Feb. 22, 1949. G. K. W. BOESTAD ET AL 2,462,600

TURBINE

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Fig. 1

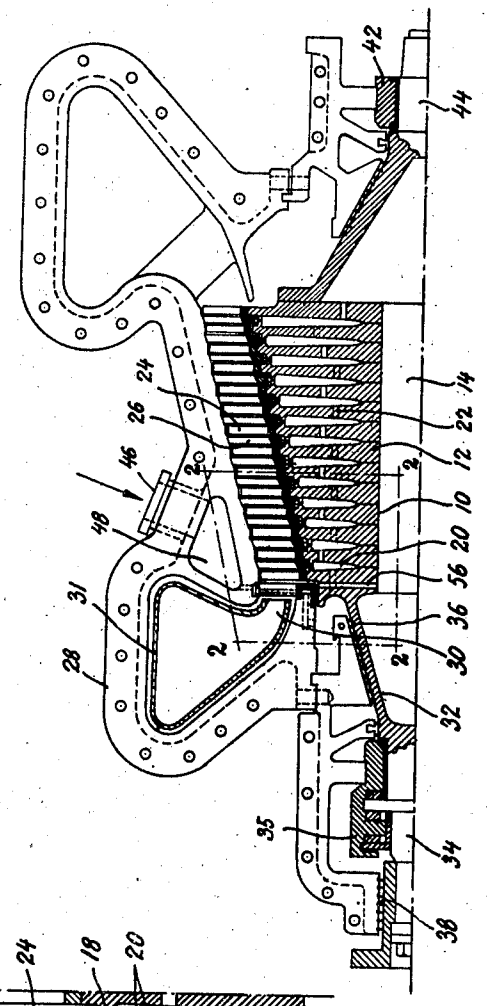
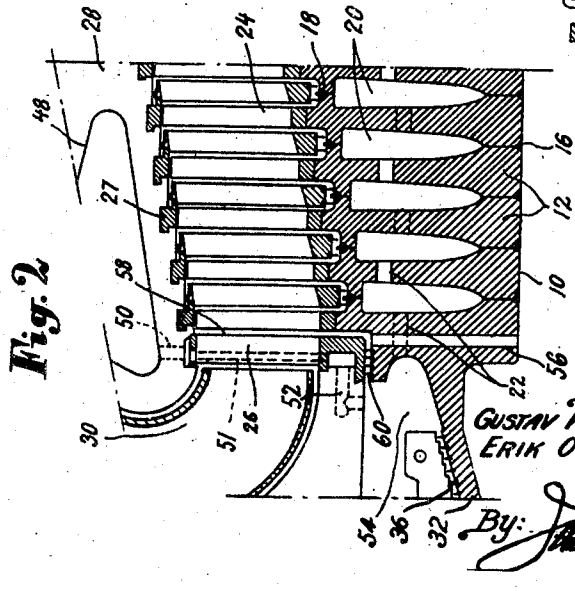


Fig. 2



Inventors:
GUSTAV KARL WILLIAM BOESTAD,
ERIK OTTO ERIKSSON.

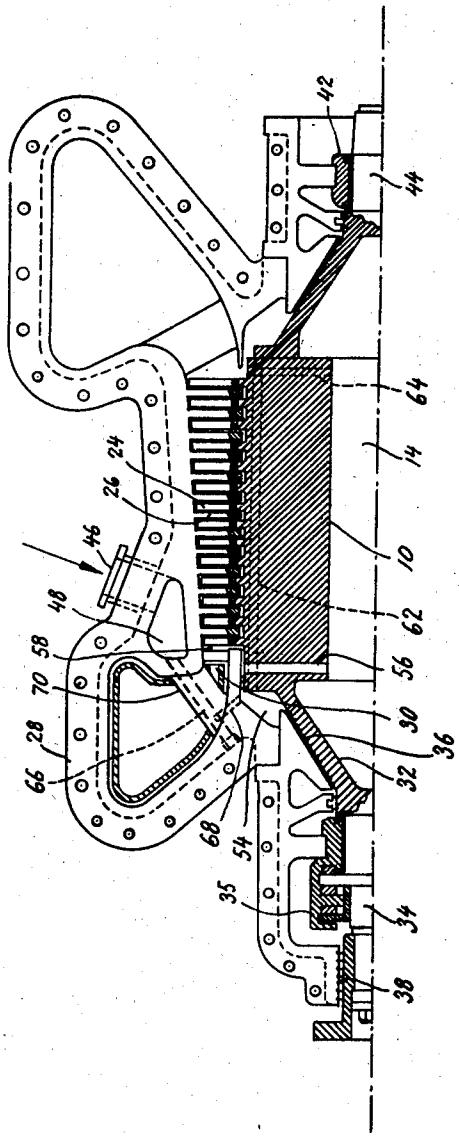
By: Jarvis C. Marble
Attorney

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Fig. 3



Inventors:
GUSTAV KARL WILLIAM BOESTAD,
ERIK OTTO ERIKSSON

By: David C. Mabee
their Attorney.

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2,462,600

TURBINE

Gustav Karl William Boestad and Erik Otto Eriksson, Lidingo, Sweden, assignors, by mesne assignments, to Jarvis C. Marble, New York, N. Y., Leslie M. Merrill, Westfield, N. J., and Percy H. Batten, Racine, Wis., as trustees

Application November 10, 1943, Serial No. 509,800
In Sweden January 16, 1943

3 Claims. (Cl. 60—41)

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It is known in gas or steam turbines operating with hot driving media to use steel the strength of which is comparatively good even at high temperatures. In particular, so-called austenitic steels are brought into consideration for this purpose. These steels, however, have coefficients of heat expansion about 50% greater than those of martensitic steels, and furthermore a heat conductivity which is much lower than that of such steels. These circumstances contribute to the fact that in the known constructions with austenitic steel it will be found difficult, for instance in gas turbines, to maintain the small clearances between their rotating and stationary parts which are necessary particularly in gas turbines of the reaction type in order to maintain a good efficiency. The heat conductivity of the material has the effect that a low rate of heat conductivity involves large temperature differences bewteen the various parts of the turbine when the temperature of the gas is changed, which frequently takes place rapidly when the turbine is started or stopped. Particularly when the turbine is brought to a stop, the rotor thereof will keep warm for a longer time than the remaining parts, and when the turbine housing is cooled down and contracts, the clearances may be taken up to a high degree, if the heat conducting capacity of the material is low. Even with a temperature difference of only 200° C. and with a diameter of the blade rim of 1 metre, the difference in heat expansion between the housing and the rotor will be above 3 millimetres with austenitic steel.

This object of the invention is to improve turbines of the above mentioned kind, so that the favourable properties for instance of austenitic steel may be fully utilized. This is accomplished substantially by the fact that the blades of the turbine consist, entirely or in part, of a material of great heat resisting properties, and that the rotor is made from another material having a lower coefficient of heat expansion than that of the first-mentioned material, the turbine being provided with means for cooling the rotor. The rotor is preferably of a material having a higher heat conductivity as well as a lower coefficient of heat expansion than the blades. The blades may be made from austenitic steel, and the rotor and the housing may be made from steel of the martensitic type, which is comparatively cheap and has a low coefficient of heat expansion. The blades occupy a relatively small portion of the radial extent of a turbine, by reason of which the greater heat expansion on the part of the blades is of no practical importance. Add to this that the surface of the blades is so large relative to the weight of the material thereof and relative to the coefficient of heat transfer at the surface, that the blades will under all

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circumstances rapidly follow any change in the temperature of the driving medium. This produces the result that the greater coefficient of heat expansion of the blades, when the turbine is stopped, aids in increasing the clearances between the blades and the housing, which is an advantage. The average stress in a blade will alawys be comparatively low, and for this reason it will be less important to provide cooling of the blade in consideration of the shrinkage of the blade material. By the fact that the rotor is cooled and is made from steel having a good heat conductivity, it will be kept at a temperature at which it is still in possession of its good strength properties. Moreover, the disadvantages of expansions of different sizes with respect to the rotor and the housing at changes in temperatures are obviated to a great extent.

The invention will be described more fully hereinafter with reference to a few forms of embodiments illustrated by way of example in the accompanying drawings.

Fig. 1 is a horizontal view, partly in section, through a gas turbine constructed according to the invention.

Fig. 2 shows the portion of the turbine framed by the lines 2 in Fig. 1, on an enlarged scale.

Fig. 3 shows a gas turbine according to a further embodiment and in the same view as in Fig. 1.

In Fig. 1, 10 designates generally a rotor, which is composed of a number of turbine disks 12, the inner diameter of which is spaced from the axis of rotation, so that an inner axial passage or bore 14 is formed. The disks 12 are connected with one another, preferably through welding, both at the inner and at the outer peripheral portion thereof, as indicated at 16, 18 (Fig. 2). The intermediate spaces 20 provided between the turbine disks, which spaces extend nearly out to the blade attachments, are thus sealed from the surrounding ambient atmosphere. The turbine disks 12 are provided with axial passages 22, which are disposed alternately on different radii, and are adapted to connect the various spaces 20 with each other.

The disks 12 of the rotor carry blades 24 which are arranged, together with guide blades 26 secured in the turbine housing 8, in a passage 30 having the gaseous working medium flowing therethrough. The outermost turbine disk 12 on the left hand side in Fig. 1 (the high pressure side of the turbine) may, over a preferably conical portion 32, be made integral with a shaft 34 cooperating in known manner with radial and axial thrust bearings 35 secured in the turbine housing. Provided between the portion 32 and the shaft 34 are packing members 36 and 38, respectively, on both sides of the bearings 35. The outermost disk 12 on the opposite side of the

rotor is connected with a shaft 44 mounted in bearing 42. A small portion of the working medium of the gas turbine plant, such as the air compressed by a compressor forming part of said plant, may be conveyed through an inlet 46 to an annular chamber 48 in the housing 28 and thence through passages 50 and through channels 51 in the first guide blade rim 26 at the high pressure end of the turbine to passages 52 opening into a space 54 on the left hand side of the disk 12 in the drawings. From the space 54, the cooling air flows through the passages 22 to the spaces 20 in the rotor, a relative rotary movement being thus produced between the cooling air and the walls of the turbine disks, so that high coefficients of heat transfer are obtained. The cooling air then enters the passage 14 closed at both ends, and continues through a radial passage 56 in the first turbine disk 12 at the high pressure end of the rotor, whereupon the cooling air is introduced into the clearance 58 behind the first guide blade rim 26 so as to be taken up by the current of driving medium flowing through the passage 30. The clearance 58 is separated from the space 54 by means of packings 60.

The cooling air is taken out at such a point on or behind the compressor that at the entrance into the interior of the rotor it has a pressure which is somewhat higher than the pressure in the clearance 58.

The rotor 10 and the disks 12, respectively, are made from a steel which is comparatively cheap, possesses a good heat conductivity and a low coefficient of heat expansion. Such steels are for instance those of the martensitic type. A suitable steel of this kind has a comparatively small percentage of chromium, that is to say 0.75–2.5%, while the percentage of molybdenum amounts to 0.3–1%. The blades 24, on the other hand, are, at least on the high pressure side of the rotor, made from a more expensive steel, having very great heat resisting properties, primarily from an austenitic steel having a high percentage of nickel and chromium and preferably also containing tungsten. A steel of this type withstands, for instance at 600° C., a stress of 4 kilograms per square millimetre, without creeping or expanding permanently by more than 1% of its length in 100,000 hours.

The turbine housing 28 is preferably made, entirely or in part, from the same material as the rotor 10, or from a material equivalent thereto as far as the coefficient of heat expansion is concerned. The guide blades 26 may be secured in rings 27 (Fig. 2), which are made from the same material as the blades 24. These rings, which are inserted into the housing 28, have a greater extent in axial direction than the guide blades, so that they will, approximately at least, form the outer bounding wall of the passage 30 so as to protect the housing against the hot working medium flowing through the passage. Inasmuch as they have, in addition thereto, a heat expansion capacity lower than that of the housing, they will exert a braking effect on the flow of heat to the housing. Aiding in this is also the fact that the portion of the rings 27 in which the guide blades are secured has little thickness and is spaced from the wall of the housing. A sheet metal partition 31 may be provided in known manner in the inlet of the turbine, said partition having a cooling medium flowing over it on the outside, such medium preferably consisting of air taken from the compressor and having a lower temperature than that of the working medium inside said wall.

By making the various parts of the turbine from such materials, combined with the cooling of the rotor, which may be effected in the manner above described, the advantages already described will be gained.

The embodiment according to Fig. 3 differs from the preceding one substantially only in that the rotor 10 is made with an integral blade-carrying member. This member is provided with axial passages 62 for the cooling air extending therethrough, which are situated outside the average radius of the rotor and near the points of attachment of the blades 24. The passages 62 are not through-passages at the right hand end of the rotor 10 in the drawing, but communicate through radial passages 64 with the central passage 14. The cooling air is conveyed from the annular space on bore 48 to the space 54 through passages 66, 68 in reinforcing members 70 located in front of the first guide blade and in the housing 28, respectively. To increase the coefficient of heat transfer in the passages 62, it is possible to lead the cooling air into the same, so that it will attain a rotary movement at a higher velocity than corresponding to the average velocity in the passage. The same effect may be attained by means of insertions in the passages, so devised that the area of the passage is reduced, without the cooling surface being diminished.

While different embodiments of the invention have been shown, it is to be understood that these are for purpose of illustration only, and that the invention is not to be limited thereby, but its scope is to be determined by the appended claims.

What we claim is:

1. In a turbine, a rotor having a blade carrying structure and blades carried by said structure, said blades and said blade carrying structure being of different materials, the blade material being an austenitic steel and the material of the blade carrying structure being a martensitic steel, and means for cooling the blade carrying structure of the rotor.

2. In a turbine, a rotor having a blade carrying structure and blades carried by said structure and a housing structure around said rotor, said structures being constructed of martensitic steel and said blades being constructed of austenitic steel and means for cooling the blade carrying structure of the rotor.

3. A turbine as set forth in claim 2, in which the housing structure carries guide blades extending between the rotor blades and in which the guide blades are secured in rings of austenitic steel.

GUSTAV KARL WILLIAM BOESTAD.
ERIK OTTO ERIKSSON.

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