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(54) **Method of producing a sheet metal fan, and fan produced thereby**

Verfahren zum Herstellen eines Metallblechventilators und so hergestellter Ventilator

Procédé de fabrication d'un ventilateur en tôle et ventilateur ainsi produit

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Description

[0001] The present invention relates to a method of producing a sheet metal fan, and to a sheet metal fan produced using such a method (see for example US-A-3 845 903).

[0002] Industrial air or gas supply systems normally feature strong sheet metal fans.

[0003] One known method of producing such fans is to first prepare a sheet metal disk with a central hole for housing a hub; separately cut and bend a number of sheet metal blades; and finally weld or rivet the blades perpendicularly to the disk.

[0004] Another known method is to prepare a number of radial elements with a substantially L-shaped circumferential section; and fit the radial L-shaped elements together by welding or riveting the edge of the L of one element to the edge of one wing of the angularly adjacent element, so that the joined wings of the L-shaped elements form a flat disk, and the wings perpendicular to them form the actual blades of the fan.

[0005] Known fans of the above type involve several drawbacks.

[0006] In particular, the edges of the blades and/or the rivets create turbulent air or gas flow, so that the fans are extremely noisy and consume an excessive amount of electric power. Moreover, actual manufacture is a long painstaking job requiring skilled labour, so that the fans are fairly expensive to produce.

[0007] It is an object of the present invention to provide a highly straightforward, reliable method for producing a sheet metal fan, and which provides for eliminating the aforementioned drawbacks typically associated with known methods.

[0008] According to the present invention, there is provided a method of producing a sheet metal fan, characterized by comprising the steps of:

- preparing a sheet metal disk having a central hole coaxial with an axis; and
- subjecting said disk to at least a first drawing operation to form an undulated body having at least a first number of undulations defining a first number of blades of said fan.

[0009] According to the present invention, there is also provided a sheet metal fan, characterized by being formed in one piece, and by comprising undulations alternating with cavities; said undulations defining at least a first number of blades of said fan.

[0010] A number of preferred, non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a view in perspective of a first fan produced using the method according to the present invention;

Figure 2 shows a view in perspective of a second fan produced using the method according to the present invention;

Figures 3 and 4 show views in perspective of semifinished parts of the Figure 1 fan;

Figure 5 shows a view in perspective of a first die in which the Figure 4 semifinished part obtained after the corresponding fabrication step is placed;

Figure 6 shows a view in perspective of a second die in which the Figure 4 semifinished part is placed before the corresponding fabrication step;

Figure 7 shows a view in perspective of a third fan produced using the method according to the present invention;

Figure 8 shows a view in perspective of a fourth fan produced using the method according to the present invention;

Figure 9 shows a view in perspective of a fifth fan produced using the method according to the present invention;

Figure 10 shows an air supply system employing the Figure 9 fan.

[0011] Number 6 in Figure 1 indicates as a whole a first fan produced using the method according to the present invention.

[0012] Fan 6 is made in one piece from appropriately thick sheet metal, and comprises a number of blades 7 extending radially with respect to an axis 8 and alternating with cavities 9 having a trapezoidal circumferential section.

[0013] More specifically, each blade 7 tapers axially, has a substantially V-shaped circumferential section, and comprises a pair of facing, converging lateral walls 11, and a connecting wall 12 connecting lateral walls 11 and having, when viewed from above, a substantially straight profile.

[0014] Connecting wall 12 comprises an outer first portion 13 having generating lines substantially perpendicular to axis 8; and an inner second portion 14 having generating lines sloping and converging towards a central hole 16.

[0015] Measured along a peripheral line, each cavity 9 is larger than each blade 7 measured along the same peripheral line, and is defined by two lateral walls 11 of the angularly adjacent blades 7, and by a flat, substantially sector-shaped bottom wall 17.

[0016] Sector-shaped walls 17 are coplanar with one another, and blades 7 extend from the same side of fan 6 with respect to the plane of bottom walls 17.

[0017] Fan 6 of the above type is known technically as a "high-pressure straight-bladed single-intake fan" by comprising one intake side - the side from which blades 7 extend - and by connecting walls 12 having, when viewed from above, a substantially straight profile.

[0018] Number 20 in Figure 2 indicates a second fan produced using the method according to the present invention, and which is substantially similar to fan 6 in Fig-

ure 1, except that, viewed from above, connecting wall 12 has a curved as opposed to a straight profile, so that fan 20 in Figure 2 is known technically as a "high-pressure curved-blade single-intake fan."

[0019] Fan 6 in Figure 1 is produced using the method described below with reference to Figures 3-6.

[0020] The method by which fan 6 is produced comprises a first step of preparing, e.g. on a blanking press, a flat sheet metal disk 28 (Figure 3) of predetermined diameter, and with a central hole 29 coaxial with axis 8 and larger in diameter than the desired central hole 16 of fan 6 in Figure 1.

[0021] The sheet may be of any metal suitable for cold drawing, and is selected of such a thickness as to ensure a certain amount of rigidity of fan 6.

[0022] Disk 28 is drawn using a first die 30 (Figure 5) defined by two complementary half-dies 31, 32, which are fitted to a forming or drawing press (not shown) and moved to and from each other.

[0023] Half-die 31 has a number of radial elements or ribs 33 for forming respective first radial undulations 34 with, viewed from above, a substantially straight profile, and so obtaining a first semifinished part 36 also shown in Figure 4.

[0024] Half-die 32 in turn has a number of radial elements or ribs 38 for forming respective cavities 9 between first radial undulations 34 of semifinished part 36 and also having, when viewed from above, a substantially straight profile. Half-die 31 also carries a number of locators 37 shown in section in Figure 5 for the sake of clarity, and which provide for centering disk 28 on half-die 31.

[0025] Disk 28 is first placed between locators 37 on half-die 31; and the press is activated to close die 30 and subject disk 28 to a first drawing operation to form radial undulations 34 and cavities 9 of semifinished part 36. The drawing operation also reduces the diameter of hole 29, so that semifinished part 36 has a central hole 42 smaller in diameter than hole 29 of disk 28.

[0026] More specifically, radial undulations 34 are formed by deforming portions of disk 28 in the same direction, and define the blades 7 of fan 6 in Figure 1.

[0027] Semifinished part 36 is then placed in a second die 43 (Figure 6) also defined by two half-dies 44 and 46 of a drawing press (not shown). Half-dies 44 and 46 have radial elements or ribs 47 and 48 similar to radial ribs 33 and 38 of half-dies 31 and 32, but such as to further draw radial undulations 34 and cavities 9 of semifinished part 36 to reduce the transverse dimension of blades 7.

[0028] More specifically, radial ribs 47 and 48 are so shaped as to reduce the radius of walls 12 connecting walls 11, and so reduce the distance between walls 11, increase the angular extension of sector-shaped bottom walls 17, and increase the extension of cavities 9.

[0029] Semifinished part 36 is first placed on half-die 44 as shown in Figure 6; and die 43 is closed to subject semifinished part 36 to a second drawing operation and

precisely form blades 7 of fan 6, so that the diameter of hole 42 of semifinished part 36 is further reduced to form hole 16 of fan 6.

[0030] The above method also provides for producing fan 20 in Figure 2, the only difference being that dies 30 and 43 have radial ribs 33,38 and 47,48 with, viewed from above, a curved as opposed to a straight profile.

[0031] In a variation of the invention, as opposed to repeat drawing using two dies 30 and 43, die 43 may be used on its own. In which case, disk 28 is placed on half-die 44, and die 43 is closed to form blades 7 and cavities 9 in a single drawing operation.

[0032] Fan 6 produced using the above method may either be fitted directly to the supply system or subjected to a further fabrication step in which each blade 7 is bent further to bring respective lateral walls 11 closer together so that they are substantially contacting each other as shown in Figures 7 and 8.

[0033] More specifically, number 60 in Figure 7 indicates a high-pressure straight-bladed single-intake fan, and number 65 in Figure 8 a high-pressure curved-bladed single-intake fan, which are obtained respectively by bending blades 7 of fan 6 in Figure 1 and fan 20 in Figure 2.

[0034] Number 70 in Figure 9 indicates yet a further fan produced using the method according to the present invention.

[0035] Fan 70 is partly similar to fan 6 in Figure 1, except that it comprises a further number of radial undulations 72 defining a further number of blades 71 opposed with respect to blades 7.

[0036] More specifically, blades 71 are identical to blades 7, extend radially with respect to axis 8 on the opposite side of the plane of bottom walls 17 to blades 7, and are offset angularly with respect to blades 7.

[0037] Blades 71 are formed by deforming respective mid portions of bottom walls 17 in exactly the same way as, but in the opposite direction to, blades 7.

[0038] Fan 70 of the above type is known technically as a "high-pressure straight-bladed double-intake" fan by having two identical intake sides, each identical to that of high-pressure straight-bladed single-intake fan 6 in Figure 1, so that the intake of fan 70 in Figure 9 is substantially twice that of fan 6 in Figure 1.

[0039] Fan 70 may also either be fitted directly to the supply system or subjected to a further fabrication step to bend blades 7, 71 and bring respective walls 11 closer together so that they are substantially contacting each other.

[0040] Purely by way of example, Figure 10 shows an air supply system fitted with fan 70 in Figure 9.

[0041] The supply system, indicated as a whole by 80, comprises a fan 82 featuring a high-pressure straight-bladed double-intake fan 70 of the type described above and powered by a drive 83. More specifically, fan 82 comprises a first and second air intake 84, 85 on opposite sides of fan 70, and a single air outlet 86.

[0042] As can be seen, fans featuring double-intake

fans 70 provide for drawing in substantially twice the volume of air, and hence for better conditioning performance, as compared with single-intake fans.

[0043] The advantages, as compared with known methods, of the method according to the present invention, and of the fan so formed, will be clear from the foregoing description.

[0044] In particular, being made of sheet metal formed in two blows of the press, fan 6 is extremely cheap to produce, the overall cost reduction, with respect to known methods, being estimated at about 50%.

[0045] Moreover, the fact that blades 7 have no sharp edges, and walls 11 of blades 7 are perfectly smooth with no welds or riveting, fan 6 is extremely silent-operating, and consumes at least 20% less electric power as compared with known fans of the same capacity.

[0046] Clearly, changes may be made to the fan and to the fabrication method as described and illustrated herein without, however, departing from the scope of the accompanying Claims.

[0047] For example, surfaces 11 of blades 7 of fan 6 may be nonsymmetrical; and the fabrication method may be implemented by an automatic multistation device.

Claims

1. A method of producing a sheet metal fan (6; 20), **characterized by** comprising the steps of:

- preparing a sheet metal disk (28) having a central hole (29) coaxial with an axis (8); and
- subjecting said disk (28) to at least a first drawing operation to form an undulated body (36, 6; 20) having at least a number of first undulations (34) defining a number of first blades (7) of said fan (6; 20).

2. A method as claimed in Claim 1, **characterized in that** said first drawing step forms first blades (7) tapering axially, and each comprising a pair of facing converging lateral walls (11), and a connecting wall (12) connecting said lateral walls (11).

3. A method as claimed in Claim 2, **characterized in that** said first blades (7) are formed by deforming portions of said disk (28) in the same direction.

4. A method as claimed in any one of the foregoing Claims, **characterized by** also comprising the step of:

- subjecting said undulated body (36) to a second drawing operation to vary a transverse dimension of each of said first blades (7).

5. A method as claimed in any one of the foregoing

Claims from 2 to 4, **characterized by** also comprising the step of:

- bending each of said first blades (7) to reduce the distance between the respective lateral walls (11).

6. A method as claimed in any one of the foregoing Claims, **characterized by** also comprising the step of:

- subjecting said undulated body (36) to a third drawing operation to form a number of second undulations (72) defining a number of second blades (71) of said fan (70).

7. A method as claimed in Claim 6, **characterized in that** said second blades (71) are formed by deforming portions (17) of said undulated body (36), located between respective pairs of adjacent first blades (7), in the opposite direction to that in which said first blades (7) are deformed.

8. A method as claimed in Claim 7, **characterized by** also comprising the step of:

- bending said second blades (71) to reduce the distance between the respective lateral walls (11).

9. A sheet metal fan, **characterized by** being formed in one piece, and by comprising undulations (34, 72) alternating with cavities (9); said undulations (34, 72) defining at least a number of first blades (7) of said fan (6; 20).

10. A fan as claimed in Claim 9, **characterized in that** each of said first blades (7) comprises a pair of facing converging lateral walls (11), and a connecting wall (12) connecting said lateral walls (11).

11. A fan as claimed in Claim 10, **characterized in that** said connecting wall (12) comprises a first portion (13) having generating lines substantially perpendicular to an axis (8) of said fan (6; 20), and a second portion (14) having generating lines sloping with respect to said axis (8).

12. A fan as claimed in Claim 11, **characterized in that** the projections of said generating lines in a plane substantially perpendicular to said axis (8) are substantially straight.

13. A fan as claimed in Claim 11, **characterized in that** the projections of said generating lines in a plane substantially perpendicular to said axis (8) are curved.

14. A fan as claimed in any one of the foregoing Claims from 10 to 13, **characterized in that** said cavities (9) have a substantially trapezoidal circumferential section.

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15. A fan as claimed in Claim 14, **characterized in that** each of said cavities (9), measured along a peripheral line, is of a dimension greater than each of said first blades (7) measured along the same peripheral line.

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16. A fan as claimed in Claim 14 or 15, **characterized in that** each of said cavities (9) is defined by two lateral walls (11) of angularly adjacent first blades (7), and by a flat, substantially sector-shaped bottom wall (17).

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17. A fan as claimed in Claim 16, **characterized in that** said bottom walls (17) are coplanar, and **in that** said first blades (7) extend on the same side of the plane of said bottom walls (17).

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18. A fan as claimed in Claim 16 or 17, **characterized in that** said undulations (34, 72) also define a number of second blades (71) opposed with respect to said first blades (7).

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19. A fan as claimed in Claim 18, **characterized in that** said second blades (71) are offset angularly with respect to said first blades (7), and extend from mid portions of respective bottom walls (17).

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Patentansprüche

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1. Verfahren zur Herstellung eines Metallblechventilators (6; 20), **dadurch gekennzeichnet, daß** es die Schritte umfaßt:

- Herstellen einer Metallblechscheibe (28) mit einem zentralen Loch (29), das zu einer Achse (8) koaxial ist; und

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- Unterziehen der Scheibe (28) mindestens einem ersten Ziehvorgang, um einen welligen Körper (36, 6; 20) mit mindestens einer Anzahl von ersten Wellen (34) auszubilden, die eine Anzahl von ersten Flügeln (7) des Ventilators (6; 20) definieren.

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2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** der erste Ziehschritt erste Flügel (7), die sich axial verjüngen und jeweils ein Paar von einander zugewandten, zusammenlaufenden Seitenwänden (11) umfassen, und eine Verbindungswand (12), die die Seitenwände (11) verbindet, ausbildet.

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3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, daß** die ersten Flügel (7) durch Verformen von Teilen der Scheibe (28) in derselben Richtung ausgebildet werden.

4. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** es auch den Schritt umfaßt:

- Unterziehen des welligen Körpers (36) einem zweiten Ziehvorgang, um eine Querabmessung von jedem der ersten Flügel (7) zu verändern.

5. Verfahren nach einem der vorangehenden Ansprüche 2 bis 4, **dadurch gekennzeichnet, daß** es auch den Schritt umfaßt:

- Biegen von jedem der ersten Flügel (7), um den Abstand zwischen den jeweiligen Seitenwänden (11) zu verringern.

6. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** es auch den Schritt umfaßt:

- Unterziehen des welligen Körpers (36) einem dritten Ziehvorgang, um eine Anzahl von zweiten Wellen (72) auszubilden, die eine Anzahl von zweiten Flügeln (71) des Ventilators (70) definieren.

7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, daß** die zweiten Flügel (71) durch Verformen von Teilen (17) des welligen Körpers (36), die sich zwischen jeweiligen Paaren von benachbarten ersten Flügeln (7) befinden, in der entgegengesetzten Richtung zu jener, in der die ersten Flügel (7) verformt werden, ausgebildet werden.

8. Verfahren nach Anspruch 7, **dadurch gekennzeichnet, daß** es auch den Schritt umfaßt:

- Biegen der zweiten Flügel (71), um den Abstand zwischen den jeweiligen Seitenwänden (11) zu verringern.

9. Metallblechventilator, **dadurch gekennzeichnet, daß** er aus einem Stück ausgeformt wird, und dadurch, daß er Wellen (34, 72), die mit Hohlräumen (9) abwechseln, umfaßt; wobei die Wellen (34, 72) mindestens eine Anzahl von ersten Flügeln (7) des Ventilators (6; 20) definieren.

10. Ventilator nach Anspruch 9, **dadurch gekennzeichnet, daß** jeder der ersten Flügel (7) ein Paar von einander zugewandten, zusammenlaufenden Seitenwänden (11) und eine Verbindungswand

(12), die die Seitenwände (11) verbindet, umfaßt.

11. Ventilator nach Anspruch 10, **dadurch gekennzeichnet, daß** die Verbindungswand (12) einen ersten Teil (13) mit Erzeugungslinien, die zu einer Achse (8) des Ventilators (6; 20) im wesentlichen senkrecht sind, und einen zweiten Teil (14) mit Erzeugungslinien, die bezüglich der Achse (8) abfallen, umfaßt. 5
12. Ventilator nach Anspruch 11, **dadurch gekennzeichnet, daß** die Vorsprünge der Erzeugungslinien in einer zur Achse (8) im wesentlichen senkrechten Ebene im wesentlichen gerade sind. 10
13. Ventilator nach Anspruch 11, **dadurch gekennzeichnet, daß** die Vorsprünge der Erzeugungslinien in einer zur Achse (8) im wesentlichen senkrechten Ebene gekrümmt sind. 15
14. Ventilator nach einem der vorangehenden Ansprüche 10 bis 13, **dadurch gekennzeichnet, daß** die Hohlräume (9) einen im wesentlichen trapezförmigen Umfangsabschnitt aufweisen. 20
15. Ventilator nach Anspruch 14, **dadurch gekennzeichnet, daß** jeder der Hohlräume (9), gemessen entlang einer Umfangslinie, eine Abmessung aufweist, die größer ist als jeder der ersten Flügel (7), gemessen entlang derselben Umfangslinie. 25
16. Ventilator nach Anspruch 14 oder 15, **dadurch gekennzeichnet, daß** jeder der Hohlräume (9) durch zwei Seitenwände (11) von winkelmäßig benachbarten ersten Flügeln (7) und durch eine ebene, im wesentlichen sektorförmige Bodenwand (17) definiert ist. 30
17. Ventilator nach Anspruch 16, **dadurch gekennzeichnet, daß** die Bodenwände (17) koplanar sind und daß sich die ersten Flügel (7) auf derselben Seite der Ebene der Bodenwände (17) erstrecken. 35
18. Ventilator nach Anspruch 16 oder 17, **dadurch gekennzeichnet, daß** die Wellen (34, 72) auch eine Anzahl von zweiten Flügeln (71) definieren, die bezüglich der ersten Flügel (7) entgegengesetzt liegen. 40
19. Ventilator nach Anspruch 18, **dadurch gekennzeichnet, daß** die zweiten Flügel (71) in einem Winkel bezüglich der ersten Flügel (7) versetzt sind und sich von mittleren Bereichen von jeweiligen Bodenwänden (17) erstrecken. 45

Revendications

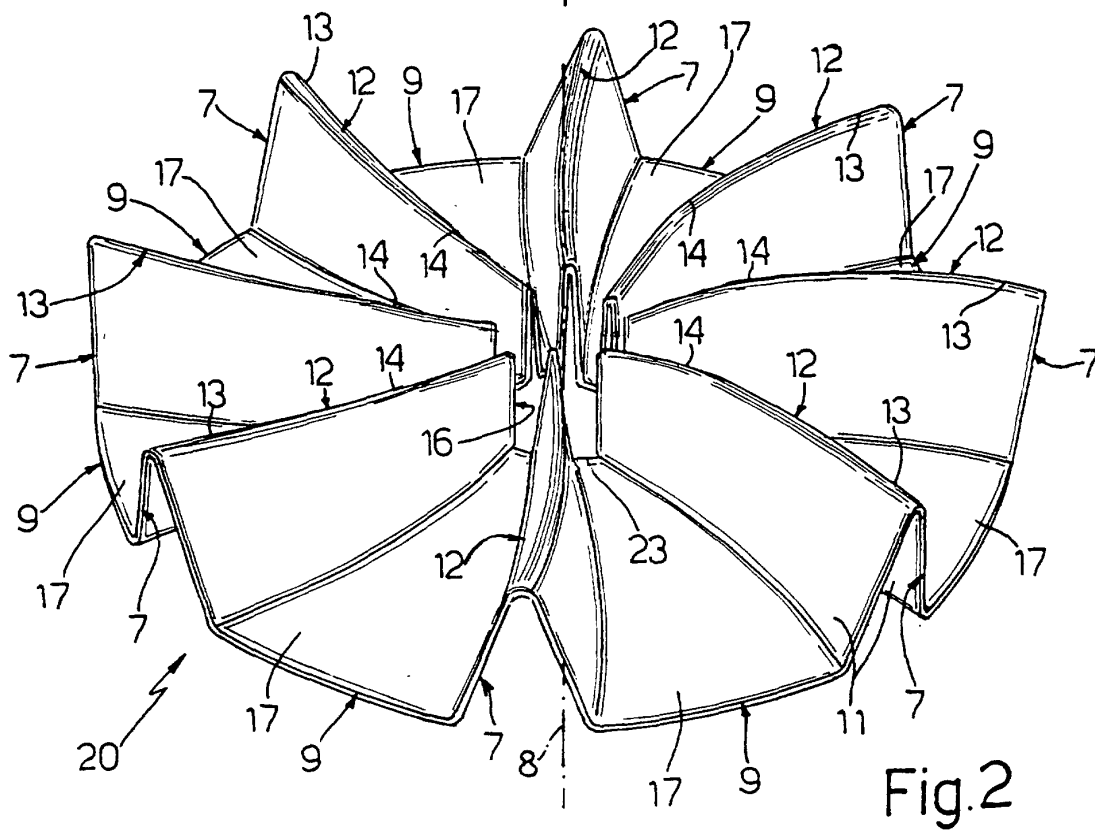
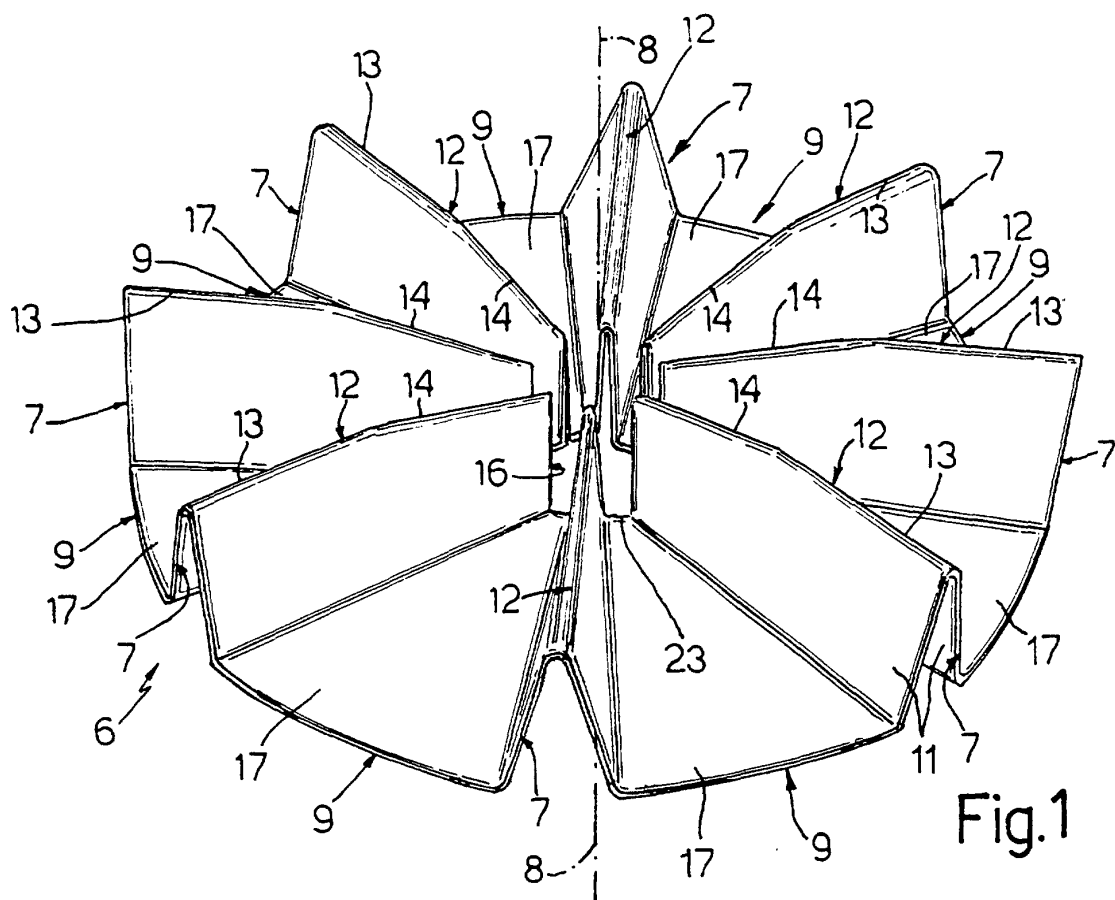
1. Procédé de fabrication d'un ventilateur en tôle (6, 20), **caractérisé en ce qu'il** consiste à :
 préparer un disque en tôle (28) possédant un trou central (29) coaxial avec un axe (8) ; et soumettre ledit disque (28) à au moins une première opération d'emboutissage pour former un corps ondulé (36, 6, 20) possédant au moins un nombre de premières ondulations (34) définissant un nombre de premières aubes (7) dudit ventilateur (6, 20). 5
2. Procédé selon la revendication 1, **caractérisé en ce que** ladite première étape d'emboutissage forme les premières aubes (7) s'effilant de manière axiale et chacune comprenant une paire de parois latérales convergentes et se faisant face (11) et une paroi de connexion (12) reliant lesdites parois latérales (11). 10
3. Procédé selon la revendication 2, **caractérisé en ce que** lesdites premières aubes (7) sont formées en déformant les parties dudit disque (28) dans la même direction. 15
4. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par** ce qu'il consiste également à :
 soumettre ledit corps ondulé (36) à une deuxième opération d'emboutissage pour varier une dimension transversale de chacune desdites premières aubes (7). 20
5. Procédé selon l'une quelconque des revendications 2 à 4 précédentes, **caractérisé par le fait qu'il** consiste également à :
 plier chacune desdites premières aubes (7) afin de réduire la distance entre les parois latérales respectives (11). 25
6. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par le fait qu'il** consiste également à :
 soumettre ledit corps ondulé (36) à une troisième opération d'emboutissage afin de former un nombre de deuxièmes ondulations (72) définissant un nombre de deuxièmes aubes (71) dudit ventilateur (70). 30
7. Procédé selon la revendication 6, **caractérisé en ce que** lesdites deuxièmes aubes (71) sont formées en déformant des parties (17) dudit corps ondulé (36), situé entre les paires respectives des premiè- 35

res aubes adjacentes (7), dans la direction opposée à celle dans laquelle lesdites premières aubes (7) sont déformées.

8. Procédé selon la revendication 7, **caractérisé par le fait qu'il** consiste également à :
 plier lesdites deuxièmes aubes (71) afin de réduire la distance entre les parois latérales respectives (11). 5
9. Ventilateur en tôle, **caractérisé par** le fait d'être formé en une seule pièce et par le fait qu'il comprend des ondulations (34, 72) alternant avec des cavités (9) ; lesdites ondulations (34, 72) définissant au moins un nombre de premières aubes (7) dudit ventilateur (6, 20). 10
10. Ventilateur selon la revendication 9, **caractérisé en ce que** chacune desdites premières aubes (7) comprend une paire de parois latérales convergentes se faisant face (11) et une paroi de connexion (12) reliant lesdites parois latérales (11). 15
11. Ventilateur selon la revendication 10, **caractérisé en ce que** ladite paroi de connexion (12) comprend une première partie (13) possédant des lignes de génération substantiellement perpendiculaires à un axe (8) dudit ventilateur (6, 20) et une deuxième partie (14) possédant des lignes de génération pen- 20
chant par rapport au dit axe (8). 30
12. Ventilateur selon la revendication 11, **caractérisé en ce que** les saillies desdites lignes de génération dans un plan substantiellement perpendiculaire au dit axe (8) sont substantiellement droites. 35
13. Ventilateur selon la revendication 11, **caractérisé en ce que** les saillies desdites lignes de génération dans un plan substantiellement perpendiculaire au dit axe (8) sont inclinées. 40
14. Ventilateur selon l'une quelconque des revendications précédentes de 10 à 13, **caractérisé en ce que** lesdites cavités (9) possèdent une section pé- 45
riphérique substantiellement trapézoïdale.
15. Ventilateur selon la revendication 14, **caractérisé en ce que** chacune desdites cavités (9), mesurée le long d'une ligne périphérique, est d'une dimen- 50
sion supérieure à chacune desdites premières aubes (7) mesurée le long de la même ligne péri-
phérique.
16. Ventilateur selon la revendication 14 ou 15, **carac- 55**
térisé en ce que chacune desdites cavités (9) est définie par deux parois latérales (11) des premières aubes adjacentes de manière angulaire (7) et par

une paroi de fond plate et substantiellement en forme de secteur (17).

17. Ventilateur selon la revendication 16, **caractérisé en ce que** lesdites parois de fond (17) sont coplanaires et **en ce que** lesdites premières aubes (7) s'étendent sur le même côté du plan desdites parois de fond (17).
18. Ventilateur selon la revendication 16 ou 17, **carac- 10**
térisé en ce que lesdites ondulations (34, 72) définissent également un nombre de deuxièmes aubes (71) opposées par rapport aux dites premières aubes (7).
19. Ventilateur selon la revendication 18, **caractérisé en ce que** lesdites deuxièmes aubes (71) sont dé- 15
calées de manière angulaire par rapport aux dites premières aubes (7) et s'étendent depuis les parties médianes des parois de fond respectives (17).



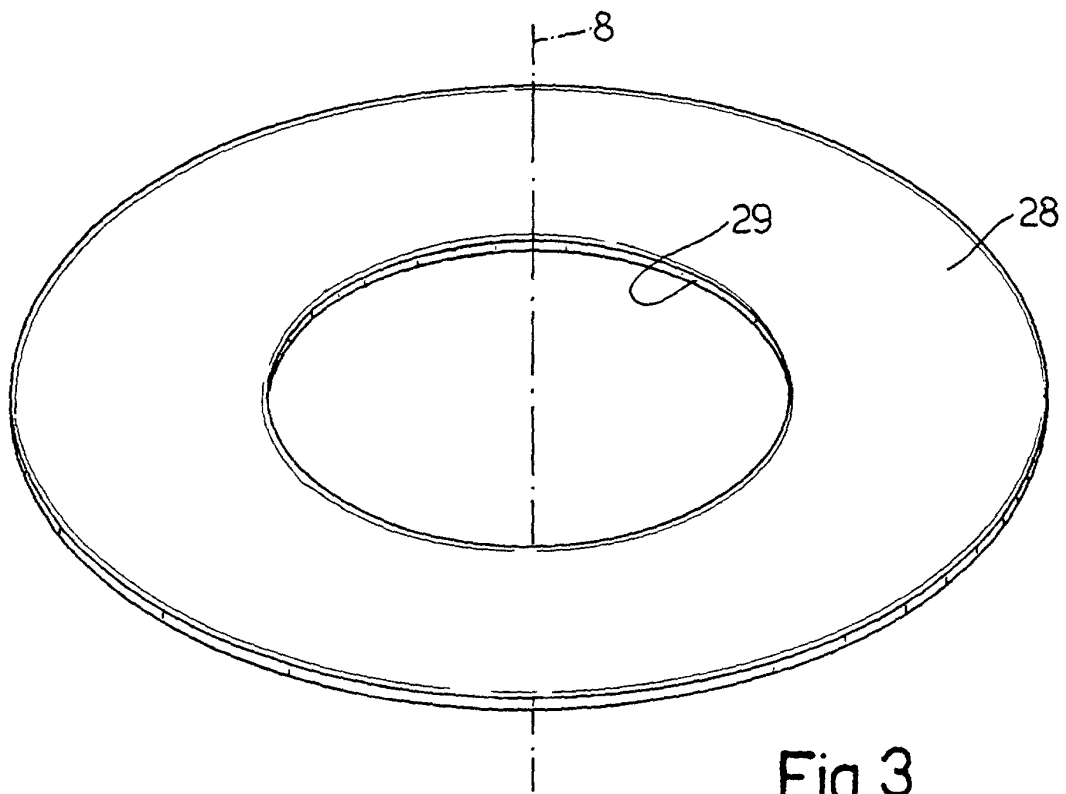


Fig. 3

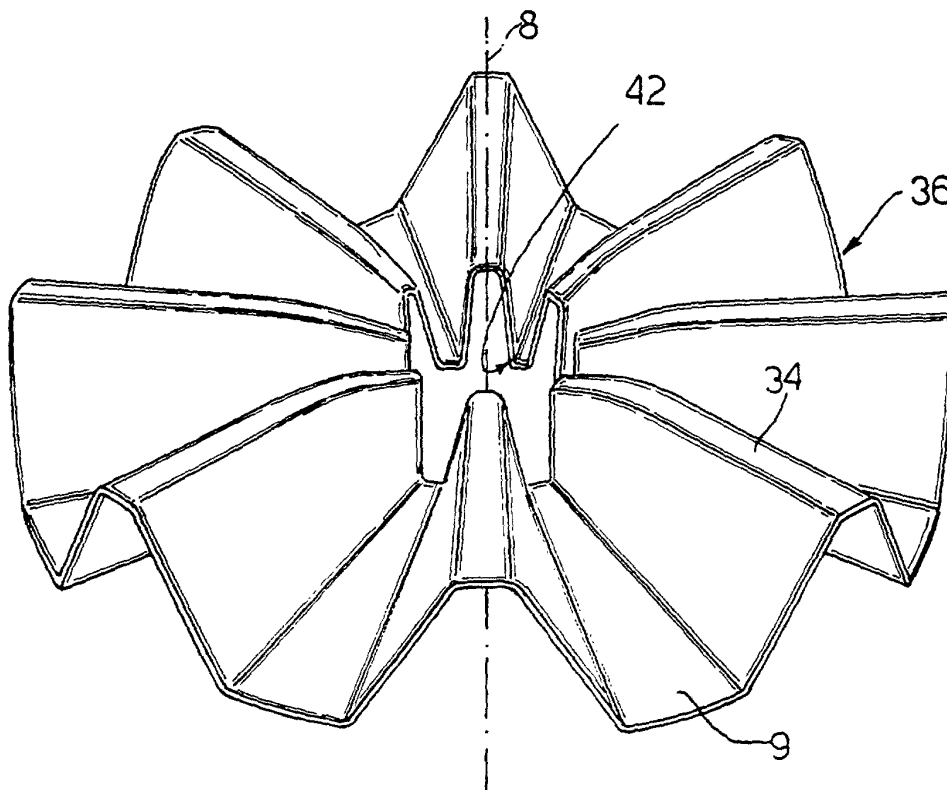


Fig. 4

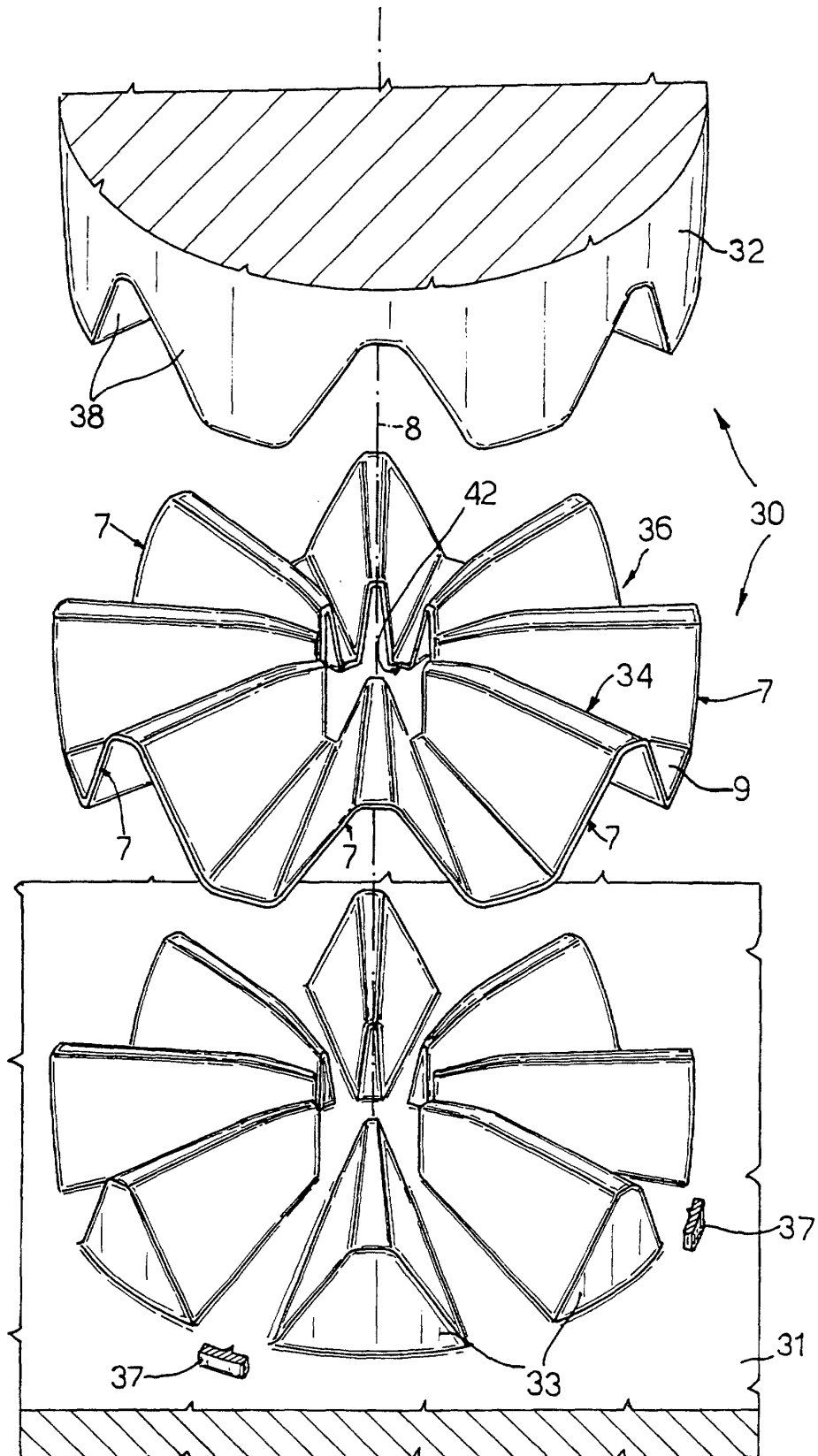


Fig. 5

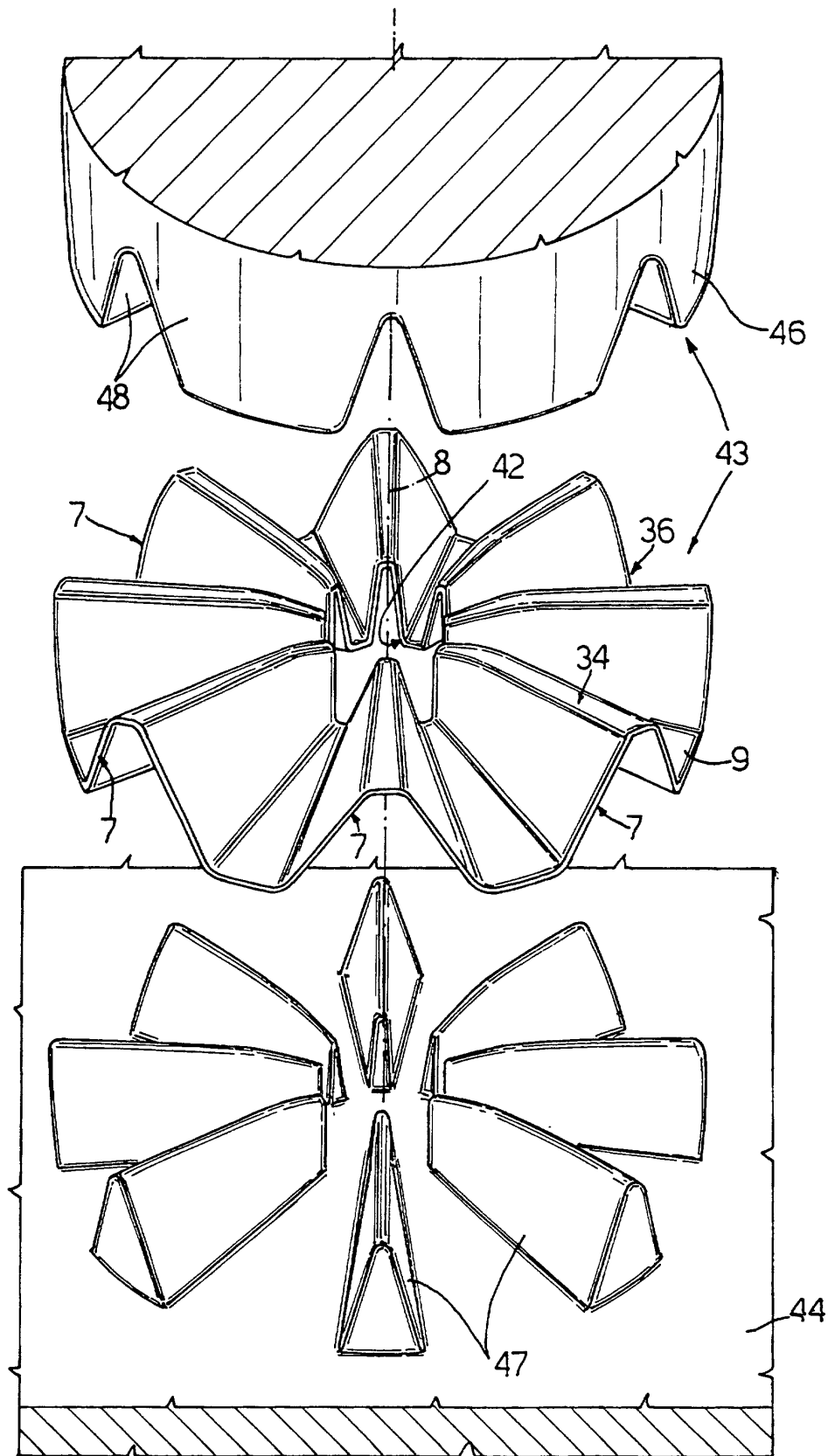
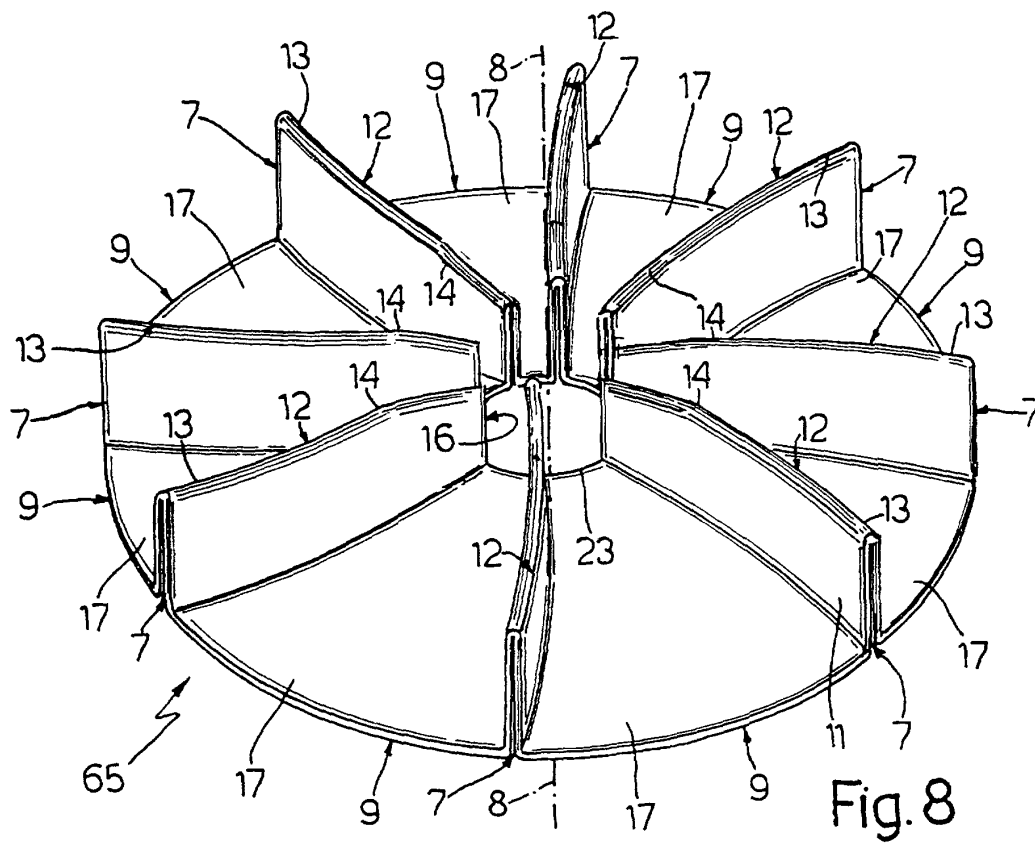
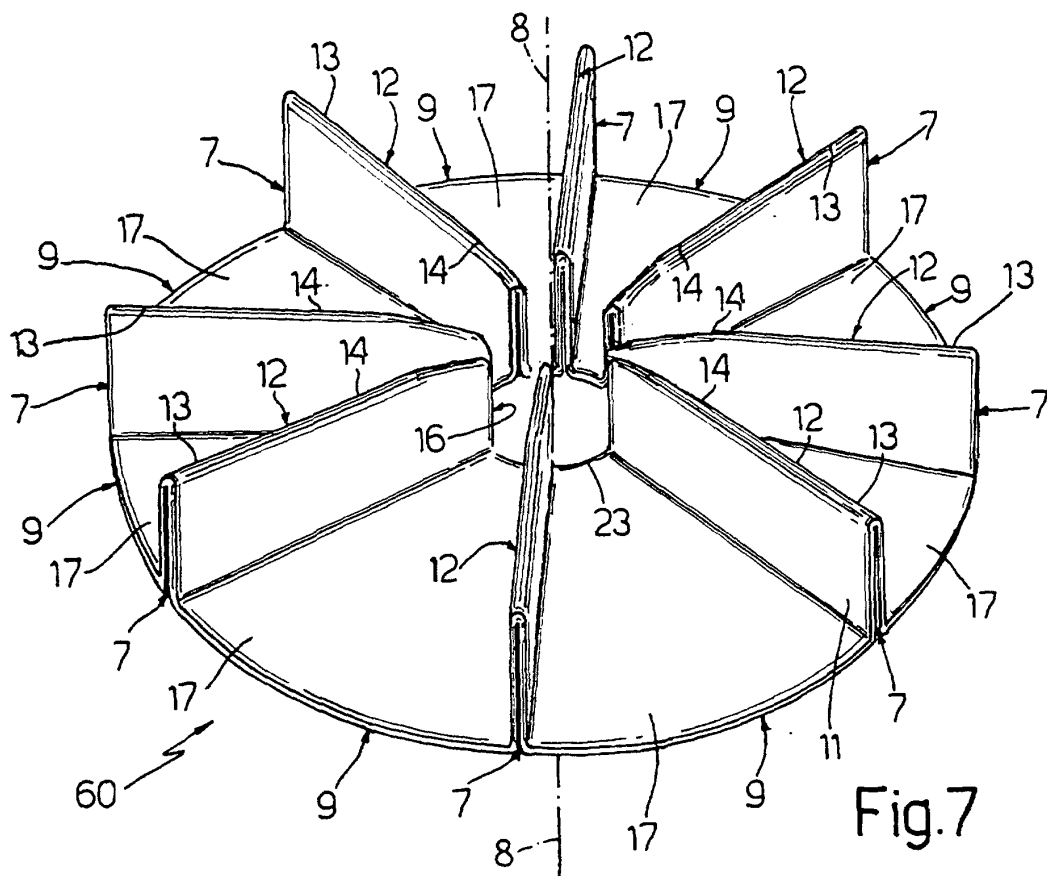


Fig.6



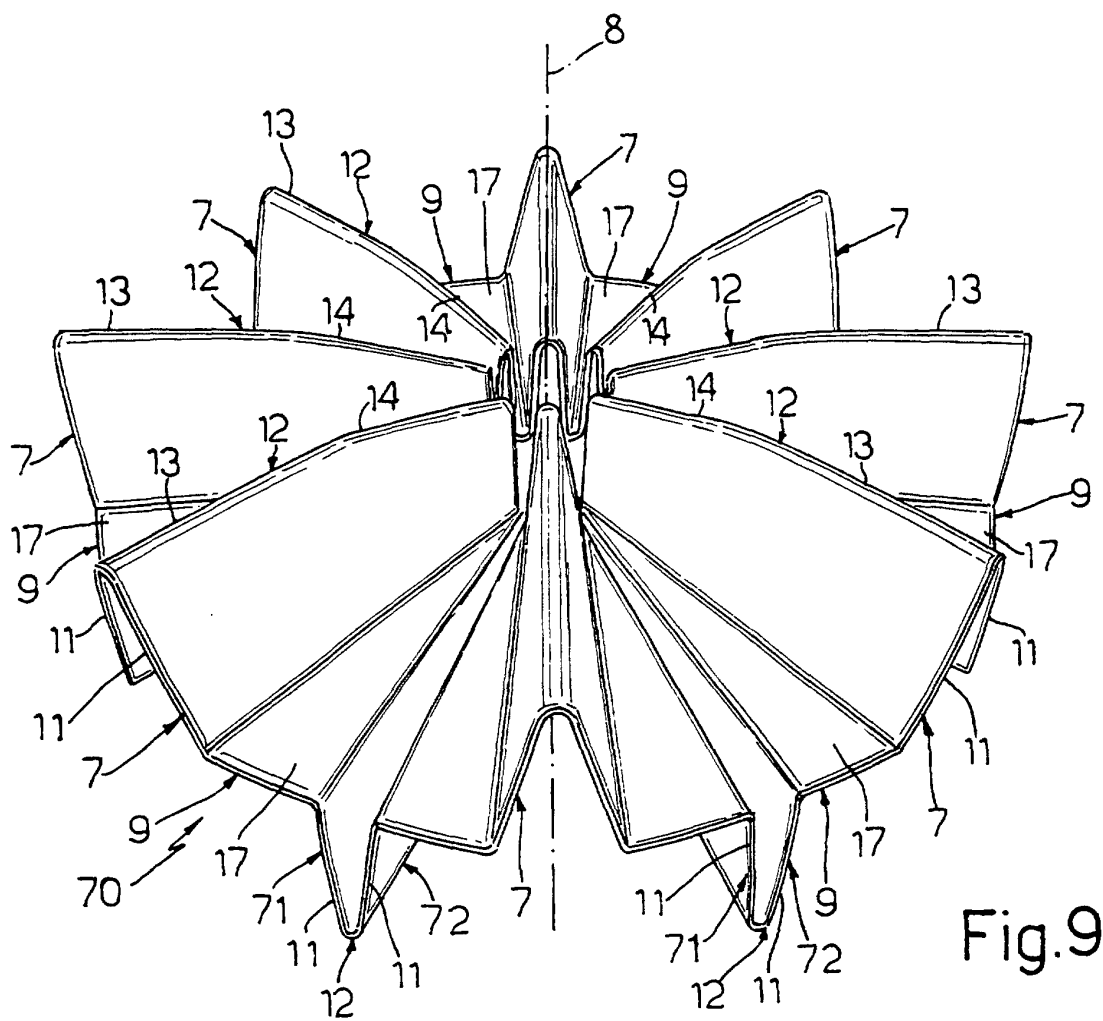


Fig.9

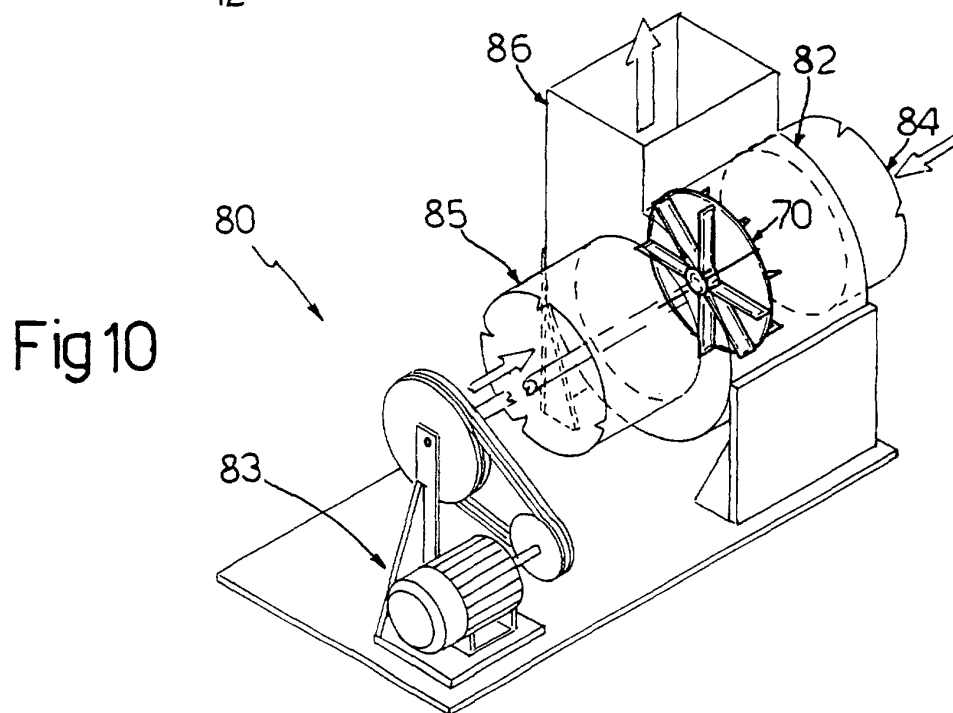


Fig 10