

SPECIFICATION

TITLE OF THE INVENTION

COMPONENT MOUNTING APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

5 The present invention relates to component mounting apparatus and method for mounting such components as electronic components, optical components and mechanical components onto a circuit board or other member onto which the components should be mounted. More specifically, the
10 invention relates to an improvement in the positional calibration of the component and the circuit board due to any shift of the optical axis of an image recognition optical system used in the component mounting apparatus or method.

15 Conventionally, in an electronic component mounting apparatus, an electronic component is mounted onto a circuit board after position recognition of the electronic component and the circuit board is executed by an image recognition optical system for enhanced mounting
20 precision. Then, calibration operation of the image recognition optical system is performed in order to suppress any shift of the mounting position due to distortion of the image recognition optical system or the like caused by changes in environmental temperature around
25 the electronic component mounting apparatus.

 Hereinbelow, an example of the electronic component mounting apparatus according to the prior art is described with reference to Figs. 16 and 17. Referring to

Fig. 16, reference numeral 921 denotes an electronic component, which is stored on a tray 922. Reference numeral 923 denotes a head, which sucks up and conveys the electronic component 921. Reference numeral 924 denotes a circuit board, which is sucked up and held to a bonding stage 925. The bonding stage 925 and the tray 922 are fixed on a slide base 926. Reference numeral 927 denotes an image recognition optical system, which performs position recognition of the circuit board 924 and the electronic component 921. Further, the head 923 is movable in an X direction, the slide base 926 is movable in a Y direction and the image recognition optical system 927 is movable in both X and Y directions.

Referring to Fig. 17, reference numeral 928 denotes a CCD camera of the image recognition optical system 927, with a magnifying lens 929 coupled thereto. Reference numeral 930 denotes a prism frame in which a prism 931 is fixed, and the magnifying lens 929 is coupled to this prism frame 930. An image of the electronic component 921 sucked up and held to the head 923 or the circuit board 924 sucked up and held to the bonding stage 925 is taken by the CCD camera 928 via the prism 931 and the magnifying lens 929. Then, the image recognition optical system 927 takes the image of either the electronic component 921 or the circuit board 924 through a switching of the field of view.

With respect to the electronic component mounting apparatus constructed as described above, its operation is

described below. First, after the head 923 and the slide base 926 have moved to specified positions, the head 923 moves down to pick up the electronic component 921 on the tray 922. Subsequently, the head 923 and the slide base 926 move again so that a coarse positioning for mounting the electronic component 921 onto the circuit board 924 is performed. Subsequently, for checking the position of the circuit board 924, the image recognition optical system 927 moves to such a position as to bring a feature point on the circuit board 924 into the field of view, performing image recognition of the feature point. Next, for checking the position of the electronic component 921, the image recognition optical system 927 moves to such a position as to bring a feature point on the electronic component 921 into the field of view, performing image recognition of the feature point. Then, position correction between the circuit board 924 and the electronic component 921 is performed based on the image recognition results of the circuit board 924 and the electronic component 921, and on an offset amount (optical-axis shift amount) between a field of view "e" on the electronic-component image recognition side and a field of view "f" on the circuit-board image recognition side which are inputted as previously measured and fixed values. After that, the head 923 moves down to mount the electronic component 921 onto the circuit board 924.

However, with the constitution as described above, even when the image-pickup positions of the electronic

component 921 and the circuit board 924 have changed because of a occurrence of distortion to the holding portion of the image recognition optical system 927 due to changes in the room temperature or heat generation inside the apparatus so
5 that the inclination of the optical axis has changed, the position correction would be performed based on a decision that merely the position of the electronic component 921 or the circuit board 924 has changed. As a result, there might occur an issue that the mounting position of the electronic
10 component 921 is shifted with an effect of the change in the inclination of the optical axis.

SUMMARY OF THE INVENTION

In view of the above issues of the prior art, an object
15 of the present invention is therefore to provide electronic component mounting apparatus and method in which the mounting position of the electronic component does not shift even when an offset amount between fields of view on the electronic-component image recognition side and the circuit-
20 board image recognition side has changed due to a change in the room temperature or heat generation inside the apparatus.

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

a component holding and conveying device for holding
5 and conveying a component and for mounting the component onto a circuit board;

a circuit board holding device for holding the circuit board;

an image recognition optical system for performing
10 position recognition of the circuit board using a first field of view and for performing position recognition of the component using a second field of view, the first field of view being different than the second field of view and both fields of view being imaged using a common image capture
15 device; and

a control section for calibrating said image recognition optical system by determining a calibration optical-axis shift amount prior to the component being mounted onto the circuit board, and for controlling said
20 component holding and conveying device and said image recognition optical system calibrated using the calibration optical-axis shift amount so as to mount the component onto the circuit board, said control section being operable to determine the calibration optical-axis shift amount by
25 repeatedly comparing a circuit board calibration position recognized by said image recognition optical system using the first field of view and a component calibration position recognized by said image recognition optical system using the second field of view so as to obtain a plurality of
30 optical-axis shift amounts and then by calculating the calibration optical-axis shift amount using the plurality of optical-axis shift amounts.

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

5 a component holding and conveying device for holding and conveying a component and for mounting the component onto a circuit board, said component holding and conveying device having a calibration stage;

a circuit board holding device for holding the circuit board;

10 an image recognition optical system for repeatedly recognizing a first position of a marking on a jig using a first field of view while holding the jig on said calibration stage, and for repeatedly recognizing a second position of the marking on the jig using a second field of view while holding the jig on said component holding and
15 conveying device, the first field of view being different than the second field of view and both fields of view being imaged using a common image capture device; and

a control section for calibrating said image
20 recognition optical system by determining a calibration optical-axis shift amount prior to the component being mounted onto the circuit board, and for controlling said component holding and conveying device and said image recognition optical system calibrated using the calibration
25 optical-axis shift amount so as to mount the component onto the circuit board, said control section being operable to determine the calibration optical-axis shift amount by repeatedly comparing the first position repeatedly recognized by said image recognition optical system using
30 the first field of view and the second position repeatedly recognized by said image recognition optical system using the second field of view so as to obtain a plurality of

optical-axis shift amounts and then by calculating the calibration optical-axis shift amount as the mean value of the plurality of optical-axis shift amounts.

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

 a component holding and conveying device for holding and conveying a component and for mounting the component onto a circuit board;

10 a circuit board holding device for holding the circuit board;

 an image recognition optical system for performing position recognition of the circuit board using a first field of view and for performing position recognition of the component using a second field of view, the first field of view being different than the second field of view and both fields of view being imaged using a common image capture device; and

 a control section for calibrating said image recognition optical system by determining a calibration optical-axis shift amount prior to the component being mounted onto the circuit board, and for controlling said component holding and conveying device and said image recognition optical system calibrated using the calibration optical-axis shift amount so as to mount the component onto the circuit board, said control section being operable to determine the calibration optical-axis shift amount by comparing a circuit board calibration position recognized by said image recognition optical system using the first field of view and a component calibration position recognized by said image recognition optical system using the second field of view, said control section being further operable to

calibrate said image recognition optical system when the circuit board is being held by said circuit board holding device.

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

 a component holding and conveying device for holding and conveying a component and for mounting the component onto a circuit board, said component holding and conveying

10 device having a calibration stage;

 a circuit board holding device for holding the circuit board;

 an image recognition optical system for recognizing a first position of a marking on a jig using a first field of view while holding the jig on said calibration stage, and
15 for recognizing a second position of the marking on the jig using a second field of view while holding the jig on said component holding and conveying device, the first field of view being different than the second field of view and both
20 fields of view being imaged using a common image capture device; and

 a control section for calibrating said image recognition optical system by determining a calibration optical-axis shift amount prior to the component being
25 mounted onto the circuit board, and for controlling said component holding and conveying device and said image recognition optical system calibrated using the calibration optical-axis shift amount so as to mount the component onto the circuit board, said control section being operable to
30 determine the calibration optical-axis shift amount by comparing the first position recognized by said image recognition optical system using the first field of view and

the second position recognized by said image recognition optical system using the second field of view so as to obtain the calibration optical-axis shift amount.

5 According to a fifth aspect of the present invention, there is provided a component mounting method comprising:

repeatedly recognizing a first position of a marking on a jig through a first field of view using an image recognition optical system to generate first position images
10 while the jig is held by a calibration stage of a circuit board holding device for holding a circuit board;

repeatedly recognizing a second position of the marking on the jig through a second field of view using the image recognition optical system to generate second position
15 images while the jig is held by a component holding and conveying device for holding a component and for mounting the component on a circuit board, the first field of view being different than the second field of view and both fields of view being imaged using a common image capture
20 device;

determining a plurality of optical-axis shift amounts between the first position and the second position using the first position images and the second position images;

calculating a calibration optical-axis shift amount as
25 a mean value of the determined plurality of optical-axis shift amounts;

calibrating the image recognition optical system using the calculated calibration optical-axis shift amount; and

mounting the component onto the circuit board using the
30 calibrated image recognition optical system.

According to a sixth aspect of the present invention, there is provided a component mounting method comprising:

5 simultaneously holding a circuit board using a circuit board holding device and recognizing a component calibration position of a component to be held by a component holding and conveying device through a first field of view by using an image recognition optical system;

10 recognizing a circuit board calibration position of a circuit board to be held by a circuit board holding device through a second field of view by using the image recognition optical system, the first field of view being different than the second field of view and both fields of view being imaged using a common image capture device;

15 determining a calibration optical-axis shift amount by comparing the component calibration position and the circuit board calibration position;

calibrating the image recognition optical system using the calibration optical-axis shift amount; and

20 mounting the component on the circuit board using the calibrated image recognition optical system.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Fig. 1 is a perspective view showing the overall
arrangement of an electronic component mounting apparatus
10 according to a first embodiment of the present invention;

Fig. 2 is a perspective view of the calibration stage
in the state that a jig is placed in the electronic
component mounting apparatus of Fig. 1;

Fig. 3 is a view representing positions of images of
15 the jig taken with the upper and lower fields of view of the
image recognition optical system of the electronic

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component mounting apparatus of Fig. 1;

Fig. 4 is a flow chart of calibration operation of the electronic component mounting apparatus of Fig. 1;

5 Fig. 5 is a block diagram showing the arrangement of the control section of the electronic component mounting apparatus of Fig. 1;

Fig. 6 is a longitudinal side view of the image recognition optical system in the first embodiment of the present invention;

10 Fig. 7 is a perspective view showing the calibration operation in the first embodiment;

Fig. 8 is a perspective view showing the overall arrangement of an electronic component mounting apparatus according to a second embodiment of the present invention;

15 Fig. 9 is a perspective view of the calibration stage provided in the electronic component mounting apparatus;

20 Fig. 10 is a view representing an image taken by the image recognition optical system provided in the electronic component mounting apparatus;

Fig. 11 is a flow chart showing operation of the electronic component mounting apparatus;

25 Fig. 12 is a flow chart showing a circuit-board supplying operation and a calibration operation of the image recognition optical system out of the operation of the electronic component mounting apparatus of the second embodiment of the invention;

Fig. 13 is a block diagram of the control section

of the electronic component mounting apparatus of the second embodiment of the invention;

5 Fig. 14 is a perspective view showing a slide base moving device of the electronic component mounting apparatus of the second embodiment of the invention;

Fig. 15 is a perspective view showing the image-recognition-optical-system moving device of the electronic component mounting apparatus of the second embodiment of the invention;

10 Fig. 16 is a perspective view showing the overall arrangement of an electronic component mounting apparatus according to the prior art; and

Fig. 17 is a longitudinal side view of the image recognition optical system of the prior art apparatus.

15 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

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

20 Hereinbelow, electronic component mounting apparatus and method as an example of component mounting apparatus and method according to a first embodiment of the present invention are described with reference to the accompanying drawings.

25 Fig. 1 is a perspective view of the electronic component mounting apparatus which carries out the electronic component mounting method in the first embodiment of the present invention. Fig. 2 is a

perspective view of the calibration stage of the image recognition optical system.

Referring to Fig. 1, reference numeral 13 denotes an electronic component, as an example of a component to be mounted, which is stored on a tray 14. Reference numeral 15 denotes a bonding head as an example of an electronic-component holding and conveying device, the bonding head 15 having a function of moving in an X direction and a function of moving up and down in a Z direction perpendicular to the X direction and a Y direction, and being operative for vacuum sucking up the electronic component 13 with a nozzle 15a and handling it. Denoted by reference numeral 16 is a circuit board as an example of a member onto which the electronic component 13 is to be mounted, the circuit board 16 being sucked up and held to a bonding stage 17 as an example of a circuit-board holding device. Then, the bonding stage 17 and the tray 14 are fixed on a slide base 18 having a function of moving in the Y direction. Reference numeral 19 denotes an image recognition optical system, which can recognize the position of the circuit board 16 located below the image recognition optical system 19 and the position of the electronic component 13 sucked up above the image recognition optical system 19 by the bonding head 15, whichever it is, by switching over the upper and lower fields of view. Also, the image recognition optical system 19 is movable in both X and Y directions. Reference numeral 20 denotes a calibration stage, which is fixed on

the slide base 18.

Referring to Fig. 2, a jig 21 made of glass for calibration of the optical system is sucked up and held on the top of the calibration stage 20 while keeping positioned by a pair of position regulating claws 20a, 20a. Also, a marking 22 for image recognition is marked at a center portion of the jig 21.

Fig. 6 shows in detail the image recognition optical system 19. Reference numeral 19a denotes a CCD camera, with a magnifying lens 19b coupled thereto. Reference numeral 19c denotes a prism frame in which a prism 19d is fixed, and the magnifying lens 19b is coupled to this prism frame 19c. An image of the electronic component 13 sucked up and held to the head 15 or the circuit board 16 sucked up and held to the bonding stage 17 is taken by the CCD camera 19a via the prism 19d and the magnifying lens 19b. Then, the image recognition optical system 19 takes the image of either the electronic component 13 or the circuit board 16 through a switching of the field of view. In Fig. 6, reference numeral 419 denotes upper and lower shutters which are for switching between upper and lower fields of view and which are driven by shutter driving units 105. For a switching to the upper field of view, the lower shutter 419 is moved to a position 420 in the figure so as to shield the lower field of view while the upper shutter 419 is moved to a retreat position, allowing only the upper field of view to be recognized by the image recognition optical system 19. Meanwhile, for a

switching to the lower field of view, the upper shutter 419 is moved to a position 420 in the figure so as to shield the upper field of view while the lower shutter 419 is moved to a retreat position, allowing only the lower field of view to be recognized by the image recognition optical system 19. The drive of these two shutters 419 is controlled by a main controller 101.

With respect to the electronic component mounting apparatus constructed as described above, its operation is explained below.

For mounting the electronic component 13 onto the circuit board 16, a calibration operation of the optical system is first executed. The operation is described from now on. Fig. 4 is a flow chart of calibration operation for the image recognition optical system 19.

In the calibration operation, first, the image recognition optical system 19 moves in the X direction or the Y direction so that the marking 22 of the jig 21 on the calibration stage 20 fixed to the slide base 18 becomes recognizable for the image recognition optical system 19. Subsequently, the field of view of the image recognition optical system 19 is switched from the upper side to the lower side, and the position recognition of the marking 22 of the jig 21 mounted on the calibration stage 20 is performed (step S1 in Fig. 4).

Next, the image recognition optical system 19 withdraws (is retreated) backward with respect to the slide base 18, i.e., obliquely upward and rightward in the Y

direction in Fig. 1. After this, the bonding head 15 moves down to pick up the jig 21 on the calibration stage 20 (step S2 in Fig. 1).

5 Next, the field of view of the image recognition optical system 19 is switched to the upper side, and the image recognition optical system 19 moves forward, i.e., obliquely downward and leftward in the Y direction in Fig. 1, where the position recognition of the marking 22 of the jig 21 is performed again (step S3 in Fig. 1). The jig 21
10 is made of glass and pervious to light, so that the same marking 22 can be recognized by the upper and lower fields of view, respectively.

 Next, after the image recognition optical system 19 has withdrawn backward, the bonding head 15 moves down
15 to mount the jig 21 onto the calibration stage 20 (step S4 in Fig. 1). Then, based on the individual recognition results, an optical-axis shift amount (offset amount) between the upper and lower fields of view of the image recognition optical system 19 is determined (step S5 in Fig.
20 5). This is explained in detail with reference to Fig. 3.

 Fig. 3 represents positions of the marking 22 on the jig 21 taken by the image recognition optical system 19, where 23 represents a position of the marking 22 resulting from recognizing an image of the marking 22 with the lower
25 field of view, and 24 represents a position of the marking 22 resulting from recognizing an image of the marking 22 with the upper field of view of the image recognition optical system 19. Distances X1 and Y1 between the marking

23 and the marking 24 in this case represent an optical-axis shift amount between the lower field of view and the upper field of view of the image recognition optical system 19. This optical-axis shift amount between the fields of view would subtly vary due to the occurrence of distortion of the image recognition optical system 19 etc. caused by effects of changes in the environmental temperature around the electronic component mounting apparatus. Unless the optical-axis shift amount between the fields of view stored in the electronic component mounting apparatus is corrected, there would occur a shift in the mounting position corresponding to the temperature change.

Next, the measurement of the optical-axis shift amount between the fields of view is performed to a plurality of times (step S6 in Fig. 4), and a mean value among the optical-axis shift amounts between the fields of view is determined (step S7 in Fig. 4). This is because one-time measurement would be so much affected by handling precision of the jig 21 that the optical-axis shift amount could not be measured with high precision. Subsequently, for prevention of any shift in the mounting position, the optical-axis shift amount between the fields of view stored in the electronic component mounting apparatus is updated, in which process the amount is updated with an optical-axis shift amount for calibration use determined as the above means value (step S8 in Fig. 4).

In this connection, as the method for achieving the measurement with enhanced calibration precision, the

following ① to ③ methods are available:

① The measurement of optical-axis shift amount is performed to three or more times at step S6 in order to suppress any effect of the handling precision of the jig 21.

5 A mean value of measured values is determined, excluding the upper-limit measured value and the lower-limit measured value, at step S7. The determined mean value is used as a calibration result, i.e., an optical-axis shift amount for calibration use, at step S8. In addition, when only one
10 measured value is left after excluding the upper-limit measured value and the lower-limit measured value, the one measured value is used as an optical-axis shift amount for calibration use.

② The measurement of optical-axis shift amount is performed to three or more times at step S6 in order to suppress any effect of the handling precision of the jig 21.

At step S7, if a measured value, even when subtracted from the other measured values, results in difference beyond a threshold value, a mean value of measured values is
20 determined, excluding the aforementioned measured value at step S7. The determined mean value is used as a calibration result, i.e., an optical-axis shift amount for calibration use, at step S8.

③ For the measurement of the position of the marking 22
25 of the jig 21 under the image pickup with the upper and lower fields of view for enhanced recognition precision, image recognition of the marking 22 is performed to a plurality of times (see flows in one-dot chain line at

steps S1 and S3 in Fig. 4). The position of the marking 22 is determined at step S5 based on the plurality of recognition results.

5 In particular, adopting the ① and ② methods makes it possible to eliminate any effect of an abrupt, large shift of the jig 21 during the handling of the jig 21, as it may arise on rare occasions.

Referring now to a control section 200 relating to the calibration operation of the image recognition
10 optical system 19, its construction and the operation flow are explained in more detail with reference to Figs. 4 and 5.

In the first place, the construction of the control section 200 provided in the electronic component
15 mounting apparatus is explained.

Referring to Fig. 5, reference numeral 101 denotes a main controller of the control section 200 that controls the whole electronic component mounting apparatus.

The main controller 101 issues operation instructions and
20 calculation instructions and puts data into and out of memories according to a concatenated control sequence. Reference numerals 102, 103, 104 denote motor drivers, which correspond to a motor for moving the image
25 recognition optical system 19 in the X direction, a motor for moving the image recognition optical system 19 in the Y direction and a motor for moving the bonding head 15 in the Z (vertical) direction, respectively. Drivers corresponding to other motors are omitted in this figure.

Reference numeral 105 denotes shutter driving units such as motors or air cylinders, which drive the shutters 419 for switching between the upper and lower fields of view of the image recognition optical system 19. Reference numeral 106 denotes a nozzle suction driver, which performs the on-off switching of the suction of the suction nozzle 15a of the bonding head 15. Reference numeral 107 denotes an image recognizing section, which captures the marking 22 of the jig 21 for calibration use as image data by the image recognition optical system 19. Then, the captured image data is stored in a memory 108. Reference numeral 109 denotes an image processing section, which determines the position of the target, i.e. the marking 22, from the image data stored in the memory 108. The positional data of the marking 22 is stored in a memory 110. Reference numeral 111 denotes a calculating section, which calculates an optical-axis shift amount (offset amount) from the position of the marking 22 of the jig 21 stored in the memory 110. Then, the calculated optical-axis shift amount is stored in the memory 110. Also, data of target coordinates for the movement of respective motor drive shafts have been stored in a memory 112. Production conditions for producing the circuit board 16 on which the electronic components 13 are mounted have been stored in a memory 113.

Next the control flow is described. First, the main controller 101 reads from the memory 112 the X- and Y-coordinates stored in the memory 112 to which the image recognition optical system 19 should be moved to recognize

the image of the marking 22 of the jig 21 on the calibration stage 20, and issues instructions to the drivers 102, 103 so that the image recognition optical system 19 moves to the X- and Y-coordinates. Then, the
5 image recognition optical system 19 moves to the X- and Y-coordinates. Subsequently, the main controller 101 issues an instruction to the shutter driving unit 105 to make the field of view of the image recognition optical system 19 switched to the lower side, thus switching the shutter 491
10 to the lower side one as previously described. Subsequently, the main controller 101 issues an instruction to the image recognizing section 107 to capture an image, thus making an image of the marking 22 of the jig 21 on the calibration stage 20 captured by the image recognition
15 optical system 19, and further storing the captured image data into the memory 108. Subsequently, the main controller 101 issues an instruction for image processing to the image processing section 109, so that the image processing section 109 calculates a position 22-1 of the
20 marking 22 of the jig 21 from the above image data stored in the memory 110, storing it into the memory 110. The processes up to this point are the operation of step S1 in Fig. 4.

Next, in order that the image recognition optical
25 system 19 withdraws up to the rear X- and Y-coordinates stored in the memory 112, the main controller 101 reads from the memory 112 the X- and Y-coordinates to which the image recognition optical system 19 should move backward,

and then issues instructions for the drivers 102, 103 to move backward to the X- and Y-coordinates, so that the image recognition optical system 19 is moved backward up to the X- and Y-coordinates.

5 Next, the main controller 101 reads from the memory 112 a Z coordinate which is stored in the memory 112 and to which the bonding head 15 should move down to pick up the jig 21 on the calibration stage 20, and issues an instruction to the driver 104 so that the bonding head 15
10 moves to the Z-coordinate, thus the bonding head 15 moving down. Subsequently, the main controller 101 issues an instruction for the nozzle suckup driver 106 to turn on the suckup of the jig 21 by the nozzle 15a, so that the jig 21 is sucked up by the nozzle 15a of the bonding head 15.
15 Subsequently, the main controller 101 issues an instruction for the driver 104 to move to the coordinate origin, thus the nozzle 15a of the bonding head 15 moving up. The processes up to this point are the operation of step S2 in Fig. 4.

20 Next, the main controller 101 issues an instruction for the shutter driving unit 105 to switch the field of view of the image recognition optical system 19 to the upper side one, thereby switching the shutter from the lower side to the upper side as previously described.
25 Subsequently, the main controller 101 issues an instruction for the image recognizing section 107 to capture an image, so that an image of the marking 22 of the jig 21 sucked up by the nozzle 15a of the bonding head 15 is captured by the

image recognition optical system 19, thus storing image data into the memory 108. Subsequently, the main controller 101 issues an instruction for the image processing section 109 to perform image processing, so that
5 the image processing section 109 calculates a position 22-2 of the marking 22 of the jig 21 from the image data stored in the memory 108, thus storing it into the memory 110. The processes up to this point are the operation of step S3 in Fig. 4.

10 Next, the main controller 101 issues an instruction for the calculating section 111 to determine an optical-axis shift amount between the upper and lower two fields of view, i.e. offset amount, of the image recognition optical system 19, so that the calculating
15 section 111 calculates the optical-axis shift amount by performing calculations from the position 22-1 of the marking 22 of the jig 21 and the position 22-2 of the marking 22 of the jig 21 stored in the memory 110, storing the calculated optical-axis shift amount into the memory
20 110. This operation is the optical-axis shift amount calculating operation of step S5. This operation of step S5 may be done after the operation of returning the jig 21 to the calibration stage 20 at step S4 as shown in Fig. 4, whereas the operation may also be done before the operation
25 of step S4. Otherwise, the steps S4 and S5 may be performed simultaneously.

Next, the main controller 101 reads the X- and Y-coordinates stored in the memory 112 to which the image

recognition optical system 19 should be moved to withdraw backward, and issues an instruction for the drivers 102, 103 to move to the coordinates, so that the image recognition optical system 19 moves to the coordinates.

5 Next, the main controller 101 reads from the memory 112 the Z-coordinate stored in the memory 112 to which the nozzle 15a of the bonding head 15 should be moved down to release the jig 21 on the calibration stage 20, and issues an instruction for the driver 104 to move the nozzle
10 15a of the bonding head 15 up to the Z-coordinate, so that the nozzle 15a of the bonding head 15 moves down to the Z-coordinate. Subsequently, the main controller 101 issues an instruction for the nozzle suckup driving unit 106 to
15 turn off the suckup of the jig 21 by the nozzle 15a, thus stopping the suckup of the jig 21 by the nozzle 15a of the bonding head 15, and returning the jig 21 onto the calibration stage 20. Subsequently, the main controller
20 101 issues an instruction to the driver 104 for the nozzle 15a of the bonding head 15 to move up to the coordinate origin, so that the nozzle 15a of the bonding head 15 moves up to the coordinate origin. These processes are the operation of step S4.

25 Then, the main controller 101 iterates the measurement of optical-axis shift amount of the steps S1 to S5 until the number of times of measurement of optical-axis shift amount stored in the memory 113 is reached (step S6 in Fig. 4).

Then, based on the optical-axis shift amounts

measured and stored in the memory 108, as shown in step S7, a mean value of the optical-axis shift amounts to be used for calibration is determined by the calculating section 111 in the following manner.

5 If it is set in the memory 113 that the measurement of optical-axis shift amount is performed to three or more times and that the upper- and lower-limit measured values are excluded, a mean value of optical-axis shift amounts is determined with the remaining measured
10 values after excluding the upper-limit measured value and the lower-limit measured value as invalid, and the resulting mean value is stored in the memory 110 as the calibration result, i.e., the optical-axis shift amount for calibration use. In addition, when only one measured value
15 is left after excluding the upper-limit measured value and the lower-limit measured value over the three times of measurement, the one measured value is used for calibration as an optical-axis shift amount for calibration use.

 Otherwise, in the case where a threshold value
20 for variations in the optical-axis shift amount is set in the memory 113, differences between the measured values are calculated by subtracting one measured value from the other measured values, and if the difference between a measured value and any of the other measured values, results beyond
25 the threshold value, a mean value of the measured values is determined, excluding the aforementioned measured value, and the determined mean value is stored in the memory 110 as an optical-axis shift amount for calibration use.

Also, without the setting for the exclusion of the upper- and lower-limit measured values, and without the setting of a threshold value, a mean value of optical-axis shift amounts is determined from all the measured values of the optical-axis shift amounts, and the determined mean value is stored in the memory 110 as an optical-axis shift amount for calibration use.

Also, when the number of times of recognition is set in the memory 113, image capturing process is performed continuously to the set number of times as shown by one-dot chain line at steps S1 and S3 in Fig. 4 in the capturing of the image of the marking 22 of the jig 21. Then, mean values among a plurality of positions of the marking 22 of the jig 21 determined from a plurality of image data are determined, respectively, and the determined mean values are stored in the memory 110 as the positions 22-1, 22-2 of the marking 22 of the jig 21 and used to calculate the optical-axis shift amounts between the fields of view, respectively.

Next, the operation of bonding the electronic component 13 onto the circuit board 16 is performed. This operation is described below.

First, in order that the image recognition optical system 19 is enabled to check the position of the circuit board 16 on the bonding stage 17 mounted on the slide base 18, the slide base 18 and the image recognition optical system 19 are moved under the control of the main controller 101. For this process, feature points for

position checking are marked in the circuit board 16.

Next, by the control of the main controller 101, the field of view of the image recognition optical system 19 is switched from the upper side to the lower side, where
5 the position recognition of the circuit board 16 mounted on the bonding stage 17 is performed.

Next, after the slide base 18 and the image recognition optical system 19 are moved to specified positions, the position recognition of the electronic
10 component 13 on the tray 14 is performed by the image recognition optical system 19.

Next, after the bonding head 15 and the slide base 18 are moved based on the above recognition results, the bonding head 15 moves down to suck and pick up the
15 electronic component 13 on the tray 14.

Next, the bonding head 15 and the image recognition optical system 19 are moved to specified positions, and the field of view of the image recognition optical system 19 is switched to the upper side, performing
20 the position recognition of the electronic component 13 sucked up to the bonding head 15. Then, by taking into consideration the image recognition results of the circuit board 16 and the electronic component 13 as well as the calibration result of the image recognition optical system
25 19, i.e., the optical-axis shift amount for calibration use, the position correction between the circuit board 16 and the electronic component 13 is performed, and after this, the bonding head 15 moves down to mount the electronic

component 13 onto the circuit board 16.

As described above, according to this first embodiment, measurement of the optical-axis shift amount (offset amount) between the fields of view of the image recognition optical system 19 is performed to a plurality of times during the calibration operation, and a measured value selected from among the measured values of the plurality of measurements or a mean value of those measured values is used as an optical-axis shift amount of calibration use. Thus, while the degree of effect of the handling precision of the jig 21 is suppressed low, the optical-axis shift amount between the lower-side field of view and the upper-side field of view of the image recognition optical system 19 can be determined with high precision so that any shift of the mounting position of the electronic component 13 relative to the circuit board 16 can be suppressed.

In this first embodiment, after a position recognition operation of the marking 22 of the jig 21 on the calibration stage 20 is performed at step S1, another position recognition operation of the marking 22 of the jig 21 sucked up by the nozzle 15a of the bonding head 15 is performed at steps S2 and S3. However, it is also possible that, conversely, after the operation of steps S2 and S3 is performed, the operation of step S1 is performed.

As shown above, according to the present invention, the optical-axis shift amount (offset amount) between the fields of view of the image recognition optical

system is determined to a plurality of times, and then based on the optical-axis shift amounts of the plurality of times of measurement, an optical-axis shift amount for calibration use is determined, for example, by taking a mean value of those values. Thus, while the degree of effect of the handling precision of the jig in determining the optical-axis shift amount for calibration use is suppressed low, the offset amount (optical-axis shift amount) between the lower-side field of view and the upper-side field of view of the image recognition optical system can be determined with high precision so that any shift of the mounting position of a component relative to the member onto which the component should be mounted can be suppressed.

Furthermore, in this first embodiment, when the plurality of times of measurement of the optical-axis shift amount is performed only once, for example, before the start of the mounting operation, there are some cases where some distortion occurs to the holding portion of the image recognition optical system due to changes in the room temperature or heat generation inside the apparatus during the mounting operation, causing the inclination of the optical axis to change, so that the mounting position of the component is shifted as a malfunction. Accordingly, to prevent this occurrence, it is preferable that, after the shift optical-axis shift amount is measured once as described above, a similar measurement is done after an elapse of another specified time, for example, two hours,

and an offset of the optical-axis shift amount is updated based on the measurement result.

This is explained more concretely with respect to an operation of mounting the electronic component 13.

5 First, after the head 15 and the slide base 18 have moved to specified positions, the head 15 moves down to pick up the electronic component 13 on the tray 14. Subsequently, the head 15 and the slide base 18 move again so that a coarse positioning for mounting the electronic component 13 onto the circuit board 16 is performed. Subsequently, for

10 checking the position of the circuit board 16, the image recognition optical system 19 moves to such a position as to bring a feature point such as a recognition mark on the circuit board 16 into the field of view, performing image recognition of the feature point by the image recognizing section 107. Next, for checking the position of the

15 electronic component 13, the image recognition optical system 19 moves to such a position as to bring the feature point such as a recognition mark on the electronic component 13 into the field of view, performing image recognition of the feature point by the image recognizing section 107. Then, position correction between the circuit board 16 and the electronic component 13 is performed based

20 on the image recognition results of the circuit board 16 and the electronic component 13 and the latest calibration result of the image recognition optical system 19 which are stored in the memory 113. After that, the head 15 moves

25 down to mount the electronic component 13 onto the circuit

board 16.

As shown above, according to this first embodiment, the position correction during the electronic component mounting operation is implemented by an amount of offset between the field of view on the electronic-
5 component image recognition side and the field of view on the circuit-board image recognition side measured and updated in the memory 113 at intervals of a specified time, for example, two hours. As a result, the mounting position
10 of the electronic component will never be shifted even if the inclination of the optical axis has changed because of an occurrence of distortion to the holding portion of the image recognition optical system due to changes in the room temperature or heat generation inside the apparatus.

15 With the electronic component mounting apparatus and method of the present invention, as apparent from the foregoing description, the offset amount between the fields of view of the image recognition optical system is measured at regular time intervals, the correction of the image
20 recognition results of the electronic component and the circuit board is made based on the measurement results. Thus, it becomes possible to achieve a position correction free from any distortion of the holding portion of the image recognition optical system during the electronic
25 component mounting operation, so that the electronic component can be mounted with high precision even upon occurrence of changes in the room temperature or heat generation inside the apparatus.

Hereinbelow, electronic component mounting apparatus and method according to a second embodiment of the present invention are described with reference to the accompanying drawings.

5 Fig. 8 is a perspective view of an electronic component mounting apparatus as an example of the component mounting apparatus. Fig. 9 is a perspective view of the stage for calibration of the image recognition optical system provided in the electronic component mounting apparatus.

10 Referring to Fig. 8, reference numeral 223 denotes an electronic component, as an example of the component, which is mounted on a circuit board 224 as an example of a member to which the component should be mounted. Reference numeral 225 denotes a storage magazine, in which a plurality of tray plates 226 are set up, where a plurality of electronic components 223 prior to the mounting to the circuit board 224 are stored on the tray plates 226. Reference numeral 227 denotes a lifter, which performs lifting and lowering operations of the storage magazine 225. Reference numeral 228 denotes a drawing unit having functions of moving forward and backward in a Y direction and clamping the tray plates 226, thus performing a drawing operation of a tray plate 226 to the storage magazine 225. Reference numeral 229 is a reversal head having a function of moving up and down, and enabled to pick up the electronic component 223 on the tray plate 226 by vacuum suction. Also, the reversal head 229 has a

function of moving in an X direction perpendicular to the Y direction and being a function of turning 180° in an A direction. Reference numeral 230 denotes a recognition camera, which has a function of checking the position of the electronic component 223 on the tray plate 226 and which moves in the X direction together with the reversal head 229. Reference numeral 231 denotes a bonding head as an example of a component holding and conveying device, the bonding head 231 having a function of moving in the X direction and a function of moving up and down along an up-and-down direction perpendicular both X and Y directions, and being enabled to pick up the electronic component 223, which has been sucked up and held to the reversal head 229, from the reversal head 229 by vacuum suction and then mounting the electronic component 223 onto the circuit board 224.

Reference numeral 232 denotes a bonding stage, as an example of a circuit-board holding device, which sucks up and holds the circuit board 224. Then, the bonding stage 232 is fixed on a slide base 233. The slide base 233 has a function of being able to move in the Y direction under the guide of guide members 341, 341 by rotationally driving a ball screw 340a with a servo motor 340 shown in Fig. 14. Reference numerals 234, 235 denote conveyor arms, each as an example of a circuit-board conveying device, which are equipped with four suction pads 236 at the tip of each of the conveyor arms 234, 235, and which have a function of moving up and down and a function of moving in

the X direction. The tip portion of the conveyor arm 235, although not shown in the figure, has a construction similar to the conveyor arm 234. The conveyor arm 234 is enabled to suck up and convey the circuit board 224, which has been conveyed up by a pair of loader conveyors 237, with the four suction pads 236 and then mount the circuit board 224 onto the bonding stage 232. Further, the conveyor arm 235 is enabled to transfer the circuit board 224 placed on the bonding stage 232 to a pair of unloader conveyors 238 with four suction pads.

Reference numeral 239 denotes an image recognition optical system, which can recognize the position of the circuit board 224 located below the image recognition optical system 239 and the position of the electronic component 223 located above the image recognition optical system 239 through the switching of the field of view. Also, the image recognition optical system 239 is movable in both X and Y directions by turning a ball screw 361 with rotation of an X-direction movement motor 360 shown in Fig. 15, and by turning a ball screw 371 with rotation of a Y-direction movement motor hidden below in Fig. 15, respectively. Reference numeral 240 denotes a calibration stage, which is mounted on the slide base 233. The calibration stage 240 is moved integrally by the Y-direction movement of the slide base 233 during the feed of the circuit board, so that a jig 241 for use of calibration of the image recognition optical system is located to an image-recognizable position for the image recognition

optical system 239. Besides, the calibration stage 240 is moved integrally by the Y-direction movement of the slide base 233 during the feed of the circuit board, so that the jig 241 for use of calibration of the image recognition optical system 239 is located to a pickup-enabled position for the bonding head 231.

Referring to Fig. 9, the jig 241 made of glass for calibration of the image recognition optical system 239 is sucked up and held on the top of the calibration stage 240. Also, a marking 242 for image recognition is marked at a center portion of the jig 241.

Various operations of the electronic component mounting apparatus are controlled by a control section 400.

This control section 400, as shown in Fig. 13, is equipped with a main controller 301 which outputs operation instructions, calculating instructions and the like according to a concatenated control sequence, and puts data into and out of a memory 310. For the main controller 301 to output the operation instructions and the like and to receive various types of signals, connected to the main controller 301 are driving units and the like for such mechanisms as the conveyor arms 234, 235, the bonding stage 232, the bonding head 231, the slide base 233, the calibration stage 240, the loader and unloader conveyors 237, 238, the image recognition optical system 239, the reversal head 229, the drawing unit 228, the lifter 227, so that these members are operation-controlled by the main controller 301, respectively. More specifically, the

members connected to the main controller 301 include: a driving unit for up-and-down and X-direction movements of the conveyor arms 234, 235 and a vacuum suction device for the suction pads 236 of the arms 234, 235; a vacuum suction
5 device for suction of the circuit board 224 by the bonding stage 232; a Y-direction movement motor for the slide base 233; an X-direction movement motor, a Y-direction movement motor, and shutter driving units for switching of the upper-and-lower fields of view for the image recognition
10 optical system 239; the memory 310 for storing various types of data; an image recognizing section 307 for capturing the marking 242 of the jig 241 for calibration by the image recognition optical system 239 as image data and making the image data stored in the memory 310; an image
15 processing section 309 for processing the image captured by the image recognizing section 307 and stored in the memory 310; a calculating section 311 for calculating an optical-axis shift amount between the upper-and-lower fields of view after the image processing by the image processing
20 section 309, and then storing calculation results into the memory 310; an X-direction movement motor, an up-and-down movement motor, and a vacuum suction device for suction of the component suction nozzle for the bonding head 231; and a vacuum suction device for suction of the calibration
25 stage 240. It is noted that the other drivers are omitted in the figure.

With respect to the electronic component mounting apparatus constructed as described above, its operation is

now explained with reference to Fig. 11. The following operations are executed under the control of the main controller 301.

5 First, (11) a feeding operation of the electronic component 223 (step S21 in Fig. 11) is executed. This operation is detailed below. The lifter 227 moves up or down so as to come to a specified height for drawing out the tray plate 226. Subsequently, the tray plate 226 set in the storage magazine 225 is clamped and drawn out by the
10 drawing unit 228. Subsequently, the position of the electronic component 223 on the tray plate 226 is checked by the recognition camera 230. Subsequently, based on the position checking results, the drawing unit 228 and the reversal head 229 are moved so that the electronic
15 component 223 can be picked up by the reversal head 229, and then the reversal head 229 moves down to pick up the electronic component 223. Subsequently, the reversal head 229 turns 180° in the A direction and moves in the X direction to a position where the electronic component 223
20 can be delivered to the bonding head 231.

While the sequential operation for feeding the electronic component 223 with the reversal head 229 is carried out, (12) a feeding operation of the circuit board 224 (step S22 in Fig. 11), (13) a calibration operation of
25 the image recognition optical system 239 (step S23 in Fig. 11), and (14) a position recognition operation of the circuit board 224 (step S24 in Fig. 11) are also carried out, where (12) the feeding operation of the circuit board

224 (step S22) and (13) the calibration operation of the image recognition optical system 239 (step S23) are carried out concurrently, and after both operations have been completed, (14) the position recognition operation of the circuit board 224 (step S24) is carried out.

First, (12) the feeding operation of the circuit board 224 (step S22) is explained. The circuit board 224 is first conveyed by the pair of loader conveyors 237 from the right of the electronic component mounting apparatus of Fig. 8 to a position where the circuit board 224 can be picked up by the conveyor arm 234. Subsequently, the conveyor arm 234 moves in the X direction for pickup of the circuit board 224, and then moves down to suck up and hold the circuit board 224 with the four suction pads 236, thus picking up the circuit board 224. Subsequently, the conveyor arm 234 moves in the X direction, and mounts onto the bonding stage 232 the circuit board 224 sucked up and held by the suction pads 236. Also, if any circuit board 224 over the mounting of all the electronic components 223 is left on the bonding stage 232, the operation of conveying out the circuit board 224 to the pair of unloader conveyors 238 by using the conveyor arm 235 is concurrently carried out with the feeding operation of the circuit board 224. During this process, the slide base 233 is located at the position of the origin on the Y-direction movement axis of the ball screw 340a driven by the servo motor 340.

Next, (13) the calibration operation of the image recognition optical system 239 (step S23) is explained.

The image recognition optical system 239 moves in the X direction and/or the Y direction so that the marking 242 of the jig 241 on the calibration stage 240 mounted on the slide base 233 becomes recognizable for the image recognition optical system 239. In this process, the slide base 233, which does not need to move, is located at the position of the origin of the Y-direction movement axis. Subsequently, the image recognition optical system 239 is switched to the lower-side field of view, and performs the position recognition of the marking 242 of the jig 241 mounted on the calibration stage 240. The recognized image is stored in the memory 310, and the position of the marking 242 is calculated by the image processing section 309 based on this image and stored in the memory 310. Subsequently, the image recognition optical system 239 withdraws backward (obliquely upward and rightward in Fig. 8), and then the bonding head 231 moves down to pick up the jig 241 by suction. Subsequently, the image recognition optical system 239 is switched to the upper-side field of view, and moves forward (obliquely downward and leftward in Fig. 8), performing the position recognition of the marking 242 of the jig 241 once again. The jig 241 is made of glass and pervious to light, so that the same marking 242 can be recognized by the respective fields of view. Therefore, the position recognition of the marking 242 of the jig 241 held by the bonding head 231 is performed, and the recognized image is stored in the memory 310, and further the position of the marking 242 is calculated by

the image processing section 309 and stored in the memory 310. Subsequently, the image recognition optical system 239 withdraws backward, and then the bonding head 231 moves down to mount the jig 241 onto the calibration stage 240. Then, based on the respective recognition results stored in the memory 310, an optical-axis shift amount (offset amount) between the fields of view of the image recognition optical system 239 is determined by the calculating section 311. This is described in detail with reference to Fig. 10.

Fig. 10 represents a position of the marking 242 of the jig 241 captured by the image recognition optical system 239, where 243 represents a position of the marking resulting from recognizing an image of the marking 242 with the lower field of view, and 244 represents a position of the marking resulting from recognizing an image of the marking 242 with the upper field of view. Distances X2 and Y2 between the marking 243 and the marking 244 in this case represent an optical-axis shift amount (offset amount) between the lower field of view and the upper field of view of the image recognition optical system 239. This optical-axis shift amount would subtly vary due to the occurrence of distortion of the image recognition optical system 239 or the like caused by effects of changes in the environmental temperature around the electronic component mounting apparatus. Unless the optical-axis shift amount stored in the memory 310 of the electronic component mounting apparatus is corrected, there would occur a shift in the mounting position corresponding to the change.

Therefore, in order to prevent any shift of the mounting position, the optical-axis shift amount between the fields of view stored in the memory 310 of the electronic component mounting apparatus is updated by the calibration operation.

Neither (12) the feeding operation of the circuit board 224 (step S22) nor (13) the calibration operation of the image recognition optical system 239 (step S23) requires the slide base 233 to be moved, and both operations can be implemented while the slide base 233 is in the position of the origin on the Y-direction movement axis. Therefore, (12) the feeding operation of the circuit board 224 (step S22) and (13) the calibration operation of the image recognition optical system 239 (step S23) can be implemented concurrently.

However, when the conveyor arms 234, 235 are moved in the X direction, any force is applied to a base 299 of the electronic component mounting apparatus due to acceleration and/or deceleration of the speeds of the conveyor arms 234, 235, so that vibrations occur to the whole electronic component mounting apparatus. When this occurs, the bonding head 231 and the calibration stage 240 are also vibrated by the vibrations of the whole electronic component mounting apparatus. If the image recognition of the marking 242 of the jig 241 is performed at this timing, the image would blur, resulting in lowered precision of image recognition and therefore lowered precision of the measurement of the optical-axis shift amount between the

upper field of view and the lower field of view, as an issue. This being the case, in this embodiment, it is controlled that, under the control of the control section 400, the conveyor arms 234, 235 start to move in the X direction after the completion of the image recognition of the marking 242 of the jig 241 with the lower field of view in the calibration operation, and the image recognition of the marking 242 of the jig 241 with the upper field of view is performed after the completion of the movement of the conveyor arms 234, 235 in the X direction. In addition, the completion of each operation can be confirmed by, as an example, outputting a completion signal from the operation-completed device to the main controller 301 at the time of the completion of the operation, and then by the main controller 301 receiving the completion signal. After the completion confirmation, a signal for driving the next driving unit may be outputted from the main controller 301 to the next driving unit. A flow chart showing such an operation is shown in Fig. 12. That is, first, while the pickup of the circuit board 224 by the conveyor arms 234, 235 or the conveyor arm 234 is performed at step S50, at the same time, the image recognition of the marking 242 of the jig 241 with the lower field of view is performed at step S53. Subsequently, while the X direction movement of the conveyor arms is performed at step S51, the pickup of the jig 241 by the bonding head 231 is performed at step S54. These operations of step S51 and step S54 do not necessarily need to be performed concurrently, but doing so

is preferable for further reduction in the mounting time. Subsequently, while the mounting of the circuit board 224 onto the bonding stage 232 by the conveyor arm 234 is performed at step S52, at the same time, the image recognition of the marking 242 of the jig 241 with the upper field of view is performed at step S55. In addition, a lateral arrow from right to left under the steps S53 and S50 in Fig. 12 imply that the operation of step S51 is performed after the completion of both the operation of step S50 and the operation of step S53. Also, a lateral arrow from left to right under the steps S51 and S54 in Fig. 12 imply that the operation of step S55 is performed after the completion of both the operation of step S51 and the operation of step S54.

Furthermore, the operation may be either ① or ② as follows. ① After the completion of the image recognition of the marking 242 of the jig 241 with both lower and upper fields of view for the calibration operation, the conveyor arm 234 starts to move in the X direction. ② After the completion of the X direction movement of the conveyor arm 234, the image recognition of the marking 242 of the jig 241 with the lower field of view is started. In addition, the completion of each operation can be confirmed by, as an example, outputting a completion signal from the operation-completed device to the main controller 301 at the time of the completion of the operation, and then by the main controller 301 receiving the completion signal. After the completion confirmation,

a signal for driving the next driving unit may be outputted from the main controller 301 to the driving unit.

Next, (14) the position recognition operation of the circuit board 224 (step S24 in Fig. 11) is explained. First, in order that the image recognition optical system 239 is enabled to check the position of the circuit board 224 on the bonding stage 232 mounted on the slide base 233, the slide base 233 and the image recognition optical system 239 are moved. For this process, a feature point (e.g., a recognition mark such as x mark) for position-checking is previously marked in the circuit board 224. Subsequently, the field of view of the image recognition optical system 239 is switched to the lower side, where the position recognition of the circuit board 224 mounted on the bonding stage 232 is performed.

After the completion of the (11) to (14) operations, i.e., operations of steps S21 to S24, (15) a bonding operation (step S25 in Fig. 11) is performed. This operation is explained below. First, the bonding head 231 moves in the X direction, and performs the pickup of the electronic component 223 sucked up to the reversal head 229. Next, the bonding head 231 is moved to a position where the position of the sucked electronic component 223 can be checked by the image recognition optical system 239. Concurrently, the image recognition optical system 239 also moves for the position checking of the electronic component 223. Subsequently, the field of view of the image recognition optical system 239 is switched to the upper

side, and the position recognition of the electronic component 223 is performed by the image recognition optical system 239. Then, based on the position recognition result of the electronic component 223 as well as the position recognition result of the circuit board 224 in (14) the position recognition operation of the circuit board 224 (step S24), position correction of the bonding head 231 and the slide base 233 is performed, and the bonding head 231 moves down to mount the electronic component 223 onto the circuit board 224.

As described above, according to this second embodiment, the slide base 233 is located at the position of the origin so that the calibration stage 240 is located at a deep-side end edge of the slide base 233 in the electronic component mounting apparatus, which is a region that will not obstruct the conveying-in and -out operations of the circuit board 224, during the feeding of the circuit board. Therefore, it becomes possible to perform the calibration operation of the image recognition optical system 239 during the process of replacement of circuit boards, so that any extension of the mounting time due to the calibration operation of the optical system can be eliminated or that such extension of the mounting time can be suppressed.

As shown above, according to the present invention, when the circuit board is held by the circuit-board holding device, the calibration stage on which the jig for use of calibration of the image recognition optical

system is to be mounted is placed at a position which is a region outside the conveying-in and -out region for the circuit board and which allows an image of the jig to be recognized by the image recognition optical system. With this and other arrangements, the position recognition for calibration by the image recognition optical system is performed. Thus, it becomes possible to perform the calibration operation of the image recognition optical system during the process of replacement of circuit boards, so that any extension of the mounting time due to the calibration operation of the image recognition optical system can be reduced.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

WHAT IS CLAIMED IS:

1. A component mounting apparatus comprising:
 - a component holding and conveying device for holding
5 and conveying a component and for mounting the component
onto a circuit board;
 - a circuit board holding device for holding the circuit
board;
 - an image recognition optical system for performing
10 position recognition of the circuit board using a first
field of view and for performing position recognition of the
component using a second field of view, the first field of
view being different than the second field of view and both
fields of view being imaged using a common image capture
15 device; and
 - a control section for calibrating said image
recognition optical system by determining a calibration
optical-axis shift amount prior to the component being
mounted onto the circuit board, and for controlling said
20 component holding and conveying device and said image
recognition optical system calibrated using the calibration
optical-axis shift amount so as to mount the component onto
the circuit board, said control section being operable to
determine the calibration optical-axis shift amount by
25 repeatedly comparing a circuit board calibration position
recognized by said image recognition optical system using
the first field of view and a component calibration position
recognized by said image recognition optical system using
the second field of view so as to obtain a plurality of
30 optical-axis shift amounts and then by calculating the
calibration optical-axis shift amount using the plurality of
optical-axis shift amounts.

2. The apparatus of claim 1, wherein said control section is operable to compare the circuit board calibration position recognized by said image recognition optical system using the first field of view and the component calibration position recognized by said image recognition optical system using the second field of view so as to obtain at least three optical-axis shift amounts, and to calculate the calibration optical-axis shift amount by:

10 excluding an upper-limit optical-axis shift amount and a lower-limit optical-axis shift amount from the at least three optical-axis shift amounts;

 if a plurality of shift amounts remain after excluding the upper-limit optical-axis shift amount and the lower-limit optical-axis shift amount, then determining the calibration optical-axis shift amount by calculating a mean value of the plurality of remaining shift amounts; and

 if only one shift amount remains after excluding the upper-limit optical-axis shift amount, and the lower-limit optical-axis shift amount, then determining the calibration optical-axis shift amount as the one remaining shift amount.

3. The apparatus of claim 1, wherein said control section is operable to compare the circuit board calibration position recognized by said image recognition optical system using the first field of view and the component calibration position recognized by said image recognition optical system using the second field of view so as to obtain at least three optical-axis shift amounts, and to calculate the calibration optical-axis shift amount by:

 excluding outer-limit optical-axis shift amounts from the at least three optical-axis shift amounts, wherein an outer-

limit optical-axis shift amount is defined as any shift amount that differs from any remaining of the at least three optical-axis shift amounts by more than a predetermined threshold value; and

- 5 determining the calibration optical-axis shift amount by calculating a mean value of the remaining shift amounts after excluding any outer-limit optical-axis shift amounts.

4. The apparatus of claim 1, wherein said control section
10 is operable to repeatedly perform a comparison process to determine the plurality of optical-axis shift amounts, wherein during each comparison process, said image recognition optical system is operable to repeatedly perform position recognition of the circuit board calibration
15 position using the first field of view so as to capture a plurality of circuit board calibration position images, and is operable to repeatedly perform position recognition of the component calibration position using the second field of view so as to capture a plurality of component calibration
20 position images, said control section being operable to determine the calibration optical-axis shift amount by:

 comparing the plurality of circuit board calibration position images and the plurality of component calibration position images captured during each comparison process so
25 as to obtain the plurality of optical-axis shift amounts; and

 calculating the calibration optical-axis shift amount using the plurality of optical-axis shift amounts.

30 5. The apparatus of claim 1, wherein said control section is operable to obtain the plurality of optical-axis shift amounts by repeatedly comparing the circuit board

calibration position recognized by said image recognition optical system using the first field of view and the component calibration position recognized by said image recognition optical system using the second field of view at
5 specified time intervals.

6. A component mounting apparatus comprising:

a component holding and conveying device for holding and conveying a component and for mounting the component
10 onto a circuit board, said component holding and conveying device having a calibration stage;

a circuit board holding device for holding the circuit board;

an image recognition optical system for repeatedly
15 recognizing a first position of a marking on a jig using a first field of view while holding the jig on said calibration stage, and for repeatedly recognizing a second position of the marking on the jig using a second field of view while holding the jig on said component holding and
20 conveying device, the first field of view being different than the second field of view and both fields of view being imaged using a common image capture device; and

a control section for calibrating said image recognition optical system by determining a calibration
25 optical-axis shift amount prior to the component being mounted onto the circuit board, and for controlling said component holding and conveying device and said image recognition optical system calibrated using the calibration optical-axis shift amount so as to mount the component onto
30 the circuit board, said control section being operable to determine the calibration optical-axis shift amount by repeatedly comparing the first position repeatedly

recognized by said image recognition optical system using the first field of view and the second position repeatedly recognized by said image recognition optical system using the second field of view so as to obtain a plurality of
5 optical-axis shift amounts and then by calculating the calibration optical-axis shift amount as the mean value of the plurality of optical-axis shift amounts.

7. The apparatus of claim 6, wherein said image
10 recognition optical system is operable to perform a recognition process by recognizing the first position of the marking on the jig one time while holding the jig on said calibration stage and then by recognizing the second position of the marking on the jig one time while holding
15 the jig on said component holding and conveying device, and said image recognition optical system being operable to repeat the recognition process a plurality of times so as to repeatedly recognize the first position and the second position of the jig.

20

8. The apparatus of claim 6, wherein said image
recognition optical system is operable to recognize the first position of the marking on the jig a plurality of times while holding the jig on said calibration stage and
25 then recognize the second position of the marking on the jig a plurality of times while holding the jig on said component holding and conveying device so as to repeatedly recognize the first position and the second position of the jig.

30 9. The apparatus of claim 6, wherein said image recognition optical system is operable to recognize the first position of the marking on the jig at least three

times while holding the jig on said calibration stage, and is operable to recognize the second position of the marking on the jig at least three times while holding the jig on said component holding and conveying device, whereby said
5 control section obtains at least three optical-axis shift amounts, said control section being operable to calculate the calibration optical-axis shift amount by:

excluding an upper-limit optical-axis shift amount and a lower-limit optical-axis shift amount from the at least
10 three optical-axis shift amounts;

if a plurality of shift amounts remain after excluding the upper-limit optical-axis shift amount and the lower-limit optical-axis shift amount, then determining the calibration optical-axis shift amount by calculating a mean
15 value of the plurality of remaining shift amounts; and

if only one shift amount remains after excluding the upper-limit optical-axis shift amount and the lower-limit optical-axis shift amount, then determining the calibration optical-axis shift amount as the one remaining shift amount.

20

10. The apparatus of claim 6, wherein said image recognition optical system is operable to recognize the first position of the marking on the jig at least three times while holding the jig on said calibration stage, and
25 is operable to recognize the second position of the marking on the jig at least three times while holding the jig on said component holding and conveying device, whereby said control section obtains at least three optical-axis shift amounts, said control section being operable to calculate
30 the calibration optical-axis shift amount by:

excluding outer-limit optical-axis shift amounts from the at least three optical-axis shift amounts, wherein an

outer-limit optical-axis shift amount is defined as any shift amount that differs from any remaining of the at least three optical-axis shift amounts by more than a predetermined threshold value; and

- 5 determining the calibration optical-axis shift amount by calculating a mean value of the remaining shift amounts after excluding any outer-limit optical-axis shift amounts.

11. A component mounting apparatus comprising:

- 10 a component holding and conveying device for holding and conveying a component and for mounting the component onto a circuit board;

 a circuit board holding device for holding the circuit board;

- 15 an image recognition optical system for performing position recognition of the circuit board using a first field of view and for performing position recognition of the component using a second field of view, the first field of view being different than the second field of view and both
20 fields of view being imaged using a common image capture device; and

- a control section for calibrating said image recognition optical system by determining a calibration optical-axis shift amount prior to the component being
25 mounted onto the circuit board, and for controlling said component holding and conveying device and said image recognition optical system calibrated using the calibration optical-axis shift amount so as to mount the component onto the circuit board, said control section being operable to
30 determine the calibration optical-axis shift amount by comparing a circuit board calibration position recognized by said image recognition optical system using the first field

of view and a component calibration position recognized by said image recognition optical system using the second field of view, said control section being further operable to calibrate said image recognition optical system when the
5 circuit board is being held by said circuit board holding device.

12. The apparatus of claim 11, further comprising a calibration stage for supporting a jig for calibration of
10 said image recognition optical system and for moving the jig such that the jig can be recognized by said image recognition optical system, said image recognition optical system being operable to recognize a position of the jig supported on said calibration stage as the circuit board
15 calibration position; and

said component holding and conveying device being operable to hold the jig for calibration of said image recognition optical system and to move the jig such that the jig can be recognized by said image recognition optical
20 system, said image recognition optical system being operable to recognize a position of the jig held by said component holding and conveying device as the component calibration position.

25 13. The apparatus of claim 12, wherein said circuit board holding device includes a slide base, said calibration stage being located at an end edge of said slide base so as to avoid obstructing the circuit board when the circuit board is conveyed.

30

14. The apparatus of claim 11, further comprising a calibration stage for supporting a jig for calibration of

said image recognition optical system and for moving the jig such that the jig can be held by said component holding and conveying device, said image recognition optical system being operable to recognize a position of the jig supported
5 on said calibration stage as the circuit board calibration position;

and said component holding and conveying device being operable to hold the jig for calibration of said image recognition optical system and to move the jig such that the
10 jig can be recognized by said image recognition optical system, said image recognition optical system being operable to recognize a position of the jig held by said component holding and conveying device as the component calibration position.

15

15. The apparatus of claim 11, further comprising a circuit board conveying device for moving the circuit board, wherein said control section is operable to prevent calibration of said image recognition optical system when said circuit
20 board conveying device is moving the circuit board.

16. The apparatus of claim 11, further comprising a circuit board conveying device for moving the circuit board and a calibration stage for supporting a jig for calibration of
25 said image recognition optical system, wherein said control section is operable to:

simultaneously control said circuit board conveying device and said image recognition optical system such that said circuit board conveying device picks up the circuit
30 board while said image recognition optical system performs image recognition of the jig supported on said calibration stage;

thereafter, control said circuit board conveying device so as to move said circuit board conveying device toward said circuit board holding device, and control said component holding and conveying device so as to pick up the
5 jig; and

thereafter, simultaneously control said circuit board conveying device and said image recognition optical system such that said circuit board conveying device mounts the circuit board onto said circuit board holding device while
10 said image recognition optical system performs image recognition of the jig held by said component holding device.

17. A component mounting apparatus comprising:

15 a component holding and conveying device for holding and conveying a component and for mounting the component onto a circuit board, said component holding and conveying device having a calibration stage;

a circuit board holding device for holding the circuit
20 board;

an image recognition optical system for recognizing a first position of a marking on a jig using a first field of view while holding the jig on said calibration stage, and for recognizing a second position of the marking on the jig
25 using a second field of view while holding the jig on said component holding and conveying device, the first field of view being different than the second field of view and both fields of view being imaged using a common image capture device; and

30 a control section for calibrating said image recognition optical system by determining a calibration optical-axis shift amount prior to the component being

mounted onto the circuit board, and for controlling said component holding and conveying device and said image recognition optical system calibrated using the calibration optical-axis shift amount so as to mount the component onto the circuit board, said control section being operable to determine the calibration optical-axis shift amount by comparing the first position recognized by said image recognition optical system using the first field of view and the second position recognized by said image recognition optical system using the second field of view so as to obtain the calibration optical-axis shift amount.

18. A component mounting method comprising:

repeatedly recognizing a first position of a marking on a jig through a first field of view using an image recognition optical system to generate first position images while the jig is held by a calibration stage of a circuit board holding device for holding a circuit board;

repeatedly recognizing a second position of the marking on the jig through a second field of view using the image recognition optical system to generate second position images while the jig is held by a component holding and conveying device for holding a component and for mounting the component on a circuit board, the first field of view being different than the second field of view and both fields of view being imaged using a common image capture device;

determining a plurality of optical-axis shift amounts between the first position and the second position using the first position images and the second position images;

calculating a calibration optical-axis shift amount as a mean value of the determined plurality of optical-axis shift amounts;

calibrating the image recognition optical system using
5 the calculated calibration optical-axis shift amount; and

mounting the component onto the circuit board using the calibrated image recognition optical system.

19. The method of claim 18, wherein said repeatedly
10 recognizing the first position of the marking and said repeatedly recognizing the second position of the marking comprises:

performing a recognition process by recognizing the first position of the marking on the jig one time while
15 holding the jig on the calibration stage and then by recognizing the second position of the marking on the jig one time while holding the jig on the component holding and conveying device, and

repeating said recognition process a plurality of times.
20

20. The method of claim 18, wherein said repeatedly recognizing the first position of the marking and said repeatedly recognizing the second position of the marking comprises:

25 recognizing the first position of the marking on the jig a plurality of times while holding the jig on the calibration stage; and

after said recognizing of the first position of the marking on the jig a plurality of times, recognizing the
30 second position of the marking on the jig a plurality of times while holding the jig on the component holding and conveying device.

21. The method of claim 18, wherein said repeatedly recognizing the first position of the marking and said repeatedly recognizing the second position of the marking
5 comprises recognizing the first position of the marking on the jig at least three times while holding the jig on the calibration stage and recognizing the second position of the marking on the jig at least three times while holding the jig on the component holding and conveying device, whereby
10 at least three optical-axis shift amounts are determined, said calculating of the calibration optical-axis shift amount comprising:

excluding an upper-limit optical-axis shift amount and a lower-limit optical-axis shift amount from the at least
15 three optical-axis shift amounts;

if a plurality of shift amounts remain after excluding the upper-limit optical-axis shift amount and the lower-limit optical-axis shift amount, then determining the calibration optical-axis shift amount by calculating a mean
20 value of the plurality of remaining shift amounts; and

if only one shift amount remains after excluding the upper-limit optical-axis shift amount and the lower-limit optical-axis shift amount, then determining the calibration optical-axis shift amount as the one remaining shift amount.

25

22. The method of claim 18, wherein said repeatedly recognizing the first position of the marking and said repeatedly recognizing the second position of the marking comprises recognizing the first position of the marking on
30 the jig at least three times while holding the jig on the calibration stage and recognizing the second position of the marking on the jig at least three times while holding the

jig on the component holding and conveying device, said calculating of the calibration optical-axis shift amount comprising:

5 excluding outer-limit optical-axis shift amounts from the determined optical-axis shift amounts, wherein an outer-limit optical-axis shift amount is defined as any shift amount that differs from any remaining of the optical-axis shift amounts by more than a predetermined threshold value; and

10 determining the calibration optical-axis shift amount by calculating a mean value of the remaining shift amounts after excluding any outer-limit optical-axis shift amounts.

23. The method of claim 18, wherein said repeatedly
15 recognizing the first position of the marking and said repeatedly recognizing the second position of the marking comprises repeatedly recognizing the first position and repeatedly recognizing the second position at specified time intervals.

20

24. A component mounting method comprising:

simultaneously holding a circuit board using a circuit board holding device and recognizing a component calibration position of a component to be held by a component holding
25 and conveying device through a first field of view by using an image recognition optical system;

recognizing a circuit board calibration position of a circuit board to be held by a circuit board holding device through a second field of view by using the image
30 recognition optical system, the first field of view being different than the second field of view and both fields of view being imaged using a common image capture device;

determining a calibration optical-axis shift amount by comparing the component calibration position and the circuit board calibration position;

5 calibrating the image recognition optical system using the calibration optical-axis shift amount; and

mounting the component on the circuit board using the calibrated image recognition optical system.

25. The method of claim 24, further comprising moving a
10 calibration jig supported on a calibration stage when the circuit board is held by the circuit board holding device such that the jig can be recognized by the image recognition optical system.

15 26. The method of claim 24, further comprising moving a calibration jig supported on a calibration stage when the circuit board is held by the circuit board holding device such that the jig can be held by the component holding and conveying device.

20

27. The method of claim 24, wherein said recognizing of a component calibration position and said recognizing of a circuit board calibration position is not performed when the circuit board is moved.

25

28. The method of claim 27, further comprising:

simultaneously picking up the circuit board using a circuit board conveying device while performing image recognition of a calibration jig supported on a calibration
30 stage using the image recognition optical system to determine the circuit board calibration position;

thereafter, moving the circuit board conveying device toward the circuit board holding device, and picking up the calibration jig using the component holding and conveying device; and

- 5 thereafter, simultaneously mounting the circuit board onto the circuit board holding device using the circuit board conveying device while performing image recognition of the calibration jig held by the component holding device using the image recognition optical system to determine the
- 10 component calibration position.