



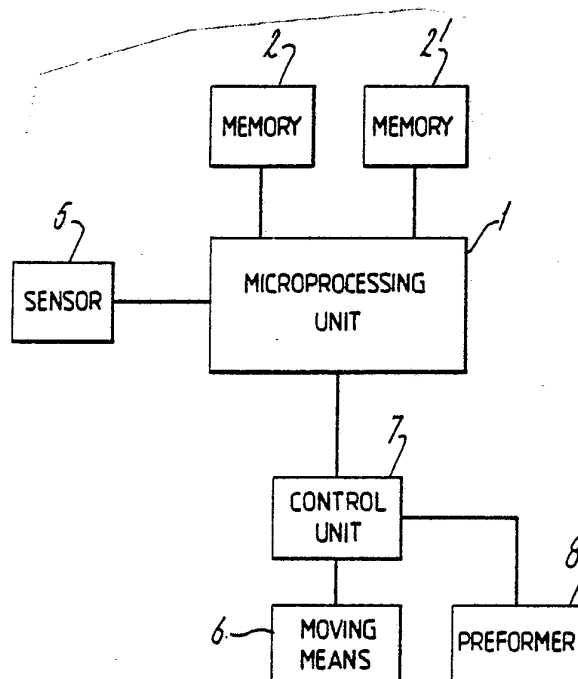
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: ASSEMBLING COMPONENTS ON A PRINTED CIRCUIT BOARD

(57) Abstract

Apparatus for and a method of assembling printed circuit boards. The apparatus comprises a microprocessing unit (1) which has a memory (2) in which the master layout of a printed circuit board is stored. A sensor head (5) is movable by mechanical moving means (6) controlled by the microprocessing unit (1). The sensor head (5) comprises a photosensitive array which provides signals to the microprocessing unit (1) to produce a digital representation of the target area. The microprocessing unit (1) then compares the representation with the image signal stored in its memory (2) to produce error signals to cause the mechanical moving means (6) to move a component insertion device to the correct location. The apparatus may also be provided with a second memory (2') to store images of the patterns of components lead receiving apertures so that the microprocessing unit (1) can control a preforming unit (8) to preform the leads of component to fit the pattern of lead receiving apertures.



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"Assembling Components On A Printed Circuit Board"

THIS INVENTION relates to assembling printed circuit boards, in particular to apparatus for and a method of assembling components on a printed circuit board.

5 In the past, components have been manually assembled onto printed circuit boards. However, manual assembly of printed circuit boards is both slow and laborious. Mechanical means have, accordingly, been devised for assembling components on printed circuit boards. In order to ensure that the components are accurately located on the circuit board, the printed
10 circuit boards and the mechanical assembly means must be manufactured to a high degree of accuracy and, moreover, a printed circuit board must be precisely positioned relative to the mechanical means during assembly of the components on the printed circuit board. The necessity for such high accuracy leads of course to high costs. Moreover, because any slight in
15 accuracies in the positioning or manufacture of the printed circuit boards and in the manufacture of the mechanical assembly means will result in errors being made during the assembly, the number of reject finished printed circuit boards will be high.

20 It is an object of the present invention to overcome or at least mitigate the disadvantages of the previously proposed methods and apparatus.

According to one aspect of the present invention, there is provided
25 apparatus for assembling components on a printed circuit board, comprising: means for effecting relative movement between a component insertion device and the printed circuit board to position the component insertion device above an area of the printed circuit board containing the desired location of the component carried by the component insertion device;
30 sensing means for producing an image of the said area; means for comparing the image sensed with a correct image stored in memory means to produce a difference signal; and control means for controlling the moving means in response to the difference signal to position the component insertion device directly over the desired location of the component.

Thus, the present invention enables components to be assembled with speed and precision on a printed circuit board so that the number of reject finished printed circuit boards is minimised.

5 Preferably, the apparatus further comprises means for storing data representing a component to be inserted in the printed circuit board and means for comparing an image of the component produced by the sensing means with the stored data to calibrate the sensing means prior to assembly of components on the printed circuit board. Such calibration thus prevents
10 the production of incorrect difference signals which may be caused by, for example, incorrect mounting of the sensing means in the apparatus by compensating for the error produced by the sensing means.

 Generally, the apparatus also comprises means for storing data
15 representing a plurality of preselected locations on the printed circuit board, means for comparing an image of the preselected location with preselected locations to produce a signal to cause the control means to effect relative movement between the printed circuit board and the component insertion device to position the printed circuit board correctly
20 prior to assembly of components on the printed circuit board.

 Normally, the apparatus comprises means for securing the pattern of component lead receiving apertures on the circuit board at a desired location of a particular component; means for comparing the pattern sensed
25 with a master pattern stored in memory means to produce a difference signal; and means for controlling a preforming means in accordance with the difference signal to preform the leads of the component to fit the sensed pattern of component lead receiving apertures.

30 According to a second aspect of the present invention, there is provided a method of assembling components on a printed circuit board, comprising: effecting relative movement between a component insertion device the printed circuit board using moving means to position the component insertion device above an area of the printed circuit board
35 containing the desired location of a component carried by the component insertion device; producing an image of the said area using sensing means; comparing the image sensed with a correct image stored in memory means



to produce a difference signal; and controlling the moving means in response to the difference signal to position the component insertion device directly over the desired location of the component.

5 Preferably, the method further comprises, prior to assembling components on a printed circuit board, storing data representing a component to be inserted in the printed circuit board and comparing the stored data with an image of the component produced by the sensing means to calibrate the sensing means. Normally, the method also comprises storing data represent-
10 ing a plurality of preselected locations on the printed circuit board, comparing an image of the preselected locations produced by the sensing means with the stored data representing the locations to produce a signal to cause the control means to effect relative movement between the printed circuit board and the component insertion device to position the printed
15 circuit board correctly prior to assembly of components on the printed circuit board. Generally, the method further comprises sensing the pattern of component lead receiving apertures on the circuit board at a desired location of a particular component, comparing the pattern sensed with a master pattern stored in the memory means to produce a difference signal;
20 and controlling a preforming means in accordance with the difference signal to preform the leads of a component to fit the sensed pattern of component lead receiving apertures prior to assembling the component on the printed circuit board.

25 The present invention also provides apparatus for preparing a component for assembly on a printed circuit board, comprising: sensing means for sensing the pattern of component lead receiving apertures on the circuit board at a desired location of a particular component; means for comparing the pattern sensed with a master pattern stored in memory means to
30 produce a difference signal; and control means for controlling a preforming means in accordance with the difference signal to preform the leads of the component to fit the sensed pattern of component lead receiving apertures.

35 The invention also provides a method of preparing a component for assembly on a printed circuit board, comprising: sensing the pattern of component lead receiving apertures at a desired location of a particular component; comparing the pattern sensed with a master pattern stored in



memory means to produce a difference signal; and controlling a preforming means in accordance with the difference signal to preform the leads of a component to fit the sensed pattern of component lead receiving apertures.

5 The invention also provides apparatus for calibrating a sensing means for use in apparatus in accordance with the first aspect, comprising means for storing data representing a component to be inserted in a printed circuit board and means for comparing an image of the component produced by the sensing means with the stored data to calibrate the sensing means.

10 In another aspect the invention provides a method of calibrating a sensing means for use in apparatus in accordance with the first aspect, comprising storing data representing a component to be inserted in a printed circuit board and comparing an image of the component with the stored data
15 to calibrate the sensing means.

 In a further aspect, the invention provides apparatus for aligning a printed circuit board on which components are to be assembled with a component insertion device, the apparatus comprising means for storing
20 data representing a plurality of predetermined locations on the printed circuit board, means for comparing the stored data with an image of the predetermined locations produced by sensing means to produce a correction signal and means for effecting relative movement between the printed circuit board and the component insertion device in accordance with the
25 correction signal to place the printed circuit board in the correct position for components to be assembled thereon.

 The invention also provides a method of aligning a printed circuit board on which components are to be assembled with a component insertion device, which method comprises storing data representing a plurality of
30 predetermined locations on the printed circuit board, comparing the stored data with an image of the predetermined locations produced by a sensing means to provide a correction signal and effecting relative movement between the printed circuit board and the component insertion device in
35 accordance with the correction signal to place the printed circuit board in the correct position for components to be assembled thereon.



In a preferred embodiment, the sensing means comprises a photo-sensitive array, for example, an array of photosensitive device and an imaging lens or lens system. Usually the apparatus is controlled by a microprocessor and normally the apparatus will have a plurality, for
5 example five, of insertion devices, each insertion device being associated with a respective sensing means.

For a better understanding of the present invention and to show how the same may be put into effect, reference will now be made, by way of
10 example, to the accompanying drawings, in which:

FIGURE 1 is a schematic block diagram of apparatus embodying the invention;

15 FIGURE 2 illustrates the positioning of a sensor head of the apparatus over a printed circuit board;

FIGURE 3 is a schematic plan view of a first target area viewed by the sensor head on a printed circuit board; and

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FIGURE 4 is a schematic plan view of a second target area on a printed circuit board viewed by the sensor.

Referring now to the drawings, Figure 1 is a schematic block diagram
25 of apparatus embodying the invention.

The apparatus comprises a microprocessor 1 having a memory 2 in which the master layout of a printed circuit board 3 (Figure 2) is stored as a plurality of master images, each master image representing a particular
30 target area 3 of the printed circuit board. The memory 2 is preferably an alterable non-volatile solid state memory such as an electrically alterable programmable memory (EAROM). Alternatively, the memory could comprise battery-backed up random access memory (RAM). A sensor head 5 is mounted in mechanical moving means 6. Movement of the mechanical
35 moving means 6 is controlled by a control unit 7 under instruction from the microprocessing unit 1. The control unit 7, or alternatively a separate control unit, also controls a preforming device 8 for adjusting the relative

orientation and position of the leads of a component to be inserted in the printed circuit board.

As shown schematically in Figure 2, the sensor head 5 comprises a
5 photosensitive array 9 which has an array of photodiodes, a vidicon or similar photosensitive device and an imaging lens or lens system 10.

In operation of the apparatus, a printed circuit board on which components are to be assembled is positioned beneath the sensor head 5 and,
10 under programmed instructions, the microprocessor 1 causes the mechanical moving means 6, which is preferably an electro-mechanical moving means, to move the sensor head over the printed circuit board 3 to position it above a target area 4 in which the first component to be assembled onto the printed circuit board is to be inserted. The lens system 10 focuses an image
15 of the target area 4 onto the photosensitive array 9 and the signals output from the elements of the photosensitive array 9 are input to the micro-processor unit 1 to provide a digital representation of the target area. The microprocessor 1 compares the digital signals representing the image sensed with signals stored in the memory representing the master image of that
20 particular target area to produce difference signals. The microprocessor 1 then causes the control unit 7 to move the electro-mechanical moving means 6 in accordance with the difference signals so as to position a component insertion device (not shown) directly over the desired location of the component carried thereby. Alternatively, the printed circuit board
25 may be moved to position the component insertion device over the desired component location. As shown in Figure 3, the desired location is provided by the component lead receiving apertures 10.

The microprocessor 1 may also be provided with a second memory 2'
30 in which signals representing a master image of the pattern of component lead receiving apertures at a particular component location on the printed circuit board 3 are stored. In such a case, the microprocessor 1 will compare the pattern of component lead receiving apertures sensed by the sensor head 5 with the corresponding master pattern stored in the memory 2'
35 to produce difference signals to instruct the control unit 7 (or a separate control unit) to cause a preforming unit 8 to preform the leads of a component to fit the stored pattern of lead receiving apertures, Figure 4



shows one such pattern of lead receiving apertures formed by the apertures 11.

5 Once a component has been correctly inserted in the printed circuit board, the microprocessor will instruct the control unit 7 to cause the mechanical moving means 6 to move the sensor head 5 to a position over the next target area 4 and the above described procedures will be repeated for the next target area. It should be noted that, when the microprocessor 1
10 compares a master pattern of component lead receiving apertures with the pattern sensed, the microprocessor will ignore any apertures which are not designed to accept a lead of the component which is being inserted even when the additional apertures occur within the pattern area.

15 In practice, the apparatus will include a number of insertion devices (not shown) each with an associated sensor head. Preferably, five insertion devices are used.

The apparatus should be self-aligning and each of the insertion devices should be independently alignable.

20 Because of errors which may be introduced due to tolerances in machining, assembly etc of the apparatus and errors in the printed circuit board, an initial calibration of the apparatus should be carried out. Re-calibration will be necessary when an insertion device or sensor head is
25 changed during the life of the apparatus.

The calibration is carried out by aligning each insertion device to the printed circuit board. A 'standard' component of known 'pitch' or length is inserted into the insertion device, illuminated and viewed by the associated
30 sensor head 5 so that the pitch of the component is stored by the microprocessor unit. The insertion device is then aligned precisely with a known pair of holes on the printed circuit board so that the standard component may be inserted. The microprocessor unit 1 then computes the coordinate centres of the pairs of holes. The difference between the known
35 pitch stored by the microprocessor and the pitch sensed by the sensor head 5 is then determined so that any magnification errors can be compensated for. This pitch correction is stored by the microprocessor unit 1 together with



the coordinate position of one of the holes, that is the "mechanical earth", so that any X-Y errors can be compensated for. The actual pitch centreline, that is the line between the two holes, is also stored so that compensation can be made for any angular errors. This stored data thus enables
5 prevention of the production of incorrect error signals when, for example, the sensor head is tilted when inserted into the apparatus and the magnification produced thereby is incorrect.

The above - described initialisation procedure is carried out for each
10 insertion device. The apparatus may then be used as described above to assemble components on a printed circuit board, the microprocessor unit 1 being provided with data indicating the pitch of a component to be inserted and the insertion device to be used.

15 The printed circuit board will normally, be aligned in the apparatus by 'dead reckoning' so that the 'mechanical earth' will be in the target area of the sensor head 5 associated with an insertion device. The pitch information provided to the microprocessor determines the target area or 'window' of the sensor head 5. The mechanical moving means 6 moves the
20 printed circuit board relative to the insertion device in accordance with the pitch information provided to the microprocessor circuit 1 from its memory 2. When the mechanical moving means 6 stops, the sensor head 5 'looks' at the target area and the image seen is compared with that stored in the memory 2 to determine any coordinate errors for the 'mechanical earth' and
25 the other holes so that the microprocessor unit 1 can compute any angular error of the printed circuit board and any X-Y error in the positioning of the printed circuit board and thereby instruct the mechanical moving means 6 to position the component carried by the insertion devices precisely in the holes on the printed circuit board.

30 The apparatus may also be used to effect an initial alignment of the printed circuit board, by example using the sensor head 5 to locate the position of two to three known holes in the printed circuit board and using the microprocessor unit 3 to compute any errors between the actual position
35 of those holes and the positions stored in memory so that the printed circuit board can be correctly aligned. Alternatively, if there are surface mounted components on the printed circuit board, the positions of the edges or

corners of the printed circuit board may be used.

The pattern recognition system may be applied to any number of component receiving apertures. However, the location of only one component lead receiving aperture, for example the aperture 10 in Figure 3 is required in order to correctly position a component insertion device above the desired location above a particular component.

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CLAIMS:

1. Apparatus for assembling components on a printed circuit board, comprising: means for effecting relative movement between a component insertion device and the printed circuit board to a position above an area of the printed circuit board containing the desired location of the component
5 carried by the component insertion device; sensing means for producing an image of the said area; means for comparing the image sensed with a correct image stored in memory means to produce a difference signal; and control means for controlling the moving means in response to the difference signal to position the component insertion device directly over the
10 desired location of the component.
2. Apparatus according to claim 1, further comprising means for storing data representing a component to be inserted in the printed circuit board and means for comparing an image of the component produced by the
15 sensing means with the stored data to calibrate the sensing means prior to assembly of components on the printed circuit board.
3. Apparatus according to claim 1 or 2, further comprising means for storing data representing a plurality of preselected locations on the printed
20 circuit board, means for comparing an image of the stored data representing the preselected locations to produce a signal to cause the control means to effect relative movement between the printed circuit board and the component insertion device to position the printed circuit board correctly prior to assembly of components on the printed circuit board.
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4. Apparatus according to claim 1 or 2, further comprising means for sensing the pattern of component lead receiving apertures on the circuit board at a desired location of a particular component; means for comparing the pattern sensed with a master pattern stored in memory means to
30 produce a difference signal, and means for controlling a preforming means in accordance with the difference signal to preform the leads of the component to fit the sensed pattern of component lead receiving apertures.
5. A method of assembling components on a printed circuit board,
35 comprising: effecting relative movement between a component insertion



device and the printed circuit board using moving means to position the component insertion device above an area of the printed circuit board containing the desired location of a component carried by the component insertion device; producing an image of the said area using sensing means; 5 comparing the image sensed with a correct image stored in memory means to produce a difference signal; and controlling the moving means in response to the difference signal to position signal to position the component insertion device directly over the desired location of hte component

10 6. A method according to claim 5, further comprising, prior to to assembling components on a printed circuit board, storing data representing a component to be inserted in the printed circuit board and comparing the stored data with an image of the component produced by the sensing means to calibrate the sensing means.

15 7. A method according to claim 5 or 6, further comprising, prior to assembling components in a printed circuit board, storing data representing a plurality of preselected locations on the printed circuit board, comparing an image of the preselected locations produced by the sensing means with 20 the stored data representing the locations to produce a signal to cause the control means to effect relative movement between the printed circuit board and the component insertion device to position the printed cicuit board correctly prior to assembly of components on the printed circuit board.

25 8. A method acccording to claim 5 or 6, further comprising sensing the pattern of component lead receiving apertures on the circuit board at a desired location of a particular component, comparing the pattern sensed with a master pattern to produce a difference signal, and controlling a 30 preforming means in accordance with the difference signal to preform the leads of a component to fit the sensed pattern of component lead receiving apertures prior to assembling the component on the printed cicuit board.

35 9. Apparatus for preparing a component for assembly on a printed circuit board, comprising: sensing means for sensing the pattern of component lead receiving apertures on the circuit board at a desired location of a particular component; means for comparing the pattern sensed



with a master pattern stored in memory means to produce a difference signal; and control means for controlling a preforming means in accordance with the difference signal to preform the leads of the component to fit the sensed pattern of component lead receiving apertures.

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10. A method of preparing a component for assembly on a printed circuit board, comprising: sensing the pattern of component lead receiving apertures at a desired location of a particular component; comparing the pattern sensed with a master pattern stored in memory means to produce a difference signal; and controlling a preforming means in accordance with the difference signal to preform the leads of component to fit the sensed pattern of component lead receiving apertures.

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AMENDED CLAIMS

(received by the International Bureau on 13 September 1984 (13.09.84))

1. [original Claim No. 9] Apparatus for preparing a component for assembly on a printed circuit board, comprising: sensing means for sensing the pattern of component lead receiving apertures on the circuit board at a desired location of a particular component; means for comparing the pattern sensed with a master pattern stored in memory means to produce a difference signal; and control means for controlling a performing means in accordance with the difference signal to preform the leads of the component to fit the sensed pattern of component lead receiving apertures.
2. [original Claim No. 1 (amended)] Apparatus according to Claim 1, comprising: means for effecting relative movement between a component insertion device and the printed circuit board to position the component insertion device above an area of the printed circuit board containing the desired location of the component carried by the component insertion device; sensing means for producing an image of the said area; means for comparing the image sensed with a correct image stored in memory means to produce a difference signal; and control means for controlling the moving means in response to the difference signal to position the component insertion device directly over the desired location of the component.
3. [original Claim No. 2 (amended)] Apparatus according to Claim 2, further comprising means for storing data representing a component to be inserted in the printed circuit board and means for comparing an image of the component produced by the sensing means with the stored data to calibrate the sensing means prior to assembly of components on the printed circuit board.
4. [original Claim No. 3 (amended)] Apparatus according to Claim 2 or 3, further comprising means for storing data representing a plurality of preselected locations on the printed circuit board, means for comparing an image of the stored data representing the preselected locations to produce a signal to cause the control means to effect relative movement between the printed circuit board and the component insertion device to position the printed circuit board correctly prior to assembly of components on the printed circuit board.

[Original Claim No. 4 (cancelled)]



5. [original Claim No. 10] A method of preparing a component for assembly on a printed circuit board, comprising: sensing the pattern of component lead receiving apertures at a desired location of a particular component; comparing the pattern sensed with a master pattern stored in memory means to produce a difference signal; and controlling a preforming means in accordance with the difference signal to preform the leads of component to fit the sensed pattern of component lead receiving apertures.

6. [original Claim No. 5 (amended)] A method according to Claim 5, comprising: effecting relative movement between a component insertion device and the printed circuit board using moving means to position the component insertion device above an area of the printed circuit board containing the desired location of a component carried by the component insertion device; producing an image of the said area using sensing means; comparing the image sensed with a correct image stored in memory means to produce a difference signal; and controlling the moving means in response to the difference signal to position the component insertion device directly over the desired location of the component.

7. [original Claim No. 6 (amended)] A method according to Claim 6, further comprising prior to assembling components on a printed circuit board, storing data representing a component to be inserted in the printed circuit board and comparing the stored data with an image of the component produced by the sensing means to calibrate the sensing means.

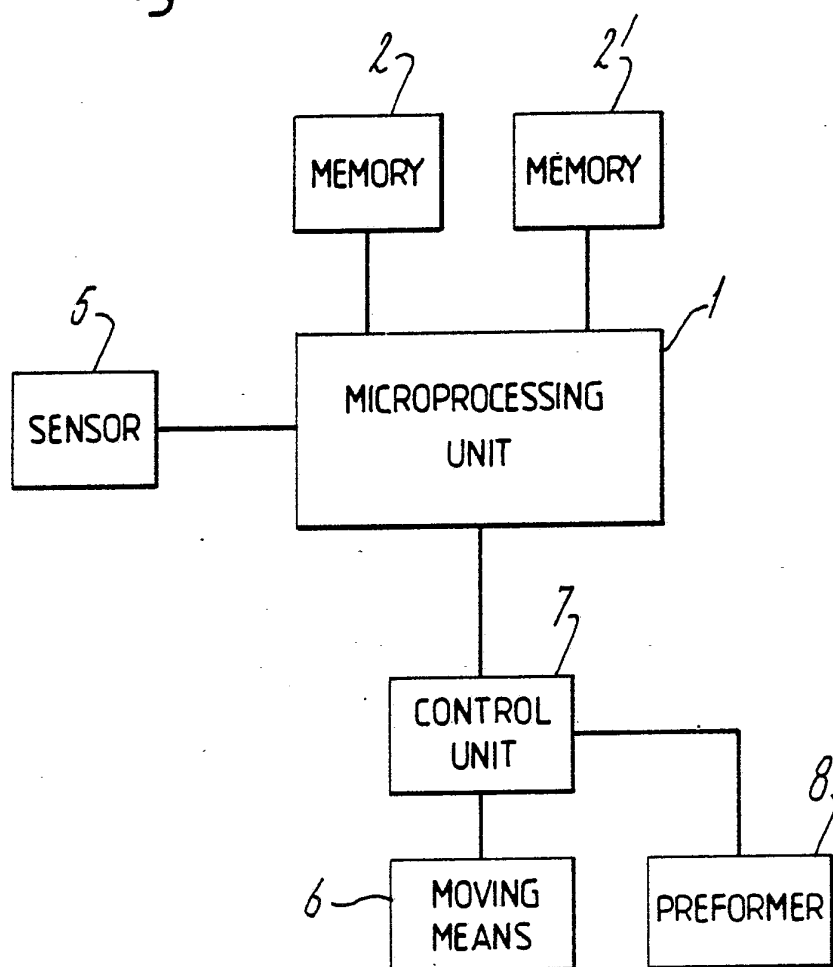
8. [original Claim No. 7 (amended)] A method according to Claim 6 or 7, further comprising, prior to assembling components in a printed circuit board, storing data representing a plurality of preselected locations on the printed circuit board, comparing an image of the preselected locations produced by the sensing means with the stored data representing the locations to produce a signal to cause the control means to effect relative movement between the printed circuit board and the component insertion device to position the printed circuit board correctly prior to assembly of components on the printed circuit board.

[original Claim No. 8 (cancelled)]



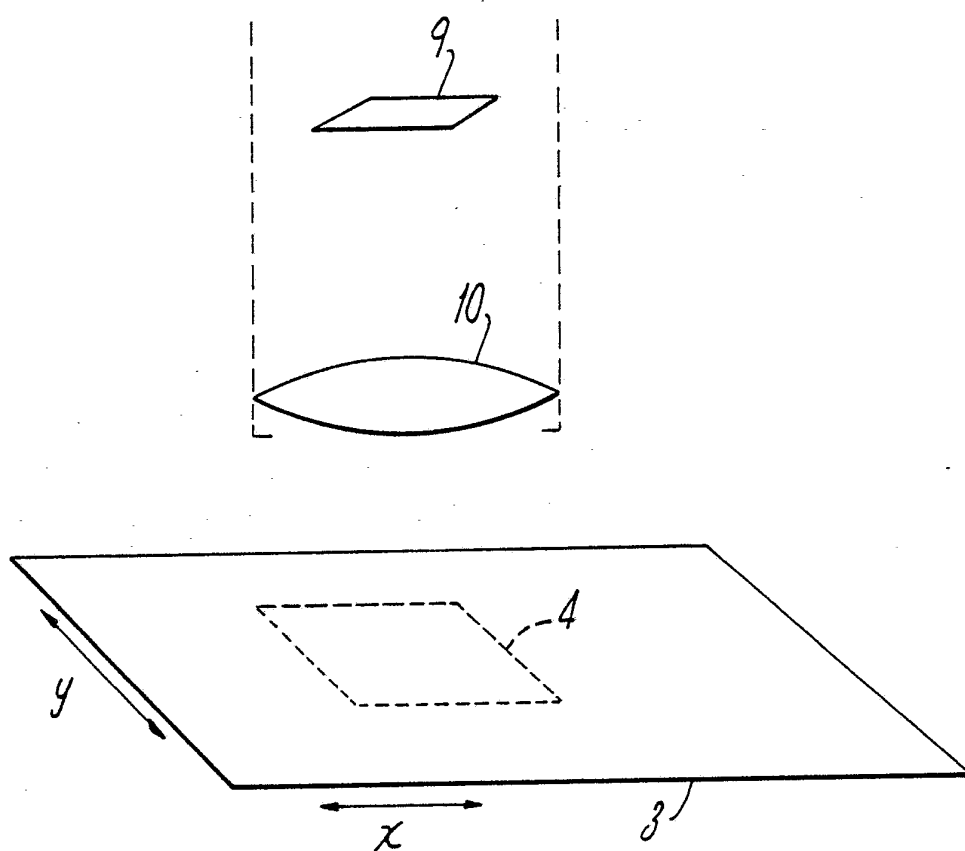
1/3

Fig.1.



2/3

Fig.2.



3/3

Fig. 3.

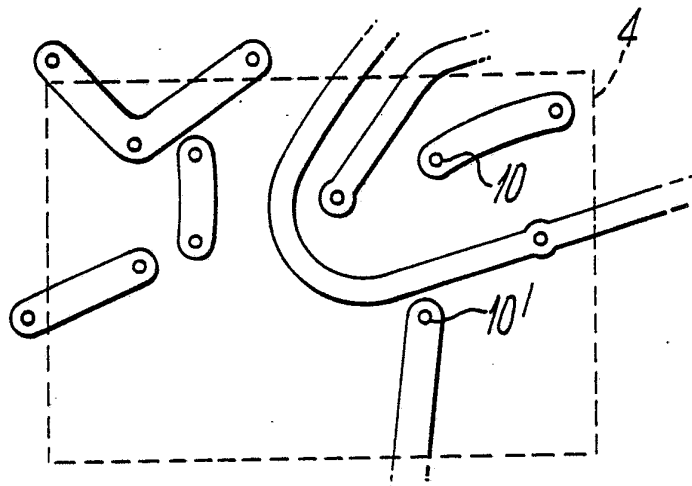
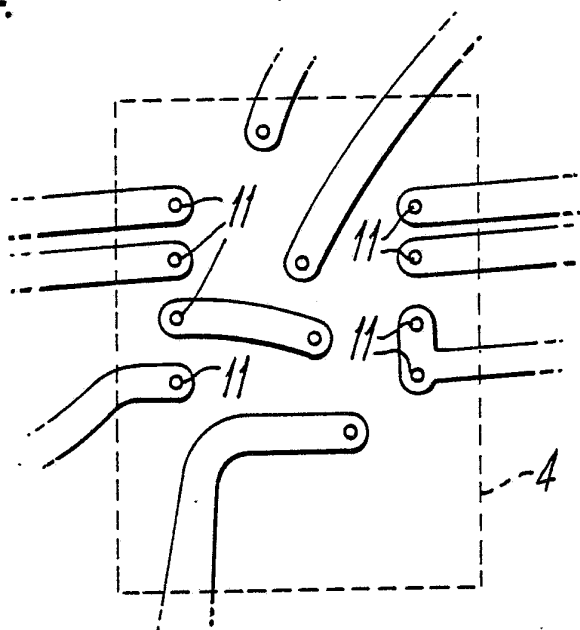


Fig. 4.



INTERNATIONAL SEARCH REPORT

International Application No **PCT/GB 84/00072**

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ³ : H 05 K 13/04		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
IPC ³	H 05 K 13/00	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category ⁶	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
X	EP, A2, 0062335 (HITACHI) 13 October 1982 see page 3, lines 4-22; page 8, lines 10-27; page 9, lines 1-7; page 17, lines 3-14	1-3,5-7
Y	--	4,8-10
Y	DE, A, 3022803 (FERNSEHGERÄTEWERKE) 4 April 1981 see page 5, paragraph 2 - page 8, paragraph 1 -----	4,8-10
¹⁵ * 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 document 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 "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		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ¹⁹		Date of Mailing of this International Search Report ²⁰
14th June 1984		18 JUL 1984
International Searching Authority ¹		Signature of Authorized Officer ²⁰
EUROPEAN PATENT OFFICE		G.L.M. Kruidenberg

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 84/00072 (SA 6717)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 12/07/84

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0062335	13/10/82	JP-A- 57164310	08/10/82
		CA-A- 1160757	17/01/84
DE-A- 3022803	02/04/81	None	

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