PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 :		(11) International Publication Number:
F03D 7/02	A1	WO 86/ 02701
		(43) International Publication Date: 9 May 1986 (09.05.86)

(21) International Application Number: PCT/DK85/00102

(22) International Filing Date: 30 October 1985 (30.10.85)

(31) Priority Application Number: 5200/84

(32) Priority Date: 1 November 1984 (01.11.84)

(33) Priority Country: DK

(71)(72) Applicant and Inventor: RIISAGER, Christian [DK/DK]; Skaergaardvej 4, DK-7400 Herning (DK).

(74) Agent: DANSK PATENT KONTOR A/S; H.C. Ørstedsvej 70, DK-1879 København V (DK).

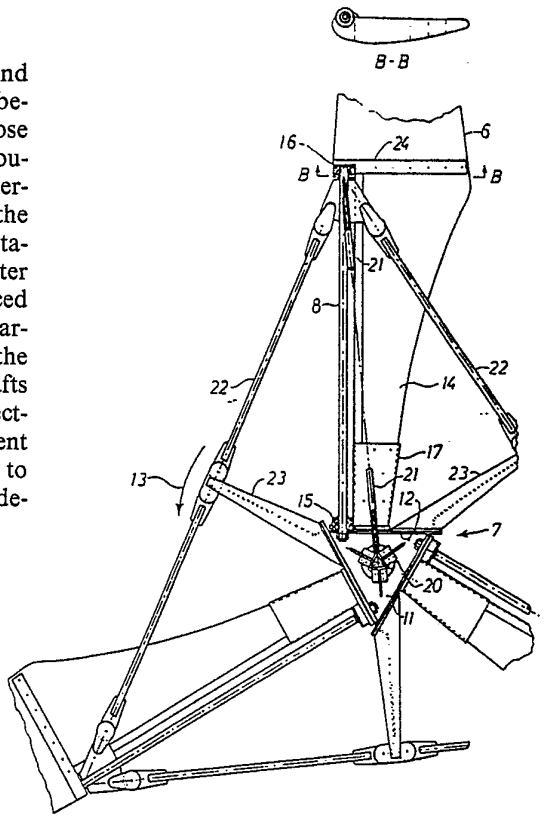
(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), LU (European patent), NL (European patent), NO, SE (European patent), US.

Published
With international search report.

(54) Title: A WINDMILL ROTOR WITH ADJUSTABLE-PITCH BLADES, AS WELL AS WINDMILLS WITH SUCH A ROTOR

(57) Abstract

In a windmill rotor with adjustable-pitch wings (6) and a nose stay (21) for each wing and intermediate stays (22) between the wings, the new feature is that at each wing the nose stays (21) and the intermediate stays (22) are secured to the outermost end of a generally radial bearing shaft (8), the innermost end of which is secured to the hub (7), and that at the part of the wing root (14) forwardmost in the direction of rotation (13), the wing (6) is supported on an inner (15) and outer (16) wing turning bearing or pitch bearing respectively, placed at the innermost and outermost ends respectively of the bearing shaft (8). With this arrangement, a stable support of the wings (6) is attained, even with relatively weak bearing shafts (8). In an embodiment, the intermediate stays (22) are connected to rigid radial arms (23) on the hub (7). This arrangement relieves the bearing shaft (8) of the tangential forces due to wind and gravity. A windmill with such a rotor is also described.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GA**	Gabon	**MR**	Mauritania
AU	Australia	**GB**	United Kingdom	**MW**	Malawi
BB	Barbados	**HU**	Hungary	**NL**	Netherlands
BE	Belgium	**IT**	Italy	**NO**	Norway
BG	Bulgaria	**JP**	Japan	**RO**	Romania
BR	Brazil	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CF	Central African Republic			**SE**	Sweden
CG	Congo	**KR**	Republic of Korea	**SN**	Senegal
CH	Switzerland	**LI**	Liechtenstein	**SU**	Soviet Union
CM	Cameroon	**LK**	Sri Lanka	**TD**	Chad
DE	Germany, Federal Republic of	**LU**	Luxembourg	**TG**	Togo
DK	Denmark	**MC**	Monaco	**US**	United States of America
FI	Finland	**MG**	Madagascar		
FR	France	**ML**	Mali		

A WINDMILL ROTOR WITH ADJUSTABLE-PITCH BLADES, AS WELL AS WINDMILLS WITH SUCH A ROTOR

TECHNICAL FIELD

The present invention relates to a windmill rotor of the kind comprising

a) a hub with an axially protruding hub nose,

b) a number of wings extending substantially radially from and being rotatably supported on said hub about axes in general extending radially,

c) a nose stay extending from the outermost part of the root of each wing to a part of the hub nose axially spaced from the hub,

d) a number of intermediate stays connecting the outermost parts of the roots of the wings with each other, and

e) means for adjusting the angle of the wings relative to the wind direction by turning the wings about said axes.

BACKGROUND ART

In windmill rotors of this kind, it is difficult to support the variable-pitch wings on the rotor in a stable

manner without using heavy and expensive bearing means. In many cases the wing roots are also required to exhibit a very great mechanical strength, which - of course - also increases weight and costs.

DISCLOSURE OF THE INVENTION

It is the object of the present invention to remedy the disadvantages described above, and this object is attained in a windmill rotor of the kind referred to initially, which rotor according to the present invention is characterized in

f) for each wing a bearing shaft, at its radially outermost end secured to the nose stay and the intermediate stays at the ends of said stays closest to the wing, said bearing shaft at its radially innermost end being secured to said hub and at its outermost and innermost ends respectively carrying pitch bearings, with which the outermost and the innermost part respectively of said wing root is connected.

With this arrangement, the force couples exerted on the wing roots by the force of the wind or gravity will for each wing be distributed over two bearings with a significant radial spacing, making the load on each bearing correspondingly less.

A first embodiment of the windmill rotor according to the present invention is characterized in that at or near its central part each intermediate stay is connected to the hub through an arm extending substantially radially and rigidly connected to the hub. With this arrangement, the bearing shaft mentioned above is relieved of tangential forces and couples caused by wind and gravity.

A second embodiment of the windmill rotor according to the present invention is characterized in that the pitch bearings are placed in such a manner relative to each wing, that the wing turning axis (the axis of the shaft) is situated between the forward edge of the wing and the aerodynamic centre line of the wing. With this arrangement, a strong wind load will attempt to move the wings into a pitch position, in which the wind load is reduced, provided - of course - that the adjustment mechanism for the wings is adapted to accommodate such movements.

The present invention also relates to a windmill with a windmill rotor of the kind referred to initially, and according to the present invention this windmill is characterized in that the windmill rotor exhibits at least the features set forth in the paragraph marked f) above.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following detailed specification the invention is explained with reference to the attached drawings, in which,

Figure 1 in perspective shows a windmill with a windmill rotor according to the present invention,

Figure 2 is a partial view showing, partly in section, the hub of the windmill rotor, the innermost portion of a wing as well as the means connecting the wing to the hub,

Figure 3 is a partial section along the line III-III in Fig. 2 and shows the control means for the wing in question, and

Figure 4 shows roughly the same as Fig. 3, but as viewed from the front along the axis of the windmill rotor.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The windmill or wind power generator shown in Fig. 1 in a known manner comprises a tower 1, on which a gear box 2 is supported rotatably about a vertical axis and adapted to be adjusted in azimuth by means of control rotors 3, the latter in a known manner keeping the main windmill rotor 4 facing towards the wind, the direction of which is indicated by the arrow 5.

Each of the wings 6 of the main windmill rotor 4 is rotatably supported on a common hub 7 by means of a bearing shaft 8, the radially innermost end of which, as shown in Fig. 4, is secured to the hub 7.

As may be seen from Fig. 2 and 4, the hub 7 consists of a hub sleeve 9 keyed onto a stub shaft 10 protruding from the gear box 2, a triangular hub plate 11 situated in a radial plane and secured by welding around the hub sleeve 9, as well as three wing base plates 12 secured by welding to the outer edges of the hub plate 11.

As will appear from Fig. 4, the inner end of the bearing shaft 8 is secured to that part of the wing base plate 12 in question lying forwardmost in the direction 13 of rotation. At the forward edge of its wing root 14 each wing 6 is rotatably supported about the bearing shaft 8 by means of outer and inner pitch bearings 15 and 16 respectively.

As best to be seen in Fig. 2 and 3, the inner part of the wing root 14 is surrounded by an inner wing root fitting 17, connected partly to the rotatable part of the inner pitch bearing 15, partly through a rod mechanism 18 to a pitch adjustment cylinder 19, the latter in a similar manner (not shown) also being connected to the re-

maining wings 6 and adapted to adjust their angle of attach in relation to the wind.

The pitch cylinder 19 is situated in a hub nose 20, in the example shown consisting of a three-legged "tower" of T-profile steel, the broadest end of which is welded to the hub plate 11. For each of the wings 6 a nose stay 21 is secured to the forward end of the hub nose 20, said nose stay 21 extending radially outwards and rearwards to the outermost end of each bearing shaft 8, to which the nose stay is secured immediately radially within the outer pitch bearing 16.

The outermost ends of the bearing shafts 8 are interconnected by means of intermediate stays 22, each at or close to the center thereof being secured to the radially outermost end of a radial arm 23, the radially innermost end of which is secured to the end of the adjacent wing base plate 12 lying rearwardmost in the direction 13 of rotation.

At this point it should be noted that the wings 6 in Fig. 1 and 2 are shown in a position substantially parallel to the wind direction 5, whereas in Fig. 4 they are shown in a position generally at right angles to this wind direction. During normal operation, the wings will, of course, be in some angular position between these two extremes.

When during normal operation the wings 6 are acted upon by the wind 5, then that force, with which the wind attempts to bend the wings in the wind direction, i.e. towards the gear box 2, will be taken up by a force couple at each of the wing roots 14, viz. firstly an outer, rearwardly directed force being taken up by the nose stay 21 through the outer pitch bearing 16 and the outermost end of the bearing shaft 8, the nose stay 21 being connected to the remaining two nose stays 21 through the forward-

most end of the hub nose 20. The other force in the couple mentioned is constituted by a forwardly directed force from the inner wing root fitting 17, transmitted to the wing base plate 12 and hence to the hub 7 through the inner pitch bearing 15 and the innermost part of the bearing shaft 8. With this arrangement, the bearing shaft 8 will only be subjected to bending stresses in its outermost and innermost ends, for which reason it may be relatively slim, although it must be able to withstand the "column loading" caused by the radially inwardly directed components of the tensional forces in the nose stay 21 and the two adjacent intermediate stays 22, and further, the shear forces at the two ends.

During normal operation, when the wings 6 form a suitable angle with the wind direction 5, the wings 6 will, of course, also be acted upon in the tangential direction, and the force of gravity, acting upon the wings 6 in the downward direction, will additionally produce periodically varying, substantially tangentially directed forces in each wing. The tangential forces due to gravity are distributed between the wings through the intermediate stays 22, while the more or less constant force due to the wind is transmitted to the hub 7 and hence to the stub shaft 10 through the rotationally forwardmost part of each intermediate stay 22 and the radial arm 23 secured thereto. Thus, the radial arms 23 will relieve the bearing shafts 8 of the tangential wind forces on the wings 6, for which additional reason the bearing shafts 8 do not have to be especially strongly dimensioned in consideration of these tangential wind forces. Also in the tangential direction force couples will arise in the same manner as in the axial direction, said force couples in the same manner as described above being taken up by the ends of the bearing shafts 8 and the bearings, stays and hub parts cooperating therewith.

The inner wing root fitting 17 serves to connect the innermost end of the wing root 14 to the inner pitch bearing 15, and an outer wing root fitting 24 serves in a corresponding manner to connect the outermost end of the wing root 14 to the outer pitch bearing 16. It is here assumed that the wings are made of wood, such as laminated wood with thick or thin laminae, but when using metal wings the wing root fittings 17 and 24 may in certain cases be omitted, provided that the metal has the requisite strength.

Both the nose stays 21 and the intermediate stays 22 may be adjustable in length in a manner not shown.

C L A I M S

1. A windmill rotor (4) of the kind comprising
a) a hub (7) with an axially protruding hub nose (20),
b) a number of wings (6) extending substantially radially from and being rotatably supported on said hub (7) about axes in general extending radially,
c) a nose stay (21) extending from the outermost part of the root (14) of each wing (6) to a part of the hub nose (20) axially spaced from the hub (7),
d) a number of intermediate stays (22) connecting the outermost parts of the roots (14) of the wings (6) with each other, and
e) means (18,19) for adjusting the angle of the wings (6) relative to the wind direction (5) by turning the wings about said axes,
c h a r a c t e r i z e d by
f) for each wing (6) a bearing shaft (8), at its radially outermost end secured to the nose stay (21) and the intermediate stays (22) at the ends of said stays closest to the wing (6), said bearing shaft (8) at its radially innermost end being secured to said hub (7) and at its outermost and innermost ends respectively carrying pitch bearings (16 and 15 resp.), with which the outermost and the innermost part respectively of said wing root (14) is connected.

2. A windmill rotor according to claim 1, c h a r a c t e r i z e d in that at or near its central part each intermediate stay (22) is connected to the hub (7) through an arm (23) extending substantially radially and rigidly connected to the hub (7).

3. A windmill rotor according to claim 1 or 2, c h a r a c t e r i z e d in that the nose stays (21) and/or the intermediate stays (22) are adjustable in length.

4. A windmill rotor according to any one or any of the claims 1-3, c h a r a c t e r i z e d in that the pitch bearings (15,16) are placed in such a manner relative to each wing (6), that the wing turning axis (the axis of the shaft (8)) is situated between the forward edge of the wing (6) and the aerodynamic centre line of the wing.

5. A windmill with a main windmill rotor (4) of the kind comprising

a) a hub (7) with an axially protruding hub nose (20),
b) a number of wings (6) extending substantially radially from and being rotatably supported on said hub (7) about axes in general extending radially,
c) a nose stay (21) extending from the outermost part of the root (14) of each wing (6) to a part of the hub nose (20) axially spaced from the hub (7),
d) a number of intermediate stays (22) connecting the outermost parts of the roots (14) of the wings (6) with each other, and
e) means (18,19) for adjusting the angle of the wings (6) relative to the wind direction (5) by turning the wings about said axes,

c h a r a c t e r i z e d in that the main windmill rotor (4) is constructed in the manner set forth in the characterizing clause of claim 1, possibly also as indicated in one or more of the claims 2-4.

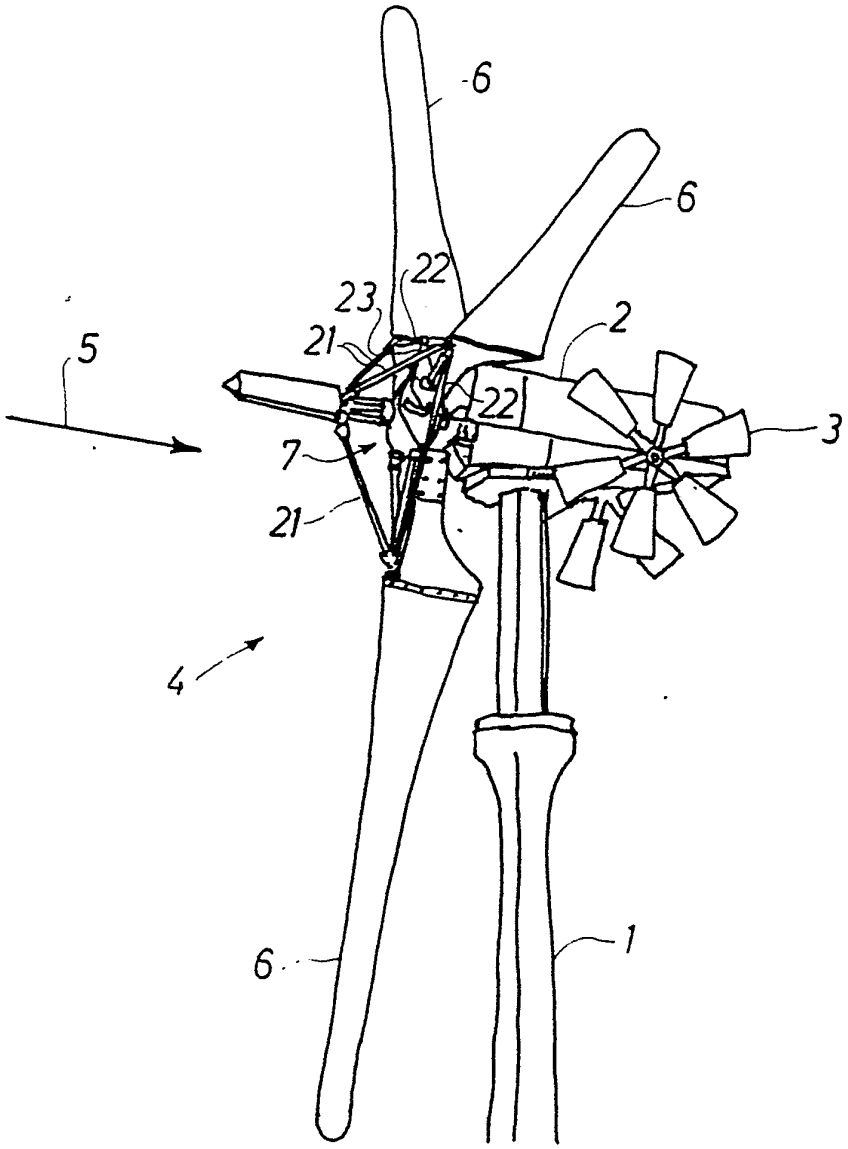


Fig.1

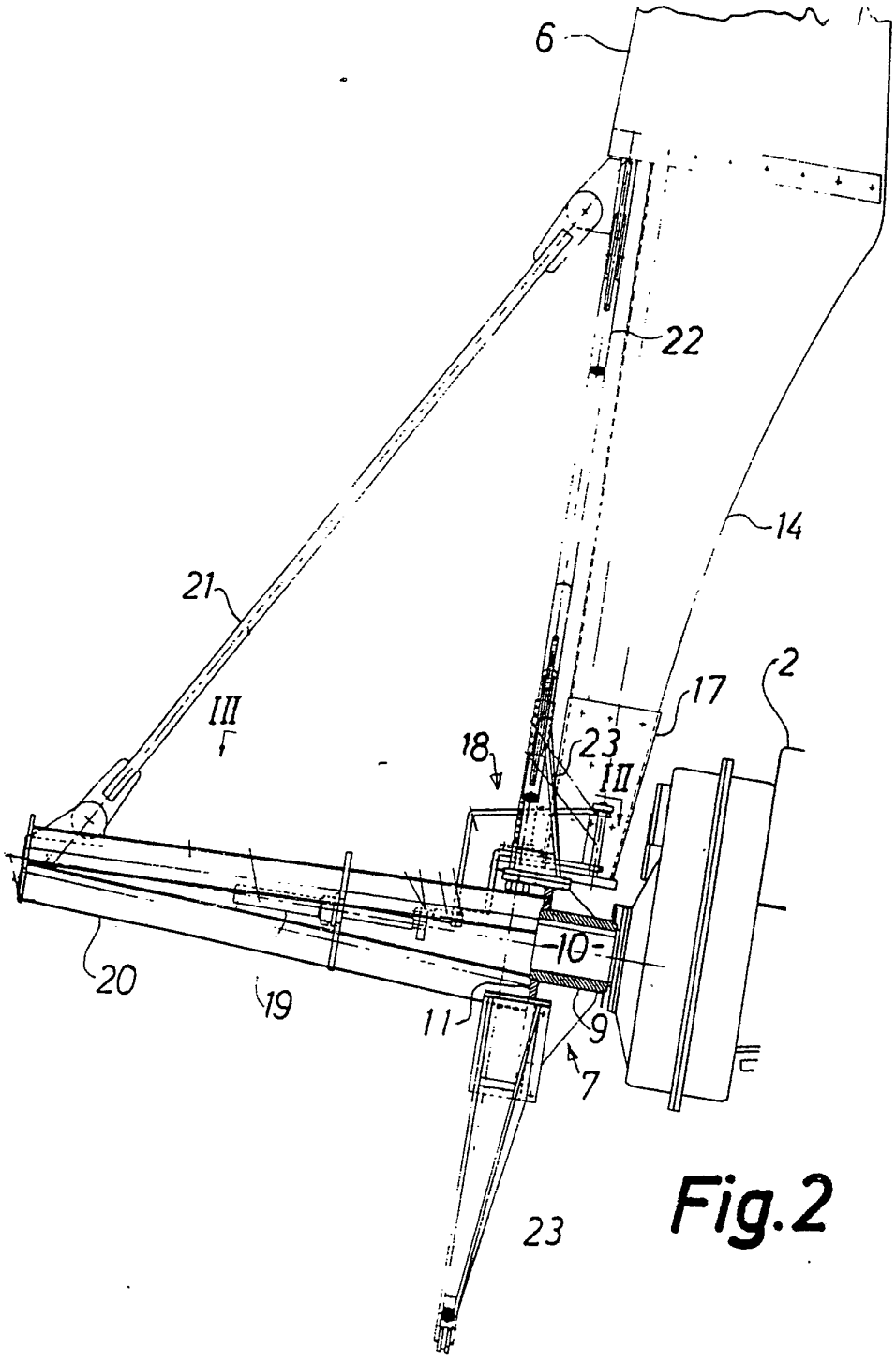


Fig.2

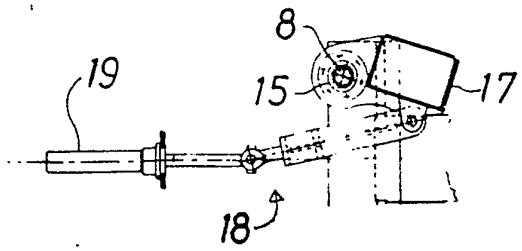


Fig.3

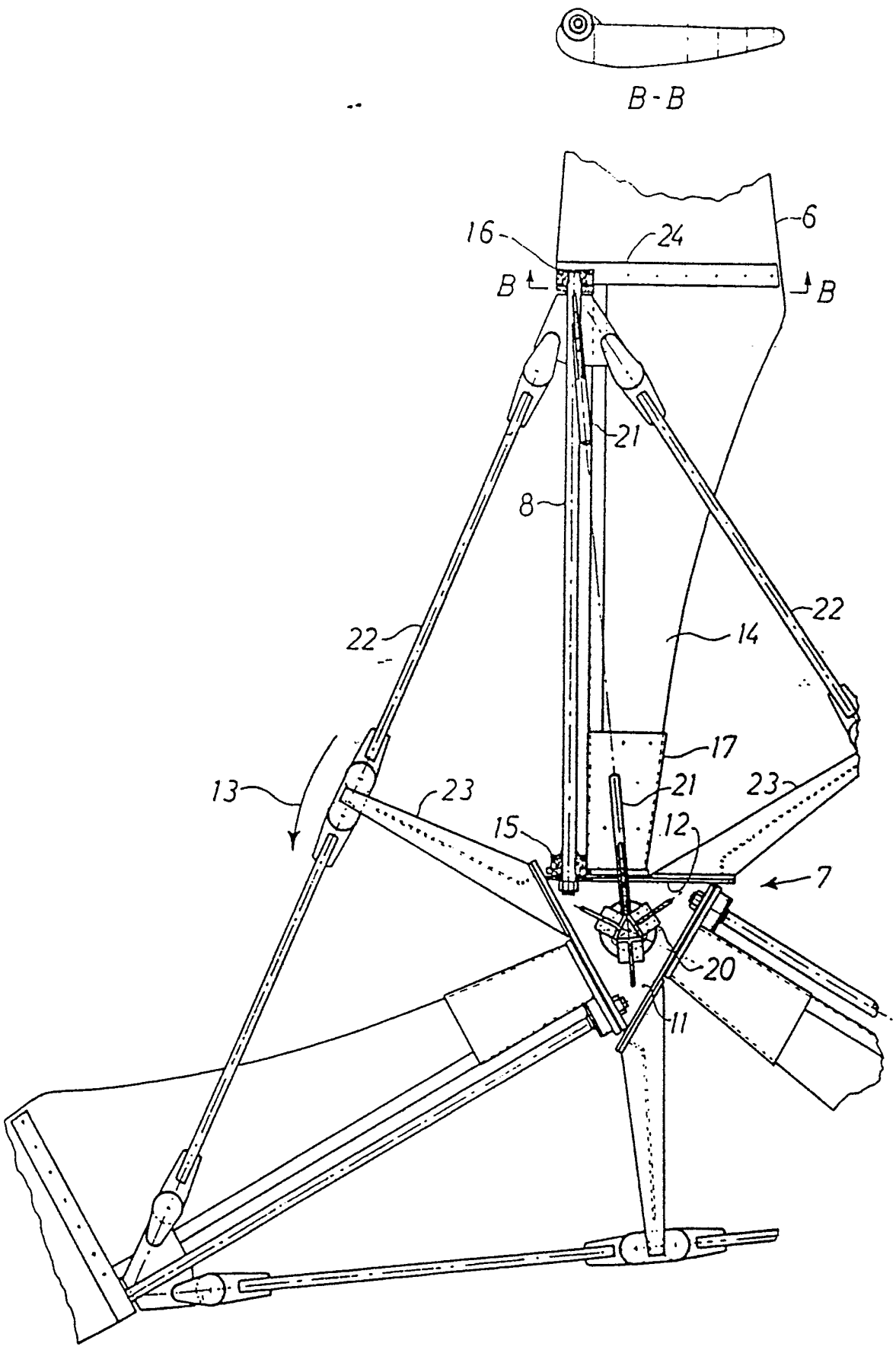


Fig.4

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK85/00102

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

F 03 D 7/02

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	F 03 D 1/00, /06, 7/00, /02, /04, 11/04
Nat Cl	88c:2/03
US Cl	290:44, 55; 416:13, 14

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

SE, NO, DK, FI Classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	SE, A, 10 361 (J. JENSEN) 21 April 1898	
A	SE, A, 34 570 (L.W. SMEDBERG) 1 June 1912	
A	DK, A, 50 919 (CH. CHRISTENSEN) 18 November 1935	
A	DE, A1, 2 825 061 (P. SPRANG) 13 December 1979	
A	US, A, 4 403 916 (D. SKELSKEY) 13 December 1983	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1986-01-21	1986 -01- 23
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	K. Bengtsson

L.E

Form PCT/ISA/210 (second sheet) (January 1985)