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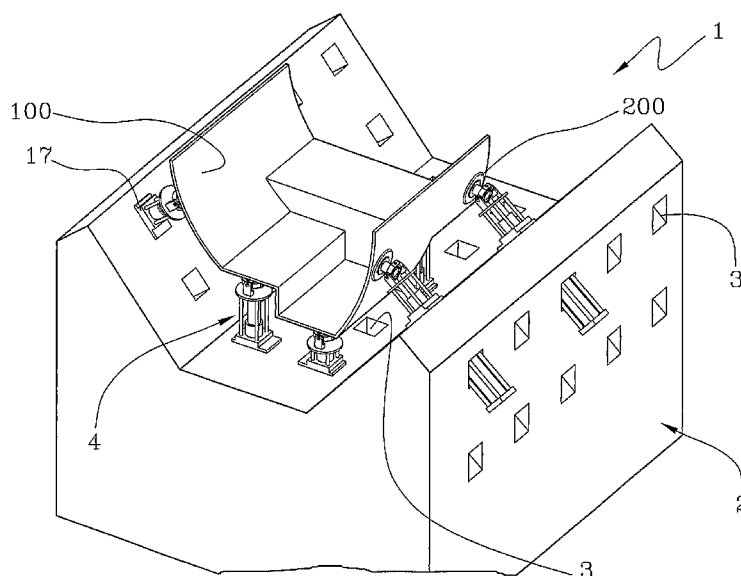
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(54) Title: A DEVICE AND A METHOD FOR HOLDING WORKPIECES IN MACHINING OPERATIONS



(57) Abstract: Workpieces of irregular or complex geometry are supported during machining operations by a table (2) affording an array of housings (3) and equipped with a battery of actuators (4), each insertable removably in a relative housing (3) and pilotable between multiple operating positions so as to support the workpiece (100). Signals containing identification codes and motion-inducing commands are generated by a master control unit and transmitted to the support table (2), in such a way that the actuators (4) can be positioned to accommodate the contours of the workpiece (100). Each actuator (4) is associated with one of the identification codes and thus directly and selectively in receipt of the motion-inducing commands.

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DescriptionA device and a method for holding workpieces in
machining operationsTechnical Field

The present invention relates to a device and a method for holding workpieces during machining operations.

5 In particular, the invention finds application in the art field of devices employed in numerically controlled multi-axis machine tools for the purpose of supporting a semi-manufactured item or a blank in a stable position, so that the piece can be machined by the tool.

Background Art

10 Conventionally, devices of the type in question appear as a simple deck on which the workpiece is rested and secured. In certain cases, especially when the workpiece is not flat, or in any event cannot be supported on a flat table, use is made of devices
15 that are shaped to match the shape of the workpiece. In these instances, however, a different device will be needed every time there is a change of workpiece, with the result that a storage facility is needed to contain the various types of support devices and an
20 extremely high production cost is incurred.

These drawbacks are addressed, by way of example, in devices and methods for holding a workpiece as disclosed in references US 5722646 and US 6209188, which teach the use of a support table affording an array of housings designed to accommodate a plurality of actuators. The actuators are raised and lowered to match the geometry of the workpiece, thus providing a flexible deck readily adaptable to the shape of any given item for machining.

In particular, such devices operate by addressing a set of commands selectively to each of the housings in the support table. The command addressed to a given housing, once received, is transferred to the actuator associated with the housing and thereupon executed by the selfsame actuator.

Notwithstanding such devices and methods are much more versatile than those based on the principle of shaping a table to match a particular workpiece, they are affected by certain drawbacks just the same, and their use consequently is not always troublefree.

In particular, should there be any kind of problem connected with recognition of the command or commands addressed to one of the housings, the support table must be dismantled so that the damaged housing can be inspected, and the damaged signal recognition unit repaired or replaced. Clearly, the device will remain out of service for as long as it may take to effect a repair, and stoppage times can therefore be lengthy.

In addition, and especially in the case where each housing is connected in parallel with the master

control unit by which the commands are transmitted, the incorporation of all the necessary wiring into the support table is not easily accomplished.

5 Similarly, where the housings are connected in series with the master control unit transmitting the commands, each housing must be equipped with suitable electronic circuitry comprising a unit programmed to recognize the address associated with the commands. Since it is often the case, conversely, that not all
10 of the housings in the table will need to be equipped with a relative actuator, the cost of assembling the device can be unnecessarily high.

The object of the present invention, accordingly, is to design a device and a method for holding
15 workpieces in machining operations, such as will be unaffected by the drawbacks described above.

In particular, the object of the invention is to provide a device for holding workpieces in machining operations that will be exceptionally versatile and
20 flexible.

It is also an object of the present invention to provide a device and a method for holding workpieces in machining operations, affording the advantages of low production and running costs.

Disclosure of the Invention

25 The stated objects are substantially realized, according to the invention, in a device and a method for holding workpieces in machining operations as characterized in one or more of the appended claims.

The invention will now be described in detail, by way of example, with the aid of the accompanying drawings, in which:

- 5 -figure 1 is a first perspective view of a device for holding workpieces in machining operations, according to the present invention;
- figure 2 is a second perspective view of the device shown in figure 1;
- 10 -figure 3 is a block diagram illustrating the operation of the device shown in figure 1;
- figure 4 is a first sectional view illustrating a detail of the device shown in figure 1;
- figure 5 is a second sectional view of the detail shown in figure 3;
- 15 -figure 6 is a circuit diagram relative to a detail of the device for holding workpieces in machining operations.

With reference to the drawings, numeral 1 denotes a device, in its entirety, for holding workpieces in machining operations.

20 The device 1 comprises a support table 2 furnished with a plurality of housings 3, and a plurality of actuators 4 insertable removably in the housings 3 of the table 2. The actuators 4 can be made to assume a plurality of operating positions and are capable thus
25 of combining to create a deck of which the shape can be matched to the contours of a workpiece 100, as illustrated in figures 1 and 2.

 Numeral 5 denotes a master control unit by which
30 signals composed of one or more identification codes

and one or more commands inducing motion in the actuators 4 are generated and thereupon relayed to the support table 2, the composition of the signals being determined by the geometry of the workpiece.

5 Each single actuator 4 is associated with a unique identification code, in such a way that the signals generated by the master control unit 5 are receivable selectively by the actuators 4. In other words, each signal emitted by the control unit 5 is addressed
10 directly to a given actuator 4 via the identification code embedded in the selfsame signal.

Referring to figure 3, in particular, the master control unit 5 comprises a first memory 6 in which a plurality of data sets are stored. Each data set
15 refers to a particular workpiece and each data item defines the operating position that must be assumed by an actuator occupying a given housing 4. In logic terms, the first memory represents a computer file of workpieces, each one of which is attributed a final
20 configuration that the deck must assume in order to match the shape of the selfsame piece.

To advantage, as already intimated, the data stored in the first memory 6 will define the locations of the housings 3. Accordingly, programming of the first
25 memory 6 is made especially simple and intuitive, as no significance is given to the particular actuator 4 that may occupy a given housing 3.

More exactly, the first memory 6 can be programmed without any thought as to which of the actuators will
30 physically execute the commands generated, but simply

by informing the memory 6 that an actuator 4 must be extended to a predetermined height at a predetermined location on the support table 2.

5 In a preferred embodiment, the programming of the first memory 6, or rather the operation of storing a plurality of data sets, is effected automatically by interfacing the first memory 6 with a computer aided modelling program, so that when a workpiece is drawn, the dimensional characteristics will be transferred
10 directly to the first memory 6. Alternatively, the memory 6 can be programmed by entering the single positional references for the workpiece one by one.

To advantage, the master control unit 5 further comprises a second memory 7 containing a conversion
15 table in which the identification code of each actuator is paired with the location of a respective housing 3. In the preferred embodiment illustrated, the second memory 7 receives information from each actuator 4 installed on the support table 2. More
20 precisely, when an actuator 4 is installed in a housing 3, the identification code of the actuator is communicated to the second memory 7, together with the code of the housing it occupies. The code is acknowledged by a reader unit 8, for example an
25 optical bar code reader or a mechanical device utilizing microswitches, and associated with the information relative to the housing in question, whereupon the conversion table will be updated. The reader unit 8 and the second memory 7 together
30 constitute self-learning means 9 serving to establish

the identification code of each actuator 4. Alternatively, the identification code of each actuator 4 and the location of the relative housing 3 can be entered in the second memory 7 by an operator, using an alphanumeric type man-machine interface, for example.

The control unit 5 further comprises a processing unit 10 connected operationally to the first memory 6 and second memory 7. In particular, the processing unit 10 outputs motion-inducing signals on the basis of data stored in the first memory 6, self-evidently according to the geometry of the workpiece. Since the data in question will refer to the locations of the housings 3, as mentioned previously, the processing unit 10 advantageously can access the second memory 7 to convert the information reflecting the location of the housings 3 into codes identifying the actuators 4 occupying the housings. In this way, the processing unit 10 associates an identification code with each motion-inducing signal generated, serving as the address for the single actuator 4.

To enable acknowledgement of the signals intended for the single actuators 4, each actuator comprises means 11 by which to recognize the identification code contained in the signal generated by the control unit 5. In the preferred embodiment illustrated, more particularly, such recognition means 11 consist in a memory (not shown) containing the identification code of the actuator, and a comparator (not shown) able to read the identification code of the signal received

from the control unit 5 and to compare it with that stored in the memory. Whenever the two codes match, the recognition means 11 will enable the actuator 4 to receive the rest of the incoming signal, or in other words, to receive the motion-inducing command.

Since the motion-inducing commands generated by the processing unit 10 are high logic level signals, the device 1 will comprise a management processor 12 connected to the control unit 5 and to each of the actuators 4, through which these same signals are routed. The function of the management processor 12 is to handle the motion-inducing commands in such a manner that they can be executed directly by the actuators 4. In the preferred embodiment illustrated, the unit 12 in question is a programmable logic controller, or PLC.

Each actuator 4 comprises actuating means 13, to be described in detail further on, such as will execute the motion-inducing signals received from the master control unit 5 by way of the management processor 12.

The single actuator 4 also comprises one or more sensors 14 serving to detect the operating position assumed by the selfsame actuator. The sensors 14 are connected to the master control unit 5, and more exactly to the processing unit 10, so as to establish a feedback loop.

To reiterate, the master control unit 5 is connected to the management processor 12, which connects in turn with each actuator 4 by way of the support table 2, as illustrated in figures 2 and 3.

In particular, the connection between the management processor 12 and the actuators can be implemented using two different data network solutions. In a first solution, shown in figure 3, the management processor 12 links all the actuators in parallel one with another via respective connector sockets 15 associated one with each housing 3. In a second solution, not illustrated, the sockets 15 associated with the various housings 3 are connected by the management unit 12 in series. In this instance the housings 3 are normally short-circuited, thereby ensuring that all the actuators 4 are connected even when one or more of the housings may not be in use.

Whichever solution is adopted, the invention advantageously guarantees simultaneous movement of all the actuators 4 when each receives the relative motion-inducing command from the control unit 5, by virtue of the fact that the commands are not executed immediately. Rather, the motion-inducing commands are first sent to all of the actuators, whereupon the control unit 5 generates a further signal serving to activate the commands. The activating signal contains the identification code of all the actuators 4, so that all the actuators receive the activation order at the same instant and will be raised or lowered in concert. This procedure is especially useful in the event of it being necessary to change the distance of the workpiece 100 from the support table 2, or its orientation.

Structurally, as illustrated in figures 4 and 5,

each actuator 4 comprises a strut 16 anchored rigidly to the support table 2 by way of a flange 17 at one end 16a of the selfsame strut. Located internally of the strut 16 is a rod 18, extendable telescopically relative to the strut 16. The telescoping movement is induced by an electric motor 19 associated rigidly with the strut 16 and comprising a drive shaft 20 coupled rigidly to a lead screw 21, and preferably a ballscrew. The ballscrew extends parallel with the rod 18 and engages a lead nut 22 coupled rigidly to the rod 18. The rotation of the drive shaft 20 causes the screw 21 to rotate, raising or lowering the lead nut 22 and causing the rod 18 to move through a plurality of operating positions. When in motion, the rod 18 is kept in alignment by a guide denoted 23, illustrated in figure 5. The guide 23 presents a channel 24 extending parallel to and integral with the strut 16, accommodating a track 25 rigidly associated with the rod 18.

The electric motor 19, the drive shaft 20, the ballscrew 21 and the lead nut 22 combine to establish mechanical means 26 forming part of the actuating means 13 aforementioned. Also forming part of these same means are pneumatic means 27 by which the actuator 4 is anchored to the workpiece 100.

In particular, the pneumatic means 27 in question comprise a suction cup 200, indicated schematically in figures 1 and 2, carried movably by one end 18a of the rod 18 and offered thus in contact to the workpiece 100. In a preferred embodiment, the suction

cup 200 will be of the type described in European patent application 06114676.1 filed 30 May 2006 by the present applicant, to which reference can be made for a detailed description of the cup 200 and of the devices essential to its operation. The pneumatic means 27 comprise means 28 by which to generate a vacuum between suction cup 200 and workpiece 100. More exactly, as illustrated in the block diagram of figure 6, such vacuum generating means 28 comprise a first solenoid valve 29 connected on the output side to a Venturi meter 30 connected in turn on the output side to a second solenoid valve 31, which is connected to the suction cup 200. Advantageously, the first solenoid valve 29 is connected to a compressed air line 32 common to all the actuators 4, which are connected physically to the line by way of the aforementioned sockets 15. When the first and second solenoid valves 29 and 31 are opened, the Venturi meter 30 draws air from the suction cup 200, thereby creating a pocket of negative pressure between the cup 200 and the workpiece 100 and securing the workpiece to the actuator 4. Also forming part of the pneumatic means 27 is a third solenoid valve 33, connected likewise to the compressed air line 32, by which air is supplied to the suction cup 200 to nullify the negative pressure when the workpiece 100 needs to be released from the actuator 4.

The pneumatic means 27 further comprise a fourth solenoid valve 34 and a fifth solenoid valve 35, both connected to the compressed air line 32, by which the

suction cup 200 is respectively raised and lowered on the end 18a of the rod 18 in such a way that it can be locked in a predetermined position.

5 In addition, the pneumatic means 27 comprise a plurality of telescopic air ducts 36 connecting the two ends of each actuator, that is to say the moving end 4a, and the fixed end 4b rigidly associated with the support table 2. These telescopic ducts 36, of which there are four in the preferred embodiment
10 illustrated, serve to connect the solenoid valves located at the fixed end 4b of the actuator 4 with the suction cup 200, or with the devices essential to its operation, so that a permanent fluid connection is assured between the valves and the cup.

15 It will be self-evident from the foregoing that in a device 1 according to the invention, all of the electronics needed to operate the actuator 4 can be installed in the actuator 4 itself, rather than in the support table 2. In addition, all the solenoid
20 valves needed to operate the actuator are mounted to the actuator itself. In short, the support table 2 is simply a "passive" component, neither carrying nor incorporating any control or motion-inducing device associated with the actuators. Thus, advantageously,
25 any fault that might develop will almost certainly be attributable to the malfunction of a component that forms a part of the actuator, and it will therefore be sufficient to remove the faulty actuator to restore normal operation of the device 1, avoiding
30 any need for prolonged stoppages.

In addition, the production costs of the device 1 can be optimized according to the invention since the design does not include any unutilized parts, as is the case conversely in prior art devices where the electronic circuitry required for the operation of the actuators is incorporated into each of the housings.

Claims

1) A device for holding workpieces in machining operations, comprising:

- 5 -a support table (2) affording a plurality of housings (3);
- a plurality of actuators (4) insertable removably in the housings (3) and pilotable between a plurality of operating positions to the end of supporting a workpiece (100);
- 10 -a master control unit (5) by which signals containing a plurality of identification codes and motion-inducing commands are generated and relayed to the support table (2), in such a way that the actuators (4) can be positioned according to the
- 15 geometry of the workpiece (100);
- characterized
- in that each actuator (4) of the plurality of actuators is associated with one code of the plurality of identification codes and thus directly
- 20 and selectively in receipt of the motion-inducing commands.

- 2) A device as in claim 1, wherein the master control unit (5) comprises a first memory (6) containing a plurality of data sets, each defining a
- 25 particular workpiece (100), in which each data item represents the operating position to be assumed by an actuator (4) occupying a predetermined housing (3) of the support table (2).

3) A device as in claim 1 or claim 2, wherein the master control unit (5) comprises a second memory (7) containing a conversion table by way of which the identification code of one actuator (4) is associated with each housing (3) occupied.

4) A device as in claim 2 and claim 3, wherein the master control unit (5) comprises a processing unit (10) connected operationally to the first memory (6), in such a way that motion-inducing commands are generated according to the data stored in the selfsame first memory, and connected to the second memory (7) in such a way that the identification code of an actuator (4) can be associated with each motion-inducing command generated.

5) A device as in preceding claims, wherein each actuator (4) is equipped with means (11) allowing recognition of the identification code emitted by the master control unit (5) and thereupon enabling reception of the motion-inducing commands.

6) A device as in preceding claims, comprising self-learning means (9) by which the identification code of each actuator (4) is acquired.

7) A device as in claim 3 and claim 6, wherein self-learning means (9) comprise a reader unit (8) able to recognize the identification code of each actuator (4) occupying a housing, and connected to

the second memory (7) for the purpose of implementing the conversion table.

8) A device as in preceding claims, wherein each housing (3) comprises a connector socket (15) by way of which the actuator (4) occupying the housing (3) is connected with the master control unit (5).

9) A device as in preceding claims, wherein each actuator (4) comprises actuating means (13) serving to execute the motion-inducing commands received.

10) A device as in claim 4 and claim 9, wherein the motion-inducing commands are handled by a management processor (12) connected operationally to the processing unit (10) and to each actuator (4) in such a way that the motion-inducing commands can be encoded and rendered directly executable by the actuating means (13).

11) A device as in claim 9, wherein the actuating means (13) comprise mechanical means (26) by which the actuator (4) is raised and lowered, and pneumatic means (27) by which the actuator (4) is anchored to the workpiece (100).

12) A device as in claim 11, wherein the mechanical means (26) comprise an electric motor (19) rigidly associated with a strut (16) of the actuator (4) and

connected to a lead screw (21) driving a telescopic rod (18) of the actuator (4), in such a way that the rod (18) can be displaced relative to the strut (16).

5 13) A device as in claim 12, wherein the mechanical means (26) further comprise a lead nut (22) rigidly associated with the rod (18) of the actuator (4) and coupled with the lead screw (21) in such a way that the rod (18) of the actuator is raised and lowered by turning the lead screw (21).

10 14) A device as in claim 13, wherein each actuator (4) comprises a guide (23) serving to maintain the alignment of the rod (18) when raised and lowered.

15 15) A device as in claim 11, wherein the pneumatic means (27) comprise a suction cup (200) carried by a movable end (18a) of the telescoping rod (18) of the actuator (4) and positionable thus in contact with the workpiece (100).

20 16) A device as in claim 15, wherein the pneumatic means (27) comprise means by which to generate a vacuum (28) between the suction cup (200) and the workpiece (100), so that the workpiece can be anchored rigidly to the actuator (4).

17) A device as in claim 15 or 16, wherein the pneumatic means (27) comprise a plurality of

telescopic air ducts (36) by which fluid connections are established between the suction cup (200) and a fixed end (4a) of the actuator (4).

18) A device as in claims 15, 16 and 17, wherein the
5 pneumatic means (27) are connected to a single compressed air supply line (32).

19) A device as in claim 8 and claim 18, wherein the
single compressed air supply line (32) extends
through the support table (2), and the pneumatic
10 means (27) of each actuator (4) are connected to the compressed air line (32) by way of the relative connector socket (15).

20) A method of holding workpieces in machining operations, including the steps of:

15 -preparing a support table (2) affording a plurality of housings (3);
-inserting a plurality of actuators (4) in respective housings (3) of the support table (2);
-generating signals containing a plurality of
20 identification codes and of motion-inducing commands addressable to the actuators (4) according to the geometry of the workpiece (100);
-transmitting the signals to the support table (2);
characterized
25 in that it includes the step of associating each actuator (4) of the plurality of actuators with one code from the plurality of identification codes, so

that the motion-inducing commands can be addressed selectively to the actuators.

21) A method as in claim 20, wherein the step of generating signals includes the step of determining
5 the operating position that must be assumed by each actuator (4) according to the housing (3) occupied, so that motion-inducing commands can be generated accordingly.

22) A method as in claim 21, wherein the step of
10 generating signals includes a step whereby each housing (3) occupied by an actuator (4) is attributed the identification code of the relative actuator.

23) A method as in claims 21 and 22, wherein the
15 step of generating signals includes a step of associating generated motion-inducing commands with respective identification codes of the actuators (4).

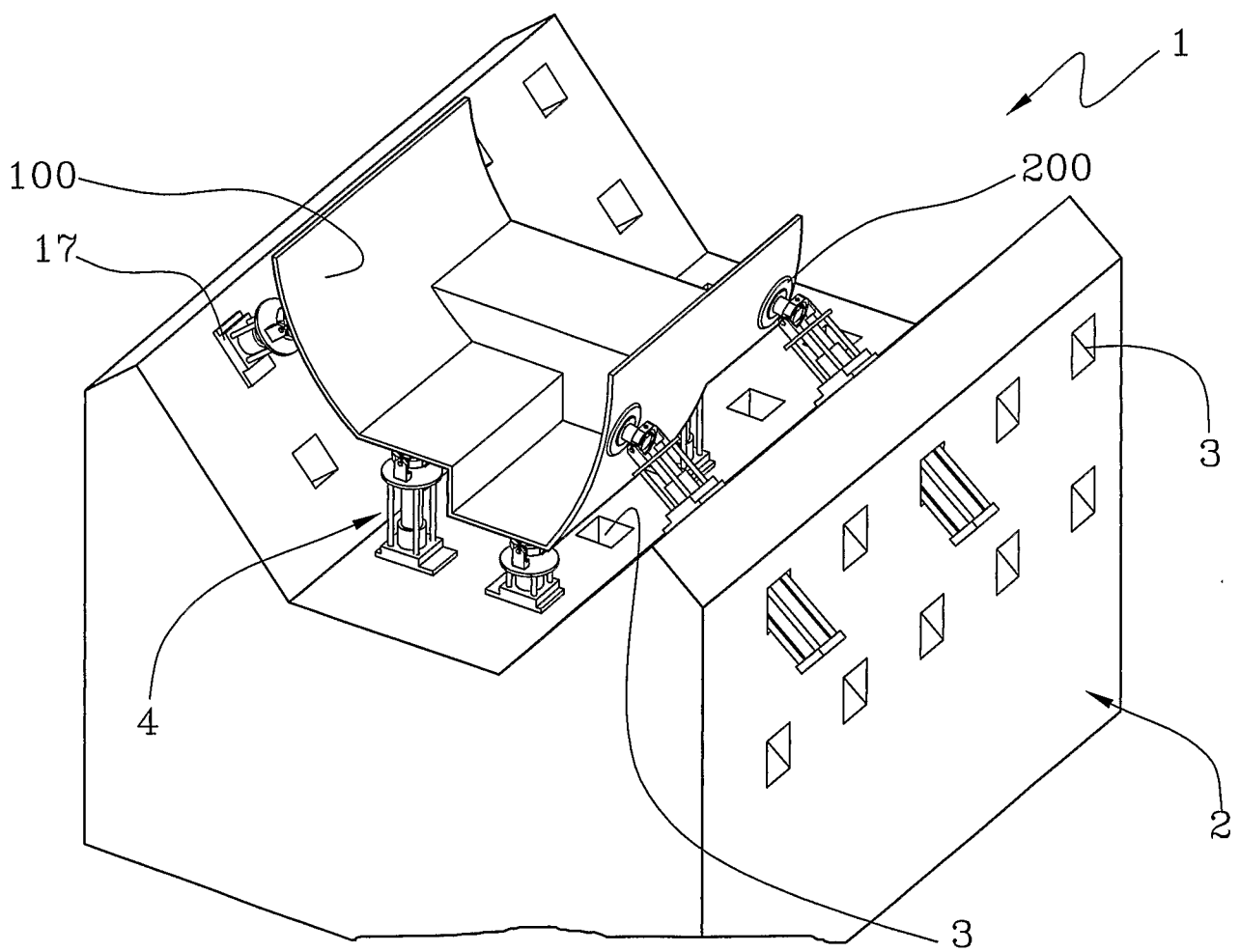
24) A method as in claims 21 to 23, wherein the step
20 of transmitting signals to the support table (2) includes a step of encoding the motion-inducing commands to render them directly executable by the actuators (4).

25) A method as in claims 21 to 24, comprising the
step of activating all the actuators (4) simultaneously to raise or lower the workpiece.

26) A method as in claim 25, wherein the step of activating all the actuators (4) simultaneously includes the subsidiary steps of transmitting the respective motion-inducing commands selectively to the various actuators (4) and thereupon transmitting a common signal to all the actuators (4) by which the motion-inducing commands are activated.

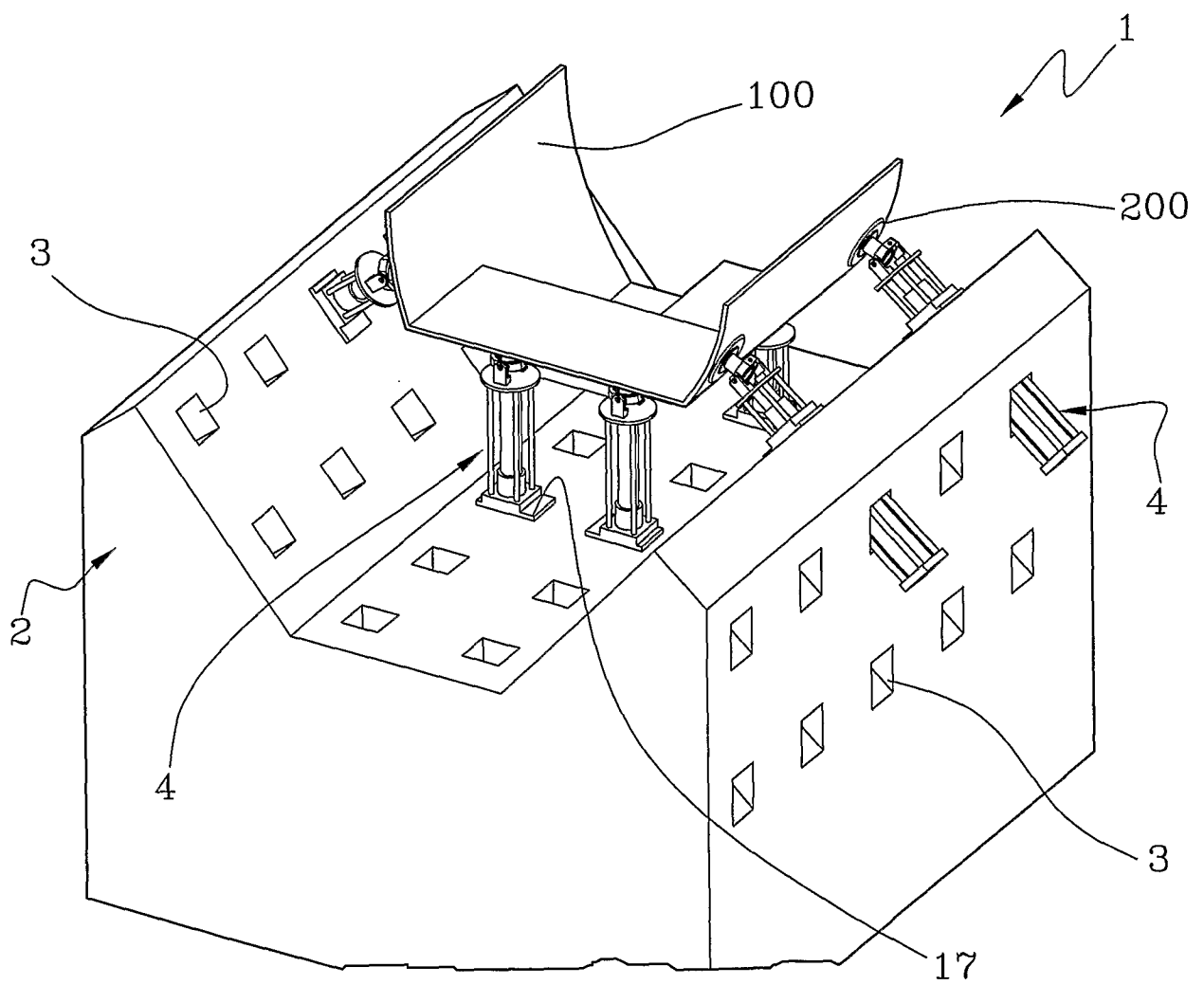
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FIG.1



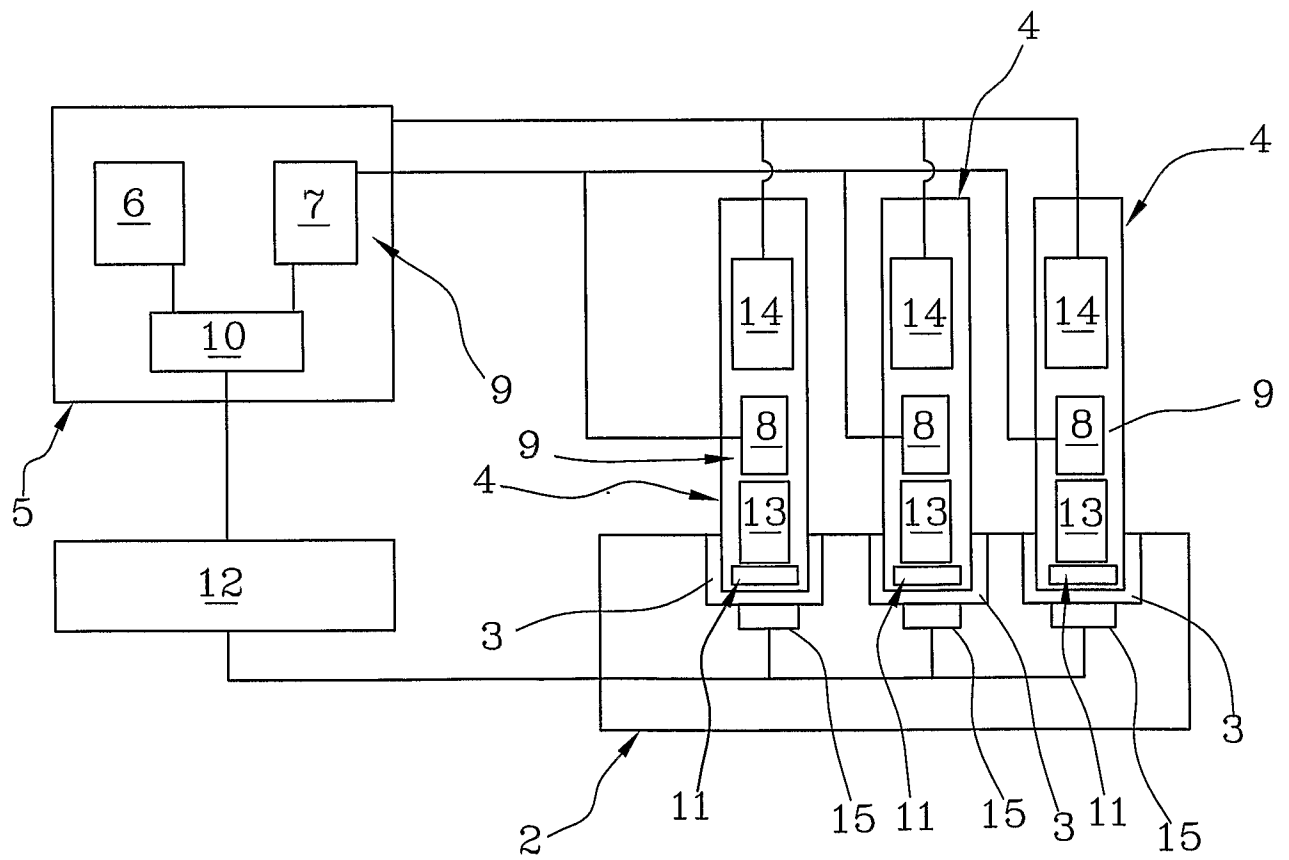
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FIG.2



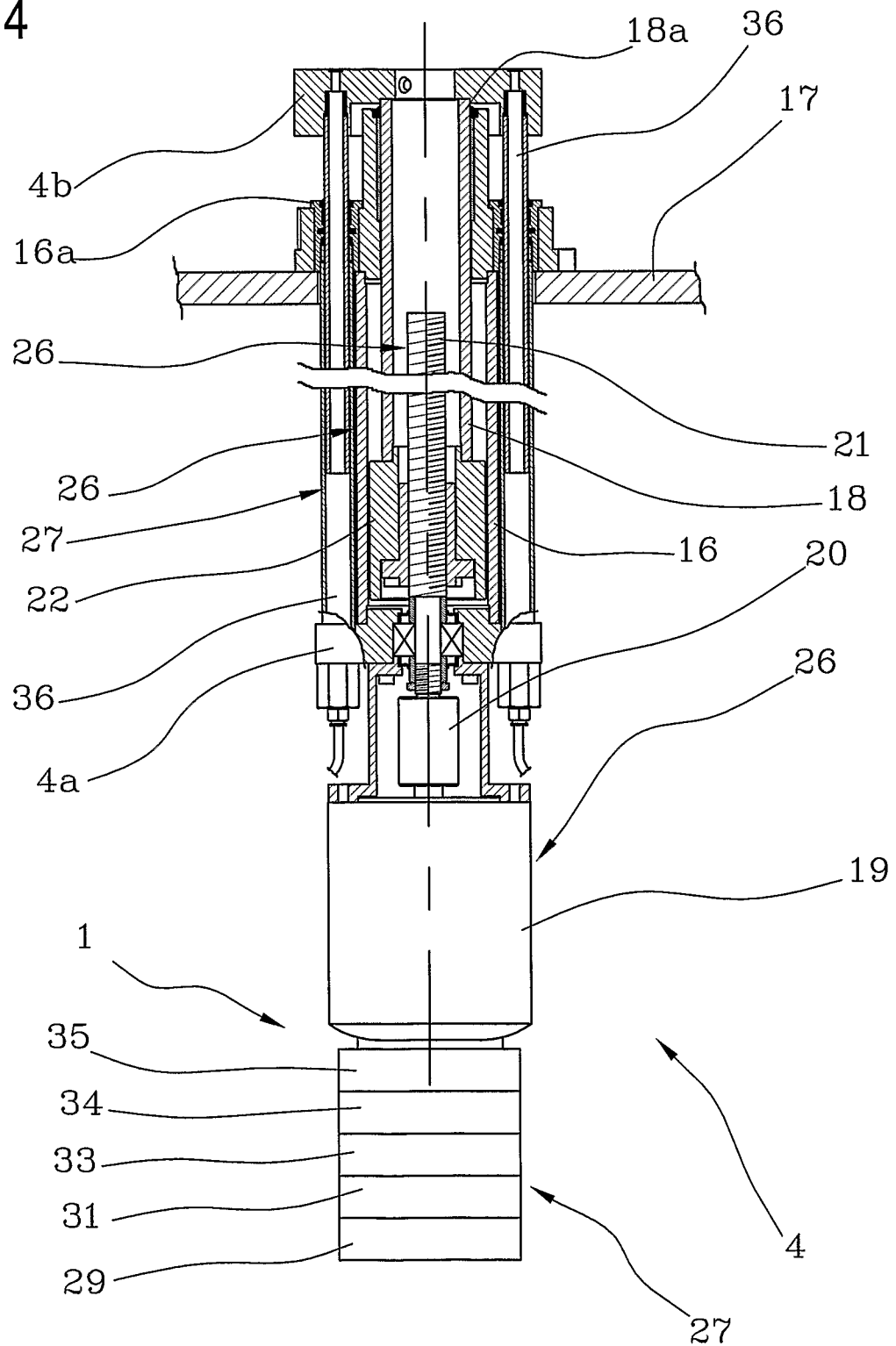
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FIG.3



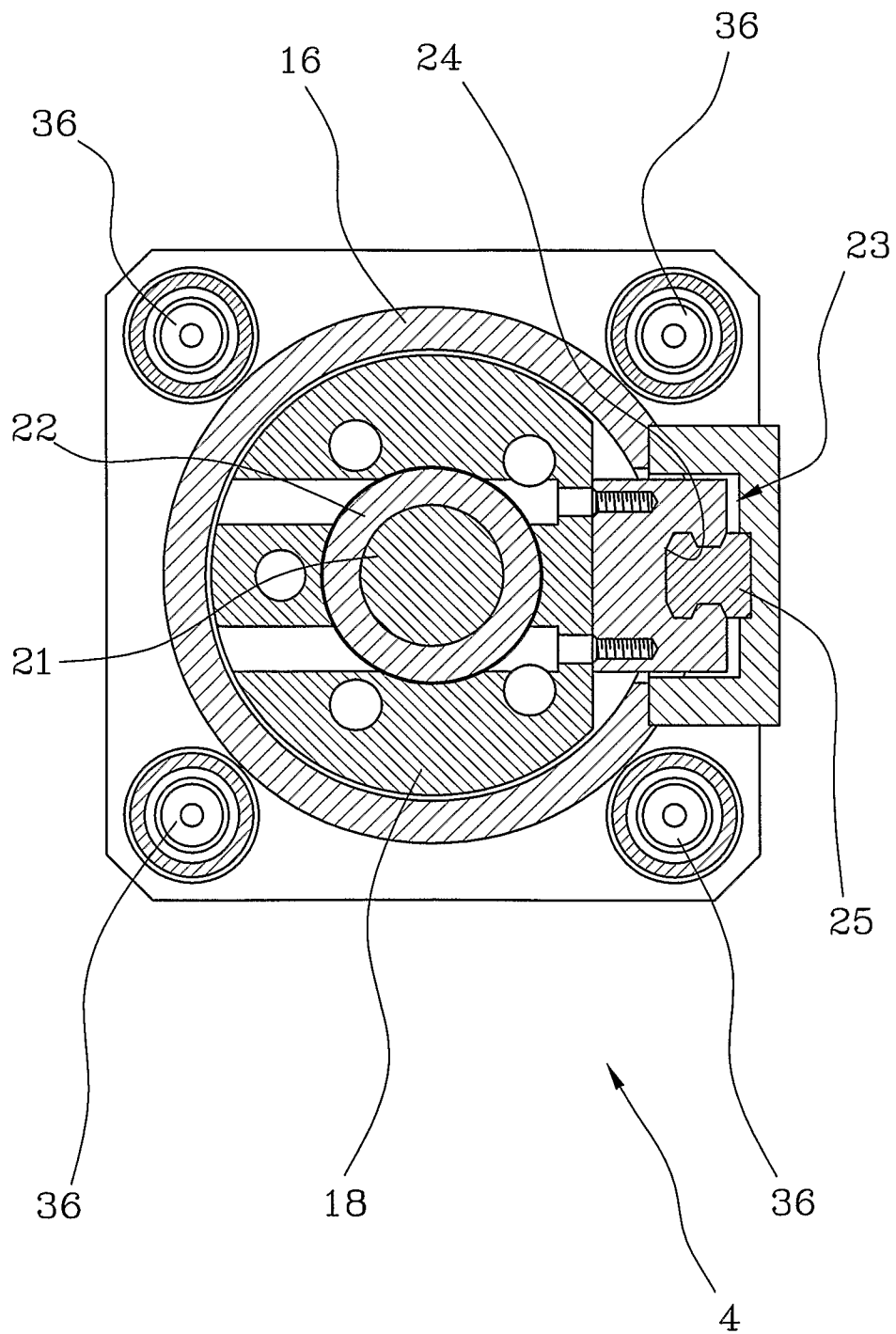
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FIG.4



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FIG.5



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FIG.6

