(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 180 142 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.05.2023 Bulletin 2023/20

(21) Application number: **22207420.5**

(22) Date of filing: **15.11.2022**

(51) International Patent Classification (IPC):
B21D 7/12 *(2006.01)* ***B21D 7/03*** *(2006.01)*
B21D 11/02 *(2006.01)* *B21D 53/88* *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B21D 7/12; B21D 7/03; B21D 11/02; B21D 53/88

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **16.11.2021 IT 202100028985**

(71) Applicant: **Itronics S.r.l.**
10064 Pinerolo (TO) (IT)

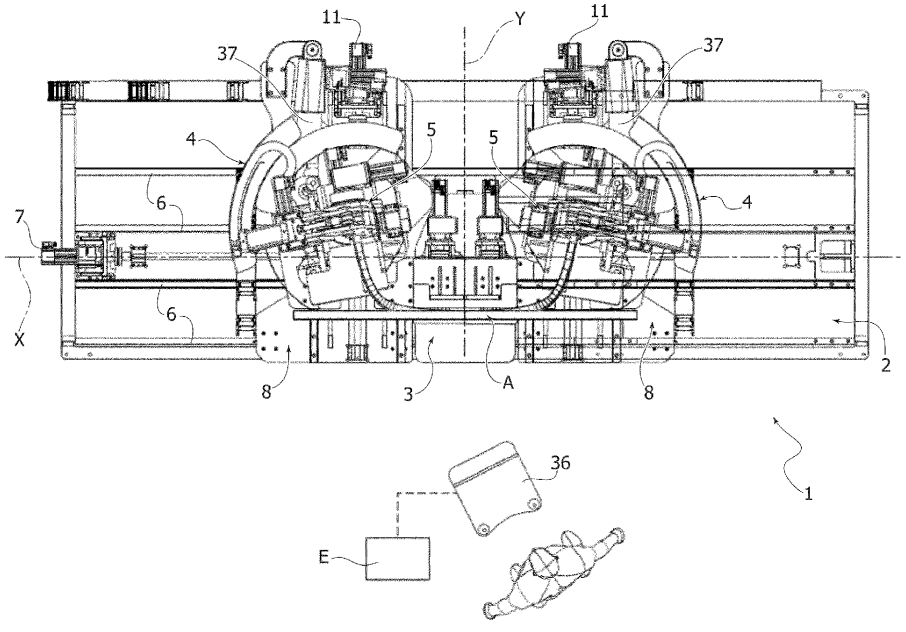
(72) Inventors:
- **CRESCIO, Federico**
  10061 Covour (Torino) (IT)
- **BARONETTO, Alessandro**
  10064 Pinerolo (Torino) (IT)

(74) Representative: **Notaro, Giancarlo**
Buzzi, Notaro & Antonielli d'Oulx S.p.A.
Corso Vittorio Emanuele II, 6
10123 Torino (IT)

(54) APPARATUS AND PROCEDURE FOR BENDING WITH STRETCHING METALLIC ELEMENTS

(57) An apparatus (1) for bending with stretching of metal elements (A) comprising a bedplate (2) on which a pair of slides (4) are slidably mounted, substantially symmetrical with respect to a transversal axis (Y) in the center line of the bedplate (2). Each slide (4) comprises:
- a base element (8) slidably mounted on the bedplate (2) along a longitudinal horizontal axis (X), and a plate element (9) slidably mounted on the base element (8) along a transverse horizontal axis (Y),
- a table element (12) rotatably mounted on the plate element (9) so as to provide a rotation (W) about a vertical axis (I) perpendicular to said horizontal axes (X, Y),
- clamp means (5) mounted on said table element (12), provided for clamping an end portion (A1, A2) of the metal element (A).

FIG. 1



EP 4 180 142 A1

Description

Field of the invention

[0001] The present invention relates in general to the bending of metal elements and relates to an apparatus and a method for bending with stretching of elongated metal elements, such as tubes or profiled bars used in industry, with cross-sections having different characteristics in terms of geometry, thickness and type of material.

[0002] These elements are mainly used in the automotive sector for producing bodywork details such as door frames, reinforcement cross-members, windscreen coverings and moldings, gaskets, ducts, etc.

[0003] However, the invention is not limited to this specific field of application. Below, the reference to "metal elements" means indicating different types of sheet metal, profiled bars or extrusions, used in industry.

Prior art

[0004] The metal elements considered above require extremely narrow dimensional tolerances, for reasons of functionality and style. For this reason, the bending processes must be carried out with extreme precision, in order to obtain the required shape, and guarantee adequate quality repeatability over time, in accordance with the needs of large-scale production.

[0005] In general, industrial machines are known, which are configured to position and support a metal element - for example shaped like a bar - to be bent, and to carry out bending with stretching by moving various mechanical components that make up the machine.

[0006] Document IT1259520 describes a machine of the type indicated above, comprising a pair of slides slidably mounted with respect to a support frame, wherein each slide is arranged to support a rotatable table carrying an apparatus configured for locking a respective end of the elongated element to be bent, so as to create a bending of the elongated element following the rotation of the table.

[0007] The main disadvantage of this solution is that it is frequently necessary to carry out further processing on the metal piece, after the bending performed with the aforesaid machine, to obtain further bent shapes that cannot be obtained with the aforesaid machine. Furthermore, these machines have complex handling mechanics, which require a considerable operating cost.

Object and summary of the invention

[0008] The present invention aims to provide an apparatus and a method for bending with stretching of elongated metal elements, which overcome the problems of the prior art.

[0009] Another object of the present invention is to provide an apparatus that allows the operations of locking, bending and stretching of the metal elements to be processed to be carried out in a simple, economical and functional way.

[0010] Another object of the present invention is to reduce the complexity of the mechanics for moving the mechanical parts of the apparatus, with respect to known solutions.

[0011] Another object of the invention is that of providing an apparatus of the type indicated above which is extremely reliable and versatile in terms of bending and stretching operations, respecting the safety requirements required in the industrial field.

[0012] Another object of the present invention is that of providing an apparatus of the type indicated above, and a relative method, which are extremely intuitive for the operators, obtaining considerable advantages of simplification and reduction of the set-up activities.

[0013] Another object of the invention is to provide an apparatus of the type indicated above which allows it to be used in all the processing cases required by the market with simple preliminary adjustments.

[0014] Another object of the invention is to provide an apparatus of the type indicated above which is extremely efficient in terms of energy impact and environmental safety.

[0015] According to the present invention, these objects are achieved by an apparatus and a method for the bending with stretching of metal elements, forming the subject of the attached claims.

[0016] The claims form an integral part of the disclosure provided here in relation to the invention.

Brief description of the drawings

[0017] The present invention will now be described in detail with reference to the attached drawings, given purely by way of non-limiting example, wherein:

- Figure 1 is a schematic plan view that illustrates a preferred embodiment of an apparatus according to the present invention,
- Figure 2 is a perspective view that illustrates a preferred embodiment of the apparatus according to the invention, in a starting condition of bending,
- Figure 3 is a schematic perspective view that illustrates the apparatus of the previous Figure, in an end condition of bending,
- Figure 4 is an additional perspective view of the apparatus of the previous Figures,
- Figure 5 is a perspective view on an enlarged scale of some components of the apparatus illustrated in the previous Figures,
- Figure 6 is a cross-sectional view, along the lines B-B of Figure 3, which illustrates some components of the apparatus of the previous Figures,
- Figures 7, 8 are perspective views on an enlarged scale of some components of Figure 6,
- Figure 9 is a perspective view on an enlarged scale of a central support unit, according to a preferred

embodiment, and

- Figure 10 is a cross-sectional view illustrating a bent metal element arranged against a shaping contrast element.

Detailed description

[0018] In the following description various specific details are illustrated aimed at a thorough understanding of examples of one or more embodiments.

[0019] The embodiments can be implemented without one or more of the specific details, or with other methods, components, materials, etc. In other cases, known structures, materials, or operations are not shown or described in detail to avoid obscuring various aspects of the embodiments. The reference to "an embodiment" in the context of this description indicates that a particular configuration, structure or characteristic described in relation to the embodiment is included in at least one embodiment.

[0020] Therefore, phrases such as "in an embodiment", possibly present in different places of this description do not necessarily refer to the same embodiment. Moreover, particular conformations, structures or characteristics can be combined in a suitable manner in one or more embodiments and/or associated with the embodiments in a different way from that illustrated here, for example, a characteristic here exemplified in relation to a figure may be applied to one or more embodiments exemplified in a different figure.

[0021] The references illustrated here are only for convenience and do not therefore delimit the field of protection or the scope of the embodiments.

[0022] With reference to the attached drawings, the number 1 generally indicates an apparatus for bending with stretching of metal elements A, according to a preferred embodiment of the invention.

[0023] The apparatus 1 is configured to simultaneously perform both a bending and a stretching of the metal element A to be processed.

[0024] In the present description, the expression "elongated metal elements" means metal elements shaped like bars, tubes or profiled bars used in industry, with cross-sections of different characteristics in terms of geometry, thickness and type of material. These elements are mainly used in the automotive sector for producing bodywork details such as door frames, reinforcement cross-members, windscreen coverings and moldings, gaskets, ducts, etc.

[0025] Figure 1 is a schematic plan view that illustrates a preferred embodiment of an apparatus according to the present invention.

[0026] The apparatus 1 comprises a bedplate 2 on which a pair of slides 4 are slidably mounted, substantially symmetrical with respect to a transversal axis Y in the center line of the bedplate 2. The bedplate 2 may be made in any known way, for example, with a box-shape structure comprising longitudinal and transverse ribs, for example, made of steel.

[0027] As indicated below, each slide 4 is arranged to support a plurality of components suitable for carrying out bending and stretching operations of a respective end portion A1, A2 of the metal element A. Note that in Figures 2-6 only one of the two slides 4 with the respective components is shown.

[0028] With reference to the attached drawings, the apparatus 1 comprises a central support unit 3 rigidly connected to the bedplate 2, in a position interposed between the slides 4. As indicated below, the central support unit 3 has a bearing structure 13, designed to support and lock a central portion A3 of the metal element A to be machined.

[0029] At the upper plane of the bedplate 2, a plurality of guides 6 parallel to each other are positioned (Figures 2-4), extending along a longitudinal horizontal axis X, arranged to allow the sliding of the slides 4 along the axis X, with respect to the central support unit 3. The sliding system may comprise an assembly of ball-bearing sliders and actuation means, for example an electrically-operated actuator unit 7.

[0030] In one or more embodiments, each slide 4 comprises a base element 8 slidably mounted on the guides 6 of the bedplate 2 along the longitudinal horizontal axis X, and a plate element 9 slidably mounted on the base element 8 along a horizontal transverse direction, parallel to the Y axis. The plate element 9 is positioned on respective parallel guides 10 spaced on the base element 8, along a horizontal transverse direction, so as to create a sliding system of the plate element 9. It should be noted that the transverse slides 10 have reduced dimensions with respect to the extension of the longitudinal slides 6. The sliding system of the plate element 9 - along the Y axis - may comprise a plurality of ball-bearing sliders. The transverse translation, similarly to the longitudinal translation, may be controlled by a ball-bearing screw which can be operated by electrically-operated actuator units 11.

[0031] Again with reference to each slide 4, the apparatus 1 comprises a table element 12 rotatably mounted on the plate element 9, so as to be able to perform a rotation W around a first vertical axis I (illustrated in Figures 5, 6). The rotation W of the table element 12 can be achieved by means of a fifth wheel mechanism arranged under the table element 12, which can be operated by an electrically-operated actuator unit 19. Preferably, this actuator unit 19 comprises a mechanical arm 37 - Figures 1-6 - connected to a coupling portion of the table element 12, which can be operated by an electric gearmotor, so as to generate a rotation of the table element 12 mounted on the fifth wheel mechanism.

[0032] The rotation mechanism indicated above determines a rotatable table element 12 which allows an overall controlled angular rotation from 0° (initial loading position of the metal element to be bent, Figure 2) to about 90° (end bending position, Figure 3), and vice versa to return to the position for loading the item A to be ma-

chined.

[0033] Again with reference to each slide 4, the apparatus 1 further comprises clamp means 5 mounted on said rotatable table element 12, arranged to clamp an end portion A1, A2 of the metal element A to be machined. The clamp means 5 comprise locking seats 50 (Figure 3) configured to receive and lock one end of the item A, for example, with the aid of locking dowels (not shown). The dowels may be electrically controlled from an inoperative position prior to loading the item A in an operating position wherein the item A is locked on the seats 50.

[0034] As also indicated below, during operation, the angular rotation of the rotatable table element 12 is synchronized point by point to the Cartesian translation of the two underlying horizontal axes X, Y, through an electronic interpolation performed by a control unit E of the apparatus 1. The control unit E is programmed to control the bending steps of the item A to be processed, by activating the actuation units designed for the handling of all the moving parts of the apparatus 1. The possibility follows of integrating the rotation of the table element 12 with a linear movement that is constantly tangent to the bending angle, resulting in a stretching with bending of the item A.

[0035] The interpolation of the rotatable table element 12 with the translations of the slides 4 below allows creation of bends without the aid of mechanical pins or rollers, simplifying the handling mechanics and obtaining a corresponding reduction in costs.

[0036] According to an advantageous characteristic of the invention, the moving parts with rolling friction - instead of bending machines with sliding friction - allow the power generated to be used without dispersion due to the passive resistances generated by the sliding friction of the various moving masses. It follows that the bending effort impressed is only that corresponding to the resistance that the element A being processed opposes to the bending, with a reduction in the power required compared to apparatuses with moving parts with sliding friction.

[0037] According to another characteristic of the invention, all the actuators are of the electric or pneumatic type, thus eliminating the lubrication of all the members in contact in the case of hydraulic type actuators. Thanks to this characteristic, a considerable simplification of the centralized lubrication system of the apparatus is achieved, as the ball-bearing sliders are equipped with self-lubricating wiper soaps that require only occasional maintenance.

[0038] Advantageously, it is therefore possible to obtain a reduction in the power required for mechanical handling, with respect to bending machines known in the field.

[0039] According to a unique characteristic of the invention, the clamp means 5 are connected in an articulated manner on the rotatable table element 12, by means of a support assembly 16 comprising an assembly of components with moving parts, and actuator means configured to control a combined movement of the clamp means 5, in addition to the translations along the underlying horizontal axes X, Y and to the rotation W around the vertical axis I.

[0040] More in detail, as illustrated in the enlarged scale views of Figures 5, 6, the support assembly 16 is configured to create said additional combined movement of the clamp means 5, in particular:

- a vertical movement along a substantially vertical axis Z, perpendicular to the plane of the rotatable table element 12,
- a first rotation K around a horizontal transverse axis II, parallel to the transverse axis Y in the configuration of the beginning of bending illustrated in Figure 5, and
- a second rotation J around a longitudinal horizontal axis III, parallel to the longitudinal axis X in the configuration of the beginning of bending illustrated in Figure 5.

[0041] According to the embodiment illustrated in Figures 5, 6, the support assembly 16 comprises a lower support portion 17 mounted on the rotatable table 12.

[0042] In one or more embodiments, the lower support portion 17 is a box-shape structure comprising a lower plate 17' and an upper plate 17" parallel to each other, mutually joined at their vertices by respective support columns 20. The lower plate 17' is fixed on the rotatable table 12, while the upper plate 17" is vertically movable by means of suitable actuator means, for example of the electric type. Preferably, the actuator means are made in such a way that the columns 20 have a structure slidably mounted on an inner support column 27 by means of bushing means 28 (Figure 6) slidably engaged on the inner support column 27, following the actuation of a gearmotor 31.

[0043] In accordance with the embodiment illustrated in the drawings, the support assembly 16 also comprises an upper support portion 18 connected to the lower support portion 17, so that the vertical movement of the lower support assembly 17 causes a vertical integral movement of the upper support assembly 18. As indicated below, the clamp means 5 are connected in an articulated manner to the upper support assembly 18. In accordance with the illustrated embodiment, the upper support portion 18 is connected to the upper plate 17" by means of a side wall 17‴ of the assembly 16 (Figure 6).

[0044] Figure 7 is an enlarged scale view of the upper support assembly 18. In one or more embodiments, the upper support portion 18 is made in a single piece comprising a plate 21 and a first connecting portion 22, arranged to connect the plate 21 to a respective actuator 29, so as to control a first rotation K around a horizontal axis II of the upper support portion 18, and therefore also of the clamp means 5. The actuator 28 is mounted at the side wall 17‴ and the first connecting portion 22 faces the side wall 17"'. The horizontal axis II is parallel to the transverse axis Y in the configuration of the beginning of

the bending illustrated in Figure 5 (table element 12 in the initial starting position of a bending cycle). The first connecting portion 22 may be an opening to allow the meshing of the actuator 28 on the plate 21. Preferably, reinforcing flanges 24 extend close to the first connecting portion 22, connecting the plate 21 to the first connecting portion 22.

[0045] The upper support portion 18 also comprises a second connecting portion 23, for connecting a base portion 51 of the clamp means 5 to a respective actuator 30, so as to provide an articulated connection to perform a second rotation J of the clamp means 5 around a longitudinal horizontal axis III. The horizontal axis III is parallel to the longitudinal axis X in the configuration of the beginning of bending illustrated in Figure 7. The articulated connection of the base portion 51 of the clamp means 5 is made by means of a connection flange 26 (illustrated in Figures 8, 10) interposed between the actuator and the base portion 51 of the clamp means 5.

[0046] With reference to Figure 7, the upper support portion 18 also comprises a support surface 25 for mounting a shaping contrast element (not shown) to be applied against a proximal portion of the elongated element A to be bent.

[0047] During operation, the upper support portion 18 and the clamp means 5 slide along a vertical direction, integral with the vertical movement of the lower support assembly 17 along the vertical axis Z. Simultaneously or sequentially, the upper support portion 18 and the clamp means 5 may be rotated around the horizontal transverse axis II (rotation K). Simultaneously or sequentially to the aforesaid movements, the clamp means 5 may be further controlled in rotation around the horizontal longitudinal axis III (rotation J).

[0048] The vertical movement along the Z axis and the rotations K, J may be controlled by respective electrically-operated actuation units 29, 30.

[0049] Thanks to the combination of the translations along the X, Y axes of the slides 4, the rotation W of the rotatable table element 12, and the further movements of the clamp means 5 (vertical translation along the Z axis and rotations K, J), it is possible to obtain extremely complex bent shapes of elongated items.

[0050] As shown in Figure 9 which illustrates an enlarged scale view of the central unit 3, a supporting structure 13 substantially shaped like a pillar is rigidly connected to the bedplate 2 at a central portion of the apparatus 1.

[0051] According to an important characteristic of the invention illustrated in Figure 9, the central support unit 3 is configured to perform bending operations at the central portion A3 of the metal element A supported by the central support unit 3.

[0052] More particularly, an assembly of movable components 14 is slidably mounted on the bearing structure 13 along respective horizontal directions perpendicular to each other IV, V, VI, VII. At least one shaping contrast element 15 (not shown) is fixed on a seat obtained at an upper portion of said assembly of movable components 14, and is arranged in abutment against a central portion A3 of the metal element A.

[0053] The shaping contrast element 15 is shaped according to the section shape to be obtained on the metal element A. As shown in the cross-sectional view of Figure 10, the metal element A to be machined abuts on the shaping contrast element 15 in such a way that, following the actuation of the assembly of moving components 14, the section of the metal element A is bent according to the profile of the shaping contrast element 15.

[0054] In one or more embodiments of the invention, the assembly of moving components 14 comprises:

- a pair of lower slides 14^{I}, 14" adjacent and arranged along the same plane, slidably mounted along a horizontal direction parallel to the longitudinal axis (X), movable away and/or approaching each other (IV, V);
- a pair of upper slides 14^{III}, 14^{IV} slidably mounted above the pair of lower slides 14^{I}, 14" along respective horizontal directions (VI, VII) parallel to the transverse axis Y;
- actuator means 32, 33, 34, 35 for driving the sliding of the lower and upper slides 14^{I}, 14", 14^{III}, 14^{IV}, in such a way as to bend a central portion A3 of the metal element A, arranged against the central shaping element 15 carried by the assembly of slides 14^{I}, 14", 14^{III}, 14^{IV}.

[0055] It should be noted that the actuator means 32, 33, 34, 35 are preferably of the electric type, with which a system of rolling friction guide sliders is associated.

[0056] During operation, the displacement of the movable components 14 allows imposing a settling force that allows calibration of the tensioning of the metal element A in the final step of bending with the slides 4. This process allows "freezing" the geometry of the item at the end of the bending, guaranteeing the absolute repeatability of the bent shapes to be obtained. The displacements of the movable components 14 of the central unit 3 may be in the order of 3 - 4 mm.

[0057] Machining on the central part of the item, performed with the aid of said movable components 14, allows targeting and maintenance of geometric tolerances very close to theoretical zero.

[0058] In accordance with the characteristics described above, the apparatus 1 according to the invention has 14 interpolated axes (six axes for each slide assembly 4 and four axes for the central unit 3) by means of digital numerical control with combined rotations and translations to obtain complex operations of bending with stretching.

[0059] The operation of the apparatus 1 is as follows.

[0060] As previously indicated, the apparatus 1 comprises an electronic control unit E designed to control the actuation of the moving parts of the apparatus 1 according to the required bending and stretching cycle. A mem-

ory device is associated with the electronic control unit E, designed to store different bending cycles comprising different translation and rotation quotas of the moving parts of the apparatus 1. The apparatus 1 also comprises a human machine interface (HMI) device 36 for entering the identification parameters of a given work cycle.

[0061] Inside the memory device, various identification codes are saved relating to different bending and stretching cycles to obtain different shapes of the metal item to be machined. Each code/cycle therefore has certain values/bending angles relating to all the X, Y, Z, I, II, III, IV, V, VI, VII movement axes of the apparatus 1. In association with each code/cycle, respective shaping contrast elements 15 are provided to obtain the required shapes by applying the correct values of the bending angles.

[0062] To define a new bending cycle, in a preliminary step of setting up the apparatus 1, the operator enters a new identification code to identify a specific piece of equipment (shaping contrast element) to be applied to the new bending cycle.

[0063] Following the input of the new code, the electronic control unit E automatically activates the longitudinal sliding (X axis) of the slides 4, to record the correct starting position of the pair of slides 4 on the sides of the central support unit. 3.

[0064] Subsequently, the operator starts several preliminary functions, such as closing the clamp means 5 to tighten the ends A1, A2 of the metal item A, checking the correct position of the item A, closing the locking dowels. In this regard, the apparatus 1 may comprise a plurality of sensors (for example, inductive or infrared) that verify the correctness of all the loading conditions.

[0065] Subsequently, the operator enters the values of the bending angles (rotations J, K, W etc.) previously estimated during a preliminary study step. Of course, in the case of an asymmetrical item with ends bent in a different way, the angles of the slide assemblies 4 will be diversified according to the shape to be obtained. Furthermore, if only one end of the item A is to be bent, only one of the slide units 4 - and the relative clamp means 5 - are activated in the bending cycle.

[0066] Subsequently, the operator starts the bending and stretching operations, interrupting the cycle according to preferred steps, to check the effect of the movements of the moving parts of the apparatus 1. Verification may be carried out with the aid of a gauge.

[0067] When verification is successful for all the steps of the cycle, the entire bending and stretching cycle is saved in the memory device of the apparatus 1. Consequently, to execute the saved cycle, the operator must select the relevant identification code, load the item, and start the previously defined and stored bending and stretching operations.

[0068] The saved cycle will automatically and correctly adopt all the strokes of the movement axes - to target in a specific sequence all the three-dimensional movements necessary to determine the required shape.

[0069] The strokes of the different axes X, Y, Z, I, II, III, IV, V, VI, VII, occur automatically simultaneously or sequentially on the basis of various preliminary parameters entered by the user, such as the values of the angles of bending (J, K, W rotations etc.) previously estimated during a preliminary study step.

[0070] During execution of the bending cycle, the control unit E is configured to automatically interpolate the strokes of the various axes X, Y, Z, I, II, III, IV, V, VI, VII on the basis of a calculation algorithm that takes into account the stroke/speed of each axis, in order to obtain the required shape.

[0071] In other words, the control unit E is configured to relate - through a plurality of trigonometric calculations - the strokes/speeds of each axis X, Y, Z, I, II, III, IV, V, VI, VII, with the other axes, in order to target in real time an adaptation of the different displacements of the moving parts, to obtain the required shape of the item A in a repeatable and reliable precise way.

[0072] Of course, without prejudice to the principle of the invention, the details of construction and the embodiments can be widely varied with respect to those described and illustrated, without thereby departing from the scope of the invention as defined by the claims that follow. This applies both to the shape of the components of the apparatus 1, and to the configuration of the actuators, as well as to the sliding systems of the moving parts.

Claims

1. An apparatus (1) for bending with stretching of metal elements (A), comprising:

- a bedplate (2) on which a pair of slides (4) are slidably mounted, substantially symmetrical with respect to a transversal axis (Y) in the center line of the bedplate (2),
- a central support unit (3) rigidly connected to said bedplate (2) at a position interposed between the slides (4) forming said pair, provided for supporting and locking a central portion (A3) of the metal element (A) to be machined,
- each slide (4) comprising:
  - a base element (8) slidably mounted on the bedplate (2) along a longitudinal horizontal axis (X), and a plate element (9) slidably mounted on the base element (8) along a transverse horizontal axis (Y),
  - a table element (12) rotatably mounted on the plate element (9) so as to provide a rotation (W) about a vertical axis (I) perpendicular to said horizontal axes (X, Y),
- clamp means (5) mounted on said table element (12), provided for clamping an end portion (A1, A2) of the metal element (A),

said apparatus (1) being **characterized in that**:

- alongside at least one slide (4), said clamp means (5) are pivotally connected on the rotary table element (12) by means of a support assembly (16) comprising an assembly of components and actuator means configured for driving a combined movement of the clamp means (5), in particular a vertical movement along a substantially vertical axis (Z) and/or a first rotation (K) about a transverse horizontal axis (II) parallel to said transverse horizontal axis (Y) and/or a second rotation (J) about a longitudinal axis (III) parallel to said longitudinal horizontal axis (X).

2. An apparatus (1) according to claim 1, **characterized in that** said assembly of components of the support assembly (16) comprises:

- a lower support portion (17) mounted on the rotary table element (12) including a plate (17") vertically movable along said substantially vertical axis (Z),
- an upper support portion (18) connected to the lower support portion (17) and to the clamp means (5), so that the vertical movement of the lower support portion (17) causes a vertical integral movement of the upper support portion (18) and the clamp means (5).

3. An apparatus (1) according to claim 2, **characterized in that** the upper support portion (18) comprises:

- a first connecting portion (22) operatively connected to an actuator (29), for driving a first rotation (K) of the upper support portion (18) and the clamp means (5) about said horizontal axis (II),
- a second connecting portion (23) operatively connected to an actuator (30), for driving a second rotation (J) of the clamp means (5) about said longitudinal horizontal axis (III).

4. An apparatus (1) according to claim 1, **characterized in that** the support assembly (16) comprises a support surface (25) for mounting a shaping contrast element (15) to be applied against a proximal portion of the elongated element (A) to be bent.

5. An apparatus (1) according to claim 1, **characterized in that** the central support unit (3) comprises:

- a bearing structure (13) rigidly connected on said bedplate (2),
- an assembly of movable components (14) slidably mounted on the bearing structure (13) along respective horizontal directions (IV, V, VII, VII) perpendicular to each other,
- at least one shaping contrast element (15) fixed on a seat obtained at an upper portion of said assembly of movable components (14), wherein a central portion (A3) of the metal element (A) abuts against the shaping contrast element (15) shaped according to the cross-section shape to be obtained,
- so as to obtain bending operations also at the central portion (A3) of the metal element (A), without further working the metal element (A) after the operations performed by means of said apparatus (1).

6. An apparatus (1) according to claim 5, **characterized in that** said assembly of movable components (14) comprises:

- a pair of lower slides (14^{I}, 14") adjacent and arranged along the same plane, slidably mounted along a horizontal direction parallel to the longitudinal axis (X), movable away and/or approaching each other (IV, V);
- a pair of upper slides (14^{III}, 14^{IV}) slidably mounted above the pair of lower slides (14^{I}, 14") along respective horizontal directions (VI, VII) parallel to the transverse axis (Y);
- actuator means (32, 33, 34, 35) for driving sliding of the lower and upper slides (14^{I}, 14^{II}, 14^{III}, 14^{IV}), in such a way as to bend a central portion of the metal element (A), arranged against the central shaping element (15) carried by the assembly of slides (14^{I}, 14", 14^{III}, 14^{IV}).

7. An apparatus (1) according to claim 1, **characterized in that** it comprises a plurality of electric- or pneumatic-type actuator units (7,11,19,29,30,31,32,33,34,35) for handling the moving parts of the apparatus (1).

8. A method for bending a metal element (A) by using an apparatus (1) according to any of the previous claims, comprising the steps of bending with stretching the metal element (A) as a result of an electronic interpolation by means of digital numerical control with combined rotations and translations to obtain elaborate folding with stretching operations, in particular:

- sliding at least one slide (4) along said longitudinal horizontal axis (X),
- sliding said plate element (9) along said transverse horizontal axis (Y),
- driving rotation of said table element (12) so as to provide a rotation (W) about a vertical axis (I) perpendicular to said horizontal axes (X, Y),
- driving a combined movement of the clamp means (5), in particular, sequentially or simulta-

neously driving:

- a vertical translation along a substantially vertical axis (Z),
- a first rotation (K) about a transverse horizontal axis (II) parallel to said transverse horizontal axis (Y), and
- a second rotation (J) about a longitudinal horizontal axis (III) parallel to said longitudinal horizontal axis (X).

9. A method according to claim 8, **characterized in that** the angular rotation of the rotatable table element (12) is synchronized point by point to the Cartesian translation of said horizontal axes (X, Y), through electronic interpolation carried out by a control unit (E) of the apparatus (1).

10. A method according to claim 9, **characterized in that** the vertical translation along said substantially vertical axis (Z), the first rotation (K) about a transverse horizontal axis (II) and the second rotation (J) around a longitudinal horizontal axis (III) are synchronized point by point to the Cartesian translation of said horizontal axes (X, Y) and to the rotation (W) of the rotatable table element (12).

FIG. 1

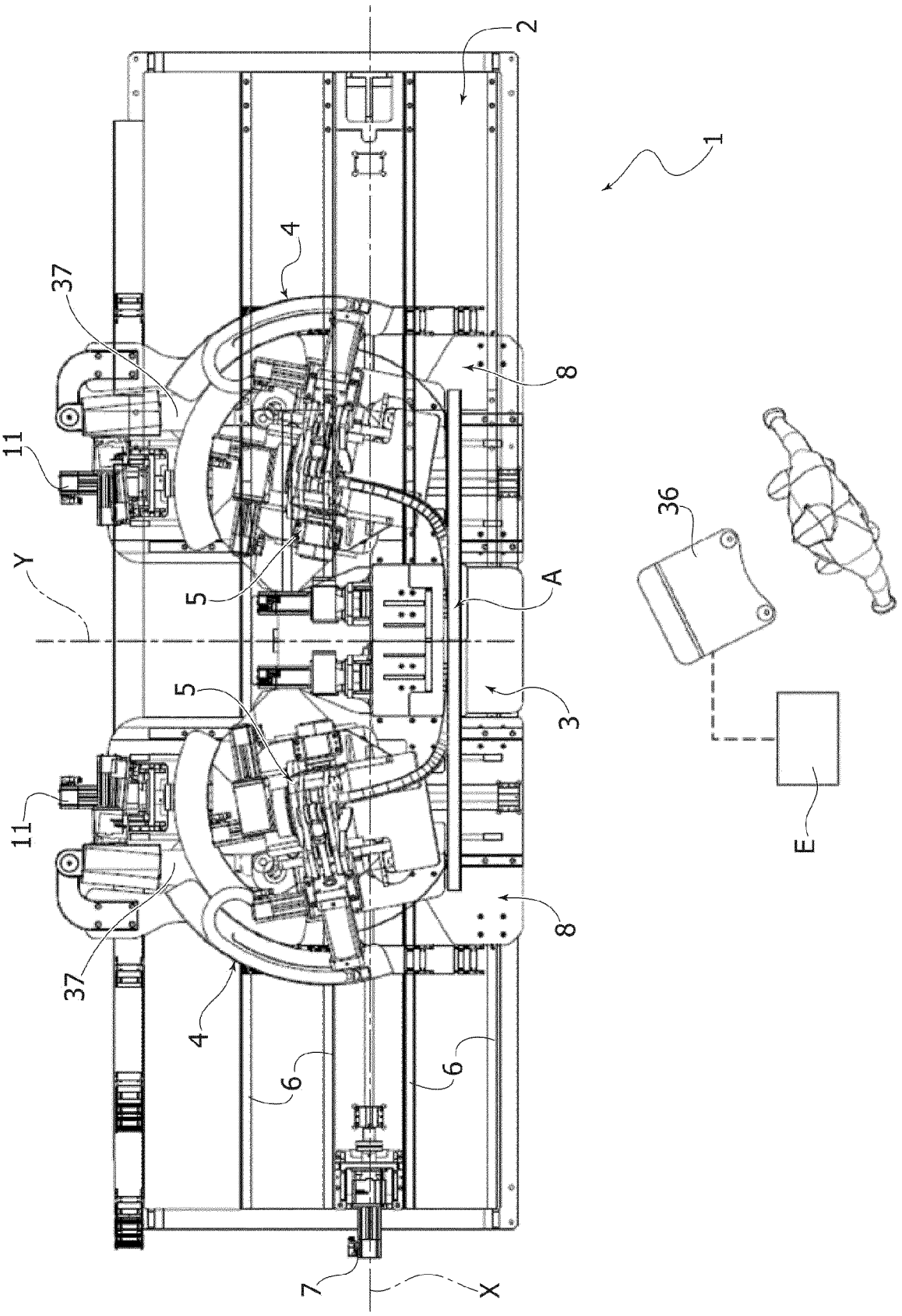


FIG. 2

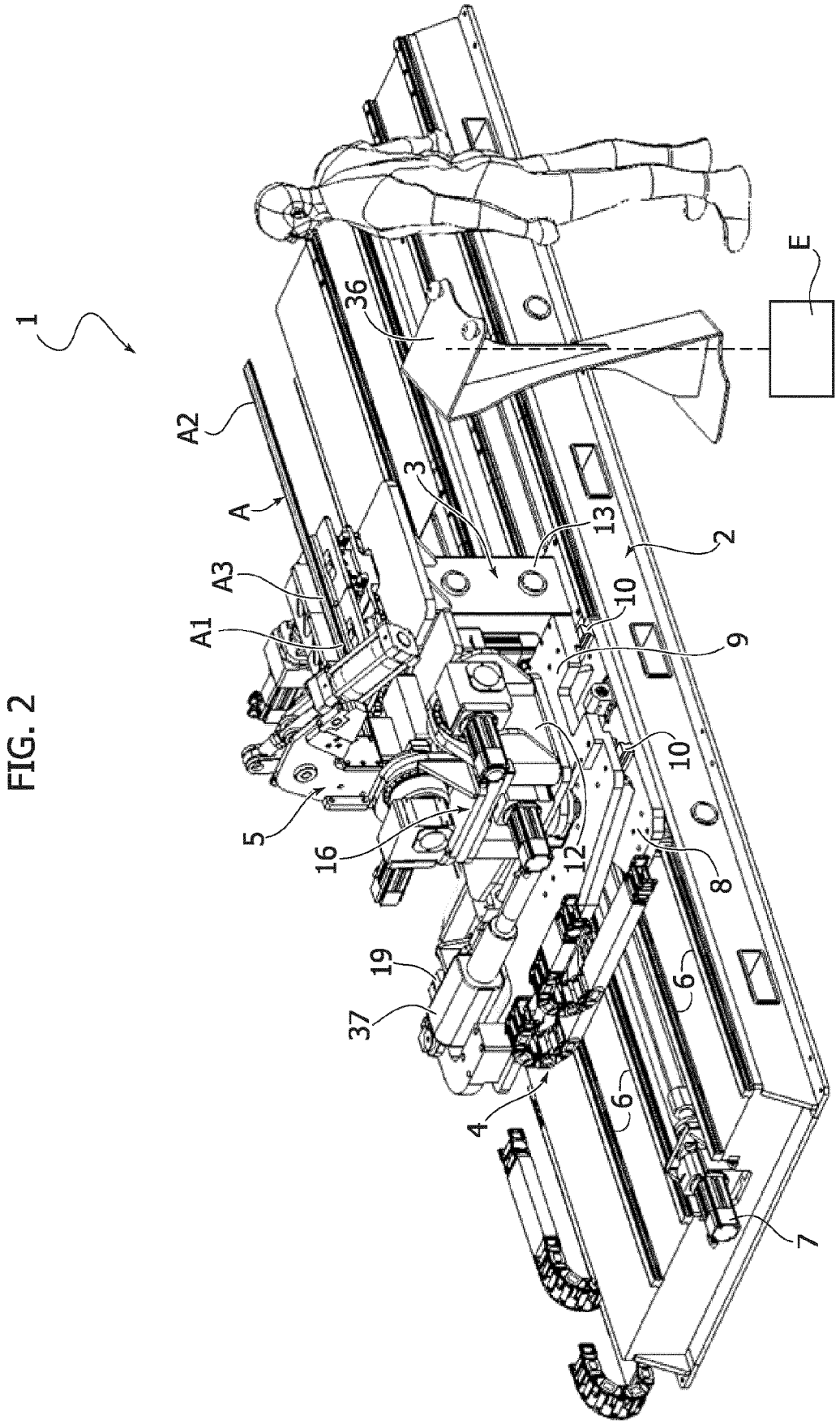
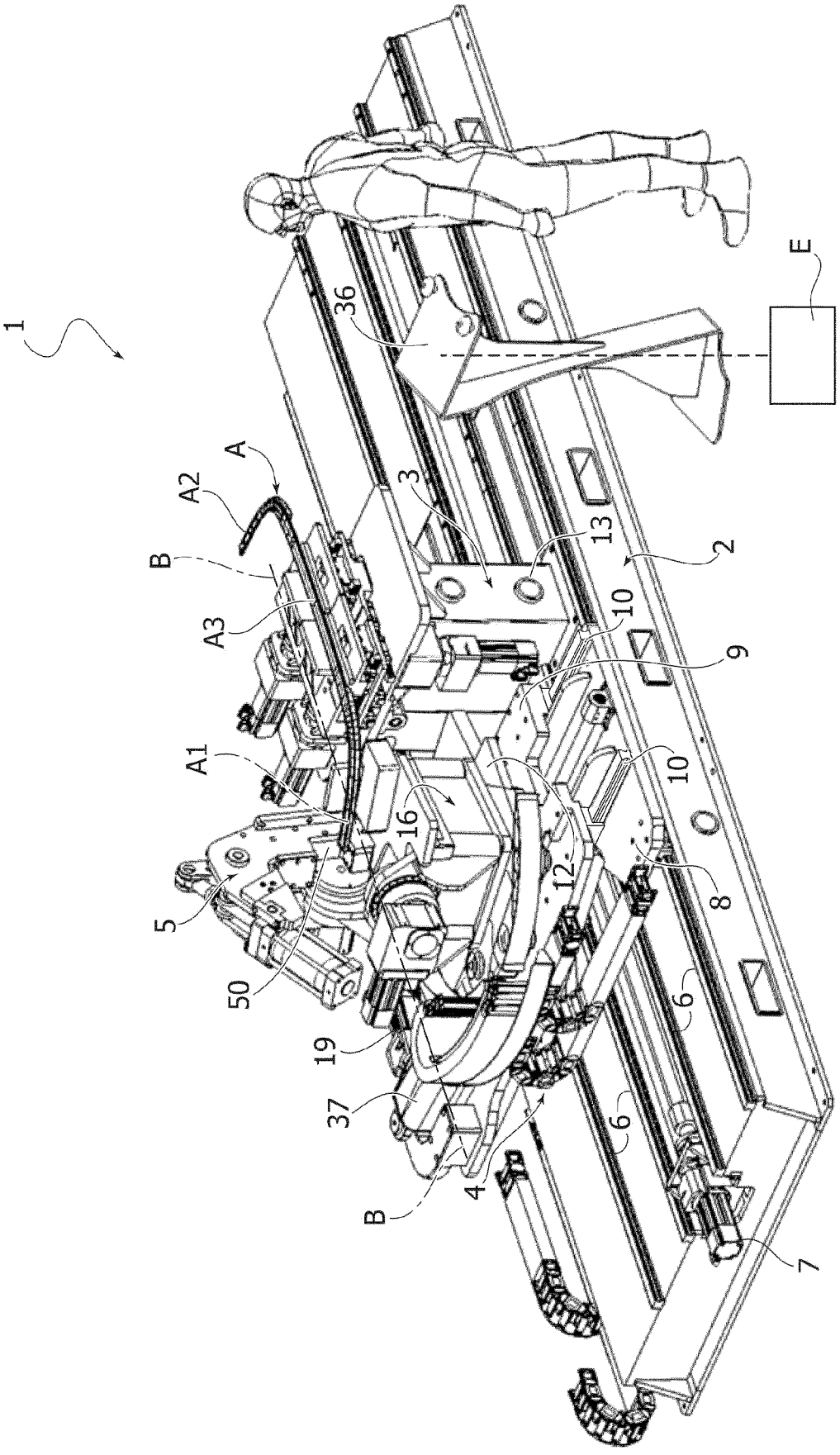


FIG. 3



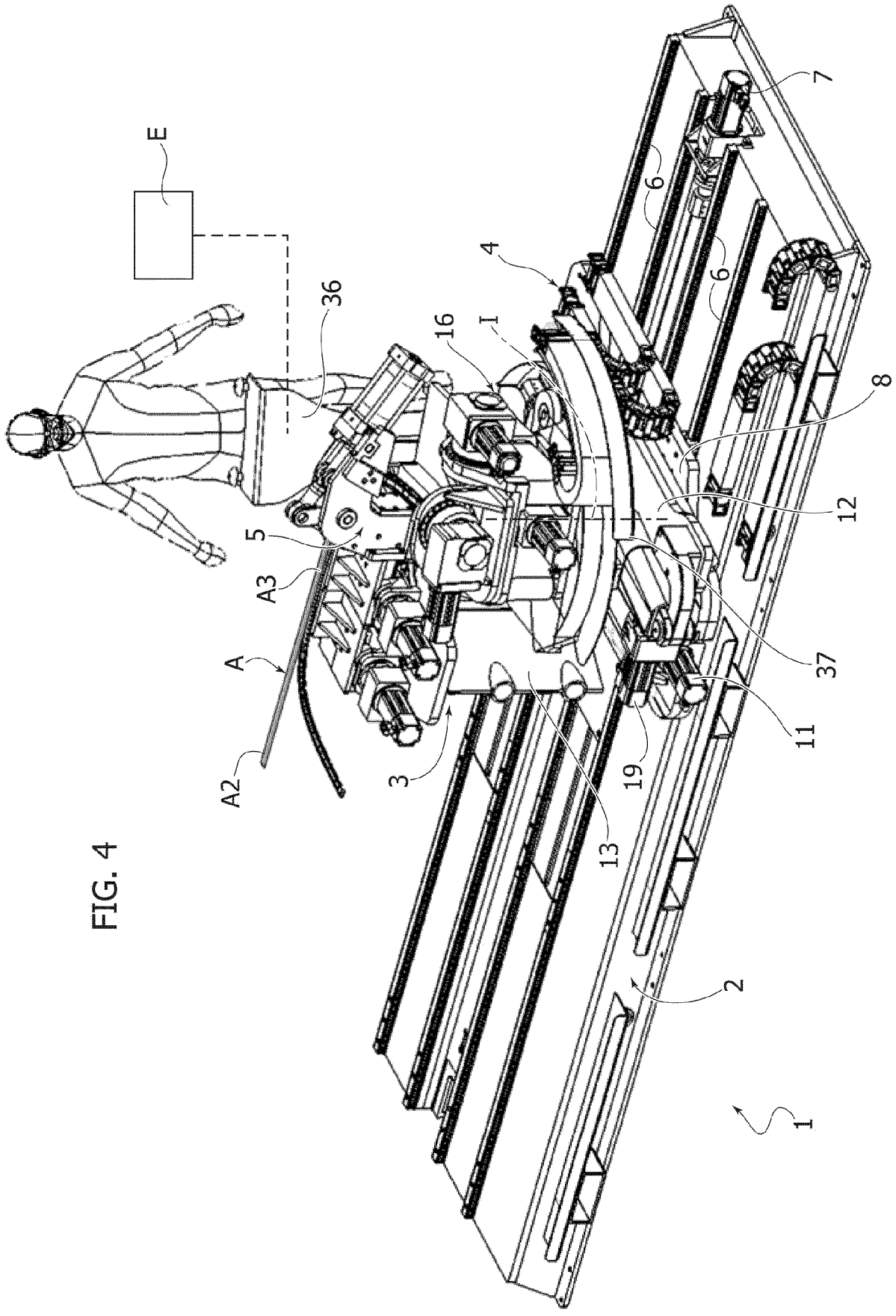
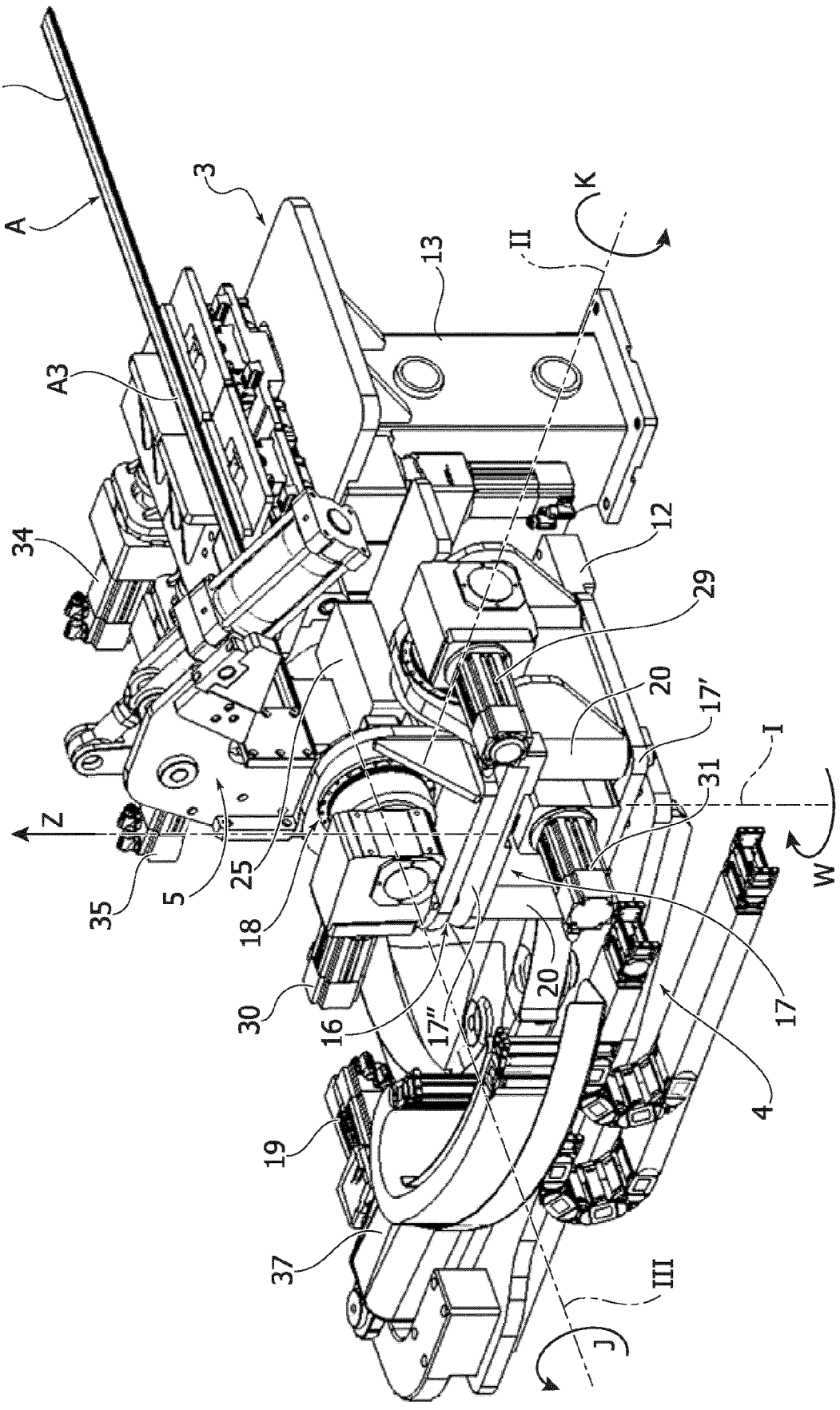


FIG. 4

FIG. 5


A2
A
3
K
II
13
A3
34
12
29
20
17'
I
31
Z
W
35
5
25
18
30
16
17''
20
17
4
19
37
III
J

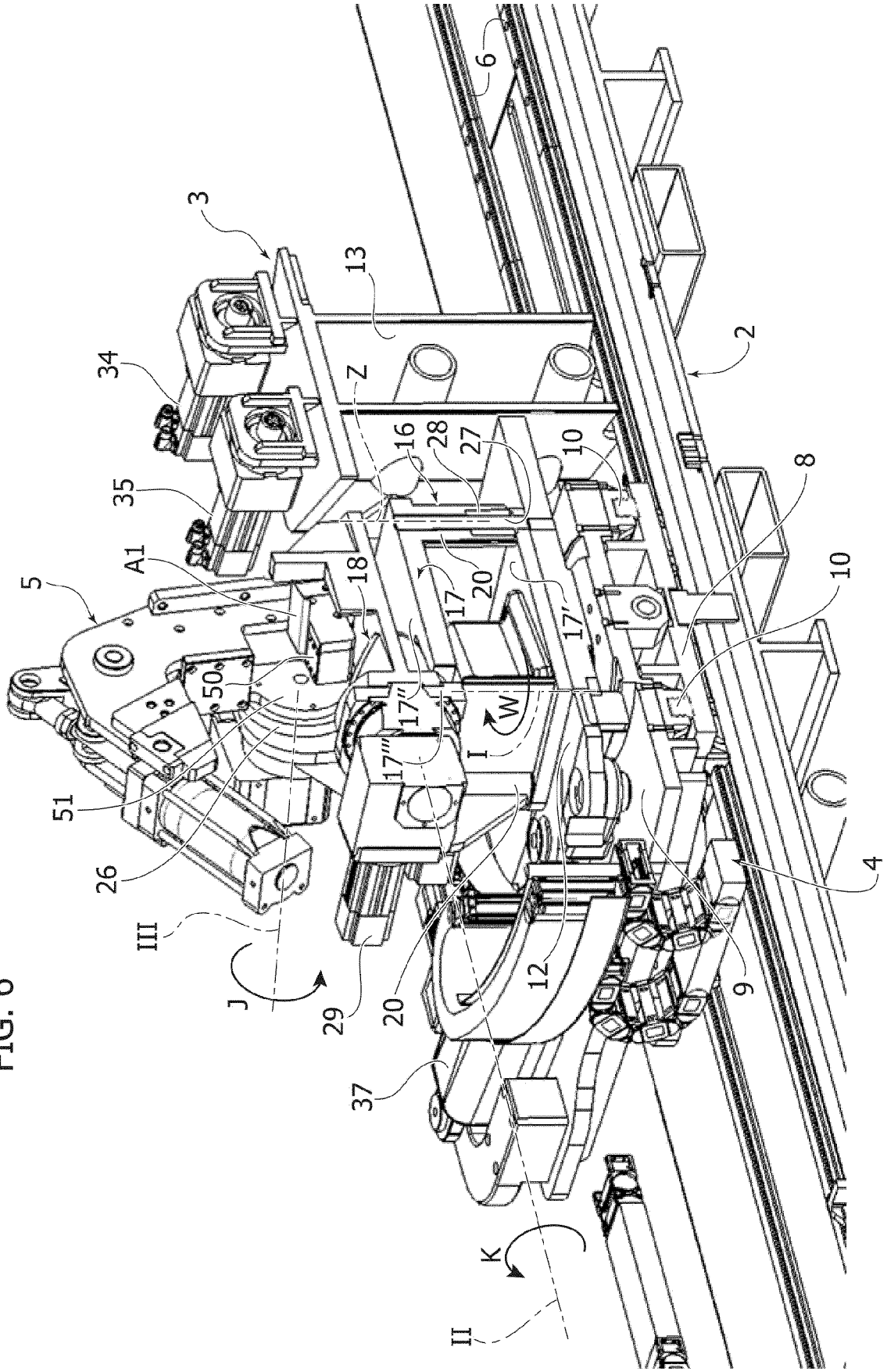

6
3
13
2
34
Z
16
28
27
10
8
35
A1
18
17
20
17'
10
5
50
17''
W
I
51
17'''
4
26
III
J
29
20
12
9
37
K
II

FIG. 6

FIG. 8

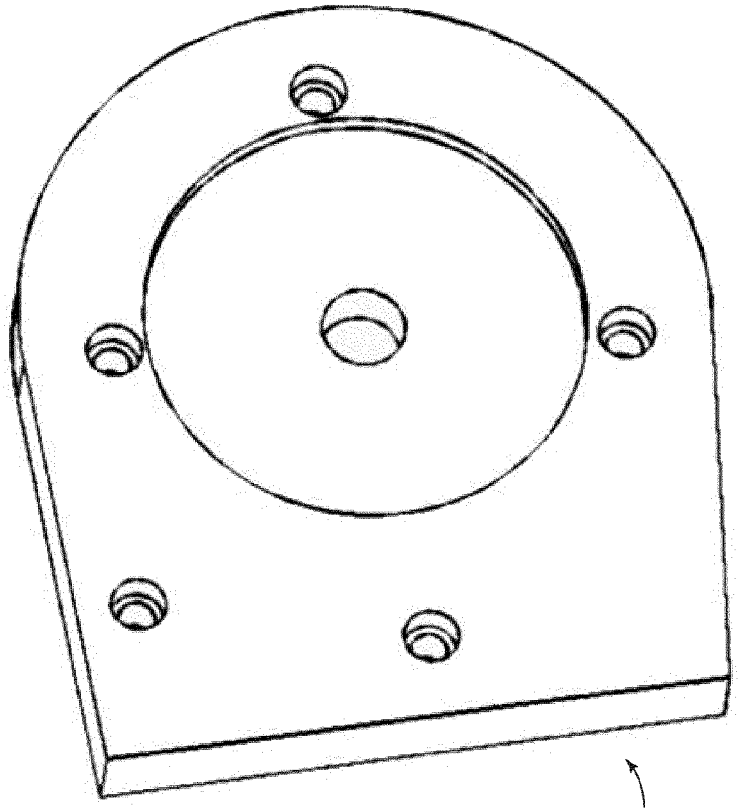


FIG. 7

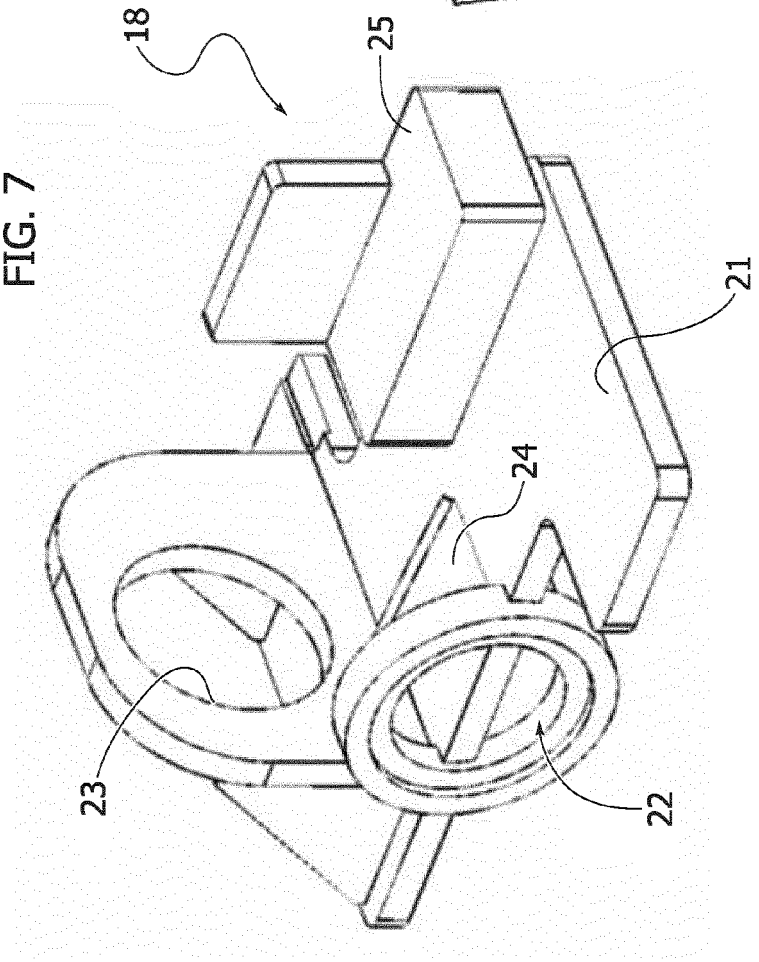


FIG. 9

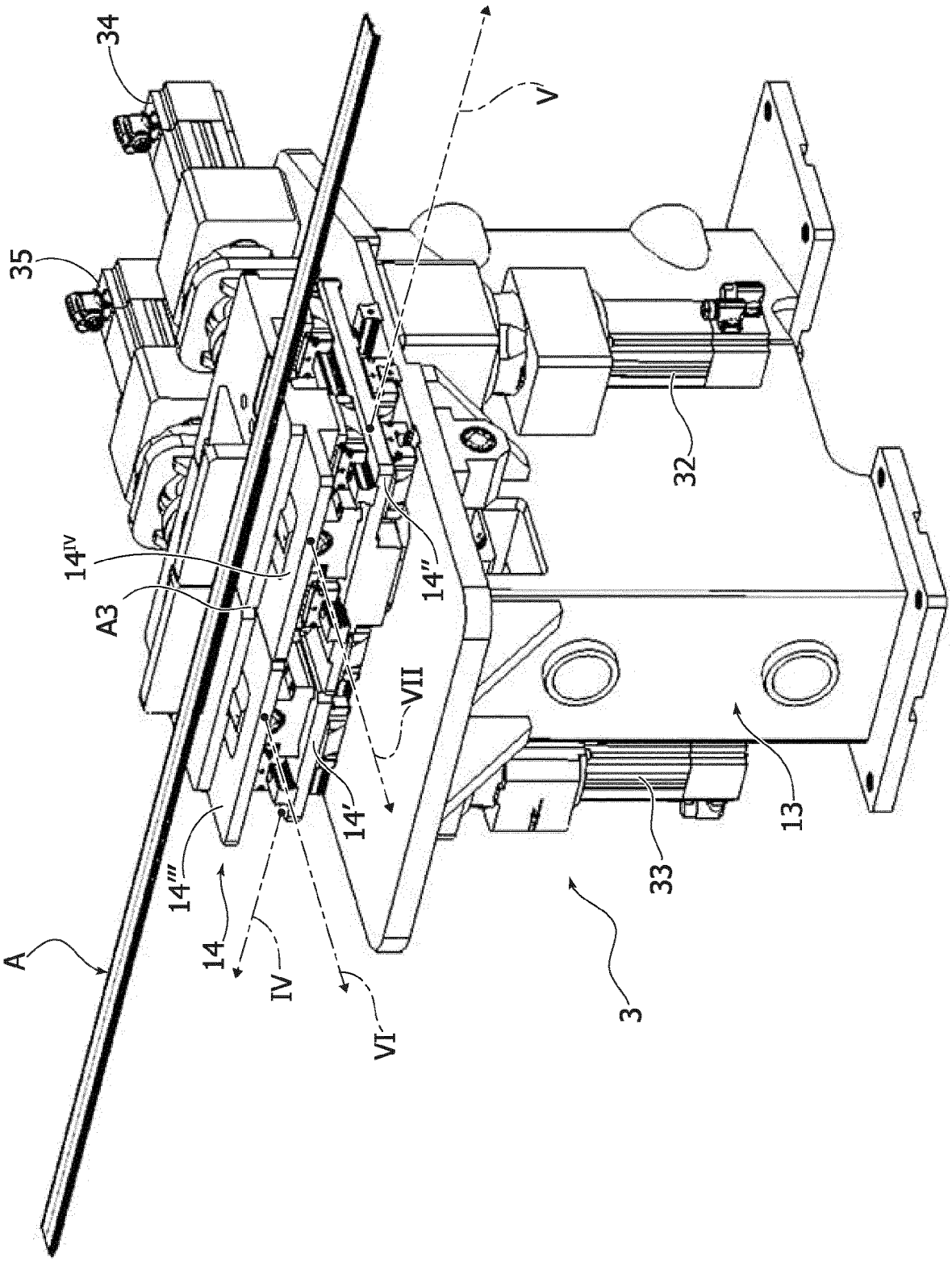
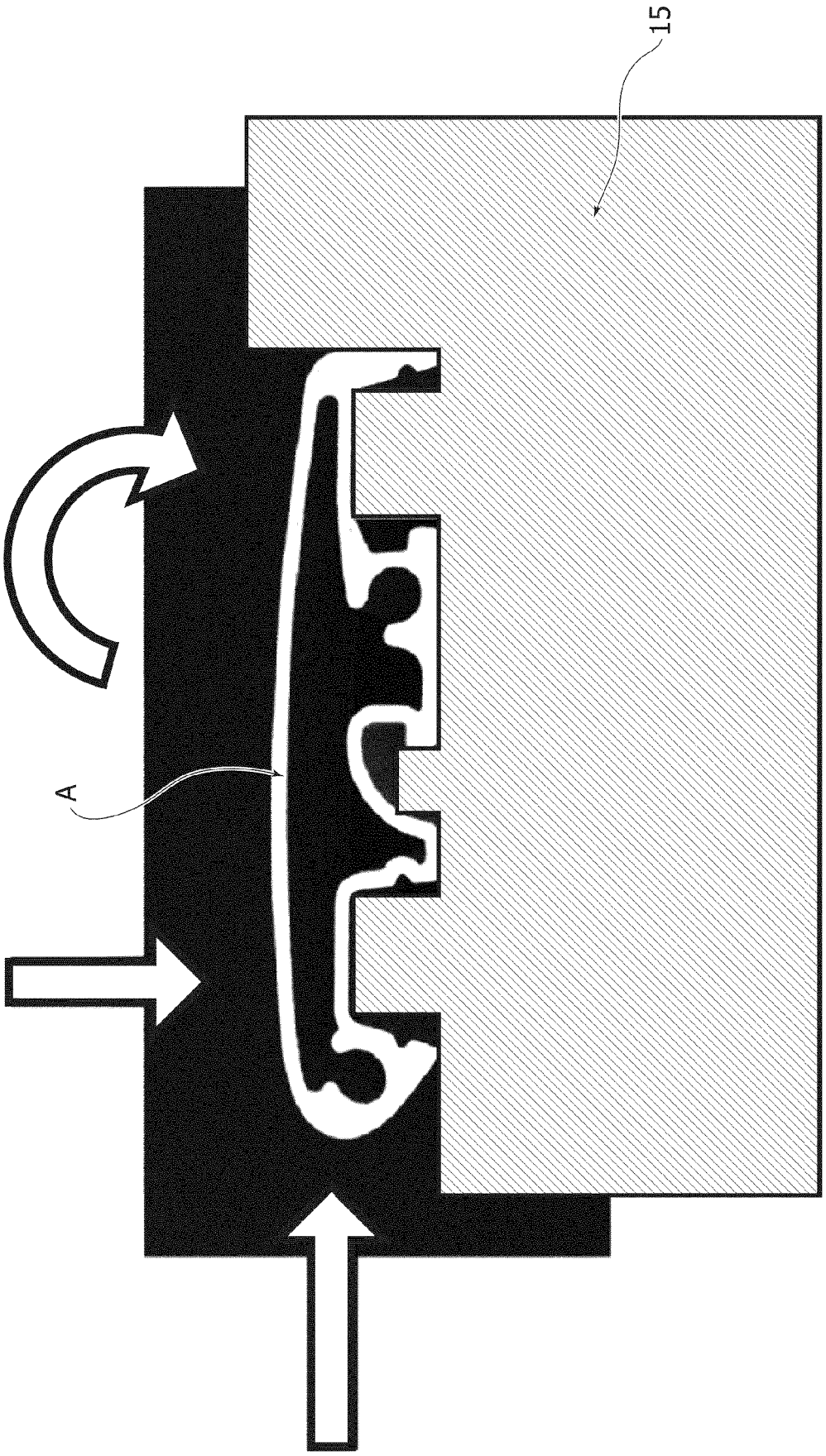


FIG. 10



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 20 7420

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	CN 111 360 115 A (BAI ZHICHAO) 3 July 2020 (2020-07-03) * figures 1-8 *	1,4,7-10 2,3,5,6	INV. B21D7/12 B21D7/03 B21D11/02
A	EP 1 702 691 A1 (LEXOVIENNE DE MECANIQUE ET OUT [FR]) 20 September 2006 (2006-09-20) * figures 1-8 *	1-10	ADD. B21D53/88
A	CN 210 847 811 U (JUYA AUTO PARTS TECH TAICANG CO LTD) 26 June 2020 (2020-06-26) * figures 1-3 *	1-10	
A	IT TO20 100 687 A1 (E M A R C S P A) 10 February 2012 (2012-02-10) * figures 1-5 *	1-10	
A	US 4 941 338 A (SPAETH WALTER [DE]) 17 July 1990 (1990-07-17) * figures 1-6 *	1-10	
			TECHNICAL FIELDS SEARCHED (IPC) B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 March 2023	Vassoille, Philippe

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 20 7420

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

10-03-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 111360115 A	03-07-2020	NONE	
EP 1702691 A1	20-09-2006	EP 1702691 A1	20-09-2006
		FR 2882947 A1	15-09-2006
CN 210847811 U	26-06-2020	NONE	
IT TO20100687 A1	10-02-2012	NONE	
US 4941338 A	17-07-1990	AT 66393 T	15-09-1991
		DE 3618701 A1	10-12-1987
		EP 0268676 A1	01-06-1988
		JP H0379091 B2	17-12-1991
		JP S63503528 A	22-12-1988
		KR 880701145 A	25-07-1988
		US 4941338 A	17-07-1990
		WO 8707537 A2	17-12-1987

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- IT 1259520 **[0006]**