

May 7, 1946.

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CENTRIFUGAL COMPRESSOR

2,399,852

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2 Sheets-Sheet 1

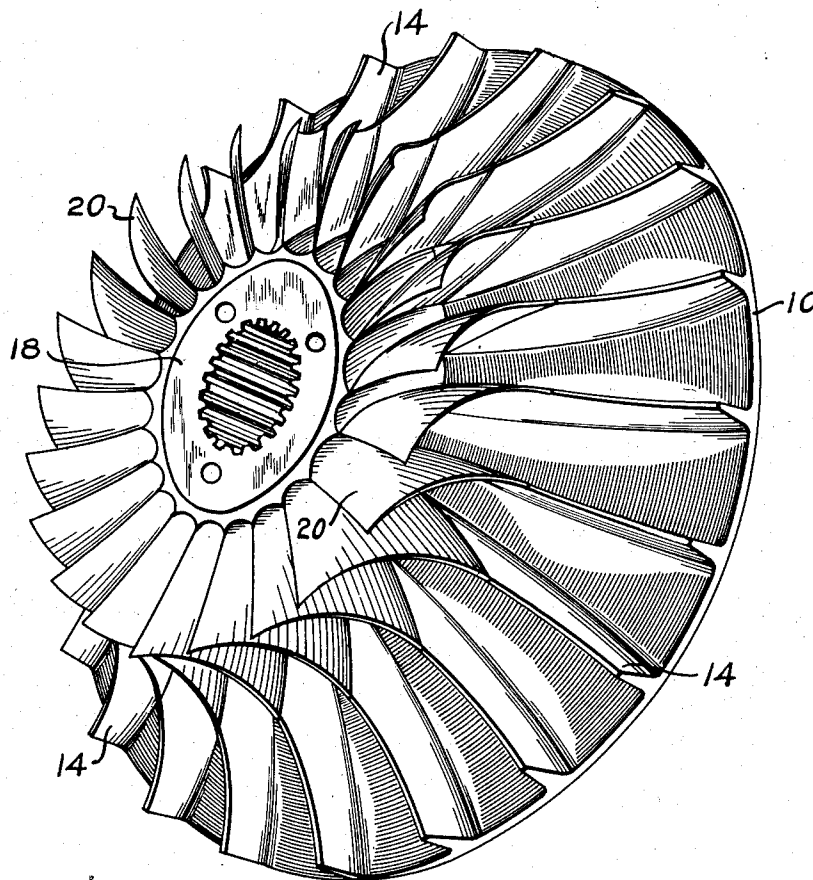


FIG. 1

INVENTOR.
KENNETH CAMPBELL.
JOHN E. TALBERT
BY *John E. Talbert*
ATTORNEY

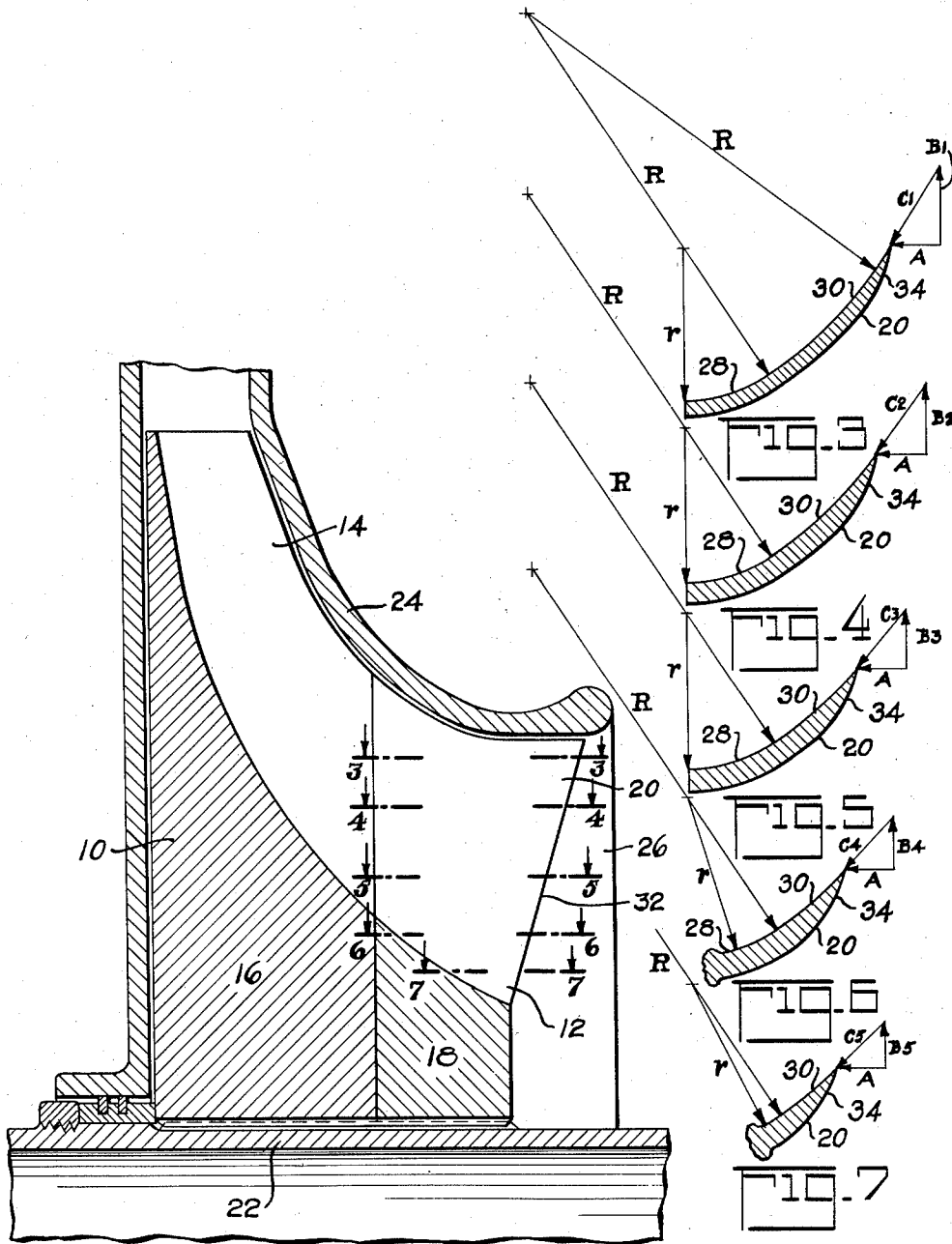
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UNITED STATES PATENT OFFICE

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CENTRIFUGAL COMPRESSOR

Kenneth Campbell, Ridgewood, and John E. Talbert, Glen Rock, N. J., assignors to Wright Aeronautical Corporation, a corporation of New York

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3 Claims. (Cl. 230-134)

This invention relates to impellers for centrifugal compressors and is particularly directed to an entrance vane construction for such an impeller. The impeller herein described is designed for use as a supercharger impeller for an aircraft engine, but obviously the invention is not limited to this specific application.

In the design of such impellers, the vanes are formed integral with and extend radially outward from the impeller hub and, in addition, it is common practice to bend the entrance edge of the impeller vanes in the direction of rotation of the impeller in order to minimize the impact shock of the entering air. This feature is highly important in connection with the impeller of an aircraft engine supercharger because of the high rotational speed of such an impeller, in the neighborhood of 20,000 R. P. M. Also, because of this high speed rotation it is essential that the impeller hub be of substantial thickness with the vanes formed integral therewith. Because of casting and/or machining difficulties, it is not readily possible to curve the root end of the vanes with the integral hub and vane construction. Therefore, it has been the prior practice to simply bend the outer peripheral entrance edge of the vanes. With this construction the fixed root end of the blades seriously limits the extent to which the entrance edge of the vanes may be curved in the direction of rotation, and in addition, makes it impossible to design the entire entrance edge of the vanes so as substantially to eliminate impact shock from the entering air along the entire entrance edge.

It is an object of this invention to provide the impeller vanes with an entrance portion curved in the direction of rotation of the impeller and of such shape that the curved vane entrance portion may be readily machined, with the root ends of the vanes curved as well as their outer periphery. It is a further object of this invention to terminate the entrance edge of these vanes in such a manner that along its entire entrance edge there is substantially no impact shock from the entering air.

Specifically, as illustrated the impeller is made in two sections: the main impeller section in which the vanes extend radially from the hub, and an entrance vane section secured thereto in which the vanes are curved in the direction of rotation of the impeller. The curvature of the entrance vanes is made such that the curvature of the root ends of the vanes is no smaller than the curvature of the portions of the vanes disposed outwardly therefrom. That is, along the

intersection of any plane substantially transverse to the impeller axis with an entrance vane, the radius of the curvature along this intersection at the root end of a vane is no larger than the radius of the curvature at the periphery of the vane. Preferably, the curvature of the vane entrance portion is uniform along this intersection from the root end of the vane to the outer periphery, but this curvature is varied in the direction of the flow path between adjacent vanes so that the radius of this curvature decreases in a downstream direction. As hereinafter described the upstream end of the entrance vanes have one curvature and their downstream end is machined to a smaller radius of curvature. With this construction the leading surface of each entrance vane comprises two adjacent segments of cylindrical surfaces with tangential adjoining edges which may be machined quite readily. If desired, the number of such cylindrical segments may be increased.

The entrance edge of each of the vanes is terminated in such a manner that at each point along its edge the tangent thereto is substantially parallel to the direction of the relative velocity of the entering air. With this construction, impact shock from the entering air is substantially eliminated along the entire entrance edge of the impeller vanes. Other objects of the invention will become apparent from the reading of the annexed detailed description in connection with the drawings in which:

Fig. 1 is a perspective view of an impeller construction in accordance with the invention,

Fig. 2 is a sectional view through the impeller, and

Figs. 3, 4, 5, 6 and 7 are sectional views taken along lines 3-3, 4-4, 5-5, 6-6 and 7-7 of Fig. 2.

Referring to the drawings, an impeller is disclosed as comprising a main section 10 and an entrance section 12 secured thereto. The main section 10 of the impeller is similar to the corresponding portion of a conventional supercharger impeller for an aircraft engine, the vanes 14 extending radially from the hub 16. The entrance section comprises a hub portion 18 bolted or otherwise secured to the main hub 16, with vanes 20 forming a smooth continuation of the impeller vanes 14, as best seen in Fig. 1. The entrance vanes 20 are curved in the direction of rotation of the impeller in a manner hereinafter described. The composite impeller is splined to an impeller drive shaft 22 and is disposed within a shroud 24 defining an entrance eye 26 for the impeller.

The curvature of the impeller entrance vanes 20 is illustrated by the sectional views of Figs. 3 to 7 which are taken at varying distances from the root end of one of the vanes 20. As illustrated, the leading face of the downstream portion 28 of each section through the entrance vanes 20 is cylindrically machined to a relatively large curvature, that is to a small radius r , while the upstream or entrance portion 30 of each vane has its leading face cylindrically machined to a relatively small curvature, that is to a curvature having a relatively large radius R . In other words, the leading surface of each vane 20 comprises a cylindrical surface, of which the downstream portion 28 comprises a segment of a cylindrical surface of radius r , while the upstream or entrance portion 30 comprises a segment of a cylindrical surface of radius R , the adjacent ends of these segmental cylindrical surfaces being tangent to each other. The vanes may be readily machined to this compound curvature and obviously the number of steps in this curvature may be increased if desired. Also, it has been found possible to vary the relative curvature of the root end and outer periphery of the vanes 20, but the radius of the root curvature of a vane preferably should be at least as small as the radius of the curvature at its outer periphery.

Although the impeller has been described as comprising two sections 10 and 12 which are secured together, it should be obvious from the foregoing description that the entire impeller could be machined from one piece.

In Fig. 3 the vector A represents the axial velocity of the entering air or other fluid, the vector B_1 represents the circumferential velocity of the periphery of the vanes 20, and the vector C_1 the relative velocity of the air with the peripheral edge of the vanes 20. As illustrated, the peripheral edge of the vanes 20 is terminated such that the tangent to its entrance edge is substantially parallel to the relative velocity C_1 of the entering air, whereby the air enters the periphery of the vanes substantially without shock. In order to obtain this same result along the entire entrance edge of each of the vanes 20, the entrance edge is cut back as illustrated at 32 in Fig. 2. This is essential since the circumferential velocity of the entrance edge of the vanes 20 decreases at points radially inward from its outer periphery, whereas the axial velocity of the entering air is substantially uniform. Thus, as illustrated by the vectors B_1 to B_5 in Figs. 3 to 7, respectively, the circumferential velocity of the entrance edge of the vanes 20 progressively decreases toward the root end of the vanes, and therefore, the direction of the resultant relative velocity of the entering air, as designated by the vectors C_1 to C_5 in Figs. 3 to 7, respectively, gradually deviates less from an axial direction toward root end of the vanes. Accordingly, the entrance edge of each of the impeller vanes 20 is cut back in order that the tangent to the entrance edge of each of the vanes is parallel to the relative velocity of the entering air at every point along its entrance edge. With this construction the air enters the impeller substantially without shock, not only at the outer periphery of the entrance vanes 20, but also at intermediate points along each of their entrance edges as well as at their root ends.

The back face or surface of each of the vanes 20 is substantially parallel to its leading face, except the entrance end is beveled or tapered,

as indicated at 34, to provide a relatively thin entrance edge.

With the above construction applicant has provided a composite impeller for a centrifugal compressor, comprising a main impeller section having radially disposed vanes and an entrance impeller section having vanes curved in the direction of rotation of the impeller. This composite impeller, although composed of two sections, is of substantially the same size as the conventional impeller in which only the outer periphery of each of the vanes is bent or curved in the direction of rotation of the impeller. The leading faces of the vanes 20 in effect comprise a series of segments 28 and 30 of cylindrical surfaces having radii r and R , respectively, and in which the adjacent edges of the cylindrical segments are tangential to each other and the downstream segment 28 has a smaller radius of curvature. Thus, the curvature of the vanes 20 of the entrance section 12 may be easily formed since the machining art permits relatively easy machining of the vane curvature when the radius of curvature at the root end of a vane is at least as small as the radius of the curvature at its outer periphery. In addition, with the entrance edge of the vanes cut back from their outer periphery to their root ends, it is possible to have the air enter the impeller vanes without shock along the entire entrance edge of said vanes, from their outer periphery to their root ends, in spite of the limitations of vane curvature imposed by machining difficulties.

While we have described our invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding our invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. We aim in the appended claims to cover all such modifications and changes.

We claim as our invention:

1. A centrifugal fluid impeller comprising a main section and an entrance section mounted for joint rotation, said sections being co-axially disposed in abutting relation and each comprising a hub portion with a plurality of vanes extending therefrom, the vanes of said main section being substantially radially disposed and coplanar with the impeller axis and the vanes of said entrance section forming a continuation of said main section vanes and being curved so that their entrance edges are circumferentially displaced in the direction of rotation of the impeller relative to downstream portions of said entrance section vanes, said curvature extending from the outer periphery of said entrance section vanes to and including the intersection of their root ends with their associated hub portion, the entrance edge of each of said entrance section vanes being cut back from their outer periphery toward their root ends to an extent determined by the curvature of the vanes such that impact shock from the entering fluid is minimized along the entire entrance edge of each vane.

2. A centrifugal impeller comprising hub means and a plurality of impeller vanes extending therefrom, each of said vanes comprising a radially disposed main portion and a curved entrance portion forming a continuation of said main portion, said entrance portions each being curved from their outer periphery to and including the intersection of their root ends with said hub means such that their entrance edges are displaced in the direction of rotation of the im-

PELLER, the entrance edges of each of said vanes being cut back from their outer periphery toward their root ends, the curvature at the root ends of said vane entrance portions being at least as large as the curvature outwardly therefrom.

3. A centrifugal impeller comprising hub means and a plurality of impeller vanes extending therefrom, each of said vanes comprising a radially disposed main portion substantially coplanar with the axis of said impeller and a curved entrance portion forming a continuation of said

5 main portion, the leading face of each of said curved entrance portions comprising a cylindrical surface disposed so that their entrance edges are displaced in the direction of rotation of the impeller and so that the main vane portions are substantially tangent to the down stream ends of the entrance portions, the entrance edges of each of said vanes being cut back from their outer periphery toward their root ends.

KENNETH CAMPBELL.
JOHN E. TALBERT.