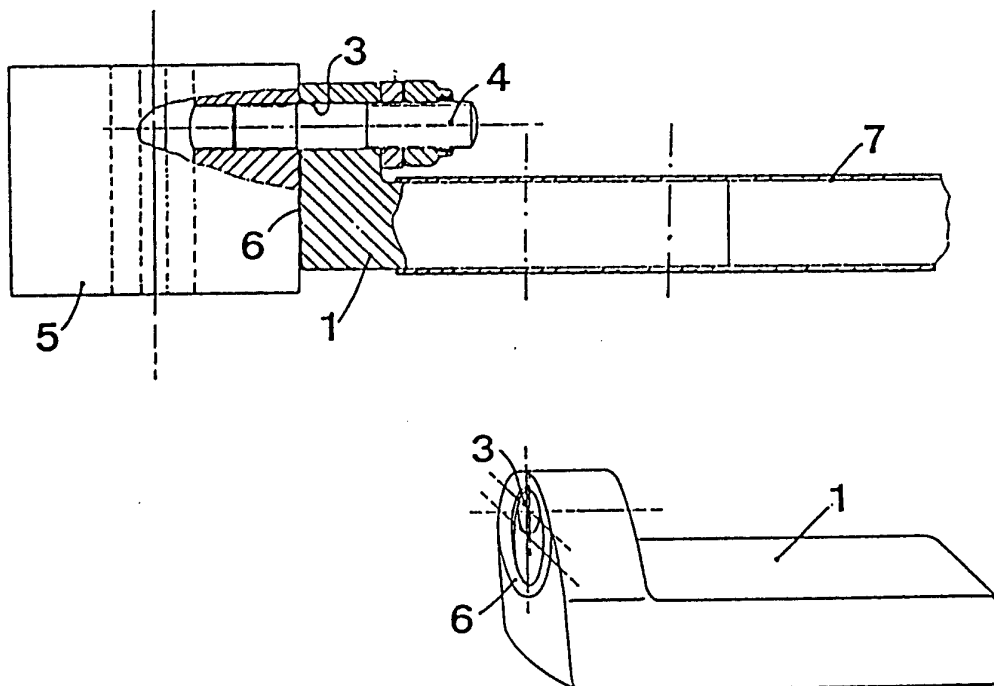




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<p>(21) International Application Number: PCT/EP93/02815 (22) International Filing Date: 13 October 1993 (13.10.93) (30) Priority data: 3233/92-4 19 October 1992 (19.10.92) CH (71) Applicant (for all designated States except US): CEUTE S.A. [CH/CH]; c/o Dominfid S.A., Via Bossi, 6, CH-6900 Lugano (CH). (72) Inventor; and (75) Inventor/Applicant (for US only) : BIANCHI, Emilio [IT/CH]; Via Zorzi, 41, CH-6900 Lugano-Paradiso (CH). (74) Agents: BAGGIOLINI, Raimondo et al.; Fiammenghi-Fiammenghi, Via San Gottardo, 15, CH-6900 Lugano (CH).</p>		<p>(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, 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).</p> <p>Published <i>With international search report.</i></p>

(54) Title: IMPROVED DEVICE FOR CONNECTING THE BLADES TO THE HUB IN PROPELLERS OF FANS, AIRCRAFT AND OTHER APPLICATIONS



(57) Abstract

The device in question provides that the connection of blades (7) to the hub (5) is realized by means of element (1) in the shape of an L, one side of which is substantially aligned with the longitudinal axis of blades (7).

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Improved device for connecting the blades to the hub in propellers of fans, aircraft and other applications.

The present invention has as its object an improved device for connecting the blades to the hub in propellers of fans, aircraft and other applications, with variable fitting when in the stopped position or in motion.

5 In the application for European patent No. 90810598.4 of the same applicant, an application that was published on February 20, 1991 with No. 0 413 663 A2 with Argentine priority of August 14, 1989, a device is claimed in which the connection of each blade to the hub took place by
10 means of a screw placed outside the contour of the blade.

Said screw acted as a pivot for the variation of the fitting of each blade, by ensuring the mechanical blocking of the blade itself to the hub, at the desired fitting.

15 In the Italian patent application in the name of Elica s.r.l. No. 91A 003500, filed on December 30, 1991, there is a blade-hub connection that falls within the above-mentioned previous European patent application of the application, inasmuch as the attachment of the blades to the
20 hub, although realized in a different manner, has the longitudinal axis of the screw located outside the contour of each blade (see for example figures 13 and 14 of that patent application).

Both in the device according to the EPO Ceute patent application, and in the Elica s.r.l. Italian patent application just cited, the blade was practically not
25 disturbed structurally at the base by maintaining the full resisting section in the areas of maximum bending moment.

The disadvantage of the "Ceute" device was that it
30 had to have hubs large in diameter since each blade, for at least 50% of the span had to be superimposed on the hub.

This did not constitute a drawback for fans of large diameter, made up of blades characterized by signifi-

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cant slenderness (by slenderness is meant the ratio: radius of the blade/span of the blade): the large diameter hub serves to reduce the length of the blade and thus the stresses, and to create a shield to prevent the reverse flow in the area of the hub.

Obviously this effect can be obtained in much less costly way by means of a simple sheet metal, aluminum or plastic disc.

On the other hand, with small diameter fans, the "Ceute" device would compromise the performance of the fan, since it necessitated a hub of excessive diameter with the resulting necessity of fairing upstream from the hub.

The "Elica" device, in practice, although it reduces costs with respect to the solution just examined inasmuch as the cost of the hub decreases significantly, presents the drawback, for small fans, of exhibiting the bases of the blades that are altered from the aerodynamic standpoint.

The presence of support 15 figure 14 in the "Elica" device significantly alters the aerodynamic field at the base.

Both the "Ceute" and the "Elica" devices can find their field of application for axial fans characterized by a ratio of radial extension of the blade outside the support/radius of the blade itself close to the unit.

This is for the reasons stated above and especially when the fans are made to operate at a high tip speed.

In this case for equal yield, few blades are required, in addition to the significant slenderness, with the high tip speed compensating for the small surface of the blades.

In the last 10 to 20 years, on the other hand, in countries with a high population density, industrial and civilian plants are required to observe ever stricter norms relating to noise.

For this reason, with equal diameter and equal yield, since the tip speed of the propellers, the major cause of noise, must be significantly reduced, the surface area of the blades must increase at least by the square of the ratio:

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$$\left(\frac{62}{45}\right)^2 = (1970\text{'s tip speed}/1990\text{'s tip speed})^2$$

in which 60 and 45 are the tip speeds of the 1970's and 1990's in meters/second. Furthermore by increasing the surface area of the blade or to say it more precisely the solidity (understood as the ratio between the surface of the blades and the surface of the fan disc), aerodynamic interference is manifested between one blade and another, and thus axial fans that operate at 45 meters/second in comparison to 60 meters/second in the 1970's, exhibit at least twice the surface area of the blade in comparison to that of years past.

Naturally, with equal diameter and yield, in terms of construction it is more economical to double the span of the blade rather than the number of blades.

Consequently: in the 1990's we are dealing with fans characterized by stubby blades (the opposite of "slender") and thus with the capacity to withstand bending moments 8 times greater as compared to the blades of the 1970's.

In fact, by doubling the dimensions, the resisting moment increases with the cube of the dimensions themselves $(2)^3 = 8$, if the span of the 1990's blades is twice the span of the 1970's blades.

Furthermore modest tip speeds intuitively involve reduced loads, thereby supporting the blades with a simple insert is sufficient even if the blade at the base is disturbed by the holes required to connect the blade to the insert itself using screws.

With this invention the intention is to combine the advantages of the previous patent, while introducing two important variations which make possible an improvement of the aerodynamic yields and at the same time a significant decrease in cost.

The present invention thus has as its object an improved device that completely fulfills all the requirements specified above.

It is characterized in that the connection of the blades to the hub is realized by means of an L-shaped

element, the longer side of which is essentially aligned with the longitudinal axis of the blade.

The attached drawings represent some preferred embodiments of the device according to the present invention, which are neither limiting nor binding.

- Figure 1A represents the partial longitudinal section of the connection of a blade of the propeller to the hub by means of the L-shaped element;

- Figure 1B represents the layout view from above with a sectioned portion;

- Figure 1C represents the corresponding lateral view;

- Figure 1D represents the perspective view of the L-shaped element alone;

- Figure 2 represents the lateral view of the L-shaped element to show the eccentricity of the hole through which the screw passes which attaches it to the hub;

- Figure 3A represents the diagram of the moments bending the blade as a function of distance R from the axis of the hub;

- Figure 3B represents an outline of the blade/hub layout to which the diagram of figure 3A refers;

- Figure 3C represents the stresses and the bending moments impinging on the blade/hub unit outlined in lateral view;

- Figure 4A represents a variant in the attachment of the blades to the blade in a partial transverse section;

- Figure 4B represents the same variant in a partial longitudinal section;

- Figure 5A represents the view of a further variant in a partial transverse section;

- Figure 5B represents the same variant in a partial longitudinal section;

- Figure 6 represents an additional device for varying the passage of the propeller in motion.

With reference to the various figures:

figures 1A, 1B, 1C, 1D represent, as previously mentioned, a preferred embodiment of the present invention in which the blade-hub connection is realized by means of

element 1 (figure 1A) in the shape of an "L" which is inserted into the cavity of the blade, and one of its sides is substantially aligned on the longitudinal axis of the blade itself.

5 In the part of the L-shaped element placed perpendicular to the plane of the blade, hole 3 (figure 1D) is made to allow for the passage of screw 4 which bolts the blade attachment to hub 5 (figures 1A, 1B and 1C).

10 To press the attachment of the L-shaped element against the surface of the hub, there is provided circular crown 6 which allows for, with equal tightening of the screw, the transfer of a higher bending moment with respect to that which can be transferred to an L-shaped element held compressed by means of a plane surface.

15 Hole 3 of screw 4 is not concentric with circular crown 6, although it is displaced in the area along the diameter of the crown itself in which the crown has the greatest tendency to "work loose" from the surface of the hub (figure 2) by the effect of the moment generated by the aerodynamic action.

20 In fact, the blades of the fan in operation create in the area of belly 7a (fig. 1C) of the profile an excess pressure (marked with + in figure 3C) with a resulting load on the blades in opposite direction and relative bending moment M_f , the stresses of which are represented in figures 3A, 3B and 3C.

30 From practical tests carried out with extensimetric profiles it is confirmed that: (see figures 3A, 3B, 3C): to an oscillating moment due to aerodynamic distances on the blades, such as non-uniformity of flow and/or interferences with supports, there is superimposed a bending moment caused by the jump in pressure that is manifested corresponding to the disk of the fan.

35 In a first rough approximation it can be assumed that aerodynamic load 8 applied to the blades is localized at 2/3 of the radius.

From this a "constant" moment derives that is to be superimposed on the oscillating moment.

As already stated, circular crown 6 (fig. 1D) placed in correspondence to the blade attachment, pressed by screw 4 against the plane surface of hub 5, transmits a bending moment in the manner described.

5 Since the oscillating bending moment is not symmetrical to the base of the blade, this brings with it the advantage of carrying by means of eccentricity "e" (fig. 2) the axis of tightening screw 4 as close as possible to part 6a of circular crown 6 which has the greatest tendency to
10 work loose from the surface of the hub (greater bending moment as an absolute value). Naturally the modulus of elasticity of the materials (hub, blade attachment, screw), the sections of the elements in play (thickness in the radial sense of the attachment, diameter of the screw, etc.) will
15 give, to whoever is programming the fan, the most suitable position for stabilizing disalignment "e" of screw 4 with respect to circular crown 6.

In practice this disalignment (or eccentricity) should be not less than 10% of the exterior diameter of the
20 crown.

It is obvious that such a solution of the blade-hub connection can be realized with blades not necessarily extruded from aluminum, but also with cast blades, made of injected plastic materials, obtained from compound materials,
25 as long as the L-shaped insert installed as one piece with the blade or installed within the contour of the blade creates the conditions stated above.

If it were desired to obtain blades having the same plane among themselves beyond that can be the combination of
30 the hole/diameter of the screw/tolerance of the hole relative to the attachment, the L-shaped insert of the blade can be connected to the hub by means of a conical seat which can be:

1) obtained in the hub with a protrusion 9 of the L-shaped insert which is coupled with notch 10 of the hub
35 (fig. 5A and 5B);

2) by means of conical protrusion 11 of the surface of the hub and concave conical surface 12 connected with it placed into the L-shaped insert (fig. 4A and 4B).

It is clear that in the case of conical surfaces, hole 3 made in element 1 must be coaxial to crown 6 with the loss of the variability of the fitting of the blade in the stopped position.

5 The blade-hub connection in the two versions with circular crown or with conical seat can be used to connect blades of axial propellers to mechanisms with variation of the fitting with propellers in motion (fig. 5) (which does not place limits on other possible configurations).

10 In such a case the blade-mechanism can be adjusted at the time of setting up.

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Claims

1. Improved device for connecting the blades to the hub in propellers of fans, aircraft and other applications, with variable fitting in the stopped position or in motion, in which the attachment of the blades to the hub has its longitudinal axis eccentric with respect to the axis of the hub, characterized in that the connection of each blade (7) to hub (5) is realized by means of L-shaped element (1), one side of which is substantially aligned with the longitudinal axis of blade (7).

2. Device according to claim 1, wherein hole (3) of screw (4) that fastens L-shaped element (1) to hub (5) is eccentric (fig. 2) with respect to circular crown (6) which presses element (1) to hub (5) (fig. 1A) that is, displaced in area (6a) where said circular crown (6) has the greatest tendency to work loose from the surface of hub (5) by the effect of aerodynamic stresses.

3. Device according to claim 2, wherein said eccentricity (e) of hole (3) and thereby of screw (4) with respect to the axis of circular crown (6) (fig. 2) is greater than 15% of the exterior diameter of crown (6).

4. Device according to claim 1, wherein said L-shaped element is connected to hub (5) by means of conical part (9) (fig. 5A, 5B), which is coupled with notch (10) of hub (5), while the axis of screw (4) and that of circular crown (6) are coincident.

5. Device according to claim 1, wherein said L-shaped element (1) is connected to the hub by means of a conical notch (12) which matches with conical protruding part (11) placed on hub (5) itself, while the axis of screw (4) and that of circular crown (6) are coincident.

6. Utilization of the device according to claim 4 to connect blades of axial propellers to mechanisms with variation of the fitting, with blades in motion.

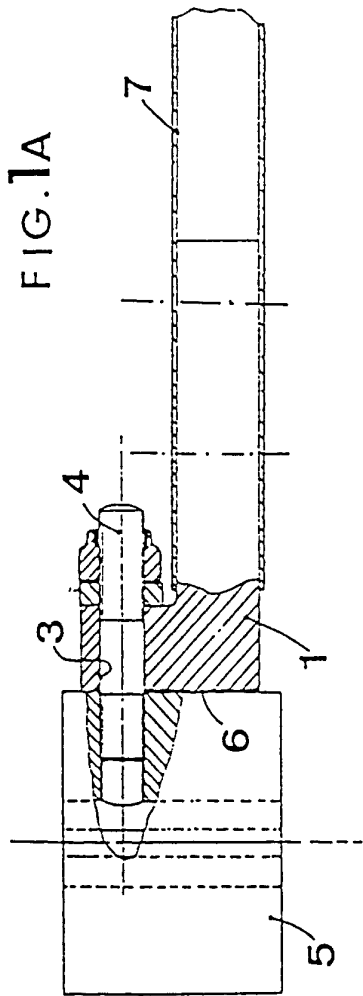


FIG. 1D

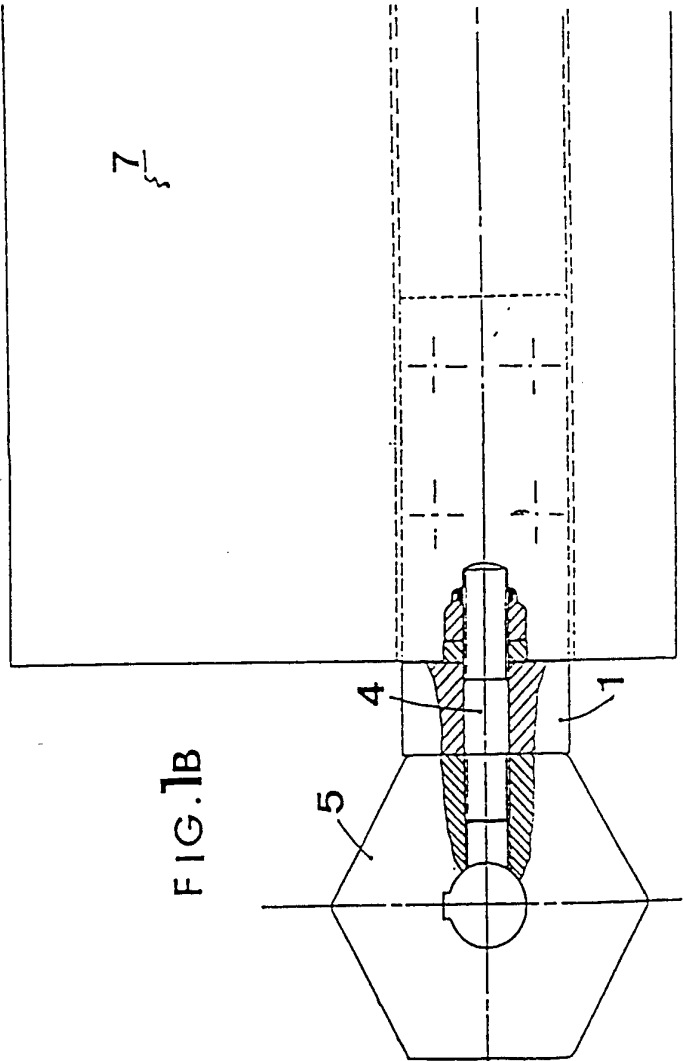
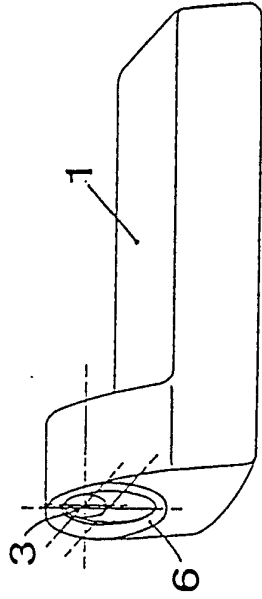
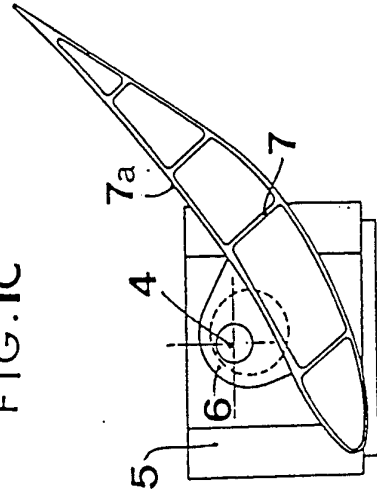


FIG. 1B

FIG. 1C



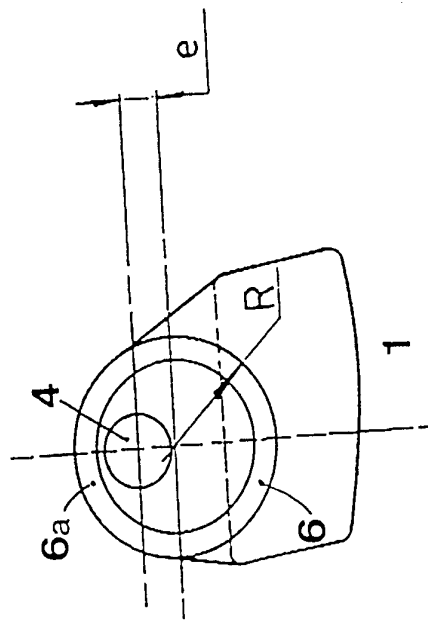


FIG. 2

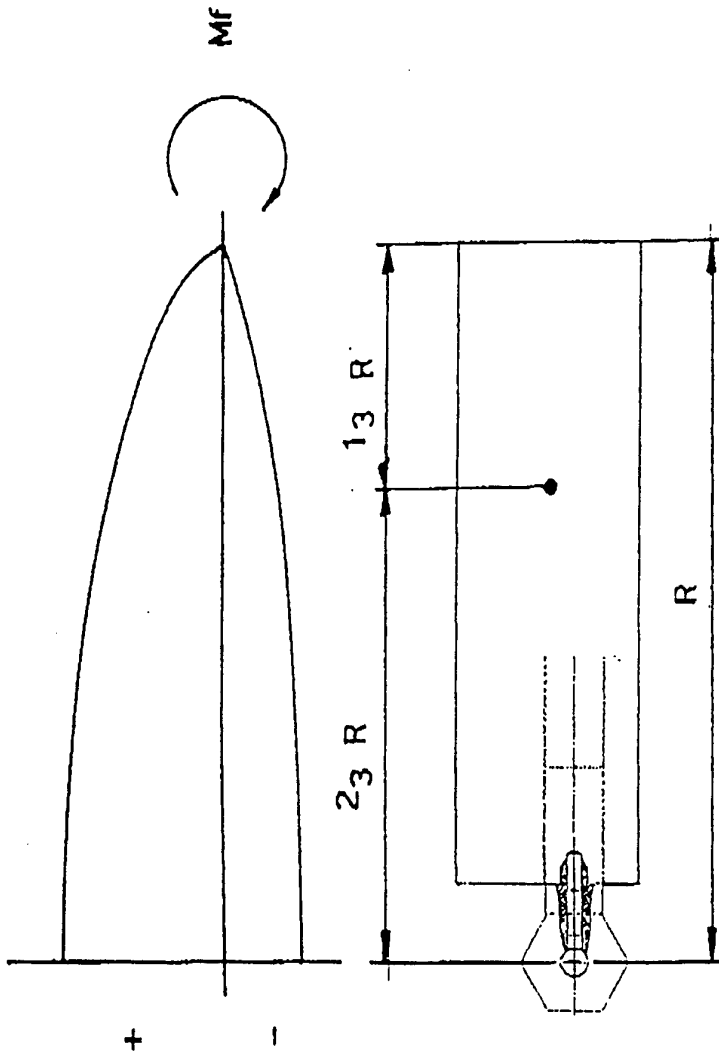


FIG. 3A.

FIG. 3B

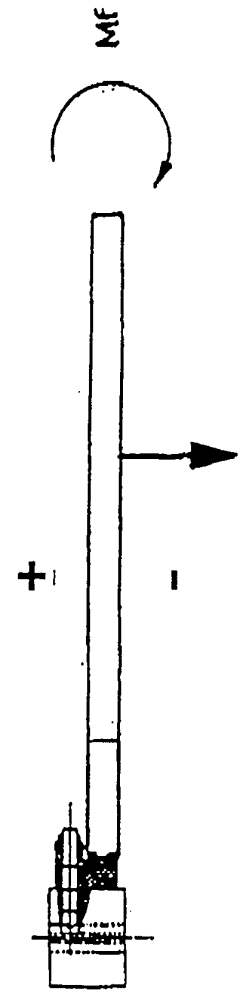


FIG. 3C

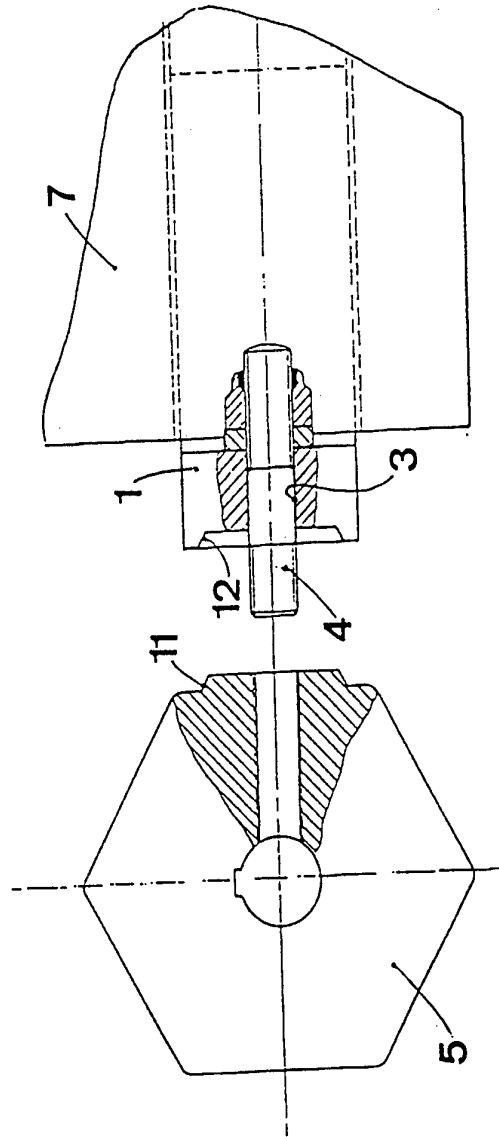


FIG. 4A

FIG. 4B

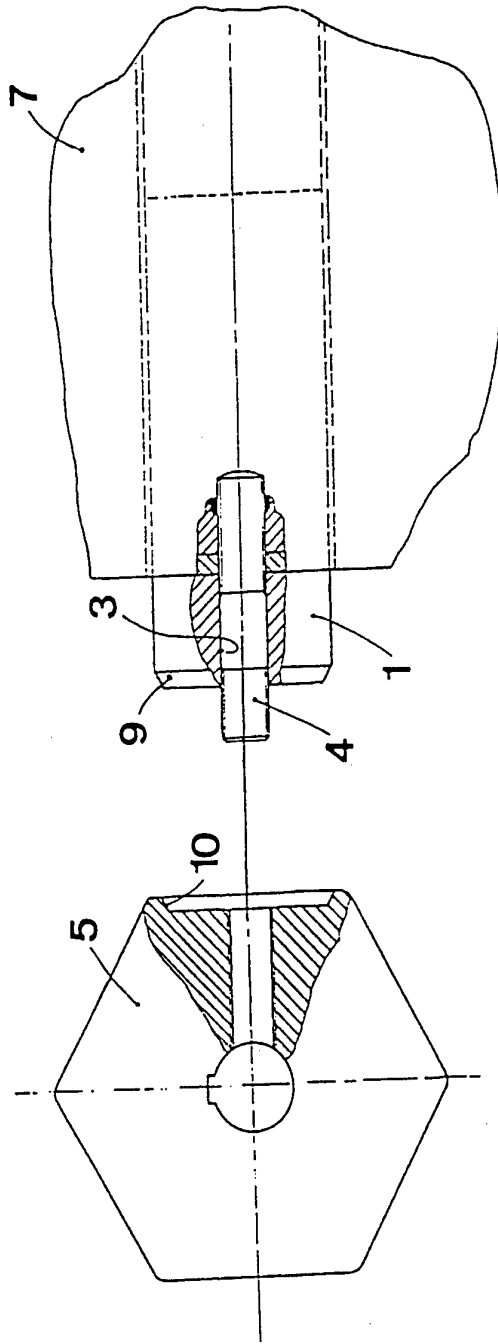


FIG. 5B

FIG. 5A

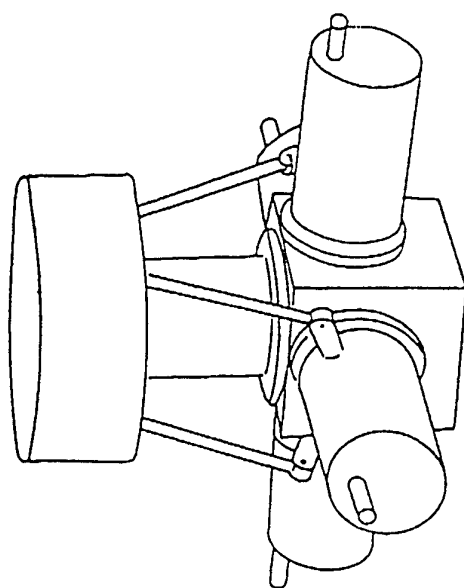


FIG. 6

INTERNATIONAL SEARCH REPORT

Interr. al Application No
PCT/EP 93/02815

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 F04D29/34 F04D29/36 F03D1/06

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)
IPC 5 F04D F03D F01D B64C

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

Electronic data base consulted during the international search (name of data base and, where practical, 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	FR,A,2 372 972 (AEROWATT) 30 June 1978 see the whole document ---	1
A	US,A,1 567 401 (STUART) 29 December 1925 see the whole document ---	1
A	US,A,4 396 352 (PEARCE) 2 August 1983 see the whole document ---	1
A	FR,A,2 381 926 (AXIAL INTERNATIONAL AKTIENGESELLSCHAFT) 22 September 1978 see figure 1 ---	1,6
A	EP,A,0 413 663 (CEUTE) 20 February 1991 cited in the application -----	

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

28 December 1993

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Information on patent family members

International Application No
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