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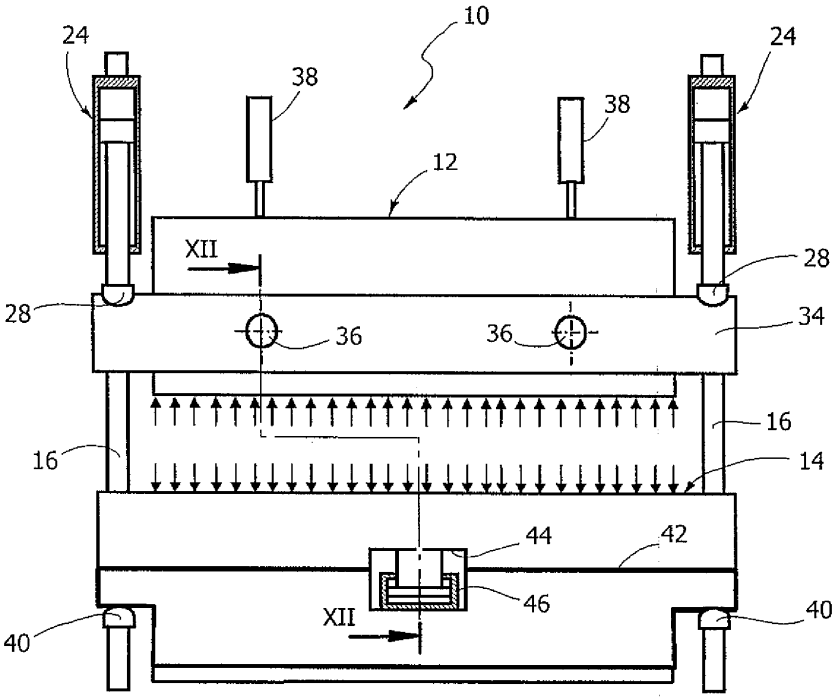
(54) **Bending press with tool-holder table with reduced deformation**

(57) Bending press (10), comprising:
- a stationary base structure (16, 18),
- a fixed tool holder table (14), fixed relative to the base structure (16, 18),
- a movable tool holder table (12), movable in a vertical plane relative to the fixed tool holder table (14),
- at least two actuator devices (24) to command the movement of the movable tool holder table (12), positioned laterally relative to the movable tool holder table (12), and
- at least one load application beam (34) whereon act said actuator devices (24), the load application beam (34) being arranged to apply the load to the movable tool holder table (12) in areas (36) positioned between said actuators (24).

FIG. 12a



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Description

[0001] The present invention relates to bending presses for bending pieces of sheet metal.

[0002] Figure 1 shows the structure of a bending press of the type most widely found on the market. With reference to Figure 1, the bending press 10 comprises an upper tool holder table 12, a lower tool holder table 14 and a support structure including two lateral uprights 16 and stiffening cross members 18. The tool holder tables 12, 14 have respective end portions 20, 22 whereto are fastened the bending tools (dies and punches). The movement and the force necessary to the bending process are obtained by means of hydraulic or electromechanical actuators 24 that move the upper tool holder table 12 relative to the lower tool holder table 14.

[0003] The bending process requires the exchange of even considerable forces between the tools and the piece of sheet metal to be bent. The force, generated by the actuators 24, must be supported by the uprights and, above all, by the tool holder tables 12, 14. These stresses inevitably cause an elastic deformation of the tool holder tables. As a result of this deformation, the rectilinear nature of the line formed by the ends of the vertices of the tools (tip of the punches and recesses of the dies) is lost, because the tools tend to follow the deformed line of the table that bears them.

[0004] The rectilinear nature of the bending line is a necessary condition to assure an accurate bending quality. The resulting bending line tends to follow the deformed line of the tool holder tables.

[0005] A diversity of the profile of the deformed line of the upper table relative to the lower table, moreover, causes a variation in the bending angle along the bending line, because the deformed line diversity causes the two tools (punch and die) to interpenetrate by a different quantity along the bending line, in addition to a non rectilinear nature of the bending line. Figure 2 shows the typical defects of a piece of bent sheet metal P caused by the deformation of the tool holder tables. The bending line L is not rectilinear and the bending angle α varies along the bending line.

[0006] From the above, it is readily apparent that it is extremely important to study and dimension the architecture of bending presses so that the deformations of the tool holder tables are small and the deformations of the upper table and of the lower table are as equal as possible, so the distance between die and punch (and hence their interpenetration during the bending operation) is nearly constant along the bending line.

[0007] Figure 3 is a front view showing a typical bending press structure. The upper tool holder table 12 has two lateral extensions 26 whereon act the actuators 24 (in this case, hydraulic) by means of cylindrical bearing elements 28. The bearing elements 28 serve as a hinge and allow mutual rotations of the lateral extensions 26 relative to the rods of the actuators 24 which derive from the elastic deformation of the upper table 12.

[0008] Since the actuators 24 are positioned laterally relative to the upper table 12, the latter is generally very high, in order to increase the moment of inertia (and hence the rigidity) and to reduce deformations.

[0009] Figure 4a shows the upper tool holder table 12 subjected to a bending load uniformly distributed along a bending line with a length equal to the length of the table. Figure 4b shows that the upper tool holder table 12 is equivalent to a beam bearing on the ends and subjected to a uniformly distributed load. Figure 4c shows the deformation of the beam equivalent to the table 12 under the action of the bending load.

[0010] With reference to Figure 5, considering also the lower tool holder table 14 to be similar to a beam set down (Figure 5b'), the deformation of the lower tool holder table 14 is obtained (Figure 5c').

[0011] Figure 6 shows the comparison between the deformed lines of the tool holders 12, 14. The difference between the two deformed lines causes on the piece a variation of the bending angle along the bending line, as shown schematically in Figure 2.

[0012] Various features have already been proposed to cause the deformation of the lower table to have a similar profile to that of the upper table. Figures 7a and 7b show a known solution used on AMADA bending presses. In this known solution, the lower tool holder table 14 is arranged in sandwich fashion between two support tables 30, fixed relative to the support structure of the press. The tool holder table 14 is connected to the support tables 30 by means of two pivot pins 32, orthogonal with respect to the tables 14, 30.

[0013] Figure 8 shows the deformation of the upper table and of the lower table in a bending press of the type shown in Figure 7.

[0014] In view of the state of the art described above, the object of the present invention is to reduce the deformations of the upper tool holder table without, however, increasing its moment of inertia. The present invention, changing the constraining conditions of the upper tool holder table, aims to obtain smaller deformations for equal inertia moments, or, for equal deformation of the upper tool holder table, a reduction in its moment of inertia.

[0015] According to the present invention, said object is achieved by a bending press having the characteristics set out in the claims.

[0016] The characteristics and the advantages of the bending press according to the present invention shall become readily apparent in the detailed description that follows, provided purely by way of non limiting example, in which:

- Figures 1 through 8, already described above, show the state of the art constituting the background of the present invention,
- Figure 9a is a schematic front view of an upper tool holder table according to the present invention,
- Figure 9b is a section according to the line IX-IX of

Figure 9a,

- Figures 10a, 10b and 10c respectively show the load distributed along the tool holder table according to the present invention, the beam equivalent to the tool holder table according to the invention and the deformation under load of the table according to the invention,
- Figure 11 shows a comparison between the deformed lines of the table according to the present invention and a table according to the prior art,
- Figure 12a is a front view of a bending press according to the invention comprising a system for compensating the deformations of the lower table,
- Figure 12b is a section according to the line XII-XII of Figure 12a,
- Figure 13 shows the deformations under load of the tool holder tables of the bending press of Figure 12, Figure 14 shows a comparison between the deformed lines of the upper tool holder table and of the lower tool holder table of the brake of Figure 12,
- Figure 15 schematically shows the system for controlling the brake according to the invention,
- Figure 16a is a front view of a variant of a brake according to the present invention, and
- Figure 16b is a section according to the line XVI-XVI of Figure 16a.

[0017] Figure 9 schematically shows the upper table of a bending press according to the present invention. The elements corresponding to the previously described ones are hereafter designated by the same numeric references.

[0018] According to the present invention, the actuators 24 do not act directly on the tool holder table 12. The ends 28 of the actuators 24 act on one or more load application beams 34 positioned forward and/or rearward relative to the tool holder table 12. In the example shown in the figure, two load application beams 34 are positioned at opposite sides relative to the tool holder table 12. The load application beams 34 are connected to the tool holder table 12 by means of two pivot pins 36 which extend orthogonally relative to the tool holder table 12 and to the load application beams 34.

[0019] The tool holder table 12 is connected to the support structure of the brake by means of guides (not shown) that constrain the tool holder table 12 to move along a vertical plane. Two position transducers 38 sense the position of the upper tool holder table 12 relative to the lower tool holder table, similarly to what occurs in bending presses available commercially.

[0020] The thrust of the actuators 24, transmitted to the load application beams 34 by means of the elements 38 or equivalent systems, is transmitted to the upper tool holder table through the pivot pins 36. The bending load is applied to the tool holder table 12 in areas situated between the actuators 24. In this way, the upper tool holder table 12 behaves like a beam with constraints placed in intermediate position and hence, for equal moment of inertia of the section and equal load, it has smaller elastic deformations than those of an equivalent beam supported at the ends.

[0021] Figure 10a shows the load distributed along the upper tool holder table 12 according to the present invention. Figure 10b shows the beam equivalent to the tool holder table 12 and Figure 10c shows the deformation under load of the tool holder table 12.

[0022] - Figure 11 shows a comparison between the deformed lines of a beam equivalent to a tool holder table according to the present invention (line a) and of a beam equivalent to a tool holder table according to the prior art (line b). From Figure 11 it is readily apparent that, for equal dimensions of the tool holder table, in the solution according to the present invention the deformations are sharply smaller. In this way, it is possible to reduce the curving effect on the bending lines due to the deformation of the tool holder tables, because the line of the tools during the bending operation is closer to the ideal condition of a straight line. Accepting instead to have the same allowable maximum deformation as a bending press according to the prior art, with the present invention it is possible to reduce the height of the tool holder table, saving material and reducing the height of the brake.

[0023] The elastic deformation of the load application beams 34 has no effect on the deformation of the tool holder table 12 except by effect of the friction couples exchanged with the pivot pins due to the deformation of the beams 34, which in any case have a minimal effect on the deformation of the tool holder table 12. The load application beams 34 can be dimensioned according to strength and/or admitting a greater deformation than that of the tool holder table 12, with consequent material savings.

[0024] The deformation of the load application beams 34 has no influence on the movement or on the deformation of the upper tool holder table 12, thanks to the management of the numeric control of the brake and thanks to the control of the position of the tool holder table 12 by means of the position transducers 38.

[0025] Figure 12 shows a possible embodiment which comprises a system compensating the lower table 14.

[0026] The lower tool holder table 14 is fastened to the lateral uprights 16 of the support structure by means of hinges 40 which allow the rotation of the lower table 14 relative to the uprights 16 deriving from the elastic deformation of the table under load.

[0027] One or more supporting cross members 42 are fastened to the uprights 16 of the support structure, also by means of hinges. The support cross members 42 are positioned to the front and/or to the rear of the lower tool holder table 14. The latter has, in a central position, a seat 44 in which is housed a hydraulic or electromechanical balancing actuator 46. The rod of the actuator 46 is fastened by means of an articulation to the upper surface of the housing 44 obtained in the lower table 14 whilst the body of the actuator 46 is fastened to the supporting cross members 42.

[0028] A position transducer 48 is integral to a measuring cross member fastened to the uprights 16 of the support structure in isostatic fashion. The position transducer 48 senses the deformation of the lower table 14 relative to the measuring cross member 50.

[0029] With reference to Figure 15, the bending press 10 is commanded by a numeric control unit 52. The control unit 52 receives the signals coming from the position transducers 38 and 48. Based on the signals provided by the transducers 38, the numeric control 52 commands the actuators 24 that actuate the upper tool holder table 12. Based on the signal provided by the position transducer 48, the numeric control 52 commands the force exerted by the balancing actuator 46. By varying the pressure that acts on the balancing cylinder 46, it is possible to control the deformation of the lower table, in order to maintain said deformation within predetermined limits. In particular, if it is imposed that the measurement provided by the position transducer 48 must remain constant, the lower table 14 behaves like a beam bearing on three points, i.e. two end bearings and an intermediate bearing.

[0030] Figure 13 shows the profile of the deformation of the tool holder tables 12 and 14 and Figure 14 shows the comparison between the two deformed lines. As can be noted, the profile of the two deformed lines is similar, so a constant bending angle is obtained along the bending line.

[0031] Figure 16 shows a possible variant of the present invention, in which the position of the constraints between the load application beams 34 and the upper tool holder table 12 was made variable. To do so, the pivot pins that transmit the forces from the beam 34 to the tool holder table were replaced by bearings 52 slidable along guides 58 along the longitudinal axis of the upper tool holder table 12. The load application beams 34 were modified introducing an upper connecting cross member 60 between the two beams 34. The force produced by the actuators 24 is transmitted to the upper tool holder table 12 by contact between the upper cross member 60, the slidable bearings 26 and the upper plane of the tool holder table 12. A securing system (not shown) prevents the tool holder table 12 from detaching from the bearings 56 under its own weight. The brake of Figure 10 is provided with a similar system to the one described above for measuring the position of the upper tool holder table 12.

[0032] Similarly, the balancing actuator 46 of the lower tool holder table 14 is movable along the longitudinal axis of the lower table 14. In the variant shown in Figure 16, the balancing actuator 46 was doubled in such a way as to balance the torque due to the fact that these actuators do not work aligned with the median plane of the lower table 14, as in the case described above.

[0033] The positioning of the bearings 56 and of the balancing cylinders 46 can occur manually or by means of the numeric control. The advantage that derives from the ability to vary the constraint condition of the upper tool holder table 12 and of the balancing actuator 46 is that it is possible to optimise the elastic deformation of the upper and lower tool holder tables 12, 14 according to the distribution of the tools (and hence of the bending stresses acting between the tables 12, 14). It is therefore possible to find a position of the constraints that minimises the elastic deformation of the tables.

[0034] The advantages of the solution according to the present invention are the following:

- for an equal moment of inertia of the upper tool holder table 12, a reduction of the deformation of the table during the bending operation is obtained; consequently, an improvement in the precision of the bent piece is obtained, i.e. an improvement in the consistency of the bending angle along the bending line and a more rectilinear bending line;
- for equal deformation, the moment of inertia of the upper tool holder table can be reduced;
- general increase in the precision of the machine, without an excessive increase in cost;
- reduction of the scraps produced and better quality of the pieces obtained;
- reduction in set-up times and attempts: use of shims between the tools and the tool holder table, to compensate for the flexion of the brake, is reduced or completely eliminated;
- controllability of the deformation according to the distribution of the tools and of the loads along the axis of the brake;
- greater flexibility in the tooling of the brake, since it is no longer necessary to position the bending tools in the central position of the brake to have a higher precision;
- possible reduction in the height of the brake and ability to avoid the use of foundation holes for long brakes.

[0035] The aforesaid advantages are the more readily apparent the longer the brake is.

[0036] In the above description, reference has been made to the situation in which the lower tool holder table is fixed and the upper tool holder table is movable. The present invention can be applied in general to the movable tool holder table of a bending press, even if the movable table is not the upper table.

[0037] Naturally, without altering the principle of the invention, the construction details and the embodiments may be widely varied from what is described and illustrated herein, without thereby departing from the scope of the present invention, as defined by the appended claims.

Claims

1. Bending press (10), comprising:

- a stationary base structure (16, 18),

- a fixed tool holder table (14), fixed relative to the base structure (16, 18),
- a movable tool holder table (12), movable in a vertical plane relative to the fixed tool holder table (14), and
- at least two actuator devices (24) to command the movement of the movable tool holder table (12), positioned laterally relative to the movable tool holder table (12),

characterised in that it comprises at least one load application beam (34) whereon act said actuator devices (24), the load application beam (34) being arranged to apply the load to the movable tool holder table (12) in areas (36) positioned between said actuators (24).

2. Bending press as claimed in claim 1, **characterised in that** it comprises two load application beams (34) positioned at opposite sides relative to the movable tool holder table (12).

3. Bending press as claimed in claim 1 or claim 2, **characterised in that** at least one load application beam (34) is fastened to the movable tool holder table (12) by means of at least one pivot pin (36) extending orthogonally relative to the movable tool holder table (12).

4. Bending press as claimed in claim 1 or claim 2, **characterised in that** at least one load application beam (34) is connected to the movable tool holder table (12) by means of at least one load application member (56) movable relative to the movable tool holder table (12) in the longitudinal direction.

5. Bending press as claimed in any of the previous claims, **characterised in that** the fixed tool holder table (14) is connected to the base structure (16, 18) by means of at least one support beam (42), and **in that** at least one compensating actuator (46) is provided, positioned between said support beam (42) and the fixed tool holder table (14).

6. Bending press as claimed in claim 5, **characterised in that** it comprises a position transducer (48) arranged to sense to deformation of the fixed tool holder table (14).

7. Bending press as claimed in claim 5, **characterised in that** it comprises a numeric control unit able to receive information about the position of the movable tool holder table (12) and the deformation of the fixed tool holder table (14) and to command the actuator devices (24) which command the movement of the movable tool holder table (12) and the compensation actuator (46) which compensates the deformations of the fixed tool holder table (14).

8. Bending press as claimed in claim 5, **characterised in that** the position of the load application members (56) relative to the upper table 12 and the position of said compensating actuator (46) relative to the lower table (14) can be varied according to the distribution of the load along the end portions (20, 22) of the tool holder tables (12, 14), in order to control the profile of the elastic deformations of the tool holder tables (12, 14).

9. Bending press as claimed in claim 8, **characterised in that** the position of the load application members (56) relative to the upper table (12) and the position of said compensating actuator (46) relative to the lower tool holder table (14) can be varied manually or automatically by means of actuators commanded by the numeric control (52).

FIG. 1

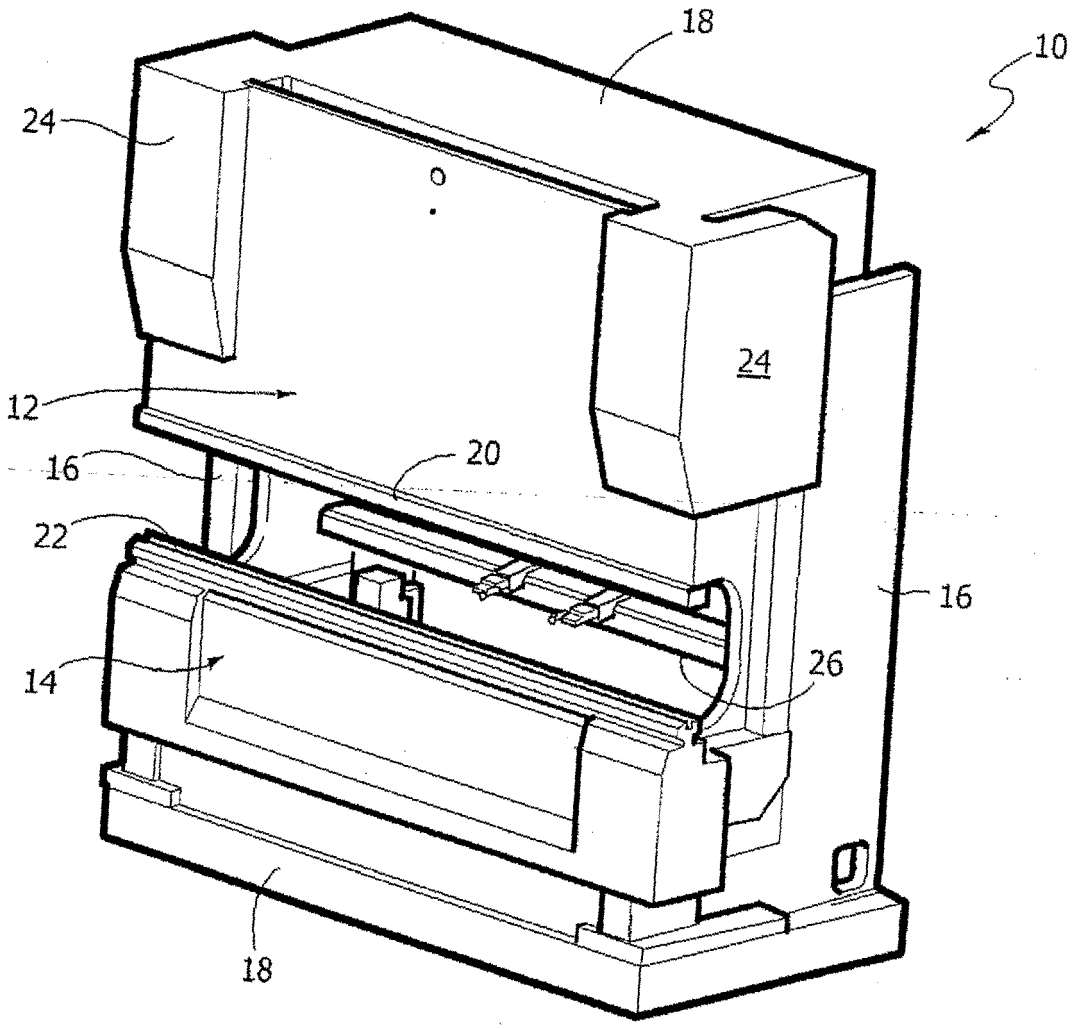
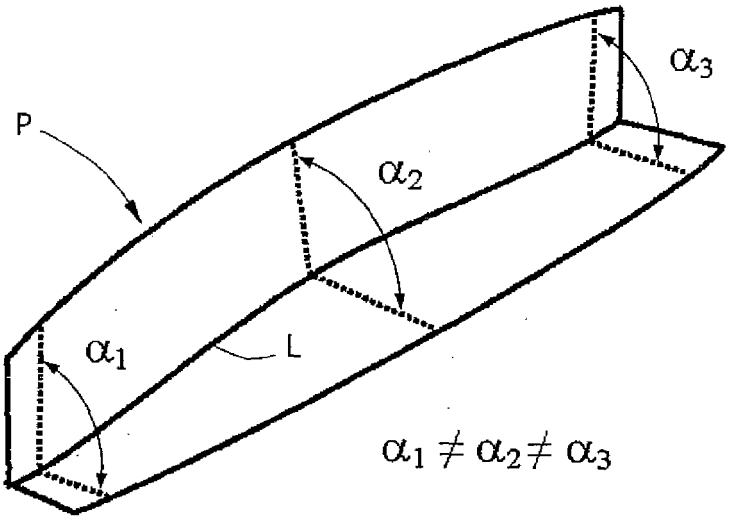


FIG. 2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α_1
α_2
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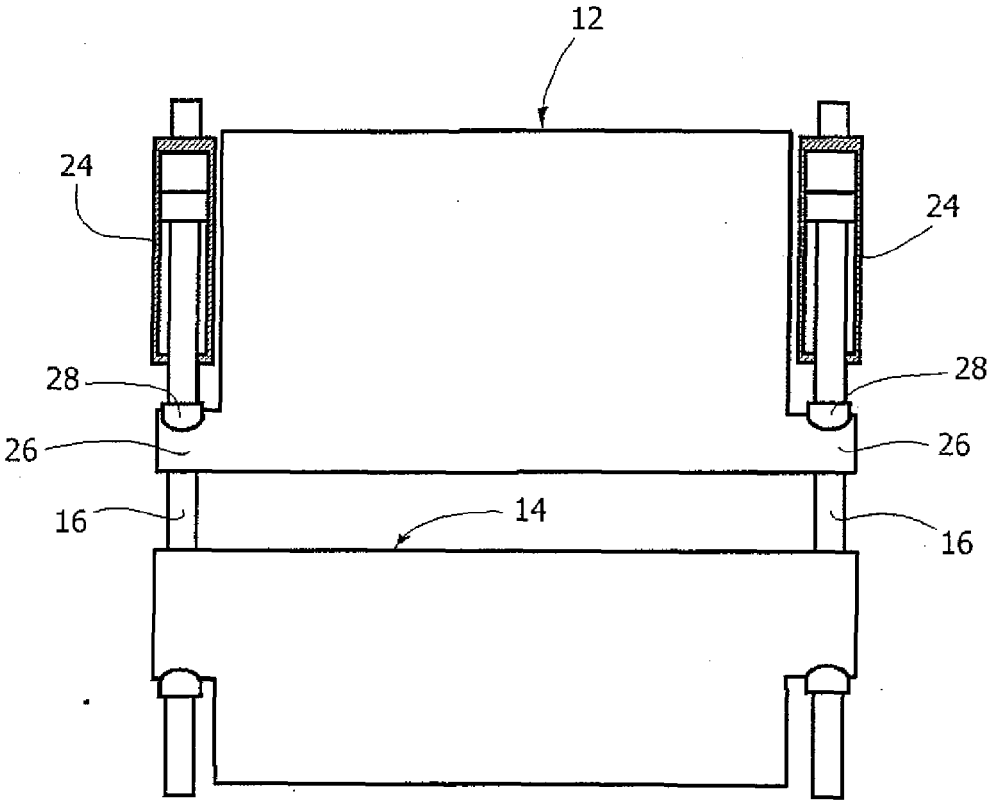
$\alpha_1 \neq \alpha_2 \neq \alpha_3$

FIG. 3


12
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16

FIG. 4

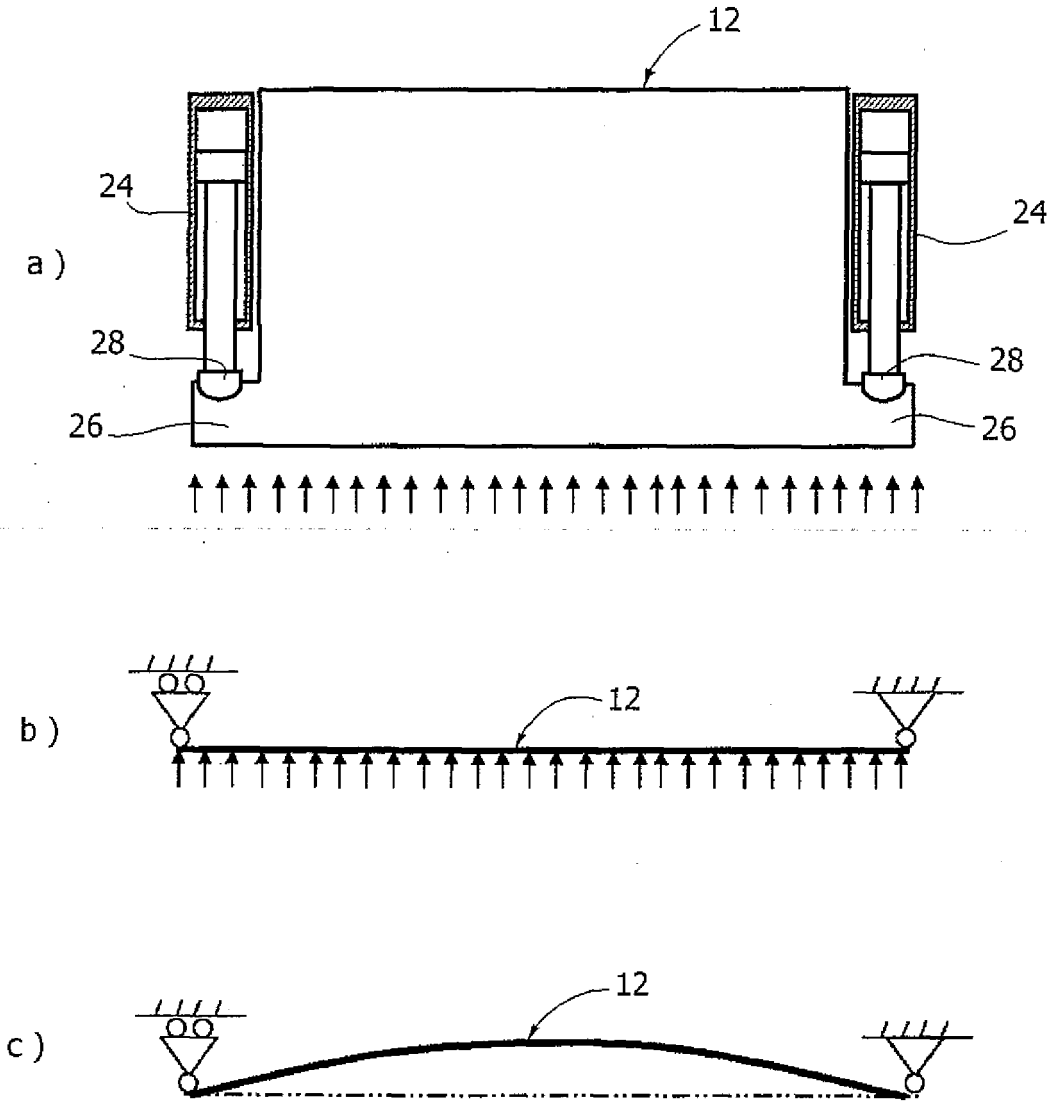


FIG. 5

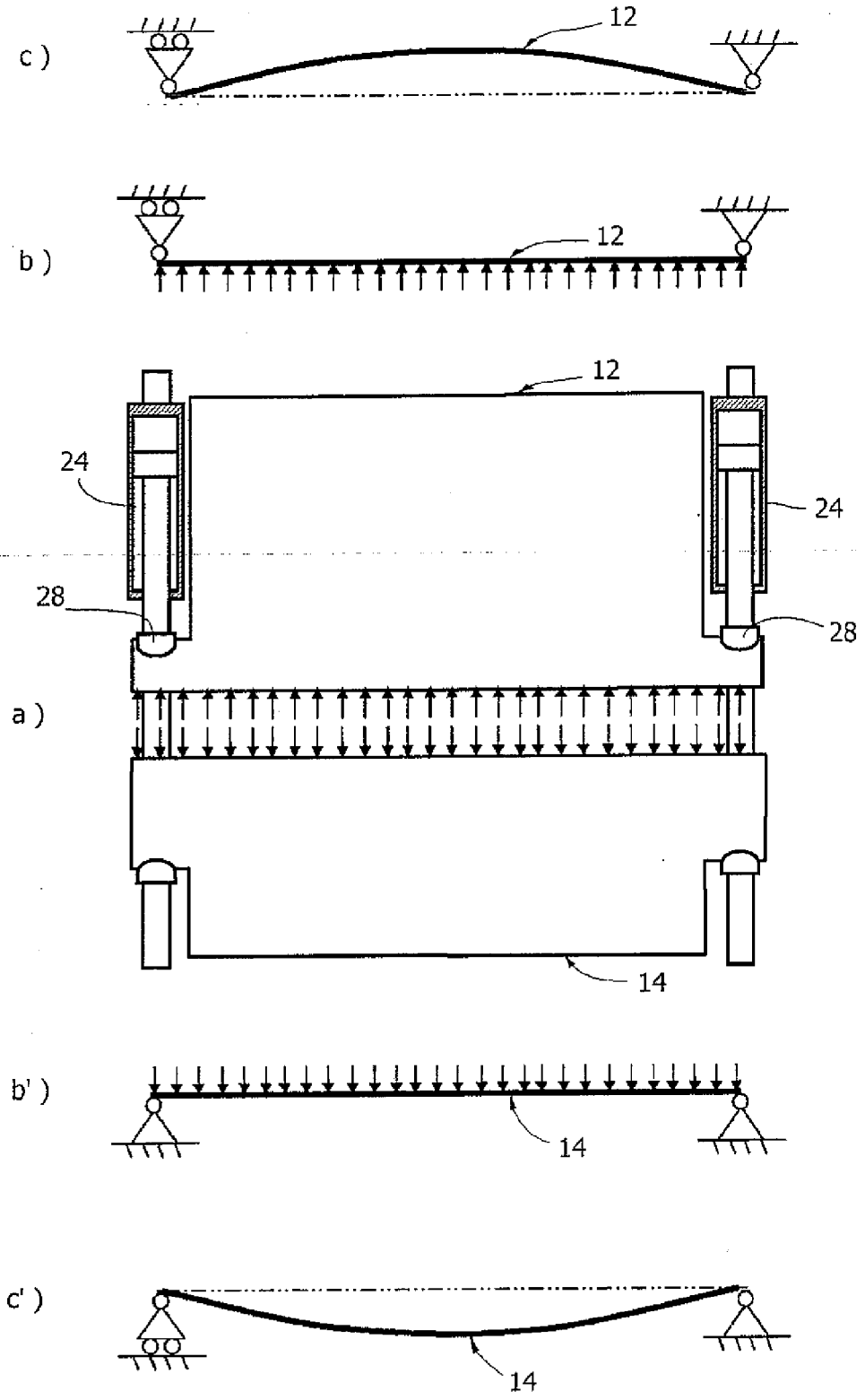


FIG. 6

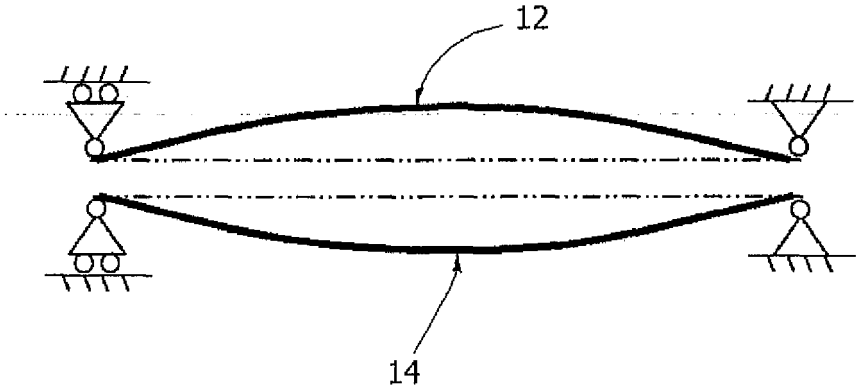


FIG. 7b

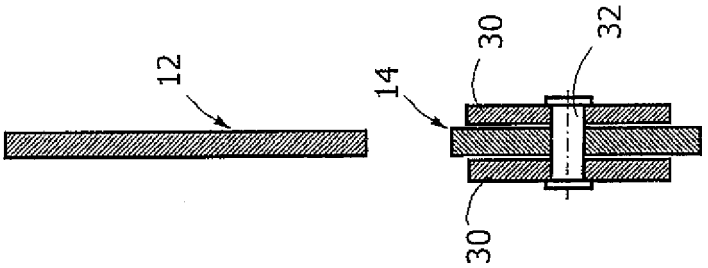


FIG. 7a

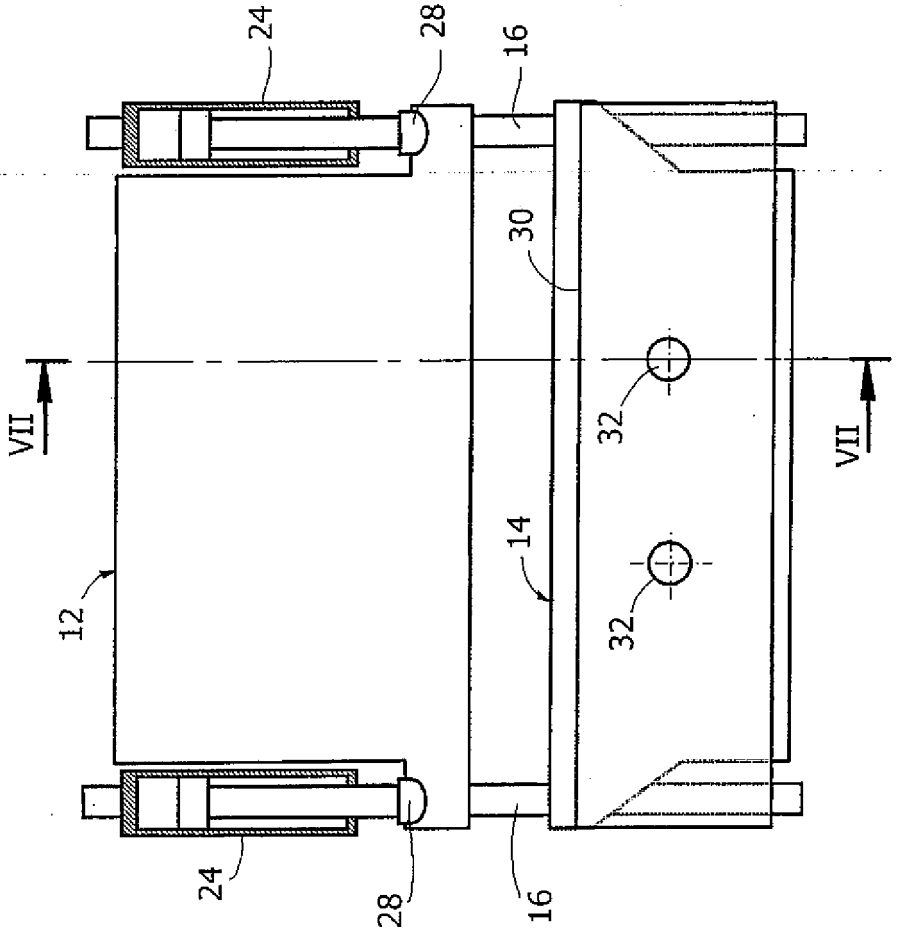


FIG. 8

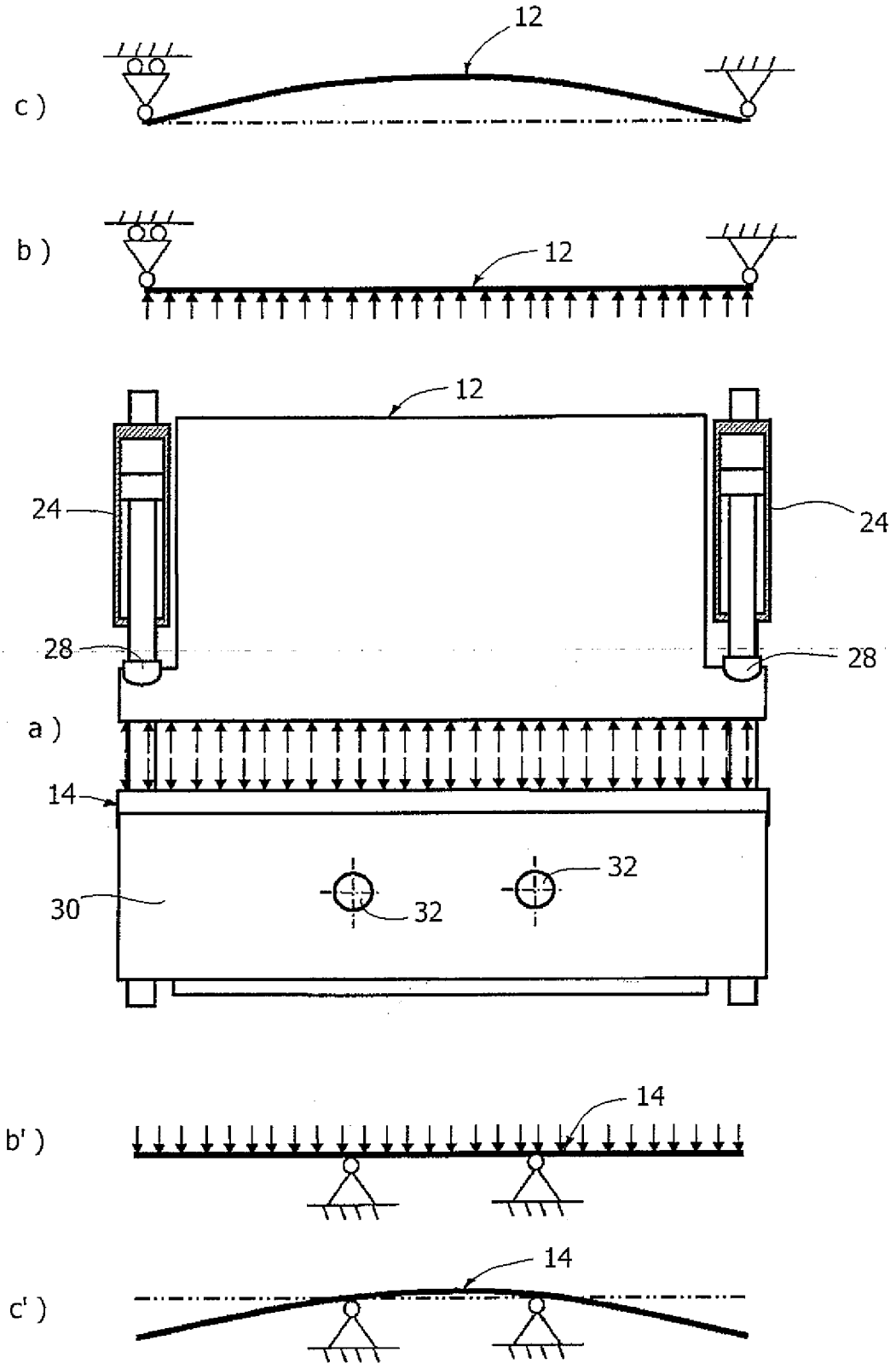


FIG. 9b

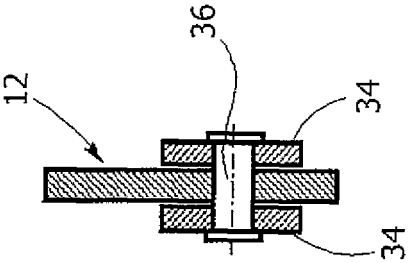


FIG. 9a

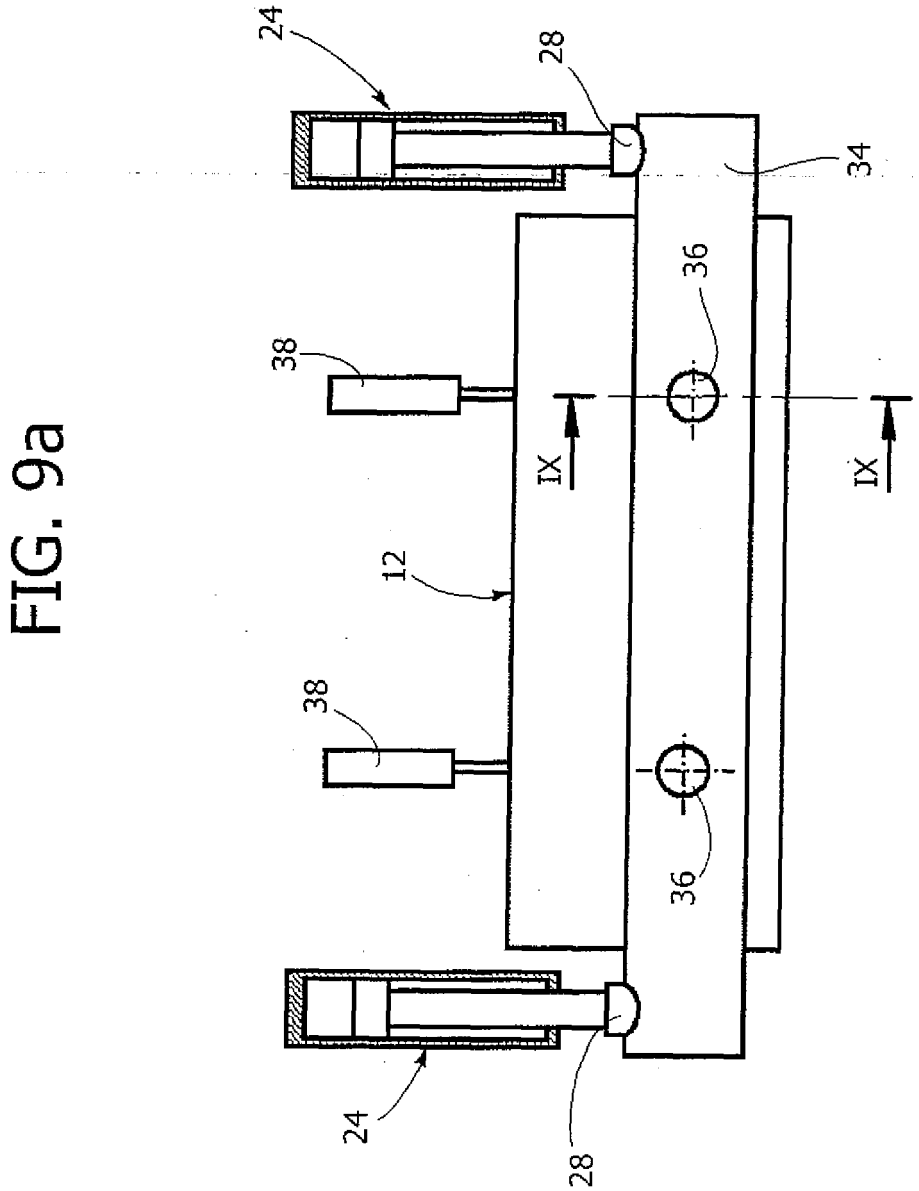


FIG. 10

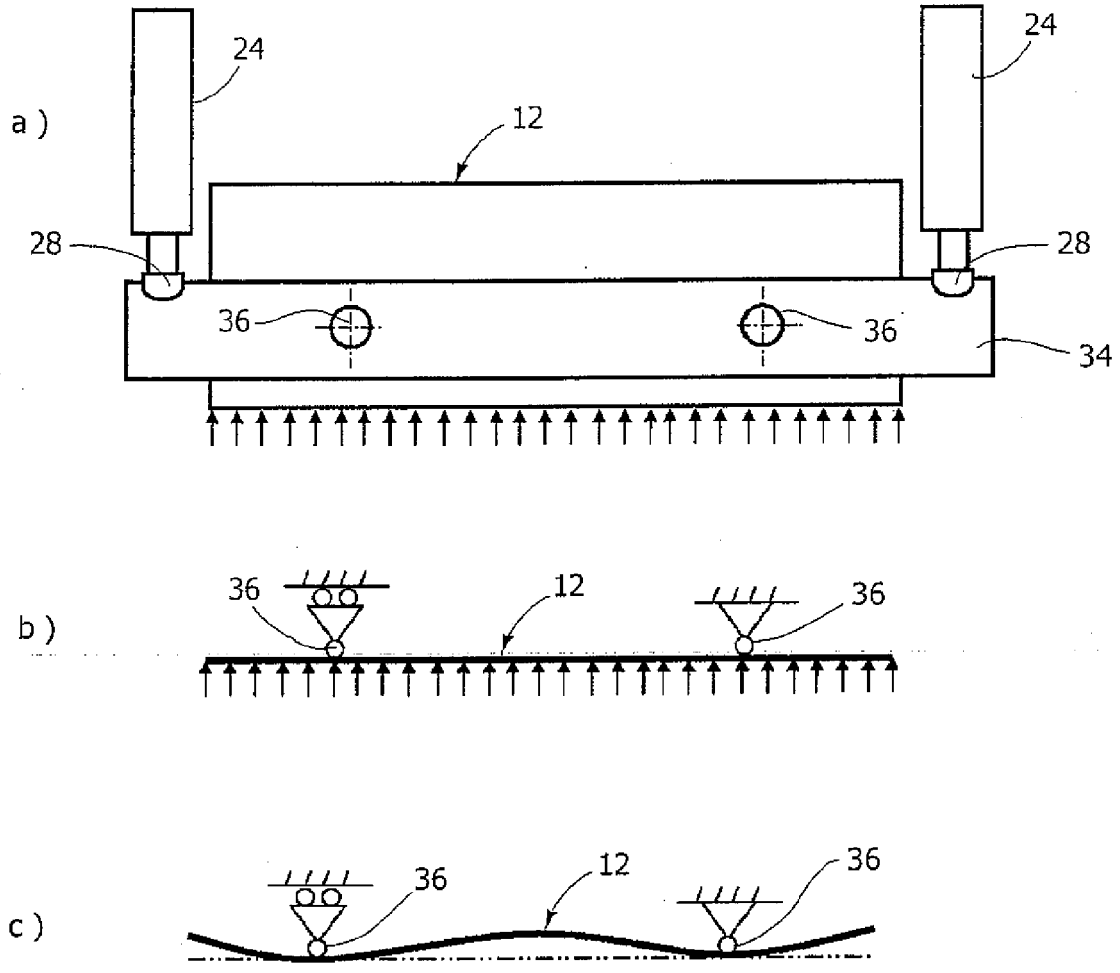


FIG. 11

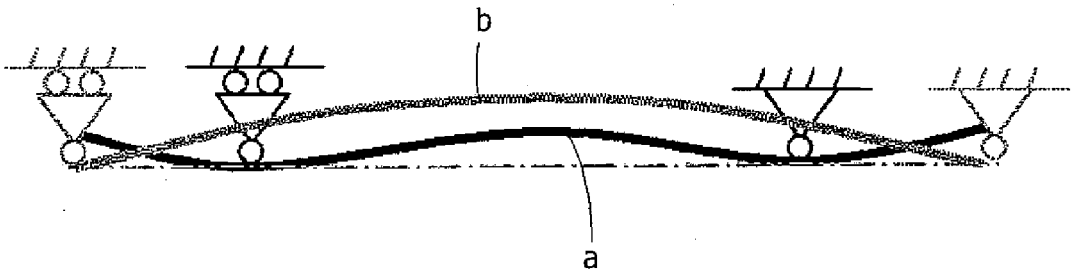


FIG. 12b

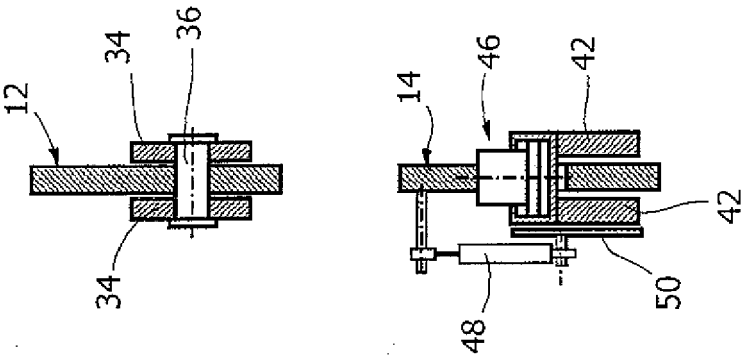


FIG. 12a

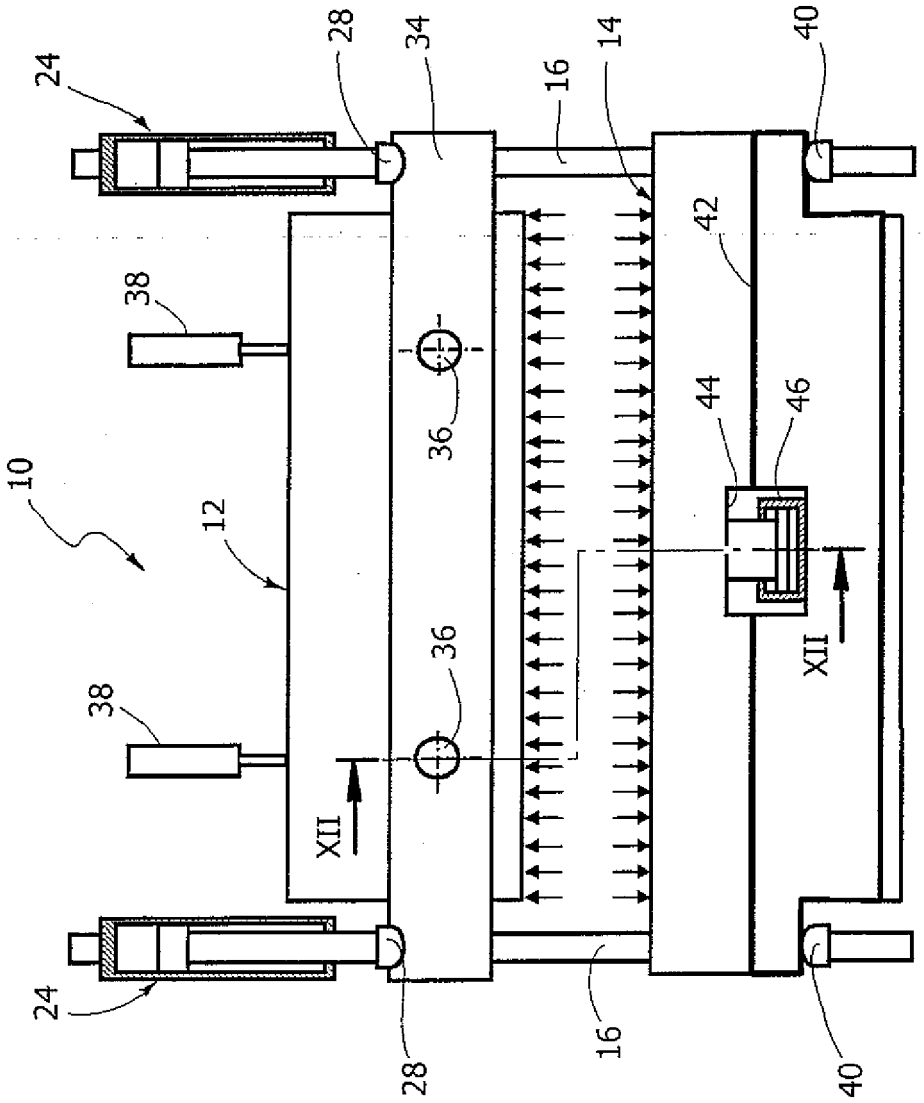
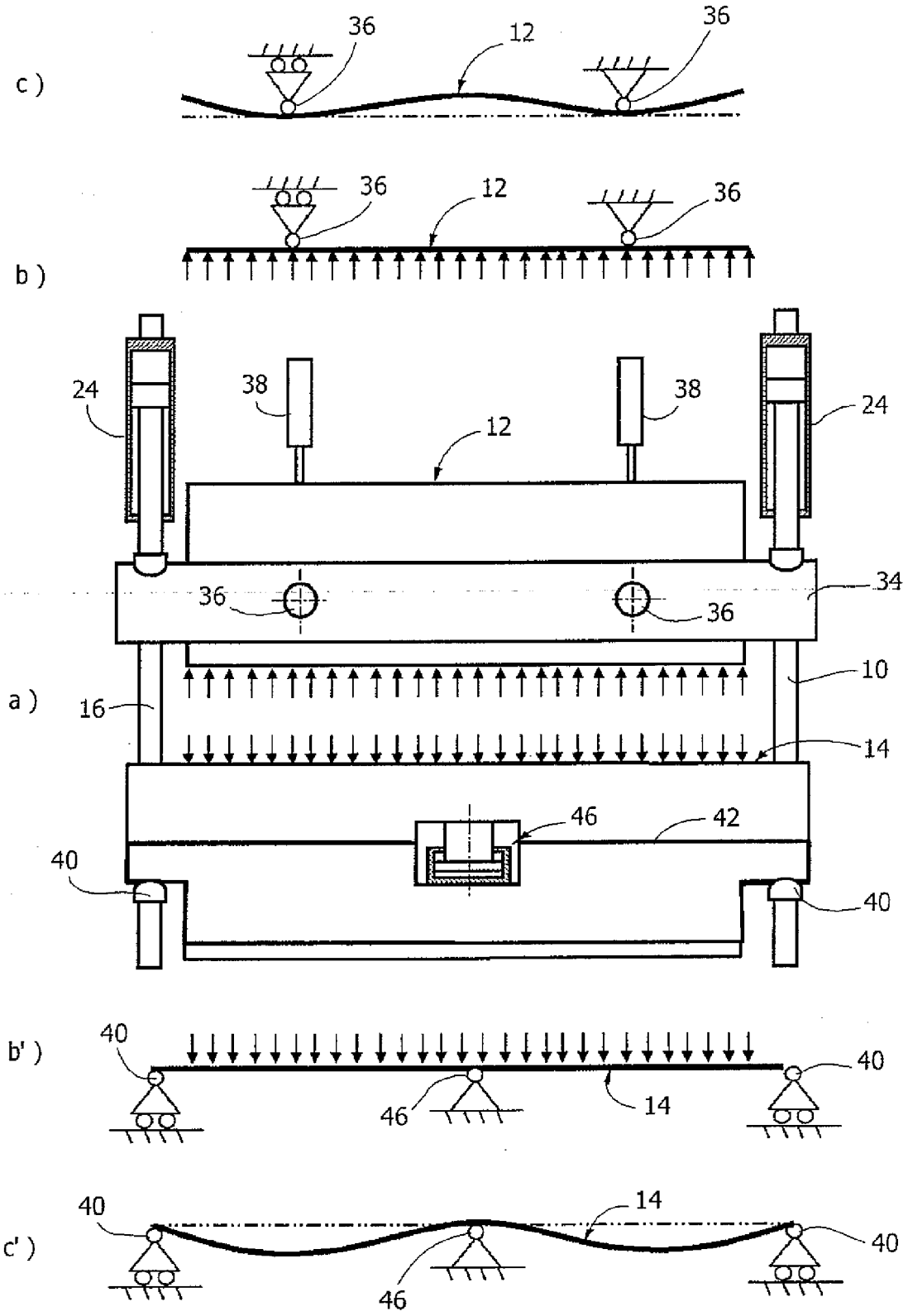


FIG. 13


c)
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b)
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36
10
a)
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b')
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40
46
14
c')
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46

FIG. 14

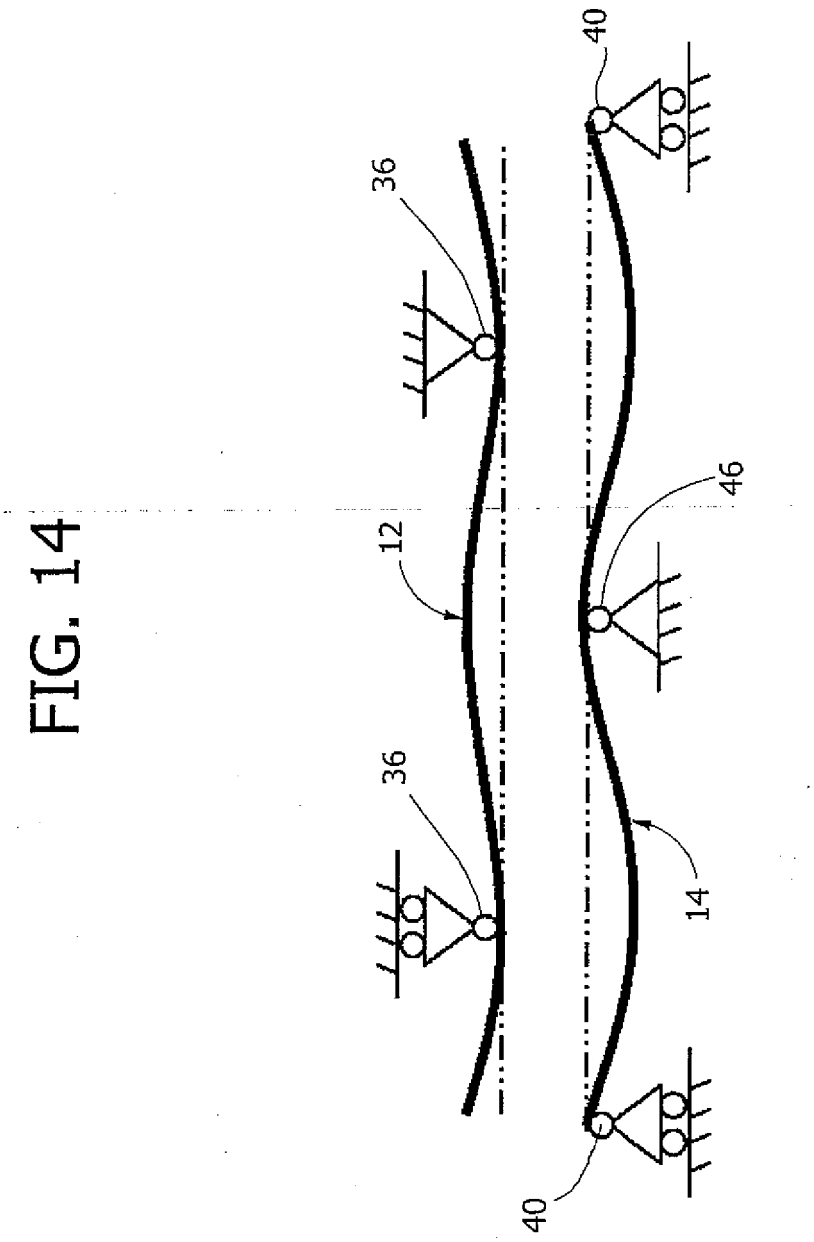

FIG. 15

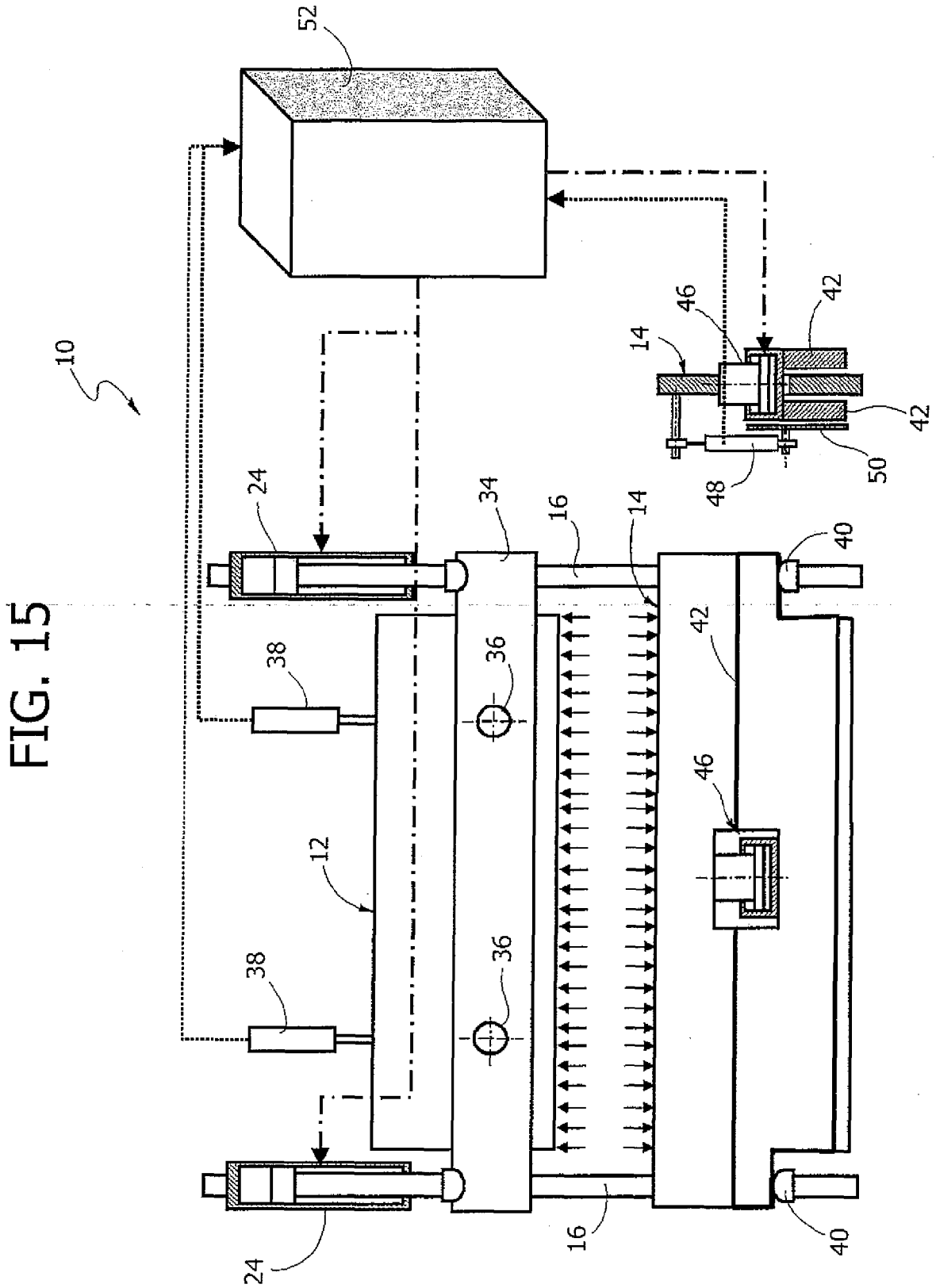

FIG. 16b

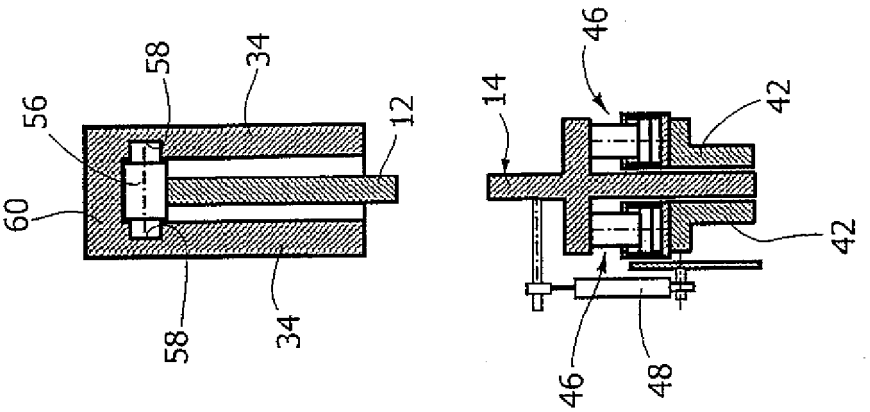

FIG. 16a