PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
B23P 19/04, H05K 3/30

A1

(11) International Publication Number: **WO 96/26809**

(43) International Publication Date: 6 September 1996 (06.09.96)

(21) International Application Number: PCT/US96/02431

(22) International Filing Date: 21 February 1996 (21.02.96)

(30) Priority Data:
08/391,394 27 February 1995 (27.02.95) US

(71) Applicant: MPM CORPORATION [US/US]; 10 Forge Park, Franklin, MA 02038 (US).

(72) Inventors: ROSSMEISL, Mark, E.; 722 Carbot Street, Beverly, MA 01915 (US). MURBY, Edna, M.; 223 Dahlia Drive, North Kingstown, RI 02852 (US).

(74) Agent: BOOTH, William, E.; Fish & Richardson, P.C., 225 Franklin Street, Boston, MA 02110-2804 (US).

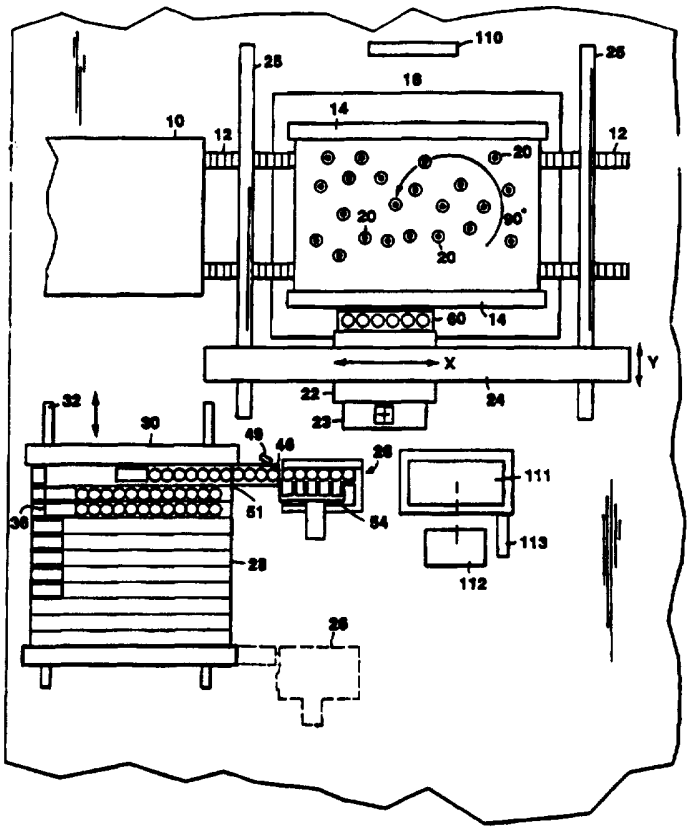
(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: METHOD AND APPARATUS FOR CIRCUIT BOARD PIN PLACEMENT AND SUPPORT

(57) Abstract

A pin placement and support apparatus for a circuit board (10) having a rigid support table (16), a supply of pins (26, 28), a pin placement head (60), and an X-Y transporter (24, 25) for moving the placement head relative to the table (16) for placing the pins (20) at desired and variable locations on the table. The apparatus includes a programmed computer to display a board area (120) of the table and pins at user-selected locations within the board area.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	**GB**	United Kingdom	**MW**	Malawi
AT	Austria	**GE**	Georgia	**MX**	Mexico
AU	Australia	**GN**	Guinea	**NE**	Niger
BB	Barbados	**GR**	Greece	**NL**	Netherlands
BE	Belgium	**HU**	Hungary	**NO**	Norway
BF	Burkina Faso	**IE**	Ireland	**NZ**	New Zealand
BG	Bulgaria	**IT**	Italy	**PL**	Poland
BJ	Benin	**JP**	Japan	**PT**	Portugal
BR	Brazil	**KE**	Kenya	**RO**	Romania
BY	Belarus	**KG**	Kyrgystan	**RU**	Russian Federation
CA	Canada	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CF	Central African Republic			**SE**	Sweden
CG	Congo	**KR**	Republic of Korea	**SG**	Singapore
CH	Switzerland	**KZ**	Kazakhstan	**SI**	Slovenia
CI	Côte d'Ivoire	**LI**	Liechtenstein	**SK**	Slovakia
CM	Cameroon	**LK**	Sri Lanka	**SN**	Senegal
CN	China	**LR**	Liberia	**SZ**	Swaziland
CS	Czechoslovakia	**LT**	Lithuania	**TD**	Chad
CZ	Czech Republic	**LU**	Luxembourg	**TG**	Togo
DE	Germany	**LV**	Latvia	**TJ**	Tajikistan
DK	Denmark	**MC**	Monaco	**TT**	Trinidad and Tobago
EE	Estonia	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**UG**	Uganda
FI	Finland	**ML**	Mali	**US**	United States of America
FR	France	**MN**	Mongolia	**UZ**	Uzbekistan
GA	Gabon	**MR**	Mauritania	**VN**	Viet Nam

METHOD AND APPARATUS FOR CIRCUIT BOARD PIN PLACEMENT AND SUPPORT

Background of the Invention

The invention relates to support apparatus for circuit boards.

When circuit boards are subjected to manufacturing processes, it is often desirable to uniformly support the board across the entire lower surface so that the entire upper surface is in the same plane. It is known to support the circuit board over a table using pins that have upper support surfaces in the same plane. When the lower surface of the circuit board is free of components, the pins can be mounted on a grid. When the circuit board has components mounted on the bottom surface, the pins need to be located to support portions of the lower surface between the components mounted thereon. One way to so locate the pins is to manually place pins having support bases with magnets on a flat upper surface of a metal support table. Another way is described in Beale U.S. Patent No. 5,157,438, which shows supporting such circuit boards by selectively raising pins mounted in holes on a grid pattern in a housing.

Summary of the Invention

In one aspect, the invention features, in general, supporting a circuit board using apparatus that has a rigid support table, a supply of pins, a pin placement head, and an X-Y transporter that moves the pin placement head relative to the table so as to place the pins at desired and variable locations on the table. Pins thus do not need to be placed on a grid, and can be aligned with regions on a lower surface of the circuit board not occupied by underboard components regardless of the locations of the unoccupied regions.

In preferred embodiments, the pin placement head is carried on an X-Y gantry that also carries a vision system for viewing the circuit board after it is mounted on the pins. The pins have magnetic bases to hold them in place on the table. The pin placement head includes a plunger that is movable between a raised position for movement by the transporter over the table and a lowered position for placing a pin at a desired location on the table.

To facilitate defining pin locations, the apparatus includes a computer that is programmed to display a board area of the table and pins at user-selected locations within the board area. The user adds pins by moving a cursor to a selected new location and clicking at the location. The user can display a grid of perpendicular lines on the board area and place pins at the intersections of the lines on the display. The user can modify the pin placement by removing individual pins, copying groups of pins, or offsetting one or more pins. The user can display a list of the pin coordinates in the order in which the pins will be placed on the board and can redefine the order. The user can have the computer sequentially add pins to the board area on the screen display in the order in which pins will be placed on the board. The user can access optimization modules to automatically redefine the placement order so as to minimize the travel of the placement head and thus the time of placement.

In another aspect, the invention features, in general, pin placement apparatus including a block and a pneumatically actuated plunger in a chamber in the block. The plunger has a central bore that extends upward from the bottom of the plunger to a side opening. A source of compressed air is connected to the chamber to move the plunger from a raised to a lowered position. The block

has a by-pass passage that communicates pressure in the chamber from above the plunger, when in the lowered position, to the side opening of the bore to eject the pin after the plunger has been moved to the lowered position.

In preferred embodiments, the block also has a side passage that is aligned with and communicates with the side opening to the bore when the plunger is in the raised position. A vacuum only check valve, a vacuum sensor and vacuum source are connected to the side passage to detect the presence or absence of a pin in the bore when the plunger is in the raised position.

Other advantages and features of the invention will be apparent from the following description of the preferred embodiment thereof and from the claims.

Brief Description of the Drawings

Fig. 1 is a partial plan view of a soldered paste screen printer including pin placement and support apparatus according to the invention.

Fig. 2 is a perspective view of a pin supply tray for use with the Fig. 1 apparatus.

Figs. 3-4 are plan views of a load station used to hold pins from the Fig. 2 tray in position for pick up by an X-Y transporter.

Fig. 5 is a partial elevation showing a pin placement head and a portion of a support table of the Fig. 1 printer.

Fig. 6 is a sectional view of the Fig. 5 placement head.

Fig. 7 is a block diagram showing pneumatic components used with the Figs. 5 and 6 pin placement head.

Fig. 8 is a partial elevation showing a rigid support table and pins of the Fig. 1 printer supporting a circuit board having underboard topology.

Fig. 9 is a flow chart describing the operation of the Fig. 1 printer to place pins.

Figs. 10 to 12 are screen displays of an interactive edit mode of a computer used to define pin locations for the Fig. 1 apparatus and to control the apparatus.

Fig. 13 is a screen display of the computer that is used during placement of the pins.

Description of the Preferred Embodiment

Referring to Fig. 1, there are shown some of the internal components that are used to support a circuit board in a screen printer that applies solder paste through a stencil. The printer is an improvement of the type of screen printer described in Freeman U.S. Reissue Patent No. 34,615 and commercially available under the ASP-24 trade designation from MPM corporation, Franklin, MA, both of which are hereby incorporated by reference.

As shown in Fig. 1, the screen printer includes tractor feed mechanism 12 to supply the boards 10 to edge tractor mechanisms 14 placed over rigid support table 16. Tractor mechanism 18 is used to remove processed boards. A plurality of pins 20 are supported on the upper surface of table 16 in a pattern so that the upper portions of pins 20 support the undersurface of a circuit board at locations not occupied by underboard components or other support pins.

Pins 20 are placed at variable predetermined positions on table 16 by pin placement head 60 (Fig. 5) carried on the back of carriage 22 movable in an X direction along frame 24, which is a linear X-axis of motion. Frame 24 in turn is movable in a Y direction

along tracks 25, which is a linear Y-axis of motion. Vision system 23 is carried on the front of carriage 22. Pin placement head 60 is at a higher elevation than load station 26 and is movable over station 26 to engage the pins. The pins 20 are dispensed by supply tray 28 located at tray support 30, which is movable in the Y direction over linear rails 32. Load station 26 is shown in a delivery position; it can also be moved to a parked position shown in phantom on Fig. 1.

Referring to Fig. 2, it is seen that tray 28 includes fifteen slots 34 for receiving the bases 21 of pins 20. Pins 20 also have shafts 23 and O-rings 19 thereon. Each slot has a spring biasing mechanism 36 having a constant force coil spring that is secured at end 38 to the end of tray 28 by a bolt 40. The coiled portion 42 of the spring sits within the biasing mechanism 36. Each mechanism 36 biases pins 20 in its respective slot 34 toward the open end of the slot after the mechanism has been released by bar 44 when rotating handle 45 to raise bar 44 and disengage spring plungers 41 from grooves 43 of spring mechanism 36.

Referring to Fig. 3, it is seen that load station 26 includes bridge 46 having a slot therein for receiving the bases of pins 20 and spacing assembly 48. Spacing assembly 48 includes a base 50 with a track 52 for receiving the bases of pin 20 supplied thereto through bridge 46. Comb 54 is slidably mounted on base 50 and is actuated by cylinder 56. Pins 20 are supplied from bridge 46 by biasing action of mechanism 36 and are pushed into channel 52 with the bases touching each other while comb 54 is retracted (Fig. 3). Air source 49 is provided to push pins across bridge 46 so that a pin 20 will not interfere with comb 54 on base 50. Comb 54 is then moved toward and into channel 52, and its teeth 58 space apart the adjacent bases of the pins 20 to provide

proper 0.4" spacing from each other by a center-to-center distance. This spacing provides the proper position for pick up of six pins 20 at one time by pin placement head 60.

Referring to Fig. 5, it is seen that placement head 60 includes a block 62, lower plate 64 and plungers 66 that extend from lower plate 64. Referring to Fig. 6, is seen that plunger 66 is seated within chamber 68 and is biased in an upward direction by spring 70. Supply hose 72 is connected to fitting 74 which communicates with the top of chamber 68 and also provides a fluid path through hose 76 to check valve 78. Check valve 78 communicates vacuum to side passage 80 but does not communicate pressure. Passage 80 is aligned with opening 82 to central bore 84 within plunger 66 when in the raised position shown in Fig. 6. O-ring 86 provides a seal between the outer surface of plunger 66 and the inner cylindrical surface of chamber 68. Block 62 also includes by-pass passage 88 having an upper end that is spaced from its lower end so that, when plunger 66 is in its lowered position, a by-pass fluid communication will be provided from the chamber 68 above the plunger 66 to side opening 82, which is aligned with the lower part of passage 88.

Referring to Fig. 7, it is seen that tube 72 is connected to blow-off valve 90 which is movable between two positions. In one position, pressure source 92 communicates with tube 72. In the other position, tube 72 communicates with line 94 connected to vacuum sensor 96 and vacuum source 98.

Referring to Fig. 8, circuit board 10 with underboard components 100, 102 is shown supported above rigid support table 16 via pins 20 that have been positioned so that the upper portions contact the

portions of the lower surface of circuit board 10 between underboard components 100, 102.

The apparatus also includes motors and actuators (not shown) to cause the movements described and a computer controller (not shown) that controls the motors and actuators. The apparatus also includes additional sensors beyond those described to control accurate movement of the components described therein. In particular, frame 24 and carriage 22 can be moved to precisely position a pin 20 at any X, Y coordinate location on table 16 to within 0.001", so long as the location does not cause interference with edge tracks 14 or previously placed pins 20. The computer includes a processor, memory for storing data and control programs to carry out the programmed procedures described in Fig. 9 and below, a display monitor for providing displays (e.g., as shown in Figs. 10-13), and interactive user input devices including a keyboard and a mouse.

The apparatus employs the screen displays shown on Figs. 10-12, to permit the user to define the locations for placing pins using the edit mode. The screen display includes a display of board area 120 indicating the area to be occupied by board 10 on table 16. Scales 122, 123 for the X and Y coordinate axes are adjacent to board area 120, and the origin is at the bottom left-hand corner of board area 120. The display of board area 120 also includes horizontal borders 124 to identify the areas at the top and bottom of the board in which pins cannot be located because they would otherwise interfere with the edge tracks 14. Board area 120 also includes the border 126 that defines an area in which pins are required not to be placed owing to other constraints. The size and orientation of the board area 120 is automatically determined in a set-up mode in which the

user inputs information as to the size of the actual board and other information.

Clear button 128, Add button 130, Remove button 131, Grid button 134 and Offset button 136 are activated using the mouse user input device. Add button 130 is used to activate the Add feature in which the user adds pins 132 to board area 120 by moving the cursor to the desired location and clicking on the location. As the cursor is moved, the X and Y position coordinates are automatically updated in box 133, which also displays the file name, the pin count and the pin ID number. The pin count is the total number of selected pins, as is shown on board area 120. The pin ID number identifies the position in the selection sequence in which the pin was originally selected; it also indicates the order in which the pins will be placed on board 10 unless the order is modified by the user or the automated optimization procedures described below.

Pins 132 can be deleted from the board area 120 using Remove button 131 to activate the Remove function and then clicking on the pin to be removed. Clear button 128 will clear the board area 120 of all pins 132.

Activation of Grid button 134 and Offset button 136 cause additional buttons to be displayed directly below them. Activation of the Grid button causes display of a Origin button 142, a Fill button 144 and an Increment button 146 as is shown in Fig. 11. When the Grid button 134 and function are activated, X and Y grid lines 138 and 140 are automatically displayed on board area 120. Box 133 can also include display of the X and Y increments. By activating the Increment button 146, the spacing between the X grid lines 138 and the spacing between the Y grid lines 140 can be independently changed. The activation of the Fill button 144 causes pins 132 to be displayed at all of the intersections of

the X grid lines 138 and the Y lines 140 unless doing so would violate a condition regarding preexisting pins 132. Origin button 142 is used to cause the origin of the grid to be moved to the defined new origin coordinates.

When Offset button 136 is activated, additional buttons--Single button 160, Group button 162, and All button 164-- and increment box 166 are displayed on the screen. The Single button 160 permits the user to select an individual pin or a selected plurality of pins to be translated according to the coordinates that define the amount and direction of offset. The Group button 162 is activated to permit the user to draw a box around a group of pins and cause them all to be moved by the selected offset. The All button 164 causes all pins displayed to be translated according to the entered offset. If moving any pins by the offset causes them to go outside of board area 120 or conflict with previously placed pins, they are automatically truncated.

While in the edit mode shown on Figs. 10-12, the user can activate a display option which lists the coordinates of the pins in the order that they will be placed. The user can, in addition, select an option to have the pins sequentially appear on the board area 120 in the order in which they will be placed on the board.

After the selected positions have been entered using the screen displays of Figs. 10-12, or by importing location information from an external file, the user can activate optimization modules of the software in order to reduce the time spent by the apparatus in placing pins by reducing the distances that the placement head 60 must move during a placement operation. For example, where there are a group of pins arranged near each other on the board from left to right, the left-hand location would be filled with a pin in the left-hand plunger 66, the adjacent location would be filled by a pin from the

adjacent plunger 66, and so on, thus minimizing the travel of placement head 60 needed between placing pins. If the pins are to be placed on the board 10 at 0.4" center-to-center spacing (the same center-to-center spacing of pins in plungers 66) or multiples of this up to five, then appropriate plungers 66 are activated at the same time. The optimization modules also take into account the location of load station 26 to minimize distance traveled in taking six pins from the load station, depositing them on the table, and returning to the load station; e.g., placement head 60 will begin or end a sequence of placing six pins at a location closest to load station 26 so that, in general, the apparatus would stop at the closest pin first and thereafter head away from station 26 or head back toward the station as it deposits pins and stop at the closest pin last. Before running, the computer verifies the validity of pin coordinates via a boundary check to confirm that pins are not specified for placement in areas in which pins cannot be placed owing to constraints of the placement equipment, an overlap check to confirm that pins are not specified for placement in overlapping areas, and a total number of pin check to confirm that a maximum pin limit is not exceeded by the specified pins.

Referring to Fig. 13, there is shown the screen display used when the user is ready to place pins. This display includes View button 148, Begin button 150, board area 152, and data window 154. View button 148 causes pins to be sequentially shown on board area 152 in the order in which they will be placed on the board 10 by the apparatus. The Begin button 150 causes the apparatus to begin its placement procedure. As the pins are placed, they are displayed on board area 152, and the coordinates of the pins being displayed are shown along with the elapsed time, the percentage placed, and the numbers that

have been placed. The user can select to run in the Continuous mode in which the apparatus runs at full speed to place the pins in the optimum minimum time. The user can also select to run in the Step mode in which the apparatus is advanced one step at a time and stops, and the user must initiate the next step. The Step mode permits the user to view the placement procedure for trouble shooting and educational purposes.

Referring to Figs. 1 and 9, in operation, tray 28 is loaded with pins 20 while the biasing mechanisms 36 are in retracted positions. All fifteen slots 34 are filled with pins, and tray 28 is loaded onto support apparatus 30. (On Fig. 1, tray 28 is shown only partially filled.) Spring biasing mechanisms 36 are then released. Tray 28 is indexed on support 30 to position a row of pins in a slot 34 for movement into bridge 46. At this time the cartridge gate 51 on the front of the support 30 is opened. Load station 26 stays in the delivery position shown in Fig. 1 when pins are being placed by placement head 60 as well as when pins are being picked up from load station 26 by head 60. Pins are automatically biased across the bridge into load station 26, while comb 54 is in the retracted position shown in Fig. 3. When there are no more pins in a slot 34, cartridge gate 51 is closed, and tray 28 is indexed on support 30 to the next slot 34 containing pins.

At this time, all bases 21 of pins 20 are adjacent to each other. Sensor 61 confirms the presence of first pin 20. Cylinder 56 then pushes comb 54 forward, and teeth 58 separate bases 21 of pins 20 by the proper distance for pick up by placement head 60. Sensor 63 confirms that comb 54 is forward, thus separating pins 20 in bridge 46 from pins 20 in load station 26. The carriage 22 is then moved over load station 26, and spacing assembly 48 of load station 26 is raised so that

the shafts 23 of pins 20 are inserted into bores 84 of plungers 66. Bridge 46 remains in its lowered position, and a plate extending downward at the end of comb 54 blocks pins from leaving bridge 46. As load station 26 is raised, roof 59 automatically retracts to completely expose the bases 21 of pins 20 (Fig. 4). Comb 54 is then retracted, and load station 26 is lowered. Roof 59 automatically closes after clearing bases 21 of pins 20 engaged by placement head 60. The use of roof 59, the overhanging portions over slots 34, and the overhanging portions on bridge 46 act to contain pins 20 at all times. Vacuum is applied to allow sensing by sensor 96 to verify pin engagement. O-ring 19 on pin shaft 23 aids in sealing for vacuum sensing and also guarantees pin retention even with loss of vacuum.

With the pins all engaged by placement head 60, head 60 is moved by frame 24 in the Y direction and by carriage 22 in the X direction until the pin 20 to be ejected first is in the desired position over rigid table 16. At this time, pressure is applied by blow-off valve 90 to supply hose 72. The pressure causes plunger 66 to be extended to the phantom position shown in Fig. 6, at which time the opening 82 is aligned with the lower portion of by-pass 88. Pressure is communicated through by-pass 88 from the chamber at the top of the plunger through the by-pass and through the opening 82 to bore 84 in plunger 66. This causes the pin to be ejected from plunger 66 with the O-ring 19 clearing the bottom of plunger 66, and the magnetic base 21 being securely attracted to rigid metal table 16. At this time, blow-off valve 90 is moved to the vacuum position, and the plunger is raised to the retracted position (by spring 70 and vacuum) while the pin remains below on table 16.

Fig. 5 shows placement head 60 after the left-hand most pin has been deposited in the desired position on

table 16. The adjacent plunger 66 has been lowered and is ejecting pin 20 via continued application of pressure through bore 84 within plunger 66. Placement head 60 is moved to desired locations to place the remaining pins in plungers 66, and then returns to load station 26 to pick up six more pins for placement.

After all pins have been placed at the desired positions, the circuit board 10 is moved over tractor mechanisms 12 and 14 to the desired location and supported on pins 20 by lowering of the board relative to table 16. When it is desired to change the pattern of pins, they are cleared from the upper surface of rigid table 16 via sweeper 110 attached to the squeegee (not shown) for the screen printing operation. Table 16 is first rotated 90°, and edge tractor mechanisms 14 are moved to be spaced from each other by 6" before sweeper 110 (just under 6" wide) is lowered to just above table 16 and moved in the Y direction toward container 112, which is raised to be even with table 16. The cleared pins 20 are collected in container 111. Sensor 113 detects the presence of container 111, and sensor 112 detects when container 111 is full with pins.

Other embodiments

Other embodiments of the invention are within the scope of the following claims. E.g., the vision could scan a board to identify locations of the components, and board area 120 could indicate locations of components to assist in determining where to place pins.

What is claimed is:

1. Pin placement and support apparatus for a circuit board comprising

a rigid support table having a flat upper support surface,

a supply of pins having upright shafts and bases that can support said pins on said support surface,

a pin placement head operable to engage pins in said supply and to release them on said flat upper surface, and

an X-Y transporter that moves said pin placement head relative to said table so as to place said pins at desired and variable locations on said table.

2. The apparatus of claim 1 wherein said transporter moves said pin placement head.

3. The apparatus of claim 1 wherein said transporter moves said table.

4. The apparatus of claim 2 wherein said X-Y transporter includes an elongated frame that is aligned with an X-axis and is movable along tracks aligned with the Y-axis, and a carriage that is movable along said frame, and wherein said pin placement head is carried on said carriage.

5. The apparatus of claim 1 wherein said carriage also carries a camera.

6. The apparatus of claim 1 wherein said pin placement head carries a plurality of pins.

7. The apparatus of claim 1 further comprising a sweeper that is movable over said surface to sweep pins therefrom.

8. The apparatus of claim 1 wherein said bases are magnetic.

9. The apparatus of claim 1 wherein said pin placement head has a plunger movable between a raised position for transport by said transporter over said board and a lowered position for placement of a pin at a desired location on said table.

10. The apparatus of claim 1 wherein said placement head has a bore for receiving a said shaft of a said pin and further comprising a vacuum source connected to said bore via a fluid path to retain said shaft in said bore.

11. The apparatus of claim 10 further comprising a vacuum sensor connected to said fluid path to detect the presence or absence of said shaft in said bore.

12. The apparatus of claim 10 further comprising a source of compressed air connected to said fluid path to eject said pin during placement.

13. The apparatus of claim 12 wherein said pin placement head has a plunger movable between a raised position for transport by said transporter over said board and a lowered position for placement of a pin at a desired location on said table, and wherein said bore is in said plunger.

14. The apparatus of claim 13 further comprising a source of compressed air connected to said fluid path to eject said pin during placement.

15. The apparatus of claim 14 further comprising a vacuum sensor connected to said fluid path to detect the presence or absence of said shaft in said bore.

16. The apparatus of claim 14 further comprising a valve on said fluid path operable to selectively connect said source of compressed air or said vacuum source to said bore.

17. The apparatus of claim 13 wherein said placement head includes a block defining a chamber in which said plunger is sealably mounted for movement into and out of said chamber, and wherein said fluid path communicates with said chamber to move said plunger to said lowered position by said source of compressed air.

18. The apparatus of claim 17 further comprising a vacuum sensor connected to said fluid path to detect the presence of said shaft in said bore, and wherein said plunger has a side opening to said bore near the top of said bore that is aligned with a side passage in said block when said plunger is in said raised position, and further comprising a first by-pass passage from said side passage to said fluid path, and a check valve along said by-pass passage for vacuum only communication in said raised position to sense the presence or absence of said shaft in said bore.

19. The apparatus of claim 17 wherein said plunger has a side opening to said bore near the top of said bore and a seal around the top of said plunger to the chamber above said side opening, and wherein said block has a by-pass passage that communicates pressure in said chamber from above said plunger, when in said lowered position, to said side opening of said bore to

eject said pin after said plunger has been moved to said lowered position.

20. The apparatus of claim 1 wherein said supply of pins is remote from said pin placement head and includes a load station that presents said pins for pick up by said pin placement head.

21. The apparatus of claim 20 wherein said pin placement head carries a plurality of pins in a fixed pattern with respect to each other, and said load station presents said pins in said pattern.

22. The apparatus of claim 21 wherein said pins are presented for pick up as a row of pins spaced from each other, and wherein said load station includes a comb that has teeth that move between pins supplied to said load station contiguously in order to separate said pins at the proper spacing.

23. The apparatus of claim 20 wherein said supply is provided by a removable tray that has a plurality of slots for arranging said pins into rows that are aligned, one at a time, with said load station, and further comprising a tray support on said apparatus for receiving said tray.

24. The apparatus of claim 23 wherein said tray includes a spring biasing mechanism for each row of pins.

25. The apparatus of claim 24 wherein said tray support includes an indexer to move said tray to align a new slot with said load station.

26. The apparatus of claim 1 further comprising a computer that generates control signals defining coordinates for placement of said pins at said desired and variable locations, said computer having a monitor and a user input device to enter data to define selected locations for placement of pins, said computer being programmed to display a board area of said table and pins at said selected locations on said table within said board area.

27. The apparatus of claim 26 wherein said computer is programmed to display a cursor on said monitor, to add a pin to said board area at a cursor location upon activation of said user input device, and to create control signals to define coordinates for said added pin by said computer.

28. The apparatus of claim 27 wherein said computer is programmed to respond to user inputs to display a grid of perpendicular lines on said board area, to place pins at the intersections of the lines on said display, and to create control signals defining the coordinates for said pins at said intersections.

29. The apparatus of claim 27 wherein said control signals define the order in which said pins will be placed on said board, and wherein said computer is programmed to display the coordinates of the selected pins in the order of placement on the board, and to receive inputs to redefine the order of placement.

30. The apparatus of claim 27 wherein said computer is programmed to sequentially add to said board area on said monitor selected pins in the order in which said control signals define placing them on said board.

31. A pin placement apparatus comprising

a block defining a chamber having a first opening at or near the top for connection to a fluid path and a second opening at the bottom,

a plunger sealably mounted for movement through said second opening into said chamber to a raised position and out of said chamber to a lowered position for placement of a pin,

said plunger having a central bore that extends upward from the bottom of said plunger to a side opening,

a seal around the top of said plunger to said chamber above said side opening,

a fluid path connected to said first opening, and

a source of compressed air connected to said fluid path to move said plunger from said raised to said lowered position,

said block having a first by-pass passage that communicates pressure in said chamber from above said plunger, when in said lowered position, to said side opening of said bore to eject said pin after said plunger has been moved to said lowered position.

32. The apparatus of claim 31 wherein said block has a side passage that is aligned with and communicates with said side opening to said bore when said plunger is in said raised position, and further comprising

a second by-pass passage from said side passage to said fluid path,

a check valve along said second by-pass passage for vacuum only communication, and

a vacuum sensor and vacuum source connected to said fluid path to detect the presence or absence of said shaft in said bore when said plunger is in said raised position.

33. The apparatus of claim 32 further comprising a valve on said fluid path operable to selectively connect said source of compressed air or said vacuum source to said bore.

34. A method of creating a support for a circuit board comprising

providing a rigid support table having a flat upper support surface and a supply of pins having upright shafts and bases that can support said pins on said support surface,

generating control signals defining coordinates for placement of said pins at desired and variable locations on the table using a computer, and

placing said pins on said upper surface at said desired and variable locations on said table with a pin placement head in response to said control signals.

35. The method of claim 34 wherein said placing includes moving said pin placement head over said table to said desired and variable locations.

36. The method of claim 34 wherein said placing includes moving said table under said pin placement head to place said pins at said desired and variable locations.

37. The method of claim 35 wherein said pin placement head is carried on a carriage that is movable along an elongated frame along an X-axis, and said frame is movable along tracks aligned with a Y-axis, and wherein said placing includes moving said frame and said carriage to place said pins at said desired and variable locations.

38. The method of claim 34 wherein said placing includes lowering a plunger carried on said pin placement head and ejecting said pin from said plunger.

39. The method of claim 37 wherein said supply of pins is at a load station that is remote from said pin placement head, and further comprising moving said pin placement head to said load station and picking up pins to be placed on said table.

40. The method of claim 34 wherein said generating includes displaying on a screen display of a monitor connected to said computer a board area of said table and pins at selected locations on said table within said board area.

41. The method of claim 40 wherein said generating includes entering data with a user input device to define said selected locations.

42. The method of claim 41 wherein said generating includes adding pins to said display by moving a cursor on said screen display to desired locations within said board area and selecting said desired locations with said user input device, and creating coordinate signals for added pins by said computer.

43. The method of claim 42 wherein said generating includes removing pins from said display by moving a cursor on said screen display to a said pin and selecting that pin for removal with said user input device.

44. The method of claim 42 wherein said screen display displays the values of the coordinate position of said cursor as said cursor is moved.

45. The method of claim 44 wherein said screen display displays the pin number for the pin that was last selected.

46. The method of claim 40 wherein said generating includes displaying a grid of perpendicular lines on said screen display, placing pins at the intersections of the lines on said display, and creating control signals defining the coordinates for said pins at said intersections.

47. The method of claim 46 wherein said displaying a grid includes changing increments between lines of the grid.

48. The method of claim 47 wherein the increments are different for the X and Y axes.

49. The method of claim 46 wherein said displaying a grid includes displaying said grid in only a portion of said board area.

50. The method of claim 40 wherein said generating includes modifying said display by activating an offset feature to move displayed pins by a defined amount.

51. The method of claim 40 wherein said generating includes modifying said display by activating a copy feature to copy the pins in a user-specified portion of the board are to an additional user-specified

location on said display, and said computer automatically generates coordinate data for copied pins.

52. The method of claim 34 wherein said control signals are generated from data imported from an external source.

53. The method of claim 40 wherein said generating includes modifying said display by activating a clear feature to remove all pins on said display.

54. The method of claim 40 wherein said generating includes modifying said display by activating a zoom feature to enlarge a portion of the display.

55. The method of claim 40 wherein said control signals define the order in which said pins will be placed on said board, said generating includes displaying the coordinates of the selected pins in the order of placement on the board, and further comprising redefining the order of placement.

56. The method of claim 40 wherein said generating includes sequentially adding to said board area on said screen display selected pins in the order in which said control signals define placing them on said board.

57. The method of claim 40 wherein said displaying includes displaying boundaries on said board area defining locations on which pins cannot be placed owing to physical constraints of placement equipment.

58. The method of claim 40 wherein said generating includes viewing a board with a vision system

and indicating locations of components on said board area on said screen display.

59. The method of claim 52 wherein said generating includes verifying the validity of pin coordinates via a boundary check to confirm that pins are not specified for placement in areas in which pins cannot be placed owing to constraints of the placement equipment, an overlap check to confirm that pins are not specified for placement in overlapping areas, and a total number of pin check to confirm that a maximum pin limit is not exceeded by the specified pins.

60. The method of claim 34 further comprising displaying on a screen display of a monitor connected to said computer the board area on said table and the pins as said pins are being placed on said table.

61. The method of claim 34 wherein said placing is operated in a step mode in which apparatus doing the placing moves one step at a time in order to permit evaluation of the placing.

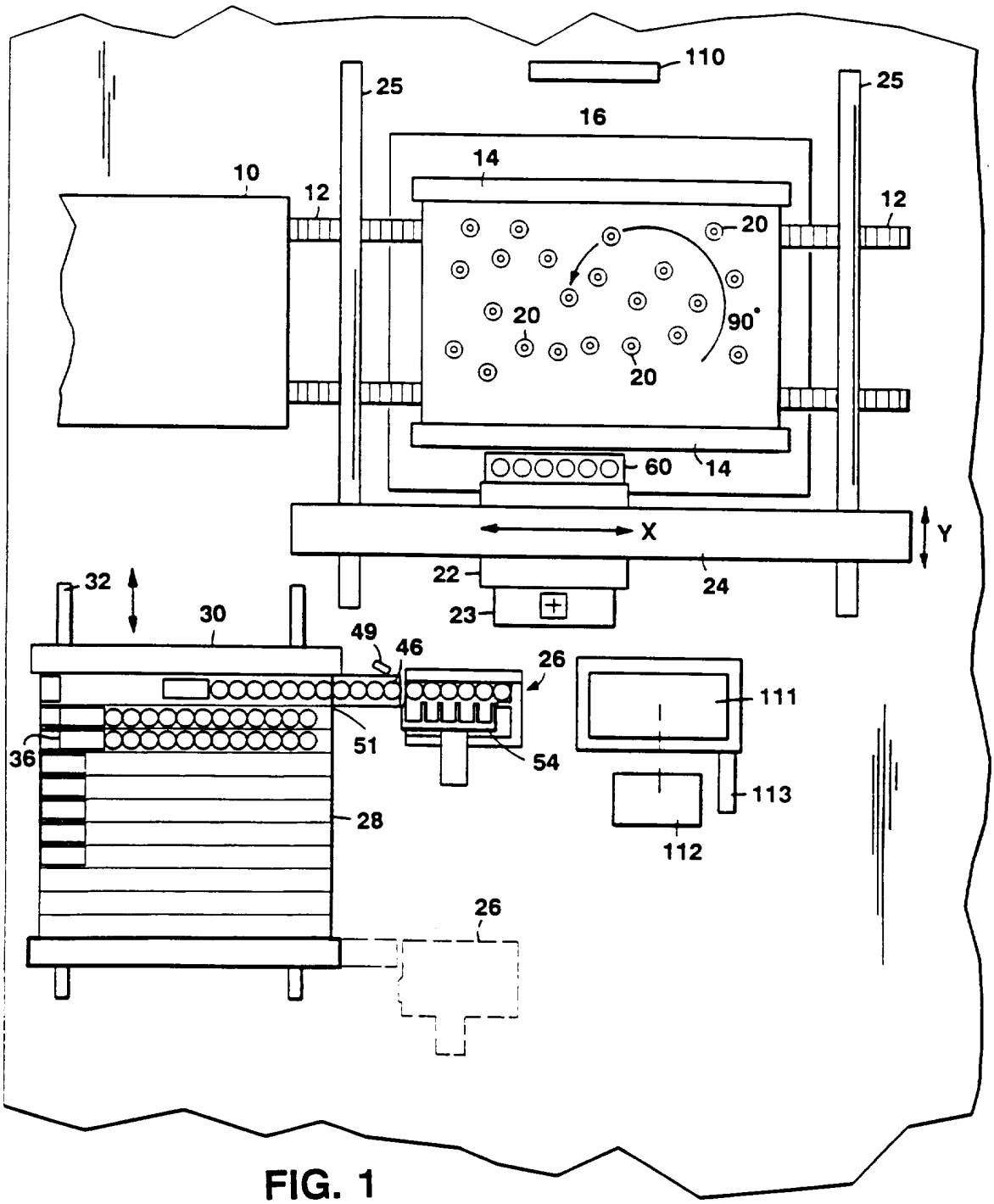

110
25
25
16
14
10
12
12
20
20
90°
20
60
14
X
Y
22
24
23
32
30
49
46
26
111
51
54
36
113
28
112
26

FIG. 1

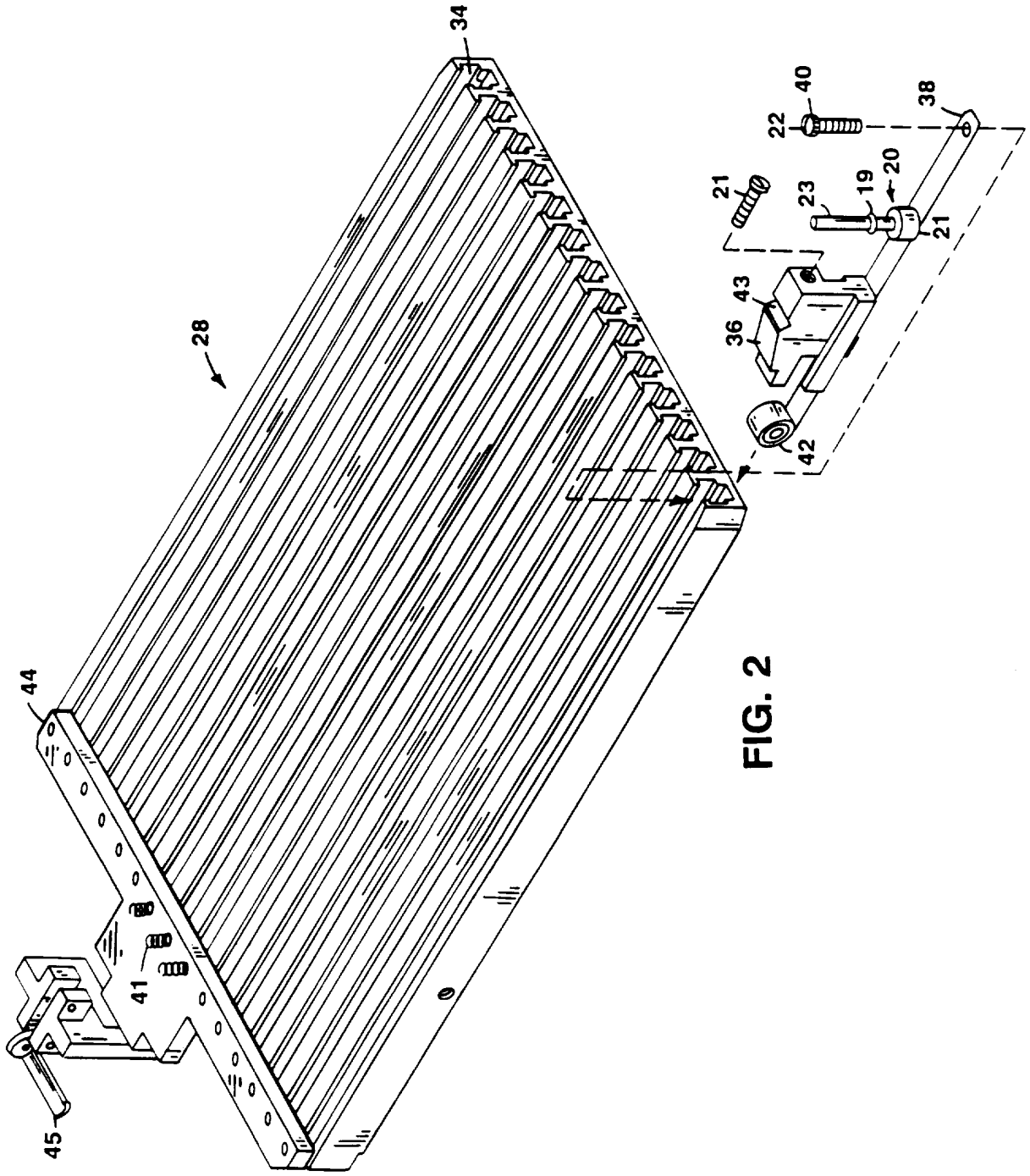


FIG. 2

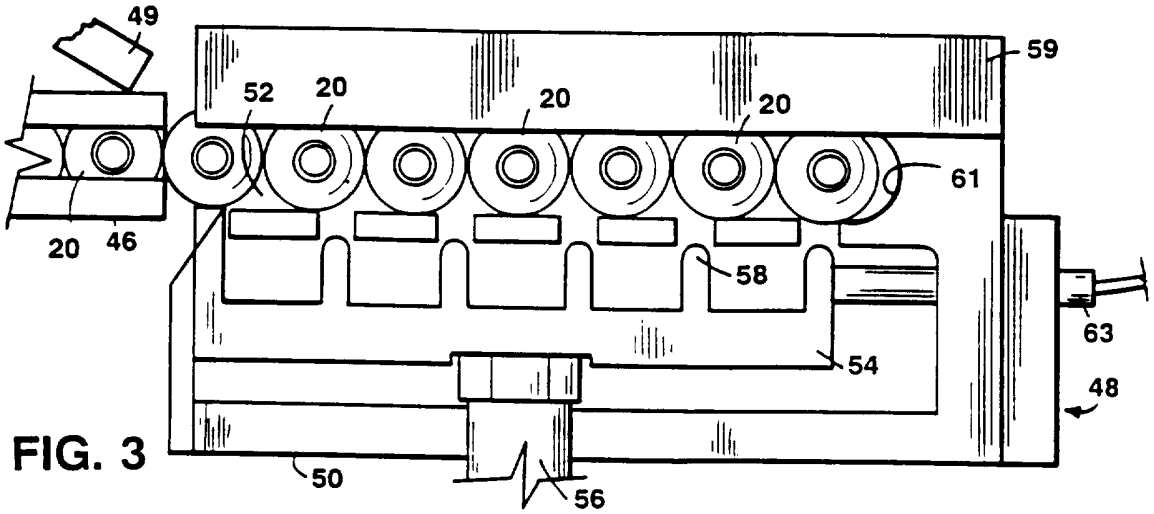


FIG. 3

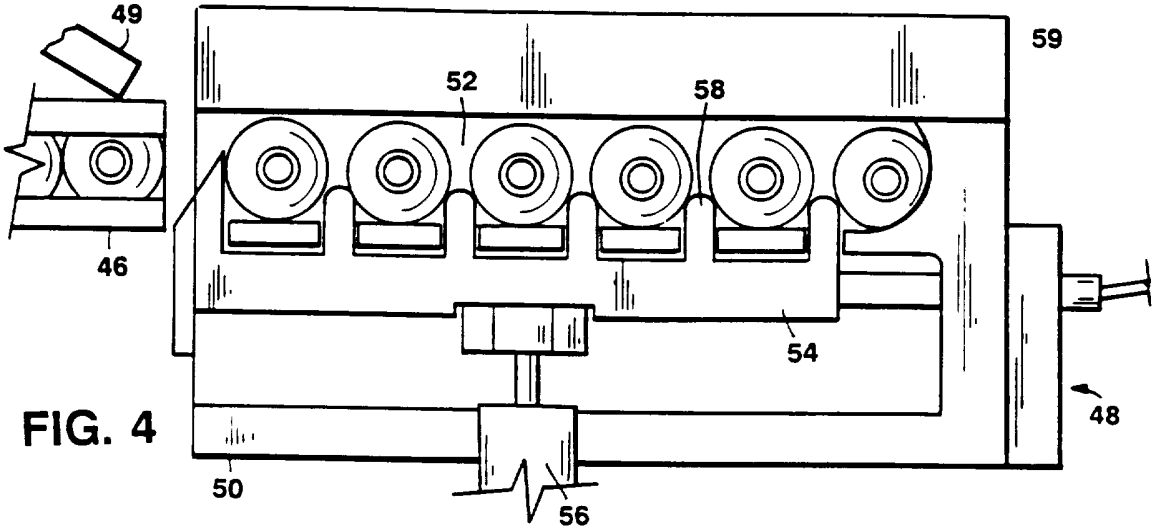


FIG. 4

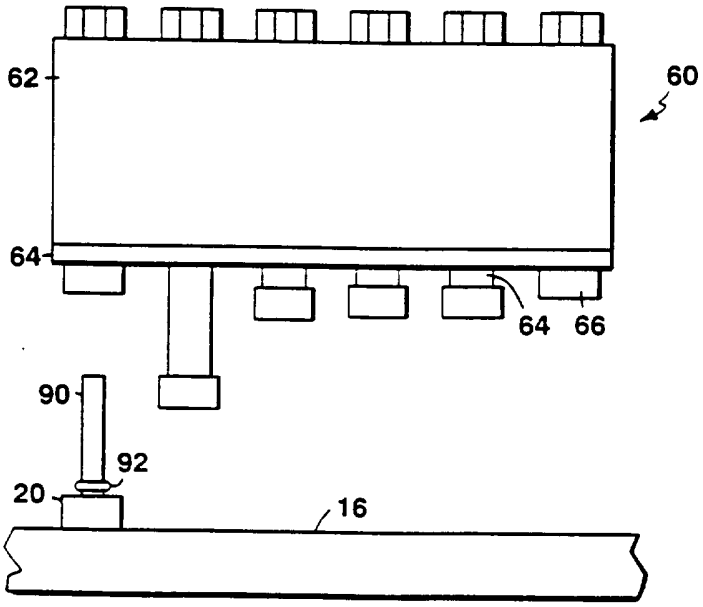


FIG. 5

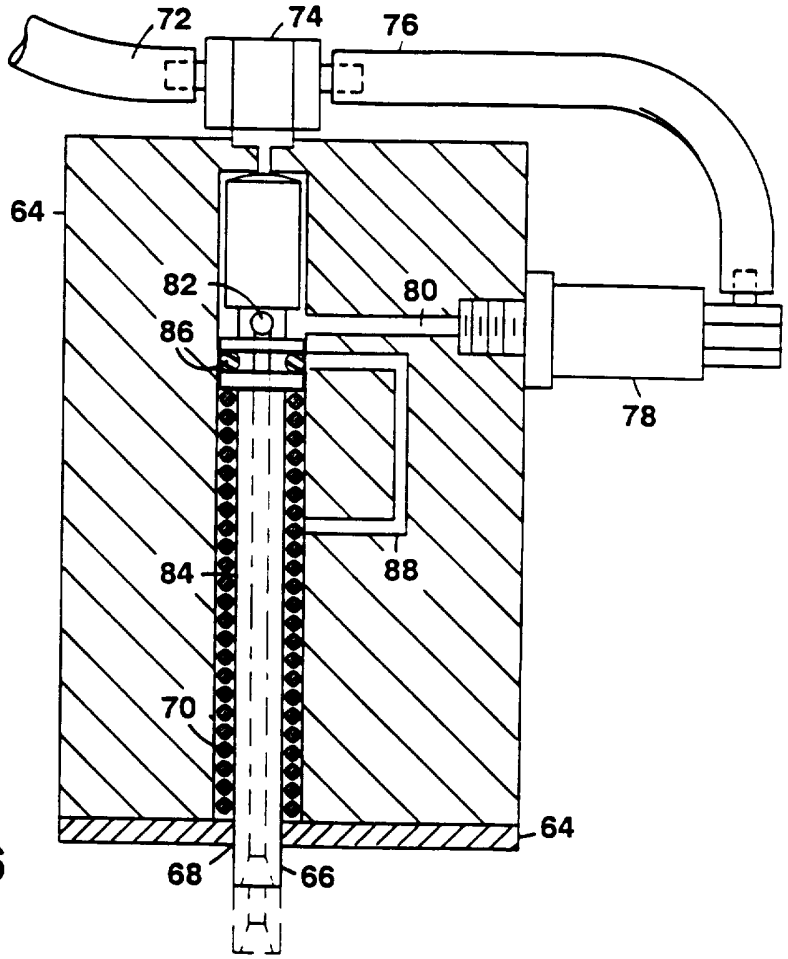


FIG. 6

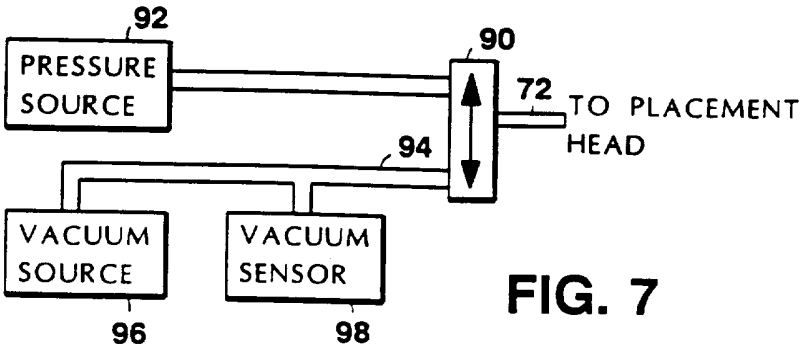


FIG. 7

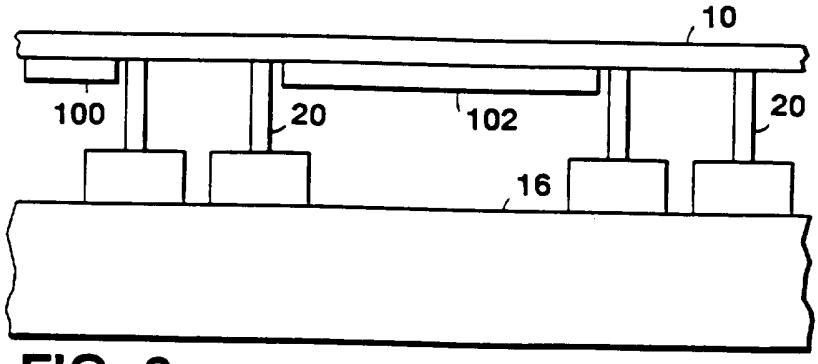


FIG. 8

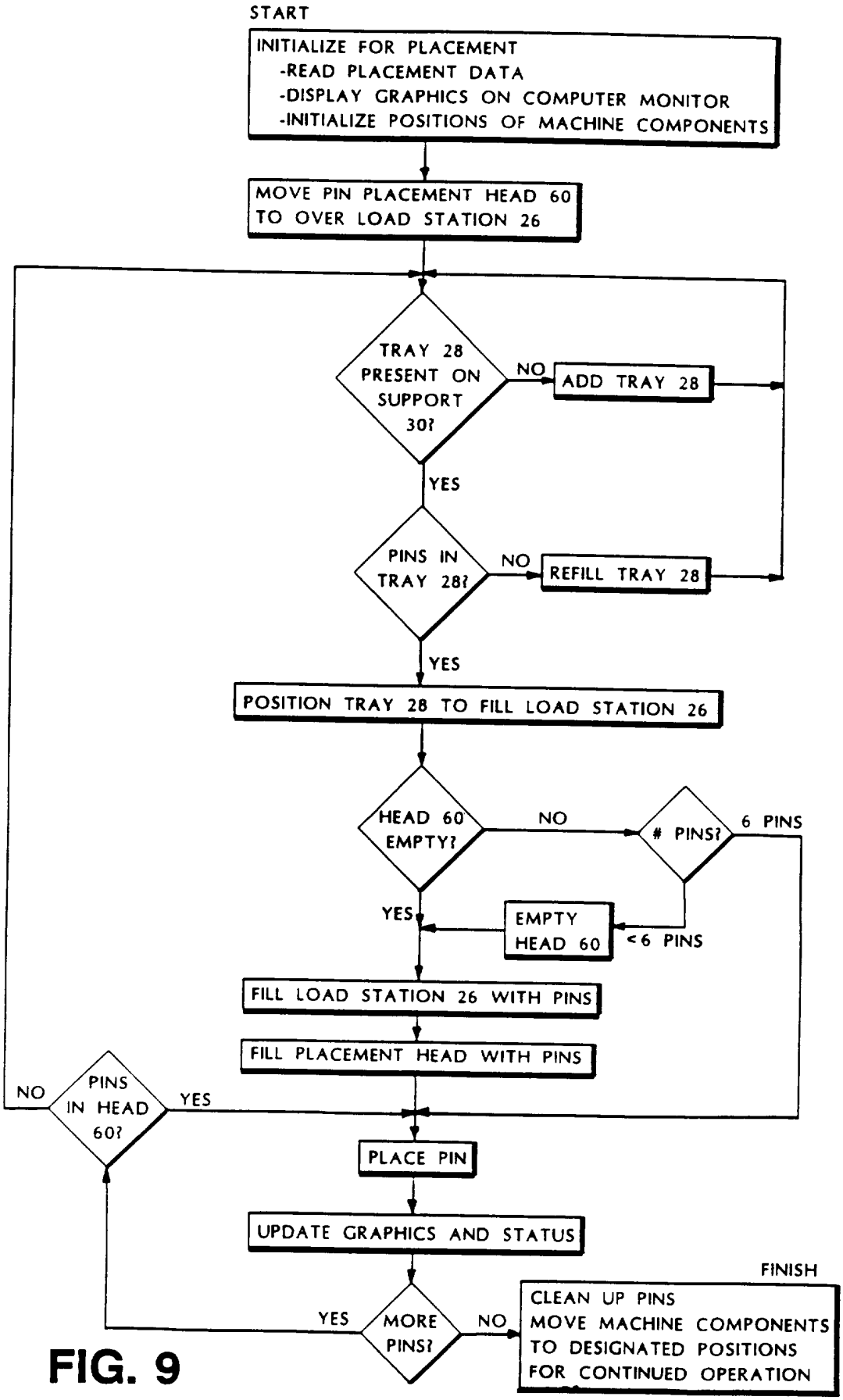

START
INITIALIZE FOR PLACEMENT
-READ PLACEMENT DATA
-DISPLAY GRAPHICS ON COMPUTER MONITOR
-INITIALIZE POSITIONS OF MACHINE COMPONENTS
MOVE PIN PLACEMENT HEAD 60 TO OVER LOAD STATION 26
TRAY 28 PRESENT ON SUPPORT 30?
NO
ADD TRAY 28
YES
PINS IN TRAY 28?
NO
REFILL TRAY 28
YES
POSITION TRAY 28 TO FILL LOAD STATION 26
HEAD 60 EMPTY?
NO
PINS?
6 PINS
YES
EMPTY HEAD 60
< 6 PINS
FILL LOAD STATION 26 WITH PINS
FILL PLACEMENT HEAD WITH PINS
NO
PINS IN HEAD 60?
YES
PLACE PIN
UPDATE GRAPHICS AND STATUS
FINISH
YES
MORE PINS?
NO
CLEAN UP PINS
MOVE MACHINE COMPONENTS TO DESIGNATED POSITIONS FOR CONTINUED OPERATION

FIG. 9

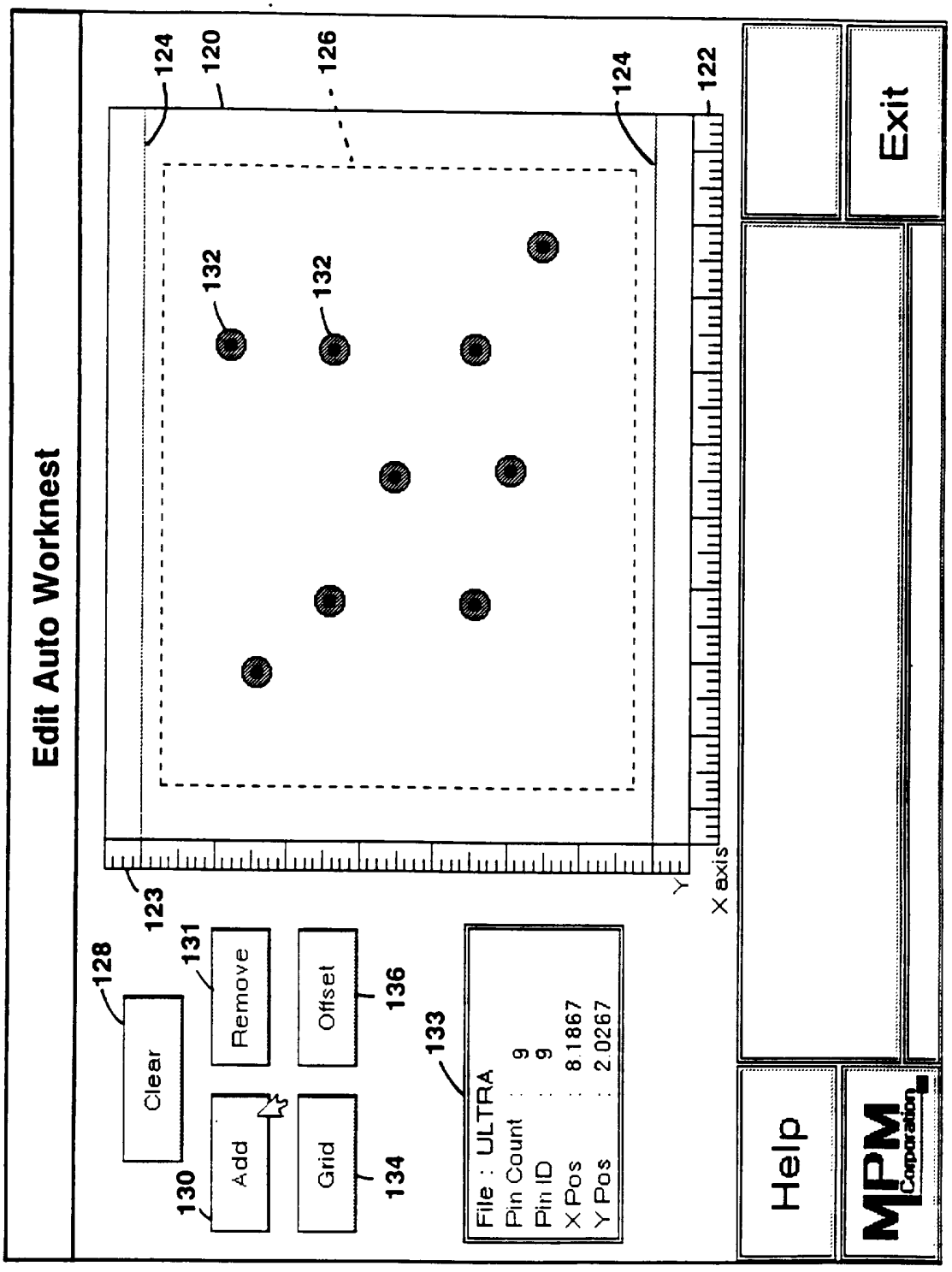

Edit Auto Worknest
124
120
126
124
122
132
132
Exit
Y
X axis
123
128
131
Clear
Remove
Offset
136
133
File : ULTRA
Pin Count : 9
Pin ID : 9
X Pos : 8.1867
Y Pos : 2.0267
Add
Grid
134
130
Help
MPM Corporation

FIG. 10

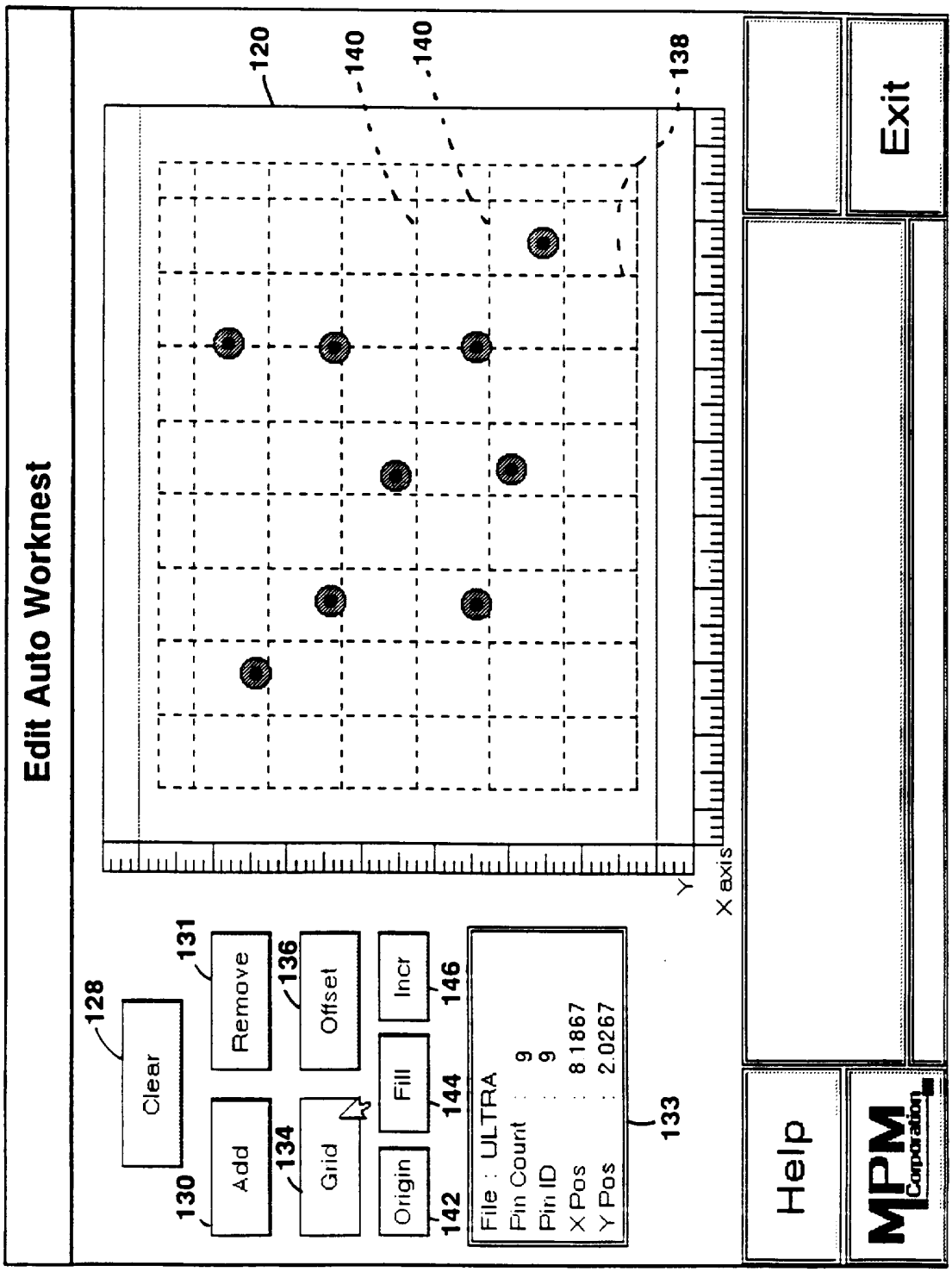

Edit Auto Worknest
120
140
140
138
Y
X axis
128
Clear
131
Remove
136
Offset
130
Add
134
Grid
Origin
142
Fill
144
Incr
146
File : ULTRA
Pin Count : 9
Pin ID : 9
X Pos : 8.1867
Y Pos : 2.0267
133
Help
MPM Corporation
Exit

FIG. 11

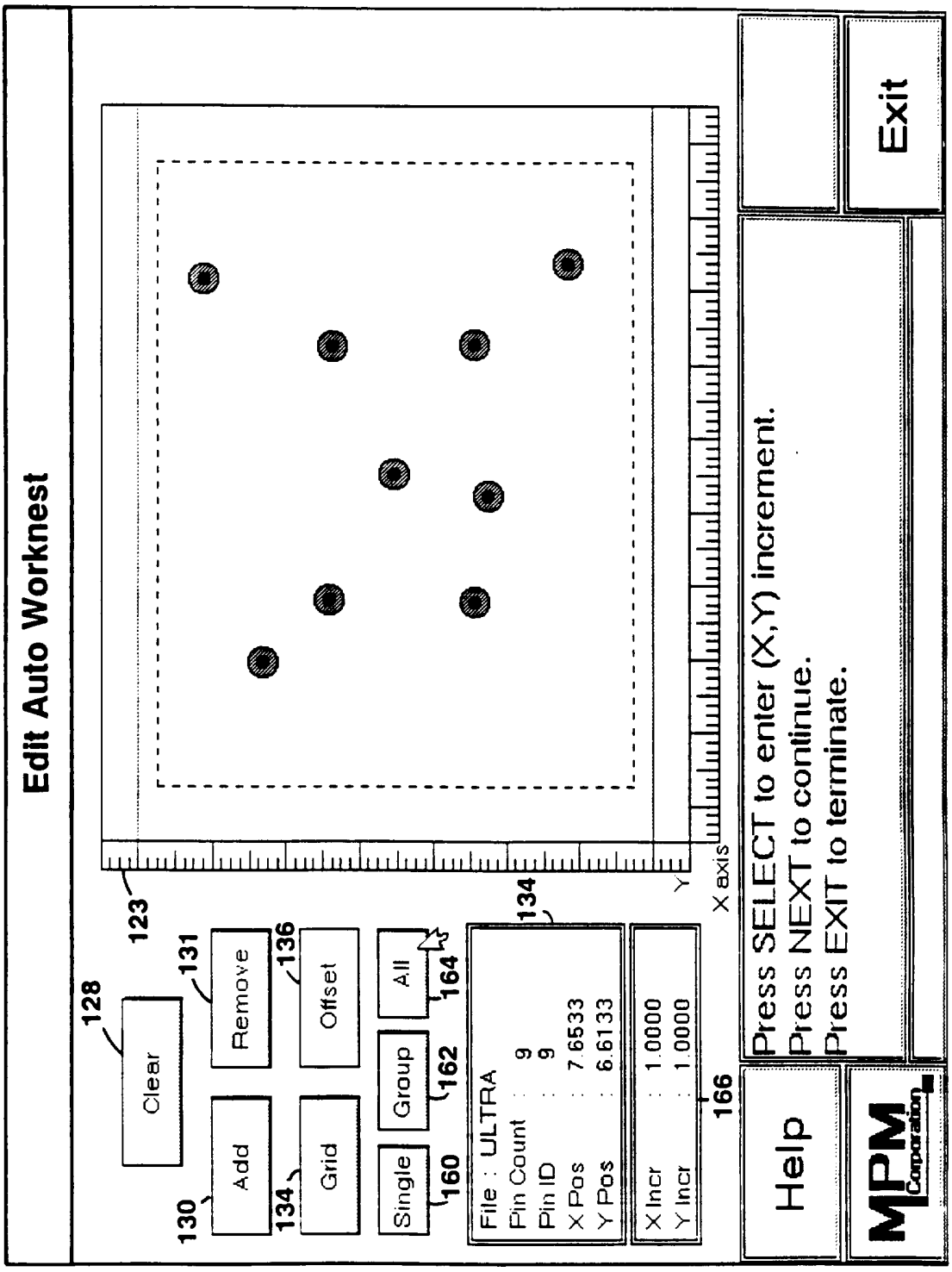

Edit Auto Worknest
Clear
Remove
Offset
Add
Grid
Single
Group
All
File : ULTRA
Pin Count : 9
Pin ID : 9
X Pos : 7.6533
Y Pos : 6.6133
X Incr : 1.0000
Y Incr : 1.0000
X axis
Y
Press SELECT to enter (X,Y) increment.
Press NEXT to continue.
Press EXIT to terminate.
Help
Exit
MPM Corporation
128
131
136
123
130
134
160
162
164
134
166

FIG. 12

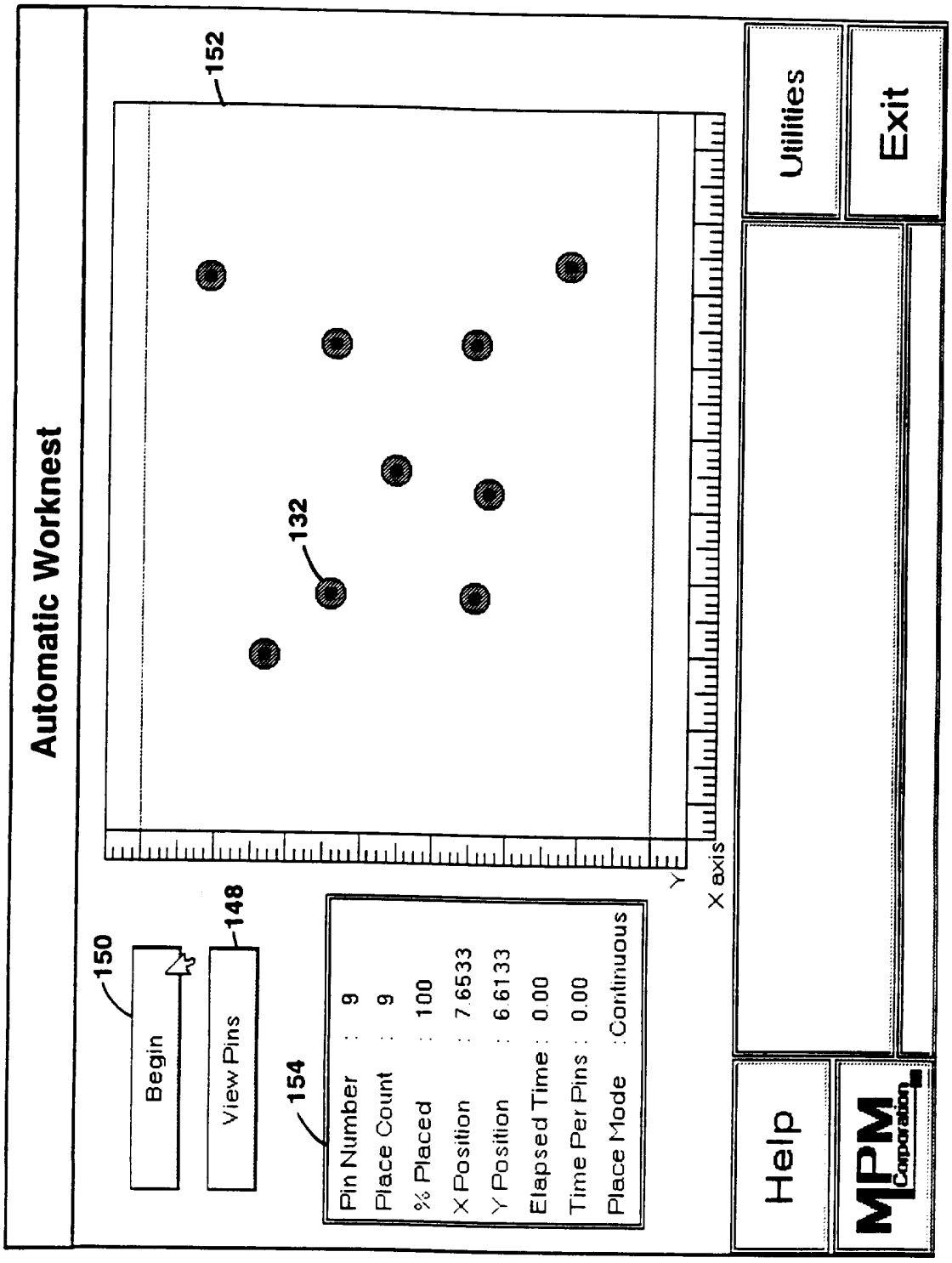

Automatic Worknest
152
132
150
Begin
148
View Pins
154
Pin Number : 9
Place Count : 9
% Placed : 100
X Position : 7.6533
Y Position : 6.6133
Elapsed Time : 0.00
Time Per Pins : 0.00
Place Mode :Continuous
Y
X axis
Utilities
Exit
Help
MPM Corporation

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/02431

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B23P 19/04; H05K 3/30
US CL : 29/703, 739, 743, 744, 833, 842; 414/737
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 29/703, 721, 739, 740, 741, 743, 744, 833, 842; Dig 44; 279/3; 414/737; 752

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

None

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,705,081 (Birk et al) 10 November 1987. See the entire reference.	1-61
A	US, A, 4,951,383 (Amao et al) 28 August 1990. See the entire reference.	1-61
X --- Y	US, A, 5,218,753 (Suzuki et al) 15 June 1993. See the entire reference.	1-17, 20-21, 23, 34-39, 52 and 61 --- 40-41, 50-58, 60
Y	US, A, 5,456,001 (Mori et al) 10 October 1995. See the entire reference.	40-41, 60

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier document published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 05 JUNE 1996	Date of mailing of the international search report 27 JUN 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer for PETER VO Sheila Veney Paralegal Specialist Group 3200 Telephone No. (703) 308-1789

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/02431

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 5,457,874 (Yonezawa et al) 17 October 1995. See the entire reference.	1-61

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/02431

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/02431

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

Group I: Claims 1-33, drawn to a pin placement and support apparatus.
Group II: Claims 34-61, drawn to a method of creating a support for a circuit board.
Group I has the special technical features of moving the pin placement head by the X-Y transporter relative to the table or moving the plunger by the compressed air.
Group II has the special technical features of using a computer to generate control signals defining coordinator at desired and variable locations.
Group I does not have the special technical features of Group II and Group II does not have the special technical features of Group I.