(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 051 192 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
22.04.2009 Bulletin 2009/17

(51) Int Cl.:
G06M 9/02 *(2006.01)*

(21) Application number: **08166494.8**

(22) Date of filing: **13.10.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(30) Priority: **12.10.2007 GB 0719959**

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(54) Sheet counter

(57) A sheet counter has a counting disc (25) mounted on a disc shaft (24) such that on rotation of the disc, sheets to be counted are transferred from one side of the disc to the other. A carrier (10) interconnects the disc shaft with a hollow drive shaft (23) through which the disc shaft extends. The carrier has an inner region (13) secured to the disc shaft and an outer region (11) secured to the drive shaft, there being circularly-extending spokes (14) interconnecting the inner and outer regions. The spokes (14) are flexible in the axial direction such that the disc may move axially through a small extent with respect to the drive shaft (23). A peg (32) on the drive shaft and groove (33) in the disc shaft serve to limit that axial movement.

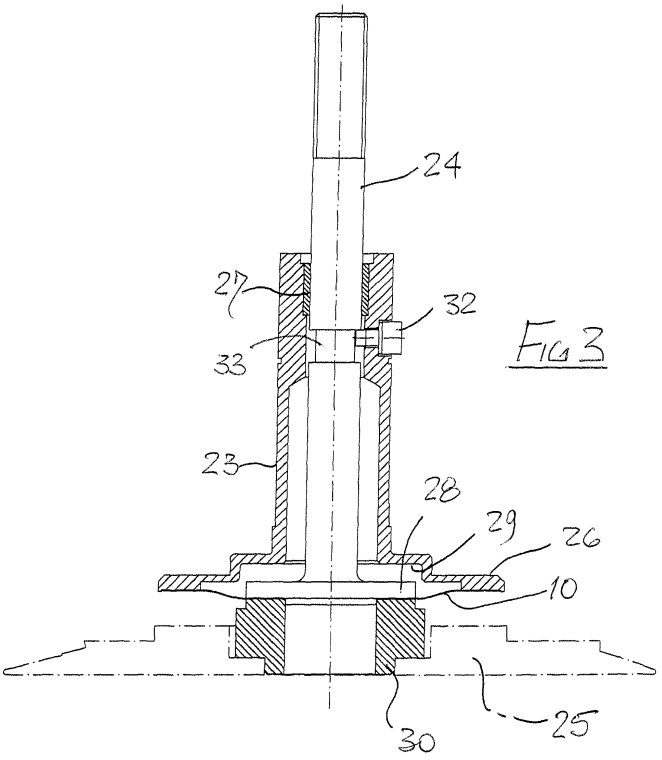

FIG 3

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Description

[0001] This invention relates to a sheet counter including a counting disc arranged to transfer sheets to be counted from one side of the disc to the other side thereof, the sheet count being incremented each time a sheet is transferred.

[0002] Sheet counters of the kind including a counting disc as mentioned above are widely used to count the number of sheets, such as of paper or similar materials, in a stack, and a particular application is for the counting of bank notes. The counting disc is mounted on a shaft for rotation and has at least one slot through the disc; the disc is engaged with a corner region of a stack of sheets and is rotated, so as to transfer the sheets one at a time through the slot, from one side of the disc to the other. The sheet counter is arranged so that the disc is moved in the direction of the height of the stack as the counting progresses, with a suitable sensing arrangement being provided to effect movement of the disc, as required.

[0003] Typically, the drive shaft mounting the disc is supported on a carriage which includes a drive arrangement to effect carriage movement so as to move the disc along the height of the stack, as the counting progresses. In this case, the disc may be mounted on the drive shaft so that the disc may slide in the axial direction while rotation is imparted to the disc from the shaft. A noncontact sensor (such as an optical sensor) for the disc position relative to the drive shaft determines when the disc has moved axially by more than a pre-set amount from a datum position and then causes the carriage to be moved in the appropriate direction in order to take the disc back to or near the datum position on the shaft.

[0004] It is most important that the disc is able to slide very freely on the drive shaft in order that the operation of the disc counter, as a whole, may progress smoothly. If there is too much friction between the disc and drive shaft, or worse if the mounting of the disc displays stiction, the movement of the disc relative to the drive shaft will not be smooth and in turn the driving of the carriage is likely to be somewhat irregular. In turn, this can lead to mis-counts or even damage to the corner region of individual sheets in the stack thereof being counted. In an attempt to allow smooth sliding movement of the disc on the shaft, a linear ball bearing may be used to mount the disc on the shaft, with a keyway and peg employed to transfer torque from the shaft to the disc. Unfortunately, the counting operation is likely to yield fine paper particles which, over time, can accumulate in the moving components, giving rise to problems with the bearing.

[0005] This invention aims at providing a sheet counter having a counting disc mounted on a shaft for rotation thereby, the mounting arrangement being such that linear sliding movement of the disc relative to the shaft is eliminated, which in turn allows smoother operation of the sheet counter.

[0006] According to this invention, there is provided a sheet counter including a counting disc mounted on a drive shaft for rotation thereby to transfer sheets to be counted from one side of the disc to the other side thereof, the disc being movable in the axial direction of the drive shaft as sheet counting progresses, characterised in that the disc is mounted to the drive shaft by means of a carrier having outer and inner regions with the disc being mounted to one of the outer and inner regions and the drive shaft being connected to the other of the outer and inner regions, the carrier having flexibility in the axial direction of the drive shaft but being configured to transmit torque to the disc on rotation of the drive shaft.

[0007] It will be appreciated that in this invention, a sliding connection which must be able to transmit torque between the drive shaft and disc is eliminated. Rather, the disc may perform small excursions from a datum position by the carrier flexing in the axial direction, which excursions can be detected optically as with the known design of sheet counter, in order to allow a carriage supporting the counting disc to be moved in the appropriate direction as required to return the disc towards its datum position.

[0008] Preferably, the carrier is in the form of a diaphragm manufactured, for example, from spring steel or a similar resiliently-flexible material, in order to exhibit sufficient flexibility to allow the disc to perform small excursions from a central, datum position as individual sheets are counted, whilst still allowing sufficient torque to be imparted to the disc from the shaft, for the counting operation. Such a diaphragm may include a series of spokes (or arms) extending from the inner region to the outer region which spokes may flex in the radial direction; typically three such spokes are provided.

[0009] Though it would be possible to have the spokes extending generally radially, this may increase the diameter of the diaphragm to an unacceptable extent if the spokes are to have sufficient flexibility to accommodate the required excursions of the disc. Advantageously, therefore, the spokes extend generally in the circular direction of the diaphragm, with one end of each spoke formed integrally with the inner region of the carrier and the other end of each spoke formed integrally with the outer region of the carrier.

[0010] A typical carrier formed in accordance with this invention may therefore have a disc-like appearance but with slits formed through the thickness of the carrier, which slits delineate the spokes.

[0011] A preferred embodiment of sheet counter of this invention has a hollow drive shaft, the counting disc being mounted on a disc shaft which extends coaxially within the hollow drive shaft, with the carrier interconnecting the disc shaft and the drive shaft. In this case, the inner region of the carrier is connected to the disc shaft and the outer region of the carrier is connected to the drive shaft. The drive shaft itself is supported in bearings which hold that shaft against axial movement, and the disc shaft being movable axially within the drive shaft between pre-set limits. A suitable drive arrangement for the drive shaft is provided, to cause rotation of the counting disc at the

required speed. Such a drive arrangement may include a stepper motor together with drive circuits and a toothed belt interconnecting the stepper motor and the drive shaft.

[0012] The pre-set limits of movement of the disc shaft with respect to the drive shaft may be defined by means of a peg mounted on the drive shaft and projecting into a groove formed in the disc shaft. In all ordinary operation with the disc position being sensed and controlling the operation of a carriage supporting the drive shaft, the peg should not contact any part of the disc shaft and so the disc should be able to move freely with respect to the drive shaft, under the control of the carrier. Further, means may be provided to limit relative axial angular movement between the drive shaft and the disc shaft such that in the event the carrier is subjected to torque with the arms in compression, the likelihood of warping or buckling of those arms is reduced.

[0013] By way of example only, one specific embodiment of sheet counter of this invention will now be described in detail, reference being made to the accompanying drawings in which:-

Figure 1 is a plan view on a carrier for a counting disc, in the form of a diaphragm spring;

Figure 2 illustrates the drive shaft, diaphragm spring, disc shaft and disc assembled together and with the disc in a central position; and

Figures 3 and 4 illustrate the counting disc deflected fully downwardly and fully upwardly, respectively.

[0014] The carrier used in this embodiment to connect a counting disc to a drive shaft therefor is shown in Figure 1. The carrier 10 is made from a thin spring steel sheet having a circular outer periphery, with an outer region 11 defining that outer periphery. The disc has a central hole 12 with an inner region 13 defining that hole. Three generally circularly-extending spokes 14 interconnect the outer and inner regions 11,13, the spokes being defined by slits 15 formed through the thickness of the carrier 10. One end 16 of each spoke connects with the outer region 11 of the carrier and the other end 17 of each spoke connects with the inner region 13 of the carrier.

[0015] Four holes 19 are formed in the outer region 11 of the carrier, those holes 19 being irregularly spaced such that the carrier may be connected to a drive shaft only in a pre-determined angular relationship with respect thereto. Similarly, four holes 20 are formed in the inner region 13 of the carrier, those holes 20 being irregularly spaced such that the carrier may be connected to a disc, or a disc shaft, only in a pre-determined angular relationship with respect thereto, as will be described below.

[0016] The outer region 11 of the carrier 10 is marked with an arrow 21 to indicate the intended direction of rotation of the carrier, when in use. It is important that the rotation of the carrier is in the direction of that arrow, in order that the spokes 14 are in tension for transmitting torque from the outer region of the carrier to the central region thereof. In the embodiment described here, where the drive shaft is connected to the outer region of the carrier and the counting disc to the inner region, the carrier is intended to rotate in the counter-clockwise sense when viewed in Figure 1. The same carrier may be employed for a counting disc to be rotated in the clockwise sense, by mounting the carrier the other way up to that illustrated in Figure 1.

[0017] Referring now to Figures 2 to 4, there is shown in section an assembly of a hollow drive shaft 23, a disc shaft 24 and a counting disc 25, with the carrier 10 mounted between the drive shaft 23 and disc shaft 24. The drive shaft 23 has at its lower end a flange 26 for imparting drive to the disc shaft 24 as will be described below. The drive shaft 23 is supported in sleeve bearings (not shown) provided as a part of a carriage (also not shown) of a sheet counter, arranged for movement in the direction of the height of a stack of sheets to be counted. The drive shaft 23 is held by those bearings against axial movement and a drive arrangement for that shaft is provided to effect rotation thereof. Typically, the drive arrangement may include a stepper motor together with an associated drive circuit and a toothed belt drive from the stepper motor to a toothed pulley (not shown) provided on the drive shaft 23.

[0018] The disc shaft 24 extends axially within the drive shaft 23 and is located by a low-friction dry bush 27 provided within the drive shaft bore at the upper end thereof. At its lower end, the disc shaft has a flange 28 which may be accommodated in a counter bore 29 formed within flange 26 of the drive shaft. The flanges 26 and 28 are provided with threaded holes at the appropriate locations to allow the outer region 11 of the carrier 10 to be bolted to flange 26 and the inner region 13 of the carrier to be bolted to the flange 28 of the disc shaft.

[0019] Figures 2 to 4 show the counting disc 25 diagrammatically and as having a mounting boss 30, with the inner region 13 of the carrier 10 clamped between flange 28 and mounting boss 30. That mounting boss should have mounting holes in the same configuration as in the inner region of the carrier and flange 28, so that the bolts may clamp the assembly together and mount the disc on the flange 28.

[0020] The drive shaft supports a radially-extending peg 32 projecting into the bore of the shaft, the disc shaft having a groove 33 formed therein within which the projecting part of the peg is received. In normal operation, there is no contact between the projecting part of the peg 32 and the disc shaft, but the peg serves to limit the maximum axial relative movement between the drive shaft 23 and the disc shaft 24.

[0021] Though not shown in the drawings, an external spring arrangement may be provided for the disc shaft 23, connected to the upper end thereof, to relieve the carrier 10 of the load of the disc and shaft. The external spring should have an appropriate spring rate for the weight of the disc and shaft such that when the apparatus is at rest, the carrier 10 is essentially planar.

[0022] Figure 2 shows the counting disc in a mid position, with the carrier essentially planar. When in use and sheets are being transferred from one side of the disc to the other on rotation of the disc, the disc will move along the height of the stack. If the carriage does not correspondingly move, the disc shaft 24 will move within the drive shaft 23, either downwardly as shown in Figure 3 or upwardly as shown in Figure 4, depending upon the configuration of the counting disc and so the direction of count. Such movement of the disc shaft is accommodated by the carrier 10, with the spokes 14 thereof flexing as required, within the limits of movement permitted by the interaction of the peg 32 and groove 33.

[0023] An optical sensing arrangement (not shown) for the disc position relative to the drive shaft 23 is provided, to control movement of the carriage supporting the drive shaft. Once the disc and disc shaft have moved relative to the carrier by more than a pre-set amount, this is sensed and an appropriate control signal is generated for a drive arrangement for the carriage, whereby appropriate carriage movement is performed to take the disc back to, or towards, its mid position. Depending upon the counting speed, the thickness of the sheets being counted and other parameters, it is possible for the carriage to be essentially continuously driven at an appropriate speed in order to maintain the disc at a position slightly displaced from the mid position, as sensed by the optical sensing arrangement. In turn, this leads to a reduced likelihood of damage to the corner regions of the sheets being counted and also to a reduction in the likelihood of a mis-count.

[0024] As mentioned above, the carrier 10 is intended to be rotated in the counter-clockwise direction (as viewed in Figure 1) when driving the counting disc, so that the spokes 14 are in tension. It can happen that if the drive to the drive shaft is braked very hard, the inertia of the disc puts the spokes into compression and in that case, it is possible the spokes could buckle. In order to eliminate this at least one dowel, but preferably two diametrically opposed dowels, may be mounted on flange 28 to project into clearance holes provided in flange 26 of the drive shaft 23. In all ordinary operation, there will be no contact between the dowels and the flange 26, but in the event there is slight rotational movement between the two flanges, the dowels will contact the sides of the clearance holes in order to protect the spokes of the carrier against buckling.

Claims

1. A sheet counter including a counting disc (25) mounted on a drive shaft (23) for rotation thereby to transfer sheets to be counted from one side of the disc to the other side thereof, the disc (25) being movable in the axial direction of the drive shaft as sheet counting progresses, **characterised in that** the disc (25) is mounted to the drive shaft (23) by means of a carrier (10) having outer and inner regions (11,13) with the disc being mounted to one of the outer and inner regions and the drive shaft (23) being connected to the other of the outer and inner regions, the carrier (10) having flexibility in the axial direction of the drive shaft but being configured to transmit torque to the disc on rotation of the drive shaft.

2. A sheet counter as claimed in claim 1, wherein the carrier comprises a resiliently-flexible diaphragm (10).

3. A sheet counter as claimed in claim 2, wherein the resiliently-flexible diaphragm (10) is made of spring steel.

4. A sheet counter as claimed in any of the preceding claims, wherein the outer and inner regions (11,13) are interconnected by a series of spokes (14), each resiliently flexible.

5. A sheet counter as claimed in claim 4, wherein each spoke (14) extends generally in the circular direction of the carrier (10), with one end of each spoke formed integrally with the inner region (13) of the carrier and the other end of each spoke formed integrally with the outer region (11) of the carrier.

6. A sheet counter as claimed in claim 5, wherein the carrier (10) comprises a disc of resilient material with the inner region (13), outer region (11) and spokes (14) defined by slits (15) extending through the disc.

7. A sheet counter as claimed in any of the preceding claims, wherein the drive shaft (23) is hollow and the counting disc (25) is mounted on a disc shaft (24) which extends coaxially within the hollow drive shaft, the carrier being arranged to interconnect the drive shaft (23) with the disc shaft (24).

8. A sheet counter as claimed in claim 7, wherein the drive shaft (23) is supported in bearings which hold the drive shaft against axial movement, the drive shaft being supported on a carriage arranged for movement in the axial direction of the drive shaft.

9. A sheet counter as claimed in claim 7 or claim 8, wherein a stop arrangement (32,33) is provided to limit axial movement of the disc shaft (24) with respect to the drive shaft (23).

10. A sheet counter as claimed in claim 9, wherein the stop arrangement comprises a peg (32) projecting internally into the bore of the drive shaft (23) and received in an annular groove (33) formed in the disc shaft (24).

11. A sheet counter as claimed in any of claims 7 to 9,

wherein means are provided to limit relative rotational movement between the drive shaft (23) and the disc shaft (24).

12. A sheet counter as claimed in claim 11, wherein axially-extending abutments provided on one of the drive shaft (23) and disc shaft (24) are received in clearance apertures provided in the other of the drive shaft and disc shaft so as to limit relative rotational movement between the drive shaft and the disc shaft.

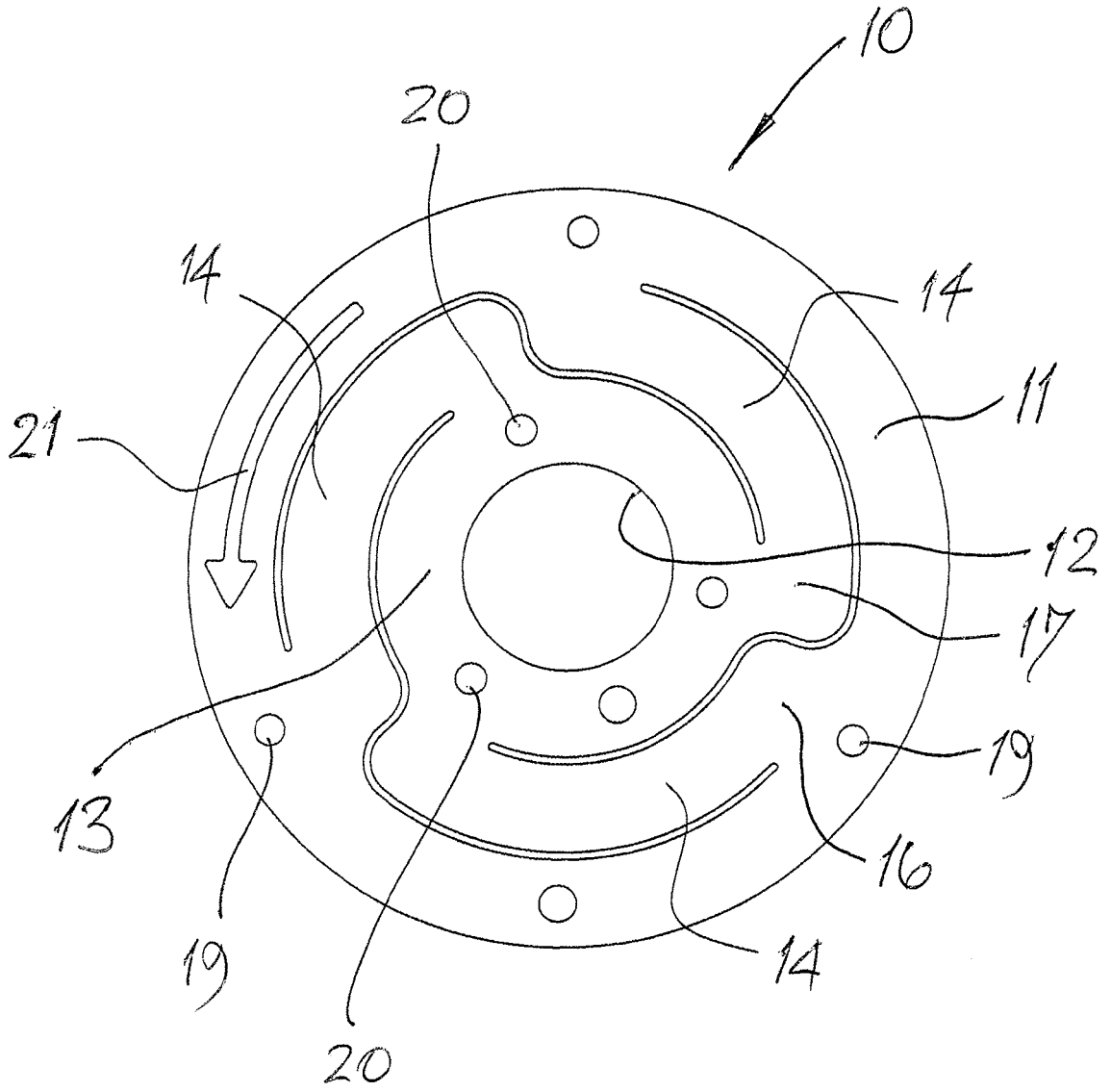

Fig 1

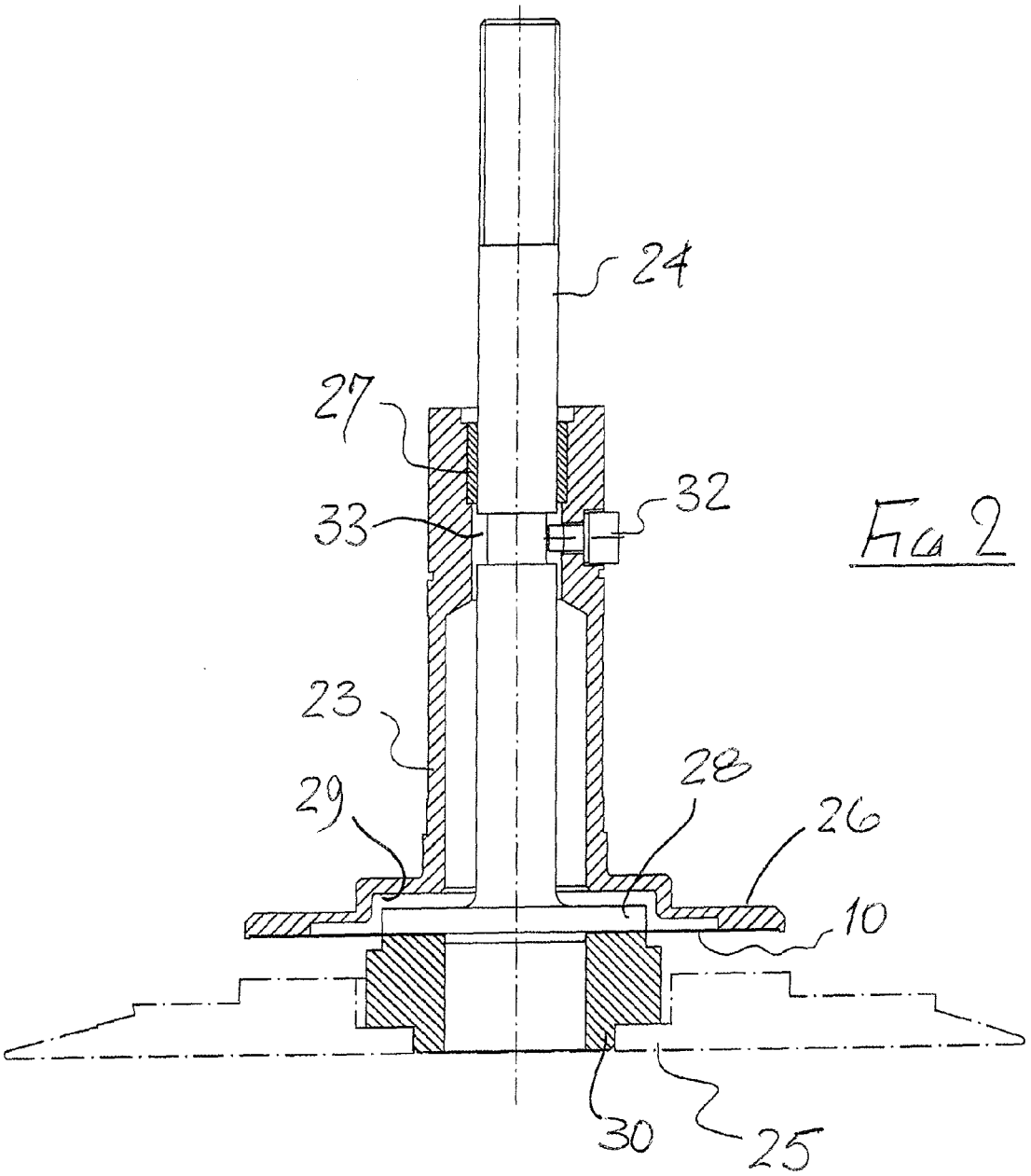

Fig 2

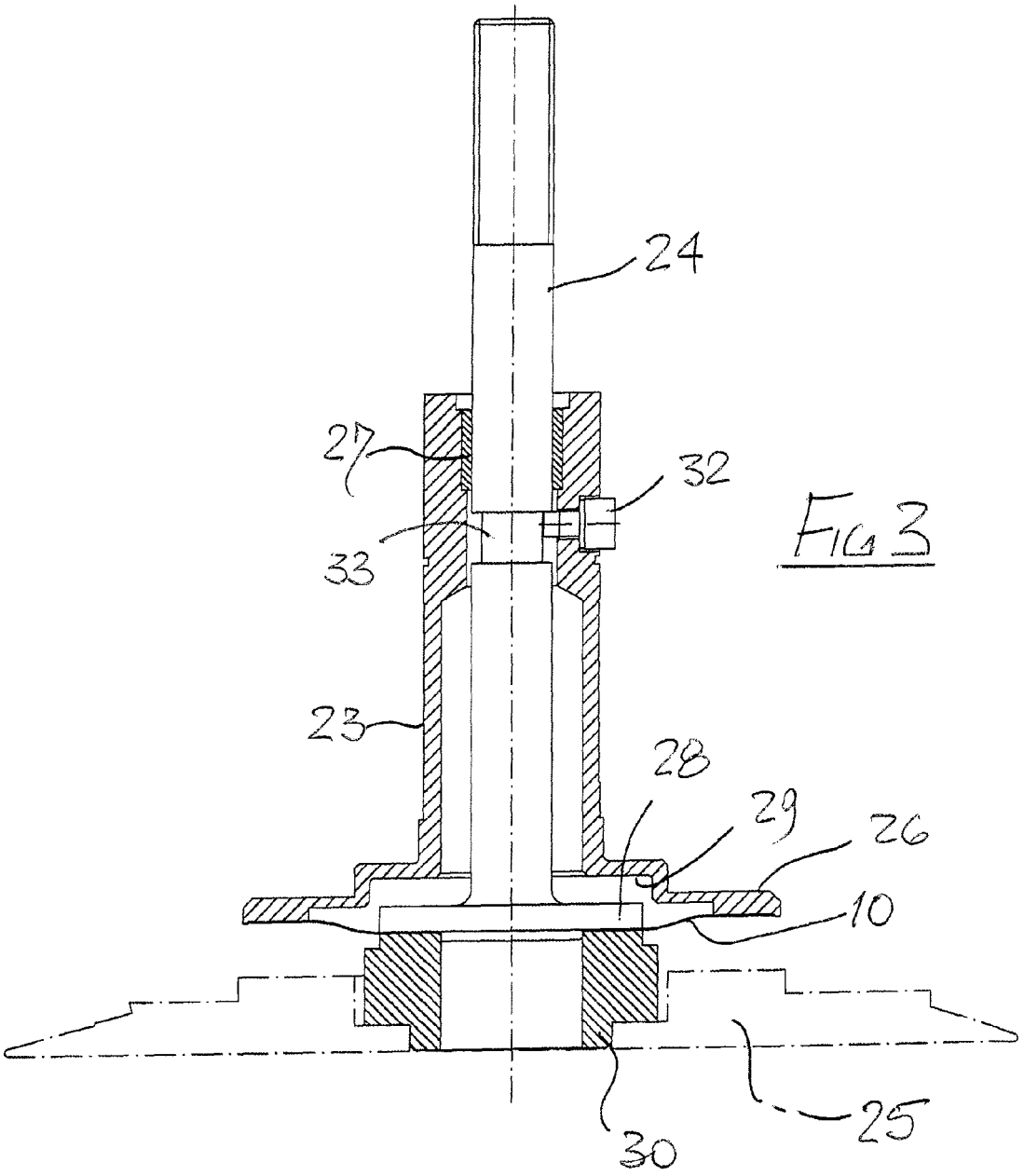

FIG 3

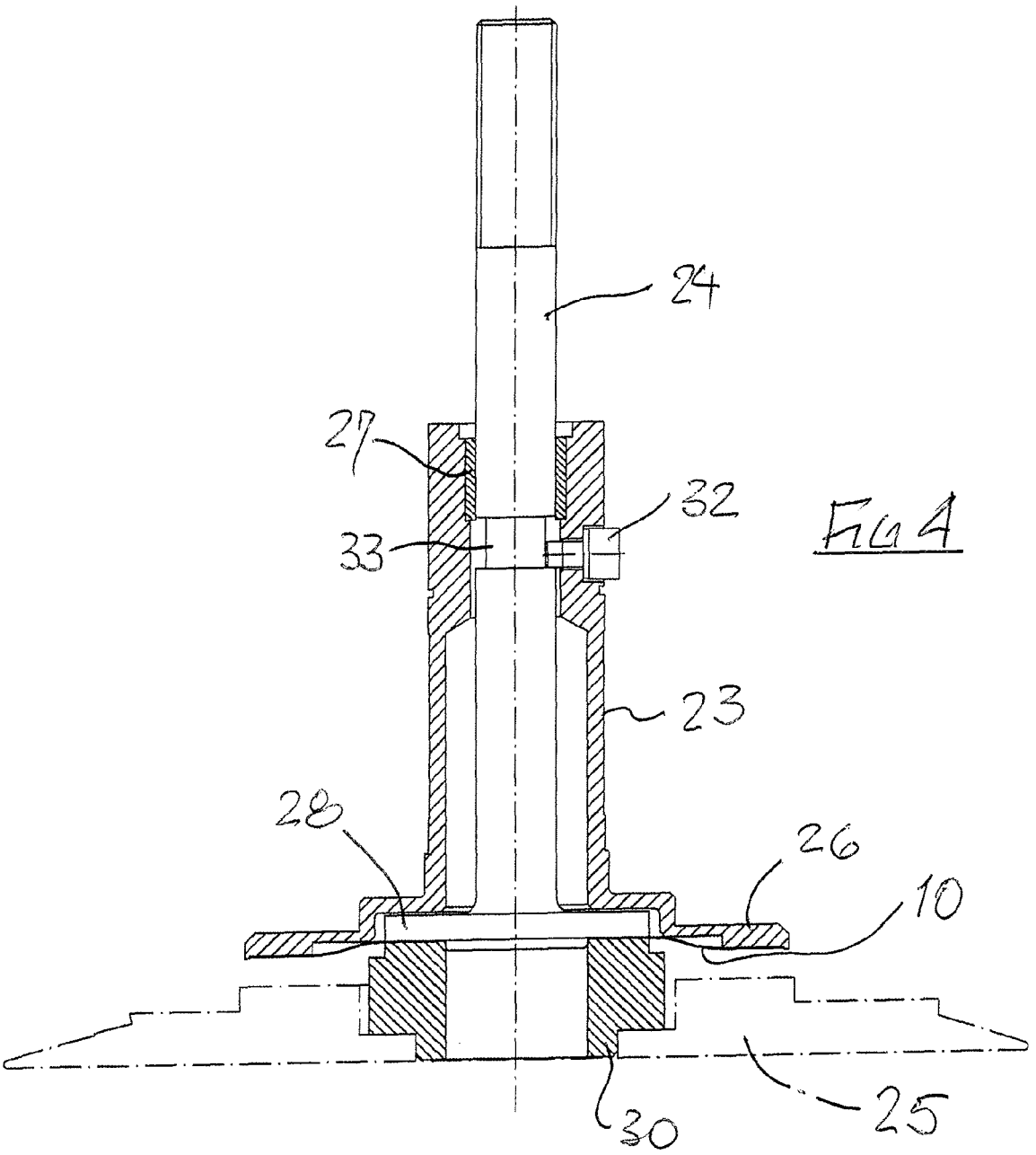

Fig 4