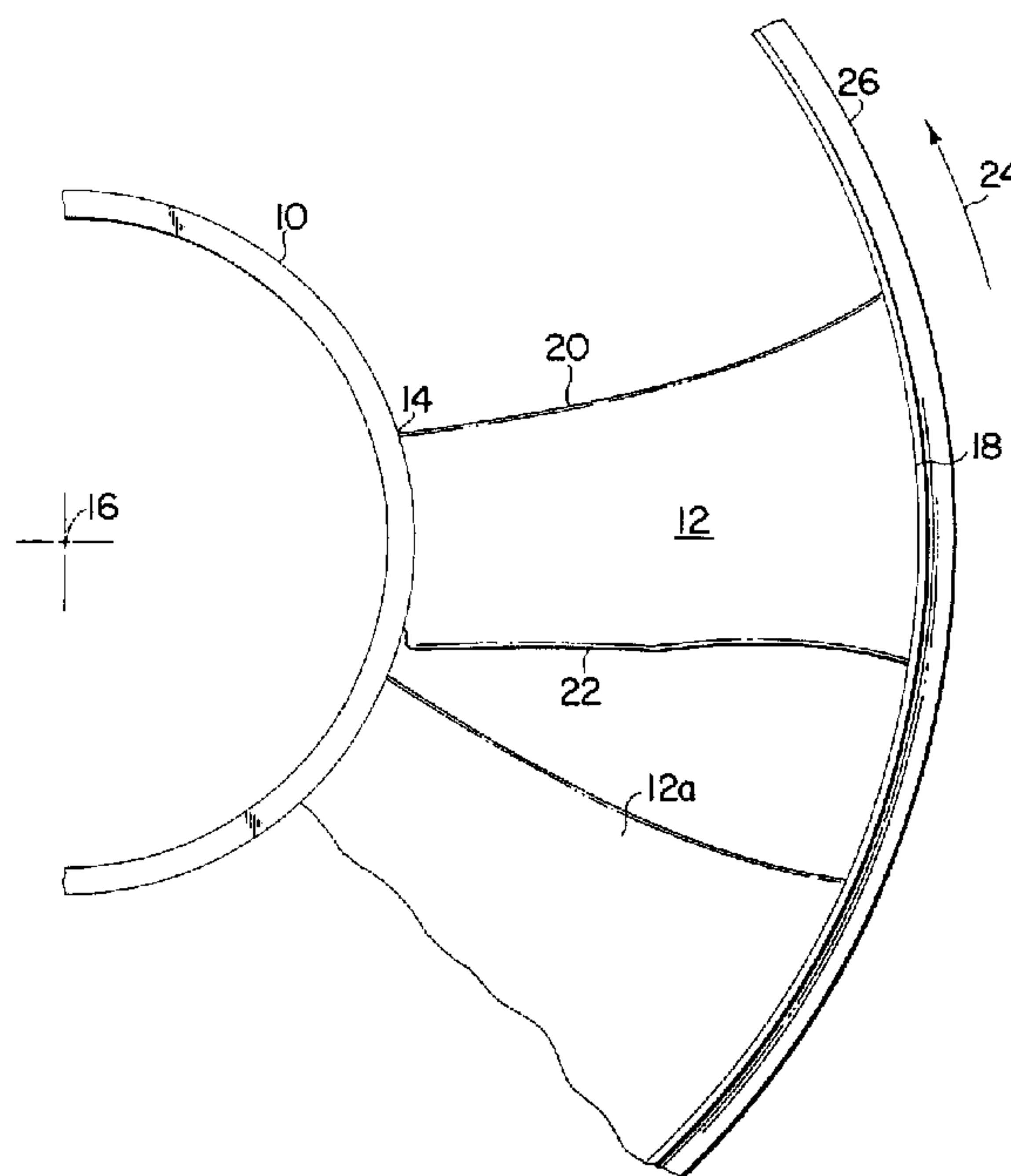




(22) Date de dépôt/Filing Date: 1990/12/13  
(41) Mise à la disp. pub./Open to Public Insp.: 1992/06/14  
(45) Date de délivrance/Issue Date: 2002/03/12

(51) Cl.Int.<sup>5</sup>/Int.Cl.<sup>5</sup> F04D 19/00, F04D 29/32  
(72) Inventeur/Inventor:  
O'Connor, John F., US  
(73) Propriétaire/Owner:  
Torrington Research Company (The), US  
(74) Agent: OGILVY RENAULT

(54) Titre : ROUE AXIALE  
(54) Title: AXIAL FLOW IMPELLER



(57) **Abrégé/Abstract:**

An axial flow air impeller for automotive radiator and heat exchanger use comprising a hub, a plurality of air moving blades and an orifice ring, the hub adapted for rotation about an axis and carrying a plurality of integrally formed similar circumaxially spaced and generally radially outwardly projecting air moving blades, each of said blades having a root end portion integral with the hub and a radially outwardly disposed tip end portion with smoothly curving side edges therebetween, said air impeller being adapted for unidirectional rotation and said side edges comprising leading and trailing edges the leading edge of which curves substantially forwardly when viewed from root end portion to tip end portion, the projected width of each blade thus being at least 40% greater at the tip end portion than at the root end portion, the maximum thickness of each blade varying from a maximum at the root end portion to a minimum at the tip end portion, and the maximum thickness at the tip end portion being at least three times the thickness at the blade trailing edge, and an orifice ring integral with each blade tip end portion and circumscribing the plurality of blades, said ring having upstream and downstream ends and having a flange at one end with a substantially smooth radius at the junction with the ring portion.

ABSTRACT

An axial flow air impeller for automotive radiator and heat exchanger use comprising a hub, a plurality of air moving blades and an orifice ring, the hub adapted for rotation about an axis and carrying a plurality of integrally formed similar circumaxially spaced and generally radially outwardly projecting air moving blades, each of said blades having a root end portion integral with the hub and a radially outwardly disposed tip end portion with smoothly curving side edges therebetween, said air impeller being adapted for unidirectional rotation and said side edges comprising leading and trailing edges the leading edge of which curves substantially forwardly when viewed from root end portion to tip end portion, the projected width of each blade thus being at least 40% greater at the tip end portion than at the root end portion, the maximum thickness of each blade varying from a maximum at the root end portion to a minimum at the tip end portion, and the maximum thickness at the tip end portion being at least three times the thickness at the blade trailing edge, and an orifice ring integral with each blade tip end portion and circumscribing the plurality of blades, said ring having upstream and downstream ends and having a flange at one end with a substantially smooth radius at the junction with the ring portion.

2032192

1 IMPROVED AXIAL FLOW IMPELLER

BACKGROUND OF THE INVENTION

5 A variety of axial flow fan designs have been employed in cooling automotive radiators and in similar heat exchanger applications and, while certain designs have been generally satisfactory, no single impeller design has been completely satisfactory in all respects.

10 It is the general object of the present invention to provide an improved axial flow air impeller which represents a judicious compromise of design objectives such as minimum noise generation, highly efficient aerodynamic operation and economy of material and manufacture.

SUMMARY OF THE INVENTION

15 In fulfillment of the foregoing object, an improved axial flow air impeller for automotive radiator fan use or the like comprises a hub adapted for rotation about an axis and carrying a plurality of integrally formed similar circumaxially spaced air moving blades. The blades project generally radially outwardly from the hub and each blade has a root end portion integral with the hub and a radially outwardly disposed tip end portion with smoothly curving opposite side edges between the root and tip end portions. The air impeller is adapted for unidirectional rotation and, accordingly, the side edges comprise leading and trailing edges of the blades.

20

1           In accordance with the present invention, the leading edge  
of each blade curves substantially forwardly when viewed from the  
root end portion to the tip end portion and, as a result, the  
projected width of each blade is at least 40% greater at the tip  
5           end portion than at the root end portion. Preferably, and in the  
presently favored design, the tip end portion of each blade is  
approximately 40% to 80% wider than the root end portion thereof.

          The maximum thickness of each fan blade also varies from a  
maximum at the root end portion to a minimum at the tip end  
10          portion and the maximum thickness at the tip end portion is  
preferably at least three times the thickness at the blade  
trailing edge.

          Finally, an orifice ring is formed integrally with each  
blade tip end portion and circumscribes the plurality of blades.  
15          The ring has upstream and downstream ends and is provided with a  
smooth radius and is optionally at least approximately bell  
mouthed as illustrated at its upstream or downstream end.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20          Fig. 1 is a fragmentary rear view of an improved axial flow  
air impeller constructed in accordance with the present  
invention.

          Fig. 2 is a fragmentary side view of the air impeller of  
Fig. 1.



1 edge 22. The air impeller of the present invention is  
unidirectional and rotates in a counterclockwise direction as  
illustrated in Fig. 1 by the directional arrow 24.

5 In accordance with the present invention, the leading edge  
of each blade 12 of the impeller of the present invention is  
curved substantially forwardly when viewed from root end portion  
to tip end portion and the width of each blade is thus increased  
substantially in progression from the root end portion to the tip  
10 end portion. That is, the trailing edge of each blade 12 is  
preferably at least approximately radial as illustrated in Fig. 1  
such that a substantial increase in blade width or "chord" occurs  
as a result of the forward sweep of the blade leading edge 20.  
Preferably, at least a 40% increase in blade projected width  
occurs throughout blade length and, as illustrated, the blade is  
15 substantially twice as wide at its tip end portion as at its root  
end portion thus showing a 100% increase in width. Further, the  
forward sweep of the leading edge of the blade preferably occurs  
at a radially outwardly disposed portion thereof. Thus, the  
major portion of the forward curve at the leading edge of each  
20 blade preferably occurs at the outer one-half of the blade length  
measured from the root end portion to the tip end portion and,  
more specifically, at the outer one-third of the blade length so  
measured.

1           The forward sweep of the leading edge of each of the blades  
 12 substantially improves the time incidence differential for  
 radial points along the outer portion of the blade leading edge.  
 This results in a significant reduction in noise generation.

5           In observation of Fig. 2, it will be observed that a  
 significant variation in thickness occurs as the blade progresses  
 from its root end portion 14 to its tip end portion 18, the  
 thickness of the blade being substantially reduced. The  
 thickness variation is designed to minimize stress in the blades  
 and at the same time reduce to the extent possible the amount of  
 10 material required to make the blade relative to a uniform  
 thickness blade of the same strength. The maximum blade  
 thickness  $T_{max}$  near the root portion of the blade is judiciously  
 selected as are various section thicknesses along the length of  
 15 the blade from its root end portion to its tip end portion. That  
 is, the blade thickness  $T_s$  at any blade section may be determined  
 as follows:

$$T_s - T_{max} (r_s / r_{root})^x$$

where:

20  $T_s$  - blade thickness at the  
 measured section, s

$T_{max}$  - maximum blade thickness near the  
 root tip end portion

$r_s$  - radius ratio x at section s



1 upstream and downstream edges or ends and the upstream or  
downstream edge or end thereof is at least approximately bell  
mouthed. This of course serves to provide for a smooth flow of  
air into or from the fan blades and tends to prevent blade to  
5 blade leakage of air around the tips of the blades. Obviously,  
the outer surface of the orifice ring may be contoured to match  
an associated housing or other opening in which the impeller is  
mounted. Clearance employed between the moving and stationary  
surfaces at the outer diameter of the ring can be provided at  
10 normal manufacturing tolerances found in high volume commercial  
applications. With this arrangement a better air seal is  
achieved than can be obtained using a conventional air impeller  
design without an orifice ring but employing very tight running  
tolerances. That is, a clearance of  $0.10$  with the ring will  
15 match a clearance of  $0.005$  without a ring.

As mentioned, the improved axial flow air impeller of the  
present invention provides for very low operating noise, maximum  
aerodynamic efficiency, improved mechanical strength and minimum  
material usage in manufacture. The thickness variation minimizes  
20 stress in the blades and at the same time reduces the amount of  
material required to make the blades. The addition of the  
orifice ring provides lateral stiffness to the impeller blades  
which accommodates the relatively thin blade sections, this in  
addition to the primary function of the orifice ring in reducing

2032192

1 blade tip leakage. The reduction in blade tip leakage  
contributes directly to higher aerodynamic efficiency and the  
resulting decrease in flow disturbance around the blade tips  
serve still further to reduce noise generation.

5

IN THE CLAIMS

1. An axial flow air impeller for automotive radiator, heat exchanger use and the like comprising a hub adapted for rotation about an axis and carrying a plurality of integrally formed similar circumaxially spaced and generally radially outwardly projecting air moving blades, each of said blades having a root end portion integral with the hub and a radially outwardly disposed tip end portion with smoothly curving side edges therebetween, said air impeller being adapted for unidirectional rotation and said side edges comprising leading and trailing edges the former of which curves substantially forwardly when viewed from root end portion to tip end portion, the projected width of each blade thus being at least 40% greater at the tip end portion than at the root end portion, the maximum thickness of each blade varying from a maximum at the root end portion to a minimum at the tip end portion, and the maximum thickness at the tip end portion being at least three times the thickness at the blade trailing edge, and an orifice ring integral with each blade tip end portion and circumscribing the plurality of blades, said ring having upstream and downstream ends and having a flange at one end with a substantially smooth radius at the junction with the ring portion.

2. An axial flow air impeller as set forth in claim 1 wherein said blade trailing edges extend at least approximately along radial lines, the blade mid-chord points thus being gradually shifted forwardly in progression from root end portion to tip end portion by the forward sweep of the blade leading edges.
3. An axial flow air impeller as set forth in claim 1 wherein the forward curve of each blade leading edge is such that blade width is approximately 40% to 80% greater at the tip end portion than at the root end portion.
4. An axial flow air impeller as set forth in claim 1 wherein the maximum blade thickness at each blade tip end portion is at least three times the thickness at the blade trailing edge.
5. An axial flow air impeller as set forth in claim 2 wherein the major portion of the forward curve at the leading edge of each blade occurs at the outer one-half of the blade measured from the root end portion to the tip end portion.
6. An axial flow air impeller as set forth in claim 5 wherein the major portion of the forward curve at the leading edge of each blade occurs at the outer one-third of the blade measured from the root end portion to the tip end portion.

7. An axial flow air impeller as set forth in claim 1 wherein blade thickness at any blade section is:

$$T_s = T_{max} (r_s/r_{root})^x$$

where:

$T_s$  = blade thickness at  
the measured section,  $s$

$T_{max}$  = maximum blade thickness near the  
root tip end portion

$r_s$  = radius ratio  $x$  at section  $s$

$r_{root}$  = section radius at blade root end

$x$  = between 1.0 and 0.5 (value assigned so that minimum value of  $T_s$  will not be less than 3 times thickness at blade trailing edge).

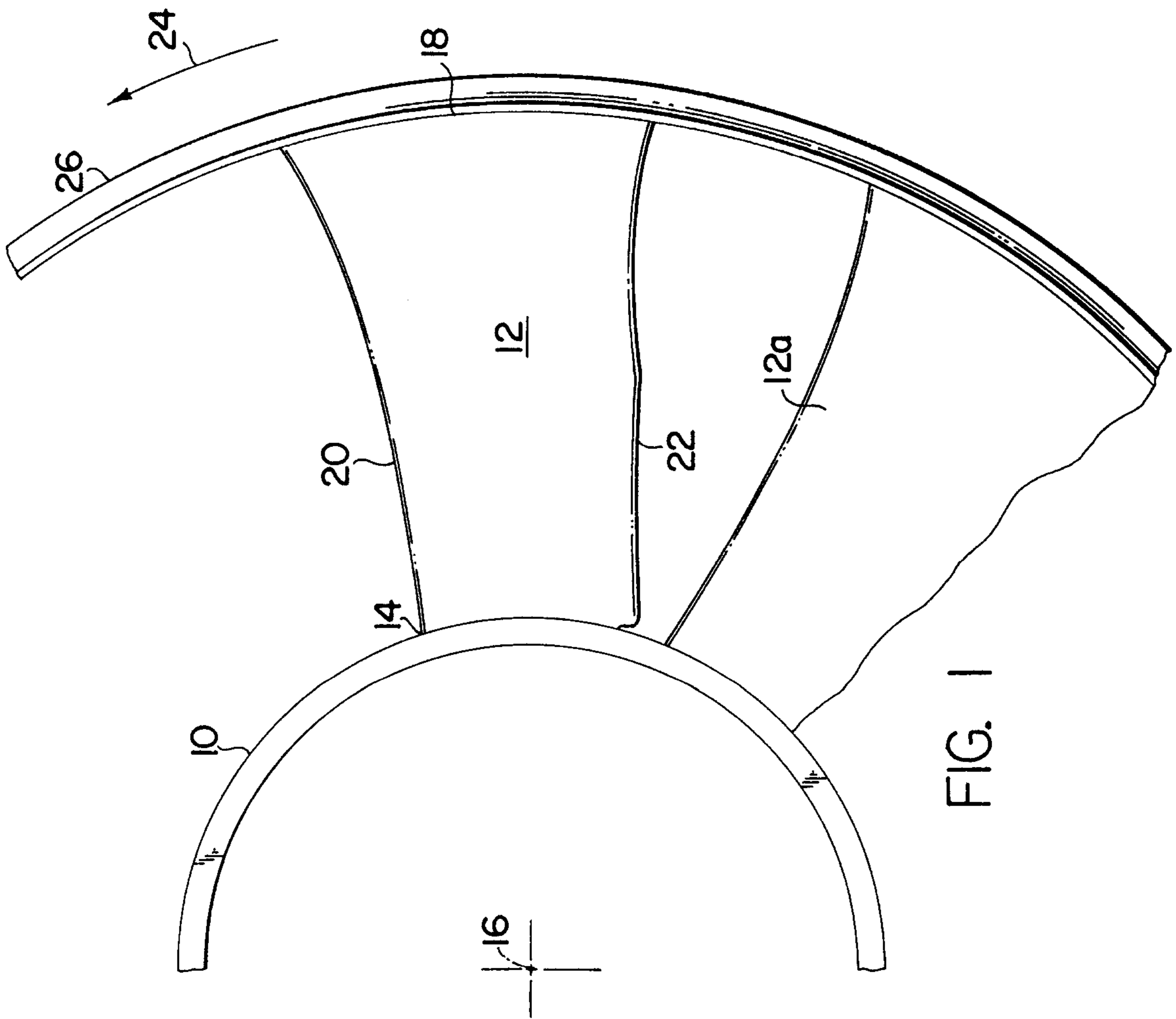


FIG. 1

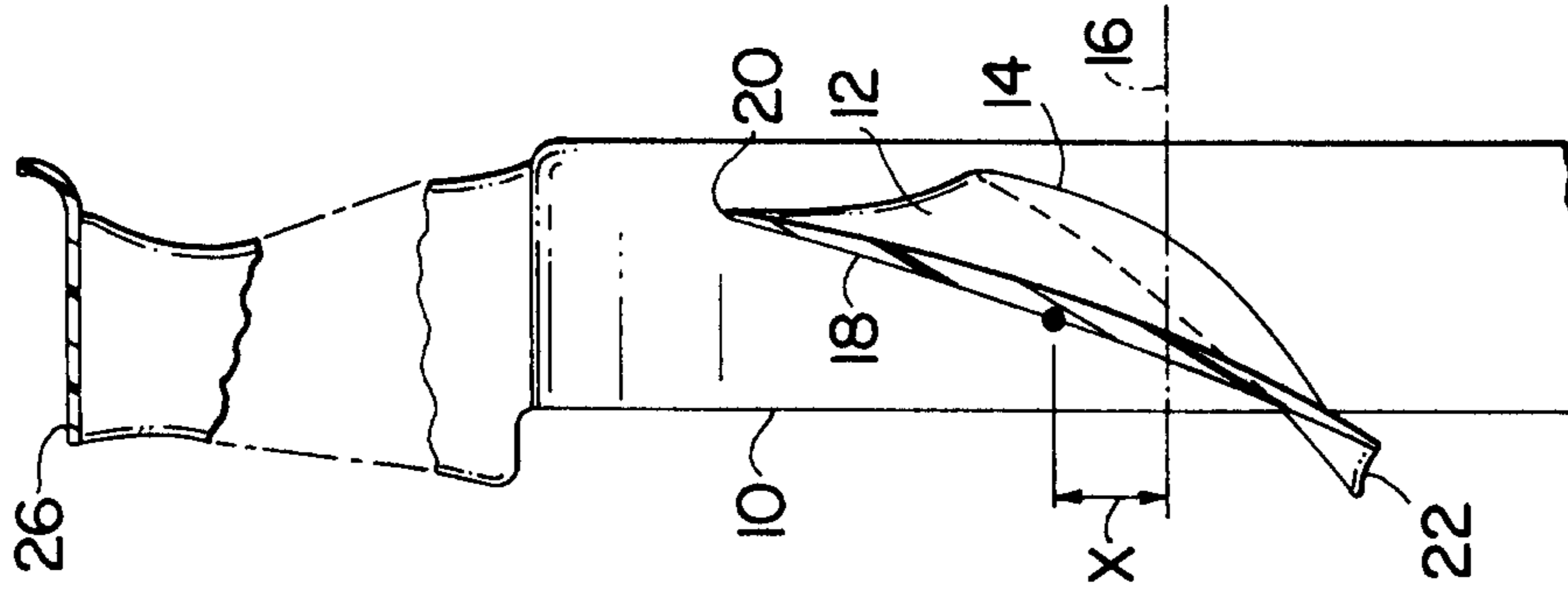


FIG. 2

Ogilvy, Renault  
Patent Agents

