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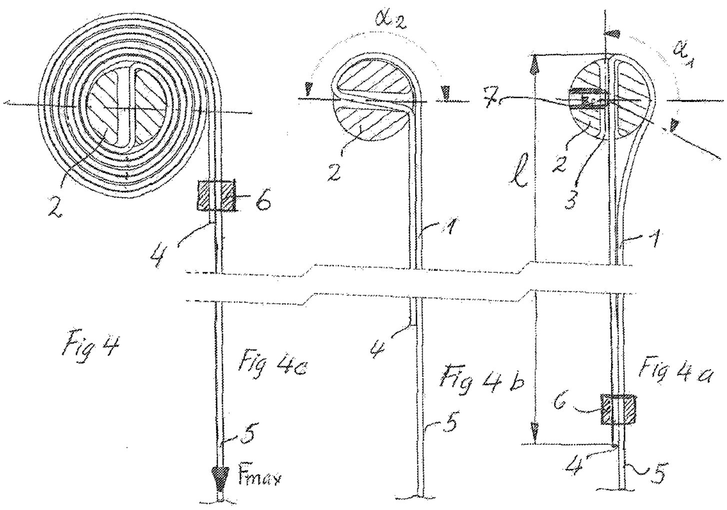
(54) **Title**: PROCEDURE AND DEVICE FOR FASTENING A SUSPENSION BELT OF AN ELEVATOR TO A FIXED POINT



(57) **Abstract**: Method of anchorage of a suspension belt (1) of an elevator to a fixed point, wherein said suspension belt (1) is wound on itself around a single cylindrical axle (2) forming a number of turns and an overall winding angle (α) sufficient for ensuring that the maximum working tension (Fmax) of the belt (1) is lower than a slipping tension necessary for making the first turn of said belt to slip over said cylindrical axle (2).

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PROCEDURE AND DEVICE FOR FASTENING A SUSPENSION BELT OF AN ELEVATOR TO A FIXED POINT

Field of the invention

The present invention relates to a method and device for fastening a belt of an elevator to a fixed point.

Prior art

The use of suspension belts in place of steel cables is widespread in the field of elevators. A suspension belt for an elevator essentially comprises core members suitable to withstand the traction and incorporated in a plastic body. Said core members are for example formed by a plurality of steel cords or textiles cords. Said belts are advantageous because, for a given load capacity, they run on pulleys of a smaller diameter compared to conventional steel cables; they are less noisy, they reduce vibrations, etc.

A suspension belt of an elevator cabin is wound around a series of pulleys; the ends of the belt have to be anchored to fixed points.

To make the anchorage to a fixed point, the background art generally relies on either the solution shown in Fig. 1 or in Fig. 2. A first solution, known for example from US 7,647,675, is schematised in Fig. 1. The belt is passed over two winding members, in practice two cylinders. On the first cylinder the belt is doubled; on the second cylinder the belt is single. A notable disadvantage of this solution is that the two superimposed loops of the belt are stressed in an opposite direction, causing friction between the loops and wear of the belt.

A second known solution is described for example in WO 2006/029544 and is schematised in Fig. 2. The load-bearing belt of an elevator is held by means of a wedge stucked in a wedge-shaped pocket. At least one of the internal surfaces of said wedge-shaped pocket has a roughness greater than that of the remaining surfaces of the pocket. This solution therefore works according to the wedging principle.

Both these solutions have disadvantages. A first disadvantage comes from requiring a relatively large room in height. The overall height dimension, indicated in Figs. 1-2 with the dimension " *l* ", represents unusable space which reduces the travel of the cabin of the elevator. Another disadvantage is that the methods of the prior art create points or zones wherein the belt is pressed, which deteriorates the belt and reduces its durability or even increases the danger of failure. Other drawbacks are the high difficulty of assembly and maintenance of the belt.

Summary of the invention

The object of the invention is to eliminate the previously mentioned disadvantages.

The object is achieved with a method for anchorage of a suspension belt of an elevator to a fixed point, characterised in that: said suspension belt is wound on itself around a single cylindrical axle forming a number of turns and an overall winding angle sufficient for ensuring that the slipping tension necessary for making the first turn of said belt slip on said cylindrical axle is at least greater than the maximum working tension of the belt, said slipping tension being determined substantially by the friction between the first turn of the belt and the cylindrical axle, and by the friction between the turns of the belt wound in superimposition one over the other.

It must be noted that the compression on the subsequent turns, wound one over the other, increases the friction coefficient between the turns. This condition contributes to fulfilment of the condition stated above, i.e. that the maximum working tension is lower than the tension named as slipping tension, i.e. lower than the tension which may cause the slipping of the first turn on said cylindrical axle.

The term maximum tension refers to at least the maximum tension that may be applied to the belt during use. The slipping tension defined above is preferably equal at least to 80% of the rupture strength of the belt, or higher; more preferably the slipping tension is greater than said rupture strength. Consequently the belt is actually prevented from slipping since the failure of the belt would occur before a slipping of the first turn in relation to the cylindrical axle.

According to one of the embodiments of the invention, a start end of the belt is fastened to said cylindrical axle, and preferably the fastening of said end is made with unloaded belt. Said axle is then rotated to wind the appropriate number of turns.

According to another preferred embodiment, the belt is wound on itself and around the cylindrical axle after a start portion of the belt has been doubled with the driving part of the belt, so that the angle of winding is doubled. The start end of the belt which remains free after the winding around said axle is preferably fastened with a clamp to the driving part of the belt. In this way the belt is doubled along a predetermined section which substantially extends from the anchorage axle to the clamp.

The method of anchorage according to the invention is usable preferably, but not exclusively, for an elevator without counterweight. One aspect of the invention consists of the use of the above described procedure for the anchorage of fixed points of the suspension belts or belt of an elevator without counterweight.

Another aspect of the invention is a device for implementing the procedure of anchorage described above. Said device preferably comprises at least one cylindrical axle which comprises at least one aperture perpendicular to the cylindrical axle, open on one side, wherein the start of the belt can be inserted. Said aperture is preferably a passing through aperture. Said aperture is for example a slot. The transverse aperture or slot is preferably provided with auxiliary fastening means, such as for example dowels, pins or the like, suitable for blocking the start of the belt in the same aperture.

The device may comprise at least one clamp for doubling the belt on itself, fastening a start end of the belt to the driving part of the belt. In a preferred embodiment the cylindrical axle is manually or mechanically rotatable to wind on the same axle the desired number of single or double belt turns, which is required to prevent slipping.

The winding angle, depending on the number of turns wound on the cylindrical axle, reaches considerably high values. Consequently the resistance of the anchorage is guaranteed. Moreover the belt is not stressed or worn, contrary to what occurs in anchorage systems of the prior art. The belt in fact is not pressed against hard surfaces, as in the wedging systems, being only wound on itself. Moreover a substantial advantage of the invention consists in the reduced overall height dimension. Another advantage comes from the simple construction.

The invention is now described in greater detail with the aid of the accompanying drawings, which correspond to some preferred embodiments.

Description of the drawings

Figs. 1 and 2 illustrate the state of the art;

Fig. 3 illustrates a fastening sequence of a belt according to a first embodiment of the invention;

Fig. 4 illustrates a fastening sequence of a belt in accordance with a second embodiment of the invention;

Fig. 5 is a perspective view of an anchorage device according to an embodiment of the invention.

Detailed description of embodiments of the invention

Figs. 3 and 4 illustrate two examples of embodiments with single turns and double turns respectively. The drawings illustrate the following details:

1. Suspension belt
2. Cylindrical axle
3. Transverse aperture
4. Start of the belt 1
5. Driving part of the belt 1
6. Clamp
7. Dowel or pin or other auxiliary fastening member.

The sequence of Fig. 3a represents the first phase of the method for anchorage of a belt 1 to a cylindrical axle 2, according to one embodiment. The start end 4 of the belt 1 is inserted in a slot 3 of the cylindrical axle 2. The start 4 of the belt can be optionally fastened to said cylindrical axle 2, although this fastening is not necessary. In fact the anchorage between belt 1 and cylindrical axle 2 is given substantially by the friction between the belt and the axle, i.e. by the winding angle of the belt around the axle.

The belt 1 is wound around the cylindrical axle 2 first with an angle $\alpha 1$ of approximately 120° (Fig. 3a). The overall winding angle α can reach quite high values according to the number of turns that are wound around the cylindrical axle 2. In Fig. 3b the winding angle is approximately 180°, whereas in Fig. 3c the overall winding angle α reaches 1350°, equal to 3 and ¾ turns wound around the axle 2.

The tensions of the belt at either ends of the winding around the axle 2, denoted for example by the symbols F_1 and F_2, are bound by the known exponential formula:

$$\frac{F_2}{F_1} = e^{\mu\alpha}$$

wherein μ is the friction coefficient and α is the winding angle in radians.

The invention provides that the winding angle α is large enough to ensure that the slipping tension is higher than the maximum tension Fmax that can be applied to the belt 1. Said slipping tension is defined as the tension which is necessary for making the first turn of the belt 1 to slip on the cylindrical axis 2. The slipping of the belt 1 is prevented by the friction between the first turns of the belt 1 and the cylindrical axle 2 as well as by the friction between the further turns of the belt 1. For example, in Fig. 3a there are three turns which cover the first turn of the belt 1. The slipping tension is also increased by the compression between superimposed turns, which increases the friction coefficient between the same turns.

In other words, the number of turns of belt 1 wound on the cylindrical axle is at least sufficient to guarantee that the winding of belt 1 cannot slip on the cylindrical axle 2 even when it is stressed with the maximum load, even if the start end 4 of the belt 1 is not directly fastened to the cylindrical axle 2.

Preferably the number of turns (or winding angle) is such that the tension necessary for making the first turn slip on the cylindrical axle 2 is higher than the tensile strength of the belt 1. In this case the number of turns of belt 1 wound on the cylindrical axle 2 is such as to exclude any possibility of slipping of the belt 1 on the axle 2. It is therefore, according to this definition, a pure safety prescription.

According to another preferred embodiment the method comprises the steps of: fastening the start end 4 of the belt 1 to the cylindrical axle 2; rotating said cylindrical axle 2 to wind on the same axle the required number of turns. The belt 1 is attached to the cylindrical axle 2 in the unstressed state, so that said fastening is only an auxiliary fastening to facilitate the work of assembly. The fastening of the belt start 4 to the axle 2 does not have to withstand the tension on the belt in the lifting phase, said fastening being performed only in order to facilitate the initial winding of the turns. The actual anchorage comes from the friction of the turns of the belt 1 under tension.

Fig. 4 shows a further embodiment. In this variant the belt 1 is wound around the cylindrical axle 2 after the start 4 of the belt 1 has been doubled (Figs. 4a and 4b) with the driving part 5 of the belt 1, i.e. with the section of belt to which the load is suspended. The arrow Fmax in Fig. 4c denotes the tension applied to the belt 1 in the driving part 5.

The initial part of the belt 1, terminating with the start end 4, is passed over the cylindrical axle 2, for example through the transverse aperture or slot 3, for a section *l* as indicated by the quote of Fig. 4a. Then the cylindrical axle 2 is rotated without load so as to form a series of double turns on the cylindrical axle 2 (Figs. 4b, 4c). The number of said double turns is sufficient to ensure the condition of non-slipping. Preferably the start 4 of the belt is secured with a clamp 6 to the driving part 5 of the belt 1, or secured to a separate clamp. The described fastening of the belt start 4 may be required by safety standards. The condition of non-slipping is ensured in any case by the number of turns which are wound around the axle 2.

The number of single turns (Fig. 3) or double turns (Fig. 4) may depend on many factors, including: friction between belt 1 and surface of the cylindrical axle 2, friction of the belt on itself, effect of compression between the superimposed turns, material of the belt, etc. Accordingly, the number of turns can be determined experimentally by a person skilled in the art. The roughness of the belt 1 or the presence of grooves on its surface may play a decisive role. Experience has shown that a number of three turns is normally sufficient in order to obtain the result required.

According to a particularly preferred embodiment, the cylindrical axle 2 has an auxiliary fastening device which serves for the formation of the turns. For this purpose the transverse aperture 3 can have (as shown in Fig. 4a) a further fastening member 7 such as dowels, pins or the like, which fasten the start 4 of the belt in the aperture 3. This technique facilitates the assembly of the belt 1. The cylindrical axle 2 can be rotated preferably by hand via a special handle, but alternatively can be rotated mechanically. The turns are wound without tension, i.e. before appending the load on the belt.

The embodiment of Fig. 4 may be preferred as the start end 4 of the belt remains visible and can be inspected from outside. This feature may be required for compliance with safety standards.

Finally, Fig. 5 shows in a perspective view the solution of Fig. 4 as may be realized in practice for the actuation of an elevator. The clamp 6 is shown, formed by two metal plates which tighten the start of belt 4 against the driving part 5.

The advantage of the invention, as already mentioned, is essentially the reduction of the space in height taken by the anchorage of the belt 1, as can be noted by comparing Figs. 1 and 2 with Figs. 3 – 5. Moreover the invention eliminates the risk of damaging of the belt 1 as a consequence of crushing against hard surfaces, because the belt is only wound on itself in turns.

CLAIMS

1. Method for anchorage of a suspension belt (1) of an elevator to a fixed point, characterised in that: said suspension belt (1) is wound on itself around a single cylindrical axle (2) forming a number of turns and an overall winding angle (α) sufficient for ensuring that the slipping tension necessary for making the first turn of said belt to slip on said cylindrical axle (2) is greater at least than the maximum working tension (Fmax) of the belt (1), said slipping tension being determined substantially by the friction between the first turn of the belt and the cylindrical axle, and by the friction between the turns of the belt wound in superimposition one over the other.

2. Method according to claim 1, wherein said slipping tension is at least 80% of the rupture strength of the belt and is preferably greater than the rupture strength of the belt.

3. Method according to claim 1, wherein: a start end (4) of said belt (1) is attached to the cylindrical axle (2) while the belt is not tensioned; said cylindrical axle (2) is rotated to wind the belt (1) on said axle (2) forming said number of turns.

4. Method according to claim 1, wherein a start end (4) of the belt (1) is doubled with a driving part (5) of the belt; the belt (1) doubled in this way is wound on itself around the cylindrical axle (2), so that the winding angle is doubled.

5. Method according to claim 4, characterised in that said start end (4) of the belt (1) is fastened with a clamp (6) to the driving part (5) of the belt.

6. Method according to any one of the previous claims, said elevator being an elevator without counterweight.

7. Device for performing the anchorage of a suspension belt (1) of an elevator to a fixed point, with the method of any one of the previous claims, said device comprising at least: a cylindrical axle (2) for anchorage of said belt (1), said axle comprising an aperture (3) perpendicular to the axial direction of said cylindrical axle (2) and open on one side, where a start end (4) of the belt (1) can be inserted.

8. Device according to claim 7, said aperture (3) being provided with auxiliary fastening members (7), such as dowels, pins or the like, suitable for blocking said start end (4) of the belt (1) in said aperture (3) of the cylindrical axle (2).

9. Device according to claim 7 or 8, comprising a clamp (6) for fastening of said end (4) of the belt, after passing through said aperture, to a driving belt part (5) with consequent doubling of a predetermined portion of the belt.

10. Device according to any one of claims 7 to 9, said axle (2) being manually or mechanically rotatable to wind the belt (1) around the axle.

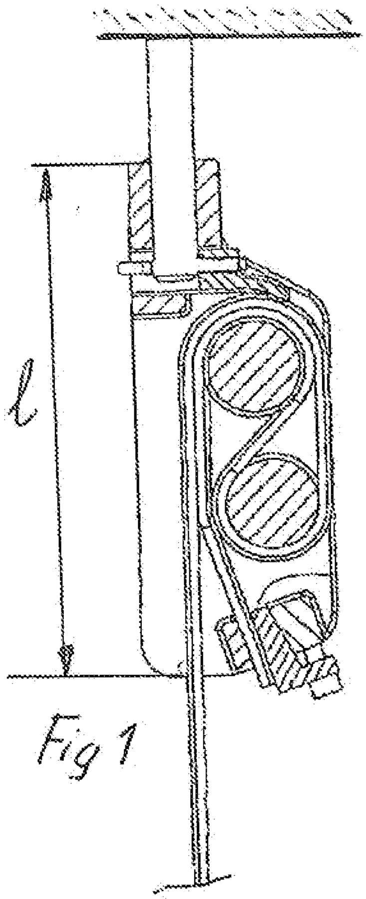

Fig 1

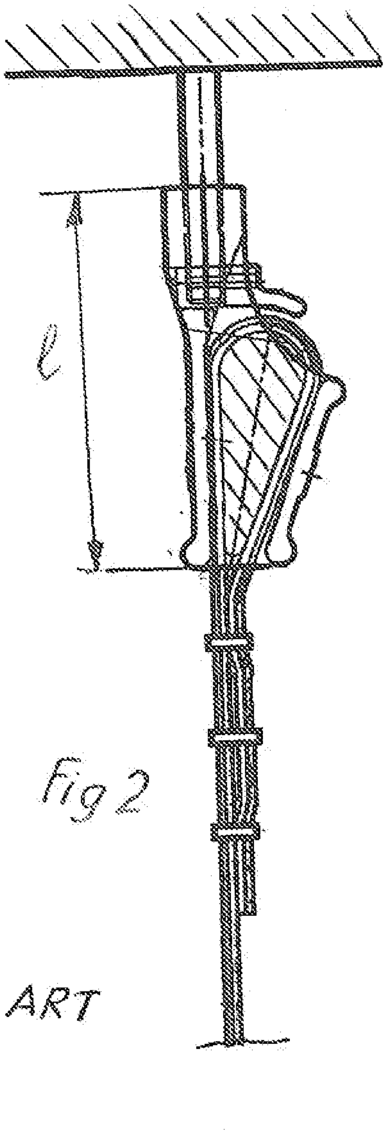

Fig 2

PRIOR ART

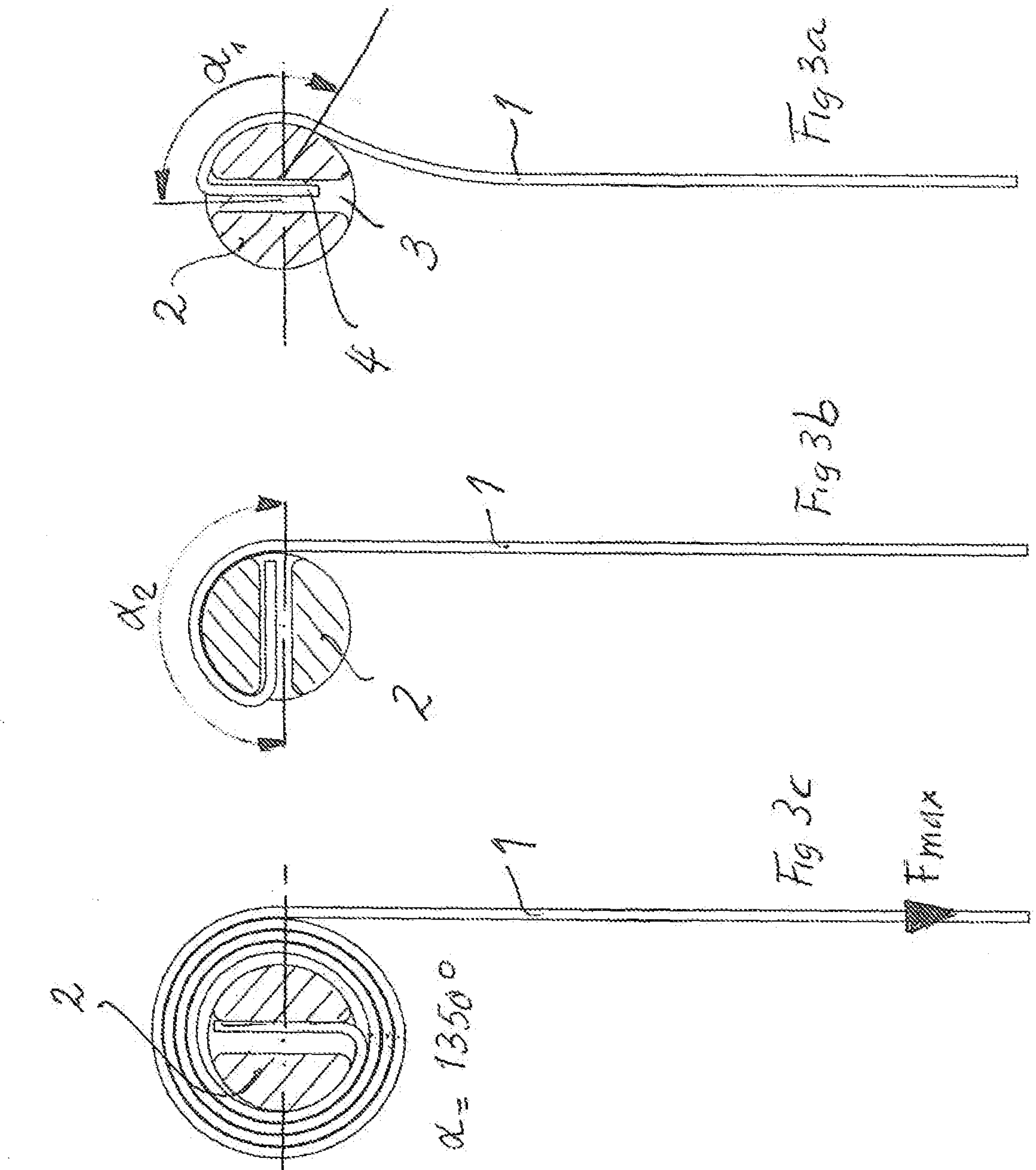

Fig 3

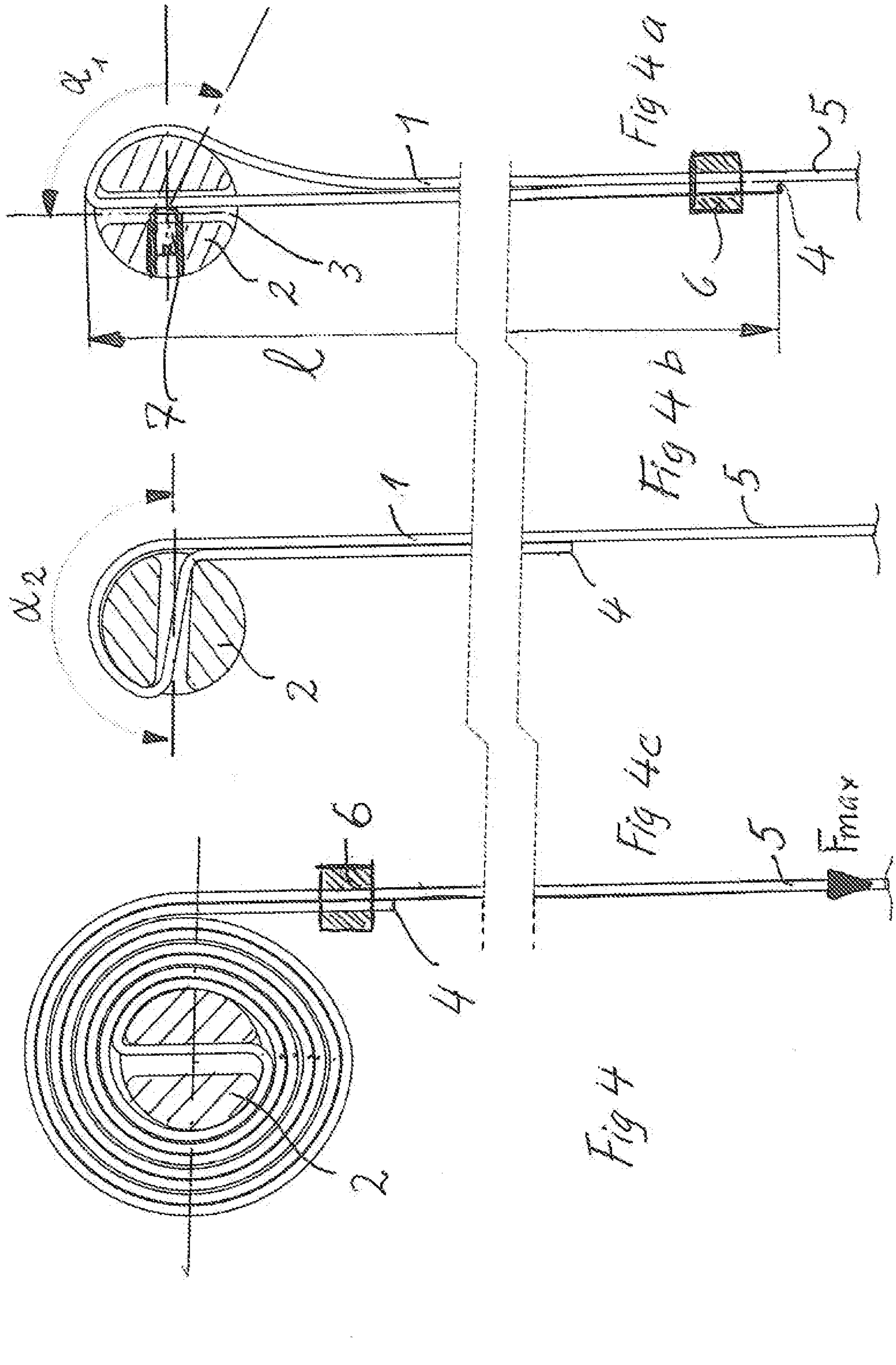

Fig 4a

Fig 4b

Fig 4c

Fig 4

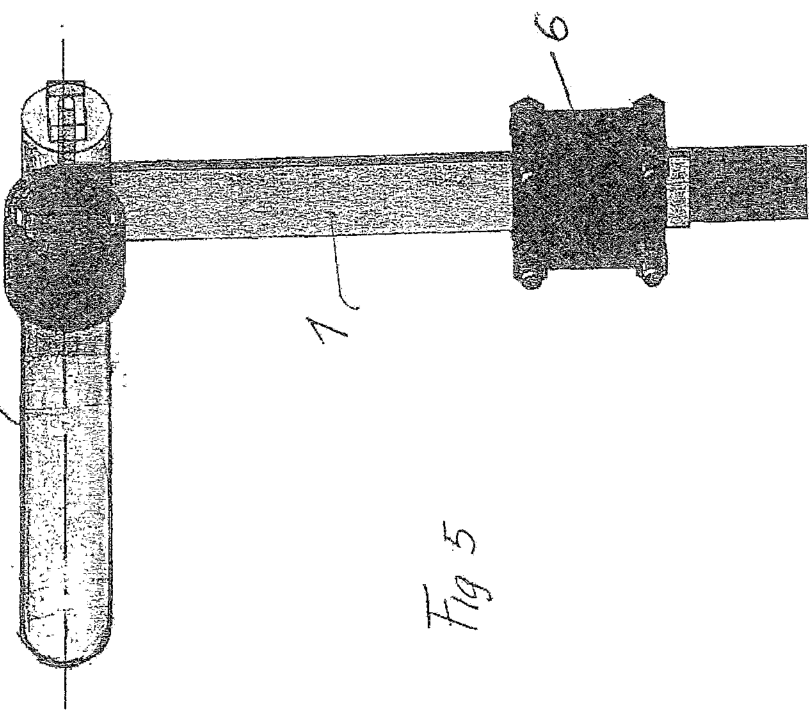

Fig 5