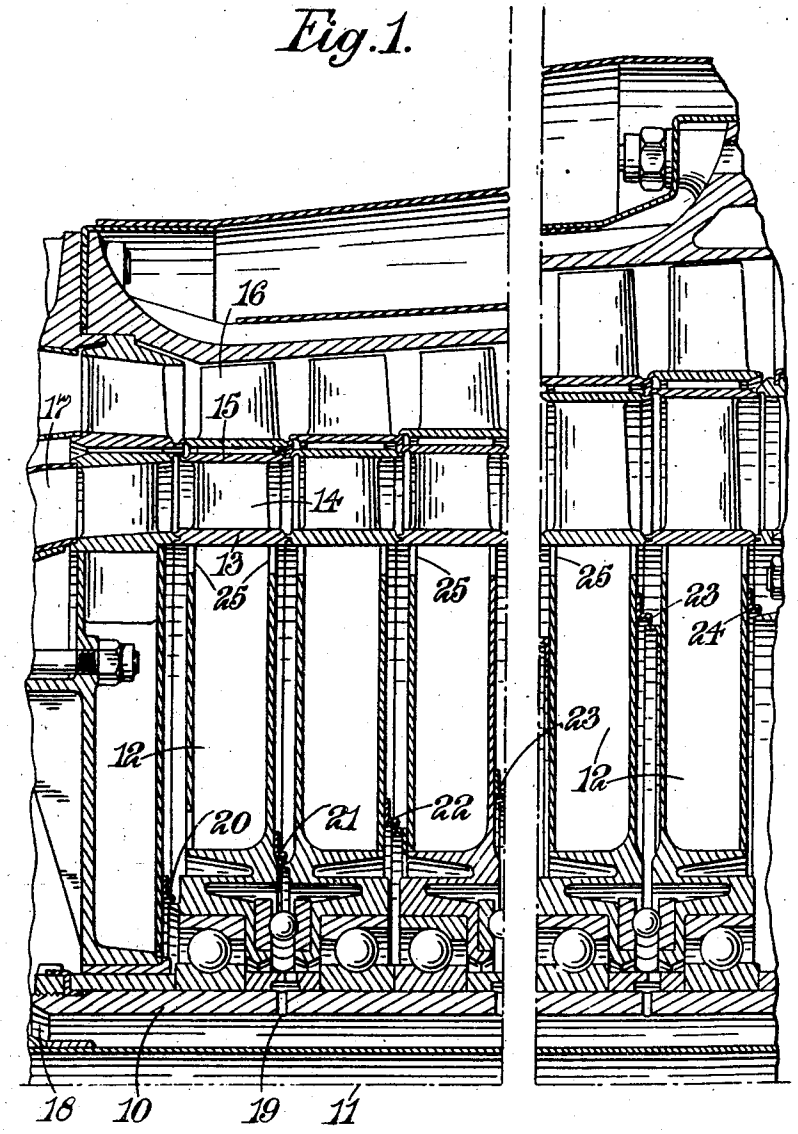
Oct. 28, 1947. A. A. GRIFFITH 2,429,681

THRUST BALANCING CONSTRUCTION FOR TURBINES, COMPRESSORS, AND THE LIKE

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Fig. 1.



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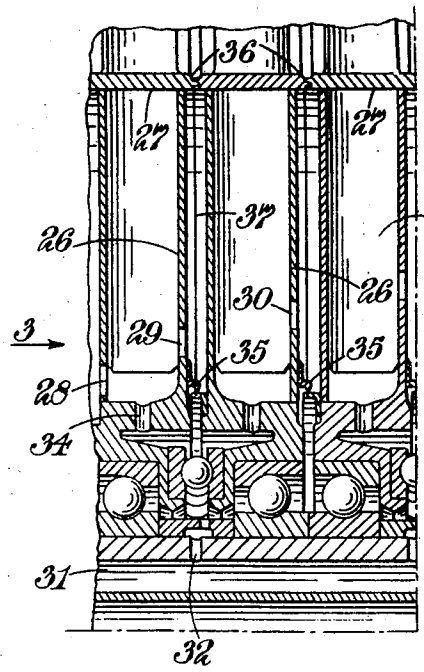
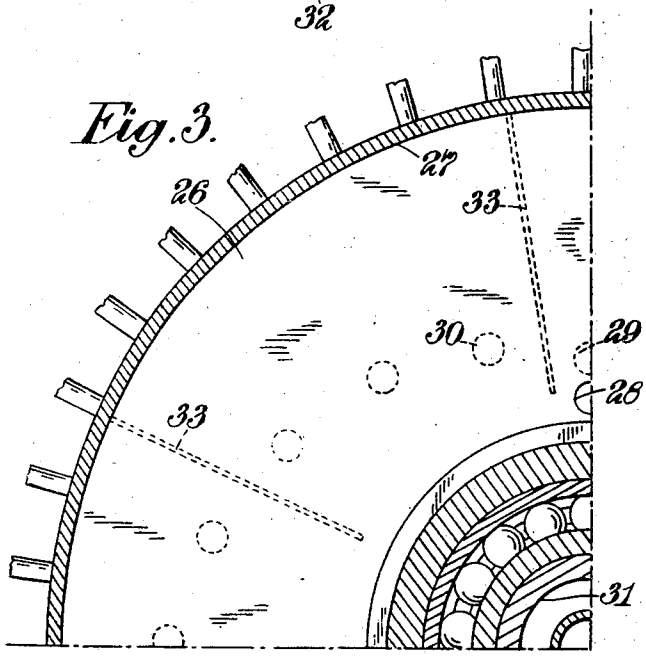


Fig. 4.

Fig. 3.



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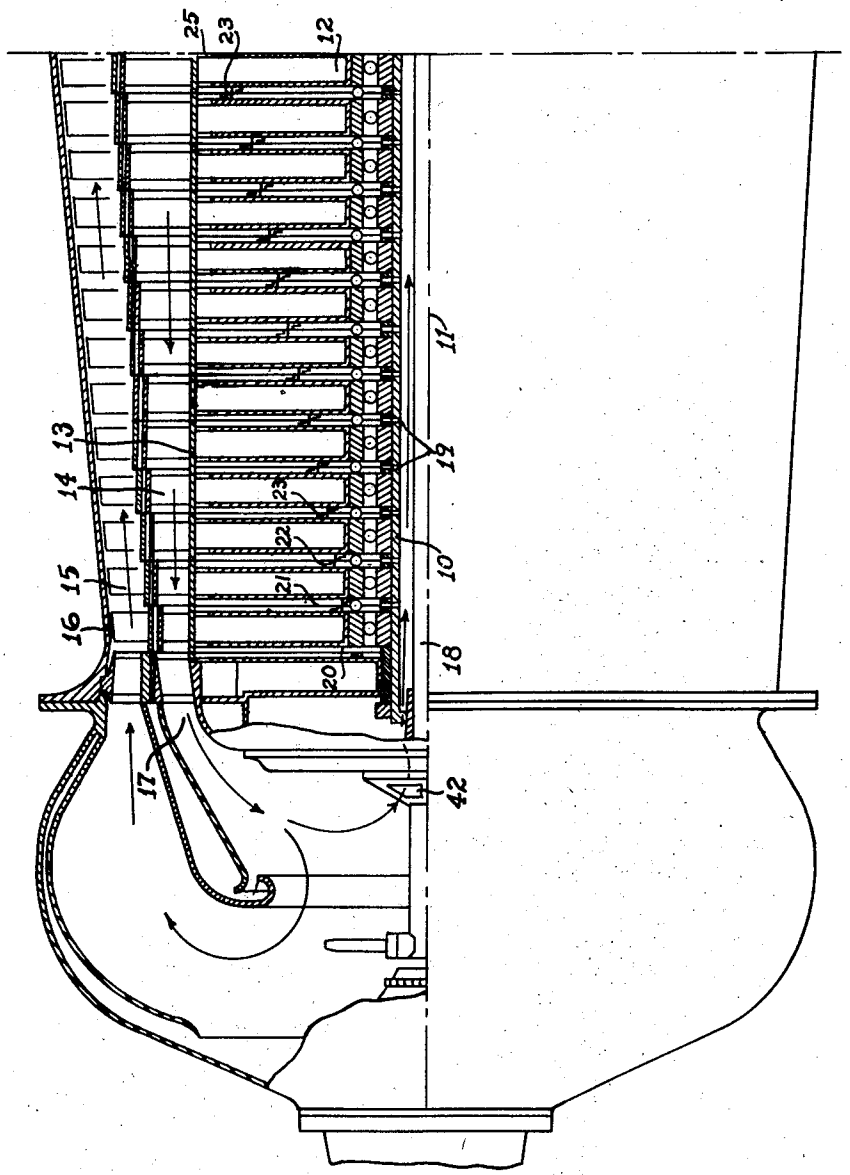


Fig 4

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2,429,681

THRUST BALANCING CONSTRUCTION FOR TURBINES, COMPRESSORS, AND THE LIKE

Alan Arnold Griffith, Derby, England

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Patent expires February 27, 1962

8 Claims. (Cl. 230—132)

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This invention concerns turbines, compressors and the like of the kind comprising separate rotor elements mounted to rotate individually on a stationary shaft, such for example as are described in the specification of British patent application No. 4699/1941, and has for its object to provide an improved means for balancing the axial end-load on the turbine-elements.

According to this invention there is provided in an axial turbine or compressor of the kind described, means for applying to opposite sides of a rotor element, or group of elements, a differential air-pressure-loading to balance the axial reaction-thrust of the blades.

The said air-pressure may be the same on both sides of the rotor, but applied to different areas thereof, or in an alternative arrangement different air-pressures may be applied to equal areas on each side of the rotor. It will be appreciated that different air-pressures and different areas may be used if it is desirable in any special circumstances.

When a uniform air-pressure is applied to different areas of the various rotor elements, this pressure is preferably taken from the delivery side of the compressor, and according to another feature of this invention when the pressure is applied to different areas on opposite sides of an element or group of elements, the remainder of the area is subjected to a datum pressure which may be any convenient value and derived from the appropriate stage of compression in the compressor.

In an alternative construction according to this invention each rotor, or group of rotors, may be hollow and provided with internal vanes to develop a static pressure internally of the rotor, which pressure varies with the density of the medium and the radial point in the rotor, for equal speeds, and two different pressures are applied to the two sides of the rotor element by openings in a rotor at the appropriate radial distance.

In the accompanying drawings,

Figure 1 is a half central section of a few rotor elements showing the invention applied thereto,

Figure 2 is a similar view showing such parts of the rotor element as are necessary to illustrate a modified construction.

Figure 3 is an end elevation looking in the direction of the arrow 3 in Figure 2, and

Fig. 4 is a diagrammatic view of a turbine-compressor incorporating the rotor elements of Fig. 1, the upper part of the figure being in section.

Referring first to the construction illustrated in Figure 1, a stationary hollow shaft 10, whereof

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the axis is shown at 11, has mounted upon it a series of rotor elements 12 each comprising a hollow disc-like member having a shroud-ring 13 around its periphery, on which there is secured compresssor-blades 14 for an axial compressor. The outer ends of these blades 14 are secured in a shroud-ring 15 which carries turbine-blades 16. The high-pressure gases driving the turbine-blades travel from left to right in Figure 1, provision being made for the expansion of the gases by the increased radial length of the blades 16, and these blades are arranged so that the alternate rotors 12 rotate in opposite directions, each rotor being mounted on the shaft by its own ball-bearing, with thrust-bearings interposed between the rotors as may be necessary. The compressor-blades 14 receive air at the right-hand end and, compressing it, deliver it at the left-hand end to a delivery passage 17, these blades being progressively shorter as the higher stages of compression of the air are attained. The compressed air passes from the passage 17 through a combustion chamber 40, in which fuel is burnt in it, to the inlet 41 of the turbine blades.

Since there is a reaction-thrust on both the turbine-blades and compressor-blades of each element, there is an axial load on each rotor-element, and this invention is concerned with the balancing of such a load. In the construction illustrated in Figure 1, high-pressure air as delivered at 17 from the compressor-blades passes through openings 42 and is taken in at the open end 18 of the shaft 10, and communication is established from the shaft through the bearing assembly by small openings 19 in the shaft to the spaces between the adjacent rotors.

Each rotor element is provided with a co-axial packing device by which it engages the adjacent rotor element so as to restrict the flow of high-pressure air from the interior of the shaft 10 to an area surrounding the shaft and closed by the shrouding 13. The left-hand rotor element 12 is provided with such a packing at 20 to engage the stationary end casing, and on its other side with a similar packing 21 engaging the adjacent rotor element 12. In order to provide the necessary differential air-pressure-loading on the first element 12, the packing 21 is situated at a larger radial distance from the axis 11 than is the packing 20 so that the high air-pressure is effective on the annular area defined by the two packings 20, 21. It will be appreciated that since the pressure between any two rotor elements is common to both of them, the packing devices have to be spaced at successively larger radii

along the series of elements as indicated at 22, 23, 24, to provide the necessary loading at the air-pressure which is available.

Although these packings substantially prevent any leakage of air, it is essential that the remainder of the area of each rotor element outside the packing should not be subjected to high air-pressure and, for this purpose, free communication is provided by openings 25, conveniently near the periphery of each rotor so that all the inter-rotor spaces are in communication with one another, and these spaces may be put in communication with atmosphere or any other steady air-pressure which is suitable; it may, for example, be the pressure developed at any particular stage in the compressor.

In the alternative construction illustrated in Figures 2 and 3, each rotor element 26 is constructed as a hollow annulus which is completely closed at its outer periphery 27 (except for the openings hereinafter described). Each element is provided in its interior with blades or vanes 33 which are disposed radially or in any other convenient manner so as to impart to the air within the rotor a rotary movement equal to the speed of rotation of the element. There is thereby developed within the rotor a centrifugal pressure-gradient, the pressure increasing with the radius. When it is desired to provide different pressures of air on the two sides of a rotor element, these pressures are derived from the air within the rotors by providing apertures at the appropriate radial distances which transmit the pressure at that point of the pressure-gradient to the space between adjacent rotor elements. Thus the left-hand rotor 26 has an aperture 28 to provide a pressure on the outside of that wall of the rotor equal to the pressure at that radial distance and it has an aperture 29 at a greater radial distance in the other wall to give a greater pressure of air to the space 37 between it and the next rotor element, so as to obtain the necessary differential air-pressure on the first element. Similarly, the next rotor element has an aperture 30 at a radial distance greater than that of the aperture 29, which provides for a higher air-pressure on the right-hand side of the second element than on the left-hand side. The whole series of rotors are therefore provided with apertures in their side walls at successively greater radial distances, as indicated in Figure 3, thereby providing differential air-pressures on each rotor element to balance the axial reaction-loading on it.

Leakage of air from between the rotors is reduced by providing suitable packings 35 between adjacent elements near their centres and also at 36 on their shroud-rings; these packings may be of any known or convenient form to reduce leakage but it will be appreciated that it is not essential entirely to prevent leakage since any leakage-flow assists in cooling the rotor elements. Cool air at a suitable pressure is admitted to the bearings to maintain them at a suitable temperature by openings 32 from the interior of the shaft 31 and this would escape through the seals to compensate for the leakage.

It will be appreciated that instead of balancing the reaction-thrust on each element individually, groups of two or more elements may be treated as a unit for the purposes of such balancing.

I claim:

1. In axial-flow turbines, compressors and the like, the combination of a shaft, a plurality of rotor disks rotatable independently thereon, a shroud ring on each disc engaging the shroud rings on adjacent discs, blades on said shroud rings subject to unbalanced reaction thrust, and means for applying axially to opposite sides of a disk within the shroud rings, a differential fluid-pressure-loading to balance the axial reaction-thrust of the blades.

2. In axial-flow turbines, compressors and the like, the combination of a shaft, a plurality of rotor disks rotatable independently thereon, a shroud ring on each disc engaging the shroud rings on adjacent discs, blades on said shroud rings subject to unbalanced reaction thrust, and means for applying axially to opposite sides of a group of disks within said shroud rings, a differential fluid-pressure-loading to balance the axial reaction-thrust of the blades.

3. In axial-flow turbines, compressors and the like, the combination of a shaft, a plurality of rotor disks rotatable independently thereon, a shroud ring on each disc engaging the shroud rings on adjacent discs, blades on said shroud rings subject to unbalanced reaction thrust, and means for applying axially to differential areas on opposite sides of a disk within said shroud rings an air-pressure-loading to balance the axial reaction-thrust of the blades.

4. In axial-flow turbines, compressors and the like, the combination of a shaft, a plurality of rotor disks rotatable independently thereon, a shroud ring on each disc engaging the shroud rings on adjacent discs, blades on said shroud rings subject to unbalanced reaction thrust, and means for applying axially to opposite sides of a disk within said shroud rings different air-pressures to balance the reaction-thrust of the blades.

5. In an axial-flow compressor having an air-pressure delivery, the combination of a shaft, a plurality of rotor disks rotatable independently thereon, a shroud ring on each disk engaging the shroud rings on adjacent disks, blades on said shroud rings, means for applying axially to opposite sides of a disk within said shroud rings a differential air-pressure-loading derived from the delivery of the compressor to balance the axial reaction-thrust of the blades.

6. In axial-flow turbines, compressors and the like, the combination of a shaft, a plurality of bladed rotor elements rotatable independently thereon, co-axial packings between adjacent rotor elements to define annular areas thereof and means for applying air-pressure to said areas on each side of a rotor element to balance the reaction-thrust of the blades.

7. In axial-flow turbines, compressors and the like, the combination of a shaft, a plurality of bladed rotor elements rotatable independently thereon, co-axial packings between adjacent rotor elements to define annular areas thereof, means for applying air-pressure to said areas on each side of a rotor element to balance the reaction thrust of the blades, means for applying a uniform pressure to both sides of all rotor elements over the area excluded by said co-axial packings.

8. In axial-flow turbines, compressors and the like, the combination of a shaft, a plurality of bladed rotor elements rotatable independently thereon, said rotors each being hollow and closed at its periphery, internal vanes in each rotor imparting rotary movement to the air therein and developing a radial pressure gradient, an opening in the side wall of a rotor to transmit the pressure developed at that radial distance in the rotor to the outer surface of that wall, whereby differential pressures derived from the said pressure

gradient are applied to the two sides of a rotor element or group of elements to balance the reaction load on it.

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