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(54) Pantograph suction arm with variable fastening of the balancing springs

(57) A pantograph suction (110) arm is described, said arm comprising a first tube section (111) connected to a base (117), a second tube section (112) connected to a frame in the form of a hinged quadrilateral (118) on the base side, and a first elongated resilient balancing element (122) cooperating with said hinged quadrilateral frame (118) on the base side, one end (122a) of said elongated resilient balancing element (122) being pivotably mounted on said hinged parallelogram frame (118) on the base side, the other end (122b) of said resilient element (122) being pivotably mounted at a point (130) movable depending on the position of said hinged parallelogram (118).

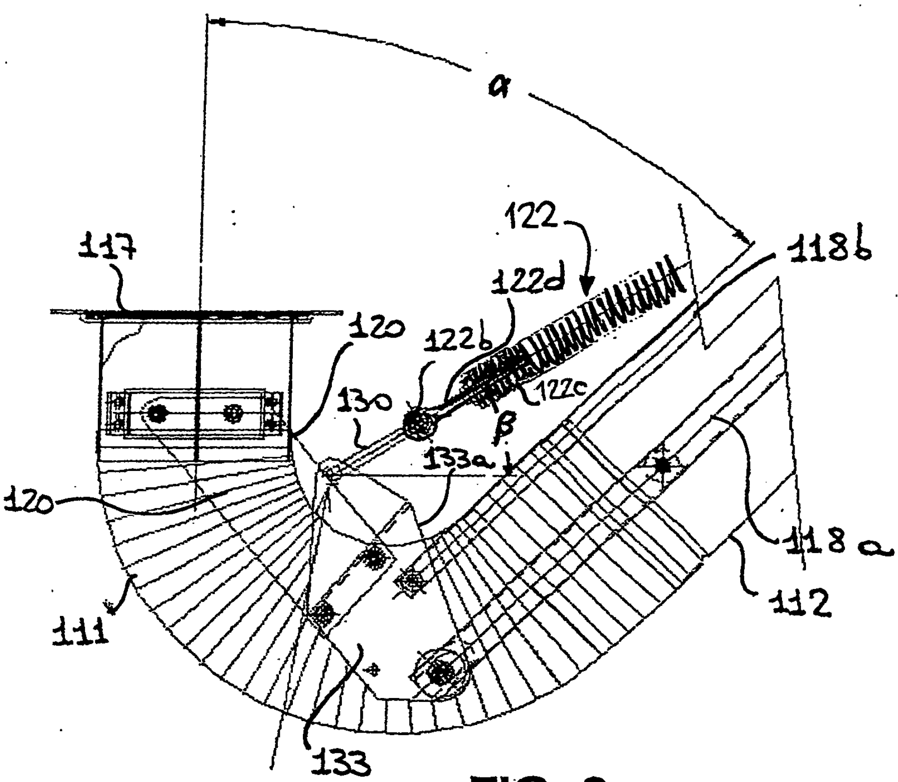

FIG. 2

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Description

[0001] The present invention relates to the suction technology sector and in particular relates to a pantograph suction arm.

[0002] Suction arms for extraction of fumes, odours, vapours, gases, dust, haze and any other air pollutant produced in various working environments are known. Generally, a known suction arm comprises a tube having one end connected to a fan-type suction system situated locally or centrally and another end connected to a suitably shaped hood. Usually, the end connected to the suction system is fixed to a base which is stationary, rotatable and projecting. In other configurations, the rotatable end, connected to the suction system, is fixed to a carriage or the like.

[0003] In particular, pantograph suction arms are known where the tube is constrained and guided by a pantograph or hinged parallelogram structure. A pantograph suction arm of the known type is described, for example, in the patent EP 0,204,662 B2 in the name of the present Applicant. The patent EP 0,204,662 B2 is considered to be the closest prior art.

[0004] The suction arm described in EP 0,204,662 B2 comprises two rigid suction tubes and three flexible duct sections. The first flexible duct connects the suction system and the outlet end of the first rigid tube. The second flexible duct connects the inlet end of the first rigid suction tube and the outlet end of the second rigid suction tube. The third flexible duct connects the inlet end of the second rigid suction tube and the hood. In this way a continuous discharge passage is formed between the hood and the suction system.

[0005] The expression "suction arm" is understood as including also the structural support means consisting of rods (bars and tie-rods) and also two rigid tubes able to form together articulated systems for movement of the said arm; in particular a conventional system is defined as being a (single, double or quadruple) pantograph system formed with bars and tie-rods in the hinged parallelogram configuration. Each rigid tube is therefore integral with one of the structural elements of the hinged quadrilateral: generally two bars are in fact rigidly and symmetrically connected to the rigid tube along two opposite directrices of its surface.

[0006] A pair of plates with four articulated joints is provided as the element for connecting each pair of adjacent articulated structures: in other words, the articulated support structures of the two rigid tubes are connected by means of plates with special articulation points. The plates with four articulated joints, generally, have a trapezoidal shape and their lower base is directed downwards. The bases of said trapezia may have variable lengths according to the different configurations of the arms.

[0007] A pair of balancing springs is associated with each rigid tube: the springs associated with the first tube are constrained at their top end to points of the base structure, while at their bottom end they are connected to points of the hinged parallelogram associated with the first tube; the springs associated with the second tube are generally connected at their top ends to points of the abovementioned plates with four articulated joints, while at their bottom ends they are connected to points of the articulated structure associated with the second tube. It is also possible to have configurations with a double pair of springs associated with a rigid tube.

[0008] In the suction arm according to EP 0,204,662 B2 the extension springs (or balancing springs) are fastened at predetermined fastening points. Considering for example a base side parallelogram of a projecting suction arm, a (top) end of the spring is fixed to the said base, either directly or by means of a bracket; the other end is fixed to an element with a variable trajectory depending on the position of the hinged parallelogram to which it is connected. In an initial configuration where the base side parallelogram is raised (i.e. is closer to the vertical), the springs of the parallelogram on the base side extend with the downwards rotation of the parallelogram to which they are connected. They therefore oppose a moment M, due to the action of the masses at play and dependent upon the position of the centre of gravity of the arm. M varies according to the inclination of the hinged parallelogram: in fact, the moment M, depending on the angle formed between the bar and the vertical or depending on the angle formed between the horizontal and the axis of the springs, increases reaching a maximum and then diminishes. Similar considerations are applicable to the springs on the hood side, i. e. associated with the second tube.

[0009] As mentioned above, the moment M varies according to the position of the centre of gravity of the arm, i.e. according to the position of the theoretical point of application of the weight force: therefore, generally it becomes smaller when the two rigid tubes move towards each other (arm closed) and increases with extension of the arm (arm open). Moreover, M increases, all other conditions being equal, with an increase in the weight of the suction hood connected to the end of the second rigid tube by means of the flexible tube and rigid structure.

[0010] The resistive moment M_r offered by the springs also has a trend increasing with a variation in the angle of the quadrilateral, namely the direction of the spring with respect to the horizontal. However, the trend of M_r does not follow the progression of the moment M, continuing to increase when M starts to decrease in value, M depending both on the elastic force of the springs, which increases with elongation thereof, and on the position of their upper fastening point.

[0011] It is possible, moreover, to reach critical positions where the axis of the springs is aligned with the rigid tube (bar) and the springs are fully extended since the lower fastening point with a variable trajectory is in the position furthest from the fixed upper fastening point: around these angular configurations the moment of the elastic force is very high and varies rapidly, making the position reached by the suction arm unstable. These critical positions are typically those where the quadrilateral on the base side is rotated downwards namely those where the second tube is vertical with the hood side at the bottom.

[0012] In order to oppose suitably this moment M, the friction devices mounted at the articulated joints are properly adjusted. In other words, the friction devices are tightened in order to compensate for the difference existing between the moment M and the moment M_r and balance the suction arm in the various positions.

[0013] The Applicant has perceived the need to provide an optimum adjustment of a suction arm upon variation in the weight of the suction hood: the latter may in fact be of a special type (as requested by the user or designed for special applications) and, therefore, involve dimensions and materials which are not envisaged during standard balancing of the suction arm.

[0014] The main object of the present invention is therefore that of providing a pantograph suction arm in which it is possible to calibrate easily the support system upon variation in the characteristics of the capturing element (hood): in other words, the object is that of providing a suction arm where the (upper and lower) fastening points of the springs may be varied so that the action of the said balancing springs may follow more closely, and therefore counteract more effectively, the flexing moment of the weight force.

[0015] A further object of the present invention is that of providing a pantograph suction arm in which the initial tension of the springs may be suitably adjusted and set so as to allow more precise balancing of the suction arm during use of special capturing accessories, in particular hoods with a weight greater than the weight of conventional hoods.

[0016] A further object of the present invention is that of providing a pantograph suction arm with a simplified articulated structure, which may be configured as a hinged quadrilateral at the base side tube (arm) and as a simple articulated forearm (i.e. not a quadrilateral) on the hood side tube: with this initial configuration, the hood side may be subsequently modified with *ad hoc* structural elements, so as to make it also into substantially a hinged quadrilateral.

[0017] These and other objects are achieved by a pantograph suction arm according to Claim 1. Further advantageous features of the present invention are described in the dependent claims. All the claims are considered to be an integral part of the present description.

[0018] According to a first aspect, the present invention relates to a suction arm with an articulated structure, comprising a first tube section connected to a base, a second tube section connected to a frame in the form of a hinged quadrilateral, and elongated resilient balancing elements, both the ends of said elongated resilient balancing elements being connected at fulcrum points with a variable trajectory depending on the position of said hinged parallelogram.

[0019] Said elongated resilient element typically comprises an extension spring, the ends of which are fastened at a point of the hinged quadrilateral (lower end) and at a rotatable rigid element (upper end).

[0020] Said rotatable rigid element is pivotably mounted directly on the said base or on a plate fixed thereto. The position of the fixing point of the rotatable rigid element may be varied by means of suitable devices or arrangements (for example eyelets which are suitably shaped, rotating elements, etc.) in order to obtain optimum adjustment of the action of the elongated resilient element on the suction arm.

[0021] The other end of said rotatable rigid element is able to travel along a trajectory following an arc of a circumference from a first position in line with the axis of the resilient element into a second position inclined with respect to said axis. During its rotation about its point of fastening to the base, the rotatable rigid element encounters an element of the base (or a plate fixed thereto) which is suitably shaped and which stops rotation thereof in a given position. The point of contact between the rotatable rigid element and the structure integral with the base may be varied by means of sliding or rotating elements (adjustable washers, screws, etc.) in order to vary the moment of the acting elastic force.

[0022] The rotatable rigid element, advantageously, is formed as a rigid (C-shaped, omega-shaped or similar) bar passing between the elements of the base. Owing to this shape, it supports simultaneously and symmetrically the elongated resilient elements. Moreover, its shape is such as to prevent the base elements form flexing under the action of the springs. In this way, the elastic forces may be transmitted, via the rotatable rigid element, in a symmetrical manner onto the base.

[0023] According to one embodiment, said suction arm comprises a third tube section connected to the second tube section and a fourth tube section connected to the third tube section and trapezoidal plates at the ends of the said hinged parallelogram frame.

[0024] Conveniently, said suction arm comprises two further elongated resilient balancing elements having one of their ends connected to said trapezoidal plate by means of at least one second rotatable rigid element.

[0025] One end of said rotatable rigid element is able to travel along a trajectory following an arc of a circumference, from a first position in line with the axis of the resilient element, into a second position inclined with respect to said axis.

[0026] Conveniently, said rigid rotatable element consists of a C-shaped or omega-shaped bracket or bar for pivotably mounting corresponding ends of the two further elongated resilient elements.

[0027] As for the rotatable rigid element on the base side, the position of the point for fixing of the rotatable rigid element (hood side) onto the trapezoidal plate may be varied by means of suitable devices or arrangements. The point of contact between this rotatable rigid element and the trapezoidal plate may be varied by means of sliding or rotatable elements in order to vary the moment of the acting elastic force.

[0028] The variable fastening system according to the present invention allows better balancing compared to the known fixed-fulcrum systems. The present invention also allows improved balancing compared to the known systems having a fulcrum variable on a cam by means of a flexible cable fastened to the base and to one end of the resilient element. In fact, whereas, in both known solutions, the balancing is based on a standard configuration of the arm (fulcrum point defined during installation or position of the fulcrum depending on a predetermined cam), in the case of the present invention with a rotating rigid element, although having only two fulcrum points, the latter may be rendered adjustable by means of the said arrangements or devices. Moreover, as described below, the resilient elements may be pretensioned further. In other words, while in the first two cases, with a variation in the load of the capturing system, it is required to modify substantially the position of the fulcrum or define a new cam for embracing the spring tensioning cable, with corresponding disassembly of parts of the support system and subsequent repositioning, in the case of the present invention it is required to perform a simple adjustment of regulators for the position of the points for fixing the rotatable rigid element and fastening the springs and for pretensioning of the springs.

[0029] Moreover, a further advantage consists in the structural rigidity and the balancing of the forces at play which is obtained using a single rigid element which connects the resilient elements.

[0030] According to an embodiment of the present invention, the resilient elements comprise a device for setting the initial tension.

[0031] Preferably, said device for setting the initial tension comprises a threaded member. Said threaded member, for example, may be in the form of a threaded bush which, connected to the resilient element, is engaged by a threaded hook pivotably mounted on the rotatable rigid element and/or on the bar integral with the rigid tube. The solution may be adopted for all the elongated resilient elements and on all the ends thereof.

[0032] Conveniently, said fourth tube section is fixed to a rigid bar pivotably mounted on said trapezoidal bracket.

[0033] According to an advantageous embodiment, a tie-rod is pivotably mounted on said trapezoidal bracket so as to form a second parallelogram frame.

[0034] A detailed description of the present invention now follows, to be read with reference to the accompanying plates of drawings in which:

- Figure 1 shows a side view of a pantograph suction arm of the known type;
- Figure 2 shows a partial side view of a suction arm according to the invention with variable fastening at the base side in an initial position;
- Figure 3 shows a partial side view of a suction arm according to the invention with variable fastening at the base side in an intermediate position;
- Figures 4 shows a partial side view of a suction arm according to the invention with variable fastening at the base side in a final position;
- Figure 5 shows a partial side view of the trapezoidal bracket and the corresponding variable fastening in an initial position;
- Figure 6 shows a partial side view of the trapezoidal bracket and the corresponding variable fastening in a final position;
- Figure 7 shows a partial side view of the suction arm according to the invention with the forearm tie-rod removed; and
- Figure 8 shows a graph illustrating the progression of the moment depending on the angle of inclination of the hinged parallelogram.

[0035] In Figures 1-7 only one side of the suction arm is shown. The views from the opposite side are mirror-images and are not illustrated.

[0036] Figure 1 shows in schematic form a suction arm 10 of the known type. The arm 10 according to Figure 1 comprises a first tube section, a second tube section, a third tube section, a fourth tube section and a fifth tube section 11, 12, 13, 14 and 15, respectively. The first tube section 11, the third tube section 13 and the fifth tube section 15 are flexible, while the second and the fourth tube section 12, 14 are substantially rigid. The first tube section 11 is connected to a base 17 situated at a certain height from the ground (generally about 2.0 to 2.5 m). With suitable assembly of its component parts, the base may be rotated so as to be positioned on horizontal surfaces such as tables or carriages. The fifth tube section 15 terminates in a suction hood 16. The base side part of the suction arm, that comprising the first and the second tube sections 11, 12, is also simply indicated as "arm" or "base side arm". The terminal part of the suction arm 10 is also indicated as "forearm".

[0037] The suction arm 10 according to Figure 1 comprises a first and a second hinged parallelogram frame 18, 19. Each hinged parallelogram frame 18, 19 comprises a bar 18a, 19a fixed to a tube section and a tie-rod 18b, 19b. In the base side parallelogram, the bar 18a is fixed to the second tube section 12; in the parallelogram 19 of the forearm, the bar 19a is fixed to the fourth rigid tube section 14. The first parallelogram frame 18 is pivotably mounted on a base bracket 20 and a trapezoidal plate 21. The second parallelogram frame 19 is also fixed to the trapezoidal plate 21 and to a connecting rod 21 which is pivotably mounted on the fifth tube section 15. The first parallelogram frame 18 cooperates with a first extension spring 22 and the second parallelogram frame cooperates with a second extension spring 23.

[0038] One end 22a of the first extension spring 22 is fixed to the bar 18a of the first parallelogram 18, while the other end 22b is fixed to the base 17, if necessary by means of a base bracket 20. In other words, one end (22b) of the first spring is pivotably mounted at a fixed point, while the other end (22a) is pivotably mounted at a point which travels along a certain trajectory variable with the movement of the first parallelogram. The elastic moment M1 opposed by the first extension spring has a complex trend, but in general it may be stated that it depends on an angle α (alpha) between the vertical and the tie-rod (or the bar) of the first parallelogram or on an angle β (beta) between the axis of the spring and the horizontal.

[0039] Figure 8 shows by way of example the trend of the moments $M_{Del.E}$ (moment of the elastic force with respect to the point D, hinge of the bar on the first base side tube, when the first fulcrum E is active) and $_{MDel.F}$ (moment of the elastic force with respect to the point D, when the second fulcrum F is active) depending on the angle of inclination α (alpha) of the first hinged parallelogram with respect to the horizontal, starting from an angle α of about 35º and up to an angle α of about 180º (theoretical position). The same graph also show the moment of the weight force (M_{DP}). It is clear how, starting from an angle α of about 70º, the moment M1 no longer follows moment of the weight force and diverges from it. This constitutes a serious drawback of the known solutions.

[0040] Considerations of an entirely equivalent nature are also applicable to the pantograph on the forearm side.

[0041] The present invention is shown in Figures 2 to 7. The suction arm 110 according to the present invention also comprises a base 117, a first, a second, a third, a fourth and a fifth tube section 111, 112, 113, 114, 115, respectively, substantially as in the known solution. Preferably the rigid suction tubes 112, 114 are made of sheet steel or aluminium, while the flexible tubes 111, 113 and 115 are made of composite fabrics and metal coils. The suction arm 110 of the present invention also comprises at least one first hinged parallelogram frame 118 at the base side which extends along the second rigid tube section 112. The first hinged parallelogram frame 118 is hinged with a base bracket 120 and with a trapezoidal plate 121. A first elongated resilient balancing element 122, typically an extension spring 122, cooperates with the first parallelogram frame 118.

[0042] According to the present invention, one end 122a of the first extension spring 122 is conventionally fixed to the hinged parallelogram frame 118. The other end 122b of the first extension spring is instead connected to the base 117 (or to a base bracket 120 as in Figures 2 and 3) by means of a rotatable substantially rigid element 130. In one embodiment, the rotatable rigid element 130 is in the form of a square C-shaped (or omega-shaped or similar) square bar for engagement simultaneously with both springs 122 on the base side. As mentioned above, in fact, the various figures show only one side of the suction arm 110, the opposite side (which is substantially a mirror image) not being shown. Therefore, there will be two springs 122, one on either side. In Figures 2 and 3 only the central part of the bar 130 is shown, the two flanges of the "C" engage with holes in the base brackets and eyelets 122a of hooks 122b of the springs 122.

[0043] Conveniently, the rotatable rigid element 130 is pivotably mounted in a hole of an additional plate 133 which is bolted (or in any case fixed) to the base bracket 120.

[0044] According to the present invention, in a first position, where the first hinged parallelogram frame 118 is raised (Figure 2), the rotatable rigid element 130 is situated on the same axis as the extension spring 122. In this position, the axis of the spring 122 forms an angle β (beta) with the horizontal and the bar 118a (or the tie-rod 118b) of the first hinged parallelogram frame 118 forms an angle α (alpha) with the vertical.

[0045] In a second intermediate position (Figure 3) the rotatable rigid element 130 is still situated on the same axis as the extension spring 122, but the rigid element 130 has substantially reached the end of its travel path, having engaged with an edge 133a of the additional plate 133. In order to reach said end-of-travel position, the rotatable rigid element 130 has travelled along an arc of a circumference corresponding to an angle β of between about -45º and +15º, typically about 60º. Using the reference numbers indicated in Figures 2 and 3, the rigid element 130 is rotated through an angle β' = 15º with respect to the horizontal direction. In practice, a second fulcrum is defined in this way.

[0046] In fact, from the end-of-travel position shown in Figure 3, each further rotation downwards of the first hinged parallelogram frame 118 will result in a rotation of the spring 122 about the said second fulcrum point. This is shown in Figure 4, where it is clear that the rigid element 130 is no longer situated on the same axis as the spring 122. In other words, the axis of the spring 122 is inclined at an angle β'' with respect to the horizontal while the rigid element 130 is inclined at β', with $\beta' < \beta''$.

[0047] Figure 8 also shows the progression of a moment $M_{MDel.F}$ as a function of the angle of inclination α (alpha) of the first hinged parallelogram with respect to the horizontal, starting from an angle α of about 35º and up to an angle of about 180º (theoretical). The moment $M_{MDel.F}$ represents the moment of the elastic force of the spring 122 assuming that it is pivotably mounted fixed at the second fulcrum (that shown in Figures 3 and 4). Owing to the present invention where it is as though the spring 122 were pivotably hinged about the first fulcrum up to an angle of rotation of the first hinged parallelogram118 equivalent to α=105º and about the second fulcrum (through angles of rotation of the first hinged parallelogram 118 greater than about α=105º), the moment of the elastic force follows the curve $M_{MDel.E}$ until it intersects the curve $M_{Del.F}$. From the point of intersection onwards it follows the curve $M_{Del.F}$. In this way, the moment of the elastic force follows in a more precise manner the moment of the weight force, allowing a reduction in the action of the friction devices at the hinging points.

[0048] Conventionally, the first hinged parallelogram frame 118 terminates in a trapezoidal plate 121. According to the present invention, pivotably mounted on the other end of the trapezoidal plate 121 there is a bar 119a connected to the fourth tube section 114. A second extension spring 123 is pivotably mounted on said forearm bar 119a, preferably at its end as shown in Figure 7. The other end of the second extension spring 123b is connected to trapezoidal plate 121. According to the present invention, a variable fastening system is provided by means of a rigid element 130 which is entirely similar to that on the base side.

[0049] In a first position (Figure 5), the rigid element 130 is situated substantially on the same axis as the second spring 123. In other words, the axis of the spring 123 and the rigid element 130 are inclined at an angle δ' (delta') with respect to the horizontal and the bar 119a is inclined at angle γ' (gamma'). By rotating the forearm downwards, an end-of-travel position (not shown) is reached where the rigid element 130 and the spring 123 are still situated on the same axis, but the rigid element 130 has entered into contact with an edge 121 a (the long side or upper side) of the trapezoidal plate 121. From this point onwards, the fulcrum about which the second spring 123 rotates is precisely the end of the rigid element 130, as shown in Figure 6.

[0050] In other words, in the case of the second spring 123, a first fulcrum 130a is identified, this fulcrum being the point of the trapezoidal bracket 121 about which the rigid element 130 is pivotably mounted, together with a second fulcrum 130b which is at the end of the rigid element 130 when it is situated against the trapezoidal plate 121. The angle beyond which there is a transition from the first fulcrum to the second fulcrum is variable and depends on the form of the trapezoidal plate 121 and the length of the rigid element 130. The fulcrum (trapezium side) of the second spring is defined as having a "variable trajectory" or simply as being "variable" because it is not fixed with respect to the trapezoidal plate 121, as instead occurred in the known solutions.

[0051] Thanks to this solution, the elastic moment provided by the spring 123 will be closer to that of the weight force. This allows the friction devices present at the various articulated joints to be stressed less, thus increasing the ease of handling and reliability of the arm 110.

[0052] In order to set the initial tension of the springs 122, 123 in a precise manner so as to allow use of special accessories (for example a hood having a weight greater than the weight of a conventional hood), the present invention envisages using a suitable device. Preferably, said device for setting the initial tension comprises a threaded member. Said threaded member, for example, may be in the form of a threaded bush 122c, 123c and a threaded hook 122b, 123b which engages with said bush. The hook has an eyelet 122a, 123a and a shank 122d, 123d. The device for setting the initial tension may be provided on one end only of the spring 122, 123 or on both ends. In any case, by screwing or unscrewing the shank 122d, 123d into/from the bush 122c, 123c the distance between one end and the other is shortened or lengthened and the elastic element becomes more rigid or softer.

[0053] As mentioned above and as shown in particular in Figure 7, a simplified version of the suction arm 110 according to the present invention comprises a single hinged parallelogram 118 on the base side and a bar 119a in the region of the forearm. Conveniently, in order to reduce the weight and cost of the suction arm, the forearm bar 119a may be shorter than the length of the fourth tube section 114.

According to a further embodiment, it is envisaged providing (if necessary later, as an additional member) a tie-rod 119b which is pivotably mounted on the trapezoidal plate 121 and on a connecting rod in turn hinged on an element integral with the rigid tube and situated suitably at the end of the tube on the hood side. In this way, from an initial configuration in the form of a single hinged quadrilateral, a suction arm 110 in the form of a double hinged quadrilateral is obtained. The modification could be required for special applications, in order to ensure greater ease of handling or withstand end loads (typically due to the weight of the hood) greater than the nominal load.

[0054] It is obvious that numerous modifications, adaptations, variations and replacements of parts with other functionally equivalent parts may occur to the person skilled in the art, but it is clear that all these modifications, adaptations, variations and replacements of parts are within the scope of the invention which is limited solely by the claims which follow.

Claims

1. Pantograph suction arm (110), comprising a first tube section (111) connected to a base (117), a second tube section (112) connected to a frame in the form of a hinged quadrilateral (118) on the base side, and a first elongated resilient balancing element (122) cooperating with said hinged quadrilateral frame (118) on the base side, one end (122a) of said elongated resilient balancing element (122) being pivotably mounted on said hinged parallelogram frame (118) on the base side, **characterized in that** the other end (122b) of said resilient element is pivotably mounted at a point (130) movable depending on the position of said hinged parallelogram (118).

2. Suction arm according to Claim 1, **characterized in that** said elongated resilient element (122) com-

prises an extension spring (122), the ends of which are constrained to the hinged parallelogram (118) and to a rotatable rigid element (130).

3. Suction arm according to Claim 2, **characterized in that** one end of said rotatable rigid element (130) is able to travel along a trajectory following an arc of a circumference from a first position in line with the axis of the resilient element to a second position inclined with respect to said axis.

4. Suction arm according to Claim 2 or 3, **characterized in that** said rigid rotatable element (130) is pivotably mounted directly on said base (117) or on a plate (133) fixed thereto.

5. Suction arm according to any one of the preceding claims, **characterized in that** it comprises a third tube section (113) connected to the second tube section (112), a fourth tube section (114) connected to the third tube section (113) and a trapezoidal plate at one end of the said first hinged parallelogram frame (118).

6. Suction arm according to Claim 5, **characterized in that** it comprises a further elongated resilient balancing element (123), preferably in the form of an extension spring, having one of its ends (122b) connected to said trapezoidal bracket (121) by means of at least one second rotatable rigid element (130).

7. Suction arm according to Claim 6, **characterized in that** one end of said rotatable rigid element (130) is able to travel along a trajectory following an arc of a circumference, from a first position in line with the axis of the resilient element (123), into a second position inclined with respect to said axis.

8. Suction arm according to any one of Claims 2 to 7, **characterized in that** said rigid rotatable element (130) comprises a C-shaped, or omega-shaped or similar bracket for pivotably mounting corresponding ends (122b, 123b) of two resilient elements (122, 123).

9. Suction arm according to any one of the preceding claims, **characterized in that** said resilient element (122, 123) comprises a device (122b, 122c) for setting the initial tension.

10. Suction arm according to Claim 9, **characterized in that** said device (122b, 122c) for setting the initial tension comprises a threaded member, preferably in the form of a threaded bush (122c), and a hook (122b) threaded in a corresponding manner such as to engage with said bush.

11. Suction arm according to any one of Claims 5 to 10, **characterized in that** said fourth tube section (114) is fixed to a rigid bar (119a) pivotably mounted on said trapezoidal bracket (121).

12. Suction arm according to Claim 11, **characterized in that** a tie-rod (119b) is pivotably mounted on said trapezoidal bracket (121) so as to form a second parallelogram frame (119).

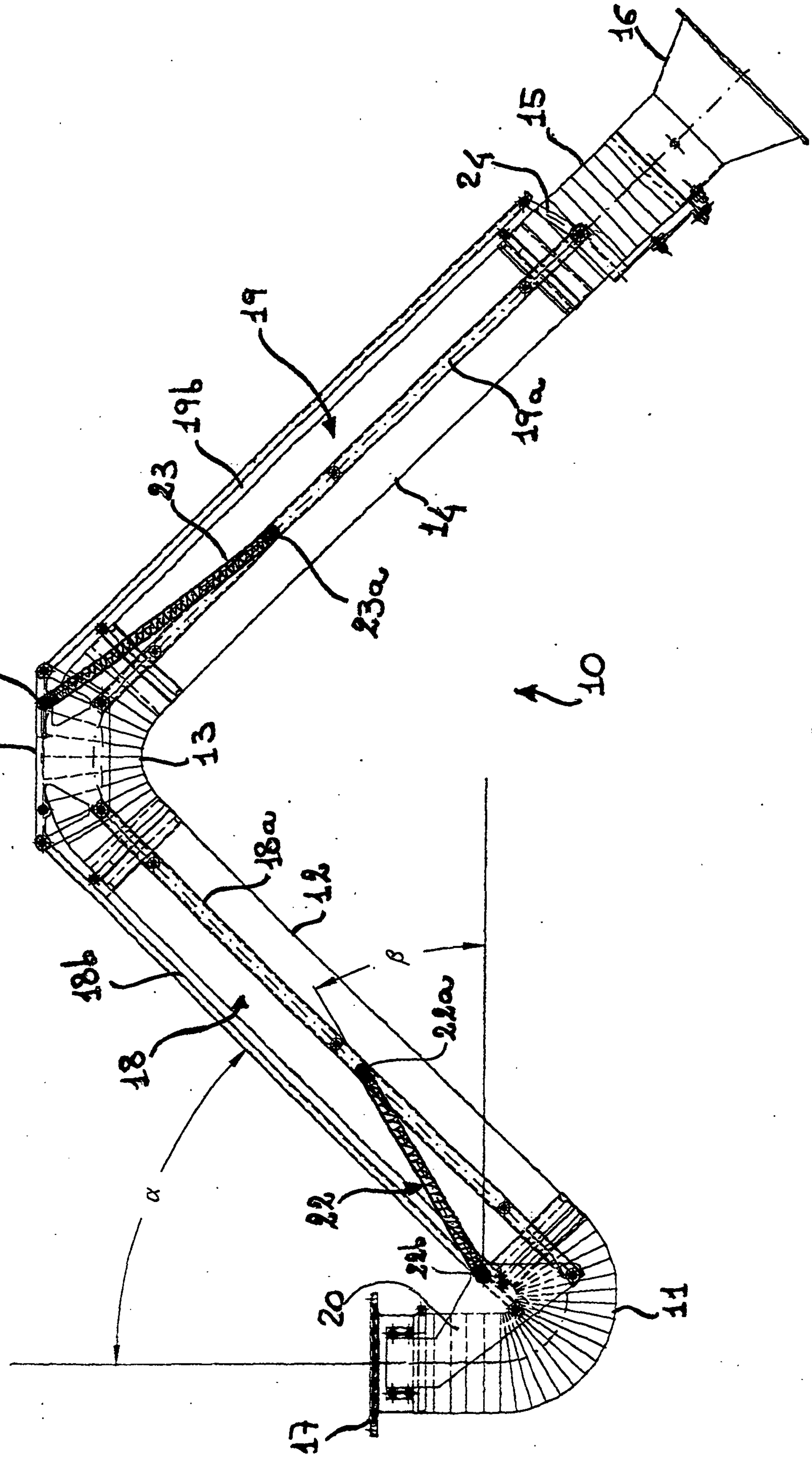
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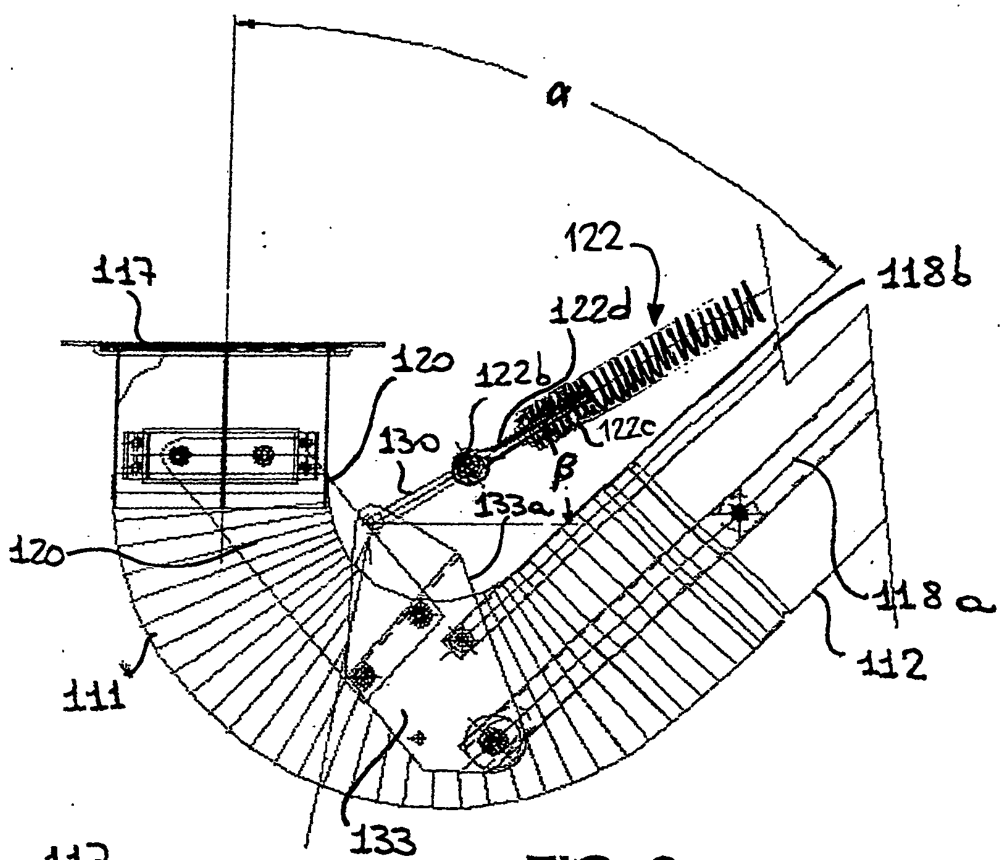
FIG.1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118a
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111
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FIG. 2

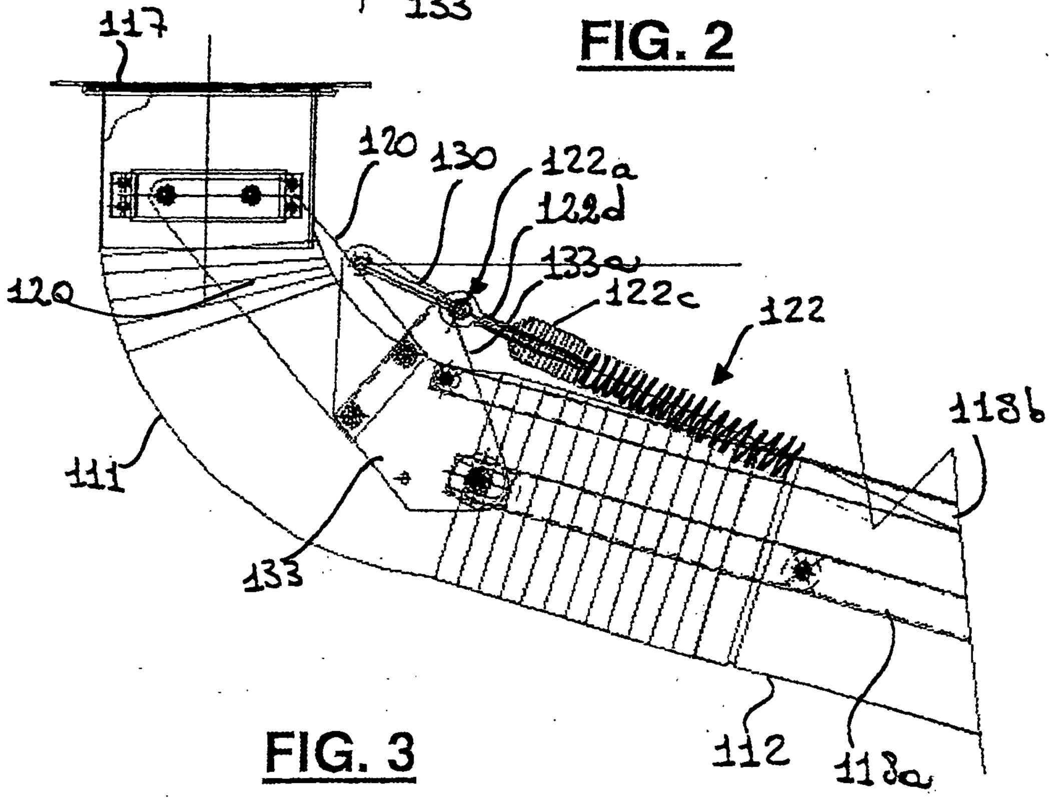
117
120
130
122a
122d
133a
120
122c
122
118b
111
133
112
118a

FIG. 3

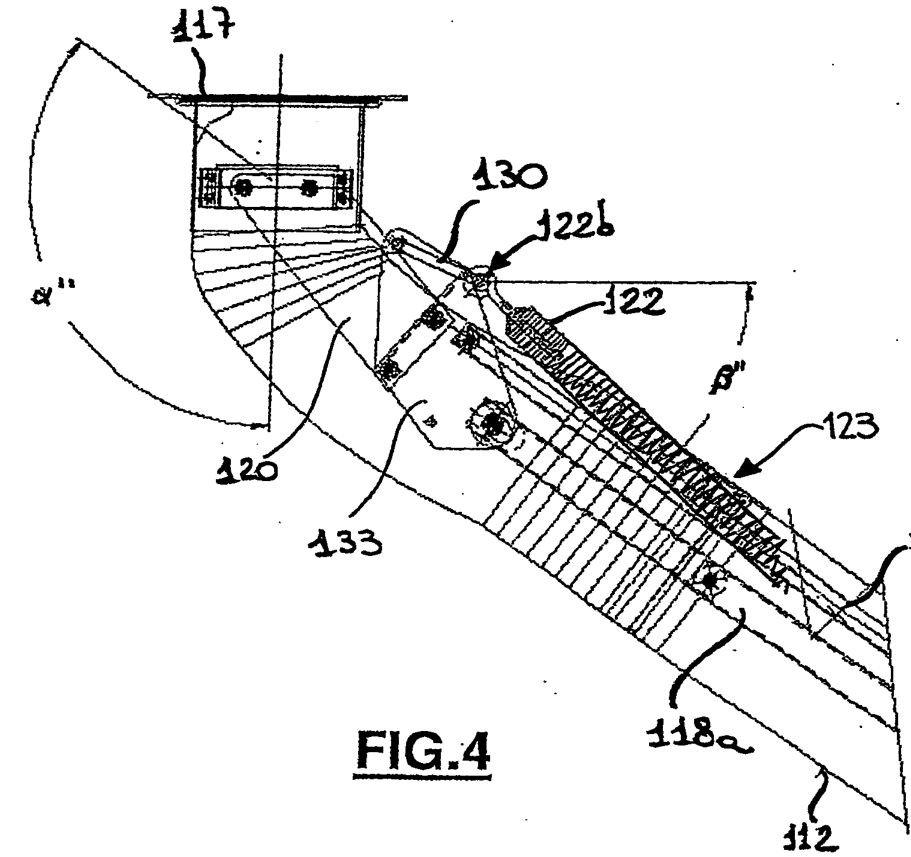
117
130
122b
122
α''
β''
123
120
133
118b
118a
112

FIG.4

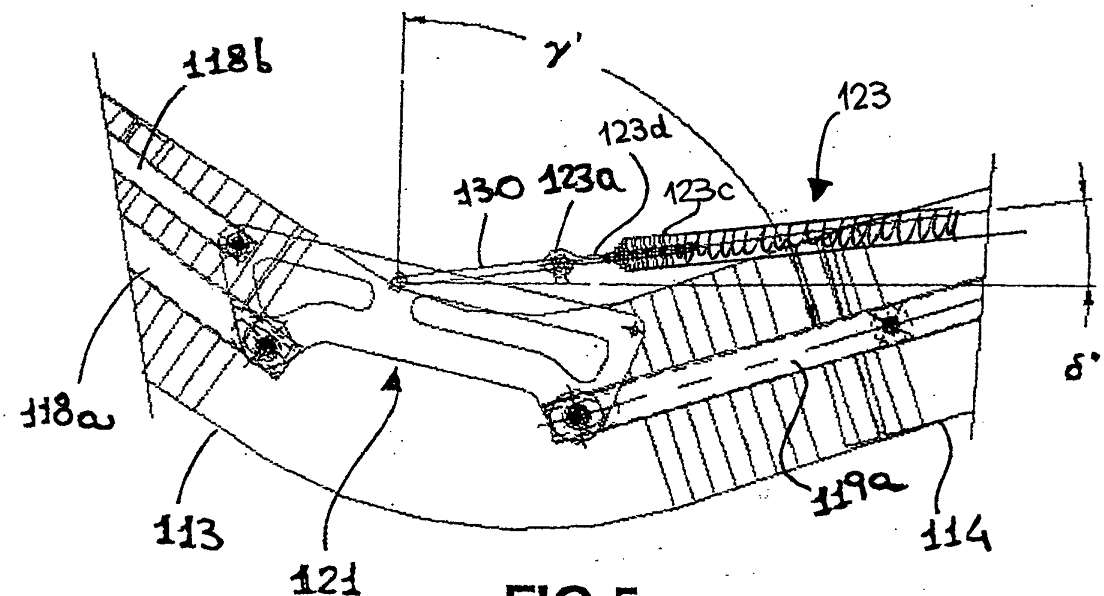
118b
γ'
123
123d
130
123a
123c
δ'
118a
113
121
119a
114

FIG.5

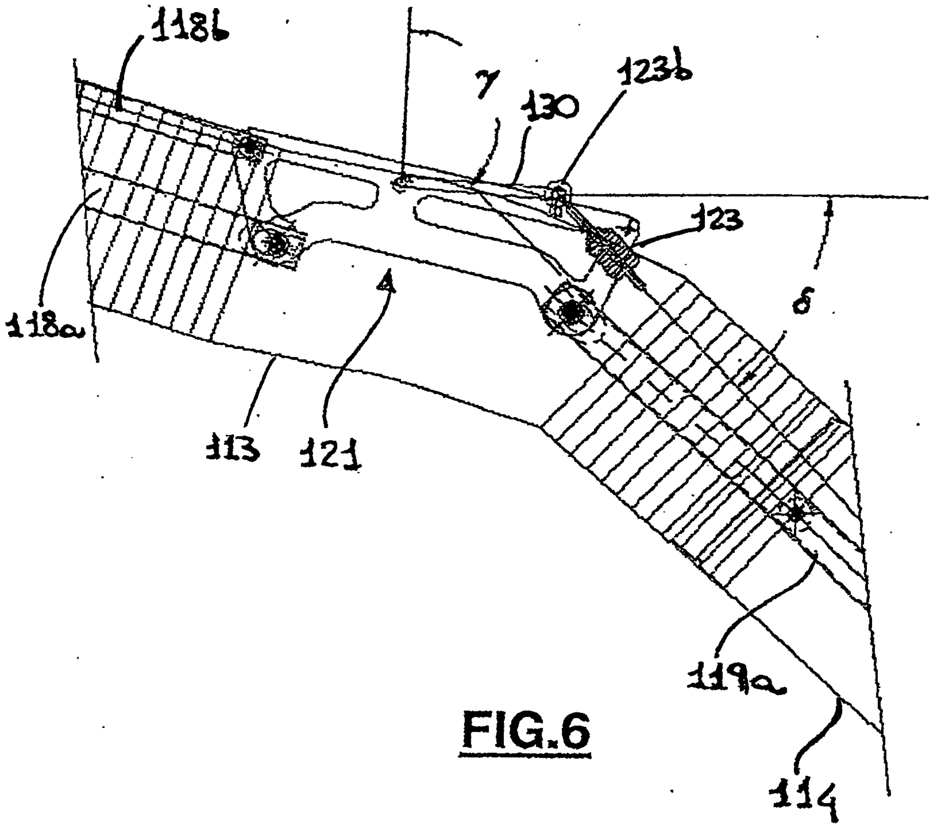
118b
γ
130
123b
123
δ
118a
A
113
121
119a
114

FIG.6

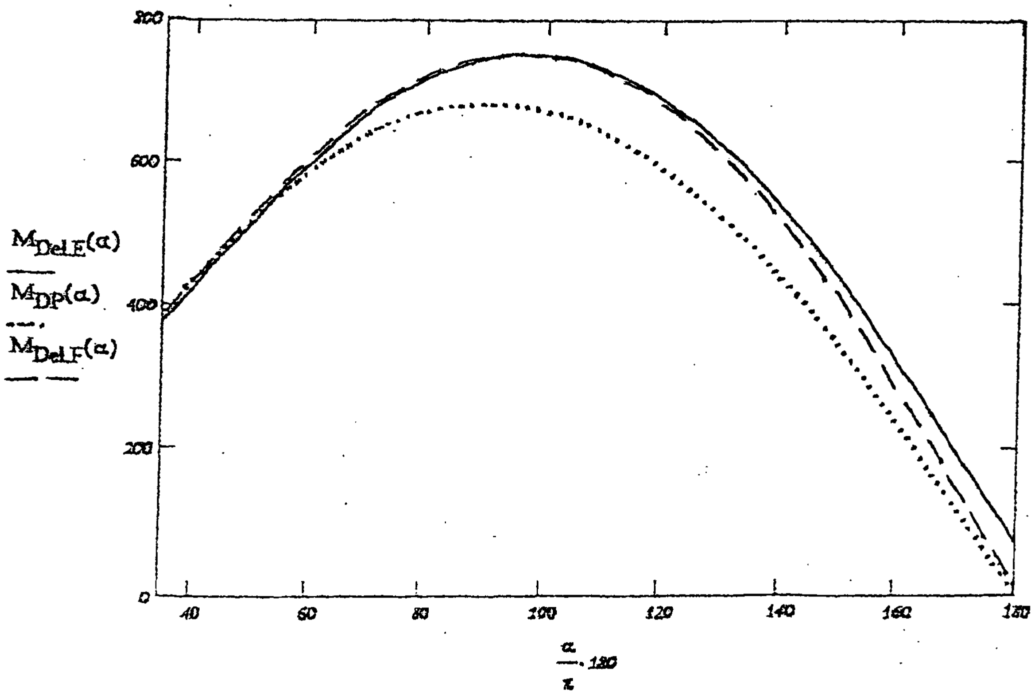
800
600
400
200
0
40
60
80
100
120
140
160
180
M_DelE(α)
M_DP(α)
M_DelF(α)

FIG.8

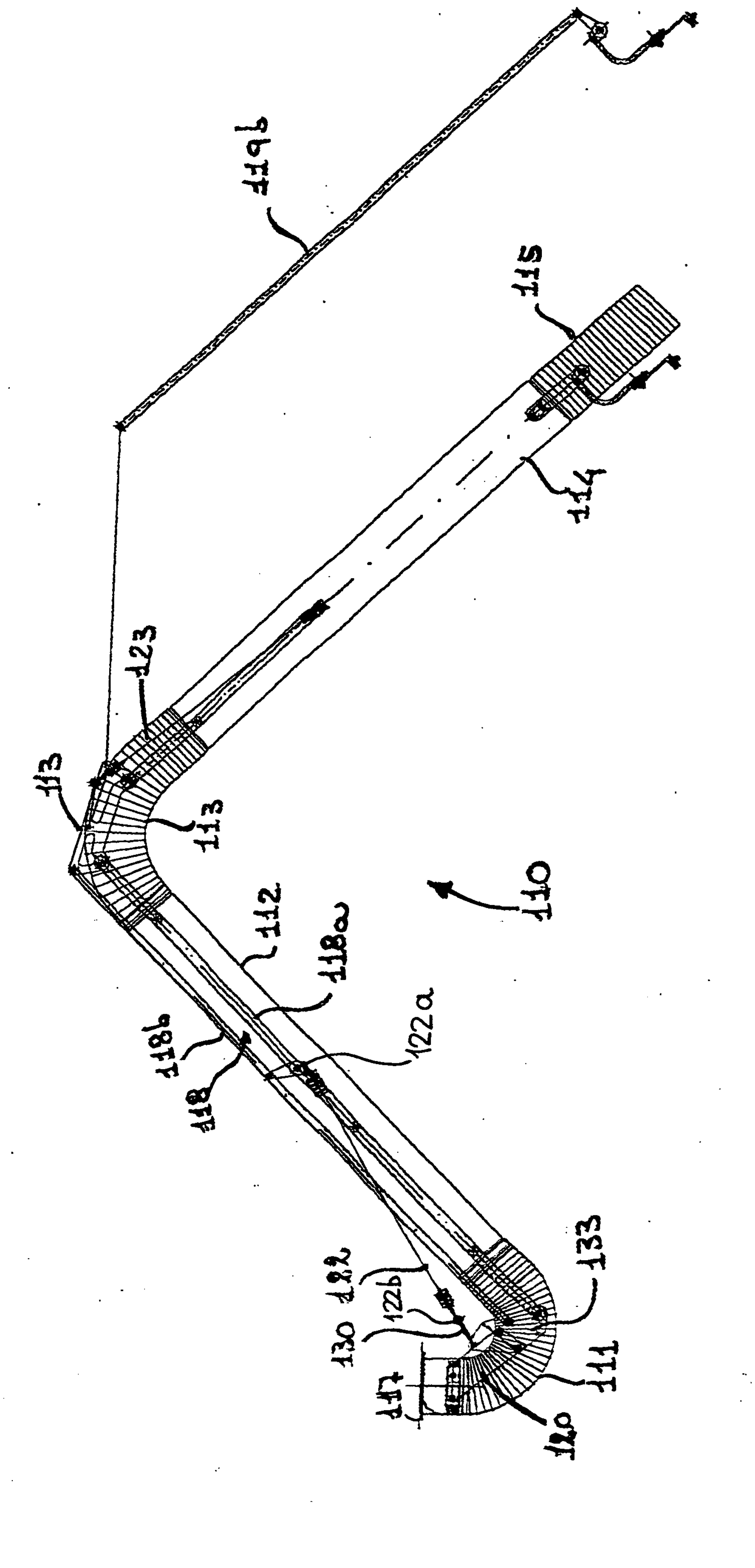
119b
115
114
123
113
113
110
112
118a
122a
118b
118
133
122
122b
130
117
111
120

FIG.7