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(54) **SHEET METAL FOLDING MACHINE**

(57) A double-sided folding machine comprising: a lower stand comprising a lower tool set, comprising a lower clamping tool and a lower bending tool; an upper stand comprising an upper tool set, comprising an upper clamping tool and an upper bending tool; an eccentric mechanism connecting the lower stand to the upper stand, comprising a shaft mounted on lower stand and a wheel with off-centred parallel axis, wherein the shaft is off-centred mounted in wheel in respect of the geometric axis of wheel upon which is mounted the upper stand; wherein the lower and upper clamping tool sets are displaceable in relation to each other by a horizontal offset between a first position for folding upwards and a second position for folding downwards, wherein the geometric axis of wheel rotates off-centred in respect of shaft to displace the upper stand by a horizontal distance of at least said horizontal offset. Also, method of bending sheet metal thereof.

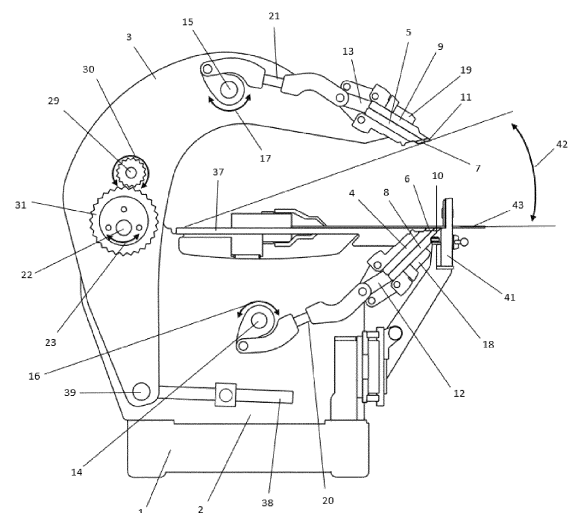


Fig. 3

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a sheet metal folding machine that bends a sheet metal in opposite directions without the need to turn or flip over the sheet metal. In particular, the sheet metal folding machine bends the sheet metal upwards and downwards.

BACKGROUND

[0002] Current state of the art's long folding machines for bending short or long sheet metal are normally based on a succession of lower stands fixed to a common base frame. An upper stand, such as a rocker arm, is arranged to rotate above each lower stand.

[0003] Most of the folding machines in the current state of the art are built according to this arrangement. These machines are for single-sided bending; the machine is arranged to bend the sheet metal only in one direction, normally upwards.

[0004] The bending of sheet metal using these machines requires the use of a clamping tool to fix the sheet metal in the bending position and at the pivoting point of the folding beam. The clamping of the sheet metal is achieved by closing the upper stand, which is fitted with clamping tools, against the lower clamping tool that is attached to the lower stand.

[0005] After clamping of the sheet metal, the folding beam with its bending tool is rotated upwards, pivoting at the stands to bend the sheet metal upwards to obtain the required angle of bent.

[0006] A limitation of such single-sided folding machines is that whenever bends in opposite directions are required, the sheet metal must be removed from the machine to flip over and re-introduce it into the machine to be bent in the opposite direction.

[0007] To avoid the problem of having to remove and reintroduce the sheet metal to obtain bends in opposite directions, double sided bending machines that can successively bend the sheet metal in both directions were developed.

[0008] Double-sided folding machines of the state of the art usually comprise lower stands, upper stands, clamping beams for each of the upper and lower stand, corresponding tools for each clamping beam, upper folding beams, lower folding beams, and corresponding tools pivoting on each clamping beam.

[0009] In such double-sided folding machines, the lower stand folding beam and its corresponding tool bends the sheet metal upwards while the upper stand folding beam and its corresponding tool bends it downwards.

[0010] A limitation of current double-sided folding machines is that the inactive folding beam must be moved away from the bending space to make room for the active folding beam to maneuver.

[0011] Different solutions have been presented by dif-

ferent manufacturers to move and keep the inactive folding beam away from the bending space. The bending space required is normally rather wide to allow the machine to perform bends of up to 150°.

[0012] Furthermore, double-sided folding machines of the state of the art are configured to be preferably operated using hydraulic power.

[0013] Some of the disadvantages of machines of the current state of the art:

The clamping action is not levelled throughout the whole bending length in cases involving shorter sheet metal and/or sheet metals that are positioned off centre.

The hemming operation is not levelled and stopped in position, mostly on operations to perform open U recesses at the panel edges.

The bending operations usually lack accuracy and repeatability of the bending angle for successive panels, usually observed on short sheet metals bent using long folding machines.

Normally configured for hydraulic power operation and do not follow the Eco Design Directive.

Usually configured without taking sustainability and power consumption savings into consideration.

[0014] These facts are disclosed to illustrate the technical problem addressed by the present disclosure.

GENERAL DESCRIPTION

[0015] The present disclosure relates to a sheet metal folding machine that bends a sheet metal in opposite directions without the need to turn or flip over the sheet metal. In particular, the sheet metal folding machine bends the sheet metal upwards and downwards.

[0016] In an embodiment, lower stands hold a fixed clamping beam with a folding beam pivoting on it.

[0017] In an embodiment, upper stands hold a clamping beam with a folding beam pivoting on it.

[0018] In an embodiment, the upper stands are turning about a wheel eccentrically connected to shaft centrally supported in lower stands.

[0019] In an embodiment, a rotating eccentric mechanism that holds the upper stand pivoting point in lower stands move it forwards or backwards to switch any folding beam from active into inactive according to the required bending direction (downwards or upwards).

[0020] In an embodiment, the rotating eccentric mechanism that holds the upper stand pivoting point in lower stands move it to a central position to keep aligned the upper and lower clamping beams for an accurate hemming operation.

[0021] In an embodiment, the lower stands receive a positive locking mechanism for the top position of the rotating eccentric mechanism.

[0022] In an embodiment, the positive locking mechanism matches one of the eccentric mechanism dead

points, bending upwards, bending downwards and hemming.

[0023] In an embodiment, the distance of the eccentric movement is more than or equal to the offset of the clamping tool for folding upwards and downwards.

[0024] In an embodiment, a second eccentric mechanism can be mounted on the first eccentric mechanism and be driven through the mechanism at a predetermined distance from the axis of rotation.

[0025] In an embodiment, the second eccentric mechanism enables the upper stand to have minor adjustments at its pivoting point relative to the lower stand to be set for wider bending radius or minor compensations after resharpening of the clamping and bending tools.

[0026] It is disclosed a double-sided folding machine comprising:

a lower stand comprising a lower tool set, comprising a lower clamping tool and a lower bending tool;
 an upper stand comprising an upper tool set, comprising an upper clamping tool and an upper bending tool;
 an eccentric mechanism connecting the lower stand to the upper stand,
 said mechanism comprising a shaft mounted on the lower stand and a wheel with an off-centred axis where the shaft is off-centred mounted in the wheel in respect of the geometric axis of the wheel upon which is mounted the upper stand;
 wherein the lower and upper clamping tool sets are displaceable in relation to each other by a horizontal offset between a first position for folding upwards and a second position for folding downwards, simultaneously adjusting the slack for each bend, wherein the geometric axis of wheel rotates off-centred in respect of shaft to displace the upper stand by a horizontal distance of at least said horizontal offset.

[0027] In an embodiment, the wheel is rotatable to cause the lower and upper stand to be displaced in respect of each other by said horizontal distance.

[0028] In an embodiment, the wheel is rotatable, and as its geometric axis is off centred in respect of shaft, the movable stand will perform an orbital movement, not linear, to attain said horizontal distance offset. This also assists in achieving an improved landing motion of the movable stand upon the piece to be folded upwards, downwards or hemmed.

[0029] Alternatively, the geometric axis of wheel rotates off-centred in respect of shaft to displace the lower stand by a horizontal distance of at least said horizontal offset.

[0030] The eccentric mechanism allows, by way of selecting two rotation positions of the wheel, a precise positioning of the lower and upper stands in respect of each other.

[0031] The movable stand will perform an orbital move-

ment, not linear, to attain said horizontal distance. This also assists in achieving an improved landing motion of the movable stand upon the piece to be folded or hemmed.

[0032] In particular, the wheel may be rotated by small angles or by incrementally smaller angles to accommodate slack or clearance as required in the folding operation. This is an advantage, since with a single drive system, we are able to move the upper stand and correct the slack.

[0033] In an embodiment, the eccentric mechanism shaft is rotatably mounted on the lower stand and the upper stand is swing mounted on the eccentric mechanism wheel.

[0034] In an embodiment, the eccentric mechanism shaft is mounted inside the wheel.

[0035] In an embodiment, the lower stands is attached to a common lower frame.

[0036] In an embodiment, further comprises a lower clamping beam fitted with the lower clamping tool, wherein the lower clamping beam and the lower clamping tool are attached to the lower stand.

[0037] In an embodiment, further comprises a lower clamping beam (4) attached to the lower stand (2), fitted with the lower clamping tool (6), and a lower bending beam (8), fitted with the lower bending tool (10), attached to the lower clamping beam (4) via a lower mechanical linkage, a lower multi-lever kinematic system (12).

[0038] In an embodiment, the machine comprises a lower bending beam fitted with the lower bending tool, wherein the lower bending beam and the lower bending tool are attached to the lower clamping beam via a lower mechanical linkage, a lower multi-lever kinematic system.

[0039] In an embodiment, the machine comprises a lower bend driving crankshaft and connecting rod for driving the lower mechanical linkage powered by means of a lower direct rotary driving mechanism (16) for the lower bend crankshaft (14).

[0040] In an embodiment, the machine comprises a lower direct rotary driving mechanism for driving the lower bend driving crankshaft.

[0041] In an embodiment, the lower bend driving crankshaft, connecting rod and lower mechanical linkage are configured such that the lower rotary driving mechanism rotates at a bending angle.

[0042] In an embodiment, the machine comprises one or more additional sets of lower crankshafts, connecting rod and lower mechanical linkage with corresponding additional lower stands distributed along the machine wherein said lower crankshaft is a torsion synchronizing bar of the lower crankshafts, connecting rods and lower mechanical linkages.

[0043] In an embodiment, the machine further comprising one or more additional sets of lower crankshaft, connecting rod and lower mechanical linkage that are configured in such way that the lower crankshaft is a torsion synchronizing bar of the movement of corresponding

lower mechanical linkages.

[0044] In an embodiment, the machine comprises an upper clamping beam fitted with an upper clamping tool, wherein the upper clamping beam and upper clamping tool are attached to the upper stand.

[0045] In an embodiment, the machine further comprising an upper clamping beam attached to the upper stand, fitted with an upper clamping tool, and an upper bending beam, fitted with the upper bending tool, attached to the upper clamping beam via an upper mechanical linkage, an upper multi-lever kinematic system.

[0046] In an embodiment, the machine comprises an upper bending beam fitted with the upper bending tool, wherein the upper bending beam and the upper bending tool are attached to the upper clamping beam via an upper mechanical linkage, an upper multi-lever kinematic system.

[0047] In an embodiment, folding machine further comprising an upper bend driving crankshaft (15) and connecting rod for driving the upper mechanical linkage powered by means of an upper direct rotary driving mechanism for the upper bend crankshaft.

[0048] In an embodiment, the machine comprises an upper bend driving crankshaft and connecting rod for driving the upper mechanical linkage.

[0049] In an embodiment, the machine comprises an upper direct rotary driving mechanism for driving the upper bend driving crankshaft.

[0050] In an embodiment, the upper bend driving crankshaft, connecting rod and upper mechanical linkage are configured such that the upper rotary driving mechanism rotates at a bending angle.

[0051] In an embodiment, the machine comprises one or more additional sets of upper crankshafts, connecting rod and lower mechanical linkage with corresponding additional upper stands distributed along the machine wherein said upper crankshaft is a torsion synchronizing bar of the upper crankshafts, connecting rods and lower mechanical linkages.

[0052] In an embodiment, the machine further comprising the one or more additional sets of upper crankshaft (15), connecting rod (21) and upper mechanical linkage (13) that are configured in such way that the upper rotary driving mechanism (17) rotates at a bending angle (33) and the upper crankshaft (15) is a torsion synchronizing bar of the movement of corresponding upper mechanical linkages (13).

[0053] In an embodiment, the machine comprises separate driving linear actuators that are controlled in force, for each upper stand, to ensure that the sheet metal is effectively clamped throughout the length of the machine, avoiding the sheet metal from sliding during the bending or trimming processes.

[0054] In an embodiment, the machine comprises separate linear actuators that controlled in force and/or position, depending on operation mode (clamping or precise open hemming).

[0055] In an embodiment, the machine further com-

prising a position control for all separate linear actuators (38) to guarantee a levelled and parallel hemming operation all the way through as to perform accurate open U recesses at the panel edges.

5 **[0056]** In an embodiment, comprises a support and gauging and feeding mechanism for holding and positioning the sheet metal.

[0057] In an embodiment, the machine comprises a gauging stop and clamping grippers for holding, feeding, and positioning the sheet metal.

10 **[0058]** In an embodiment, the machine comprises a rotary actuator for rotating the eccentric mechanism.

[0059] In an embodiment, the machine further comprising a direct rotary actuator for rotating one or each of additional the eccentric mechanism (22,23) is a torsion synchronizing bar of the eccentric mechanisms.

15 **[0060]** In an embodiment, the machine comprises one or more additional eccentric mechanisms and corresponding additional upper stands distributed along the machine wherein shaft is a torsion synchronizing bar of the eccentric mechanisms.

[0061] In an embodiment, the machine comprises displaceable locking stops for locking the eccentric mechanism wheel in one of a plurality of dead point positions.

20 **[0062]** In an embodiment, comprising displaceable locking stops for locking the eccentric mechanism wheel (23) in one of a plurality of dead point positions (24, 25, 26) corresponding to a bending upwards position (24), a bending downwards position (25), and a hemming position (26).

30 **[0063]** In an embodiment, the locking dead point positions comprise a bending upwards position, a bending downwards position, and a hemming position.

[0064] In an embodiment, the machine comprises a double eccentric mechanism comprising a secondary driven eccentric sleeve that transverses the first eccentric shaft. This configuration allows for a better resolution and accuracy in the adjustment be of wider bending radius, or of minor compensations after resharpening the clamping and bending tools. In an embodiment, the wheel comprises a driven eccentric sleeve that surrounds the wheel.

35 **[0065]** In an embodiment, the double eccentric mechanism comprising a secondary driven eccentric sleeve (28), that transverses the first eccentric shaft (22/23), and consists of one output stage with gear, chain, belt, or similar wheels (31) and of one input stage with a centralized shaft (29) and attached pinion, chain, belt, or similar wheels (30) that is a torsion synchronizing bar of the second eccentric mechanisms (28, 31).

40 **[0066]** In an embodiment, the machine comprises a rotary driving of the second eccentric mechanism consisting of one output stage with gear, chain, belt, or similar wheels and of one input stage with a centralized shaft and attached pinion, chain, belt, or similar wheels.

45 **[0067]** In an embodiment, the machine comprises one or more additional connecting second eccentric mechanisms and corresponding upper stands distributed along the machine wherein shaft is a torsion synchronizing bar

of the second eccentric mechanisms.

[0068] In an embodiment, the machine comprises a sheet metal shearing machine for sheet plate trimming.

[0069] In an embodiment, the machine comprises a computer numerical control unit configured for controlling all the mechanism actuators.

[0070] It is also disclosed a method of bending sheet metal using the folding machine according to any of the disclosed embodiments, comprising:

rotating the wheel about the shaft of the eccentric mechanism to displace the upper stand by a horizontal distance of at least said horizontal offset between the lower and upper tools for bending either upwards or downwards, typically the upper stand moving in an orbital motion for attaining said horizontal distance.

[0071] In an embodiment, the method comprises a step for rotating the wheel about the shaft of the eccentric mechanism to a bending downwards dead point position to displace the upper stand forward in respect of the lower stand for bending metal sheet downwards.

[0072] In an embodiment, the method comprises a step for rotating the wheel about the shaft of the eccentric mechanism to a bending upwards dead point position to displace the upper stand backwards in respect of the lower stand for bending metal sheet upwards.

[0073] In an embodiment, the method comprises the preceding steps of moving a gauge stop of the guiding and feeding system to define a pre-determined unfolded sheet metal length to be trimmed after feeding the sheet backwards until it reaches the gauge stop.

[0074] In an embodiment, during the trimming of the sheet metal, the eccentric mechanism wheel is rotated and locked in position, in particular locked in a hemming dead point position.

[0075] In an embodiment, comprises a preceding step of opening the upper stand to place sheet metal in the machine.

[0076] In an embodiment, the method comprises the subsequent steps of:

closing the upper stand;

clamping sheet metal between the upper and lower clamping tools;

trimming the sheet plate with shear;

opening the upper stand to move sheet metal through a gripper to a first bending position;

closing the upper stand;

rotating the eccentric shaft until the desired bending direction is achieved, specifically upwards or downwards and correspondingly eccentric mechanism positions;

clamping sheet metal between the upper and lower clamping tools;

rotating a bending tool upwards or downwards to bend sheet metal upwards or downwards;

opening the upper stand to move sheet metal through the gripper to a second bending position;

and successively for any bending positions.

[0077] In an embodiment, the method comprises a step of determining the bending position by a computer numerical control.

[0078] The described folding machine is easily suited to be servo control powered either hydraulically or electromechanically.

[0079] An embodiment of the described folding machine has servo controlled electromechanically axes, being more energy efficient and complying with the Eco Design Directive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0080] The following figures provide preferred embodiments for illustrating the disclosure and should not be seen as limiting the scope of invention.

Figure 1 is an illustration of an overall perspective of the machine of the present disclosure.

Figure 2 is an illustration of an overall perspective of the machine of the present disclosure forming a tapered part

Figure 3 is an illustration of a side view of the machine of the present disclosure.

Figure 4 is an illustration of a side view of the machine of the present disclosure, positioned for bending upwards with the lower bending beam.

Figure 5 is an illustration of a side view of the machine of the present disclosure, positioned for bending downwards with the upper bending beam.

Figure 6 is an illustration of a side view of the machine of the present disclosure, positioned for precise and levelled hemming, with the gauging and feeding system at half travel.

Figure 7 is an illustration of different folding operations performed on a single side sheet metal folding machine of current state of the art.

Figure 8 is an illustration of the double eccentric, positioned for bending downwards with the upper bending beam (25 locked at top).

Figure 9 is an illustration of a side view of the machine of the present disclosure, showing an opening position of the upper stands.

Figure 10 is a side view zoom on the lower and upper clamping beams, lower and upper bending beams, currently positioned for bending downwards with the upper bending beam.

Figure 11 is a side view zoom on the lower and upper

clamping beams, lower and upper bending beams, currently positioned for bending upwards with the lower bending beam.

Figure 12 is a side view zoom on the lower and upper clamping beams, lower and upper bending beams, currently positioned for precise and levelled hemming.

Figure 13 is a side view zoom on system of gauging and feeding in position of the sheet metal gripping.

Figure 14 is an illustration of a side view of the machine of the present disclosure, with the upper bending beam performing the operation of bending downwards.

Figure 15 is an illustration of a side view of the machine of the present disclosure, with the lower bending beam performing the operation of bending upwards.

DETAILED DESCRIPTION

[0081] The present disclosure relates to a sheet metal folding machine that bends a sheet in opposite directions without the need to turn or flip over the sheet. In particular, the sheet metal folding machine bends the sheet upwards and downwards.

[0082] In an embodiment, the sheet metal folding machine of the present disclosure is a double-sided folding machine.

[0083] The present disclosure relates to a double-sided folding machine comprising: a lower stand comprising a lower tool set, comprising a lower clamping tool and a lower bending tool; an upper stand comprising an upper tool set, comprising an upper clamping tool and an upper bending tool; an eccentric mechanism connecting the lower stand to the upper stand, comprising a shaft mounted on lower stand and a wheel with off-centred parallel axis, wherein the shaft is off-centred mounted in wheel in respect of the geometric axis of wheel upon which is mounted the upper stand; wherein the lower and upper clamping tool sets are displaceable in relation to each other by a horizontal offset between a first position for folding upwards and a second position for folding downwards, wherein the geometric axis of wheel rotates off-centred in respect of shaft to displace the upper stand by a horizontal distance of at least said horizontal offset. Also, method of bending sheet metal thereof.

[0084] In an embodiment, the machine of the present disclosure comprises:

lower stands (2) that are attached to a common lower frame (1);
a lower clamping beam (4) fitted with a lower clamping tool (6), wherein the lower clamping beam and the lower clamping tool are attached to the lower

stands (2);

a lower folding beam (8) with a lower bending tool (10), wherein the lower folding beam and lower bending tool are attached to the lower clamping beam via a multi-lever kinematic system (12);

a centralized driving crankshaft (14) for the multi lever kinematic system (12);

upper stands (3) that are connected to the lower stands (2);

an upper clamping beam (5) fitted with an upper clamping tool (7), wherein the upper clamping beam and upper clamping tool are attached to the upper stands (3);

an upper folding beam (9) with an upper bending tool (11), wherein the upper folding beam and the upper bending tool are attached to the upper clamping beam (5) via a multi lever kinematic system (13);

a centralized driving crankshaft (15) for the multi lever kinematic system (13);

an eccentric mechanism shaft (22), rotatable with an eccentric wheel (23), to position the upper stands (3) at their pivoting point (23) relative to its trunnion (eccentric shaft 22) in the lower stands (2);

a support (37) and gauging (34) mechanism for holding and positioning the sheet metal.

[0085] In an embodiment, the machine of the present disclosure further comprises actuators and a power unit to supply the actuators with power.

[0086] In an embodiment, the machine of the present disclosure further comprises a sheet metal shearing machine (41) for sheet trimming.

[0087] In an embodiment, the machine of the present disclosure further comprises a computer numerical control unit (47).

[0088] In an embodiment, the lower stands are a succession of lower stands (2) fixed to a common lower frame (1).

[0089] In an embodiment, the lower clamping beam (4), fitted with a lower clamping tool (6), is attached to all the lower stands.

[0090] In an embodiment, the lower folding beam is a driven lower folding beam (8) fitted with a lower bending tool (10). The lower folding beam and the lower bending tool is linked to the lower clamping beam (4) through a multi-lever kinematic system (12) which is configured to keep the crankshaft (14) movement (16) congruent with the bending axis in order to bend the sheet metal upwards (32).

[0091] In an embodiment, the centralized driving crankshaft (14) for the multi lever kinematic system (12) is easily suited to be servo control powered either hydraulically or electromechanically.

[0092] In an embodiment, the centralized driving crankshaft (14) also operates as a torsion synchronizing bar to ensure that an accurate bending is achieved throughout the length of the machine.

[0093] In an embodiment, the upper stands are a suc-

cession of upper stands (3) pivoting in position (23) off centered relative to its trunnion (eccentric shaft 22) in the lower stands (2).

[0094] In an embodiment, the upper clamping beam (5), fitted with an upper clamping tool (7), is attached to all the upper stands (3).

[0095] In an embodiment, the driven upper folding beam (9), with the upper bending tool (11), is linked to the upper clamping beam (5) via a multi-lever kinematic system (13) which is configured to keep the crankshaft (15) movement (17) congruent with the bending axis to bend the sheet metal downwards (33).

[0096] In an embodiment, the centralized driving crankshaft (15) for the multi-lever kinematic system (13) is easily suited to be servo control powered either hydraulically or electromechanically.

[0097] In an embodiment, the centralized driving crankshaft (15) also operates as a torsion synchronizing bar to ensure that an accurate bending is achieved throughout the length of the machine.

[0098] In an embodiment, each multi-lever mechanism (12 and 13), which is linked to their corresponding bending beam, has a direct driving (20 and 21).

[0099] In an embodiment, the shaft (22) is eccentrically placed relative to a wheel (23). This allows the upper stands (3) to be positioned at their pivoting point (23) relative to the lower stands (2).

[0100] In an embodiment, the shaft (22), running over the lower stands (2) from end to end, receive the eccentric wheels (23) over which pivots the upper stands, also functions as a torsion synchronizing bar.

[0101] In an embodiment, the eccentric shaft (22, 23) may be powered either hydraulically or electromechanically.

[0102] In an embodiment, for fine adjustment of the bending radius, an eccentric sleeve (28) is used. The eccentric sleeve (28) which transverses across the eccentric mechanism (22 and 23), has a separate driving (30/31). This allows for setting a wider bending radius or minor compensations after resharpening of the clamping and bending tools.

[0103] In an embodiment, the driving of the second eccentric mechanism comprises a differed transmission by gears (31). This allows for the power input through a centralized shaft (29) to be easily adapted to be servo control powered either hydraulically or electromechanically.

[0104] In an embodiment, the centralized shaft which transverse end to end (29) across the machine also functions as a torsion synchronizing bar.

[0105] In an embodiment, the dual eccentric configuration driving ensures that a positive positioning of the upper stands relative to the lower stands is achieved.

[0106] In an embodiment, the positive positioning is optionally achieved or by convenient motor stall torque, or by means of actuated mechanical stops to lock the eccentric mechanism (22/23) in position (24, 25 and 26).

[0107] In an embodiment, an accurate horizontal position of the upper stands (3) relative to the lower stands

(2) is thus ensured in every required critical process: bending upwards (24 and 32), bending downwards (25 and 33) and precise and levelled hemming (26 and 44).

[0108] In an embodiment, the machine of the present disclosure further comprises a set of actuators for each required powered movement (lower bending beam (8), upper bending beam (9), clamping/hemming bend (40 and 44), eccentric shaft adjustment (22/23) of the rocker pivoting point position, eccentric shaft stops (24/25/26) and eccentric sleeve (28) adjustments for bending radius setting.

[0109] In an embodiment, to obtain bending space and vertical separation (42) between upper clamping / bending beams and lower stands for the upper stands' rotation, a set of individual linear actuators (38) is used.

[0110] In an embodiment, the individual linear actuators are easily adapted to be servo control powered either hydraulically or electromechanically.

[0111] In an embodiment, each linear actuator (38) may be controlled in force and/or position depending on operation mode (clamping or precise hemming).

[0112] In an embodiment, all the actuators are powered.

[0113] In an embodiment, the machine comprises a support (37) and a gauging (34) and feeding System (35) (Sheet Metal Positioning System) to hold and position the sheet metal in the required flange length.

In an embodiment, the support and the gauging and feeding system comprise a set of fitted grippers (35) to automatically feed the sheet metal to the required bending points.

[0114] In an embodiment, the machine of the present disclosure further comprises a sheet metal shearing machine (41) for trimming the sheet.

[0115] In an embodiment, the machine of the present disclosure further comprises a computer numerical control unit ("CNC control") (47) for synchronizing, positioning and stopping the different driven axes at required points.

[0116] In an embodiment, the CNC Control unit stores data, functions, parameters, and program libraries. The CNC Control unit has a screen for human machine interface, for data input and friendly programming. For example, while the machine is bending or hemming one sheet metal, the CNC Control unit may be programmed to prepare for the bending or hemming of subsequent undeveloped sheet metals (43).

[0117] In an embodiment, the method of folding sheet metal using the double-sided folding machine of the present disclosure comprises:

Open the upper stand to place the sheet metal in the machine;
Rotate the eccentric shaft (22, 23) until the hemming position (26) is achieved;
Move the gauge stop (36) of the gauging and feeding system to define the required unfolded sheet metal length (43);

Feed the sheet metal up until it reaches the gauge stop (36);
 Close the upper stand;
 Clamp the sheet metal between the upper and the lower clamping beams;
 Trim the sheet metal to the desired unfolded length by using the shearing machine (41);
 Open the upper stand to move the sheet metal through the grippers (35) to the first folding position as defined by the CNC (47);
 Rotate the eccentric shaft (22, 23) until the desired bending direction is achieved, specifically upwards (32) or downwards (33);
 Bend upwards (32) or downwards (33) as chosen up the required bending angle;
 Open the upper stand to move the sheet metal through the grippers (35) to the second bending position as defined by the CNC (47).
 Repeat the process until the desired length and number of folds is obtained.

[0118] In an embodiment, the upper stand is opened to a variable top limit (42) sufficient for feeding the sheet metal. The sheet metal may be flat (43) or pre bent (44, 45).

[0119] In an embodiment, the method of the present disclosure may optionally comprise the preceding step of trimming the undeveloped sheet metal (43) with the shearing machine (41).

[0120] In an embodiment, to define the required undeveloped sheet metal width, the sheet metal is positioned against the gauging stops (36) located on the gauging and feeding system (34 and 35).

[0121] In an embodiment, the upper stand closes and the upper beams clamp the sheet metal in position against the fixed lower beams throughout the length (46) of the machine.

[0122] In an embodiment, the shearing machine (41) transverse along the machine length and trims (43) the undeveloped sheet metal to the required length.

[0123] In an embodiment, the upper stands open to a new top limit.

[0124] In an embodiment, a wider bending radius can be set in the eccentric sleeve (28).

[0125] In an embodiment, the gauging and feeding system moves to fix the flange dimension (45) to be bent.

[0126] In an embodiment, prior to bend downwards (33), we rotate the eccentric shaft (22, 23) to the downwards dead point (25) to move the upper stand beams as shown in Fig. 10.

[0127] In an embodiment, during downwards bending (33), the upper stand closes and the clamping beam (5) and corresponding tool (7) fix and clamp the sheet metal against the fixed lower clamping (4) and bending beams (8) and corresponding tools (6 and 10) throughout the length of the machine.

[0128] In an embodiment, prior to bend upwards (32), we rotate the eccentric shaft (22, 23) to the upwards dead

point (24) to move the upper stand beams as shown in Fig. 11.

[0129] In an embodiment, during upwards bending (32), the upper stand closes and the clamping (5) and bending beams (9) and corresponding tools (7 and 11) fix and clamp the sheet metal against the fixed lower clamping beam (4) and its corresponding clamping tool (6) throughout the length of the machine.

[0130] In an embodiment, to allow for more room to maneuver and rotate pre-bent sheet metals for subsequent further bending, the upper stand is opened to the variable upper limit (42) to provide a wider opening.

[0131] In an embodiment, the same upper stand opening limit that is used for maneuvering and rotating pre-bent sheet metals is also chosen for removing the sheets from the machine after further bends have been made.

[0132] In an embodiment, the machine of the present disclosure is versatile as it can be adapted for either hydraulic drive, electromechanical drive, or hybrid drive, as it is based on rotary intakes.

[0133] In an embodiment, the mechanical synchronism along the length of the machine is eased as it is based on an interconnecting torsion shaft as the machine is based on rotary motions.

[0134] In an embodiment, the machine of the present disclosure may be further modified to increase the capacity of the machine, the number of driving motors and their interconnecting torsion shafts (22, 29, 14 and 15) can be increased while ensuring electronic synchronism on all the motors.

[0135] In an embodiment, the operating speeds of the modified machine can be easily kept high ensuring short cycle operation time.

[0136] In an embodiment, the rotary driving enables the control system to guarantee an accurate stopping point and a precise folding operation as the driving angle (see 16 and 17) is the same as the bending angle (32 and 33).

[0137] In an embodiment, each set of the multi-lever kinematic system (12 and 13) of the bending tools (10 and 11) has direct drive from shaft (14 and 15) through corresponding rod (20, 21), thus allowing the bending tools to be able to perform precise movements.

[0138] In an embodiment, the machine of the present disclosure may be further modified to comprise one, or more eccentric shafts (22/23 and 29/30/31) for moving the upper stand pivoting point relative to the lower fixed stands.

[0139] In an embodiment, the machine of the present disclosure may be configured to comprise a single eccentric shaft (22/23) to reduce the number of controlled drives. This configuration requires an extra torque on driving to keep the rocker arm in position during the operation. The fine rotation adjustment (23) ensures the required bending radius setting.

[0140] In an embodiment, the machine of the present disclosure may be configured to comprise a double eccentric shaft by introducing a second driven eccentric

sleeve (28) that transverses the first eccentric shaft (22/23). This configuration allows for a better resolution and accuracy in the adjustment of wider bending radius or minor compensations after resharping of the clamping and bending tools.

[0141] In an embodiment, the driving power on the eccentric shaft (22/23) of a double eccentric shaft configuration can be reduced by using a positive lock position device for the eccentric dead points (24, 25 and 26).

[0142] The use of an eccentric mechanism (22 and 23) in comparison to the direct linear horizontal displacement used in other solutions has the large advantage of providing a more positive locking position without any play. It has the disadvantage of inducing a vertical upper stand movement during bending direction setting.

[0143] In an embodiment, the sheet metal is held in position by the clamping tools (6 and 7) which are attached to their corresponding fixed lower stands (2) and upper stands (3).

[0144] In an embodiment, the upper stands have separate driving actuators (38) to ensure that the sheet metal is effectively clamped throughout the length of the machine when the upper (5) and lower (4) clamping beams and their corresponding clamping tools (7 and 6) are firmly closed. This has the effect of avoiding the sheet metal from sliding during the bending or trimming processes.

[0145] In an embodiment, in addition, a fine positioning of the actuators ensures a precise hemming operation (26) regardless of the sheet plate location (43) and its length (43).

[0146] In an embodiment, the CNC control (47) of the machine is for programming and computing the sequence of bending (47) to be performed. The CNC also controls the shafts and movements (16, 17, 23, 30 and 38) gauging position (36) and simulate the full process. In case of collisions, the CNC will alert the operator to adapt or change the job accordingly.

[0147] In an embodiment, the CNC control (47) optimizes the process by defining the sequence of bending to be performed and by positioning, synchronizing and stopping the different driven shafts and movements (16, 17, 23, 30 and 38) at the required points and at the right moment.

[0148] In an embodiment, the CNC of the machine allows full control of all the shafts and movements (16, 17, 23, 30 and 38) and their actuators to ensure fast, precise movement and accurate stopping of the bending tools. This ensures that accurate bending radius and angle are achieved regardless of the folding direction.

[0149] In an embodiment, the CNC control defines the sheet metal support position, as well as the gauging and feeding system position (34) according to the required length of the bending flange (45).

[0150] In an embodiment, the gauging and feeding system of the machine may further comprise an independent driving (34) for each upper stand, along the machine length, that allows to produce tapered bends (27), enhancing more complex tasks.

[0151] In an embodiment, the machine of the present disclosure comprises a special side positioning stop of the sheet plate associated to the end one independent driving of the gauging and feeding system. That side stop when hit by the sheet side defines a positive coordinate origin to ensure the right flange lengths in tapered bends.

[0152] In an embodiment, the machine of the present disclosure has a wide angular opening (42) between the upper stands (3) and the supporting table (37), with a minimum opening at the pivoting points of 30°, to ease in side, front feeding and maneuvering of the parts.

[0153] In an embodiment, the linear opening between the upper clamp beam tool (5/7) at the top position and lower tool (4/6) reaches a minimum of 400 mm (42) which allows sufficient space for housing pre-bent parts (45) for opposite side bends.

[0154] In an embodiment, the lower and upper stands (2 and 3) of the machine of the present disclosure have a protruding end with a nose shape to allow for folding angles up to 150° in both directions (upwards and downwards).

[0155] In an embodiment, different types of materials with different thicknesses may be folded using the machine of the present disclosure.

[0156] The disclosure should not be seen in any way restricted to the embodiments described and a person with ordinary skill in the art will foresee many possibilities to modifications thereof.

[0157] The embodiments described above are combinable.

Claims

1. A double-sided folding machine comprising:

a lower stand (2) comprising a lower tool set (6,10), comprising a lower clamping tool (6) and a lower bending tool (10);

an upper stand (3) comprising an upper tool set (7,11), comprising an upper clamping tool (7) and an upper bending tool (11);

an eccentric mechanism connecting the lower stand (2) to the upper stand (3),

said mechanism comprising a shaft (22) mounted on the lower stand (2) and a wheel (23) with an off-centred parallel axis wherein the shaft (22) is off-centred mounted in the wheel (23) in respect of the geometric axis of the wheel (23) upon which is mounted the upper stand (3);

wherein the lower and upper clamping tool sets are displaceable in relation to each other by a horizontal offset between a first position for folding upwards and a second position for folding downwards,

wherein the geometric axis of the wheel (23) is rotatable off-centred in respect of the shaft (22) to displace the upper stand (3) by a horizontal

distance of at least said horizontal offset.

2. The folding machine according to the previous claim, wherein the eccentric mechanism shaft (22) is rotatably mounted on the lower stand (2) and the upper stand (3) is swing mounted on eccentric mechanism wheel (23), preferably the eccentric mechanism shaft (22) is mounted inside the wheel (23). 5
3. The folding machine according to any of the previous claims further comprising a lower clamping beam (4) fitted with the lower clamping tool (6), wherein the lower clamping beam (4) and the lower clamping tool (6) are attached to the lower stand (2). 10
4. The folding machine according to any of the previous claims further comprising a lower bending beam (8) fitted with the lower bending tool (10), wherein the lower bending beam (8) and the lower bending tool (10) are attached to the lower clamping beam (4) via a lower mechanical linkage, a lower multi-lever kinematic system (12), preferably further comprising a lower bend driving crankshaft (14) and connecting rod (20) for driving the lower mechanical linkage (12). 15 20
5. The folding machine according to the previous claim further comprising a lower direct rotary driving mechanism (16) for driving the lower bend driving crankshaft (14), preferably the lower bend driving crankshaft (14), connecting rod (20) and lower mechanical linkage (12) are configured such that the lower rotary driving mechanism (16) rotates at a bending angle (32). 25 30
6. The folding machine according to the previous claim further comprising one or more additional sets of lower crankshaft (14), connecting rod (20) and lower mechanical linkage (12) with corresponding additional lower stands distributed along the machine wherein said lower crankshaft (14) is a torsion synchronizing bar of the lower crankshafts (14), connecting rods (20) and lower mechanical linkages (12). 35 40
7. The folding machine according to any of the previous claims further comprising an upper clamping beam (5) fitted with an upper clamping tool (7), wherein the upper clamping beam (5) and upper clamping tool (7) are attached to the upper stand (3), preferably further comprising an upper bending beam (9) fitted with the upper bending tool (11), wherein the upper bending beam (9) and the upper bending tool (11) are attached to the upper clamping beam (5) via an upper mechanical linkage, an upper multi-lever kinematic system (13). 45 50
8. The folding machine according to the previous claim further comprising an upper bend driving crankshaft (15) and connecting rod (21) for driving the upper mechanical linkage (13). 55
9. The folding machine according to the previous claim further comprising an upper direct rotary driving mechanism (17) for driving the upper bend driving crankshaft (15), preferably the upper bend driving crankshaft (15), connecting rod (21) and upper mechanical linkage (13) are configured such that the upper rotary driving mechanism (17) rotates at a bending angle (33).
10. The folding machine according to the previous claim further comprising the one or more additional sets of upper crankshaft (15), connecting rod (21) and lower mechanical linkage (12) with corresponding additional upper stands distributed along the machine wherein said upper crankshaft (15) is a torsion synchronizing bar of the upper crankshafts (15), connecting rods (21) and lower mechanical linkages (12).
11. The folding machine according to any of the previous claims further comprising a rotary actuator for rotating the eccentric mechanism (22,23), preferably further comprising one or more additional eccentric mechanisms (22,23) and corresponding additional upper stands distributed along the machine wherein shaft (22) is a torsion synchronizing bar of the eccentric mechanisms (22, 23).
12. A method of bending sheet metal using the folding machine according to any of the previous claims, comprising:
rotating the wheel (23) about the shaft (22) of the eccentric mechanism to displace the upper stand (3) by a horizontal distance of at least said horizontal offset between the lower and upper tools for bending either upwards or downwards.
13. The method of bending sheet metal according to the previous claim further comprising a step for rotating the wheel (23) about the shaft (22) of the eccentric mechanism to a bending downwards dead point position (25) to displace the upper stand (3) forward in respect of the lower stand (2) for bending metal sheet downwards (33), wherein the wheel is rotatable through small angles or through increasingly smaller angles to accommodate slack or slack as needed in the bending operation.
14. The method of bending sheet metal according to claim 12 or 13 further comprising a step for rotating the wheel (23) about the shaft (22) of the eccentric mechanism to a bending upwards dead point position (24) to displace the upper stand (3) backwards in respect of the lower stand (2) for bending metal sheet upwards (32), wherein the wheel is rotatable

be rotated through small angles or through increasingly smaller angles to accommodate slack or slack as needed in the bending operation.

15. The method of bending sheet metal according to any of the claims 12-14, wherein during the trimming of the sheet metal, the eccentric mechanism wheel (23) is rotated and locked in position, in particular locked in a hemming dead point position (26).

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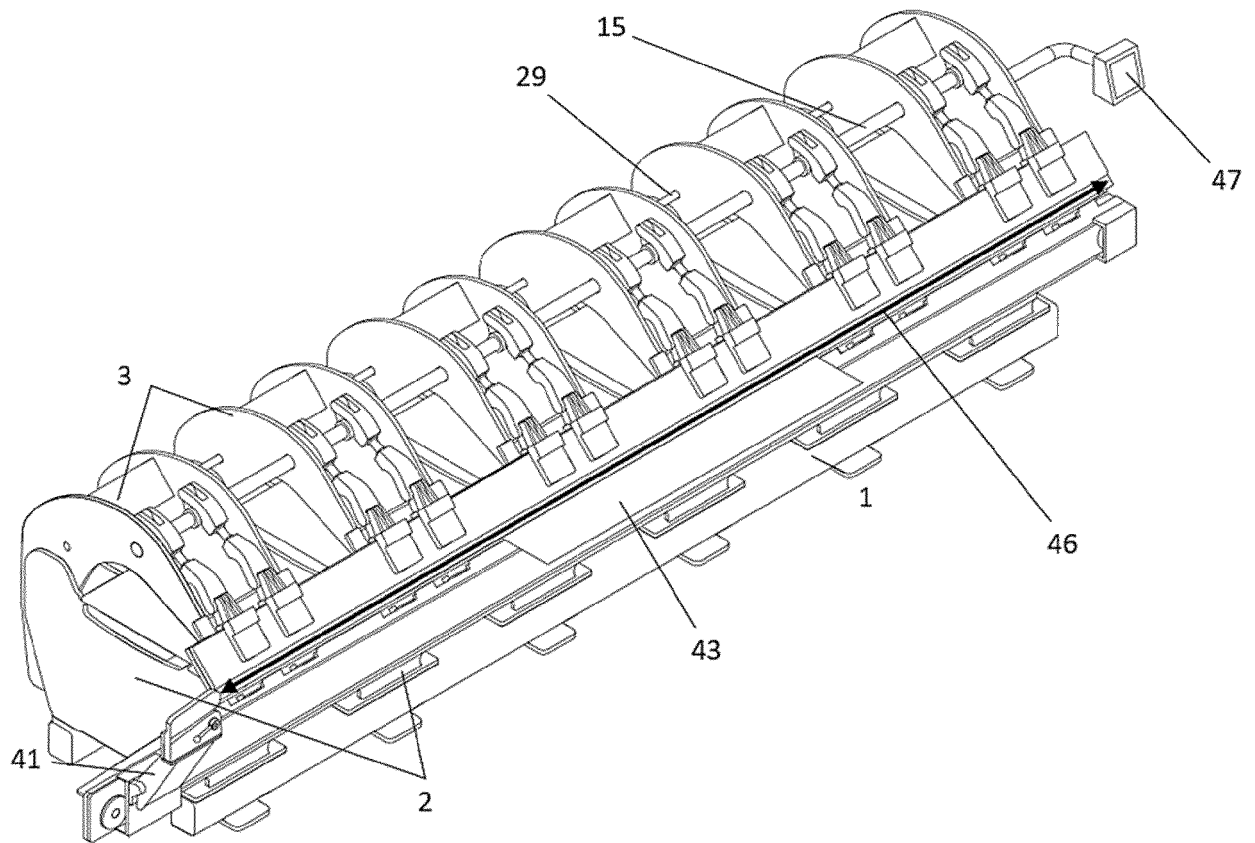


Fig. 1

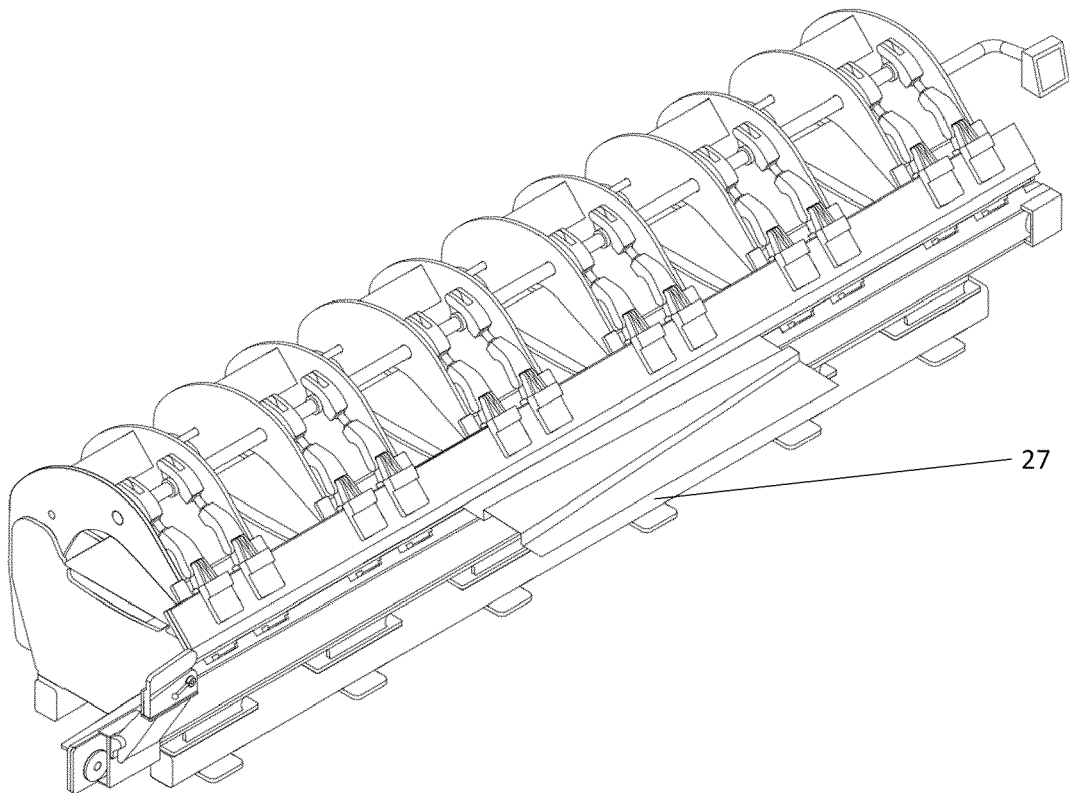


Fig. 2

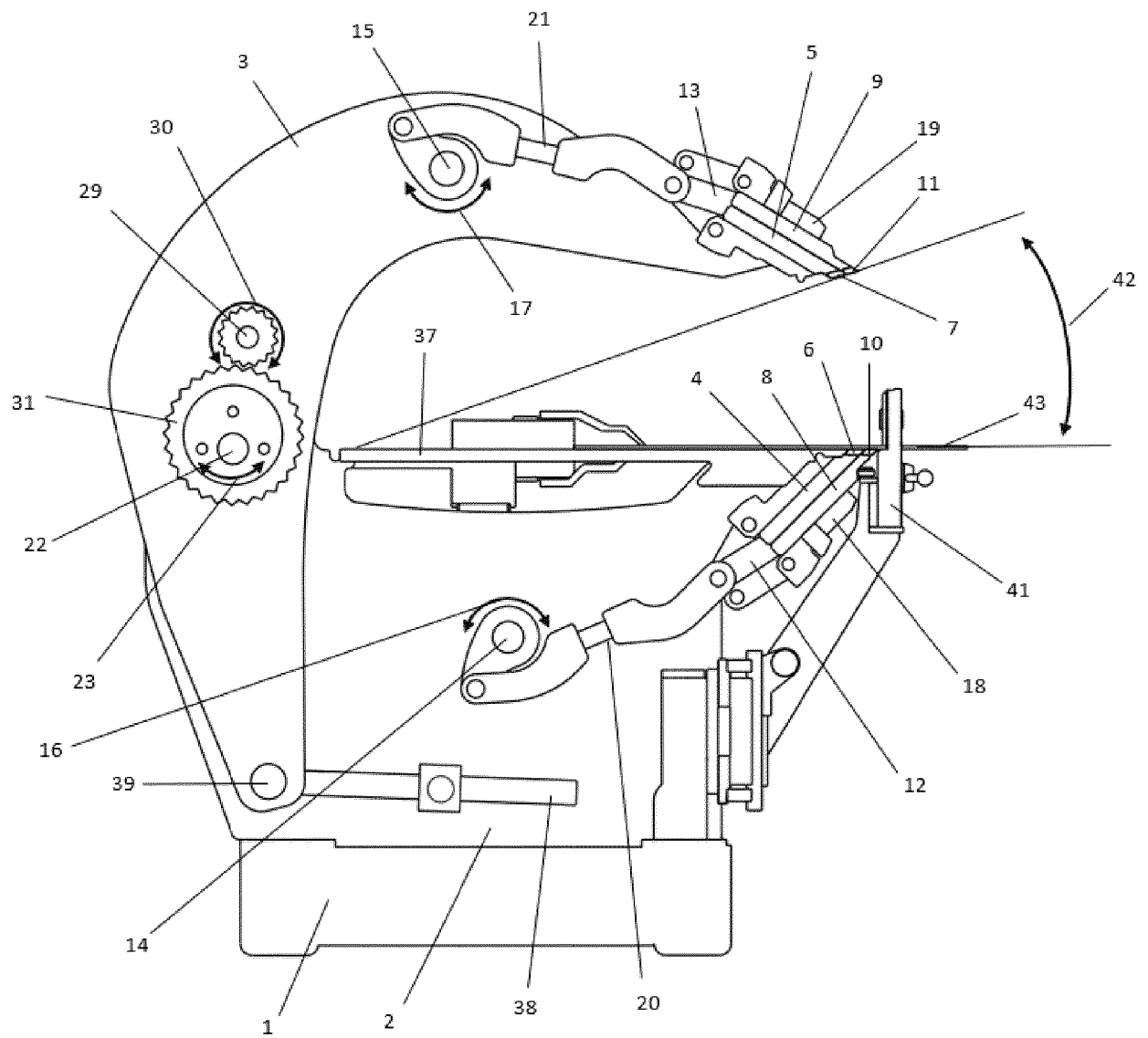


Fig. 3

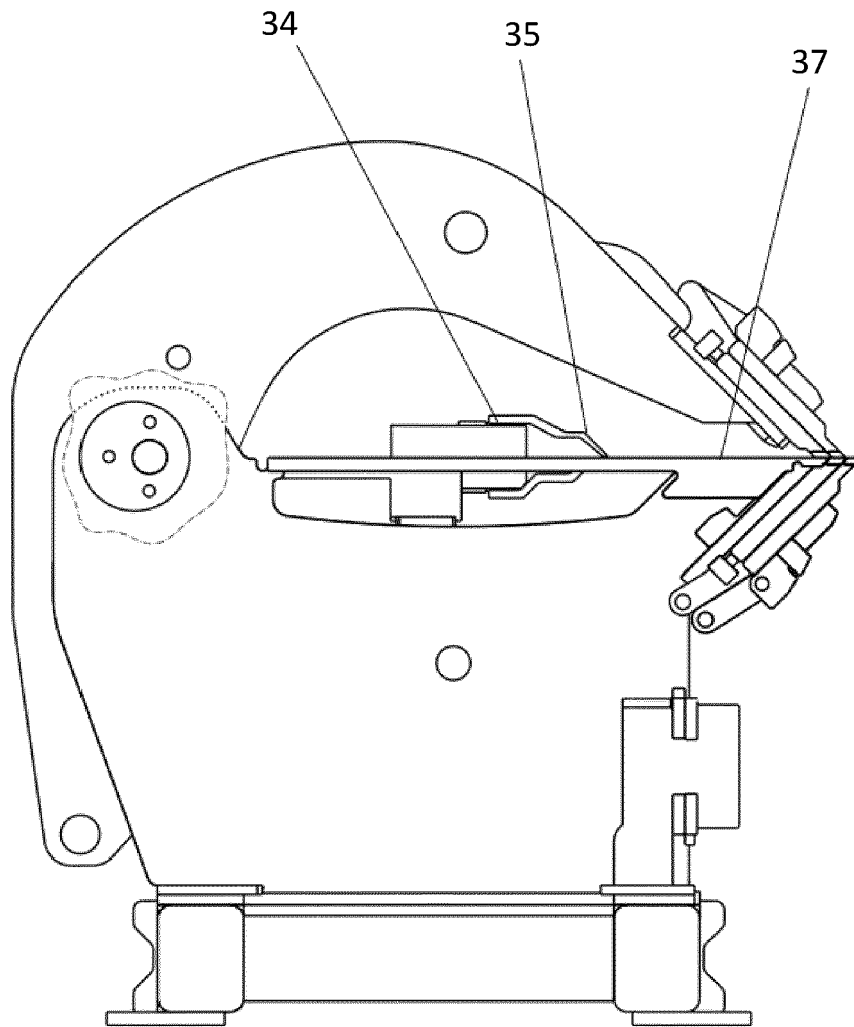


Fig. 4

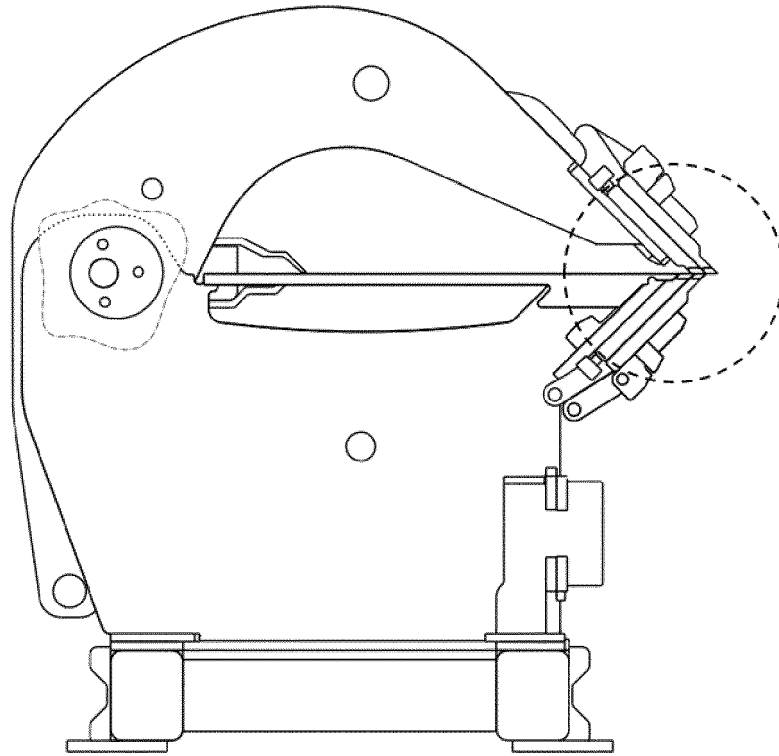


Fig. 5

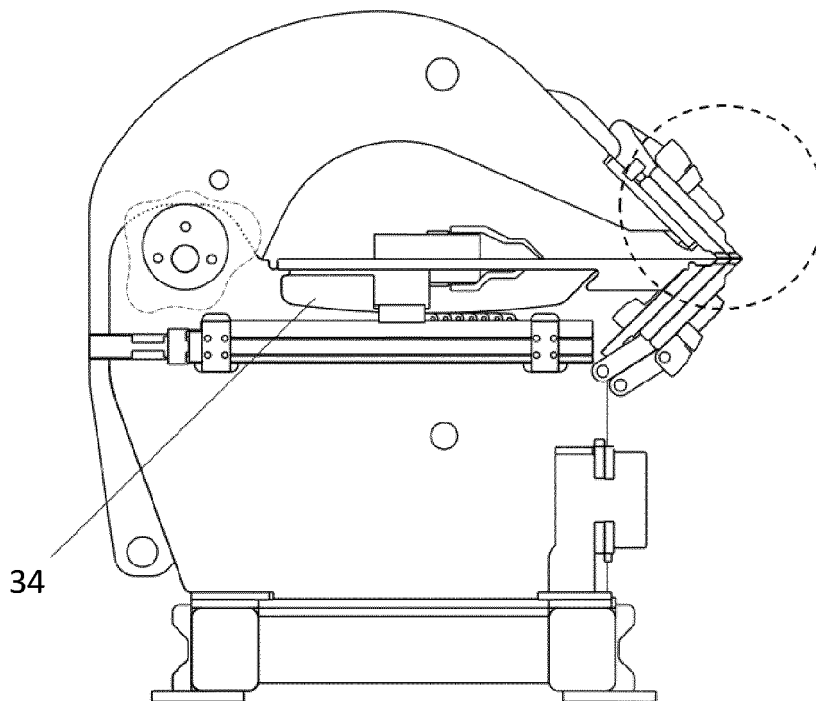


Fig. 6

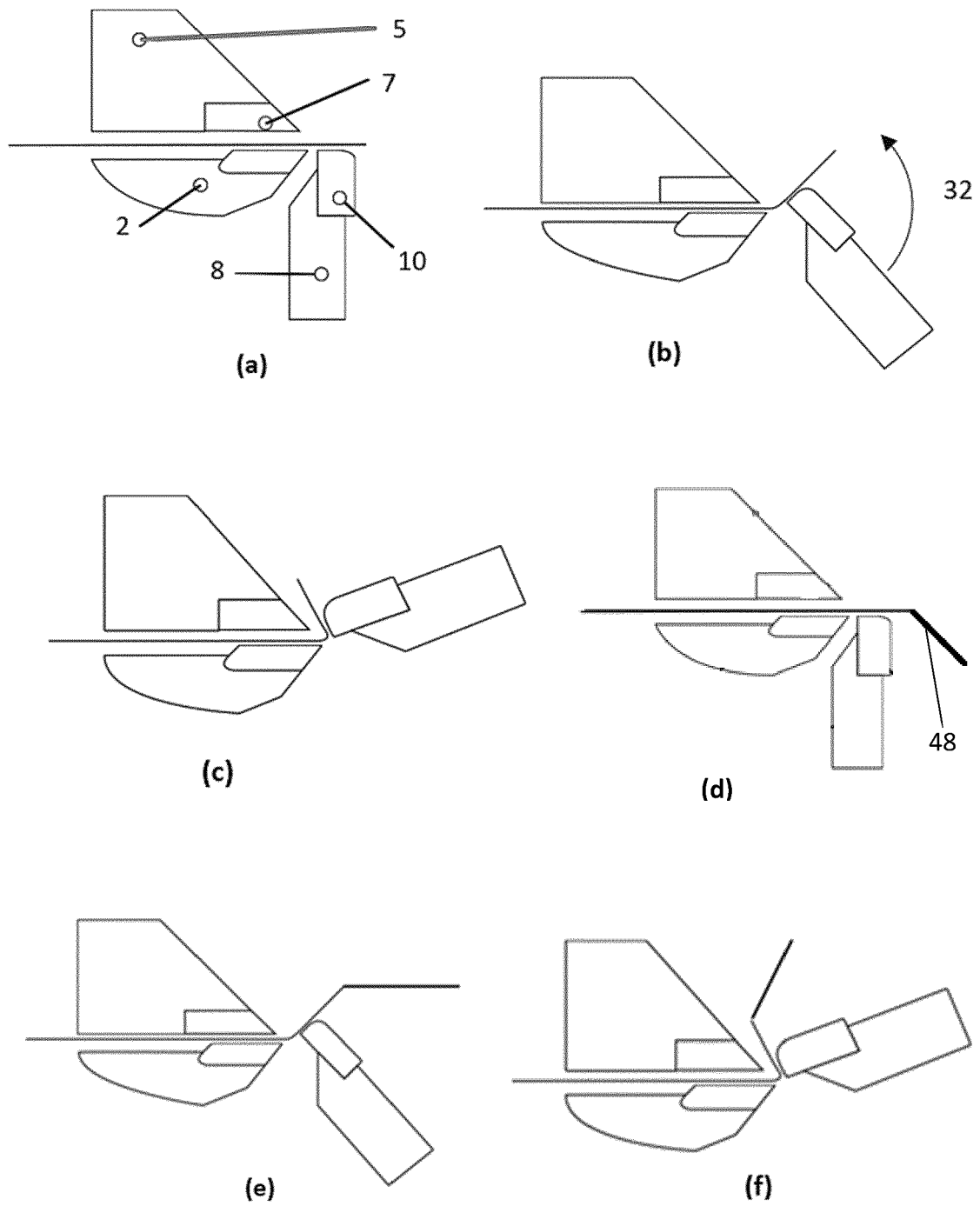


Fig. 7

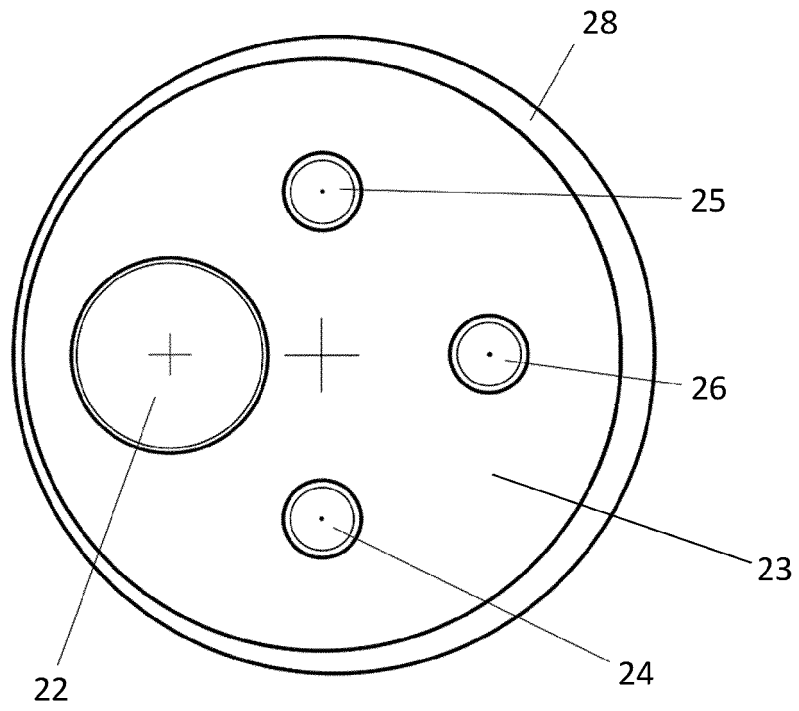


Fig. 8

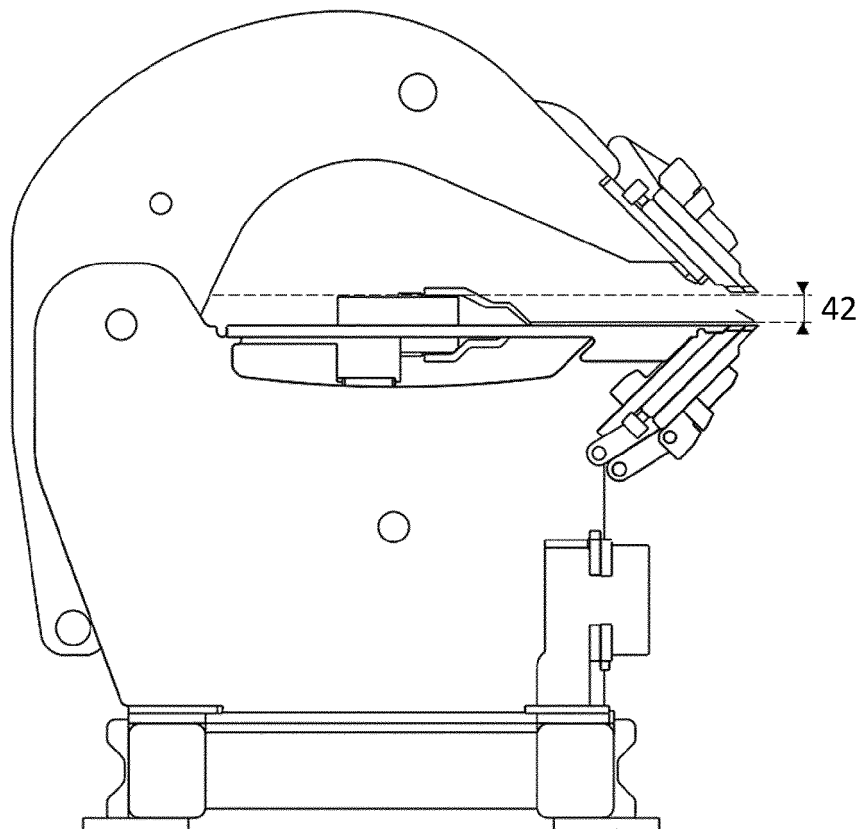


Fig. 9

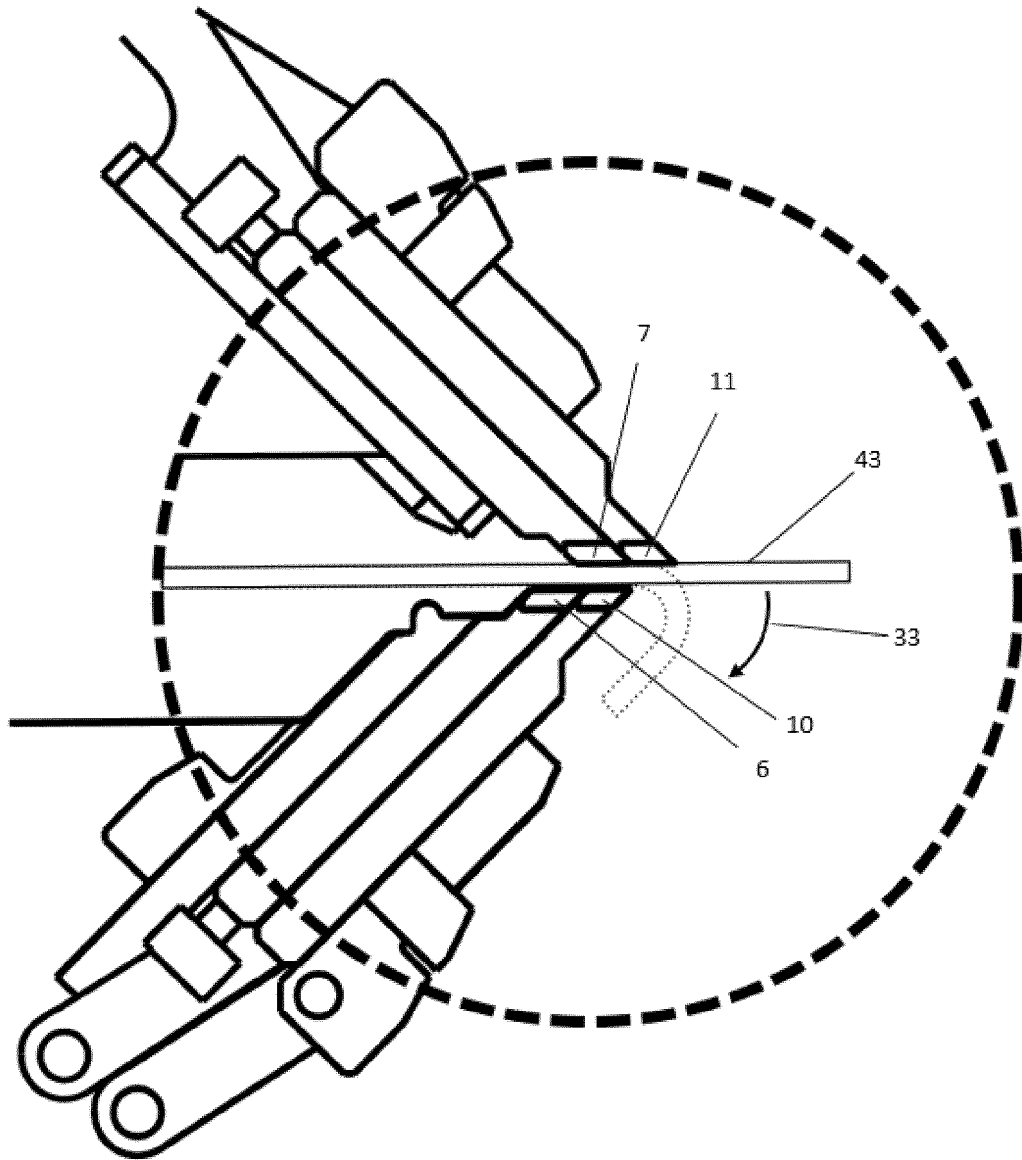


Fig. 10

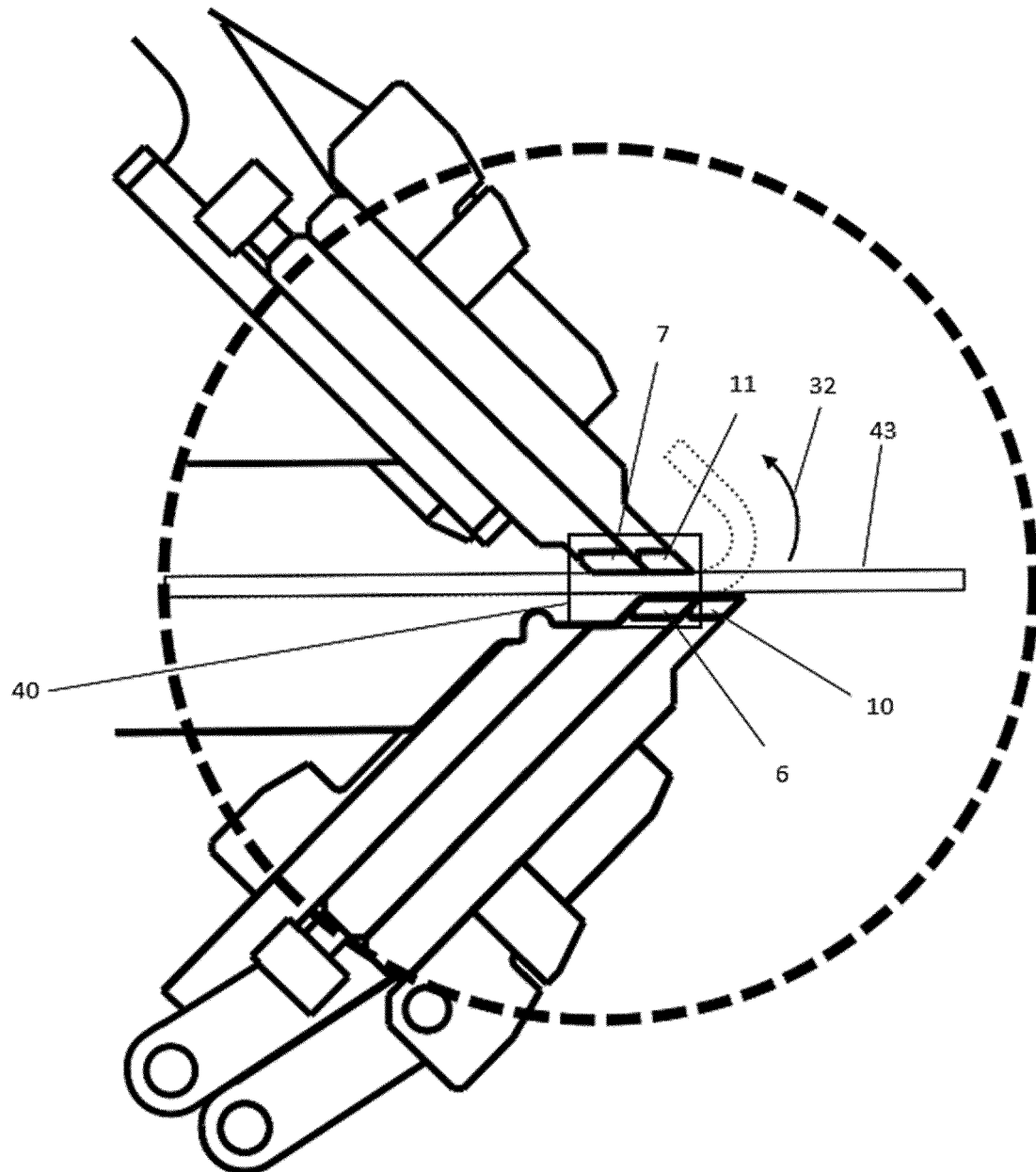


Fig. 11

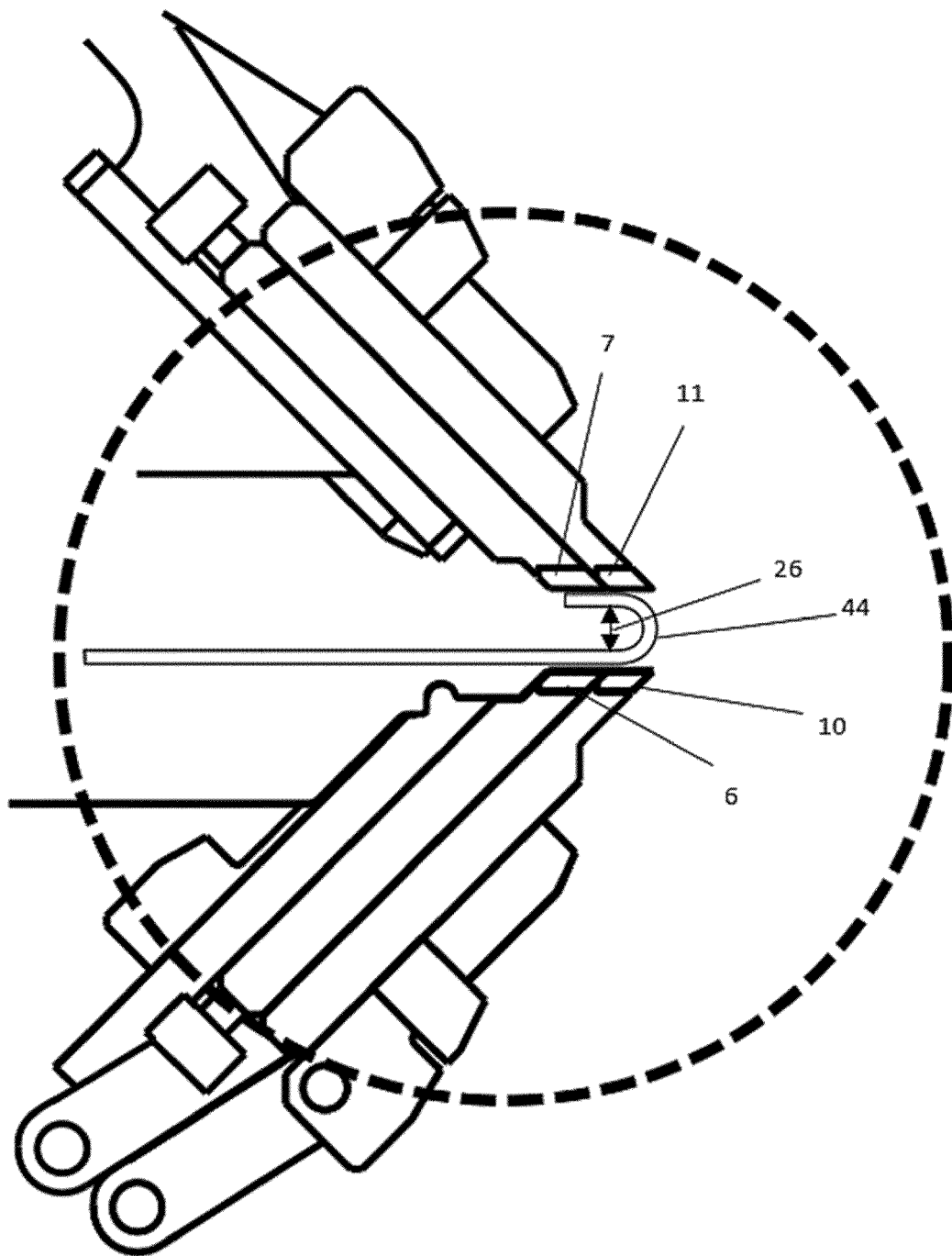


Fig. 12

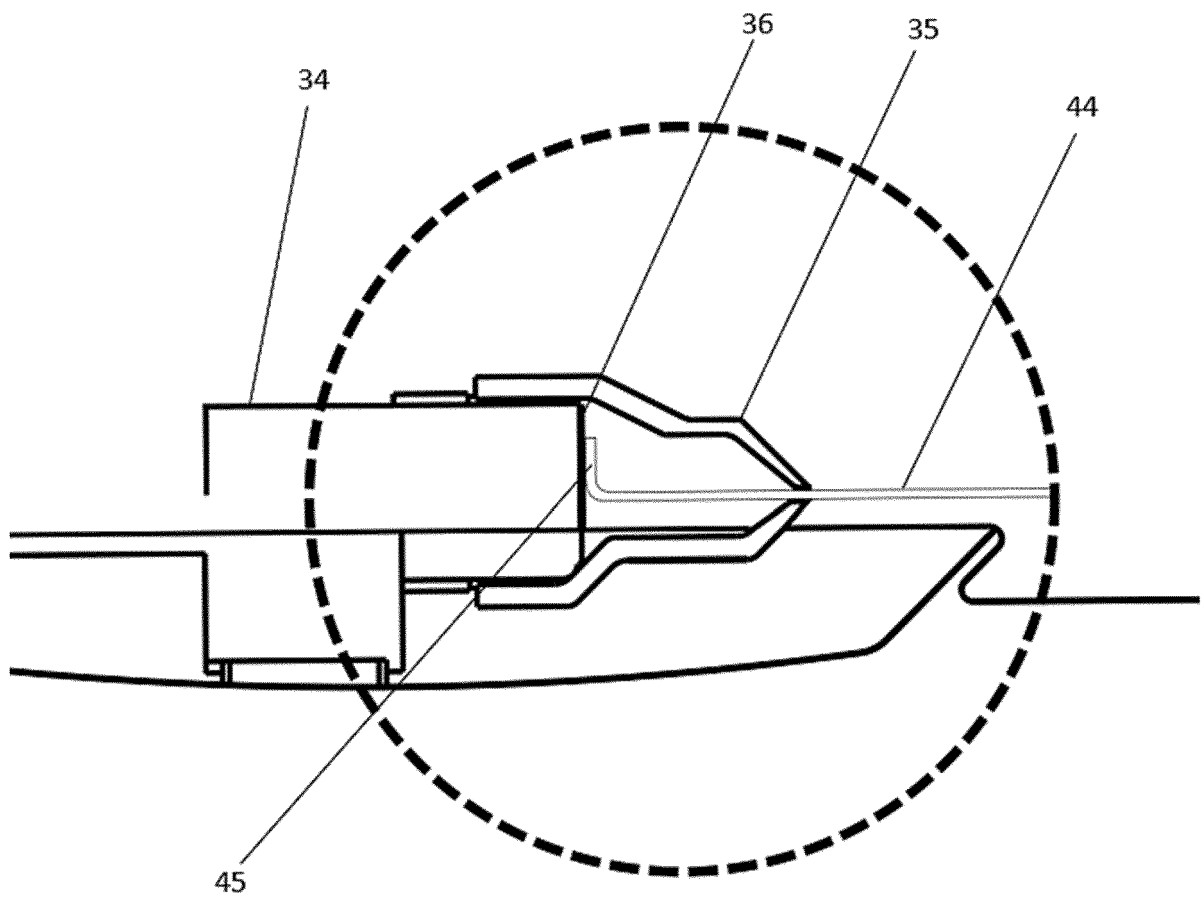


Fig. 13

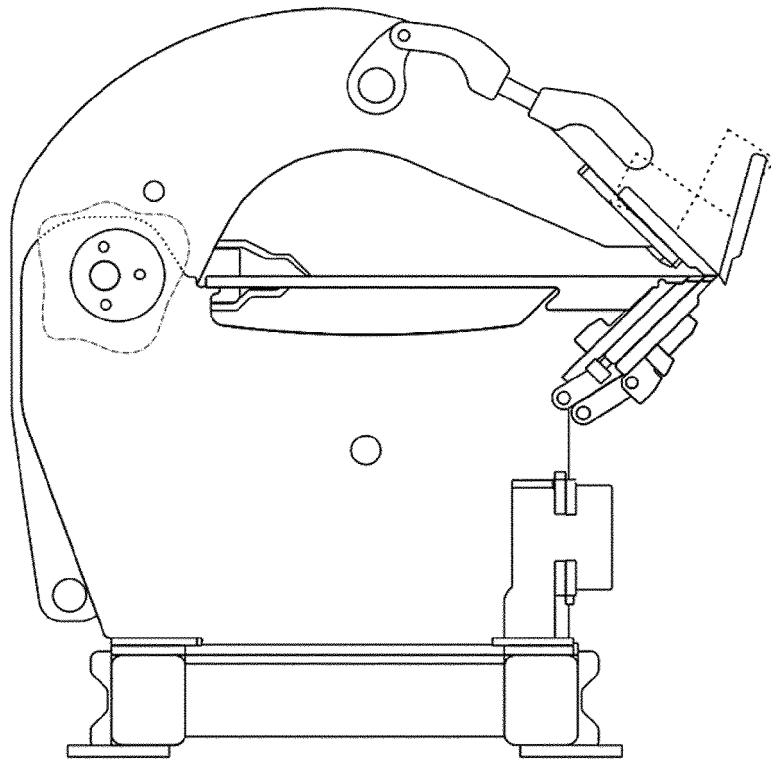


Fig. 14

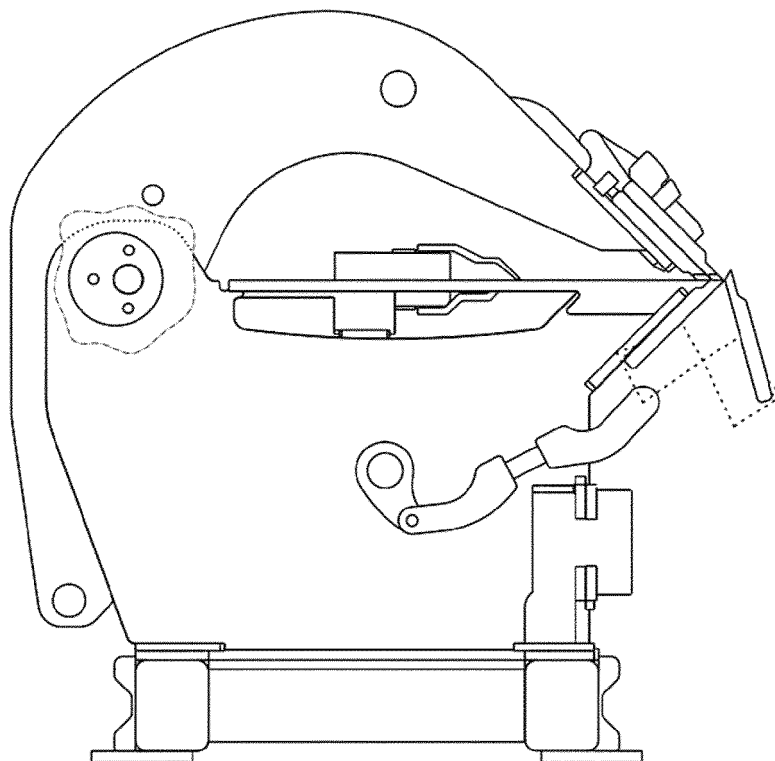


Fig. 15



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Application Number

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Place of search Munich		Date of completion of the search 13 April 2023	Examiner Knecht, Frank
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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