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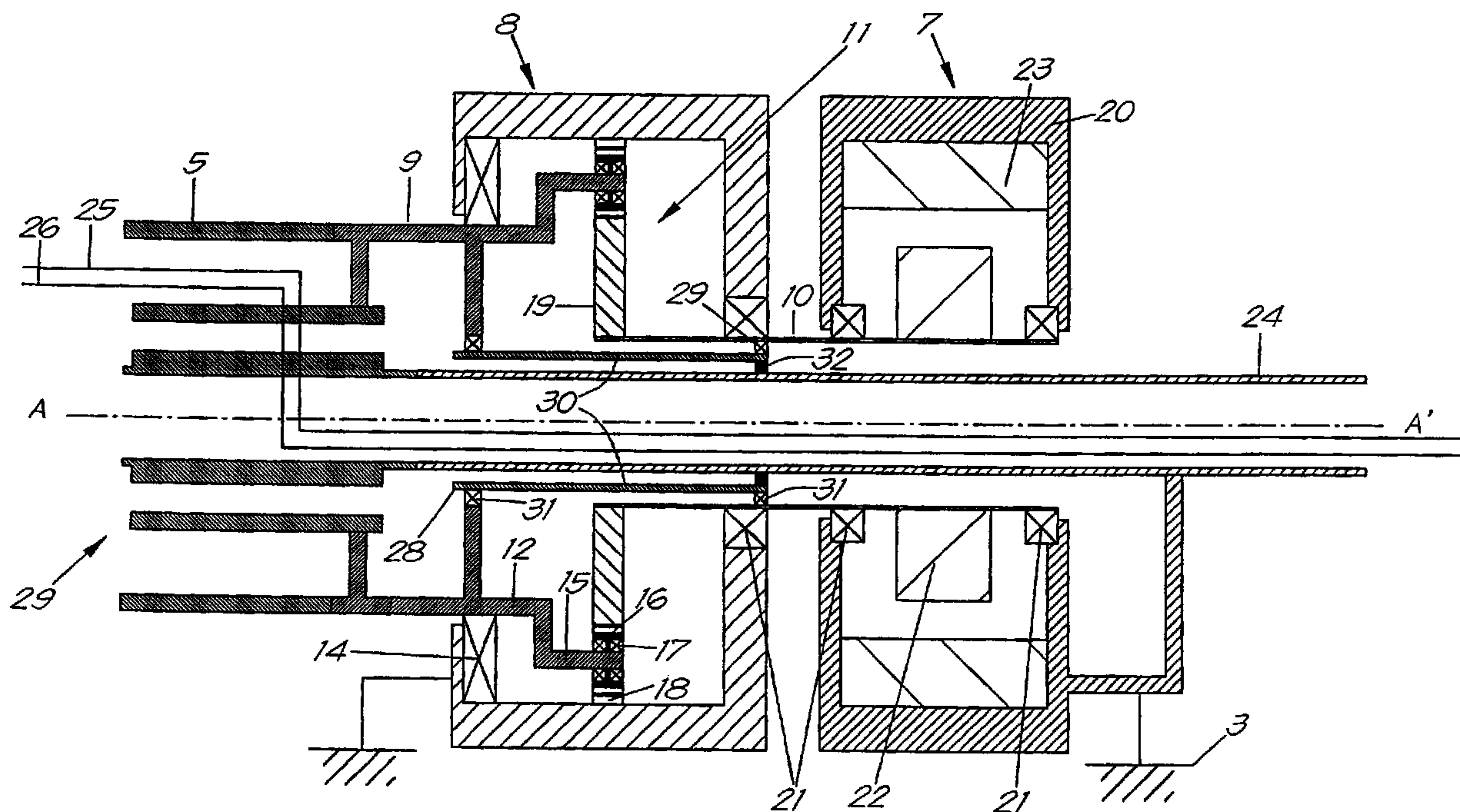
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(54) Titre : TRAIN D'ENGRENAGES POUR EOLIENNE

(54) Title: A GEAR UNIT FOR A WIND TURBINE



(57) Abrégé/Abstract:

A gear unit for a wind turbine having an input shaft connected to the rotor hub of the wind turbine and an output shaft for connection to an electrical power generator, characterized in that the gear unit is provided with a hollow tube which is concentric with the main rotation axis and which extends through the gear unit from the input shaft to the output shaft, whereby this hollow tube provides a sealing for the gear unit in storage and transport.

Abstract of the disclosure

A gear unit for a wind turbine having an input shaft connected to the rotor hub of the wind turbine and an output shaft for connection to an electrical power generator, characterized in that the gear unit is provided with a hollow tube which is concentric with the main rotation axis and which extends through the gear unit from the input shaft to the output shaft, whereby this hollow tube provides a sealing for the gear unit in storage and transport.

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A gear unit for a wind turbine.

5 The present invention relates to a gear unit for a wind turbine.

More specifically, the present invention relates to a gear unit for a wind turbine having an input shaft connected to the rotor blades of the wind turbine and an output shaft for
10 connection to an electrical power generator.

Such gear units are already known according to the state of the art. Hereby, the gear unit usually contains one or more planetary stages, whereby the planet carrier of the first
15 planetary stage fulfils the role of the input shaft and the output shaft is usually a shaft on which the sun wheel of the last planetary gear stage is mounted.

In this manner the slow rotation of the rotor blades is
20 transformed in a rotation that is sufficiently fast in order to let the power generator function properly.

However, a practical problem for example with all the known gear units is how to control the so-called pitch of the
25 rotor blades. This pitch is the amount of rotation that is given to the rotor blades along their longitudinal axis with regard to the plane in which the blades are rotating.

Depending on the wind speed, this pitch has to be more or
30 less in order to obtain an acceptable speed of rotation of

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the rotor blades. Often the pitch of the rotor blades can be set by means of electrical motors or hydraulic actuators.

In order to allow the pitch of the rotor blades to be
5 controlled and set, there is a need to pass electrical power and signal cables through the gear unit and possibly even hydraulic tubes, for instance in the case the blades are driven through an hydraulic actuator.

10 A problem hereby is that the power and/or the hydraulic drive are normally supplied from a static point on the housing of the wind turbine, while the rotor blades are rotating when the wind turbine is functioning.

15 As is known, usually some kind of rotational energy connection is used.

For example, for the transfer of electrical current from a stationary conductor into a rotating conductor often a
20 rotational energy connection in the form of a slip ring assembly, also called a collector ring assembly or a rotary electrical contact assembly, is used.

Typically, it is comprised of a stationary graphite or metal
25 contact (brush) which rubs on the outside diameter of a rotating metal ring. As the metal ring turns, the electrical current or signal is conducted through the stationary brush to the metal ring making the connection.

30 Similar rotational energy connectors exist for the transfer of hydraulic power from a static housing to a rotating part,

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for example from the housing of a wind turbine to its rotor hub.

A difficulty of such systems is that one side of the cabling
5 and tubing is on the rotor blades, the other side on the
wind turbine housing, whereby the rotor blades and the wind
turbine housing only come together during the final assembly
on site.

10 Therefore, it is unavoidable that cabling and tubing have to
be installed, at least in part, during the final assembly on
site of the wind turbine, which is far from practical.

Hereby a lot of care needs to be taken to avoid contact of
15 the cabling and tubes with the rotating parts of the gear
unit of the wind turbine.

Another problem is that cabling has to be passed through a
zone that has to be lubricated severely and on a permanent
20 basis because of its nature.

In some known designs of wind turbines an energy tube is
used for this purpose, which energy tube is a kind of hollow
pipe in which the cabling and tubing is to be installed.

25

Usually, this energy tube is passed through the centre of
the gear unit and often also through the centre of the
electrical power generator.

30 Normally, the energy tube is rigidly connected to the rotor
hub and the actual transfer of electrical and/or hydraulic

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power from the static housing to the rotating hub is obtained by a rotational energy connector, which is installed between the rotating energy hub and the housing of the wind turbine, at the generator side of the energy tube.

5

The cabling and tubing are static with regard to the energy tube. Nevertheless, these cables or tubes are often damaged through the rotating action of the energy tube and because of a bad fixation of the cables and tubes on the inner
10 surface of the energy tube.

A practical problem with the use of an energy tube is that often the gear unit is manufactured by specialists in that technical field, while the final assembly of the complete
15 wind turbine is the responsibility of a wind turbine manufacturer.

So, there is a need for having a proper interface between both manufacturers. Often, it is the gear unit manufacturer
20 that installs the energy tube directly in the gear unit during the assembly of the gear unit in the factory.

Hereby, the energy tube provides in the same time a seal for the gear unit, for example during storage in a warehouse and
25 during transport of the gear unit from the factory to site, as well as after the installation of the gear unit on site.

The seal avoids oil leaking out of the gear unit or dirt from the environment entering into the gear unit.

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With this solution the energy tube is actually fulfilling two tasks, on the one hand it provides a housing for passing cables, etc ... that can take a certain load, force as well as torque, exerted by the rotational energy connector, and on
5 the other hand, it provides a sealing for the gear unit.

It is clear that in such a case the responsibilities with regard to technical failure of the energy tube are not sharply defined between the gear unit manufacturer and the
10 wind turbine manufacturer.

Indeed, for example when a gear unit is not sealed correctly due to leakage through the energy tube, the cause could be a bad assembly under the responsibility of the gear unit
15 manufacturer, as well as for example the application of an overload by the wind turbine manufacturer on a correctly installed energy tube.

Another disadvantage of these known gear units with rotating
20 energy tube is that the rotational energy connector consumes a lot of space, which hinders the development of more integrated designs of wind turbines.

The present invention aims at a gear unit for use in a wind
25 turbine, which does not show one or more of the above and other disadvantages.

To this aim, the invention relates to a gear unit for a wind turbine having an input shaft connected to the rotor hub of
30 the wind turbine and an output shaft for connection to an electrical power generator, whereby the gear unit is

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provided with a hollow tube which is concentric with the main rotation axis and which extends through the gear unit from the input shaft to the output shaft and whereby the hollow tube provides a sealing for the gear unit in storage
5 and transport.

An important advantage of such a gear unit according to the present invention is that the hollow tube can be mounted on the gear unit during manufacturing of the gear unit, for
10 example by bolting or welding, whereby the gear unit is sealed completely at the same time, the seal being provided in a controlled manner in well defined circumstances which are easily obtained in a factory or workshop.

15 Hereby, the function of sealing the gear unit is completely fulfilled by the hollow tube, the hollow tube providing a good interface that divides the responsibilities between the gear unit manufacturer and the wind turbine manufacturer.

20 According to a preferred embodiment of a gear unit in accordance with the present invention an energy tube is provided inside the hollow tube or dummy tube for housing cabling and/or tubing for the transmission of electrical and/or hydraulic power from the static housing of the wind
25 turbine to the rotatable rotor hub, for example by a shrink fit or a welded connection of the energy tube on the hollow tube.

An advantage of a gear unit in accordance with the present
30 invention is that through the hollow tube an energy tube can

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be easily installed, whereby no special attention is needed anymore with regard to the sealing of the gear unit.

Hereby, the classic problems encountered during the assembly
5 of the wind turbine are solved.

According to a preferred embodiment of a gear unit in accordance with the present invention, the energy tube is connected fixedly to the housing of the gear unit or to the
10 nacelle of the wind turbine.

An advantage of this embodiment of a gear unit in accordance with the present invention is that the energy tube containing cables and tubing is static, so that there is
15 less risk for damage on these parts.

For the actual transfer of the energy from the static housing to the rotating hub, the energy tube is according to the present invention preferably linked to a rotating energy
20 connector, which is installed on the energy tube at the input shaft side of the gear unit.

An advantage of this embodiment in accordance with the present invention is that the rotating energy connector is
25 positioned in front of the gear unit, so that more space is available at the generator side of the wind turbine, and more reduced dimensions of the wind turbine can be obtained.

With the intention of better showing the characteristics of
30 the invention, hereafter, as an example without any restrictive character whatsoever, a preferred form of

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embodiment of a gear unit according to the present invention is described, with reference to the accompanying drawings, wherein:

5 figure 1 represents a cross-section of a typical wind turbine having a gear unit;
figures 2 represents schematically and on a bigger scale the part of the wind turbine indicated by F2 in figure 1, for a wind turbine having a known gear
10 unit;
figure 3 represents the known gear unit of figure 2 before assembly in the wind turbine; and,
figures 4 and 5 represent analogously to figures 2 and 3 a gear unit according to the present
15 invention, respectively after and before assembly in the wind turbine.

The wind turbine 1 represented in figure 1 consists mainly of a supporting structure 2 on which a nacelle 3 is mounted
20 in a rotatable manner.

This allows for the positioning of the wind turbine 1 with regard to the wind direction.

25 The nacelle 3 contains the rotor 4 of the wind turbine 1, having a rotor hub 5 and rotor blades 6, which rotor 4 is connected to an electrical power generator 7 by means of a gear unit 8.

30 Such a gear unit 8 is the subject of the present invention and is represented schematically more in detail in figures 2

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and 3 for an embodiment known according to the state of the art, respectively after and before assembly in a wind turbine.

5 As is known, the aim of such a gear unit 8 is to transform the slow rotation of the rotor hub 5 and rotor blades 6 which are connected to the input shaft 9 of the gear unit 8 into a fast rotation at the output shaft 10 of the gear unit 8 which is connected to the electrical power generator 7, in
10 order to have a sufficient rotational speed at the generator 7 for its correct functioning.

Usually a good transmission ratio of the gear unit 8 is provided by one planetary gear stage 11, as in the case of
15 the figures 2 and 3, or more planetary gear stages.

The planet carrier 12 of the planetary gear stage 11 is in the represented case mounted rotatably with regard to the housing 13 of the gear unit 8 by means of planet carrier
20 bearings 14.

Hereby the planet carrier 12 serves as an input shaft 9 of the gear unit 8, which input shaft 9 is connected to the rotor hub 5 of the wind turbine 1.

25

Furthermore, the planet carrier 12 is provided with planet shafts 15 on which planet wheels 16 are mounted rotatably by means of planet bearings 17.

30 The planet wheels 16 interact on the one hand with a ring wheel 18 which is fixedly connected to the housing 13 of the

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gear unit 8, and on the other hand with a sun gear 19, which is mounted on the output shaft 10 of the gear unit 8, this output shaft 10 of the gear unit 8 serving as an input shaft of the electrical power generator 7.

5

The output shaft 10 is rotatably mounted with regard to the nacelle 3, gear unit housing 13 and the electrical power generator housing 20.

10 In the represented case of figure 2 this is obtained by output shaft bearings 21 which are for example installed in the gear unit housing 13 or in the generator housing 20, but a lot of other mountings are possible.

15 Typically, in an electrical power generator 7 the rotating shaft 10 is bearing a rotor 22 which interacts with a stator winding 23 in order to generate electrical power.

As explained in the introduction, there is often a need to
20 pass electrical power and signal cabling as well as, or alternatively, hydraulic tubing from the output shaft 10 side to the input shaft 9 side, for example in order to provide control means for setting the pitch of the rotor blades 6.

25

One can understand that if no special measures are taken, it is rather difficult to provide sufficient space for these cabling and tubing, the great number of gears and shafts making this a big challenge.

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Furthermore, a gear unit 8 as shown is normally provided with a lubrication system, the lubrication being spread throughout the whole gear box. Such a situation is not favorable for the installation of electrical wiring,
5 maintenance of the pitch control system, etc...

A known solution to this problem is represented in the figures 2 and 3.

10 Hereby, a so-called energy tube 24 is inserted through the gear unit 8, in this particular case through the input shaft 9 and the output shaft 10, whereby electrical power and signal cabling 25 as well as hydraulic tubing 26 can be installed in this energy tube 24 during the installation of
15 the gear unit in the nacelle 3.

At the input shaft 9 side of the gear unit 8 this energy tube 24 is to be connected to the rotor hub 5, for example by a shrink fit or by a welded connection 27, and as a
20 consequence, the energy tube 24 is rotating with the rotor hub 5.

Usually, during the assembly of the gear unit one or more seals 28 are also provided in order to seal the gear unit 8
25 so that no oil leaks out of the gear unit housing 13, nor impurities from the environment can enter the gear unit 8, for example during storage and transport of the gear unit 8, as well as after the installation of the gear unit 8 in the wind turbine nacelle.

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At the output shaft side 10 of the gear unit 8 the energy tube 24 is connected to a rotating energy connector 29, as for example a slip ring assembly or the like, in which energy is passed from the rotating rotor hub 5 to the static
5 wind turbine housing 3.

As mentioned in the introduction, such a known gear unit 8 with the typical known solution of transferring electric cabling 25 and/or hydraulic tubing 26 through the gear unit
10 8 and/or generator 7 has several disadvantages.

For example, it is clear that the cabling 25 and tubing 26 are rotating with the rotor hub 5 and are therefore submitted to the rotating action of the rotor hub 5 which is
15 a possible cause of damage to the cables 25 and the tubes 26.

Furthermore, the energy tube 24 is typically a part provided by the wind turbine manufacturer, whereby it provides, on
20 the one hand, a housing for the cabling 25 and tubing 26, but on the other hand, also a seal for the gear unit 8 itself. This means that the load on the energy tube 24 exerted by the rotating energy connector 29 is affecting the seal, but on the other hand also the quality of the seal
25 limits the load that can be taken by the energy tube 24.

Furthermore, it is clear that the rotating energy connector 29 requires a lot of space at the generator 7 side, so that
30 it limits the possibilities of reducing the dimensions of the wind turbine 1.

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With a gear unit 8 in accordance with the present invention these problems can be solved, as is shown in figures 4 and 5.

5

Such a gear unit 8 is provided with a hollow or dummy tube 30 which is concentric with the main rotation axis AA' and which extends through the gear unit 8 from the input shaft 9 to the output shaft 10.

10

Hereby, this hollow tube 30 provides a sealing for the gear unit 8 in storage and transport, as becomes clear from figure 5 showing the gear unit 8 in this situation before the installation in a wind turbine nacelle 3.

15

In this particular case for example, the sealing of the gear unit 8 is obtained , for example by bearings 31 supporting the hollow tube in a rotatable manner with regard to the rotating parts of the gear unit 8, i.e. the input shaft 9 and the output shaft 10, which bearings 31 are for example provided with a bearing cap that seal the gear unit 8.

20

Of course other embodiments are not excluded according to the present invention.

25

In this way a first aim of the invention is obtained, since a gear unit 8 having such a hollow tube 30 is completely sealed, so that leakage of oil out of the gear unit 8 during transport, storage and / or installation is impossible.

30

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The hollow tube 30 can be mounted during the assembly of the gear unit 8, for example in a factory or a workshop, so that the conditions in which the gear unit 8 is sealed are controllable and adaptable to the required needs.

5

An advantage of such a gear unit 8 according to the present invention with such a hollow tube 30 with regard to the known gear units 8 without hollow tube 30 is that the hollow tube 30 takes completely the function of sealing the gear
10 unit 8, so that an appropriate interface is obtained on which the responsibilities between a gear unit manufacturer and a wind turbine manufacturer can be clearly divided.

Another advantage of a gear unit 8 in accordance with the
15 present invention is that inside the hollow tube 30 an energy tube 24 is easily installed for housing cabling 25 and/or tubing 26 for the transmission of electrical and/or hydraulic power from the static housing 3 of the wind turbine 1 to the rotatable rotor hub 5.

20

It is clear that the installation of an energy tube 24 in the case of a gear unit 8 according to the invention is much easier than with the known gear units 8.

25 Indeed, there is no need for special measures in order to seal the gear unit 8, since this seal is already provided by the hollow tube 30.

Preferably, the energy tube 24 is connected fixedly to the
30 housing 13 of the gear unit 8 or to nacelle 3 of the wind turbine 1.

- 15 -

This means the energy tube 24 is static with regard to the nacelle 3 of the wind turbine 1, so that there is less risk for damage to cables 25 and tubes 26 inside the energy tube 24 due to the rotating action of the energy tube 24.

This static connection of the energy tube 24 is only possible since the energy tube 24 is linked to a rotating energy connector 27 for the actual transfer of the energy from the rotating hub 5 to the static housing 3, the rotating energy connector 27 being installed on the energy tube 24 at the input shaft 9 side of the gear unit 8.

In that manner, another aim of the invention is obtained, i.e. there is no space required at the generator 7 side for an rotating energy connector 27, so that smaller dimensions of the wind turbine 1 become possible.

In the embodiment of the figures 4 and 5 the hollow tube 30 is fixedly connected to the energy tube 24 for example by means of a shrink fit type connection or by a welded connection 32, so that the hollow tube 30 is also fixedly connected to the housing 13 of the gear unit 8.

In another embodiment the hollow tube 28 is connected fixedly to the rotatable input shaft 9 and the energy tube is connected to the static nacelle 3.

As a consequence in such an embodiment in accordance with the present invention, there is a difference of rotation speed between the energy tube 24 and the hollow tube 30, so

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that it is preferable to support the energy tube 24 rotatably in the hollow tube 30, for example by bearings.

It is clear that such embodiments of a gear unit 8 in accordance with the present invention are particularly interesting for application in a wind turbine 1 having a pitch control system, whereby the energy tube 24 installed in the hollow tube 30 is used for passing electrical and/or hydraulic energy from the static housing 3 to the rotor hub 5 for the functioning of the pitch control system.

In some cases it can be interesting to provide the gear unit 8 with a hollow tube 30 or energy tube 24 which extends additionally through the electrical power generator 7.

15

One can understand that such a hollow tube 30 or energy tube 24 according to this embodiment is particularly interesting, since it allows to pass cabling and tubing through the whole central axis AA' of the assembled gear unit 8 and electrical power generator 7.

20

In some other cases it can be advantageous to execute the hollow tube 30 as a tube which is composed of multiple parts.

25

This can be advantageous for example during the assembly of the gear unit 8.

However, in the case the hollow tube 30 is composed of multiple parts, it is preferable according to the present invention that these multiple parts of the hollow tube 30

30

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are connected to one another in such a way that torque can be transmitted through the tube 30.

5 The reason for this is that the hollow tube 30 is for example supported by bearings rotating with regard to other rotating parts of the gear unit 8, so that loosening of the multiple parts of the hollow tube 30 due to friction for example has to be avoided.

10 A lot of other practical solutions are possible than the one represented in figure 3.

For example, gear units 8 having two or even more planetary gear stages 11 are not excluded from the present invention.

15

Also completely other ways of supporting the different shaft are possible using bearings that are placed in other positions and so on.

20 Also it is possible to realize a fixed connection between the output shaft 10 and the hollow tube 30 while supporting the other end of the hollow tube 30 in a rotatable manner with regard to the input shaft 9 by means of a bearing.

25 The present invention is in no way limited to the embodiments described above and represented in the drawings, but such a gear unit 8 may be realised in different shapes and dimensions, without departure from the scope of the invention.

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Claims.

1.- A gear unit (8) for a wind turbine (1) having an input
5 shaft (9) connected to the rotor hub (5) of the wind turbine
(1) and an output shaft (10) for connection to an electrical
power generator (7), characterized in that the gear unit (8)
is provided with a hollow tube (30) which is concentric with
the main rotation axis (AA') and which extends through the
10 gear unit (8) from the input shaft (9) to the output shaft
(10), whereby this hollow tube (30) provides a sealing for
the gear unit (8) in storage and/or transport.

2.- A gear unit (8) for a wind turbine (1) according to
15 claim 1, characterized in that the hollow tube (30) extends
additionally through the electrical power generator (7).

3.- A gear unit (8) for a wind turbine (1) according to
claim 1 or 2, characterized in that the hollow tube (30) is
20 fixedly connected to the housing (13) of the gear unit (8).

4.- A gear unit (8) for a wind turbine (1) according to
claim 1 or 2, characterized in that the hollow tube (30) is
fixedly connected to the input shaft (9) of the gear unit
25 (8).

5.- A gear unit (8) according to any of the preceding
claims, characterized in that the hollow tube (30) is
30 composed of multiple parts.

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6.- A gear unit (8) according to claim 5, characterized in that the multiple parts of the hollow tube (30) are connected to one another in such a way that torque can be transmitted through the hollow tube (30).

5

7.- A gear unit (8) according to any of the preceding claims, characterized in that inside the hollow tube (30) an energy tube (24) is provided for housing cabling (25) and/or tubing (26) for the transmission of electrical and/or
10 hydraulic power from the static housing (3) of the wind turbine (1) to the rotatable rotor hub (5).

8.- A gear unit (8) according to claim 7, characterized in that the energy tube (24) is supported rotatably in the
15 hollow tube (30) by bearings.

9.- A gear unit (8) according to claim 7, characterized in that the energy tube (24) is connected fixedly to the hollow tube (28).

20

10.- A gear unit (8) according to any of the claims 7 to 9, characterized in that the energy tube (24) is connected fixedly to the housing (13) of the gear unit (8) or the nacelle (3) of the wind turbine (1).

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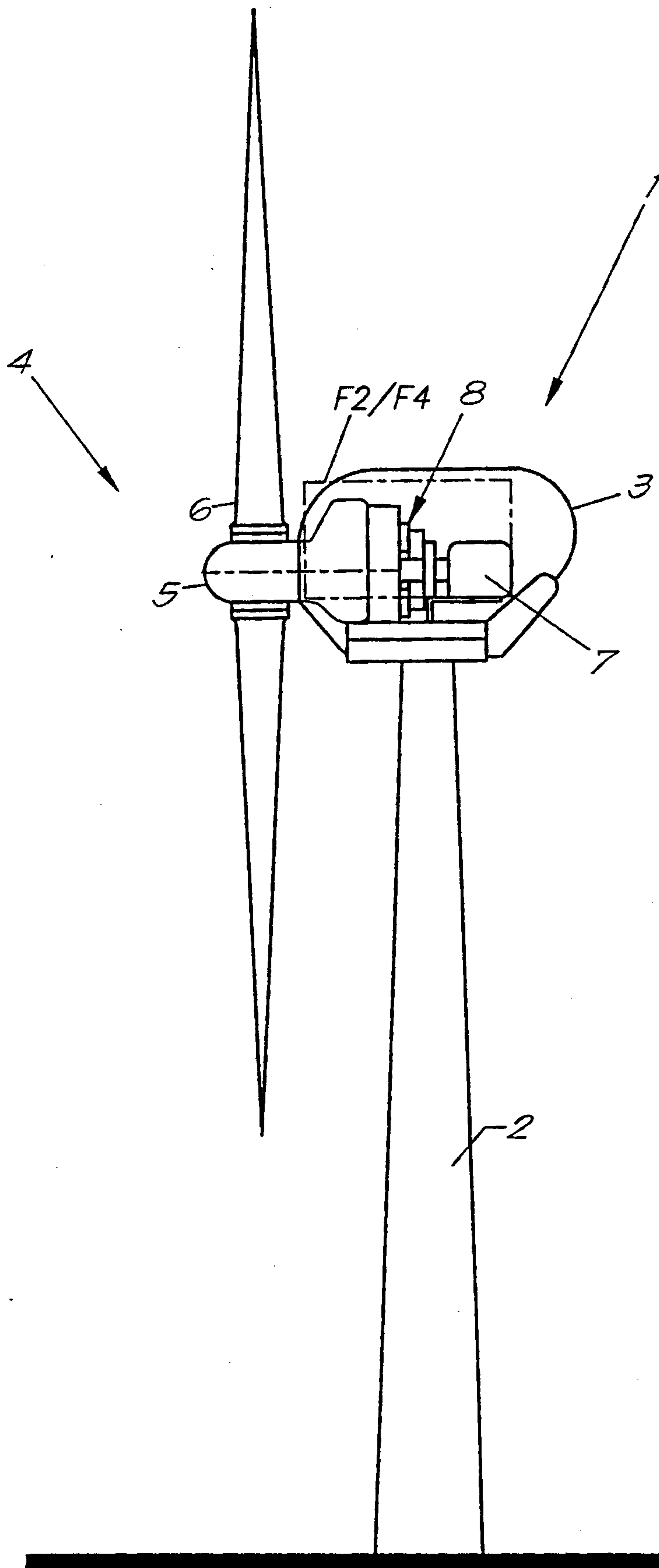
11.- A gear unit (8) according to any of claims 7 to 10, characterized in that the energy tube (24) is linked to a rotating energy connector (29) for the actual transfer of the energy from the static housing (3) to the rotating hub
30 (5), the rotating energy connector (29) being installed on

- 20 -

the energy tube (24) at the input shaft (9) side of the gear unit (8).

12.- A gear unit (8) according to any of the preceding
5 claims, characterized in that it is applied in a wind
turbine (1) having a pitch control system, whereby an energy
tube (24) is installed in the hollow tube (30) for passing
electrical and/or hydraulic energy from the static housing
(3) to the rotor hub (5) for the functioning of the pitch
10 control system.

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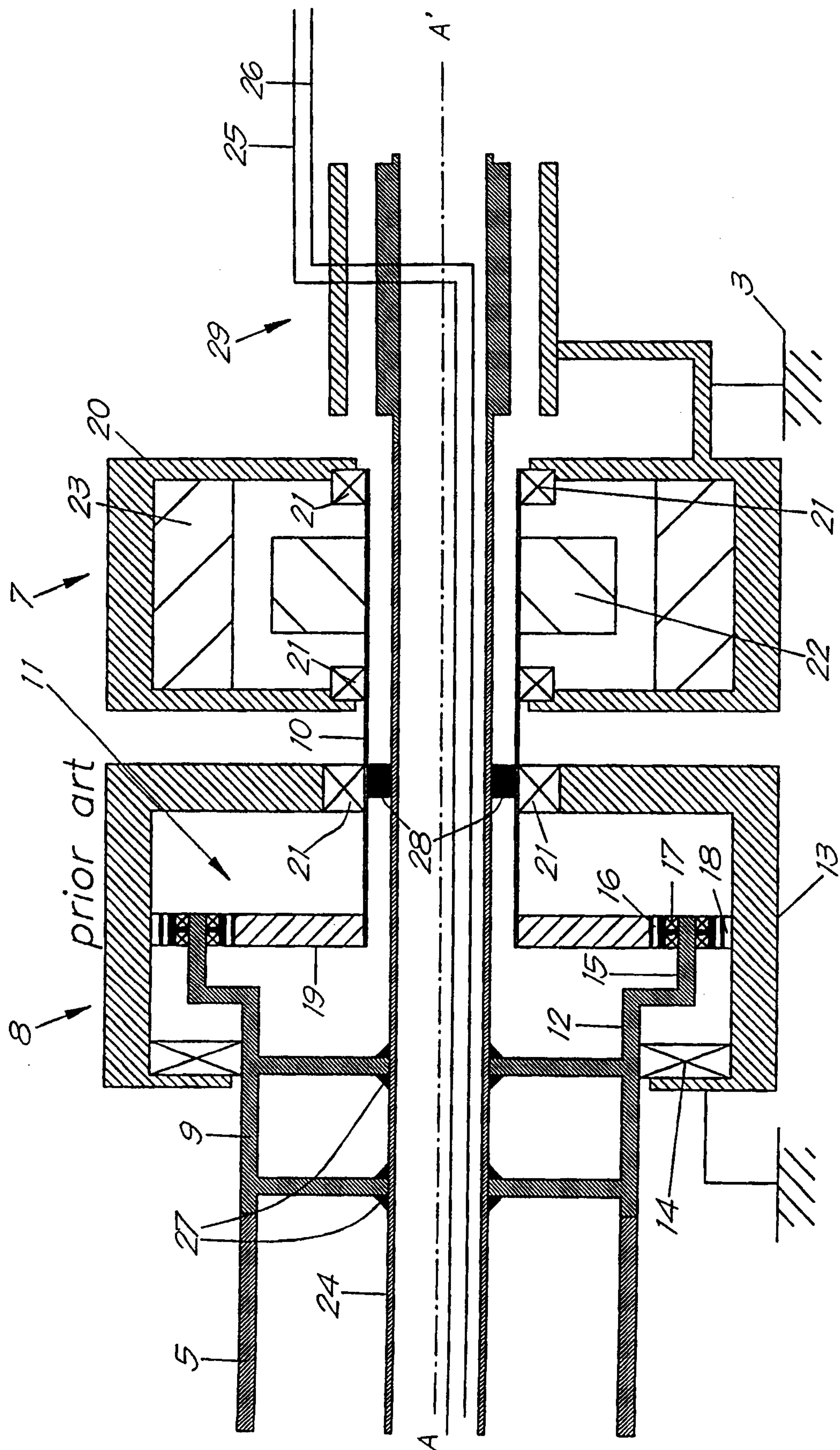
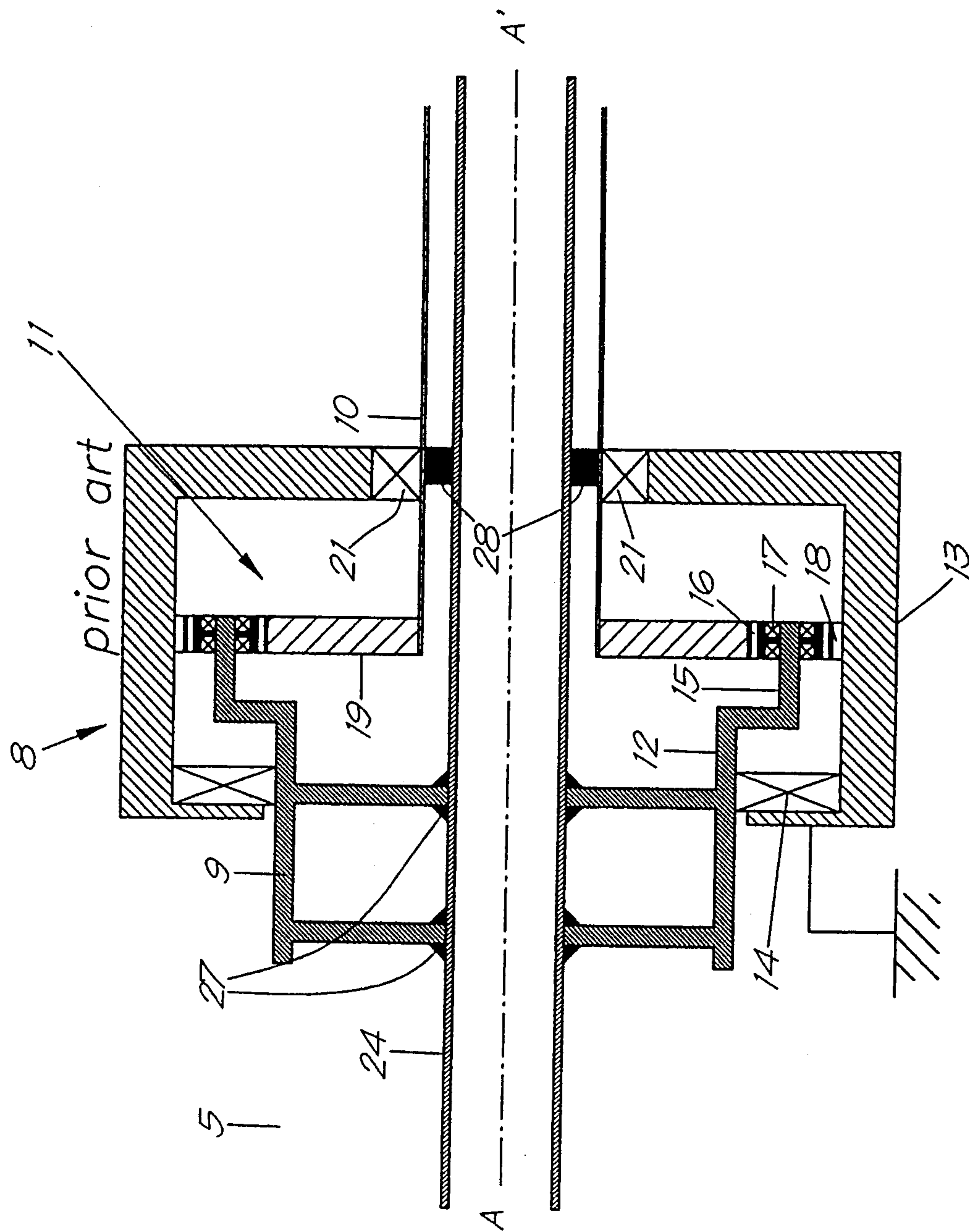


Fig. 2

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**Fig. 3**

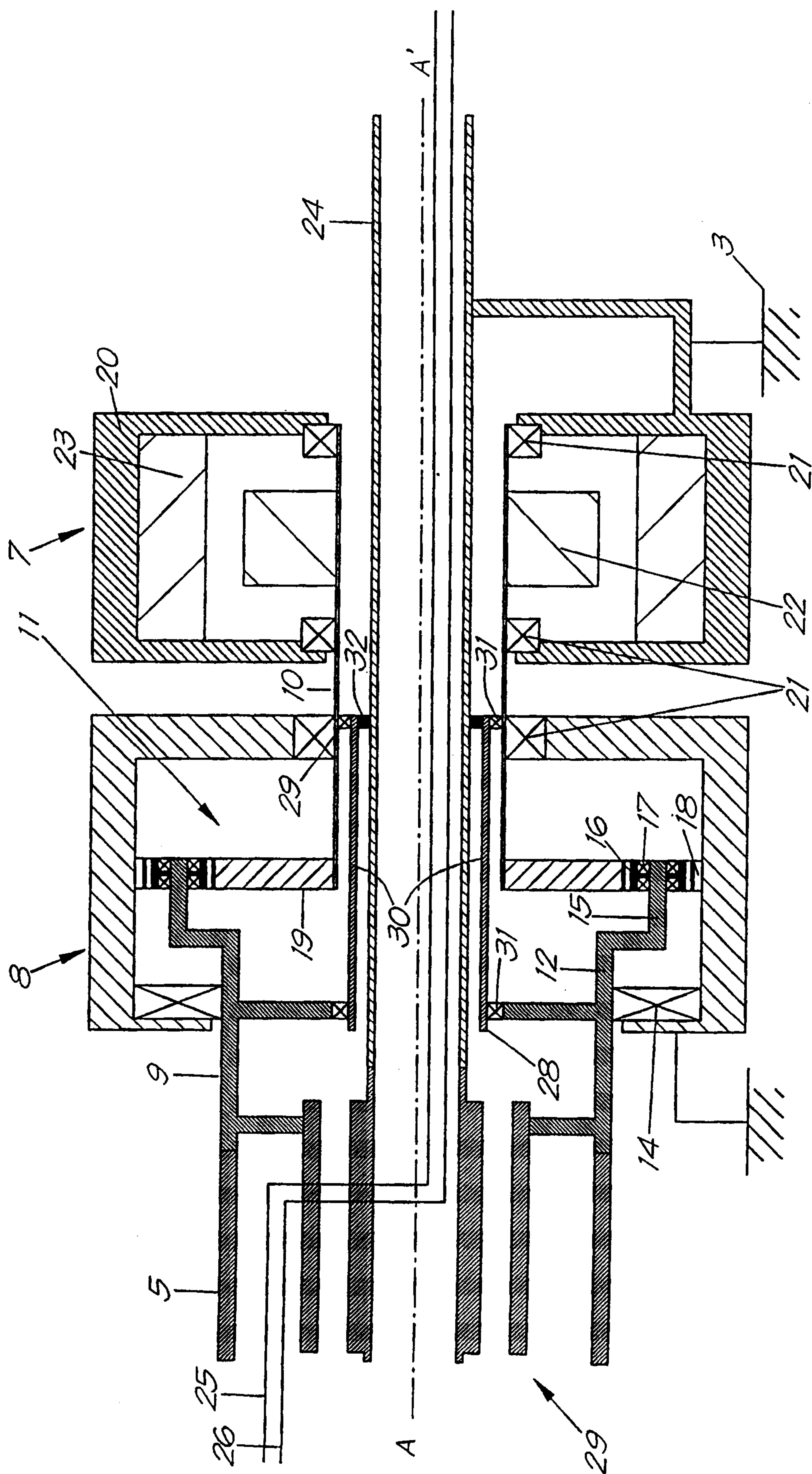


Fig. 4

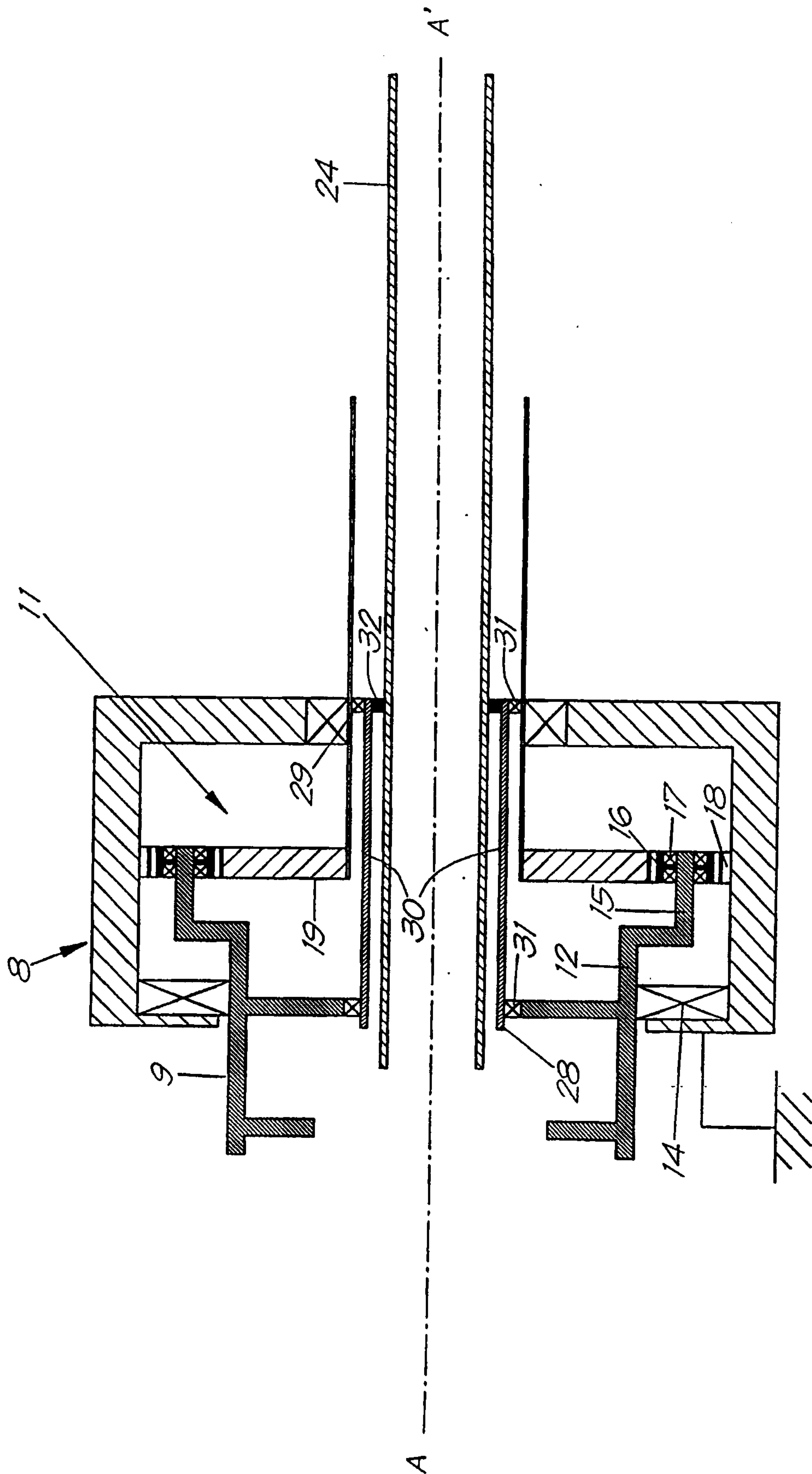


Fig. 5

