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TURBINE APPARATUS

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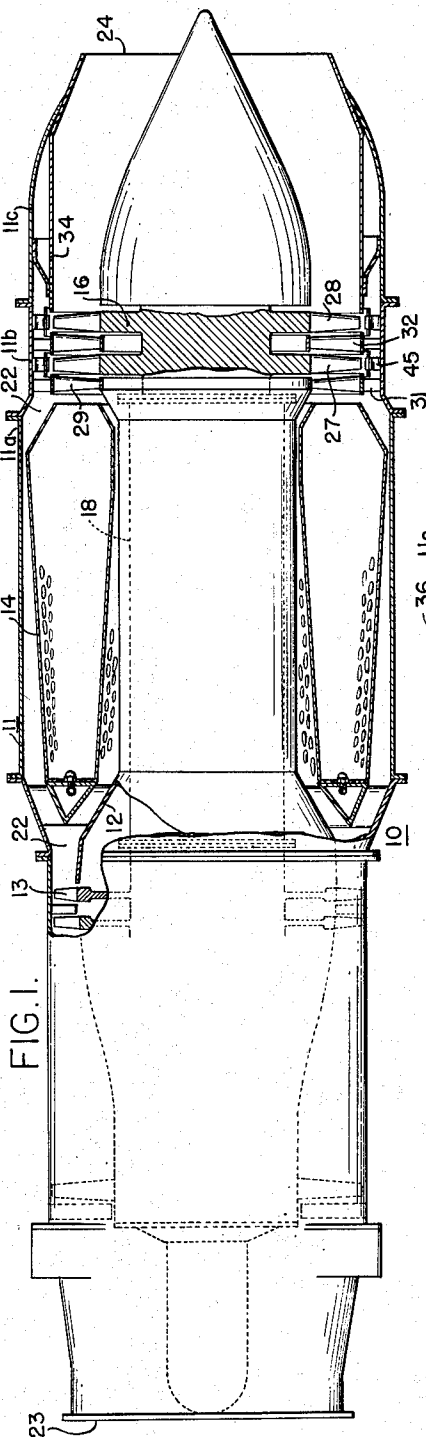
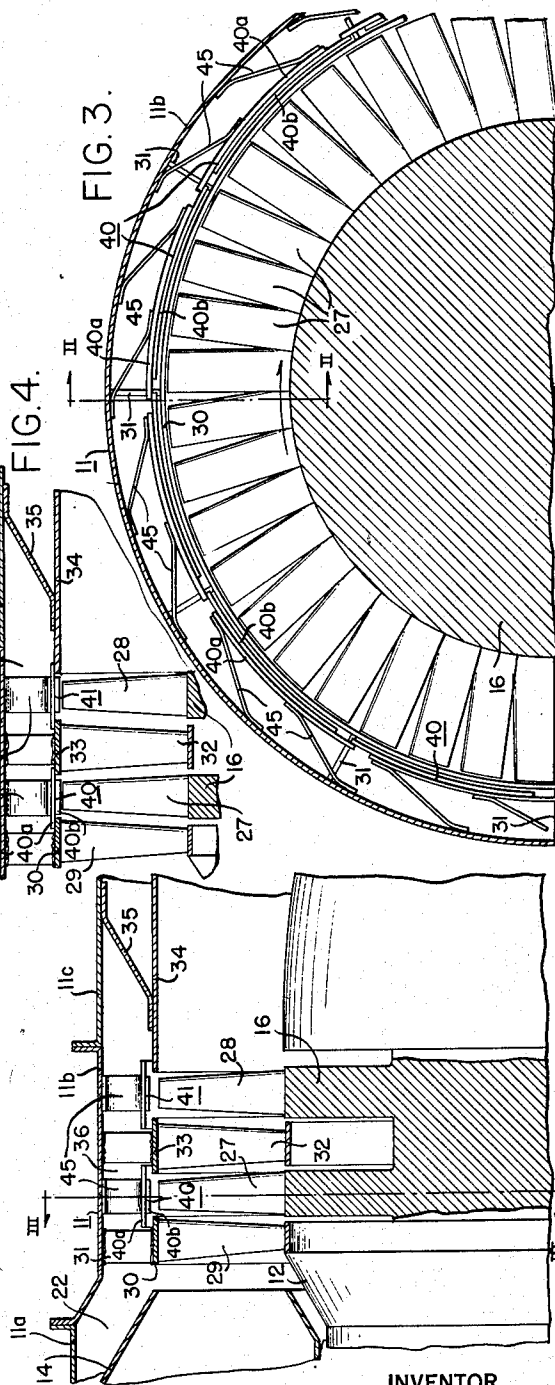


FIG. 2.

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TURBINE APPARATUS

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1

This invention relates to rotary fluid pressure plants, and more particularly to shroud structure for the bladed rotor of a gas turbine or the like.

In the construction of a power plant operative at high temperatures, such as an aviation turbo-jet engine, it has been considered necessary to provide considerable clearance between the tips of the turbine rotor blades and the surrounding annular shrouding or casing structure, in order to avoid possible seizure of the blades due to contraction of the casing during the initial interval of cooling following shutdown after a period of operation of the plant. In the absence of adequate clearance, contraction of the thin-walled outer casing structure, which tends to cool at a more rapid rate than does the shielded, relatively large mass of the rotor, might cause the turbine shrouding to engage the tips of the rotor blades. With a conventional rigid casing and shroud structure, such forcible contact between shroud surfaces and rotor blades would tend to cause undesired distortion of the casing and unfavorable subsequent starting conditions. Although ample blade tip clearance is thus desirable upon shut-down of the turbine plant, it is well known that excessive clearances promote energy losses and are detrimental to efficiency of the plant in operation.

It is an object of the present invention to provide improved rotor blades shrouding structure which will allow adequate clearance upon shut-down while minimizing clearance losses in operation.

Another object of the invention is the provision of shroud structure for a bladed rotor, comprising a plurality of circumferentially arranged segments yieldably supported by suitable flexible means serving to prevent damage or inconvenience due to contact of the rotor blades with the shroud structure.

A further object of the invention is to provide improved shroud structure for a bladed rotor including automatically adjustable shroud elements which are retractible to an outer position for establishing maximum blade clearance at one time, and which are movable inwardly to a normal operating position for minimizing blade clearance at other times.

These and other objects are effected by the invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a longitudinal partly sectional view of a typical aviation gas turbine power plant having

2

a turbine and shroud assembly constructed in accordance with the invention;

Fig. 2 is a fragmentary enlarged detail sectional view of a portion of the apparatus shown in Fig. 1, taken along line II—II of Fig. 3;

Fig. 3 is a sectional view taken along the line III—III of Fig. 2; and

Fig. 4 is a sectional view similar to Fig. 2 illustrating the adjustable shroud structure in another position.

In Fig. 1 of the drawing there is illustrated a typical aviation gas turbine engine 10, comprising a generally cylindrical outer casing structure 11, in which are mounted a core structure 12 and operating elements including an axial-flow compressor 13, combustion apparatus 14, and a turbine having a rotor 16, which is connected to the rotor of the compressor by means of a tubular shaft 18. The rotor of the compressor 13, shaft 18 and turbine rotor 16 are journaled on suitable bearings (not shown) supported in the casing and core structure. These rotary elements are disposed along the axis of the casing and core structures 11 and 12, which jointly form an annular passageway generally indicated at 22, extending through the power plant from a frontal air intake opening 23 to a rearwardly disposed discharge nozzle 24.

The power plant 10 is adapted to be mounted in a suitably ventilated compartment of an aircraft (not shown) with the intake 23 directed forwardly. In operation, air entering the intake opening 23 is compressed and delivered through passage 22 by the compressor 13 to the combustion apparatus 14, where fuel is burned to provide hot motive fluid, which, when partly expanded through the turbine and discharged in the form of a jet through the nozzle 24, imparts a propulsive thrust to the aircraft.

As best shown in Fig. 2 of the drawing, the turbine rotor 16 may have one or more stages of blading, the rotor assembly chosen for illustration being provided with two suitably connected disc portions carrying groups of radial blades 27 and 28. The cylindrical outer casing structure 11 enclosing the turbine may comprise a plurality of abutting annular sections, including casing sections 11a, 11b and 11c, which are adapted to be secured together by means of complementary bolting flanges. Mounted in advance of the turbine blades 27 are the radial vanes of nozzle assembly 29, which is supported between the outer casing section 11b and the core structure 12, and includes an outer shroud ring 30 connected to the casing section by spaced radial members 31. A stationary diaphragm assembly

32 is also interposed between turbine blades 27 and 28, this diaphragm assembly including an outer shroud ring 33 similarly supported by the casing structure 11. Aligned with the shroud ring 33 on the downstream side of the blades 28 is an annular nozzle liner 34, which is supported within the casing section 11c by means of an inclined annular member 35. An annular chamber 36 is thus formed between the outer casing structure 11 and the respective rings 30 and 33, in communication with the passage 22.

According to the invention, generally annular segmental shroud structures 40 and 41 are yieldably supported from the outer casing structure 11 in close clearance relation with the tips of turbine blades 27 and 28, respectively. Referring to Figs. 2 and 3, the shroud structure 40 for the turbine blades 27, which is representative of both of the similarly arranged shroud structures, comprises a plurality of arcuate segments 40a adapted to be mounted circumferentially of the tips of the turbine blades, each such segment being wide enough, axially of the turbine assembly, to overlap the stationary shroud rings 30 and 33. The shroud segments 40a are disposed in chamber 36 inwardly of the outer casing section 11b, to which the segments are yieldably connected through the medium of circumferentially spaced, substantially tangentially disposed flexible webs or leaf springs 45. Each of the movable shroud segments 40a has an inwardly projecting portion 40b of reduced width, which is adapted to be received between and in alignment with the stationary shroud rings 30 and 33 when the overlapping marginal portions of the segment are brought into engagement with the stationary members. As best shown in Fig. 3, each inner portion 40b is longitudinally offset with respect to the outer portion of the integral shroud segment 40a and at one end slidably engages beneath an overlapping portion of the adjacent shroud segment, thereby facilitating circumferential alignment of all of the shroud segments regardless of relative expanding or contracting movement of the shroud structure 40 as a whole.

With the shroud structures 40 and 41 thus yieldably urged outwardly by the limited spring force of the flexible webs 45, and adapted for movement from the outer position to an inner operational position, starting of the power plant and initial warm-up acceleration thereof will be accomplished while ample clearance space is maintained between the respective shroud structures and the rotating turbine blades 27 and 28. Upon acceleration in engine speed and build up of gas pressure in the passage 22 and chamber 36 to a value approaching the normal turbine inlet pressure of the power plant at full speed, the pressure drop incident to expansion of gas through the turbine will force the respective groups of shroud segments 40a and 41a inwardly into engagement with the adjacent stationary shroud members, as shown in Fig. 4, so that clearance relative to the blade tips will be reduced to the desired minimum. During continued operation of the power plant under normal speed and relatively steady-state temperature conditions, such reduced clearance will not result in objectionable blade rub.

Upon shut-down of the power plant, the flexible webs 45 will effect return of the segments of the shroud structures 40 and 41 to the outer or expanded position thereof, as shown in Fig. 2, thereby increasing clearance relative to the turbine blades for preventing seizure during subse-

quent cooling and differential contraction of the engine components. Restarting of the power plant will thus be facilitated.

It will be understood that, since the flexible webs in effect serve as non-rigid positioners for the shroud segments, any relaxing of the spring effect of the webs or failure thereof to withdraw the segments entirely out of reach of the turbine blades would not appreciably impede a starting operation, inasmuch as even in the event of friction between segments and blades, the resistance offered by the yieldably supported segments to rotation of the blades would be negligible and would not necessitate provision of any substantial additional starting motor effort.

While the invention has been shown in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. In a turbine power plant, an outer casing structure, a turbine rotor having radial blades and operatively mounted in said casing structure, annular shroud structure comprising a plurality of circumferentially arranged movable arcuate shroud segments encompassing said blades in closely spaced relation to the tip portions thereof, means directing fluid pressure from a source of fluid pressure within said power plant to said shroud segments to urge them toward said tip portions of the blades, and flexible means yieldably supporting said shroud segments from said casing structure for facilitating adjustment of clearances of said shroud segments relative to said rotor blades upon thermal expansion thereof during initial operation and upon shut-down of the power plant.

2. In a turbine power plant, an outer casing structure, a turbine rotor having radial blades and operatively mounted in said casing structure, a stationary annular nozzle assembly concentrically mounted in said casing structure adjacent the blades of said rotor, said stationary nozzle assembly including a shroud ring, movable annular shroud structure encompassing said turbine rotor comprising a plurality of circumferentially arranged arcuate shroud segments disposed in overlapping relation with respect to said shroud ring, yieldable means for supporting said shroud segments from said casing structure, and fluid pressure means directing pressure from a source of fluid pressure within said power plant to said shroud segments for moving said shroud segments into engagement with said shroud ring in closely spaced relation to the tip portions of said rotor blades.

3. In a turbine power plant, an outer casing structure, means therein forming an annular outer passage adapted to receive fluid under pressure, a turbine rotor having radial blades and operatively mounted in said casing structure in alignment with a source of motive fluid, axially spaced stationary annular members concentrically mounted in said casing structure on opposite sides of the tips of said rotor blades and inwardly of said outer passage, a plurality of circumferentially arranged arcuate shroud segments mounted in encompassing relation about said rotor blades and having peripheral surfaces subject to pressure of fluid in said outer passage, said shroud segments having shoulder portions overlapping and engageable with said annular members, and a plurality of substantially tangentially disposed flexible members

5

having end portions secured respectively to said shroud segments and to said casing structure for supporting said segments in spaced relation to the tip portions of said rotor blades, said shroud segments being movable inwardly in response to pressure drop across said turbine blades, said flexible members being adapted to yield as said shroud segments are moved into engagement with said annular members for minimizing clearance relative to said rotor upon initial thermal expansion of the power plant assembly.

4. In a turbine power plant, a cylindrical casing structure having a turbine passage adapted to receive hot motive gases, annular flow guide means concentrically mounted therein and including axially spaced stationary annular members disposed concentrically within said casing structure for separating an outer annular passage from the turbine passage, means for supplying fluid under pressure from a source of pressure fluid within said power plant to said outer passage, a turbine rotor operatively mounted in the turbine passage of said casing structure intermediate said annular members, the peripheral diameter of said rotor corresponding substantially with the inside diameter of said annular members, annular shroud structure encompassing the space between said annular members outwardly of said turbine rotor comprising a plurality of circumferentially arranged arcuate shroud segments having shoulder portions disposed radially outwardly of and overlapping said annular members, and a plurality of circumferentially spaced flexible supporting elements disposed in said outer passage and having ends substantially

6

tangentially secured to said casing structure and to the respective shroud segments, said supporting elements being adapted to bias said shroud segments out of engagement with said annular members during initial warm-up operation of said turbine prior to full thermal expansion of the assembly, and being yieldable, in response to increase of pressure drop between said outer passage and said turbine passage as the power plant approaches normal speed, for permitting inward movement of said shroud segments into engagement with said annular members, thereby effecting reduction in clearances between the peripheral edges of said rotor and said shroud structure upon attainment of relatively steady state operative temperature and consequent thermal expansion of the associated elements of the power plant.

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