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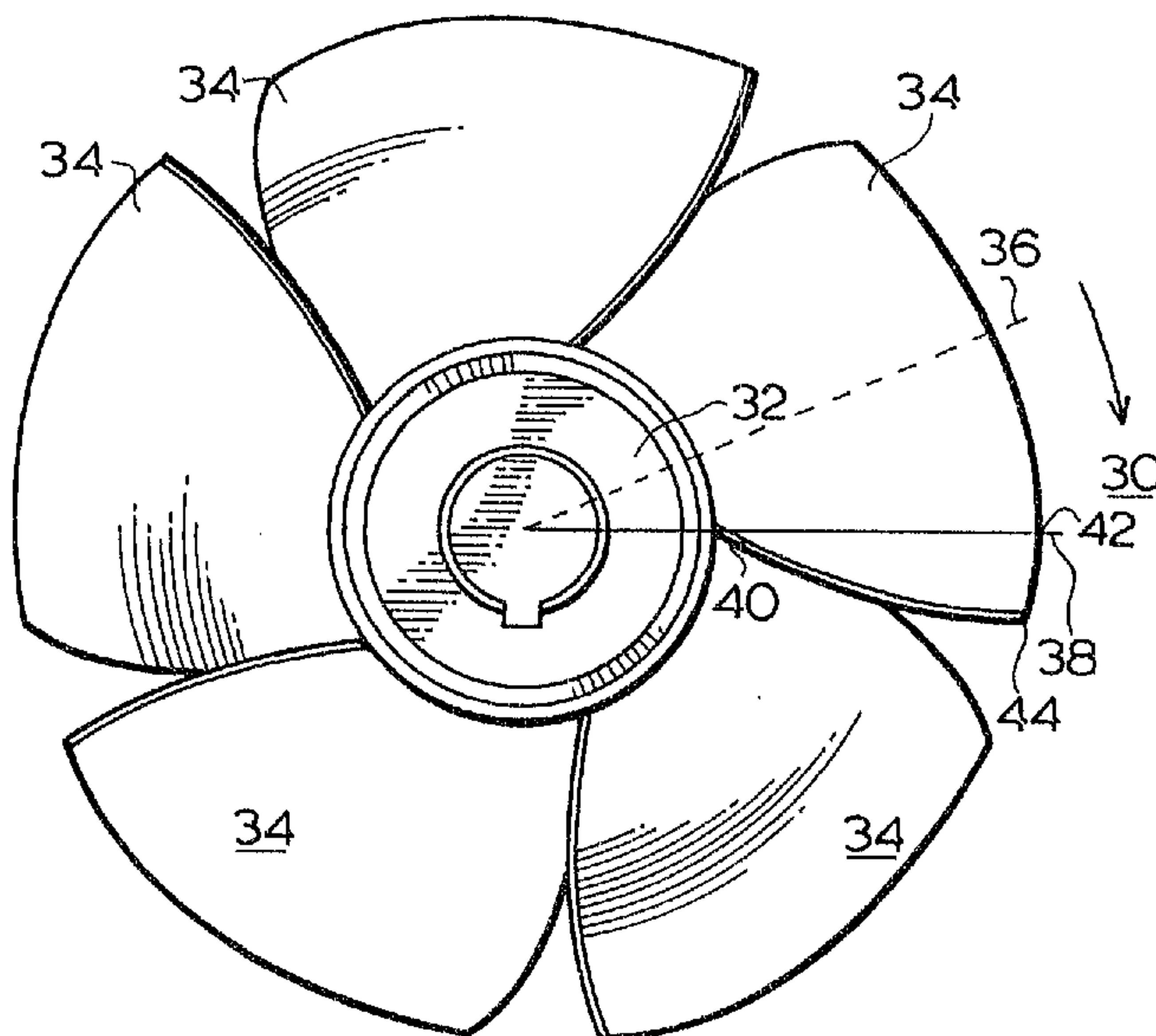
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(54) **CONFIGURATION DE PALE D'HELICE**

(54) **PROPELLER BLADE CONFIGURATION**



(57) A propeller type runner is described in which the leading edge of each blade "leans" forward from the root in the direction of rotation to reduce cavitation and increase efficiency. The "lean" provided to each blade of a five blade design is such that the leading edge of each blade obscures a large portion of the trailing edge of the preceding blade.

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PROPELLER BLADE CONFIGURATIONABSTRACT OF THE DISCLOSURE

A propeller type runner is described in which the leading edge of each blade "leans" forward from the root in the direction of rotation to reduce cavitation and increase efficiency. The "lean" provided to each blade of a five blade design is such that the leading edge of each blade obscures a large portion of the trailing edge of the preceding blade.

PROPELLER BLADE CONFIGURATION

This invention relates to a runner for a water turbine which is generically classified as a propeller type turbine runner, i.e. a runner having a diameter generally greater than 10 feet.

5 Propeller turbine runners generally find applications in power generation situations where low head, high volume water conditions are present. The runner of the present invention will be found suitable for application in large hydro power generation
10 installations and as such will rotate at a constant speed (optimum design) but will respond to environments where a constant speed is not a condition of operation.

When designing a runner of this type, the designer is faced with optimizing several conditions.

15 The extraction of power from the water supply requires that the moving water be deflected by the runner blades in such a manner as to produce a force which results in drive torque. At the same time, a drag force is also produced which tends to reduce the
20 drive torque. An optimum design of the blade shape, and pitch etc would seem to be an exercise in optimization in maximizing the force which results in producing drive torque, while minimizing the force which produces drag, but such is not the case. A
25 phenomenon known as "cavitation" must also be dealt

with by the runner designer because the design which
may produce maximum output power may be destroyed
quickly by the erosion of runner blades by cavitation.
Cavitation appears to result when the blade foil
5 deflects the moving water in such a manner as to
produce velocity differences which produces pressure
differentials in the water which are sufficient to
produce pressure levels so low that bubbles of water
vapour are produced in the low pressure areas
10 (generally at the suction side of the blade). As the
water at low pressure moves through the runner, the
pressure will be increased and the bubbles of water
vapour collapse. If the bubbles of water vapour
collapse or implode in areas spaced some distance from
15 the surface of the runner blades little or no damage
seems to result, however if the implosion of the water
vapour occurs at the surface of the runner blades,
serious erosion of the blade surfaces will certainly
result.

20 The designer is thus faced with another
design criteria, to produce a minimum of cavitation
erosion of the runner blade surfaces, while producing
maximum output torque.

I have been able to produce an extremely
25 efficient propeller type runner which has a minimum of
erosion produced by cavitation by altering the blade
profile to a shape which has a forward or leading edge
of the blade which "leans" forward from the hub in the
direction of rotation.

30 BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a propeller runner used in PRIOR
ART applications.

FIGURE 2 is a propeller runner which is
utilized in the present invention.

35 FIGURE 3A is a plan view of an individual

PRIOR ART blade.

FIGURES 3B-3D are sectional views of FIGURE 3A.

FIGURE 4A is a plan view of a blade of the instant invention.

5 FIGURES 4B-4D are sectional views of FIGURE 4A.

FIGURE 5 is a view of a PRIOR ART blade taken looking inwardly toward the hub along the blade axis.

10 FIGURE 6 is a view of the blade of the instant invention looking radially inwardly toward the hub along the blade axis.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the Figures and Figure 1 in particular it will be seen that Figure 1 is a plan view of a runner 10 of PRIOR ART propeller turbine used for extracting
15 energy from a water stream.

Runner 10 is composed of hub 12 surrounded by blades 14. An axis 16 is shown for one of the blades 14. A blade axis is located at the approximate geometric centre line around which the foil shape of the blade is designed.
20 It may also be used by the designer as the preferred axis of twist, to provide a reference axis for changing the angle of twist of the blade during the design stage.

A second line 18 is shown on blade 14 which passes through the outer periphery 20 of the tip of the leading
25 edge of blade 14. Note that line 18 also passes through a point 22 where blade 14 is attached to the hub (leading edge).

Referring now to Figure 2 wherein the improved runner 30 of my invention is illustrated, it will
30 immediately be seen that the blade configuration is substantially different than the prior art. Runner 30 comprises a hub 32 surrounded by blades 34. Blade 34 is shown having a blade axis 36. Also shown is line 38 which

corresponds with line 18 of Figure 1, line 38 intersection points 40 and 42 at the hub and blade periphery respectively. It will be seen that a substantial portion of each blade 36 extends forward beyond line 38 in such a manner that a substantial portion (at least 10%) of the trailing edge of each preceding blade is obscured (approximately 60 percent). The lead angle of the forward edge of the blade is such that about 1/7th of the blade (at the periphery) leans ahead of line 38. This means that this portion of the blade which did not exist in prior art designs is now available to extract energy from the moving water stream. It is not entirely understood how the shape and twist of the blades of the runner influences efficiency or the production of cavitation in the final runner design, but the runner of Figure 2 produces superior torque and a minimum of cavitation. It would appear that the extraction of energy from the moving water column is more evenly distributed across the blade and hence the widely differing water pressures experienced in prior art designs are not present in this blade configuration.

A more specific pictorial description of the prior art blade and the new improved blade is given in FIGS. 3 and 4. Note that although the curvature is slightly different, the main departure in the two designs resides in the present of the extra "lean" of the improved blade which extends the blade forward in the direction of rotation.

The twist and radial curvature of the improved blade and the prior art blade are not exactly the same in that the prior art blade has slightly more radial curvature at the leading edge than the improved blade which tends to have the leading and trailing edges more closely approximating a straight line. For

this reason when looking radially inwardly along the blade axis of Figure 6 the whole of the high pressure surface adjacent the leading edge is open to view. This is not true of the prior art design. Both the
5 blades present much the same view however when viewing the trailing edge of the blade looking inwardly along the blade axis in Figures 5 and 6; that is the entire suction side adjacent the trailing edge of the blade is available for viewing.

10 The runner of the present design is a five blade design, but the invention is equally valid for blade configurations using more or less than five blades on a hub.

It is not entirely understood why the
15 blade of this device exhibits the desirable qualities of superior performance and little or no cavitation, but because of the extra blade area produced by the forward "lean" of the improved blade, the energy extraction from
20 the moving water stream is probably more gradual than the prior art blade. It will also be seen that the "extra" area of the improved blade tends to be located in an area overlapping the trailing edge of the blade immediately preceding it on the
25 hub. This may provide a more evenly distributed pressure profile of the water between the trailing edge of the preceding blade and the leading edge of the blade following.

The runner of the present design is a five
30 blade design but it will be obvious to those skilled in this art that the number of blades required for each design will be governed by the head and volume of water available for each application in which the blade design is to be applied.

35 It will be evident that the overlap of blades

will be greater than that shown in the figures accompanying this application if the number of blades in a particular design embodying this invention is greater than five.

5 Similarly if the water head and volume available necessitate the use of blades less than five, there may be less or no overlap of the blades at all even though the degree of "lean" on the leading edge of the blade is kept at the
10 same value as described for the five blades of this invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A propeller type runner having a diameter of at least ten feet for the extraction of energy from a moving water stream for use in a low head hydro power generation applications comprising a symmetrical fan type configuration having two to five blades mounted on a hub wherein each blade of said propeller type runner has a leading edge which has a substantial forward skew to produce a lean in the direction of rotation of said runner, said forward skew serving to reduce the cavitation effects on said runner by reducing localized water pressure gradients existing across the surface of said blades.

2. A propeller type runner having a diameter of at least ten feet for use in a low head hydro power generation applications comprising a hub surrounded by at least two and not more than five blades in a multi-bladed symmetrical arrangement for extraction of power from a moving water stream, the shape of each blade being such that a radial line drawn from the axis of the propeller through the point where the leading edge of each blade joins the hub intersects the periphery of each blade at a point rearwardly from the leading blade tip at the periphery of said blade.

3. A runner as claimed in claim 2 in which the distance between the point on the periphery where the intersection of said radial line intersects and the leading peripheral blade tip equals substantially fifteen percent of the peripheral dimension of said blade.

4. A propeller type runner having a diameter of at least ten feet for use in a low head hydro power generation applications, comprising a central hub to which at least two and no more than five blades are attached in a fan configuration, the blades being symmetrical and of such

shape that each blade defines a leading edge and a trailing edge, the leading edge of each blade having a substantial forward skew to produce a lean causing each leading edge of the blade to obscure at least ten percent of the trailing edge of each preceding blade when viewed in an axial direction from the upstream side of the propeller type runner.

5. A propeller type runner as claimed in claim 4 in which substantially 60% of the trailing edge is obscured.

6. A propeller type runner having a diameter of at least ten feet for the extraction of energy from a moving water stream for use in a low head hydro power generation applications comprising a multi-bladed fan configuration wherein each blade of said propeller type runner has at least ten percent of the blade surface lying ahead of a line passing through a point where the leading edge of each blade intersects the hub of each blade and the propeller axis.

7. A propeller type runner for the extraction of energy from a moving water stream for use in a low head hydro power generation applications comprising a symmetrical fan type configuration having two to five blades mounted on a hub wherein each blade of said propeller type runner has a leading edge which has a substantial forward skew to produce a lean in the direction of rotation of said runner, said forward skew serving to reduce the cavitation effects on said runner by reducing localized water pressure gradients existing across the surface of said blades.

FIG. 1 PRIOR ART

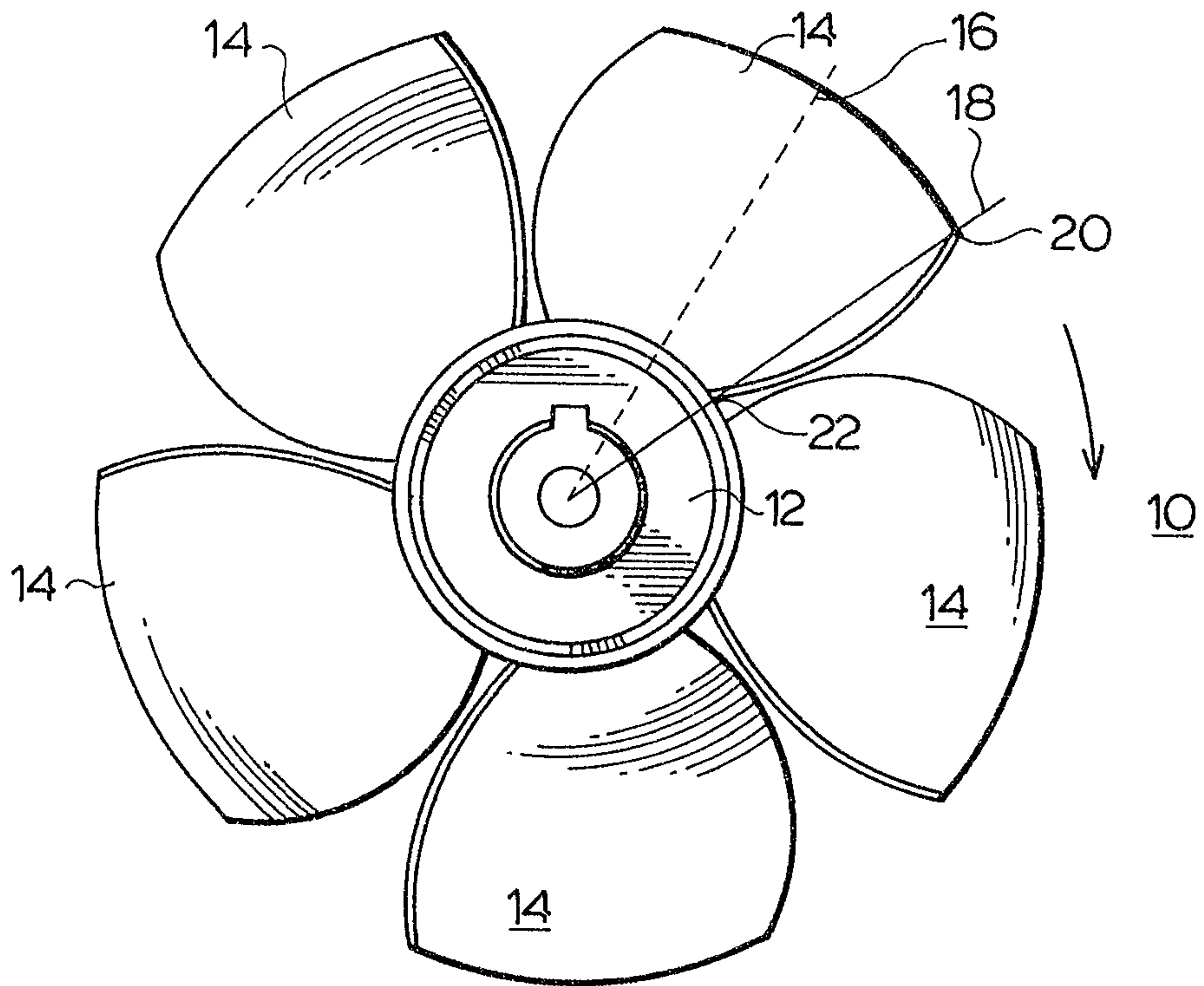
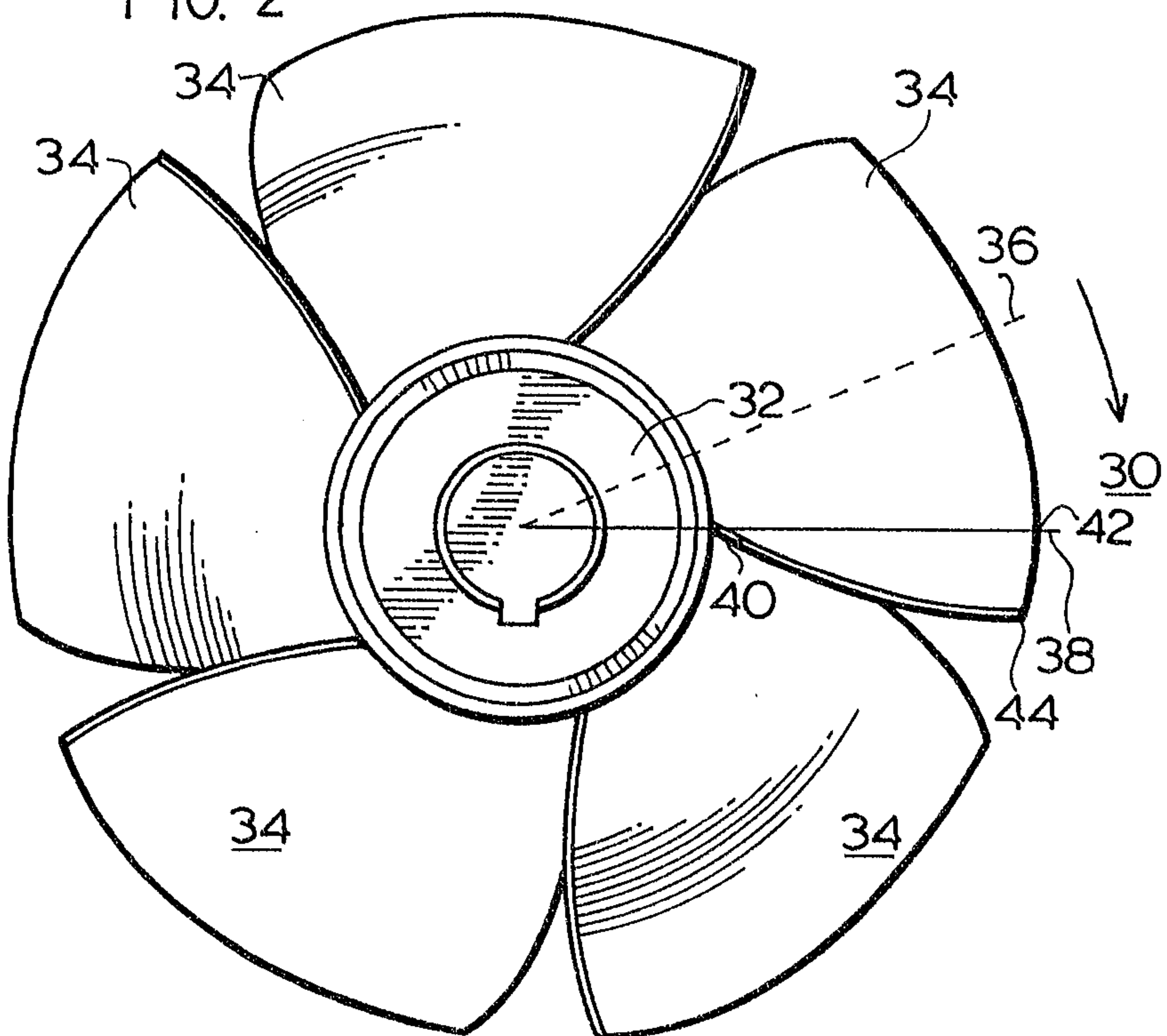


FIG. 2



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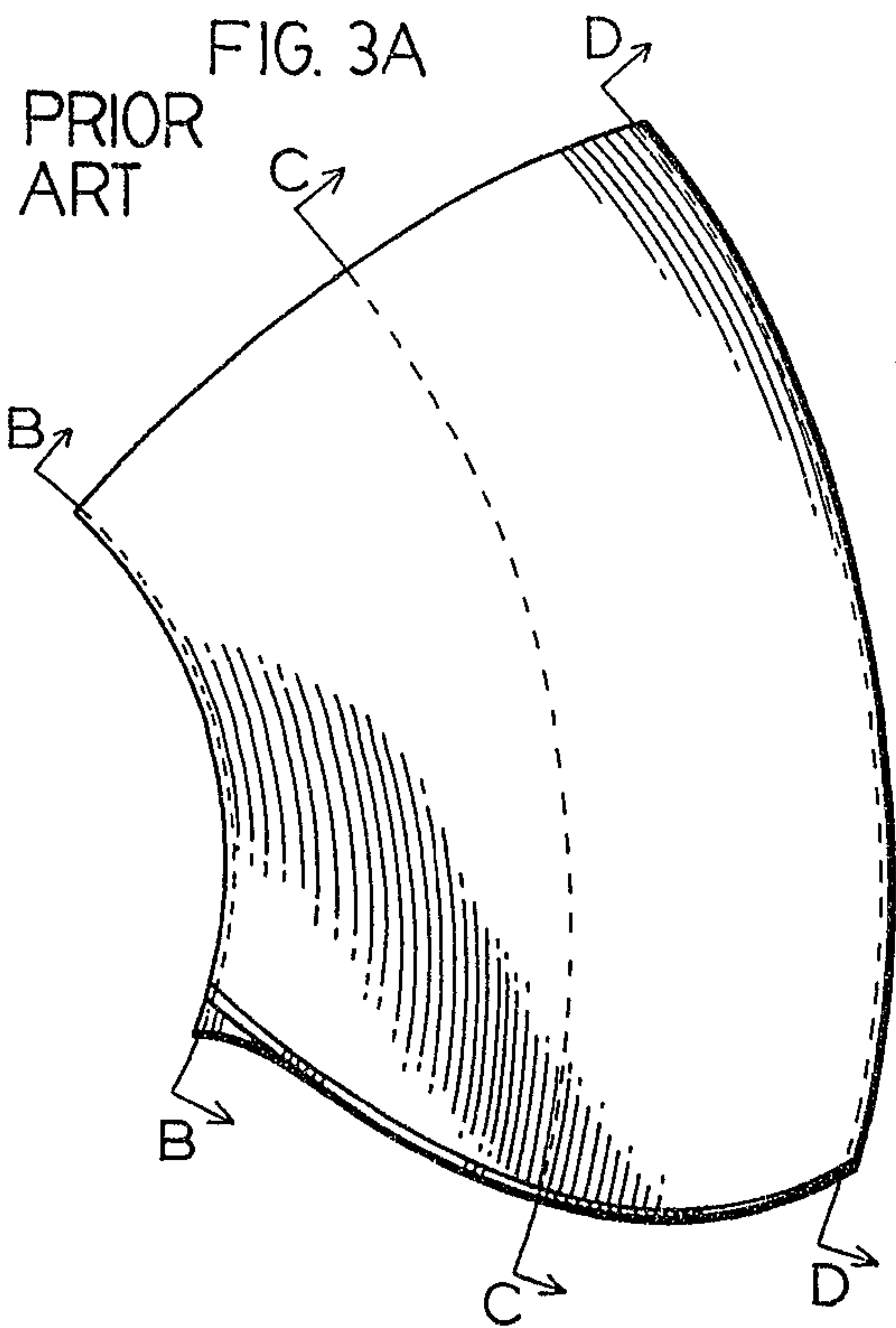


FIG. 3B
PRIOR ART

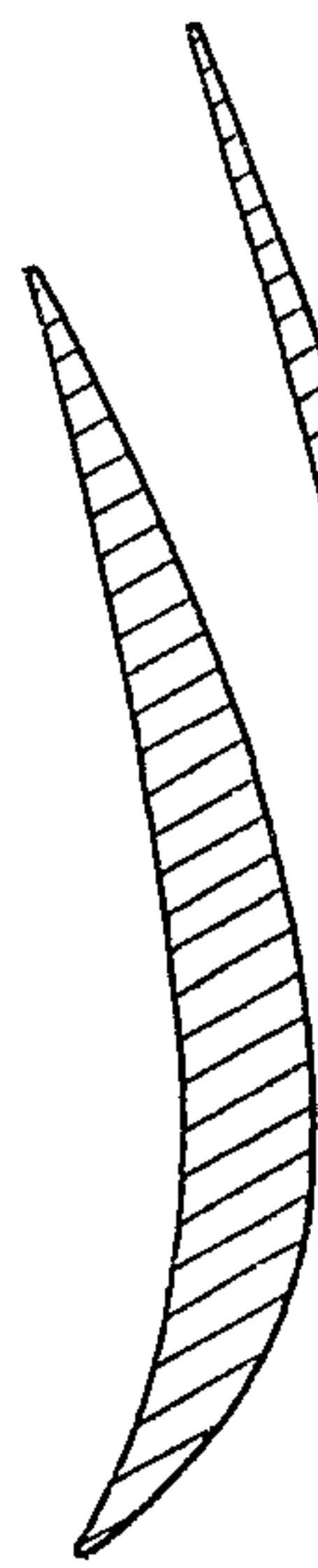


FIG. 3C
PRIOR ART

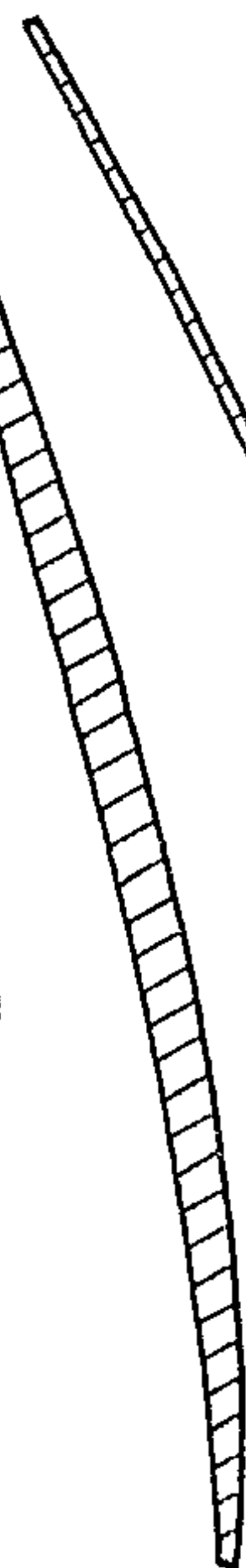


FIG. 3D
PRIOR ART

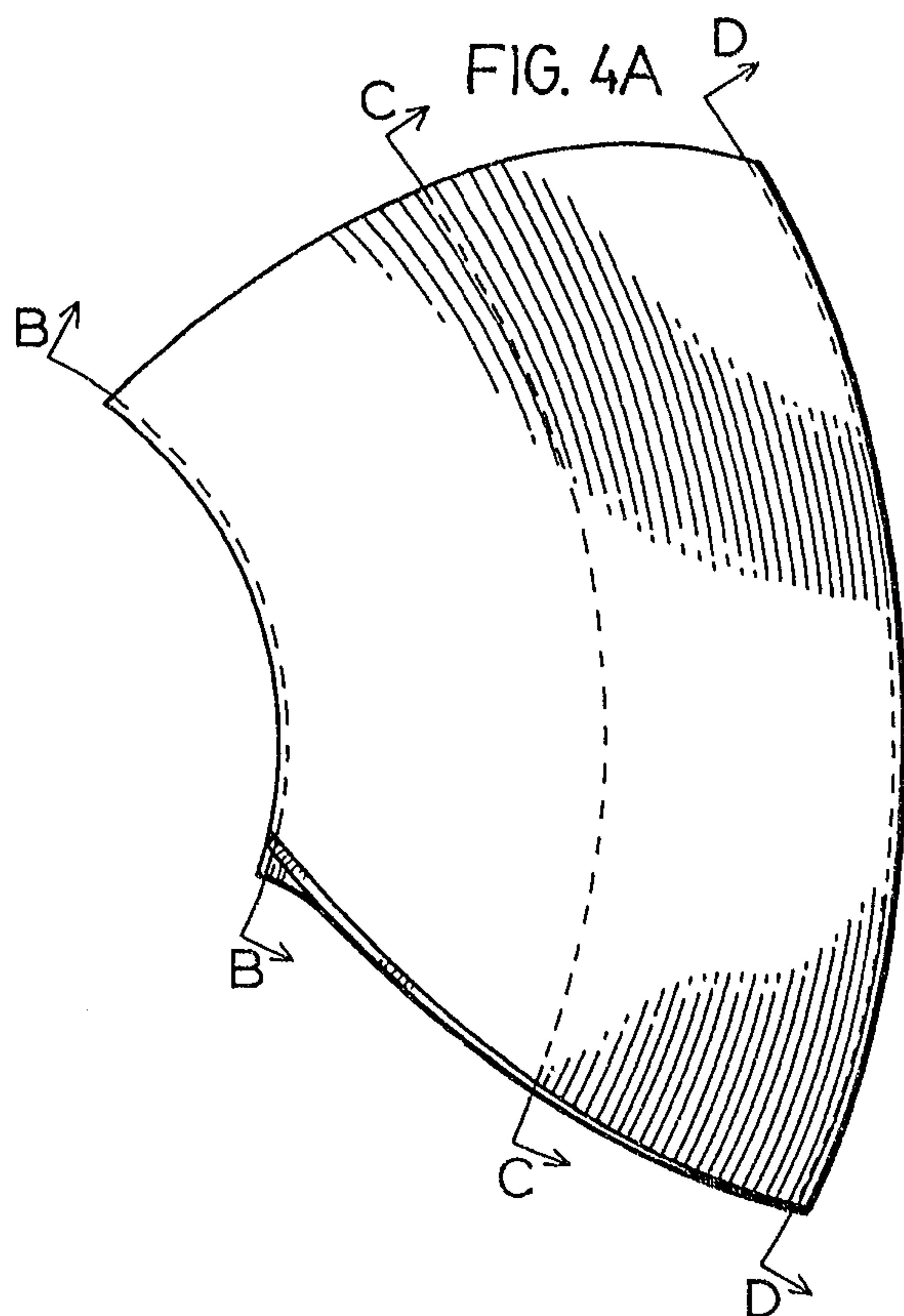
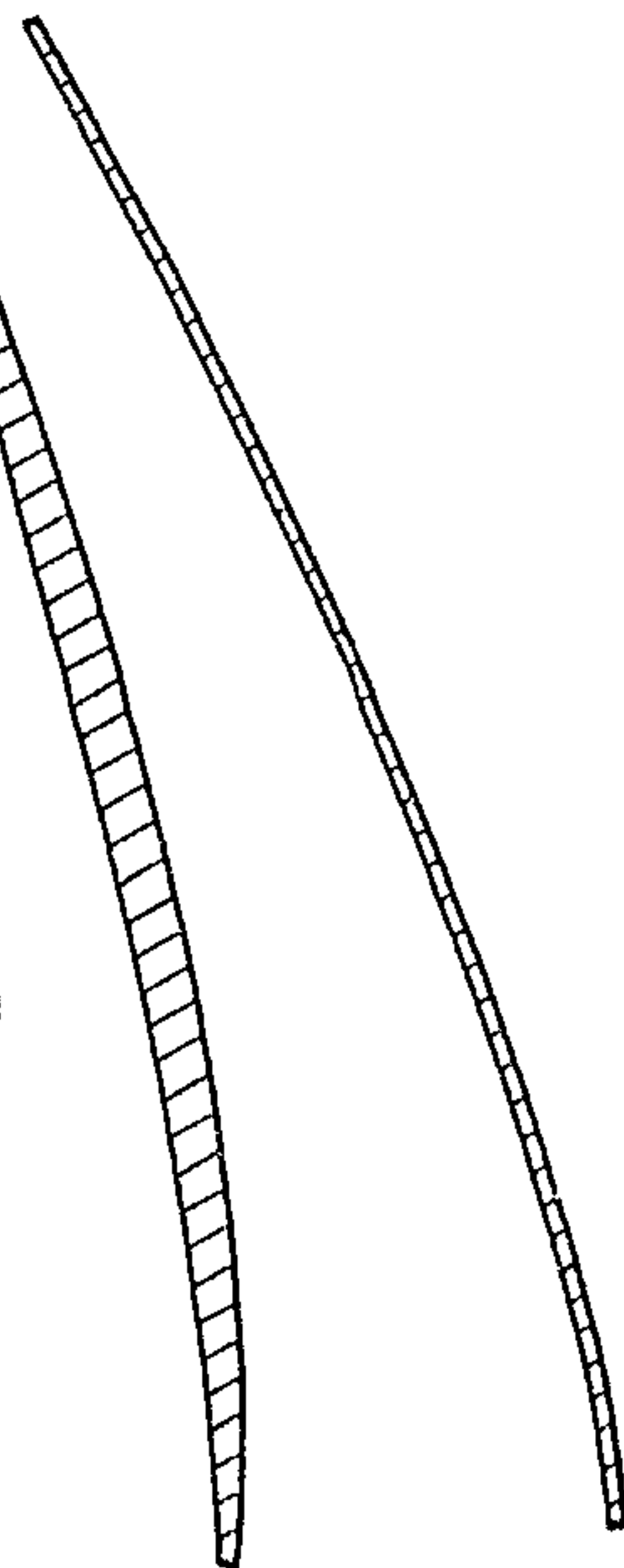


FIG. 4B

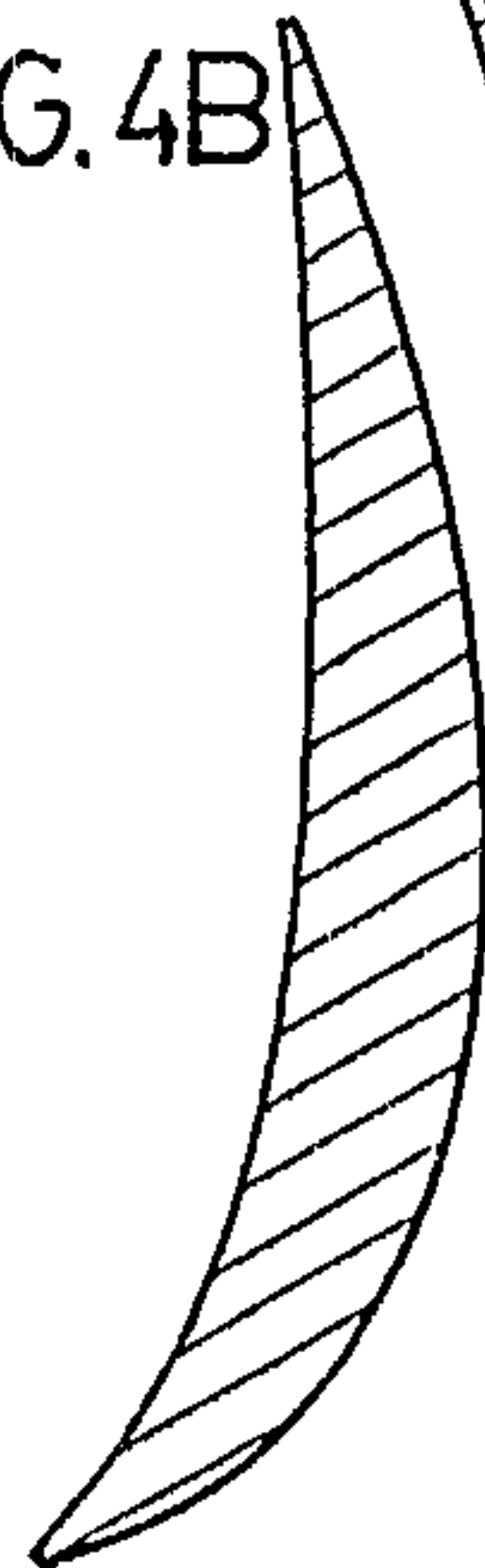


FIG. 4C

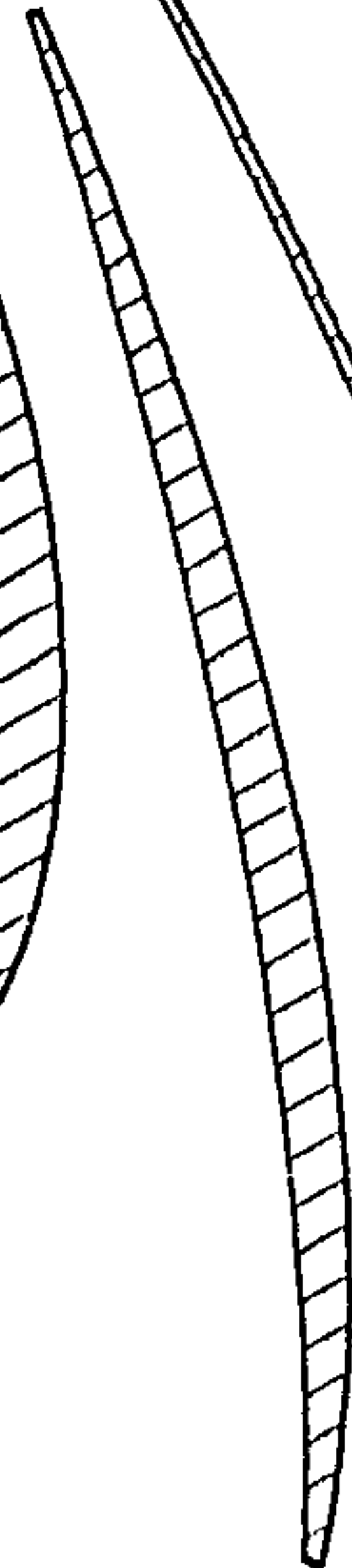
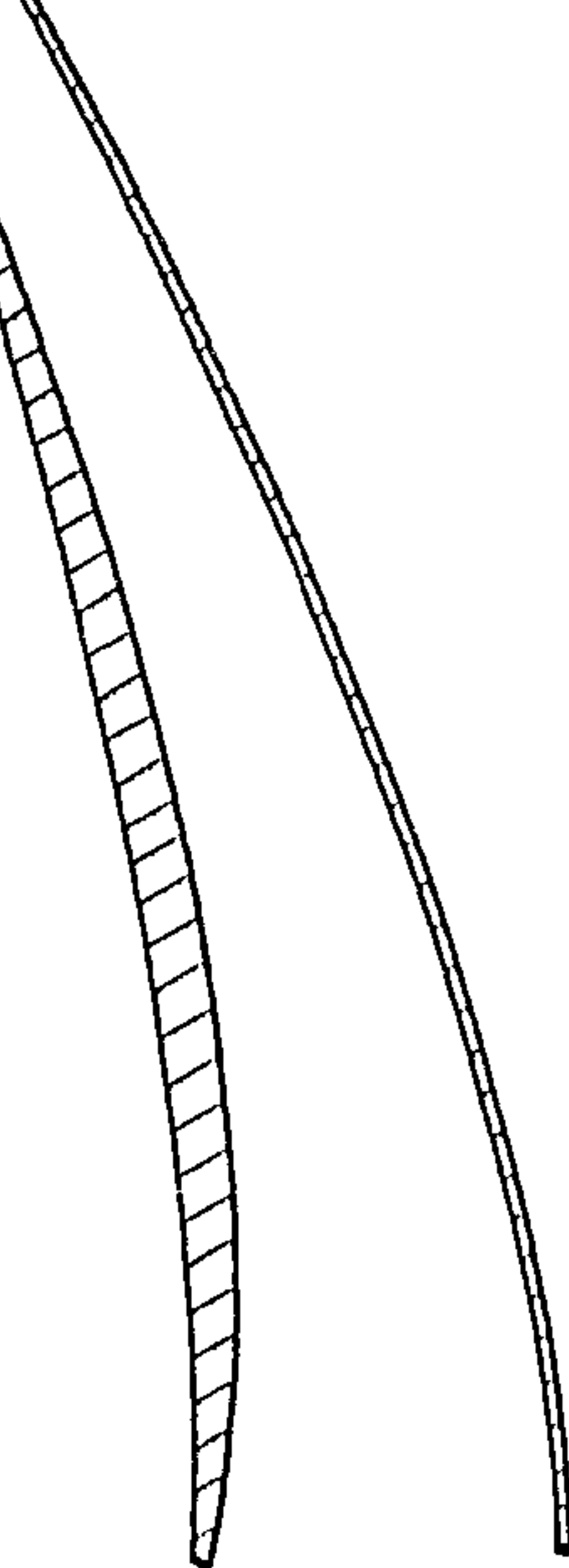


FIG. 4D



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FIG. 6

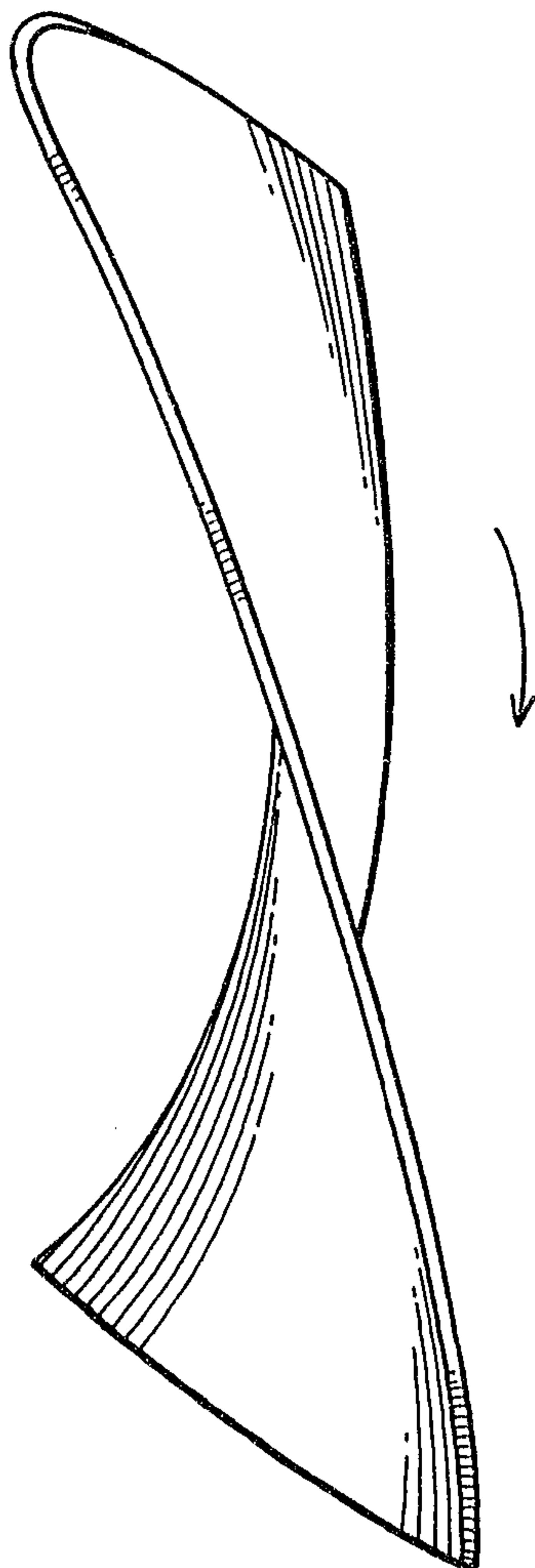


FIG. 5 PRIOR ART



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