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(54) **METHOD FOR PRODUCING A BENT PIPE COMPRISING AT LEAST ONE DESIRED CURVATURE, A DEVICE SUITABLE FOR CARRYING OUT SUCH A METHOD**

VERFARHREN ZUR HERSTELLUNG EINES GEKRÜMMTEN ROHRS MIT MINDESTENS EINER GEWÜNSCHTEN KRÜMMUNG, VORRICHTUNG ZUR AUSFÜHRUNG EINES DERARTIGEN VERFAHRENS

PROCÉDÉ POUR PRODUIRE UN TUBE CINTRÉ COMPRENANT AU MOINS UNE COURBURE DÉSIRÉE, DISPOSITIF APPROPRIÉ POUR LA MISE EN OEUVRE DE CE PROCÉDÉ

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Description

[0001] The invention relates to a method for producing a bent pipe comprising at least one desired curvature, wherein a substantially straight pipe is divided into a number of segments and zones present between two successive segments.

[0002] The invention also relates to a device suitable for carrying out such a method
and comprising a number of pivotally interconnected parts. Such a device is for example disclosed in GB-A-1081597.

[0003] With such a method, which is known from US patent US-B2-7,222,512, outwardly extending bulges are formed in zones in a substantially straight pipe, whilst segments located on either side of a zone are present in parts which are pivotable relative to each other. The bulges form a beginning of a crease to be formed in the zone. After the bulges have been formed, the segments are pivoted relative to each other by means of the aforesaid parts, as a result of which bending of the pipe takes place. Since the dimension in axial direction of a bulge formed on an inside bend of the bent pipe to be formed is larger than that of the bulge on an outside bend of the bent pipe, it is possible to compensate for the difference in length in the inside bend and the outside bend of the bent pipe, or, in other words, the difference in radius between the inside bend and the outside bend of the bent pipe.

[0004] A drawback of the known method is that the bulges formed in the zones form creases which extend along the entire circumference of the pipe. In addition, the segments located between the zones are substantially identical in shape both in the original, substantially straight pipe and in the bent pipe that is eventually formed. As a result, walls including an angle with each other are obtained in the interior of the pipe, so that an even flow is not obtained in the bent pipe when the pipe is used as a flow channel.

[0005] The object of the invention is to provide a method by means of which a pipe can be given practically any curvature, whilst an even transition between the segments is obtained.

[0006] This object is accomplished with the method according to the features of claim 1 and a device according to the features of claim 11.

[0007] Starting from a desired curvature in a pipe, the local curvatures in the pipe wall are determined for every segment of the bent pipe, along the entire circumference of said pipe.

[0008] Then a substantially straight pipe is theoretically divided into said segments, and the walls of said segments are given the local curvatures. Since the segments form part of a curvature, for example a circular arc or a differently configured bend, zones will be present between the segments, at least on inside bend of the curvature to be formed, when a substantially straight pipe is divided into said segments. When the substantially straight pipe is bent to form the bent pipe, the segments are moved towards each other, with the local curvatures of the adjoining segments becoming aligned and the, preferably contiguous, local curvatures forming a continuous curvature in the bent pipe.

[0009] In this way it is possible to form practically any curvature or bend in a pipe, whilst a smooth surface can be realised at least on an outside bend of the curvature.

[0010] The term "pipe" as used herein is understood to mean a tubular section having a circular or other cross-section, which may be constant or change in the longitudinal direction of the pipe.

[0011] It is noted that from US 1,958,447 a method for forming a bent pipe is known wherein part of the pipe is bent relative to the remaining straight part of the pipe and provided with creases. Then a part of the pipe between the bent part of the pipe and the remaining part of the pipe is bent and provided with creases. This process is repeated until the pipe has obtained the desired curvature. The device used for carrying out the method comprises a single part which is pivotable relative to a part in which the remaining pipe part is clamped down.

[0012] With the pipe according to the present invention, all the segments in the substantially straight pipe are provided with a local curvature. Only then are the segments moved relative to each other so as to form the curved pipe. The device that is used for this purpose comprises a number of pivotally interconnected parts, which number preferably corresponds to the number of segments of which the curved pipe is formed.

[0013] One embodiment of the method according to the invention is characterised in that the local curvature of a segment of the substantially straight pipe has a smaller radius on an inside bend of the curvature to be formed than on an outside bend of the curvature to be formed.

[0014] In this way both the inside bend and the outside bend will have obtained the radius associated with the respective inside bend and outside bend after the substantially straight pipe has been bent to form the bent pipe.

[0015] Another embodiment of the method according to the invention is characterised in that the internal wall on the outside bend of the curvature of the bent pipe is substantially smooth.

[0016] By providing each segment of the original straight pipe with a local curvature, at least on the outside bend of the curvature to be formed, which curvature corresponds to the eventually desired curvature of the bent pipe, the outside bend part of the bent pipe that is eventually formed will be substantially completely smooth. The interior of the pipe will be substantially completely smooth as well, thus enabling a smooth flow through the bent pipe.

[0017] Yet another embodiment of the method according to the invention is characterised in that a segment of the substantially straight pipe tapers off from an inside bend of the curvature to be formed to an outside bend of the curvature to be formed.

[0018] As a result, a bent pipe will be obtained when

the sides of the segments facing the inner side are moved together, in which bent pipe the segments are substantially contiguous.

[0019] Another embodiment of the method according to the invention is characterised in that a zone comprises a part of the straight pipe that can be creased between two successive segments, each zone in the bent pipe being folded into a crease.

[0020] As a result of the zones being folded into a crease, the segments are moved together. The crease is larger near the inside bend than near the outside bend, and gradually decreases in size in the circumferential direction of the pipe. Creases need not be formed near the outside bend, since the segments can directly join one another at that location. As a result of the presence of the aforesaid creases, hardly any stretch will occur when the material is being bent. As a result, also materials having a low plastic deformation capability, to be expressed in elongation at break, for example, can be used for producing bent pipes. Think in this connection of materials such as steel, aluminium and other metals or plastics.

[0021] Yet another embodiment of the method according to the invention is characterised in that a beginning of a crease is formed in each zone of the substantially straight pipe.

[0022] In this way each zone will be creased to the desired configuration when the substantially straight pipe is bent to form the bent pipe.

[0023] Instead of forming creases, it is also possible to remove the zone that is present between two successive segments from a substantially straight pipe, wherein, after the straight pipe has been bent to form the bent pipe, sides of adjacent segments of the bent pipe will at least substantially abut against each other. Preferably, said abutting sides are connected together. Said removal of the zones present between two successive segments can take place prior to the formation of the local curvature in the segments; preferably, however, it will take place after the formation of the local curvatures in the segments.

[0024] In this way a more precise formation of the segments is ensured.

[0025] Yet another embodiment of the method according to the invention is characterised in that the substantially straight pipe is positioned in a number of pivotally interconnected parts, each part comprising at least one curvature to be locally provided of a segment positioned therein, whereupon the pipe is deformed, during which deformation each segment is pressed against the wall of the associated part, as a result of which the segment is provided with the local curvature, and the parts are subsequently pivoted relative to each other, thus forming the desired curvature in the pipe.

[0026] In this way a controlled formation of the local curves in the segments is realised, wherein, once the local curvatures have been formed, the substantially straight pipe is bent to formed the bent pipe by pivoting the parts relative to each other.

[0027] Creases may be formed in the zones between the parts, if desired.

[0028] The invention will now be explained in more detail with reference to the drawings, in which:

Figure 1 shows a theoretical model of a bent pipe;
Figure 2 shows the bent pipe of figure 1, divided into segments;
Figure 3 shows the bent pipe of figure 2 developed along a line;
Figure 4A shows a theoretical model of the substantially straight pipes comprising removed zones that is to be formed;
Figure 4B shows a detail of the substantially straight pipe shown in figure 4A;
Figure 5 shows a theoretical model of the substantially straight pipe comprising removed zones that is to be formed, in which zones to be creased are present between the segments;
Figures 6A-6L and figures 7A-7E show various views of the forming of a bent pipe from a substantially straight pipe;
Figures 8A-8C show a perspective front view, a perspective top plan view and perspective side view, respectively, of another bent pipe according to the invention;
Figure 9 shows a perspective front view, a perspective top plan view and perspective side view, respectively, of yet another bent pipe according to the invention;
Figure 10 shows a perspective front view, a perspective top plan view and perspective side view, respectively, of yet another bent pipe according to the invention;
Figures 11A and 11B show a perspective view and a top plan view, respectively, of a device according to the invention;
Figures 12A and 12B show top plan views of a device according to the invention with a substantially straight pipe and a bent pipe formed by means of the device, respectively, present therein.

[0029] Like parts are indicated by the same numerals in the figures.

Figure 1 shows a theoretical model of a bent pipe 1 which extends along an axis 2. The bent pipe 1 has a circular cross-section. The bent pipe 1 has an inside bend 3 with a radius R_i as well as an outside bend 4 with a radius R_o" wherein $R_o > R_i$.
Figure 2 shows the bent pipe 1 of figure 1, in which the bent pipe 1 is divided into segments S_1, S_2...S_n formed by lines 5 which extend from the centre M of the radii R_i and R_o. Each segment S_1, S_2...S_n extends through the same angle α. Each segment S_1, S_2...S_n has an inside radius R_{i1}, R_{i2} ..... R_{in} and an outside radius R_{o1} R_{o2}..R_{on} which, in this theoretical model,

are the same as the radii R_i and R_o, respectively, of the bent pipe 1. Segment S_1 is bounded by the angular points a_o and a_1 on the outside of the bend and angular points b_o and b_1 on the inside of the bend. Segment S_2 is bounded by the angular points a_1, a_2, b_1, b_2. The angular point a_1 thus forms an angular point both of the segment S_1 and of the segment S_2. Similarly, the angular point b_1 forms an angular point of the segments S_1 and S_2.

Figure 3 shows the bent pipe 1 shown in figure 2, in which the segments S_1 - S_4 have been pivoted away from each other, such that the angular points a_o, a_1, a_2, a_3, a_4 lie on a straight line L. The opposite longitudinal sides 7, 8 of adjacent segments S_1, S_2 include the angle α with each other.

[0030] As is clearly shown in figure 3, each segment S_1, S_2 .... S_n has an inside radius R_{i1}, R_{i2} ..... R_{in} and an outside radius R_{o1} R_{o2}..R_{on}. Because the segments S_1, S_2 have been pivoted away from each other, the angular point b_1 is no longer a common angular point, but it is now formed by two angular points b_1.

[0031] Figure 4A shows the bent pipe 1 fully developed into a substantially straight pipe 10, in which all the angular points a_1, a_2 ..... a_s lie on the line L. Zones Z_1, Z_2 .... Z_n are present between the adjacent segments S_1, S_2 .... S_n, which zones are not filled in the substantially straight pipe 10 that is shown in figure 4.

[0032] Figure 4B shows a larger-scale detail of segment S_3, in which the outside radius R_{o3} can be clearly distinguished.

[0033] Figure 5 shows a substantially straight pipe 11, which is different from the straight pipe 10 shown in figure 4A in that, in contrast to figure 4, the zones Z_1, Z_2 ..... Z_{n-1} present between the segments S_1, S_2 ..... S_n are filled.

[0034] When the substantially straight pipe 10 shown in figure 4A is being bent, with the segments S_1, S_2 ..... S_n being moved together, the bent pipe shown in figure 1 is obtained again. By interconnecting the sides 7, 8 of the segments S_1, S_2 ..... S_n, a pipe 1 having a fully closed wall is obtained again. It is also possible, of course, not to interconnect the longitudinal sides 7, 8 if the intended use of the pipe 1 allows this.

[0035] With the substantially straight pipe 11 shown in figure 5, the zones Z_1, Z_2 ..... Z_{n-1} will need to be folded to form a crease when the pipe 11 is bent to obtain the pipe 1 shown in figure 1, so as to ensure that the sides 7, 8 of adjacent segments can be positioned substantially opposite each other.

[0036] The theory of determining the local curvatures in the segments of a substantially straight pipe as well as the subsequent formation of a bent pipe from a substantially straight pipe comprising segments and zones present therebetween has been explained with reference to figures 1-5.

[0037] Now various practical examples will be explained with reference to figures 6A-11B.

[0038] Figures 6A-7E show the deformation of a cylindrical pipe 21 having a constant diameter over its entire length, via a substantially straight pipe 22 that is divided into segments and zones present therebetween, into a bent pipe 23. In addition to the deformation of the straight pipe 21 into the bent pipe 23, also the cross-sectional shape of the pipe 21 is changed from a cylindrical cross-section with a constant diameter to a cross-sectional shape that changes along the length of the pipe from triangular into cylindrical.

[0039] Figure 6A shows a longitudinal section of the substantially straight pipe 22, which has been divided into a number of segments S_1, S_2 ..... S_n and zones Z_1, Z_2 ..... Z_{n-1} present therebetween in the above-described manner, on the basis of the desired curvatures in the bent pipe to be formed. As figure 6A clearly shows, zone Z_1 extends less far towards the wall 24 that is to form the outside bend than the zone Z_{n-1}. The segments S_1, S_2 ..... S_n have a curvature with a radius R_{o1}, R_{o2} ..... R_{on} at the wall 24. If all the radii are identical, the outside bend of bent pipe to be formed will be circular in shape. It is also possible for the radii to change gradually, to that the final bent pipe 23 will have a curvature different from a circular arc. The same applies, of course, with regard to the wall 25 of the substantially straight pipe 22 that is to form the inside bend.

[0040] Seen in the circumferential direction of the substantially straight pipe 22, the curvature of a segment S_1, S_2 ..... S_n changes gradually from the curvature with radius R_{i1}, R_{i2} ..... R_{in} near the wall 25 that is to form the inside bend to the curvature with radius R_{o1}, R_{o2} ..... R_{on} at the wall 24. Each zone Z_1, Z_2 ..... Z_{n-1} has an outwardly projecting bulge 26 in the wall thereof, whose degree of bulging varies along the circumference of the substantially straight pipe 22.

[0041] The substantially straight pipe 22 with the segments S_1, S_2 ..... S_n formed therein and the zones Z_1, Z_2 ..... Z_{n-1} present therebetween can be formed by means of a hydroforming technique. With this technique, which is known per se, the cylindrical pipe 21 is placed in a space present in a device. Said space is bounded by walls comprising a profile corresponding to the profile to be formed in the substantially straight pipe 22 that is to be produced. Then a fluid, such as oil, is introduced into the pipe 21 under pressure, whilst simultaneously forces are exerted on the pipe 21, in axial direction. As a result, the pipe 21 is deformed to obtain the substantially straight pipe 22 comprising the segments, the zones and the curvatures and bulges formed therein. The straight axis of the pipe 21 is substantially identical to the axis of the substantially straight pipe 22 with the local curvatures formed in the segments.

[0042] Once the substantially straight pipe 22 has been formed, the pipe 22 is bent to form the bent pipe 23. Said bending comprises moving the segments S_1, S_2 ..... S_n towards each other on a side facing the wall 25, causing the zones Z_1, Z_2 ..... Z_{n-1} to be folded together, resulting in the formation of a crease 27 (see figure 6E). The wall

25 that forms the inside bend comprises the substantially contiguous segments S_1, S_2 ..... S_n, with the local curvature with radii R_{i1}, R_{i2} ..... R_{in} forming a substantially continuous internal wall 28, which is interrupted only by the creases 27.

[0043] Since the zones Z_1, Z_2 ...., Z_{n-1} do not extend to the wall 24 that forms the outside bend, the segments S_1, S_2 ..... S_n join one another in a perfectly contiguous manner at the wall 24, so that a substantially completely smooth inner wall is obtained. Thus a good flow is obtained in the bent pipe 23 when the pent pipe 23 is used as a flow channel. The central axis of the bent pipe 23 has a curvature with the same centre of curvature as the outside bend of the bent pipe 23.

[0044] Figure 6E1 and figure 6E2 show the same view of the bent pipe 23 but with different details VID, VIE and VIH, VIL, VIK, respectively.

[0045] As appears from the cross-sections VIH-VIH, VIL-VIL and VIK-VIK shown in figure 6H, figure 6K, figure 6L, the cross-sectional shape of the bent pipe 23 gradually changes from circular to triangular.

[0046] This also appears from figure 6F and figure 6G, which show a side view of the substantially straight pipe 22 and the bent pipe 23 formed therefrom, respectively.

[0047] As figures 7D, 7E clearly show, the creases 27 formed by zone Z_1, Z_2 ..... Z_{n-1} do not extend along the entire circumference of the bent pipe 23. Moreover, each crease 27 decreases in size, seen in circumferential direction from the inside bend to the outside bend.

[0048] Figures 8A-8C show another bent pipe 31 formed by using the method according to the invention, which pipe is provided with identical cylindrical openings 32, 33 at both ends and which comprises a part 34 having a triangular cross-section near the centre. The bent pipe 31 comprises a first bent part 35, which extends between the circular passage 32 to the part 34 with the triangular cross-section, and a second bent part 36, which extends from the part 34 with the triangular cross-section to the circular passage. Such a pipe 31 is for example obtained by providing inter alia the segments and zones desired for the bent parts 35, 36 in a straight pipe. Then the substantially straight pipe thus formed is bent in a number of steps to obtain the desired bent pipe.

[0049] Figures 9A-9C show another embodiment of a bent pipe 41 which is different from the bent pipe 31 shown the in figure 8A-8C in that the circular passages 42, 43 at the ends of the bent pipe 41 are different in diameter.

[0050] Figures 10A-10C show yet another embodiment of a bent pipe 51 according to the invention, which comprises two bent parts 52, 53 and a part 54 with a triangular cross-section, which extends therebetween. A cylindrical pipe 55, which has a larger diameter near the end 56 than near the bent part 53 and the other end 57, joins the bent part 53.

[0051] Figures 11A and 11B show a perspective view and top plan view, respectively, of a device 61 according to the invention, which is suitable for producing the bent pipe 23, for example. The device 61 comprises two parts 62, 63 to be positioned opposite each other, which are each provided with parts 65 interconnected via pivot arms 64. Mating parts 65 of the lower part 63 and the part 62 positioned thereabove jointly define a passage 66, whose wall 67 is provided with local curvatures which correspond to curvatures to be formed in a segment S_1, S_2 ..... S_n.

[0052] The operation of the device 61 is as follows. The upper part 62 is removed from the lower part 63, whereupon a pipe 21 is placed in the passages 66. Then the upper part 62 is positioned over the straight pipe 21. Subsequently, fluid pressure is applied in the pipe 21, whilst at the same time axial forces are exerted on the ends of the pipe 21. As a result, the wall of the pipe 21 is deformed, and the curvatures are formed in the segments S_1, S_2 ..... S_n by the walls 67 of the passages 66. As is shown in figure 11A, free spaces 68 are present between the passages of adjacent parts 65. The pipe 21 will slightly move out at the location of the free space 68, as a result of which the bulges 26 are formed in the zones Z_1, Z_2 .... Z_{n-1}. Thus, the substantially straight pipe 22 is obtained.

[0053] Figures 12A-12B show a similar device 71 according to the invention, which is provided with supports 72, 73 at both ends. After the pipe 21 has been deformed by means of the device 61 or 71 into the substantially straight pipe 22 with segments S_1, S_2 ..... S_n formed therein and zones Z_1, Z_2 .... Z_{n-1} present therebetween, the parts 65 are pivoted relative to each other in the directions indicated by the double arrow, as a result of which the substantially straight pipe 22 is bent to obtain the bent pipe 23. Since the segments S_1, S_2 ..... S_n firmly abut against the walls 67 of the passages 66 during said bending, the segments S_1, S_2 ..... S_n will not deform. The hydraulic pressure applied by the fluid may or may not be maintained during the bending of the substantially straight pipe to form the bent pipe.

[0054] The zones Z_1, Z_2 ..... Z_{n-1} present between the segments S_1, S_2 ..... S_n are deformed further outwards upon forming the bent pipe 23, resulting in the formation of the creases 27. Walls of each crease 27 are pressed firmly together by the ends 69 of the parts 65 during this process.

[0055] It is also possible to carry out the bending of the substantially straight pipe provided with the segments and the zones to obtain the bent pipe by means of a separate device.

[0056] In the theoretical model shown in figure 1-5, the angle α is the same for all the segments S_1, S_2 ..... S_n. It is also possible, however, to have the segments S_1, S_2 ..... S_n extend through different angles α_1, α_2 ..... α_n.

[0057] The forming of the segments and zones in the pipe can take place not only by hydroforming but also by means of explosion transformation, rubber pressing, hot forming, etc.

Claims

1. A method for producing a bent pipe (1, 23, 31, 41, 51) comprising at least one desired curvature, wherein a substantially straight pipe (10, 11, 22) is divided into a number of segments (S_1, S_2...S_n) and zones present between two successive segments (S_1, S_2...S_n), **characterised in that** prior to the forming of the bent pipe (1, 23, 31, 41, 51), each segment of the substantially straight pipe (10, 11, 22) is provided with a local curvature of the segment (S_1, S_2...S_n) in question of the bent pipe (1, 23, 31, 41, 51) eventually to be formed, whereupon all segments (S_1, S_2...S_n) of the substantially straight pipe (10, 11, 22) are pivoted relative to each other and are moved towards each other, with the local curvatures of the adjoining segments (S_1, S_2...S_n) becoming aligned and the, preferably contiguous, local curvatures forming a continuous curvature in the bent pipe (1, 23, 31, 41, 51), with the bent pipe (1, 23, 31, 41, 51) exhibiting the desired curvature.

2. A method according to claim 1, **characterised in that** the local curvature of a segment (S_1, S_2...S_n) before pivoting the segments (S_1, S_2...S_n) relative to each other has a smaller radius (R_{i1}, R_{i2}...R_{in}) on a side which will form an inside bend (3) than on a side which will form an outside bend (4) of the to be formed bent pipe (1, 23, 31, 41, 51).

3. A method according to claim 1 or 2, **characterised in that** the internal wall (24) on the outside bend (4) of the curvature of the bent pipe (1, 23, 31, 41, 51) is substantially smooth.

4. A method according to any one of the preceding claims, **characterised in that** a segment (S_1, S_2...S_n) of the substantially straight pipe (10, 11, 22) tapers off from a side which will form an inside bend (3) of the bent pipe (1, 23, 31, 41, 51) to a side which will form an outside bend (4) of the bent pipe (1, 23, 31, 41, 51).

5. A method according to any one of the preceding claims, **characterised in that** a zone (Z_1, Z_2...Z_n) comprises a part (34) of the substantially straight pipe (10, 11, 22) that can be creased between two successive segments (S_1, S_2...S_n), wherein each zone (Z_1, Z_2...Z_n) in the bent pipe (1, 23, 31, 41, 51) is folded into a crease (27).

6. A method according to claim 5, **characterised in that** a beginning of a crease (27) is formed in each zone of the substantially straight pipe (10, 11, 22).

7. A method according to any one of the preceding claims 1-4, **characterised in that** a zone (Z_1, Z_2...Z_n) comprises a part (34) of the substantially straight pipe (10, 11, 22) that has been removed between two successive segments (S_1, S_2...S_n), wherein sides of adjacent segments (S_1, S_2 ... S_n) of the bent pipe (1, 23, 31, 41, 51) at least substantially abut against each other.

8. A method according to claim 7, **characterised in that** the abutting sides of the segments (S_1, S_2...S_n) are connected together.

9. A method according to any one of the preceding claims, **characterised in that** the local curvatures are formed by hydroforming.

10. A method according to any one of the preceding claims, **characterised in that** a straight pipe (21) is positioned in a number of pivotally interconnected parts (65), each part (65) comprising at least one curvature to be locally provided on a segment positioned therein, whereupon the pipe is deformed, during which deformation each segment is pressed against the wall (67) of the associated part (65), as a result of which the substantially straight pipe (10, 11, 22) is being formed with each segment (S_1, S_2 ...S_n) being provided with its local curvature, whereupon the parts (65) are subsequently pivoted relative to each other, thus forming the desired curvature in the bent pipe (1, 23, 31, 41, 51).

11. A device (61) suitable for carrying out the method according to any one of the preceding claims, which device (61) comprises a number of pivotally interconnected parts (65), **characterised in that** each part (65) has at least one local curvature, the device (61) comprising two parts (62, 63) to be positioned opposite each other, which are each provided with the pivotally interconnected parts (65) being interconnected via pivot arms (64), wherein mating pivotally interconnected parts (65) of the lower part (63) and the part (62) positioned thereabove jointly define a passage (66) for a pipe to be bent, whose wall (67) is provided with local curvatures which correspond to curvatures to be formed in a segment (S1, S2, ...Sn) of the pipe, and wherein adjoining local curvatures of adjacent pivotally interconnected parts (65) define the curvatures of a bent pipe (1, 23, 31, 41, 51) to be formed by means of the device (61).

Patentansprüche

1. Verfahren zum Herstellen eines gebogenen Rohrs (1, 23, 31, 41, 51), das wenigstens eine gewünschte Krümmung aufweist, wobei ein im Wesentlichen gerades Rohr (10, 11, 22) in eine Anzahl von Segmenten (S_1, S_2,... S_n) und zwischen zwei aufeinanderfolgenden Segmenten (S_1, S_2,... S_n) vorhandenen Zonen unterteilt wird, **dadurch gekennzeichnet,**

dass vor dem Bilden des gebogenen Rohrs (1, 23, 31, 41, 51) jedes Segment des im Wesentlichen geraden Rohrs (10, 11, 22) mit einer lokalen Krümmung des betreffenden Segments (S_1, S_2... S_n) des schließlich zu bildenden gebogenen Rohrs (1, 23, 31, 41, 51) versehen wird, worauf alle Segmente (S_1, S_2... S_n) des im Wesentlichen geraden Rohrs (10, 11, 22) relativ zueinander geschwenkt werden und zueinander hin bewegt werden, wobei die lokalen Krümmungen der benachbarten Segmente (S_1, S_2... S_n) ausgerichtet werden und die, bevorzugt zusammenhängenden, lokalen Krümmungen eine kontinuierliche Krümmung in dem gebogenen Rohr (1, 23, 31, 41, 51) bilden, wobei das gebogene Rohr (1, 23, 31, 41, 51) die gewünschte Krümmung zeigt.

2. Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, dass** die lokale Krümmung eines Segments (S_1, S_2... S_n) vor dem Schwenken der Segmente (S_1, S_2... S_n) relativ zueinander auf einer Seite, die eine innere Biegung (3) des zu bildenden gebogenen Rohrs (1, 23, 31, 41, 51) bilden wird, einen kleineren Radius (R_{i1}, R_{i2} ... R_{in}) hat als auf einer Seite, die eine äußere Biegung (4) desselben bilden wird.

3. Verfahren gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Innenwand (24) an der äußeren Biegung (4) der Krümmung des gebogenen Rohrs (1, 23, 31, 41, 51) im Wesentlichen glatt ist.

4. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** ein Segment (S_1, S_2... S_n) des im Wesentlichen geraden Rohrs (10, 11, 22) sich von einer Seite, die eine innere Biegung (3) des gebogenen Rohrs (1, 23, 31, 41, 51) bilden wird, zu einer Seite, die eine äußere Biegung (4) des gebogenen Rohrs (1, 23, 31, 41, 51) bilden wird, verjüngt.

5. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** eine Zone (Z_1, Z_2... Z_n) einen Teil (34) des im Wesentlichen geraden Rohrs (10, 11, 22), der mit Falten versehen sein kann, zwischen zwei aufeinanderfolgenden Segmenten (S_1, S_2... S_n) aufweist, wobei jede Zone (Z_1, Z_2... Z_n) in dem gebogenen Rohr (1, 23, 31, 41, 51) zu einer Falte (27) gefaltet ist.

6. Verfahren gemäß Anspruch 5, **dadurch gekennzeichnet, dass** ein Anfang einer Falte (27) in jeder Zone des im Wesentlichen geraden Rohrs (10, 11, 22) gefaltet ist.

7. Verfahren gemäß einem der vorhergehenden Ansprüche 1 - 4, **dadurch gekennzeichnet, dass** eine Zone (Z_1, Z_2... Z_n) einen Teil (34) des im Wesentlichen geraden Rohrs (10, 11, 22), der entfernt wurde, zwischen zwei aufeinanderfolgenden Segmenten (S_1, S_2... S_n) aufweist, wobei Seiten von angrenzenden Segmenten (S_1, S_2,... S_n) des gebogenen Rohrs (1, 23, 31, 41, 51) zumindest im Wesentlichen gegeneinander anliegen.

8. Verfahren gemäß Anspruch 7, **dadurch gekennzeichnet, dass** die anliegenden Seiten der Segmente (S_1, S_2... S_n) miteinander verbunden sind.

9. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die lokalen Krümmungen durch Innenhochdruckumfornung gebildet sind.

10. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** ein gerades Rohr (21) in einer Anzahl von schwenkbar verbundenen Teilen (65) angeordnet wird, wobei jeder Teil (65) wenigstens eine lokal an einem darin angeordneten Segment bereitzustellende Krümmung aufweist, worauf das Rohr verformt wird, wobei während dieser Verformung jedes Segment gegen die Wand (67) des zugeordneten Teils (65) gepresst wird, wodurch das im Wesentlichen gerade Rohr (10, 11, 22) geformt wird, wobei jedes Segment (S_1, S_2... S_n) mit seiner lokalen Krümmung versehen wird, worauf die Teile (65) nachfolgend relativ zueinander geschwenkt werden, so dass die gewünschte Krümmung in dem gebogenen Rohr (1, 23, 31, 41, 51) gebildet wird.

11. Vorrichtung (61), die zum Durchführen des Verfahrens gemäß einem der vorhergehen Ansprüche geeignet ist, wobei die Vorrichtung (61) eine Anzahl von schwenkbar verbundenen Teilen (65) aufweist, **dadurch gekennzeichnet, dass** jeder Teil (65) wenigstens eine lokale Krümmung hat, wobei die Vorrichtung (61) zwei einander gegenüber anzuordnende Teile (62, 63) aufweist, die jeweils mit den schwenkbar verbundenen Teilen (65) versehen sind, die über Schwenkarms (64) verbunden sind, wobei zusammenpassende schwenkbar verbundene Teile (65) des unteren Teils (63) und des darüber angeordneten Teils (62) gemeinsam einen Durchgang (66) für ein zu biegendes Rohr bilden, dessen Wand (67) mit lokalen Krümmungen versehen ist, die in einem Segment (S_1, S_2... S_n) des Rohrs zu bildenden Krümmungen entsprechen, und wobei benachbarte lokale Krümmungen von angrenzenden schwenkbar verbundenen Teilen (65) die Krümmungen eines mittels der Vorrichtung (61) zu bildenden gebogenen Rohrs (1, 23, 31, 41, 51) bestimmen.

Revendications

1. Procédé de production d'un tube cintré (1, 23, 31,

41, 51) comprenant au moins une courbure souhaitée, dans lequel un tube sensiblement droit (10, 11, 22) est divisé en un nombre de segments (S_1, S_2... S_n) et de zones présentes entre deux segments successifs (S_1, S_2... S_n), **caractérisé en ce qu'**avant la formation du tube cintré (1, 23, 31, 41, 51), chaque segment du tube sensiblement droit (10, 11, 22) est doté d'une courbure locale du segment (S_1, S_2... S_n) en question du tube cintré (1, 23, 31, 41, 51) à former éventuellement, après quoi tous les segments (S_1, S_2... S_n) du tube sensiblement droit (10, 11, 22) sont pivotés les uns par rapport aux autres et sont déplacés les uns vers les autres, les courbures locales des segments attenants (S_1, S_2... S_n) s'alignant et les courbures locales, de préférence contiguës, formant une courbure continue dans le tube cintré (1, 23, 31, 41, 51), le tube cintré (1, 23, 31, 41, 51) présentant la courbure souhaitée.

2. Procédé selon la revendication 1, **caractérisé en ce que** la courbure locale d'un segment (S_1, S_2... S_n), avant le pivotement des segments (S_1, S_2... S_n) les uns par rapport aux autres, a un rayon plus petit (R_{i1}, R_{i2}... R_{in}) sur un côté qui formera un coude intérieur (3) que sur un côté qui formera un coude extérieur (4) du tube cintré à former (1, 23, 31, 41, 51).

3. Procédé selon la revendication 1 ou 2, **caractérisé en ce que** la paroi interne (24) sur le coude extérieur (4) de la courbure du tube cintré (1, 23, 31, 41, 51) est sensiblement lisse.

4. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**un segment (S_1, S_2... S_n) du tube sensiblement droit (10, 11, 22) s'effile depuis un côté qui formera un coude intérieur (3) du tube cintré (1, 23, 31, 41, 51) jusqu'à un côté qui formera un coude extérieur (4) du tube cintré (1, 23, 31, 41, 51).

5. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**une zone (Z_1, Z_2... Z_n) comprend une partie (34) du tube sensiblement droit (10, 11, 22) qui peut être pliée entre deux segments successifs (S_1, S_2... S_n) ; dans lequel chaque zone (Z_1, Z_2... Z_n) du tube cintré (1, 23, 31, 41, 51) est pliée en un pli (27).

6. Procédé selon la revendication 5, **caractérisé en ce qu'**un début de pli (27) est formé dans chaque zone du tube sensiblement droit (10, 11, 22).

7. Procédé selon l'une quelconque des revendications 1 à 4 précédentes, **caractérisé en ce qu'**une zone (Z_1, Z_2... Z_n) comprend une partie (34) du tube sensiblement droit (10, 11, 22) qui a été retirée entre deux segments successifs (S_1, S_2... S_n) ; dans lequel des côtés de segments adjacents (S_1, S_2... S_n) du tube cintré (1, 23, 31, 41, 51) viennent au moins sensiblement en butée les uns contre les autres.

8. Procédé selon la revendication 7, **caractérisé en ce que** les côtés en butée des segments (S_1, S_2... S_n) sont reliés entre eux.

9. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les courbures locales sont formées par hydroformage.

10. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**un tube droit (21) est positionné à l'intérieur d'un certain nombre de parties reliées entre elles en pivotement (65), chaque partie (65) comprenant au moins une courbure à former localement dans un segment positionné à l'intérieur ; après quoi le tube est déformé, déformation pendant laquelle chaque segment est appuyé contre la paroi (67) de la partie associée (65), en conséquence de quoi le tube sensiblement droit (10, 11, 22) est formé avec chaque segment (S_1, S_2... S_n) doté de sa courbure locale ; après quoi les parties (65) sont par la suite pivotées les unes par rapport aux autres, formant ainsi la courbure souhaitée dans le tube cintré (1, 23, 31, 41, 51).

11. Dispositif (61) adapté pour réaliser le procédé selon l'une quelconque des revendications précédentes, lequel dispositif (61) comprend un certain nombre de parties reliées entre elles en pivotement (65), **caractérisé en ce que** chaque partie (65) a au moins une courbure locale ; le dispositif (61) comprenant deux parties (62, 63) à positionner en opposition l'une par rapport à l'autre, qui sont dotées chacune de parties reliées entre elles en pivotement (65), reliées entre elles via des bras de pivot (64) ; dans lequel les parties reliées entre elles en pivotement (65) couplant la partie inférieure (63) et la partie (62) positionnée dessus, définissent conjointement un passage (66) pour un tube à cintrer ; dont la paroi (67) est dotée de courbures locales qui correspondent à des courbures à former dans un segment (S_1, S_2... S_n) du tube, et dans lequel des courbures locales attenantes de parties adjacentes (65) reliées en pivotement définissent les courbures d'un tube cintré (1, 23, 31, 41, 51) à former au moyen du dispositif (61).

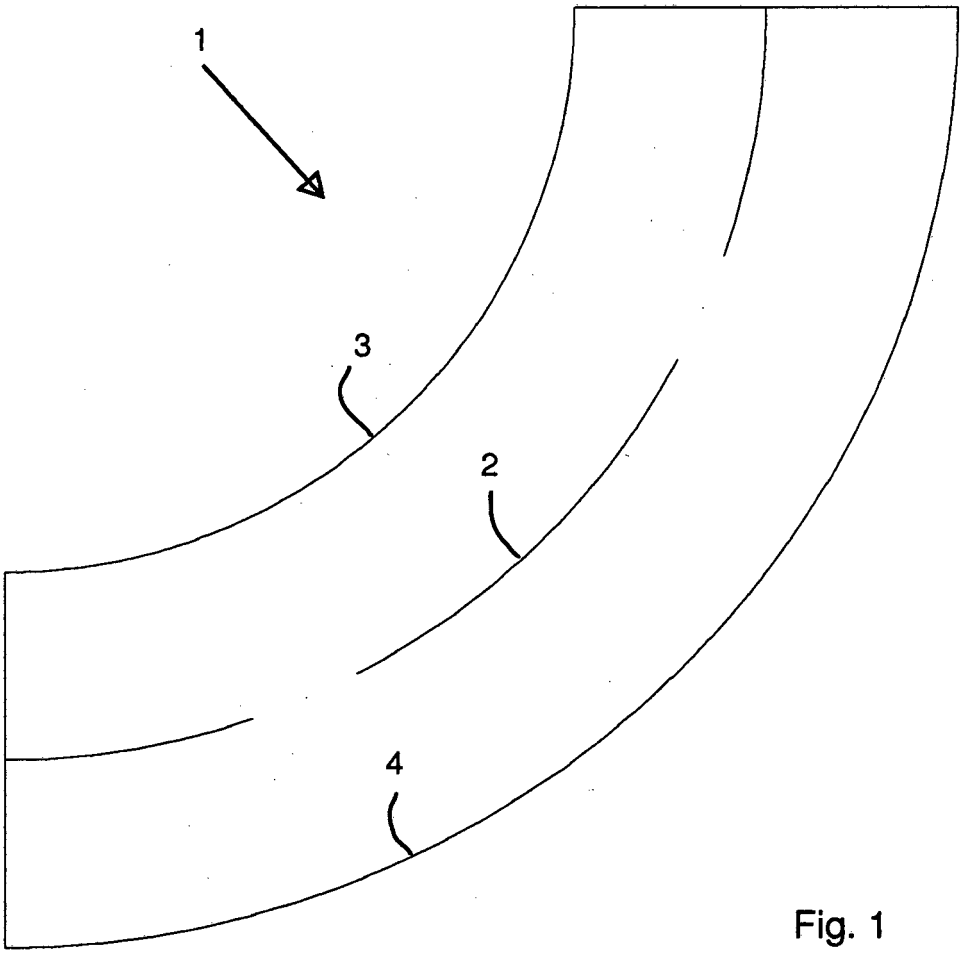


Fig. 1

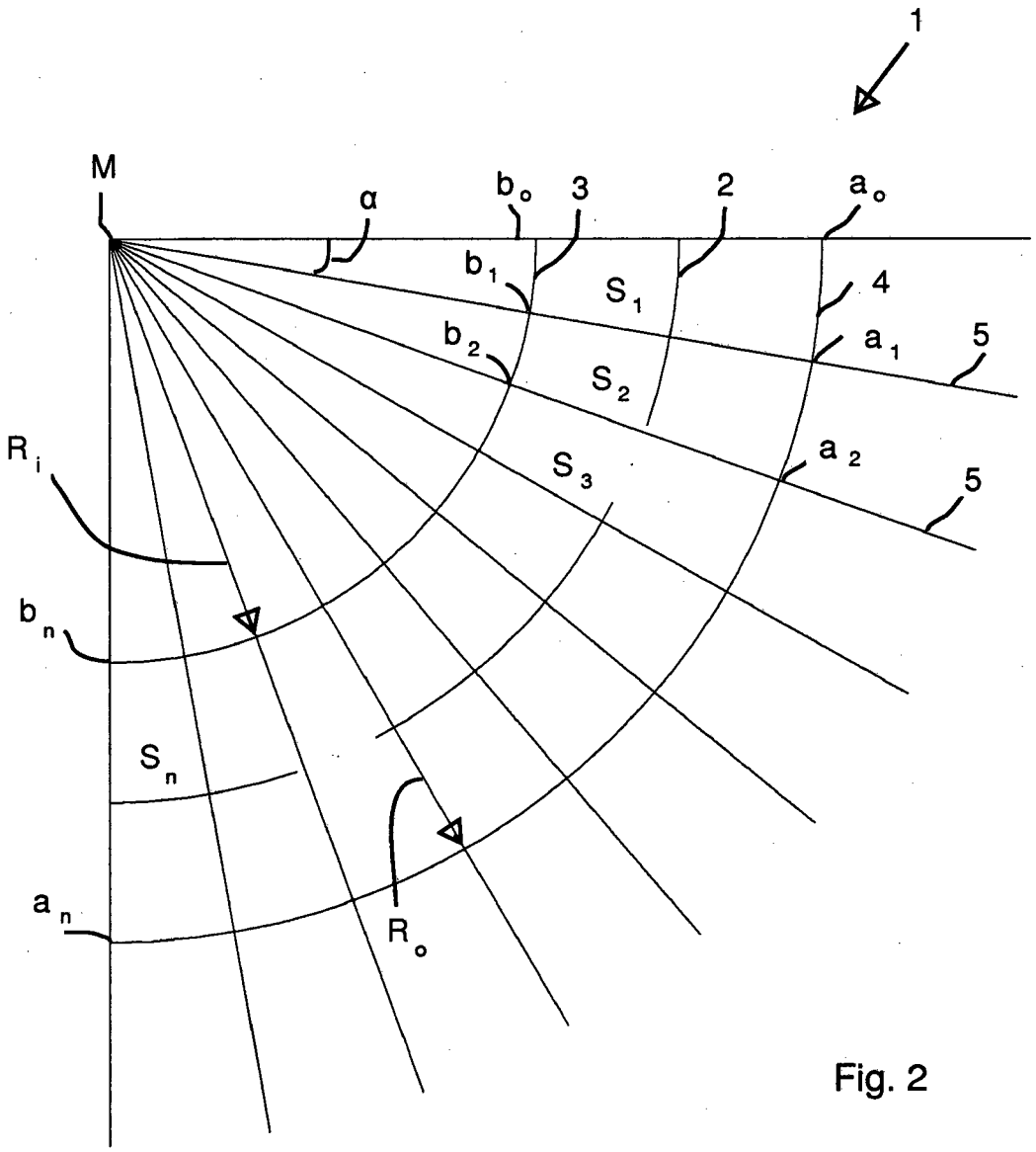


Fig. 2

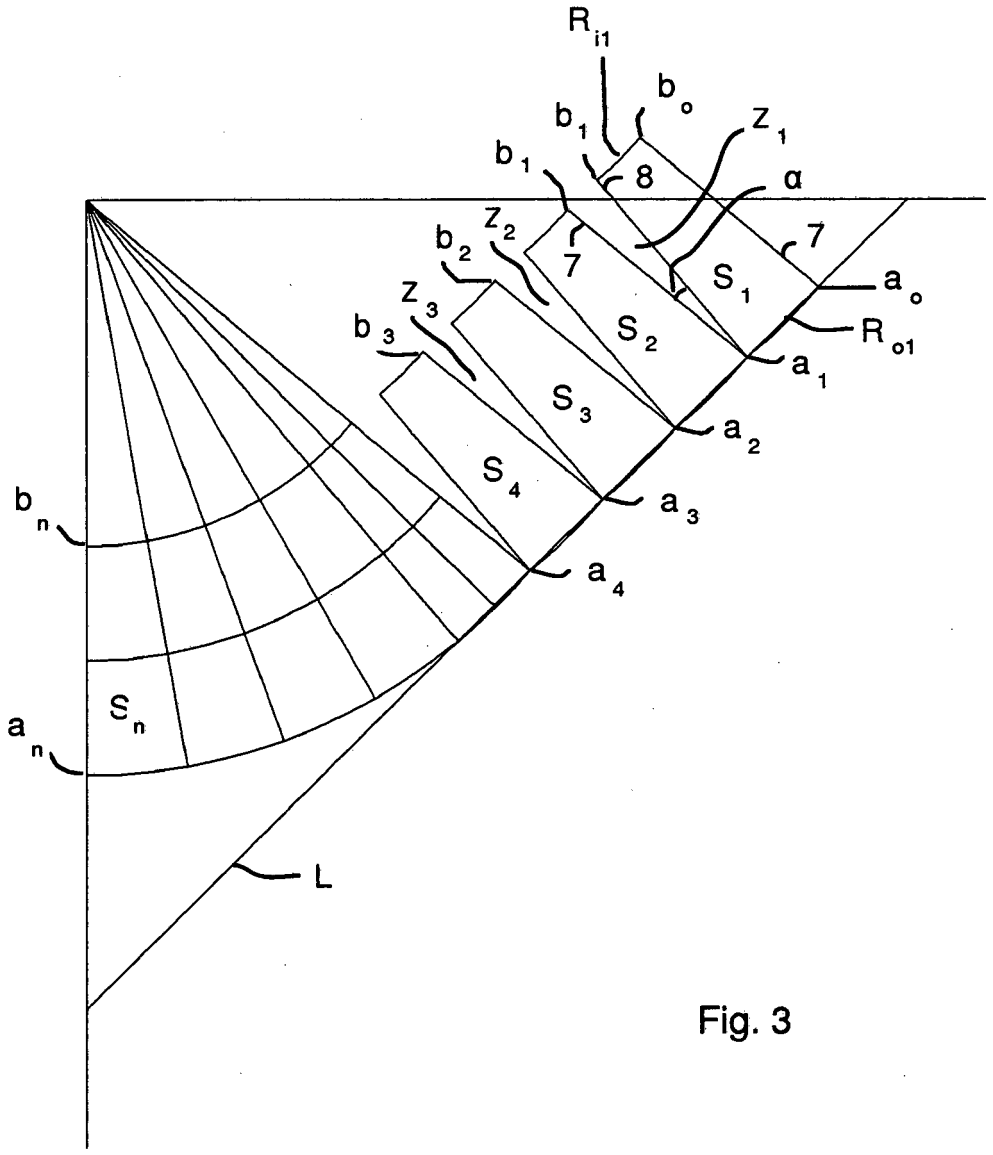

R i1
b o
b 1
Z 1
b 1
8
α
Z 2
b 2
7
7
S 1
a o
Z 3
S 2
R o1
b 3
a 1
S 3
a 2
S 4
a 3
b n
a 4
S n
a n
L

Fig. 3

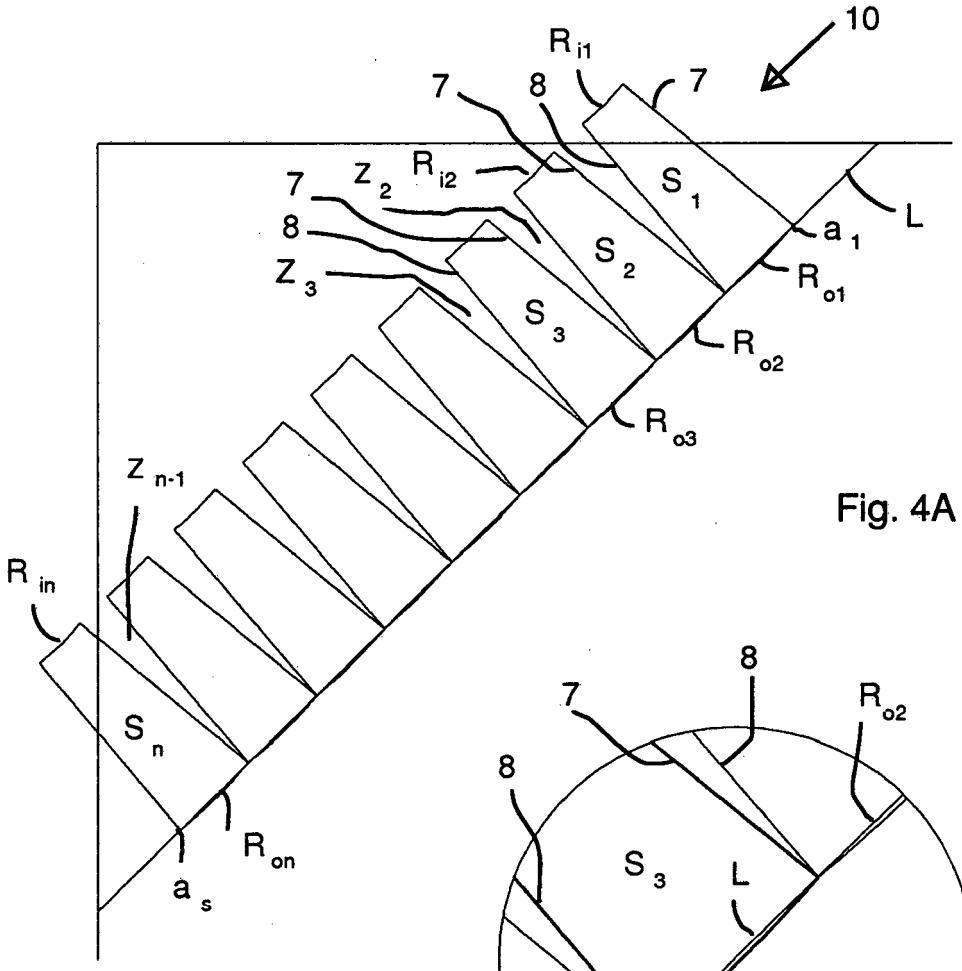

10
R_{i1}
7
8
7
Z_2
R_{i2}
7
8
Z_3
S_1
S_2
S_3
L
a_1
R_{o1}
R_{o2}
R_{o3}
Z_{n-1}
R_{in}
S_n
R_{on}
a_s

Fig. 4A

8
7
R_{o2}
8
S_3
L
R_{o3}

Fig. 4B

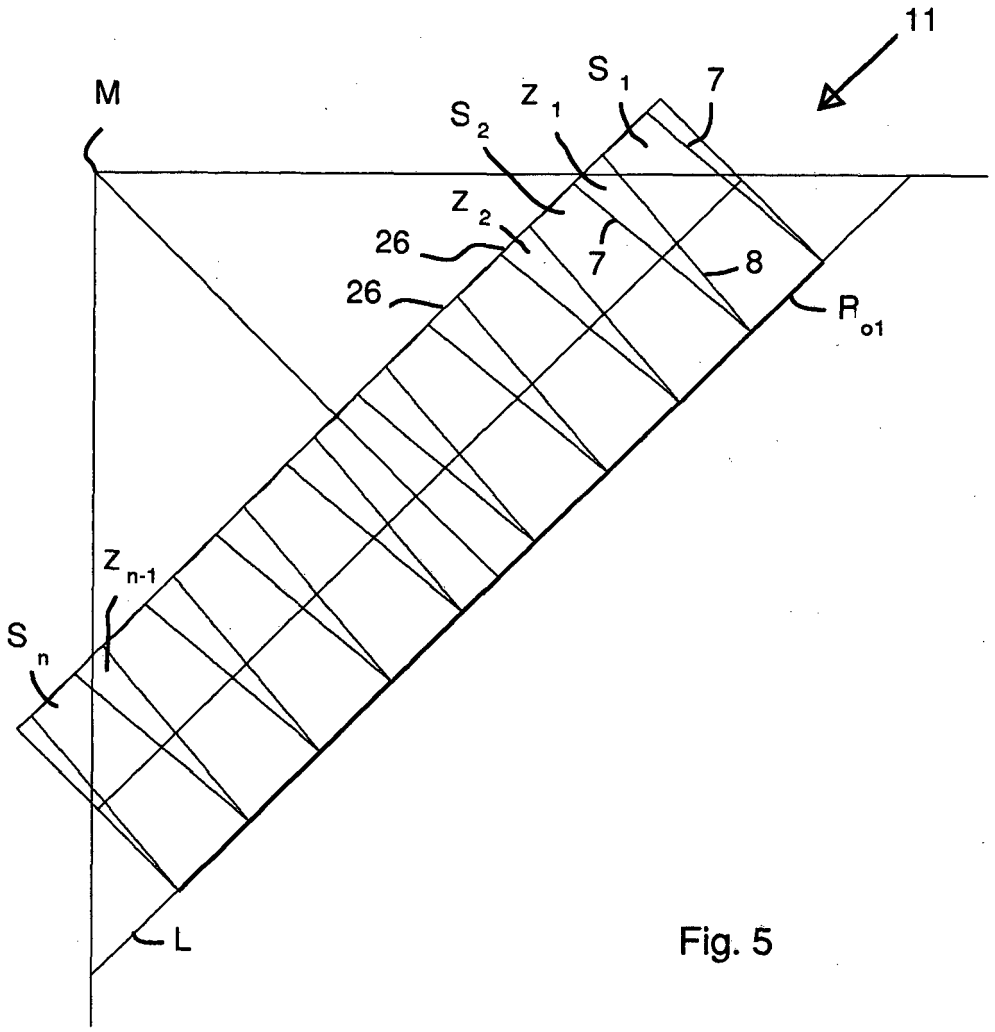


Fig. 5

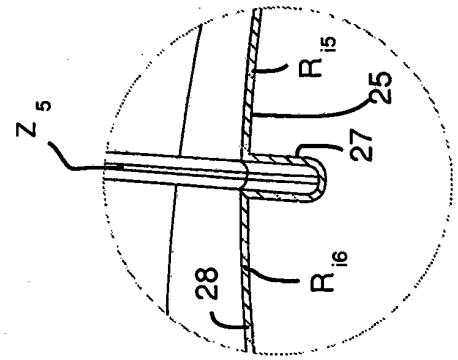


Fig. 6E

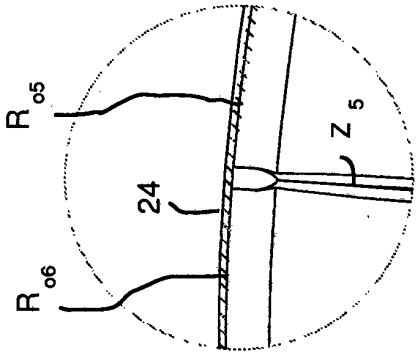


Fig. 6D

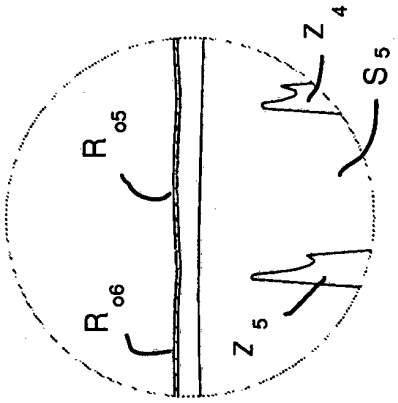


Fig. 6B

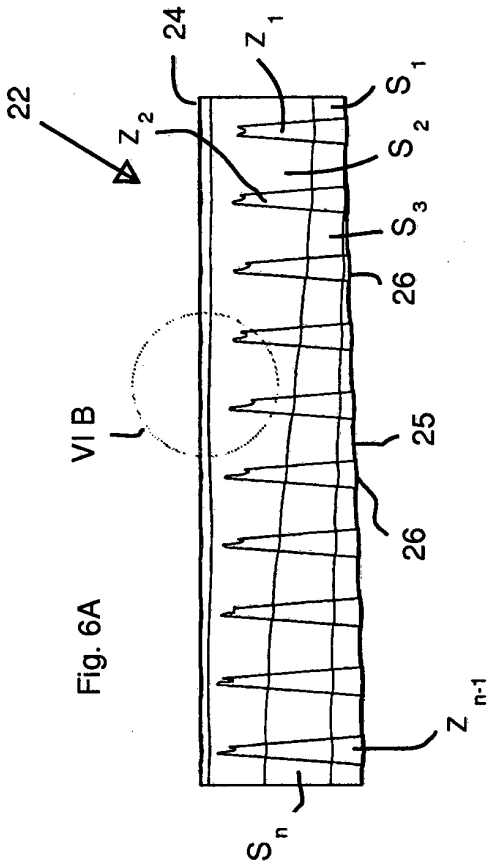


Fig. 6A

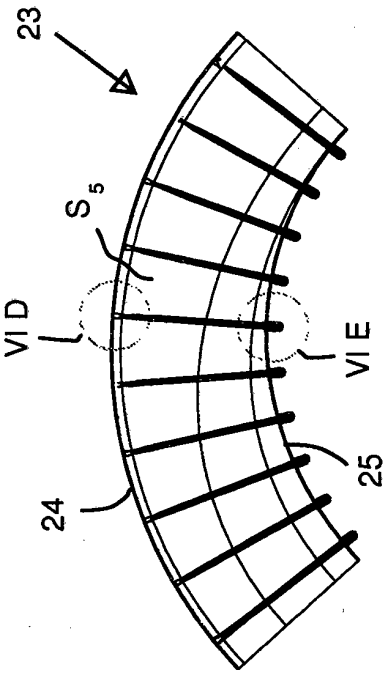
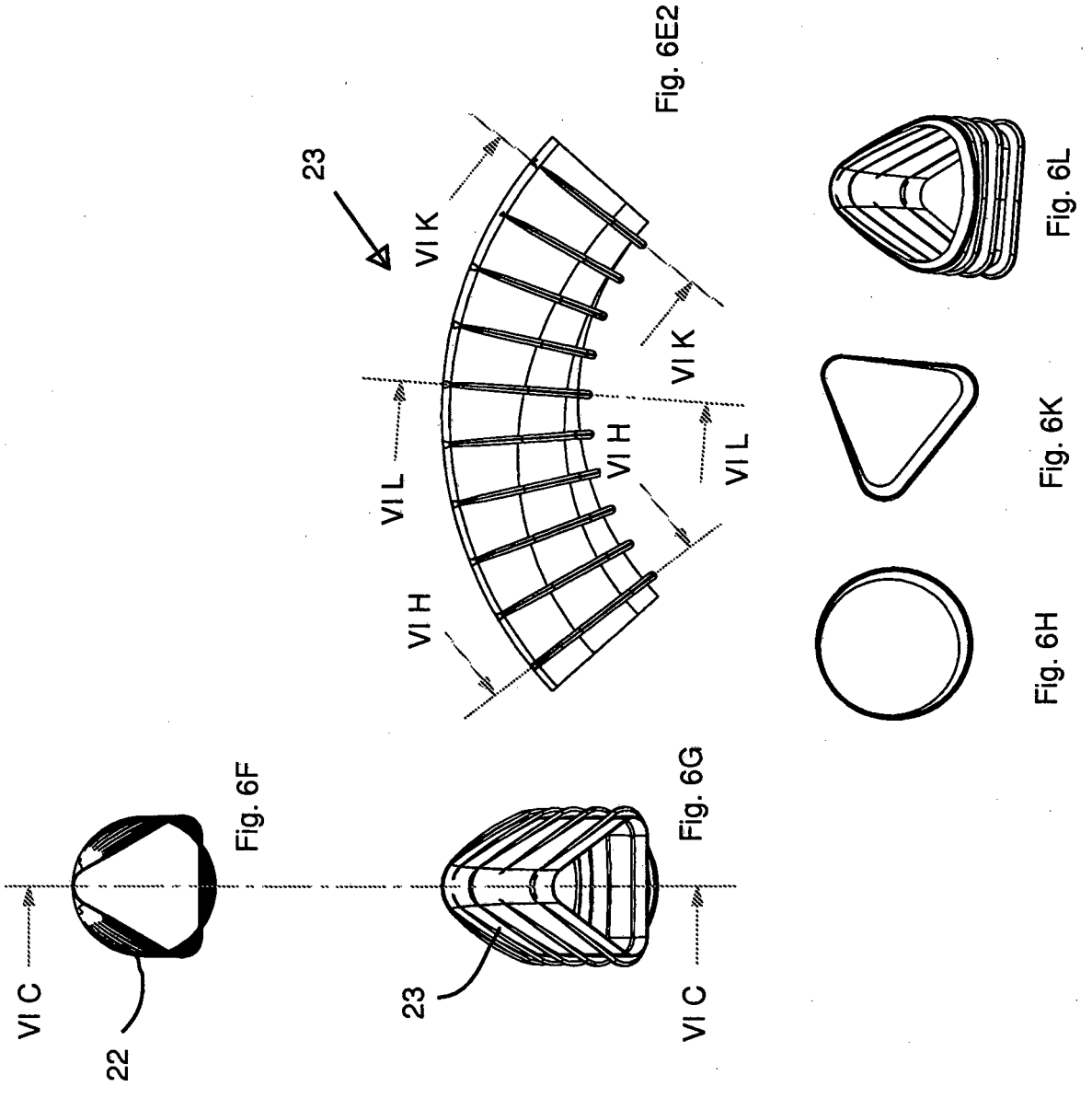


Fig. 6E1


VI C
22
VI C
23
VI L
VI H
VI K
VI H
VI L
VI K
23
Fig. 6F
Fig. 6G
Fig. 6E2
Fig. 6H
Fig. 6K
Fig. 6L

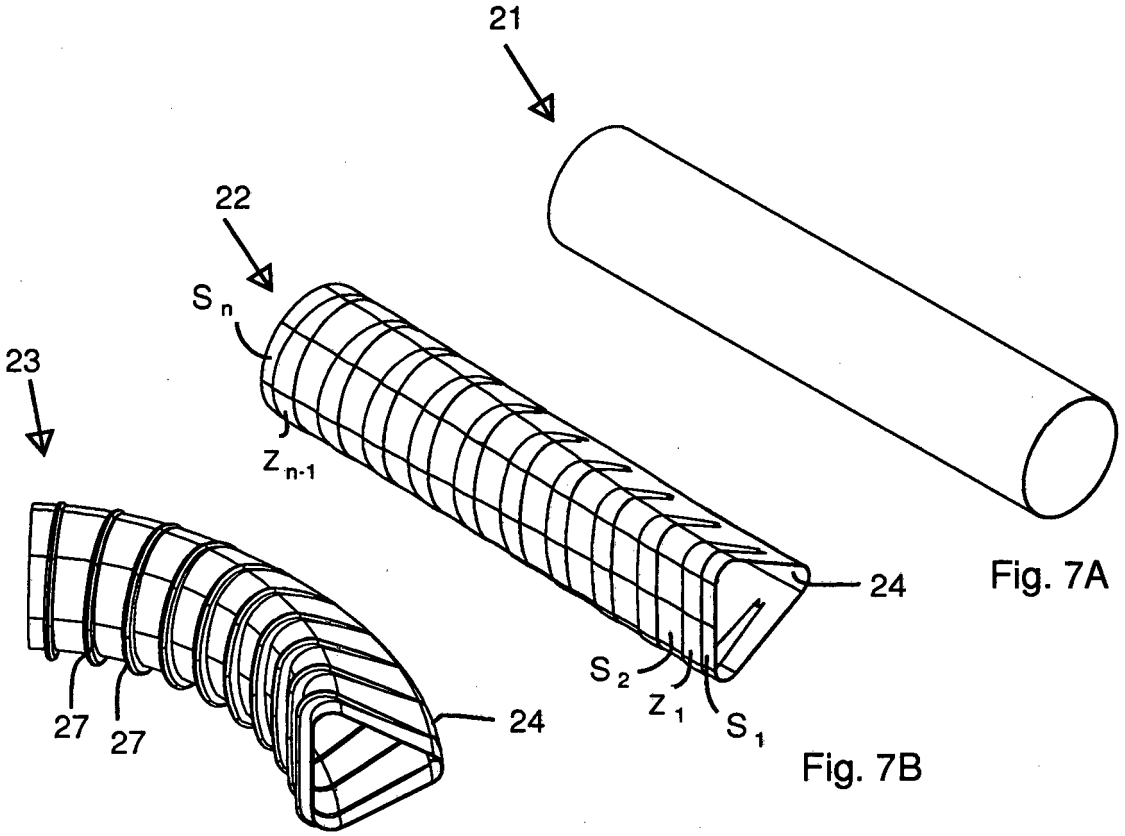


Fig. 7A

Fig. 7B

Fig. 7D

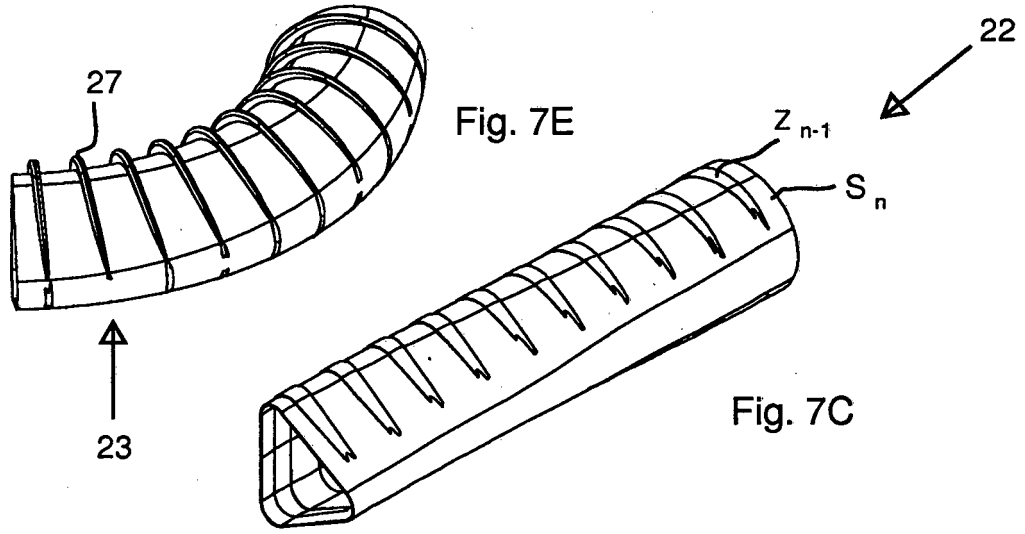


Fig. 7E

Fig. 7C

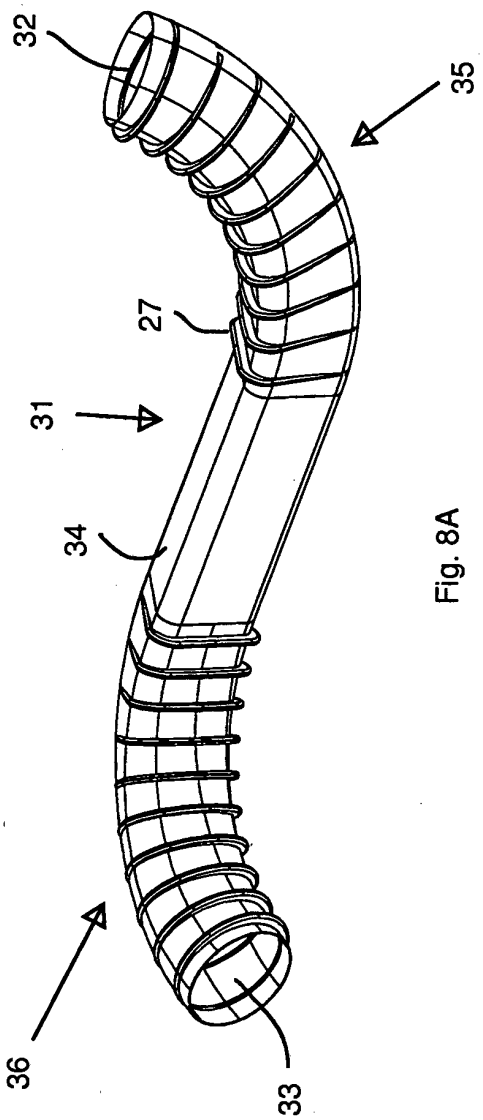


Fig. 8A

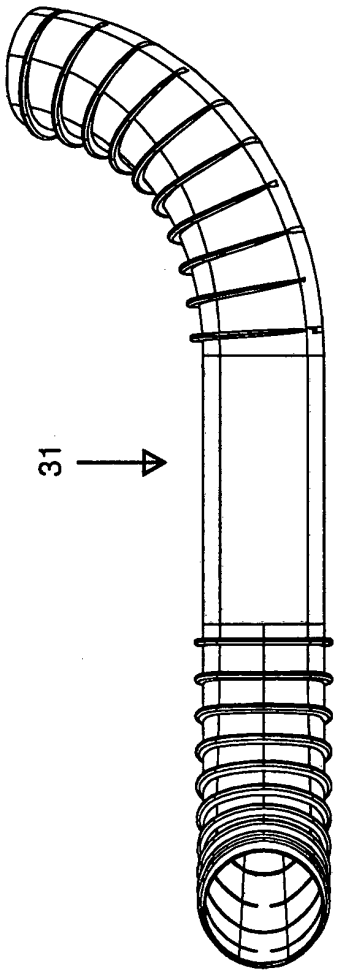


Fig. 8b

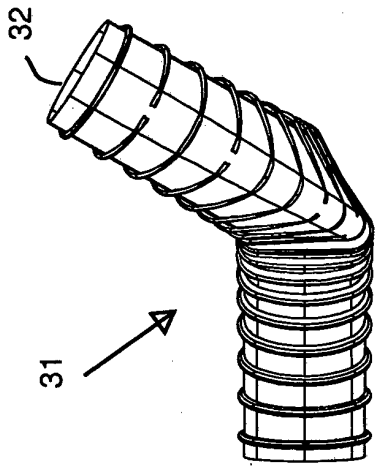


Fig. 8C

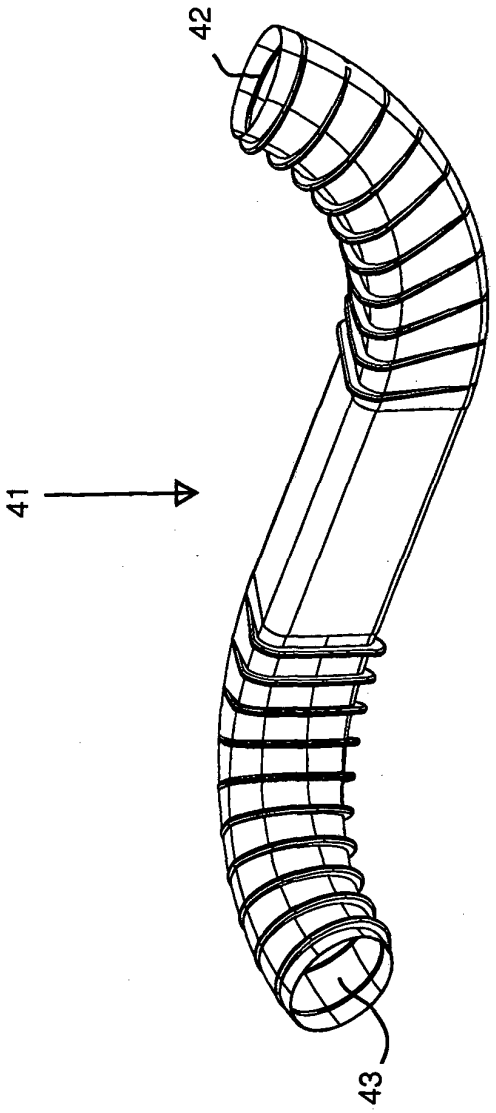


Fig. 9A

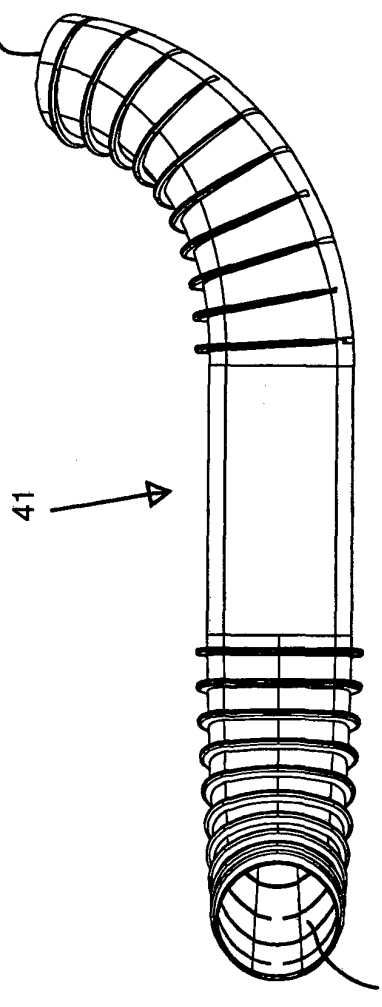


Fig. 9B

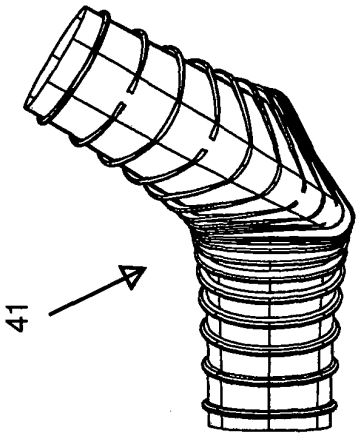


Fig. 9C

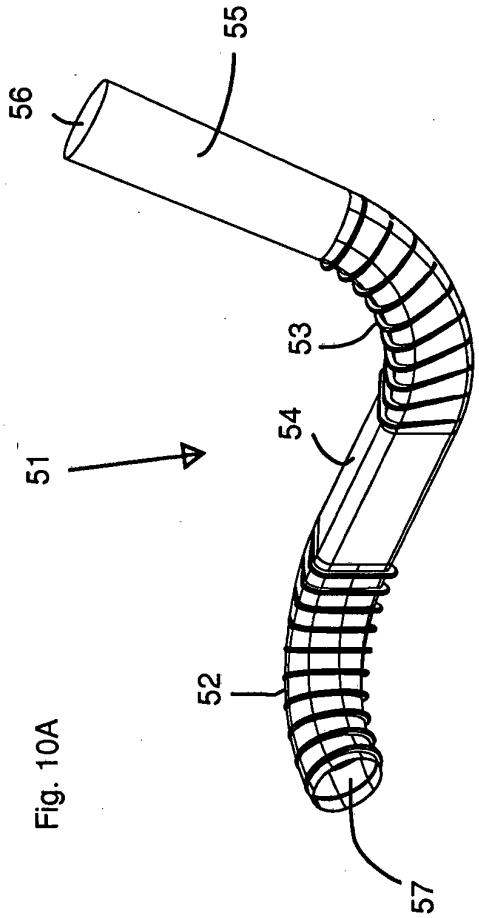


Fig. 10A

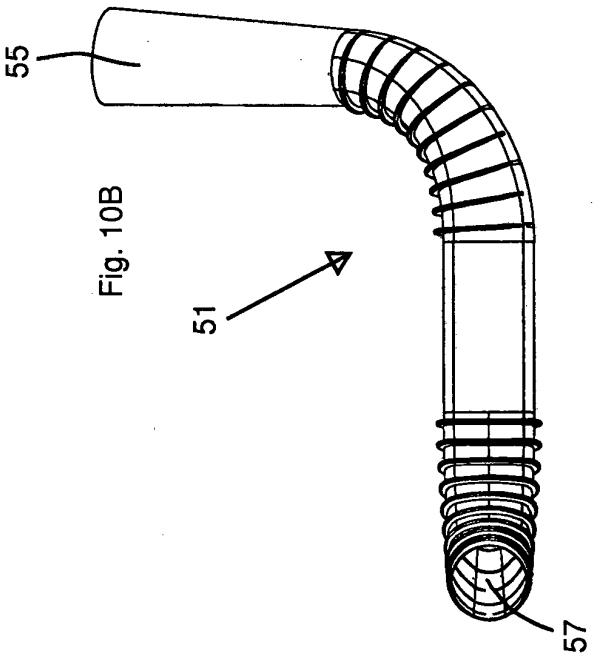


Fig. 10B

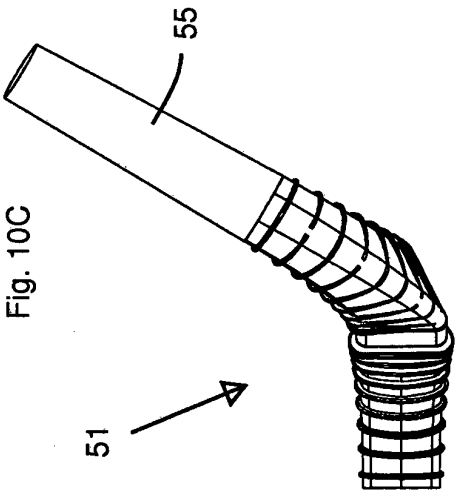


Fig. 10C

fig. 11B

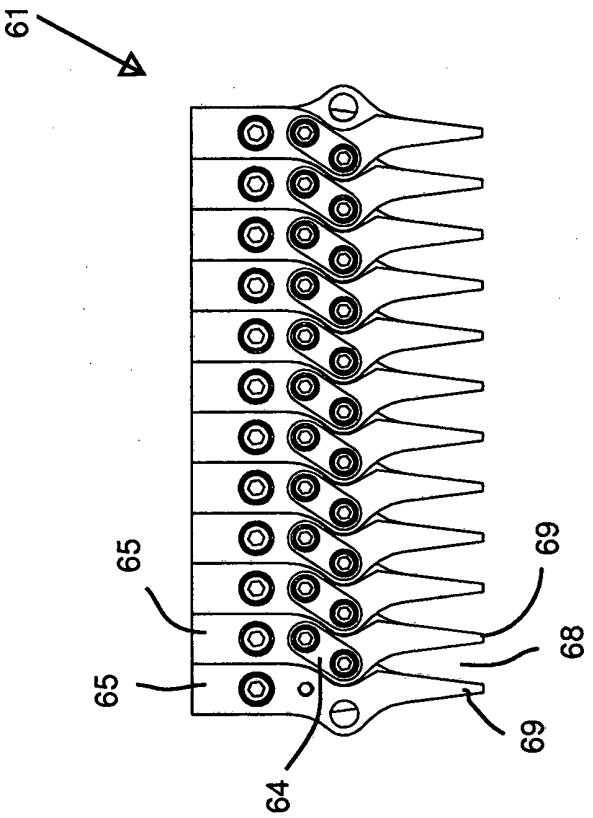
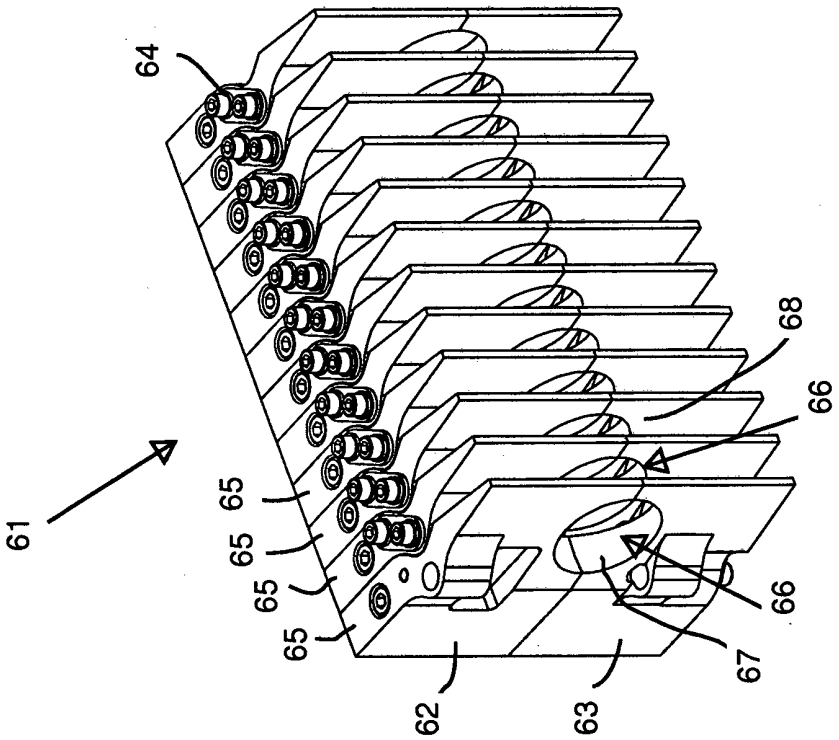


fig. 11A



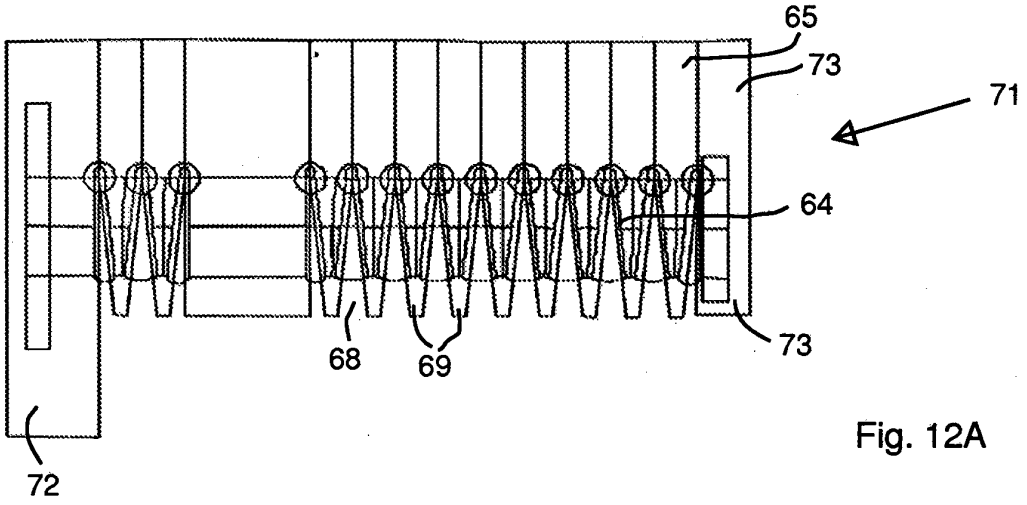


Fig. 12A

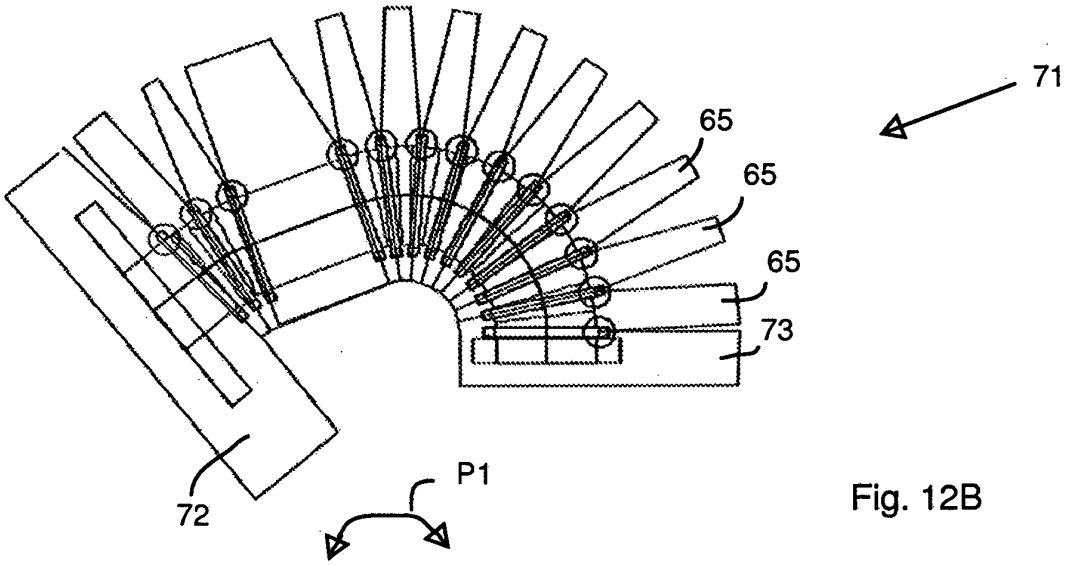


Fig. 12B

REFERENCES CITED IN THE DESCRIPTION

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