United States Patent

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[72] Inventor Norman B. Vogt
Utica, Mich.

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[73] Assignee General Motors Corporation
Detroit, Mich.

[54] METHOD OF MANUFACTURING A ONE-PIECE FAN

9 Claims, 8 Drawing Figs.

[52] U.S. Cl. ..... 29/156.8 B, 113/116 D
[51] Int. Cl. B21k 3/04, B23p 15/02, B23p 15/04
[50] Field of Search ..... 29/156.8 CF, 156.8 T, 156.8 B, 156.8 P, 156.8 H, 159.01; 113/116 D, 116 BB

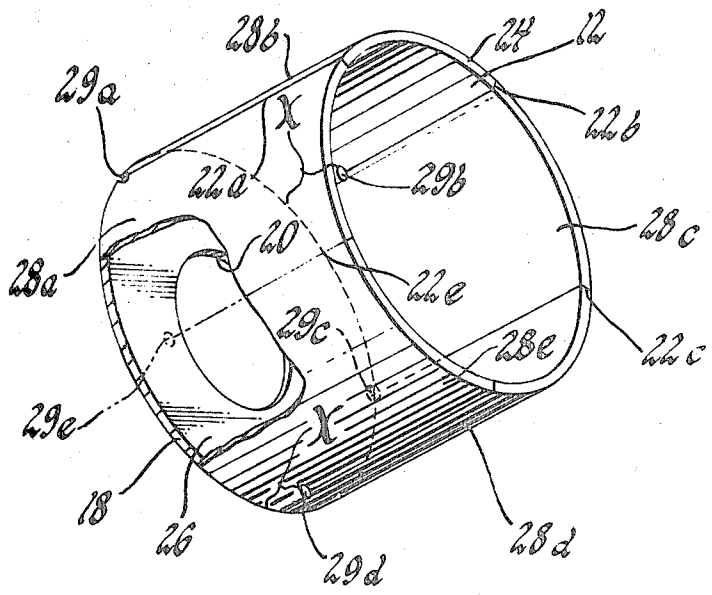
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Primary Examiner—John F. Campbell
Assistant Examiner—Donald P. Rooney
Attorneys—E. W. Christen, A. M. Heiter and John P. Moran

ABSTRACT: A method of manufacturing a one-piece axial flow fan including the following steps: (1) forming one end of a cylindrical tube into a partially closed flat end surface having an opening therein of a predetermined diameter; (2) separating the wall of the cylinder into a predetermined number of arcuate sections; (3) bending the sections to extend radially outwardly from the partially closed end; (4) trimming off the edges of the radial extensions and portions of the bottom flat surface to form fan blades and a hub; and (5) twisting the blades to the desired final curvature, the final product being a one-piece axial flow fan having blades, each with one edge thereof on the same plane as the hub and a trailing edge bending away from the leading edge.



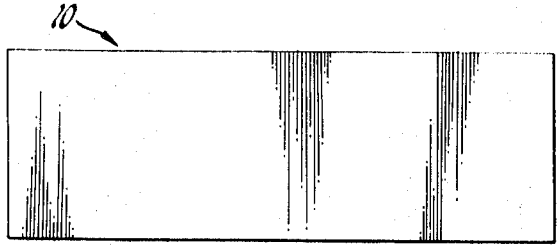


Fig. 1

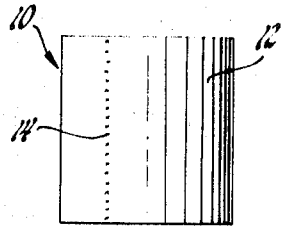


Fig. 2

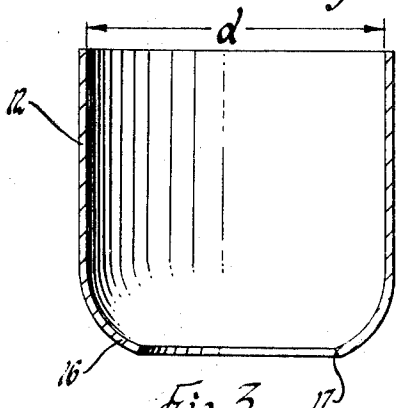


Fig. 3

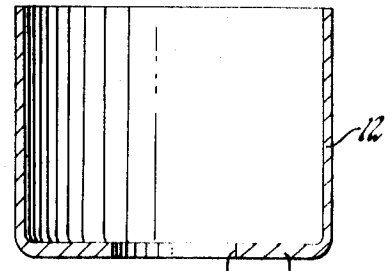


Fig. 4

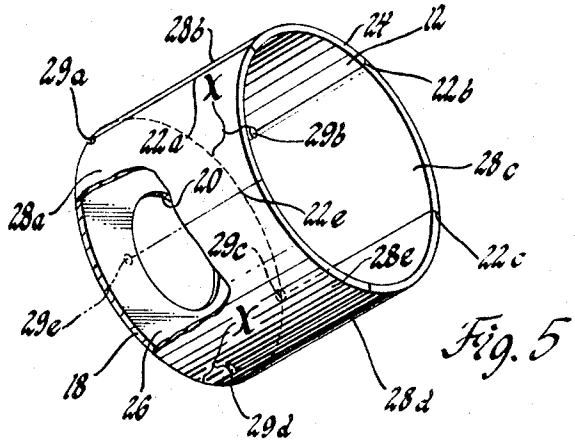


Fig. 5

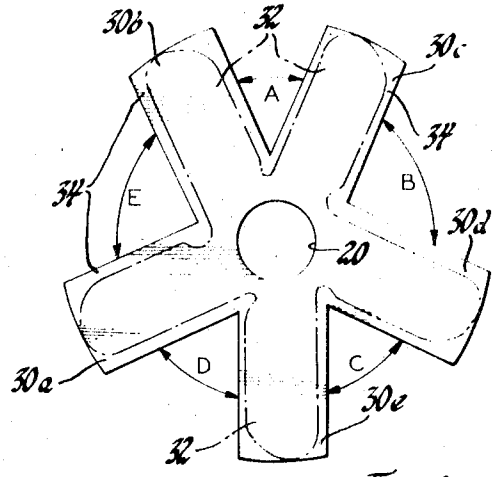


Fig. 6

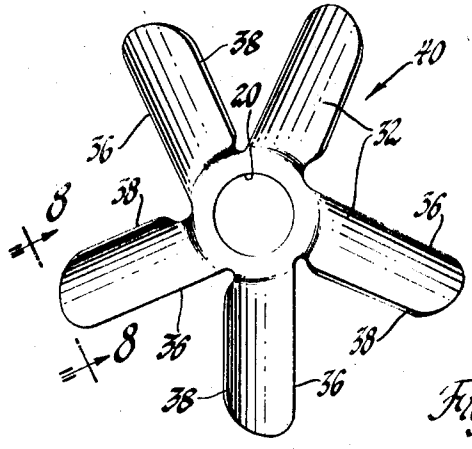


Fig. 7



Fig. 8

INVENTOR.
Norman B. Vogt

BY

A. M. Heiter

ATTORNEY

METHOD OF MANUFACTURING A ONE-PIECE FAN

This invention relates to fluid propulsion devices, such as fans, propellers and the like, and, more particularly to a novel method of manufacturing a one-piece axial flow fan.

Present methods of manufacturing metal axial flow fans include such methods as forming a hub or spider, forming blades and then assembling the blades to the spider and balancing the assembly; or assembling blades to form a hub as part of the blade material; or blanking the fan as one piece from sheet metal stock and shaping the blades thereof. The latter method results in considerable waste of material, thereby greatly increasing material cost.

Accordingly, a primary object of the invention is to provide a novel method of manufacturing a one-piece axial flow fan from a strip of sheet metal which is formed into welded cylindrical tubing, or seamless cylindrical tubing, with very little offal or waste material.

Another object of the invention is to provide a manufacturing method which is simple and economical and which results in the production of a durable and efficient finished product.

A further object of the invention is to provide a novel method of manufacturing a one-piece fan whose blades are variably spaced about an integral hub and have trailing edges which terminate variable blade curvatures, the variable spacing and curvatures serving to produce a minimal operative noise level.

Other objects and advantages of the invention will become apparent when reference is made to the following specification and accompanying drawings wherein:

FIG. 1 is a top view of a sheet of metal material which may be employed in the invention;

FIG. 2—6 illustrate the results of the various manufacturing steps used in the invention;

FIG. 7 illustrates a typical finished product resulting from the invention; and

FIG. 8 is an end view taken along the plane of the line 8–8 of FIG. 7, and looking in the direction of the arrows.

Referring now to the drawings in greater detail, FIG. 1 illustrates a flat strip 10 of sheet metal which may be used in the novel method embodied in the invention.

The metal strip 10 is first formed into an open-ended cylinder 12 (FIG. 2), the mating longitudinal edges of which are then fixedly attached to one another by any suitable method, such as welding, resulting in a welded seam 14. The seam 14 is thereupon smoothed by any suitable method, for example, along its outer surface by scarfing or planishing, and along its inner surface by being drawn over a mandrel. It is apparent that the cylinder 12 could consist of seamless tubing of suitable diameter and thickness in lieu of a welded cylinder.

The cylinder 12 may then be annealed, if necessary, after which one end of the cylinder 12 is formed in a forming die to include a radial end 16 (FIG. 3), resulting in an opening 17 remaining in the formed end 16 which is substantially smaller then the inside diameter "*d*" of the cylinder 12. The forming die would normally include a die set comprising an upper shoe and a lower shoe, and suitable tooling inserts.

The radial end 16 of the cylinder 12 is further formed in a suitable forming die to produce a flat end surface 18 (FIG. 4), which is substantially perpendicular to the wall of the cylinder 12. The opening in the formed end 18 becomes a substantially smaller opening 20 during this operation. The latter opening 20 may be sized by being formed around a pilot on the die set. As the openings 17 and 20 are made progressively smaller, the adjacent end portion 18 would become thicker by virtue of the displacement of metal. This is desirable from the standpoint of having a finished fan whose hub is thicker than its blades.

The wall of the cylinder 12 is next separated (FIG. 5) along predetermined equally spaced lines *22a, 22b, 22c, 22d and 22e by any suitable shearing operation, such as lancing. Preferably, the designated lines are all lanced simultaneously by utilizing a plurality of shearing tools, cams and cam drivers, the number thereof corresponding to the number of separations 22 required. Each separation 22 extends longitudinally along the cylindrical wall from the edge 24 of the open end to the inner face 26 of the end 18, or to some predetermined distance there along, as illustrated in FIG. 5. The separations 22 result in a number of arcuate wall segments 28, the total number thereof being determined by the number of fan blades desired. Holes 29a, 29b, 29c, 29d* and *29e* may be pierced at the bottom end of each of the lanced edges of the separations *22a, 22b, 22c, 22d* and *22e*, respectively, to prevent tearing in this area during subsequent operations.

Each of the arcuate wall sections 28 is next bent outwardly from the axis of the cylinder 12 and flattened along the plane of the bottom surface 18 so as to form flat extensions 30 (FIG. 6) extending radially outwardly from the central opening 20. This may be accomplished be using a flared or tapered punch to start spreading the individual wall segments 28 at their free ends 24. After some predetermined angle is reached between the outer surface of the wall segments 28 and the plane of the bottom surface 18, a downwardly descending, flat upper die will complete the flattening process, the original arcuate shape of each wall segment 28 being caused to assume a flat condition.

It may be noted by referring to FIGS. 5 and 6 that, where some one line 22 has not been lanced the full length of the segments 28, such as line *22b* in FIG. 5, when the segments *28d* and *28e* are flattened, they will tend to pull toward one another, the solid wall portion "x" below the pierced hole *29b* preventing a full spread therebetween. The result will be a reduced included angle, such as angle "A" of FIG. 6, between adjacent segments. It may be visualized that, when the wall of the cylinder 12 is lanced full length, such as represented at line *22a* in FIG. 5, the flattening process will spread the segments *28a* and *28b* farther apart, as represented by angle "E" in FIG. 6. Thus it can be seen that by controlling the lengths of the lanced cuts, variable included angles may be attained between segments during the flattening operation, the arced segments *28a, 28b, 28c, 28d* and *28e* having been formed into flat radial extensions *30a, 30b, 30c, 30d* and *30e*, respectively.

After flattening, the extensions *30a, 30b, 30c, 30d* and *30e*, as well as portions of the flat end 18, are trimmed by any convenient means, such as with a trim die, producing the individual blades represented by 32 in FIG. 6. It may be noted that each of the radial extensions 30 includes sufficient area to form a fan blade 32 with very little waste area, the latter being represented by 34. If desired, the hub I.D. 20 may be trimmed in the same operation as just described; however, as discussed above, the I.D. 20 would have been formed around a pilot on the die set during the operation described relative to FIG. 4.

As a result of the above lancing, flattening and trimming operations, a fan structure is produced with a minimal amount of scrap material involved, since the size of the cylinder 12 is selected such that each segment 28 and 30 will include an area which is suitable for a particular blade 32 width plus sufficient stock for trimming, but without an excessive amount of the latter.

It may be realized that if the segments *28a, 28b, 28c, 28d* and *28e* were lanced to include different arc lengths, and each lancing operation were performed along the full length of the cylinder 12, rather than variable lengths therealong, the fan blades 32 could be individually located on their respective variable-width flat segments 30 such that variation in the angles "A," "B," "C," "D," and "E" would result. However, such a technique would require a slightly larger cylinder 12 for a given fan size than in the steps described above.

After trimming, the resultant flat, one-piece structure would next be placed in another forming die wherein the mating upper and lower shoes and/or tooling inserts would have curved mating surfaces formed in pockets or openings, there being one pocket for each blade 32. The flattened fan structure would be placed therein such that each of the blades 32 would be seated in some one of the pockets and pressed therein to conform to the curvature of its respective pocket.

Obviously, the curvature need not be the same for all the blades **32**. The result of this operation is illustrated in FIG. **8**, wherein it may be noted that the leading edge **36** of a blade **32** remains on the same plane as the flat hub, while the trailing edge **38** thereof terminates the blade's arcuate or curved shape.

The finished fan **40** is similar in appearance to that illustrated in FIG. **7**, with each of the variably spaced blades **32** having its own predetermined twist and/or curvature relative to the central hub portion thereof. The number of blades, however, could vary from that illustrated. Hence, it is apparent that the fan resulting from the above-described novel method includes desirable high-speed noise abatement characteristics.

It should also be apparent that, in the method described above, a one-piece axial flow fan is produced with a negligible amount of scrap material, representing substantial savings in material costs.

While but one general product has been illustrated and described as being manufactured by the above-described method, it should be apparent that variations in the structure of the product could be attained by the method described.

I claim:

1. A method of producing a one-piece metal fan, said method comprising forming one end of a cylindrical tube to include a flat end surface having an opening therein of a predetermined diameter, longitudinally cutting said formed cylindrical tube to produce a plurality of adjacent arcuate segments, said arcuate segments being unequally spaced and separated by lanced edges extending the full length of the remaining wall of said cylindrical tube after said flat end has been formed thereon, bending said arcuate segments outwardly so as to cause said segments to become flattened, and to extend substantially radially from said flat end surface, trimming said segments and said flat end surface to form a hub with integral flat fan blades extending therefrom, said flat fan blades being variably spaced with respect to one another, and forming predetermined blade curvatures on said fan blades.

2. A method of manufacturing a one-piece metal fan, said method comprising the following steps:

a. forming a rectangular piece of sheet metal material of predetermined dimensions into a cylindrical shape;
b. joining the longitudinal mating edges thereof as a seam to produce a cylindrical tube;
c. smoothing said seam;
d. forming one end of said cylindrical tube to produce a flat end surface having an opening therein of a predetermined diameter;
e. cutting the wall of said cylindrical tube into a predetermined number of adjacent longitudinal arcuate sections;
f. bending said sections outwardly so as to cause said sections to become flattened and to lie on the plane of said flat end surface;
g. trimming of the edges of said sections and a portion of said flat end surface to form a hub with integral fan blades extending therefrom; and
h. forming the individual blades to include predetermined blade curvatures thereon.

3. A method of manufacturing a one-piece metal fan, said method comprising the following steps:

a. forming one end of a cylindrical tube to produce a flat end surface having an opening therein of a predetermined diameter;
b. separating the wall of said cylindrical tube into a predetermined number of adjacent longitudinal arcuate sections by cutting said wall of said cylindrical tube such that the resultant cut edges between adjacent sections are variable in length;
c. bending said sections outwardly so as to cause said sections to become flattened and to lie on the plane of said flat end surface;
d. trimming off the edges of said sections and a portion of said flat end surface to form a hub with integral fan blades extending therefrom; and
e. forming the individual blades to include predetermined blade curvatures thereon.

4. The method described in claim **3**, wherein a hole is pierced at the bottom of each lanced separation.

5. The method described in claim **3**, wherein said arcuate sections are equally spaced prior to said bending operation.

6. The method described in claim **5**, wherein said fan blades are variably spaced from one another after said trimming operation.

7. A method of producing a one-piece metal fan from a cup-shaped member having a base portion and a circular sidewall portion, said method comprising longitudinally cutting said sidewall portion of said cup-shaped member into a plurality of adjacent arcuate segments of said circular sidewall portion, bending said circular sidewall portion and said arcuate segments outwardly substantially into the plane of said base portion to form a substantially flat blank, trimming said blank to form said base portion into a hub and said arcuate segments into integral flat fan blades integrally extending substantially radially from said base portion and being variably spaced with respect to one another, and forming predetermined blade pitch curvatures on said fan blades.

8. A method of producing a one-piece metal fan, said method comprising forming a cup-shaped member having a substantially flat bottom portion and a circular wall portion extending therefrom, longitudinally cutting said circular wall portion of said cup-shaped member to form a plurality of adjacent arcuate segments, said arcuate segments being unequally spaced and separated by adjacent edges extending the full length of said wall portion of said cup-shaped member, bending said arcuate segments outwardly so as to cause said segments to become flattened and to extend substantially radially from said bottom portion, trimming said segments and said bottom portion of said cup-shaped member to form a hub with integral planar fan blades extending therefrom and being variably spaced with respect to one another, and forming predetermined blade curvatures on said fan blades.

9. A method of manufacturing a one-piece metal fan, said method comprising the following steps:

a. forming a cup-shaped member having a substantially flat bottom portion and a circular wall portion extending therefrom;
b. cutting said wall portion of said cup-shaped member into a predetermined number of adjacent longitudinal arcuate sections such that the resultant edges therebetween are variable in length;
c. bending said arcuate sections outwardly so as to cause said arcuate sections to become flattened and to lie substantially on the plane of said flat bottom portion;
d. trimming off said edges of said flattened sections and a portion of said bottom portion to form a hub with integral fan blades extending substantially radially therefrom; and
e. forming the individual fan blades to include predetermined blade curvatures thereon.