



- (51) **International Patent Classification:**
H01L 21/67 (2006.01) **H01L 21/66** (2006.01)
H05K 13/00 (2006.01)
- (21) **International Application Number:**
PCT/FI2011/051138
- (22) **International Filing Date:**
20 December 2011 (20.12.2011)
- (25) **Filing Language:** Finnish
- (26) **Publication Language:** English
- (30) **Priority Data:**
20106357 21 December 2010 (21.12.2010) FI
- (71) **Applicant (for all designated States except US):** **TEKNOLOGIAN TUTKIMUSKESKUS VTT** [FI/FI]; Vuorimiehentie 3, FI-02044 VTT (FI).
- (72) **Inventors; and**
- (75) **Inventors/Applicants (for US only):** **JOKELAJINEN, Kimmo** [FI/FI]; Vtt, PI1100, FI-90571 Oulu (FI). **MOILANEN, Ville** [FI/FI]; VTT, PI 1100, FI-90571 Oulu (FI). **VASALA, Hannu** [FI/FI]; VTT, PI 1100, FI-90571 Oulu (FI). **MÄKELÄ, Kimmo** [FI/FI]; VTT, PI 1100, FI-90571

Oulu (FI). **HAAPALAINEN, Ahti** [FI/FI]; VTT, PI1100, FI-90571 Oulu (FI).

- (74) **Agent:** **BERGGREN OY AB**; Kirkkokatu 9, FI-90100 Oulu (FI).

- (81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States (unless otherwise indicated, for every kind of regional protection available):** ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,

[Continued on next page]

- (54) **Title:** METHOD AND APPARATUS FOR PERFORMING AN OPERATION AIMED AT A PART OF AN ELECTRONIC STRUCTURE

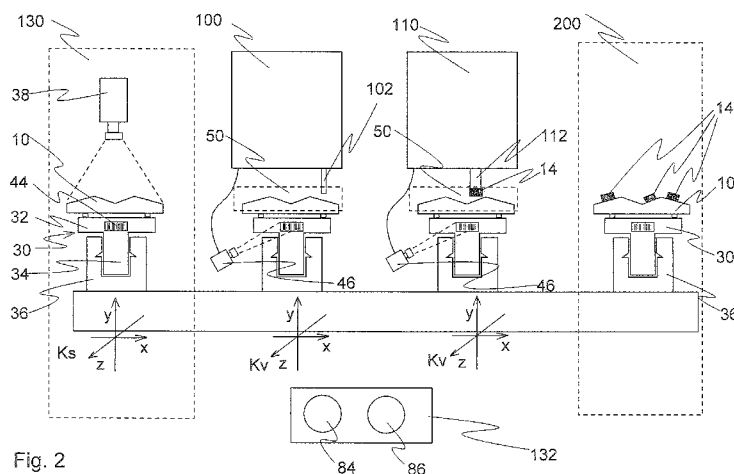


Fig. 2

- (57) **Abstract:** In the method at least one operation requiring location precision aimed at a part (10, 80) of an electronic structure is performed in a serial production apparatus for electronic structures. The operation can be printing of solder paste, dosing solder paste, assembling an electronic component, die bonding, wire bonding, tuning an electronic structure or protecting an electronic component by dispensing. The part of the electronic structure has an operation area (81), where the operation requiring location precision is aimed. The part of the electronic device can for example be a circuit board, the operation area of which is the circuit layout of the circuit board, whereby the method comprises defining the geometry of the circuit layout and the operation is aimed at the circuit layout area. The part of the electronic structure is moved into a standard position in the working area of the processing unit (100, 110, 120, 150, 160, 170), the geometry of the operation area of the part of the electronic structure is defined using computer vision technology (38) and the processing unit is used to perform the location precise operation aimed at the operation area of the part of the electronic structure. The defining of the geometry of the operation area of at least one part of an electronic structure and the operation requiring location precision aimed at the operation area of at least one second part of an electronic structure are performed at least partly at the same time. The method comprises utilising a predefined geometry of the operation area of the part of the electronic structure for performing the operation in a location precise manner in the operation area.



SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG). **Published:**

— *with international search report (Art. 21(3))*

Method and apparatus for performing an operation aimed at a part of an electronic structure

The object of the invention is a method for performing at least one operation requiring location precision aimed at a part of an electronic structure in the serial
5 production of electronic structures, which part of an electronic structure has an operation area and in which method the part of the electronic structure is moved into a standard position in the working area of a processing unit, the geometry of the operation area of the part of the electronic structure is defined by utilizing computer vision technology and the processing unit is used to perform the location
10 precise operation in the operation area of the part of the electronic structure. The invention also relates to an apparatus used in the method.

In the manufacturing process for electronic structures, electronic components are attached to the surfaces of substrates. The substrate can be a two-dimensional plate-like part, such as a circuit board, or it can be a piece with a three-
15 dimensional shape. Attaching electronic components according to plans to the surface of a substrate requires knowing the geometry of the substrate and precise control of its location and position during the manufacturing process.

Two-dimensional electronic structures, such as circuit boards, are manufactured on automatic production lines, which have several different manufacturing units
20 performing manufacturing operations. The circuit board arriving at the manufacturing unit is first locked into place in an attaching station of the manufacturing unit, whereafter the manufacturing unit identifies the position of the circuit board in the manufacturing unit with a camera-based position identification method based on the reading of aligning markers and performs the necessary
25 aligning operations and the manufacturing and/or examination operation planned for the circuit board. Thereafter the circuit board moves forward on the production line to the next manufacturing unit for performing the next manufacturing operation. Typical manufacturing units in the production lines for circuit boards are paste printing devices, dispensing devices, automatic optical inspection devices,
30 high-speed assembly devices and precision assembly devices, die bonding devices, wire bonding devices, flip chip bonding devices, assembly and programming machines for memory circuits, and testing and tuning devices for a circuit board. In each of the afore-mentioned manufacturing units the circuit board must first be attached to the attaching station in the working area of the
35 manufacturing unit, the position of the circuit board in the attaching station must be identified using optical or mechanical position identification, and aligning

operations must be performed either on the circuit board or actuators of the manufacturing unit in the working area of the manufacturing unit, before the manufacturing unit can perform the planned manufacturing operation. The manufacturing unit typically has at least one camera for the aligning, which camera
5 is used to read aligning markers in the circuit board. The camera is in some cases attached to the actuator doing the actual work, and in some cases it is a separate moving or fixed part in the working area of the actuator. After the aligning markers are read, either the actuators of the manufacturing unit and/or the circuit board being manufactured are aligned in the right place in relation to each other. The
10 aligner can also be a mechanical sensor identifying the position or a mechanical limiter, where to the circuit board is aligned.

Typically in aligning occurring with a camera, two or three aligning markers in the circuit board are read and the reading of each aligning marker can take for example about 0.5 seconds. After the aligning markers are read, the actual
15 aligning occurs, which comprises for example manoeuvring of actuators and/or calculation of compensated travelling lines. The time used for aligning the circuit board thus constitutes a significant part of the time used by the manufacturing unit for performing the manufacturing operation. In known production lines for electronics the aligning is performed again each time that the circuit board moves
20 to the next manufacturing unit on the production line. This multiplies the total time used for aligning.

It is an object of the invention to provide a method and an apparatus for performing an operation requiring location precision aimed at a part of an electronic structure, which method and apparatus can be used to make
25 manufacturing processes for electronics significantly more effective, to improve yield and quality of the production.

The objects of the invention are obtained with a method and an apparatus, which are characterised in what is presented in the independent claims. Some advantageous embodiments of the invention are presented in the dependent
30 claims.

In the method at least one operation requiring location precision aimed at a part of an electronic structure is performed in the serial production of electronic structures. The operation can be printing of solder paste, dosing solder paste, assembling an electronic component, die bonding, wire bonding, tuning an
35 electronic structure or protecting an electronic component by dispensing. The part

of the electronic structure has an operation area, where the operation requiring location precision is aimed.

The part of the electronic device can for example be a circuit board, the operation area of which is the circuit layout of the circuit board, whereby the method
5 comprises defining the geometry of the circuit layout and the operation is aimed at the circuit layout area. The operation area can in addition to the afore-mentioned for example be a printed area including secondary markings, such as alignment markings. The part of the electronic structure can also refer to panelled circuit boards in a preform, a three-dimensional electronic structure, a 3D piece
10 implemented for example with laser direct structuring technique or in any other manner according to prior art.

In the method the part of the electronic structure is moved into a standard position in the working area of the processing unit, the geometry of the operation area of the part of the electronic structure is defined using computer vision technology and
15 the processing unit is used to perform the location precise operation aimed at the operation area of the part of the electronic structure. The basic idea of the method is that the defining of the geometry of the operation area of at least one part of an electronic structure and the operation requiring location precision aimed at the operation area of at least one second part of an electronic structure are performed
20 at least partly at the same time. Additionally a predefined geometry of the operation area of the part of the electronic structure is utilised in the method for performing the operation in a location precise manner in the operation area. Performing at least partly at the same time means that at least during some time interval the defining of the geometry of at least one part of an electronic structure
25 is performed in the method simultaneously with the operation requiring location precision aimed at a second part of an electronic structure. The starting times of the defining of the geometry and the performing of the location precise operation do not have to be the same and they can have different time durations.

In the method the geometry of the operation area of a part of an electronic
30 structure is its actual, realized geometry, and not for example the planned geometry defined by a design file. This predefined geometry of the operation area of the part of the electronic structure is utilised for aiming the operation in a location precise manner in the operation area.

In one advantageous embodiment of the method according to the invention the
35 geometry of the operation area of at least one part of an electronic structure is

defined in at least one standard position in the working area at least partly simultaneously as the actuator of the processing unit performs an operation aimed at least at one second part of an electronic structure in at least one second standard position in the working area. Advantageously the defining of the geometry of at least one part of an electronic structure and the operation requiring location precision aimed at the operation area of at least one second part of an electronic structure, which operation immediately precedes the geometry defining in the serial production, are performed at least partly simultaneously.

In a second advantageous embodiment of the method according to the invention the geometry of the operation area of at least one part of an electronic structure, which will later be moved into a standard position in the working area of the processing unit, is defined at least partly simultaneously as the operation requiring location precision aimed at the operation area of at least one previous part of an electronic device in the standard position in the working area of the processing unit is performed.

In a third advantageous embodiment of the method according to the invention a predefined geometry of the operation area of a part of an electronic structure is utilized for positioning the part of the electronic structure in the working area of the processing unit. The positioning can be done completely with the aid of geometry data of the operation area, whereby the geometry data can replace separate aligning markings.

In still another advantageous embodiment of the method according to the invention the geometry of the operation area of a part of an electronic structure is defined in the standard position of the processing unit for performing an operation in the working area of the processing unit, when the part of the electronic structure is within the working area of the processing unit, but before said part of the electronic structure is attached in the standard position.

In still another advantageous embodiment of the method according to the invention the part of the electronic structure is attached in a standard position within the working area of the processing unit and the geometry of the part of the electronic structure attached in said standard position is defined in a second standard position of the processing unit, in which second standard position the operation aimed at the part of the electronic structure is performed. The defining of the geometry and the performing of the location precise operation thus take place in different standard positions.

In still another advantageous embodiment of the method according to the invention the part of the electronic structure is attached in a first standard position within the working area of the processing unit and the geometry of the part of the electronic structure attached in the first standard position is defined in said standard position of the processing unit. Additionally a location precise operation aimed at a part of an electronic structure is performed at least partly simultaneously in some other standard position within the working area of the processing unit, utilizing the previously made geometry identification in said second standard position. Thereafter a location precise operation aimed at a part of the electronic structure in the first standard position is started in the method, utilizing the geometry defined previously in said first standard position, and the identification of the geometry of some subsequent part of an electronic structure is performed at least partly simultaneously in some other standard position within the working area of the processing unit.

There are advantageously at least two standard positions within the working area of the processing unit, to which a part of an electronic structure is alternately brought and attached in order to identify the geometry. The geometry identification is done at least partly simultaneously as a location precise operation aimed at some other part of an electronic structure, the geometry of which has previously been identified, is performed in some other standard position within the working area of said processing unit. The operation performed in the second standard position is performed with the same actuator or the same actuators, which are subsequently used to perform the location precise operation aimed at a part of an electronic structure in the first standard position of the processing unit, when geometry identification of some subsequent part of an electronic structure is performed in the second standard position.

In still another advantageous embodiment of the method according to the invention there are at least two standard positions within the working area of the processing unit, in which alternately at least partly simultaneously a part of an electronic structure is in one standard position attached and its geometry data is identified and a location precise operation aimed at another previously identified part of an electronic structure in the second standard position and the thereafter performed detaching of the part of the electronic structure from the standard position is performed.

In still another advantageous embodiment of the method according to the invention the geometry of the operation area of a part of an electronic structure is

defined in the standard position in the processing unit in order to perform an operation outside the working area of the processing unit while the part is attached in the standard position used for identifying the geometry. Geometry identification outside the working area of the processing unit can be done also without attaching
5 the part of the electronic structure in question to any standard position for the duration of the geometry defining. Thus the geometry of the operation area of the part of the electronic structure in the standard position, where it will be attached at a later stage, is determined beforehand with a sufficient precision. For example the edges of the circuit board and their relationship to the circuit layout of the circuit
10 board are described and thus the placement of the circuit layout, i.e. the operation area of the part of the electronic structure, in the standard position can be predicted.

In still another advantageous embodiment of the method according to the invention at least one second operation aimed at said part of an electronic
15 structure is in the method performed with at least one second processing unit. The same predefined geometry of the operation area of the part of the electronic structure is utilized in said second processing unit for aiming the operation in a location precise manner at the working area of the second processing unit.

In still another advantageous embodiment of the method according to the invention the part of the electronic structure is attached in the standard position to
20 an attaching base outside the working area of the processing unit and the geometry of the operation area of the part of the electronic structure is defined in relation to the attaching base. Thereafter the attaching base is moved into the standard position in the working area of the processing unit. Advantageously a
25 supply station is in the method formed outside the working area, which has an attaching base for attaching the part of the electronic structure in a standard position, the part of the electronic structure is attached in the standard position to an attaching base at the supply station and the geometry of the operation area of the part of the electronic structure is defined in the supply station. A travelling line
30 is formed from the supply station to the standard position in the working area of the processing unit for moving the attaching base, and the attaching base is moved from the supply station into the standard position in the working area of the processing unit along said travelling line.

In still another advantageous embodiment of the method according to the invention supply coordinates $K_s(x, y, z, \omega_1, \omega_2)$ are defined for the supply station,
35 operation coordinates $K_v(x, y, z, \omega_1, \omega_2)$ are defined for the working area of the

processing unit, and the working area of the actuators of the processing unit and the location of the attaching base arranged into the standard position are defined in the operation coordinates K_v . A conversion algorithm A_m is additionally defined, which expresses the correlation between the coordinates defined in the supply
5 coordinates K_s and the coordinates defined in the operation coordinates K_v . The part of the electronic structure is attached in the standard position to the attaching base of the supply station and its location and position is defined in the supply coordinates K_s . With the aid of the conversion algorithm the calculatory location and position of the part of the electronic structure attached in the standard position
10 of the processing unit is calculated in the operation coordinates K_v . The actuators of the processing unit and the geometry of the part of the electronic structure in the standard position are aligned with each other according to the calculatory location and position for performing the operation.

The method according to the invention, where the geometry of the operation area
15 of the electronic structure is defined in the supply station and aligned in relation to the attaching base of the standard position, can be applied for example in paste printing for aligning a paste printing stencil, so that by looking through the openings in the stencil the geometry, advantageously circuit layout, of the operation area of the electronic structure is aligned to correspond to the openings
20 in the stencil. In such a case it is not necessarily necessary to know and/or actively use the conversion algorithm A_m , even if it exists and is otherwise available.

When applied to paste printing the standard position in the method according to the invention can mean a standard position arrangement, which has a mechanical structure performing an substantially precise and repeated movement, for example
25 a manipulator, a precise conveyor or another prior art implementation, to which the part of the electronic structure is attached. When using such a standard position arrangement the geometry identification is done in one known position of the manipulator, which position may be in the working area of the paste printing unit or outside the working area of the paste printing unit, and the actual paste printing
30 operation aimed at the part of the electronic structure is performed in some other known position of the manipulator. In this arrangement the geometry identification and the paste printing operation take place at least partly simultaneously. An advantage of such an arrangement is the time-parallelism of the geometry identification and the actual productive operation, the paste printing, of the paste
35 printing apparatus.

In component assembly the standard position in the method according to the invention can mean a standard position arrangement, which has a mechanical structure performing an substantially precise and repeated movement, for example a manipulator, a precise conveyor or another prior art implementation, to which the part of the electronic structure is attached. When using such a standard position arrangement the geometry identification is done in one known position of the manipulator, which position may be in the working area of the assembly unit or outside the working area of the assembly unit, and the actual component assembly operation aimed at the part of the electronic structure is performed in some other for example known position. In this arrangement the geometry identification and the assembly operation take place at least partly simultaneously. An advantage of such an arrangement is the time-parallelism of the geometry identification and the component assembly.

In still another advantageous embodiment of the method according to the invention a machine-readable individual identifier is in the supply station attached to the part of the electronic structure for identification of the part of the electronic structure, and a measurement file is generated for storing data regarding the part of the electronic structure. The measurement data of the operation area of the part of the electronic structure, such as the geometry of the surface, is defined and stored in the measurement file. In connection with defining the geometry, flaws in the operation area of the part of the electronic structure, such as deformations and missing parts, are advantageously defined by comparing the part of the electronic structure to its design data. Discovered flaws are stored in the measurement file and the effect of the flaws are compensated in the operations aimed at the part of the electronic structure.

In still another advantageous embodiment of the method according to the invention the part of the electronic structure arriving at the processing unit is identified in the processing unit with the aid of the identifier, and the data regarding the part of the electronic structure is read from the measurement file. The geometry data regarding the part of the electronic structure read from the measurement file and the identifier data regarding the part of the electronic structure is used for performing the operation requiring location precision aimed at the part of the electronic structure.

In one advantageous embodiment of the method according to the invention the part of the electronic structure arriving at the processing unit is known with the aid of the process sequence and the data regarding the geometry of the part of the

electronic structure is known based on the process sequence. Thus the geometry data of the part of the electronic structure known based on the process sequence is used in the processing unit for performing the operation requiring location precision aimed at the part of the electronic structure.

- 5 In still another advantageous embodiment of the method according to the invention the part of the electronic structure is attached in the supply station to a moveable attaching base, which is attached to a counterpart in the supply station with a so-called zero point principle, the location of which counterpart in the supply coordinates K_s is known. A second counterpart is arranged in the processing unit
10 for receiving the attaching base, the location of which counterpart in the operation coordinates K_v is known. The part of the electronic structure is thus moved from the supply station to the processing unit while attached to the attaching base and the attaching base is attached to the second counterpart in the processing unit.

- In still another advantageous embodiment of the method according to the invention at least two operations aimed at a part of an electronic structure are
15 performed with at least two different processing units. Thus at least one second conversion algorithm A_m is defined, which expresses the correlation of the coordinates defined in the supply coordinates K_s and the coordinates defined in the operation coordinates K_v of the at least one second processing unit, and the
20 conversion algorithm is used to calculate the calculatory location and position of said part of the electronic structure to be attached in the standard position of the second processing unit in the operation coordinates K_v of said second processing unit. The actuators of the second processing unit and the geometry of the part of the electronic structure are aligned with each other in the standard position
25 according to the calculatory location and position. The part of the electronic structure is moved from the first processing unit to the second processing unit, attached in the standard position to the attaching base of the second processing unit, and the operation aimed at the operation area of the part of the electronic structure is performed with the second processing unit.

- 30 A serial production apparatus for performing a location precise operation in the operation area of a part of an electronic structure comprises at least one processing unit for performing said location precise operation aimed at the part of the electronic structure in the working area of the actuator and a computer vision system for identifying the geometry of the operation area of the part of the
35 electronic structure. The location precise operation to be performed with the apparatus can be printing of solder paste, dosing solder paste, assembling an

electronic component, die bonding, wire bonding, tuning an electronic structure or protecting an electronic component by dispensing. According to the basic idea of the invention the apparatus is arranged to perform the defining of the geometry of the operation area of at least one part of an electronic structure and an operation
5 requiring location precision aimed at the operation area of at least one other part of an electronic structure at least partly simultaneously and to utilize a predefined geometry of the operation area of the part of the electronic structure for performing the operation in a location precise manner in the operation area. The apparatus is advantageously arranged to utilise the predefined geometry of the operation area
10 of the part of the electronic structure for positioning the part of the electronic structure in the working area of the processing unit.

In one advantageous embodiment of the apparatus according to the invention there are at least two standard positions in the working area of the processing unit for performing the defining of the geometry of the processing unit of at least one
15 first part of an electronic structure in the first standard position and the operation aimed at least at one second part of an electronic structure in the second standard position at least partly simultaneously. In the invention a standard position can thus mean the standard position in the area for identifying the geometry of a part of an electronic structure and on the other hand the standard position of the
20 actuator performing the operation requiring location precision on the part of the electronic structure. These positions do not need to be mechanically identical, but their operation geometrically in relation to each other should be known and/or possible to make known. The standard position can also be moveable, whereby its location in the working area of the actuator and/or in the geometry identification
25 area during the identification is known. Location in this context means that for example the place and time of the operation area of a part of an electronic structure is substantially known.

In a second advantageous embodiment of the apparatus according to the invention the defining of the geometry of at least one part of an electronic structure
30 and the operation requiring location precision aimed at the operation area of at least one second part of an electronic structure, which operation immediately precedes the geometry defining in the serial production, are arranged to occur at least partly simultaneously.

A third advantageous embodiment of the apparatus according to the invention is
35 arranged to define the geometry of the operation area of a part of an electronic structure, when the part of the electronic structure is within the working area of the

processing unit, before said part of the electronic structure is attached in the standard position.

In still another advantageous embodiment of the apparatus according to the invention there are at least two standard positions within the working area of the processing unit, a first standard position for attaching and defining the geometry of a part of an electronic structure and a second standard position for performing a location precise operation on a part of an electronic structure, the geometry of which has previously been defined. The apparatus is arranged to perform the attaching and geometry defining of the first part of the electronic structure and the location precise operation aimed at the second part of the electronic structure in turns and at least partly simultaneously.

In still another advantageous embodiment of the apparatus according to the invention the apparatus has at least one standard position outside the working area of the processing unit for attaching and identifying the geometry of a part of an electronic structure. The apparatus can also be arranged to define the geometry of the processing unit of the part of the electronic structure outside the working area, without attaching the part of the electronic structure in question in any standard position in the apparatus for identifying the geometry.

In still another advantageous embodiment of the apparatus according to the invention the apparatus has at least one second processing unit and the apparatus is arranged to perform at least one second operation aimed at a part of the electronic structure with said second processing unit. Said second processing unit is arranged to utilise said predefined geometry of the operation area of the part of the electronic structure for aiming the operation in a location precise manner at the operation area.

In still another advantageous embodiment of the apparatus according to the invention the apparatus has a control unit for controlling the functions of the processing unit and the computer vision system. The control unit has a processor, a memory and a control application loaded into the memory.

Still another advantageous embodiment of the apparatus according to the invention comprises a moveable attaching base for attaching the part of the electronic structure in the standard position for defining the geometry of the operation area of the part of the electronic structure.

In still another advantageous embodiment of the apparatus according to the invention said processing units have actuators for performing the operation, which actuators have a working area, and said attaching base for defining the geometry of the operation area of the part of the electronic structure is within the working area. The attaching base for defining the geometry of the operation area of the part of the electronic structure can also be outside the working area. The apparatus advantageously additionally comprises means for moving the attaching base into the standard position in the working area of the processing unit.

Still another advantageous embodiment of the apparatus according to the invention comprises a supply station outside the working area of the processing unit, which supply station has an attaching base for attaching the part of the electronic structure in the standard position. The supply station has means for defining the geometry of the operation area of the part of the electronic structure attached to the attaching base. The apparatus further includes a travelling line leading from the supply station to the standard position in the working area of the processing unit for moving the attaching base.

Still another advantageous embodiment of the apparatus according to the invention further comprises supply coordinates K_s in the supply station, means for defining the location and geometry of a part of an electronic structure attached to the attaching base of the supply station in the supply coordinates, and operation coordinates K_v in the working area of the processing unit, where the working area of the actuators and the location of the attaching base arranged in the standard position is defined. The apparatus further has a conversion algorithm A_m for defining the calculatory location and geometry of a part of an electronic structure to be attached in the standard position of the processing unit in the operation coordinates based on the location and geometry defined in the supply coordinates, and means for aligning the actuators of the processing unit according to the calculatory location and position of the part of the electronic structure.

In still another advantageous embodiment of the apparatus according to the invention the attaching base for attaching the part of the electronic structure is a moveable so-called zero point base and the supply station and processing units have counterparts, to which the attaching base can be attached in a dimensionally accurate manner with the zero point principle. The attaching base is advantageously equipped with a computer-readable identifier and the supply station and processing units have a computerized reader for reading the identifier.

In still another advantageous embodiment of the apparatus according to the invention said means for moving the attaching base into the standard position in the working area of the processing unit comprise a turntable rotating around an axis. The apparatus thus comprises at least two attaching bases attached to the turntable, which attaching bases have a standardised travelling line, and the processing units are placed along said travelling line.

In still another advantageous embodiment of the apparatus according to the invention said means for moving the attaching base into the standard position in the working area of the processing unit comprise a stepping conveyor, which has a standardised travelling line. The apparatus thus comprises at least two attaching bases attached to the conveyor, and the processing units are placed along said travelling line.

Still another advantageous embodiment of the apparatus according to the invention comprises at least two separate processing units for performing at least two location precise operations aimed at the same part of an electronic structure. The processing unit can be a dosing device for an adhesive, such as glue or solder paste, a paste printing device, an assembly device for electronic components, or a tuning device or electric testing device for an electronic structure.

It is an advantage of the invention that it significantly improves dimensional accuracy and repeatability of the manufacturing of electronic structures, wherefore the quality and reliability of the electronic structures is improved. The dimensional accuracy and repeatability remain at the same level during the entire manufacturing process.

It is further an advantage of the invention that the time used for aligning parts used in the manufacturing of structures is therein decidedly shorter, whereby the total time needed for manufacturing an electronic structure also shortens. A shorter production time improves the efficiency of the production. The shortening of the time is substantially based on the fact that the actuator performing the operation on the electronic structure does not necessarily need to wait for identification of the geometry of the operation area of the electronic structure to be performed in the working area of the actuator. The identification of the geometry of the operation area of the electronic structure advantageously takes place at least partly at the same time, for example in the supply station, during the actual, advantageously productive operation by the actuator of a second processing unit

at the same actuator at the time in question aimed at the electronic structure. It is obvious that the most production time is saved in a serial production, where time is traditionally wasted for identifying geometry in the working area of each processing unit. A significant production time advantage is naturally not achieved in the beginning and end of the manufacturing series in serial production, and not in the production of individual pieces.

In the following, the invention will be described in detail. In the description, reference is made to the appended drawings, in which

Figure 1a shows as an example an apparatus used in the method according to the invention seen from the side,

Figure 1b shows as an example the supply station of the apparatus of Figure 1a,

Figure 1c shows as an example a processing unit of the apparatus of Figure 1a,

Figure 2 shows as an example an advantageous embodiment of an apparatus according to the invention seen from the side and

Figure 3 shows as an example a second advantageous embodiment of an apparatus according to the invention seen from above and

Figure 4 shows the method according to the invention by means of a simple flowchart.

Figure 1a shows as an example an apparatus according to the invention seen from the side. The apparatus makes up a typical entire production line constructed of different processing units to be used for manufacturing electronic structures. The production line can be used for example for furnishing circuit boards. The apparatus comprises a paste printing device 120, an assembly device 110 for electronic components, a reflow oven 140, an assembly and programming device 150 for memory circuits and a testing device 160 for a circuit board, which are arranged subsequently in a line formation. For the sake of simplicity Figure 1 only shows one paste printing device, which may be for example the paste printing device for the upper side of the circuit board or the paste printing device for the lower side of the circuit board. The apparatus can also have two paste printing devices, a first device for the upper side of the circuit board and a second device for the lower side of the circuit board. The paste printing device is used to dose solder paste on the surface of a circuit board with the aid of a stencil as wafers in

those points, where electronic components will be assembled with the assembly device 110. The electronic component may be any prior art component meant to be connected to a circuit board, such as a chip, a semiconductor chip, a multi-component and/or chip module, a resistor, a condenser, a transistor, an integrated circuit or a light-emitting diode i.e. a LED, or some other part to be connected with the connecting technique in question. The assembly device 110 for the components can be a high-speed assembly machine or a precision assembly machine. The apparatus can also have two assembly devices, of which the first is for example a high-speed assembly device and the second is a precision assembly device. The solder paste is hardened by means of thermal treatment in a reflow oven. Some other prior art thermal treatment device can also be used in the apparatus, such as a vapour phase solder device or an induction solder device. Some other prior art connecting substance can also be used as the connecting substance instead of solder paste.

The apparatus additionally has two automatic optical inspection stations 170, of which the first is as an example placed between the paste printing device and the assembly device and the second as an example between the reflow oven and the assembly and programming device of the memory circuit. In the beginning of the apparatus there is a supply station 130, through which the circuit boards are fed into the apparatus, and in the end there is a discharge station 180, through which completed circuit boards exit from the apparatus. The functions of the processing units comprised in the apparatus are controlled with a control unit 132. The control unit is advantageously a computer, which has a processor, a memory for storing data and programs, an operating system and means for entering and receiving data. The apparatus further comprises a conveyor system, the task of which is to move parts of electronic structures in different stages of the manufacturing process forward in the apparatus, i.e. from the working area of one processing unit to the working area of the next processing unit (the conveyor system is not shown in the figure). The above-presented structure and operating principle of the apparatus depicting a production line for electronics and the individual processing units comprised therein are known technique, so they are not described further in this context.

Figure 1b shows as an example a supply station 130 of an apparatus according to the invention. The supply station has a fixed attaching base 30, on the edges of which there are locking pins 60 for attaching and locking a part used in the manufacturing of an electronic structure. In the case shown in the figure said part

of an electronic structure is a circuit board 80. The locking pins can be support members, against which the edges of the circuit board are pressed, or they can advantageously be fitted into locking holes 62 in the edges of the circuit board and/or in the circuit board. Advantageously at least some of the locking pins are

5 arranged in the attaching base in a moveable manner, so that an attaching imprecision caused by a gap between the locking pin and the attaching hole can be minimized by moving the surface of the locking pin fitted into the locking hole flush with the wall surface of the attaching hole. Standardised attaching of the circuit board to the fixed attaching base can be implemented with the aid of the

10 locking pins. A standardised attaching in this context means an attaching manner, where the circuit board is always attached in the same way and in the same point in relation to the fixed attaching base, i.e. the circuit board is attached in a standard position in relation to the fixed attaching base. In such an arrangement according to the invention the fixed attaching base and the attaching manner are

15 substantially repeated in accordance with the supply station in the working area of at least one processing unit. In the arrangement according to the invention the positioning of the operation area of the electronic structure when attaching in the standard position to the fixed attachment bases is identified and this information is used for aligning the operation area of the electronic structure and the operation

20 member of the actuator. Such an arrangement according to the invention requires that the attachment of the electronic structure to the fixed attaching base is sufficiently precise and repeated with regards to the process. In the supply station different mechanical machining operations, such as drillings and millings, can if necessary be performed on the circuit board attached in the standard position. The

25 supply station has its own coordinates, which are in this presentation called the supply coordinates $K_s (x, y, z, \omega_1, \omega_2)$. The location and position of the circuit board attached to the fixed attaching base in a standardised manner can thus always be expressed precisely with the aid of the coordinate points of the supply coordinates.

30 On the surface of the circuit board there is a machine-readable individual circuit board-specific identifier 44, by means of which each circuit board can be identified. This identifier can for example be a bar code or an RFID tag. The supply station has a computerised reader 46 for reading the identifier, which reads the identifier of the circuit board and stores it into the control unit 132 of the apparatus. On the

35 surface of the circuit board there are further machine-readable aligning markings 82. The aligning markings are placed in the corner areas of the circuit board and there are at least two of them, generally 3–4 in each circuit board. The supply

station has a computer vision camera 38 for reading the alignment markings. The computer vision camera can be used to read the aligning markings in the circuit board and define with their aid the position and place of the circuit board in the supply coordinates K_s .

- 5 In the method according to the invention the circuit boards 80 arriving in turn at the supply station are first locked into place in the standard position to the attaching base 30. The circuit board 80 is identified by reading the circuit board identifier 44 with a computerised reader 46 and a measurement file 84 is generated, where data regarding the circuit board is stored. The location and position of the circuit
10 board in the supply coordinates K_s is defined with a computer vision camera and the data is stored in the measurement file 84. In the same way the computer vision camera can be used to define geometry data of the surface of the circuit board and/or wirings of the circuit board and/or locations of the contact surfaces and/or measureable structures attached to the circuit board for example in the circuit
15 board's own coordinates K_p . A circuit board design file 86 can have been stored in the control unit 132, where the layout of the circuit board, i.e. the measurement information of the circuit board and the circuitry and placement of contact surfaces of the circuit board are presented in the planned form in the design coordinates K_d of the circuit board. The design file presents the circuit board in its ideal i.e.
20 flawless form. By comparing the design file and the data measured from the circuit board possible extensions and other tolerance deviations of the circuit board and missing and flawed contact bases and wirings are thus immediately discovered. Based on the design file and the measured actual measurement data of the circuit board a correction algorithm A_k can be calculated in the control unit 132, which
25 expresses how the measurement deviations of the circuit board should be taken into account in the later furnishing of the circuit boards. For example an increase in distance between the connection points caused by extension of the circuit board can be taken into account by changing the position of the stencil of the paste printing device from the one defined in the design stage. In the method according
30 to the invention the correction algorithm can be used to correct the control file of the actuator. For example dosing of solder paste onto substrates containing non-systematic and/or nonlinear measurement flaws, such as for example LTCC substrates, can be implemented for the paste dosing with dispensing and/or jet printing operations by utilizing the correction algorithm. The correction algorithm
35 procedure can also be applied for component assembly.

Figure 1c shows as an example a processing unit of the production line for electronics according to the invention. The processing unit can for example be a paste printing device 120, an assembly device 110 for electronic components, an optical inspection station 170, an assembly and programming device 150 for memory circuits, a testing device 160 or a dosing device for an adhesive, a so-called dispenser. Just as the supply station, the processing unit has an attaching base 30', which has mechanical attaching members, such as locking pins 60, by means of which the circuit board 80, which is the target of the manufacturing, is attached in an immobile manner in the working area of the processing unit. Even though the attaching base of the processing unit is not necessarily identical to the attaching base of the supply station, the attaching members therein can also be used to implement a standardised attaching of the circuit board to the attaching base. Each processing unit has its own operation coordinates $K_v(x, y, z, \omega_1, \omega_2)$, in relation to which the working area of the processing unit is defined. Working area in this context means the area, within which the actuators of the processing unit can perform the planned operations. For example in a paste printing device the operation is the printing of solder paste onto the circuit board and the actuators for performing the operation comprise a stencil and a doctor blade or for example a proflow dosing head. Correspondingly in an assembly device the operation is the assembly of components, and the actuator, with which the assembly is performed, is an assembly head. Before the operation is started the circuit board and the actuators must be aligned in relation to each other.

In the method according to the invention the aligning is done so that the circuit board arriving at the processing unit is attached directly in a predefined location and position, i.e. in a standard position, in the working area of the processing unit. This location and position of the standard position is precisely defined in the operation coordinates K_v . When the location of the circuit board in the operation coordinates is known, the actuators of the processing unit can move directly to the right point in relation to the circuit board and perform the planned operations advantageously automatically with the aid of commands loaded into the control unit 132. The commands of the control unit require for example conveying a conversion algorithm A_m and/or a correction algorithm A_k . These algorithms can be used and/or conveyed also with some other known course of action than by using a control unit 132, for example with direct data transfer procedures between computers. The processing unit has a computerised reader 46, which can read the identifier 44 in the circuit board 80 arriving at the processing unit. Based on the identifier the control unit of the processing unit finds the individual measurement

file 84 of the circuit board in question from the memory, in which measurement file all the data measured in the supply station has been stored, such as the geometry, flaws, deficiencies and missing parts of the circuit board.

- 5 In the method according to the invention a conversion algorithm A_m between the supply coordinates K_s and the operation coordinates K_v is defined. A conversion algorithm means a mathematic formula, which expresses the correlation between the standard position of the attaching base 30 defined in the supply coordinates K_s and the standard position of the attaching base 30' defined in the operation coordinates K_v . Each point of the circuit board locked in the standard position of
- 10 the supply coordinates can thus be given a corresponding point in the operation coordinates with the aid of the conversion algorithm. In the method the aligning of the circuit board, i.e. the defining of the coordinates defining the location and position of the circuit board in the operation coordinates, is done so that the location and position of the circuit board is first defined in the supply coordinates,
- 15 when the circuit board is attached in the standard position to the attaching base 30 of the supply station 130. Thereafter the location and position of the circuit board is defined in the operation coordinates with a mathematical calculation with the aid of a conversion algorithm and the calculated coordinates are stored in the measurement file 84 of the circuit board.
- 20 When the circuit board is moved into the working area of the processing unit it is locked into place in the standard position to the attaching base 30' of the processing unit. The reader 46 reads the identifier 44 of the circuit board and based thereon retrieves the measurement data stored in the measurement file 84 of the circuit board in question and the processing unit-specific conversion
- 25 algorithm A_m and the possible correction algorithm A_k from the memory of the control unit and defines with their aid the calculatory location and position of the circuit board in the operation coordinates. The location and position of the circuit board is thus substantially immediately known by the processing unit, when the circuit board has been attached in the standard position, and the actuators of the
- 30 processing unit can be positioned directly into the right point in relation to the circuit board without having to perform prior art identification of geometry and/or aligning markings, which delay the actual operation of the actuators. The operations can thus be started without separate aligning of the circuit board and/or the actuators. The operation to be performed on the circuit board at any given time
- 35 is defined according to the processing unit. Thus the operation to be performed with the processing unit can for example be paste printing on the upper and/or

lower surface of the circuit board, assembly of an electric component on the upper and/or lower surface of the circuit board, assembly and/or programming of a memory circuit, a testing operation for the function of an electronic component or structure or optical inspection of the circuit board or any other prior art operation
5 requiring precision.

The conversion algorithm A_m for the coordinates of the processing unit and the supply station can be defined in a calculatory manner or with the aid of functions of the processing units of the production line. For example for a paste printing device the conversion algorithm can be defined as follows: Working area of the paste
10 printing device means the area, which the paste printing device requires for performing the paste printing occurring through an installed stencil. When defining the conversion algorithm an empty printing base is first attached in the standard position to the attaching base 30 of the supply station 130. Thereafter the aligning circuit board is moved into the working area of the paste printing device, locked
15 into the standard position and an examination pattern and/or an actual pattern constructed from paste wafers is with the aid of the stencil printed onto the empty printing base. During the printing of the examination pattern the stencil is in the basic position, the location of which in the operation coordinates K_v is known, but the position of which pattern in relation to the operation coordinates K_v is not yet
20 known. Thereafter the printed printing base is returned to the supply station and locked again into the standard position. In the supply station the realised location of the printing pattern constructed from paste wafers and used in the examination on the printed printing base in relation to the standard position of the supply unit in the supply coordinates K_s is defined with a computer vision camera 38. The
25 position of the realised paste printing pattern is now known in the supply coordinates K_s , which position can be compared to the geometry of the operation area of the electronic structure arriving at the supply station in the same supply coordinates K_s . A conversion algorithm A_m can now be calculated from the relationship between the realised paste printing pattern and the geometries of the
30 operation area of the electronic structure arriving at the supply station. The conversion algorithm A_m is a mathematic formula, which expresses how the stencil and/or the operation area of the electronic structure to be printed must be moved in relation to each other, so that the operation area of the electronic structure to be printed and the openings of the stencil would settle precisely on top of each other
35 and/or in an aligned manner on the substrates to be printed.

Each processing unit of the production line advantageously has its own attaching base 30', which has its own operation coordinates K_v and a standard position. The location of the standard position in the operation coordinates can vary between processing units. Therefore each processing unit of the production line must have
5 its own conversion algorithm A_m defined. The processing units in the production line can also be such that they do not require precise aligning of the circuit board in the working area of the processing unit. Such a processing unit is for example a Reflow oven, where the attaching of electronic components occurs with the aid of thermal treatment. Conversion or correction algorithms naturally do not need to be
10 defined for such processing units.

Figure 2 shows as an example an advantageous embodiment of the apparatus according to the invention as a simplified view. The embodiment shown in Figure 2 has many of the same parts and entities as in Figures 1a, 1b and 1c. The same names and the same reference numbers have been used for these parts and
15 entities in the description. The apparatus shown in the figure forms a part of a production line for electronic structures. The apparatus is used to form a three-dimensional electronic structure, which comprises a substrate 10 and at least one electronic component 14 to be attached to the surface of the substrate. The electronic component may be any known component, for example a chip, a
20 resistor, a condenser, a transistor, an integrated circuit, a light-emitting diode (LED) or any component, semiconductor chip, multi-component and/or chip module meant to be connected to a substrate or any other part, which is connected with these techniques. The attaching of the electronic component to the substrate is done with an apparatus according to Figure 2, which has a dosing
25 device 100 for dosing an adhesive and an assembly device 110 for assembling an electronic component. Each device has its own working area 50, where the attaching operation advantageously occurs automatically. A prerequisite of the dosing of adhesive and the assembly of the components is that the precise location of the substrate in relation to the actuator and its position in the working
30 area of the dosing device and the assembly device is known.

The supply station 130 of the apparatus comprises an attaching base 30, which has an attaching level 32 for attaching a substrate 10 and a protruding locking part 34, by means of which the attaching base is attached to a counterpart 36 in the supply station. The locking part is the second part, which is attached to the
35 counterpart with a mechanical attachment advantageously in a form-fixed manner, these are advantageously attaching members which fit together, for example a

female and male part. The attaching base and the counterpart are thus always attached to each other very precisely and always in the same way. The above-described quick attachment method is used in many machine tools and machining centres in the field of precision mechanics. As an example of such quick
5 attachment systems on the market is mentioned the quick attachment system manufactured by the company Erowa, where the attachment between the attaching base and the counterpart can be implemented with great precision. 3M for example also manufactures equivalent quick attaching systems. The location of the counterpart is precisely defined in the supply coordinates K_s of the supply
10 station. Because the attaching base is always attached to the counterpart in the same way, the location of the attaching base in the supply coordinates K_s is also known substantially precisely at any time when it is attached to the counterpart.

In the supply station the substrate 10 is attached to the attaching level 32 of the attaching base 30 in the standard position with mechanical attaching members, by
15 means of underpressure or in some other suitable known manner. Thereafter the location and position and the geometry of the surface of the substrate are defined in the supply coordinates K_s . In order to define these pieces of data the supply station has a computer vision camera 38 or some other measuring device suitable for defining location and surface geometry, such as a 2D or 3D scanner, a laser
20 measuring device or one or several mechanical measuring means. The zero point of the measuring device is advantageously attached at the origin of the supply coordinates. With the aid of the measuring device the location and geometry of the substrate in the supply coordinates can thus be directly defined. The geometry, location and position of the operation area of the substrate can be defined with the
25 aid of aligning markings in the substrate, based on the edges of the substrate identified with a computer vision camera or based on a circuit layout in the substrate or generally with the aid of the measured geometry of the substrate.

In connection with the defining of the location and geometry of the substrate, the quality of the substrate can simultaneously be examined by comparing data
30 measured from the substrate with design data in the design file 86 of the substrate. Substrate properties to be examined are thus among others extensions and other tolerance deviations, cuts in the solder resist and missing or flawed contact bases and wirings. Substrates left outside the acceptance limits can at this stage be discarded, and data regarding the discarding of the substrate is stored in
35 the measurement file 84 or the discarded substrate is otherwise marked. In the same way data regarding possible small deficiencies discovered in accepted

substrates is stored in the measurement file. All measured and stored data of the substrates is available in later operations aimed at the operation area of the electronic structures, for example substrate furnishing stages. The attaching base 30 is equipped with a computer-readable identifier 44, such as an RFID tag, a bar code or the like, which makes possible quick and reliable identification of the attaching base and the substrate attached thereto in all different stages of the method.

The attaching base 30 and the thereto attached substrate 10 are moved from the supply station to the working areas of the processing units (100, 110) with the aid of a conveyor system in the apparatus. The conveyor system can comprise for example conveyor belts, turntables and loading and/or unloading units or other known actuators which provide a sufficiently precise movement for the process, the structure of which actuators is not described in more detail in this context. In the working area 50 of the processing unit there is a counterpart 36, where to the attaching base arriving at the processing unit is attached. The location of the counterpart is precisely defined in the operation coordinates K_v . Because the attaching base is always attached to the counterpart in the same way, the location of the attaching base in the supply coordinates K_s is also precisely known at any time when it is attached to the counterpart. The substrate 10 is attached to the attaching base 30 in the standard position already in the supply station and the substrate is attached to the attaching base during the entire transfer stage. After being attached to the counterpart the substrate is thus immediately in the standard position in the working area of the processing unit.

In the apparatus in Figure 2 the location and position of the substrate in the operation coordinates of the dosing device and the assembly device are defined in the same way as was told in connection with the description of Figures 1a, 1b and 1c, i.e. the location and position of the substrate is first defined in the supply coordinates, when the circuit board is attached in the standard position to the attaching base 30 of the supply station 130. Thereafter the location and position of the circuit board is defined in the operation coordinates with a mathematical calculation with the aid of a conversion algorithm stored in the measurement file 84. The conversion algorithm expresses the correlation between the standard position of the attaching base 30 defined in the supply coordinates K_s and the standard position of the attaching base 30' defined in the operation coordinates K_v . The conversion algorithm A_m for the coordinates of the processing unit and the supply station can be defined by calculation or by applying the above-described

definition method of the conversion algorithm of the paste printing device. Their own conversion algorithm A_m is defined for the dosing device and the component assembly device. Both conversion algorithms are stored in the measurement file 84.

- 5 The first processing unit for performing an operation belonging to the apparatus presented in Figure 2 is a dosing device 100, a so-called dispensing device, which is used to dose an adhesive onto the surface of the substrate in the points defined by the design file and/or in the points, where an electronic component will be attached in a later stage of furnishing the substrate. The adhesive can be glue or
10 solder paste. The dosing device has a moveable dosing head 102, by means of which the dosing of the adhesive occurs. The dosing device has its own working area 50, within which the dosing occurs, i.e. within which the dosing head can be moved. The working area of the dosing head in the operation coordinates K_v of the dosing device is known.
- 15 In connection with the dosing device there is advantageously a computerised reader 46, which reads the identifier 44 of the attaching base and enters the identification data into the control unit 132 of the apparatus. The reader can for example be an RFID reader or a bar code reader. Based on the identification data the control unit retrieves the measurement file 84 of the substrate from the
20 memory of the device, which file advantageously comprises for example the two-dimensional dimensions of a horizontal projection of the substrate and a three-dimensional geometry of the surface and possible other data affecting the treatment of the substrate, such as extensions, tolerance deviations and various missing parts. A conversion algorithm A_m calculated in relation to the dosing
25 device and defined in the supply station and a possible correction algorithm A_k is also stored in the measurement file. With the aid of the conversion algorithm and the correction algorithm the dosing head of the dosing device is positioned precisely in the right point in relation to the substrate in its working area. Thereafter the dosing device doses adhesive in the points on the surface of the
30 substrate, where the design file defines that adhesive should be dosed and/or where an electronic component 14 or any other part or structure to be thus attached will at a later stage be attached. The reader identifies such specimens from the substrates arriving at the dosing device, which do not fulfil the acceptance limits, based on the data stored in the measurement file. On such substrates the
35 dosing of adhesive can be left undone.

When adhesive has been dosed in all the necessary points on the surface of the substrate, the attaching base 30 and the substrate 10 attached thereto are moved with the aid of the conveyor system or other transport system of the apparatus to the working area of the next processing unit, i.e. the component assembly device
5 110. In the working area of the component assembly device there is a counterpart 36, the location of which is precisely defined in the operation coordinates K_v of the assembly device.

In connection with the component assembly device there is a computerised reader 46, which reads the identifier 44 of the attaching base and enters the identification
10 data into the control unit 132 of the apparatus. The identification of the substrate and/or the attaching base can be implemented with a reader in connection with the conveyor system or the identity of the substrate and/or attaching base and the geometry related to the identity and other properties significant for the process are otherwise known. In other words if the transmission of the identification data of the
15 substrate and/or attaching base can be guaranteed and the geometry data and operation order is otherwise clear or can be made clear, the substrate and/or attaching base does not need an identifier at all. The reader can for example be an RFID reader or a bar code reader. Based on the identification data the control unit retrieves the measurement file 84 of the substrate from the memory of the device,
20 which file comprises among other the two-dimensional dimensions of a horizontal projection of the substrate and a three-dimensional geometry of the surface and possible other data affecting the treatment of the substrate, such as extensions, tolerance deviations and various missing parts. A conversion algorithm A_m calculated in relation to the component assembly device and defined in the supply
25 station and a possible correction algorithm A_k is also stored in the measurement file. With the aid of the conversion algorithm and the correction algorithm the assembly head of the component assembly device is positioned precisely in the right point in relation to the substrate in its working area. Thereafter the assembly head 112 of the assembly device 110 assembles the components in place in the
30 points, where adhesive has been dosed with the dosing device. The reader identifies such specimens from the substrates arriving at the assembly device, which do not fulfil the acceptance limits, based on the data stored in the measurement file. On such substrates the components can be left unassembled.

After the components are assembled the substrate is moved with the aid of the
35 transport system of the apparatus away from the working area of the assembly device for post-processing 200. The post-processing can comprise for example a

thermal treatment taking place in a reflow oven, a vapour phase soldering machine or another known thermal treatment device for hardening the adhesive, the protection of components attached to the substrate for example through dispensing or hot spraying, or testing operations for the electronic components on the substrate. Some of the post-processing operations are such that the substrate must be precisely aligned in the right place in the working area of the processing unit performing the post-processing. Such post-processing operations are for example the protecting of components through dispensing, through hot spraying, laser tuning, programming, electric testing or adjustment. Thus the substrate is moved also to the post-processing while attached to the attaching base 30 in the manner described above, whereby its location and geometry is always known by the control unit of the manipulator. If the post-processing operation does not require precise aligning of the substrate in the right place for performing the operation, the substrate can be detached from the attaching base for the duration of the post-processing. Empty attaching bases are sent back and/or they are returned to the supply station, where new substrates to be used in manufacturing electronic structures are attached to them.

The method and apparatus according to the invention can be used for furnishing substrate with different sizes, shapes and surface geometries with electronic components. In its most simple form the substrate can be a planar, substantially two-dimensional piece, such as a circuit board. The substrate can also be a three-dimensional piece, for example the cover or part of the cover of a mobile phone, the frame of a lamp or a part of an electric device, which has surfaces on different levels and/or at different angles, where electronic components are attached.

The substrate 10 to be used in the method can be manufactured in advance in some suitable manner and it can be furnished with the above-described method. The substrate can also be manufactured immediately before it is furnished, whereby the manufacturing of the substrate and its furnishing are implemented in subsequent stages of the manufacturing process. Such a method can be used especially when manufacturing and furnishing three-dimensional substrates. The mechanical structure of three-dimensional substrates and their furnishing is nowadays designed in a computer-assisted manner with the aid of 3D design programs. When manufacturing the substrate some computer-assisted manufacturing method can be used, such as hot spraying or laser sintering or some other additive method. The substrate can also be manufactured from a preform by mechanically machining the preform for example by chipping.

Mechanic machining is advantageously done with a numerically controllable machine tool, a so-called NC machine tool, the control commands of which are received directly from the design program. The above-described computer-assisted substrate manufacturing methods require precise aligning of the substrate in relation to the machine tool. Data regarding the geometry of the substrate defined when designing and manufacturing a substrate in a computer-assisted manner can thus be utilized directly in the later furnishing stage of the substrate.

Figure 3 shows as an example a second advantageous embodiment of an apparatus to be used in the method according to the invention seen from above. The embodiment shown in Figure 3 has many of the same parts and entities as in Figures 1a, 1b, 1c and 2. The same names and the same reference numbers have been used for these parts and entities in the description. The embodiment shown in Figure 3 has a turntable 300, which can be rotated around an axis 302 in the middle of it with the aid of an actuator belonging to the apparatus and a control unit 132, advantageously a computer, controlling the actuator (the actuator is not shown in the figure). As an example the turntable has four branches, a first branch 310, a second branch 320, a third branch 330 and a fourth branch 340. Each branch advantageously has an identical or at least known attaching base 30 for attaching a circuit board 80. The apparatus has a supply station 130, where the circuit board is attached to the attaching base, two processing units for performing operations aimed at the circuit board and a discharge station 350, where the circuit board is detached from the attaching base after the operations have been performed. The processing units illustrated in Figure 3 are a dosing device 100 for adhesive paste and a component assembly device 110. The apparatus further comprises a supply conveyor 360, with which the circuit boards are transported into the supply station of the apparatus, and a discharge conveyor (370), with which the circuit boards detached at the discharge station are moved away from the apparatus for post-processing. In connection with the conveyor there is advantageously an automatic circuit board handling robot or some other prior art actuator arrangement, which moves the circuit board from the supply conveyor to the supply station and from the discharge station to the discharge conveyor (the handling robots are not shown in the figure).

All the attaching bases are attached to branches at a known distance from the axis 302 and in a known position, so that as the turntable rotates the attaching bases circulate around the axis 302 along a known circular travelling line. The processing units are situated along this travelling line advantageously at subsequent quarter

points, so that when the first branch 310 of the turntable is in the supply station 130 its second branch 320 is in the discharge station 350, the third branch 330 is in the working area of the second processing unit 110 and the fourth branch 340 in the working area of the first processing unit 100. The turntable is rotated by
5 stepping advantageously always a quarter of a circle at a time, so that the attaching bases 30 in the branches always stop precisely in a known point in the supply station, the discharge station and the working area of the processing units. The attaching bases thus move in the apparatus along a predefined known travelling line. Due to the known travelling line the location and/or position of the
10 attaching base is always known in advance in the working area of each processing unit.

In the method according to the invention the first circuit board is attached in the supply station 130 in the standard position to the attaching base of the first branch 310. The supply station advantageously has a computer vision camera 38 or some
15 other prior art method for identifying geometry, which is used to define the geometry of the circuit layout in the circuit board. The circuit board 80 is identified by reading the circuit board identifier 44 with a computerised reader 46 and a measurement file 84 is generated, where data regarding the circuit board is stored. The location and position of the circuit layout of the circuit board in relation to the
20 attaching base 30 is defined with the computer vision camera and the data is stored in the measurement file 84.

The identification of the circuit board is however not essential, since the travelling line of the turntable unambiguously defines the movement of the circuit board from the supply station to the first processing unit, from the first processing unit to the
25 second processing unit and from the second processing unit further to the discharge station. The location and position of the circuit board to be moved from the supply station to the processing units in relation to the attaching base can thus reliably be transmitted to the processing units also in some other manner than by attaching this data to the identifier of the circuit board.

30 After the first circuit board is attached the turntable is rotated by a quarter of a circle, whereby the first branch 310 settles in the working area of the first processing unit and the second branch 320 moves to the supply station 130. The geometry of the circuit layout of the circuit board in relation to the attaching base 30 is defined in advance already in the supply station, i.e. before the circuit board
35 is moved to the working area of the processing unit. This geometry data can be stored in a measurement file in the control unit controlling the function of the

processing units of the apparatus. If the circuit board is aligned in relation to an individual branch, the geometry data does not need to be stored anywhere. The actuators of the first processing unit can thus be ready-aligned already before the circuit board arrives in the working area of the processing unit. The processing unit
5 can thus start to perform the planned operation immediately when the circuit board has arrived in the working area of the processing unit. In the embodiment shown in Figure 3 the first processing unit is a dosing device 100 for solder paste, with which dosing of solder paste is performed in planned points of the circuit layout (81) of the circuit board. Simultaneously with the dosing of solder paste a second
10 circuit board is attached to the attaching base 30 of the second branch 320, for which second circuit board the defining of the geometry of the circuit layout is performed in the above-described manner.

Thereafter the turntable is again rotated by a quarter of a circle, whereby the first circuit board 80 attached to the attaching table 30 of the first branch 310 moves
15 into the standard position in the working area of the second processing unit 110, the second circuit board attached to the attaching base of the second branch 320 moves into the standard position in the working area of the first processing unit 100 and the attaching base of the third branch 330 moves to the supply station 130. In the working area of the second processing unit a second operation is now
20 performed on the circuit board. The geometry of the circuit layout of the circuit board in relation to the attaching base 30, defined in advance in the supply station 130, is utilized also in the second processing unit by aligning the actuator of the second processing unit already before the circuit board arrives in the working area of the processing unit. In the second processing unit no new aligning of the circuit
25 board in relation to the actuators of the processing unit thus needs to be made. In the embodiment shown in Figure 3 the second processing unit is an assembly device for electronic components, which is used for assembling components in planned points on the circuit board, wherein solder paste has advantageously been dosed. During the rotation of the turntable the components of the circuit
30 board arriving for assembly are advantageously loaded onto the assembly head/heads of the assembly device. Simultaneously with the component assembly, dispensing of solder paste is performed on the second circuit board in the first processing unit, and a third circuit board is attached to the attaching base in the supply station and the geometry of the circuit layout of this circuit board is
35 defined in the above-described manner.

Next the turntable is again rotated by a quarter of a circle, whereby the attaching base of the first branch moves to the discharge station 350, where the first circuit board 80 is detached from the attaching base and moved onto the discharge conveyor 370. Simultaneously component assembly is performed on the second circuit board in the working area of the second processing unit, dispensing of solder paste on the third circuit board is performed in the working area of the first processing unit and a fourth circuit board is attached to the attaching base 30 of the fourth branch 340 in the supply station.

The first circuit board has now passed through the apparatus and it has undergone the operations planned in the apparatus. The attaching base of the first branch of the turntable is now empty and ready to receive a new circuit board, i.e. a new cycle starts. In the above-described manner the production can be continued as desired. The principle of the method according to the invention is an at least partly parallel processing of a circuit board and identification of the geometry of a subsequent circuit board.

The processing units presented as examples in Figure 3 are a dosing device for solder paste and a component assembly device. For a skilled person it is clear that the processing unit can also be some other processing unit of a production line for electronics, such as a paste printing device 120, an optical inspection station 170, an assembly and programming device 150 for memory circuits or an electric testing device 160. In Figure 3 there are two processing units, but there may also be some other number of them.

A turntable is one exemplary manner of implementing the solution according to this embodiment of the invention, and there are many other prior art actuation methods, with which the same inventive implementation can be arranged, for example an advantageously stepping multi-station conveyor functioning with precise movements. There is at least one operation station in the arrangement according to the invention and thus there are at least two standard positions in the arrangement according to the invention, the supply station and the operation station. Advantageously there are however two more standard positions in the arrangement according to the invention than there are operation stations, i.e. the supply station and the discharge station.

Instead of a turntable the movement of the attaching bases in the working area of the processing units can also be implemented in some other manner. One advantageous manner of moving the attaching bases 30 is to attach them at

standard intervals on a belt, which is moved in steps. The supply station, discharge station and processing units are attached along the belt advantageously at standard intervals, so that the attaching base attached to the belt always settles precisely in a beforehand known point in the supply station, discharge station and
5 in the working area of each processing unit. The geometry of the circuit layout of the circuit board defined in the supply station can thus be utilised in each processing unit and thus the cycle time of the product is advantageously shortened and the productivity of the production line improved.

The description of Figure 3 describes the performing of an operation on a circuit
10 board. It is clear that the method according to the invention and the device according to the embodiment of Figure 3 can be used to perform operations also on other parts of an electronic device than circuit boards.

Figure 4 shows the basic stages of the method according to the invention when using the apparatus according to Figure 3 by means of a simple flowchart. In the
15 method a circuit board 80 is attached to the attaching base 30, when the attaching base is in the supply station, i.e. the attaching base is outside the working areas of the processing units. Thereafter the geometry of the circuit layout of the circuit board is defined in relation to the attaching base and the geometry data is stored in the memory of the control unit of the apparatus. After the geometry has been
20 defined the attaching base and the thereto attached circuit board are moved into a predefined standard position in the working area of the first processing unit 100. In the second processing unit the geometry data of the circuit board defined in the supply station is utilized and a first operation is performed on the circuit board, which operation is the dosing of solder paste. Thereafter the attaching base and
25 the thereto attached circuit board are moved into the working area of the second processing unit 110, where the geometry data of the circuit board defined in the supply station is again utilized. In the second processing unit the assembly of electronic components, i.e. the second operation, is performed on the circuit board. Thereafter the attaching base is moved to the discharge station 350, where
30 the circuit board is detached from the attaching base.

In addition to the embodiments described above, the method and apparatus according to the invention can be used also in virtually all manufacturing processes and stages of electronic components, where some part of an electronic structure must be precisely aligned in relation to the actuators of the processing
35 unit performing the operation. Such operations are for example paste printing, dispensing, automatic optical inspection, high-speed assembly, precision

assembly, die bonding, wire bonding, flip chip bonding, assembly and programming of memory circuits and testing of a circuit board.

Some advantageous embodiments of the method and apparatus according to the invention have been described above. The invention is not limited to the solutions
5 described above, but the inventive idea can be applied in numerous ways to the manufacturing of electronic structures and/or entities within the scope of the claims.

Claims

1. A method for performing at least one operation requiring location precision aimed at a part (10, 80) of an electronic structure in the serial production of electronic structures, which part of an electronic structure has an operation area (81) and in which method the part of the electronic structure is moved into a standard position in the working area (50) of a processing unit (100, 110, 120, 150, 160, 170), the geometry of the operation area of the part of the electronic structure is defined by utilizing computer vision technology (38) and the processing unit is used to perform the location precise operation aimed at the operation area of the part of the electronic structure, **characterised** in that in the method
- the defining of the geometry of the operation area (81) of the at least one part (10, 80) of the electronic structure and the operation requiring location precision aimed at the operation area of at least one second part of an electronic structure are performed at least partly at the same time, and
 - a predefined geometry of the operation area of the part of the electronic structure is utilised for performing the operation in a location precise manner in the operation area.
2. The method according to claim 1, **characterised** in
- defining the geometry of the operation area (81) of at least one part (10, 80) of an electronic structure in at least one standard position in the working area (50) at least partly simultaneously as an actuator of the processing unit (100, 110, 120, 150, 160, 170) performs an operation aimed at least at one second part of an electronic structure in at least one second standard position in the working area.
3. The method according to claim 1 or 2, **characterised** in
- attaching a part (10, 80) of an electronic structure in a first standard position within the working area (50) of the processing unit (100, 110, 120, 150, 160, 170) and defining the geometry of the part of the electronic structure attached in the first standard position in the standard position in question of the processing unit and
 - performing a location precise operation aimed at a part of an electronic structure at least partly simultaneously in some second standard position within the working area (50) of the processing unit (100, 110, 120, 150, 160, 170), utilizing in said second standard position the previously made geometry identification, whereafter
 - the location precise operation aimed at the part of the electronic device in the first standard position is started, utilizing the geometry defined previously in said first standard position, and

– at least partly simultaneously defining the identification of the geometry of some subsequent part of an electronic structure in some second standard position within the working area (50) of the processing unit (100, 110, 120, 150, 160, 170).

4. The method according to any of the claims 1–3, **characterised** in that there are at least two standard positions within the working area (50) of the processing unit (100, 110, 120, 150, 160, 170), into which standard positions a part (10, 80) of an electronic structure is in turn brought and attached for identifying the geometry at least partly simultaneously as a location precise operation aimed at some other part of an electronic structure, the geometry of which has previously been identified, is performed in some second standard position within the working area of said processing unit with the same actuator or actuators, which will next be used to perform a location precise operation aimed at a part of an electronic structure in the first standard position, while the identification of the geometry of some subsequent part of an electronic structure is performed in the second standard position.

5. The method according to claim 1, **characterised** in

- attaching a part (10, 80) of an electronic structure in a standard position to the attaching base (30) outside the working area (50) of the processing unit (100, 110, 120, 150, 160, 170),
- defining the geometry of the operation area (81) of the part (10, 80) of the electronic structure in relation to the attaching base and
- moving the attaching base into the standard position in the working area of the processing unit.

6. The method according to claim 5, **characterised** in

- forming a supply station (130) outside the working area (50) of the processing unit (100, 110, 120, 150, 160, 170), which supply station has an attaching base (30) for attaching the part (10, 80) of the electronic structure in the standard position,
- attaching the part of the electronic structure in the standard position to the attaching base (30) in the supply station (130) and defining the geometry of the operation area (81) of the part (10, 80) of the electronic structure in the supply station,
- forming a travelling line leading from the supply station to the standard position in the working area (50) of the processing unit for moving the attaching base,
- moving the attaching base from the supply station to the standard position in the working area of the processing unit along said travelling line.

7. The method according to claim 6, **characterised** in
- defining supply coordinates $K_s(x, y, z, \omega_1, \omega_2)$ in the supply station (130),
 - defining operation coordinates $K_v(x, y, z, \omega_1, \omega_2)$ for the working area (50) of the processing unit (100, 110, 120, 150, 160, 170) and defining the working area of the actuators of the processing unit and the location of the attaching base arranged in the standard position in the operation coordinates K_v ,
 - defining a conversion algorithm A_m , which expresses the correlation between the coordinates defined in the supply coordinates K_s and the coordinates defined in the operation coordinates K_v ,
 - attaching the part (10, 80) of the electronic structure in the standard position to the attaching base (30) of the supply station (130) and defining its location and position in the supply coordinates K_s ,
 - calculating with the aid of the conversion algorithm the calculatory location and position of the part (10, 80) of the electronic structure to be attached in the standard position of the processing unit in the operation coordinates K_v ,
 - aligning the actuators of the processing unit and the geometry of the part of the electronic structure in the standard position with each other according to the calculatory location and position for performing the operation.
8. The method according to claim 7, **characterised** in
- attaching the part (10, 80) of the electronic structure in the supply station (130) to a moveable attaching base (30), which is attached to a counterpart (36) in the supply station with a so-called zero point principle, the location of which counterpart is known in the supply coordinates K_s ,
 - arranging a counterpart (36) in the processing unit (100, 110, 120, 150, 160, 170) for receiving the attaching base, the location of which counterpart is known in the operation coordinates K_v ,
 - moving the part of the electronic structure from the supply station to the processing unit while attached to the attaching base and
 - attaching the attaching base to the counterpart in the processing unit.
9. The method according to claim 7 or 8, **characterised** in that at least two operations aimed at a part (10, 80) of an electronic structure are performed with at least two different processing units (100, 110, 120, 150, 160, 170), whereby
- at least one second conversion algorithm A_m is defined, which expresses the correlation between the coordinates defined in the supply coordinates K_s and the coordinates defined in the operation coordinates K_v of at least one second processing unit,

- the calculatory location and position of the part (10, 80) of the electronic structure to be attached in the standard position of said second processing unit in the operation coordinates K_v of said second processing unit is calculated with the aid of the conversion algorithm,
 - 5 – the actuators of the second processing unit and the geometry of the part of the electronic structure in the standard position are aligned with each other according to the calculatory location and position,
 - the part (10, 80) of the electronic structure is moved from the first processing unit to the second processing unit,
 - 10 – the part of the electronic structure is attached in the standard position to the attaching base (30') of the second processing unit and
 - the second processing unit is used to perform the operation aimed at the operation area (81) of the part of the electronic structure.
10. The method according to any of the claims 1–6, where the part (10, 80) of the electronic structure arriving in the processing unit (100, 110, 120, 150, 160, 170) is known with the aid of the process sequence and where the data relating to the geometry of the part of the electronic structure is known based on the process sequence, **characterised** in that the geometry data of the part of the electronic structure known in the processing unit based on the process sequence is used for
- 15 performing an operation requiring location precision aimed at the part of the electronic structure.
11. The method according to any of the claims 1–9, **characterised** in that said part of an electronic structure is a circuit board (80), the operation area (81) of which is a circuit layout, whereby the geometry of the circuit layout is defined in the
- 20 method and the operation is aimed at the area of the circuit layout.
12. The method according to any of the claims 1–10, **characterised** in that said operation is the printing of solder paste, dosing of solder paste, assembly of an electronic component (14), die bonding, wire bonding, tuning of an electronic structure or the protection of an electronic component by dispensing.
13. A serial production apparatus for performing a location precise operation in the operation area (81) of a part (10, 80) of an electronic structure, which apparatus comprises at least one processing unit (100, 110, 120, 150, 160, 170) for performing said location precise operation aimed at the part of the electronic structure in the working area (50) of the actuator, and a computer vision system
- 30

(38) for identifying the geometry of the operation area of the part of the electronic structure, **characterised** in that said apparatus is arranged to

- perform the definition of the geometry of the operation area (81) of the at least one part (10, 80) of the electronic structure and the operation requiring location precision aimed at the operation area of at least one second part of an electronic structure at least partly at the same time and
- utilise a predefined geometry of the operation area of the part of the electronic structure for performing the operation in a location precise manner in the operation area.

10 14. The apparatus according to claim 13, **characterised** in that there are at least two standard positions in the working area (50) of the processing unit (100, 110, 120, 150, 160, 170) for performing the definition of the geometry of the operation area (81) of at least one first part (10, 80) of an electronic structure in the first standard position and the operation aimed at least at one second part of an
15 electronic structure in the second standard position at least partly simultaneously.

15. The apparatus according to claim 13 or 14, **characterised** in that there are at least two standard positions within the working area (50) of the processing unit (100, 110, 120, 150, 160, 170), a first standard position for attaching and defining the geometry of a part (10, 80) of an electronic structure and a second standard
20 position for performing a location precise operation on a part of an electronic structure, the geometry of which has previously been defined, and the apparatus is arranged to perform the attaching and geometry definition of the first part of the electronic structure and the location precise operation aimed at the second part of the electronic structure in turns and at least partly simultaneously.

25 16. The apparatus according to any of the claims 13–15, **characterised** in that it comprises a moveable attaching base (30) for attaching the part (10, 80) of the electronic structure in the standard position for defining the geometry of the operation area (81) of the part of the electronic structure and means for moving the attaching base (30) into the standard position in the working area (50) of the
30 processing unit (100, 110, 120, 150, 160, 170).

17. The apparatus according to any of the claims 13–16, **characterised** in that it comprises
– a supply station (130) outside the working area (50) of the processing unit (100, 110, 120, 150, 160, 170), which supply station has an attaching base (30) for
35 attaching the part (10, 80) of the electronic structure in the standard position,

– means (38) in the supply station (130) for defining the geometry of the operation area (81) of the part (10, 80) of the electronic structure attached to the attaching base (30) and

- 5 – a travelling line (300, 302) leading from the supply station to the standard position in the working area of the processing unit for moving the attaching base.

18. The apparatus according to claim 17, **characterised** in that said apparatus further comprises

- supply coordinates $K_s(x, y, z, \omega_1, \omega_2)$ in the supply station (130),
- 10 – means (38) for defining the location and geometry of the part of the electronic structure attached to the attaching base (30) of the supply station in the supply coordinates $K_s(x, y, z, \omega_1, \omega_2)$,
- operation coordinates $K_v(x, y, z, \omega_1, \omega_2)$ in the working area (50) of the processing unit (100, 110, 120, 150, 160, 170), where the working area of the actuators and the location of the attaching base arranged in the standard position
- 15 is defined,
- a conversion algorithm A_m for defining the calculatory location and geometry of the part (10, 80) of the electronic structure to be attached in the standard position of the processing unit in the operation coordinates K_v , based on the location and geometry defined in the supply coordinates $K_s(x, y, z, \omega_1, \omega_2)$ and
- 20 – means for aligning the actuators of the processing unit according to the calculatory location and position of the part of the electronic structure.

19. The apparatus according to claim 17 or 18, **characterised** in that

- the attaching base (30) for attaching a part (10, 80) of an electronic structure is a moveable so-called zero point base and
- 25 – the supply station (130) and processing units (100, 110, 120, 150, 160, 170) have counterparts (36), whereto the attaching base can be attached in a measurement precise manner with the zero point principle.

20. The apparatus according to any of the claims 13–19, **characterised** in that the apparatus has at least one second processing unit (100, 110, 120, 150, 160,
- 30 170) and the apparatus is arranged to perform at least one second operation aimed at a part (10, 80) of the electronic structure with said second processing unit and said second processing unit is arranged to utilise said predefined geometry of the operation area (81) of the part (10, 80) of the electronic structure for aligning the operation in a location precise manner in the operation area.

21. The apparatus according to claim 16 or 17, **characterised** in that said means for moving the attaching base (30) into the standard position in the working area (50) of the processing unit (100, 110, 120, 150, 160, 170) comprise a turntable (300) rotating around an axis (302), and the apparatus comprises at least two
5 attaching bases (30) attached to the turntable, which attaching bases have a standardised travelling line, and the processing units are placed along said travelling line.
22. The apparatus according to claim 16 or 17, **characterised** in that said means for moving the attaching base (30) into the standard position in the working area
10 (50) of the processing unit (100, 110, 120, 150, 160, 170) comprise a stepping conveyor, which has a standardised travelling line, and the apparatus comprises at least two attaching bases (30) attached to the conveyor, and the processing units are placed along said travelling line.
23. The apparatus according to any of the claims 13–22, **characterised** in that
15 said processing unit is a paste printing device (120), a dosing device (100) for adhesive, an assembly device (110) for an electronic component, an assembly and programming device (150) for memory circuits or a testing device (160) for a circuit board.
24. The apparatus according to any of the claims 13–23, **characterised** in that
20 the apparatus has a control unit (132) for controlling the functions of the processing unit (100, 110, 120, 150, 160, 170) and the computer vision system (38), which control unit has a processor, a memory, and a control application loaded into the memory.

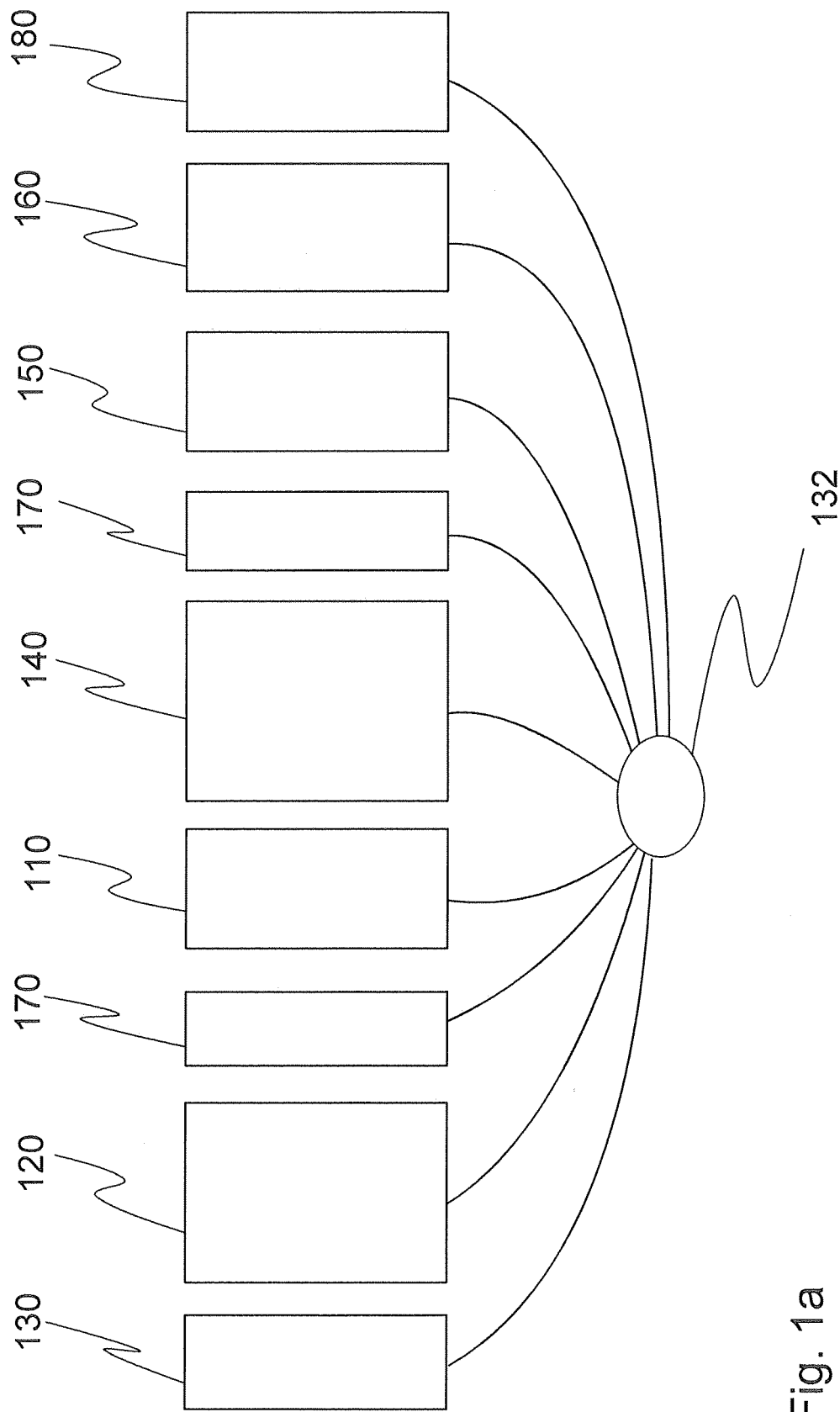


Fig. 1a

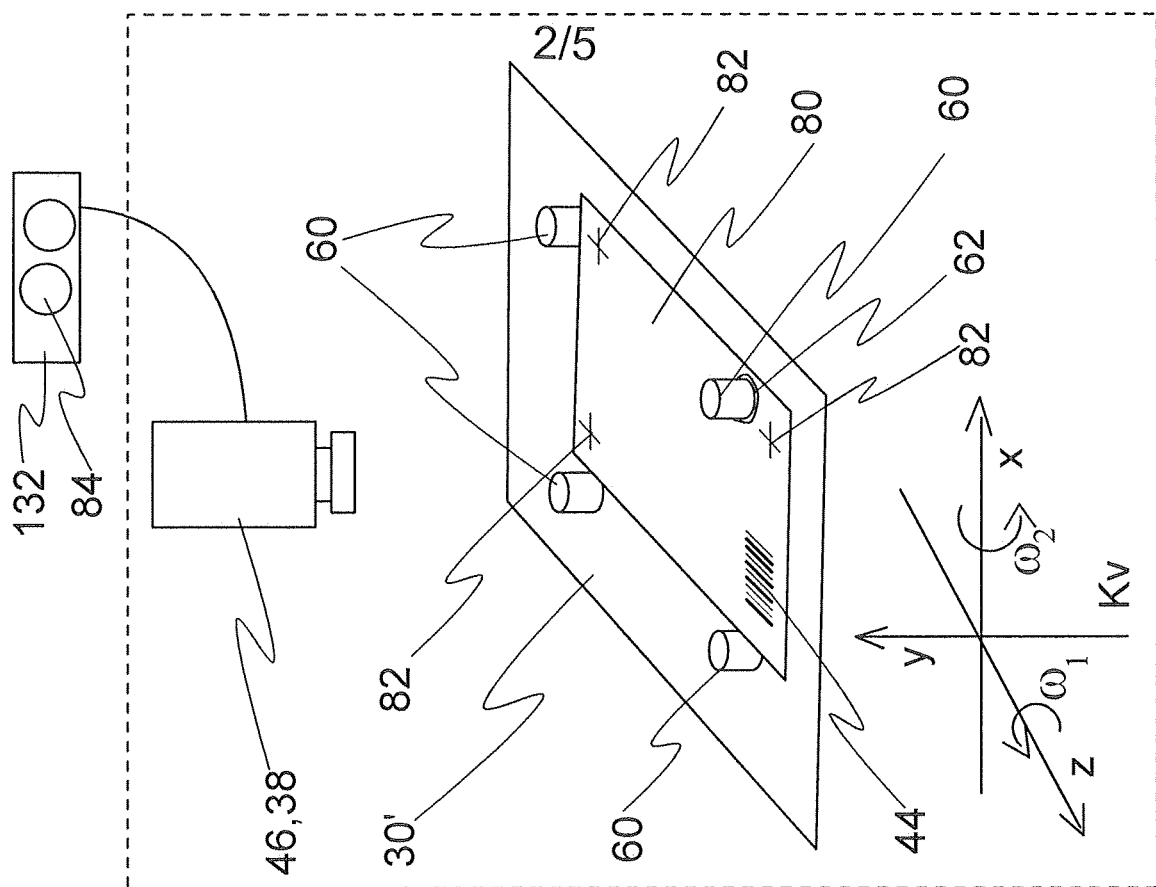


Fig. 1c

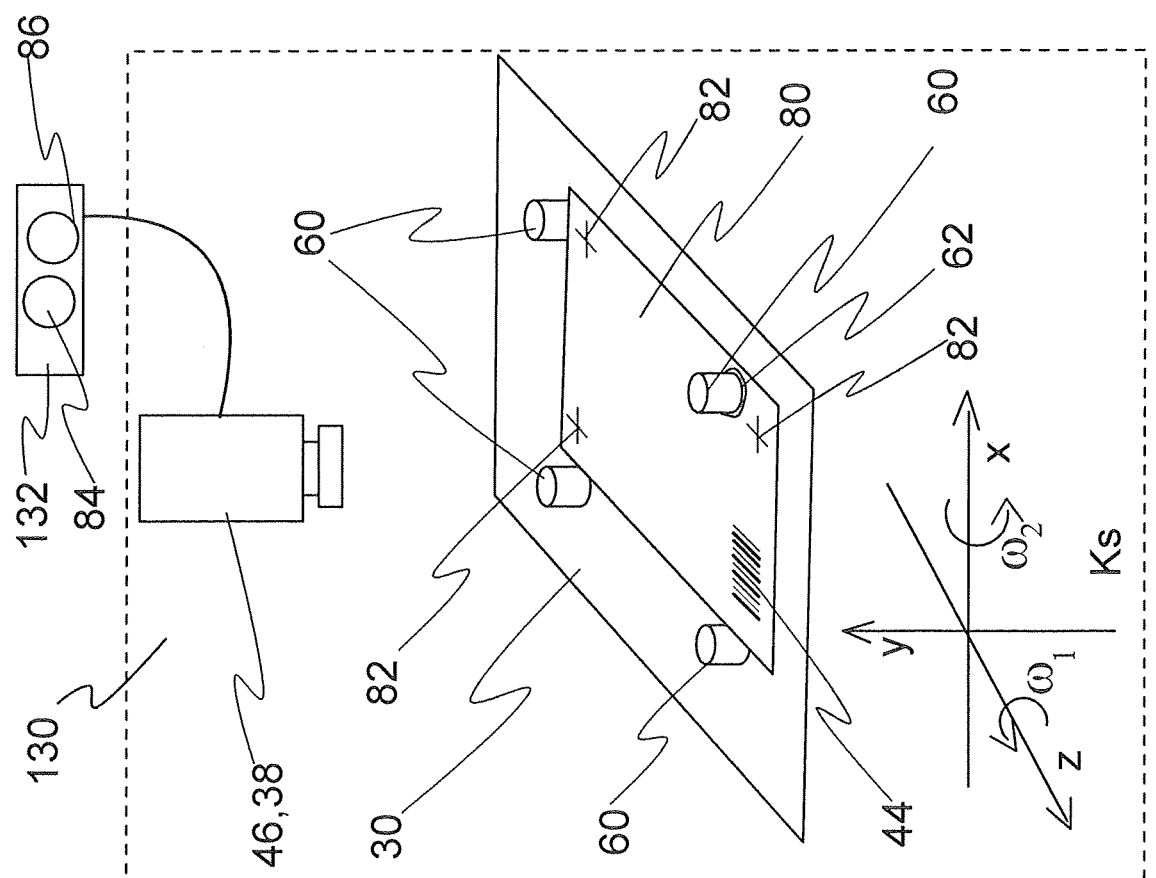


Fig. 10

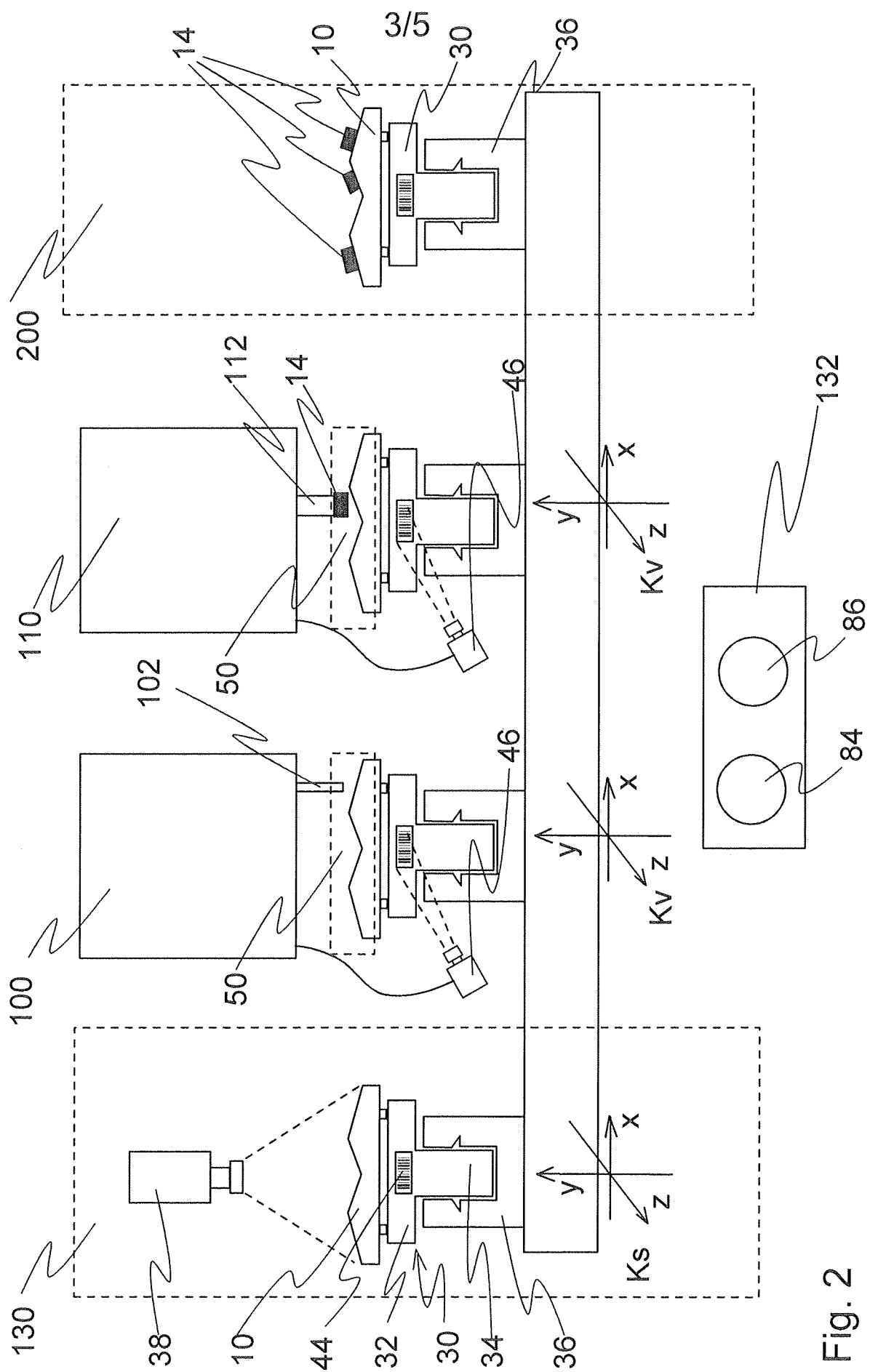


Fig. 2

4/5

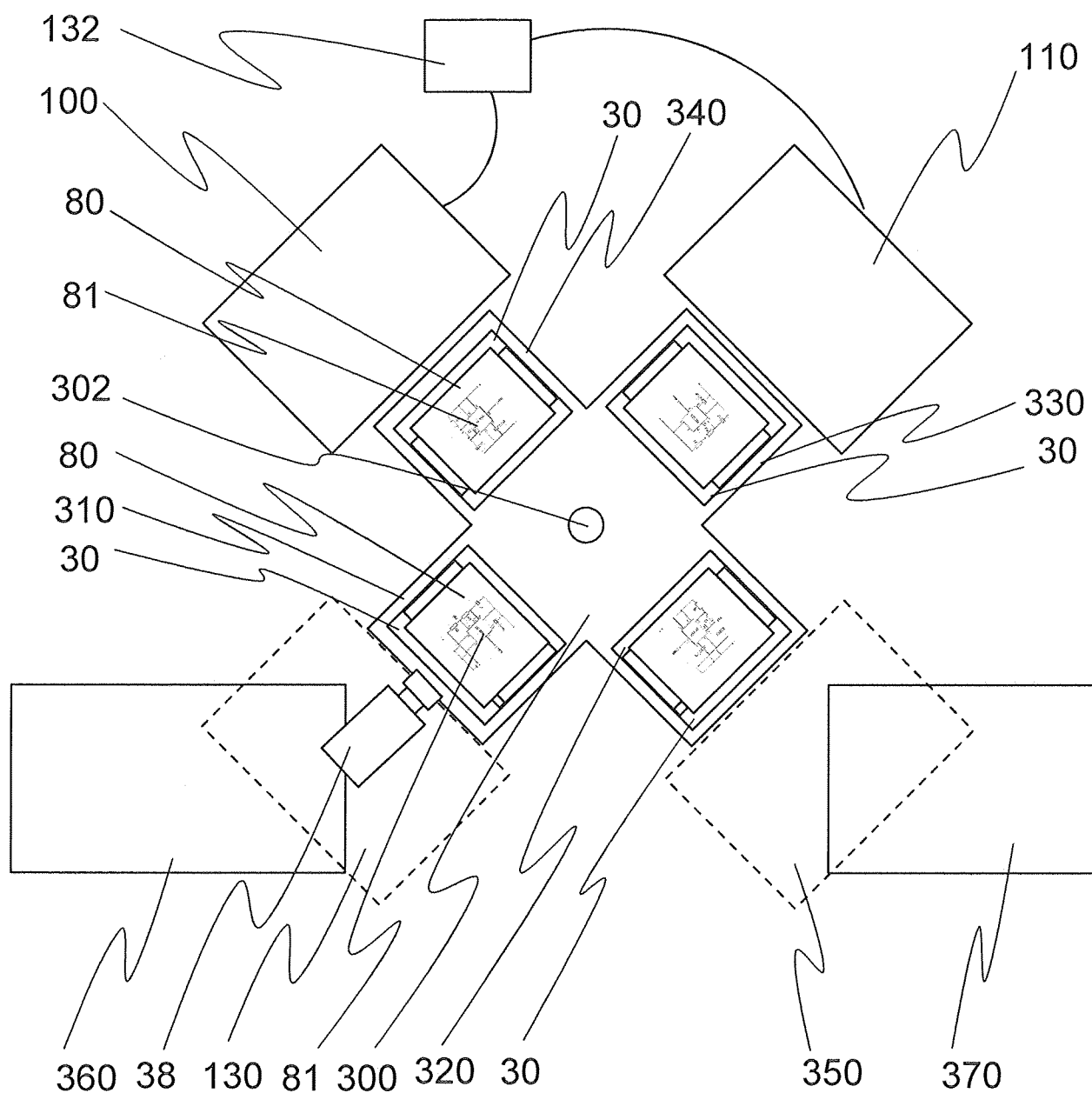


Fig. 3

5/5

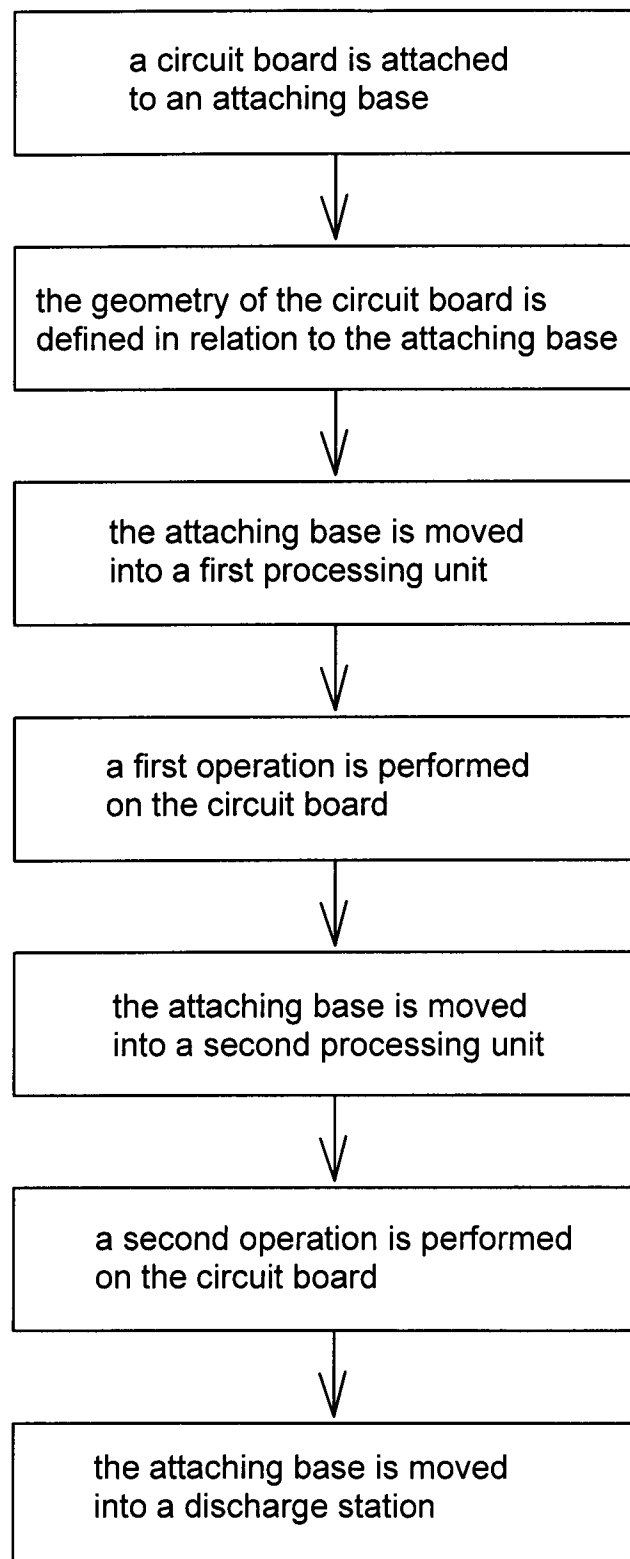


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2011/051138

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H01L, H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DK

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

EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010154870 A1 (BATEMAN NICHOLAS et al.) 24 June 2010 (24.06.2010) paragraphs [0013],[0029],[0030],[0034],[0037],[0046],[0053]-[0055]	1-2, 5-14, 16-24
X	US 4342090 A (CACCOMA GEORGE A et al.) 27 July 1982 (27.07.1982) column 1 lines 6-12, column 3 lines 39-61, column 4 lines 17-28 and 29-41, column 5 lines 3-10 and 44-59, column 8 lines 16-36, column 10 lines 36-39 and 54-58 and figure 7	1-2, 5-14, 16-24
A	US 2009225285 A1 (OTSUKA TAKAHISA) 10 September 2009 (10.09.2009)	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

20 March 2012 (20.03.2012)

Date of mailing of the international search report

03 April 2012 (03.04.2012)

Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland

Facsimile No. +358 9 6939 5328

Authorized officer
Thomas Carlsson

Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2011/051138

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
US 2010154870 A1	24/06/2010	TW 201003740 A	16/01/2010
		JP 2011525303 A	15/09/2011
		US 2011198514 A1	18/08/2011
		CN 102119436 A	06/07/2011
		KR 20110027781 A	16/03/2011
		EP 2301066 A2	30/03/2011
		WO 2009155498 A2	23/12/2009
.....			
US 4342090 A	27/07/1982	EP 0042977 A1	06/01/1982
		JP 57015436 A	26/01/1982
.....			
US 2009225285 A1	10/09/2009	TW 201005795 A	01/02/2010
		CN 101527259 A	09/09/2009
		KR 20090096332 A	10/09/2009
		JP 2009212404 A	17/09/2009
.....			

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2011/051138

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

H01L 21/67 (2006.01)

H05K 13/00 (2006.01)

H01L 21/66 (2006.01)