

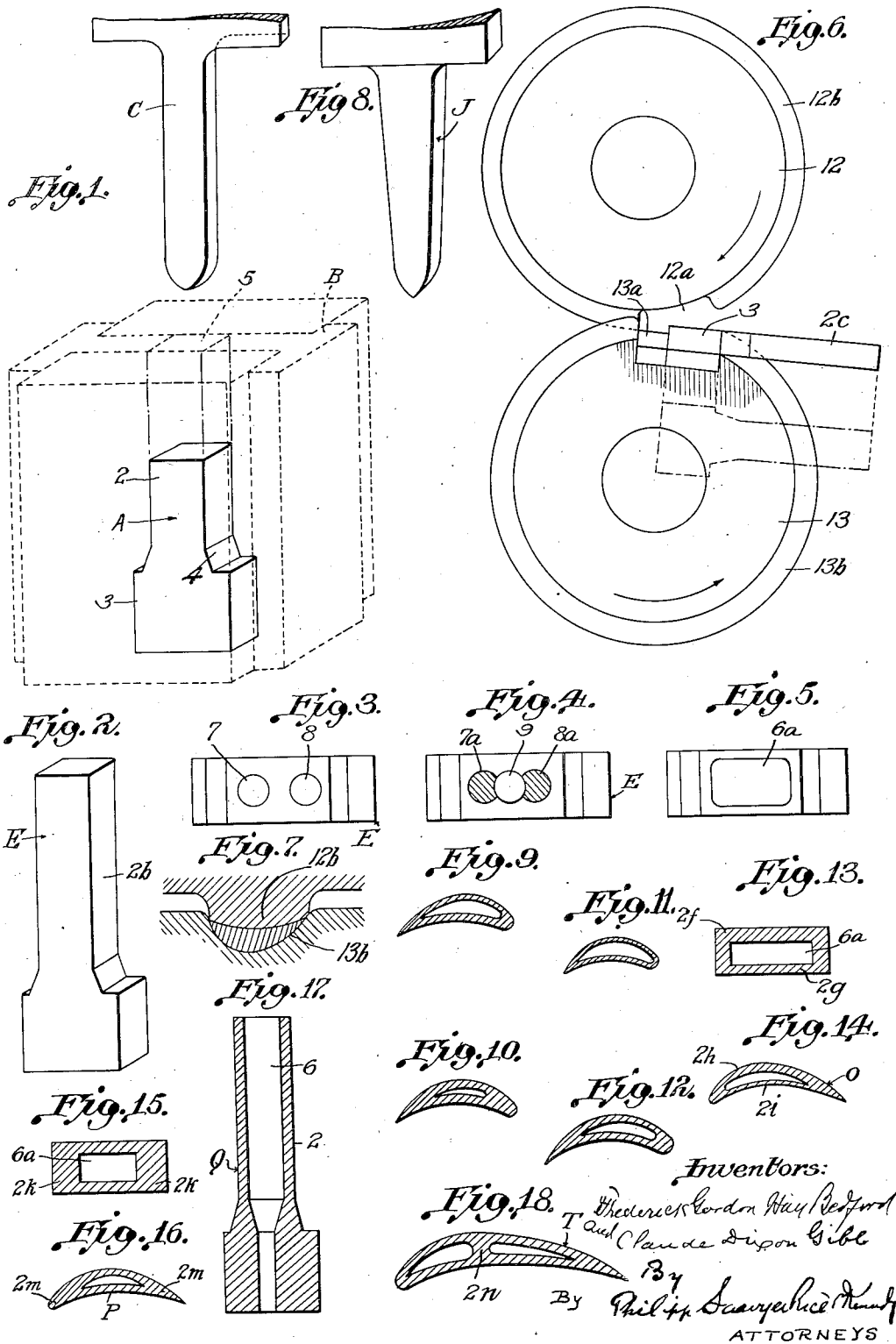
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HOLLOW TURBINE BLADE

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HOLLOW TURBINE BLADE

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1 Claim. (Cl. 253—77)

The invention relates to hollow blades suitable for steam turbines, compressors and the like, hereinafter referred to generically as "turbine blades" or "turbine blading". This application is a division of our copending application #639,756 filed Oct. 27, 1932, now Patent #2,013,622 of Sept. 3, 1935.

One object of the present invention is to provide hollow seamless turbine blading which shall be the better adapted for withstanding the working stresses to which it is subjected.

Another object of the invention is to provide hollow turbine blading which by an improved distribution of metal over its cross-sections, or some of them, shall the more accurately proportion the different parts of the blade in relation to the functions they severally perform.

With these main objects, the invention consists in the improved hollow turbine blading as hereinafter described and particularly pointed out in the appended claim.

Referring to the accompanying drawing which forms part of the specification and is of a diagrammatic nature:—

Figure 1 shows in perspective one form of apparatus for producing a hollow blade by punch and die,

Figure 2 shows a perspective view of a form of solid blade blank prior to its being given a hollow formation,

Figure 3 shows an end view of the blank with two holes drilled endwise in the blade-forming part thereof.

Figure 4 is a like view showing the addition of a third hole and

Figure 5 a like view showing the final form of the hole in the blade-forming part of the blank, while

Figure 6 shows in outside elevation a filled tubular blade blank about to be passed between gapped rolls,

Figure 7 being a cross section through the profiled rims of the rolls;

Figure 8 shows a form of tapered punch;

Figures 9 and 10 are cross sections of a blade, the cross sections being taken on different lines lengthwise of the blade.

Figures 11 and 12 are cross sections of a blade of different form, the cross sections being taken on different lines lengthwise of the blade.

Figure 13 shows an end view of the blade-forming part of a blank in which the hollow is displaced to one side,

Figure 14 showing a cross-section of the resulting blade;

Figure 15 shows an end view of the blade-forming part of a billet in which the length of the hollow rectangle as seen in cross-sections relatively reduced,

Figure 16 showing a cross-section of the resulting blade with extra metal at the edges;

Figure 17 shows a longitudinal section of a hollow blank in which the hollow passes through both the blade-forming and root-forming parts of the blank;

Figure 18 shows a cross-sectional plan of a hollow blade provided with a transverse bridge of metal serving as a stiffener.

In carrying the invention into effect according to one form, applicable to the blades of a steam reaction turbine, a blank, A, is formed (see Figure 1) having a blade-forming part, 2, of uniform rectangular cross-section and a laterally-extending root-forming part, 3, integral therewith, such blade-forming and root-forming parts being connected by a fillet, 4.

According to one method of procedure, the blank, A, so formed and at a proper temperature, is suitably held in a built-up die, B, the blade-forming part, 2, being enclosed in an elongated recess, 5, in the die or mould of like cross-section, and a former punch, C, likewise of rectangular cross-section, it may be with the corners rounded, is forced longitudinally into the blade-forming part, 2, of the blank, A, from one end, with the sides of the two rectangles approximately parallel; the metal of the billet is thus caused by an extrusion action to flow into the annular space between the punch, C, and mould, B, thereby elongating the blade-forming part, 2, of the blank and giving it a hollow 6 so that the blade-forming part has a preliminary tubular form for a desired length, as shown by the blank Q in Figure 17.

According to another method of procedure, a solid blank, E, is prepared having the form shown in Figure 3, with a blade-forming part, 2b, of the required length; a hole, 6a (see Figure 5) of the required shape is then formed longitudinally in the blade-forming part, 2b, of the blank, E, by drilling two holes, 7 and 8, (see Figure 3), providing these holes with plugs, 7a and 8a, and drilling an intermediate hole, 9, (see Figure 4); a hole of irregular shape is thus produced which may be given its final shape, 6a, (see Figure 5) by milling, broaching, drifting, punching or other machine or hand operation.

Or again, the three holes, 7, 8 and 9, may be pin drilled, smaller pilot holes being first drilled at the appropriate centres.

In order to give the desired cross-section to the blade-forming part of the hollow blank produced by any of the above methods, (or by any other suitable method), the hollow, 6 or 6a, is filled with a suitable resistant material, and the filled blade-forming part of the blank is then elongated to a straight blade of uniform cross-section by passing it between suitable dies or rolls, 12, 13, preferably of the same diameter (see Figure 6) having peripheral gaps, 12a, 13a, for the reception of the root, 3, of a blade, the remainder of the periphery, 12b, 13b, being profiled (see Figure 7) to impart the desired cross-section to the blade.

The action of the elongating process, whatever the particular method adopted, is to extend the grain structure of the metal in the direction of the length of the blade.

The filling material is then removed to give as a final result of the process (apart from any finishing processes such as grinding, buffing or the like, or machining as hereinafter indicated) a blade and root the hollow blade proper, being of the correct reaction cross-section, with walls of substantially uniform thickness, and integral with its root, 3.

If the blade is of stainless steel, which is rolled at a temperature of about 950° C. and melts at approximately 1500° C. copper may very suitably be used as the filling material, this metal having a melting point of about 1085° C. so that it can very readily be melted out by raising the temperature of the filled blade to say 1100° C.

By tapering the former punch of Figure 1, in both directions, if necessary, as shown at J, (Figure 8), it will be seen that the thickness of the walls of the resulting blank and finished blade gradually decreases from the root towards the tip, the external form of the blade being maintained parallel.

Or alternatively, a blank may be formed as described with relatively thick walls and a tapered mandrel forced into the hole so as to flare out the blade-forming part of the blank; the flared blank is then forged or machined on the outside, to restore the external parallel form and leave a hole internally.

While the weight of the blade is thus decreased with a corresponding reduction in root and rotor stresses, the parallel external form of the blade gives a steam passage between the blades that is much superior to that obtained with externally-tapered solid blades so that the blading efficiency is improved.

With higher blade-tip speeds, however, it may in some cases be necessary to taper the blades externally, this result being secured according to one form by preparing a hollow blade with relatively thick walls of parallel (or tapered) cross-section in the manner above described, and subsequently machining the outside of the blade on the concave and/or convex face or faces to give the externally-tapered form desired.

A non-uniform disposition of the metal in the walls of the finished hollow blade can be obtained by locating the hollow asymmetrically in the blank in any desired manner.

For example, by arranging the hollow, 6a, in the blade-forming part of the blank (see Figure 13) nearer to one side of the rectangle so as to provide a thick wall, 2f, and a thin wall, 2g, the corresponding walls, 2h, 2i, of the resulting blade, O, may be given different thicknesses as shown (see Figure 14).

Or again, in order to strengthen the thin out-

let edge of the blade and/or in order to provide a solid attachment for erosion-resisting shields, if fitted on the leading edges, it may be desirable to reduce the length of the rectangular hole, as seen in cross-section, (see Figure 15) in relation to that of the blank so as to provide extra metal, 2k for the formation of the solid leading and outlet edges, 2m, of the resulting blade, P.

With any of the processes and forms described, the axial hole, 6, in the blank preferably passes not only through the blade-forming part, 2, but also through the root-forming part, 3, of the blank, Q, (see Figure 17) changing its cross-section abruptly, as shown at the point of transition.

Instead of forming a single rectangular, circular or other longitudinal hole in the blank, two or more parallel (or tapered) holes, such as 7 and 8, (Figure 3), may be formed to a desired depth, or alternatively, two or more such holes at the base may merge into a single hole at the tip end.

According to this plan, one or more bridges of metal, 2n, which may be made to decrease in thickness from root to tip, will extend transversely from the convex to the concave wall of the resulting blading, T, (see Figure 18) and serve as efficient stiffeners.

With such processes, it will be seen that the thickness of each wall of the resulting hollow blade may be made substantially uniform, though the thickness of the concave side and of the convex side may differ. Similarly the thickness may vary over any desired length of the blade by decreasing in the direction from root to tip, any of these forms being readily obtained either by forming the blank with a tapered hole or by external machining of the surface of the blade, or by a combination of these methods.

Parallel blades with walls of uniform thickness may also be finished by external machining.

Hollow turbine blades manufactured as above described have all the characteristics desirable in the rotor blade of a steam turbine running at high peripheral speeds, since the blade proper is integral with its root, the latter, which is the most highly stressed part, being solid, while by virtue of the hollow formation of the blade, its weight is much reduced in comparison with a solid blade of the same external contour, and consequently the stresses on the root and on the turbine rotor are also reduced to a corresponding degree.

In addition, owing to the longitudinal extension to which the blank or billet has been subjected, the grain structure of the resulting hollow blade takes the desired longitudinal direction.

The filling material used may be a metal with a melting point lower than that of the material of which the blade is formed, so that when the rolling is completed, the core may be melted out. As above stated, copper filling is suitable and convenient with the usual blading materials but other metals or alloys or other suitable material, may, however, be used as filling material and removed in any desired manner.

For instance, the filling material may be a non-metallic substance of a granular nature, such as sand or sand mixed with a suitable oil, which can be broken up for removal from the rolled blade. With this type of filling the ends of the hollow blank must be plugged with copper or other suitable material to retain the filling during the rolling process described above.

It will be understood that the illustrative

5 methods of manufacturing hollow blading and the forms above described are not intended as limitations on the manufacture of the blade claimed but this may be made by any desired method or of forms other than the preferred methods and forms described.

Having now described our invention, what we claim as new and desire to secure by Letters Patent is:—

A hollow seamless turbine blade having an integral root-block in which the hollow is partly in the blade proper and partly in the root-block and changes its cross-section abruptly at the point of transition.

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