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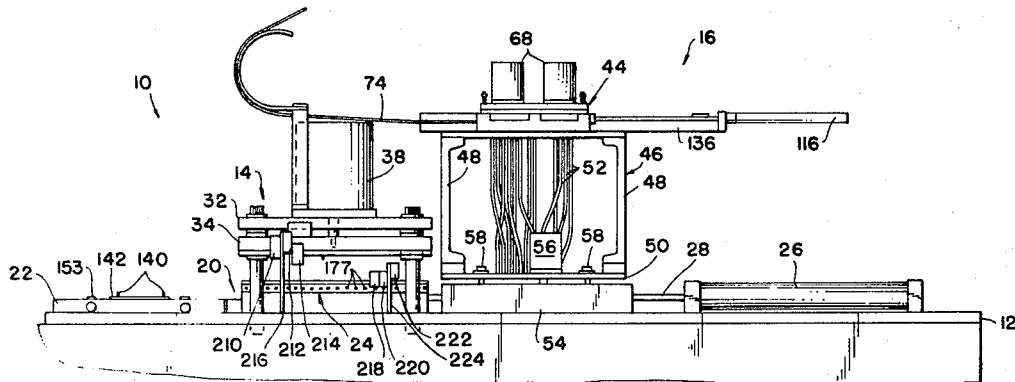
[54] **APPARATUS AND METHOD FOR APPLYING
TERMINALS TO A CIRCUIT BOARD**
23 Claims, 18 Drawing Figs.

Primary Examiner—Thomas H. Eager
Attorney—Thomas Hooker

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29/203
[51] Int. Cl.:..... **H05k 3/30,**
H05k 13/04
[50] Field of Search..... 29/203,
626, 203 (B), 203 (DT), 203 (V), 604

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ABSTRACT: Apparatus and method for simultaneously mounting a plurality of terminals on a circuit board. The terminals are severed from a carrier strip, individually conveyed to a transfer plate so that the plate holds the terminals in the same pattern in which they will be attached to the circuit board. The terminals are transferred to the lower face of a ram in the same pattern and are held thereon by parasitic drag resulting from a flow of air past the terminals and into the ram. The ram with the terminals positioned on its lower face is lowered to seat the terminals on the circuit board in the desired pattern and to secure the terminals thereto.



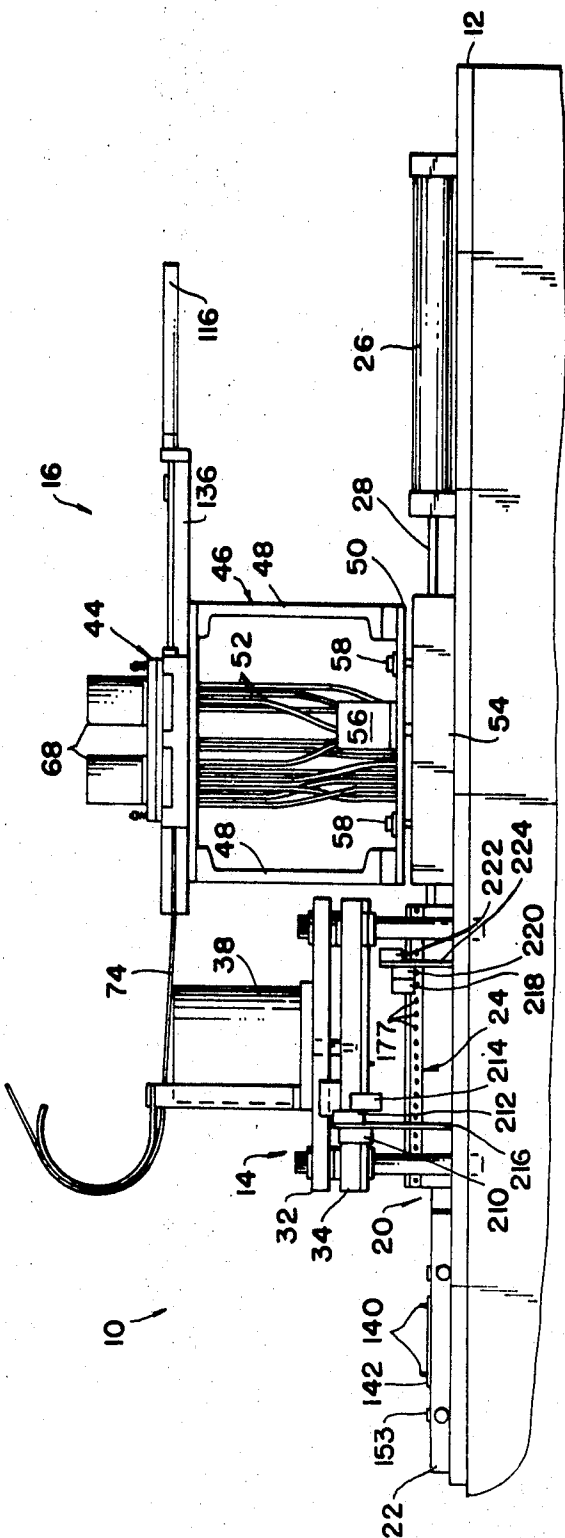


FIG. 1

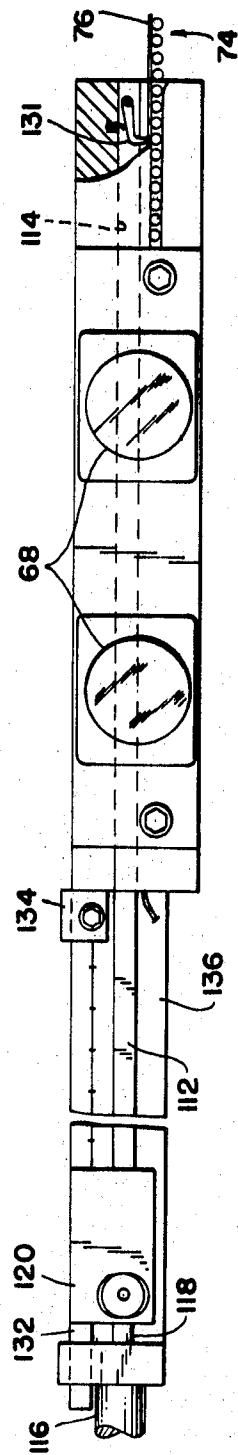
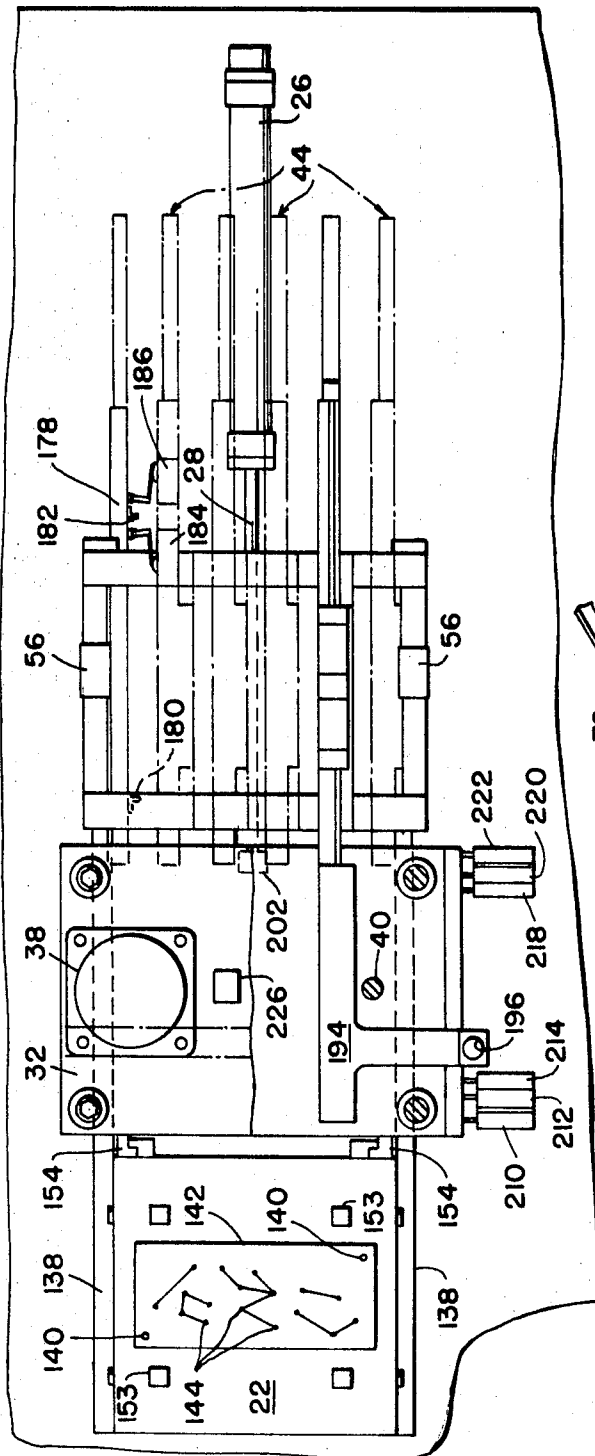
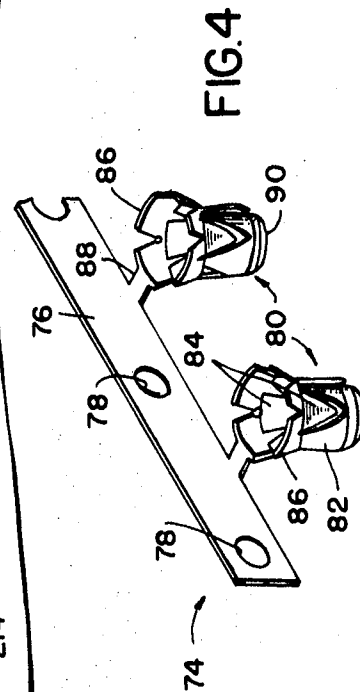


FIG. 5

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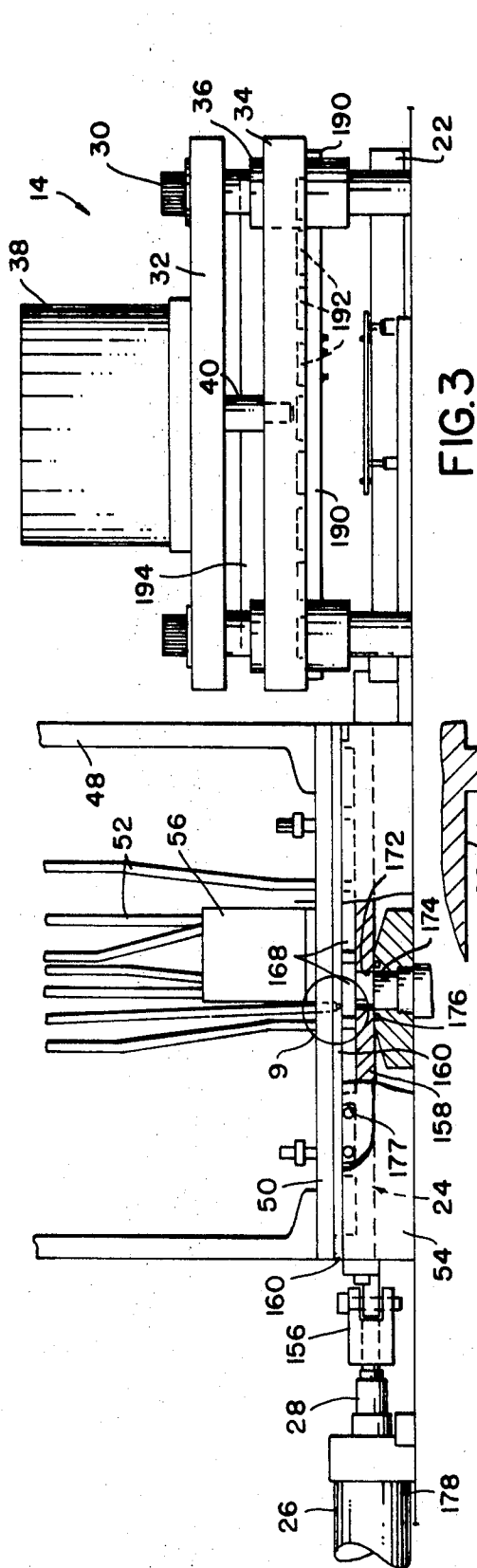


FIG. 3

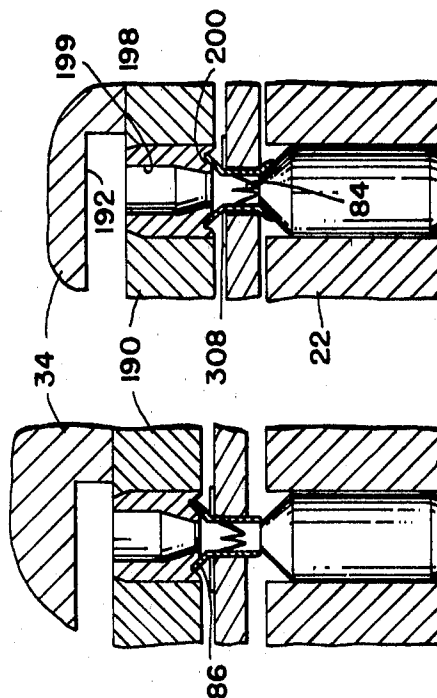


FIG. 13

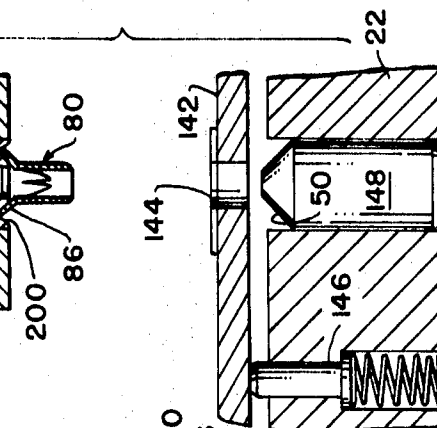


FIG. 12

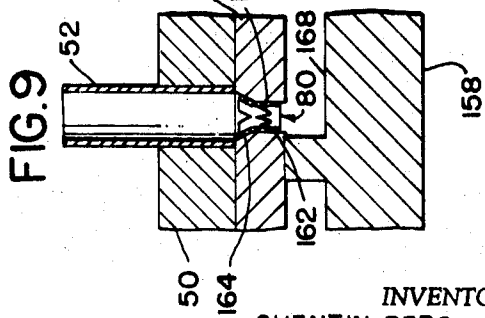


FIG. 9

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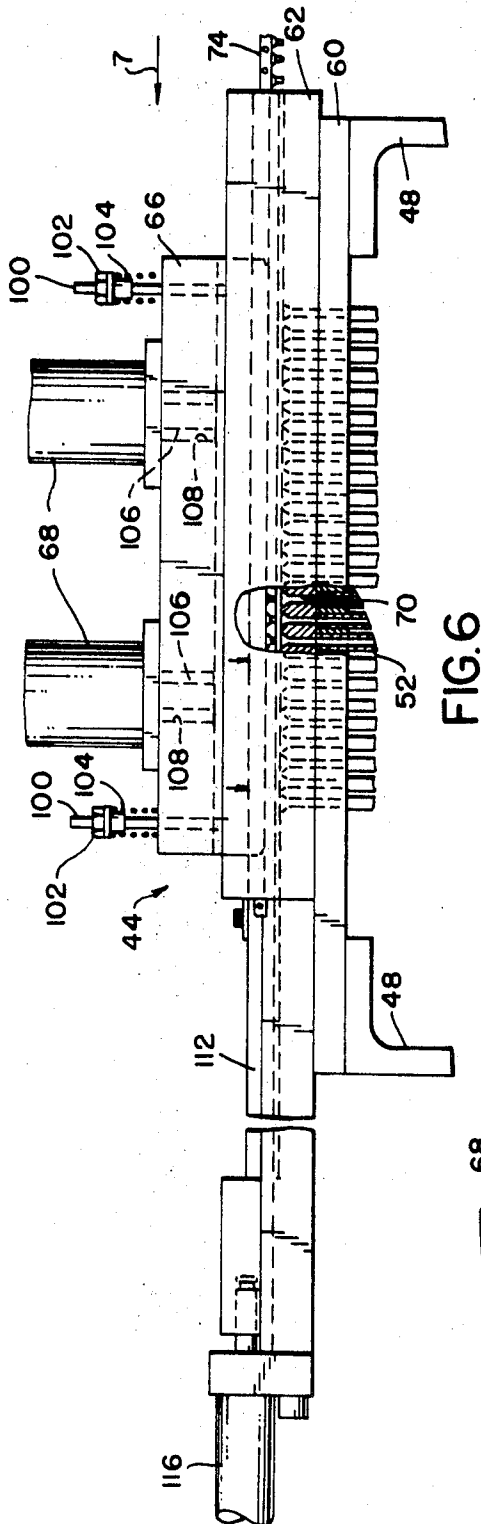


FIG. 6

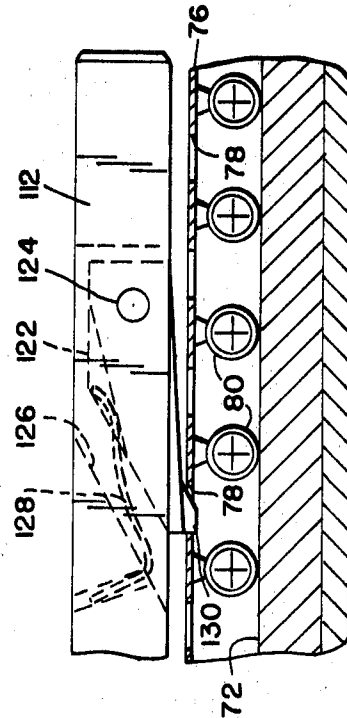


FIG. 7

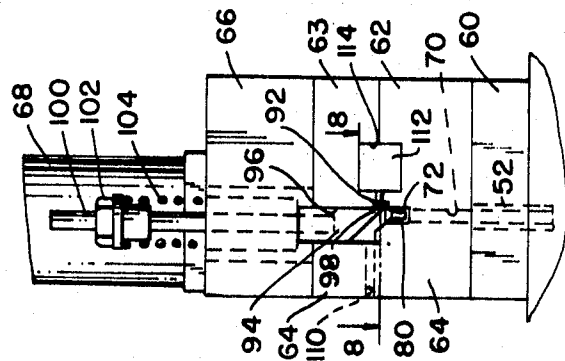


FIG. 8

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FIG. 16

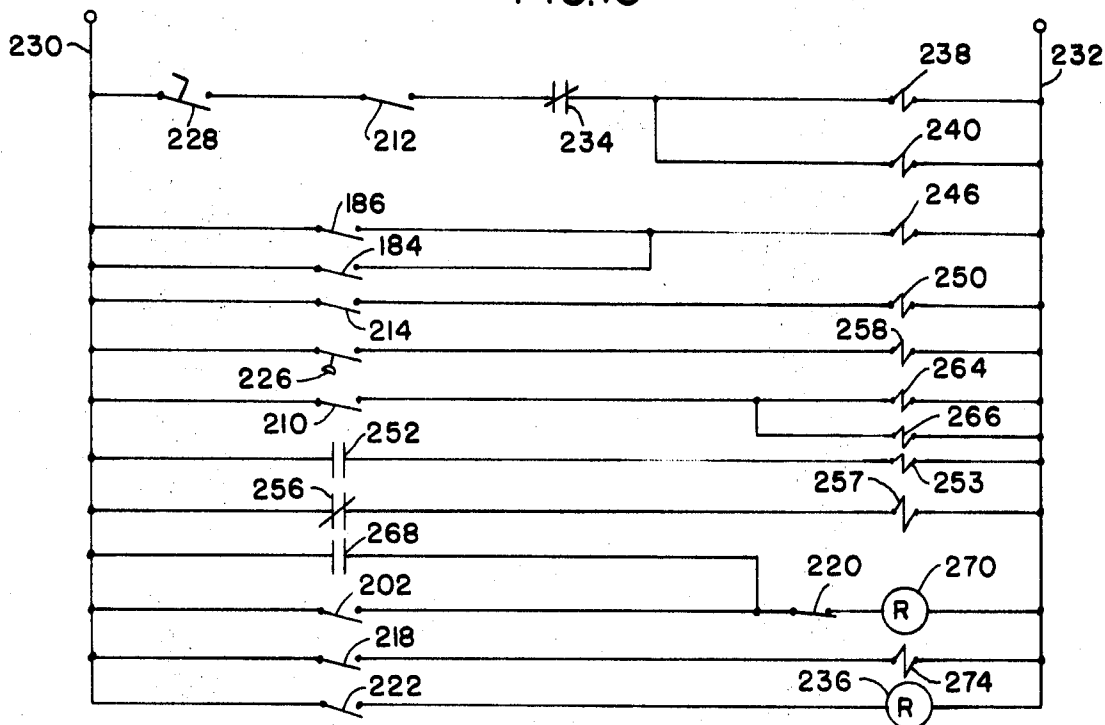
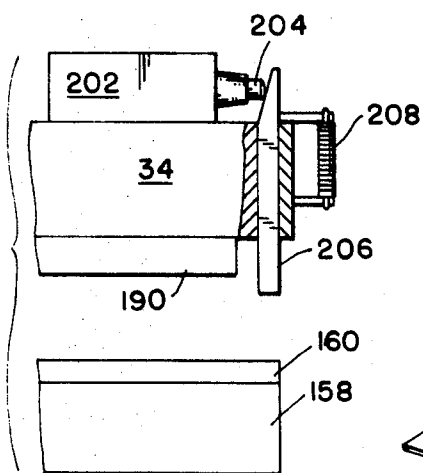


FIG. 10

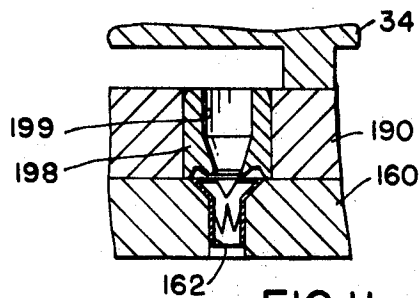


FIG. 11

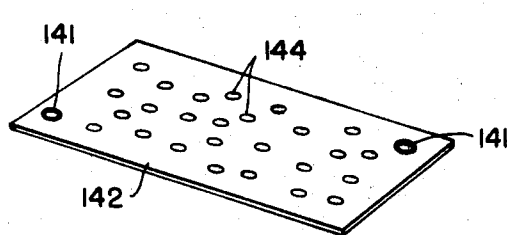
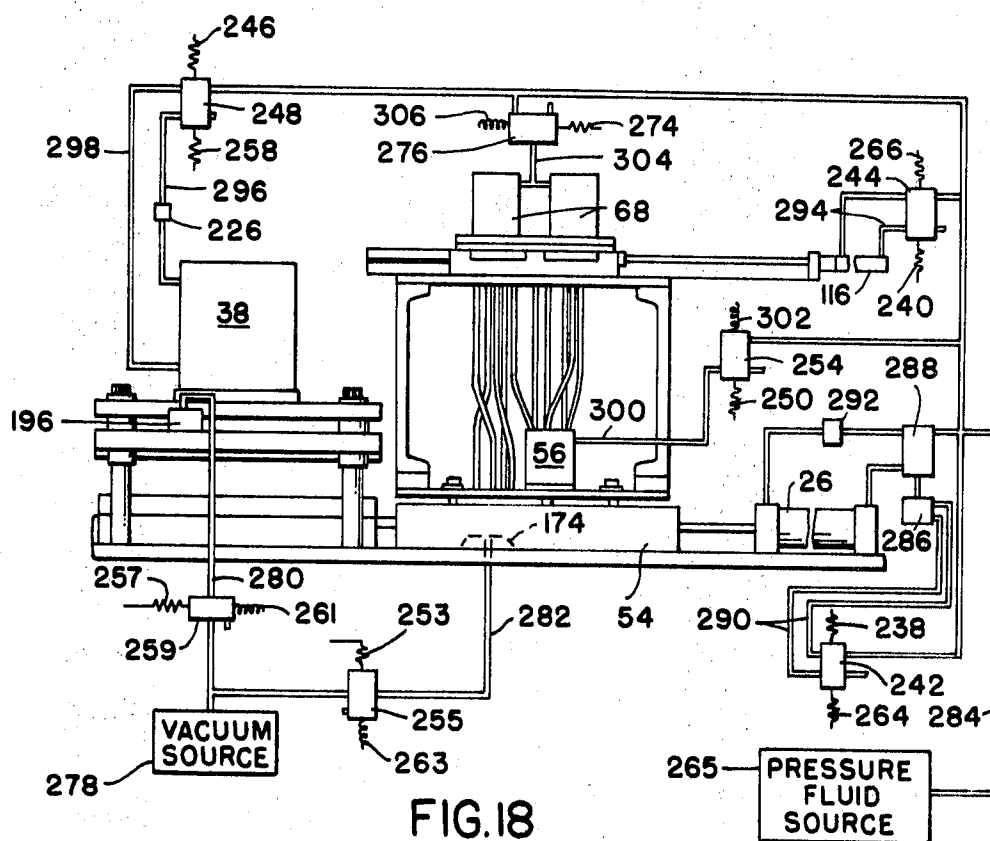
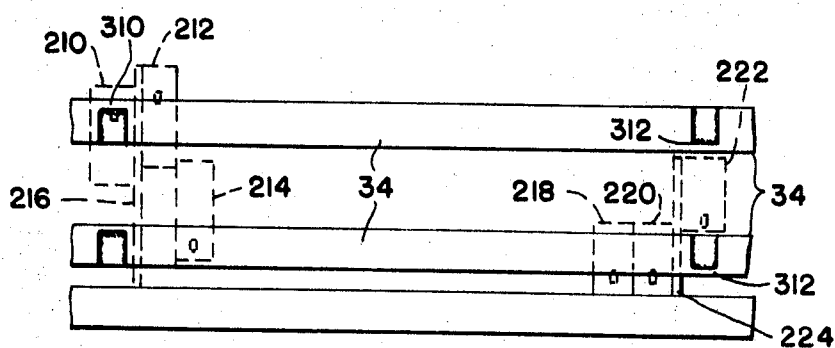


FIG. 15

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APPARATUS AND METHOD FOR APPLYING TERMINALS TO A CIRCUIT BOARD

In the electronics industry it is desirable to attach a large number of terminals to a circuit board in order to facilitate solder connections between circuit elements and the circuit board. Conventionally the terminals are individually mounted in preformed holes in the circuit board through the use of a single head type applicator. Since the circuit board holes are located in random distribution, the operator must position each circuit board hole relative to the applicator so that a terminal is mounted in a hole. There may be a hundred or more terminals to be mounted on a single circuit board in this manner.

The conventional one-by-one mounting of terminals on circuit boards is exceedingly slow, expensive and can be unreliable. While the single head applicator may be rapid in operation, the amount of time required for the operator to present each circuit board hole to the applicator so that a terminal is attached in the hole is large. Additionally, the operator must check to be sure that terminals are applied in each hole where required since failure to mount a single terminal will cause the entire circuit board to be rejected.

The invention relates to an apparatus for simultaneously and reliably attaching a large number of terminals on a circuit board and is particularly useful in mounting eyelet type terminals in preformed circuit board holes. The terminals are supplied in strip form to cutoff units which sever the terminals from the strips so that the terminals fall through drop tubes to terminal receiving recesses in a transport plate. The recesses in the transport plate are arranged in a pattern identical to the pattern of the holes in the circuit board on which the terminals will be secured. Movement of the terminals through the drop tube is facilitated by flowing air through the tubes to carry the terminals from the cutoff to the transport plate.

Following seating of the terminals in the transport plate, the plate is moved to a position beneath a ram and the ram is lowered to rest on the plate. Terminal holding recesses are provided in the ram above each terminal receiving recess in the transport plate. Each holding recess includes a bore extending to a vacuum manifold in the ram so that when the ram is seated on the transport plate and vacuum is applied to the manifold, air flows through the receiving recesses, past the terminals in the recess plate and into the ram. The parasitic drag on the terminals resulting from this flow of air lifts the terminals from the transport plates and holds them against the ram in the terminal recesses. The recesses in the ram are located in the same pattern as the circuit board holes so that the terminals are now positioned on the ram in the pattern of the circuit board holes. The ram is then raised from the transport plate, the plate is moved back to the terminal receiving position and a circuit board is positioned beneath the ram in alignment with the terminals held thereon so that each terminal is located above its respective circuit board hole. The ram is then lowered to seat each terminal in its circuit board hole and, with continued downward movement of the ram, to stake the terminals to the circuit board.

The terminal applicator is rapid in operation and can stake as many as 150 terminals on each of six circuit boards in a minute. This rapidity of operation together with the inherent accuracy of the machine which attaches the desired number of terminals in the desired locations on the circuit board results in a marked saving in time and labor. The tooling of the applicator is easily changed to adapt the applicator to attaching terminals to circuit boards having different patterns of terminal receiving holes therein.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawings, of which there are six sheets, illustrating a preferred embodiment of the invention, wherein:

FIG. 1 is an elevational view of one side of a terminal applicator according to my invention;

FIG. 2 is a partially broken away top view of the terminal applicator;

FIG. 3 is a partially broken away elevational view of the other side of the terminal applicator;

FIG. 4 is a perspective view of a portion of a strip of terminals used by the applicator;

FIG. 5 is a top view of a terminal cutoff unit;

FIG. 6 is a partially broken away side view of the cutoff unit;

FIG. 7 is an end view of a terminal cutoff taken looking in the direction of arrow 7 of FIG. 6;

FIG. 8 is a sectional view taken along line 8-8 of FIG. 6;

FIG. 9 is an enlarged view of that portion of FIG. 3 in circle 9;

FIG. 10 illustrates a mounting of a microswitch on the ram of the terminal applicator;

FIG. 11 is an enlarged broken away view illustrating the transfer of a terminal from the transfer plate to the ram;

FIGS. 12, 13 and 14 illustrate staking of the terminals to the circuit board upon lowering of the ram;

FIG. 15 is a perspective view of a circuit board on which the applicator applies terminals;

FIG. 16 is an electrical diagram of the circuitry of the terminal applicator;

FIG. 17 illustrates the position of certain switches relative to the terminal applicator ram; and

FIG. 18 is a diagram of the pneumatic circuitry of the terminal applicator.

THE TERMINAL APPLICATOR

Terminal applicator 10 is mounted on base 12 and includes a ram assembly 14 located adjacent terminal cutoff and drop-tube assembly 16. A shiftable transfer assembly 20 which includes staking plate 22 and transfer plate 24 is moved from the position shown in FIG. 1 where the transfer plate is located below ram assembly 14 to a position where the staking plate 22 is below the ram assembly and the transfer plate is located beneath the cutoff and drop-tube assembly. The transfer assembly is moved between the two positions by air cylinder 26, the piston rod 28 of which is connected to plate 24.

Ram assembly 14 includes four vertical guideposts 30 which support a fixed upper plate 32. Ram 34 is reciprocally mounted on posts 30 by means of sleeve bearings 36. A pair of air cylinders 38 are mounted on top of plate 32 with piston rods 40 extending through openings in the plate and secured to the ram 34 so that the ram is lowered and raised on posts 30 by extension and retraction of the air cylinders 38.

The terminal cutoff and drop-tube assembly includes a number of terminal cutoff units 44 which are mounted on the top of a drop-tube frame 46. The frame comprises a top member and a pair of side supports 48 which are mounted on bottom plate 50. A plurality of drop tubes 52 extend from each terminal cutoff unit 44 to predetermined locations in plate 50. As many as 25 tubes may extend from a single cutoff unit to plate 50 so as to transport 25 terminals from the cutoff unit to desired locations in the plate. The assembly may include as many as six cutoff units.

Frame 46 normally rests on supports 54 located to each side of the frame. Lift air cylinders 56 are provided at each side of the frame above supports 54 at the pivot point of the cutoff unit and frame assembly so that when actuated the piston rods thereof extend through cutouts in the plate 50 to engage the tops of the supports 54 and lift the assembly from the bars. Bolts 58 extend from the supports through holes in the plate 50 to limit upward movement of the terminal cutoff and frame assembly by cylinders 56.

Cutoff units 44 are illustrated in FIGS. 5 through 8. Each unit is mounted on a plate 60 secured to supports 48. 25 drop tubes 52 mounted in bores in plate 60 extend in a line along the axis of the unit. Lower terminal guide 62, upper terminal guide 63, backup plate 64, and cover block 66 are secured together and to plate 60 as illustrated in FIG. 7. Two air cylinders 68 are located on top of cover block 66. Bores 70 in lower guide 62 are coaxial with the interior passages of tubes 52 and extend upwardly therefrom to a terminal feed recess 72 which extends the length of guide 62.

FIG. 4 illustrates a portion of a terminal strip 74 which may be used in conjunction with terminal cutoff units 44. Strip 74 includes carrier strip 76 having pilot holes 78 formed therein at regular intervals between individual terminals 80. Terminals 80 are like those illustrated in Billy E. Olsson U.S. Pat. application Ser. No. 712,317, filed Jan. 3, 1968, for "Circuit Board Eyelet," as a continuation of Olsson Ser. No. 631,992, filed Apr. 19, 1967. Each terminal includes a generally cylindrical body 82 having a plurality of wire grip fingers 84 cut out therefrom. A generally conical outwardly extending flange 86 is provided at the upper end of terminals 80 with each terminal being secured to an edge of strip 76 by a lead portion 88 at the edge of the flange. The lower portion 90 of body 82 is rounded to facilitate insertion of the terminal into a circuit board hole.

In each cutoff unit 44 upper and lower guides 62 and 63 are spaced to provide a feed path 92 for the carrier strip 76 of a terminal strip which supplies terminals to the unit. The feed path is located above and to one side of feed recess 72 so as to permit feeding of terminals 80 to positions above bores 70. As indicated in FIG. 6, the upper end of each bore 70 is outwardly beveled to facilitate receiving terminals. The spacing between adjacent bores is the same as the spacing between terminals 80 on carrier strip 76. Terminal cutoff 94 is confined in a recess 96 located above recess 72 and extends axially along the cutoff assembly past all of bores 70. Cutoff 94 is provided with a sharp cutting edge 98 immediately above the juncture between terminal strip lead portions 88 and terminal flanges 86 and is movable within recess 96 toward and away from the terminal strip to sever the terminals from strip 76.

Pins 100 carry stop nuts 102, extend through cover block 66, and are secured to cutter 94. Springs 104 are secured between nuts 102 and the top of block 66 to hold the cutoff 94 against block 66 in the up position so that the cutting edge 98 thereof is positioned above terminals 80. The piston rods 106 of air cylinders 68 extend through bores 108 in cover block 66 to engage the top of cutoff 94 so that upon extension of the air cylinders 68 the cutoff is lowered against springs 104 and cutting edge 98 severs the terminals 80 from leading portion 88. When the air cylinders are vented, springs 104 raise cutoff 94 from engagement with the terminal strip and retract the piston rods 106. A vent hole 110 extends through backup plate 64 adjacent each terminal 72 to communicate recess 96, bores 70 and tubes 52 to atmosphere to facilitate movement of the severed terminals through the bores and tubes, as will be explained later in greater detail.

Terminal feed bar 112 is slidably confined in longitudinal recess 114 between upper and lower guides 62 and 63 and extends outwardly of the guides toward feed air cylinder 116. Air cylinder piston rod 118 is secured to bar 112 by connection 120 so that extension and retraction of the piston rod moves the feed bar back and forth in recess 114. As illustrated in FIG. 8, a feed pawl 122 is pivotally mounted on pin 124 in a recess 126 in bar 112 adjacent the end thereof away from cylinder 116. Spring 128 biases the pawl 122 so that the free end 130 thereof is held within a pilot hole 78 of terminal strip 76. During retraction of the air cylinder the pawl engages strip 76 and moves it and the terminals 80 thereon through feed recess 72 to a cutoff position as shown in FIG. 6. When the air cylinder is extended, the pawl is disengaged from pilot hole 78 and rides upstream past strip 76. One-way back latch 131 is provided in the upstream end of recess 114 to prevent backward movement of the terminal strip 76 during extension of air cylinder 116.

As indicated in FIG. 5, the stroke of the air cylinder is limited by stops 132 and 134. Stop 132 is carried on a bracket at the end of the air cylinder 116 and limits retraction of the piston rod 118 and feed bar 112 so that when in the retracted position terminals 80 are in alignment with bores 70. Stop 134 may be adjustably mounted on air cylinder support 136 to limit the extension of the air cylinder and determine the number of terminals which are fed to the cutoff position in unit 44 upon retraction of the feed bar. In FIG. 5, the air

cylinder 116 is retracted and connection 120 engages stop 132. Upon extension of the air cylinder, the connection 120 is moved away from the air cylinder until it engages adjustable stop 134.

The transfer assembly 20 is mounted on tracks 138 to facilitate movement of the assembly between the extended position, as illustrated in FIGS. 1 and 2, and the position wherein air cylinder 26 is retracted and staking plate 22 is located beneath ram assembly 14 and transfer plate 24 is located beneath plate 50 of the cutoff and drop-tube assembly 16. The top surface of staking plate 22 is provided with upwardly projecting dowel pins 140 which extend through locating holes 141 in circuit board 142 when the board is mounted on the top of the plate. A number of terminal receiving circuit board holes 144 are provided in the circuit board in a predetermined pattern. Applicator 10 attaches a terminal 80 in each circuit board hole 144.

As illustrated in FIG. 12, the circuit board 142 is normally held above the surface of plate 22 by a plurality of spring-backed pins 146. Terminal flaring inserts 148 are mounted in plate 22 beneath each circuit board hole 144 and have upwardly extending conical terminal flaring faces 150. The flaring surfaces 150 extend slightly above the top of plate 22. Pins 146 prevent circuit board 142 from engaging the inserts during mounting of the circuit board on dowel pins 140. Four spacers 153 are mounted on plate 22 around circuit board 142 and project upwardly from the plate a distance somewhat greater than the thickness of the circuit board.

Transfer plate 24 is joined to staking plate 22 by links 154 so that both plates move together along tracks 138 in response to extension or retraction of air cylinder 26. As illustrated in FIG. 3, the transfer plate 24 is secured to piston rod 28 by link 156 and includes a baseplate 158 with cover plate 160 mounted on top of the baseplate. With air cylinders 56 retracted, drop-tube assembly plate 50 rests flush on plate 160. The lower ends of drop tubes 52 are mounted in plate 50 in a pattern conforming to the pattern of circuit board holes 144 in circuit board 142. A terminal receiving recess 162 is provided in plate 160 beneath the end of each drop tube 52 in plate 50 so that the recesses 162 are located in plate 160 in the same pattern as circuit board holes 144 in circuit board 142. Each recess 162 includes an upper flared portion 164 having a maximum diameter at the upper surface of plate 160 approximately equal to the inside diameter of tube 52, and a cylindrical lower portion 166 having a diameter less than the inside diameter of tube 52. The maximum diameter of terminal flange 86 is somewhat less than the inside diameter of tube 52 so that terminals 80 are transported freely through tubes 52 and fall into recesses 162 with flanges 86 engaging flared portions 164. The flared portion 164 is deep enough to assure that terminal 80 does not project above the top of plate 160.

A number of laterally extending recesses 168 are provided in the top of plate 158 to form a vacuum manifold between plates 158 and 160. Ridges 170 separate recesses 168 and support plate 160. The recesses all communicate with port 172 which extends through the bottom of the plate. When the transfer plate 24 is positioned beneath plate 50, port 172 is in communication with fixed vacuum port 174 which is in turn connected to a vacuum source through a solenoid control valve. An O-ring seal 176 is provided to assure a tight connection between ports 172 and 174. Ports 172 and 174 are offset laterally from the path of link 156 so that when the transfer assembly is shifted to move plate 24 out from under plate 50, the link does not come into contact with port 174. In order to provide recesses 162 in plate 160 in a pattern the same as the pattern of the circuit board holes in board 142, it may be necessary to remove portions of ridges 170 so that each recess communicates with the vacuum manifold.

Vent holes 177 extend through the sides of baseplate 158 to communicate with recesses 168. When the transfer plate 24 is positioned beneath the cutoff and drop-tube assembly the holes 177 are closed by bars 54 so that air flows down drop tubes. When the transfer plate is positioned beneath ram 34,

the vent holes 177 are open to the atmosphere to permit air to flow freely through the holes, into the recesses 168 and through recesses 162.

Cam bar 178, illustrated in FIG. 2, is mounted on the end of plate 24 adjacent cylinder 26 so as to reciprocate with the transfer assembly in response to extension and retraction of the cylinder. Cams 180 and 182 are carried by bar 178 and are so positioned thereon that cam 180 engages the one-way trigger of normally open switch 184 when the air cylinder is almost fully retracted, and cam 182 engages the one-way trigger of normally open switch 186 when the air cylinder 26 is almost fully extended.

Upper staking plate 190 is secured to the lower face of ram 34 which is recessed to provide a number of vacuum cavities 192. Cavities 192 all communicate with manifold 194 mounted on top of ram 34 and illustrated in FIG. 2. The manifold is provided with a port 196 which is connected to a vacuum source through a control valve so that when the valve is open a vacuum is maintained in the cavities 192. When air cylinder 26 is extended, transfer plate 24 is positioned beneath plate 190 so that upon extension of air cylinders 38 ram 34 is lowered to seat plate 190 on top of plate 160. A plurality of inserts 198 are provided in plate 190 in the same pattern as the circuit board holes 144 in circuit board 142 so that an insert 198 is located immediately above each recess 162 in plate 160. Each insert 198 is provided with a circumferential groove 200 having a conical inner face adapted to fit within flange 86 of a terminal 80 and an axial bore 199 which communicates a cavity 192 with the lower surface of plate 190. Plate 190 is provided with recesses to accommodate pins 140 on plate 22 during staking.

Normally open microswitch 202 is mounted on the top of ram 34 at the edge thereof adjacent cylinder 26 with trigger 204 adjacent the edge of the ram. A trigger slide 206 is reciprocally mounted in a recess at the edge of the ram and is biased down in the position illustrated in FIG. 10 by spring 208. The upper end of the slide is tapered so that when the ram is lowered to position plate 190 on plate 160 the slide engages plate 160 and is moved up relative to the ram to depress trigger 204 to turn switch 202 on. When the ram lowers onto plate 22, the slide is not shifted and switch 202 is not turned on.

A group of three microswitches 210, 212 and 214 is mounted on the support 216 adjacent one side of ram 34 with their triggers extending toward the ram so that as the ram is moved up and down, the triggers are tripped to turn the switches off and on, as indicated in FIG. 17. All of switches 210, 212 and 214 are normally open. A second group of microswitches 218, 220 and 222 is mounted on a support 224 adjacent the side of ram 34 so that movement of the ram turns the switches on and off. Switches 218 and 222 are normally open and switch 220 is normally closed.

A normally open pressure switch 226 is mounted on the top of ram upper plate 32 between cylinders 38 and is connected to the pressure lines thereof so that when the ram is lowered and the pressure in the cylinders increases, the switch 226 is turned on. The apparatus is additionally provided with a normally open foot switch 228 (not shown) and with solenoid control valves, shown in FIG. 18, operable in response to the condition of the various switches.

FIG. 16 illustrates the electrical circuitry of terminal applicator 10. Electrical leads 230 and 232 are connected to a suitable power source to provide power to a number of parallel circuits extending therebetween. Foot switch 228, normally open microswitch 212, and normally closed contacts 234 of ratchet relay 236 are connected in series with solenoids 238 and 240 of control valves 242 and 244. Microswitches 184 and 186 are connected parallel to each other and are joined in series with solenoid 246 of control valve 248. Microswitch 214 is in series with solenoid 250 of control valve 254.

Pressure switch 226 is connected in series with solenoid 258 of control valve 248. Microswitch 210 is connected in series with solenoid 264 of control valve 242 and solenoid 266 of

control valve 244. Normally open contacts 252 of relay 270 are in series with solenoid 253 of control valve 255. Normally closed contacts 256 of relay 270 are in series with solenoid 257 of control valve 259. Normally open contacts 268 of relay 270 and microswitch 202 are connected in parallel and are in series with normally closed microswitch 220 and the solenoid of relay 270. Microswitch 218 and solenoid 274 of control valve 276 are connected in series. Microswitch 222 is connected in series with the solenoid of ratchet relay 236.

The pneumatic circuitry of the terminal applicator 10 is illustrated in FIG. 18. Solenoid control valve 259 is connected to vacuum source 278 and is shiftable in response to actuation of solenoid 257 to connect the vacuum source to ram manifold port 196 through line 280. When solenoid 257 is deactivated, spring 261 shifts valve 259 and cuts off the vacuum source from port 196. Solenoid control valve 255 is also connected to vacuum source 278 and is shiftable upon actuation of solenoid 253 to connect the vacuum source to port 174 through line 282. When solenoid 253 is deactivated, spring 263 shifts valve 255 and cuts off the vacuum source from port 174.

Pressure fluid from source 265 is supplied to solenoid control valves 242, 244, 248, 254 and 276 through line 284. Valve 242 is connected to the control cylinder 286 of the pilot valve 288 by leads 290. Valve 288 is connected to line 284 and to the air cylinder 26 so that depending upon the position of control cylinder 286, cylinder 26 is extended or retracted. A flow control 292 may be provided in one of the leads connecting cylinder 26 with valve 288 to prevent rapid movement of the transfer assembly which could dislodge terminals 80 held on the bottom of ram 34 by air flow.

Cutoff feed cylinders 116 are connected to control valve 244 through leads 294 so that, depending upon actuation of solenoids 240 and 266, the cylinders are extended or retracted. Likewise, ram air cylinders 38 are connected to solenoid control valve 248 through leads 296 and 298 and the extension or retraction of the air cylinder is determined by actuation of solenoids 246 and 258. Pressure switch 226 is located in lead 296 so that when the pressure therein builds up following bottoming of the ram, the switch is turned on.

Drop tube and terminal cutoff assembly lift air cylinders 56 are connected to solenoid valve 254 through lead 300. Spring 302 normally holds valve 254 in position to supply pressure fluid to air cylinders 56 so that the cutoff and drop-tube assembly is normally held in the up position. Actuation of solenoid 250 vents the air cylinders and lowers the cutoff and drop-tube assembly onto bars 54. Solenoid control valve 276 is connected to terminal cutoff air cylinders 68 through lead 304. Spring 306 normally holds the valve 276 in position so that air cylinders 68 are vented and the cutters 94 are held above terminal strip 74 by springs 104. Actuation of solenoid 274 shifts valve 276 so that air cylinders 68 lower the cutters and sever terminals 80 from the carrier strips.

OPERATION OF THE TERMINAL APPLICATOR

FIG. 1 illustrates terminal applicator 10 in the start position. The transfer assembly 20 is shifted to the left so that staking plate 22 is in position to receive circuit board 142 on dowel pins 140 and transfer plate 24 is positioned beneath ram assembly 14. The ram air cylinders 38 are retracted so that the ram is in the up position. Control valve 259 is held by solenoid 257 in position to connect vacuum source 278 to cavities 192 through manifold 194 and line 280. A terminal 80 is held on the bottom surface of upper staking plate 190 in each insert groove 200 by the parasitic drag of air flowing through the body of the terminal and the cutouts therein, through the central bore 199, and into the cavities 192. The drag caused by the flow of air through and past the terminals 80 holds the flanges 86 thereof within grooves 200 to maintain the terminals in the desired pattern on the upper staking plate. In the start position solenoid valve 254 is shifted by spring 302 to extend air cylinders 56 and hold the drop tube and cutoff assembly 16 above bars 54.

The operator initiates the cycle of operation by placing circuit board 142 on pins 140 and then tripping foot switch 228. Because ram 34 is up (see FIG. 17), the trigger of the switch 212 engages the side of the ram and the normally open switch is held closed. Relay contacts 234 are closed so that a power pulse is sent through solenoids 238 and 240. Actuation of solenoid 238 shifts the control valve 242 to supply pressure fluid to control cylinder 286 to shift pilot valve 288, thereby retracting transfer assembly cylinder 26. When cylinder 26 is fully retracted, the transfer assembly is moved to the position illustrated in FIG. 3 with the circuit board located beneath upper staking plate 190 and the transfer plate 158 located beneath the drop tube and cutoff assembly 16. Air cylinders 56 hold assembly 16 above the transfer plate to facilitate movement of the transfer assembly upon retraction of air cylinder 26. Actuation of solenoid 240 shifts control valve 244 so that pressure fluid is supplied to retract cutoff unit air cylinders 116, thereby indexing the carrier strips into the cutoff units and positioning terminals 80 in alignment with bores 70.

Prior to full retraction of air cylinder 26, cam 180 trips the one-way trippers of normally open switch 184 to actuate solenoid 246 of control valve 248 so that pressure fluid is supplied through line 296 to ram air cylinders 38 to lower the same. Switch 184 is open when cylinder 26 is fully retracted. During retraction of cylinder 26 cam 182 rides over the one-way trigger of normally open switch 186 but does not close the switch.

Lowering of the ram on the first cycle actuates switches 212, 222, 214, 218 and 220. As the ram starts down, the trigger of normally open switch 212 falls from the edge of the ram to open the switch, thus assuring that accidental tripping of foot switch 228 does not recycle the applicator. The one-way trigger of normally open switch 210 is tripped by a cam 310 on the side of the staking ram as the ram lowers, but the switch is not closed. Switch 222 is tripped by cam 312 to energize the coil of ratchet relay 236 momentarily. This relay has alternate positions and may be type AP 11 A, manufactured by Potter Brumfield. Actuation of switch 222 shifts the ratchet relay 236 to a first position which opens normally closed contacts 234, thereby assuring against accidental recycling of the applicator 10 by closing foot switch 228 during the interval when normally open switch 212 is closed prior to the end of the completed applicator cycle.

As the ram continues to lower, normally open switch 214 is closed and is held closed until the ram is fully bottomed and raised. Closing of this switch sends a pulse through solenoid 250 of control valve 254 so as to shift the same and vent air cylinders 56 so that the cutoff and drop-tube assembly 16 falls by gravity and plate 50 rests flush on transfer plate 160 with the lower end of each drop tube 52 positioned above a terminal receiving recess 162 in the lower plate.

Normally open switch 218 and normally closed switch 220 are tripped as the ram bottoms are held in the tripped position until the ram is raised. Opening of normally closed switch 220 deactivates relay 270, thereby opening contacts 268 which were closed during the first part of the cycle of operation, opening contacts 256 and closing contacts 252. Opening of contacts 256 deactivates solenoid 257, allowing spring 261 to shift valve 259 and cut off the vacuum supply to the ram. Closing of contacts 252 activates solenoid 253 and shifts valve 255 to supply vacuum to the transfer plate 24 through line 282. At the time when switch 220 is tripped, the terminals 80 carried by the ram are already staked to the circuit board so that there is no possibility that the terminals will fall from upper staking plate 190 when the vacuum is released.

Closing of switch 218 actuates solenoid 274 of control valve 276 to supply pressure fluid through lead 304 to cutoff air cylinders 68 so that cutters 94 are lowered and sever terminals 80 from carrier strips 76. The free terminals are carried down bores 70 and drop tubes 52 and into recesses 162 in plate 160 by the flow of air to the vacuum supply. The terminals 80 are held in recesses 162 by drag due to the flow of air through recesses 162 into the transfer plate. The terminals 80 are located on plate 160 in the same pattern as the terminal receiving holes 144 in circuit board 142.

As the ram bottoms, the terminals 80 held in the upper staking plate 190 are staked to circuit board 142, as illustrated in FIGS. 12, 13 and 14. During lowering each terminal 80 is held against an insert 198 by parasitic drag resulting from the flow of air into cavities 192. This drag is sufficient to hold the terminals tightly against the staking plate 190 during motion of the ram. With circuit board 142 accurately located on dowel pins 140, each terminal receiving circuit board hole 144 therein is located beneath a terminal 80 on the ram and above an insert 148 in the lower staking plate 22. The circuit board is held above the upper surface of plate 22 by a number of spring-backed pins 146.

Continued lowering of the ram positions terminals 80 carried thereby in their respective circuit board holes 144 until the terminals are fully seated in the circuit board holes with flanges 86 engaging the top of the circuit board. At this position the circuit board is fixed relative to the ram and further lowering of the ram pushes the circuit board down and retracts the spring pins 146. Movement of the ram from the position shown in FIG. 13 to the bottomed position of FIG. 14 flares the lower ends of terminals 80 against the conical flaring surfaces 150 of inserts 148.

Bottoming of the ram occurs when plate 190 abuts the four spacers 153 on lower staking plate 22. During staking (FIG. 14) plates 190 and 22 do not engage the surfaces of circuit board 142, thereby preventing damage to the circuit board or printed circuitry carried thereon. The height of stops 153 above plate 22 is sufficient to assure that the bottom portions of terminals 80 are flared outwardly and tightly engage the bottom of the circuit board so that the terminals are secured to the circuit board between upper and lower terminal flanges. Circuit board 142, illustrated in FIGS. 12, 13 and 14, is provided with a copper printed circuit pad 308 which surrounds the top of circuit board hole 144. A similar printed circuit pad may be provided on the bottom of the circuit board hole, if desired, and the hole may be plated. These features form no part of this invention as applicator 10 attaches terminals to circuit boards, regardless of whether the circuit board holes are plated or surrounded by printed circuit pads.

When the ram bottoms and stakes the terminals 80 carried thereby to the circuit board, the pressure in air cylinders 38 rises and closes normally open pressure switch 226 to send a power pulse through solenoid 258, thereby reversing control valve 248 to provide fluid pressure to cylinders 38 through lead 298 to raise the ram. As the ram is raised from the bottomed position, switches 214 and 218 open and switch 220 closes.

At the time switch 220 is closed, switch 202 is open, and relay 270 is not actuated. Opening of switch 218 deactivates solenoid 274 and spring 306 shifts valve 276 to vent air cylinders 68 and permit springs 104 to raise cutters 94. Opening of switch 214 deactivates solenoid 250, thereby allowing spring 302 to shift valve 254 and raise assembly 16 above plate 160 and blocks 54. Terminals 80 remain in recesses 162 in the plate. The one-way trigger of switch 222 is tripped as the ram raises, but the switch is not closed.

As the ram approaches the top position, switch 210 is tripped by cam 310 to send a power pulse through solenoid 264 to shift control valve 242, thereby retracting control cylinder 286 and shifting pilot valve 288 to extend air cylinder 26 and move the transfer assembly to the position of FIG. 1. Closing of switch 210 also sends a pulse through solenoid 266 to shift control valve 244 and extend terminal feed cylinders 116. Switch 212 is closed when the ram approaches the top position. However, at this time contacts 234 are open so that it is not possible to close foot switch 228 and actuate solenoids 238 and 240.

Movement of the transfer assembly 20 back toward the position illustrated in FIG. 1 moves cam 182 into contact with the one-way trigger of switch 186 to momentarily close the same and actuate solenoid 246 to shift valve 148, provide fluid pressure through lead 296 to air cylinders 38 and lower the ram for the second time. The one-way trigger of switch 184 is tripped mechanically by cam 180 during extension of air

cylinder 26. However, the switch is not actuated. When air cylinder 26 is fully extended the transfer plate 160 is positioned beneath the ram and lower staking plate 22 carrying circuit board 142 with terminals 80 staked thereto is positioned to the right of the ram assembly so that the operator can remove the finished circuit board from pins 140. The second lowering of the ram actuates switches 210, 212 and 222. As indicated in FIGS. 1 and 3, the upper surfaces of transfer plate 160 is located a distance above the upper surface of lower staking plate 22 so that the second time the ram lowers it bottoms on plate 160 and does not move down far enough to actuate switches 214, 218 and 220.

During the second descent of the ram, switch 212 is opened. The one-way trigger of switch 210 is tripped. However, this switch is not closed during ram descent. Switch 222 is tripped to cycle ratchet relay 236 back to the start position, thereby closing contacts 234.

When the ram bottoms on the transfer plate, each terminal holding insert 198 in plate 190 is positioned above a terminal 80 in a recess 162 in transfer plate 160. Bottoming of the ram on the transfer plate raises slide 206 to close normally open switch 202 so that relay 270 is actuated through normally closed switch 220 to close contacts 268 and 256, and open contacts 252. Closing of contacts 256 and opening of contacts 252 shift the vacuum source back to the ram manifold 194. Closing of contacts 268 holds relay 270 on. With application of vacuum to the ram manifold, a flow of air passes through terminal receiving recesses 162 in plate 160 and the central bore 199 of inserts 198 to provide a parasitic drag on the terminals 80 so that they are lifted from the seated position in recesses 162 and are held against the bottom of inserts 198. Switch 202 is not closed when the ram bottoms to stake terminals on the circuit board.

When the ram bottoms, pressure builds up in cylinders 38 to trip pressure switch 226, thereby actuating solenoid 258 to reverse valve 248 and raise the ram. The air flow past terminals 80 holds them against inserts 198 so that they are carried up with the ram above the plate 160. As the ram approaches the upper position, switch 210 is closed to send power pulses through solenoids 246 and 266. However, these pulses do not shift the valves 242 and 244 since cylinders 26 and 116 are already extended. Switch 212 is closed to permit the operator to initiate a second cycle of operation by closing foot switch 228. The cycle of operation is now complete and the operator may remove the circuit board 142 with terminals 80 attached thereto, place a new circuit board on plate 22, and then start a new cycle of operation by tripping foot switch 228.

During the cycle of operation of applicator 10, terminals 80 are assisted into recesses 162 in plate 160 by a flow of air which passes down through the recesses and into cavities 168. Transfer of the terminals from the plate 162 to plate 190 is effected by flow of air up through the recesses in the opposite direction.

The parasitic drag on the terminals is exerted by the flow of air past the terminals which is caused by the pressure differential between atmosphere and the vacuum manifold. There is only a small pressure drop across the terminals 80 as they are held in the transport plate 160 and on the ram plate 190. Other types of terminals may be held by parasitic drag and it is not necessary that the terminals have cut out interior fingers in order for sufficient drag to be exerted upon them by air flow. Thus, terminals having solid cylindrical bodies could be applied to circuit boards by the disclosed applicator. The pressure differential may hold other terminals against the ram without any flow of air into the ram.

While I have illustrated and described a preferred embodiment of my invention, it is understood that this is capable of modification, and I therefore do not wish to be limited to the precise details set forth but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. Apparatus for simultaneously positioning a plurality of terminals in a predetermined pattern on a circuit board including a support, a drop-tube assembly mounted above said support, terminal feed means on top of said assembly, a ram mounted above said support adjacent said assembly, means for moving said ram toward and away from said support, a terminal transport plate movable between a position beneath said assembly and a position beneath said ram, a circuit board plate movable between a position beneath said ram and a loading position, said drop-tube assembly including a plurality of terminal drop tubes extending from said terminal feed means to the bottom of said assembly with the lower ends of said tubes arranged in a pattern identical to the pattern of terminals to be positioned on the circuit board, the upper end of each tube communicating with said feed means to receive a terminal from said feed means upon actuation thereof, a plurality of terminal receiving recesses in said transfer plate arranged in said pattern so that when said transfer plate is located beneath said assembly a recess therein is located immediately beneath the lower end of each tube to receive a terminal from such tube, a plurality of terminal holding means on the lower face of said ram arranged in said pattern so that when said transport plate is located beneath said ram and said ram is lowered upon said transport plate each terminal holding means is located above a terminal holding recess in said transport plate, a vacuum manifold in said ram communicating with each of said terminal holding means so that the terminals in said recesses are transferred to said terminal holding means when the ram is on said transport plate and are held against said terminal holding means in said pattern during further movement of the ram, locating means on said circuit board plate for mounting a circuit board thereon with each terminal receiving location on the board positioned below one of said holding means when said circuit board plate is located beneath said ram whereby lowering of said ram mounts the terminals carried thereby on said circuit board in said pattern.

2. Apparatus as in claim 1 wherein said transport plate and said circuit board plate are joined to form a transport unit, and including drive means for shifting said unit between a first position where said transport plate is beneath said assembly and said circuit board plate is beneath said ram and a second position where said transport plate is beneath said ram and said circuit board plate is at said loading position.

3. Apparatus as in claim 1 including a plurality of terminal staking means arranged on said circuit board plate in said pattern with one staking means located below each holding means on said ram when the circuit board plate is beneath said ram whereby following mounting of the terminals on said circuit board continued lowering of said ram brings the terminals into contact with said staking means to deform the terminals and secure them to the circuit board.

4. Apparatus as in claim 1 including means for lifting said drop-tube assembly above said transport plate to facilitate movement of said transport plate between said positions.

5. Apparatus as in claim 1 including a second vacuum manifold located beneath said transport plate when said transport plate is below said assembly, passages communicating each of said terminal holding means with said second vacuum manifold to permit a flow of air down each drop tube and into such manifold to carry terminals from said feed means to said transport plate, each terminal recess including a stop to prevent terminals from being carried into said second manifold.

6. Apparatus as in claim 5 including a plurality of vents in said second manifold, valving means operable to close said vents when said transport plate is beneath said assembly and to open said vents when said transport plate is beneath said ram.

7. Apparatus for positioning a plurality of terminals in a pattern on a substrate comprising a plate for receiving a plurality of terminals in a pattern, feed means for supplying terminals to

said plate, a support for receiving terminals from said plate in said pattern including terminal holders arranged in said pattern and vacuum holding means communicating with said holders, and drive means for positioning said support adjacent said plate with each terminal holder adjacent a terminal on the plate so that the terminals are transferred from said plate to said support by said vacuum holding means, said drive means also operable to locate said transfer means with terminals held against said holders in said pattern adjacent a substrate to position said terminals on said substrate in said pattern.

8. Apparatus as in claim 7 wherein said plate includes a plurality of terminal receiving cavities arranged in said pattern on one side of said plate and said feed means and said transfer means are located to said one side of said plate.

9. Apparatus as in claim 8 wherein said feed means includes a plurality of drop tubes extending from a terminal supply toward said plate with the ends of the drop tubes adjacent said plate arranged in said pattern above the cavities of said plate and including means for supplying a flow of air through said drop tubes to carry terminals from said supply to said cavities.

10. Apparatus for simultaneously positioning a plurality of terminals in a predetermined pattern on a substrate including a base for holding a plurality of terminals in said pattern, a terminal support including a plurality of terminal holders arranged in said pattern for holding said terminals on said terminal support, and drive means for bringing said terminal support and said base together to position each terminal holder adjacent a terminal on said base and for separating said base and support whereby the terminals are transferred from said base to said support and are held on said support in said pattern by said terminal holders, said drive means also operable to bring said terminal support with the terminals held thereon adjacent a substrate to position said terminals on said substrate in said pattern.

11. Apparatus as in claim 10 wherein said terminal holders include means for biasing said terminals against said terminal support.

12. A method of simultaneously mounting terminals in openings in a circuit board including the steps of arranging a number of terminals in a predetermined pattern, moving a ram adjacent said terminals to position the lower face thereof above the terminals, passing a flow of air into said ram at locations above each terminal to hold said terminals against said ram by parasitic drag resulting from the flow of air past said terminals, raising said ram while holding the terminals thereon by parasitic drag, positioning a circuit board beneath said ram with each terminal receiving opening therein located beneath a terminal on said ram, and lowering said ram to position each terminal in one of said openings.

13. The method of claim 12 including the step of securing said terminals to said circuit board.

14. A method for simultaneously mounting terminals on a substrate in a predetermined pattern comprising the steps of arranging a plurality of terminals in a predetermined pattern, flowing air past said terminals to transfer the terminals to a ram and hold the terminals on said ram by parasitic drag while in said pattern, and effecting relative movement between the ram and a substrate to position the terminals on the substrate in said pattern.

15. A method of simultaneously mounting terminals on a circuit board in a predetermined pattern including the steps of arranging the terminals in said pattern on a support, transferring the terminals to a ram and biasing the terminals against such ram in said pattern by an air pressure induced force, bringing said ram and a circuit board together to position the terminals on the circuit board in said pattern, and then staking the terminals to the circuit board.

16. The method of claim 15 including the step of biasing the terminals against said ram by a flow of air past the terminals.

17. The method of mounting a plurality of terminals on a substrate in a predetermined pattern including the steps of holding a plurality of terminals on a ram by the parasitic drag resulting from the flow of air past said terminals and into the ram and while the terminals are held on the ram effecting relative movement between the ram and a substrate to position the terminals on the substrate in said pattern.

18. The method of mounting a plurality of terminals on a support in a predetermined pattern comprising the steps of positioning a plurality of terminals to one side of a transfer plate and directing a first flow of air past said terminals and toward said plate to move the terminals toward the plate, guiding each terminal to a predetermined location on the plate so that the terminals are seated thereon in a pattern, directing a second flow of air in a direction generally opposite to the direction of the first flow of air to move the terminals away from the plate and mount the terminals on a support in said pattern.

19. The method of claim 18 including the step of positioning said support on said plate before mounting said terminals on said support.

20. The method of claim 18 including the step of retaining said terminals on said support by parasitic drag.

21. The method of claim 18 including the step of passing both said air flows through the thickness of said plate.

22. The method of mounting a plurality of terminals on a support in a predetermined pattern comprising the steps of directing a first flow of air past a plurality of terminals toward a plate to seat the terminals on said plate in a predetermined pattern, and directing a second flow of air in a direction generally opposite to the direction of the first flow of air to mount the terminals on a support in said pattern.

23. Apparatus as in claim 11 wherein said means for biasing said terminals includes a vacuum manifold communicating with each terminal holder.

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