

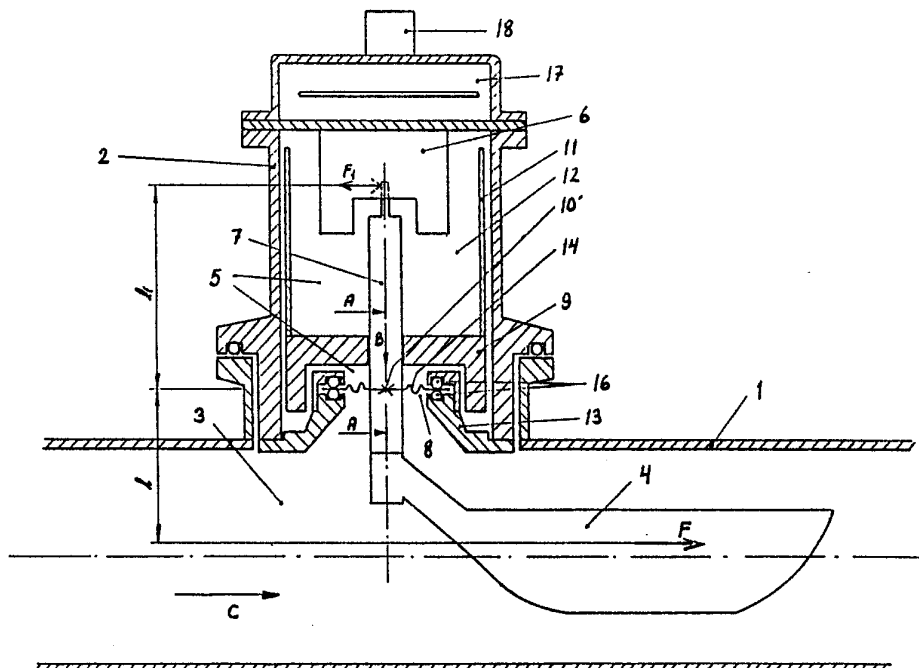


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(54) Title: THROUGH HOLE CONSTRUCTION FOR PROCESS MEASURING DEVICES**(57) Abstract**

The measuring device (2) comprises a sensing element (4) communicating with the process substance as well as a lever-like transfer element (7) connected with the sensing element and arranged to transfer the force acting on the sensing element due to the process substance to a measuring element (6) using the torque applied to the transfer element (7) about its fulcrum. The through hole (8) has a diaphragm (14) of elastic material covering the hole, being in engagement with the transfer member (7) in the position substantially perpendicular to the longitudinal axis thereof and acting as a sealing member separating the portion outside the process substance from the process substance. The diaphragm is mounted between two elastic gaskets (16) located in the side region of the through hole (8) in order to allow the free movement of the diaphragm in the direction of its main plane for eliminating tension forces applied to the diaphragm by the translation and the rotation of the transfer element (7) and causing measurement inaccuracy.



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Through hole construction for process measuring devices

The invention relates to a through hole construction for process measuring devices transferring force or movement from the measuring element communicating with the process substance to a measuring mechanism outside the process substance.

The above mentioned measuring devices are in wide use in the measuring operations applied in various processes. For carrying out the measuring operation, the measuring devices are provided with a sensing element in communication with the process substance and effected by a force resulting from the process substance to be measured, the device being further provided with a lever-like transfer element connected with the sensing element and transferring the said force and/or the movement using the torque about the transverse axis of the transfer element to a member performing the actual measuring operation and being located outside the process substance. The transfer member is led from the portion communicating with the process substance to the portion outside the process substance via a through hole. The through hole must in this case have a sealing member for separating the portion outside the process substance and at the same time the measuring mechanism from the process substance. Because the purpose is to measure the force and/or the movement, the construction at the through hole must be as elastic as possible in order to minimize the forces and/or the movements acting on the transfer member and resulting from the construction of the through hole. It is also not allowable, that other factors than those caused by

the process substance to be measured effect on the measuring results.

5 The invention relates more particularly to a through hole construction in devices measuring the consistency, i.e. the percentage of solids in the mixture, of flowing solid-liquid-mixtures, e.g. paper stock and being of the type disclosed in US-patent 4 062 226. One of the requirements for devices of this type is that the resistance to torque about the
10 transverse axis of the transfer element must be directly proportional to the actual torque applied by the sensing element to the transfer element. This kind of resistance or "counter-torque" results from the structure of the sealing member in the through
15 hole. Due to the considerable friction and hysteresis caused by the internal friction or plasticity characteristic of elastomers used in the through hole construction, the above mentioned requirements are not met sufficiently.

20 In well-known measuring devices of the above type the leading-through of the transfer element is realized by disposing an elastic rubber seal, such as a O-ring, around the transfer member to lie against the side surfaces of the through hole. The leading-
25 through is also realized by a bellows tube of metal fixed between the transfer element and the side of the hole. The above mentioned constructions are insufficient as far as the elasticity of the seal is concerned. When a rubber seal is used, the hysteresis
30 error is a considerable drawback and, moreover, this error will change during the life-time of the seal. Further, the changes in the stiffness of the rubber

during the life-time give rise to errors in the measurement. The elasticity of the rubber may also be temperature-dependent, and as a result of this in some cases the rubber seal must be heated for maintaining its temperature in a certain range. The adjustment of the measuring device to be independent of the changes of static pressure is also difficult. The drawback of the leading-through using the bellows tube is the possible clogging of the tube, which results in the stiffening of the through hole construction. This construction has further a considerable torsion stiffness, which causes extra tensions at the leading-through, thus making the measurement difficult.

15 The object of the present invention is to eliminate all the above mentioned drawbacks, which are caused by the constructions presented by the state of the art. For achieving this purpose the through hole construction according to the invention is characterized

20 by features set forth in the characterizing part of the claim 1. By using a diaphragm of elastic material in the through hole, the requirements of elasticity can be met by most suitable way. For receiving the force caused by the pressure of process as well as

25 the peak forces caused by the lumps such as pulp lumps which may be present in the process substance, the diaphragm is well supported by the support means of the lever-like transfer member. The support means can e.g. constitute of bearings. Due to the

30 elasticity of the diaphragm, no greater tensions are present in the diaphragm e.g. in the case of peak load directed on the diaphragm. By allowing the relative movement of the diaphragm and the region of

engagement with respect to each other in the direction of the main plane of the diaphragm at least in one of the regions of engagement, the elasticity of the construction of the through hole can be
5 increased and at the same time the rupture of the diaphragm due to peak load forces and the measurement error due to the diaphragm tensions caused by the clearance of the bearings are avoided. The tensions
10 in the diaphragm, which develop during the assembly and securing of the parts can also be eliminated with this arrangement. The realization in accordance with this invention facilitates also the adjustment of the static pressure.

The accompanying subclaims present advantageous ways
15 of fixing the diaphragm as well as constructional alternatives. The diaphragm can be mounted in its region of engagement into connection with an elastic gasket, e.g. between gaskets, which can be selected from various suitable materials. Moreover, there are
20 several possibilities concerning the material and the shape of the diaphragm.

In the following, the invention is described in more detail with reference to one preferred embodiment thereof, wherein the invention is applied in a
25 measuring device measuring the consistency of paper stock or corresponding mixtures. In the description, references are also made to the accompanying drawings, wherein

fig. 1 and 2 show through hole constructions
30 according to the state of the art,

fig. 3 shows the measuring device incorporating the through hole construction according to the invention as a sectional view,

5 fig. 4 shows the through hole construction as a view similar to that of fig. 3,

fig. 5 shows the through hole construction as a sectional view seen in the direction of arrow A in fig. 3,

10 fig. 6 shows the through hole construction seen in the direction of arrow B in fig. 3, and

fig. 7a and 7b show various alternatives for engagement of the through hole diaphragm with the structure of the device.

15 Fig. 1 shows a through hole construction of prior art, wherein the through hole is sealed by means of O-ring packing 19 disposed between the lever-like transfer rod 7 and the side wall of the opening. The transfer rod is supported by the bearings in the body of the measuring device and the position of the
20 bearings is denoted by the common axis 10' of the bearings, which axis extends perpendicularly to the plane of the drawing.

25 Fig. 2 shows further an embodiment belonging to the state of the art, wherein a bellows tube 20 made of metal is fixed onto the transfer rod 7 and on the side wall of the hole and acts as the sealing member.

Fig. 3 shows a measuring device 2 for measuring the consistency of paper stock flow. The device is

illustrated as a sectional view, the section being taken along the plane parallel to the process pipe 1, on which the device is installed. The measuring device comprises a sensing element 4 in contact with the paper stock 3 flowing in the process pipe (the direction of the flow is denoted by arrow C). The sensing element consists of an elongated blade having the configuration of a paddle, to which shearing force is applied due to the flowing paper stock. The force is dependent on the consistency of the paper stock and is denoted in the figure by letter F. The measuring device comprises further the portion 5 outside the process substance incorporating the measuring mechanism 6 for measuring the force acting on the sensing element. The said force is transferred to the measuring mechanism by means of a lever-like transfer rod 7 using the torque about its transverse axis (arms l and l' and force F_1). The transfer rod is attached at its one end to the sensing element and at its other end it communicates with the measuring mechanism. The transfer rod is led from the process substance to the portion of the measuring device outside the process substance via a through hole 8 and it is pivotally mounted to the body by means of a bushing 9. The bushing 9 is pivotally fixed to the body of the measuring device by means of ball bearings 10 (not shown in the figures). The common axis of the bearings is denoted in fig. 1 by reference numeral 10' and it passes the through hole via the transfer rod thus defining the transverse axis extending perpendicularly to the flow of the paper stock and creating the fulcrum, on the basis of which the measurement is realized using the above described torque. The portion of the measuring device outside the process substance comprises further a

damping cylinder 11 fixed onto the bushing 9. The damping cylinder 11 is surrounded by damping oil 12 for eliminating disturbances caused by various oscillations. The measuring device comprises further the electronics unit 17 and the connection plug 18. The output signal proportional to the force F to be measured is obtained by means of the measuring mechanism 6 and the electronics unit 17 using well-known methods belonging to the state of art and therefore they will not be described in more detail.

For forming the through hole construction of the measuring device, a bushing 13 having the shape of a frustum of a cone is attached to the body of the measuring device. The aperture at the smaller diameter end of the bushing forms the said through hole 8. For separating the device portion 5 outside the process substance from the process substance 3, the through hole contains an elastic diaphragm 14, which is preferably of metal and corrugated to a wave-like configuration. The diaphragm is attached to the transfer rod 7 its main plane directed perpendicularly to the longitudinal axis thereof. The main plane of the diaphragm coincides with the axis 10' of the bearings. The diaphragm covers the hole 8 and acts in this way as a sealing member preventing the process substance from penetrating into the device portion 5, which is situated outside the process substance.

Fig. 4 shows the through hole construction of fig. 3 in a greater scale and fig. 5 shows the construction of the through hole and the pivotal arrangement of the transfer rod as a sectional view taken along a plane perpendicular to the process pipe 1 and seen in

the direction of arrows A of fig. 3. The bushing 9 fixed onto the transfer rod 7 is fixed to the body of the measuring device by means of ball bearings 10 and a bearing pivot 21. The diaphragm 14 is attached at its outer periphery into a peripheral recess 15 situated in the main plane of the diaphragm and extending along the side wall of the through hole 8 so, that the motion of the diaphragm 14 in the direction of its main plane is possible. The depth of the recess in the direction perpendicular to the longitudinal axis of the transfer rod 7 is dimensioned to allow the slight lateral movement of the edge of the diaphragm. In the construction shown in the figures this is realized so, that gaskets 16 having the shape of a O-ring seal are disposed in the recess on the both sides of the diaphragm. The seal rings lie tightly against the diaphragm influenced by the pressure from the side walls 15' of the recess. As illustrated in fig. 4, a guide groove 15" is provided in each side wall 15' of the recess 15 for fitting the seal ring securely against the side wall of the recess. The O-ring seals are made of elastic material, such as rubber, which contributes to a good sealing effect, but has frictional properties allowing at the same time the diaphragm to be shifted on sliding between the gaskets.

Fig. 7 shows another alternative for mounting the diaphragm movably in the direction of its main plane. An equally advantageous result is obtained, compared with two elastic gaskets, when the gasket 16' at the side of the portion 5 outside the process substance is elastic and the gasket 16" at the side of the process substance 3 is a non-elastic gasket of chemically resistant material. The material of the

latter can be e.g. polytetrafluorethylene (PTFE), known also by its trade name TEFLON[®], or the material can be also metal. A similar result is obtained by changing the locations of the gaskets. The gasket at the side of the process substance is in this case made of an elastic, chemically resistant material, such as of a suitable rubber material, and at the opposite side of the diaphragm there is a non-elastic gasket. As illustrated in fig. 7, the cross-section of the ring-like gasket does not necessarily have to be round, but it can have also a rectangular shape.

The relative movement between the diaphragm and its region of engagement in the direction of the main plane of the diaphragm is arranged in the embodiments described above by mounting the diaphragm rigidly on the transfer rod and at the region adjacent to its outer periphery it is mounted movably on the side wall of the through hole. However, the through hole construction can also be realized so, that the diaphragm is mounted rigidly on the side wall of the through hole and the mounting of the diaphragm onto the transfer rod is realized following the same principle as is applied in the mounting of the diaphragm on the side wall of the hole and is described in the foregoing examples, i.e. the diaphragm containing an opening in its central portion for leading the transfer rod through it, is disposed between gaskets provided in the transfer rod. The transfer rod can in this case move freely with respect to the diaphragm when necessary. The region of engagement with the diaphragm allowing the above described possibility for movement can thus be located in the transfer rod or in the side wall of

the through hole 8 and the practical applications presented hereinabove can be used in both cases.

5 The movements of the diaphragm and the region of engagement with respect to each other can be arranged at the region of engagement by fixing the elastic gasket onto the diaphragm itself, e.g. to surround the edge of the diaphragm, and the region of engagement is provided with a recess of sufficient depth allowing the movement of the gasket and the
10 diaphragm attached thereto relative to the region of engagement. The gasket can be attached to the diaphragm in many ways such as by vulcanizing, gluing, etc.

15 The through hole construction described hereinabove has various important advantages compared with the constructions belonging to the state of art. Compared with a rubber seal surrounding the transfer rod, the elasticity of the diaphragm remains always the same, e.g. hysteresis is infinitesimal and there is no
20 temperature-dependency. Due to the clearance always present in the bearings, the transfer rod shows a certain degree of translation and rotation causing lateral forces between the transfer rod and the sealing member covering the through hole. As the
25 diaphragm is able to move together with the transfer rod in the hole or, analogously, as the transfer rod is able to move relative to the diaphragm, such forces causing inaccuracies in the measurement are avoided. The through hole according to the invention
30 has also excellent properties of flexibility when subjected to peak load forces.

The diaphragm and the seals lying against it can easily be installed to their places in the through hole between a ring-like member 13' forming the smaller diameter end in the bushing 13 of the shape of a frustum of a cone and between the body 13" forming the actual main portion of the bushing. The ring member 13' can be rotated to its place by means of threads provided in the body 13" and the member 13'. These two elements are dimensioned so that, when joined together, the recess 15 for the outer edge of the diaphragm and the seals remains therebetween. When it is desirable to arrange the seals in connection with the transfer rod, the installation can be carried out in an analogous way, in which case the transfer rod is constituted of two portions joined together by means of threads at the height of the through hole and these portions are shaped at the joining region in such a way, that the recess for the seals and the diaphragm remains at the joining point. Due to the construction of the through hole the diaphragm will be free of tensions, which normally exist in the diaphragm during the installation and which could cause errors in the measurement results.

The cross-section of the recess 15 at the point of fixation of the diaphragm 14 can be dimensioned and shaped in various alternative ways. The most important functional feature is the good sealing effect and the possibility of the relative movement between the diaphragm and the region of engagement in the direction of the main plane of the diaphragm. The cross-section of the recess can have e.g. a shape of a semicircle. The seals are retained by the suitably shaped walls of the recess, but it is also possible to secure the seals e.g. by gluing.

The diaphragm shown in the figures is corrugated into a wave-like configuration at its portions overlapping the free passage area of the hole. The convolutions extend parallelly with the cocentric circles, whose common mid-point coincides with the longitudinal axis of the transfer rod. These convolutions have been formed in order to minimize the resistance to tilting of the transfer rod, and the most advantageous effect is obtained when the convolutions follow the configuration of a sine-wave. However, in some ranges of measurement, even a planar diaphragm can be used.

Fig. 6 shows the through hole construction as a sectional view, the section being taken perpendicularly to the longitudinal axis of the transfer rod 7 at the height of the through hole 8, seen in the direction of arrow B in fig. 3. Due to slight inaccuracies in the manufacture, the mid-point 7' of the transfer rod 7 can be shifted laterally relative to the axis 10' of the bearings. This distance is denoted by letter e_1 in fig. 6. For eliminating this, the cone-like bushing 13 can be arranged to be movable with respect to the axis 10' of bearings. Due to the construction of the through hole, the position of the hole area covered by the diaphragm 14 can be easily adjusted with respect to the axis 10'. This is done by moving the cone-like bushing 13 with respect to the axis 10'. The hole area covered by the diaphragm can thus be adjusted to lie in the position, where the changes of the static pressure of the process substance do not cause errors in the measurement results. This adjustment is shown schematically also in fig. 4 by arrow D. This possibility of adjustment is realized in practice most suitably so, that the cone-like bushing 13 and

the recesses for the gaskets are located excentrically of the axis 10' (distance e_2 in fig. 6), in which case the adjustment can be done by rotating the cone-like bushing 13, which for this purpose is arranged to a rotatable connection with the body of the measuring device at its larger diameter end.

It will be understood, that the invention is not described above in order to refer only to one preferred embodiment thereof, but it can be modified within the scope represented by the accompanying claims, wherein the inventive idea is disclosed. All materials having the suitable properties required by the practical application and the process substance can be applied as a manufacture material of the seals and the diaphragms. The choice can be done from materials in common use in the instrumentation using the knowledge of a man skilled in the art and taking into consideration the circumstances, where they are to be applied. At the side of the process substance, the gasket must be of a chemically resistant material, such as a chemically resistant rubber, PTFE or metal. The diaphragm must be made of elastic material and for this purpose diaphragms made of acid and corrossion resistant metal, such as titanium, are applicable. Also chemically resistant plastic diaphragms can be used and these materials are well known in process instrumentation.

The invention can be applied in the transmitter measuring the consistency, i.e. the percentage of fibres in the water, of paper stock and similar pulp mixtures. The transmitter uses the above described measuring principle and is manufactured by the

applicant under the trade name PULP-EL. The application range of the invention is, however, not restricted to only measuring devices measuring the consistency of the process substance, but it can be also applied in all measuring devices, in which the force and/or the movement is transferred from the process substance to a portion of the measuring device located outside the process substance. As an example of these kinds of devices can be mentioned different liquid level detectors. The invention is especially suitable for those measurements, wherein a high accuracy is needed and all factors causing errors must be eliminated or at least minimized.

Claims:

1. Through hole construction for a measuring device (2), which comprises a sensing element (4) communicating with the process substance (3), and a device portion (5) outside the process substance, said portion being bounded by the boundary surface of the process substance, the device further comprising a lever-like transfer element (7) connected with the sensing element (4) and led from the process substance to the portion (5) outside the process substance via a through hole (8) located at the boundary surface of the process substance, the transfer element being supported by the rest of the measuring device by fixing means, such as by means of bearings (10), and arranged to transfer the force acting on the sensing element due to the process substance to be measured and/or to transfer the movement of the sensing element effected by the process substance to a measuring element (6) in the portion outside the process substance using the torque applied by the sensing element (4) to the transfer element (7) about the fulcrum defined by the said fixing means, the through hole (8) having a sealing member for separating the portion outside the process substance from the process substance, characterized in that the sealing member is a diaphragm (14) of elastic material being in engagement with the transfer element (7) and covering the through hole in a position substantially perpendicular to the longitudinal axis of the transfer element, the first region of engagement with the measuring device being the side region of the through hole at the outer periphery of the diaphragm and the second region of engagement with the measuring device being the

transfer element located at the central portion of the diaphragm, at least one of the said regions of engagement allowing the diaphragm and the region of engagement to move relative to each other substantially in the direction of the main plane of the diaphragm in order to eliminate the forces causing measurement inaccuracy, such as the tension forces applied to the diaphragm by the translation and rotation of the transfer element relative to the through hole.

2. Through hole construction as claimed in claim 1, characterized in that the diaphragm is rigidly attached at its central portion to the transfer element (7) and mounted movably at its outer periphery to the side region of the through hole (8) in order to allow the free movement of the diaphragm relative to the through hole in the main plane of the diaphragm during the translation and rotation of the transfer member.

3. Through hole construction as claimed in claim 1, characterized in that the diaphragm (14) is rigidly attached at its outer periphery to the side region of the through hole (8) and mounted at its central portion to the transfer member (7) in such a way, that the transfer member can move freely relative to the diaphragm in the direction of the main plane of the diaphragm during the translation and rotation of the transfer member.

4. Through hole construction as claimed in claim 1, characterized in that for allowing the relative movement in the region of engagement, the diaphragm (14) is mounted into connection with an elastic gasket (16) in the region of engagement.

5. Through hole construction as claimed in claim 4, characterized in that the elastic gasket (16) is fixed on the diaphragm (14) and the gasket and the region of engagement are arranged to move relative to each other.

6. Through hole construction as claimed in claim 4, characterized in that the diaphragm (14) is mounted to lie against a separate elastic gasket (16) located in the region of engagement.

7. Through hole construction as claimed in claim 6, characterized in that the elastic gasket (16) lies against the surface of the diaphragm (14) on the side thereof facing the portion (5) outside the process substance, whereas, lying against the surface of the diaphragm facing the process substance (3), there is a non-elastic gasket, such as a gasket made of polytetrafluorethylene or metal.

8. Through hole construction as claimed in claim 6, characterized in that the elastic gasket (16) lies against the surface of the diaphragm (14) facing the process substance (3) and lying against the surface of the diaphragm facing the portion (5) outside the process substance, there is a non-elastic gasket, such as a gasket made of polytetrafluorethylene or metal.

9. Through hole construction as claimed in claim 6, characterized in that the diaphragm (14) is mounted between two elastic gaskets (16) disposed in the region of engagement.

10. Through hole construction as claimed in claim 9,
c h a r a c t e r i z e d in that the gaskets
(16) are constituted of O-rings mounted into the
recess (15) along the side wall of the through hole
5 (8) and arranged to be pressed against the surfaces
of the diaphragm (14) at the opposite sides thereof
due to the pressure caused by the walls (15') of the
recess.

11. Through hole construction as claimed in claim 1,
10 c h a r a c t e r i z e d in that the diaphragm
is a planar metal diaphragm.

12. Through hole construction as claimed in claim 1,
c h a r a c t e r i z e d in that the diaphragm
is a corrugated metal diaphragm, which is corrugated
15 to have a wavelike cross-section, preferably of a
sine-wave type, the convolutions of the wavelike
configuration being parallel to the cocentric
circles, whose mid-point coincides with the
longitudinal axis of the transfer element.

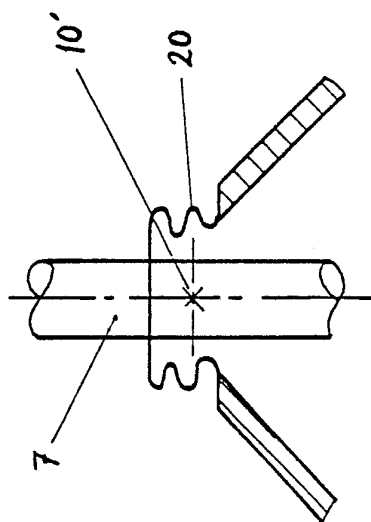


Fig. 2

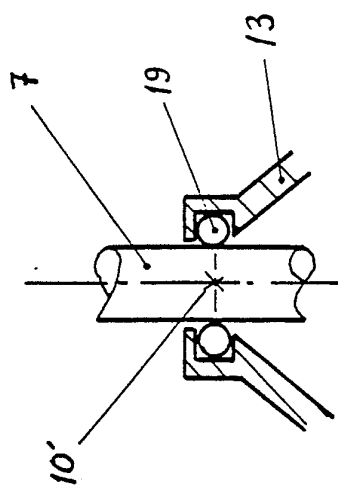
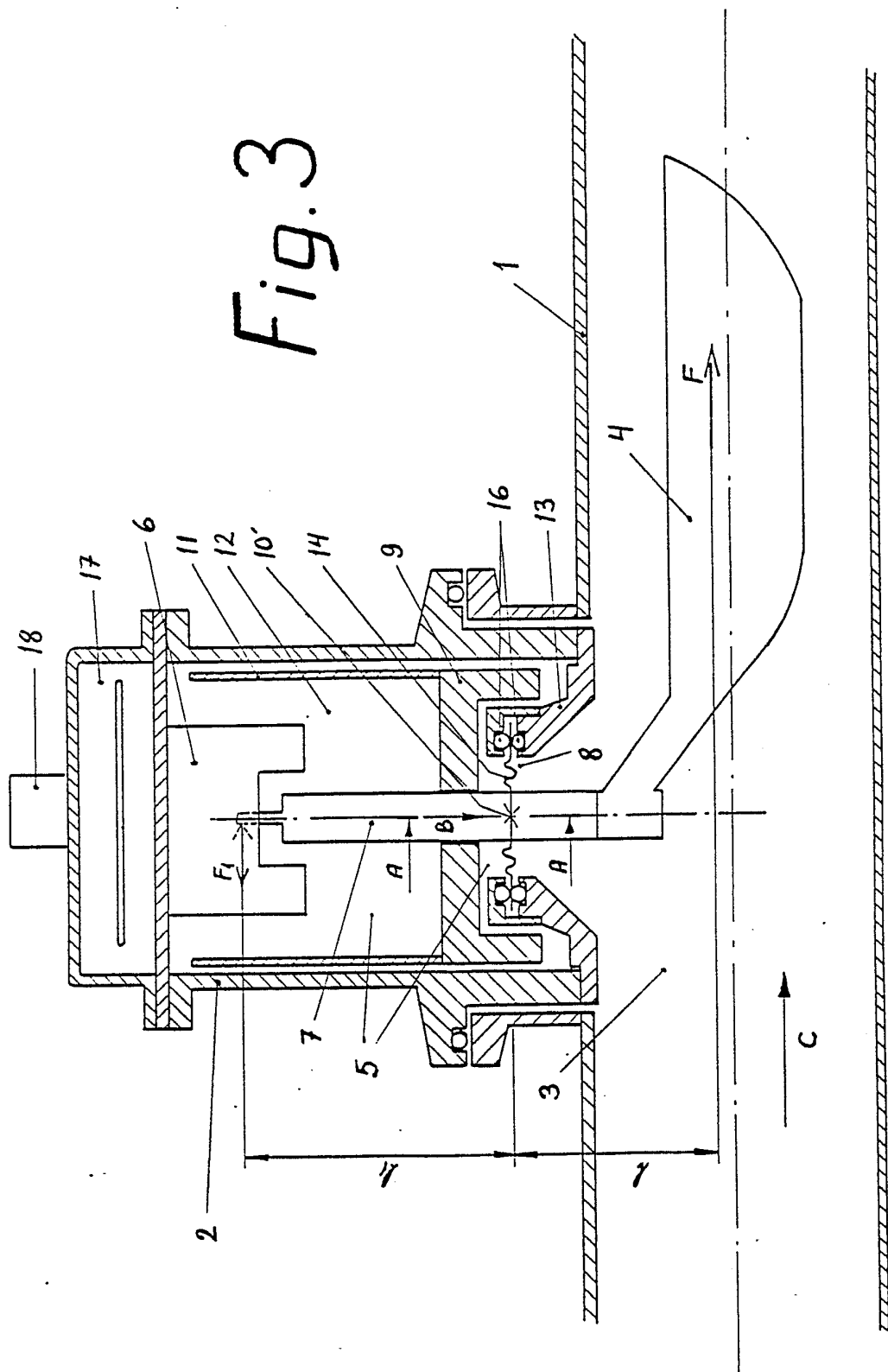


Fig. 1

Fig. 3



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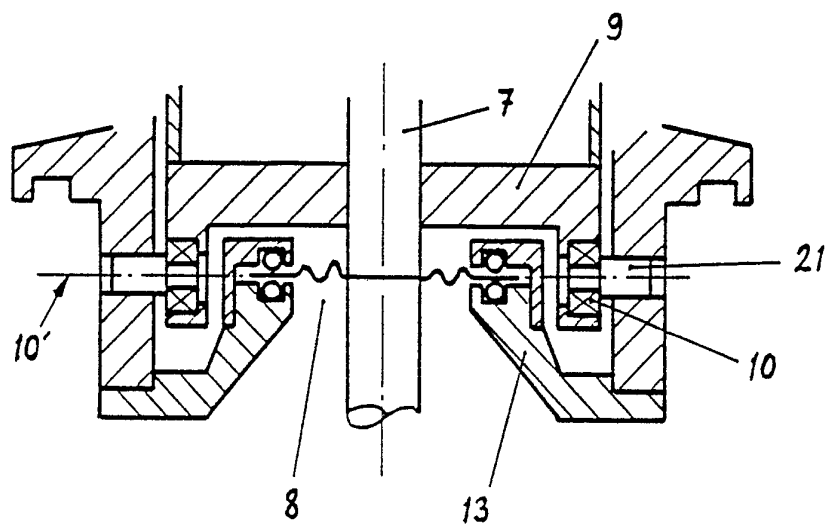


Fig. 5

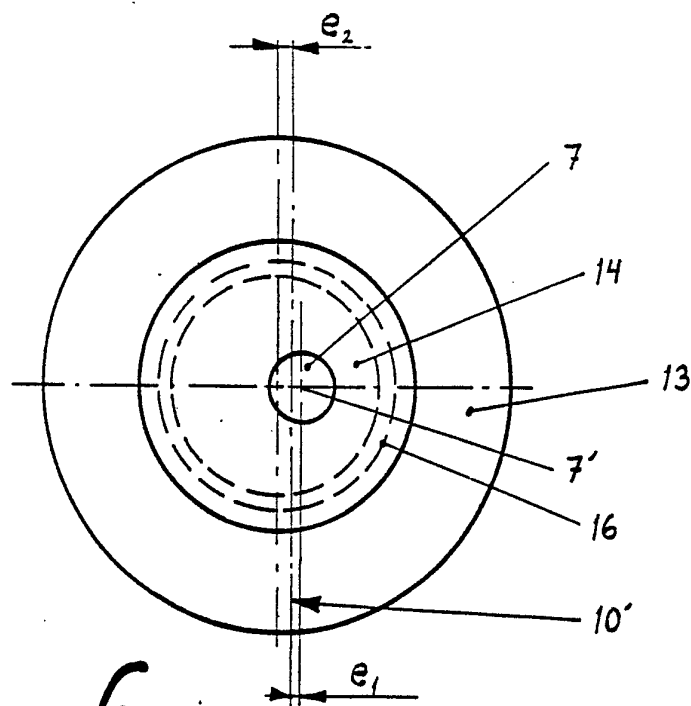


Fig. 6

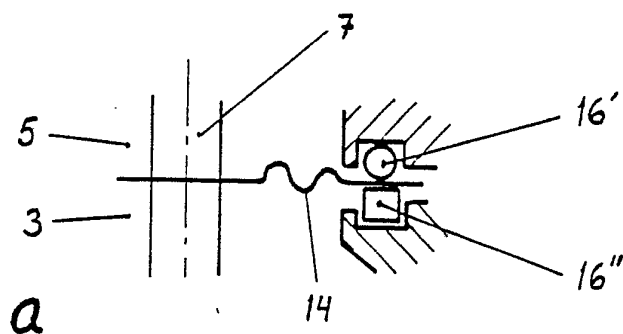
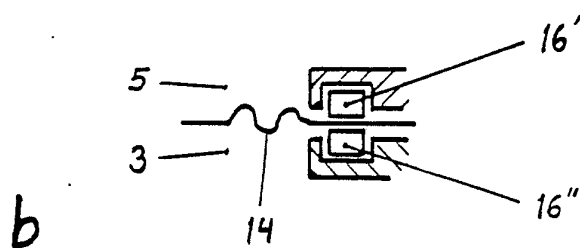


Fig. 7

INTERNATIONAL SEARCH REPORT

International Application No PCT/FI87/00036

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC ⁴		
G 01 F 1/30, G 01 D 5/06		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC 4 US C1	G 01 F 1/28, /30; G 01 D 5/02-/10; F 16 J 15/50, /52 73: 228, 861.71-76	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
SE, NO, DK, FI classes as above		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ^a	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	DE, A1, 3 309 552 (ECKART AG) 20 September 1984	1-12
X	US, A, 4 291 583 (J W BUIKE) 29 September 1981 & EP, 0026715 JP, 56051616 CA, 1136879	1-12
Y	US, A, 2 826 914 (J L REILEY) 18 March 1958	1
Y	US, A, 2 742 784 (J C BROUS) 24 April 1956	1
Y	US, A, 4 229 010 (W H St LAURENT Jr) 21 October 1980 especially figure 2	1
Y	US, A, 4 522 414 (H SHULTE) 11 June 1985 especially figure 1 & DE, 3333163	.../...
<p>^a Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
1987-04-27		1987-05-22
International Searching Authority		Signature of Authorized Officer
Swedish Patent Office		<i>Sven-Olof Wirleé</i> Sven-Olof Wirleé

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	US, A, 3 424 011 (W G POINTIS) 28 January 1969	
A	DE, A1, 3 204 817 (SAMSON AG) 18 August 1983	