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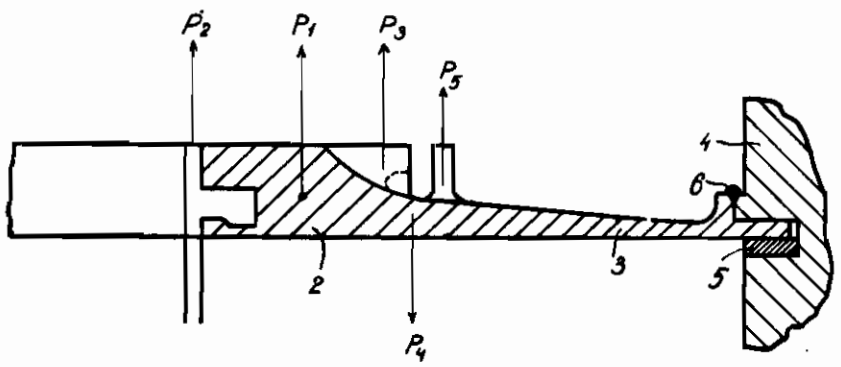

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This invention relates to the fixing of blade rings for centrifugal machines with radial admission of the working fluid, particularly for steam turbines.

The two main constructional parts of a steam turbine with radial admission of the working medium, i. e., blade ring and disc represent bodies having an entirely differing mass and surface so that these parts when heated, cooled or deformed by external mechanical forces, for instance, by the centrifugal force react in a different manner. For instance, the ring with its small mass and large surface when heated expands quicker than the disc. If a rigid connection would be used between the ring and the disc, such high stresses would result owing to the difference in expansion that the material cannot absorb the same without damaging its texture, so that a rigid connection between the ring and disc must be avoided and such constructions must be used as to permit a free and independent expansion of the ring and disc.

According to the German Patent Nr. 237,541 this connection is obtained by the fact that between the blade ring and the disc, thin-walled cylinders are inserted whose thickness is so chosen that, on the one hand, a transfer of heat between the blade rings and the disc is prevented to a considerable extent and that, on the other hand, the blade ring when being deformed is as far as possible free to expand. However, in this case such considerable bending stresses occur in the cylinder-shaped connecting piece with increasing enlargement that the material can no longer take up the stresses. To meet this requirement the cylinder-shaped ring must be slotted, so that its cross-section is weakened, whereby the tangential stresses are so to say split up. Besides other drawbacks the slotting of the ring may present the great disadvantage in that the structure is no longer steam-tight.

The other possibility of providing a joint between the blade ring and the disc as free as possible is the kidney-shaped intermediate ring employed by Ljungström and which has given satisfactory results in a large number of turbines. This intermediate ring is, however, capable of being improved, insofar as it presupposes a bead joint. Such joints not only cause a stressing of the material beyond its yield point but also easily bring about a non-circular cross-section of the ring. In this case either the faults caused by the out of balance must be put up with or a rather complicated balancing method must be employed in order to ensure a smooth running of the turbine. From the manufacturing and operating point of view, the joint according to the German Patent 237,541 would therefore be preferable, provided that it would be possible to eliminate the faults inherent in the joint. The problems resulting therefrom are solved according to the present invention.

If the conditions presented when fixing the blade ring according to the German Patent 237,541 are investigated, it will be found that the moments which occur in the connecting ring between the blade ring and disc as a result of the enlargement of the blade ring are very great at the point where the blade ring is fixed but then decrease relatively rapidly in the form of a hyperbole. The material is therefore highly stressed at the point where the blade ring is fixed, whereas the other part of the cross-section is only subjected to relatively small stresses. As already mentioned above the high stresses have been reduced by slotting the ring. The abovesaid drawbacks may be removed according to the invention by arranging that the entire cross-section be as far as possible uniformly stressed, for if the entire blade ring were so dimensioned as to take up the maximum stress and would be left not slotted, this would not remove the abovementioned drawback, since the ring would have to be so amply dimensioned that a rigid connection between the ring and disc would result which would not meet the desired requirements. The resiliency of the ring which enables the free expansion of the blade ring with respect to the disc must therefore be retained. This may be accomplished according to the invention if the cross-section of the intermediate ring connecting the blade ring with the disc is given a height which decreases towards the point where the ring is secured to the disc, the cross-section being preferably of the triangular form. As already mentioned above the moment curve is similar to that of a hyperbole. Accordingly also the contour line of the cross-section is adapted to the moment curve. It is then possible without slotting the intermediate ring to absorb all stresses without overstressing the material and to utilize at the same time the material of the intermediate ring in a most favorable manner, since its entire cross-section or a substantial portion thereof is uniformly stressed.

According to the invention it is possible to design such an intermediate ring in a manner as has hitherto been done in connection with other proposals. In the case of a revolving disc the centrifugal force acting thereon has its point of

application in the center of gravity of the blade ring. The centrifugal force tends to shift outwardly the center of gravity of the blade ring cross-section, i. e., the intermediate ring integral with the blade ring is enlarged to a certain extent in the form of a funnel. In the same direction in which acts the centrifugal force of the blade ring, acts also the centrifugal force resulting from the blades and which therefore causes the intermediate ring to enlarge to a further extent. Consequently, the blade ring has the tendency to assume an inclined position. In this manner difficulties may arise in maintaining the clearances between the blades, for it is assumed that the sealing clearance has a cylindrical but not a conical form. By applying additional weights to the blade ring or to the intermediate ring or to both, moments may be produced which more or less balance the moments resulting from the two centrifugal forces mentioned above. When selecting these balance weights, the fact must be still considered that the shearing force produced by the enlargement of the intermediate ring produces a moment which opposes the enlargement. Under circumstances it may be necessary to consider this moment when determining the balance weights.

As already mentioned above this form of the invention is based on the proposals which have been made in another connection, as is described in the German Patent 512,883. When fixing the blades according to the Ljungström with the aid of kidney-shaped intermediate rings as mentioned above, the blade centrifugal force whose point of application is in the center of gravity of the blade causes a twisting of the cross-section of the blade ring about its center of gravity, i. e., the blade with its support assumes than the form of an arc. To straighten the cross-section of the support ring it has been proposed in this publication to employ additional masses whose centrifugal forces produce moments in the ring which balance the moments produced in the rings by the centrifugal forces of the blades and acting in the opposite direction. However, this refers as mentioned above only to such blades which are secured between two ring groups hingedly connected to the turbine discs, whereas the present invention is based on the fact that the blade ring ends in a thin tubular portion which is secured to the disc.

An embodiment of the invention is shown in the accompanying drawing in diagrammatic form.

The blades 1 of a steam turbine with radial admission of the working fluid are firmly held in position by the support ring 2 which ends in a tubular portion 3. The latter is firmly secured to the disc 4 by means of a caulking joint 5 and is prevented from being displaced by a weld joint 6. The centrifugal force P_1 is applied to the center of gravity of the support ring 2 and causes an enlargement of the ring 3. The rim force P_2 produced by the blades acts in the same direction. As a result of the rigid connection between the support ring 2 and the tubular portion 3, shearing forces P_4 are produced in the latter which tend to retain the ring 2. In view of the very high stresses to which the intermediate ring 3 is subjected the tubular portion 3 is not given a cylindrical shape as has hitherto been proposed but its cross-section decreases as shown in the drawing from the ring to the disc. In order to prevent the blades 1 from assuming an inclined position, balance weights are provided which produce the balance forces P_3 and P_5. In this case the force P_3 balances the forces P_1 and P_2, whereas the force P_5 balances the force P_4. The representation of the balance weights is purely diagrammatic. It is not necessary that two balance weights be provided. The two weights may also be combined to a single mass. It is also not necessary to arrange the balance mass as shown in the drawing.

The above considerations on the revolving disc of a steam turbine with radial admission of the working fluid apply also to other centrifugal machines with radial admission of the working fluid in which similar conditions occur. The same considerations apply also to the stationary disc in which no stresses due to centrifugal forces but other stresses caused by the unilateral superatmospheric pressure may occur.

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