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(54) Device for measuring a bending angle in a programmable sheet bending brake.

(57) A device for the measurement of an angle of bending of an edge (8) of a polygonal sheet of metal (7), particularly for a machine for programmable bending on all the sides of the sheet (7), comprises actuators (39) apt to bring a bending blade (3, 4), without thrust, against the bent edge (8) and detectors (36, 37, 38) apt to measure the angle of rotation of the blade (3, 4). The detectors (36, 37, 38), in their turn, are operationally connected to correctors (15, 53; 18; 54) of the angle of bending of the edge (8).

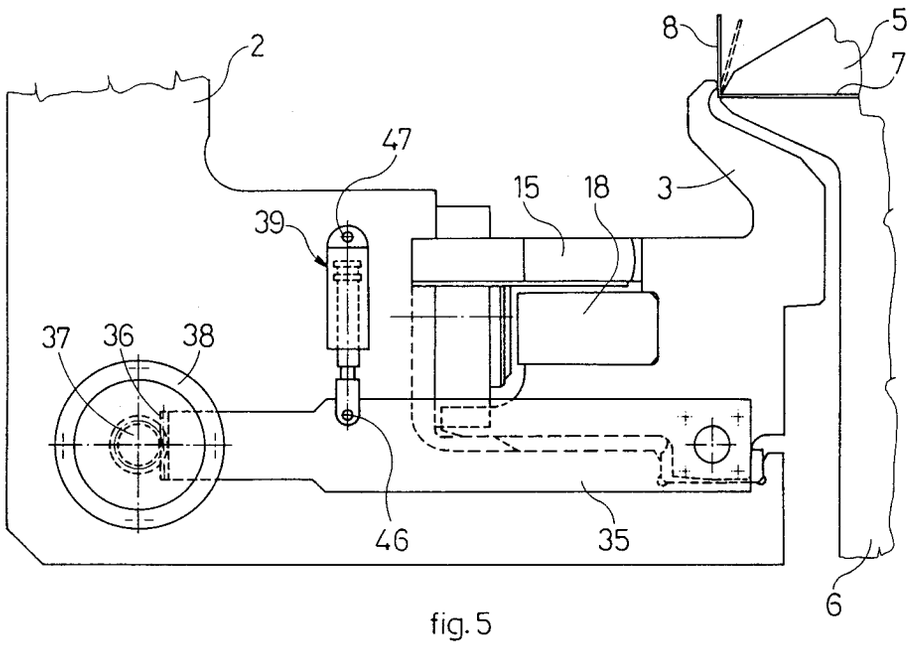

fig. 5

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The present invention relates to a device for the measurement of an angle of bending of an edge of a polygonal sheet of metal and for the automatic correction of errors of bending, particularly for a machine for programmable bending on all the sides of the sheet.

The sheet of metal is originally available in strips wound in coils. According to the quantity of like pieces that it is required to manufacture with the sheet metal, the transformation process is different. If the quantity of like pieces to be produced one after the other is relatively small, and this is the case to which the present invention refers, the first operation of the transformation process is the transversal division of the strip into sheets of the maximum length compatible with the method of transport and with the dimensions of the machines that continue the transformation process.

The length of the sheets that are obtained from the strip with the first shear is selected as long as possible so as to constrain the subsequent shears as little as possible and to allow each sheet to be subdivided with a minimum of scrap.

In order to facilitate the handling of the small pieces and in any case to reduce the machining time, it is convenient to postpone the subdivision of the sheet into several parts, that is achieved by shearing, until after the execution of operations such as punching and bending, that take advantage of the large dimensions of the sheet.

Automatic programmable bending and panelling machines are known, that automatically produce only one piece of sheet metal at a time, variously bent, that receive a flat sheet at inlet, possibly already punched, from which they subtract no material. Machines of this type are described in the patents US-A-4 242 898 and EP-A-0 023 894.

After the bending operation has been executed, it occurs that the bent edge of the sheet metal does not maintain exactly the inclination that has been given to it by the bending machine, but it springs back to a smaller inclination; this final inclination of the bent edge, for an equal inclination caused by the machine, can be different from sheet to sheet due to the small differences in thickness and crystalline structure; the final inclination of the bent edge can also be different from one side to the other of the same sheet due to the different crystalline structure on sides that are parallel or orthogonal to the direction of lamination.

In the practice of sheet metal bending with automatic machines the first bent sheet of a given lot, for which the sheets are sufficiently like one another, since they originate from one same strip with uniform thickness and structure, is carefully measured, while production is in the meantime suspended, in order to read the deviations from the desired values of the angles of bending and to deduce from them the appropriate corrections of the bending programme, that is, of the end positions of the bending tools.

The object of the present invention is that of taking away from the operator of the machine the task of measuring the angles of bending at the start of the production of a lot and of introducing into the programme being executed the appropriate corrections, suitable for containing within the ranges of tolerance the errors of bending of all the pieces of the lot subsequent the first.

The abovementioned objects are attained, according to the invention, by a device for the measurement of an angle of bending of an edge of a polygonal sheet of metal, particularly for a machine for programmable bending on all the sides of the sheet, said machine comprising a supporting structure having a substantially C-shaped transversal cross-section, a fixed lower counterblade and an upper blank holder vertically movable, both supported by said supporting structure, a blade holder having a substantially C-shaped transversal cross-section, in turn movably supported by said supporting structure, and at least one bending blade rotatably supported by said blade holder and cooperating with said counterblade and said blank holder for bending one edge of said sheets of metal in a programmable manner, characterized in that said bending blade is operationally connected to actuating means apt to bring it, without thrust, against said bent edge and to detecting means apt to measure the angle of rotation of the blade.

According to a preferred embodiment of the invention, said detecting means are operationally connected to means for adjusting the angle of bending of said edge to automatically correct errors of the angle of bending, so that they remain within predetermined ranges of tolerance.

The device according to the invention allows an improvement to be made in the quality of the pieces produced and reduces machining times, because it is sufficient to measure the angle of bending of the first machined sheet and, in case of error, to introduce the necessary correction into the bending machine, so that the following sheets of a lot are machined with the prescribed angle of bending.

The features of the present invention will be made more evident by the following description of an embodiment thereof, illustrated as a non-limiting example, in the enclosed drawings, wherein:

Fig. 1 is a side view of a machine for bending sheets of metal comprising two bending blades, one upper and one lower, supported by a single blade holder;

Fig. 2 is a vertical cross-sectional view of a lower blade of the machine of Fig. 1 and of means for positioning the blade itself in a rest

position;

Fig. 3 is a vertical cross-sectional view of the lower blade and of means for controlling its bending motion;

Fig. 4 is partial plan view of a blade holder, of wedge-shaped spacers and of the lower blade of the machine of Fig. 1;

Fig. 5 is a side view of the lower blade of the bending machine of Fig. 1 and of a device for the measurement of an angle of bending of an edge of a polygonal sheet of metal, accomplished according to the invention.

There is shown in Fig. 1 a programmable bending machine that comprises a base 1 having a substantially C-shaped transversal cross-section, provided with guides (not shown), wherein a piston stem 50 causes a blank holder 5 to slide vertically, that, by pressing up against a fixed counterblade 6, clamps a sheet of metal 7 having a polygonal shape. An edge 8 of the sheet 7 has been bent along a "line of bending" defined by active edges of the counterblade 6 and of the blank holder 5. The base 1 is also provided with guides 60 on which further piston stems 51 cause to slide vertically a blade holder 2, also having a substantially C-shaped transversal cross-section. In the blade holder 2 there are rotatably supported, by means of a hinge 12, a lower blade 3 and, by means of a hinge 52, an upper blade 4, that are used for the automatic, programmable bending on all the sides of the sheets 7. The blade 4, above the sheet 7, generates downward bends, and the blade 3, below the sheet, generates upward bends. The two blades 3 and 4 are hinged on the blade holder 2 with an axis parallel to the line of bending of the sheet 7 and, together with the blade holder, they perform a movement of translation in a direction orthogonal to the plane in which the undeformed sheet metal lies. With this first movement, one or the other blade, 3 or 4, engages with the edge 8 and carries out a bending of a pre-set angle along the entire length of one side of the sheet.

There is shown in Fig. 2 one of a series of simple-acting hydraulic cylinders 13 that, operating on a protrusion 14 of the lower blade 3, keep the latter, at rest, against a wedge-shaped spacer 15, as shown in Figs. 2 and 4. An active edge 16 of the lower blade 3 is thus at a predetermined distance from the active edges of the counterblade 6 and of the blank holder 5 depending on whether the wedge-shaped spacer 15 is inserted to a greater or lesser extent, by means of a double-acting longitudinal positioning hydraulic cylinder 53 (Fig. 4). The initial angular position of the lower blade 3 is adjusted, in relation to the thickness of the sheet metal and of the radius of curvature that is desired along the bend, by means of the longitudinal displacement of the wedge-shaped spacer 15.

As shown in Figs. 3 and 4, a succession of simple-acting hydraulic cylinders 19 operate, during the bending step, on the lower blade 3 through a planar-spherical pad 20 and a wedge-shaped spacer 18. The final angular position of the blade 3 and thus the angle of bending of the edge 8 depend on the longitudinal position of the wedge-shaped spacer 18. The cylinders 19 push the blade 3 against the edge 8 of the sheet 7, causing the edge of the blade to perform a motion that is almost parallel to the plane of the sheet. To this second movement of the blade 3 there corresponds a motion of rotation of the edge 8 around the line of bending and a further bending of the edge 8 along the entire length of one side of the sheet 7. The action of bending of the edge 8 ends when expansions 21 of pistons 22 of the cylinders 19 come against abutments 23. The longitudinal position of the wedge-shaped spacer 18 is determined by a double-acting longitudinal positioning hydraulic cylinder 54.

A pair of simple-acting hydraulic cylinders 17 cause the cylinders 13 to move back, after having been discharged, and separate the blade 3 from the wedge-shaped spacers 15 and 18, to allow the longitudinal displacement of the spacers themselves, without the resistance due to the friction with the blade.

When the bending machine has to bend the edge 8 of the sheet 7 upward, the wedge-shaped spacers 15 and 18, after the blade 3 has been pushed away by the cylinders 17, are brought to the positions corresponding to the start and to the end, respectively, of the operating stroke of the blade 3. The blade holder 2 moves upwards causing the active edge 16 of the blade 3 to interfere with the edge 8, that thus starts to be bent; the cylinders 19 push the blade 3 to the end of the bending stroke, while at the same time causing the cylinders 13 to move back and lastly the cylinders 13 cause the blade 3 to return to the initial position, while at the same time causing the cylinders 19 to move back. Thus, the blade 3 performs two distinct motions, that take place simultaneously or in succession, one of translation in a direction orthogonal to the plane in which the undeformed sheet metal 7 lies, thus vertical, and one of rotation around the hinge 12 parallel to the line of bending, to which there corresponds a motion of the edge of the blade that is almost parallel to said plane.

The upper bending blade 4 is, except for the edge that is in contact with the sheet 7, symmetrical with respect to a median plane parallel to the plane of the undeformed sheet metal 7 and executes symmetrical movements under the control of means similar to those just described for the lower blade 3.

By means of the blade 3, or the blade 4, the machine bends the edge 8 of the sheet 7 by an angle and radius that are programmable (programmable by means of the displacements of the two wedge-shaped spacers 15 and 18).

The angle of bending of the edge 8 is determined by the longitudinal position of the wedge-shaped spacer 18.

As shown in Fig. 5, an arm 35 is fastened to one end of the lower blade 5. A double-acting hydraulic cylinder 39 is hinged at 46 to the arm 35 and at 47 to the blade holder 2. The arm 35 ends with a sector gear 36, which, through a pinion 37, drives an encoder 38.

To measure the angle of bending of the edge 8, if the bend thus executed is the first of one lot of pieces, the cylinders 13 do not operate and the hydraulic cylinder 39 operates the arm 35 first to discharge the oil from the cylinders 19 and to separate the blade 3 from the edge 8. Then the cylinder 39, inverting its motion, operates the arm 35 to move the active edge 16 of the blade 3 delicately towards the bent edge 8.

The number of impulses issued by the encoder 38, after it has passed through an angular position of reference, indicates the angular position of the blade 3, from which the angle of bending of the edge 8 is deduced with an experimentally determined algorithm that takes into account the thickness of the sheet metal and the position of the blade during the motion of the blade holder. From the information provided by the encoder 38 the error of bending due to the spring-back of the sheet metal is deduced. The value detected of the angle of bending is compared with a design value and, in case of deviations, the hydraulic cylinder 53 intervenes to displace the wedge-shaped spacer 18 and to adjust the final angular position of the blade 3, so that the angle of bending of sheets 7 following the first remains within the prescribed ranges of tolerance and the errors of bending detected on the first sheet are corrected.

The lower blade 3, steadily hinged on the blade holder 2 along its entire length, thus participates in all the operations of the machine meant to execute upward bends and to measure the angle of bending. The same can take place for the upper blade 4, if it is provided in a similar manner with an angle measuring device like the one just described.

It should in any case be considered that in the machines of this type, capable of executing bends both upward and downward, the last bend is usually executed upward. Since it is the angle of the last bend that is of greater interest for the user, the angle measuring device can be limited to the lower blade.

The fact that all the hydraulic cylinders 13, 19 and 17, that operate the lower blade push and do not pull, that is that none of them is constrained to the blade but they rest only on it, is essential for the measurement of the angle of bending. The blade can in fact be completely relieved from external forces that are not its weight and the very small friction of the hinge 12, expanding the hydraulic cylinder 39 applied to the end of the blade.

The blade rest then delicately on the edge 8 of the sheet that has just been bent and still held by the blank holder 5 and by the counterblade 6. With this delicate contact, that does not move the bent edge 8 from its natural position, the blade assumes an angular position that is univocally linked with the angle of bending through an algebraic relation that, as already said, is determined experimentally.

A sufficiently accurate reading of the angle of inclination of the blade induces a sufficiently accurate knowledge of the angle of bending, of its difference with respect to the desired angle and, lastly, of the correction to make to the bending programme.

Claims

1. Device for the measurement of an angle of bending of an edge (8) of a polygonal sheet of metal (7), particularly for a machine for programmable bending on all the sides of the sheet (7), said machine comprising a supporting structure (1) having a substantially C-shaped transversal cross-section, a fixed lower counterblade (6) and an upper blank holder (5) vertically movable, both supported by said supporting structure (1), a blade holder (2) having a substantially C-shaped transversal cross-section, in turn movably supported by said supporting structure (1), and at least one bending blade (3, 4) rotatably supported by said blade holder (2) and co-operating with said counterblade (6) and said blank holder (5) for bending one edge (8) of said sheets of metal (7) in a programmable manner, characterized in that said bending blade (3, 4) is operationally connected to actuating means (39) apt to bring it, without thrust, against said bent edge (8) and to detecting means (36, 37, 38) apt to measure the angle of rotation of the blade (3, 4).

2. Device according to claim 1, characterized in that said detecting means (36, 37, 38) are operationally connected to adjusting means (15, 53; 18, 54) of the angle of bending of said edge (8) to automatically correct errors of the angle of bending, so that they remain within predetermined ranges of tolerance.

3. Device according to claim 1, characterized in that said actuating means (39) are constituted by a double-acting hydraulic cylinder hinged to an arm (35) of said blade (3, 4) and to said blade holder (2).

4. Device according to claim 3, characterized in that said detecting means (36, 37, 38) are constituted by a sector gear (36) integral with said arm (35), said sector gear (36) engaging with a pinion (37) that drives an encoder (38).

5. Device according to claim 1, characterized in that said blade (3, 4) is vertically movable together with said blade holder (2) to perform a bending of said sheet (7) and is engaged with first, second and third hydraulic cylinders (13, 19, 17), said first cylinders (13) operating on a protrusion (14) of said blade (3, 4) keep the blade (3, 4) against a first wedge-shaped spacer (15) in an initial angular position, said second cylinders (19) operating on the blade (3, 4) through a second wedge-shaped spacer (18) to cause it to rotate around said hinge (12) up to a final angular position and to perform a further bending along the entire length of said sides, said third cylinders (17) operating on said blade (3, 4) to separate it from said wedge-shaped spacers (15, 18) and to allow the longitudinal position of said spacers (15, 18) to be adjusted.

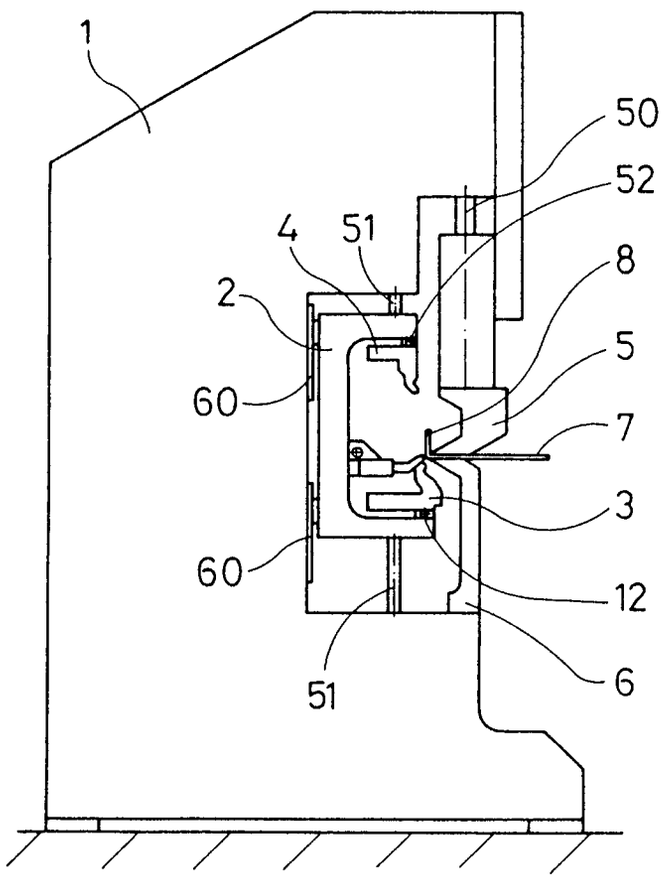

fig. 1

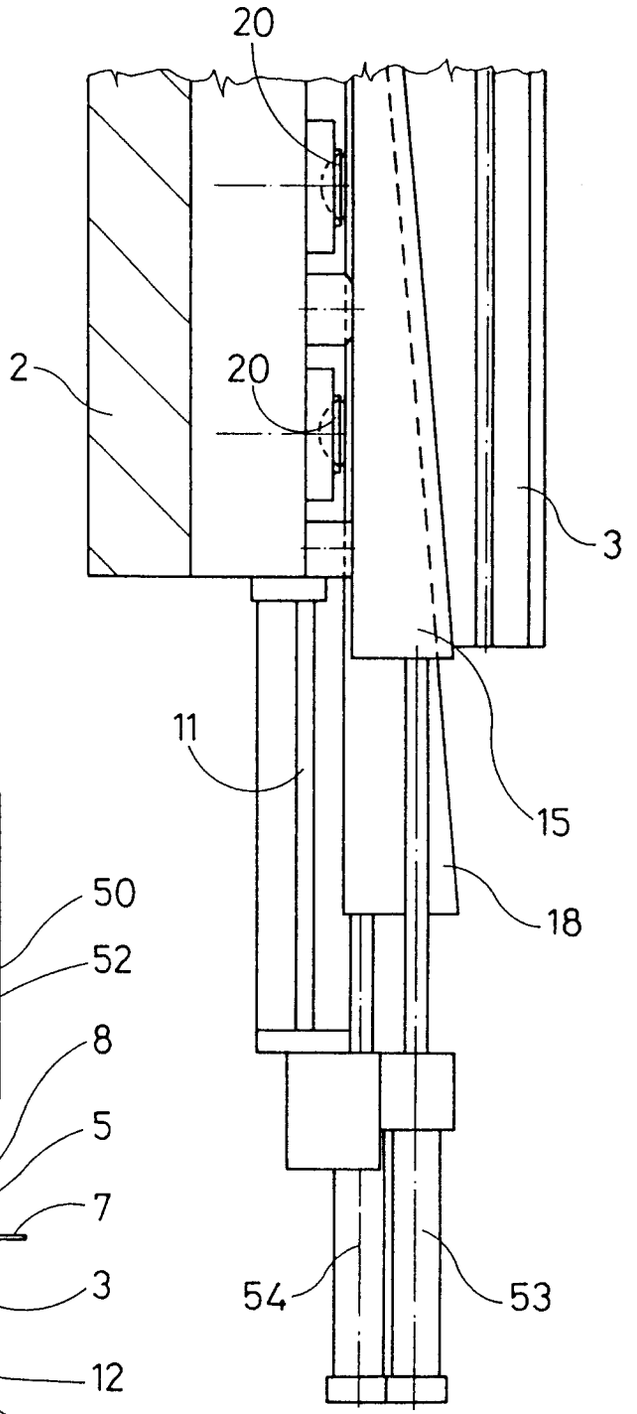

fig. 4

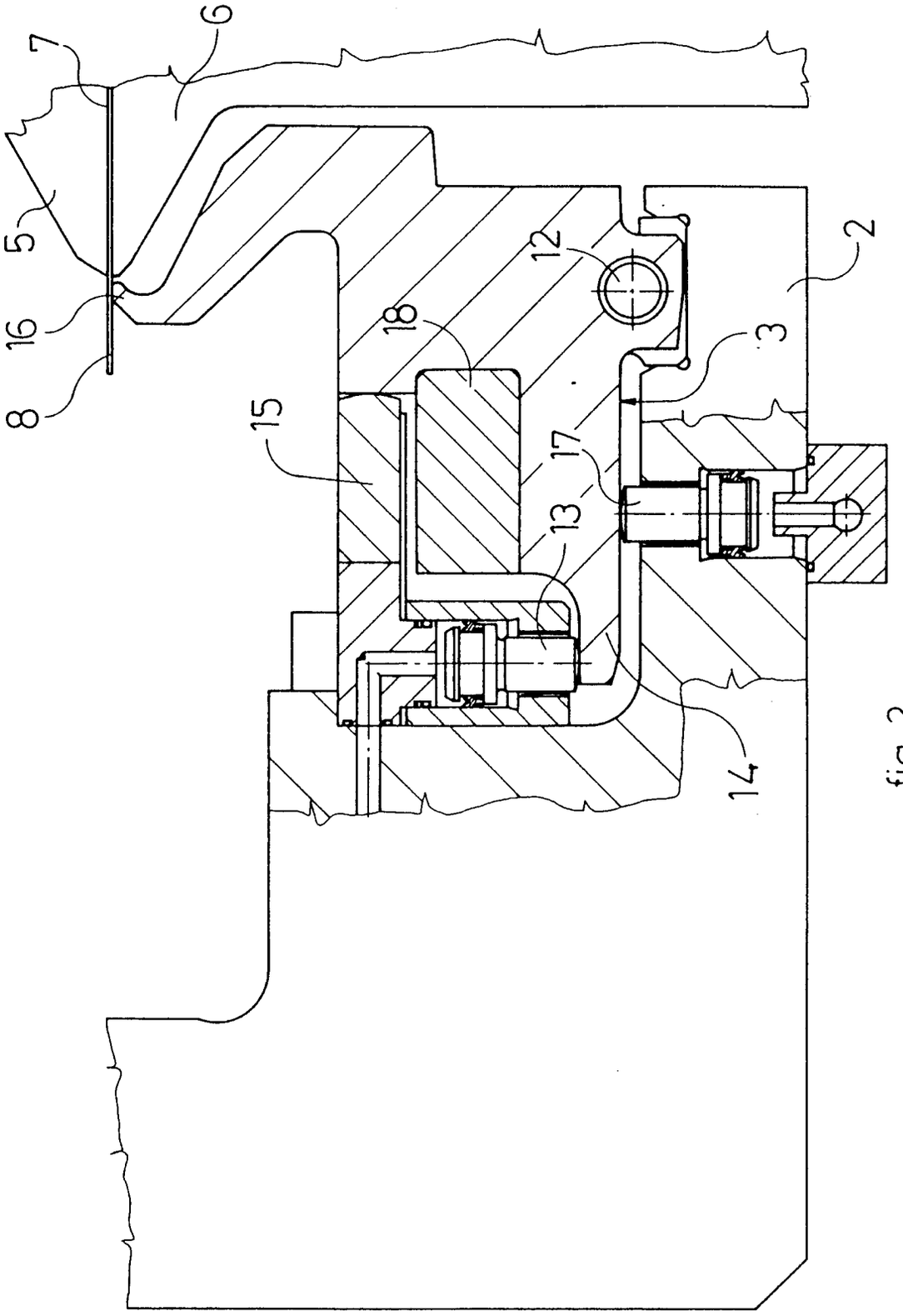

fig. 2

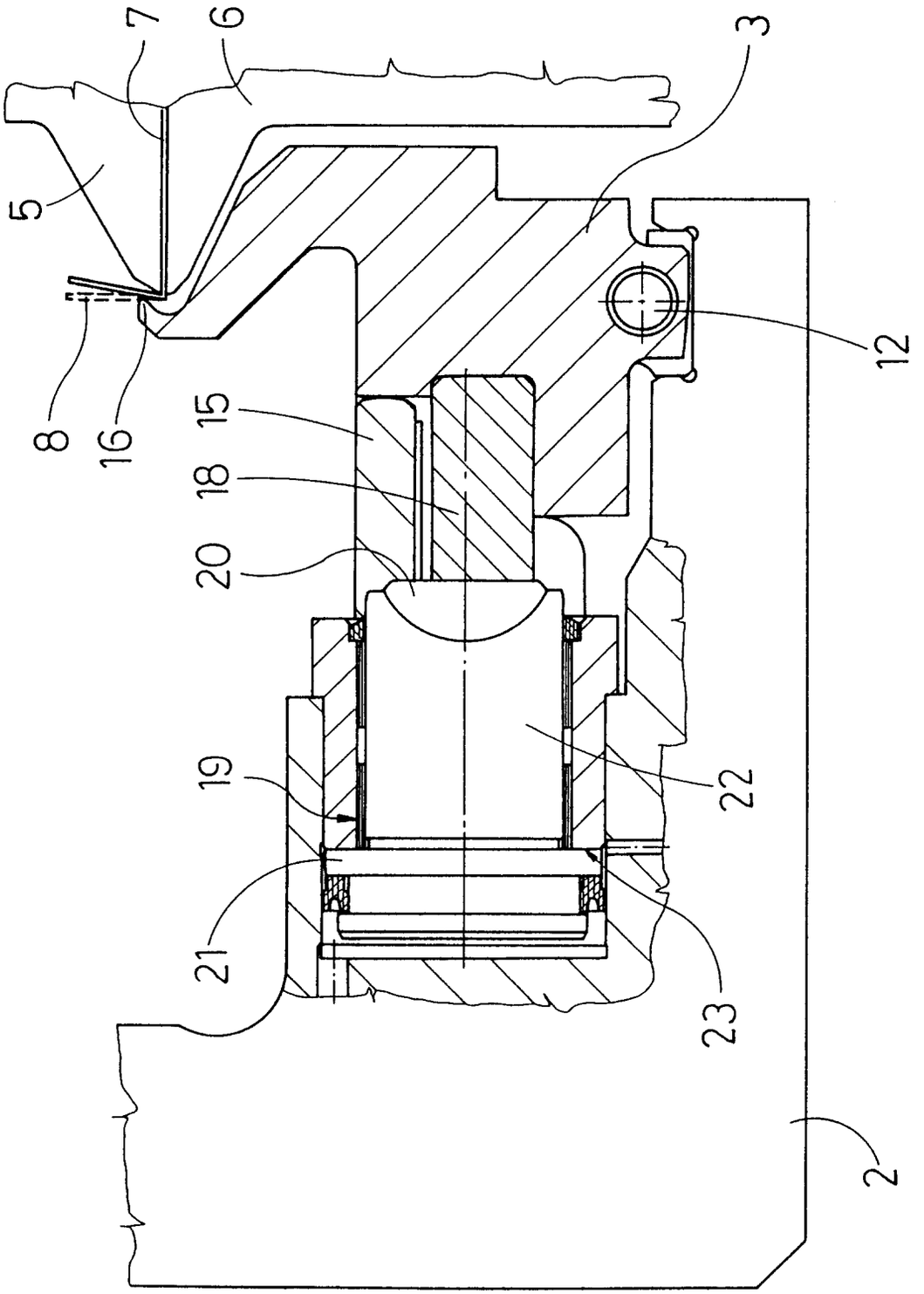

fig. 3

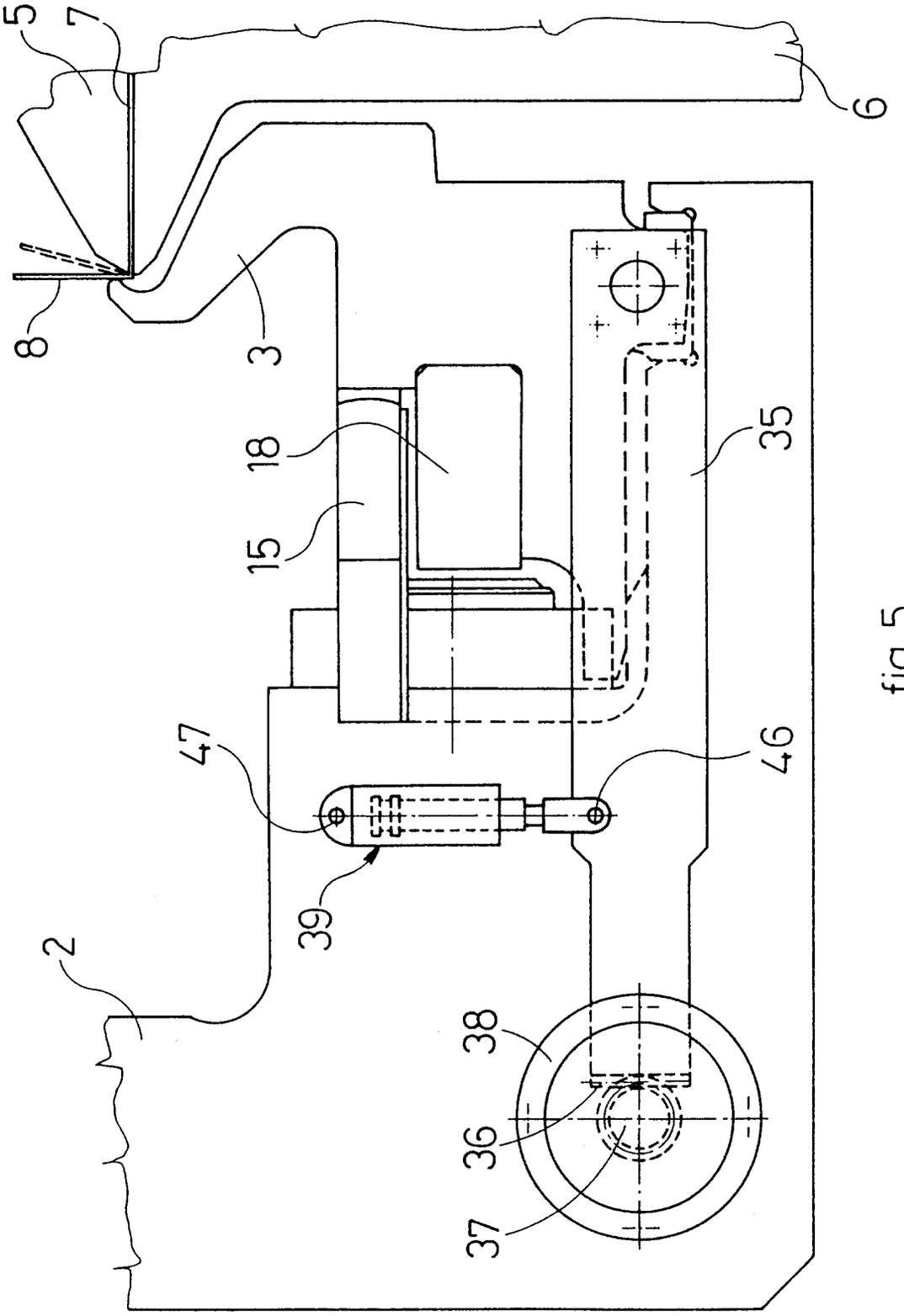

fig.5

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EUROPEAN SEARCH REPORT

Application Number
EP 95 20 0994

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.6)
D,Y	EP-A-0 023 894 (SALVAGNINI) * the whole document * ---	1,2	B21D5/04
Y	DE-A-34 41 113 (KLÖCKNER-MÖLLER ELEKTRIZITÄTS GMBH) * page 4, line 12 - page 5, line 19; figures 1,2 * ---	1,2	
A	PATENT ABSTRACTS OF JAPAN vol. 10 no. 227 (M-505) [2283] ,7 August 1986 & JP-A-61 063317 (HITACHI LTD) 1 April 1986, * abstract * ---	1	
A	DE-A-36 43 190 (FASTI-WERK) * column 4, paragraph 3; figure 2 * ---	1	
A	PATENT ABSTRACTS OF JAPAN vol. 18 no. 23 (M-1541) ,14 January 1994 & JP-A-05 261444 (MATSUSHITA) 12 October 1993, * abstract * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 August 1995	Gerard, O

CATEGORY OF CITED DOCUMENTS

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