

Dec. 11, 1945.

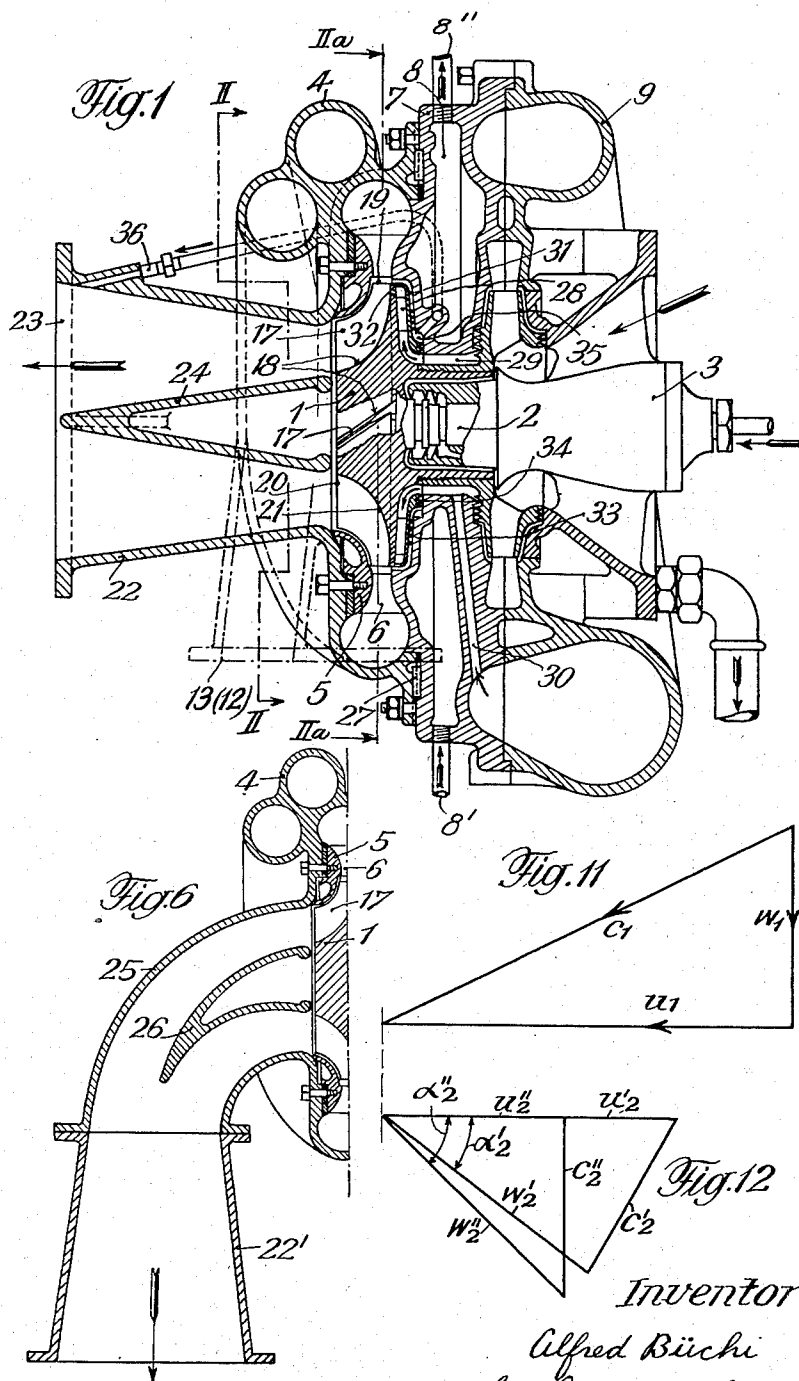
A. BÜCHI

2,390,506

TURBINE WITH OVERHUNG ROTOR

Filed Oct. 21, 1942

4 Sheets-Sheet 1



Inventor:

Alfred Büchi
by Sommers & Young
Attorneys

Dec. 11, 1945.

A. BÜCHI

2,390,506

TURBINE WITH OVERHUNG ROTOR

Filed Oct. 21, 1942

4 Sheets-Sheet 2

Fig. 1a.

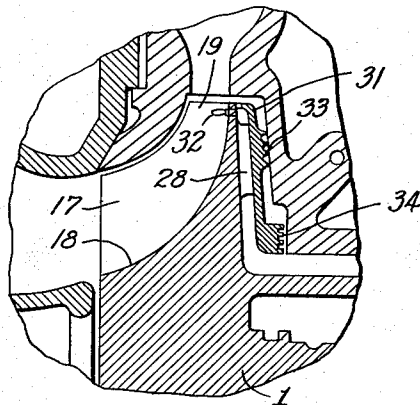


Fig. 2a.

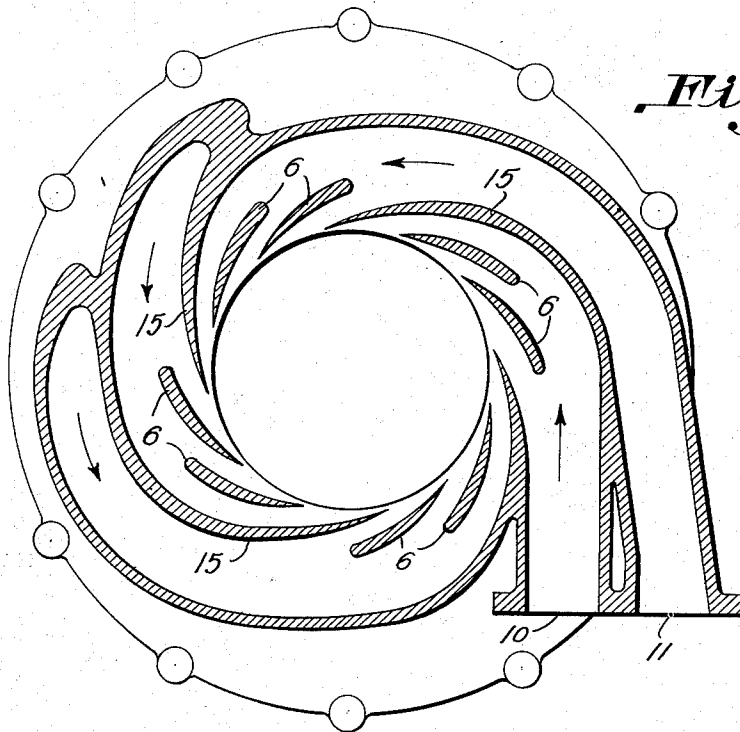
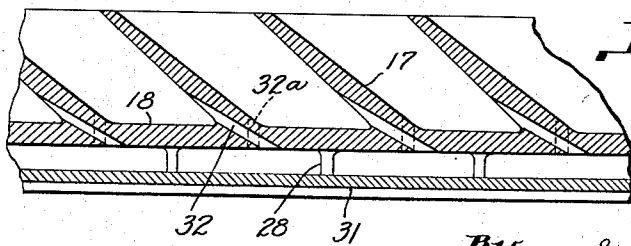


Fig. 4a.



Inventor

Alfred Büchi

By

Sommers + Young
Attorneys.

Dec. 11, 1945.

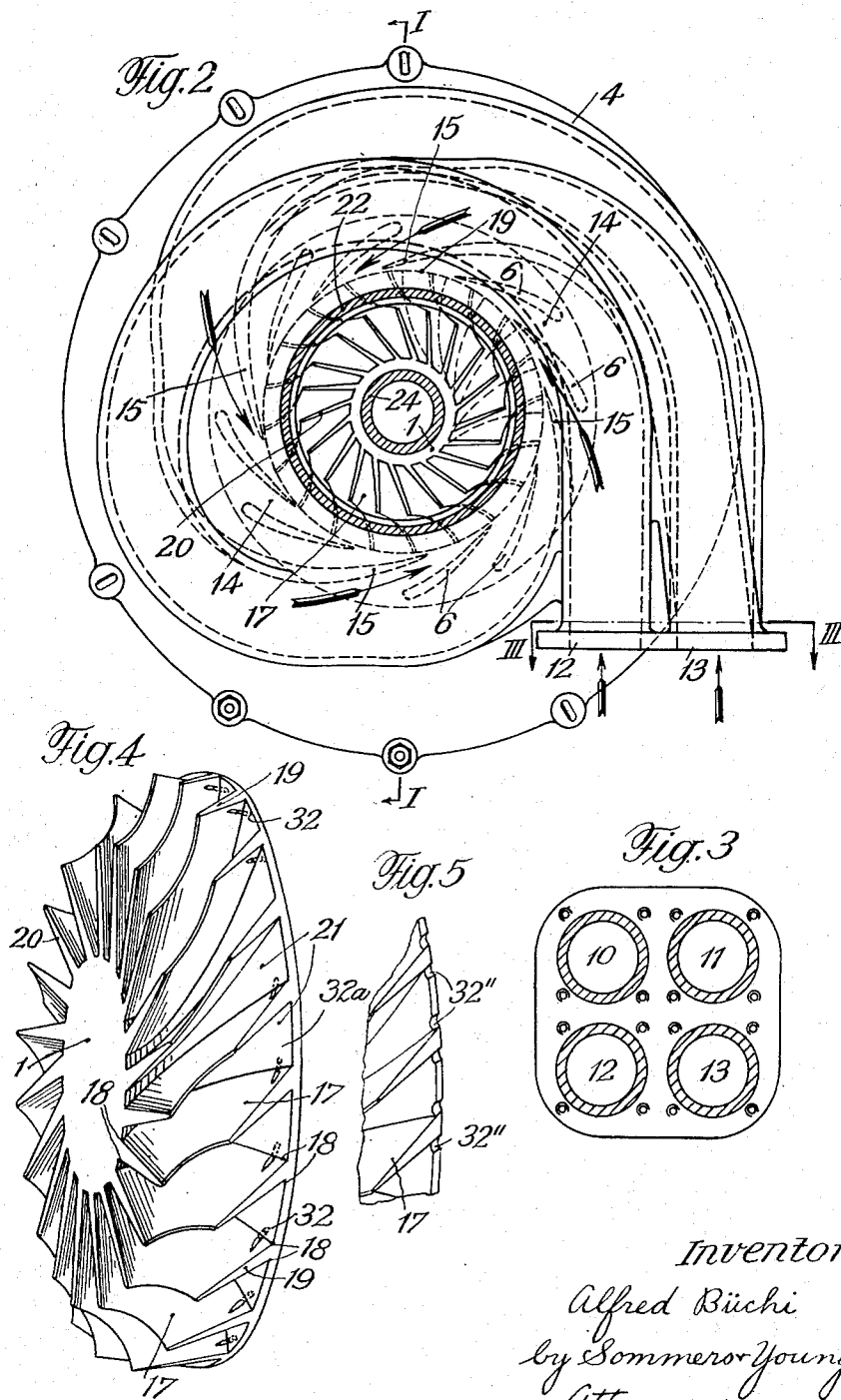
A. BÜCHI

2,390,506

TURBINE WITH OVERHUNG ROTOR

Filed Oct. 21, 1942

4 Sheets-Sheet 3



Inventor:
Alfred Büchi
by Sommer & Young
Attorneys

Dec. 11, 1945.

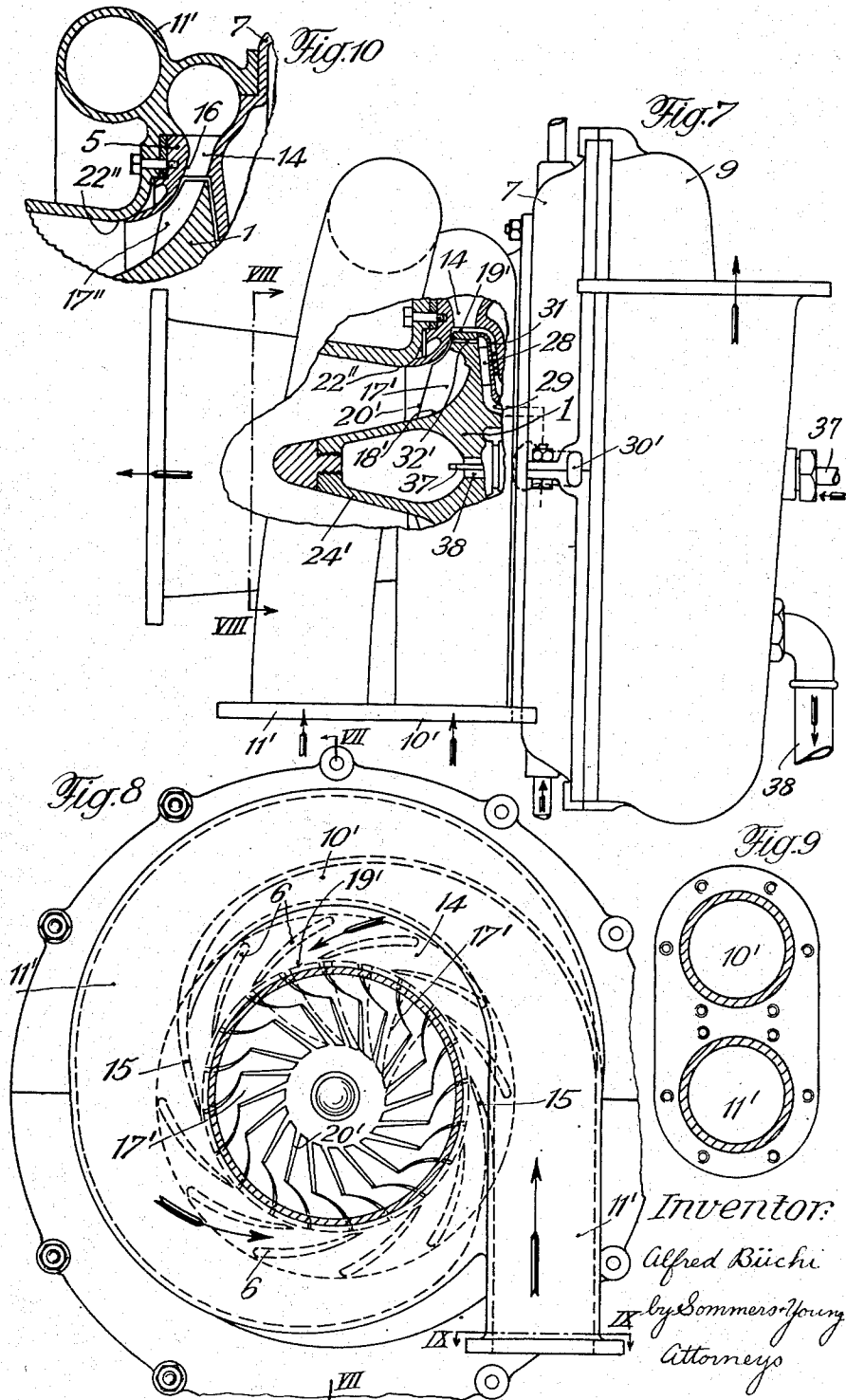
A. BÜCHI

2,390,506

TURBINE WITH OVERHUNG ROTOR

Filed Oct. 21, 1942

4 Sheets-Sheet 4



11' Inventor:
Alfred Büchi
by Sommer & Young
Attorneys

UNITED STATES PATENT OFFICE

2,390,506

TURBINE WITH OVERHUNG ROTOR

Alfred Büchi, Winterthur, Switzerland

Application October 21, 1942, Serial No. 462,859
In Switzerland May 23, 1942

5 Claims. (Cl. 253—39)

This invention relates to overhung rotor turbines, particularly for motive fluids, such as hot gases, and is distinguished in that the turbine rotor, to which the motive fluid is admitted tangentially from without through one or more inlet devices and a limited number of inlet nozzles, is composed of a relatively small number of blades that are approximately radially directed along an outer portion thereof at least and are substantially plane transversely to the turbine axis, the blading being gradually and smoothly so deflected from the radial into the axial direction that the entering gases are diverted at a great radius of curvature into the axial direction and then pass into a diffuser under a lower pressure than the final discharge pressure behind the respective turbine stage but at a relatively high velocity whereupon the velocity of the gases is converted to correspond to the pressure against which the gases discharge. The turbine inlet parts can surround the turbine rotor spirally and their cross sections of free passage may decrease to such an extent that the velocity of admission of the gas is substantially uniform throughout up to the inlet nozzles.

If several conduits supplying the motive gas independently of each other to the tangentially directed inlet nozzles are provided said conduits may surround said nozzles in a crowded arrangement of helical convolutions. With such independent gas supply conduits the gas admission casing may be integral with the diffuser arrangement. The blading of the turbine rotor may be designed for such a discharge velocity that interiorly of the diffuser arrangement a substantially axially directed flow of gas and at the outer periphery of said arrangement a flow of gas with a rotative component is set up in order to prevent separation of gas from the outer peripheral portions of the diffuser arrangement and to obtain a satisfactory conversion of velocity into pressure also in a diffuser arrangement which has a relatively short length and is flared at a relatively large angle of inclination.

The rotor blades can be worked out of the material of the rotor body and may have bases that are thickened particularly in the radial direction, that is, toward the wheel hub and, if desired, also the disc of the turbine rotor.

In the interior of the diffuser joining with the turbine rotor a conically tapering guide or filler piece extending in the direction of the turbine axis may be arranged for the purpose of obtaining conversion of velocity into pressure at a minimum of energy losses.

The flared diffuser can be arranged to join the

exit of the turbine rotor immediately as regards the direction of the turbine axis, or the flow of exhaust gas may be compelled to pass over into another differently directed diffuser by means of a flow change-over device. The cooling of the inner end portion of the turbine rotor and of the adjoining filler piece of the diffuser can be effected by means of a cooling medium which may be supplied particularly from the end of the driving shaft remote from the turbine rotor.

The uncooled turbine casing can be closed by means of a hollow closure member provided with a cooling device only at the driving end of the turbine. With a view to ensuring accurate centering of the hot and consequently expanding turbine casing by means of the cooled scarcely expanding closure member, between these two parts at least two pairs of diametrically opposed keys may be arranged the axes of which intersect each other in the turbine axis.

The backside of the turbine rotor disc may be provided, for example, with a cooling fan blading and, if desired, also with an associated covering disc for cooling the turbine rotor by means of cool air. In conjunction with this cooling arrangement cooling air may be forced through the turbine rotor blades through bores thereof or through openings in the rotor disc against the surfaces of the turbine blades, particularly adjacent to the points of entry of the gases and the blade bases. The cooling air may be derived from the surroundings or any other suitable extraneous place, for example, from any suitable spot on the pressure sides of the turbine driven blower. In such an event the arrangement of a cooling fan blading on the backside of the turbine rotor can be dispensed with. However, in order to provide substantial cooling also on that side it is appropriate to employ cooling ribs or the like.

With a view to obtain equalisation of pressure during the operation in the axial direction of the rotating turbine parts as completely as possible, on the backside of the turbine rotor sealing means are arranged at a portion within the outer diameter of the turbine rotor. In order to prevent penetration of exhaust gases to the driven side conduction means communicating with the atmosphere or the exhaust gas conduit may be arranged to lead rearwardly away from the point of sealing.

Two embodiments of the invention and several detail modifications are illustrated by way of example only in the accompanying drawings, in which

Figs. 1 to 6 represent a single stage gas turbine, as a first embodiment of the invention, the tur-

bine being in driving engagement with a blower rotor and having four different gas supply conduits,

Fig. 1 being a section on the line I—I in Fig. 2. Fig. 1a is an enlarged sectional view of a detail.

Fig. 2 is a section on the line II—II in Fig. 1.

Fig. 2a is a sectional view on the line IIa—IIa of Fig. 1, the turbine rotor being omitted for the sake of simplicity.

Fig. 3 is a section on the line III—III in Fig. 2.

Fig. 4 is a perspective view of the turbine rotor inclusive of the blading thereof.

Fig. 4a is an enlarged sectional view of a detail.

Fig. 5 is a view of a modified detail of Fig. 4.

Fig. 6 is a sectional view of a modified detail of Fig. 1.

Fig. 7 shows a side elevation partly in section on the line VII—VII in Fig. 8 of a second embodiment of the invention.

Fig. 8 is a sectional view on the line VIII—VIII in Fig. 7.

Fig. 9 is a sectional view on the line IX—IX in Fig. 8.

Fig. 10 shows a modification of a detail of Fig. 7, and

Figs. 11 and 12 each represent diagrammatically various velocities.

Fig. 1 shows the overhung turbine rotor 1 which is rotating in a bearing support 3 by means of a shaft 2. The numeral 4 designates the turbine admission casing, whereas 5 refers to the nozzle carrier ring containing the inlet blades 6 and 15, and 7 refers to a closure member which is provided with a cooling space 8 and is arranged between the gas inlet casing 4 and the compressor collector casing 9. A flow of cooling liquid may be maintained through cooling space 8 by inlet pipe 8' and exit pipe 8'', and this prevents to a large extent transfer of heat from the hot turbine gases to the cooler air being compressed. The turbine rotor forms an integral piece having a wheel body 1 the blades 17 of which are, for example, worked out of the material of this body. These blades 17, one of which is shown in elevation centrally of the wheel, have the characteristic feature that at least the outer portions, that is, the entrance ends 19 thereof, extend radially of the rotor axis and the substantially plane blade flanks extend transversely to the turbine axis. At the bases 18 of the blades 17 at the points where the latter are connected to the wheel disc 1 thickened blade portions are provided for reasons of strength.

The turbine rotor 1 is hollowed out in the axial direction toward the exit end 20 of the rotor between the blades 17, in such manner, that relatively slightly curved contours 21 are formed. The direction of inclination and the cross sections of the rotor blades are so designed that the gases leave the discharge edges 20 under a lower pressure than the discharge pressure and at relatively high velocity and then enter the rectilinearly conically widening diffuser 22. The build of the diffuser 22 is such that at the end 23 thereof the pressure of the gases increases substantially to the value of the discharge pressure.

In order to provide for the conversion of velocity taking place in the diffuser 22 to be efficient a conically tapering guide piece 24 joining with the hub of the turbine rotor may be arranged in the interior of the diffuser. This guide piece prevents the velocity of discharging from the turbine

rotor from vanishing abruptly, at loss of energy on the inside of the blading of the turbine rotor.

Instead of arranging the diffuser 22 coaxially with the turbine it may be arranged to discharge in another direction, for example as shown at 22' in Fig. 6. In such a case the gases discharging from the turbine rotor blading 17 are supplied in the diffuser 22' through an intervening pipe bend 25 which also may be provided with a guide piece, such as 26, having the effect of preventing vanishing of discharge velocity.

For providing that true alignment between the gas inlet casing 4, expanding due to heat, as well as the cooled closure casing 7, the turbine rotor 1, and the blower casing 9 is maintained both casings 4 and 7 are fixed in relative position to each other by means of four keys 27 the axes of which intersect the axis of the turbine.

For cooling the turbine rotor disc provision may be made for supplying cooling air to the backside thereof. To this end, in an arrangement as shown in Fig. 1, on the backside of the turbine rotor 1 blades 28 are arranged through which cooling air is withdrawn from a space 29. This cooling air can be atmospheric air or, for example, air withdrawn from the blower collector casing 9 through a conduit 30. The cooling fan blades 28 are covered by a covering disc 31. The air thus supplied passes through bores 32 and 32a, which are appropriately arranged in the disc 1 at least peripherally thereof and are so directed as to lead the air in the direction toward the surfaces of the blades 17, that is, the outer ends 19 adjacent the bases 18 thereof so that the temperature of said parts is also decreased.

For preventing the escape of gases from the backside of the turbine rotor sealing means 33 are provided. For the same purpose similar means 34 of smaller diameters may be provided in conjunction therewith, for example, on the covering disc 31. The space 35 between the sealing means 33 and 34 may be put in communication with the atmosphere or with the discharge conduit 23 of the gas turbine through a conduit 36. These seals 33 and 34 may be of the conventional labyrinth type as indicated in Fig. 1a.

In the center of Fig. 2, being a section on the line II—II in Fig. 1, the construction of the turbine rotor blades 17 is shown in detail. Of these blades 17, which are plane, the outer portions 19, at least, extend in the radial direction while the blades taken as a whole extend transversely to the turbine axis. The discharge edges 20 of these blades also extend radially or are only slightly inclined to the radial direction. The inlet casing 4 of the turbine is integral with the diffuser arrangement 22. Four supply conduits 10, 11, 12 and 13 (see also Figs. 1 and 3) form an arrangement of crowded convolutions so that the outer diameter of the casing 4 is reduced to a minimum. The areas of free passage of the spiral entrance portions of the conduits 10, 11, 12 and 13 decrease to such an extent that uniformity of velocity is maintained up to the entry of all the tapering nozzles 14 and but a relatively slight diversion of the gases into the direction of admission is required to take place. Between the spiral inlet conduits 10, 11, 12 and 13 four separating blades 15 (Fig. 2) are provided and in each interstice therebetween are arranged only two nozzle blades 6 which also extend in the tangential direction and which jointly ensure that the gases are admitted to the turbine rotor in the required direction and at the appropriate velocity. Due to the tangential guiding effect produced by the inlet

conduits 10, 11, 12 and 13, that is, that of the separating blades 15 and the intervening blades 6 the flow of gas undergoes diverting movements of large radii of curvature throughout. Consequently the losses of energy suffered in advance of the turbine rotor are only small. Fig. 2 further shows plainly the manner in which the supply conduits 10, 11, 12 and 13 are crowded into narrow convolutions up to their exit ends. At 22 and 24 in Fig. 1 the outer wall and the inner guide wall respectively of the diffuser are shown in cross section.

Fig. 3, being a section on the line III—III in Fig. 2 exemplifies the manner in which the four separate supply conduits 10, 11, 12 and 13 are relatively arranged.

Fig. 4, being a perspective view of the turbine rotor 1, clearly shows the radially directed entrance ends 19 and the approximately radially directed exit ends 20 of the turbine rotor blading 17. From this illustration it is plainly discernible that the approximately plane flanks of the rotor blades extend transversely to the turbine axis and that the thickness of these blades increases particularly in the radial direction and toward the blade bases 18 at the turbine wheel disc.

Fig. 4 further shows the bores 32 and 32a as arranged in the turbine rotor disc 1 on a single common diameter, at least, for the passage of cooling air, the bores being so directed that this air is projected onto the surfaces of the blades, particularly those situated adjacent to the entrance edges and the bases of the blades. Fig. 4 also illustrates that the cooling air is projected onto both flanks of the rotor blades, the front flank as well as the rear flank. This feature is also illustrated in enlarged Fig. 4a. Instead of bores 32, for example, notches 32' serving the same purpose may be provided in the peripheral edge of the turbine rotor disc 1 (Fig. 5). The cooling air may also flow over on the circumference of the turbine disc from its back side into the turbine blading.

The second embodiment of the invention as shown in Fig. 7 comprises a gas turbine with only two inlet conduits 10' and 11'. The numeral 17' refers to the turbine rotor blades having inlet edges 19' and exit edges 20'. These exit edges 20' are cut off obliquely to the turbine axis. It will be clearly seen that the innermost diameter of smallest length of the diffuser 22'' is smaller than the extreme diameter of the outer exit edges 20' of the turbine blades 17'. The reason for this construction is to maintain the absolute velocity of the gas discharging from the turbine rotor at the inlet end of the diffuser 22'' as completely as possible, for the purpose of avoiding energy losses due to vanishing of velocity. This is accomplished by keeping down the cross section of free passage at the inlet end of the diffuser 22'' at least to such a size as to correspond with the effective absolute gas discharge area of the turbine rotor blading minus the terminal thickness of blades. In this construction the exit edges 20' of the blades lie in a conical surface coaxial with the turbine axis. By this means the angle through which the flow of gas must be diverted from its inlet up to the outer exit area of the turbine rotor is reduced. The losses through deflection of the gas flow in the turbine blading are therefore decreased. Because of the relative velocity of the gases in the turbine blading being greater than its absolute exit velocity the deflection behind and outside of the turbine blading before entering the diffuser causes less losses.

This construction also provides for arranging a cooling blading 28 on the backside of the turbine rotor 1 for withdrawing cooling air from the space 29. These cooling blades are again closed laterally and towards outside by a covering disc 31. The individual blades 17' are however provided with bores 32' through which the cooling air delivered by the cooling fan is forced, in contrast to the construction shown in Fig. 1. The cooling fan withdraws air through the space 29 from without by means of a conduit 30'. The conically tapering interior piece 24' of the diffuser is in this case integral with the turbine rotor 1. Alternatively bores 32, 32' and 32'' (see also Figs. 4 and 5) for cooling air may be provided in the turbine rotor disc 1 at the same time.

In a construction as shown in Fig. 7 no gap losses arise in the discharging gas in contrast to the construction shown in Fig. 1, due to the fact that no gaps exist between the stationary and the rotatable parts.

The central portion of the hub of the rotor 1 as well as said interior piece of the diffuser 24' are hollowed and cooled by a cooling means entering at 37 and discharging at 38.

In Fig. 8 representing a section on the line VIII—VIII in Fig. 7, as seen from the left hand side of the latter, the form of the turbine rotor blades 17' inclusive of their radially directed inlet edges 19' and their substantially radially extending exit edges 20' is shown. The two supply conduits 10' and 11' forming a crowded arrangement of convolutions taper also in this case spirally toward the two blades 15 separating said conduits from each other. Within the interstices between said blades 15 only five nozzle blades 6 are arranged in the nozzle carrier ring 5 for each supply conduit, for leading the gases into the turbine rotor.

Fig. 9 being a section on the line IX—IX in Fig. 8 shows the conduits 10' and 11' in their collateral disposition in parallelism with the turbine axis.

Fig. 10 represents a modification of the construction of the inlet nozzles 14 and a corresponding form of the turbine rotor blading 17''. The inlet direction of the nozzles 14 is not radial, but inclined towards the axis of the turbine rotor 1. This results in a reduced angle of diversion of the flow of the entering gas during its passing through the turbine rotor 1. Fig. 10 shows the inclination of the inlet nozzle walls 16 to the turbine axis. The direction of the hollow parts of the turbine rotor blading 17'' must be, of course, in correspondence with this inlet direction, as will also be seen in this figure.

Fig. 11 represents the gas inlet velocity triangle at the blade entrance 19 of the turbine in which c_1 designates the absolute gas admission velocity, u_1 the velocity at the circumference of the rotor, and w_1 the relative gas admission velocity which is approximately radially directed in accordance with the present invention.

Fig. 12 represents the gas velocity diagrams at the exit end 20 of the turbine rotor. The character u_2' refers to the circumferential velocity at the extreme outer exit diameter, w_2' to the relative gas velocity thereat, and c_2' to the corresponding absolute gas velocity. The character u_2'' represents the smaller circumferential velocity at the blade bases, w_2'' the relative gas velocity at the lastnamed point, and c_2'' the corresponding absolute gas velocity.

According to the invention the directions and the cross sectional areas are so chosen that, as illustrated in Fig. 12, the relative gas velocities

w_2' and w_2'' are substantially equal to each other and also to the absolute velocities c_2' and c_2'' at the exit end of the turbine rotor. Further in the interior of the diffuser according to the invention a substantially axially directed velocity c_2'' must result and at the outer diffuser circumference a slightly tangentially directed velocity c_2' producing a vortex in the gas flow. Both measures are intended to obtain in the diffuser 22 a conversion of velocity into pressure as favorable and uniform as possible and in addition little separation of gas from the wall surfaces even in a more widely flared and relatively shorter diffuser. For this purpose on the outer end the working angle α_2' of the blades must be chosen to be smaller than at the inner end in conformity with α_2'' . For obtaining the various exit angles α_2' and α_2'' in an arrangement according to the present invention the blade surfaces can be formed firstly of initially plane surfaces in conformity with the exit angle α_2'' at the blade base 18 and then the outer exit ends are bent up or pressed into the desired other direction in accordance with the exit angle α_2' , if required in hot state.

I claim:

1. In an overhung rotor turbine, particularly adapted for gaseous motive fluids, such as hot gases, and discharging through a diffuser, a composite gas inlet casing having various individual supply conduits, at least part of said conduits extending at the entrance to said casing in the direction of the turbine axis and all said conduits being crowded into an arrangement of closely spaced convolutions terminating in a nozzle arrangement having a limited number of tangentially directed inlet nozzles, a turbine rotor body carrying a blading arranged in said casing within said nozzle arrangement, the individual blades of said rotor body being substantially radially directed along at least a radially outer blade portion and being substantially plane transversely to the turbine axis, said rotor body confining said blading by a concave portion having a relatively large radius of curvature adapting said blading to smoothly divert said motive fluid into the direction of said axis and pass it at a high velocity but under a lower pressure into said diffuser where the gas velocity is converted into a pressure approximating the pressure confronting the discharging gases.

2. In an overhung rotor turbine, particularly adapted for gaseous motive fluids, such as hot gases, and discharging through a diffuser, an inlet casing terminating in a nozzle arrangement, said arrangement having a limited number of tangentially directed inlet nozzles, a turbine rotor body carrying a blading arranged in said casing within said nozzle arrangement and having a hub portion prolonged beyond said blading so as to extend into said diffuser to at least some extent thereby forming a rotating inner limiting member of said diffuser, the individual blades of said rotor body being substantially radially directed along at least a radially outer blade portion and being substantially plane transversely to the turbine axis, said rotor body confining said blading by a concave portion having a relatively large radius of curvature adapting said blading to smoothly divert said motive fluid into the direction of said axis and pass it at a high velocity but under a lower pressure into said diffuser where the gas velocity is converted into a pressure approximating the pressure confronting the discharging gases.

3. In an overhung rotor turbine, particularly

adapted for gaseous motive fluids, such as hot gases, and discharging through a diffuser, an inlet casing having spirally tapering supply conduits terminating in a nozzle arrangement, said nozzle arrangement having a limited number of tangentially directed inlet nozzles, said casing being integral with said diffuser, a turbine rotor body carrying a blading arranged in said casing within said nozzle arrangement, the individual blades of said rotor body being substantially radially directed along at least a radially outer blade portion and being substantially plane transversely to the turbine axis, said rotor body confining said blading by a concave portion having a relatively large radius of curvature adapting said blading to smoothly divert said motive fluid into the direction of said axis and pass it at a high velocity but under a lower pressure into said diffuser where the gas velocity is converted into a pressure approximating the pressure confronting the discharging gases.

4. In an overhung rotor turbine, particularly adapted for gaseous motive fluids, such as hot gases, and discharging through a diffuser, a composite gas inlet casing having various individual supply conduits, at least part of said conduits at the entrance to said casing having a component of extent in the direction of the turbine axis and all of said conduits being crowded into an arrangement of closely spaced convolutions terminating in a nozzle arrangement having a limited number of tangentially directed inlet nozzles, and a turbine rotor body carrying a blading arranged in said casing within said nozzle arrangement, the individual blades of said rotor body being substantially radially directed along at least a radially outer blade portion and being substantially plane transversely to the turbine axis, said rotor body confining said blading by a concave portion having a relatively large radius of curvature adapting said blading to smoothly divert said motive fluid into the direction of said axis and pass it at a high velocity but under a lower pressure into said diffuser where the gas velocity is converted into a pressure approximating the pressure confronting the discharging gases.

5. In an overhung rotor turbine, particularly adapted for gaseous motive fluids, such as hot gases, and discharging through a diffuser, a composite gas inlet casing having various individual supply conduits, at least part of said conduits at the entrance to said casing having a component of extent in the direction toward the turbine axis and all of said conduits being crowded into an arrangement of closely spaced convolutions terminating in a nozzle arrangement having a limited number of tangentially directed inlet nozzles, and a turbine rotor body carrying a blading arranged in said casing within said nozzle arrangement, the individual blades of said rotor body being substantially radially directed along at least a radially outer blade portion and being substantially plane transversely to the turbine axis, said rotor body confining said blading by a concave portion having a relatively large radius of curvature adapting said blading to smoothly divert said motive fluid into the direction of said axis and pass it at a high velocity but under a lower pressure into said diffuser where the gas velocity is converted into a pressure approximating the pressure confronting the discharging gases.