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

(11) **EP 1 227 711 B9**

(12) **CORRECTED EUROPEAN PATENT SPECIFICATION**
Note: Bibliography reflects the latest situation

(15) Correction information:
Corrected version no 1 (W1 B1)
Corrections, see
Drawings
Drawing(s) deleted

(48) Corrigendum issued on:
19.03.2008 Bulletin 2008/12

(45) Date of publication and mention of the grant of the patent:
18.07.2007 Bulletin 2007/29

(21) Application number: **00962845.4**

(22) Date of filing: **26.09.2000**

(51) Int Cl.:
H05K 13/04 *(2006.01)*

(86) International application number:
PCT/JP2000/006598

(87) International publication number:
WO 2001/024598 (05.04.2001 Gazette 2001/14)

(54) COMPONENT MOUNTING METHOD AND COMPONENT MOUNTING APPARATUS

BAUTEILBESTUCKUNGSVERFAHREN UND -EINRICHTUNG

PROCEDE ET DISPOSITIF DE MONTAGE DE COMPOSANTS

(84) Designated Contracting States:
DE GB

(30) Priority: **27.09.1999 JP 27311199**
22.09.2000 JP 2000288806

(43) Date of publication of application:
31.07.2002 Bulletin 2002/31

(60) Divisional application:
07009527.8 / 1 816 906

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Description

Technical Field

[0001] The present invention relates to a component mounting method and a component mounting apparatus according to claims 1 and 2, which are used for manufacturing circuit boards by placing a multiplicity of components onto a plurality of sub-boards defining a multiple board.

Background Art

[0002] In recent years, needs for mounting apparatus for electronic components have been changing from rotary type high-speed mounters to robot type mounters that can flexibly be adapted to various forms of production, in terms of area productivity and component adaptability. Under such circumstances, for more improvement in productivity, those mounting apparatuses of which the number of placement heads to be mounted on one robot has evolved from one to pluralities and in which the suction nozzle to be used for each placement head is removable and interchangeable have been forming a mainstream.

[0003] In this type of electronic component mounting apparatus, there are some cases to use a so-called multiple board which is prepared by providing a plurality of circuits having an identical pattern on one circuit board, mounting a plurality of electronic components onto this circuit board, and thereafter cutting the board according to individual circuit patterns so that a plurality of sub-boards having an identical circuit pattern are fabricated. It is noted that such a multiple board herein refers to a multiple board composed of a plurality of sub-boards in this DESCRIPTION.

[0004] The following methods are available as example of the prior art for placing electronic components onto such a multiple board composed of a plurality of sub-boards:

(1) A step repeat method including the steps of applying a step of placing particular components (hereinafter, referred to as placement step) to all the sub-boards, and after the completion of the placement step, moving to the next placement step; and

(2) A pattern repeat method including the steps of performing all the placement steps for one sub-board, and after the completion of all the placement steps, moving to the placement on the next sub-board.

[0005] Both of these step repeat and pattern repeat methods have been widely used since preparing only an NC program as a mounting program for only one sub-board makes it possible to develop the program for all components to be mounted on the circuit board by setting relative distances to other sub-boards.

[0006] The component mounting method for this multiple board is described below.

[0007] Fig. 7 shows a mounting procedure by the conventional step repeat method. Fig. 11 sequentially shows this placement procedure through.component placement steps with an electronic component mounting apparatus having four placement heads (placement head Nos. 1 - 4) connected to one another.

[0008] In Fig. 11, the column "STEP NO." shows numbers sequentially assigned to steps of placement, where it is assumed that steps corresponding to the number of placement heads are involved in one-cycle operation from suction to placing of components by the four connected placement heads. The column "SUB-BOARD" shows, by numbers of sub-boards, on which sub-board on the circuit board a component is to be placed. The column "COMPONENT" shows components to be placed at respective steps. The column "PLACEMENT HEAD NO." shows placement heads to be used at individual steps. The column "SUCTION NOZZLE" shows which type of suction nozzle is used at individual steps. The type of suction nozzle to be used depends on the configuration and size of a component, where suction nozzles come in S (small), M (medium), and L (large) sizes. It is assumed here, as an example, that small-size components are sucked by the S-size suction nozzle, medium-size components are sucked by the M-size suction nozzle, and large-size components are sucked by the L-size suction nozzle. If there are some placement heads that do not suck any component in one-cycle operation, the placement head actually does not suck and place any component, and so the fields of component and suction nozzle are marked with "-" in Fig. 11.

[0009] As shown in Fig. 11, in this placement procedure, components of the same type are placed for individual patterns in an order of a chip component C1 of a first pattern to C5 of a second pattern to C9 of a third pattern, ..., and upon completion of one placement step, the working step moves to a placement step for the next same type of chip components C2, C6, and C10. This placement step is performed for all components. It is noted that the suction nozzle is changed from S size for small-size components to M size for medium-size components after the placement of the chip component C12 of the third pattern, and changed from M size for medium-size components to L size for large-size components after the placement of SOP1 - SOP3 (where "SOP" is an abbreviation of Small Outline Package).

[0010] Next, the conventional pattern repeat mounting method is described.

[0011] Fig. 12 shows a mounting procedure according to the conventional pattern repeat method. Fig. 13 shows this

sequential placement procedure through electronic-component placement steps with an electronic component mounting apparatus having four placement heads (placement head Nos. 1 - 4).

[0012] In this placement procedure, as shown in Fig. 13, after all the placement steps for the first pattern are completed in the order of chip components C1 - C4, SOP1, and QFP1 of the first pattern (where "QFP" is an abbreviation of Quad Flat Package), the working step moves to the placement for the second pattern. Then, upon the completion of the placement for the second pattern, the working step moves to the placement for the third pattern. It is noted that the changing of suction nozzles is done respectively after the completion of the placement for one kind of components of each pattern. In the case of Fig. 19, the changing of suction nozzles is done three times for each pattern, totally eight times (the last one time is unnecessary).

[0013] However, in the case of the step repeat method, since only one among the four suction nozzles is used at all times, component suction and component placement are repetitively performed for every one component, causing the mounting time to be prolonged. Thus, the mounting method does not take full advantage of a multiple-head construction having a plurality of suction nozzles, resulting in an inefficient mounting method.

[0014] On the other hand, in the case of the pattern repeat method, since the changing of suction nozzles is frequently done, the mounting time would be prolonged each time the time-consuming nozzle changing work is done to a plurality of times. Thus, the method results in an inefficient mounting method.

[0015] Applying such a mounting method to recently increasing large-scale multiple boards composed of, for example, 50 - 200 boards would cause the mounting apparatus to operate quite tediously. Since such an inefficient mounting method can hardly achieve any improvement in process time, there has been a keen desire for mounting methods of higher efficiency.

[0016] International patent application WO 99-31948 discloses a component placement system which has a pair of gantry-beams each supporting six placement heads and a camera on the opposite side. All are independently driven by linear motors. The six heads pick six components simultaneously according to a programmed picking configuration. Each beam is coupled to fixed rails by couplers and the linear motors are controlled to skew the beam. This allows the heads to move two-dimensionally with respect to each other for simultaneously placement.

[0017] Moreover, Japanese patent application having the publication number 64-47100 discloses a component mounting system for mounting electronic components on a plurality of sub-boards defining a multiple board.

[0018] The present invention having been achieved in view of these and other issues, an object of the present invention is to provide a component mounting method and a component mounting apparatus which allows the mounting time to be shortened by reducing such a suction preparation operation for suction nozzles as suppressing the changing frequency of the suction nozzles in the process of component mounting onto the multiple board.

Disclosure Of Invention

[0019] In order to achieve the above object, the present invention has the following constitution.

[0020] According to a first aspect of the present invention, there is provided a component mounting method as defined by the features of claim 1.

[0021] According to a further aspect of the present invention, there is provided a component mounting apparatus as defined by the features of claim 2.

Brief Description Of Drawings

[0022] 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 perspective view of a component mounting apparatus as a first embodiment of the present invention;
Fig. 2 is an enlarged perspective view of a transfer head of the component mounting apparatus;
Fig. 3 is a schematic plan view of the electronic component mounting apparatus;
Fig. 4 is a view showing an order of placement by a task repeat method in an example of a multiple board composed of three sub-boards having an identical pattern;
Fig. 5 is a view sequentially showing placement steps by the task repeat method;
Fig. 6 is a view showing a multiple board having totally 16 sub-boards, longitudinally 4 $\times$ laterally 4;
Fig. 7 is a view showing an order of placement by an improved step repeat method in an example of a multiple board composed of three sub-boards having an identical pattern;
Fig. 8 is a view sequentially showing placement steps by the improved step repeat method;
Fig. 9 is a view showing an order of placement by a reversal method in an example of a multiple board composed of three sub-boards having an identical pattern;
Fig. 10 is a view sequentially showing placement steps by the reversal method;

Fig. 11 is a view sequentially showing placement steps by the conventional step repeat method;
Fig. 12 is a view showing an order of placement by a conventional pattern repeat method in an example of a multiple board composed of three sub-boards having an identical pattern;
Fig. 13 is a view sequentially showing placement steps by the conventional pattern repeat method;
Figs. 14A, 14B, 14C, and 14D are views showing respective states of component placement operation by suction nozzles by a vertical motion of the suction nozzles; and
Fig. 15 is a block diagram related to the control section of the electronic component mounting apparatus according to the foregoing embodiment of the present invention.

Best Mode for Carrying Out the Invention

[0023] 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.

[0024] Hereinbelow, preferred embodiments of the present invention are described in detail with reference to the drawings.

[0025] Fig. 1 is a perspective view of an electronic component mounting apparatus which is an example of the component mounting apparatus as an embodiment of the present invention, Fig. 2 is an enlarged perspective view of a transfer head of the electronic component mounting apparatus according to Fig. 1, and Fig. 3 is a schematic plan view of the electronic component mounting apparatus.

[0026] First, construction of an electronic component mounting apparatus 100 of the embodiment is described.

[0027] As shown in Fig. 1, a pair of guide rails 14 for a circuit board 12 are provided at each of a loader section 16, a board holding section 18, and an unloader section 20 in the top center of a base 10 of the electronic component mounting apparatus 100. By synchronously driving transfer belts provided to these each-one pairs of guide rails 14, respectively, the circuit board 12 is transferred from the pair of guide rails 14 of the loader section 16 on one end side to the pair of guide rails 14 of the board holding section 18 located at a position where components, e.g., electronic components are mounted, and further from the pair of guide rails 14 of the board holding section 18 to the pair of guide rails 14 of the unloader section 20 on the other side. The board holding section 18 positions and holds the transferred-up circuit board 12, preparing for component mounting.

[0028] Y-axis robots 22, 24 are provided at both side portions, respectively, of the top surface of the base 10 upward of the circuit board 12, and an X-axis robot 26 is suspended between these two Y-axis robots 22, 24, where the X-axis robot 26 is advanceable and retreatable in a Y-axis direction by the drive of the Y-axis robots 22, 24. Also, a transfer head 28 is attached to the X-axis robot 26 so as to be advanceable and retreatable in an X-axis direction, which arrangement makes the transfer head 28 movable within an X-Y plane. In each of the robots, for example, ball screws are rotated forward and reverse by motors, and nut members screwed with the ball screws are advanceable and retreatable in their respective axial directions, where members to be advanced and retreated are fixed to the nut members.

[0029] The transfer head 28, which is mounted on the X-Y robot (one example of the transfer-head moving device) composed of the X-axis robot 26 and the Y-axis robots 22, 24 and which freely moves on the X-Y plane (e.g., a horizontal plane or a plane generally parallel to the top surface of the base 10), is so constructed that desired electronic components are sucked by suction nozzles 34 from a plurality of component feeders 30 as an example of the component feed section for feeding such electronic components as resistor chips or chip capacitors, or from a component tray 32 as another example of the component feed section for feeding such relatively large-size electronic components as ICs such as SOPs or QFPs or connectors, and that the sucked electronic components can be placed to component placing positions on the circuit board 12. Such an electronic-component mounting operation is controlled by a control section 52 of Fig. 15 according to a mounting program stored and preset in a storage section 1001.

[0030] These component feeders 30 and component tray 32 correspond to an example of the component feed sections, where the array interval of components in the component feed sections refers to a distance between component feed ports of adjoining component feeders 30 in the case of the component feeders 30, or to a distance between accommodation recessed portions for accommodating the components in the component tray 32 in the case of the component tray 32.

[0031] The component feeders 30 are arrayed in a multiplicity on both sides (upper right side and lower left side in Fig. 1) in the transfer direction of the pair of guide rails 14. In each of the component feeders 30, are attached taped component rolls on which a multiplicity of electronic components such as resistor chips or chip capacitors are accommodated.

[0032] The component tray 32 can accommodate totally two trays 32a which are longitudinal along a direction perpendicular to the board transfer direction of the pair of guide rails 14. Each tray 32a slides toward the pair of guide rails 14 according to the number of fed components so that the component takeout position in the Y direction is maintained at a constant position. On these trays 32a are placed a multiplicity of QFPs or other electronic components.

[0033] At a side portion of the circuit board 12 positioned to the pair of guide rails 14, is provided a recognition device

36 for detecting any two-dimensional positional shift (suction posture) of electronic components sucked by the suction nozzles 34 and allowing a correction on the transfer head 28 side so that this positional shift is canceled.

[0034] The transfer head 28, as shown in Fig. 2, is provided as a multiple head in which a plurality (four in the first embodiment) of placement heads (first placement head 38a, second placement head 38b, third placement head 38c, fourth placement head 38d) as an example of the component holding devices are laterally connected together. The four placement heads 38a, 38b, 38c, 38d are of the same construction, each placement head having a suction nozzle 34, an actuator 40 for driving the suction nozzle 34 into vertical (up-and-down) operation, and a pulley 46. Forward-and-reverse rotation driving force of a θ-rotation motor 42a is transmitted to the pulley 46 of the first placement head 38a and the pulley 46 of the third placement head 38c by a timing belt 44, so that the suction nozzles 34 of both placement heads are put into θ-rotation (rotation around the axis of the suction nozzles 34) simultaneously. Also, forward-and-reverse rotation driving force of a θ-rotation motor 42b is transmitted to the pulley 46 of the second placement head 38b and the pulley 46 of the fourth placement head 38d by a timing belt 44, so that the suction nozzles 34 of both placement heads are put into θ-rotation simultaneously. Each actuator 40 is given by, for example, an air cylinder, and turning on and off the air cylinder to move the suction nozzle 34 vertically, or up and down, makes it possible to perform component holding or component mounting operation selectively. It has been arranged here that power of the θ-rotation motor 42a is transmitted by the timing belt 44, by which the suction nozzles 34 of the placement heads 38a, 38c are put into θ-rotation, respectively, while power of the θ-rotation motor 42b is transmitted by the timing belt 44, by which the suction nozzles of the placement heads 38b, 38d are put into θ-rotation, as shown in Fig. 2. However, such an arrangement is only an example, and it may be arranged that the first placement heads 38a, 38b, 38c, 38d are equipped with θ-rotation driving motors, respectively, that drive those placement heads into θ-rotation individually. However, it is preferable that the number of θ-rotation driving motors that serve for drive into θ-rotation be smaller to reduce the weight of the transfer head 28.

[0035] The suction nozzles 34 of the placement heads are replaceable, and auxiliary suction nozzles for replacement are previously stored in a nozzle stocker 48 on the base 10 of the electronic component mounting apparatus 100. The suction nozzles 34 are provided in, for example, S-size nozzles for sucking very small chip components of about 1.0 × 0.5 mm, M-size nozzles for sucking 18 mm square QFPs, and the like, and put into use according to the type of electronic components to be placed.

[0036] Operation of the electronic component mounting apparatus having the above constitution is described below.

[0037] As shown in Fig. 3, when the circuit board 12 carried in from the loader section 16 of the pair of guide rails 14 is transferred to the board holding section 18, the transfer head 28 is moved laterally, i.e., within the X-Y plane by the X-Y robot to suck up desired electronic components from the component feeders 30 or the component tray 32, then moves to over the posture recognition camera of the recognition device 36, recognizing the suction posture of the electronic components. Then, based on the recognition result, the θ-rotation motor is driven to put the suction nozzles 34 into θ-rotation, thereby making a correction operation for suction posture. Thereafter, the electronic components are placed to the component placing positions on the circuit board 12.

[0038] In suction of electronic components from the component feeders 30 or the component tray 32 by the suction nozzles 34, as well as in placement of electronic components to the component placing positions on the circuit board 12, the placement heads 38a, 38b, 38c, 38d make the suction nozzles 34 moved down by actuation of the actuators 40 from on the X-Y plane in the vertical direction (Z-direction). Also, the placement operation is performed with the suction nozzles 34 replaced, as required, according to the type of the electronic components.

[0039] By repeating the above operation of sucking electronic components and placing them onto the circuit board 12, the mounting of electronic components onto the circuit board 12 is completed. The circuit board 12 over the mounting is carried out from the board holding section 18 to the unloader section 20, while a new circuit board is carried in from loader section 16 to the board holding section 18 and the above operation is repeated.

[0040] It is noted here that mounting operations for electronic components are classified in speed in terms of mounting cycle time, such as high, medium, and low speeds, according to the type (size and weight) of electronic components. This is due to the inertia of electronic components, where the classification is determined depending on the suction force of the suction nozzles 34 and the adhesion of the electronic components with the circuit board. Also, component suction is performed simultaneously by a plurality of placement heads, or component suction is performed with placement head by placement head.

[0041] Next, examples of the electronic component mounting method for multiple boards with the electronic component mounting apparatus according to the embodiment of the present invention is described with reference to Figs. 4 to 10.

(Example 1)

[0042] First, mounting operation by a task repeat method is described as Example 1. The task repeat method refers to a method of repeating to a number of times corresponding to patterns the task of sucking components with a plurality of placement heads all simultaneously, or each individually, and then after recognition, placing all the components held

on the placement heads onto the circuit board 12 simultaneously or individually.

[0043] Fig. 4 shows an example of a multiple board composed of three sub-boards of an identical pattern for explanation's sake, where it is assumed that chip components C1 - C12, SOP1 - SOP3, and QFP1 - QFP3 are to be placed onto the pattern (first, second and third patterns) of each sub-board of this multiple board.

[0044] According to this mounting method, the mounting of the electronic components is carried out in an order of chip components to SOPs to QFPs as shown by arrows in Fig. 4. More specifically, as placement steps are shown sequentially in Fig. 5, the first steps include sucking up the chip component C1 to the first placement head 38a, the chip component C2 to the second placement head 38b, the chip component C3 to the third placement head 38c, and the chip component C4 to the fourth placement head 38d by S-size suction nozzles, respectively, moving the transfer head 28 to the component placing positions for the individual chip components on the sub-board of the first pattern, and placing the chip components C1 - C4 onto the board in this order. Steps following this include sucking up the chip components C5 - C8 by the placement heads 38a - 38d, respectively, moving and placing those components to the component placing positions on the sub-board of the second pattern, and likewise, further sucking up the chip components C9 - C12 to the placement heads 38a - 38d and placing the components to the component placing positions on the sub-board of the third pattern in the similar way.

[0045] Next, for example, with the suction nozzle of the first placement head 38a changed from S to M size (where the placement head may be any other one), SOP1 is sucked up by the first placement head 38a and placed at the component placing position on the sub-board of the first pattern. Next, SOP2 and SOP3 are sucked up successively by the first placement head and placed at the component placing positions on each sub-board in the similar manner.

[0046] Then, with the suction nozzle 34 of the first placement head 38a changed from M to L size, QFPs 1 - 3 are placed at the component placing positions on each sub-board.

[0047] With this task repeat method, in the placing of electronic components onto three sub-boards, suction nozzles are changed only upon transitions from C12 to SOP1 and from SOP3 to QFP1. This minimizes the number of changes of suction nozzles, allowing electronic components to be placed on boards at high efficiency. Thus, a reduction in the electronic-component mounting time can be achieved.

[0048] With this task repeat method, the mounting time for placing electronic components onto a multiple board having, for example, longitudinally 4 $\times$ laterally 4, totally 16 sub-boards as shown in Fig. 6 can be calculated on trial as follows:

Successive placement of four types of chip components:	3 sec. $\times$ 16 patterns = 48 sec.
Nozzle change (S $\rightarrow$ M):	2 sec.
SOP Placement:	1.5 sec. $\times$ 16 patterns = 24 sec.
Nozzle change (M $\rightarrow$ L):	2 sec.
QFP placement:	1.5 sec. $\times$ 16 patterns = 24 sec.
	Total: 100 sec.

(Example 2)

[0049] Next, mounting operation by an improved step repeat method is described as Example 2.

[0050] In this improved step repeat method, the order of mounting of electronic components is similar to that of the conventional step repeat method as shown in Fig. 7, where the mounting is carried out in the order of chip components $\rightarrow$ SOPs $\rightarrow$ QFPs as shown by arrows in Fig. 7. More specifically, as placement steps are shown sequentially in Fig. 8, the first steps include sucking up the chip component C1 to the first placement head 38a, the chip component C5 to the second placement head 38b, and the chip component C9 to the third placement head 38c by S-size suction nozzles, respectively, all simultaneously or each individually, moving the transfer head 28, and placing the chip components C1, C5, C9 onto the respective sub-boards in this order. Similarly, steps following this include sucking up the chip components C2, C6, C10 by the placement heads 38a, 38b, 38c, placing those components onto the respective sub-boards, and further sucking up and placing the chip components C3, C7, C11 and sucking up and placing the chip components C4, C8, C12.

[0051] Next, with the suction nozzle 34 of the first placement head 38a changed from S to M size, SOP1 is sucked up by the suction nozzle 34 of the first placement head 38a and placed at the component placing position on the sub-board of the first pattern. Next, SOP2 is sucked up by the first placement head 38a and placed onto the sub-board of the second pattern, and further SOP3 is sucked up and placed to the sub-board of the third pattern in the similar manner.

[0052] Then, with the suction nozzle 34 of the first placement head 38a changed from M to L size, QFPs 1 - 3 are placed successively onto the respective sub-boards in the similar manner.

[0053] With this improved step repeat method, in the placing of electronic components onto three sub-boards, the number of component suction operations can largely be reduced as compared with the step repeat method that involves one suction operation for each component, allowing electronic components to be placed on boards at high efficiency.

Thus, the mounting time can be shortened.

[0054] With this improved step repeat method, the mounting time for placing electronic components onto a multiple board having longitudinally 4 × laterally 4, totally 16 sub-boards as shown in Fig. 6 in the similar manner can be calculated on trial as follows:

Successive placement of one type of components:	(3 sec. × 4 patterns) × 4 types of components = 48 sec.
Nozzle change (S → M):	2 sec.
SOP placement:	1.5 sec. × 16 patterns = 24 sec.
Nozzle change (M → L):	2 sec.
QFP placement:	1.5 sec. × 16 patterns = 24 sec.
	Total: 100 sec.

(Example 3)

[0055] Next, mounting operation by a reversal method is described as Example 3. The reversal method refers to an improved version of the pattern repeat method, where the order of use of suction nozzles for individual patterns is reversed from the order of use of suction nozzles for one-preceding pattern.

[0056] The order of mounting of components to be mounted according to this reversal method is described with reference to Fig. 9. The order of mounting for individual electronic components includes, as shown by arrows in Fig. 9, placing electronic components onto a sub-board of the first pattern, and then, as the suction nozzle that has been used at the time point of completion of the placement step remains unchanged, beginning a placement step for the second pattern.

[0057] More specifically, as placement steps are shown sequentially in Fig. 10, the first steps include sucking up the chip component C1 by the first placement head 38a, the chip component C2 by the second placement head 38b, the chip component C3 by the third placement head 38c, and the chip component C4 by the fourth placement head 38c by S-size suction nozzles, respectively, moving the transfer head 28 to the component placing positions on the sub-board of the first pattern, and placing the chip components C1 - C4 onto the board in this order. Thereafter, with the suction nozzle 34 of the first placement head 38a changed from S to M size, SOP1 is sucked up by the first placement head 38a and placed at the component placing position on the sub-board of the first pattern. Subsequently, similarly, with the suction nozzle 34 of the first placement head 38a changed from M to L size, QFP1 is placed at the component placing position on the sub-board of the first pattern.

[0058] Next, the placing of electronic components for the sub-board of the second pattern is performed, where while the suction nozzle (L size) for QFP1, which has been the last placed to the sub-board of the first pattern, is used as it is without being changed, QFP2 is first placed onto the sub-board of the second pattern. Upon completion of the placing of QFP2, SOP2 is placed with the suction nozzle changed from L to M size, and further the chip components C5 - C8 are placed with the suction nozzle changed from M to S size.

[0059] Subsequently, for the sub-board of the third pattern, while the S-size suction nozzle is used as it is without being changed in the similar manner, the chip components 9 - 12 are first placed onto the sub-board of the third pattern. Then, SOP3 and QFP3 are placed.

[0060] Carrying out the placing in this way eliminates the need for changing the suction nozzle upon completion of the placing step onto one sub-board, allowing the number of changes of suction nozzles to be largely reduced. Thus, electronic components can be placed onto the board with high efficiency, and the mounting time can be shortened.

[0061] With this reversal method, the mounting time for placing electronic components onto a multiple board having longitudinally 4 × laterally 4, totally 16 sub-boards as shown in Fig. 6 in the similar manner can be calculated on trial as follows:

Successive placement of four types of chip components:	3 sec.
Nozzle change (S → M):	2 sec.
SOP placement:	1.5 sec.
Nozzle change (M → L) :	2 sec.
QFP placement:	1.5 sec.
	Sub-total: 10 sec.
	10 sec. × 16 patterns = 160 sec.
	Total: 160 sec.

(Comparative Example 1)

[0062] For comparison's sake, mounting times by the step repeat method and by the pattern repeat method are given below.

[0063] First, the mounting time by the step repeat method is as follows:

For one type of component:	1.5 sec. × 16 patterns × 6 types of components = 148 sec.
Nozzle change (S → M):	2 sec.
Nozzle change (M → L):	2 sec.
	Total: 152 sec.

(Comparative Example 2)

[0064] Also, the mounting time by the pattern repeat method is as follows:

Successive placement of four types of chip components:	3 sec.
Nozzle change (S → M):	2 sec.
SOP placement:	1.5 sec.
Nozzle change (M → L):	2 sec.
QFP placement:	1.5 sec.
Nozzle change (On → S):	2 sec.
	Sub-total: 12 sec.
	(12 sec. × 16 patterns) - (last nozzle change: 2 sec.) = 190 sec.
	Total: 190 sec.

[0065] Table 1 lists the mounting times by all the individual mounting methods described above. As shown in Table 1, the task repeat method, the improved step repeat method, and the reversal method are capable of largely reducing the number of component suction operations as compared with the step repeat method, and of largely reducing the number of nozzle changes as compared with the pattern repeat method. Further, particularly with the task repeat method and the improved step repeat method, the mounting time can be reduced remarkably, allowing the throughput of equipment to be improved.

[0066] It is noted that the mounting time shown in Table 1 is an example of trial calculation under the above-described conditions, and when the component mounting is performed under other different conditions, there are some cases where more remarkable mounting-time reduction effects can be obtained in the mounting time of the individual Examples as compared with the mounting time of Comparative Examples.

Table 1:

	Mounting method	Number of Component suction operations	Number of times of nozzle change	Mounting time
Example 1	Task repeat	48	2	100 sec.
Example 2	Improved Step repeat	48	2	100 sec.
Example 3	Reversal	48	32	160 sec.
Comparative Example 1	Step repeat	96	2	152 sec.
Comparative Example 2	Pattern repeat	48	47	190 sec.

[0067] According to the component mounting method and the component mounting apparatus of the present invention, in the process of mounting components onto a multiple board,

(1) a change of suction nozzles is done after a placement step of placing onto the board all components that can be held by an identical suction nozzle has been applied to all the sub-boards, which makes it possible to suppress the number of times of change of suction nozzles to a minimum;
(2) after a placement step of placing components onto individual sub-boards successively with components of an identical type held by the suction nozzles, respectively, has been applied to all the sub-boards, the working step moves to the next placement step, which makes it possible to replace an operation of repeating suction and placement component by one component with an operation of previously sucking plural components all at a time and placing the components; and
(3) when the placement of components to one sub-board is completed and succeeded by the placement of components to the next sub-board, the suction nozzle that is the last used for the placement-completed sub-board is used as it is for the next sub-board, which makes it possible to reduce the number of times of change of suction nozzles.
By these methods of (1) to (3), mounting operation can be carried out efficiently so as to be free from any waste. Thus, the component mounting time can be shortened and the throughput of equipment can be improved.

[0068] 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 claims unless they depart therefrom.

Claims

1. A component mounting method adapted for carrying out the mounting of components onto a plurality of sub-boards defining a multiple board, comprising:

   (i) picking up simultaneously or individually components by a plurality of identical nozzles (34) such that said components are held by said suction nozzles (34); and then
   (ii) placing said components onto said multiple board; then changing at least one of said identical suction nozzles (34) with a different suction nozzle (34); and then

   mounting other components onto said multiple board by said different suction nozzle (34) so that a minimum of nozzle changes is achieved.

2. A component mounting apparatus for mounting components onto a plurality of sub-boards defining a multiple board, comprising:

   a placement head (28) having suction nozzles (34),
   a nozzle stocker (48), and
   a control section (52) for controlling the changes of the nozzles (34) according to the method of claim 1.

Patentansprüche

1. Bauteilmontageverfahren, das dafür ausgelegt ist, die Montage von Bauteilen auf mehreren Teil-Leiterplatten, die eine Mehrfachleiterplatte definieren, auszuführen, umfassend:

   (i) gleichzeitiges oder individuelles Aufnehmen von Bauteilen mittels mehrerer identischer Düsen (34), so dass die Bauteile von den Saugdüsen (34) gehalten werden; und anschließend
   (ii) Platzieren der Bauteile auf der Mehrfachleiterplatte; anschließend Austauschen wenigstens einer der identischen Saugdüsen (34) durch eine andere Saugdüse (34); und anschließend

   Montieren anderer Bauteile auf der Mehrfachleiterplatte mittels der verschiedenen Saugdüse (34), so dass ein Minimum an Düsentauschvorgängen erreicht wird.

2. Bauteilmontagevorrichtung zur Montage von Bauteilen auf mehrere Teil-Leiterplatten, die eine Mehrfachleiterplatte definieren, umfassend:

   einen Platzierungskopf (28), der Saugdüsen (34) aufweist,

ein Düsenlager (48), und
einen Steuerabschnitt (52) zum Steuern der Tauschvorgänge der Düsen (34) gemäß dem Verfahren nach Anspruch 1.

Revendications

1. Procédé de montage de composants adapté à la réalisation du montage de composants sur une pluralité de sous-cartes définissant une carte multiple, comprenant :

(I) le ramassage simultané ou individuel des composants par une pluralité de buses identiques (34) de telle sorte que lesdits composants soient tenus par lesdites buses d'aspiration (34) ; et puis
(II) le positionnement desdits composants sur ladite carte multiple ; puis le changement d'au moins une desdites buses d'aspiration identiques (34) avec une buse d'aspiration différente (34) ; et puis

le montage d'autres composants sur ladite carte multiple par ladite buse d'aspiration différente (34) de sorte qu'un minimum de changements de buses soit obtenu.

2. Dispositif de montage de composants pour le montage de composants sur une pluralité de sous-cartes définissant une carte multiple, comprenant :

une tête de positionnement (28) comportant des buses d'aspiration (34),
un stockeur de buses (48), et
une section de contrôle (52) pour contrôler les changements des buses (34) selon le procédé de la revendication 1.

Fig. 1

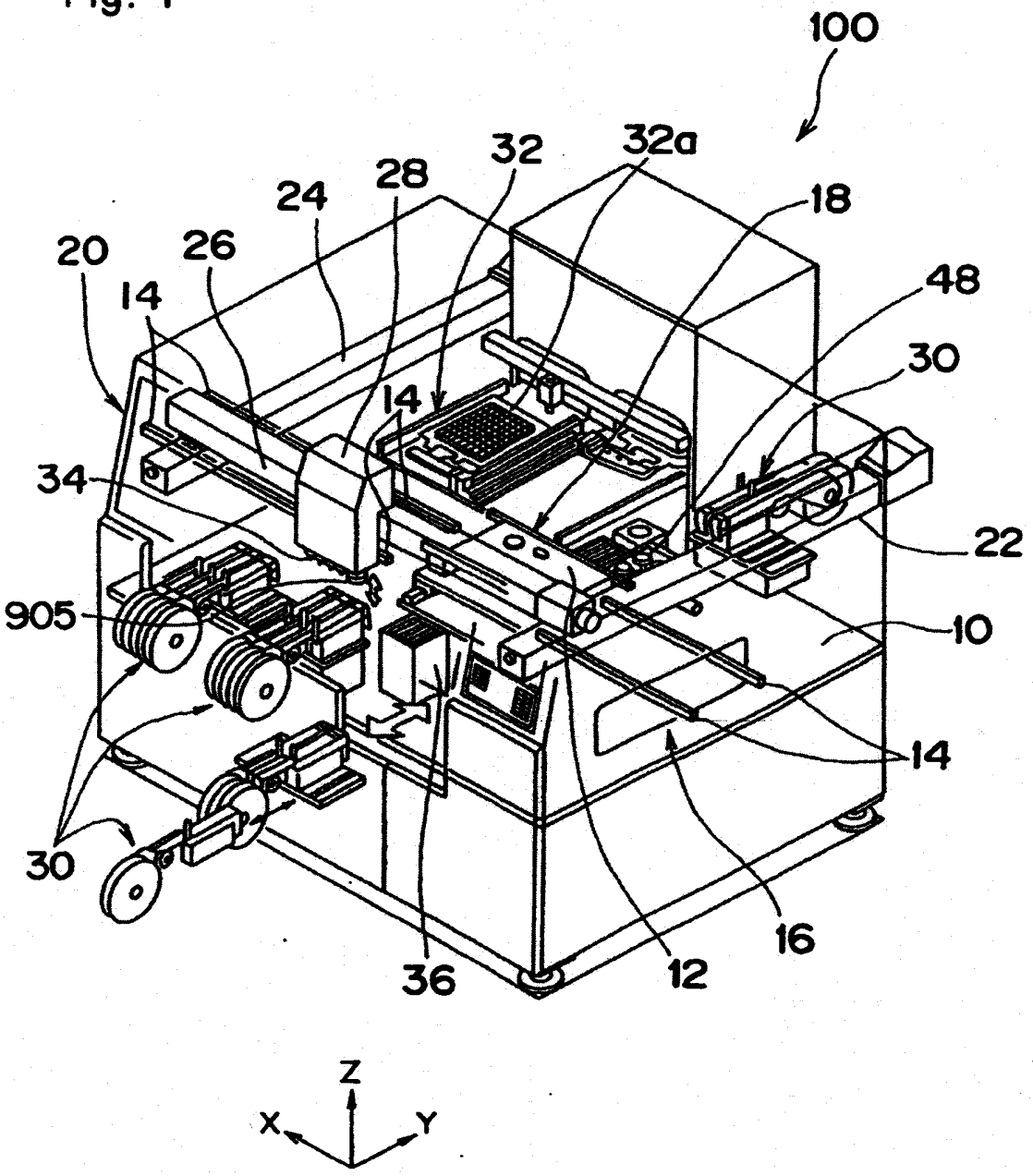


Fig. 2

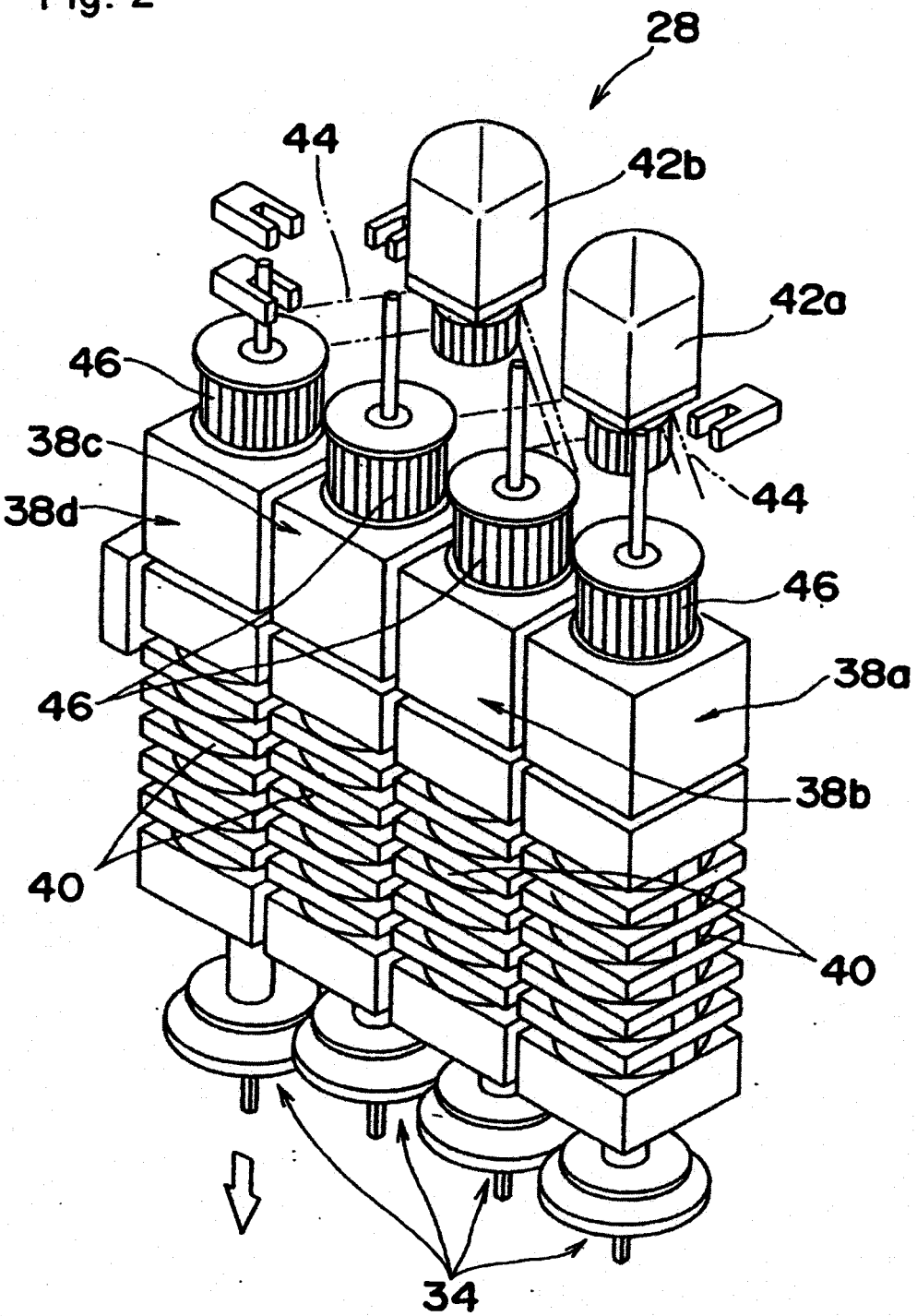


Fig. 3

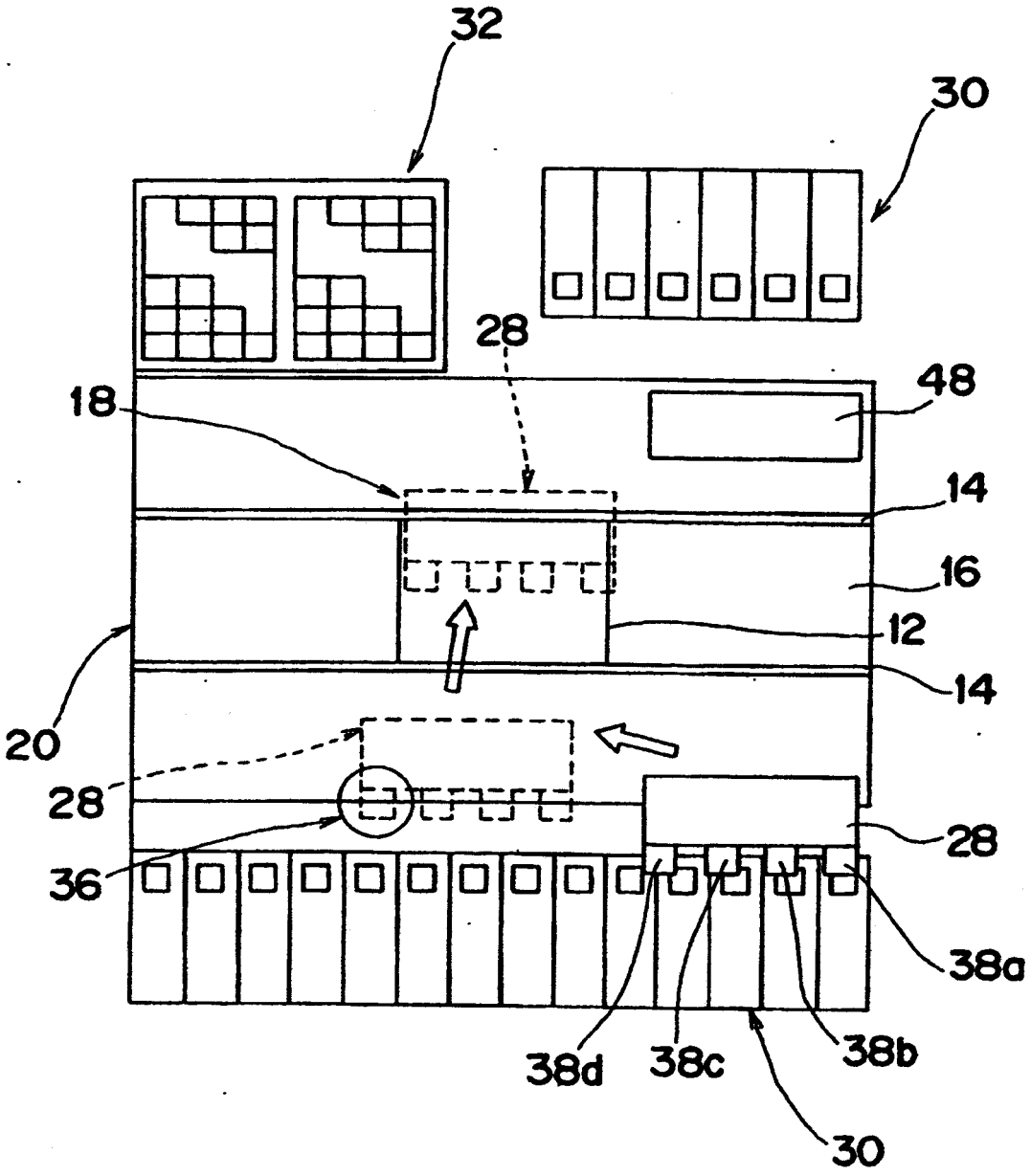


Fig.4

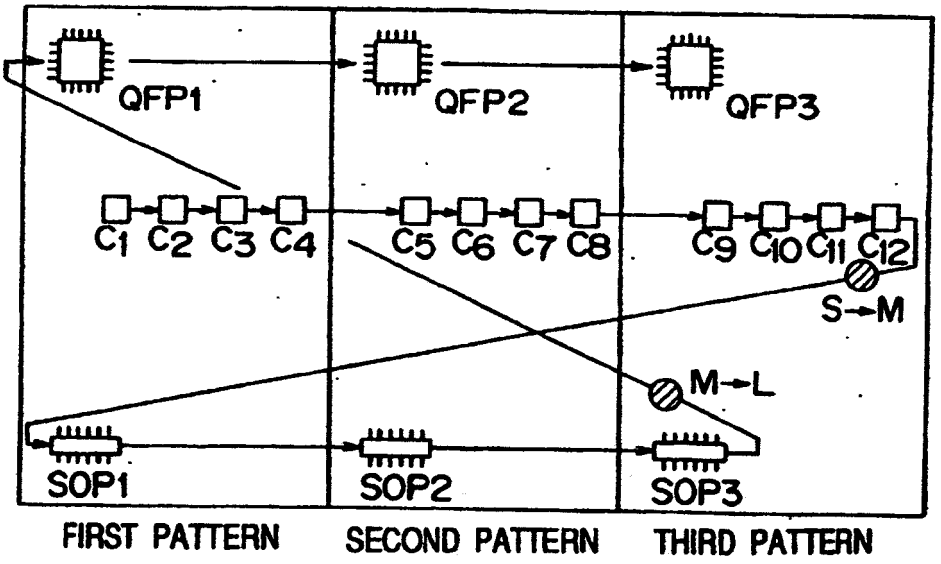

QFP1
QFP2
QFP3
C1 C2 C3 C4
C5 C6 C7 C8
C9 C10 C11 C12
S→M
M→L
SOP1
SOP2
SOP3
FIRST PATTERN
SECOND PATTERN
THIRD PATTERN
NOZZLE CHANGE

Fig.5

TASK REPEAT METHOD

	SUB-BOARD	COMPONENT	PLACEMENT HEAD NO.	SUCTION NOZZLE
1	1	C1	1	S
2	1	C2	2	S
3	1	C3	3	S
4	1	C4	4	S
5	2	C5	1	S
6	2	C6	2	S
7	2	C7	3	S
8	2	C8	4	S
9	3	C9	1	S
10	3	C10	2	S
11	3	C11	3	S
12	3	C12	4	S
13	1	SOP1	1	M
14		—	2	—
15		—	3	—
16		—	4	—
17	2	SOP2	1	M
18		—	2	—
19		—	3	—
20		—	4	—
21	3	SOP3	1	M
22		—	2	—
23		—	3	—
24		—	4	—
25	1	QFP1	1	L
26		—	2	—
27		—	3	—
28		—	4	—
29	2	QFP2	1	L
30		—	2	—
31		—	3	—
32		—	4	—
33	3	QFP3	1	L
34		—	2	—
35		—	3	—
36		—	4	—

Fig.6

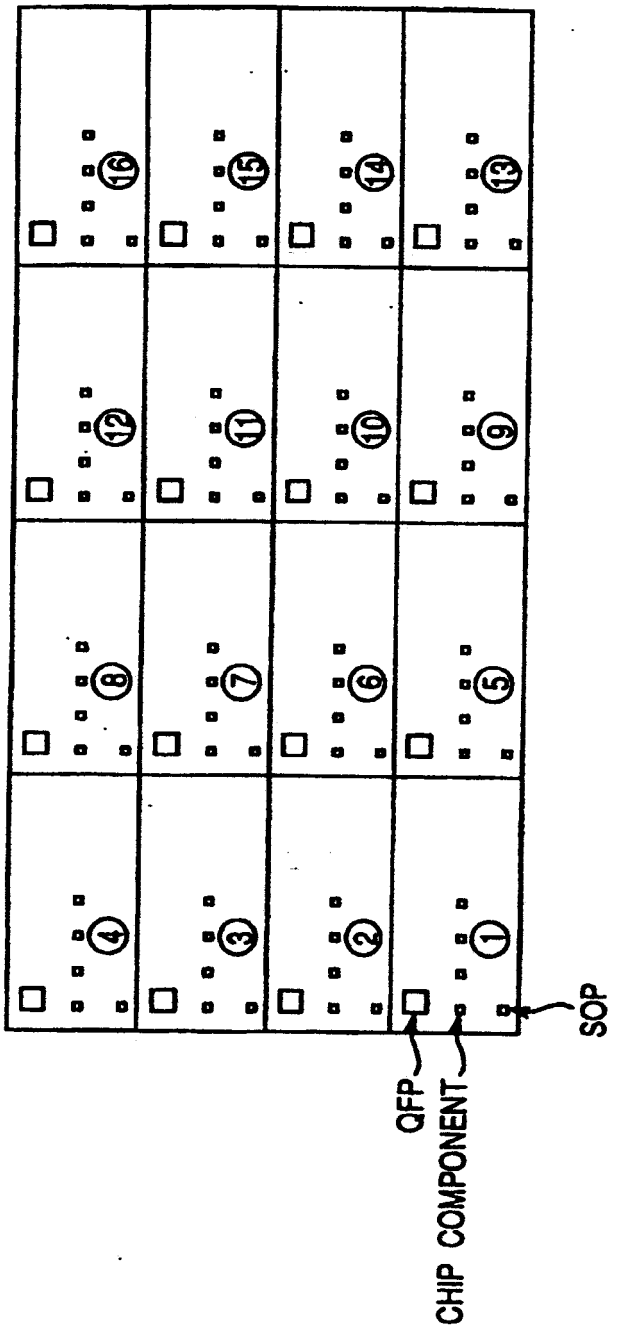


Fig.7

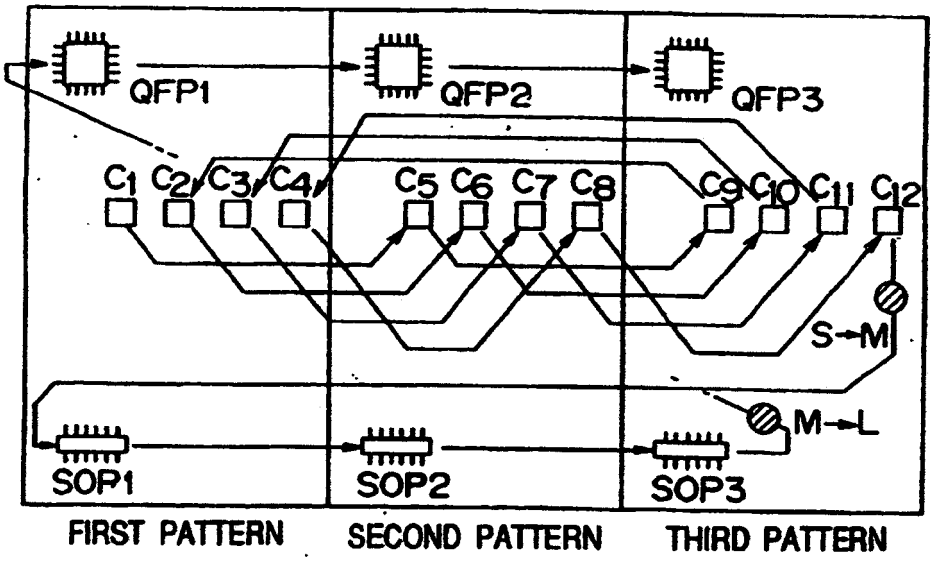

QFP1
QFP2
QFP3
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12
S→M
M→L
SOP1
SOP2
SOP3
FIRST PATTERN
SECOND PATTERN
THIRD PATTERN
NOZZLE CHANGE

Fig.8

IMPROVED STEP REPEAT METHOD

	SUB-BOARD	COMPONENT	PLACEMENT HEAD NO.	SUCTION NOZZLE
1	1	C1	1	S
2	2	C5	2	S
3	3	C9	3	S
4		—	4	—
5	1	C2	1	S
6	2	C6	2	S
7	3	C10	3	S
8		—	4	—
9	1	C3	1	S
10	2	C7	2	S
11	3	C11	3	S
12		—	4	—
13	1	C4	1	S
14	2	C8	2	S
15	3	C12	3	S
16		—	4	—
17	1	SOP1	1	M
18		—	2	—
19		—	3	—
20		—	4	—
21	2	SOP2	1	M
22		—	2	—
23		—	3	—
24		—	4	—
25	3	SOP3	1	M
26		—	2	—
27		—	3	—
28		—	4	—
29	1	QFP1	1	L
30		—	2	—
31		—	3	—
32		—	4	—
33	2	QFP2	1	L
34		—	2	—
35		—	3	—
36		—	4	—
37	3	QFP3	1	L
38		—	2	—
39		—	3	—
40		—	4	—

Fig.9

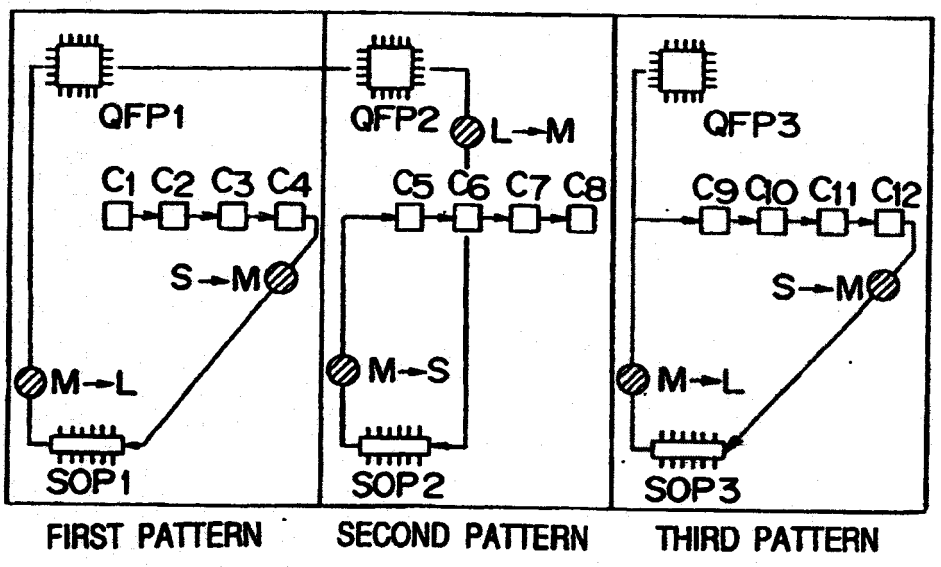

QFP1
C1 C2 C3 C4
S→M
M→L
SOP1
QFP2
L→M
C5 C6 C7 C8
M→S
SOP2
QFP3
C9 C10 C11 C12
S→M
M→L
SOP3
FIRST PATTERN
SECOND PATTERN
THIRD PATTERN
NOZZLE CHANGE

Fig.10

REVERSAL METHOD

	SUB-BOARD	COMPONENT	PLACEMENT HEAD NO.	SUCTION NOZZLE
1	1	C1	1	S
2	1	C2	2	S
3	1	C3	3	S
4	1	C4	4	S
5	1	SOP1	1	M
6		—	2	—
7		—	3	—
8		—	4	—
9	1	QFP1	1	L
10		—	2	—
11		—	3	—
12		—	4	—
13	1	QFP2	1	L
14		—	2	—
15		—	3	—
16		—	4	—
17	2	SOP2	1	M
18		—	2	—
19		—	3	—
20		—	4	—
21	2	C5	1	S
22	2	C6	2	S
23	2	C7	3	S
24	2	C8	4	S
25	3	C9	1	S
26	3	C10	2	S
27	3	C11	3	S
28	3	C12	4	S
29	3	SOP3	1	M
30		—	2	—
31		—	3	—
32		—	4	—
33	3	QFP3	1	L
34		—	2	—
35		—	3	—
36		—	4	—

Fig. 11

STEP REPEAT METHOD

	SUB-BOARD	COMPONENT	PLACEMENT HEAD NO.	SUCTION NOZZLE
1	1	C1	1	S
2		—	2	—
3		—	3	—
4		—	4	—
5	2	C5	1	S
6		—	2	—
7		—	3	—
8		—	4	—
9	3	C9	1	S
10		—	2	—
11		—	3	—
12		—	4	—
13	1	C2	1	S
14		—	2	—
15		—	3	—
16		—	4	—
17	2	C6	1	S
18		—	2	—
19		—	3	—
20		—	4	—
21	3	C10	1	S
22		—	2	—
23		—	3	—
24		—	4	—
45	3	C12	1	S
46		—	2	—
47		—	3	—
48		—	4	—
49	1	SOP1	1	M
50		—	2	—
51		—	3	—
52		—	4	—
53	2	SOP2	1	M
54		—	2	—
55		—	3	—
56		—	4	—
57				

Fig. 12

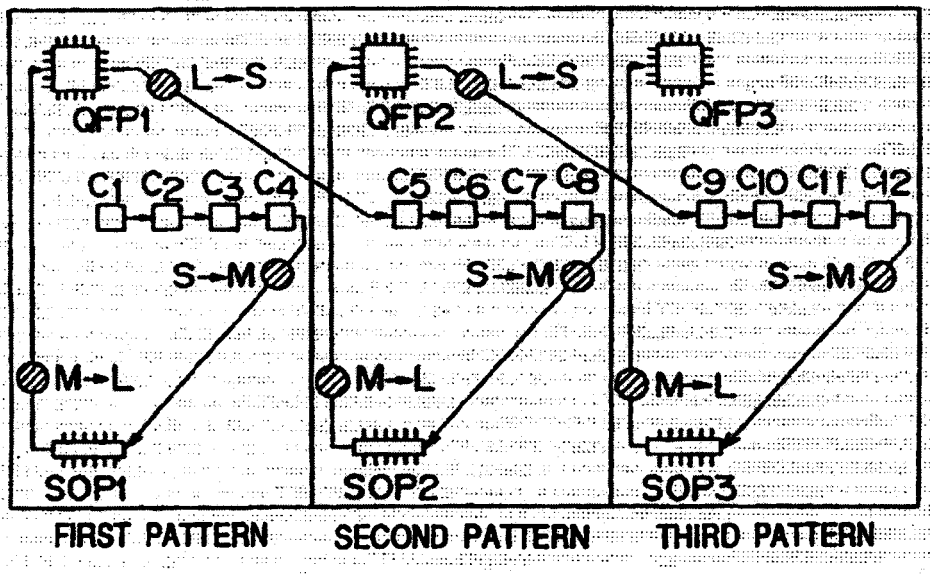

L→S
QFP1
C1 C2 C3 C4
S→M
M→L
SOP1
L→S
QFP2
C5 C6 C7 C8
S→M
M→L
SOP2
QFP3
C9 C10 C11 C12
S→M
M→L
SOP3
FIRST PATTERN
SECOND PATTERN
THIRD PATTERN
NOZZLE CHANGE

Fig. 13

PATTERN REPEAT METHOD

	SUB-BOARD	COMPONENT	PLACEMENT HEAD NO.	SUCTION NOZZLE
1	1	C1	1	S
2	1	C2	2	S
3	1	C3	3	S
4	1	C4	4	S
5	1	SOP1	1	M
6		—	2	—
7		—	3	—
8		—	4	—
9	1	QFP1	1	L
10		—	2	—
11		—	3	—
12		—	4	—
13	2	C5	1	S
14	2	C6	2	S
15	2	C7	3	S
16	2	C8	4	S
17	2	SOP2	1	M
18		—	2	—
19		—	3	—
20		—	4	—
21	2	QFP2	1	L
22		—	2	—
23		—	3	—
24		—	4	—
25	3	C9	1	S
26	3	C10	2	S
27	3	C11	3	S
28	3	C12	4	S
29	3	SOP3	1	M
30		—	2	—
31		—	3	—
32		—	4	—
33	3	QFP3	1	L
34		—	2	—
35		—	3	—
36		—	4	—

Fig. 14A

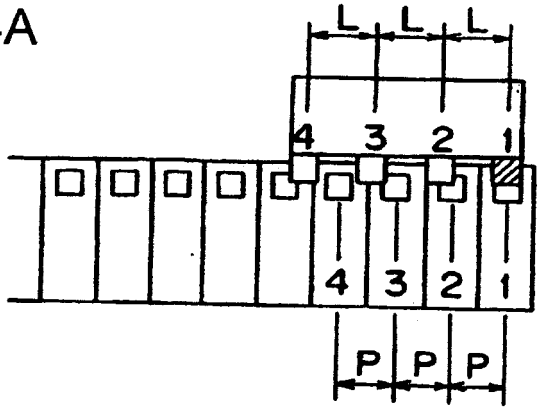


Fig. 14B

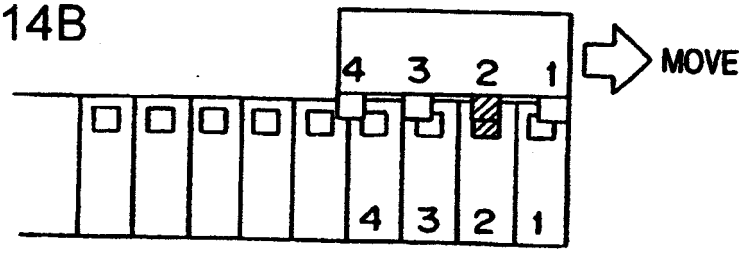


Fig. 14C

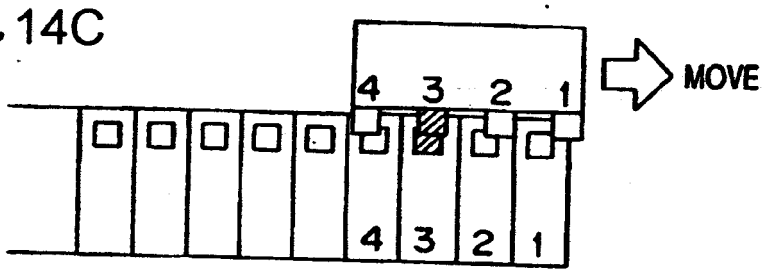


Fig. 14D

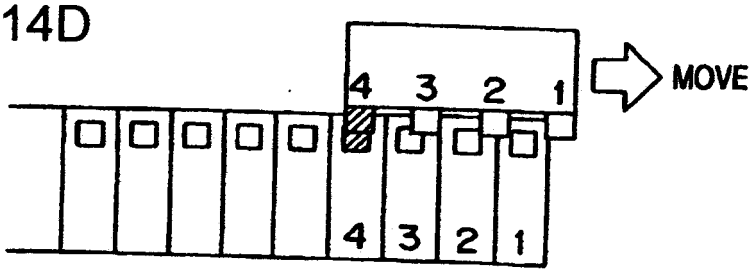


Fig. 15

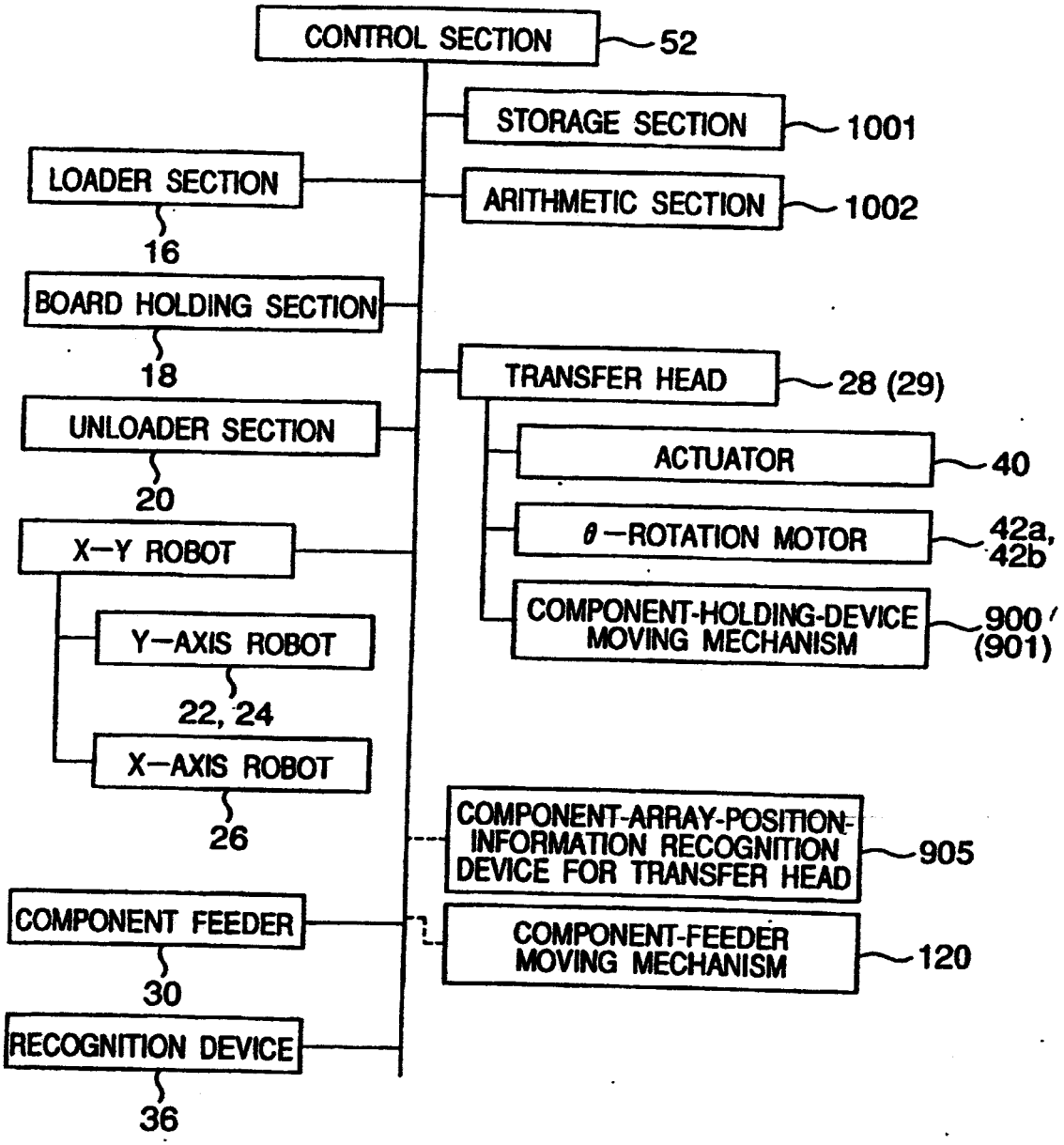

CONTROL SECTION
52
STORAGE SECTION
1001
ARITHMETIC SECTION
1002
LOADER SECTION
16
BOARD HOLDING SECTION
18
UNLOADER SECTION
20
X–Y ROBOT
Y–AXIS ROBOT
22, 24
X–AXIS ROBOT
26
COMPONENT FEEDER
30
RECOGNITION DEVICE
36
TRANSFER HEAD
28 (29)
ACTUATOR
40
θ–ROTATION MOTOR
42a, 42b
COMPONENT-HOLDING-DEVICE MOVING MECHANISM
900 (901)
COMPONENT-ARRAY-POSITION-INFORMATION RECOGNITION DEVICE FOR TRANSFER HEAD
905
COMPONENT-FEEDER MOVING MECHANISM
120

Fig.16

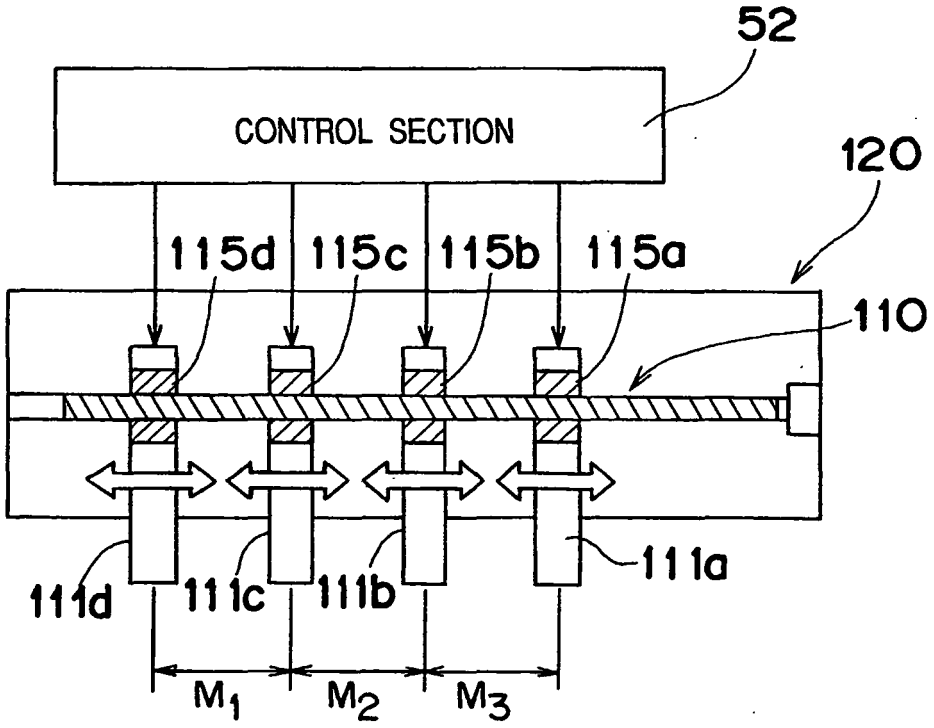

52
CONTROL SECTION
120
115d
115c
115b
115a
110
111d
111c
111b
111a
M1
M2
M3

Fig.17

STEP REPEAT METHOD

	SUB-BOARD	COMPONENT	PLACEMENT HEAD NO.	SUCTION NOZZLE
1	1	C1	1	S
2		—	2	—
3		—	3	—
4		—	4	—
5	2	C5	1	S
6		—	2	—
7		—	3	—
8		—	4	—
9	3	C9	1	S
10		—	2	—
11		—	3	—
12		—	4	—
13	1	C2	1	S
14		—	2	—
15		—	3	—
16		—	4	—
17	2	C6	1	S
18		—	2	—
19		—	3	—
20		—	4	—
21	3	C10	1	S
22		—	2	—
23		—	3	—
24		—	4	—
45	3	C12	1	S
46		—	2	—
47		—	3	—
48		—	4	—
49	1	SOP1	1	M
50		—	2	—
51		—	3	—
52		—	4	—
53	2	SOP2	1	M
54		—	2	—
55		—	3	—
56		—	4	—
57				

Fig.18

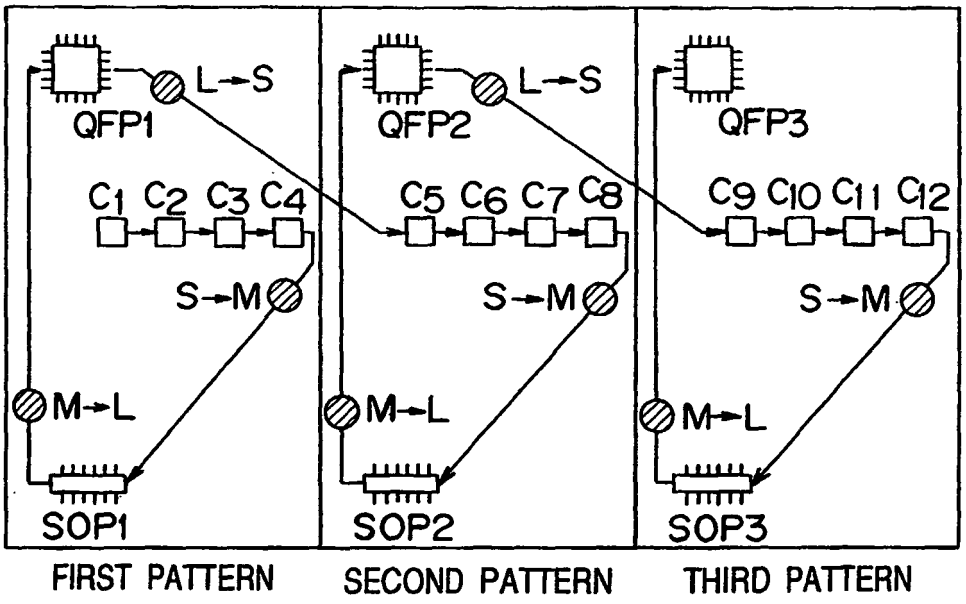

L→S
QFP1
C1 C2 C3 C4
S→M
M→L
SOP1
L→S
QFP2
C5 C6 C7 C8
S→M
M→L
SOP2
QFP3
C9 C10 C11 C12
S→M
M→L
SOP3
FIRST PATTERN
SECOND PATTERN
THIRD PATTERN
NOZZLE CHANGE

Fig.19

PATTERN REPEAT METHOD

	SUB-BOARD	COMPONENT	PLACEMENT HEAD NO.	SUCTION NOZZLE
1	1	C1	1	S
2	1	C2	2	S
3	1	C3	3	S
4	1	C4	4	S
5	1	SOP1	1	M
6		—	2	—
7		—	3	—
8		—	4	—
9	1	QFP1	1	L
10		—	2	—
11		—	3	—
12		—	4	—
13	2	C5	1	S
14	2	C6	2	S
15	2	C7	3	S
16	2	C8	4	S
17	2	SOP2	1	M
18		—	2	—
19		—	3	—
20		—	4	—
21	2	QFP2	1	L
22		—	2	—
23		—	3	—
24		—	4	—
25	3	C9	1	S
26	3	C10	2	S
27	3	C11	3	S
28	3	C12	4	S
29	3	SOP3	1	M
30		—	2	—
31		—	3	—
32		—	4	—
33	3	QFP3	1	L
34		—	2	—
35		—	3	—
36		—	4	—

Fig.20A

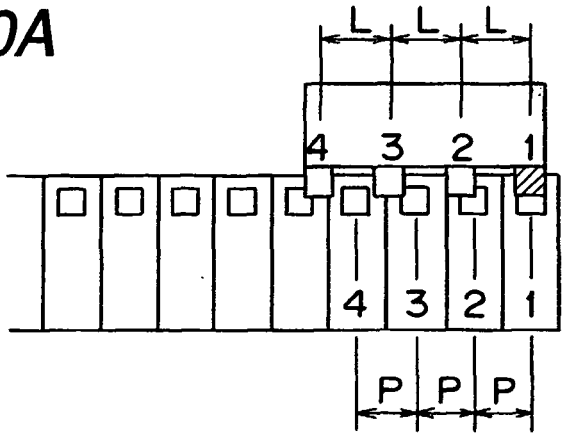


Fig.20B

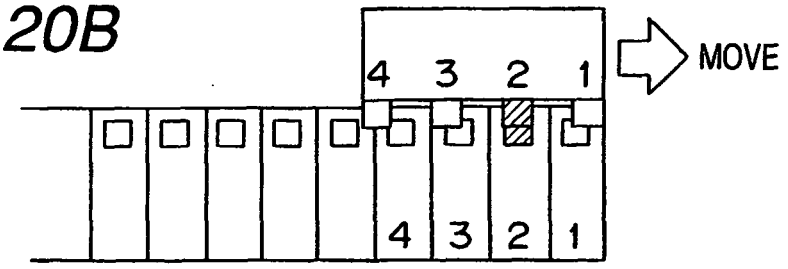


Fig.20C

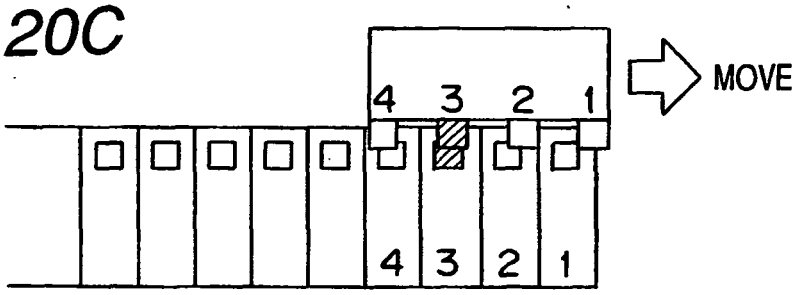


Fig.20D

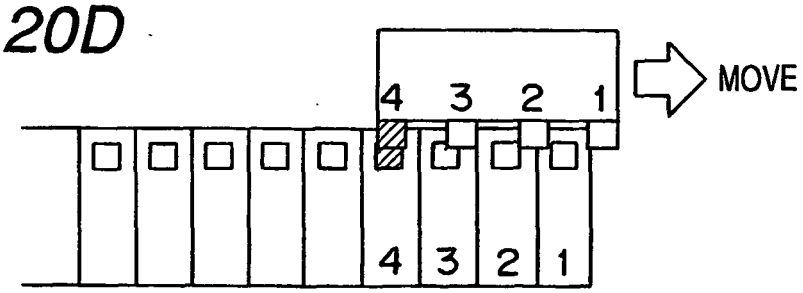
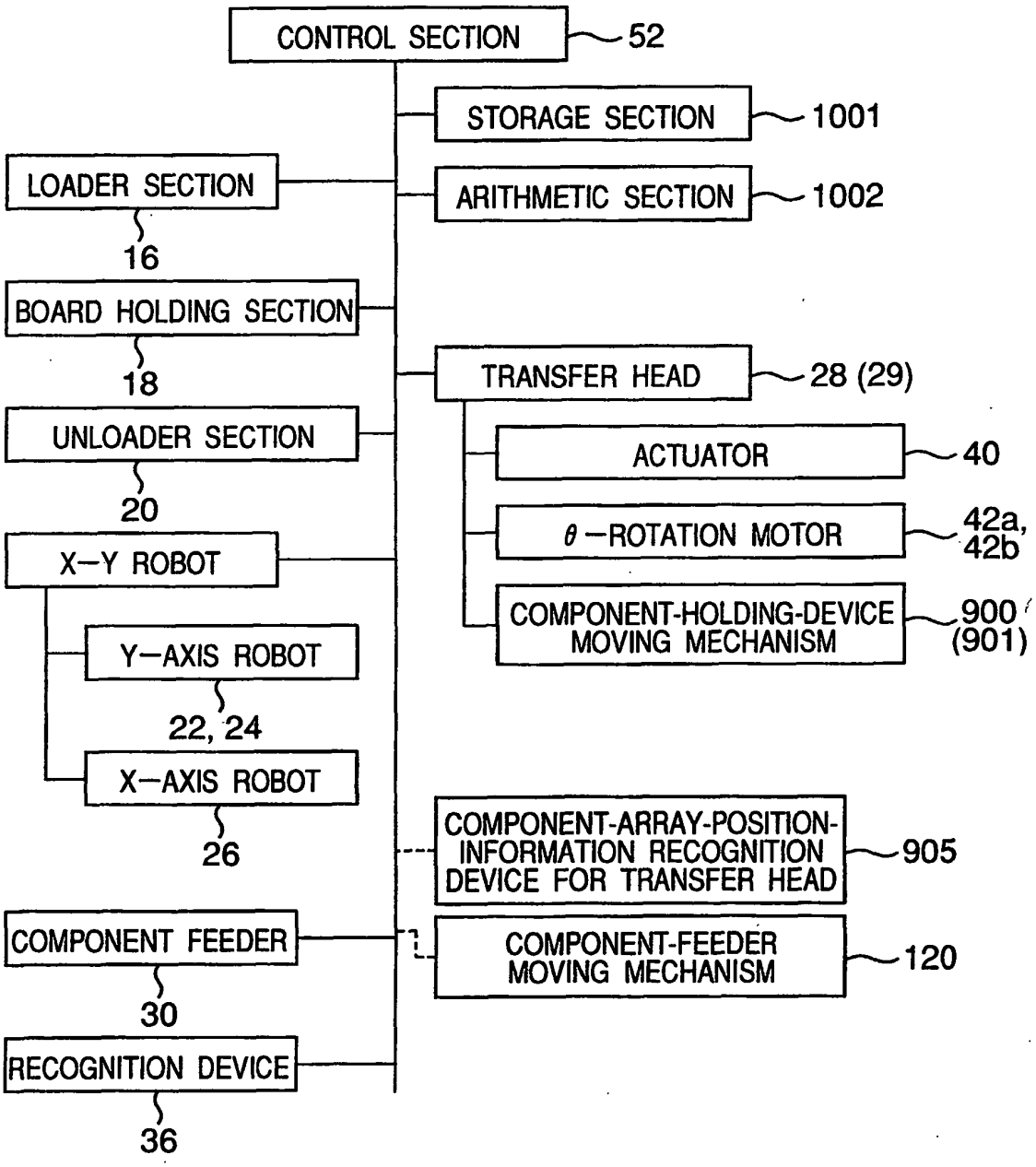


Fig.21


CONTROL SECTION
52
STORAGE SECTION
1001
LOADER SECTION
ARITHMETIC SECTION
1002
16
BOARD HOLDING SECTION
18
TRANSFER HEAD
28 (29)
UNLOADER SECTION
ACTUATOR
40
20
θ−ROTATION MOTOR
42a, 42b
X−Y ROBOT
COMPONENT-HOLDING-DEVICE MOVING MECHANISM
900 (901)
Y−AXIS ROBOT
22, 24
X−AXIS ROBOT
26
COMPONENT-ARRAY-POSITION-INFORMATION RECOGNITION DEVICE FOR TRANSFER HEAD
905
COMPONENT FEEDER
COMPONENT-FEEDER MOVING MECHANISM
120
30
RECOGNITION DEVICE
36

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 9931948 A **[0016]**
- JP 6447100 B **[0017]**