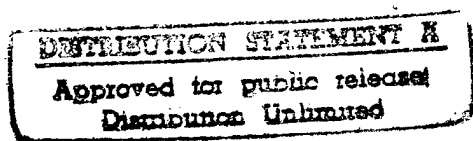


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NOTICE

The above identified patent application is available for licensing. Requests for information should be addressed to:

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CODE OCCC
ARLINGTON VA 22217-5660



DTIC QUALITY INSPECTED 8

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1 Navy Case No. 77316

2 DEFORMABLE PROPELLER BLADE AND SHROUD

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4 STATEMENT OF GOVERNMENT INTEREST

5 The invention described herein may be manufactured and used
6 by or for the Government of the United States of America for
7 governmental purposes without the payment of any royalties
8 thereon or therefor.

9

10 BACKGROUND OF THE INVENTION

11 (1) Field of the Invention

12 This invention relates generally to composite materials
13 which move in response to environmental changes, such as changes
14 in temperature, and more specifically to a composite material
15 installed as part of a propeller blade which is capable of
16 changing its shape upon being heated.

17 (2) Description of the Prior Art

18 The basic objective of the present invention is to optimize
19 the operation of a propeller for various angles of attack. A
20 propeller blade is an airfoil that operates at a fixed angle of
21 attack. The angle of attack of a fixed airfoil is only optimal
22 at a single forward speed or a single rotation speed for a
23 propeller. The drop off in efficiency is significant for the off

1 design operation of the propeller. Prior art means of
2 controlling propeller blade or wing angle of attack such as flaps
3 or other articulated devices that rely on moving parts are prone
4 to problems associated with wear, control and generation of
5 noise.

6 In this regard, variable camber blades are well-known in the
7 art. Reference can be made to U.S. Patent Nos. 3,042,371 to
8 Fanti and 4,619,580 to Snyder as representative prior art in this
9 field. The patent to Fanti discloses a blade having a trailing
10 end portion with upper and lower bimetallic sheets that changes
11 the blade's shape upon being subjected to varying temperatures of
12 the fluid through which it is operating. Snyder shows a variable
13 camber vane that is also capable of changing its overall shape
14 upon being subjected to thermal variations of its working fluid.

15 A significant shortcoming with the blades of Fanti and
16 Snyder is that they change shape only when the fluid in which
17 they are operating changes its temperature. Thus, there is no
18 independent means for changing the shape of the blade apart from
19 varying the temperature of the working fluid. In operation of a
20 vehicle, it is impractical to change the temperature of the
21 working fluid.

22 Reference can also be made to U.S. Patent No. 5,114,104 to
23 Cincotta et al. which discloses a fin having a mechanically

1 controlled system for changing its shape. The system
2 incorporates shape memory alloys which are embedded within the
3 fin for changing its shape during use. A disadvantage associated
4 with this design is that it is costly to manufacture since the
5 design requires several expensive moving parts and additional
6 labor costs.

7 There is presently a need for a propeller blade mechanism
8 that is capable of changing the shape of the blade by a simpler,
9 more reliable means.

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SUMMARY OF THE INVENTION

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It is an object of the present invention to provide a
propeller blade fabricated from a material which has no moving
parts requiring assembly.

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Another object is that of an improved propeller blade which
is capable of changing its shape upon demand by varying the
temperature of the blade.

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A further object of the present invention is that of an
improved propeller blade which is capable of changing its shape
and therefore its angle of attack and noise signature.

21

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Another object is that of an improved propeller blade which
responds quickly in changing its shape upon being subjected to a

1 temperature change by means of an element embedded within the
2 propeller blade.

3 An additional object of the present invention is that of an
4 improved propeller blade that can be mass produced.

5 Another object of the present invention is that of an light
6 weight propeller blade, which is simple in design and easy to
7 manipulate with common available power sources, e.g.,
8 electricity.

9 In general, the invention is directed to an improved
10 propeller blade fabricated from composite material comprising a
11 plurality of upper layers, each upper layer being flexible and
12 having fibers oriented in a first direction. The material
13 further includes a plurality of lower layers, each lower layer
14 being flexible and having fibers oriented in a second direction
15 which is different than the first direction of the fibers of the
16 upper layers. A flexible layer of resistive heating material is
17 disposed between the upper and lower layers, and suitable means
18 is provided for heating the layer of resistive heating material.
19 The composite material is adapted to change its shape upon
20 heating the resistive heating material by the heating means
21 wherein the fibers of the upper and lower layers expand or
22 contract upon changing their temperature.

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BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention and many of the attendant advantages thereto will be readily appreciated as the same become better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic elevational view of a stern end of a vessel, e.g., a torpedo, having propeller and duct fabricated from the composite material of the present invention;

FIG. 2 is a rear end view of the propeller and duct of the vessel illustrated in FIG. 1;

FIG. 3 is a top perspective view of a single blade of the propeller;

FIG. 4 is a schematic view of a prior art material having multiple layers with carbon fibers indicated by arrows, the layers being oriented in a well-known manner;

FIG. 5 is a schematic view of multiple layers of the composite material of the present invention illustrating with arrows the preferred orientation of carbon graphite fibers in the respective layers; and

FIG. 6 is a side cross-sectional view of a shroud having the present invention embodied therein.

1 Corresponding reference numerals designate corresponding
2 parts throughout the several views of the drawings.

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DETAILED DESCRIPTION

5 Referring to the drawings, and more particularly FIG. 1,
6 there is generally indicated at 10 a vessel, e.g., a torpedo,
7 having the composite material of the present invention
8 incorporated into its propeller, generally indicated at 12, and
9 duct, generally indicated at 14. A suitable power supply 16 and
10 controller 18 deliver power and control the operation of the
11 propeller 12 and duct 14 in a manner which will be fully
12 described below. As shown, a wire 20 electrically connects the
13 controller 18 to the propeller 12 and another wire 22
14 electrically connects the controller 18 to the duct 14. Also,
15 the power supply 16 and controller 18 are suitably connected by
16 wire 24. The controller 18 is designed to control the amount of
17 electricity transmitted through the wires 20, 22 from the power
18 supply 16.

19 As shown, FIG. 1 is a schematic view of the stern end of the
20 vessel 10. The propeller 12 has a hub 26 for mounting it onto a
21 propeller shaft 28 which is suitably driven by a motor (not
22 shown) of the vessel 10. The hub 26 has mounted thereon a
23 plurality of propeller blades each indicated at 30 which are

1 fabricated in accordance with the present invention. The
2 propeller 12 is received within the duct 14, in the traditional
3 manner. The duct 14 is also fabricated in accordance with the
4 current invention.

5 Referring to FIGS. 2 and 3, the propeller blades 30, as
6 mentioned above, are fabricated utilizing the present invention.
7 The blades 30 are shaped in the usual manner to have an angle of
8 twist so that water (or air) is displaced when the blades are
9 rotated about the shaft's axis. FIG. 4 illustrates by a
10 schematic view a traditional composite material which is made up
11 of multiple layers 32a-32e having carbon fibers indicated by
12 arrows 34, 36, the layers 32a-32e being oriented in a well-known
13 manner. As indicated by arrows 36, the carbon fibers of one
14 layer 32b are aligned perpendicularly with respect to the carbon
15 fibers 34 of its adjacent layers 32a, 32c. This well-known
16 construction provides strength and rigidity necessary for
17 performance purposes.

18 Referring particularly to FIGS. 3 and 5, the blades 30 of
19 the present invention each have a first outwardly facing surface
20 38 and a second outwardly facing surface 44. The blade 30
21 includes an intermediate strip or section of material 30a
22 fabricated from a plurality of first layers 40a, 40b, (FIG. 5)
23 each of which is flexible and has fibers (as indicated by arrows

1 42) which are oriented in a first direction. The strip of
2 material 30a also has a plurality of second layers 46a, 46b, each
3 of which is also flexible and has fibers 48 which are oriented in
4 a second direction which is generally angled with respect to the
5 fibers 42 of the first layers 40a, 40b. The first and second
6 flexible layers 40, 46 provide the strip of material 30a of blade
7 30 with the flexibility and rigidity required to propel the
8 vessel 10. Preferably the first and second layers 40, 46 are
9 fabricated from carbon graphite material. However, it should be
10 understood that any other fibrous material which has fibers for
11 orienting the layers 40, 46 in a particular direction may be used
12 instead of carbon graphite material. The inner and outer end
13 sections 30b, 30c, respectively, of the blade 30 are fabricated
14 from the prior art composite material illustrated in FIG. 4.

15 A flexible layer of a resistive heating material 50 is
16 disposed between the first and second layers 40, 46 at the strip
17 of material 30a for changing the shape of the blade 30. More
18 specifically, this heat resistive heating element layer 50 is
19 preferably fabricated from aluminum and/or copper foil and is in
20 thermal contact with the first and second layers 40, 46 for
21 heating the layers and thereby changing the shape of the blade
22 30. Referring back to FIG. 1, the wire 20 is in electrical
23 communication with the propeller 12 from the controller 18 so as

1 to control, upon demand, the amount of heat being transmitted to
2 the propeller blades 30.

3 The intermediate strip of material 30a deforms so as to
4 change the angle of twist of the blade 30 in the following
5 manner. Fibers 42, 48 of the first and second layers 40, 46,
6 respectively, expand in their axial direction when heated by the
7 layer of resistive heating material 50. With the conventional
8 composite material of FIG. 4, the fibers 34, 36 in interleaved
9 layers are oriented at right angles to each other. Thus, any
10 expansion of the fibers (e.g., fibers 34) is canceled out by the
11 other layer fibers (e.g., fibers 36). In the strip of material
12 30a having the composite material of the present invention, the
13 fibers 42, 48 are arranged around the heating element 50 so that
14 when they deform, the strip 30a takes a different shape thereby
15 causing the end of the propeller blade 30 to twist. It should be
16 noted that the first and second layers 40, 46 can be staggered so
17 as to accommodate differing amounts of twist. Obviously, the
18 entire blade 30 can be constructed using composite material as in
19 FIG. 5. Likewise, several independently controlled deformation
20 regions can be applied on each blade.

21 It has been discovered that five watts per square inch will
22 produce a forty degree temperature change across the blade 30.
23 This temperature change causes the fibers 42, 48 to stretch along

1 their axis thereby causing the blade to twist. For a blade 30
2 having, for example, seven first layers 40 and seven second
3 layers 46, forty degrees of temperature change causes the pitch
4 angle of the blade 30 to change five degrees.

5 Thus, it should be observed that each propeller blade 30
6 fabricated with the composite material of the present invention
7 is capable of deforming to a desired shape upon command. More
8 specifically, the pitch angle of the propeller blade 30 can be
9 changed so that it is at its optimal angle of attack for the
10 speed at which the vessel 10 is traveling. Such pitch angles are
11 well-known in the art of water propulsion devices and will not be
12 described herein for purposes of economy. It should be further
13 observed that the noise signature of the vessel 10 can be changed
14 at any time by merely changing the temperature of the layer of
15 resistive heating material 50 for each propeller blade 30. This,
16 of course, is controlled by the controller 18 which increases or
17 decreases the amount of electricity delivered to the propeller 12
18 by the power supply 16.

19 Referring now to FIGs. 2 and 6, the duct 14 is shown to
20 comprise a plurality of outer layers 52 and a plurality of inner
21 layers 54. A layer of a resistive heating material 56 is
22 disposed between the outer and inner layers 52, 54, and operates
23 in an identical manner as the layer of resistive heating element

1 50 for the propeller 12. This construction enables the duct 14
2 to curve and change its shape in the same manner as the propeller
3 blades 30. Upon heating, duct 14 is deformed to position 58
4 thereby changing the flow characteristics through duct 14.

5 It should be noted that this construction can be used on a
6 torpedo wherein an inflow temperature sensor (not shown) is used
7 to provide information to the torpedo's controller 18 that
8 supplies electric power to each propeller blade 30. This
9 information is used to gauge how much power is supplied to each
10 blade 30 for a given ambient condition. For most of the time
11 during a torpedo mission, it operates at a search speed wherein
12 no power is delivered to the layer of resistive heating material
13 50. At times, the torpedo 10 will operate prior to its ignition
14 at attack speed wherein power is supplied to the layers 40, 46
15 via the layer of resistive heating material 50 so as to change
16 the pitch angle of the blades 30. During either the attack or
17 search speed, if power is supplied to the duct 14, the shape of
18 the duct 14 will change. This change will cause the propulsion
19 characteristics of the duct and propeller system to change. This
20 change assists in achieving greater propulsion efficiencies in
21 torpedo 10.

22 It should be further noted that a number of alternative
23 devices can be constructed using the principles taught herein to

1 construct air foils from composite material. For example, a
2 fixed wing of an aircraft can be constructed of composite
3 material so as to replace the traditional metal superstructure
4 and flaps. Any application requiring propeller-like blades (such
5 as fixed or rotary aircraft with propellers and turbo-machinery)
6 can utilize the composite material of the present invention.

7 While there is shown and described herein certain specific
8 structure embodying the invention, it will be manifest to those
9 skilled in the art that various modifications and rearrangements
10 of the parts may be made without departing from the spirit and
11 scope of the underlying inventive concept and that the same is
12 not limited to the particular forms herein shown and described
13 except insofar as indicated by the scope of the appended claims.

1 Navy Case No. 77316

2 DEFORMABLE PROPELLER BLADE AND SHROUD

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4 ABSTRACT OF THE DISCLOSURE

5 A propeller blade fabricated from composite material having
6 a plurality of upper layers, each upper layer being flexible and
7 having fibers oriented in a first direction. The material
8 further includes a plurality of lower layers, each lower layer
9 being flexible and having fibers oriented in a second direction
10 which is different than the first direction of the fibers of the
11 upper layers. A flexible layer of resistive heating material is
12 disposed between the upper and lower layers. A control and power
13 supply are provided for controlling the amount of electricity
14 delivered to the layer of resistive heating material. The
15 composite material changes its shape upon changing the
16 temperature of the layer of resistive heating material by
17 manipulating the controller.

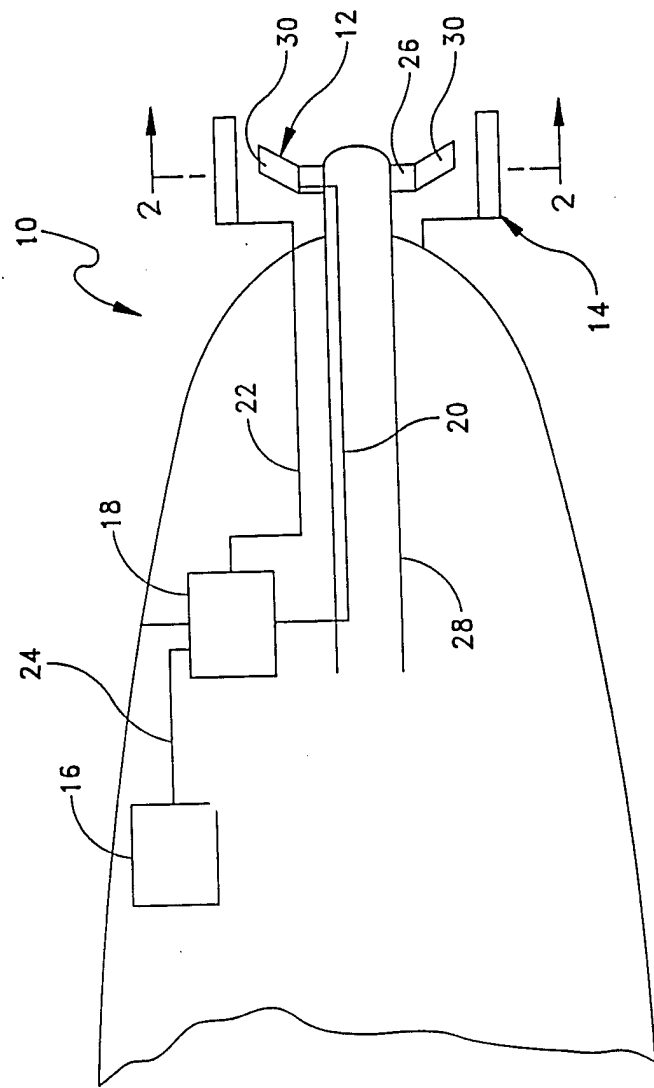


FIG. 1

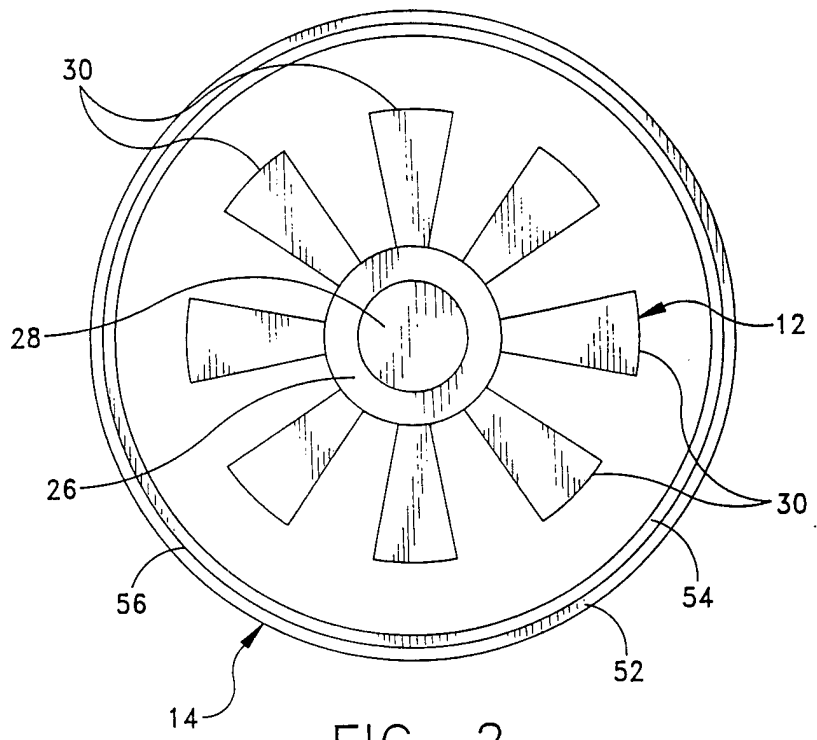


FIG. 2

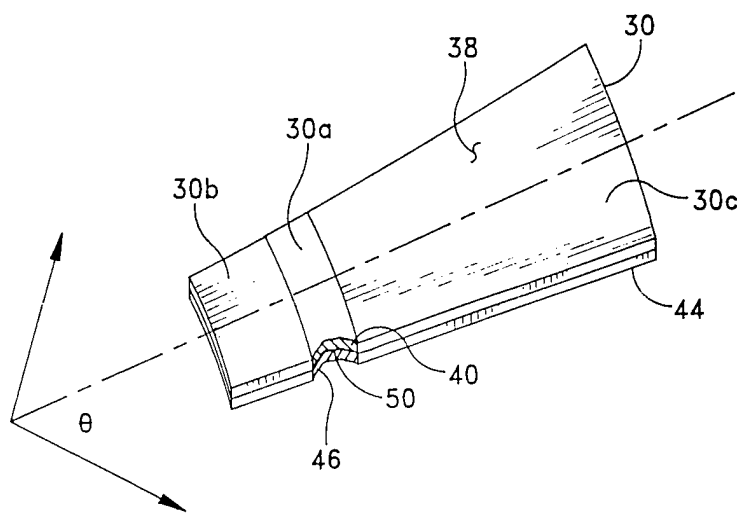


FIG. 3

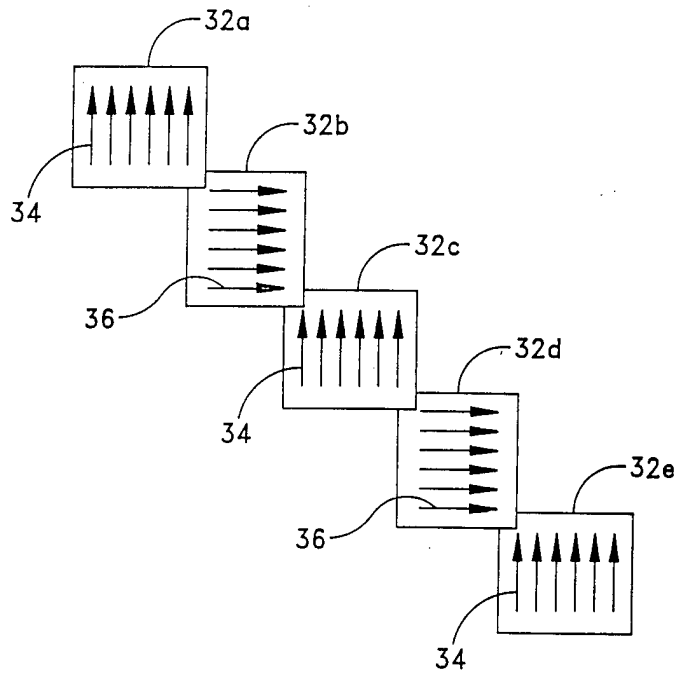


FIG. 4
(PRIOR ART)

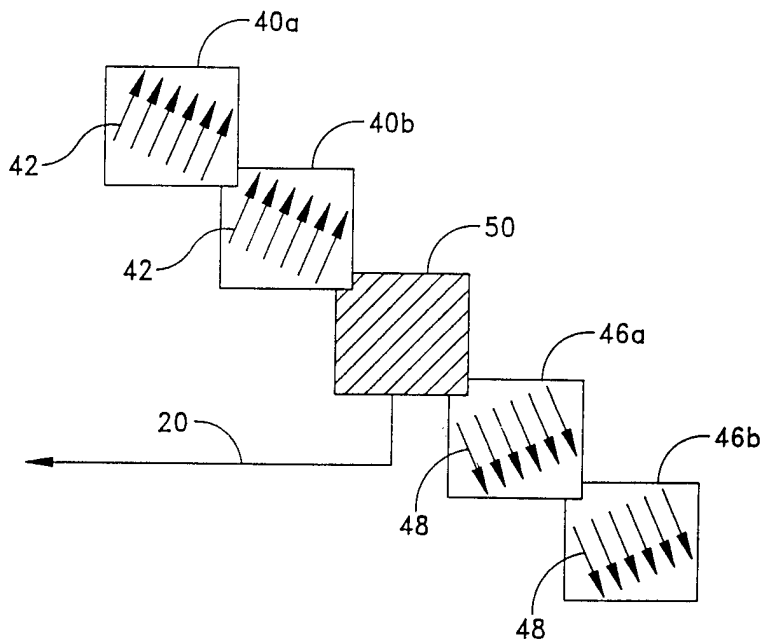


FIG. 5

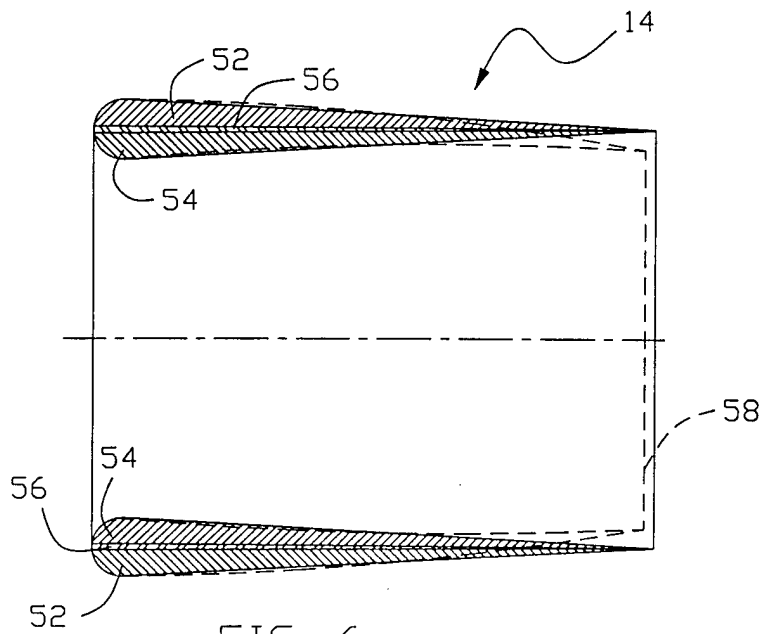


FIG. 6