

"METHOD AND APPARATUS FOR MACHINING OR OTHERWISE
TREATING A MEMBER AT AT LEAST TWO DESIRED POSITIONS"

5 The present invention relates to a method and
apparatus for machining or otherwise treating a member
at at least two desired positions, e.g. a printed
circuit board perforating method and apparatus for
producing holes for mounting or positioning a circuit
10 element on the basis of reference patterns for
identifying perforating positions formed beforehand on
the printed circuit board.

 A method is known for perforating a printed
circuit board in which reference patterns for
identifying perforating positions which have been formed
15 on the printed circuit board are imaged by TV cameras.
Image signals thereof are stored. Based on these image
signals, central positions of the patterns are
calculated by an image processing device. The central
positions of the patterns are perforated after moving
20 the printed circuit board on XY tables in XY directions
in accordance with the calculated values.

 When forming a plurality of holes in a single
printed circuit board, perforation is performed in one
portion by the method described above. After moving the
25 printed circuit board, the next hole is bored by the
same method.

 In the known perforating method, however, only one
perforating means is employed. Therefore, when a
plurality of holes for positioning are formed in a
30 single printed circuit board, the same operation has to
be carried out twice or more times. If there is an

error between the patterns indicating the perforating positions, it follows that perforation is directly affected. This exerts an influence on the accuracy of perforating of lead or wiring patterns, which perforation is to be executed at the next step.

According to the present invention, there is provided a method of machining or otherwise treating a member at at least two desired positions comprising forming reference patterns for identifying the said positions; imaging said patterns so as to produce image signals; employing said image signals to detect the respective pattern positions of said patterns; calculating the inter-pattern spacing between said patterns in accordance with the result of the detection of the said pattern positions; calculating any error between the spacing of the desired positions and the inter-pattern spacing of the said patterns; calculating each of the desired positions from the inter-pattern spacing when the positions of each of the reference patterns has been corrected by moving it through a distance equal to half the said error; and employing the last-mentioned calculation to machine or otherwise treat the member at the desired positions.

The member may be a printed circuit board which is to be formed with holes at the said desired positions.

The said imaging may be effected by TV cameras. The last-mentioned calculation is preferably effected by machining members movable relatively to the member in XY directions.

The reference patterns may be constituted by holes in a gauge.

The invention also comprises an apparatus for machining or otherwise treating a member at at least two desired positions comprising mounting means for mounting the member; two devices for effecting the said machining or other treatment at the desired positions, the devices being movable relatively to the mounting means; imaging means for forming images of reference patterns which have been provided on a gauge; image processing means for detecting the positions of said patterns in accordance with image signals produced by the imaging means; an arithmetic circuit for calculating the inter-pattern spacing between said patterns in accordance with the result of the

detection of said pattern positions and for correcting any error in the inter-pattern spacing by moving each of the devices by a distance equal to half said error; and a control circuit, controlled by the arithmetic circuit, for relatively positioning the member mounting means and the said two devices, and for effecting operation of the latter.

The devices are preferably perforating means and the imaging means preferably comprise TV cameras.

The member mounting means is preferably fixed and at least one of the devices is movable relatively thereto in XY directions.

In its preferred form, the invention provides a method for perforating a printed circuit board by a pair of perforating means on the basis of at least two reference patterns for identifying perforating positions formed beforehand on the printed circuit board. This comprises the steps of: imaging the two reference patterns for identifying the perforating positions of the printed circuit board by the use of TV cameras; detecting the respective positions of the patterns by an image processing device on the basis of image signals obtained when the TV cameras effect imaging; calculating the spacing between the patterns in accordance with the result of detection of the pattern positions; calculating any error between the inter-perforating hole spacing stored beforehand and the inter-pattern spacing

so calculated; calculating perforating positions from the patterns which are, after the error has been halved, corrected by the halved values; moving the perforating members which are disposed on XY tables provided in each of the perforating means to said perforating positions, and causing said perforating members to perforate.

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The perforating method of this invention may further include the steps of employing a standard gauge having two holes formed therein at a predetermined spacing, imaging the two holes by a pair of TV cameras, detecting the positions of the two holes by the image processing device, and calculating the spacing between the pair of TV cameras on the basis of the result of the detection.

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In its preferred form, the invention provides a perforating apparatus for perforating a printed circuit board on the basis of at least two reference patterns for identifying perforating positions formed beforehand on the printed circuit board, the apparatus comprising a pair of perforating means which are relatively movable and have perforating members provided on XY tables, TV cameras disposed opposite to the perforating members with the printed circuit board therebetween, the TV cameras being capable of imaging the patterns. The perforating apparatus preferably also comprises: an image processing device for detecting the positions of the patterns in accordance with image signals obtained when the TV cameras effect imaging; an arithmetic circuit for calculating the inter-pattern spacing in accordance with the result of detection of the pattern positions and an error between the inter-perforating-hole spacing and the inter-pattern spacing, and calculating the perforating positions from the patterns,

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which are, after halving the error, corrected by the halved values; and a perforating control circuit for moving the perforating members to the perforating positions by the XY tables, and for causing the perforating members to perforate.

5 In the perforating apparatus of this invention, a standard gauge formed with two holes at a predetermined spacing may be provided, and the image processing device may further incorporate the function of detecting the positions of the two holes imaged by the pair of TV cameras. At this time, the arithmetic circuit may
10 further incorporate the function of calculating the spacing between the pair of TV cameras on the basis of the result of the detection of positions of the two holes.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

15 Figure 1 is a plan view partially in section of an embodiment of an apparatus according to the present invention, the view being taken substantially along the line E-E of Figure 3;

20 Figure 2 is a partially cut-away front elevation illustrating a first perforating means A in the said embodiment;

Figure 3 is an enlarged sectional view taken substantially along the line F-F of Figure 2;

25 Figure 4 is a sectional view taken substantially along the line G-G of Figure 3;

Figure 5 is an enlarged sectional view taken substantially along the line H-H of Figure 2;

Figure 6 is a block diagram of the said apparatus;

30 Figure 7 is a flowchart of the operation of a method according to the present invention;

Figure 8 is a partially cut-away plan view of a

printed circuit board which may be perforated by the method and apparatus of the present invention;

Figure 9 is a partially cut-away plan view of a standard gauge which may be employed in the method of the present invention; and

5 Figures 10 to 13 are drawings illustrating calculations which may be made by an arithmetic circuit forming part of an apparatus according to the present invention.

10 Referring first to Figure 8, a copper lead pattern (not shown) is formed on a printed circuit board 1. Formed thereon are copper-based reference patterns 11, 12 for identifying positions to be perforated. The spacing L' between the reference patterns 11, 12 is made up both of the true perforating spacing L (Figure 11) therebetween and errors derived from deformation of the printed circuit board 1 during or after printing and so
15 on.

20 As shown in Figure 1, a perforating apparatus according to the present invention performs perforation by means of a pair of perforating means A, B which are relatively movable. In this embodiment, the first perforating means A is movably mounted, while the second perforating means B is fixed. By rotating a lead screw C, rollers R (shown in Figure 2) which are provided on a bottom face of the perforating means A roll on rails D, D so that the perforating means A may be moved to a
25 position A' and is movable away therefrom. This arrangement is intended to adjust the spacing between the pair of perforating means A, B so that it may be adapted to a variety of printed circuit boards having different perforating spacings. This is necessary
30 because printed circuit boards have a variety of sizes, and the perforating spacings are different from each

other.

The perforating means A, B include drills 61, 61B serving as perforating members, the drills 61, 61B being mounted on XY tables. The positions of the respective drills are minutely adjustable in XY directions.

5 The first and second perforating means A, B have absolutely the same structure. Therefore, the structure of only one of them, namely that of the perforating means A, will be explained in detail.

10 Figures 2 and 3 are a partially cut-away front elevation and an enlarged sectional view each illustrating the perforating means A. A work table 2 is fixedly mounted on an upper surface of a case 21. A mounting member 22 for the printed circuit board 1 is provided on the work table 2 which moves across between the drill 61 and a TV camera 4 disposed opposite
15 thereto. The printed circuit board 1 is fixedly set in the mounting member 22 by a printed circuit board holding device 8 which will be mentioned later.

20 A light-emitting means 3 (Figure 3) provided obliquely downwardly of the table 2 emits light towards the printed circuit board 1 disposed on the mounting member 22. The reference patterns 11, 12 for identifying the perforating positions are imaged by TV cameras provided upwardly of the table 2, i.e. the first TV camera 4 and a second TV camera 4B illustrated in
25 Figure 6. Image signals obtained when these TV cameras effect imaging are processed by an image processing device 5. Central positions thereof are thus detected. Detected values are supplied to a perforating control circuit (CPU) 7. Based on the detected values, an
30 arithmetic operation, which will hereinafter be described, is carried out by an arithmetic circuit 71.

A value which has been calculated by the arithmetic circuit 71 is supplied to the CPU 7 and at the same moment is stored in a memory circuit 72. The CPU 7 controls driving of the XY tables of the perforating means A, B. An input device 10 is capable of inputting (presetting) to the CPU 7 data relating to the spacing L between the holes or the like to be formed. The spacing L is then stored in the memory circuit 72.

The following is a description of a shifting device 6 for shifting the drill 61 in the XY directions. As illustrated in Figures 2 and 3, support plates 23, 23 are attached to the underside of the work table 2. A base 24 is fixed to the lower ends of the support plates 23, 23. A Y table 62 is so mounted on the base 24 as to be movable in the Y direction, the movement of the Y table 62 being controlled by cross roller guides 63. An X table 64 is so mounted on the Y table as to be movable in the X direction, the movement of the X table 64 being controlled by a cross roller guide 65. To move the Y table 62, as shown in Figure 3, a Y-axis motor 67 is disposed on a mounting plate 66 secured to the end of the base 24.

A Y driving shaft 69 is connected via a coupling 68 to a motor shaft 67a. On the outer periphery of the Y driving shaft 69 there is cut a ball screw (not shown). The Y driving shaft 69 is rotatably mounted in bearings 602, 602a on support members 601, 601a which are fixed to the underside of the base 24. Fixed to the underside of the Y table 62 is a connecting plate 603 to which a nut 604 for a ball screw is fixed. The ball screw nut 604 is mounted on the middle of the Y driving shaft 69. The nut 604 is moved in the Y directions by rotations of the Y driving shaft 69. The Y table 62 is thereby movable in the Y directions. The

numeral 605 designates an axial sensor for setting an origin of the Y-axis motor 67.

To move an X table 64, as illustrated in Figures 3 and 4, an X-axis motor 607 is disposed on a mounting plate 606 secured to the base 24. An X driving shaft 609 is connected via a coupling 608 to the motor shaft of the motor 607. The outer periphery of the X driving shaft 609 is cut to form a ball screw (not shown). The X driving shaft 609 is rotatably mounted in bearings on support members 611, 611a fixed to the upper surface of the base 24. A connecting lever 613 is fixed onto the upper surface of the X table 64. A ball screw nut 614 which is mounted on the middle of the X driving shaft 609 is fixed to a connecting member 610. The top end of the connecting lever 613 is sandwiched in between pins 612, 612 attached to the upper surface of the connecting member 610. The connecting member 610 is connected to a linear ball slider 617 movable in the X directions along a guide 616 provided on the upper surface of the base 24. The ball screw nut 614 moves in the X directions as a result of rotations of the X driving shaft 609. The connecting member 610, the pins 612 and the connecting lever 613 are moved by the ball screw nut 614. The X table 64 is thereby movable in the X directions. The numeral 615 denotes an axial sensor for setting an origin of the X-axis motor 607.

As illustrated in Figure 3, a cylindrical mounting member 618 is mounted so as to pass through the front end portion of the X table 64. A spindle motor 620 extends through the mounting member 618 so that the motor 620 is movable up and down through a slide bearing 619. A collet chuck 621 is provided at the upper end of the spindle motor 620. The collet chuck 621 is fitted with the drill 61. A chip housing 622 is fixed to the

upper end of the mounting member 618.

The chip housing 622 is provided with a hole 622a through which may pass the light from the light emitting means 3. The housing 622 is provided with a duct 623 through which the chips produced in drilling are sucked by a vacuum pump (not shown).

5 Figure 5 shows a means for moving forward
(raising) the drill 61 and adjusting the height of the
top end thereof. A support plate 624 is fixed to an
internal surface of the case 21. An air cylinder 625 is
mounted on a lower end portion of the support plate 624.
10 A connecting member 626 is fixed to an upper end of a
shaft of the air cylinder 625 by use of a stopping member
627. Designated at 628 is a cylindrical stopper in
which an oil dumper 629 is mounted. The lower end of
the oil dumper 629 is engageable by the stopping member
627. A retaining plate 630 of the stopper 628 is
15 provided at the upper end of the support plate 624. A
shaft of a clamp lever 631, which is provided outwardly
of the case 21, is screwed into the retaining plate
630. The end of the lever 631 retains the stopper 628
in a predetermined position. One end portion of the
20 connecting member 626 which is formed in an L-shape is
connected to a lower connecting shaft 632. An upper
connecting shaft 633 is drivingly connected to a holder
634 fastened to the lower end of the spindle motor 620.
The case 21 is provided with a recess or aperture 21a.
25 Positioned in this aperture 21a are a head portion of
the oil dumper 629 and an operating portion 635 thereof
connected to the upper end of the stopper 628. These
components are operable from outside.

30 After attaching the drill 61 to the collet chuck
621, the height of the drill is adjusted. At this time,
the clamp lever 631 is slackened to depress or raise the

operating portion 635 disposed in the aperture 21a. The position of the lower end of the stopper 628 is thereby moved up and down. The highest position of the stopping member 627 is thus determined. The following

is a description of a printed circuit board holding means for securing the printed circuit board 1 to the work table 2. As illustrated in Figure 3, a mounting plate 81 is fixed to the underside of the work table 2. A cylinder 82 is fixed to the mounting plate 81.

Connecting rods 83, 84 are successively drivingly linked by pins 83a, 84a to the outer end of the shaft of the cylinder 82. The rod 84 passes through the table 2 and extends upwards. The rod 84 is supported on a support plate 85 fixed to the upper surface of the table 2

so that the rod 84 may be pivoted about a shaft 86. An arm 87 is pivotally supported on the shaft 86. The rod 84 is linked via a spring pin 88 to the upper end of an arm 87a connected to the arm 87 and extending upwards.

The front end of the arm 87 is mounted in a forked presser lever 89 and connected thereto through pins 801, 302. The front end of the presser lever 89 is formed into a substantially U-shape as seen in plan. A ring-like presser tip 803 is pivotally connected via a pin 804 to the front end of the lever 89.

In operation, the printed circuit board 1 is placed in a predetermined position on the member 22, and a start switch (not shown) is turned ON. The cylinder 82 is thereby actuated, and its shaft moves forwards.

The lower end of the connecting rod 84 is pushed by way of the connecting rod 83 and pivots about the shaft 86 to a position indicated by a solid line in Figure 3. As a result, the front end of the arm 87 is lowered, and a press member 803 descends correspondingly. The printed circuit board 1 is held and thus fixed. The lower

surface of the press member 803 uniformly holds the upper surface of the printed circuit board 1. No biasing force acts on the printed circuit board.

The two reference patterns 11, 12 for identifying perforating positions are simultaneously detected. The inter-pattern spacing L' is calculated. Calculated also is an error between the spacing L' and the true inter-perforating-hole spacing L . This error is halved. Perforating positions, which have been corrected by the halved values, are calculated from the patterns 11, 12. The error is allocated to the two perforating positions, and perforating is then effected.

An arithmetic operation by the arithmetic circuit 71 will next be explained.

Figure 9 illustrates a standard gauge K having two holes k_1 , k_2 which are perforated exactly at a predetermined spacing l .

The standard gauge K is set in the pair of perforating means A, B, the positions of the TV cameras being indicated in Figure 10 by PA, PB. It is assumed that a line which connects the two cameras is an X-axis, while a line orthogonal thereto is a Y-axis. The letter p represents the spacing between the two TV cameras. The letter l indicates the spacing between the two holes of the standard gauge K. The spacing in the X-axial direction between the two holes is expressed by lX , while the spacing in the Y-axial direction therebetween is expressed by lY . The two holes k_1 , k_2 are imaged by use of the TV cameras. The image processing device 5 detects coordinates (x_1, y_1) of the hole k_1 and coordinates (x_2, y_2) of the hole k_2 . Based on these detected values, the spacing p between the TV cameras is calculated as follows:

$$\Delta Y = y_2 - y_1$$

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$$\Delta X = \sqrt{\Delta^2 - (\Delta Y)^2}$$

$$p = \Delta X - (x_2 - x_1)$$

$$= \sqrt{\Delta^2 - (\Delta Y)^2} - (x_2 - x_1).$$

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Next, the perforating means A moves by a distance equivalent to the difference $(L - p)$ between the inter-perforated-hole spacing L and the inter-TV-camera spacing p . With this movement, the spacing between the TV cameras PA, PB is made to coincide with L .

The printed circuit board 1 to be perforated is subsequently set in the two perforating means A, B. The reference patterns 11, 12 for identifying the perforating positions are imaged. The image processing device 5 detects central coordinates (x_3, y_3) (Figure 11) of the pattern 11 and also central coordinates (x_4, y_4) of the pattern 12. The spacing L' between the two patterns is calculated based on these detected values. Namely, the spacing in the X-axial direction of the spacing L' is given by:

$$L'X = L + (x_4 - x_3)$$

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$$\begin{aligned} L'^2 &= (L'X)^2 + (y_4 - y_3)^2 \\ &= \{L + (x_4 - x_3)\}^2 + (y_4 - y_3)^2 \end{aligned}$$

so that

$$L' = \sqrt{\{L + (x_4 - x_3)\}^2 + (y_4 - y_3)^2} \quad \dots (1)$$

The inter-pattern spacing L' is thus calculated.

5 With respect to the thus calculated spacing L' , positions 11a, 12a (Figure 11) for producing the required perforating spacing L are then calculated. In this case, the error between the spacings L' and L is allocated equally to both sides, thereby determining the perforating positions.

10 Figure 12 illustrates one perforating position 11a in enlargement. On the basis of the TV camera PA, let (x_5, y_5) be the central coordinates of the position 11a to be formed after correcting the error in accordance with the coordinates (x_3, y_3) of the pattern 11, and let θ be the angle made by the line connecting the patterns 11, 12 and the X-axis. In this case, the following relationships are attained:

$$\begin{aligned} x_5 - x_3 &= (L' - L)/2 \times \cos \theta \\ y_5 - y_3 &= (L' - L)/2 \times \sin \theta, \end{aligned}$$

when

$$\tan \theta = a$$

$$\cos \theta = 1/\sqrt{1 + a^2}$$

$$\sin \theta = a/\sqrt{1 + a^2}$$

$$x_5 = x_3 + (L' - L)/(2\sqrt{1 + a^2}) \quad \dots (2)$$

$$y_5 = y_3 + a(L' - L)/(2\sqrt{1 + a^2}) \quad \dots (3)$$

where

$$\begin{aligned} a &= (y_4 - y_3)/(L + x_4 - x_3) \\ &= (y_5 - y_3)/(x_5 - x_3) \end{aligned}$$

Similarly, let (x_6, y_6) (shown in Figure 11) be the coordinates of the position 12a to be formed after modifying the error corresponding to the pattern 12. In this case, the following relationships are established:

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$$x_6 = x_4 - (L' - L) / (2 \sqrt{1 + a^2}) \quad \dots (4)$$

$$y_6 = y_4 - a(L' - L) / (2 \sqrt{1 + a^2}) \quad \dots (5)$$

10 Next, an arithmetic operation when forming a third hole 13 (Figure 13) will be described. The third hole 13 is provided in order to discriminate between the obverse and reverse of the board. In this embodiment, the third hole 13 is spaced a distance M away from the above-mentioned position 12a. The third hole 13 is so
15 positioned that a line which connects positions 12a, 13 is perpendicular to one which connects the positions 11a, 12a.

When calculating central coordinates (x_7, y_7) of the third hole 13, as shown in Figure 13, the following
20 relationships are given:-

$$x_7 - x_6 = M \times \sin \theta$$

$$y_7 - y_6 = M \times \cos \theta$$

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when

$$\tan \theta = a$$

$$\cos \theta = 1 / \sqrt{1 + a^2}$$

$$\sin \theta = a / \sqrt{1 + a^2}$$

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$$x_7 = x_6 + M \times a / (\sqrt{1 + a^2}) \quad \dots (6)$$

$$y_7 = y_6 + M / (\sqrt{1 + a^2}) \quad \dots (7)$$

or

$$x_7 = x_4 - \{1/(\sqrt{1 + a^2})\} \{(L' - L) / 2 + aM\} \dots (6)'$$

$$y_7 = y_4 - \{1/(\sqrt{1 + a^2})\} \{a(L' - L)/2 - M\} \dots (7)'$$

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These arithmetic operations are executed by the arithmetic circuit 71. Therefore, the spacing L' between the patterns 11, 12 is obtained from the formula (1). The coordinates (x_5, y_5) of the positions 11a, 12a to be formed are obtained from the formulae (2), (3), (4) and (5). The central coordinates (x_7, y_7) of the hole 13 to be formed is given in accordance with the formulae (6), (7), or (6)', (7)'.

The position of the third hole is not limited to the example given above so that the calculation of the hole position can be appropriately set.

A perforation operation will now be described in conjunction with the flowchart of Figure 7.

If the spacing p between the two perforating means is not yet known (step a), the standard gauge K is set (step b). The holes k_1, k_2 are imaged in the manner described above by the TV cameras 4, 4B (step c). The image processing device 5 detects the positions thereof (step d). The inter-camera spacing p is calculated in the above-mentioned manner by the arithmetic circuit 71 (step e).

On the other hand, when the inter-perforating means spacing p is known (step a) or when the steps (b) - (e) are finished the CPU 7 transmits the inter-perforating-hole spacing L to the two perforating means A, B. The perforating means A, B move to the perforating positions, i.e. to positions such that the

TV cameras 4, 4b become coincident with the spacing L (step g). Subsequently, the perforating members 61, 61B are set opposite to the TV cameras 4, 4B (step h). These positions are the initial positions of the two perforating means A, B.

5 Next, the printed circuit board 1 to be perforated is set in position (step i). In the same manner as above, the reference patterns 11, 12 for identifying the perforating positions are imaged by the cameras (step j). The image processing device 5 detects the pattern positions (step k). As described in detail above, the arithmetic circuit 71 calculates the perforating
10 positions 11a, 12a (step m), wherein the error is halved and corrected. The perforating members 61, 61B of the two perforating means A, B are shifted to these perforating positions under the control of the CPU 7 (step n). At the same moment, two holes are formed
15 (step q).

 When forming the third hole (step r), the data of the third perforating position which have been calculated by the arithmetic circuit 71 (step m) and stored in the memory circuit 72 are accessed by the CPU
20 7. The perforating member 61 or 61B is shifted to the third perforating position under the control of the CPU 7 (step s), and perforating is then effected (step t). The perforating members 61, 61B return to positions facing the cameras 4, 4B. Note that if perforating of
25 the third hole is not performed the perforating members 61, 61B immediately return to the positions opposite to the cameras 4, 4B (step u). Subsequent to this step, the perforating operation is terminated, and the printed circuit board 1 is taken out (step v).

30 When perforating is continuously effected (step w), the subsequent printed circuit boards are set (step

1). The operations described above are repeated. Perforating comes to an end just when no printed circuit board to be perforated is left.

The embodiment described above relates to an apparatus in which the light is emitted from the underside, and the upper side camera receives the transmitted image of the pattern. The arrangement is not, however, limited to this example. Another possible arrangement is that the light is reflected by the printed circuit board, and the apparatus receives a reflected image thereof.

Moreover, the perforating member is not limited to a drill but may involve a punch or the like. There are also no restrictions on the way in which the perforating members are driven.

The perforating method described above comprises the steps of detecting the two reference patterns for identifying the perforating positions formed on the printed circuit board, calculating the spacing therebetween, calculating an error between this spacing and the predetermined spacing, calculating the perforating positions by halving this error and forming the two holes simultaneously. Therefore, even if a slight error is produced between the pattern positions, a correction therefor is automatically effected. No defective product is therefore manufactured. The two holes are formed simultaneously, whereby the working time can be reduced.

The perforating apparatus described above is capable of simultaneously detecting the two patterns and effecting the perforations thereof by use of the pair of perforating means. Perforating can be accurately quickly carried out. The pair of perforating means are relatively movable and are therefore adaptable to

perforating printed circuit boards having a variety of sizes.

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CLAIMS

1. A method of machining or otherwise treating a member at at least two desired positions comprising forming reference patterns for identifying the said positions; imaging said patterns so as to produce image signals; employing said image signals to detect the respective pattern positions of said patterns; calculating the inter-pattern spacing between said patterns in accordance with the result of the detection of the said pattern positions; calculating any error between the spacing of the desired positions and the inter pattern spacing of the said patterns; calculating each of the desired positions from the inter-pattern spacing when the positions of each of the reference patterns has been corrected by moving it through a distance equal to half the said error; and employing the last-mentioned calculation to machine or otherwise treat the member at the desired positions.
2. A method as claimed in claim 1 in which the member is a printed circuit board which is to be formed with holes at the said desired positions.
3. A method as claimed in claim 1 or 2 in which the said imaging is effected by TV cameras.
4. A method as claimed in any preceding claim in which the last-mentioned calculation is effected by machining members movable relatively to the member in XY directions.
5. A method as claimed in any preceding claim in which the reference patterns are constituted by holes in a gauge.
6. A method of machining or otherwise treating a member at at least two desired positions substantially as hereinbefore described with reference to the accompanying drawings.



7. Apparatus for machining or otherwise treating a member at at least two desired positions comprising mounting means for mounting the member; two devices for effecting the said machining or other treatment at the desired positions, the devices being movable relatively to the mounting means; imaging means for forming images of reference patterns which have been provided on a gauge; image processing means for detecting the positions of said patterns in accordance with image signals produced by the imaging means; an arithmetic circuit for calculating the inter-pattern spacing between said patterns in accordance with the result of the detection of said pattern positions and for correcting any error in the inter-pattern spacing by moving each of the devices by a distance equal to half said error; and a control circuit, controlled by the arithmetic circuit, for relatively positioning the member mounting means and the said two devices, and for effecting operation of the latter.
8. Apparatus as claimed in claim 7 in which each of the devices is a perforating means.
9. Apparatus as claimed in claim 7 or 8 in which the imaging means comprise TV cameras.
10. Apparatus as claimed in any of claims 7-9 in which the member mounting means is fixed and at least one of the devices is movable relatively thereto in XY directions.
11. Apparatus for machining or otherwise treating a member at at least two desired positions substantially as hereinbefore described with reference to and as shown in the accompanying drawings.



12. A method for perforating a printed circuit board by a pair of perforating means on the basis of at least two reference patterns for identifying perforating positions formed beforehand on said printed circuit board, comprising the steps of: imaging said two reference patterns of said printed circuit board by use of TV cameras; detecting respective positions of said patterns by an image processing device on the basis of image signals obtained when said TV cameras effect imaging; calculating a spacing between said patterns in accordance with the result of detection of said pattern positions; calculating an error between an inter-perforating hole spacing stored beforehand and an inter-pattern spacing calculated; calculating perforating positions from said patterns which are, after said error has been halved, corrected by said halved values; and moving perforating members which are disposed on an XY table provided in each of said perforating means to said perforating positions, and causing said perforating members to perforate.

13. A perforating apparatus for perforating a printed circuit board on the basis of at least two reference patterns for identifying perforating positions formed beforehand on said printed circuit board, comprising a pair of perforating means being relatively movable and having perforating members provided on XY tables and TV cameras disposed opposite to said perforating member with said printed circuit board between said TV cameras being capable of imaging said patterns; an image processing device for detecting positions of said patterns in accordance with image signals obtained when said TV cameras effect imaging; an arithmetic circuit for calculating an inter-pattern spacing in accordance with the result of detection of said pattern positions and an error between an inter-perforating-hole spacing and said inter-pattern spacing and calculating perforating positions from said patterns, which are, after halving said error, corrected by said halved values; and a perforating control circuit for moving said perforating members to said perforating positions by said XYtables and causing said perforating members to perforate.
