Nov. 12, 1946. K. BAUMANN 2,411,124

INTERNAL-COMBUSTION TURBINE PLANT

Filed Jan. 13, 1944 8 Sheets-Sheet 1

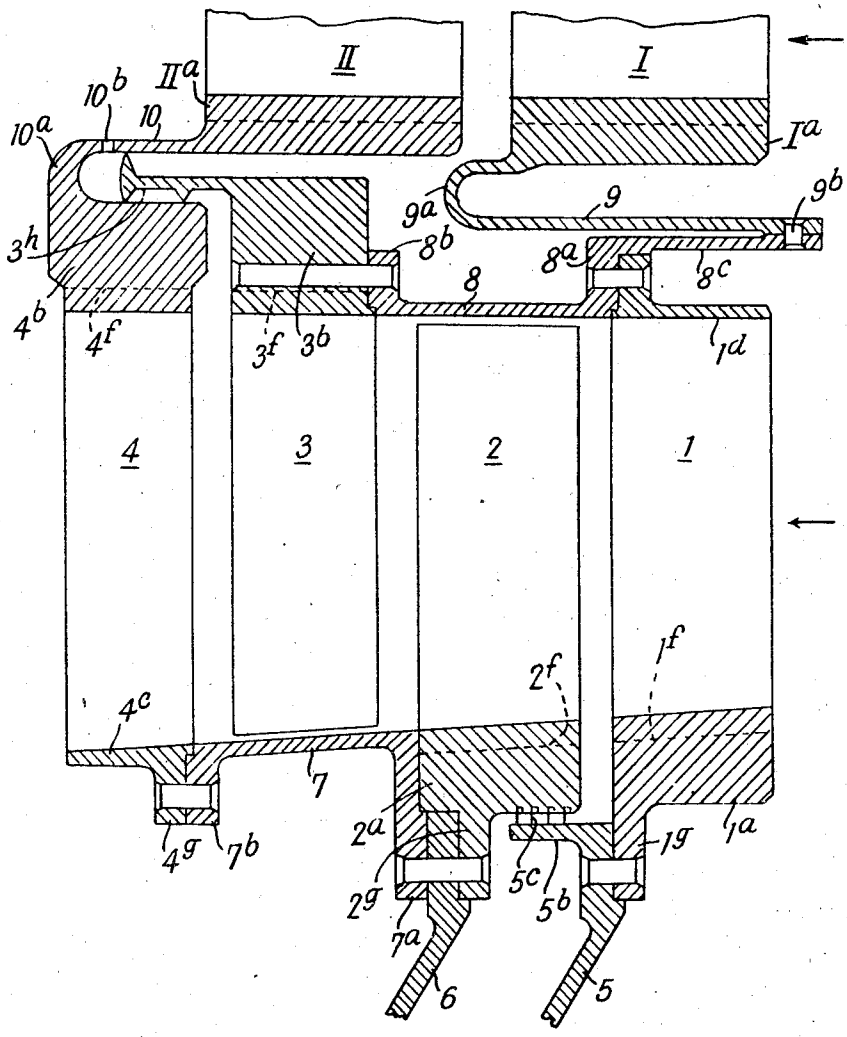


FIG. 1.

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INTERNAL-COMBUSTION TURBINE PLANT

Filed Jan. 13, 1944 8 Sheets-Sheet 2

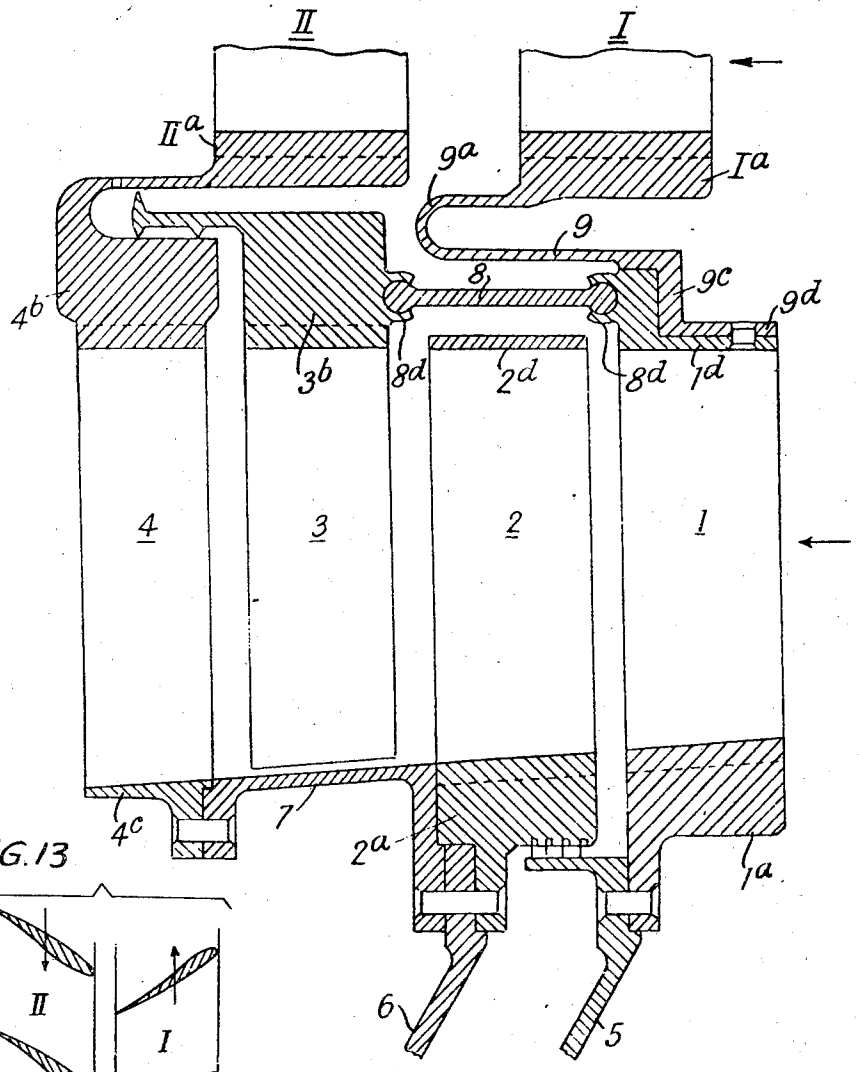


FIG. 2.

FIG. 13

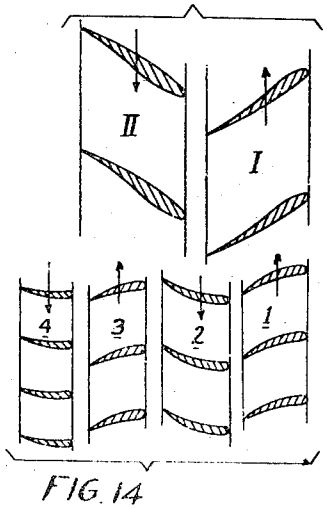


FIG. 14

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Nov. 12, 1946. K. BAUMANN 2,411,124

INTERNAL-COMBUSTION TURBINE PLANT

Filed Jan. 13, 1944 8 Sheets-Sheet 3

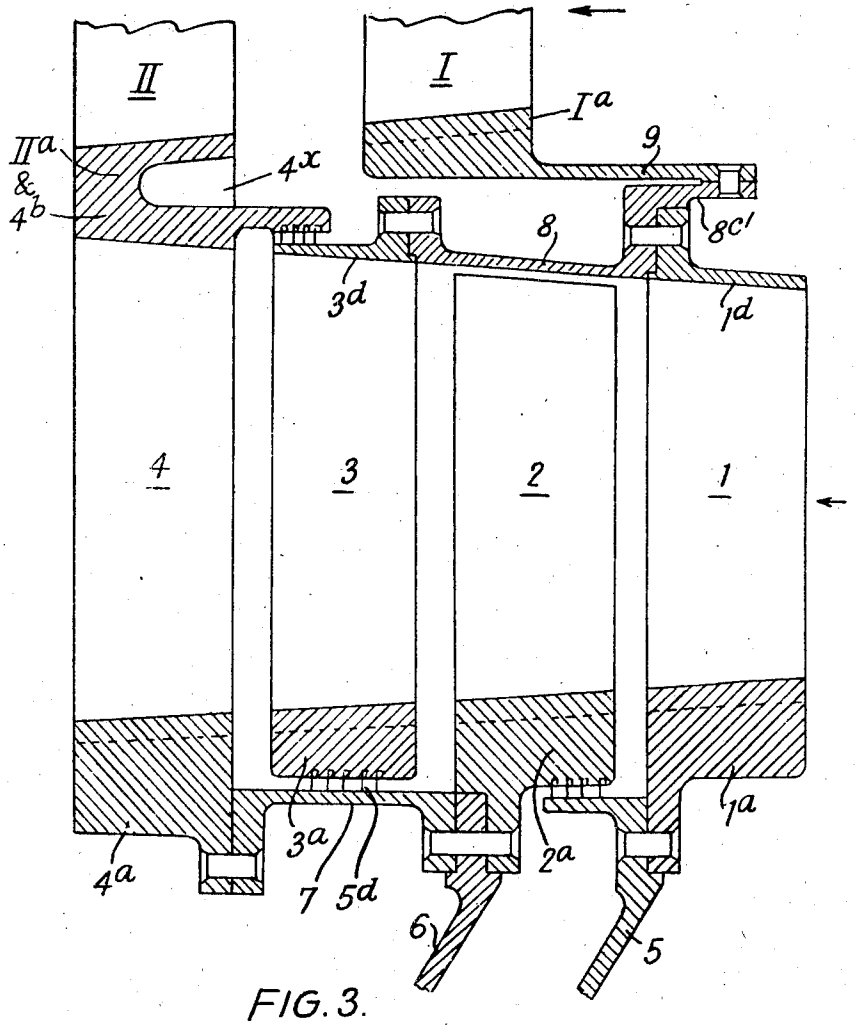


FIG. 3.

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INTERNAL-COMBUSTION TURBINE PLANT

Filed Jan. 13, 1944 8 Sheets-Sheet 4

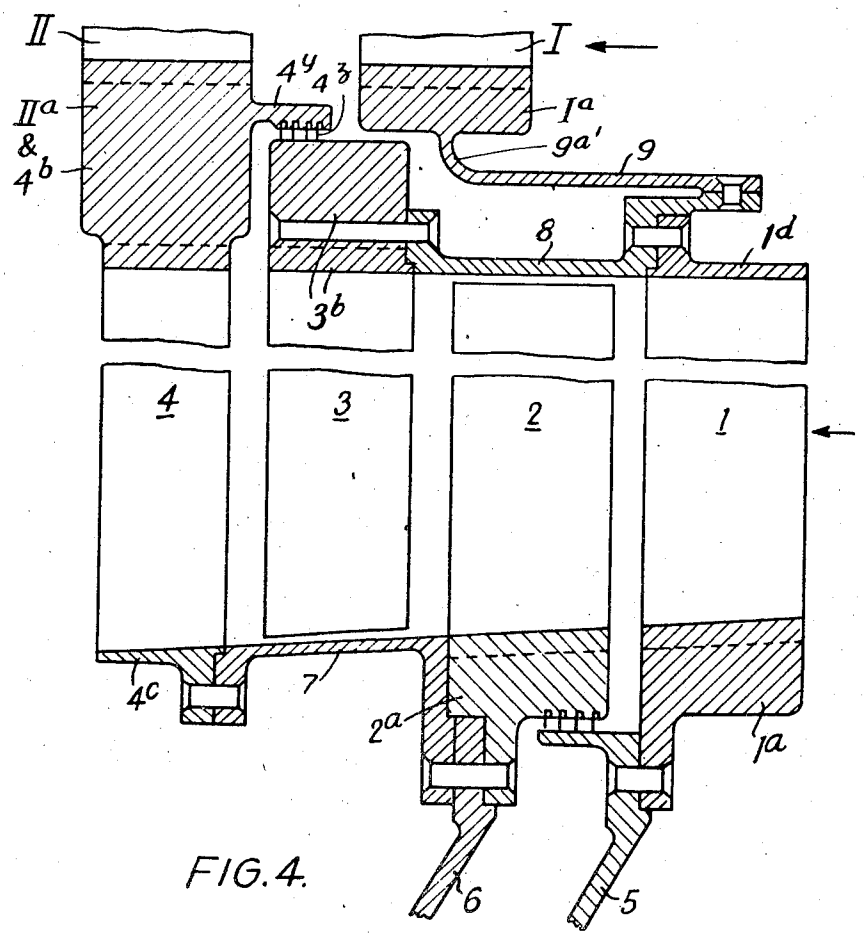


FIG. 4.

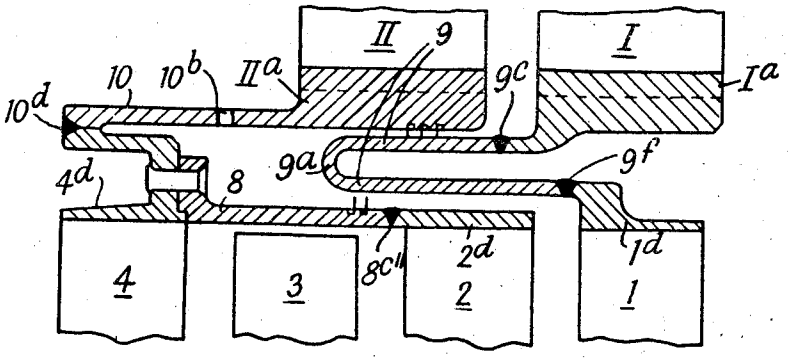


FIG. 5.

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INTERNAL-COMBUSTION TURBINE PLANT

Filed Jan. 13, 1944 8 Sheets-Sheet 5

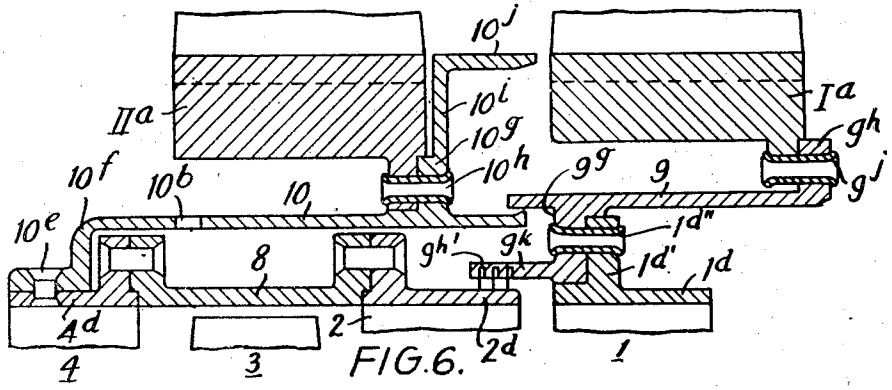


FIG.6.

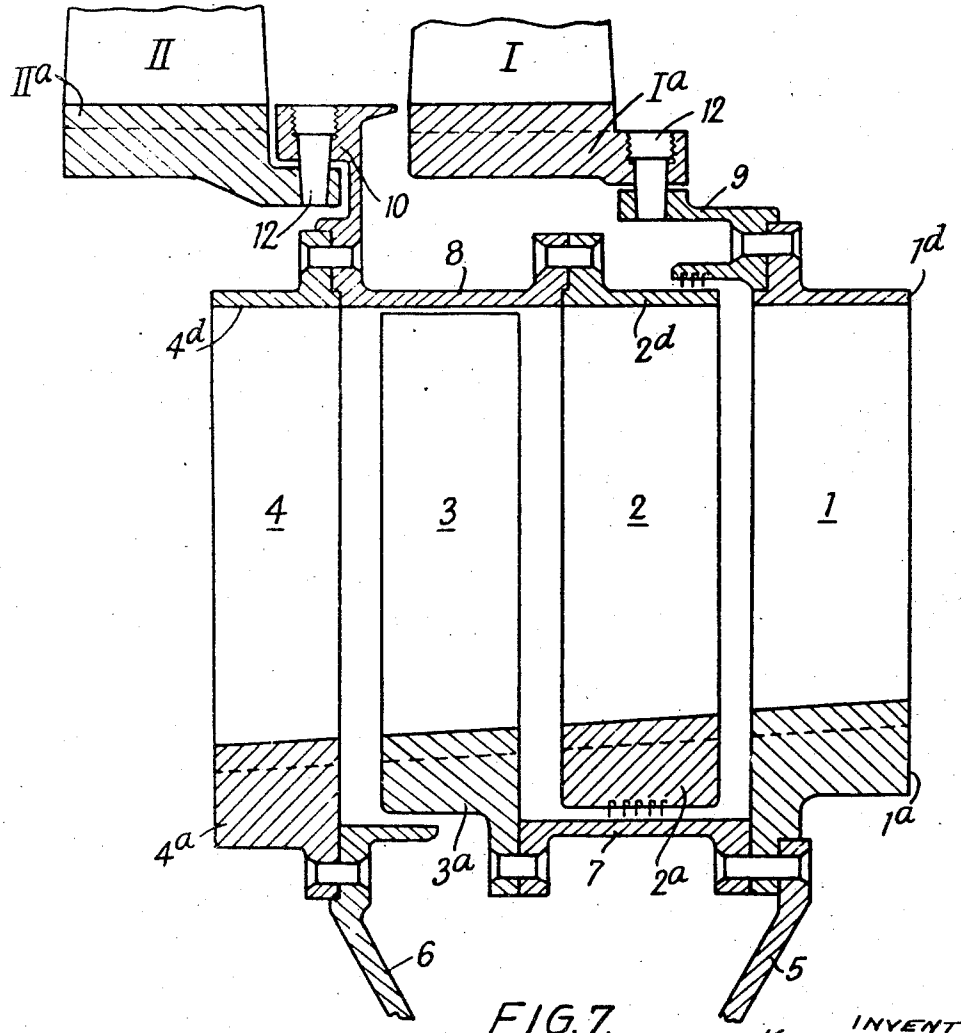


FIG.7.

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INTERNAL-COMBUSTION TURBINE PLANT

Filed Jan. 13, 1944 8 Sheets-Sheet 6

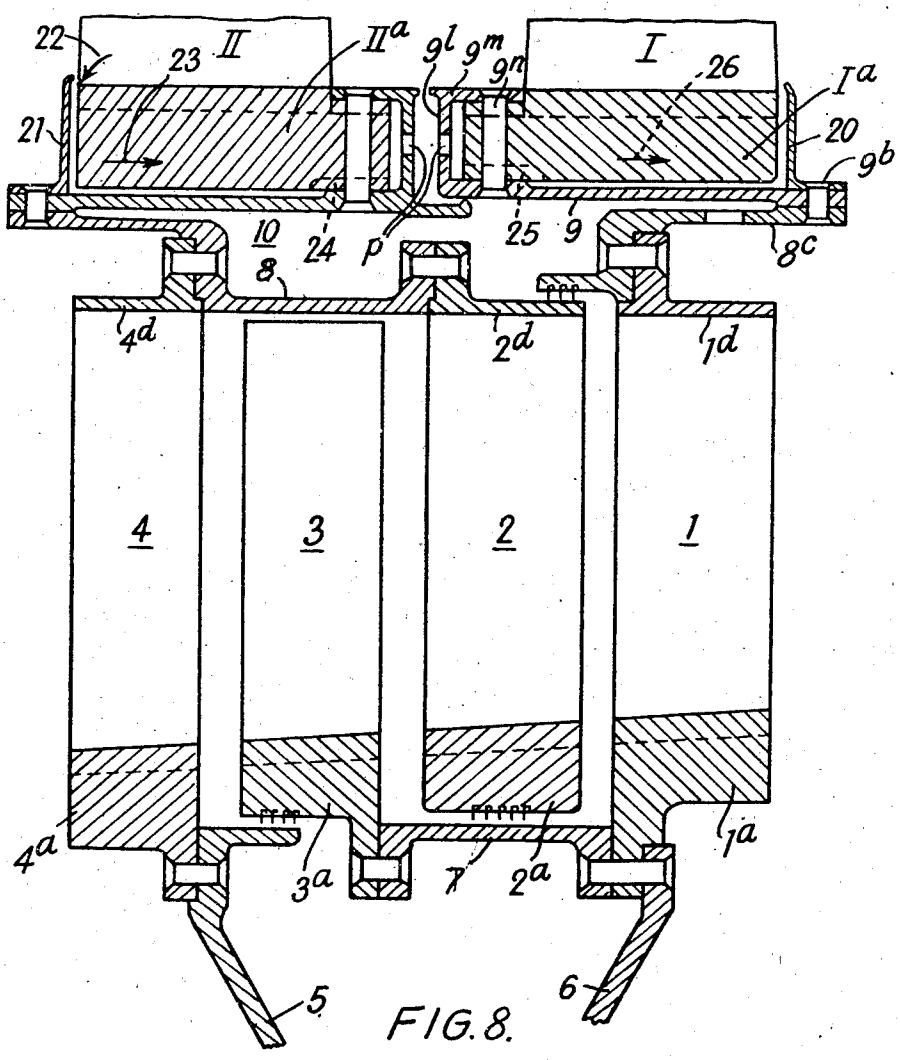


FIG. 8.

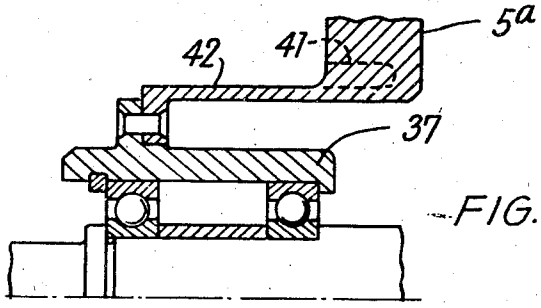


FIG. 12.

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Nov. 12, 1946. K. BAUMANN 2,411,124

INTERNAL-COMBUSTION TURBINE PLANT

Filed Jan. 13, 1944 8 Sheets-Sheet 7

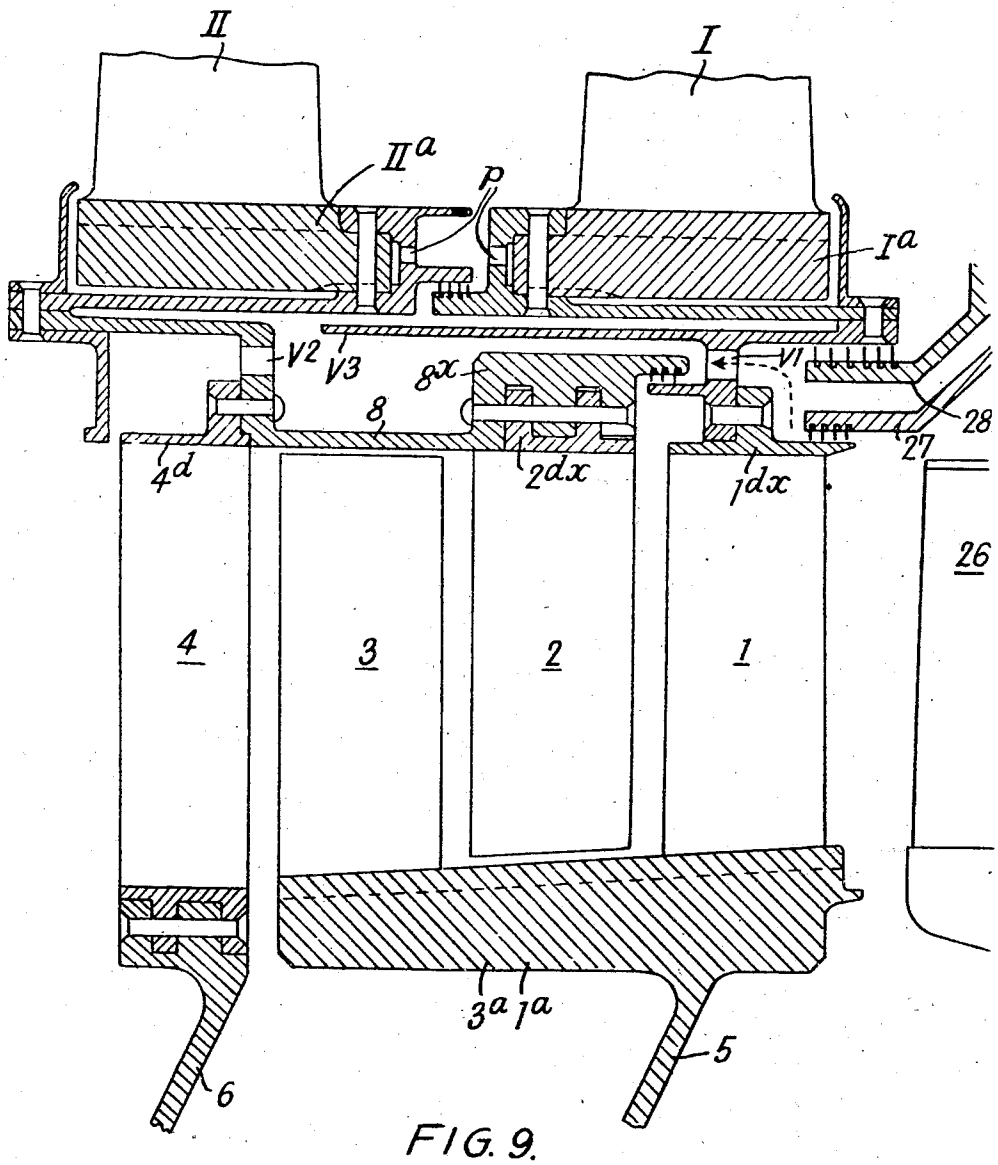


FIG. 9.

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INTERNAL-COMBUSTION TURBINE PLANT

Filed Jan. 13, 1944 8 Sheets-Sheet 8

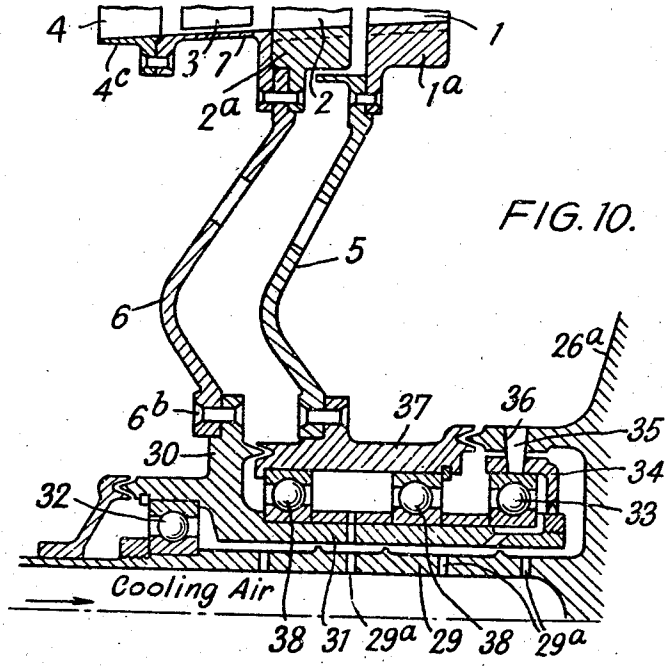


FIG. 10.

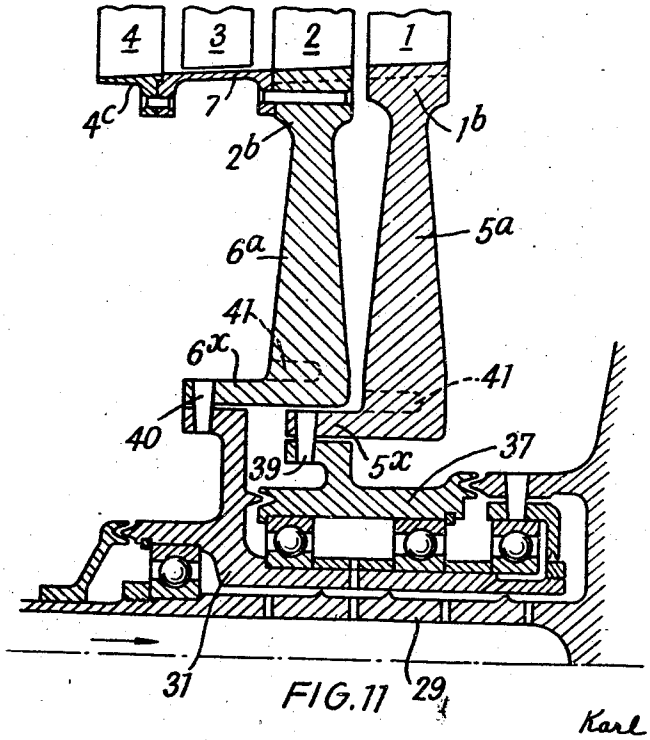


FIG. 11

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Patented Nov. 12, 1946

2,411,124

UNITED STATES PATENT OFFICE

2,411,124

INTERNAL-COMBUSTION TURBINE PLANT

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Application January 13, 1944, Serial No. 518,166
In Great Britain November 1, 1941

5 Claims. (Cl. 230—116)

1

This invention relates to internal combustion power plant for propulsion in air of the kind wherein the energy in the rearwardly exhausting products of combustion is utilised at least to assist in the propulsion by so-called jet action, such plant being notably but not exclusively employed for the propulsion of aircraft.

The invention furthermore specifically concerns an internal combustion power turbine component operated by the exhausting products of combustion and arranged to drive or work upon air additional to that used for the internal combustion, whereby essentially to increase the propulsion effect in at least one way.

The invention mainly but not exclusively concerns subsidiary features and structural details of, and also some improvements in, the contra-rotational "thrust augmentor" and plant in accordance with copending application Serial No. 518,165, filed January 13, 1944, and is directed to the convenient production of a plant of desirably low weight and small volume with provision for flexibility for differential thermal expansion.

In the following specification for the sake of brevity, clearness and convenience of description, the subject matter of the invention will be referred to broadly as applied to a thrust augmentor and the turbine forming an essential part thereof, preferably a low pressure turbine, will mostly be referred to as the power turbine, whilst the air screws or ducted fan stages or low pressure compressor driven by said power turbine will be referred to mostly as air blading or ducted fan stages. Furthermore, for convenience and by way of example it will be assumed that the combustion products driving the power turbine of the thrust augmentor are those discharging from a "compressor" turbine, that is, another turbine used wholly or mainly for driving the compressor which supplies air to a combustion chamber, the gases leaving which pass through both of said turbines.

According to the present invention at least one air blading stage, and preferably each air blading stage, is mounted on a foundation ring at the base or radially inner end of the blading row (such row also having if desired outer shrouding), so as to form a self-supporting structure which, or each of which, is carried by the or a rotor of the power turbine through the medium of an axially extending member or members which may assume various forms (some of which are per se known) and which permit radial flexibility between the members thereby connected, for accommodating differential thermal expansion. Conveniently also at least one and preferably each of the stages of the power turbine blading is formed or provided with a foundation ring (and conveniently also with shrouding as and where may be found necessary) again to provide a self-supporting structure in the case of each turbine stage.

2

In carrying out the invention according to a feature thereof, a or the self-supporting air blading structure or element may have the foundation ring of the inner blading periphery carried from the corresponding rotor of the power turbine by means of a thin axially extending or cylindrical flange, preferably also with a connecting portion or portions of re-entrant or annularly dished form, or by means of inner and outer cylindrical portions united at one end by an integral annular portion which is itself of semi-circular section or substantially so, these two coaxial cylindrical portions and the uniting portion being hereinafter for brevity referred to as a "swan-neck" member or portion: the other ends of these members are integral with or rigidly attached respectively to the foundation ring of the air blading stage and, within that, to the shrouding or foundation ring of the outer periphery of a row of power turbine blading driving the air blading. In a modification of the former of the two specific arrangements just above described the cylindrical member may be articulated with respect to one or both of the rings with which it connects, that is to say the connecting member may comprise a relatively thin walled coaxial cylinder the two edges of which are formed or provided with enlargements of part circular cross-section engaged in correspondingly shaped annular recesses in the foundation members which are thereby united. In another arrangement each of the foundation members may be formed or provided with a short axially extending flange, the one overlapping the other, and the two connected together by tapered radial pins engaged in similarly tapered holes in both flanges, the tapering converging to the axis of rotation; this arrangement again providing for thermal expansion effects in per se known manner in steam turbines, and previously proposed in other situations in internal combustion turbine plant.

Several arrangements in accordance with the invention and further features thereof will now be described with reference to the accompanying drawings, in all the figures of which it can be assumed that there are two stages of air screws or ducted fan blading and four stages of power

turbine blading, all operating on the contra-rotation principle.

In the drawings like or similar reference numerals will be used for the same parts, where possible, in the several figures, all the figures of which are fragmentary views illustrating conventionally in sectional elevation the upper halves of the several arrangements.

In the drawings:

Fig. 1 is an axial section of the turbine and fan blading of a turbine structure embodying the present invention.

Fig. 2 is a view similar to Fig. 1, but showing a modified construction of the shrouding of the turbine blading and foundation rings of stages of the turbine blading.

Fig. 3 is a view similar to Fig. 1, but showing inner foundation rings for all of the turbine stages and a modification of the outer shrouding thereof.

Fig. 4 is a view similar to the preceding figures but showing a modification of the connections between the turbine stages and the fan blading.

Fig. 5 is a fragmentary axial section of a built-up and welded structure between the turbine stages and the fan blading.

Fig. 6 is a detail axial section showing a riveted assembly connecting the bladings of the turbine and fan and providing for flow of cooling air.

Fig. 7 is an axial section showing a tapered pin arrangement for connecting the bladings of the turbine and fan.

Fig. 8 is an axial section showing another modified arrangement for connecting the turbine and fan bladings.

Fig. 9 is an axial section showing dished discs for mounting the turbine bladings and ventilating holes for protecting the fan bladings from high temperatures.

Fig. 10 is an axial section showing the bearings for mounting the turbine rotors.

Fig. 11 is a view similar to Fig. 10, but showing radial turbine discs and the bearings for supporting them.

Fig. 12 is a detail view in axial section, showing a flexible connection between one of the turbine rotor discs and its bearings.

Figs. 13 and 14 are sectional views through the air blading and the turbine blading, respectively.

In all the illustrated arrangements it will be assumed that the gas and air flows are from right to left, the four rows of turbine blading being numbered respectively 1, 2, 3 and 4, whilst the two air screws or rows of ducted fan blading are designated I and II.

In Figs. 1 to 9 the foundation rings of the ducted fan blading are indicated at I*a* and II*a*.

It will be appreciated from an inspection of Figs. 1 to 9 and a perusal of the description of these figures that in all the arrangements illustrated in these figures the four contra-rotational intercalated stages of the power turbine blading 1, 2, 3 and 4 (Fig. 14) are carried on two rotors variously constructed as hereinafter described in detail, namely what are herein for convenience called an outer rotor cylinder structure and an inner one, but these terms are in no way related to mean blade diameters: these rotors are carried from a shaft or axle preferably but not necessarily in the manner illustrated in Figs. 10, 11 and 12 of the accompanying drawings and as described hereinafter with reference thereto, through annularly dished discs such as 5 and 6 (only parts of which are shown in Figs. 1, 2, 3, 4, 7, 8 and 9) or by undished radial discs, preferably of tapering section such as illustrated in Figs. 11 and 12.

Preferably at least one, and maybe two or three or four of the turbine blading stages are provided at their inner peripheries with foundation rings designated 1*a*, 2*a*, 3*a* and 4*a*, whilst, as illustrated only in Fig. 9 there may alternatively be a common inner foundation ring such as 3*a*1*a* for the first and third blading stages, or alternatively and similarly a common outer foundation ring for the second and fourth stages. Certain of these turbine inner foundation rings, or, in the case of Fig. 9, both of them, may be integral with, but are preferably formed separately from and rigidly connected with the discs 5 and 6 (Figs. 1 to 10). On the other hand, in Figs. 11 and 12 the inner foundation rings indicated at 1*b* and 2*b* in Fig. 11 form the rims of the radial undished discs 5*a* and 6*a*.

Thus in most of the figures of the drawings, in general the two foundation rings of the ducted fan blading rows are designated I*a* and II*a*; inner foundation rings of the power turbine blading stages are indicated by 1*a*, 2*a*, 3*a* and 4*a*; outer foundation rings of the turbine blading are indicated similarly by the suffix *b*. Inner shrouding rings of the turbine blading stages 1, 2, 3 and 4 are indicated by similar numerals with the suffix *c* and outer shrouding rings of such blading are indicated by the suffix *d* applied to the same numerals 1, 2, 3 and 4.

Since the generally cylindrical structures of the herein called inner and outer rotors of the turbine must be substantially rigid and the continuity of the annular passage containing the contra-rotational blading must be ensured, inner turbine connecting sleeves are employed for the inner rotor cylinder, designated by the reference numeral 7 with certain suffix letters as appropriate, whilst the outer sleeves are designated 8 also with certain suffix letters as appropriate.

The flexible axially extending members connecting the inner foundation rings I*a* and II*a* of the ducted fan blading stages with the respective turbine rotors are indicated in general by the reference numerals 9 and 10 with suffix letters as appropriate.

The several figures of the drawings will now be described in such detail as seems necessary.

Referring to Fig. 1, it will be noticed that the blading stages 1 and 2 of the power turbine have inner foundation rings 1*a* and 2*a* whilst the blading stages 3 and 4 of this turbine have outer foundation rings 3*b* and 4*b*. It is to be assumed that the blades are in most arrangements secured in the foundation rings by the provision of roots on the blades engaging in axial grooves in the foundation rings, as indicated by the dotted lines such as 1*f* and 4*f*. On the other hand, the shrouding such as 1*d* and 4*c* in Fig. 1 can be assumed to be integral with the evenly circumferentially distributed blading in the stages 1 and 4, each blade carrying a segment of shrouding.

In Fig. 1 the inner foundation ring 1*a* of the turbine blading stage 1 has an inward flange 1*g* which is riveted to the outer periphery of the dished disc 5, which is provided with a cylindrical flange 5*b* between which and the inner cylindrical surface of the foundation member 2*a* of stage 2 is the labyrinthine packing gland 5*c*. The foundation ring 2*a* has the internal radial flange 2*g* which is riveted not only to the outer periphery of the dished disc 6 but also to the inner

radial flange 7a of the connecting sleeve 7 which at its other end has a flange 7b riveted to the inwardly projecting segmental lugs 4g formed on the shrouding ring 4c of blading stage 4 of the power turbine; thus is constituted the inner rotor cylinder carrying stages 2 and 4. It is to be understood that the rivets may be replaced by screws or nuts and bolts.

The outer rotor cylinder of the power turbine is similarly constituted namely by the provision of the axially extending connecting sleeve 8 having a flange 8a riveted or bolted to the segmental external flange on the segmental shrouding ring 1d and having a flange 8b riveted to the outer foundation ring 3b.

The foundation ring Ia in Fig. 1 is shown as having the integral axially extending cylindrical member 9 with the "swan-neck" portion 9a, the right-hand end of which member 9 is connected by radial rivets at 9b to the right-hand end of a cylindrical extension 8c of the radial flange 8a.

The foundation ring IIa of the second row II of the ducted fan blading has integral with it the axially extending cylinder 10 which at its left-hand end joins integrally as shown at 10a the outer foundation ring 4b of the turbine blading stage 4.

It will be noticed that the turbine outer foundation ring 3b has a cylindrical flange 3h extending into the swan-neck 10a and provided with ridges as shown to constitute labyrinthine packing against escape of gases from the radial gap between the turbine foundation rings 3b and 4b. At 10b is shown one of a plurality of radial ventilation holes in the axially extending member 10 to allow turbine gases which may pass the labyrinth flange 3h to escape into the air duct (not shown).

The arrangement shown in Fig. 2 differs only from that shown in Fig. 1 in the main in that the turbine blading stage 2 is provided with the outer shrouding 2d, whilst the member 8 of Fig. 1 is not bolted or riveted at its ends to the shrouding 1d and foundation ring 3b but is articulated with respect to these members as indicated at 8d in the manner hereinbefore set forth. Furthermore the member 8c is omitted and the member 9a, 9 is provided with the internal flange 9c with the cylindrical extension 9d riveted to the flanged shrouding ring 1d.

The arrangement shown in Fig. 3 differs from the arrangement shown in Fig. 1 in the following respects: all the turbine blading stages have inner foundation rings 1a to 4a. The stages 1 and 3 have outer shrouding rings 1d and 3d, which are preferably formed in segments each segment being integral with one blade. The use of complete rings is not, however, excluded, and these of course will be relatively light in weight compared with foundation rings. The member 7 connects the foundation rings 2a and 4a by riveted flanged joints, whilst labyrinthine packing 5d may be provided, as shown.

A member 8, likewise, connects the shrouding ring 1d with the shrouding ring 3d. The axially extending member 9 is of more elementary form than is shown in Figs. 1 and 2, being a simple integral extension of the ducted fan foundation ring Ia, and riveted or bolted at its right-hand end to a short axial extension 8c' of the member 8.

Furthermore, the ducted fan blading stage II is shown integral with the turbine blading stage 4 as a "double-tier" stage in which the fan blades

are formed directly on the outer ends of some or all of the turbine blades. The boundaries of the gas and air passages are formed by the bridge pieces IIa, 4b which are integral with the blades, and which butt together to form a complete circle. There may, however, be fewer air blades than turbine blades in the row.

There may be an annular recess 4x as shown.

The arrangement shown in Fig. 4 only differs in detail from that shown in the preceding figures in that the member 9 is integral through a semi-swan-neck part 9a' at the centre of the foundation ring Ia, the right-hand end of the part 9 being connected to the shroud ring 1d as shown in Fig. 3. There is also the difference regarding Fig. 4 that there is a common foundation ring IIa and 4b between the fan blading II and the turbine blading stage 4, plus the cylindrical flange 4y extending outwardly around the foundation ring 3b, with labyrinth packing 4z therebetween as shown.

In the arrangements illustrated by Figs. 1, 2, 3 and 4, the first row 1 of turbine blading is mechanically connected with the third row 3 thereof through the outer rotor cylinder comprising outer foundation or shrouding rings respectively, connected by the essential member 8. In the arrangements shown in Figs. 5, 6, 7, 8 and 9, on the other hand, it is the second and fourth rows of the turbine blading which are connected to the outer rotor cylinder. In all cases the first row I of ducted fan blading is mechanically connected with the first and third rows of power turbine blading at the outer periphery of the latter, although the invention is not limited in this respect.

Referring to Fig. 5, the flexible axially extending swan-neck member 9, 9a is connected by the welds at 9c and 9f as shown between the short cylindrical extensions on the left-hand ends of the foundation ring Ia and the shrouding 1d. The connection of the ducted fan foundation ring IIa is by the cylindrical extension 10 welded at its left-hand end at 10d to the cylindrical outer portion of the externally flanged shrouding 4d (as shown) the radial flange being in this case riveted to the left-hand radial flange of the sleeve 8 which at its right-hand end is welded at 8c'' to a left extension of the shrouding 2d.

The further modification illustrated by Fig. 6 is characterised by several minor features, as follows: The cylindrical member 8 has its flanges connected by "axial" rivets, at its right-hand end to the flange formed on the turbine blade shrouding 2d, and at its left-hand end to a similar flange on the fourth turbine stage shrouding 4d radially riveted at 10e to the doubly flanged end 10f of the flexible cylinder 10, near the right-hand end of which is the radial flange 10g secured by the hollow rivets 10h to the inward flange of the ducted fan foundation ring IIa, as shown. The flange 10g is extended outwards at 10i to terminate in a cylinder portion 10j bridging the gap between the ducted fan foundation rings Ia and IIa.

In the arrangement illustrated by Fig. 6, furthermore, the turbine shrouding 1d has an outward flange 1d' secured by hollow rivets 1d'' to an internal flange 9g on the flexible member 9 which at its other end has an outward flange 9h secured by hollow rivets 9j to an inward flange of the foundation ring Ia. Furthermore, the flange 9g has a cylindrical extension 9k overlapping the shroud 2d, with labyrinthine packing 9h' therebetween. The hollow rivets 9j and 10h have

flowing through them cooling air inducted by the air blades, while the hollow rivets 1*d*'' prevent the establishment of a hot pocket by gases passing the labyrinth packing between the stationary structure and the facing surfaces of member 1*d* and 9.

The arrangement of Fig. 6 enables the foundation rings I*a* and II*a* to be of a different material from the flexible members 10 and 9. Also, owing to the cooling effect of the air stream passing through the hollow rivets, the material of the said foundation rings I*a* and II*a* may be chosen without regard to its suitability for high temperature operation. It may, for example, be an aluminium alloy.

Referring to Fig. 7, the per se constructions of the ducted fan and power turbine need no particular description after perusal of the description of and the inspection of Figs. 1 to 6; except by the hereinbefore set forth means of connection of the two contra-rotational turbine rotors to the respective foundation rings I*a* and II*a* of the ducted fans. Namely, the comparatively shorter axially extending members 9 and 10 are connected to relatively short overlapping axial extensions of the air blade foundation rings I*a* and II*a* respectively, by the tapered pins 12, as and for the purpose hereinbefore set forth. It will also be noted from an inspection of Fig. 7 that the discs 5 and 6 may be dished oppositely in contrast with those indicated in Figs. 1 to 4.

In the arrangement illustrated by Fig. 8 the power turbine is shown by way of example as in Fig. 7, but the connection of the ducted fan blading to the turbine rotors is different in a respect as follows: In this figure the foundation rings I*a* and II*a* are of "light alloy" and are connected by the steel, axially extending members 9 and 10, preferably of "swan-neck" form generally similar, as an example, to that shown in Fig. 1 as regards the members 9*b* and 8*c*, and similarly as regards ducted fan stage II illustrated by Fig. 5 at 10, but with the following changes, namely: The member 8*c* (compare Fig. 1) at its right-hand end is riveted or otherwise connected to the right-hand end of the outer flexible cylinder 9 which at its left-hand end is formed as follows for its connection to the foundation ring I*a*. The left-hand end of the flexible cylinder 9 is formed with a radial flange portion 9*l* integral with a re-entrant cylindrical flange 9*m*, thereby providing as shown the annular channel holding, by the rivets 9*n*, the inserted extension edge of the foundation ring I*a*, as shown. The other foundation ring II*a* is similarly drivingly connected to the other rotor of the power turbine, as can be readily seen by examination of Fig. 8 of the accompanying drawings. In Fig. 8 there is also shown the following adjuncts, viz:

An annular shield disc 20 is clamped by its cylindrical portion by the rivets 9*b*, at the inlet end of the ducted fan stage I, and an annular deflector disc 21 at the left-hand end of the foundation ring II*a*: there are also holes *p*, as shown, in the radial parts holding the foundation rings I*a* and II*a*, which rings necessarily have cylindrical clearance from the outer parts of the flexible cylindrical members 9 and 10. Thus, as shown by the short arrows 22 and 23, cool air, due to pressure difference, flows back to the axial grooves 24 in the foundation ring II*a* to and through the holes *p* and then through the grooves 25 in the ring I*a*, as shown by the arrow 26, to the shield 20 to be returned to the annular stream of inducted air. The subject matter of this paragraph is per se broadly claimed in copending application Serial No. 518,174, filed January 13, 1944, and is only claimed herein strictly subordinately to the main features of the present invention.

Fig. 9 of the drawings of the present application shows an arrangement which differs only in details (which should be readily apparent now) from the arrangement shown in Fig. 8. At 26 is shown in dotted lines the final blading stage of the compressor turbine, namely the turbine driving the compressor which supplies the combustion chamber supplying the gas for said compressor turbine. In Fig. 9 are fragmentally shown labyrinth packing members 27 and 28 separating moving parts from the last stage 26 of the compressor turbine. There is also shown in Fig. 9 at 2*dx* a double tongue projection formed at the outer end of the blades of stage 2, engaged and held by rivets in a correspondingly formed extension 8*x* of the connecting member 8, thus forming the foundation ring for the blading stage 2. There are also shown in this Fig. 9 the ventilation holes V1 and V2, and the cylinder V3 for preventing the light alloy foundation rings of the ducted fans being subjected to too high temperatures.

Fig. 10 shows how the dished discs 5 and 6 can be contra-rotationally carried on ball bearings about a shaft which, as an example, is a stub shaft extension 29 of the compressor turbine, being integral with or secured to the disc 26*a* of the last stage 26 (Fig. 9) of the compressor turbine. In the illustrated example the annularly dished disc 6 is secured at its inner periphery by rivets 6*b* (or bolts) to a radial flange 30 on the left-hand end of the sleeve shaft 31 carrying at that end the outer race of a ball bearing 32 the inner race of which is carried on the stub shaft or extension 29. The bearing 33 at the right-hand end of the sleeve shaft 31 is carried within a member 34, the outer cylindrical part of which is connected by taper pins 35 from a cylindrical hub part 36 of the disc 26*a* for accommodating radial differential thermal expansion.

The inner periphery of the annularly dished disc 5 is rigidly attached to an outer sleeve shaft 37 relatively rotatable with respect to the sleeve shaft 31 through the ball bearings 38.

Cooling of the ball bearings and their sleeve shafts may be effected, together with some cooling of the discs 5 and 6 or 5*a* and 6*a* and the blade foundation rings, by the introduction of cooling air at the outer end of the stub extension 29 of the compressor turbine shaft, which extension is made hollow for the purpose and furnished with radial holes 29*a* providing outlets into labyrinthine passages about the sleeves and bearings, with final discharge into spaces from which the air may emerge to join the gas stream.

Fig. 11 is similar to Fig. 10, only differing therefrom, as hereinbefore indicated, in that instead of the dished discs, there are the radial discs 5*a* and 6*a* each having inner cylindrical parts 5*x* and 6*x* connected by taper pins 39 and 40 to the sleeve shafts 37 and 31 respectively. For giving some further flexibility to the discs 5*a* and 6*a* they may be provided with the annular grooves indicated at 41.

Finally, Fig. 12 illustrates the flexible connection of a disc, for example 5*a*, to the sleeve shaft, for example 37, by the cylinder 42.

It will be understood that there may be more than four low pressure turbine stages. For in-

stance, if there are six turbine stages the disc or dished web for the first rotating member may carry or be connected directly to the blading of the first turbine stages while the rows of blading of the third and fifth stages are carried by exteriorly located foundation rings. The disc or dished disc for the second rotating member may carry or be connected directly to the blading of the fourth stage whilst the rows of blading of the second and sixth stages are carried by foundation rings located respectively interiorly and exteriorly of the blading. The exterior cylindrical and/or "swan-neck" connections for driving the ducted fan stages may be made respectively with the first and sixth low pressure turbine stage structures.

It is now herein pointed out that the structures of the inner and outer rotors of the power turbine as hereinbefore described may involve the progressive building up of the separate constituent parts and intercalated blading stages of these rotors, in the axial direction, and this subject matter, which can be carried out in other ways, per se forms the subject matter of copending application Serial No. 518,167, filed January 13, 1944.

I claim:

1. In an internal combustion turbine structure, an air impeller comprising a power turbine comprising a plurality of intercalated stages of axial flow turbine blading constituted as inner and outer rotor members, at least one of said rotor members comprising axially spaced ring supports for a pair of stages of turbine blading and a coaxial sleeve member interposed between and connecting said supports, and air blading carried and driven by said rotor members, at least one air blading stage having a foundation ring at the base of the blading row so as to form a self-supporting structure which is carried by one of said rotor members of the power turbine, and an axially extending member capable of radial flexibility for accommodating differential thermal expansion, said axially extending member being connected to one of said rotor members and extending axially therefrom to said foundation ring.

2. In an internal combustion turbine structure, an air impeller comprising a power turbine having axial flow turbine blading and air blading carried and driven by a turbine rotor outwardly of said turbine blading, at least one air blading stage having a foundation ring at the base of the blading row so as to form a self-supporting structure which is carried by said rotor of the power turbine, and an axially extending member capable of radial flexibility for accommodating differential thermal expansion, said member being connected to said rotor and extending axially therefrom to said ring, and comprising everlapping portions, and radial tapered pins uniting said portions.

3. In an internal combustion turbine structure, the combination of a power turbine having axial flow turbine blading and air blading carried and driven by a turbine rotor outwardly of said turbine blading, at least one air blading stage having a foundation ring at the base of the blading row so as to form a self-supporting structure which is carried by said rotor of the power turbine, and an axially extending member capable of radial flexibility for accommodating differential thermal expansion, said member being connected to said rotor and extending axially therefrom to said ring and terminating in radially spaced cylindrical portions, and the inner foundation ring of said row of air blading having a cylindrical portion extending between and secured to said portions.

4. In an internal combustion turbine structure, the combination of a power turbine having axial flow turbine blading and air blading carried and driven by a turbine rotor outwardly of said turbine blading, at least one air blading stage having a foundation ring at the base of the blading row so as to form a self-supporting structure which is carried by said rotor of the power turbine, and an axially extending member capable of radial flexibility for accommodating differential thermal expansion, said member being connected to said rotor and extending axially therefrom to said ring and having a cylindrical extension arranged to constitute a heat shield between the driven structure and the hotter turbine parts.

5. In an internal combustion turbine structure, an air impeller comprising a power turbine having axial flow turbine blading and air blading carried and driven by a turbine rotor outwardly of said turbine blading, at least one air blading stage having a foundation ring at the base of the blading row so as to form a self-supporting structure which is carried by said rotor of the power turbine, and an axially extending member capable of radial flexibility for accommodating differential thermal expansion, said member being connected to said rotor and extending axially therefrom to said ring, and comprising a cylindrical portion within the inner substantially cylindrical surface of said foundation ring and spaced therefrom to provide an annular channel for cooling air whereby said ring and associated structures are protected from the heating effect of adjacent turbine parts and of turbine gases, and means providing an induced air circulation in said channel.

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