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Wilkie

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(54) **PROPELLER WITH VARIABLE GEOMETRY AND METHOD FOR VARYING GEOMETRY OF A PROPELLER**

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B63H 1/22 (2006.01)
B64C 11/28 (2006.01)
B64C 27/50 (2006.01)

(52) **U.S. Cl.** **440/49**; 416/88; 416/142

(58) **Field of Classification Search** .... 440/49, 440/50; 416/87, 88, DIG. 5, 142, 143; 244/218, 244/219

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,716,460 A * 8/1955 Young 416/24
2,852,207 A * 9/1958 Jovanovich .... 244/7 R
2,885,012 A * 5/1959 Heintzelman 416/88
2,996,121 A * 8/1961 Stub 416/88
3,249,160 A * 5/1966 Messerschmitt 416/174
5,024,031 A 6/1991 Hoberman

FOREIGN PATENT DOCUMENTS

JP 08142987 A * 6/1996

OTHER PUBLICATIONS

U.S. Appl. No. 10/613,172, Filed Jul. 3, 2003 (Wilkie).

* cited by examiner

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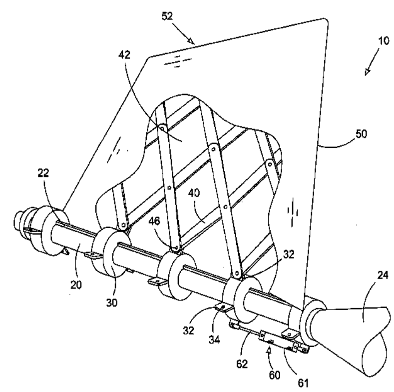
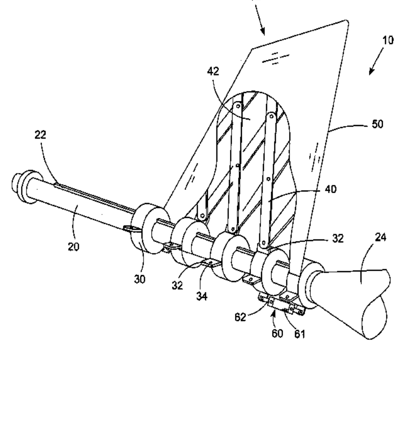
(57) **ABSTRACT**

The present invention broadly comprises a propeller having a blade assembly with a plurality of linking members operatively connected to change dimensions of the blade assembly as the linking members are moved with respect to one another. It further includes a blade surface operatively arranged to cover at least a portion of the blade assembly and to change shape in response to the changes in the dimensions for the blade assembly.

26 Claims, 13 Drawing Sheets





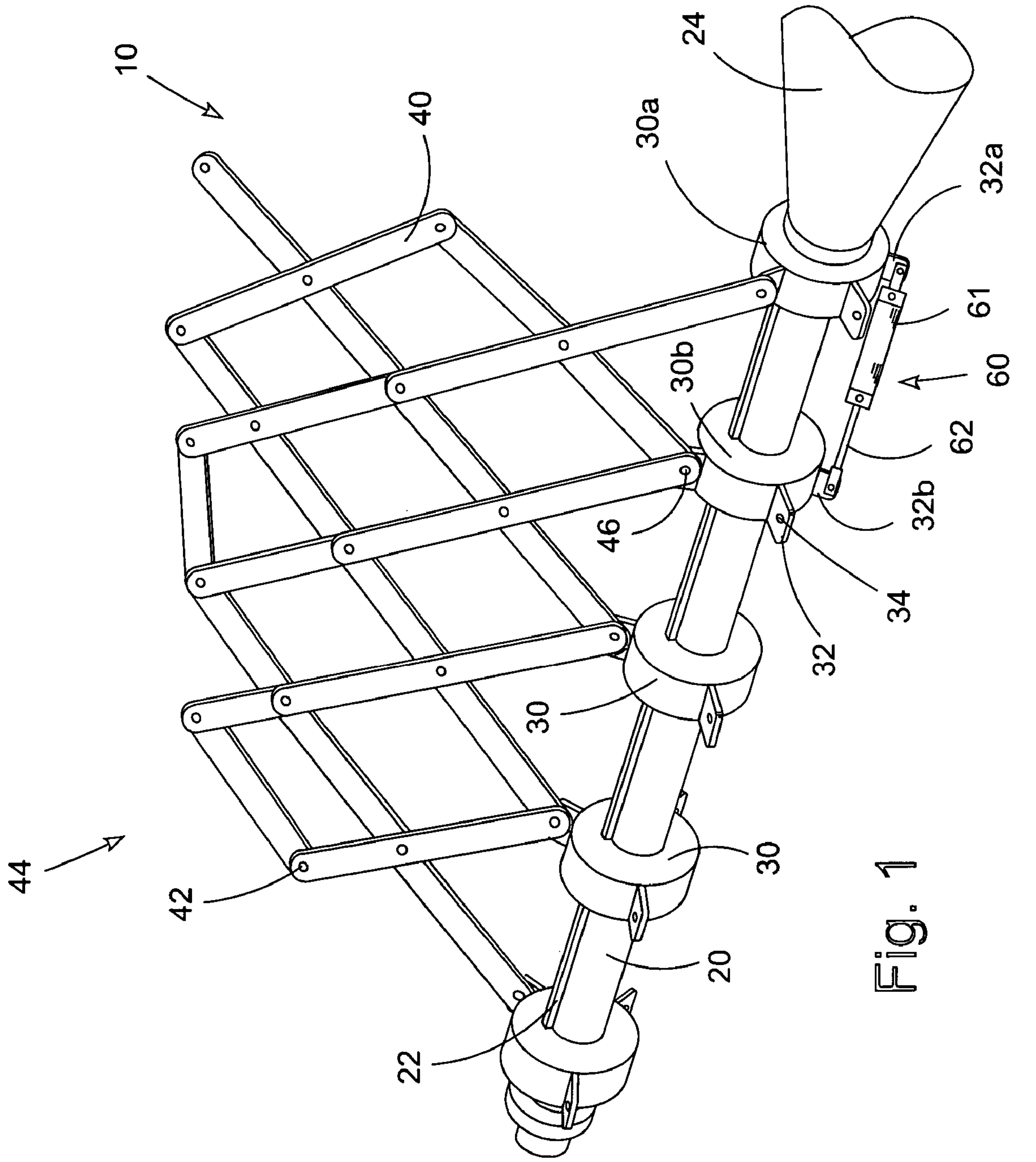


Fig. 1

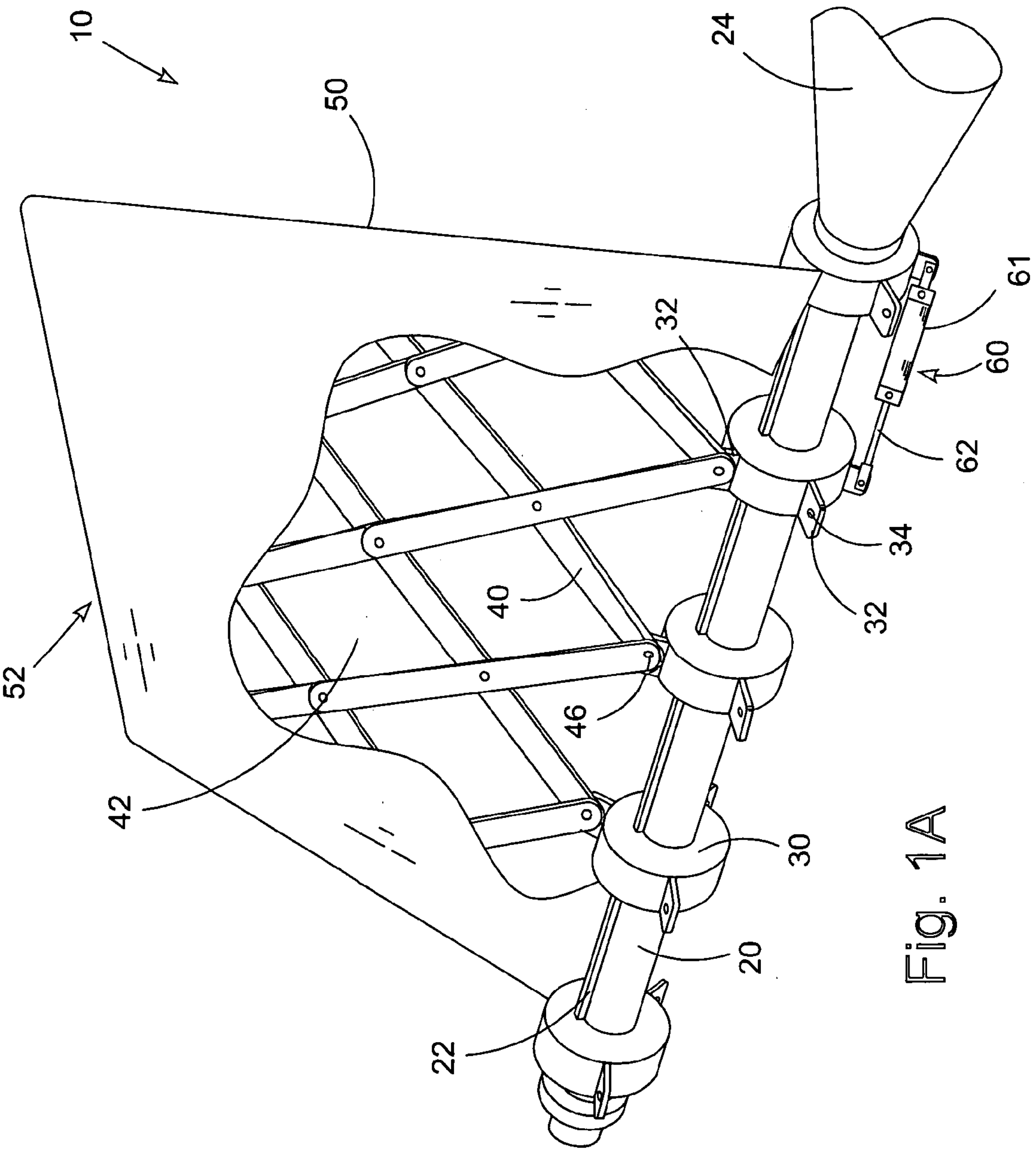


Fig. 1A

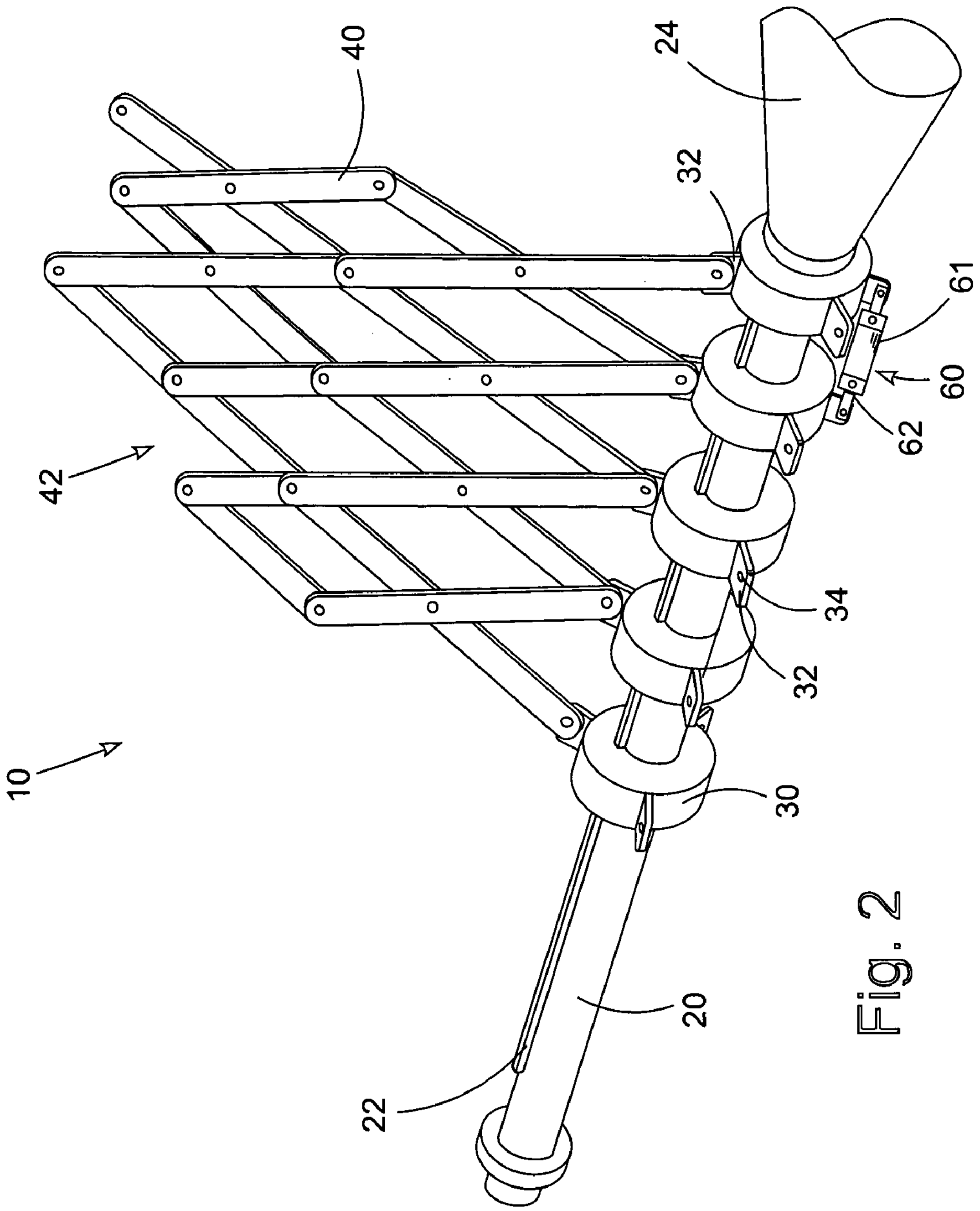


Fig. 2

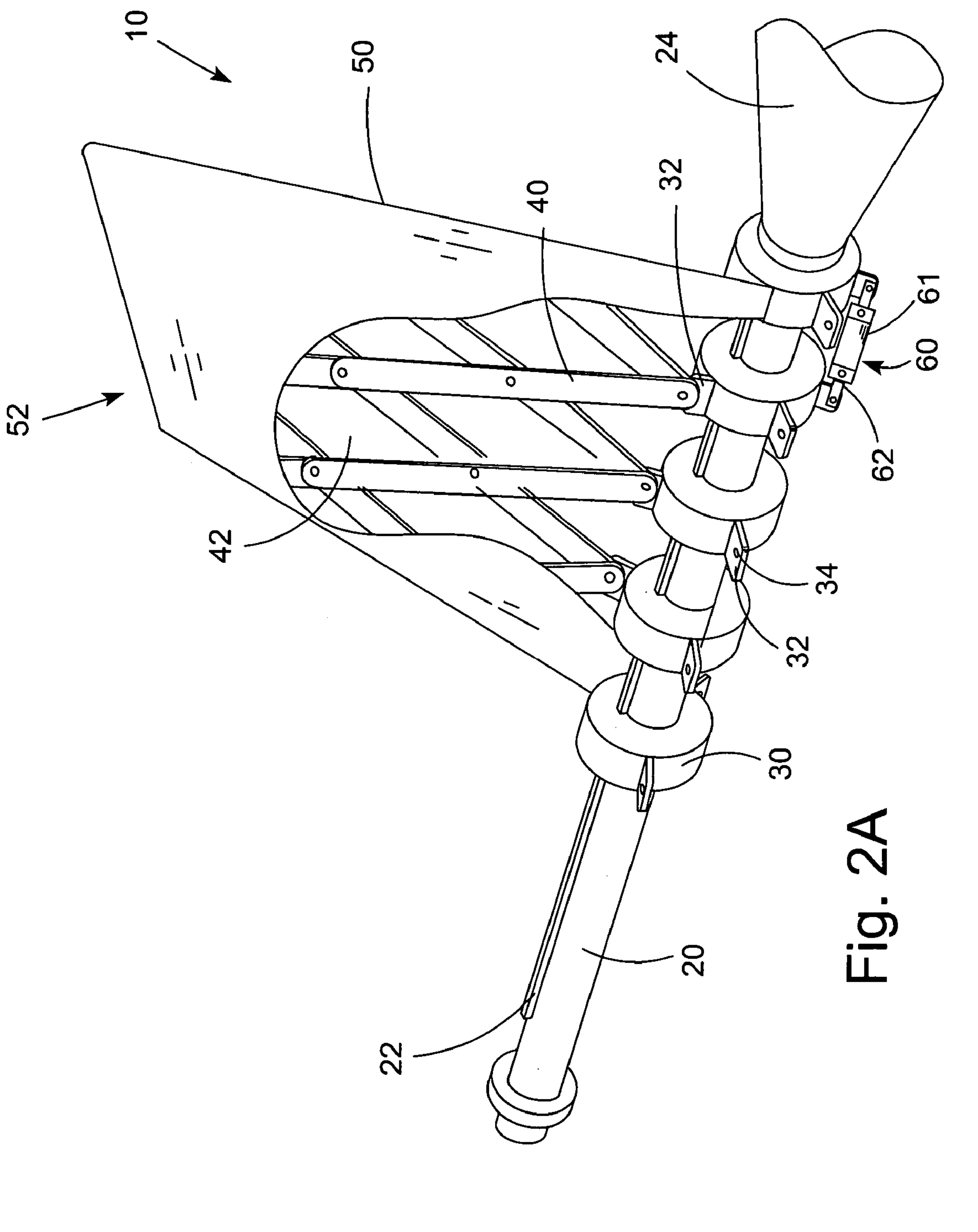


Fig. 2A

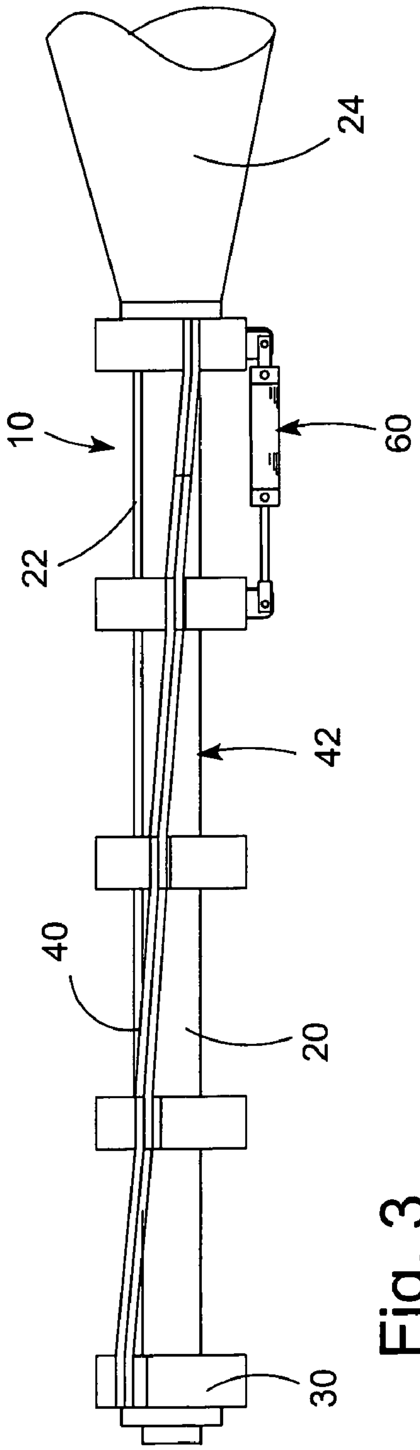


Fig. 3

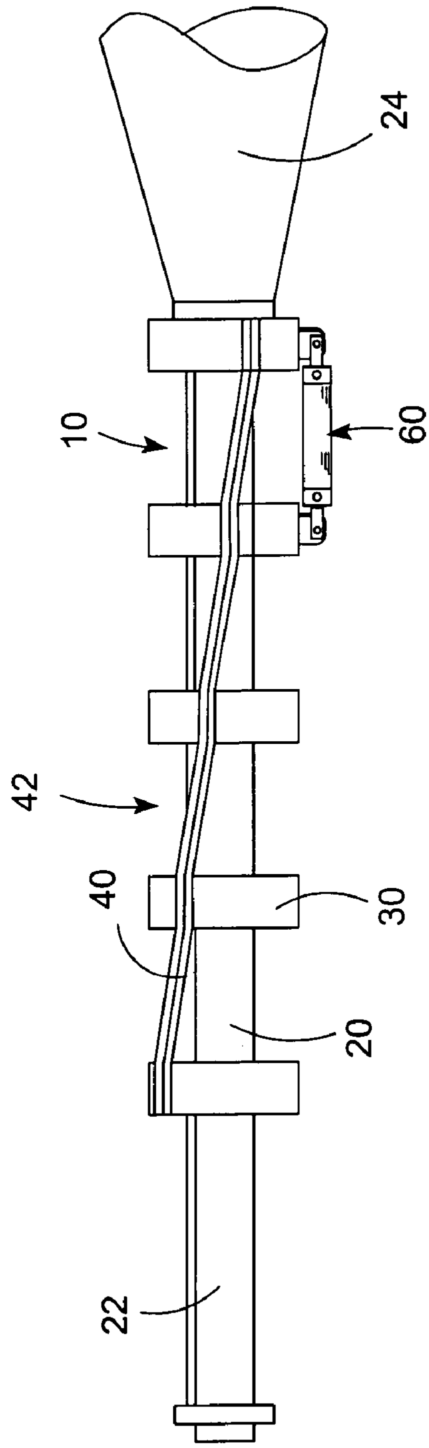


Fig. 4

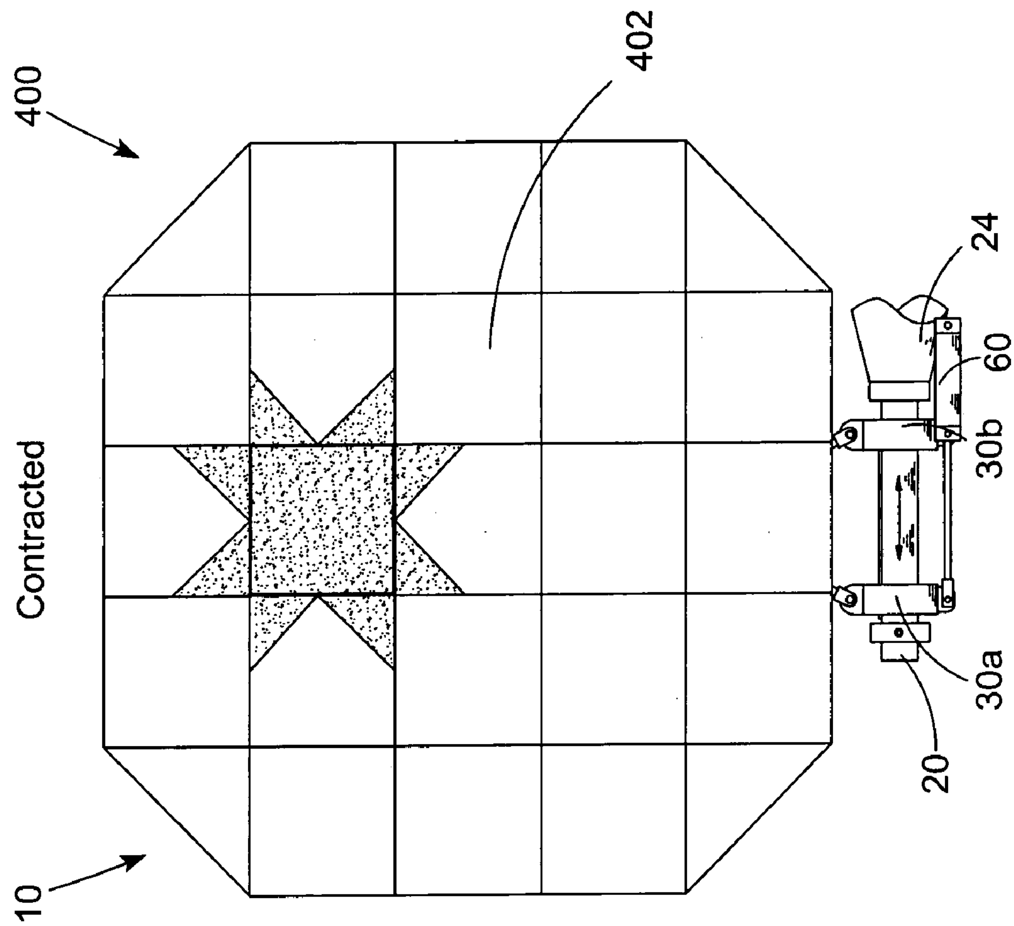


Fig. 5A

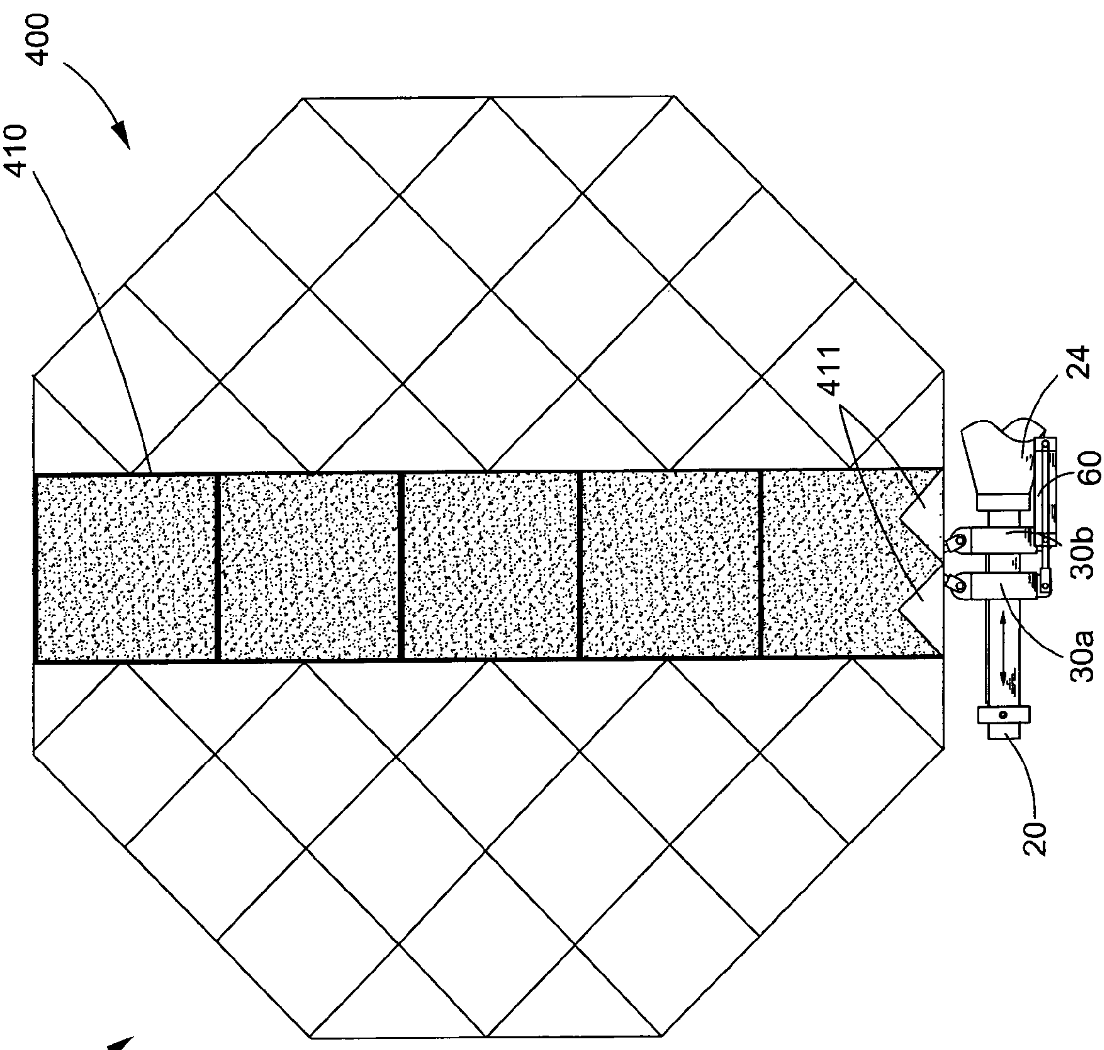


Fig. 5B

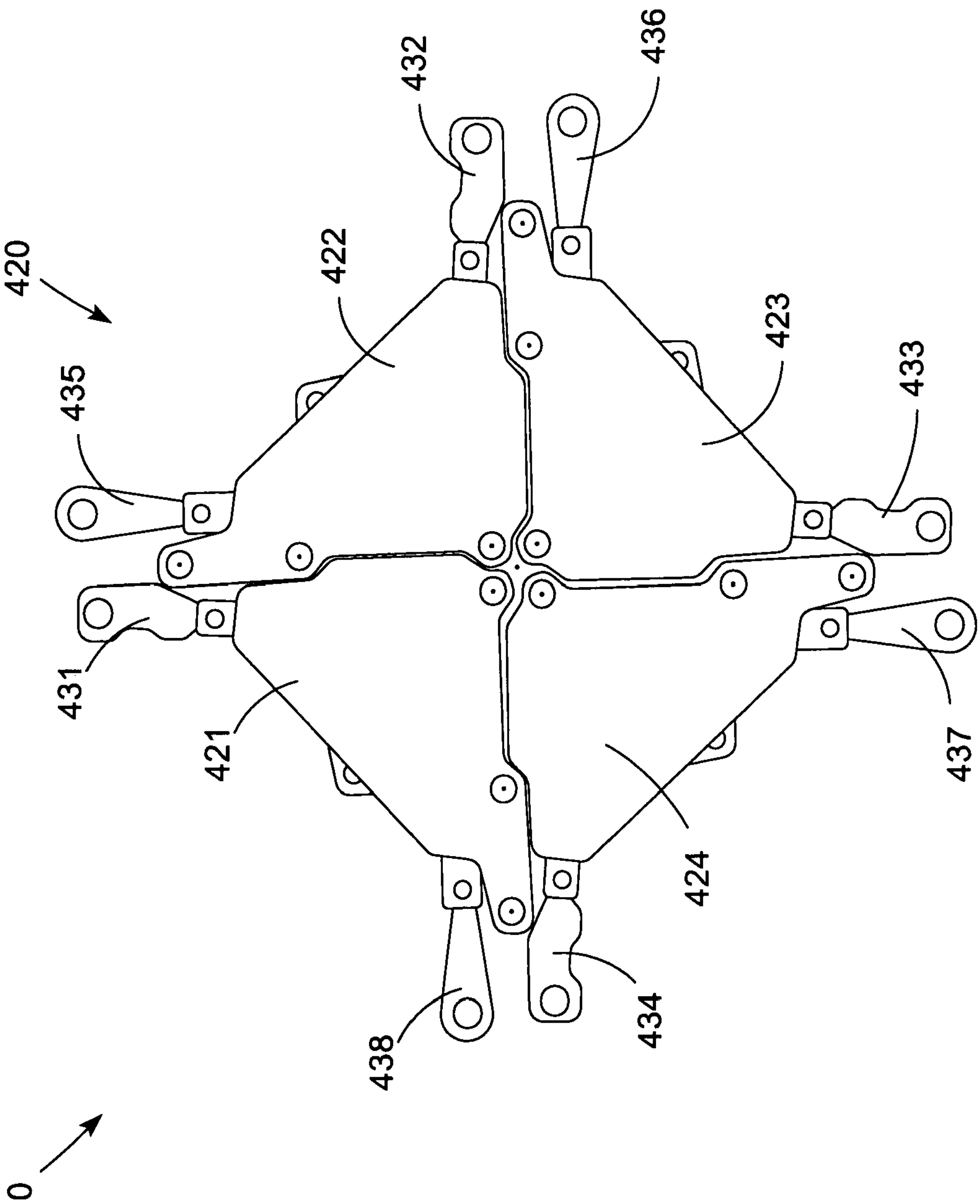


Fig.6A

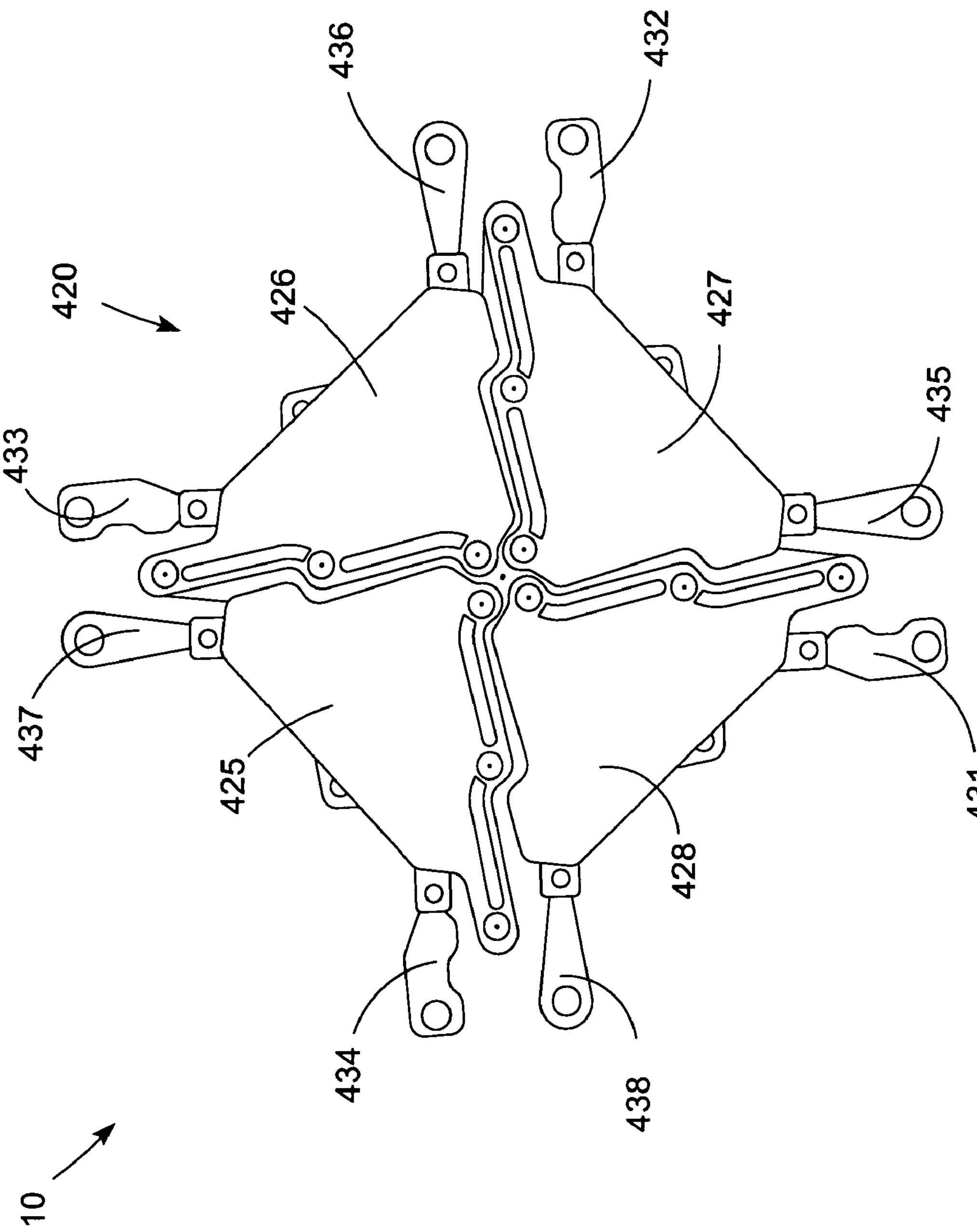


Fig. 6B

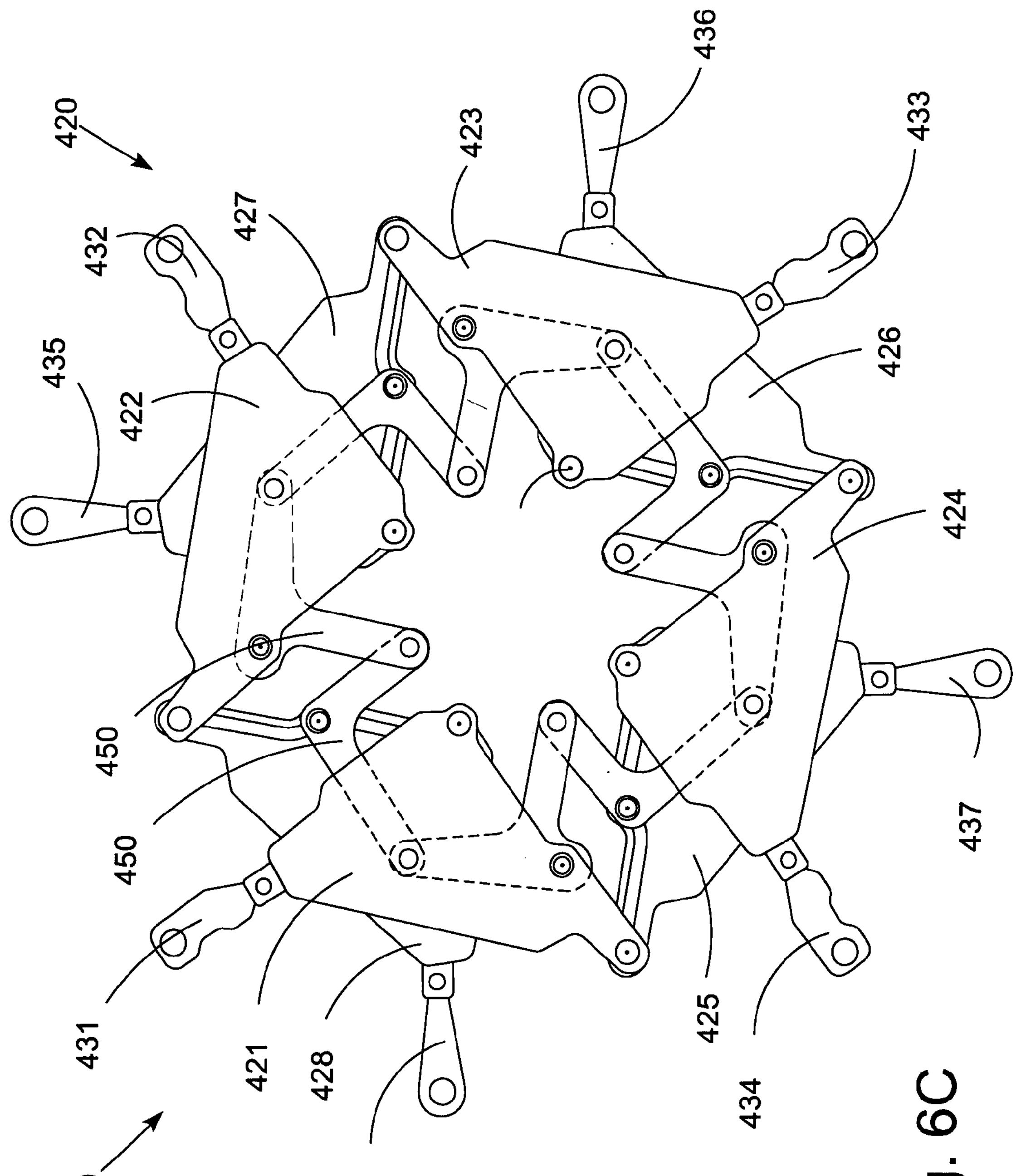

420
436
433
423
427
432
435
422
426
424
437
450
450
431
421
428
425
434
438
10

Fig. 6C

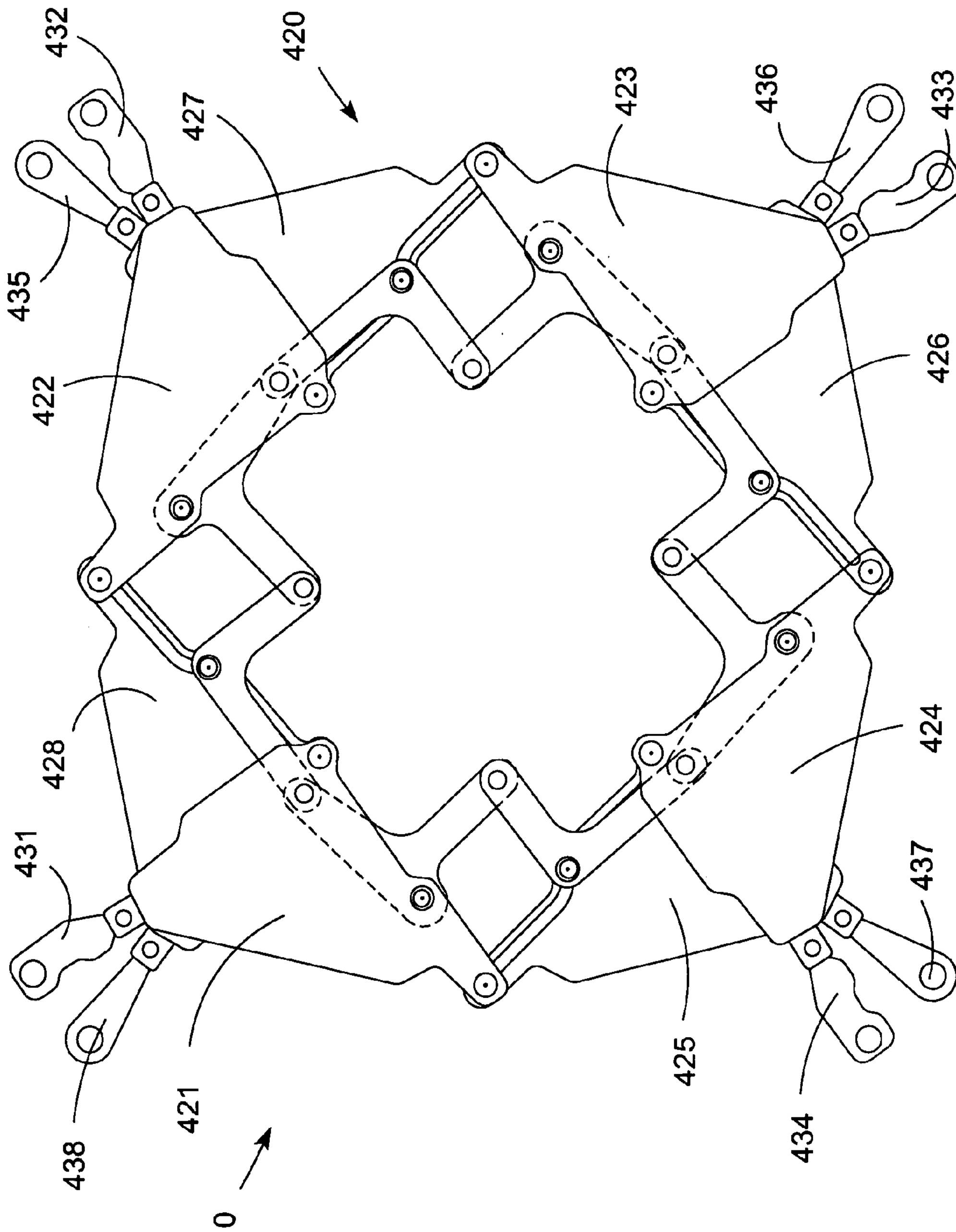

432
420
427
423
436
433
435
422
426
428
424
431
437
438
421
425
434
10

Fig. 6D

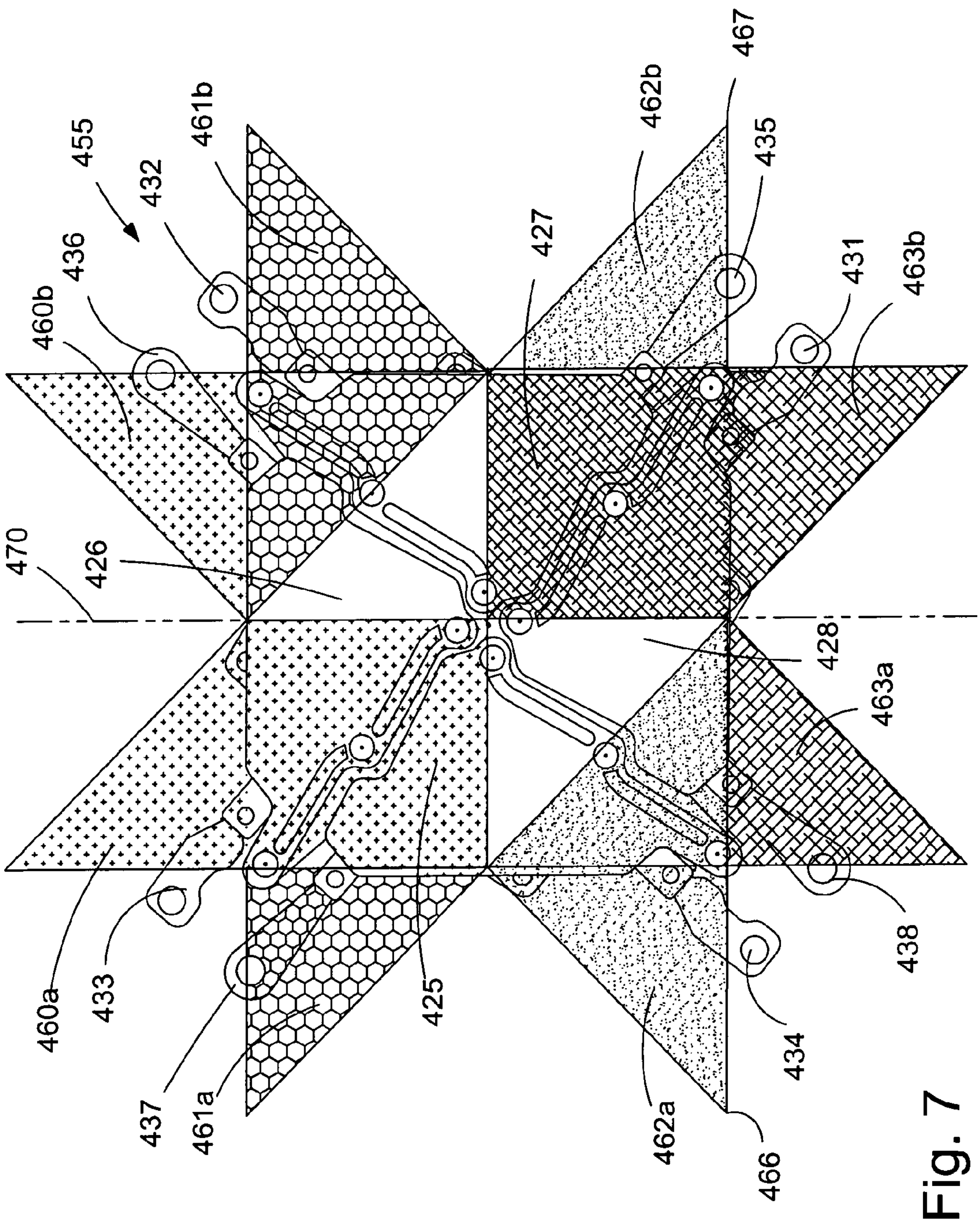

455
432
436
460b
461b
462b
467
435
427
431
463b
470
426
428
463a
425
438
434
466
462a
461a
437
433
460a

Fig. 7

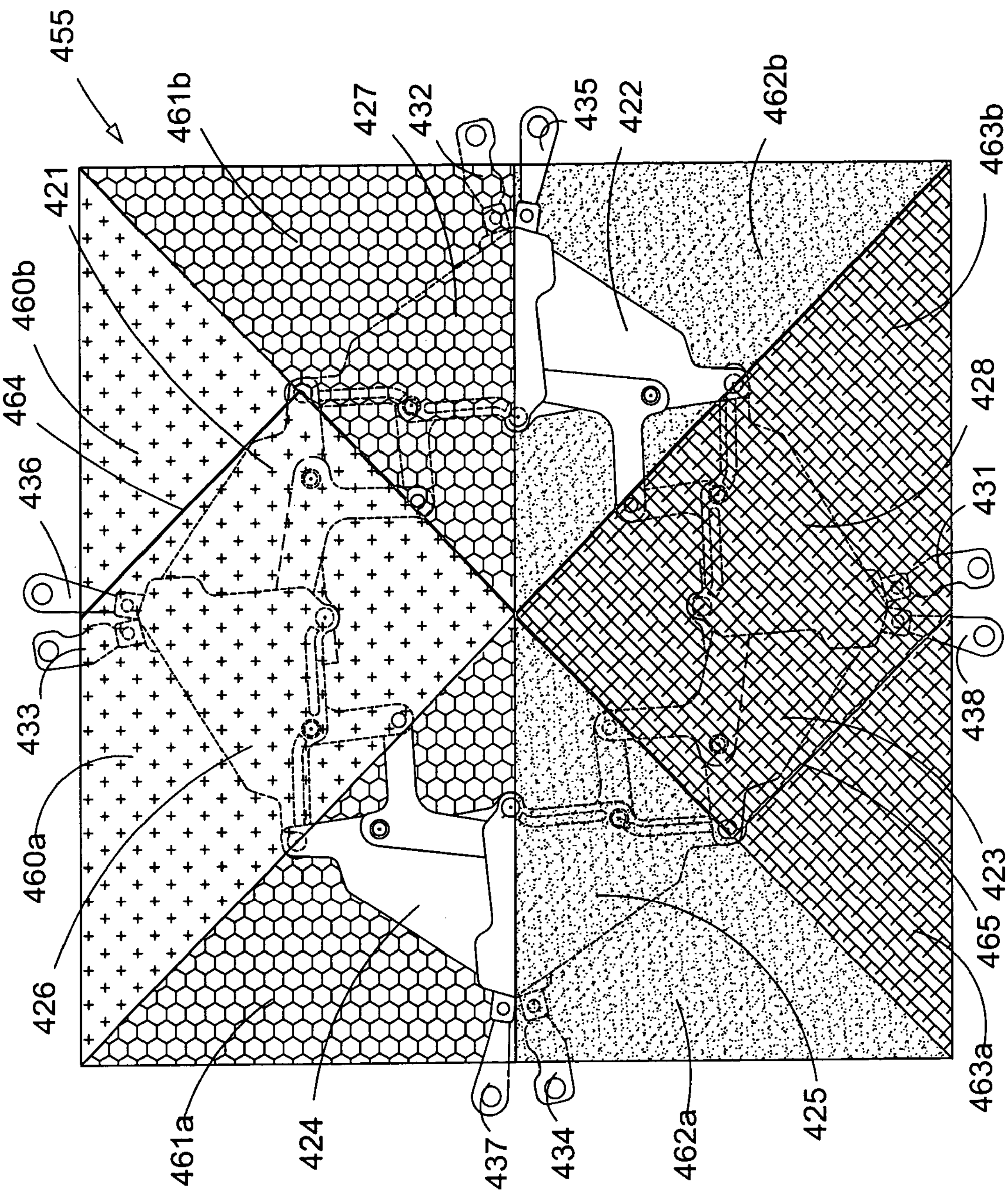

455
461b
427
432
435
422
462b
463b
421
460b
464
436
433
460a
426
461a
424
437
434
462a
425
463a
465
423
438
431
428

Fig. 8

PROPELLER WITH VARIABLE GEOMETRY AND METHOD FOR VARYING GEOMETRY OF A PROPELLER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. §119 (e) of U.S. Provisional Application No. 60/442,129, filed Jan. 24, 2003.

FIELD OF THE INVENTION

This invention relates to the construction of propellers. More specifically it relates to a propeller having propeller blades with variable dimensions. Even more specifically, the present invention relates to an aircraft or waterborne or submersible craft having a propeller whose size and shape can be modified.

BACKGROUND OF THE INVENTION

Aircraft and waterborne and submersible vessels are typically constructed having propellers of fixed dimensions. The dimensions chosen affect the amount of force created by the propeller per unit torque on the propeller shaft. A greater diameter is desired for many applications. However, a fixed diameter propeller is limited in size by, for example, the need for an aircraft to land and for a waterborne or submersible craft to enter port.

Clearly, then, there is a longfelt need for a vessel having a propeller with variable dimensions.

SUMMARY OF THE INVENTION

The present invention broadly comprises a propeller having a blade assembly with a plurality of linking members operatively connected to change dimensions of the blade assembly as the linking members are moved with respect to one another. It further includes a blade surface operatively arranged to cover at least a portion of the blade assembly and to change shape in response to the changes in the dimensions for the blade assembly.

A general object of the present invention is to provide a propeller having variable dimensions.

Another object of the present invention is to provide a propeller blade having variable dimensions.

Yet another object of the present invention is to provide a propeller having a variable shape.

Still another object of the present invention is to provide a propeller blade having a variable shape.

These and other objects, features and advantages of the present invention will become readily apparent to those having ordinary skill in the art upon a reading of the following detailed description of the invention in view of the drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The nature and mode of operation of the present invention will now be more fully described in the following detailed description of the invention taken with the accompanying drawing figures, in which:

FIG. **1** is a perspective view of the present invention propeller in an expanded configuration;

FIG. **1**A is a perspective view of the propeller shown in FIG. **1** with a flexible member covering the folding lattice;

FIG. **2** is a perspective view of the propeller with the folding lattice in a contracted configuration;

FIG. **2**A is a perspective view of the propeller shown in FIG. **2** with a flexible membrane covering the folding lattice;

FIG. **3** is a top view of the propeller shown in FIG. **1**;

FIG. **4** is a top view of the propeller shown in FIG. **2**;

FIG. **5**A is an expanded or flattened view of a second embodiment of the propeller in a contracted configuration;

FIG. **5**B is an expanded view of the second embodiment in an expanded configuration;

FIG. **6**A is a front view of a truss for the second embodiment in a contracted configuration;

FIG. **6**B is a back view of the truss for the second embodiment in a contracted configuration;

FIG. **6**C is a front view of the truss in a partially expanded/contracted configuration;

FIG. **6**D is a front view of the truss in an expanded configuration;

FIG. **7** is a back view of a plate assembly, in a contracted configuration, corresponding to the area shown in FIG. **5**A; and,

FIG. **8** is a back view of the plate assembly, in an expanded configuration, corresponding to the area shown in FIG. **5**B.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

It should be appreciated that, in the detailed description of the invention that follows, like reference numbers on different drawing views are intended to identify identical or similar structural elements of the invention in the respective views.

Furthermore, it is understood that this invention is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is also understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to limit the scope of the present invention, which is limited only by the appended claims.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this invention belongs. Although any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the invention, the preferred methods, devices, and materials are now described.

The invention broadly comprises a propeller with a blade assembly having variable dimensions. The invention further comprises an adjustable blade surface that changes size and shape and covers at least a portion of the blade assembly. The blade assembly may be a radial extension/retraction truss structure as disclosed by U.S. Pat. No. 5,024,031 (Hoberman), incorporated by reference herein.

FIG. **1** is a perspective view of the present invention propeller **10** in an expanded configuration. Shaft **20** includes a key **22** running the length of shaft **20**. However, any number of key members may be used. Shaft **20** is connected to member **24**, which delivers torque from a vehicle power plant (not shown) to shaft **20**. Collars **30** radially surround shaft **20** and include a slot that engages key **22**, preventing collars **30** from rotating about shaft **20** as power is applied to member **24** to rotate shaft **20**. However, it should be readily apparent to one skilled in the art that other means of preventing rotation of collars **30** may be used, and such means are within the spirit and scope of the invention as claimed. Collars **30** can slide longitudinally along shaft **20**.

Each collar **30** has a collar extension **32** with aperture **34**. Respective extensions **32** can be located at various radial angles with respect to a radial axis for shaft **20**. The angles can be varied to provide a desired blade pitch, as further described below. However, it should be readily apparent to one skilled in the art that other angle configurations are possible, and such configurations are within the spirit and scope of the invention as claimed.

Lattice bars, or linking members, **40** are substantially straight in shape and have a plurality of pivoting connection points **42**, aligned in a straight line. It should be readily apparent to one skilled in the art that other shapes are possible for bars **40**, and that such shapes are within the spirit and scope of the invention as claimed. Collectively, bars **40** form folding lattice **44**. Folding lattice **44** is pivotally connected to respective collar extensions **32** using fasteners **46** that extend through apertures (not shown) in bars **40** and apertures **34** in collar extensions **32**. The connection between collars **30** and bars **40** may have a generous tolerance or may pivot or fold to allow a small amount of rotation about an axis radial from shaft **20** and through the connection. Folding lattice **44** forms the basic structure for a propeller blade as is further described below. Bars **40** may be identical for efficiency of production, or individually designed for operation efficiency or strength, with different cross sections to better approximate typical foil sections when assembled.

FIG. **1** shows each collar **30** with three collar extensions **32**, corresponding to attachment points for three folding lattice **44** assemblies (only one of which is shown). To simplify this presentation, only one folding lattice assembly is shown in FIG. **1**. It should be readily apparent to one skilled in the art that any number of collar extensions may be used on collars **30**, and that such number of collar extensions is within the spirit and scope of the invention as claimed. Linear actuator **60** is substantially parallel to the longitudinal axis of shaft and is connected to collar extensions **32***a* and **32***b*. However, it should be readily apparent to one skilled in the art that actuator **60** can be connected to other or additional collars extensions **32**, and such connections are within the spirit and scope of the invention as claimed. Collar extensions **32***a* and **32***b* are connected to collars **30***a* and **30***b*, respectively. Actuator **60** has a body **61** connected to collar extension **32***a* and a shaft **62** connected to collar extension **32***b*. Actuator **60** moves shaft **62** substantially parallel to the longitudinal axis of shaft **20**. That is, the actuator **60** extends or withdraws shaft **62** with respect to body **61**. In FIG. **1**, shaft **62** is extended. Movement of shaft **62** causes movement of collars **30***a* and **30***b* and subsequently, movement of bars **40**. For example, in FIG. **1**, shaft **62** is extended, causing collars **30***a* and **30***b* to move further apart along shaft **20**. This movement of collars **30***a* and **30***b*, in turn, causes bars **40** to unfold, changing the configuration of folding lattice **44**. Specifically, the width of folding lattice **44** (measured substantially parallel to the longitudinal axis of shaft **20**) increases and the length of folding lattice **44** (measured substantially parallel to a radial axis of shaft **20**) decreases. It should be readily apparent to one skilled in the art that additional actuators may be used, and the use of such additional actuators is within the spirit and scope of the invention as claimed. The actuator **60** can be a pneumatic or hydraulic device or a micro-electrical-mechanical system (MEMS), or any other means known in the art. It should be understood that actuator **60** also could be directly connected to lattice bars **40** (not shown). The collars **30** then slide along shaft **20** responsive to the motion of the lattice bars. A rotational actuator may be similarly powered to rotate any adjacent or set of adjacent lattice bars **40** at their common pivot points **42**. In addition, a multiplicity of actuators can be used and combinations of linear and rotational actuators also are possible.

FIG. **1**A is a perspective view of the propeller **10** shown in FIG. **1** with a flexible member **50** covering the folding lattice **44**. In FIG. **1**A, folding lattice **44** is covered by flexible membrane **50**, forming propeller blade **52**. In some embodiments, membrane **50** is urethane. However, it should be readily apparent to one skilled in the art that other flexible materials may be used for membrane **50**, and that these materials are within the spirit and scope of the invention as claimed.

FIG. **2** is a perspective view of the propeller with the folding lattice **44** in a contracted configuration. In FIG. **2** actuator **60** is retracted. As a result, collars **30***a* and **30***b* move toward one another, changing the configuration of folding lattice **44**. Specifically, the width of lattice **44** in FIG. **2**A (measured substantially parallel to the longitudinal axis of shaft **20**) decreases and the length of lattice **44** (measured substantially parallel to a radial axis of shaft **20**) increases.

FIG. **2**A is a perspective view of the propeller **10** shown in FIG. **2** with a flexible membrane covering the folding lattice **44**.

The following discussion should be considered in light of both FIGS. **1**A and **2**A. In the retracted aspects, FIG. **2**A, and the extended aspects, FIG. **1**A, flexible membrane **50** conforms to the shape of folding lattice **44**. Flexible membrane **50** may be replaced by a multitude of plates (not shown) attached to folding lattice **44** so as to provide a complete (if not fluid-tight) surface on one or both sides of a blade, in at least two folding lattice **44** positions.

FIG. **3** is a top view of the propeller **10** shown in FIG. **1**.

FIG. **4** is a top view of the propeller **10** shown in FIG. **2**. The following discussion should be considered in light of FIGS. **1** through **4**. FIGS. **3** and **4** illustrate the radial spacing of extensions **32** about successive collars **30** on shaft **20**. For example, moving front right to left in FIG. **3**, collar extensions **32** on successive collars **30** are positioned further clockwise looking from the right hand end of shaft **20**. One propeller blade is shown in FIGS. **1**–**4** for simplicity. However, it should be readily apparent to one skilled in the art to include multiple blades to construct a full propeller.

FIG. **5**A is an expanded or flattened view of a second embodiment of the propeller **10** in a contracted configuration.

FIG. **5**B is an expanded view of the second embodiment in an expanded configuration. The following description should be considered in light of FIGS. **5**A and **5**B. In FIG. **5**A, expandable blade **400** is shown in a contracted configuration. In this configuration, blade **400** consists of a plurality of contracted areas **402**. Each of areas **402** has four pairs of plates. These pairs of plates partially overlap, as will be more fully described below. The plates are fully described below, however, to give a simplified overview of the areas **402**, plates for only one area **402** are shown. However, it is understood that the following description applies to each of areas **402** in blade **400**. The plates noted in the previous sentence are not labeled and boundaries between individual plates are not shown. Instead, only the outline of the plates is shown. Note that portions of the plates overlap into neighboring areas **402**. Each area **402** is associated with a truss structure (not shown, but described further below). The plates shown in FIG. **5**A are connected to a respective truss.

Blade **400** is connected to collars **30***a* and **30***b*.

FIG. **5**B shows blade **400** in the expanded configuration. In this configuration, blade **400** is made up of a plurality of expanded areas **410**. Each area **410** corresponds to an area **402**. To aid in understanding the transformation of areas **402** to areas **410**, five areas **410** are shaded in FIG. **5**B. The second area **410** from the top of the page for FIG. **5**B corresponds to area **402** in FIG. **5**A. To form an area **410**, a truss associated with a respective area **402** is expanded, as shown below. The force for this expansion is provided by the movement of collars **30***a* and **30***b* as is described below, and/or by rotation of any number of adjacent truss elements. As a result, the plates rotate and shift position, resulting in the plates occupying a greater area as shown in FIG. **5**B. Only the outline of the plates is shown in FIG. **5**B. The process also works in the reverse direction. That is, the above-mentioned truss can be contracted, causing the plates to rotate and shift position, resulting in the plates occupying a smaller area. A respective area **410** has approximately twice the surface area of a respective area **402**.

FIG. **6**A is a front view of a truss **420** for the second embodiment in a contracted configuration.

FIG. **6**B is a back view of the truss **420** for the second embodiment in a contracted configuration. The following should be considered in light of FIGS. **5**A, **5**B, **6**A, and **6**B. For each area **402** or area **410**, the respective truss noted above is formed by radial extension/retraction truss structure **420**. The truss structure **420** may be a radial extension/retraction truss structure as disclosed by U.S. Pat. No. 5,024,031 (Hoberman). FIG. **6**A shows the front of truss **420** and FIG. **6**B shows the back. It should be understood that the terms "front" and "back" are relative and therefore, fully interchangeable. Mounting members **421** through **424** are shown in FIG. **6**A and mounting members **425** though **428** are shown in FIG. **6**B. The above-described pairs of plates are securely attached, one plate each, to a corresponding mounting member as is further described below.

FIG. **6**C is a front view of the truss **420** in a partially expanded/contracted configuration.

FIG. **6**D is a front view of the truss **420** in an expanded configuration. The following should be considered in light of FIGS. **5**A, **5**B, **6**A, **6**C, and **6**D. In FIGS. **6**C and **6**D, the front side of truss **420** is shown. However, it is understood that the description that follows is applicable to the backside of truss **420** also. Mounting members **421** through **428** are connected to linking members **450**. Blade link points **431** through **434** are attached to mounting members **421** through **424**, respectively. Blade link points **435** through **438** are attached to mounting members **425** through **428**, respectively. Truss **420** expands and contracts due to the movements of linking members **450** in FIGS. **6**C and **6**D. To focus the present description on the essentials of the present invention, only a cursory explanation of the movement of linking members **450** is provided. The reader is referred to the incorporated patent for further details. Linking members **450** and the mounting members each form a closed loop and have pivoting connection points and pivoting/slotted connections points, enabling the mounting members to execute the relatively complex movements shown in FIGS. **6**C and **6**D.

Linking members **450** move in response to movement of blade link points **431** through **438**. For example, blade link points **433** and **436** could be connected to the collars as shown in FIGS. **5**A and **5**B. Then, as the collar link points are moved progressively closer, blade link points **433** and **436** move closer together, causing linking members **450** to pivot, slide, and move further apart with respect to one another. This results in the mounting members rotating and translating through space to realign in the expanded configuration shown in FIG. **6**D. Thus, the plates attached to the mounting members shift from the configuration shown in FIG. **5**A to the configuration shown in **5**B. Moving the collar link points further apart reverses this process.

It should be understood that actuator **60** also could be directly connected to linking members **450** (not shown). A rotational actuator may be similarly powered to rotate any adjacent or set of adjacent linking members **450** at their common pivot points. In addition, a multiplicity of actuators can be used and combinations of linear and rotational actuators also are possible.

FIG. **7** is a back view of a plate assembly **455**, in a contracted configuration, corresponding to the area **402** shown in FIG. **5**A. The following discussion should be considered in light of FIGS. **5**A, **6**A, **6**B, and **7**. The two plates in each of the four pairs of plates noted in the descriptions for FIG. **5**A are matched in size and shape. However, it should be readily apparent to one skilled in the art that the sizes and shapes need not be matched, and that such variation in sizes and shapes are within the spirit and scope of the invention as claimed. For each pair, one plate is securely attached to a mounting plate on the front side of truss **420** and the remaining plate is securely attached to a mounting plate on the back side of truss **420**, as is further described below. A back side of truss **420** is shown in FIG. **7**, although it is understood that a front side could also be shown for the following description. The first pair of plates includes plates **460***a* and **460***b*, roughly trapezoidal in shape. Plate **460***a* is attached to mounting member **426** and plate **460***b* is attached to mounting member **421** (not shown). The second pair includes plates **461***a* and **461***b*, roughly triangular in shape. Plate **461***a* is attached to mounting member **424** (not shown) and plate **460***b* is attached to mounting member **427**. The third pair includes plates **462***a* and **462***b*, roughly triangular in shape. Plate **462***a* is attached to mounting member **425** and plate **462***b* is attached to mounting member **422** (not shown). The fourth pair includes plates **463***a* and **463***b*, roughly trapezoidal in shape. Plate **463***a* is attached to mounting member **423** (not shown) and plate **463***b* is attached to mounting member **428**.

For those trusses **420** connected to collar link points, a modification (not shown) may be made for plates **463***a* and **463***b*. The portions of plates **463***a* and **463***b* below the line between points **466** and **467** are eliminated to prevent these portions from interfering with the operation of the shaft **20** and collars **30**. As a result, there are two gaps **411** in FIG. **5**B, for each respective area **410**. Each gap **411** is approximately the size of the portion of plate **463***a* or **463***b* below the line between points **466** and **467**, and may be closed with a flexible fabric or with attachments on the shaft itself.

Each pair of plates in FIG. **7** is symmetrical with respect to axis of symmetry **470**. For example, the portions of plate **460***a*, not visible in FIG. **7** because plate **460***a* is mounted to the front side of truss **420**, are positioned in a mirror image of the portions of plate **460***b* that are visible in FIG. **7**. There is overlapping of the plates in FIG. **7**. For example, portions of plate **461***a* overlap portions of plate **460***a* and portions of plate **460***b* overlap portions of plate **461***b*. The thickness, or distance between the front and back sides, of truss **420** helps provide the separation between overlapping plates needed for respective plates to slide over and past one another, as described below. The thickness may be tailored on individual assemblies and overlap sides varied to better approximate a typical foil cross-section to the propeller blade.

Multiple assemblies **455** are connected to form blade **400** shown in FIGS. **5**A and **5**B. To do this, pivotal connections are made at corresponding blade link points. For example, for an assembly **455** (not shown) positioned to the left of assembly **455** in FIG. **7**, blade link points **435** and **432** would be pivotally connected to blade link points **434** and **437** for assembly **455** in FIG. **7**.

FIG. **8** is a back view of the plate assembly **455**, in an expanded configuration, corresponding to the area **410** shown in FIG. **5**B. The following discussion should be considered in light of FIGS. **5**B, **6**D, **7**, and **8**. FIG. **8** shows the disposition of the plates described in FIGS. **7** after truss **420** is moved to the expanded position shown in FIG. **6**D. In FIG. **8**, the plates present the greatest surface area. There is no overlapping between plates **461***a* and **461***b* and plates **462***a* and **462***b*. Plates **460***a* and **460***b* and plates **463***a* and **463***b*, respectively, partially overlap. In FIG. **8**, all of plate **460***a* is visible, and line **464** shows the overlap between plates **460***a* and **460***b*. In FIG. **8**, all of plate **463***b* is visible, and line **465** shows the overlap between plates **463***a* and **463***b*.

The following should be considered in light of FIGS. **5**A through **8**. It should be understood that the truss **420** can have more or less than the four pairs of linking members **450** and associated mounting members shown in FIGS. **6**A through **6**D. For example, truss **420** could have three, five, or six pairs of linking members **450** and three, five, or six pairs of associated mounting members, respectively. It also is understood that the number of plates can vary accordingly. For example, in the previous example, a respective assembly **455** could have three, five, or six pairs of overlapping plates.

The present invention can be applied to a number of propeller or blade applications. For example, the present invention can be used in applications providing propulsion for transportation units including, but not limited to, aircraft, waterborne vessels, and submersible vessels. In addition, the present invention can be used in rotational fans or blowers.

Thus, it is seen that the objects of the present invention are efficiently obtained, although modifications and changes to the invention should be readily apparent to those having ordinary skill in the art, which modifications are intended to be within the spirit and scope of the invention as claimed. It also is understood that the foregoing description is illustrative of the present invention and should not be considered as limiting. Therefore, other embodiments of the present invention are possible without departing from the spirit and scope of the present invention.

What is claimed is:

1. A propeller comprising:

a blade assembly having a plurality of linking members operatively connected to one another, where at least two of said linking members are pivotally connected one to the other;

a blade surface engaged with said blade assembly, covering at least a portion of said blade assembly, and operatively arranged to change shape when said linking members are moved with respect to one another

a propeller shaft; and,

a plurality of collars, each collar in said plurality of collars radially surrounding said shaft, operatively arranged to slide longitudinally along said shaft while remaining rotationally fixed about said shaft, and having a collar link point; and,

wherein said blade assembly includes a plurality of blade link points pivotally connected to respective collar link points.

2. The propeller recited in claim **1** wherein said shaft further comprises an end; and,

wherein each successive collar in said plurality of collars:

is positioned further from said end than a preceding collar; and,

has a collar link point at a greater radial angle from a radial axis for said shaft than a collar link point for said preceding collar.

3. The propeller recited in claim **1** further comprising:

an actuator operatively connected to at least two collars in said plurality of collars; wherein said actuator operates to vary a longitudinal distance between said at least two collars along said shaft; and,

wherein said linking members move with respect to one another in response to varying said distance between said collars.

4. The propeller recited in claim **3** wherein said actuator is selected from a group of actuators consisting of pneumatic actuators, hydraulic actuators, and micro-electrical mechanical systems.

5. The propeller recited in claim **3** wherein said plurality of linking members further comprises a plurality of lattice bars; and,

wherein each lattice bar has a plurality of connection points in a straight line and said plurality of lattice bars are pivotally connected to one another at said connection points; and,

wherein said blade assembly further comprises a folding lattice.

6. The propeller recited in claim **5** wherein at least two lattice bars in said plurality of lattice bars have blade link points; and,

wherein each of said at least two lattice bars is connected, respectively, to one of said respective collar link points.

7. The propeller recited in claim **5** wherein said blade surface comprises a flexible material conforming to a shape of said folding lattice and covering said folding lattice.

8. The propeller recited in claim **7** wherein said flexible material comprises urethane.

9. The propeller recited in claim **1** wherein said propeller is connected to a waterborne vessel.

10. The propeller recited in claim **1** wherein said propeller is connected to a submersible vessel.

11. A propeller comprising:

a blade assembly having a truss structure,

a blade surface engaged with said blade assembly, covering at least a portion of said blade assembly,

wherein said truss structure further comprises a radial expansion and retraction structure having:

a plurality of linking members pivotally connected to one another to form a closed loop; and,

a plurality of mounting members pivotally connected to one another to form a closed loop and pivotally and slidingly connected to corresponding linking members; and,

wherein each of said mounting members has a blade link point,

wherein said blade surface varies in size as said blade link points are moved with respect to one another, and

wherein said blade surface is operatively arranged to change shape when said linking members are moved with respect to one another.

12. The propeller recited in claim **11** further comprising:

a propeller shaft; and,

a plurality of collars, each collar in said plurality of collars radially surrounding said shaft, operatively arranged to slide longitudinally along said shaft while remaining rotationally fixed about said shaft, and having a collar link point; and,

wherein at least two of said blade link points are pivotally connected to first respective collar link points.

13. The propeller recited in claim **12** wherein said shaft further comprises an end; and,

wherein each successive collar in said plurality of collars:

is positioned further from said end than a preceding collar; and,

has a collar link point at a greater radial angle from a radial axis for said shaft than a collar link point for said preceding collar.

14. The propeller recited in claim **12** further comprising:

an actuator operatively connected to at least two collars in said plurality of collars; wherein said actuator operates to vary a longitudinal distance between said at least two collars along said shaft; and,

wherein said blade surface varies in size in response to varying said distance between said at least two collars.

15. The propeller recited in claim **14** wherein said actuator is selected from a group of actuators consisting of pneumatic actuators, hydraulic actuators, and micro-electrical mechanical systems.

16. The propeller recited in claim **14** wherein said blade surface comprises a flexible material conforming to a shape of said radial expansion and retraction structure and covering said radial expansion and retraction structure.

17. The propeller recited in claim **16** wherein said flexible material comprises urethane.

18. The propeller recited in claim **14** wherein said blade surface further comprises a plurality of overlapping plates having a surface area, each plate in said plurality of overlapping plates fixedly connected to a corresponding mounting member in said plurality of mounting members; and,

wherein said surface area varies in size in response to varying said distance between said at least two collars.

19. The propeller recited in claim **18** wherein said plurality of mounting members further comprises four pairs of overlapping mounting members;

wherein blade link points for one pair of said four pairs of overlapping mounting members are pivotally connected to second corresponding collar link points; and,

wherein said surface area decreases in size as said second corresponding collar link points are moved further apart and increases in size as said second corresponding collar link points are moved closer together.

20. The propeller recited in claim **19** wherein for each pair of members in said four pairs of overlapping mounting members, a first mounting member is a part of a front surface for said blade assembly structure and a second mounting member is a part of a back surface for said blade assembly structure;

wherein said plurality of overlapping plates further comprises four pairs of plates; and,

wherein for each pair of said four pairs of plates, a first plate is connected to a respective said first mounting member and a second plate is connected to a respective said second mounting member.

21. The propeller recited in claim **20** wherein for said each pair in said four pairs of plates, both plates have a same shape.

22. The propeller recited in claim **21** wherein for two pairs of said four pairs of plates, said plates are approximately triangular in shape; and,

wherein for a remaining two pairs of said four pairs of plates, said plates are approximately trapezoidal in shape.

23. The propeller recited in claim **20** wherein said blade assembly further comprises a plurality of radial expansion and retraction structures.

24. A method for varying dimensions of a propeller comprising:

operatively connecting a plurality of linking members to form a blade assembly;

moving said linking members with respect to one another, where for two linking members in said plurality of linking members, said moving is a pivoting movement;

covering at least a portion of said blade assembly with a blade surface; and,

changing a shape for said blade surface in response to moving said linking members, wherein the propeller further comprises a shaft, and radially surrounding the shaft, a plurality of collars; and,

wherein the method further comprises:

operatively connecting said blade surface and said plurality of collars;

sliding said collars along said shaft to vary a distance between said collars; and,

changing said shape of said blade surface in response to sliding said collars.

25. The method recited in claim **24** wherein said propeller further comprises a linear actuator; and,

wherein the method further comprises:

operatively connecting said actuator to at least two collars in said plurality of collars; and,

wherein changing said shape of said blade surface in response to sliding said collars further comprises operating said actuator to slide said at least two collars.

26. The method recited in claim **24** wherein said propeller further comprises a rotational actuator, and

wherein the method further comprises:

operatively connecting said rotational actuator to at least two linking members in said plurality of linking members, and

wherein changing a shape for said blade surface in response to moving said linking members includes using said rotational actuator to move said linking members.

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