

DEVICE AND METHOD FOR PERFORATING PRINTED CIRCUIT BOARD

The present invention relates to a device for perforating printed circuit boards and a method of perforation using the perforating device.

Prior Art

Circuit boards have conventionally been manufactured using methods wherein a multiplicity of circuit patterns are printed on a single substrate having a large surface area and, thereafter, each circuit pattern is cut and separated to obtain a multiplicity of circuit boards. Such cutting is sequentially performed after providing at least a pair of guide holes on the substrate and positioning the guide holes by inserting guide pins provided on a processing device into them. Therefore, the guide holes provide a basis for determining the cutting position and must be perforated in accurate positions.

As a perforating device for such perforation, devices are used wherein when circuit patterns are printed, marks are provided in a pair of perforating positions in advance; the marks are imaged by an imaging means such as a TV camera or X-ray camera provided on the perforating device; perforation is performed by moving a perforating means such as a drill to positions obtained from image processing on the same. As disclosed in Japanese unexamined patent publication (KOKAI) No. H3(91)-277411, there are devices which include a pair of imaging means and a pair of perforating means to be able to perforate a pair of holes simultaneously. In such devices, one each of the imaging means and perforating means are movably provided to allow printed circuit boards of various sizes to be perforated. The interval between both imaging means in their initial positions are known in advance. Then, after moving the movable imaging means and perforating means under numerical control in accordance with the interval between the holes to be perforated, reference marks for both of them are imaged by the respective imaging means; image processing is performed to obtain the central positions of both reference marks; and perforation is performed by both perforating means at the central positions.

Problems to be Solved by the Invention

In the above-described configuration of the prior art, the imaging means and perforating means are moved under numerical control in accordance with the size of the printed circuit board. Specifically, they are moved by an amount which is the interval between the holes to be perforated minus the interval between both imaging means in the initial state. However, perforating accuracy is reduced if the interval between both imaging means in the initial state is inaccurate. Perforating accuracy can be also reduced when a mechanical error occurs as time passes depending on the environment in which the machine is used (temperature, humidity, etc.).

Ball screws are used in some cases to move the movable imaging means and perforating means from the initial state to the positions where perforation is to be performed. Since the accuracy of ball screws is insufficient, the movement is confirmed using a linear scale to correct an error if any. Such a linear scale is expensive and can lead to a cost increase.

It is therefore an object of the present invention to provide a device and method for perforating printed circuit boards which allow accurate perforation by coping with an error that occurs as time passes without the need for an expensive scale.

Means for Solving the Problems

In order to achieve the above-described object, according to the present invention, there is provided a device for perforating printed circuit boards characterized in that it comprises a work table on which a printed circuit board having a pair of reference marks provided thereon, imaging means provided on fixed and movable sides for imaging the respective reference marks, perforating means provided on the fixed and movable sides for perforating the printed circuit board on the work table based on the result of the imaging of the reference marks, a first shifting means for adjusting the positions of the imaging means and perforating means on the fixed side, a second shifting means for shifting the imaging means and perforating means on the movable side integrally toward and

away from the imaging means and perforating means on the fixed side, a jig plate disposed on the work table, and a plurality of reference-holes for confirming the positions of the imaging means provided at predetermined intervals on the jig plate, and in that at least one of the plurality of reference-holes can be faced with the imaging means on the fixed side, and other reference-holes are arranged in the direction in which the imaging means on the movable side is shifted by the second shifting means toward and away from the imaging means on the fixed side.

The jig plate can be attached to and detached from the work table. The jig plate is preferably made of the same material as that for the printed circuit board.

Further, a method for perforation according to the present invention is characterized in that the imaging means and perforating means on the movable side are shifted by the second shifting means in accordance with the interval between holes to be perforated on a printed circuit board; each of reference-holes among the plurality of reference-holes located in the vicinity of both imaging means is imaged to obtain the center position of each of the reference-holes in image areas of both imaging means through image processing; the interval between both imaging means is calculated based on each of the center positions of the reference-holes and the interval between the imaged reference-holes obtained in advance; the printed circuit board is set on the work table so that both reference marks are in the image areas of respective imaging means; both reference marks are imaged by both imaging means to detect the center positions of both reference marks through image processing; the interval between both reference marks is obtained based on the center position of each of the reference marks and the interval between both imaging means, and an error between the interval between both reference marks and the interval between the holes to be perforated is obtained, and perforating positions corrected from the center positions of the reference marks are set by an amount corresponding to the error; and the printed circuit board is perforated after shifting both perforating means by both shifting means to the respective perforating positions.

Embodiment of the Invention

Fig. 1 shows an overall structure of a perforating device according to the present invention. A pair of X-ray irradiating means 4 are supported at a predetermined interval above a work table 1. First, the configuration of the X-ray irradiating means 4 will be described. The X-ray irradiating means 4 is connected to a protecting cylinder 6 which constitutes a path 5 of X-rays for irradiation. The protecting cylinder 6 includes a shutter 7 provided across the path 5 which is driven back and forth to open and close the path 5. A guide groove 8 in the vertical direction is formed on the outer circumference of the protecting cylinder

6. A protecting pipe 10 having a path 9 for X-rays in communication with the path 5 is provided under the protecting cylinder 6 so that it can be moved toward and away from the work table 1. The protecting pipe 10 is secured to the lower end of a cylindrical element 13 fitted to the outer circumference of the protecting cylinder 6. A guide 14 slidable in the guide groove 8 is provided in a part of the cylindrical element 13. A shield member 12 which can be moved up and down by a cylinder 11 is provided around the protecting pipe 10. The shield member 12 is formed by two synthetic resin sheets containing lead arranged in parallel having vertical slits at appropriate intervals at the skirts thereof and a metal chain disposed therein for improving the X-ray shielding effect. When a work piece on the table is irradiated by X-rays, the portion of the skirts abuts on the work piece to seal the inside to allow the X-rays to be shielded so that they will not leak out.

The X-ray irradiating means having such a configuration is constituted by a fixed side X-ray irradiating means 4a provided on the left hand side of Fig. 1 and a movable side X-ray irradiating means 4b provided on the right hand side. The movable side X-ray irradiating means 4b includes a nut 15 which engages with a lead screw 17 rotated by a motor 16.

Further, the movable side X-ray irradiating means 4b includes a slider 19 which slides on a rail 18. Therefore, the movable side X-ray irradiating means 2b can

be moved to the left and right in Fig. 1 by the operation of the motor 16.

Figs. 2 and 3 show a part under the work table 1 in which there is disposed a pair of imaging means 2 for obtaining transmitted images of the work piece irradiated by X-rays, a pair of perforating means 3, and a pair of shifting means 20. First, the imaging means 2 and perforating means 3 will be described. A supporting plate 39 is erected on a Y-table 21, and an X-ray camera 2 which is the imaging means is held on the supporting plate 39 with a clip 40 and a cylindrical member 41 interposed therebetween. The X-ray camera 2 is connected to an image processor, central processing unit, and the like for controlling the operation of the shifting means 20 to be described later and the like based on image processing on the transmitted images of the work piece. A pair of rails 42 are mounted on one side of the supporting plate 39. A rail guide 44a is provided on a retaining frame 44 for retaining the perforating means 3 and fits in the rails 42 to be slidable on it. The perforating means 3 includes an air spindle 43a, a collect chuck 43b secured to the upper end thereof, and a drilling means such as a drill 43c held by the collect chuck 43b. The air spindle 43a drives the drill 43c for rotation to perforate the printed circuit board. A chip cover 45 is mounted on the upper end of the perforating means 3.

A description will now be made with reference to Fig. 3 on a driving mechanism 46 for driving the perforating means 3 in the vertical direction (Z-direction). A lead screw 48 extending in the Z-direction is rotatably mounted on the supporting plate 39 with a mounting member 47 interposed therebetween.

The lead screw 48 engages with a nut 49 which is secured to the above-described retaining frame 44 with a nut holder 50 interposed therebetween.

The upper end of the lead screw 48 is connected to a belt pulley 51. Further, a motor 52 is held by the mounting member 47, and the driving shaft of the motor 52 is connected to a belt pulley 53. A belt 54 is stretched around the belt pulleys 51 and 53. Therefore, when the motor 52 drives the belt pulley 53 for rotation,

the rotation is transferred by the belt 53 to the belt pulley 51 to rotate the lead screw 48. As a result, the nut holder 50 and retaining frame 44 are moved integrally with the nut 49 in the Z-direction to move the perforating means 3 retained by the retaining frame up and down.

The imaging means 2 and perforating means 3 having such configurations are constituted by a fixed side imaging means 2a and a fixed side perforating means 3a provided on the left hand side of Fig. 3 and a movable side imaging means 2b and a movable side perforating means 3b provided on the right hand side.

The shifting means 20 shifts the imaging means 2 and perforating means 3 located under the work table 1 to operating positions and is constituted by a first shifting means 20a for shifting the imaging means 2a and perforating means 3a on the fixed side and a second shifting means 20b for shifting the imaging means 2b and perforating means 3b on the movable side. They are substantially identical in configuration except that their shifting distances in the horizontal direction of Figs. 1 and 2 (X-direction) are different, and parts having like configurations are indicated by like reference numbers.

A pair of rails 29 commonly used for the first and second shifting means 20a and 20b are provided in the horizontal direction of Figs. 1 and 2 (X-direction). Sliders 22 are mounted on the rails 29 to be slidable in the X-direction, and an X-table 23 is mounted on the sliders 22. A nut 24a engaging with a short lead screw 26a connected to a motor 25a is secured to an X-table 23a on the fixed side.

A pair of nuts 24b engaging with a pair of long lead screws 26b connected to a motor 25b through a timing belt 35 stretched around a roller 33 and pulleys 34 in the form of "T" are secured to an X-table 23b on the movable side. Therefore, when the motor 25 drives the lead screw 26 for rotation, the X-table 23 is moved integrally with the nut 24 in the X-direction. The shifting range of the movable side X-table 23b is greater than the shifting range of the fixed side X-table 23a.

A rail 27 extending in the vertical direction of Fig. 2 (Y-direction) is

secured on the X-table 23. A slider 28 is slidably fit on the rail 27. A Y-table 21 is secured on the slider 28. A nut 32 is secured on the underside of the Y-table 21. Further, a motor 30 is secured on the X-table 23, and a lead screw 31 connected to the driving shaft of the motor is rotatably disposed on the X-table 23. The above-described nut 32 engages with the lead screw 31. Therefore, when the motor 30 drives the lead screw 31 for rotation, the Y-table 21 moves integrally with the nut 32 in the Y-direction.

As shown in Figs. 1 and 4, on the work table 1, there is provided a through hole 60 in a position facing the imaging means 2a or perforating means 3a on the fixed side and a slot 63 extending in the X-direction in a face-to-face relationship with the shifting range of the imaging means 2b or perforating means 3b on the movable side as the movable side X-table 23b is shifted. A jig plate 61 of a sufficient size to cover the through hole 60 and slot 63 is disposed on the work table 1. The jig plate 61 shown in Fig. 5 is made of the same material as the printed circuit board to be perforated, is fit to a step portion 1a (see Fig. 1) and is secured by a set-screw 61a. The jig plate 61 has a through hole 61b which faces the through hole 60 and which is smaller in diameter than the through hole 60, a slot 61c which faces the slot 63 and which is smaller in width than the slot 63, a reference-hole 62 having a small diameter formed in each of spot facing portions 61d provided above and under the through hole 61b, and the spot facing portions 61d and reference-holes 62 provided at predetermined intervals above and under the slot 61c. The through hole 61b and slot 61c are holes through which the drill 43c is inserted to perforate the printed circuit board. The reference-holes 62 are used for confirming the positions of both imaging means 2, and the interval between the reference-holes 62 is known in advance.

A description will now be made on a method for perforating a printed circuit board according to the present invention.

In the present embodiment, the printed circuit board to be perforated is a layered board on which circuit patterns and reference marks for perforation are not

exposed. The reference marks are provided symmetrically on the printed circuit board.

The present invention is characterized in that the interval between both imaging means 2 is confirmed prior to perforation. The positions of both imaging means 2 may be inaccurate due to errors at the time of manufacture or may include positional deviations produced when they are moved from initial positions to perforating positions. Then, accurate perforation is carried out by correcting them.

An interval L between holes (two holes in this embodiment) to be formed in the printed circuit board is input in advance, and the imaging means 2b and perforating means 3b on the movable side are shifted by the second shifting means 2 in accordance with the interval. However, at this time, the imaging means 2b and perforating means 3b on the movable side may not be in positions which are precisely at the distance L from the imaging means 2a and perforating means 3a on the fixed side due to deviations of the initial positions of the imaging means 2b and perforating means 3b on the movable side, an error in the second shifting means 2 0b, and errors in the mounting positions of the imaging means 2b and perforating means 3b on the movable side.

Then, the work table 1 is irradiated by X-rays from both X-ray irradiating means 4 before the printed circuit board is placed thereon, and X-ray transmitted images of the reference-holes 62 located in the vicinity of respective X-ray irradiating means 4 are obtained by both imaging means (X-ray cameras) 2a and 2b and are subjected to image processing to obtain the central positions of each of the reference-holes 62. In Fig. 6, 62a and 62b designate the reference-holes as imaged by the fixed side imaging means 2a, and 62c and 62d designate the reference-holes as imaged by the movable side imaging means 2b. For example, the difference between the positions of the center of the reference-hole 62a located above the slot 61c and a center 2a' of the fixed side imaging means 2a is obtained and, further, the difference between the positions of the center of the

reference—hole 62c located above the through hole 61b and a center 2b' of the fixed side imaging means 2b is obtained. Since an interval L1 between the reference—holes 62a and 62c on the jig plate is known in advance, an interval L2 between both imaging means 2a and 2b can be calculated from the positional deviations between the reference—hole 62a and the center 2a' of the imaging means and between the reference—hole 62c and the center 2b' of the imaging means taking the interval L1 into consideration. If high accuracy has left no error, L and L2 are equal to each other and the printed circuit board can be perforated without a need for correction. However, any error between L and L2 indicates that the imaging means are out of desired positions.

Then, the printed circuit board is set on the work table 1, and both imaging means 2 image reference marks M1 and M2 which are subjected to image processing to obtain the respective central positions thereof. As shown in Fig. 7, the difference between the positions of the center of the reference mark M1 and the center 2a' of the fixed side imaging means 2a is obtained and, further, the difference between the positions of the center of the reference mark M2 and the center 2b' of the movable side imaging means 2b is obtained. Since the interval L2 between both imaging means has been obtained in the previous step, an interval L3 between the reference marks M1 and M2 can be accurately calculated. The reference marks M1 and M2 should have been formed so that the interval L3 between them equals the interval L between the desired holes, but L3 can be unequal to L due to errors in the printed circuit board originating from manufacturing processes, thermal deformation and the like. In this case, if perforation is carried out exactly in the positions of the reference marks, holes will be produced at an incorrect interval. This results in a problem in that positioning pins of jigs at subsequent steps (punching and the like) can not fit in all of the holes, which prevents the printed circuit board from being mounted on the jigs. The present invention addresses this problem by correcting the positions of the reference marks to allow perforation exactly at the interval L. Specifically, the

positions of the reference marks M1 and M2 each shifted by $(L3 - L)/2$ which is the difference between L3 and L ($L3 - L$) divided into left and right halves are set as perforating positions P1 and P2. It goes without saying that the interval between the perforating positions P1 and P2 is exactly equal to L. In the present embodiment, correction is possible in the vertical direction because a multiplicity of pairs of reference-holes are arranged on both sides of the through hole and slot.

Specifically, if a straight line Y1 connecting the reference-hole 62a and 62b (and a straight line connecting the reference-holes 62c and 62d) is not in parallel with the vertical axis (Y-axis) of the figure, it can be thought that there is an error due to low accuracy of the mounting of the imaging means and perforating means to the shifting means. Then, the error in the parallelism between the straight line and the vertical line may be stored as correction data, and the image processing on the reference marks and the setting of the perforating positions may be corrected by the amount of such an error to allow perforation with higher accuracy.

Thereafter, both shifting means 20a and 20b are operated to position the both drills 43c in the perforating positions P1 and P2, and the air spindle 43a is operated to carry out perforation. At this time, the drills 43c on the fixed and movable sides penetrate through the hole 60 and slot 63, respectively, to perforate the printed circuit board.

It is desirable that perforation is carried out with the perforating positions set by distributing two halves of the error in the both reference marks to both reference marks as in the present embodiment, but the method of distributing the error is not limited thereto.

Further, it is desirable that the operation of obtaining the accurate interval between both imaging means is carried out each time the imaging means and perforating means on the movable side are shifted by the shifting means. When there is a possibility that the jig plate will be deformed as time passes, the intervals between the reference-holes may be measured with the jig plate removed from the work table to allow accurate calculations at all times. In the case that the

jig plate is made of the same material as the printed circuit board, however, the deformation of the jig plate may be neglected during calculations because they are subjected to similar deformation as a result of temperature changes and the like.

It is desirable that the reference—holes 62 are provided in positions and sizes such that any of the reference—holes 62 is always included in the image area of the movable side imaging means 2b wherever the imaging means is moved to.

In the present embodiment, the printed circuit board to be perforated is a layered board, and X—ray cameras are used as the imaging means to image the reference marks which are not exposed on the surface. However, normal TV cameras may be used if perforation is to be carried out on a printed board which is not a layered board and on which the reference marks are exposed. The use of normal TV cameras is advantageous from the viewpoint of cost because there is no need for expensive X—ray generators and safety measures. Further, although drills are used as the perforating means, they may be replaced with other means including punches.

Fig. 8 shows another embodiment of the jig plate. This jig plate 65 has reference—holes 65b arranged in a row in the longitudinal direction thereof and is secured to the work table 1 by set—screws 65a in place of the jig plate 61 in the above—described embodiment. The interval between the reference—holes 65b is known and, as in the above—described embodiment, two of the reference—holes 65b are imaged by the imaging means 2a and 2b and are subjected to image processing to identify the accurate interval between both imaging means 2a and 2b.

A printed circuit board is perforated by drills 43c which penetrate through the reference—holes 65b. In the present embodiment, printed circuit board can be perforated only in positions facing the reference—holes 65b, but the jig plate is simple in configuration and is easy to manufacture.

Effect of the Invention

According to the present invention, the interval between both imaging means can be accurately identified using the jig plate prior to the perforation of a printed

circuit board, based on which the accurate interval between the reference marks can be calculated. This allows highly accurate perforation and makes it possible to improve the quality of printed circuit boards. The use of a detachable jig plate will provide a solution to deformation or the like of the jig plate. In addition, if the jig plate is formed from the same material as printed circuit boards, errors due to deformation of the same can be neglected because the deformation of the jig plate will be accompanied by similar deformation of the printed circuit boards.

Brief Description of the Drawings

Fig. 1.

A front sectional view of a perforating device according to the present invention.

Fig. 2.

A partially cutaway plan view of the perforating device in a part thereof under a work table.

Fig. 3.

A partially cutaway side view of the perforating device in the part thereof under the work table.

Fig. 4.

A plan view of the work table of the perforating device.

Fig. 5.

A plan view and a side sectional view of a jig plate of the perforating device.

Fig. 6.

An illustration for explaining the calculation of the interval between imaging means according to a method of perforating of the present invention.

Fig. 7.

An illustration for explaining the setting of perforating positions according to the method of perforating of the present invention.

Fig. 8.

A plan view and a side sectional view of another embodiment of a jig plate.

Description of Numerals

1	work table
2, 2a, 2b	imaging means (X-ray camera)
3, 3a, 3b	perforating means
20a	first shifting means
20b	second shifting means
62, 65	reference-hole
M1, M2	reference mark



Scope of Claims for a Patent

Claim 1. A device for perforating printed circuit boards characterized in that it comprises:

a work table on which a printed circuit board having a pair of reference marks provided thereon;

imaging means provided on fixed and movable sides for respectively imaging said reference marks;

perforating means provided on the fixed and movable sides for perforating said printed circuit board on said work table based on the result of the imaging of said reference marks;

a first shifting means for adjusting the positions of said imaging means and said perforating means on the fixed side;

a second shifting means for shifting said imaging means and said perforating means on the movable side integrally toward and away from said imaging means and said perforating means on the fixed side;

a jig plate disposed on said work table; and

a plurality of reference—holes for confirming the positions of said imaging means provided at predetermined intervals on said jig plate, and in that:

at least one of said plurality of reference—holes can be faced with said imaging means on the fixed side and others of said reference—holes are arranged in the direction in which said imaging means on the movable side is shifted by said second shifting means toward and away from said imaging means on the fixed side.

Claim 2. A device for perforating printed circuit boards according to Claim 1, characterized in that said jig plate can be attached to and detached from said work table.

Claim 3. A device for perforating printed circuit boards according to Claim



1 or Claim 2, characterized in that said jig plate is made of the same material as that for said printed circuit board.

Claim 4. A method for perforation utilizing a device for perforating printed circuit board according to any of Claims 1, 2, and 3, characterized in that it comprises the steps of:

shifting said imaging means and said perforating means on the movable side by said second shifting means in accordance with the interval between holes to be perforated on said printed circuit board;

imaging each of reference--holes among said plurality of reference--holes located in the vicinity of both of said imaging means and obtaining the center position of each of said reference--holes in image areas of both of said imaging means through image processing;

calculating the interval between both of said imaging means based on each of the center positions of said reference--holes and the interval between said imaged reference--holes obtained in advance;

setting said printed circuit board on said work table so that both of said reference marks are in the respective image areas of both of said imaging means;

imaging both of said reference marks by both of said imaging means to detect the center positions of both of said reference marks through image processing;

obtaining the interval between both of said reference marks based on the center position of each of said reference marks and the interval between both of said imaging means, and an error between the interval between both of said reference marks and the interval between the holes to be perforated, and setting perforating positions corrected from the center positions of said reference marks by an amount corresponding to said error; and

perforating said printed circuit board after shifting both of said perforating means by both of said shifting means to said respective perforating positions.