

H. GUYER.
BLADING FOR TURBINES.
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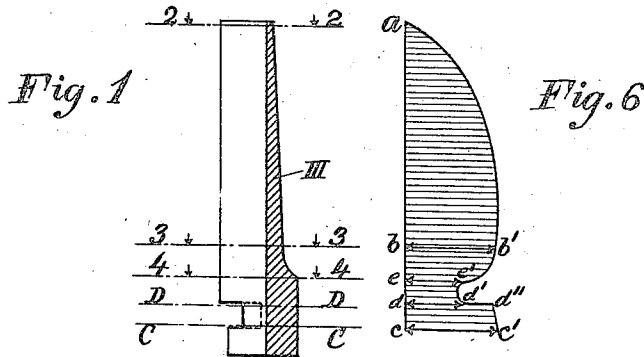


Fig. 2

Fig. 3

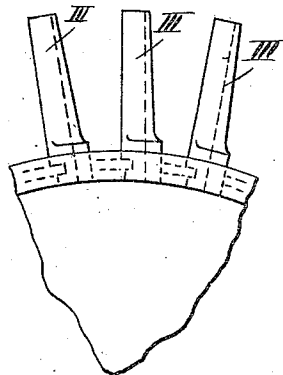
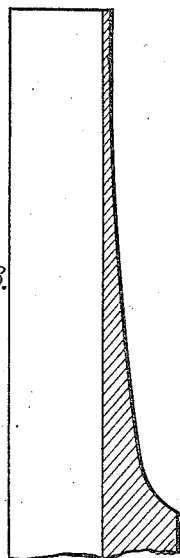
Fig. 4

Fig. 5



Fig. 7

Fig. 8.



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UNITED STATES PATENT OFFICE.

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BLADING FOR TURBINES.

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To all whom it may concern:

Be it known that I, HANS GUYER, a citizen of Switzerland, residing at Zürich, in the Canton of Zürich, Switzerland, have invented certain new and useful Improvements in Blading for Turbines, of which the following is a full, clear, and exact specification.

This invention relates to blading for turbines, rotary compressors, or the like, and has particular reference to improvements in the structure of the blades whereby they will be of substantially uniform rigidity in all directions throughout the portions subjected to the driving stresses, of increased strength at the base, and composed of a minimum amount of material.

The invention has especial reference to structures wherein the blades are fastened at one end, as to a wheel or rotor, and having the other end free. In such blades, the forces are applied generally normal to their surface, and the resultant of all the forces acting on a blade tends to bend the blade about its point of fastening, the forces applied at a distance from the point of fastening having a greater bending moment than those applied near the point of fastening or support. In order to secure the designed efficiency of a turbine, it is desirable to provide blades which shall have little or no deflection, since any deflection involves loss of power, which becomes appreciable where large numbers of blades are used. Furthermore, it is desirable to use as little material for each blade as possible, since unnecessary weight is objectionable.

The object of the present invention is to produce blades for steam or gas turbines, compressors, and the like, which will have approximately equal rigidity throughout their length in all directions with a minimum amount of material, and which will not be weakened at the base. So far as I am aware, such a blade is broadly new.

The novelty of the invention resides in a blade having a cross-section gradually increasing from the top toward the bottom, and having a bottom portion made thicker in such manner that, when cut in for securing in the keyway the rigidity will not be affected and sufficient cross-section be left for the necessary strength.

The advantage of this invention will be

clear by comparing the mass and characteristics of rigidity of the types of blades heretofore made known with the reduced mass and more constant characteristic of rigidity of blades constructed according to the present invention.

In the accompanying drawings, Figure 1 represents in longitudinal section, a blade constructed according to the invention, Figs. 2, 3 and 4 represent cross-sections on the lines 2—2, 3—3, and 4—4 of Fig. 1, Fig. 5 is a cross-section on the line D—D of Fig. 1, Fig. 6 represents diagrammatically the characteristic of rigidity of a blade embodying the invention, Fig. 7 is a detail showing a portion of a rotor or wheel having blades constructed according to this invention, and Fig. 8 is a section on an enlarged scale.

The blade III, having the construction of the present invention, increases slightly in thickness from the top, that is, at the section 2—2, to the section 3—3, from which it increases rapidly to the section 4—4 (Fig. 4), when it remains constant to the bottom or may be slightly larger or slightly less. Such blades usually have at their feet, cut away portions, for example, of rectangular shape, so that the blades can be shoved into keyways of T-shaped or dovetail section, disposed about the periphery of the rotating disk or other part. Fig. 5 also shows the section of blade III taken at D—D or C—C where the foot of the blade is cut away to fit the keyway. If such a blade be positioned on a wheel and subjected to the driving medium, then the individual sections of such a blade bear certain specific stresses which are schematically represented in Fig. 6. In this matter, it is only necessary to consider the sections between 2—2 and C—C. In Fig. 6, the length of the blade from the point to the lowermost edge of the cut away portion is represented by the distance $a-c$, measured in any unit corresponding to the specific relationship of each section taken between the head and the foot of the blade.

The blade III has, in accordance with the present invention, a corresponding relationship of thickness to the specific characteristics of rigidity of individual sections, which are shown clearly in Fig. 6. From the top, that is, from the beginning at the section 2—2, the rigidity characteristic, measured by the horizontal lines in Fig. 6, increases at

first rapidly and then remains close to or substantially at the same value $b-b'$ to the section 3-3. From this point the rigidity characteristic is less on account of the constant thickness as shown, which becomes somewhat less at this point from a value $b-b'$ to a value $e-e'$. The rigidity increases sharply from the point where the cut away portion begins, that is, at the section D-D, from the value $d-d'$ to the value $d-d''$, and then gradually to the value $c-c'$ at the lower edge of the cut away portion. The thickness of the foot of the blade can be sufficiently large so that the highest characteristic of rigidity value $c-c'$ which obtains at the cut away portion is not substantially higher than the highest value $b-b'$ which obtains on the active portion of the blade, so that this blade has approximately equal rigidity at all points and in all directions more closely than previously known types, and furthermore has a greater rigidity with less material, than previously known types.

In that part of the blade III which comes in contact with the driving or active medium, that is, between the sections 2-2 and 3-3, the cross-section from the head to the foot increases in a curve according to a law such that the specific characteristic of rigidity, after it has once been given a particular value for a given point, remains for the principal active portion of the blade at substantially this same value, or can slightly increase proportionally as the thickness of the blade slightly increases toward the foot. In other words, if it be predetermined that the free end of the blade shall have a certain degree of rigidity, or resistance to deflection when a predetermined force is applied at the end and normal to its active face, the remaining portion of the blade down to the line 4-4 must have a continually varying and increasing cross-section calculated to have the same or slightly increased rigidity. For instance, a given force applied normal to the blade at the end has a greater bending or deflecting moment, measured from the point of support, than the same force applied at an intermediate point. The point at which the resultant of all these moments is applied, is, according to this invention, given the greatest or predetermined rigidity, as for instance the line $b-b'$, Fig. 6, and points above this line, may, for factor of safety and ample strength, have approximately the same rigidity, decreasing at first gradually and lastly suddenly as the end is approached.

Having thus determined the cross-section to secure approximately constant and also a maximum rigidity in all directions with a minimum of metal, for the active portion of the blade, the remaining portion or foot is, according to this invention, given a

greater thickness, so as to leave, when notched for fastening in the keyway, proper thickness for fastening.

As shown in Fig. 6, the rigidity with reference to the blade as a whole theoretically decreases between the sections $b-b'$ and $e-e'$, remains practically constant between $e-e'$ and $d-d'$, suddenly increases at $d-d''$, and more slightly to $c-c'$, which is the bottom of the notch. However, from the shaded portion of Fig. 5, it will be seen that the minimum cross-section H is thicker than at any point of the active portion of the blade, and has approximately the same, or slightly greater, rigidity than at $b-b'$. Since the section of lower rigidity $e-e'$ to $d-d'$ is nearer the foot than the section $b-b'$ where the greatest rigidity is necessary, the resultant stresses will be less, and consequently the blade will not be weakened if the rigidity at 4-4 and D-D be of about the same values as $e-e'$ and $d-d'$ respectively. It is immaterial, for the purpose of this invention, how the blade is fastened or cut in for fixing it to the disk. Blades of this character are applicable for use for radially, as well as in particular for axially, operating wheels of steam or gas turbines, compressors, or the like. This invention is particularly advantageous for long blades, which are given high circumferential velocity because the heaviest portion of the blade is nearest the periphery of the wheel, and the blade will have, consequently, a centrifugal characteristic near that of the wheel itself.

From the foregoing description it is thought that the nature and advantages of the invention will be understood. It will be seen that by this invention, a blade having a greater moment of resistance and of less weight is provided. Consequently, wheel rims may be made lighter, also wheels, shafts and bearings, resulting in a large saving of weight in a large machine. These advantages will be realized in various types of gas and steam turbines, compressors, &c., but are especially apparent in stationary turbines of large units, wherein the centrifugal forces and velocities are ordinarily greater than in marine turbines.

Having thus described my invention, I declare that what I claim as new and desire to secure by Letters Patent is:—

1. An end supported side notched blade for a turbine, compressor or the like having a longitudinal cross section of varying rate of increase from the free end to the notched portion, said blade having a gradually increasing approximately constant characteristic of rigidity throughout the active portion, and a substantially equal characteristic of rigidity at the notched portion of maximum cross section.

2. An end supported blade for a turbine,

compressor or the like having a cross-section gradually increasing in thickness from the free end toward the base at such a rate as to have a gradually increasing, approximately constant characteristic of rigidity from the free end to adjacent the point of support, and having an increasing characteristic of rigidity at the foot of the blade, the characteristic of rigidity of the portion between said approximately constant portion and the increasing portion being somewhat reduced while the cross-section of such portion is not reduced.

3. An end supported blade for a turbine, compressor or the like having a longitudinal cross-section gradually increasing in a curve from the free end toward the base, said curve sharply increasing at the end near the foot, and the remaining portion of the blade surface being straight.

4. An end supported blade for a turbine, compressor or the like having its active surface straight and its rear surface gradually curved away from the active surface as the base is approached, the base being thickened in the direction of strain and cut away at the side.

5. An end supported blade for a turbine, compressor or the like having its active surface straight and its rear surface gradually curved away from the active surface as the base is approached, the curvature being sharply increased adjacent the foot of the blade.

6. An end supported blade for a turbine, compressor or the like having its active surface straight and its rear surface gradually curved away from the active surface as the base is approached, the curvature being sharply increased adjacent the foot of the blade and the remaining portion of the back surface being parallel to the active surface.

7. An end supported blade for a turbine, compressor or the like having its longitudinal cross-section straight on one face and curved on the opposite face away from the straight face from the free end toward the

base, the thickness on the curved side being sharply increased at the end of the curve nearest the base.

8. The combination with a wheel of a turbine, compressor or the like, of a blade fixed at one end to said wheel, said blade being of equal rigidity in all directions and having the cross-section normal to the axis gradually increasing from the free end toward the base, and at a point adjacent and close to the wheel having its cross-section sharply increased, the base of the blade being cut away near the end to permit fastening to the wheel within its surface, whereby the mass of the blade does not vary the centrifugal characteristic of the wheel.

9. In a turbine, the combination with a movable element, of a blade, the thickness of whose active portion increases at a continually varying rate from the top to some point toward the foot, then increases at a greater rate of variation to another point nearer the foot, and then remains substantially constant through the foot portion of the blade.

10. In a turbine, a blade, the thickness of the active portion of which increases at a continually varying rate from the top to some point toward the foot, then increases at a greater rate of variation to another point nearer the foot to a value such as to provide for a notched foot portion adapted to be attached to a supporting element.

11. A blade for a turbine or the like, said blade having an upper part of the portion thereof which is acted upon by the steam, or other medium, whose thickness in longitudinal section increases at a continually varying rate, and a lower part of said portion whose thickness in longitudinal section increases at a greater rate of variation.

In testimony whereof I affix my signature, in presence of two witnesses.

HANS GUYER.

Witnesses:

CARL GUBLER,

F. HULDREICH KELLER.