



GR 98 P 2471 Foreign version

Description

Method and apparatus for calibration of a movement path
and/or of an angular position of a holding apparatus in
5 a device for producing electrical assemblies as well as
a calibration substrate

The invention relates to a method, an apparatus
and a calibration substrate for calibration of a
10 movement path and/or of an angular position of a
holding apparatus in a device for producing electrical
assemblies, in particular for placing components on
printed circuit boards, as claimed in the
precharacterizing clauses of patent claim 1, 6 or 9.

15 In the past, by way of example, a calibration
substrate like a printed circuit board has been fitted
with disk-like models of the components at defined
placement points in order to calibrate a movement path
and/or an angular position of a holding apparatus in a
20 device for producing electrical assemblies. The models
are in this case transported from a magazine to the
calibration substrate on the holding apparatus,
analogously to the transportation of components from
feed units to the placement point on a printed circuit
25 board. In this case, it is normal to use a glass plate
which is similar to a printed circuit board and has
centering marks in its corner regions, as a calibration
substrate. The glass plate, which is provided with
double-sided adhesive film or with a spray adhesive, is
30 inserted into the device which, for example, is in the
form of an automatic placement machine, and the
position of the centering marks is then determined by
means of a position-resolving printed circuit board
camera in the automatic placement machine. The
35 calibration substrate is then fitted with models of
components at points which are defined relative to the
centering marks.

The populated glass plate can then be measured
in various ways. In a first method which, for example,



is known from US 5,537,204 or from DE 42 27 667, the populated glass plate is inserted into an optical measurement machine. The small glass plates have defined markings whose position is determined relative to the centering marks of the glass plate in the measuring machine. The position discrepancies from the desired ideal position are used to determine correction values in the coordinate directions and with respect to the rotation position, and these correction values are entered as correction parameters in the automatic placement machine, which takes account of these discrepancies when components are subsequently being placed on printed circuit boards.

The prior art German Patent Application 19711476.8 (published as WO 98/42171) has already proposed a further method, with the populated glass plate being measured by the printed circuit board camera in the automatic placement machine. For this purpose, the printed circuit board camera records local reference marks in its field of view, which reference marks are provided on the glass plate, together with the defined markings on the small glass plates, and uses their relative position with respect to one another to determine the corresponding correction values, which are then taken into account when components are being placed on printed circuit boards.

However, the printed circuit board cameras have their own individual camera distortion, which is particularly pronounced with short focal length objectives. When carrying out measurements for automatic placement machines, with this optical sensor unit being used a number of times in the process, this situation results in systematic errors in the range $\pm 15 \mu\text{m}$.

The object of the invention is to specify an improved method and an apparatus, by means of which the movement path and/or the angular position of a holding apparatus in a device for producing electrical

19 February 2003

GR 98 P 2471 Foreign version

- 2a -

assemblies can be calibrated, using an optical sensor device which is provided in the device itself.

The object is achieved according to the invention by a method having the characterizing features of patent claim 1, by an apparatus having the characterizing features of patent claim 6, and by a
5 calibration substrate having the characterizing features of patent claim 9.

In the method according to the invention, the optical sensor advantageously first of all measures the distance between a first correction mark and a second
10 correction mark using the apparatus according to the invention and using the calibration substrate according to the invention, in which case these correction marks are applied to the calibration substrate (the glass plate) with a predetermined nominal separation. The
15 distance which has been determined is compared with the nominal separation to determine a sensor correction factor, which is taken into account when determining the position of the individual models on the calibration substrate. This method results in the
20 optical sensor being calibrated accurately in a limited region of its field of view (partial mapping).

In the advantageous refinement as claimed in patent claim 2, with the respective optical structural features being in the same position (position and
25 distance) relative to one another, this ensures that the optical sensor is used only in the region for which it has also been measured accurately.

The method as claimed in patent claim 3 works particularly accurately if the respective optical
30 structural features also have the same or a similar form.

The method as claimed in patent claim 4 is particularly simple and fast if the nominal separation is chosen to be smaller than the field of view of the
35 optical sensor, so that the first correction mark and the second correction mark, as well as the local reference marks and the optical structural features,

19 February 2003

GR 98 P 2471 Foreign version

- 3a -

are recorded by the optical sensor at the same time.

GR 98 P 2471 Foreign version

- 4 -

A further improvement in the accuracy is achieved if, as claimed in patent claim 5, the local reference marks are recorded at least approximately at the same point in the field of view of the optical sensor as the first correction mark. This ensures that the same, already calibrated region of the optical sensor is always used for the measurement process.

In the advantageous apparatus for carrying out a method as claimed in patent claim 8, the imaginary connecting line between the local reference marks and the structural features runs at right angles to the edges of the models, so that the measurement process is not made harder by additional reflections on other edges of the models.

The invention will be explained in more detail using exemplary embodiments and with reference to the figures in the drawing, in which:

Figure 1 shows a plan view of a calibration substrate with models of components placed on it.

Figure 2 shows an enlarged detail of the calibration substrate shown in Figure 1, with the first correction mark and the second correction mark.

Figure 1 shows a calibration substrate 1 which has been fitted, in an automatic placement machine for electrical components, with models 2 of those components at defined points. For this purpose, the models 2 are taken from magazines, which are not illustrated, and are transported on a holding apparatus (not illustrated) to the calibration substrate 1, on which they are placed at the position intended for that purpose, analogously to the transportation of components from feed devices to the placement position on the printed circuit board. The models 2 consist of small glass plates which, at two mutually diagonally opposite corners, each have markings 4 as optical structural features such as crosswires. The calibration substrate 1 is provided with local

GR 98 P 2471 Foreign version

- 5 -

reference marks 3 at a short distance from the markings 4 at these points, with these local reference marks 3 being applied with high positioning precision.

5 The markings 4 and the reference marks 3 are sufficiently close together that they fit into a field of view 7 on a position-resolving optical sensor which is mounted on a placement head for the components. This placement head can be moved in such a manner that the sensor can be positioned over all the marked corner
10 regions.

The position-resolving sensor is connected to evaluation electronics which are able to determine the relative position of the markings 4 with respect to the respective reference mark 3, without the sensor needing
15 to be moved in the process. A controller (not illustrated) for the placement device has an evaluation module which processes the individual discrepancies between the markings 4 and the reference marks 3 to form correction parameters for the machine. These
20 correction parameters are transferred automatically by the controller.

For accurate calibration of the optical sensor, a first correction mark 5 and a second correction mark 6 are applied to the calibration substrate 1 with a
25 fixed predetermined nominal separation a . In this case, the optical sensor first of all measures the distance between the first correction mark 5 and the second correction mark 6 and uses this, in comparison with the nominal separation a , to determine a sensor correction
30 factor, which is taken into account when determining the position of the models 2. If the optical sensor now subsequently measures the position of the local reference marks 3 relative to the markings 4 and if the same region of the field of view 7 is used in the
35 process as when measuring the first correction mark 5 and the second correction mark 6, then the relative position between the marking 4 and the local reference

19 February 2003

GR 98 P 2471 Foreign version

- 5a -

mark 3 can be determined accurately by taking into account the sensor correction factor. The best possible accuracy is achieved if the point in the field of view 7 at which the first correction mark 5 was measured
5 corresponds

GR 98 P 2471 Foreign version

- 6 -

with the point in the field of view 7 at which the local reference mark 3 is measured. The marking 4 is then located approximately at that point in the field of view 7 at which the second correction mark 6 was located. This results in the use of a region of the field of view 7 of the optical sensor which was previously used when determining the sensor correction factor, thus resulting in the desired accuracy in the measurement of the automatic placement machine.

10 The markings 4 are arranged relative to the local reference marks 3 in this case such that their imaginary connecting line is at right angles to the edges of the models. This minimizes the influence of interference reflections on the measurement of the
15 relative position of the markings with respect to one another.

What is claimed is:

1. A method for calibrating a travel path and/or an angular position of a holding device in an apparatus for equipping printing circuit boards with components, comprising the steps of:

equipping a calibration substrate in a manner of a printed circuit board with simulations of the components that define placement locations;

obtaining via an optical sensor an optically measured spacing between first and second correction marks that are applied on the calibration substrate at a predetermined nominal spacing which is different than said optically measured spacing;

determining a sensor correction factor by comparing the optically measured spacing to the nominal spacing, said sensor correction factor to be taken into consideration in a subsequent positional determination of the simulations for compensation of an optical distortion of the optical sensor; and

determining said subsequent positioned determination by determining a position of the simulations relative to local reference marks of the calibration substrate based on positionally defined optical structure features on the simulations by said optical sensor.

2. The method for calibrating according to claim 1 wherein a spacing of the respective local reference marks from the respective optical structure features is selected approximately equal to the nominal spacing; and

wherein a position of the optical structure features relative to the local reference marks corresponds to the nominal spacing of the second correction mark from the first correction mark.

3. The method according to claim 2 wherein a shape of the local reference marks and the optical structure

features corresponds to a shape of the first and second correction marks.

4. The method according to claim 1 wherein said nominal spacing is selected smaller than a field of view of the optical sensor; and
wherein the first and second correction marks are simultaneously registered by the optical sensor.

5. An apparatus for equipping printed circuits boards with components, comprising:

a calibration substrate equipped in a manner of a printed circuit board with simulations of the components at defined placement locations, said calibration substrate having local reference marks thereon and also first and second correction marks, the first and second correction marks being spaced apart at a predetermined nominal spacing, and said simulations having optical structure features thereon as markings;

an equipping head having a holding device thereon for transporting components and also the simulations;

an optical sensor also on the equipping head for use in calibrating a travel path and/or an angular position of said holding device;

with said optical sensor and an evaluation electronics connected to said optical sensor, obtaining an optically measured spacing between said first and second correction marks, said predetermined nominal spacing being different than said optically measured spacing;

by use of said evaluation electronics and evaluation module connected to said evaluation electronics, determining a sensor correction factor by comparing the optically measured spacing to the nominal spacing, said sensor correction factor to be taken into consideration in a subsequent positional determination of the simulations for compensation of an optical distortion of the optical sensor; and

providing a control device for receiving said sensor correction factor from said evaluation module and for controlling movement of said equipping head with the holding device thereon, said control device together with said output from said evaluation module determining said subsequent positional determination by determining a position of the simulations relative to the local reference marks of the calibration substrate based on said optical structure features on the simulations by use of said sensor.

6. The apparatus according to claim 5 wherein the correction marks, the local reference marks, and the optical structure features are crosses.

7. The apparatus according to claim 5 wherein an imaginary connecting line between the local reference marks and the optical structures features proceeds at least approximately perpendicular to edges of the simulation.

8. A calibration substrate for use in calibrating a travel path and/or an angular position of a holding device on an equipping head of an apparatus for equipping printed circuit boards with components, comprising:

a substrate having a plurality of simulations of electrical components positioned thereon, each simulation having a respective optical structure features as a marking thereon;

a respective local reference mark for each simulation with the simulations being positioned using the respective optical structure features thereon for positioning the simulations relative to the respective local reference marks; and

first and second correction marks on the substrate which are spaced from one another at a predetermined nominal spacing where said predetermined nominal spacing is at

least approximately equal to a spacing between the respective local reference marks and the respective optical structure feature marking on the respective simulations.