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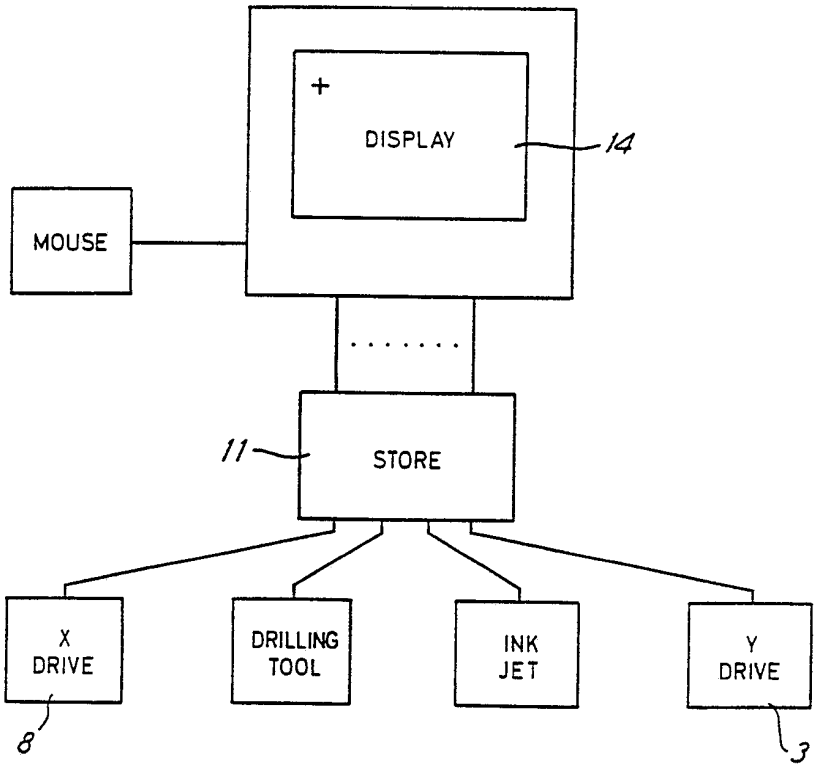
(54) Title: APPARATUS AND METHOD FOR THE MANUFACTURE OF PRINTED CIRCUIT BOARD PROTOTYPES



(57) Abstract

A printed circuit board layout is first designed on a screen (14) using a computer aided design system. The layout is then marked either onto a film or a PCB substrate. Holes are drilled in the substrate at positions corresponding to pads on the circuit layer and the board is then developed.

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APPARATUS AND METHOD FOR THE MANUFACTURE OF PRINTED CIRCUIT BOARD PROTOTYPES

This invention relates to a method and apparatus especially for producing printed circuit board prototypes.

The manufacture of printed circuit board prototypes is a long and tedious process. Hitherto the designer of a printed circuit board has normally produced a design on paper or film, the design is traced onto a printed circuit board precursor or is used for making a mask which is applied to the printed circuit board precursor or is used for making a mask which is applied to the printed circuit board precursor and the board is then developed, for example by etching. Since the circuit has to be present on both sides of the printed circuit board transfer of the design to the two surfaces of the board has to be very accurately carried out to ensure that at least the pads are sufficiently in register to allow electrical components to be functionally connected to the board. Very large numbers of rejects are produced by the prior method mainly due to lack of registration on the two sides of the board which does not become apparent until after the board has been completed.

This invention provides an apparatus for use in producing prototype printed circuit boards comprising an X-Y table, means for positively locating a substrate on the carriage of the X-Y table, a mounting head or heads arranged over the carriage of X-Y table, mounting means carried by the mounting head or heads and at least two interchangeable means capable of being mounted in the mounting means and including a marking instrument and a drilling tool, drive means for moving the

mounting head or heads relative to the substrate and/or for moving the substrate relative to the mounting head or heads in mutually perpendicular X and Y directions and for raising and lowering at least the drilling tool when carried in the mounting means, in response to signals in accordance with a predetermined pattern and store means for storing said drive pattern signals and for passing the signals to the drive means.

Because the substrate is positively located on the X-Y table and the marking instrument and/or the substrate is positively driven in accordance with the signals passed to the drive means accurate registration of the circuit layout on the two sides of the board is easily achieved.

The drive means may be means for moving a mounting means in both X and Y directions relative to a stationary substrate, means for moving the substrate in the X and Y directions relative to a stationary mounting means but preferably includes means for moving the mounting means in either the X or Y direction and means for moving the substrate in the other direction.

The marking instrument may be means such as a pen or the like for applying a line of ink or the like to the substrate when bought into contact with the substrate or means for applying ink or the like when spaced from the substrate, for example an ink jet printing means, or may be means for applying polymerising radiation, especially UV radiation. Preferably the marking instrument operates in a raster mode, that is to say, it scans the substrate and at the places where marking is to be produced applies the marking in

overlapping circular form.

The substrate may be a conductive coated dielectric sheet, in which case the markings are made in etch resistant masking ink so that after marking and drilling the unmasked surface of the sheet can be etched away. As a first alternative the substrate may be covered with a polymerisable resist that can be polymerised by means of polymerising radiation from the marking instrument, whereafter the unpolymerised coating is removed and the resulting substrate is subjected to etching. As a further alternative the marking instrument may be used to apply a conductive ink directly onto the surface of a dielectric substrate thereby avoiding the need for chemical etching or other developing of the printed circuit board. As a still further alternative the marking instrument may apply the markings to a drafting film which may then be applied to the dielectric sheet, exposed, and developed. The film and sheet are registered by aligning holes drilled in the sheet with pads on the film.

A single mounting head may be provided with mounting means for releasably receiving the marking instrument and drilling tool or two or more mounting heads may be provided, one with mounting means for the marking instrument and the other with mounting means for the drilling. In this latter case each mounting head must be moveable to a rest position in which it does not interfere with operation of the other mounting head.

The invention also provides a method of forming a prototype printed circuit board which comprises designing the circuit layout for a printed circuit board using a CAD system,storing the layout for example, in microcomputer means or on a

recording medium for use with microcomputer means, positioning a substrate on the X-Y table of an apparatus according to the invention for forming the circuit pattern thereon, passing the stored signals to the drive means to cause a marking instrument mounted in the mounting means to move relative to a first surface of the substrate to reproduce the circuit layout on said first surface, substituting the marking instrument by a drilling tool and passing stored signals to the drive means to cause the drilling tool to move relative to the substrate and to drill holes through the substrate in the positions corresponding to positions of pads in the circuit pattern of the circuit and then, if necessary, developing the printed circuit board.

Where the circuit is reproduced onto the substrate, the substrate is turned over and the marking process is repeated on the other surface of the substrate so that the circuit lines and pads are substantially in line on the two sides of the substrate.

It will of course be appreciated that when the substrate is turned over the circuit layout must be reproduced in mirror image or in inverted mirror image depending on how the substrate is turned.

The invention will now be described in greater detail by way of example with reference to the drawings in which Fig.1 is a schematic view of one form of X-Y table usable in the invention and Fig.2 is a block diagram illustrating the process of the invention.

Referring first to Fig.1 the X-Y table comprises a carriage 1

with means, not shown, for positively locating a substrate on the carriage 1. The substrate may be mounted on a frame, the frame having locating holes which register with mounting pegs on the carriage. The carriage 1 is supported on slides 2 and is driveable by drive motor 3 via drive belt 4 to be movable in the X-direction.

Positioned above the carriage 1 is a mounting head 5 which is carried on slides 6 and is movable by drive belt 7 driven by drive motor 8, in the Y-direction of the X-Y table.

Mounting head 5 has means 9 for interchangeably mounting a marking instrument (not shown) and a drilling tool (not shown) the munting means 9 is arranged on the mounting head such that a tool carried on the mounting head can be moved to an operative position in which it carried out a desired operation on the substrate and to an inoperative position in which it is spaced from the substrate. Such means are not shown in the drawing but the arrangement for such means will be readily apparent to the man skilled in the art.

Control of the drive means for the carriage 1 in the X-direction and for the mounting head 5 in the Y-direction and for raising and lowering the tool carried in mounting head 5 is in response to signals generated from memory store 11 (see Fig.2). Initially the signals output from the store control the marking instrument and the X and Y drive motors 3 and 8 to deposit the circuit layout in etch resistant ink directly onto the substrate surface of the sheet.

The output signals are then used to control the motors 3 and 8 while the drilling tool is in position, the signals also

controlling raising and lowering of the drill bit as required.

The PCB layout may be designed on a display terminal 14. To speed up design, all software in the design package is stored in the system memory which requires that a comparatively large memory is required.

1.2 M Bytes has proved satisfactory. Library information may be stored, for example, on disc.

The PCB layout is designed using a combination of components stored in the system library and user defined components. The need for a standard keyboard is dispensed with by using a mouse. The centre mouse key provides a menu for user defined components the pad footprint is first defined and then a label attached to each pad text and a component outline is then added.

Positioning of the components on the screen is controlled by the mouse which may rotate, move or copy components. Tracks between pads may be removed and replaced withj logical temporary connection. Higher magnification of an area is possible to assist in making connections between pads.

Tracks may be drawn on the screen using the cursor, movement of which is controlled by the mouse. Tracks may be edited by positioning the cursor at the starting point and drawing the track. Via pads may be inserted to continue the track on the other conductive layer. Alternatively the logical connections may be made first. The cursor locks onto the pads being connected, causing the label attached to the pad to be displayed. This method enables error free connections to be

made very quickly. The connections made can them be edited as tracks manually.

Tracks may be erased and redrawn and areas of the design may be moved and reproduced. Once the connections to be made have been selected, the system will automatically route the tracks on the screen until the complete layout has been drawn.

The multipass auto route system used provides tracks that can have 45° angles, and vias are only included when necessary. On complex circuits, more than one pass may be necessary to define all the connection paths. Subsequent passes learn from previous attempts until all paths have been connected.

The prototype PCB is then produced as previously described.

CLAIMS

1. Apparatus for use in producing prototype printed circuit boards comprising an X-Y table, means for positively locating a substrate on the carriage of the X-Y table, a mounting head or heads arranged over the carriage of X-Y table, mounting means carried by the mounting head or heads and at least two interchangeable means capable of being mounted in the mounting means and including a marking instrument and a drilling tool, drive means for moving the mounting head or heads relative to the substrate and/or for moving the substrate relative to the mounting head or heads in mutually perpendicular X and Y directions and for raising and lowering at least the drilling tool when carried in the mounting means, in response to signals in accordance with a predetermined pattern and store means for storing said drive pattern signals and for passing the signals to the drive means.

2. Apparatus according to claim 1 wherein the drive means includes means for moving the mounting means in either the X or Y direction and means for moving the substrate in the other direction.

3. Apparatus according to claim 1 or claim 2 wherein the marking instrument is a pen or the like for applying a line of ink or the like to the substrate when bought into contact with the substrate.

4. Apparatus according to claim 1 or claim 2 wherein the marking instrument is an ink jet printing means.

5. Apparatus according to claim 1 or claim 2 wherein the marking instrument operates in a raster mode.

6. A method of forming a prototype printed circuit board which comprises designing the circuit layout for a printed circuit board using a CAD system, storing the layout for example, in a microcomputer means or on a recording medium for use with microcomputer means, positioning a substrate on the X-Y table of an apparatus according to the invention for forming the circuit pattern thereon, passing the stored signals to the drive means to cause a marking instrument mounted in the mounting means to move relative to a first surface of the substrate to reproduce the circuit layout on said first surface, substituting the marking instrument by a drilling tool and passing stored signals to the drive means to cause the drilling tool to move relative to the substrate and to drill holes through the substrate in the positions corresponding to positions of pads in the circuit pattern of the circuit and then, if necessary, developing the printed circuit board.

7. A method according to claim 6, wherein the substrate is a conductive coated dielectric sheet and the markings are made in etch resistant marking ink.

8. A method according to claim 6, wherein the substrate is covered with a polymerisable resist that can be polymerised by means of polymerising radiation from the marking instrument.

9. A method according to claim 6, wherein a conductive ink is applied directly onto the surface of a dielectric substrate.

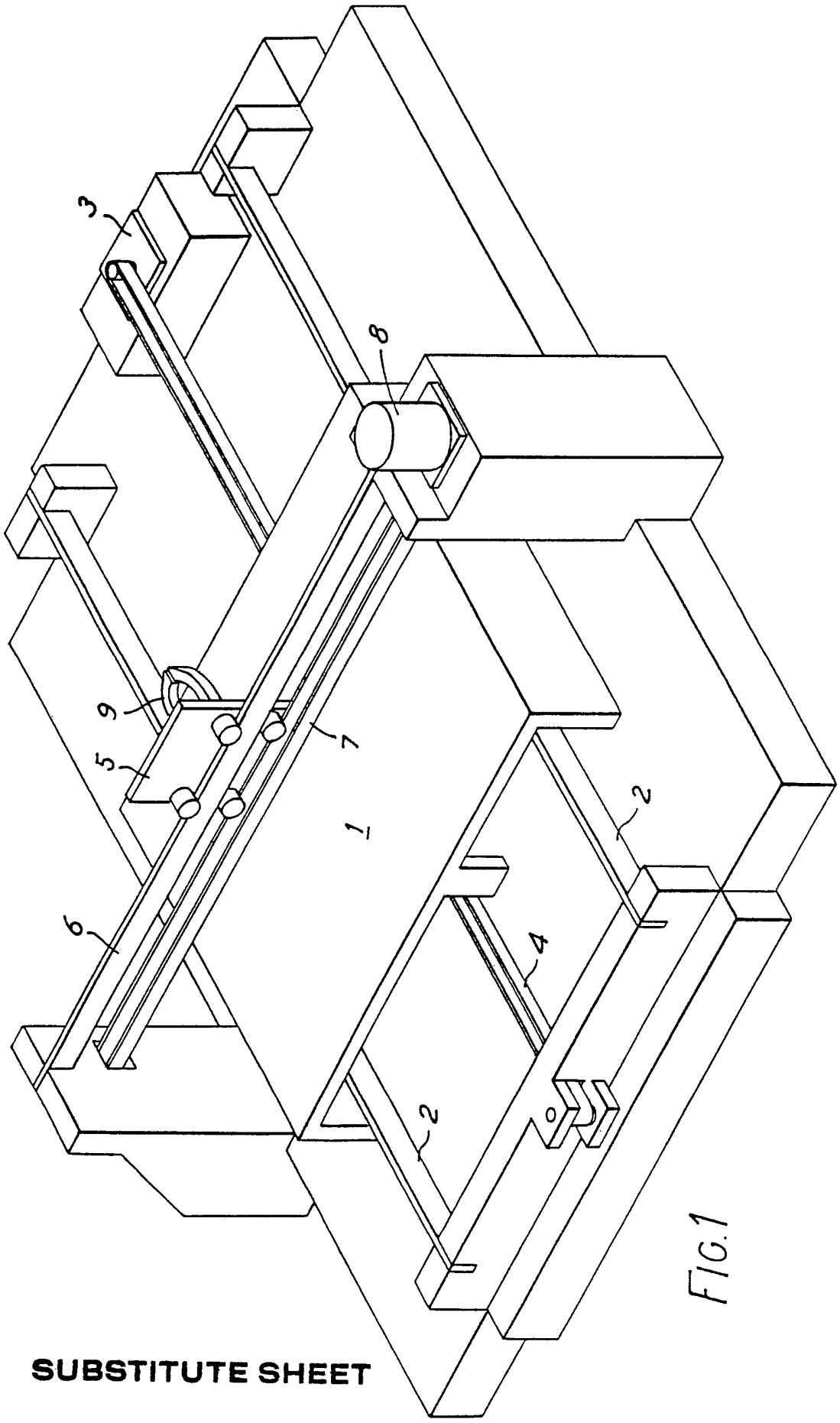

FIG.1

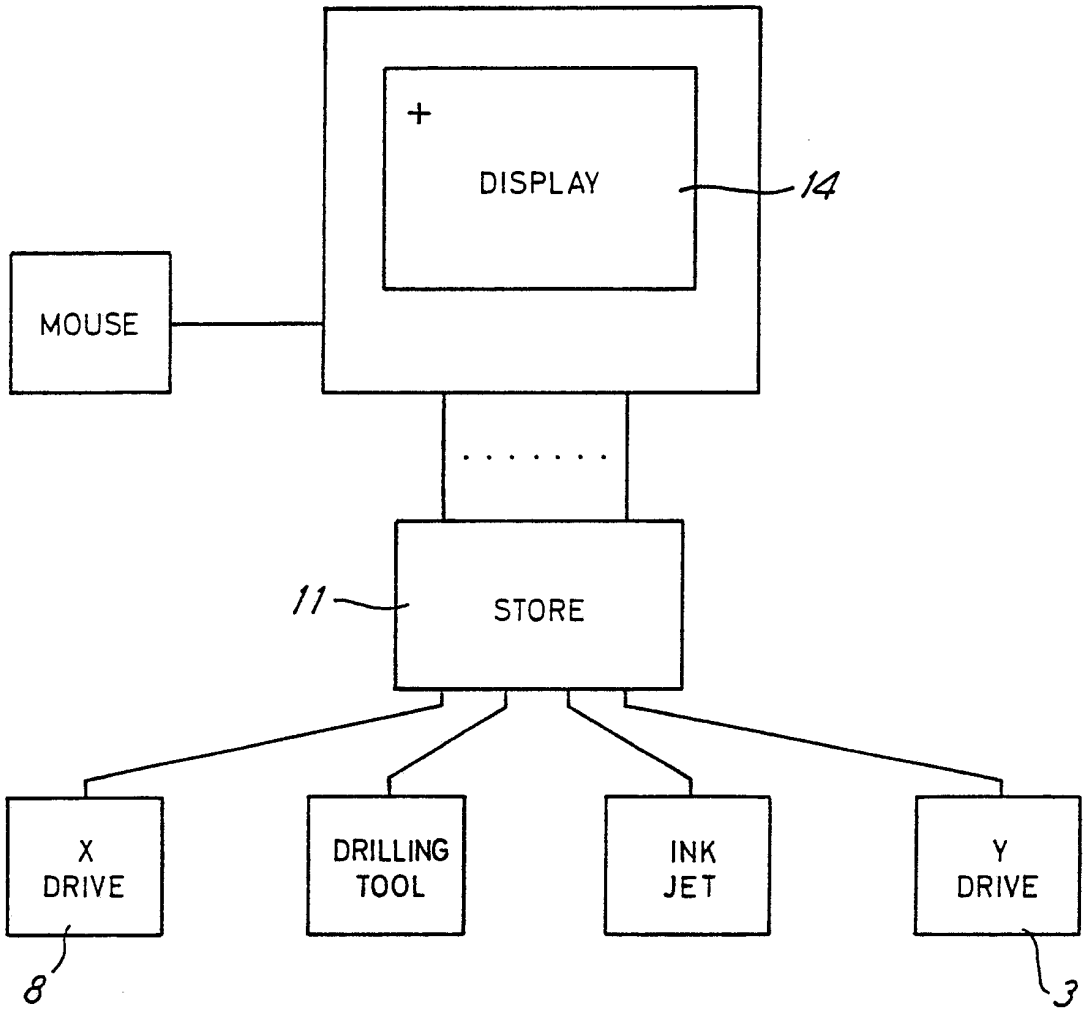
DISPLAY
14
MOUSE
11
STORE
X DRIVE
DRILLING TOOL
INK JET
Y DRIVE
8
3

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 88/01124

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: H 05 K 3/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	H 05 K; B 25 H; G 01 D

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 4654956 (REED et al.) 7 April 1987, see column 1, lines 5-38; column 4, line 23 - column 5, line 30; figures 1-3	1-3,6
Y	--	4,5,7-9
A	IBM Technical Disclosure Bulletin, vol. 21, no. 4, September 1978 (New York, US) J.R. Booth et al.: "Ink jet flat-bed plotter", pages 1543-1544, see the whole document	1
Y	--	4
A	Elektronik, vol. 34, no. 11, May 1985 (München, DE) R. Kleberhoff: "Leiter-platten-Entflechtung im Rasterverfahren - eine kostensparende Variante" pages 151-154, see page 153, left-hand column, paragraph 6; page 154, left-hand column, paragraphs 1,2; right-hand column, last paragraph; figure 3	1,6
Y	--	5

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* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
12th April 1989	02 MAY 1989
International Searching Authority: EUROPEAN PATENT OFFICE	Signature of Authorized Officer: I. VAN MOL

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	GB, A, 1367601 (HARRIS et al.) 18 September 1974, see page 2, right-hand column, lines 71-79; page 3, left-hand column, lines 1-14	1
Y		7
	--	
A	GB, A, 1140976 (MARCONI CO.) 22 January 1969, see page 1, left-hand column, line 16 - right-hand column, line 80; figure 1	1,6
Y		8
	--	
A	WO, A, 84/01825 (MICROSCIENCE) 10 May 1984, see page 1, lines 12-15; page 3, lines 1-14	1,6
Y		9

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 8801124 SA 26321

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 24/04/89
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4654956	07-04-87	None	
GB-A- 1367601	18-09-74	None	
GB-A- 1140976		None	
WO-A- 8401825	10-05-84	AU-A- 2263883	22-05-84
		EP-A- 0126742	05-12-84
		US-A- 4485387	27-11-84
		JP-T- 60500011	10-01-85
		CA-A- 1205569	03-06-86