a rest state, i.e. it is motionless.

When the turbine is actuated, a working medium, e.g. steam from a steam generator or gas from a combustion chamber, is urged by its initial
5 pressure to enter the inlet of the wheel 2, into inlet openings 6 of the centrifugal passages 5 at an initial speed; upon passing through said elements, the working medium flows from outlet openings 7 through opening 9 into inner chamber 10 of the toroid-shaped collector 8. From the chamber 10, the working medium moves through side cuts 15 into jet
10 nozzles 14. The initial pressure of the working medium acts upon bottoms 16, resulting in acceleration of the working medium in the jet nozzles 14 to supersonic speed; the working medium then exits the nozzles into surrounding space substantially perpendicular to the radius of the impulse wheel 2, thus forming a propelling force pulse that rotates the impulse
15 wheel 2 on the shaft 1.

Since the rotation velocity of the impulse wheel 2 in the initial time interval and in the subsequent short time interval is negligible with respect to the design rotation velocity, the working medium at this stage is not compressed due to geometry of the flow duct of centrifugal passages 5
20 and due to centrifugal forces acting upon the working medium neither in the impulse wheel 2 nor in the toroid-shaped collector 8.

The rotation of impulse wheel 2 of the jet turbine at the initial stage occurs exclusively due to the propelling force pulse created when the working medium exits jet nozzles 14, wherein prior to said exit, the
25 working medium generally possesses the initial thermodynamic characteristics. Therefore, the single-flow jet turbine utilizing only the difference of the initial working medium pressure acts in accordance with the Segner wheel principle. That a short operational interval of the single-flow jet turbine is the time interval required for the turbine to reach the
30 design operation.

As the rotational velocity of the impulse wheel 2 increases, approaching the design values, blades 3 forming the flow duct geometry of centrifugal passages 5, together with the centrifugal forces acting upon the working medium flow in centrifugal passages 5, compress the working
5 medium flow with a corresponding increase in density.

As a result of said compression, the temperature, pressure and velocity of the working medium at outlet from centrifugal passages 5 are increased such that they substantially exceed the temperature, pressure and velocity of the working medium at the inlet into the impulse wheel 2.

10 Then, the compressed working medium flow having the high temperature, pressure and velocity values passes from the centrifugal passages 5 into the inner chamber 10 of the toroid-shaped collector 8, where said flow is slowed due to counterpressure of the working medium present therein and is further compressed to increase pressure and
15 temperature of the working medium with respect to the pressure and temperature of the working medium at outlet openings 7.

As this takes place, due to intensive turbulent mixing of the working medium mass in the whole volume of chamber 10 of toroid-shaped collector 8, the gradients of density, temperature, pressure and velocity
20 are leveled, wherein the working medium flow is slowed and the working medium flow pressure is increased to a maximum value known as the slowed working medium flow pressure.

The pressure of the working medium inside the collector 8 is further increased by centrifugal forces. Thus, prior being expelled through the jet
25 nozzles 14, the working medium reaches maximum pressure.

Potential energy of the high working medium pressure thus obtained in the single-flow jet turbine is converted into kinetic energy of the supersonic flow of the working medium during acceleration and exit thereof into the surrounding space by means of jet nozzles 14 that fully
30 utilize the working medium pressure difference obtained in said jet turbine.

Thus the maximum propelling force pulse is achieved, which provides rotation of the single-flow centrifugal impulse wheel 2 of the single-flow jet turbine on the shaft 1 with required operational parameters.

5 The single-flow jet turbine can be actuated and efficiently operated when the initial working medium pressure at the input into the impulse wheel 2 is insufficient for actuating the turbine and achieving normal operation thereof. In this case, forced initial rotation of the shaft 1 can be used (e.g. using a mechanical or electromechanical drive), which creates a
10 necessary and sufficient compression of the working medium in the impulse wheel 2 of the jet turbine, said compression providing further operation of the jet turbine without forced rotation of the shaft 1.

By way of example, the table (Fig. 13) shows results of
15 mathematical simulation and preliminary bench testing of the disclosed single-flow jet turbine obtained in different operation modes (modes I to IV, and also modes V to VI) thereof in relation to initial working medium pressure at the inlet into the jet turbine and in relation to compression of the working medium therein.

20

The single-flow jet turbine is made of BT6 titan alloy.

Wet saturated steam with parameters also shown in the table (Fig. 13) was used as a working medium.

25

The results of mathematical simulation and preliminary testing of the single-flow jet turbine show that power thereof and efficiency of producing mechanical energy are affected by two primary factors: initial pressure and temperature of the working medium entering the turbine inlet, as well as
30 working medium compression in the flow part of the single-flow jet turbine. The following parameters are controllable: vapor flow rate through the turbine; vapor pressure at inlet of the impulse wheel; vapor

temperature at inlet of the impulse wheel; diameter of the impulse wheel; rotational velocities of the impulse wheel; and quantity of the jet nozzles. Working medium flow compression values can be changed indirectly, for example, by changing rotational velocity of the impulse wheel.

5

Here are the values of the parameters of the single-flow jet turbine based on the preliminary testing experiments. The value of the vapor flow rate through the turbine lies within range 1000 kg/h – 50000 kg/h, preferably 5000 kg/h – 15000 kg/h. Vapor pressure at inlet of the impulse wheel has the value 10 kPa – 5000 kPa, preferably within ranges 400 kPa – 800 kPa and 1500 kPa – 2000 kPa. Vapor temperature at inlet of the impulse wheel has the value 100°C - 250°C, preferably within ranges 150°C - 170°C and/or 190°C - 210°C. Diameter of the impulse wheel lies within 0,1 m – 2 m, preferably 0,5 m - 0,8 m. Rotational velocities of the impulse wheel has the value 1000 rpm – 10000 rpm, preferably within ranges 3000 rpm – 4500 rpm and/or 5500 rpm – 7000 rpm. The number of the jet nozzles is selected from 2 to 50, preferably from 10 to 20.

As can be seen from the table, vapor flow rate through the turbine, diameter of the impulse wheel, and quantity of the jet nozzles had the same values for all modes I to VI. Vapor pressure at inlet of the impulse wheel and vapor temperature at inlet of the impulse wheel were increased for modes V and VI. Working medium flow compression values in the impulse wheel were changed in modes I to VI.

25

Initial pressure and temperature of the working medium relate to parameters that are usually defined by the type and operation of working medium source (generator), for example, a steam generator, and the increase of initial pressure and temperature of the working medium is not directly associated with the jet turbine. It shall be appreciated that the increase in initial pressure and temperature of the working medium is associated with substantial additional energy consumption, e.g. by the

30

steam generator, which is not always feasible due to technical, operational, financial and other reasons.

The compression of the working medium in the single-flow jet turbine is defined solely by design efficiency thereof and constitutes the primary factor behind the significant increase in efficiency of producing mechanical energy in said turbine.

As can be appreciated from the analysis of results shown in the table (Fig. 13), the single-flow jet turbine provides practically identical power and efficiency of producing mechanical energy when operating in modes III and V, and in modes IV and VI. Therefore, the increase in working medium compression in the single-flow jet turbine operating in modes III and IV up to 5.08 and 5.95, respectively, allows to use lower working medium pressure and temperature values (630 kPa and 158°C instead of 1600 kPa and 200°C) at the inlet, while still providing required power. The increase in working medium flow compression can be achieved, for example, by adjusting rotational velocity of the impulse wheel. Rotational velocities of the impulse wheel in modes III and IV were increased to increase working medium flow compressions in these modes, as shown in the table.

Therefore, due solely to an increase in working medium compression, the single-flow jet turbine is capable of achieving required performance in terms of efficiency and power thereof with a low initial working medium pressure at the inlet. The data presented herein supports the claimed advantage of the disclosed method for increasing efficiency of producing mechanical energy in the disclosed single-flow jet turbine, wherein said method is based on an innovative operational thermodynamic cycle that provides compression of working medium entering the turbine prior to the exit of said working medium.

The method for producing mechanical energy is similarly implemented in a double-flow jet turbine provided with a double-flow centrifugal impulse wheel.

5 When the double-flow centrifugal impulse wheel is formed with a common hollow toroid-shaped collector, the common hollow collector is more evenly filled with working medium. Such arrangement results in a more steady combined operation of the toroid-shaped collector and jet nozzles without pressure fluctuations, and consequently, increases
10 operational efficiency of the double-flow jet turbine.

The method for producing mechanical energy is similarly implemented in turbo-jet apparatuses based on single-flow and/or double-flow jet turbines. Such technical solution provides a compact-sized turbo-jet
15 apparatus with a manifold increase in power.

The single-flow and double-flow jet turbines implementing a thermodynamic cycle with working medium flow compression prior to acceleration and subsequent exit thereof directly in the flow part of their
20 gas-dynamic tracts, as well as the turbo-jet apparatuses based thereon provide a substantial increase in power and efficiency of producing mechanical energy compared to the prior art, with efficiency ratio of about 55-65% and more.

25 The above description provides sufficient information for a specialist in the art to enable him to successfully design a single-flow and double-flow jet turbines in accordance with the present invention and is clear and precise terms, so that it provides sufficient instructions to a person skilled in the art to enable him to reproduce and successfully manufacture the
30 claimed invention at a specialized manufacturing plant. All the modifications and variants of the described single-flow and double-flow jet

turbines shall be regarded as being within the scope of the invention as it is defined in the appended claims.

CLAIMS

1. A method for producing mechanical energy in a jet turbine, the method comprising:

5 supplying a working medium into a centrifugal impulse wheel of the jet turbine;

compressing the working medium inside the centrifugal passages of the wheel to increase temperature, pressure, and speed of the working medium;

10 outputting the flow of the working medium into a collector having nozzles;

further compressing the flow of the working medium inside the collector to decrease the flow speed and increase the pressure so as to cause the working medium to be accelerated in the nozzles; and

15 expelling the working medium out of the nozzles into surrounding space, thus forming a propelling force pulse providing rotation of the centrifugal impulse wheel of the jet turbine.

2. A single-flow jet turbine comprising:

20 a single-flow centrifugal impulse wheel having blades and rotatably mounted on a shaft, the wheel being adapted to compress a working medium entering the wheel, and covered with a cowl along upper side edges of the blades to form centrifugal passages having outlet openings, and

25 a hollow toroid-shaped collector having an opening extending along the inner circumference of the collector,

wherein the collector is rigidly fixed and sealingly attached to the single-flow centrifugal impulse wheel in such manner that the outlet openings of the centrifugal passages are in fluid connection with an inner
30 chamber of the toroid-shaped collector,

wherein the collector further has exhaust openings with jet nozzles mounted therein, the exhaust openings being arranged substantially along the outer circumference of the toroid-shaped collector.

5 3. The single-flow jet turbine according to claim 2, characterized in that the centrifugal impulse wheel is an impulse wheel of a single-flow centrifugal compressor.

 4. The single-flow jet turbine according to claim 2, characterized in
10 that the blades of the double-flow centrifugal impulse wheel are radial.

 5. The single-flow jet turbine according to claim 2, characterized in that the blades of the single-flow centrifugal impulse wheel have a deflection angle at the outlet directed against the direction of rotation.

15 6. The single-flow jet turbine according to claim 2, characterized in that the toroid-shaped collector is formed integral with inlet portions of the jet nozzles.

20 7. The single-flow jet turbine according to claim 2, characterized in that the opening extending along the inner circumference of the toroid-shaped collector is continuous, or multiple openings are formed by dividers installed in the collector.

25 8. The single-flow jet turbine according to claim 2, characterized in that the width of the opening extending along the inner circumference of the toroid-shaped collector is generally does not exceed the blade height in outlet cross-section of centrifugal passages of the single-flow centrifugal impulse wheel.

30 9. The single-flow jet turbine according to claim 2, characterized in that the jet nozzles are substantially supersonic.

10. The single-flow jet turbine according to claim 2, characterized in that the jet nozzles are mounted into the toroid-shaped collector tangentially, and are uniformly directed in a plane perpendicular to the
5 rotation axis of the single-flow centrifugal impulse wheel.

11. The single-flow jet turbine according to claim 2, characterized in that the jet nozzles are mounted into the toroid-shaped collector of the jet turbine tangentially,
10 wherein some of the jet nozzles are mounted in a plane perpendicular to the rotation axis of the single-flow centrifugal impulse wheel, and some other jet nozzles are mounted at an angle to the plane perpendicular to the rotation axis of the single-flow centrifugal impulse wheel.

15 12. The single-flow jet turbine according to claim 2, characterized in that the jet nozzles are provided with an elongated inlet section.

13. The single-flow jet turbine according to claim 11, characterized
20 in that a side cut is made in the elongated inlet section in order to supply the working medium through said cut.

14. The single-flow jet turbine according to claim 2, characterized in that the jet nozzles are provided with a fixedly secured bottom on the side
25 of inlet section end, wherein the dimensions of said bottom correspond to cross-sectional dimensions of the toroid-shaped collector.

15. The single-flow jet turbine according to claim 2, characterized in that the toroid-shaped collector is provided with dividers closing the
30 collector in cross-section plane, wherein said dividers are fixedly secured generally in the vicinity of the inlet section end of each of the jet nozzles.

16. The single-flow jet turbine according to claim 2, characterized in that the number of the jet nozzles is generally less than the number of the centrifugal passages in the impulse wheel.

5 17. A double-flow jet turbine, comprising:

 a double-flow centrifugal impulse wheel having blades and rotatably mounted on a shaft, the wheel being adapted to compress a working medium entering the wheel,

10 wherein the wheel further comprises

 two single-flow centrifugal impulse wheels rigidly fixed and sealingly connected to each other in a coaxial manner or formed as a single integral element,

15 wherein one impulse wheel is formed with blade shape mirroring the blade shape of the other of said wheels and

 said wheels are covered with cowls along upper side edges of the blades to form centrifugal passages having outlet openings, and,

20 at least one hollow toroid-shaped collector having an opening extending along the inner circumference of the collector,

 wherein the collector is securely and sealingly attached to the double-flow centrifugal impulse wheel in such manner that the outlet openings of the centrifugal passages open into an inner chamber of the
25 toroid-shaped collector,

 wherein the collector further has exhaust openings with jet nozzles mounted therein, the exhaust openings being arranged substantially along the outer circumference of the toroid-shaped collector.

30 18. The double-flow jet turbine according to claim 17, characterized in that the single-flow centrifugal impulse wheels forming the double-flow

impulse wheel are each implemented as an impulse wheel of a single-flow centrifugal compressor.

19. The double-flow jet turbine according to claim 17, characterized
5 in that the blades of the centrifugal impulse wheel are radial.

20. The double-flow jet turbine according to claim 17, characterized
in that the blades of the centrifugal impulse wheel have a shaped
deflection angle at the outlet directed against the direction of rotation.
10

21. The double-flow jet turbine according to claim 17, characterized
in that the toroid-shaped collector is formed integrally with inlet portions of
the jet nozzles.

22. The double-flow jet turbine according to claim 17, characterized
15 in that the opening extending along the inner circumference of the toroid-
shaped collector is continuous or provided with dividers.

23. The double-flow jet turbine according to claim 17, characterized
20 in that the width of the opening extending along the inner circumference of
the toroid-shaped collector is generally at least equal to the total blade
height in outlet cross-section of centrifugal passages of the double-flow
centrifugal impulse wheel.

24. The double-flow jet turbine according to claim 17, characterized
25 in that the jet nozzles are substantially supersonic.

25. The double-flow jet turbine according to claim 17, characterized
in that the jet nozzles are mounted into the toroid-shape collector of the
jet turbine tangentially, in a plane perpendicular to the rotation axis of the
30 double-flow centrifugal impulse wheel.

26. The double-flow jet turbine according to claim 17, characterized in that the jet nozzles are mounted into the toroid-shape collector tangentially,

5 wherein some of the jet nozzles are mounted in a plane perpendicular to the rotation axis of the double-flow centrifugal impulse wheel, and some of the other jet nozzles are mounted at an angle to the plane perpendicular to the rotation axis of the double-flow centrifugal impulse wheel.

10 27. The double-flow jet turbine according to claim 17, characterized in that the jet nozzles are provided with an elongated inlet section.

28. The double-flow jet turbine according to claim 27, characterized in that a side cut is made in the elongated inlet section in order to supply
15 the working medium through said cut.

29. The double-flow jet turbine according to claim 17, characterized in that the jet nozzles are provided with a fixedly secured bottom on the side of inlet section end, wherein the dimensions of said bottom
20 correspond to cross-sectional dimensions of the toroid-shape collector.

30. The double-flow jet turbine according to claim 17, characterized in that the toroid-shaped collector is provided with dividers extending across the collector in cross-section plane, wherein said dividers are fixedly
25 secured generally in the vicinity of the inlet section end of each of the jet nozzles.

31. The double-flow jet turbine according to claim 17, characterized in that the number of the jet nozzles does not generally exceed half of the
30 number of the centrifugal passages in the double-flow centrifugal impulse wheel when utilizing one toroid-shape collector, and is preferably equal to the number of passages when utilizing two toroid-shape collectors.

32. A turbo-jet apparatus, comprising:

a shaft with bearing supports, wherein at least two single-flow jet turbines according to any of claims 2-16 and/or two double-flow jet turbines jet turbines according to any of claims 17-31 are mounted on the shaft in a spaced manner and adapted to rotate in one direction,

inlet collectors for supplying a working medium, the collectors being fixedly mounted around the shaft and connected to inlet openings of the impulse wheels by means of tube assemblies, wherein

the tube assemblies are arranged coaxially around the shaft, the tube assemblies being fixedly connected to the collectors, and moveably connected to the inlet openings of the impulse wheels of the turbines in a sealed manner.

33. The turbo-jet apparatus according to claim 32, characterized in that the single-flow jet turbines comprise impulse wheels arranged such that shape of the blades in one of said wheels is mirror-like to shape of the blades in the other of said wheels, wherein the jet nozzles are directed in opposite directions.

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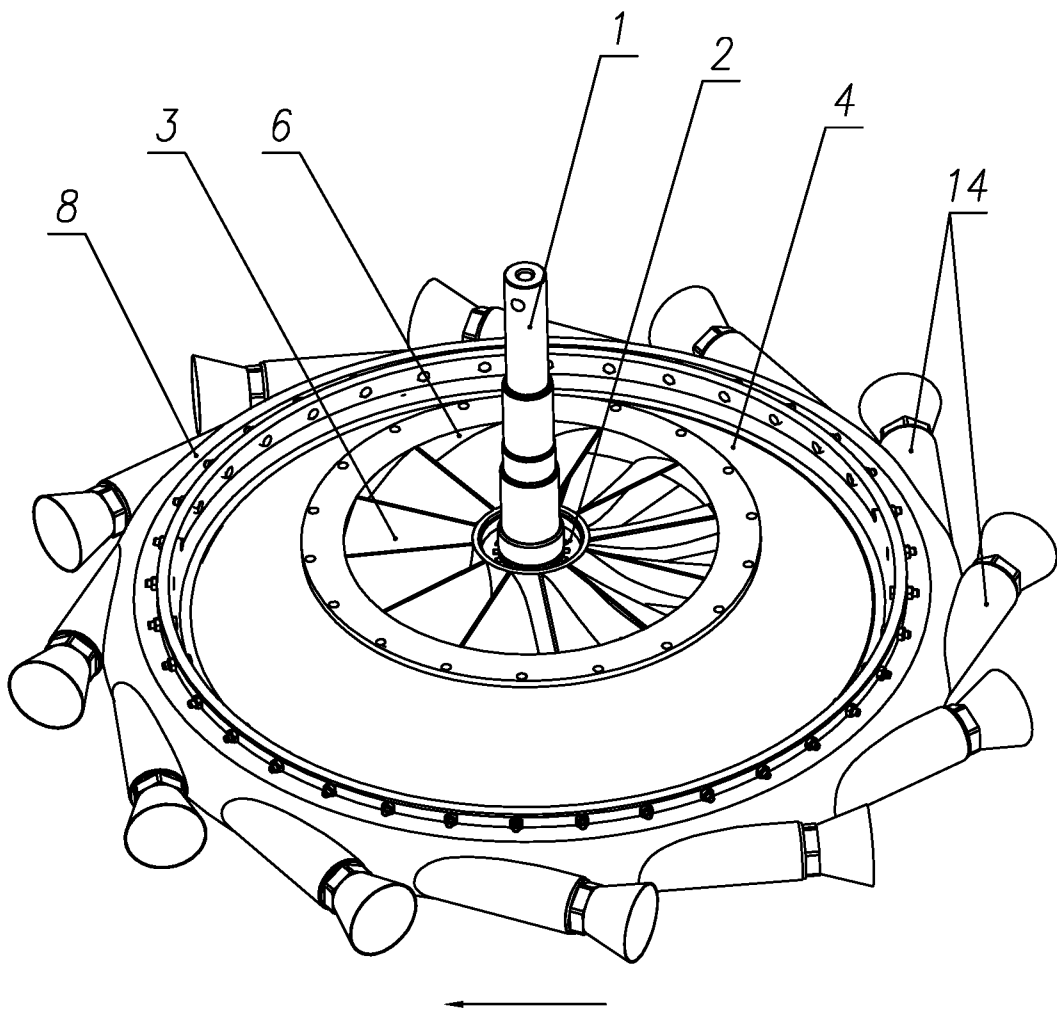


FIG. 1

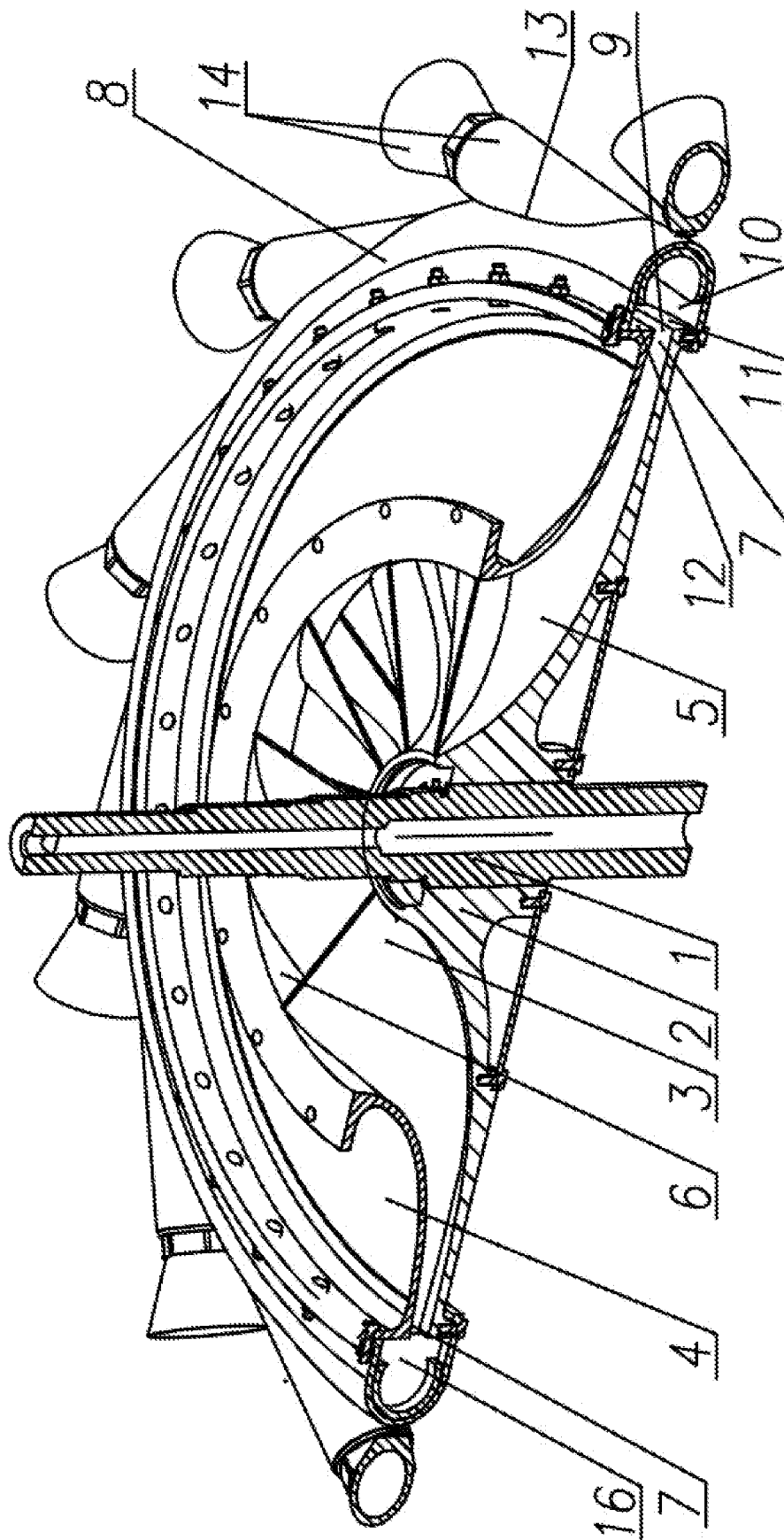


FIG. 2

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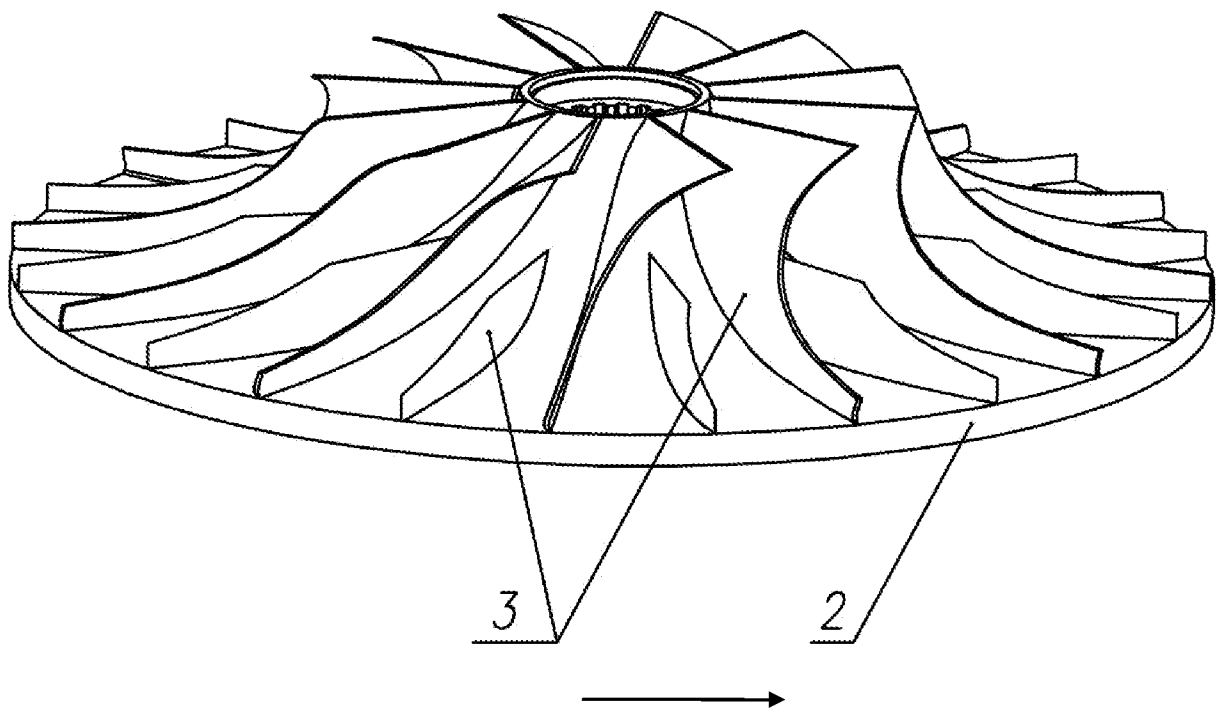


FIG. 3

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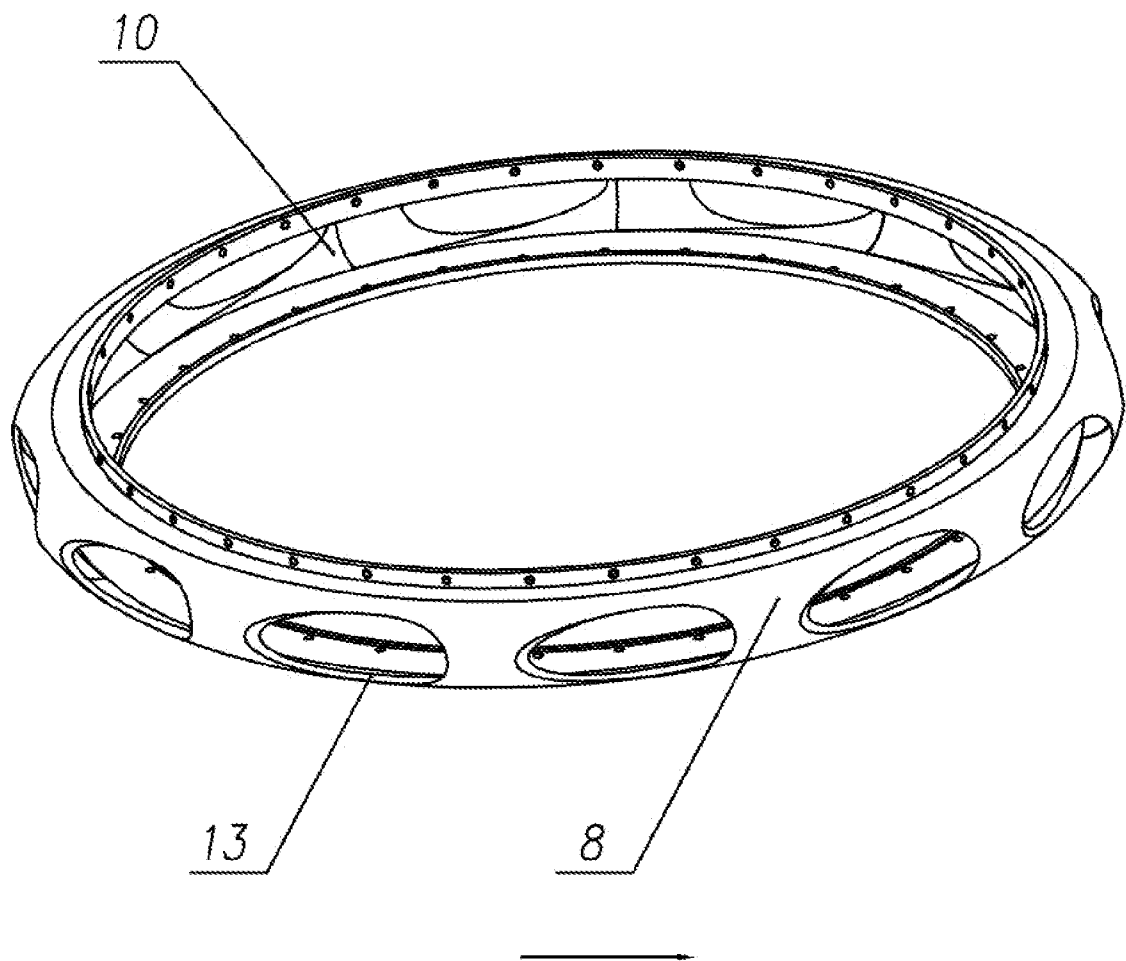


FIG. 4

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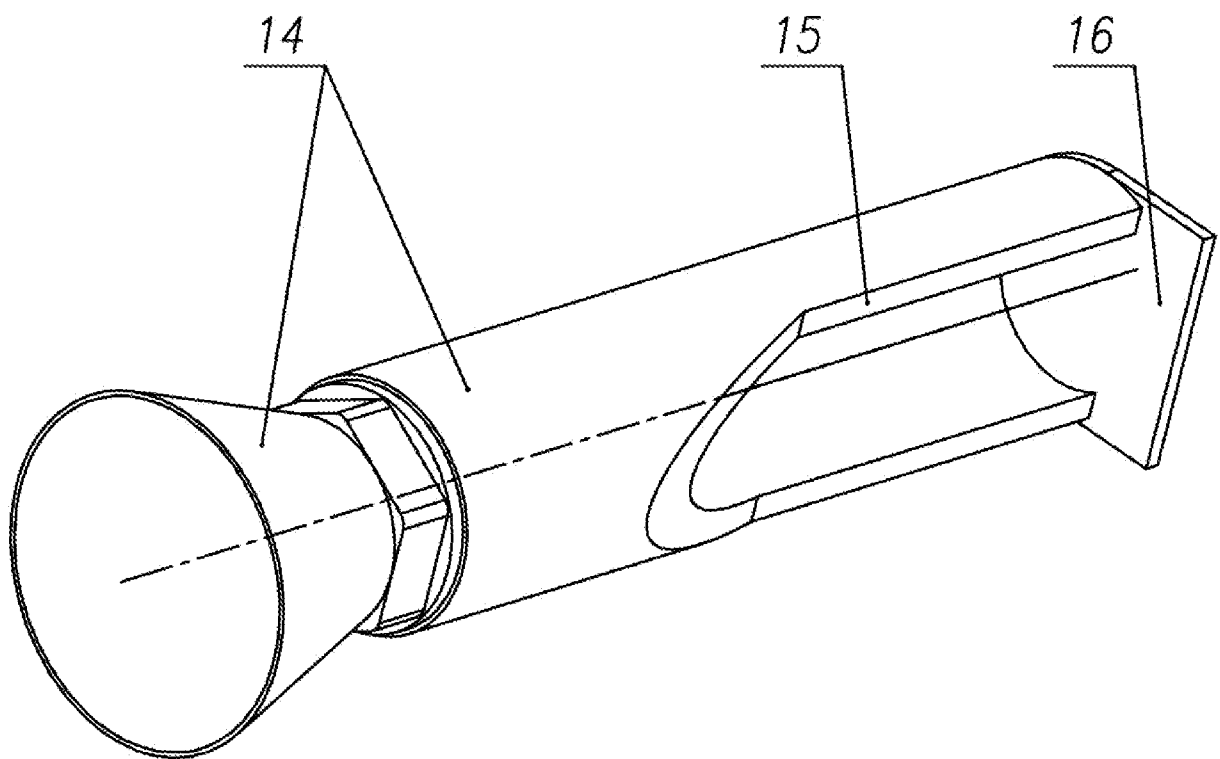


FIG. 5

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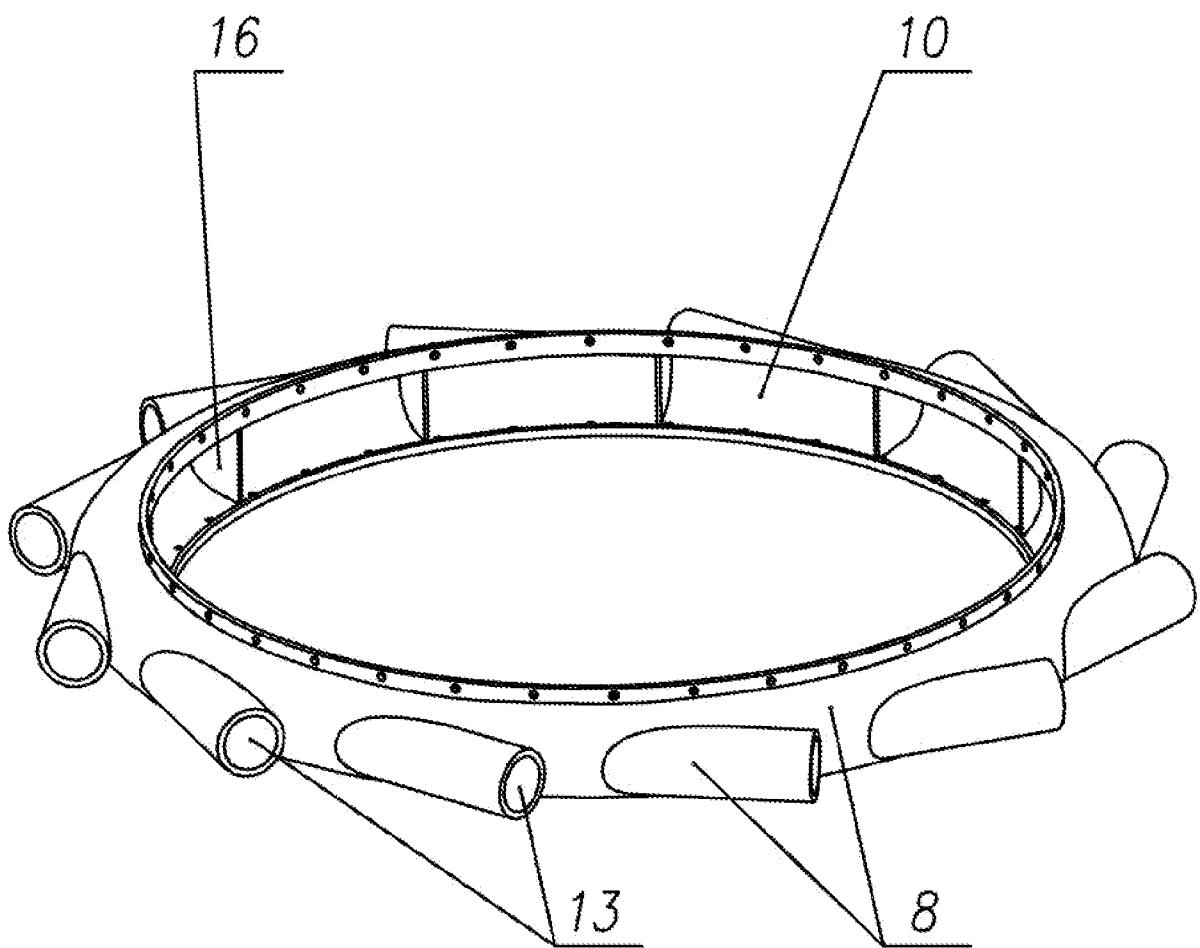


FIG. 6

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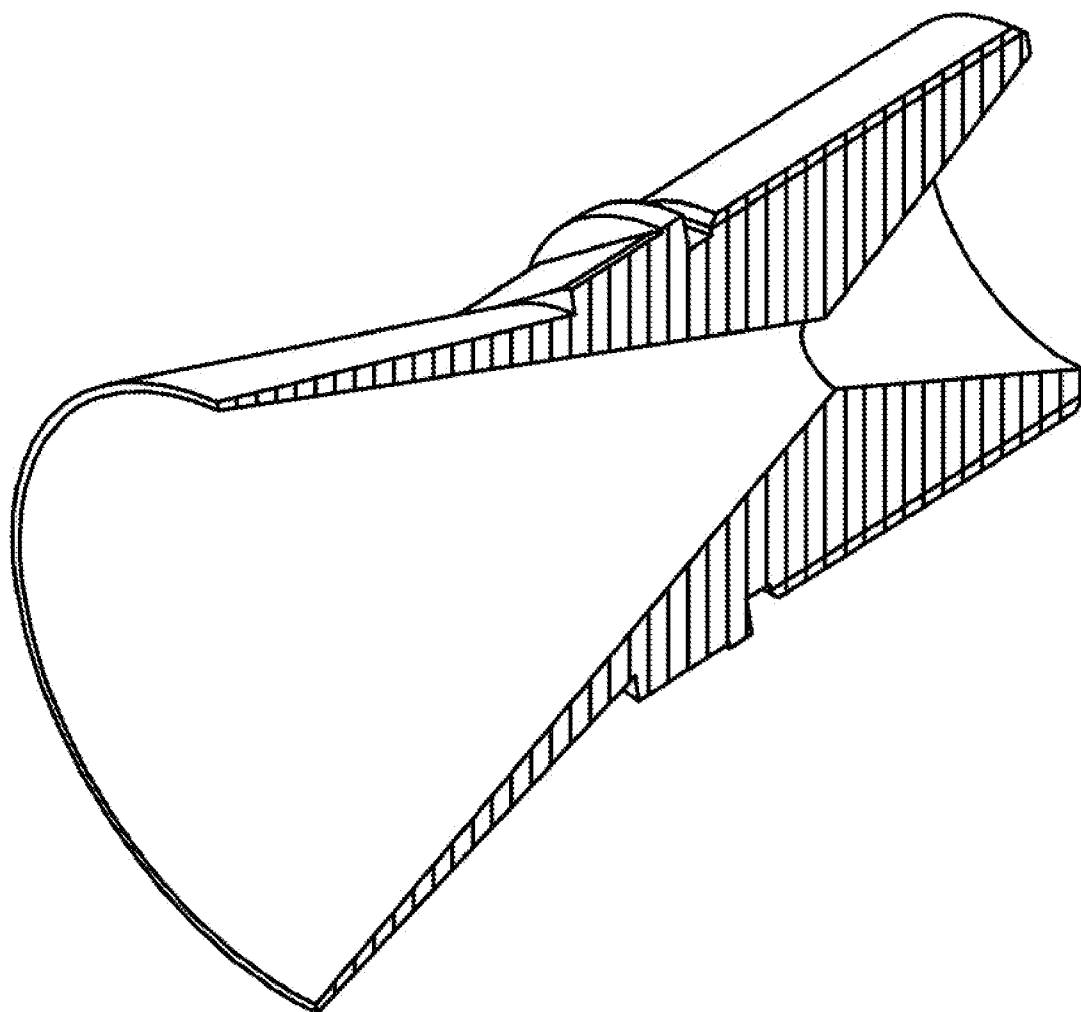


FIG. 7

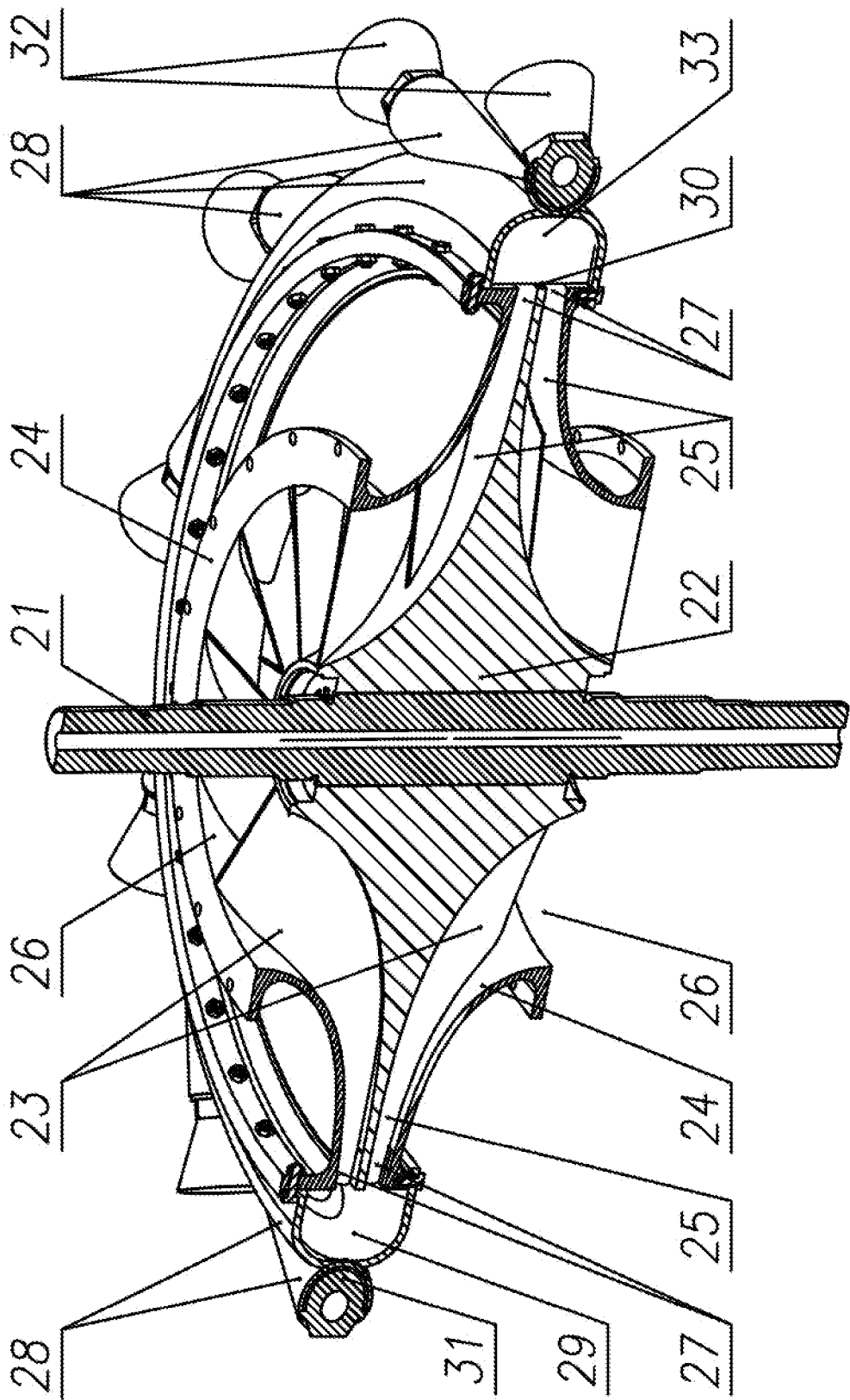


FIG. 8

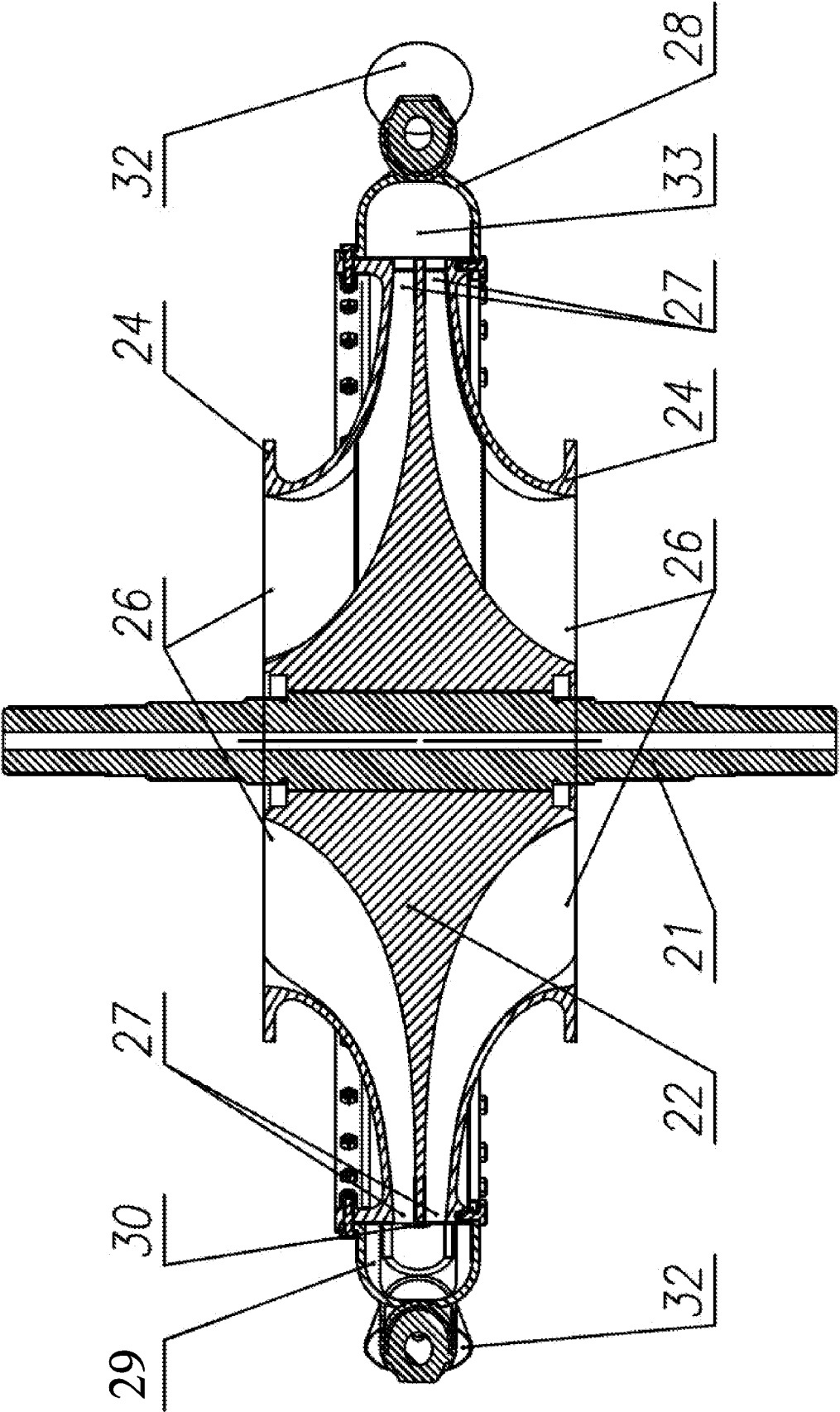


FIG. 9

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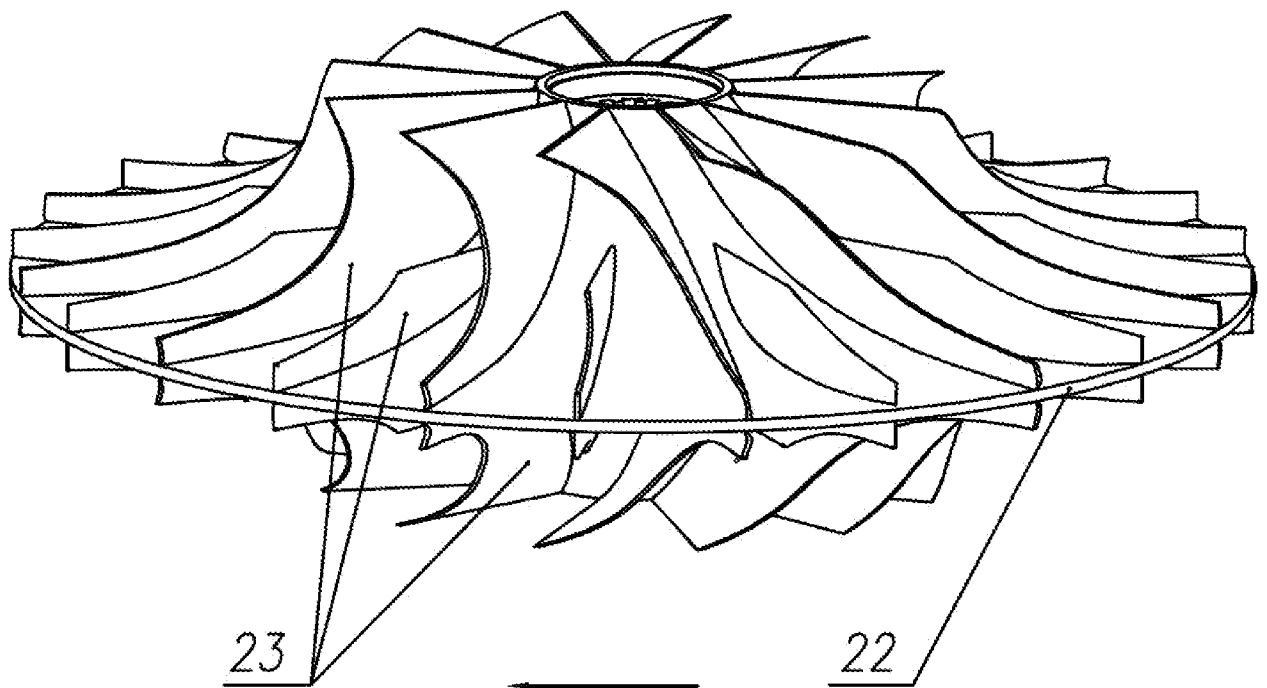


FIG. 10

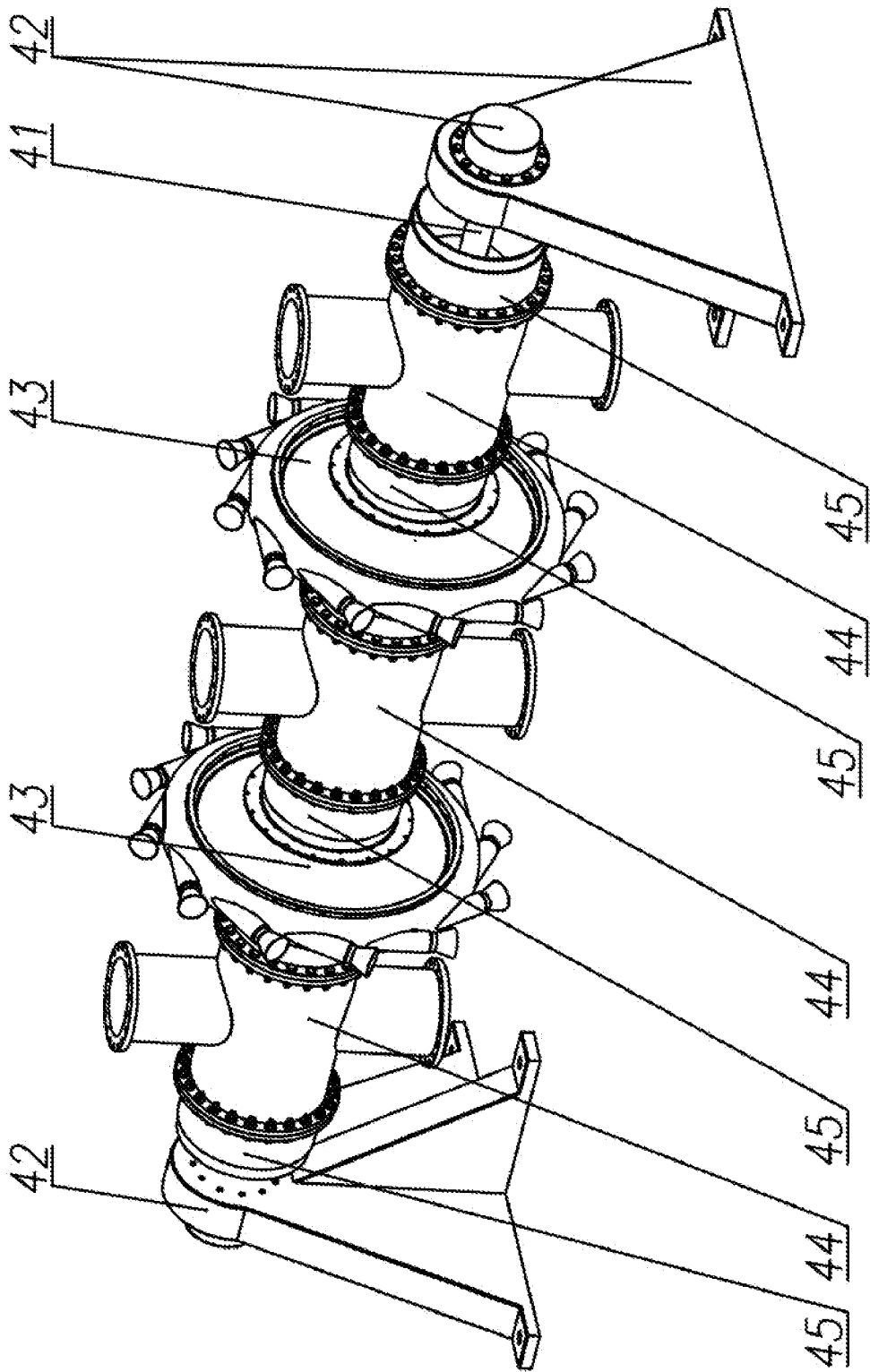


FIG. 11

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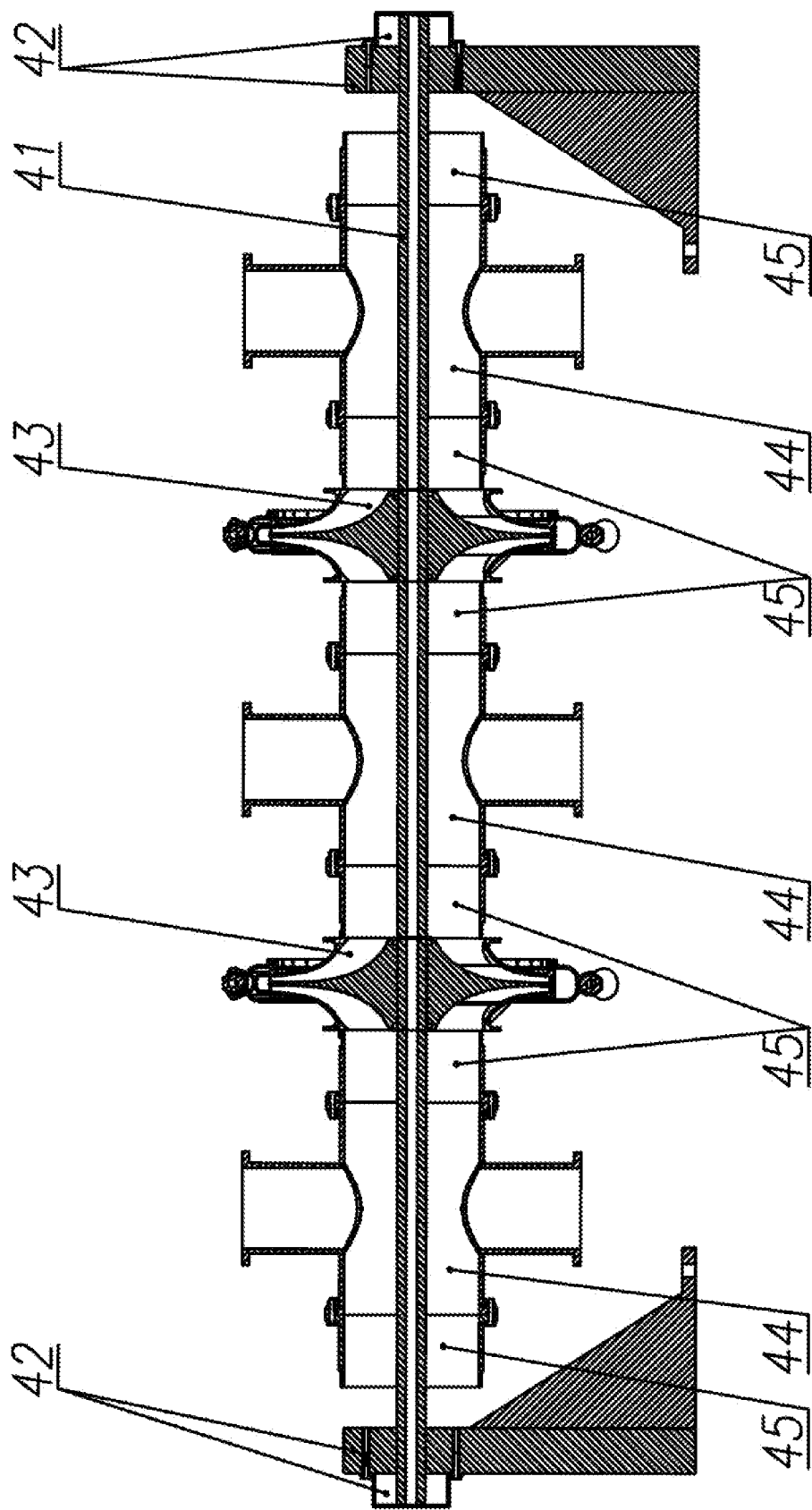


FIG. 12

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No	Parameters	Turbine operation modes					
		I	II	III	IV	V	VI
1	Vapor flow rate through the turbine , (<i>kg/h</i>)	10000	10000	10000	10000	10000	10000
2	Vapor pressure at inlet of the impulse wheel in the jet turbine, (<i>kPa</i>)	630	630	630	630	1600	1600
3	Vapor temperature at inlet of the impulse wheel in the jet turbine, (<i>°C</i>)	159	159	159	159	200	200
4	Diameter of the impulse wheel, (<i>m</i>)	0.66	0.66	0.66	0.66	0.66	0.66
5	Rotational velocities of the impulse wheel, (<i>rpm</i>)	3210	4120	5970	6800	3350	4140
6	Working medium flow compression values in the impulse wheel	1.74	2.91	5.08	5.95	2.00	2.34
7	Vapor pressure at inlet of the jet nozzle, (<i>kPa</i>)	1088.2	1825.3	3192.5	3740.2	3198.0	3736.1
8	Quantity of the jet nozzles	12	12	12	12	12	12
9	Expansion ratio of the jet nozzle	8:1	8:1	8:1	8:1	8:1	8:1
10	Vapor pressure at outlet of the jet nozzle, (<i>kPa</i>)	140	153	171	193	177	198
11	Differential pressure in the jet nozzle, (<i>kPa</i>)	948.2	1672.2	3021.1	3547.2	3014.3	3538.1
12	Exiting velocity of the working medium, (<i>m/s</i>)	1130	1242	1605	1815	1601	1801
13	Power of the jet turbine, (<i>kW</i>)	3138.9	3450.0	4458.3	5002.8	4447.2	5041.6
14	Efficiency of the jet turbine, (%)	40.8	44.9	58.0	65.1	57.7	65.4

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/063718

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01D1/32
ADD.

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 F02K

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	CZ 302 324 B6 (MAJCHRAKOVA VIKTORIA [SK]) 9 March 2011 (2011-03-09) figures page 3, line 52	2-10,12, 16,32,33 1,11, 13-15, 17-31
A	----- RU 2 200 848 C1 (000 MIDERA K) 20 March 2003 (2003-03-20) cited in the application the whole document	1-33
A	----- RU 99 540 U1 (PAWLOW ALEXANDER ALEKSEEVICH) 20 November 2010 (2010-11-20) cited in the application figures -----	1-33



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

16 December 2014

Date of mailing of the international search report

14/01/2015

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Georgi, Jan

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2014/063718

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CZ 302324	B6	09-03-2011	NONE

RU 2200848	C1	20-03-2003	AU 2003235542 A1 22-09-2003
			EP 1489262 A1 22-12-2004
			RU 2200848 C1 20-03-2003
			US 2005147493 A1 07-07-2005
			WO 03076767 A1 18-09-2003

RU 99540	U1	20-11-2010	NONE

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2014/063718

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-33

Jet turbine

1.1. claim: 1

Method for producing mechanical energy in a jet turbine,
with a second step flow compression inside a collector.

1.2. claims: 2-16(completely); 32, 33(partially)

A single-flow jet turbine without a second step flow
compression inside a collector.

1.3. claims: 17-31(completely); 32, 33(partially)

A double-flow jet turbine without a second step flow
compression inside a collector.
