



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**12.01.2011 Bulletin 2011/02**

(51) Int Cl.:  
**B63H 25/38 (2006.01)**

(21) Application number: **10154249.6**

(22) Date of filing: **22.02.2010**

(84) Designated Contracting States:  
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR**  
Designated Extension States:  
**AL BA RS**

(72) Inventors:  
• **Jin, Chang Bae**  
**Gyeonggi-do 410-785 (KR)**  
• **Choi, Young Bok**  
**Gyeonggi-do 435-040 (KR)**

(30) Priority: **10.07.2009 KR 20090009001 U**

(74) Representative: **Intès, Didier Gérard André et al**  
**Cabinet Beau de Loménie**  
**158, rue de l'Université**  
**75340 Paris Cedex 07 (FR)**

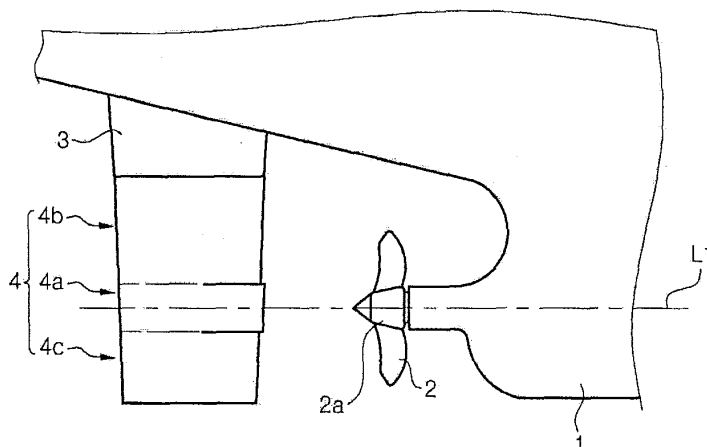
(71) Applicant: **Daewoo Shipbuilding&Marine Engineering Co., Ltd.**  
**Seoul 100-180 (KR)**

(54) **Rudder for a ship**

(57) Disclosed herein is a ship rudder (4) disposed behind a propeller (2) at a stern of a ship (1) to control a movement direction of the ship. The rudder includes a middle blade (4a) located around an axis of the propeller and upper and lower blades (4b, 4c) located at upper and lower sides of the middle blade. The middle blade has a leading edge part having a bilaterally symmetrical shape with respect to a plane passing through the axis of the propeller and a perpendicular centerline of the rudder. The upper blade (4b) has a leading edge part twisted with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder to be biased in a reverse rotational direction of the pro-

PELLER. The lower blade (4c) has a leading edge part twisted with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder to be biased in a forward rotational direction of the propeller. The leading edge part of the middle blade does not form a step, with respect to the leading edge parts of the upper and lower blades, at sides of the rudder in twisted directions of the upper and lower blades, but forms steps, where the leading edge part of the middle blade meets the leading edge parts of the upper and lower blades, at sides of the rudder in directions opposite to the twisted directions of the upper and lower blades, respectively.

**FIG. 1**



## Description

### BACKGROUND

#### Technical Field

[0001] The present disclosure relates to a rudder for ships.

#### Description of the Related Art

[0002] Generally, ship rudders are located behind a propeller of a ship to control a movement direction of the ship. In this case, the rudders are subjected to propeller induced velocities and propeller induced flow angles that vary along the rudder span. The induced flow generates different pressures at right and left sides of the rudders according to upper and lower locations on an axis of the propeller. Viewing the rudder from behind the ship, a right-hand rotating propeller will produce a pressure distribution on the rudder surface such that a pressure side is created at a left upper portion and a right lower portion of the rudder, and a suction side is created at a right upper portion and a left lower portion thereof. Accordingly, when a rudder having a symmetrical cross-section is located behind a high speed (20 Knots or more) or highly loaded propeller of a ship, the suction pressure peak causes cavitation on the surface of the rudder where the suction side is created. In order to suppress the cavitation on the rudder surface, asymmetrical rudders have been developed which have leading edge parts, that is, front parts of the upper and lower blades of the rudders on the axis of the propeller twisted so as to have profiles along its entire span that are aligned with the propeller induced flow into the rudder. In other words, viewing the rudder from behind the ship with the propeller rotating in the right-hand direction about the rudder, the leading edge parts of the upper and lower blades of such a conventional asymmetrical rudder on the axis of the propeller are twisted towards the port side and the starboard side, respectively. In this structure, the leading edge parts of the rudder are asymmetrically located on the axis of the propeller. As a result, it is possible to reduce the lower suction pressure region along the leading edge parts of the rudder that normally causes the cavitation on the rudder surface, thereby solving the problems of the conventional symmetrical rudders.

[0003] Since the leading edge parts of the upper and lower blades of the rudder centered on the axis of the propeller are twisted toward the port and starboard sides, however, the conventional asymmetrical rudder has a discontinuous cross-section and must include a scissors plate for structural rigidity. Further, a leading-edge asymmetrical rudder having the discontinuous cross-section is liable to suffer cavitation on the discontinuous surfaces of the leading edge parts and scissors plate due to a hub vortex of the propeller.

[0004] Further, for the conventional twisted rudder

having a single discontinuous cross-section, there is a problem in that only a single scissors plate is used to resist the twisting or shear load.

[0005] Furthermore, for the conventional twisted rudder that has a discontinuously asymmetrical cross-section on the axis of the propeller, the overall section of the leading edge parts has an asymmetrical shape, thereby deteriorating productivity.

#### BRIEF SUMMARY

[0006] The present disclosure is directed to solve the problems of the conventional techniques as described above, and one embodiment includes a rudder, specifically, a leading-edge asymmetrical rudder, that can reduce influence acting on the rudder due to the accelerated cross-flow induced by the rotating propeller while preventing the risk of cavitation erosion on a discontinuous surface of leading edge parts.

[0007] In accordance with one aspect, the present disclosure provides a rudder for a ship disposed behind a propeller at a stern of the ship to control a movement direction of the ship, including a middle blade located around an axis of the propeller and upper and lower blades located at upper and lower sides of the middle blade, wherein the middle blade has a leading edge part having a bilaterally symmetrical shape with respect to a plane passing through the axis of the propeller and a perpendicular centerline of the rudder, the upper blade has a leading edge part twisted with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder to be biased in a reverse rotational direction of the propeller, the lower blade has a leading edge part twisted with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder to be biased in a forward rotational direction of the propeller, and the leading edge part of the middle blade does not form a step, with respect to the leading edge parts of the upper and lower blades, at sides of the rudder in twisted directions of the upper and lower blades, but forms steps, where the leading edge part of the middle blade meets the leading edge parts of the upper and lower blades, at sides of the rudder in directions opposite to the twisted directions of the upper and lower blades, respectively.

[0008] In the case where the forward rotational direction of the propeller is the clockwise direction when viewing the propeller from behind the ship, the leading edge parts of the upper and lower blades are twisted towards port and starboard of the ship on the axis of the propeller, respectively.

[0009] Each of the leading edge parts of the upper and lower blades may be twisted at an angle of 2 to 8 degrees with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder.

[0010] Each of the leading edge parts of the upper and lower blades may be curvedly twisted with respect to the plane passing through the axis of the propeller and the

perpendicular centerline of the rudder.

[0011] The leading edge part of the middle blade may have a vertical length corresponding to 15 to 30% of a diameter of the propeller.

[0012] The leading edge part of the middle blade may have a streamlined blunt cross-section.

[0013] In each of the upper and lower blades, an offset distance of the leading edge part to a centerline of a section of the rudder may be limited to within half of a maximum thickness of the section of the rudder.

[0014] In accordance with another aspect, the present disclosure provides a rudder for a ship disposed behind a propeller at a stern of the ship to control a movement direction of the ship, wherein the ship rudder is divided into upper, middle and lower blades, in which a leading edge part of the middle blade has a bilaterally symmetrical cross-section on an axis of the propeller, and leading edge parts of the upper and lower blades are twisted in a reverse rotational direction and a forward rotational direction of the propeller on the axis of the propeller, respectively.

[0015] As such, in the rudder according to one embodiment, the leading edge parts of the upper and lower blades are twisted on the axis of the propeller, and the leading edge part of the middle blade located around axis of the propeller has a bilaterally symmetrical shape with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder, thereby reducing the risk of cavitation erosion damage due to the accelerated cross-flow induced by the rotating propeller onto the rudder. Further, the rudder according to the embodiment prevents the cavitation on the rudder surface around the discontinuous plane at the asymmetrically located sections in the leading edge parts of the upper and lower blades by a vortex generated at a hub of the propeller.

[0016] Further, according to the embodiment, the discontinuous plane is divided into two parts, thereby distributing twisting or shear load.

[0017] Further, according to the embodiment, the leading edge part of the middle blade has a bilaterally symmetrical shape, thereby improving productivity as compared with the conventional rudder, the overall section of the leading part of which has an asymmetrical shape.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Figure 1 is a partial side view of a ship including a rudder according to one embodiment of the present disclosure;

Figure 2 is a perspective view of a rudder according to one embodiment of the present disclosure;

Figure 3 is a front view of the rudder according to the embodiment of the present disclosure; and

Figure 4 is a plan view of the rudder according to the embodiment of the present disclosure.

## DETAILED DESCRIPTION

[0019] Exemplary embodiments of the present disclosure will now be described in detail with reference to the accompanying drawings.

[0020] Figure 1 is a partial side view of a ship including a rudder according to one embodiment, Figure 2 is a perspective view of a rudder according to one embodiment, Figure 3 is a front view of the rudder according to the embodiment, and Figure 4 is a plan view of the rudder according to the embodiment. Referring to Figure 1, a ship rudder 4 according to one embodiment is provided behind a propeller 2 located at the stern of a ship 1 to control a movement direction of the ship 1.

[0021] In this embodiment, a full-spade rudder will be illustrated as one example of the rudder 4. The rudder 4 is provided to a rudder trunk 3 located at the stern of the ship 1. Figure 1 shows the rudder connected to the rudder trunk 3, and Figures 2 to 4 show only the rudder.

[0022] Recently, full-spade rudders have been developed for large vessels.

[0023] The full-spade rudder is formed at an upper surface thereof with a rudder stock, which is inserted into a lower surface of the rudder trunk at the stern via bearings such that the full-spade rudder can be rotatably supported by the rudder trunk. Such a full-spade rudder is well-known in the art and details thereof are not shown in Figure 1.

[0024] The rudder 4 is generally divided into a middle blade 4a located around an axis L1 of the propeller 2 and upper and lower blades 4b and 4c located at upper and lower sides of the middle blade 4a, respectively. Each of the middle, upper and lower blades 4a, 4b, 4c is also divided into a leading edge part 41a, 41b, 41c corresponding to a front part of the rudder 4 and a trailing edge part 42a, 42b, 42c corresponding to a back part of the rudder 4. Referring to Figures 2 to 4, the terms "leading edge part" and "trailing edge part" herein refer to the front and back parts of the rudder 4 with reference to a maximum thickness spanwise centerline L3, respectively.

[0025] Referring to Figure 3, the axis L1 of the propeller 2 is indicated by a dotted line. A perpendicular centerline L2 of the rudder 4 is a spanwise centerline orthogonal to the rudder 4 and crosses the axis L1 of the propeller 2 and the maximum thickness spanwise centerline L3.

[0026] In the rudder 4 according to this embodiment, the leading edge part 41a of the middle blade 4a has a bilaterally symmetrical shape with respect to a plane passing through the axis L1 of the propeller 2 and the perpendicular centerline L2 of the rudder 4. The leading edge part 41b of the upper blade 4b is twisted at a predetermined angle with respect to the plane passing through the axis L1 of the propeller 2 and the perpendicular centerline L2 of the rudder 4 to be biased in a reverse rotational direction of the propeller 2. The leading edge part 41c of the lower blade 4c is twisted at a predetermined angle with respect to the plane passing through the axis L1 of the propeller 2 and the perpendicular cen-

terline L2 of the rudder 4 to be biased in a forward rotational direction of the propeller 2. Here, the forward rotational direction of the propeller 2 is a rotational direction of the propeller when the ship is advancing, and the reverse rotational direction of the propeller 2 is a rotational direction of the propeller 2 when the ship is reversing.

**[0027]** More specifically, in the case where the forward rotational direction of the propeller is the clockwise direction (when viewing the propeller 2 from behind the ship), the leading edge part 41b of the upper blade 4b is twisted towards the port of the ship on the axis L1 of the propeller 2, and the leading edge part 41c of the lower blade 4c is twisted towards the starboard of the ship on the axis L1 of the propeller 2.

**[0028]** When the leading edge parts 41b, 41c of the upper and lower blades 4b, 4c are twisted at a predetermined angle on the axis L1 of the propeller 2, the leading edge parts 41b, 41c of the upper and lower blades 4b, 4c must be twisted towards the port and the starboard of the ship, respectively, in order to counterbalance the asymmetrical pressure acting on the rudder surface due to the trailing flow induced onto the rudder and rotating in one direction by the propeller rotating in one direction (right-screw direction).

**[0029]** The middle blade 4a may have a vertical length corresponding to 15 to 30% of the diameter of the propeller 2.

**[0030]** Further, as illustrated in Figure 4, the leading edge part 41b of the upper blade 4b and the leading edge part 41c of the lower blade 4c may be twisted at an angle ( $\alpha, \beta$ ) of 2 to 8 degrees with respect to the plane passing through the axis L1 of the propeller 2 and the perpendicular centerline L2 of the rudder 4. Here, it should be noted that the angle  $\alpha$  may be the same as or different from the angle  $\beta$ .

**[0031]** Further, in this embodiment, on a cross-section of the upper and lower blades 4b, 4c of the rudder 4, each of the leading edge parts 41b, 41c is twisted, from a point through which the perpendicular centerline L2 of the rudder passes, at a predetermined angle with respect to the plane passing through the axis L1 of the propeller 2 and the perpendicular centerline L2 of the rudder 4, as shown in Figure 4.

**[0032]** In this embodiment, the leading edge parts 41b, 41c of the upper and lower blades 4b, 4c of the rudder 4 are illustrated as being linearly twisted with respect to the plane passing through the axis L1 of the propeller 2 and the perpendicular centerline L2 of the rudder 4 (see Figure 3). In another embodiment, however, the leading edge parts 41b, 41c of the upper and lower blades 4b, 4c of the rudder 4 may be curvedly twisted with respect to the plane passing through the axis L1 of the propeller 2 and the perpendicular centerline L2 of the rudder 4.

**[0033]** Further, in this embodiment, the leading edge part 41a of the middle blade 4a does not form a step, with respect to the leading edge parts 41b, 41c of the upper and lower blades 4b, 4c, at sides of the rudder in twisted directions of the upper and lower blades 41b, 41c,

but forms steps, where the leading edge part 41a of the middle blade 4a meets the leading edge parts 41b, 41c of the upper and lower blades 4b, 4c, at sides of the rudder in directions opposite to the twisted directions of the upper and lower blades 4b, 4c, respectively.

**[0034]** In this embodiment, the leading edge part 41a of the middle blade 4a is illustrated as having a streamlined blunt cross-section. Although many cavitation experiments have clearly shown that the leading edge parts having a blunt cross-section are effective in reducing influence of a vortex at a propeller hub, the existing rudders are still formed to have sharp leading edge parts due to inherent purpose of the ship rudder. In this embodiment, in the middle blade 4a which is affected by the vortex at the propeller hub, the leading edge part 41a is formed to have the blunt cross-section, thereby minimizing the influence by the hub vortex.

**[0035]** As such, in the rudder 4 according to the embodiment, each of the leading edge parts 41b, 41c of the upper and lower blades 4b, 4c is twisted at a predetermined angle with respect to the plane passing through the axis L1 of the propeller 2 and the perpendicular centerline L2 of the rudder 4, and the leading edge part 41a of the middle blade 4a located around the axis L1 of the propeller 2 has a bilaterally symmetrical shape with respect to the plane passing through the axis L1 of the propeller 2 and the perpendicular centerline L2 of the rudder 4. Accordingly, the rudder 4 can reduce the risk of cavitation erosion damage due to the accelerated cross-flow induced by the rotating propeller 2 onto the rudder 4. Further, the rudder 4 prevents the cavitation on the rudder surface around the discontinuous plane at the asymmetrically located sections in the leading edge parts 41b, 41c of the upper and lower blades 4b, 4c by a vortex generated at a hub 2a of the propeller 2.

**[0036]** Further, according to the embodiment, the discontinuous plane is divided into two parts, thereby distributing twisting or shear load.

**[0037]** Further, according to the embodiment, the leading edge part 41a of the middle blade 4a has a bilaterally symmetrical shape, thereby improving productivity as compared with the conventional rudder, the overall section of the leading part of which has an asymmetrical shape.

**[0038]** The various embodiments described above can be combined to provide further embodiments. Aspects of the embodiments can be modified, if necessary, to employ concepts of the various patents, applications and publications to provide yet further embodiments. These and other changes can be made to the embodiments in light of the above-detailed description. In general, in the following claims, the terms used should not be construed to limit the claims to the specific embodiments disclosed in the specification and the claims, but should be construed to include all possible embodiments along with the full scope of equivalents to which such claims are entitled. Accordingly, the claims are not limited by the disclosure.

## Claims

1. A rudder (4) for a ship (1) disposed behind a propeller (2) at a stern of the ship to control a movement direction of the ship, **characterized by** comprising:
 

a middle blade (4a) located around an axis of the propeller; and

upper and lower blades (4b, 4c) located at upper and lower sides of the middle blade, wherein the middle blade (4a) has a leading edge part (41a) having a bilaterally symmetrical shape with respect to a plane passing through the axis (L1) of the propeller and a perpendicular centerline (L2) of the rudder, wherein the upper blade (4b) has a leading edge part (41b) twisted with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder to be biased in a reverse rotational direction of the propeller, wherein the lower blade (4c) has a leading edge part (41c) twisted with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder to be biased in a forward rotational direction of the propeller, and wherein the leading edge part of the middle blade does not form a step, with respect to the leading edge parts of the upper and lower blades, at sides of the rudder in twisted directions of the upper and lower blades, but forms steps, where the leading edge part of the middle blade meets the leading edge parts of the upper and lower blades, at sides of the rudder in directions opposite to the twisted directions of the upper and lower blades, respectively.
2. The rudder (4) according to claim 1, wherein, in the case where the forward rotational direction of the propeller is a clockwise direction when viewing the propeller from behind the ship, the leading edge part (41b) of the upper blade (4b) is twisted towards port of the ship on the axis of the propeller, and the leading edge part (41c) of the lower blade (4c) is twisted towards starboard of the ship on the axis of the propeller.
3. The rudder (4) according to claim 2, wherein each of the leading edge parts of the upper and lower blades (4b, 4c) is twisted at an angle of 2 to 8 degrees with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder.
4. The rudder (4) according to claim 2 or 3, wherein each of the leading edge parts of the upper and lower blades (4b, 4c) is curvedly twisted with respect to the plane passing through the axis of the propeller and the perpendicular centerline of the rudder.
5. The rudder (4) according to any one of claims 1 to 4, wherein the leading edge part of the middle blade (4a) has a vertical length corresponding to 15 to 30% of a diameter of the propeller.
6. The rudder (4) according to any one of claims 1 to 5, wherein the leading edge part of the middle blade has a streamlined blunt cross-section.
7. The rudder (4) according to any one of claims 1 to 6, wherein, in each of the upper and lower blades, an offset distance of the leading edge part to a centerline of a section of the rudder (4) is limited to within half of a maximum thickness of the section of the rudder.

FIG. 1

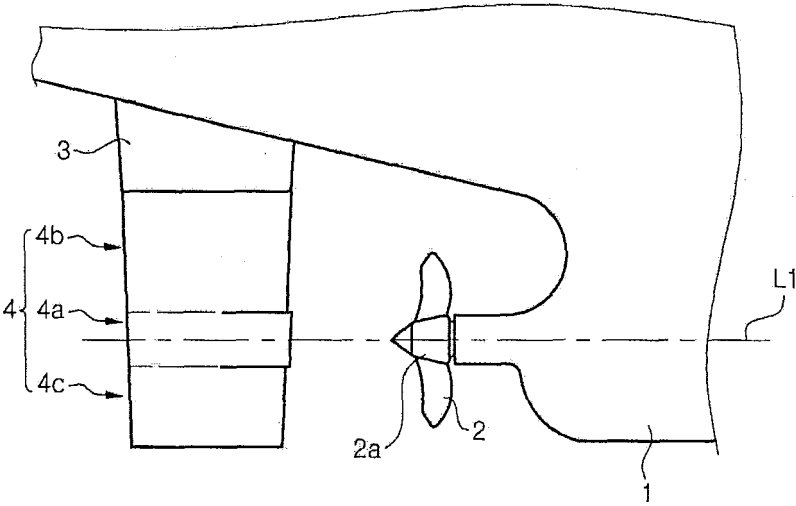


FIG. 2

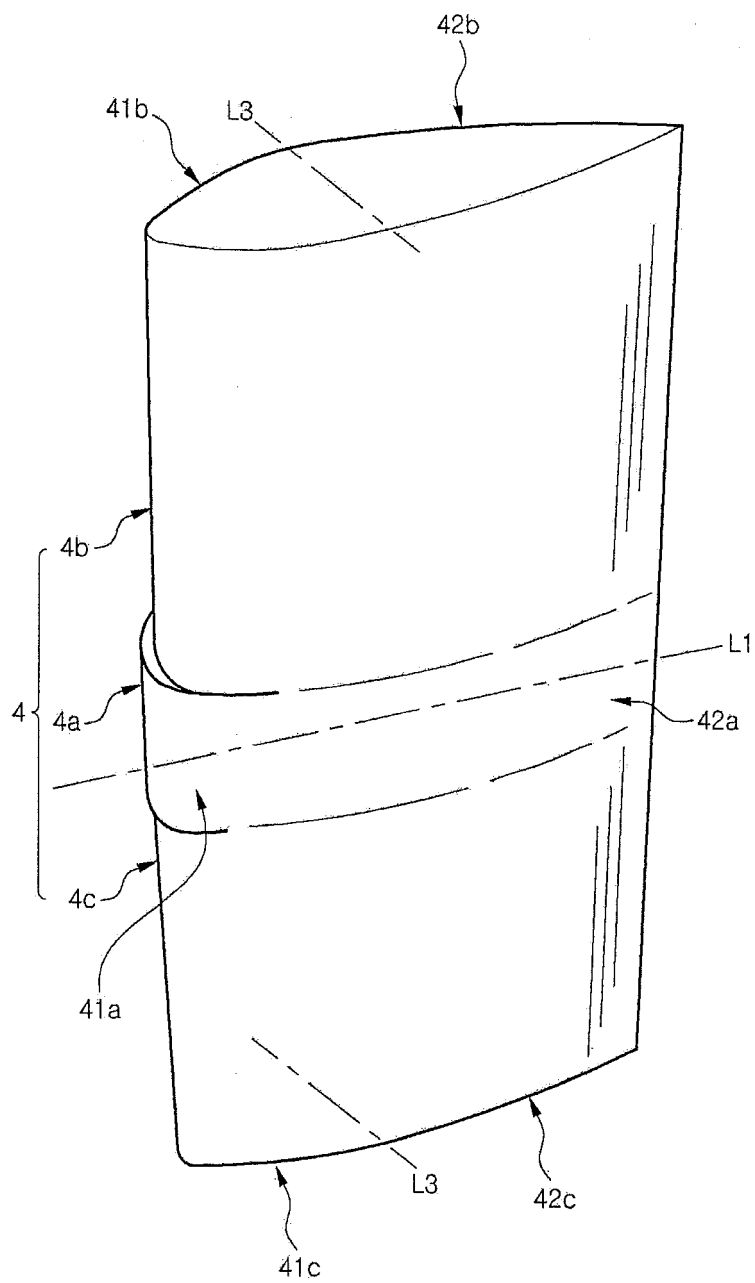


FIG. 3

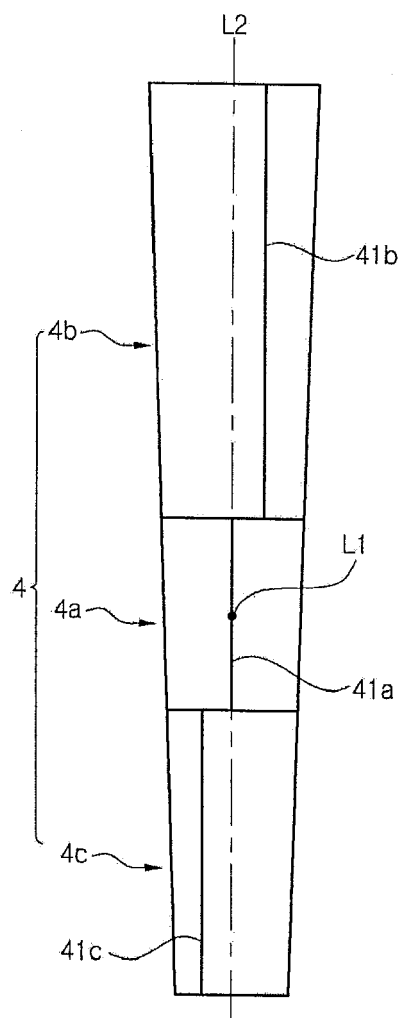


FIG. 4

