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Publication number:

0 565 200 A1

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EUROPEAN PATENT APPLICATION

21 Application number: **93201018.4**

51 Int. Cl.⁵: **E21D 9/06**

22 Date of filing: **06.04.93**

30 Priority: **10.04.92 NL 9200673**

71 Applicant: **LCT PROJECT ONTWIKKELING B.V.**
33, Ertveldweg
NL-5231 XA 's-Hertogenbosch(NL)

43 Date of publication of application:
13.10.93 Bulletin 93/41

72 Inventor: **van der Hoorn, Rudolf Johannes**
Gerardus Antonius
5, Pijlkruidhof
NL-5672 BK Nuenen(NL)

84 Designated Contracting States:
AT CH DE FR IT LI NL

74 Representative: **Timmers, Cornelis Herman**
Johannes et al
EXTERPATENT B.V.
P.O. Box 3241
NL-2280 GE Rijswijk (NL)

54 **Tunnelling machine with cylindrical shield.**

57 In a tunnelling machine with a cylindrical shield adjustability of the excavating direction in three dimensions is obtained through the fact that said shield comprises a number of cylindrical segments (2a,2b) connecting to each other in the lengthwise direction and having radial end edges, at least one

adjusting ring (34) which is rotatable about the axis of the segment being fitted between at least a number of two adjacent end edges, the two radial ring surfaces (40a,40b) of which ring include an acute angle and put this adjusting ring in a certain angular position.

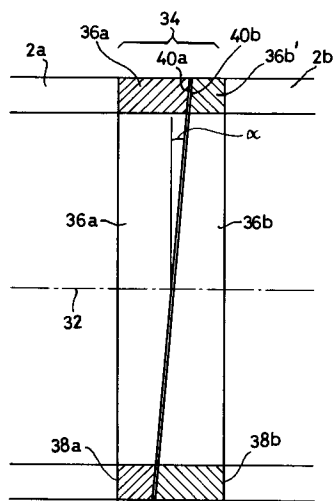


FIG. 2a.

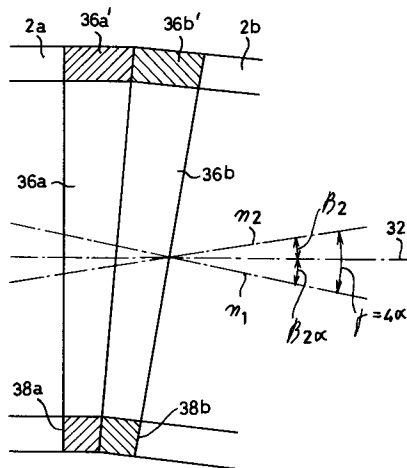


FIG. 2b.

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The invention relates to a tunnelling machine with a cylindrical shield.

In such tunnelling machines, which are generally known (see "Handbook of Mining and Tunnel Machinery", Barbara Stack, 1982, published by John Wiley and Sons, Chapter 10), an excavating head is fitted in front of the shield, said excavating head in a known embodiment (DE-A-2,164,816) being adjustable relative to the shield, so that the direction of excavation can be adjusted. This combination of two different functions - determining the direction of excavation to be followed by the position of the excavating head, on the one hand, and the excavation itself, on the other - leads to a situation in which irregular resistances experienced by the excavating head have a direct influence on the direction of excavation, so that it becomes particularly difficult to maintain a predetermined direction of excavation in certain types of ground.

The object of the invention is to overcome this drawback, and to provide a tunnelling machine by means of which it is ensured in a particularly simple way that a predetermined direction of excavation is in fact followed accurately, any marked-out curved route also has precisely the predetermined radius of curvature, and this marked-out plan can have any desired course in three-dimensional terms.

This object is achieved according to the invention in that the shield is divided into a number of cylindrical segments interconnected in the lengthwise direction and having radial end edges, at least one adjusting ring which is rotatable about the axis of the segment being fitted between two adjacent end edges, while the two radial ring surfaces of said ring include an acute angle.

Due to the fact that with the measures according to the invention, the angle between the respective segments can be determined accurately in three dimensions, so that the shape of the shield itself can be controlled - of course within practical limits - in three dimensions, it is ensured that the tunnel route accurately follows a predetermined marked-out plan. There are no problems when this tunnel route is a sineous one, even in three dimensions.

Another advantage is that the entire tunneling machine tends to follow any curvature in its path initiated by the shield.

It is observed that DE-A-2545041 describes a tunneling machine comprising a shield which is connected to a following tunneltube by means of a connecting tube, divided into two parts; the dividing plane of this connecting tube includes an acute angle with the plane normal to the axis of both the shield and the tunneltube. Each half of the connecting tube can be rotated around its respective axis. In this way it is possible to adjust the

position of the entire shield with respect to the tunneltube which follows it. This arrangement does not result in the unique adjustability and flexibility in following a predetermined path which is obtained by the arrangement according to the invention.

Each adjusting ring preferably co-operates with an identical second adjusting ring which is also rotatable about the axis of the segment. An increased adjustability is obtained thereby.

In a preferred embodiment, a groove which is concentric with the axis of the ring is formed in each ring, said groove being provided with internal toothing which meshes with a pinion driven by an adjusting motor. This results in particularly simple adjustability of the adjusting rings.

In a preferred embodiment, the ring(s) is (are) enclosed in an annular chamber formed by, on the one hand, the radially inward directed end edges - lying opposite each other at a distance from each other - of two adjacent segments and, on the other, coaxial, cylindrical end edges which connect thereto at the top and bottom edge thereof, respectively, and which each by means of a cylindrical elastic connecting piece bear a cylindrical seal which rests against the top and bottom edge of the ring(s), respectively, said chamber being filled under pressure with a lubricant.

The invention is explained with reference to the drawing, in which:

Figure 1 is a diagrammatic view of the front part of a tunnelling machine in which the invention is embodied;

Figure 2 is a diagrammatic view illustrating the way in which the adjusting rings used according to the invention operate;

Figure 3 is a longitudinal section through a part of the shield of the tunnelling machine in which the invention is used;

Figure 4 is a more detailed longitudinal section of a part of the adjusting rings;

Figure 5 is a diagrammatic view, to illustrate the adjustment range which can be achieved with the measure according to the invention.

The tunnelling machine, of which Figure 1 shows the front part, is of the so-called shield type with the shield 2, and has at the front end, shown on the left in Figure 1, a diagrammatically shown excavating head 4 with excavating cutters 6 and a collection unit 8 for the excavated material, which is removed by means of the conveyor belt 10. The excavating head is accommodated together with the diagrammatically shown drive 12 in the front compartment 14 of the tunnelling machine. Since these parts do not constitute a subject of the invention and their actual embodiment depends entirely on the circumstances in which the tunnelling machine is to be used, they will not be discussed in any further detail.

Situated in the compartment 16, following the compartment 14, is a compact concrete batching and mixing plant with four hoppers 18, containing the constituent materials for the concrete to be formed, a centrifuge 20, and a mixer 22 for these materials. Water, sand, cement and gravel are supplied by means of a suitable system of ducts and pipes. The still fluid concrete is supplied by means of the system of plunger pumps 28 through pipes 30 to a number of injection pipes opening out at the rear end of the machine, which is not shown. This is not essential for the invention either; other layouts and embodiments are possible.

Formwork is erected in the usual way inside the shield 2, comprising segments (not shown) which define the inner periphery of the tunnel to be formed, and which are combined to form a closed formwork cylinder by means of a suitable handling and erection system which is known per se. These parts are situated at the rear end of the machine.

The tunnelling machine is operated in the usual way: when the shield advances in the direction of the arrow 50, which can take place in any suitable manner, but for which the so-called self-advancing blade system (developed by Westfalia-Luene) will preferably be used, the space around the formwork is filled up with concrete coming out of the injection pipes. This concrete, hardening round the formwork, eventually forms the outside tunnel wall.

Of course, measures have to be taken to permit movement of the tunnelling machine in a controlled manner in a certain direction. According to the prior art, as documented by, for example, e.e. DE-A-2,164,816, for this purpose the front compartment 14 with the excavating head 4 can be placed in a certain angular position relative to the axis 32 of the tunnelling machine (for example, by means of jacks and coupling rods). However, this has the disadvantages mentioned in the preamble.

According to the invention, these disadvantages are overcome by the shield being subdivided into a number of segments 2a...2e etc., the mutual angular position of which can be adjusted within certain limits. This adjustability is achieved by means of at least one adjusting ring fitted between two segments connecting to each other, and preferably through the use of two such adjusting rings.

Thus, according to Figure 1, a pair of adjusting rings 34a is fitted between the segments 2a, 2b, an adjusting ring is fitted at 34b between the segments 2b and 2c, a pair of adjusting rings 34c between the segments 2c and 2d, a pair of adjusting rings 34d between the segments 2d and 2e, etc. The way in which such a pair of adjusting rings, indicated by 34 in Figures 2 to 5, operates can be seen in particular from Figures 2a and 2b.

Each pair of adjusting rings in the preferred embodiment comprises two adjusting rings 36a, 36b. They are identical and each have a radial end surface 38a, 38b, respectively, situated at right angles to the axis 32, and a second end surface 40a, 40b, respectively, which includes a small angle α with said surfaces 38a, 38b. In the situation shown in Figure 2a, the widest part 36a' of adjusting ring 36 rests against the narrowest part 36b' of adjusting ring 36b, so that the shield wall segments connected to the segments 36a, 36b, respectively, for example the segments 2a and 2b, are accurately in line with each other.

When, however, the adjusting ring 36b is rotated through 180° relative to the adjusting ring 36a, the situation shown in Figure 2b arises, in which the widest part 36b' of adjusting ring 36b rests against the widest part 36a' of adjusting ring 36a, and in which the normal n_1 to the surface 38b, which in fact forms the axis of the segment 2b, includes an angle 2α with the axis 32a of the segment 2a. Of course, it is also possible to rotate the ring 36a relative to the ring 36b, so that a situation can arise in which the normal to the surface 38b, and thus in fact the axis of the segment 2a, also includes an angle $\beta_2 = 2\alpha$ relative to the original axis 32. The total angle variation range = $\gamma = \beta_1 + \beta_2 = 4\alpha$. In practice, the magnitude of α will lie between 5 and 10 minutes.

Figure 3 diagrammatically shows how an adjustment in all directions with segment axes touching a cone with an apex angle = γ can be achieved in the above-described way.

For the practical embodiment of the invention, it is, of course, necessary that the rings can be driven so that they rotate relative to the segment walls.

Figure 4 shows how this can be achieved.

The figure shows the segment wall parts 2a, 2b with the annular end edges 42a, 42b positioned at right angles thereto. Confined between them are the rings 36a, 36b, respectively, each of which has the configuration shown in Figures 2a and 2b. These rings rest with their side faces 38a, 38b against the flat, radial side walls of the edges 42a, 42b and are enclosed at the top and bottom edges, respectively, by a locking ring 44, 46, respectively, which locking rings are connected by means of vulcanised-on sealing rings 48a, 48b and 50a, 50b, respectively, to the end rings 52a, 52b and 54a, 54b, respectively, supported by the segment 2a, 2b, respectively. Each of the adjusting rings 36a, 36b bears a ring-shaped inner toothing 56a, 56b, in which meshes a pinion 58a, 58b fitted on the shaft of an adjusting motor 60a and 60b. These motors are supported by the respective segment end edges 42a, 42b.

It is clear that the adjusting rings 36a, 36b can be moved into any desired angular position relative to each other by rotation of the pinions 58a, 58b.

In the embodiment described above, the two adjusting rings 36a, 36b are accommodated in a closed chamber which is filled under pressure with a suitable lubricant through a conduct 49, connected to a schematically shown source of pressurised lubricant 51.

Figure 5 shows a somewhat modified embodiment. This figure shows two segments 60a, 60b of the shield of a tunnelling machine around which the drive blades of the so-called self-advancing blade system, as developed by Westfalia Luenen, are fitted, and of which two are shown, indicated by 62, 64, respectively. Here too, there are adjusting motors 66a, 66b with the pinion 68a, 68b which mesh with a gear ring 70a, 70b provided on the adjusting rings 72a, 72b, each with the configuration described above. Here again, the space accommodating the rings is filled under pressure with a suitable lubricant, in a manner similar to the one described above and not illustrated in any further detail.

Claims

1. Tunnelling machine with a cylindrical shield (2), **characterized in that** said shield (2) is divided into a number of cylindrical segments (2a...2e) interconnected in the lengthwise direction and having radial end edges, at least one adjusting ring (34a) which is rotatable about the axis of the segment being fitted between two adjacent end edges, the two radial ring surfaces of which ring include an acute angle.
2. Tunnelling machine according to claim 1, **characterized in that** each adjusting ring (34a...34d) co-operates with an identical second adjusting ring (34b... 34d) which is also rotatable about the axis of the segment.
3. Tunnelling machine according to claims 1 - 2, **characterized in that** a groove which is concentric with the axis of the ring is formed in each ring, said groove being provided with internal toothing (56a,56b) which meshes with a pinion (58a,58b) driven by an adjusting motor (60a,60b).
4. Tunnelling machine according to claims 1 - 3, **characterized in that** the ring(s) is (are) confined in an annular chamber formed by, on the one hand, the radially inward directed end edges (42a,42b) - lying opposite each other at a distance from each other - of two adjacent segments (2a,2b) and on the other hand, by

coaxial, cylindrical end edges (52a,52b;54a,54b) which are connected thereto at the top and bottom edge thereof, respectively, and which each by means of a cylindrical elastic connecting piece (48a,48b;50a,50b) bear a cylindrical seal (44,46) which rests against the top and bottom edge of the ring(s) (36a,36b), respectively, said chamber being filled under pressure with a lubricant.

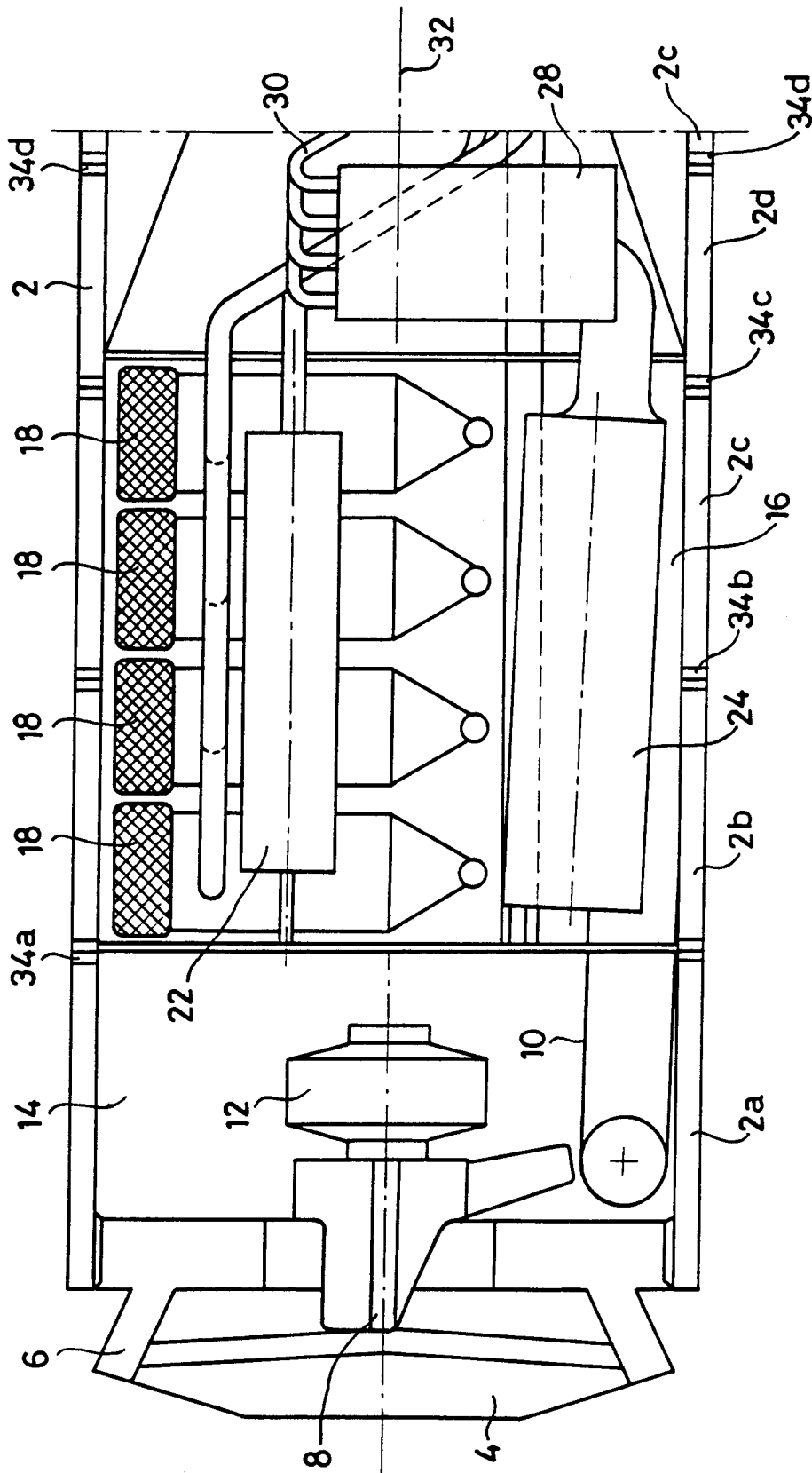


FIG. 1.

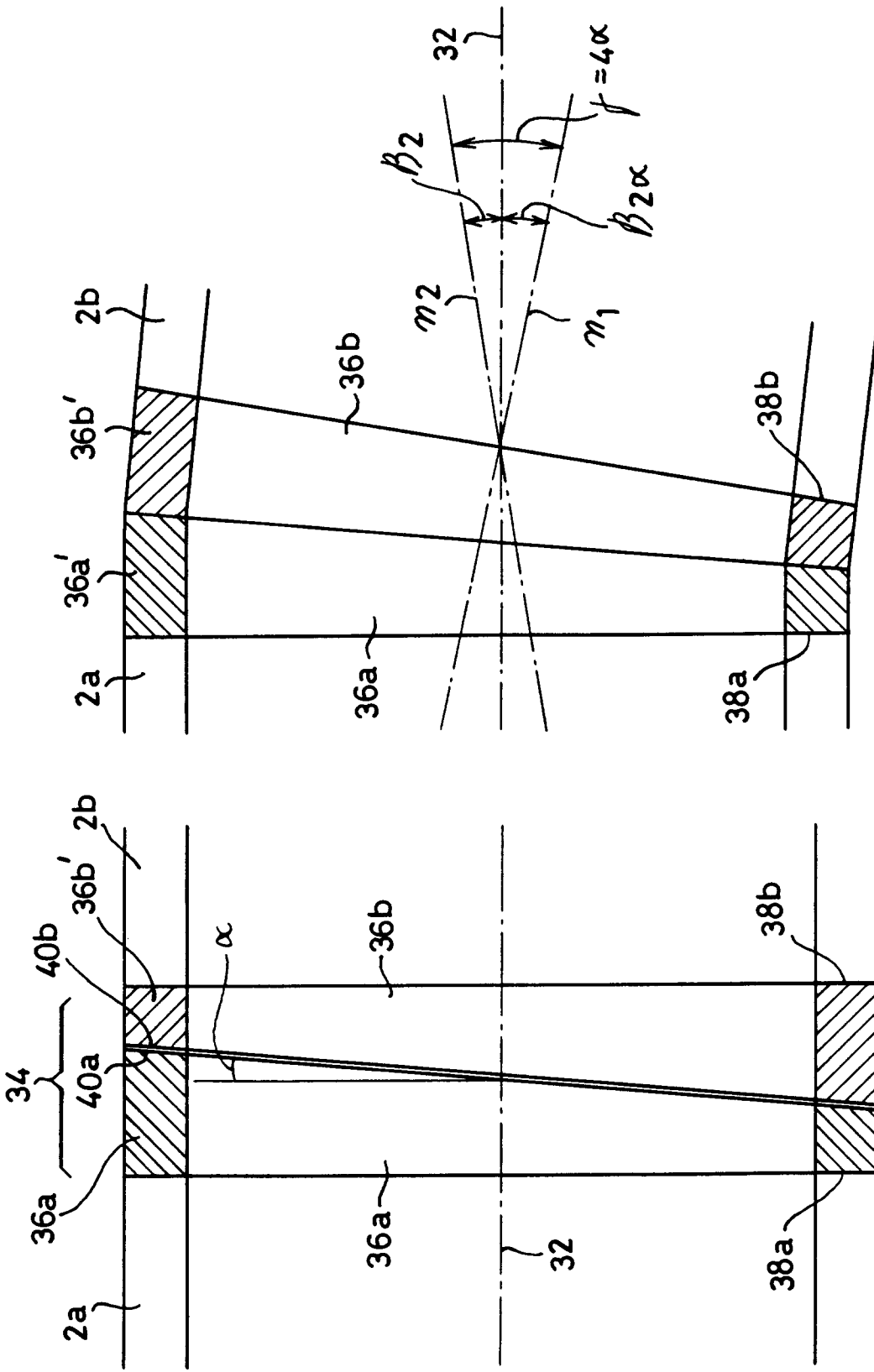


FIG. 2b.

FIG. 2a.

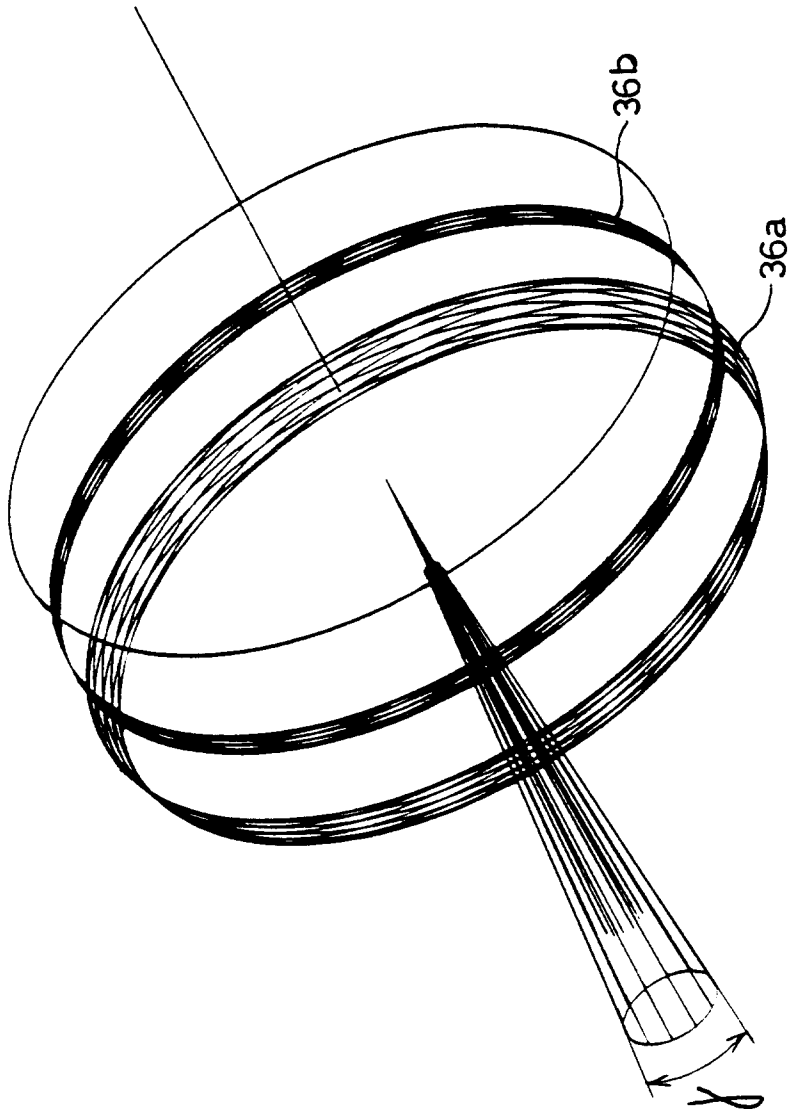


FIG. 5.

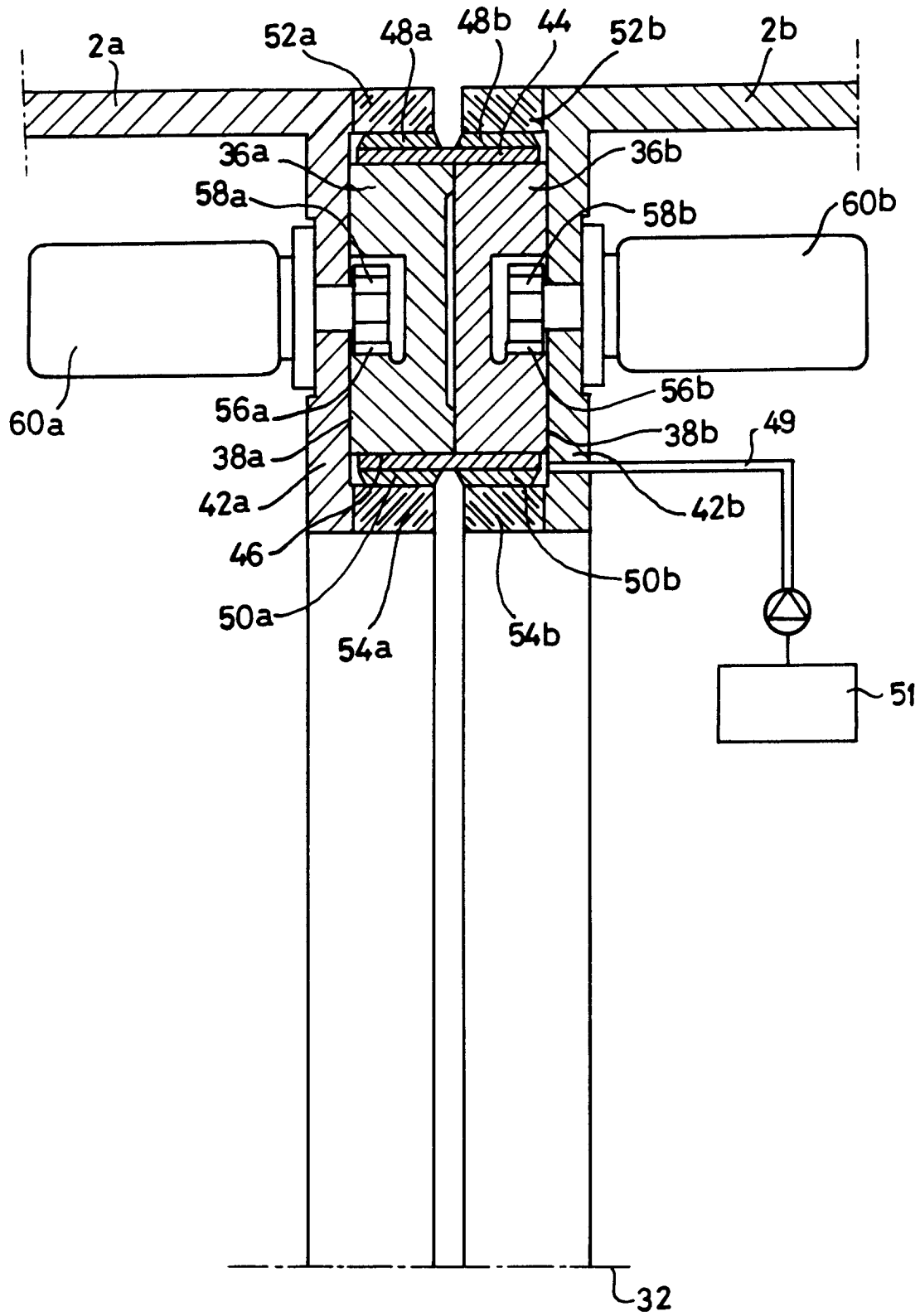


FIG. 4.

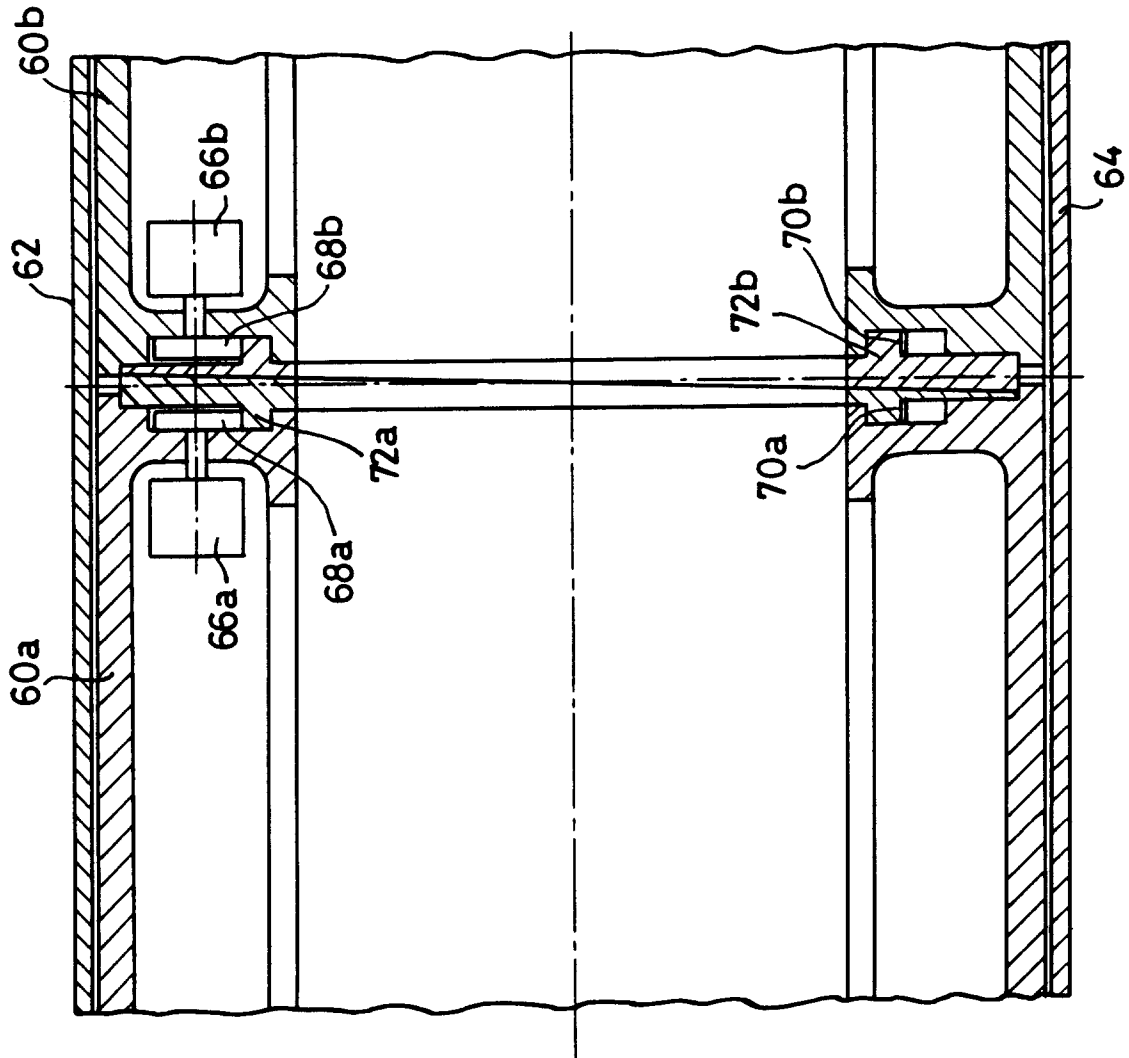


Fig. 5.



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EUROPEAN SEARCH REPORT

Application Number

EP 93 20 1018

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-A-2 545 041 (PEINER MASCHINEN- UND SCHRAUBENWERKE AG) * claims; figures * -----	1-3	E21D9/06
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			E21D
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	24 JUNE 1993	RAMPELMANN J.	
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