PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01R 1/067, 31/28

A1

(11) International Publication Number: WO 97/50001

(43) International Publication Date: 31 December 1997 (31.12.97)

(21) International Application Number: PCT/SE97/01124

(22) International Filing Date: 23 June 1997 (23.06.97)

(30) Priority Data:
9602486-4 24 June 1996 (24.06.96) SE

(71) Applicant *(for all designated States except US)*: IMC INDUSTRIELLT MIKROELEKTRONIKCENTRUM AB [SE/SE]; P.O. Box 1084, S-164 21 Kista (SE).

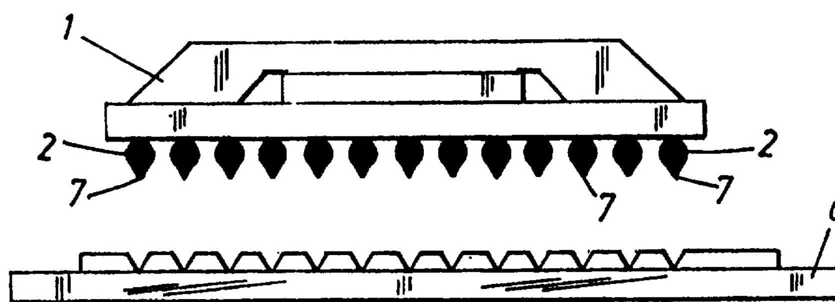
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: GONG, Shaofang [SE/SE]; Rättaregatan 102, S-583 30 Linköping (SE). BODÖ, Peter [SE/SE]; Odalgatan 11, S-583 31 Linköping (SE). HENTZELL, Hans [SE/SE]; Heidenstams gata 12, S-584 37 Linköping (SE).

(74) Agents: ÖRTENBLAD, Bertil et al.; Noréns Patentbyrå AB, P.O. Box 10198, S-100 55 Stockholm (SE).

(81) Designated States: CN, JP, KR, SG, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
In English translation (filed in Swedish).

(54) Title: A METHOD OF TESTING AND FITTING ELECTRONIC SURFACE-MOUNTED COMPONENTS



(b) Ga-based alloy sticks on balls after dipping in the paste.

(57) Abstract

A method of testing and mounting electronic components that are to be surface-mounted. The components include on one side a plurality of contact pads that shall be connected electrically to contact pads on one side of a test board, particularly BGA components and corresponding components. The invention is characterized by applying to the component contact pads (2) a metal (5) which is liquid at room temperature or at an elevated room temperature, in a first method step; lifting the component (1) away from the surface of the metal (5) in a second method step, wherewith part (7) of the liquid metal remains on the component contact pads (2); and bringing the component contact pads (2) provided with the liquid metal into abutment with corresponding contact pads (3) on the test board (4), in a third method step.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

Code	State	Code	State	Code	State	Code	State
AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

A METHOD OF TESTING AND FITTING ELECTRONIC SURFACE-MOUNTED COMPONENTS

The present invention relates to a method of testing and fitting
5 electronic components that are to be surface mounted on a circuit board.

Examples of such components are ball grid array components (BGA) or flip-chip components, and other components that include on one
10 side thereof solder balls or the like that are to be connected electrically to pads on a test board so as to enable the function of the surface component to be tested subsequent to mounting said components. The method can also be applied to chip scale packages (CSP).
15

Although the present invention is not limited to any particular surface-mounted component, it will be described hereinafter with reference to BGA components.

20 BGA component packaging of chips in the form of integrated circuits or multichip modules is a rapidly growing technology. It is anticipated that BGA components will have a significant share of the market in the very near future.

25 One problem encountered with BGA components is that the performance of said components in operation cannot be tested prior to mounting the components on a printed circuit board, PCB. It is particular difficult to test BGA components at high analog signal frequencies and at high digital signal speeds. The difficulty is
30 actually encountered in achieving good electric contact and other effective electrical conditions between the BGA component and a test board to which the BGA component shall be connected during a test.

A few techniques have been proposed in this respect. One technique uses an interposer, which is a layer applied between the BGA component and the test board and electrically conductive in directions perpendicular to the plane of the interposer. This may refer to electrically conductive needles that extend perpendicular to the plane of the interposer between the BGA component and the test board, or anisotropically conductive films. A few mounting bases have also recently been developed for connection to the BGA component and to the test board respectively.

One drawback with all of these known techniques is that a heavy mechanical pressure must be applied to the BGA component in order to achieve sufficiently effective physical, and therewith electrical, contact with the test board.

However, other problems often remain in the form of high electrical contact resistance, the occurrence of parasitic inductance and capacitance. Furthermore, the aforesaid interposer, anisotropically conductive film and said mounting bases are expensive, both in construction and in production.

These problems are solved by the present invention.

The present invention provides an inexpensive method which requires only a low contact pressure between the BGA component and the test board, which also gives low contact resistances and low parasitic inductances and capacitances.

Accordingly, the present invention relates to a method of testing and, in certain cases, mounting electronic surface-mounted components which include on one side a plurality of contact pads intended for electrical connection with contact pads on one side of a test board, particularly BGA components and corresponding components, and is characterized by applying to the component

contact pads or points a metal that is liquid at room temperature or at an elevated room temperature, in a first method step; by lifting the component from the surface of the liquid metal in a second method step, such that part of the liquid metal remains on
5 the contact points; and by bringing the contact pads provided with said liquid metal into abutment with corresponding contact pads on the test board, in a third method step.

The invention will now be described in more detail with reference
10 to exemplifying embodiments thereof and with reference to the accompanying drawings, in which

- Figure 1-3 illustrate different steps of the inventive method; and
15 - Figure 4 illustrates an embodiment of the invention.

Figures 1-3 illustrate the inventive method of testing the performance of electronic components that are to be surface-mounted on a printed circuit board. The electronic component
20 exemplified in the Figures is a BGA component 1. One side of the BGA component 1 includes a plurality of contact pads 2, which normally consist of about 60% tin and 40% lead. These contact pads 2 are intended for electrical connection with corresponding contact pads 3 on one side of a test board (PCB) 4; see Figure 3.

25

According to the present invention, the contact pads 2 on the component 1 are coated in a first method step with a metal 5 that is liquid at room temperature or at elevated room temperatures. This step is illustrated in Figure 2. The contact pads 2 are
30 preferably dipped into the liquid metal. Alternatively, the metal can be applied to the contact pads by a process corresponding to a pressure process, in which a cylindrical surface containing the liquid metal is rolled over the component surface on which the contact pads are found.

According to one preferred embodiment, the liquid metal is contained on a flat surface, such as on a glass plate 6 or a silicon plate. The depth of the metal on the plate will preferably be less than the height of the contact pads 2 on the component 1, so as to ensure that only the pads 2 will come into contact with the liquid metal 5. The contact pads 2 are wetted with the metal in this way.

In a second step of the inventive method, the component is lifted from the surface of the liquid metal, as illustrated in Figure 2, wherewith a part 7 of said metal will remain on the contact pads.

In a third step of the invention, the contact pads 2 provided with said liquid metal 7 are brought into abutment with corresponding contact pads 3 on the test board 4, as illustrated in Figure 3, therewith establishing effective electric contact between the contact pads 2 on the component and the corresponding contact pads 3 on the test board.

The electronic component 1 is then tested.

In an optional fourth step of the method, the component 1 is lifted and the liquid metal 7 removed from its contact pads 2. It has been found that the metal 7 can be readily removed with water and a conventional detergent. The fourth step is optional for the reason made evident hereinafter, although it is not always carried out. According to one highly preferred embodiment, the liquid metal is gallium (Ga) or a gallium alloy.

According to another embodiment of the invention, the liquid metal is mercury (Hg) or a mercury compound, although this metal is not equally as well preferred, because of its detriment to the environment.

Gallium and gallium alloys exist in a liquid phase at room temperature or temperatures slightly above room temperature. They also have low resistivity, namely a resistively of about 14 microOhm x cm. By way of comparison, it can be mentioned that copper has a resistivity of 1.56 microOhm x cm. Furthermore, gallium and its alloys are easy to use, and consequently are not hazardous to the health or to the environment hazard, due to their low vapour pressure among other things. Liquid gallium has an extremely low vapour pressure, namely only 10^{-10} torr at 400°C. Mercury has a much higher vapour pressure, normally 10^{+3} torr at 400°C.

The following Table show examples of alloys that can be used in the present context:

Table 1

	Melting Temperature	Powder Additive
Ga	30°C	Ag
Ga/Sn	16°C	Cu
Ga/In	15°C	Sn
Ga/In/Sn	5°C	Ni

As evident from Table 1, a number of gallium alloys with tin, or indium, or both tin and indium, have melting points beneath room temperature. The substances in the Table are alloys that have an eutectic composition.

These alloys can also be tailor-made with respect to viscosity, by admixing metal powder with the liquid alloy. Many different metals can be used to this end. Table 1 discloses examples of

preferred metals in the right-hand column. It is preferred to admix at most 20% by weight metal powder. Admixture with metal powder can produce a liquid-gallium based paste into which the contact pads are dipped in the aforesaid manner. The thickness of 5 the paste on the plate 6 and the viscosity of the paste determines the amount of paste that will adhere to the contact pads when said pads are dipped into the paste.

Table 2 below shows the wetting properties of gallium and 10 gallium-based alloys.

Table 2

Material	Metal	Glass	Silicon	Ceramic	Epoxy
Wetting properties	Good	Good	Good	Poor	Poor

As evident from Table 2, gallium and a gallium-based alloy have good or very good metal wetting properties, but poor ceramic and epoxy wetting properties. This is an important property that 25 makes gallium-based alloys ideal for the present purpose, since the contact pads 2, 3 on the component 1 and test board 4 respectively are comprised of metal while surrounding material is either a ceramic or an epoxy material.

30 Another important property of gallium and gallium-based alloys is that they will break down any oxide present on the contact pads 2, 3, due to the fact that gallium forms alloys with the material from which the contact pads are comprised. This means that an

extremely good electric contact is obtained, where the contact resistance is normally below 1 mohm.

The afore-mentioned parasitic inductance and parasitic capacitance will be very low, due to the small amount of material at the point of contact between respective contact pads 2, 3.

What has been said above with respect to gallium and gallium-based alloys also applies to mercury. Although the function of the invention will not be impaired if mercury or mercury alloys is/are used instead of gallium and gallium alloys, the use of gallium or gallium alloys is preferred from an environmental and handling aspect. If mercury is used, measures must be taken with regard to the high vapour pressure of mercury and because of the toxicity of mercury compounds. For instance, the use of mercury would require the method to be carried out in a closed room in which the mercury compounds are recovered in a manner that is acceptable from a* health aspect and an environmental aspect.

According to one preferred embodiment of the invention, the component 1 is mounted in a frame 8 that carries the test board 4, so as to bring the component 1 into a predetermined position of alignment with the test board 4, see Figure 4. The frame 8 may include a bottom part 9 and a top part 10. The bottom part 9 will preferably have internal measurements that correspond to the external measurements of the component 1. The upper part 10 is preferably provided with an overlying arm 11 adapted to abut the upper side of the component. The illustrated frame includes pull springs 12, 13 that are adapted to draw the top part 10 down towards the bottom part 9 with a suitable force such as to press the component 1 against the test board with a force that will ensure that all contact pads 2 are in good abutment with the pads 3 on the test board.

It has been mentioned above that in a fourth step of the inventive method the component is lifted from the test board upon completion of the test and the contact pads then cleaned.

5 In one alternative embodiment of the invention, the test board 4 is the circuit board on which the component 1 shall be finally surface-mounted in a predetermined position.

In this alternative embodiment, the first, second and third
10 method steps are carried out and the component is tested after having been placed in said predetermined position. When the test shows that the component performs in the manner intended, the component 1 is retained on the circuit board 4 with a flux applied to the contact pads 2 and 3, and the circuit board is
15 then heated with the component in said position to a temperature at which the contact pads 2 of the component fuse to corresponding contact pads 3 on the circuit board 4. This temperature may be about 200°C. In the fusion process, gallium and gallium alloys will fuse together with the material in the contact pads 2 and
20 the contact pads 3.

In a third alternative embodiment of the invention in which the test board is also comprised of a circuit board 4 on which the component 1 shall finally be mounted in a predetermined position,
25 the component is also tested after having been placed in this predetermined position.

In this embodiment, the component is fixed mechanically in its intended position relative to the circuit board. Fixation of the
30 component may be achieved with the aid of a frame, as shown in Figure 1, or in some other suitable manner. When the test shows that the component 1 performs in the manner intended, the component 1 is kept in said position when using the circuit board.

It will be noted that in the case of this latter embodiment, the liquid metal remains in a liquid state during the use of the component and that the contact pads 2, 3 are thus not fused together. One of the advantages of this embodiment is that the
5 component can be readily changed and that the liquid metal on the contact pads relieves the component and the circuit board of mechanical stresses due to temperature changes.

The drawbacks mentioned in the introduction are eliminated by the
10 present invention. The inventive method can be applied cheaply. The method is highly effective with regard to high frequency testing and high testing speeds, owing to the fact that the contact resistance, the parasitic inductance and the parasitic capacitance are low. Furthermore, the method is easy to apply,
15 since the contact pressure between the contact pads can be kept very low.

Although the invention has been described above with reference to a number of exemplifying embodiments, it will be understood that
20 alloys other than those mentioned may also be used. For instance, non-eutectic compounds can be used at room temperature or at an elevated room temperature.

The present invention is therefore not restricted to the
25 aforedescribed embodiments, since variations and modifications can be made within the scope of the following Claims.

CLAIMS

1. A method of testing and in certain instances mounting electronic components that are to be surface-mounted on a printed circuit board and that include on one side a plurality of contact pads that shall be connected electrically to contact pads on one side of a test board, particularly BGA components and corresponding components, **characterized** by applying to the component contact pads (2) a metal (5) which is liquid at room temperature or at elevated room temperatures, in a first method step; lifting the component (1) away from the surface of the metal (5) in a second method step, wherewith part (7) of the liquid metal remains on the component contact pads (2); and bringing the component contact pads (2) with said liquid metal applied thereon into abutment with corresponding contact pads (3) on the test board (4), in a third method step.

2. A method according to Claim 1, **characterized** by placing the liquid metal (5) on a flat surface, such as a glass plate (6) or silicon plate, in an amount such that the depth of the liquid metal will be below the height of the component contact pads (2).

3. A method according to Claim 1 or 2, **characterized** in that the liquid metal (5) is gallium (Ga) or a gallium alloy.

4. A method according to Claim 3, **characterized** by including an electrically conductive metal powder, such as silver (Ag), tin (Sn), copper (Cu) or nickel (Ni) in the liquid metal (5).

5. A method according to Claim 1 or 2, **characterized** in that the liquid metal (5) is mercury (Hg) or a mercury alloy.

6. A method according to Claim 5, **characterized** by including an electrically conductive metal powder, such as silver (Ag), tin (Sn), copper (Cu) or nickel (Ni) in the liquid metal.

5 7. A method according to any one of the preceding Claims, **characterized** by placing the component (1) in a frame (8) carried by the test board (4), such as to bring the component (1) to a predetermined position of alignment in relation to the test board (4).

10

8. A method according to any one of the preceding Claims, **characterized** by a fourth method step in which the component (1) is lifted up and the liquid metal (5) thereafter removed from the component contact pads (2).

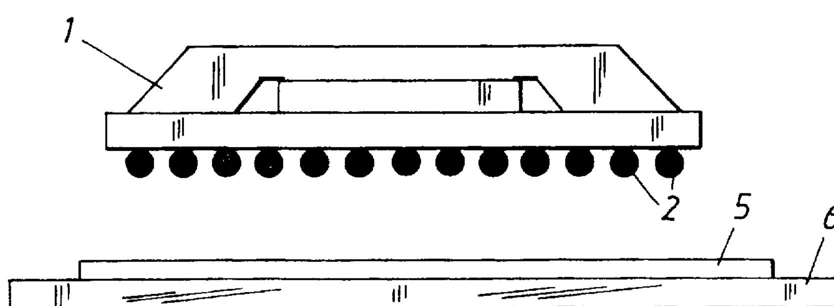
15

9. A method according to any one of Claims 1-7, **characterized** in that the test board is a printed circuit board (4) on which the component (1) shall finally be surface-mounted in a predetermined position; in that the component (1) is tested subsequent to
20 being positioned in said predetermined position; and in that when the test shows that the component (1) has the intended performance, the circuit board (4) with the component in said position is heated to a temperature at which the component contact pads (2) will fuse together with corresponding contact points (3) on
25 the circuit board.

10. A method according to any one of Claims 1-7, **characterized** in that the test board is a printed circuit board (3) on which the component (1) shall be finally mounted in a predetermined
30 position; in that the component (1) is tested subsequent to having been placed in said predetermined position; in that the component (1) is fixed mechanically relative to the circuit board (3) in said position; and in that the component is retained in

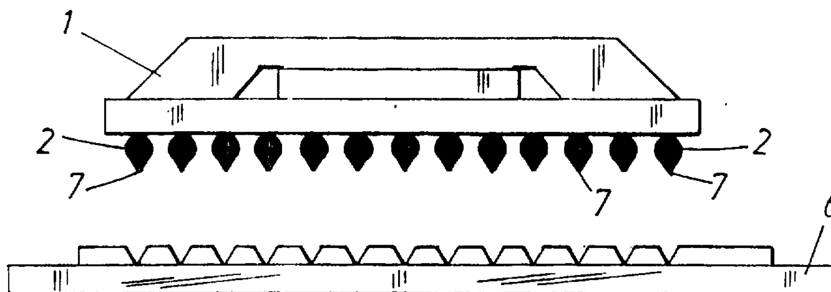
said position when using the circuit board (3) when the test shows that the component (1) has the intended performance.

Fig. 1



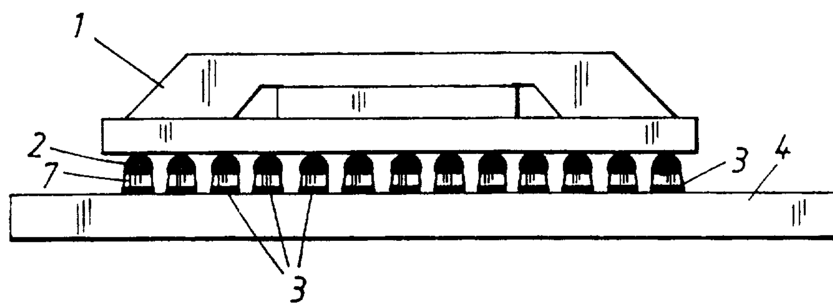
(a) Dip a BGA component in the Ga-based alloy pasted on a glass sheet.

Fig. 2



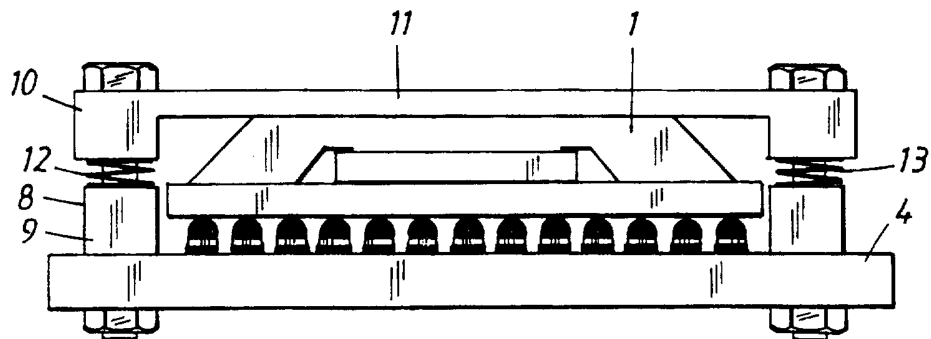
(b) Ga-based alloy sticks on balls after dipping in the paste.

Fig. 3



(c) Mount the BGA component with Ga-based alloy joints on a PCB for testing.

Fig. 4



(d) To ease an alignment and testing a frame may be utilized.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/01124

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01R 1/067, G01R 31/28

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)

IPC6: G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

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

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0453147 A1 (INTERNATIONAL BUSINESS MACHINES CORPORATION), 23 October 1991 (23.10.91), column 2, line 18 - line 52, figure 5 --	1-10
X	EP 0621486 A1 (KABUSHIKI KAISHA TOSHIBA), 26 October 1994 (26.10.94), abstract --	1-10
A	US 5170930 A (THOMAS P. DOLBEAR ET AL.), 15 December 1992 (15.12.92), abstract -- --------	4,5

☐ 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" erlier 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 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	Date of mailing of the international search report
31 October 1997	07 -11- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Magnus Hjalmarsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/10/97

International application No.
PCT/SE 97/01124

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0453147 A1	23/10/91	JP 2102108 C	22/10/96
		JP 4226046 A	14/08/92
		JP 7111993 B	29/11/95
		US 5007163 A	16/04/91
EP 0621486 A1	26/10/94	JP 6302656 A	28/10/94
		US 5491425 A	13/02/96
US 5170930 A	15/12/92	NONE	