May 9, 1950 C. H. ZIMMERMAN 2,507,079

ABRADING MECHANISM

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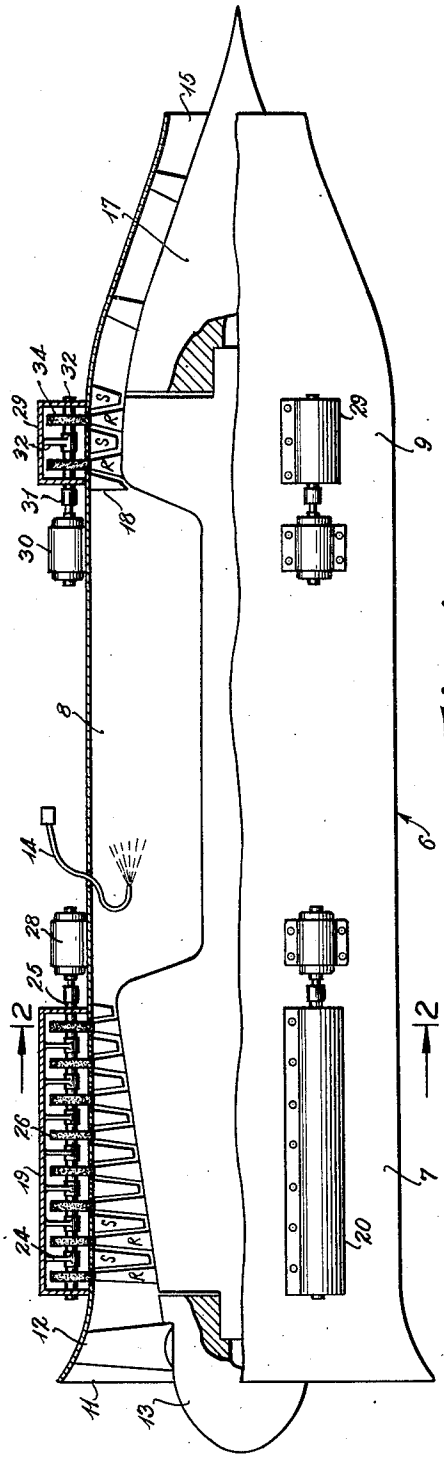


Fig. 1.

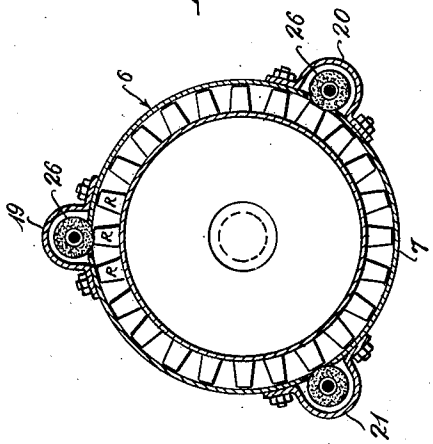


Fig. 2.

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Fig. 3.

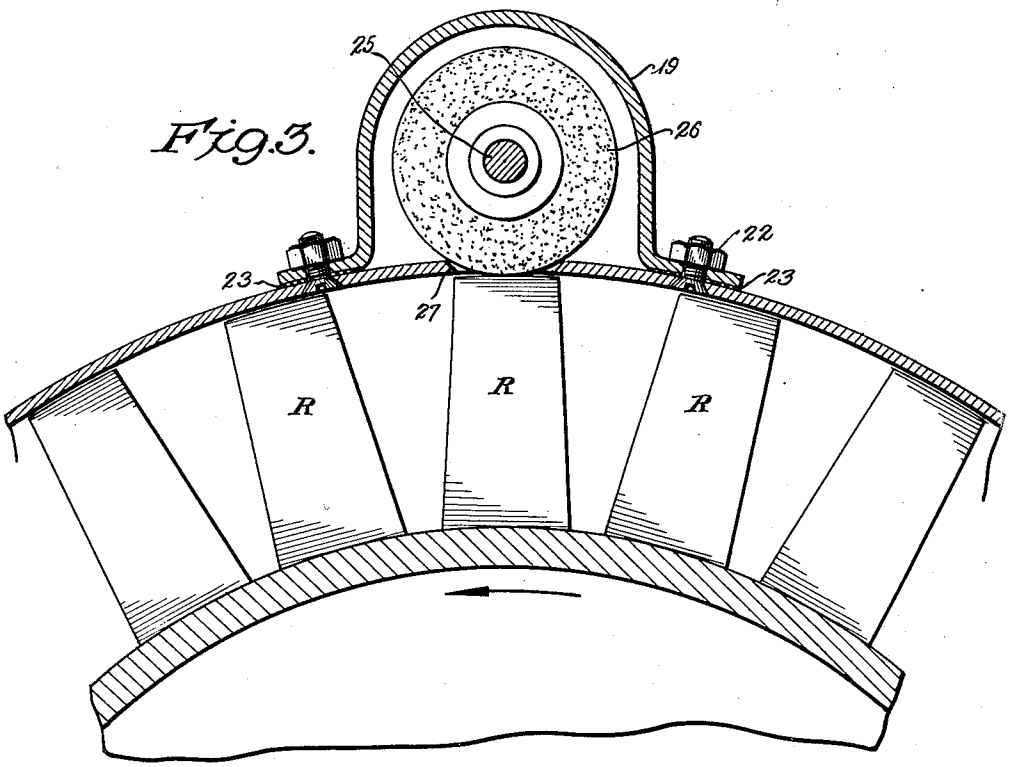


Fig. 4.

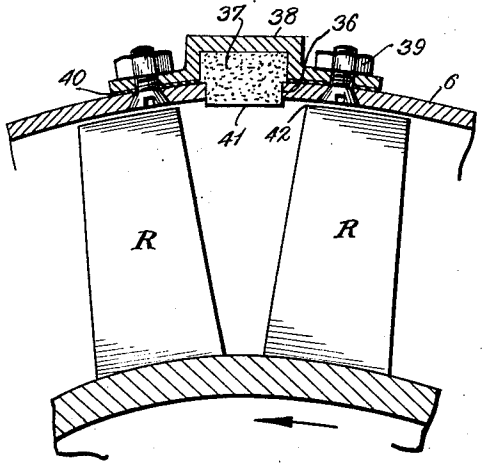
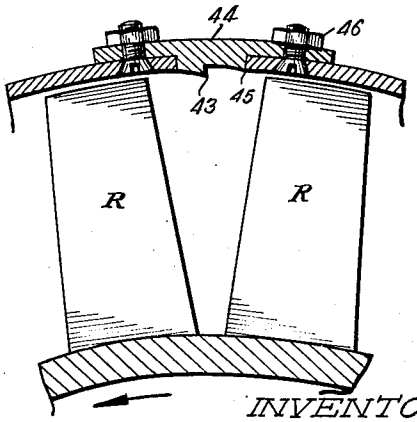


Fig. 5.



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ABRADING MECHANISM

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5 Claims. (Cl. 253—1)

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This invention relates to abrading means for enclosed rotor elements, and more particularly to abrading means permanently associated with the casing of a machine such as a turbine unit for producing and maintaining a predetermined clearance between the rotary element of the turbine and its surrounding casing.

It has long been recognized in the use of turbines, compressors or the like having heavy rotors that it was important to maintain minimum clearance between the rotor element and its surrounding casing. Consequently it has been the practice, when the rotor—due to bearing wear or other factors—is caused to hit the casing, to open the casing and grind away the periphery of the rotor so as to prevent it from striking the casing, and yet to maintain a minimum amount of clearance sufficient to assure efficiency of operation. Such grinding operations were time consuming and necessitated putting the units out of action for considerable periods. Since the clearance factor was not as critical as it might have been, the practice has long been followed. With the advent, however, of modern gas or jet turbines such as are used in high speed aircraft, it is recognized that the efficiency of such units is very dependent in most cases upon the maintenance of an extremely small clearance between the tips of the rotor blades and the stationary casing. This not only requires the closest tolerances in manufacture, but necessitates difficult servicing operations to maintain that clearance when the rotor strikes the casing. This striking may be due to bearing wear or to distortion of the casing due to uneven heating, but, most important of all, due to creep of the rotor blade material due to the high stresses which it encounters at the high temperatures characteristic of the operation of gas turbines or jet engines.

The present invention is therefore concerned in providing means permanently carried by the machine casing for abrading the tips of the rotor blades whenever, due to any cause, they assume a position which causes them to strike the casing. This means abrades the surfaces which project too far, and by proper positioning of the abrading means the minimum clearance for most effective operation can be maintained permanently without dismantling the turbine structure, and even without stopping it, to perform this grinding or abrading operation.

It is to be understood that this invention is capable of application to a turbine of any type or to a similar machine which is subject to the

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difficulties herein stated. However, for purposes of illustration, the invention will be described in connection with a modern unit composed of an axial-flow compressor and a gas turbine of the type used in jet propulsion of aircraft but without any limitation to that particular type of apparatus. It is chosen for purposes of illustration because it presents in its most acute form the problem to which this invention is addressed.

Referring now to the drawings,

Fig. 1 is a side elevation, partly in vertical section, of a combined axial-flow compressor and turbine unit showing rotatable abrading means of the present invention attached thereto.

Fig. 2 is a vertical section on line 2—2 of Fig. 1 showing the position of the various abrading means with respect to the tips of the rotor blades.

Fig. 3 is an enlarged detail of one of the abrading devices shown in Fig. 2.

Fig. 4 is a view similar to Fig. 3 showing a modification of the invention in which the abrading means is a stationary abrasive block element carried by the casing.

Fig. 5 is a view similar to Fig. 4 showing still another modification in which the abrading means takes the form of a fixed cutting blade carried by the casing.

Referring now to Fig. 1 of the drawing, reference character 6 designates the casing of an axial-flow compressor-turbine unit of known type. This elongated hollow casing, details of which are not important to the present invention, carries at its forward or inlet end a compressor unit designated generally as 7, communicating through the inside of the casing with a combustion chamber 8 and a turbine unit 9. The inlet end of the unit comprises the usual bell-shaped mouth 11 supporting through a spider 12 the bearing 13 of the main shaft which carries the rotor of the compressor and that of the turbine. Means designated 14 are provided for supplying a jet of fuel to the combustion chamber 8 where it mixes with the compressed air, is ignited, and passes to the turbine, whence it is discharged through the outlet at 15, said outlet having the usual conical form employed in jet propulsion.

The compressor unit comprises the usual structure for directing the incoming air in proper direction, through the alternating rotor and stator blades designated R and S respectively. The rotor blades are carried by the shaft of the machine, which shaft is supported in bearing 13

at the compressor end and in the member 17 adjacent the discharge end of the unit, and carries the rotor of the turbine in accordance with usual practice. The turbine unit also includes the nozzle ring 18 which directs the flow of hot gas and air through the blades of the turbine, these rotor and stator blades being designated, as in the case of the compressor, R and S respectively. Since the details of these blades are not important to the present invention, they are shown diagrammatically and a brief description will suffice.

It will be apparent from what has already been said that in accordance with usual practice in starting the unit, the rotor shaft will be rotated so as to draw air through the inlet 11 where it passes between the rotor and stator blades, is compressed and enters the combustion chamber 8 into which liquid fuel is injected by the means 14. In this chamber the mixture is ignited, by means of a sparkplug in starting, and then subsequently by the heat of combustion, and expands and escapes with great velocity through the nozzle ring 18 and through the blades of the turbine, whence it is discharged along with excess air through the outlet 15 so as to produce a high speed propelling jet. This is merely a brief description of the general operation of devices of this sort. They are characterized by the fact that the tips of the rotor blades must be maintained in close proximity to the inside of the casing so as to obtain maximum effect from the gases supplied to the turbine. Since these units operate at extremely high temperatures, there is a definite tendency on the part of the rotor blade to expand and to contact the inside of the casing. Inasmuch as the rotor operates at extremely high speed, it is obviously essential that this striking be prevented, and yet the blade tips not be ground away sufficiently to cut down upon the efficiency of the machine by providing too great clearance.

In accordance with the present invention it is proposed to mount permanently in connection with each rotor one or more abrading elements capable of independent rotation, or capable of abrading by contact with the rotating rotor, so as to maintain the clearance at a proper value without attention on the part of the machine operator, or at least without dismantling the machine to perform the grinding or abrading operation.

Referring again to Fig. 1, where one proposal is illustrated, there are disposed on the periphery of the casing 6, at the end adjacent the compressor 3, abrading units 19, 20, and 21. As here shown, these units are spaced 120° apart in order to maintain symmetrical clearance throughout the peripheral extent of the rotor. Such an arrangement would be desirable, for example, in a unit which assumes in use several different positions as in aircraft. Were the unit a stationary power plant, it is possible that a single abrading unit might be sufficient to maintain desired clearance, and in such a case it would probably be placed at the bottom of the casing where the clearance reduction would be most pronounced due to bearing wear. As shown, each of these units comprises a casing bolted as at 22 (Fig. 3) to the periphery of the casing 6. In order to seal the connection between the abrading chamber and the inside of the turbine, gasket means designated 23 may also be provided and may also serve as shims. Rotatively mounted within this casing and carried in spaced bearings 24 is a shaft 25 carrying a plurality of abrading wheels 26 fixed thereon and projecting through openings 27 in the periphery of casing 6. The shaft 25 is coupled to a driving means such as an electric motor 28, one motor being provided for each set of grinding wheels, that is, for each of units 19, 20 and 21. In the illustration, therefore, a separate driving means for the abrading wheels is indicated, but it is obvious that they may be driven through suitable connection with the rotor shaft or through a small turbine within the casing 28 and supplied with propulsion fluid from the combustion chamber 8. Inasmuch as the units may be identical, a description of one of them is believed to be sufficient. These abrading means may be driven whenever it is apparent that the rotor blades are striking the casing or the grinding means may be run at predetermined intervals in order to insure maintenance of proper clearance and without waiting for it to reach a dangerous and undesired minimum. Furthermore the units may be employed to grind the rotor blade tips to proper clearance during assembly of the machine. In this way it will not be necessary to reduce the rotor blades to the precision which would normally be required, but after a mere rough grinding they may be mounted in the casing and then ground down to proper clearance by the abrading means on the casing.

As shown in Fig. 1, the turbine unit which is particularly vulnerable to the action of the high temperature gases, is provided with an abrading unit similar to that already described. This unit designated 29 includes a driving motor 30, coupled to a shaft 31 mounted in bearings 32 and which shaft carries abrading wheels 34. As indicated, there is a set of three abrading wheels, as in Fig. 2, disposed at 120° intervals around the periphery of the turbine, and one set of wheels is provided for each set of rotor blades as indicated. The driving means 30 may be similar to that described in connection with 28 and it may be an electric motor, a small turbine, or other means driven from the rotor shaft of the unit.

Referring now especially to Fig. 3, it will be seen that the abrading wheel 26 may be so disposed as to provide a proper clearance between the tips of blades R, and the casing. Whenever there is an indication that the clearance is too small or that there is no clearance, the abrading device may be run for a short period sufficient to restore the clearance to its proper value. Inasmuch as wearing away of the abrading wheel 26 will change its position, it will in practice be advisable to provide some means for adjusting the position of shaft 25 to compensate for this wearing of the abrading wheel, and the provision of such means is contemplated by this invention. For example, the sealing shims 23 may perform this function.

While it has been indicated above that a rotating abrading means is used, it is contemplated within the scope of the present invention to provide fixed means carried by the casing for maintaining proper clearance. One form which may be adopted is that shown in Fig. 4 where the opening 36 in the casing 6 is adapted to receive a block of abrading material 37 held in a suitable carrier 38 bolted over the opening in the casing by means 39. There again the casing may be sealed against the escape of gas by the provision of sealing shim 40. It will be understood that in the practice of the invention using the device of Fig. 4, the inside face 41 of the abrading material will be so disposed as to provide proper

blade clearance between the casing and the tip of a blade, for example, 42. Then as the rotor rotates this clearance will be automatically maintained without attention on the part of the operator. When the abrading material 37 becomes worn away, a new block may be substituted. It is obvious also that while Fig. 4 shows but a single one of these abrading blocks, a plurality of them may be provided disposed at 120° intervals as shown in Fig. 2, or a greater number than three may be provided if this is necessary.

Fig. 5 is a view similar to that of Fig. 4 showing a further modification in which the abrading means takes the form of a hardened metal cutting blade 43 carried by a plate 44 bolted over the opening 45 in the casing and held by bolts 46. Any desired number of these means may be provided and they may be positioned to maintain proper clearance. The operation of the arrangement shown in Fig. 5 is similar to that already described in that it performs its function automatically without attention on the part of the operator and without manipulation of any outside driving means.

It is to be understood that in practicing this invention it is not necessary that the turbine unit be of the gas type or that the particular abrading means disclosed be employed as the device is of general utility and may be applied to the grinding away of rotor tips in any turbine where it would be useful, and by any suitable abrading means permanently carried by the casing.

Having thus described my invention, what is claimed is:

1. In combination a turbine having a casing, a rotor mounted in said casing, blades on said rotor, and at least one abrading unit disposed on the outside of said casing and extending through an opening in said casing for abrading the peripheral surfaces of said blades when they become deformed sufficiently to strike the interior of said casing.

2. In combination a turbine having a casing, a rotor mounted in said casing, blades on said rotor, and a plurality of removable abrading units disposed on the outside of said casing at peripherally displaced points, said units being accessible from the outside of said casing and extending through openings in said casing for abrading the peripheral surfaces of the blades when they strike the interior of said casing.

3. In combination a turbine having a casing, a runner rotatably mounted in said casing and having blades thereon, and rotatable abrading means mounted on the outside of said casing and extending through said casing for engaging and abrading the peripheral surfaces of said blades when they become deformed sufficiently to engage the interior of said casing.

4. In combination a turbine having a casing, a runner rotatably mounted in said casing and having blades thereon, rotatable abrading means mounted on the outside of said casing and extending through said casing for engaging and abrading the peripheral surfaces of said blades when they become deformed sufficiently to engage the interior of said casing, and a motor for driving said abrading means.

5. In combination a turbine having a casing, a runner rotatably mounted in said casing and having blades thereon, a plurality of rotatable abrading wheels mounted at spaced points around the periphery of said casing and extending therethrough, and motor means for driving said abrading means to abrade the peripheral surfaces of said blades when the runner becomes deformed sufficiently to strike the interior of said casing.

CHARLES H. ZIMMERMAN.

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