This is a Multiple Use Form Covering:
Convention
Non-Convention
PCT National Phase
Not suitable for microorganism cases

NOTICE OF ENTITLEMENT

Insert name of applicant

I/We DIOMED LIMITED

of, THE JEFFREYS BUILDING, ST JOHN'S INNOVATION PARK, COWLEY ROAD, CAMBRIDGE CB4 4WS

being the applicant in respect of Application No. PCT/GB91/00207

state the following:-

Only complete if application filed before 30 April 1991.

The inventor(s) of the invention is as follows:

Name(s) and address(es) of inventor(s)

DR ANTHONY RAVEN
THE OLD ORCHARD, CHAPEL LANE,
MELBOURN, ROYSTON,
HERTFORDSHIRE SG8 6BN ENGLAND

Complete only for non-PCT applications

The person(s) nominated for the grant of the patent:

(i) is/are the actual inventor(s)

(ii) has/have entitlement from the actual inventor(s) by virtue of

(ii) is/are the applicant(s) of the basic application(s)

(ii) has/have entitlement from the applicant(s) of the basic application(s) listed on the patent request form by virtue of

Complete only for PCT applications

The person(s) nominated for the grant of the patent:

(i) is/are the applicant(s) of the application(s) listed in the declaration under Article 8 of the PCT

(i) has/have entitlement from the inventor(s) and/or the applicant(s) of the application(s) listed in the declaration under Article 8 of the PCT by virtue of an assignment

Complete for all Convention cases

The basic application(s) listed:

(i) on the request form

(i) in the declaration made under Article 8 of the PCT

is/are the first application(s) made in a Convention country in respect of the invention.

DIOMED LIMITED

BY: .....

Signature

20 Jul 1992

Date

A. RAVEN
CHIEF EXECUTIVE OFFICER

AU9172305

(12) PATENT ABRIDGMENT (11) Document No. AU-B-72305/91
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 646660

(54) Title
SOLID STATE LASER DIODE LIGHT SOURCE

International Patent Classification(s)
(51)[5] H01S 003/25 A61B 017/36 G02B 006/42

(21) Application No. : 72305/91 (22) Application Date : 12.02.91

(87) PCT Publication Number : WO91/12641

(30) Priority Data

(31) Number	(32) Date	(33) Country
9003097	12.02.90	GB UNITED KINGDOM

(43) Publication Date : 03.09.91

(44) Publication Date of Accepted Application : 03.03.94

(71) Applicant(s)
DIOMED LIMITED

(72) Inventor(s)
ANTHONY RAVEN

(74) Attorney or Agent
DAVIES COLLISON CAVE , 1 Little Collins Street, MELBOURNE VIC 3000

(56) Prior Art Documents
GB 2182168

(57) Claim

1. A laser diode light source comprising at least two solid state laser diodes, a flexible optical fibre, and optical means, interposed between said diodes and said fibre, comprising means for combining the beams produced by said diodes into a combined beam and for focusing said combined beam into said fibre, wherein said optical means comprises an imaging means and anamorphic beam shaping means arranged such that the optical means produces at the fibre end a magnified combined image of the laser stripes of said diodes, the magnification being less in the long direction of the image stripe relative to the magnification in the width direction and being chosen such that the image stripe size in its long direction does not substantially exceed the core diameter of the fibre, the anamorphic beam shaping means being arranged to adjust the relative numerical apertures of the combined beam along said long and width directions such that the numerical apertures in said two directions of the beam focused into the end of the fibre do not substantially exceed the numerical aperture of the fibre.

OPI DATE 03/09/91 APPLN. ID 72305 / 91
AOJP DATE 10/10/91 PCT NUMBER PCT/GB91/00207
INTERN. ... TREATY (PCT)

(51) International Patent Classification 5 :
H01S 3/25, A61B 17/36
G02B 6/42

A1

(11) International Publication Number: WO 91/12641

(43) International Publication Date: 22 August 1991 (22.08.91)

(21) International Application Number: PCT/GB91/00207

(22) International Filing Date: 12 February 1991 (12.02.91)

(30) Priority data:
9003097.4 12 February 1990 (12.02.90) GB

see folio 3

DIOMED LIMITED

(71) Applicant *(for all designated States except US)*: ~~SCIENTIF-IC GENERICS LIMITED~~ [GB/GB]; ~~King's Court, Kirkwood Road, Cambridge CB4 2PF (GB)~~.

(72) Inventor; and

(75) Inventor/Applicant *(for US only)* : RAVEN, Anthony [GB/GB]; The Old Orchard, Chapel Lane, Melbourn, Royston, Hertfordshire SG8 6BN (GB).

(74) Agent: FRANK B. DEHN & CO ; Imperial House, 15-19 Kingsway, London WC2B 6UX (GB).

The Jeffreys Building St. John's Innovation Park Cowley Road Cambridge CB4 4WS United Kingdom

(81) Designated States: AT (European patent), AU, BE (European patent), BR, CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GB, GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), NO, SE (European patent), US.

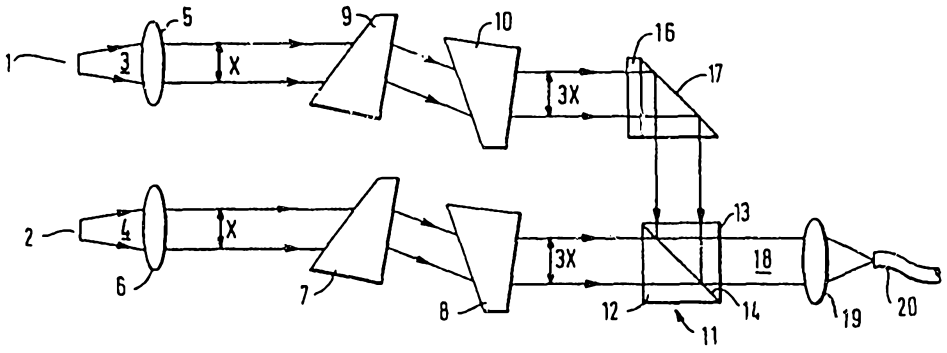
Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

AUSTRALIAN 92 Bis 8/10/91 PATENT OFFICE

646660

AUSTRALIAN SEC. 104 PATENT OFFICE

(54) Title: SOLID STATE LASER DIODE LIGHT SOURCE



(57) Abstract

A laser diode light source comprises at least two laser diodes (1, 2). The beams (3, 4) of the diodes (1, 2) are combined together by, for example, a polarising beam combiner (11) and the combined beam (18) is focused by a lens (19) onto an optical cable (20). The beams (3, 4) are also acted on in the long direction of the laser stripes of the diodes (1, 2) by anamorphic beam shaping means (7, 8; 9, 10) to reduce the length of the image formed at the end of fibre (20) by a predetermined factor, chosen such that the numerical aperture of the focused beam (18) in said long direction does not substantially exceed that of the optical fibre (20).

SOLID STATE LASER DIODE LIGHT SOURCE

The present invention relates to solid state laser diode light sources for use particularly, but not exclusively, in laser probes for treating tissue in applications such as laser angioplasty and contact laser surgery.

Medical laser devices for the treatment of e.g. blocked arteries are well known. Laser energy is directed through an optical fibre so as to either directly irradiate and destroy tissue, or indirectly irradiate and destroy tissue by heating a thermally conductive tip which contacts and destroys the tissue. In general, such devices have previously used gas lasers or solid state lasers such as Nd:YAG and as such are large and not easily portable. Semiconductor laser diodes have been used in ophthalmic surgery which requires relatively modest optical power (~1W) since they provide an inexpensive, compact and robust source of laser light. However they have not been applied to other areas of surgery where higher powers are required because of the difficulty in coupling sufficient laser power from laser diodes into an optical fibre of sufficient flexibility and small diameter for use in surgical applications.

To provide a higher power laser diode light source from an optical fibre it has been proposed to use a plurality of laser diodes.

In one system, the light from each laser diode is fed into a respective optical fibre, a plurality of which are then bundled together to produce the required beam. However commercially available laser diodes produce a stripe source of light (typically 100 x 1 μm) rather than a point source which means that relatively large diameter optical fibres (which are traditionally

circular) are required to contain the entire laser stripe, which if bundled together in sufficient numbers to give a suitable power output for surgical use, would result in an assembly which is too large for effective use in conjunction with a medical or surgical probe such as an angioplasty device. It has been proposed to deform the end portion of a circular fibre into a generally oblong shape with the intention that the output of the laser stripe may be more effectively captured and funnelled into a fibre of reduced diameter, but this is an expensive procedure and the funnelling is not energy efficient in practice.

According to a first aspect of the present invention there is provided a laser diode light source comprising at least two solid state laser diodes, a flexible optical fibre, and optical means, interposed between said diodes and said fibre, comprising means for combining the beams produced by said diodes into a combined beam and for focusing said combined beam into said fibre, wherein said optical means comprises an imaging means and anamorphic beam shaping means arranged such that the optical means produces at the fibre end a magnified combined image of the laser stripes of said diodes, the magnification being less in the long direction of the image stripe relative to the magnification in the width direction and being chosen such that the image stripe size in its long direction does not substantially exceed the core diameter of the fibre, the anamorphic beam shaping means being arranged to adjust the relative numerical apertures of the combined beam along said long and width directions such that the numerical apertures in said two directions of the beam focused into the end of the fibre do not substantially exceed the numerical aperture of the fibre.

In accordance with the invention, the optical power transmitted through the or each flexible fibre is

increased with the result that a lesser number of fibres of smaller diameter may be conveniently bundled together to provide a source of sufficient brightness for e.g. surgical use within the size constraints imposed by an angioplasty or other medical device. A source in accordance with the invention may have other applications, such as laser soldering irons in which laser light passed through an optical fibre provides the heat for the soldering process. In such an application, the light from two laser diodes focused into a single optical fibre may provide sufficient power.

The invention enables the shape of the image to be optimised with respect to minimising the fibre core diameter without power losses arising due to numerical aperture mis-match. The magnified image stripe is a better fit with the end of a fibre core. Whilst the absolute value of magnifications in the long and width directions may vary (provided that relative magnification is less than one) depending on the application concerned and the size constraints imposed on the fibre, in many applications, it is desirable that the diameter of the or each fibre of such a source is minimized as far as possible without leading to power loss. In this case the optical means is effective to reduce the size of the image with respect to the source in the long direction of the stripes consistent wit not substantially exceeding the numerical aperture of the fibre.

Commercially available laser diodes produce a beam of light from a stripe source, the beam having a lower numerical aperture along the direction of the stripe than perpendicular to the stripe. Typical values would be 0.1NA and 0.33NA respectively, which means that in the direction along the stripe, the numerical aperture of the beam is substantially less than that of a standard optical fibre, if, in the other direction, the beam and fibre numerical apertures approximately match one another.

With a circular fibre core, the minimum diameter is set by the length of the image of the laser source stripes formed at the fibre end, since if the diameter is less than the length of the image stripe, power will be lost as a result of the fibre not intersecting all of the beam. Moreover an optical means which reduces the length of the image stripe will result in a corresponding increase in divergence and thus in the numerical aperture of the combined beam focused onto the fibre end, and it is important that the beam numerical aperture does not significantly exceed that of the fibre if power loss is to be avoided.

As stated, in a preferred embodiment intended to minimise fibre diameter, the magnification provided by the optical means is chosen to reduce the length of the image stripe formed at the end of the fibre with respect to the source stripes by a certain factor chosen such that the numerical aperture of the combined focused beam does not substantially exceed that of the optical fibre and in the direction perpendicular to the stripes (in which direction the beam thickness does not impose size constraints on the fibre) the preferred optical means may have unit magnification provided that the beam numerical aperture in that direction also does not substantially exceed that of the fibre.

Thus, the core diameter of the fibre may be correspondingly reduced with resultant practical advantages in many applications, particularly where a plurality of fibres need to be bundled together into a closely packed array within certain size constraints.

In a particularly preferred embodiment the optical means is arranged such that the numerical aperture in the long direction of the image stripe of the beam focused onto the fibre end approximately matches the numerical aperture of the fibre. In this way, a maximum demagnification of the image in the long direction relative to the width direction and thus maximum optimising of image shape with respect to fibre core

diameter may be achieved without power losses arising as a result of the beam's numerical aperture exceeding that of the fibre. The beam and fibre numerical apertures preferably match in the width direction also. In a preferred embodiment the optical means is arranged to decrease the length of the image stripe in the long direction relative to the width direction and increase the numerical aperture of the focused beam in the long direction by a factor of around 3. If the optical means has no effect on the beam in the direction perpendicular to the laser stripes, then with known diodes as described above it will be seen that the numerical apertures of the combined beam focused into the fibre will be substantially equal in the directions parallel and perpendicular to the stripe.

A preferred embodiment comprises means for collimating the beams from the laser diodes (which are normally divergent) located between the diodes and the beam combining means. This enables location of the beam combining means and, optionally, the beam shaping means between the diodes and the fibre without energy loss occurring as a result of beam divergence over the optical path between the diodes and fibre.

The preferred optical means comprises a collimating lens, an anamorphic telescope e.g. a pair of anamorphic prisms and an imaging lens. Such an arrangement acts, in the manner of a cylindrical telescope with magnification less than one in the long direction of the stripes relative to the width direction, whereby the length of the refocused, combined image of the stripes is reduced by the desired factor, for example around 3, relative to the width whilst the numerical aperture in such direction is correspondingly increased. The anamorphic telescope first acts relatively to widen the beam in this direction by a factor x, and the imaging lens produces an image which is relatively reduced by a desired factor. If the focal lengths of the collimating and imaging lenses are equal, the length of the

refocused image will be relatively reduced by the same factor x although these focal lengths need not of course be equal and could be adjusted to vary magnification in both directions.

It will be appreciated that each beam may be provided with such an arrangement, although certain components of the beam shaping means may be common to a number of beams. Thus in a preferred embodiment a single imaging lens is provided downstream of the beam combining means and which acts therefore on a combined beam, with separate collimating lenses and anamorphic telescopes provided for the laser diode beams upstream of the beam combining means. However it is also envisaged that it may be possible to position a single anamorphic telescope downstream of the beam combining means to act on the combined beam.

There are a number of ways in which the two laser diode beams may be combined. If the wavelengths of the beams differ by any substantial amount, then it may be possible to use a dichroic beam combiner. However since in practice most laser diode sources emit light (e.g. infra red) of around the same wavelength, it is preferred that the beam combination is effected by a polarising beam combiner. A cube constructed from two right angled triangular prisms having their respective hypotenuses in contact and coated in a dielectric material is a particularly simple form of polarising combiner. The beam from one source which is "S" polarised is incident upon the coated surface and reflected therefrom, along the same path as the other beam, which is "P" polarised, is incident on another surface, of the cube and passes straight through the coated surface, to produce a combined beam. Preferably the outer surfaces of the cube have an anti-reflective coating. Other forms of polarising beam combiners are known.

The stripe shaped light beam produced by known laser diodes is polarised in the direction parallel to

the stripe axis. Accordingly if the laser diodes are so arranged as to produce images of the stripes which are aligned in the same direction, the polarisation of one beam must be rotated by 90° before it enters the beam combining means. In a preferred arrangement, this may be achieved by inserting a half wave plate in the path of one of the beams. The half wave plate may conveniently be placed in front of a reflecting prism which reflects the respective beam onto the beam combining means. The use of the half wave plate could be avoided by mounting the diodes spatially in a mutually orthogonal arrangement. However, this complicates the mounting of the beam shaping and combining optics in that they have to be mounted orthogonally for the two beams.

As described above, a light source in accordance with the invention is applicable to any number of surgical applications for example contact laser surgery. It is also particularly suitable for use in a bundled assembly to provide an enhanced source for a body implantable probe such as an angioplasty device.

The invention extends to a light source comprising a plurality of light sources in accordance with the invention, with the optical fibres being arranged into a closely packed bundle. This bundle may for example comprise a pair of central fibres surrounded by a number of fibres. The bundle may be coupled in a suitable manner with a further optical fibre for delivery to a point of use. Where the source is butt coupled to the further fibre, the core diameter and numerical aperture of that fibre should preferably be equal to or larger than that of the array to transmit the light effectively. Similarly if it is to be imaged, the product of the core diameter and numerical aperture of the further fibre should preferably be equal or greater to that of the bundle.

The invention also provides a medical device comprising an optical fibre whose distal end is provided



with means for heating body tissue, the proximal end of the fibre being optically coupled to a light source in accordance with the invention. This may be, for example, an angioplasty device having a body implantable fibre.

A preferred embodiment of the invention will now be described, by way of example only with reference to the accompanying drawings, in which:-

Figure 1 is a plan view of a light source embodying the invention;

Figure 2 is a side view of the light source shown in Figure 1, and

Figure 3 shows, schematically, a plurality of light sources in accordance with the invention formed in a closely packed array.

With reference to Figures 1 & 2, two 1W solid state laser diodes 1, 2 produce light beams 3, 4. Each laser diode in this embodiment has an emitting stripe of 100 x 1 μm in a numerical aperture of 0.1 x 0.33. The beams 3, 4 are collimated by collimating lenses 5, 6 and passed through anamorphic telescopes in the form of anamorphic prism pairs 7,8,9,10. As can be seen from the Figures, the anamorphic prism pairs 7,8,9,10 act to initially increase the dimension of the beams 3,4 by a factor of about 3 in the direction parallel to the stripe but do not affect them in the direction perpendicular to the stripe.

After passing through the anamorphic prism pairs 7, 8,9,10 the beams 3,4 are combined in a beam combining cube 11. Cube 11 is constructed from two prisms 12,13 having their respective hypotenuses in contact. The interface 14 is provided with a dielectric coating so that it will transmit light which is 'P' polarised but reflect light that is 'S' polarised.

Since the light beams emitted by the laser diodes 1,2 will both be "P" polarised, at the cube 11, it is necessary to rotate the polarisation of one beam by 90°. To achieve this, the beam 3 is passed through a half

AUSTRALIAN PATENT OFFICE

wave plate 16 which is arranged on the front face of a prism 17 which reflects the beam 3 onto the interface 14 of the beam combining cube 11.

The dielectric coated surface 14 of the cube 11 is transparent to the beam 4, which accordingly passes through the cube undeflected, but acts as a mirror to the beam 3 which is reflected along the same path as beam 4 to produce a combined beam 18. This beam 18 is then focused by an imaging lens 19 into a flexible optical fibre 20. The imaging lens 19 has the same focal length as the collimating lenses 5, 6 and acts, with the anamorphic prisms (7, 8, 9, 10) to produce a combined image of the original light sources 1, 2 which

AUSTRALIAN PATENT OFFICE

is of the same dimension as the originals in the direction perpendicular to the emitting stripe , but which is of a dimension in the direction parallel to the emitting stripe reduced by a factor equal to the increase in thickness of each beam in such direction caused by the prisms. In this particular embodiment, the imaging lens 19 focuses the combined beam to a spot 33 x 1 μm of 0.3 x 0.33 NA at the input face of the optical fibre 20 which has a 50 μm diameter (55 μm with cladding) of 0.37 NA.

It will thus be seen that the relative length of the image of the emitting stripe of the laser diodes 1,2 has been reduced by a factor of about 3, which means that the shape of the image is a better match with the fibre end and optical fibre 20 may have a correspondingly reduced diameter. Moreover the intensity of the beam incident on the optical fibre 20 is, disregarding losses, substantially double that of the beams produced by individual laser diodes. Also the numerical aperture of the source is closely matched with that of the optical fibre 20.

These factors mean that to produce a source of a given power relatively fewer and smaller fibres will be required, which is of particular importance in angioplasty devices.

Fig. 3 is a top schematic view of a bundled light source which may be used with an angioplasty device.

The source comprises eight light sources 21 (only four shown) each similar to that shown in Figs. 1 and 2, but with the half-wave plate 16 sandwiched between the beam shaping prism 10 and the reflecting prism 17 and with the prism 8 and the combining cube 11 spaced apart by a glass plate 22 provided therebetween.

The four shown sources 21 are mounted together within the source housing 23 as a module 24. An identical module consisting of the other four sources is invertedly mounted beneath the module 24 shown.

The fibres 20 from the eight sources are bundled

together so that two central fibres are surrounded by the other six fibres. Thi combined source is at 200 μm diameter and 0.37 NA, and allowing for coupling and transmission losses provides a 10W source.

The source from this bundle of fibres is then imaged by ball lenses mounted in connector 25 into a single circular fibre 26, the other end of which is coupled to an optical fibre connector 27 mounted on the housing 23, to provide a light source with which a further optical fibre of an angioplasty device may be coupled.

The fibre 25 is of sufficient diameter and numerical aperture for delivery of the light to a point of use such as the distal end of an angioplasty device. The use of such a single circular fibre will also serve to remove at the distal end of the fibre any spatial structure in the light emitted from the array of closely packed fibres caused by variations in the emitted power from the individual fibres within the array and from the discrete structure of the fibre bundle.

Where the source is butt coupled to the further fibre, the core diameter and numerical aperture of the fibre should be equal to or larger than that of the array to transmit the light effectively. Similarly if it is to be imaged, the product of the core diameter and numerical aperture of the further fibre should be equal or greater to that of the bundle.

As an example, the bundle source of this embodiment could be imaged with a magnification of 2 into a fibre of 330 μm core and 0.19 NA which is suitable for use in angioplasty devices.

It will be understood by the person skilled in the art that the particular numerical values used in the above embodiments are used purely by way of example. It will also be apparent that other amendments may be made which fall within the scope of the invention.

Claims

1. A laser diode light source comprising at least two solid state laser diodes, a flexible optical fibre, and optical means, interposed between said diodes and said fibre, comprising means for combining the beams produced by said diodes into a combined beam and for focusing said combined beam into said fibre, wherein said optical means comprises an imaging means and anamorphic beam shaping means arranged such that the optical means produces at the fibre end a magnified combined image of the laser stripes of said diodes, the magnification being less in the long direction of the image stripe relative to the magnification in the width direction and being chosen such that the image stripe size in its long direction does not substantially exceed the core diameter of the fibre, the anamorphic beam shaping means being arranged to adjust the relative numerical apertures of the combined beam along said long and width directions such that the numerical apertures in said two directions of the beam focused into the end of the fibre do not substantially exceed the numerical aperture of the fibre.

2. A laser diode light source as claimed in claim 1, wherein the numerical aperture of said focused beam in said long direction of the source stripes substantially matches that of the fibre.

3. A laser diode light source as claimed in claim 1 or 2, wherein the size of the image in the long direction relative to the width direction is reduced by a factor of about 3.

4. A laser diode light source as claimed in any preceding claim wherein the image stripe is demagnified in the long direction relative to the source stripes.

5. A laser diode light source as claimed in any preceding claim wherein said optical means includes a collimating lens, an anamorphic telescope, and an imaging lens.

6. A laser diode light source as claimed in claim 5, wherein a single imaging lens is provided downstream of the beam combining means to act on said combined beam, and separate collimating lenses and anamorphic telescopes are provided upstream of said beam combining means for each light beam.

7. A laser diode light source as claimed in any preceding claim, wherein said combining means comprises a polarising beam combiner.

8. A laser diode light source as claimed in claim 7, wherein said laser diodes are orientated such that they emit beams polarised in the same direction, and said combining means further comprises a half wave plate through which one of said beams passes prior to the combination of both beams in said polarising chamber.

9. A light source comprising a plurality of laser diode light sources as claimed in any preceding claim, said optical fibres being arranged into a closely packed bundle.

10 A light source as claimed in any preceding claim wherein the numerical aperture of said fibre is approximately 0.37.

11. A medical device comprising an optical fibre, a distal end of the optical fibre being provided with means for heating body tissue, and a proximal end of the ~~optical fibre being~~ and a respective plurality of optical fibres, said fibres being optically coupled to a light source as claimed in any preceding claim.

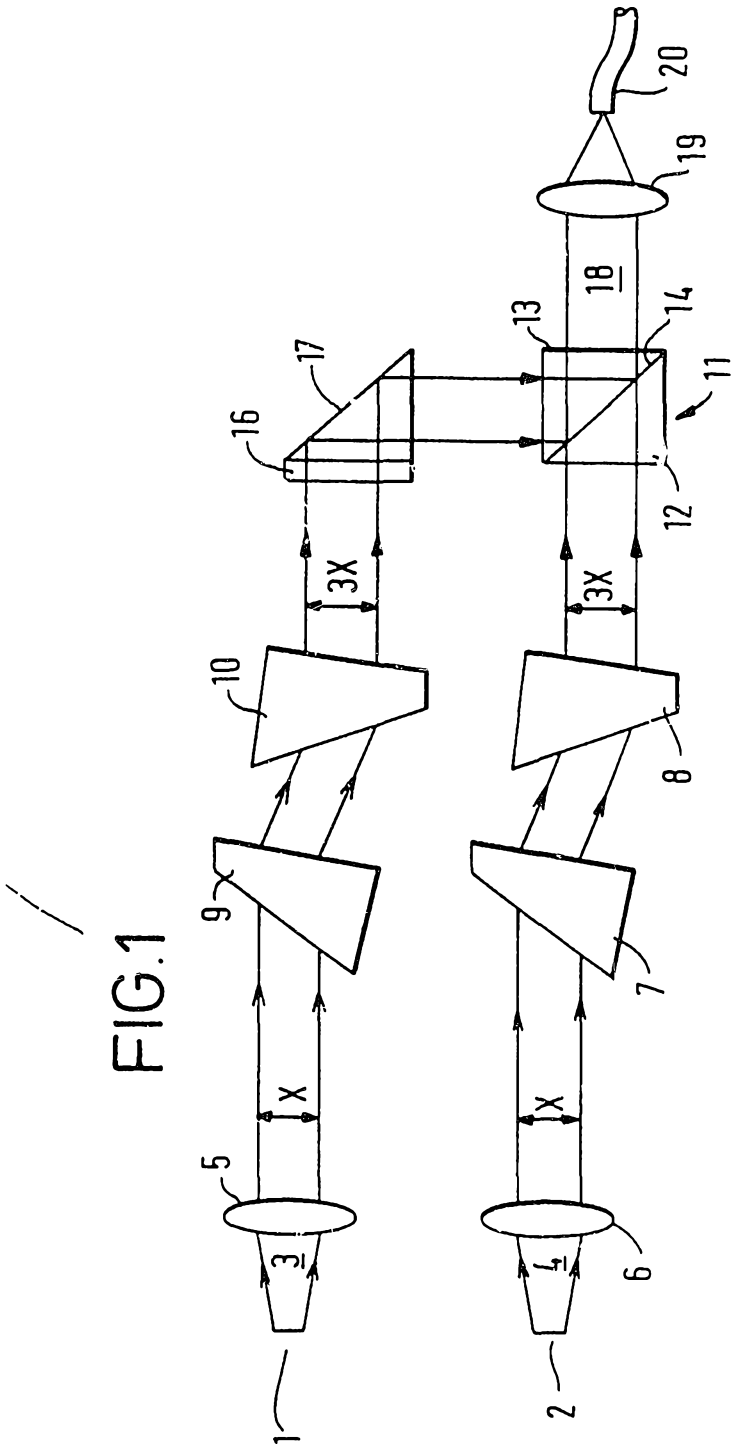


FIG.1

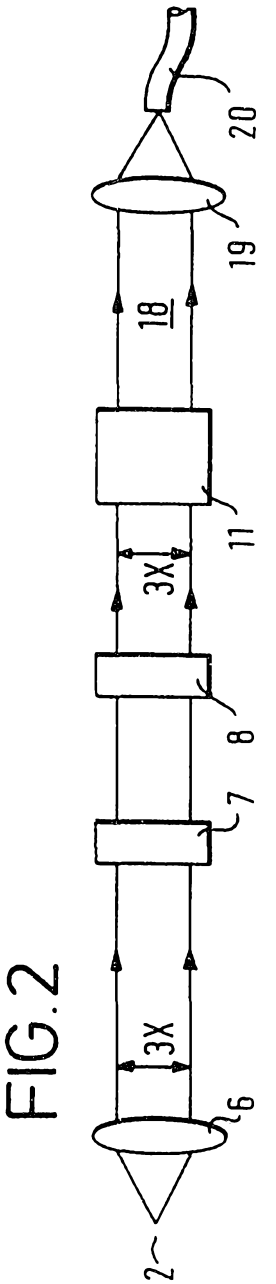


FIG.2

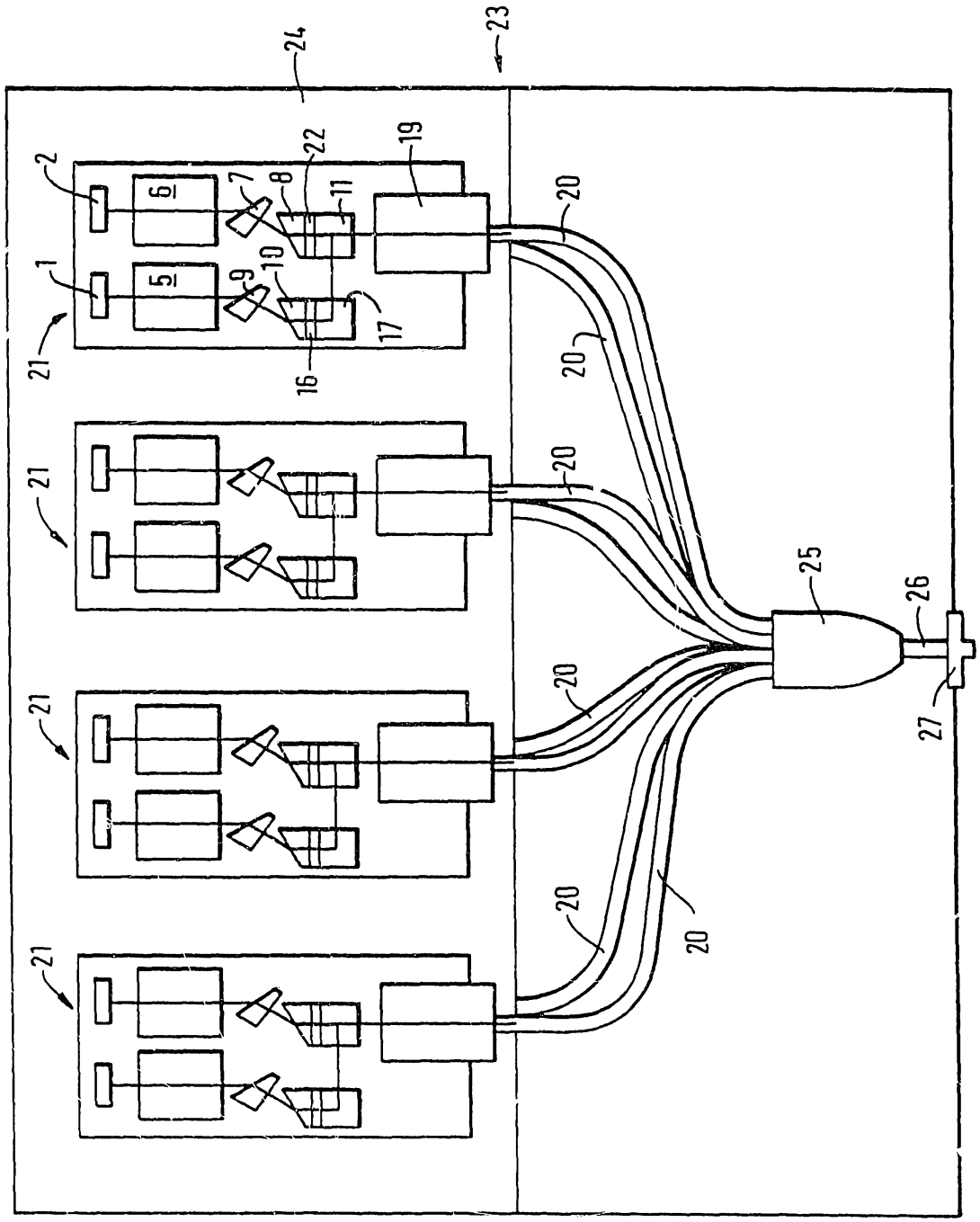


FIG.3

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/00207

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

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

IPC[5]: H 01 S 3/25, A 61 B 17/36, G 02 B 6/42

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	H 01 S, A 61 B, G 02 B, B 23 K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	Applied Optics, volume 28, no. 21, 1 November 1989, (New York, US), K. Tatsuno et al.: "Diffraction-limited circular single spot from phased array lasers", pages 4560-4568 see abstract; figures 10,13	1,5,7,8
Y		9,10,12,13
X	GB, A, 2182168 (K. TATSUNO et al.) 7 May 1987 see abstract	1,5,7,8
Y	US, A, 4763975 (D.R. SCIFRES et al.) 16 August 1988 see abstract; figures	9,10,12,13
A	US, A, 4794615 (J. BERGER et al.) 27 December 1988 see column 4, lines 6-33	1-6,9

./.

* 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

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
22nd May 1991	27 JUN 1991
International Searching Authority	Signature of Authorized Officer
EUROPEAN PATENT OFFICE	MISS T. TAZELAAR

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

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US, A, 3590248 (E.J. CHATTERTON JR) 29 June 1971 see figure 6	12,13
A	US, A, 4770653 (L. SHTURMAN) 13 September 1988 see abstract	1,11

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9100207 SA 44520

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 11/06/91
The European 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	Publication date	Patent family member(s)	Publication date
GB-A- 2182168	07-05-87	JP-A- 62098320	07-05-87
		JP-A- 62147790	01-07-87
		DE-A- 3636336	30-04-87
		US-A- 4791650	13-12-88
US-A- 4763975	16-08-88	US-A- 4818062	04-04-89
		US-A- 4820010	11-04-89
US-A- 4794615	27-12-88	None	
US-A- 3590248	29-06-71	None	
US-A- 4770653	13-09-88	AU-A- 1935088	19-01-89
		EP-A- 0365554	02-05-90
		JP-T- 2503994	22-11-90
		WO-A- 8810132	29-12-88