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## (54) Schock-absorbable workpiece-supporting device for bending machines.

(57) A workpiece-supporting device for a bending machine such as a press brake wherein a total weight of a workpiece, a table on which the workpiece is mounted and an arm to raise the table and workpiece is borne by a supporting spring, thus enabling the raising of the table and workpiece to start precisely simultaneously with the start of the supply of compressed-air to an air cylinder which raises the table and workpiece. The air cylinder is equipped with a cushion cylinder in it to stop the raising of the table and workpiece without any shock when the bending work has been compmleted. Then, when table and workpiece are again laid horizontally, the supporting spring absorbs any shock which may occur at the time the table and workpiece reach the horizontal position.

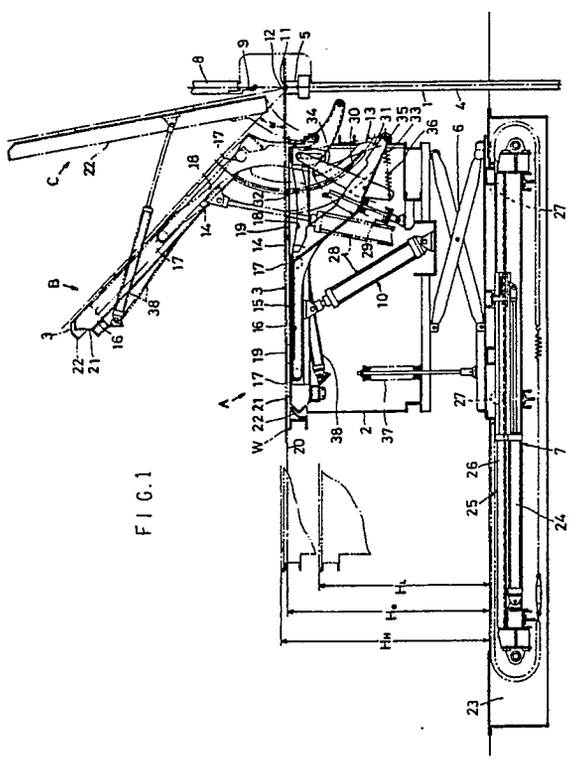

FIG.1

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# SHOCK-ABSORBABLE WORKPIECE-SUPPORTING DEVICE FOR BENDING MACHINES

## BACKGROUND OF THE INVENTION

The present invention relates to a device to support a workpiece which is being bent by a bending machine such as a press brake.

Machines to bend a heavy workpiece such as a steel sheet such as a press brake are widely equipped with a device to support the workpiece which is raised as the bending progresses. The supporting device functions to prevent the workpiece from bending at a shoulder of a die of the bending machine because of the dead load or force of inertia, as well as to remove the workpiece safely out of the bending machine after the bending is completed.

The supporting device comprises typically a fundamental frame placed before a bed of the bending machine. The frame is equipped with an arm pivotaly fixed to the frame, near the bed. The rear half, or the farther half from the bed, of the arm is directed toward a die fixed on the bed. The rear half supports a table by way of a guidance means which allows the table to approach or go away from the die. The top of the table is positioned on the same level with that of the die before the processing starts. A raising means is provided to raise the table by means of the arm in synchronization with the processing of the workpiece. The supporting device is further equipped with a position control means which maintains the distance between the table and die throughout the processing.

The raising means usually comprises a cylinder connecting between the fundamental frame and arm. Compressed air is preferred to drive the cylinder because its viscosity is comparatively small. The cylinder is accordingly allowed to extend or contract quickly. The way to drive the cylinder is, however, not restricted to that.

When the workpiece is a rigid body, the speed by which the workpiece is raised changes depending on that by which a ram of the bending machine descends. In a friction press, for instance, the descending speed of the ram is the highest at the top dead center, reduces as the ram descends and becomes zero at the bottom dead center. When a ram is driven by means of a slider crank such as a press brake, the speed reaches the maximum in the course of the descent, then reduces and becomes zero at the bottom dead center. The reduction of the descending speed after the maximum is passed is represented by a sine curve. Additionally, the descending speed tends to reduce more steeply after the punch fixed to the ram gets in touch with the workpiece because of work hardening of the workpiece. As a result, the descending speed of the punch is the highest when the punch gets in touch with the workpiece, then reduces and becomes zero at the bottom dead center. The rising speed of the workpiece is, accordingly, the highest at the beginning of the processing, then reduces and becomes zero at the end of the processing.

On the other hand, after working fluid begins to be supplied to the cylinder of the raising means, the cylinder does not start extending until the inner pressure of the cylinder exceeds the total weight of the arm, table and workpiece. The supply of the working fluid must be started previously to the contact between the punch and workpiece to let the extension and contact occur simultaneously. The time necessary for the cylinder to start extention, however, changes according to the weight of the workpiece. Additionally, it varies depending on the thickness of the workpiece when the punch gets in touch with the workpiece. When various kinds of workpieces are treated, it is hence too complecated a work to let the table start rising precisely when the punch reaches the workpiece.

The table is not able to keep up well with the workpiece when the workpiece is raised at a high speed at the beginning of the processing. The workpiece may, as a result, be bent at the shoulder of the die or by the table itself. Additionally, when the table catches up with the workpiece during the processing, collision between the table and workpiece may cause displacement of the workpiece on the table.

The cylinder extends at a constant speed as long as the working fluid continues to be supplied thereto. Because of the force of inertia, however, the table and arm continue to rise and the cylinder continues to extend even after the supply of the working fluid has stopped. Such unnecessary additional extension of the cylinder is usually blocked mechanically by means of a stopper provided inside or outside the cylinder in the prior art. However, because a shock which accompanies such mechnical stop often cause the workpiece to bounce on the table. The accuracy of the processing is often deteriorated as a result.

A similar stopper is in the prior art also used to stop the contraction of the cylinder when the table is lowered and laid horizontally again after the processing is finished. the table is stopped with a shock again, which may also let the workpiece rebounce and displace on the table.

## SUMMARY OF THE INVENTION

It is hence an object of the present invention to provide a supporting device capable of following up and supporting the workpieces well, of which the rising speed reduces as the descending speed of the ram reduces as the processing progresses.

It is another object to provide a supporting device which causes no considerable shock when the table stops rising as well as when it is returned to the original horizontal position, preventing bouncing and displacement of the workpiece on the table.

To attain the objects, the raising means of the present invention comprises a supporting spring, a cylinder and a cushion means. The supporting spring is to support the weight of the table and workpiece at the beginning of the processing, the cylinder to raise and lower the arm and table and the cushion means to absorb the shock which occurs when the extension or contraction of the cylinder is stopped.

According to the present invention, the load which falls on the cylinder is zero at the beginning of the processing because the weight of the table and workpiece is supported by the supporting spring. The cylinder is thereby able to start extension precisely simultaneously with the start of supply of the working fluid into the cylinder.

The weight of the arm, table and workpiece, which is supported by the supporting spring at the beginning of the processing, is by degrees shared by the cylinder as the cylinder extends. The extension speed of the cylinder is hence the largest at the beginning of the extension and reduces as the extension progresses.

Because the shock which occurs when the extension stops is absorbed by the cushion means, the workpiece is prevented from being bounding on the table at that time.

Additionally, because the weight of the arm, table and workpiece is supported by the supporting spring also when the table is returned to the horizontal position, the arm, table and workpiece is able to be stopped without any considerable shock. The workpiece is thereby prevented from bouncing and displacement on the table.

Further objects and advantages of the present invention will be apparent from the following description, reference being made to the accompanying drawings wherein a preferred embodiment of the invention is clearly shown.

In the drawing:

Figure 1 is a side elevational view in a cross section of an embodiment of the workpiece-supporting device for a press break according to the present invention;

Figure 2 is a diagram illustrating action of the arm and table of the supporting device;

Figure 3 is a schematic side view of the supporting device when the workpiece is mounted on the table;

Figure 4 is a schematic side view of the supporting device when the workpiece is positioned between the punch and die of the press break;

Figure 5 is a schematic side view of the supporting device when the workpiece is positioned on the die;

Figure 6 is a schematic side view of the supporting device after processing of the workpiece is completed;

Figure 7 is a schematic side view of the supporting device when the workpiece are lifted apart the die;

Figure 8 is a schematic side view of the supporting device after the workpiece is withdrawn out of the press break;

Figure 9 is a schematic side view of the supporting device when the workpiece is returned to the original position after the processing; and

Figure 10 is a timing chart illusrating time relation between actions of parts of the supporting device.

Figure 11 is a schematic diagram of a supplier of compressed air employed in the present invention.

## DETAILED DESCRIPTION OF AN EMBODIMENT OF THE PRESENT INVENTION

The workpiece-supporting device of the present invention comprises a fundamental frame 2 placed in front of a press break 1. A table 3 having a plane top is supported by the frame 2. The frame 2 and table 3 can be shifted toward or away from the press brake by means of a shifting means 7.

The frame 2 and table 3 are positioned in the rear or farthest from the press brake 1, as illustrated in Figures 3 and 9, to mount a workpiece W such as a steel plate onto the table at a prdetermined position from a conveyor not illustrated in the drawings or to return the workpiece from the table to the conveyor. On the other hand, they are positioned in the front or nearest the press brake as illustrated in Figures 4-7 while the workpiece is processed. When the frame 2 and table 3 are in the front, the point of the workpiece to which the punch of the press brake should be applied is located vertically above the center line of a groove 11 which is cut on the top of a die 5.

The shifting means 7 comprises an air cylinder 24 and a guidance means 25 as illustrated in Figure 1. The air cylinder 24 is fixed at one end in a pit 23 and connected at the other to a lifting means 6, which carries the frame 2 and table 3.

The forward and backward movement of the lifting means carrying the frame and table is guided by the guidance means 25, which further comprises a pair of parallel guide rails 26 and two pairs of guide rollers 27. The guide rails 26, which is made of channel steel, extend in the pit 23 toward the press break. The pairs of the guide rollers 27 comprise, arranged at an appropriate distance between each other, roll on the rails 26.

Other structures of the shifting means 7 than described above are also applicable as far as the frame 2 and table 3 can be carried to and fro between the front and rear.

The lifting means 6 comprises a table lifter which further comprises pairs of bars each consisting of two bars crossing each other as illustrated in Figure 1. The structure enables the frame 2 and table 3 placed thereon to be lifted and lowered very accurately. The lifting means 6 is constructed so that it can lift and lower the table 3 at least between a standard position HO and a high position Hh as illustrated in Figure 1. The table 3 is positioned at the standard position HO while the workpiece is processed, where the bottom of the workpiece W mounted on the table is in touch with the top of the die 5. After the processing finishes, the table is lifted to the high position Hh to lift the workpiece W off the processing groove 11. Other structures than described above are also applicable as long as they can lift and lower the table 3 at least between the standard and high positions HO and Hh.

Preferably, the lifting means 6 is constructed so that it can lower the table 3 to a low position Hl as illustrated in Figure 1. When the workpiece W has been bent so deep, for example, that it will touch a punch 9 of the press brake if withdrawn horizontally, the table 3 is lowered from the high position Hh to the low position Hl while being withdrawn to the rear. The workpiece is thus able to pass obliquely between the punch 9 and die 5. Figures 7 and 8 illustrate such oblique lowering of the workpiece.

After the table 3 is positioned in the front and the punch 9 gets in contact with the workpiece W, the table 3 at the standard position HO is raised by a raising means 10 to support the portion of the workpiece which is raised on a ridge 12 of the die 5 as the punch 9 descends and the processing progresses. In the present embodiment, the table 3 is raised from a horizontal position A to an inclined position B as indicated in Figures 1 and 2 in synchronization with the processing. The workpiece is raised at about 45 ° at the inclined position B. The punch 9 is lifted off the workpiece after the processing finishes. The table 3 is then shifted to the rear by the shifting means 7 and returned to the horizontal position by the raising means 10. The distance between the table 3 and ridge 12 is maintained by a position control means 13 throughout the raising and lowering of the table.

The raising means 10 comprises an air cylinder 28, supporting spring 29 and compressed air supplier 38. The air cylinder 28 raises and lowers the table 3 between the horizontal and inclined positions by means of an arm 14, which is pivotaly attached to the fundamental frame 2 with a fulcrum shaft 35. The supporting spring 29 supports the weight of the arm, 14 table 3 and workpiece W at the beginning of the processing. The air cylinder is provided with compressed air by the air supplier 38.

Figure 11 is a schematic diagram of the compressed air supplier 38. Air inhaled by way of an air filter 39 is pressurized by an air compressor 40. After pulsation is eliminated by an accumulator 41, the pressure of the air is adjusted with a pressure setting valve 42 and the compressed air is supplied to a pressure cell 44 of the air cylinder 28 by way of an electro-magnetic valve 43. The pressure cell 44 can be open to the atmosphere by way of another electro-magnetic valve 45.

A cushion cylinder 47 is separated by a piston 46 from the pressure cell 44 in the cylinder 28. The cushion cylinder 47 is open to the atmosphere by way of an electro-magnetic valve 48 while the piston 46 is at the bottom dead center. The valve 48 is closed before the piston begins to move to the top dead center and remains closed until the piston returns to the bottom dead center.

The arm 14 is so incorported in the system that its rear half, or the farther one from the die 5, is always directed toward the die throughout the processing. The table 3 supported by the rear half is able to move to and fro along the rear half while being guided by a guidance means.

The position control means 13 is to push the table 3 away from the die 5 along the rear half of the arm as the table is raised to maintain distance between the table 3 and ridge 12 without respect to the angle $\alpha$ by which the table is raised.

The position control means 13 comprises a pair of parrallel position control boards 31, a pair of position control pins 32 and, preferably, a supporting means 33. The pair of position control boards 31 are fixed under the table 3 with an appropriate distance between each other. They have congruent position control grooves 30 opened therein respectively. Each of the grooves 30 is an arc of which center is the ridge 12. The position control pins 32 are fixed on the sides of the fundamental frame 2 to be inserted movably in the grooves 30. Any other structure of the position control means 13 is applicable as long as it can maintain the distance between the table and ridge throughout the operation.

The supporting means 33 is preferably included in the position control means 13, which comprises a link lever 34 and coil spring 36. The top end of the link lever 34 is connected to the front of the table 3, slidably in the vertical dierection to the table top, while the middle of the lever is connected with the front half of the arm 14 with a pivot. The coil spring 36 on the other hand connects between the bottom end of the link lever 34 and the fulcrum shaft 35.

The higher the table 3 is raised, the larger weight of the table 3 falls on the position control pins 32. The supporting means 33 is provided to share the wieght so that the pins 32 and boards 31 can be of a smaller size. The supporting means is, however, not indispensable to the present invention. Even when it is added to the system, the structure is not restricted to the above-described one.

The guidance means 15 comprises a pair of guide rails 16 and two pairs of guide rollers 17. The guide rails 16 are fixed under the table 3. The guide rollers 17 are attached to both the sides of the rear half of the arm 14 with an appropriate distance between the pairs so that they can roll on the rails 16. The table 3 is pushed away from the ridge 12 by the position control means 13 as the arm14 is raised, while being guided by the guidance means 15.

A raising control means 18 is provided on the front half of each of the rails 16, which curves convexly, swelling downwards. After the table 3 starts being raised and the front pair of the rollers 17 reach the raising control, the front end of the table is pushed up by degrees by the rollers proceeding along the raising control. After the rollers pass the summit of the raising control, the displacement of the table front is removed as the raising continues. As a result, the rising angle $\alpha$ of the table 3 is made smaller than the rising angle $\beta$ of the arm 14 through a predetermined range of the angle $\beta$.

A number of fixing devices 19 are provided on the table top at appropriate intervals to fix the workpiece W on the table 3 while the workpiece is taken away from the press brake. Though, strictly speaking, the follow-up surface 20 which is in contact with the workpiece is determined by the tops of the fixing devices 19, the follow-up surface 20 is illustrated in Figure 2 as coinciding with the table top for the sake of simplicity of the drawing.

Any kinds of the fixing devices, such as electric magnets or vacuum absorbtion devices, will do as the devices 19 as far as they can firmly fix the workpiece W on the table 3. The vacuum absorbtion devices are preferred in the present embodiment because they can fix the workpiece irrespective of tis intensity of magnetism. The fixing devices 19 functions while, after the processing of the workpiece has been completed, the punch is lifted off the workpiece, the workpiece is lifted off the die and the table returns to the rear horizontal position.

Additionally, the table 3 is divided into a middle table 21 and a pair of side tables 22 at both sides of the middle table. The middle and side tables are linked by means of a pivot and the bottoms of the tables are connected by a pair of second air cylinders. The side tables 22 can be raised to a standing position C as illustrarted in Figure 1 by extending the second air cylinders after the table 3 reaches the inclined position B. The fixing devices 19 are provided on the side tables 22 so that the workpiece can be fixed between the inclined and standing positions B and C, too. When the front end of the bent workpiece W is positioned higher than the tip of the punch 9 after both the punch and workpiece have been lifted off the die 5, the side tables are raised further to the standing position C with the bent workpiece so that the workpiece can be taken away from the press brake horizontally without touching the tip.

The side tables 22 are equipped, though not illustrated in the drawings, on their tops with ball or roller bearings to facilitate the mounting or removing of the workpiece W onto or from the table 3.

The weight of the table and workpiece falls more and more on the front portion of the fundamental frame 2 as the table and workpiece are raised. A supporting spring 37 is therefore provided connecting the frame 2 with the base of the lifting means 6 to prevent the rear portion of the frame 2 from being raised.

Plate bending work is achieved as follows by the press break equipped with the follow-up supporting device of the present invention, under the control of a program incorporated in the system, or following instructions provided by the operator to the system:

At setting step, the frame 2 is positioned in the rear while the table 3 is laied horizontally at the high position Hh so that a workpiece W is mounted thereon at a predetermined position with a conveyor not illustrated. The frame 2 is then shifted to the front position, where the point of the workpiece to which the punch should be applied is positioned vertically above the center line of the groove 11, as illustrated in Figure 4 by extending the air cylinder 4 of the driving means 7. The table 3 is then descended to the standard position HO and the setting of the workpiece W in the pres brake 1 is completed.

At processing step, the ram 8 starts descending and, after the punch 9 gets in touch with the workpiece W, the table 3 starts being raised.

In this embodiment, the total weight of the arm 14, table 3 and workpiece W is wholly supported

by the supporting spring 29 when the compressed air begins to be supplied to the air cylinder 28. Since no load falls on the air cylinder 28 at the beginning, the air cylinder can start the extension as soon as the compressed air begins to be supplied thereto. The simultaneous start of the raising and processing of the workpiece is, consequently, able to be achieved simply by letting the supply of compressed air begin at the time the punch 9 reaches the workpiece.

Since the punch 9 is driven by a motor by way of a slider-crank, though neither of the motot and slider-crank are illustrated in the drawings, the velocity of the descending punch is the maximum at the middle of the punch's stroke, then reduces to be zero at the bottom dead center. The reduction of velocity is represented by a sine curve. Additionally, the load received by the punch 9 which is comparatively small at early stages of the processing increases as the processing progresses because of work hardening. The velocity thereby reduces further sharply. Consequently, the workpiece W is raised at the highest velocity at the beginning of the processing. The further the processing progresses, the lower the velocity becomes.

The total weight of the arm, table and workpiece which is wholly supported by the supporting spring 29 at the beginning is more and more shared by the air cylinder 28 as the cylinder extends. Resistance against the extension of the air cylinder accordingly increases. Additionally, since the cushion cylinder 47 is closed directly before the extension starts, pressure also increases inside the cushion cylinder as the cylinder extends. As a result, the velocity of extension of the air cylinder 28 is the maximum at the very beginning of the extension, then reduces as the extension progresses.

Both the table and workpiece are raised at the maximum velocity at the beginning of the processing, which velocity reduces by degrees thereafter. The workpiece can thus be well supported by the table throughout the processing, which is effective to prevent the plastic deformation of the workpiece at the ridge as well as bouncing and displacment thereof on the table.

Additionlly, the shock which occurs when the air cylinder 28 is fully extended and stops the extension is absorbed by the cushion cylinder 47 having the high pressure. Since the table 3 stops very smoothly, the precision of the processing is prevented from deterioration due to the shock.

Because the workpiece W is not a perfectly rigid body but a sheet of plastic material, the portion of the workpiece W remote from the die 5 is raised behind the portion near the die 5 at early stages of the processing when the workpiece is raised quickly because of the dead load and force of inertia. As a result, the workpiece curves convexly, swelling upwards. The angle by which the remote portion is raised becomes smaller than that by which the near portion is raised.

The front pair of the guide rollers 17 pushs up the front end of the table 3 at the early stages and thereby makes the rising angle $\alpha$ of the table smaller than the rising angle $\beta$ of the arm as pointed to by an arrow B' in Figure 2. After the rollers pass the summit of the raising control, the displacement of the table front is removed by degrees as the raising continues. The angles $\alpha$ and $\beta$ agree again when the rollers pass over the raising control, as an arrow B points to. The separate rising of the table and workpiece, which would cause the plastic deformation or displacement on the table of the workpiece, can be prevented even at the early stages of the processing.

The table 3 is at the inclined position as illustrated in Figure 6 when the workpiece W is pressed down to the bottom of the groove 11 and the processing of the workpiece finishes. Next, at removal step, the ram 8 and punch 9 are lifted after the fixing devices 19 are turned on to fix the workpiece on the table 3. The bent workpiece is then lifted apart from the die 5 by lifting the table to the high position Hh by means of the lifting means 6, as illustrated in Figure 7. The frame 2 and table 3 are withdrawn to the rear by contracting the air cylinder 24 of the driving means 7 before or after the table is laid horizontally to take the workpiece away from the press break 1.

When the front end of the bent workpiece may get in touch with the lifted punch because the workpiece has been bent so deep for instance, the workpiece can be taken away from the press brake passing obliquely through between the punch and die d to the low position Hl. The lifting means 6 is controlled in synchronization with the driving means 7 so that the table is lowered to the low position Hl while it is withdrawn to the rear. In this case the table 3 is laid horizontally again after the withdrawl to the rear is completed.

To return the table 3 to the horizontal position, the pressure cell 44 of the air cylinder 28 is opened to the air. The cylinder is contracted because of the weight of arm, table and workpiece. The weight is more and more shared by the supporting spring 29 as the cylinder 28 contracts. None of the weight falls on the air cylinder after the table has returned to the horizontal position. The table and workpiece can stop at the horizontal position because the shock is absorbed by the supporting spring.

Thereafter, the table 3 is again lifted to the standard position HO with the lifting means 6 and the bent workpiece is transferred onto a conveyor not illustrated in the drawings, which carries the

workpiece away. Hereby one cycle of the processing is completed.

The way to achieve the processing is not restricted to the one described above. For example, when the workpiece has not been bent so deep, the table 3 can be withdrawn to the rear without lifting the table 3 to the high position Hh. The table 3 is lowererd from the inclined position B to the horizontal position A while the punch 9 is being lifted. The table is then withdrawn to the rear. To take the bent workpiece away from the press break 1, the order of the three works, i.e. lifting of the table and workpiece to the high position, lowering to the horizontal position and withdrawal to the rear is variable or can be performed simultaneously. Positions of the table at which the workpiece is transferred from the conveyor to the table vice versa can be determined freely and may even be different from each other.

While the embodiments of the present invention, as herein disclosed, constitue a preferred form, it is to be understood that other forms might be adopted.

## Claims

1. A device to support a workpiece which is being bent by a bending machine such as a press brake, comprising:
a fundamental frame placed in front of the bending machine;
an arm fixed pivotaly to the fundamental frame so that its farther half from the bending machine is always directed to the die of the bending machine;
a table supported by said half of the arm above the fundamental frame, on whichthe workpiece is mounted;
an air cylinder which raises the table together with the workpiece mounted thereon bmeans of the arm in synchronization with the progress of the bending;
a compressed air supplier which provides the air cylinder with compressed air;
a supporting spring which bears a total weight of the table, arm and workpiece at the beginning of the bending work.

2. A device to support a workpiece as recited in Claim 1, in which said air cylinder further comprises:
a piston;
a pressure cell capable of being opened to the air to which pressure air is supplied by the compressed air supplier; and
a cushion cylinder capable of being opened to the air which is separated from the pressure cell by the piston.

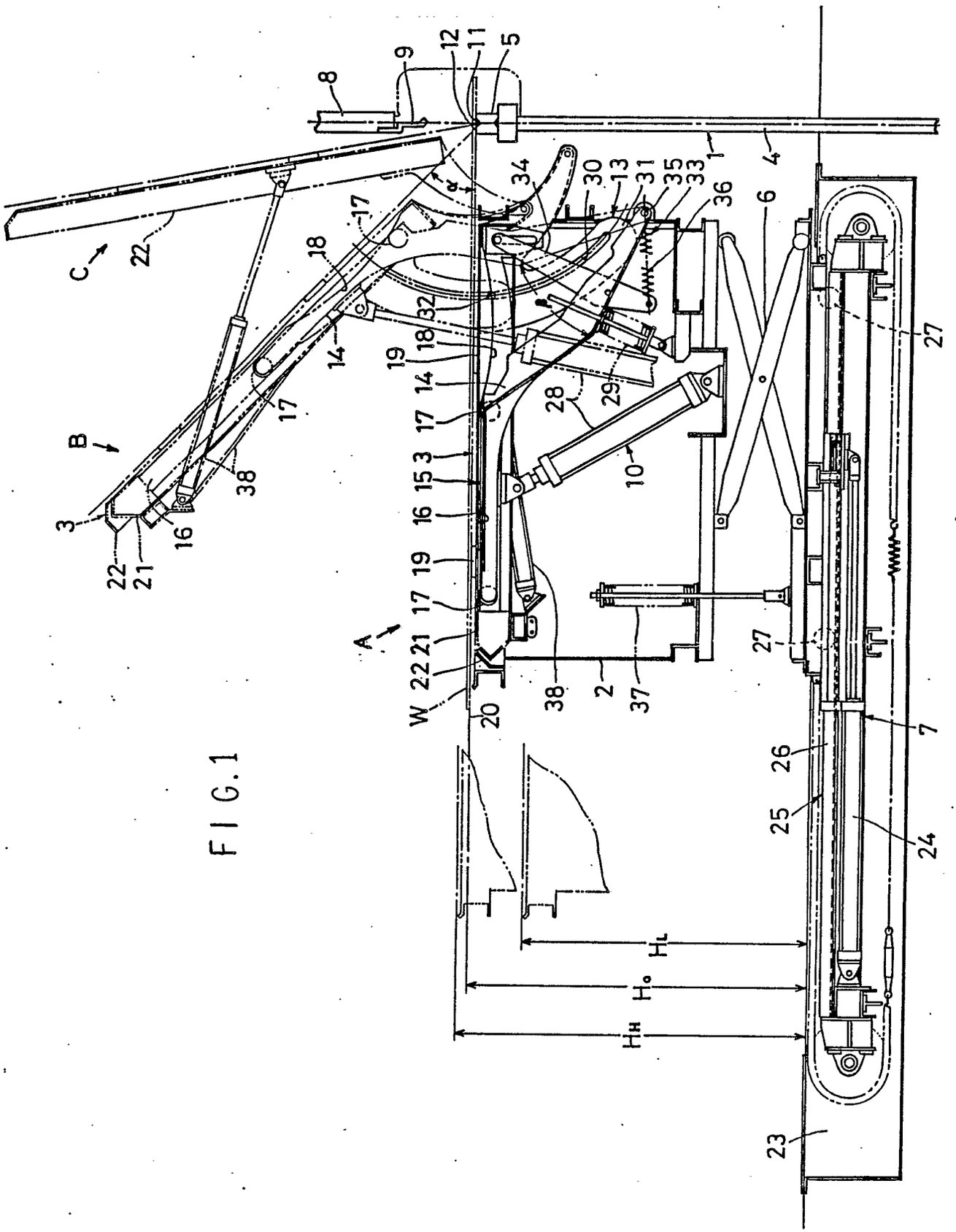


FIG.1

FIG.2

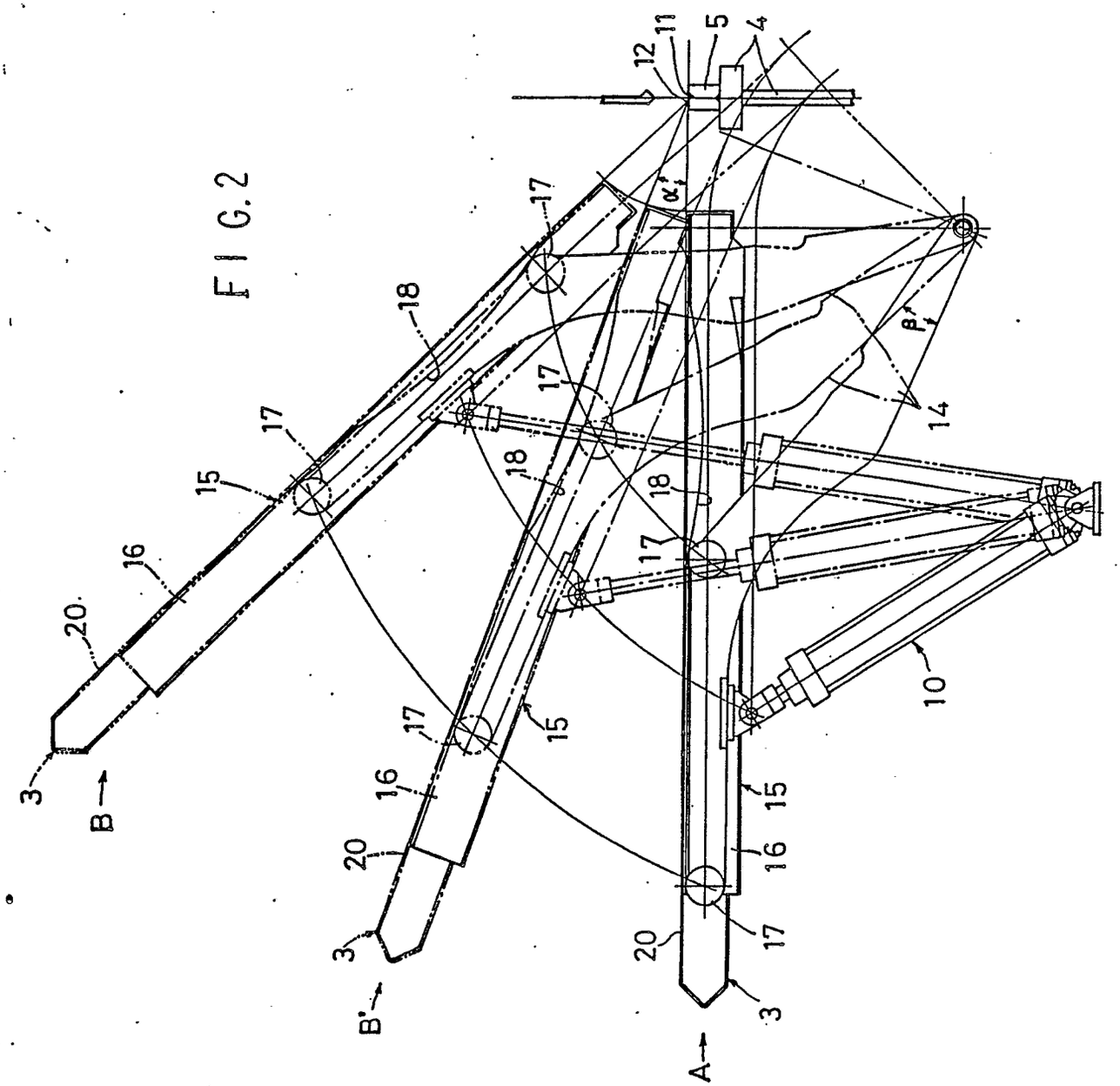

FIG.5

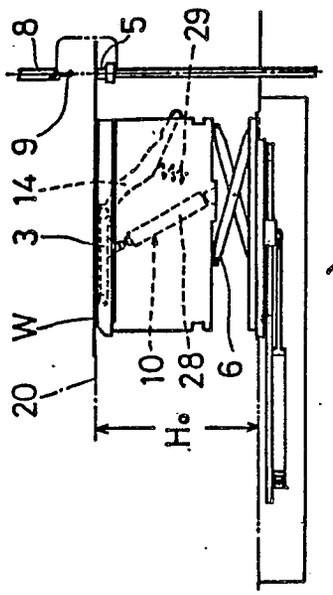


FIG.6

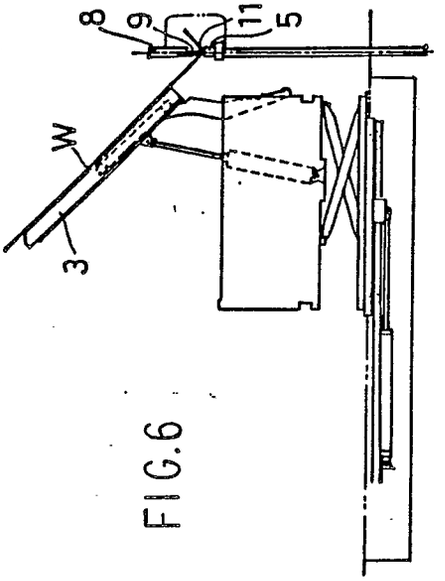


FIG.7

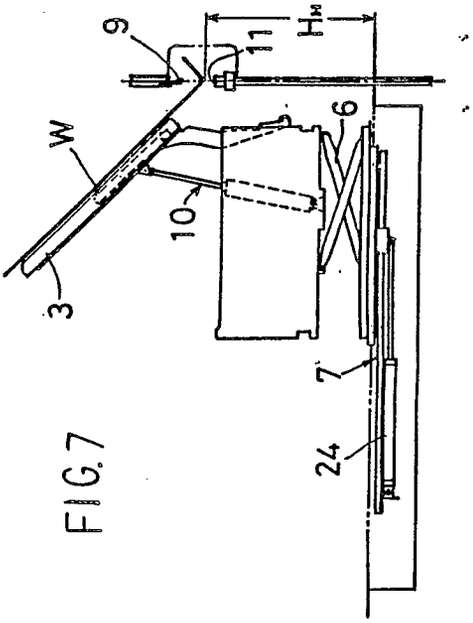


FIG.4

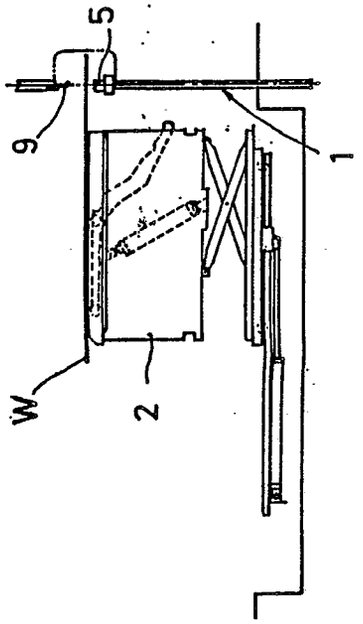


FIG.8

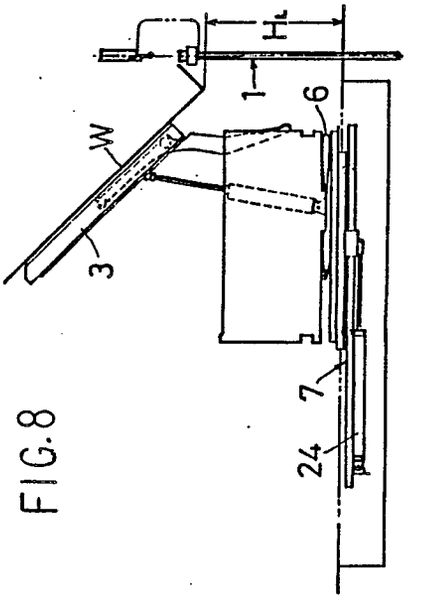


FIG.3

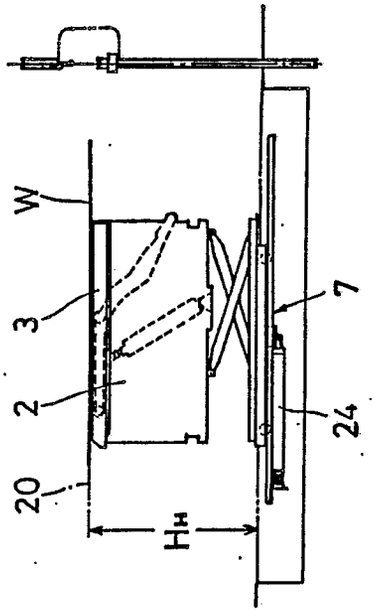


FIG.9

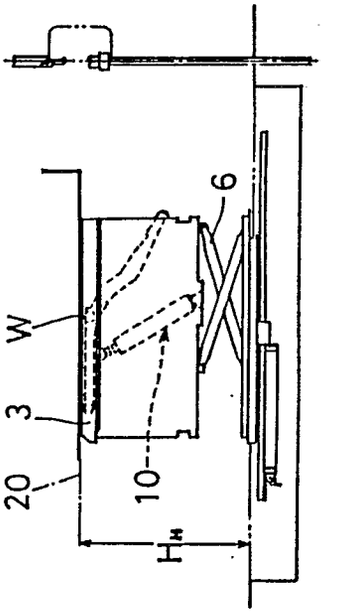

FIG. 10

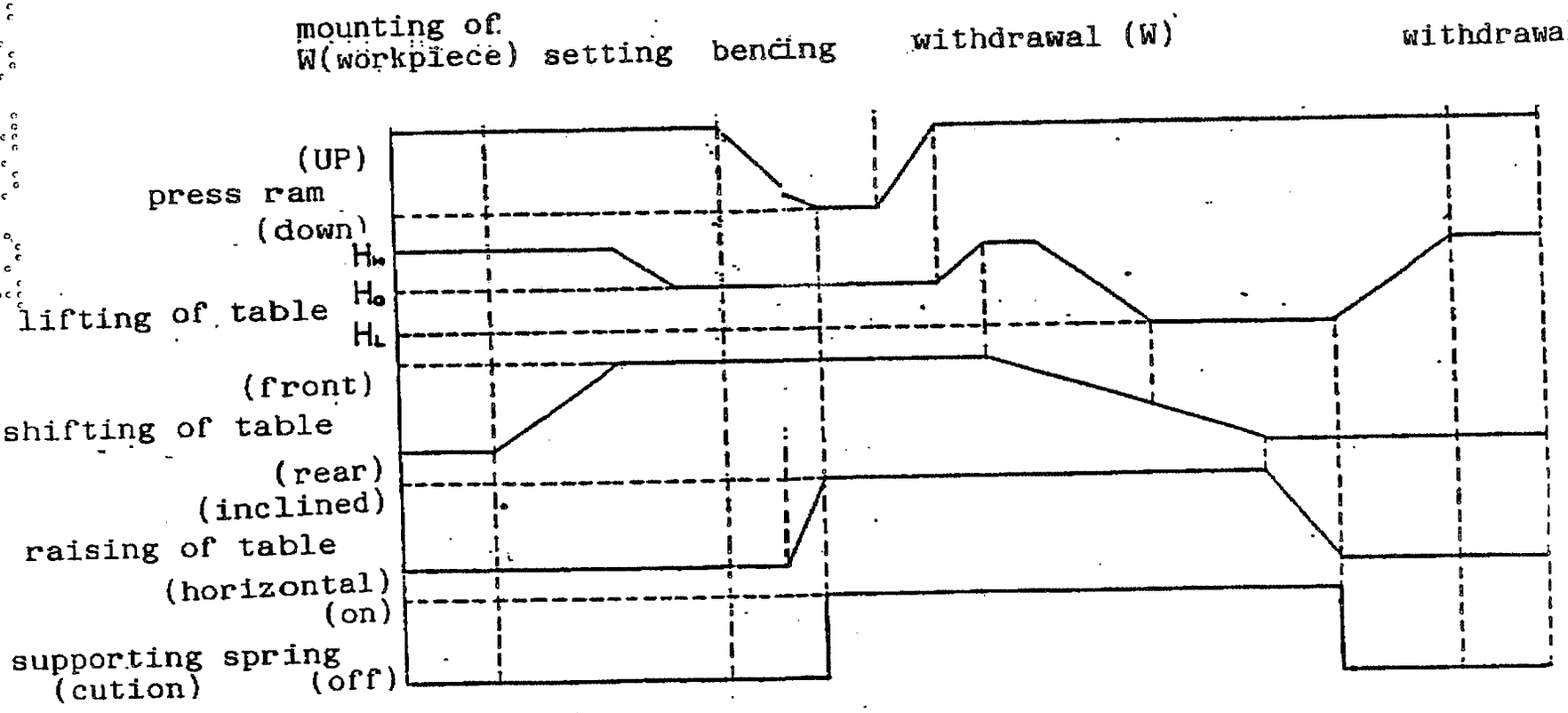


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FIG. 11