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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [3] :
G02B 27/10 // A61B 17/00
A61N 5/06; A61K 41/00

A1

(11) International Publication Number: **WO 83/ 01311**

(43) International Publication Date: 14 April 1983 (14.04.83)

(21) International Application Number: PCT/AU82/00167

(22) International Filing Date: 8 October 1982 (08.10.82)

(31) Priority Application Number: PF 1110

(32) Priority Date: 8 October 1981 (08.10.81)

(33) Priority Country: AU

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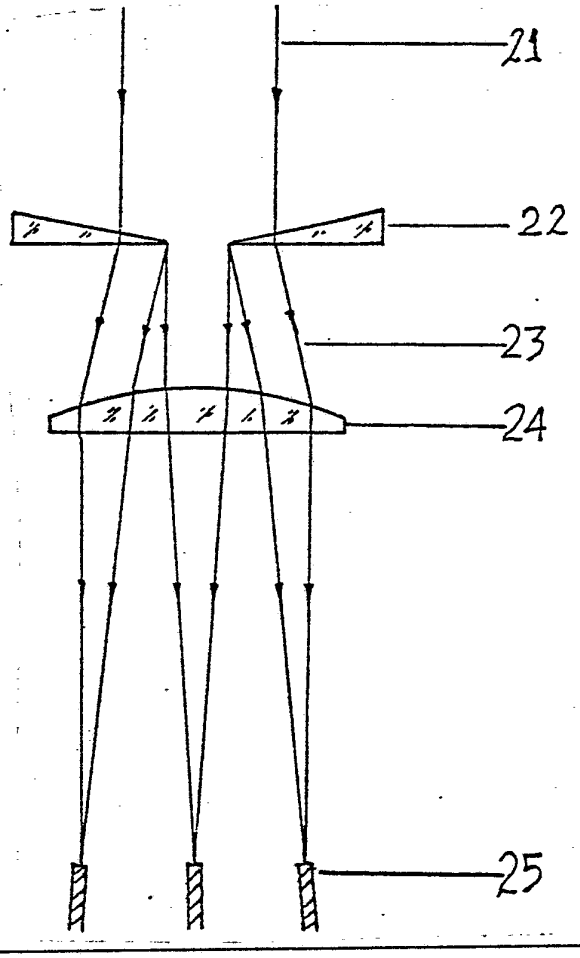
(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.

(54) Title: IMPROVEMENTS RELATING TO LIGHT DELIVERY FOR TUMOUR TREATMENT

(57) Abstract

A method and apparatus for providing separate secondary beams (23) of light from a primary light beam (21) achieved by locating diversionary means such as prisms (22) partially across the main beam (21) so that the degree of insertion provides for control of the magnitude of the secondary beam (23) especially useful for activating in more uniform manner a sensitizing drug when in a tumour. The secondary beams (23) can be commonly focused through lens (24) onto light fibre ends (25) for transmission into the activating areas.



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"IMPROVEMENTS RELATING TO
LIGHT DELIVERY
FOR TUMOUR TREATMENT"

This invention relates to a method and apparatus for effecting a plurality of separate secondary light beams from a single primary light beam where such plurality of secondary light beams are useful for providing a more uniform delivery of light into tumours for activation of a drug within a tumour.

It has been discovered that there can be benefit where a drug being a derivitive of hematoporphyrin (HPD)has been selectively retained within a tumour, that subsequent irradiation of the tumour with light of a selected wavelength will assist in some destruction of the tumour.

An aspect of successful treatment has been found to rely on sufficient light at a selected frequency irradiating the tumour and it has been found that some assistance to this requirement can be achieved by dividing a primary light source into a plurality of secondary beams and locating the output of such beams in distributed locations around the area to be treated.

A factor critical to more successful use of this method however is that the output of each secondary beam shall be controllable but at the same time it is important that there be an adequate supply of light at the required frequency so that treatment time need not be excessive.

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It is of very significant advantage that the light being supplied be restricted as closely as possible to a selected wavelength which is most effective for activating the drug while at the same time being selected to minimise burning of the flesh.

Such a light supply can be most effectively provided from a gold vapour laser.

Accordingly the light derived from the laser providing output provides a major output in the selected frequency area namely approximatlely 630 nanometres and accordingly it is a feature of this invention that there can be provided such a source as a primary beam of light.

It is self evident in relation to the technology and costs associated with supply of such a laser beam that there will be only one beam normally associated with any treatment process supplied as a primary beam and accordingly maximum efficiency of usage is essential while providing nonetheless close control of a plurality of output beams for location of such resultant beams around a tumour to be treated.

In systems hitherto proposed, the arrangement has provided a partially reflective transparent member inserted fully across the primary beam so that the quantity of light being diverted is a factor directly the result of the specific characteristic of the coating on the diversionary member.

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Accordingly there would be provided a plurality of such diversionary members located in series along the eventual path of the primary beam.

The difficulty that has been experienced and indeed the problem to which this invention has been directed is the difficulty with such an arrangement in that it is very difficult to provide any effective close control of the output from each diversionary member, which has hitherto required a full replacement of one member with another for such alterations.

Furthermore the partially reflective diversionary member in order to minimise losses has hitherto had to be coated dielectrically and this has been an expensive requirement so making the system hitherto used very expensive.

A further difficulty is that in terms of the degree of control offered, it is difficult in so far that any variation is governed by the number of reflective mirrors and their characteristic having different reflective strengths which are available at any time. In view of the individual expensiveness of such mirrors, the system is therefore both expensive and indeed cumbersome in operation.

It has now been discovered that instead of using a partial reflector full within the beam, dividing the beam could be achieved by providing diversions of segments of the beam so that the control

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of intensity can be achieved by a variation of the proportions of the whole beam that are in fact diverted.

A convenient way of achieving this method is by providing for means to controllably insert in a partial or fully intersecting manner a multifaceted prism in which the cleavage or apex between the facets is within the beam.

With such an arrangement, there can be a common converging lens targeting the resultant split beams onto a target such as the ends of fibre optic members or the like.

The invention in one form can be said to reside in a method of effecting a plurality of separate secondary beams of light each of a selected magnitude from a single primary beam of light the method including the step for effecting each secondary beam, of locating a diversionary portion for each secondary beam of a diversionary member across only a selected portion of the single primary beam of light whereby the magnitude of the secondary beam is controllable by changing such relative position of the diversionary portion of the diversionary member across the primary beam with respect to the primary beam.

The term "magnitude" is intended to refer to the useful power of light that will reside in a beam and can result in a higher end intensity of light or a greater cross-sectional area with the same intensity or a combination of both.

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The invention in a further form can be said to reside in an apparatus providing for the irradiation of hematoporphyrin derivative (HPD) within a tumour and including means to provide a plurality of separate secondary light outputs for distributing around the tumour such irradiation where such secondary light outputs are derived from a single primary beam, the apparatus being characterised in that each separate secondary light beam is adapted to be derived from a diversionary member with a diversionary portion for each said secondary beam being located across the expected path of the primary beam to intersect only a portion of that primary beam.

Preferably, there are means to vary the position of the diversionary member with respect to the primary beam so as to provide control means by which the magnitude of the secondary beam can thereby be established.

In the above statements, the reference to "diversionary member" or "diversionary portion" or "diversionary means", is understood to include means providing for diversion of a part of the beam either by way of refraction or by reflection.

It is preferred that the portion of the beam being diverted shall then be directed and focused by a common lens on to an optical fibre end so that the portion of the beam is eventually directed to the output of such optical fibres.

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For a further understanding of this invention it will now be described with reference to specific forms of the invention it being emphasised that is not intended that the invention should be necessarilly limited to the specific instances described.

Three categorised examples of this inventon are reported here which all utilise a common principle:

Segments of a broad beam are deviated by either prisms or inclined reflectors which intrude the beam by a controlled and variable amount. The resulting deviated beams which may be irregular in shape are then focused by a common lens to a spot onto the optical fibre ends. The position of the focused spots are independent of prism or mirror translations or diversions, such translations or diversions providing the means of redistributing the light.

The invention will become clearer when specific instances utilizing this general principle are considered and regard is had to the accompanying drawings. The examples may be classified into three categories:

(1) Single, multifaceted prism
(2) Single, multifaceted reflector
(3) Multiple, single prisms.

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In the following treatise reference to a broad input beam relates to collimated beams of diameter greater than about 5mm. Expansion of narrower beams is necessary to achieve the broad beam condition.

Although specific reference has been made to laser beams as the source, the systems may also use as the source either a light emiting diode (LED) or a fibre optic output. The concept of a broad beam will henceforth also incorporate the output obtained from a 'collimating' lens with an above-mentioned source located at its focal point. Under such conditions the subsequent focusing lens will reimage the source onto the plurality of optical fibre ends. Obviously for optimal coupling into the fibres, due regard need be given to the relative focal lengths of the 'collimating' and focusing lenses.

While lenses of certain configurations are depicted in the accompanying diagrams and are illustrated as single lenses, it is to be understood that any one of the lenses shown may be composed of several parts in order to correct any or all the well known aberrations produced by lenses, and no attempt has been made in these figures to illustrate these corrections which are well-known in the art.

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Though a specific direction of light deviation by the prisms is shown, this direction is not to be considered limited and may be directed either toward or away from the optical axis to a greater or lesser extent by means of a differently configured prism or prisms. However in practice the deviation will be such as to be towards the optical axis and small so as to provide better conditions for optical imaging.

No attempt has been made to describe the mechanical method for locating or adjusting fibre positions nor translating any optical elements as these would be rudimentary to the engineering art.

For a first preferred embodiment a two faceted prism (biprism) acting as a diversionary member with two diversionary portions is treated. Turning to FIGURE 1, numeral 1 indicates the incident broad beam which strikes a transparent two faceted element 2, which thereby angularly separates emerging beams 3. The beams 3 pass through lens 4 to yield converging beams 5 which are focused onto two appropriately positioned fibre ends 6.

It is evident that the distribution of the light between the two fibres may be varied by translation of the biprism in an axis orthogonal to both the input beam axis and the roof top edge of the prism.

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It is possible under various favourable conditions that the positions of the faceted element and the lens be interchanged. However generally this will provide an inferior system.

The above example may be extended to a multifaceted prism whereby the focused spots lie in a plane. A noteworthy example is that of four facets in the form of a square pyramid; such an element may be used to yield one, two or four beams depending on the number of facets intercepting the beam. When the incident beam strikes the apex centrally four beams of equal intensity are produced (assuming a rotationally symmetric incident beam).

Beam splitters of the second preferred embodiment type are particularly suited for narrow input beams. FIGURE 2 illustrates such a system in the case of a two faced reflector. The incident narrow beam 11 passes through diverging lens 12 to produce diverging beam 13. The beam 13 is collimated by lens 14 to produce beam 15 which is reflected off the two faceted reflector 16 to produce two angularly separated beams 17. The beams pass through lens 14 and emerge as converging beams 18 to focus on the optical fibre ends 19. This system can be extended to a multifaceted system in the same manner as the first preferred embodiment.

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If an LED or fibre end output is used as the source the diverging lens 12 need be removed and the source suitably positioned at the focal point of the lens 14.

A system could also be devised whereby the reflector 16 is of a partially reflecting nature, and therefore also behaves as a prism. Under these circumstances a system can be devised which exhibits the features of both first and second preferred embodiments. It is evident that the reflected and refracted sets of beams of such a system are characteristic of each other. Measurement of either the reflected or refracted intensities would provide a means of monitoring the distribution of the intensities of the sets of beams that are not being measured.

A third preferred embodiment as in FIGURE 3 exhibits the multifaceted behaviour by combining a plurality of single prisms. FIGURE 3 illustrates the simple case of a three fibre delivery system.

A broad incident beam 21 partially strikes the prisms 22, the three resultant beams 23 being focused by the converging lens 24 onto the fibre ends 25. The quantity and intensity distribution of the delivered light is controlled by the degree of intrusion of the prisms into the beam. FIGURE 4 illustrates two pairs of prisms arranged so as to generate 9 beams. A second pair of prisms is introduced into the beam so as to

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deviate the beam in a direction perpendicular to the deviation produced by the primary set of prisms. Translation of the prisms in such a system permits selection of either 1, 2, 3, 4, 6 or 9 beams.

A permutation of this system is possible by positioning the focusing lens immediately before or in between the prisms. However such an arrangement will generally be inferior to that cited above.

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The Claims defining the invention are as follows:

1. A method of effecting a plurality of separate secondary beams of light each of a selected magnitude from a single primary beam of light the method including the step for effecting each secondary beam, of locating a diversionary portion for each secondary beam, of a diversionary member across only a selected portion of the single primary beam of light whereby the magnitude of the secondary beam is controllable by changing such relative position of the diversionary portion of the diversionary member across the primary beam with respect to the primary beam.

2. A method as in Claim 1 wherein each diversionary portion is constituted by a prism.

3. A method as in either of Claims 1 or 2 wherein a diversionary member includes at least two diversionary portions constituted by two prisms adapted to divert two separate portions of the primary beam differently to provide said separate secondary beams.

4. A method as in Claim 1 or 2 wherein each diversionary member includes only one diversionary portion constituted by being a prism and there being means to move each diversionary member separately from any of the other diversionary members with respect to the primary beam.

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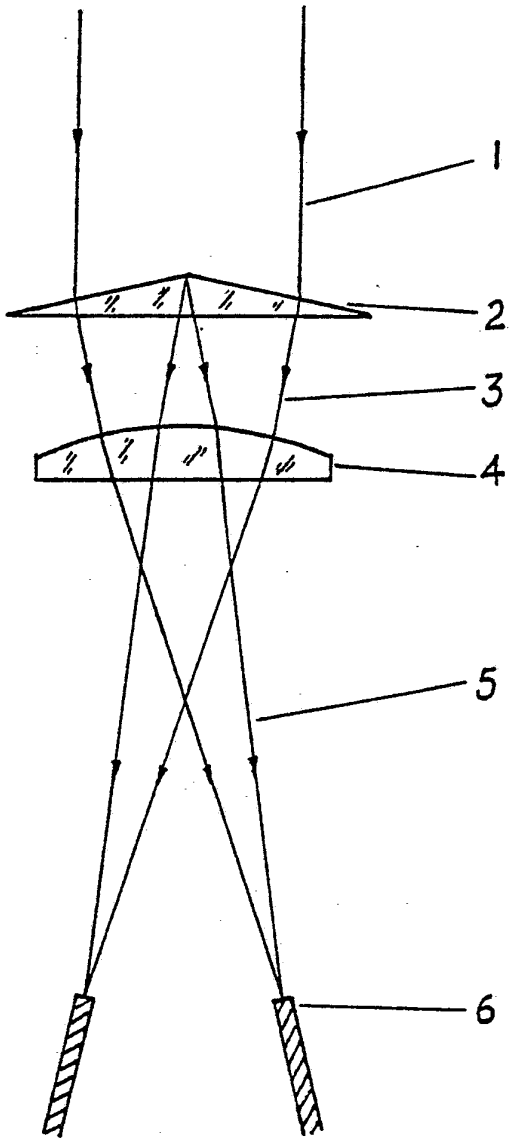
5. A method as in any one of the preceding Claims wherein each secondary beam is focused onto a first end of a light fibre the other end being adapted to be located adjacent a selected portion of a tumour.

6. An apparatus for providing irradiation of hematoporphyrin derivative (HPD) within a tumour the apparatus including means to provide a plurality of separate secondary light outputs for distributing around the tumour such irradiation where such secondary light outputs are derived from a single primary beam, the apparatus being characterised in that there are provided means to generate a primary beam, and means to effect a plurality of separate secondary light beams derived from the first said primary beam wherein there is a diversionary member or diversionary members each with a diversionary portion or portions such that each said secondary beam is effected by a diversionary portion being located across the expected path of the primary beam such as to intersect only a portion of that primary beam with respect to each said secondary light beam.

7. An apparatus as in the last preceding Claim further characterised in that each diversionary portion is constituted by a prism.

8. A method substantially as described in the specification with reference to and as illustrated by each of the embodiments described.

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- FIGURE 1 -

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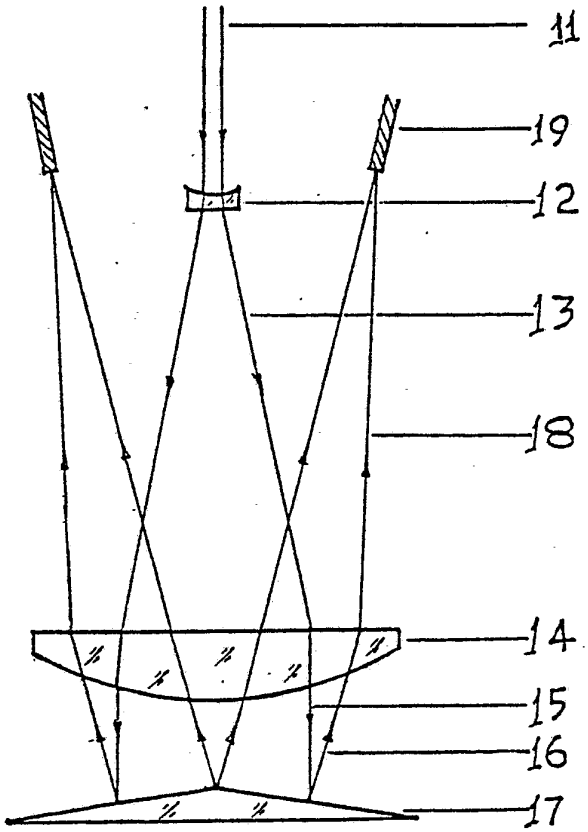


FIGURE 2

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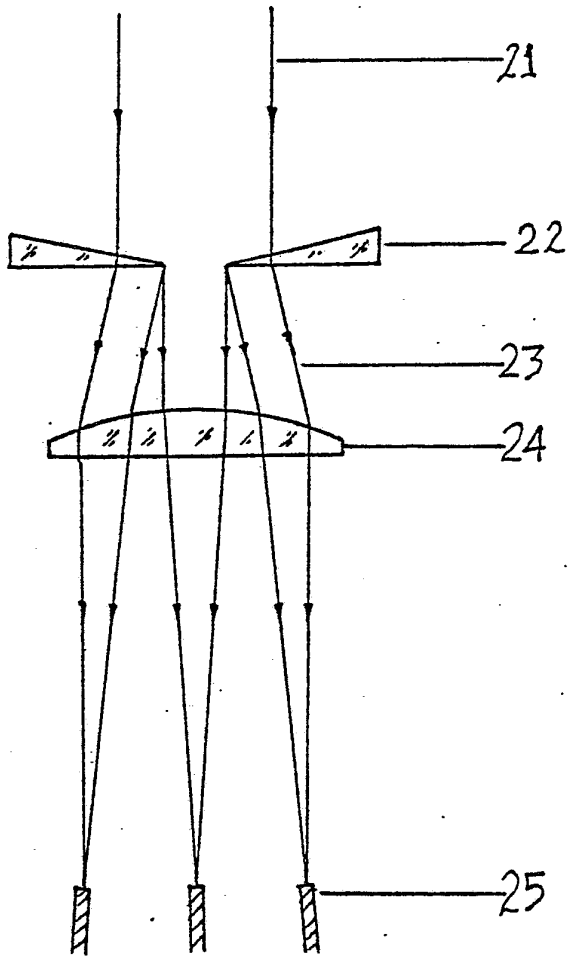
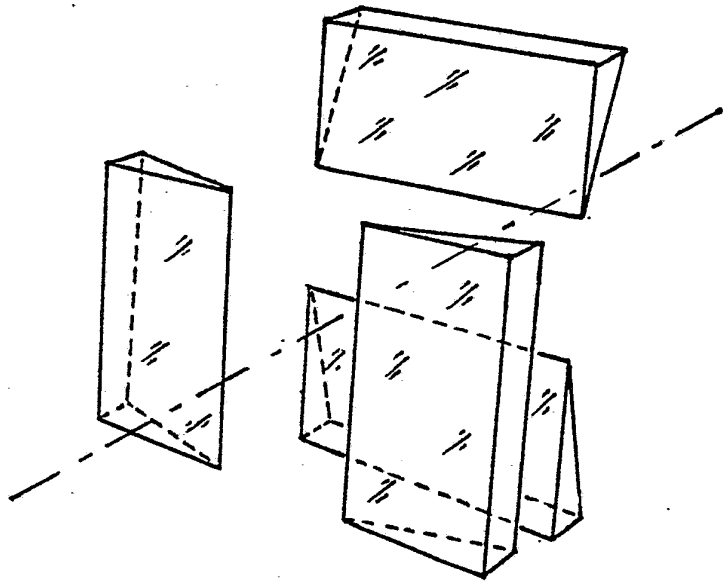


FIGURE 3.

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- FIGURE 4 -

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INTERNATIONAL SEARCH REPORT

International Application No PCT/AU82/00167

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [3]

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

Int Cl.[3] G02B 27/10 // A61B 17/00, A6IN 5/06, A61K 41/00

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC	G02B 27/10, 27/12, 27/14, 27/16

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

AU: IPC AS ABOVE, AUSTRALIAN CLASSIFICATION 00.4

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
P, X	JP,A, 57-13409 (SHARP K.K.) 23 January 1982 (23.01.82) (JAPATIC English Language Abstract)	(1-8)
X	JP, A, 53-95651 (MITSUBISHI DENKI K.K.) 22 August 1978 (22.08.78) (JAPATIC English Language Abstract).	(1,6)
X	JP,A,54-146643 (MITSUBISHI DENKI K.K.) 16 November 1979 (16.11.79) (JAPATIC English Language Abstract)	(1,6,8)
X	US,A, 3977764 (D'AURIA, LE GUEN, SPITZ) 31 August 1976 (31.08.76) (& DE, A, 2540761, & FR, A, 2284892, & JP, A, 51056239)	(1-8)
P, X	JP, A, 57-16403 (SHARP K.K.) 27 January 1982 (27.01.82) (JAPATIC English Language Abstract)	(1-8)

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
11 January 1983 (11.01.83)	14 JANUARY 1983 (14.01.1983)
International Searching Authority [1]	**Signature of Authorized Officer [20]**
Australian Patent Office	P.F. Gotham

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

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
P, X	JP, A, 57-5006 (MATSUSHITA DENKI SANGYO K.K.) 11 January 1982 (11.01.82) (JAPATIC English Language Abstract).	(1,6)
X	US, A, 4143402 (BRICOT, LEHUREAU) 6 March 1979 (06.03.79) See figure 2 (& DE, A, 2624746, & JP, A, 51150303, & FR, A, 2313716).	(6,7)
X	FR, A, 781107 (SCHERER) 9 May 1935 (09.05.35)	(6,7)