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(71) Applicant(s)
Donald P. Stubblefield

(72) Inventor(s)
Donald P. Stubblefield

(74) Agent/Attorney
Freehills Carter Smith Beadle,Level 43,101 Collins
Street,MELBOURNE VIC 3000

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(71)(72) Applicant and Inventor: STUBBLEFIELD, Donald, P. [US/US]; 7020 S.W. Tierra Del Mar Drive, Beaverton, OR 97007 (US).

(74) Agent: SAIDMAN, Perry, J.; Saidman DesignLaw Group, Suite 510, 1110 Bonifant Street, Silver Spring, MD 20910 (US).

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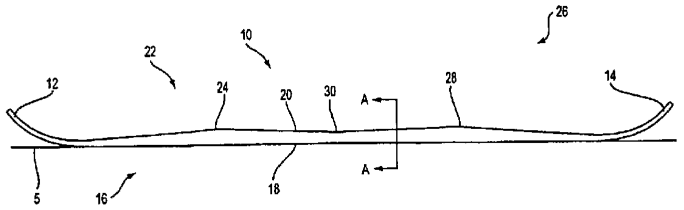

(57) Abstract

A snowboard is disclosed whose base is designed such that under normal loading, applied through the rider's feet to the snowboard, the snowboard will bow into a substantially circular arc. Consequently, the portions of the snowboard coming in contact with the surface of the snow will substantially lie on segments of a circular arc, and the back half of the snowboard will substantially follow in the track of the front half of the snowboard. This is accomplished by applying beam-design principles to the design of the snowboard in order to select appropriate geometry of the transverse cross-sections of the snowboard along its entire length.

TITLE: SNOWBOARD BODY

TECHNICAL FIELD

This invention relates to snowboards, and, more particularly, to a snowboard that may be designed to carve an ideal or "perfect" turn during use.

BACKGROUND ART

In order to initiate a turn (also called "carving" a turn), a skier or snowboarder applies pressure to the ski or snowboard in a manner that rotates the ski or snowboard about its longitudinal axis, tilting the ski or snowboard up onto one of its edges (often called the "riding edge") and deflecting the ski or snowboard away from the skier or snowboarder. Under ideal conditions, the riding edge of the ski or snowboard will create a single slender cut into the snow as the skier or snowboarder carves the turn. This type of turn is desirable because it minimizes the friction or drag on the ski or snowboard as it moves through the turn. In addition, this type of turn is the easiest to control.

Snowboards were initially manufactured by ski manufacturers, and most of the initial designers of snowboards were therefore ski designers who understandably borrowed heavily from the accepted wisdom of the ski industry. As a consequence, there are many similarities today between skis and snowboards. For example, both skis and snowboards use essentially the same materials, e.g., fiberglass ultra high molecular weight polyethylenes, either singly or in laminated combinations with wood cores, steel edges, and plastic tops and sidewalls. Also, ski construction, e.g., sidewall, sandwich or capped construction, and techniques of manufacture, e.g., presses, composites and laminating, were transferred virtually unchanged to snowboards.

Of importance to the present invention is the way in which skis, and therefore conventional snowboards, are designed to flex longitudinally when in use. Trimble et al. (U.S. Pat. No. 5,413,371) disclose that conventional skis are designed to form a "U-shaped" curve when in use. A skier using a ski designed to form a U-shaped curve when in use will be able to carve an ideal turn without a great deal of difficulty. This is primarily because only one of the skier's feet is positioned on each ski, thereby applying a single, centrally positioned load onto each ski, making it easier for those portions of the ski on both sides of the single load to curve.

Unfortunately, the foregoing ski technology does not hold true for snowboards. In fact, it is nearly impossible for a snowboarder to carve an ideal turn on a conventionally designed snowboard. This is because, in contrast to a skier, both of the snowboarder's feet are positioned on the snowboard, and between the two feet the snowboard is generally flat and resistant to curving. Consequently, the snowboarder applies two non-centrally located loads onto the snowboard during a turn. As a result, it is very common for the back half of the snowboard to cut its own path through the snow during a turn (sometimes called "plowing"). Plowing is undesirable because it makes the snowboard more difficult to control in turns and greatly increases the friction or drag on the snowboard as it moves through the snow.

During use, the longitudinal curvature of a conventional snowboard comprises a curve of varying radii, assuming a U-shape which typically comprises an essentially flat, inflexible portion in the middle of the snowboard, between the foot mounting zones, and upwardly curved ends.

I have discovered that if the riding edge of the snowboard were to form an arc having a constant radius of curvature, i.e., if the curvature of the cutting edge coincided with a segment of a circle, the back half of the snowboard would have to follow in the same track as the front half. However, with conventional snowboards it is virtually impossible for a snowboarder to control the forces applied by his/her two feet sufficiently finely to cause the snowboard to bow into a circular arc.

The problem in carving ideal turns lies not so much in the skills of the rider as in the construction of the snowboard itself, mainly in the resistance of current snowboards to being bent into a circular arc under the loads applied thereto. As with skis, conventional snowboards are designed in a manner that prevents bending of the longitudinal

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dimension of the snowboard into a circular arc when in use. Because of the inherent inability of prior art snowboards to bend in their central sections, they favor long, languid turns. Tight, abrupt turns are effected only by the rider imposing extremely complex combinations of weight shifts on the snowboard. In effect, the rider has to fight the snowboard in order to properly control it.

Further, most prior art snowboards have a single camber. As explained in my prior U.S. utility patent application Serial No. 08/918,906, now U.S. Pat. No. 5,823,562, a snowboard having a single camber is difficult to control regardless of the longitudinal flexibility of the snowboard.

Most prior art snowboards also include side cuts which narrow the central portion of the snowboard. Side cuts improve the flexibility of the central portion of a snowboard slightly, but far from overcome the deficiencies of conventional snowboards.

Representative of the prior art snowboards are Remondet, U.S. Pat. No. 5,018,760, Carpenter et al., U.S. Pat. No. 5,261,689, Nyman, U.S. Pat. No. 5,462,304, Deville et al., U.S. Pat. No. 5,573,264, Kniessl, German Patent No. DE-A-42 07 768, and Vision, German Pat. No. DE-A-92 17 464.

Remondet shows (Figure 4) a snowboard having a thickness that is at a maximum in the center of the snowboard, gradually diminishes towards the tail and nose portions of the snowboard. Thus, the center section has the least flexibility and thereby resists bending the most. A rider cannot apply any combination of pressures which will bend the central portion of the snowboard into a circular arc.

Carpenter et al. show (Figure 1) a snowboard having thinner fore and aft sections separated by a thicker central platform having an essentially constant thickness. While being more flexible than Remondet's snowboard, the central platform is still the thickest part of the snowboard, and consequently is resistant to bending.

Nyman shows (Figure 2) a snowboard having a single camber and an essentially constant thickness from nose to tail (it is not clear whether the constant thickness is an intended characteristic of Nyman's snowboard, or whether it is merely the draftsman's contribution, for the thickness of the snowboard is not mentioned in his specification). While Nyman's snowboard may be a slight improvement over Remondet and Carpenter et al., a rider still cannot apply any combination of pressures which will bend the central portion of Nyman's snowboard into a circular arc.

Deville et al. disclose a snowboard with a core having a constant thickness in which the torsional and longitudinal stiffness characteristics of the snowboard can be more precisely selected by adding reinforcing members to the surface of the snowboard in various patterns. Deville et al. mention incorporating the reinforcements within the "base structure" of the snowboard but do not show nor explain how this would be accomplished. In addition, while the Deville et al. teach providing less reinforcement in the central portion of the snowboard, there is no mention or suggestion of any desire to control the flexibility such that the snowboard will bow into circular arc when in use. Further, if the widths and thicknesses of the reinforcing members in all of the figures shown the Deville et al. patent are taken literally, the reinforcements will act to prevent such a result.

Kniessl discloses a snowboard having a back, center and front sections, wherein the center section includes an area of reduced flexural rigidity relative to the back and front sections. The area of reduced flexural rigidity is designed to produce a "hinge effect" which de-couples the front section from the back section. However, Kniessl does not teach or suggest the desirability of configuring the longitudinal flexibility of a snowboard to bow into a circular arc during turns nor any means of doing so.

Vision discloses a snowboard having a backside and a frontside, as seen from the perspective of the snowboard's gliding motion I (see Vision, FIG. 1), wherein the backside is stiffer than the frontside. Vision does not teach or suggest the desirability of configuring the longitudinal flexibility of a snowboard to bow into a circular arc during turns nor any means of doing so. Like Remondet, Vision teaches a snowboard having maximum rigidity between foot positions. Thus, a rider cannot apply any combination of pressures which will bend the snowboard disclosed in Vision into a circular arc.

Summary of the Invention

The present invention overcomes the difficulties described above by providing a snowboard such that under normal loading, the snowboard will naturally bow into an arc having a radius which is substantially constant. Consequently, the edge segments of the snowboard coming in contact with the surface of the snow will substantially be portions of a circular arc, and the back half of the snowboard will substantially follow the track of the front half of the snowboard.

An explanation of the meaning of "normal loading," as used in the specification and claims, is appropriate here. When a rider is supported by a snowboard, the loading applied throughout the snowboard is defined by the length of the snowboard, the feet placement on the board, and the weight of the rider. The length of the snowboard and the weight of the rider is fixed for any given situation. Consequently, the loading depends on the placement of the feet on the board. The rider's feet are secured to the snowboard by means of bindings fixed to the snowboard. The bindings are not usually limited to being attached to the snowboard in only one location, however. Provision is made for varying the location of the bindings both longitudinally and transversely of the snowboard, usually in the form of two arrays, one for each binding, of threaded inserts embedded in the body of the snowboard. Each array, and its immediate surrounding area, defines a segment of the board which we are calling a "mounting zone". Each snowboard has two mounting zones separated longitudinally along the length of the snowboard. When the bindings are secured within the mounting zones, the loading of the board by the rider is what is referred to herein as "normal loading". It is the purpose of this invention, as will be brought out in more detail hereinafter, to provide a snowboard which, when subjected to loads within "normal loading," will bow into a reasonably close approximation of a constant radius arc.

It is therefore an object of the invention to provide a snowboard which is constructed to assist the rider in the carving of perfect turns.

It is a further object of the invention to provide a snowboard which, under normal loading, will flex such as to conform the body thereof to a reasonable approximation of a circular arc, thereby producing a turn which approximates the carving of a perfect turn.

It is a further object of the invention to provide a snowboard in which the flexures of the zones directly beneath the rider's feet relative to flexure of the zone between the rider's feet, in combination with the elastic properties of the materials from which the snowboard is constructed, permits the snowboard under normal loading to naturally bow into an arc having a substantially constant radius.

It is a further object of the invention to provide a snowboard in which the central section of the snowboard extending between the rider's feet has a smaller Area Moment of Inertia than that under the mounting zones, thereby providing a flexure such that the board will respond naturally to the rider and assume the curvature of a segment of a circle.

The present invention achieves the foregoing objects, in a first aspect, by providing an apparatus for use on a snow surface, comprising:

a nose, a tail, and a body connecting said nose and tail, said body including, a top surface, a bottom surface, a front half, and a rear half, said top and bottom surfaces separated by a thickness;

said body further including a first mounting zone located in said front half and adapted to receive one foot of a rider of said apparatus and a second mounting zone located in said rear half and adapted to receive the other foot of said rider;

said body further including a plurality of cross-sectional portions; and wherein the value of the following expression is substantially constant when a first static loading condition is applied to said body and the expression is applied to each of said plurality of cross-sectional portions, respectively:

M/EI

wherein:

E is the modulus of elasticity of said body for said respective cross-sectional portion;

I is the area moment of inertia for said respective cross-sectional portion;

M is the bending moment acting on said respective cross-sectional portion under said first static loading condition; and

said first static loading condition comprises a first downward load applied to said first mounting zone, a second downward load applied to said second mounting zone, and an upward load applied along said bottom surface.

A second aspect of the invention provides a method of designing and making a snowboard or ski body having a number of parts including a cap, a base, and a core, said body being partitioned into a plurality of cross-sectional portions, said cap having a top surface and a first mounting zone located on said top surface for mounting a first snowboard binding, said base having a bottom surface, said core having a thickness, wherein said method comprises the steps of:

(1) selecting a loading condition comprising a first downward load acting on said first mounting zone and an upward force acting on said bottom surface and selecting a desired curvature of said bottom surface under said loading condition;

(2) determining said thickness of said core at one of said cross-sectional portions, so that the following equation is satisfied;

$I=M/(EC_m)$

where:

C_m is said desired curvature of said bottom surface under said loading condition at said one of said cross-sectional portions;

E is the composite modulus of elasticity of said body at said one of said cross-sectional portions;

I is the composite area moment of inertia of said body at said one of said cross-sectional portions;

M is the bending moment acting on said one of said cross-sectional portions under said loading condition;

(3) repeating step (2) for each of said plurality of cross-sectional portions; and

manufacturing a snowboard wherein said thickness of said core at each of said plurality of cross-sectional portions corresponds to the thicknesses determined in steps (2) and (3).

The snowboard's flexibility, which among other things is a function of the dimensions of the board at any given cross-section, can be controlled to yield bending into a particular radius of curvature (i.e., a circle) if one first determines the desired area moments of inertia of the snowboard at numerous transverse cross-sections. Since the desired area moments of inertia for a given rider and a given snowboard material can be iteratively calculated (preferably with the aid of a computer), the dimensions of the snowboard, and thus bending of the snowboard, at any such cross-section, and thus the ability of the snowboard to bow into an arc having a substantially constant radius of curvature, can be designed, all in accordance with a preferred embodiment of the present invention.

More particularly, in accordance with more specific aspects of the present invention, in designing a snowboard that bends into a circular arc, one first selects the type of material(s) to be used for the snowboard, and then determines the weight and skill of the rider for whom the snowboard is being designed (thus lending the present invention to being custom designed). Using these parameters, the bending moments at numerous transverse cross sections along the length of the board can be calculated, as well as the desired maximum curvature of the snowboard when in use. The next step is to select the desired area moments of inertia for such numerous transverse cross-sections. The desired area moments of inertia are functions of the previously calculated bending moments, the desired maximum curvature, and the moduli of elasticity of the materials being used. Finally, the cross-sectional dimensions at each transverse cross-section are selected so that the actual area moment of inertia at each such cross section is equal to the desired area moment of inertia.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, aspects, uses, and advantages of the present invention will be more fully appreciated as the same becomes better understood from the following detailed description of the present invention when viewed in conjunction with the accompanying drawings, in which:

FIG. 1 is a side view of a snowboard which illustrates a preferred embodiment of the present invention;

FIG. 2 is a cross-sectional view of a preferred core construction of the present invention;

FIG. 3 is a cross-sectional view of an alternative core construction of the invention;

FIG. 4 is a cross-sectional view of another alternative core construction of the invention;

FIG. 5 is a side view of the preferred embodiment shown in FIG. 1 when under normal loading due to a rider;

FIG. 6 is a side view of a snowboard which illustrates a second preferred embodiment of the present invention;

FIG. 7 is a side view of the preferred embodiment shown in FIG. 6 when loaded;

FIG. 8 is a side view of a snowboard which illustrates a third embodiment of the present invention;

FIG. 9 is a side view of the preferred embodiment shown in FIG. 8 when loaded;

FIG. 10 shows a preferred embodiment of the geometry of the cross-sectional area of the core; and

FIGS. 11-16 illustrate a few examples of acceptable alternatives of the geometry of the cross-sectional area of the core which fall within the scope of the present invention.

MODES FOR CARRYING OUT THE INVENTION

Before discussing the preferred embodiments in detail, a discussion of a few general concepts used in the present invention is in order.

From the point of view of its general operational characteristics, I considered a snowboard as a beam, and a snowboard with a rider thereon as a beam under a load.

One skilled in the art of beam mechanics is familiar with the well-known equation:

$$C = 1/\rho = M/(EI) \qquad (1)$$

where C = the curvature of the beam
ρ = the radius of curvature of the beam
M = the bending moment of the beam

E = the modulus of elasticity of the beam, and
I = the area moment of inertia of the beam.

As is apparent from equation (1), the curvature C of a beam is directly proportional to the load bending the beam (or bending moment M). As applied to snowboards, the bending moment M is determined by the length of the snowboard, the placement of the feet on the snowboard, and the weight of the rider. As a preliminary to designing the structure of a particular snowboard, these variables may be considered as constants.

The curvature is also inversely proportional to the modulus of elasticity of the materials comprising the snowboard and to the area moment of inertia of the cross-sectional area transverse to any point along the longitudinal axis of the snowboard. The modulus of elasticity is either uniform throughout the snowboard, or at least is known as a function of the length of the snowboard, so for design purposes, it too may be considered a constant. This leaves the area moment of inertia as the operative variable in controlling the curvature of the snowboard at any point along its length.

For a given loading M and a given elasticity E, the curvature of a snowboard built in accordance with the present invention is less, i.e., flatter, for large values of the area moment of inertia I and greater, i.e. more curved, for small values of I. That is, for large values of I, the snowboard will not deflect as much under a given load than it will for small values of I. One should, therefore, select large values of I for cross-sectional areas in segments of the snowboard which have high bending moments, and small values of I for cross-sectional areas in segments of the snowboard which have low bending moments.

As used in the specification and claims, the flexibility of segments of the snowboard of the present invention are determined by placing each segment under a known, fixed load. Segments that bend less are less flexible, and segments that bend more are more flexible. Consequently, the relative flexibilities of the various segments are amenable to direct, visual testing.

The formula for calculating the area moment of inertia is given in equation (2):

$$I = \iint y^2 da \qquad (2)$$

where I = area moment of inertia of the area,

da = the differential area, and

y = distance to the differential area from a reference point.

See Beer, *supra*, page 157. From the mathematical definition (2), it can be seen that, significantly, the area moment of inertia I depends only on the geometry of the cross section of the beam, i.e., its cross-sectional shape.

Equation (2) has been applied to common shapes, e.g., rectangles, triangle, circles, semi-circles, etc., with known results. To wit:

Rectangle: $$I = \frac{bh^3}{12} \qquad (3)$$

Triangle: $$I = \frac{bh^3}{36} \qquad (4)$$

Circle: $$I = \frac{\pi r^4}{4} \qquad (5)$$

Semi-circle: $$I = \frac{\pi r^4}{8} \qquad (6)$$

where I = the area moment of inertia of the area,

b = width of the base of the area,

h = the height of the area, and

r = the radius of the circle and/or semi-circle.

These equations show that the area moment of inertia I is more sensitive to the height of the cross-sectional area than it is to the width of the area.

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The area moment of inertia of complex shapes can be determined by subdividing the complex shapes into parts having simpler shapes and by summing the area moments of inertia of the parts. See Beer, *supra*, pp. 443-447.

For the benefit of those not familiar with the foregoing concepts, a feel for them sufficient for the purpose of understanding the present invention can be gleaned from the following simple examples from everyday life.

Consider a common one-by-eight plank, i.e., a snowboard of any particular length having a rectangular cross-section of 1 inch by 8 inches, and thereby a cross-sectional area of eight square inches, placed across a chasm side-by-side with a two-by-four of similar length and same cross-sectional area. Experience tells us that the plank will bend much more (have a higher curvature) than will the two-by-four under the same load, say a person crossing the chasm on them. This can also be seen by referring to equation (3), *supra*. Since its height is less, the plank has a smaller area moment of inertia than does the two-by-four, even though they both have the same cross-sectional area. Since the area moment of inertia is smaller, the plank is more flexible. Turn the two-by-four on edge with the four inches extending vertically and the area moment of inertia of the same piece of wood increases, thereby increasing the rigidity of the snowboard. This is true because the area moment of inertia for rectangles increases linearly with width and cubically with height; thus, the height of the area is the dominating factor.

As mentioned above, equation (1) states that the radius of curvature ρ of a beam is directly proportional to both the modulus of elasticity E of the material from which the beam is made and the area moment of inertia I of the beam and inversely proportional to the bending moment M of the beam (the resultant of all the forces imposed upon the beam). From this, it can be seen that many of the variables are either constant or can be considered as effectively constant.

Applying these principles to the snowboard of the present invention, once the particular materials for the snowboard components have been selected, the modulus of elasticity E for the combination is set, i.e., is known. The bending moment M is dependent upon the weight of the rider of the snowboard. Since only one person will be riding the snowboard at any given time, bending moment M can be assumed to be known. (It should be noted that the overall bending moment M is the resultant of two input forces, i.e., the feet, which are applied to the snowboard. As such, their contribution to the radius of curvature is more complex than the other constants in the equation, but since all of the calculations which are effected in designing the snowboard of the present invention are preferably performed by a programmed computer, their inclusion is not insurmountable.) The result is that only the area moment of inertia *I* needs to be solved for, i.e., varied in a controlled manner, to achieve the desired goals of the invention.

It is readily apparent that since the height of the cross-sectional area of the hypothetical beam corresponds to the vertical thickness of the snowboard, a thicker snowboard is stiffer than a thinner snowboard; this relationship is generally known. The dependence of the area moment of inertia on the vertical thickness of the snowboard is utilized in the preferred embodiments disclosed below in FIGS. 1-12. It is to be emphasized, however, that other cross-sectional configurations, such as those shown in FIGS. 13-16, are equivalent structures within the scope of the present invention, since by properly selecting their geometric dimensions, they will all have equivalent area moments of inertia. The critical design characteristic is the cross-sectional area moment of inertia. How the geometry of the cross-sectional area is configured is determined by aesthetic and other constructional considerations, but it is critical that the set of area moments of inertia along the length of the snowboard be properly selected.

Returning to equation (1), it can be seen that the radius of curvature is inversely proportional to the bending moment. That is, the amount of bowing will depend on the magnitude of the load applied thereto, increasing with increased load. Thus, regardless of the absolute value of the load, the snowboard will bow into a curve of substantially constant radius, when taken in combination with an appropriate set of area moments of inertia.

One possible method of calculating the appropriate area moment of inertia I at any longitudinal point on the snowboard (hereinafter called the "selected point") begins with determining the weight and snowboarding style of the rider that the snowboard is being designed for. The rider's style will determine a maximum desired curvature C_m of the snowboard. A snowboard designed for a more aggressive rider will have a larger maximum curvature C_m, and vice versa.

Next, the horizontal planar dimensions of the snowboard, i.e., length, width and side cut depth, are chosen. Generally, a larger maximum curvature C_m results in a shallower side cut. Once these characteristics are chosen, the position of the rider's feet (also called "mounting zones") on the snowboard are determined. Typically, the mounting zones are positioned to balance the rider's weight on the snowboard during use.

Next, the bending moment M at the selected point on the snowboard can be calculated given the weight of the rider. It is assumed that the downward force applied by the rider on the snowboard is balanced between the rider's feet and that the snow imposes a uniform upward force on the snowboard equal in magnitude and opposite in direction to the total downward force applied by the rider.

Once the bending moment M and maximum curvature C_m of the snowboard are determined, the core material of the snowboard, which has a fixed modulus of elasticity E, is selected. As will be explained below, laminated wood is the most common material. Then, equation (1) is used to determine the desired area moment of inertia I_d for the selected point on the snowboard.

Next, the construction of the snowboard is selected. This includes determining the location, materials and dimensions of the components of the snowboard, e.g., the core, top surface, sidewalls, edges and base (which are discussed in more detail below). However, the thickness of the core is left as a variable and is assumed constant across each transverse cross-section.

Of course, other dimensions of the core, or dimensions of other components of the snowboard could be varied instead of the thickness of the core. Also the thickness of the core could be varied along each transverse cross-section (as shown in FIGS. 11-16, discussed below). In this example, the thickness of the core is assumed to be constant across each transverse cross-section and chosen as the design variable because it results in the simplest actual composite area moment of inertia I_a expression (as discussed below) and is the least costly to manufacture.

Knowing the construction of the snowboard, an expression for the actual composite area moment of inertia I_a is created. All of the variables in this expression, i.e. the locations of all of the components of the snowboard, are expressed as a function of the thickness of the core.

In order to achieve the desired curvature C of the snowboard, the actual area moment of inertia I_a must be equal to the desired area moment of inertia I_d. Unfortunately, the expression for the actual area moment of inertia I_a is typically a 4th order polynomial and is not easily solvable. Thus, in accordance with the present invention, a value for the appropriate core thickness is "guessed". Then, the composite area moment of inertia I_a is compared to the desired area moment of inertia I_d. If the composite area moment of inertia I_a is larger than the desired area moment of inertia I_d the process is repeated using a smaller value for the core thickness. Conversely, if the composite area moment of inertia I_a is smaller than the desired area moment of inertia I_d the process is repeated using a larger value for the core thickness. This process is repeated until the actual area moment of inertia I_a equals the desired area moment of inertia I_d. This iterative process can be expedited by the use of a programmable digital computer.

The above-described method is repeated for along the entire length of the snowboard, by selecting a set of longitudinal points at small increments, for example, 5 millimeters apart.

Referring now to the drawings, a first preferred embodiment of the present invention is shown in a side view in FIG. 1. As shown therein, a snowboard 10 has a nose 12, a tail 14, and a body indicated generally by reference numeral 16.

Body 16 includes a bottom surface 18, a top surface 20, a front half 22 including a front mounting zone 24, and a rear half 26 including a rear mounting zone 28. The front half 22 and rear half 26, and thereby said front and rear mounting zones 24 and 28, are separated by a center section 30. (The separate regions, areas, zones, sections, portions, and segments of the snowboard of the invention are discussed herein as if they are separate entities. This is for clarity of discussion only. In fact, the inventive snowboard is an integral structure from nose to tail.)

The term "normal loading" as used herein refers to the load exerted on snowboard 10 by a rider while snowboard 10 is in use. The load is transmitted from the rider to snowboard 10 through the rider's boots, each of which are secured within a conventional snowboard binding. Each of the bindings is preferably affixed to top surface 20 of snowboard 10 within front and rear mounting zones 24 and 28, respectively. The magnitude of the load exerted on snowboard 10 by the rider will be equal to the weight of the rider, plus any additional forces exerted by the rider on snowboard 10 during use, such as when the rider is executing a turn or landing after executing a jump. Normal loading does not include circumstances under which the magnitude of the load exerted on the snowboard is substantially less than the weight of the rider, such as when the rider is in mid-air while executing a jump.

FIG. 1 depicts a snowboard resting on the surface of the snow without being loaded by the weight of a rider. Under these conditions, bottom surface 18 between nose 12 and tail 14 is flat and coincides with a segment of a circle 5 of infinite radius (FIGS. 1, 6, and 8).

In accordance with the present invention, also shown in FIG. 1, the vertical thickness of body 16 from bottom surface 18 to top surface 20 changes as a function of the distance along the length of snowboard 10 from nose 12 to tail 14. In this preferred embodiment, the cross-sectional area, as viewed transversely of the snowboard, has a constant thickness, as shown in FIG. 10. That is, the shape of any cross-section taken perpendicular to the longitudinal axis will be essentially a rectangle. The corners may be rounded for aesthetic or functional reasons, as suggested in FIGS. 2-4 and 11-12, but other than these slight modifications, the thickness is essentially uniform across snowboard 10. As can be seen in FIG. 1, the thickness of snowboard 10 is relatively thin throughout the upturned curvature of nose 12, thicker in the front mounting zone 24, thinner in center section 30 between front mounting zone 24 and rear mounting zone 28, thicker again in rear mounting zone 28, and thinner again through tail 14. The exact boundaries between the sections identified above, namely, nose, front mounting zone, center section, rear mounting zone, and tail, are not precisely defined, nor do they need be. Mounting zones 24 and 28 are those areas which support the rider's boots, which as stated above can be variably placed both fore and aft and side to side, as is well known in the art. The nose and tail sections extend outboard from the closest mounting zone, and the center section extends between the mounting zones. The exact locations of the boundaries may change from snowboard to snowboard, but they are characterized by the relative thicknesses and thinnesses as defined above. It should be understood that the drawings do not show exact proportions for thicknesses, but rather are exaggerated for clarity.

The most visible difference between snowboard 10 and prior art snowboards is that center section 30 is relatively thin instead of being the thickest part of the snowboard. The mounting zones are thick, as is customary, in order to provide structural strength for supporting the rider and to not be overwhelmed by the highly localized forces of the rider's two feet. Making center section 30 thinner permits snowboard 10 to bend more readily under normal loading, thereby making snowboard 10 easier to control. Also, center section 30 is thin enough that, when the snowboarder shifts his/her weight in a normal manner so as to direct a turn, snowboard 10 will respond by assuming a circular arc of a radius commensurate with the weight shifts. Under those conditions, snowboard 10 will make the turn expected. That is, snowboard 10 will carve a turn in the snow in which rear half 26 substantially follows in the track of front half 22.

It is not merely the increased flexibility of center section 30 which is the hallmark of the present invention, however, for other snowboards, particularly Deville et al., *supra*, share that characteristic. The set of flexibilities of snowboard 10 as measured incrementally along its longitudinal axis must also be selected such that under a normal load, body 16 will bow into a segment of a circle, i.e., an arc of constant radius, as seen at 7 in FIGS. 5, 7, and 9. In the preferred embodiment, this is accomplished by gradually varying the Area Moments of Inertia of body 16, specifically of its core, as explained above.

In models constructed to verify the principles of the present invention, the thickness of center section 30 ranged between about 69% and 79% of the thickness of the mounting zones 24, 28. However, a thickness of the center section 30 that is 95% or less than that of mounting zones 24, 28 will meet the objectives of the present invention.

FIGS. 2-4 show alternative embodiments of cross-sections of snowboard 10 of the present invention, using different materials. Each cross-section is taken along line A-A of FIG. 1, however, the cross-sections shown would be representative of a transverse cross-section taken at any point along a snowboard.

Also, it should be understood that the various elements shown in FIGS. 2-4 are conventional from the standpoint that they all exist in the prior art and are customarily used in the construction of conventional snowboards. Of course, the selection of the particular cross-sectional dimensions of a snowboard along its length to enable the rider to carve an ideal turn, i.e., to enable the snowboard to bow into a circular arc when the rider executes a turn, constitutes part of the present invention.

Referring to FIG. 2, one preferred embodiment of a transverse cross-section of body 16 of snowboard 10 is seen. Body 16 includes base 32, the major portion of snowboard 10 which comes in contact with the snow. Base 32 is preferably made of an ultra high molecular weight (UHMW) polyethylene, either extruded or sintered, chosen for its durability and the ease with which it glides over the surface of the snow. Flanking base 32 and bonded thereto are a pair of edges 34, preferably made of a high grade steel.

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Edges 34 cut into the snow when snowboard 10 is carving its turns. Bottom surface 18 comprises the flush bottom surfaces of base 32 and edges 34.

A lower structural layer 36, extending from side to side of snowboard 10, is preferably bonded in an epoxy adhesive to base 32 and edges 34. The predominant material for structural layer 36 is fiberglass cloth, although there is some use of hemp cloth, other textile materials, and even wood veneer. Fiberglass cloth is preferred and is laid up in either a triaxial, biaxial, or uniaxial direction, depending on the design required.

Structural layer 36 is also preferably bonded in an epoxy adhesive to a core 38. Cores can be made of just about any material. Typically, mainly to ensure economy in manufacture, core 38 is constructed of wood (FIG. 2), foam (FIG. 3), or a combination of wood and foam (FIG. 4). Wood is preferred, but foam, wood and foam, and laminates of fiberglass cloth (not shown) are within the purview of the invention. The details of core 38 will be discussed shortly.

A cap 40 comprising an upper structural layer 42 and a top sheet 44 is also preferably bonded in an epoxy adhesive to core 38. Like lower structural layer 36, upper structural layer 42 is usually made of fiberglass cloth, although hemp cloth, other cloths, and wood veneer are also known. Top sheet 44 is typically a polyester sheet which functions as a canvas on which the snowboard's graphics are displayed. Cap 40 is smoothly adhered to core 38 with outwardly extending extremities 46 of upper layer 42 being bonded to edges 48 of lower layer 36 to form a cover which seals core 38 and provides aesthetic protection for body 16.

The term "cover" or "core cover" as used herein and in the claims refers to all structural elements which surround core 38, including cap 40, upper structural layer 42, lower structural layer 36, base 32, and edges 34.

Several structural elements included in the cross-sectional structure of body 16 are important to the over-all construction of snowboard 10 but are not active participants in the preferred method of varying of the area moment of inertia. For example, steel edges 34 have a high rigidity which resists bending of body 16, but their cross-sectional dimensions along the snowboard are substantially constant. That is, they are not varied as a function of the length of the snowboard with a view as to varying the area moment of inertia thereof. Their contribution, therefore, to the flexibility of body 16 is constant, is known, and as such can be accounted for when computing each cross-section's area moment of Inertia. The same can be said for the contributions of base 32, upper and lower layers 42 and 36, and top sheet 44. Although all of these structural elements are a visible part of the cross-section of body 16 and have finite area moments of inertia, they are considered to be substantial constants in the process of controlling the instantaneous area moments of inertia. Of course, varying other structural elements other than the core in a manner that results in a snowboard that bows into an circular arc when under normal loading is within the scope of the present invention. However, varying other structural elements has been found to be prohibitively expensive and complex to manufacture.

Prior to the present invention, the main purpose of a core was to act as a spacer between the upper and lower structural layers to provide shape and solidity to the snowboard body. The instant invention expands the functionality of the core by utilizing its cross-sectional shape as the variable of choice in controlling the specific area moment of inertia at any given point along the length of the snowboard. Thus, in the preferred method of implementing the present invention, it is the core which is modified to control the area moments of inertia.

As described above, the area moment of inertia of core 38 is dependent only on the shape of its cross-section and is independent of the materials comprising same. (The modulus of elasticity of core 38 is a factor in the radius of curvature of snowboard 10, as is seen from equation (1) above, but it does not enter into the calculations of the area moment of inertia of core 38.) The materials for core 38 are chosen primarily from cost and availability considerations.

Wood is the preferred material. In FIG. 2, core 38 is shown as composed of wood. Preferably, thin strips of wood are laminated together to form core 38. The strips are typically laminated in a vertically orientation, as shown in FIG. 2, however, horizontal lamination is also employed. Lamination is preferred to using single, solid piece of wood for two reasons. First, using a single piece of wood would require a much larger, and therefore more expensive piece of wood. More importantly, obtaining a piece of solid wood that does not contains defects, such as knots, would be extraordinarily expensive.

In FIG. 3, core 38 is made of foam 52. Core 38 can be manufactured as a solid, prefabricated foam block, or it can be the result of injecting a foaming material into the pocket formed by top layer 42 and lower layer 36. Foam is typically less expensive and more durable than wood, but usually is slightly heavier and more damp.

FIG. 4 shows a combination of wooden strips 50 encased within a sheath of foam 52 to form core 38. In this alternative, the cross-sectional shape of core 38, e.g., its thickness, can be controlled by varying either the height of wooden strips 50 or the thickness of foam 52, or both.

It is preferable for the materials forming core 38 to be uniformly distributed across the transverse cross-sections of core 38, so that there are no sudden, large changes in moduli of elasticity that have to be taken into account when calculating the appropriate set of area moments of inertia for the snowboard. In that case, only one variable, namely, the relative vertical thicknesses of core 38, needs to be varied to realize the desideratum of the snowboard bowing into an arc of constant radius. Of course, snowboards having cores with non-uniformly distributed flexibilities are within the scope of the present invention, however, having a core with a uniform consistency, and thereby a uniform flexibility, simplifies the manufacture of the snowboard, which reduces the costs thereof.

In FIGS. 2 and 3, a single material is used, i.e., wood and foam, respectively, for core 38, so a uniform distribution of materials, and thereby a uniformly distributed flexibility, is to be expected. FIG. 4, however, includes two disparate materials, wood and foam, in the formation of core 38. The core nevertheless exhibits a uniform flexibility, since both the wooden center and the foam sheath are uniformly distributed and symmetrically oriented relative to the geometry of the cross-sectional area.

FIG. 5 shows snowboard 10 under the load imposed thereon by a rider. The weight of the rider is applied to snowboard 10 in two separated locations, indicated by arrows 54 and 56, in mounting zones 24 and 28, respectively.

In general, other than ice or hard packed snow, snow is proportionally resistant to the weights applied thereto. That is, snow will depress further under heavier weights than it will under lighter weights, as evidenced by the tracks of different people walking through the snow. In FIG. 5, loading snowboard 10 at two separated locations 54 and 56 causes snowboard 10 to depress in the middle, because the snow applies a uniform reactive force along bottom surface 18. As before stated, according to the principles of the invention, for a snowboard to perform optimally it needs to bend under loading into a circular arc. As shown in FIG. 5, bottom surface 18 of snowboard 10 is curved to approximate a segment of a circle having a constant radius ρ. FIG. 5 shows the curvature snowboard 10 under a static load. When carving a turn, snowboard 10 will ride on one edge of body 16.

It should be noted that the magnitude of the load applied to snowboard 10 by the rider during normal loading will vary, as described above. For example, the load exerted by the rider on snowboard 10 will be greater when the rider is executing a sharp turn than when the rider is moving in straight line. Similarly, under normal loading, the snowboard 10 will flex longitudinally into one of a number of arcs, each having a constant radius curvature. The magnitude of the radius of curvature of snowboard 10 will vary in direct proportion to the magnitude of the load exerted by the rider. Thus, when a rider executes a turn on snowboard 10, designed in accordance with the present invention, rear half 26 will follow in the track of front half 22, and the rider will have carved an ideal turn. Riders will find snowboard 10 much easier to control, especially in sharp turns, than the snowboards of the prior art.

In the first preferred embodiment shown in FIGS. 1-5, bottom surface 18 is flat in repose, i.e., it has no camber. As will become apparent, although this embodiment permits the thickness criteria to be visualized most clearly, bottom surface 18 may assume other shapes and still remain within the teachings of the present invention.

FIG. 6 shows a second preferred embodiment of the present invention. As before, FIG. 6 depicts a side view of snowboard 10 having a nose 12, a tail 14, and a body 16. Body 16 includes a bottom surface 18, a top surface 20, a front half 22 including a front mounting zone 24, and a rear half 26 including a rear mounting zone 28, separated by a center section 30. Snowboard 10 in FIG. 6 is depicted as if resting on the surface of the snow without a rider mounted thereon. Bottom surface 18 is unstressed and rests on snow on three riding areas 58, 60, and 62. As in the first preferred embodiment, snowboard 10 is thinnest in the areas of nose 12 and tail 14, thinner in center section 30, and thickest under the rider's feet in front mounting zone 24 and rear mounting zone 28.

The embodiment of FIG. 6 shows snowboard 10 as including dual cambers indicated generally by reference numerals 64 and 68. A dual-cambered snowboard affords additional ease of control of snowboard 10.

FIG. 7 shows snowboard 10 of FIG. 6 loaded by a rider. As in the first embodiment, the materials and area moments of inertia are selected to facilitate the bowing of snowboard 10 into a reasonably close approximation of a circular segment of constant radius. Of course, with this embodiment, the flexibility of body 16 must take into account the presence of the two cambers. As in FIG. 5, when snowboard 10 is under a normal loading, body 16 is longitudinally curved, and when turning, the edge which contacts the snow follows an arc of a circle.

The third embodiment shown in FIGS. 8 and 9 has a single camber 70. The application of the inventive principles disclosed herein to a single camber snowboard is also beneficial. As in the previous embodiments, the variation in thicknesses along the length of snowboard 10 are thinner in nose 12, center section 30, and tail 14 while being thicker in the mounting zones 24 and 28. In the quiescent state shown in FIG. 8, snowboard 10 rests on riding areas 72 and 74. When bowed by the weight of the rider (FIG. 9), riding areas 72 and 74 are flattened and the direction of the camber is reversed, such that, as in the previous embodiments, bottom surface 18 is in contact with the snow coincident with an arc of a circle 7 of constant radius ρ. As before, this is due to proper selections of the area moments of inertia along body 16, and again results in a thinner center section 30 between mounting zones 24 and 28.

FIGS.10-16 show preferred and alternative cross-sectional shapes of transverse areas of core 38 of snowboard 10. Inasmuch as the active parameter in controlling the area moments of inertia is the cross-sectional shape of core 38, only the shapes thereof are shown in FIGS. 10-16. All have essentially equivalent area moments of inertia. The shapes shown are merely illustrative of the possibilities and are not exhaustive of the shapes contemplated as falling within the scope of the present invention.

FIGS. 10-12 show essentially rectangular cores having a flat top surface 76, a flat bottom surface 78, and mirror-image sides 80-84, respectively. Sides 80 in FIG. 10 are at right angles to top and bottom surfaces 76 and 78, which are parallel to each other; this core is the simplest to manufacture. Sides 82 in FIG. 11 comprises sloping portions 86 merging into vertical portions 88. Sides 84 in FIG. 12 are more stylized, combining an arcuate portion 90 sloping from top surface 76 to a vertical edge 92. The latter two are shaped more for aesthetic reasons than functional ones, although the smoother edges aid in protecting cap 40 (FIGS. 2-4) from stress-related tears.

The cores shown in FIGS. 13-16 are cross-sections taken between mounting zone 24 and nose 12, in central section 30, and between mounting zone 28 and tail 14. Preferably, the cross-sectional shapes shown merge smoothly into the cross-sections of FIG. 10 (for FIGS. 13-14) and FIG. 12 (for FIGS. 15-16) in the areas of mounting zones 24 and 28. Mounting zones 24 and 28 should have reasonably flat, top surfaces 76 in order to provide adequate support for the bindings and boots of the rider. Alternatively, the sloping top surfaces 94 and 96 of FIG. 13 and the arcuate surface 98 of FIG. 14 can extend the length of the snowboard, but those configurations require the bindings be shaped to conform thereto while maintaining the boots' bottoms parallel to bottom surfaces 78.

FIGS. 15 and 16 illustrate cross-sectional shapes which are designed to increase

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torsional flexibility of snowboard 10 while maintaining the correct longitudinal flexibility of the snowboard. Ridges 100 and 102 of FIG. 15 and ridges 104 and 106 of FIG. 16 extend along the full length of the sides of body 10. Ridge 108 (FIG. 16), which runs the full length of the midsection of body 16, adds strength longitudinally to the central axis thereof. Thinner sections 110, 112, and 114 between ridges 100-102, 104-108, and 108-106, respectively, reduce the weight of snowboard 10, as compared to boards having the cross-sections of FIGS. 10-12, and they permit increased torsional flexibility in the portions of the snowboard in which they are present.

Any of the preceding embodiments may have side cuts in order to be able to include all of the advantages derivable therefrom. Such side cuts have not been shown in the drawings, since they are not a part of the present inventive concepts.

It is clear from the above that the objects of the invention have been fulfilled.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1 An apparatus for use on a snow surface, comprising:

a nose, a tail, and a body connecting said nose and tail, said body including, a top surface, a bottom surface, a front half, and a rear half, said top and bottom surfaces separated by a thickness;

said body further including a first mounting zone located in said front half and adapted to receive one foot of a rider of said apparatus and a second mounting zone located in said rear half and adapted to receive the other foot of said rider;

said body further including a plurality of cross-sectional portions;

wherein the value of the following expression is substantially constant when a first static loading condition is applied to said body and the expression is applied to each of said plurality of cross-sectional portions, respectively:

$$M/EI$$

wherein:

E is the modulus of elasticity of said body for said respective cross-sectional portion;

I is the area moment of inertia for said respective cross-sectional portion;

M is the bending moment acting on said respective cross-sectional portion under said first static loading condition; and

said first static loading condition comprises a first downward load applied to said first mounting zone, a second downward load applied to said second mounting zone, and an upward load applied along said bottom surface.

2 The apparatus of claim 1, wherein said upward load is proportionally resistant to downward loads applied thereto.

3 The apparatus of claim 1, wherein said body further includes a center section located between said first and second mounting zones, and said thickness of said body in said center section is less than said thickness of said body in said first and second mounting zones.

4 The apparatus of claim 3, wherein said thickness of said body in said center section is equal to 95% or less of said thickness of said body in said first and second mounting zones.

5 The apparatus of claim 4, wherein said thickness of said body in said center section is equal to between 69% and 79% of said thickness of said body in said first and second mounting zones.

6 The apparatus of claim 1, further comprising a second static loading condition wherein said body is subjected to no substantial external loading, wherein said bottom surface forms a dual camber when said second static loading condition is applied to said body.

7 The apparatus of claim 1, further comprising a second static loading condition wherein said body is subjected to no substantial external loading, wherein said bottom surface forms a single camber when said second static loading condition is applied to said body.

8 The apparatus of claim 1, wherein a desired curvature of said apparatus when said rider is executing a turn on said apparatus is circular.

9 A method of designing and making a snowboard or ski body having a number of parts including a cap, a base, and a core, said body being

partitioned into a plurality of cross-sectional portions, said cap having a top surface and a first mounting zone located on said top surface for mounting a first snowboard binding, said base having a bottom surface, said core having a thickness, wherein said method comprises the steps of:

(1) selecting a loading condition comprising a first downward load acting on said first mounting zone and an upward force acting on said bottom surface and selecting a desired curvature of said bottom surface under said loading condition;

(2) determining said thickness of said core at one of said cross-sectional portions, so that the following equation is satisfied;

$I=M/(EC_m)$

where:

C_m is said desired curvature of said bottom surface under said loading condition at said one of said cross-sectional portions;

E is the composite modulus of elasticity of said body at said one of said cross-sectional portions;

I is the composite area moment of inertia of said body at said one of said cross-sectional portions;

M is the bending moment acting on said one of said cross-sectional portions under said loading condition;

(3) repeating step (2) for each of said plurality of cross-sectional portions; and

manufacturing a snowboard wherein said thickness of said core at each of said plurality of cross-sectional portions corresponds to the thicknesses determined in steps (2) and (3).

10 The method of claim 9, wherein said body further includes a second mounting zone located on said top surface for mounting a second snowboard binding and said loading condition further comprises a second downward load acting on said second mounting zone.

11 The method of claim 10, wherein said first and second downward loads are equal in magnitude.

12 The method of claim 10, wherein the magnitude of said first downward load is larger than the magnitude of said second downward load.

13 The method of claim 9, wherein said upward force is uniformly distributed along said bottom surface.

14 The method of claim 9, further comprising the step of selecting the relative position, materials and dimensions of said parts of said body, except for said thickness of said core, prior to step (2).

15 The method of claim 9, wherein said desired curvature, C_m, of said bottom surface under said loading condition comprises a circular arc.

Donald P. Stubblefield
By his Registered Patent Attorneys
Freehills Carter Smith Beadle 19 August 2003

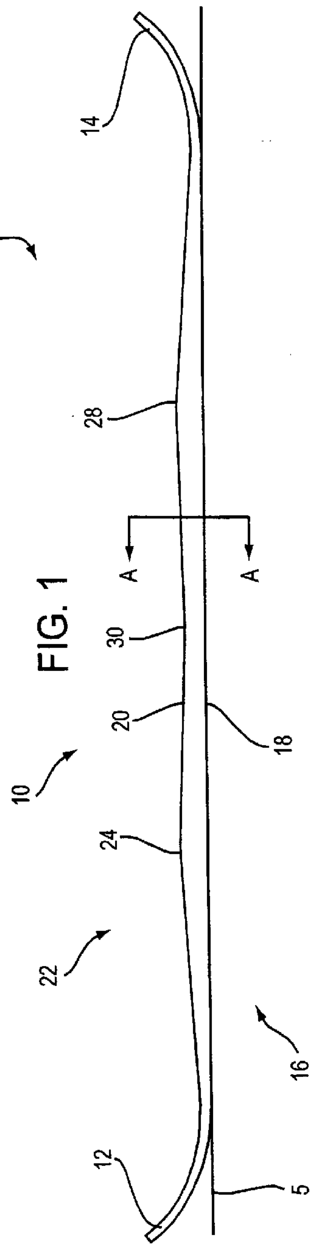


FIG. 1

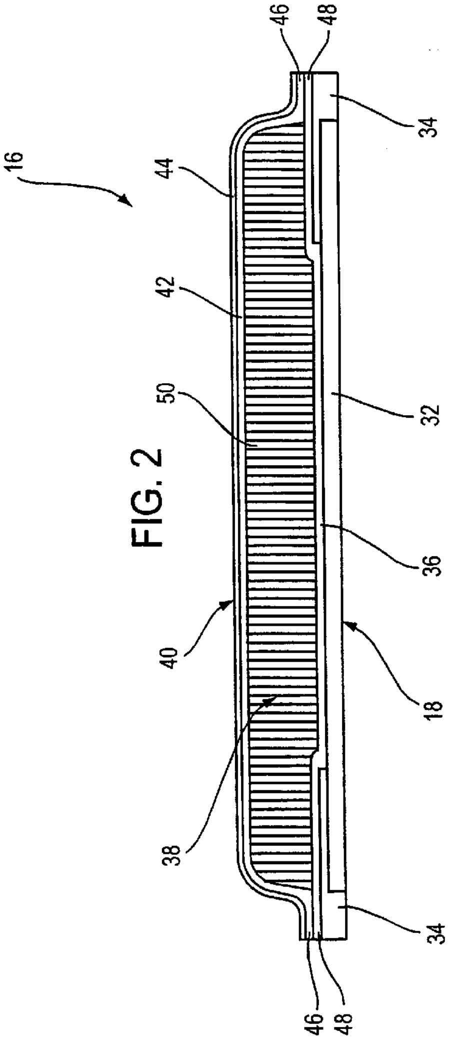


FIG. 2

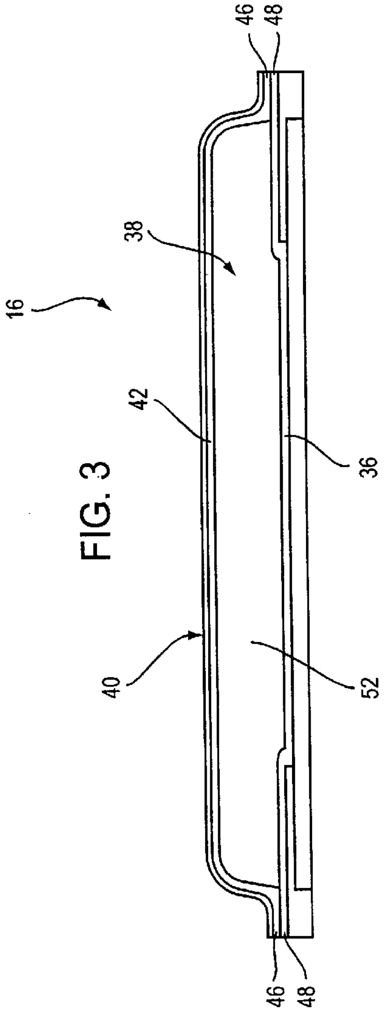
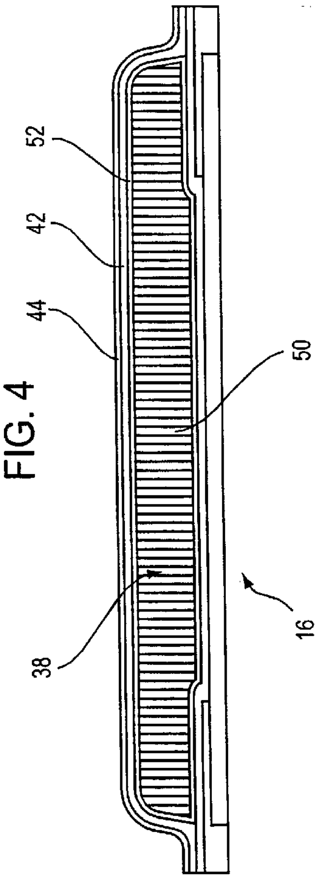


FIG. 3

FIG. 4



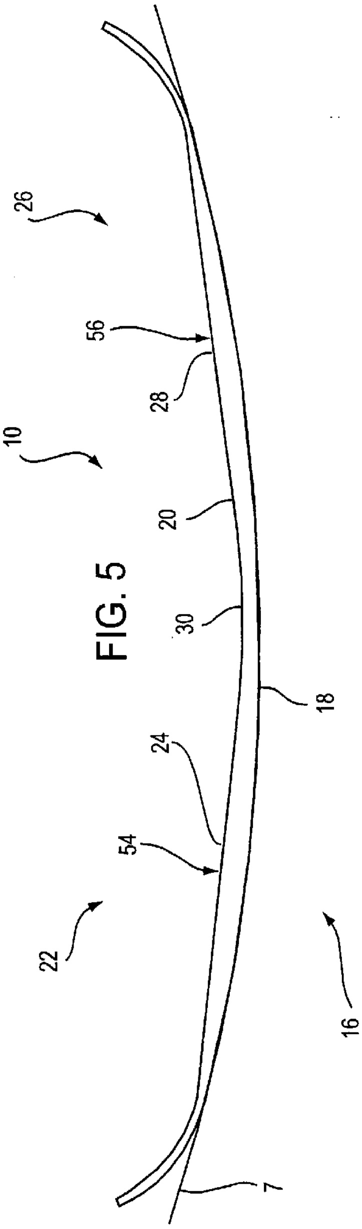


FIG. 5

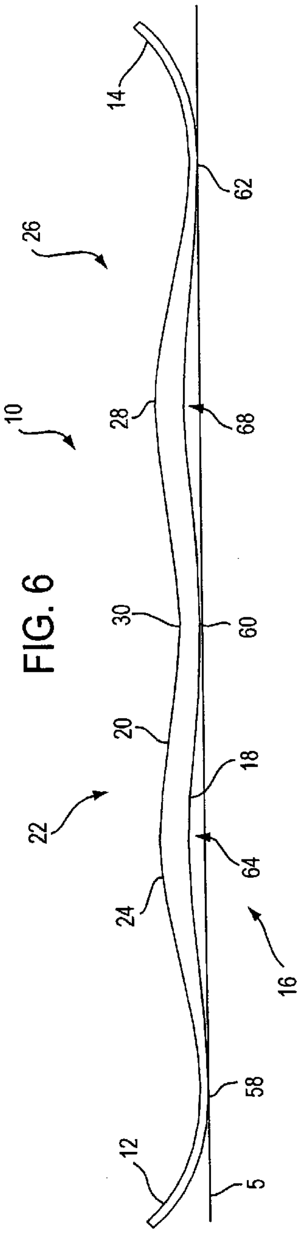

14
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FIG. 6

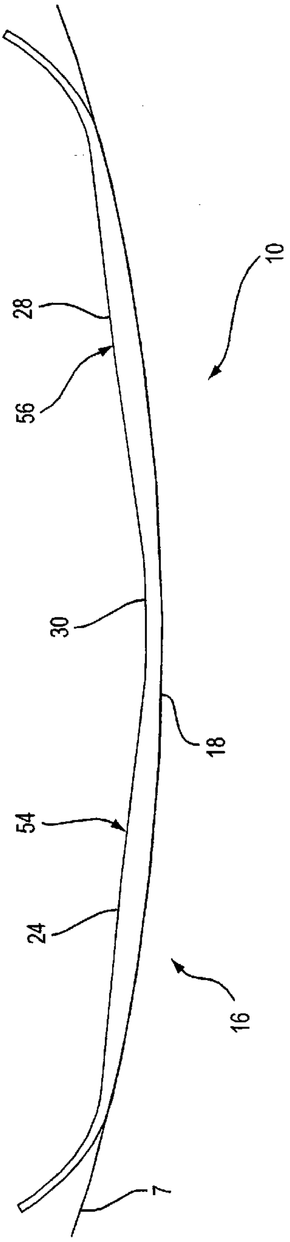
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FIG. 7

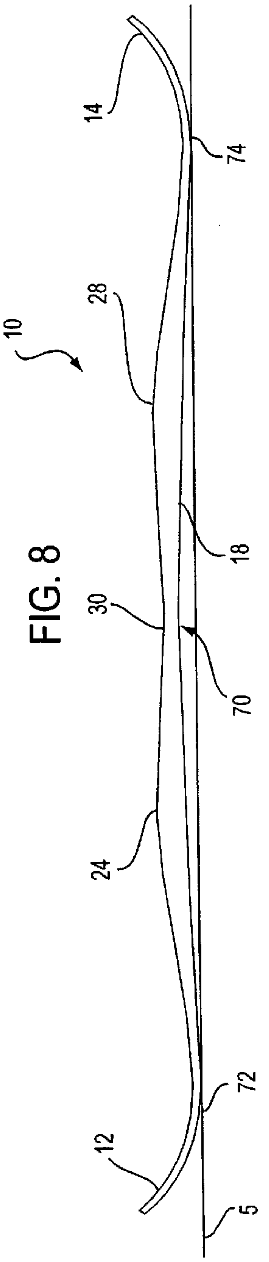

FIG. 8

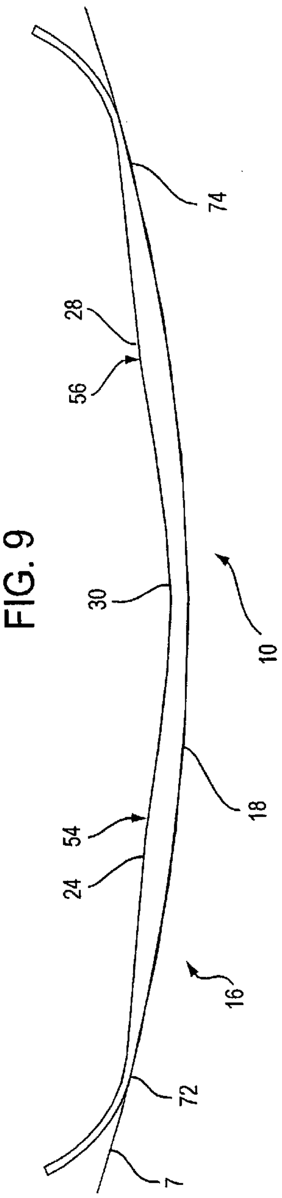

FIG. 9

FIG. 10

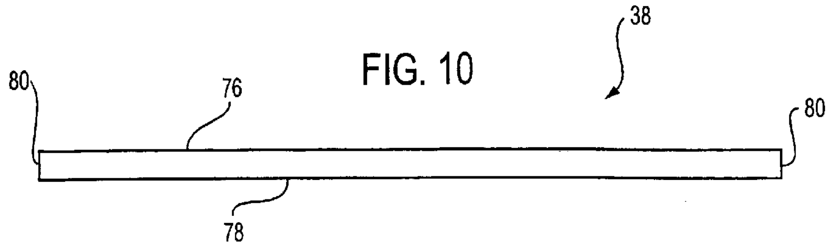

FIG. 11

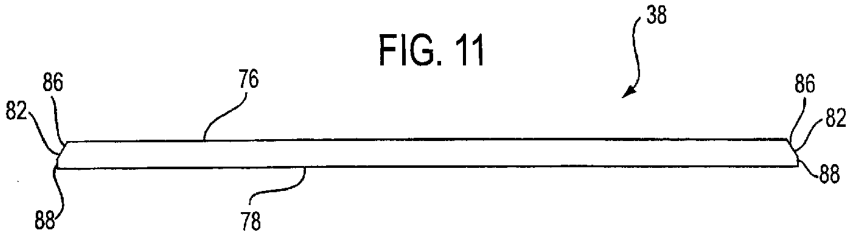

FIG. 12

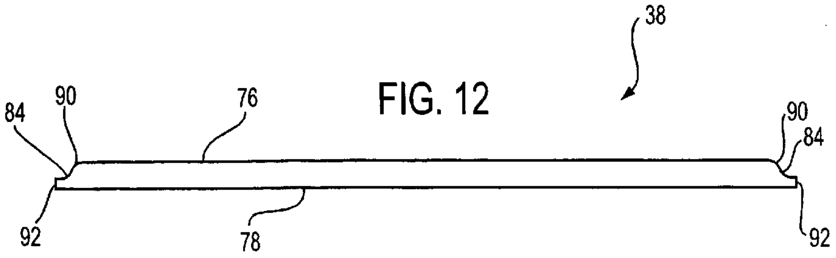

FIG. 13

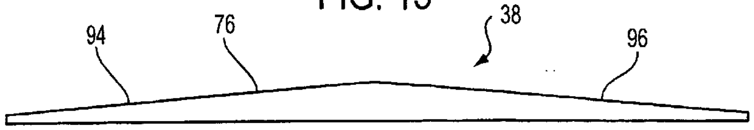

FIG. 14

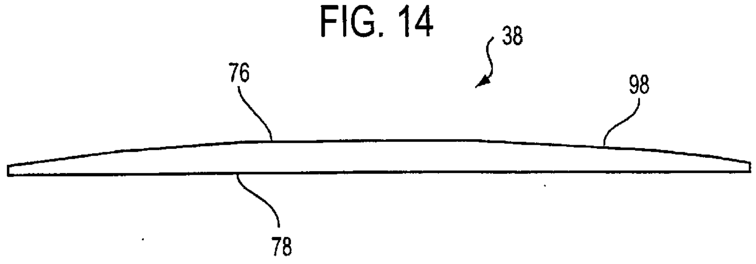

FIG. 15

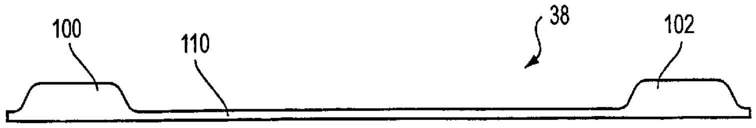

FIG. 16