

SPECIFICATION

Apparatus for and method of mounting elements on printed circuit boards

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The invention relates to an apparatus for mounting plate-shaped electrical elements on printed circuit boards, comprising tubular magazines which are each constructed to contain a stack of said elements and which are arranged in given positions relative to each other which correspond to the desired positions of the elements relative to each other on each printed circuit board.

The invention furthermore relates to a method of mounting plate-shaped electrical elements on printed circuit boards by means of this apparatus.

It is known to manufacture printed circuit boards by printing conductor tracks on a substrate of an insulating material, the conductor tracks being connected in accordance with the desired circuit pattern by means of electrical elements which are arranged on the insulating substrate. Generally, for these printed circuit boards elements are used which have connection wires which are inserted through holes in the substrate and which are soldered to the conductor tracks. For miniaturization of these circuits both sides of the substrate are provided with conductor tracks, one side of the substrate preferably being provided with elements having connection wires which are inserted through the holes in the substrate and project slightly beyond the other side of the substrate. The other side of the substrate is provided, in the spaces between the wire connections, with plate-shaped elements, commonly referred to as "chips". The term "chips" is to be understood herein to mean elements which do not comprise the conventional connection wires; these chips comprise either contact or connection pads or very short connection studs.

German Offenlegungsschrift 27 16 330 describes an apparatus for mounting plate-shaped or block-shaped electrical elements on printed circuit boards. With this apparatus, elements can be mounted on a printed circuit board which is provided in advance with a quantity of adhesive at each of a given number of positions on one side of the board. The elements are transferred to the printed circuit board from a number of tubular magazines which are arranged in a magazine array and in which the elements are stacked. At each operation of the apparatus the upper element of the stack in each magazine is pressed onto the corresponding quantity of adhesive on the printed circuit board.

Said German Offenlegungsschrift also describes a method of mounting plate-shaped or block-shaped elements on printed circuit boards by means of said apparatus.

The known apparatus and the known method have a number of drawbacks which impede rational and accurate manufacture in bulk. Miniaturization of the circuits is possible only to a limited extent, because the printed circuit board is provided with elements directly from the magazines containing stacks of elements. The magazines are comparatively large and a corresponding large space, including the

required tolerances, must remain free between the locations on the printed circuit board where the parts are to be accommodated.

It is a further drawback of the known apparatus that elements of different thicknesses cannot be simultaneously mounted on the printed circuit board. During one mounting operation only elements of substantially the same thickness can be handled, because the magazines which are arranged underneath the printed circuit board and which contain the elements are guided in the array of magazines so that the openings are always situated in one plane the step-wise transport of the elements from the magazines takes place with substantially the same stroke; only the thickness tolerances of the individual elements are compensated for by the resilient mounted of the individual transport devices. When the distance between the openings of the magazines and the printed circuit board is so large that each time only elements of the smallest thickness just contact the printed circuit board, thicker elements from the other magazines will not be released. If the distance between the openings of the magazines and the printed circuit board, however, is so large that the elements having the largest thickness also emerge from the magazines, in given circumstances several elements will be simultaneously released from the magazines containing the elements having a smaller thickness, said several elements being loose, without guide and holder, except for the one element which is retained by the printed circuit board by way of the adhesive provided thereon.

Moreover, with this known apparatus it is not ensured that each time only a single element is taken from each magazine. The elements may stick for various reasons in practice. This drawback is not always eliminated by the magazine embodiment comprising resilient tongues as disclosed in German Offenlegungsschrift 2716 330, because the operation thereof is dependent on the individual tolerances of the successive elements. For example, an element of smallest dimension between two elements of largest dimension within the tolerance limits of the elements in a magazine is not retained.

Perfect operation of the apparatus, moreover, is very dependent on the shape of the magazines and imposes severe requirements as regards their uniformity which requirements are not always satisfied when magazines obtained from different manufacturers are used.

It is to be noted that an absolutely reliable separation of the elements after the release from the magazines is a condition to be satisfied in order to obtain perfect mounting of these elements on the printed circuit boards.

According to the invention there is provided an apparatus for mounting plate-shaped electrical elements on a printed circuit board, comprising tubular magazines which are each constructed to contain a stack of said elements and which are arranged in given positions relative to each other which correspond to the desired positions of the elements relative to each other on the printed circuit board, wherein a transfer device for transferring elements

from the magazines to the printed circuit board is arranged opposite the openings at one end of the magazines, the transfer device comprising suction tubes for holding the elements during their transfer-
ence, which suction tubes are arranged to be interchangeable in the transfer device.

In a preferred embodiment of the apparatus according to the invention for mounting plate-shaped elements of different thicknesses on a printed circuit board, the transfer device comprises a plate from which the suction tubes project through distances which differ in accordance with the difference or differences in thickness of the elements to be held by the respective suction tubes.

Preferably, the apparatus according to the invention comprises a calibration plate which cooperates with the transfer device and which is movable relative thereto in an x and/or y direction, said calibration plate comprising openings which correspond to the magazines in their number and relative positions and in which the elements can fit with a clearance, the suction tubes each projecting into a respective one of said openings for a distance such that within that opening a free space remains which corresponds to the thickness of the elements to be held by the respective suction tube. The calibration plate may comprise separate tapered calibration members with openings, which members are arranged in a matrix frame. Thus, extremely accurate centring and positioning of the elements with respect to the locations on the printed circuit board where elements are to be mounted is achieved and changing over to other circuit patterns can be very simply carried out by corresponding rearrangement of the calibration members.

Preferably, the suction tubes are resiliently supported in the transfer device. Each suction tube may have a cross-sectional shape which corresponds proportionally to the shape of the elements to be held by that tube. This is important when, as is usually the case, the elements are rectangular and extremely small, because a large part of the surface of each element would be unused in the application of the suction to the element if the tubes had a round cross-section. However, round-section suction tubes, whose manufacture is easier than tubes having a rectangular cross-section, can be used advantageously when the elements have comparatively large dimensions and a correspondingly larger surface for engagement by the suction tubes.

The invention also provides a method of mounting plate-shaped electrical elements on printed circuit boards by means of an apparatus according to the invention comprising the aforesaid calibration plate, in which method the suction tubes are arranged opposite the openings of the magazines, the suction tubes corresponding to the magazines in their number and relative positions and projecting into the respective openings in the calibration plate for distances such that in each of the openings a free space remains which corresponds to the thickness of the elements in the respective magazine, after which one element from each magazine is moved against the suction tube in the respective opening in the calibration plate and is held by said suction tube, the

transfer device and the calibration plate together then being moved in the x and/or y direction relative to the magazines so that the openings of the magazines are at least partly covered by the calibration plate, and the elements held by the suction tubes subsequently being transferred by movement of the transfer device to said locations on the printed circuit board, where they are retained by an adhesive applied to the printed circuit board and/or to the elements.

Preferably, the transfer device is inverted together with the calibration plate after each pick-up of elements by the suction tubes. As a result, the elements picked up from the magazines remain situated on the same side as the openings of the magazines, so that all steps in the operation of the apparatus can be performed from one side. This enables particularly easy and also automatic testing and remeasurement of the individual elements if necessary. The adhesive can be also readily applied in this inverted position of the transfer device. Moreover, the printed circuit board can be provided with elements on both sides without having to turn the board over between the mounting of the elements on one side and the mounting of the elements on the other side. Other elements which have already been mounted on the printed circuit board before the mounting of the plate-shaped elements cannot drop off the printed circuit board and, therefore, need not be soldered to the board in advance.

A major advantage to be obtained by means of the invention is that a large number of plate-shaped elements of diverse thicknesses and shape can be simultaneously positioned on a printed circuit board at the desired locations thereon because the suction tubes can be utilized separately and their lengths can be selected in accordance with the thicknesses of the elements so that the elements to be transferred to the printed circuit board are all situated in one plane, even though the thicknesses of the individual elements may differ greatly.

A further advantage of the invention is that a step-wise transport of the elements in each magazine can be performed with an individual stroke which corresponds to the thickness of the elements stacked in that magazine.

Another advantage is the certainty of the separation of the elements removed from the stacks in the magazines, which is achieved by the fact that after each pick-up of elements from the magazines by the suction tubes, the calibration plate together with the transfer device is shifted relatively to the magazines in the x and/or y direction so that the individual elements removed from the magazines are slid over the edges of the magazines and also the magazines are partly covered by the calibration plate so that the removal of other elements from the magazines during this phase is prevented.

It is a further advantage that the locations on the printed circuit board at which elements are to be mounted may be situated at a distance from each other which is only slightly larger than the elements itself in an extreme case, because the elements can be extremely accurately positioned and centred by

means of the apparatus in accordance with the invention and can, moreover, be positioned on very small areas on the printed circuit board because the suction tubes carrying the elements have themselves only very small cross-sections which correspond proportionally in shape to the elements and are slightly smaller than the elements.

It is another advantage of the invention that the apparatus can be readily integrated into the existing machinery of a manufacturing plant. As has already been stated, printed circuit boards can first be provided with conventional elements with connection wires and these printed circuit boards can subsequently be provided, preferably before the soldering of said elements, with plate-shaped elements by means of the apparatus and method in accordance with the invention, only very small areas being required for the mounting of the latter elements between the elements already mounted on the printed circuit board, because the adhesive can be applied also between projecting elements, the suction tubes used for arranging the elements on the printed circuit board having, as described, a cross-section smaller than the surface area of the elements and also a length such that they can reach as far as the printed circuit board between projecting elements already mounted on the board.

An embodiment of the apparatus in accordance with the invention will now be described in detail with reference to the accompanying diagrammatic drawings, in which

Figure 1 is a perspective sectional view of a magazine containing a stack of plate-shaped elements and arranged in a matrix holder, and a transport device,

Figure 2 is a sectional perspective view of two magazines in the holder, a transfer device and the transport device,

Figure 3 is a sectional view on an enlarged scale of the transfer device shown in Figure 2,

Figure 4 is a perspective view on an enlarged scale of a calibration plate shown in Figure 3,

Figures 5a, 5b and 5c show the transfer device in different stages of its operation,

Figures 6a, 6b are sectional views of a device for the application of adhesive to the elements, the device being shown in two stages of its operation,

Figures 7a, 7b and 7c show a device for the application of adhesive to the printed circuit boards, the device being shown in various stages of its operation,

Figure 7d is a sectional perspective view of an alternative embodiment of the device for applying adhesive to the printed circuit boards,

Figures 8a, 8b, 8c and 8d illustrate diagrammatically the operation of the calibration plate shown in Figure 2,

Figures 9a-9g illustrate the principle of the cooperation between the calibration plate and the transfer device,

Figure 10 is a sectional view of the transport device on an enlarged scale, and

Figure 11 shows diagrammatically the separate steps in the method according to the invention.

Figure 1 is a perspective view of a magazine 1 in a

matrix holder 3 which comprises several matrix frames 5. The matrix frames 5 comprise tapered openings 7, the largest cross-section of each opening 7 being remote from a cover plate 9 which covers the frames 5. The frames 5 are spaced from each other by distances which increase in the direction of the cover plate 9. The situation of the openings 7 of the frames 5 offers the advantage that the magazines 1 containing the stacks of plate-shaped elements 11 can be particularly quickly and simply inserted into the frames 5, because the largest cross-section of the tapered openings 7 of each frame is situated at the side of the frame at which the magazines 1 are inserted. The magazines 1 are guided very effectively by the taper of the openings. The fact that the distance between the frames 5 increases in the direction of the cover plate 9 offers the advantage that the matrix holder 3 is very light and the magazines are accurately retained and guided, in spite of the long length. In order to provide a large number of elements on a printed circuit board in one operation, a large number of magazines are arranged in the openings 7 in positions relative to each other which correspond to the desired positions of the elements relative to each other on a printed circuit board. For the transport of the plate-shaped elements 11 in the magazines 1, on the side of the cover plate 9 which is remote from the matrix holder 3 there is arranged a distribution box 14 for a fluid-pressure medium 34 (Figure 10) for the displacement of transport units which each consist of a transport piston 15 with a needle-shaped rod 17, said distribution box being moved upwards by a drive device 12 (Figure 10). The transport pistons 15 are guided in bores 18 which are interconnected via a space 16 which is filled with the fluid-pressure medium 34, for example, air or a viscous liquid which cannot be compressed. This intercommunicating system compensates for the necessarily different strokes of the individual transport pistons 15. The needle-shaped rod 17 passes through openings 21 in the cover plate 9 (only four of these openings 21 are shown in the drawing for the sake of clarity), the plate-shaped elements being transported at the rate at which they are removed from the magazine 1. The distance required between adjacent frames 5 is adjusted by means of spacers 23. The reference numeral 25 denotes a spacer plate which comprises grooves 36 and which ensures that, should no pressure be built up in the guide between the magazines 1 due to leakage of the individual transport pistons 15, no contamination of the individual parts 11 or disturbance of the transport can occur.

Figure 2 diagrammatically shows the transport of plate-shaped elements 11 of different thicknesses in two magazines 1 by the transport pistons 15 and their needle-shaped rods 17. The magazines 1 are situated in the matrix holder 3, the matrix of the frames 5 of this holder not being shown in Figure 2. The transport pistons 15 are combined in the distribution box 14 for the fluid-pressure medium and are exposed to the fluid-pressure medium 34 present in the space 16 and the bores 18. The drive unit 12 lifts the distribution box 14 until the rods 17 slide the elements 11 in a corresponding manner.

They slide the stacks of plate-shaped elements 11 first in the direction of a calibration plate 27 (to be described in detail hereinafter) until the elements 11 at the tops of the stacks contact suction tubes 29. The pressure exerted in the space 16 can be transmitted by the fluid-pressure medium to a pressure sensor (not shown) which in turn switches off the transport movement for the distribution box 14. A partial vacuum can be created in the suction tubes 29 via the bores 33. It is possible to mount the suction tubes 29 separately and interchangeably in a transfer plate 31 so that tubes of different lengths can be used in order to enable plate-shaped elements of different thicknesses (shown in Figure 2 for two stacks of elements in two magazines 1) to be picked up by the suction tubes 29 so that all the elements 11 held by the suction tubes 29 are situated in one plane, in spite of their different thicknesses. Using the transfer plate 31, elements of different thicknesses can thus be transferred in a single operation to a printed circuit board. The cross-sectional shape of the suction tubes may correspond proportionally to the shape of the elements.

Figure 3 shows the transfer plate 31 and suction tubes 29 on an enlarged scale. The plate-shaped elements 11 (of different thicknesses) are present in the magazines 1. At each operation of the apparatus, one element 11' is moved into the calibration plate 27, where it contacts a suction tube 29. The calibration plate 27 comprises openings 19 which vary in accordance with the dimensions of the elements to be transferred to the printed circuit board and which are preferably slightly larger than these elements.

In order to achieve suitable matching of the various sections of the complete device to the various dimensions of the elements 11, the calibration plate 27 is constructed as a matrix frame in which tapered blocks 37 (see also Figure 4) formed with openings 19 of different shapes can be arranged.

The suction tubes 29 are resiliently supported in the transfer plate 31 by means of resilient members 39 in order to provide cushioned positioning of the elements 11' held by the suction tubes 29 on a printed circuit board and to compensate for the thickness tolerance of the individual elements to be mounted.

The Figures 5a to 5c illustrate the transfer of the elements 11' to a printed circuit board 41 by means of the suction tubes 29. On the side of the printed circuit board 41 which faces the transfer plate 31, elements 43 having connection wires 45 have already been mounted during a preceding mounting step. Due to the very small dimensions of the suction tubes 29, which have a slightly smaller cross-section than the plate-shaped elements 11' to be mounted on the printed circuit board, the plate-shaped elements 11' can be extremely accurately positioned between the connection wires 45 of the elements 43, very accurate guiding of the elements 11' being ensured by the calibration plate 27. Abutments 47, having a height corresponding to the free length of the connection wires 45 inserted through the printed circuit board 41 (this height should be slightly larger), ensure that the calibration plate 27 cannot

abut the connection wires projecting through the printed circuit board 41.

Fig. 5a shows the suction tubes 29 in an initial position in which they hold the elements 11' just inside the openings of the calibration plate 27. During a preceding mounting step, a quantity 69' of one component of a two-component contact adhesive has been deposited on the printed circuit board at the locations thereon where the elements 11' are to be mounted. In another preceding mounting step, a quantity 59' of the other component of the two-component contact adhesive has been provided on the elements 11' held by the suction tubes 29.

Figure 5b shows how the suction tubes 29 press the elements 11' onto the printed circuit board 41 exactly at the locations where the adhesive is provided.

Figure 5c shows the mounting step in which the plate-shaped elements 11' of different thicknesses are simultaneously transferred to the printed circuit board 41 by the suction tubes 29 by removal of the partial vacuum in the tubes, the elements 11' being retained on the board by adhesive and the suction tubes 29 being withdrawn.

Figures 6a and 6b show a device for applying adhesive to the elements 11' held by the suction tubes 29. Stamps 55 each comprising a stamping portion 57 consisting of an elastic material are resiliently mounted in a plate 53. In order to take up adhesive 59 from a container 61, the plate 53 is moved in the direction of the container 61 sufficiently for a quantity of adhesive 59' to be picked up by the tips of the stamping portions 57. The transfer plate 31 and the calibration plate 27 are positioned so that the adhesive 59' on the stamps 55 can be transferred by lowering the plate 53, to the plate-shaped elements 11' which are retained on the transfer plate 31 by the suction tubes 29.

Figure 6b shows the plate-shaped elements 11' provided with adhesive 59.

Figures 7a, 7b and 7c show a device for applying adhesive to the printed circuit board 41. Stamps 65 are resiliently mounted in a plate 63. The stamps 65 each comprise a stamping portion 67 which consists of an elastic material. For taking up adhesive 69 from a container 71, the plate 63 is moved towards the container 71 sufficiently for a quantity of adhesive 69' to be picked up by the tips of the stamping portions 67. The printed circuit board 41, already provided with the elements 43, is positioned so that the adhesive 69' on the stamps 65 is transferred, by movement of the plate 63, to the locations on the printed circuit board 41 where the plate-shaped elements 11' are to be mounted.

Figure 7c shows the printed circuit board 41 provided with the adhesive 69'.

Figure 7d shows a further embodiment of the device for applying adhesive to the printed circuit board. This device can also be used for applying adhesive to the elements to be mounted on the board. The stamps 65 are formed integrally with the plate 63 from an elastic material (for example, rubber) and correspond in number and position to the maximum number of locations to be provided with adhesive in one operation.

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If only a selected number of locations has to be provided with adhesive by means of the device shown in Figure 7d, a template 83 having openings 89 which correspond in number and position to the locations to be provided with adhesive is arranged between the plate 63 with the stamps 65 and a distribution box 75 for a fluid-pressure medium, for example, air.

Over the elastic plate 63 there is arranged a stationary mask 77 which is formed with a number of holes 79 corresponding in number and distribution to the maximum number of locations to be provided with adhesive in one operation. The stamps 65 are moved through the holes 79 of the mask 77, for example, by means of air pressure which is transmitted from the distribution box 75, via a first apertured plate 81, the template 83 arranged over the apertured plate 81, a cover plate 85 and a second apertured plate 87, to the elastic plate 63 and which presses the stamps 65 upwards at the locations where openings 89 are present in the template 83.

Figure 8a to 8d diagrammatically illustrate the extremely accurate positioning of the elements 11 by means of the calibration plate 27. As has already been stated, the calibration plate 27 is constructed as a matrix in which tapered blocks formed with openings 19 can be separately arranged. Until the instant at which plate-shaped elements 11 are situated in the vicinity of the calibration plate 27 (see Figure 8a), this plate is shifted, together with the transfer plate 31, in the y-direction (Figure 8b) and in the x-direction (Figure 8c) until the elements 11 in the openings 19 of the calibration plate 27 are accurately aligned with respect to the locations on the printed circuit board where the elements 11' are to be mounted (Figure 8d). The shifting of the calibration plate 27 in the x and/or y direction not only serves for the accurate positioning of the elements 11' but also provides protection against the pick-up of more than one element from any of the magazines 1. Moreover, after the shifting, the calibration plate serves as a cover for the remaining parts stacked in the magazine.

Figures 9a to 9g illustrate the cooperation between the calibration plate 27 and the transfer plate 31. The transfer plate 31 and the calibration plate 27 are arranged at a distance from each other such that the suction tubes 29 of the transfer plate 31 extend just so far into the openings 19 of the calibration plate 27 that a free space remains in each opening 19 beyond the end of the tube 29 therein, which space corresponds to the thickness of the elements 11 in the magazine 1 directly beneath the calibration plate 27 (see Fig. 9a).

Figure 9b shows an element 11' in mechanical contact with the respective suction tube 29 in one of the openings 19. In order to ensure that the element 11' in each opening 19 is properly removed from the stack of elements 11 in the respective magazine 1, and in order to prevent more than one element from being picked up from any of the magazines, the calibration plate 27 is shifted together with the transfer plate 31 so that the openings of the magazines 1 are covered by the calibration plate 27 (see Figure 9c). In order to facilitate further treatment of

the elements 11' in the openings 19 of the calibration plate 27, for example, from the same side, the transfer plate 31 and the calibration plate 27 are simultaneously inverted (see Figure 9d), regardless of the situation of the openings of the magazines 1.

Figure 9e shows the transfer plate 31 and the calibration plate 27 in the inverted position and the elements 11' in the opening 19 provided with a quantity of adhesive 59'. Subsequently, a calibration step is performed with the calibration plate 27, preferably directly before the mounting of the elements 11' on the printed circuit board, in order to obtain accurate alignment and positioning of the elements 11'. To this end, the calibration plate 27 is shifted in the x and/or y direction so that the elements 11' to be transferred to the printed circuit board are each guided by at least one side wall of the respective opening 19 (see Figure 9f).

Subsequently, the transfer plate 31 is moved towards the printed circuit board 41 so that the suction tubes 29 and the elements 11' held thereby pass through the openings 19 of the calibration plate 27 and the elements 11' reach the locations 73 on the printed circuit board 41 where they are to be mounted. When a two-component adhesive is used, prior to the mounting of the elements 11' on the printed circuit board 41 one component 69' of the adhesive is applied to the locations 73 where the elements are to be mounted and the other component 59' of the adhesive is applied to the elements 11'.

Figure 10 illustrates the principle of a pressure-controlled transport system for the transport of the elements 11 stacked in the magazines 1.

For the transport of the elements 11 in the direction of the suction tubes 29 situated opposite the respective stacks of elements, the transport pistons 15 are arranged in the distribution box 14 for the fluid-pressure medium 34, which distribution box comprises a system of intercommunication spaces, namely, the space 16 and the bores 18. The bores 18 on the one hand guide the transport pistons 15 but on the other hand they communicate with the space 16 according to the principle of intercommunicating vessels. The space 16 is closed at both ends, at one end by a seal 20 and at the other end by a switch-actuating piston 24 which is loaded by a spring 22 and to which there is secured a plunger 26 which passes through the wall of the distribution box 14. When the distribution box 14, with the transport pistons 15, is moved by means of the pressure controlled drive 12 towards the stacks of elements 11 of different thicknesses which are situated opposite the transport pistons 15 in the magazines 1, first the needle-shaped rod 17 of the relevant transport piston 15 will make mechanical contact with the bottom end of the longest stack, which is held at the top end by the relevant suction tube 29. When the distribution box 14 is moved further towards the stacks of elements, a slight increase in pressure will occur in the system formed by the space 16 and the bores 18, so that the other transport pistons 15 are also pressed upwards until each piston contacts a stack of elements or a dummy 28 where there is no stack. When the distribution

box 14 is moved further towards the stacked elements 11, the pressure in the system formed by the space 16 and the bores 18 increases further and the switch-actuating piston 24 is pressed outwards so that a pressure sensor or, for example, the plunger 26 connected to the switch-actuating piston 24, ultimately operates a switch 30 which terminates the movement of the distribution box 14 by de-energising the drive 12, thus reducing the pressure in the fluid-pressure medium 34. The elements 11' situated at the suction tubes 29 are then picked up by the suction tubes 29 and removed from the respective stacks of elements. When the pressure in the system decreases, the switch-actuating piston 24 is pressed back into the system 16, 18 by the spring 22 and the above operation may be repeated. In order to cut off the suction or retaining action of the suction tubes 29 at the areas where dummies 28 are present, the relevant suction tubes 29 are closed by caps 32.

Either a gas or a viscous, notably paste-like liquid which cannot be compressed, can be used as the fluid-pressure medium 34 in the system formed by the space 16 and the bores 18.

Figure 11 illustrates the method of mounting elements on printed circuit boards by means of the apparatus shown in the Figures 1 to 10.

The printed circuit boards 41 to be provided with elements are provided with adhesive at the areas 73 where the elements are to be mounted by means of stamps 65 which are arranged on the plate 63 and which are first dipped into the adhesive container 71.

Elements 11' are removed from the magazines in the matrix holder 3 by means of the suction tubes in the transfer plate 31, and adhesive 59' is applied to these elements 11' from the adhesive station K (see Figure 6).

The printed circuit board 41, provided with adhesive at the locations 73 where the elements 11' are to be mounted, is so positioned with respect to the transfer plate 31 that the elements 11' provided with adhesive 59' can be positioned at the locations 73.

CLAIMS

1. An apparatus for mounting plate-shaped electrical elements on a printed circuit board, comprising tubular magazines which are each constructed to contain a stack of said elements and which are arranged in giving positions relative to each other which correspond to the desired positions of the elements relative to each other on the printed circuit board, wherein a transfer device for transferring elements from the magazines to the printed circuit board is arranged opposite the openings at one end of the magazines, the transfer device comprising suction tubes for holding the elements during their transference, which suction tubes are arranged to be interchangeable in the transfer device.

2. An apparatus as claimed in Claim 1, wherein the suction tubes are resiliently supported in the transfer device.

3. An apparatus as claimed in Claim 1 or 2, wherein each suction tube has a cross-sectional shape which corresponds proportionally to the shape of the elements to be held by that tube.

4. An apparatus as claimed in Claim 1, 2 or 3, wherein the suction tubes have a round cross-section.

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5. An apparatus as claimed in any of Claims 1 to 4 for mounting plate-shaped elements of different thicknesses on a printed circuit board, wherein the transfer device comprises a plate from which the suction tubes project through distances which differ in accordance with the difference or differences in thickness of the elements to be held by the respective suction tubes.

6. An apparatus as claimed in any of the preceding Claims, comprising a calibration plate which cooperates with the transfer device and which is movable relative thereto in an x and/or y direction with respect thereto, said calibration plate comprising openings which correspond to the magazines in their number and relative positions and in which the elements can fit with a clearance, the suction tubes each projecting into a respective one of said openings for a distance such that within that opening a free space remains which corresponds to the thickness of the elements to be held by the respective suction tube.

7. An apparatus as claimed in Claim 6, wherein the calibration plate comprises separate tapered calibration members with openings, which members are arranged in a matrix frame.

8. A method of mounting plate-shaped elements on printed circuit boards by means of an apparatus as claimed in Claim 6 or 7, wherein the suction tubes are arranged opposite the openings of the magazines, said tubes corresponding to the magazines in their number and relative positions and projecting into the respective openings in the calibration plate for distances such that in each of these openings a free space remains which corresponds to the thickness of the elements in the respective magazine, after which one element from each magazine is moved against the suction tube in the respective opening in the calibration plate and is held by said suction tube, the transfer device and the calibration plate together then being moved in the x and/or y direction relative to the magazines so that the openings of the magazines are at least partly covered by the calibration plate, and the elements held by the suction tubes subsequently being transferred by movement of the transfer device to said locations on the printed circuit board, where they are retained by an adhesive applied to the printed circuit board and/or to the elements.

9. A method as claimed in Claim 8, wherein the transfer device is inverted together with the calibration plate after each pick-up of elements by the suction tubes.

10. A method as claimed in Claim 8 or 9, wherein prior to the arrangement of the elements on the printed circuit board the calibration plate is shifted in the x and/or y direction relative to the transfer device while the suction tubes project into the openings of the calibration plates, so that the elements held by the suction tubes are positioned with respect to the relevant locations on the printed circuit board by the walls of said openings.

11. A method as claimed in Claim 8, 9 or 10, wherein the transfer device is moved relative to the calibration plate in the direction of the printed circuit



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box 14 is moved further towards the stacked elements 11, the pressure in the system formed by the space 16 and the bores 18 increases further and the switch-actuating piston 24 is pressed outwards so that a pressure sensor or, for example, the plunger 26 connected to the switch-actuating piston 24, ultimately operates a switch 30 which terminates the movement of the distribution box 14 by de-energising the drive 12, thus reducing the pressure in the fluid-pressure medium 34. The elements 11' situated at the suction tubes 29 are then picked up by the suction tubes 29 and removed from the respective stacks of elements. When the pressure in the system decreases, the switch-actuating piston 24 is pressed back into the system 16, 18 by the spring 22 and the above operation may be repeated. In order to cut off the suction or retaining action of the suction tubes 29 at the areas where dummies 28 are present, the relevant suction tubes 29 are closed by caps 32.

Either a gas or a viscous, notably paste-like liquid which cannot be compressed, can be used as the fluid-pressure medium 34 in the system formed by the space 16 and the bores 18.

Figure 11 illustrates the method of mounting elements on printed circuit boards by means of the apparatus shown in the Figures 1 to 10.

The printed circuit boards 41 to be provided with elements are provided with adhesive at the areas 73 where the elements are to be mounted by means of stamps 65 which are arranged on the plate 63 and which are first dipped into the adhesive container 71.

Elements 11' are removed from the magazines in the matrix holder 3 by means of the suction tubes in the transfer plate 31, and adhesive 59' is applied to these elements 11' from the adhesive station K (see Figure 6).

The printed circuit board 41, provided with adhesive at the locations 73 where the elements 11' are to be mounted, is so positioned with respect to the transfer plate 31 that the elements 11' provided with adhesive 59' can be positioned at the locations 73.

CLAIMS

1. An apparatus for mounting plate-shaped electrical elements on a printed circuit board, comprising tubular magazines which are each constructed to contain a stack of said elements and which are arranged in giving positions relative to each other which correspond to the desired positions of the elements relative to each other on the printed circuit board, wherein a transfer device for transferring elements from the magazines to the printed circuit board is arranged opposite the openings at one end of the magazines, the transfer device comprising suction tubes for holding the elements during their transference, which suction tubes are arranged to be interchangeable in the transfer device.

2. An apparatus as claimed in Claim 1, wherein the suction tubes are resiliently supported in the transfer device.

3. An apparatus as claimed in Claim 1 or 2, wherein each suction tube has a cross-sectional shape which corresponds proportionally to the shape of the elements to be held by that tube.

4. An apparatus as claimed in Claim 1, 2 or 3, wherein the suction tubes have a round cross-section.

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5. An apparatus as claimed in any of Claims 1 to 4 for mounting plate-shaped elements of different thicknesses on a printed circuit board, wherein the transfer device comprises a plate from which the suction tubes project through distances which differ in accordance with the difference or differences in thickness of the elements to be held by the respective suction tubes.

6. An apparatus as claimed in any of the preceding Claims, comprising a calibration plate which cooperates with the transfer device and which is movable relative thereto in an x and/or y direction with respect thereto, said calibration plate comprising openings which correspond to the magazines in their number and relative positions and in which the elements can fit with a clearance, the suction tubes each projecting into a respective one of said openings for a distance such that within that opening a free space remains which corresponds to the thickness of the elements to be held by the respective suction tube.

7. An apparatus as claimed in Claim 6, wherein the calibration plate comprises separate tapered calibration members with openings, which members are arranged in a matrix frame.

8. A method of mounting plate-shaped elements on printed circuit boards by means of an apparatus as claimed in Claim 6 or 7, wherein the suction tubes are arranged opposite the openings of the magazines, said tubes corresponding to the magazines in their number and relative positions and projecting into the respective openings in the calibration plate for distances such that in each of these openings a free space remains which corresponds to the thickness of the elements in the respective magazine, after which one element from each magazine is moved against the suction tube in the respective opening in the calibration plate and is held by said suction tube, the transfer device and the calibration plate together then being moved in the x and/or y direction relative to the magazines so that the openings of the magazines are at least partly covered by the calibration plate, and the elements held by the suction tubes subsequently being transferred by movement of the transfer device to said locations on the printed circuit board, where they are retained by an adhesive applied to the printed circuit board and/or to the elements.

9. A method as claimed in Claim 8, wherein the transfer device is inverted together with the calibration plate after each pick-up of elements by the suction tubes.

10. A method as claimed in Claim 8 or 9, wherein prior to the arrangement of the elements on the printed circuit board the calibration plate is shifted in the x and/or y direction relative to the transfer device while the suction tubes project into the openings of the calibration plates, so that the elements held by the suction tubes are positioned with respect to the relevant locations on the printed circuit board by the walls of said openings.

11. A method as claimed in Claim 8, 9 or 10, wherein the transfer device is moved relative to the calibration plate in the direction of the printed circuit



board so that the suction tubes with the elements held thereon project through the openings in the calibration plate, the elements thus reaching the locations on the printed circuit board where they are to be mounted.

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12. An apparatus for mounting plate-shaped electrical elements on a printed circuit board, the apparatus being constructed and arranged to operate substantially as herein described with reference
- 10 to the accompanying drawings.
13. A method of mounting plate-shaped electrical elements on a printed circuit board, substantially as herein described with reference to the accompanying drawings.
- 15 14. A printed circuit board having plate-shaped electrical elements mounted thereon by means of the apparatus claimed in Claim 12 or any of Claims 1 to 7.

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