

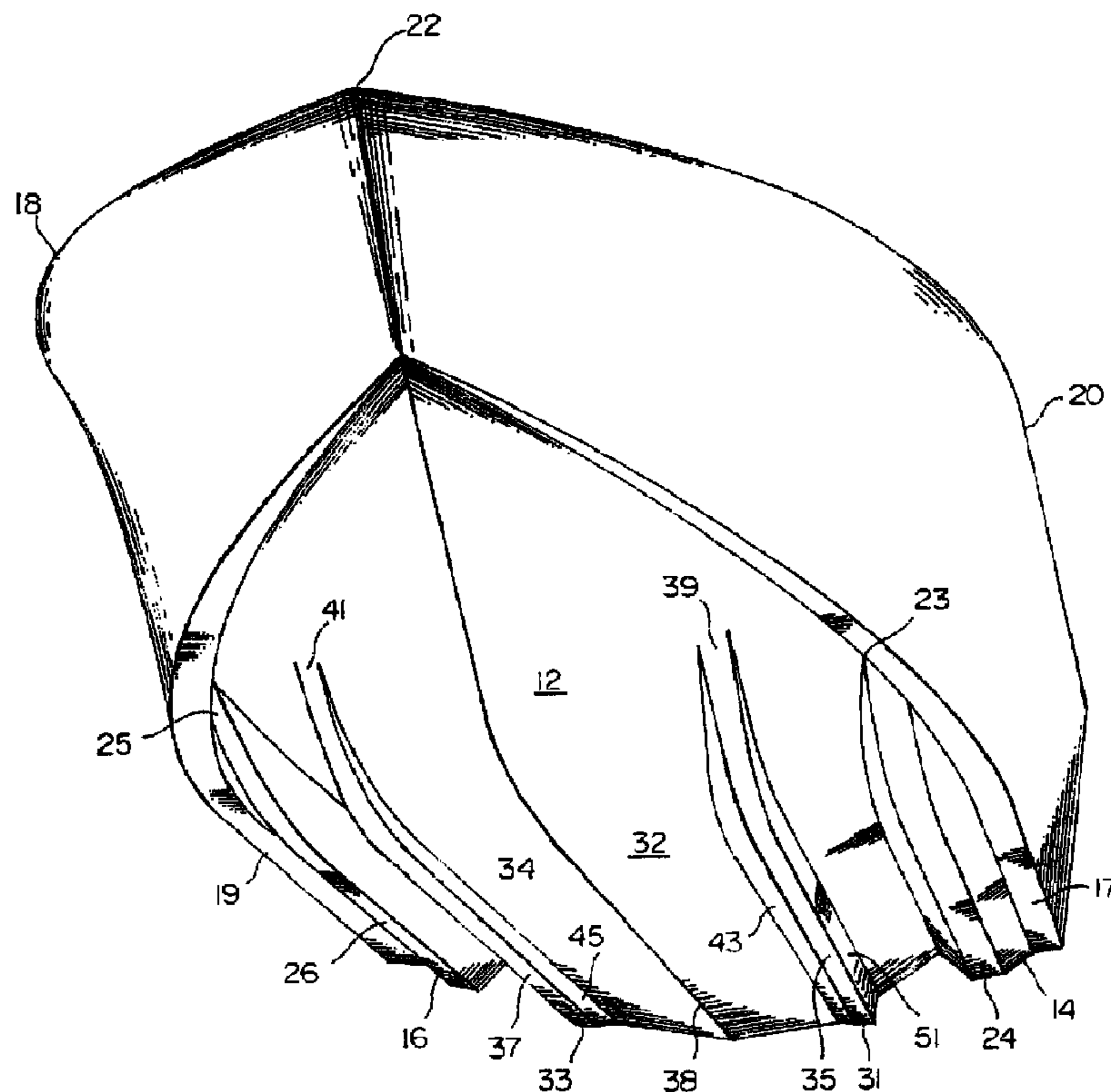


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(57) Abrégé/Abstract:

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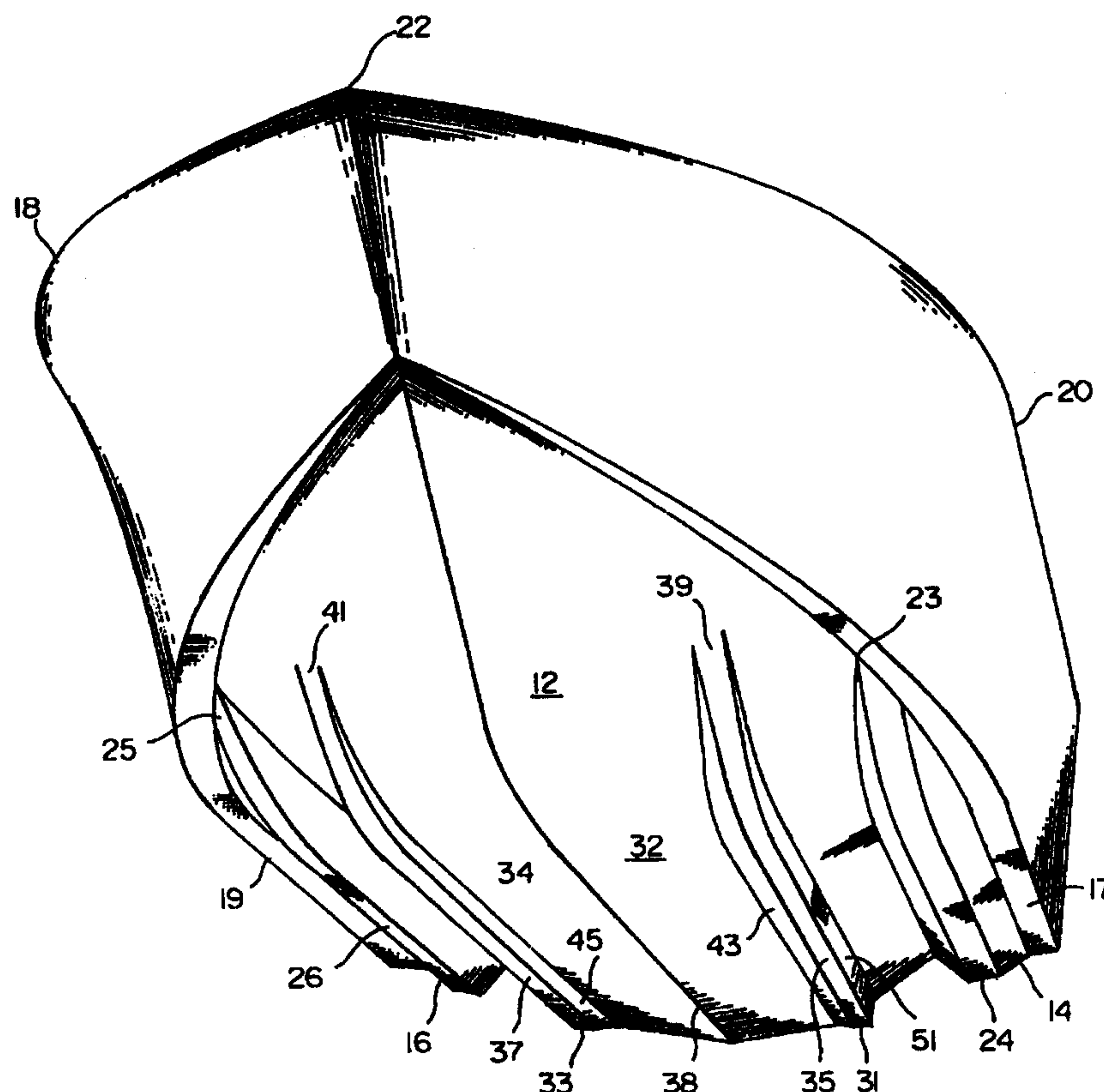
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(54) Title: BOAT HULL WITH CENTER V-HULL AND SPONSONS

(57) Abstract

A high performance boat hull structure is provided which combines a V-hull bottom portion (12) with mid hull sponsons (31 and 33) which form longitudinal tunnels with adjacent structures. The midhull sponsons (31 and 33) have horizontally disposed running surfaces to provide lift at high speeds. Outer sponsons (14 and 16) incorporate running surfaces (24 and 26) and together with mid hull sponsons (31 and 33) form a second air tunnel and engage and deflect side directed spray and wake downwardly providing additional lift and decreasing or eliminating spray and signature wake. Entrance of injected or inducted air into the air tunnel area decreases frictional engagement of the hull with water to improve efficiency and ride.



0 **BOAT HULL WITH CENTER V-HULL AND SPONSONS**

TECHNICAL FIELD

5 This invention relates to high performance boat hull structures. In particular,
it pertains to an advanced hull structure which improves upon the handling
characteristics of a V-bottom hull by combining V-bottom characteristics with those
of a flat bottom planing hull combined with the speed and acceleration characteristics
10 of a tunnel hull boat with a further improvement of substantially flat progressive lift
surfaces with multiple tunnel and multiple reverse deadrise hydrochines providing
surfaces upon which the hull predominantly rides at higher speeds, while providing
lower speed running surfaces for mid speed optimal performance. These advanced
features may be further combined with forced and natural air movement along the
hull-water interface to provide added lift and control at low and high speeds.

15 **BACKGROUND OF THE INVENTION**

Tunnel hull boats are designed to trap air underneath the boat hull as the boat
moves through water, thereby compressing the air and lifting the boat above the
20 water line defined by the boat's natural buoyancy. The effect of lifting the boat
decreases the boat's resistance through the water and allows for faster acceleration
and greater boat speeds.

25

Conventional tunnel hull designs have inherently sacrificed handling characteristics for higher speed performance. In particular, the same hull design that has allowed for lifting the hull out of the water has inhibited banking of the boat when turned, and contributes to porpoising (up and down oscillation of the bow) while turning. Moreover, performance of conventional tunnel hull boats is load sensitive and sea state dependent. That is to say, heavy loads detract from the air capturing and speed enhancing ability of tunnel hull boats, and, as compared to the more traditional V-bottom hull boat, tunnel hull boats are less stable in choppy water.

V-bottom displacement hull boats inherently and inefficiently displace water outwardly in spray and excursive wake.

A high performance boat that combines the speed and acceleration advantages of the tunnel hull with the handling characteristics and stability of the traditional V-bottom hull and certain of the ride characteristics of a sled or flat bottomed hull would provide decided advantages.

15

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention there is provided a hull for a boat adapted for operation on a water surface, the hull having a bow section, a mid hull section, a keel and a stern. The hull includes a center V-hull portion extending substantially from the bow to the stern, and includes a pair of angled panels symmetrically positioned about a hull center plane. The panels define a V-hull apex line and the angled panels each define a V-hull dead rise angle measured from the apex line relative to a normal plane containing the apex line and perpendicular to the hull center plane. The hull also includes at least one set of first and second opposed mid hull sponsons positioned on the mid hull section on opposite sides of the V-hull portion, each mid hull sponson including a substantially horizontally disposed running surface and connected to the V-hull portions by reverse deadrise panels, whereby the mid-hull sponsons, and the V-hull portion, together with the water surface, define a pair of mid-hull air capturing tunnels while minimizing the wetted surface area of the mid-hull sponsons. The hull further includes first and second outer V-hull panels extending

outwardly and upwardly from the mid hull sponsons. The hull also includes first and second opposed outer sponsons, positioned on opposite sides of the outer V-hull panels, each outer sponson including a lower most running surface and connected to the outer V-hull panels by second reverse deadrise panels, whereby the outer sponsons, and the
5 V-hull panels, together with the water surface, define a pair of outer air capturing tunnels while minimizing the wetted surface area of the mid-hull sponsons. The hull further includes gunwales extending upwardly from the outer sponsons.

Each of the outer sponsons may further include an outer sidewall oriented
10 between 40 degrees and 60 degrees to the horizontal.

The lowermost running surface of the hull may interconnect the inner and outer sidewalls on each of the outer sponsons.

15 The outer sponsons may each extend from a sponson point ahead of the mid hull section to the stern of the hull and may be oriented generally parallel to the longitudinal axis of the hull, whereby air may be deflected from the V-hull portion as the hull moves through the water and is captured by the sponson forward portions and directed rearwardly through the mid-hull air capturing tunnels.

20

The mid-hull sponsons may extend from a mid-hull sponson point ahead of the mid hull section to the stern whereby air may be deflected from the V-hull portion as the hull moves through the water and is captured by the mid-hull sponson forward portions and directed rearwardly through the outer air capturing tunnels.

25

The plurality of the mid hull sponsons may be disposed between the keel and the outer sponsons, adjacent mid hull sponsons forming air capturing tunnels.

The hull may further include a step positioned aft of the bow section, the step
30 diverging from the keel toward the stern.

The step may include a plurality of spaced apart steps.

The step may include an air injector to insert air into the tunnels.

5 The boat hull may have a bow section, a mid hull section, a heel and a stern. The hull may include a step positioned aft of the bow section on the mid hull section, the step diverging from the keel toward the stern.

10 The step may include a plurality of steps each diverging outwardly from the keel toward the stern.

 In accordance with another aspect of the invention there is provided a hull for a boat adapted for operation on a water surface, the hull having a bow section, a mid hull section, a keel and a stern. The hull includes a center hull portion extending
 15 substantially from the bow to the stern, and includes a pair of angled panels symmetrically positioned about a hull center plane. The panels define a V-hull apex line and a flat horizontally disposed panel extending forwardly from the stern, the angled panels each defining a V-hull deadrise angle measured from the apex line relative to a normal plane containing the apex line and perpendicular to the hull center
 20 plane. The hull also includes at least one set of first and second opposed mid hull sponsons, positioned upon the mid hull section on opposite sides of the V-hull portion. Each mid hull sponson includes a substantially horizontally disposed running surface and is connected to the V-hull portions by reverse deadrise panels, whereby the mid hull sponsons, and the V-hull portion, together with the water surface, define a pair of
 25 mid hull air capturing tunnels while minimizing the wetted surface area of the mid hull sponsons. The hull further includes first and second outer V-hull panels extending outwardly and upwardly from the mid hull sponsons. The hull also includes first and second opposed outer sponsons, positioned on opposite sides of the outer V-hull panels, each outer sponson including a lower most running surface and connected to the outer
 30 V-hull panels by second reverse deadrise panels, whereby the outer sponsons, and the V-hull panels, together with the water surface, define a pair of outer air capturing

tunnels while minimizing the wetted surface area of the mid hull sponsons. The hull further includes gunwales extending upwardly from the outer sponsons.

Each of the outer sponsons may include a reverse deadrise inner sidewall, and
5 an outer sidewall oriented between 40 degrees and 60 degrees to the horizontal.

Each of the outer sponsons may further include a generally planar lower running surface interconnecting the inner and outer sidewalls.

10 Each of the outer sponsons may extend from a sponson point ahead of the mid hull section to the stern of the hull and may be oriented generally parallel to the longitudinal axis of the hull. Air may be deflected from the V-hull portion as the hull moves through the water and may be captured by the sponson forward portions and directed rearwardly through the tunnels.

15 The mid hull sponsons may extend from a mid hull sponson point ahead of the mid hull section to the stern whereby air deflected from the V-hull portion as the hull moves through the water and is captured by the mid hull sponson forward portions and directed rearwardly through the tunnels.

20 A plurality of mid hull sponsons may be disposed between the keel and the outer sponsons, adjacent mid hull sponsons forming air capturing tunnels.

The hull may further include a step positioned aft of the bow section, the step
25 diverging from the keel toward the stern.

The step may include a plurality of spaced apart steps.

The step may include air injection provisions to insert air into the tunnels.
30

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of one embodiment of the boat hull constructed in accordance with the present invention taken from a point below and ahead of the bow;

FIG. 2 is a side elevational view of the hull shown in Figure 1;

FIG. 3 is a bottom elevational view of the hull shown in Fig 1;

FIG. 4 is a front elevational view of the hull shown in Figure 1;

FIG. 5 is a schematic cross sectional view taken along lines 5-5 of Fig. 2;

FIG. 6 is a perspective view similar to Fig. 1 showing a second embodiment of the invention having a central flat running surface in place of a portion of the V-hull;

FIG. 7 is a front elevational view of the boat hull shown in Fig. 6;

FIG. 8 is a side elevational view of the boat hull shown in Fig 6;

0 FIG. 9 is a bottom plan view of the boat hull shown in Fig. 6;

FIG. 10 is a front elevational view of a boat hull showing a third embodiment of the invention;

5 FIG. 11 is a bottom plan view of the boat hull shown in Fig. 10;

FIG. 12 is a bottom perspective view of another embodiment of this invention showing a modified bow section and provision for introduction of air into the tunnels from a swept back step;

10

FIG. 13 is a partial bottom plan view of the hull shown in Fig. 12 inverted;

FIG. 14 is a side elevational view of the device shown in Fig. 12;

15

FIG. 15 is a front elevational view partly cut away of the device shown in Fig. 12;

20

FIG. 16 is a front elevational view of a larger hull having multiple sponson structures positioned at intervals across the width of the hull in a substantially parallel configuration to define multiple tunnels;

FIG. 17 is a side elevational view of the device shown in Fig. 16;

25

FIG. 18 is a front elevational view of the device shown in Fig. 16 in a patrol boat version;

FIG. 19 is a side elevational view of the apparatus shown in Fig. 18;

0 FIG. 20 is a bottom plan view of another embodiment of this invention in which there are a plurality of steps positioned along the bottom surface of the hull to enhance and control air entrainment and injection at a plurality of locations;

5 FIG. 22 is a graphical representation of Transport Factor plotted against volumetric Froude Number for various boat hulls.

DETAILED DESCRIPTION OF THE DRAWINGS

10 Referring to the drawings, an improved hull 10 in accordance with the present invention broadly includes center V-hull portion 12, and a pair of opposed, generally parallel outer sponsons 14, 16 positioned to either side of the V-hull portion 12. Outer low speed running surfaces 17, 19 extend from the bow 22 to the stern 28 at the lower margins of respective opposed gunwales 18, 20. Running surfaces 17 and 19 also serve to interrupt and deflect part or all of the splash and spray from adjacent parts of the hull. Positioned adjacent running surfaces 17, 19, the sponsons 14, 16 extend rearwardly from sponson points 23 and 25 aft of the bow 22 and terminate at stern 28. Sponsons 14 and 16 have a running surface 24 and 26 respectively at the lowermost extent thereof, extending along the length of each sponson and positioned in a near horizontal plane as is more fully described below.

20 One or more pairs of mid-hull sponsons may be positioned between outer sponsons 14, 16 and keel 38. In the figures, one pair of mid-hull sponsons 31, 33 are shown depending from the generally V-hull, with a reverse deadrise and mid-hull sponson running surfaces 35, 37.

25

0 The V-hull portion 12 of hull 10 is defined by inclined panels 32, 34 which extend rearwardly from the bow transition area to the stern 28, and from keel to reverse deadrise 43 and 45 forming the keelward surface of mid-hull sponsons 31 and 33.

5 Referring to the schematic drawing shown in Fig. 5, which is an elevational cross section at line 5-5 of Fig 2 and viewing along the central axis of the hull, the panels 32, 34 define the dead rise angle of the V-hull portion 12 of the boat hull 10. The panels 32, 34 are symmetrically positioned about the hull center plane H. The V-hull dead rise angle that is measured from the normal plane N containing the apex
10 46 and perpendicular to the hull center plane H, to the respective V-hull panel portion 32, 34 is approximately in the range of 5-15 degrees and preferably approximately 7 degrees. It will be appreciated that the angles defined by panels 32, 34 with the horizontal plane N may increase as the panels move forward from a point approximately midships on the hull. The V-hull dead rise angle is properly measured
15 aft of the midship's point, where the angle defined by the panels with the horizontal is relatively constant. The V-hull portion 12 terminates in a generally vertical transom 28.

20 At the margins of panels 32, 34 a pair of mid-hull sponson-like elongated structures extending from mid-hull sponson points 39, 41 to transom or stern 28. Reverse deadrise 43, 45 are angled in the range of 0 to minus 10 degrees and preferably at about minus 5 degrees with respect to horizontal plane N, and fair into mid-hull sponson running surfaces 35, 37 which extend along the length of mid-hull sponsons 31, 33. Substantially vertical panels 51, 53 extends upwardly from running
25 surfaces 35, 37 to outer V-panels 47, 49 which are angled at a deadrise angle of from 30 to 40 degrees and preferably about 35 degrees from horizontal plane N. A second reverse deadrise panel 47, 49 extend downwardly from said outer V-panels 44 and 46 defining interior surfaces of outer sponsons 14 and 16. Sponsons 14 and 16

0 extend from sponson points 23, 25 to the transom or stern 28. Outer sponson exterior
panels 50, 52 extend along the length of outer sponsons 14, 16 and are connected to
second reverse deadrise panels 47, 49 by running surfaces 24, 26. Running surfaces
24, 26 are designed to provide sufficient lift to the hull for planing purposes at mid
5 speeds and are angled with respect to the horizontal plane N in the range of
approximately 0 to 20 degrees and preferably at about 10 degrees. The sponsons
intercept side directed spray and wake from the V-hull portion and direct them
downwardly to enhance lift and reduce signature wake.

10 A combined splash rail and low speed running surface is positioned at the
upper margin of each outer sponson exterior panel 50, 52 and preferably extends
from bow to stern of the hull with an angle for the surfaces 17, 19 being
approximately 0 to 10 degrees and preferably about 4 degrees from the horizontal
plane N. Gunwales 18, 20 extend upwardly from surfaces 17, 19 and may be
substantially vertical or flare outwardly as desired. The splash rail intercepts splash
15 and wake and directs them downwardly, resulting in both added lift for the boat and
further reduction or elimination of signature wake.

The sponsons 14, 16, and V-hull portions 44, 46 define a pair of opposed,
longitudinally extending tunnels, with the water providing the tunnel bottom wall.

20 The unique handling characteristics of the hull 10 in accordance with the
present invention are in large part due to the placement of the outer sponsons 14, 16
relative to the dead rise angle of the outer V-hull panels 44, 46, coupled with the mid-
hull sponsons and their placement with respect to V-panels 32, 34. Capture and re-
direction of spray and wake downwardly contribute to the unique handling
25 characteristics of the hulls constructed according to this invention.

0 The lower limit of the outer sponson base line is established by yaw stability
requirements. The V-hull panels 44, 46 inherently counteract forces transverse to the
forward path of travel of the boat, and maintains the boat in a single, forward
direction. Lowering the outer sponson base line as shown allows the natural
buoyancy and upward planing force of the sponsons to counteract the inherent,
5 positive yaw stability characteristic of the V-hull.

 The upper limit of the mid hull and outer sponson base lines are established
by the depth of each sponson required to provide an adequate air capturing and
air-compressing tunnel. As will be appreciated by those skilled in the art, the cross
10 section area of the forward end of a boat hull tunnel must be greater than the cross
section area at the rear end of the tunnel for compression of air traveling down the
tunnel as the boat travels through the water. The compression of air within the tunnel
creates the desired result that, as a boat travels through the water, the bow will rise
until planing speed is attained, and, to provide the desired air compression effect, the
15 leading edge of the sponson must be low enough to intersect the water line at a point
far enough forward on the hull to define an air capturing tunnel of adequate length.
On the other hand, it is not desirable to submerge any more of the outer sponson than
is necessary to effect proper tunneling, in order to avoid unduly increasing the wetted
hull perimeter and related skin drag. A sponson depth that is not higher than about
20 two-thirds the V-hull dead rise angle has been found to provide a tunnel of adequate
length for air compression purposes, while minimizing the wetted surface area of the
sponson. Interception and downwardly direction of the spray and wake is
accomplished with the sponson configured as described.

25 The shape of the sponsons 14, 16 is unique in several aspects other than the
angles described and the presence of the outer splash rail and running surface 17, 19.

0 The width of sponson base panels 80, 82, and the preferred angle of the
vertical rise of the outer sponson sidewalls is determined by several competing
factors. In particular, the sponson sidewalls and bottom wall preferably defines a
sponson width that provides a certain, limited amount of lift to the hull due to
5 buoyancy spray interception and hydraulic planing effects. The displacement lift
provided by the sponsons enhances the boat's stability at rest and at slow speeds. At
high speeds, however, the displacement lift effect of the sponsons is preferably
minimal, allowing the boat to maneuver in the manner combining the characteristics
of a tunnel hull with a traditional V-hull boat. Redirection of spray and wake
provides significant control and lift and higher speed. The result is a highly stable
10 and maneuverable boat

 The maximum design width of the outer sponsons is determined by the
planing effect provided by the mid hull and outer sponsons as the boat moves through
15 the water. Water flow past the sponsons can be either laminar or turbulent with
efficiency enhanced by turbulent flow with air bubbles at the hull-water interface.
The laminar or turbulent characteristic of the flow is a function of boat speed and
geometry of the sponson; in particular, the geometry of the sponson effective base
width. The addition of forced air flow to the hull surface as is described below
20 remarkably effects the performance characteristics of the hull.

 The sponson effective base width is determined by the effective cross
sectional area of the sponson in the plane of flow. Referring to the drawings, the
effective cross sectional area of the sponson is a combination of the planar base
25 panels on outer panels 50, 52. Those skilled in the art will appreciate that, as the
angle of each outer panels 50, 52 decreases, as measured from the horizontal, the area
of the outer sidewall presented to the plane of water flow increases, and accordingly
the planing effect of the sponson outer sidewall also increases.

0 The minimum width of the outer sponsons is determined by the need for the
sponsons to provide some buoyancy to stabilize the boat when the boat is at rest.
Buoyancy is a function of displaced water (volume of the sponson). The shape of the
sponson inner sidewalls and the minimum angle of the sponson outer sidewall,
relative to the horizontal, are determined by desired turning characteristics, and the
5 planing effect, respectively. Moreover, the maximum sponson effective planar base
width is determined by desired sponson lift characteristics. The length and depth of
the sponsons are determined by the need to have an air tunnel of appropriate length
(see above). The volume of the sponsons (i.e., water displacement capability) can
therefore be controlled only by varying effectively the planar base panel width, and
10 by varying the sponson outer sidewall angle. Effective volume of the sponsons is
primarily controlled by varying the width of sponson running surfaces 24, 26.

As noted above, the angular configuration of the surfaces forming the mid
hull sponsons 31, 33 and the outer sponsons 14, 16 may be varied somewhat to
15 accommodate different load and ride characteristics. The operational and preferred
ranges of dimensions and angles for the component parts of the hull are set out
below, with particular reference to Figures 1-5.

	Angle	Operable Range	Preferred Range	Most Preferred Range
	α	10° - 40°	30° - 40°	35° - 37°
20	β	0° - 15°	0° - 10°	5° - 7°
	γ	20° - 50°	30° - 45°	35° - 40°
	δ	-5° - 15°	0° - 10°	6° - 8°
	θ	0° - 15°	2° - 10°	5° - 7°
	ς	-5° - 15°	0° - 10°	2° - 4°
25	μ	30° - 90°	40° - 60°	45° - 55°
	η	70° - 90°	80° - 90°	80° - 90°

0 Surfaces 17, 19, which constitute the outer sponsons margin, may be
configured as shown in Fig. 5 at the preferred angular range to the horizontal of about
2° - 5°. The operable range may extend from -5° to 15°. Additionally, to further
control splash, the surfaces 17, 19 may include a downwardly projecting member, or
a wedge shaped member thereon to redirect the spray downwardly, if desired, over
5 part or all of the length of hydrosponsons 24, 26. Alternatively, the modifications
mentioned to surfaces 17, 19 may extend over part or all of the length of the boat,
including the bow portion thereof.

10 The alternative embodiments of this invention shown in Figs. 6-20 have most
elements in common with the first embodiment shown in Figs. 1-5 and described in
detail above. When a more nearly flat bottom type performance is needed the
embodiment shown in Figs. 6-9 may be used, in which the rearward central area of
the hull is configured with a flat horizontal panel 170 extending from the juncture of
the bow and main hull rearwardly to the stern. Panel 170 may be varied in area to
15 achieve the performance needed, for example for a greater buoyancy and less draft,
the panel 170 would be larger, whereas, if performance more nearly resembling a V-
hull is desired, the panel 170 would be smaller. Other elements of the embodiment
shown in Figs. 6-9 are similar to comparably disposed elements shown in Figs. 1-5
and are similarly labeled, prefaced with the number "1".

20 The embodiment shown in Figs. 10 and 11 is particularly well suited to the
need for a wider, more stable hull with additional flotation provided in the outermost
sponson area 80, 81. In common with the previously described embodiments, the
device shown in Figures 10 and 11 combine a multiple tunnel forming configuration
25 in which lift is provided on a central, generally v shaped area with provision to
capture spray lift. Running surfaces on the sponsons provide lift and stability. The
tunnels act as lift areas enhanced by the air entrainment or in some versions by air
induction or injection so that a bubble interface at the hull surface is formed to

0 decrease friction and enhance lift. The unique spray capture configuration reduces
or eliminates wake as the hull traverses the water. This configuration may readily be
adapted to existing hull designs since the outer sponsons extend outwardly from the
conventional hull line. A highly efficient hull results having higher Transport Factors
and Volumetric Froude Numbers as compared to prior art boat hulls. Other
5 elements of the embodiment shown in Figs. 10 and 11 are similar to comparably
disposed elements shown in Figs. 1-5 and are similarly labeled, prefaced with the
number "2".

10 In Figures 12-15, a further modification of the hull of Figures 1-4 is presented
in which a modified bow section provides for a step transition into the previously
described hull. The step transition is uniquely configured in a swept back v
configuration with air injectors 90 for introduction of air into the tunnels.
Conventional step structures adapted to induce air into prior art tunnel structures are
positioned perpendicular to the centerline or swept forward in an attempt to induce
15 air flow. The configuration of Figures 12-15 and the multiple step version of Figure
20 provide a unique method of inducing air flow with smooth ride. Elements
comparable to those described above are labeled similarly with the prefix number
"3".

20 In Figures 16-19, larger boat hulls are depicted in which multiple tunnel
forming sponsons are disposed across the hull bottom as shown. The patrol boat
version of the hull of this invention shown schematically in Figures 16-19 would be
in the range of about 30 to 100 feet in length and have a beam dimension of from
about 12 to 50 feet. Typically, a 42 foot patrol boat would be designed with two
25 longitudinal sponsons with substantially flat running surfaces thereon positioned on
each side of the keel to form two tunnel structures while a 100 foot patrol boat would
have five to seven longitudinal sponsons with substantially flat running surfaces
thereon positioned on each side of the keel to form five to seven tunnels. Other

0 elements of the embodiment shown in Figures 16-19 are similar to comparably
disposed elements shown in Figures 1-5 and are similarly labeled, prefaced with the
number "4".

5 Larger hulls may be constructed using the concepts of the inventions
described above by enlarging the design and incorporating even more longitudinal
sponsons with flat running surfaces arrayed across the hull surface to form additional
tunnel structures. With air injection, enhanced lift and running efficiency, as well as
significant wake reduction results. Length to beam ratios of up to 2:1 are feasible for
large ships such as aircraft carriers and cargo vessels with remarkably improved
10 efficiency and handling.

Alternative air injection or inducement structures are envisioned for the hull
designs described above, as is shown in Figures 20-22. In Figure 20, multiple swept
back steps 88, similar in configuration to the step structure 88 shown in Figures 12-
15 are shown advantageously positioned along the length of the boat hull. By using
multiple steps, the air inducement or injection can be effectively controlled to provide
optimum bubble formation and lift along the length of the boat hull. Two alternative
air inducement or injection means are schematically shown in Figures 21 and 22. In
Figure 21, the air is injected through ports recessed into the surface of the hull 99
while in Figure 22, a step configuration is used. In each configuration of the air
20 induction means, air is provided at the water hull interface to provide lift and reduce
frictional drag in the tunnels defined by the longitudinal sponsons. Individualized
control of air volumes entering the various hull areas will permit operational
optimization.

25 Certain load carrying and efficiency aspects of a boat hull may be described
and compared to other hull configurations by calculating two well known hull
parameters, the Transport Factor and the Volumetric Froude Number. When

0 graphically presented as more fully described below, these parameters present a descriptive comparison of hull properties.

Transport Factor is calculated using the following equation:

$$\text{T.F.} = 6.88 V_k D_{1t} / \text{BHP}$$

5

Where V_k is the hull velocity in Knots

D_{1t} is the displacement of the hull in long tons

BHP is the brake horsepower

Volumetric Froude Number is calculated using the following equation:

10

$$F_D = 0.165 V_k / D_{1t}^{1/6}$$

A plot of the Transport Factor vs the Volumetric Froude Number for various hulls obtained from the David Taylor Model Basin in Maryland is shown in Figure 23. The data for hulls described herein incorporating the invention compares very favorably with the best designed hulls of the prior art.

15

Data obtained from various sources and assembled at the David Taylor Model Basin for various small craft is presented in tabular form below. The highest transport factor for all small boat hulls studied is the hull constructed according to the teachings of this invention and described in Example 3 below, using the 200 horsepower Mercury engine.

20

WO 99/12804

PCT/US98/18927

TABLE 1

	Vehicle's Name	Vehicle's Type	Vehicle's Mode	Engine BPH	Length (ft)	Diapl'mnt (longtone)	Max Spd (kts)	Volum. Froude	Transport Factor
5	Roth Bitt	Pleasure Craft	Stepped	50	16.00	0.40	30.4	5.82	1.88
	Master Craft Pro State 190	Sailboat	Planing	255	19.00	1.12	38.2	6.17	1.15
	Chaparral 204 Fisherman	Pleasure Craft	Planing	150	19.25	1.12	38.5	5.90	1.87
	Four Winds 207 Quest CC	Cabin Cruiser	Planing	150	19.83	1.34	39.1	6.13	2.40
	Shamrock 200 Walkthru	Motor Yacht	Planing	130	20.00	1.45	25.1	4.03	2.00
10	Shamrock 200 Walkthru	Motor Yacht	Planing	215	20.00	1.45	34.7	5.38	1.51
	Aquasport	Cabin Cruiser	Planing	150	20.00	1.03	39.1	6.41	1.84
	Elite Craft old style	Classic	Planing	220	20.00	1.34	39.1	6.13	1.64
	Proline 17 walkaround	Cabin Cruiser	Planing	88	20.50	1.29	28.7	4.52	2.90
	Correct Craft Fish Nautique	Pleasure Craft	Planing	240	23.00	1.79	36.5	5.45	1.87
15	Grady White Gulfstream	Fishing	Planing	230	23.42	1.80	38.2	5.71	2.05
	Pursuit 2550	Pleasure Craft	Planing	300	24.75	1.50	41.7	6.41	1.43
	Donzi	Performance	Planing	260	25.00	2.23	38.2	5.50	2.25
	North Pacific 26	Pleasure Craft	Tunnel	115	26.00	1.79	31.0	4.63	3.31
	North Pacific 26	Pleasure Craft	Tunnel	200	26.00	3.88	31.7	4.14	4.24
20	Bayliner 2855 Sunbridge	Pleasure Craft	Planing	340	27.58	2.95	36.4	5.01	2.17
	Hustler Cobalt	Performance	Planing	540	28.00	2.23	60.8	8.76	1.73
	Northstar 28	Pleasure Craft	Planing	520	28.00	4.24	34.0	4.40	1.91
	Blacktin 29 SF	Sport Fisherman	Planing	630	29.30	5.58	32.0	3.96	1.95
	Chaparral Villain	Performance	Planing	730	30.00	3.90	62.5	8.44	1.95
25	Pursuit 2800	Performance	Planing	400	30.33	2.90	47.8	8.59	2.38
	Bayliner 3255 Avanti Sunb	Pleasure Craft	Planing	470	31.58	4.98	32.0	4.04	2.32
	Bayliner 3255 Avanti Sunb	Pleasure Craft	Planing	520	31.58	5.00	40.0	5.04	2.65
	Marinette 41	Performance	Planing	700	41.00	7.77	28.7	3.35	2.19
30	Stolcraft 450	Pleasure Craft	Cavity	830	44.50	10.18	41.8	4.88	3.53

The boat hull described in various embodiments herein can be constructed from any of the usual boat-building materials such as fiberglass reinforced polymers, aluminum, steel, other metals, wood and the various sheet plastics. It may be constructed as a unitary structure or be manufactured in modular elements which are later assembled into the finished hull structure. Interior strengthening beams, ribs and the like may be used to provide adequate strength for the purpose intended. It is contemplated that the hull described herein may be used in small craft as well as larger, ocean-going high speed craft. The excellent performance and unique handling characteristics of this hull design makes the boats equipped with these features desirable for use as patrol boats, high speed ocean going racers and many other uses.

0 EXAMPLE 1.

5 A boat hull was constructed from an existing seventeen foot long hull form by having the new bottom "grafted" onto it to form a boat having a beam of approximately eight feet and a hull configuration substantially as shown in Figures 1-5. It performed admirably, hinting at the potential of the design. From the first speed and loading tests, it was obvious this design was a decided improvement in performance from what had been done before. This first hull construction was run extremely hard, testing her beyond normal limits with extreme weight loads at high speeds. She was damaged in one speed test and filled with water. While filled, she 10 was able to plane until the trailer was in the water, and they were able to drive the sinking boat onto the trailer. Really intrigued by this performance, the boat was repaired and testing began anew. The boat was found to be overweight, having more beam to length than desired, and the new sponsons were faired too tightly into the hull. This caused drag in high wave conditions, but with a 115 HP outboard she still 15 clocked over 50 MPH with a radar gun. Unfortunately, the second repair was inadequate and the boat was retired before fully tested. It was decided to build a larger boat that would test the inventor's theories as applied to boats from sixteen to over thirty feet in length.

20 Example 2.

25 Using the information learned from the boat described in Example 1, the new prototype was built in aluminum for strength and possibly to be used as a plug when the prototype phase was over. Built heavy with all 3/16 inch plate in the configuration shown in Figures 1-4, the boat weighed approximately 4000 pounds. At eight feet, her beam is the same as the first prototype so the beam/length ratio is a little closer to normal, with an overall length of 26 feet 6 inches. She was initially fitted out with running rigging and a 115 HP Yamaha outboard engine. Fully loaded at approximately 1.79 long tons displacement (including water in barrels for the test

0 procedure) the boat achieved speeds of 31 miles per hour and was calculated to have
a Volumetric Froude Number of 4.63 with a transport factor of 3.31. With adequate
power, she is projected to well exceed the target speed of 45 to 50 MPH.

Example 3.

5 The boat hull described in Example 2 modified as shown in Figures 12- 15,
was fitted out with a 200 horsepower Mercury Engine and tested with a gross weight
of 8700 pounds including crew and observers. When running at maximum engine
speed recorded of 5850 rpm, the boat loaded as described achieved 36.5 miles per
hour in one test and 36.0 miles per hour in the second test. These tests resulted in a
10 Transport Factor of 4.24 and a Volumetric Froude Number of 4.18.

The Design

Figure 1 generally shows the hull lines of the second prototype in perspective.
What one sees is a fairly complex bottom at first glance. However, as you look, you
15 will note that there are actually two bottoms here. The fast riding bottom and the
stable low speed bottom. The deadrise angle is quite low on the fast riding bottom.
This equates to speed. From the center V-hull section out to the outer sponson, you
will note the deadrise is similar to that of a deep V-hull. This forms a pocket with
the outer sponson which also has considerable deadrise with flat lifting surface on the
20 bottom. These sponsons are called hydro-sponsons as they do multiple duty in the
design. You will note the multiple lifting surfaces. Even when heavily loaded with
water, Prototype One was able to plane easily because of these lifting surfaces.

25 The inventors theorize that when power is applied to this hull and it moves
forward, the lifting surfaces cause the hull to rise. As the boat lifts, more and more
hull comes free of the water, reducing drag. As speed is built and the angle of attack
is fairly high, air pressure builds in the tunnels created by the hydrosponsons and the
center hull section. This pressure helps to further lift the boat. With little effort and

0 very quickly, the hull levels on plane with most of the bottom out of the water riding on the center bottom, the sponson running surfaces and a cushion of air in the tunnels. At speed, the hull is stabilized by spray hitting the hydrosponsons which has the dual result of providing lift and decreasing or eliminating the signature wake.

5 In a high speed turn, the hull will bank only a little for comfortable "feel", but it can bank no further than the angle allowed by the hydrosponson. It does not "fall over" as is so typical of many deep V-types. When rough water is encountered, the center flat hull section is small enough that it offers little resistance to waves. The wave rushes past the flat bottom and encounters the air in the tunnel. This acts as a
10 cushion, effectively dampening the impact of the wave. (Moisture laden air actually has been observed rushing out either end of the tunnel in these conditions upon wave impact.) The lifting surfaces bring the boat immediately on plane again, and the whole sequence starts over.

15 With the first prototype, it was found that varying the angle of attack of the hull to the water surface could significantly improve comfort without affecting speed significantly. In trips across rough water found in the Straits of Juan de Fuca, one could drive the boat at 37 knots, but it was much more comfortable in sloppy conditions to trim the bow a little high and slow the boat to 32-33 knots. It is
20 believed that this causes the tunnel to fill with compressed air as the angle of attack would serve to close off the aft end of the tunnel effecting an air cushion. (It should also be noted that the design of Prototype One was impaired by the fairing of the hydrosponsons into the utilized hull. This caused her speed to drop when larger waves hit this bluff fairing, lowering her speed.

25

 With the hull structure described herein it is possible to support a larger beam to length ratio with no compromise in performance. This allows for more load carrying and more stability. The hull structures described herein achieve a plane very

WO 99/12804

PCT/US98/18927

0 easily at lower horsepower. The boat hulls of this invention will perform at higher
speeds with substantially less horsepower resulting in a hull form that is more
economical than the devices of the prior art. The hull appears to have easy riding
attributes that are as significant as the deep V without resulting loss of stability and
efficiency. The speed potential of this hull form has yet to be fully explored. It
5 appears she is very, very fast with moderate horsepower. We intend to explore the
limits with a variety of outboard and inboard combinations in Prototype Two. Based
on experience the hulls described herein have a very broad range of applications from
pleasure to commercial/military.

10 In compliance with the statute, the invention has been described in language
more or less specific as to structural features. It is to be understood, however, that
the invention is not limited to the specific features shown, since the means and
construction herein disclosed comprises a preferred form of putting the invention into
practice. The invention is, therefore, claimed in any of its forms or modifications
15 within the legitimate and valid scope of the appended claims, appropriately
interpreted in accordance with the doctrine of equivalents.

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

- 5 1. A hull for a boat adapted for operation on a water surface, said hull having a
 bow section, a mid hull section, a keel and a stern, comprising:

10 a center V-hull portion extending substantially from said bow to said
 stern, and including a pair of angled panels symmetrically positioned
 about a hull center plane, said panels defining a V-hull apex line, said
 angled panels each defining a V-hull dead rise angle measured from said
 apex line relative to a normal plane containing said apex line and
 perpendicular to said hull center plane;

15 at least one set of first and second opposed mid hull sponsons,
 positioned upon said mid hull section on opposite sides of said V-hull
 portion, each mid hull sponson including a substantially horizontally
 disposed running surface and connected to said V-hull portions by
 reverse deadrise panels, whereby said mid-hull sponsons, and said V-
20 hull portion, together with said water surface, define a pair of mid-hull
 air capturing tunnels while minimizing the wetted surface area of said
 mid-hull sponsons;

25 first and second outer V-hull panels extending outwardly and upwardly
 from said mid hull sponsons;

30 first and second opposed outer sponsons, positioned on opposite sides of
 said outer V-hull panels, each outer sponson including a lower most
 running surface and connected to said outer V-hull panels by second
 reverse deadrise panels, whereby said outer sponsons, and said V-hull
 panels, together with said water surface, define a pair of outer air

capturing tunnels while minimizing the wetted surface area of said mid-hull sponsons; and

gunwales extending upwardly from said outer sponsons.

5

2. A hull as claimed in claim 1, wherein each of said outer sponsons further comprise an outer sidewall oriented between 40 degrees and 60 degrees to the horizontal.

10 3. A hull as claimed in claim 2, wherein said lowermost running surface interconnects said inner and outer sidewalls on each of said outer sponsons.

15 4. A hull as claimed in claim 1, said outer sponsons each extending from a sponson point ahead of the mid hull section to the stern of said hull and oriented generally parallel to the longitudinal axis of said hull, whereby air deflected from said V-hull portion as said hull moves through the water is captured by said sponson forward portions and directed rearwardly through said mid-hull air capturing tunnels.

20 5. A hull as claimed in claim 1 wherein said mid-hull sponsons extend from a mid-hull sponson point ahead of the mid hull section to said stern whereby air deflected from said V-hull portion as said hull moves through the water is captured by said mid-hull sponson forward portions and directed rearwardly through said outer air capturing tunnels.

25

6. A hull as claimed in claim 1, wherein a plurality of said mid hull sponsons are disposed between said keel and said outer sponsons, adjacent mid hull sponsons forming air capturing tunnels.

30 7. The hull of claim 1, further including a step positioned aft of said bow section, said step diverging from said keel toward said stern.

8. The hull of claim 7, wherein said step comprises a plurality of spaced apart steps.
- 5 9. The hull of claim 7, wherein said step includes an air injector to insert air into said tunnels.
- 10 10. The hull of claim 1 wherein said hull has a step positioned aft of said bow section on said mid hull section, said step diverging from said keel toward said stern.
11. The hull of claim 10, wherein said step comprises a plurality of steps each diverging outwardly from said keel toward said stern.
- 15 12. A hull for a boat adapted for operation on a water surface, said hull having a bow section, a mid hull section, a keel and a stern, comprising:
- 20 a center hull portion extending substantially from said bow to said stern, and including a pair of angled panels symmetrically positioned about a hull center plane, said panels defining a V-hull apex line and a flat horizontally disposed panel extending forwardly from said stern, said angled panels each defining a V-hull dead rise angle measured from said apex line relative to a normal plane containing said apex line and perpendicular to said hull center plane;
- 25 at least one set of first and second opposed mid hull sponsons, positioned upon said mid hull section on opposite sides of said V-hull portion, each mid hull sponson including a substantially horizontally disposed running surface and connected to said V-hull portions by
- 30 reverse deadrise panels, whereby said mid hull sponsons, and said V-hull portion, together with said water surface, define a paid of mid hull

air capturing tunnels while minimizing the wetted surface area of said mid hull sponsons;

5 first and second outer V-hull panels extending outwardly and upwardly from said mid hull sponsons;

10 first and second opposed outer sponsons, positioned on opposite sides of said outer V-hull panels, each outer sponson including a lower most running surface and connected to said outer V-hull panels by second reverse deadrise panels, whereby said outer sponsons, and said V-hull panels, together with said water surface, define a pair of outer air capturing tunnels while minimizing the wetter surface area of said mid hull sponsons; and

15 gunwales extending upwardly from said outer sponsons.

13. A hull as claimed in claim 12, wherein each of said outer sponsons includes a reverse deadrise inner sidewall, and an outer sidewall oriented between 40 degrees and 60 degrees to the horizontal.

20

14. A hull as claimed in claim 13, wherein each of said outer sponsons further comprising a generally planar lower running surface interconnecting said inner and outer sidewalls.

25 15. A hull as claimed in claim 12, wherein each of said outer sponsons extends from a sponson point ahead of the mid hull section to the stern of said hull and is oriented generally parallel to the longitudinal axis of said hull, whereby air deflected from said V-hull portion as said hull moves through the water is captured by said sponson forward portions and directed rearwardly through said
30 tunnels.

16. A hull as claimed in claim 12 wherein said mid hull sponsons extend from a mid hull sponson point ahead of the mid hull section to said stern whereby air deflected from said V-hull portion as said hull moves through the water is captured by said mid hull sponson forward portions and directed rearwardly through said tunnels.
- 5
17. A hull as claimed in claim 12, wherein a plurality of said mid hull sponsons are disposed between said heel and said outer sponsons, adjacent mid hull sponsons forming air capturing tunnels.
- 10
18. The hull of claim 12, further including a step positioned aft of said bow section, said step diverging from said keel toward said stern.
19. The hull of claim 18, wherein said step comprises a plurality of spaced apart steps.
- 15
20. The hull of claim 17, wherein said step includes air injection means to insert air into said tunnels.

-1/11-

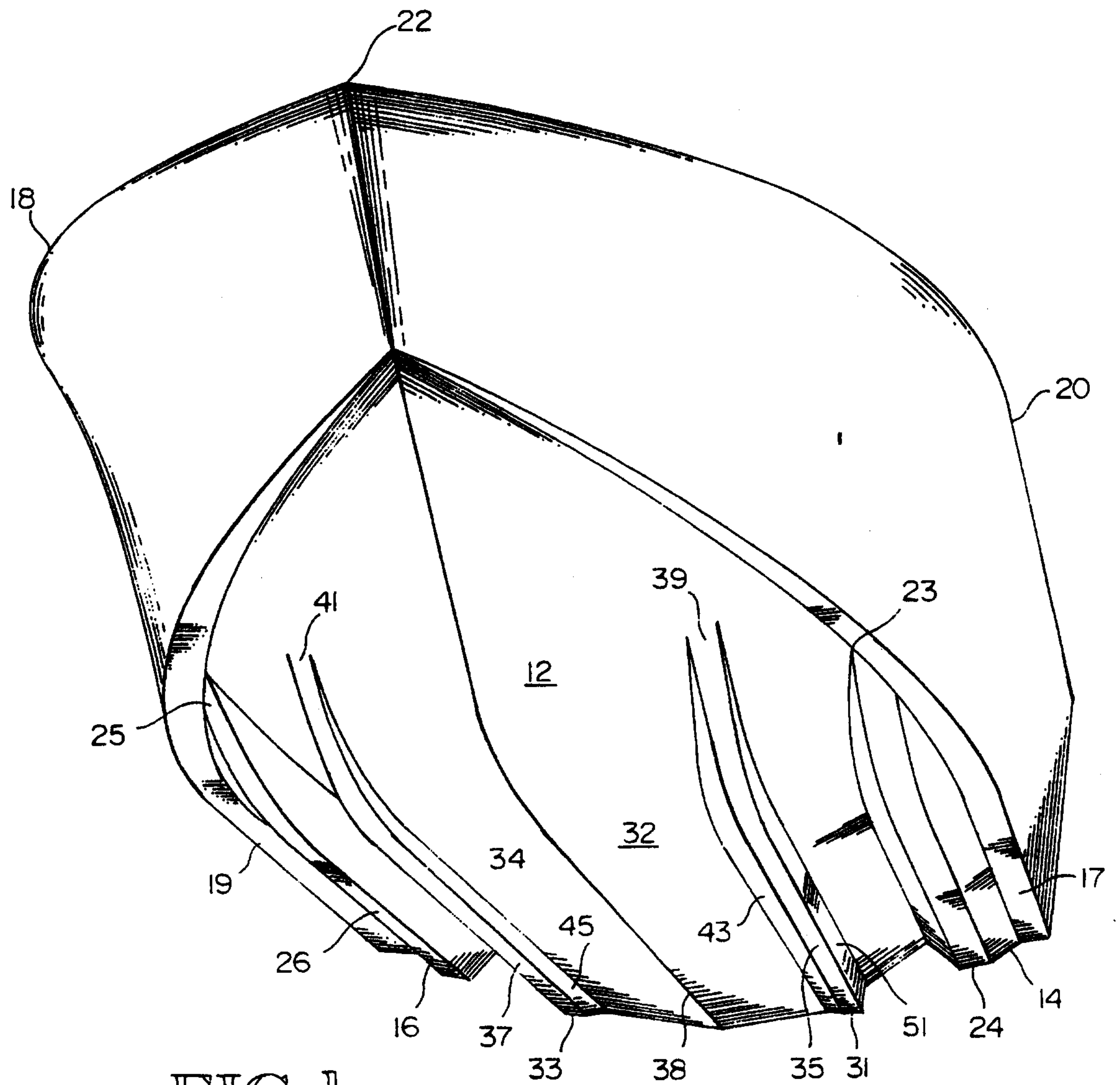


FIG. 1

FIG. 2

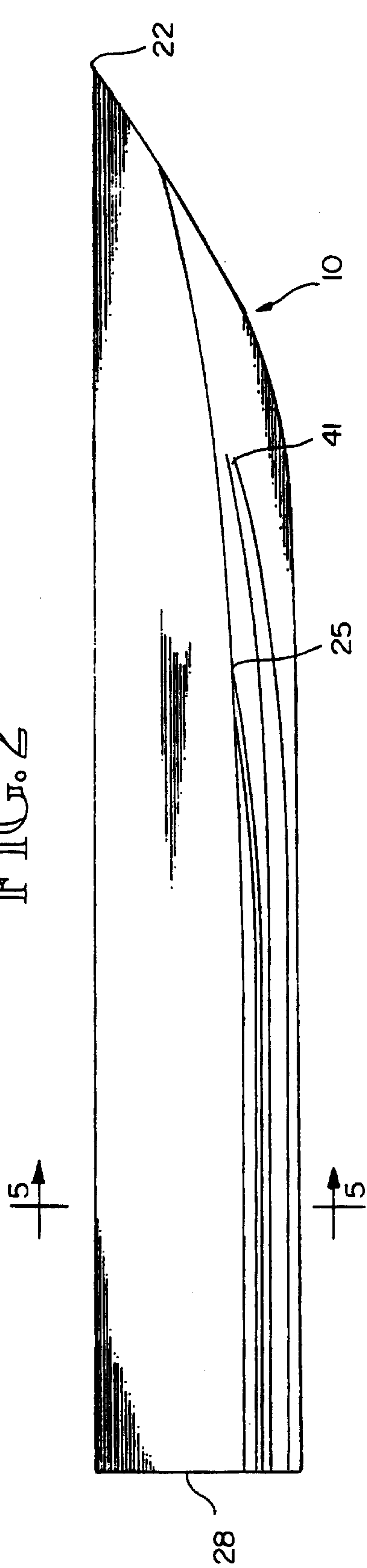
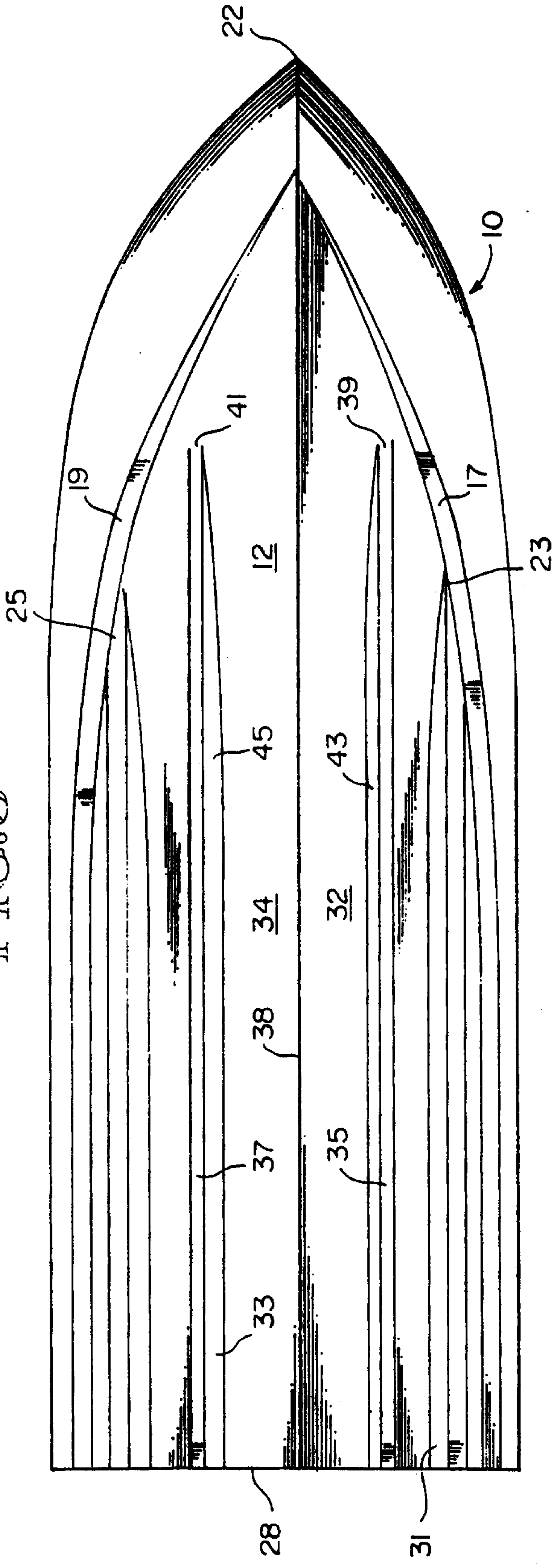


FIG. 3



- 3/11 -

FIG. 4

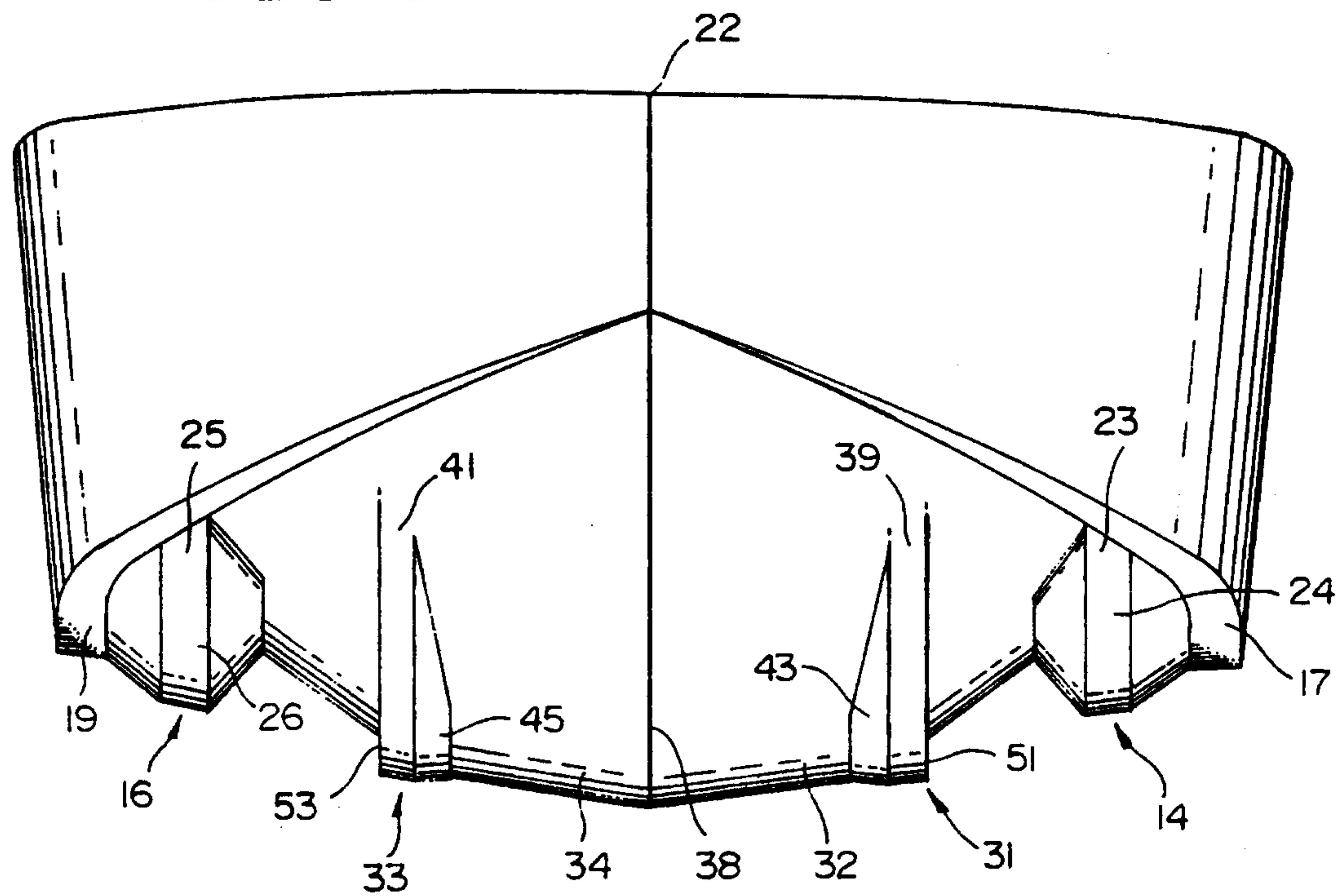
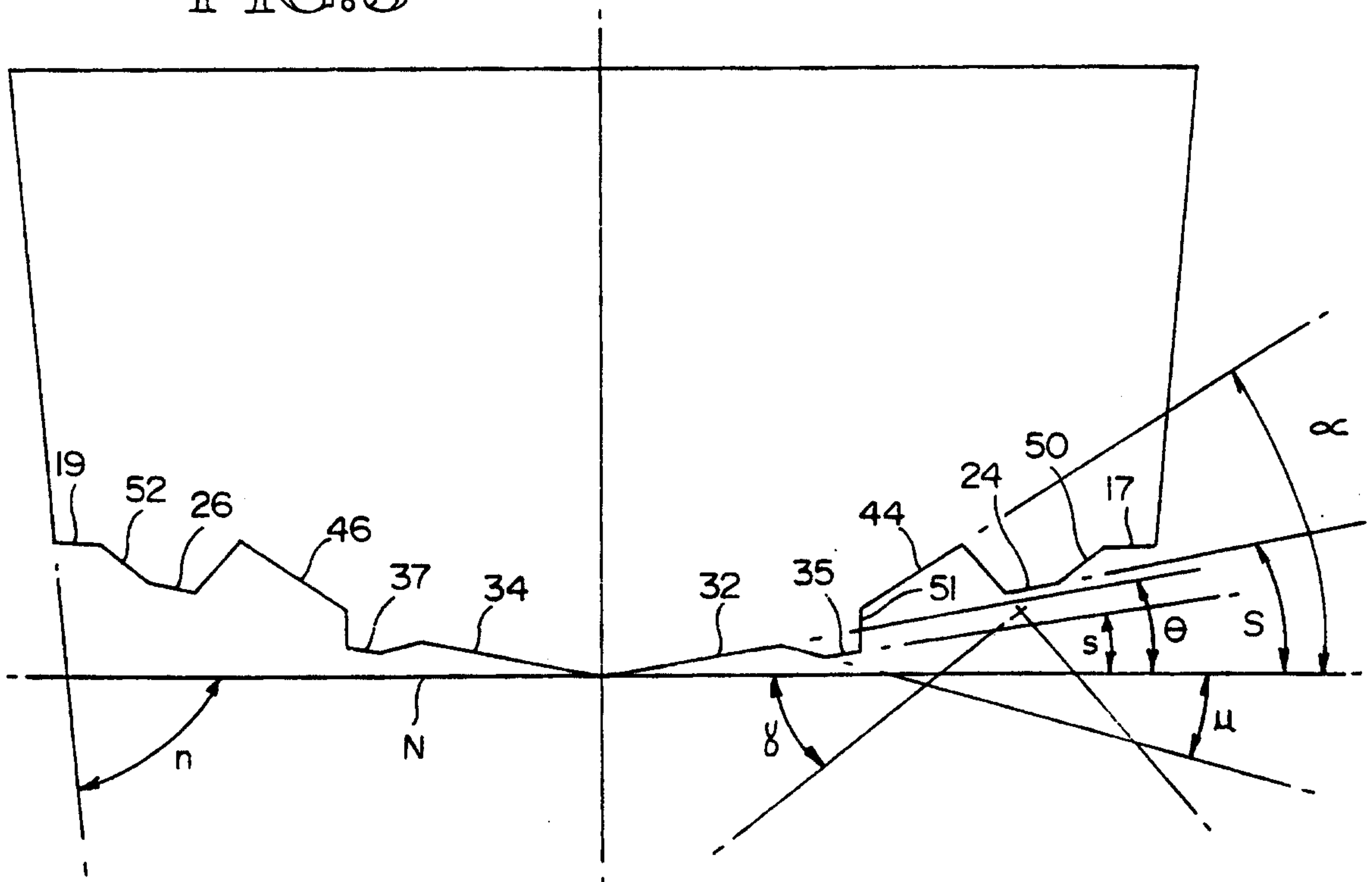


FIG. 5



- 4/11 -

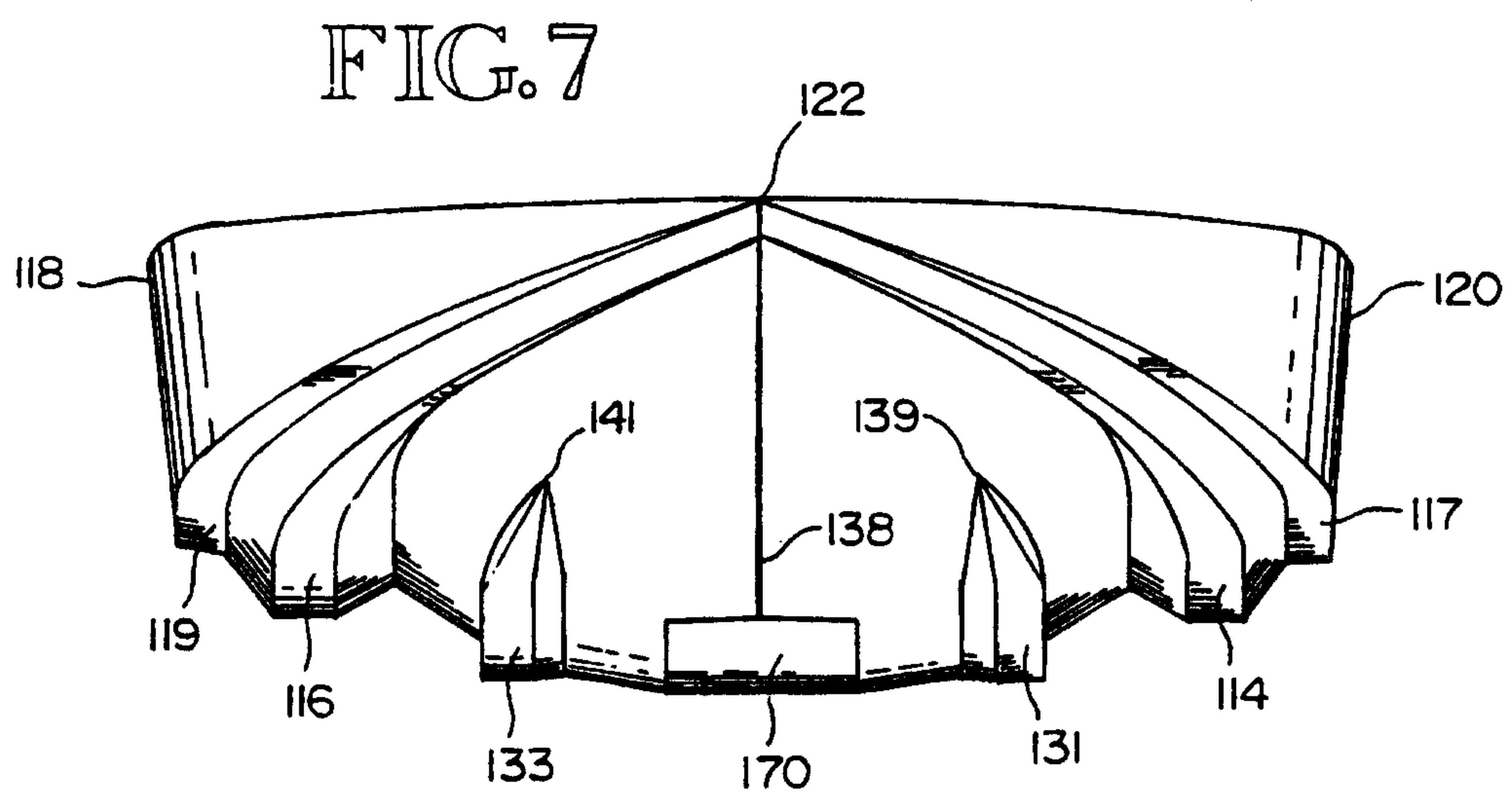
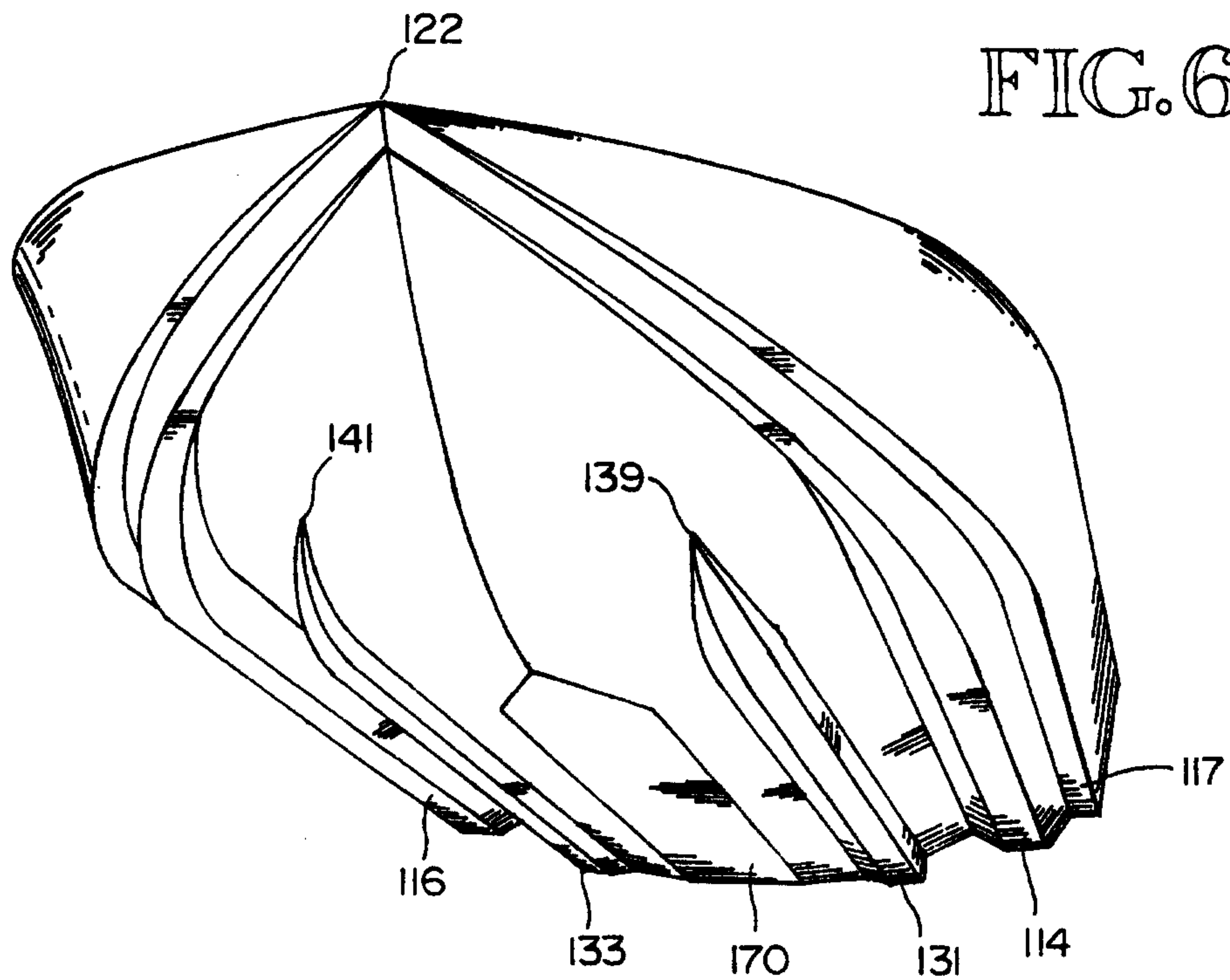


FIG. 8

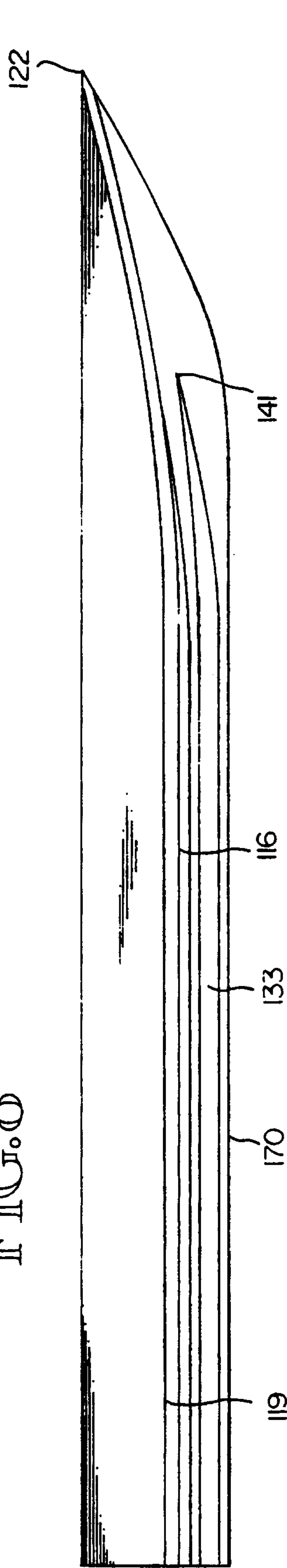
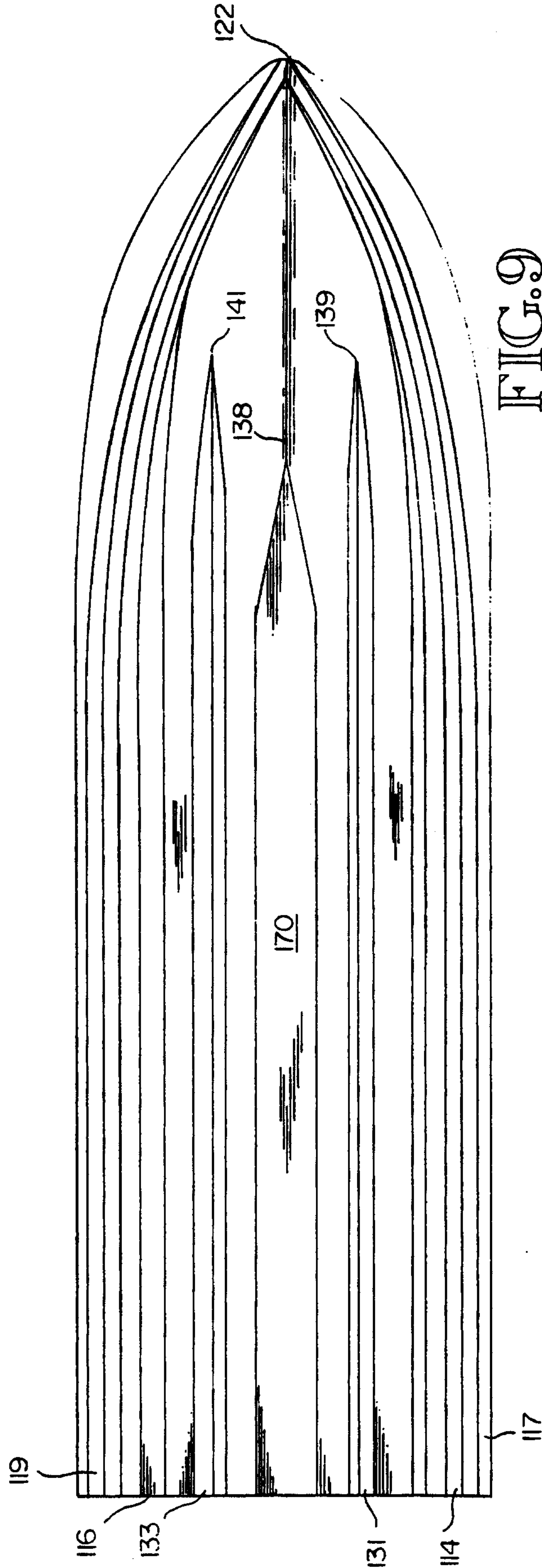
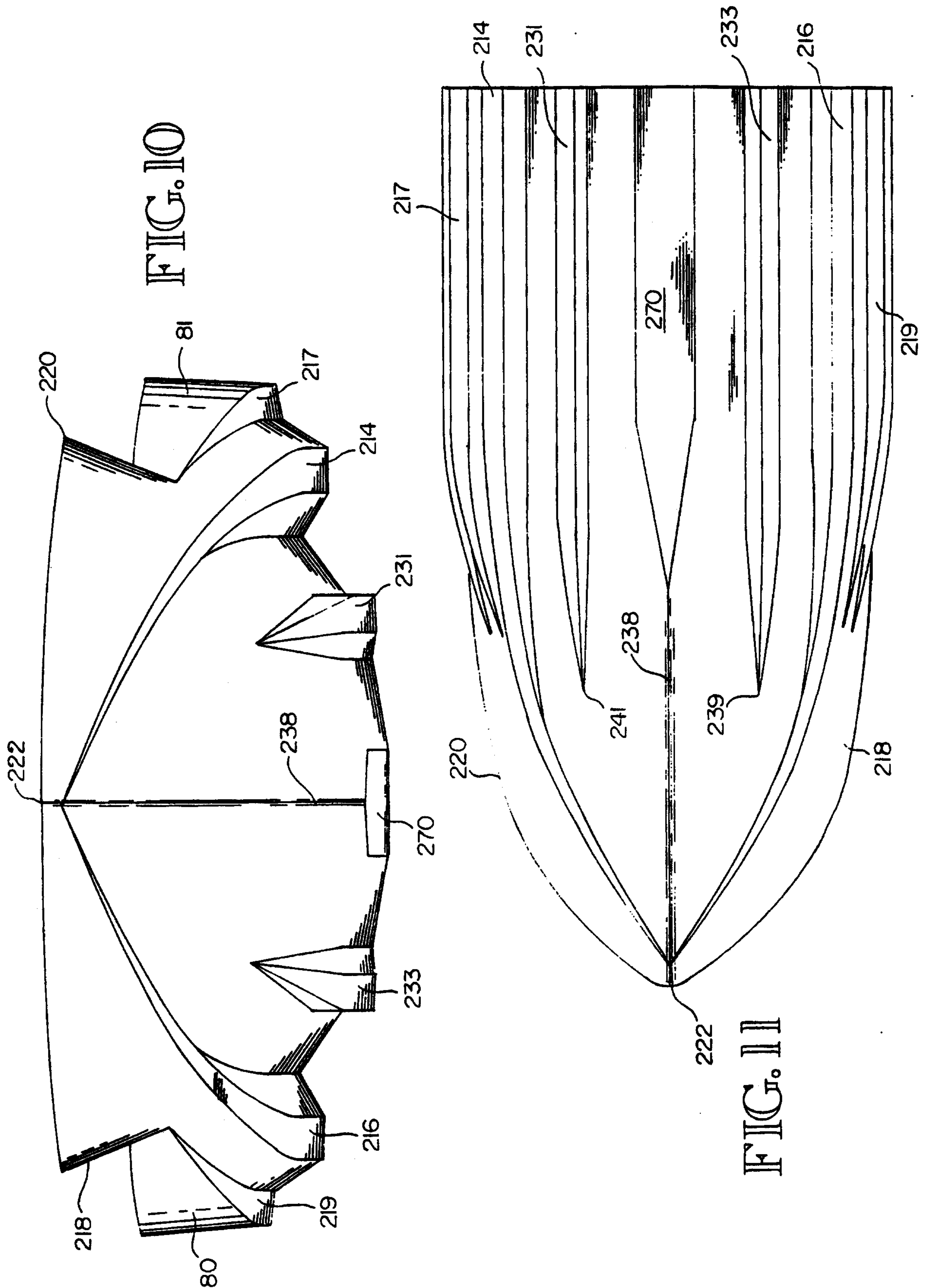


FIG. 9



- 6/11 -



-7/11-

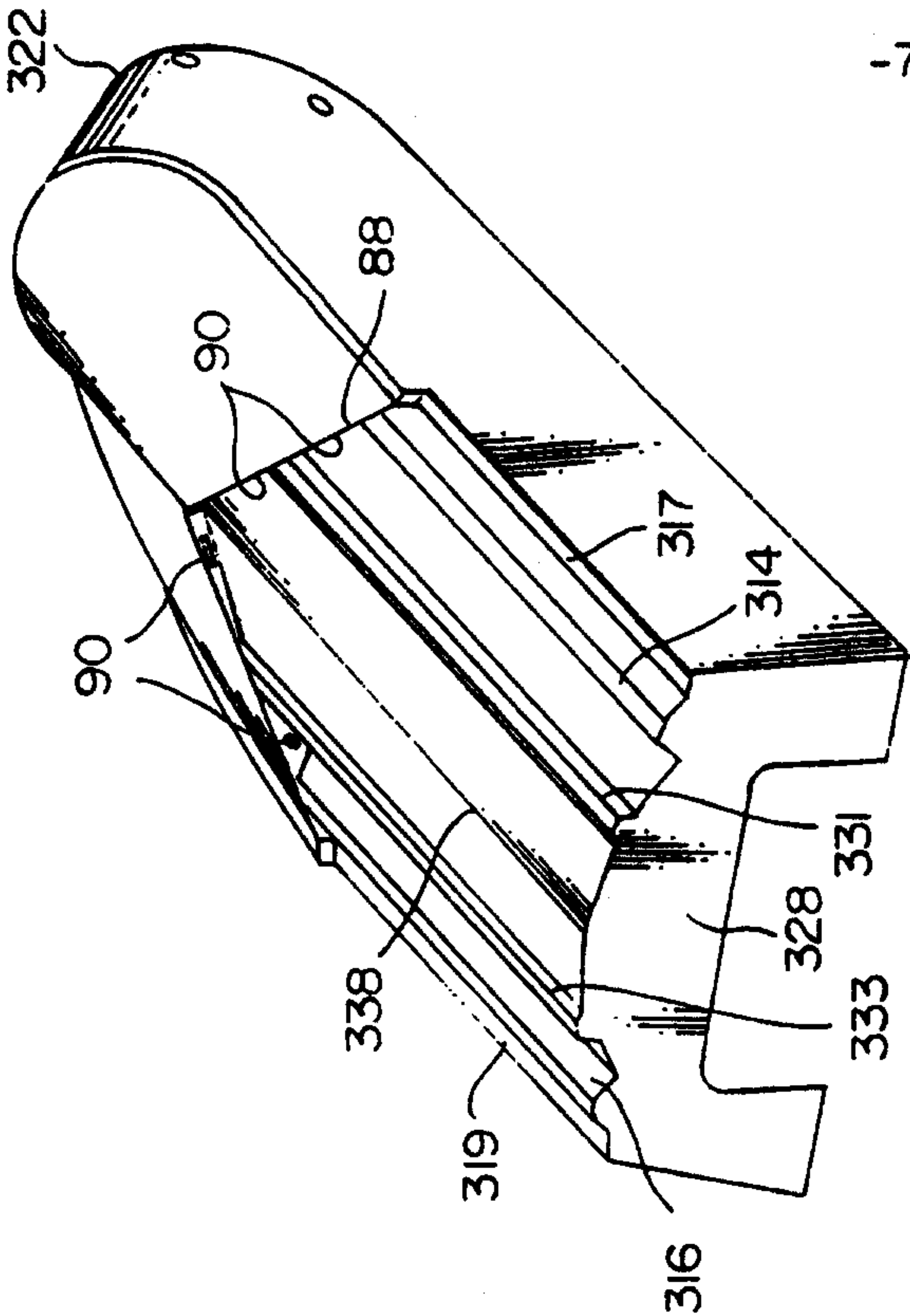


FIG. 12

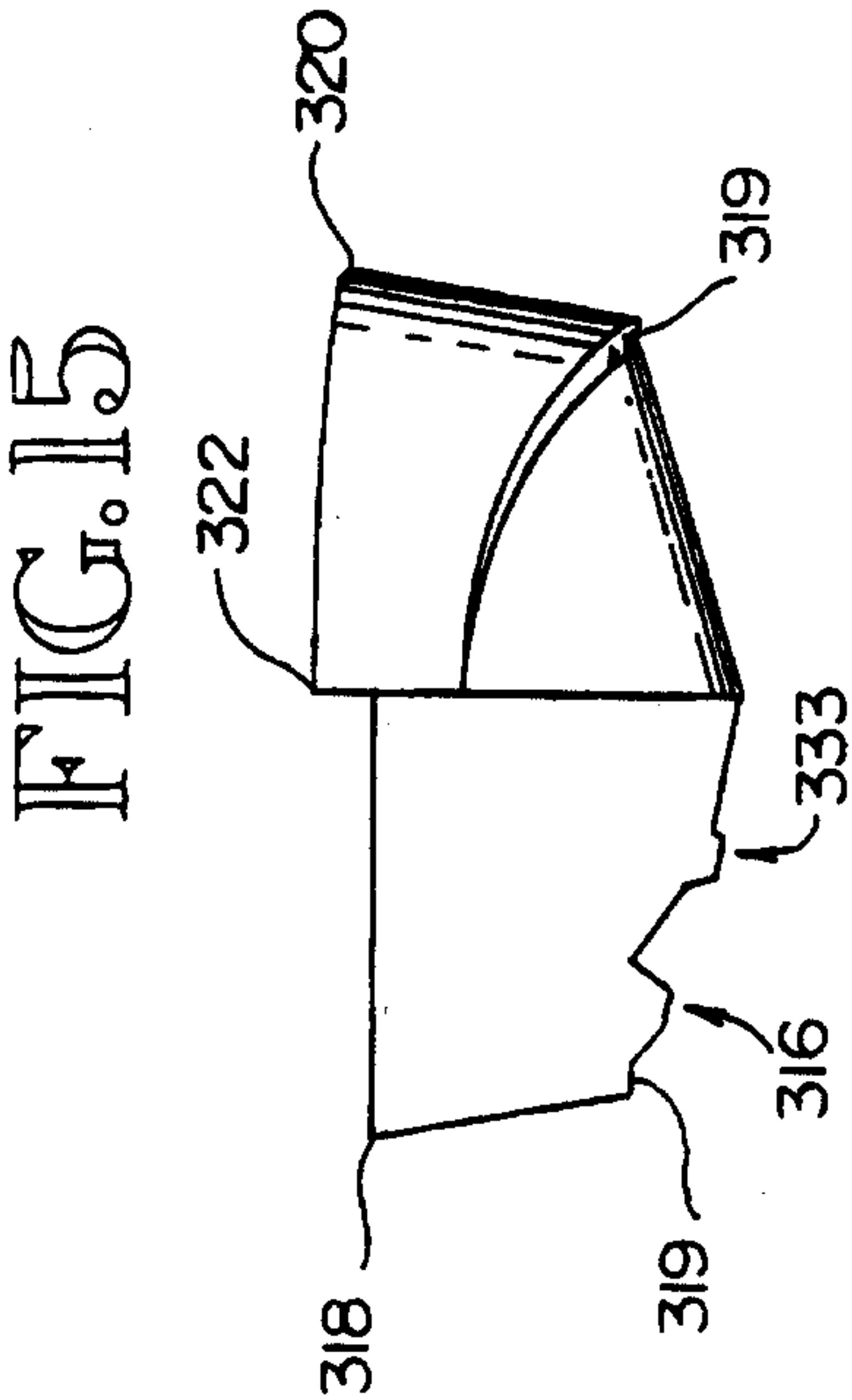


FIG. 15

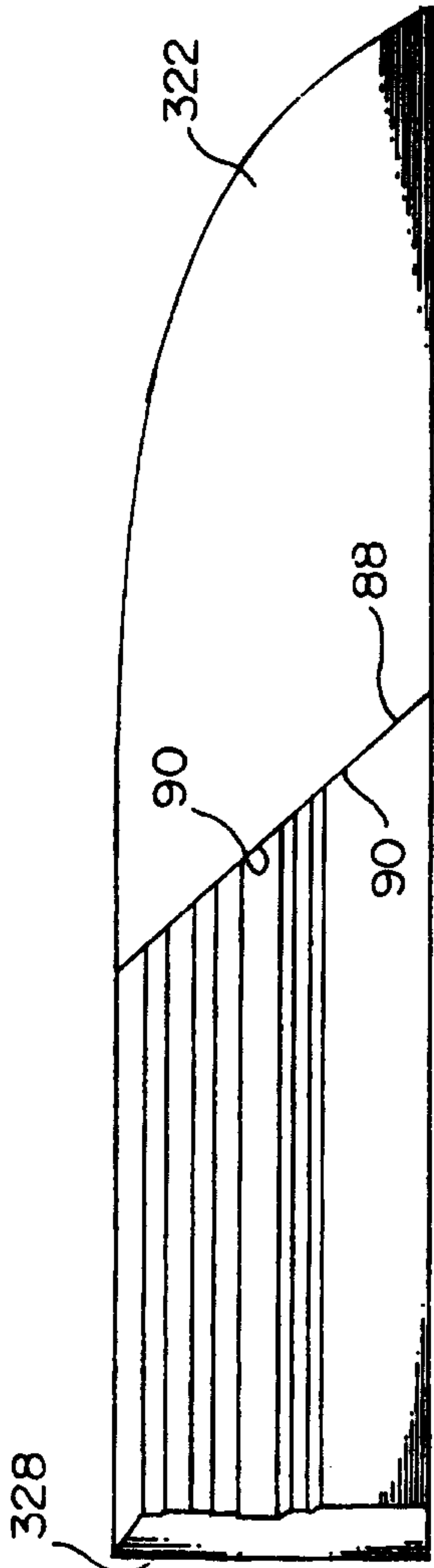


FIG. 13

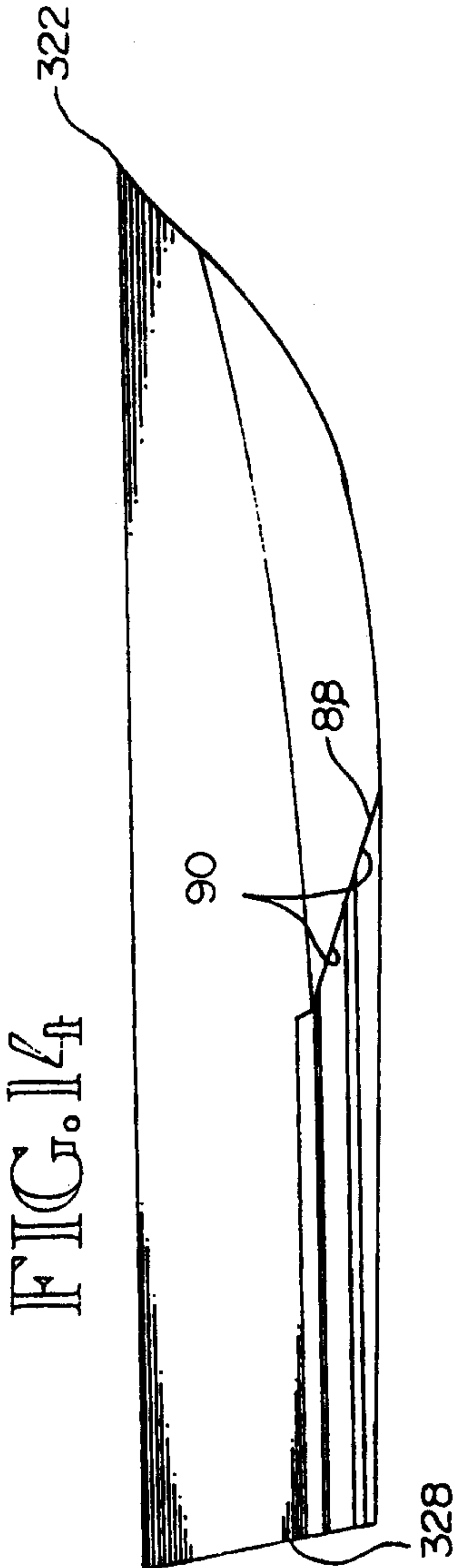


FIG. 14

- 8/11 -

FIG. 16

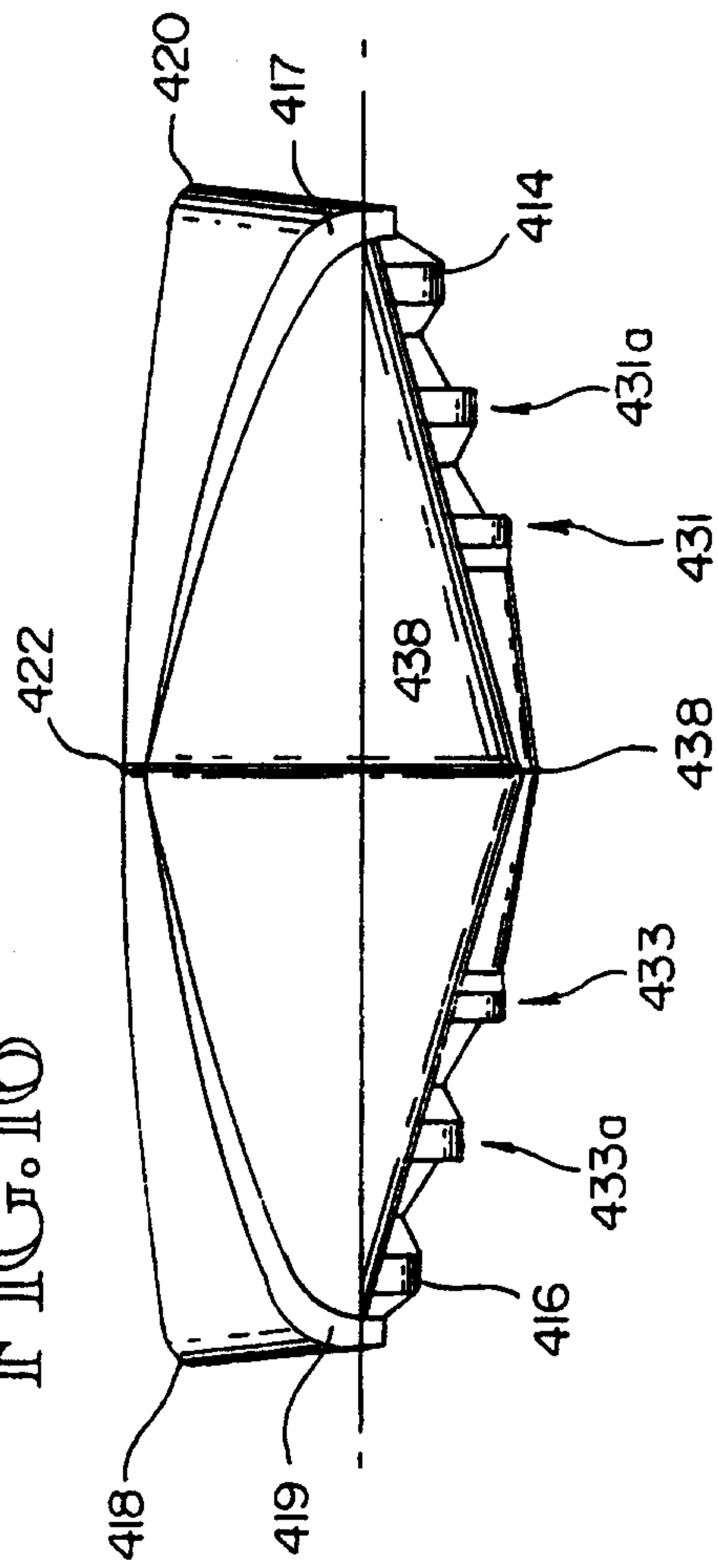
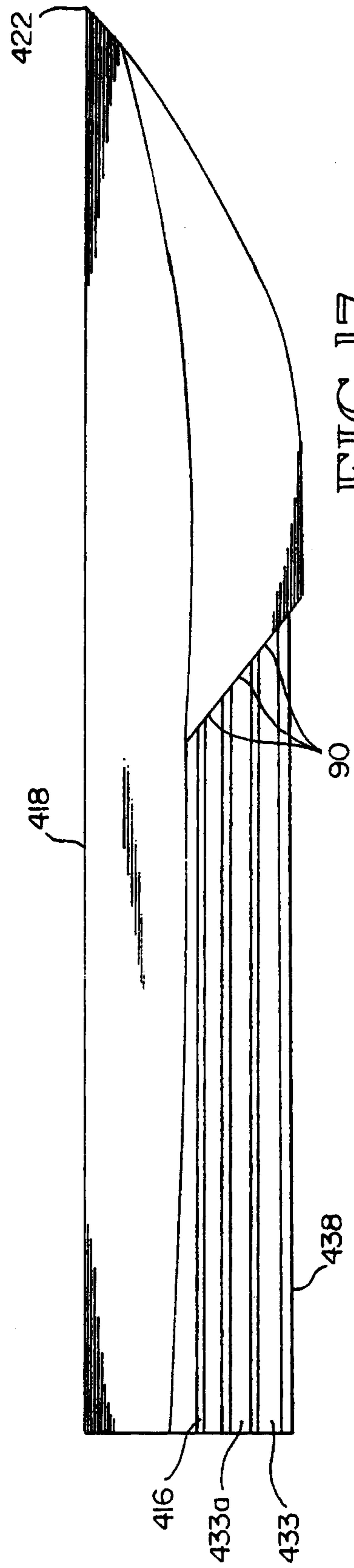
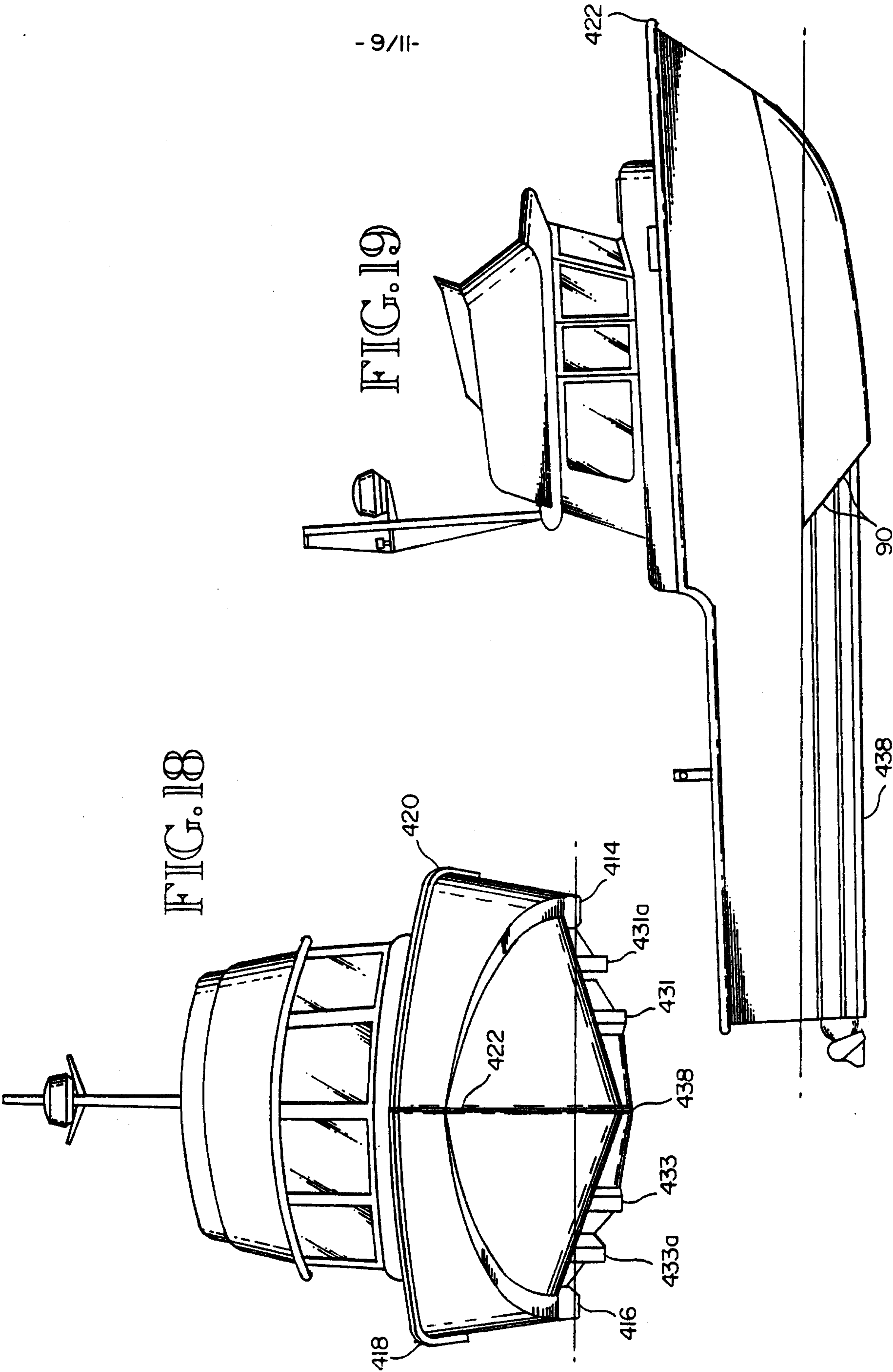


FIG. 17



- 9/II -



-10/11-

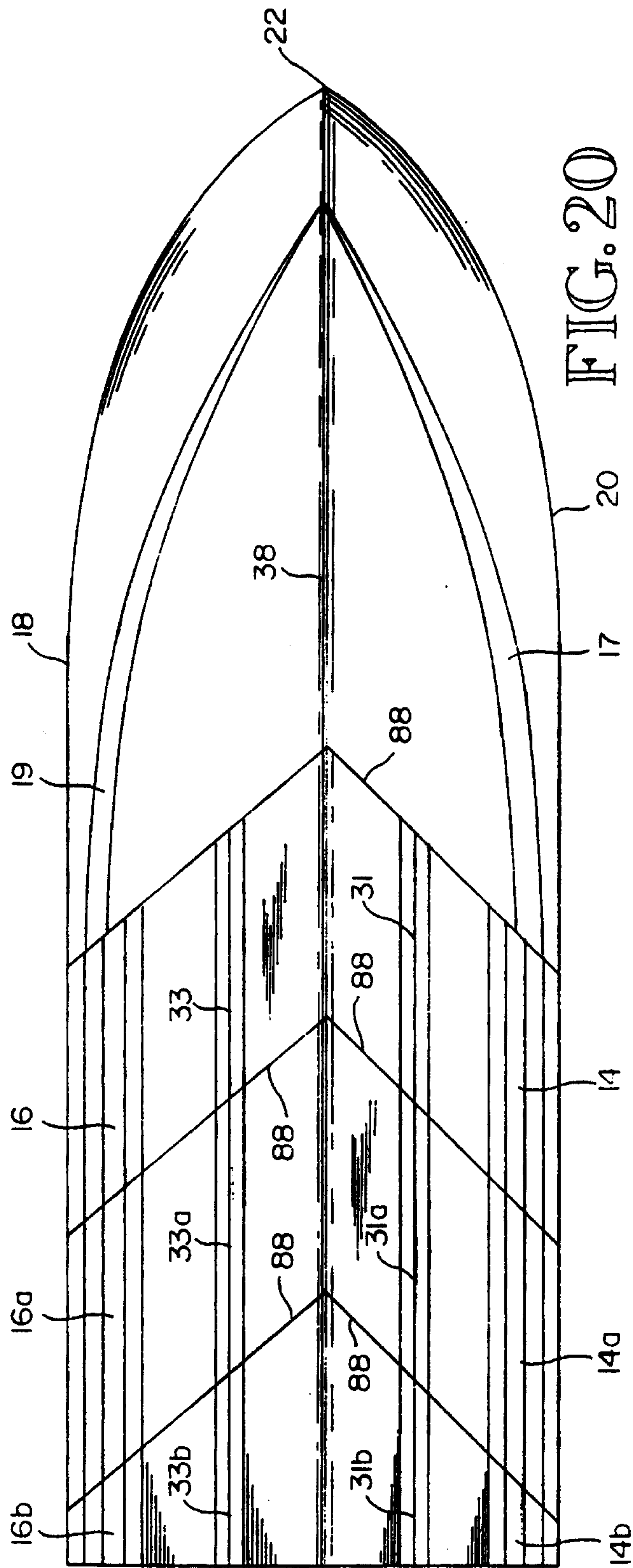


FIG. 20

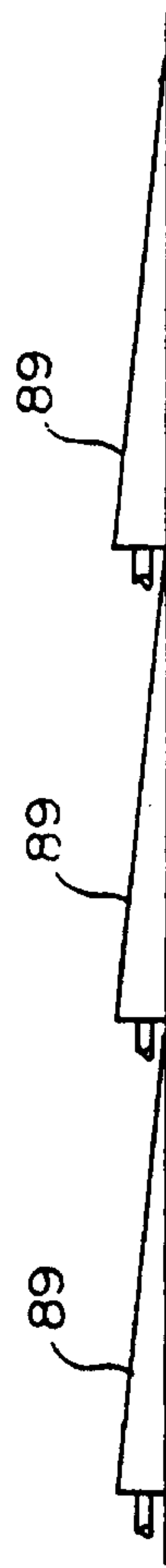


FIG. 21

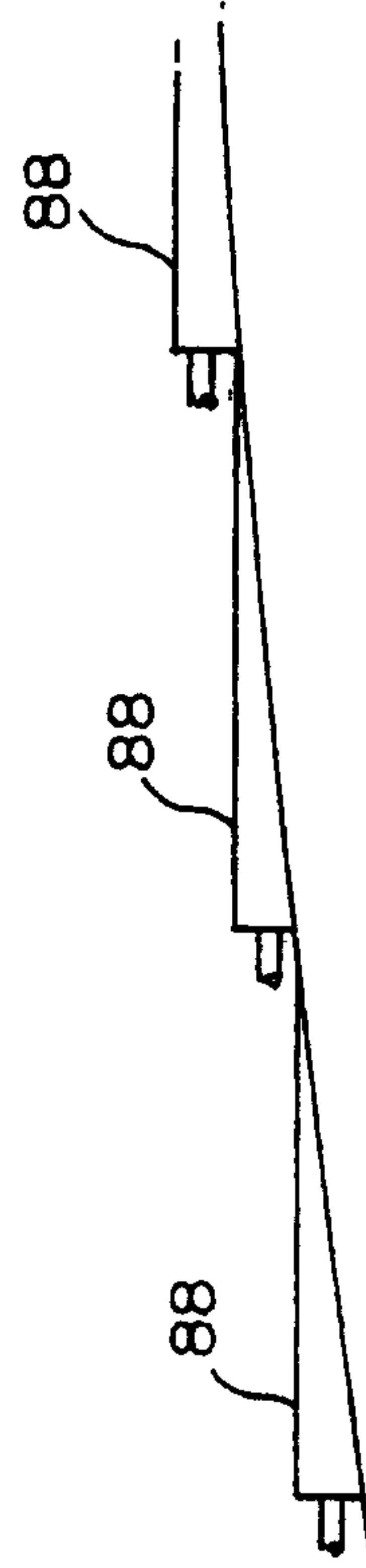


FIG. 22

