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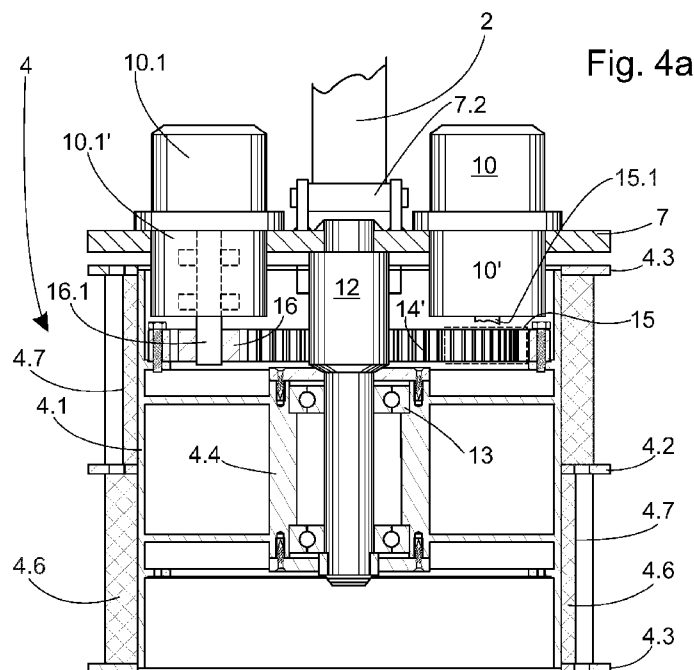
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(54) Title: FEEDING APPARATUS FOR A TREE HARVESTER



(57) Abstract: The invention relates to a feeding apparatus for a tree harvester, which includes opposing arms (2) pivoted to a frame (1), two opposing feed rollers (4.4.1) installed in the arms (2) as the only feed rollers (4.4.1) for feeding a tree (5) through the throat, hydraulic motors (10, 11) driving the feed rollers (4.4.1) and at least two pressure-medium lines (L1, L2) operating them.



FEEDING APPARATUS FOR A TREE HARVESTER

The invention relates to a feeding apparatus for a harvester, which includes

- opposing arms, with operating devices, pivoted to a frame, for creating transverse compression,
- two opposing feed rollers installed in the arms as the only feed rollers for feeding a tree through the throat, and
- hydraulic motors driving the feed rollers and at least two pressure-medium lines operating them.

In felling machines, the branches are stripped by pulling the trunk of the tree through stripping blades conforming to the trunk.

In continuous-feed devices, either crawler tracks or a feed device consisting of several rollers are used.

A typical tractive-force requirement is 10 kN - 30 kN. The very largest devices can develop a tractive force of about 50 KN. Further, when we know that a suitable stripping speed is ~4-6 m/s, in theory the power required will be 180 KW. Larger devices have a lower speed, but nonetheless a power of 200 KW is usual.

As the friction coefficient between a feed roller and a tree varies from moment to moment, the use of high power cannot be ensured without a precise distribution of the rollers' tractive force. The momentary slipping of a roller will cause "pitting" that reduces the quality of the wood. Further, a hydraulic motor can fail if it runs at high revolutions.

For these reasons, it is sought to ensure the simultaneous rotation of the rollers in the same direction. Each roller can

have its own control valve, or the rollers can be connected to each other hydraulically.

The most usual way is to use two proper feed rollers and then add an extra feed roller. In this case two hydraulic motors
5 are connected mechanically in the roller. The proper feed roller and the hydraulic motor of the second extra roller are connected in series.

The extra roller now acts as a synchronizing element for the movements of the proper feed rollers.

10 The problem with this is the contact of the proper feed rollers and the extra roller with the tree. With large trees, the proper feed rollers pull the tree, the extra roller acting only to synchronize. With small trees, the extra roller receives the compressive force of the actual rollers. But the
15 construction works reasonably. Narrow rollers can be used and a wider range of commercial hydraulic motors is available.

Figure 1 shows the construction of the most usual modern feed device. The figure shows the construction in a very simplified form. The frame structure is not shown in the figure and the
20 hydraulic circuit is drawn in the same figure.

Roller 32 is common to motors 30 and 30.1. The diameter of the roller is about 200 - 300 mm. The tree 5 is thus between feed rollers 32, 33, and 33.1. Rollers 33 and 33.1, suspended on pivot points 34 and 34.1, turn according to the diameter of
25 the tree.

Let us examine a situation, in which, for example, due to snow or ice only feed roller 33 receives tractive force, but its torque is insufficient by itself to move the tree 5.

The directional control valve 35 is now in the position "straight". Pressurized oil is not now allowed through motor 31, in which case motor 30 does not receive oil. However, the same pressure affects 31.1 and then, for example, due to ice on the surface of the tree 33.1 and 32 spin "idle". This is possible because a vacuum due to suction arises between motors 31 and 30. The situation is unusual, but for this reason an actual feed movement forwards can be made using the so-called "cross" position of the directional control valve 35. Both ways are used, but one direction is always worse.

Harvesters containing two feed-roller pairs or groups are also known. In Finnish patent FI 901119 (Sampo Hydraulics), multi-capacity motors are used to rotate two rollers, in which the second capacity of the multi-capacity motor rotating both rollers is connected in series with a separate hydraulic motor. Another solution using multi-capacity hydraulic motors is known from application publication US 2005/0098231A1 (Alftan). A four-roller harvester is known from publication EP 2944189A1 (Waratah), in which the hydraulic motors of the rollers can be connected diversely in parallel and in series. A three-roller harvester equipped with four hydraulic motors is known from application publication WO 99/41972 (Pinomäki).

It is known that the construction of a feed device using wide feed rollers is advantageous in terms of tree feed. Thanks to the wide roller, the roller's path of movement can be mainly lateral. The path of movement of a narrow roller also demands a vertical path of movement. In a wide roller, a small tree travels on the upper edge, a large tree on the lower edge. Further, twisty trees move better with two opposing rollers giving freedom to move in an up-and-down direction.

The strong bearings required by a wide roller make it difficult to find commercial hydraulic motors. In addition, the motors cannot be connected in series, due to internal leaks. For this reason, opposed, wide feed rollers are difficult to use in a totality.

Using known solutions, operation is optimal over only a narrow power range, only in one direction, or else considerable throttling must be used before the motors, which increases power losses.

10 The rotation of a large feed roller demands a high torque, which in known solutions leads to the use of a very large hydraulic motor. This increases the weight of the felling head unreasonably.

A large feed roller also often has the problem of the gripping surface becoming blocked particularly with bark material, when its grip weakens.

The invention is intended to eliminate the aforementioned drawbacks of the prior art and create a better harvester feed-roller arrangement than previously. The intention of the invention is achieved according to what is stated in Claim 1. On the basis of the analysis of the prior art, the basic point of departure of the invention is that there should be two, and only two opposing feed rollers.

When each feed roller is driven by two hydraulic motors in different pressure-medium lines, this creates a mechanical connection between the hydraulic motors and thus control of the feed of the other hydraulic motors of the feed lines with the aid of the first mentioned.

In the feeding apparatus according to the invention, there are preferably two wide feed rollers moving mainly opposite each

other. Preferably parallelograms can be used to suspend the rollers.

In one preferred feeding apparatus, the forces caused by the wide feed roller are received by a separate shaft with bearings, in which case one or two hydraulic motors are installed in an auxiliary frame, which also carried the shaft. 20 % (generally 10 - 35 %) of the torque carried by the shaft of the feed roller is sufficient as the torque-carrying capacity of the bearings integrated in each hydraulic motor. In addition, there are preferably two hydraulic motors in both feed rollers, which are connected to the actual feeding part in the roller by a sprocket or chain drive.

In one preferred embodiment, the motors of the opposing rollers are separated connected to each other hydraulically, i.e. in series. For this purpose, two feed lines are formed, in which the hydraulic motors are mutually in an opposite order, i.e., for example, one hydraulic motor of the right-hand roller is first in the first line, but the same roller's second hydraulic motor is second in the second line feed line.

The invention is pre-eminently suitable for large machines, in which the diameter of the feed roller is 30 - 120 cm, preferably 45 - 70 cm. The width of the feed roller (4) is usually 75 - 150 %, preferably 85 - 120 % of its diameter.

In one preferred embodiment, a gear ring equipped with internal gearing is used, which is rotated by gearwheels driven by hydraulic motors. The construction is advantageous in other connections too (a single rotating gearwheel), but in this invention there are two rotating gearwheels to each feed roller.

The simplest construction involves four motors of the same size, as long as the gear ratio to the roller is the same. Further adjacent motors can be of a different size, as long as

it is symmetrical in the second roller too. The gear ratio of the driving gearwheel and the internal gearing is $1:4.5 \pm 50\%$, preferably in the range $\pm 15\%$.

The advantage of the construction is complete synchronization
5 between the rollers. In addition, if necessary the tractive force can be fine-tuned by altering the sizes of the motors operating as pairs, as long as they are mutually of the same size. It is characteristic that in the feed stage so-called full-pressure is fed to the second motor of both rollers.

10 In the following, the invention is described with examples and with reference to the accompanying figures.

Figure 1 shows a three-roller feeding apparatus according to the prior art,

Figure 2 shows one feeding apparatus according to the
15 invention, seen in the direction of feeding the tree,

Figure 3 shows a side view of the arrangement of Figure 2,

Figure 4a shows one transmission arrangement of a feed roller using a new feed roller,

20 Figure 4b shows an end view of the feed roller of Figure 4a,

Figure 4c shows an axonometric view of the feed roller of Figures 4a and 4b,

Figure 4d shows the gripping element used in the feed roller of Figure 4c,

25 Figure 5 shows a schematic hydraulics diagram of the feeding apparatus, and

Figures 6a and 7a show the annular forces of the feed roller in normal and one-sided loading situations.

Figure 2 shows one embodiment of the construction of the feed-
30 ing apparatus. The pins 1.1 and 1.2 and arms 2 and 3 are suspended from the frame 1. The other end of the arms 2 and 3 is attached to the holder 7 of the roller with the aid of pins

7.1 and 7.2. A parallelogram, particularly a trapezium, is formed by the pins and arms. The hydraulic cylinder 6 moves the parallelograms around the pins 1.1 and 1.2, so that the rollers 4 move towards or away from each other. The synchroni-
5 zation rod is not shown. The tree 5 being fed is pressed between the rollers 4 when the cylinder 6 moves the rollers towards each other. The diameter of the roller 4 can be 300 mm or as much as 800 mm, its width 200 mm or as much as 600 mm. The roller 4 is mounted in bearings on shaft 12 of the roller
10 holder 7. The stripping blades 40 carry the tree being processed in the throat. The path of movement of the feed rollers is thus made linear, with a maximum deviation from linearity of 1 - 6 % of the lateral shift.

It is quite advantageous that, with the aid of the pins 1.1
15 and 1.2, and the arms 2 and 3 and the pins 7.1 and 7.2 the parallelogram can be dimensioned in such a way that mainly the rollers 4, 4.1 are closer to each other at the lower edge than at the upper edge. Only in the fully open position is it advantageous for the lower edge to have a greater distance than
20 the upper edge. Normally, the "opening" of the lower edge is about 1.3 times greater than the diameter of the tree 5 being fed. Figure 3 shows a side view of the construction. In it, the stripping blades 18, 18' can be seen, normally two moving (18) and one fixed (18'). The diameter of the smallest tree to
25 be stripped is about 50 mm, the largest max. 800 mm.

Figure 4a shows the roller 4 is partial cross-section. It also shows the holder 7, shaft 12, and the hydraulic motors 10 and 10.1, as well as the bearing assemblies 10' and 10.1' of the associated drive shafts 15.1, 16.1.

30 This embodiment presents one construction. The shaft 12 is attached to the roller holder 7. In turn, the shaft 12 is at-

tached to the roller 4 through the bearings 13. The outer surface of the roller 4 is equipped with gripping elements in order to make the roller 4 create a feeding force. As the distance of the bearings 13 is considerable, about 25 % (usually
5 20 - 40 %) of the feed roller's effective diameter, it can easily create a large torque and thus a large carrying power of the compressive force. It is many times the carrying power of the driving hydraulic motors.

The gripping elements can be of any type whatever in relation
10 to the feed roller's basic construction described above. Here a generally preferred gripping-element construction is described. The gripping elements (4.8 Figure 4d) are not shown in this figure, but it does show the vulcanized rubber layer
4.6 of the surface of the outer cylinder 4.1 underneath them
15 and the spiked rings 4.3 and 4.2, which divide the cylinder surface into two narrower parts. Figure 4a shows the grooves 4.7 and holes in the spiked rings 4.2 and 4.3 made for the swing shaft 4.9 of the gripping element 4.8. The ends of each
shaft 4.9 are fitted into a hole in the spiked ring at the lo-
20 cation of the groove 4.7.

A gear ring 14 is attached to the upper edge of the roller 4. Hydraulic motors 10 and 11, equipped with a smaller gearwheel
15 and 16, are fitted to the holder 7. The gear ratio can be preferably 1:3, even 1:7. As an internal gear ring, the construction of the ring 14' permits a more compact construction
25 and the gearwheels can be lubricated with grease, like the rotation rings of excavators. A feeding apparatus construction using the internal gear ring according to the figure can naturally be used in other connections than the hydraulic system
30 according to this invention and using one or more gearwheels.

Figures 4b and 4c show the feed roller 4 as a separate totality. The gripping elements 4.8 are installed in two separate

rings. Figures 4c and 4d show the special features of this gripping element, i.e. the tongues and their overlapping in the direction of the circumference (5 - 15 % of the dimension of the gripping element). In such a gripping element 4.8 there is a sheet-metal component cut to shape, gripping spikes, and a swing shaft 4.9, the end of which is fitted in holes in the spiked rings 4.2 and 4.3.

In the version according to Figures 2, 3, and 4a, the hydraulic motors are on opposite sides relative to the rotating ring. Preferably the internal gear ring 14' is driven by two gearwheels 15, 16 which are both on the same side of the gear ring 14', being situated outside the pivots arms 2 relative to the throat and as close to each other as the motors driving them could be practically placed.

The thickness of the vulcanization is about 30 mm (generally 20 - 40 mm). During installation, the gripping elements 4.8 are compressed with pre-compression, when each head flexes restrainedly under load. Loading causes the gripping elements 4.8 to swing, when the tongues move relative to each other. This cleans the surface of the feed roller effectively.

A hydraulics diagram of the feeding apparatus according to the invention in a normal situation is drawn in Figure 5. Here, hydraulic pressure is directed to lines L1 and L2, which are reverse-coupled, so that in the figure full pressure is directed to motor 11 in line L2 and motor 10.1 in line L1. Due to leakage losses, the motors in series do not produce precisely quite the same torque, but the situation is symmetrical, as the full pressure is always directed to one of the feed roller's motors.

In an imaginary situation (Figure 6a), when there is, for example, ice or snow on top of feed roller 4, only feed roller

4.1 can pull. Further envisage that the torque of roller 4.1 is now insufficient. Now, for example, when the directional control valve is in the position "straight", pressurized oil comes to motor 10.1, but cannot pass through, because the roller is "locked". However, motor 10.1 develops a torque that is about double, because the whole pressure acts over this motor, motor 10 being "idle".

Correspondingly, the same pressure acts on motor 11, but as it is "idle" this pressure bypasses it nearly without loss and acts on 11.1. When the whole pressure level acts on motor 11.1, a torque develops in it that is nearly double the normal level.

In normal running, one motor creates half of the maximum torque (Figure 6b). In other words the normal torque F of one roller pulling by itself is twice one motor's normal torque F_2 in symmetrical traction. More specifically, it can be estimated that

$F > 95 \% \times (2 \times F_2)$, which has also be measured on the test bench.

If we sum the torque coming to the roller 4.1 in the imaginary case, it totals nearly four times the normal torque of one motor. From this it follows that, in the feeding apparatus according to the invention, when one roller is "idle", the other feed roller that has held its grip will develop a torque that it nearly two times greater. I.e., even though one roller is "idle", the other roller is able by itself to create the same tractive force as both rollers normally.

Further, the direction of rotation does not matter now, i.e. whether the direction is feeding or reverse. Operation is com-

pletely symmetrical in both directions. Operation does not demand throttling in the feed line, instead operation is naturally very flexible.

Because the roller is on a separate shaft, the width of the
5 roller can be changed, nor will this affect the shafts of the
motors. Thus commercial motors can be found easily.

CLAIMS

1. Feeding apparatus for a harvester, which includes

- opposing arms (2), with operating devices (6), pivoted to
5 a frame (1), for creating transverse compression,
- two opposing feed rollers (4, 4.1) installed in the arms
(2) as the only feed rollers for feeding a tree through a
throat, and
- hydraulic motors (10, 11) driving the feed rollers (4)
10 and at least two pressure-medium lines (L1, L2) operating
them,

characterized in that at least one feed roller (4, 4.1) is
driven by two hydraulic motors (10.1, 11.1) in different pres-
sure-medium lines (L1, L2) thus creating a mechanical connec-
15 tion between the hydraulic motors and thus control of the feed
of the other hydraulic motors (10.1), 11.1) of the feed lines
(L1, L2) with the aid of the previously mentioned.

2. Feeding apparatus for a harvester, according to Claim 1, char-
acterized in that each feed roller (4, 4.1) has two hydraulic
20 motors (10, 11) driving it, each connected in series with a
single hydraulic motor (10.1, 11.1) rotating the opposite feed
roller (4, 4.1), when the feeding apparatus includes at least
two parallel pressure-medium lines (L1, L2), in each of which
are two hydraulic motors (10, 10.1 /11.1, 11) connected in
25 series, but connected in the opposite order.

3. Feeding apparatus, according to Claim 2, for a harvester,
characterized in that the hydraulic motors (10, 10.1; 11.1,
11) connected in series are of the same size and of a single
capacity.

4. Feeding apparatus, according to any of Claims 1 - 3, for a harvester, characterized in that the width of the feed roller (4, 4.1) is 50 - 150%, preferably 85 - 120% of its diameter.
- 5 5. Feeding apparatus, according to any of Claims 1 - 4, for a harvester, characterized in that the path of movement of the feed rollers (4, 4.1) is arranged to be essentially linear, the maximum linear deviation being 1 - 6 % of the lateral displacement.
- 10 6. Feeding apparatus, according to any of Claims 1 - 5, for a harvester, characterized in that the arms (2) carrying the said feed rollers (4, 4.1) are trapezium arms.
7. Feeding apparatus, according to any of Claims 1 - 6, for a harvester, characterized in that the diameter of the feed
15 roller (4, 4.1) is 30 - 120 cm, preferably 45 - 70 cm.
8. Feeding apparatus, according to any of Claims 1 - 7, for a harvester, characterized in that in connection with each feed roller (4, 4.1) is its own auxiliary frame (7, 12) and the bearings (13) carrying the feed roller (4, 4.1), as well as
20 two hydraulic motors ((10, 11 / 10.1, 11.1) rotating the feed roller (4, 4.1), attached to the auxiliary frame (7).
9. Feeding apparatus, according to Claim 8, for a harvester, characterized in that in at least one feed roller (4. 4.1) there is a gear ring (14) equipped with internal gearing,
25 which the hydraulic motors drive through gearwheels (15, 16).
10. Feeding apparatus, according to Claim 8 or 9, for a harvester, characterized in that a gear ratio of the driving gearwheel (15, 16) and the internal gearing (14') is 1:4.5 $\pm$ 50 %, preferably in a range $\pm$ 15%.

11. Feeding apparatus, according to Claim 9, for a harvester, characterized in that the two gearwheels (15, 16) driving the internal gear ring (14') are both on the same side of the gear ring (14'), being thus situated outside the said arms (2) relative to the throat.
12. Feeding apparatus, according to any of Claims 1 - 11, for a harvester, characterized in that the bearings (10', 10.1') of at least one gearwheel (15, 16) are integrated in the hydraulic motor (10, 10.1) driving it.
13. Feeding apparatus, according to any of Claims 1 - 12, for a harvester, characterized in that at least one feed roller (4, 4.1) includes a rubberized flexible ring, and gripping elements (4.8) supported with the aid of a swing shaft (4.9), which press into it when loaded, and which overlap.
14. Harvester, which includes
- a frame with suspension devices, being in the longitudinal direction of the frame,
 - stripping blades pivoted to the frame, with operating devices, for compressing the stripping blades transversely in order to form a throat, characterized in that it includes a feeding apparatus according to any of Claims 1 - 9.

AMENDED CLAIMS

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1. Feeding apparatus for a harvester, which includes

- opposing arms (2), with operating devices (6), pivoted to a frame (1), for creating transverse compression,
- 5 • two opposing feed rollers (4, 4.1) installed in the arms (2) as the only feed rollers for feeding a tree through a throat, and
- hydraulic motors (10, 11) driving the feed rollers (4) and at least two pressure-medium lines (L1, L2) operating
- 10 them,

characterized in that

- each feed roller (4, 4.1) has two hydraulic motors (10, 11) driving it in different pressure-medium lines (L1, L2) thus creating a mechanical connection between the hy-
- 15 draulic motors and thus control of the feed of the other hydraulic motors (10.1, 11.1) of the feed lines (L1, L2) with the aid of the previously mentioned,, each hydraulic motor (10, 11) connected in series with a single hydraulic motor (10.1, 11.1) rotating the opposite feed roller
- 20 (4, 4.1), when the feeding apparatus includes at least two parallel pressure-medium lines (L1, L2), in each of which are two hydraulic motors (10, 10.1 /11.1, 11) connected in series, but connected in the opposite order.

2. Feeding apparatus, according to Claim 2, for a harvester,

25 characterized in that the hydraulic motors (10, 10.1; 11.1, 11) connected in series are of the same size and of a single capacity.

3. Feeding apparatus, according to any of Claims 1 - 2, for a harvester, characterized in that the width of the feed roll-

er (4, 4.1) is 50 - 150%, preferably 85 - 120% of its diameter.

4. Feeding apparatus, according to any of Claims 1 - 3, for a harvester, characterized in that the path of movement of the feed rollers (4, 4.1) is arranged to be essentially linear, the maximum linear deviation being 1 - 6 % of the lateral displacement.
5. Feeding apparatus, according to any of Claims 1 - 4, for a harvester, characterized in that the arms (2) carrying the said feed rollers (4, 4.1) are trapezium arms.
6. Feeding apparatus, according to any of Claims 1 - 5, for a harvester, characterized in that the diameter of the feed roller (4, 4.1) is 30 - 120 cm, preferably 45 - 70 cm.
7. Feeding apparatus, according to any of Claims 1 - 6 for a harvester, characterized in that in connection with each feed roller (4, 4.1) is its own auxiliary frame (7, 12) and the bearings (13) carrying the feed roller (4, 4.1), as well as two hydraulic motors ((10, 11 / 10.1, 11.1) rotating the feed roller (4, 4.1), attached to the auxiliary frame (7).
8. Feeding apparatus, according to Claim 7, for a harvester, characterized in that in at least one feed roller (4. 4.1) there is a gear ring (14) equipped with internal gearing, which the hydraulic motors drive through gearwheels (15, 16).
9. Feeding apparatus, according to Claim 7 or 8, for a harvester, characterized in that a gear ratio of the driving gearwheel (15, 16) and the internal gearing (14') is 1:4.5 $\pm$ 50 %, preferably in a range $\pm$ 15%.

10. Feeding apparatus, according to Claim 8, for a harvester, characterized in that the two gearwheels (15, 16) driving the internal gear ring (14') are both on the same side of the gear ring (14'), being thus situated outside the said arms (2) relative to the throat.
11. Feeding apparatus, according to any of Claims 1 - 10, for a harvester, characterized in that the bearings (10', 10.1') of at least one gearwheel (15, 16) are integrated in the hydraulic motor (10, 10.1) driving it.
12. Feeding apparatus, according to any of Claims 1 - 11, for a harvester, characterized in that at least one feed roller (4, 4.1) includes a rubberized flexible ring, and gripping elements (4.8) supported with the aid of a swing shaft (4.9), which press into it when loaded, and which overlap.
13. Harvester, which includes
- a frame with suspension devices, being in the longitudinal direction of the frame,
 - stripping blades pivoted to the frame, with operating devices, for compressing the stripping blades transversely in order to form a throat, characterized in that it includes a feeding apparatus according to any of Claims 1 - 8.

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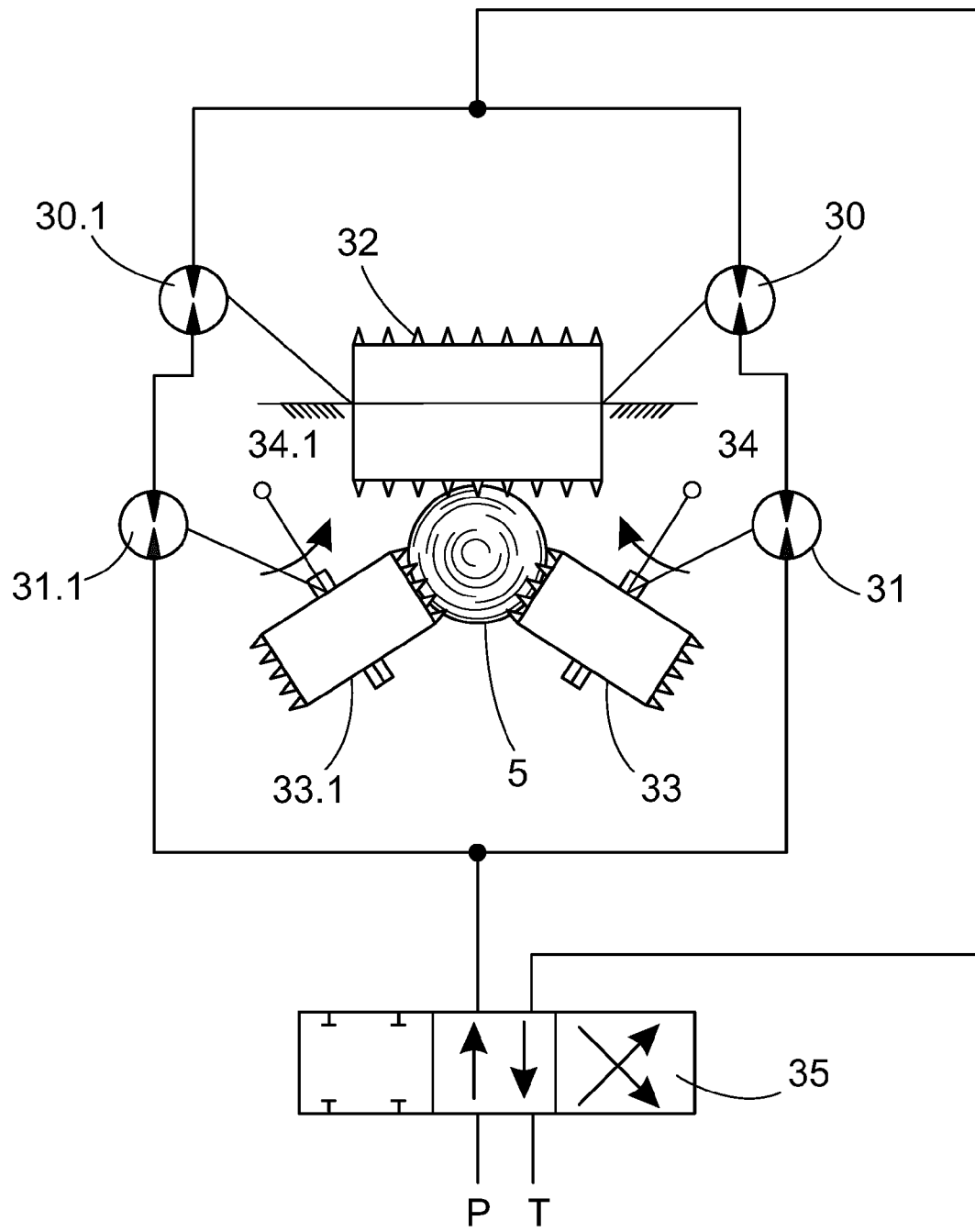


Fig. 1

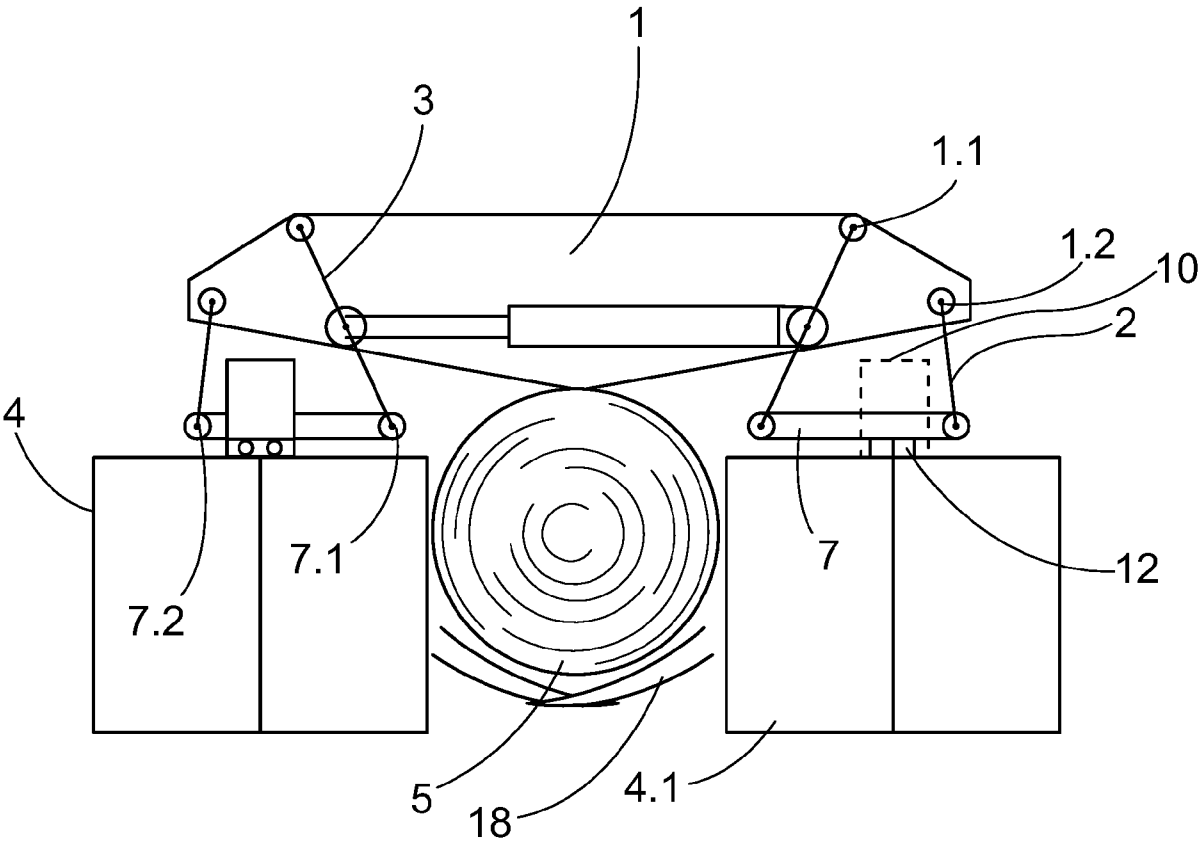


Fig. 2

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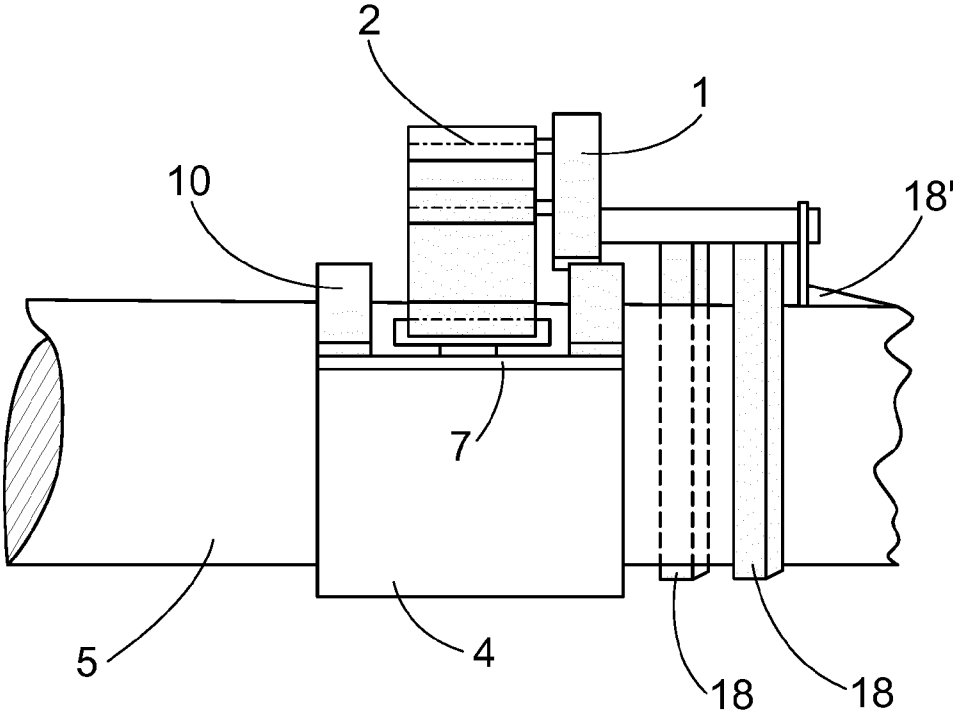
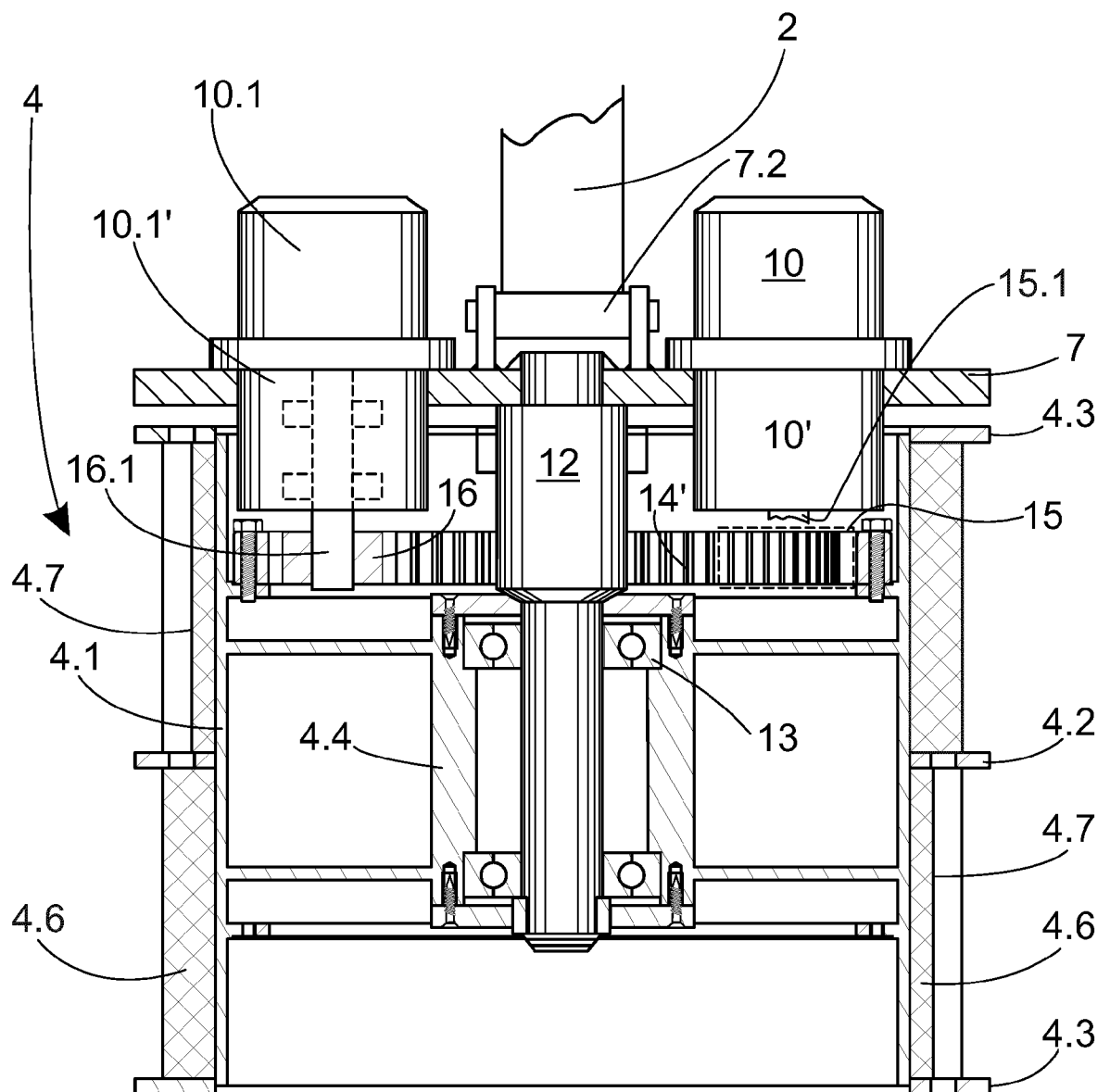
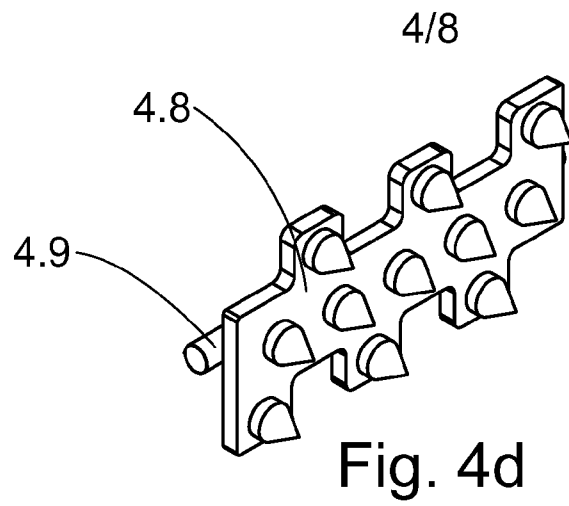


Fig. 3



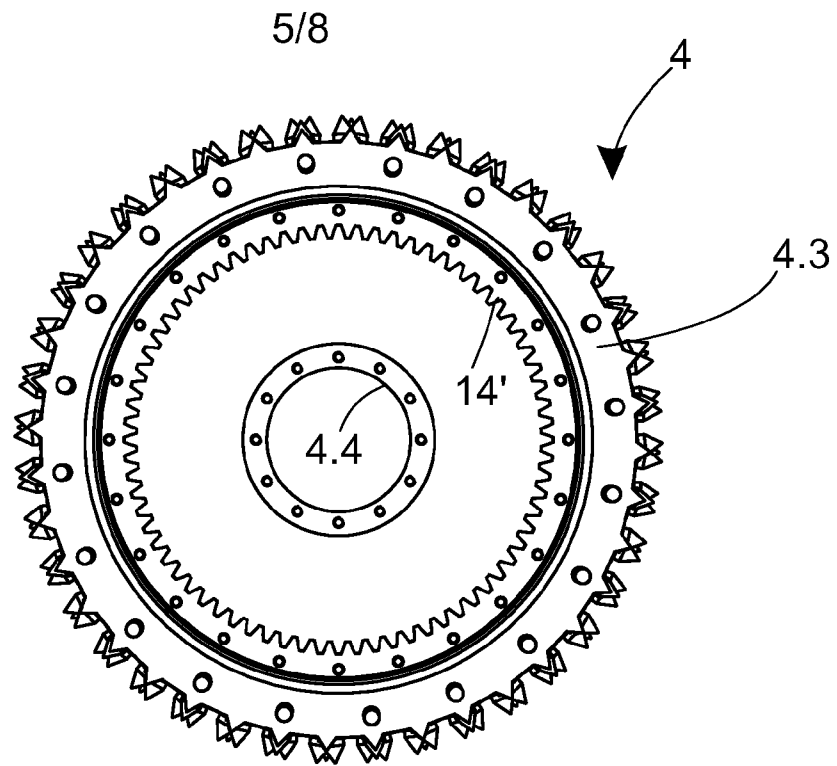


Fig. 4b

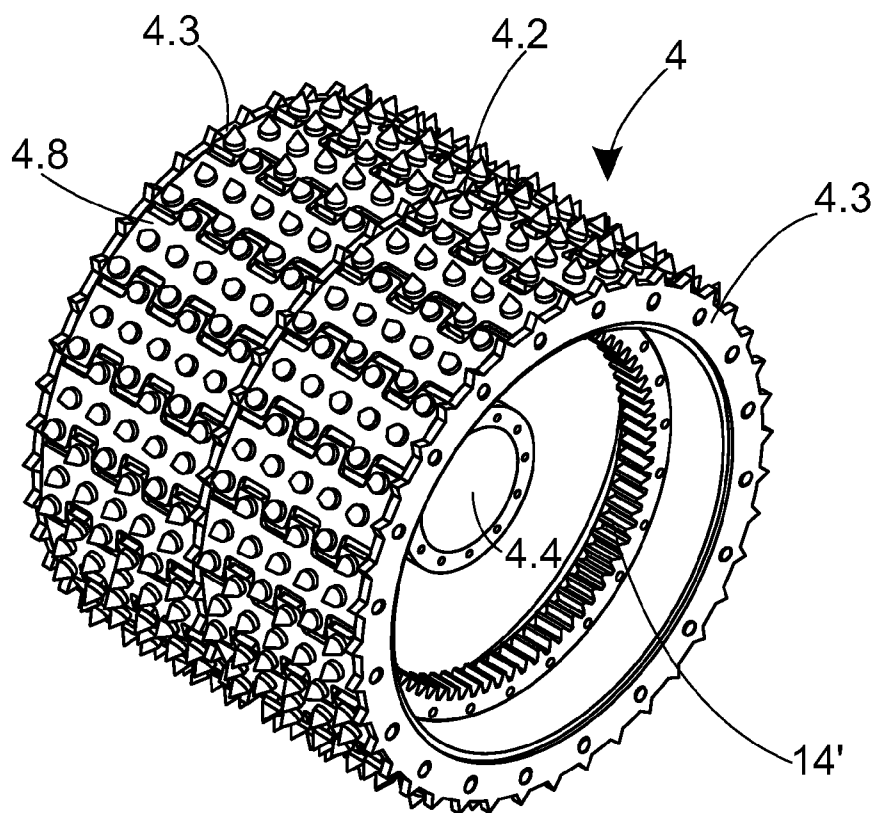


Fig. 4c

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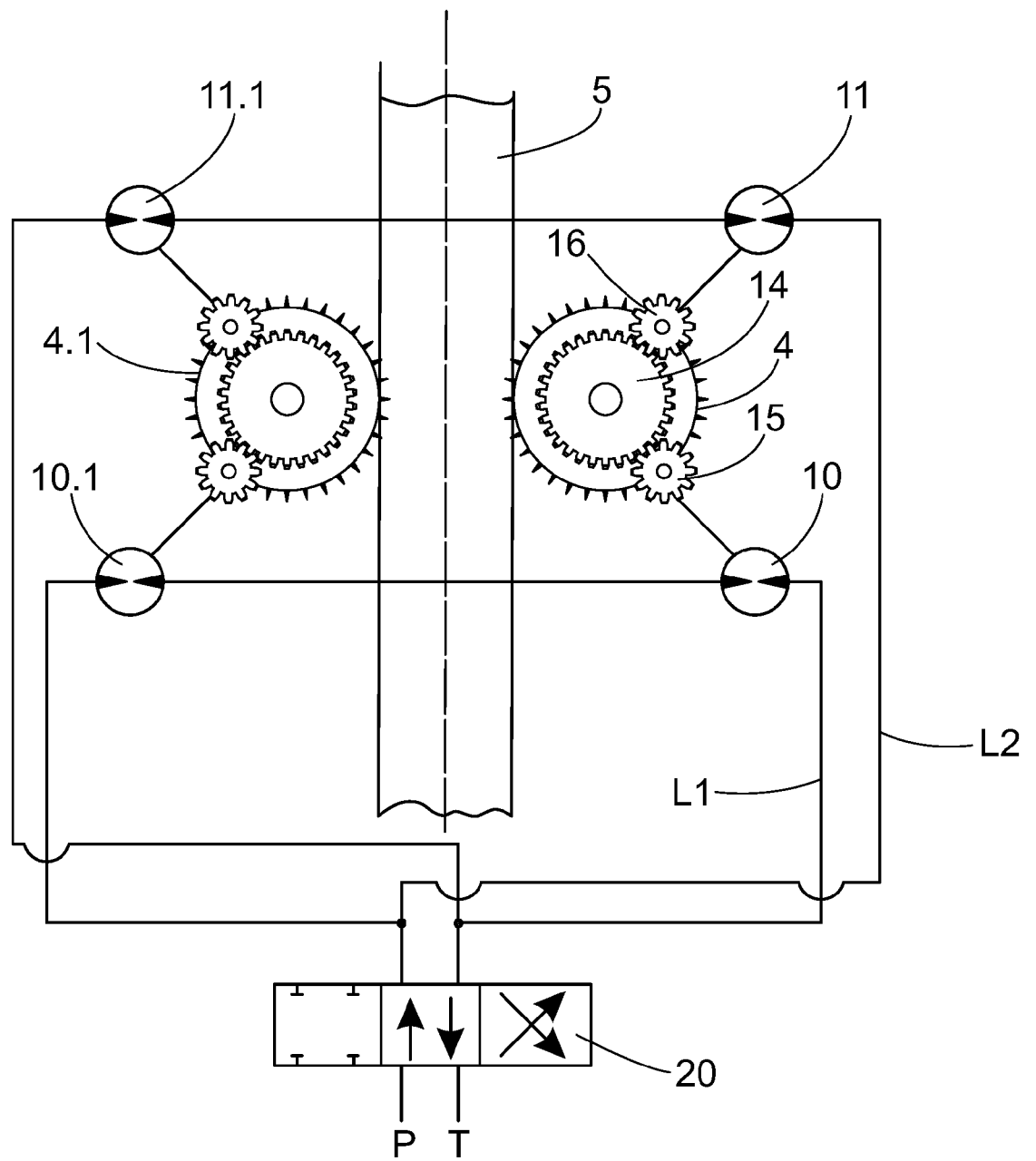


Fig. 5

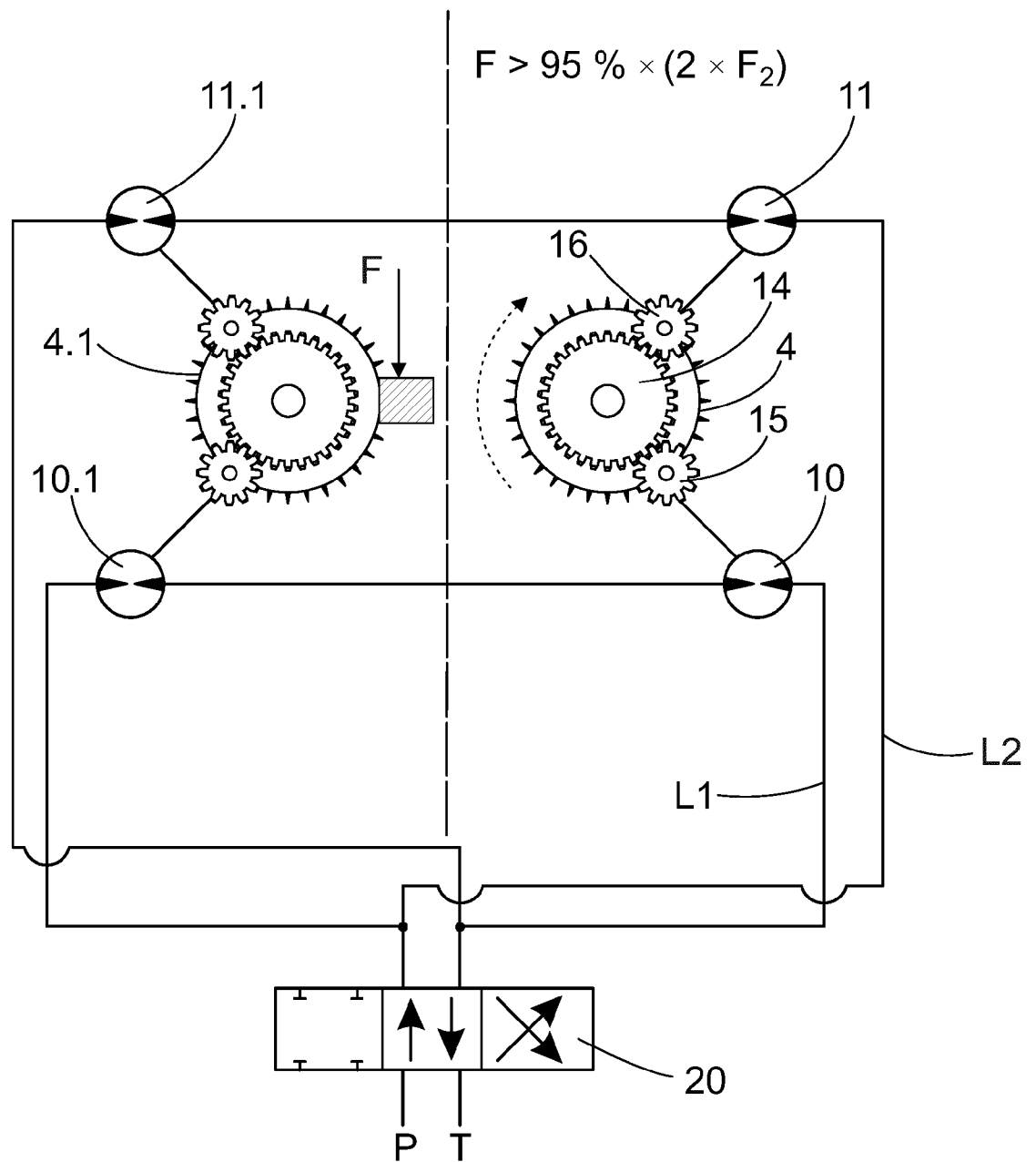


Fig. 6a

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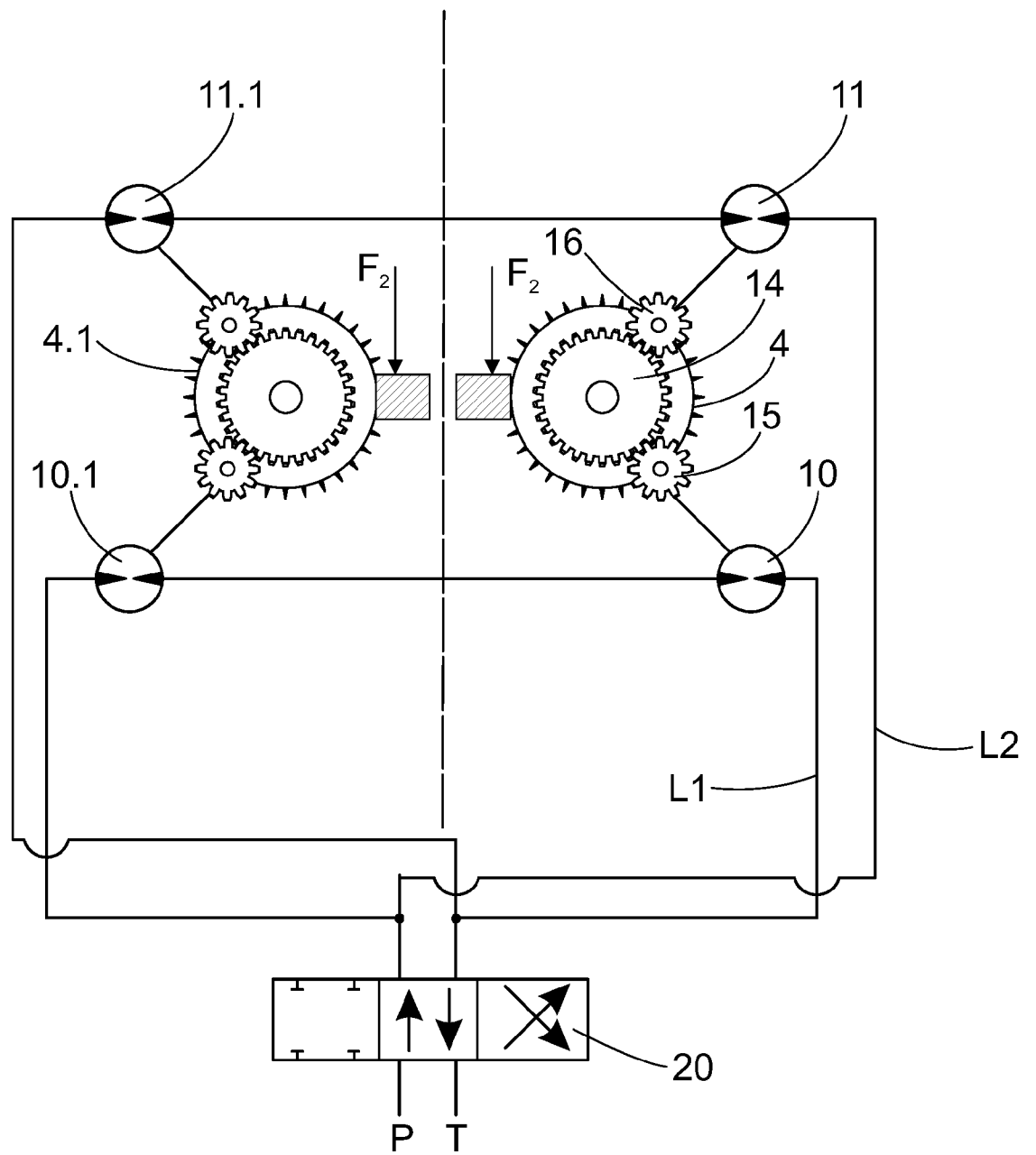


Fig. 6b

INTERNATIONAL SEARCH REPORT

International application No

PCT/FI2017/050734

A. CLASSIFICATION OF SUBJECT MATTER

INV. A01G23/081 A01G23/083
ADD.

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)

A01G

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/098231 A1 (ALFTAN ARTO [FI]) 12 May 2005 (2005-05-12)	1-10, 12-14
A	the whole document	11
A	WO 99/41972 A1 (PINOMAEKI SAKARI [FI]) 26 August 1999 (1999-08-26)	1-14
A	US 2007/125447 A1 (ALFTHAN ARTO [FI]) 7 June 2007 (2007-06-07)	1-14
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A	US 2006/278305 A1 (BARLOW DUANE A [US] ET AL) 14 December 2006 (2006-12-14)	1-14



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

22 January 2018

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

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