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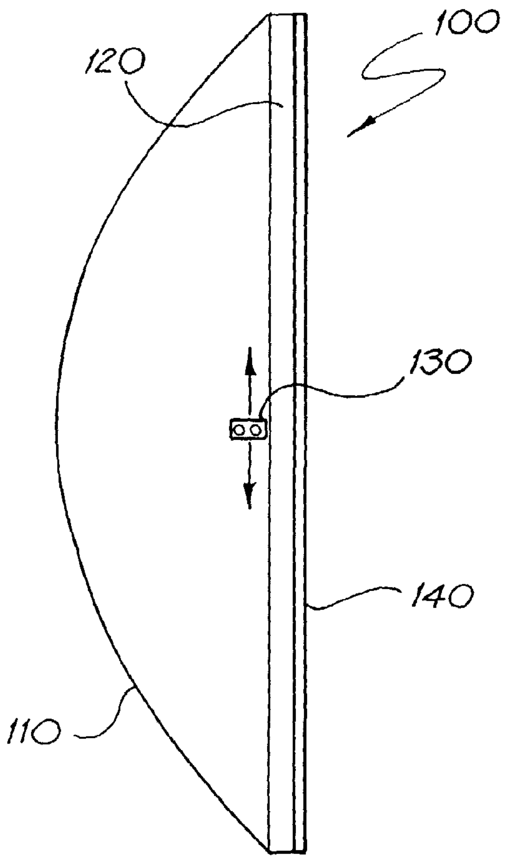
(54) Title: WAVEGUIDE ANTENNAS



(57) Abstract: A waveguide antenna (100) for use with a cellular-communications base station includes a pair of parallel plate waveguides (110), a vertical horn (120) coupled to said waveguide (110), a feed (130) having at least one probe (132), and a polarizer (140) for rotating the plane of polarization of a radiation beam. A wall of the waveguide (110) forms the curved backwall reflector, which may have a parabolic or semi-parabolic shape. The probe (312) is located within the parallel plate waveguides (110) and the vertical horn (120). The feed (130) may have two probes (132) and be moveably connected to the waveguides (110) for adjusting the tilt of the radiation beam.

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Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WAVEGUIDE ANTENNAS

Field of the Invention

The invention relates generally to antennas and in particular to antennas of base stations of cellular communications systems.

Background

Cellular base station antennas are typically implemented as phased-array antennas that use stripline- or microstrip-circuit technology or cable harnesses to feed radiating elements, such as dipoles or patches. A disadvantage of this technology is that, as higher frequencies are used, losses increase.

If the beam is desired to be tilted electrically, phase shifters are required. Disadvantageously, this further increases the complexity and loss in such antennas. Also, as the size of apertures of such antennas is increased, the gain increases. However, losses increase with the size of the antenna, leading to a diminishing return of gain as length is increased.

Thus, a need clearly exists for an improved antenna for use with a base station in a cellular communications system.

Summary

A waveguide antenna is provided for use with a cellular-communications base station. This antenna includes: parallel plate waveguides, one or more portions of the waveguides forming a curved backwall reflector; one or more radiating elements coupled to the parallel plate waveguides to shape a radiation beam pattern; a feed having at least one source of electromagnetic energy located within the parallel plate waveguides; and a polarizer for rotating a plane of polarization of a radiation beam.

The shape of the curved backwall portion may approximate a portion of a parabolic curve.

The curved backwall portion may be shaped to achieve a particular antenna pattern textures or characteristics.

Optionally, the feed has two sources of electromagnetic energy located therein in the form of two probes, but may have other numbers of probes. Alternatively, other sources of electromagnetic energy can be used, such as loops or slots.

The feed is moveably coupled to the parallel plate waveguide for adjusting the tilt of the radiation beam.

At least two waveguide antennas can are used in combination to provide dual polarization. Each waveguide antenna may have a rectangularly shaped portion of waveguide, with the rectangularly shaped portions of waveguide arranged in parallel with each other. The antenna portions containing the curved backwall portions may be located adjacent each other or at opposite ends from each other. Alternatively, each waveguide antenna has a curved shape portion of waveguide.

Brief Description of the Drawings

A small number of waveguide antenna configurations are described hereinafter with reference to the drawings, in which:

Figs 1A and 1B are side elevation and top plan views of a waveguide antenna for use in cellular communications in accordance with a first configuration;

Fig. 1C is a side elevation view of the movable feed 130 of Fig. 1A;

Fig. 2 is a feed pattern for the antenna of Figs. 1A and 1B;

Fig. 3 is a top plan view of a waveguide antenna for use in cellular communications in accordance with a second configuration;

Fig. 4 is a top plan view of a waveguide antenna for use in cellular communications in accordance with a third configuration;

Fig. 5 is a top plan view of a waveguide antenna for use in cellular communications in accordance with a fourth configuration;

Fig. 6 is a top plan view of a waveguide antenna for use in cellular communications in accordance with a fifth configuration; and

Figs. 7A and 7B are side elevation and top plan views of a waveguide antenna for use in cellular communications in accordance with a sixth configuration.

Detailed Description

A number of waveguide antenna configurations are described hereinafter. The antennas implement high gain, low loss waveguide antennas. Generic features of these antenna configurations are as follows:

- A parallel plate waveguide region comprising a pair of conducting plates supporting the TEM mode with a shaped reflecting wall is used to form a beam with desired characteristics. The spacing of the parallel plates is less than half a wavelength so that the only waveguide mode that can propagate is one in which the electric field is uniform between the plates.

- A feed, typically comprising probes or slots, is used to illuminate the reflector from a focal region. The feed normally directs a signal towards the reflecting wall. If a narrow beam is required the optimum reflector shape approximates a parabola.

- Typically, cellular base station antennas require a narrow beam in the elevation plane and a wide beam in the azimuth plane. The plates of the parallel plate waveguide region are therefore mounted vertically. The parallel plate region is expanded into a horn to form the desired azimuth beam shape.

- The antenna radiates horizontal polarization, since this is the orientation of the field emerging from the parallel plate region. Cellular base station antennas are normally required to radiate vertical polarization or slant polarization (linear polarization with the electric vector inclined at 45 degrees to the vertical). Where a polarization other than horizontal is required, a polarizer is placed in front of the horn to effect a rotation of the plane of polarization.

- Steering of the beam over a limited range of angle such as is required to provide adjustable electrical downtilt of the beam may be accomplished by physically changing the location if the feed, typically in a vertical direction. The motion of the feed can, if desired be derived from a motor and be remotely controlled.

- The polarizer may consist of spaced layers of printed patterns designed to produce different phase shifts for the transmission of different polarizations.

To provide a dual-polarisation capability for an antenna system, two of the waveguide structures of the type described above can be arranged in any of a number of arrangements shown in the drawings. These arrangements involve the notion of "wrapping" or interlocking the waveguide cavities to provide a more compact structure.

The following variations are foreseen:

- Offset feeding of the reflecting wall to prevent blockage by the feed.

- Use of radiating elements such as dipoles or patches fed from probes or slots in the parallel plate waveguide.

- Shaping of reflector to compensate for phase characteristics of feed.

- Shaping of reflector to modify sidelobe structure for example to reduce the sidelobe level above the main beam at the expense of those below the main beam or to fill certain nulls in the pattern below the main beam.

A waveguide antenna 100 for use with a cellular-communications base station is shown in Figs. 1A and 1B. The corresponding feed pattern is depicted in Fig. 2. The antenna includes parallel plate waveguides 110, a vertical horn 120 coupled to the parallel plate waveguides, a feed 130 having at least one probe 132, and a polarizer 140 for rotating the plane of polarization of a radiation beam. The waveguides 110 have a curved backwall reflector, which may have a parabolic or semi-parabolic shape. Optionally, the profile of the curved waveguide backwall may be varied for beam shaping.

The probe 132 is located within the parallel plate waveguides 110 in the focal region of the curved backwall reflector. As shown in Fig. 1C, the feed 130 may have two probes 132. The feed is moveably connected to the parallel plate waveguide 110 for adjusting the tilt of the radiation beam.

The antenna 100 uses an extremely low-loss parallel plate waveguide region to form the required beam. As stripline- and microstrip-circuit components are dispensed with, losses are consequently reduced compared with existing technology.

Figs. 7A and 7B illustrate a different configuration for the antenna in which the reflector portion is semi-parabolic in shape.

Figs. 3 and 5 respectively illustrate a pair of waveguide antennas 300 and 500. Notably, a portion of each waveguide pair 310A and 310B is curved, outwardly or inwardly from or to each other, respectively. Moveable probes 330 and 530 are located in the waveguides 310 and 510.

Figs. 4 and 6 respectively illustrate a pair of waveguide antennas 400 and 600. A portion of the waveguide 410 and 610 is rectangularly shaped with the reflectors in parallel at one end and at opposite ends, respectively. The reflectors in Fig. 6 may be angled from the central axis of each rectangular portion of waveguide.

Only a small number of configurations described herein. However, in view of this disclosure, variations and changes may be made by those skilled in the art without departing from the scope and spirit of the invention.

Claims

1. A waveguide antenna for use with a cellular-communications base station, said antenna including:

parallel plate waveguides, one or more portions of said waveguides forming a curved backwall reflector;

one or more radiating elements coupled to said parallel plate waveguides to shape a radiation beam pattern;

a feed having at least one source of electromagnetic energy located within the parallel plate waveguides; and

a polarizer for rotating a plane of polarization of said radiation beam.

2. The waveguide antenna according to claim 1, wherein the shape of said curved backwall portion approximates a portion of a parabolic curve.

3. The waveguide antenna according to claim 1, wherein said curved backwall portion is shaped to achieve particular antenna pattern shapes or characteristics.

4. The waveguide antenna according to claim 1, wherein said feed has located therein two probes acting as sources of electromagnetic energy.

5. The waveguide antenna according to claim 1, wherein said feed is moveably coupled to said parallel plate waveguide for adjusting the tilt of said radiation beam.

6. The waveguide antenna according to claim 1, wherein said feed is moveably coupled to one of said waveguides for adjusting the tilt of said radiation beam.

7. The waveguide antenna according to claim 6, wherein movement of said feed derived from a motor and is remotely controllable.

8. The waveguide antenna according to claim 1, wherein said one or more radiating elements include a vertical horn coupled to said parallel plate waveguides;

9. In combination, at least two waveguide antennas in accordance with any one of claims 1 to 6 for providing dual polarization.

10. The combination according to claim 9, wherein each waveguide antenna has a rectangularly shaped portion of waveguide, said rectangularly shaped portions of waveguide arranged in parallel with each other.

11. The combination according to claim 10, wherein antenna portions containing the curved backwall portions are located adjacent each other.

12. The combination according to claim 10, wherein antenna portions containing the curved backwall portions are located at opposite ends from each other.

13. The combination according to claim 9, wherein each waveguide antenna has a curved shape portion of waveguide.

14. A waveguide antenna for use with a cellular-communications base station, said antenna substantially as hereinbefore disclosed with reference to any one or more of Figs. 1 to 7 of the accompanying drawings.

15. A combination having at least two waveguide antennas waveguide antenna for use with a cellular-communications base station, said combination substantially as hereinbefore disclosed with reference to any one or more of Figs. 1 to 7 of the accompanying drawings.

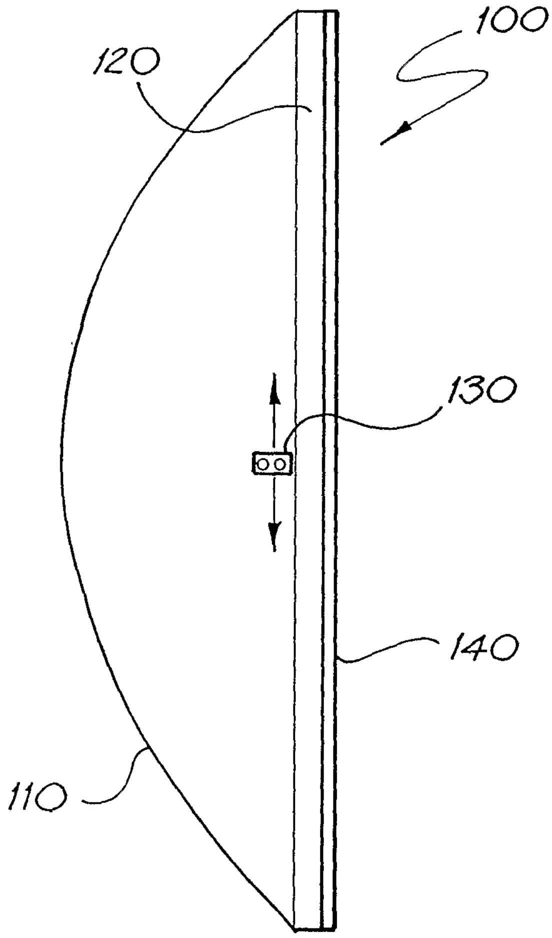


FIG. 1A

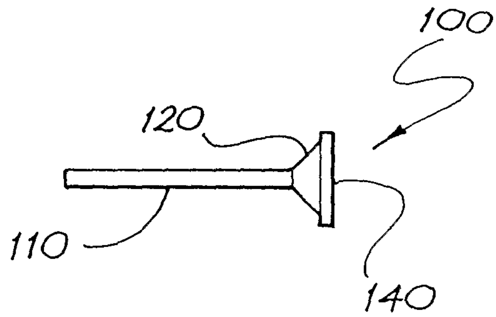


FIG. 1B

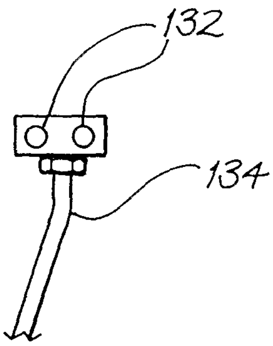


FIG. 1C

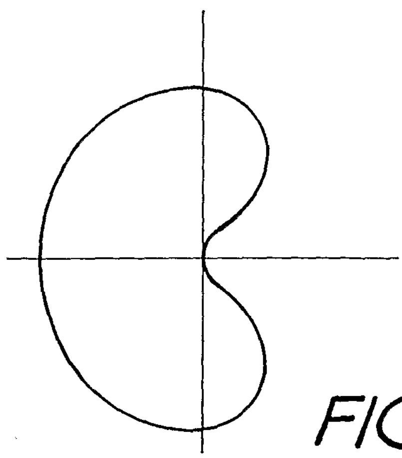
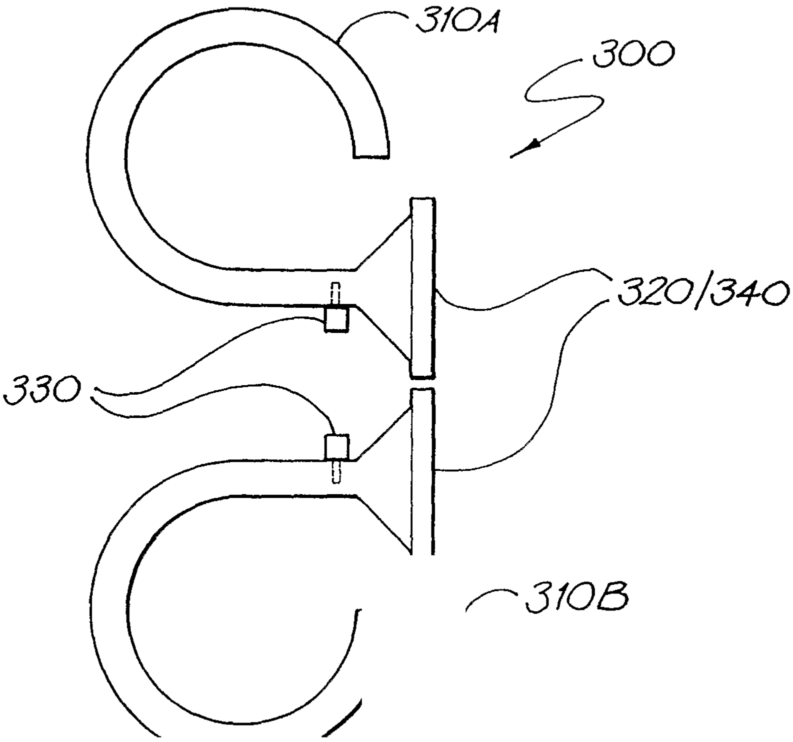


FIG. 2



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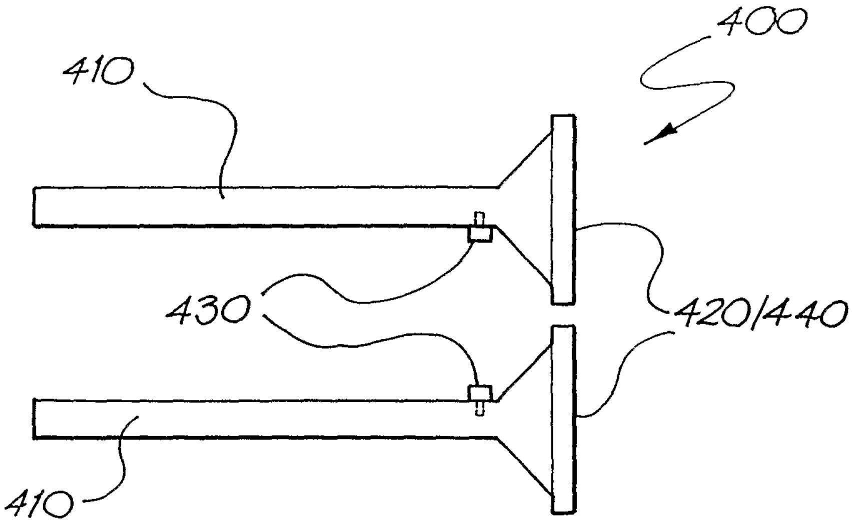


FIG. 4

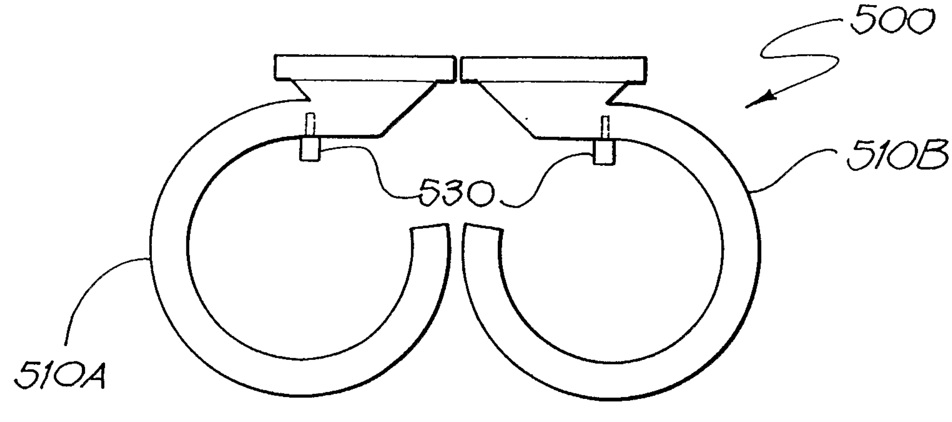


FIG. 5

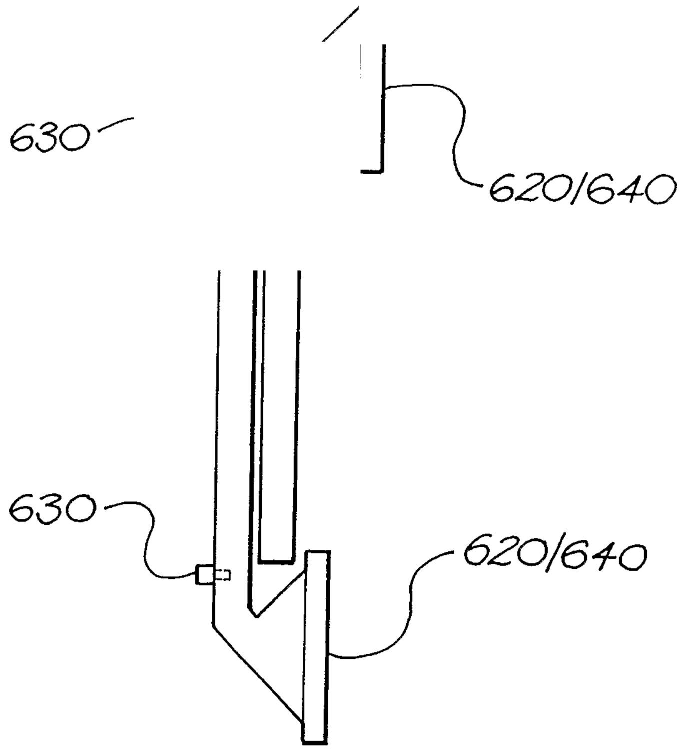
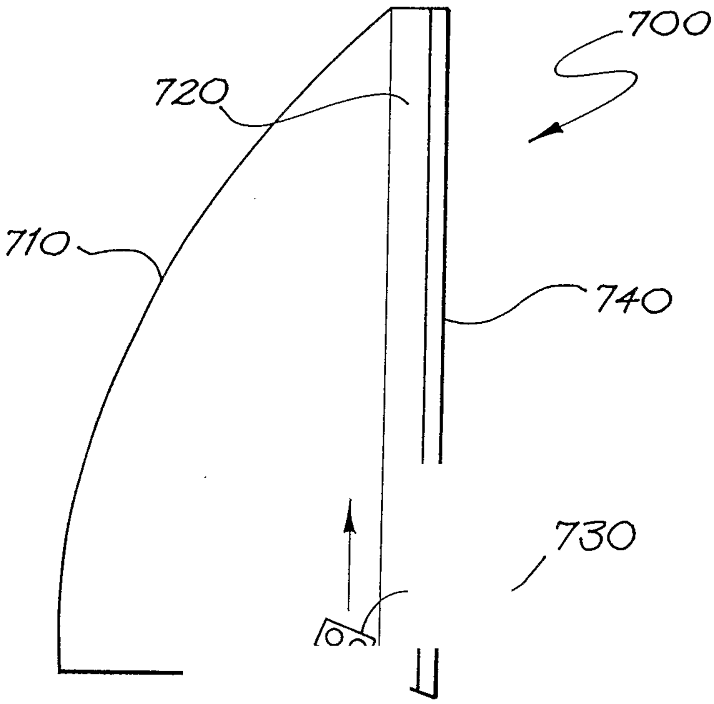


FIG. 6



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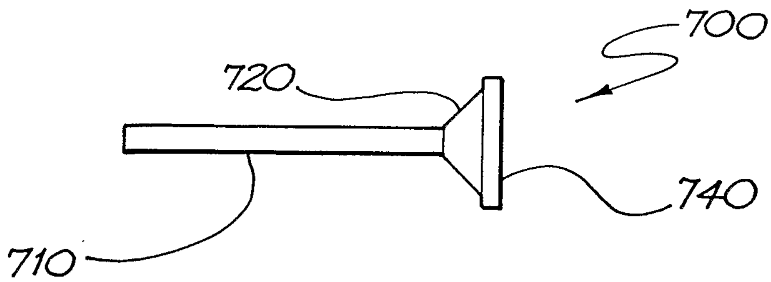

FIG. 7B

INTERNATIONAL SEARCH REPORT

International application No. **PCT/AU02/00367**

A.	**CLASSIFICATION OF SUBJECT MATTER**
Int. Cl. [7]:	H01Q 19/12, H01Q 13/06, H01P 3/12

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 and keywords (antenna, aerial, waveguide, parallel, polar, radiation, curve) and like terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3775773 (NEMIT) 27 November 1973 column 2 line 54 to line 66, column 4 line 35 to line 44, column 6 line 20 to line 24	1-15
X Y	US 5061943 (RAMMOS) 29 October 1991 column 3 line 40 to line 65, Figs 1, 2, 8	1-4, 8-15 5-7
X Y	US 5596338 (SMITH) 21 January 1997 column 2 line 14 to line 67, Figs 1-3	1-4, 9-15 5-8

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
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- "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 23 April 2002	Date of mailing of the international search report 8 MAY 2002
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. (02) 6285 3929	Authorized officer **Mani Ramachandran** Telephone No : (02) 6283 2233

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4051476 (ARCHER et al) 27 September 1977 column 2 line 34 to line 55	1-15
Y	US 4349827 (BIXLER et al) 14 September 1982 column 2 line 40 to line 67, Fig 1	1-15
A	US 5325105 (CERMIGNANI et al) 28 June 1994 Abstract, Figs 1, 2	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/AU02/00367

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	3775773	AU	58167/73	DE	2335792	ES	416978
		FR	2193268	GB	1434986	JP	49060155
US	5061943	CA	1323419	EP	355898	FR	2635228
		JP	2270406				
US	5596338	CA	2165220	EP	751582	JP	9018229
US	4051476	NONE					
US	4349827	NONE					
US	5325105	NONE					

END OF ANNEX