

MOUNTING APPARATUS ✓

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copyBACKGROUND OF THE INVENTIONField of the Invention

The present invention generally relates to a method and an apparatus for mounting electronic components on a printed circuit board. More specifically, the present invention is directed to a technique capable of shortening so-called "mounting tact time" per one electronic component.

Description of the Related Art

Electronic components are mounted on printed circuit boards by automatic machines, for instance, components mounting apparatuses for using so-termed "mounting type electronic components". One of these automatic components mounting apparatuses is described in, e.g., Japanese Laid-open Patent Application No. 5-192824.

This components mounting apparatus is equipped with the turn table 13 and a plurality of mounting heads 15. The turn table 13 is hung on the supporting base 28 and is intermittently and rotatably provided in such a manner that the rotation shaft is extended along the vertical direction. These mounting heads 15 are arranged on the outer peripheral portion of this turn table 13 along the peripheral direction. One of positions where the mounting head 15 is stopped corresponds to the absorption station. At this

absorption station, the components supplying apparatus 8 for supplying the chip components 5 is provided. On the other hand, another position located opposite to the turn table 13 of the absorption station corresponds to the mounting station. The board 6 movably supported along the X-Y direction is mounted on the lower portion of the mounting head 15 positioned at this mounting station.

A plurality of components supplying apparatuses 8 are arranged within a preselected range containing a portion of the position corresponding to the absorption station of the turn table 13. A designated components supplying apparatus 8 is transported to the position corresponding to the absorption station.

One mounting head 15 absorbs the chip component 5 supplied from the components supplying apparatus 8 in the absorption station. Then, the turn table 13 is intermittently rotated by one pitch. The next mounting head 15 is located at the absorption station, and then absorbs the chip component 5 similar to the above-described mounting head 15. Then, the turn table 13 is again intermittently rotated. Thus, the chip component 5 is absorbed by the mounting head 15 located at the absorption station in this manner.

Then, the mounting head 15 which has absorbed the chip component 5 is transported to the mounting station by rotating the turn table 13. At this mounting station, the



mounting head 15 descends so as to mount the chip component 5 on the board 6.

Prior to mounting of the chip component 5, the board 6 is moved by the X-Y table 3, so that this designated component mounting place is positioned in correspondence with the mounting station.

The above-described absorbing and mounting operations of the chip components 5 are carried out in accordance with a previously designated sequence. In other words, one components supplying apparatus designated in accordance with the above-described sequence among the components supplying apparatuses 8 is transported to the position corresponding to the absorption station. After this designated chip component 5 has been absorbed by the mounting head 15, this chip component 5 is transported by the turn table 13 to the mounting station. At the same time, the board 6 is transported by the X-Y table 3, and thus a predetermined position where this chip component 5 is mounted corresponds to the mounting station, so that the mounting head 15 descends so as to mount the designated chip component 5 on the board 6.

To shorten the components mounting tact time in such a conventional components mounting apparatus, while the respective mechanical elements (components supplying apparatuses, turn table, mounting head, etc.) are operated in high speed, the arranging sequence of these components

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supplying apparatuses 8 and also the transporting sequence (transporting sequence to mounting position) of the X-Y table 3 must be optimized. The cooperation between the respective mechanical elements and other mechanical elements must be optimized to thereby shorten the work waiting time. As a consequence, the absorbing sequence and/or the mounting sequence of the components by the mounting head 15 must be effectively set.

For instance, the transporting sequence of the X-Y table 3 is determined in this order, namely such a predetermined mounting position located near the edge of preselected mounting positions on the board 6. This way causes the transporting sequence to be optimized if only the transport time of the X-Y table 3 is considered. However, when this transporting sequence is designed on the basis of the arranging order of the components supplying apparatuses 8, since there are many possibilities that a plurality of same sorts of components are mounted on the board 6, the components supplying apparatuses 8 must be transported in the reciprocation motion every time the same sort of components are mounted. Therefore, the above-described transporting sequence of the X-Y table 3 is not always the optimum transporting sequence for the components supplying apparatus 8. Accordingly, the overall mounting tact time could not be shortened.

Also, in such a case that the components supplying

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apparatuses 8 are arranged in accordance with a certain sequence, for example, in a higher use-frequency order, and the transporting sequence of the X-Y table 3 is designed based on this arranging sequence, this transporting sequence of the X-Y table 3 does not always correspond to the optimum transporting sequence with respect to the X-Y table (3). In other words, this designed transporting sequence is not substantially equal to the optimum transporting sequence. As a result, there are many problems that when such a design is made on the basis of any one of the arranging sequence of the components supplying apparatuses 8 and the transporting sequence of the X-Y table 3, the other sequence would become unsuitable. It is practically difficult to determine either the optimum sequences or the sequences close to these optimum sequences for both cases.

This is caused by such a fact that the transportation of the components as the works between absorbing of the components and mounting of the components is performed by rotating the turn table 13 along one direction, and thus such a fact that the degree of freedom in designing of these sequences is low.

Eventually, since the transportation of the components as the works between absorbing of the components and mounting of the components is carried out by rotating the turn table 13 along one direction, a limitation is made in designing of optimizing the arranging sequence and the

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transporting sequence. Accordingly, the components mounting tact time could not be shortened.

SUMMARY OF THE INVENTION

The present invention has been made to solve the above-described problems, and therefore, has an object to provide a components mounting method which is featured by that a plurality of electronic components are individually gripped by a plurality of gripping means in a components supplying region; and after these gripping means are transported to the components mounting region, each of said gripped electronic components is mounted on a predetermined mounting position thereof.

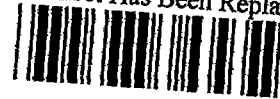
As a consequence, in accordance with the components mounting method of the present invention, the frequency of transportation between the components supply region and the components mounting region can be reduced, and the mounting tact time per a single electronic component can be shortened.

A components mounting method of the present invention is featured by comprising the steps of:

subdividing at least one of the components supplying region and the components mounting region into a plurality of sections; and

mounting the electronic components in a entire region of the mounting region by repeating one of the steps of:

gripping the electronic components by a plurality of



the gripping means in one of the subdivided sections of the components supplying region and mounting the electronic components in the components mounting region and then gripping the electronic components by a plurality of the gripping means in another subdivided section of the components supplying region and mounting the electronic components in the components mounting region;

gripping the electronic components by a plurality of the gripping means in the components supplying region and mounting the electronic components in one of the subdivided sections of the components mounting region and then gripping the electronic components by a plurality of the gripping means in the components supplying region again and mounting the electronic components in another subdivided section of the components mounting region; and

gripping the electronic components by a plurality of the gripping means in one of the subdivided sections of the components supplying region and mounting the electronic components in one of subdivided section of the components mounting region and then gripping the electronic components by a plurality of the gripping means in another subdivided section of said components supplying region and mounting the electronic components in another subdivided section of the components mounting region.

As a consequence, the components supplying region and/or the components mounting region properly subdivided



into a plurality of sections can reduce the transport distance of the components gripping means while gripping and/or mounting the electronic components in the components supplying region and/or the components mounting region. The mounting tact time per a single electronic component can be further shortened.

A components mounting method is further featured by that the components supplying region is subdivided into two groups of subdivided sections arranged on both sides of the components mounting region in a direction identical to a direction along which the subdivided sections of the components mounting region are disposed, and the components mounting method comprises steps of:

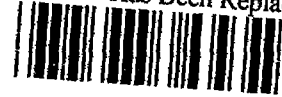
gripping individually a plurality of the electronic components in one of the subdivided sections of said components supplying region by a plurality of the components gripping means;

transporting a plurality of the components gripping means to one of the subdivided sections of the components mounting region;

mounting each of the electronic components on a predetermined mounting position;

transporting a plurality of the components gripping means to another subdivided sections of the components supplying region;

gripping a plurality of the electronic components



again in another subdivided sections of the components supplying region by a plurality of the components gripping means;

transporting a plurality of the components gripping means to another subdivided sections of the components mounting region;

mounting each of the electronic components on a predetermined mounting position;

repeating above steps until the electronic components are mounted in the entire region of the mounting region.

As a consequence, the subdivided groups of the components supplying region arranged on both sides of the components mounting region can increase a degree of freedom in designing of the gripping sequence as well as the mounting sequence of these electronic components. Also, these sequences can be optimized.

Moreover, a components mounting method of the present invention is featured by that the electronic components are mounted from such a predetermined mounting position located closest to the components supplying apparatus where previous final gripping of the electronic components has been performed by the components gripping means among the components supplying apparatuses in the subdivided sections of the components supplying region.

As a consequence, the transport distance between the components supplying region and the components mounting



region can be shortened. The mounting tact time per a single electronic component can be further shortened.

A components mounting method of the present invention is further featured by that the electronic components are mounted in the components mounting region at a predetermined mounting position located closest to such a components supplying apparatus where next first gripping of the electronic component is to be performed in the components supplying region to which the components gripping means are to be subsequently transported is designated as a final predetermined mounting position within the components mounting region among the predetermined mounting positions in the components mounting region.

As a consequence, the transport distance between the components supplying region and the components mounting region can be further reduced and the mounting time per a single electronic component can be further shortened.

In addition, a components mounting apparatus of the present invention is featured by comprising: components gripping means for individually gripping the electronic components; and

a tool head on which a plurality of the components gripping means are mounted, and which is movably provided between the components supplying region and the components mounting region; wherein the components gripping means is supported movably in the upward and downward direction with



respect to the tool head, and moves up and down for gripping and releasing the electronic components when positioned to a preselected position in the tool head;

the tool head is provided rotatably in the forward and reverse directions so that the tool head is rotated for selecting the components gripping means and positioning the selected components gripping means to a preselected position.

As a consequence, the electronic components can be gripped by a plurality of components gripping means within the components supplying means in a random sequential order. Also, the electronic components can be mounted by a plurality of components gripping means in the components mounting means in a random sequential order. Accordingly, the gripping and mounting sequences of the electronic components can be set freely. It is possible to provide such a components mounting apparatus not restricted to these gripping and mounting sequences. The mounting tact time per a single electronic component can be further shortened.

The components mounting apparatus of the present invention may be applied to a surface mounting apparatus for mounting chip type electronic components (will be referred to as "chip components" hereinafter).

The components mounting apparatus is featured by that the components gripping means can be a means for absorbing the electronic component by using negative pressure.

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As a consequence, in accordance with the components mounting apparatus of the present invention, the electronic components can be gripped and mounted in higher speed. The mounting tact time per a single electronic component can be further shortened.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, reference may be made to the accompanying drawings, in which:

Fig. 1 schematically indicates a side view of an entire components mounting apparatus according to an embodiment of the present invention;

Fig. 2 schematically shows a plan view of the components mounting apparatus of Fig. 1;

Fig. 3 schematically represents a front view of the components mounting apparatus of Fig. 1;

Fig. 4 is a side view for schematically showing a tool head of the components mounting apparatus in an enlarging form;

Fig. 5 is a graphical representation for representing a motor speed characteristic of an X-Y direction transport motor used in the components mounting apparatus of Fig. 1;

Fig. 6 is an explanatory diagram for explaining a first transport path of the tool head over a plane in a components mounting method according to a first embodiment of the present invention;

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Fig. 7 is an explanatory diagram for explaining a second transport path of the tool head over the plane in accordance with the first components mounting method;

Fig. 8 is an explanatory diagram for explaining a third transport path of the tool head over the plane in accordance with the first components mounting method;

Fig. 9 is an explanatory diagram for explaining a fourth transport path of the tool head over the plane in accordance with the first components mounting method;

Fig. 10 is an explanatory diagram for explaining a fifth transport path of the tool head over the plane in accordance with the first components mounting method;

Fig. 11 is an explanatory diagram for explaining a sixth transport path of the tool head over the plane in accordance with the first components mounting method;

Fig. 12 is an explanatory diagram for explaining a seventh transport path of the tool head over the plane in accordance with the first components mounting method;

Fig. 13 is an explanatory diagram for explaining an eighth transport path of the tool head over the plane in accordance with the first components mounting method;

Fig. 14 is an explanatory diagram for explaining a ninth transport path of the tool head over the plane in accordance with the first components mounting method;

Fig. 15 is an explanatory diagram for explaining a tenth transport path of the tool head over the plane in

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accordance with the first components mounting method; and

Fig. 16 is a conceptional diagram for describing a components mounting method according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to drawings, a description will be made of various preferred embodiments of components mounting methods and components mounting apparatus in detail.

FIRST COMPONENTS MOUNTING APPARATUS

Fig. 1 to Fig. 4 schematically represents a components mounting apparatus according to a first preferred embodiment of the present invention.

First, a components mounting apparatus 1 according to the present invention will now be explained. The components mounting apparatus 1 is provided with regions for absorbing chip components on both sides of a region for mounting the chip components on a board.

The components mounting apparatus 1 is arranged by employing a base unit 2, a base station 3 for supporting this base unit 2, and four sets of pillars 4, ---, 4 stood at positions of right and left edges of both edge portions of this base station 3 along a front/rear direction, as viewed in Fig. 1. This components mounting apparatus 1 is further constructed of bridges 5 and 5 supported by the two sets of pillars 4 and 4 separated from each other along the front/rear direction and supported between the upper ends of



the pillars 4 and 4 along a longitudinal direction of the base station 3; two sets of head mounting columns 6 and 6 hung between these bridges 5 and 5; a tool head 7 hung on each of the head mounting columns 6; and a polarity of absorbing nozzles 8, ---, 8 arranged on this tool head 7. It should be noted that a direction indicated by an arrow shown in Fig. 1 or Fig. 2 is expressed as either a "front/rear direction" or an "arrow X-direction", whereas a direction indicated by an arrow Y is expressed as either a "right/left direction" or an "arrow Y-direction". This direction definition is similarly applied to the below-mentioned descriptions.

A central region of an upper surface of the base unit 2 along the right/left direction is used as a work arranging unit on which a work such as a board 9 is arranged. A fixing means 10 for fixing the board 9 is arranged on this work arranging unit so as to position the board 9. Also, two sheets of boards 9 are arranged on the work arranging unit in such a manner that these boards 9 and 9 are separated from each other along the front/rear direction.

Guide rails 11 and 11 are fixed on the lower surfaces of the above-explained bridges 5 and 5 in such a manner that these guide rails 11 and 11 are extended along the arrow X-direction. Guided members 12, ---, 12 which are fixed on the upper surfaces of the both edge portions of the head mounting column 6 are engaged with the guide rails 11 and 11

in a slidable manner. As a result, the head mounting column 6 is slidably supported by the bridges 9 and 9 along the arrow X-direction. It should also be noted that drive means (not shown) are separately provided between the bridges 5 and 5, so that the head mounting columns 6 and 6 may be separately self-driven with respect to the bridges 5 and 5.

The tool heads 7 and 7 are separately provided on the head mounting columns 6 and 6 in such a manner that these tool heads 7 and 7 are hung thereon, and are slidably supported along the arrow Y-direction with respect to the head mounting columns 6. It should also be noted that the tool heads 7 and 7 are transported along the arrow Y-direction by rotating ball screws provided within the head mounting columns 6 and 6.

As a result, the tool heads 7 and 7 can be separately and freely transported along the X and Y directions by the transport of the head mounting columns 6 and 6 along the arrow X direction with respect to the bridges 5 and 5, and by the transport of the tool heads 7 and 7 along the arrow Y direction with respect to the head mounting columns 6 and 6.

Rotation shafts of the tool heads 7 and 7 are provided in such a manner that these rotation shafts are inclined respectively with respect to the vertical direction in such a way that the lower end of the front-sided tool head 7 is energized toward the front direction, whereas the lower end of the rear-sided tool head 7 is energized toward the rear



direction (see Fig. 1), and furthermore, these tool heads 7 and 7 can be freely rotated in the normal/reverse directions.

20 sets of absorbing nozzles 8, ---, 8 are arranged on the tool head 7 in an equiinterval at an outer peripheral portion thereof along the peripheral direction. Central axes of these absorbing nozzles 8, ---, 8 are mounted on the rotation shaft of the tool head 7 with having inclination angles with respect to this rotation shaft. This inclination is determined by that the upper ends of the respective absorbing nozzles 8, ---, 8 are approached to the rotation shaft of the tool head 7. As a whole structure, these absorbing nozzles 8, ---, 8 are arranged in a conically extending manner with respect to the tool head 7.

The absorbing nozzles 8, ---, 8 are movably supported along the axial center directions thereof with respect to the tool head 7. When the absorbing nozzle 8 is located at an operation position (will be described later), this absorbing nozzle 8 is depressed by a depression means (not shown) from the upper direction to thereby descend.

Among these absorbing nozzles 8, ---, 8, the axial center of the absorbing nozzle located at the rear end of the front-sided tool head 7 is directed to the vertical direction, and the axial center of the absorbing nozzle positioned at the front end of the rear-sided tool head 7 is directed to the vertical direction. These rear end position



and front end position correspond to the above-described operation position, respectively. Then, chip components 13, ---, 13 may be absorbed and/or released by the absorbing nozzles 8, ---, 8 which are located at the operation positions and are directed to the vertical direction.

As to the chip components 13, ---, 13 mounted on one sheet of board 9, there are, for example 120 sorts. These different sorts of chip components 13, ---, 13 cannot be absorbed and mounted by using one type of absorbing nozzle 8. For instance, in such a case that there are 120 sorts of chip components 13, ---, 13, for example, 5 types of absorbing nozzles 8, ---, 8 are prepared. Then, 5 types of absorbing nozzles 8, ---, 8 are arranged in such a set that, for instance, 9 pieces of first type of absorbing nozzles are prepared, 5 pieces of second type of absorbing nozzles are prepared, 3 pieces of third type of absorbing nozzles are prepared, 2 pieces of fourth type of absorbing nozzles are prepared, namely, the quantities of these absorbing nozzles are selected, depending upon use frequencies thereof.

It should be noted that the respective absorbing nozzles 8, ---, 8 are connected to air compressors (not shown in detail), and a tip portion of the absorbing nozzle 8 located at the operation position is switched to either negative pressure or positive pressure at predetermined timing. As a consequence, at this tip portion, the chip

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component 13 is absorbed, or released.

There is a region where the chip components 13, ---, 13 are mounted on the boards 9 and 9 positioned and held by the fixing means 10 and 10, and such a region will be referred to as a "components mounting region M" hereinafter.

Also, 60 sets of components supplying apparatuses 14, ---, 14 are arranged on both right and left sides of the components mounting region M. A large number of same sorts of chip components 13, ---, 13 are stored in the respective components supplying apparatuses, 14, ---, 14, and are supplied to the absorbing nozzles 8, ---, 8 in response to requirements. It should be understood that this embodiment has described that the components supplying apparatuses 14, ---, 14 are arranged on both the right and left sides of the component mounting region M. However, the present invention is not limited thereto, but may be also applied to such a case that the components supplying apparatuses 14, ---, 14 are arranged only one side of these right/left sides of the components mounting region M.

The different sorts of chip components 13, ---, 13 are stored into the corresponding components supplying apparatuses 14, ---, 14 with respect of the sorts of the components supplying apparatuses 14, ---, 14. Depending upon the sort of chip component 13 mounted on the position of the board 9, the absorbing nozzle 8 and the components supplying apparatus 14 are selected, and then this chip

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component 13 is absorbed.

Components supplying ports 15, ---, 15 of the respective components supplying apparatuses 14, ---, 14 are arranged on both the right and left sides of the fixing means 10 in parallel thereto. The chip components 13, ---, 13 positioned to these components supplying ports 15, ---, 15 are absorbed by the absorbing nozzles 8, ---, 8. As a consequence, the region where a large number of components supplying ports 15, ---, 15 corresponds to a region where the chip components 13, ---, 13 are absorbed, which will be referred to as a "components supplying region S" hereinafter.

Then, the tool head 7 is designed in such a manner that the absorbing nozzles 8 and 8 are moved within a range of such a region for connecting the above-described components supplying region S and components mounting region M, and these absorbing nozzles are approached to the operation position thereof.

A description will now be made of the components mounting method according to the present invention, assuming now that a target mounting speed of the above-described components mounting apparatus 1 is set to, e.g., 0.2 second/chip. This mounting speed is defined by so-called "mounting tact time". In other words, this mounting tact time implies such a 1 cycle time period defined by that the chip component 13 is absorbed in the components supplying



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region S by the absorbing nozzles 8 and is transported to the components mounting region M, and thereafter this absorbed chip component 13 is mounted on the board 9, and then this absorbing nozzle 8 is returned to the components supplying region S. It should be noted that since the above-described components mounting apparatus 1 is equipped with the two tool heads 7 and 7, the chip components 13, ---, 13 can be mounted on two sets of boards 9 and 9 at the same time. Accordingly, the target mounting tact time is one of these tool heads 7 and 7 is 0.4 seconds/chip.

In the following embodiment, such an assumption is made that the dimension of the board 9 is defined by 250 mm x 400 mm, and 120 sorts of chip components 13, ---, 13 are mounted.

Assuming now that an interval between the adjoining components supplying ports 15 and 15 of the adjoining components supply apparatuses 14 and 14 is selected to be 20 mm, a length of the components supplying regions S and S located on both the right and left sides thereof along the arrow X-direction becomes $20 \text{ mm} \times (60-1) = 1180 \text{ mm}$. Also, it is assumed that a distance defined between the components supplying port 15 of the components supplying region S and the closest edge in the board 9 from this components supplying port 15 is 40 mm.

It should be understood that as is known, the transport speed of the tool head along the horizontal (X-Y

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direction) in the existing (conventional) components mounting apparatus is practically 40 mm/0.1 second. Since it slightly takes time until the tool head becomes uniform motion, as indicated by a solid line of Fig. 5, the tool head starts to move after 0.02 seconds when a start instruction is issued, and the motion of this tool head becomes uniform after 0.07 seconds when this start instruction is issued, namely after the tool head has passed the point of 20 mm. Then, when the speed graph line of this conventional tool head is expressed by linear approximation formula (will be referred to as a "conversion formula" hereinafter), it is given as follows:

$$t = 0.043 + (0.055 \times \text{transport distance}/40) \text{ seconds.}$$

In this graphic representation, the motion of the tool head is under acceleration condition during $t < 0.07$ seconds. Even when the transport time is calculated based on the above-described linear approximation formula under this acceleration condition (namely, portion indicated by a dotted line of Fig. 5), since the transport time becomes longer than the actual transport time with respect to the transport distance, there is no problem in order to prove that it is fast.

Practically speaking, time required to transport the absorbing nozzle 8 along the vertical direction is 0.08 seconds, and the normal confirmation work requires 0.04 seconds. This confirmation work by a vision camera system



(not shown) is required so as to confirm the direction of the chip component 13 absorbed by the absorbing nozzle 8 in this components mounting apparatus 1. Moreover, it is designed that an average interval between the chip component 13 and the chip component 13 mounted on the board 9 is approximately 10 mm.

On the other hand, assuming now that one chip component 13 is mounted on a central position (functioning as a typical point) of the board 9, the absorbing nozzle 8 must be moved over the minimum distance (namely, $40 + 250/2 = 165$ mm) from the components supplying port 15. To move this absorbing nozzle 8 over this minimum distance, it would take $165/400 =$ approximately 0.4125 seconds. As a consequence, the above-described target mounting tact time of 0.4 seconds/chip could not be achieved.

COMPONENTS MOUNTING METHODS

As a consequence, in accordance with the components mounting method according to the present invention, since the member of tool head transport between the components supplying regions S and the components mounting region M is reduced as being permitted as possible, the above-described target mounting tact time can be achieved. For the sake of simple explanations, the components supplying region S of the components mounting apparatus 1 exists only on a single side of the components mounting region M in the below-mentioned embodiments.



In accordance with a components mounting method of a first embodiments of the present invention, a large quantity of chip components 13, ---, 13 are absorbed as many as possible from the components supplying region S by 20 sets of absorbing nozzles 8, ---, 8 provided on the tool head 7, and this tool head 7 is transported to the components mounting region M, so that the respective chip components 13, ---, 13 are mounted on the board 9.

When a plurality of chip components 13, ---, 13 are mounted in this manner, the transport of the tool head 7 between the components supplying region S and the components mounting region M may be carried out only one time, so that the transport time per a single chip component 13 between the above-described two regions can be reduced. As a result, the mounting speed (mounting tact time) can be shortened.

Next, an explanation will be made how to shorten the mounting tact time of the chip component 13 by employing concrete manners.

As previously described, the mounting tact time per single chip component is assumed as follows. That is, 0.4 seconds correspond to the target mounting tact time. In this target mounting tact time of 0.4 seconds, 0.2 seconds are required by adding time of $0.08 \times 2 = 0.16$ seconds which require the up/down movement of the absorbing nozzle 8 (during absorbing operation, and mounting operation) to

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confirmation time of 0.04 seconds required for confirming the absorption condition of the chip component 13 by using the vision camera system. Accordingly, the tool head must be transported along the X-Y direction within 0.2 seconds ($= 0.4 - 0.2$).

Moreover, this X-Y target transport time of 0.2 seconds corresponds to a total of target transport times of the tool head 7 between the components supplying region S and the components mounting region M. As a consequence, assuming now that the transport time of the tool head 7 in the components supplying region S is equal to that in the components mounting region M in view of averaged values, the target transport time of the tool head 7 in each of these components supplying/mounting regions becomes 0.1 second. It should be understood that the transport time between the component supplying region S and the components mounting region M is merged into the target transport time in the components mounting region M to be calculated.

While using the above-described 0.1 second as each of the target transport times for the tool head 7 in the components supplying region S and the components mounting region M (will be referred to as a "region-S target transport time" and a "region-M target transport time", a sequential operation for absorbing or mounting the chip components 13, ---, 13 will now be explained. It is assumed that 20 pieces of absorbing nozzles 8, ---, 8 mounted on the



tool head 7 may absorb 11 pieces of chip components 13, ---, 13 while these absorbing nozzles are transported within the components supplying region S one time. This assumption is established from the following prediction. That is, if desired chip components are absorbed by all of 20 pieces of absorbing nozzles 8, ---, 8, then the transport range of these absorbing nozzles will be extended within the components supplying region S, so that the above-explained target transport time of 0.1 second within the components supplying region S could not be achieved.

As a consequence, the components supplying region S (its entire length: 1,180 mm) is subdivided into some sections. An assumption is made by that the tool head is transported in a range of a transport distance within this subdivided straight line, and then 11 pieces of chip components 13, ---, 13 are absorbed.

It should be understood that although this embodiment will describe that the components supplying region S is subdivided into several sections and the tool head 7 is transported within the area of this subdivided section, a decision as to whether or not the components supplying region S is subdivided may be made based on the quantity of absorbing nozzles 8, ---, 8 mounted on the tool head 7, the dimension of the board 9, and either the sort or the quantity of chip components 13, ---, 13 to be mounted. It is of course possible to apply the components mounting



method according to the present invention to such a case that the components supplying region S is not subdivided.

Therefore, a length of a subdivided straight line (namely, transport distance within straight line) is determined, 11 points are selected at random within this range, and a check is made as to whether or not averaged transport time between these points becomes the above-described region-S target transport time of 0.1 second, so that the subdivided transport distance within the straight line is determined in which the transport time is shorter than, or nearly equal to the above-described region-S target transport time of 0.1 second.

Concretely speaking, the following investigation will be made as to such a case that the subdivided transport distances within the straight line are 800 mm, 600 mm, 400 mm, and 200 mm.

In any one of these subdivided transport distances within the straight line, 10 sets of cases are investigated. A calculation is made of an average value of transport time as to each of these 10 cases, and further a total value of these average values is calculated.

In a table 1 to a table 4, random numbers in a distance implies 11 point (a, b, c, ---, k) selected based on the random numbers within a predetermined length. These points are rearranged in a small order and then represented in the respective tables. Transport distances among the

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respective points imply that distances (ab, bc, cd, ---, jk) among the above-described points (a, b, c, ---, k) and points adjacent to these points are displayed. Transport time indicates transport time between the respective times by substituting the above-described transport distances among the respective points for the above-described conversion formula.

The table 1 indicates such a case that the transport distance within the straight line is 800 mm.

Table 1

Condition 1 distance: 800 mm
 number of target point: 11 points
 distance/time conversion: (conversion formula = $0.043 + (0.055 \times \text{transport distance}/40)$)

random number within distance (rearranged)

	a	b	c	d	e	f	g	h	i	j	k
case 1	64	146	150	176	196	252	254	288	372	440	724
case 2	104	232	436	452	462	500	598	602	624	662	752
case 3	0	68	74	96	308	578	624	630	636	644	664
case 4	20	98	162	264	436	448	512	608	650	696	758
case 5	14	26	220	296	332	396	424	436	508	678	734
case 6	38	208	232	266	316	386	388	612	666	756	768
case 7	22	98	142	254	296	372	450	494	570	636	730
case 8	60	196	282	318	334	338	566	572	650	726	750
case 9	36	190	290	318	374	390	420	564	636	700	794
case 10	24	48	148	180	504	604	664	720	756	768	788

transport distance among points (mm)

	ab	bc	cd	de	ef	fg	gh	hi	ij	jk
case 1	82	4	26	20	56	2	34	84	68	284
case 2	128	204	16	10	38	98	4	22	38	90
case 3	68	6	22	212	270	46	6	6	8	20
case 4	78	64	102	172	12	64	96	42	46	62
case 5	12	194	76	36	64	28	12	72	170	56
case 6	170	24	34	50	70	2	224	54	90	12
case 7	76	44	112	42	76	78	44	76	66	94
case 8	136	86	36	16	4	228	6	78	76	24
case 9	154	100	28	56	16	30	144	72	64	94
case 10	24	100	32	324	100	60	56	36	12	20

transport time (sec)

	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	averaged value
case 1	0.16	0.05	0.08	0.07	0.12	0.05	0.09	0.16	0.14	0.43	0.134
case 2	0.22	0.32	0.07	0.06	0.10	0.18	0.05	0.07	0.10	0.17	0.132
case 3	0.14	0.05	0.07	0.33	0.41	0.11	0.05	0.05	0.05	0.07	0.134
case 4	0.15	0.13	0.18	0.28	0.06	0.13	0.18	0.10	0.11	0.13	0.144
case 5	0.06	0.31	0.15	0.09	0.13	0.08	0.06	0.14	0.28	0.12	0.142
case 6	0.28	0.08	0.09	0.11	0.14	0.05	0.35	0.12	0.17	0.06	0.143
case 7	0.15	0.10	0.20	0.10	0.15	0.15	0.10	0.15	0.13	0.17	0.14
case 8	0.23	0.16	0.09	0.07	0.05	0.36	0.05	0.15	0.15	0.08	0.138
case 9	0.25	0.18	0.08	0.12	0.07	0.08	0.24	0.14	0.13	0.17	0.147
case 10	0.08	0.18	0.09	0.49	0.18	0.13	0.12	0.09	0.06	0.07	0.148

total averaged value of 0.14SEC

Considering now a case 1 in the table 1, the points (a, b, ---, k) selected at random are given as follows: a: 64, b: 146, c: 150, d: 176, e: 196, f: 252, g: 254, h: 288, i: 372, j: 440, k: 724. The distances among the respective points are given as follows: ab: 82, bc: 4, cd: 26, de: 20, ef: 56, fg: 2, gh: 34, hi: 84, ij: 68, jk: 284 (mm).

When these values are used in the above-described conversion formula to calculate the transport times among the respective points, these transport times are given as follows: ab: 0.16, bc: 0.05, cd: 0.08, de: 0.07, ef: 0.12, fg: 0.05, gh: 0.09, hi: 0.16, ij: 0.14, jk: 0.43 (seconds). An averaged value of these transport times is given as 0.134 seconds.

When averaged values of the respective transport times are similarly calculated from a case 2 to a case 10, these

values are given as follows: case 2: 0.132, case 3: 0.134, case 4: 0.144, case 5: 0.142, case 6: 0.143, case 7: 0.14, case 8: 0.138, case 9: 0.147, case 10: 0.148 (seconds). Furthermore, when an averaged value of the summed transport times is calculated, it becomes 0.14 seconds.

As a result, since the above-described averaged value of 0.14 seconds becomes longer than the above-defined region-S target transport time of 0.1 second, it can be understood that the transport distance within a straight line of 800 mm could not be employed.

A table 2 indicates such a case that the transport distance within a straight line is 600 mm.

Table 2

Condition 2 distance: 600 mm
 number of target point: 11 points
 distance/time conversion: (conversion formula = $0.043 + (0.055 \times \text{transport distance}/40)$)

random number within distance (rearranged)

	a	b	c	d	e	f	g	h	i	j	k
case 1	48	109.5	112.5	132	147	189	190.5	216	279	330	543
case 2	78	174	327	339	346.5	375	448.5	451.5	468	496.5	564
case 3	0	51	55.5	72	231	433.5	468	472.5	477	483	498
case 4	15	73.5	121.5	198	327	336	384	456	487.5	522	568.5
case 5	10.5	19.5	165	222	249	297	318	327	381	508.5	550.5
case 6	28.5	156	174	199.5	237	289.5	291	459	499.5	567	576
case 7	16.5	73.5	106.5	190.5	222	279	337.5	370.5	427.5	477	547.5
case 8	45	147	211.5	238.5	250.5	253.5	424.5	429	487.5	544.5	562.5
case 9	27	142.5	217.5	238.5	280.5	292.5	315	423	477	525	595.5
case 10	18	36	111	135	378	453	498	540	567	576	591

transport distance among points (mm)

	ab	bc	cd	de	ef	fg	gh	hi	ij	jk
case 1	61.5	3	19.5	15	42	1.5	25.5	63	51	213
case 2	96	153	12	7.5	28.5	73.5	3	16.5	28.5	67.5
case 3	51	4.5	16.5	159	202.5	34.5	4.5	4.5	6	15
case 4	58.5	48	76.5	129	9	48	72	31.5	34.5	46.5
case 5	9	145.5	57	27	48	21	9	54	127.5	42
case 6	127.5	18	25.5	37.5	52.5	1.5	168	40.5	67.5	9
case 7	57	33	84	31.5	57	58.5	33	57	49.5	70.5
case 8	102	64.5	27	12	3	171	4.5	58.5	57	18
case 9	115.5	75	21	42	12	22.5	108	54	48	70.5
case 10	18	75	24	243	75	45	42	27	9	15

transport time (sec)

	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	averaged value
case 1	0.13	0.05	0.07	0.06	0.10	0.05	0.08	0.13	0.11	0.34	0.111
case 2	0.18	0.25	0.06	0.05	0.08	0.14	0.05	0.07	0.08	0.14	0.11
case 3	0.11	0.05	0.07	0.26	0.32	0.09	0.05	0.05	0.05	0.06	0.111
case 4	0.12	0.11	0.15	0.22	0.06	0.11	0.14	0.09	0.09	0.11	0.119
case 5	0.06	0.24	0.12	0.08	0.11	0.07	0.06	0.12	0.22	0.10	0.117
case 6	0.22	0.07	0.08	0.09	0.12	0.05	0.27	0.10	0.14	0.06	0.118
case 7	0.12	0.09	0.16	0.09	0.12	0.12	0.09	0.12	0.11	0.14	0.116
case 8	0.18	0.13	0.08	0.06	0.05	0.28	0.05	0.12	0.12	0.07	0.114
case 9	0.20	0.15	0.07	0.10	0.06	0.07	0.19	0.12	0.11	0.14	0.121
case 10	0.07	0.15	0.08	0.38	0.15	0.10	0.10	0.08	0.06	0.06	0.122

total averaged value of 0.116SEC

Considering the table 2, when an averaged value of transport times as to the transport distance within a straight line of 600 mm is calculated in a similar manner to the above table 1, it becomes 0.116 seconds.

As a result, since this averaged value of 0.116

seconds becomes longer than the region-S target transport time of 0.1 second, it can also be understood that the transport distance within a straight line of 600 mm could not be employed.

A table 3 indicates such a case that the transport distance within a straight line is 400 mm.

Table 3

Condition 3 distance: 400mm
 number of target point: 11 points
 distance/time conversion: (conversion formula = $0.043 + (0.055 \times \text{transport distance}/40)$)

random number within distance (rearranged)

	a	b	c	d	e	f	g	h	i	j	k
case 1	32	73	75	88	98	126	127	144	186	220	362
case 2	52	116	218	226	231	250	299	301	312	331	376
case 3	0	34	37	48	154	289	312	315	318	322	332
case 4	10	49	81	132	218	224	256	304	325	348	379
case 5	7	13	110	148	166	198	212	218	254	339	367
case 6	19	104	116	133	158	193	194	306	333	378	384
case 7	11	49	71	127	148	186	225	247	285	318	365
case 8	30	98	141	159	167	169	283	286	325	363	375
case 9	18	95	145	159	187	195	210	282	318	350	397
case 10	12	24	74	90	252	302	332	360	378	384	394

transport distance among points (mm)

	ab	bc	cd	de	ef	fg	gh	hi	ij	jk
case 1	41	2	13	10	28	1	17	42	34	142
case 2	64	102	8	5	19	49	2	11	19	45
case 3	34	3	11	106	135	23	3	3	4	10
case 4	39	32	51	86	6	32	48	21	23	31
case 5	6	97	38	18	32	14	6	36	85	28
case 6	85	12	17	25	35	1	112	27	45	6
case 7	38	22	56	21	38	39	22	38	33	47
case 8	68	43	18	8	2	114	3	39	38	12
case 9	77	50	14	28	8	15	72	36	32	47
case 10	12	50	16	162	50	30	28	18	6	10

transport time (sec)

	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	averaged value
case 1	0.10	0.05	0.06	0.06	0.08	0.04	0.07	0.10	0.09	0.24	0.088
case 2	0.13	0.18	0.05	0.05	0.07	0.11	0.05	0.06	0.07	0.10	0.088
case 3	0.09	0.05	0.06	0.19	0.23	0.07	0.05	0.05	0.05	0.06	0.089
case 4	0.10	0.09	0.11	0.16	0.05	0.09	0.11	0.07	0.07	0.09	0.094
case 5	0.05	0.18	0.10	0.07	0.09	0.06	0.05	0.09	0.16	0.08	0.093
case 6	0.16	0.06	0.07	0.08	0.09	0.04	0.20	0.08	0.10	0.05	0.093
case 7	0.10	0.07	0.12	0.07	0.10	0.10	0.07	0.10	0.09	0.11	0.092
case 8	0.14	0.10	0.07	0.05	0.05	0.20	0.05	0.10	0.10	0.06	0.09
case 9	0.15	0.11	0.06	0.08	0.05	0.06	0.14	0.09	0.09	0.11	0.095
case 10	0.06	0.11	0.07	0.27	0.11	0.08	0.08	0.07	0.05	0.06	0.096

total averaged value of 0.092SEC

Considering the table 3, when an averaged value of transport times as to the transport distance within a straight line of 400 mm is calculated in a similar manner to the above table 1, it becomes 0.092 seconds.

As a result, since this averaged value of 0.092

seconds becomes shorter than the region-S target transport time of 0.1 second, it can also be understood that the transport distance within a straight line of 400 mm could be employed.

A table 4 indicates such a case that the transport distance within a straight line is 200 mm.

Table 4

Condition 4 distance: 200mm
 number of target point: 11 points
 distance/time conversion: (conversion formula = $0.043 + (0.055 \times \text{transport distance}/40)$)

random number within distance (rearranged)

	a	b	c	d	e	f	g	h	i	j	k
case 1	16	36.5	37.5	44	49	63	63.5	72	93	110	181
case 2	26	58	109	113	115.5	125	149.5	150.5	156	165.5	188
case 3	0	17	18.5	24	77	144.5	156	157.5	159	161	166
case 4	5	24.5	40.5	66	109	112	128	152	162.5	174	189.5
case 5	3.5	6.5	55	74	83	99	106	109	127	169.5	183.5
case 6	9.5	52	58	66.5	79	96.5	97	153	166.5	189	192
case 7	5.5	24.5	35.5	63.5	74	93	112.5	123.5	142.5	159	182.5
case 8	15	49	70.5	79.5	83.5	84.5	141.5	143	162.5	181.5	187.5
case 9	9	47.5	72.5	79.5	93.5	97.5	105	141	159	175	198.5
case 10	6	12	37	45	126	151	166	180	189	192	197

transport distance among points (mm)

	ab	bc	cd	de	ef	fg	gh	hi	ij	jk
case 1	20.5	1	6.5	5	14	0.5	8.5	21	17	71
case 2	32	51	4	2.5	9.5	24.5	1	5.5	9.5	22.5
case 3	17	1.5	5.5	53	67.5	11.5	1.5	1.5	2	5
case 4	19.5	16	25.5	43	3	16	24	10.5	11.5	15.5
case 5	3	48.5	19	9	16	7	3	18	42.5	14
case 6	42.5	6	8.5	12.5	17.5	0.5	56	13.5	22.5	3
case 7	19	11	28	10.5	19	19.5	11	19	16.5	23.5
case 8	34	21.5	9	4	1	57	1.5	19.5	19	6
case 9	38.5	25	7	14	4	7.5	36	18	16	23.5
case 10	6	25	8	81	25	15	14	9	3	5

transport time (sec)

	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	averaged value
case 1	0.07	0.04	0.05	0.05	0.06	0.04	0.05	0.07	0.07	0.14	0.066
case 2	0.09	0.11	0.05	0.05	0.06	0.08	0.04	0.05	0.06	0.07	0.065
case 3	0.07	0.05	0.05	0.12	0.14	0.06	0.05	0.05	0.05	0.05	0.066
case 4	0.07	0.07	0.08	0.10	0.05	0.07	0.08	0.06	0.06	0.06	0.068
case 5	0.05	0.11	0.07	0.06	0.07	0.05	0.05	0.07	0.10	0.06	0.068
case 6	0.10	0.05	0.05	0.06	0.07	0.04	0.12	0.06	0.07	0.05	0.068
case 7	0.07	0.06	0.08	0.06	0.07	0.07	0.06	0.07	0.07	0.08	0.067
case 8	0.09	0.07	0.06	0.05	0.04	0.12	0.05	0.07	0.07	0.05	0.067
case 9	0.10	0.08	0.05	0.06	0.05	0.05	0.09	0.07	0.07	0.08	0.069
case 10	0.05	0.08	0.05	0.15	0.08	0.06	0.06	0.06	0.05	0.05	0.069

total averaged value of 0.067SEC

Considering the table 4, when an averaged value of transport times as to the transport distance within a straight line of 200 mm is calculated in a similar manner to the above table 1, it becomes 0.067 seconds.

As a result, since this averaged value of 0.067



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seconds becomes shorter than the region-S target transport time of 0.1 second, it can also be understood that the transport distance within a straight line of 200 mm could be employed.

As previously explained, when the tool head 7 is transported within the straight line, if the transport distance within this straight line is smaller than, or equal to 400 mm, then it can be seen that the region-S target transport time of 0.1 second could be achieved.

Next, another investigation is carried out as to such a case that the tool head 7 is moved in a plane manner (namely, X-Y direction) within the components mounting region M. As explained above, the dimension of the board 9 is 250 mm x 400 mm. If the tool head 7 is tried to be moved within this entire range along the X-Y direction, then since this range is too wide, it is predictable that the region-M target transport time of 0.1 second cannot be achieved. Then, the components mounting region M is properly subdivided into several subdivided plane sections in a similar manner to the above-described components supplying region S, and the following consideration is carried out under such a condition that the tool head 7 is transported within the subdivided plane section.

In this embodiment, the components mounting region M is subdivided into several section, and then the tool head 7 is transported within this subdivided section. Similar to

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the subject matter as to whether or not the components supplying region S is divided, a decision as to whether or not the components mounting region M is made based on such a condition, namely, the number of absorbing nozzles 8, ---, 8 mounted on the tool head 7, the dimension of the board 9, and the sort or quantity of chip components 13, ---, 13 to be mounted. It is of course possible to apply the component mounting method according to the present invention to such a case that the components mounting region M is not subdivided.

Then, a subdivided plane section is determined, and 11 points are selected at random within this subdivided plane section. A position is recognized as a starting point, which is located apart from a center of a short edge of each plane section, or a center of a long edge thereof by 40 mm outwardly. A path is determined from this starting point by properly connecting the above-described 11 points to each other in a predetermined sequence until the starting point (it becomes an end point). Among the respective points, a longer component of the X-Y component is selected as a main axis. Then, a check is made as to whether or not an averaged transport time for the length of this main axis becomes the above-described region-M target transport time of 0.1 second. As a consequence, such a subdivided plane section is determined in which the averaged value is shorter than, or nearly equal to the region-M target transport time

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of 0.1 second.

Concretely speaking, the following investigation is performed as to three cases of subdivided plane sections, namely 250 mm x 200 mm, 125 mm x 200 mm, and 125 mm x 100 mm.

In any one of the subdivided plane sections, 10 cases will now be considered. A calculation is made of an averaged value of transport times as to the respective cases, and further, a total value of averaged values is calculated.

It should be understood that the path started from the starting point via 11 points in a predetermined sequential order and returned again to the starting point may be determined by properly connecting these 11 points in accordance with the artificially better order, which are selected based on the random numbers on the plane. It should also be understood that the expression of "artificially better order" implies as follows. That is, while a point located at the closest position, or the second closest position with respect to the starting point "s" is selected as a first point within the component mounting region M among these 11 points, and also another point located at the second closest position, or the closest position from the starting point "s" among the 11 points is selected as a final point within the component mounting region M, these points are connected to each other.

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Fig. 6 to Fig. 15 represent 10 cases in which a starting point is connected to 11 points selected based upon random numbers in a plane section defined by 250 mm x 200 mm. Symbol "☆" denotes a starting point (end point) "s", and point "◎" shows 11 points (a, b, c, ..., k) selected at random.

In a table 5 to a table 7, a transport amount implies that a two-point distance for connecting either a starting point or a point to another point is expressed by an X component and a Y component. For instance, an X component and a Y component of two-point distance for connecting the starting point "s" and a point "a" are indicated in a column "sa". Also, a transport amount of a main axis implies that among the above-described X components and Y components of the transport amounts, a longer transport amount is selected. A transport time is to indicate transport times among the respective points by substituting the transport amounts of the main axis among the respective points for the above-described conversion formula.

The table 5 indicates such a case that the plane section is defined by 250 mm x 200 mm.

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Table 5

Condition 1 region: 250mm x 200mm
 : starting point: 40mm outside center of short edge
 end point: ditto
 number of target points: 11 points within region
 distance/time conversion: (conversion formula = $0.043 + (0.055 \times \text{transport distance}/40)$)

transport amount (X:axis of 250 • Y:axis of 200)

	sa	ab	bo	cd	de	ef	fg	gh	hi	ij	jk	ks
case 1 (X)	80	10	120	20	10	20	10	20	80	60	60	90
case 1 (Y)	50	20	30	10	30	0	60	10	80	30	60	0
case 2 (X)	100	40	40	10	10	50	0	10	70	10	70	90
case 2 (Y)	50	30	50	40	20	40	30	70	80	10	20	20
case 3 (X)	70	100	50	70	40	40	40	80	10	50	40	70
case 3 (Y)	80	30	20	10	70	110	40	30	70	40	20	40
case 4 (X)	60	40	40	20	50	70	30	10	0	40	140	70
case 4 (Y)	10	20	40	20	20	0	40	60	20	0	40	90
case 5 (X)	50	20	40	110	40	90	0	10	170	40	10	70
case 5 (Y)	30	0	30	50	40	30	70	30	50	10	40	90
case 6 (X)	60	0	30	130	10	50	90	30	40	20	10	180
case 6 (Y)	30	50	10	20	40	10	20	20	30	80	10	30
case 7 (X)	80	40	70	0	20	10	10	100	20	90	70	100
case 7 (Y)	60	20	10	20	40	30	0	30	10	40	40	50
case 8 (X)	60	50	0	100	30	60	20	10	130	40	40	60
case 8 (Y)	0	30	20	40	20	10	80	20	40	20	50	80
case 9 (X)	150	40	10	20	10	40	10	20	0	90	130	60
case 9 (Y)	50	40	0	10	30	60	80	50	60	40	30	30
case 10 (X)	60	10	60	20	40	50	50	10	30	110	10	130
case 10 (Y)	10	40	30	10	30	50	50	70	60	20	10	100

transport amount of main axis

	sa	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	ks
case 1	80	20	120	20	30	20	60	20	80	60	60	90
case 2	100	40	50	40	20	50	30	70	80	10	70	90
case 3	80	100	50	70	70	110	40	80	70	50	40	70
case 4	60	40	40	20	50	70	40	60	20	40	140	90
case 5	50	20	40	110	40	90	70	30	170	40	40	90
case 6	60	50	30	130	40	50	90	30	40	80	10	180
case 7	80	40	70	20	40	30	10	100	20	90	70	100
case 8	60	50	20	100	30	60	80	20	130	40	50	80
case 9	150	40	10	20	30	60	80	50	60	90	130	60
case 10	60	40	60	20	40	50	50	70	60	110	10	130

transport time (sec)													
	sa	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	ks	averaged value
case 1	0.15	0.07	0.21	0.07	0.08	0.07	0.13	0.07	0.15	0.13	0.13	0.17	0.119
case 2	0.18	0.10	0.11	0.10	0.07	0.11	0.08	0.14	0.15	0.06	0.14	0.17	0.117
case 3	0.15	0.18	0.11	0.14	0.14	0.19	0.10	0.15	0.14	0.11	0.10	0.14	0.138
case 4	0.13	0.10	0.10	0.07	0.11	0.14	0.10	0.13	0.07	0.10	0.24	0.17	0.12
case 5	0.11	0.07	0.10	0.19	0.10	0.17	0.14	0.08	0.28	0.10	0.10	0.17	0.134
case 6	0.13	0.11	0.08	0.22	0.10	0.11	0.17	0.08	0.10	0.15	0.06	0.29	0.134
case 7	0.15	0.10	0.14	0.07	0.10	0.08	0.06	0.18	0.07	0.17	0.14	0.18	0.12
case 8	0.13	0.11	0.07	0.18	0.08	0.13	0.15	0.07	0.22	0.10	0.11	0.15	0.126
case 9	0.25	0.10	0.06	0.07	0.08	0.13	0.15	0.11	0.13	0.17	0.22	0.13	0.132
case 10	0.13	0.10	0.13	0.07	0.10	0.11	0.11	0.14	0.13	0.19	0.06	0.22	0.123

total averaged value of 0.126SEC

In the table 5, considering a case 1, an X component and a Y component of an interval between one point and another point preceding to the first-mentioned point are given as follows: sa: X=80, Y=50, ab: X=10, Y=20, bc: X=120, Y=30, cd: X=20, Y=10, de: X=10, Y=30, ef: X=20, Y=0, fg: X=10, Y=60, gh: X=20, Y=10, hi: X=80, Y=80, ij: X=60, Y=30, jk: X=60, Y=60, ks: X=90, Y=0. A transport amount of a main axis as to a layer interval within the intervals among the respective points is given as follows: sa: 80, ab: 20, bc: 120, cd: 20, de: 30, ef: 20, fg: 60, gh: 20, hi: 80, ij: 60, jk: 60, ks: 90 (mm).

When a calculation is made of transport times among the respective points by using these values based on the conversion formula, the following transport times are given as follows: sa: 0.15, ab: 0.07, bc: 0.21, cd: 0.07, de;

0.08, ef: 0.07, fg: 0.13, gh: 0.07⁴³, hi: 0.15, ij: 0.13, jk: 0.13, ks: 0.17 (seconds). An averaged value of these transport times becomes 0.119 seconds.

Similarly, when averaged values of the respective transport times from the case 2 to the case 10 are calculated, the following values are given: case 2: 0.117, case 3: 0.138, case 4: 0.12, case 5: 0.134, case 6: 0.134, case 7: 0.12, case 8: 0.126, case 9: 0.132, case 10: 0.123 (seconds). Furthermore, when an averaged value of the summed transport times is calculated, it becomes 0.126 seconds.

As a consequence, since this averaged value becomes longer than the above-described region-M target transport time of 0.1 second, it can be seen that the plane section defined by 250 mm x 200 mm could not be employed.

The table 6 indicates such a case that the plane section is defined by 125 mm x 200 mm.

Table 6

Condition 1 region: 250mm x 200mm
 starting point: 40mm outside center of short edge
 end point: ditto
 number of target points: 11 points within region
 distance/time conversion: (conversion formula = $0.043 + (0.055 \times \text{transport distance}/40)$)

transport amount (X:axis of 125 • Y:axis of 200)

	sa	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	ks
case 1 (X)	60	5	60	10	5	10	5	10	40	30	30	65
case 1 (Y)	60	20	30	10	30	0	60	10	80	30	60	50
case 2 (X)	70	20	20	5	5	25	0	5	35	5	35	65
case 2 (Y)	60	30	50	40	20	40	30	70	80	10	20	50
case 3 (X)	55	50	25	35	20	20	20	40	5	25	20	55
case 3 (Y)	80	30	20	10	70	110	40	30	70	40	20	80
case 4 (X)	50	20	20	10	25	35	15	5	0	20	70	55
case 4 (Y)	10	20	40	20	20	0	40	60	20	0	40	10
case 5 (X)	45	10	20	55	20	45	0	5	85	20	5	55
case 5 (Y)	30	0	30	50	40	30	70	30	50	10	40	30
case 6 (X)	50	0	15	65	5	25	45	15	20	10	5	110
case 6 (Y)	30	50	10	20	40	10	20	20	30	80	10	30
case 7 (X)	60	20	35	0	10	5	5	50	10	45	35	70
case 7 (Y)	60	20	10	20	40	30	0	30	10	40	40	60
case 8 (X)	50	25	0	50	15	30	10	5	65	20	20	50
case 8 (Y)	0	30	20	40	20	10	80	20	40	20	50	0
case 9 (X)	95	20	5	10	5	20	5	10	0	45	65	50
case 9 (Y)	50	40	0	10	30	60	80	50	60	40	30	50
case 10 (X)	50	5	30	10	20	25	25	5	15	55	5	85
case 10 (Y)	10	40	30	10	30	50	50	70	60	20	10	10

transport amount of main axis

	sa	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	ks
case 1	60	20	60	10	30	10	60	10	80	30	60	65
case 2	70	30	50	40	20	40	30	70	80	10	35	65
case 3	80	50	25	35	70	110	40	40	70	40	20	80
case 4	50	20	40	20	25	35	40	60	20	20	70	55
case 5	45	10	30	55	40	45	70	30	85	20	40	55
case 6	50	50	15	65	40	25	45	20	30	80	10	110
case 7	60	20	35	20	40	30	5	50	10	45	40	70
case 8	50	30	20	50	20	30	80	20	65	20	50	50
case 9	95	40	5	10	30	60	80	50	60	45	65	50
case 10	50	40	30	10	30	50	50	70	60	55	10	80

transport time (sec)

	sa	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	ks	averaged value
case 1	0.13	0.07	0.13	0.06	0.08	0.06	0.13	0.06	0.15	0.08	0.13	0.13	0.1
case 2	0.14	0.08	0.11	0.10	0.07	0.10	0.08	0.14	0.15	0.06	0.09	0.13	0.105
case 3	0.15	0.11	0.08	0.09	0.14	0.19	0.10	0.10	0.14	0.10	0.07	0.15	0.119
case 4	0.11	0.07	0.10	0.07	0.08	0.09	0.10	0.13	0.07	0.07	0.14	0.12	0.095
case 5	0.10	0.06	0.08	0.12	0.10	0.10	0.14	0.08	0.16	0.07	0.10	0.12	0.103
case 6	0.11	0.11	0.06	0.13	0.10	0.08	0.10	0.07	0.08	0.15	0.06	0.19	0.105
case 7	0.13	0.07	0.09	0.07	0.10	0.08	0.05	0.11	0.06	0.10	0.10	0.14	0.092
case 8	0.11	0.08	0.07	0.11	0.07	0.08	0.15	0.07	0.13	0.07	0.11	0.11	0.099
case 9	0.17	0.10	0.05	0.06	0.08	0.13	0.15	0.11	0.13	0.10	0.13	0.11	0.111
case 10	0.11	0.10	0.08	0.06	0.08	0.11	0.11	0.14	0.13	0.12	0.06	0.16	0.105

total averaged value of 0.103SEC

Considering now the table 6, when an averaged transport times in the plane section defined by 125 mm x 200 mm is calculated in a similar manner to the above table 5, it becomes 0.103 seconds.

As a result, although this averaged value becomes slightly longer than the region-M target transport time of 0.1 second, it can be understood that there are some possibilities that this plane section may be employed due to combinations with the transport time in the components supply region S.

The table 7 indicates such a case that the plane section is defined by 125 mm x 100 mm.

Table 7

Condition 3 region: 250mm x 200mm
 starting point: 40mm outside center of short edge
 end point: ditto
 number of target points: 11 points within region
 distance/time conversion: (conversion formula = 0.043
 + (0.055 x transport distance/40))

transport amount (X:axis of 125 • Y:axis of 100)

		sa	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	ks
case 1	(X)	60	5	60	10	5	10	5	10	40	30	30	65
	(Y)	25	10	15	5	15	0	30	5	40	15	30	0
case 2	(X)	70	20	20	5	5	25	0	5	35	5	35	65
	(Y)	25	15	25	20	10	20	15	35	40	5	10	10
case 3	(X)	55	50	25	35	20	20	20	40	5	25	20	55
	(Y)	40	15	10	5	35	55	20	15	35	20	10	20
case 4	(X)	50	20	20	10	25	35	15	5	0	20	70	55
	(Y)	5	10	20	10	10	0	20	30	10	0	20	45
case 5	(X)	45	10	20	55	20	45	0	5	85	20	5	55
	(Y)	15	0	15	25	20	15	35	15	25	5	20	45
case 6	(X)	50	0	15	65	5	25	45	15	20	10	5	110
	(Y)	15	25	5	10	20	5	10	10	15	40	5	15
case 7	(X)	60	20	35	0	10	5	5	50	10	45	35	70
	(Y)	30	10	5	10	20	15	0	15	5	20	20	25
case 8	(X)	50	25	0	50	15	30	10	5	65	20	20	50
	(Y)	0	15	10	20	10	5	40	10	20	10	25	40
case 9	(X)	95	20	5	10	5	20	5	10	0	45	65	50
	(Y)	25	20	0	5	15	30	40	25	30	20	15	15
case 10	(X)	50	5	30	10	20	25	25	5	15	55	5	85
	(Y)	5	20	15	5	15	25	25	35	30	10	5	50

transport amount of main axis

	sa	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	ks
case 1	60	10	60	10	15	10	30	10	40	30	30	65
case 2	70	20	25	20	10	25	15	35	40	5	35	65
case 3	55	50	25	35	35	55	20	40	35	25	20	55
case 4	50	20	20	10	25	35	20	30	10	20	70	55
case 5	45	10	20	55	20	45	35	15	85	20	20	55
case 6	50	25	15	65	20	25	45	15	20	40	5	110
case 7	60	20	35	10	20	15	5	50	10	45	35	70
case 8	50	25	10	50	15	30	40	10	65	20	25	50
case 9	95	20	5	10	15	30	40	25	30	45	65	50
case 10	50	20	35	10	20	25	25	35	30	55	5	85

transport time (sec)

	sa	ab	bc	cd	de	ef	fg	gh	hi	ij	jk	ks	averaged value
case 1	0.13	0.06	0.13	0.06	0.06	0.06	0.08	0.06	0.10	0.08	0.08	0.13	0.085
case 2	0.14	0.07	0.08	0.07	0.06	0.08	0.06	0.09	0.10	0.05	0.09	0.13	0.085
case 3	0.12	0.11	0.08	0.09	0.09	0.12	0.07	0.10	0.09	0.08	0.07	0.12	0.095
case 4	0.11	0.07	0.07	0.06	0.08	0.09	0.07	0.08	0.06	0.07	0.14	0.12	0.085
case 5	0.10	0.06	0.07	0.12	0.07	0.10	0.09	0.06	0.16	0.07	0.07	0.12	0.092
case 6	0.11	0.08	0.06	0.13	0.07	0.08	0.10	0.06	0.07	0.10	0.05	0.19	0.093
case 7	0.13	0.07	0.09	0.06	0.07	0.06	0.05	0.11	0.06	0.10	0.09	0.14	0.086
case 8	0.11	0.08	0.06	0.11	0.06	0.08	0.10	0.06	0.13	0.07	0.08	0.11	0.088
case 9	0.17	0.07	0.05	0.06	0.06	0.08	0.10	0.08	0.08	0.10	0.13	0.11	0.092
case 10	0.11	0.07	0.08	0.06	0.07	0.08	0.08	0.09	0.08	0.12	0.05	0.16	0.088

total averaged value of 0.089SEC

Considering now the table 7, when an averaged transport times in the plane section defined by 125 mm x 100 mm is calculated in a similar manner to the above table 5, it becomes 0.089 seconds.

Accordingly, since this calculated averaged time is shorter than the region-M target transport time of 0.1 second, it can be seen that this plane section defined by 125 mm x 100 mm can be employed.

When the above-described calculation results are combined, a table 8 is obtained.



Table 8

components absorbing region S		components mounting region M	
range (mm)	transport time (sec)	range (mm)	transport time (sec)
800	0.140	250 x 200	0.126
600	0.116	125 x 200	0.103
400	0.092	125 x 100	0.089
200	0.067		

Considering now the table 8, when a combined case is selected in which a total time of the transport time required for the transport distance within a straight line and the transport time required for the plane section becomes shorter than, or equal to the X-Y target transport time of 0.2 seconds, the following combinations are given as follows:

That is, to say, in such a combination case that the transport distance within a straight line is 200 mm and the plane section is defined by 125 mm x 100 mm, the summed averaged transport time becomes 0.156 seconds. In such a combination case that the transport distance within a straight line is 200 mm and the plane section is defined by 125 mm x 200 mm, the summed averaged transport time becomes 0.17 seconds.

In such a combination case that the transport distance within a straight line is 200 mm and the plane section is defined by 250 mm x 200 mm, the summed averaged transport time becomes 0.193 seconds. In such a combination case that

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the transport distance within a straight line is 400 mm and the plane section is defined by 125 mm x 100 mm, the summed averaged transport time becomes 0.181 seconds.

Also, in such a combination case that the transport distance within a straight line is 400 mm and the plane section is defined by 125 mm x 200 mm, the summed averaged transport time becomes 0.195 seconds. In any one of these combination cases, the summed averaged transport times can satisfy the X-Y target transport time of 0.2 seconds.

Also, in such a combination case that the transport distance within a straight line is 600 mm and the plane section is defined by 125 mm x 100 mm, a summed X-Y transport time becomes 0.205 seconds, and is not equal to the above-described X-Y target transport time of 0.2 seconds. However, since this summed X-Y transport time is substantially equal to the X-Y target transport time, if the target transport time is set to be lower than 0.2 seconds, then this combination case may be employed.

It should be noted that although the above-described embodiment has explained that the starting point is coincident with the end point when the X-Y transport time is calculated within the plane section, there is a very few case that the starting point is not actually coincident with the end point. In the latter case, it is predictable that the X-Y transport time becomes shorter than that of the embodiment. In other words, it is conceivable that the

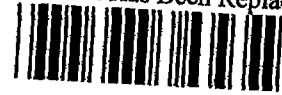


distance defined by adding the distance between the components supplying apparatus 14 of the finally absorbed chip component 13 and a predetermined mounting place where the chip component is firstly mounted to the distance between a predetermined mounting place where the chip component is finally mounted and the components supplying apparatus 14 of the chip component 13 which will be subsequently absorbed, is shorter than the distance defined in such a case that the starting point is coincident with the end point.

As a consequence, according to the components mounting method of the present invention, while the tool head 7 is transported within the components supplying region S, a large number of chip components 13, ---, 13 are absorbed as many as possible, and this tool head 7 is moved to the components mounting region M in which the chip components 13, ---, 13 are mounted on a predetermined mounting place. Therefore, the transportation of the tool head 7 between the components supplying region S and the components mounting region M can be suppressed in a minimum value when the chip components 13, ---, 13 are mounted on the board 9. As a result, the transport time per single chip component 13, namely the mounting speed (mounting tact time) can be shortened.

Also, as explained in the above embodiment, the components supplying region S and the components mounting

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region M are properly subdivided, and then the chip components 13, ---, 13 are absorbed/mounted between the subdivided supplying region S and the subdivided mounting region M. As a consequence, the sequential operations about the absorption and mounting of the chip components 13, ---, 13 can be optimized by considering the quantity of absorbing nozzles 8, ---, 8 mounted on the tool head 7, the dimension of the board 9, and the sort/quantity of chip components 13, ---, 13 to be mounted.

SECOND COMPONENTS MOUNTING METHOD

Fig. 16 schematically represents a components mounting method according to a second embodiment of the present invention. In this second embodiment, such a components mounting apparatus 1 that two components supplying regions "S" and "S" are located on both sides of a components mounting region "M". This components mounting region M is subdivided along the X direction, and also chip components 13, --- 13 are absorbed in one components supplying region S. Thereafter, the chip components 13, --- 13 are mounted in the subdivided components mounting region M, and then the tool head 7 is transferred to the other components supplying region S in order to absorb the chip components 13, ---, 13.

Under such a circumstance, the sequential operations for absorbing and mounting the chip components can be optimized, namely the mounting tact time can be shortened by employing the following manners. That is, a place where the

chip component 13 is firstly mounted within the subdivided components mounting region M is set to such a position located closest to one components supply region S. A position where the chip component 13 is finally mounted among this components mounting region M is set to such a position located closest to the other components supplying region S.

It should also be noted that although the components gripping means is operated by the negative pressure absorption in the above-described components mounting apparatus according to the embodiment of the present invention, the present invention is not limited thereto, but may be applied to, for instance, such a components gripping means that electronic components are gripped by means of a clamp and the like.

It should also be noted that the components mounting methods according to the respective embodiments, and also the concrete shapes/structures of the components mounting apparatuses according to the respective embodiments are only exemplified examples. Therefore, these exemplified examples never restrict the technical scope and spirit of the present invention.



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WHAT IS CLAIMED IS:

1. In a components mounting method in which a large number of electronic components are transported from a components supplying region where a plurality of components supplying apparatuses are arranged with said large number of electronic components stored thereinto to a components mounting region in which a board is arranged with said electronic components mounted thereon, and said electronic components are mounted on a predetermined mounting position of said board, the improvement wherein:

a plurality of said electronic components are individually gripped by a plurality of gripping means in said components supplying region; and after these gripping means are transported to the components mounting region, each of said gripped electronic components is mounted on a predetermined mounting position thereof.

2. A components mounting method as claimed in claim 1 wherein said components mounting method comprises the steps of:

subdividing at least one of said components supplying region and said components mounting region; and

mounting said electronic components in a entire region of said mounting region by repeating one of the steps of:

gripping said electronic components by a plurality of said gripping means in one of said subdivided sections of said components supplying region and mounting said

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electronic components in said components mounting region and then gripping said electronic components by a plurality of said gripping means in another subdivided section of said components supplying region and mounting said electronic components in said components mounting region;

gripping said electronic components by a plurality of said gripping means in said components supplying region and mounting said electronic components in one of said subdivided sections of said components mounting region and then gripping said electronic components by a plurality of said gripping means in said components supplying region again and mounting said electronic components in another subdivided section of said components mounting region; and

gripping said electronic components by a plurality of said gripping means in one of said subdivided sections of said components supplying region and mounting said electronic components in one of subdivided section of said components mounting region and then gripping said electronic components by a plurality of said gripping means in another subdivided section of said components supplying region and mounting said electronic components in another subdivided section of said components mounting region.

3. A component mounting method as claimed in claim 2 wherein:

said components supplying region is subdivided into two groups of subdivided sections arranged on both sides of



said components mounting region in a direction identical to a direction along which said subdivided sections of said components mounting region are disposed, and

said step of gripping said electronic components in one of said subdivided sections of said components supplying region and mounting said electronic components in one of subdivided section of said components mounting region and then gripping said electronic components in another subdivided section of said components supplying region and mounting said electronic components in another subdivided section of said components mounting region further comprises steps of:

gripping individually a plurality of said electronic components in one of said subdivided sections of said components supplying region by a plurality of said components gripping means;

transporting a plurality of said component gripping means to one of said subdivided sections of said components mounting region;

mounting each of said electronic components on a predetermined mounting position;

transporting a plurality of said components gripping means to another subdivided sections of said components supplying region;

gripping a plurality of said electronic components again in said another subdivided sections of said components

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supplying region by a plurality of said components gripping means;

transporting a plurality of said components gripping means to another subdivided sections of said components mounting region;

mounting each of said electronic components on a predetermined mounting position;

repeating above steps until said electronic components are mounted in the entire region of said mounting region.

4. A components mounting method as claimed in claim 2 wherein:

said electronic components are mounted from such a predetermined mounting position located closest to said components supplying apparatus where previous final gripping of said electronic components has been performed by said components gripping means among said components supplying apparatuses in said subdivided sections of said components supplying region.

5. A components mounting method as claimed in claim 3 wherein:

said electronic components are mounted from such a predetermined mounting position located closest to said components supplying apparatus where previous final gripping of said electronic components has been performed by said components gripping means among said components supplying apparatuses in said subdivided sections of said components

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supplying region.

6. A components mounting method as claimed in claim 2 wherein:

said electronic components are mounted in said components mounting region at a predetermined mounting position located closest to such a component supplying apparatus where next first gripping of said electronic component is to be performed in said components supplying region to which said components gripping means are to be subsequently transported is designated as a final predetermined mounting position within said components mounting region among said predetermined mounting positions in said components mounting region.

7. A components mounting method as claimed in claim 3 wherein:

said electronic components are mounted in said components mounting region at a predetermined mounting position located closest to such a component supplying apparatus where next first gripping of said electronic component is to be performed in said components supplying region to which said components gripping means are to be subsequently transported is designated as a final predetermined mounting position within said components mounting region among said predetermined mounting positions in said components mounting region.

8. A components mounting method as claimed in claim

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4 wherein:

said electronic components are mounted in said components mounting region at a predetermined mounting position located closest to such a component supplying apparatus where next first gripping of said electronic component is to be performed in said components supplying region to which said components gripping means are to be subsequently transported is designated as a final predetermined mounting position within said components mounting region among said predetermined mounting positions in said components mounting region.

9. A components mounting method as claimed in claim 5 wherein:

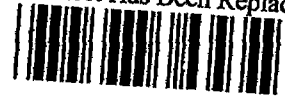
said electronic components are mounted in said components mounting region at a predetermined mounting position located closest to such a component supplying apparatus where next first gripping of said electronic component is to be performed in said components supplying region to which said components gripping means are to be subsequently transported is designated as a final predetermined mounting position within said components mounting region among said predetermined mounting positions in said components mounting region.

10. A components mounting apparatus in which a large number of electronic components are transported from a components supplying region where a plurality of components

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supplying apparatuses are arranged with said large number of electronic components stored thereinto to a component mounting region in which a board is arranged with said electronic components mounted on preselected mounting positions of said board, said components mounting apparatus comprising:

components gripping means for individually gripping said electronic components; and

a tool head on which a plurality of said components gripping means are mounted and which is movably provided between said component supplying region and said components mounting region,

said components gripping means being supported movably in the upward and downward direction with respect to said tool head, and moving up and down for gripping and releasing said electronic components when positioned to a preselected position in said tool head;

said tool head being provided rotatably in the forward and reverse directions so that said tool head is rotated for selecting said components gripping means and positioning the selected components gripping means to a preselected position.

11. A components mounting apparatus as claimed in claim 10 wherein:

said electronic components are chip type electronic components.

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12. A components mounting apparatus as claimed in claim 10 wherein:

said components gripping means is an absorbing nozzle for absorbing the electronic component by using negative pressure.

13. A components mounting apparatus as claimed in claim 11 wherein:

said components gripping means is an absorbing nozzle for absorbing the electronic component by using negative pressure.

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MOUNTING APPARATUS

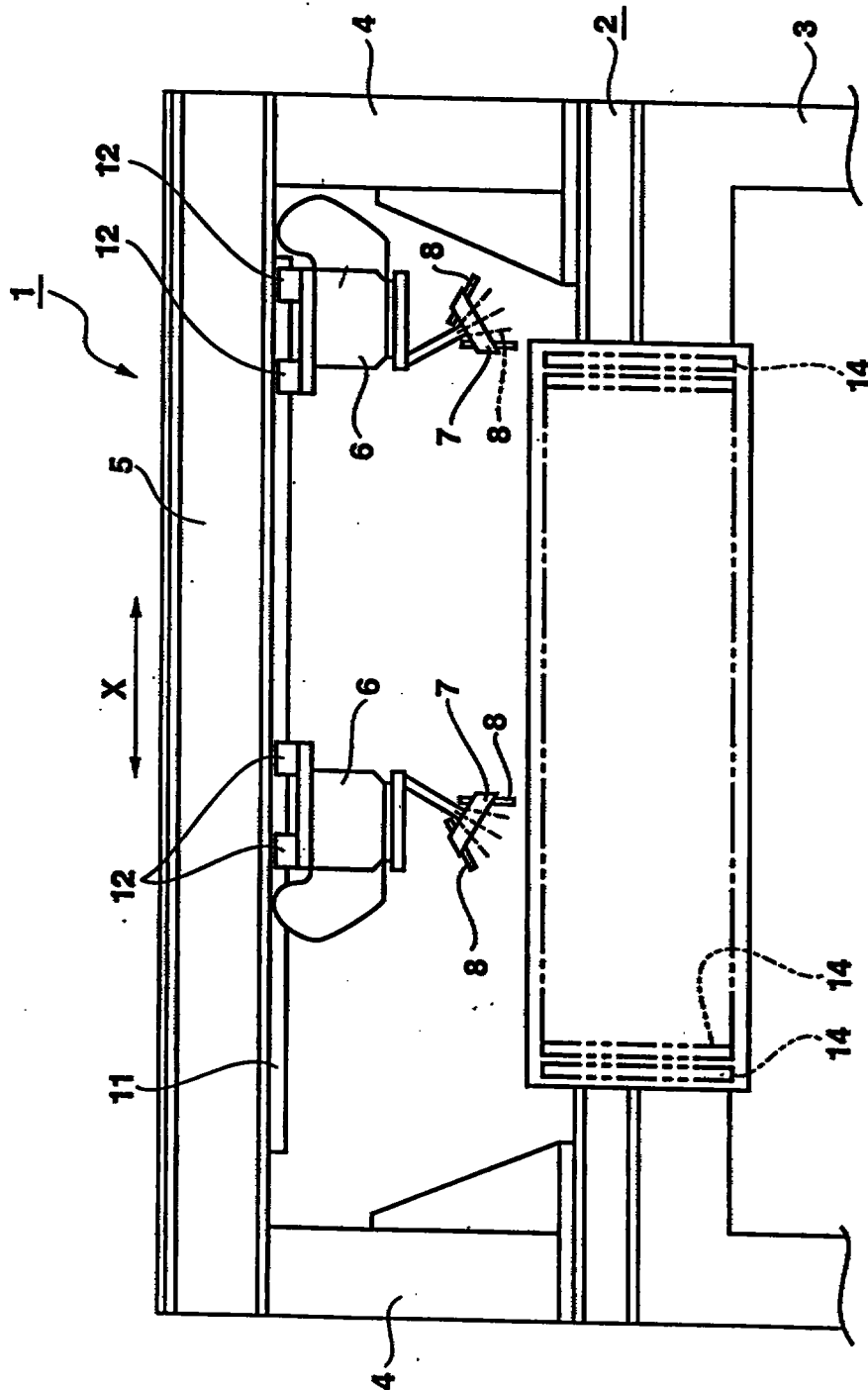
ABSTRACT OF THE DISCLOSURE

In a components mounting apparatus, so-called mounting tact time per a single electronic component is shortened. The components mounting apparatus in which a large number of electronic components are transported from a components supplying region where a plurality of components supplying apparatuses are arranged with the large number of electronic components stored thereinto to a components mounting region in which a board is arranged with the electronic components mounted on preselected mounting positions of the board thereon is comprised of: components gripper for individually gripping the electronic components; and a tool head on which a plurality of components gripper are mounted and which is movably provided between the components supplying region and the components mounting region. The components gripper is supported movably in the upward and downward direction with respect to the tool head, and moves up and down for gripping or releasing the electronic components when positioned to a preselected position in the tool head. The tool head is provided rotatably in the forward and reverse directions so that the tool head is rotated for selecting the components gripper and positioning the selected components gripper to a preselected position.

Figure 4

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FIG. 1



- S...components supplying region
M...components mounting region
1...components mounting apparatus
7...tool head
8...absorbing nozzle (components gripping means)
9...board
14...components supplying apparatus

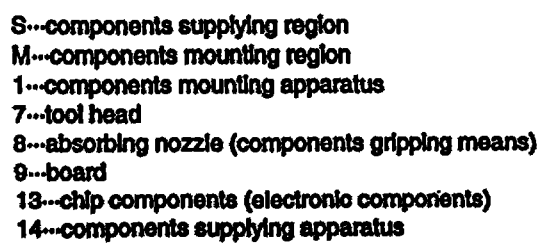
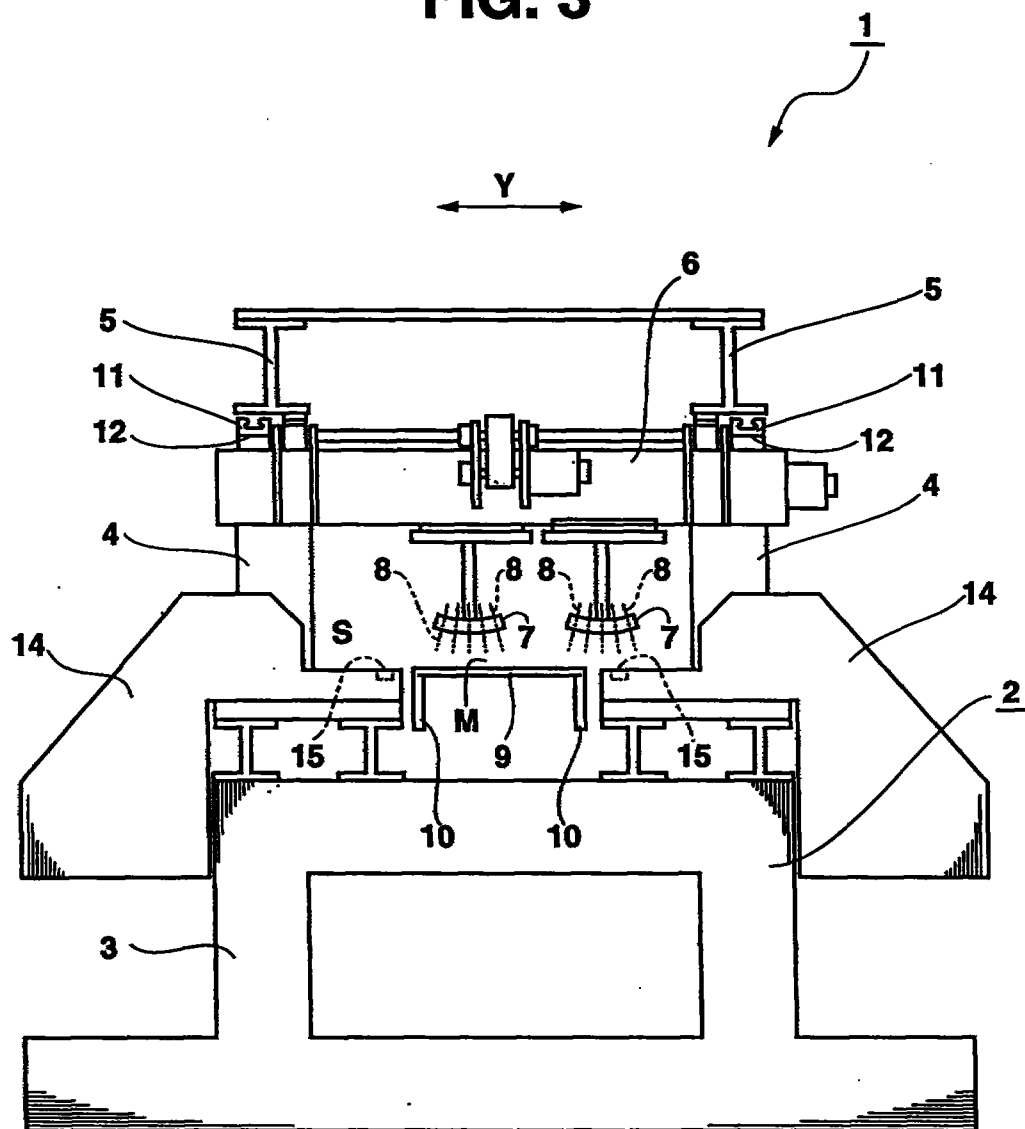


FIG. 3

S...components supplying region

M...components mounting region

1...components mounting apparatus

7...tool head

8...absorbing nozzle (components gripping means)

9...board

14...components supplying apparatus

FIG. 4

- 1...components mounting apparatus
7...tool head
8...absorbing nozzle

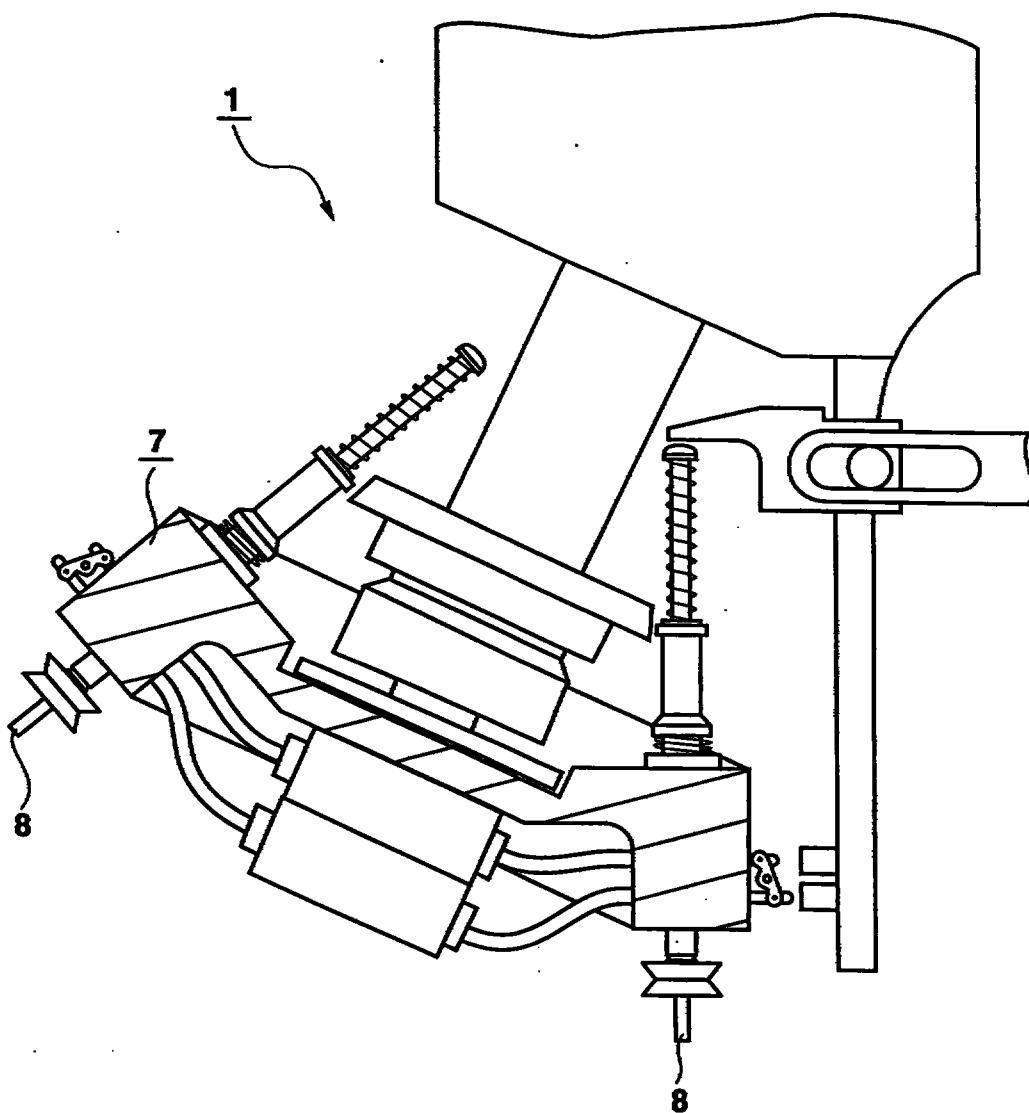


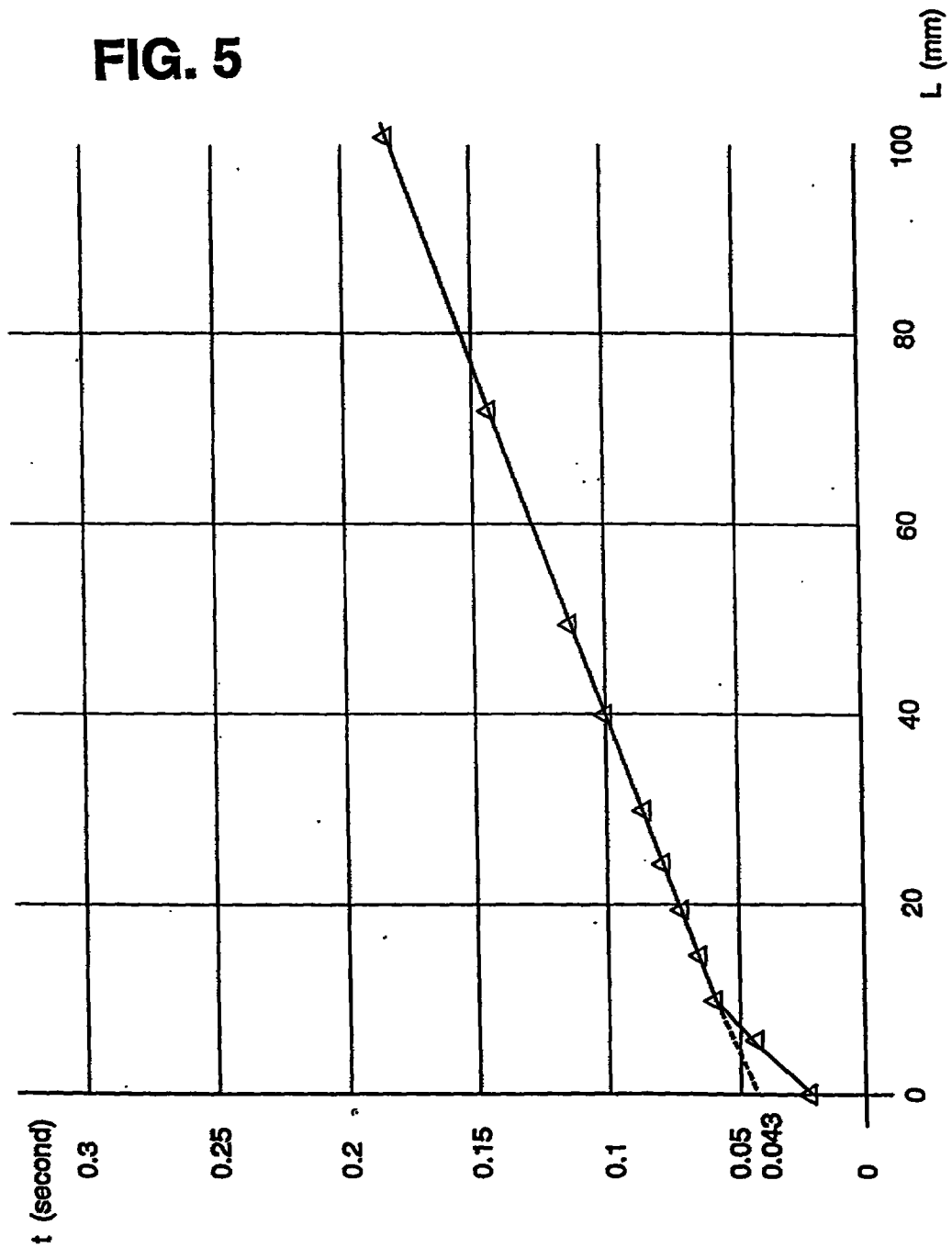
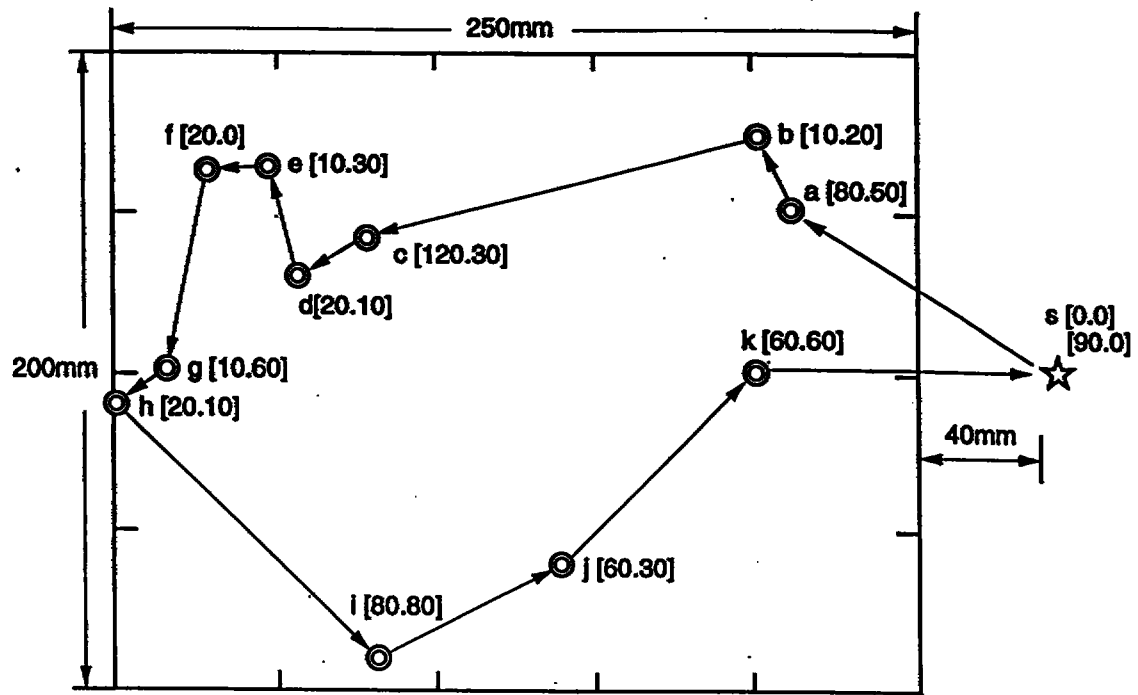
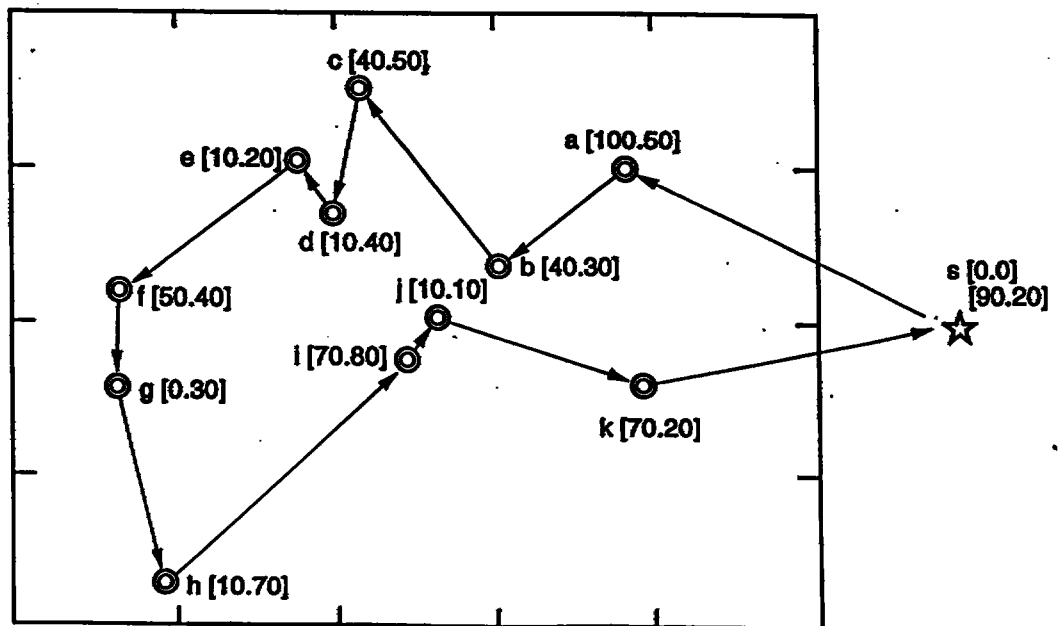
FIG. 5

FIG. 6**FIG. 7**

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FIG. 8

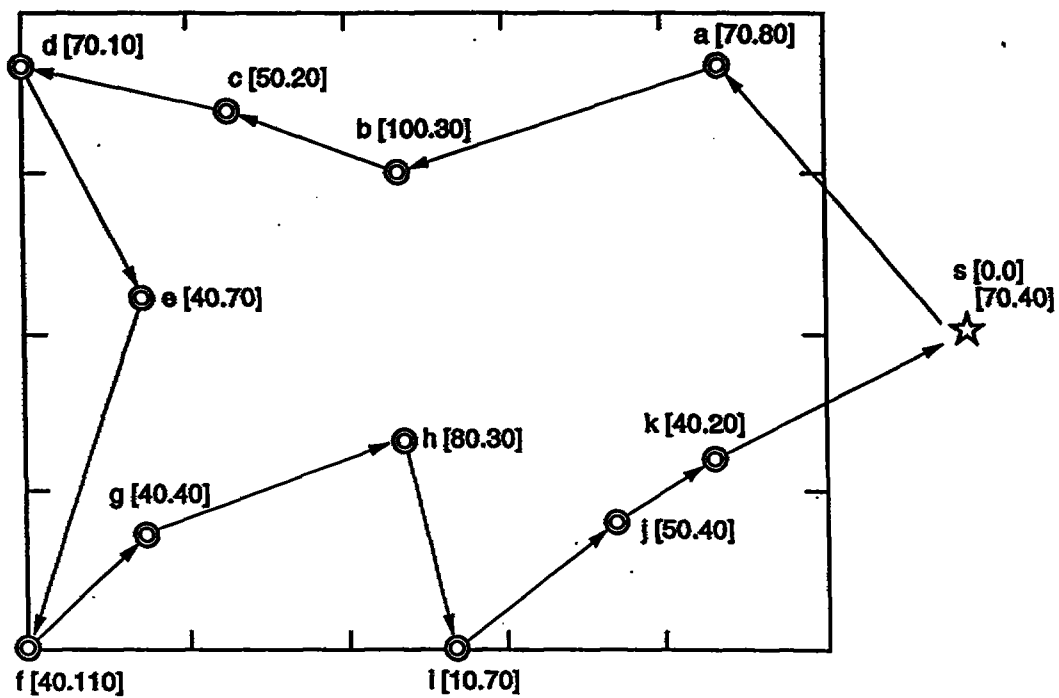


FIG. 9

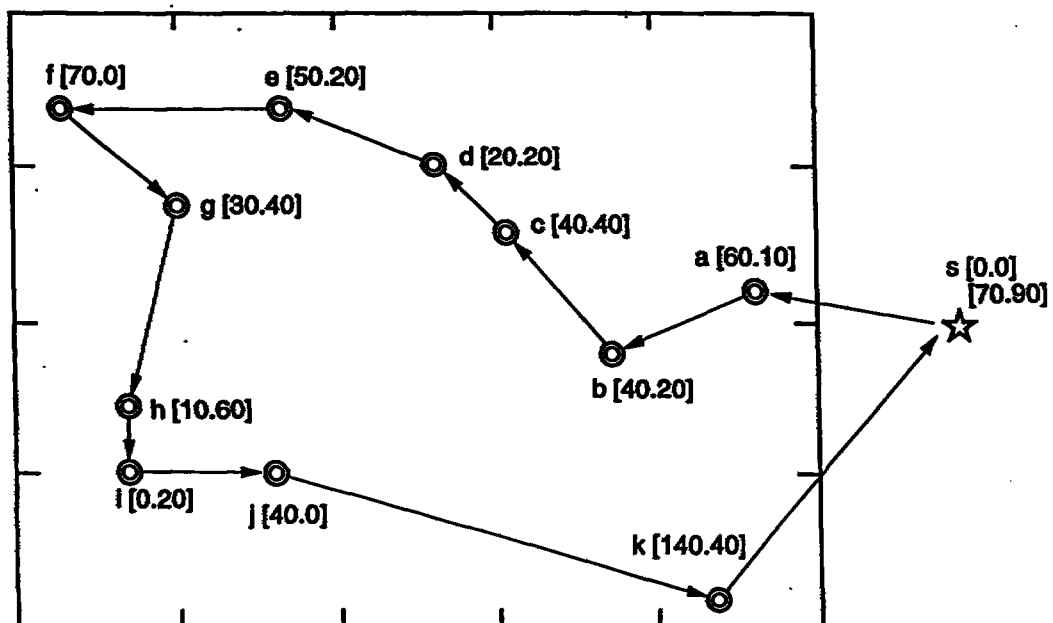


FIG. 10

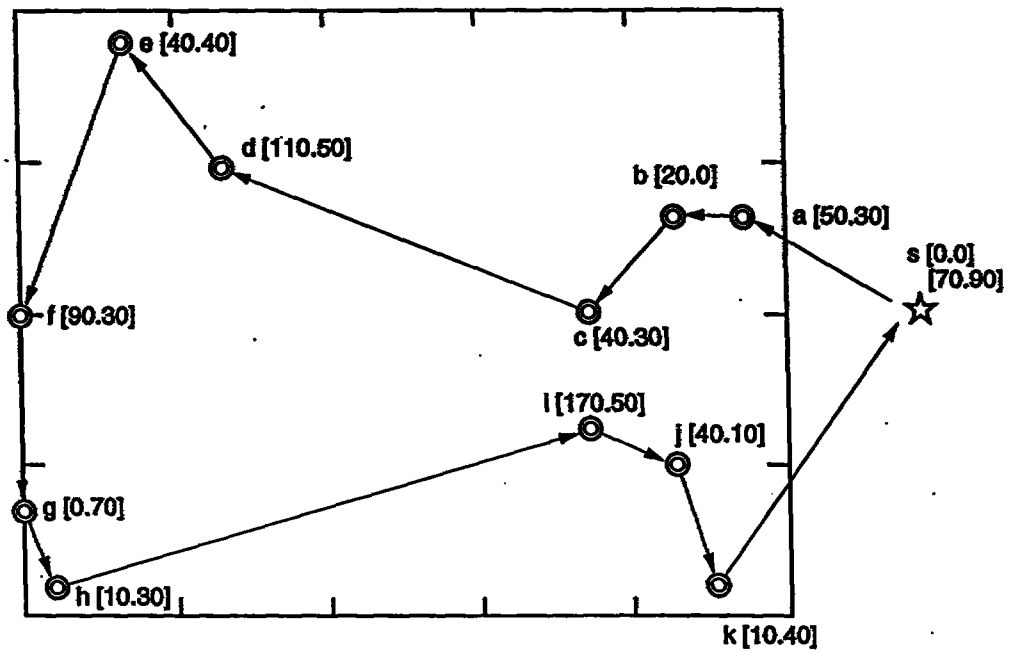


FIG. 11

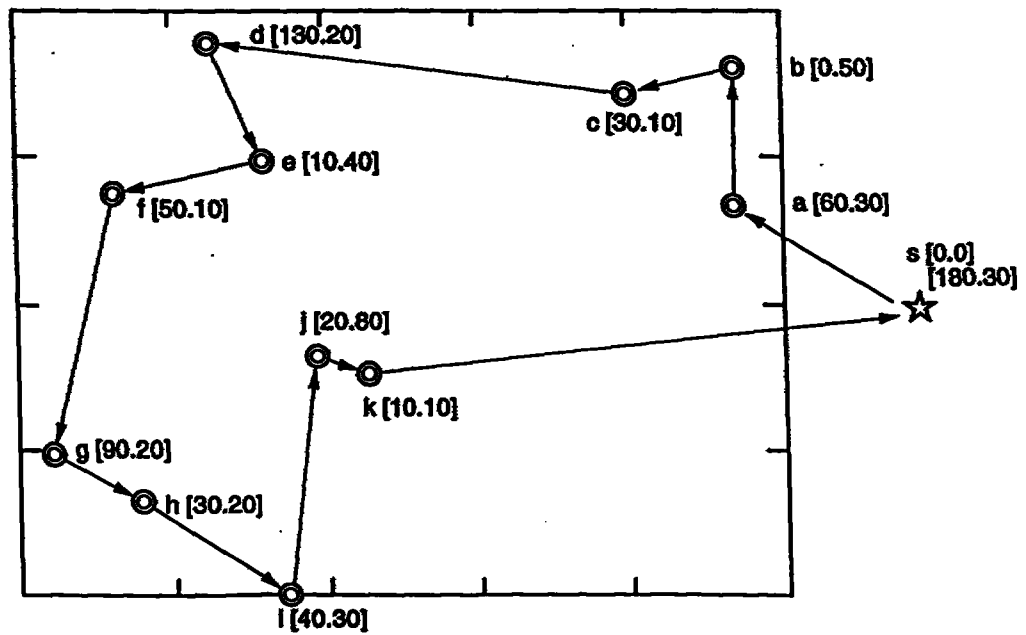


FIG. 12

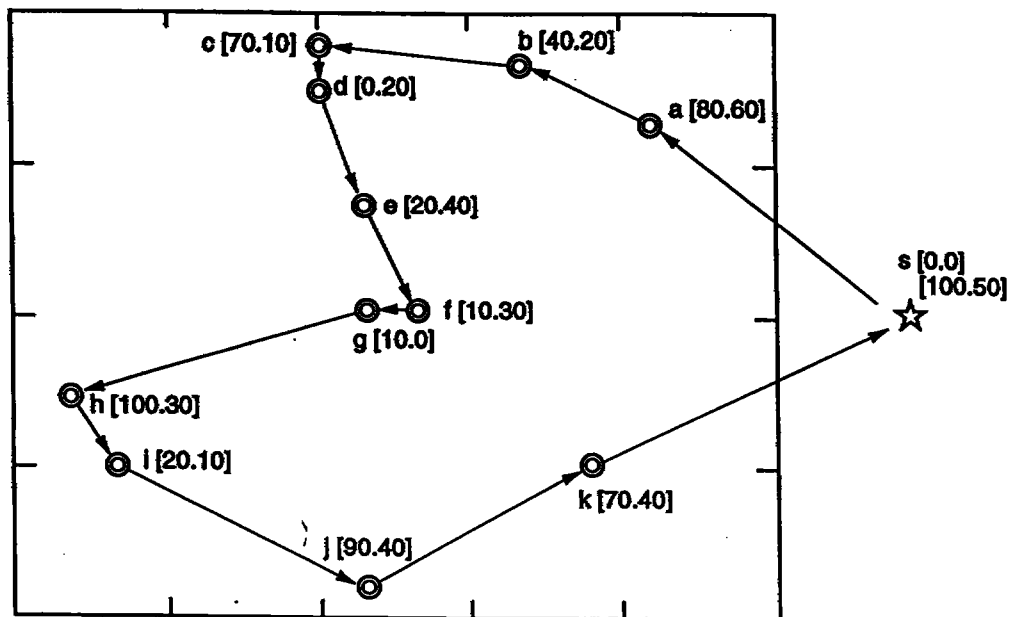


FIG. 13

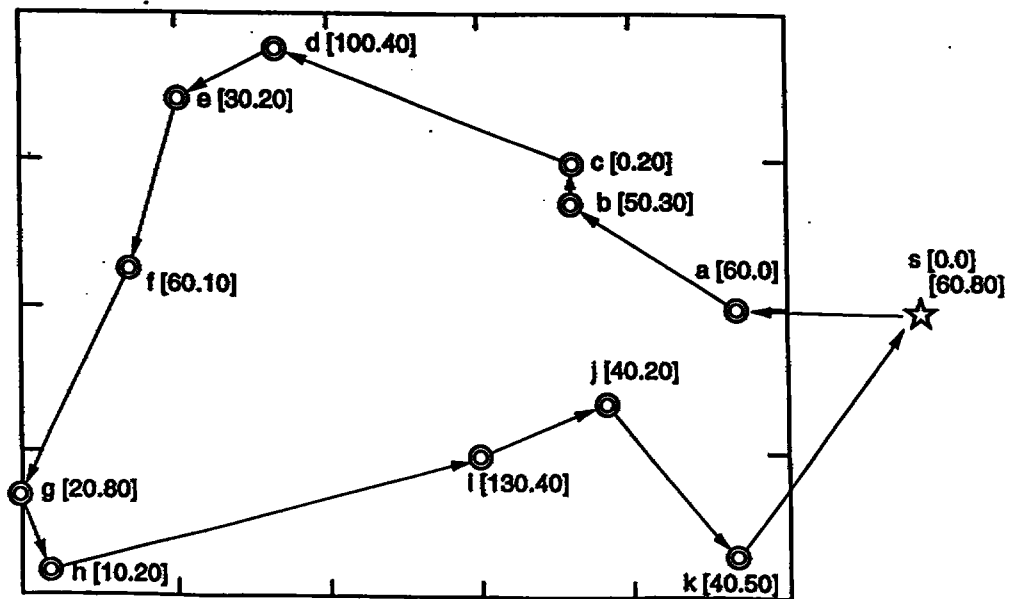


FIG. 14

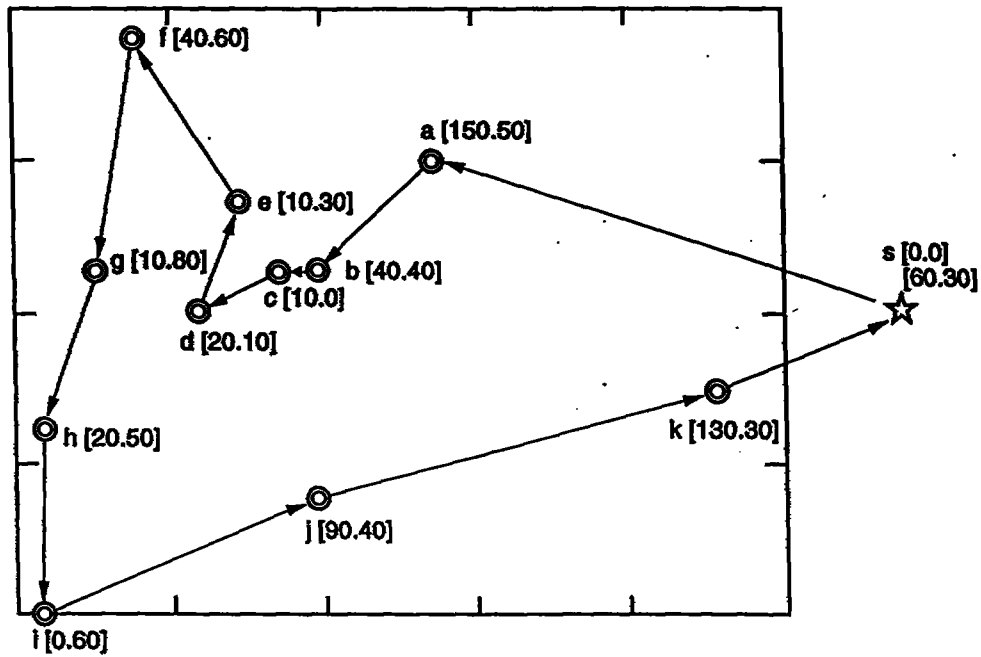


FIG. 15

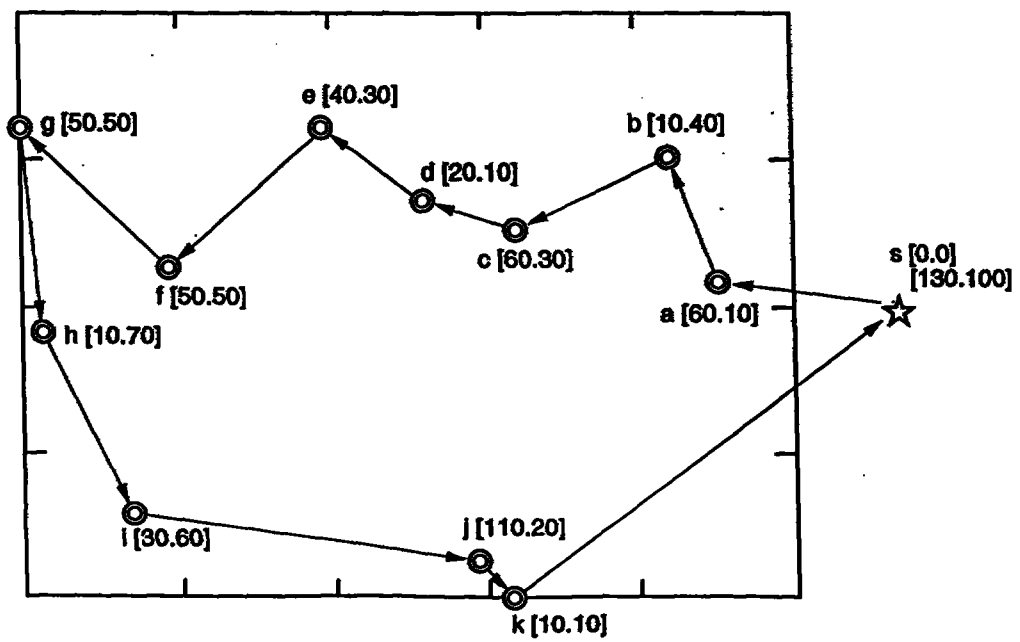
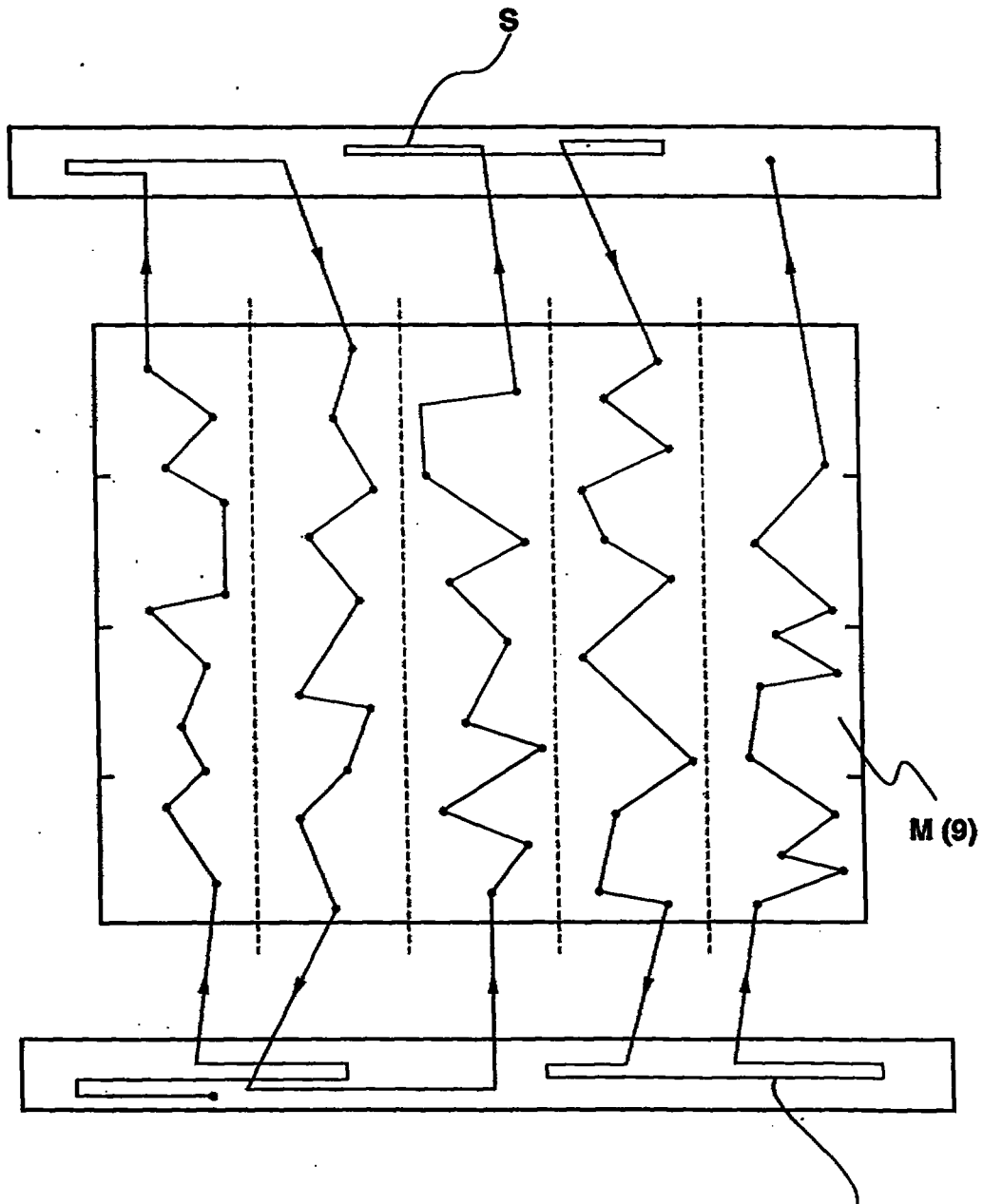


FIG. 16



S...components supplying region
M...components mounting region
9...board

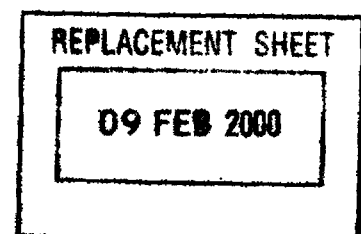
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mounting head 15 descends ~~so as~~ to mount the chip component 5 on the board 6.

Prior to mounting of the chip component 5, the board 6 is moved by the X-Y table 3, so that this designated component mounting place is positioned in correspondence with the mounting station.

The above-described absorbing and mounting operations of the chip components 5 are carried out in accordance with a previously designated sequence. In other words, one components supplying apparatus designated in accordance with the above-described sequence among the components supplying apparatuses 8 is transported to the position corresponding to the absorption station. After this designated chip component 5 has been absorbed by the mounting head 15, this chip component 5 is transported by the turn table 13 to the mounting station. At the same time, the board 6 is transported by the X-Y table 3, and thus a predetermined position where this chip component 5 is mounted corresponds to the mounting station, so that the mounting head 15 descends so as to mount the designatedⁱ chip component 5 on the board 6.

To shorten the components mounting tact time in such a conventional components mounting apparatus, while the respective mechanical elements (components supplying apparatuses, turn table, mounting head, etc.) are operated ^{at} ~~in~~ high speed, the arranging sequence of these components



supplying apparatuses 8 and also the transporting sequence (transporting sequence to mounting position) of the X-Y table 3 must be optimized. The cooperation between the respective mechanical elements and other mechanical elements must be optimized to thereby shorten the work waiting time. As a consequence, the absorbing sequence and/or the mounting sequence of the components by the mounting head 15 must be effectively set.

For instance, the transporting sequence of the X-Y table 3 is determined in this order, namely such a predetermined mounting position located near the edge of preselected mounting positions on the board 6. This way causes the transporting sequence to be optimized ~~if~~ ^{if} only the transport time of the X-Y table 3 is considered. However, when this transporting sequence is designed on the basis of the arranging order of the components supplying apparatuses 8, since there are many possibilities that a plurality of same sorts of components are mounted on the board 6, the components supplying apparatuses 8 must be transported in the reciprocation motion every time the same sort of components are mounted. Therefore, the above-described transporting sequence of the X-Y table 3 is not always the optimum transporting sequence for the components supplying apparatus 8. Accordingly, the overall mounting tact time could not be shortened.

Also, in such a case that the components supplying

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apparatuses 8 are arranged in accordance with a certain sequence, for example, in a higher use-frequency order, and the transporting sequence of the X-Y table 3 is designed based on this arranging sequence, this transporting sequence of the X-Y table 3 does not always correspond to the optimum transporting sequence with respect to the X-Y table (3). In other words, this designed transporting sequence is not substantially equal to the optimum transporting sequence. As a result, there are many problems that when such a design is made on the basis of any one of the arranging sequence of the components supplying apparatuses 8 and the transporting sequence of the X-Y table 3, the other sequence would become unsuitable. It is practically difficult to determine either the optimum sequences or the sequences close to these optimum sequences for both cases.

This is caused ^{because} ~~by such a fact that~~ the transportation of the components as the ^{operation switches} ~~works~~ between absorbing of the components and mounting ~~of~~ the components is performed by rotating the turn table 13 along one direction, and thus such a fact that the degree of freedom in designing of these sequences is low.

Eventually, since the transportation of the components as the ^{operation switches} ~~works~~ between absorbing of the components and mounting of the components is carried out by rotating the turn table 13 along one direction, ^{there are} ~~a~~ limitations ~~is made~~ in designing ^{and} ~~of~~ optimizing the arranging sequence and the

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transporting sequence. Accordingly, the components mounting tact time could not be shortened.

SUMMARY OF THE INVENTION

The present invention has been made to solve the above-described problems, and therefore, has an object to provide a components mounting method which is featured by that a plurality of electronic components are individually gripped by a plurality of gripping means in a components supplying region; and after these gripping means are transported to the components mounting region, each of said gripped electronic components is mounted on a predetermined mounting position thereof.

As a consequence, in accordance with the components mounting method of the present invention, the frequency of transportation between the components supply region and the components mounting region can be reduced, and the mounting tact time per ~~a~~ single electronic component can be shortened.

A components mounting method of the present invention is featured by comprising the steps of:

subdividing at least one of the components supplying region and the components mounting region into a plurality of sections; and

mounting the electronic components in a entire region of the mounting region by repeating one of the steps of:

gripping the electronic components by a plurality of

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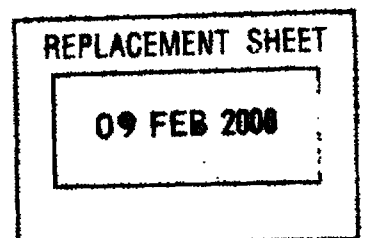
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the gripping means in one of the subdivided sections of the components supplying region and mounting the electronic components in the components mounting region and then gripping the electronic components by a plurality of the gripping means in another subdivided section of the components supplying region and mounting the electronic components in the components mounting region\,

gripping the electronic components by a plurality of the gripping means in the components supplying region and mounting the electronic components in one of the subdivided sections of the components mounting region and then gripping the electronic components by a plurality of the gripping means in the components supplying region again and mounting the electronic components in another subdivided section of the components mounting region; and

gripping the electronic components by a plurality of the gripping means in one of the subdivided sections of the components supplying region and mounting the electronic components in one of subdivided section of the components mounting region and then gripping the electronic components by a plurality of the gripping means in another subdivided section of said components supplying region and mounting the electronic components in another subdivided section of the components mounting region.

As a consequence, the components supplying region and/or the components mounting region properly subdivided



into a plurality of sections, can reduce the transport distance of the components gripping means while gripping and/or mounting the electronic components in the components supplying region and/or the components mounting region. The mounting tact time per ~~a~~ single electronic component can^{therefore} be further shortened.

A components mounting method is further featured by that the components supplying region is subdivided into two groups of subdivided sections arranged on both sides of the components mounting region in a direction identical to a direction along which the subdivided sections of the components mounting region are disposed, and the components mounting method comprises steps of:

gripping individually a plurality of the electronic components in one of the subdivided sections of said components supplying region by a plurality of the components gripping means;

transporting a plurality of the components gripping means to one of the subdivided sections of the components mounting region;

mounting each of the electronic components on a predetermined mounting position;

transporting a plurality of the components gripping means to another subdivided sections of the components supplying region;

gripping a plurality of the electronic components

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again in another subdivided sections of the components supplying region by a plurality of the components gripping means;

transporting a plurality of the components gripping means to another subdivided sections of the components mounting region;

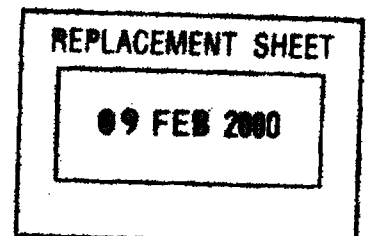
mounting each of the electronic components on a predetermined mounting position;

repeating above steps until the electronic components are mounted in the entire region of the mounting region.

As a consequence, the subdivided groups of the components supplying region arranged on both sides of the components mounting region can increase^{the}~~a~~ degree of freedom in designing ~~of~~ the gripping sequence as well as the mounting sequence of these electronic components. Also, these sequences can be optimized.

Moreover, a components mounting method of the present invention is featured by that the electronic components are mounted from such a predetermined mounting position located closest to the components supplying apparatus where previous final gripping of the electronic components has been performed by the components gripping means among the components supplying apparatuses in the subdivided sections of the components supplying region.

As a consequence, the transport distance between the components supplying region and the components mounting



region can be shortened. The mounting tact time per a single electronic component can be further shortened.

A components mounting method of the present invention is further featured by that the electronic components are mounted in the components mounting region at a predetermined mounting position located closest to such a components supplying apparatus where^{the} next first gripping of the electronic component is to be performed in the components supplying region to which the components gripping means are to be subsequently transported is designated as a final predetermined mounting position within the components mounting region among the predetermined mounting positions in the components mounting region.

As a consequence, the transport distance between the components supplying region and the components mounting region can be further reduced and the mounting time per a single electronic component can be further shortened.

In addition, a components mounting apparatus of the present invention is featured by comprising: components gripping means for individually gripping the electronic components; and

a tool head on which a plurality of the components gripping means are mounted, and which is movably provided between the components supplying region and the components mounting region; wherein the components gripping means is supported movably in the upward and downward direction with

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respect to the tool head, and moves up and down for gripping and releasing the electronic components when positioned to a preselected position in the tool head;

the tool head is provided rotatably in the forward and reverse directions so that the tool head is rotated for selecting the components gripping means and positioning the selected components gripping means to a preselected position.

As a consequence, the electronic components can be gripped by a plurality of components gripping means within the components supplying means in a random sequential order. Also, the electronic components can be mounted by a plurality of components gripping means in the components mounting means in a random sequential order. Accordingly, the gripping and mounting sequences of the electronic components can be set freely. It is possible to provide such a components mounting apparatus not restricted to these gripping and mounting sequences. The mounting tact time per ~~a~~ single electronic component can be further shortened.

The components mounting apparatus of the present invention may be applied to a surface mounting apparatus for mounting chip type electronic components (will be referred to as "chip components" hereinafter).

The components mounting apparatus is featured by that the components gripping means can be a means for absorbing the electronic component by using negative pressure.

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As a consequence, in accordance with the components mounting apparatus of the present invention, the electronic components can be gripped and mounted in higher speed. The mounting tact time per a single electronic component can be further shortened.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, reference may be made to the accompanying drawings, in which:

Fig. 1 schematically indicates a side view of an entire components mounting apparatus according to an embodiment of the present invention;

Fig. 2 schematically shows a plan view of the components mounting apparatus of Fig. 1;

Fig. 3 schematically represents a front view of the components mounting apparatus of Fig. 1;

Fig. 4 is a side view for schematically showing a tool head of the components mounting apparatus in an enlarging form;

Fig. 5 is a graphical representation for representing a motor speed characteristic of an X-Y direction transport motor used in the components mounting apparatus of Fig. 1;

Fig. 6 is an explanatory diagram for explaining a first transport path of the tool head over a plane in a components mounting method according to a first embodiment of the present invention;

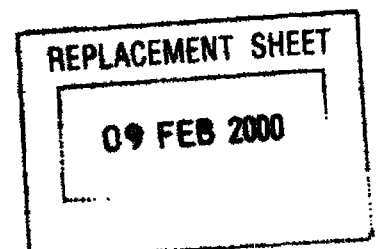
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the pillars 4 and 4 along a longitudinal direction of the base station 3; two sets of head mounting columns 6 and 6 hung between these bridges 5 and 5; a tool head 7 hung on each of the head mounting columns 6; and a ^{plurality} ~~polarity~~ of absorbing nozzles 8, ---, 8 arranged on this tool head 7. It should be noted that a direction indicated by an arrow shown in Fig. 1 or Fig. 2 is expressed as either a "front/rear direction" or an "arrow X-direction", whereas a direction indicated by an arrow Y is expressed as either a "right/left direction" or an "arrow Y-direction". This direction definition is similarly applied to the below-mentioned descriptions.

A central region of an upper surface of the base unit 2 along the right/left direction is used as a work arranging unit on which a work such as a board 9 is arranged. A fixing means 10 for fixing the board 9 is arranged on this work arranging unit so as to position the board 9. Also, two sheets of boards 9 are arranged on the work arranging unit in such a manner that these boards 9 and 9 are separated from each other along the front/rear direction.

Guide rails 11 and 11 are fixed on the lower surfaces of the above-explained bridges 5 and 5 in such a manner that these guide rails 11 and 11 are extended along the arrow X-direction. Guided members 12, ---, 12, which are fixed on the upper surfaces of the both edge portions of the head mounting column 6, are engaged with the guide rails 11 and 11



direction (see Fig. 1), and furthermore, these tool heads 7 and 7 can be freely rotated in the normal/reverse directions.

20 sets of absorbing nozzles 8, ---, 8 are arranged on the tool head 7 ^{at equal intervals} in an equinterval at an outer peripheral portion thereof along the peripheral direction. Central axes of these absorbing nozzles 8, ---, 8 are mounted on the rotation shaft of the tool head 7 ^{at} with having inclination angles with respect to this rotation shaft. This inclination ^{angle} is determined ^{such} by that the upper ends of the respective absorbing nozzles 8, ---, 8 ~~are~~ approached to the rotation shaft of the tool head 7. As a whole structure, these absorbing nozzles 8, ---, 8 are arranged in a conically extending manner with respect to the tool head 7.

The absorbing nozzles 8, ---, 8 are movably supported along the axial center directions thereof with respect to the tool head 7. When the absorbing nozzle 8 is located at an operation position ^{to} (~~will~~ be described later), this absorbing nozzle 8 is depressed by a depression means (not shown) from the upper direction to thereby descend.

Among these absorbing nozzles 8, ---, 8, the axial center of the absorbing nozzle located at the rear end of the front-sided tool head 7 is directed to the vertical direction, and the axial center of the absorbing nozzle positioned at the front end of the rear-sided tool head 7 is directed to the vertical direction. ^{This} ~~These~~ rear end position

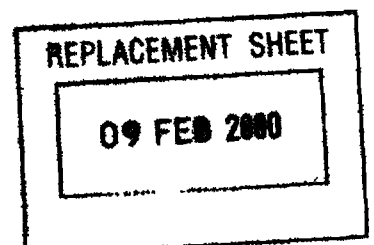
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and front end position correspond to the above-described operation position, respectively. Then, chip components 13, ---, 13 may be absorbed and/or released by the absorbing nozzles 8, ---, 8 which are located at the operation positions and are directed to the vertical direction.

As to the chip components 13, ---, 13 mounted on one sheet of board 9, there are, for example 120 sorts. These different sorts of chip components 13, ---, 13 cannot be absorbed and mounted by using one type of absorbing nozzle 8. For instance, in such a case that there are 120 sorts of chip components 13, ---, 13, for example, 5 types of absorbing nozzles 8, ---, 8 are prepared. Then, 5 types of absorbing nozzles 8, ---, 8 are arranged in such a set that, for instance, 9 pieces of first type of absorbing nozzles are prepared, 5 pieces of second type of absorbing nozzles are prepared, 3 pieces of third type of absorbing nozzles are prepared, 2 pieces of fourth type of absorbing nozzles are ^{prepared} ~~pre~~pared, namely, the quantities of these absorbing nozzles are selected, depending upon use frequencies thereof.

It should be noted that the respective absorbing nozzles 8, ---, 8 are connected to air compressors (not shown in detail), and a tip portion of the absorbing nozzle 8 located at the operation position is switched to either negative pressure or positive pressure at ^apredetermined timing. As a consequence, at this tip portion, the chip

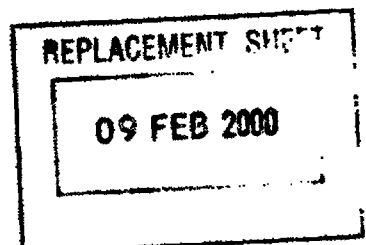


component 13 is absorbed, or released.

There is a region where the chip components 13, ---, 13 are mounted on the boards 9 and 9 positioned and held by the fixing means 10 and 10, and such a region will be referred to as a "components mounting region M" hereinafter.

Also, 60 sets of components supplying apparatuses 14, ---, 14 are arranged on both right and left sides of the components mounting region M. A large number of same sorts of chip components 13, ---, 13 are stored in the respective components supplying apparatuses, 14, ---, 14, and are supplied to the absorbing nozzles 8, ---, 8 in response to requirements. It should be understood that this embodiment has described that the components supplying apparatuses 14, ---, 14 are arranged on both the right and left sides of the component mounting region M. However, the present invention is not limited thereto, but may be also applied to such a case that the components supplying apparatuses 14, ---, 14 are arranged only one side of ^{the} ~~these~~ right/left sides of the components mounting region M.

The different sorts of chip components 13, ---, 13 are stored into the corresponding components supplying apparatuses 14, ---, 14 with respect of the sorts of the components supplying apparatuses 14, ---, 14. Depending upon the sort of chip component 13 mounted on the position of the board 9, the absorbing nozzle 8 and the components supplying apparatus 14 are selected, and then this chip



component 13 is absorbed.

Components supplying ports 15, ---, 15 of the respective components supplying apparatuses 14, ---, 14 are arranged on both the right and left sides of the fixing means 10 in parallel thereto. The chip components 13, ---, 13 positioned to these components supplying ports 15, ---, 15 are absorbed by the absorbing nozzles 8, ---, 8. As a consequence, the region where a large number of components supplying ports 15, ---, 15 corresponds to a region where the chip components 13, ---, 13 are absorbed, which will be referred to as a "components supplying region S" hereinafter.

Then, the tool head 7 is designed in such a manner that the absorbing nozzles 8 and 8 are moved within a range of such a region for connecting the above-described components supplying region S and components mounting region M, and these absorbing nozzles are approached to the operation position thereof.

A description will now be made of the components mounting method according to the present invention, assuming now that a target mounting speed of the above-described components mounting apparatus 1 is set to, e.g., 0.2 second/chip. This mounting speed is defined by so-called "mounting tact time". In other words, this mounting tact time ^{is} ~~implies such~~ a 1 cycle time period ^{during which} ~~defined by that~~ the chip component 13 is absorbed in the components supplying

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region S by the absorbing nozzles 8 and is transported to the components mounting region M, ^{the} ~~and thereafter this~~ absorbed chip component 13 is mounted on the board 9, and ^{the} ~~then this~~ absorbing nozzle 8 is returned to the components supplying region S. It should be noted that since the above-described components mounting apparatus 1 is equipped with the two tool heads 7 and 7, the chip components 13, ---, 13 can be mounted on two sets of boards 9 and 9 at the same time. Accordingly, the target mounting tact time is one of these tool heads 7 and 7 is 0.4 seconds/chip.

In the following embodiment, such an assumption is made that the dimension of the board 9 is defined by 250 mm x 400 mm, and 120 ^{types} ~~sorts~~ of chip components 13, ---, 13 are mounted.

Assuming now that an interval between the adjoining components supplying ports 15 and 15 of the adjoining components supply apparatuses 14 and 14 is selected to be 20 mm, a length of the components supplying regions S and S located on both the right and left sides thereof along the arrow X-direction becomes $20 \text{ mm} \times (60-1) = 1180 \text{ mm}$. Also, it is assumed that a distance defined between the components supplying port 15 of the components supplying region S and the ^{closest} ~~close~~ ~~most~~ edge in the board 9 from this components supplying port 15 is 40 mm.

It should be understood that as is known, the transport speed of the tool head along the horizontal (X-Y

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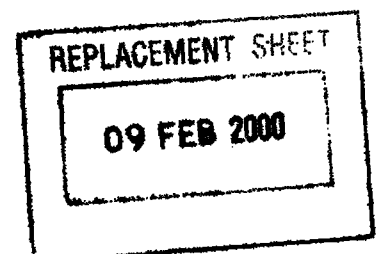
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direction) in the existing (conventional) components mounting apparatus is practically 40 mm/0.1 second. Since it slightly takes time until the tool head becomes uniform motion, as indicated by a solid line of Fig. 5, the tool head starts to move after 0.02 seconds when a start instruction is issued, and the motion of this tool head becomes uniform after 0.07 seconds when this start instruction is issued, namely after the tool head has passed the point of 20 mm. Then, when the speed graph line of this conventional tool head is expressed by linear approximation formula (will be referred to as a "conversion formula" hereinafter), it is given as follows:

$$t = 0.043 + (0.055 \times \text{transport distance}/40) \text{ seconds.}$$

In this graphic representation, the motion of the tool head is under acceleration condition during $t < 0.07$ seconds. Even when the transport time is calculated based on the above-described linear approximation formula under this acceleration condition (namely, portion indicated by a dotted line of Fig. 5), since the transport time becomes longer than the actual transport time with respect to the transport distance, there is no problem in ^{proving} ~~order to prove~~ that it is fast.

Practically speaking, ^{the} time required to transport the absorbing nozzle 8 along the vertical direction is 0.08 seconds, and the normal confirmation work requires 0.04 seconds. This confirmation work by a vision camera system



(not shown) is required so as to confirm the direction of the chip component 13 absorbed by the absorbing nozzle 8 in this components mounting apparatus 1. Moreover, it is designed ^{such} that an average interval between the chip component 13 and the chip component 13 mounted on the board 9 is approximately 10 mm.

On the other hand, assuming now that one chip component 13 is mounted on a central position (functioning as a typical point) of the board 9, the absorbing nozzle 8 must be moved over the minimum distance (namely, $40 + 250/2 = 165$ mm) from the components supplying port 15. To move this absorbing nozzle 8 over this minimum distance, it would take $165/400 =$ approximately 0.4125 seconds. As a consequence, the above-described target mounting tact time of 0.4 seconds/chip could not be achieved.

COMPONENTS MOUNTING METHODS

As a consequence, in accordance with the components mounting method according to the present invention, since the member of tool head transport between the components supplying regions S and the components mounting region M is reduced as being permitted as possible, the above-described target mounting tact time can be achieved. For the sake of simple explanations, the components supplying region S of the components mounting apparatus 1 exists only on a single side of the components mounting region M in the below-mentioned embodiments.

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In accordance with a components mounting method of a first embodiments of the present invention, a large quantity of chip components 13, ---, 13, ^{as many as possible,} are absorbed ~~as many as possible~~ from the components supplying region S by 20 sets of absorbing nozzles 8, ---, 8 provided on the tool head 7, and this tool head 7 is transported to the components mounting region M, so that the respective chip components 13, ---, 13 are mounted on the board 9.

When a plurality of chip components 13, ---, 13 are mounted in this manner, the transport of the tool head 7 between the components supplying region S and the components mounting region M may be carried out only one time, so that the transport time per a single chip component 13 between the above-described two regions can be reduced. As a result, the mounting speed (mounting tact time) can be shortened.

^{a more concrete} Next, ~~an~~ explanation will be made how to shorten the mounting tact time of the chip component 13, ~~by employing concrete manners,~~

As previously described, the mounting tact time per single chip component is assumed as follows. That is, 0.4 seconds correspond to the target mounting tact time. In this target mounting tact time of 0.4 seconds, 0.2 seconds are required by adding time of $0.08 \times 2 = 0.16$ seconds which require the up/down movement of the absorbing nozzle 8 (during absorbing operation, and mounting operation) to

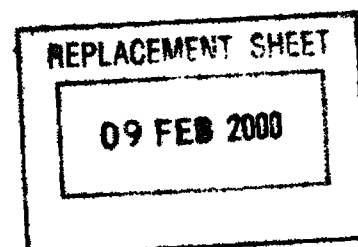
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confirmation time of 0.04 seconds required for confirming the absorption condition of the chip component 13 by using the vision camera system. Accordingly, the tool head must be transported along the X-Y direction within 0.2 seconds ($= 0.4 - 0.2$).

Moreover, this X-Y target transport time of 0.2 seconds corresponds to a total of target transport times of the tool head 7 between the components supplying region S and the components mounting region M. As a consequence, assuming now that the transport time of the tool head 7 in the components supplying region S is equal to that in the components mounting region M in view of averaged values, the target transport time of the tool head 7 in each of these components supplying/mounting regions becomes 0.1 second. It should be understood that the transport time between the component supplying region S and the components mounting region M is merged into the target transport time in the components mounting region M to be calculated.

While using the above-described 0.1 second as each of the target transport times for the tool head 7 in the components supplying region S and the components mounting region M (will be referred to as a "region-S target transport time" and a "region-M target transport time", a sequential operation for absorbing or mounting the chip components 13, ---, 13 will now be explained. It is assumed that 20 ~~pieces of~~ absorbing nozzles 8, ---, 8 mounted on the



tool head 7 may absorb 11 pieces of chip components 13, ---, 13 while these absorbing nozzles are transported within the components supplying region S one time. This assumption is established from the following prediction. That is, if desired chip components are absorbed by all of 20 ~~pieces of~~ absorbing nozzles 8, ---, 8, then the transport range of these absorbing nozzles will be extended within the components supplying region S, so that the above-explained target transport time of 0.1 second within the components supplying region S could not be achieved.

As a consequence, the components supplying region S (its entire length: 1,180 mm) is subdivided into some sections. An assumption is made ~~by~~ that the tool head is transported in a range of a transport distance within this subdivided straight line, and then 11 pieces of chip components 13, ---, 13 are absorbed.

It should be understood that although ⁱⁿ this embodiment, ~~will describe that~~ the components supplying region S is subdivided into several sections and the tool head 7 is transported within the area of this subdivided section, a decision as to whether or not the components supplying region S is subdivided may be made based on the quantity of absorbing nozzles 8, ---, 8 mounted on the tool head 7, the dimension of the board 9, and either the ^{type} ~~sort~~ or the quantity of chip components 13, ---, 13 to be mounted. It is of course possible to apply the components mounting

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method according to the present invention to ~~such~~ a case ^{where} ~~that~~ the components supplying region S is not subdivided.

Therefore, a length of a subdivided straight line (namely, ^q transport distance within ^q straight line) is determined, 11 points are selected at random within this range, and a check is made as to whether or not ^{the} averaged transport time between these points becomes the above-described region-S target transport time of 0.1 second, so that the subdivided transport distance within the straight line is determined in which the transport time is shorter than, or nearly equal to the above-described region-S target transport time of 0.1 second.

Concretely speaking, the following investigation will be made as to such a case that the subdivided transport distances within the straight line are 800 mm, 600 mm, 400 mm, and 200 mm.

In any one of these subdivided transport distances within the straight line, 10 sets of cases are investigated. A calculation is made of an average ~~value of~~ transport time as to each of these 10 cases, and further a total value of these average values is calculated.

In a table 1 to a table 4, random numbers in a distance implies 11 point (a, b, c, ---, k) selected based on the random numbers within a predetermined length. These points are rearranged in a small order and then represented in the respective tables. Transport distances among the

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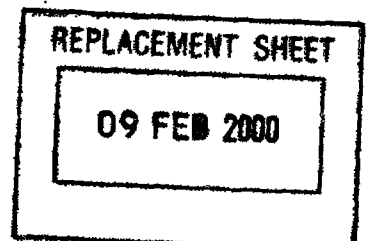
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seconds becomes shorter than the region-S target transport time of 0.1 second, it can also be understood that the transport distance within a straight line of 200 mm could be employed.

As previously explained, when the tool head 7 is transported within the straight line, if the transport distance within this straight line is smaller than, or equal to 400 mm, then it can be seen that the region-S target transport time of 0.1 second could be achieved.

Next, another investigation is carried out ^{for} ~~as to such~~ ^{where} ~~that~~ the tool head 7 is moved in a plane manner (namely, X-Y direction) within the components mounting region M. As explained above, the dimension of the board 9 is 250 mm x 400 mm. If the tool head 7 is ~~tried to be~~ moved within this entire range along the X-Y direction, then since this range is too wide, it is predictable that the region-M target transport time of 0.1 second cannot be achieved. Then, the components mounting region M is properly subdivided into several subdivided plane sections in a similar manner to the above-described components supplying region S, and the following consideration is carried out under such a condition that the tool head 7 is transported within the subdivided plane section.

In this embodiment, the components mounting region M is subdivided into several sections³ and then the tool head 7 is transported within ⁴ ~~this~~ subdivided section. Similar to



the subject matter as to whether or not the components supplying region S is divided, a decision as to whether or not the components mounting region M is made based on such a condition, namely, the number of absorbing nozzles 8, ---, 8 mounted on the tool head 7, the dimension of the board 9, and the sort or quantity of chip components 13, ---, 13 to be mounted. It is of course possible to apply the component mounting method according to the present invention to such a case that the components mounting region M is not subdivided.

Then, a subdivided plane section is determined, and 11 points are selected at random within this subdivided plane section. A position is recognized as a starting point, which is located apart from a center of a short edge of each plane section, or a center of a long edge thereof by 40 mm outwardly. A path is determined from this starting point by properly connecting the above-described 11 points to each other in a predetermined sequence until ^{the path returns to} the starting point. ~~(it becomes an end point)~~. Among the respective points, a longer component of the X-Y component is selected as a main axis. Then, a check is made as to whether or not an averaged transport time for the length of this main axis becomes the above-described region-M target transport time of 0.1 second. As a consequence, such a subdivided plane section is determined in which the averaged value is shorter than, or nearly equal to, the region-M target transport time

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of 0.1 second.

Concretely speaking, the following investigation is performed as to three cases of subdivided plane sections, namely 250 mm x 200 mm, 125 mm x 200 mm, and 125 mm x 100 mm.

In any one of the subdivided plane sections, 10 cases will now be considered. A calculation is made of an averaged value of transport times as to the respective cases, and further, a total value of averaged values is calculated.

It should be understood that the path ^{starts} ~~started~~ from the starting point via 11 points in a predetermined sequential order and ^{returns} ~~returned again~~ to the starting point ^{and that this path} may be determined by properly connecting these 11 points in accordance with the artificially better order, which are selected based on the random numbers on the plane. It should also be understood that the expression of "artificially better order" implies as follows. That is, while a point located at the closest position, or the second closest position with respect to the starting point "s" is selected as a first point within the component mounting region M among these 11 points, and also another point located at the second closest position, or the closest position from the starting point "s" among the 11 points is selected as a final point within the component mounting region M, these points are connected to each other.

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Fig. 6 to Fig. 15 represent 10 cases in which a starting point is connected to 11 points selected based upon random numbers in a plane section defined by 250 mm x 200 mm. Symbol "☆" denotes a starting^{ending} point (end point) "s", and point "◎" shows 11 points (a, b, c, ---, k) selected at random.

In a table 5 to a table 7, a transport amount implies that a two-point distance for connecting either a starting point or a point to another point is expressed by an X component and a Y component. For instance, an X component and a Y component of two-point distance for connecting the starting point "s" and a point "a" are indicated in a column "sa". Also, a transport amount of a main axis implies that among the above-described X components and Y components of the transport amounts, a longer transport amount is selected. A transport time is to indicate transport times among the respective points by substituting the transport amounts of the main axis among the respective points for the above-described conversion formula.

The table 5 indicates such a case that the plane section is defined by 250 mm x 200 mm.

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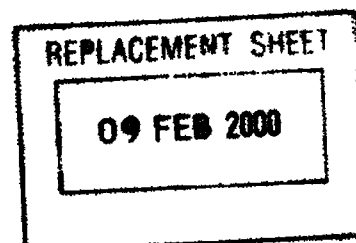
Table 8

components absorbing region S		components mounting region M	
range (mm)	transport time (sec)	range (mm)	transport time (sec)
800	0.140	250 x 200	0.126
600	0.116	125 x 200	0.103
400	0.092	125 x 100	0.089
200	0.067		

Considering now the table 8, when a combined case is selected in which a total time of the transport time required for the transport distance within a straight line and the transport time required for the plane section becomes shorter than, or equal to the X-Y target transport time of 0.2 seconds, the following combinations are given as follows:

That is, to say, in ~~such~~ ^{where} a combination case ~~that~~ ^{where} the transport distance within a straight line is 200 mm and the plane section is defined by 125 mm x 100 mm, the summed averaged transport time becomes 0.156 seconds. In ~~such~~ a combination case ~~that~~ ^{where} the transport distance within a straight line is 200 mm and the plane section is defined by 125 mm x 200 mm, the summed averaged transport time becomes 0.17 seconds.

In ~~such~~ ^{where} a combination case ~~that~~ ^{where} the transport distance within a straight line is 200 mm and the plane section is defined by 250 mm x 200 mm, the summed averaged transport time becomes 0.193 seconds. In ~~such~~ ^{where} a combination case ~~that~~ ^{where}

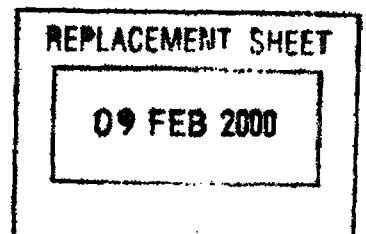


the transport distance within a straight line is 400 mm and the plane section is defined by 125 mm x 100 mm, the summed averaged transport time becomes 0.181 seconds.

Also, in ~~such~~ a combination case ^{where} ~~that~~ the transport distance within a straight line is 400 mm and the plane section is defined by 125 mm x 200 mm, the summed averaged transport time becomes 0.195 seconds. In any one of these combination cases, the summed averaged transport times can satisfy the X-Y target transport time of 0.2 seconds.

Also, in such a combination case that the transport distance within a straight line is 600 mm and the plane section is defined by 125 mm x 100 mm, a summed X-Y transport time becomes 0.205 seconds, and is not equal to the above-described X-Y target transport time of 0.2 seconds. However, since this summed X-Y transport time is substantially equal to the X-Y target transport time, if the target transport time is set to be lower than 0.2 seconds, then this combination case may be employed.

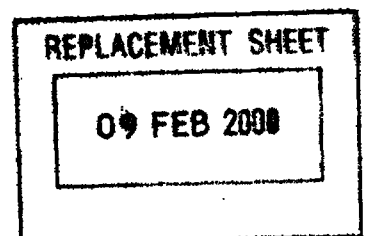
It should be noted that although the above-described embodiment has explained that the starting point is coincident with the end point when the X-Y transport time is calculated within the plane section, there ^{are} ~~is~~ a very few ^{cases where} ~~case that~~ the starting point is not actually coincident with the end point. In the latter case, it is predictable that the X-Y transport time becomes shorter than that of the ^{above explained} embodiment. In other words, it is conceivable that the



distance defined by adding the distance between the components supplying apparatus 14 of the finally absorbed chip component 13 and a predetermined mounting place where the chip component is firstly mounted to the distance between a predetermined mounting place where the chip component is finally mounted and the components supplying apparatus 14 of the chip component 13 which will be subsequently absorbed, is shorter than the distance defined in such a case that the starting point is coincident with the end point.

As a consequence, according to the components mounting method of the present invention, while the tool head 7 is transported within the components supplying region S, a large number of chip components 13, ---, 13 are absorbed ~~as many as possible~~, and this tool head 7 is moved to the components mounting region M in which the chip components 13, ---, 13 are mounted on a predetermined mounting place. Therefore, the transportation of the tool head 7 between the components supplying region S and the components mounting region M can be suppressed in a minimum value when the chip components 13, ---, 13 are mounted on the board 9. As a result, the transport time per single chip component 13, namely the mounting speed (mounting tact time) can be shortened.

Also, as explained in the above embodiment, the components supplying region S and the components mounting

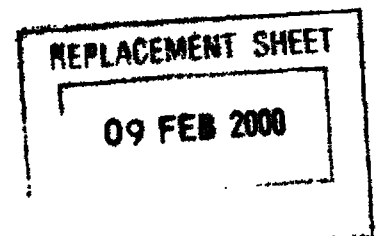


region M are properly subdivided, and then the chip components 13, ---, 13 are absorbed/mounted between the subdivided supplying region S and the subdivided mounting region M. As a consequence, the sequential operations about the absorption and mounting of the chip components 13, ---, 13 can be optimized by considering the quantity of absorbing nozzles 8, ---, 8 mounted on the tool head 7, the dimensions of the board 9, and the sort/quantity of chip components 13, ---, 13 to be mounted.

SECOND COMPONENTS MOUNTING METHOD

Fig. 16 schematically represents a components mounting method according to a second embodiment of the present invention. In this second embodiment, such a components mounting apparatus 1 that two components supplying regions "S" and "S" are located on both sides of a components mounting region "M". This components mounting region M is subdivided along the X direction, and also chip components 13, --- 13 are absorbed in one components supplying region S. Thereafter, the chip components 13, --- 13 are mounted in the subdivided components mounting region M, and then the tool head 7 is transferred to the other components supplying region S in order to absorb the chip components 13, ---, 13.

Under such a circumstance, the sequential operations for absorbing and mounting the chip components can be optimized, namely the mounting tact time can be shortened by employing the following manners. That is, a place where the



WHAT IS CLAIMED IS:

~~1. In a components mounting method in which a large~~
number of electronic components are transported from a
components supplying region where a plurality of components
supplying apparatuses are arranged with said large number of
electronic components stored thereinto to a components
mounting region in which a board is arranged with said
electronic components mounted thereon, and said electronic
components are mounted on a predetermined mounting position
of said board, the improvement wherein:

a plurality of said electronic components are
individually gripped by a plurality of gripping means in
said components supplying region; and after these gripping
means are transported to the components mounting region,
each of said gripped electronic components is mounted on a
~~predetermined mounting position thereof.~~

¹ 2. A components mounting method ~~as claimed in claim~~
for transporting a plurality of positions, the method comprising
~~1 wherein said components mounting method comprises the~~
steps of:

subdividing at least one of said components supplying
into at least two subdivided sections
region and said components mounting region; and

mounting said electronic components in ~~a entire region~~
components
~~of said mounting region by repeating one of the steps of:~~

individually using
gripping said electronic components ~~by~~ a plurality of
from a first
said gripping means ~~in one of said subdivided sections~~ of
said components supplying region; ~~and~~ mounting said

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electronic components ~~in~~ *from said first subdivided section of said component's supplying region into* said components mounting region; and ~~then~~ *individually using* gripping said electronic components ~~by~~ *from a second* a plurality of said gripping means ~~in another~~ subdivided section of said components supplying region; and mounting said electronic components ~~in~~ *from said second subdivided section of said component's supplying region into* said components mounting region.

~~gripping said electronic components by a plurality of~~
said gripping means in said components supplying region and
mounting said electronic components in one of said
subdivided sections of said components mounting region and
then gripping said electronic components by a plurality of
said gripping means in said components supplying region
again and mounting said electronic components in another
subdivided section of said components mounting region; and

gripping said electronic components by a plurality of
said gripping means in one of said subdivided sections of
said components supplying region and mounting said
electronic components in one of subdivided section of said
components mounting region and then gripping said electronic
components by a plurality of said gripping means in another
subdivided section of said components supplying region and
mounting said electronic components in another subdivided
~~section of said components mounting region.~~

23. A component mounting method as claimed in claim 2
10, *further comprising the step of subdividing*
~~wherein~~

said components supplying region ~~is subdivided~~ into
that are two groups of subdivided sections *each side* ~~arranged on both sides of~~

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said components mounting region in a direction identical to a direction along which said subdivided sections of said components mounting region are disposed, and

wherein
~~^ said step of gripping said electronic components in one of said subdivided sections of said components supplying region and mounting said electronic components in one of subdivided section of said components mounting region and then gripping said electronic components in another subdivided section of said components supplying region and mounting said electronic components in another subdivided section of said components mounting region further comprises~~
gripping and mounting steps comprise the
~~^ steps of:~~

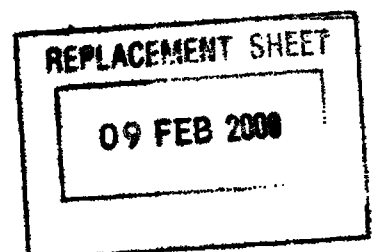
gripping individually a plurality of said electronic components in one of said subdivided sections of said components supplying region by a plurality of said components gripping means;

transporting^{*said*}~~^~~ a plurality of said component gripping means to one of said subdivided sections of said components mounting region;

mounting each of said electronic components^{*gripped by said..... means onto*}~~^~~ on a predetermined mounting position;

transporting^{*said*}~~^~~ a plurality of said components gripping means to another^{*of said*}~~^~~ subdivided sections of said components supplying region;

^{*gripping individually*}~~^~~ gripping a plurality of said electronic components ~~again~~ in said another subdivided sections of said components





supplying region by ^{said} a plurality of said components gripping means;

transporting ^{said} a plurality of said components gripping means to another ^{of said} subdivided sections of said components mounting region;

mounting each of said electronic components ^{gripped by said..... means onto another} ~~on a~~ predetermined mounting position; and

repeating ^{the} above steps until said electronic components ^{over the entire components} are mounted ~~in the entire region of said~~ mounting region.

3. A components mounting method as claimed in claim 2, wherein:
further comprising the step of positions at a location
~~A said electronic components are mounted from such a predetermined mounting position located closest to ⁹ said components supplying apparatus, where previous final gripping of said electronic components has been performed by said components gripping means, among said components supplying apparatuses in said subdivided sections of said components supplying region.~~

4. A components mounting method as claimed in claim 2, wherein:
further comprising the step of positions at a location
~~A said electronic components are mounted from such a predetermined mounting position located closest to ⁹ said components supplying apparatus, where previous final gripping of said electronic components has been performed by said components gripping means, among said components supplying apparatuses in said subdivided sections of said components~~

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supplying region.

5. A components mounting method as claimed in claim 4, wherein:
further comprising the steps of:
~~1. said electronic components are mounted in said~~
~~components mounting region at a predetermined mounting~~
~~position located closest to such a components supplying~~
~~apparatus, where next first gripping of said electronic~~
~~components is to be performed in said components supplying~~
~~region to which said components gripping means are to be~~
~~subsequently transported, is designated as a final~~
~~predetermined mounting position within said components~~
~~mounting region among said predetermined mounting positions~~
~~in said components mounting region.~~
locating one of..... at a location
among said plurality..... apparatuses, at which a
and designating said..... mounting positions

6. A components mounting method as claimed in claim 5, wherein:
further comprising the steps of:
~~1. said electronic components are mounted in said~~
~~components mounting region at a predetermined mounting~~
~~position located closest to such a components supplying~~
~~apparatus, where next first gripping of said electronic~~
~~components is to be performed in said components supplying~~
~~region to which said components gripping means are to be~~
~~subsequently transported, is designated as a final~~
~~predetermined mounting position within said components~~
~~mounting region among said predetermined mounting positions~~
~~in said components mounting region.~~
locating one of..... at a location
among said plurality..... apparatuses, at which a
and designating said..... mounting positions

7. A components mounting method as claimed in claim

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8 ~~9~~, wherein:

further comprising the steps of:

~~A said electronic components are mounted in said components mounting region at a predetermined mounting position located~~ ^{*locating one of..... at a location*} ~~closest to such a components supplying apparatus,~~ ^{*among said plurality..... apparatuses, at which a*} ~~where next first gripping of said electronic components is to be performed in said components supplying region to which said components gripping means are to be subsequently transported;~~ ^{*and*} ~~A is designated~~ ^{*designating said..... mounting positions*} ~~A as a final predetermined mounting position within said components mounting region among said predetermined mounting positions in said components mounting region.~~

8 ~~9~~. A components mounting method as claimed in claim

8 ~~9~~, wherein:

further comprising:

~~A said electronic components are mounted in said components mounting region at a predetermined mounting position located~~ ^{*locating one of..... at a location*} ~~closest to such a components supplying apparatus,~~ ^{*among said plurality..... apparatuses, at which a*} ~~where next first gripping of said electronic components is to be performed in said components supplying region to which said components gripping means are to be subsequently transported;~~ ^{*and*} ~~A is designated~~ ^{*designating said..... mounting positions*} ~~A as a final predetermined mounting position within said components mounting region among said predetermined mounting positions in said components mounting region.~~

10. ~~A components mounting apparatus in which a large number of electronic components are transported from a components supplying region where a plurality of components~~

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~~supplying apparatuses are arranged with said large number of~~
electronic components stored thereinto to a component
mounting region in which a board is arranged with said
electronic components mounted on preselected mounting
positions of said board, said components mounting apparatus
comprising:

components gripping means for individually gripping
said electronic components; and

a tool head on which a plurality of said components
gripping means are mounted and which is movably provided
between said component supplying region and said components
mounting region,

said components gripping means being supported movably
in the upward and downward direction with respect to said
tool head, and moving up and down for gripping and releasing
said electronic components when positioned to a preselected
position in said tool head;

said tool head being provided rotatably in the forward
and reverse directions so that said tool head is rotated for
selecting said components gripping means and positioning the
selected components gripping means to a preselected
position.

11. A components mounting apparatus as claimed in
claim 10 wherein:

said electronic components are chip type electronic
~~components.~~

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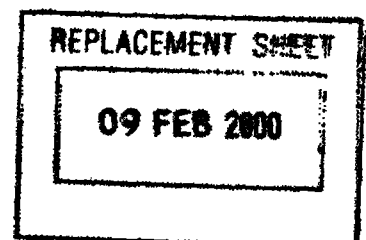
~~12. A components mounting apparatus as claimed in~~
claim 10 wherein:

said components gripping means is an absorbing nozzle
for absorbing the electronic component by using negative
pressure.

13. A components mounting apparatus as claimed in
claim 11 wherein:

said components gripping means is an absorbing nozzle
for absorbing the electronic component by using negative
~~pressure.~~

DISSET NEW CLAIMS 9-12.



MOUNTING APPARATUS
ABSTRACT OF THE DISCLOSURE

In a components mounting apparatus, so-called mounting tact time per a single electronic component is shortened. The components mounting apparatus in which a large number of electronic components are transported from a components supplying region where a plurality of components supplying apparatuses are arranged with the large number of electronic components stored thereinto to a components mounting region in which a board is arranged with the electronic components mounted on preselected mounting positions of the board thereon is comprised of: components gripper for individually gripping the electronic components; and a tool head on which a plurality of components gripper are mounted and which is movably provided between the components supplying region and the components mounting region. The components gripper is supported movably in the upward and downward direction with respect to the tool head, and moves up and down for gripping or releasing the electronic components when positioned to a preselected position in the tool head. The tool head is provided rotatably in the forward and reverse directions so that the tool head is rotated for selecting the components gripper and positioning the selected components gripper to a preselected position.

Figure 4

