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(54) **MACHINE FOR WORKING SHEET METAL AND THE LIKE**

(57) A machine (10) for working sheet metal and the like, comprising a frame (11) for supporting means (12) for the retention of a piece of sheet metal (13) or the like and at least one unit (14, 114, 214, 314) for the working of the sheet metal piece (13). The working unit (14, 114,

214, 314) is at least able to translate on the frame (11) along a direction that is parallel to the plane of arrangement of the sheet metal piece (13) and is adapted to support at least one tool (18, 118, 218, 318) designed for contact with one face of the sheet metal piece (13).

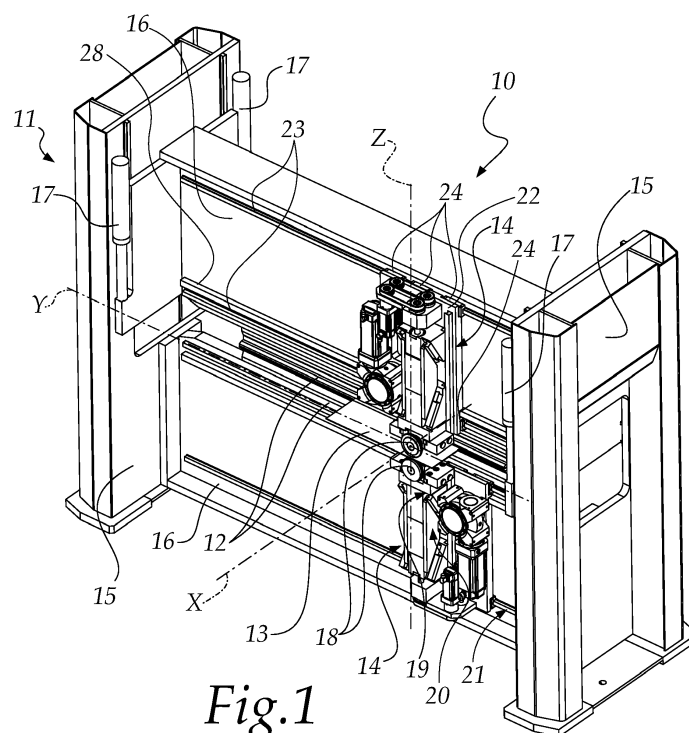


Fig.1

Description

[0001] The present invention relates to a machine for working sheet metal and the like.

[0002] The machine is conceived, particularly but not exclusively, for profiling, edging, flanging and cutting sheets of metallic material, such as sheet metal and plates, or other metallic components with at least one plate-like portion to be deformed or cut.

[0003] Processes for bending and edging plate-like metallic components, such as sheet metal, in order to generate solids with profiles having complex cross-sections, are known. The apparatuses currently used for these processes are distinguished into two categories:

- bending machines with linear actuation of the tools with respect to the sheet metal piece, in a direction that is at right angles to it, and
- profiling lines based on the actuation of rollers, between which the sheet metal piece is moved in order to obtain a progressive deformation.

[0004] The first category includes bending presses, i.e., presses with tools of the prismatic type and with vertical movement on the sheet metal piece to be bent. The tools can have a standardized shape, in order to reproduce the shape of the profile to be provided by means of a succession of bending processes, or a dedicated profile, in order to directly reproduce the desired shape. In both cases, the tools perform the deformation along the entire length of the sheet metal piece.

[0005] Although these presses are widespread in the industry, they are not without drawbacks, including the cost of the tools and the complexity of sizing the structure: the force required in deformation is proportional to the length of the worked part and depends on the thickness of the sheet metal piece and on the intrinsic characteristics of its material, and the structure of the presses is subject to flexing in proportion to the length of the sheet metal piece to be worked.

[0006] Another type of machine with tools with vertical movement is the paneling machine. Such machine offers a higher final productivity than the bending press. However, the tools, which are prismatic, have a particularly complex shape and a consequently high cost. Furthermore, as for the press, the deformation occurs along the entire length of the sheet metal piece and the bending force depends not only the complexity of the shape to be reproduced but also on the intrinsic characteristics of the material and on the length of the bend to be provided.

[0007] Bending machines with linear actuation allow a scarcely flexible production, using tools dedicated to obtaining specific profiles, which therefore are not usable for different profiles.

[0008] In profiling lines the tools are constituted by a train of rollers, in pairs, which make it possible to deform in successive steps the transverse cross-section of the sheet metal piece, from flat to the desired shape. The

rotation axis of the rollers is fixed, and the sheet metal piece is moved along the train of rollers, between the pairs. Often the pairs of rollers have profiles with a relatively complex shape, and the sequence of steps depends on the complexity of the final shape. Profiling lines, while allowing high productivities, require trains of rollers in a relatively large number which are difficult to optimize and therefore entail high costs and long processing times.

[0009] The aim of the present invention is to provide a machine for working sheet metal and the like that is capable of improving the background art in one or more of the aspects mentioned above.

[0010] Within this aim, an object of the invention is to provide a machine capable of working a sheet metal piece or the like with a reduced number of tools and with reduced deformation forces with respect to machines of the known type, regardless of the dimensions of the sheet metal piece and of the complexity of the shape to be reproduced.

[0011] Another object of the invention is to provide a machine which is more flexible than known ones, with which it is possible to provide profiles having different geometries, even by using the same tools.

[0012] Another object of the invention is to provide a machine which allows working sheet metal of different dimensions and performing different work even on a same sheet metal piece, according to the requirements.

[0013] Another object of the invention is to provide a machine with tools that have a lower cost than those used by currently known machines, such as low surface hardness tools which, while having rapid wear, make it possible to obtain a high quality of the surface of the piece being worked.

[0014] A further object of the present invention is to overcome the drawbacks of the background art in a manner that is alternative to any existing solutions.

[0015] Not the least object of the invention is to provide a machine that is highly reliable, relatively easy to provide and has competitive costs.

[0016] This aim and these and other objects which will become more apparent hereinafter are achieved by a machine for working sheet metal and the like, characterized in that it comprises a frame for supporting means for the retention of a piece of sheet metal or the like and at least one unit for the working of said sheet metal piece, said working unit being at least able to translate on said frame along a direction that is parallel to the plane of arrangement of said sheet metal piece and being configured to support at least one tool designed for contact with one face of said sheet metal piece.

[0017] Further characteristics and advantages of the invention will become more apparent from the description of a preferred but not exclusive embodiment of the machine according to the invention, illustrated by way of non-limiting example in the accompanying drawings, wherein:

Figure 1 is a perspective view of the machine according to the invention;

Figure 2 is a perspective view of a first variation of a working unit;

Figure 3 is another perspective view of the working unit shown in the preceding figure;

Figure 4 is a side view, according to four different configurations, of a working unit, again in the first variation;

Figure 5 is a perspective view of a second variation of a working unit;

Figure 6 is a perspective view of a third variation of a working unit;

Figure 7 is another perspective view of the third variation of a working unit;

Figure 8 is a perspective view of a fourth variation of a working unit;

Figure 9 is another perspective view of the machine.

[0018] With reference to the figures, the machine according to the invention, generally designated by the reference numeral 10, comprises a frame 11 for supporting means 12 for the retention of a piece of sheet metal 13 or the like and at least one unit 14 for the working of said sheet metal piece 13. The above cited elements are shown in Figure 1.

[0019] The frame 11 comprises two posts 15 and, between them, also two crossmembers 16, of which one is higher and the other is lower. The means 12 for the retention of the sheet metal piece 13 consist of a pair of retention elements, substantially closing profiles, adapted to close like a vise on the sheet metal piece 13, being integral with the crossmembers 16. In particular, the upper crossmember 16 can translate upward and downward, causing the closing and opening of the retention elements. The translation of said crossmember 16, with the respective retention element, occurs by means of cylinders 17 installed on the frame 11.

[0020] The pressure applied by the retention elements on the sheet metal piece is adjustable by controlling the closing force.

[0021] Figures 2 and 3 show the first variation of a working unit 14 (the same variation is shown by way of example in Figure 1) in a perspective view from the front part and from the rear part, respectively, where the term "rear" is understood to mean the part that is not visible, facing the crossmember 16, with the unit installed on the frame 11.

[0022] Hereinafter, the machine 10 is described with a working unit 14 in its first variation, but such unit can be replaced by a unit according to the variations 114, 214, 314 described hereinafter, as a function of the working requirements of the sheet metal piece.

[0023] The working unit 14 can at least translate on the frame 11, particularly on a crossmember 16, along a direction that is parallel to the plane of arrangement of the sheet metal piece 13, and is configured to support a tool 18 designed for contact with a face of the sheet metal

piece 13. The direction of translation of the working unit 14 is the advancement direction of the tool 18 on the sheet metal piece 13 during working and is designated by the axis Y in Figure 1.

[0024] The deformation, or cutting, of the sheet metal piece 13 is obtained by means of the action of the tool 18 against the surface of the sheet metal piece 13 while said piece is supported with the retention elements 12.

[0025] As in the case shown, the machine 10 preferably comprises a pair of working units 14 installed on opposite sides with respect to the plane of arrangement of the sheet metal piece 13 and each adapted to support at least one tool 18 designed for contact with a respective face of the sheet metal piece 13.

[0026] The deformation of the sheet metal piece 13 is obtained by the combined action of two working units 14, both movable in a coordinated manner. In particular, in this case working occurs by virtue of the action of the tool 18 of one of the two units against the surface of the sheet metal piece 13, while said piece is supported by a contrast tool, i.e., the tool 18 of the other working unit 14, as well as being retained with the means 12.

[0027] Optionally, in versions not shown, the machine according to the invention can be provided with one or more working units on both sides with respect to the crossmembers, i.e., both on the side that is visible in the view of Figure 1 and on the opposite side, which is not visible in the same view. One or more pairs of working units can also be present on both sides.

[0028] Each working unit 14 comprises a toolholder 19 and means 20 for the movement of said toolholder 19.

[0029] As shown, each tool 18 is preferably constituted by a roller which is mounted freely on the respective toolholder 19. In this first variation of the unit 14, said roller is mounted freely on an axis that is parallel to the plane of arrangement of the sheet metal piece 13 to be worked and is also at right angles to the plane of the crossmember 16. Said axis is designated by X. For the sake of simplicity, in the figures the axes X, Y and Z pass through the tool.

[0030] The roller is adapted to bend the sheet metal piece 13 in order to obtain the profiling and/or edging thereof.

[0031] The tool 18 can be replaced, for example due to wear thereof, as a function of the intrinsic characteristics of the sheet metal piece 13 to be worked (or other similar object) and of the bending radius that one seeks to obtain or of the type of work.

[0032] For example, a roller can be replaced by another roller with a profile that is contoured to recreate directly a particular shape or a bending roller can be replaced by a roller with a sharp edge, in order to cut the sheet metal piece, or by a blade.

[0033] The position of a tool 18 and the position of the working unit 14 on which it is mounted can be controlled and modified at any time by means of a programmable control system, for example of the numeric control type or of the PLC (Programmable Logic Controller) type. The mutual position of two tools 18 in a same pair of working

units 14 and the position of said units on the frame 11 also can be controlled and modified by virtue of the control system. Each tool 18 is in fact movable with the respective unit, in translation in the advancement direction along the sheet metal piece during working, and with respect to it in translation in the directions at right angles to the advancement direction of said unit, as will become more apparent in the continuation of the description.

[0034] The machine 10 comprises means 21 for the translation of each working unit 14 on the respective crossmember 16, in the advancement direction of the tool 18 on the sheet metal piece 13, i.e., the axis Y, and also comprises the mentioned means 20 for the movement of the toolholder 19.

[0035] As mentioned previously, the frame 11 comprises the two posts 15 and, between them, two crossmembers 16 which support at least one working unit 14. The working unit 14 comprises a carriage 22 on which there is a motor drive 25 adapted to actuate, by virtue of means for converting the motion from rotary to linear, the translation of the working unit 14 on the respective crossmember 16 with the translation means 21. The translation means 21 comprise at least one guide 23 on at least one of the crossmembers 16 and series of sliders 24 on the carriage 22. In the example shown there are two parallel guides 23 on each crossmember 16 and two series of sliders 24 (three for each series) on the rear of the carriage 22 with which it, and therefore the unit 14, slides on the guides 23. The sliders 24 are mounted on the rear part of the carriage 22 (i.e., the part directed toward the crossmember 16).

[0036] In the example shown there is a motor drive 25, referenced from now on in the rest of the description as first motor drive 25, which is constituted by an electric motor, coupled to a reduction unit 26 (preferably an angular one) mounted on the carriage 22.

[0037] The means for converting motion from rotary to linear comprise at least one rack 28, on at least one of the crossmembers 16, and at least one pinion 27, which is coupled to the carriage 22 (as shown in Figure 3) and is adapted to mesh with the rack 28, being turned by means of the first motor drive 25. More precisely, in the example shown there is a pinion 27 on each carriage 22 (the pinion protrudes from the rear part of the carriage) and there is a rack 28 on each crossmember, with which the pinion 27 can mesh. The pinion/rack coupling makes it possible to convert the rotary motion in output from the motor drive 25 into linear motion in order to make the working unit 14 translate along the crossmember 16 in the direction Y. The rack 28 and the guides 23 are shown and designated in Figure 1.

[0038] In the first motor drive 25 the electric motor shown can be replaced by an electric motor of the high-torque type or by a hydraulic motor, adapted to move the pinion directly without the reduction unit.

[0039] The means 20 for the movement of the toolholder 19 allow other degrees of freedom to the tool 18.

[0040] Such means 20 are installed on the carriage 22

and comprise an assembly 29 for the translation of the toolholder 19 in directions which are perpendicular to the direction of translation of the working unit 14 and therefore of advancement of the carriage 22 along the respective crossmember 16. The translation assembly 29 is in fact adapted to cause a translation of the toolholder 19 in the direction of the axis Z which is at right angles to that of the plane of arrangement of the sheet metal piece 13, or along the direction of the axis X, which is parallel to the plane of arrangement of the sheet metal piece 13 and at right angles to Y.

[0041] On the working unit 14 there are means for actuating the translation assembly 29, chosen selectively from: a motor drive 30, provided with means adapted to convert its rotary motion in output into translational motion; and at least one hydraulic cylinder. In the example shown there is a motor drive 30, from now on referenced in the text as second motor drive 30, which comprises preferably a pair of electric motors. As mentioned previously, with the second motor drive 30 there are also conveniently means adapted to convert the rotary motion in output from the motors into translational motion; said means comprise two ballscrews 31, each coupled to a respective wedge element 34 connected to the toolholder 19.

[0042] In particular, the electric motors of the second motor drive 30, conveniently with respective coaxial reduction units, are connected by means of a belt drive 32 and pulleys 33 to the two ballscrews 31. Optionally, the coaxial reduction units can be replaced by angular reduction units to be connected directly to the ballscrews.

[0043] In a variation not shown, with two hydraulic cylinders as an alternative to the second motor drive, the cylinders can be connected to the two wedge elements and controlled by directional proportional valves and by position transducers.

[0044] The movement of the translation assembly 29 is shown in Figure 4, where four different configurations of the toolholder 19 are shown as a function of the type of translation performed. The rotation of the ballscrews 31, induced by the second motor drive 30, causes the translation of the wedge elements 34.

[0045] If the translation of the two wedge elements 34 is concordant, it determines in turn the translation of the toolholder 19 along a direction that is perpendicular to the plane of arrangement of the sheet metal piece 13, i.e., along the direction of the axis Z, as shown in Figure 4 in the transition from the configuration designated by A to the configuration designated by B and from the configuration C to the configuration D and detectable with the displacement of the axis X.

[0046] If the translation of the two wedge elements 34 is discordant, it determines in turn the translation of the toolholder 19 along a direction that is parallel to the plane of arrangement of the sheet metal piece 13 and perpendicular to the plane of the crossmember 16, i.e., along the direction of the axis X, as shown in Figure 4 in the transition from the configuration B to the configuration C.

The distance covered by the tool is designated here by the reference letter H.

[0047] In order to obtain these translations, the translation assembly 29 of the toolholder 19 comprises conveniently the wedge elements 34 and trapezoidal portions 35, which interface with the inclined sides of the wedge element 34, by means of sliding guides 36.

[0048] The other variations of the working unit 114, 214 and 314 apply to the structure of the machine 10 as a replacement of the first variation 14 or in combination therewith. Therefore, as described for the first variation, the machine 10 can comprise at least one working unit 114, 214, 314 adapted to support at least one respective tool 118, 218, 318 designed for contact with a face of the sheet metal piece 13. Similarly to the first variation, there can be pairs of working units 114, 214, 314 installed on opposite sides with respect to the plane of arrangement of the sheet metal piece 13 on respective crossmembers 16 of the frame 11 and each adapted to support at least one tool 118, 218, 318 designed for contact with a face of the sheet metal piece 13.

[0049] Optionally, there can be working units in different variations mounted on the same frame 11 and not exclusively in pairs. As an alternative, the pairs can be constituted by units in different variations.

[0050] Each working unit 114, 214, 314, similarly to what has been described for the first variant 14, comprises a carriage 22 with the means 21 for its translation along the advancement direction, a respective toolholder 119, 219, 319, and respective means 120, 220, 320 for moving the toolholder 119, 219, 319.

[0051] The movement means 120, 220, 320 comprise the assembly 29 for the translation, as already described, of the respective toolholder 119, 219, 319 in directions at right angles to the translational advancement direction of the whole unit 114, 214, 314, i.e., of the respective carriage 22.

[0052] Figure 5 shows a second variation of a working unit, in this case generally designated by the numeral 114. This variation differs from the previous one in the configuration of the tool 118: the tool consists of a roller which is mounted freely on the toolholder 119, on an axis that is perpendicular to the plane of arrangement of the sheet metal piece 13, i.e., the axis designated here by the reference letter Z'.

[0053] Figure 6 and Figure 7 show a third variation of a working unit, in a front view and a rear view, respectively, generally designated by the reference numeral 214. The tool 218 in the example shown is again constituted by a roller which is mounted freely, on the toolholder 219, on an axis that is parallel to the plane of arrangement of the sheet metal piece 13, as in the first variation 14. In this case, the third variation of the unit 214 differs from the first variation 14 in that the toolholder 219 is able to rotate. In the case of the working unit 214, the means 220 for the movement of the toolholder 219 in fact comprise an assembly 237 for the rotation of said toolholder 219 with respect to the carriage 22.

[0054] In this variation, the tool 218 therefore has one more degree of freedom than the first variation of the working unit 14 due to the possibility to rotate, with a support 238, about an axis which is perpendicular to the plane of arrangement of the sheet metal piece 13, i.e., the axis Z" (along one direction of rotation or the opposite one).

[0055] In particular, the working unit 214 comprises a motor drive 239, referenced in the remainder of the description as third motor drive 239, for the rotation assembly 237. The third motor drive 239, which is installed on the carriage 22 and is constituted preferably by an electric motor, is designed to rotate, by means of a belt coupling 240, a ring gear 241 with which the support 238 is integral. The rotation assembly 237 comprises therefore the support 238, which, connected to the third motor drive 239, can be rotated with respect to the rest of the toolholder 219.

[0056] The rotation assembly 237 substantially determines also the rotation of the axis X, on which the roller is free, on a plane that is parallel to the plane of arrangement of the sheet metal piece 13.

[0057] A fourth variation of a working unit 314 is shown in Figure 8. The tool 318 in the example shown is again constituted by a roller which is mounted freely, on the toolholder 319, on an axis that is at right angles to the plane of arrangement of the sheet metal piece 13, as in the second variation 114, i.e., on the axis Z'.

[0058] The fourth variation of the working unit 314 differs from the second variation 114 in that the toolholder 319 can rotate.

[0059] The means 320 for the movement of the toolholder 319 comprise an assembly 337 for the rotation of the toolholder 319 with respect to the carriage 22. The working unit 314 comprises a (fourth) motor drive 339, again preferably constituted by an electric motor, for the rotation assembly 337.

[0060] The tool 318 therefore has one more degree of freedom than the second variation due to the possibility to rotate, with a support 338, about an axis which is parallel to the plane of arrangement of the sheet metal piece 13, i.e., the axis Y" (in one direction of rotation or in the opposite one) and also parallel to the direction of translation of the working unit 314. The rotation assembly 337 therefore comprises the support 338 which, connected to the fourth motor drive 339, can rotate with respect to the rest of the toolholder 319. The rotation assembly 337 substantially determines also the rotation of the axis Z', on which the roller is free, and therefore the inclination of the tool 318.

[0061] In other variations, not shown, the toolholder can be fixed on the carriage and can support a roller arranged according to a position that is intermediate between X and Z'.

[0062] The machine 10 is provided, as already mentioned, with a numeric control system, PLC or other programmable systems, which ensures, during work, the correct arrangement of the tools 18, 118, 218, 318, the

control of the speed of the movements and of the force on each individual axis. Therefore, the machine controls at least the translation means 21 and the movement means 20, 120, 220, 320.

[0063] In fact, besides guiding their translation along the sheet metal piece 13, the system controls:

- the vertical translation of the toolholders 19, 119, 219, 319, as a function of the thickness of the sheet metal piece 13, of the characteristics of the tool and of the force to apply in work,
- the translation of the toolholders 19, 119, 219, 319 along the direction perpendicular to the crossmember (such as the axis X in Figure 1 and in Figure 4), as a function of the distance from the crossmembers at which the deformation is to be performed,
- the rotation of the toolholders 219 and 319 about the axis Z" in the third variation of the unit 214 and about the axis Y" in the fourth variation of the unit 314,
- the retention means 12,
- means for the advancement and handling of the sheet metal piece 13.

[0064] If there are multiple working units in a same machine 10, their movements are coordinated by the control system during work. The translation and rotation movements of one unit can also be controlled independently of the movements of another unit.

[0065] Furthermore, the movements of the toolholder 19 with respect to the carriage 22 (with each unit variation), therefore all the additional movements with respect to translation along the respective crossmember 16, are combined in order to obtain even complex bending profiles.

[0066] In the example shown there is a pair of working units 14; however, in other versions not shown there can be more than one pair of such units, optionally in the different variations described, or there can be pairs of working units on opposite sides of the crossmembers 16, or individual working units arranged side-by-side or on opposite sides of the crossmembers in order to easily bend U-shaped or closed profiles and/or perform work simultaneously on opposite sides, reducing the working time and allowing a better balancing of the static and dynamic loads.

[0067] There may also be a sort of magazine of working units in one or more variations, proximately to at least one post 15, which are adapted to be moved along the respective crossmember, one after the transit of another on the sheet metal piece or simultaneously, one after the other, by virtue of the control system.

[0068] The toolholders can be stored in a magazine and retrieved and replaced in an automated manner, optionally with the same control system.

[0069] The loading side of the sheet metal piece is preferably the one opposite, with respect to the crossmembers, to the side where the working units are present,

excluding, in case of manual or semi-manual loading and handling of the sheet metal piece, contact of the operator with moving tools. As an alternative, the movement speeds of the units and of the toolholders are reduced.

[0070] The handling of the sheet metal piece 13 occurs while the retention elements are open. The machine 10 comprises means 42 for the advancement and handling of the sheet metal piece 13, which are shown in Figure 9. In the example, they are installed on the opposite side with respect to that of the working units 14.

[0071] The advancement and handling means 42 comprise two handling devices 44, and in particular a pair of supporting structures 43 for the handling devices 44. Such devices are adapted to retain and handle the sheet metal piece 13 by means of portions 44a, 44b. The supporting structures 43 extend in the direction at right angles to the crossmembers 16.

[0072] The two handling devices 44 can be translated, with the supporting structures 43, along the crossmembers 16, therefore along a direction parallel to the translation direction of the working units 14, 114, 214, 314. Each supporting structure 43 in fact translates by means of first sliders 45, which are present at the interface with the crossmember 16, on parallel guides. The translation of each supporting structure 43 occurs by activation of a respective fourth electric motor 46 designed to rotate a pinion 47 adapted to move on a rack.

[0073] The two handling devices 44 can also translate in opening and closing on opposite sides of the sheet metal piece 13. The upper handling device 44 moves upward and downward integrally with the respective support structure 43, which in turn moves integrally with the respective upper crossmember 16.

[0074] Moreover, the two handling devices 44 can translate also in a direction at right angles to the translation direction of the working units and parallel to the plane of arrangement of the sheet metal piece, i.e., along the two respective supporting structures 43, in order to make the sheet metal piece move forward during work. In particular, they are provided with second sliders 48 in order to slide on pairs of guides 49. The translation is activated by means of a fifth electric motor 50 for each handling device 44.

[0075] One of the two handling devices 44, the lower handling device, with the portion 44b, can also rotate, since it is provided with a sixth electric motor 51, which rotates a ring gear on which the portion 44b, designed to rest the sheet metal piece 13 by rotating it, is mounted. The other portion 44a is instead free and is entrained by friction. As an alternative, both handling devices can be provided with the rotary motion. One of the two handling devices must also be provided with a pressing system in order to ensure the suitable closing force on the work-piece to be handled.

[0076] In other working unit variations not shown, such unit may also be provided with a laser system, adapted to heat the sheet metal piece before bending, in order to reduce the deformation forces and obtain therefore a re-

duced elastic return. This solution is particularly suitable for deforming plates.

[0077] The machine 10 can also comprise a device, preferably a laser scanner or camera system, mounted on the working units and adapted to detect the profile of the sheet metal piece 13 being worked, or in general of the part of the component being worked, and to communicate with the control system, interacting to optionally correct the profile.

[0078] The use of the machine according to the invention is as follows.

[0079] The machine 10 is adaptable in a flexible manner in order to obtain different profiles using a single set of tools, by adjusting the positions, the inclinations and the absolute and mutual distances of the tools being used. The sheet metal piece is retained with the retention means 12 and by virtue of the advancement and handling means 42 it is caused to advance and optionally also rotate in order to obtain even complex-shaped profiles.

[0080] Work can be performed also with just one working unit, retaining the sheet metal piece 13 between the retention elements and working with the tool on the cantilever part of said sheet metal piece. In this manner it is possible to cut the sheet metal piece, with a cutting tool, or deform it with a roller tool, in one or more passes.

[0081] By way of example, only some of the possible combinations of multiple working units are given herein after.

[0082] Two working units can be installed as a pair, on opposite sides with respect to the plane of arrangement of the sheet metal piece, for example two units 14 according to the first variation, which support rollers as tools 18. These are arranged with axes X and Z which are parallel and do not coincide, being therefore both at different heights and at different distances from the crossmembers 16. The bending of the sheet metal piece occurs in a single pass of the tool or progressively in various passes, as a function of the bending radius and the dimensions of the roller, particularly its blending radius. For complex work, the sheet metal piece is then moved in order to perform other bending processes.

[0083] As an alternative, the pair can be constituted by two different variations of the working unit, for example the upper unit in the second variation 114 and the lower one in the first variation 14, or the upper one in the first variation 14 and the lower one in the third variation 214 or in the fourth variation 314, or vice versa. The PLC control or the numeric control of the working units allows a progression of passes in different and controlled positions of the tools, in order to obtain complex profiles.

[0084] Another possible combination of units can provide, on a same side of the crossmember, a working unit magazine. In one working step, a pair of working units can be used as in the previously described case, such units supporting rollers in order to bend the sheet metal piece. In another work step the sheet metal piece can be moved and another working unit can be caused to advance which supports a cutting tool, in order to cut the

sheet metal piece, separating therefrom a profile freshly obtained in the previous steps, or which supports another deformation roller, in order to provide another bend. As an alternative, in the other work step a working unit supporting a roller of different dimensions can be caused to advance, for example with a smaller bending radius in order to reduce the bending radius of the bend obtained with the previous step, or for example in order to obtain a rib inside the previous bend. Each one of these bending steps can require multiple passes of the tool on the sheet metal piece.

[0085] Moreover, according to a further combination, there can be a pair of working units on one side of the machine and a pair on the opposite side, with respect to the crossmembers, or there can be a pair on one side and a single unit on the other side. The presence of working units on either side of the machine, regardless of the number and variations, makes it possible to perform simultaneously at least two work processes on the same sheet metal piece.

[0086] In general, simply by replacing the tools it is possible to perform different operations, for example cutting or flanging, ribbing, trimming and incremental bending.

[0087] It has been found that the machine, besides being able to be guided progressively during the execution of the work processes, can be modified in a simple way, by replacing the units or the tools that they support, as well as the number of units, in order to perform different types of work and on metal pieces with different characteristics, in terms of shape, size and even intrinsic characteristics of the material. Moreover, with a same set of tools and working units it is possible to work different sheet metal pieces and to obtain different, even complex, profiles by virtue of the possibility to control the movements of the sheet metal and of said tools, the latter in rotation and also in translation along three different directions.

[0088] Moreover, it should be noted that the tools, mounted on their toolholders, can be replaced easily in case of wear or due to requirements dictated by the work to be performed.

[0089] Moreover, since the deformations are progressive and obtained by acting at each instant on limited areas of the sheet metal piece, regardless of the length of said sheet metal piece, the machine according to the invention requires much lower workloads than those required by bending and paneling presses, allowing a reduction of the weights of the structures and associated costs as well as a lower deformability of the structures and therefore a greater precision of the finished piece.

[0090] Although reference has been made, for the sake of simplicity, to a sheet metal piece, the machine according to the invention is suitable to work also other similar objects, for example plates, or objects having at least one plate-like portion to be deformed or cut, with which to define also a plane of arrangement as for the sheet metal piece.

[0091] In practice it has been found that the invention achieves the intended aim and objects, providing a machine for working sheet metal and other similar elements reproducing shapes of different complexity and substantially independently of the characteristics of the metallic material and of the dimensions of the sheet metal piece.

[0092] The invention thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the appended claims; all the details may furthermore be replaced with other technically equivalent elements.

[0093] In practice, the materials used, as long as they are compatible with the specific use, as well as the contingent shapes and dimensions, may be any according to the requirements and the state of the art.

[0094] The disclosures in Italian Patent Application No. 102020000027711 from which this application claims priority are incorporated herein by reference.

[0095] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. A machine for working sheet metal and the like, **characterized in that** it comprises a frame (11) for supporting means (12) for the retention of a piece of sheet metal (13) or the like and at least one unit (14, 114, 214, 314) for the working of said sheet metal piece (13), said working unit (14, 114, 214, 314) being at least able to translate on said frame (11) along a direction that is parallel to the plane of arrangement of said sheet metal piece (13) and being configured to support at least one tool (18, 118, 218, 318) designed for contact with one face of said sheet metal piece (13).
2. The machine according to claim 1, **characterized in that** it comprises at least one pair of said working units (14, 114, 214, 314), installed on opposite sides with respect to the plane of arrangement of said sheet metal piece (13) and each adapted to support at least one said tool (18, 118, 218, 318) designed for contact with a respective face of said sheet metal piece (13).
3. The machine according to one or more of the preceding claims, **characterized in that** said working unit (14, 114, 214, 314) comprises a toolholder (19, 119, 219, 319) and means (20, 120, 220, 320) for the movement of said toolholder (19, 119, 219, 319).
4. The machine according to one or more of the preceding claims, **characterized in that** said tool (18, 218) is constituted by a roller which is mounted freely on said toolholder (19, 219) on an axis that is parallel to the plane of arrangement of said sheet metal piece (13).
5. The machine according to one or more of the preceding claims, **characterized in that** said tool (118, 318) is constituted by a roller which is mounted freely on said toolholder (119, 319) on an axis that is perpendicular to the plane of arrangement of said sheet metal piece (13).
6. The machine according to one or more of the preceding claims, **characterized in that** it comprises means (21) for the translation of said working unit (14, 114, 214, 314) on said frame (11).
7. The machine according to one or more of the preceding claims, **characterized in that** said frame (11) comprises two posts (15) and, between them, two crossmembers (16) which support at least one said working unit (14, 114, 214, 314), which comprises a carriage (22) on which there is a motor drive (25) adapted to actuate, by virtue of means for converting the motion from rotary to linear, the translation of said working unit (14, 114, 214, 314) on the respective said crossmember (16) with said translation means (21), said means comprising at least one guide (23) on at least one of said crossmembers (16) and series of sliders (24) on said carriage (22).
8. The machine according to one or more of the preceding claims, **characterized in that** said means for the conversion of motion from rotary to linear comprise at least one rack (28), on at least one of said crossmembers (16), and at least one pinion (27), which is coupled to said carriage (22) and is adapted to mesh with said rack (28), being turned by means of said motor drive (25).
9. The machine according to one or more of the preceding claims, **characterized in that** said movement means (20, 120, 220, 320) comprise an assembly (29) for the translation of said toolholder (19, 119, 219, 319) in directions which are perpendicular to the direction of translation of said working unit (14, 114, 214, 314), on the latter there being means for the actuation of said translation assembly (29), selectively from a motor drive (30) provided with means adapted to convert its rotary motion in output into a translational motion, and at least one hydraulic cylinder.
10. The machine according to one or more of the preceding claims, **characterized in that** said movement means (220, 320) comprise an assembly (237, 337) for the rotation of said toolholder (219, 319),

said working unit (214, 314) comprising a motor drive (239, 339) for said rotation assembly (237, 337).

11. The machine according to one or more of the preceding claims, **characterized in that** it comprises advancement and handling means (42) which in turn comprise two handling devices (44) adapted to retain and handle said sheet metal piece (13), said handling devices (44) being able to translate along a direction that is parallel to the direction of translation of the working units (14, 114, 214, 314) and along a direction that is perpendicular to the preceding one and is parallel to the plane of arrangement of said sheet metal piece (13), at least one of said handling devices (44) being also able to rotate.
12. The machine according to one or more of the preceding claims, **characterized in that** it comprises a control system adapted at least to control and modify the position of said tool (18, 118, 218, 318) and of said working unit (14, 114, 214, 314).
13. The machine according to one or more of the preceding claims, **characterized in that** it comprises at least one device adapted to detect the profile of said sheet metal piece (13) being worked and to communicate with said control system.

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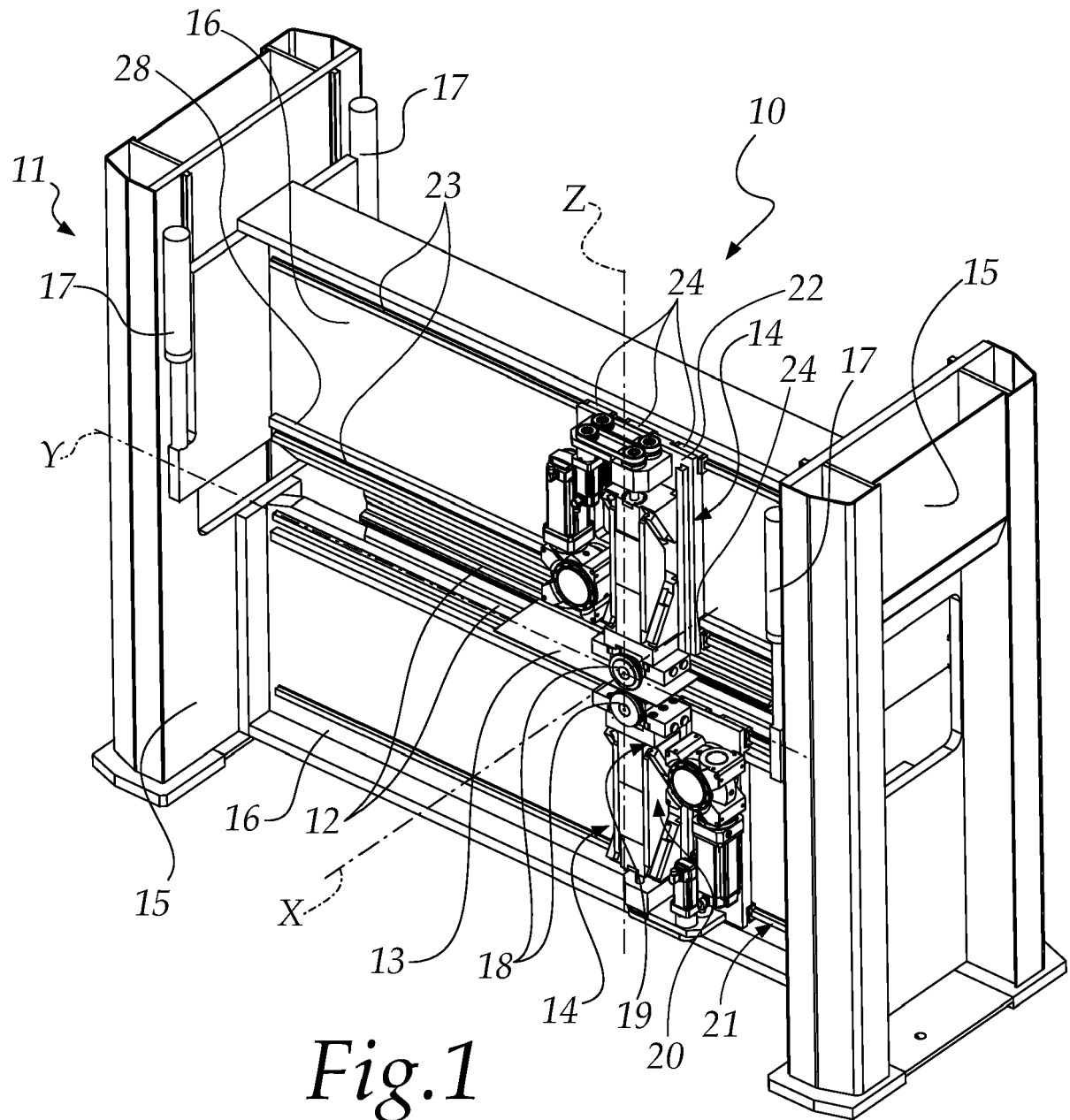
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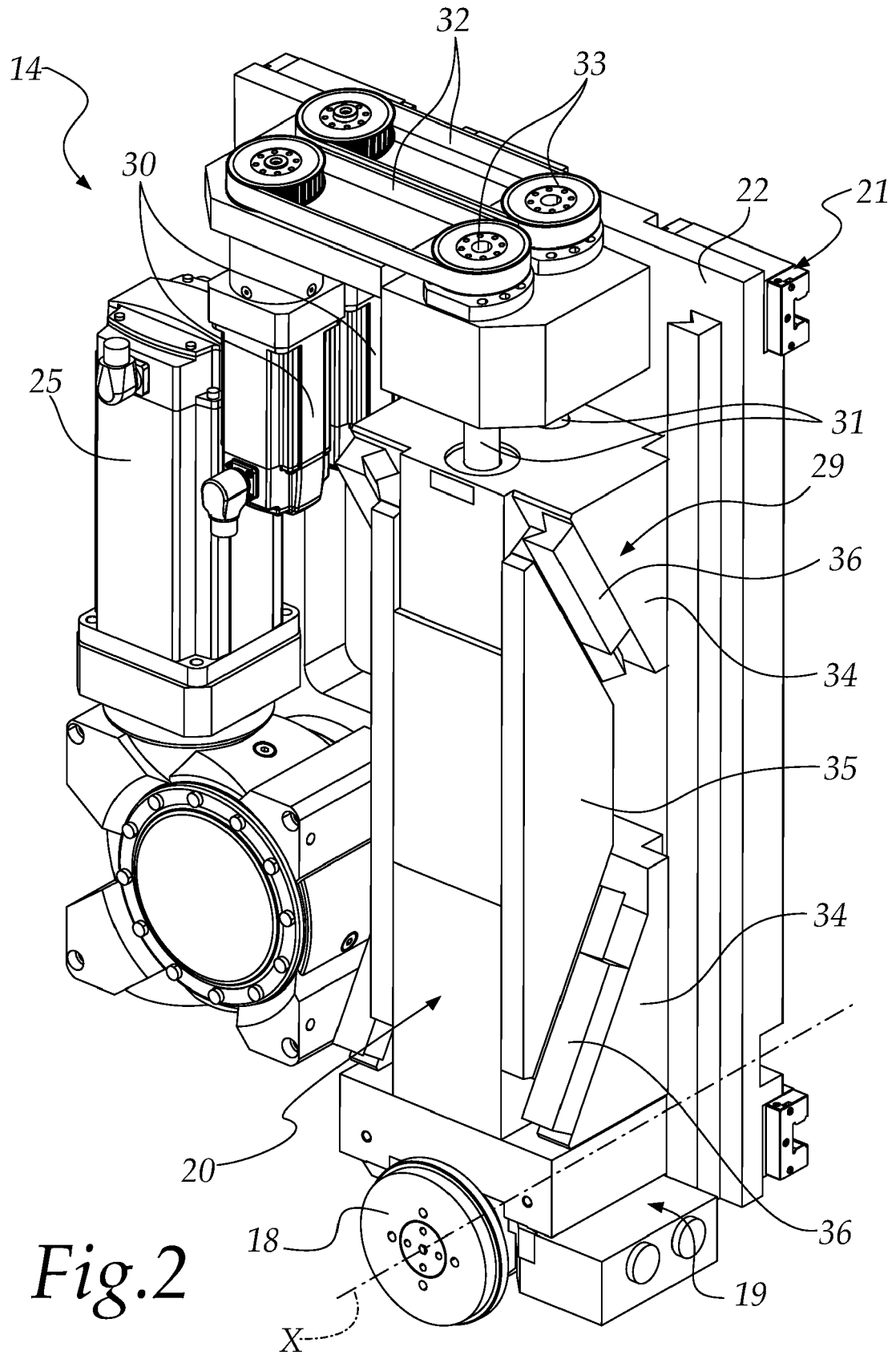
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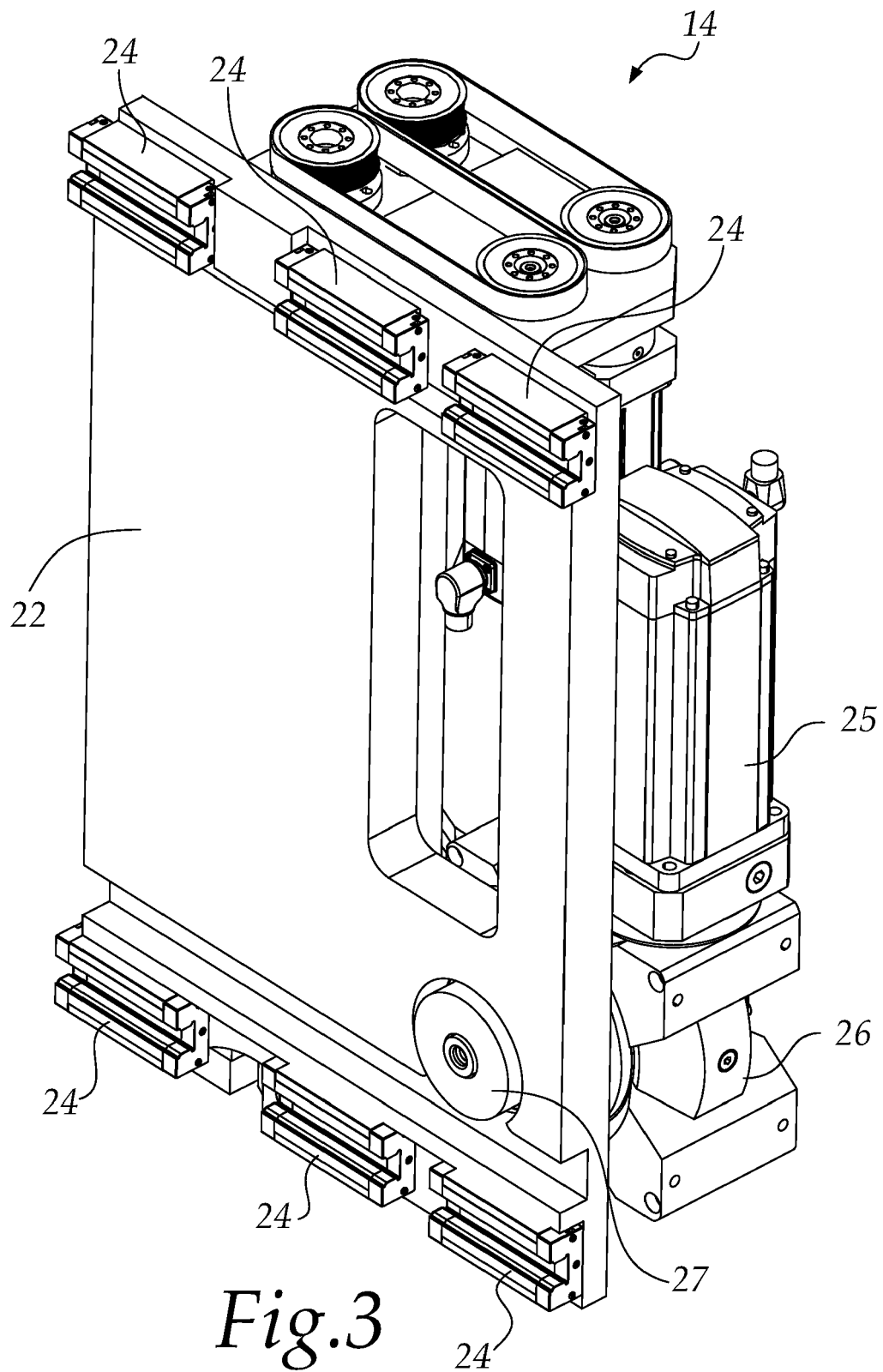
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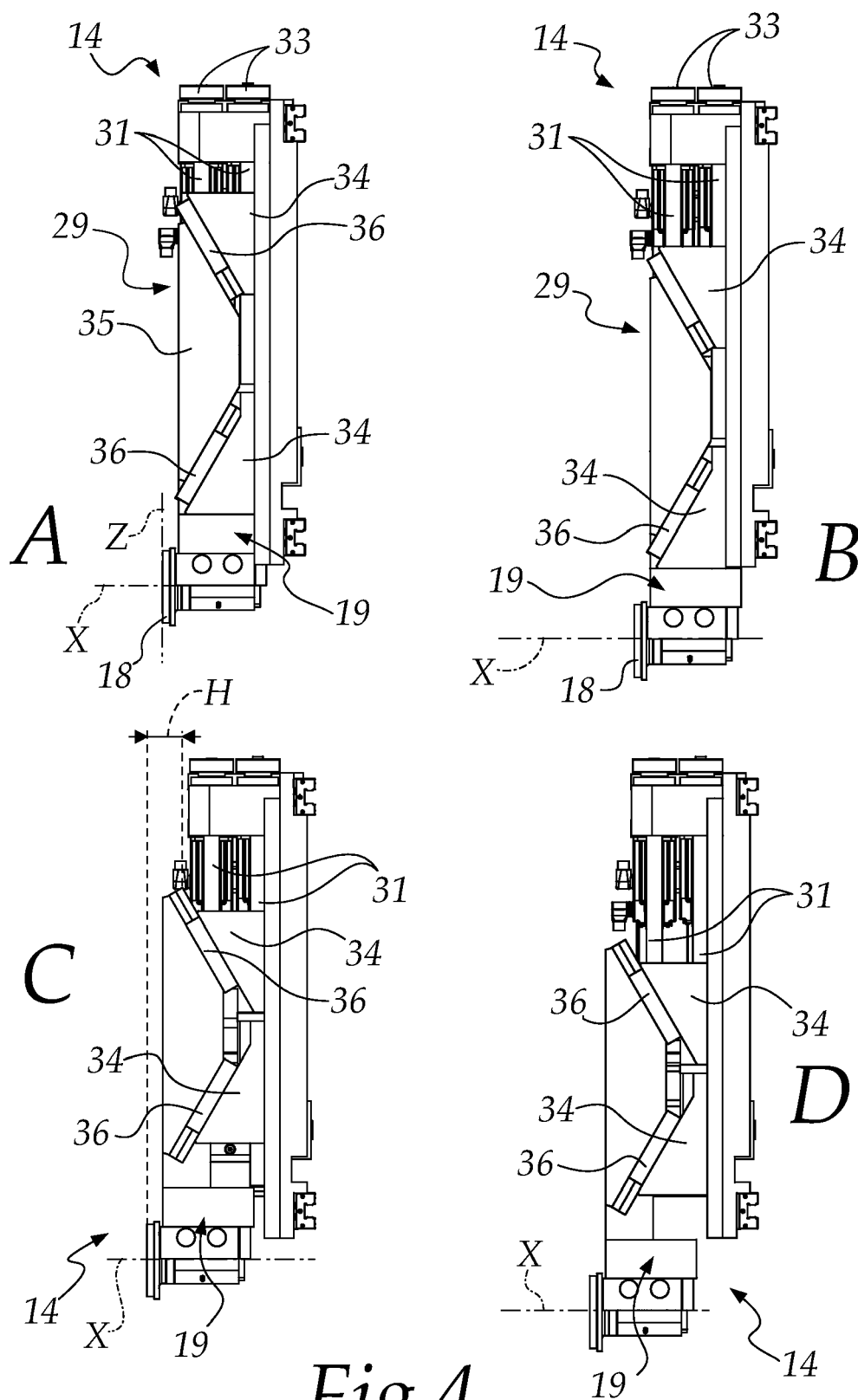
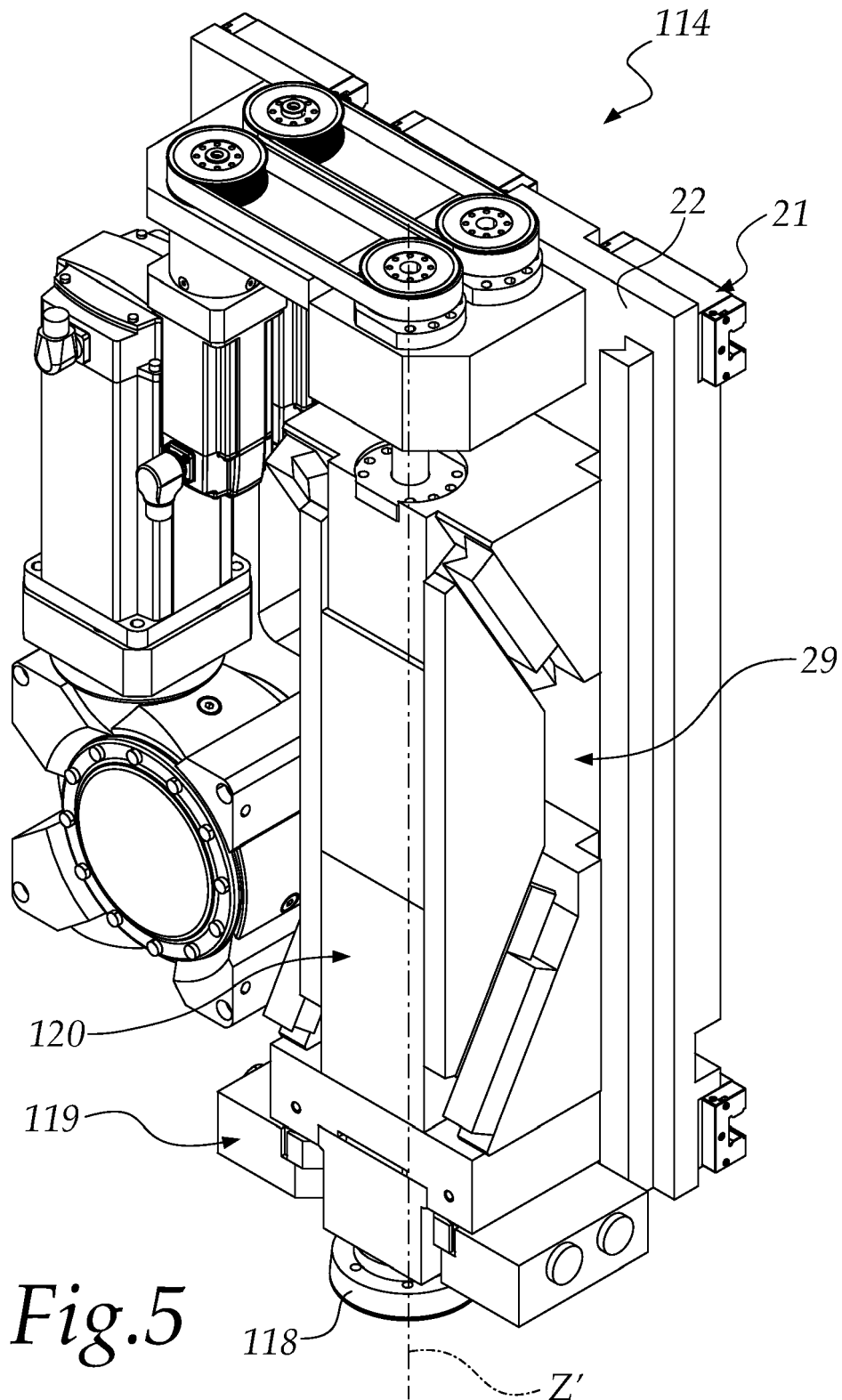
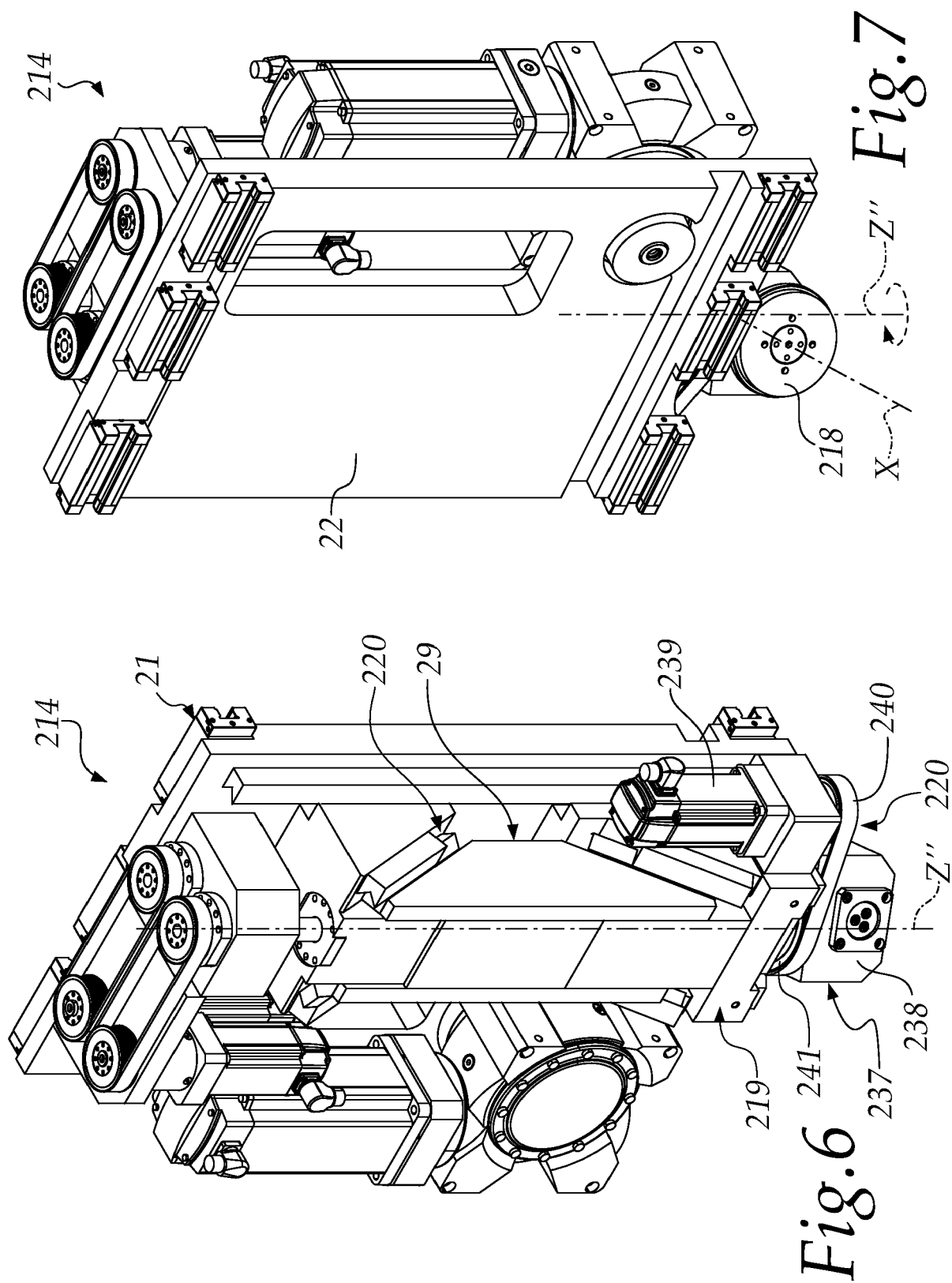


Fig.4





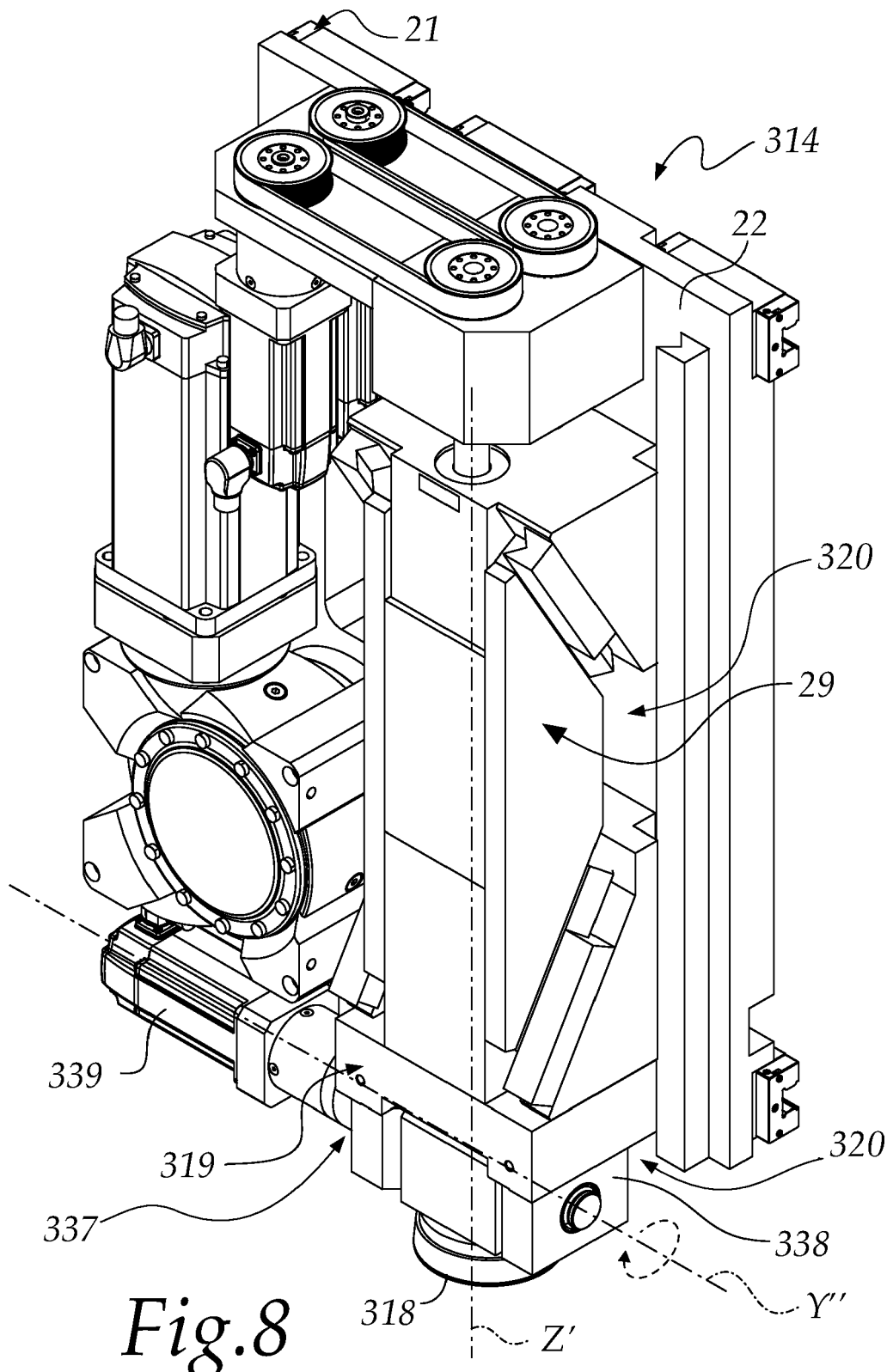
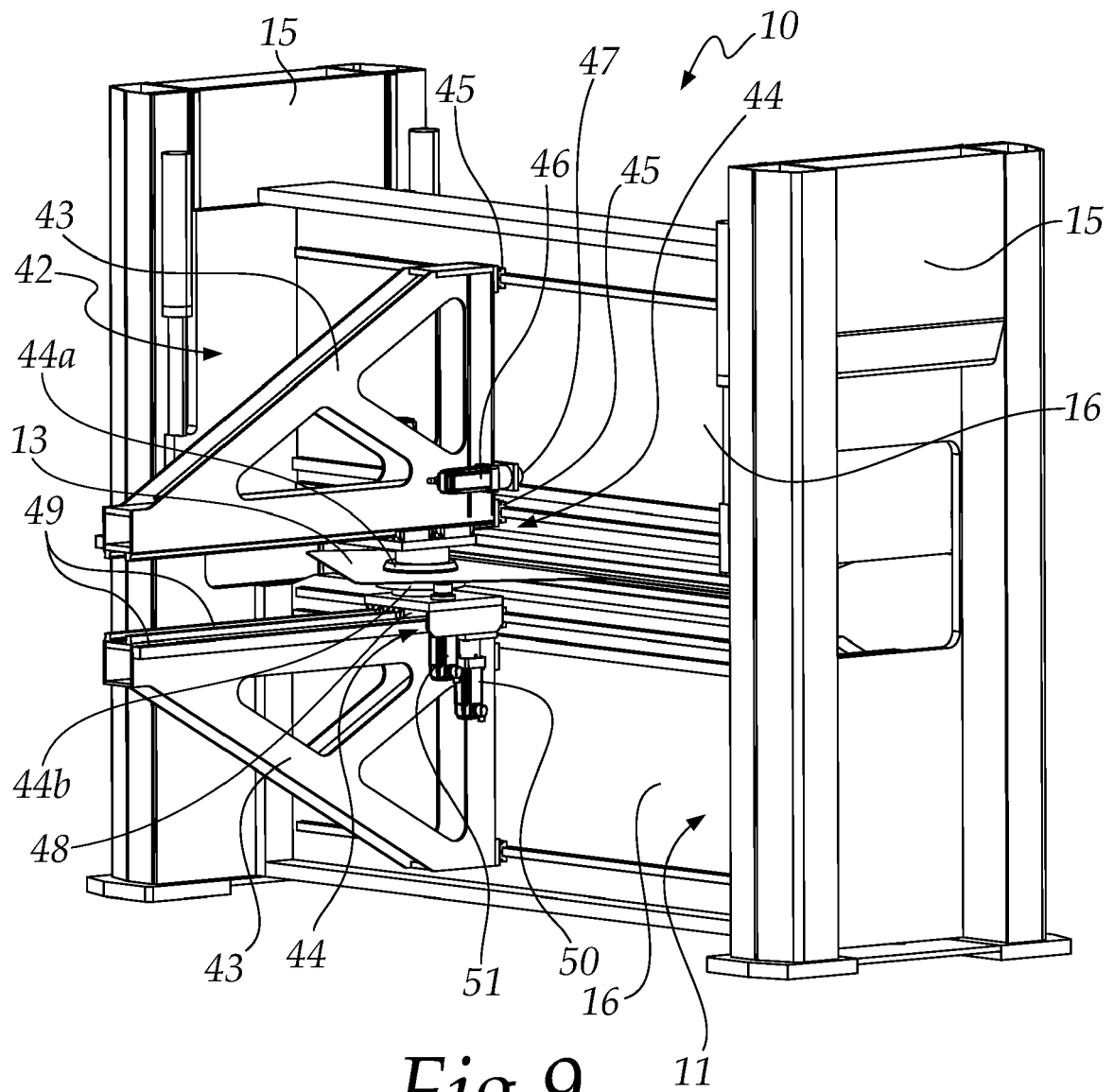


Fig. 8





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Place of search Munich		Date of completion of the search 16 March 2022	Examiner Knecht, Frank
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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