

## Description

Method for providing substrates with inserted components

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The invention relates to a method for providing substrates with inserted components according to the precharacterizing clause of patent claim 1 or 2.

10 When providing substrates with inserted components, in particular printed-circuit boards, the components are removed from feeding units with the aid of insertion heads and positioned by the insertion head into a predetermined position on the substrate. For a high  
15 insertion rate (number of substrates provided with inserted components per unit of time), as many components per unit of time as possible are to be positioned in this way on the substrates.

20 WO 98/37744 discloses a device for producing electrical components which has in a central area two parallel, linear longitudinal guides situated closely next to each other, in which carts can be moved accordingly. These carts have in each case a cross bar for  
25 respectively suspending an insertion head. This creates two separate processing areas, which can be operated independently of each other. As a result, a high insertion rate of the device is made possible.

30 For a still higher insertion rate, automatic insertion machines are combined in a line. In this case, the various insertion machines have different stores of component types, and can be specially designed for the respective component types. The automatic insertion  
35 machines arranged in a line consequently form processing areas arranged in a line, a single processing area respectively comprising an insertion head and feeding units assigned to the insertion head being assigned to specific component types. All the

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components to be inserted for a single substrate are then divided between the two processing areas, that is to say the feeding units are also divided between the individual processing areas.

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In order not to allow downtimes, such as the moving of the substrate into the processing area, to affect the insertion rate, two transporting devices are used. However, in the case of substrates with a small number  
10 of components to be inserted (< around 100 components), it must be taken into account that the downtimes account for a very high proportion in percentage terms. For example, renewed measurement of the reference marks on the substrate is required after transport into the  
15 next processing area. A further effect which leads to reductions in the rate when there are small numbers of components to be inserted is the quantization on the basis of the suction pipettes located on the head (for example 12 or 18). An only partly filled insertion  
20 head must nevertheless complete almost the entire number of head cycles in the same way as a fully filled insertion head.

It is therefore the object of the invention to specify  
25 a method for inserting components onto substrates which achieves a high insertion rate when there are few components to be inserted and a number of processing areas.

30 The object is achieved according to the invention by a method of the type stated at the beginning with the characterizing features of claim 1 or 2.

The method according to the invention has the effect  
35 that, in the case of a number of components to be inserted which is less than or equal to the number of feeding units in the processing area, the complete substrate is already provided with inserted components

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on the first processing area. As a result, no unnecessary downtimes occur, such as a renewed measurement of markings of the substrate in the second processing area, or there are reduced

downtimes, for reasons such as the smaller number of insertion head cycles to be completed.

According to claim 2, it is additionally provided in  
5 this case that, when there are few component types to  
be inserted, it is additionally determined  
theoretically on the basis of the assumed time behavior  
of the insertion head whether a time saving is obtained  
by insertion in one operating area and, only if there  
10 is a time saving, is insertion also carried out in one  
processing area. The time saving is generally obtained  
in particular when there is a small number of  
components to be inserted.

15 In the advantageous refinement of the method as claimed  
in claim 3, it is ensured by the use of what is known  
as dual transport, with two transporting devices  
arranged essentially parallel, that, when there are  
small numbers of components to be inserted, two  
20 insertion lines operating essentially in isolation from  
each other are used. Thus, in this case, a first  
substrate is provided with inserted components in the  
first processing area in such a way that no further  
insertion of components is required in the second  
25 processing area, whereas a second substrate is provided  
with inserted components on the second transporting  
device in the second processing area.

If the number of component types to be inserted is less  
30 than the number of feeding units which can be arranged  
on one side of a transporting device, it is  
advantageous according to claim 4 to arrange all the  
component types in the feeding units on the side of the  
transporting devices which lies closer to the  
35 transporting device on which the substrate to be  
provided with inserted components is located.

If on both transporting devices there are substrates

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with a small number of components to be inserted, it is advantageous, according to claim 5, that the component types to be kept in store for the two insertion processes are in each case arranged on the side of the  
5 transporting

devices which lies closer to the transporting device on which the substrate respectively to be provided with inserted components is located.

5 The invention is explained in more detail on the basis of an exemplary embodiment in the figures of the drawing, in which:

10 figure 1 shows a schematic plan view of a line for the insertion of components, with two processing areas for when there is a large number of components to be inserted,

15 figure 2 shows a schematic plan view of a line of processing areas for when there is a small number of components to be inserted,

20 figure 3 shows a flow diagram of a first exemplary embodiment of the method according to the invention and

figure 4 shows a flow diagram of a second exemplary embodiment of the method according to the invention.

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Represented in figure 1 is a schematic plan view of a line of processing areas 6, 11. In the first processing area 6, a first substrate 1 is provided with inserted components 2, which are made available in  
30 feeding units 3. An insertion head 4 picks up the components 2 from the feeding units 3 by holding devices 5, for example suction pipettes, transports them by a movement essentially parallel to the surface of the substrate 1 into a predetermined position above  
35 the substrate 1 and places them there onto the substrate 1. The insertion head 4 is in this case movable within the processing area 6. The first substrate 1 is moved by means of a first transporting

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device 7 into the first processing area 6, provided with a first group 8 of inserted components and, after the component-insertion process, is transported into a second processing area 11. The two

processing areas 6, 11 are therefore arranged in a line. In the second processing area 11, the substrate 1 is analogously provided with a second group 9 of inserted components 2 from feeding units 3 with the aid of a second insertion head 10. Additionally represented in figure 1 is a second substrate 13, which moves on a second transporting device 12, likewise through the two processing areas 6, 11, and is provided with inserted components 2 in a first group 8 and a second group 9 in the respective processing areas 6, 11 with the aid of the first insertion head 4 and the second insertion head 10. To insert further components, further processing areas may be provided in the line. Components 2 of a specific component type, for example specific resistors, specific integrated circuits or other specific electronic components, are stored here in each feeding unit 3. The division of all the components to be inserted into two processing areas makes it disadvantageous, in particular when there are few components to be inserted, that in each processing area it is necessary for example for the position of the individual substrate 1 to be determined before the actual component-insertion process can begin. When there are few components 2 to be inserted, it is also frequently the case that the insertion head 4, which in this example has a total of 12 suction pipettes 5, often has to cover the distance from the feeding units 3 to the substrate 1 in a not completely filled state. However, this time from the feeding unit 3 to the substrate 1 decisively affects the level of the insertion rate, that is to say the number of components inserted per unit of time.

In figure 2 it is shown that, when there are few components to be inserted, all the components to be inserted, that is to say both the first group 8 and the second group 9, are inserted only in one of the two processing areas. Not shown, but possible, is the use

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of the respectively empty places on the transporting  
devices 7, 12 in the respective

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processing areas as buffers for further substrates, to keep changing times as small as possible.

As schematically represented in figure 3 on the basis  
5 of the flow diagram, in a first exemplary embodiment it is determined before the component-insertion process whether the total number of component types to be inserted onto a substrate is greater than the number of feeding units in a processing area. Only if this  
10 number is greater is the component insertion divided between two processing areas, otherwise the component insertion of all the components to be inserted takes place in one processing area.

15 A further exemplary embodiment is represented in figure 4 in the form of a further flow diagram. In this case, it must be taken into account that the time advantage from inserting components in only one processing area is particularly great whenever the number of components  
20 to be inserted is small, since in this case the downtimes are reduced particularly effectively. Before the component insertion, it is therefore determined as part of what is known as setup optimization, taking into account the theoretical moving times of the  
25 insertion head, whether or not a time saving is achieved when there are few component types by dividing the components to be inserted between two processing areas. Dependent on this result, the component insertion then takes place in one or two processing  
30 areas.

If a first transporting device 7 and a second transporting device 12 are used, the two transporting devices and the two processing areas 6, 11 are  
35 essentially isolated by this method. Therefore, the method advantageously allows both substrates with a high number of components to be inserted, which are then divided between a number of processing areas, and

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substrates with a low number of components to be  
inserted, in which case the component insertion takes  
place only in one processing area, to be produced in  
one component-insertion line with a high insertion  
5 rate.

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A further increase in the insertion rate can be achieved if the number of component types 2 to be inserted onto the substrate 1, 13 is less than or equal to the number of feeding units 3 arranged in a group 14, 15 on one side of the transporting device 7, 12. If all the component types 2 to be inserted are then set up in feeding units 3 in a first group 14 directly next to the first transporting device 7, the insertion head moves only the short distance between the feeding unit 3 and the substrate 1. In a corresponding way, in the case of the second substrate 13 in the second processing area 11, the component insertion can take place by feeding units 3 exclusively using the components to be inserted of the second group 15.

## CLAIMS

1. A method for equipping a substrate with a plurality of components of respectively different components types, comprising the steps of:

providing at least a first processing area and a second processing area through which a substrate is successively moveable;

at each of said first and second processing areas, disposing an equipping head in connection with a number of supply units, each of said supply units containing only components of one component type;

determining a number of said different component types to be placed on said substrate and comparing said number of different component types to be placed on said substrate with said number of supply units;

if said number of different component types to be placed on said substrate is less than or equal to said number of supply units, equipping said substrate in only one of said processing areas; and

if said number of different component types to be placed on said substrate is greater than said number of supply units, successively equipping said substrate in at least said first and second processing areas.

2. The method according to claim 1 further comprising a plurality of substrates that are each successively moveable via a transport member into at least one of said first and second processing areas, said substrates including a first and second substrate portion, said transport member includes a first and second transport member for respectively moving said first and second substrate portions into at least said first and second processing areas, if said number of different component types to be placed on each of said substrates is less than or equal to said number of supply units, respectively equipping said first and second substrate portions in said first and second processing areas.

3. The method according to claim 2 wherein each of said supply units includes a first and second supply group respectively disposed adjacent to said first and second transport members, determining said number of different component types to be placed

on one of said substrates that is located on said first transport member and comparing said number of different component types with a number of supply units within said first supply group, and if said number of different component types is less than or equal to said number of supply units within said first supply group, equipping the substrate with the components from the first supply group in only one of the processing areas.

4. The method according to claim 2 wherein each of said supply units includes a first and second supply group respectively disposed adjacent to said first and second transport members, determining said number of different component types to be placed on one of said substrates that is located on said second transport member and comparing said number of different component types with a number of supply units within said second supply group, and if said number of different component types is less than or equal to said number of supply units within said second supply group, equipping the substrate with the components from the second supply group in only one of the processing areas.

5. A method for equipping a substrate with a plurality of components of respectively different component types, comprising the steps of;

providing at least a first processing area and a second processing area through which a substrate is successively moveable;

at each of said first and second processing areas, disposing an equipping head in connection with a number of supply units, each of said supply units containing only components of one component type, each equipping head having a time characteristic associated therewith;

determining a number of said different component types to be placed on said substrate and comparing said number of different component types to be placed on said substrate with said number of supply units;

if said number of different component types to be placed on said substrate is less than or equal to said number of supply units, determining and comparing a time required to equip said substrate with said plurality of components using said equipping head in said first processing area with a time required to equip said substrate with said plurality of components using said equipping head in said second processing area,

dependent on the respective time characteristics of said equipping heads, to obtain a time difference, and if said time difference is positive, equipping said substrate in only one of said processing areas and if said time difference is negative, successively equipping said substrate in at least said first and second processing areas; and

if said number of different component types to be placed on said substrate is greater than said number of supply units, successively equipping said substrate in at least said first and second processing areas.

6. The method according to claim 5 further comprising a plurality of substrates that are each successively moveable via a transport member into at least one of said first and second processing areas, said substrates including a first and second substrate portion, said transport member includes a first and second transport member for respectively moving said first and second substrate portions into at least said first and second processing areas, if said number of different component types to be placed on each of said substrates is less than or equal to said number of supply units, respectively equipping said first and second substrate portions in said first and second processing areas.

7. The method according to claim 6 wherein each of said supply units includes a first and second supply group respectively disposed adjacent to said first and second transport members, determining said number of different component types to be placed on one of said substrates that is located on said first transport member and comparing said number of different component types with a number of supply units within said first supply group, and if said number of different component types is less than or equal to said number of supply units within said first supply group, equipping the substrate with the components from the first supply group in only one of the processing areas.

8. The method according to claim 6 wherein each of said supply units includes a first and second supply group respectively disposed adjacent to said first and second transport members, determining said number of different component types to be placed on one of said substrates that is located on said second transport member and comparing said number of different component types with a number of supply units

within said second supply group, and if said number of different component types is less than or equal to said number of supply units within said second supply group, equipping the substrate with the components from the second supply group in only one of the processing areas.