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(54) Title: PHOTOTHERAPY OF SKIN WOUNDS (57) Abstract A method and apparatus for irradiating wounds with UV radiation from which the UVB component is substantially removed or attenuated. UV light from a mercury vapour lamp (1) is passed through a filter (2) and thence through a lens (3) which focuses the radiation onto a target region (18). The filter (2) is formed from a number of alternating layers of dielectric material of different refractive indexes.		

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PHOTOTHERAPY OF SKIN WOUNDS

The present invention relates to the phototherapy of skin wounds and, in particular, to the phototherapy of skin wounds with ultra violet light from which the UVB component (wavelengths of 280nm to 315nm) has been substantially removed or attenuated so that the wound is irradiated with UVC (wavelengths of 200 to 280nm) and UVA (315 to 400nm). Preferably the wound is also irradiated with visible and infra-red radiation.

BACKGROUND ART

Prior to the advent of modern antibiotics, it was known that beneficial effects could be obtained in the treatment of skin wounds in mammals by the irradiation of the wounds by sunlight and by carbon-arc radiation. In addition, the germicidal action of significant levels of UVC radiation is well known. Furthermore, the beneficial properties of UVA radiation have also been reported.

Such ultraviolet radiation fell into a decline with the advent of antibiotics since it suffers from the problem that the ultraviolet radiation used included excessive emissions of damaging erythematous UVB radiation which readily causes burning and blistering and is generally regarded as being carcinogenic. Since the UVB radiation was itself harmful, it was necessary to maintain the radiation level overall at a fairly low level thereby preventing the beneficial properties of the UVC and UVA components from being applied at



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an effective dosage level.

Whilst antibiotics were initially spectacularly successful, many organisms have now developed resistance to antibiotics and therefore higher doses and longer periods of treatment are required. In addition, in some applications, such as the treatment of racehorses, there are objections to the use of antibiotics and it is often difficult to apply bandages and other surface treatments to the legs of racehorses in particular.

It is therefore an object of the present invention to overcome the disadvantages inherent with antibiotic treatment and provide a method and apparatus whereby the germicidal and other beneficial properties of UV radiation can be utilized without the unnecessary, short-term damage and possible carcinogenic problems inherent with UVB radiation by the reduction or substantial elimination of the UVB component.

SUMMARY OF THE INVENTION

According to one aspect of the present invention there is disclosed a method of phototherapy of skin wounds of mammals, said method comprising the step of irradiating the wound area with ultraviolet light from which the UVB component has been substantially removed or attenuated whereby the wound is irradiated with substantially UVA and UVC radiation. Preferably the wound is also irradiated with visible light and/or infra-red radiation.

In accordance with another aspect of the present

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invention there is disclosed apparatus for carrying out the above method and comprising a source of UV radiation, focusing means to focus the UV radiation onto a target area, and a filter placed in said radiation to substantially remove or attenuate any UVB component in said radiation. Preferably a monitor device is provided in order to monitor the radiation dosage.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will now be described with reference to the drawings in which:-

Fig. 1 is a horizontal cross-sectional view through the apparatus of the preferred embodiment,

Fig. 2 is a centrally located vertical cross-section through the apparatus of Fig. 1,

Fig. 3 is an enlarged view of the vertical section through the monitor optics illustrated in Fig. 2, and

Fig. 4 is a front elevational view of the monitor optics arrangement of Fig. 3.

As seen in the drawings, the apparatus of the preferred embodiment comprises a high-pressure mercury-vapor gas-discharge lamp 1, with a quartz envelope, preferably having a power of approximately 100 W which is mounted vertically within a lamp enclosure 16 formed from UV stable material. The enclosure 16 is provided with light baffles 13 and a cooling fan 15. At one end of the lamp enclosure 16 is a selective-UV filter 2 (to be described hereafter) which substantially prevents

the passage of UVB radiation.

The UV and visible radiation which passes through the filter 2 is allowed to fall onto a plano-convex fused silica lens 3 which focuses the radiation into a beam 17 which falls upon a target region 18. Mounted in front of the lens 3 is a removeable UV-absorbing lens-cover filter 4 which, as best seen in Fig. 2, is pivoted or slidable as indicated by arrows 12 into, and out of, the beam 17. This filter is used during initial target selection and to control the UV exposure time.

Centrally positioned on the lens 3 is a prism 5 which is shielded on its surface facing the mercury discharge lamp 1 and gathers reflected light 19 from the target region. A monitor-imaging lens 6 is secured to the lower surface of the prism 5 in order to focus the reflected beam 19 through a monitor-cell aperture 8 and onto a monitor photoelectric cell 10, via a monitor-cell filter 9. As best seen in Figs. 3 and 4, the monitor imaging-lens 6, aperture 8, filter 9, and photoelectric cell 10 are all located within a tubular light-tight monitor housing 7.

A pair of infra-red heaters 14, each with an associated reflector 20, are mounted one to either side of the light baffles 13 as illustrated in Fig. 1. The infra-red heaters 14 preferably comprise the ballast for the mercury vapor lamp 1 and can also separately be energized if only infra-red radiation 21 is desired.

The filter 2 is of special construction and

comprises at least 2, and preferably upto 21 layers of dielectric material which are non-absorbing in the UV region and which have different refractive indexes.

Thus if the filter 2 is regarded as a series of layers ABABAB and so on then the material A can be selected from the group consisting of hafnium dioxide (HfO_2), magnesium oxide (MgO), and yttrium oxide (Y_2O_3) and the material B of the alternate layers can be selected from the group consisting of aluminium oxide (Al_2O_3), magnesium fluoride (MgF_2) and silicon dioxide (SiO_2). It will be apparent that the stack of dielectric layers constitutes an interference filter and for the materials mentioned above the filter is operable so as to reject radiation in the UVB band thereby allowing UVA and UVC to pass through the filter 2 and hence through the lens 3. Preferably the spectral transmittance for a beam normal by incidence on the filter 2 in the UVC and UVA regions is not less than 0.5 and preferably is approximately 0.8 to 0.9 whereas the spectral transmittance in the UVB region does not exceed 0.05. More layers than 21 provides an even smaller transmittance.

It will be apparent that the monitor optics enable the dosage actually received by the target area to be monitored. The choice of the monitor-cell filter 9 enables a selection to be made as to whether the UV, visible, or infra-red radiation is monitored. The monitor is focused at infinity and views directly along the main beam axis. The photo-cell aperture 8

determines the divergence of the accepted beam 19 away from the lens 3. Preferably the arrangement is such that the diameter of the beam 19 is approximately 3 cm at a distance of 50 cm from the lens 3. This gives reasonable results for a target distance of from 20 to 100 cm.

It will be apparent that by monitoring the reflected radiation, the correct dose is delivered irrespective of beam dimensions in the target plane, provided that the beam cross-section is at least as big as the monitor beam cross-section. The monitor also allows accurate dose delivery independent of the loss of radiant output of the lamp with time, which typically is approximately 50% over its useful life.

Preferably, a small disc-shaped piece (not illustrated) of retro-reflective sheeting such as that sold under the trade mark SCOTCHLITE by 3M and used for reflecting motor vehicle head lamp light, is positioned in the target plane and illuminated by the beam 17. This can be accomplished by swivelling the apparatus to locate the centre of the beam 17 on the disc-shaped piece, taking a reading and then swivelling the apparatus back again, the wound 18 and the disc-shaped piece being equidistant from the UV source 1. This measurement is used to determine the time of exposure required to give the desired dose and overcomes the problems of low wound reflectivity and variation between wounds.

The lens 3 is approximately 40 - 60 mm in diameter

and has a focal length of approximately 50 - 100 mm. As illustrated in Fig. 2 the lens 3 is preferably reciprocable as indicated by arrows 11 to permit a degree of focussing, giving a beam area from approximately 25 mm² to approximately 200 m² at a distance from the lens of from 10 cm to 50 cm.

Preferably, an additional shutter 25 which is reciprocable in a vertical plane as indicated by arrows 26 in Fig. 2 can be added between the filter 2 and the monitor housing 7. The shutter 25 is illustrated by broken lines in Figs. 1 and 2 and allows a background signal level from the monitor to be established in the absence of the UV radiation. This enables corrections to be made for the photo-cell darkcurrent, circuit bias, any detected ambient radiation, and the like.

The above described arrangement results in the treatment beam 17 from the mercury lamp having intensities in the following wavelength regions in the following proportions: UVC: UVB: UVA plus visible plus near infra-red being approximately equal to 1:0.05:2. The desired level for UVC radiation for a beam area of approximately 50 cm² is an average of approximately 1 to 2 mW/cm². The IR radiation delivered from the infra-red heaters 14 preferably has an intensity of approximately 100 mW/cm² at a distance of approximately 30 cm and thus is approximately the same as the total irradiance from sunlight.

Experimental results to date show indications

of a reduction in scarring (which is important with pedigree show animals). Also preliminary work with racehorses indicates that wounds are healed more quickly than without the radiation and, as a consequence, the racehorse suffers less loss of condition than previously.

The foregoing describes only one embodiment of the present invention and modifications, obvious to those skilled in the art, can be made thereto without departing from the scope of the present invention.

CLAIMS

1. A method of phototherapy of skin wounds of mammals, said method comprising the step of irradiating the wound area with ultraviolet light from which the UVB component has been substantially removed or attenuated whereby the wound is irradiated with substantially UVA and UVC radiation.
2. A method as claimed in claim 1 including the step of substantially removing or attenuating said UVB component by passing said ultraviolet light through an interference filter comprising a plurality of layers of dielectric material which are non-absorbing in the UV region, alternate ones of said layers having different refractive indexes.
3. A method as claimed in claim 2 wherein said filter comprises a stack formed from a plurality of layers of said dielectric material, the even numbered layers of said stack being a material selected from the group consisting of hafnium dioxide, magnesium oxide, and yttrium oxide; and the odd number layers of said stack being a material selected from the group consisting of aluminium oxide, magnesium fluoride and silicon dioxide.
4. A method as claimed in any one of claims 1 to 3 including the step of monitoring the radiation reflected by said wound to determine the dose received by said wound.
5. A method as claimed in claim 4 including the step

of simultaneously irradiating said wound with infra-red radiation and/or visible light.

6. Apparatus for phototherapy of skin wounds of mammals, said apparatus comprising a source of UV radiation, focusing means to focus the UV radiation onto a target area, and a filter placed in said radiation to substantially remove or attenuate any UVB component in said radiation.

7. Apparatus as claimed in claim 6 including an interference filter through which said UV radiation passes and which comprises a plurality of layers dielectric material which are non-absorbing in the UV region, alternate ones of said layers having different refractive indexes.

8. Apparatus as claimed in claim 6 wherein said filter comprises a stack formed from a plurality of layers of said dielectric material, the odd numbered layers of said stack being a material selected from the group consisting of hafnium dioxide, magnesium oxide, and yttrium oxide; and the even numbered layers of said stack being a material selected from the group consisting of aluminium oxide, magnesium fluoride and silicon dioxide.

9. Apparatus as claimed in any one of claims 6 to 8 wherein a prism is located in the path of said radiation focused on said target area, the side of said prism adjacent said source of UV radiation is rendered opaque, radiation reflected from the target plane is

incident on said prism and directed thereby through a lens to focus said reflected radiation onto a light sensitive device which is shielded from direct radiation from said UV source.

10. Apparatus as claimed in claim 9 wherein a first shutter is moveable into and out of the path of said radiation to shield said target from said radiation and a second shutter is moveable into and out of the path of said radiation at a location between said prism and said UV source to shield said prism and target from radiation from said UV source whereby substantially only background radiation from said target plane or wound is received by said light sensitive device.

ORIGINAL
2 SHEETS, SHEET 1

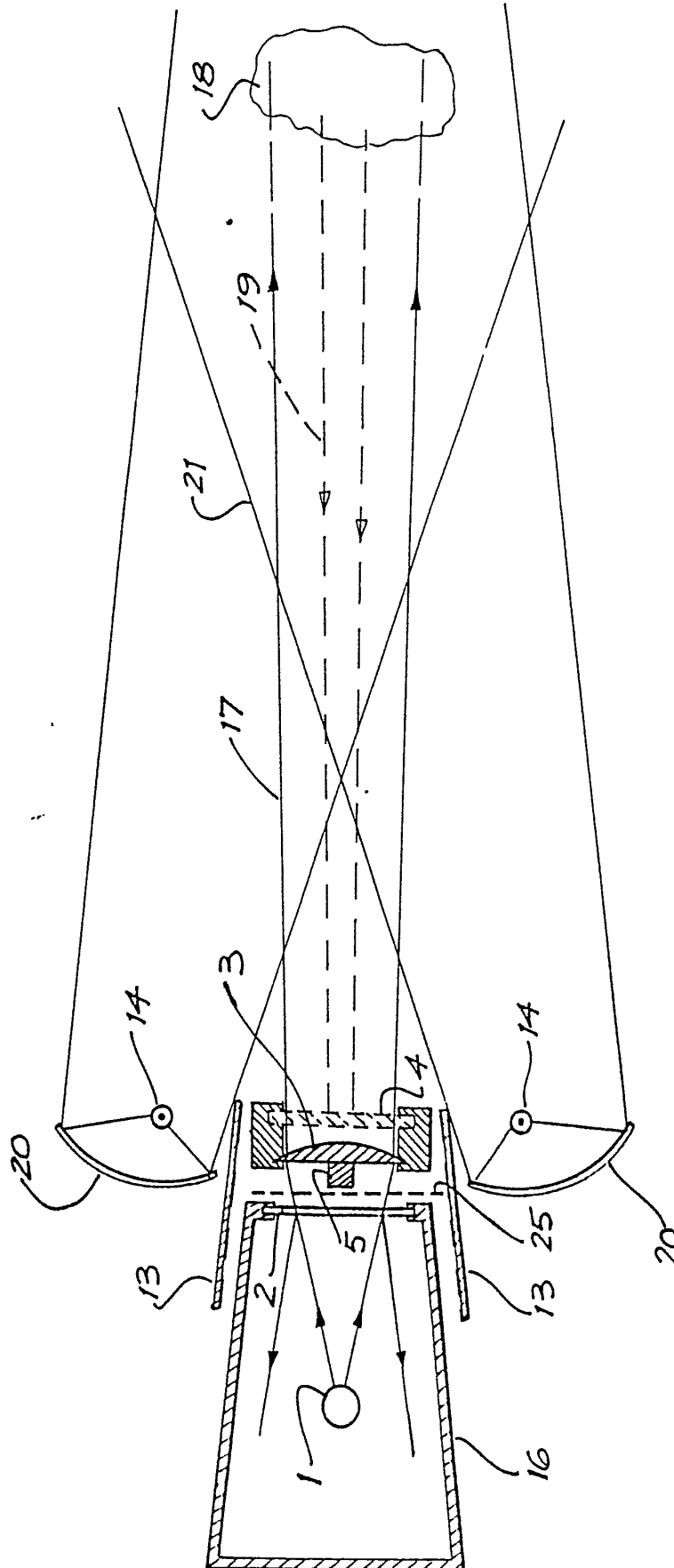


FIG. 1

SUBSTITUTE SHEET

ORIGINAL
2 SHEETS, SHEET 2

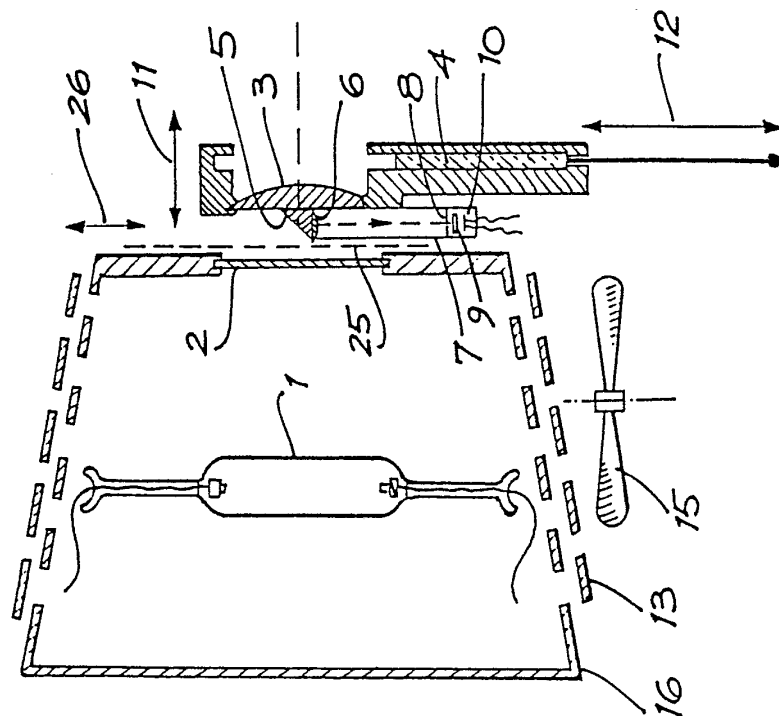


FIG. 2

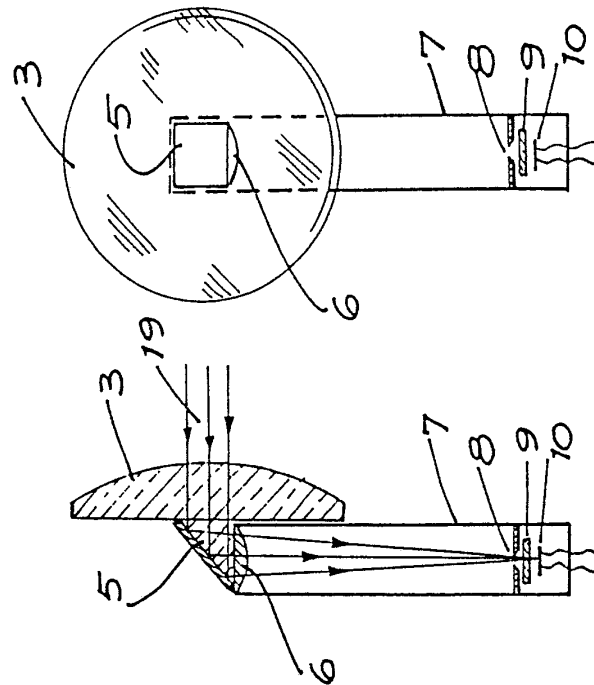


FIG. 3

FIG. 4

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 86/00297

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ¹ According to International Patent Classification (IPC) or to both National Classification and IPC Int. Cl.⁴ A61N 5/08																							
II. FIELDS SEARCHED Minimum Documentation Searched² <table style="width: 100%; border: none;"> <tr> <td style="width: 30%; border: none;">Classification System</td> <td style="border: none;">Classification Symbols</td> </tr> <tr> <td style="border: none; text-align: center; padding-top: 10px;">IPC</td> <td style="border: none; text-align: center; padding-top: 10px;">A61N 5/06, A61N 5/08</td> </tr> </table> Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched³ AU : IPC as above			Classification System	Classification Symbols	IPC	A61N 5/06, A61N 5/08																	
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III. DOCUMENTS CONSIDERED TO BE RELEVANT⁵ <table style="width: 100%; border: none;"> <tr> <th style="width: 10%; border: none;">Category⁶</th> <th style="width: 70%; border: none;">Citation of Document,¹¹ with indication, where appropriate, of the relevant passages¹²</th> <th style="width: 20%; border: none;">Relevant to Claim No.¹³</th> </tr> <tr> <td style="border: none; text-align: center;">X</td> <td style="border: none;">US,A, 1856969 (REITER et al) 3 May 1932 (03.05.32)</td> <td style="border: none; text-align: center;">1,6</td> </tr> <tr> <td style="border: none; text-align: center;">X</td> <td style="border: none;">AU,B, 17021/76 (505720) (WOLFF) 23 February 1978 (23.02.78)</td> <td style="border: none; text-align: center;">6</td> </tr> <tr> <td style="border: none; text-align: center;">X</td> <td style="border: none;">DE,A, 2906512 (HUBNER) 21 August 1980 (21.08.80)</td> <td style="border: none; text-align: center;">6</td> </tr> <tr> <td style="border: none; text-align: center;">X</td> <td style="border: none;">GB,B, 813118 (23294/55) (QUARZLAMPEN GESELLSCHAFT) 6 May 1959 (06.05.59)</td> <td style="border: none; text-align: center;">6</td> </tr> <tr> <td style="border: none; text-align: center;">X</td> <td style="border: none;">DE,A, 2804228 (WOLFF) 2 August 1979 (02.08.79)</td> <td style="border: none; text-align: center;">6</td> </tr> <tr> <td style="border: none; text-align: center;">A</td> <td style="border: none;">AU,A, 87776/82 (MARTA FENYO et al) 10 March 1983 (10.03.83)</td> <td style="border: none;"></td> </tr> </table>			Category ⁶	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	X	US,A, 1856969 (REITER et al) 3 May 1932 (03.05.32)	1,6	X	AU,B, 17021/76 (505720) (WOLFF) 23 February 1978 (23.02.78)	6	X	DE,A, 2906512 (HUBNER) 21 August 1980 (21.08.80)	6	X	GB,B, 813118 (23294/55) (QUARZLAMPEN GESELLSCHAFT) 6 May 1959 (06.05.59)	6	X	DE,A, 2804228 (WOLFF) 2 August 1979 (02.08.79)	6	A	AU,A, 87776/82 (MARTA FENYO et al) 10 March 1983 (10.03.83)	
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• Special categories of cited documents: ¹⁰ "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 <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">Date of the Actual Completion of the International Search</td> <td style="width: 50%; border: none;">Date of Mailing of this International Search Report</td> </tr> <tr> <td style="border: none; text-align: center;">15 December 1986 (15.12.86)</td> <td style="border: none; text-align: center;">(13.01.87) 13 JANUARY 1987</td> </tr> <tr> <td style="width: 50%; border: none;">International Searching Authority</td> <td style="width: 50%; border: none;">Signature of Authorized Officer</td> </tr> <tr> <td style="border: none; text-align: center;">Australian Patent Office</td> <td style="border: none; text-align: center;"> J.I. WELSH </td> </tr> </table>			Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	15 December 1986 (15.12.86)	(13.01.87) 13 JANUARY 1987	International Searching Authority	Signature of Authorized Officer	Australian Patent Office	 J.I. WELSH													
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Australian Patent Office	 J.I. WELSH																						

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON
INTERNATIONAL APPLICATION NO. PCT/AU 86/00297

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 Members	
AU 17021/76	AT 5907/76	AT 5908/76	AU 16924/76
	BE 845554	BE 845555	CA 1074382
	CA 1100168	CA 1100169	CH 604746
	CH 619143	DE 2537855	DK 3824/76
	DK 3823/76	FI 762425	FI 762426
	FR 2321908	FR 2322329	GB 1540488
	GB 154089	GB 1540866	IT 1069671
	IT 1078636	JP 52028337	JP 52034587
	LU 75652	LU 75653	NL 7609410
	NL 7609465	NO 762886	NO 762887
	SE 7609401	SE 7609402	US 4095113
	US 4106083	US 4196354	US 4309616
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	DE 2624297	US 4177384	DE 2707920
	FR 2381530	GB 1554702	JP 53111690
AU 87776/82	BE 894290	BR 8205145	CA 1197563
	CH 657991	DD 204850	DE 3220218
	DK 3879/82	ES 515325	FI 822940
	FR 2511877	GB 2105195	IL 66643
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	ZA 8206320		

END OF ANNEX