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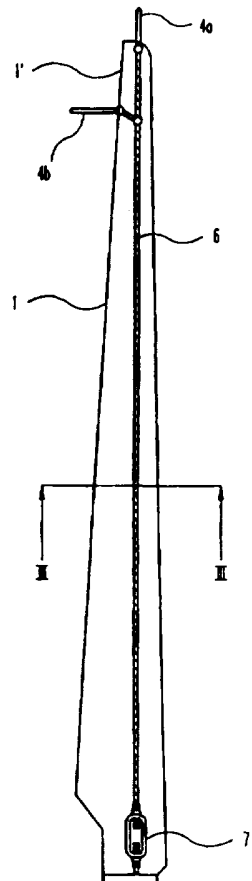
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<p>(21) International Application Number: PCT/DK95/00358 (22) International Filing Date: 7 September 1995 (07.09.95) (30) Priority Data: 9400343 U 7 September 1994 (07.09.94) DK (71) Applicant (for all designated States except US): BONUS ENERGY A/S [DK/DK]; Fabriksvej 4, DK-7330 Brande (DK). (72) Inventor; and (75) Inventor/Applicant (for US only): STIESDAL, Henrik [DK/DK]; Noerre voldgade 45, DK-5000 Odense C (DK). (74) Agent: LARSEN &amp; BIRKEHOLM A/S SKANDINAVISK PATENTBUREAU; Banegårdspladsen 1, P.O. Box 362, DK-1570 Copenhagen (DK).</p>		<p>(81) Designated States: AM, AT, AT (Utility model), AU, BB, BG, BR, BY, CA, CH, CN, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: LIGHTNING ARRESTER FOR WINDMILL BLADES

(57) Abstract

The invention relates to a lightning arrester arrangement for mounting in a windmill blade (1). The lightning arrester arrangement consists of at least one lightning conductor (4a, 4b, 4', 4'') placed in the tip (1') of a windmill blade (1). The lightning conductor or the lightning conductors are connected to earth via an inner conductor (6). The novelty aspect of the invention is partly that the earthing of the lightning is effected only in or from the tip (1') of the blade, and partly that the further earthing towards the earth connection through the blade is effected via an inner conductor which wholly or partly extends between the blade tip and the mill hub (3). The invention also relates to a windmill blade with a lightning arrester arrangement of the type described above, and also to a lightning conductor for mounting in the tip (1') of a windmill blade (1).



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LIGHTNING ARRESTER FOR WINDMILL BLADES5 Background of the invention

10 The invention relates to a lightning arrester arrangement for the blade of a windmill as disclosed in the preamble to claim 1. The invention also relates to a windmill blade with such a lightning arrester arrangement built into said blade, and a lightning conductor for building into the said lightning arrester arrangement. Finally, the invention relates to the use of said lightning arrester arrangement for mounting in an existing windmill blade.

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A number of known techniques are used in the normal protection of constructions against lightning. The most used comprises an earthed cage around the construction it is desired to protect. In a more simplified form, the lightning arrester can be reduced to an earthed conductor which extends over the highest part of the construction, and said conductor can possibly be provided with one or more vertical projections.

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A traditional lightning arrester of this type is, however difficult to establish on, for example, a windmill, where the highest point is the blade, which from the point of view of security is desired to be protected against a stroke of lightning. The technique is complicated in comparison with stationary constructions, in that the part of the construction which it is desired to protect is movable. This means that a possible stroke of lightning is not so well-defined or predictable, and it is herewith difficult to prevent or to lead away. Moreover, in connection with windmill blades struck by lightning, there is a great risk that the blade suffers damage. This necessitates time-consuming repairs, in that a possible replacement or repair

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of a windmill blade is complicated.

In connection with composite materials, of which windmill blades are typically made, lightning conductor arrangements are known in the form of metal foil or wire laminated into or affixed by adhesive to the blade.

Such lightning conductor arrangements are always based on conductors which are placed on or in the surface of the blade. Normally, it is thus the intention to create a metallic net around the inner structure of the blade in order to create a combined longitudinal lightning arrester and conductor along the rear edge of the blade. However, it is common to all these arrangements that it is difficult to achieve the necessary cross-sectional area with hereby incurring undesired aerodynamic effects, for example in the form of noise and/or reduced efficiency. Furthermore, it can prove problematic to get a metallic material to maintain the degree of tension in a blade of composite material, in that the degree of tension in a blade of composite material will normally be higher than the permissible fatigue influence for a metallic material, and it will therefore require special arrangements to avoid fatigue cracks. Without the necessary cross-sectional area, it can be necessary to repair the lightning conductor arrangement after influence by lightning.

#### Advantages of the invention

As disclosed in claim 1, by letting the lightning arrester arrangement consist of one or more lightning conductors of an electrically-conducting material on or in the surface of the blade in the vicinity of the blade tip, where the lightning conductors are connected to an inner conductor which extends inside the blade, and connecting the lightning conductor or lightning conductors to an earth

connection, an effective lightning arrester is achieved and herewith a good protection for the blade. It has thus proved to be sufficient to provide lightning protection for the area in the vicinity of the blade tip, in that lightning most often strikes the tip of the blade. By letting the inner conductor extend inside the blade, undesired disadvantages with regard to strength, aerodynamics and accoustics are avoided. Moreover, the arrangement is ideal in connection with any subsequent mounting of a blade without lightning protection.

As disclosed in claim 2, by connecting the lightning arrester arrangement's inner conductor to an earth connection via the windmill hub, the most simple conduction from the root of the blade is achieved.

As disclosed in claim 3, by placing the inner conductor in or in the immediate vicinity of the neutral axis of the windmill blade, the degree of tension achieved at the inner conductor is lower than the fatigue limit for the material. An advantage from the point of view of strength can hereby be achieved by the placing of the inner conductor in a windmill blade.

As disclosed in claim 4, by configuring the lightning in a streamlined manner, preferably with a torpedo-shape or guttiform, there is achieved a combination of the desired lightning arrester effect and a similarly-desired damping of acoustic noise stemming from the effects of turbulence at the tip of the blade.

As disclosed in claim 5, by letting the inner conductor extend in a hollow tip axle, when this may exist in a windmill blade, there is achieved an effective earthing through the inside of the blade, a reinforcement of the tip axle and a better securing of the rotatable tip for the windmill

blade.

As disclosed in claim 6, by letting the inner conductor wholly or partly consist of an electrically-conducting tip  
5 axle, the lightning arrester arrangement thus achieved can be used for known systems without any great reconstruction and adaptation of the technique.

As disclosed in claim 7, by letting the inner conductor  
10 wholly or partly consist of a metal wire with or without a cladding of insulating material, a simple and inexpensive embodiment is achieved.

As disclosed in claim 8, by configuring the lightning con-  
15 ductor or lightning conductors aerodynamically from an electrically-conducting material, and placing this in or in the vicinity of the tip of the windmill blade, the lightning conductor thus achieved is one which is ideal for use in a lightning arrester arrangement, in that this will  
20 be easy to mount afterwards, and moreover it will result in a damping of acoustic noise which may possibly arise at the tip of the blade due to the effects of turbulence.

As disclosed in claim 9, by mounting the lightning arrester  
25 arrangement on a windmill blade, an inexpensive and effective protection for windmill blades against lightning is achieved, in that this can be mounted without any great side-effects in connection with the blade's aerodynamic or acoustic characteristics or from the point of view of  
30 strength. Thus the blade of the windmill will be well protected against damage as a result of being struck by lightning, and this will also afford protection for the system that it may be a part of, in that both the windmill housing and the electrical control will be better protected  
35 as a consequence, in that the lightning will be earthed in an expedient manner.

It is thus particularly advantageous, in connection with windmill blades which have a rotatable tip and a metallic tip axle, that the lightning-arrester arrangement can be mounted afterwards, in that the blade tip can easily be dismantled for the building-in of the lightning conductor, after which this can be connected to the metallic part of the tip axle.

#### The drawing

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In the foillowing section, example embodiments of the invention will be described in more detail with reference to the drawing, where

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fig. 1 shows a known windmill,

fig. 2 shows an embodiment according to the invention,

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fig. 3 shows a cross-section of the embodiment in fig. 2 seen in the direction III-III,

fig. 4 shows a further embodiment according to the invention, and

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fig. 5 similarly shows a further embodiment according to the invention.

#### Description of the example embodiments

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In fig. 1 is seen an ordinary windmill, where the windmill blades 1 are suspended in a mill hub 3, which in turn is anchored on a tower 2.

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In fig. 2 is seen an embodiment according to the invention, where two lightning conductors 4a, 4b, which consist of an electrically-conducting material, are connected to an inner

conductor 6 consisting of a steel wire. The inner conductor 6 is anchored to and electrically connected with the mill hub 3 (not shown). In the shown embodiment, there are mounted two lightning conductors 4a and 4b which project out from the windmill blade 1 and the blade tip 1'.

In fig. 3 is seen a cross-section of the windmill blade 1 in fig. 2 in the section III-III, where the inner conductor 6 is seen to extend in the vicinity of the neutral axis of the blade.

The two lightning conductors 4a, 4b placed at the tip 1' of the blade 1 will be sufficient to protect the whole of the windmill blade 1, in that experience has shown that lightning most often strikes at the tip 1' of the windmill blade 1. When the blade is struck, the lightning will thus flow from the lightning conductors 4a, 4b via the inner conductor 6 towards the mill hub 3 (not shown). The result of the inner conductor 6 being thus placed is that the blade will retain its original strength and dynamic characteristics, combined with an effective earthing of the lightning.

In fig. 4 is seen a further embodiment according to the invention. A lightning conductor 4', which consists of an aluminium rod, extends to form a point towards the rear edge of the lightning conductor 4'. Via a bored hole 8 and a terminal 9, the lightning conductor 4' is connected to a blade tip 1' with an inner conductor 6. The inner conductor 6 extends towards the hub of the mill in a tip axle 10 which is configured from a composite material. The tip axle is connected at a terminal 14 to a guide 11 by means of a lock-washer 13 and a nut 12.

The actual earthing of the lightning with the embodiment shown in fig. 4 will take place in the same way as with the



system shown in fig. 2, in that the lightning will flow from the lightning conductor 4' via the inner conductor 6 in towards an earth connection at the root of the blade.

5 The streamlined configuration of the lightning conductor 4' contributes towards giving the blade a further advantage, in that a blade configured with this streamlined conductor at the tip of the blade gives the blade an improved efficiency and a smaller emission of noise.

10

The inner conductor 6 also serves to secure the rotatable tip 1' to the blade itself.

15 In connection with the protection of a windmill blade 1 with a rotatable tip 1', the invention is particularly advantageous in that the protection is implemented in the tip 1' of the blade, and in that the earthing takes place via an inner conductor. The inner conductor 6 earths a possible stroke of lightning, regardless of whether or not the  
20 rotatable tip 1' is rotated.

In fig. 5 is seen a further embodiment according to the invention. A lightning conductor 4'' is disposed in the tip of a rotatable blade tip 1', and is connected to a tip axle  
25 15 which is made of stainless steel. The tip axle 15 is secured to a blade 1, in that the blade 1 has a pair of in-laminated brackets 16. An inner conductor 6, consisting of a stainless steel wire, is connected to the tip axle 15 by means of a clamp, and extends in towards the anchoring of  
30 the windmill blade 1.

The shown embodiments are particularly advantageous in connection with the subsequent mounting of a lightning arrester on an existing windmill blade 1, in that the  
35 existing installations can easily be utilized or replaced.

The actual lightning conductor 4'' can thus easily be mounted, in that this must merely be mounted instead of a closing plug which sits in the same place in an existing blade.

## C L A I M S

1. Lightning arrester arrangement for mounting in a windmill blade (1) of composite material, with or without rotatable tip (1'), characterized in that the lightning arrester arrangement consists of one or more lightning conductors (4a, 4b, 4', 4'') of an electrically-conducting material in or in the vicinity of the tip (1') of the blade and on or in the surface of the blade (1), where the lightning conductor or conductors (4a, 4b, 4', 4'') are connected with an inner conductor (6) which extends inside the blade (1) and connects the lightning conductor or conductors (4a, 4b, 4', 4'') to an earth connection.
2. Lightning arrester arrangement according to claim 1, characterized in that the inner conductor (6) of the lightning arrester arrangement is connected to an earth connection via the hub (3) of the windmill.
3. Lightning arrester arrangement according to claim 1 or 2, characterized in that the inner conductor (6) is disposed in or in the vicinity of the neutral axis of the windmill blade (1).
4. Lightning arrester arrangement according to any of the claims 1 to 3, characterized in that the lightning conductor or conductors (4a, 4b, 4', 4'') are streamlined, preferably with torpedo-shape or guttiform.
5. Lightning arrester arrangement according to any of the foregoing claims 1 to 4, characterized in that the inner conductor (6) extends inside a hollow tip axle.
6. Lightning arrester arrangement according to any of the foregoing claims 1 to 5, characterized in that

the inner conductor (6) wholly or partly consists of an electrically-conducting tip axle (15).

5 7. Lightning arrester arrangement according to any of the foregoing claims 1 to 6, characterized in that the inner conductor wholly or partly consists of a metal wire with or without a cladding of insulation material.

10 8. Lightning conductor for mounting on a windmill blade, characterized in that this is aerodynamically configured of an electrically-conducting material and is disposed in or in the vicinity of the tip of the windmill blade.

15 9. Use of the lightning arrester arrangement according to claims 1 to 7, characterized in that the arrangement is used on a windmill blade (1).

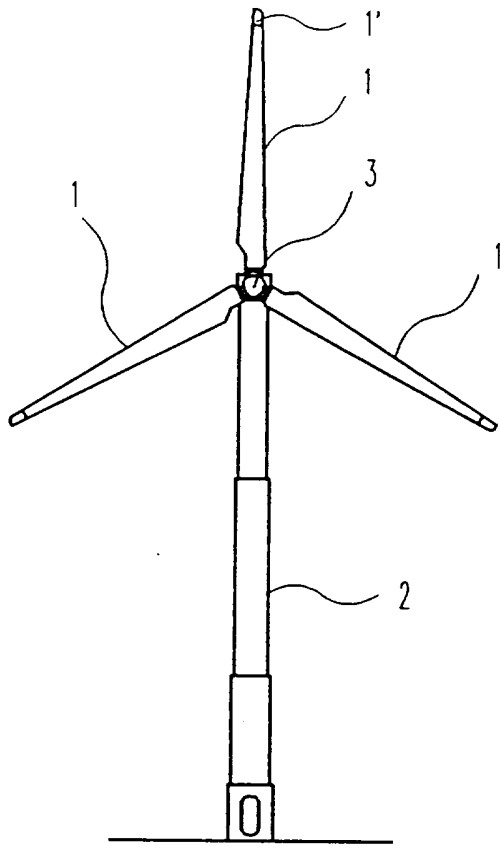


Fig. 1

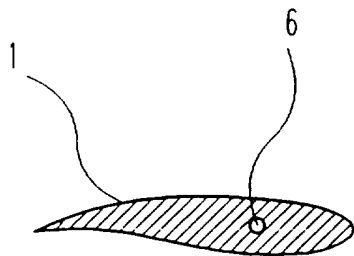


Fig. 3

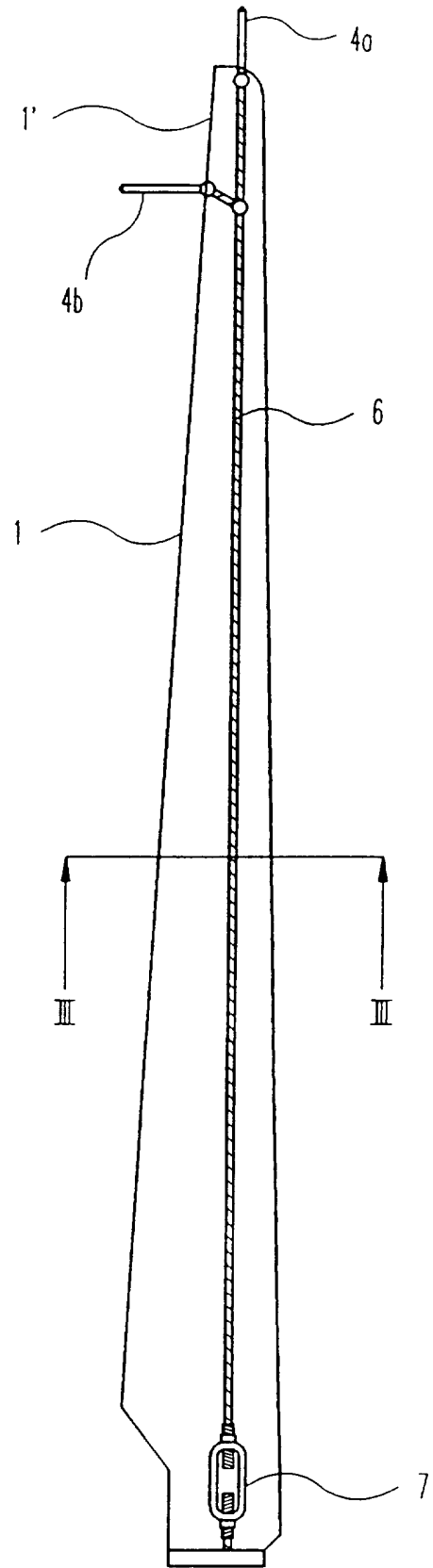
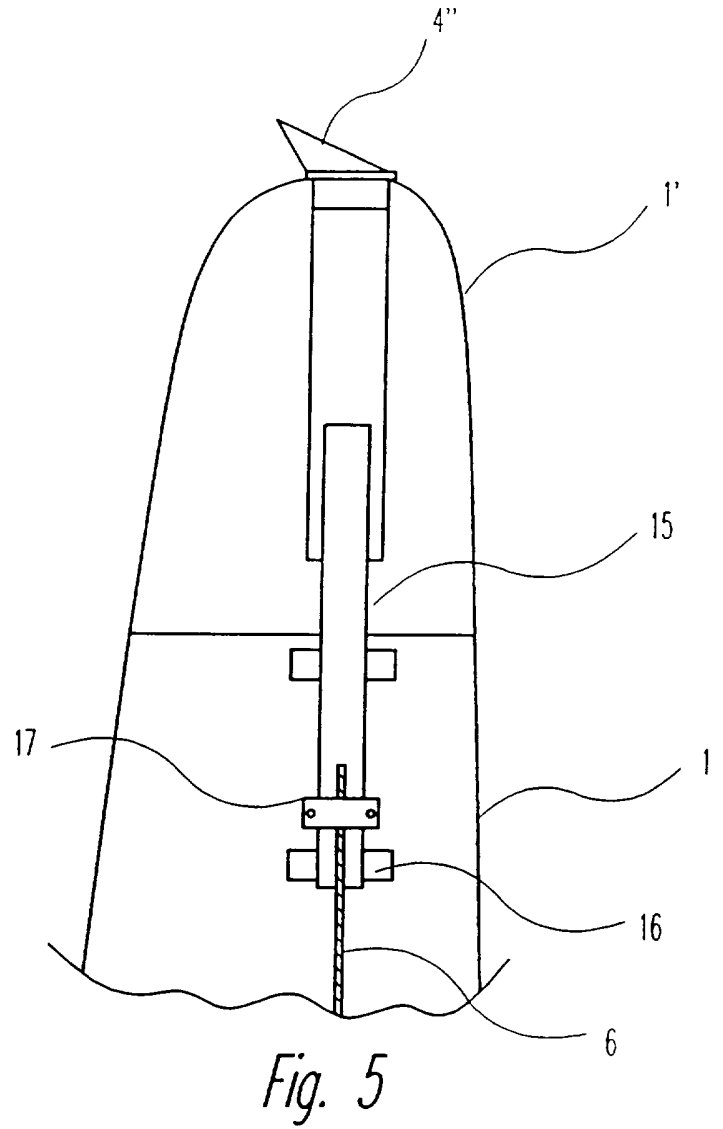
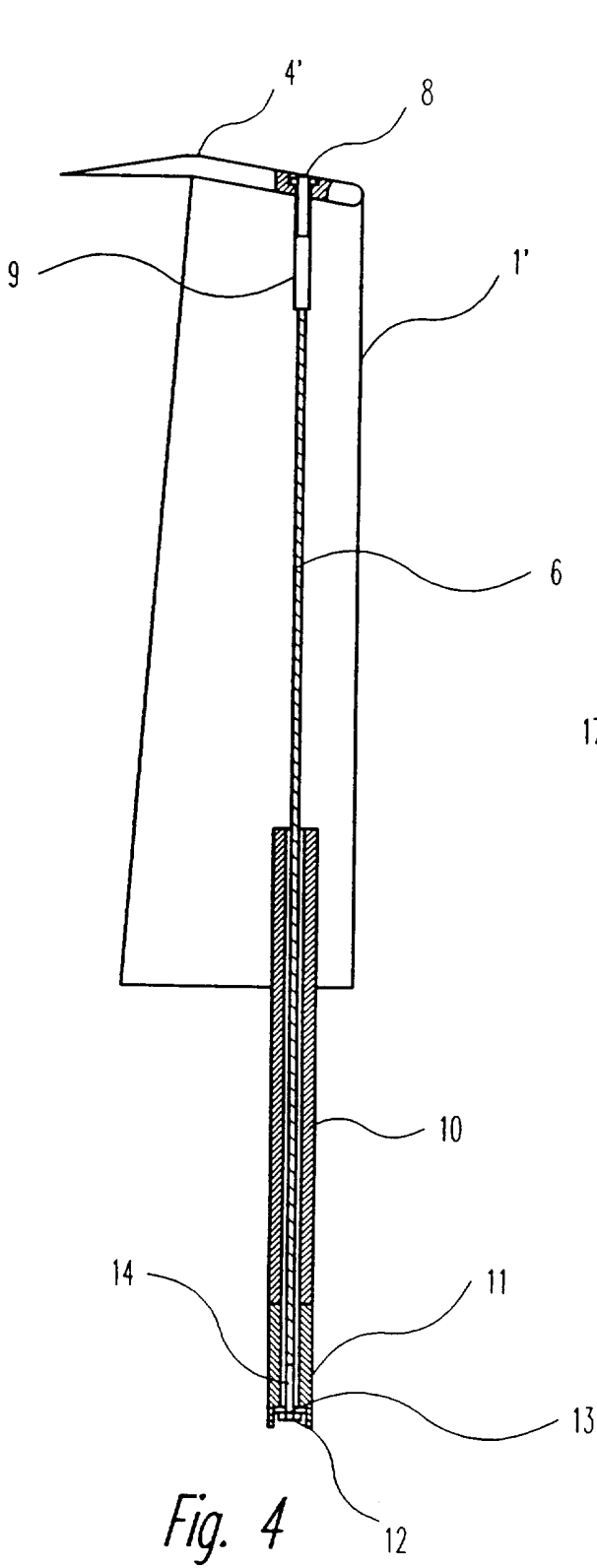


Fig. 2



# INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 95/00358

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F03D 11/00, H02G 13/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F03D, H02G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SE 429279 B (TELEFON AB L M ERICSSON), 22 August 1983 (22.08.83)  -- -----	1

Further documents are listed in the continuation of Box C.       See patent family annex.

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

11/12/95

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PCT/DK 95/00358

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
SE-B- 429279	22/08/83	CA-A- 1221729	12/05/87
		EP-A, B- 0121546	17/10/84
		US-A- 4625256	25/11/86
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