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⑤④ **Turbine.**

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**The file contains technical information
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Description

The invention relates to a dual pressure turbine, which is arranged to be driven by a working fluid such as steam, and of the kind (hereinafter referred to as of the kind described) comprising a high pressure section having at least one radial impulse turbine stage with a rotor; a low pressure section having at least one axial flow turbine stage with a rotor; means for connecting the rotors coaxially as a single rotary unit; means for introducing working fluid at one pressure into the high pressure section to drive the radial impulse stage; and means for introducing working fluid at a lower pressure into the low pressure section to drive the axial flow stage; the radial impulse stage rotor having buckets spaced around and opening at the periphery thereof, and a nozzle ring comprising an annular array of nozzles for introducing the higher pressure working fluid into the buckets to turn the rotor. A turbine of this kind is disclosed in GB—A—543098.

The surfaces of the vanes, which define the outlets of the nozzles adjacent to the buckets are conventionally flat, as exemplified in GB—A—543098, US—A—1896809 and US—A—4150918, and the edges of the vanes adjacent to the buckets usually include a wedge angle of 11° or more.

The inventor has now recognised that an unexpectedly large increase in turbine efficiency can be achieved if, in a turbine of the kind described, the nozzle ring has vanes separating and defining the contours of adjacent nozzles; the vanes having surfaces which face the axis of the rotor and which are continuously curved from their edges at the nozzle outlets to their portions lying radially outwardly of the edges of the adjacent vanes; and the edge of each vane presenting an included wedge angle of not more than 3°.

The use of continuously curved vane surfaces and of wedge angles of not more than 3° leads to a surprising increase in efficiency. The small wedge angle reduces wakes and comparable flow disturbances, and, in addition, reduces stresses imposed on the rotor by working fluid distributed to it from the turbine nozzles.

Preferably, the curvature of the vane surfaces is similar to that of the outer periphery of the rotor.

The turbine may have means for combining working fluid exhausted from the high pressure section with further working fluid to provide the lower pressure working fluid to be introduced into the low pressure section. In this case, for example, steam discharged from the high pressure section may combine with steam supplied to the turbine at low pressure, the mixture being delivered to the low pressure turbine stage. Maximum utilization of available energy is promoted by this arrangement.

Alternatively, the turbine may have a single inlet, this inlet communicating with the or the first of the radial impulse stages; whereby the working fluid discharged from the or the last of the radial impulse stages is transferred to the or the first

axial flow stage to provide the whole of the working fluid which is supplied to the low pressure section. A turbine of this construction is of the "once-through" type. Thus all of the working fluid is supplied to the turbine at one pressure, and the working fluid is discharged directly from the radial impulse staging into the first of the axial flow stages. At some sacrifice in efficiency, this design reduces complexity, lowers maintenance costs, and increases reliability; and it has a faster response time. Consequently this one-through arrangement may prove superior in applications, such as naval shipboard use, where the advantages identified above take precedence over efficiency.

The connection of the rotors of each of the radial impulse and axial flow stages coaxially as a single rotary unit eliminates the need for gearing between the high and low pressure sections along with the associated expense and power loss. In this case there will usually be a common casing containing both the high and low pressure sections.

Certain valuable features may be incorporated in the, or at least one radial impulse stage, particularly to accommodate higher than conventional working fluid velocities.

According to one of these features, each of the buckets has an entrance at one side of the rotor and an exit at the other side of the rotor, and the bucket is so shaped that the flow vectors of the fluid entering and exiting from the bucket, in use, are substantially parallel to one another and to planes perpendicular to the axis of the rotor. This leads to significantly greater efficiency than in conventional flow designs.

According to a second of the features, efficiency is promoted if the cross sections of the buckets and of the nozzle outlets, perpendicular to the flow of working fluid, have substantially right angular corners. This arrangement effectively reduces unwanted power-wasting shock and turbulence.

According to a third of the features, the rotor is completely shrouded between entrances and exits of the buckets by a surrounding shroud to maximize the work available from the working fluid; and the nozzle ring abuts an upstream face of the shroud whereby the shroud provides the downstream walls of the nozzles. The shrouding keeps the character of the flow, the circulation of which is otherwise of generally unspecified character, constant adjacent to the buckets. This eliminates the windage loss that occurs in conventional, unshrouded or partially shrouded radial impulse turbines.

The high pressure section may include first and second radial impulse stages each with one of the rotors and one of the nozzle rings; each of the nozzles having an inlet opening at the outer periphery of the ring and an outlet opening at the inner periphery of the ring; and flow directing means for turning working fluid discharged radially outwardly from the buckets of the first stage rotor axially towards the second stage rotor

and then radially inwardly into the inlets of the nozzles of the second stage nozzle ring.

In a further useful arrangement the high pressure section also includes a discharge plenum on the downstream side of the rotor of the, or the most downstream, radial impulse stage, the bucket of which rotor being so shaped as to dump the working fluid into the discharge plenum after that fluid has passed once through the buckets of that rotor.

Two examples of turbines constructed, in accordance with the invention are illustrated in the accompanying drawings, in which:—

Figure 1 is a partial side view of a first turbine;

Figure 2 is a partial axial section through the high pressure section of the first turbine;

Figure 3 is a similar section through the low pressure section of the first turbine;

Figure 4 is a fragmentary section in a radial plane through part of a rotor and nozzle ring of a radial impulse stage in the high pressure section of the first turbine; and,

Figure 5 is a partial side view with some parts in axial section of a second turbine.

The turbine 6 of Figures 1 to 4, includes an elongate, external casing 7 which has a generally circular cross-section and is made up of a number of bolted-together casing components.

The interior of the casing 7 is divided into a high pressure section 8 and a low pressure section 9 (see Figures 2 and 3).

The high pressure section 8 has two impulse turbine stages 10 and 11; the low pressure section 9 has six conventional, axial flow turbine stages 12, 13, 14, 15, 16 and 17.

Each of the high and low pressure turbine stages includes a rotor which is identified by the same reference character as the stage but followed by the letter R.

The eight rotors 10R...17R are coupled together with splines (assembled fittings are shown diagrammatically in Figure 3 and identified by reference character 18). The components of the resulting assembly are held together by a single tension bolt 19, and the assembly is rotatably supported in the casing 8 by appropriate bearings (not shown). The upstream (or front) end of the assembly is splined to accept a drive coupling (the splines are not shown), and provide a power take-off upstream of the high pressure section.

Referring now specifically to Figure 2, the first and second stage rotors 10R and 11R in the high pressure section 8 of the turbine 6 are cast from 17-4PH stainless steel or a comparable material for steam service.

The first stage rotor 10R is surrounded by an annular nozzle ring 20 of which nozzles 21 are of the convergent configuration illustrated in Figure 4. The nozzles are defined between vanes 21A formed by metal left in the process of milling the ring 22 to form the nozzles. The vanes have sharp edges 21C, presenting a wedge angle of up to 3°, and curved surfaces 21B which face radially inwardly towards the axis of the rotor and extend from the edges 21C to positions overlying the

edges 21C of the next vane. The curvature of the surfaces 21B is similar to, i.e. within $\pm 10\%$ of, that of the outer periphery of the rotor. Each nozzle has an inlet 22 opening onto the outer periphery of the nozzle ring and an outlet 23 opening onto its inner periphery, and they are of square cross section perpendicular to the fluid flow at their discharge ends. The outlets of the nozzles 21 are radially aligned with entrances 24 to buckets 25 in a peripheral flange 26 of the first stage rotor 10R as shown in Figure 2.

These buckets are equiangularly spaced and they are typically formed by milling with the cutter inclined at an angle of 18° to the radial.

The buckets 25 have a section perpendicular to the fluid flow with substantially right angular corners 27 (see Figure 4), an entrance 24 adjacent to the upstream side of the rotor, an exit 28 adjacent to the downstream side of the rotor and a part circular impulse surface 29 between the entrance and the exit.

Maximum efficiency can be obtained by so milling the buckets as to produce transition curves on their entrance and exit sides. This minimizes losses attributable to the working fluid impinging on the rotor as it changes direction in flowing through the buckets.

High efficiency can be obtained by making the profile of the trailing edge surface 30 of each bucket as a smooth curve terminating in a sharp edge as shown in Figure 4. Appropriate curves can be readily generated by casting. Alternatively, these curves could be milled off to provide flats which produce a sharp wedge, with an included angle of about 3°, with the adjacent surface of the next bucket. This removes excess metal from the rotor and also produces a good match to the relative spouting velocity of the working fluid discharged from the nozzle ring. That, together with the sharp leading edges produced by milling the flats, minimizes flow irregularities and contributes to efficiency.

A groove is milled in the rotor before the buckets 25 are milled. This groove extends continuously around, and opens into, the periphery of the rotor and generates slots in the eventual leading edges of the buckets. The groove is primarily provided to accommodate the shank of a cutter used to form the buckets, but also eliminates excess metal from the rotor and lowers rotor and bucket stresses.

The outlets 23 of the nozzles 21 form an almost continuous circle around the rotor 10R. This, together with the sharp edge between adjacent buckets provides essentially full arc admission of working fluid to the buckets and ensures that the buckets are smoothly filled. That contributes significantly to the efficiency of the turbine.

The nozzle ring 20 is coupled by an antirotation pin 31 to a radial flange 32 at the downstream end of an annular, high pressure inlet manifold 33. The manifold is bolted between casing components 34 and 35 on the upstream side of high pressure section first stage rotor 10R.

The nozzle ring 20 is clamped against the flange

32, and the downstream walls of the nozzles 21 are formed, by a plate-like inner shroud 36 of the casing component 35. The latter is bolted between the manifold 33 and an outer casing component 37.

Working fluid is supplied to the first stage 10 of the turbine 6 through an inlet 38 which communicates with the interior of the high pressure inlet manifold 33. The working fluid flows axially from the manifold through an annular inlet 39 between the outer periphery of the nozzle ring 20 and the inner wall of the manifold 33. It then flows radially inwards into the nozzles 21 in the nozzle ring 20 as shown by arrow 40 in Figure 2.

The working fluid is discharged from the nozzles into the buckets 25 of the rotor 10R, flowing through the latter to drive the rotor. It then flows radially outwards as indicated by arrow 41. The entrance and exit flow vectors of the working fluid are parallel.

Efficiency is also promoted by completely shrouding the buckets 25 between their entrances 24 and exits 28 by the shroud 36, which completely surrounds the rotor 10R. This complete shrouding minimizes power-robbing turbulence. It also promotes efficiency by maintaining a free surface on the exit side of each bucket. Furthermore, because the exiting working fluid does not impinge on the shroud 36, its exit momentum is preserved. This is an attribute of particular importance in multi-stage turbines.

The outwardly flowing working fluid discharged from the buckets of the rotor 10R is turned first axially and then radially inwards (see arrow 42) by the cooperation between the casing component 37 and an annular, disc-like flow director 43. The latter is fixed to the upstream side of a radially and inwardly extending annular flange 44 on the casing component 37 by screw threaded fasteners 45.

Leakage between flow director 43 and the assembly of turbine rotors 10R...17R is inhibited by cooperating seals 46 and 47. These seals are supported by the flow director at its inner periphery and by high pressure section first and second stage rotors 10R and 11R.

The working fluid discharged from the first stage 10 flows into nozzles 48 formed in a nozzle ring 49 surrounding the second stage rotor 11R. Again, the nozzle outlets are aligned with entrances 50 to buckets 51 which are similar to the buckets 25.

The nozzle ring 49 is seated in a recess 52 in the flow director 43 and is clamped against the upstream side of the flange 44 by the flow director and the fasteners 45. The upstream face of the flange forms the rear or downstream walls of the nozzles.

The nozzles 48, not shown in detail herein, will preferably be of a convergent configuration like that shown in Figure 4.

The second stage rotor 11R is, like that discussed previously, completely shrouded. In this case, the shrouding is effected by the circular, radially oriented flange 44 on the casing component 37.

After passing through the buckets 51 of the

second stage turbine rotor 10R, the working fluid is discharged radially outwards from the buckets through exits 53 into an annular plenum 54 located between the high and low pressure turbine sections 8 and 9. Here, the working fluid discharged from the high pressure section of the turbine is combined with working fluid introduced to the turbine through an inlet 55 and an annular low pressure inlet manifold 56 surrounding the plenum 54.

Communication between the manifold and the plenum 54 is effected by an inwardly directed, circular opening 57. The nozzle is defined by axially extending, circular bosses 58 and 59, which are integral parts of the casing component 37, and by the manifold 56 and the inlet 55.

The working fluid mixture flows axially as indicated by arrow 60 in Figures 2 and 3 into the low pressure section 9 of the turbine 6. That section of the turbine 6 (which is of conventional axial flow design) is best shown in Figure 3.

Each turbine stage in the low pressure section includes one of the previously mentioned rotors, composed of a disc 61 to which an annular array of blades 62 is attached. Upstream from each rotor is a conventional annular array of stationary nozzles 63. The nozzles of each stage are attached to an annular nozzle support 64 which is fixed to the casing component 37.

Leakage past the nozzles in each stage is inhibited by a circular diaphragm 65, a seal 66 at the inner circumference of the diaphragm, and a cooperating seal 67 supported by the discs of adjacent rotors.

An axially extending, circular flange 68 is fixed to the diaphragm 65 of the first axial flow stage 12 to guide the working fluid mixture from the annular exhaust plenum 54 into the nozzles 63 of the first axial turbine stage.

As is also shown in Figure 3, each of the low pressure, axial flow stages preferably includes an annular, abradable rub ring 69 which is part of the nozzle support of that stage and surrounds its rotor. These rub rings allow minimum tip clearance for the working fluid to be employed, lowering leakage of the working fluid past the blade tips.

Flow of the working fluid through the low pressure section is conventional with the working fluid being discharged from the blades 62 of the sixth stage rotor 17R into an annular exhaust manifold (not shown). The working fluid is discharged from this manifold and the turbine casing through an exhaust duct 70 (see Figure 1).

One turbine of the character just described, designed to produce 13.4×10^5 W (1800 shaft horsepower) [4.5×10^5 W (600 shaft horsepower) of that in the high pressure impulse section], is shown in Figures 2 and 3.

Typically, this turbine will be supplied with high pressure steam at 13.7×10^5 Pa (200 psia) and 382°C (720°F) at a rate of 1.47 kg/s (3.23 lbs/second) and with low pressure steam at 2.76×10^5 Pa (40 psia) and 421°C (790°F) at 0.35 kg/s (0.76 lbs/second).

The design pressure of the steam exhausted from the last stage of the low pressure, axial flow section of the turbine is 4.48×10^3 Pa (0.65 psia).

The rotors of the two impulse stages 10 and 11 in the high pressure section 8 of the turbine 6 are, respectively, 0.30 and 0.35 m (11.75 and 13.875 inches) in diameter; and the mid-chord lengths of the blades 62 in the low pressure axial flow section of the turbine range from 0.015 m (0.6 inch) in the first stage 12 to 0.13 m (5.16 inches) in the sixth stage 17. The discs on which the blades are mounted are all 0.34 m (13.5 inches) in diameter.

The invention may also be applied to a once-through turbine having a combination of radial impulse and axial flow stages. A turbine of this type, which also includes a more efficient arrangement for transferring working fluid from one radial impulse stage to the next and which demonstrates that more than two radial impulse stages can be employed, is shown at 71 in Figure 5.

In many respects, the turbine 71 is similar to the previously described example. Consequently, and for the sake of clarity and conciseness, the turbine 71 will be described primarily in reference to those features which distinguish it from the previously described turbine.

The turbine 71 includes an elongate, external casing 72 housing three radial impulse stages 73, 74, and 75 and seven axial flow stages 76... (only one of which is shown).

Each of the axial flow stages (which can be of the character described above in conjunction with the turbine 6) and each of the impulse turbine stages includes a rotor which is identified by the same reference character as the stage but followed by the letter R.

The ten rotors 73R...76R are coupled together by Curvic fittings 77 and held in assembled relationship by a tension bolt 78. Appropriate bearings (not shown) rotatably support the resulting assembly in the casing 72.

The rotors 73R, 74R, and 75R of the radial impulse stages may be like those employed in the turbine 6; and they are surrounded by shrouds 79, 80, and 81 to obtain those above discussed benefits which complete shrouding is capable of providing.

The first stage rotor 73R is surrounded by an annular nozzle ring 82 with nozzles of the type illustrated in Figure 4.

The nozzle ring 82 is clamped between the shroud 79 and a working fluid inlet manifold 83.

Working fluid is supplied to the first stage 73 of the turbine 71 through a working fluid inlet 84 which communicates with the interior of inlet manifold 83. The working fluid flows from the manifold through an annular inlet 85 into the nozzles in the nozzle ring.

The working fluid is discharged from the nozzles into the buckets of the rotor 73R, flowing through the latter to drive the rotor.

The outwardly flowing working fluid discharged from the buckets of the rotor 73R is

turned first axially and then radially inward by the cooperation between the turbine casing 72 and a flow director 86. The latter is similar to the flow directors employed in the turbine 6 shown in Figure 2. This keeps the stream of working fluid exiting from the buckets from spreading as it is directed from the first stage rotor 73R to a nozzle ring 87 in the second radial impulse stage 74. That is important in that it minimizes energy losses as the transfer of fluid is affected.

The operation of the second and third radial impulse stages 74 and 75 and the transfer of the working fluid between the latter are both essentially as just described and as discussed in conjunction with the previous embodiment.

From the rotor of the third radial impulse stage 75 the working fluid flows against the surface of the shroud 81, turning into the first of the axial flow stages 76.

Flow of the working fluid through the axial flow stage is conventional with the working fluid being discharged from the last stage rotor into an annular exhaust manifold (not shown). The working fluid is discharged from this manifold and the turbine casing through an exhaust duct similar to that shown in Figure 1.

It will be apparent to those skilled in the relevant arts that three is not a limit on the number of radial impulse stages that can be employed in the radial impulse turbine sections and that efficiency can be increased by increasing the number of stages. However three stages is considered a practical limit for the most part, simply because subsequent stages tend to become too massive.

Claims

1. A dual pressure turbine (6) comprising a high pressure section (8) having at least one radial impulse turbine stage (10) with a rotor (10R); a low pressure section (9) having at least one axial flow turbine stage (12) with a rotor (12R); means (18, 19) for connecting the rotors coaxially as a single rotary unit; means (38) for introducing working fluid at one pressure into the high pressure section to drive the radial impulse stage; and means (54, 56) for introducing working fluid at a lower pressure into the low pressure section to drive the axial flow stage; the radial impulse stage rotor (10R) having buckets (25) spaced around and opening at the periphery thereof, and a nozzle ring (20) comprising an annular array of nozzles (21) for introducing the higher pressure working fluid into the buckets to turn the rotor; characterized in that the nozzle ring (20) has vanes (21A) separating and defining the contours of adjacent nozzles; the vanes having surfaces (21B) which face the axis of the rotor and which are continuously curved from their edges (21C) at the nozzle outlets (23) to their portions lying radially outwardly of the edges of the adjacent vanes; and the edge (21C) of each vane presenting an included wedge angle of not more than 3° .

2. A turbine according to claim 1, in which the

curvature of the vane surfaces (21B) is similar to that of the outer periphery of the rotor.

3. A turbine according to claim 1 or claim 2, which has means (54) for combining working fluid exhausted from the high pressure section with further working fluid to provide the lower pressure working fluid to be introduced into the low pressure section.

4. A turbine according to claim 3, in which the combining means comprises an annular plenum (54) between the high and low pressure sections (8, 9); an annular inlet manifold (56) surrounding the plenum; an annular flow passage (57) interconnecting the inlet manifold and plenum; and means (55) through which working fluid can be introduced into the inlet manifold.

5. A turbine according to claim 1 or claim 2, which has a single inlet (84), this inlet communicating with the or the first of the radial impulse stages (73); whereby the working fluid discharged from the or the last of the radial impulse stages (75) is transferred to the or the first axial flow stage (76) to provide the whole of the working fluid which is supplied to the low pressure section.

6. A turbine according to any one of the preceding claims, in which the rotary unit provides power take-off means upstream of the high pressure section.

7. A turbine according to any one of the preceding claims, in which each of the buckets has an entrance (24) at one side of the rotor and an exit (28) at the other side of the rotor, and the bucket is so shaped that the flow vectors of the fluid entering and exiting from the bucket, in use, are substantially parallel to one another and to planes perpendicular to the axis of the rotor.

8. A turbine according to any one of the preceding claims, in which the cross sections of the buckets (25) and of the nozzle outlets (23), perpendicular to the flow of working fluid, have substantially right angular corners.

9. A turbine according to any one of the preceding claims, in which the rotor is completely shrouded between entrances (24) and exits (28) of the buckets by a surrounding shroud (36) to maximize the work available from the working fluid; and the nozzle ring (20) abuts an upstream face of the shroud whereby the shroud provides the downstream walls of the nozzles.

10. A turbine according to any one of the preceding claims, in which the high pressure section (8) includes first and second radial impulse stages (10, 11) each with one of the rotors (10R, 11R) and one of the nozzle rings (20); each of the nozzles having an inlet (22) opening at the outer periphery of the ring (20) and an outlet (23) opening at the inner periphery of the ring; and flow directing means (37, 43) for turning working fluid discharged radially outwardly from the buckets of the first stage rotor (10R) axially towards the second stage rotor (11R) and then radially inwardly into the inlets of the nozzles (48) of the second stage nozzle ring (49).

11. A turbine according to claim 10, in which the

flow directing means comprises a radially oriented annular member (43) disposed between the first and second stage rotors (10R, 11R) in abutting relationship with the upstream side of the second stage nozzle ring (49), the outer periphery of the member (43) being spaced inwardly from a casing (37) to provide a flow passage therebetween; and seal means (46, 47) being provided at the inner periphery of the member for keeping working fluid discharged from the first stage rotor (10R) from leaking around the member to the second radial impulse stage (11).

12. A turbine according to any one of the preceding claims, in which the high pressure section also includes a discharge plenum (54) on the downstream side of the rotor (11R, 75R) of the, or the most downstream, radial impulse stage (11, 75), the buckets of which rotor being so shaped as to dump the working fluid into the discharge plenum after that fluid has passed once through the buckets of that rotor.

Patentansprüche

1. Eine Dual-Druckturbine (6) die folgendes aufweist:

einen Hochdruckabschnitt (8) mit mindestens einer Radialimpulsturbinstufe (10) mit einem Rotor (10R);

einen Niederdruckabschnitt (9) mit mindestens einer Axialflußturbinstufe (12) mit einem Rotor (12R);

Mittel (18, 19) zur Verbindung der Rotoren koaxial als eine einzige Dreheinheit;

Mittel (38) zur Einführung von Arbeitsmittel mit einem Druck in den Hochdruckabschnitt zum Antrieb der Radialimpulsstufe; und

Mittel (54, 56) zur Einführung von Arbeitsmittel mit einem niedrigeren Druck in den Niederdruckabschnitt zum Antrieb der Axialströmungsstufe;

wobei der Radialimpulsstufenrotor (10R) Mulden (25) aufweist, die mit Abstand um den Umfang herum angeordnet sind und sich dort öffnen, und wobei ferner ein Düsenring (20) eine Ringanordnung von Düsen (21) aufweist, um das einen höheren Druck besitzende Arbeitsmittel in die Mulde zur Drehung des Rotors einzuführen,

dadurch gekennzeichnet, daß der Düsenring (20) Schaufeln (21A) aufweist, die die Konturen benachbarter Düsen trennen und definieren, daß die Schaufeln Oberflächen (21B) besitzen, die zur Achse des Rotors hinweisen und die kontinuierlich gekrümmt sind von ihren Kanten (21C) an den Düsenauslässen (23) zu ihren Teilen hin, die radial nach außen gegenüber der Kanten der benachbarten Schaufeln liegen, und daß die Kante (21C) jeder Schaufel einen eingeschlossenen Keilwinkel von nicht mehr als 3° besitzt.

2. Turbine nach Anspruch 1, wobei die Krümmung der Schaufeloberflächen (21B) ähnlich der des Außenumfanges des Rotors ist.

3. Turbine nach Anspruch 1 oder 2, wobei Mittel (54) vorgesehen sind zur Kombination des vom Hochdruckabschnitt ausgestoßenen Arbeitsmit-

tels mit weiterem Arbeitsmittel zum Vorsehen des einen niedrigeren Druck aufweisenden Arbeitsströmungsmittels zur Einführung in den Niederdruckabschnitt.

4. Turbine nach Anspruch 3, wobei die Kombinationsmittel einen Ringraum (54) zwischen den Hoch- und Niederdruckabschnitten (8, 9) aufweisen, wobei ferner eine ringförmige Einlaßsammelleitung (56) den Ringraum umgibt, und wobei ein ringförmiger Strömungsdurchlaß (57) die Einlaßsammelleitung und den Raum (54) verbindet, und wobei schließlich Mittel (55) vorgesehen sind, durch die Arbeitsmittel in die Einlaßsammelleitung eingeführt werden kann.

5. Turbine nach Anspruch 1 oder 2, wobei ein einziger Einlaß (84) vorgesehen ist, wobei dieser Einlaß mit der oder der ersten der Radialimpulsstufen (73) in Verbindung steht, wodurch das von der oder der letzten der Radialimpulsstufen (75) abgegebene Arbeitsmittel zu der oder der ersten Axialströmungsstufe (76) übertragen wird, um das ganze Arbeitsmittel vorzusehen, welches dem Niederdruckabschnitt zugeführt wird.

6. Turbine nach einem der vorhergehenden Ansprüche, wobei die Dreheinheit Leistungsabnahmemittel stromaufwärts gegenüber dem Hochdruckabschnitt vorsieht.

7. Turbine nach einem der vorhergehenden Ansprüche, wobei jeder der Mulde einen Einlaß (24) an einer Seite des Rotors und einen Auslaß (28) an der anderen Seite des Rotors aufweist, und wobei die Mulde derart geformt ist, daß die Strömungsvektoren des eintretenden und des aus der Mulde austretenden Strömungsmittels im Gebrauch im wesentlichen parallel zueinander und zu Ebenen senkrecht zur Rotorachse verlaufen.

8. Turbine nach einem der vorhergehenden Ansprüche, wobei die Querschnitte der Mulde (25) und der Düsenauslässe (23) senkrecht zur Strömung des Arbeitsmittels im wesentlichen rechtwinklige Ecken besitzen.

9. Turbine nach einem der vorhergehenden Ansprüche, wobei der Rotor vollständig abgedeckt ist zwischen den Einlässen (24) und den Auslässen (28) der Mulden durch ein umgebendes Abdeckelement (36), um die aus dem Arbeitsmittel verfügbare Arbeit zu maximieren, und wobei der Düsenring (20) an der stromaufwärts gelegenen Stirnfläche des Abdeckelements anstößt, wodurch das Abdeckelement die stromabwärts gelegenen Wände der Düsen vorsieht.

10. Turbine nach einem der vorhergehenden Ansprüche, wobei der Hochdruckabschnitt (8) erste und zweite Radialimpulsstufen (10, 11) aufweist, jede mit einem der Rotoren (10R, 11R) und einem der Düsenringe (20), und wobei ferner jede der Düsen eine Einlaß (22)-Öffnung am Außenumfang des Rings (20) und eine Auslaß (23)-Öffnung am inneren Umfang des Rings besitzt, wobei schließlich Strömungsleitmittel (37, 43) vorgesehen sind, um das Arbeitsmittel abgegeben radial nach außen von den Mulden des Rotors (10R) der ersten Stufe axial zum Rotor (11R) der zweiten Stufe zu leiten und sodann

radial nach innen zu den Einlässen der Düsen (48) des Düsenrings (49) der zweiten Stufe.

11. Turbine nach Anspruch 10, wobei die Strömungsleitmittel ein radial orientiertes Ringglied (43) aufweisen, und zwar angeordnet zwischen den Rotoren (10R, 11R) der ersten und zweiten Stufen in Anschlagbeziehung mit der stromaufwärts gelegenen Seite des Düsenrings (49) der zweiten Stufe, und wobei der Außenumfang des Glieds (43) mit Abstand nach innen gegenüber einem Gehäuse (37) vorgesehen ist, um einen Strömungsdurchlaß dazwischen vorzusehen, und wobei ferner Dichtungsmittel (46, 47) am Innenumfang des Glieds vorgesehen sind, um das Arbeitsströmungsmittel, abgegeben von dem Rotor (10R) der ersten Stufe, am Lecken um das Glied herum zur zweiten Radialimpulsstufe (11) zu hindern.

12. Turbine nach einem der vorhergehenden Ansprüche, wobei der Hochdruckabschnitt ebenfalls einen Abgaberaum (54) auf der stromabwärts gelegenen Seite des Rotors (11R, 75R) aufweist, wobei die Mulden dieses Rotors derart geformt sind, daß sie das Arbeitsströmungsmittel in den Abgaberaum abgeben, nachdem das Strömungsmittel einmal durch die Mulde dieses Rotors gelaufen ist.

Revendications

1. Turbine (6) à deux niveaux de pression, qui comprend une section haute pression (8) possédant au moins un étage de turbine à impulsions radiales (10) muni d'un rotor (10R); une section basse pression (9) possédant au moins un étage de turbine à écoulement axial (12) muni d'un rotor (12R); des moyens (18, 19) pour accoupler coaxialement les rotors entre eux sous la forme d'un ensemble rotatif unique; des moyens (38) pour introduire un fluide de travail, sous une pression donnée, à l'intérieur de la section haute pression en vue de l'entraînement de l'étage à impulsions radiales; et des moyens (54, 56) pour introduire un fluide de travail, sous une pression réduite, à l'intérieur de la section basse pression en vue de l'entraînement de l'étage à écoulement axial; le rotor (10R) de l'étage à impulsions radiales comportant des augets (25) formés à distance les uns des autres sur la périphérie du rotor et s'ouvrant sur cette dernière, et un anneau d'ajutages (20) comprenant un réseau annulaire d'ajutages (21) permettant d'introduire le fluide de travail sous haute pression dans les augets pour faire tourner le rotor; caractérisée en ce que l'anneau d'ajutages (20) est pourvu d'aubes (21A) séparant les ajutages adjacents et définissant les contours de ces derniers; les aubes présentant des surfaces (21B) qui sont tournées vers l'axe du rotor et qui s'incurvent en continu depuis leur arête (21C) située au niveau des sorties (23) des ajutages jusque dans leur partie s'étendant radialement vers l'extérieur par rapport aux arêtes des aubes adjacentes; et l'arête (21C) de chaque aube présente un angle au sommet non supérieur à 3°.

2. Turbine selon la revendication 1, dans la-

quelle la courbure des surfaces (21B) des aubes est similaire à celle du pourtour extérieur du rotor.

3. Turbine selon la revendication 1 ou la revendication 2, qui comporte des moyens (54) pour combiner le fluide de travail sortant de la section haute pression avec un fluide de travail additionnel, afin de produire le fluide de travail de pression réduite destiné à être introduit dans la section basse pression.

4. Turbine selon la revendication 3, dans laquelle les moyens de combinaison comprennent une chambre annulaire (54) située entre les sections haute et basse pression (8; 9); un collecteur d'admission annulaire (56) entourant la chambre; un passage d'écoulement annulaire (57) reliant entre eux le collecteur d'admission et la chambre et des moyens (55) par lesquels le fluide de travail peut être introduit dans le collecteur d'admission.

5. Turbine selon la revendication 1 ou la revendication 2, qui comporte une ouverture d'admission unique (84), cette ouverture d'admission communiquant avec l'étage ou le premier étage à impulsions radiales (73), et le fluide de travail, qui s'échappe de l'étage ou du dernier étage à impulsions radiales (75), étant transféré dans l'étage ou le premier étage à écoulement axial (76) pour constituer la totalité du fluide de travail qui est fourni à la section basse pression.

6. Turbine selon l'une quelconque des revendications précédentes, dans laquelle l'ensemble rotatif constitue un moyen de prélèvement de puissance en amont de la section haute pression.

7. Turbine selon l'une quelconque des revendications précédentes, dans laquelle chacun des augets possède une entrée (24) sur un côté du rotor et une sortie (28) sur l'autre côté du rotor, et l'auget présente une forme telle que les vecteurs d'écoulement du fluide entrant dans l'auget et sortant de celui-ci sont, en service, sensiblement parallèles entre eux et parallèles à des plans perpendiculaires à l'axe du rotor.

8. Turbine selon l'une quelconque des revendications précédentes, dans laquelle les sections transversales des augets (25) et des sorties (23) des ajutages, dans un plan perpendiculaire à l'écoulement du fluide de travail, ont leurs coins formés sensiblement à angles droits.

9. Turbine selon l'une quelconque des revendications précédentes, dans laquelle le rotor est, entre les entrées (24) et les sorties (28) des augets, complètement ceint d'une enveloppe de blindage

(36) pour optimiser l'énergie disponible dans le fluide de travail; et l'anneau d'ajutages (20) est en butée contre une face amont de l'enveloppe, l'enveloppe constituant ainsi les parois aval des ajutages.

10. Turbine selon l'une quelconque des revendications précédentes, dans laquelle la section haute pression (8) comporte un premier et un second étages à impulsions radiales (10, 11) chacun muni de l'un des rotors (10R, 11R) et de l'un des anneaux d'ajutages (20); chacun des ajutages présentant un orifice d'entrée (22) s'ouvrant sur la surface périphérique extérieure de l'anneau (20) et un orifice de sortie (23) débouchant sur la surface périphérique intérieure de l'anneau; et des moyens d'orientation de l'écoulement (37, 43) grâce auxquels le fluide de travail s'échappant radialement vers l'extérieur des augets du rotor (10R) du premier étage, est dévié tout d'abord selon une direction axiale vers le rotor (11R) du second étage, puis selon une direction radiale et vers l'intérieur, pour pénétrer dans les orifices d'entrée des ajutages (48) de l'anneau d'ajutages (49) du second étage.

11. Turbine selon la revendication 10, dans laquelle les moyens d'orientation de l'écoulement comprennent un organe annulaire (43) orienté dans une direction radiale et disposé entre les rotors (10R, 11R) des premier et second étages, tout en étant en butée contre la face amont de l'anneau d'ajutages (49) du second étage, la surface périphérique extérieure de l'organe (43) étant placée intérieurement à distance d'un carter (37) pour délimiter avec celui-ci un passage d'écoulement; tandis que des moyens d'étanchéité (46, 47) sont prévus sur la surface périphérique intérieure de l'organe pour prévenir toute fuite, autour de l'organe et en direction du second étage à impulsions radiales (11), du fluide de travail s'échappant du rotor (10R) du premier étage.

12. Turbine selon l'une quelconque des revendications précédentes, dans laquelle la section haute pression comporte également une chambre d'évacuation (54) sur le côté aval du rotor (11R, 75R) de l'étage à impulsions radiales ou de celui de ces étages qui est situé le plus en aval (11, 74), les augets du rotor de cet étage profilés de façon à pouvoir déverser le fluide de travail dans la chambre d'évacuation après que ce fluide a passé une fois à travers les augets dudit rotor.

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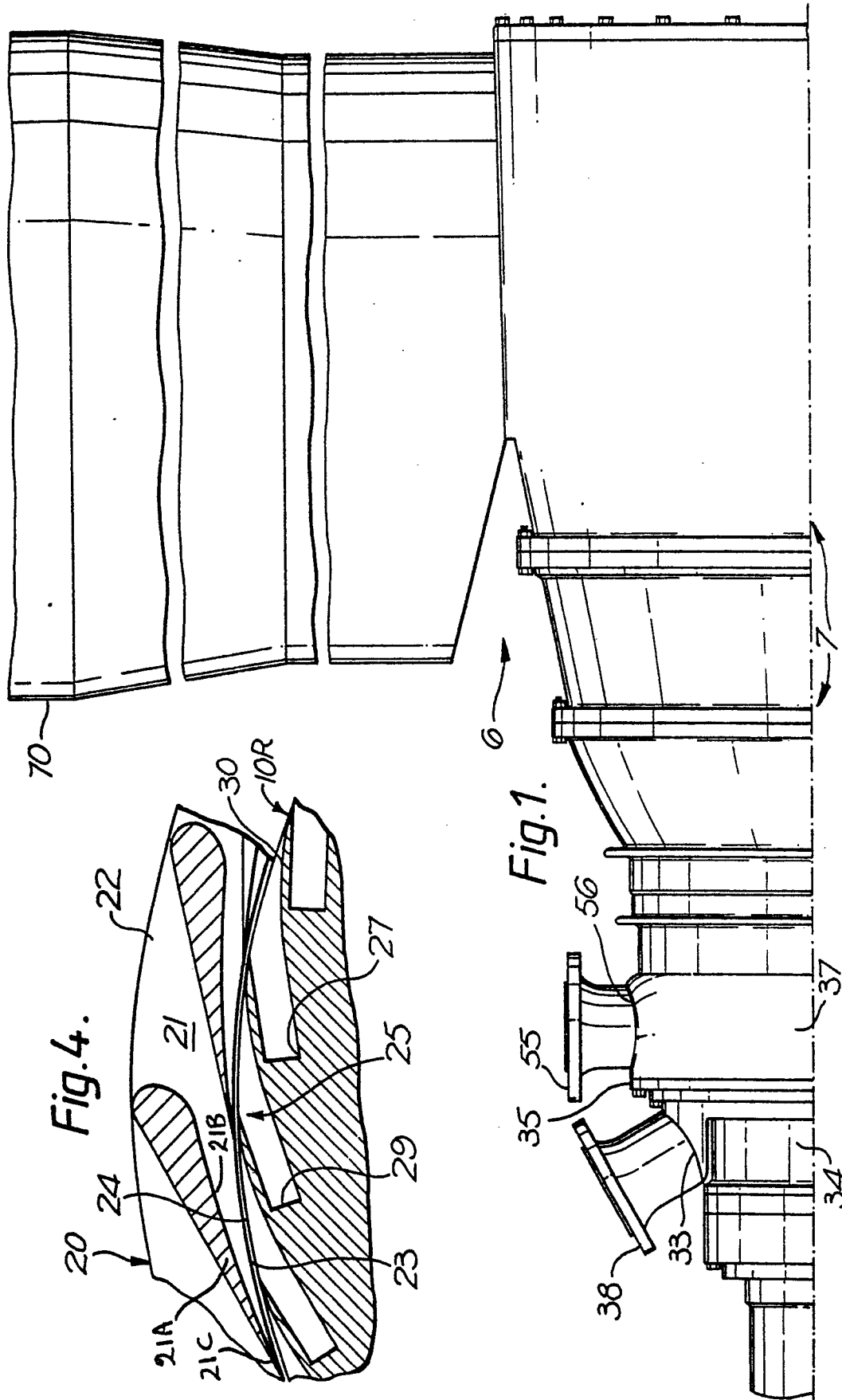
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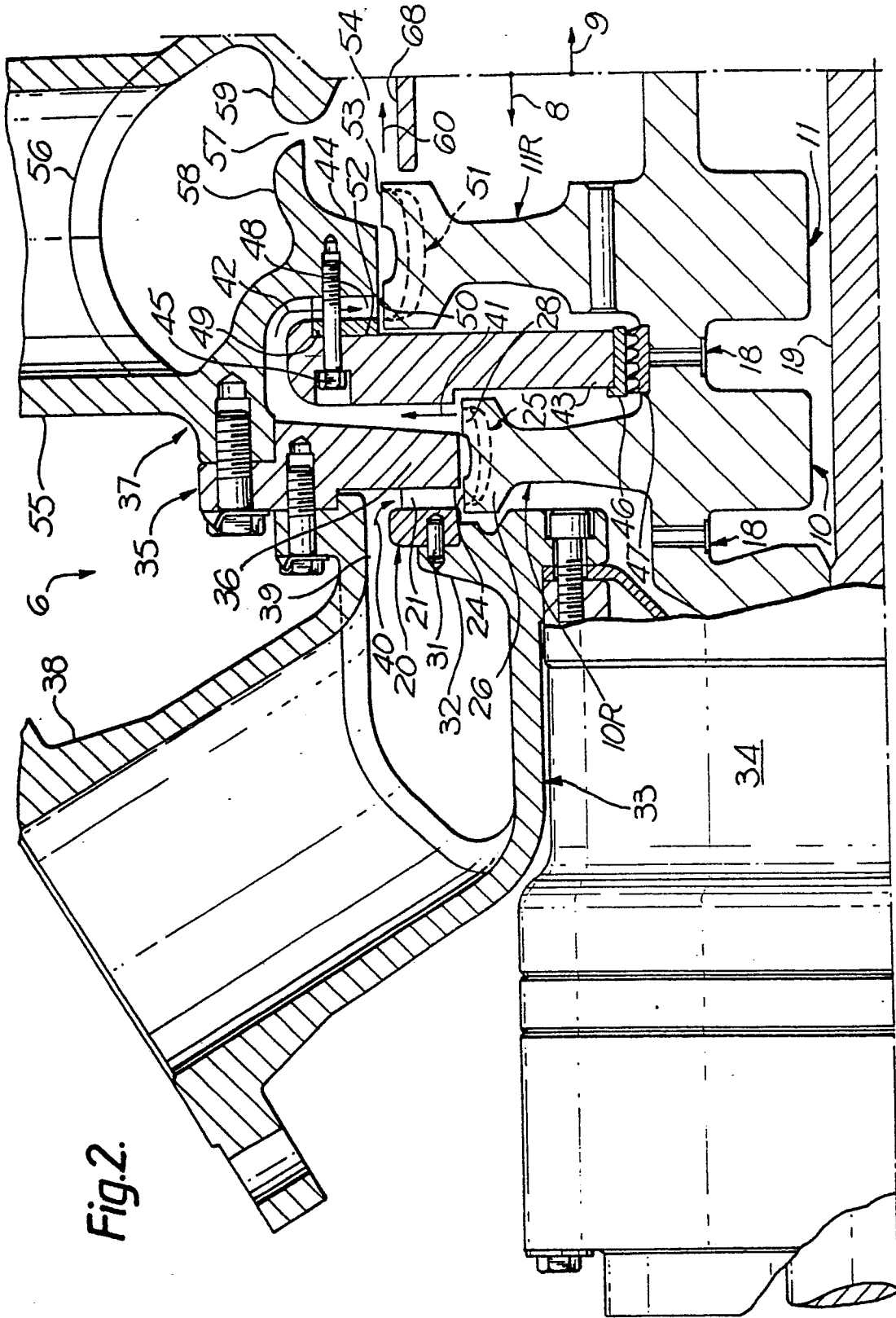
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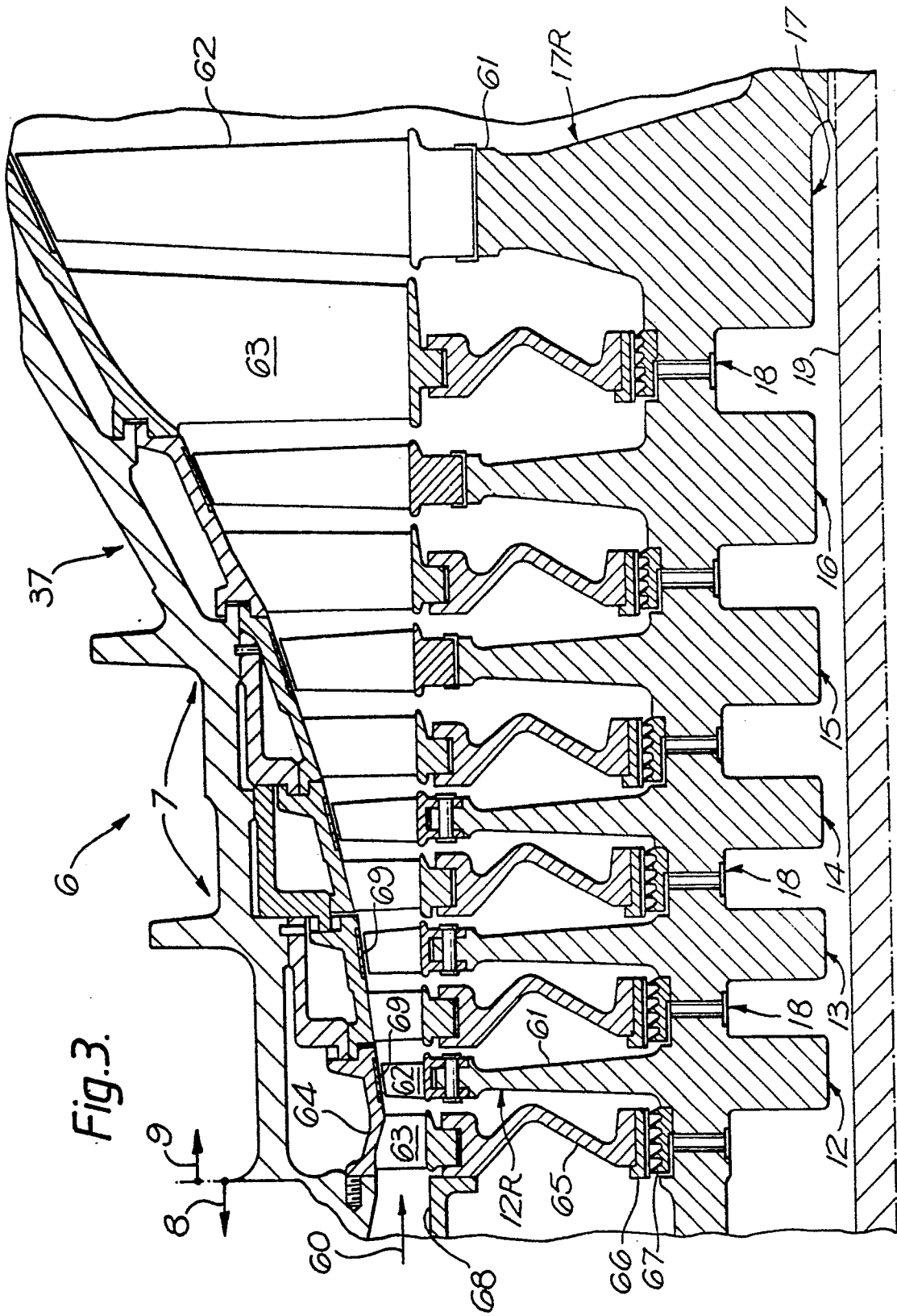


Fig.5.

