

Fig. 12

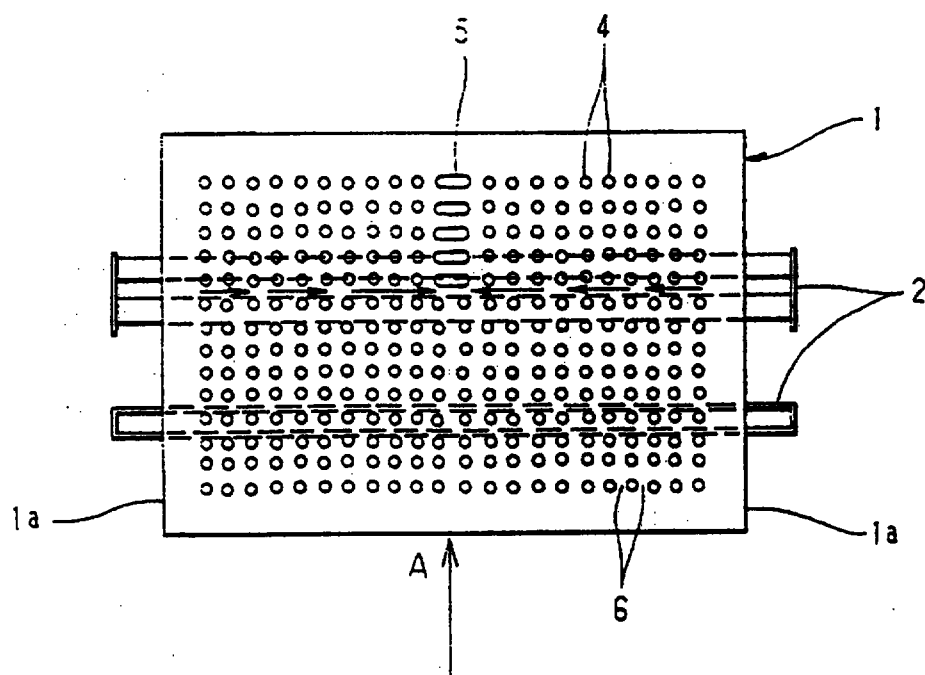
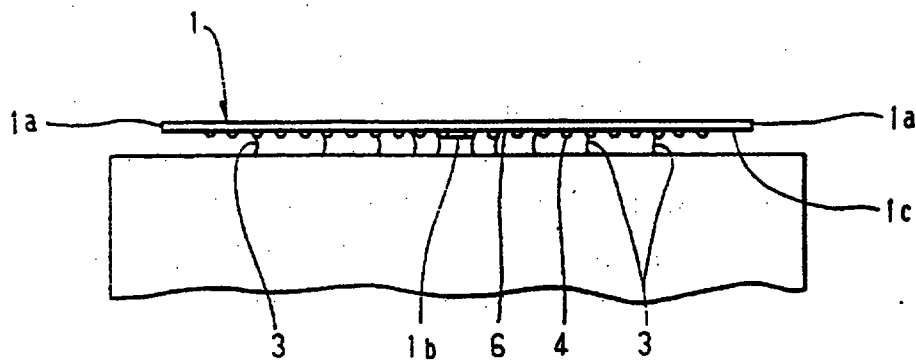


Fig. 13



AUTOMATIC SOLDERING APPARATUS

The invention relates to automatic soldering apparatus.

A conventional automatic soldering method and apparatus is shown in Figs. 12 and 13, wherein a base board 1 having electronic elements mounted thereon is soldered with molten solder 3 jetted up from an elongate open nozzle 2 by the action of a molten solder pressing device while the base board is transported over the nozzle which is arranged transversely of the base board transporting direction at right angles thereto.

According to the conventional method and apparatus, when a lower side 1c of the base board 1 is moved past the molten solder 3 jetting up from the nozzle 2, that is, when the soldering process is ended, the molten solder 3 will progressively flow from one end 1a toward a centre 1b on the lower side 1c of the base board 1 while the molten solder is separating one after another at the soldering points of the base board. In this case, it is unavoidable that the flow of molten solder will result in phenomena such as bridges, icicles, drops or dews formed at the centre 1b of the width of the base board 1. Such defective soldering places 5 have to be confirmed by inspection and have to be amended by means of a soldering iron. Such inspection and amendment operations will increase the soldering processes and further decrease the operational efficiency. Moreover the failure of defection confirmation and incomplete amendment will inevitably lower the quality of products.

As particularly shown in Fig. 12, the base board 1 has many points 4 provided on the lower side 1c thereof which are required to be soldered. Each of the spaces 6 between the soldering points 4 arranged laterally of the base board is

very small due to the increased density of electronic parts mounted on the base board. The smallest spaces may be about 0.2mm. Therefore if the molten solder 3 comes together to one point when the base board 1 is transported past the molten solder jetting nozzle, the defective soldering phenomena will be caused such as the bridges, icicles, etc., as mentioned hereinbefore.

EP-A-0 203 623 discloses apparatus for automatically soldering a base board having electronic components mounted on a surface thereof, comprising transporting means operative to move the base board along a base board transporting path which runs at an upward inclination from a base board entrance to a soldered base board exit, and a molten solder storage tank which is arranged in a substantially horizontal plane below the base board transporting path and had an elongate molten solder jetting nozzle directed upwards towards the base board transporting path, said nozzle extending transversely of the base board transporting path at an oblique angle relative thereto so that, in use, as the board is moved at an upward inclination above the nozzle solder is applied progressively to the lower surface of the base board, but owing to the oblique disposition of the nozzle is supplied to locations at one side of the board sooner than to opposing locations at the other side of the board.

Japanese patent applications 59-997 and 59-15668 disclose similar apparatus and methods.

It is admitted that the features of the prior art will have an effect in decreasing the defective soldering results such as the soldering phenomena 5 shown in Fig. 12. However, in view of the fact that in the prior art the base board is progressively moved up as the base board is transported, the vertical distance between the base board and the nozzles

becomes progressively greater all through the length of the nozzles. More precisely, the period of time is progressively shorter in which the molten solder contacts the lower side of the base board as the base board is moved past the nozzles. It is therefore apparent that the soldering condition is progressively different along the length of the nozzles, that is, from one end to the opposite end of the base board. Such variant soldering condition is far from a desired condition in which the molten solder contacts the base board for 3 seconds to attain the very best soldering effect.

Depending upon the arrangement of the points to be soldered, it may be possible to prevent the formation of such defective soldering phenomena as the parts 5 shown in Fig. 12 by enlarging the inclination of the nozzles with respect to the base board transporting direction. However, such enlargement of inclination is limited, and excessive inclination would make it impossible for the molten solder 3 to contact the lower side 1c of the base board 1.

The object of the invention is to eliminate the defects and disadvantages of the prior art.

This is achieved by keeping the distance between the lower side of the base board and the top end of the nozzles constant all through the length of the nozzles as the base board is transported past the nozzles.

More specifically, this object is achieved, in accordance with the invention by apparatus having the features specified in the prior art but characterised in that the transporting means is operative to move the base board along the base board transporting path with the base board tilted laterally with respect to the path so that the base board is lowered laterally of the base board transporting path at the

same side as where the nozzle is farther from the base board entrance and the distance between the lower surface of the board and the nozzle is kept constant along the entire length of the nozzle as the base board is transported thereover.

Advantageously, adjusting means are provided to adjust the tilt angle of the base board with respect to the base board transporting path.

Advantageously, further adjusting means are provided to adjust the angle of the molten solder jetting nozzle with respect to the base board transporting path.

In certain embodiments the molten solder storing tank may be elongated and arranged at an inclination of about 45° with respect to the base board transporting direction.

In some embodiments a carrier may be provided for carrying the base board, the carrier being transported by the transporting device from the base board entrance to the soldered base board exit of the base board transporting path.

Also some embodiments of the apparatus of the invention may comprise feed back means for feeding back the soldered base board from the soldered base board exit to the base board entrance of the base board transporting path, the feed back means including a conveyer arranged below the base board transporting path and extending the length of the base board transporting path, first lift means arranged at the soldered base board exit and movable between the soldered base board exit and one end of the conveyer, and second lift means arranged at the base board entrance and movable between the base board entrance and the opposite end of the conveyer, the first lift means transporting the carrier from the

soldered base board exit to the one end of the conveyer, the conveyer transporting the carrier to the second lift means and the second lift means transporting the carrier to the base board entrance.

In the drawings:

Figs. 1 through 7 show a first embodiment of the invention, in which:

Fig. 1 is a front elevational view of an automatic soldering apparatus according to the invention;

Fig. 2 is a plan view of the automatic soldering apparatus;

Fig. 3 is a right side elevational view of the apparatus in Fig. 1;

Fig. 4 is an enlarged perspective view of a base board angle adjusting device;

Fig. 5 is a perspective view showing a positional relation between a base board and nozzles of the invention;

Fig. 6 is a plan view of the base board and the nozzles showing flow of molten solder with respect to the base board;

Fig. 7 is a side elevational view of the base board and the nozzles showing the points of the base board to be soldered and the flow of molten solder;

Figs. 8 through 11 show a second embodiment of the invention in which:

Fig. 8 is a plan view of an automatic soldering apparatus of the invention;

Fig. 9 is a side elevational view of the apparatus;

Fig. 10 is a side elevational view shown in vertical section taken along a line III-III in Fig. 8;

Fig. 11 is a diagrammatical representation of a carrier transporting device and a carrier feed back device of the invention;

Figs. 12 and 13 show the essential parts of a conventional automatic soldering device, in which:

Fig. 12 is a plan view of a base board and nozzles showing the phenomena of solder bridges formed on the base board; and

Figs. 13 is a side elevational view of the base board and the nozzles showing a flow of molten solder causing the solder bridges.

The invention will be described with reference to preferred embodiments as shown in the attached drawings. With reference to Figs. 1 through 4, an automatic soldering apparatus 8 comprises a base board transporting device 9, a solder storing tank 10 and a base board angle adjusting device 11.

Particularly with reference to Figs. 1 and 2, the base board transporting device 9 holds a base board 1 at the opposite sides 1a thereof and transports the base board in the direction indicated by an arrow A by means of a pair of chain conveyers 12 arranged in parallel with each other. Each of the chain conveyers 12 is connected to an electric motor 13 by way of a belt 16 which engages a pulley 15 secured to a shaft 14 of the motor. The rotation of the motor 13 is transmitted by a transmission mechanism 18 and a shaft 19 to a chain guide wheel 20 which is secured to the shaft 19 and is in engagement with the belt conveyer 12. Thus each of the belt conveyers 12 is moved.

The pair of belt conveyers 12 are arranged at an angle with respect to a horizontal plane so that the belt conveyers will advance with the base board 1 in an upward direction. The angle may be adjusted by an handle or the like (not shown).

The solder storing tank 10 is composed of a first solder storing tank 21 and a second solder storing tank 22 each storing heated and molten solder 3 therein which is jetted up from elongate nozzles 25, 26 by means of impellers (not

shown) driven by electric motors 23 and belts 24 respectively.

The solder storing tank 10 has a device 27 for changing the angle of the nozzles. Namely a base 28 has a rotational station 29 provided on the top thereof, and the solder storing tank 10 is secured to the top of the rotational station. A handle 30 is provided so as to be manually rotated to thereby rotate bevel gears 31, 31 to transmit the rotation to a vertical shaft 32 of the rotational station 29. Thus the rotational station, that is, the solder storing tank 10 is slowly rotated in a horizontal plane as shown in Fig. 3.

With further reference to Figs. 3 and 4, the base board angle adjusting device 11 is provided to change the inclination angle γ of the pair of belt conveyers 12 with respect to the direction intersecting the base board transporting direction (arrow A) at right angles. In order to attain this aim, a pair of inclination bases 33 are provided. One of the inclination bases 33 is arranged near the board entrance while the other is arranged near the base board exit. The pair of inclination bases 33 carry an elongate support 34 on which the pair of chain conveyers 12 are arranged.

Each of the inclination bases 33 is turnable around a hinge 36 secured to the housing 35 of the automatic soldering apparatus 8. A handle 38 is provided so as to be manually rotated to thereby rotate a shaft 40 through worm gears 39, 39. A cam 41 secured to the shaft 40 is therefore rotated in the direction B or B' to move the inclination base 33 in the direction C or C' through a guide roller 42 which is in engagement with the cam.

The automatic soldering apparatus 8 has a fluxer 43, a

preheater 44, base board cooling fans 45 and ventilation ducts 46, which are all generally known, provided at respective predetermined places thereof.

In operation of the apparatus the base board 1 is transported in an upward direction at a predetermined angle α with respect to a horizontal plane. The molten solder jetting nozzles 25, 26 are arranged in a horizontal plane at a predetermined inclination with respect to the base board transporting direction and the base board itself is tilted from side to side in such manner that the lower side 1c of the base board 1 is lowered in the same direction laterally of the base board transporting path where the elongated nozzles 25, 26 are inclined farther from the base board entrance of the base board transporting path, so as to obtain a substantially constant vertical distance between the lower side 1c of the base board 1 and the elongated nozzles 25, 26 all through the length of the nozzles when the base board passes over the nozzles. This is illustrated in Fig. 5.

In more detail and with reference to Figs. 1 and 2, the solder in the solder storing tank 10 is made molten when a heater (not shown) is electrically energized and heated. When power is supplied to the electric motors 23, the motors are driven and the impellers (not shown) are rotated by way of the transmission belts 24 so that the nozzles 25, 26 jet up the molten solder 3 as shown in Fig. 7.

When the motor 13 is electrically energized it drives the pair of chain conveyers 12 which transport the base board 1, by engaging the opposite sides 1a thereof, in the direction indicated by the arrow A. The base board 1 is fluxed by the fluxer 43 and preheated by the preheater 44 and is then soldered at the solder storing tank 10.

With reference to Figs. 5 and 6, if the handle is rotated to incline only the nozzles 25, 26 with an angle β in the horizontal plane so as to solder a plurality of points 4 on the base board 1 as required, the soldering condition will be progressively varied as the base board 1 is advanced because the lower side 1c of the base board 1 will be progressively higher above the nozzles 25, 26 where they are farther from the base board entrance of the base board transporting path.

It is therefore necessary to operate the handle 38 shown in Fig. 4 so as to make the soldering condition constant and attain the best soldering effect. The cam 41 is rotated to laterally tilt the base board angle adjusting device 11 about the hinge 36 so that the heights of the respective chain conveyers 12 are different from one other. More precisely, the base board angle adjusting device 11 is to be inclined to such a degree that the lower side 1a of the base board 1 will be tilted at an angle γ with respect to the horizontal plane so that the base board 1 is lowered laterally of the base board transporting path at the same side at which the elongate nozzles 25, 26 are farther from the base board entrance of the base board transporting path so as to obtain a constant vertical distance between the lower side 1c of the base board 1 and the upper sides 25a, 26a of the nozzles 25, 26 all through the length of the nozzles when the base board 1 passes over the nozzles. The required inclination angle γ of the base board 1 can be determined by the ascending angle α of the base board and the inclination angle β of the nozzles with respect to the cross section of the base board transporting path, that is, to satisfy the relation; $\tan \gamma = \tan \alpha \cdot \tan \beta$.

With the soldering condition as mentioned above, a constant soldering time, that is, 3 seconds may be set for contacting the entire soldering side of the base board 1 with molten

solder 3 jetted up from the nozzles so as to attain an ideal and faultless soldering effect without deflections.

With reference to Figs. 6 and 7, since the nozzles 25, 26 are inclined at angle β with respect to a perpendicular intersection of the base board transporting path, the molten solder 3 flows with respect to the base board in the direction indicated by arrow D intersecting the base board transporting direction indicated by arrow A at right angles. The soldering operation is therefore initiated from the right side end 1d of the base board 1 and is progressively shifted in the leftward direction and ends at the left side end 1e of the base board 1. Therefore the molten solder 3 does not converge to one point of the base board 1 and phenomena of so called bridges, icicles, drops or dews do not arise.

According to the embodiment, the base board angle adjusting device and the nozzle angle adjusting device are described as independent devices. These devices may however be designed to operate in association with each other in accordance with the formula $\tan \gamma = \tan \alpha \cdot \tan \beta$. In this case, a change of the inclination angle β of the nozzles 25, 26 will cause a relative adjustment of the inclination angle γ of the base board 1.

Another embodiment of the invention will now be described with reference to Figs. 8 and 9 where an automatic soldering apparatus 111 has a transporting device 112, a feed back device 113, a heater 114 and a solder storing tank 115.

As shown in Figs. 10 and 11, the transporting device 112 includes a carrier 118 having a pair of arms 218a, 218b which are forked and each provided with a pawl 118a for clamping and holding a base board 116. A pair of lift structures 218A, 218B are arranged opposite to each other,

one being arranged at one end lengthwise of the apparatus 111 and the other arranged at the opposite end of the apparatus 111. Each of the lift structures 218A, 218B has pulleys 219, 220 having a pair of belts 221 laterally spaced from each other and wound therearound to form a belt conveyer of a width slightly smaller than the width of the carrier 118 so as to carry the carrier 118. The belts 221 are driven by an electric motor 223 by way of a pair of gears 24.

As particularly shown in Fig. 11, the transporting device 112 and the feed back device 113 have a plurality of sensors LS_1 - LS_{11} such as microswitches each arranged at predetermined places thereof. The sensors will produce electric signals to operate a control device 225 for controlling electric motors 11, 23 and other parts, as will be described in detail.

A fluxer 226 is arranged below the transporting device 112 so as to flux the required points of the base board 116 which is transported over the fluxer so that the base board may be easily soldered. The transporting device 112 is designed to transport the base board 116 in the direction A ascending at an angle with respect to a horizontal plane.

The heater 114 is provided to preheat the base board 116 up to a predetermined temperature, for example, about 110°C and is composed of a plurality of electric heating elements 228 arranged side by side. According to the embodiment, the solder storing tank 115 is elongated laterally of the base board transporting direction A and is arranged in a horizontal plane at an inclination with respect to the base board transporting direction. In accordance with such arrangement of the solder storing tank 115, the heating elements 228 of the heater 14 are so arranged as shown, that is, the first heating element 114a is laterally shortest and

the following heating elements are progressively elongated to a maximum substantially corresponding to the length of the solder storing tank 115 and then the following heating elements are progressively shorter to a minimum at the last part 114b of the heater 114. Thus the heater 114 is designed to uniformly heat the base board 116 as the base board 116 is exposed all through the entire part thereof to the heater in a same period of time as the base board is transported.

The solder storing tank 115 is composed of a first tank 229 and a second tank 230 each storing therein a solder (not shown) made molten by a heater (not shown). The molten solder is jetted up from nozzles 236, 238 onto a lower side 116a of the transported base board 116 by impellers 235 which are driven by respective electric motors 231 through pulleys 232 and belts 233. The nozzles 236, 238 are arranged in the first and second solder storing tanks 228, 230 respectively with an inclination of about 45° with respect to the base board transporting direction A. The nozzle 236 in the first solder storing tank 229 is provided with a parallel rotation plate structure 239 which is elongated along the nozzle 236 and is rotated by an electric motor 240 to give pulse-like waves to the molten solder jetted up from the nozzle 236.

Next to the solder storing tank, a fan 241 is provided to cool down the base board 116 which has been heated up to a high temperature by the soldering treatment. The apparatus 111 is provided with a cover 242 which has a plurality of ventilating fans 243 provided thereon for discharging gas and smoke which may be produced during the soldering treatment of the base board 116.

With the structure of the invention as mentioned above, the operation is as follows:

With reference to Figs. 8 and 9, the first and second solder storing tanks 229, 230 are heated by heaters (not shown) so that the solder in the tanks is molten. The molten solder is jetted up from the nozzles 236, 238 by the impellers 235 rotated by the motors 231 through the belts 233. The molten solder jetted up from the nozzle 236 is pulse-like waved by the parallel rotation plate structure 239 rotated in the nozzle 236 by the motor 240. A guide plate (not shown) is provided adjacent to the nozzle 238 so as to flatten the top of the molten solder wave jetted up from the nozzle 238.

With further reference to Figs. 10 and 11, when the motor 11 is energized and rotated, the rotation of the motor is transmitted to a chain 210 through a pair of gears 212 which are in engagement with each other. As a result, the chain 210 is rotated in a clockwise direction in Fig. 11. An engaging piece 213 secured to the chain 210 holds one side 118b of the carrier 118 and the opposite side 118c of the carrier is slidably placed on a guide rail 215. The carrier 118 is therefore transported in the direction A together with the base board 116 which is clamped and held by the oppositely arranged pawls 118a of the carrier 118. The base board 116 is fluxed at the required points thereof by the fluxer 226. The fluxer 226 is inclined with respect to the base board transporting direction with the angle of about 45° in the horizontal plane so that the opened fluxing area of the fluxer is substantially 1.4 times the actual opened fluxing area in effect to efficiently flux the base board 116.

The base board 116 pretreated with the flux is transported over the heater 114 and heated to a temperature of about 110°C. The heater 114 is inclined at the forward part 114a and at the backward part 114b in parallel with the solder storing tank 115 with the angle of about 45° in the

horizontal plane so that the base board 116 is exposed all through the entire part thereof to the heater 114 in a same period of time, and therefore the base board is uniformly heated without deflections.

Further the base board 116 is transported to the first solder storing tank 29 which is jetting up the molten solder having the pulse like waves generated therein. The pulse like waves are effective to exhaust the gas, which is produced from the flux heated by the molten solder, from the lower side 116a of the base board 116 to thereby uniformly wet the base board with the molten solder. Subsequently the base board 116 is soldered most desirably at the second solder storing tank 30 where the molten solder jetting up has flat waves formed at the top thereof which will contact the precededly attached molten solder for 3 seconds at the lower side 116a of the base board 116.

The solder storing tank 115 is inclined at about 45° with respect to the base board transporting direction A while the base board 116 is transported in an ascending plane with an inclination toward one side, so that the molten solder will flow eventually in a direction at about 90° with respect to the base board transporting direction A. The soldering operation is therefore initiated from the left end of the base board in Fig. 8 and is ended at the right end of the base board 116 as the base board is transported in the direction A. It is accordingly observed that the molten solder does not come to the centre of the base board 116, and thus the undesired soldering phenomena such as bridges, icicles, drops of dews, etc., are not be produced. The soldered base board 116 is then cooled down by the fan 241 and is further transported to the end 112b of the base board transporting device 112.

With reference to Figs. 9 and 11 showing the feed back

device 113, a pair of first carrier holders 245 are arranged on an extension of the chain 210 and the guide rail 215 at the end 112b of the base board transporting device 112. The first carrier holders 245 are turnable on respective shafts 244 and are normally closed as shown by arrows F, F. When the carrier 118 transported by the transporting device 112 is located on the holding faces 145a of the carrier holders 245, a microswitch LS_1 is pushed by the carrier 118 and is turned on to give an electric signal. The control device 225 is responsive to the electric signal to turn the carrier holders 245 in the directions E through a drive mechanism (not shown) and take the carrier up onto the forked arms 218a, 218b of the lift structure 218A located at an upper station. The carrier holders 245 are turned in the directions E respectively to push microswitches LS_2 , LS_2 to turn the same on to thereby move down the lift structure 218A in the direction B. The carrier holders 245 are moved down past the pair of belts 221 therebetween and are stopped at a lower station as shown while leaving the carrier 118 on the belts 221 which are driven at all times in the direction C. Simultaneously the lift structure 218A pushes a microswitch LS_4 , to turn the same on to thereby move the carrier holders 245 back in a direction F to the upper station for carrying thereon the next carrier.

The carrier 118 transported by the conveyer 222 in the direction C pushes a microswitch LS_5 to turn the same on to thereby move up a stop-up member 246 to hold the carrier 118 in an upper position off the conveyer 222 to temporarily stop the transportation of the carrier while moving down the lift structure 218B at the start position of the transporting device 222. The lift structure 218B pushes a microswitch LS_6 at the lowest position to turn the same on to thereby move down the stop-up member 246 so that the carrier 118 is placed on the conveyer 222 again which transports the carrier 118 in the direction C and onto the

lift structure 218B.

When the carrier 218 is placed on the lift structure 218B, the carrier 218 pushes a microswitch LS₇ to turn the same on to thereby move up the lift structure 218B in the direction D on confirmation that a pair of second carrier holders 248 located above are opened in contact with microswitches LS₈, LS₉ respectively so that the carrier 218B may vertically pass through between the carrier holders 248. The lift structure 218B is moved up to a predetermined position and pushes a microswitch LS₁₀ to turn the same on to thereby turn the second carrier holders 248 in the direction F to hold the carrier 118.

Then the machine operator takes off the soldered base board 116 from the carrier 118 and puts a new base board onto the carrier. The chain 210 will then transport the carrier 118 in the direction A, and the carrier 118 will push a microswitch LS₁₁ to turn the same on to thereby turn the second carrier holders 248 in the direction E respectively to hold the next base board 116.

Thus the base board 116 carried by the carrier 118 is transported one after another so as to be soldered.

**CLAIMS**

1. Apparatus for automatically soldering a base board having electronic components mounted on a surface thereof, comprising transporting means operative to move the base board along a base board transporting path which runs at an upward inclination (angle α) from a base board entrance to a soldered base board exit, and a molten solder storage tank which is arranged in a substantially horizontal plane below the base board transporting path and has an elongate molten solder jetting nozzle directed upwards towards the base board transporting path, said nozzle extending transversely of the base board transporting path at an oblique angle relative thereto so that, in use, as the board is moved at an upward inclination above the nozzle solder is applied progressively to the lower surface of the base board, but owing to the oblique disposition of the nozzle is supplied to locations at one side of the board sooner than to opposing locations at the other side of the board, characterised in that the transporting means is operative to move the base board along the base board transporting path with the base board tilted laterally (angle γ) with respect to the path so that the base board is lowered laterally of the base board transporting path at the same side as where the nozzle is farther from the base board entrance and the distance between the lower surface of the board and the nozzle is kept constant along the entire length of the nozzle as the base board is transported thereover.

2. Apparatus according to claim 1 wherein first adjusting means is provided and is operable to adjust the tilt angle (γ) of the base board with respect to the base board transporting path.

3. Apparatus according to claim 1 or 2 wherein second adjusting means is provided and is operable to adjust the



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angle (β) of the molten solder jetting nozzle with respect to the base board transporting path.

4. Apparatus according to claim 2 and 3 wherein the first and second adjusting means are operatively connected to each other such that the adjustment of either one of the tilt angle (γ) of the base board or the angle of inclination (β) of the nozzle is made in association with the adjustment of the other.

5. Apparatus according to any preceding claim wherein the molten solder storage tank is elongated and is arranged at an inclination of about 45° with respect to the base board transporting direction (A).

6. Apparatus according to any preceding claim further comprising a heater for heating the base board to be soldered, the heater being arranged in the base board transporting path between the base board entrance and the molten solder storing tank.

7. Apparatus according to any preceding claim further comprising a carrier for carrying the base board, the carrier being transported by the transporting means from the base board entrance to the soldered base board exit of the base board transporting path.

8. Apparatus according to any preceding claim further comprising feed back means for feeding back the soldered base board from the soldered base board exit to the base board entrance of the base board transporting path, the feed back means including a conveyer arranged below the base board transporting path and extending the length of the base board transporting path, first lift means arranged at the soldered base board exit and movable between the exit side and one end of the conveyer, and second lift means arranged



at the base board entrance and movable between the entrance side and the opposite end of the conveyer, the first lift means transporting the carrier from the exit to the one end of the conveyer, the conveyer transporting the carrier to the second lift means and the second lift means transporting the carrier to the entrance.

9. An automatic soldering apparatus substantially as described and exemplified herein with reference to Figs. 1 to 11.
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