

H. F. FULLAGAR.
FLUID PRESSURE TURBINE.
APPLICATION FILED MAR. 19, 1904.

3 SHEETS—SHEET 1.

Fig. 1.

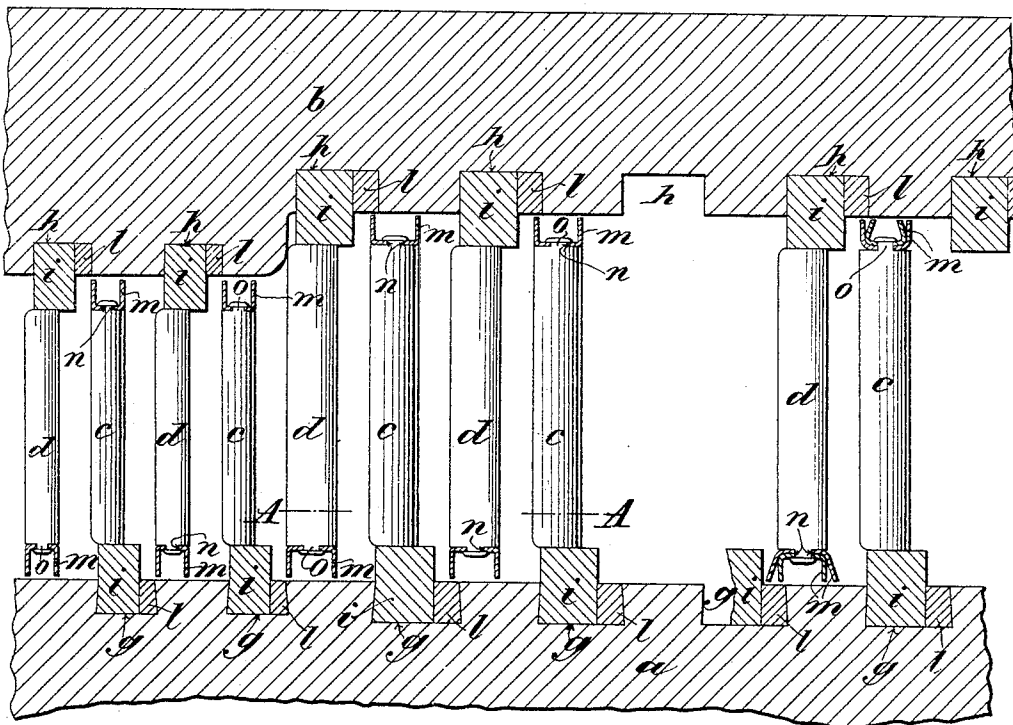
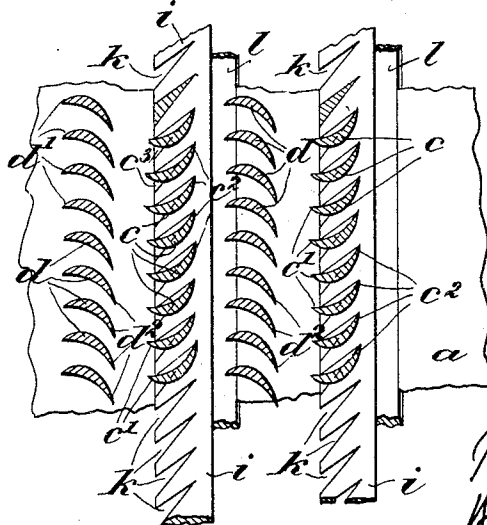


Fig. 2.



Witnesses.
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3 SHEETS—SHEET 2.

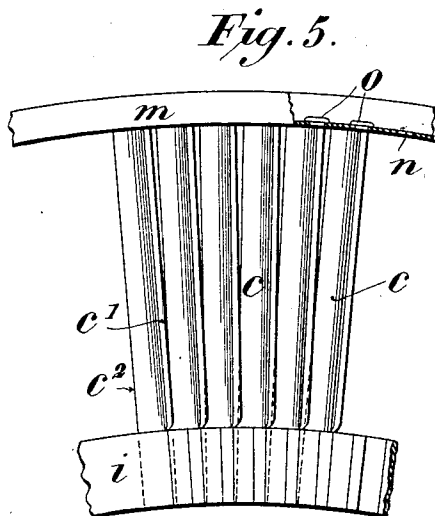
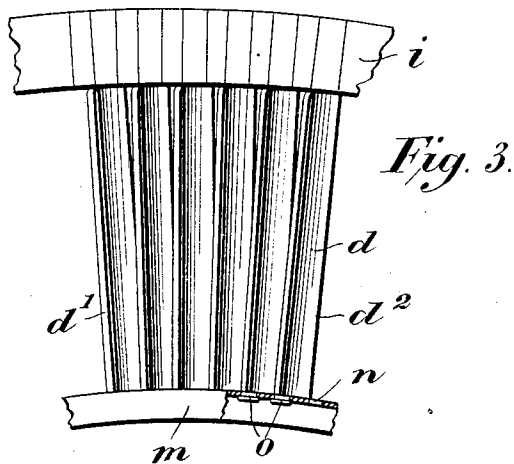


Fig. 7.

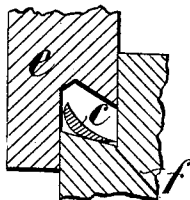
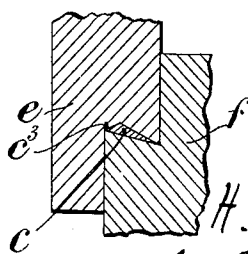


Fig. 8.



Witnesses.

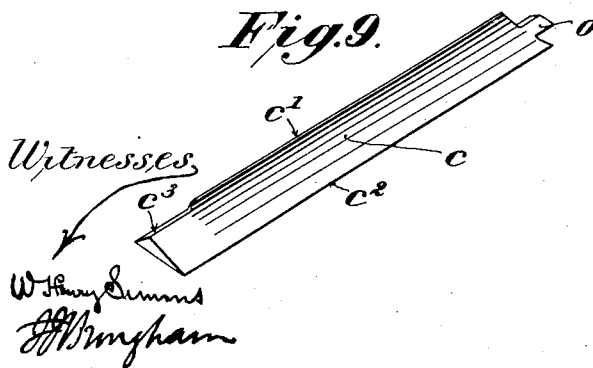
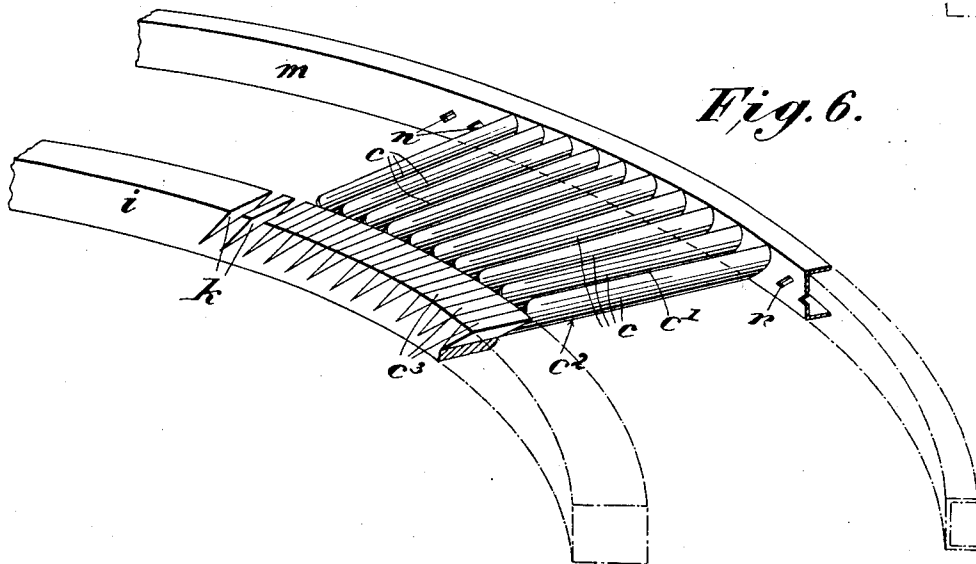
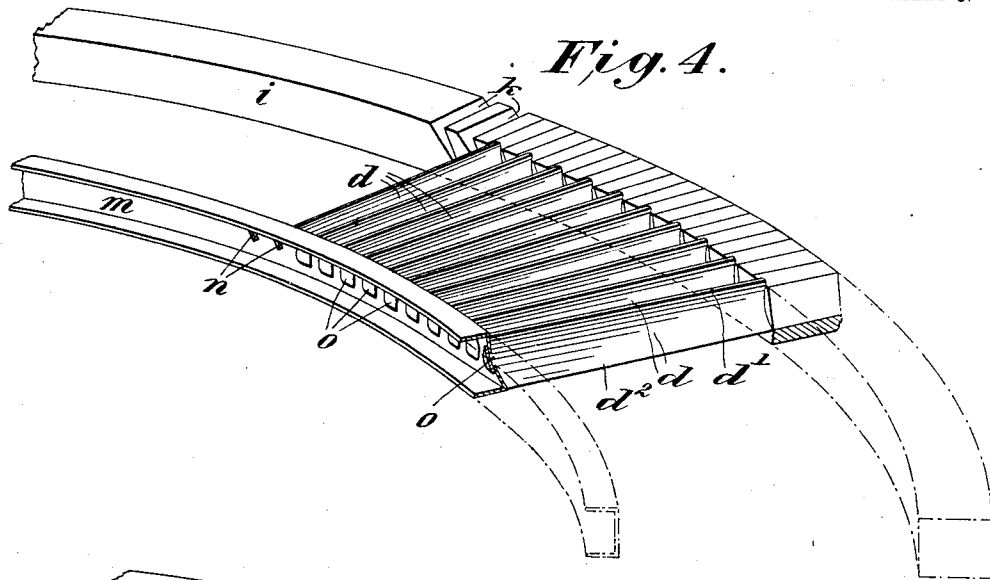
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3 SHEETS—SHEET 3.



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UNITED STATES PATENT OFFICE.

HUGH FRANCIS FULLAGAR, OF NEWCASTLE-UPON-TYNE, ENGLAND.

FLUID-PRESSURE TURBINE.

SPECIFICATION forming part of Letters Patent No. 784,670, dated March 14, 1905.

Application filed March 19, 1904. Serial No. 199,012.

To all whom it may concern:

Be it known that I, HUGH FRANCIS FULLAGAR, a subject of the King of Great Britain and Ireland, residing at Newcastle-upon-Tyne, in the county of Northumberland, England, have invented Improvements in Fluid-Pressure Turbines and Turbine-Pumps, of which the following is a specification.

This invention has reference, *inter alia*, to the method of attaching the vanes or blades to the stationary casings and rotating spindles or drums of steam and other fluid-pressure turbines and turbine-pumps, (hereinafter referred to as "turbines.") According thereto annular grooves are formed in the casing and spindle or drum, as well understood, and the blades, which are cut from drawn or rolled metal strips of the irregular crescent-section commonly used, are each formed of wedge shape in section at that end which is to form the root and is to be fixed in the groove. These root ends are fitted into correspondingly wedge-shaped notches cut in one of the sides or flat faces of rings or curved strips of brass or other suitable metal of rectangular section, which are inserted in the grooves of the turbine casing or spindle or drum, (hereinafter referred to as the "drum.") The notches are inclined at an angle corresponding to that at which it is desired to fix the blades. The rings or curved strips, with the wedge-shaped ends of the blades inserted in the notches, are secured in the grooves by calking strips of metal into the grooves alongside the notched ring or curved strip, which causes the oblique notches to very firmly nip the wedge-shaped ends of the blades along their whole width. When desired, each ring or curved strip may project beyond the surface of the drum or casing to form an annular face, opposite to which a baffle that is attached to and extends laterally from the ends of the adjacent circle of blades may be arranged, so as to reduce leakage past the blades. The strips of brass or other metal may be bent to form before being notched. The blades may be placed in the notches of the rings or curved strips before the latter are placed in the grooves. The wedge-shaped notches may be produced either

by wedge-shaped saws or by cutting parallel saw-kerfs with a thin saw and opening the notches afterward by bending up the teeth.

The arrangement of blade-fastening herein described enables the roots of blades to be firmly gripped over the whole of their width by a single notched strip held in a groove by lateral pressure only and is a simple, inexpensive, and rapid method of attaching the blades, involving few parts and lending itself readily to fixing the blades at any desired pitch and angle relatively to the plane of rotation.

The above-described method of fixing the blades is particularly applicable when the blades have been attached at or near their outer ends to a baffling-ring, shroud-ring, or supporting-ring, and in consequence of which it is difficult or undesirable to place the blades singly in the grooves or to calk metal between them.

In compound axial-flow steam-turbines containing many successive rings of stationary and rotary blades it has heretofore been usual to turn or machine the rotary rings of blades and to bore out the stationary rings of blades, so that they shall fit the casing and drum, respectively, with the very small clearance necessary in such turbines. This method of manufacture is somewhat tedious and costly, as the blades being slender and weak and unsupported at their free ends can only be turned and bored very carefully and by taking a great many cuts. The longer blades of the turbine usually have a shroud or stiffening ring soldered to them at a short distance from their ends. Not only does such soldering soften the blades, if they be made, as usual, of drawn-brass strips, but the shrouding is inapplicable to short blades of a turbine, owing to the disproportionate obstruction which it would offer to the steam. Moreover, such leakage as occurs over the ends of the blades takes place in a direction contrary to and tending to destroy the properly-directed stream of steam. To obviate these disadvantages, the rings of blades, or some of them, are each provided at the free or unfixed ends of the blades of which it is composed with one or more rings (hereinafter called for distinction "combined fitting and baffling rings") of thin sheet

material, that is or are arranged to extend transversely or in a direction more or less at right angles to the longitudinal axis of the turbine and is or are turned or bored according as the ring of blades is to form a rotary or fixed ring of blades to fit the interior of the casing or the exterior of the drum with the necessary clearance. The combined fitting and baffling ring or rings may conveniently be formed of a strip of thin sheet metal, such as delta metal or brass, bent to an angular or channel section in cross-section and secured around the free ends of the blades by causing projections formed thereon to project through and fit perforations in the strip and riveting over the free ends of the projections. The effective edge portion or portions of the strip of material of which the combined fitting and baffling ring or rings is or are formed may be bent up before or after the strip is attached to the blades. Also the strip may be laminated and the edges of these several laminations bent apart, so as to present successive baffling edges to the steam. The edge or edges of the combined fitting and baffling ring or rings which can be applied to blades of any length being continuous can be readily machined to fit the casing or spindle by a single cut with a suitable tool, and being very thin the presence of water will not cause serious friction between them and the casing or drum, nor will they become dangerously heated or melted should accidental contact occur at high speed, while such leakage as may occur will not be liable to seriously affect the direction of the acting stream of steam. By the means described the rings of blades will be rendered strong and light and can be easily, quickly, and cheaply machined to fit the casing and spindle or drum.

In order that those skilled in the art may the more easily understand the manner in which this invention may be carried out, reference will now be made to the accompanying drawings, wherein—

Figure 1 shows in longitudinal section part of the drum and casing of a steam-turbine with rings of blades fixed in position and provided with combined fitting and baffling rings according to this invention. Fig. 2 is a developed section on the line A A, Fig. 1. Figs. 3 and 4 are end and perspective views of a portion of a ring of blades adapted to be fixed in an annular groove in the stationary turbine-casing. Figs. 5 and 6 are similar views of a ring of blades adapted to be fixed in an annular groove in the rotary spindle or drum of the turbine. Figs. 7 and 8 are diagrammatic views illustrating in two positions a pair of dies or tools for imparting to the root end of the blade-blank the required wedge shape. Fig. 9 is a perspective view of a detached blade.

a is the rotary turbine-drum, and b is the stationary casing. Rings of blades c are fixed

to the drum a , and rings of blades d are fixed to the casing b , so as to alternate. The blades c and d are cut from a strip of metal of the required crescent-like section, and the root end of each is formed by pressure between dies e and f , Figs. 7 and 8, which have the effect of flattening out and compressing the end of the blade, the thicker inlet edge portion c' d' of which is bent back so that its surfaces are brought into the planes of the surfaces of the outlet edge portion c'' d'' . The thicker inlet edge c' d' is at the same time compressed, upset, or thickened, so that while the two surfaces of the wedge are approximately in the same planes as the surfaces of the outlet edge portion of the blade (or the center line of the wedge is approximately parallel to that of the issuing jet of steam) the third side c''' d''' of the wedge is approximately parallel to the plane of rotation. The cooperating dies may conveniently be reversely rabbeted, as shown, the space between the rabbeted portions when closed home corresponding to the form to be given to the root of the blade.

The drum a and the casing b are formed with grooves g and h , respectively, as well understood, and the roots of the blades are secured therein in the following manner: A strip i , of brass or other metal, of suitable width is curved to fit the bottom of each groove, and in one of its flat sides are cut notches k , corresponding in pitch and inclination to the blades. The strip is inserted in its groove, and the wedge-like root ends of the blades are fitted into the notches and secured by a calking-strip l , which is calked into the groove alongside the strip i , so as to force the blade-roots sidewise into the oblique notches and cause them to be firmly gripped over the whole of their width. The calking-strip l may be located on either side of the holding-strip, as may be found convenient.

Instead of being secured in the grooves by calking-strips l the strips i , with the blades, may be secured by calking the sides of the grooves.

In the drawings the rings or curved strips i are of such a radial depth that they project from the grooves beyond the drum or casing. In some cases the back or unnotched side of each ring may serve as an annular face, into proximity with which a baffling-ring attached to the ends of the adjacent ring of blades may extend, so as to reduce leakage, as well understood; but in the drawings the rings of blades are shown provided with combined fitting and baffling rings m , portions of which lie in planes at right angles, or nearly so, to the axis of the turbine and whose effective edges extend into proximity to the drum or the casing, as hereinbefore described. The examples of these combined fitting and baffling rings m which are illustrated are formed of thin sheet metal of channel shape in cross-section formed with perforations n , pitched at the required

distance to receive projections *o* on the free ends of the blades, to which the rings *m* are secured by riveting over said projections.

The combined fitting and baffling rings *m* shown to the left of Fig. 1 and in Figs. 3 to 6 are of single channel form, while to the right in Fig. 1 are shown examples of perforated laminated fitting and baffling rings, each comprising two strips of sheet metal of channel-section, one within the other. The rings *m* may be of the same or of greater or less width than the blades, and instead of being of channel-section, as shown, each ring may be angular or other suitable form which provides a radially-extending effective portion capable of being turned or bored, according to whether they are fixed to the drum or the casing.

What I claim is—

1. A number of turbine-blades whose roots are of wedge-like section and a curved holding-strip formed with wedge-like notches in which the roots of the blades are fitted.

2. In a turbine, a number of blades whose roots are of wedge-like section and a curved holding-strip formed with wedge-like notches in which the roots of the blades are fitted, said strip with blades being secured in a groove.

3. In a turbine, a ring of blades comprising a number of blades whose roots are of wedge-like section and a curved holding-strip formed with wedge-like notches in which the roots of the blades are fitted, said strip with blades being secured in a groove by calking.

4. In a turbine, a ring of blades comprising a number of blades whose roots are of wedge-like section and a curved holding-strip formed with wedge-like notches in which the roots of the blades are fitted, said strip with blades being secured in a groove by a calking-strip.

5. In a turbine, a number of radially-arranged blades whose roots are of wedge-like section and curved holding-strip having one of its sides formed with wedge-like notches in which the roots of the blades are fitted, said strip with blades being secured in a groove.

6. In a turbine a ring of blades comprising a number of radially-arranged blades whose roots are of wedge-like section, a ring of curved holding-strip having one of its sides formed with wedge-like notches in which the roots of the blades are fitted, a groove in a blade-carrying portion of the turbine and a calking-strip, the strip with blades and the calking-strip being fixed by the calking of the latter in the said groove.

7. In a turbine, the combination of a drum formed with a series of annular grooves, rings of radially-arranged blades having wedge-like roots, a curved holding-strip formed at one side with wedge-like notches into which the blade-roots fit, said strips with blades being secured in said grooves by calking, a casing surrounding said drum and formed with a se-

ries of internal annular grooves, radially-arranged blades having wedge-like roots, the curved holding-strip formed at one side with wedge-like notches in which the blade-roots are fitted, said strips with blades being secured in said grooves by calking and the rings of drum-blades alternating with rings of casing-blades as set forth.

8. A turbine-blade the body of which is of crescent-like cross-section and the root of wedge-like cross-section, as set forth.

9. A number of turbine-blades whose bodies are of crescent-like cross-section and whose roots are of wedge-like cross-section and a curved holding-strip formed with wedge-like notches into which the roots of the blades are wedged, as set forth.

10. In a turbine, a casing, a drum or spindle within the casing, rings of blades alternately secured to the casing and to the drum, and a baffling-strip attached to the free ends of each of said rings of blades and provided with a transversely-arranged flanged portion the free edges of which extend into close proximity of the casing and of the drum respectively, substantially as described.

11. In a turbine, a casing provided with a cylindrical bore, a cylindrical drum or spindle within the casing, rings of blades alternately secured to the casing and to the drum, and a baffle attached to the free ends of each of said rings of blades and having a relatively thin central portion and transversely-extending circumferential flanges at each lateral edge the free edges of which extend into close proximity with the bore of the casing and cylindrical surface of the drum respectively, substantially as described.

12. In a turbine, the combination of a turbine-drum, rings of radial blades, secured to said drum, a combined fitting and baffling strip attached to the outer ends of the blades of each of said rings, an inclosing casing, rings of radially-arranged blades secured to said casing, a combined fitting and baffling strip attached to the inner ends of the blades of each of said rings, the blade-rings of the drum and casing being arranged alternately and the fitting and baffling rings extending transversely of the turbine-axis into proximity to the casing and drum respectively, as set forth.

13. In a turbine, the combination of a turbine-drum, rings of radial blades formed with roots of wedge-like section, holding-strips formed at one side with wedge-shaped notches into which the roots of the said blades fit, said holding-strips being secured to the drum, combined fitting and baffling strips attached to the outer ends of the said rings of drum-blades, an inclosing casing, rings of radial blades formed with roots of wedge-like section, holding-strips formed at one side with wedge-shaped notches into which the roots of the blades fit, said holding-strips being secured to the casing, combined fitting and baffling strips

attached to the ends of the blades of each of said rings, the blade-rings of the drum and casing being arranged alternately and the fitting and baffling strips extending transversely of the turbine-axis into proximity to the casing and drum respectively, as set forth.

14. In a turbine, the combination of a blade-carrying portion, a groove formed therein, a holding-strip formed at one side with wedge-shaped notches, radial blades whose roots are of wedge-like cross-section and fit in said notches and a calking-strip, said holding-strip with inserted blades and calking-strip occupying said groove and the calking-strip being located at the plain side of the holding-strip, as set forth.

15. In a turbine, the combination of a blade-carrying portion, a groove formed therein, a holding-strip formed at one side with wedge-shaped notches, radial blades whose roots are of wedge-like cross-section and fit in said notches and a calking-strip, said holding-strip with inserted blades and calking-strip occupying said groove and a fitting and baffling strip attached to the free ends of the blades and extending transversely of the turbine-axis, as set forth.

16. In a turbine, the combination of a blade-carrying portion, a groove formed therein, a holding-strip formed at one side with wedge-shaped notches, radial blades whose roots are of wedge-like cross-section and fit in said notches and a calking-strip, said holding-strip with inserted blades and calking-strip occupying said groove and a perforated angular fitting and baffling strip attached to the free ends of the blades and extending transversely of the turbine-axis, as set forth.

17. In a turbine, the combination of a blade-carrying portion, a groove formed therein, a holding-strip formed at one side with wedge-shaped notches, radial blades whose roots are of wedge-like cross-section and fit in said

notches and a calking-strip, said holding-strip with inserted blades and calking-strip occupying said groove with the calking-strip at the plain side of the holding-strip and a fitting and baffling strip attached to the free ends of the blades and extending transversely of the turbine-axis, as set forth.

18. In a turbine, the combination of a blade-carrying portion, a groove formed therein, a holding-strip formed at one side with wedge-shaped notches, radial blades whose roots are of wedge-like cross-section and fit in said notches and a calking-strip, said holding-strip with inserted blades and calking-strip occupying said groove with the calking-strip at the plain side of the holding-strip and a perforated angular fitting and baffling strip attached to the free ends of the blades and extending transversely of the turbine-axis, as set forth.

19. A turbine-blade the body of which is of irregular crescent-like cross-section and the root of wedge-like cross-section, the two side surfaces of the wedge-like root being approximately in the same planes as the surfaces of the outlet edge portion of the blade-body, as set forth.

20. A turbine-blade the body of which is of irregular crescent-like cross-section and the root of wedge-like cross-section, the two side surfaces of the wedge-like root being approximately in the same planes as the surfaces of the outlet edge portion of the blade-body, and the third side of the wedge-like root being approximately parallel to the plane of rotation, as set forth.

Signed at Newcastle-upon-Tyne, England, this 3d day of March, 1904.

HUGH FRANCIS FULLAGAR.

Witnesses:

PERCY CORDER,

WALTER HEATHCOTE GOLDING.