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(54) Virsraksts: **VĒJA ENERĢĒTISKĀ IEKĀRTA**

(57) Kopsavilkums: Izgudrojums attiecas uz vēja enerģētisko iekārtu ar vēja turbīnu, kura ar ģeneratora vārpstas (22) palīdzību, kas var būt turbīnas vārpstas pagarinājums, ir savienota ar elektriskā ģeneratora (11) rotoru (12). Turbīnas vārpsta balstās divos gultņu korpusos (6, 7) ar gultņiem (9, 10), kas uzmontēti uz pamatnes (4) torņa (1) augšējā galā. Ģeneratora vārpsta (22) ir integrēta fleksīvajā turbīnas vārpstā (8) vai stingi ar to savienota. Stators (19) un rotors (12) ir izvietoti uz ģeneratora vārpstas (22), lai ļautu ģeneratoram (11) sekot fleksīvās turbīnas vārpstas (8) kustībai. Stators (19) ir nobloķēts attiecībā pret griešanos ar nerotējoša savienojuma (20) palīdzību, kurš būtībā nepārnes lieces momentu vai aksiālo spēku, kas darbojas pretim turbīnas vārpstas (8) fleksijai, ko izraisa lieces moments, kas darbojas uz turbīnas vārstu (8) no tās rumbas puses, pie kam gultņi (9 un 10) ir izveidoti tā, lai nodrošinātu turbīnas vārpstas (8) fleksiju.

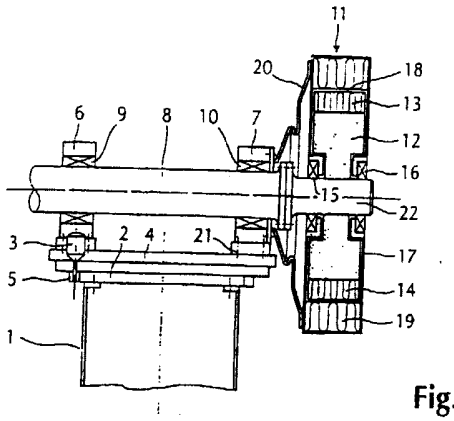


Fig. 1

Izgudrojuma formula

1. Vēja enerģētiskā iekārta, kura satur vēja turbīnu ar turbīnas vārpstu (8), kura ar ģeneratora vārpstas palīdzību, kas var būt turbīnas vārpstas pagarinājums, ir savienota ar elektriskā ģeneratora (11) rotoru (12),

- kurā rotoru (12) radiāli aptver stators (19),
- kurā turbīnas vārpsta (8) balstās divos gultņu korpusos (6, 7) ar gultņiem (9,10), kas uzmontēti uz pamatnes (4) torņa (1) augšējā daļā,
- kurā pamatne var griezties ap vertikālo asi un
- kura ir aprīkota ar motoru (3), lai realizētu griešanos,

raksturīga ar to, ka ģeneratora vārpsta (22) ir integrēta fleksīvajā turbīnas vārpstā (8) vai stingi ar to savienota,

- stators (19) un rotors (12) ir izvietoti uz ģeneratora vārpstas (22), lai ļautu ģeneratoram (11) sekot fleksīvās turbīnas vārpstas (8) kustībai, un
- ka stators (19) ir nobloķēts attiecībā pret griešanos ar nerotējoša savienojuma (20) palīdzību, kurš būtībā nepārnes lieces momentu vai aksiālo spēku, kas darbojas pretim turbīnas vārpstas (8) fleksijai, ko izraisa lieces moments, kas darbojas uz turbīnas vārpstu (8) no tās rumbas puses, pie kam gultņi (9 un 10) ir izveidoti, lai pieļautu turbīnas vārpstas (8) fleksiju.

2. Vēja enerģētiskā iekārta saskaņā ar 1. punktu, kurā ģenerators ir novietots tajā pamatnes (4) pusē, kas ir pretēja vēja turbīnai, vai starp gultņu korpusiem (6, 7),

raksturīga ar to, ka stators ir savienots ar nerotējošu savienojumu (20), kas paredzēts griezes momenta pārnešanai, bet būtībā nepārnes lieces momentu, un kas, vislabāk, ir izveidots kā gredzenveida disks ar riņķveida ieloci, kas savieno statoru ar gultņa korpusu.

3. Vēja enerģētiskā iekārta saskaņā ar 1. vai 2. punktu, kas **raksturīga ar to**, ka nerotējošais savienojums (20) ir izveidots griezes momenta pārnešanai, bet slāpē spēkus, kas rodas ģeneratora īsslēguma gadījumā.

4. Vēja enerģētiskā iekārta saskaņā ar jebkuru punktu no 1. līdz 3. punktam, kas **raksturīga ar to**, ka stators (19) ir piestiprināts pie ģeneratora vārpstas (2) vienā no tās galiem (fig.1) vai ar dubultgultņa (fig.2-4) palīdzību, un rotors ir piestiprināts tieši pie ģeneratora vārpstas (fig.1, 3 un 4) vai ar šķīvja palīdzību ģeneratora vārpstas galā (fig.2).

5. Vēja enerģētiskā iekārta saskaņā ar 1. punktu, kas **raksturīga ar to**, ka stators (11) ir novietots abās pusēs ar elementu (17) palīdzību, kas nefleksīvi balsta statoru (11), kurš ir nefleksīvs attiecībā pret ģeneratora vārpstu un turbīnas vārpstu (8), piestiprināru pie gultņiem (15, 16), kuri atrodas uz ģeneratora vārpstas (fig.1 un 4).

6. Vēja enerģētiskā iekārta saskaņā ar 1. punktu, kas **raksturīga ar to**, ka stators (11) ir novietots vienā pusē ar šķīvveida elementa (17) palīdzību, kas nefleksīvi balsta statoru attiecībā pret ģeneratora vārpstu un turbīnas

vārpstu (8), piestiprinātu pie gultņiem (15, 16), kuri atrodas uz ģeneratora vārpstas (fig.2 un 3).

7. Vēja enerģētiskā iekārta saskaņā ar 1. punktu, kas **raksturīga ar to**, ka stators (19) un pamatne (4) (fig.5) ir savienoti ar spēku pāra palīdzību, kas pārvieto elementus (28), izvietotus radiāli prom no ģeneratora vārpstas (22) griezes momenta pārnesei, piem., elastīgu slāpējošu elementu formā, kuri ir izvietoti starp konsolsiju pāra (26) galiem uz statora un siju (27), kuras pie tam ir savstarpēji paralēlas un piestiprinātas pie pamatnes, lai pārnestu griezes momentu no statora (19) uz pamatni (4), neradot nekādu lieces momentu vai aksiālo spriegumu, kas var apgrūtināt tubīnas vārpstas (8) fleksiju ar lieces momentu, kas darbojas uz vārpstu no rumbas puses un arī slāpē spēkus, kas var rasties īsslēguma gadījumā ģeneratorā.

8. Vēja enerģētiskā iekārta saskaņā ar jebkuru punktu no 1. līdz 3. punktam, kas **raksturīga ar to**, ka gultņi ir (9 un 10) ir sfēriskie gultņi.

9. Vēja enerģētiskā iekārta ar vēja turbīnu, kura ir savienota ar elektrisko ģeneratoru (31) ar pārnesumkārbas (29) palīdzību, pie kam pārnesumkārba (29), ģeneratora pamatne (30) un ģenerators (31) ir novietoti uz turbīnas vārpstas (8),

raksturīga ar to, ka pārnesumkārba (29), ģeneratora pamatne (30) un ģenerators (31) brīvi var pārvietoties kopā ar turbīnas vārpstu visos spēka pielikšanas virzienos, izņemot turbīnas vārpstas griezes momenta virzienu, un ar to, ka pārnesumkārba (29), ģeneratora pamatne un ģenerators (31) visi kopā, neatkarīgi viens no otra vai grupās pārnes griezes momentu no turbīnas vārpstas (8) uz galveno pamatni (4) ar nerotējoša savienojuma (33) starpniecību, kurš netraucē minēto komponentu kustību citos spēka pielikšnas virzienos.

10. Vēja enerģētiskā iekārta saskaņā ar 9. punktu, kas **raksturīga ar to**, ka ātrumkārba (29), ģeneratora pamatne (30) un ģenerators (31) var atrasties dažādās pozīcijās un virzienos attiecībā pret turbīnas vārpstu (8).

Wind power plant

Description of invention

Prior art and its weaknesses

A major technical challenge in the design and development of wind power plants, is to ensure that the bending moment acting on the turbine hub from the blades does not create damaging deformations in the remaining structure. This relates particularly to deformations which may influence the air gap between the rotor and the stator when the turbine shaft carries an electric generator without any intermediate gearbox, or deformations straining the wheels of the gearbox and reducing the service life when a gearbox is used between the turbine shaft and the generator.

It is known to provide having wind turbine powering a generator arranged at the top of a column or tower. One solution is to connect the hub of the wind turbine directly to the rotor. The rotor is in turn carried by a base connected to the top of the tower, and the stator is carried by the base without making any effort to coordinate the movements of the rotor and the stator. Experience shows that this design does not give the necessary control of the air gap between the rotor and the stator upon a bending moment strain being set up on the turbine shaft from the hub of the wind turbine. Also the generator can not be made ready for use prior to mounting. Another solution is proposed in German Patent Publication 4402184 A1, wherein the hub of the wind turbine is connected directly to the rotor of the generator without any connecting gearbox and wherein the rotor and the stator is connected through two bearings providing a coordinated movement. This solution allows for premounting of the generator as a complete unit in a factory, and testing prior to the on site mounting.

Calculations shows that even this design will not provide a desirable constant air gap, when the wind turbine exceeds a certain size in power and weight, without making the dimensions of the supporting base unecessary large.

It has also been proposed to arrange the generator on the opposite side of the wind turbine relative to the top of the tower and connect the wind turbine to the generator over a turbine shaft between the hub and the rotor of the generator - either in a rigid connection or over a coupling which transfers no bending moment, and without an intermediate gearbox - and wherein the turbine shaft and the generator are journalled in a support arrangement with two or more bearings integrated in the support arrangement. The purpose of this arrangement is to reduce the bending acting on the part of the shaft adjoining the generator, by forcing the shaft through radial reaction forces from the bearing, back to the neutral position relative to the bending of the shaft without this arrangment, to have a tight

as possible air gap between the rotor and the stator. With this solution the bearings are subject to high bearing forces, and additionally the design requires a very rigid base to accomodate the increased bearing .

Object

The main object of the invention is to provide a wind power plant wherein the stator and the rotor during operation maintain their mutual distance (air gap), independent on the deflection of the turbine shaft due to the bending moment acting on the hub of the wind turbine in the cases where the turbine shaft is connected directly to the generator. In the embodiments wherein a gearbox is arranged between the turbine shaft and the generator, the invention should relieve the gearbox from unexpected forces, which may reduce the service life relative to the norm.

The Invention

The present invention is described in patent claim 1. This can be embodied in different ways and designs, which are adaptable to various sizes of wind turbines and different generator designs.

The present invention concerns the journalling of the turbine shaft in a wind power plant powered by a wind turbine at one end of the shaft, and wherein an electric generator is connected to the shaft either outside relative to two bearing housings, or between a bearing housing facing the wind turbine and a rear bearing housing, to reduce the effect of the bending moment acting on the shaft, due to forces acting on the hub of the wind turbine , on the air gap between the rotor and the stator of the generator, using a journalling according to patent claim 1.

This provides an advantageous combination of simple structure and favourable journalling properties which contributes to keep the air gap between the rotor and the stator of the generator as small and constant as possible during the operation of the wind power plant. and without straining the bearings excessively due to the forces created by the bending moment acting on the hub.

This enables a transfer of torque from the turbine shaft to the rotor, and from the rotor through the electrical field to the stator and via a non-rotatable coupling to one of or both bearing housings. or directly to the base.

Further advantageous features are stated in claims 2-10.

When using a gearbox interposed between the turbine shaft and the generator, the invention allows for a direct attachment of input in shaft of the gearbox to the turbine shaft, which then carries the gearbox which in turn carries a generator base supporting the

generator, and wherein the rotor of the generator is connected to the output shaft of the gearbox, with a rigid or elastic coupling. The transfer of torque from the rotor to the stator and from there to the base will also in this case be carried out by the non-rotatable coupling which will be described for the direct driven generator.

Examples

The invention is further described below with reference to the drawings, wherein:

Fig. shows a vertical section through an embodiment with a two-sided journalling of the stator on the shaft,

Fig. 2 shows a vertical section of a corresponding embodiment with a single-sided journalling of the stator on the shaft,

Fig. 3 shows a vertical section through a third embodiment with a two-sided journalling of the stator, which is carried by the shaft,

Fig. 4 shows a vertical section through a further embodiment of the invention, with the generator arranged between two bearings,

Fig. 5 shows a perspective view of an alternative embodiment of a non-rotatable coupling,

Fig. 6 shows a perspective view of an alternative embodiment, with a gearbox connected to the turbine shaft, with a generator further being arranged on a generator support carried by the gear box in the extension of the, and wherein the torque transmission to the main base is provided by an adapted non-rotatable coupling, and

Fig. 7 shows a perspective view of a further embodiment, with a gear box connected to the turbine shaft, and with a generator arranged on a generator base carried by the gear box over the turbine shaft, and wherein the torque transmission to the main base is provided by an adapted non-rotatable coupling

The invention illustrated in Fig. 1 is based on a coupling of the turbine shaft directly to the generator. It shows a vertical section lenghtwise through a shaft bearing according to an embodiment of the invention. On the top of a tower 1 a horizontal gear rim 2 is attached, which is used for turning of the higher parts of a wind power plant which is described in more detail below. Over the gear rim is a rigid base 4 which serves as a support for the shaft. The base 4 is rotable relative to the gear rim 2 around its vertical shaft by a suitable bearing. The rotation is activated by a motor 3 arranged at the side of the base 4 with a depending shaft with a gear 5 engaging the gear rim 2.

The base 4 provides support for two bearing housings, a front bearing housing 6 facing the turbine, and a rear bearing housing 7. The bearing housings together carry the turbine

shaft 8, which in turn carries a complete generator 11. Each bearing housing contains a bearing 9, 10, and is attached to the base 4 with bolts 21.

The generator rotor is carried by a generator shaft 22 which can be a continuation of the turbine shaft 8. The stator housing 17 is carried by bearings 15, 16 on the shaft 8. Bearings 15, 16 provide an air gap 18 which is as constant and small a possible, between the stator 19 and the rotor 12, independent of the deflection of the shaft.

The torque from the turbine shaft 8, which through the electic field is transferred to the stator housing 17, is transferred to the base via a non-rotatable coupling 20.

In Fig. 6 and 7 an alternative embodiment of the invention is shown. A gearbox is arranged between the turbine shaft 8 and the generator 31, both of which mainly correspond to the previous description. The gearbox 29, the generator base 30 and the generator 31 all are free to follow the movement of the turbine shaft 8 in the opening between the bearing housing 7 and its connection to the gearbox 29, except in the direction of the torque. A non-rotatable coupling 33 provides transfer of the torque from the turbine shaft via the gearbox 29 to the generator 31 and the main base 4 and limits or totally eliminates damaging forces, which may otherwise result in damaging deformations of the gearbox and the generator. The non-rotatable coupling 33 comprises a bracket 34 in the form of two arms extending from the main base 4 towards the generator 31. The bracket 34 is rigidly attached to the main base and at the free end connected with a cross yoke 35. Further, at the free end, a knee link with two linked arms 36, 37 are linked to the end of the bracket or yoke 35 and at a bracket 38 on the side of the gearbox 29. A corresponding, symmetrically arranged knee link may be provided at the oposite side.

Function

The function of this arrangement is mainly described by the description and Fig. 1. The weight of and the forces acting on the shaft 8 and the generator 11 is carried by the bearings 9, 10 and transferred to the base 4. The turbine shaft 8 transfers the torque directly to the rotor 12 of the generator. The stator housing 17 is carried directly on the turbine shaft. A suitable size of shaft in the vacinity of the generator 11 provides sufficient rigidity to ultimately keep a constant and small air gap 18 between the rotor 12 and the stator 19. A non-rotatable coupling 20 in the form of an annular dish with a central, circumferential fold increases the pliability in an axial direction, results in transfer of the torque acting on the stator housing 17, due to the electrical field from the rotor 12, to the base 4 with minimum bending moment.

The non-rotatable coupling 20 is designed and sized to transfer only torque from the vind turbine, without deflection of the generator shaft 22 due to torque acting on the hub of the wind turbine.

The stator housing 17 thus will follow the movements of the rotor 12 and the generator shaft 22 and the air gap 18 is maintained mainly constant.

The total structure allows for testing the wind turbine and the generator as a complete unit before mounting in situ, and to hoist and mount it to the top of the tower as a readymade unit.

Modifications

In Fig. 2 an alternative embodiment is shown, similar parts being provided with identical reference numerals as in Fig. 1, and wherein the generator shaft 22 is carried by a double journalled bushing 23 providing a stator hub, which with another bearing 24 carries the rotor 12. The generator shaft 22 has a dish 25 at the free end attached to the rotor 12 for transferring torque thereto.

In Fig. 3 a further embodiment based on the same principle is shown. In this case a stator dish 17 with a hub is carried by the generator shaft 22 with a double bearing, and extendeds into a flange on one side, carrying the active stator parts.

In Fig. 4, in which the same reference numerals as the previous Figures are used an embodiment is shown, which differs from the embodiments of Figs. 1- 3 by having the generator arranged between the bearing housings 6, 7. The non-rotatable coupling 20 is fastened correspondingly to the bearing housing 6 adjoining the wind turbine.

Generally, the non-rotatable coupling 20 may be fastened to an arbitrary bearing housing, or to the base 4.

In Fig. 5 a further modified embodiment of the base 4 and the bearing units 6, 7 is shown. In this case the stator 19 is provided with a radial pair of arms 26, extending horizontally at the base 4. The base 4 carries a beam 27 which is arranged parallell to the pair of arms 26. At both ends, the pair of arms and the beam is connected to a damping element 28, which can take torque, but not bending moment and axial forces. The damping elements 28 are provided to take possible moment shock, e g. due to short circuit.

Fig. 6 and 7 shows usage of the invention wherein a gearbox 29 is arranged between the turbine shaft 8 and generator 31. Other embodiments of the non-rotatable coupling for transferring of torque from the turbine shaft via gearbox 29 and the generator 31, as long as it is provided for minimal force transfer between the turbine shaft 8 and the same elements in all directions except for the torque direction.

Claims:

1. Wind power plant with a wind turbine with a turbine shaft (8) which with a generator shaft (22), which can be an extension of the turbine shaft, is connected to the rotor (12) of an electric generator (11),

- wherein the rotor (12) is radially surrounded by a stator (19),
- wherein the turbine shaft (8) is journalled in two bearing housings (6, 7) with bearings (9, 10) arranged on a base (4) at the top of a tower (1),
- wherein the base (4) is pivotable around a vertical axis, and
- wherein a motor (3) is provided to effect the pivoting,

characterized in

- that the generator shaft (22) is integrated with or rigidly connected to a flexing turbine shaft (8),
- that the stator (19) and rotor (12) are carried by the generator shaft (22), to allow the generator (11) to follow the flexing movement of the turbine shaft (8), and
- that the stator (19) is locked against turning by a non-rotatable coupling (20) which transfers substantially no bending moment or axial force acting against the flexing of the turbine shaft (8) due to the bending moment acting on the turbine shaft (8) from its hub, the bearings (9 and 10) being provided to allow flexing of the turbine shaft (8).

2. Wind power plant according to claim 1, wherein the generator (11) is arranged on a side of the base (4), opposite to the wind turbine or between the bearing housings (6, 7), **characterized** in that the stator is connected to a non-rotatable coupling (20) provided to transfer torque and substantially no bending moment, preferably an annular dish with a circumferential fold, which connects the stator to a bearing housing.

3. Wind power plant according to claim 1 or 2, **characterized** in that the non-rotatable coupling (20) is provided for transferring the torque and dampening forces created upon a short circuit of the generator.

4. Wind power plant according to anyone of the claims 1-3, **characterized** in that the stator (19) is attached at the generator shaft (22) at one of its ends (Fig. 1) or with a double bearing (Figs. 2-4) and that the rotor (12) is attached directly to the generator shaft (Fig. 1, 3-4) or with a dish to the end of the generator shaft (Fig. 2).

5. Wind power plant according to claim 1, **characterized** in that the stator (11) is carried on both sides with side elements (17) non-flexingly supporting the stator (11) non-flexing

relative to the generator shaft (22) and the turbine shaft (8) attached to bearings (15, 16) which are carried by the generator shaft (Fig. 1, 4).

6. Wind power plant according to claim 1, **characterized** in that the stator (11) is carried at one side by a dish element (17) non-flexingly supporting the stator relative to the generator shaft (22) and the turbine shaft (8) attached to bearings (15, 16) which are carried by the generator shaft (Fig. 2, 3).

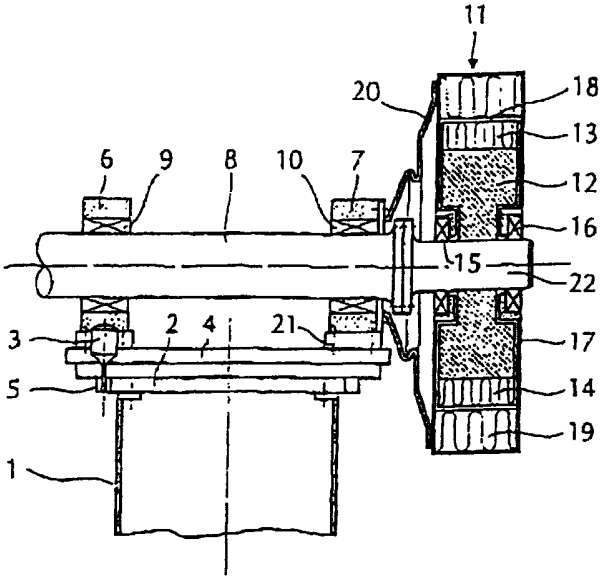
7. Wind power plant according to claim 1, **characterized** in that the stator (19) and the base (4) (Fig. 5) are connected by a couple of force transferring elements (28) being arranged radially away from the generator shaft (22) for transferring torque, e.g. in the form of elastic damping elements which are arranged between the ends of a pair of arms (26) on the stator and a beam (27) parallel therewith and attached to the base (4) to transfer torque from the stator (19) to the base (4) without exerting any bending moment or axial tension which may prevent flexing of the turbine shaft (8) with a bending moment acting on the shaft from the hub and also dampening forces which can be created by short circuit in the generator.

8. Wind power plant according to anyone of the claims 1-7, **characterized** in that the bearings (9 and 10) are spherical.

9. Wind power plant with a wind turbine which is connected to an electric generator (31) through an interposed gearbox (29), wherein the gearbox (29), a generator base (30), and the generator (31) is carried by the turbine shaft (8), **characterized** in that the gearbox (29), the generator base (30) and the generator (31) can move freely together with the turbine shaft in all directions of force except for the torque direction of the turbine shaft, and that the gearbox (29), the generator base (30) and the generator (31) together, independently or in groups transfer torque from the turbine shaft (8) to the main base (4) via a non-rotatable coupling (33) which does not inhibit movement of said components in other directions of force.

10. Wind power plant according to claim 9, **characterized** in that the gearbox (29), the generator base (30), and the generator (31) can be in different positions and directions relative to the turbine shaft (8).

Abstract



Wind power plant with a wind turbine with a turbine shaft (8) which with a generator shaft (22), which can be an extension of the turbine shaft, is connected to the rotor (12) of an electric generator (11). The turbine shaft (8) is journalled in two bearing housings (6, 7) with bearings (9, 10) arranged on a base (4) at the top of a tower (1). The generator shaft (22) is integrated with or rigidly connected to a flexing turbine shaft (8). The stator (19) and rotor (12) are carried by the generator shaft (22), to allow the generator (11) to follow the flexing movement of the turbine shaft (8). the stator (19) is locked against turning by a non-rotatable coupling (20) which transfers substantially no bending moment or axial force acting against the flexing of the turbine shaft (8) due to the bending moment acting on the turbine shaft (8) from its hub. the bearings (9 and 10) being provided to allow flexing of the turbine shaft.

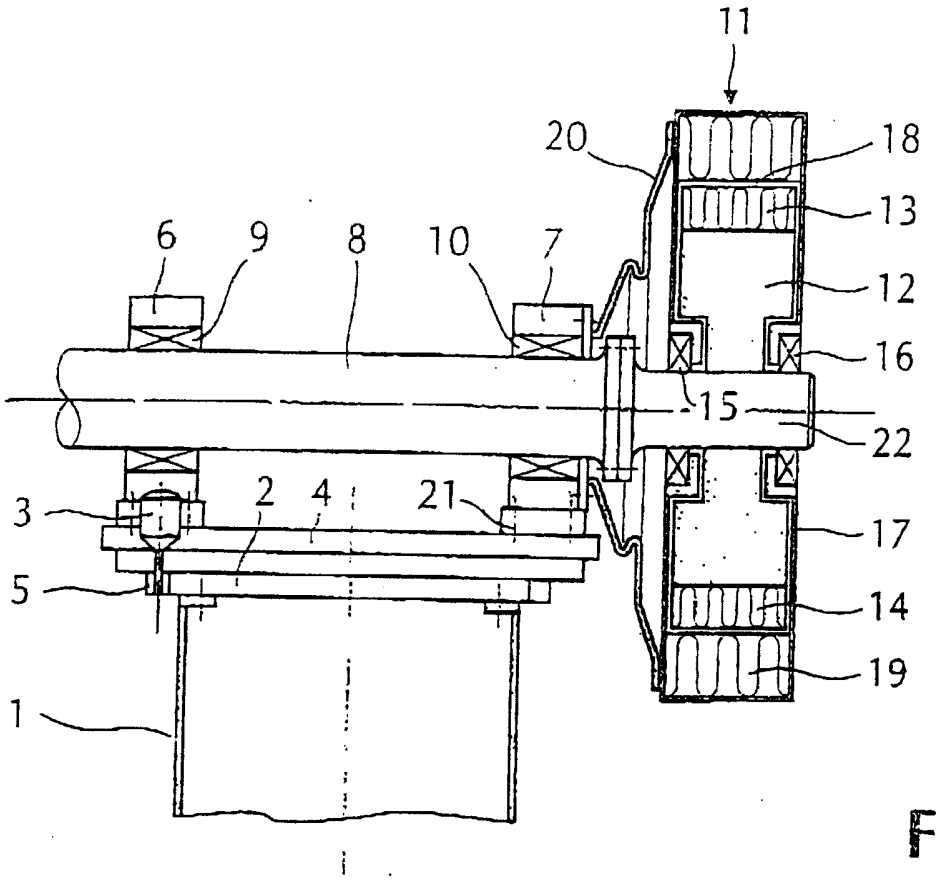

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Fig. 1

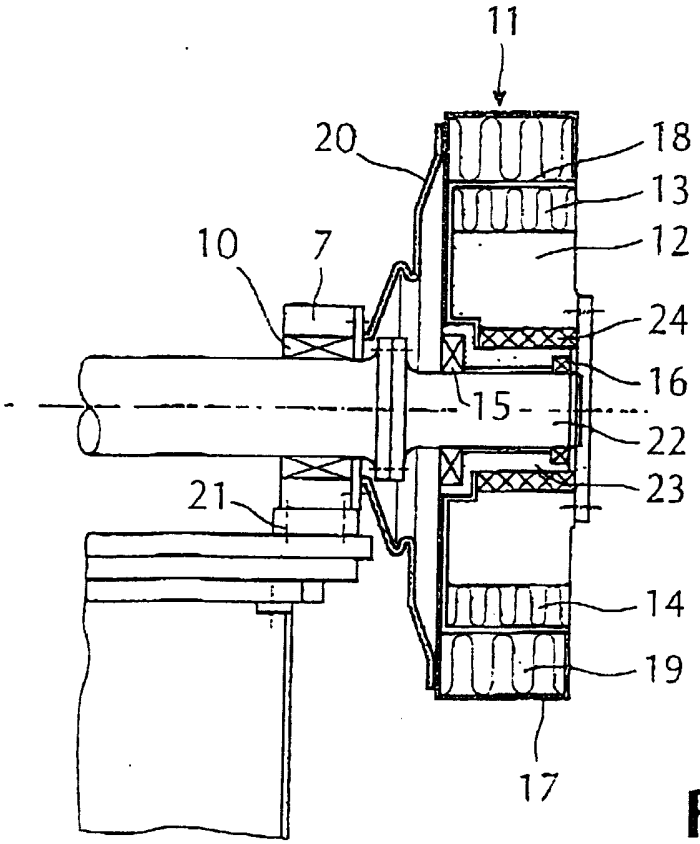
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Fig. 2

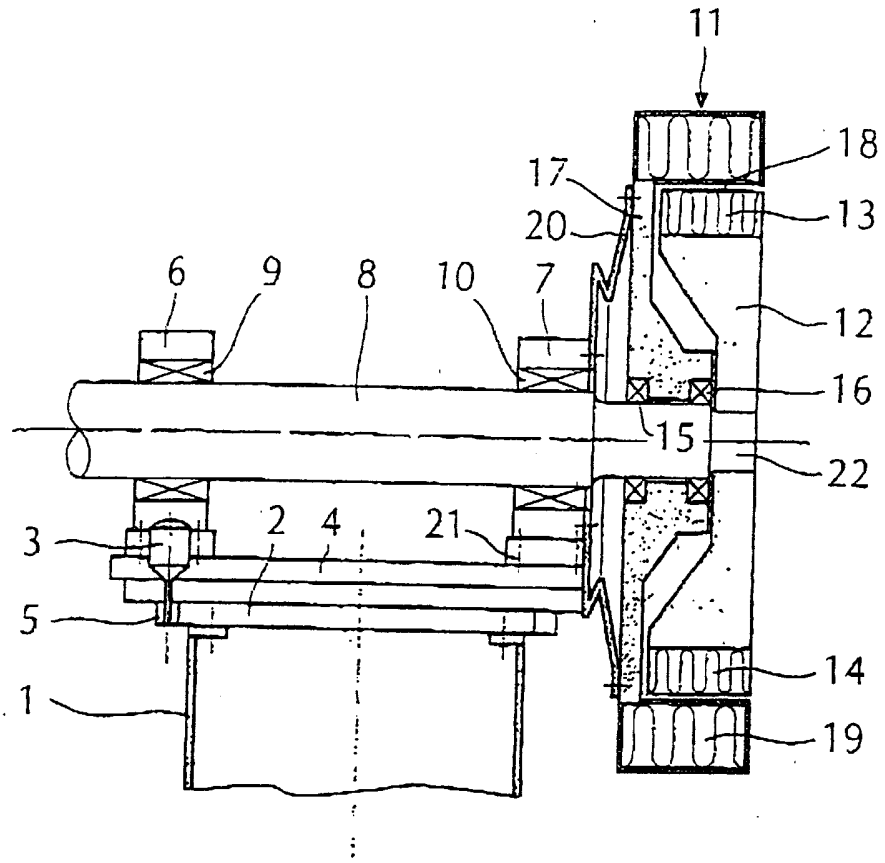
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Fig. 3

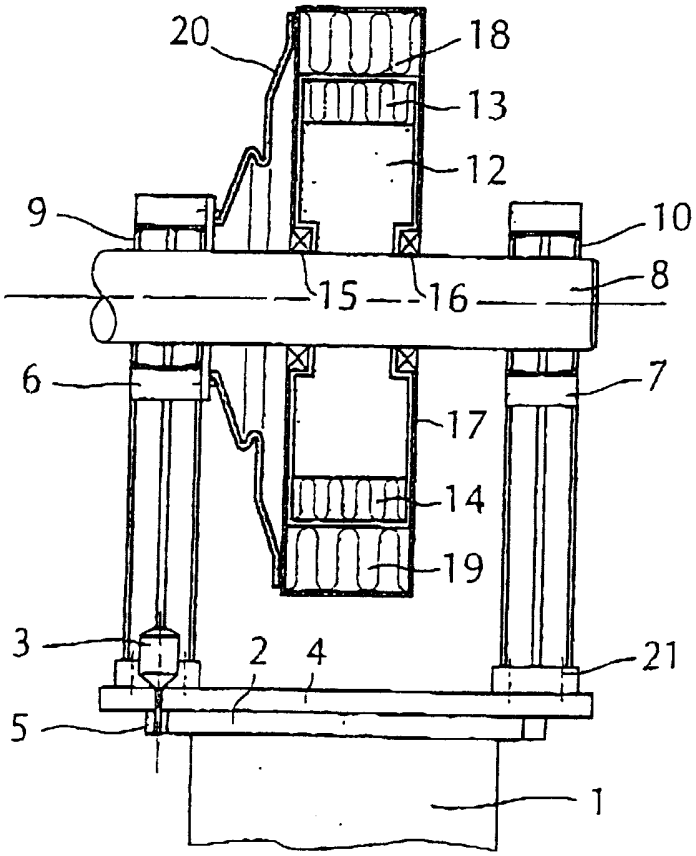
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Fig. 4

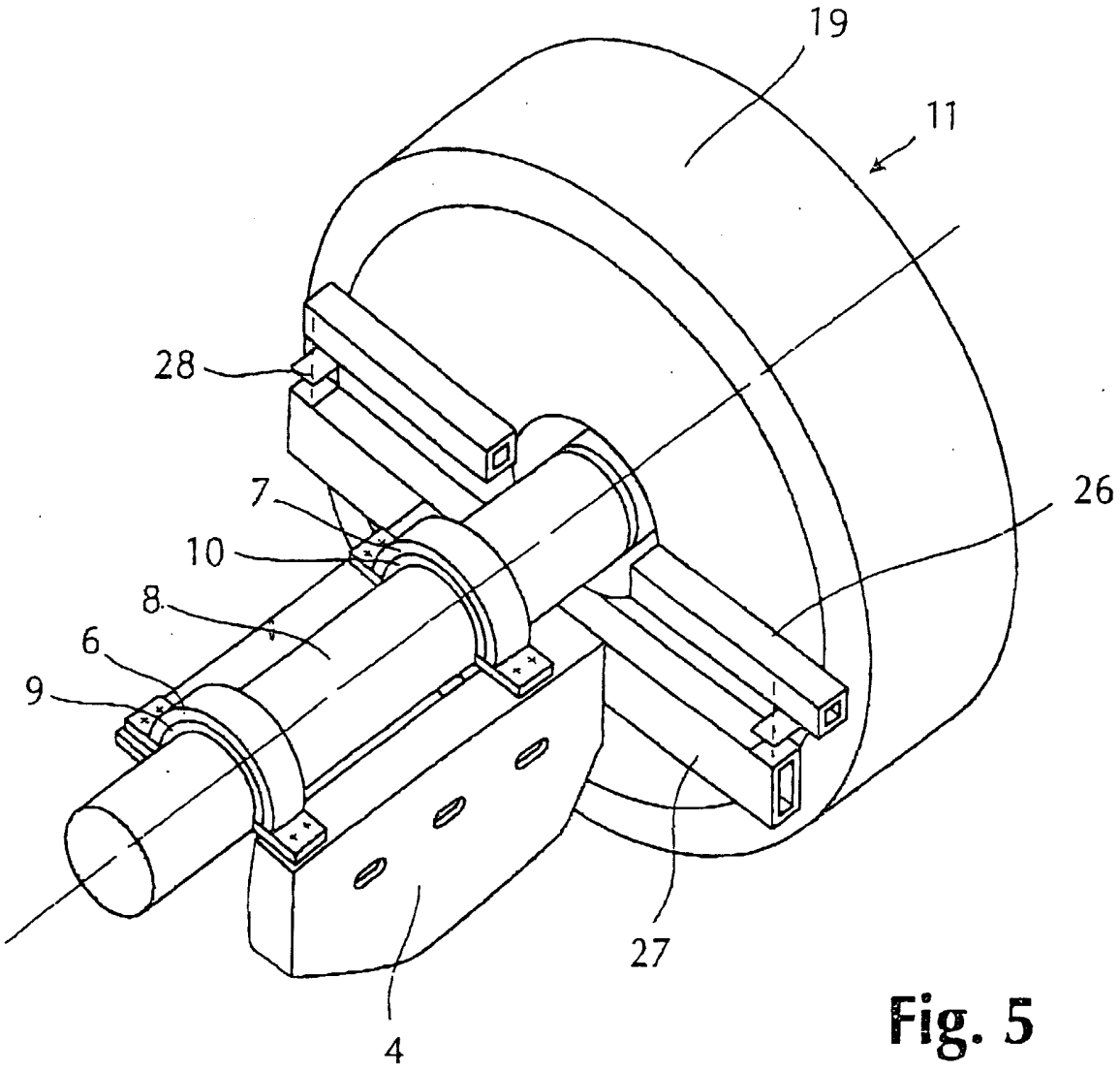

Fig. 5

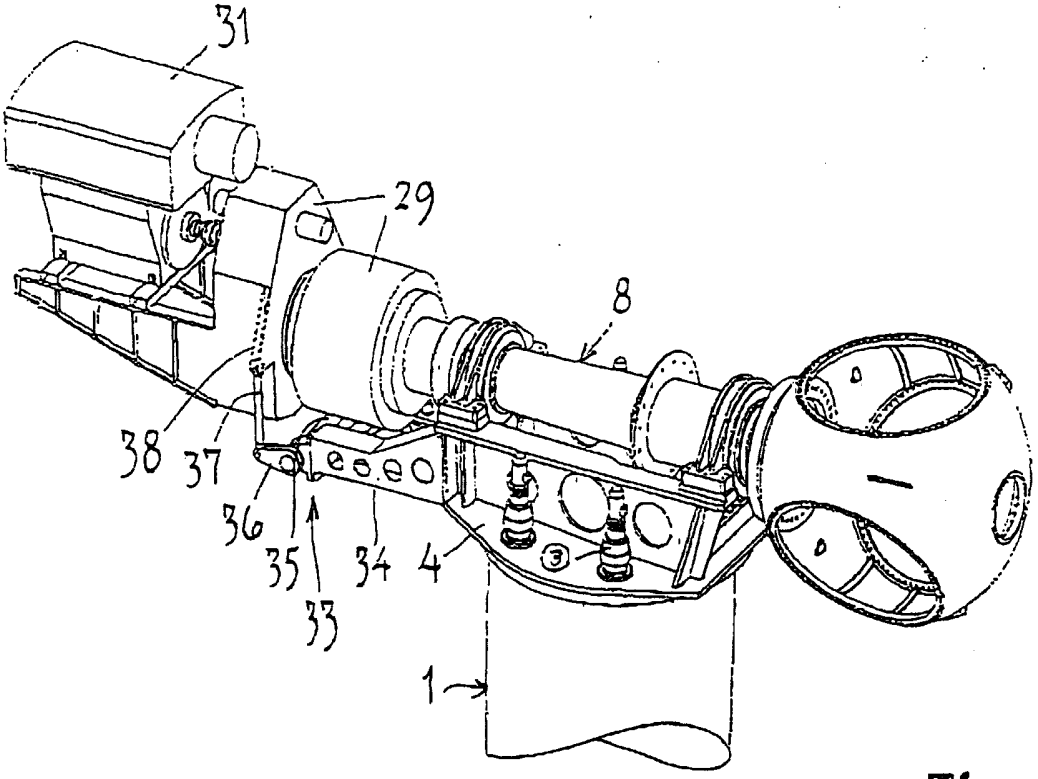

Fig. 6

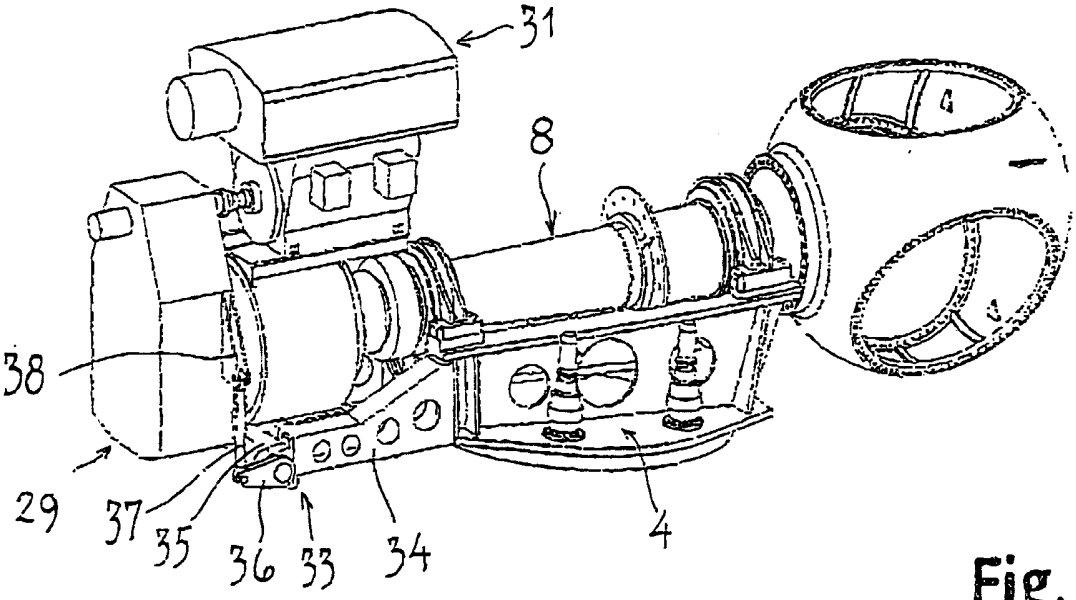

Fig. 7