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(71) Applicant: **Pedrazzoli lbp spa**
36061 Bassano del Grappa (VI) (IT)

(72) Inventor: **Pedrazzoli, Antonio Maria,**
c/o Pedrazzoli IBP SPA
36061 Bassano del Grappa (VI) (IT)

(74) Representative: **Bonini, Ercole**
c/o STUDIO ING. E. BONINI SRL
Corso Fogazzaro 8
36100 Vicenza (IT)

(54) Method and machine for bending tubular elements to a variable radius of curvature

(57) A bending method for tubular elements in a bending machine (1) comprising a central vice (3) and two moving bending heads (4, 5) provided with bending means (11) and positioned on the sides of the vice (3). The method comprises the following operations: positioning a tubular element (T) inside the vice (3) and the bending heads (4, 5); holding a tubular element (T) in bending position inside the vice (3) and the bending heads (4, 5); rotating the bending means (11) of the bending heads (4, 5) to bend the tubular element (T), the rotation of the bending means (11) being combined with the travel of the bending heads (4, 5) with respect to the vice (3) to make bends with variable radius of curvature on the tubular element (T).

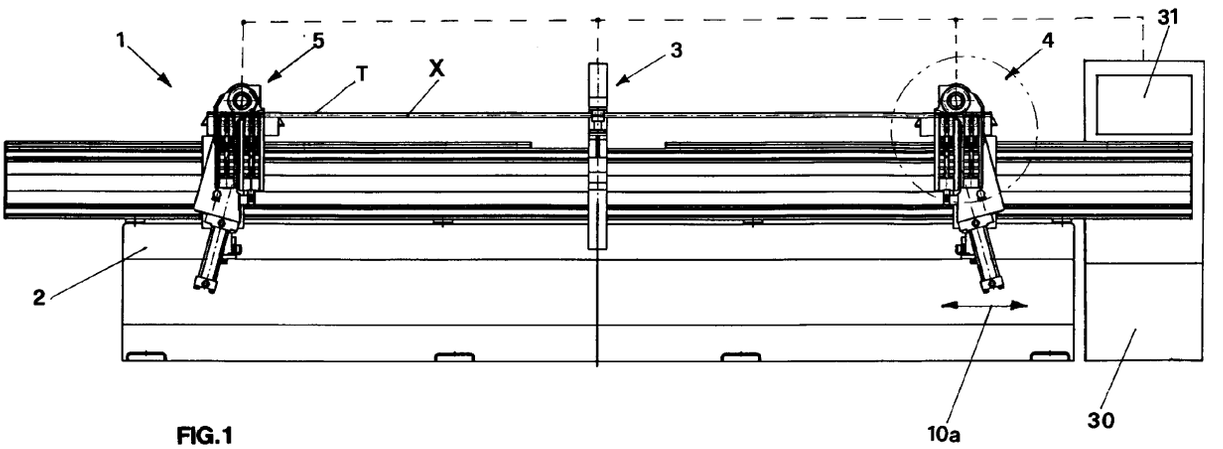

FIG.1

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Description

[0001] The invention concerns a method for bending tubular elements to an adjustable radius of curvature and a bending machine that implements said method for bending tubular elements.

[0002] It is known that to bend tubular elements apposite bending machines are used, which basically comprise a vice to hold the tubular element firmly in bending position and a bending head provided with a female die and a male die that are set rotating around an axis by power means.

[0003] The bending head can be moved with respect to the vice, so that the tubular element can be bent in different positions.

[0004] To obtain greater productivity, sometimes bending machines are equipped with two bending heads positioned at the sides of the vice, in such a way as to obtain two bends at the same time.

[0005] The bending machines of the known type have the drawback that to vary the radius of curvature it is necessary to use dies with different average radius; therefore, the user must have several male and female dies, according to the different radiuses of curvature to be obtained on the same tubular element.

[0006] Bending machines with a single bending head are also known, in which the vice that holds the tubular element in bending position can be moved with respect to the bending head.

[0007] In this way, with suitable equipment installed on the bending head, it is possible to obtain bends with variable radius, by moving the vice with respect to the bending head, so that the tubular element slides between the female die and the male die that make the bend.

[0008] These bending machines make it possible to obtain bends with variable and also with fixed radius of curvature using the same equipment, but have the drawback that only one bend at a time can be made on the tubular element.

[0009] The invention intends to overcome the drawback mentioned above, through the implementation of a method that makes it possible to obtain two bends in two different positions on the tubular element, at least one of which with variable radius of curvature, with no need to replace the bending female and male dies.

[0010] The invention also aims to make bends with fixed radius of curvature in any position on the same tubular element.

[0011] A further aim is to make one bend with fixed radius of curvature and another bend with variable radius of curvature at the same time on the same tubular element.

[0012] The aims mentioned above are achieved through the implementation of a bending method particularly suitable for bending tubular elements with a bending machine of the type comprising a central vice and two movable bending heads provided with bending means, positioned one on the right side and one on the left side of said vice, wherein according to the main claim said bending method comprises the following operations:

- positioning a tubular element in said vice and between said bending heads;
- holding said tubular element in bending position in said vice and between said bending heads;
- rotating said bending means of said bending heads to bend said tubular element,

and is characterized in that said rotation of said bending means is combined with the travel of said bending heads with respect to said vice to obtain bends with variable radius of curvature on said tubular element.

[0013] The value of the angular displacement of the bending means during rotation and the value of the linear displacement of the bending head during travel are variable and independent of each other.

[0014] The profile of the bend to carry out is defined by properly combining the value of the angular displacement of the bending means and the value of the linear displacement of the bending head.

[0015] The bending machine that implements the method described above comprises:

- a base with mainly longitudinal configuration;
- a central vice resting on said base and provided with clamping means to hold the tubular element that must be bent;
- two bending heads that can be moved along said base, provided with means to bend said tubular element and positioned one on the right side and the other on the left side of said vice;
- power means to rotate said vice and to move said bending heads along said base;
- actuators to rotate said bending means,

and is characterized in that said power means and said actuators are interfaced with an electronic storage, processing and control unit suited to combine the rotation of said bending means with the longitudinal movement of said bending heads along said base according to preset values, in order to obtain bends with variable radius of curvature on said tubular element.

[0016] According to a favourite application of the invention the vice is also provided with power means suited to move it on a horizontal plane in orthogonal direction with respect to the movement of the bending heads along the base, in order to allow the tube to be adapted to the different equipment installed on the heads.

[0017] Furthermore, the bending heads are provided with means to move them vertically, in order to adapt the bending equipment to the tubular element that must be bent.

[0018] To advantage, the bending machine that carries out the method of the invention can be derived from

a bending machine of the known type, comprising a base with central vice and two side heads positioned one on the right and one on the left of the vice, which is modified through the application of the above mentioned electronic storage, processing and control unit to manage the power means and the actuators.

[0019] In particular, the combination of the linear movement of the bending head with the rotation of the bending means gives the opportunity to make bends with variable radius of curvature in different positions on the tubular element.

[0020] The machine object of the invention thus makes it possible to obtain two bends with variable radius of curvature at the same time on the same tubular element, thus increasing productivity in comparison with the known bending machines that allow bends with variable radius of curvature to be made only one by one.

[0021] Still to advantage, the machine object of the invention may in any case be used also to make bends with fixed radius of curvature, if during the bending operation the bending heads are not moved longitudinally with respect to the vice.

[0022] Another advantage is represented by the fact that the machine object of the invention can make one bend with fixed radius of curvature and one bend with variable radius of curvature at the same time, by keeping only one of the two bending heads fixed.

[0023] A further advantage is represented by the fact that the movement of the vice on the horizontal plane perpendicularly to the movement of the bending heads and the vertical movement of the latter allows the tube that must be bent to be adapted to different bending equipment.

[0024] The aims and advantages mentioned above will be highlighted in greater detail in the description of one among many possible embodiments of the bending machine and bending method implemented by said machine, with reference to the enclosed drawings, in which:

- Figure 1 is a front view of the bending machine object of the invention at rest;
- Figure 2 shows an enlargement of a detail of Figure 1;
- Figure 3 shows the bending machine of Figure 1 during the first step of the process;
- Figure 4 shows an enlargement of a detail of Figure 3;
- Figure 5 shows the bending machine of Figure 3 during the second step of the process;
- Figure 6 shows an enlargement of a detail of Figure 5;
- Figures from 7 to 12 show the machine object of the invention during the performance of a bending cycle on a tubular element.

[0025] The bending method object of the invention is described with reference to a bending machine, indicated as a whole by **1,** which can be seen in a front view in Figures 1, 3, 5 and also in the successive Figures from 7 to 12, where it is represented in total or partial axonometric view.

[0026] The bending machine **1** comprises a base **2** that supports a vice, indicated as a whole by **3,** practically positioned at the centre of the base **2,** wherein on the right and left side of said vice there are two bending heads, indicated by **4** and **5**, respectively.

[0027] The two bending heads **4** and **5** can be moved along the base with respect to the vice **3,** with a linear sliding movement.

[0028] In particular, each bending head can be moved in a direction parallel to the longitudinal axis **X** of the tubular element to be bent **T,** which is practically placed in horizontal position and supported by the bending heads **4** and **5** and by the vice **3**.

[0029] As to the vice **3**, it can be observed, with particular reference to Figures 7 and 9, that it includes a substantially circular disc **6** provided with a radial slot **7** that develops with a length that is greater than its radius.

[0030] In the slot **7** there are the clamping means for the tubular element to be bent **T,** which are indicated as a whole by **8** and include, as can be observed in greater detail in Figures 11 and 12, a pair of opposing jaws **8a, 8b,** between which the tubular element to be bent **T** is interposed.

[0031] First power means, indicated as a whole by **9,** of the known type, which can be hydraulic, pneumatic or electric, set the disc **6** rotating clockwise or anticlockwise, as indicated by the arrows **6a** around the longitudinal axis **X,** to define the angular position where the tubular element **T** must be bent.

[0032] Analogously, first actuators of the known type and not represented, are combined with the jaws **8a**, **8b** to open and close them with respect to the tubular element **T.**

[0033] As to the bending heads **4, 5,** they are equal to each other and one of them is even visible in greater detail in the enlargements of Figures 2, 4, 6 and in the axonometric views of the Figures from 7 to 12.

[0034] It can be observed that each bending head **4, 5** substantially comprises a carriage **10** supported by the base **2,** to which a closing slide **14** and bending means indicated as a whole by **11** are connected, said bending means comprising a bending female die **12** that cooperates with a bending arm **13.**

[0035] It must be pointed out in particular that the bending female die **12** may be simple or with several grooves.

[0036] The carriage **10** is associated with second power means, not represented in the drawing for the sake of simplicity and of the known type, which move the carriage **10** and therefore the whole bending head in both the directions indicated by the arrows **10a** along the base **2,** according to a longitudinal direction parallel to the longitudinal axis **X** defined by the tubular element **T.**

[0037] As to the female die **12,** it is of the simplest type

known, in fact it consists of a grooved roller **12a** that defines a rotation axis **Y** substantially orthogonal to the longitudinal axis **X** of the tubular element **T**, around which it rotates owing to the action of second actuators, not represented in the drawing and of the known type.

[0038] Also the bending arm **13** rotates around the same axis **Y,** owing to the action of third actuators not represented and of the known type, and supports a male die **15** constituted by a grooved roller **15a** supported by a slide **16** that travels on the bending arm **13**.

[0039] Alternatively, the female die may also be provided with several grooves.

[0040] The slide **16** is also combined with fourth actuators, not represented, but of the known type, which serve to move the male die **15** with respect to the female die **12,** in order to bring it near to or move it far from the tubular element **T.**

[0041] Finally, as to the closing slide **14,** it is provided with an opposing grooved roller **17** and is associated with fifth actuators, not represented and of the known type, which serve to move it with respect to the tubular element **T.**

[0042] All the power means of the disc **6,** the vice **3** and the carriage **10** of each bending head **4, 5,** as well as the actuators of the jaws **8a, 8b,** the vice **3,** the female die **12,** the bending arm **13,** the slide **16** supporting the male die **15** and the slide **14** supporting the opposing roller **17,** are actuators of the known type that, according to the requirements regarding torque, speed and power, can be hydraulic, pneumatic or electric.

[0043] They are also provided with drive kinematic motions of the known type, which include screw-nut or pinion-rack connections, or similar ones.

[0044] To adapt the position of the vice **3** to the tubular element to be bent **T** and the latter to the position of the equipment installed on the bending heads **4, 5,** the vice **3** is slidingly supported by slides **3a** obtained in the base **2**, along which it can be moved in a direction parallel to the direction of rotation Y of the female die **12**, owing to the action of third power means **20**, as can be observed in particular in Figures 7, 9, 11 and 12.

[0045] Each bending head **4**, **5** is provided in turn with fourth power means, not visible in the drawings, suited to move it in a vertical direction **Z**, indicated in Figure 8, to adapt its position with respect to the tubular element **T.**

[0046] According to the invention, the power means and the actuators are interfaced with an electronic storage, processing and control unit **20** suited to combine the rotation of the bending means **11** with the linear movement of the bending heads **4, 5** along the base **2** according to preset values, to obtain bends with variable radius of curvature on the tubular element **T.**

[0047] The bending method object of the invention is described with reference to the Figures from 1 to 6 and its first step consists in positioning the tubular element to be bent **T** horizontally, as can be seen in Figure 1, between the bending heads **4**, **5** and the vice **3**, which are open.

[0048] The tubular element **T** is thus locked in the vice **3** by clamping the jaws **8a, 8b** and between the bending heads **4, 5** by bringing near it the opposing roller **17** of the closing slide **14.**

[0049] The operations needed to clamp the jaws **8a**, **8b** and to bring the opposing roller **17** near the tubular element **T** take place owing to the activation of the corresponding actuators by the electronic unit **30** according to a program registered in the programmable memory supports with which it is equipped, after the input of a cycle start command given by the operator through the control panel **31.**

[0050] With reference to the bending head **4,** the electronic unit **20** makes the female die **12** and the bending arm **13** rotate anticlockwise around the axis **Y** of a preset angle α, as shown in Figure 4, thus forcing the male die **15** to start bending the tubular element **T** following the profile of the female die **12.**

[0051] When the angle α has reached the set amplitude, the unit **20** stops the rotation of the bending arm **13** and forces the bending head to move leftwards as indicated by the arrow **S** shown in Figure 6.

[0052] In this way the tubular element **T** is bent continuously with a radius **R** whose value is determined by the combination of the value of the angular rotation α applied to the bending arm **13** with the movement towards the vice **3** applied to the bending head **4**.

[0053] At the same time, similar movements are applied also to the left bending head **5,** so that at the end of the bending operation the tubular element **T** has the shape shown in Figure 5.

[0054] Obviously, by properly varying the displacement values of each bending head **4, 5** along the base **2,** the value of the rotation of the bending arm **13** and if necessary the value of the synchronization of the two movements, it is possible to obtain bends with different radiuses.

[0055] Another bending cycle intended to make bends with fixed and variable radius of curvature on the tubular element **T** is described here below with reference to the Figures from 7 to 12.

[0056] The tubular element to be bent **T** is positioned in the vice **3** between the bending heads **4** and **5,** as shown in Figure 7, and is locked in bending position.

[0057] The bend with fixed radius is then carried out through the clockwise rotation of the bending arm **13,** as shown in Figure 8, thus obtaining the first bend **C1** with fixed radius of curvature.

[0058] The clockwise 90° rotation of the vice **3** from the position represented in Figure 7 to the position represented in Figure 9 makes it possible to vary the angular position of the tubular element **T,** on which a second bend **C2** with variable radius of curvature is thus carried out on a plane orthogonal to that of the previous bend **C1,** as shown in Figure 10.

[0059] Once the second bend **C2** with variable radius of curvature has been completed, the clockwise rotation

of the vice **3** brings the tubular element **T** back to the angular position that can be seen in Figure 11, and is bent again to obtain a further bend **C3** with variable radius of curvature, until reaching the final configuration that can be observed in Figure 12.

[0060] Obviously, the same bending cycle is performed by the bending head **5** on the tubular element on the left side of the vice **3.**

[0061] Once the cycle has been concluded, the vice **3** and the bending heads **4**, **5** are opened and the tube **T** bent as described above is unloaded from the machine. It is important to point out that the opportunity to make two bends with variable radius of curvature at the same time on the same tubular element being processed doubles productivity compared to the known machines that make bends with variable radius, but only one by one.

[0062] According to the above, it is clear that the method and the machine object of the invention achieve all the goals set.

[0063] Upon implementation variants may be made to the method and machine of the invention, which if included within the scope of the following claims must be considered protected by this patent.

Claims

1. Bending method particularly suited to bend tubular elements with a bending machine (1) of the type comprising a central vice (3) and two moving bending heads (4, 5) provided with bending means (11) and positioned one on the right and one on the left side of said vice (3), comprising the following operations:

   - positioning a tubular element (T) in said vice (3) and between said bending heads (4, 5);
   - holding said tubular element (T) in bending position in said vice (3) and between said bending heads (4, 5);
   - rotating said bending means (11) of said bending heads (4, 5) to bend said tubular element (T),

   characterized in that said rotation of said bending means (11) is combined with the travel of said bending heads (4, 5) with respect to said vice (3) to make bends with variable radius of curvature on said tubular element (T).

2. Bending method according to claim 1), **characterized in that** it includes the movement of said tubular element (T) in a direction orthogonal to the longitudinal axis (X) defined by it, before locking it in said vice (3) in bending position, aligned with said vice (3) and with said bending heads (4, 5).

3. Bending method according to claim 1), **characterized in that** the values of the angular displacement (α) of said bending means (11) during rotation and of the linear displacement of each one of said bending heads (4, 5) during travel are variable.

4. Bending method according to claim 3), **characterized in that** the values of the angular displacement (α) of said bending means (11) during rotation and of the linear displacement of each one of said bending heads (4, 5) during travel are independent of each other.

5. Bending machine (1) particularly suited to bend tubular elements (T), comprising:

   - a base (2) with mainly longitudinal configuration;
   - a central vice (3) fixed to said base (2) and provided with means (8) to clamp a tubular element (T) to be bent;
   - two bending heads (4, 5) moving along said base (2), provided with means (11) to bend said tubular element (T) and positioned one on the right and one on the left side of said vice (3);
   - power means for rotating said vice (3) and for moving said bending heads (4, 5) along said base (2);
   - actuators for rotating said bending means (11),

   characterized in that said power means and said actuators are interfaced with an electronic storage, processing and control unit (20) suited to combine the rotation of said bending means (11) with the linear movement of said bending heads (4, 5) along said base (2) according to preset values, in order to obtain bends with variable radius of curvature on said tubular element (T).

6. Bending machine (1) according to claim 5), **characterized in that** said vice (3) comprises a substantially circular disc (6) associated with said power means (9) suited to set it rotating around its longitudinal axis and provided with a radial slot (7) that develops with a length greater than its radius, in which there are means (8) to clamp said tubular element to be bent (T).

7. Bending machine (1) according to claim 6), **characterized in that** said clamping means (8) of said vice comprise a pair of opposing jaws (8a, 8b) positioned on opposite sides of said tubular element (T), associated with first actuators suited to move them against said tubular element (T).

8. Bending machine (1) according to claim 5), **characterized in that** each one of said bending heads (4, 5) comprises:

- a carriage (10) associated with said power means suited to move it along said base (2);
- bending means (11) connected to said carriage (10) and comprising a bending female die (12) that defines a rotation axis (Y) substantially orthogonal to the longitudinal axis (X) of said tubular element (T) around which said female die (12) rotates owing to the action of second actuators, and a bending arm (13) that defines the same rotation axis (Z) as that of said female die (12) around which it rotates owing to the action of third actuators and which supports a bending male die (15) positioned opposite said female die (12) with respect to which it is moved by fourth actuators;
- a closing slide (14) provided with an opposing roller (17) facing said female die (12) and beside said male die (15), said closing slide (14) being coupled with fifth actuators suited to move it with respect to said tubular element (T).

9. Bending machine (1) according to claim 5) or 6), **characterized in that** said power means comprise:

- first power means (9) associated with said vice (3) and suited to set it rotating around its own rotation axis (Y);
- second power means associated with said bending head (4, 5) and suited to move it along said base (2) according to the longitudinal axis (X) of said tubular element (T).

10. Bending machine (1) according to claim 5), **characterized in that** it comprises also third power means (20) associated with said vice (3), suited to move said vice on a horizontal plane in orthogonal direction with respect to the movement of said bending heads (4, 5).

11. Bending machine (1) according to claim 5), **characterized in that** it comprises also fourth power means associated with each one of said bending heads (4, 5), to move each bending head in a vertical direction (Z).

12. Bending machine (1) according to claim 6) or 8), **characterized in that** said actuators and power means are hydraulic.

13. Bending machine (1) according to claim 6), 8), or 9), **characterized in that** said actuators and power means are electric.

14. Bending machine (1) according to claim 6), 8), or 9), **characterized in that** said actuators and power means are pneumatic.

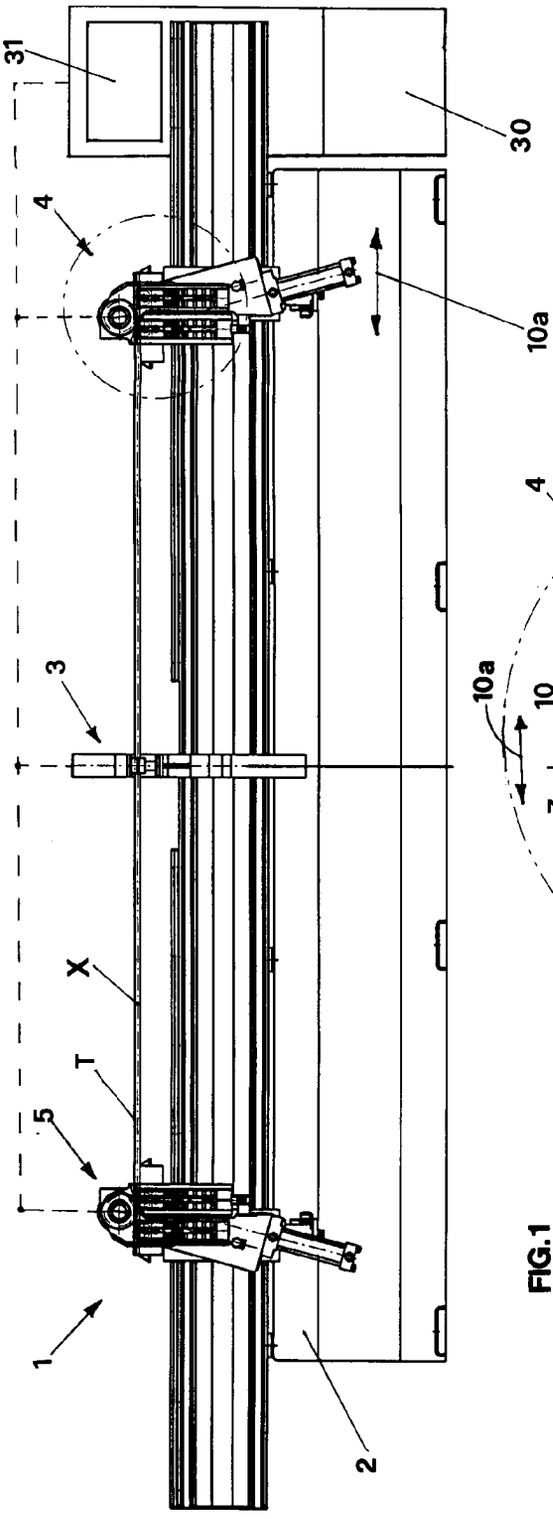

FIG.1

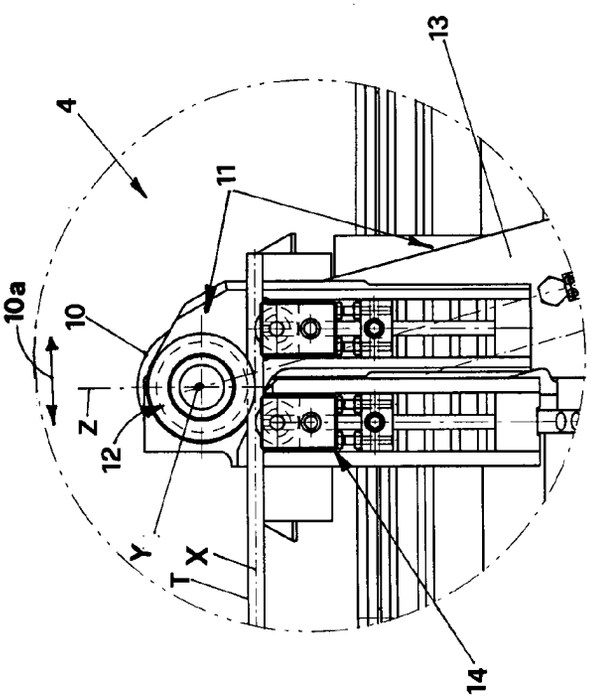

FIG.2

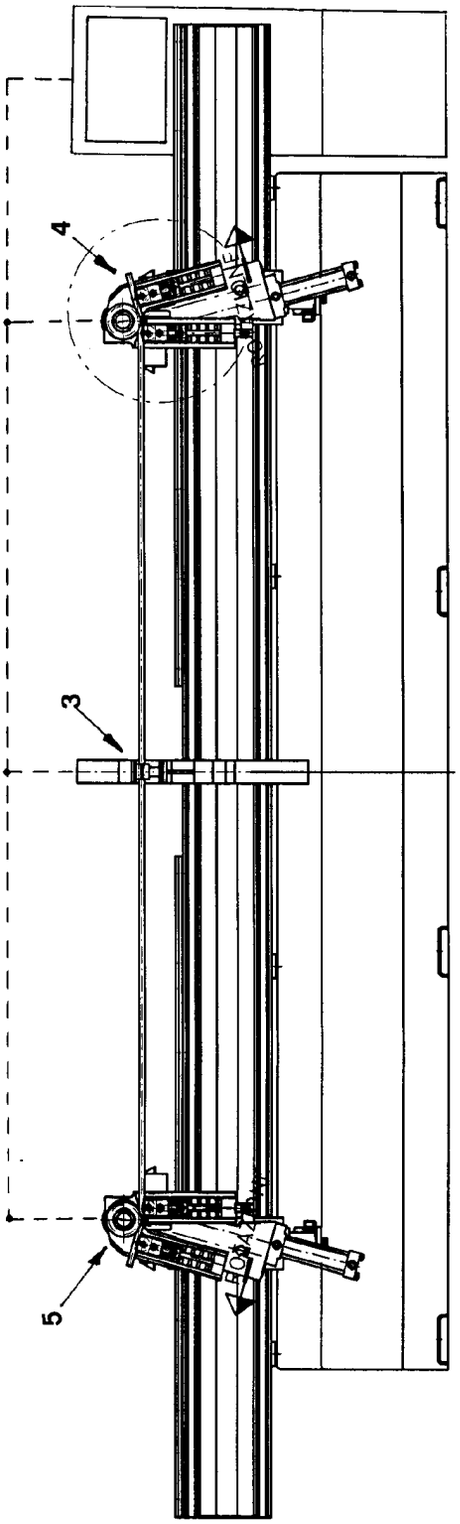

FIG.3

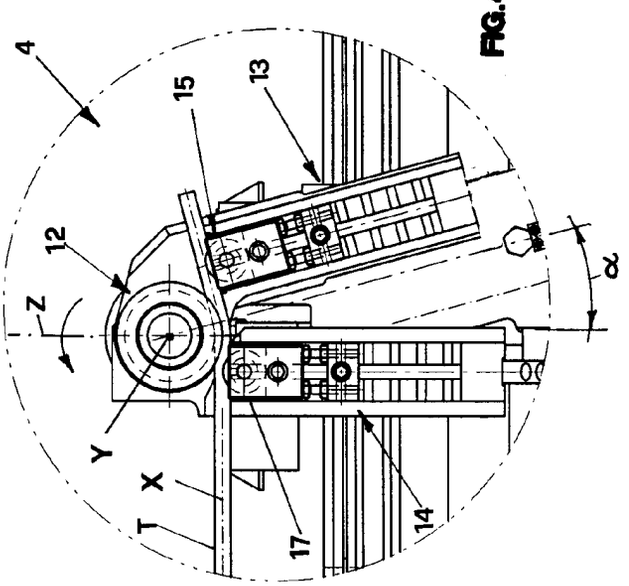

FIG.4

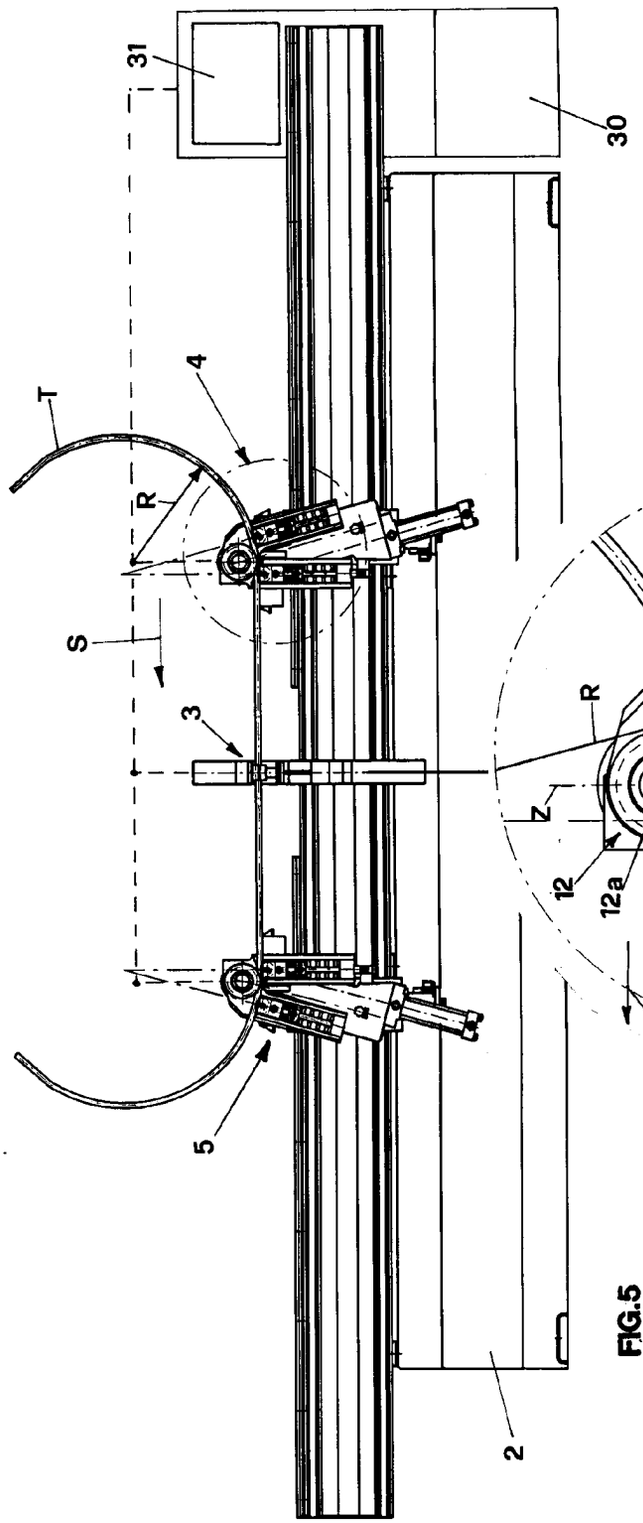

FIG.5

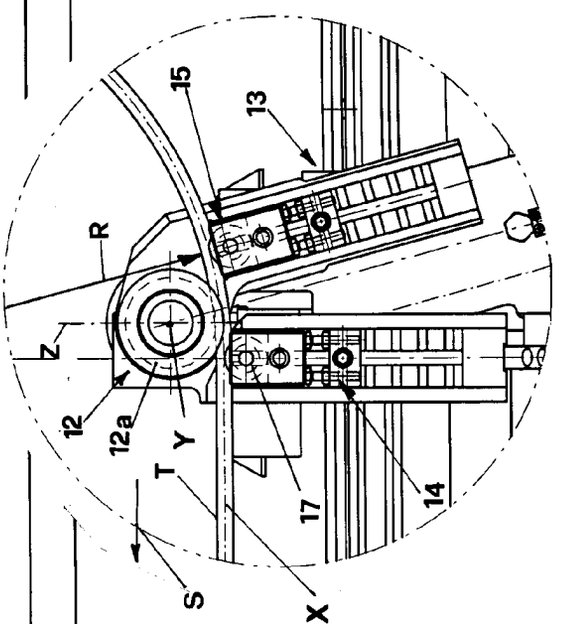

FIG.6

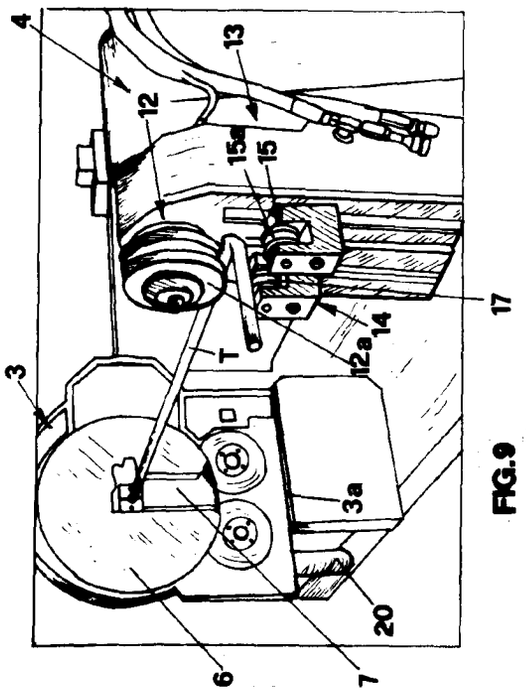

FIG.9

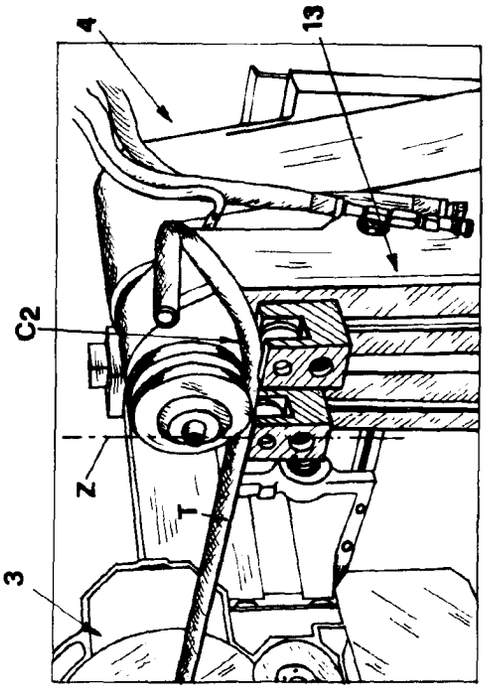

FIG.10

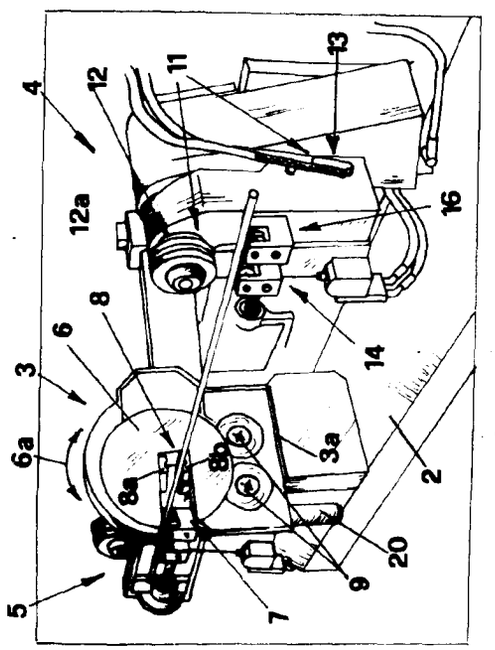

FIG.7

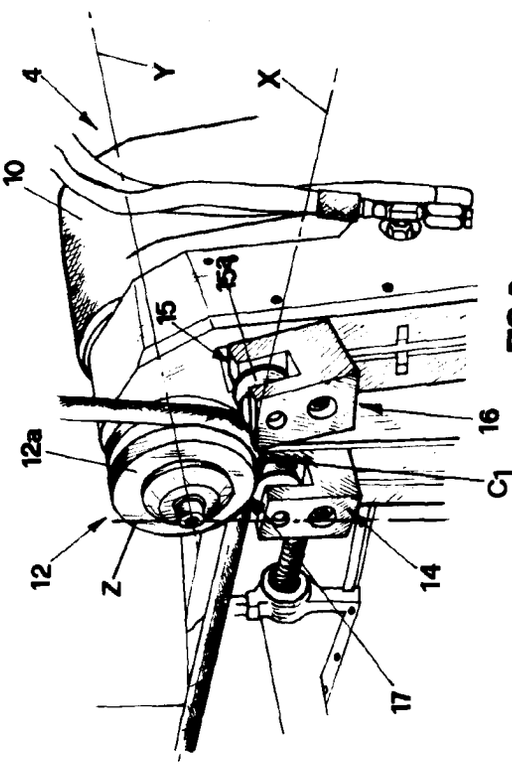

FIG.8

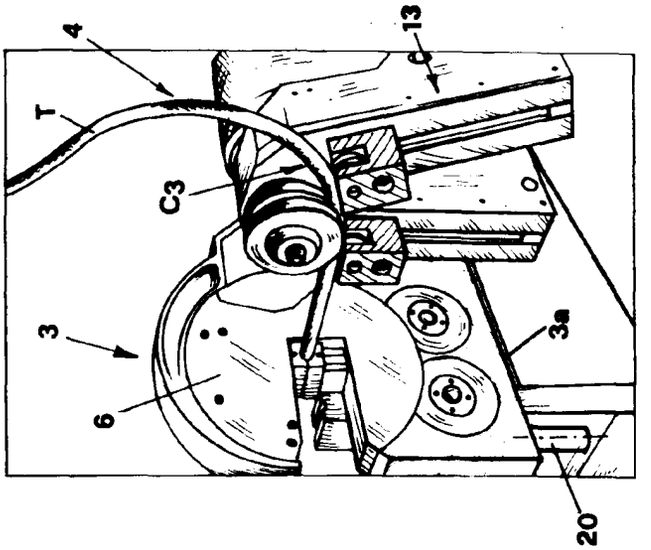

FIG.12

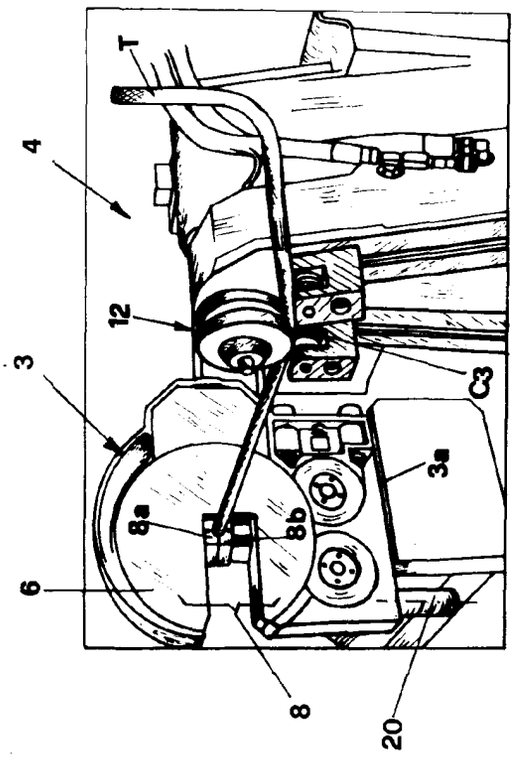

FIG.11

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 10 1562

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 4 604 885 A (LANG THOMAS P) 12 August 1986 (1986-08-12) * column 2, line 68 - column 3, line 8; figures * ---	1,5	B21D7/12 B21D7/024 B21D7/08
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 388 (M-1297), 18 August 1992 (1992-08-18) -& JP 04 127919 A (OPTON CO LTD), 28 April 1992 (1992-04-28) * abstract; figures 2,3 * ---	1,5	
A	DE 25 46 695 A (DAIICHI KOSHUHA KOGYO KK) 24 March 1977 (1977-03-24) * page 10, line 11 - page 11, line 11; figures 1,2 * -----	1,5	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	16 June 2004	Meritano, L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

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D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 10 1562

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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16-06-2004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4604885 A	12-08-1986	DE 3311766 A1	04-10-1984
		EP 0121077 A2	10-10-1984
		JP 1761257 C	20-05-1993
		JP 3021243 B	22-03-1991
		JP 59183938 A	19-10-1984
JP 04127919 A	28-04-1992	NONE	
DE 2546695 A	24-03-1977	DE 2546695 A1	24-03-1977

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82