(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 168 594**
B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification: **01.02.89**

(51) Int. Cl.[4]: **F 04 D 29/38,** F 01 P 5/02

(21) Application number: **85106245.5**

(22) Date of filing: **22.05.85**

(54) **Improved axial fan.**

(30) Priority: **27.06.84 US 624880**

(43) Date of publication of application:
22.01.86 Bulletin 86/04

(45) Publication of the grant of the patent:
01.02.89 Bulletin 89/05

(84) Designated Contracting States:
DE FR GB IT

(56) References cited:
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EP 0 168 594 B1

Courier Press, Leamington Spa, England.

Description

This invention relates generally to automotive fans and more specifically to axial flow fans exhibiting low acoustic noise. This invention further relates to the cooling fans appropriate for vehicles where the fan may continue to operate after the engine is turned off or where the other noise sources have been intentionally quieted to a degree that the fan is the dominant noise source.

In automotive applications a fan is placed behind a radiator to draw air through the radiator. These fans are conventionally engine driven. However, present practice indicates many fans will be driven by an electric motor. Often to control the cooling of the engine these electrically controlled fans operate after the engine has been turned off. Consequently, the fan is now operating in an environment where it is now the only or major source of noise. In order to avoid calling attention to the operation of the fan, after the engine has been turned off, it is desirable to utilize fans which emit low levels of acoustic noise.

Early automotive fans and marine propellers have utilized a structure comprising an inner hub, a plurality of fan blades emanating therefrom and an outer ring that surrounds and is secured to the tips of the blades.

US—A—4,358,245 illustrates a later automotive fan having a set of blades each secured at its root ends to a hub and its outer ends secured to an annular rim that is generally centered around the hub. The blades are secured to the band continuously along their widths. Each fan blade comprises a cross-section which is defined by a blade chord length and a blade thickness which change as a function of blade length. More particularly, the blades have varying cross sections to produce a narrowing air passage in the direction of air flow through the fan and the blades are highly forwardly skewed. In addition to having blades which are highly forwardly skewed, the angle of each blade makes with the plane of rotation increases with blade radius over at least the outer 30% of the blade.

It is another object of the present invention to eliminate noise sources that contribute to the fan efficiency, such as air recirculation around the blade tip, i.e., tip vortices.

Blade tip vortices have been studied since very early days of the turbomachinery; the tip clearance, the distance between the blades and the casing or shroud, create a leakage of flow from the pressure side to the suction side of the blade. This leakage not only causes a loss in the efficiency (flow output/power input) but creates two major vortices, usually referred as clearance vortex and passage vortex, which contribute to the increased noise levels. In this invention the configuration of the ring around the blades has been designed to eliminate the tip vortices and to eliminate the direct air recirculation once the flow is discharged out of the fan (US—A—4,358,248).

Through extensive experimental work towards identifying the optimum configuration of the blade to improve fan efficiency while lowering the noise level of the fan, it was found this configuration necessitates having a large airfoil section at the blade tip. In addition, the blade thickness should increase in the vicinity of the ring.

According to the invention there is provided a fan (32) comprising a hub (50) rotationally supported and adapted to be driven;

a plurality of fan blades (62) each secured at a root end (80) to said hub (50) and at a tip end (64) to a ring (66) concentric to the hub; said fan blades (60) comprising a cross section which is defined by a blade chord length and a blade thickness, the chord length and blade thickness changing as a function of blade length, characterized in that the blade chord length increases as a function of blade length (1) over the outer 80% thereof and a blade thickness (t) which increases as a function of blade length over the outer 30% thereof.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic depiction of the invention.
FIGURE 2 is a perspective view of the present invention.
FIGURE 3 is a front plan view of the present invention.
FIGURE 4 illustrates another embodiment of the invention.
FIGURE 5 shows the variation in blade thickness as a function of radius.
FIGURES 6—9 illustrate circumferential cross sections of a blade adjacent to the outer ring of the fan.
FIGURE 10 is a cross-sectional view through section A—A of FIGURE 3.
FIGURE 11 shows a plan view of an isolated fan blade.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIGURE 1 which illustrates a typical automotive application of an electrically driven fan. There is illustrated an engine 20 positioned behind a radiator 22. An air conditioning condenser 24 may be located in a known manner in front of the radiator 22. The system 10 may comprise a shroud 26 which extends from the radiator over a portion of an electrically driven fan 32. The shroud 26 has a generally circular cross section in the vicinity of the fan 32 and is closely spaced from the ends thereof. The fan 32 is driven by an electric motor 30 in a conventional manner.

With reference to FIGURES 2 and 3, there is shown a perspective view of the rear and a plan front view of the fan 32. The solid arrows adjacent the fan indicate its direction of rotation. The fan 32 is preferably fabricated of molded plastic and comprises a hub 50. The hub 50 may be reinforced through some radial vanes 52 having a central member 54 which defines an opening 56. The opening 56 is adapted to accept the shaft of a motor, such as motor 30. The front surface of the hub 50 supports a mounting clip 58 that secures the fan 32 on the drive shaft of the electrical motor 30.

The fan 32 further includes a plurality of blades 62 (a-c) which are symmetrically positioned relative to and extend from the hub 50. The tip edge or end 64 of each blade 62 is secured to a ring 66 which is centrally and axially positioned relative to the axis of the hub 50. The tip edge 64 of blade 62a is shown in the cutout portion of FIGURE 2. The ring 66 comprises an axially extending band 68 having a flared out, bell shaped leading edge 70 at the forward or low pressure side thereof. The inner surface 72 of the band 68 flares radially outwardly to provide a cross section of decreasing thickness as illustrated in FIGURE 10. The inner surface 72 is also referred to as a flared out trailing edge 72. It has been found good performance is achieved if the inner surface 72 tapers over at least 40% of its length. The inner surface 72 terminates at an internal edge 76. The bell mouth shaped leading edge 70 serves to block air recirculation thus increasing operating efficiency and enhancing the quiet operation of the cooling system.

Each blade further comprises a root end 80, a leading edge 84 and a trailing edge 86. Each root end 80 is attached over its full width to the hub 50. In the embodiment of the invention shown in FIGURE 2, the tip end 64 is secured over its entire length to the inner surface 72 of the ring 66. In contrast, in the embodiment of the invention shown in FIGURE 4, a greater portion of the tip end 64 is connected to the ring 66 with the exception of the trailing portion of the tip end 69 proximate the trailing edge 86 which extends beyond the internal edge 76 of the ring 66. The extension of the blade above the ring may provide an increase in the rate of the air flow depending on the location of the trailing edge of the shroud 26.

Reference is made to FIGURE 5 which graphically illustrates the relationship of cord length, 1, and blade thickness t, as a function of radius. Selective blade sections are shown in greater detail in FIGURES 6—9. It can be seen from these FIGURES that the cord length increases dramatically over the outer 30% of the blade length 62 thereby giving the blade its forwardly swept appearance. In addition, the thickness of the cord or blade thickness is shown to increase over the outer 80% of the radius. In addition the blade angle decreases along the fan blade.

Reference is again made to FIGURE 3 which illustrates a plan frontal view of the fan 32 and to FIGURE 10 which is a cross-sectional view taken through section A—A of FIGURE 3. FIGURE 10 illustrates in greater detail the structure of the ring 66, hub 50 and reinforcing vanes 52 construction. In the embodiment of the invention illustrated in FIGURES 3 and 10, the reinforcing vanes 52 are formed as an integral extension of the hub 50. FIGURE 10 further illustrates the relationship of an exemplary blade 62 to the ring 66 and, more particularly, illustrates how the underside 94 of each blade 62 intersects the inner surface 72 of the ring 66 in a smooth transition.

Reference is made to FIGURE 11 which illustrates a plan view of a single blade and to TABLE 1. FIGURE 11 illustrates a number of points (1—49) located on both surfaces of the fan blade 62 which, when used in conjunction with the information on TABLE 1, identify the detailed construction of the blade. It should be appreciated the precise dimensions of the fan blade will vary with application. The identifying numerals in FIGURE 11 are located at the intersection of varying radii with rays which are located at various angles such as: +10°, −10°, +20°, −20°, etc., from the Section A—A reference line.

In the preferred embodiment of the invention, the radius of the fan is approximately 178 mm and the radius of the hub is approximately 70 mm. The cord length of the blade at its root, taken through points 1—37, is approximately 80 mm while the cord length at its tip end is approximately 180 mm. In addition, the blade angle at its root is approximately 25° and decreases to approximately 10° at its tip edge. The variation in the blade angle can be seen from FIGURES 6—9. As can be seen from FIGURES 6—9, and TABLE 1, each fan blade has a blade cord which is a function of blade radius and increases over at least the outer 80% of the radius of the blades. Further, each blade has an increasing blade thickness as a function of radius and, more particularly, the blade thickness increases over the outer 30% of the radius of each blade. With reference to FIGURES 6—9, the underside 94 of each blade, especially in the vicinity of the tip edge, has a modified airfoil configuration wherein the cross section of the blade, starting at its leading edge, has a concavo-convex cross section due to the curvilinear nature of the lower or underside 94.

TABLE 1

Point No.	Angle	Top	Bot.	Point No.	Angle	Top	Bot.	Point No.	Angle	Top	Bot.	Point No.	Angle	Top	Bot.
1	50°25′	1.0	0.0	12	20°	10.8	9.6	23	0°	28.2	24.7	34	−20°	42.6	41.1
2	41°55′	3.5	2.5	13	10°	29.8	21.8	24	0°	26.4	19.3	35	−20°	40.2	35.0
3	28°30′	9.0	8.0	14	10°	29.1	22.0	25	−10°	38.5	31.3	36	−20°	39.1	23.5
4	21°35′	10.6	9.6	15	10°	26.2	21.1	26	−10°	39.1	33.7	37	−33°5′	40.0	38.8
5	17°20′	10.5	9.5	16	10°	22.5	19.0	27	−10°	40.1	37.7	38	−23°20′	40.5	39.3
6	16°10′	10.2	9.2	17	10°	18.3	16.0	28	−10°	39.4	37.2	39	−26°	43.6	42.9
7	30°	15.4	10.6	18	10°	16.7	14.7	29	−10°	35.7	31.1	40	−30°	42.4	38.1
8	30°	11.8	8.5	19	0°	35.1	26.8	30	−10°	33.4	21.6	41	−30°	42.0	31.2
9	20°	23.0	16.4	20	0°	34.8	27.5	31	−20°	39.6	37.2	42	−37°55′	42.9	40.0
10	20°	20.5	15.6	21	0°	33.5	28.5	32	−20°	41.9	38.6	43	−40°	42.9	39.9
11	20°	16.0	10.0	22	0°	31.3	27.9	33	−20°	42.9	41.4	44	−45°50′	43.0	42.0
												45	22°20′	9.6	8.6
												46	10°	23.6	19.8
												47	0°	32.9	28.7
												48	−10°	39.9	37.7
												49	−20°	43.2	41.9

Claims

1. A fan (32) comprising a hub (50) rotationally supported and adapted to be driven:

a plurality of fan blades (62) each secured at a root end (80) to said hub (50) and at a tip end (64) to a ring (66) concentric to the hub; said fan blades (60) comprising a cross section which is defined by a blade chord length and a blade thickness, the chord length and blade thickness changing as a function of blade length, characterized in that the blade chord length increases as a function of blade length (l) over the outer 80% thereof and a blade thickness (t) which increases as a function of blade length over the outer 30% thereof.

2. The fan as defined in Claim 1 wherein said blades (62) comprise a generally rounded forwardly swept leading edge (84) which terminates at said ring (66).

3. The fan as defined in Claim 1 wherein the blade chord length at the tip end (64) is at least twice as large as the blade chord length at the root end (80).

4. The fan as defined in Claim 2 wherein most of the tip edge (64) is secured to said ring (66) and includes a portion (69) of said tip edge which extends above a rear edge (76) of said ring (66) and wherein each said blade includes a trailing edge (86) which joins said extending portion of said tip edge.

5. The fan as defined in Claim 1 wherein said ring (66) comprises an axially extending portion having a tapered inner wall (72) defining a flared out inner or trailing edge (76).

6. The fan as defined in Claim 1 wherein the blade angle of each chord decreases over the outer 30% of the blade (32).

7. The fan as defined in Claim 6 wherein the blade angle decreases from approximately 25° at said root end (80) to approximately 10° at said tip end (64).

8. The fan as defined in Claim 5 wherein said inner wall (72) is partially tapered.

9. The fan as defined in Claim 4 wherein each blade (62) comprises an underside (94) which joins said inner wall (72) in a smooth transition.

Patentansprüche

1. Ventilator (32) mit einer Nabe (50), die drehbar gelagert ist und angetrieben werden kann, einer Vielzahl von Ventilatorflügeln (62), die jeweils mit ihrem Ausgangsende (80) an der Nabe (50) und mit ihrem Spitzenende (64) an einem konzentrisch zur Nabe angeordneten Ring (66) befestigt sind, wobei die Ventilatorflügel (60) einen Querschnitt bestizen, der durch die Flügelsehnenlänge und die Flügeldicke festgelegt wird, und wobei sich die Sehnenlänge und die Flügeldicke in Abhängigkeit von der Flügellänge ändern, dadurch gekennzeichnet, daß die Flügelsehnenlänge in Abhängigkeit von der Flügellänge (1) über die äußeren 80% derselben und die Flügeldicke (p) in Abhängigkeit von der Flügellänge über die äußeren 30% derselben ansteigen.

2. Ventilator nach Anspruch 1, bei dem die Flügel (62) eine allgemein abgerundete, vorwärts gekrümmte Vorderkante (84) aufweisen, die am Ring (66) endet.

3. Ventilator nach Anspruch 1, bei dem die Flügelsehnenlänge am Spitzenende (64) mindestens doppelt so groß ist wie die Flügelsehnenlänge am Ausgangsende (80).

4. Ventilator nach Anspruch 2, bei dem der größte Teil der Spitzenkante (64) am Ring (66) befestigt ist und einen Abschnitt (69) der Spitzenkante umfaßt, welcher sichüber eine hintere Kante (76) des Rings (66) hinaus erstreckt, und bei·dem jeder Flügel eine Hinterkante (86) aufweist, die sich an den verlängerten Abschnitt der Spitzenkante anschließt.

5. Ventilator nach Anspruch 1, bei dem der Ring (66) einen axial verlaufenden Abschnitt aufweist, der eine sich verjüngende Innenwand (72) besitzt, die eine erweiterte innere oder hintere Kante (76) bildet.

6. Ventilator nach Anspruch 1, bei dem der Flügelwinkel einer jeden Sehne über die äußeren 30% des Flügels (32) abnimmt.

7. Ventilator nach Anspruch 6, bei dem der Flügelwinkel von etwa 25° am Ausgangsende (80) bis auf etwa 10° am Spitzenende (64) abnimmt.

8. Ventilator nach Anspruch 5, bei dem sich die Innenwand (72) teilweise verjüngt.

9. Ventilator nach Anspruch 4, bei dem jeder Flügel (62) eine Unterseite (94) umfaßt, die sich über einen glatten Übergang an die Innenwand (72) anschließt.

Revendications

1. Ventilateur (32) comprenant un moyeu (50) prévu pour être supporté en entraîné en rotation;

une pluralité d'ailettes (62) fixées chacune par une embase (80) au moyeu (50) son extrémité opposée (64) à un anneau (66) concentrique au moyeu; les ailettes du ventilateur (32) présentant une section transversale définie par la longueur d'une corde d'ailette et par l'épaisseur d'une ailette, la longueur de la corde et l'épaisseur de l'ailette variant en fonction de la longueur de l'ailette, caractérisé en ce que la longueur de la corde de l'ailette augmente en fonction de la longueur (l) de l'ailette sur les 80% extérieurs de celle-ci, l'épaisseur (t) de l'ailette augmentant en fonction de la longueur de l'ailette sur les 30% extérieurs de celle-ci.

2. Ventilateur selon la revendication 1, dans lequel les ailettes (62) comprennent un bord d'attaque (84)

arrondi en général balayé vers l'avant et aboutissant à l'anneau (66).

3. Ventilateur selon la revendication 1, dans lequel la longueur de la corde en bout d'ailette (64) est au moins le double de la longueur de la corde du côté de la base (80).

4. Ventilateur selon la revendication 2, dans lequel la plus grande partie de l'extrémité du bord (64) est fixé à l'anneau (66) et inclut une partie (69) de la dite extrémité du bord qui se prolonge au-dessus du bord arrière (76) de l'anneau (66) et dans lequel chaque ailette inclut un bord de sortie (86) qui rejoint la partie prolongée de la dite extrémité de bord.

5. Ventilateur selon la revendication 1, dans lequel l'anneau (66) comprend une partie s'étendant axialement pourvue d'une paroi interne dont l'épaisseur diminue (72) définissant un bord évasé, intérieur ou de sortie (76).

6. Ventilateur selon la revendication 1, dans lequel l'angle de chaque corde diminue sur les 30% extérieurs de l'ailette (32).

7. Ventilateur selon la revendication 6, dans lequel l'angle de l'ailette décroit allant d'approximativement 25° à la base (80) en descendant à environ 10° en bout d'ailette (64).

8. Ventilateur selon la revendication 5, dans lequel la paroi interne (72) est partiellement amincie.

9. Ventilateur selon la revendication 4, dans lequel chaque ailette (62) comprend une partie inférieure (94) qui rejoint la paroi intérieure (72) en transition douce.

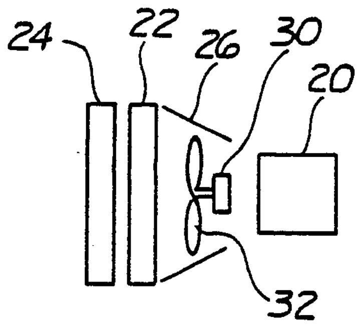


Fig-1

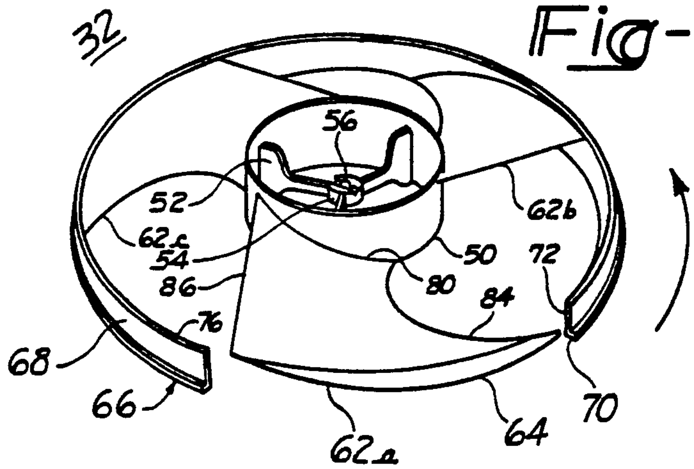


Fig-2

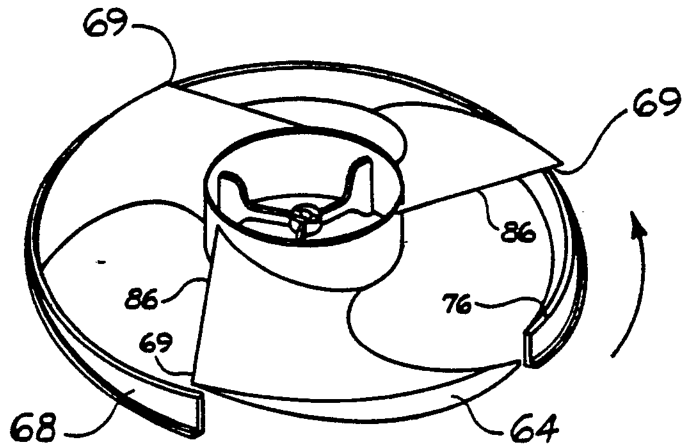


Fig-4

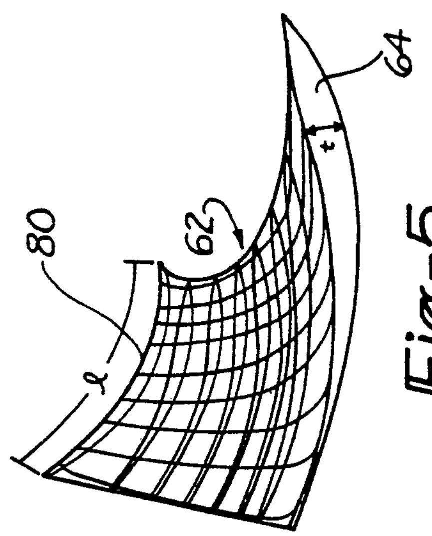


Fig-5

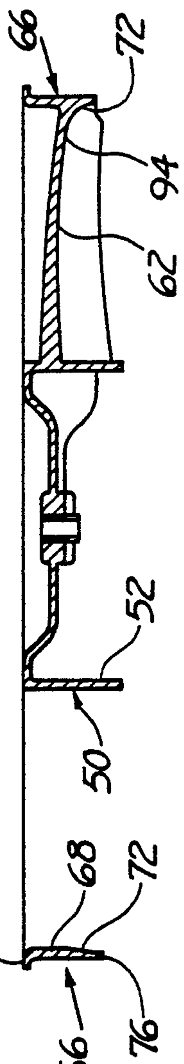


Fig-10

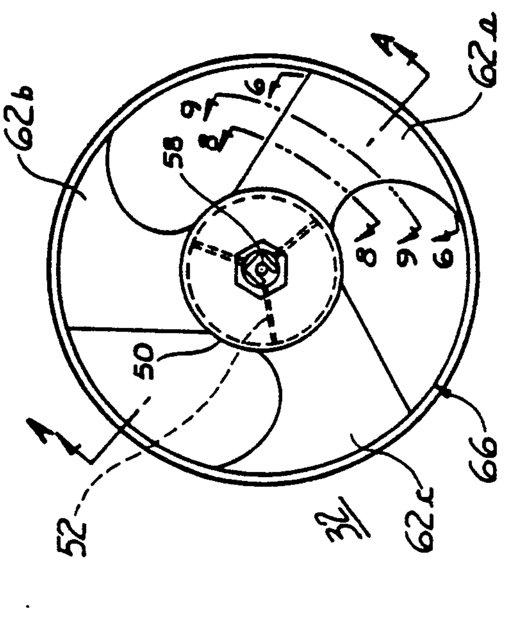


Fig-3

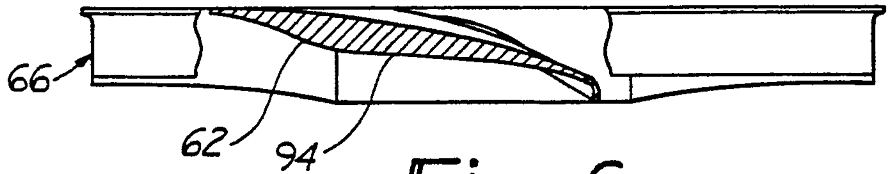


Fig-6

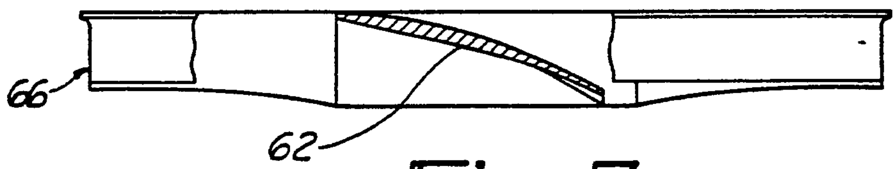


Fig-7

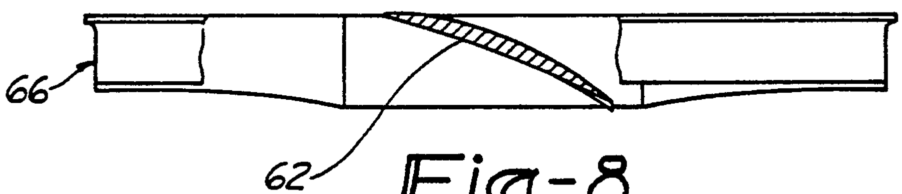


Fig-8

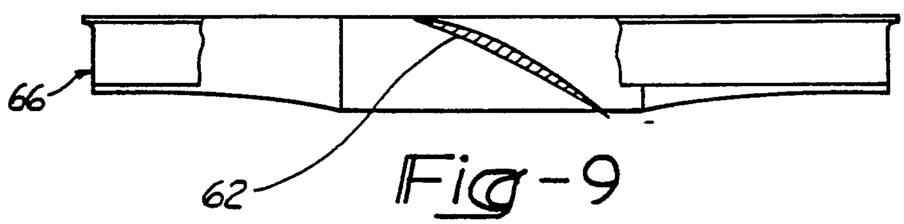
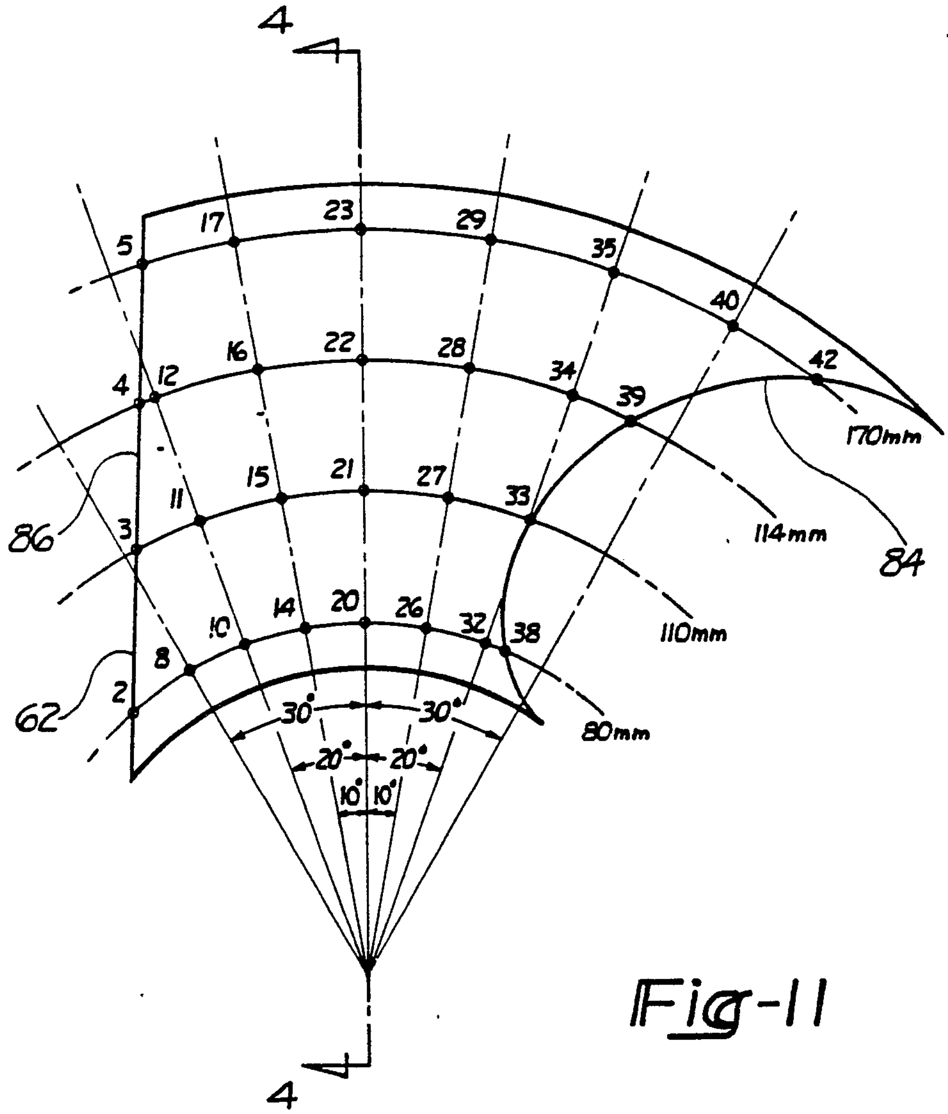


Fig-9


4
5
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29
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170mm
4
12
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22
28
34
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33
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32
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80mm
62
30°
30°
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20°
10°
10°
4

Fig-11