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US-A- 6 155 785

DESCRIPTION

[0001] This invention relates to turbine blade support assemblies. This invention also relates to wind turbines incorporating turbine blade support assemblies.

[0002] Wind turbine generators are constructed with one or more blades to and rotating about an axis. With the requirement for energy from renewable sources increasing, a high demand has arisen for wind turbines to generate increasingly more power. However, factors such as cost and weight limit the design of wind turbines and, hence, amount of power that can be achieved from conventional wind turbine generators. Hub arrangements aimed at overcoming these limits are e.g. disclosed in FR2850137, DE10019214, US6155785, NL1002324 and EP1596064 . According to the invention, there is provided a turbine blade support assembly comprising a central hub, a plurality of carrying members extending outwardly from the central hub, and a respective subsidiary hub on each of the carrying members for securing a respective turbine blade to each carrying member. Each carrying member is arranged in compression.

[0003] Each carrying member is elongate and extends radially outwardly from the main hub arrangement. Each carrying member has first and second opposite end regions, the first end region being secured to the main hub arrangement and the second end region having the subsidiary hub mounted thereon.

[0004] A plurality of support members is provided to support the carrying members. Each support member is elongate and may comprise a tie member. Each support member is arranged in tension. In use, the loading on at least some of the support members at different times may be such that they are in compression.

[0005] At least some of the support members extend between respective second ends of the carrying members, and/or between adjacent respective subsidiary hubs on the carrying members. The support members may extend between adjacent carrying members.

[0006] At least some of the support members may extend between the carrying members and the central hub. Where the support members extend between the carrying members and the central hub, the support members may extend from the central hub to the second end regions of the carrying members. If desired, the support members may extend from the central hub to the subsidiary hubs on the carrying members.

[0007] Where the support members extend between the carrying members and the central hub, the support members may extend to a region of the central hub forward of the carrying members and/or to the region of the central hub rearward of the carrying members. The central hub may include an extension member extending forwardly of the carrying members to which the forwardly extending support members are attached. The central hub may extend forwardly to which the rearwardly extending support members are attached.

[0008] In one embodiment, the support members may comprise cables, rods, tubes, angle members or any other suitably profiled structure.

[0009] In one embodiment, the support members have the advantages that they can reduce deflection of the carrying members and can reduce stress on the turbine blade support assembly.

[0010] The carrying members may be in the form of struts and each may have an aerofoil formation. Each aerofoil formation may comprise a flap to alter the lift thereon, for example with different wind speeds.

[0011] Each subsidiary hub may define a securing formation to secure a connecting portion of a turbine blade. The securing formation may be a recess defined in the subsidiary hub. Each subsidiary hub may comprise suitable operating means to effect a rotation of the blade about the respective subsidiary hub, for example to vary the angle of attack of the blade.

[0012] The carrying members and the subsidiary hubs may comprise corresponding securing formations to secure the subsidiary hubs to the respective carrying members. The corresponding securing formations may comprise a cavity in the respective subsidiary hub, and a projection on each carrying member to be received in the respective cavity. Alternatively, the corresponding securing formations may comprise a cavity in the carrying member and a projection on each subsidiary hub to be received by the respective cavity in the carrying member.

[0013] In one embodiment, the subsidiary hubs may be received substantially wholly within the carrying members. In this embodiment, the hub carrying member defines a recess to hold the subsidiary hub within the carrying member. The subsidiary hub may define a cavity to receive a projection on the turbine blade.

[0014] According to another aspect of this invention, there is provided a wind turbine incorporating a turbine blade support assembly as described above.

[0015] Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings, in which:

Fig 1 is a perspective view of a wind turbine;

Fig 2 is a front view showing a part of a turbine blade support arrangement;

Fig 3 is a perspective view of a turbine blade support arrangement showing a turbine blade thereon;

Fig 4 is a front view of the turbine blade support arrangement shown in Fig 3;

Fig 5 is a side view of a turbine blade support arrangement shown in Fig 3;

Fig 6 is a diagrammatic view showing the connection of a turbine blade to the blade support arrangement;

Fig 7 is a perspective view of the region for the connection of the turbine blade to the turbine blade support arrangement;

Fig 8 is a sectional side view showing the connection of a turbine blade to another embodiment of a blade support arrangement; and

Fig 9 is a sectional side diagrammatic view of the embodiment shown in Fig 8 showing a component for lifting the blade.

[0016] Referring to drawings, Fig 1 shows a wind turbine 10 arranged offshore, the numeral 12 designating the sea. It will be appreciated, of course, that the wind turbine 10 could be mounted on land instead of offshore. The wind turbine 10 comprises a pylon 14, and a generator assembly 16 housing the electrical generation equipment, as would be understood by those skilled in the art.

[0017] An embodiment of a turbine blade support assembly 18 is rotatably mounted on the generator assembly 16, and is operatively connected to the electrical generation equipment.

[0018] The turbine blade support assembly 18 supports a plurality of turbine blades 20. The turbine blade support assembly comprises a central hub 22, and a plurality of radially outwardly extending carrying members 24 mounted on the central hub 22. The carrying members 24 shown in Fig 1 are aerodynamically configured, and may include flaps as explained below.

[0019] Each of the carrying members 24 has a first end region 26 at which the carrying members are connected to the main hub arrangement 22 and an opposite second end region 28 at which a subsidiary hub 30 is mounted. The subsidiary hubs 30 can be seen in more detail in Fig 6. The turbine blades 20 are connected to the carrying members 24 by the subsidiary hubs 30.

[0020] Referring to Fig 2, there is shown part of the turbine blade support arrangement 18, in which the central hub 22 is shown with one of the elongate carrying members 24 extending therefrom. The subsidiary hub 30 attached to the second end 28 of the carrying member 24. The turbine blades 20 extends radially outwardly from the subsidiary hub 30. The arrow X represents the direction of movement of the blade 20 by the wind.

[0021] Circumferential support members 32 extend in generally opposite directions to each other from the subsidiary hub 30 shown in Fig 2 to the subsidiary hub 30 of an adjacent carrier member 24. Alternatively, the circumferential support members 32 could be connected directly to the carrying members 24.

[0022] The arrows A designate the forces on the carrying member 24, indicating that it is in compression. The support members 32, on the other hand, are in tension, as shown by the arrows B designating the direction of the forces thereon.

[0023] Referring to Figs 3 to 5, there is shown another embodiment of a blade support assembly 18. In the embodiment shown in Figs 3 to 5, the carrying members 24 are in the form of cylindrical struts. The central hub 22 is generally the same as the central hub 22 in Fig 1 but is shown more clearly in Figs 3 to 5. The central hub 22 comprises a central hub axle 40 which extends to the electricity generating equipment 16, and an extension member 42 extending from the central hub axle 40.

[0024] Each subsidiary hub 30 is provided with a suitable drive means (see Fig 6) for altering the angle of attack of the blade 20, e.g. as shown by the arrow Y.

[0025] Referring again to Figs 3 to 5, a plurality of generally circumferentially extending support members 32 extend from the subsidiary hubs 30 on each of the carrying members 24 to the subsidiary hub 30 on each adjacent carrying member 24. In addition to the support members 32 extending between adjacent subsidiary hub members 30, a forward radially extending support member 34 extends from each subsidiary hub 30 to the free end of the extension 42. In addition, a rearward radially extending support member 36 extends from each subsidiary hub member 30 to the axle 40. The circumferentially extending support members 32 are shown more clearly in Fig 4, and the radially extending hub members 34, 36 are shown more clearly in Fig 5.

[0026] Referring to Fig 6, there is shown a diagrammatic view of the region of the connection between a turbine blade 20 and a carrying member 24 via a subsidiary hub 30. The turbine blade 20 is provided with a projection 44 on its radially inner end which is received in a recess 46 in the subsidiary hub 30. Similarly, the subsidiary hub 30 comprise a further projection 48 which is received within a cavity 50 in the carrying member 24.

[0027] The subsidiary hub 30 is provided with suitable means, for example a motor, schematically shown at 52, rotates the blade 20 about the hub 30 as shown by the arrow Y, to vary the angle of attack of the blade 20.

[0028] Referring to Fig 7, there is shown an embodiment of the carrying member 24 which comprises a main part 54 of an aerodynamic configuration, and a flap 56 pivotally mounted on the main part 54. The flap 56 can be operated in a way known in the art to alter the lift on the carrying member 24 dependent upon wind speed and direction.

[0029] Fig 8 shows a further embodiment, in which a second end region 28 of a carrying member 124 defines a cylindrical cavity 149. A subsidiary hub 130 is mounted in the cylindrical cavity 149. The subsidiary hub 150 comprises an outer cylindrical housing 152, in which a projection 144 of the turbine to blade 20 is received. Three bearing arrays 154, 156, 158 are

provided one after the other along the projection 144, between the projection 144 and the outer cylindrical housing 152. Each bearing array 154, 156, 158 extends circumferentially around the projection 144, and allows smooth relative rotation between the turbine blade 20 and the subsidiary hub 150.

[0030] The housing 152 defines a pair of opposed apertures 160, in which securing buttons 162 are received. The buttons 162 are attached to the carrying member 124, thereby securing the subsidiary hub 150 on a fixed position in the carrying member 124.

[0031] A motor 164 is mounted on the outer cylindrical housing 152. A gear cog 166 is mounted on a shaft 160 extending from the motor 164. The gear cog 166 is in meshing engagement with an annular rack 170 fixedly mounted on the projection 144. The annular rack 170 has inwardly facing teeth to engage the gear cog 166. Alternatively, the motor 164 could be fixedly mounted on the projection 144 and the annular rack could be fixedly mounted on the outer cylindrical casing 152 of the subsidiary hub 150.

[0032] Operation of the motor 164 causes the turbine blade 20 to pivot about the subsidiary hub 130, as shown by the arrow Z, or in the opposite direction.

[0033] Fig 9 shows schematically the arrangement shown in Fig 8, and also shows a lifting arrangement 172 for lifting the turbine blade 20, with the subsidiary hub 130 mounted thereon. The lifting apparatus 172 lifts the subsidiary hub 130 with the turbine blade 20 and pulls the subsidiary hub 130 into the cavity 149 until it is fitted firmly in place. The lifting apparatus 172 comprises a cable 174 mounted on a winch 176. The winch 176 is rotatably mounted on a shaft 178.

[0034] The motor 164 may be an electric motor or an hydraulic motor.

[0035] In the above described embodiments, the turbine blade 20 is of the same size as normal turbine blades, but by being moved outwardly from the main hub arrangement 22, the area swept by the turbine blade 20 during its rotation about the main hub arrangement 22 is of a greater area than the area swept by the blade if it was connected directly to the main hub arrangement 22. This provides a greater amount of power produced by the blade 20. There is thus described embodiments of a blade support arrangement which support a turbine blade radially outwardly from the position at which conventional turbine blades are supported to allow the turbine blade to provide a greater amount of electrical power.

[0036] Various modifications can be made without departing from the scope of the invention.

[0037] Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- FR2850137 [0002]
- DE10019214 [0002]
- US6155785A [0002]
- NL1002324 [0002]
- EP1596064A [0002]

P a t e n t k r a v

5 1. Vindmøllevingeunderstøtningsenhed (18) omfattende et centralt nav (22), en flerhed af bærende elementer (24,124), der strækker sig udad fra det centrale nav, og et respektivt hjælpenav (30,150) på hvert af de bærende elementer til fastgørelse af en respektiv vindmøllevinge (20) til hvert bærende element, **kendetegnet ved, at:**

10 enheden omfatter en flerhed af aflange støtteelementer (32,34,36) til understøtning af de bærende elementer, hvor hvert støtteelement er anbragt under spænding, og hvert af de bærende elementer er under kompression; hvor hvert bærende element er aflangt og strækker sig radialt udad fra det centrale nav og har et første og et andet modstående endeområde (26,28), hvor det første endeområde er fastgjort til det centrale nav, og det andet endeområde har et hjælpenav (30,150) monteret derpå, hvor mindst nogle af støtteelementerne strækker sig mellem bærende elementer i det andet endeområde.

15

2. Vindmøllevingeunderstøtningsenhed ifølge krav 1, hvor mindst nogle af støtteelementerne strækker sig fra de bærende elementer til det centrale nav.

20

3. Vindmøllevingeunderstøtningsenhed ifølge krav 2, hvor støtteelementerne strækker sig til et område af det centrale nav foran de bærende elementer og/eller til området af navindretningen bag de bærende elementer.

25

4. Vindmøllevingeunderstøtningsenhed ifølge krav 3, hvor det centrale nav omfatter et forlængelseselement (42), der strækker sig foran de bærende elementer, hvortil mindst nogle af støtteelementerne er fastgjort.

30

5. Vindmøllevingeunderstøtningsenhed ifølge et af de foregående krav, hvor støtteelementerne omfatter kabler, stænger, rør, vinkelementer eller en hvilken som helst anden egnet profileret aflang struktur.

35

6. Vindmøllevingeunderstøtningsenhed ifølge et af de foregående krav, hvor hvert hjælpenav (30,150) omfatter driftsmidler (52,164,166,168,170) til at bewirke en rotation af vingen omkring det respektive hjælpenav for at variere vingernes indfaldsvinkel.

5 **7.** Vindmøllevingeunderstøtningsenhed ifølge krav 6, hvor driftsmidlerne omfatter en motor (52,164) og en gearindretning (166,168,170), hvor motoren er fast monteret på en af vindmøllevingen og hjælpenavet, og komponenten (170) af gearindretningen er fast monteret på den anden af vindmøllevingen og hjælpenavet.

10 **8.** Vindmøllevingeunderstøtningsenhed ifølge krav 7, hvor gearindretningen omfatter et tandgear (166), der er monteret på en aksel (168), som strækker sig fra motoren, og en ringformet tandstang (170), hvor den ringformede tandstang udgør den ovennævnte komponent i gearindretningen.

15 **9.** Vindmøllevingeunderstøtningsenhed ifølge et af de foregående krav, hvor hvert bærende element er i form af en stiver og har en bæreplansformation.

15 **10.** Vindmøllevingeunderstøtningsenhed ifølge krav 9, hvor bæreplansformationen omfatter en flap til at ændre opdriften på vingen.

20 **11.** Vindmølle, der inkorporerer en vindmøllevingeunderstøtningsenhed ifølge et af de foregående krav.

DRAWINGS

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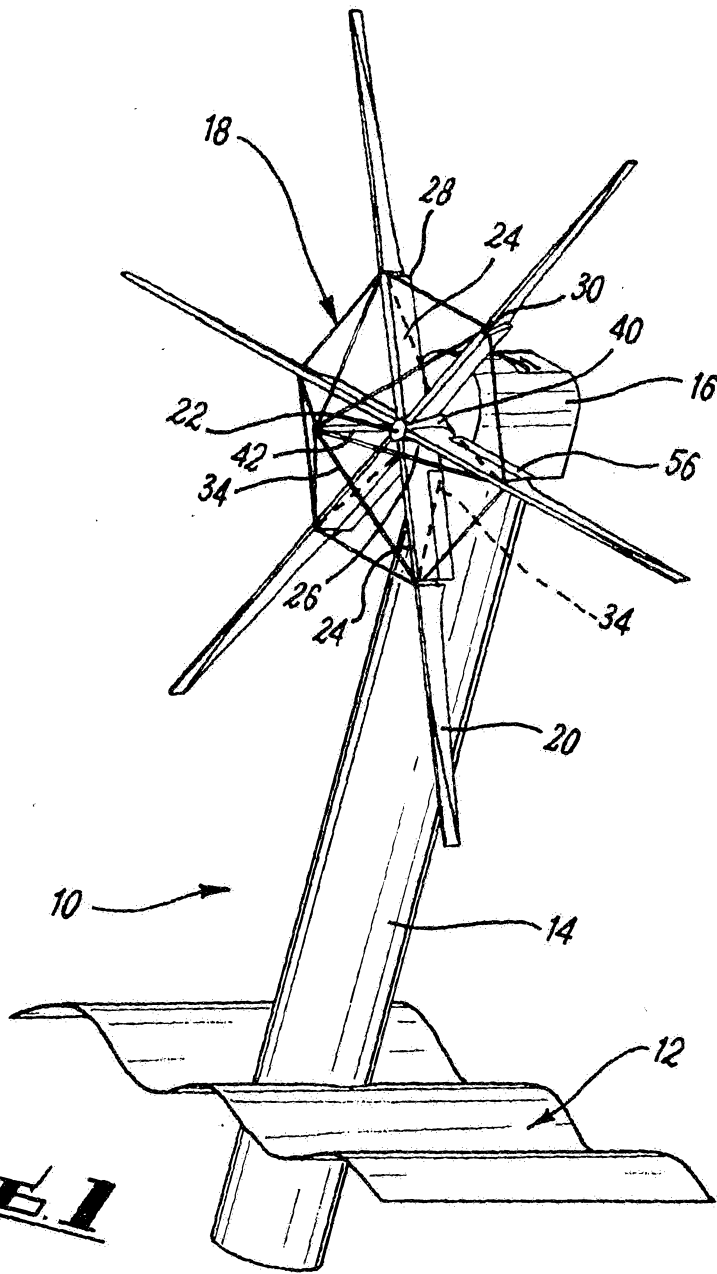
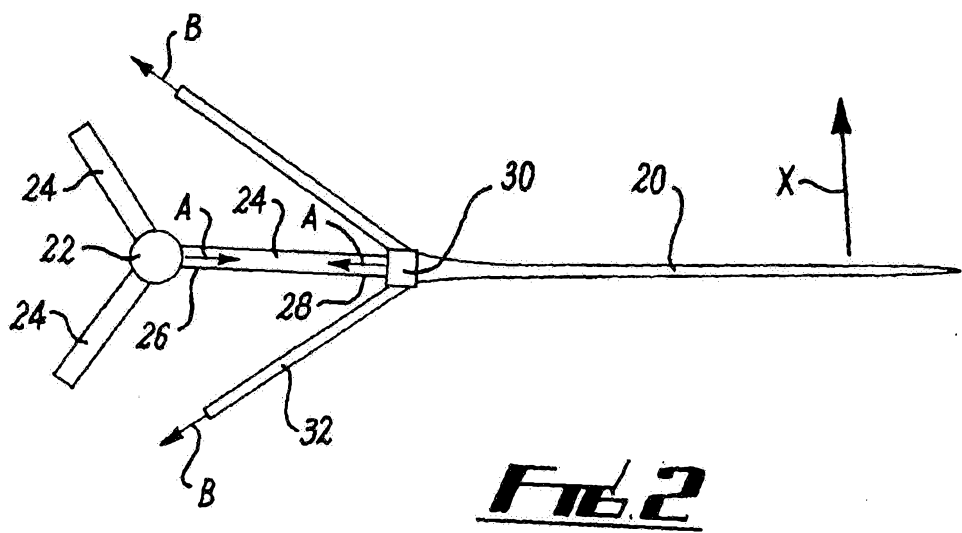
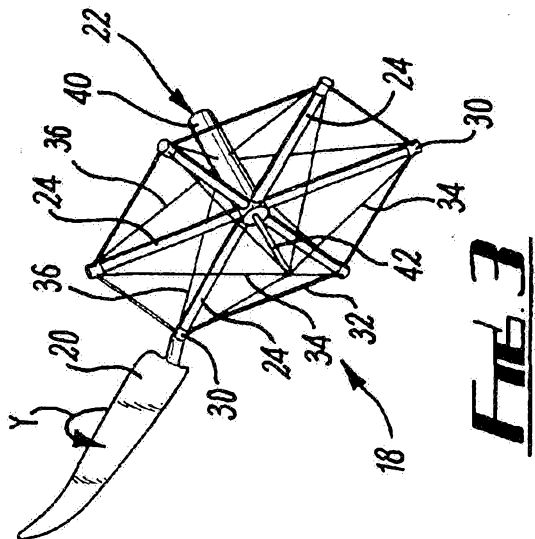
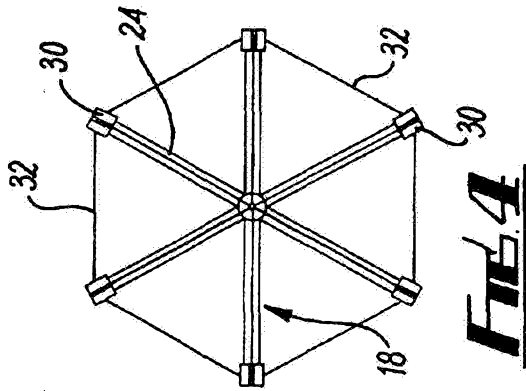
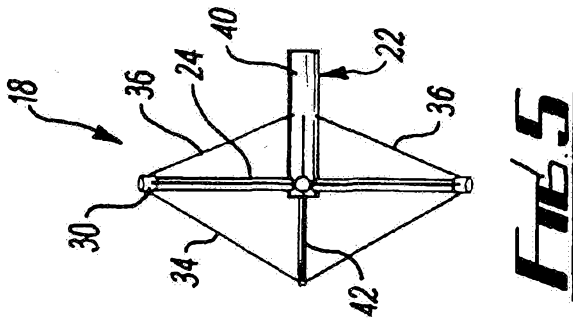


FIG. 1





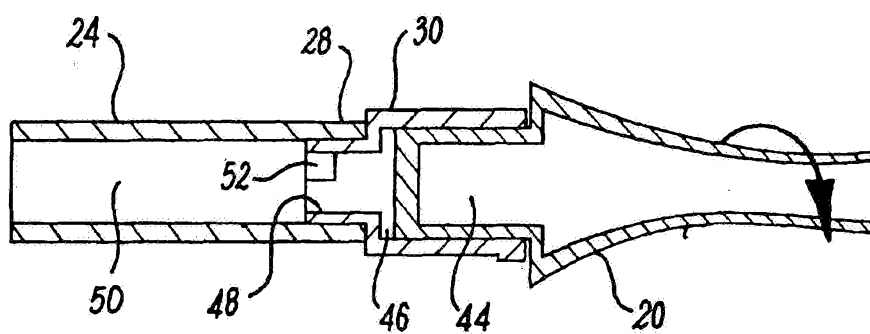


FIG. 6

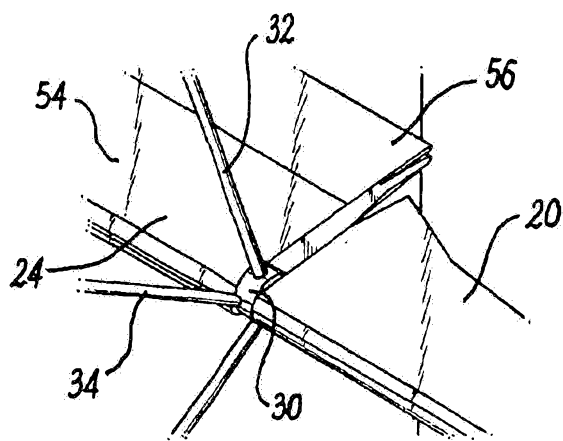


FIG. 7

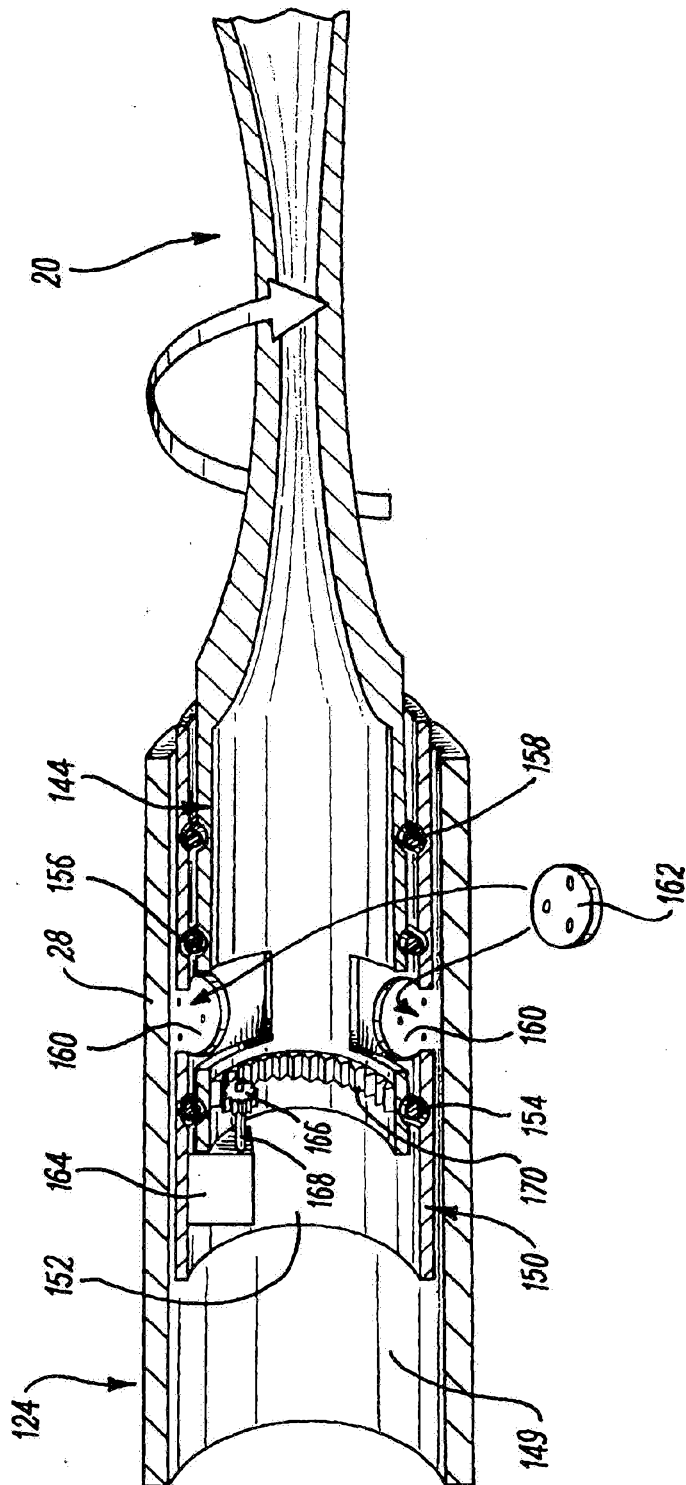


Fig. 8

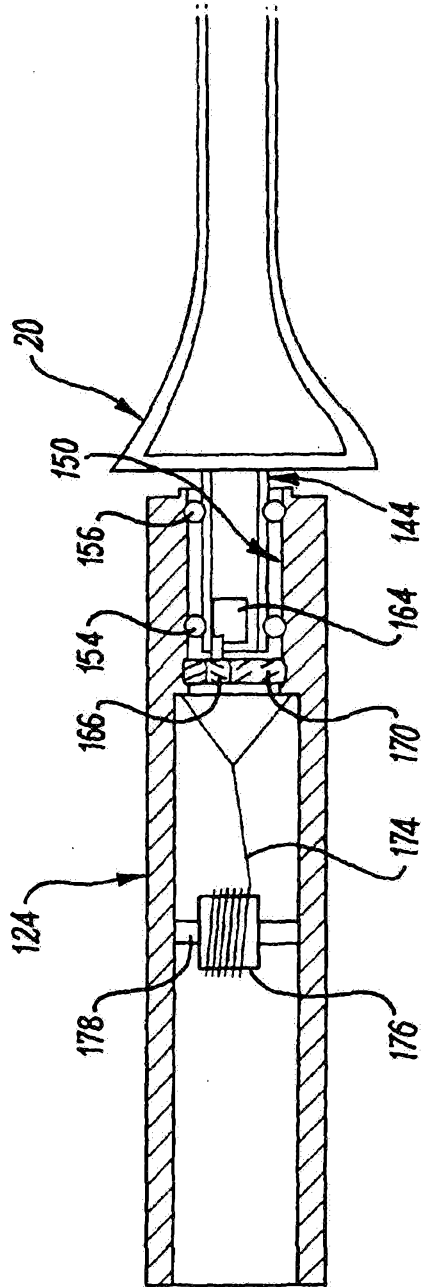


Fig. 9