Feb. 8, 1949. C. R. SODERBERG 2,461,242

ROTOR CONSTRUCTION FOR TURBINES

Filed Aug. 23, 1944 3 Sheets-Sheet 1

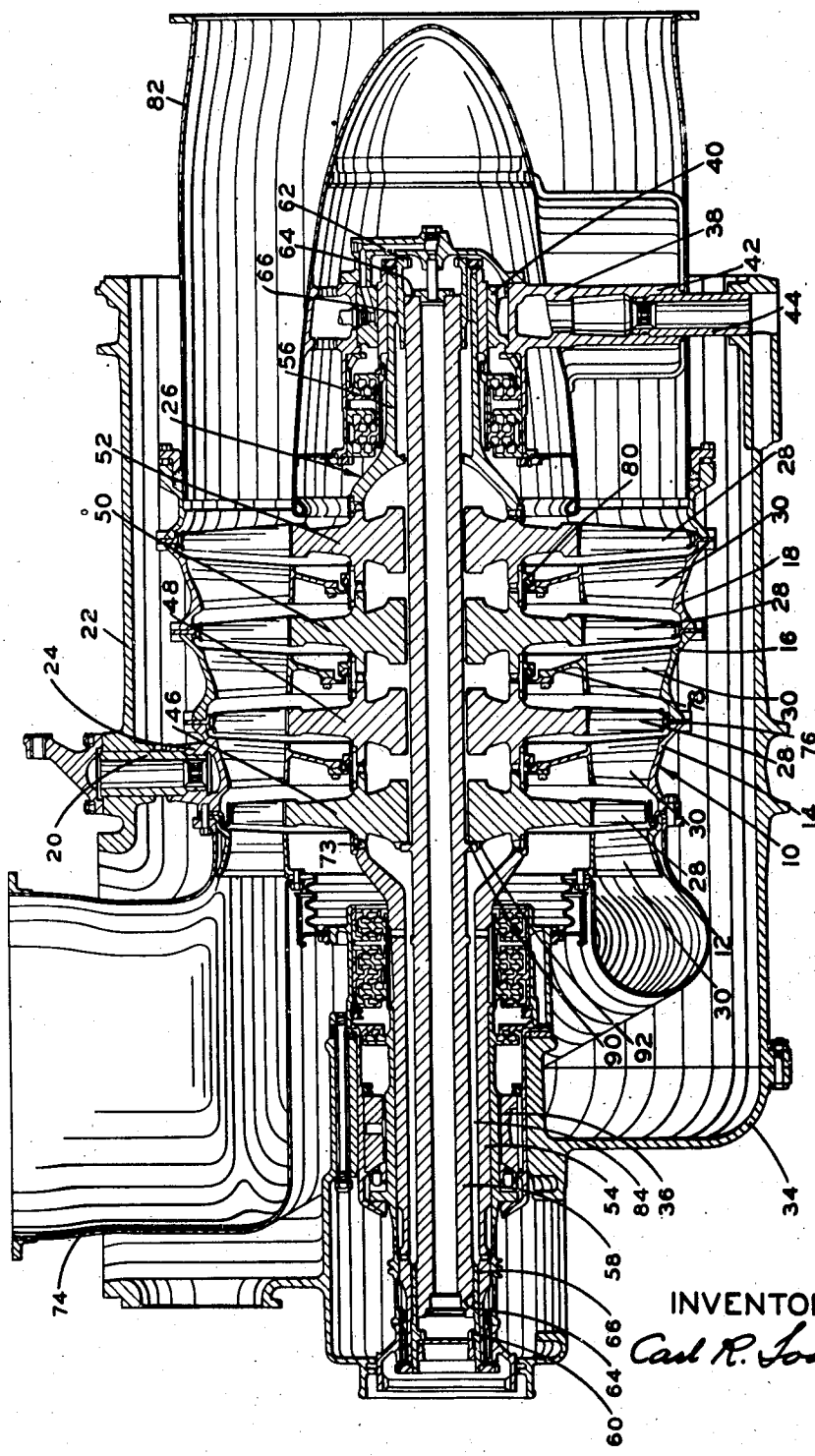



FIG. 1

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Filed Aug. 23, 1944 3 Sheets-Sheet 2

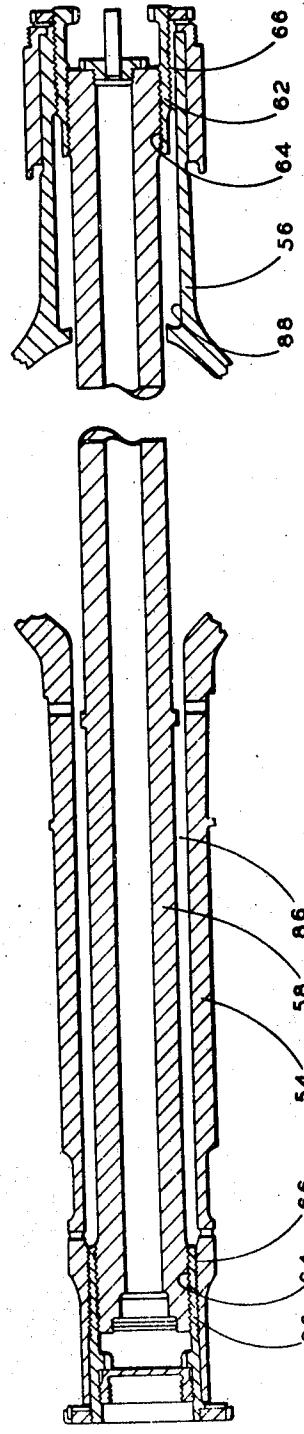



FIG. 2

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ROTOR CONSTRUCTION FOR TURBINES

Filed Aug. 23, 1944 3 Sheets-Sheet 3

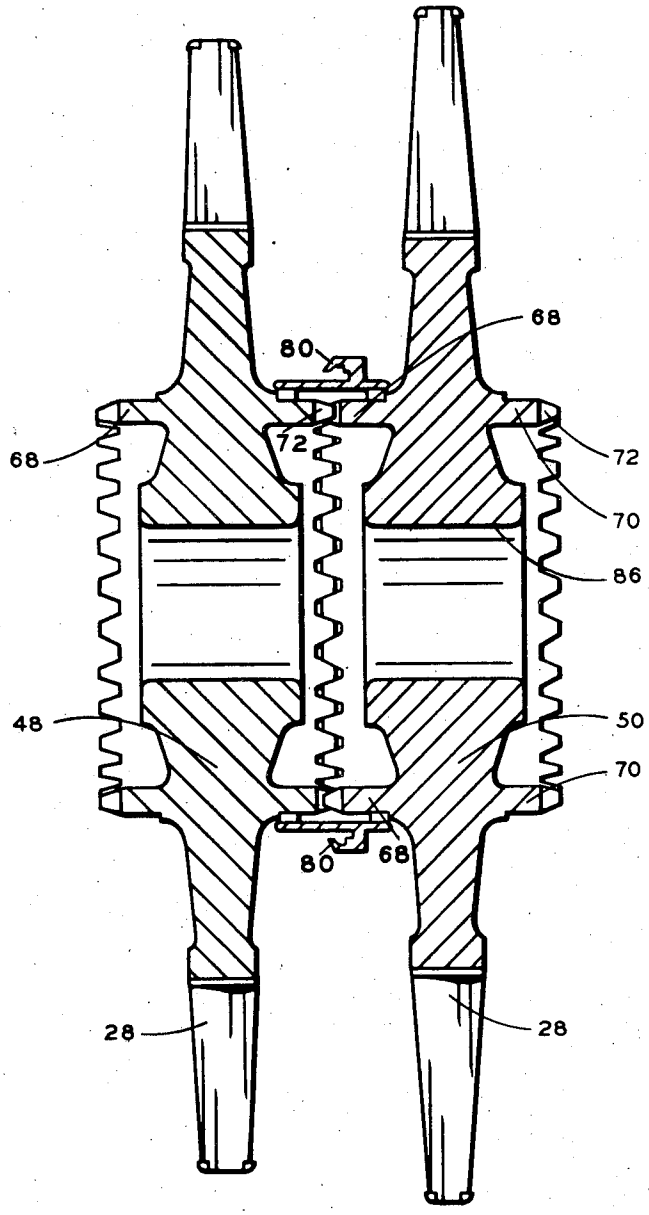



FIG. 3

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Patented Feb. 8, 1949

2,461,242

# UNITED STATES PATENT OFFICE

2,461,242

## ROTOR CONSTRUCTION FOR TURBINES

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Application August 23, 1944, Serial No. 550,899

4 Claims. (Cl. 253—39)

1

This invention relates to gas turbines and the like and especially to rotor constructions adapted for use in aircraft.

Turbines or compressors generally have a heavy solid rotor having a number of rows of blades alternating with rows of nozzles in a surrounding casing. The casing is necessarily split lengthwise to permit assembly with the rotor. A feature of this invention is a rotor split into discs each carrying a row of blades to make possible assembly of the rotor with a casing not having a longitudinal split.

Endwise assembly of an axial flow compressor or turbine having a solid rotor is difficult, if not impossible, although such endwise assembly is frequently desirable. Another feature is a built-up rotor arranged to permit endwise assembly of the complete turbine.

A solid rotor is difficult to machine and difficult to handle during assembly of the blades and shrouds. Furthermore, it may be difficult to obtain a solid piece of material from which the rotor may be made which will be homogeneous throughout. Since the rotor may be highly stressed in operation, a flaw in the rotor may cause failure. An object of the invention is to avoid these difficulties by a rotor built up of separate discs each having a row of blades.

A feature of the invention is a built-up rotor held together by a central bolt to form a unitary operative assembly. The bolt may be tightened within the rotor by differential threads for a more rigid assembly.

Another feature is a light weight rotor which will make possible a light weight turbine adapted for use in aircraft.

Other objects and advantages will be apparent from the specification and claims, and from the accompanying drawings which illustrate an embodiment of the invention.

Fig. 1 is a sectional view through the turbine.

Fig. 2 is a fragmentary sectional view on a larger scale through the central bolt.

Fig. 3 is a fragmentary sectional view of the rotor.

The invention is shown in a turbine which includes a casing 10 built up of rings 12, 14, 16 and 18 supported by radial pins 20 in a housing 22. These pins which are all in substantially the same plane and which constitute the support for the casing within the housing, engage bores in bosses 24 in one ring 14 of the casing. Rotor 26 within the casing has a number of rows of blades 28 alternating with rows of nozzles 30 in the casing.

Housing 22 has a head 34 which forms a part

2

of the housing and supports a bearing sleeve 36 for the front end of rotor 26. At the other end of the turbine, the housing 22 supports a mounting 38 within which is a bearing 40 for the rotor. Mounting 38 has a number of legs 42 engaging with radial pins 44 which locate the mounting within the housing.

Rotor 26 is made up of a number of thin, substantially flat, discs 46, 48, 50 and 52, and shaft-forming end elements or end bells 54 and 56. The discs and the shaft elements are all held together by a central bolt 58. The ends of the bolt are positioned within the end elements 54 and 56 and are connected to the end elements by threaded sleeves or nuts 60 and 62. Each sleeve 60, 62 has inner and outer threads 64 and 66 engaging respectively with cooperating threads on the bolt and on the end elements. On one of the sleeves (sleeve 60 as shown) the inner and outer threads may differ in pitch so that as the sleeve is screwed into place, a substantial tension may be applied to the bolt.

To avoid overstressing the center bolt as the turbine discs become heated and expand axially during turbine operation, the connections between the center bolt and the surrounding shaft elements are preferably adjacent the outer ends of the elements. The part of the bolt which must elongate to accommodate the axial disc expansion is thus relatively long and will not be as highly stressed as a shorter bolt would be.

Since the casing is built up of casing rings bolted together, each ring having a row of nozzles, and since the rotor is built up of discs, each having a row of blades, it is apparent that the turbine is adapted for endwise assembly. To assist in aligning the discs during assembly and to prevent relative rotation in operation, each disc has projecting annular flanges 68 and 70 on opposite sides having interengaging elements preferably in the form of face splines 72 cooperating with similar elements on the adjoining disc. Similarly, the inner ends of shaft elements 54 and 56 have face splines 73 cooperating with splines on the end discs. The relatively thin flanges 68 and 70 are spaced from central openings 86, hereinafter described, at distances several times greater than the thickness of the flanges and define, when the discs are assembled, a substantially rigid cylindrical support for the discs. The flanges extend axially beyond the thickest part of the disc.

Gas enters the first stage nozzles of the turbine through an inlet scroll 74 which is attached to the end of casing 10. Leakage of power gas

past the outer ends of the blades is prevented by seals 76 which may be positioned between adjoining casing rings and leakage of power gas surrounding the inner edges of the diaphragm 78 extending inwardly from each row of nozzles is prevented by a labyrinth seal 80. Gas from the turbine discharges through a duct 82 connected to the end casing ring and surrounding the rear bearing mounting.

The discs which make up the power section of the turbine rotor have substantially constant-stress cross-sections have central openings 86, preferably larger in diameter than the fastening bolt, and the shaft elements 54 and 56 have central openings 86 and 88, Fig. 2, also larger in diameter than the fastening bolt. The discs and shaft elements of the rotor are thus free to expand radially without affecting the alignment of the parts. Stability of the assembled rotor parts may be maintained by a number of projections 90 on the bolt engaging in radial grooves 92 in one of the discs.

In applying tension to the bolt by the differential threads 64 and 66 on sleeve 60, it will be apparent that, if thread 64 has a higher pitch than outer threads 66, the sleeve will tend to move the bolt endwise while the sleeve is being screwed in. By selection of proper pitches, a predetermined tension may be applied to the bolt.

For additional tension, the bolt may be heated prior to assembly, so that, after assembly, as the bolt cools, the contraction of the bolt will apply the desired tension.

It is to be understood that the invention is not limited to the specific embodiments herein illustrated and described, but may be used in other ways without departure from its spirit as defined by the following claims.

I claim:

1. A rotor construction including a number of discs having rows of blades, each disc having a central opening, a shaft at each end of the set of discs and engaging the end discs, each shaft having a central recess, a tie bolt extending through the openings in said discs and into the recesses in the shafts for holding the discs and shafts together, the ends of the bolt being within the recesses in the shafts, said tie bolt having threads at each end, a nut engaging the threads at one end and engaging one of the shafts, another nut engaging the threads at the other end, one of said nuts having threads of different pitch on inner and outer surfaces, one set of the threads on the nut engaging the bolt threads, the other threads on the nut engaging cooperating threads on the other projecting shaft.

2. A rotor construction including a number of discs each having a row of blades, each disc having a central opening, a shaft at each end of the set of discs, and engaging the end disc, each shaft having a central recess, a tie bolt extending through the openings in said discs and into the recesses in the shafts for holding the discs and shafts together, said bolts having threads at one end, a nut having threads engaging said bolt threads, other threads on said nut having a different pitch from the threads on the bolt, the adjoining shaft having cooperating threads engaging with said other threads on the bolt, and means interconnecting the other end shaft and said bolt for holding the bolt against endwise movement relative to said other end shaft.

3. A rotor including a number of thin substantially flat discs each having a row of blades thereon projecting radially from the periphery and each having a central opening, each disc having a substantially constant-stress cross-section, thereby being substantially thicker at the central opening than over the remainder of the disc, the thickness decreasing rapidly toward the periphery of the disc, annular flanges on opposite sides of each disc extending axially of and concentric to the disc, said flanges extending from the disc at a radius substantially greater than that of the central opening and at a radius where the discs are relatively thin, the spacing of the flange from the central opening being several times the thickness of the flange, the flanges of adjacent discs engaging with one another and constituting the sole contact between the adjacent discs, each flange projecting axially beyond the thickest part of the disc, said flanges, when in engagement, defining a substantially rigid cylindrical support for said discs with the diameter of the cylinder substantially greater than the diameter of the central opening in the disc, a through bolt extending through said central openings and out of contact therewith for clamping said discs together with the ends of the flanges in interengagement, and end bells extending between the ends of the through bolt and the flanges on the outer surfaces of the endmost discs, said end bells having contact with the disc only through said flanges, said bolt holding said end bells against the end discs, and clamping the discs together.

4. A rotor including a number of thin substantially flat discs each having a row of blades thereon projecting radially from the periphery and each having a central opening, each disc having a substantially constant-stress cross-section, thereby being substantially thicker at the central opening than over the remainder of the disc, the thickness decreasing rapidly toward the periphery of the disc, annular flanges on opposite sides of each disc extending axially of and concentric to the disc, said flanges extending from the disc at a radius substantially greater than that of the central opening and at a radius where the discs are relatively thin, the spacing of the flange from the central opening being several times the thickness of the flange, the flanges of adjacent discs engaging with one another and constituting the sole contact between adjacent discs, each flange projecting axially beyond the thickest part of the disc, said flanges, when in engagement, defining a substantially rigid cylindrical support for said discs with the diameter of the cylinder substantially greater than the diameter of the central opening in the discs, a shaft at each end of the set of discs and engaging with the projecting flange at the outer side of each end disc, each shaft having a central recess, a tie bolt extending through the openings in said discs and into the recesses in the shafts for holding the discs and shaft together, the openings in said discs being larger than the bolt so that the discs are out of contact with the bolt, said bolt having threads at one end, a nut having threads cooperating with the threads on the bolt and fitting within the recess of and engaging the adjoining shaft, and means interconnecting the other end of said bolt and the other shaft for holding said other end of the bolt in fixed relation to said other shaft such that the bolt holds the discs and shafts in assembled relation.

CARL R. SODERBERG.

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## Certificate of Correction

Patent No. 2,461,242. February 8, 1949.

CARL R. SODERBERG

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 3, line 65, claim 2, for the word "bolts" read *bolt*;

and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of June, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
*Assistant Commissioner of Patents.*