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DESCRIPTION



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MOUNTING APPARATUS

Technical Field

5 The present invention relates to a mounting apparatus for mounting electronic components (hereinafter, referred to as components) onto a circuit board (hereinafter, referred to as board).

10 Background Art

 The mounting apparatus of this kind has conventionally had a construction that it comprises: a feed section for feeding specified type and quantity of electronic components; a board holding section which serves
15 for holding a circuit board, on which those electronic components are to be mounted, and which is movable longitudinally and laterally; a mounting section for mounting those electronic components onto the circuit board; and a plurality of drive units for driving the
20 individual sections.

 That is, it has been the case that the components fed from the feed section are mounted on and on appropriately in order.

 In the conventional mounting apparatus, when the
25 effective torque of a drive unit has exceeded a specified

upper-limit value due to the mounting-apparatus operation mode or load variation, the drive unit would increase in temperature due to the heat generation of the internal parts, where continuing the operation as it is could result
5 in a failure of the drive unit.

For prevention of this failure, in the case where the effective torque of a drive unit could exceed a specified upper-limit value, it has been practiced to select a large-capacity drive unit in which the safety
10 factor, i.e. degree of margin, of the controllable drive unit capacity is set higher.

This would hitherto cause an excessive capacity selection of the drive unit to be involved in the drive unit selection, further leading to an increase in
15 mechanical cost.

Accordingly, an object of the present invention is to provide a mounting apparatus which is capable of suppressing temperature increases due to heat generation of components inside a drive unit caused by the drive unit's
20 effective torque exceeding a specified upper-limit value, suppressing the safety factor, i.e. degree of margin, for the selection of a drive unit to a lower one, and thus preventing failures of the drive unit even if the drive unit is as small in capacity as a minimum requirement, and
25 low in price, and therefore which makes it possible to

perform high-efficiency production without halting the machine.

Disclosure Of Invention

5 In order to achieve the above object, the present invention has the following constitution.

 According to a first aspect of the present invention, there is provided a mounting apparatus comprising:

10 an electronic component feeding unit for feeding a plurality of electronic components;

 a board holding section serving for holding a circuit board, onto which the electronic components are to be mounted, and being capable of moving the circuit board
15 in orthogonal two directions along a mounting surface;

 a mounting section for mounting the electronic components fed from the electronic component feeding unit onto the circuit board held by the board holding section;

 a plurality of drive units for driving the
20 electronic component feeding unit, the board holding section, and the mounting section, respectively;

 an effective torque detecting section for detecting an effective torque required by at least one drive unit among the plurality of drive units at an
25 effective-torque detection cycle;

an effective torque deciding section for deciding whether or not the detected effective torque has exceeded its upper-limit value, or whether or not the effective torque has been restored from the excess state to its safety value;

a detection error eliminating means for deciding whether or not the effective torque detected by the effective torque detecting section is a detection error, before a decision made by the effective torque deciding section, to assign the effective torque, which has been decided as a non detection error, to an object for the decision by the effective torque deciding section; and

a control section for performing control of each of the electronic component feeding unit, the board holding section, the mounting section, the plurality of drive units, the effective torque detecting section, the effective torque deciding section, and the detection error eliminating means,

wherein the control section performs control operation so that if the detected effective torque has been decided by the detection error eliminating means as a non detection error and moreover decided by the effective torque deciding section as having exceeded the upper-limit value, then an original rotational speed of the drive unit from which the effective torque has been detected is

decelerated to a specified deceleration speed of the relevant drive unit, and if the effective torque of the drive unit detected by the effective torque detecting section has lowered to not more than its safety value, the drive unit is restored again to the original rotational speed.

That is, in the present invention, an effective torque required, for example, within a specified time by any one of a plurality of drive units is detected at a specified cycle or period by the effective torque detecting section, and it is decided by the effective torque deciding section whether or not the effective torque has exceeded a specified upper-limit value, where if the effective torque has exceeded the specified upper-limit value, then a rotational speed of the drive units is decelerated to a specified speed, and if the effective torque has lowered to a specified value or lower, the drive units is restored to the original rotational speed. As a result of this, failures of the drive units can be prevented, and high-efficiency production can be fulfilled without halting the machine.

According to a second aspect of the present invention, there is provided the mounting apparatus according to the first aspect, wherein each of the electronic components is an electronic component having a

lead wire.

According to a third aspect of the present invention, there is provided the mounting apparatus according to the first aspect, wherein the electronic component feeding unit comprises: an electronic component feed section for storing therein a multiplicity of electronic components and feeding the electronic components independently of one another; a plurality of conveyor members for taking out the fed electronic components and conveying the electronic components to the mounting section; and a conveying section for moving the plurality of conveying members as the conveying members are arranged in a stringed annular shape.

According to a fourth aspect of the present invention, there is provided the mounting apparatus according to the first aspect, wherein the upper-limit value of the effective torque in the effective torque deciding section is set to 105% of a rated torque of the drive unit corresponding to a permissible number of successive overload operations in continuously performing an overload operation that the drive unit is decelerated, once halted and then immediately accelerated.

According to a fifth aspect of the present invention, there is provided the mounting apparatus according to the forth aspect, wherein in the effective

torque deciding section, the safety value of the effective torque that allows the drive unit to be restored to the original rotational speed is set to 95% of the rated torque of the drive unit.

5 According to a sixth aspect of the present invention, there is provided the mounting apparatus according to any one of the first to fourth aspects, wherein the detection period of the effective torque detecting section for detection of the effective torque
10 required in a specified unit time of the drive unit is set to not more than 1 sec.

 According to a seventh aspect of the present invention, there is provided the mounting apparatus according to the sixth aspect, wherein the control section
15 performs control so that if the effective torque does not become lower than the specified upper-limit value even if the rotational speed of the drive unit is decelerated, the drive unit is halted.

 According to an eighth aspect of the present
20 invention, there is provided the mounting apparatus according to the seventh aspect, wherein the drive unit comprises a servomotor and a drive control device for controlling drive of the servomotor.

 According to a ninth aspect of the present
25 invention, there is provided the mounting apparatus

according to the seventh aspect, wherein the drive unit comprises a motor controlled by an inverter and a drive control device for controlling drive of the motor.

5 According to a 10th aspect of the present invention, there is provided the mounting apparatus according to the seventh aspect, wherein the drive unit comprises a stepping motor and a drive control device for controlling drive of the stepping motor.

10 According to an 11th aspect of the present invention, there is provided the mounting apparatus according to the seventh aspect, wherein a time constant of the detection error eliminating means is set to 100 sec.

15 According to a 12th aspect of the present invention, there is provided the mounting apparatus according to the seventh aspect, further comprising an input section by which a set value of the deceleration speed for the rotational speed of the drive unit in the deceleration operation can be inputted from external of the mounting apparatus.

20 According to a 13th aspect of the present invention, there is provided the mounting apparatus according to the 12th aspect, wherein the input section is an operation panel.

25 According to a 14th aspect of the present invention, there is provided the mounting apparatus

according to the 12th aspect, wherein the input section is a floppy disk drive.

According to a 15th aspect of the present invention, there is provided the mounting apparatus according to the 12th aspect, wherein the input section is an interface which allows data to be inputted from a higher-order computer.

According to a 16th aspect of the present invention, there is provided the mounting apparatus according to the first aspect, wherein if the effective torque detected by the effective torque detecting section is decided by the effective torque deciding section as having exceeded the upper-limit value, then the detection error eliminating means decides that the effective torque detected by the effective torque detecting section is a non detection error only when the same decision result has succeeded to a specified number of times, and the detection error eliminating means decides that the effective torque detected by the effective torque detecting section is a detection error, and neglects the effective torque, when the same decision result does not succeed to the specified number of times.

According to a 17th aspect of the present invention, there is provided the mounting apparatus according to the first or 16th aspect, wherein if the

effective torque detected by the effective torque detecting section is decided by the effective torque deciding section as being not more than the upper-limit value, then the detection error eliminating means decides that the effective torque detected by the effective torque detecting section is a non detection error only when the same decision result has succeeded to a specified number of times, and the detection error eliminating means decides that the effective torque detected by the effective torque detecting section is a detection error, and neglects the effective torque, when the same decision result does not succeed to the specified number of times.

Brief Description Of Drawings

These and other aspects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram of a mounting apparatus according to a first embodiment of the present invention;

Fig. 2 is a flowchart of an effective torque deciding section of the mounting apparatus of the first embodiment;

Fig. 3 is a block diagram of a mounting apparatus

according to a second embodiment of the present invention;

Fig. 4 is a block diagram of a mounting apparatus according to a third embodiment of the present invention;

Figs. 5A and 5B are timing charts, respectively,
5 of the mounting apparatus of the first embodiment of the present invention;

Fig. 6 is a graph showing a relationship between speed and time for presenting a speed waveform of a rotating cam drive unit of the mounting apparatus of the
10 first embodiment of the present invention, where the move amount of an X-Y table is not more than 30 mm;

Fig. 7 is a graph showing a relationship between speed and time for presenting a speed waveform of the rotating-cam drive unit of the mounting apparatus of the
15 first embodiment of the present invention, where the move amount of the X-Y table is over 30 mm;

Fig. 8 is a flowchart showing operation of a first-order lag filter section of the mounting apparatus of the second embodiment of the present invention;

20 Fig. 9 is a perspective view of the X-Y table as an example of a board holding section of the mounting apparatus of the first embodiment of the present invention;

Fig. 10 is an explanatory view showing component-insertion start operation of a mounting section of the
25 mounting apparatus of the first embodiment of the present

invention;

Fig. 11 is an explanatory view showing component insertion operation of the mounting apparatus of the first embodiment of the present invention;

5 Fig. 12 is an explanatory view showing component-insertion completing operation of the mounting apparatus of the first embodiment of the present invention;

Fig. 13 is an explanatory view showing move-up operation after the component insertion of the mounting apparatus of the first embodiment of the present invention;

10 Fig. 14 is a flowchart of deceleration deciding operation of a drive unit of the mounting apparatus of the first embodiment of the present invention;

Fig. 15 is a perspective view of an X-Y orthogonal type mounting apparatus according to a fourth embodiment of the present invention;

Fig. 16 is a perspective view of a rotary type mounting apparatus according to a fifth embodiment of the present invention;

20 Fig. 17 is a perspective view of the mounting section of the mounting apparatus of the first embodiment of the present invention;

Fig. 18 is a perspective view of a head body of the mounting section of the mounting apparatus of the first embodiment of the present invention;

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Fig. 19 is a perspective view of a rotating member of the mounting section of the mounting apparatus of the first embodiment of the present invention;

Fig. 20 is a perspective view of an insertion
5 claw of the mounting section of the mounting apparatus of the first embodiment of the present invention;

Fig. 21 is an exploded perspective view of the insertion claw of the mounting section of the mounting apparatus of the first embodiment of the present invention;

10 Fig. 22 is a plan view of the insertion claw of the mounting section of the mounting apparatus of the first embodiment of the present invention;

Fig. 23 is a plan view of the insertion claw of the mounting section of the mounting apparatus of the first
15 embodiment of the present invention;

Fig. 24 is an operation explanatory view of the mounting section of the mounting apparatus of the first embodiment of the present invention;

Fig. 25 is an operation explanatory view of the
20 mounting section of the mounting apparatus of the first embodiment of the present invention;

Fig. 26 is a partial sectional view showing a component insertion state by the mounting section of the mounting apparatus of the first embodiment of the present
25 invention;

Fig. 27 is a partial sectional view showing a component insertion state by the mounting section of the mounting apparatus of the first embodiment of the present invention; and

5 Fig. 28 is a partial sectional view showing a component insertion state by the mounting section of the mounting apparatus of the first embodiment of the present invention.

10 Best Mode for Carrying Out the Invention

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

15 Hereinbelow, a first embodiment of the present invention is described in detail with reference to the accompanying drawings.

(First Embodiment)

20 The mounting apparatus of the first embodiment of the present invention is explained below with reference to the accompanying drawings.

As shown in Fig. 1, under control by a control section 2, electronic components 3 are fed in a direction of arrow A by an electronic component feed section 1, in
25 which a multiplicity of electronic components are stored in

a linear array and which is capable of feeding the electronic components independently of one another, and then a plurality of conveyor members 5 arranged in a stringed annular shape on a belt 4 as an example of the electronic component feed section are made to hold the components 3. The components 3 are fed in a state that the components 3 are fitted to a paper tape 3A or the like, and the electronic component feed section 1 also has a function of cutting the paper tape to separate the electronic components 3 into individual pieces. This electronic component feed section 1 and the conveyor members 5 constitute an example of the electronic component feeding unit.

A conveyor member 5 is so designed that a pair of chucks are opened and closed to hold a plurality of lead wires 6 of the component 3. A belt 4 is stretched via pulleys 7, 8, 9 so as to form a generally triangular shape, and the conveyor members 5 are fitted to this belt 4 at equal intervals. By instructions of the control section 2, the belt 4 is turned normally in a direction of arrow B by a belt drive unit 10 composed of a motor and a motor driver or the like that is a drive control device for the motor, and rotating cams 11, 12, 13 are intermittently rotated via pulleys 15, 16 and power transmission units 17, 18 such as gear mechanisms by a rotating-cam drive unit 14 composed of

a motor and a motor driver or the like that is a drive control device for the motor, where each one rotation of the rotating cams causes the conveyor members 5 to move by one conveyor-member shift. When a component 3 held by each
5 conveyor member 5 has come to a position where the component is to be transferred from the conveyor member 5 to a transfer unit 19, the transfer unit 19 grasps the plurality of lead wires 6 of the component 3 held by the conveyor member 5, where the conveyor member 5 is opened,
10 and the transfer unit 19 transfers the plurality of lead wires 6 of the component 3 to a mounting section 20. This sequence of operations are performed by making use of a driving force based on the rotational operation of the rotating cam 12. The mounting section 20 performs the
15 steps of: holding the plurality of lead wires 6 of the component 3; moving down; inserting the plurality of lead wires 6 into a plurality of insertion holes 22 of a board 21, respectively; releasing the plurality of lead wires 6; and moving up, thus the component 3 being mounted on the
20 board 21. This sequence of operations are performed by making use of a driving force based on the rotational operation of the rotating cam 11. This board 21 is held by an X-Y table 25 as shown in Fig. 9, which is an example of the board holding section and which is capable of moving
25 the circuit board 21 in X-Y directions that are two

directions orthogonal to each other and extending along the mounting surface of the circuit board 21. Further, the circuit board 21 is positioned by an X-direction drive unit 23 which is composed of a motor and a motor driver or the like that is a drive control device for the motor and which drives and controls the X-direction move of the board, as well as by a Y-direction drive unit 24 which is composed of a motor and a motor driver or the like that is a drive control device for the motor and which drives and controls the Y-direction move of the board, by means of the X-Y table 25. It is noted that a lead-wire support member (anvil mechanism) 26, which is located below the plurality of insertion holes 22 provided in the board 21, is moved up and down so as to receive the plurality of lead wires 6 of the component 3, and then performs the cutting of the plurality of lead wires 6 and the clinching of the plurality of lead wires 6 with the board 21, thus the mounting of the component 3 onto the board 21 being completed, where the up-and-down move of the lead-wire support member 26 is effected by the rotating cam 13. These rotating cams 11, 12, 13 are rotated by the rotating-cam drive unit 14. That is, the motive power of this rotating-cam drive unit 14 is transmitted to the pulleys 15, 16, and thereafter the respective rotating cams 11, 12, 13 are rotationally driven via the power transmission units 17,

18.

In addition, the drive units 10, 23, 24 are so designed as to intermittently operate when located at certain predetermined rotational positions, i.e. rotational
5 angles, of the rotating cams 11, 12, 13 connected to the drive unit 14 via mechanical mechanism.

This is an example of the process for mounting the component 3 onto the board 21.

Now described in detail is the component
10 insertion operation, as well as the mechanism therefor, which is performed by making use of the driving force based on the rotational operation of the rotating cam 11 that is rotated by the rotating-cam drive unit 14.

Fig. 17 shows the mounting section (mounting
15 head) 20. This mounting section 20 includes: a head body 80 having an L-shaped-in-cross-section side wall 80a and a top face 80b; an up-down moving unit 81 for the head body 80; an insertion claw 68 provided in a lower portion of the head body 80; an opening/closing unit 82 for the insertion
20 claw 68; and a pivoting unit 83 toward back and forth directions of the insertion claw 68, where a cam plate 84 forming the pivoting unit 83 is removably fitted to the head body 80. The up-down moving unit 81 is constituted of an outer shaft 81a fitted to the top face 80b of the head
25 body 80, and the cam plate 84 is removably fitted by means

of a screw 81d to a fitting portion 81c fitted to a lower portion of a core shaft 81b which is provided within the outer shaft 81a to transmit the rotational power of the rotating cam 11.

5 Next, the pivoting unit 83 is constructed as follows. This pivoting unit 83, as shown in Figs. 17 and 18, has a pivot shaft 83a pivotally held at two through holes A provided in the side wall 80a of the head body 80.

10 In a right-side portion of this pivot shaft 83a in Fig. 17, an opening/closing lever 85, which is an example of the drive lever shown also in Fig. 20, is fixedly integrated, while a spring lever 86 of Fig. 17 is fixedly integrated on the left-end side.

15 Further, rearward of this opening/closing lever 85 is provided a U-shaped pivot member 87. A right side wall 87a on the right side of this pivot member 87 passes through an opening 81e of the side wall 80a of the head body 80 so as to plunge toward the head body 80 side as shown in Fig. 17, while a left side wall 87b protrudes
20 forward outside the head body 80, in which state the right-and-left side walls 80b, 80a are pivotably held to the pivot shaft 83a by through holes B.

25 Also, the pivot member 87 has a lever 87c that protrudes forward from outside of the side wall 87b as shown in Fig. 19, and a tip end of the lever 87c makes

contact with a lower-end contact portion 80c of the head body 80, by which the pivot member 87 is prevented from pivoting forward further (more than the state of Fig. 17).

Furthermore, an upper end of a first insertion
5 claw 68a is fixed to a bottom wall 87d of the pivot member 87 by means of an unshown fixture as shown in Figs. 17 and 20.

Also, the first insertion claw 68a and a second
insertion claw 68b are overlapped each other, while a
10 middle portion of the second insertion claw 68b is pivotally held to the middle portion of the first insertion claw 68a by a pin 88. By overlapping the first, second insertion claws 68a, 68b each other, the structure can be made more compact, and besides, higher positional accuracy
15 between the first, second insertion claws 68a, 68b can be obtained more easily, thereby allowing higher reliability of operation to be obtained.

Further, each three, totally six pinching claws
89 to 91, 92 to 94 are formed on the tip end side of the
20 first, second insertion claws as shown in Fig. 21. Even if the component 3 is one having three lead terminals 6 as shown in Figs. 22 and 23, those terminals 6 can be pinched securely by the pinching claws 89 to 94 as shown in Figs. 22 and 23. Still more, since the lead terminals 6 are
25 pinched by the pinching claws 89 to 91, 92 to 94 of the

first, second insertion claws 68a, 68b, respectively, there occurs no variations in pitch between the lead terminals 6, so that the mounting operation can be achieved smoothly.

Now, a cam follower 95 is rotatably provided at an upper end of the second insertion claw 68b as shown in Fig. 20. This cam follower 95 is in contact with a left-end cam surface 96 of the opening/closing lever 85.

In addition, as shown in Fig. 20, a cam follower 97 at a right end of the opening/closing lever 85 is in contact with a cam surface 98 of a cam plate 84.

Then, with this construction, as shown in Fig. 17, a spring 101 is stretched between a pin 99 of the spring lever 86 and a pin 100 of the contact portion 80c of the head body 80, and a spring 104 is stretched between a pin 102 of the pivot member 87 and a pin 103 of the contact portion 80c, where tensile force is applied to each of the springs. Further, a spring 105 is provided between the lever 87c and an upper portion of the second insertion claw 68b, where a repulsive force is applied to the spring.

Next, operation is explained. First, as shown in Fig. 24, at an upward place, a component 3 is transferred to the insertion claw 68 by a transfer chuck 69 of the component transfer unit 19.

In this operation, the first, second insertion claws 68a, 68b have to be opened as shown in Fig. 22. For

this purpose, the core shaft 81b is pushed down by the rotational power of the rotating cam 11, by which the opening/closing lever 85 is pushed down by the cam plate 84.

As a result of this, the cam surface 96 of the opening/closing lever 85 is pivoted backward, by which the frontage of the cam surface 96 comes to confront the cam follower 95 placed at the upper end of the second insertion claw 68b. Thus, the upper portion of the second insertion claw 68b is pushed rightward of Figs. 17 and 20 by the repulsive force of the spring 105.

Then, as a result, the first, second insertion claws 68a, 68b are opened as shown in Fig. 22, in which state the transfer of the component 3 from the transfer chuck 69 is carried out.

Next, the core shaft 81b is moved up for the closing of the first, second insertion claws 68a, 68b, by which the lead terminals (lead wires) 6 are pinched by the pinching claws 89 to 94 as shown in Fig. 23, where the holding of the component 3 is carried out as shown in Fig. 10.

Next, the outer shaft 81a and the core shaft 81b are synchronously moved down, by which the head body 80 is lowered to the board 21 as shown in Fig. 25, where the plurality of lead terminals 6 are inserted into the plurality of insertion holes 22 of the board 21 of Fig. 26.

At this point, under the board 21, a receiving pin 108 that has been moved up is awaiting the move-down of the lead terminals 6. In the state that the lead terminals 6 have been inserted into the plurality of insertion holes 22 like this, a pusher 109 provided coaxially within the core shaft 81b has been pushed down so as to be in contact with the upper end of the component 3, by which the component 3 has its upper and lower ends pinched by the pusher 109 and the receiving pin 108.

Fig. 11 shows a state that the core shaft 81b has been pushed down so that the first, second insertion claws 68a, 68b are opened as shown in Fig. 22. In this state, since the component 3 has its upper and lower ends pinched by the pusher 109 and the receiving pin 108 as shown in Fig. 26, the component 3 is never tilted down even if the first, second insertion claws 68a, 68b are opened.

In this state, first, the insertion claw 68 escapes outward of the component 3 as shown in Fig. 27. Upon completion of this escape, the pusher 109 and the receiving pin 108 start to move down, so that the component 3 has its lower end eventually brought into contact with the top face of the board 21 as shown in Figs. 12 and 28. Next, with the top face of the component 3 pressed by the pusher 109, the receiving pin 108 is moved down as shown in Fig. 28, and thereafter the lower ends of the plurality of

lead terminals 6 are cut and clinched by the lead-wire support member (anvil mechanism) 26. Thus, the mounting of the component 3 is completed.

Figs. 5A and 5B are timing charts, respectively,
5 of mounting operation of the mounting apparatus of the first embodiment of the present invention. In Figs. 5A and 5B, the term "cam power" refers to a driving force of the rotating-cam drive unit 14. The term "insertion head up-and-down rotating cam" refers to the mounting section up-and-down rotating cam 11 for moving up and down the
10 mounting section 20. The term, pusher up-and-down rotating cam, refers to a pusher up-and-down rotating cam (not shown) for moving up and down the pusher 109. The term "X-Y table" refers to the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25. Further, in
15 the figure, reference character (a) shows the state of component insertion start operation of Fig. 10, (b) shows the state of component insertion operation of Fig. 11, (c) shows the state of component insertion completion of Fig. 12, and (d) shows the state of move-up operation after
20 component insertion of Fig. 13.

In the following description of operation, first, since the driving state of the rotating-cam drive unit 14 needs to be changed in response to the distance between
25 mounting positions for successive component mounting

operations on the board 21 of the X-Y table 25, the operation description is parted by a criterion, whether or not the distance is not more than 30 mm, as an example.

First described is a case, as shown in Fig. 5A, where the distance between mounting positions for successive component mounting operations on the board 21 of the X-Y table 25 is not more than 30 mm, i.e., where the time for moving the board 21 by the X-Y table 25 is shorter than the move-down and -up time of the insertion head and the pusher 109.

Referring to Fig. 5A, while the rotation angle of each rotating cam changes from 0 to 180 degrees, then returns again to 0 degrees, and further via 180 degrees, returns to 0 degrees, the rotating-cam drive unit 14 normally continues rotating at, for example, 3000 rpm, continuously outputting the cam power. The speed waveform of the rotating-cam drive unit 14 in this case is shown in Fig. 6.

First, during the period in which the rotation angle of each rotating cam is in the range of 0 to around 90 degrees, the insertion head is positionally held at the upper-end position by the insertion head up-and-down rotating cam as shown by (a) of Fig. 5A and Fig. 10, and moreover the pusher 109 is also positionally held at the upper-end position by the pusher-109-up-and-down rotating

cam. In this case, the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25 are rotationally driven at 3000 rpm, which is a maximum speed, to make the drive control so that the succeeding mounting position of the board 21 held on the X-Y table 25 comes to under the insertion head.

When the rotation angle of each rotating cam becomes around 90 degrees, the insertion head starts to be moved down from the upper-end position toward the lower-end position by the insertion head up-and-down rotating cam, and moreover the pusher 109 also starts to be moved down from the upper-end position toward the lower-end position by the pusher 109 up-and-down rotating cam. At this point, the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25 enter a deceleration operation.

When the rotation angle of each rotating cam becomes around 180 degrees, the succeeding mounting position of the board 21 is positioned under the insertion head by the drive of the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25, where the drive of the X-direction drive unit 23 and the Y-direction drive unit 24 is halted. At this point, the insertion head continues to be moved down from the upper-end position toward the lower-end position by the insertion head up-and-down rotating cam, and moreover the pusher 109 also

continues to be moved down from the upper-end position toward the lower-end position by the pusher 109 up-and-down rotating cam.

When the rotation angle of each rotating cam becomes beyond 180 degrees, the insertion head reaches the lower-end position and is once stopped from moving down by the rotation of the insertion head up-and-down rotating cam 12, and after maintaining the halt state during several degrees of rotation angle of each rotating cam, starts to move up, as shown by (b) of Fig. 5A and Fig. 11. In this operation, as shown by (c) of Fig. 5A and Fig. 12, the pusher 109 also reaches the lower-end position with a slight delay behind the insertion head by the pusher 109 up-and-down rotating cam, but immediately starts to move up. In this case, the drive of the X-direction drive unit 23 and the Y-direction drive unit 24 is kept halted.

During the period in which the rotation angle of each rotating cam is around 180 degrees and up to 270 degrees after the passage of the angle, the plurality of lead terminals 6 of the component 3 held by the insertion head start to be inserted and completely inserted by press of the pusher 109 into the plurality of insertion holes 22 of specified mounting positions of the board 21 held on the drive-halted X-Y table 25, and then the lead terminals 6 are further cut and clinched by the anvil mechanism 26.

Thus, the mounting of the component 3 onto the board 21 is completed.

When the rotation angle of each rotating cam becomes around 270 degrees, the insertion head is positionally held at the upper-end position again by the insertion head up-and-down rotating cam as shown by (d) of Fig. 5A and Fig. 13.

When the rotation angle of each rotating cam becomes over 270 degrees and around 360 degrees (i.e., 0 degrees), the pusher 109 is also positionally held at the upper-end position again by the pusher 109 up-and-down rotating cam. In this case, the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25 are rotationally driven at 3000 rpm, which is the maximum speed, to make the drive control so that the succeeding mounting position of the board 21 held on the X-Y table 25 comes to under the insertion head. The drive start, driving, and drive halt of the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25 are performed when the insertion head is positioned at the upper-end position or its proximity and moreover the pusher 109 is also positioned at the upper-end position or its proximity.

When the distance between mounting positions for successive component mounting operations on the board 21 of the X-Y table 25 is not more than 30 mm, the above-

described steps are iterated in principle.

However, when the distance between mounting positions for successive component mounting operations on the board 21 of the X-Y table 25 is over 30 mm and, for example, 100 mm, steps to be performed are as shown in Fig. 5B (see step S20 of Fig. 14; it is decided whether or not the move amount of the board 21 by the drive of the X-direction drive unit 23 or the Y-direction drive unit 24 is over 30 mm. Only when the move amount is over 30 mm, steps S21 to S23 are performed; when the move amount is not over 30 mm, the steps S21 to S23 are not performed).

More specifically, the time for moving the board 21 by the X-Y table 25 becomes longer than the move-down and -up time of the insertion head and the pusher 109, so that operation allocation time and halt allocation time increase. That is, referring to Fig. 5A, assuming that the period in which the rotation angle of each rotating cam changes from 0 to 180 degrees and then returns again to 0 degrees is set as one operation allocation period, positions of 180 degrees and 0 degrees in the second operation allocation period correspond to positions of 180 degrees and 0 degrees of the first operation allocation period of Fig. 5B. This means that the operation allocation period in Fig. 5B becomes a double of the operation allocation period in Fig. 5A.

While the rotation angle of each rotating cam progresses from 0 to 180 degrees in the first operation allocation period in Fig. 5B, the rotating-cam drive unit 14 is decelerated, for example, from 3000 rpm to 0 rpm in consideration of the drive time of the X-Y table 25 for the board 21 as described later (see step S21 in Fig. 14; the rotating-cam drive unit 14 is decelerated. This deceleration operation is performed until the drive of the X-direction drive unit 23 or the Y-direction drive unit 24 is completed at step S22 of Fig. 14). Then, the rotating-cam drive unit 14, after once halted with the rotation angle of each rotating cam in proximity to 90 degrees, is immediately accelerated to 3000 rpm to output the cam power so that 3000 rpm is maintained during the period from around 180 degrees to 360 degrees (0 degrees).

While the rotation angle of each rotating cam is within a range of 0 to 180 degrees, the insertion head is positionally held at the upper-end position by the insertion head up-and-down rotating cam, and moreover the pusher 109 is also positionally held at the upper-end position by the pusher 109 up-and-down rotating cam, as shown in Fig. 10. In the period in which the rotation angle of each rotating cam is within the range of 0 to 90 degrees, the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25 are rotationally driven

at 3000 rpm, which is the maximum speed, to make the drive control so that the succeeding mounting position of the board 21 held on the X-Y table 25 is positioned under the insertion head. When the rotation angle of each rotating
5 cam becomes at around 90 degrees, the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25 are decelerated so as to be stopped from being driven.

When the rotation angle of each rotating cam becomes around 180 degrees, the insertion head starts to be
10 moved down from the upper-end position toward the lower-end position by the insertion head up-and-down rotating cam, and moreover the pusher 109 also starts to be moved down from the upper-end position to the lower-end position by the pusher 109 up-and-down rotating cam.

15 When the rotation angle of each rotating cam becomes over 180 degrees, the insertion head reaches the lower-end position and is once stopped from moving down by the rotation of the insertion head up-and-down rotating cam 12, and after maintaining the halt state during several
20 degrees of rotation angle of each rotating cam, starts to move up, as shown in Fig. 11. In this operation, as shown in Fig. 12, the pusher 109 also reaches the lower-end position with a slight delay behind the insertion head by the pusher 109 up-and-down rotating cam, but immediately
25 starts to move up. In this case, the drive of the X-

direction drive unit 23 and the Y-direction drive unit 24 is kept halted.

During the period in which the rotation angle of each rotating cam is around 180 degrees and up to 270
5 degrees after the passage of the angle, the plurality of lead terminals 6 of the component 3 held by the insertion head start to be inserted and completely inserted by press of the pusher 109 into the plurality of insertion holes 22 of specified mounting positions of the board 21 held on the
10 drive-halted X-Y table 25, and then the lead terminals 6 are further cut and clinched by the anvil mechanism 26. Thus, the mounting of the component 3 onto the board 21 is completed.

When the rotation angle of each rotating cam
15 becomes around 270 degrees, the insertion head is positionally held at the upper-end position again by the insertion head up-and-down rotating cam as shown in Fig. 13.

When the rotation angle of each rotating cam becomes over 270 degrees and around 360 degrees (i.e., 0
20 degrees), the pusher 109 is also positionally held at the upper-end position again by the pusher 109 up-and-down rotating cam. In this case, the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25 are accelerated from the halt state so as to be rotationally
25 driven at 3000 rpm, which is the maximum speed, (see step

S23 of Fig. 14; the rotating-cam drive unit 14 is driven for acceleration) to make the drive control so that the succeeding mounting position of the board 21 held on the X-Y table 25 comes to under the insertion head. The drive start, driving, and drive halt of the X-direction drive unit 23 and the Y-direction drive unit 24 of the X-Y table 25 are performed when the insertion head is positioned at the upper-end position or its proximity and moreover the pusher 109 is also positioned at the upper-end position or its proximity.

As described above, the drive operation of each drive member largely differs between the case where the distance between mounting positions for successive component mounting operations on the board 21 of the X-Y table 25 is not more than 30 mm, and the case where the distance is over 30 mm, e.g. 100 mm.

The reason of this is explained based on Fig. 7. Fig. 7 is a graph showing a relationship between speed and time for presenting a speed waveform of the rotating-cam drive unit 14, where the move amount of the X-Y table 25 is over 30 mm.

A graph in which a down is depicted by solid line and an up is depicted by dotted line shows a state that given a move amount of 95 mm of the X-Y table 25, the speed is reduced from 3000 rpm and, without a halt once at around

0 rpm, changed from deceleration to acceleration. In this state, the rotating-cam drive unit 14 is not so much loaded.

A graph in which a down is depicted by solid line and an up is depicted by solid line shows a state that
5 given a move amount of 100 mm of the X-Y table 25, the speed is reduced from 3000 rpm and, after a halt once, and immediately accelerated. In this state, the rotating-cam drive unit 14 is much loaded.

A graph in which a down is depicted by solid line
10 and an up is depicted by one-dot chain line shows a state that given a move amount of 105 mm of the X-Y table 25, the speed is reduced from 3000 rpm and, with a slight halt at around 0 rpm, and thereafter changed to acceleration. In this state, the rotating-cam drive unit 14 is not so much
15 loaded.

Accordingly, it is when the move amount of the X-Y table 25 is 100 mm that the rotating-cam drive unit 14 is most loaded. That is, the rotating-cam drive unit 14 is most loaded when the rotating-cam drive unit 14 is driven
20 for deceleration and, with a halt once, immediately driven for acceleration. Iterating such an operation would involve a continued state in which effective torque over 110% of the rated torque is necessary, where abrupt temperature increases would occur in the drive units 10, 14,
25 23, 24, which would cause failures. The present embodiment

is intended to prevent the failures of the rotating-cam drive unit 14 without halting the operation, in the case where such an overload state of the rotating-cam drive unit 14 continuously keeps, by reducing the load against such an overload-state operation, for example, as in the state shown by dotted line, before occurrence of any failure of the rotating-cam drive unit 14. However, whereas the move amount of 100 mm causes the most overload-acting state in the above example, the distance varies in many ways due to various factors such as the characteristics of the rotating-cam drive unit 14, the structure, material, and thermal resistance of other devices and mechanisms, the cooling function, and the like. A distance of 90 mm can be the distance at which overload acts most for one rotating-cam drive unit 14, while a distance of 110 mm can be the distance at which overload acts most for another rotating-cam drive unit 14. Therefore, in summary, in this embodiment, since the overload acts most when the drive unit targeted for detection of effective torque is operated so as to be decelerated, halted once, and then immediately accelerated, and since failures more likely take place when such an overload state occurs in succession to a certain number of times (i.e., which could be called number of successive overload operations that induce failures; the number differs depending on the characteristics of the

drive unit or its use environment), the drive unit is so designed that when overload-state operations are performed to a specified number of times (i.e., permissible number of successive overload operations) smaller than the above
5 certain number of times, similar overload-state operations are not performed any more and, instead, the operation is continued with a sufficiently light load state without any halt of operation, by which considerable reduction of production efficiency (i.e., reduction of production
10 efficiency due to a halt of the drive unit) is prevented.

In the mounting apparatus of such a constitution, an effective torque detecting section 27 determines effective torque for operation of each of the drive units 10, 14, 23, 24 (at least rotating-cam drive unit 14) on a
15 basis of an effective torque detection period (a specified period unit which is the period for detecting effective torque periodically), and informs an effective torque deciding section 28 of detection results on the detection-period basis. That is, the effective torque detecting
20 section 27 determines an effective value of a specified period that is the detection period from a torque of which is informed by a torque detector contained in or fitted to each of the drive units 10, 14, 23, 24 and which is needed (e.g., within a specified time) by each of the drive units
25 10, 14, 23, 24, and then informs the effective torque

deciding section 28 of the effective value determined for each of the drive units 10, 14, 23, 24. The specified period as the detection period is usually set to not more than 1 sec., and the period for detecting an effective torque and informing the effective torque deciding section 28 of the effective torque is set also to not more than 1 sec. Thus, detecting the effective torque at such a short period of not more than 1 sec. makes it possible to detect the effective torque reliably even with load changes due to any abnormalities.

Although it is convenient that the detection period is constant at all times, yet without being limited to this, the detection period may be set more rough for periods immediately after the start-up of drive units 38, 39, 40, 41, i.e., periods in which the temperature of the drive units 38, 39, 40, 41 has not increased so much against the ambient temperature so that an abrupt temperature increase immediately causing a failure does not occur even with the effective torque over the upper-limit value.

Also, setting all or some of detection periods of the drive units 10, 14, 23, 24 coincident with one another makes it possible to provide a simpler, more convenient structure. However, without being limited to this, the detection period may differ among the drive units 10, 14,

23, 24 in consideration of the motor type and the level of load application.

The effective torque deciding section 28 decides whether or not an effective torque of any one of the drive units 10, 14, 23, 24 has exceeded a specified upper-limit value, based on results from the effective torque detecting section 27, and then informs the control section 2 of the decision result. For example, when the effective torque of any one of the drive units has exceeded the specified upper-limit value, the control section 2 controls the drive of the one of the drive units so that the drive unit is decelerated to a specified rotational speed. In this case, if necessary, the other drive units may also be drive-controlled appropriately in accordance with the above drive control of the any one drive unit.

The specified upper-limit value for each drive unit is ordinarily set to a value that is 105% of the rated torque of each drive unit 10, 14, 23, 24. This value is one corresponding to the permissible number of successive overload operations in continuously performing the overload operation that the drive units 10, 14, 23, 24 are decelerated, once halted and then immediately accelerated. The drive units 10, 14, 23, 24 are ordinarily presumed to be used at 100% or lower of the rated torque. In particular, in a continued state that an effective torque

over 110% of the rated torque is needed, there would occur an abrupt temperature increase to the drive units 10, 14, 23, 24, causing failures. The setting of the upper-limit value to 105% of the rated torque makes it possible to prevent the abrupt temperature increase.

The upper-limit values for the drive units 10, 14, 23, 24 have been set to 105% of the their rated torques for convenience' sake. However, without being limited to this, the upper-limit values of effective torques may differ among the drive units 10, 14, 23, 24 in consideration of the type and thermal characteristics of the motor.

After the any one drive unit has been decelerated to the specified rotational speed, the any one drive unit is accelerated to the original rotational speed at a time point when the effective torque for the any one drive unit has recovered to a specified lower-limit value, i.e., a safety value.

This safety value is ordinarily set to a value that is 95% of the rated torque. In this connection, although the safety value may be set to 100% of the rated torque, yet there is no margin to the 105% of the rated torque, which is the upper-limit value, so that the effective torque may go beyond the upper-limit value immediately when the original rotational speed has been restored. Such a state, if continued, would cause

occurrence of a case where the temperature would not lower at the drive units 10, 14, 23, 24. Furthermore, the frequency of deceleration and acceleration of the rotational speed would increase, there is a fear that the machine productivity would lower, conversely. Thus, the appropriate value for the safety value is 95% of the rated torque.

In addition, the respective safety values for the drive units 10, 14, 23, 24 are not limited to 95% of their respective rated torques, and the specified safety values may differ among the drive units 10, 14, 23, 24 in consideration of the type, thermal characteristics, and the like of the motor.

This operation is explained with reference to Fig. 2.

Based on results of which the effective torque detecting section 27 has informed the effective torque deciding section 28, at decision step S29, it is decided by the effective torque deciding section 28 whether or not any one of the effective torques has exceeded its specified upper-limit value. These specified upper-limit values are ordinarily set to values that are 105% of the rated torques of the drive units 10, 14, 23, 24, as described above.

For instance, if the effective torque of any one of the drive units 10, 14, 23, 24 has exceeded its

specified upper-limit value, then, at processing step S30, the effective torque deciding section 28 informs the control section 2 of a deceleration to a specified speed that is slower than the rotational speed at which the any one drive unit is currently running and, then, under the control of the control section 2, the rotational speed of the any one drive unit is decelerated to the lower-limit value, i.e. safety value. This safety value is ordinarily set to a value that is 95% of the rated torque as described above.

The drive units 10, 23, 24 are respectively so designed as to intermittently operate at certain predetermined rotational positions, i.e. rotation angles, of the rotating cams 11, 12, 13 each connected to the rotating-cam drive unit 14 via a mechanical mechanism. Therefore, decelerating the rotating-cam drive unit 14 causes the operation allocation time and the halt allocation time of the drive units 10, 23, 24 to increase. Thus, it becomes possible to make the effective torque to lower.

At decision step S31, it is decided whether or not the any one drive unit whose rotational speed had been decelerated has recovered to the safety value.

At decision step S32, if the effective torque deciding section 28 decides that the effective torque of

the any one drive unit has recovered to the safety value,
the effective torque deciding section 28 informs the
control section 2 to accelerate the any one drive unit to
the original rotational speed, and the any one drive unit
5 is accelerated by the control section 2.

Meanwhile, at decision step S33, it is decided
whether or not a specified time or more has elapsed since
the any one drive unit was decelerated in rotational speed.
If the specified time or more has elapsed, the any one
10 drive unit as well as the other drive units are halted at
processing step S34, on the decision that some other
abnormality has occurred at the any one drive unit.

In addition, also when the drive units 10, 14, 23,
24 are each composed of a servomotor and a drive control
15 device, those drive units can be controlled by the control
section 2 with the same constitution.

Further, also when the drive units 10, 14, 23, 24
are each composed of a motor controlled by an inverter and
a drive control device, those drive units can be controlled
20 by the control section 2 with the same constitution.

Furthermore, also when the drive units 10, 14, 23,
24 are each composed of a stepping motor and a drive
control device, those drive units can be controlled by the
control section 2 with the same constitution.

25 (Second Embodiment)

Next, the mounting apparatus according to the second embodiment of the present invention is described with reference to Fig. 3.

As shown in Fig. 3, a first-order lag filter
5 section 35 as an example of detection error eliminating means is added to the above-described mounting apparatus of the first embodiment.

The first-order lag filter section 35, with the time constant set to T , receives a value of effective
10 torque from an effective torque detecting section 36 (equivalent to the effective torque detecting section 27), and outputs the result to an effective torque deciding section 37 (equivalent to the effective torque deciding section 28).

15 The temperatures of the drive units 38, 39, 40, 41 increase in first-order lag fashions with respect to the effective torques. If the effective torque has exceeded the upper-limit value and the temperature increase lasts, the drive units 38, 39, 40, 41 would lead to a failure.
20 However, immediately after the start-up of the drive units 38, 39, 40, 41, i.e., in periods in which the temperature of the drive units has not increased so much against the ambient temperature, an abrupt temperature increase immediately causing a failure does not occur even with the
25 effective torque over the upper-limit value. Meanwhile,

since the effective torque, which is within a specified period, may exceed the upper-limit value for the effective torque even immediately after the start-up, the drive units 38, 39, 40, 41, in such a case, might be decelerated due to the excess of the effective-torque upper-limit value even without temperature increase, which could cause the productivity to deteriorate. Therefore, the effective torque is passed through the first-order lag filter section 35, and the effective torque deciding section 37 is informed of the result, thus making it possible to eliminate the deceleration of the rotational speed of the drive units 38, 39, 40, 41 immediately after the start-up, and to prevent the productivity deterioration.

More specifically, as shown in Fig. 8, at step S1, it is decided by the first-order lag filter section 35 whether or not 5 min. has elapsed after the start-up of the drive units 38, 39, 40, 41. If 5 min. has not elapsed, effective torques obtained by the effective torque detecting section 27 are neglected until 5 min. elapses. After the elapse of 5 min., an effective torque obtained by the effective torque detecting section 27 is treated as an effective one by the first-order lag filter section 35.

Furthermore, it may be considered additionally whether or not 30 min. or more has elapsed since the last halt until the current start-up. That is, with the

mounting apparatus in operation, and with the drive units 38, 39, 40, 41 kept continuously driven, when the drive units 38, 39, 40, 41, after once halted due to some trouble, are started up again after a time elapse of less than 30 min., the drive units 38, 39, 40, 41 may hold the temperature-increased state in some cases. In such a case, it may be preferable not that effective torques obtained by the effective torque detecting section 27 are neglected by the first-order lag filter section 35 until 5 min. elapses, but that an effective torque is treated as an effective one by the first-order lag filter section 35 even if 5 min. has not elapsed. Therefore, the processing flow may also be done in the following manner. That is, prior to step S1, it is decided by the first-order lag filter section 35 whether or not 30 min. or more has elapsed since the last halt until the current start-up. Then, if 30 min. or more has elapsed, the step S1 is executed, while if 30 min. or more has not elapsed, the processing flow may jump to the step S2 in Fig. 8 (step S29 in Fig. 2) without executing the step S1.

Further, a detection error eliminating operation as shown in the steps S2 and following in Fig. 8 may be executed by the first-order lag filter section 35. In the following example, it is assumed that counters C1 and C2 are provided for each of the drive units 10, 14, 23, 24.

That is, at step S2, it is decided by the first-order lag filter section 35 (or effective torque deciding section 28) whether or not an effective torque of any one of the drive units 10, 14, 23, 24 has exceeded its specified upper-limit value (e.g., a value of 105% of the rated torque).

If the effective torque of any one of the drive units has exceeded its specified upper-limit value at step S2, then the counter C1 corresponding to the relevant drive unit is incremented by one at step S6, and thereafter it is decided at step S7 whether or not the counter C1 counts larger than 3. This means that when the excess of the effective torque over its specified upper-limit value is an unusual error temporarily caused from some reason, this error is eliminated. That is, more specifically, only when the excess of the effective torque over its specified upper-limit value has succeeded more than three times, the effective torque is treated as an effective one. This number of times, three times, is given above only as an example, and it may be given by an arbitrary number smaller than the number of times that causes the relevant drive unit to lead to a failure.

If the counter C1 counts not more than 3 at step S7, the timer is set to the period of detection period, for example, 1 sec. at step S10, and then it is decided at step

S11 whether or not 1 sec. has elapsed, where only if 1 sec. has elapsed at step S11, the processing flow returns to step S2.

5 If the counter C1 is larger than 3 at step S7, the counter C2 corresponding to the drive unit that has exceeded the upper-limit value is cleared at step S8, and then it is decided at step S9 whether or not the counter C1 corresponding to the drive unit that has exceeded the upper-limit value counts larger than 30. If the counter C1
10 counts larger than 30 at step S9, the processing flow goes to processing step S30. If the counter C1 counts not more than 30 at step S9, the processing flow goes to step S10.

Meanwhile, if an effective torque of any one of the drive units 10, 14, 23, 24 is not more than its
15 specified upper-limit value at step S2, then the counter C2 corresponding to the drive unit is incremented by one at step S3, and thereafter it is decided at step S4 whether or not the counter C2 counts larger than 3. This means that when the non-excess of the effective torque over its
20 specified upper-limit value is an unusual error temporarily caused from some reason, this error is eliminated. That is, more specifically, only when the non-excess of the effective torque over its specified upper-limit value has succeeded more than three times, the effective torque is
25 treated as an effective one. This number of times, three

times, is given above only as an example, and it may be given by an arbitrary number smaller than the number of times that causes the relevant drive unit to lead to a failure.

5 If the counter C2 is larger than 3 at step S4, the counter C1 corresponding to the drive unit that has counted not more than the upper-limit value is cleared at step S5, and then the processing flow goes to step S10.

10 If the counter C2 counts not more than 3 at step S4, the processing flow returns to step S2.

 Through these steps, in deciding as to whether or not the effective torque of any one of the drive units 10, 14, 23, 24 exceeds its specified upper-limit value, not that the decision is made for every one time of comparison results of effective torques against the upper-limit value, 15 but that the decision can be made as an effective one only when the same results have succeeded to a plurality of times or a specified number of times, so that detection errors can be eliminated and more accurate decision can be 20 achieved. Accordingly, it never occurs that unnecessary deceleration operations are performed due to detection errors, and any unintentional deterioration of production efficiency can be prevented, so that unnecessary deterioration of productivity can be prevented reliably. 25 On the other hand, the deceleration operation can be

performed only when properly necessary, so that drive control of the drive units can be achieved appropriately.

In addition, this Fig. 8, without being limited to applications to the upper-limit value, may also be applied to the lower-limit value, which is the safety value, in the same manner, thereby eliminating the possibility that the drive units might be mis-driven due to detection errors even without enough temperature decrease, so that any unintentional deterioration of the production efficiency can be prevented and unnecessary deterioration of productivity can be prevented reliably. On the other hand, the acceleration operation can be performed only when properly necessary, so that drive control of the drive units can be achieved appropriately.

Further, in the cases where the drive units 38, 39, 40, 41 are each composed of a servomotor and a drive control device, and where those are each composed of a motor controlled by an inverter and a drive control device, since the temperature increase characteristics are empirically approximated to a case where the time constant T of the first-order lag filter section 35 is set to 100 sec., setting the time constant to 100 sec. allows further working effects to be produced.

(Third Embodiment)

Next, the mounting apparatus according to the

third embodiment of the present invention is described with reference to Fig. 4.

As shown in Fig. 4, in this embodiment, an input section 42 is added to the mounting apparatus of the foregoing first embodiment so that data input is enabled.

In this embodiment, when a deceleration of the rotational speed is performed to a specified rotational speed when an effective torque of drive units 43, 44, 45, 46 has exceeded an upper-limit value, this embodiment is enabled to input the specified rotational speed from external via the input section 42.

This specified rotational speed is determined depending on use environment, machine structure (type of machine), the way of use of the drive units, and rotational speeds required for the drive units.

Accordingly, there is a need for setting specified rotational speeds for the drive units 43, 44, 45, 46, respectively, according to the place of use and the purpose of application.

The setting can be easily achieved by virtue of the provision of the input section 42 even with the presence of a plurality of drive units 43, 44, 45, 46.

In addition, when the input section 42 is implemented by an operation panel, it becomes possible to directly input specified rotational speeds, i.e., to do the

input so as to change the deceleration speed value that is the specified safety value, the lower-limit value or upper-limit value of the counter C1 or C2 of the first-order filter section 35, and the like in consideration of use
5 environment, machine type or characteristic, or the like, of course, in consideration of use environment, machine type or characteristic, or the like, it is possible to do input so as to change the upper-limit value of the effective torque.

10 Further, when the input section 42 is implemented by a floppy disk, it is possible to input rotational speeds and the like.

 Further, when the input section 42 is implemented by an interface which allows data to be inputted from a
15 higher-order computer, it becomes possible similarly to input rotational speeds and the like from the high-order computer.

 In addition, the case is the same also when the input section 42 is provided in the second embodiment of
20 the present invention.

 According to this embodiment, the mounting apparatus comprises: an effective torque detecting section 27, 36 for detecting an effective torque required by at least one rotating-cam drive unit 14 among the plurality of
25 drive units 10, 14, 23, 24 at an effective-torque detection

cycle; an effective torque deciding section 28, 37 for deciding whether or not the detected effective torque has exceeded its upper-limit value, or whether or not the effective torque has been restored from the excess state to its safety value; a detection error eliminating means 35 for deciding whether or not the effective torque detected by the effective torque detecting section 27, 36 is a detection error, before a decision made by the effective torque deciding section 28, 37, to assign the effective torque, which has been decided as a non detection error, to an object for the decision by the effective torque deciding section 28, 37; and a control section 2 for performing control of each of the electronic component feeding unit, the board holding section, the mounting section 20, the plurality of drive units, the effective torque detecting section 27, 36, the effective torque deciding section 28, 37, and the detection error eliminating means 35, wherein the control section 2 performs control operation so that if the detected effective torque has been decided by the detection error eliminating means 35 as a non detection error and moreover decided by the effective torque deciding section 28, 37 as having exceeded the upper-limit value, then an original rotational speed of the rotating-cam drive unit 14 from which the effective torque has been detected is decelerated to a specified deceleration speed of the

relevant rotating-cam drive unit 14, and further if the effective torque of the rotating-cam drive unit 14 detected by the effective torque detecting section 27, 36 has been decided by the effective torque deciding section 28, 37 as having lowered not more than its safety value, the rotating-cam drive unit 14 is restored again to the original rotational speed. As a result, it becomes possible to suppress temperature increases of the rotating-cam drive unit 14 that would occur due to the deceleration of the rotational speed of the rotating-cam drive unit 14 to the specified deceleration speed when the effective torque, which is a non detection error, has exceeded the upper-limit value. Thus, failures of the rotating-cam drive unit 14 due to temperature increases can be prevented, allowing the operation to go on without halting the machine. Further, when the effective torque has lowered to not more than a specified safety value, the rotational speed is restored again to the original rotational speed, thus making it possible to high-efficiency production to be carried out without incurring failures of the rotating-cam drive unit 14 and without unnecessarily halting the machine. Furthermore, by making a decision as to the upper limit of an effective torque that has been decided by the detection error eliminating means 35 as a non detection error, it becomes possible to eliminate any detection error and make

a decision in accordance with the temperature increase curve of the rotating-cam drive unit 14, thus making it possible, for example, to lower the frequency of rotational-speed deceleration for the rotating-cam drive unit 14 immediately after the start-up of the drive unit.

It is noted here that the significance of applying this embodiment to the rotating-cam drive unit 14 is as follows. Under the condition that, on the board 21, the distance between a current-time mounting position where one component has been inserted and mounted and a next component mounting position is so large that a large move amount of the board 21 by the X-Y table 25 is involved in driving the X-Y table 25 until the next component mounting position comes to be positioned under the mounting section 20, it is necessary to temporarily halt the drive of the rotating-cam drive unit 14 until the move of the X-Y table 25 is halted. When the drive is resumed several seconds after the halt, there does not act so much load on the rotating-cam drive unit 14. However, when the drive is resumed 1 to 2 seconds after, there acts a large load on the rotating-cam drive unit 14 such that a load causing the effective torque to go over 105% is liable to be applied. Such a state, if continued more than the permissible number of successive overload operations, e.g. about 30 times, would cause the rotating-cam drive unit 14 to incur

considerable heat generation, resulting in a failure such as a halt or runaway of the drive of the rotating-cam drive unit 14. To preliminarily prevent this, when the permissible number of successive overload operations has
5 been reached, further continued overload operation afterwards is prohibited, and the operation mode is forcibly switched to a light-load state operation. By doing so, such failures are prevented while a complete halt of the operation is prevented so that the necessary minimum
10 production efficiency is maintained.

It is noted that the present invention is not limited to the above embodiments, and may further be embodied in other various ways.

For instance, although the present invention has
15 been described above about those drive units 10, 14, 23, 24, yet the present invention may be applied to at least one drive unit, for example, the rotating-cam drive unit 14 at the least.

Also, the present invention may be applied not
20 only to such a mounting apparatus shown in Fig. 1 but also to such mounting apparatuses of other types as shown in Figs. 15 and 16.

For instance, Fig. 15 is a perspective view of the X-Y orthogonal type mounting apparatus according to the
25 fourth embodiment of the present invention. This X-Y

orthogonal type mounting apparatus comprises: a board holding section 226 composed of a pair of rails for holding a board 21; an X-axis direction drive unit 223 composed of a pair of motors for driving a pair of X-axis direction screw shafts 224 into synchronous rotation to parallelly
5 move a Y-axis drive member 225 along an X axis; a Y-axis direction drive unit 221 implemented by a self-propelled motor or the like for a Y-axis direction screw shaft 222 fixed to the Y-axis drive member 225; and a mounting
10 section 220 implemented by a suction nozzle held on the Y-axis direction drive unit 221, wherein a component 3A fed from a component feed cassette or tray or the like is sucked and held by the mounting section 220 and mounted onto the board 21. In the X-Y orthogonal type mounting
15 apparatus as shown above, the present invention may be applied to any one of the X-axis direction drive unit 223, the Y-axis direction drive unit 221, and an up-down drive device such as an up-down drive motor and the like for moving up and down the nozzle of the mounting section 220.

20 Fig. 16 is a perspective view of the rotary type mounting apparatus according to the fifth embodiment of the present invention. This rotary type mounting apparatus comprises: an X-Y table 231 having an X-direction drive unit 231x and a Y-direction drive unit 231y; a multiplicity
25 of component suction nozzles 233 constituting a mounting

section; a rotating member 232 on which the multiplicity of component suction nozzles 233 are arranged circumferentially; a rotating-member drive unit 235 implemented by a motor or the like for intermittently driving the rotating member 232 into rotation; and a transfer mechanism 234 for transferring a rotational force of the rotating-member drive unit 235 to the rotating member 232 and moreover moving up and down the component suction nozzles 233 at component mounting positions, wherein the respective component suction nozzles 233 are positioned to at least component sucking positions and component mounting positions for the board 21 by the intermittent rotation of the rotating member 232, where component suction and component mounting are performed. In such a rotary type mounting apparatus, the present invention may be applied to any one of the X-direction drive unit 231x, the Y-direction drive unit 231y, and the rotating-member drive unit 235.

Furthermore, combining any arbitrary embodiments together appropriately from among the foregoing various embodiments allows their respective effects to be produced.

According to the present invention, the mounting apparatus comprising: an effective torque detecting section for detecting an effective torque required by at least one drive unit among the plurality of drive units at an

effective-torque detection cycle; an effective torque deciding section for deciding whether or not the detected effective torque has exceeded its upper-limit value, or whether or not the effective torque has been restored from the excess state to its safety value; a detection error eliminating means for deciding whether or not the effective torque detected by the effective torque detecting section is a detection error, before a decision made by the effective torque deciding section, to assign the effective torque, which has been decided as a non detection error, to an object for the decision by the effective torque deciding section; and a control section for performing control of each of the electronic component feeding unit, the board holding section, the mounting section, the plurality of drive units, the effective torque detecting section, the effective torque deciding section, and the detection error eliminating means, wherein the control section performs control operation so that if the detected effective torque has been decided by the detection error eliminating means as a non detection error and moreover decided by the effective torque deciding section as having exceeded the upper-limit value, then an original rotational speed of the drive unit from which the effective torque has been detected is decelerated to a specified deceleration speed of the relevant drive unit, and if the effective torque of

the drive unit detected by the effective torque detecting section has lowered to not more than its safety value, the drive unit is restored again to the original rotational speed. As a result of this, it becomes possible to suppress temperature increases of the drive unit that would occur due to the deceleration of the rotational speed of the drive unit to the specified deceleration speed when the effective torque, which is a non detection error, has exceeded the upper-limit value. Thus, failures of the drive unit due to temperature increases can be prevented, allowing the operation to go on without halting the machine. Further, when the effective torque has lowered to not more than a specified safety value, the rotational speed is restored again to the original rotational speed, thus making it possible to high-efficiency production to be carried out without incurring failures of the drive unit and without unnecessarily halting the machine. Furthermore, by making a decision as to the upper limit of an effective torque after the processing by the detection error eliminating means, it becomes possible to eliminate any detection error and make a decision in accordance with the temperature increase curve of the drive unit, thus making it possible, for example, to lower the frequency of rotational-speed deceleration for the drive unit immediately after the start-up of the drive unit.

The invention described in the second aspect of the present invention is a mounting apparatus defined in the first aspect, wherein each of the electronic components is an electronic component having lead wires. In a mounting apparatus for mounting the electronic components 5 equipped with leads, it becomes possible to suppress temperature increases of the drive unit that would occur due to the excess of the effective torque over the specified upper-limit value. Thus, failures of the drive 10 unit due to temperature increases can be prevented, allowing the operation to go on without halting the machine.

The invention described in the third aspect of the present invention is a mounting apparatus as defined in the first or second aspect, wherein the electronic 15 component feeding unit comprises: an electronic component feed section for storing therein a multiplicity of electronic components and feeding the electronic components independently of one another; a plurality of conveyor members for taking out the fed electronic components and 20 then conveying the electronic components to the mounting section; and a conveying section for moving the plurality of conveying members as the conveying members are arranged in a stringed annular shape. By these plurality of conveying members and the conveying section, in the 25 mounting apparatus in which the components are conveyed, it

becomes possible to suppress temperature increases of the drive unit that would occur due to the excess of the effective torque over the specified upper-limit value. Thus, failures of the drive unit due to temperature
5 increases can be prevented, allowing the operation to go on without halting the machine.

The invention described in the fourth aspect of the present invention is a mounting apparatus as defined in the any one of the first to third aspects, wherein the
10 upper-limit value of the effective torque in the effective torque deciding section is set to 105% of a rated torque of the drive unit. By the upper limit set to 105% of the rated torque, it becomes possible to suppress temperature increases of the drive unit even with the load varied more
15 or less.

The invention described in the fifth aspect of the present invention is a mounting apparatus as defined in any one of the first to fourth aspects, wherein in the effective torque deciding section, the safety value of the
20 effective torque that allows the drive unit to be restored to the original rotational speed is set to 95% of the rated torque of the drive unit. By the safety value set to 95% of the rated torque of the drive unit, it becomes possible to suppress the deceleration of the rotational speed of the
25 drive unit to a minimum.

The invention described in the sixth aspect of the present invention is a mounting apparatus as defined in any one of the first to fifth aspects, wherein the detection period of the effective torque detecting section for detection of the effective torque required in a specified unit time of the drive unit is set to not more than 1 sec. By the detection period set to not more than 1 sec., it becomes possible to detect the effective torque also when an abrupt load change has occurred.

10 The invention described in the seventh aspect of the present invention is a mounting apparatus as defined in any one of the first to sixth aspects, wherein the control section performs control so that if the effective torque does not become lower than the specified upper-limit value even if the rotational speed of the drive unit is decelerated, the drive unit is halted. Thus, it becomes possible to suppress damage of the machine to a minimum even when the drive unit has incurred a mechanically unrotatable state.

20 The invention described in the eighth aspect of the present invention is a mounting apparatus as defined in any one of the first to seventh aspects, wherein the drive unit comprises a servomotor and a drive control device for controlling drive of the servomotor. By the drive unit comprising the servomotor and the drive control device, it

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becomes possible to perform high-speed, high-precision positional control.

The invention described in the ninth aspect of the present invention is a mounting apparatus as defined in
5 any one of the first to seventh aspects, wherein the drive unit comprises a motor controlled by an inverter and a drive control device for controlling drive of the motor. By the drive unit comprising the inverter-controlled motor and the drive control device, it becomes possible to
10 perform positional control with simplicity and low cost.

The invention described in the tenth aspect of the present invention is a mounting apparatus as defined in any one of the first to seventh aspects, wherein the drive unit comprises the stepping motor and the drive control
15 device for controlling drive of the stepping motor. By the drive unit comprising a stepping motor and a drive control device, it becomes possible to perform positional control with low cost and simplicity.

The invention described in the eleventh aspect of the present invention is a mounting apparatus as defined in
20 the tenth aspect, wherein a time constant of the detection error eliminating means is set to 100 sec. By the setting to 100 sec., it becomes possible to detect the effective torque approximate to the actual temperature increase curve
25 of the drive unit.

The invention described in the twelfth aspect of the present invention is a mounting apparatus as defined in any one of the first to eleventh aspects, further comprising an input section by which a set value of the deceleration speed for the rotational speed of the drive unit in the deceleration operation can be inputted from external of the mounting apparatus. Thus, the set value of the deceleration speed can be easily changed when the load is changed.

10 The invention described in the thirteenth aspect of the present invention is a mounting apparatus as defined in the twelfth aspect, wherein the input section is an operation panel. Thus, it becomes possible to determine the rotational speed while the machine is being adjusted.

15 The invention described in the fourteenth aspect of the present invention is a mounting apparatus as defined in the twelfth aspect, wherein the input section is a floppy disk drive. When a multiplicity of similar mounting apparatuses are used, it becomes possible to set the rotational speed without errors even if the operator has no knowledge as to the rotational-speed setting.

20 The invention described in the fifteenth aspect of the present invention is a mounting apparatus as defined in the twelfth aspect, wherein the input section is an interface which allows data to be inputted from a higher-

25

order computer. Thus, it becomes possible to collectively manage rotational-speed set values by the higher-order computer.

The mounting apparatus described in the sixteenth and seventeenth aspects of the present invention is a mounting apparatus as defined in any one of the first to fifteenth aspects, wherein in a case where the effective torque detected by the effective torque detecting section is decided by the effective torque deciding section as having exceeded the upper-limit value, or as being not more than the upper-limit value, the detection error eliminating means decides that the effective torque detected by the effective torque detecting section is a non detection error only when the same decision result has succeeded to a specified number of times, and the detection error eliminating means decides that the effective torque detected by the effective torque detecting section is a detection error, when the same decision result does not succeed to the specified number of times. In this case, it becomes possible to eliminate detection errors with reliability, allowing required operations to be carried out as truly required.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is

to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended
5 claims unless they depart therefrom.

CLAIMS

1. A mounting apparatus comprising:

an electronic component feeding unit (1, 4, 5)
for feeding a plurality of electronic components (3);

5 a board holding section (25) serving for holding
a circuit board (21), onto which the electronic components
are to be mounted, and being capable of moving the circuit
board in orthogonal two directions along a mounting
surface;

10 a mounting section (20) for mounting the
electronic components fed from the electronic component
feeding unit onto the circuit board held by the board
holding section;

a plurality of drive units (10, 14, 23, 24) for
15 driving the electronic component feeding unit, the board
holding section, and the mounting section, respectively;

an effective torque detecting section (27, 36)
for detecting an effective torque required by at least one
drive unit among the plurality of drive units at an
20 effective-torque detection cycle;

an effective torque deciding section (28, 37) for
deciding whether or not the detected effective torque has
exceeded its upper-limit value, or whether or not the
effective torque has been restored from the excess state to
25 its safety value;

a detection error eliminating means (35) for deciding whether or not the effective torque detected by the effective torque detecting section is a detection error, before a decision made by the effective torque deciding section, to assign the effective torque, which has been
5 decided as a non detection error, to an object for the decision by the effective torque deciding section; and

a control section (2) for performing control of each of the electronic component feeding unit, the board
10 holding section, the mounting section, the plurality of drive units, the effective torque detecting section, the effective torque deciding section, and the detection error eliminating means,

wherein the control section performs control
15 operation so that if the detected effective torque has been decided by the detection error eliminating means as a non detection error and moreover decided by the effective torque deciding section as having exceeded the upper-limit value, then an original rotational speed of the drive unit
20 from which the effective torque has been detected is decelerated to a specified deceleration speed of the relevant drive unit, and if the effective torque of the drive unit detected by the effective torque detecting section has lowered to not more than its safety value, the
25 drive unit is restored again to the original rotational

speed.

2. The mounting apparatus according to Claim 1, wherein each of the electronic components (3) is an electronic component (3) having a lead wire (6).

5 3. The mounting apparatus according to Claim 1, wherein the electronic component feeding unit (1, 4, 5) comprises: an electronic component feed section (1) for storing therein a multiplicity of electronic components and feeding the electronic components independently of one
10 another; a plurality of conveyor members (5) for taking out the fed electronic components and conveying the electronic components to the mounting section; and a conveying section (4) for moving the plurality of conveying members as the conveying members are arranged in a stringed annular shape.

15 4. The mounting apparatus according to Claim 1, wherein the upper-limit value of the effective torque in the effective torque deciding section is set to 105% of a rated torque of the drive unit corresponding to a permissible number of successive overload operations in
20 continuously performing an overload operation that the drive unit is decelerated, once halted and then immediately accelerated.

5. The mounting apparatus according to Claim 4, wherein in the effective torque deciding section, the
25 safety value of the effective torque that allows the drive

unit to be restored to the original rotational speed is set to 95% of the rated torque of the drive unit.

6. The mounting apparatus according to any one of Claims 1 to 4, wherein the detection period of the effective torque detecting section for detection of the effective torque required in a specified unit time of the drive unit is set to not more than 1 sec.

7. The mounting apparatus according to Claim 6, wherein the control section performs control so that if the effective torque does not become lower than the specified upper-limit value even if the rotational speed of the drive unit is decelerated, the drive unit is halted.

8. The mounting apparatus according to Claim 7, wherein the drive unit comprises a servomotor and a drive control device for controlling drive of the servomotor.

9. The mounting apparatus according to Claim 7, wherein the drive unit comprises a motor controlled by an inverter and a drive control device for controlling drive of the motor.

10. The mounting apparatus according to Claim 7, wherein the drive unit comprises a stepping motor and a drive control device for controlling drive of the stepping motor.

11. The mounting apparatus according to Claim 7, wherein a time constant of the detection error eliminating

means is set to 100 sec.

12. The mounting apparatus according to Claim 7,
further comprising an input section (42) by which a set
value of the deceleration speed for the rotational speed of
5 the drive unit in the deceleration operation can be
inputted from external of the mounting apparatus.

13. The mounting apparatus according to Claim 12,
wherein the input section is an operation panel.

14. The mounting apparatus according to Claim 12,
10 wherein the input section is a floppy disk drive.

15. The mounting apparatus according to Claim 12,
wherein the input section is an interface which allows data
to be inputted from a higher-order computer.

16. The mounting apparatus according to Claim 1,
15 wherein if the effective torque detected by the effective
torque detecting section is decided by the effective torque
deciding section as having exceeded the upper-limit value,
then the detection error eliminating means (35) decides
that the effective torque detected by the effective torque
20 detecting section is a non detection error only when the
same decision result has succeeded to a specified number of
times, and the detection error eliminating means (35)
decides that the effective torque detected by the effective
torque detecting section is a detection error, and neglects
25 the effective torque, when the same decision result does

not succeed to the specified number of times.

17. The mounting apparatus according to Claim 1 or 16, wherein if the effective torque detected by the effective torque detecting section is decided by the effective torque deciding section as being not more than the upper-limit value, then the detection error eliminating means (35) decides that the effective torque detected by the effective torque detecting section is a non detection error only when the same decision result has succeeded to a specified number of times, and the detection error eliminating means (35) decides that the effective torque detected by the effective torque detecting section is a detection error, and neglects the effective torque, when the same decision result does not succeed to the specified number of times.