A REGISTRATION METHOD AND APPARATUS FOR SCREEN PRINTING

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The present invention relates to a registration method and apparatus for screen printing.

In conventional screen printing, a print object is arranged under a screen plate and an image pickup camera such as a CCD camera is arranged above the screen plate. The shift amount between a registration hole which is provided in the screen and a registration mark which is formed on an upper surface of the print object is measured by this image pickup camera, thereby the screen plate and the print object get registered. In this method, however, the camera being located above the screen plate is interfered by a squeegee which is moved on the screen plate, so that precise measurement of the shift amount became difficult.

On the other hand, Japanese Patent Publication Gazette No. 3-39461 (1991) proposes a registration apparatus comprising a CCD camera which is set under a print object having two through holes for registration and a screen plate, having a screen with two registration marks corresponding to the through holes, which is arranged above the print object. In this case, the shift amounts are calculated from distances between reference points of the CCD camera and the registration marks of the screen as well as the through holes of the print object on x and y axes,

so that the screen plate is moved to be automatically registered with the print object.

In this method, no problem of interference between the camera and a squeegee is caused since the camera is located under the print object.

In the case of this registration method, the shift amounts between the reference points of the CCD camera and the registration marks of the screen are detected in an unelongated state of the screen before operation of the squeegee. In practice, However, a screen 40 is necessarily elongated as shown in Fig. 5 upon operation of a squeegee 41, and hence a position (shown on a solid line in Fig. 5) of a mark a before printing differs from a position (shown on a two-dot chain line) during printing. Such elongation is varied with the pressure of the squeegee 41 and expansibility of the screen 40. Even if the shift amounts are correctly measured before printing, therefore, misregistration δ may be caused on the printing position upon actual screen printing.

The present invention aims to overcome at least some of the abovementioned problems.

Therefore, the present invention aims to provide a registration method for screen printing, which can accurately register a screen with a print object, in consideration of elongation of a screen.

The present invention also aims to provide a registration apparatus for screen printing, which can

accurately and automatically register a screen with a print object.

According to one aspect of the present invention there is provided a registration method for screen printing wherein a reference mark on a screen is aligned with a registration part of a print object by way of an image pickup apparatus, said method comprising: sensing the position of said reference mark using said image pickup apparatus; operating a squeegee to stretch the screen; sensing the position of the reference mark on said stretched screen using said image pickup apparatus; calculating the amount of stretching of the screen from the positions of said reference mark sensed before and during stretching of said screen; sensing the position of said registration part using said image pickup apparatus; calculating a shift amount as a difference between said sensed position of said reference mark and said registration part; correcting the calculated shift amount by said calculated amount of stretching of said screen; and moving said screen and/or said print object according to the corrected shift amount.

According to another aspect of the present invention there is provided a registration apparatus for screen printing, said apparatus comprising: a screen having a reference mark; a print object having a registration part; an image pickup apparatus for sensing the positions of said reference mark and said

registration part; a squeegee for stretching said screen; stretch calculating means for calculating the amount of stretching of said screen from the positions of said reference mark sensed before and during stretching of said screen; shift calculating means for calculating a shift amount as a difference between said sensed positions of said reference mark and said registration part; correcting means for correcting the calculated shift amount by said amount of stretching of said screen; and moving means for moving said screen and/or print object according to said corrected shift amount.

In the practice of this invention, a screen plate is first set on a prescribed position and an image pickup apparatus is set under the screen plate, to carry out the following setup steps. In the setup steps, the position of a reference mark which is provided on a screen is photoed by the image pickup apparatus before printing, i.e., in an unelongated state of the screen, and when a squeegee is moved on the screen so that the position of the reference mark is photoed by the image pickup apparatus in an elongated state of the screen.

The image pickup apparatus is preferably prepared from a CCD camera, for example, which can accurately recognize images with digital signals. signals from the image pickup apparatus are inputted in a controller such as a microcomputer, which then

calculates the shift amount of the reference mark resulting from elongation of the screen, i.e., the amount of elongation of the screen.

Next the process is advanced to the following registration steps. First, the position of the reference mark provided on the screen before printing is recognized by the image pickup apparatus, and then the position of a registration part of the print object is recognized. The shift amount between the registration part of the print object and the reference mark of the screen is calculated by the controller from these recognized data. Then, the shift amount is corrected by the amount of elongation of the screen calculated in the setup steps. Assuming that x represents the shift amount between the registration part and the reference mark along an x axis and Δ x represents the amount of elongation of the screen along the x axis, the corrected shift amount is $x+\Delta x$.

The screen plate or the print object is moved in a direction for eliminating the as-detected shift amount, so that they can be accurately registered with each other in consideration of elongation of the screen.

The registration part of the print object may be prepared from a simple through hole, a notch, or an edge of the print object, so far as the part can form a contrast image on the image pickup apparatus. Also

a part of a pattern which is formed on the screen can be used as the reference mark of the screen, or the screen may be particularly provided with a portion transmitting or not transmitting light for the reference mark. The number of each of the registration part and the reference mark is not restricted to one, nor the shapes thereof are restricted. A light source is preferably arranged under the print object or above the screen plate, so that the positions of the registration part and the reference mark can be clearly recognized by the image pickup apparatus. A three-axis (x, y, θ) driving mechanism is preferably provided in order to move the screen plate or the print object in arbitrary directions on a plane.

When the registration part of the print object is formed by a through portion which allows the camera to recognize the reference mark on the screen located at the back thereof, it is possible for the camera to simultaneously recognize the reference mark and the registration part before printing. In this case, the shift amount between the reference mark and the through portion can be so directly measured that it is possible to decrease a measurement error as compared with the case in which the camera recognizes the positions one by one. Moreover, arithmetic processing can be simplified since it is not necessary to calculate the shift amount as difference with respect

to a reference point of the camera.

According to an embodiment of the present invention, to be described, the amount of elongation of the screen upon operation of the squeegee is previously measured to correct the shift amount between the registration part of the print object and reference mark of the screen, whereby it is possible to accurately register the print object with the screen no matter how the screen is elongated by expansibility thereof or a pressure of the squeegee.

The above and further features of the present invention are set forth with particularity in the appended claims and together with the advantages thereof should become clearer from consideration of the following detailed description of an exemplary embodiment of the invention given with reference to the accompanying drawings.

In the drawings:

Fig. 1 is a perspective view showing a registration apparatus embodying the present invention;

Fig. 2A is a flow chart of setup steps showing the procedure used to set up the registration apparatus of Fig. 1;

Fig. 2B is a flow chart of registration steps showing the procedure for registering a screen and a print object using the registration apparatus of Fig 1;

Fig. 3A is a sectional view of the registration apparatus of Fig. 1 in an initial position in the setup procedure;

Fig. 3B is a sectional view of a registration apparatus of Fig. 1 in a halfway position during the setup procedure;

Fig. 4 illustrates a registration hole and a reference mark, which are photoed by a camera of the registration apparatus; and

Fig. 5 illustrates the state of elongation of a screen following movement of a squeegee of the registration apparatus.

Fig. 1 illustrates a registration apparatus according to an embodiment of the present invention.

A CCD camera 1, which is an exemplary image pickup apparatus, is fixed on a horizontal printing table 2 so that its lens portion 1a is upwardly directed. Every print object 3 such as a printed circuit board is independently carried onto the printing table 2. Stopper pins 4 which go up and down from the table 2 are adapted to stop the forward end surface of the print object 3 and guide plates 5 are adapted to guide both side surfaces of the object 3. Thus, the object 3 is necessarily registered on a constant position of the table 2. In such a registered state, a registration hole 3a, which is a registration part formed in the object 3, is positioned above the lens portion 1a of the camera 1.

A screen plate 6 is horizontally arranged above the printing table 2. Acting rods of first and second actuators 10 and 11 are connected to a back surface of its frame portion 7 and an acting rod of a third actuator 12 is connected to a side surface which is adjacent to the back surface. These actuators 10 to 12 can drive the screen plate 6 along three axes x, y and θ on a horizontal

plane. The actuators 10 to 12, which are formed by pulse motors having ball screw mechanisms, for example, are provided on support portions (not shown). An extensible screen 8 is spread tensely inside of the frame portion 7 of the screen plate 6, and a prescribed printing pattern (not shown) is formed on this screen 8. This screen 8 is provided on its prescribed position with a reference mark 8a, corresponding to the registration hole 3a, which is located above the lens portion 1a of the camera 1. The screen plate 6 is further equipped with a squeegee 9, the lower edge of which slides along the screen 8.

Image pickup signals generated from the camera 1 are inputted in a controller 13, being formed by a microcomputer, which detects the positions of the registration hole 3a and the reference mark 8a from the image pickup signals and memorizes the positions thereof. The controller 13 performs predetermined arithmetic processing on the basis of the signals received from the camera 1, to output drive signals to the actuators 10 to 12.

A transmitted illumination light source 14 and a reflected light source 15 are arranged to illuminate the upper surface of the screen plate 6 and lower surface of the print object 3 respectively, so that the camera 1 can clearly recognize contrast images of the hole 3a and the

mark 8a.

The inventive registration method is now described with reference to the flow chart shown in Figs. 2A and 2B.

First, a transparent panel 16 which has absolutely the same shape as the print object 3 is carried onto the printing table 2, and registered by the stopper pins 4 and the guide plates 5 (step 20). Then, the squeegee 9 is located on an initial position of the screen 8 as shown in Fig. 3A (step 21), so that the position of the mark 8a in an unexpanded state of the screen 8 is photoed by the camera 1 through the panel 16 and this position is memorized (step 22). Then, the squeegee 9 is driven toward the position of the mark 8a (step 23), so that the position of the mark 8a in an expanded state of the screen 8 is photoed by the camera 1 through the panel 16 as shown in Fig. 3B and this position is memorized (step 24). Thus, the amount of elongation of the screen 8 is measured from the shift amount between the two position (step 25).

Although the transparent panel 16 of the same shape as the print object 3 is employed in the above description, the object 3 itself may be employed if it is possible to see the screen 8 through the hole 3a provided in the object 3, since the positions of the mark 8a can be photoed by the camera 1 during operation of the squeegee 9 in this case. In any case, it is necessary to photo the positions under

conditions similar to those for elongation of the screen 8 in actual printing steps. These are setup steps, which are carried out while supplying no printing ink to the screen 8.

Then, the process is advanced to the following registration steps. First, the squeegee 9 is located on the initial position of the screen 8 (step 26), so that the mark 8a of the screen 8 is photoed by the camera 1 before printing and its position is memorized (step 27). Thereafter the object 3 is carried onto the table 2 and stopped by the stopper pins 4 and the guide plates 5, so that the hole 3a of the object 3 is photoed by the camera 1 and its position is memorized (step 28). Then, the shift amount along the three axes x, y and θ is calculated from the two positions (step 29).

When the print object 3 is provided with the hole 3a, it is possible to photo the mark 8a through this hole 3a, whereby the positions of the mark 8a and the hole 3a can be simultaneously recognized after the object 3 is carried onto the table 2. In this case, the shift amount between the mark 8a and the hole 3a can be directly measured as shown in Fig. 4. Thus it is possible to decrease a measurement error as compared with the case of separately recognizing the two positions by the camera 1. Moreover the arithmetic processing is simplified since it is not necessary to calculate the shift amount between the mark 8a

and the hole 3a with respect to a reference point of the camera 1.

Thereafter the as-detected shift amount is corrected by the amount of elongation of the screen 8 obtained in the setup steps (step 30). Assuming that the shift amount between the mark 8a and the hole 3a is expressed as (x, y and θ) and the amount of elongation of the screen 8 is expressed as (Δ x, Δ y, and $\Delta\theta$), for example, the corrected shift amount is ($x+\Delta x$, $y+\Delta y$, $\theta+\Delta\theta$).

The actuators 10 to 12 are driven in directions for decreasing the aforementioned shift amount, so as to register the screen plate 7 (step 31). After the registration is completed, a printing ink is supplied on the screen 8 and the squeegee 9 is moved (step 32), so that screen printing can be precisely carried out on a predetermined position of the print object 3.

Although the screen plate 6 is moved for registration in the aforementioned embodiment, the table 2 supporting the object 3 may alternatively be moved by driving apparatuses which are similar to the actuators 10 to 12.

In the case of screen printing, displacement in ink transfer may by caused not only by expansion of the screen 8 following movement of the squeegee 9, but by viscosity of the printing ink or deterioration of the screen 8. If a transparent or semi-transparent sheet or plate is prepared

in place of the object 3 to be preliminarily printed, it is possible to observe such displacement in transfer of the printing ink from the screen 8 to the sheet or plate. Thus, it is possible to manage viscosity of the ink and the state of deterioration of the screen 8, as well as to correct misregistration following ink transfer.

Having thus described the present invention with reference to a particular embodiment, it is to be appreciated that the described embodiment is exemplary only and is susceptible to modification and variation without departure from the scope of the invention as determined by the appended claims.

CLAIMS:

1. A registration method for screen printing wherein a reference mark on a screen is aligned with a registration part of a print object by way of an image pickup apparatus, said method comprising:

sensing the position of said reference mark using said image pickup apparatus;

operating a squeegee to stretch the screen;

sensing the position of the reference mark on said stretched screen using said image pickup apparatus;

calculating the amount of stretching of the screen from the positions of said reference mark sensed before and during stretching of said screen;

sensing the position of said registration part using said image pickup apparatus;

calculating a shift amount as a difference between said sensed position of said reference mark and said registration part;

correcting the calculated shift amount by said calculated amount of stretching of said screen; and

moving said screen and/or said print object according to the corrected shift amount.

2. A method according to claim 1, further comprising sensing said reference mark on said screen by said image pickup apparatus through a through-hole provided as said registration part in said print object.

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3. A method according to claim 1 or 2, further comprising providing a charged coupled device camera as said image pickup apparatus.

4. A method according to claim 3, further comprising carrying said print object onto a substantially horizontal printing table to which said camera is fixed.

5. A method according to claim 4, further comprising locating said print object on said printing table by way of reciprocating stopper pins and guide plates on said printing table.

6. A method according to any preceding claim, further comprising providing transmitted illumination by a light source positioned above said screen.

7. A method according to any of claims 1 to 5, further comprising providing reflected illumination by a light source positioned below said print object.

8. A method according to any preceding claim, further comprising moving said screen and/or said print object in a substantially horizontal plane by way of a three-axis driving mechanism.

9. A method according to claim 8, wherein image pickup signals representative of said reference mark are

produced by said image pickup apparatus, the method further comprising controlling movement of said screen and/or said print object in response to said signals.

10. A registration apparatus for screen printing, said apparatus comprising:

a screen having a reference mark;

a print object having a registration part;

an image pickup apparatus for sensing the positions of said reference mark and said registration part;

a squeegee for stretching said screen;

stretch calculating means for calculating the amount of stretching of said screen from the positions of said reference mark sensed before and during stretching of said screen;

shift calculating means for calculating a shift amount as a difference between said sensed positions of said reference mark and said registration part;

correcting means for correcting the calculated shift amount by said amount of stretching of said screen; and

moving means for moving said screen and/or print object according to said corrected shift amount.

11. An apparatus according to claim 10, wherein said registration part comprises a through hole in said print object through which said image pickup apparatus can sense the reference mark on said screen.

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12. An apparatus according to claim 10 or 11, wherein said image pickup apparatus comprises a charge coupled device camera.

13. An apparatus according to any of claims 10 to 12, further comprising a printing table for receiving said print object on its upper surface and for supporting said print object in a substantially horizontal state.

14. An apparatus according to claim 13, wherein said image pickup apparatus is fixed to said printing table with its lens portion being directed upwardly.

15. An apparatus according to claim 13 or 14, wherein said printing table is provided with reciprocating stopper pins and guide plates for locating said print object on said printing table.

16. An apparatus according to any of claims 10 to 15, further comprising a light source for providing transmitted illumination, said light source being positioned above said screen.

17. An apparatus according to any of claims 10 to 15, further comprising a light source for providing reflected illumination, said light source being positioned below said print object.

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18. An apparatus according to any of claims 10 to 17, wherein said moving means comprises a three-axis driving mechanism for moving said screen and/or said print object in a substantially horizontal plane.

19. An apparatus according to any of claims 10 to 18, wherein said image pickup apparatus produces image pickup signals representative of said reference mark and said signals are inputted into a controller, and wherein said controller controls said moving means in response to said signals.

20. A method or apparatus substantially as described herein with reference to the accompanying drawings.