Summary

The invention relates to a turbofan engine (1) that is designed to generate thrust for an aircraft (22) or a watercraft (23) and includes at least one torque stage (2) formed by a smaller ring wing (C1) positioned upstream in the thrust direction with a radius (r1) and a subsequent larger ring wing (C2) with a radius (r2). The ring wings (C1, C2) each have effective planes (Q1, Q2) with circular pressure point lines (q1, q2), the center points (M1, M2) of which are located on a rotational axis (R) for at least one ring wing (C1, C2) connected to a hub (H1, H2) by means of radial rotor blades (B1, B2). The pressure point lines (q1, q2) of the two ring wings (C1, C2) are arranged one behind the other along the length (x) of the rotational axis (R) and are spaced apart by a radial height (y) such that a two-layered casing (20) is formed, which, during the operation of the vehicle (22, 23), acts as a fluid dynamically effective torque stage (2). The smaller ring wing (C1), with a suction side facing the rotational axis (R) and an outer pressure side, forms a guide ring (10) and, together with the wing nose (n) of the larger ring wing (C2), creates an annular guide nozzle (11) with guide surfaces (12) for a resulting inflow (c) towards the larger ring wing (C2) with a convergent or divergent cone angle (α1, α2). Both ring wings (C1, C2) have, in a sectional plane (N1, N2) inclined at an angle of 20-90 degrees relative to the respective effective planes (Q1, Q2) through the relevant center point (M1, M2), an aerodynamically effective asymmetric wing profile (13).

(see Fig. 1)

G71.013P-WO
Description

Turbofan Engine with at least one Torque Stage

The term "turbofan engine" in the context of the invention pertains to the arrangement of two differently sized ring wings with suction and pressure sides, which, during the operation of the turbofan engine, create a turbofan flow. Accordingly, the invention relates to a turbofan engine designed to generate thrust for an aircraft or a watercraft and includes at least one torque stage formed by a smaller ring wing positioned in the thrust direction and a larger ring wing positioned behind it. With reference to the term "pressure point," which designates the intersection of the resultant air force with the chord line on the wing profile of an airfoil at approximately one-third of the wing depth, the term "pressure point line" is used analogously for a ring wing within the scope of the invention. The ring wings each have effective planes with circular pressure point lines, the center points of which lie on a rotational axis for at least one ring wing connected by rotor blades with a hub. The pressure point lines of the two ring wings are arranged sequentially along the rotational axis and are spaced from each other by a radial height such that the two ring wings form a dual-layer casing, which preferably functions as a torque stage during the vehicle's operation. The ring wing with the smaller radius has an inner suction side facing the rotational axis and an outer pressure side, and it forms a guide ring within a flow induced by the rotor blades, which, together with the wing nose of the larger ring wing, forms the annular guide nozzle with guide surfaces for the inflow to the larger ring wing with a convergent or divergent cone angle. Both ring wings exhibit, in a sectional plane inclined at an angle of 20-90 degrees relative to the respective effective plane through the relevant center point on the rotational axis, an aerodynamically effective, asymmetric wing profile with a profile depth, a wing nose aligned in the thrust direction, and a chord line extending between the wing nose and the wing trailing edge, so that the torque stage within the flow preferably induces a torque on the rotational axis at least at one of the two ring wings. A preferred application for the turbofan engine pertains to aircraft with propfan engines or with air-breathing jet engines, each featuring at least one torque stage. The aircraft itself can be designed as a passenger aircraft or as an unmanned drone. In a preferred embodiment, the turbofan engine is pivotally mounted to the wings of the aircraft, with the suction side of the larger ring wing designed as a tire, thus forming a landing gear for the aircraft. A preferred application for the turbofan engine with at least one torque stage concerns propellers for watercraft, which can be designed as fixed pitch, variable pitch, or rudder propellers. In a jet drive for a watercraft, the turbofan engine is positioned within a fixed casing of the watercraft.

State of the Art

Jet engines for aircraft operate wholly or partially according to the principle of recoil, by ejecting an exhaust jet against the flight direction as air-breathing engines, thereby generating thrust in the flight direction of the aircraft as a counter-reaction. In a turboprop-turbofan engine, the rotational power on the propeller shaft is generated by a gas turbine. A jet engine combines the recoil of a turbofan engine with the recoil of the turbofan flow generated by a fan. The high energy density of today's electrochemical energy storage systems enables electrically driven turbofan engines with a fan that also operates on the recoil principle. The same applies to so-called water jet drives, which generate a water jet within a nozzle fixedly connected to the vehicle. For the propulsion of a watercraft, a propeller nozzle is known in which a propeller is surrounded by a nozzle. The nozzle consists of a convergent stage tapering in the direction of travel and a diffuser stage following the nozzle constriction and is designed to direct the flow accelerated at the convergent stage onto the rotor blades of the ship's propeller, to increase the propeller thrust, especially for slow-moving watercraft. The propeller, located inside the propeller nozzle, is connected to the watercraft via a propeller shaft rigidly mounted along the longitudinal axis with a drive unit inside the ship. The nozzle itself is also referred to as a Kort nozzle and is fixedly connected to the ship's hull. In the downstream of the Kort nozzle, a movable rudder is used to steer the watercraft. Especially in tugboats, nozzle propellers are now used that can rotate in all directions and are connected to the bow and stern of the tugboat to achieve good maneuverability. The nozzle propeller in this case is also referred to as a rudder propeller, where the control of the vehicle is achieved through a thrust vector, which is composed of the propeller downstream and the nozzle thrust vector. The efficiency of conventional propeller drives is unsatisfactory. From a fan wheel, designs are known in which radial rotor blades are connected to each other at their outer ends by a ring.

The US 5 096 382 A discloses a propeller with a ring wing constructed from three segments. The ring wing segments each exhibit an abrupt change in the pitch angle of their chord line at the junctions to three radial rotor blades, causing the propeller to deviate from the circular ring shape.

The EP 0 244 515 A2 discloses an arrangement for a fan, in which two oppositely rotating variable-pitch propellers with two separate hubs are connected by a common wing-shaped sleeve to form an air-jet engine.

The EP 2 799 334 A1 discloses a propeller in which the radial rotor blades connected to a hub and a ring wing are adjustable. The ring wing, together with a circular opening at the rear of an aircraft, forms a ring nozzle.

The EP 3 315 787 A1 discloses a ring wing and an arrangement of two sequentially arranged ring wings, each of which is subjected to a conical flow during the takeoff phase of an aircraft and is designed to generate thrust. The inner side of the ring wings is oriented towards the rotational axis of a turbofan engine, with the ring wings arranged at a horizontal distance from each other.

The FR 3 030 445 A1 discloses a ring wing propeller for the turboprop propulsion of an aircraft, in which the radial rotor blades are adjustable and are connected at their inner end to a hub and at their outer end to a ring wing. In terms of the adjustability of the radial rotor blades, the convexly curved inner side of the ring wing lies on the outer side of the ring. With this arrangement, it is not possible to generate thrust.

The DE 10 2015 209 673 A1 discloses a shrouded propeller, in which a stationary ring wing has a convex outer side and accommodates a stator ring as well as a rotor ring connected to the rotor blade tips for a dual-coil accumulator.

The WO 2009/153124 A2 discloses a stationary ring wing that houses the electric drive for at least two sequentially rotating, hubless propellers.

The EP 1 502 852 A1 discloses an aircraft with two counter-rotating propellers mounted in an outer ring.

Task

Based on the described state of the art, the task of the invention is to provide a novel turbofan engine that is designed to generate thrust for an aircraft or a watercraft.

This task is fulfilled by the features mentioned in the main claim. Further tasks and advantageous properties of the invention are derived from the subclaims.

A stepped arrangement for two differently sized ring wings forms a two-layered shroud, which preferably functions fluid-dynamically as a torque stage. The smaller of the two ring wings is designed as a guide ring for the airflow to the larger ring wing with a conical angle, so that the torque stage formed by the two ring wings is impinged upon with a conical angle during every operating phase of an air or water vehicle and generates a torque on at least one rotating ring wing from the conical angle of the airflow induced by the turbofan engine.

There are multiple solutions available:

Provision of a turbofan engine with a fluid-dynamically activated shroud formed by two ring wings.

Provision of a turbofan engine with an annular guide nozzle formed by two ring wings for airflow to the larger ring wing with a conical angle.

Provision of a turbofan engine whose aerodynamically effective diameter is greater than the constructive diameter of the larger ring wing.

Provision of a turbofan engine that is pivotally connected to the wing of an aircraft, allowing the aircraft to take off and land vertically.

Provision of a turbofan engine that can be used as a landing gear for an aircraft, with the suction side of the larger ring wing designed as a tire.

Generation of a tangential driving force in the effective plane of at least one ring wing of the torque stage.

Generation of a tangential driving force in both effective planes of the torque stage.

Generation of thrust on both ring wings of the torque stage, especially during the takeoff operation of the vehicle.

Generation of thrust on a stationary ring wing of the torque stage.

Provision of a turbofan engine with a torque stage for a drone.

Provision of a adjustable propeller with a torque stage for powering an aircraft or a watercraft.

Provision of a fixed-pitch propeller with a torque stage for powering a watercraft.

Provision of a rudder propeller with a torque stage for the propulsion and steering of a watercraft.

Provision of a turbofan engine with a torque stage for thrust vector control of an air or water vehicle.

Provision of a propeller with a steady thrust performance and vibration-free, smooth rotation.

Provision of a quiet propeller with a torque stage for comparatively very low noise development.

Prevention of vortex formation and vortex shedding at the blade tips of the radial rotor blades.

Prevention of cavitation on a ship's propeller.

Increase of the propeller's stability through dual bearing of the rotor blades on the hub and ring wing.

Reduction of the risk of injury from the rotating rotor blades by the surrounding ring.

Provision of a 360-degree rotatable nacelle for a propeller with a torque stage.

Provision of a novel jet drive for a fast, sea-going ship.

Provision of a turbofan engine with an electric drive for aircraft and watercraft.

Structure of the Turbofan Engine

The turbofan engine is designed to generate thrust for an air or water vehicle and has at least one torque stage, which is formed by a smaller ring wing positioned ahead in the thrust direction and a larger ring wing positioned behind. The ring wings each have effective planes with circular center point of pressure lines, whose center points lie on a rotational axis for at least one of the ring wings, and in a sectional plane inclined at an angle of 20-90 degrees to the respective effective plane, they exhibit an aerodynamically effective, asymmetric wing profile with a profile depth, with a wing nose oriented in the thrust direction and a chord line extending between the wing nose and a wing trailing edge. The center point of pressure lines of the two ring wings are arranged one behind the other along the length of the rotational axis and spaced apart by a radial height such that they form a two-layered shroud that preferably functions fluid-dynamically as a torque stage during vehicle operation. The smaller ring wing is designed with a suction side facing the rotational axis and an outer pressure side in a flow induced by the rotor blades as a guide ring, which together with the wing nose of the larger ring wing forms an annular guide nozzle with guide surfaces for a resulting airflow to the larger ring wing with a convergent or divergent conical angle, so that the torque stage preferably generates a torque on the rotational axis at least on one of the two ring wings. In a preferred embodiment, the two ring wings are spaced apart along the length of the rotational axis such that the trailing edge of the smaller ring wing overlaps with the wing nose of the larger ring wing to form the annular guide nozzle.

The ring wings each have an aerodynamically effective wing profile in a sectional plane inclined at a tilt angle to their effective plane.

The Design of the Profile of the Annular Wings

The guide ring formed by the smaller annular wing has, in the sectional plane inclined at a tilt angle to its effective plane, either a single asymmetric wing profile with a convex inner side facing the rotational axis or a tandem profile formed by two asymmetric wing profiles. The convex inner sides of the asymmetric wing profiles of the tandem profile are each facing the rotational axis, whereby the chord lines of the profiles in the direction of flow relative to the rotational axis exhibit an increasing angle of incidence in magnitude. The design of the profile of an annular wing is carried out for a design speed number λ within a certain range. The aerodynamically optimal asymmetric wing profile for a lift rotor is situated on a rotating annular wing in the sectional plane inclined at a tilt angle to the respective effective plane through the relevant center point, whereby the magnitude of the tilt angle is determined by the design speed number λ of the respective annular wing and the vehicle's travel speed. On a stationary annular wing, the aerodynamically effective asymmetric wing profile is accordingly located in a sectional plane that runs lengthwise through the rotational axis with a tilt angle of 90 degrees relative to the respective effective plane.

Turbofan Engines for Aircraft

In a turbofan engine for an aircraft, the torque stage is formed on a two-stage fan, which consists of two adjustable propellers rotating around the rotational axis in opposite directions. Both annular wings of the torque stage are each connected to the hubs and to two shafts arranged concentrically and coaxially to each other by means of at least eight adjustable rotor blades. In the airflow, the two annular wings are spaced apart along the rotational axis lengthwise and by a radial height, which is the difference between the radii of the circular center point of pressure lines, so that they form the two-layered casing of the turbofan engine, which is aerodynamically effective as a two-stage torque stage. The distance between the two annular wings on the rotational axis is specified by the length between the center points of the circular center point of pressure lines, whereby the radial height of the torque stage is defined by the difference in the radii of the circular center point of pressure lines of the annular wings and is at least half the length. In this arrangement, the chord line of the smaller annular wing has a positive angle of incidence relative to the rotational axis, while the chord line of the larger annular wing is aligned parallel to the rotational axis. With their pressure sides facing each other, the annular wings form between them the annular guide nozzle with flow guide surfaces for the airflow to the larger annular wing with a divergent cone angle. This arrangement of the annular wings has the advantage that a circulation flow forms at the asymmetric wing profiles of a pair of annular wings, which intensifies into a circulation vortex at the pressure sides of the annular wings of the torque stage that face each other. During the takeoff operation of an aircraft, the rotor blades rotate, thereby accelerating the surrounding fluid and generating a rearward flow. The thrust of the turbofan engine results from the reversal of momentum. The pressure reduction associated with the acceleration of the flow is manifested in a convergent contraction of the flow. Particularly during the takeoff phase of an aircraft, the turbofan engine induces a convergent flow. At the torque stage, the chord line of the smaller annular wing has an angle of incidence, so that the asymmetric wing profile of the smaller annular wing in the first effective plane of the torque stage, in the sectional plane inclined at the tilt angle to the effective plane through the center point, has a pitch angle against the convergent inflow. The inflow to the smaller annular wing results from the flow speed, the circulation speed, and the convergent cone angle relative to the rotational axis, which generates a lift force attacking the entire inner circumference with an offset to the rotational axis, from which in the first effective plane of the torque stage, a tangential driving force acting in the direction of rotation and a thrust force acting in the direction of flight of the aircraft are derived. Upon reaching cruising speed, the flow becomes only slightly convergent. The trailing edge of the smaller annular wing, together with the leading edge of the larger annular wing, forms the annular guide nozzle for the divergent inflow to the larger annular wing, whose chord line is preferably aligned parallel to the rotational axis, so that the divergent cone angle of the flow acts as a pitch angle for the inflow to the asymmetric wing profile on the larger annular wing. In the sectional plane inclined at a tilt angle to the second effective plane of the torque stage, the resulting inflow forms from the flow speed, the circulation speed, and the divergent cone angle relative to the rotational axis, generating a lift force attacking the entire outer circumference of the larger annular wing with an offset to the rotational axis. In the second effective plane of the torque stage, the lift force can therefore generate the tangential driving force acting in the direction of rotation and the thrust force acting in the direction of flight of the aircraft. In the vectorial consideration of the aerodynamically generated forces, the lift force acting on the smaller annular wing rotating as a lift rotor attacks the circular center point of pressure line in the sectional plane inclined at a tilt angle to the first effective plane of the torque stage on the inner side with an offset to the rotational axis, while the lift force acting on the larger annular wing rotating as a lift rotor attacks the circular center point of pressure line in the sectional plane inclined at a tilt angle to the second effective plane of the torque stage on the outer side with an offset to the rotational axis. The asymmetric wing profiles inscribed into the sectional planes inclined at a tilt angle of, for example, 45 degrees relative to the planes of action of the annular wings respectively act aerodynamically as lift rotors on both annular wings and have the least resistance in the sectional planes, so that the cone angle of the resulting inflow in the sectional planes generates a lift force inclined in the respective direction of rotation and toward the thrust direction of the annular wings, which attacks with an offset to the rotational axis in each case. Therefore, in both planes of action of the torque stage, torque and thrust are generated for an aircraft. In an aircraft, the turbofan engine can be pivotably articulated to the fuselage or to the wings, so that the turbofan engine forms a landing gear, in which the suction side of the larger annular wing has a tire, which is designed as a solid rubber tire or as an air-filled tire.

Turbofan Engines for Watercraft

In the turbofan engine for watercraft, the inner surfaces of both ring wings are each designed to be convex. One embodiment of the turbofan engine concerns fixed propellers, where the rotor blades are rigidly connected to a hub. In this case, either the smaller and larger ring wings are rigidly connected to a single shaft via three rotor blades and a hub and rotate in the same direction around the rotational axis, or the smaller and larger ring wings are each rigidly connected to a hub and a shaft via three rotor blades and rotate in opposite directions around the rotational axis, with the shafts arranged concentrically and coaxially to each other, and one of the shafts being designed as a hollow shaft. Another embodiment of the turbofan engine concerns adjustable propellers, where the rotor blades are adjustably connected to at least one of the ring wings and to a hub. For example, the smaller ring wing is fixedly connected to the underwater hull of the watercraft at the stern, while the larger ring wing is connected to, for example, three adjustable rotor blades, the hub, and the shaft, and rotates around the rotational axis. In this case, the two ring wings are spaced apart along the rotational axis by a length and by a height such that they overlap in the direction of the flow and form the torque stage between them, with the convex suction sides of both ring wings facing the rotational axis, so that the larger ring wing with a convex suction tip and the smaller ring wing, designed as a fixed guide ring with a concave outer pressure side, form the annular guide nozzle for the inflow of the larger ring wing with a convergent cone angle. In the first and second effective planes of the torque stage, both ring wings generate thrust, with the lift force on the rotating larger ring wing over the entire outer circumference in the second effective plane of the torque stage resulting in a tangential driving force acting in the direction of rotation with an offset to the rotational axis and a thrust force acting in the direction of travel of the watercraft. In the case of an adjustable propeller, the turbofan engine has rotor blades that are rotatably connected to the hub and the ring wing on a radial rotation axis, enabling a variable pitch angle of the rotor blades. Another embodiment for an adjustable propeller with a torque stage concerns a rudder propeller, which is rotatably connected to the underwater hull of the watercraft on a vertical axis, in which the larger ring wing is fixedly designed with a profile chord aligned parallel to the rotational axis and a convex inner side with a convex suction tip. The smaller ring wing is connected to the hub and the shaft via adjustable rotor blades and forms as an adjustable propeller the guide ring for a convergent inflow of the larger ring wing with respect to the rotational axis. In this case, the concave outer side of the smaller ring wing is arranged at a distance from the convex suction tip of the larger ring wing, so that the guide nozzle for the inflow of the larger ring wing is formed.

In the first effective plane of the torque stage, the inflow of the smaller ring wing resulting from the flow speed, the circulation speed, and the convergent cone angle generates a lift force acting in the direction of rotation and attacking with an offset to the rotational axis, from which the tangential driving force and a thrust force acting in the direction of travel of the watercraft can be derived in the first effective plane. In the second effective plane of the torque stage, the fixed larger ring wing generates a lift force attacking at the circular pressure point line, from which a thrust force can be derived. The embodiments for fixed and adjustable propellers concern torque stages in which preferably at least one rotating ring wing generates torque and thrust, while a fixed ring wing generates thrust. For a given rotor diameter, the turbofan engine is characterized by comparatively greater drive power. For a fast-moving, seaworthy ship, either a fixed propeller or an adjustable propeller is proposed, each with at least one torque stage, in which the turbofan engine is arranged within a casing formed by the ship's underwater hull and is connected to an electric drive working inside the ship via at least one shaft, so that a jet drive is formed for the fast-moving, seaworthy ship, which is preferably arranged at the stern of the ship designed according to fluid dynamic principles. A particularly advantageous arrangement for an adjustable propeller concerns a streamlined engine nacelle that houses the electric drive and is suspended on a vertical rotation axis on the underwater hull, so that the engine nacelle with the propeller can rotate 360°. Inside the ship, either an electrochemical energy storage device or a gas turbine with a generator is available for powering the electric motor. Such pod drives significantly improve the maneuverability of large ships, thereby increasing safety in confined waterways.

The figures show different embodiments and applications of the invention. The detailed sectional views of the torque stage shown in the figures each illustrate the fluid dynamically effective, asymmetric wing profiles in the sectional plane inclined at a tilt angle to the effective plane.

Figures show:
Fig. 1: A turbofan engine for an aircraft with a two-stage fan and with a torque stage of the fan in a perspective overview with a sectional view of the ring wing arrangement at the torque stage.
Fig. 2: The turbofan engine according to Fig. 1, showing the aerodynamically effective ring wing profiles of the torque stage in a longitudinal section parallel to the rotational axis.
Fig. 3: The turbofan engine according to Figs. 1-2, showing all forces dynamically affected by the torque stage as vectors in a perspective section.
Fig. 4: The turbofan engine according to Figs. 1-3 in a frontal view, showing the torques induced by the torque stage.
Fig. 5: The turbofan engine according to Figs. 1-4, with a sectional view of the circulation flow at the top and a schematic longitudinal section showing the length and height of the torque stage at the bottom.
Fig. 6: A turbofan engine for an aircraft, where the torque stage is formed at a two-stage fan and features a guide ring with a tandem profile, in a perspective overview.

Fig. 7: The turbofan engine according to Fig. 6, showing the aerodynamically effective ring wing profiles of the torque stage in a longitudinal section parallel to the rotational axis.

Fig. 8: An electrically driven turbofan engine for an aircraft with a two-stage fan, with a compression module positioned in front, in a schematic cross-section.

Fig. 9: An electrically driven turbofan engine for an aircraft with a compression module following the two-stage fan in a schematic cross-section.

Fig. 10: An aircraft with two turbofan engines corresponding to the embodiment shown in Fig. 9, in a perspective overview.

Fig. 11: An electrically driven aircraft engine with two two-stage fans spaced apart from each other, at the top in a schematic cross-section of the torque stage, at the bottom in an overview cross-section of the turbofan engine.

Fig. 12: A turbofan engine for a watercraft, designed as a fixed propeller with two ring wings rotating in the same direction, in a perspective overview.

Fig. 13: The fixed propeller according to Fig. 12 in a schematic longitudinal section.

Fig. 14: A turbofan engine for a watercraft, designed as a fixed propeller with a stationary smaller ring wing, in a perspective overview.

Fig. 15: The fixed propeller according to Fig. 14 in a schematic longitudinal section.

Fig. 16: The fixed propeller according to Figs. 14-15 in a frontal view, showing the torque induced by the larger ring wing.

Fig. 17: A turbofan engine for a watercraft, designed as a rudder propeller with a stationary larger ring wing, in a perspective overview.

Fig. 18: The rudder propeller according to Fig. 17 in a longitudinal section along the rotational axis.

Fig. 19: At the top, a jet drive for a watercraft in an overview section, and at the bottom, in a schematic longitudinal section along the rotational axis.

Fig. 20: An aircraft powered by four turbofan engines, at the top in operational mode, in the middle during takeoff, and at the bottom in flight mode, each in a perspective overview.

Fig. 1 shows a turbofan engine 1 for an aircraft formed by a two-stage fan 200, where a smaller ring wing C1 with radius r1 and a larger ring wing C2 with radius r2 form a fluid-dynamically effective casing 20 with the torque stage 2. The smaller ring wing C1 is connected to the hub H1 at the flow inlet of the turbofan engine 1 via ten clockwise rotating rotor blades B1, while the larger ring wing C2 is connected to the hub H2 at the flow outlet of the turbofan engine 1 via ten counterclockwise rotating rotor blades B2. The rotor blades B1 and B2 are each rotatably mounted on the hubs H1 and H2 and the ring wings C1 and C2 around an rotation axis u, so that the two-stage fan 200 is constructed from two adjustable propellers 204. The ring wings C1 and C2 each have an asymmetric wing profile 13, with the profile chord p extending between a wing nose n and a wing trailing edge m over a profile depth t. In the effective planes Q1 and Q2, there are circular pressure point lines q1 and q2, which have a distance x between the center points M1 and M2 and are spaced apart by a radial height y. On the smaller ring wing C1, with its convex inner side oriented towards the rotational axis R, the profile chord p has a pitch angle δ, while on the larger ring wing C2, the profile chord p is aligned parallel to the rotational axis R and the convex suction side is formed on the outer side. Within the flow F, the ring wings C1 and C2 are each traversed obliquely in the sectional planes N1 and N2, which are inclined at a tilt angle β1 and β2 relative to the effective planes Q1 and Q2. The detail of the torque stage 2 shows the asymmetric wing profile 13 in the sectional planes N1 and N2 in the fluid dynamically effective position within the flow F. The counter-rotating rotor blades B1 and B2 accelerate and direct the flow F with a convergent cone angle α1 towards the rotational axis R. The smaller ring wing C1 is thus approached in the sectional plane N1 with the convergent cone angle α1, so that, as shown in Fig. 3, from the lift force d in the effective plane Q1, a tangential driving force g and a thrust force f result. The smaller ring wing C1 forms a guide ring 10 for a divergent redirection of the flow F, so that the larger ring wing C2 is approached with a divergent cone angle α2 and from the lift force d, the thrust force f and a tangential driving force g in the effective plane Q2 can be derived. The two ring wings C1 and C2 are arranged such that the wing trailing edge m of the smaller ring wing C1 overlaps with the wing nose n of the larger ring wing C2 and forms a guide nozzle 11 for the divergent inflow of the larger ring wing C2.

Fig. 2 shows the turbofan engine 1 with the torque stage 2 formed by the ring wings C1 and C2 in a cross-section along the rotational axis R, depicting the flow F, at the top during the takeoff phase of an aircraft and at the bottom when the aircraft has reached its cruising speed. During the takeoff phase of the aircraft, the rotor blades B1 and B2 are set at an angle of approximately 45 degrees relative to the effective planes Q1 and Q2 and draw in a large volume of air. At cruising speed, the smaller ring wing C1 is only slightly convergently approached and acts as a guide ring 10, directing the inflow to the larger ring wing C2 with a divergent cone angle α2, with the result that, as shown in Fig. 3, from the lift force d acting on the larger ring wing C2, a thrust force f and a tangential driving force g can be derived.

Fig. 3 depicts the counter-rotating ring wings C1 and C2 of the torque stage 2 of the turbofan engine 1 shown in Figs. 1-2, each illustrating the aerodynamically induced forces. The leading ring wing C1 in the thrust direction of the two-stage fan 200 is approached during the takeoff phase of an aircraft with a convergent cone angle α1 by the resulting inflow c deriving from the flow speed a and the circulation speed b, such that at the pressure point line q1 of the ring wing C1 in the sectional plane N1, which is inclined at a tilt angle β1 relative to the effective plane Q1, a lift force d is generated in the sectional plane N1, which can be divided into a suction force h, a forward thrust force e, and a drag j. From the forward thrust force e, the tangential driving force g and the thrust force f in the effective plane Q1 are derived. The opposing force to the thrust force f is the drag l, and the opposing force to the tangential driving force g is the rotational resistance k. The ring wing C1 has a radius r1 and forms, as shown in Figs. 1-2, a guide ring 10 for the inflow of the larger ring wing C2 with a radius r2, where the ring wings C1 and C2 overlap and form a guide nozzle 11 for the inflow of the ring wing C2 with a divergent cone angle α2. The suction side on the outer side of the ring wing C2 causes, in the sectional plane N2 inclined at a tilt angle β2 relative to the effective plane Q2, an resulting inflow c deriving from the flow speed a and the circulation speed b with a divergent cone angle α2, so that in the sectional plane N2, the resulting inflow c produces a lift force d inclined in the thrust direction and the rotational direction at the outer side of the ring wing. Here too, the lift force d is divided into a suction force h and a forward thrust force e, from which the tangential driving force g in the effective plane Q2 and the thrust force f in the flight direction can be derived. The drag j opposes the forward thrust force e, while the rotational resistance k opposes the tangential driving force g, and the drag l opposes the thrust force f.

Fig. 4 shows the frontal view of the turbofan engine 1 from Figs. 1-3 in the thrust direction with the clockwise rotating smaller ring wing C1, which forms a guide ring 10 for the inflow to the counterclockwise rotating larger ring wing C2, each illustrating the lift force d, the suction force h, and the tangential driving force g induced by the ring wings C1 and C2. The rotor blades B1 are each connected at their hub-side end to a hub H1 and at their outer end to the ring wing C1, while the rotor blades B2 are each connected at their hub-side end to a hub H2 and at their outer end to the ring wing C2. The rotor blades B1 and B2 are each pivotable around a rotation axis u, so that the two-stage fan 200 is formed by two adjustable propellers 204.

Fig. 5 at the top shows the torque stage 2 depicted in Figs. 1-4 with a circulation flow that intensifies into a circulation vortex in the area of the guide nozzle 11 formed by the ring wings C1 and C2. The middle and bottom of Fig. 5 show the asymmetric wing profiles 13 of the torque stage 2 depicted in Figs. 1-4 in the sectional planes N1 and N2 of the counter-rotating ring wings C1 and C2, with the representation of the aerodynamically induced forces. The pressure point lines q1 and q2 are spaced apart by the distance between the center points M1 and M2 in the length x and by the radial height y, so that the ring wings C1 and C2 form a two-layered casing 20 and the guide nozzle 11 for the inflow to the larger ring wing C2 with a divergent cone angle α2. The profile chord p of the smaller ring wing C1 has a pitch angle δ relative to the rotational axis R, while the profile chord p of the larger ring wing C2 is preferably aligned parallel to the rotational axis R. The resulting inflow c of the smaller ring wing C1 has a convergent cone angle α1 and generates the lift d, from which the thrust force f can be derived in the effective plane Q1. As a guide ring 10, the smaller ring wing C1 causes the resulting inflow c to the larger ring wing C2 with the divergent cone angle α2, so that in the effective plane Q2 of the torque stage 2, the lift force d results in the thrust force f.

Fig. 6 shows a two-stage fan 200 consisting of a first, clockwise rotating fixed propeller 203 formed by the smaller ring wing C1, the rotor blades B1, and the hub H1, and a second, counterclockwise rotating fixed propeller 203 formed by the larger ring wing C2, the rotor blades B2, and the hub H2. In contrast to the embodiment shown in Fig. 1, the ring wing C1 has a tandem profile 132, which is explained in more detail in Fig. 7 and is designed as a two-part guide ring 10 to enable the inflow to the larger ring wing C2 with a significantly divergent cone angle α2.

Fig. 7 shows the turbofan engine 1 with the torque stage 2 formed by the ring wings C1 and C2 in a cross-section along the rotational axis R with the depiction of the flow F, at the top during the takeoff phase of an aircraft and at the bottom when the aircraft has reached its cruising speed. During the takeoff phase of the aircraft, the rotor blades B1 and B2 are set at an angle of approximately 45 degrees relative to the effective planes Q1 and Q2 and draw in a large volume of air. At cruising speed, the smaller ring wing C1 is approached only slightly convergently and acts as a two-part guide ring 10 to direct the inflow to the larger ring wing C2 with the divergent cone angle α2, so that, as shown in Fig. 3, from the lift force d acting on the larger ring wing C2, a thrust force f and a tangential driving force g can be derived. In contrast to the embodiment shown in Figs. 1-5, where the smaller ring wing C1 has a single asymmetric wing profile 13, the ring wing C1 here has a tandem profile 132 formed by two asymmetric wing profiles 13 with radii r1a and r1b, which is designed to deflect the flow F in two stages, so that the larger ring wing C2 is approached with a steeply divergent cone angle α2 to generate, as shown in Figs. 3-4, a tangential driving force g and a thrust force f from the lift force d.

Fig. 8 shows a turbofan engine 1 for an aircraft in a schematic longitudinal section and partially in cross-sectional view. In the direction of the flow F, four clockwise and four counterclockwise rotating fixed propellers 203 are arranged in sequence on the rotational axis R, forming a compressor module 201 with a stationary casing 20, to which a larger two-stage fan 200 follows downstream, corresponding to the embodiment shown in Figs. 1-5. The compressor module 201, formed by eight fixed propellers 203, has a total of eight torque stages 2, with the guide rings 10 formed by the ring wings C1 being each connected to a rotor ring of a casing-side electric drive 21 integrated into the casing 20, while the ring wings C2 are each connected to a rotor ring of a hub-side electric drive 21.

Fig. 9 shows a turbofan engine 1 for an aircraft in a schematic longitudinal section and partially in cross-sectional view. The two-stage fan 200 corresponds to the embodiment shown in Figs. 1-5 and has a two-layered casing 20 effective as a torque stage 2, formed by the ring wings C1 and C2, and forms the flow inlet of the turbofan engine 1. Following the two-stage fan 200 in the direction of the flow F is a compressor module 201 with a total of eight torque stages 2, distributed over eight fixed propellers 203 rotating in opposite directions. The ring wings C1, formed as guide rings 10, are followed in the direction of the flow F by the ring wings C2. The ring wings C1 are connected to the rotor ring of an electric drive 21 integrated into the stationary casing 20 of the compressor module 201, while the larger ring wings C2 are connected to a rotor ring of a hub-side electric drive 21 not further illustrated. At the flow outlet of the multi-stage turbofan engine 1, a nozzle constriction for the thrust consisting solely of air is depicted.

Fig. 10 shows an aircraft 22 with two turbofan engines 1, each having a torque stage 2 in flight operation.

Fig. 11 at the top shows an interval arrangement for two successive torque stages 2 in the direction of flow F on the turbofan engine 1 for an aircraft, depicted in a longitudinal section and as a partial view in the middle of Fig. 11. Fig. 11 at the top illustrates the flow conditions during the aircraft's start-up phase, where the convergent cone angle α1 determines the airflow over the ring wings C1, C2, and the ring wing C1 forms a guide ring 10 for the airflow over the ring wing C2 with a divergent cone angle α2. Fig. 11 at the bottom shows the interval arrangement of the torque stages 2 with representation of the flow conditions at the aircraft's cruising speed, where the ring wings C2 of the torque stages 2 are each flown over with the divergent cone angle α2. The turbofan engine 1 has a hub-side electric drive 21 for two shafts S1, S2, which are not depicted in detail, allowing the counter-rotation of the ring wings C1, C2. Rotor blades B1, B2 respectively connect the ring wings C1, C2 to the hubs H1, H2.

Fig. 12 shows a turbofan engine 1 as a fixed propeller 203, which is connected to the stern of a watercraft 23 via the underwater hull. Three rotor blades B1 are rigidly connected to the smaller ring wing C1 and the larger ring wing C2, as well as to the hub H1 and the shaft S1, at the fixed propeller 203. The ring wings C1, C2 rotate in the same direction and together form a torque stage 2 with the annular nozzle 11 for the airflow over the larger ring wing C2 with the divergent cone angle α2, as shown in Fig. 13. The asymmetric wing profile 13 of the ring wings C1, C2 is aerodynamically effective in the sectional planes N1, N2, inclined at a tilt angle β1, β2 relative to the effective planes Q1, Q2.

Fig. 13 shows the fixed propeller 203 according to Fig. 12 in a longitudinal section along the rotational axis R, illustrating the aerodynamic effect of the torque stage 2 during the start-up operation of the watercraft 23 at the upper end of the fixed propeller 203 and at the operating speed of the watercraft 23 at the lower end of the fixed propeller 203. The length x on the rotational axis specifies the distance between the ring wings C1, C2, while height y defines the radial distance of the pressure point lines q1, q2, with the concave pressure sides of the ring wings C1, C2 overlapping to form the guide nozzle 11 with the guide surfaces 12. The ring wing C1 is inclined as a guide ring 10 so that the larger ring wing C2, aligned parallel to the rotational axis R, is flown over with the divergent cone angle α2.

Fig. 14 shows a turbofan engine 1 with a torque stage 2, using the example of a fixed propeller 203 connected to the stern of a watercraft 23 via the underwater hull. In this embodiment, the smaller ring wing C1 is fixedly connected to the stern of the watercraft 23 and forms a guide ring 10 for the airflow over the larger ring wing C2 with a convergent cone angle α1, as shown in Fig. 15. At the fixed propeller 203, three rotor blades B2 are rigidly connected to the larger ring wing C2, as well as to the hub H2 and the shaft S2.

Fig. 15 shows a longitudinal section of the fixed propeller from Fig. 14, illustrating the convergent flow F with the cone angle α1, generated by the rotor blades B2 and the torque stage 2. The stationary smaller ring wing C1 and the right-rotating larger ring wing C2 form a torque stage 2, in which the convex suction tip 131 of the larger ring wing C2, together with the concave pressure side of the stationary guide ring 10, forms a guide nozzle 11 for the airflow over the larger ring wing C2 with the convergent cone angle α1. The two ring wings C1, C2 are spaced from each other along the rotational axis R, in both length x and height y, so that together they form a two-layered casing 20 with the guide nozzle 11 for a convergent airflow over the larger ring wing C2.

Fig. 16 shows the fixed propeller 203 depicted in Fig. 14-15 in a sectional view, illustrating the smaller ring wing C1 formed as a guide ring 10 and the larger ring wing C2, which, together with the rotor blades B2 and the hub H2, forms the fixed propeller 203 connected to the shaft S2. The torque stage 2, where the suction sides of the ring wings C1, C2 face the rotational axis R, ensures that both ring wings C1, C2 generate a thrust force f derived from the lift force d during both the start-up operation of the watercraft 23 and at operating speed, with the asymmetric wing profile 13 of the rotating larger ring wing C2, as shown in Fig. 14, additionally generating a tangential driving force g in the sectional plane N2, inclined at a tilt angle β2 relative to the effective plane Q2. Both the stationary ring wing C1 and the rotating ring wing C2 generate a thrust force f derived from the lift force d at the circular pressure point lines q1, q2 in the effective planes Q1, Q2.

Fig. 17 shows a turbofan engine 1 with a torque stage 2 on a rudder propeller 205, which is pivotally attached to the underwater hull of a watercraft 23 around a vertical rotation axis z. At the rudder propeller 205, the smaller ring wing C1 rotates around the rotational axis R and is connected to the hub H1 via three rotor blades B1, while the larger ring wing C2 is stationary and connected to a propeller gondola. The sectional plane N1 on the smaller ring wing C1 has a tilt angle β1 of, for example, 45 degrees relative to the effective plane Q1.

Fig. 18 shows the turbofan engine 1 according to Fig. 17 in a longitudinal section along the rotational axis R and in a partial view. A concave suction tip 131 on the suction side of the asymmetric wing profile 13 of the stationary ring wing C2, facing the rotational axis R, forms, together with the concave pressure side of the asymmetric wing profile 13 on the smaller ring wing C1, formed as a guide ring 10, the guide nozzle 11 for a convergent airflow over the larger ring wing C2, whose sectional plane N2 is arranged perpendicular to the effective plane Q2. The larger stationary ring wing C2 is connected to the pivotable propeller gondola around the vertical rotation axis z via three arms not shown in detail. The convergent airflow over both ring wings C1, C2 generates a thrust force on both ring wings and a tangential driving force on the rotating smaller ring wing C1 in the effective plane Q1.

Fig. 19 shows a turbofan engine 1 designed for the jet propulsion 202 of a watercraft 23. The turbofan engine 1 is constructed as a fixed propeller 203, in which both ring wings C1, C2 are connected to a hub H1 and a shaft S1 via radial rotor blades B1. The turbofan engine 1 with the torque stage 2 rotates within a stationary casing 20, which is formed by the underwater hull of the watercraft. The fixed propeller 203 corresponds in its structure to the embodiment shown in Fig. 12-13.

Fig. 20 at the top shows an aircraft 22 with four turbofan engines 1 in driving operation, in the middle 22 during takeoff, and at the bottom in flight operation. The four turbofan engines 1, each mounted on the outer ends of the aircraft's 22 wings, can be rotated and locked in position using an unspecified joint arrangement so that they serve as landing gear for the aircraft 22 with wheels and tires 14 in driving mode, as rotors for vertical takeoff of the aircraft 22 in takeoff mode, and as fixed propellers 203 or as adjustable propellers for thrust generation in flight operation. For driving mode, the outer surface of the larger ring wing C2, formed as a suction side, is equipped with a tire 14. The aircraft 22 has front and rear wings. The front wings are rigidly connected to the underside of the fuselage and have a positive dihedral angle, while the rear wings are connected to the upper side of the fuselage and have a negative dihedral angle, so that the wingtips and turbofan engines 1 are arranged in one plane. The function of the torque stage 2 of the turbofan engine 1 corresponds to the embodiment explained in detail in Fig. 1-5.

Reference Signs

Turbofan Engine	1	Torque Stage	2
Rotational Axis	R	Casing	20
Length	x	Height	y
Ring Wing	C1,C2	Two-Stage Fan	200
Pressure Point Line	q1,q2	Compressor Module	201
Radius	r1,r2	Jet Propulsion	202
Center Point	M1,M2	Fixed Propeller	203
Effective Plane	Q1,Q2	Adjustable Propeller	204
Sectional Plane	N1,N2	Rudder Propeller	205
Tilt Angle	β1,β2	Vertical Rotation Axis	z
Guide Ring	10	Electric Drive	21
Guide Nozzle	11	Aircraft	22
Guide Surface	12	Watercraft	23
Asymmetric Wing Profile	13	Flow	F
Suction Tip	131	Convergent Cone Angle	α1
Tandem Profile	132	Divergent Cone Angle	α2
Radius	r1a,r1b	Flow Speed	a
Wing Nose	n	Circulation Speed	b
Wing Trailing Edge	m	Resulting Inflow	c
Profile Chord	p	Lift Force	d
Pitch Angle	δ	Propulsion Force	e
Profile Depth	t	Thrust Force	f
Hub	H1,H2	Tangential Driving Force	g
Shaft	S1,S2	Suction Force	h
Rotor Blade	B1,B2	Drag	j
Rotation Axis	u	Rotational Resistance	k
Design Speed Number	λ	Travel Resistance	l
Tire	14	Offset	v1,v2

Patent Claims

1. Turbofan engine (1), which is designed to generate thrust for an aircraft (22) or for a watercraft (23), and comprises at least one torque stage (2) formed by a smaller ring wing (C1) positioned upstream in the thrust direction, with a radius (r1), and a larger ring wing (C2) positioned downstream, with a radius (r2), wherein each ring wing (C1, C2) has effective planes (Q1, Q2) with circular pressure point lines (q1, q2), the center points (M1, M2) of which lie on a rotational axis (R) for at least one of the ring wings (C1, C2), and in a sectional plane (N1, N2) inclined at an angle of 20-90 degrees relative to the respective effective plane (Q1, Q2), through the respective center point (M1, M2), exhibit an aerodynamically effective, asymmetric wing profile (13) with a profile depth (t), with a wing nose (n) oriented in the thrust direction, and a profile chord (p) extending between the wing nose (n) and a wing trailing edge (m) of the wing, and the pressure point lines (q1, q2) of the two ring wings (C1, C2) are arranged one behind the other along the rotational axis (R) according to their length (x) and spaced apart by a radial height (y) such that a two-layered casing (20) is formed, wherein the smaller ring wing (C1), with a suction side facing the rotational axis (R) and a pressure side on the outside, forms a guide ring (10) in a flow (F) induced by rotor blades (B1, B2), and together with the wing nose (n) of the larger ring wing (C2) forms a ring-shaped guide nozzle (11) with guide surfaces (12) for a resulting inflow (c) to the larger ring wing (C2) with a convergent or a divergent cone angle ($\alpha1$, $\alpha2$).

2. Turbofan engine (1) according to claim 1, wherein the guide ring (10) formed by the smaller ring wing (C1) with the radius (r1) is designed in one or two parts and

in the sectional plane (N1) has a single asymmetric wing profile (13) with a suction side facing the rotational axis (R), or a suction tip (131), consisting of two asymmetric wing profiles (13) with radii (r1a, r1b), whose suction sides are oriented towards the rotational axis (R) and whose profile chords (p) have an increasing pitch angle (δ) in the direction of the flow (F) relative to the rotational axis (R), wherein the larger ring wing (C2) with the radius (r2) has an asymmetric wing profile (13) with an outer suction side, an inner pressure side, and a profile chord (p) arranged parallel to the rotational axis (R).

3. Turbofan engine (1) according to claim 1 or 2, wherein the length (x) of the torque stage (2), which defines the distance between the two ring wings (C1, C2) on the rotational axis (R), is chosen such that the wing trailing edge (m) of the smaller ring wing (C1) overlaps with the wing nose (n) of the larger ring wing (C2), and the height (y) of the torque stage (2) amounts to up to half the length (x) to form the ring-shaped guide nozzle (11) with the guide surfaces (12), wherein the ring wings (C1, C2) have the same or different profile depths (t).

4. Turbofan **engine (1)** according to one of the preceding claims, wherein a circulation flow is established within the flow (F) at a pair of ring wings (C1, C2) of a torque stage (2), whose asymmetric wing profiles (13) have pressure sides facing each other, which strengthens as a circulation vortex on the outer side of the smaller ring wing (C1) and on the inner side of the larger ring wing (C2) of the torque stage (2).

5. Turbofan engine (1) according to one of the preceding claims, wherein both ring wings (C1, C2) rotate as lift rotors with opposite rotational directions around the rotational axis

(R), wherein the aerodynamically effective, asymmetric wing profile (13) of the smaller ring wing (C1) is acted upon in the sectional plane (N1) of the torque stage (2), inclined at a tilt angle (β1) of 20-60 degrees relative to the effective plane (Q1), through the center point (M1), by the resulting inflow (c) derived from a flow speed (a), from a circulation speed (b) of the ring wing (C1), and from the convergent cone angle (α1), and wherein the aerodynamically effective, asymmetric wing profile (13) of the larger ring wing (C2) is acted upon in the sectional plane (N2) of the torque stage (2), inclined at a tilt angle (β2) of 110-160 degrees relative to the effective plane (Q2), through the center point (M2), by the resulting inflow (c) derived from the flow speed (a), from the circulation speed (b) of the ring wing (C2), and from the divergent cone angle (α2), such that the resulting inflow (c) in the sectional planes (N1, N2) of the ring wings (C1, C2) causes the least drag (j), wherein the lift force (d) exerted by the resulting inflow (c) at the circular pressure point lines (q1, q2) acts with an offset (v1, v2) on the rotational axis (R), so that a tangential driving force (g) and a thrust force (f) can be derived from the lift force (d) in the effective planes (Q1, Q2) of the torque stage (2).

6. Turbofan engine (1) according to one of the preceding claims, which is designed for an aircraft (22), and wherein the torque stage (2) is formed by two ring wings (C1, C2) rotating in opposite rotational directions around the rotational axis (R), each connected via at least eight adjustable rotor blades (B1, B2) on a rotation axis (u) to hubs (H1, H2) and with concentrically and coaxially arranged shafts (S1, S2), and spaced apart in the direction of the flow (F) according to their length (x) and by the radial

height (y), as the difference between the radii (r1, r2) of the circular pressure point lines (q1, q2), such that a two-stage fan (200) is formed with the fluid-dynamically effective torque stage (2), wherein the pressure sides of the ring wings (C1, C2) face each other, and the profile chord (p) of the smaller ring wing (C1) rises in the direction of the flow (F) with a pitch angle (δ) relative to the rotational axis (R), and wherein the profile chord (p) of the larger ring wing (C2) is aligned parallel to the rotational axis (R), so that the ring wings (C1, C2) together form the ring-shaped guide nozzle (11) with flow guide surfaces (12) for the inflow to the larger ring wing (C2) with a divergent cone angle (α2).

7. Turbofan engine (1) according to one of the preceding claims, which is designed for an aircraft (22), and wherein a plurality of fixed propellers (203), arranged one behind the other within a stationary casing (20), form a compressor module (201), wherein an upstream fixed propeller (203) in the direction of the flow (F) comprises at least two smaller ring wings (C1) and is connected via rotor blades (B1) to a shroud-side rotor ring of a first electric drive (21) integrated into the stationary casing (20), while a downstream fixed propeller (203) in the direction of the flow (F) comprises at least two larger ring wings (C2) connected via rotor blades (B2) to a hub-side rotor ring of a second electric drive (21), such that the ring wings (C1, C2) together form multiple torque stages (2) of the compressor module (201) arranged in series, and a larger two-stage fan (200) is provided at the turbofan engine (1), which is arranged either before or behind the compressor module (201) on the rotational axis (R).

8. Turbofan engine (1) according to one of the preceding claims, which, in the launch phase of an aircraft (22) or a watercraft (23), induces a converging flow (F) so that the smaller ring wing (C1) is acted upon with a convergent cone angle (α1) and the pitch angle (δ) of the profile chord (p) of the smaller ring wing (C1) acts as an angle of attack, wherein upon reaching the operating speed, only a slightly converging flow (F) impinges on the smaller ring wing (C1), which, with its wing trailing edge (m) together with the wing nose (n) of the larger ring wing (C2), forms the annular guide nozzle (11) of the torque stage (2) with guide surfaces (12) for the resulting inflow (c) of the larger ring wing (C2) with the divergent cone angle (α2), whereby the asymmetric wing profile (13) of the larger ring wing (C2) in the plane of the sectional plane (N2), inclined with the tilt angle (β2) relative to the effective plane (Q2), at the pressure point line (q2) over the entire outer circumference of the larger ring wing (C2) generates a lift force (d), which acts with an offset (v2) on the rotational axis (R), from which, in the second effective plane (Q2) of the torque stage (2), a tangential driving force (g) acting in the direction of rotation and a thrust force (f) acting in the direction of travel of the aircraft (22) or the watercraft (23) result.

9. Turbofan engine (1) according to one of the preceding claims, wherein the suction side of the larger ring wing (C2) lies on the outer side of the ring and features a tire (14), which is designed either as a solid rubber tire or an air-filled tire, so that a vehicle (22,23) can temporarily also travel on land, whereby the turbofan engine (1) is pivotably mounted to the wings of the aircraft (22) or to the hull of the watercraft (23).

10. Turbofan engine (1) according to one of the preceding claims, which is designed for a watercraft (23) and either has a fixed propeller (203) with a torque stage (2), where the ring wings (C1, C2) are rigidly connected to the shaft (S1) via three rotor blades (B1) and the hub (H1) and rotate with the same rotational direction around the rotational axis (R), or in which the turbofan engine (1) has a torque stage (2) formed by two fixed propellers (203) rotating in opposite directions around the rotational axis (R), wherein the first fixed propeller (203) with the smaller ring wing (C1) is connected in the first effective plane (Q1) of the torque stage (2) via three rotor blades (B1) with the hub (H1) and with the shaft (S1), while the second fixed propeller (203) with the larger ring wing (C2) is connected in the second effective plane (Q2) of the torque stage (2) via three rotor blades (B2) with the hub (H2) and with the shaft (S2), and one of the shafts (S1, S2) is designed as a hollow shaft.

11. Turbofan engine (1) according to one of the preceding claims, which is designed for a watercraft (23), in which the smaller ring wing (C1) is stationary and is rigidly connected to the stern of the watercraft (23) with the underwater hull, while the larger ring wing (C2), together with the rotor blades (B2), with the hub (H2), and with the shaft (S2), rotates as a fixed propeller (203) around the rotational axis (R), wherein the two ring wings (C1, C2) overlap in the direction of the flow (F) such that a convex suction tip (131) on the suction side of the larger ring wing (C2) facing the rotational axis (R), together with a concave outer pressure side of the smaller ring wing (C1), designed as a guide ring (10), forms the annular guide nozzle (11) for the inflow of the larger ring wing (C2) with a convergent cone angle ($\alpha 1$), and the stationary smaller ring wing (C1) in the effective plane (Q1) generates a thrust force (f), and the larger ring

wing (C2) generates a thrust force (f) and a lift force (d), which acts over the entire outer circumference with an offset (v2) on the rotational axis (R), whereby in the second effective plane (Q2) of the torque stage (2), the lift force (d) results in a tangential driving force (g) acting in the direction of rotation and a thrust force (f) acting in the direction of travel of the watercraft (23).

12. Turbofan engine (1) according to one of the preceding claims, which is designed for a watercraft (23), wherein the torque stage (2) is formed on a rudder propeller (205) that is rotatably connected to the underwater hull of the watercraft (23) around a vertical rotation axis (z), wherein the torque stage (2) is formed by a rotating smaller ring wing (C1) and a stationary larger ring wing (C2), and the larger ring wing (C2) has a profile chord (p) aligned parallel to the rotational axis (R) as well as a suction side facing the rotational axis (R) with a convex suction tip (131), and the smaller ring wing (C1), with adjustable rotor blades (B1), the hub (H1), and the shaft (S1), forms an adjustable propeller (204), which, as a guide ring (10), induces a converging airflow onto the larger ring wing (C2), and its outer pressure side, together with the convex suction tip (131) of the larger ring wing (C2), forms the annular guide nozzle (11) for the airflow onto the larger ring wing (C2) with a convergent cone angle (α1), so that both ring wings generate a thrust force (f) acting at the circular pressure point lines (q1, q2) in the effective planes (Q1, Q2), and the smaller ring wing (C1) generates a lift force (d) over the entire circumference of the inner side, from which, in the effective plane (Q1) of the torque stage (2), a tangential driving force (g) acting in the direction of rotation and a thrust force (f) acting in the direction of

travel of the watercraft (23) result.

13. Turbofan engine (1) according to one of the preceding claims, which is designed for a watercraft (23), wherein two counter-rotating adjustable propellers (204) are arranged within a casing (20) formed by the underwater hull of the watercraft (23) and are connected to concentric and coaxial rotating shafts (S1, S2) with an electric drive (21) operating inside the watercraft (23), forming a jet propulsion (202) for the watercraft (23).

14. Turbofan engine (1) according to one of the preceding claims, wherein the dual-layer casing (20) is fluid-dynamically effective as a torque stage (2) during the operation of a vehicle (22, 23), and wherein the torque stage (2) generates torque on the rotational axis through the guide ring formed by the smaller ring wing (C1) and the guide nozzle formed by the larger ring wing (C2) on at least one of the two ring wings (C1, C2).

15. Turbofan engine (1) according to one of the preceding claims, wherein in the torque stage (2), at least one ring wing (C1, C2) is connected to a hub (H1, H2) via radial rotor blades.

Anhängende Zeichnungen

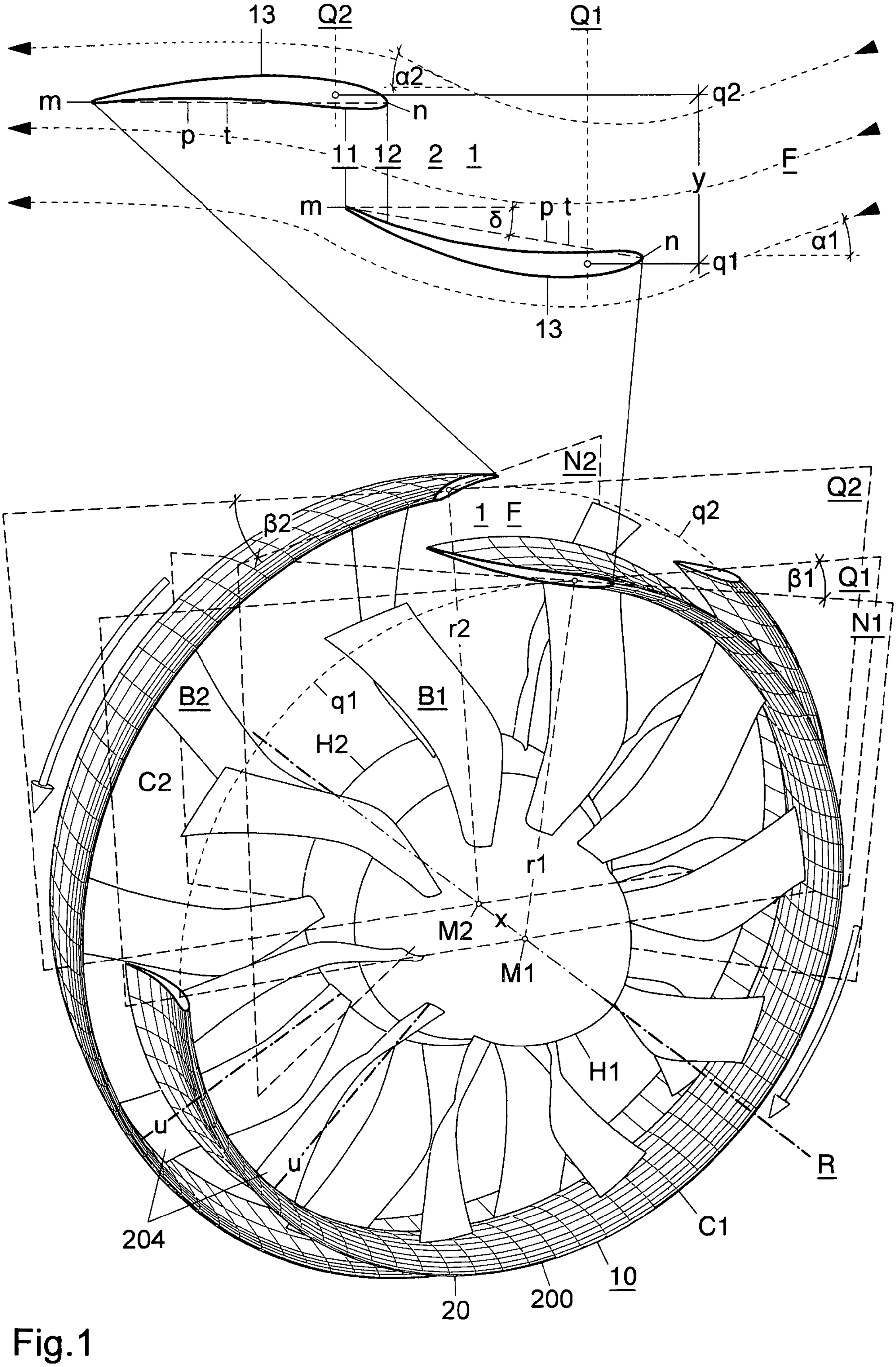

Fig. 1

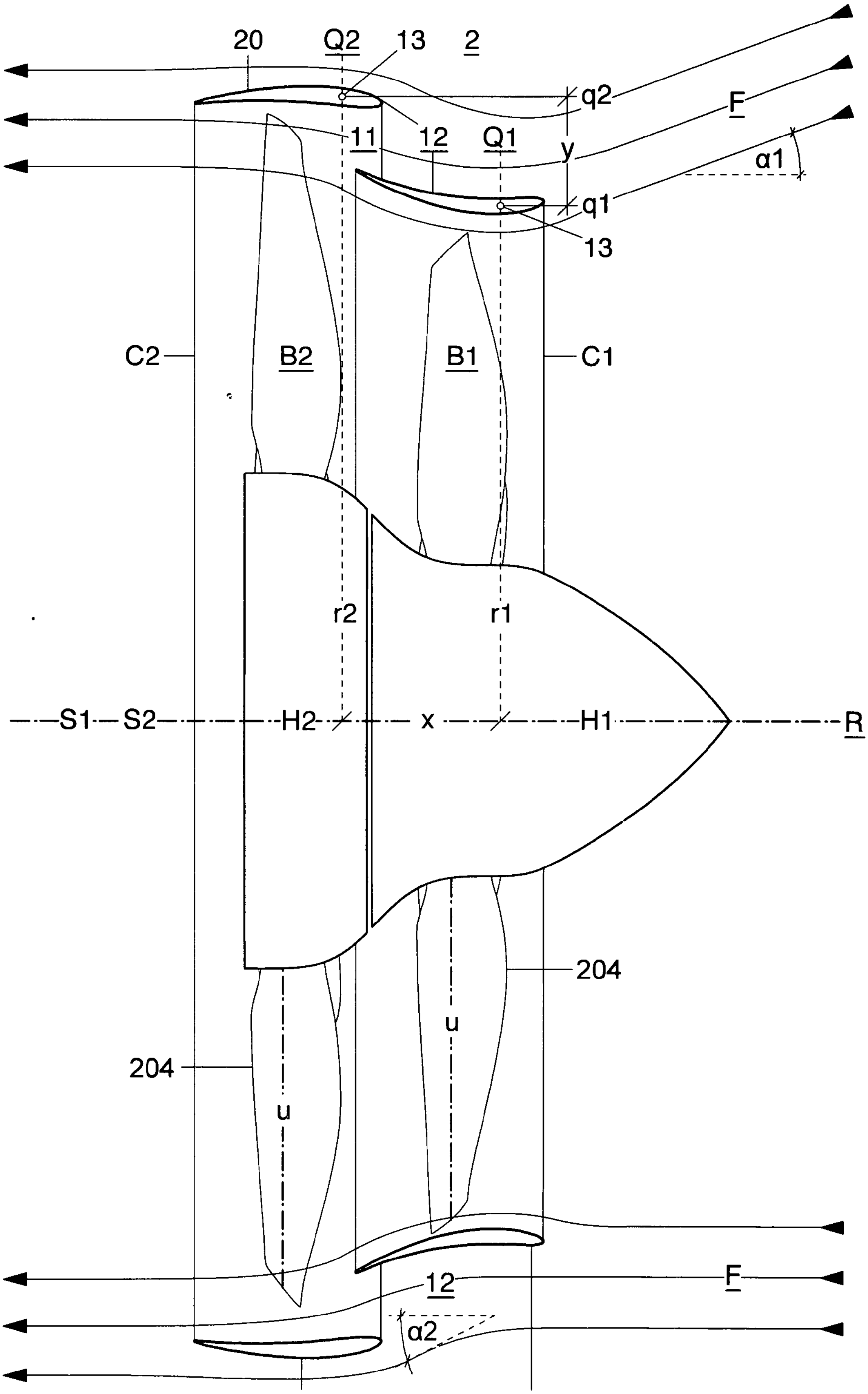
20
Q2
13
2
q2
F
11
12
Q1
y
α1
q1
13
C2
B2
B1
C1
r2
r1
S1
S2
H2
x
H1
R
204
u
u
204
F
12
α2
C2
C1

Fig.2

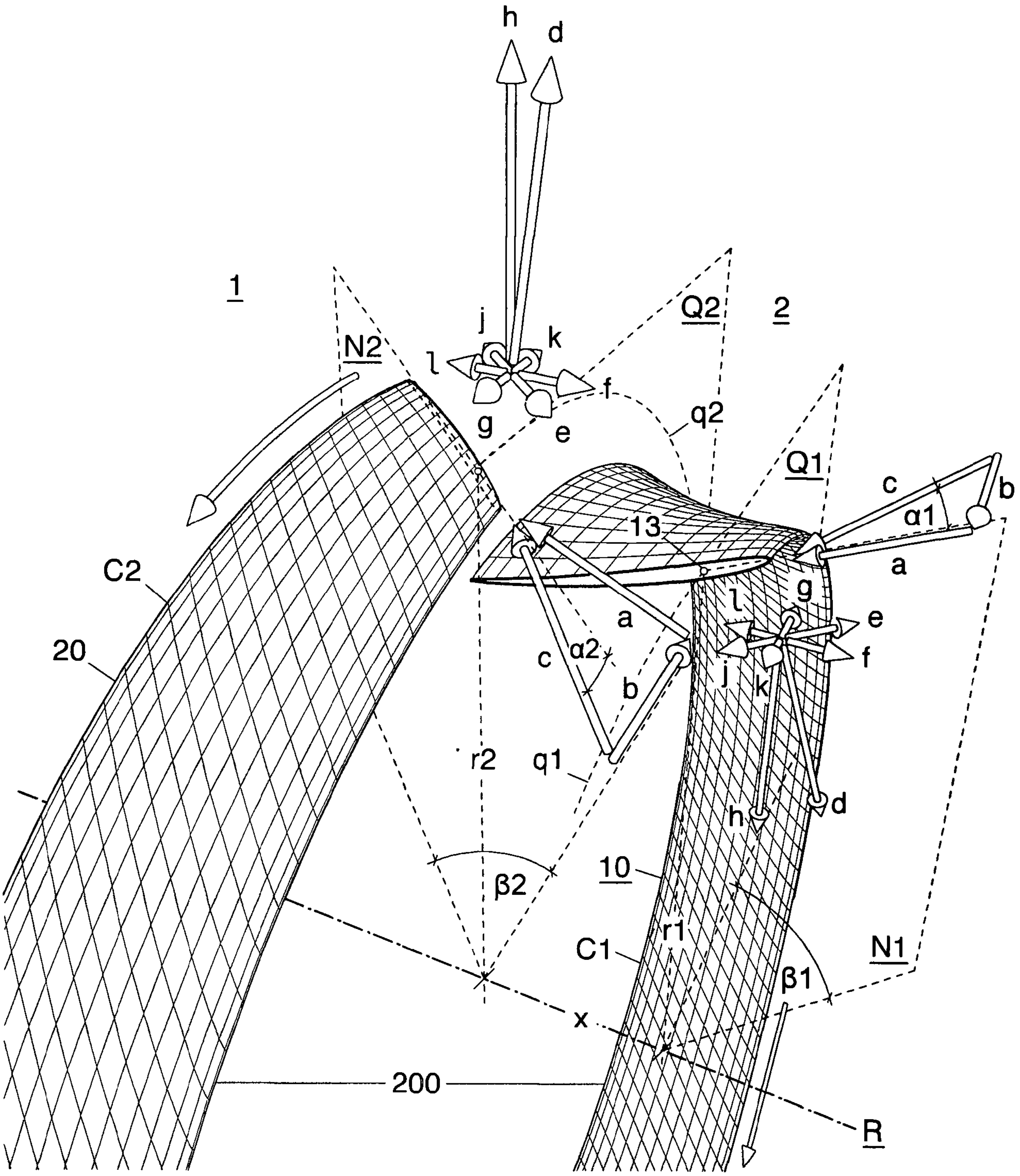
h
d
1
N2
j
k
l
f
g
e
Q2
2
q2
Q1
c
b
α1
13
a
g
l
e
j
f
k
a
c
α2
b
r2
q1
h
d
C2
20
10
β2
r1
C1
N1
β1
x
200
R

Fig.3

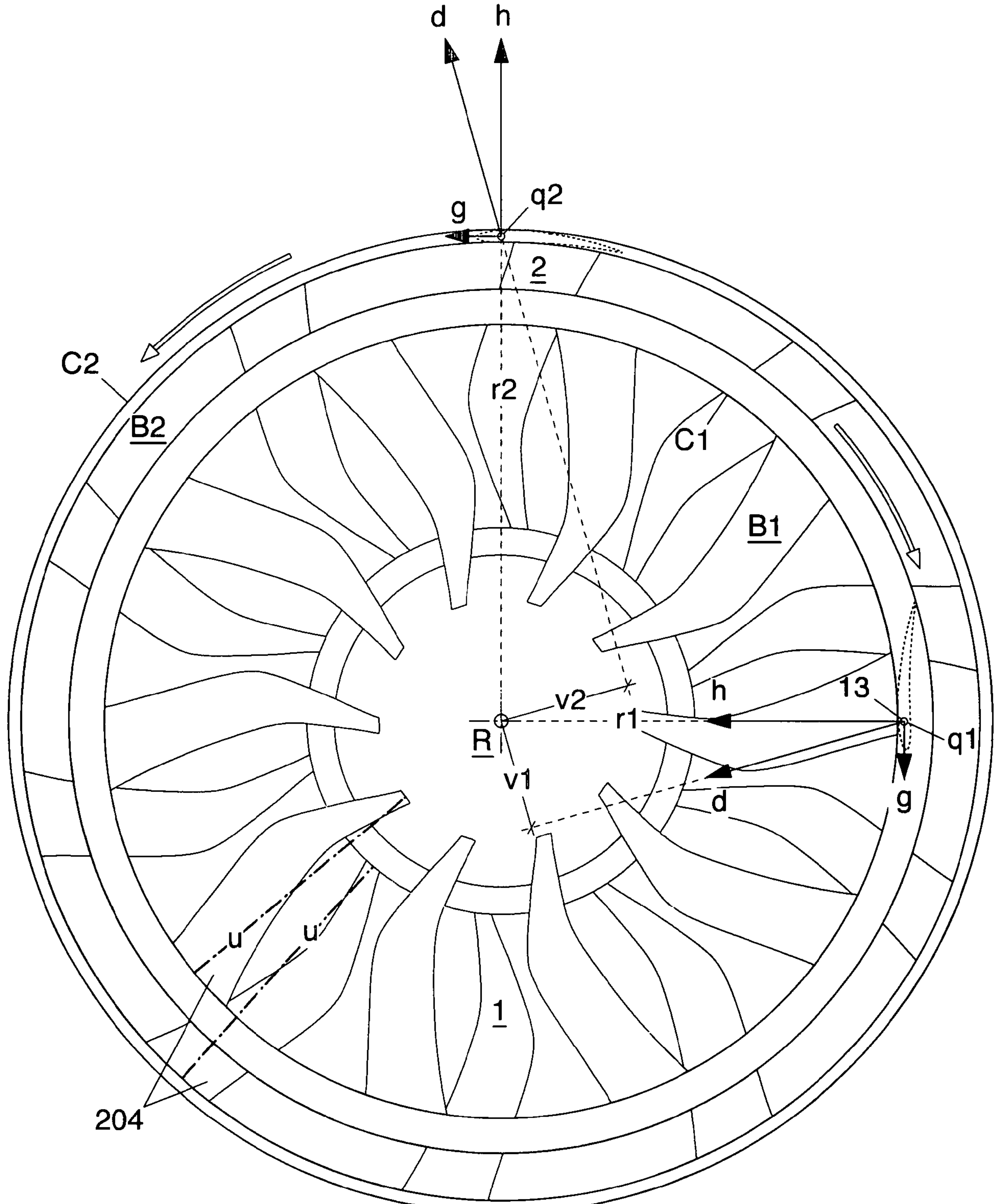

Fig.4

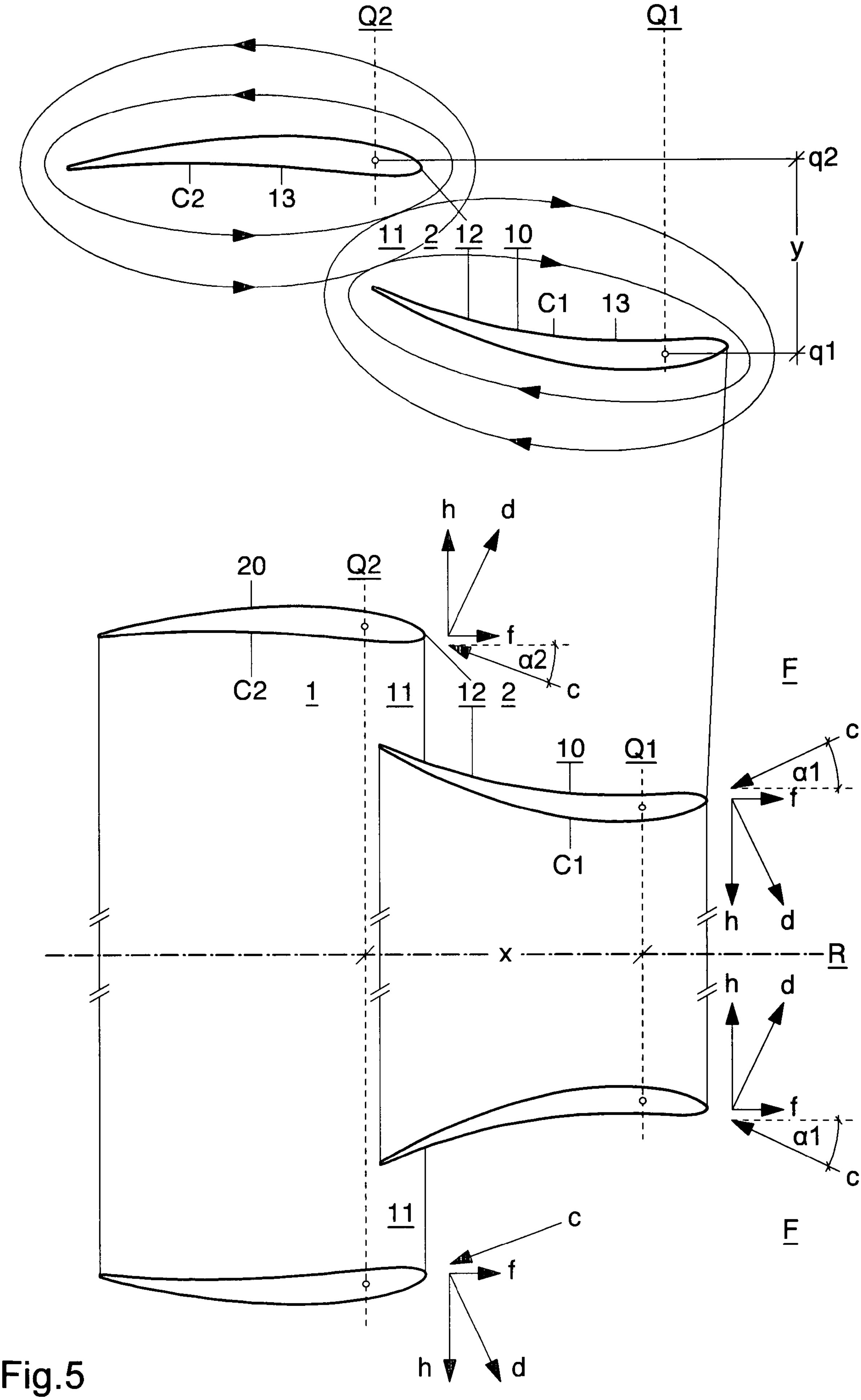
Q2
Q1
q2
C2
13
11
2
12
10
y
C1
13
q1
h
d
20
Q2
f
α2
c
F
C2
1
11
12
2
10
Q1
c
α1
f
C1
h
d
x
R
h
d
f
α1
c
11
c
F
f
h
d

Fig.5

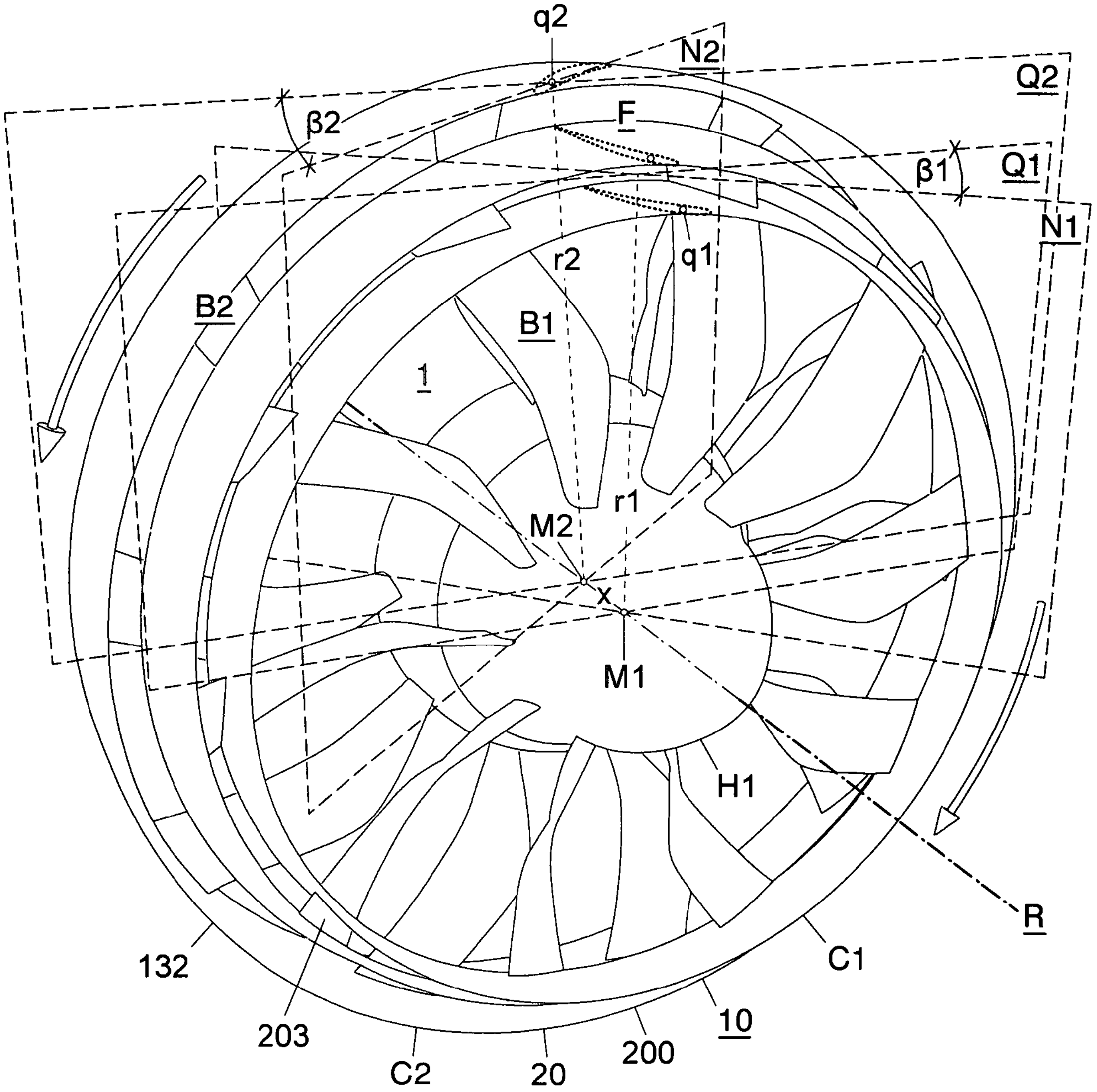
q2
N2
Q2
F
β2
β1
Q1
N1
r2
q1
B2
B1
1
r1
M2
x
M1
H1
R
132
C1
203
10
200
C2
20

Fig.6

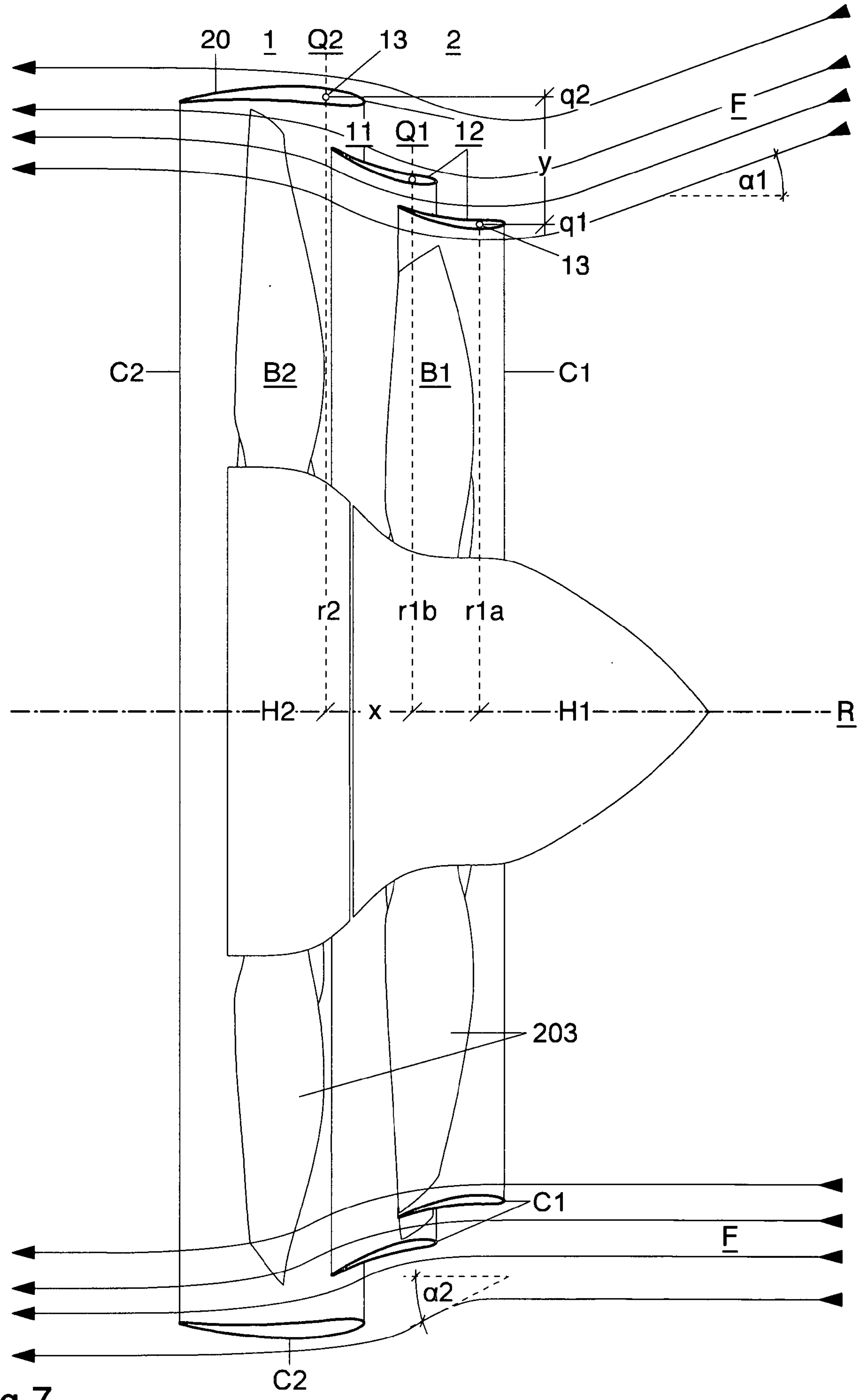
20
1
Q2
13
2
q2
F
11
Q1
12
y
α1
q1
13
C2
B2
B1
C1
r2
r1b
r1a
H2
x
H1
R
203
C1
F
α2
C2

Fig.7

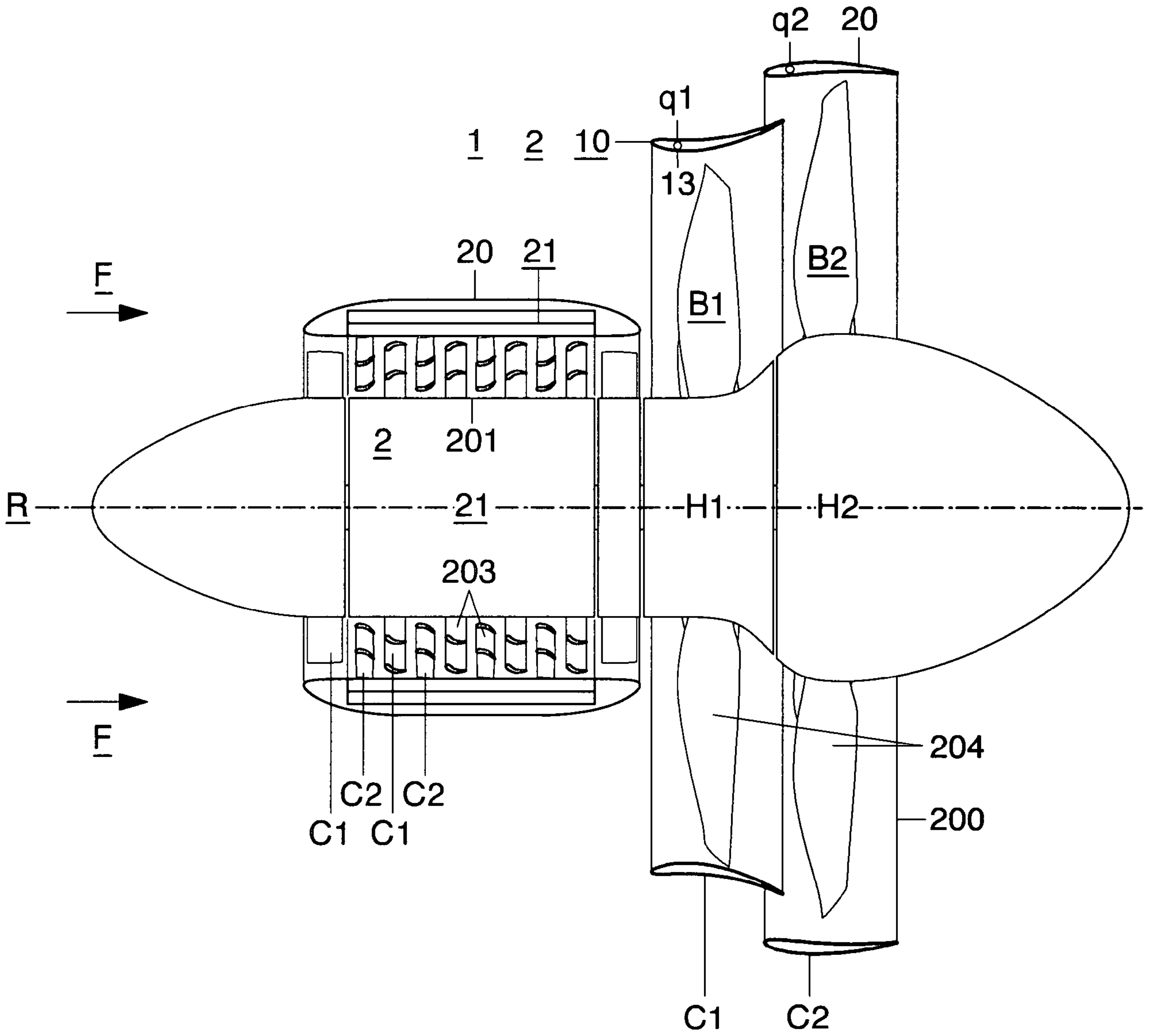
q2
20
q1
1
2
10
13
B2
20
21
B1
F
2
201
R
21
H1
H2
203
F
204
C2
C2
C1
C1
200
C1
C2

Fig.8

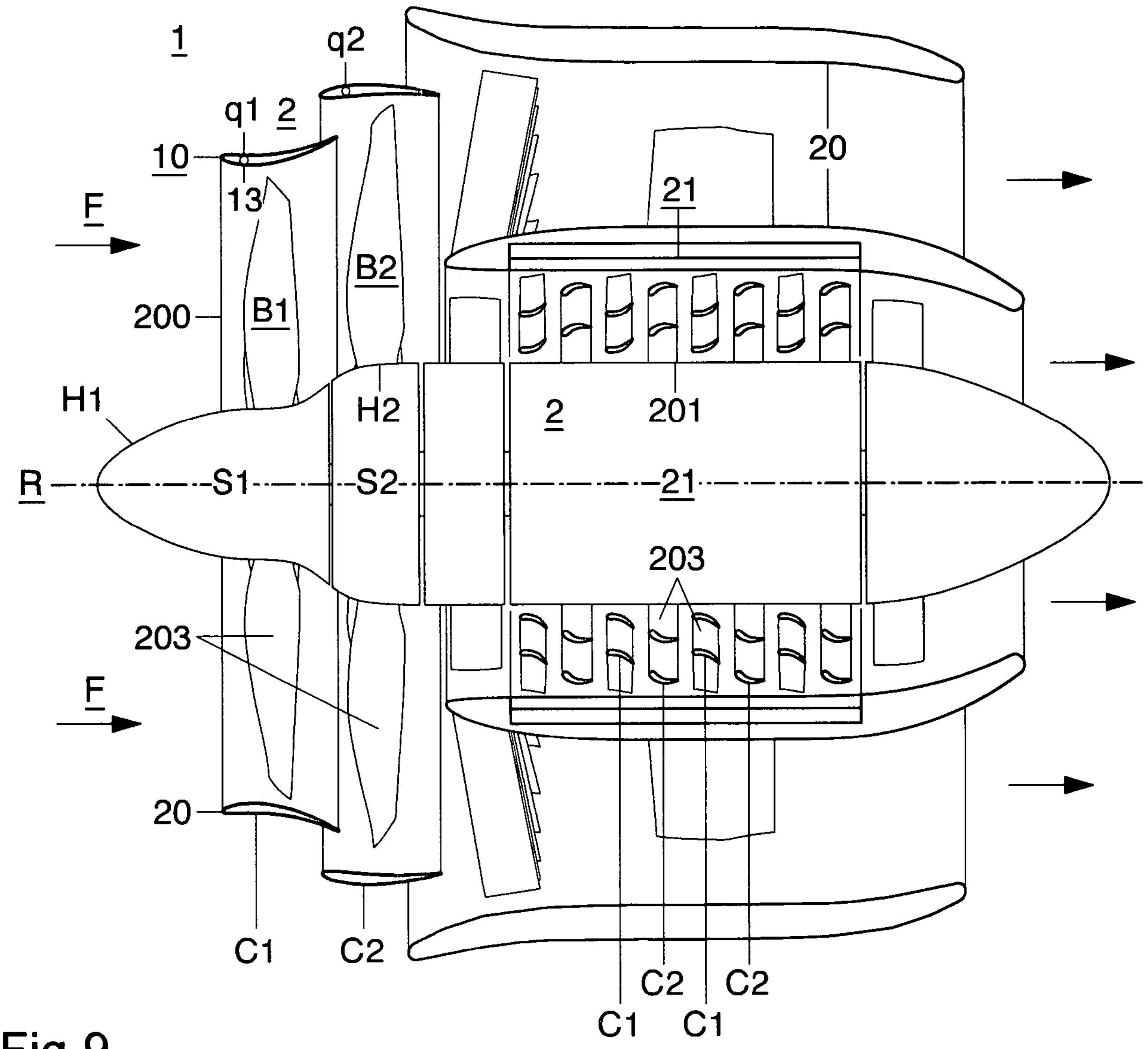
1
q2
q1
2
10
13
F
200
B1
B2
20
21
H1
H2
2
201
R
S1
S2
21
203
203
F
20
C1
C2
C2
C2
C1
C1

Fig.9

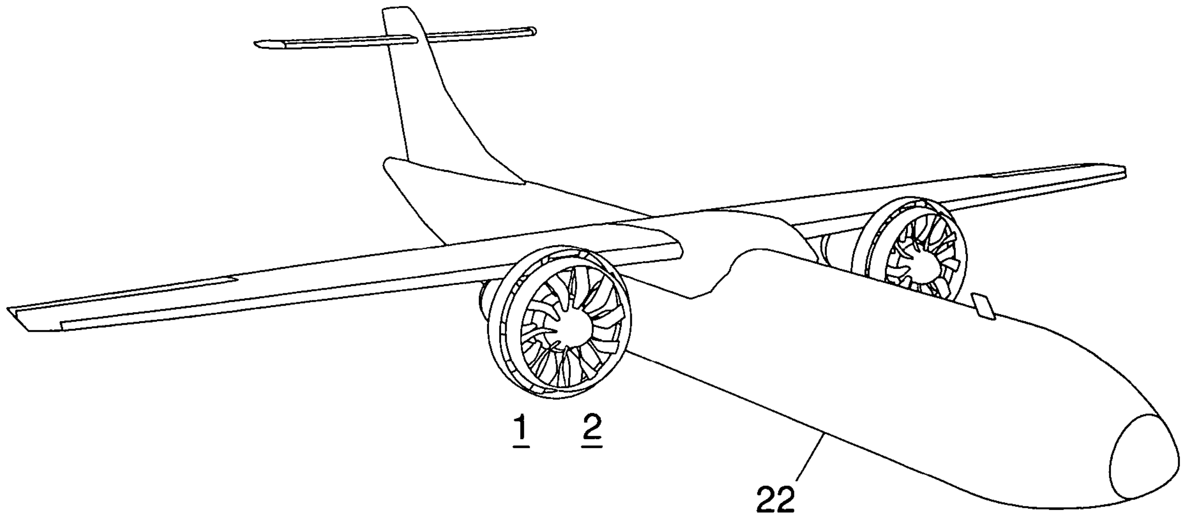
1
2
22

Fig.10

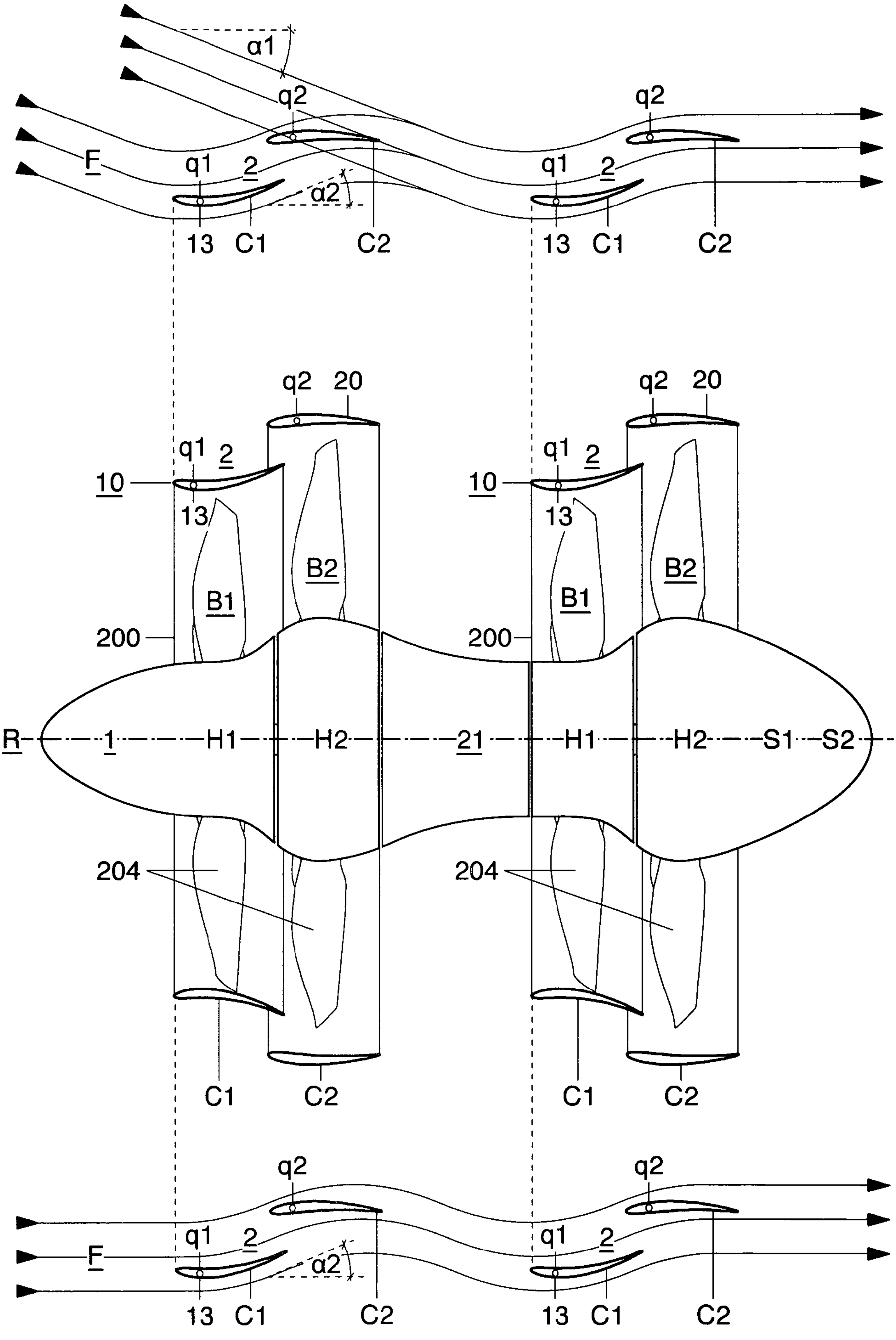
α1
q2
q2
F
q1
2
α2
q1
2
13
C1
C2
13
C1
C2
q2
20
q2
20
q1
2
10
13
B2
q1
2
10
13
B2
B1
B1
200
200
R
1
H1
H2
21
H1
H2
S1
S2
204
204
C1
C2
C1
C2
q2
q2
q1
2
F
α2
q1
2
13
C1
C2
13
C1
C2

Fig.11

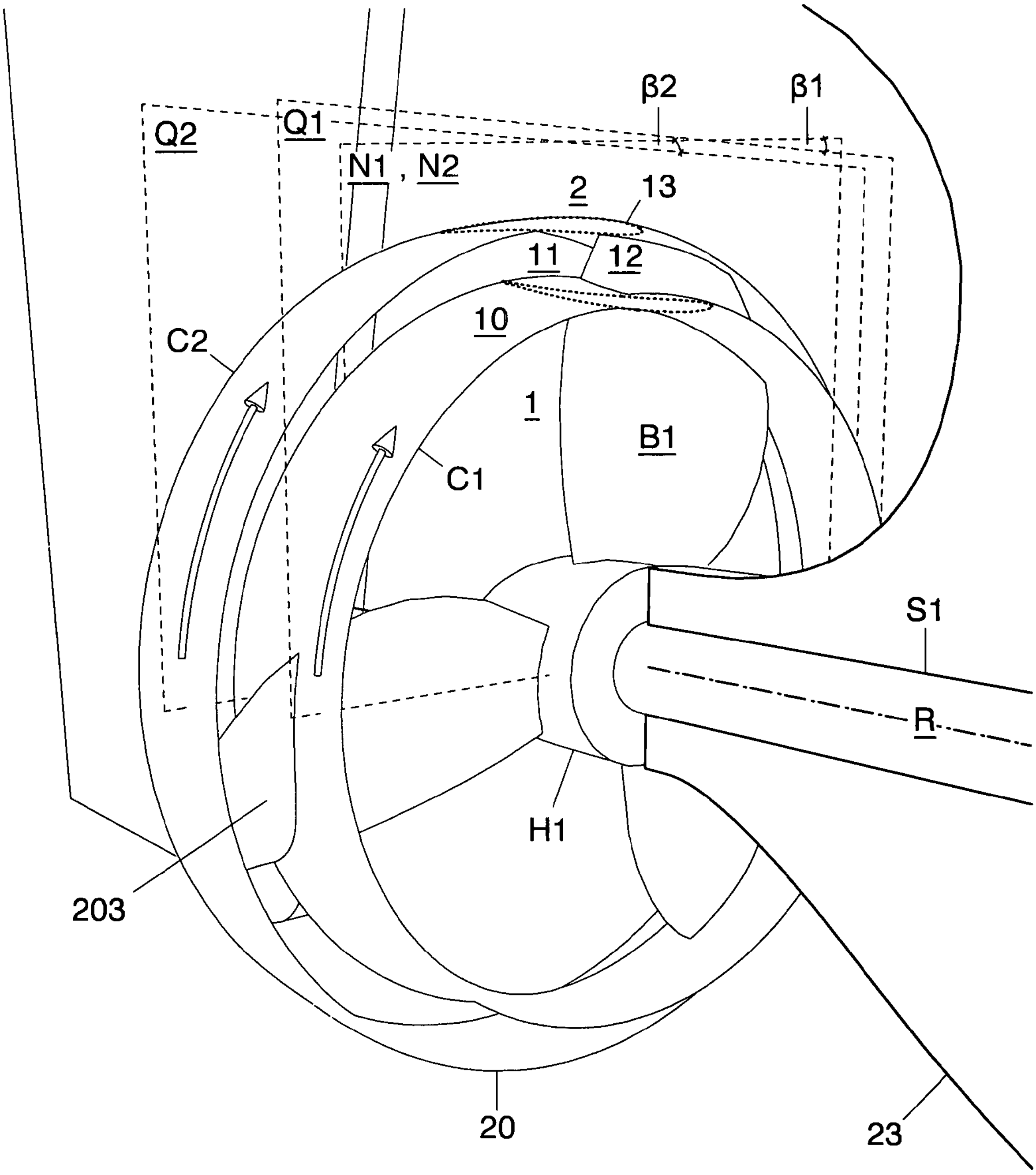

Fig.12

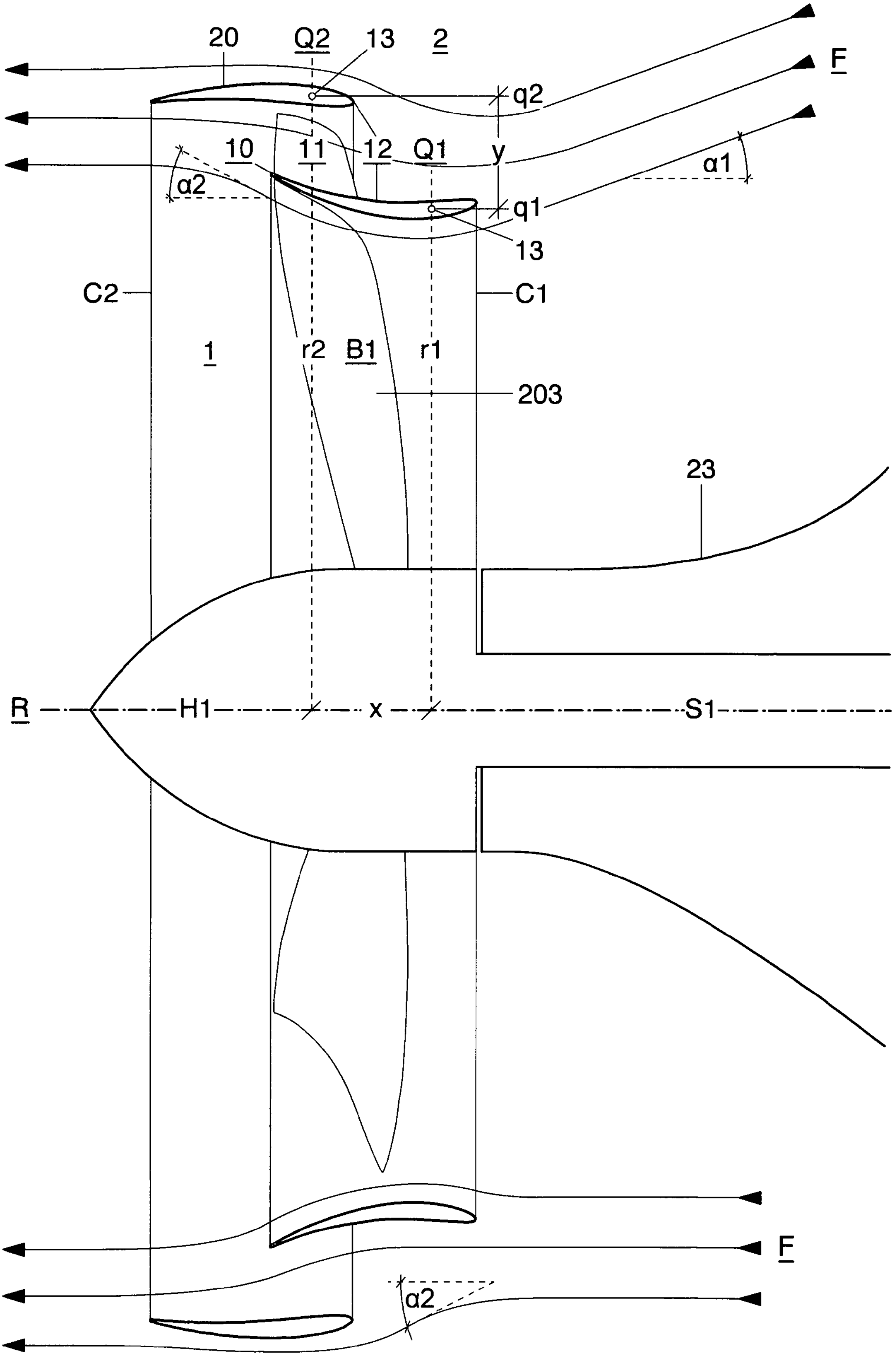
20
Q2
13
2
F
q2
y
10
11
12
Q1
α2
α1
q1
13
C2
C1
1
r2
B1
r1
203
23
R
H1
x
S1
F
α2

Fig.13

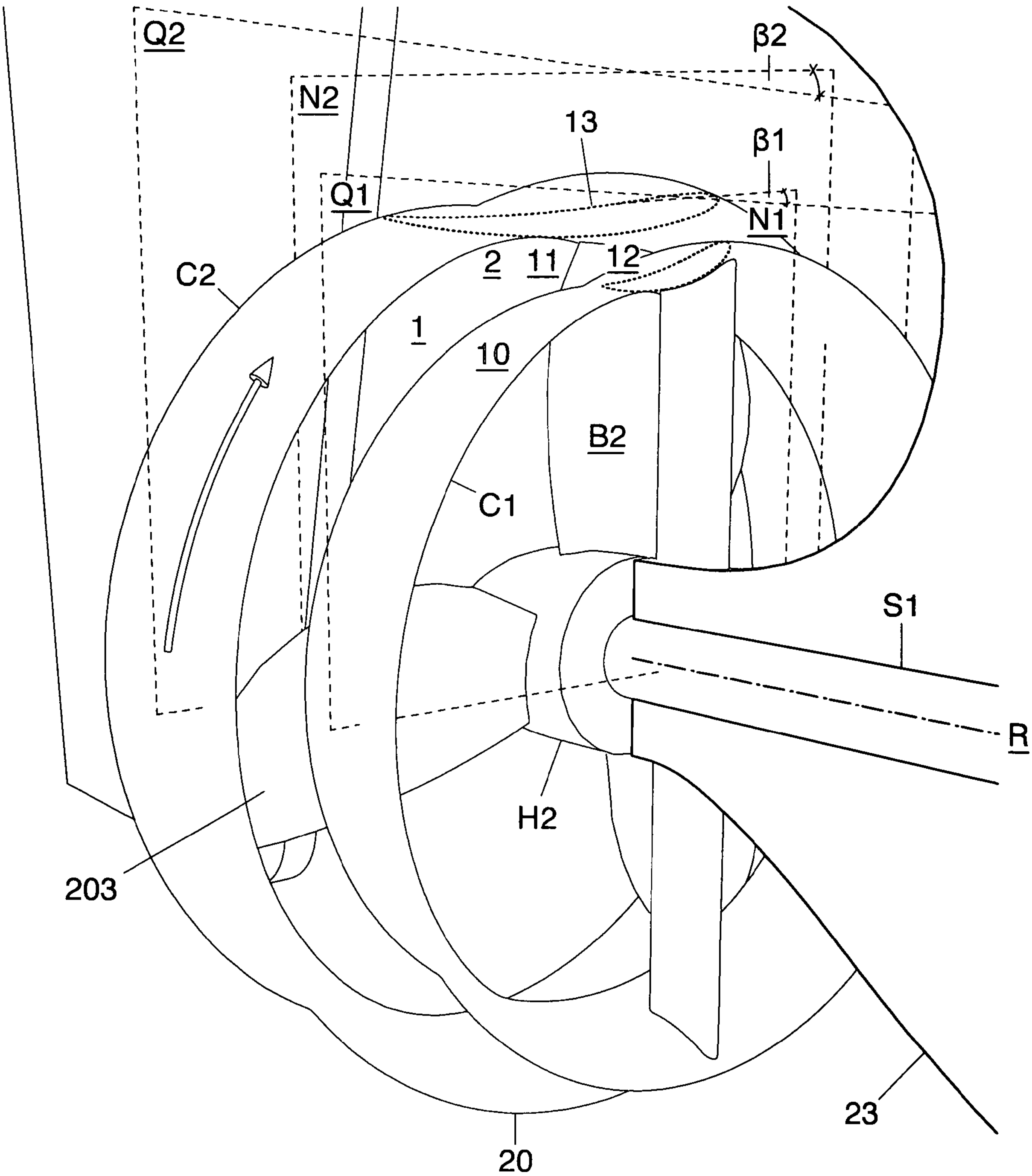

Fig.14

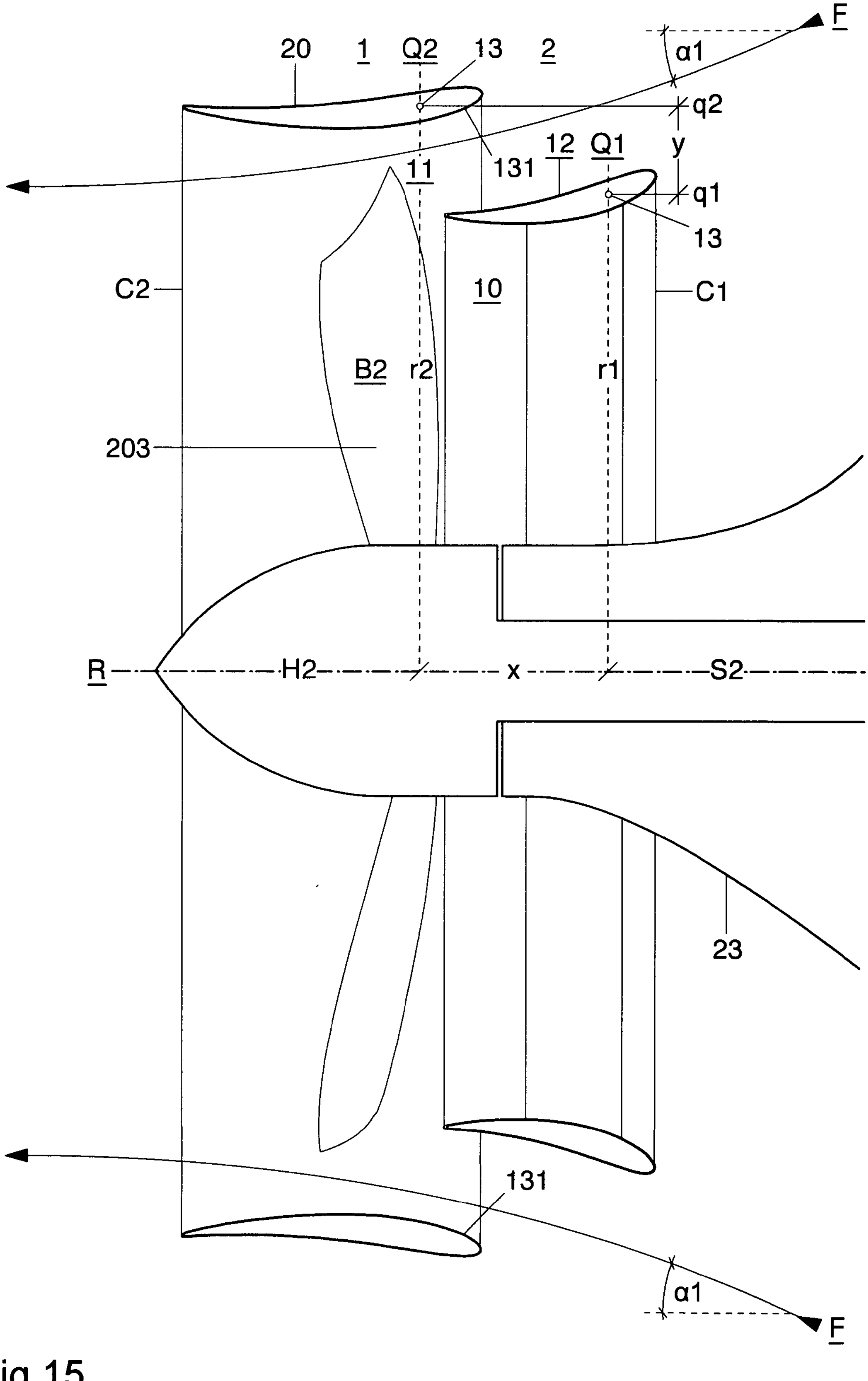
F
20
1
Q2
13
2
α1
q2
131
12
Q1
y
11
q1
13
C2
10
C1
B2
r2
r1
203
R
H2
x
S2
23
131
α1
F

Fig.15

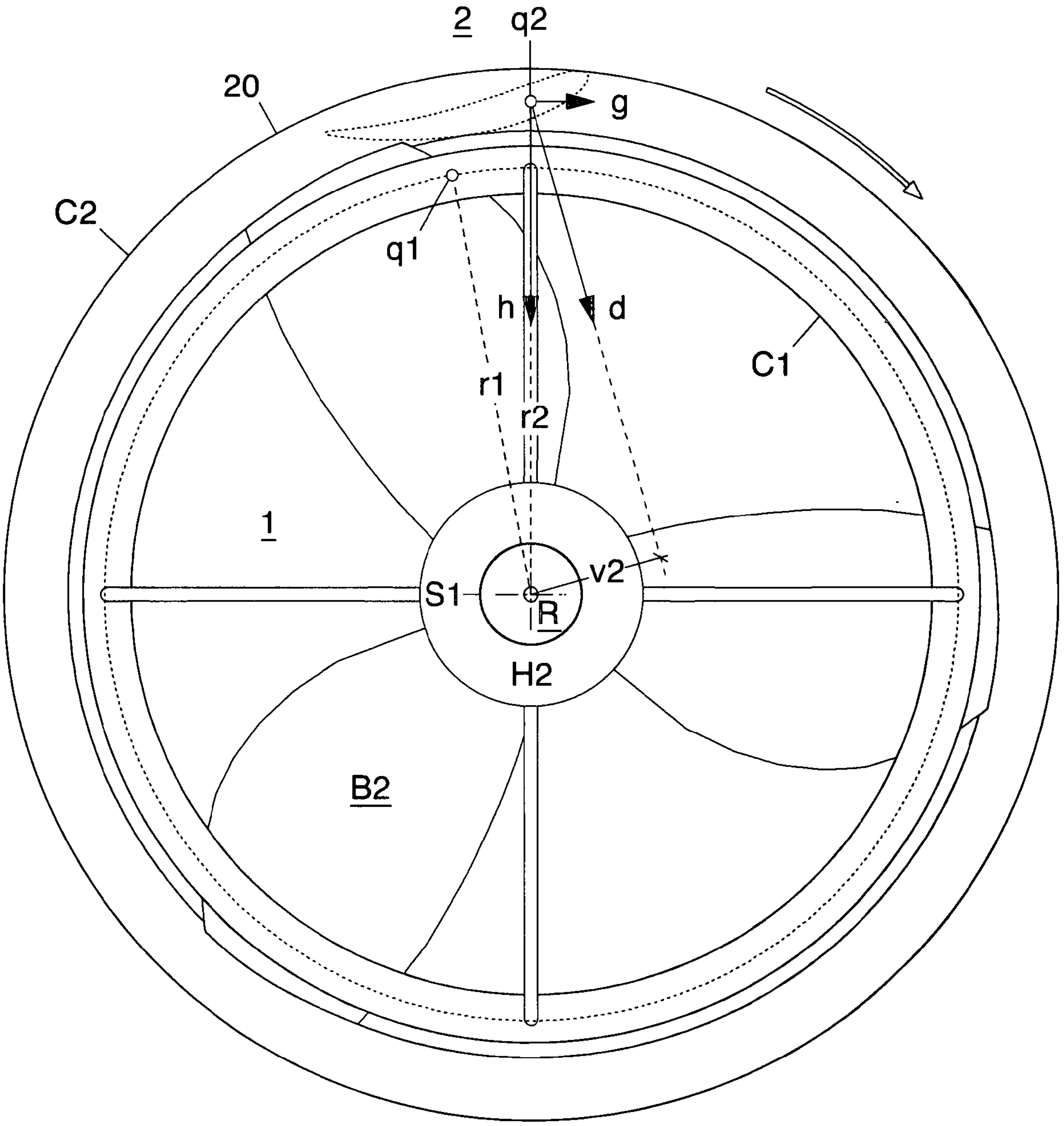

Fig.16

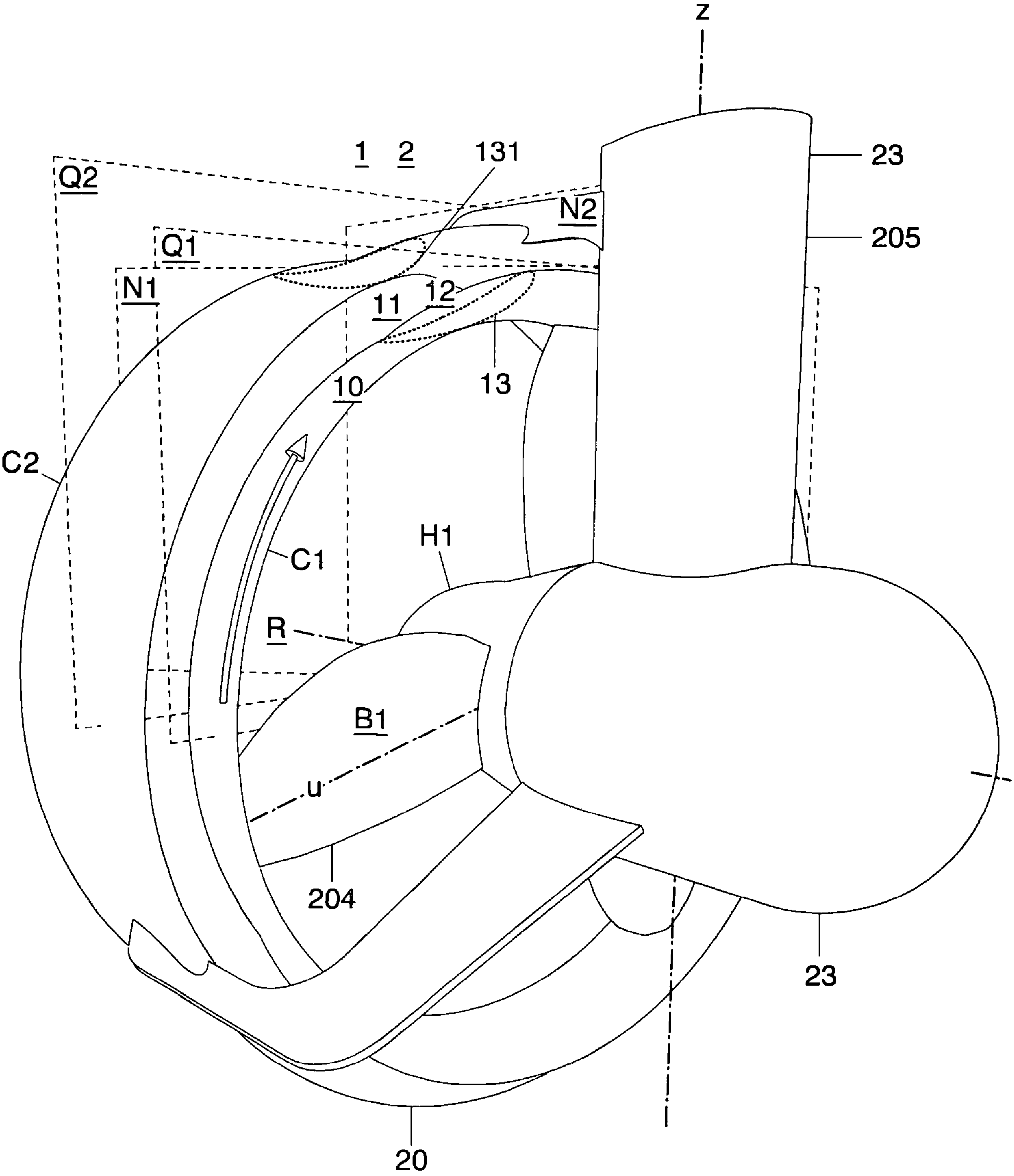

Fig.17

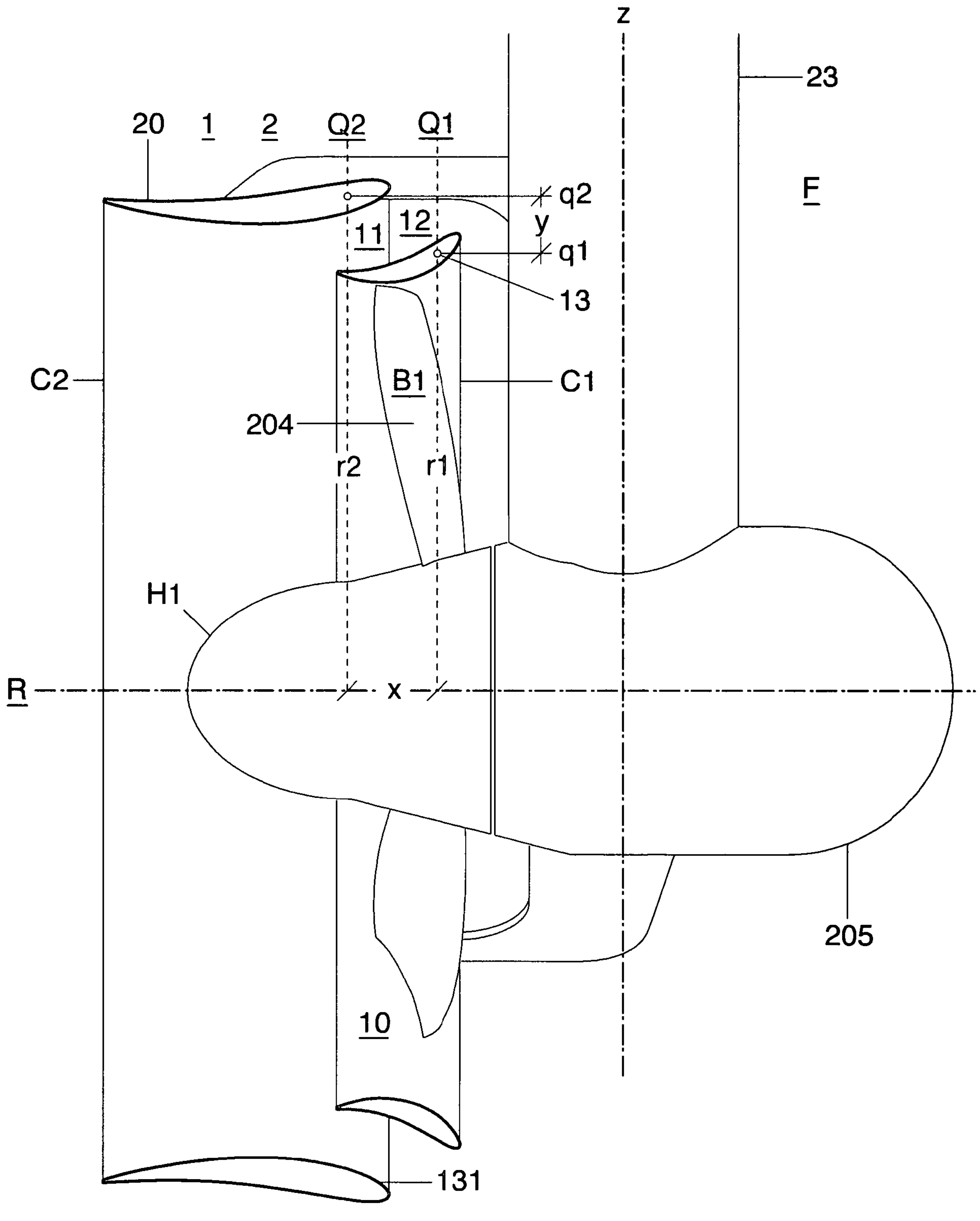

Fig.18

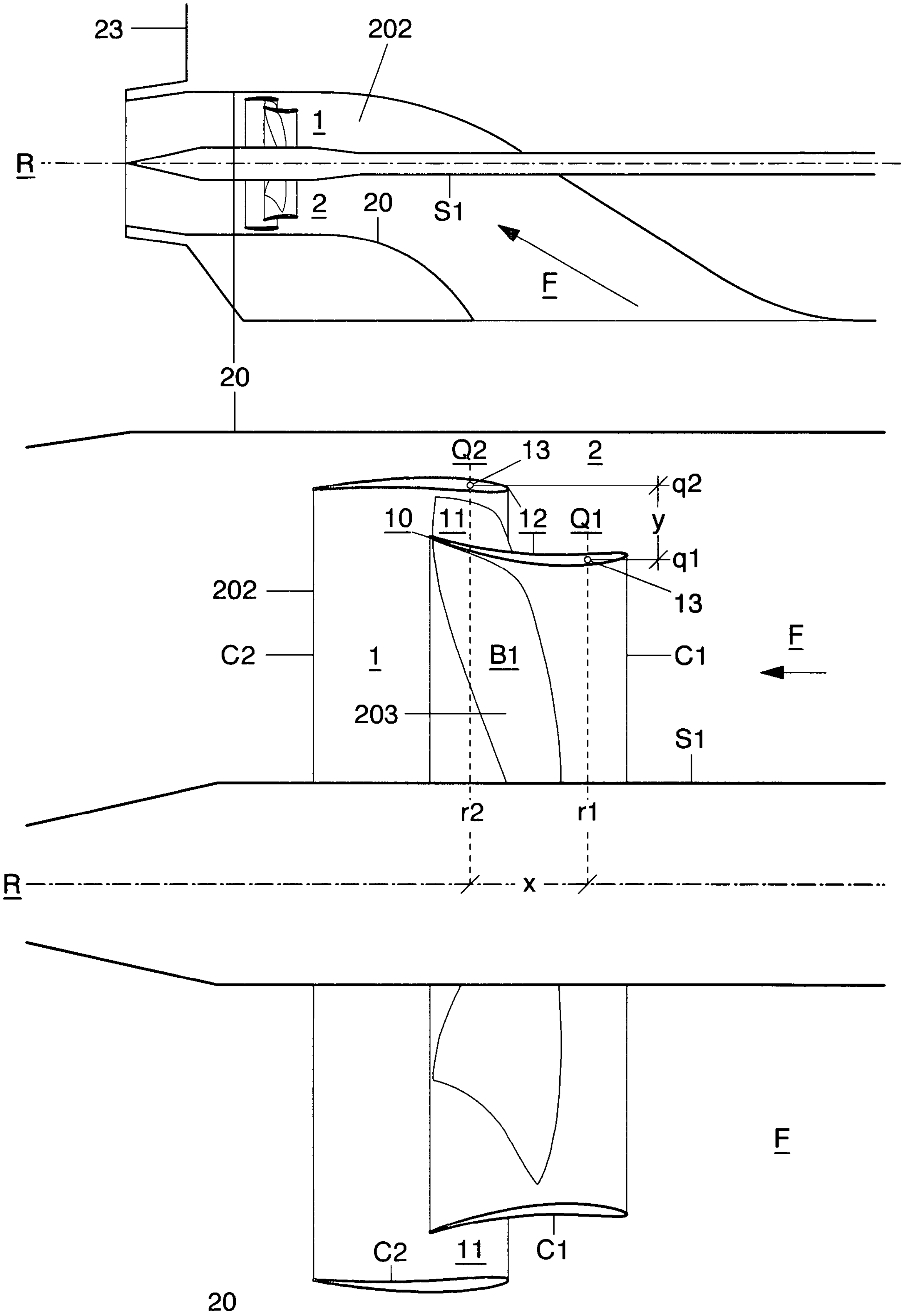
23
202
1
R
2
20
S1
F
20
Q2
13
2
q2
10
11
12
Q1
y
q1
202
13
C2
1
B1
C1
F
203
S1
r2
r1
R
x
F
C2
11
C1
20

Fig.19

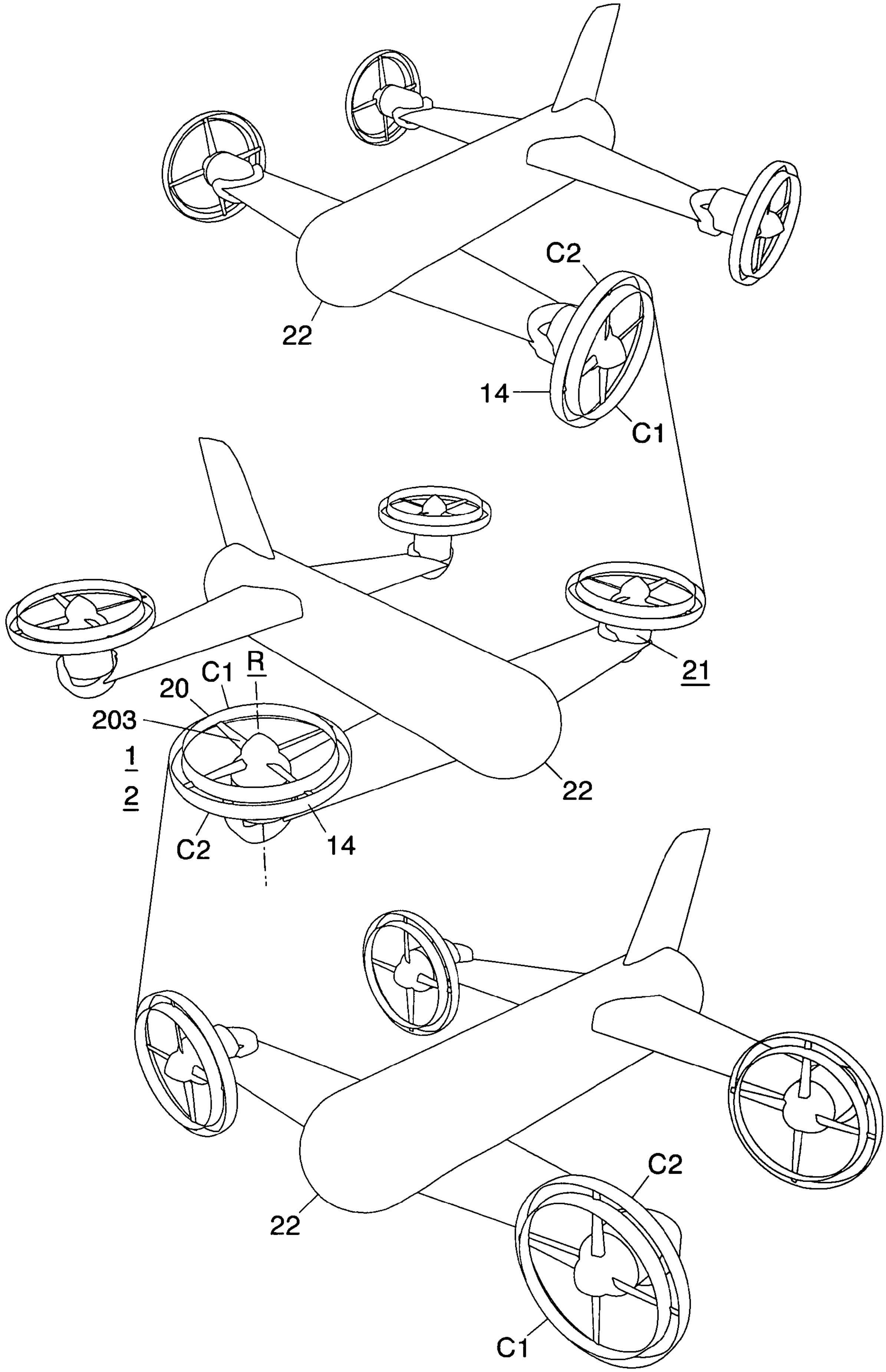

Fig.20

Das Dokument wurde durch die Firma Jouve erstellt.