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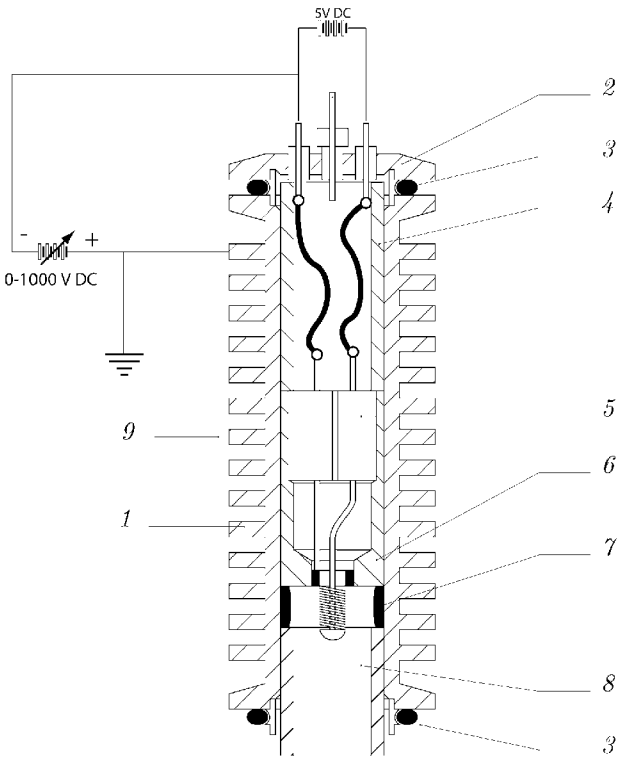
(54) **Title:** ION IMPLANTATION DEVICE

Fig 1.



(57) **Abstract:** A novel device and method for ionizing and implanting molecules of gas into a vacuum system, the said device having a heated filament cathode, nested inside an annular anode, the said cathode filament being heated by a low voltage current, and negatively biased with respect to the anode by a high voltage potential, the device, when operating, creates a steady planar current of electrons from the said cathode to the said anode, the gas to be ionized is fed through the said filament, where the gas molecules are first heated, then consequently stripped of one or more of their electrons.

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Description

ION IMPLANTATION DEVICE

Technical Field

[1] Plasma physics, specifically ion implantation devices

Background Art

[2] US patent 4,103,042

[3] US patent 5,256,947

[4] US patent 5,300,785

[5] US patent 5,497,006

[6] US patent 5,675,152

[7] US patent 5,856,674

[8] US patent 5,350,905

Disclosure of Invention

Technical Problem

[9] The technical challenge was to create a compact yet powerful ion source for ion implantation into vacuum chambers, in particular, but not limited to, those vacuum chambers with a negative potential energy well, such as inertial electrostatic fusion reactors.

Technical Solution

[10] The technical solution was to utilise a standard off the shelf filament and plug found in the common microwave magnetron (US patent # 5,350,905) and construct a hermetically sealed ionisation chamber around this filament and in such a way that the gas to be ionized must enter the ion chamber through the windings of the said filament. The said filament which during operation will serve as a cathode, is then positioned in the centre of an annular shaped metal ring, which will during operation serve as the anode.

[11] The magnetron filament cathode, being electrically heated and negatively biased compared to the annular anode, will during operation emit a planar stream of electrons outwards from the filament and towards the inside of the annular anode. The gas to be ionized may then be fed directly into the filament, where the gas will first be heated, before entering the ion chamber through the said planar stream of electrons, the consequent collisions between the gas molecules and the streaming electrons, will result in a high proportion of the gas molecules becoming ionized. The ionized gas molecules may consequently be accelerated or guided by way of electric potential fields.

Advantageous Effects

[12] The advantageous effects of the Starfire Ion Implantation device are,
[13] Low energy consumption
[14] High efficiency
[15] High ionising capacity
[16] Easy removal of filament
[17] Easy replacement of filament
[18] Convection cooling
[19] Compact design

Disclosure of Invention

Disclosure

[20] This invention relates to an ion implantation device, which can be manufactured with one of several standard vacuum flanges, in order that it may easily be fitted to existing vacuum chambers, where the implantation of gaseous ions are required. Unlike existing ion sources, this device utilizes a commonly available microwave magnetron filament to heat and ionize the gas. The utilisation of a common microwave magnetron filament, results in a highly effective device and significantly reduces the cost. The effectiveness of the novel design results from the way that the gas to be ionized is guided through the heated filament and injected directly into a powerful planar stream of electrons.

Description of Drawings

[21] Parts in [Fig 1.] & [Fig 2.] Have been given the same numbers for convenience. Standard vacuum flange clamps are required, and have been omitted from the diagram.
[22] (1) Machined nipple with vacuum flange at both ends
[23] (2) Vacuum flange with welded feedthrough connectors
[24] (2a) Gas feedthrough tube
[25] (2b) Electrical feedthrough (copper-ceramic)
[26] (2c) Electrical feedthrough (copper-ceramic)
[27] (3) Standard vacuum gasket
[28] (4) Ceramic sleeve
[29] (5) Microwave magnetron assembly
[30] (5a) Filament electrodes
[31] (5b) Ceramic plug
[32] (5c) Gas feed channel
[33] (5d) Filament support ring
[34] (5e) Filament (ideally but not essentially made from Tungsten)
[35] (6) Cradle machined from glass ceramic
[36] (6a) Aperture to fit filament support ring (5d)

[37] (7) Annular anode (ideally but not essentially made from Tungsten)

[38] (8) Ceramic sleeve

[39] (9) Convection cooling ribs

Industrial Applicability

[40] The Starfire ion implantation device may be used wherever high flow rates of ionized gas is required, processes such as ion etching, ion cutting, ion implantation into particle accelerators or ion injection into electrostatic or magnetic confinement fusion reactors.

Claims

[1] (1) A compact apparatus for ionising and implanting molecules of gas into a vacuum system at a high rate, by way of, first heating the said molecules of gas, and then stripping the electrons off the said molecules, by forcing the heated gas to flow through a planar stream of electrons before entering the ion chamber, the apparatus comprising as follows;

(a) a nipple constructed from a material, having both a high thermal conductivity and suitable hermetic properties, and manufactured in such a way as to have a standard or non standard vacuum flange at one end or both ends, and which may or may not have a ribbed surface on the outside for convection cooling, into which,

(b) a tubular cradle made from ceramic or similar dielectric and heat resistant material with an external diameter equal to the internal diameter of the said nipple, which internally is machined to fit a standard microwave magnetron assembly, in such a way, that the filament of the said magnetron assembly protrudes through an aperture at one end, the aperture forming a tight fit with the filament support ring, into which,

(c) a standard microwave magnetron filament and plug assembly is positioned, comprising the filament, the filament support, the ceramic plug and the filament electrodes, the said plug requiring the minor modification of having a longitudinal hole drilled, for the purpose of allowing the said gas to flow from the gas end to the ion end of the device,

(d) the anode, comprising an annular ring of tungsten or other suitable high temperature conducting material, is press fitted into the said nipple, in such a way that the ring is in direct contact with the internal surface of the nipple and aligned with the said magnetron filament,

(e) the remaining internal surfaces of the nipple, not including the anode, are lined with a ceramic or similar heat resistant and dielectric material,

(f) a suitable vacuum flange with two insulated electrical feedthoughs and one or more gas feedthrough is fitted to the gas end of the ion implantation device with the said electrical feedthrough, connected to the said filament electrodes in a conventional way, and powered by

(g) a conventional power supply capable of delivering sufficient DC

or AC current to heat the said magnetron filament to a bright orange glow, and

(h) a second conventional power supply connected between the magnetron filament electrode, and the annular anode ring, in such a way as to charge the magnetron filament with a negative bias of sufficient voltage to cause a planar current of electrons to flow from the cathode to the anode.

(2) An apparatus essentially the same as in claim 1, where cooling is provided by a liquid heat exchange system

(3) An apparatus essentially the same as in claim 1, but where the filament used is other than a standard microwave magnetron filament

(4) An apparatus essentially the same as in claim 1, where the polarity is reversed, and the anode is the cathode and vice versa.

(5) An apparatus essentially the same as in claim 1, having multiple gas feed-throughs, and allowing for a mix of gases to be ionised.

AMENDED CLAIMS

received by the International Bureau on 11 March 2008 (11.03.08)

(1) A compact apparatus for ionizing molecules of gas, herein after referred to as the "Ion Gun", the purpose or use of the Ion Gun, is to ionize molecules of gas, so that these molecules may subsequently be accelerated and implanted, into a target material which may be introduced into the ion beam produced by the Ion Gun, such ionization taking place, by way of, first heating the said molecules of gas, and consequently stripping the electrons off the said molecules, this is achieved, by first forcing the gas to first flow through a heated filament and consequently forcing it to flow through a planar stream of electrons, before being accelerated through an electrostatic potential, the Ion Gun so constructed will be considered an Anode relative to a Cathode component positioned a distance from the Ion Gun exhaust aperture, the said Cathode having a negative potential differential voltage relative to the Ion Gun, this potential difference being supplied by a separate circuit to that maintaining the Ion gun operation, the apparatus comprising as follows;

(a) a nipple constructed from a conductive material, having both high thermal conductivity and suitable hermetic properties, and manufactured in such a way as to have a standard or non standard vacuum flange at one end or both ends, herin after referred to as the Nipple

(b) a standard OEM microwave magnetron Ceramic Plug and Filament , herein after referred to as the Heater, consists of a short cylindrical ceramic plug which has two electrode wires embedded in it and extending from the face ends of this cylinder, the electrodes protruding from the filament end, are so formed, as to ensure one of them is aligned axially and the other off axis, the axial electrode extends a suitable distance and is capped with a small disc which is welded to the electrode, forming a rigid support, the off axis electrode extends to a lesser distance and is welded to an annular support which circumvents the co-axial electrode and has a central hole diameter which ensures no contact to the central co-axial electrode, a robust Tungsten filament coil is welded to both the said electrode cap and the said annular support and describes a helix about the axial electrode, the electrodes protruding from the opposite end form connections for the filament current and electrical potential

(c) the Heater component, modified by having a small hole consequently drilled through the face end of the Ceramic plug section in such a way that the hole extends longitudinally through the Ceramic plug and exits through the other face end, to allow gas passage from end to end

(d) a tubular cradle made from ceramic or similar dielectric and heat resistant material with an external diameter equal to the internal diameter of the said nipple, and an internal bore, machined in such a way as to have a large aperture at one end, allowing for the Heater to be inserted, and a smaller aperture, forming a tight fit with the outside diameter of the said annular filament support ring, allowing for the Heater filament to protrude through the smaller aperture, herein after called the Cradle

(e) an annular ring of tungsten or other suitable conducting material with a high melting temperature, herein after referred to as the Anode

(f) a suitable electrical and gas feed through vacuum flange with two insulated electrodes and one or more gas feed through, hereinafter referred to as the Feed Through Flange

(g) a conventional low voltage power supply capable of delivering sufficient DC or AC current to power the Heater filament to a temperature above 800° C

(h) a second conventional power supply capable of creating a HV bias of 1000 volts or more between the Heater filament and the Anode

(i) a third conventional power supply capable of creating a HV bias between the Ion Gun and a target cathode, for the purpose of accelerating ions of gas

the Heater is inserted into the Cradle, in such a way that the said filament protrudes through the smaller aperture of the Cradle, the Cradle and Heater are consequently inserted into the Nipple, and the annular Tungsten ring forming the Anode, is press fitted into the Nipple in such a way that it aligns perfectly with the Heater filament and makes a tight fit with the Nipple, the two vacuum side electrodes on the Feed Through Flange are connected to the two electrodes on the Heater, and the Feed Through Flange is hermetically sealed to the Nipple, the exhaust end of the Ion Gun must then be mounted to a vacuum chamber, and the said vacuum chamber must contain a minimum of one cathode, having a negative voltage potential with respect to the Ion Gun, the two air side electrodes on the Feed Through Flange are connected to the said low voltage power supply for the purpose of providing a current to the Heater filament, and the said second high voltage power supply is connected between one of the Heater electrodes and the Ion Gun chassis, in such a way as to give the Heater filament a negative bias with respect to the Ion Gun chassis, the said third high voltage power supply, is connected between the Ion Gun chassis and a cathode located within the vacuum chamber in such a way as to create a voltage potential between the Ion Gun and the said vacuum chamber cathode, which is significantly higher than the voltage potential between the Heater filament and the Ion Gun chassis

(2) A device and method as in claim 1, where cooling of the Nipple is provided by a liquid heat exchange system

(3) A device and method as in claim 1, where the Heater used is other than a modified OEM microwave magnetron filament

(4) A device and method as in claim 1, where the applied polarity between the Heater filament and the Anode is reversed, and the anode is the cathode and vice versa.

(5) A device and method as in claim 1, having a Feedthough Flange with multiple gas feedthroughs, thereby allowing for a mix of gases to be ionized.

(6) A device and method as in claim 1, where the Nipple has a ribbed surface and cooling is provided by air convection

Fig 1.

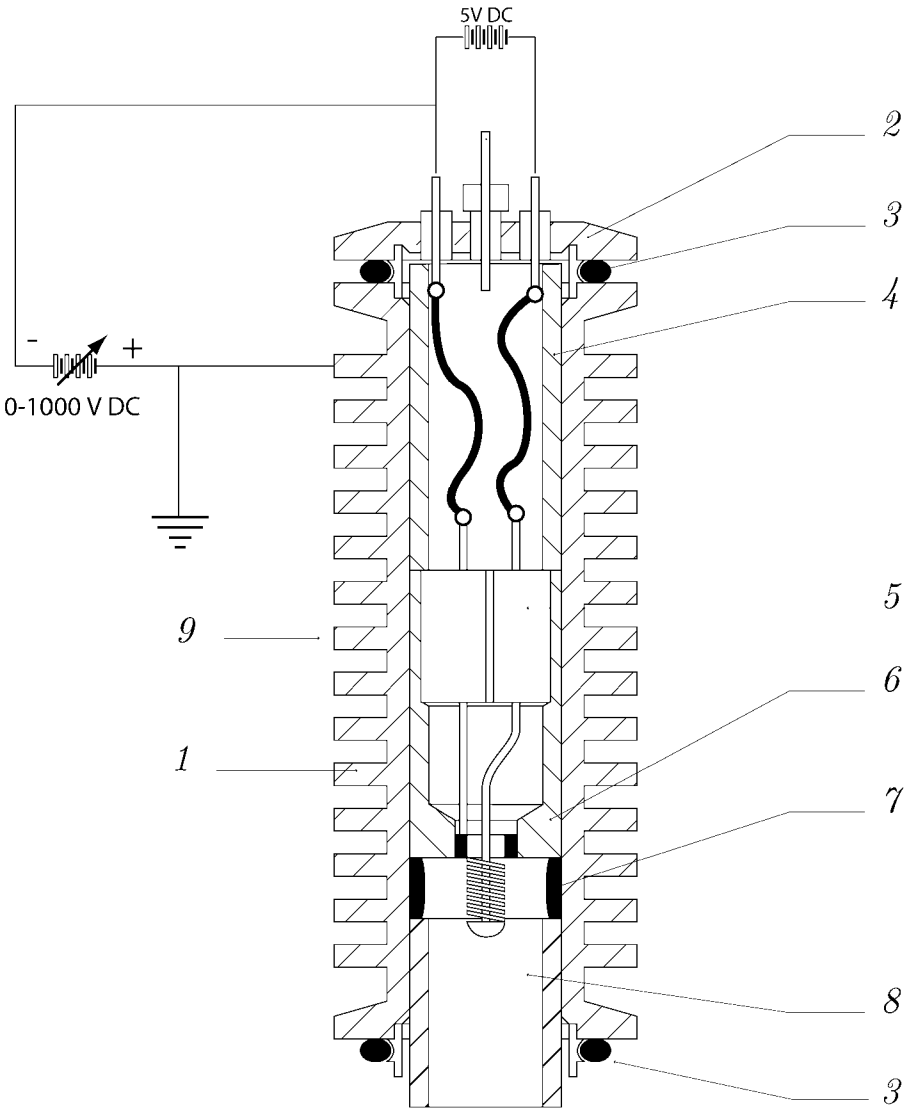
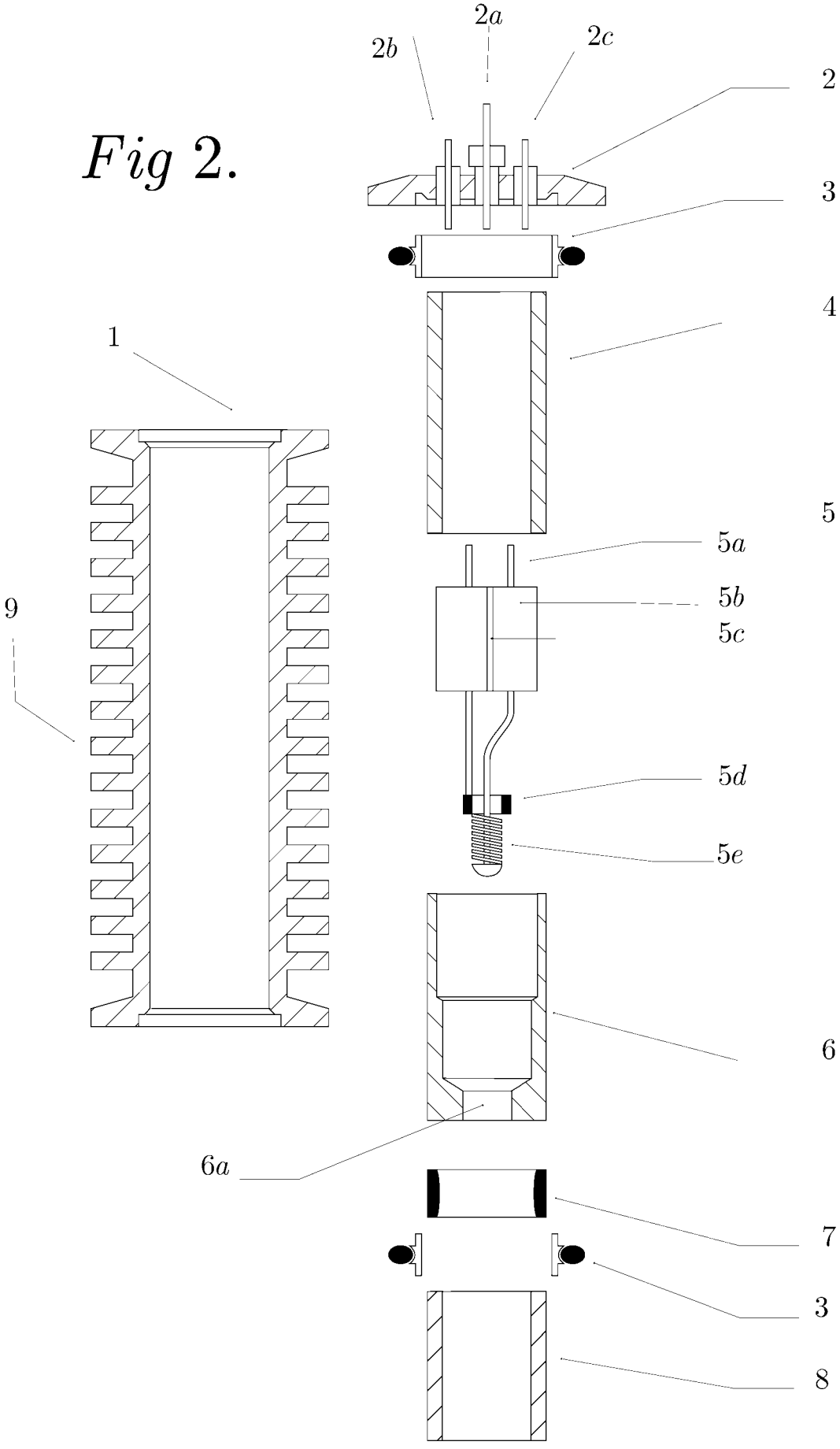


Fig 2.



INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/001709

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

H01J 37/08 (2006.01)

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)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI: ion, ionisation, implantation, source, inject, filament, compact, magnetron anode, flange and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5350905 A (CHOI) 27 September 1994 See whole document	
A	US 6350356 B1 (WELTY) 26 February 2002 See whole document	
A	US 2007/0114435 A1 (KWON ET AL.) 24 May 2007 See whole document	

☐ 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

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"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
17 January 2008	30 JAN 2008
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **ANDREW WALKER** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6222 3676

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2007/001709

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	5350905	NONE					
US	6350356	AU	94104/98	BR	9816084	CA	2254677
		CA	2385393	DE	19853943	FR	2772185
		GB	2331768	IT	RM980725	JP	2000026966
		PL	329905				
US	2007114435	NONE					

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX