

SCORE Placeholder Sheet for IFW Content

Application Number: 18387089

Document Date: 11/06/2023

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

Since this was an electronic submission, there is no physical artifact folder, no artifact folder is recorded in PALM, and no paper documents or physical media exist. The TIFF images in the IFW record were created from the original documents that are stored in SCORE.

- Drawing

At the time of document entry (noted above):

- USPTO employees may access SCORE content via DAV or via the SCORE web page.
- External customers may access SCORE content via PAIR using the Supplemental Content tab.

Electronic Acknowledgement Receipt

EFS ID:	48799613
Application Number:	18387089
International Application Number:	
Confirmation Number:	7969
Title of Invention:	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER
First Named Inventor/Applicant Name:	Rudolph Huber
Customer Number:	26161
Filer:	Yunbo Guo/Cheryl Forrest
Filer Authorized By:	Yunbo Guo
Attorney Docket Number:	15540-0370006
Receipt Date:	06-NOV-2023
Filing Date:	
Time Stamp:	09:38:07
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
------------------------	----

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ADS.pdf	2226331	no	9
			e50ed899790fa367c7153c86a4c1abf89524e3e1		

Warnings:

Information:					
2		Application.pdf	155859	yes	20
			61d68afe19dee6a0609db3c5f75f234b77dd3002		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	14	
	Claims		15	19	
	Abstract		20	20	
Warnings:					
Information:					
3	Drawings-other than black and white line drawings	Drawings.pdf	1538478	no	5
			a13edccc556ca24ed2923a41446243325f7057a2		
Warnings:					
Information:					
4	Oath or Declaration filed	ExecutedDeclaration.pdf	778969	no	3
			343d433ab0cbd6287290c427874dda4e5665470b		
Warnings:					
Information:					
5	Power of Attorney	POA.pdf	1981912	no	2
			d3dcc70c274957fcb1c03ed44b71e5f03d79c11b		
Warnings:					
Information:					
6	Transmittal of New Application	PAP.pdf	87873	no	2
			94565e6b0c8871f1d855386c273186570f04a71d		
Warnings:					
Information:					
Total Files Size (in bytes):			6769422		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	15540-0370006
		Application Number	
Title of Invention	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
--------------------------	---

Inventor Information:

Inventor	1				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Rudolph		Huber		
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service					
City	Aldingen-Aixheim		Country of Residence ⁱ	DE	
Mailing Address of Inventor:					
Address 1		Johann-Maus-Strasse 2			
Address 2					
City	Ditzingen		State/Province		
Postal Code	D-71254		Country ⁱ	DE	
Inventor	2				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Wolfgang		Andreasch		
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service					
City	Weinstadt		Country of Residence ⁱ	DE	
Mailing Address of Inventor:					
Address 1		Johann-Maus-Strasse 2			
Address 2					
City	Ditzingen		State/Province		
Postal Code	D-71254		Country ⁱ	DE	
Inventor	3				Remove
Legal Name					

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	15540-0370006
		Application Number	
Title of Invention	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

Prefix	Given Name	Middle Name	Family Name	Suffix
	Martin		Huonker	
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service				
City	Dietingen		Country of Residence ⁱ	DE

Mailing Address of Inventor:

Address 1	Johann-Maus-Strasse 2			
Address 2				
City	Ditzingen	State/Province		
Postal Code	D-71254	Country ⁱ	DE	
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button. Add				

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ An Address is being provided for the correspondence information of this application.			
Customer Number	26161		
Email Address	apsi@fr.com	Add Email	Remove Email

Application Information:

Title of the Invention	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		
Attorney Docket Number	15540-0370006	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	5	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country ⁱ

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	15540-0370006
		Application Number	
Title of Invention	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	26161		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
	Continuation of	17552455	2021-12-16		
Prior Application Status	Patented	Remove			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
17552455	Division of	16398362	2019-04-30	11215761	2022-01-04
Prior Application Status	Patented	Remove			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
16398362	Continuation of	15279781	2016-09-29	10281656	2019-05-07
Prior Application Status	Patented	Remove			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
15279781	Continuation of	14300138	2014-06-09	9482821	2016-11-01

Application Data Sheet 37 CFR 1.76		Attorney Docket Number		15540-0370006	
		Application Number			
Title of Invention	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER				

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14300138	Continuation of	13639401	2012-12-20	8781269	2014-07-15
Prior Application Status	Expired				Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
13639401	a 371 of international	PCT/EP2011/055484	2011-04-08		
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.					Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)	Remove
102010003750.8	DE	2010-04-08		
Additional Foreign Priority Data may be generated within this form by selecting the Add button.				Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

- ☒ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
- NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	15540-0370006
		Application Number	
Title of Invention	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	15540-0370006
		Application Number	
Title of Invention	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant	1	Remove
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section. Clear		
☒ Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:		
Name of the Deceased or Legally Incapacitated Inventor:		
If the Applicant is an Organization check here. ☒		
Organization Name	TRUMPF Laser- und Systemtechnik GmbH	
Mailing Address Information For Applicant:		
Address 1	Johann-Maus-Strasse 2	
Address 2		
City	Ditzingen	State/Province
Country	DE	Postal Code
Phone Number		Fax Number
Email Address		
Additional Applicant Data may be generated within this form by selecting the Add button. Add		

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	15540-0370006
		Application Number	
Title of Invention	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

Assignee	1			
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
Remove				
If the Assignee or Non-Applicant Assignee is an Organization check here. ☐				
Prefix	Given Name	Middle Name	Family Name	Suffix
Mailing Address Information For Assignee including Non-Applicant Assignee:				
Address 1				
Address 2				
City		State/Province		
Country ⁱ		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.				Add

Signature:	Remove				
NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).					
This Application Data Sheet must be signed by a patent practitioner if one or more of the applicants is a juristic entity (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, all joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of all joint inventor-applicants.					
See 37 CFR 1.4(d) for the manner of making signatures and certifications.					
Signature	/Yunbo Guo/	Date (YYYY-MM-DD)	2023-11-06		
First Name	Yunbo	Last Name	Guo	Registration Number	70538
Additional Signature may be generated within this form by selecting the Add button.					Add

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	15540-0370006
		Application Number	
Title of Invention	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Method and Arrangement for Generating a Laser Beam Having a Differing Beam Profile Characteristic by a Multi-Clad Fiber

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and claims priority under 35 U.S.C. §120 to
5 U.S. Serial No. 17/552,455, filed on December 16, 2021, which is a divisional of U.S.
Serial No. 16/398,362, filed on April 30, 2019, now U.S. Patent No. 11,215,761, which is
a continuation of U.S. Serial No. 15/279,781, filed on September 29, 2016, now U.S.
Patent No. 10,281,656, which is a continuation of U.S. Serial No. 14/300,138, filed on
June 9, 2014, now U.S. Patent No. 9,482,821, which is a continuation of U.S. Serial No.
10 13/639,401, filed on December 20, 2012, now U.S. Patent No. 8,781,269, which is a 371
National Phase Application of PCT Application No. PCT/EP2011/055484 filed on April
8, 2011, which claims priority to German Application No. DE 10 2010 003750.8, filed on
April 8, 2010. The entire contents of these priority applications are incorporated herein
by reference.

TECHNICAL FIELD

The invention concerns a method and arrangement for the generation of a laser
beam with different beam profile characteristics.

BACKGROUND

20 In materials processing by means of laser beams, different processes and
applications have different requirements for characteristic laser beam parameters such as
focal diameter, intensity distribution or beam profile quality at the processing point.
Therefore, changing a process or application in a laser machining system usually involves
the necessary resetting work, which may range from relatively simple replacement of
25 individual optical components to transfer to a different system.

For example, DE 38 33 992 A1 describes a method for achieving specific laser
beam properties in which the laser beams of two laser beam sources are coupled into a
conventional optical fiber at different coupling angles. A beam is thus created, depending

on the coupling angles of the two laser beams, with various wavelengths which are selected to suit the biological or medical processing task at hand. In addition to the use of two laser sources, this method may also employ just one laser source with a variable wavelength. The coupling conditions into the optical fiber depend greatly on the wavelength here. However, if, for example, the applications do not have different wavelengths or rather even require the use of a single wavelength, the method outlined proves not to be optimum on account of its disproportionate complexity for such cases and its limiting specialization in applications of a different type. Moreover, the method proposed is limited to the beam formation dependent on the wavelength which, in turn, leads to limitations for its potential applications.

SUMMARY

Therefore, the object of the present invention is to indicate a method for generating a laser beam with different laser beam profile characteristics which, using several laser beam sources or just one laser beam source, in particular with a single wavelength, allows an application-specific change to the laser beam characteristics with relatively little effort, and to provide an arrangement for this method. A further aim is to expand the range of adaptation potential of beam profile characteristics to miscellaneous applications as far as possible, while reducing the complexity of the arrangement and the method.

In accordance with the invention, this object is solved by a method in which a laser beam is coupled into one fiber end of a multi-clad fiber, in particular a double-clad fiber, and coupled out of the other end of the multi-clad fiber and, to generate different beam profile characteristics of the output laser beam, the input laser beam is electively coupled either at least into the inner fiber core of the multi-clad fiber or at least into at least one outer ring core of the multi-clad fiber or, however, electively a first laser beam is coupled at least into the inner fiber core of the multi-clad fiber and a different, second laser beam is coupled at least into at least one outer ring core of the multi-clad fiber.

In this invention, a multi-clad fiber means a fiber with one inner fiber core and at least one outer ring core, for example a double-clad fiber with a single outer ring core or also a triple-clad fiber with an additional outer ring core adjacent to the first outer ring

core. To change the beam profile characteristics of the output laser beam, the input laser beam is coupled variously into one or more of the cores of the multi-clad fiber.

For the sake of simplicity, the invention will be described in the following using a double-clad fiber. It will be clear to an expert that the principle of the invention can easily
5 also be transferred to multi-clad fibers with additional outer ring cores adjacent to the first outer ring core.

A double-clad fiber with two cores has an inner fiber core and cladding surrounding this fiber core that is as thin and low-refractive as possible. This is followed by a single outer ring core which is also surrounded by low-refractive second cladding.
10 This may be followed by an additional layer of glass which determines the external diameter of the fiber but has no influence on its function in terms of beam guidance. This is completed by a coating of a synthetic material such as silicone and/or nylon which serves to protect the fiber.

By using a double-clad fiber, the present invention makes it possible to choose
15 between different beam profile characteristics at the fiber output, depending on whether the beam is coupled into the inner fiber core, the outer ring core or into both the inner fiber core and the outer ring core. In material processing using laser beams, in particular using high power in the kW range, the ability to switch between these coupling variants makes it possible, for example to choose between a comparatively good beam quality
20 with a sharp focus as is required, for example, for a laser cutting process, and, in contrast, a 'reduced' beam quality with a 'blurred' focus with almost uniform intensity distribution in the beam cross-section, which is particularly suitable for welding processes.

To achieve a high laser beam quality, the laser beam is coupled into the inner fiber core of the double-clad fiber, which, in this case, behaves like a conventional
25 standard fiber, the fiber core of which is surrounded by low-refractive cladding. However, if a laser beam with a wider profile and, for example, with uniform intensity is required, the laser beam is coupled into the outer ring core or into both the inner fiber core and the outer ring core. Depending on the application, therefore, at the output of the double-clad fiber, a laser beam can be achieved with a filled circular profile in
30 accordance with the inner fiber core, with a ring profile in accordance with the outer ring core, with a filled circular profile in accordance with the two core areas together (with a

narrow missing ring through the first cladding) or with the corresponding intermediate stages of the stated profile characteristics.

In a preferred version of the method in accordance with the invention, for the elective coupling of the laser beam into the double-clad fiber, relative motion takes place between the input laser beam and the coupling-side face of the double-clad fiber in a direction transverse to the laser beam, in particular in the form of parallel displacement. If the coupling-side face of the double-clad fiber is moved transverse to the laser beam, no additional optical elements are required to switch between the various couplings. With sufficiently long free beam propagation of the laser beam before it strikes the double-clad fiber, angular deflection of the laser beam, which is also understood as deflection transverse to the axis of the coupling-side face, is also possible in order to couple the laser beam into the inner fiber core and/or into the outer ring core of the double-clad fiber. In this case, this involves rotation of the laser beam axis about a point instead of displacement, whereby the change in the angle of incidence should remain negligible for the coupling.

In another preferred version of the method in accordance with the invention, for electively coupling of the laser beam into the double-clad fiber, the input laser beam is projected with different beam cross-sections, in particular with different beam diameters, onto the coupling-side face of the double-clad fiber. These different beam diameters can be set, for example with optics that can travel along the laser beam axis such as a lens or aperture which, depending on its travel position, couples the laser beam either only into the inner fiber core or into the outer ring core or into both the inner fiber core and the outer ring core. Alternatively, a different beam cross-section or diameter can also be set by optics such as a lens or aperture being electively moved into or out of the beam path of the laser beam. In another alternative, the beam cross-section or diameter can be adapted to desired coupling conditions into the double-clad fiber using a laser source with alternative guidance options via optical fibers with different beam guidance characteristics, which can, for example, be set via the diameter of the beam guidance optical fiber core. This principle of choosing the coupling conditions into the double-clad fiber can also be applied to the use of the laser beam sources assigned to the upstream optical fibers, in particular to laser beam sources of different beam qualities.

In another preferred version of the method in accordance with the invention, for the coupling of the laser beam both into the inner fiber core and into the at least one outer ring core, the input laser beam is divided into at least two sub-beams, each of which is coupled into one of the two cores of the double-clad fiber. This allows the division of the beam power between the inner fiber core and the outer ring core to be particularly well controlled if they are to be used simultaneously. With the two sub-beams, it is also possible, in a particularly easy fashion, to omit the area of the first cladding of the double-clad fiber in connection with coupling. Specifically for applications in the high-power area, it is important that no laser beam is coupled into the first or second cladding of the double-clad fiber. Any such beam coupled into the cladding is propagated with a large angle in relation to the fiber axis in the inner fiber core or outer ring core and emerges at the fiber end also with a large angle, as a result of which connecting optics can become heated. In addition, a beam in the second cladding can destroy the coating of the fiber. To safely prevent the propagation of the laser beam in the cladding, mode strippers can be used, for example. Accordingly, it is preferred also not to couple any laser beam into the double-clad fiber during the switching process in order to prevent any propagation in the cladding. This can be done, for example, by switching the laser off or deflecting the beam into an absorber by using beam shutters.

In another aspect, the invention also concerns an arrangement suitable for implementing the method described above. The arrangement in accordance with the invention comprises a double-clad fiber with one inner fiber core and at least one outer ring core and a switchable device with at least two switch positions in which the input laser beam is electively coupled either at least into the inner fiber core of the double-clad fiber or at least into the at least one outer ring core of the double-clad fiber or, electively, a first laser beam is coupled at least into the inner fiber core of the multi-clad fiber and a different, second laser beam is coupled at least into one outer ring core of the multi-clad fiber.

In a preferred embodiment of the arrangement in accordance with the invention, the switchable device is formed by adjustable deflection optics which, in their at least two switch positions, deflect an input laser beam in a direction transverse to the axis of the coupling-side face of the double-clad fiber to varying extents or formed by a control

device which, in its at least two switch positions, moves the coupling-side face in a direction transverse to the input laser beam to varying extents. Deflection optics in accordance with the invention mean any adjustable optics that couples a laser beam, depending on the adjustment position, into at least partially different fiber areas of the double-clad fiber.

In another preferred embodiment of the arrangement in accordance with the invention, the switchable device is formed by mobile optics or a mobile aperture which, in their at least two switch positions, project the input laser beam with different beam cross-sections, in particular with different beam diameters, onto the coupling-side face of the double-clad fiber. The mobile optics can, for example, be prisms, plane-parallel (glass) plates, convex and concave lenses, mirrors, diffractive optical elements, etc. individually or in combinations.

It is particularly preferred for the optics to be formed by a beam divider, in particular by an optical wedge plate that can be moved into the laser beam, to divide the input laser beam into at least two sub-beams, each of which is coupled into one of the cores of the double-clad fiber. Advantageously, the division of the intensity between the inner fiber core and the outer ring core depends on how far the beam divider intervenes in the beam path. This makes it possible to adapt the intensity division and thus the beam profile of the output laser beam optimally to each application.

However, the wedge plate can also be used as a beam switch to couple the laser beam in its entirety either into the inner fiber core or into the outer ring core. Moving/displacing the coupling optics transverse to the optical axis of the laser beam causes a comparable effect. In this version, the coupling optics are located in the beam path in the switchable states, producing different beam deflections, depending on the position of the coupling optics. As the beam is not divided here and the intensities cannot be divided via sub-beams, it is preferred to deflect either into the inner fiber core or into the outer ring core and to switch between at least two states representing these positions.

Preferably, the diameter of the inner fiber core of the double-clad fiber is maximum approximately 200 μm , in particular maximum approximately 150 μm , preferably maximum approximately 120 μm . For example, with a diameter of the inner fiber core of approximately 100 μm , a good quality of the output laser beam can be

achieved for demanding laser applications, such as laser cutting processes, in connection with the beam being coupled into the inner fiber core.

The ring thickness of the at least one outer ring core of the double-clad fiber is preferably greater than or equal to the diameter of the inner fiber core. The outer ring diameter corresponds to the wider laser beam profile required for specific applications, such as laser welding, and is approximately 600 μm or 400 μm , for example, depending on the application.

In an advantageous embodiment of the arrangement in accordance with the invention, the numerical aperture of the first cladding surrounding the inner fiber core is higher than the numerical aperture of the second cladding surrounding the at least one outer ring core in a double-clad fiber. As a result, a beam coupled inadvertently into the first cladding can penetrate the second cladding and be emitted and displayed there by a mode stripper. This facilitates the adjustment of the inner fiber core and fault monitoring. For example, the first cladding has a standard numerical aperture of 0.22 (tolerance ± 0.02), whereby the second cladding in this case preferably has a numerical aperture of 0.18 (tolerance ± 0.015) and should be thick enough to guide the laser beam well, for example 10 μm thick, preferably less, such as 3 to 5 μm , with a cladding core diameter ratio (CCDR) of 1.2. The first cladding forms a conventional transport fiber with the inner fiber core.

In another preferred embodiment, the switchable device has, on the input side, at least two optical fibers via which at least two different laser beams can be supplied, whereby the switchable device electively couples one laser beam at least into the inner fiber core of the multi-clad fiber and the other laser beam at least into at least one outer ring core of the multi-clad fiber.

The embodiments described with the use of one or more laser beam sources can also be used in combination, for example within a cascaded system.

Further advantages of the invention are provided in the following description and the drawing. The embodiments shown and described should not be considered to be an exhaustive list. They are instead examples for the purposes of describing the invention. Similarly, the above-mentioned characteristics and those described below can be used individually or in any combinations.

The invention is presented in a number of embodiments in the drawing and will be described in further detail in the following description. The presentation in the figures in the drawing should only be considered to be an outline. It contains no restrictions in respect of details or dimensions and is not to scale.

DESCRIPTION OF DRAWINGS

Figs. 1, 2A, 2B, and 3 show three arrangements in accordance with the invention for generating a laser beam with different beam profile characteristics, in which a laser beam is coupled into the fiber end of a double-clad fiber and emitted from the other fiber end of the double-clad fiber.

Fig. 4 shows the radial course of the refractive index of the double-clad fiber shown in Figs. 1 to 3.

Figs. 5A, 5B and 5C show various possible beam profiles of the laser beam emitted from the double-clad fiber in Figs. 1 to 3.

Fig. 6 shows another arrangement in accordance with the invention for generating a laser beam with different beam profile characteristics, whereby, electively, a first laser beam is coupled into the inner fiber core of a double-clad fiber and a different, second laser beam is coupled both into the inner fiber core and into the outer ring core of the double-clad fiber.

DETAILED DESCRIPTION

Figs. 1 to 3 show three different arrangements 10, 20, 30 for generating a laser beam with different beam profile characteristics, whereby the laser beam is coupled into one fiber end 1a of a multi-clad fiber 1, which is a double-clad fiber 1 in the present case, and is emitted from the other fiber end 1b of the double-clad fiber 1. The input laser beam is labelled 2 and the emitted laser beam is labelled 3.

As shown in Fig. 1, the double-clad fiber 1 has an inner fiber core 4 (for example of undoped quartz glass) with a refractive index n_1 and thin first cladding 5 (for example of doped quartz glass) surrounding the inner fiber core 4, the refractive index n_2 of which is lower than n_1 . This is followed by an outer ring core 6 (for example of undoped quartz glass) with refractive index n_3 which is also surrounded by low-refractive second

cladding 7 (for example of doped quartz glass) with refractive index n_4 . The refractive indices n_1 and n_3 can be the same or different; the same applies to the refractive indices n_2 and n_4 . This may be followed by an additional layer of glass (not shown) which determines the external diameter of the fiber but has no influence on its function in terms of beam guidance. This is typically completed by a coating (not shown) of a synthetic material such as silicone and/or nylon which serves to protect the fiber.

Fig. 4 shows an outline of the radial dependence of the refractive index n within the double-clad fiber 1, where $n_1 = n_3$ and $n_2 = n_4$. The figure shows an area with radius r_1 and high refractive index n_1 corresponding to the inner fiber core 4, a ring area between radii r_1 and r_2 with lower refractive index n_2 corresponding to the first cladding 5, a ring area with external radius r_3 and high refractive index n_1 corresponding to the outer ring core 6 and, finally, the second cladding 7 with low refractive index n_2 . On account of the lower refractive index of the cladding 5, 7, light is guided in the inner fiber core 4 and in the outer ring core 6 by means of total reflection.

To change the beam profile characteristics of the emitted laser beam 3, it is possible, as described below in detail, for the input laser beam 2 striking the coupling-side face 8 of the double-clad fiber 1 to be coupled, by means of a switchable device, electively either into the inner fiber core 4 or into the outer ring core 6 or both into the inner fiber core 4 and into the outer ring core 6 of the double-clad fiber 1.

In the arrangement 10 shown in Fig. 1, the switchable device for electively coupling the laser beam 2 into the double-clad fiber 1 is formed by adjustable deflection optics 11 with two switch positions, which are represented by continuous and dotted lines. In these two switch positions, the laser beam 2 focused on the coupling-side face 8 is deflected in a direction 12 transverse to the axis of the coupling-side face 8 to varying extents, in particular displaced in parallel to varying extents. In one switch position, the laser beam 2 is coupled centrically or eccentrically to the fiber axis only into the inner fiber core 4 and in the other switch position it is coupled eccentrically to the fiber axis only into the outer ring core 6. In the first case, the emitted laser beam 3 has the beam profile shown in Fig. 5A, i.e. a narrow filled circular profile 51 corresponding to the inner fiber core 4, and a comparatively high beam quality with a sharp focus, as is required for material processing, for example for a laser cutting process. In the second case, the

emitted laser beam 3 has the wider beam profile shown in Fig. 5B, i.e. a ring profile 52 corresponding to the outer ring core 6, and a comparatively lower beam quality, as is required for material processing, for example for a laser welding process. Under suitable coupling conditions into the outer ring core 6, the emitted laser beam 3 has a top hat ring beam profile, the quality of which is suitable for many applications.

The deflection optics 11, the components of which are not shown individually in Fig. 1, are based on beam deflection principles familiar to an expert. In particular, a deflection mirror can be used here. The location of the coupling into the coupling-side face of the double-clad fiber 1 can be determined by the angular position of the deflection mirror or the deflection mirror can deflect the beam, depending on position, to various outputs which, in turn, define various coupling areas. A semireflecting deflection mirror or a deflection mirror that is only partially in the beam path can also perform the described function of a beam divider. Preferably, the deflection optics 11 contain additional means for coupling the laser beam 2 into the coupling-side face 8 of the double-clad fiber 1, such as, for example, a focusing lens, which can alternatively also be arranged before or after the deflection optics 11.

A sufficiently long double-clad fiber 1 also allows for angularly homogeneous intensity distribution in the output laser beam 3 with eccentric coupling of the laser beam 2 to the fiber axis into the inner fiber core 4 or the outer ring core 6.

If, however, the beam is coupled both into the inner fiber core 4 and into the outer ring core 6 of the double-clad fiber 1, the output laser beam 3 has the uniformly filled wide beam profile 53 shown in Fig. 5C with an omitted ring corresponding to the first cladding 5.

Alternatively (or in addition) to the deflection optics 11, the switchable device for electively coupling the laser beam 2 into the double-clad fiber 1 can also be formed, for example, by a motor-driven control device 13 which displaces the coupling-side face 8 of the double-clad fiber 1 in a direction 12 transverse to the input laser beam 2 to varying extents, whereby the laser beam 2 focused on the coupling-side face 8 can be coupled either into the inner fiber core 4 or into the outer ring core 6.

In the arrangement 20 shown in Fig. 2A, the switchable device for electively coupling the laser beam 2 into the double-clad fiber 1 is formed by adjustable

telescopic/expansion optics 21 which are shown here only in outline. In their switch positions, not shown here, the telescopic/expansion optics 21 expand the input laser beam 2 to different beam diameters. Depending on the beam diameter, the laser beam 2 is then projected by coupling optics (for example a lens) 22 with different beam diameters, in this case different focal diameters, onto the coupling-side face 8 of the double-clad fiber 1. As shown with continuous and dotted lines, the laser beam 2 is, for example, coupled centrically only into the inner fiber core 4 in one switch position of the telescopic/expansion optics 21 and coupled centrically both into the inner fiber core 4 and into the outer ring core 6 in another switch position. In the first case, the output laser beam 3 has beam profile 51 and in the second case beam profile 53.

Via the diameter of the expanded laser beam 2, the proportion of the laser beam coupled into the outer ring core 6 can be set continuously and thus also the intensity distribution into the inner fiber core 4 and the outer ring core 6, allowing the beam profile of the output laser beam 3 to be adapted to each application optimally.

In the arrangement 20 shown in Fig. 2B, the switchable device for electively coupling the laser beam 2 into the double-clad fiber 1 is formed by focusing optics 23 shown here as a lens which can be displaced along the laser beam axis to various switch positions, which are represented by continuous, dotted, and dashed and dotted lines. In these switch positions, the input laser beam 2 is coupled by the focusing optics 23 with different beam diameters onto the coupling-side face 8 of the double-clad fiber 1. In one switch position, the focused laser beam 2 is coupled centrically only into the inner fiber core 4. In the two other switch positions, the defocused laser beam 2 is coupled centrically both into the inner fiber core 4 and into the outer ring core 6. In the first case, the output laser beam 3 has beam profile 51 and in the second case beam profile 53.

In the arrangement 30 shown in Fig. 3, the switchable device for electively coupling the laser beam 2 into the double-clad fiber 1 is formed by a beam switch implemented here only by way of example as an optical wedge plate 31 which can be adjusted continuously between two end positions that are shown with continuous and dotted lines. In one of its end positions, the optical wedge plate 31 is arranged outside the beam path of the input laser beam 2 so that the entire input laser beam 2 is coupled via coupling optics (for example a lens) 32 only into the inner fiber core 4, whereby the

output laser beam 3 has beam profile 51. In its other end position, shown by the dotted line, the wedge plate 31 is arranged in the entire beam path of the laser beam 2 so that the entire laser beam 2 is deflected by the wedge plate 31 and is coupled via the coupling optics 32 only into the outer ring core 6, whereby the output laser beam 3 has beam profile 52.

Moving/displacing the coupling optics 32 transverse to the optical axis of the laser beam 2 causes a comparable effect. In this version, the coupling optics 32 are located in the beam path in the switchable states, producing different beam deflections, depending on the position of the coupling optics 32. As the beam is not divided here and the intensities cannot be divided via sub-beams, it is preferred to deflect either into the inner fiber core 4 or into the outer ring core 6 and to switch between at least two states representing these positions.

As indicated with a dotted line, partially introducing the wedge plate 31 into the input laser beam 2 creates two sub-beams 2a, 2b, so that here, for example, the optical wedge plate 31 acts as a beam divider. The first sub-beam 2a is not influenced by the wedge plate 31 and thus continues to be coupled via the coupling optics 32 into the inner fiber core 4, while the second sub-beam 2b is deflected by the wedge plate 31 in relation to the first sub-beam 2a and coupled via the coupling optics 32 into the outer ring core 6. The output laser beam 3 has beam profile 53. Partially introducing the wedge plate 31 into the input laser beam 2 therefore creates two sub-beams 2a, 2b, with a division of intensity between the inner fiber core 4 and the outer ring core 6, depending on the degree of introduction, whereby the beam profile of the output laser beam 3 can be optimally adapted to each application.

Moreover, the two sub-beams 2a, 2b offer the significant advantage that they omit the area of the first cladding 5 in connection with coupling. Specifically for applications in the high-power area, it is important that no laser beam is coupled into the inner or outer cladding 5, 7. This beam is propagated with a large angle in the inner core or outer ring core and emerges at the fiber end also with a large angle, as a result of which connecting optics can become heated. In addition, the beam in the outer cladding 7 can destroy the coating of the fiber 1.

A diameter of the inner fiber core 4 of approximately 100 μm guarantees, for typical applications with high power in the kW range, the production of good beam profile quality in connection with coupling the laser beam 2 into the inner fiber core 4. The first cladding 5 is already sufficiently thick, at approximately 10 μm , preferably at approximately 5 μm , to guide the laser beam well. With a ring thickness of the outer ring core 6 of approximately 240 μm , the external diameter of the outer ring core 6 is approximately 600 μm . For certain applications, such as laser welding, this corresponds to the necessary widening of the laser beam profile.

Fig. 6 shows another arrangement 60 for generating a laser beam with different beam profile characteristics, whereby, electively, a first laser beam 61 is coupled into the inner fiber core 4 of the double-clad fiber 1 and a different, second laser beam 62 is coupled both into the inner fiber core 4 and into the outer ring core 6 of the double-clad fiber 1. The two laser beams 61, 62, which can, for example, have different beam qualities, are guided in optical fibers 63, 64 to switching optics 65 (for example an optical switch system), shown here only in outline, which can be switched between two switch positions. In one switch position, the first laser beam 61 with the higher beam quality is coupled into the inner fiber core 4 of the double-clad fiber 1 and, in the second switch position, the second laser beam 62 is coupled both into the inner fiber core 4 and into the outer ring core 6 of the double-clad fiber 1. In the first case, the output laser beam 3 has beam profile 51 and in the second case beam profile 53. The double-clad fiber 1 leads to a laser processing machine (not shown) so that the arrangement 60 is used to switch laser beams 61, 62 with different beam qualities for the laser processing machine. However, the laser beam 62 can also only be directed at the outer ring core 6 of the double-clad fiber 1 via the switching optics 65.

Up to now, laser processing machines that are to be supplied with several laser beams of different beam qualities needed several sockets for the various optical fibers and a corresponding optical switch system to allow the various laser beams to be coupled into the following beam path. For a desired laser beam, the appropriate optical fiber cable has to be manually replugged, which is undesirable on account of an increased risk of soiling, or beam guidance optics are required on the laser processing machines themselves. This is disadvantageous as several optical fiber cables have to be laid within

the laser processing machine, the entire switching optics have to be mounted and moved on the axis system of the laser processing machine and the size of the switching optics, in connection with the space available, limits the possibilities or the possible optical concepts.

5 In the arrangement 60, the switching optics 65 are supplied on the input side by two lasers with the two laser beams of different beam qualities, and the respective laser beams 61, 62 are coupled into the central double-clad fiber 1 via the switching optics 65. In this way, the switching between the two laser beams 61, 62 is separated from the axis system of the laser processing machine and takes place outside the laser processing
10 machine itself. The laser beams are then supplied to the machine via the double-clad fiber 1. One or more additional light-guiding ring cores around the outer ring core 6 are also conceivable so that additional laser beams with different beam qualities can be guided via the switching optics 65.

15 A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

WHAT IS CLAIMED IS:

1. A method of generating a laser beam with different beam profile characteristics, comprising:

5 coupling an input laser beam into a first fiber end of a multi-clad fiber, wherein the coupling comprises electively one of

coupling the input laser beam at least into an inner fiber core of the multi-clad fiber, and

10 coupling the input laser beam at least into at least one outer ring core of the multi-clad fiber; and

emitting an output laser beam from a second fiber end of the multi-clad fiber.

2. The method of claim 1, wherein coupling the input laser beam into the first fiber end of the multi-clad fiber comprises:

15 relatively moving the input laser beam and a coupling-side face of the multi-clad fiber in a direction transverse to the input laser beam.

3. The method of claim 1, wherein coupling the input laser beam into the first fiber end of the multi-clad fiber comprises:

20 projecting the input laser beam with respectively different beam cross-sections onto the coupling-side face of the multi-clad fiber.

4. The method of claim 3, wherein the different beam cross-sections of the input laser beam comprise respectively different beam diameters.

25 5. The method of claim 1, wherein the multi-clad fiber comprises a double-clad fiber.

6. A method of generating a laser beam with different beam profile characteristics, comprising:

coupling an input laser beam into a first fiber end of a multi-clad fiber, wherein the coupling comprises electively one of

coupling a first input laser beam at least into the inner fiber core of the multi-clad fiber, and

5 coupling a second, different input laser beam at least into the at least one outer ring core of the multi-clad fiber; and

emitting an output laser beam from a second fiber end of the multi-clad fiber.

7. The method of claim 6, wherein coupling the input laser beam into the first fiber
10 end of the multi-clad fiber comprises:

dividing the input laser beam into at least two sub-beams including a first sub-beam and a second sub-beam; and

coupling the first sub-beam into the inner fiber core of the multi-clad fiber as the first input laser beam and the second sub-beam into the outer ring core of the multi-clad
15 fiber as the second input laser beam.

8. The method of claim 6, wherein the multi-clad fiber comprises a double-clad fiber.

20 9. A system for generating a laser beam with different beam profile characteristics, comprising:

a multi-clad fiber having one inner fiber core and at least one outer ring core; and

a switchable device with at least two switch positions, the switchable device configured to couple an input laser beam into a first fiber end of the multi-clad fiber by
25 electively coupling one of

the input laser beam into the inner fiber core of the multi-clad fiber, and

the input laser beam into the at least one outer ring core of the multi-clad fiber.

30 10. The system of claim 9, wherein the switchable device comprises adjustable optical deflector configured to, in the at least two switch positions, deflect the input laser

beam in a direction transverse to an axis of a coupling-side face of the multi-clad fiber to varying extents.

11. The system of claim 10, wherein the optical deflector comprises an optical device
5 that is positionable in the at least two switch positions transverse to an optical axis of the input laser beam.

12. The system of claim 11, wherein the optical device is arrangeable in one of the
10 switch positions outside a beam path of the input laser beam and in at least one other of the switch positions at least partially in the beam path of the laser beam.

13. The system of claim 11, wherein the optical device comprises an optical wedge plate.

14. The system of claim 9, wherein the switchable device comprises a controller
15 configured to, in the at least two switch positions, move a coupling-side face of the multi-clad fiber in a direction transverse to the input laser beam to varying extents.

15. The system of claim 9, wherein the switchable device comprises an adjustable
20 optical device configured to, in the at least two switch positions, project the input laser beam with different beam cross-sections onto a coupling-side face of the multi-clad fiber.

16. The system of claim 15, wherein the adjustable optical device is configured to be
25 moved back and forth along an optical axis of the input laser beam axis between the at least two switch positions.

17. The system of claim 9, wherein the switchable device comprises an adjustable
aperture configured to, in the at least two switch positions, project the input laser beam
with different beam cross-sections onto a coupling-side face of the multi-clad fiber.

18. The system of claim 9, wherein a diameter of the inner fiber core of the multi-clad fiber is no more than 200 μm .

19. The system of claim 9, wherein a ring thickness of the at least one outer ring core of the multi-clad fiber is no smaller than a diameter of the inner fiber core.

20. The system of claim 9, wherein, for the multi-clad fiber, a numerical aperture of a first cladding surrounding the inner fiber core is higher than a numerical aperture of a second cladding surrounding the at least one outer ring core.

21. The system of claim 9, wherein the switchable device comprises two optical fibers on an input side, via which the first and second sub-beams are supplied, whereby the switchable device electively couples the first sub-beam at least into the inner fiber core of the multi-clad fiber and the second sub-beam at least into at least the one outer ring core of the multi-clad fiber.

22. A system for generating a laser beam with different beam profile characteristics, comprising:

- a multi-clad fiber having one inner fiber core and at least one outer ring core; and
- a switchable device with at least two switch positions, the switchable device configured to couple an input laser beam into a first fiber end of the multi-clad fiber by electively coupling one of
 - a first input laser beam at least into the inner fiber core of the multi-clad fiber, and
 - a second, different input laser beam at least into the at least one outer ring core of the multi-clad fiber.

23. The system of claim 22, wherein the switchable device comprises a beam divider configured to be moved into the input laser beam to divide the input laser beam into at least two sub-beams, each of the at least two sub-beam being coupled into a respective one of the cores of the multi-clad fiber.

24. The system of claim 22, wherein a diameter of the inner fiber core of the multi-clad fiber is no more than 200 μm .

5 25. The system of claim 22, wherein a ring thickness of the at least one outer ring core of the multi-clad fiber is no smaller than a diameter of the inner fiber core.

26. The system of claim 22, wherein, for the multi-clad fiber, a numerical aperture of a first cladding surrounding the inner fiber core is higher than a numerical aperture of a
10 second cladding surrounding the at least one outer ring core.

27. The system of claim 22, wherein the switchable device comprises two optical fibers on an input side, via which the first and second input laser beams are supplied, whereby the switchable device electively couples the first input laser beam at least into
15 the inner fiber core of the multi-clad fiber and the second sub-beam at least into at least one outer ring core of the multi-clad fiber.

ABSTRACT

Methods and systems for generating a laser beam with different beam profile characteristics are provided. In one aspect, a method includes coupling an input laser beam into one fiber end of a multi-clad fiber, in particular a double-clad fiber and
5 emitting an output laser beam from the other fiber end of the multi-clad fiber. To generate different beam profile characteristics of the output laser beam, the input laser beam is electively coupled either at least into the inner fiber core of the multi-clad fiber or at least into at least one outer ring core of the multi-clad fiber, or a first sub-beam of the input laser beam is coupled into at least into the inner fiber core of the multi-clad
10 fiber and a second, different sub-beam of the input laser beam is coupled at least into the at least one outer ring core of the multi-clad fiber.

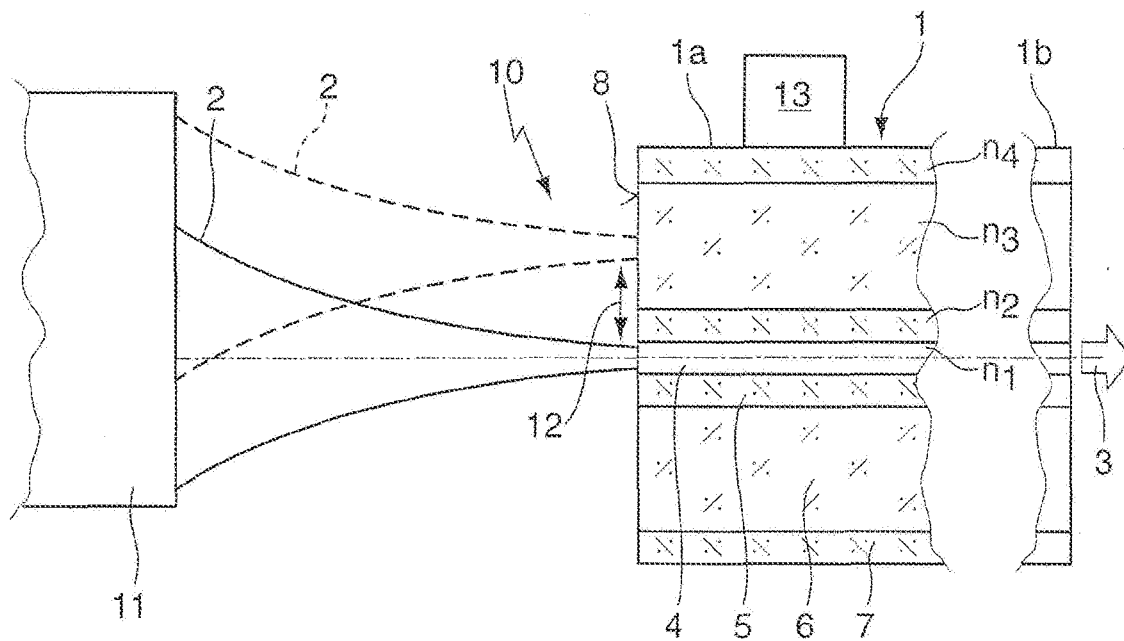


Fig. 1

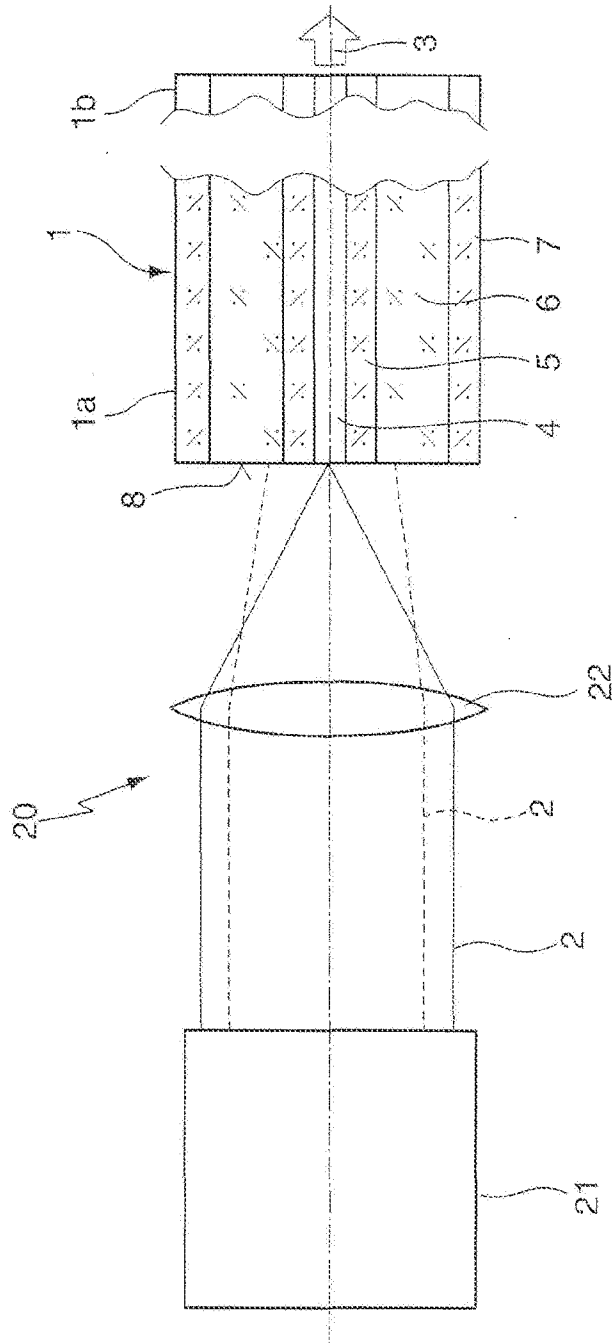


Fig. 2A

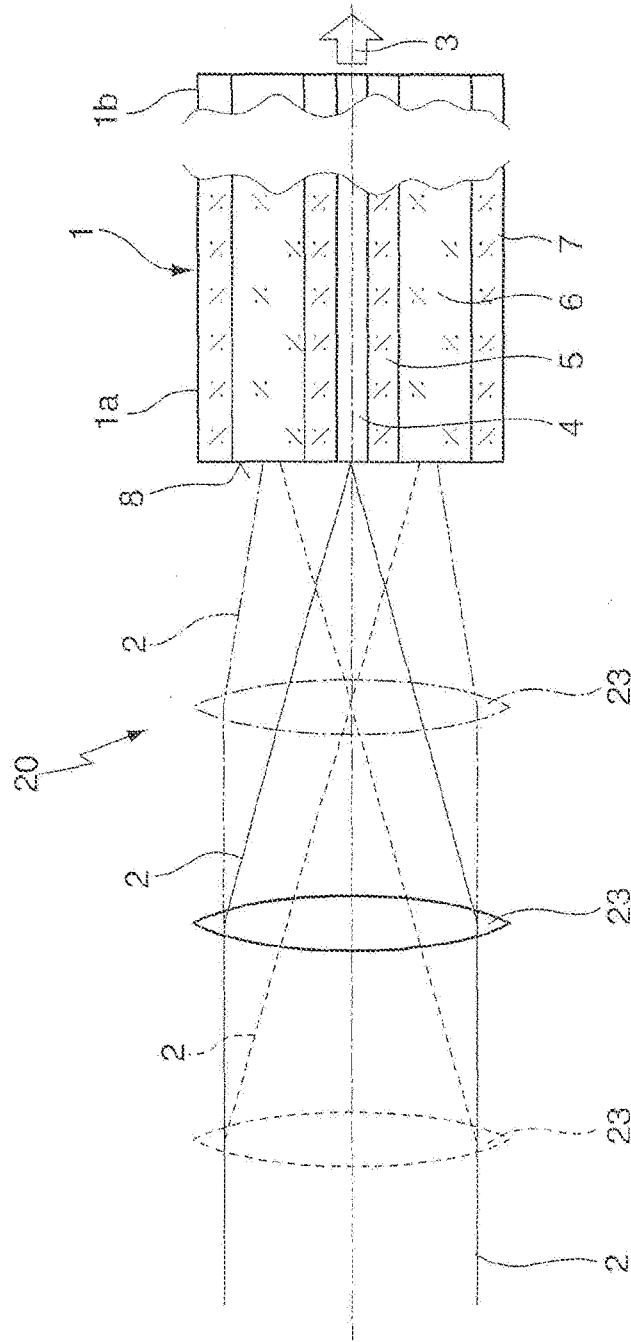


Fig. 2B

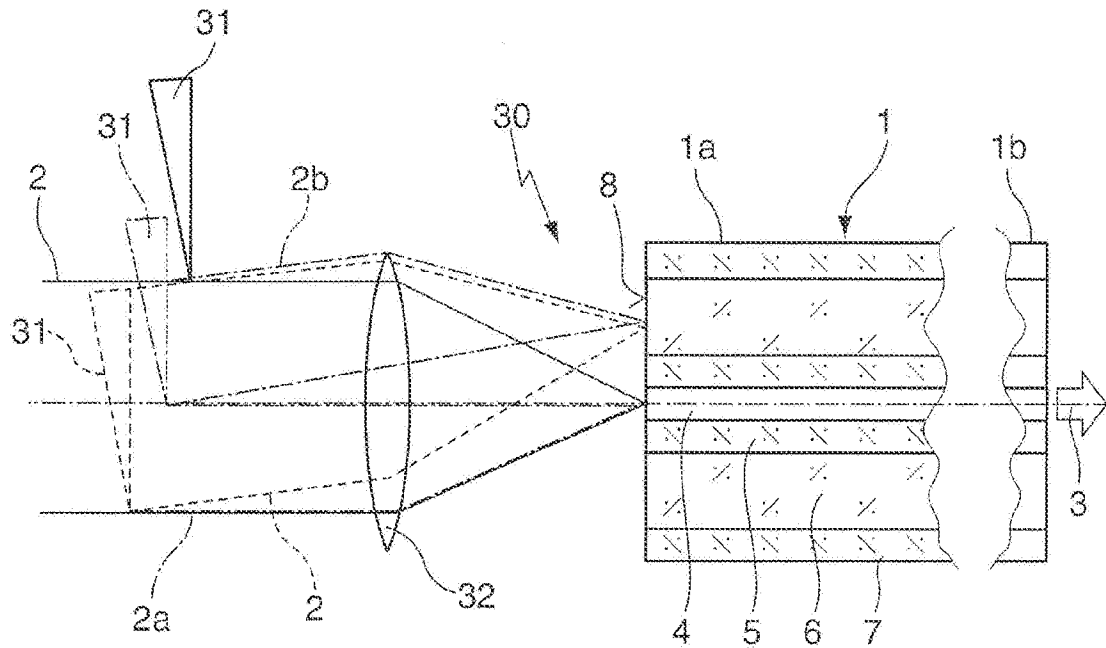


Fig. 3

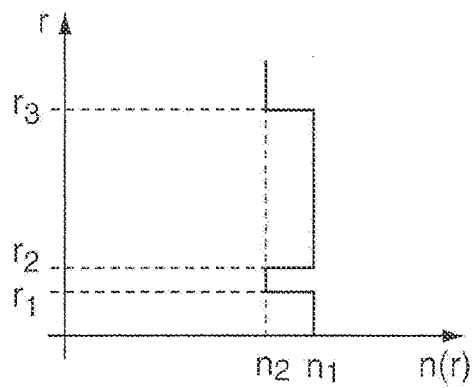


Fig. 4



Fig. 5A

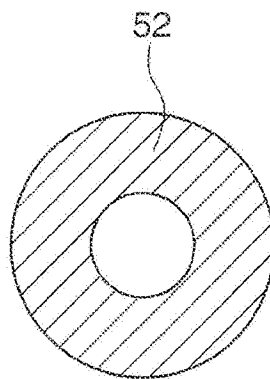


Fig. 5B

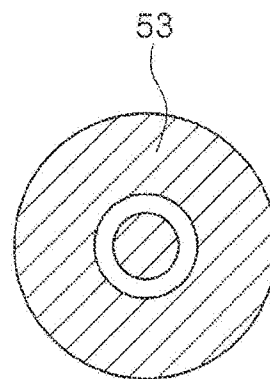
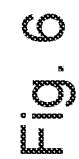


Fig. 5C



18.01127
TLS51024

Attorney Docket No.: 15540-0370003
/ Client Ref: SPI0120US(PCT)CON2, 18.01127, DSI0502

**ERKLÄRUNG (37 CFR 1.63) FÜR UTILITY- ODER DESIGNANMELDUNG MITTELS EINES ANMELDEFORMULARS
DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET
(37 CFR 1.76)**

Bezeichnung der Erfindung | **METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM
Title of Invention** | **PROFILE CHARACTERISTIC BY MEANS OF A MULTI-CLAD FIBER**

Als unten benannter Erfindern erkläre ich hiermit:
As the below named inventor, I hereby declare that:

Diese Erklärung
bezieht sich auf:
This declaration
is directed to:

- ☐ Die beigefügte Anmeldung, oder
The attached application, or
- ☒ United States Anmeldung oder PCT internationale Anmeldung mit der Anmeldenummer 15/279.781
eingereicht am September 29, 2016
United States application or PCT International application number 15/279.781
filed on September 29, 2016.

Die oben genannte Anmeldung wurde von mir gefertigt oder autorisiert.
The above-identified application was made or authorized to be made by me.

Ich glaube, dass ich der ursprüngliche Erfinder oder ein ursprünglicher Miterfinder einer beanspruchten Erfindung in der Anmeldung bin.
I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

Ich nehme hiermit zur Kenntnis, dass jede vorsätzliche falsche Aussage in dieser Erklärung gemäß 18 USC 1001 mit Geldstrafe oder mit Freiheitsstrafe
von bis zu fünf (5) Jahren, oder mit beidem ahndbar ist.
I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more
than five (5) years, or both.

**HINWEIS:
WARNING:**

Der Antragsteller / Anmelder wird darauf hingewiesen, in Dokumenten in einer Patentanmeldung die Übermittlung solcher persönlicher Daten, die
zu einem Identitätsmissbrauch führen können, zu vermeiden. Persönliche Daten wie Sozialversicherungsnummern, Kontonummern oder
Kreditkartennummern (außer dem Scheck- oder Kreditkartenermächtigungsformular PTO-2038 für Zahlungszwecke) werden durch das USPTO
im Rahmen eines Antrags oder einer Anmeldung niemals erhoben. Wenn in Unterlagen, die das USPTO erhalten wird, solche persönliche Daten
enthalten sind, dann wird dem Antragsteller/Anmelder oder den Antragstellern/Anmeldern empfohlen, solche Daten vor Absendung an das
USPTO zu entfernen. Der Antragsteller / Anmelder wird darauf hingewiesen, dass die Unterlagen einer Patentanmeldung nach Veröffentlichung
der Anmeldung der Öffentlichkeit zugänglich sind (es sei denn, bei Anmeldung wurde ein Nichtveröffentlichungsantrag gemäß 37 CFR 1.213(a)
gestellt), spätestens jedoch nach Patenterteilung. Darüber hinaus können die Unterlagen einer abgebrochenen Patentanmeldung ebenfalls der
Öffentlichkeit zugänglich sein, wenn die in einer veröffentlichten Anmeldung oder in einem erteilten Patent auf diese verwiesen wird (siehe 37
CFR 1.14). Das Scheck- und das Kreditkartenermächtigungsformular PTO-2038 für Zahlungszwecke sind nicht in den der Öffentlichkeit
zugänglichen Unterlagen der Anmeldung und sind somit nicht öffentlich zugänglich.

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identify
theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card
authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type
of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal
information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is
available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the
application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application
is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted
for payment purposes are not retained in the application file and therefore are not publicly available.

**RECHTSGÜLTIGER NAME DES ERFINDERS
LEGAL NAME OF INVENTOR**

Erfinder: Rudolph Huber
Inventor: _____

Datum (freiwillig): 17.11.2016
Date (Optional): _____

Unterschrift: _____

Signature: _____

Hinweis: Ein Anmeldeformular (PTO/AIA/14 oder gleichwertig), einschließlich der Benennung aller Rechtsträger der Erfindung, muss dieses Formular beigelegt sein,
oder muss zuvor eingereicht worden sein. Verwenden Sie ein zusätzliches PTO/AIA/01-Formular für jeden weiteren Erfinder.
Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously
filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the
USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete,
including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount
of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S.
Department of Commerce, P.O. Box 1460, Alexandria, VA 22313-1460. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner
for Patents, P.O. Box 1460, Alexandria, VA 22313-1460. If you need assistance in completing the form, call 1-800-PTO-9198 and select option 2.

23571744.doc

18.01127
TW57000

Attorney Docket No.: 15540-0370003
Client Ref: SP10120US(PCT)CON2, 18.01127, DS10502

**ERKLÄRUNG (37 CFR 1.63) FÜR UTILITY- ODER DESIGNANMELDUNG MITTELS EINES ANMELDEFORMULARS
DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET
(37 CFR 1.76)**

Bezeichnung der Erfindung / Title of Invention METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY MEANS OF A MULTI-CLAD FIBER

Als unten benannter Erfinderm erkläre ich hiermit:
As the below named inventor, I hereby declare that:

Diese Erklärung bezieht sich auf:
This declaration is directed to:

☐ Die beigefügte Anmeldung, oder
The attached application, or

☒ United States Anmeldung oder PCT internationale Anmeldung mit der Anmelde­nummer 15/279.781
eingereicht am September 29, 2016.
United States application or PCT international application number 15/279.781
filed on September 29, 2016.

Die oben genannte Anmeldung wurde von mir getätigt oder autorisiert.
The above-identified application was made or authorized to be made by me.

Ich glaube, dass ich der ursprüngliche Erfinder oder ein ursprünglicher Miterfinder einer beanspruchten Erfindung in der Anmeldung bin.
I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

Ich nehme hiermit zur Kenntnis, dass jede vorsätzliche falsche Aussage in dieser Erklärung gemäß 18 USC 1001 mit Geldstrafe oder mit Freiheitsstrafe von bis zu fünf (5) Jahren, oder mit beidem ahndbar ist.
I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

**HINWEIS:
WARNING:**

Der Antragsteller / Anmelder wird darauf hingewiesen, in Dokumenten in einer Patentanmeldung die Übermittlung solcher persönlicher Daten, die zu einem Identitätsmissbrauch führen können, zu vermeiden. Persönliche Daten wie Sozialversicherungsnummern, Kontonummern oder Kreditkartennummern (außer dem Scheck- oder Kreditkartenermächtigungsformular PTO-2038 für Zahlungszwecke) werden durch das USPTO im Rahmen eines Antrags oder einer Anmeldung niemals erhoben. Wenn in Unterlagen, die das USPTO erhalten wird, solche persönliche Daten enthalten sind, dann wird dem Antragsteller/Anmelder oder den Antragstellern/Anmeldern empfohlen, solche Daten vor Absendung an das USPTO zu entfernen. Der Antragsteller / Anmelder wird darauf hingewiesen, dass die Unterlagen einer Patentanmeldung nach Veröffentlichung der Anmeldung der Öffentlichkeit zugänglich sind (es sei denn, bei Anmeldung wurde ein Nichtveröffentlichungsantrag gemäß 37 CFR 1.213(a) gestellt), spätestens jedoch nach Patenterteilung. Darüber hinaus können die Unterlagen einer abgebrochenen Patentanmeldung ebenfalls der Öffentlichkeit zugänglich sein, wenn die in einer veröffentlichten Anmeldung oder in einem erteilten Patent auf diese verwiesen wird (siehe 37 CFR 1.14). Das Scheck- und das Kreditkartenermächtigungsformular PTO-2038 für Zahlungszwecke sind nicht in den der Öffentlichkeit zugänglichen Unterlagen der Anmeldung und sind somit nicht öffentlich zugänglich.

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

**RECHTSGÜLTIGER NAME DES ERFINDERS
LEGAL NAME OF INVENTOR**

Erfinder: Wolfgang Andreasch

Datum (freiwillig): 09.11.2016

Inventor:

Date (Optional):

Unterschrift:

Signature:

Hinweis: Ein Anmeldeformular (PTO/AIA/14 oder gleichwertig), einschließlich der Benennung aller Rechtsträger der Erfindung, muss dieses Formular beigelegt sein, oder muss zuvor eingereicht worden sein. Verwenden Sie ein zusätzliches PTO/AIA/01-Formular für jeden weiteren Erfinder.

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450. If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

15.01.27
TLS SZDhr

ERKLÄRUNG (37 CFR 1.63) FÜR UTILITY- ODER DESIGNANMELDUNG MITTELS EINES ANMELDEFORMULARS
DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET
(37 CFR 1.76)

Bezeichnung der Erfindung | **METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM**
Title of Invention | **PROFILE CHARACTERISTIC BY MEANS OF A MULTI-CLAD FIBER**

Als unten benannter Erfinderm erkläre ich hiermit:

As the below named inventor, I hereby declare that:

Diese Erklärung

bezieht sich auf:

This declaration

is directed to:



Die beigelegte Anmeldung, oder
The attached application, or



United States Anmeldung oder PCT internationale Anmeldung mit der Anmeldenummer 15/279.781
eingereicht am September 29, 2018.
United States application or PCT international application number 15/279.781
filed on September 29, 2018.

Die oben genannte Anmeldung wurde von mir getätigt oder autorisiert.

The above-identified application was made or authorized to be made by me.

Ich glaube, dass ich der ursprüngliche Erfinder oder ein ursprünglicher Miterfinder einer beanspruchten Erfindung in der Anmeldung bin.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

Ich nehme hiermit zur Kenntnis, dass jede vorsätzliche falsche Aussage in dieser Erklärung gemäß 18 USC 1001 mit Geldstrafe oder mit Freiheitsstrafe von bis zu fünf (5) Jahren, oder mit beidem ahndbar ist.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

HINWEIS:

WARNING:

Der Antragsteller / Anmelder wird darauf hingewiesen, in Dokumenten in einer Patentanmeldung die Übermittlung solcher persönlicher Daten, die zu einem Identitätsmissbrauch führen können, zu vermeiden. Persönliche Daten wie Sozialversicherungsnummern, Kontonummern oder Kreditkartennummern (außer dem Scheck- oder Kreditkartenermächtigungsformular PTO-2038 für Zahlungszwecke) werden durch das USPTO im Rahmen eines Antrags oder einer Anmeldung niemals erhoben. Wenn in Unterlagen, die das USPTO erhalten wird, solche persönliche Daten enthalten sind, dann wird dem Antragsteller/Anmelder oder den Antragstellern/Anmeldern empfohlen, solche Daten vor Absendung an das USPTO zu entfernen. Der Antragsteller / Anmelder wird darauf hingewiesen, dass die Unterlagen einer Patentanmeldung nach Veröffentlichung der Anmeldung der Öffentlichkeit zugänglich sind (es sei denn, bei Anmeldung wurde ein Nichtveröffentlichungsantrag gemäß 37 CFR 1.213(a) gestellt), spätestens jedoch nach Patenterteilung. Darüber hinaus können die Unterlagen einer abgebrochenen Patentanmeldung ebenfalls der Öffentlichkeit zugänglich sein, wenn die in einer veröffentlichten Anmeldung oder in einem erteilten Patent auf diese verwiesen wird (siehe 37 CFR 1.14). Das Scheck- und das Kreditkartenermächtigungsformular PTO-2038 für Zahlungszwecke sind nicht in den der Öffentlichkeit zugänglichen Unterlagen der Anmeldung und sind somit nicht öffentlich zugänglich.

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

RECHTSGÜLTIGER NAME DES ERFINDERS

LEGAL NAME OF INVENTOR

Erfinder: Martin Huonker

Inventor: _____

Datum (freiwillig): _____

Date (Optional): _____

Unterschrift: _____

Signature: _____

Hinweis: Ein Anmeldeformular (PTO/AIA/14 oder gleichwertig), einschließlich der Benennung aller Rechtsträger der Erfindung, muss dieses Formular beigelegt sein, oder muss zuvor eingereicht worden sein. Verwenden Sie ein zusätzliches PTO/AIA/01-Formular für jeden weiteren Erfinder.

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 118 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1480, Alexandria, VA 22313-1480. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1480, Alexandria, VA 22313-1480. If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.



November 6, 2023

Attorney Docket No.: 15540-0370006 / 18.01127; DS10502

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Street Address
Fish & Richardson P.C.
One Eleven Congress
Suite 2000
111 Congress Avenue
Austin, TX 78701

Mail Address
P.O. Box 1022
Minneapolis, MN 55440-1022
512 472 5070 main
512 320 8935 fax

Presented for filing is a new continuation patent application of:

Inventor(s): RUDOLPH HUBER, WOLFGANG ANDREASCH AND MARTIN HUONKER

Title: METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM
HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-
CLAD FIBER

The requirement for a certified copy of the foreign priority document under 37 CFR 1.55 is satisfied in this application, as the certified copy is contained in the file of the related Application No. **13/639,401**, filed **December 20, 2012**.

Enclosed are the following papers, including those required to receive a filing date under 37 CFR 1.53(b):

	<u>Pages</u>
Specification	14
Claims	5
Abstract	1
Declaration	3
Drawing(s)	5

Enclosures:

- Application Data Sheet, 9 pages.
- Power of Attorney, 2 pages.

Basic Filing Fee	\$320
Search Fee	\$700
Examination Fee	\$800
Total Claims 0 over 20	0 x \$100
Independent Claims 0 over 3	0 x \$480
Fee for Multiple Dependent claims	\$0
Application size fee for each 50 pages over 100	

Commissioner for Patents
November 6, 2023
Page 2

Total Sheets: $25 \times .75 - 100/50 = 0x$ \$0

Total Filing fee \$1820

No filing fee is being paid now.

I hereby authorize the USPTO to communicate in response to email communications from the undersigned and practitioners under Customer No. 26161 in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via email. I understand that a copy of these communications will be made of record in the application file. (MPEP 502.03).

If this application is considered to be incomplete, or if a telephone conference would otherwise be helpful, call the undersigned at +1 (512) 226-8108.

Send all correspondence to:

26161
Customer Number

Respectfully submitted,

/Yunbo Guo/

Yunbo Guo
Registration No. 70,538

Enclosures

YYG/czc
24349662.doc

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

Application Number	Unknown
Filing Date	Herewith
First Named Inventor	Rudolph Huber
Title	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER
Art Unit	
Examiner Name	
Attorney Docket Number	15540-0370006

SIGNATURE of Applicant or Patent Practitioner

Signature	/Yunbo Guo/	Date (Optional)	November 6, 2023
Name	Yunbo Guo	Registration Number	70,538
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			
NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.			
☒ *Total of <u>1</u> forms are submitted.			

POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on the Transmittal.)

- ☒ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter, which may be an application filed after the date of this power of attorney, or identified above:

26161

OR

- ☐ I hereby appoint Practitioner(s) named in the attached list as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter, which may be an application filed after the date of this power of attorney, or identified above.

Please recognize or change the correspondence address for the application identified in the attached transmittal letter to:

- ☐ The address associated with the above-mentioned Customer Number

OR

- ☒ The address associated with Customer Number: **26161**

OR

Firm or Individual Name			
Address			
City	State	Zip	
Country			
Telephone	Email		

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

TRUMPF Laser- und Systemtechnik GmbH

- ☐ Inventor or Joint Inventor (title not required below)
- ☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)
- ☒ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)
- ☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	Date (Optional)
Name	
Title	

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

- ☐ *Total of _____ forms are submitted.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
18/387,089	11/06/2023		0	15540-0370006	27	4

CONFIRMATION NO. 7969

26161
FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

FILING RECEIPT



0000000064970754

Date Mailed: 11/28/2023

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Rudolph Huber, Aldingen-Aixheim, GERMANY;
Wolfgang Andreasch, Weinstadt, GERMANY;
Martin Huonker, Dietingen, GERMANY;

Applicant(s)

TRUMPF Laser- und Systemtechnik GmbH, Ditzingen, DE;

Power of Attorney: The patent practitioners associated with Customer Number 26161

Domestic Priority data as claimed by applicant

This application is a CON of 17/552,455 12/16/2021 PAT 11,806,804
which is a DIV of 16/398,362 04/30/2019 PAT 11,215,761
which is a CON of 15/279,781 09/29/2016 PAT 10,281,656
which is a CON of 14/300,138 06/09/2014 PAT 9,482,821
which is a CON of 13/639,401 12/20/2012 PAT 8,781,269
which is a 371 of PCT/EP2011/055484 04/08/2011

Foreign Applications (You may be eligible to benefit from the Patent Prosecution Highway program at the USPTO. Please see <http://www.uspto.gov> for more information.)
GERMANY 102010003750.8 04/08/2010 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 11/24/2023

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 18/387,089**

Projected Publication Date: To Be Determined - pending completion of Missing Parts.

Non-Publication Request: No

Early Publication Request: No

Title

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING
BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: Yes

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER
Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number
18/387,089

APPLICATION AS FILED - PART I

(Column 1)		(Column 2)		SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)			RATE(\$)	FEE(\$)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A				N/A	320
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A				N/A	700
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A				N/A	800
TOTAL CLAIMS (37 CFR 1.16(i))	27	minus 20 =	*	7			x 100 =	700
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4	minus 3 =	*	1			x 480 =	480
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).							0
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))								0
			TOTAL				TOTAL	3000

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED - PART II

		(Column 1)	(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY			
AMENDMENT A		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)	
		Total (37 CFR 1.16(i))	*	Minus	**	=	x	=		x	=
		Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=		x	=
		Application Size Fee (37 CFR 1.16(s))									
		FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
						TOTAL ADD'L FEE			TOTAL ADD'L FEE		

		(Column 1)	(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY			
AMENDMENT B		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)	
		Total (37 CFR 1.16(i))	*	Minus	**	=	x	=		x	=
		Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=		x	=
		Application Size Fee (37 CFR 1.16(s))									
		FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
						TOTAL ADD'L FEE			TOTAL ADD'L FEE		

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
18/387,089	11/06/2023	Rudolph Huber	15540-0370006

CONFIRMATION NO. 7969

26161
FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

FORMALITIES LETTER



OC00000064970756

Date Mailed: 11/28/2023

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

An application number and filing date have been accorded to the above-identified nonprovisional application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee has not been received.
- The application search fee must be submitted.
- The application examination fee must be submitted.
- Additional claim fees of **\$1180** as an undiscounted entity, including any required multiple dependent claim fee, are required. Applicant must submit the additional claim fees or cancel the additional claims for which fees are due.
- Surcharge as set forth in 37 CFR 1.16(f) has not been received.

The surcharge is due for any one of:

- late submission of the basic filing fee, search fee, or examination fee,
- late submission of inventor's oath or declaration,
- filing an application that does not contain at least one claim on filing, or
- submission of an application filed by reference to a previously filed application.

SUMMARY OF FEES DUE:

The fee(s) required (including the fees noted above) are as follows. No entity status discount is in effect. If applicant is qualified for small entity status, a written assertion of small entity status must be submitted to establish small entity status. (See 37 CFR 1.27). If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- **\$320** basic filing fee.
- **\$160** surcharge.
- **\$700** search fee.
- **\$800** examination fee.

- **\$480** for 1 independent claims over 3.
- **\$700** for 7 total claims over 20.
- **\$(0)** previous unapplied payment amount.
- **\$3160** TOTAL FEE BALANCE DUE.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be addressed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

REPLY VIA ELECTRONIC FILING

A reply may be submitted via electronic filing only by registered users of the appropriate USPTO patent electronic filing system and must include:

- A separate document having the document description, "**Applicant response to Pre-Exam Formalities Notice**"; and
- the item(s) for which a reply period is set forth above.

For more information about electronic filing, contact the Patent Electronic Business Center (EBC) 1-866-217-9197 or visit <https://www.uspto.gov/ebc>

NOTE: If the reply is not being submitted electronically, a copy of this notice must be included.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/agizaw/



United States Patent and Trademark Office

Under Secretary of Commerce for Intellectual Property and
Director of the United States Patent and Trademark Office

WELCOME TO THE UNITED STATES PATENT AND TRADEMARK OFFICE (USPTO)

*Congratulations on taking the first step to protect your invention. You can now advertise or mark any products covered by this application for your invention as **"Patent Pending"** for as long as this application is pending!*

We are here to help you on the rest of your journey.

New to the process? The Patent Basics page will take you from "What is a patent?" to assistance with the application process.

- www.uspto.gov/PatentBasics

Consider cost savings. You might qualify for small entity or micro entity status, which means a discount on most USPTO patent fees.

- www.uspto.gov/EntityStatus

Become a registered electronic filer (eFiler). You'll gain access to the full capabilities of Patent Center. As a registered eFiler, you can electronically view your submission, track the progress of your application, and respond to USPTO correspondence.

- www.uspto.gov/NewPatentFilers

Learn how to identify which of your creative ideas might be intellectual property assets and how to protect them by using the USPTO Intellectual Property (IP) Identifier.

- ipidentifier.uspto.gov

We also provide Pro Se Assistance, support specifically geared for **independent inventors without an attorney or agent**. Follow the link below, call us at 866-767-3848, or email proseassistancecenter@uspto.gov.

- www.uspto.gov/ProSePatents

Need help near you? We have regional offices across the country, as well as Patent and Trademark Resource Centers in libraries in nearly every state, with specialists standing by to help you at no cost.

- www.uspto.gov/locations
- www.uspto.gov/ptrc

Contact us:

- **General information:** USPTO Contact Center
 - www.uspto.gov/help
- **Patent Center:**
 - Patent Electronic Business Center
 - www.uspto.gov/EBC
- **Pre or post-examination:** Application Assistance Unit
 - www.uspto.gov/PatentAssistance

Want to learn more?

- **Access our free services** all in one spot. Find all of our contact centers, nationwide services, events, education, and training.
 - www.uspto.gov/FreeServices
- **Connect with us** on Instagram, LinkedIn, Twitter, Facebook, and YouTube.
- **Hear about resources for startups, inventors, and entrepreneurs**, as well as our initiatives engaging women, the military community, and others. These programs offer helpful tips and tricks on identifying and managing your IP, finding options for funding, and expanding your network to support your business.
 - www.uspto.gov/startups
 - www.uspto.gov/inventors
 - www.uspto.gov/initiatives
- We hope you connect with us by subscribing to receive important notifications by email.
 - www.uspto.gov/subscribe

Kathi Vidal

Under Secretary of Commerce for Intellectual Property and
Director of the United States Patent and Trademark Office

Derrick Brent

Deputy Under Secretary of Commerce for Intellectual Property and
Deputy Director of the United States Patent and Trademark Office



ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/387,089

RECEIPT DATE / TIME
01/19/2024 12:51:12 PM Z ET

ATTORNEY DOCKET #
15540-0370006

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 7969

FILED BY Cheryl Forrest

PATENT CENTER # 64014795

FILING DATE 11/06/2023

CUSTOMER # 26161

FIRST NAMED INVENTOR Rudolph Huber

CORRESPONDENCE ADDRESS -

AUTHORIZED BY Yunbo Guo

Documents

TOTAL DOCUMENTS: 4

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ReplyNTFMP.pdf	1	Applicant Response to Pre-Exam Formalities Notice	56 KB
PrelimAmend.pdf	7	-	73 KB
PrelimAmend-A.PE.pdf (1-1)	1	Preliminary Amendment	53 KB
PrelimAmend-CLM.pdf (2-6)	5	Claims	67 KB
PrelimAmend-REM.pdf (7-7)	1	Applicant Arguments/Remarks Made in an Amendment	53 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
ReplyNTFMP.pdf	BA2FD5E62D94D7949E03C7FE20190D3F3A11A308ECEC4DFD D1879435BDA59C923C5357F4011154D74CC998DB3BE1C72FA 8FC3615D83E74282F243136110734FB
PrelimAmend.pdf	E831346AE2AFEE5669CAFA677B9F854CDA63ECE454B63761D 3DF993386A9A125059A88346F2D427A5869A9E036DE76A5ABF AFF1523C8EDAE7C0943E5F88DC486
PrelimAmend-A.PE.pdf	BC5D6A76D5289DBB8505E7B6D02AC96CEE071254640EA4B2 8942F78444FD783064AF33387A4EDCF9AB3447BAA2E07D3C6 0FBF8CD5EF392DC6355C444E286CFBC
PrelimAmend-CLM.pdf	BD57CCA66D6416159A7E8580CC371579195CFD8E4B83CD84 B1935C03D7E17AE4E3EFA4DFF80ACD4F074F80DD2F5A4E1A 5B94622DBE07BE6233956ADB05AFE7B8
PrelimAmend-REM.pdf	15F15017094FF950507A89CD3051CDDFEB988D0726BF4AF41 A20BA4FA8CF6389F1630A202ADC7F96D4897F32C604D17EBB FD8B987168EF5A83DE87DED6403C5F

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #
18/387,089

RECEIPT DATE / TIME
01/19/2024 12:51:12 PM Z ET

ATTORNEY DOCKET #
15540-0370006

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	7969	FILED BY	Cheryl Forrest
PATENT CENTER #	64014795	AUTHORIZED BY	Yunbo Guo
CUSTOMER #	26161	FILING DATE	11/06/2023
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Rudolph Huber

Payment Information

PAYMENT METHOD DA / 061050	PAYMENT TRANSACTION ID E20241IC51497656	PAYMENT AUTHORIZED BY Cheryl Forrest
-------------------------------	--	---

FEE CODE	DESCRIPTION	ITEM PRICE(\$)	QUANTITY	ITEM TOTAL(\$)
1051	SURCHARGE- LATE FILING FEE, SEARCH FEE, EXAMINATION FEE, INVENTOR'S OATH OR DECLARATION, OR APPLICATION FILED WITHOUT AT LEAST ONE CLAIM OR BY REFERENCE	160.00	1	160.00
1111	UTILITY PATENT APPL. SEARCH FEE	700.00	1	700.00
1011	BASIC FILING FEE - UTILITY (PAPER FILING ALSO REQUIRES NON-ELECTRONIC FILING FEE UNDER 1.16(T))	320.00	1	320.00

1311	PATENT APPL. EXAMINATION FEE	800.00	1	800.00
TOTAL AMOUNT:				\$1,980.00

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor : Rudolph Huber Art Unit : Unknown
Application No. : 18/387,089 Examiner : Unknown
Filed : November 6, 2023 Conf. No. : 7969

Title : METHOD AND ARRANGEMENT FOR GENERATING A LASER
BEAM HAVING A DIFFERING BEAM PROFILE
CHARACTERISTIC BY A MULTI-CLAD FIBER

MAIL STOP MISSING PARTS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY TO NOTICE TO FILE MISSING PARTS OF APPLICATION

In response to the Notice to File Missing Parts of Application under 37 CFR §1.53(b) dated November 28, 2023, applicant as a large entity submits herewith the following:

- ☒ Payment of the basic filing fee of \$320;
- ☒ Payment of the search fee of \$700;
- ☒ Payment of the examination fee of \$800; and
- ☒ Payment of the surcharge of \$160 for late filing of the basic filing fee and/or declaration.

The fees in the amount of \$1,980 are being paid with this reply on the USPTO patent electronic filing system. Apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: 01/19/2024

/Yunbo Guo/

Yunbo Guo, Reg. No. 70,538

Customer Number 26161
Fish & Richardson P.C.
Telephone: +1 (512) 226-8108
Facsimile: (877) 769-7945

24367932.doc

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Rudolph Huber	Art Unit :	Unknown
Application No. :	18/387,089	Examiner :	Unknown
Filed :	November 6, 2023	Conf. No. :	7969
Title :	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Prior to examination, please amend the application as indicated on the following pages.

AMENDMENTS TO THE CLAIMS

This listing of claims replaces all prior versions and listings of claims in the application:

1. – 27. (Cancelled).

28. (New) A system for generating a laser beam with different beam profile characteristics, the system comprising:

a multi-clad fiber having an inner fiber core and at least one outer ring core; and
a first optical fiber configured to guide a first input laser beam to the multi-clad fiber; and
a second optical fiber configured to guide a second input laser beam to the multi-clad fiber,

wherein the system is configured to couple at least one of:

the first input laser beam at least into the inner fiber core of the multi-clad fiber, or
the second input laser beam at least into the at least one outer ring core of the multi-clad fiber.

29. (New) The system of claim 28, wherein the system is configured to couple the first input laser beam only into the inner fiber core of the multi-clad fiber.

30. (New) The system of claim 28, wherein the system is configured to couple the second input laser beam only into the at least one outer ring core of the multi-clad fiber.

31. (New) The system of claim 28, wherein the multi-clad fiber comprises one or more claddings respectively around the inner fiber core and the at least one outer ring core, and
wherein the system is configured such that no laser beam is coupled into the one or more claddings.

32. (New) The system of claim 28, wherein the multi-clad fiber is configured to have at least one of:

the inner fiber core with a diameter of no greater than 200 μm ,
the at least one outer ring core with a diameter of no greater than 600 μm , or
an inner cladding with a thickness of no greater than 10 μm , the inner cladding being
between the inner fiber core and the at least one outer ring core.

33. (New) The system of claim 28, wherein the multi-clad fiber comprises the inner fiber core with a refractive index n_1 , a first cladding with a refractive index n_2 , and an outer ring core with a refractive index n_3 , and the first cladding surrounds the inner fiber core and is between the inner fiber core and the outer ring core, and
wherein $n_1 = n_3$ and $n_1 > n_2$.

34. (New) The system of claim 33, wherein the multi-clad fiber further comprises a second cladding surrounding the outer ring core, and
wherein a refractive index n_4 of the second cladding is identical to the refractive index of the first cladding n_2 .

35. (New) The system of claim 28, wherein the multi-clad fiber comprises two or more outer ring cores, and the system is configured to couple two or more corresponding input laser beams into the two or more outer ring cores.

36. (New) The system of claim 28, wherein the system is configured to generate an output laser beam with a power of at least 1 kW.

37. (New) The system of claim 28, further comprising a switchable device coupled between the first and second optical fibers and the multi-clad fiber,
wherein the switchable device is configured to electively couple the first input laser beam at least into the inner fiber core of the multi-clad fiber and the second input laser beam at least into the at least one outer ring core of the multi-clad fiber.

38. (New) A method of generating a laser beam with different beam profile characteristics, the method comprising:

guiding a first input laser beam by a first optical fiber to a fiber end of a multi-clad fiber, wherein the multi-clad fiber has an inner fiber core and at least one outer ring core;

guiding a second input laser beam by a second optical fiber to the fiber end of the multi-clad fiber;

coupling the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber, comprising at least one of:

coupling the first input laser beam at least into the inner fiber core of the multi-clad fiber, or

coupling the second input laser beam at least into the at least one outer ring core of the multi-clad fiber; and

generating an output laser beam by interaction of the first input laser beam and the second input laser beam with the multi-clad fiber, wherein a beam profile characteristic of the output laser beam differs depending upon the coupling of the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber.

39. (New) The method of claim 38, wherein coupling the first input laser beam at least into the inner fiber core of the multi-clad fiber comprises:

coupling the first input laser beam only into the inner fiber core of the multi-clad fiber.

40. (New) The method of claim 38, wherein coupling the second input laser beam at least into the at least one outer ring core of the multi-clad fiber comprises:

coupling the second input laser beam only into the at least one outer ring core of the multi-clad fiber.

41. (New) The method of claim 38, wherein the multi-clad fiber comprises one or more claddings respectively around the inner fiber core and the at least one outer ring core, and

wherein coupling the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber comprises:

coupling no laser beam into the one or more claddings.

42. (New) The method of claim 38, wherein the multi-clad fiber comprises an inner cladding between the inner fiber core and the at least one outer ring core, and

wherein the multi-clad fiber is configured to have at least one of:

the inner fiber core with a diameter of no greater than 200 μm ,

the at least one outer ring core with a diameter of no greater than 600 μm , or

the inner cladding with a thickness of no greater than 10 μm .

43. (New) The method of claim 38, wherein the multi-clad fiber comprises the inner fiber core with a refractive index n_1 , a first cladding with a refractive index n_2 , and an outer ring core with refractive index n_3 , and the first cladding surrounds the inner fiber core and is between the inner fiber core and the outer ring core, and

wherein $n_1 = n_3$ and $n_1 > n_2$.

44. (New) The method of claim 43, wherein the multi-clad fiber further comprises a second cladding surrounding the outer ring core, and

wherein a refractive index n_4 of the second cladding is identical to the refractive index of the first cladding n_2 .

45. (New) The method of claim 38, wherein the multi-clad fiber comprises two or more outer ring cores, and the method comprises:

coupling two or more corresponding input laser beams into the two or more outer ring cores.

46. (New) The method of claim 38, wherein the output laser beam has a power of at least 1 kW.

47. (New) The method of claim 38, wherein coupling the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber comprises:

electively coupling, by a switchable device coupled between the first and second optical fibers and the fiber end of the multi-clad fiber, one of

the first input laser beam at least into the inner fiber core of the multi-clad fiber and
the second input laser beam at least into the at least one outer ring core of the multi-clad fiber.

First Named Inventor : Rudolph Huber
Application No. : 18/387,089
Filed : November 6, 2023
Page : 7 of 7

Attorney Docket No.: 15540-0370006 / 18.01127;
DS10502

REMARKS

Applicant asks that all claims be examined in view of the amendment to the claims.

Please apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: 01/19/2024

/Yunbo Guo/

Yunbo Guo, Reg. No. 70,538

Customer Number 26161
Fish & Richardson P.C.
Telephone: +1 (512) 226-8108
Facsimile: (877) 769-7945

24350327.doc



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
18/387,089	11/06/2023		1980	15540-0370006	20	2

26161
FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

CONFIRMATION NO. 7969

UPDATED FILING RECEIPT



0000000067381089

Date Mailed: 01/25/2024

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Rudolph Huber, Aldingen-Aixheim, GERMANY;
Wolfgang Andreasch, Weinstadt, GERMANY;
Martin Huonker, Dietingen, GERMANY;

Applicant(s)

TRUMPF Laser- und Systemtechnik GmbH, Ditzingen, DE;

Power of Attorney: The patent practitioners associated with Customer Number 26161

Domestic Priority data as claimed by applicant

This application is a CON of 17/552,455 12/16/2021 PAT 11,806,804
which is a DIV of 16/398,362 04/30/2019 PAT 11,215,761
which is a CON of 15/279,781 09/29/2016 PAT 10,281,656
which is a CON of 14/300,138 06/09/2014 PAT 9,482,821
which is a CON of 13/639,401 12/20/2012 PAT 8,781,269
which is a 371 of PCT/EP2011/055484 04/08/2011

Foreign Applications (You may be eligible to benefit from the Patent Prosecution Highway program at the USPTO. Please see <http://www.uspto.gov> for more information.)
GERMANY 102010003750.8 04/08/2010 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 11/24/2023

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 18/387,089**

Projected Publication Date: 05/02/2024

Non-Publication Request: No

Early Publication Request: No

Title

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING
BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: Yes

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER
Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number
18/387,089

APPLICATION AS FILED - PART I

(Column 1)		(Column 2)		SMALL ENTITY		OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)	RATE(\$)	FEE(\$)	
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A		N/A	320	
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A		N/A	700	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A		N/A	800	
TOTAL CLAIMS (37 CFR 1.16(i))	20	minus 20 =	*		x	= 0	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2	minus 3 =	*		x	= 0	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).					0	
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))						0	
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL		TOTAL	1820	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OTHER THAN SMALL ENTITY	
AMENDMENT A		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)	RATE(\$)	ADDITIONAL FEE(\$)		
	Total (37 CFR 1.16(i))	*	Minus	**	=	x	=	x	=		
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=	x	=		
	Application Size Fee (37 CFR 1.16(s))										
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))										
						TOTAL ADD'L FEE		TOTAL ADD'L FEE			
AMENDMENT B		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)	RATE(\$)	ADDITIONAL FEE(\$)		
	Total (37 CFR 1.16(i))	*	Minus	**	=	x	=	x	=		
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=	x	=		
	Application Size Fee (37 CFR 1.16(s))										
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))										
						TOTAL ADD'L FEE		TOTAL ADD'L FEE			

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES
PATENT AND TRADEMARK OFFICEP.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/387,089RECEIPT DATE / TIME
04/10/2024 01:59:24 PM Z ETATTORNEY DOCKET #
15540-0370006

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM
PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 7969

FILED BY Matthew O'Brien

PATENT CENTER # 65039438

FILING DATE 11/06/2023

CUSTOMER # 26161

FIRST NAMED INVENTOR Rudolph Huber

CORRESPONDENCE ADDRESS -

AUTHORIZED BY Yunbo Guo

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
IDS.pdf	5	Information Disclosure Statement (IDS) Form (SB08)	143 KB

Warning: This is not a USPTO supplied IDS fillable form. Data in the form cannot be
automatically loaded to other USPTO systems.

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
IDS.pdf	09A9793045CE2495F35480D9C0645419AEE465899746048FC9 C48AB4C6DD5DF8F1DFF04E9D51D806AB3E18E418934D0EB1

A084D5BDCA5DFCD279B41F05CDDD6F

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Rudolph Huber	Art Unit :	Unknown
Application No. :	18/387,089	Examiner :	Unknown
Filed :	November 6, 2023	Conf. No. :	7969
Title :	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

MAIL STOP AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT

Please consider the documents listed on the disclosure form submitted with this statement. Copies of the documents are being submitted with this statement to the extent required under 37 C.F.R. § 1.98(a)(2).

This application relies on the earlier filing date of application number 17/552,455, filed on December 16, 2021, application number 16/398,362, filed on April 30, 2019, application number 15/279,781, filed on September 29, 2016, application number 14/300,138, filed on June 9, 2014, and application number 13/639,401, filed on December 20, 2012. Under 37 CFR § 1.98(a)(2) and 37 CFR § 1.98(d), the earlier application is properly identified and is relied on for an earlier effective filing date under 35 U.S.C. § 120 and therefore copies of foreign and non-patent literature documents cited in the earlier application are not provided. Copies of U.S. patents and U.S. patent application publications also are not provided.

This statement is being filed before the receipt of a first action on the merits.

First Named Inventor : Rudolph Huber
Application No. : 18/387,089
Filed : November 6, 2023
Page : 2 of 2

Attorney Docket No.: 15540-0370006 / 18.01127;
DS10502

Apply any necessary charges or credits applicable under 37 C.F.R. § 1.17(p) to deposit account 06-1050, referencing the above attorney docket number.

Please contact the undersigned if there are any questions regarding this statement.

Respectfully submitted,

Date: 04/10/2024

/Yunbo Guo/

Yunbo Guo, Reg. No. 70,538

Customer Number 26161
Fish & Richardson P.C.
Telephone: +1 (512) 226-8108
Facsimile: (877) 769-7945

63437944.doc

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 15540-0370006	Application No. 18/387,089
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant TRUMPF Laser- und Systemtechnik GmbH	
		Filing Date 11/6/2023	Group Art Unit Unknown

U.S. Patent Documents							
Examiner Initial	Cite No.	Document Number	Publication Date	Patentee	Filing Date If Appropriate	Class	Subclass
	1.	3,941,670	3/2/1976	Pratt			
	2.	3,975,082	8/17/1976	Winzer			
	3.	4,475,788	10/9/1984	Tomassini et al			
	4.	4,575,181	3/11/1986	Ishikawa			
	5.	5,461,692	10/24/1995	Nagel			
	6.	5,475,704	12/12/1995	Lomashevich			
	7.	5,684,642	11/4/1997	Zumoto et al			
	8.	6,819,815	11/16/2004	Corbalis et al.			
	9.	7,372,877	5/13/2008	Shirakawa et al			
	10.	7,379,237	5/27/2008	Di Teodoro et al			
	11.	7,379,648	5/27/2008	Brooks et al			
	12.	7,592,568	9/22/2009	Vamham et al			
	13.	7,720,340	5/18/2010	Lewis et al			
	14.	7,738,166	6/15/2010	Murison et al			
	15.	7,809,225	10/5/2010	Bouma et al			
	16.	7,839,902	11/23/2010	Li et al.			
	17.	7,933,479	4/26/2011	Gonthier et al			
	18.	8,008,600	8/30/2011	Nakamae et al			
	19.	8,076,632	12/13/2011	Kreysing et al			
	20.	8,094,370	1/10/2012	Lewis			
	21.	8,326,099	12/4/2012	Singer et al			
	22.	8,456,523	6/4/2013	Stork Gennant Wersborg			
	23.	8,781,269	7/15/2014	Huber et al.			
	24.	8,861,910	10/14/2014	Yun			
	25.	9,482,821	11/1/2016	Huber et al.			
	26.	9,755,739	9/5/2017	Wang et al.			

Examiner Signature	Date Considered
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 15540-0370006	Application No. 18/387,089
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant TRUMPF Laser- und Systemtechnik GmbH	
		Filing Date 11/6/2023	Group Art Unit Unknown

U.S. Patent Documents							
Examiner Initial	Cite No.	Document Number	Publication Date	Patentee	Filing Date If Appropriate	Class	Subclass
	27.	10,281,656	5/7/2019	Huber et al.			
	28.	11,215,761	1/4/2022	Huber et al.			
	29.	11,806,804	11/7/2023	Huber et al.			
	30.	2002/0071647	6/13/2002	Manzur			
	31.	2002/0168139	11/14/2002	Clarkson et al			
	32.	2002/0172485	11/21/2002	Keaton et al			
	33.	2005/0031261	2/10/2005	Tanaka			
	34.	2006/0219673	10/5/2006	Varnham et al.			
	35.	2006/0251367	11/9/2006	Seifert et al			
	36.	2006/0263024	11/23/2006	Dong et al			
	37.	2011/0305249	12/15/2011	Gapontsev et al.			
	38.	2013/0064706	3/14/2013	Schwarze et al			
	39.	2013/0223792	8/29/2013	Huber et al.			
	40.	2015/0217402	8/6/2015	Hesse et al.			
	41.	2015/0293306	10/15/2015	Huber et al.			
	42.	2015/0378184	12/31/2015	Tayebati et al.			
	43.	2017/0031105	2/2/2017	Huber et al.			
	44.	2019/0025502	1/24/2019	Zediker et al.			
	45.	2019/0118299	4/25/2019	Kangastupa et al.			
	46.	2019/0258009	8/22/2019	Huber et al.			
	47.	2022/0179153	6/9/2022	Huber et al.			

Foreign Patent Documents or Published Foreign Patent Applications							
Examiner Initial	Cite No.	Document Number	Publication Date	Country or Patent Office	Translation	Class	Subclass
	48.	CN 1580865	2/16/2005	CN	English Abstract		
	49.	DE 3833992	4/12/1990	DE	English Abstract		

Examiner Signature	Date Considered
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 15540-0370006	Application No. 18/387,089
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant TRUMPF Laser- und Systemtechnik GmbH	
		Filing Date 11/6/2023	Group Art Unit Unknown

Foreign Patent Documents or Published Foreign Patent Applications							
Examiner Initial	Cite No.	Document Number	Publication Date	Country or Patent Office	Translation	Class	Subclass
	50.	DE 3833993	4/12/1990	DE	English Abstract		
	51.	DE 4200587	4/1/1993	DE	English Abstract		
	52.	FR 0362466	9/26/1990	FR	English Abstract		
	53.	FR 2284892	4/9/1976	FR	English Abstract		
	54.	GB 2449689	12/3/2008	GB			
	55.	KR 100750511	8/13/2007	KR	English Abstract		
	56.	WO 2009/155536	12/23/2009	WO			
	57.	WO 2010009101	1/21/2010	WO			

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Cite No.	Document
	58.	DE German Office Action dated November 22, 2010
	59.	EP Extended European Search Report dated July 1, 2013
	60.	IN Office Action for Indian Application No. 8560/CHENP/2012 by Controller Ambigaapathy A, dated November 20, 2017, 6 pages (with English translation)
	61.	PCT International Search Report dated May 6, 2011

Examiner Signature	Date Considered
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
18/387,089	11/06/2023	Rudolph Huber	15540-0370006

CONFIRMATION NO. 7969

26161
FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

PUBLICATION NOTICE



OC000000072064758

Date Mailed: 05/02/2024

Title:METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Publication No.US-2024-0139866-A1

Publication Date:05/02/2024

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be viewed using the USPTO's publicly available Searchable Databases via the Patent Public Search tool at www.uspto.gov. The direct link to access the Patent Public Search tool is currently <https://ppubs.uspto.gov/pubwebapp/static/pages/ppubsbasic.html>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through Patent Center, the USPTO's electronic patent application filing and management system. The direct link to access this status information is currently <https://patentcenter.uspto.gov/>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of Patent Center.

Further assistance in electronically accessing the publication, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

Notice of References Cited	Application/Control No. 18/387,089		Applicant(s)/Patent Under Reexamination Huber et al.	
	Examiner MICHELLE R CONNELLY		Art Unit 2874	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-20060219673-A1	2006-10-05	Varnham; Malcolm Paul	B23K26/0734	219/121.85
*	B	US-5461692-A	1995-10-24	Nagel; Richard	G02B6/03627	385/38
*	C	US-7592568-B2	2009-09-22	Varnham; Malcolm Paul	B23K26/0734	219/121.73
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Country	Name	CPC Classification
	N	DE-3833992-C2	1988-10-06	DE	Hessel, Stefan	G02B6/4296
	O	JP-3645013-B2	2005-05-11	JP	ISHIMORI A	B23K26/032
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in YYYY-MM-DD format are publication dates. Classifications may be US or foreign.

<i>Index of Claims</i> 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47										
CLAIM		DATE								
Final	Original	09/07/2024								
	1	-								
	2	-								
	3	-								
	4	-								
	5	-								
	6	-								
	7	-								
	8	-								
	9	-								
	10	-								
	11	-								
	12	-								
	13	-								
	14	-								
	15	-								
	16	-								
	17	-								
	18	-								
	19	-								
	20	-								
	21	-								
	22	-								
	23	-								
	24	-								
	25	-								
	26	-								
	27	-								
	28	✓								
	29	✓								
	30	✓								
	31	✓								
	32	✓								
	33	✓								
	34	O								
	35	O								
	36	✓								
	37	O								
	38	✓								
	39	✓								
	40	✓								
	41	✓								
	42	✓								

<i>Index of Claims</i> 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

CLAIM			DATE							
Final	Original	09/07/2024								
	43	✓								
	44	○								
	45	○								
	46	✓								
	47	○								

<i>Search Notes</i> 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

CPC - Searched*		
Symbol	Date	Examiner
G02B6/3508 OR B23K26/067 OR B23K26/064 OR G02B6/02042 OR G02B6/35 OR B23K26/073 OR G02B6/03644 OR G02B6/262 OR G02B6/4206 OR G02B6/4296	09/07/2024	/MC/

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
G02B6/3508 OR B23K26/067 OR B23K26/064 OR G02B6/02042 OR G02B6/35 OR B23K26/073 OR G02B6/03644 OR G02B6/262 OR G02B6/4206 OR G02B6/4296 limited with text (see attached text search strategy)	09/07/2024	/MC/
Inventor & Assignee search	09/07/2024	/MC/
PE2E SEARCH (see attached text search strategy)	09/07/2024	/MC/

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/MICHELLE R CONNELLY/ Primary Examiner, Art Unit 2874	
--	--

<i>Search Notes</i> 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

/MICHELLE R CONNELLY/ Primary Examiner, Art Unit 2874	
--	--

(19) 日本国特許庁(JP)

(12) 特 許 公 報(B2)

(11) 特許番号
特許第3645013号
(P3645013)

(45) 発行日 平成17年5月11日(2005. 5. 11)

(24) 登録日 平成17年2月10日(2005. 2. 10)

(51) Int. Cl. ⁷	F 1
HO 1 S 3/101	HO 1 S 3/101
GO 2 B 6/02	GO 2 B 6/02 B
GO 2 B 6/18	GO 2 B 6/18
GO 2 B 6/32	GO 2 B 6/32

請求項の数 22 (全 45 頁)

(21) 出願番号	特願平7-253637	(73) 特許権者	000006013 三菱電機株式会社
(22) 出願日	平成7年9月29日(1995. 9. 29)		東京都千代田区丸の内二丁目2番3号
(65) 公開番号	特開平8-167754	(74) 代理人	100066474 弁理士 田澤 博昭
(43) 公開日	平成8年6月25日(1996. 6. 25)	(74) 代理人	100088605 弁理士 加藤 公延
審査請求日	平成13年11月19日(2001. 11. 19)	(74) 代理人	100103090 弁理士 岩壁 冬樹
(31) 優先権主張番号	特願平6-249459	(72) 発明者	久場 一樹 東京都千代田区丸の内二丁目2番3号 三 菱電機株式会社内
(32) 優先日	平成6年10月14日(1994. 10. 14)	(72) 発明者	石森 彰 東京都千代田区丸の内二丁目2番3号 三 菱電機株式会社内
(33) 優先権主張国	日本国(JP)		最終頁に続く

(54) 【発明の名称】 光伝送装置、固体レーザ装置、及びこれらを用いたレーザ加工装置

(57) 【特許請求の範囲】

【請求項1】

グレーデッドインデックス光ファイバから構成され、前記光ファイバのコア径が φ_c 、コア中心での屈折率が n_0 、コア中心とコア周囲部の屈折率差が Δn の光ファイバと、レーザ光のビームウェストでの直径が φ_0 、前記レーザ光のビーム開き角が 2θ である時、前記レーザ光が前記光ファイバの入射端面上または前記光ファイバの入射端面近傍に最小集光点を持ち、前記最小集光点での直径 φ_{in} が

$$0.5\varphi_s \leq \varphi_{in} \leq 1.5\varphi_s$$

ただし、

$$\varphi_s = (\varphi_c \varphi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}$$

となるような光ファイバ入射光学系とを備えたマルチモードレーザビームを用いたレーザ光を光ファイバで伝送する光伝送装置。

【請求項2】

レーザ光の波長を λ とした時に、前記レーザ光の集束性 $\pi\theta\varphi_0/\lambda$ の値が100以下となることを特徴とする請求項1記載の光伝送装置。

【請求項3】

光ファイバの入射端面近傍に、開口部の直径が光ファイバのコア径 φ_c よりも小さく、かつ φ_s よりも大きな値を有するアパーチャを備えたことを特徴とする請求項1から請求項2のうちのいずれか1項記載の光伝送装置。

【請求項4】

10

20

光ファイバの出射端面近傍に、開口部の直径が光ファイバのコア径 ϕ_c よりも小さく、かつ ϕ_c よりも大きな値を有するアパーチャを備えたことを特徴とする請求項 1 から請求項 2 のうちのいずれか 1 項記載の光伝送装置。

【請求項 5】

光ファイバ入射光学系は集光レンズを有しており、前記集光レンズは二枚または二組の集光レンズにより構成されたことを特徴とする請求項 1 から請求項 4 のうちのいずれか 1 項記載の光伝送装置。

【請求項 6】

光ファイバに近接している側の集光レンズはグレーデッドインデックスレンズから構成されており、前記グレーデッドインデックスレンズを前記光ファイバに近接または密着して設置したことを特徴とする請求項 5 記載の光伝送装置。 10

【請求項 7】

グレーデッドインデックスレンズの入射端近傍にアパーチャを備えたことを特徴とする請求項 6 記載の光伝送装置。

【請求項 8】

光ファイバのレーザ光入射端面でのレーザビームの大きさを計測する入射ビームモニタ装置、及び光ファイバ入射光学系の位置を移動させる移動手段をさらに備え、前記入射ビームモニタ装置からの出力をもとに前記光ファイバ入射光学系の位置を調整することを特徴とする請求項 1 から請求項 7 のうちのいずれか 1 項記載の光伝送装置。

【請求項 9】 20

光ファイバからの出射ビームを計測する出射ビームモニタ装置、及び光ファイバ入射光学系の位置を移動させる移動手段をさらに備え、前記出射ビームモニタ装置からの出力をもとに前記光ファイバ入射光学系の位置を調整することを特徴とする請求項 1 から請求項 7 のうちのいずれか 1 項記載の光伝送装置。

【請求項 10】

出射ビームモニタ装置はパワーセンサにより構成され、光ファイバの入射端面近傍にアパーチャを設置し、前記パワーセンサで検知されるレーザビームの出力が最大になるようにファイバ入射光学系を移動することを特徴とする請求項 9 記載の光伝送装置。

【請求項 11】

出射ビームモニタ装置は、光ファイバの出射側の光軸からずれた位置に設置したフォトダイオードで構成され、前記フォトダイオードの出力が最小になるようにファイバ入射光学系を移動することを特徴とする請求項 9 記載の光伝送装置。 30

【請求項 12】

出射ビームモニタ装置は、光ファイバの出射側に設置したアパーチャと前記アパーチャを通過したレーザビームを検知するパワーセンサにより構成され、前記アパーチャを通過するレーザビームのパワーが最大になるようにファイバ入射光学系を移動することを特徴とする請求項 9 記載の光伝送装置。

【請求項 13】

レーザ光を発振するレーザ発振器と、前記レーザ発振器から発振されたレーザ光を集光する集光レンズと、前記集光レンズで収束された前記レーザ光を光ファイバの入射端面に集光し、前記光ファイバで伝送する光ファイバ入射光学系を有する光伝送装置において、前記光ファイバはグレーデッドインデックス光ファイバから構成され、さらに前記光ファイバ入射光学系と前記光ファイバの入射端面の片方または両方の位置を移動させる移動手段を備え、前記光ファイバ入射光学系と前記光ファイバの入射端面の片方または両方の位置を移動させることによって前記光ファイバから出射するレーザビームの集束性を制御することを特徴とする請求項 1 から請求項 12 のうちのいずれか 1 項記載の光伝送装置。 40

【請求項 14】

請求項 1 から請求項 13 のうちのいずれか 1 項記載の光伝送装置と、光源から投光された光で励起されてレーザ媒質となり、光を発生する固体素子と、前記レーザ媒質から発生した光をレーザ光として取り出すレーザ共振器と、前記レーザ共振器内に少なくともミラ 50

ーと集光レンズとの組み合わせで構成される像転写光学系と、前記ミラーと前記集光レンズとを前記レーザ共振器の光軸方向に移動させる移動手段とを備え、前記ミラーと前記集光レンズの片方または両方を移動することにより前記光ファイバの入射端面に入射されるレーザビームのビーム直径を調節することを特徴とする固体レーザ装置。

【請求項 15】

光ファイバから出射される出射レーザビームのパワーの大きさを計測する出射ビームモニタ装置をさらに備え、前記出射ビームモニタ装置からの出力をもとにミラーと集光レンズの片方または両方を移動することを特徴とする請求項 14 記載の固体レーザ装置。

【請求項 16】

請求項 1 から請求項 13 のうちのいずれか 1 項記載の光伝送装置と、光源から投光された光で励起されてレーザ媒質となり、光を発生する固体素子と、前記レーザ媒質から発生された光をレーザ光として取り出すレーザ共振器と、前記レーザ共振器内に置かれたアパーチャ及び前記アパーチャの開口部の直径を増減する調節手段とから構成され、前記固体素子を励起するためのレーザ励起入力を一定に保ったままで、前記アパーチャの開口直径を増減することにより、前記レーザ光のパワーを調節することを特徴とする固体レーザ装置。 10

【請求項 17】

請求項 1 から請求項 13 のうちのいずれか 1 項記載の光伝送装置と、光源から投光された光で励起されてレーザ媒質となり、光を発生する固体素子と、前記レーザ媒質から発生した光をレーザ光として取り出すレーザ共振器と、該レーザ共振器内に置かれたアパーチャ及び該アパーチャをレーザ共振器の光軸方向に移動させる移動手段とから構成され、前記レーザ共振器内でレーザ励起入力一定のままで、前記アパーチャの位置を移動することにより前記レーザ光のパワーを調節することを特徴とする固体レーザ装置。 20

【請求項 18】

光源から投光された光で励起されてレーザ媒質となり、光を発生する固体素子と、前記レーザ媒質から発生した光をレーザ光として取り出すレーザ共振器と、前記レーザ光としてマルチモードレーザビームを用い、前記レーザ光を伝送する光ファイバとからなる光伝送装置を備えた固体レーザ装置において、前記光ファイバは、コア径 φ_c 、コア中心での屈折率が n_0 で、前記コア中心とコア周囲部の屈折率差が Δn のグレーデッドインデックス光ファイバから構成されており、前記レーザ共振器は曲率の等しい全反射ミラーと出力ミラーとから構成され、前記固体素子は、前記全反射ミラーと前記出力ミラー間の中心近傍に配置されたいわゆる対称型共振器内に置かれ、ある出力レベルにおける前記レーザ光のビームウェイスットの直径が φ_c 、前記レーザ光のビーム開き角が 2θ である時、前記レーザ光が前記光ファイバの入射端面上あるいはそのごく近傍に最小集光点を持ち、前記最小集光点での前記出力レベルでのレーザ光の直径 φ_{in} が 30

$$0.5\varphi_s \leq \varphi_{in} \leq 1.5\varphi_s$$

ただし、

$$\varphi_s = (\varphi_c \varphi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}$$

となるようなファイバ入射光学系を備えていることを特徴とする固体レーザ装置。

【請求項 19】

光源から投光された光で励起されてレーザ媒質となり、光を発生する固体素子と、前記レーザ媒質から発生した光をレーザ光として取り出すレーザ共振器と、前記レーザ光を伝送する光ファイバとから成る光伝送装置とを備えた固体レーザ装置において、前記光ファイバは、コア径 φ_c 、コア中心での屈折率が n_0 でコア中心とコア周囲部の屈折率差が Δn のグレーデッドインデックス光ファイバから構成され、前記固体素子は、薄板状のスラブ形状で構成され、前記レーザ共振器から取り出されたレーザ光は、x 軸 y 軸 2 つの方向で集光特性の異なる異方性を持っており、x 軸方向 y 軸方向のそれぞれにおいて前記レーザ光のビームウェイスットの直径が φ_{0x} 、 φ_{0y} 、前記レーザ光のビーム開き角が $2\theta_x$ 、 $2\theta_y$ である時、前記レーザ光が前記光ファイバの入射端面上あるいはそのごく近傍に x 軸方向、y 軸方向それぞれにおいて最小集光点を持ち、前記最小集光点での直径 φ_{inx} 、 φ_{iny} が 50

i_{ny} がそれぞれ

$$0.5 \varphi_{sx} \leq \varphi_{inx} \leq 1.5 \varphi_{sx}, \quad 0.5 \varphi_{sy} \leq \varphi_{iny} \leq 1.5 \varphi_{sy}$$

ただし、

$$\varphi_{sx} = (\varphi_c \varphi_{0x} \theta_x (2n_0 \Delta n)^{-1/2})^{1/2}$$

$$\varphi_{sy} = (\varphi_c \varphi_{0y} \theta_y (2n_0 \Delta n)^{-1/2})^{1/2}$$

となるようなファイバ入射光学系を備えたことを特徴とする固体レーザ装置。

【請求項 20】

光源から投光された光で励起されてレーザ媒質となり、光を発生する固体素子と、前記レーザ媒質から発生した光をレーザ光として取り出すレーザ共振器と、前記レーザ光を伝送する光ファイバから成る光伝送装置を備えた固体レーザ装置において、前記光ファイバは、コア径 φ_c 、コア中心での屈折率が n_0 でコア中心とコア周囲部の屈折率差が Δn のグレーデッドインデックス光ファイバから構成され、前記固体素子は、薄板状のいわゆるスラブ形状で構成され、前記レーザ共振器から取り出された前記レーザ光が x 軸 y 軸の2つの方向で集光特性の異なる異方性を持っており、 x 軸方向 y 軸方向のそれぞれにおいて、前記レーザ光のビームウェイトの直径が φ_{0x} 、 φ_{0y} 、前記レーザ光のビーム開き角が $2\theta_x$ 、 $2\theta_y$ である時、前記レーザ光は、光ファイバ入射端面上あるいはそのごく近傍に最小集光点を持ち、 $\varphi_{0x}\theta_x$ と $\varphi_{0y}\theta_y$ の大きな方の軸の前記最小集光点での直径 φ_{in} が

$$0.5 \varphi_s \leq \varphi_{in} \leq 1.5 \varphi_s$$

ただし、

$$\varphi_s = (\varphi_c \varphi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}$$

ただし、

$$\varphi_0 \theta = \text{MAX}(\varphi_{0x} \theta_x, \varphi_{0y} \theta_y)$$

となるようなファイバ入射光学系を備えていることを特徴とする固体レーザ装置。

【請求項 21】

請求項1から請求項13のうちのいずれか1項記載の光伝送装置、または請求項14から請求項20のうちのいずれか1項記載の固体レーザ装置と、前記光伝送装置または前記固体レーザ装置から出射されたレーザ光を集光する集光光学系とから構成され、前記集光光学系で集光された前記レーザ光を被加工物に照射し、レーザ加工を行なうことを特徴とするレーザ加工装置。

【請求項 22】

請求項1から請求項13のうちのいずれか1項記載の光伝送装置、または請求項14から請求項20のうちのいずれか1項記載の固体レーザ装置から構成され、前記光伝送装置または前記固体レーザ装置から出射されたレーザ光を被加工物に直接照射しレーザ加工を行なうことを特徴とするレーザ加工装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】

この発明は、加工用や医療用等の目的に使用される集束性の良好なレーザ光を伝送するための光伝送装置、該光伝送装置を備えた固体レーザ装置、及び該光伝送装置や該固体レーザ装置を組み込んだレーザ加工装置に関するものである。

【0002】

【従来の技術】

図35は、例えば、特公平2-55157号公報に示された従来の光伝送装置を示す構成図であり、図において、8は集光レンズ、90はレーザ光の導光路としての光ファイバ、10はレーザ発振器、70はレーザ発振器10から外部に取り出されたレーザビーム、101はレンズホルダ、102は光ファイバホルダである。

【0003】

次に動作について説明する。

図において、レーザ発振器10から取り出されたレーザビーム70は集光レンズ8によ

10

20

30

40

50

って光ファイバ90の入射端面へ集光照射され、光ファイバ内へ導光される。レンズホルダ101、光ファイバホルダ102の片方、もしくは両方は移動ステージで構成されており、レーザビーム70は、光ファイバ90の入射端面の中心に集光されるように位置設定される。

【0004】

一般に損失なく、例えば散乱ロス等の損失なく、光伝送を行うには、光ファイバ90への入射角 θ_{in} は、 $\theta_{in} < \sin^{-1}(NA)$ でなければならない。ここで、NAは光ファイバ固有の数値であり、すなわちファイバコア中心の屈折率を n_0 、クラッドの屈折率を n_1 としたときに $(n_0^2 - n_1^2)^{1/2}$ で表される。一方、光ファイバ90を介してレーザビームを伝送すると、一般にレーザ光の集束性は劣化する。レーザビームの集束性はレーザのビームウェスト直径を d 、ビーム開き角を 2θ と置いたときに、 $d\theta$ を指標として表すことができる。光ファイバを伝送した光はファイバのコア部全体に広がり、出射ビームのビーム径はほぼファイバのコア径となる。よって、集束性の良いレーザビームを光ファイバから取り出すためには、光ファイバからのレーザビームの出射角を小さくすればよいことがわかる。

10

【0005】

ここで、レーザビームの集束性を表す指標について整理しておく。ビーム径には様々な定義があるが、ここではエネルギーが86.5% (すなわち $1 - e^{-2}$) に集中している径をレーザビーム径として表す。一般にレーザビームで最も集束性の良いビームはTEM₀₀、すなわちガウシアンビームと呼ばれるものである。ガウシアンビームのビームウェスト半径を ω_0 、ビーム開き角を θ_0 とすると、以下の関係が成り立つ。

20

【0006】

【数1】

$$\theta_0 = \tan^{-1} \left(\frac{\lambda}{\pi \omega_0 n} \right) \cong \frac{\lambda}{\pi \omega_0 n}$$

【0007】

ただし、 λ はレーザビームの波長、 n は屈折率であり、 θ_0 は π より充分小さいとする。空気中の場合、 $n = 1$ と置いて、 $\theta_0 = \lambda / \pi \omega_0 = 2\lambda / \pi \varphi_0$ となる。なお、 $\varphi_0 = 2\omega_0$ はレーザビームウェスト直径である。

30

【0008】

また、レーザビームの集束性を表す指標として M^2 値が知られている。図36はレーザビームの集束性の指標 M^2 を示す説明図である。図36に示すように、波長 λ 、ビームウェスト直径 φ_0 、ビームの開き角(全角) 2θ のビーム(実線)の M^2 値は、同じ波長のガウスビーム(破線)を同じ直径に絞った場合の開き角(全角) $2\theta_0$ に対する比で表される。すなわち、 $\theta = M^2 \theta_0$ となる。したがって、ガウスビームと該ビームが焦点距離 f のレンズに同じ径でコリメートされて入射したとき、該ビームの集光点でのビーム径、すなわちビームウェスト径はガウスビームの M^2 倍となる。これより明らかなように、 M^2 値が小さいほど高集束のビームである。これとは逆に、ガウスビームとビーム開き角が等しい場合はビームウェスト径が M^2 倍となる。また、ガウスビームの M 倍のビームウェスト径を持つ場合はレーザビーム開き角もガウスビームの M 倍となる。 $\theta = M^2 \theta_0$ を θ_0 の表式に代入して M^2 について解くと、 $M^2 = \pi \varphi_0 \theta / 2\lambda$ となる。ゆえに、同じ開き角を持つならばビームウェスト直径の小さい方が M^2 値が小さく、集束性の良いビーム、あるいは別の言い方をすれば、高輝度のビームであるといえる。

40

【0009】

図37は図35と同様に特公平2-55157号公報に示された光ファイバへの入射角 θ_{in} と出射角 θ_{out} との関係を示す説明図であり、ファイバコアの屈折率が一定の値を示すステップインデックスファイバについて成り立つものである。この図から明らかなよう

50

に、入射角が小さいほど出射角が小さくなり、その結果、集束性の良い出射ビームが得られるが、6度から8度程度に出射角の下限があることがわかる。これより、従来の光伝送装置では長焦点距離のレンズで入射角 $2\theta_{in}$ が8度以下となるようにしている。

【0010】

【発明が解決しようとする課題】

従来の光伝送装置は以上のように構成されているので、出射角の限界によりいくら集束性のよいレーザビームを入射しても光ファイバから出射されるビームの集束性には限界があるという課題があった。集束性を上げるためにファイバのコア径の小さいものを選ぶことも有効だが、コア径の小さい光ファイバでは大出力のレーザ光を伝送することができない。YAGレーザ光を例にとると、一般に500Wのレーザ光を伝送するためには0.4mm以上、それ以上のパワーのレーザ光を伝送するためには0.6mm以上を有する光ファイバのコア径が必要とされている。図35によると出射角 $2\theta_{out}$ の最小値はせいぜい6度程度であり、前述の式より0.4mmのコア径のファイバから出射されるビームの M^2 値は最小でも30程度、0.6mmのコア径では46程度である。このため、いくら集束性の良いビームを光ファイバに入射しても、ファイバ伝送された出射光の集束性には限界があるという課題があった。

【0011】

さらに、従来の光伝送装置ではステップインデックスファイバを用いた場合に、集束性の高い出射レーザビームを得る設計基準を与えているが、グレーデッドインデックス光ファイバを用いて集束性の高いレーザ出射ビームを得るための設計基準については明らかになっていなかった。即ち、レーザ学会編「レーザーハンドブック」p66～p67、オーム社、1982での記載に見られるように、グレーデッドインデックス光ファイバは原理的には集光レンズが隙間なく連なった配列状態と等価であり、理想的な集光レンズ配列を考えれば入射レーザ光の集束性は保存されるはずである。しかしながら、現在までにそれに関する報告はなく、光ファイバ内を伝送されたレーザビームは元々有していた、つまり入射前の集束性を失うというのが一般的な認識であった。また、上記文献、レーザ学会編「レーザーハンドブック」p66～p67（オーム社、1982）の記載においては、光通信に用いるような小出力の基本モードのレーザビーム、言い換えるとTEM₀₀モードのレーザビームに対する解析がされているが、加工用の大出力レーザ、特に固体レーザに関してはマルチモードでの発振が一般的であり、マルチモードビームに対して集束性を保ったまま光ファイバ伝送を行う技術については記載がなく、これまでに全く明らかになっていないという課題があった。

【0012】

この発明は、上記のような課題を解決するためになされたもので、グレーデッドインデックス光ファイバを用いて入射ビームの集束性のレベルを変化させることなく、きわめて良好に保存して伝送することのできる光伝送装置を得ることを目的とする。

【0013】

またこの発明は、入射レーザビームの集束性のレベルをきわめて良好に保存し、かつレーザ光の光ファイバ端面への光軸を自動的に調整することができる光伝送装置を得ることを目的とする。

【0014】

さらにこの発明は、出射レーザビームの集束性のレベルを容易に制御することができる光伝送装置を得ることを目的とする。

【0015】

さらにこの発明は、発振されたレーザビームの集束性のレベルをきわめて良好に保存したまま光ファイバ伝送を行い出射することのできる固体レーザ装置を得ることを目的とする。

【0016】

さらにこの発明は、発振されたレーザビームの集束性のレベルを容易に制御することができる固体レーザ装置を得ることを目的とする。

【0017】

さらにこの発明は、集束性のレベルの良いレーザビームを、集束性のレベルを良好に保存したまま、あるいは出射レーザビームの集束性のレベルを制御しつつ光ファイバ伝送して加工のできるレーザ加工装置を得ることを目的とする。

【0018】

【課題を解決するための手段】

請求項1記載の発明に係る光伝送装置は、グレーデッドインデックス光ファイバから構成され、前記光ファイバのコア径が ϕ_c 、コア中心での屈折率が n_0 、コア中心とコア周囲部の屈折率差が Δn の光ファイバと、レーザ光のビームウェストでの直径が ϕ_0 、前記レーザ光のビーム開き角が 2θ である時、前記レーザ光が前記光ファイバの入射端面上または前記光ファイバの入射端面近傍に最小集光点を持ち、前記最小集光点での直径 ϕ_{in} が、

$$0.5\phi_s \leq \phi_{in} \leq 1.5\phi_s$$

ただし、

$$\phi_s = (\phi_c \phi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}$$

となるような光ファイバ入射光学系とを備えており、集束性の劣化なく維持しながらマルチモードレーザビームを用いたレーザ光を光ファイバを介して外部へ出射するものである。

【0019】

請求項2記載の光伝送装置は、レーザ光の波長を λ とした時に、前記レーザ光の集束性 $\pi\theta\phi_0/\lambda$ の値が100以下となるように設定したものである。

【0020】

請求項3記載の発明に係る光伝送装置は、光ファイバの入射端面近傍に、開口部の直径が光ファイバのコア径 ϕ_c よりも小さく、かつ ϕ_s よりも大きな値を有するアパーチャを設け、このアパーチャにより光ファイバの入射端面でのレーザ光の光軸ずれの影響を最小限にとどめ、光ファイバ内でのレーザ光の集束性の劣化を起こすことなくレーザ光を伝送するものである。

【0021】

請求項4記載の発明に係る光伝送装置は、光ファイバの出射端面近傍に、開口部の直径が光ファイバのコア径 ϕ_c よりも小さく、かつ ϕ_s よりも大きな値を有するアパーチャを備え、光ファイバの出射端側における反射ビームがクラッド等に照射されるのをこのアパーチャで防止し反射ビームの影響を最小限にとどめるものである。またレーザ光のモニタを容易にしつつ光ファイバ内でのレーザ光の集束性の劣化を起こすことなくレーザ光を伝送するものである。

【0022】

請求項5記載の発明に係る光伝送装置は、光ファイバ入射光学系は集光レンズを有しており、この集光レンズは二枚または二組の集光レンズにより構成されており、この集光レンズの位置を調整することによって、レーザビームのビーム特性に合わせて光ファイバの入射端面でのレーザ光の直径を容易に調整するものである。

【0023】

請求項6記載の発明に係る光伝送装置は、光ファイバに近接している側の集光レンズをグレーデッドインデックスレンズで構成している。このグレーデッドインデックスレンズを光ファイバに近接または密着して設置し、グレーデッドインデックスレンズの少しの位置調整により広い範囲のビーム特性に合わせて光ファイバの入射端面でのレーザ光のビーム直径を容易に調整するものである。

【0024】

請求項7記載の発明に係る光伝送装置は、グレーデッドインデックスレンズの入射端近傍にアパーチャを備え、このアパーチャによりグレーデッドインデックスレンズならびに光ファイバの入射端面周辺への思わぬレーザ光照射を防止し、容易に光ファイバ内でのレーザ光の集束性の劣化を起こすことなくレーザ光を伝送するものである。

【 0 0 2 5 】

請求項 8 記載の発明に係る光伝送装置は、光ファイバの入射端面でのレーザ光を計測する入射ビームモニタ装置、及び光ファイバ入射光学系の位置を移動させる移動手段を備え、入射ビームモニタ装置からの出力をもとに光ファイバ入射光学系の位置を調整する。入射ビームモニタ装置により、光ファイバ入射端面でのビーム位置、ビーム直径をモニタし、これらが最適となるように集光レンズの位置を集光レンズ移動手段により制御するものである。

【 0 0 2 6 】

請求項 9 記載の発明に係る光伝送装置は、光ファイバから出射される出射ビームを計測する出射ビームモニタ装置、及び光ファイバ入射光学系の位置を移動させる移動手段を備え、出射ビームモニタ装置からの出力をもとに光ファイバ入射光学系の位置を調整する。出射ビームモニタ装置により光ファイバから出射されたビームの集光特性が最適となるように集光レンズの位置を集光レンズの移動手段により制御するものである。

10

【 0 0 2 7 】

請求項 10 記載の発明に係る光伝送装置では、出射ビームモニタ装置はパワーセンサにより構成され、光ファイバの入射端面近傍にアパーチャを設置し、パワーセンサで検知されるレーザビームの出力が最大になるようにファイバ入射光学系を移動する。パワーセンサにより出射ビームをモニタし、例えば入射側に設置したアパーチャと組み合わせて出射ビームパワーが最大となるように集光レンズの位置を制御させるものである。

【 0 0 2 8 】

請求項 11 記載の発明に係る光伝送装置では、出射ビームモニタ装置は、光ファイバの出射側の光軸からずれた位置に設置したフォトダイオードで構成され、フォトダイオードの出力が最小になるようにファイバ入射光学系を移動させるものである。

20

【 0 0 2 9 】

請求項 12 記載の発明に係る光伝送装置では、出射ビームモニタ装置は、光ファイバの出射側に設置したアパーチャと前記アパーチャを通過したレーザビームを検知するパワーセンサにより構成され、アパーチャを通過するレーザビームのパワーが最大になるようにファイバ入射光学系を移動させるものである。

【 0 0 3 0 】

請求項 13 記載の発明に係る光伝送装置は、レーザ発振器と、集光レンズと、集光レンズで収束されたレーザ光を光ファイバの入射端面に集光し、光ファイバで伝送する光ファイバ入射光学系を有する光伝送装置において、光ファイバをグレーデッドインデックス光ファイバで構成し、さらに光ファイバ入射光学系と光ファイバの入射端面の片方または両方の位置を移動させる移動手段を備え、光ファイバ入射光学系と前記光ファイバの入射端面の片方または両方の位置を移動させることによって光ファイバから出射するレーザビームの集束性を制御するものである。そして、集光レンズ、光ファイバ入射端面の片方もしくは両方の位置を最適な集光位置から故意にずらすことにより光ファイバの出射ビームの集光特性を任意に変化するものである。

30

【 0 0 3 1 】

請求項 14 記載の発明に係る固体レーザ装置は、この発明に係る光伝送装置と、光源から投光された光で励起されてレーザ媒質となり、光を発生する固体素子と、レーザ媒質から発生した光をレーザ光として取り出すレーザ共振器と、レーザ共振器内に少なくともミラーと集光レンズとの組み合わせで構成される像転写光学系と、ミラーと集光レンズとをレーザ共振器の光軸方向に移動させる移動手段とを備え、ミラーと集光レンズの片方または両方を移動することにより光ファイバの入射端面に入射されるレーザビームのビーム直径を調節するものである。そして、レーザ共振器内部の像転写光学系により高集束性を持つレーザビームを発振し、そのビーム品質を保ったまま光ファイバを介して外部へレーザ光を出射するものである。

40

【 0 0 3 2 】

請求項 15 記載の発明に係る固体レーザ装置は、光ファイバから出射される出射レーザ

50

ビームのパワーの大きさを計測する出射ビームモニタ装置を備え、出射ビームモニタ装置からの出力をもとにミラーと集光レンズの片方または両方を移動し、出射ビームの集束性が最も良くなるよう共振器内部の像転写光学系の位置を制御するものである。

【 0 0 3 3 】

請求項 1 6 記載の発明に係る固体レーザ装置は、この発明に係る光伝送装置と、光源から投光された光で励起されてレーザ媒質となり、光を発生する固体素子と、レーザ媒質から発生された光をレーザ光として取り出すレーザ共振器と、レーザ共振器内に置かれたアパーチャ及びアパーチャの開口部の直径を増減する調節手段とから構成され、固体素子を励起するためのレーザ励起入力を一定に保ったままで、アパーチャの開口直径を増減することにより、レーザ光のパワーを調節するものである。換言すると、レーザ共振器内のアパーチャの開口直径を増減させることによりレーザ共振器からのレーザ光の出力の制御を行い、あらゆるレーザ出力に対し、常にレーザビームのビーム質を保ったまま光ファイバ伝送し、出力できるものである。

10

【 0 0 3 4 】

請求項 1 7 記載の発明に係る固体レーザ装置は、この発明に係る光伝送装置と、光源から投光された光で励起されてレーザ媒質となり、光を発生する固体素子と、レーザ媒質から発生した光をレーザ光として取り出すレーザ共振器と、レーザ共振器内に置かれたアパーチャ及びアパーチャをレーザ共振器の光軸方向に移動させる移動手段とから構成され、レーザ共振器内でレーザ励起入力一定のままで、アパーチャの位置を移動することによりレーザ光のパワーを調節するものである。換言すると、レーザ共振器内のアパーチャを移動させることによりレーザ共振器の出力制御を行い、あらゆるレーザ出力に対し、常にレーザ光のビーム質を保ったまま光ファイバ内を伝送させ外部へ出力するものである。

20

【 0 0 3 5 】

請求項 1 8 記載の発明に係る固体レーザ装置は、固体素子と、レーザ共振器と、レーザ光としてマルチモードレーザビームを用い、レーザ光を伝送する光ファイバとからなる光伝送装置を備えた固体レーザ装置において、光ファイバをコア径 φ_c 、コア中心での屈折率が n_0 で、コア中心とコア周囲部の屈折率差が Δn のグレーデッドインデックス光ファイバで構成し、レーザ共振器を曲率の等しい全反射ミラーと出力ミラーで構成し、固体素子は、全反射ミラーと出力ミラー間の中心近傍に配置されたいわゆる対称型共振器内に置かれ、ある出力レベルにおけるレーザ光のビームウェイストの直径が φ_c およびレーザ光のビーム開き角が 2θ である時、レーザ光が光ファイバの入射端面上あるいはそのごく近傍に最小集光点を持ち、最小集光点における出力レベルのレーザ光の直径 φ_{in} が

30

$$0.5\varphi_s \leq \varphi_{in} \leq 1.5\varphi_s$$

ただし、

$$\varphi_s = (\varphi_c \varphi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}$$

となるようなファイバ入射光学系を備えているものである。 $\varphi_0 \theta$ の大きな出力レベルにおいて、ファイバ入射端面のごく近傍に最小集光点を持ちその直径が

$$(\varphi_c \varphi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2} \pm 50\%$$

となるようにレーザ光を集光し、レーザ出力が変化しても収束性の変化が少ないレーザビームを光ファイバから外部へ出射するものである。

40

【 0 0 3 6 】

請求項 1 9 記載の発明に係る固体レーザ装置は、固体素子と、レーザ共振器と、光伝送装置とを備えた固体レーザ装置において、光伝送装置内の光ファイバをコア径 φ_c 、コア中心での屈折率が n_0 でコア中心とコア周囲部の屈折率が Δn のグレーデッドインデックス光ファイバで、また固体素子を薄板状のスラブ形状で構成する。レーザ共振器から取り出されたレーザ光は、 x 軸 y 軸 2 つの方向で集光特性の異なる異方性を持っており、 x 軸方向 y 軸方向のそれぞれにおいてレーザ光のビームウェイストの直径が φ_{0x} 、 φ_{0y} 、レーザ光のビーム開き角が $2\theta_x$ 、 $2\theta_y$ である時、レーザ光が光ファイバの入射端面上あるいはそのごく近傍に x 軸方向、 y 軸方向それぞれにおいて最小集光点を持ち、最小集光点での直径 φ_{inx} 、 φ_{iny} がそれぞれ

50

$$0.5 \varphi_{sx} \leq \varphi_{inx} \leq 1.5 \varphi_{sx}, \quad 0.5 \varphi_{sy} \leq \varphi_{iny} \leq 1.5 \varphi_{sy}$$

ただし、

$$\varphi_{sx} = (\varphi_c \varphi_{0x} \theta_x (2n_0 \Delta n)^{-1/2})^{1/2}$$

$$\varphi_{sy} = (\varphi_c \varphi_{0y} \theta_y (2n_0 \Delta n)^{-1/2})^{1/2}$$

となるようなファイバ入射光学系を備え、x方向とy方向で集光性能が異なる発振器に対しファイバ伝播後も全体として集光特性が保存されたレーザビームを出射するものである。

【0037】

請求項20記載の発明に係る固体レーザ装置は、固体素子と、レーザ共振器と、光伝送装置を備えた固体レーザ装置において、光伝送装置内の光ファイバをコア径 φ_c 、コア中心での屈折率が n_0 でコア中心とコア周囲部の屈折率差が Δn のグレーデッドインデックス光ファイバで、また固体素子を薄板状のいわゆるスラブ形状で構成する。レーザ共振器から取り出されたレーザ光はx軸y軸の2つの方向で集光特性の異なる異方性を持っておりx軸方向y軸方向のそれぞれにおいて、レーザ光のビームウエイストの直径が φ_{0x} 、 φ_{0y} 、レーザ光のビーム開き角が $2\theta_x$ 、 $2\theta_y$ である時、レーザ光が光ファイバ入射端面上あるいはそのごく近傍に最小集光点を持ち、 $\varphi_{0x}\theta_x$ と $\varphi_{0y}\theta_y$ の大きな方の軸の最小集光点での直径 φ_{in} が

$$0.5 \varphi_s \leq \varphi_{in} \leq 1.5 \varphi_s$$

ただし、

$$\varphi_s = (\varphi_c \varphi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}$$

また、 $\varphi_0 \theta = \text{MAX}(\varphi_{0x}\theta_x, \varphi_{0y}\theta_y)$

となるようなファイバ入射光学系を備えたものであり、非常に簡単なレンズ構成で、光ファイバ伝播後も全体として集光性能が大きく損なわれないレーザビームを出射するものである。

【0038】

請求項21記載の発明に係るレーザ加工装置は、この発明に係る光伝送装置、または固体レーザ装置と、光伝送装置または固体レーザ装置から出射されたレーザ光を集光する集光光学系とから構成され、集光光学系で集光されたレーザ光を集束性を保ったまま被加工物に照射し高精度のレーザ加工を行なうものである。

【0039】

請求項22記載の発明に係るレーザ加工装置は、この発明に係る光伝送装置または固体レーザ装置から構成され、光伝送装置または固体レーザ装置から出射されたレーザ光を集束性を保ったまま被加工物に直接照射し、レーザ焼き入れなどの比較的広い面積の加工を行なうものである。

【0040】

【発明の実施の形態】

以下、この発明の実施の一形態を説明する。

実施の形態1.

図1は、この発明の実施の形態1に係る光伝送装置を示す構成図である。図において、8、10、70、101、102で示した構成要素は図35に示した従来の光伝送装置の構成要素の構成および機能と同一なので、同一の参照番号を用い、その説明を省略する。9はコアの屈折率分布がほぼ二乗分布となっている光ファイバ(グレーデッドインデックス光ファイバ)である。101は集光レンズホルダであり光軸方向へ手動で位置調整できる移動ステージと径方向へ手動で位置調整できる十字動ステージの組み合わせから構成されている。光ファイバ入射に際して、図35に示した従来例の光伝送装置では、集光レンズ(光ファイバ入射光学系)8に長焦点レンズを用いて入射角度 θ_{in} を8度以下に規定していたのに対し、この実施の形態1の光伝送装置では、光ファイバ9の入射端面上あるいはそのごく近傍にレーザビーム70の最小集光点を持ちその直径 φ_{in} が

$$0.5 \varphi_s \leq \varphi_{in} \leq 1.5 \varphi_s$$

ただし、

$$\varphi_s = (\varphi_c \varphi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}$$

となるように集光レンズ8の焦点距離及び位置を設定している。ここで、 φ_c 、 n_0 、 Δn はそれぞれ光ファイバ9のコア直径、コア中心での屈折率、コアとクラッドの屈折率差であり、 φ_0 、 θ はレーザ発振器10から発生したレーザビーム70のビームウェスト直径およびビーム開き角(半角)を示す。なお、図に示す実施の形態1の光伝送装置では、レーザ発振器10のレーザ出口近傍にレーザビーム70のビームウェストがあるとしている。

【0041】

次に動作について説明する。

レーザ発振器10から出射されたレーザビーム70は、集光レンズホルダ101の位置調整によってレーザビームが光ファイバ入射端面の中心に集光するように、集光レンズ8により集光される。 10

【0042】

図2は、光ファイバ内でのレーザビームの伝播状況を示す説明図である。図において、光ファイバ9内でのレーザビームの伝播状況は、図2に示すように概念的に表すことができる。即ち、光ファイバ9の入射端面で最小集光点を持つようにレーザビーム70が集光された場合、図2の最下段に示すように最小集光点における径 φ_{in} がある値 φ_s よりも大きいときには($\varphi_{in} > \varphi_s$)、光ファイバ9内で一旦入射径よりも小さな直径に集光され、以下発散、集光を繰り返しながら光ファイバ9内を伝送される。

【0043】

一方、図2の最上段に示すように最小集光点における径 φ_{in} が φ_s よりも小さいときには($\varphi_{in} < \varphi_s$)、レーザビーム70は光ファイバ9内でまず発散し、以下集光、発散を繰り返しながら伝送される。 20

これらに対し、図2の中段に示すように最小集光点における径 φ_{in} が φ_s にほぼ一致する場合は($\varphi_{in} = \varphi_s$)、光ファイバ9内でレーザビーム径がほとんど変化することなく伝送される。

【0044】

グレーデッドインデックス光ファイバを純粋の集光レンズの集合配列として考察すると、図2に示す3つのどの伝送形態でも集束性が理論的には保存されるが、實際上、グレーデッドインデックス光ファイバをレンズとして考えた場合の収差成分やビームの分散などから、図2の最上段や最下段の伝送形態では集束性が失われることが予想される。 30

【0045】

また、大出力ファイバ伝送では光ファイバの破壊も考慮に入れる必要があり、光ファイバ内に集光点を持つ伝送形態では耐伝送パワー特性に問題が生ずることが予想される。

以上の考察より、高集束性レーザビームの伝送には図2の中段に示すレーザビームの伝送形態が有利であると結論づけられる。

【0046】

なお、「レーザハンドブック」(p66 ~ p67、日本レーザ学会編、オーム社)に記載されてるように、光通信に用いるような小出力の基本モードのレーザビーム、換言すると、TEM₀₀モードのレーザビームに対する φ_s については解析的に導出できることが知られている。 40

【0047】

しかし、加工に用いる大出力レーザ、特に固体レーザではマルチモードでの発振が一般的であり、マルチモードレーザビームに対して集束性を保ったまま光ファイバ伝送を行う技術はこれまでに明らかになっていなかった。

【0048】

我々はこの高集束ビーム光ファイバ伝送の研究を進め、前述のM²値を用いて一般のビームに対する φ_s を導出する方法を開発し、さらにレーザビームのビームウェスト径とビーム開き角からの φ_s の導出式を見いだした。

【0049】

まず、 M^2 値で集束性が表現されているレーザビームを、 TE_{M00} モードのレーザビームと同等に計算するために以下の近似を行う。ただし、ここでは一応エネルギーが86.5%集中している径をビーム直径として計算を行う。ビーム開き角 θ を波長 λ_1 と M^2 値の関数として $\theta(\lambda_1, M^2)$ と表すと、前述のように

$$\theta(\lambda_1, M^2) = M^2 \cdot \theta(\lambda_1, 1)$$

となる。

【0050】

一方、異なる波長の2つのガウスビームを同じ直径に絞ると、開き角は波長に比例するので、

$$\theta(\lambda_2, 1) = (\lambda_2 / \lambda_1) \cdot \theta(\lambda_1, 1)$$

10

となる。ここで $\lambda_2 = M^2 \cdot \lambda_1$ とおくと、

$$\theta(\lambda_1, M^2) = \theta(\lambda_2, 1)$$

となる。これより、 M^2 値で集束性が定義されているビームの挙動は波長を $M^2 \cdot \lambda_1$ に置き換えたガウスビームによって近似できること明らかになった。

【0051】

上記した近似を用いて、 M^2 値で集束性が表現されるレーザビームに対する ϕ_s の導出を行う。なお、以下の導出式において $M^2 = 1$ とすると、従来から知られているガウスビームに対する ϕ_s となる。グレーデッドインデックス光ファイバは二乗屈折率分布を持っており、例えば単行本(「Optical Electronics, 4th Edition」、A Yariv 著、Saunders College Publishing, harcourt Brace Jovanovich College Publishers, p42, 1991)に示されているように、屈折率を以下のように表現できる。 20

【0052】

【数2】

$$n(r) = n_0 \left(1 - \frac{k_2}{2k} r^2 \right)$$

【0053】

ここで、 $n(r)$ はコア中心から r の位置での屈折率、 n_0 はコア中心での屈折率、 $k = 2\pi n / \lambda_0$ は波数、 k_2 は屈折率分布に応じた定数である。長さ l のグレーデッドインデックス光ファイバの光線行列は 30

【0054】

【数3】

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cos\left(\sqrt{\frac{k_2}{k}}\ell\right) & \sqrt{\frac{k}{k_2}} \sin\left(\sqrt{\frac{k_2}{k}}\ell\right) \\ -\sqrt{\frac{k_2}{k}} \sin\left(\sqrt{\frac{k_2}{k}}\ell\right) & \cos\left(\sqrt{\frac{k_2}{k}}\ell\right) \end{bmatrix}$$

40

【0055】

で表される。ガウスビームの伝播は、 q という指標と光線行列によって記述できることが知られており、ガウスビームの曲率を R 、ビーム半径を ω 、波長を λ 、光ファイバの屈折率を n とすると、

【0056】

【数4】

$$\frac{1}{q} = \frac{1}{R} - i \frac{\lambda}{\pi \omega^2}$$

50

【 0 0 5 7 】

と表される。この式を、前節の近似を用いてマルチモードビームに拡張して考えると、

【 0 0 5 8 】

【数 5】

$$\frac{1}{q} = \frac{1}{R} - i \frac{M^2 \lambda}{\pi n \omega^2}$$

【 0 0 5 9 】

となる。ここで、グレーデッドインデックス光ファイバ内でビーム径が変化しない ω の条件を求めるには、任意の長さのグレーデッドインデックス光ファイバの入射端に平面波を入射し、出射端で同じビーム径の平面波が得られる条件を求めればよい。平面波の場合には $R = \infty$ 、すなわち $1/R = 0$ なので、上式の第二項のみを考えればよいことになる。ある光学系に入射するビームと出射するビームの指標をそれぞれ q_1 、 q_2 とおくと、

【 0 0 6 0 】

【数 6】

$$q_2 = \frac{Aq_1 + B}{Cq_1 + D}$$

20

【 0 0 6 1 】

であるので、 $q_1 = q_2 = -i (\pi n \omega_s^2 / M^2 \lambda)$ と置いて、 ω_s について解き、以下の解を得る。

【 0 0 6 2 】

【数 7】

$$\omega_s = \left(\frac{M^2 \lambda}{\pi n \sqrt{k_2 / k}} \right)^{1/2}$$

30

【 0 0 6 3 】

グレーデッドインデックス光ファイバのコア径を ϕ_c 、コア中心とコア端部間の屈折率差を Δn とすると、

【 0 0 6 4 】

【数 8】

$$n_0 \frac{k_2}{2k} \left(\frac{\phi_c}{2} \right)^2 = \Delta n$$

【 0 0 6 5 】

となる。この式を ω_s の表式に代入して、 n が n_0 にほぼ等しいことを考慮すると、

【 0 0 6 6 】

【数 9】

$$\omega_s = \left(M^2 \cdot \frac{\phi_c}{2} \cdot \frac{\lambda}{\pi \sqrt{2n_0 \Delta n}} \right)^{1/2}$$

【 0 0 6 7 】

となるので、結局マルチモードビームに対する $\phi_s = 2 \omega_s$ は次式で表現される。

50

【 0 0 6 8 】

【 数 1 0 】

$$\phi_s = 2 \cdot \left(M^2 \cdot \frac{\phi_c}{2} \cdot \frac{\lambda}{\pi \sqrt{2n_0 \Delta n}} \right)^{1/2}$$

【 0 0 6 9 】

以上より、 M^2 で集束性が表現されているビームに対する高集束光ファイバ伝送のためのファイバ入射径の基準となる ϕ_s が求められた。

10

【 0 0 7 0 】

次に、通常レーザビームの集束性の指標として用いられているビームウェイト径、ビーム開き角 θ による ϕ_s の表式を導出する。前述のように、ビームウェイト径 ϕ_0 、ビーム開き角 θ と M^2 値の間には、 $M^2 = \pi \phi_0 \theta / 2\lambda$ の関係がある。これを ϕ_s の表式に代入すると、

【 0 0 7 1 】

【 数 1 1 】

$$\phi_s = \left(\frac{\phi_c \phi_0 \theta}{\sqrt{2n_0 \Delta n}} \right)^{1/2}$$

20

【 0 0 7 2 】

となる。これにより、ビームウェイト径とビーム開き角によって集束性が表現されているビームに対する、高集束光ファイバ伝送のための光ファイバ入射径の基準となる ϕ_s が求められた。

【 0 0 7 3 】

ここで ϕ_s の計算例を示す。例えば、 $n_0 = 1.473$ 、 $\Delta n = 0.021$ コア径 $40 \mu\text{m}$ のグレーデッドインデックス光ファイバに M^2 値が 20 のNd:YAGレーザビーム（波長 $\lambda = 1.064 \mu\text{m}$ ）を伝播させることを考えると、 ϕ_s は $148 \mu\text{m}$ となる。

30

【 0 0 7 4 】

図3は、グレーデッドインデックス光ファイバ9の入射端に最小集光点を持つようにレーザビーム70を集光し、集光レンズの焦点距離を変化させて出射ビームの M^2 値（ M^2_{out} ）を測定した実験結果を示す。図に示す実験条件では入射ビームの直径 ϕ_{in} は入射角度 $2\theta_{in}$ の逆数に比例する。図により入射ビーム径を ϕ_s 付近にすると出射ビームの M^2 値（ M^2_{out} ）が入射ビームの M^2 値（ M^2_{in} ）とほとんど同じ値で出射され、最も集束性の良いレーザビームが得られることがわかる。また、図35に示した従来例の光伝送装置の例で説明したレーザビーム70及び光ファイバ90を用いて入射角度 $2\theta_{in}$ を8度以下にすると、光ファイバ90からの出射ビームの集束性が悪化し、従来例で説明した理想的なステップインデックスファイバに対する入射特性の検討結果とは全く異なるものとなっている。

40

【 0 0 7 5 】

さらに、図3に示す実験結果では、入射ビームの直径 ϕ_{in} が $\phi_s \pm 50\%$ の範囲（即ち、 $0.5\phi_s \leq \phi_{in} \leq 1.5\phi_s$ ）では入射ビームの集束性をあまり劣化させることなく光ファイバ伝送可能であることがわかる。

【 0 0 7 6 】

また、上記実験結果よりレーザビームの集光位置がファイバコア中心からずれると出射ビームの集束性が劣化すること、ならびにグレーデッドインデックス光ファイバからの出射ビームの集束性がよいほど出射ビームのビーム開き角 θ_{out} （半角）が小さく、ほぼM

50

2_{out} 値の平方根に比例することがわかった。

【0077】

以上のように、この実施の形態1においては、ファイバ入射端面のごく近傍に最小集光点を持ち、その直径が $\phi_s \pm 50\%$ の範囲となるように集光レンズ8の焦点距離及び位置を設定しているので、これまでの議論から明らかなように、光ファイバ9内で集束性を保ったままレーザビーム伝送が行われる。その結果、レーザ発振器で発生された集束性の良いレーザビームが、その集束性を保ったまま光ファイバ9から出射される。

【0078】

なお、実施の形態の光伝送装置は、上述したようにガウスビームだけでなく、 M^2 が1以上のマルチモードビームに対しても集束性を保ったまま光ファイバ伝送が可能な構成を示すものであるが、 $M^2 < 50$ 、望ましくは $M^2 < 40$ のマルチモードビームに対して特に有効である。換言すれば、 $M^2 = \pi \phi_0 \theta / 2\lambda$ の関係から、 $\pi \phi_0 \theta / \lambda$ が100以下、のぞましくは80以下のレーザビームに対して特に有効である。

【0079】

また、実施の形態1の光伝送装置では、レーザ発振器10のレーザ出口近傍にレーザビーム70のビームウェストがあるとしたが、この条件からはずれる場合でも、あらかじめ任意の焦点距離 f_1 を持つ集光レンズで集光したときのビームウェスト径 ϕ_1 とビーム開き角 θ_1 を測定すれば、容易に ϕ_s ならびに ϕ_s を与える焦点距離 f_s を求めることができる。すなわち、ビームウェスト径とビーム開き角の積がレンズ系を通過しても不変である性質を利用して、 $\phi_1 \theta_1 = \phi_0 \theta$ を用いて ϕ_s を導出し、 $\phi = 2 f \theta$ から $f_s = f_1 \phi_s / \phi_1$ となる。また、ビームウェストがレーザ発振器10内にある場合、ビーム開き角が極端に大きくなければレーザ出口でのビーム直径を用いて計算しても誤差は少ないので、カタログデータのビーム径、ビーム開き角から計算しても良い。

【0080】

また、実施の形態1の光伝送装置では、集光レンズホルダ101の構成としてZ軸移動ステージと十字動ステージの組み合わせを用いたが、若干の調整機能があれば他の形態のホルダを用いても良い。

【0081】

さらに、実施の形態1の光伝送装置では、集光レンズホルダ101に調整機構を設けているが、光ファイバホルダ102に調整機構を設けても良い。

また、集光レンズ8により、レーザビーム70を光ファイバ9の入射端面上またはその近傍に最小集光点を持つように集光し、かつ最小集光点でのレーザビーム径が所定値となるようにしていたが、集光レンズ8の変わりに、ミラー等により同様の機能を実現してもよい。

【0082】

実施の形態2.

図4は、この発明の実施の形態2に係る光伝送装置を示す構成図である。図において、図1に示す実施の形態1の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、11は開口直径が ϕ_s よりも大きく、ファイバコア直径 ϕ_c よりも小さくなるように設定されているアパーチャであり、開口中心がファイバ9のコア中心とほぼ一致し、光ファイバ9の入射端面に近い位置に設置されている。

なお、図では詳細を省略しているが、集光レンズホルダ101は実施の形態1の光伝送装置の場合と同様に、光軸方向へ手動で位置調整できる移動ステージと径方向へ手動で位置調整できる十字動ステージとを組み合わせた構成となっている。

【0083】

次に動作について説明する。

レーザ発振器10から出射されたビームウェスト径 ϕ_0 、ビーム開き角 θ を持つレーザビーム70は、集光レンズ8によりアパーチャ11を通過して光ファイバ入射端面で $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、光ファイバ9内を集束性を保ったまま伝

送し、光ファイバ 9 の出射端より出力される。また、光ファイバ 9 の中心からずれたレーザービームはアパーチャ 1 1 によって遮断される。

【 0 0 8 4 】

以上のように、この実施の形態 2 においては、図で示したように光ファイバ 9 へのレーザービーム 7 0 の光軸調整の際に、極端にレーザービームの位置ずれが生じた際、光ファイバ 9 のクラッドや被覆等にレーザービーム 7 0 が照射されることをアパーチャ 1 1 によって防止できる。また、光ファイバ 9 の中心からのレーザービームの位置ずれや、集光レンズ 8 と光ファイバ 9 の入射端の距離の誤差が生じたときに、アパーチャ 1 1 に当たって光ファイバ 9 へ入射されるレーザービームの出力が減少するので、光ファイバ出射端にパワーメータ等を設置して出射レーザービームのパワーをモニタし、パワーメータの出力に基づいて容易に集光レンズ 8 の位置調整を行うことができる。 10

【 0 0 8 5 】

実施の形態 3 .

図 5 は、この発明の実施の形態 3 に係る光伝送装置を示す構成図である。図において、図 1 に示す実施の形態 1 の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。

【 0 0 8 6 】

図において、1 2 は開口直径が ϕ_s よりも大きく、ファイバコア直径 ϕ_c よりも小さくなるように設定されているアパーチャであり、開口中心が光ファイバ 9 のファイバコア中心とほぼ一致し、光ファイバ 9 の出射端に近い位置に設置されている。 20

【 0 0 8 7 】

次に動作について説明する。

レーザー発振器 1 0 から出射されたビームウェイト径 ϕ_0 、ビーム開き角 θ を持つレーザービーム 7 0 は、集光レンズ 8 により光ファイバ 9 の入射端面で $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、光ファイバ 9 内を集束性を保ったまま伝送され、光ファイバ 9 の出射端よりアパーチャ 1 2 を通過して外部へ出力される。

【 0 0 8 8 】

以上のように、この実施の形態 3 においては、光ファイバ 9 からの出射光を例えば加工等に用いた場合に、加工対象物からレーザービームが光ファイバ 9 の出射端へ反射された場合でも、アパーチャ 1 2 により光ファイバ 9 のクラッドや他の思わぬ場所へのレーザービームの照射が防げられ、光ファイバ 9 の損傷を防止することができる。また、光ファイバ 9 の中心からのレーザービーム 7 0 の位置ずれや集光レンズ 8 と光ファイバ 9 の入射端の距離の誤差が生じた場合に、光ファイバ 9 から出射されるレーザービームの開き角が大きくなってアパーチャ 1 2 に当たる。これによりアパーチャ 1 2 を通過するレーザービームの出力が減少するので、アパーチャ 1 2 の出力側にパワーメータ等を設置して出射されるレーザービームのパワーをモニタし、モニタの結果をもとに容易に集光レンズ 8 の位置調整を行うことができる。 30

【 0 0 8 9 】

実施の形態 4 .

図 6 は、この発明の実施の形態 4 に係る光伝送装置を示す構成図である。図において、図 1 に示す実施の形態 1 の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、8 1、8 2 はそれぞれ集光レンズ（光ファイバ入射光学系）であり、1 0 1 はそれぞれの集光レンズ 8 1、8 2 を搭載した集光レンズホルダである。 40

【 0 0 9 0 】

次に動作について説明する。

レーザー発振器 1 0 から出射されたビームウェイト径 ϕ_0 、ビーム開き角 θ を持つレーザービーム 7 0 は、集光レンズ 8 1、8 2 により光ファイバ 9 の入射端面で $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、光ファイバ 9 内を集束性を保ったまま伝送し、光ファイバ 9 の出射端より外部へ出力される。 50

【0091】

以上のように、この実施の形態4においては、2つの集光レンズ81、82間の距離を調整することにより光ファイバ9の入射端面でのレーザビームの直径を容易に変更できるので、既存の集光レンズを用いて安価に光伝送装置を得ることができる。また、レーザ発振器10から出射されたレーザビーム70のビームウェスト径やビームウェストの位置、ビーム開き角が変化した場合でも、容易に $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} を得ることができる。

【0092】

なお、本実施の形態4の光伝送装置では、集光レンズホルダ101を2つに分離した形の場合を示したが、一体型としても良い。

10

【0093】

実施の形態5.

図7は、この発明の実施の形態5に係る光伝送装置を示す構成図である。図において、図1に示す実施の形態1の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、83は光ファイバ9の入射端面に近接もしくは密着して設置されたグレーデッドインデックスレンズであり、グレーデッドインデックスレンズ83の両端面はレーザビーム70の波長に対して無反射のコーティングが施されている。103はグレーデッドインデックスレンズホルダである。グレーデッドインデックスレンズ83は、その中心軸が光ファイバ9のコア中心に一致するように設置されている。

20

【0094】

次に動作について説明する。

レーザ発振器10から出射されたビームウェスト径 ϕ_0 、ビーム開き角 θ を持つレーザビーム70は、集光レンズ8によりグレーデッドインデックスレンズ83の端面に集光され、さらにグレーデッドインデックスレンズ83により光ファイバ9の入射端面で $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、光ファイバ9内を集束性を保ったまま伝送され、その後光ファイバ9の出射端より外部へ出力される。

【0095】

以上のように、この実施の形態5においては、前述した実施の形態4の光伝送装置に比べ、二枚の集光レンズ8および83のうちの一つに、焦点距離の短いものが実現できるグレーデッドインデックスレンズ83を用いるため、径を大きく変化させることができ、従って、集光レンズ8とグレーデッドインデックスレンズ83の位置を少し動かすだけで光ファイバ9の入射端面でのレーザビーム70のビーム径を大きく変化させることができる。この結果、レーザ発振器10から出射されたレーザビーム70の集束性の変化があった場合でも容易に対応できる。

30

【0096】

なお、上記した実施の形態5の光伝送装置では、単にグレーデッドインデックスレンズ83を光ファイバ9の入射端面の近接もしくは密接配置としたが、グレーデッドインデックスレンズ83と光ファイバ9とをオプティカルコンタクトを用いて結合させてもよい。また、グレーデッドインデックスレンズ83と光ファイバ9との間にインデックスマッチング液を介して結合させてもよい。この場合、グレーデッドインデックスレンズ83と光ファイバ9の間の端面での反射損失をなくすことができ、伝送効率がさらに上昇するという効果がある。

40

【0097】

実施の形態6.

図8は、この発明の実施の形態6に係る光伝送装置を示す構成図である。図において、図5に示す実施の形態3の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、13はアパーチャであり、その開口中心はグレーデッドインデックスレンズ83の光軸とほぼ一致し、グレーデッドインデックスレンズ83に近接して設置されている。

50

【 0 0 9 8 】

次に動作について説明する。

レーザ発振器 1 0 から出射されたビームウェスト径 ϕ_0 、ビーム開き角 θ を持つレーザビーム 7 0 は、集光レンズ 8 によりアパーチャ 1 3 を通過してグレーデッドインデックスレンズ 8 3 端面に集光され、さらにグレーデッドインデックスレンズ 8 3 により光ファイバ 9 の入射端面で $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、光ファイバ 9 内を集束性を保ったまま伝送し、その後光ファイバ 9 の出射端より外部へ出力される。また、本アパーチャ 1 3 によりグレーデッドインデックスレンズ 8 3 の光軸からずれたレーザビームは遮断される。

【 0 0 9 9 】

10

以上のように、この実施の形態 6 においては、グレーデッドインデックスレンズ 8 3 へのレーザビームの光軸調整の際に、極端にレーザビーム 7 0 の位置ずれが生じた場合でも光ファイバ 9 のクラッドや被覆等に該レーザビーム 7 0 が照射されることを防止できる。また、グレーデッドインデックスレンズ 8 3 の光軸中心からレーザビーム 7 0 の位置ずれや集光レンズ 8 と光ファイバ 9 の入射端の距離の誤差が生じた際に、アパーチャ 1 3 にレーザビームが当たり、その分光ファイバ 9 へ入射されるレーザビームのパワーが減少する。この場合、光ファイバ 9 の出射端にパワーメータ等を設置して出射されたレーザビームのパワーをモニタすることにより、容易に集光レンズ 8 の位置調整を行うことができる。

【 0 1 0 0 】

実施の形態 7 .

20

図 9 は、この発明の実施の形態 7 に係る光伝送装置を示す構成図である。図において、図 8 に示す実施の形態 6 の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図においては、グレーデッドインデックスレンズ 8 3 および光ファイバ 9 のそれぞれの入射端近傍にアパーチャ 1 3 および 1 1 を設置した構成を示す。

【 0 1 0 1 】

次に動作について説明する。

レーザ発振器 1 0 から出射された、ビームウェスト径 ϕ_0 、ビーム開き角 θ を持つレーザビーム 7 0 は、集光レンズ 8 によりアパーチャ 1 3 を通過してグレーデッドインデックスレンズ 8 3 の端面に集光され、さらにグレーデッドインデックスレンズ 8 3 によりアパーチャ 1 1 を通過して光ファイバ入射端面で $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、光ファイバ 9 内を集束性を保ったまま伝送され、その後光ファイバ 9 の出射端より外部へ出力される。

30

【 0 1 0 2 】

以上のように、この実施の形態 7 においては、アパーチャ 1 1 を設けたことにより、グレーデッドインデックスレンズ 8 3 の光軸および光ファイバ 9 のコア中心からずれたレーザビームは遮断される。この実施の形態 7 の光伝送装置によると、グレーデッドインデックスレンズ 8 3 の光軸と光ファイバ 9 のコア中心の両方に光軸が合致したレーザビームのみが光ファイバ 9 内を伝送されるので、光軸ずれによる光ファイバ 9 の損傷防止の機能がより完全なものとなる。また、光ファイバ 9 の出射端にパワーメータ等を設置して出射されるレーザビームのパワーモニタをすることにより、容易に集光レンズ 8 又はグレーデッドインデックスレンズ 8 3 の位置調整を行うことができる。

40

【 0 1 0 3 】

実施の形態 8 .

図 1 0 は、この発明の実施の形態 8 に係る光伝送装置を示す構成図である。図において、図 1 に示す実施の形態 1 の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、1 4 はレーザビーム 7 0 のごく一部のパワーを反射させるビームスプリッタ、1 5 はビーム検出面とビームスプリッタ 1 4 間の距離が光ファイバ 9 の入射端面とビームスプリッタ 1 4 間との距離に等しくなるように設置された入射ビームモニタ装置であり、例えば、スリットを走査させ、スリ

50

ット透過後のレーザビーム 70 のパワーを検出することにより、レーザビーム 70 の位置及びビーム直径を算出する装置である。104 は入射ビームモニタ装置 15 で検知されるレーザビーム径及びビーム位置が設計値になるようにレンズホルダ 101 を移動させるレンズホルダ移動装置（移動手段）である。

【0104】

なお、図の光伝送装置には明示していないが、レンズホルダ移動装置 104 は DC モータあるいは piezo 素子から構成されており、例えば実施の形態 1 の光伝送装置内のレンズホルダ 101 を構成する移動ステージおよび十字動ステージに直接に接続され自動的に集光レンズ 8 の位置の調整を行うことができるように構成されている。

【0105】

次に動作について説明する。

レーザ発振器 10 から出射されたビームウェイト径 ϕ_0 、ビーム開き角 θ を持つレーザビーム 70 は、集光レンズ 8 によりそのほとんどのパワーはビームスプリッタ 14 を透過して光ファイバ 9 の入射端面に集光される。ビームスプリッタ 14 でごく一部反射されたレーザビームは入射ビームモニタ装置 15 上に光ファイバ 9 の入射端面と同じ直径で集光される。入射ビームモニタ装置 15 ではビーム直径およびビーム位置を算出し、ここで得られたデータをレンズホルダ移動装置 104 へ送信し、これを元にレンズホルダ移動装置 104 は DC モータあるいは piezo 素子などで集光レンズホルダ 101 を移動させる。具体的には、例えばレーザビーム 70 のビーム位置に関しては所定の設定値における XY 方向からのずれ量によってレンズホルダ 101 の移動量を決定する。また、光軸方向の最適位置に関しては、レンズホルダ 101 内の移動ステージを移動させてビーム直径が最小となる点を探索する。この結果、レーザビーム 70 は光ファイバ 9 の入射端面の中心に、 $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、このレーザビームは光ファイバ 9 内を集束性を保ったまま伝送され、その後光ファイバ 9 の出射端より外部へ出力される。

【0106】

以上のように、この実施の形態 8 においては、レーザビーム 70 の最適な集光が自動的に行われるとともに、レーザビーム 70 の方向が仮に変化してもそれに追従して光軸調整が自動的に行われる。

【0107】

実施の形態 9 .

図 11 は、この発明の実施の形態 9 に係る光伝送装置 900 を示す構成図である。図において、図 6 および図 10 に示す実施の形態 4 および 8 の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、図 10 に示した実施の形態 8 の光伝送装置の集光レンズ 8 の代わりに、図 6 に示した実施の形態 4 の光伝送装置の構成と同様に、81 および 82 で示される 2 個あるいは 2 組の集光レンズを用いている。

【0108】

次に動作について説明する。

この実施の形態 9 の光伝送装置によると、光ファイバ 9 の入射端面でのレーザビーム 70 のビーム直径とビーム位置をモニタしながら、入射ビームモニタ装置 15 からの出力を基にレンズホルダ移動装置 104 により 2 つの集光レンズ 81、82 の位置を変えることが可能である。

【0109】

以上のように、この実施の形態 9 においては、ビームウェイトやビームの集束性が仮に変化しても、自動的に追従して光ファイバ 9 の入射端面でのビーム径が $\phi_s \pm 50\%$ の範囲内に入るようにしてコア中心に集光させることができる。

【0110】

実施の形態 10 .

図 12 は、この発明の実施の形態 10 に係る光伝送装置を示す構成図である。図において、図 10 に示す実施の形態 8 の光伝送装置の説明で用いられている番号と同一の番号は

10

20

30

40

50

同一の構成要素を示し、ここではその説明を省略する。図において、15は、図10に示した実施の形態8の光伝送装置と同様、入射ビームモニタ装置を示すが、この実施の形態10の光伝送装置では、例えばCCDカメラのような画像入力装置を備えており、光ファイバ9の入射端面を直接観測している。

【0111】

次に動作に関しては、入射ビームモニタ装置15で、光ファイバ9に入射するレーザービーム70のパワーを観測する以外の動作は実施の形態8の光伝送装置の動作と同様であるのでここでは説明を省略する。

【0112】

以上のように、この実施の形態10においては、実施の形態8の光伝送装置と同様、光軸調整を自動的に行うことができる。さらに、この実施の形態10の光ファイバ9の入射端面を直接観測しているため、ファイバ9の端面の損傷などのモニタも同時に行うことができ、安全装置としても用いることができる。

【0113】

実施の形態11.

図13は、この発明の実施の形態11に係る光伝送装置を示す構成図である。図において、図11に示す実施の形態9の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、14は光ファイバ9から出射されたレーザービームのごく一部を反射させるビームスプリッタであり、16は光ファイバ9から出射されたレーザービームをモニタする出射ビームモニタ装置で、例えば、スリットを走査させ、出射ビームのスリット透過後のパワーを検出することにより、ビーム直径を測定するモニタである。

【0114】

次に動作について説明する。

レーザー発振器10から出射されたビームウェイト径 ϕ_0 、ビーム開き角 θ を持つレーザービーム70は、集光レンズ81、82により光ファイバ9の入射端面で、 $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、このレーザービーム70は光ファイバ9内を集束性を保ったまま伝送され、その後光ファイバ9の出射端より外部へ出力される。光ファイバ9から出射されたビームの大部分はビームスプリッタ14を透過して加工等に用いられるが、ごく一部のパワーはビームスプリッタ14により反射されて出射ビームモニタ装置16に入射される。出射ビームモニタ装置16は出射ビームのビーム直径を計測し、そのデータをレンズホルダ移動装置104に出力する。レンズホルダ移動装置104は、出射ビームモニタ装置16から送られてきたデータを受け取り、出射ビームモニタ装置16で計測されるビーム直径が最小となるように集光レンズ81、82の位置を調節する。

【0115】

以上のように、この実施の形態11においては、前述のように、レーザービームの集束性が良いほどビーム開き角が小さく、その結果出射ビームモニタ装置16で計測されるビーム直径が小さくなるので、上記の手法で最適な入射条件が設定可能となる。また、上記の実施の形態11の光伝送装置では、同時に射出ビームの集束性が概略常時モニタできる利点がある。なお、この実施の形態11の光伝送装置では、射出ビームを直接ビームスプリッタ14へ入射したが、光ファイバ9の出射側に集光レンズを設置し、一旦レーザービームをコリメートしてからビームスプリッタ14に入射しても良い。

【0116】

実施の形態12.

図14は、この発明の実施の形態12に係る光伝送装置を示す構成図である。図において、図13に示す実施の形態11の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、11は開口直径が ϕ_s よりも大きく、ファイバコア直径 ϕ_c よりも小さくなるように設定されているアパーチャであり、その開口中心がファイバ9のコア中心とほぼ一致し、光ファイバ9の入射端に近い位置に設置されている。14は光ファイバ9から出射されたレーザービームのごく一

部を反射させるビームスプリッタ、161はパワーセンサである。

【0117】

次に動作について説明する。

レーザ発振器10から出射された、ビームウェイト径 ϕ_0 、ビーム開き角 θ を持つレーザビーム70は、集光レンズ81、82によりアパーチャ11を通過して光ファイバ9の入射端面で $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、光ファイバ9内を集束性を保ったまま伝送し、その後光ファイバ9の出射端より外部へ出力される。また、アパーチャ11を配置したことにより光ファイバ9の中心からずれたレーザビームはこのアパーチャ11により遮断される。光ファイバ9からの出力の大部分はビームスプリッタ14を透過し、ごく一部のパワーのみ反射されパワーセンサ161に入射される。出射レーザビームのパワーのデータはレンズホルダ移動装置104にフィードバックされ、出射レーザビームのパワーが最大になるように集光レンズ81、82の位置が調整される。

10

【0118】

以上のように、この実施の形態12においては、図に示すような簡単な構成で集光レンズの位置調整を自動的に行うことができる。また、図には明示していないが、出射レーザビームのパワーが極端に落ちたときにレーザ発振器10を停止するフィードバックを行うことにより、光ファイバを損傷から守るための安全装置にもなる。

【0119】

実施の形態13.

図15は、この発明の実施の形態13に係る光伝送装置を示す構成図である。図において、図13に示す実施の形態11の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、162は光ファイバ9の出射側の光ファイバ9の光軸からずれた位置に設置されたフォトダイオードである。

20

【0120】

次に動作について説明する。

レーザ発振器10から出射されたビームウェイト径 ϕ_0 、ビーム開き角 θ を持つレーザビーム70は、集光レンズ81、82により光ファイバ9の入射端面で $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} に集光され、光ファイバ9内を集束性を保ったまま伝送され、光ファイバ9の出射端より外部へ出力される。光ファイバ9へのレーザビーム70の入射条件が設定された値の範囲内にある場合、光ファイバ9から出射されたレーザビームはほとんどフォトダイオード162に検知されないが、光ファイバ9への入射条件が設定値よりもずれている場合には出射ビームの開き角が大きくなる。このためフォトダイオード162に入力されるレーザビームのパワーが増大する。フォトダイオード162からの出力はレンズホルダ移動装置104に入力され、レンズホルダ移動装置104はフォトダイオード162の出力が最小になるように集光レンズ81、82の位置を調整制御する。

30

【0121】

以上のように、この実施の形態13においては、実施の形態12と同様に図に示した簡単な構成でファイバ9の入射端の光軸調整を自動的に行うことができる。

【0122】

実施の形態14.

図16は、この発明の実施の形態14に係る光伝送装置を示す構成図である。図において、図13に示す実施の形態11の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、17は光ファイバ9の出射端近くに設置したアパーチャ、161はパワーセンサである。

40

【0123】

次に動作について説明する。

アパーチャ17の直径は、レーザビーム70が光ファイバ9の中心に入射し、レーザビームの直径が $\phi_s \pm 50\%$ の範囲であるときにわずかにレーザビームを遮断するように設定している。

50

【 0 1 2 4 】

以上のように、この実施の形態 1 4 においては、入射ビーム 7 0 の位置ずれ等が生じたときにアパーチャ 1 7 で遮断されるパワーが増大し、パワーセンサ 1 6 1 の出力が減少するため、パワーセンサ 1 6 1 の出力が最大となるようにレンズホルダ移動装置 1 0 4 により集光レンズ 8 1、8 2 の位置を調整制御することにより、図に示した簡単な構成でファイバ 9 の入射端面でのレーザビーム径の調整、ビーム位置の調整ができる。

【 0 1 2 5 】

実施の形態 1 5 .

図 1 7 は、この発明の実施の形態 1 5 に係る光伝送装置を示す構成図である。図において、図 1 0 に示す実施の形態 8 の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、1 8 は集束性設定機構であり、例えばボリューム、回転スイッチ、あるいはデジタル入力機器などで構成され、これにより M^2 を設定するものである。

10

【 0 1 2 6 】

次に動作について説明する。

レーザ発振器 1 0 から出射されたビームウェスト径 φ_0 、ビーム開き角 θ を持つレーザビーム 7 0 は、集光レンズ 8 により光ファイバ入射端面に、 $\varphi_0 \pm 50\%$ の範囲のビーム直径 φ_{in} に集光される。この条件を満足するようにレーザビームが集光された場合、これまでの他の実施の形態の説明で述べたように光ファイバ 9 の中心にレーザビーム 7 0 が入射したときは集束性を保って光ファイバ 9 内を伝送されるが、中心からずれた位置にレーザビーム 7 0 が入射した場合は集束性の劣化が生ずる。

20

【 0 1 2 7 】

図 1 8 は、コア直径 $\varphi_c = 400 \mu m$ 、中心の屈折率 $n_0 = 1.473$ 、コアとクラッドの屈折率差 $\Delta n = 0.021$ のグレーデッドインデックス光ファイバに M^2 値が 2.0 の Nd:YAG レーザビーム (波長 $\lambda = 1.064 \mu m$) を伝播させた実験における、光ファイバ 9 の入射端面での径方向のレーザビームの位置ずれ量 Δx と出射ビームの集束値 M^2_{out} との関係を示す説明図である。この条件では前述のように φ_0 が $148 \mu m$ となるので、入射されたレーザビームの位置が光ファイバ 9 のコア中心から $80 \mu m$ ずれた場合であってもレーザビームのすべてがこの光ファイバ 9 のコア内に導入さる。よって、この位置ずれによる光ファイバ 9 からの出射されるレーザビームのパワーの減少は無い。これより、この実施の形態 1 5 では、レーザビーム 7 0 の入射位置を $80 \mu m$ の範囲で移動させることにより出射レーザビームの集束性を制御することができ、 M^2 値で言うと 2.0 から 5.0 の範囲の出射レーザビームを得ることができる。

30

【 0 1 2 8 】

そこで、この実施の形態 1 5 の光伝送装置では、集束性設定機構 1 8 で指定した値に従い、あらかじめ求めてあるずれ量 (Δx) と出射レーザビーム集束性 (M^2 値) の関係に基づいてレンズホルダ移動装置 1 0 4、レンズホルダ 1 0 1 により集光レンズ 8 の位置を移動させ、その結果、光ファイバ 9 より集束性設定機構 1 8 で指定した集束性を持つビームを出射させる。

【 0 1 2 9 】

以上のように、この実施の形態 1 5 においては、容易に出射レーザビームの集束性を変化させることができ、溶接、切断など用途に応じて最適なパワーの出射レーザビームを容易に得ることができる。

40

【 0 1 3 0 】

なお、この実施の形態 1 5 の光伝送装置では光ファイバ 9 の入射端面での径方向のレーザビームのずれ量 Δx と出射レーザビームの M^2_{out} 値との関係を示したが、レーザビーム 7 0 の最小集光点が光ファイバ 9 の軸方向にずれた場合にも、出射レーザビームの M^2_{out} 値が変化する。よってこれを利用して、集束性設定機構 1 8 で指定した値に従い、あらかじめ得られている軸方向のずれ量と出射レーザビームの集束性 (M^2 値) との関係に基づいて、レンズホルダ移動装置 1 0 4、レンズホルダ 1 0 1 により集光レンズ 8 の位置を軸

50

方向に移動させ、その結果、集束性設定機構 18 で指定した集束性を持つレーザビームを光ファイバ 9 から出射させてもよい。

【0131】

また、この実施の形態 15 の光伝送装置では集光レンズ 8 により光ファイバ 9 の入射端面、またはその近傍で、 $\phi_s \pm 50\%$ の範囲のビーム直径 ϕ_{in} にレーザビームを集光した例を示したが、この条件を満たさないレーザビームに対しても、この実施の形態 15 と同様にして集光性の制御が行える。

【0132】

実施の形態 16 .

図 19 は、この発明の実施の形態 16 に係る光伝送装置を示す構成図である。図において、図 17 に示す実施の形態 15 の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、105 は光ファイバホルダ移動装置（移動手段）であり、該光ファイバホルダ移動装置 105 上に光ファイバホルダ 102 を搭載し、光ファイバホルダ 102 の位置を移動調整する。 10

【0133】

次に動作について説明する。

上記した実施の形態 15 の光伝送装置では、レンズホルダ移動装置 104 及びレンズホルダ 101 により集光レンズ 8 の位置を移動させ、その結果光ファイバ 9 より集束性設定機構 18 で指定した集束性を持つレーザビームを光ファイバ 9 から外部へ出射させていたが、図に示すこの実施の形態 16 の光伝送装置では、光ファイバホルダ移動装置 105 及び光ファイバホルダ 102 によりファイバ 9 の入射端面の位置を移動させ、その結果集束性設定機構 18 で指定した集束性を持つレーザビームを光ファイバ 9 から出射させる。 20

【0134】

以上のように、この実施の形態 16 においては、集光レンズ 8 と光ファイバ 9 の入射端面の両方の位置をレーザレンズホルダ 101 および光ファイバホルダ移動装置 105 により移動させることによって、光ファイバ 9 から出射するビームの集束性を制御できる。

【0135】

実施の形態 17 .

図 20 は、この発明の実施の形態 17 に係る固体レーザ装置を示す断面構成図である。同図において、1 は全反射ミラー（レーザ共振器）、2 は部分反射コーティングが施された出力ミラー（レーザ共振器）、3 は活性固体媒質を含む固体素子で、ヤグレーザを例にとれば活性固体媒質として Nd をドーピングした Nd : YAG (Yttrium Aluminum Garnet)、4 は光源であって、例えばアークランプで形成されている。5 は光源 4 を点灯する電源、6 は光源 4 の集光器であって、例えば断面形状が楕円状で内面は光反射面より構成されている。7 は全反射ミラー 1、部分反射ミラー 2 で構成されたレーザ共振器内に発生したレーザ光、100 はレーザ共振器を搭載する基台である。その他の構成要素 9、101、102 は図 1 に示した光伝送装置の構成要素と同一なのでその説明は省略する。 30

【0136】

次に動作について説明する。

光源 4 と固体素子 3 は内面が光源 4 に対して反射体、例えば白色セラミックで構成された集光器 6 の中に収納配置される。電源 5 で点灯された光源 4 からの光が投光され、投光された光は、直接もしくは集光器 6 内で反射された後、間接的に固体素子 3 に導かれる。固体素子 3 に導かれた光の一部は固体素子 3 内に吸収され、固体素子 3 を励起してレーザ媒質となる。レーザ媒質より発生された自然放出光は全反射ミラー 1 と部分反射ミラー 2 で構成されるレーザ共振器内を往復する間に増幅されてレーザ光 7 となり、所定値以上の大きさに達するとビームウェイスト径が ϕ_0 、ビーム開き角が 2θ のレーザビーム 70 としてレーザ共振器の外部に放出される。外部へ取り出されたレーザビーム 70 は、集光レンズ 8 により、光ファイバ 9 の入射端面のごく近傍に最小集光点を持ちその直径が $\phi_s \pm 50\%$ の範囲内のレーザビーム 70 となるように集光され、光ファイバ 9 内を集束性を保ったまま伝送され、その後光ファイバ 9 の出射端より外部へ出力される。 40 50

【 0 1 3 7 】

なお、上記説明では出力ミラー 2 を平面あるいは両面の曲率の絶対値が等しいメカニズム構造、すなわちレンズとしてのパワーを持たない構造として説明したが、出力ミラー 2 の透過特性が焦点距離 f のレンズと同様の特性を持ち、かつビームウェイストがレーザ共振器内にある場合は、光ファイバ 9 の入射端面での基準ビーム直径の計算に用いる φ_0 。または θ の値を焦点距離 f とビームウェイストの出力ミラーからの距離から計算して修正する必要がある。修正については簡単な幾何光学計算により行うことができ、一般的に公知の事項なのでここではその説明を省略する。

【 0 1 3 8 】

以上のように、この実施の形態 17 においては、レーザ発振器で増幅されたレーザ光 7 10 の集束性を保持したままレーザビーム 70 を光ファイバ 9 内を通じて伝送し、外部へ出力できる固体レーザ装置を得ることができる。

【 0 1 3 9 】

実施の形態 18 .

図 21 は、この発明の実施の形態 18 に係る固体レーザ装置を示す断面構成図である。図において、図 20 に示す実施の形態 17 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、21 は集光レンズ、22 は部分反射ミラー、106 は部分反射ミラー移動させるための部分反射ミラー移動装置（移動手段）、107 は集光レンズを移動させるための集光レンズ移動装置（移動手段）である。ここで、集光レンズ 21 と部分反射ミラー 22 は像転写光学系 20 を構成している。すなわち、集光レンズ 21 の焦点距離 f_r と部分反射ミラー 22 の曲率半径を同じ値に設定し、両者間の距離を $2f_r(1+\Delta)$ としている。この像転写光学系においては Δ の値によって全体として非常に広い曲率の可変範囲をもつ可変曲率ミラーとして機能する。

【 0 1 4 0 】

次に動作について説明する。

集光レンズ 21 及び部分反射ミラー 22 の微細な位置調整によってレーザビーム 70 のビームウェイスト位置およびビーム開き角を広い範囲にわたって調節することができる。

【 0 1 4 1 】

以上のように、この実施の形態 18 においては、光ファイバ 9 の入射端面近傍に最小集光点を持ち、そのビーム直径が $\varphi_0 \pm 50\%$ の範囲となるようなレーザビームを容易に調節できる。また、レーザ光 7 の出力を調整するために光源 4 への電気入力を変化させたときに生じる固体素子 3 内での活性固体媒質の熱レンズの変化に対しても対応でき、上記のレーザビーム 70 の光ファイバ 9 への入射条件を保つことができる。

【 0 1 4 2 】

図 22 は、この発明の実施の形態 19 に係る固体レーザ装置を示す断面構成図である。図において、図 21 に示す実施の形態 18 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。この実施の形態 19 の固体レーザ装置では、実施の形態 18 の固体レーザ装置像転写光学系に加えて、図 16 に示す実施の形態 14 の光伝送装置内のアパーチャ 17 およびパワーセンサ 161 を構成要素に加えている。

【 0 1 4 3 】

次に動作について説明する。

図における固体レーザ装置では、光ファイバ 9 から出射されたレーザビームを受けて、出射レーザビームのパワーを計測するパワーセンサ 161 からの出力に基づいて集光レンズ 21 と部分反射ミラー 22 の片方もしくは両方の位置を調整する。

【 0 1 4 4 】

以上のように、この実施の形態 19 においては、実際に光ファイバ 9 の出射端から出射されたレーザビームの集束性をパワーセンサ 161 でモニタしながらレーザ共振器の調整を行うことができ、固体媒質の熱レンズ変化に対応してもビームウェイスト位置、ビーム 50

直径の調整をより確実に、また自動的に行うことができる。また、光ファイバ 9 からの出射レーザビームの集束性が常時モニタできる効果がある。

【0145】

実施の形態 20 .

図 23 は、この発明の実施の形態 20 に係る固体レーザ装置を示す断面構成図である。図において、図 20 に示す実施の形態 17 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、19 は開口直径を外部から調節できる開口可変アパーチャ、20 はレーザ光 7 の出力の設定を行う出力設定機構であり、例えばボリューム、回転スイッチ、あるいはデジタル入力機器等のいずれかで構成されている。開口可変アパーチャ 19 はレーザ共振器の内部に設置されている。

10

【0146】

次に動作について説明する。

この実施の形態 20 の固体レーザ装置において、集光レンズ 8 の焦点距離および位置は、最大出力のレーザビーム 70 を得るための条件の電気入力に対し、レーザビーム 70 が光ファイバ 9 の入射端面のごく近傍に最小集光点を持ち、その直径が ϕ 、 $\pm 50\%$ の範囲となるように設定されている。レーザビーム 70 の出力の調節は、出力設定機構 20 の指示に従って機械的あるいは電氣的に開口可変アパーチャ 19 の開口径を調節することによって行う。この際、光源 4 への電気入力の変化はないので、固体素子の熱レンズ効果は不変であり、共振器の光学的な条件はアパーチャ 19 によるレーザビームの外縁の遮蔽のみである。この結果、レーザビームのビームウェイスの位置も変化しない。アパーチャ 19 の開口直径の変化によってレーザビーム 70 の出力、ビーム径、 M^2 値、ビーム開き角は変化するが、一方ビームウェイスの位置とミラーの曲率は変化しない。この条件下ではビーム径、ビーム開き角がいずれも M^2 値の平方根に比例することが知られている。また、集光レンズ 8 により集光レンズ 8 の左側のビームウェイスでの像を光ファイバ 9 の入射端近傍へ結像しているため、ビームウェイスの位置が変わらなければ、結像位置も倍率も変わらない。よって、光ファイバ 9 の入射端近傍でのレーザビーム 70 のビームウェイス径は M^2 値の平方根に比例する。一方、 ϕ も M^2 値の平方根に比例する。したがって、アパーチャ 19 の開口直径の変化でレーザビームのパワー調整をした場合、レーザビーム 70 は必ず光ファイバ 9 の入射端面のごく近傍に最小集光点を持ち、その直径は ϕ 、 $\pm 50\%$ の範囲となる。

20

30

【0147】

以上のように、この実施の形態 20 においては、図に示すように簡単な構成でどのようなパワーを有するレーザビームに対しても集束性を保ったまま光ファイバ 9 内を通じて外部へ伝送できる。なお、この実施の形態 20 の固体レーザ装置では、従来型の共振器を用いた構成について説明したが、共振器内部に像転写光学系を含んだ固体レーザに適用してもよく同様の効果を得ることができる。

【0148】

実施の形態 21 .

図 24 は、この発明の実施の形態 21 に係る固体レーザ装置を示す構成断面図である。図において、図 21 に示す実施の形態 18 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、191 は像転写光学系を構成する集光レンズ 21 と部分反射ミラー 22 との間に配置されたアパーチャ、108 はアパーチャ 191 を光軸方向に移動させるアパーチャ移動装置（調節手段）である。集光レンズ 8 の焦点距離、位置は最大出力のレーザビームを取り出す条件の電気入力に対し、レーザビームが、光ファイバ 9 の入射端面のごく近傍に最小集光点を持ちその直径が ϕ 、 $\pm 50\%$ の範囲となるように設定している。

40

【0149】

次に動作について説明する。

この実施の形態 21 の固体レーザ装置において、レーザビーム 70 の出力の調節は、出

50

力設定機構 20 の指示に従って、アパーチャ移動装置 108 によりアパーチャ 191 を光ファイバ 9 の光軸方向に移動してレーザ光 7 の外縁を遮断して行う。

【0150】

以上のように、この実施の形態 21 においては、前述した実施の形態 20 の固体レーザ装置と同様に、光源 4 へ供給される電気入力是不変で、固体素子の熱レンズ効果は不変であり、実施の形態 20 の固体レーザ装置と同様、どのような出力のレーザビームに対しても集束性を保ったまま光ファイバ 9 内を通じて外部へ伝送できる。なお、この実施の形態 21 の固体レーザ装置は、共振器内部に像転写光学系を含んだ共振器について説明したが、従来型の共振器で構成される固体レーザに適用してもよく同様の効果を得ることができる。

10

【0151】

実施の形態 22 .

図 25 は、この発明の実施の形態 22 に係る固体レーザ装置を示す構成断面図である。図において、図 20 に示す実施の形態 17 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図の固体レーザ装置において、光源 4 と固体素子 3 は内面が光源 4 に体して反射体、例えば白色セラミックで構成された集光器 6 の中に配置されている。

【0152】

次に動作について説明する。

電源 5 からの電圧の供給により点灯された光源 4 から光が投光され、投光された光は、直接もしくは集光器 6 内で反射後間接的に固体素子 3 に導かれる。固体素子 3 に導かれた光の一部は固体素子 3 内に吸収され、固体素子 3 を励起してレーザ媒質となる。レーザ媒質より発生された自然放光は全反射ミラー 1 と部分反射ミラー 2 で構成されるレーザ共振器間を往復する間に増幅されてレーザ光 7 となり、所定値以上の大きさに達するとビームウェイト径 ϕ_0 、ビーム開き角 2θ のレーザビーム 70 としてレーザ共振器の外部に放出される。外部へ取り出されたレーザビーム 70 は、集光レンズ 8 によってファイバ入射端面のごく近傍に最小集光点を持ちその直径が $\phi_s \pm 50\%$ の範囲となるように集光される。光ファイバホルダ移動装置 105、光ファイバホルダ 101 は、集束性設定機構 18 で指定した値に従いあらかじめ求めてあるずれ量と出射レーザビーム集束性の関係に基づいて光ファイバ 9 の入射端面の位置を移動させ、その結果光ファイバ 9 より集束性設定機構 18 で指定された集束性を持つレーザビームを外部へ出射させる。

20

30

【0153】

以上のように、この実施の形態 22 においては、光ファイバ 9 から出射される出射レーザビームの集束性を容易に変化させることができ、溶接、切断など用途に応じて最適なパワーを有するレーザビームを出射する固体レーザ装置を得ることができる。なお、この実施の形態 22 の固体レーザ装置では、光ファイバホルダ移動装置 105 により光ファイバ 9 の入射端面の位置を移動させたが、集光レンズホルダ移動装置を設けて集光レンズ 8 の位置を移動させても良く、同様の効果を得ることができる。また、この実施の形態 22 の固体レーザ装置では、従来型の共振器について説明したが、共振器内部に像転写光学系や、パワー調整のためのアパーチャを組み込んだ固体レーザ装置に使用してもよく、この場合も同様の効果を得ることができる。

40

【0154】

実施の形態 23 .

図 26 は、この発明の実施の形態 23 に係る固体レーザ装置を示す構成図である。図において、図 25 に示す実施の形態 22 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図の固体レーザ装置において、レーザ共振器を構成する全反射ミラー 1 と出力ミラー 2 は、同じ曲率を持ち、固体素子 3 が共振器のほぼ中央に位置するいわゆる対称型共振器として構成されている。光源 4 と固体素子 3 は内面が光源 4 に対して反射体、例えば白色セラミックで構成された集光器 6 の中に配置される。

50

【 0 1 5 5 】

次に動作について説明する。

電源 5 から電圧が供給されて点灯された光源 4 からの光が投光され、投光された光は、直接もしくは集光器 6 内で反射後間接的に固体素子 3 に導かれる。固体素子 3 に導かれた光の一部は固体素子 3 内に吸収され、固体素子 3 を励起してレーザ媒質と変える。このレーザ媒質より発生された自然放出光は全反射ミラー 1 と部分反射ミラー 2 で構成されるレーザ共振器間を往復する間に増幅されてレーザ光 7 となり、所定値以上の大きさに達するとビームウェイスト径 φ_0 、ビーム開き角 2θ のレーザビーム 7 0 としてレーザ共振器の外部に放出される。この構成を有する共振器では非常に安定なレーザ発振が可能であるが、レーザ出力レベルによってビームウェイスト径、ビーム開き角が大きく変化するという特性も有する。その結果、 φ_0 、 θ の値も大きく変化し、これに比例する M^2 値も大きく変化する。

10

【 0 1 5 6 】

図 2 7 は、ある対称型共振器構成における入射ビームとレーザ出力と出射レーザビームの M^2 値との関係を示す説明図である。図において、レーザ出力と M^2 値との間係は細線で示されている。レーザ出力が小さいほど M^2 値の小さなレーザビームが発生している。これから明らかなように、それぞれの出力レベルによって高輝度ビームファイバ伝播のための入射ビーム直径が異なる。

【 0 1 5 7 】

以上のように、この実施の形態 2 3 においては、最大の M^2 値での 3 0 0 W 出力における φ_0 、 θ を基準として、外部へ取り出されたレーザビーム 7 0 が集光レンズ 8 によって光ファイバ 9 の入射端面のごく近傍に最小集光点を持ち、その直径が

20

$$(\varphi_c, \varphi_0, \theta (2n_0 \Delta n)^{-1/2})^{1/2} \pm 50\%$$

となるように集光し、他の出力レベルにおいても光学系を移動させずにレーザビーム 7 0 をそのまま伝播させる。

【 0 1 5 8 】

図の固体レーザ装置によると、レーザ出力 3 0 0 W 時以外ではビーム直径等の変化によりファイバ伝播後の M^2 値が増加するが、もともとのビームの M^2 値が 3 0 0 W 時より小さいため、レーザ出力による M^2 値の変化量がむしろ縮小され、レーザビームの出力が変化した場合であっても集束性の変化が少ないレーザビームを出射する固体レーザ装置を得ることができる。

30

【 0 1 5 9 】

図 2 7 の説明図内での太線は、細線で示されるビームを 3 0 0 W 時の φ_0 、 θ に合わせてレーザビームの入射ビーム径を調整してファイバ 9 内を伝播させた実験結果を示している。図によると、入射ビームの M^2 値の変化が 5 から 2 1 なのに対し、出射ビームの M^2 値が 1 5 から 2 2 となっている。よって、実際にレーザビームの出力が変化しても集束性の変化が少ないレーザビームを出射する固体レーザ装置を得ることができる。

【 0 1 6 0 】

実施の形態 2 4 .

図 2 8 は、この発明の実施の形態 2 4 に係る固体レーザ装置を示す構成図であり、(b) は (a) の平面図である。図において、図 2 5、2 6 に示す実施の形態 2 2、2 3 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図の固体レーザ装置において、固体素子 3 は、薄板状のいわゆるスラブレーザ媒質で構成されている。スラブレーザ媒質は厚み方向 (以下 y 方向) と幅方向 (以下 x 方向) で大きさが異なるため、通常の球面レンズで共振器を構成すると、x 方向での φ_{0x} 、 θ_x と y 方向での φ_{0y} 、 θ_y との値が大きく異なる。また、集光レンズとして、シリンドリカルレンズ 8 4、8 5 を用いている。

40

【 0 1 6 1 】

次に動作について説明する。

図に示すこの実施の形態 2 4 では、シリンドリカルレンズ 8 4、8 5 を用いて x 方向と

50

y 方向を独立に集光させる。すなわち、外部へ取り出されたレーザビーム 70 を、x 方向に関してはシリンドリカルレンズ 84 によってファイバ 9 の入射端面のごく近傍に最小集光点を持ちその直径が

$$(\varphi_c \varphi_{0x} \theta_x (2n_0 \Delta n)^{-1/2})^{1/2} \pm 50\%$$

y 方向に関してはシリンドリカルレンズ 85 によってファイバ入射端面のごく近傍に最小集光点を持ちその直径が

$$(\varphi_c \varphi_{0y} \theta_y (2n_0 \Delta n)^{-1/2})^{1/2} \pm 50\%$$

となるようにレーザビーム 70 を集光する。

【0162】

以上のように、この実施の形態 24 においては、光ファイバ 9 から出射される出射レーザビームの M^2 値は光ファイバ 9 に入射される入射レーザビームの x 方向の M^2 値と y 方向の M^2 値との間の値をとり、x 方向と y 方向で集光性能が異なる発振器に対しファイバ 9 内を伝播後も全体として集光性能が保存されたレーザビームを出射する固体レーザ装置を得ることができる。さらにまた、ファイバ伝播の過程でビームの異方性が改善されるという効果も併せてもつ。

【0163】

実施の形態 25 .

図 29 は、この発明の実施の形態 25 に係る固体レーザ装置を示す構成図である。図 29 の (b) は (a) の平面図である。図において、図 25、26、28 に示す実施の形態 22、23、24 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図の固体レーザ装置において、固体素子 3 はスラブレザ媒質で構成されており、またレーザ共振器は、x 方向については安定型、y 方向については一次元不安定型のいわゆるハイブリッド共振器として構成されている。また、集光レンズはシリンドリカルレンズ 84、85 で構成されている。

【0164】

次に動作について説明する。

図の固体レーザ装置内で用いられている共振器では、原理的に集光性能の優れたレーザビームを発生される。一般には、不安定型共振器の方が集光性能の良いレーザビームを得やすいが、x 方向での $\varphi_{0x} \theta_x$ と y 方向での $\varphi_{0y} \theta_y$ と値が大きく異なりその関係は $\varphi_{0x} \theta_x < \varphi_{0y} \theta_y$ となる。この実施の形態 25 の固体レーザ装置においても、前記した実施の形態 24 の固体レーザ装置と同様に、シリンドリカルレンズ 84、85 を用いてレーザビーム 70 の x 方向と y 方向を独立に集光させる。すなわち、外部へ取り出されたレーザビーム 70 を、x 方向に関してはシリンドリカルレンズ 84 によってファイバ 9 の入射端面のごく近傍に最小集光点を持ちその直径が

$$(\varphi_c \varphi_{0x} \theta_x (2n_0 \Delta n)^{-1/2})^{1/2} \pm 50\%$$

y 方向に関してはシリンドリカルレンズ 85 によってファイバ入射端面のごく近傍に最小集光点を持ちその直径が

$$(\varphi_c \varphi_{0y} \theta_y (2n_0 \Delta n)^{-1/2})^{1/2} \pm 50\%$$

となるように集光する。

【0165】

以上のように、この実施の形態 25 においては、前述した実施の形態 23、24 の固体レーザ装置と同様、光ファイバ 9 から出射される出射レーザビームの M^2 値は、光ファイバ 9 に入射される入射レーザビームの x 方向の M^2 値と y 方向の M^2 値との間の値をとり、光ファイバ 9 内を伝播後も集光性能の優れたレーザビームを出射する固体レーザ装置を得ることができる。

【0166】

実施の形態 26 .

図 30 は、この発明の実施の形態 26 に係る固体レーザ装置を示す構成図である。図 30 の (b) は (a) の平面図である。図において、図 25、26、28、29 に示す実施の形態 22、23、24、25 の固体レーザ装置の説明で用いられている番号と同一の番

号は同一の構成要素を示し、ここではその説明を省略する。図において、固体素子 3 はスラブレザ媒質で構成され、レーザ共振器はハイブリッド共振器として構成されている。集光レンズ 8 は通常の球面レンズで構成されている。

【0167】

次に動作について説明する。

レーザビーム 70 の光ファイバ 9 の入射端への集光は通常の集光レンズ 8 で行う。そして、y 方向に関してファイバ入射端面のごく近傍に最小集光点を持ち、最小集光点の直径が

$$(\varphi_c \varphi_{oy} \theta_y (2n_0 \Delta n)^{-1/2})^{1/2} \pm 50\%$$

となるようにレーザビーム 70 を集光する。一方、x 方向については最小集光点の位置、最小集光点の直径が最適値からかなりずれることが予想される。しかしながらこの実施の形態 26 の固体レーザ装置内の共振器は、 $\varphi_{ox} \theta_x < \varphi_{oy} \theta_y$ の関係を有し、出射レーザビームの M^2 値は、入射レーザビームの x 方向の M^2 値と y 方向の M^2 値との間の値をとる。したがって、x 方向についての最小集光点の位置、最小集光点の直径が少々最適値からずれた場合であっても、光ファイバ 9 から出射される出射レーザビームの M^2 値は y 方向の入射ビームの M^2 値程以下となり、その結果、全体として優れた集光性能を保存したまま光ファイバ 9 内の伝播が可能である。

【0168】

以上のように、この実施の形態 26 においては、x 方向と y 方向で集光性能が異なる発振器を用いた場合であっても、図に示したように非常に簡単なレンズ構成で、光ファイバ 9 内の伝播後も全体として集光性能が大きく損なわれないレーザビームを出射できる固体レーザ装置を得ることができる。さらにまた、光ファイバ 9 内の伝播過程でレーザビームの異方性が改善されるという効果も有する。

【0169】

実施の形態 27 .

図 31 は、この発明の実施の形態 27 に係るレーザ加工装置を示す構成図である。図において、図 1 に示す実施の形態 1 の光伝送装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、23 は集光レンズ（集光光学系）、800 は被加工物、810 は加工ノズル、820 は加工ガスの導入口である。

【0170】

次に動作について説明する。

レーザ発振器 10 から出射されたビームウェイト径 φ_0 、ビーム開き角 2θ を持つレーザビーム 70 は、集光レンズ 8 により光ファイバ 9 の入射端面で $\varphi_s \pm 50\%$ の範囲のビーム直径に集光され、光ファイバ 9 内を集束性を保ったまま伝送され、その後光ファイバ 9 の出射端より外部へ出力される。このレーザ光は集光レンズ 23 によりさらに集光され、この集光されたレーザビームを用いて被加工物 800 はレーザ加工される。

【0171】

以上のように、この実施の形態 27 においては、光ファイバ 9 から出射する集束性の保たれたレーザビームをさらに集光レンズ 23 で集光しているので、被加工物 800 の切断、溶接等において、きわめて高精度なレーザ加工が可能である。

【0172】

なお、この実施の形態 27 のレーザ加工装置の説明においては、図 1 に示した実施の形態 1 に係る光伝送装置を用いたが、図 4 に示した実施の形態 2 に係る光伝送装置、から図 16 に示した実施の形態 14 に係る光伝送装置、ならびに図 20 に示した実施の形態 17 に係る固体レーザ装置から図 24 に示した実施の形態 21 に係る固体レーザ装置を用いた場合にも同様の効果を得ることができる。

【0173】

実施の形態 28 .

図 32 は、この発明の実施の形態 28 に係るレーザ加工装置を示す断面構成図である。

図において、図 25 に示す実施の形態 22 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、光源 4 と固体素子 3 は、内面が光源 4 に体して反射体、例えば白色セラミックで構成された集光器 6 の中に配置される。

【0174】

次に動作について説明する。

電源 5 からの電圧の供給により点灯された光源 4 から光が投光され、投光された光は、直接もしくは集光器 6 内で反射後間接的に固体素子 3 に導かれる。固体素子 3 に導かれた光の一部は固体素子 3 に吸収され、固体素子 3 を励起してレーザ媒質となる。レーザ媒質より発生された自然放出光は全反射ミラー 1 と部分反射ミラー 2 で構成されるレーザ共振器間を往復する間に増幅されてレーザ光 7 となり、所定値以上の大きさに達するとビームウェイスト径 φ_0 、ビーム開き角 2θ のレーザビーム 70 としてレーザ共振器の外部に放出される。外部へ放出されたレーザビーム 70 は集光レンズ 8 によって光ファイバ 9 の入射端面のごく近傍に最小集光点を持ち、その直径が $\varphi_s \pm 50\%$ の範囲となるように集光される。集束性設定機構 18 で指定した値に従って、あらかじめ設定されているずれ量と出射レーザビーム集束性との関係に基づいて、光ファイバ 9 の入射端面の位置を光ファイバホルダ移動装置 105、光ファイバホルダ 102 により移動させる。その結果、光ファイバ 9 より集束性設定機構 18 で指定した集束性を持つレーザビームを出射させる。このレーザビームは集光レンズ 23 によりさらに集光され、この集光されたレーザビームを用いて被加工物 800 のレーザ加工を行なう。

【0175】

以上のように、この実施の形態 28 においては、光ファイバ 9 によるレーザビーム 70 の伝送を、集束性を保った状態から集束性を变化させた状態に故意に変えることが可能なので、容易に出射ビームの集束性を变化させることができ、溶接、切断などにおいて、高精度なレーザ加工、広い面積の加工等が自由に選択可能であり、用途に応じて最適な出射ビームを容易に得ることができる。

【0176】

なお、この実施の形態 28 のレーザ加工装置の説明においては、図 25 に示した実施の形態 22 に係る固体レーザ装置を用いたが、図 17 に示した実施の形態 15 に係る光伝送装置または図 19 に示した実施の形態 16 に係る光伝送装置を用いた場合にも同様の効果を得ることができる。

【0177】

実施の形態 29 .

図 33 は、この発明の実施の形態 29 に係るレーザ加工装置を示す構成図である。図において、図 1 に示す実施の形態 1 の光伝送装置および図 31 に示す実施の形態 27 のレーザ加工装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。

【0178】

次に動作について説明する。

レーザ発振器 10 から出射されたビームウェイスト径 φ_0 、ビーム開き角 2θ を持つレーザビーム 70 は、集光レンズ 8 から光ファイバ入射端面で $\varphi_s \pm 50\%$ の範囲のビーム直径 φ_{in} に集光され、光ファイバ 9 内を集束性を保ったまま伝送され、その後光ファイバ 9 の出射端より外部へ出力される。図においては、この比から出射されたレーザビームを集光せずに、そのまま直接に被加工物 800 に照射しレーザ加工を行なう。

【0179】

以上のように、この実施の形態 29 においては、光ファイバ 9 によるレーザビームの伝送が集束性を保ったまま行なわれるので、光ファイバ 9 の出射端から出射されるレーザビームの開き角が従来に比較して小さく、例えばレーザ焼き入れなどの比較的照射面積の大きなレーザ加工であれば、図 31、32 に示した実施の形態 27、28 での集光レンズ 23 を用いることなしに、図に示すように非常に簡単な構成で行うことができる。

【 0 1 8 0 】

なお、この実施の形態 29 においては、図 1 に示した実施の形態 1 に係る光伝送装置を用いて説明を行ったが、図 4 に示した実施の形態 2 の光伝送装置から図 19 に示した実施の形態 16 に係る光伝送装置を用いた場合にも同様の効果を得ることができる。図 4 に示した実施の形態 2 の光伝送装置を用いた場合、ビーム開き角 2θ を持つレーザビーム 70 は、集光レンズ 8 からアパーチャ 11 を介して光ファイバ 9 の入射端面で $\varphi_s \pm 50\%$ の範囲のビーム直径 φ_{in} に集光され、光ファイバ 9 内を集束性を保ったまま伝送されし、図 33 に示す様に光ファイバ 9 の出射端より外部へ出力される。

【 0 1 8 1 】

実施の形態 30 .

10

図 34 は、この発明の実施の形態 30 に係るレーザ加工装置を示す構成断面図である。図において、図 20 に示す実施の形態 17 の固体レーザ装置の説明で用いられている番号と同一の番号は同一の構成要素を示し、ここではその説明を省略する。図において、光源 4 と固体素子 3 は内面が光源 4 に対して反射体、例えば白色セラミックで構成された集光器 6 の中に配置されている。

【 0 1 8 2 】

次に動作について説明する。

電源 5 からの電圧の供給により点灯された光源 4 からの光が投光され、投光された光は、直接もしくは集光器 6 内で反射後間接的に固体素子 3 に導かれる。固体素子 3 に導かれた光の一部は固体素子 3 に吸収され、固体素子 3 は励起されレーザ媒質となる。レーザ媒質より発生された自然放光はミラー 1 と 2 で構成されるレーザ共振器間を往復する間に増幅されてレーザ光 7 となり、所定値以上の大きさに達するとビームウェスト径 φ_0 、ビーム開き角 2θ のレーザビーム 70 としてレーザ共振器の外部に放出される。外部へ取り出されたレーザビーム 70 は集光レンズ 8 によって光ファイバ 9 の入射端面のごく近傍に最小集光点を持ち、その直径が $\varphi_s \pm 50\%$ の範囲のビーム直径 φ_{in} を有するレーザビーム 70 に集光され、光ファイバ 9 内を集束性を保ったまま伝送され、光ファイバ 9 の出射端より外部へ出力される。この光ファイバ 9 から出射されたレーザビームを集光せずにそのまま直接の被加工物に照射、加工物のレーザ加工を行なう。

20

【 0 1 8 3 】

以上のように、この実施の形態 30 においては、光ファイバ 9 によるレーザビームの伝送が集束性を保ったまま行なわれるので、光ファイバ 9 の出射端から出射されるレーザビームの開き角が従来に比較して小さく、例えばレーザ焼き入れなどの比較的照射面積の大きなレーザ加工が図 34 に示されるように非常に簡単な構成で実行できる。なお、この実施の形態 30 のレーザ加工装置においては、図 20 に示した実施の形態 17 に係る固体レーザ装置を用いて説明を行ったが、図 21 に示した実施の形態 18 に係る固体レーザ装置から図 25 に示した実施の形態 22 に係る固体レーザ装置を用いた場合にも同様の効果を得ることができる。

30

【 0 1 8 4 】

【発明の効果】

以上のように、請求項 1 記載の発明によれば、光ファイバをグレーデッドインデックス光ファイバで構成し、光ファイバのコア径 φ_c 、コア中心での屈折率 n_0 、コア中心とコア周囲部の屈折率差 Δn 、レーザ光のビームウェストでの直径 φ_0 、レーザ光のビーム開き角 2θ である時、レーザ光が光ファイバの入射端面上または光ファイバ入射端面近傍に最小集光点を持ち、最小集光点での直径 φ_{in} が

40

$$0.5\varphi_s \leq \varphi_{in} \leq 1.5\varphi_s$$

ただし、

$$\varphi_s = (\varphi_c \varphi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}$$

となるようなファイバ入射光学系を備えたので、レーザ共振器で発生された高集束性のレーザビームを集束性のレベルの減少なく光ファイバの出射端から出射できる効果がある。

【 0 1 8 5 】

50

請求項2記載の発明によれば、レーザ光の波長を λ とした時に、 $\pi \theta \varphi_0 / \lambda$ の値が100以下となるように設定されるので、集束性のレベルが低下することなく光ファイバの出射端からレーザビームを出射できる効果がある。

【0186】

請求項3記載の発明によれば、光ファイバの入射端近傍にアパーチャを設置したので、光ファイバの入射端付近の不要な場所へのレーザ照射を防止でき、光ファイバを保護できる効果がある。

【0187】

請求項4記載の発明によれば、光ファイバの出射端近傍にアパーチャを設置したので、出射側で反射される反射ビームがクラッド等に照射されるのをアパーチャにより防止でき、反射ビームの影響を最小限にとどめ、光ファイバを保護できる効果がある。 10

【0188】

請求項5記載の発明によれば、二枚もしくは二組の集光レンズを用いてファイバ入射光学系を構成したので、レーザ光のビーム特性に合わせて光ファイバ入射端面でのビーム直径を容易に調整することができる効果がある。

【0189】

請求項6記載の発明によれば、集光レンズの1つとしてグレーデッドインデックスレンズを用い、光ファイバの近接位置に配置したので、グレーデッドインデックスレンズの位置を少し調整することにより、広い範囲のレーザビームのビーム特性に合わせながら、光ファイバの入射端面でのビーム直径を容易に調整することができ、様々な応用が可能となる効果がある。 20

【0190】

請求項7記載の発明によれば、グレーデッドインデックスレンズの入射端近傍にアパーチャを設置したので、このアパーチャによりグレーデッドインデックスレンズならびに光ファイバの入射端面周辺への思わぬレーザ光照射を防止でき、これらを保護できる効果がある。

【0191】

請求項8記載の発明によれば、入射ビームモニタ装置と集光レンズのための移動手段を設置したので、レーザビームの最適な集光を自動的にできる効果がある。

【0192】

請求項9記載の発明によれば、出射ビームモニタ装置と集光レンズのための移動手段を設置したので、レーザビームの最適な集光を自動的にできるとともに出射ビームの集束性を常時モニタでき、装置の状態を随時監視できる効果がある。 30

【0193】

請求項10記載の発明によれば、光ファイバの入射側に設置したアパーチャと出射側に設置したパワーセンサとで出射ビームモニタ装置を構成したので、非常に簡単な構成でレーザビームの自動的な最適集光が可能となる効果がある。

【0194】

請求項11記載の発明によれば、光ファイバの出射側の光軸よりずれた位置に設置したフォトダイオードにより出射ビームモニタ装置を構成したので、レーザビームの自動的な最適集光が可能となり、装置の状態を随時監視できる効果がある。 40

【0195】

請求項12記載の発明によれば、光ファイバの出射側に設置したアパーチャとパワーセンサにより出射ビームモニタ装置を構成したので、非常に簡単な構成でレーザビームの最適な集光を自動的に行うことができ、出射ビームの集束性を常時モニタできる効果がある。

【0196】

請求項13記載の発明によれば、集光レンズと光ファイバの入射端面の片方もしくは両方の位置を移動させる移動手段を設置して双方の位置関係を最適な集光位置に移動できるようにしたので、集束性を任意に変化できる光伝送装置を容易に得られる効果がある。 50

【0197】

請求項14記載の発明によれば、レーザ媒質となる固体素子、レーザ共振器及びこの発明の光伝送装置により固体レーザ装置を構成し、さらにレーザ共振器内にミラーと集光レンズからなる像転写光学系、及びそれらの移動手段を備えたので、共振器内部の像転写光学系により高集束性を持つビームを発振すると同時に、光ファイバの入射端面のビーム直径を $\phi_0 \pm 50\%$ の範囲となるように容易に調整可能であり、高集束性のレーザビームを得ることができる効果がある。

【0198】

請求項15記載の発明によれば、光ファイバからの出射ビームを計測するモニタ装置を備えたのでレーザ共振器のレーザ光の集束性のレベルを自動調整でき、これにより集束性のレベルを保持したまま光ファイバ伝送を行うことができる効果がある。 10

【0199】

請求項16記載の発明によれば、レーザ共振器内にアパーチャならびにアパーチャ開口直径の調節手段を設けたので、レーザ光学系を調節することなくあらゆるレーザ出力の要求に対し常にレーザ光の集束性のレベルを保ったまま光ファイバを介してレーザ光を出射できる効果がある。

【0200】

請求項17記載の発明によれば、レーザ共振器内にアパーチャならびにアパーチャの光軸方向の移動手段を設けたので、レーザ光学系を調節することなくあらゆるレーザ出力の要求に対し常にレーザ光の集束性を保ったまま光ファイバを介してレーザ光を出射できる効果がある。 20

【0201】

請求項18記載の発明によれば、対称型共振器において外部へ取り出されたレーザ光を、 $\phi_0 \theta$ の大きな出力レベルにおいてファイバ入射端面のごく近傍に最小集光点を持ちその直径が

$$\frac{(\phi_c \phi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}}{}$$

となるように集光したので、レーザ出力が変化しても集束性の変化が少ないレーザビームを出射できる固体レーザ装置を得られる効果がある。

【0202】

請求項19記載の発明によれば、固体素子3がスラブレレーザ媒質で構成され、外部へ取り出されたレーザ光を、x方向とy方向で独立に集光し、それぞれファイバ入射端面のごく近傍に最小集光点を持ちその直径が 30

$$\frac{(\phi_c \phi_{0x} \theta_x (2n_0 \Delta n)^{-1/2})^{1/2}}{(\phi_c \phi_{0y} \theta_y (2n_0 \Delta n)^{-1/2})^{1/2}}$$

となるように集光したので、x方向とy方向で集光性能が異なるレーザ発振器に対しファイバ伝播後も全体として集光性能が保存されたレーザビームを出射できる固体レーザ装置を得ることができる効果がある。

【0203】

請求項20記載の発明によれば、固体素子3がスラブレレーザ媒質で構成され、 $\phi_0 \theta$ の大きい方向に関してファイバ入射端面のごく近傍に最小集光点を持ち、最小集光点の直径が 40

$$\frac{(\phi_c \phi_0 \theta (2n_0 \Delta n)^{-1/2})^{1/2}}{}$$

となるように集光したので、x方向とy方向で集光性能が異なる発振器に対し非常に簡単なレンズ構成で、ファイバ伝播後も全体として集光性能が大きく損なわれないレーザビームを出射できる固体レーザ装置を得ることができる効果がある。

【0204】

請求項21記載の発明によれば、この発明の光伝送装置または固体レーザ装置から出射されたレーザ光を、さらに集光するための集光光学系で集光し被加工物に照射しレーザ加工を行なうようにしたので、光ファイバ伝送を行ったにも関わらず極めて高精度のレーザ加工ができる効果がある。 50

【0205】

請求項22記載の発明によれば、この発明の光伝送装置または固体レーザ装置から出射されたレーザ光を直接被加工物に照射しレーザ加工を行なうようにしたので、集光レンズなしの非常に簡単な構成でレーザ焼き入れ等の加工が可能である効果がある。

【図面の簡単な説明】

【図1】 この発明の実施の形態1による光伝送装置を示す構成図である。

【図2】 グレーデッドインデックス光ファイバ内でのレーザビームの伝播状況を示す説明図である。

【図3】 集光レンズの焦点距離を変化させて出射ビームの M^2 値(M^2_{out})を測定した実験結果を示す説明図である。

10

【図4】 この発明の実施の形態2による光伝送装置を示す構成図である。

【図5】 この発明の実施の形態3による光伝送装置を示す構成図である。

【図6】 この発明の実施の形態4による光伝送装置を示す構成図である。

【図7】 この発明の実施の形態5による光伝送装置を示す構成図である。

【図8】 この発明の実施の形態6による光伝送装置を示す構成図である。

【図9】 この発明の実施の形態7による光伝送装置を示す構成図である。

【図10】 この発明の実施の形態8による光伝送装置を示す構成図である。

【図11】 この発明の実施の形態9による光伝送装置を示す構成図である。

【図12】 この発明の実施の形態10による光伝送装置を示す構成図である。

【図13】 この発明の実施の形態11による光伝送装置を示す構成図である。

20

【図14】 この発明の実施の形態12による光伝送装置を示す構成図である。

【図15】 この発明の実施の形態13による光伝送装置を示す構成図である。

【図16】 この発明の実施の形態14による光伝送装置を示す構成図である。

【図17】 この発明の実施の形態15による光伝送装置を示す構成図である。

【図18】 グレーデッドインデックス光ファイバにおける光ファイバ入射端でのレーザビームの位置ずれと出射ビームの集束値との関係を示す説明図である。

【図19】 この発明の実施の形態16による光伝送装置を示す構成図である。

【図20】 この発明の実施の形態17による固体レーザ装置を示す構成図である。

【図21】 この発明の実施の形態18による固体レーザ装置を示す構成図である。

【図22】 この発明の実施の形態19による固体レーザ装置を示す構成図である。

30

【図23】 この発明の実施の形態20による固体レーザ装置を示す構成図である。

【図24】 この発明の実施の形態21による固体レーザ装置を示す構成図である。

【図25】 この発明の実施の形態22による固体レーザ装置を示す構成図である。

【図26】 この発明の実施の形態23による固体レーザ装置を示す構成図である。

【図27】 図26に示す実施の形態23における入射ビームと出射ビームの M^2 値との関係を示す説明図である。

【図28】 この発明の実施の形態24による固体レーザ装置を示す構成図である。

【図29】 この発明の実施の形態25による固体レーザ装置を示す構成図である。

【図30】 この発明の実施の形態26による固体レーザ装置を示す構成図である。

【図31】 この発明の実施の形態27によるレーザ加工装置を示す構成図である。

40

【図32】 この発明の実施の形態28によるレーザ加工装置を示す構成図である。

【図33】 この発明の実施の形態29によるレーザ加工装置を示す構成図である。

【図34】 この発明の実施の形態30によるレーザ加工装置を示す構成図である。

【図35】 従来の光伝送装置を示す構成図である。

【図36】 レーザビームの集束性の指標 M^2 を示す説明図である。

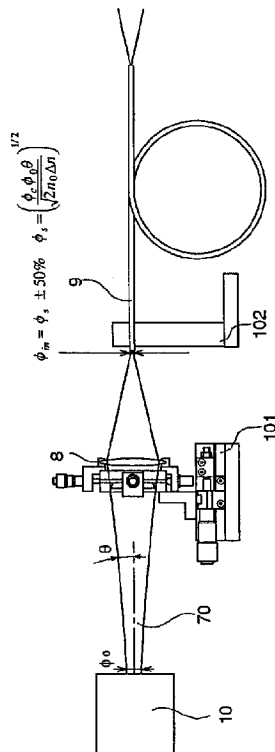
【図37】 光ファイバへの入射角と出射角との関係を示す説明図である。

【符号の説明】

1 全反射ミラー(レーザ共振器)、2 出力ミラー(レーザ共振器)、3 固体素子、4 光源、7 レーザ光、8、81、82 集光レンズ(光ファイバ入射光学系)、9 光ファイバ(グレーデッドインデックス光ファイバ)、10 レーザ発振器、11、1 50

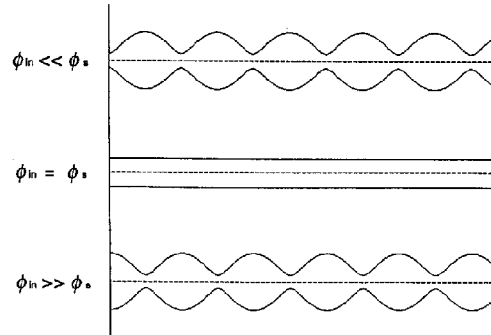
2, 13, 17, 191 アパーチャ、15 入射ビームモニタ装置、16 出射ビームモニタ装置、20 出力設定機構(調節手段)、21 集光レンズ(像転写光学系)、22 部分反射ミラー(像転写光学系)、23 集光レンズ(集光光学系)、70 レーザビーム、83 グレーデッドインデックスレンズ、84、85 シリンдриカルレンズ(光ファイバ入射光学系)、104 レンズホルダ移動装置(移動手段)、105 光ファイバホルダ移動装置(移動手段)、106 部分反射ミラー移動装置(移動手段)、107 集光レンズ移動装置(移動手段)、108 アパーチャ移動装置(調節手段)、161 パワーセンサ、162 フォトダイオード、800 被加工物。

【図1】

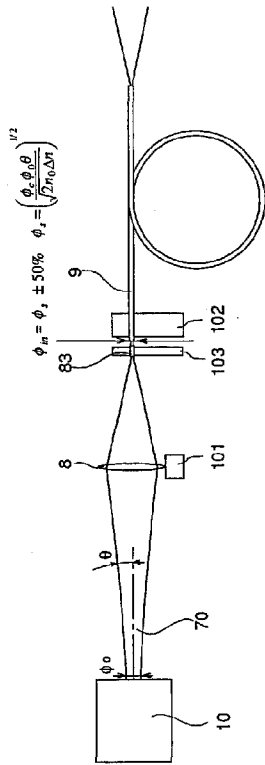


8: 集光レンズ(光ファイバ入射光学系)
9: 光ファイバ(グレーデッドインデックス光ファイバ)
10: レーザ架装器
70: レーザビーム

【図2】

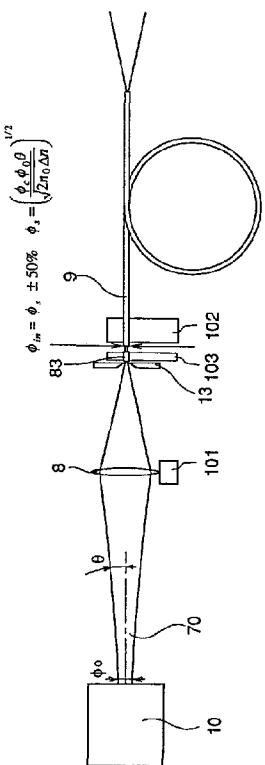


【 図 7 】



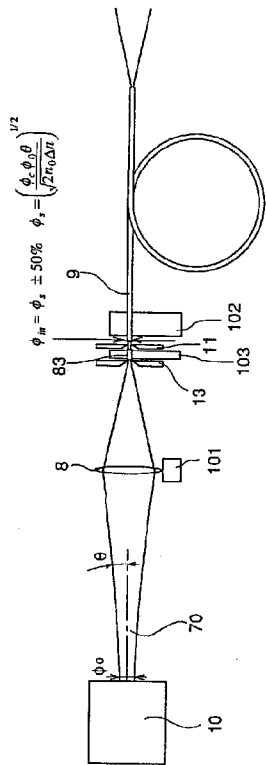
8 3 : グレーティング型回折レンズ

【 図 8 】

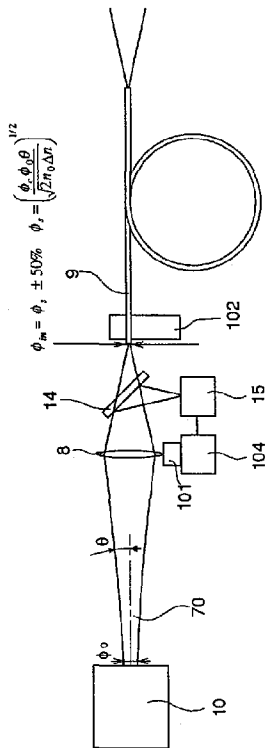


1 3 : アパーチャ

【 図 9 】

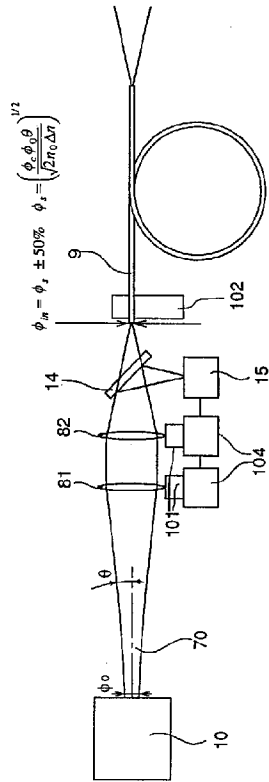


【 図 1 0 】

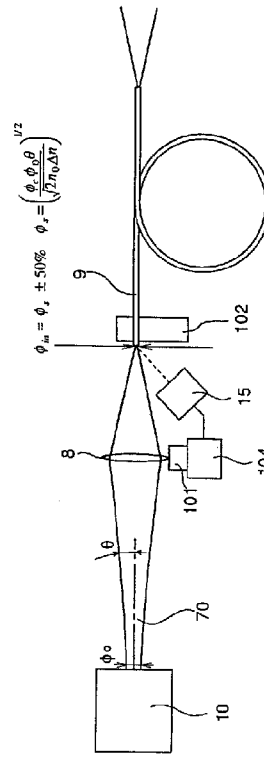


1 5 : 入射ビームモニタ装置
1 0 4 : レンズホルダ移動装置 (移動手段)

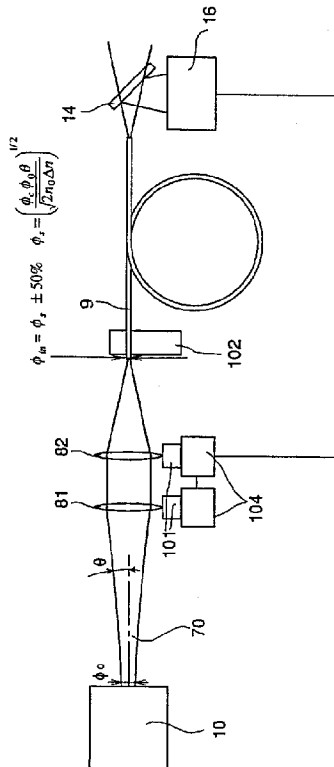
【 図 1 1 】



【 図 1 2 】

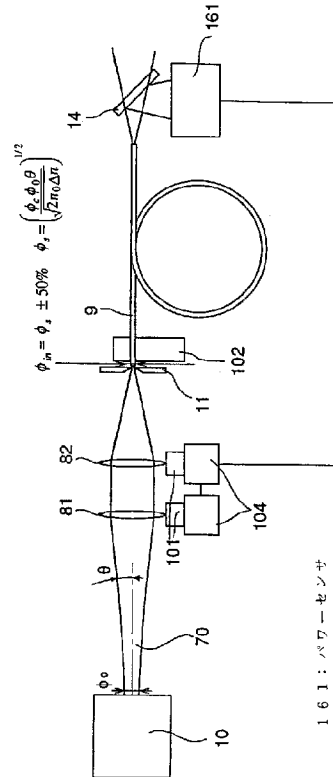


【 図 1 3 】



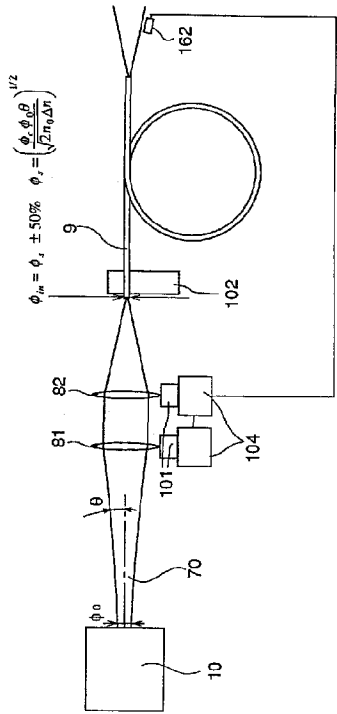
1 6 : 出射ビームセンサ装置

【 図 1 4 】



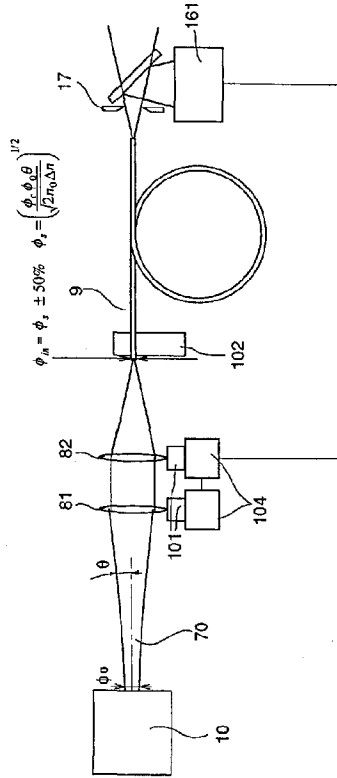
1 6 1 : パワーセンサ

【 図 1 5 】



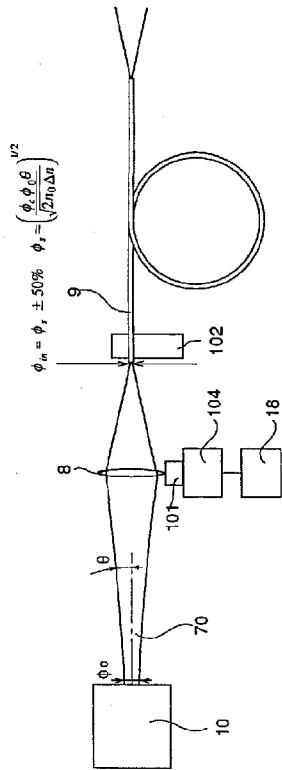
1 6 2 : フ ァ ー ト フ ァ イ ト フ ァ ー ト

【 図 1 6 】

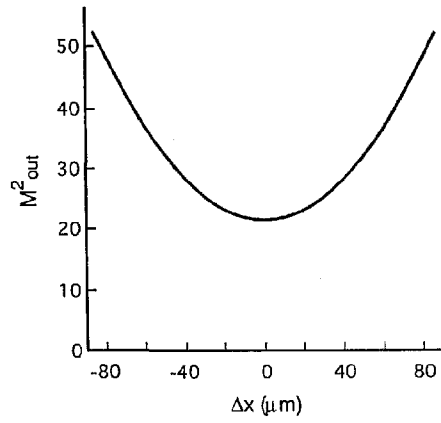


1 7 : ア ー バ ー チ ャ

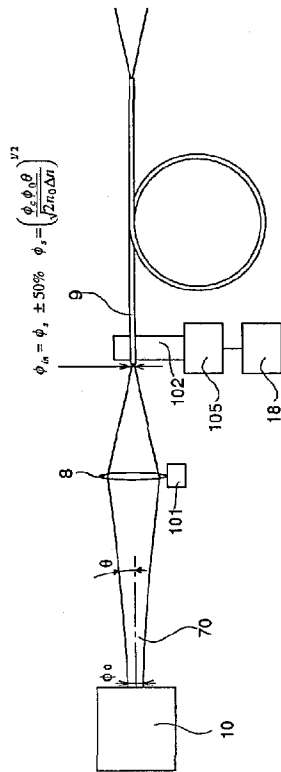
【 図 1 7 】



【 図 1 8 】

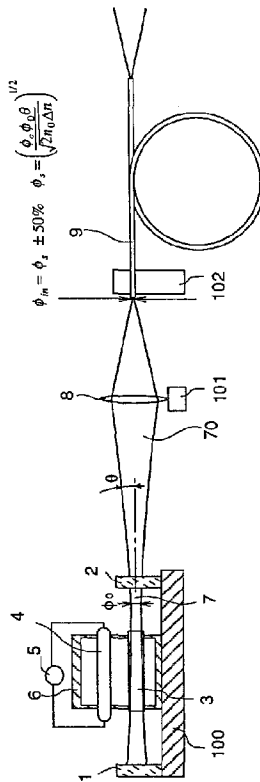


【 図 1 9 】



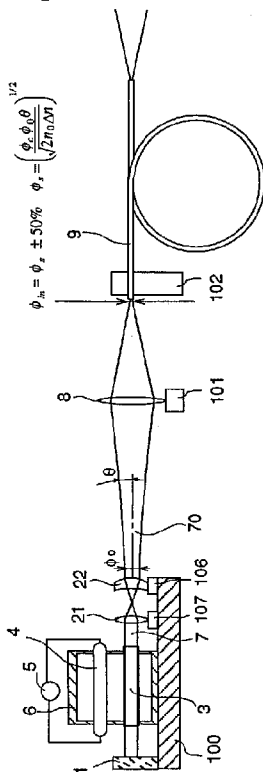
1 0 5 : 光ファイババルダ移動装置 (移動手段)

【 図 2 0 】



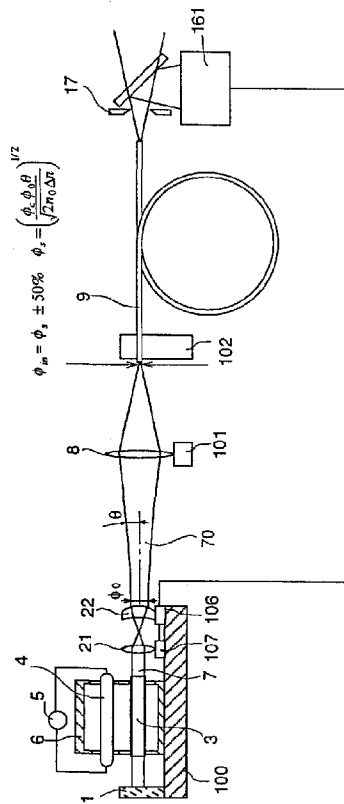
- 1 : 全反射ミラー (レーザー共振器)
- 2 : 出力ミラー (レーザー共振器)
- 3 : 固体素子
- 4 : 光源
- 7 : レーザ光

【 図 2 1 】

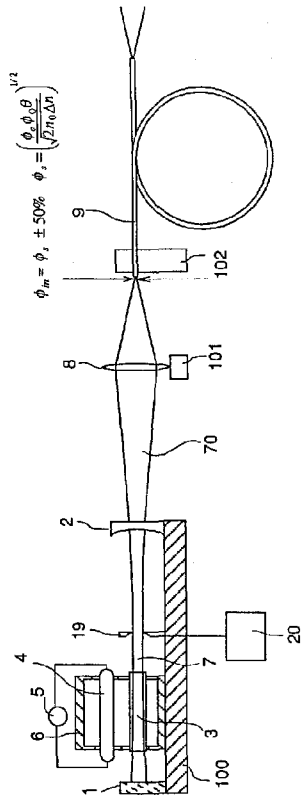


- 2 1 : 集光レンズ (像転写光学系)
- 2 2 : 部分反射ミラー (像転写光学系)
- 1 0 6 : 部分反射ミラー移動装置 (移動手段)
- 1 0 7 : 集光レンズ移動装置 (移動手段)

【 図 2 2 】

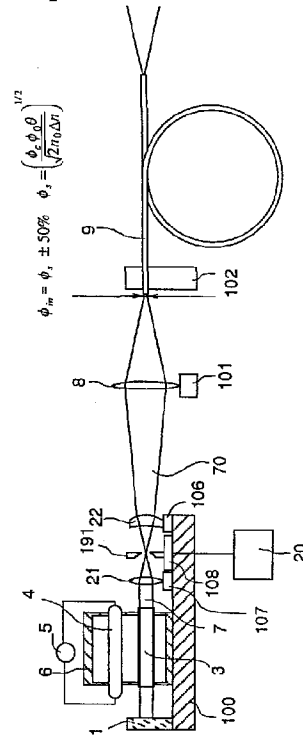


【圖 23】



20:出力設定機構(調節手段)

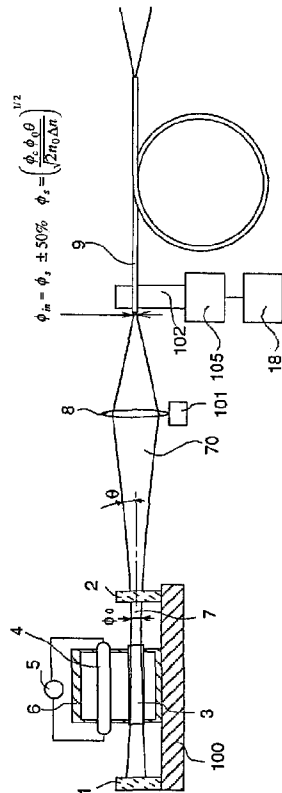
【 図 2 4 】



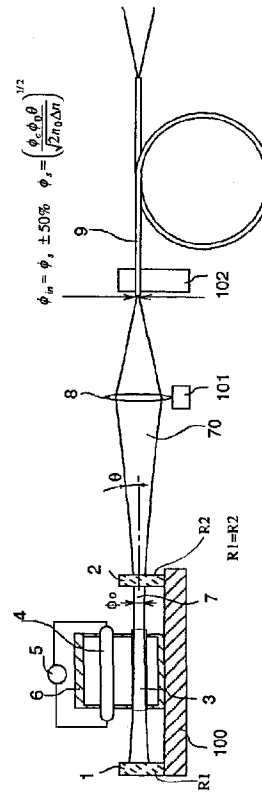
108: アパーチャ移動装置(調節手段)

191:アパーチャ

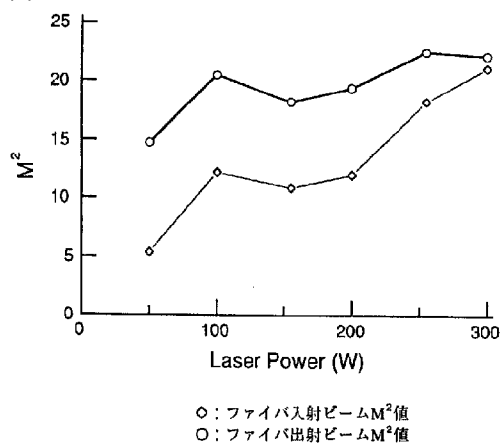
【圖 25】



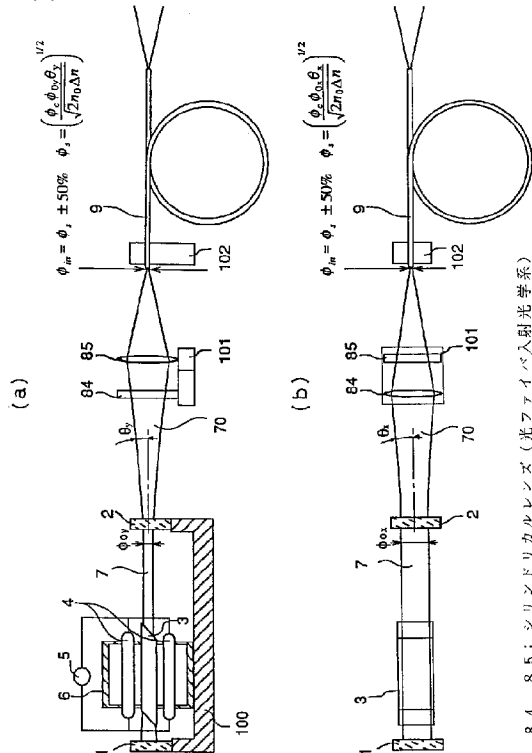
【 図 2 6 】



【圖 27】

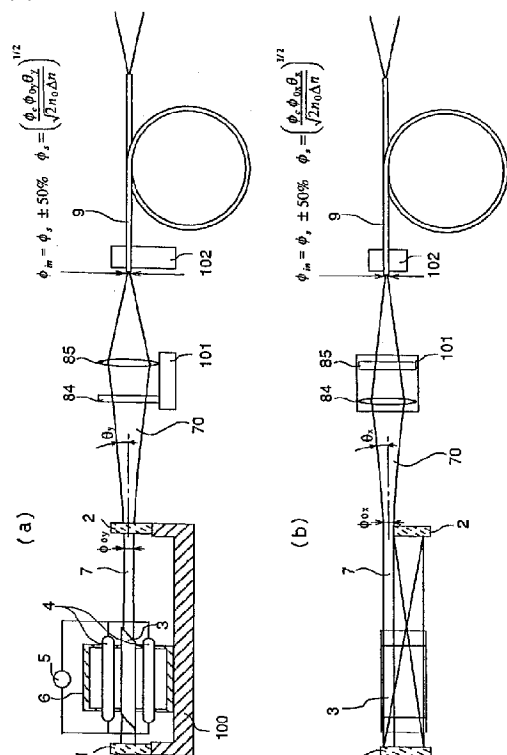


【圖 28】

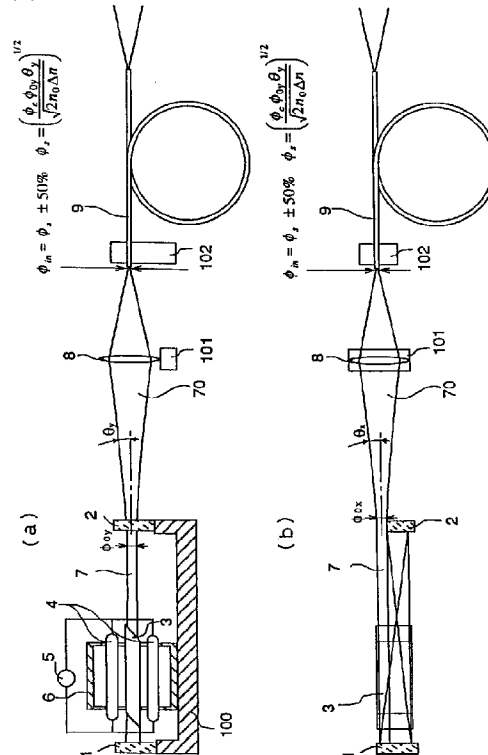


34、85: シリンドリカルレンズ (光ファイバ入射光学系)

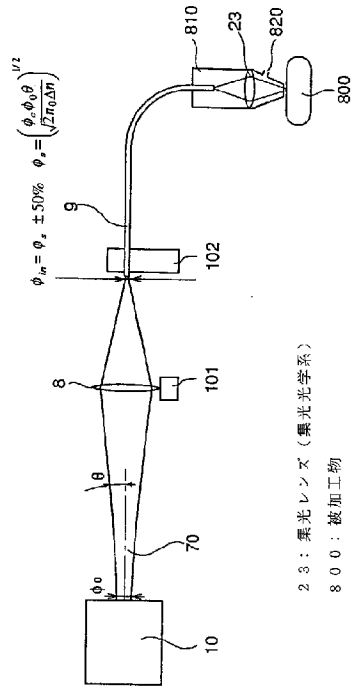
【 図 2 9 】



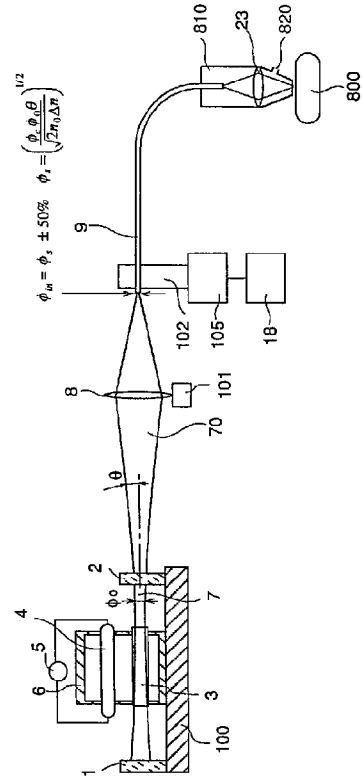
【 図 3 0 】



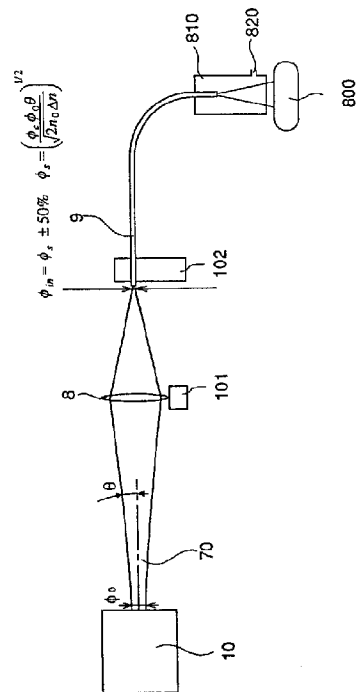
【 図 3 1 】



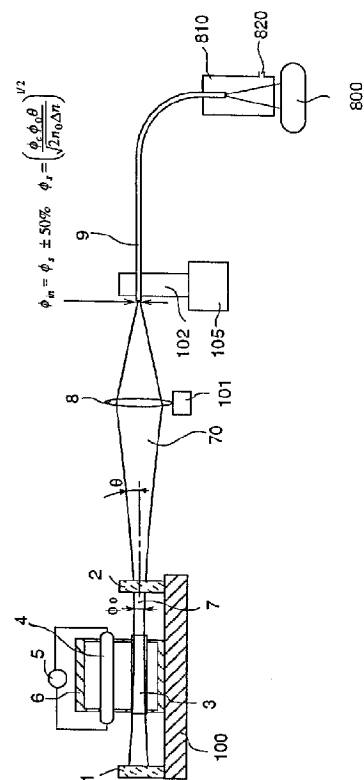
【 図 3 2 】



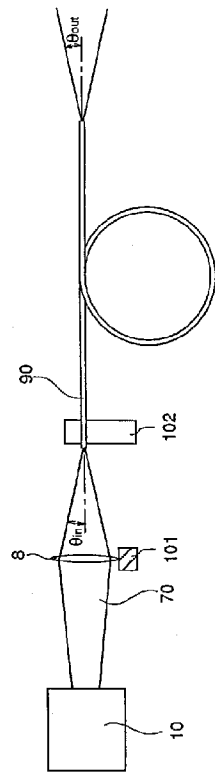
【 図 3 3 】



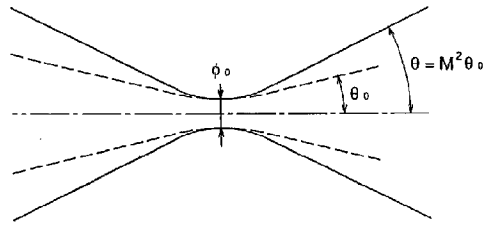
【 図 3 4 】



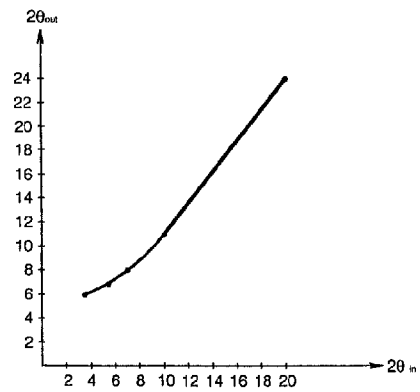
【 図 3 5 】



【 図 3 6 】



【 図 3 7 】



フロントページの続き

- (72) 発明者 安井 公治
東京都千代田区丸の内二丁目 2 番 3 号 三菱電機株式会社内
- (72) 発明者 熊本 健二
東京都千代田区丸の内二丁目 2 番 3 号 三菱電機株式会社内
- (72) 発明者 岩城 邦明
東京都千代田区丸の内二丁目 2 番 3 号 三菱電機株式会社内

審査官 河原 正

- (56) 参考文献 レーザー学会編「レーザーハンドブック」オーム社 (昭和 5 7 - 1 2 - 1 5) , 6 6 - 6 8 頁
IEEE PROCEEDINGS- J Vol. 140 No. 4 (1993) , p. 221- 226
レーザー研究 第 1 6 巻 第 6 号 , 3 1 0 - 3 1 7 頁

- (58) 調査した分野 (Int. Cl. ⁷ , D B 名)

H01S3/00- 3/30

G02B6/02

G02B6/12

G02B6/32

Attorney Docket No.: 15540-0370006 / 18.01127; DS10502

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Rudolph Huber	Art Unit :	Unknown
Application No. :	18/387,089	Examiner :	Unknown
Filed :	November 6, 2023	Conf. No. :	7969
Title :	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

MAIL STOP AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT

Please consider the documents listed on the disclosure form submitted with this statement. Copies of the documents are being submitted with this statement to the extent required under 37 C.F.R. § 1.98(a)(2).

This application relies on the earlier filing date of application number 17/552,455, filed on December 16, 2021, application number 16/398,362, filed on April 30, 2019, application number 15/279,781, filed on September 29, 2016, application number 14/300,138, filed on June 9, 2014, and application number 13/639,401, filed on December 20, 2012. Under 37 CFR § 1.98(a)(2) and 37 CFR § 1.98(d), the earlier application is properly identified and is relied on for an earlier effective filing date under 35 U.S.C. § 120 and therefore copies of foreign and non-patent literature documents cited in the earlier application are not provided. Copies of U.S. patents and U.S. patent application publications also are not provided.

This statement is being filed before the receipt of a first action on the merits.

First Named Inventor : Rudolph Huber
Application No. : 18/387,089
Filed : November 6, 2023
Page : 2 of 2

Attorney Docket No.: 15540-0370006 / 18.01127;
DS10502

Apply any necessary charges or credits applicable under 37 C.F.R. § 1.17(p) to deposit account 06-1050, referencing the above attorney docket number.

Please contact the undersigned if there are any questions regarding this statement.

Respectfully submitted,

Date: 04/10/2024

/Yunbo Guo/

Yunbo Guo, Reg. No. 70,538

Customer Number 26161
Fish & Richardson P.C.
Telephone: +1 (512) 226-8108
Facsimile: (877) 769-7945

63437944.doc

Sheet 1 of 3

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 15540-0370006	Application No. 18/387,089
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant TRUMPF Laser- und Systemtechnik GmbH	
		Filing Date 11/6/2023	Group Art Unit Unknown

U.S. Patent Documents							
Examiner Initial	Cite No.	Document Number	Publication Date	Patentee	Filing Date If Appropriate	Class	Subclass
/M.R.C/	1.	3,941,670	3/2/1976	Pratt			
	2.	3,975,082	8/17/1976	Winzer			
	3.	4,475,788	10/9/1984	Tomassini et al			
	4.	4,575,181	3/11/1986	Ishikawa			
	5.	5,461,692	10/24/1995	Nagel			
	6.	5,475,704	12/12/1995	Lomashevich			
	7.	5,684,642	11/4/1997	Zumoto et al			
	8.	6,819,815	11/16/2004	Corbalis et al.			
	9.	7,372,877	5/13/2008	Shirakawa et al			
	10.	7,379,237	5/27/2008	Di Teodoro et al			
	11.	7,379,648	5/27/2008	Brooks et al			
	12.	7,592,568	9/22/2009	Vamham et al			
	13.	7,720,340	5/18/2010	Lewis et al			
	14.	7,738,166	6/15/2010	Murison et al			
	15.	7,809,225	10/5/2010	Bouma et al			
	16.	7,839,902	11/23/2010	Li et al.			
	17.	7,933,479	4/26/2011	Gonthier et al			
	18.	8,008,600	8/30/2011	Nakamae et al			
	19.	8,076,632	12/13/2011	Kreysing et al			
	20.	8,094,370	1/10/2012	Lewis			
	21.	8,326,099	12/4/2012	Singer et al			
	22.	8,456,523	6/4/2013	Stork Gennant Wersborg			
	23.	8,781,269	7/15/2014	Huber et al.			
	24.	8,861,910	10/14/2014	Yun			
↓	25.	9,482,821	11/1/2016	Huber et al.			
/M.R.C/	26.	9,755,739	9/5/2017	Wang et al.			

Examiner Signature /MICHELLE R CONNELLY/	Date Considered 09/07/2024
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.R.C/

Substitute Disclosure Form

Sheet 2 of 3

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 15540-0370006	Application No. 18/387,089
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant TRUMPF Laser- und Systemtechnik GmbH	
		Filing Date 11/6/2023	Group Art Unit Unknown

U.S. Patent Documents							
Examiner Initial	Cite No.	Document Number	Publication Date	Patentee	Filing Date If Appropriate	Class	Subclass
/M.R.C/	27.	10,281,656	5/7/2019	Huber et al.			
	28.	11,215,761	1/4/2022	Huber et al.			
	29.	11,806,804	11/7/2023	Huber et al.			
	30.	2002/0071647	6/13/2002	Manzur			
	31.	2002/0168139	11/14/2002	Clarkson et al			
	32.	2002/0172485	11/21/2002	Keaton et al			
	33.	2005/0031261	2/10/2005	Tanaka			
	34.	2006/0219673	10/5/2006	Varnham et al.			
	35.	2006/0251367	11/9/2006	Seifert et al			
	36.	2006/0263024	11/23/2006	Dong et al			
	37.	2011/0305249	12/15/2011	Gapontsev et al.			
	38.	2013/0064706	3/14/2013	Schwarze et al			
	39.	2013/0223792	8/29/2013	Huber et al.			
	40.	2015/0217402	8/6/2015	Hesse et al.			
	41.	2015/0293306	10/15/2015	Huber et al.			
	42.	2015/0378184	12/31/2015	Tayebati et al.			
	43.	2017/0031105	2/2/2017	Huber et al.			
	44.	2019/0025502	1/24/2019	Zediker et al.			
	45.	2019/0118299	4/25/2019	Kangastupa et al.			
	46.	2019/0258009	8/22/2019	Huber et al.			
	47.	2022/0179153	6/9/2022	Huber et al.			

Foreign Patent Documents or Published Foreign Patent Applications							
Examiner Initial	Cite No.	Document Number	Publication Date	Country or Patent Office	Translation	Class	Subclass
	48.	CN 1580865	2/16/2005	CN	English Abstract		
/M.R.C/	49.	DE 3833992	4/12/1990	DE	English Abstract		

Examiner Signature /MICHELLE R CONNELLY/	Date Considered 09/07/2024
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.R.C/

Sheet 3 of 3

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 15540-0370006	Application No. 18/387,089
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant TRUMPF Laser- und Systemtechnik GmbH	
		Filing Date 11/6/2023	Group Art Unit Unknown

Foreign Patent Documents or Published Foreign Patent Applications							
Examiner Initial	Cite No.	Document Number	Publication Date	Country or Patent Office	Translation	Class	Subclass
/M.R.C/	50.	DE 3833993	4/12/1990	DE	English Abstract		
	51.	DE 4200587	4/1/1993	DE	English Abstract		
	52.	FR 0362466	9/26/1990	FR	English Abstract		
	53.	FR 2284892	4/9/1976	FR	English Abstract		
	54.	GB 2449689	12/3/2008	GB			
	55.	KR 100750511	8/13/2007	KR	English Abstract		
	56.	WO 2009/155536	12/23/2009	WO			
	57.	WO 2010009101	1/21/2010	WO			

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Cite No.	Document
	58.	DE German Office Action dated November 22, 2010
	59.	EP Extended European Search Report dated July 1, 2013
	60.	IN Office Action for Indian Application No. 8560/CHENP/2012 by Controller Ambigaapathy A, dated November 20, 2017, 6 pages (with English translation)
/M.R.C/	61.	PCT International Search Report dated May 6, 2011

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.R.C/

Examiner Signature /MICHELLE R CONNELLY/	Date Considered 09/07/2024
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form



①⑨ BUNDESREPUBLIK
DEUTSCHLAND



DEUTSCHES
PATENTAMT

⑫ Patentschrift
⑩ DE 38 33 992 C 2

⑤① Int. Cl.⁵:
A 61 B 17/36
A 61 N 5/06
G 02 B 6/26

②① Aktenzeichen: P 38 33 992.7-35
②② Anmeldetag: 6. 10. 88
④③ Offenlegungstag: 12. 4. 90
④⑤ Veröffentlichungstag
der Patenterteilung: 19. 3. 92

DE 38 33 992 C 2

Innerhalb von 3 Monaten nach Veröffentlichung der Erteilung kann Einspruch erhoben werden

⑦③ Patentinhaber:

Messerschmitt-Bölkow-Blohm GmbH, 8012
Ottobrunn, DE

⑦② Erfinder:

Hessel, Stefan, Dr., 8000 München, DE

⑤⑥ Für die Beurteilung der Patentfähigkeit
in Betracht gezogene Druckschriften:

DE 34 15 293 C2
DE 37 17 142 A1
DE 32 14 042 A1

DRISCOLL, W.G., VAUGHAN, W.: Handbook of
Optics New York: McGraw-Hill Inc. 1978, S.13-7
bis 13/8;

⑤④ Bestrahlungseinrichtung

DE 38 33 992 C 2

Die Erfindung geht aus von einer Bestrahlungseinrichtung nach dem Oberbegriff des Patentanspruchs 1.

Es ist bekannt, daß der therapeutische Effekt von Laserstrahlen auf biologisches Gewebe wellenlängenabhängig ist. So läßt sich mit einer langwelligeren Laserstrahlung von 2,94 µm oder auch 1,32 µm eine vorwiegend schneidende Wirkung erzielen, während eine kurzwelligere Laserstrahlung, z. B. die 1,06 µm-Strahlung eines Neodym-Lasers, eine vorwiegend koagulierende Wirkung besitzt. Bei dem aus der DE 37 17 142 A1 bekannten Bestrahlungsgerät der beanspruchten Art werden die beiden Laserstrahlungen durch eine einzige, umschaltbare Laserlichtquelle erzeugt und nacheinander über ein und denselben Quarzlichtleiter zur Applikationsstelle übertragen. Häufig müssen jedoch im Operationsfeld beide Wirkungen gleichzeitig in räumlich voneinander abgegrenzten Teilzonen, nämlich die präzise kontaktlose Schnittwirkung im Zentrum und der blutstillende Koagulationseffekt an den Randflächen der Schnittstelle, zur Anwendung kommen, was bei diesem bekannten Gerät nicht möglich ist.

Ferner ist im "Handbook of Optics", S. 13-7 bis 13-8, der Zusammenhang zwischen dem Ein- und Auskoppelwinkel eines Lichtbündels bezüglich der Längsachse einer Lichtleitfaser dergestalt beschrieben, daß ein konvergentes Lichtbündel, dessen Mittelachse nicht coaxial, sondern schräg geneigt zur Flächennormalen der Fasereintrittsfläche verläuft, am distalen Lichtleiterende nicht zentralkegelförmig mit axialer Abstrahlcharakteristik, sondern als zur Faserlängsachse coaxialer Ringkegel mit zirkumferenzieller Abstrahlcharakteristik austritt.

Aufgabe der Erfindung ist es, die Bestrahlungseinrichtung der eingangs genannten Art so auszubilden, daß sich die unterschiedlichen Bestrahlungseffekte der beiden Lichtbündel unter Beibehalt einer einzigen Lichtleitfaser in jeweils zueinander konzentrischen Teilzonen der Applikationsstelle unabhängig voneinander und jeweils individuell dosierbar wahlweise simultan oder zeitlich nacheinander erzielen lassen, ohne das es abstrahlseitig der Lichtleitfaser irgendwelcher selektiv wirkender Steuer- oder Trennorgane für die Lichtbündel bedarf.

Diese Aufgabe wird erfindungsgemäß durch die im Kennzeichnungsteil des Patentanspruchs 1 angegebenen Merkmale gelöst.

Erfindungsgemäß werden aufgrund der besonderen Ein- und der zueinander coaxialen Auskoppelung der beiden Lichtbündel in Verbindung mit der achsgleichen, zur Applikationsstelle hin konvergenten Lichtführung abstrahlseitig der Lichtleiterfaser jeweils unabhängig voneinander individuell steuerbare Bestrahlungswirkungen einerseits in einer zentralen und andererseits in einer diese ringförmig umschließenden Teilzone des Applikationsbereichs mit geringem Bauaufwand erzielt. Die erfindungsgemäße Bestrahlungseinrichtung ist insbesondere, aber nicht ausschließlich zum kontaktlosen Schneiden und Koagulieren von biologischem Gewebe geeignet, wobei die schneidend wirkende Strahlung den zur Applikationsstelle konvergenten, zentralen Lichtkegel und die koagulierend wirkende den hierzu coaxialen Ringkegel bildet. Hierdurch wird z. B. in der Parenchymchirurgie eine optimale Lichtbündelsteuerung und -konzentration und eine problemlose, simultane Bedienung im Operationsfeld gewährleistet.

In weiterer vorteilhafter Ausgestaltung der Erfindung

besitzen beide Lichtbündel gemäß Anspruch 1 einen gemeinsame Fokuspunkt, wodurch es möglich ist, allein durch Änderung des Abstands zur Applikationsstelle beide Lichtbündel-Einzeleffekte gemeinsam zu verstärken oder abzuschwächen. Gemäß einem weiteren, bevorzugten Aspekt der Erfindung ist jedoch nach Anspruch 3 der Fokuspunkt des ringkegelförmig ausgekoppelten Lichtbündels von der Fokussiereinrichtung weiter entfernt als der Fokuspunkt des zentral ausgekoppelten, so daß sich die beiden Lichtbündel-Einzeleffekte wiederum allein durch Abstandsänderungen gegenüber dem Applikationsbereich und ohne weitere Steuereingriffe noch erheblich besser dosieren lassen, derart, daß sich der eine Einzeleffekt verstärkt und gleichzeitig der andere abschwächt, wenn der Applikationsbereich relativ zur Fokussiereinrichtung im Bereich zwischen den Fokuspunkten der Lichtbündel bewegt wird.

Eine baulich besonders einfache Ausbildung der Fokussiereinrichtung mit voneinander beanstandeten Fokuspunkten wird zweckmäßigerweise dadurch erzielt, daß als Fokussiereinrichtung gemäß Anspruch 4 ein asphärisches Linsensystem bzw. nach Anspruch 5 für Lichtbündel unterschiedlicher Wellenlängen ein von beiden Lichtbündeln durchstrahltes Linsensystem aus einem Material hoher Farbdispersion vorgesehen ist. Aus Handhabungsgründen ist das das distale Lichtleiterende und die Fokussiereinrichtung aufnehmende Gehäuse teil gemäß Anspruch 6 vorzugsweise als Fokussier-Handstück ausgebildet.

Abgesehen von den erwähnten Abstandsänderungen sind die unterschiedlichen Bestrahlungseffekte der Lichtbündel gemäß Anspruch 7 vorzugsweise auch jeweils individuell dadurch dosierbar, daß die Lichtbündel hinsichtlich Strahlungsleistung, Wellenlänge und/oder Betriebsart verschiedenartig bzw. unabhängig voneinander gesteuert werden.

Zur Erzeugung der beiden Lichtbündel in Form von Laserlichtbündeln unterschiedlicher Wellenlänge mit jeweils individuell steuerbarer Intensität sind gemäß Anspruch 8 vorzugsweise zwei getrennte Laserlichtquellen mit nachgeschalteter einkoppelseitiger Optik oder in weiterer baulicher Vereinfachung gemäß Anspruch 9 eine einzige, entsprechend der gewünschten individuellen Dosierung wellenlängenumschaltbare Laserlichtquelle mit einem nachgeschalteten, die Laserstrahlung wellenlängenabhängig auf den jeweiligen Einkoppelwinkelbereich ablenkenden Prisma vorgesehen, wobei zum selektiven Ein- und Ausblenden jeden Lichtbündels gemäß Anspruch 10 vorzugsweise ein umschaltbares, optisches Element im Strahlengang der einkoppelseitigen Optik angeordnet ist, wodurch sich auf baulich einfache Weise auch jeder der beiden Bestrahlungseffekte für sich allein zur Anwendung bringen läßt.

Die Erfindung wird nunmehr anhand der in den Figuren schematisch dargestellten Ausführungsbeispiele näher beschrieben. Es zeigt

Fig. 1 eine Bestrahlungseinrichtung zum gleichzeitigen Schneiden (a) und Koagulieren (b) von biologischem Gewebe; und

Fig. 2 die Bestrahlungseinrichtung gemäß **Fig. 1** mit einer modifizierten Laserlichtquelle und einem abgewandelten Linsensystem.

Gemäß **Fig. 1** enthält die Bestrahlungseinrichtung eine flexible Multimode-Lichtleitfaser 2 einschließlich einer Faserhülle 4, sowie ein am distalen Lichtleiterende angeordnetes Gehäuse 6 in Form eines Fokussierhandstücks mit einem zentralen, das distale Lichtleiter-

ende aufnehmenden Hohlraum 8, in dem sich eine als Linsensystem ausgebildete Fokussiereinrichtung 10 befindet.

Auf der senkrecht zur Faser-Längsachse verlaufenden Einkoppel-Stirnfläche 12 sind der Lichtleitfaser 2 innerhalb des in Fig. 1 gestrichelt gezeichneten Akzeptanzkegels (Akzeptanzwinkel γ) zwei unterschiedliche Einkoppelwinkelbereiche 14 und 16 zugeordnet, von denen der eine — 14 — durch einen zur Faserlängsachse coaxialen Innenkegel mit dem halben Scheitelwinkel α und der zweite — 16 — durch einen zum Innenkegel 14 coaxialen und diesen ringförmig umschließenden Außenkegel gebildet wird, welcher letzterer von zwei Kegelmantelflächen 18 und 20, die einen gegenüber dem Winkel α stufenweise erhöhten Öffnungswinkel β_1 bzw. β_2 besitzen, begrenzt wird.

Der schneidende Effekt der Bestrahlungseinrichtung wird durch ein von einer Laserlichtquelle 22.1 emittiertes Lichtbündel 24 erzeugt, das eine hauptsächlich ablativ, vaporisierende Wirkung auf biologisches Gewebe, also eine Wellenlänge von z. B. 2,94 μm besitzt und durch eine Fokussierlinse 26 innerhalb des Einkoppelwinkelbereichs 14 auf die Lichtfaser-Stirnfläche 12 fokussiert wird, so daß es an der distalen, ebenfalls senkrecht zur Lichtfaser-Längsachse verlaufenden Faser-Stirnfläche 28 mit axialer Abstrahlcharakteristik innerhalb eines dem Einkoppelwinkelbereich 14 geometrisch entsprechenden, zentralkegelförmigen Auskoppelwinkelbereichs 30 in den Hohlraum 8 austritt und durch das Sammellinsensystem 10 in Form eines in Strahlungsrichtung konvergenten, zentralen Lichtkegels 32 auf einen außerhalb des Gehäuseteils 6 liegenden Fokuspunkt F fokussiert wird (Fig. 1a).

Um zusätzlich zum schneidenden auch zugleich einen blutstillenden Effekt durch Gewebekoagulation im Operationsfeld zu erzielen, ist eine zweite Laserlichtquelle 22.2 vorgesehen, die eine hauptsächlich koagulierend wirkende Lichtbündel 34 mit einer Wellenlänge von z. B. 1,06 μm erzeugt, welches über ein Spiegelsystem 36.1, 36.2 und eine Fokussierlinse 38 in Form eines innerhalb des zweiten Einkoppelwinkelbereichs 16 liegenden Lichtkegels auf die Lichtfaser-Stirnfläche 12 fokussiert wird. Aufgrund der andersartigen Einkoppelung tritt dieses Lichtbündel 34 am distalen Lichtfaserende mit zirkumferenzieller Abstrahlcharakteristik in einem dem Einkoppelwinkelbereich 16 bezüglich der Flächennormalen der Lichtfaser-Stirnflächen 12 bzw. 28 geometrisch entsprechenden Auskoppelwinkelbereich 40, also in Form des in Fig. 1b kreuzschraffierten Ringkegels, in den Hohlraum 8 aus, derart, daß es das Sammellinsensystem 10 radial außerhalb des zentralen Lichtbündels 24 durchdringt und dabei ebenfalls auf den Fokuspunkt F fokussiert wird, so daß es einen zum schneidend wirkenden Zentralkegel 32 coaxialen und diesen ringförmig umschließenden Außenkegel 42 mit zum Fokalebereich F hin zunehmender Koagulationswirkung bildet.

Aufgrund der besonderen, räumlichen Zuordnung der beiden Laserlichtkegel 32, 42 mit Hilfe des für beide Wellenlängen transparenten, fokussierenden Linsensystems 10 wird somit die schneidend wirkende 2,94 μm Laserstrahlung auf das Zentrum des Operationsfeldes gelenkt, während die 1,06 μm Strahlung den umliegenden Randbereich koaguliert, so daß ein präzises kontaktloses Schneiden von biologischem Gewebe mit der zentralen Laserstrahlung 24 bzw. 32 bei gleichzeitiger Blutstillung durch Koagulation der randseitigen Schnittflächen mit dem Laserstrahlbündel 34 bzw. 42 möglich

ist.

Durch eine Änderung des Abstands des Gehäuseteils 6 vom Operationsfeld können der Koagulations- und der Ablations-Effekt gemeinsam variiert werden. Zur individuellen Dosierung der beiden Laserlichteffekte unabhängig voneinander sind die Laserlichtquellen 22.1 und 22.2 hinsichtlich der Betriebsparameter, z. B. der Strahlungsleistung, der Bestrahlungsdauer oder der Betriebsart jeweils einzeln steuerbar. Eine wechselweise Umschaltung von dem einen auf den anderen Laserlichteffekt läßt sich nicht nur durch entsprechende Steuerung der beiden Lichtquellen 22, sondern auch durch umschaltbare, im Strahlengang der Laserlichtbündel 24 und 34 angeordnete, optische Elemente erreichen, also etwa eine in den Strahlengang des Lichtbündels 24 einführbare Blende 44 oder den umklappbaren Spiegel 36.2 des Spiegelsystems 36.1, 36.2.

Die in Fig. 2 gezeigte Bestrahlungseinrichtung unterscheidet sich von dem ersten Ausführungsbeispiel im Wesentlichen nur durch eine andere Art des einkoppelseitigen Lichtzeugungssystems sowie dadurch, daß die Lichtbündel unterschiedliche Fokuspunkte besitzen. Die dem ersten Ausführungsbeispiel entsprechenden Bauelemente sind daher durch das gleiche Bezugszeichen gekennzeichnet. Bei dem Bestrahlungssystem gemäß Fig. 2 ist nur eine einzige Lichtquelle 22.3 vorhanden, etwa in Form eines Neodym-YAG-Lasers der zwischen zwei unterschiedlichen Wellenlängen, nämlich einer hauptsächlich schneidend wirkenden Laserstrahlung von z. B. 1,32 μm und einer hauptsächlich koagulierend wirkenden Laserstrahlung von z. B. 1,06 μm , umschaltbar ist. Durch ein dem Laser 22.3 nachgeschaltetes Prisma 46 wird die Laserstrahlung wellenlängenabhängig abgelenkt, so daß das langwelligere Laser-Lichtbündel 24 in der der Fig. 1 entsprechenden Weise zentral in die Faser-Stirnfläche 12 eingekoppelt wird und an dem distalen Ende des Gehäuseteils 6 in Form eines schneidend wirkenden Zentralkegels 32 austritt, während die am Prisma 46 stärker abgelenkte, kurzwelligere Laserstrahlung über einen Spiegel 48 innerhalb des Einkoppelwinkelbereichs 16 gemäß Fig. 1 schräg in die Lichtleitfaser 2 eingekoppelt und am distalen Ende des Gehäuseteils 6 in Form eines den Zentralkegel 32 ringförmig umschließenden Außenkegels 42 abgestrahlt wird. Durch Verwendung von asphärischen Linsen 10 oder durch gezielte Ausnutzung der chromatischen Linsenfehler mit optischen Materialien hoher Farbdispersion für das Linsensystem 10 wird der Fokuspunkt F_1 des Außenkegels 42 in Strahlungsrichtung vor den Fokuspunkt F_2 des Zentralkegels 32 gelegt. Somit können durch einfache Variation des Arbeitsabstandes des Gehäuseteils 6 vom Operationsfeld innerhalb des Fokusabstandes e die schneidende Wirkung des zentralen Lichtbündels 32 und die koagulierende Wirkung des außenliegenden Lichtbündels 42 gegensinnig zueinander selektiv verändert werden.

Im übrigen ist die Bau- und Betriebsweise der in Fig. 2 gezeigten Bestrahlungseinrichtung die gleiche wie bei dem ersten Ausführungsbeispiel.

Patentansprüche

1. Bestrahlungseinrichtung zum kontaktlosen Schneiden und Koagulieren von biologischem Gewebe mit einer Lichtleitfaser zur Übertragung eines ersten, vorwiegend schneidenden und eines zweiten, vorwiegend koagulierenden Licht-, insbesondere Laserlichtbündels hoher Intensität von ei-

ner Lichtquelle zu einem Applikationsbereich, dadurch gekennzeichnet, daß die beiden Lichtbündel (24, 34) mit jeweils unterschiedlichen Einkoppelwinkeln (14, 16) in die Lichtleitfaser (2) eingestrahlt werden derart, daß das erste Lichtbündel (24) am distalen Lichtleiterende innerhalb eines zur Faserlängsachse zentralkegelförmigen Auskoppelwinkelbereichs (30) mit axialer Abstrahlcharakteristik und das zweite Lichtbündel (34) koaxial zum ersten innerhalb eines den Zentralkegel (30) umschließenden, ringkegelförmigen Auskoppelwinkelbereichs (40) mit zirkumferenzieller Abstrahlcharakteristik austritt, und daß beide Lichtbündel durch eine am distalen Lichtleiterende angeordnete, optische Fokussiereinrichtung (10) unter Beibehalt ihrer zueinander koaxialen, räumlichen Zuordnung (32, 42) auf den Applikationsbereich (F, F₁, F₂) fokussiert werden.

2. Bestrahlungseinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß beide Lichtbündel (24, 34) einen gemeinsamen Fokuspunkt (F) im Applikationsbereich besitzen.

3. Bestrahlungseinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Lichtbündel (23, 34) in Richtung ihrer gemeinsamen Strahlungsachse hintereinanderliegende Fokuspunkte (F₁, F₂) besitzen, wobei der Fokuspunkt (F₁) des ringkegelförmig ausgekoppelten, zweiten Lichtbündels (34) von der Fokussier-Einrichtung (10) weiter entfernt ist als der Fokuspunkt (F₂) des zentral ausgekoppelten, ersten Lichtbündels (24).

4. Bestrahlungseinrichtung nach Anspruch 3, dadurch gekennzeichnet, daß als Fokussier-Einrichtung (10) ein von beiden Lichtbündeln (24, 34) durchstrahltes asphärisches Linsensystem vorgesehen ist.

5. Bestrahlungseinrichtung nach Anspruch 3, dadurch gekennzeichnet, daß für die Lichtbündel (24, 34) unterschiedlicher Wellenlänge haben und als Fokussier-Einrichtung (10) ein von beiden Lichtbündeln durchstrahltes Linsensystem aus einem Material hoher Farbdispersion vorgesehen ist.

6. Bestrahlungseinrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das distale Lichtleiterende und die Fokussier-Einrichtung (10) aufnehmende Gehäuseteil (6) als Fokussierhandstück ausgebildet ist.

7. Bestrahlungseinrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Lichtbündel (24, 34) hinsichtlich Strahlungsleistung, Wellenlänge und/oder Betriebsart verschiedenartig bzw. unabhängig voneinander steuerbar sind.

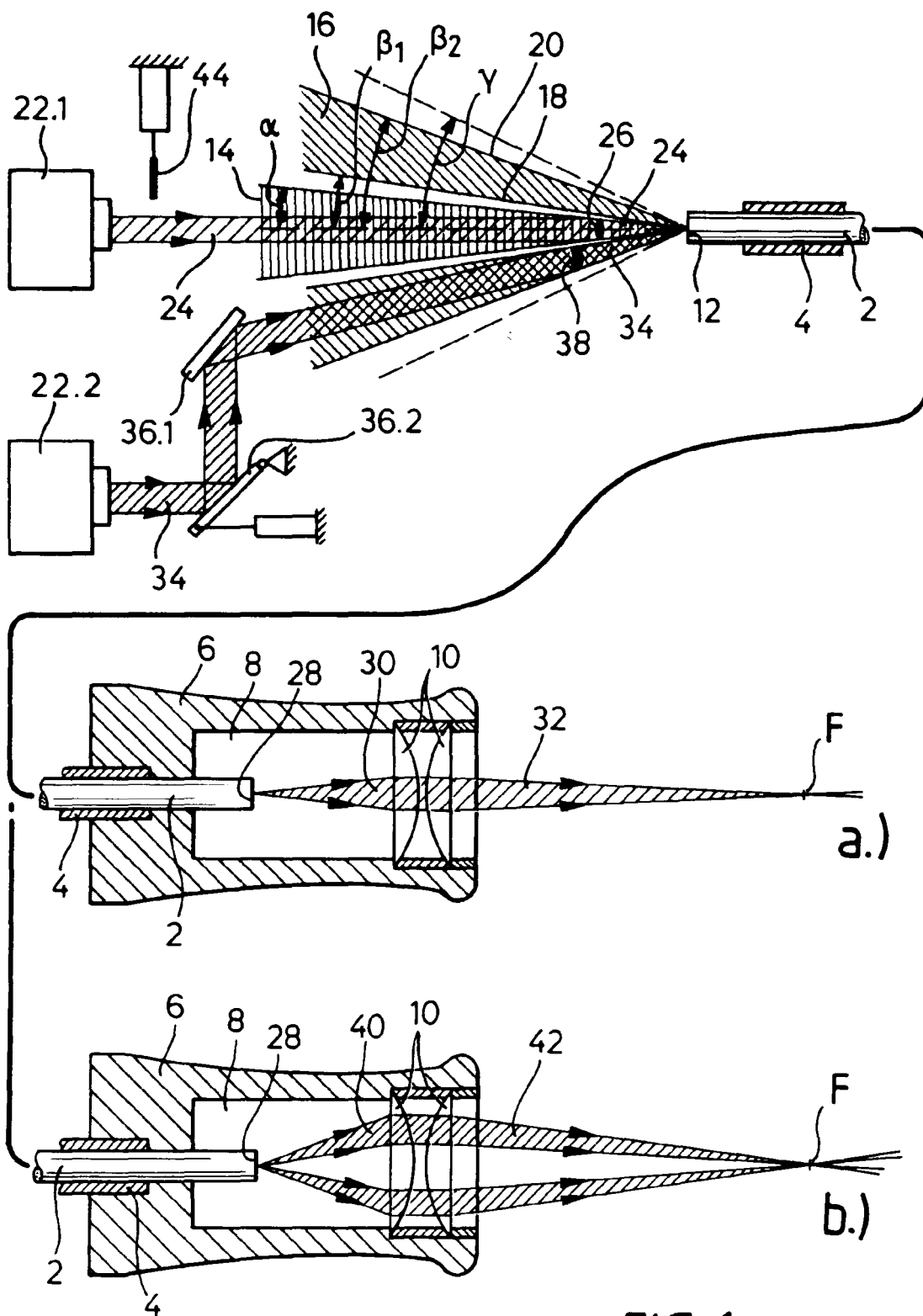
8. Bestrahlungseinrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß zur gleichzeitigen Erzeugung beider Lichtbündel (24, 34) zwei getrennte Laserlichtquellen (22.1, 22.2) mit unterschiedlichen Wellenlängen und einer einkoppelseitigen Optik (26, 36.1, 36.2, 38) zur Einkoppelung der Lichtbündel innerhalb des jeweils vorgegebenen Einkoppelwinkelbereichs (14 bzw. 16) vorgesehen sind.

9. Bestrahlungseinrichtung nach einem der Ansprüche 1 – 7, dadurch gekennzeichnet, daß eine einzige Laserlichtquelle (22.3) zur Erzeugung der beiden Lichtbündel (24, 34) mit unterschiedlichen Wellenlängen und eine einkoppelseitige Optik (46, 48) einschließlich eines die Lichtbündel wellenlängenab-

hängig ablenkenden Prismas (46) vorgesehen sind.

10. Bestrahlungseinrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die einkoppelseitige Optik mindestens ein umschaltbares optisches Element (36.2, 44) zum selektiven Ein- und Ausblenden zumindest eines der Lichtbündel (24, 34) enthält.

Hierzu 2 Seite(n) Zeichnungen



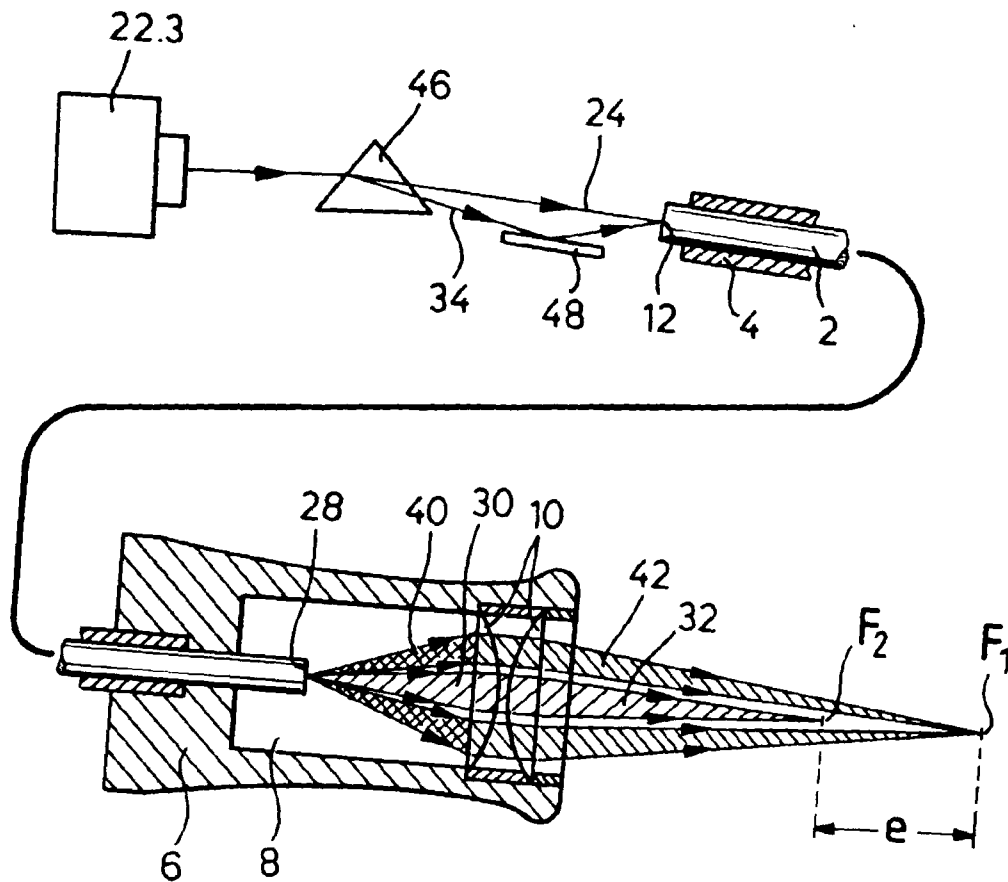


FIG. 2

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	1	16/398,362	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 03:40 PM
L2	8	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and laser and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:17 PM
L3	0	("2020/0310055").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L4	3	("2019/0258009").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L5	0	("2017/0031105").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L6	24	("2015/0293306").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L7	46	("2013/0223792").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L8	37	("20020071647" "20020168139" "20020172485" "20050031261" "20060251367" "20060263024" "20110305249" "20130064706" "20150217402" "20150378184"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/04/15 05:19 PM

L9	43	"3941670" "3975082" "4475788" "4575181" "5461692" "5475704" "5684642" "6819815" "7372877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902" "7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269" "9482821").PN. OR ("10281656").URPN. ("20020071647" "20020168139" "20020172485" "20050031261" "20060251367" "20060263024" "20130064706" "3941670" "3975082" "4475788" "4575181" "5461682" "5461692" "5684642" "7372877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902" "7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269").PN. OR ("9482821").URPN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/04/15 05:19 PM
L10	55	("20020071647" "20020168139" "20020172485" "20060251367" "20060263024" "3941670" "4475788" "4575181" "5684642" "7372877" "7379237" "7379648" "7720340" "7738166" "7809225" "7839902" "7933479" "8076632" "8094370" "8456523").PN. OR ("8781269").URPN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/04/15 05:19 PM
L11	92	(L3 or L4 or L5 or L6 or L7 or L8 or L9 or L10)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/04/15 05:19 PM
L12	9	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:20 PM

L13	186	G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:20 PM
L14	5	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:22 PM
L15	1	L12 not L2	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:22 PM
L16	5	((laser adj beam) and coupl\$3 and fiber and	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	ON	2021/04/15 05:24 PM

		(multiclad or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam) and divid\$3).clm.	JPO; DERWENT; IBM_TDB)				
L17	4	((laser adj beam) and coupl\$3 and fiber and (multiclad or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam) and divid\$3 and different).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:27 PM
L18	59	"8781269"	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/19 10:58 AM
L19	1	("8781269").PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2021/04/19 10:59 AM
L20	79	((("HUBER") near3 ("Rudolph")) OR (("ANDREASCH") near3 ("Wolfgang")) OR (("HUONKER") near3 ("Martin"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2021/04/19 11:01 AM
L21	54	((("TRUMPF") near3 ("LASER-") near3 ("UND") near3 ("SYSTEMTECHNIK") near3 ("GMBH"))).AS,AANM.	(USPAT)	OR	ON	ON	2021/04/19 11:01 AM
L22	7	(L20 or L21) and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclad or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/19 11:01 AM
L23	3	("2019/0258009").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:58 PM
L24	1	16/398,362	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:58 PM
L25	9	(G02B6/3508 or B23K26/067 or	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	ON	2021/08/28 07:58 PM

		B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and laser and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical- fib\$3 or opticfib\$3 or optic-fib\$3 or fiberoptic\$3 or fibre- optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi- core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub- beam)	JPO; DERWENT; IBM_TDB)				
L26	0	("2020/0310055").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:58 PM
L27	3	("2019/0258009").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L28	0	("2017/0031105").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L29	24	("2015/0293306").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L30	47	("2013/0223792").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L31	37	("20020071647" "20020168139" "20020172485" "20050031261" "20060251367" "20060263024" "20110305249" "20130064706" "20150217402" "20150378184" "3941670" "3975082" "4475788" "4575181" "5461692" "5475704" "5684642" "6819815" "7372877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902" "7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/08/28 07:59 PM

L32	43	"9482821").PN. OR ("10281656").URPN. ("20020071647" "20020168139" "20020172485" "20050031261" "20060251367" "20060263024" "20130064706" "3941670" "3975082" "4475788" "4575181" "5461682" "5461692" "5684642" "7372877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902" "7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269").PN. OR ("9482821").URPN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/08/28 07:59 PM
L33	55	("20020071647" "20020168139" "20020172485" "20060251367" "20060263024" "3941670" "4475788" "4575181" "5684642" "7372877" "7379237" "7379648" "7720340" "7738166" "7809225" "7839902" "7933479" "8076632" "8094370" "8456523").PN. OR ("8781269").URPN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/08/28 07:59 PM
L34	93	(L26 or L23 or L28 or L29 or L30 or L31 or L32 or L33)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/08/28 07:59 PM
L35	10	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre- optic\$3 or fiberoptic\$3 or fiber-optic\$3) same	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM

L36	199	(multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam) (G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L37	5	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L38	1	L35 not L25	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L39	5	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam) and divid\$3).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L40	4	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM

L41	62	near2 core) and (subbeam or sub-beam) and divid\$3 and different).clm. "8781269"	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L42	1	("8781269").PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2021/08/28 07:59 PM
L43	80	((("HUBER") near3 ("Rudolph")) OR ((("ANDREASCH") near3 ("Wolfgang"))) OR ((("HUONKER") near3 ("Martin"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2021/08/28 07:59 PM
L44	58	((("TRUMPF") near3 ("LASER-") near3 ("UND") near3 ("SYSTEMTECHNIK") near3 ("GMBH"))).AS,AANM.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L45	7	(L43 or L44) and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L46	18	(L23 or L24 or L25 or L26 or L27 or L28 or L29 or L30 or L31 or L32 or L33 or L34 or L35 or L36 or L37 or L38 or L39 or L40 or L41 or L42 or L43 or L44 or L45) and @pd>"20210419"	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 08:05 PM
L54	7	((("10795090") or ("10197741") or ("9778422") or ("9354402") or ("8992095") or ("8845205") or ("8382382")).PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2021/08/29 09:36 PM
L55	1	((US-20190258009-A1).did. AND PGPB.dbnm.)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY,	OR	ON	ON	2022/09/19 11:41 AM

			CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L56	3	("2019/0258009").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:42 AM
L57	30	(michelle near2 connelly).xp. AND (beam near2 profile)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:43 AM
L58	21	("5012069" "5449881" "5684642" "8399803" "9620925" "10310201" "10807190" "20020198622" "20060219673" "20070170157" "20090211700" "20110127697" "20110240617" "20130073071" "20130148925" "20130223792" "20140010508" "20150372444" "20180147661" "20190118299").pn. OR ("11022747").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:44 AM
L59	67	("2013/0148925").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:46 AM
L60	3	("2019/0258009").urpn. AND (PGPB USPT USOC).dbnm.L56	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:58 AM
L61	45	("10281656" OR "11215761" OR "20020071647" OR "20020168139" OR "20020172485" OR "20050031261" OR "20060219673" OR "20060251367" OR "20060263024" OR "20110305249" OR	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/19 12:07 PM

		"20130064706" OR "20130223792" OR "20150217402" OR "20150293306" OR "20150378184" OR "20170031105" OR "20190025502" OR "20190118299" OR "20190258009" OR "3941670" OR "3975082" OR "4475788" OR "4575181" OR "5461692" OR "5475704" OR "5684642" OR "6819815" OR "7372877" OR "7379237" OR "7379648" OR "7592568" OR "7720340" OR "7738166" OR "7809225" OR "7839902" OR "7933479" OR "8008600" OR "8076632" OR "8094370" OR "8326099" OR "8456523" OR "8781269" OR "8861910" OR "9482821" OR "9755739").pn.					
L62	45	("10281656" OR "11215761" OR "20020071647" OR "20020168139" OR "20020172485" OR "20050031261" OR "20060219673" OR "20060251367" OR "20060263024" OR "20110305249" OR "20130064706" OR "20130223792" OR "20150217402" OR "20150293306" OR "20150378184" OR "20170031105" OR "20190025502" OR "20190118299" OR "20190258009" OR "3941670" OR "3975082" OR "4475788" OR	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/19 03:32 PM

		"4575181" OR "5461692" OR "5475704" OR "5684642" OR "6819815" OR "7372877" OR "7379237" OR "7379648" OR "7592568" OR "7720340" OR "7738166" OR "7809225" OR "7839902" OR "7933479" OR "8008600" OR "8076632" OR "8094370" OR "8326099" OR "8456523" OR "8781269" OR "8861910" OR "9482821" OR "9755739").pn.					
L63	23	((US-20190258009-A1 OR US-20190118299- A1 OR US- 20180147661-A1 OR US-20150372444-A1 OR US-20130223792- A1 OR US- 20130148925-A1 OR US-20060219673-A1 OR US-20190025502- A1 OR US- 20170031105-A1 OR US-20150293306-A1 OR US-20150217402- A1).did. AND PGPB.dbnm.) OR ((US- 10916911-B2 OR US- 11215761-B2 OR US- 11022747-B2 OR US- 10807190-B2 OR US- 9620925-B2 OR US- 11435538-B2 OR US- 10281656-B2 OR US- 9755739-B1 OR US- 9482821-B2 OR US- 8781269-B2 OR US- 7592568-B2 OR US- 5461692-A).did. AND USPT.dbnm.)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/09/19 08:36 PM
L65	1	("20060219673").pn.	(US-PGPUB)	OR	ON	ON	2022/09/19 09:36 PM
L66	109	(L23 OR L24 OR L25 OR L26 OR L27 OR L28 OR L29 OR L30	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2022/09/20 11:52 AM

L67	3	OR L31 OR L32 OR L33 OR L34 OR L35 OR L36 OR L37 OR L38 OR L39 OR L40 OR L41 OR L42 OR L43 OR L44 OR L45) AND @pd>"20210415" "20060219673"	IBM_TDB) (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/01/14 11:38 AM
L68	287	(mov\$3 near3 laser) SAME (mov\$3 near3 fib\$3) SAME ((rotat\$3 OR mov\$3) near3 (lens OR mirror OR microlens OR micromirror OR micro-lens OR micro-mirror OR optics))	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/01/14 11:59 AM
L69	10	(mov\$3 near3 laser) SAME (mov\$3 near3 fib\$3) SAME ((rotat\$3 OR mov\$3) near3 (lens OR mirror OR microlens OR micromirror OR micro-lens OR micro-mirror OR optics)) SAME (angl\$3 near3 inciden\$4)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/01/14 12:00 PM
L70	38	(L2 OR L11) AND	(US-PGPUB; USPAT;	OR	ON	ON	2023/06/26

		@pd>"20210415"	USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				07:55 AM
L71	196	(L12 OR L13 OR L14 OR L16 OR L17 OR L22) AND @pd>"20210415"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 07:58 AM
L72	1114	((("HUBER") near3 ("Rudolph")) OR (("ANDREASCH") near3 ("Wolfgang"))) OR (("HUONKER") near3 ("Martin"))).INV.) OR (((("TRUMPF") near3 ("LASER-") near3 ("UND") near3 ("SYSTEMTECHNIK") near3 ("GMBH"))).AS,AANM.)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 08:01 AM
L73	14	L25 AND @pd>"20210828"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO,	OR	ON	ON	2023/06/26 08:01 AM

L74	92613	(G02B6/3508 OR B23K26/067 OR B23K26/064 OR G02B6/02042 OR G02B6/35 OR B23K26/073 OR G02B6/03644 OR G02B6/262 OR G02B6/4206 OR G02B6/4296).cpc.	NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB) (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 08:02 AM
L75	11	L72 AND (((laser OR light OR optic\$3 OR photonic) near3 ((beam OR spot) near2 profile))) AND (((optic\$3 near2 fib\$3) OR opticalfib\$3 OR optical-fib\$3 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$3 OR fibre-optic\$3 OR fiberoptic\$3 OR fiber-optic\$3) SAME (multi-clad OR multiclad OR multicore OR multi-core OR (multiple ADJ core) OR (plural\$3 near2 core))) AND (divid\$3 WITH (light OR beam OR input)) AND (subbeam OR sub-beam))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 08:04 AM
L76	32	L74 AND (((laser OR light OR optic\$3 OR photonic) near3 ((beam OR spot) near2 profile))) AND (((optic\$3 near2 fib\$3) OR opticalfib\$3 OR optical-fib\$3 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$3 OR fibre-optic\$3 OR fiberoptic\$3 OR fiber-optic\$3) SAME (multi-clad OR multiclad OR multicore OR multi-	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO;	OR	ON	ON	2023/06/26 08:05 AM

L77	396	core OR (multiple ADJ core) OR (plural\$3 near2 core))) AND (divid\$3 WITH (light OR beam OR input)) AND (subbeam OR sub-beam)) L46 AND @pd>"20210828"	JPO; DERWENT; IBM_TDB) (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 08:07 AM
L78	5	("11806804" "11215761" "10281656" "9482821" "8781269").pn.	(USPAT)	OR	ON	ON	2024/09/07 12:21 PM
L79	1	("20060219673").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2024/09/07 12:36 PM
L80	52	("2006/0219673").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/07 12:37 PM
L81	6	("2013180295").pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 12:42 PM
L82	40	(Artificial Intelligence) More like doc: <u>JP-2013180295-A</u> Text: (JP-2013176800-A OR WO-2013133128-A1 OR TW-201825217-A OR JP-2020513325-A	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV,	OR	ON	ON	2024/09/07 12:43 PM

		OR US-11022747-B2 OR EP-3551372-A1 OR US-20190383998-A1 OR WO-2010123068- A1 OR JP-6887502-B2 OR TW-I758365-B OR JP-WO2010123068-A1 OR EP-3551372-B1 OR KR-102636850-B1 OR KR-20190093622-A OR CN-110087817-A OR CN-110087817-B OR JP-2018043256-A OR JP-5639046-B2 OR JP- 2018043257-A OR WO- 2012063348-A1).did.	MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L83	34	((US-20190258009-A1 OR US-20190118299- A1 OR US- 20180147661-A1 OR US-20150372444-A1 OR US-20130223792- A1 OR US- 20130148925-A1 OR US-20060219673-A1 OR US-20190025502- A1 OR US- 20170031105-A1 OR US-20150293306-A1 OR US-20150217402- A1 OR US- 20220179153-A1 OR US-20200310055-A1 OR US-20190383998- A1).did. AND PGPB.dbnm.) OR ((US- 10916911-B2 OR US- 11215761-B2 OR US- 11022747-B2 OR US- 10807190-B2 OR US- 9620925-B2 OR US- 11435538-B2 OR US- 10281656-B2 OR US- 9755739-B1 OR US- 9482821-B2 OR US- 8781269-B2 OR US- 7592568-B2 OR US- 5461692-A OR US- 11351633-B2).did. AND USPT.dbnm.) OR ((JP- 3645013-B2 OR CN- 113568089-B OR KR- 102498030-B1 OR KR- 102636850-B1 OR EP- 3551372-B1).did. AND FTDB.dbnm.) OR ((DE- 102010003750-A1).did.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 12:45 PM

L84	52	AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.) ("2006/0219673").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/07 12:47 PM
L85	97	(outer near2 core) AND connelly.xp.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/07 12:51 PM
L86	34	((US-20190258009-A1 OR US-20190118299-A1 OR US-20180147661-A1 OR US-20150372444-A1 OR US-20130223792-A1 OR US-20130148925-A1 OR US-20060219673-A1 OR US-20190025502-A1 OR US-20170031105-A1 OR US-20150293306-A1 OR US-20150217402-A1 OR US-20220179153-A1 OR US-20200310055-A1 OR US-20190383998-A1).did. AND PGPB.dbnm.) OR ((US-10916911-B2 OR US-11215761-B2 OR US-11022747-B2 OR US-10807190-B2 OR US-9620925-B2 OR US-11435538-B2 OR US-10281656-B2 OR US-9755739-B1 OR US-9482821-B2 OR US-8781269-B2 OR US-7592568-B2 OR US-5461692-A OR US-11351633-B2).did. AND USPT.dbnm.) OR ((JP-3645013-B2 OR CN-113568089-B OR KR-102498030-B1 OR KR-102636850-B1 OR EP-3551372-B1).did. AND FTDB.dbnm.) OR ((DE-102010003750-A1).did. AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.) ("3777150" "4467168" "5028118" "5220149"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 12:56 PM
L87	61	("3777150" "4467168" "5028118" "5220149"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/07 12:57 PM

L88	14	"5231464" "5237150" "5469292" "5570384" "5609781" "5684617" "5747771" "5877890" "5956447" "6018533" "6118097" "6288363" "6288835" "6376797" "6423928" "6487340" "6614975" "6687046" "7215858" "7259907" "20020080832" "20020088784" "20020153360" "20020181512" "20040104202").pn. OR ("7592568").urpn. AND (PGPB USPT USOC).dbnm. ("3833992").pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 12:59 PM
L89	14	("1580865").pn.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 01:01 PM
L90	2	("3941670" "3975082").pn.	(USPAT)	OR	ON	ON	2024/09/07 01:01 PM
L91	11	("4200587").pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2024/09/07 01:02 PM

L92	8	("2009155536").pn.	CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 01:03 PM
L93	35	((US-20190258009-A1 OR US-20190118299-A1 OR US-20180147661-A1 OR US-20150372444-A1 OR US-20130223792-A1 OR US-20130148925-A1 OR US-20060219673-A1 OR US-20190025502-A1 OR US-20170031105-A1 OR US-20150293306-A1 OR US-20150217402-A1 OR US-20220179153-A1 OR US-20200310055-A1 OR US-20190383998-A1).did. AND PGPB.dbnm.) OR ((US-10916911-B2 OR US-11215761-B2 OR US-11022747-B2 OR US-10807190-B2 OR US-9620925-B2 OR US-11435538-B2 OR US-10281656-B2 OR US-9755739-B1 OR US-9482821-B2 OR US-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 01:04 PM

L94	40	8781269-B2 OR US-7592568-B2 OR US-5461692-A OR US-11351633-B2).did. AND USPT.dbnm.) OR ((JP-3645013-B2 OR CN-113568089-B OR KR-102498030-B1 OR KR-102636850-B1 OR EP-3551372-B1).did. AND FTDB.dbnm.) OR ((DE-102010003750-A1).did. AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.) OR ((DE-3833992-C2).did. AND FPRS.dbnm.) (Artificial Intelligence) More like doc: JP-2013180295-A Text: (JP-2013176800-A OR WO-2013133128-A1 OR TW-201825217-A OR JP-2020513325-A OR US-11022747-B2 OR EP-3551372-A1 OR US-20190383998-A1 OR WO-2010123068-A1 OR JP-6887502-B2 OR TW-I758365-B OR JP-WO2010123068-A1 OR EP-3551372-B1 OR KR-102636850-B1 OR KR-20190093622-A OR CN-110087817-A OR CN-110087817-B OR JP-2018043256-A OR JP-5639046-B2 OR JP-2018043257-A OR WO-2012063348-A1).did.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 01:04 PM
L95	3856	((optic\$3 near2 fib\$3) WITH ((ring OR outer near2 core)) SAME ((radius OR diameter) WITH (microns OR micrometers OR µm))	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2024/09/07 01:39 PM

L96	475	((optic\$3 near2 fib\$3) WITH ((ring OR outer) near2 core)) SAME ((radius OR diameter) WITH (microns OR micrometers OR μm))	IBM_TDB) (USPAT)	OR	ON	ON	2024/09/07 01:40 PM
L97	223	((optic\$3 near2 fib\$3) WITH ((ring OR outer) near2 core)) SAME ((radius OR diameter) WITH (microns OR micrometers OR μm)) AND @pd<"20110101"	(USPAT)	OR	ON	ON	2024/09/07 01:40 PM
L98	55	"4200587"	(USPAT)	OR	ON	ON	2024/09/07 03:22 PM
L99	11	("4200587").pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:22 PM
L100	36	((US-20190258009-A1 OR US-20190118299-A1 OR US-20180147661-A1 OR US-20150372444-A1 OR US-20130223792-A1 OR US-20130148925-A1 OR US-20060219673-A1 OR US-20190025502-A1 OR US-20170031105-A1 OR US-20150293306-A1 OR US-20150217402-A1 OR US-20220179153-A1 OR US-20200310055-A1 OR US-20190383998-A1).did. AND PGPB.dbnm.) OR ((US-10916911-B2 OR US-11215761-B2 OR US-11022747-B2 OR US-10807190-B2 OR US-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:25 PM

L101	258	9620925-B2 OR US-11435538-B2 OR US-10281656-B2 OR US-9755739-B1 OR US-9482821-B2 OR US-8781269-B2 OR US-7592568-B2 OR US-5461692-A OR US-11351633-B2 OR US-7773845-B2).did. AND USPT.dbnm.) OR ((JP-3645013-B2 OR CN-113568089-B OR KR-102498030-B1 OR KR-102636850-B1 OR EP-3551372-B1).did. AND FTDB.dbnm.) OR ((DE-102010003750-A1).did. AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.) OR ((DE-3833992-C2).did. AND FPRS.dbnm.) (L70 OR L71 OR L72 OR L73) AND @pd>"20230626"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:29 PM
L102	271	(L75 OR L76 OR L77) AND @pd>"20230626"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:32 PM
L103	82	laser AND ((optic\$2	(US-PGPUB; USPAT;	OR	ON	ON	2024/09/07

		near2 fib\$2) OR opticalfib\$2 OR optical-fib\$2 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$2 OR fiberoptic\$2 OR fibre-optic\$2 OR fiber-optic\$2) SAME ((inner OR inside OR first OR primary OR center OR central OR centre) near2 core) AND ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 core) AND ((inner OR inside OR first OR primary OR center OR central OR centre) near2 clad\$4) AND ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 clad) AND ((coupl\$3 WITH (first near2 (beam OR ray OR light OR input OR wavelength))) WITH ((inner OR inside OR first OR primary OR center OR central OR centre) near2 core)) AND ((coupl\$3 WITH (second near2 (beam OR ray OR light OR input OR wavelength))) WITH ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 core))	USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				03:38 PM
L106	16	((("3940670" "3975082" "4475788" "4575181" "5461692" "5475704" "5684642" "6819815" "7373877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902").pn.)	(USPAT)	OR	ON	ON	2024/09/07 03:44 PM
L107	10	("7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269" "8861910" "9482821" "9755739").pn.	(USPAT)	OR	ON	ON	2024/09/07 03:45 PM
L109	21	((("10281656"	(US-PGPUB; USPAT)	OR	ON	ON	2024/09/07

		"11215761" "11806804" "20020071647" "20020168139" "20020172485" "20050031261" "20060219673" "20060251367" "20060263024" "20110305249" "20130064706" "20130223792" "20150217402" "20150293306" "20150378184" "20170031105" "20190025502" "20190118299" "20190258009" "20220179153").pn.)					03:47 PM
L110	81	("3833993" "4200587" "0362466" "2284892" "2499689" "100750511" "2009155536" "2010009101").pn.	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2024/09/07 03:49 PM
L111	38	((US-20190258009-A1 OR US-20190118299- A1 OR US- 20180147661-A1 OR US-20150372444-A1 OR US-20130223792- A1 OR US- 20130148925-A1 OR US-20060219673-A1 OR US-20190025502- A1 OR US- 20170031105-A1 OR US-20150293306-A1 OR US-20150217402- A1 OR US- 20220179153-A1 OR US-20200310055-A1 OR US-20190383998- A1).did. AND PGPB.dbnm.) OR ((US- 10916911-B2 OR US- 11215761-B2 OR US- 11022747-B2 OR US- 10807190-B2 OR US-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:53 PM

		9620925-B2 OR US-11435538-B2 OR US-10281656-B2 OR US-9755739-B1 OR US-9482821-B2 OR US-8781269-B2 OR US-7592568-B2 OR US-5461692-A OR US-11351633-B2 OR US-7773845-B2).did. AND USPT.dbnm.) OR ((JP-3645013-B2 OR CN-113568089-B OR KR-102498030-B1 OR KR-102636850-B1 OR EP-3551372-B1).did. AND FTDB.dbnm.) OR ((DE-102010003750-A1 OR DE-4200587-C1).did. AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.) OR ((DE-3833992-C2 OR DE-3833993-A1).did. AND FPRS.dbnm.)					
L112	7	L111 AND @pd<"20100408"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:54 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N47	9	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:05 PM

N48	10	laser and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam) (G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam)	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:05 PM
N49	194	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam)	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:05 PM

N50	5	or fiber-optic\$3) same (multi-clad or multiclad or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) ((laser adj beam) and coupl\$3 and fiber and (multiclad or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:06 PM
N51	5	((laser adj beam) and coupl\$3 and fiber and (multiclad or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam) and divid\$3).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:06 PM
N52	4	((laser adj beam) and coupl\$3 and fiber and (multiclad or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam) and divid\$3 and different).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:06 PM
N53	194	(N48 or N48 or N49 or N50 or N51 or N52)	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:08 PM
N54	29	(N48 OR N48 OR N49 OR N50 OR N51 OR N52) AND @pd>"20210415"	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/20 11:50 AM
N55	11	((G02B6/3508 OR B23K26/067 OR B23K26/064 OR G02B6/02042 OR G02B6/35 OR B23K26/073 OR G02B6/03644 OR G02B6/262 OR G02B6/4206 OR G02B6/4296).cpc.) AND (((laser OR light OR optic\$3 OR photonic) near3 ((beam OR spot) near2 profile))) AND (((optic\$3 near2 fib\$3) OR opticalfib\$3 OR optical-fib\$3 OR opticfib\$3 OR	(US-PGPUB; USPAT)	OR	ON	ON	2023/06/26 08:05 AM

N56	14	optic-fib\$3 OR fibreoptic\$3 OR fibre-optic\$3 OR fiberoptic\$3 OR fiber-optic\$3) SAME (multi-clad OR multiclاد OR multicore OR multi-core OR (multiple ADJ core) OR (plural\$3 near2 core))) AND (divid\$3 WITH (light OR beam OR input)) AND (subbeam OR sub-beam)) ((((laser OR light OR optic\$3 OR photonic) near3 ((beam OR spot) near2 profile))) AND (((optic\$3 near2 fib\$3) OR opticalfib\$3 OR optical-fib\$3 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$3 OR fibre-optic\$3 OR fiberoptic\$3 OR fiber-optic\$3) SAME (multiclاد OR multiclاد OR multicore OR multi-core OR (multiple ADJ core) OR (plural\$3 near2 core))) AND (divid\$3 WITH (light OR beam OR input)) AND (subbeam OR sub-beam))	(US-PGPUB; USPAT)	OR	ON	ON	2023/06/26 08:06 AM
N57	13	(N47 OR N48 OR N49 OR N50 OR N51 OR N52) AND @pd>"20220920"	(US-PGPUB; USPAT)	OR	ON	ON	2023/06/26 08:36 AM
N58	17	(N55 OR N56 OR N57) AND @pd>"20230626"	(US-PGPUB; USPAT)	OR	ON	ON	2024/09/07 03:27 PM
N59	37	laser AND ((optic\$2 near2 fib\$2) OR opticalfib\$2 OR optical-fib\$2 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$2 OR fiberoptic\$2 OR fibre-optic\$2 OR fiber-optic\$2) SAME ((inner OR inside OR first OR primary OR center OR central OR centre) near2 core) AND ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second)	(US-PGPUB; USPAT)	OR	ON	ON	2024/09/07 03:41 PM

		near2 core) AND ((inner OR inside OR first OR primary OR center OR central OR centre) near2 clad\$4) AND ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 clad) AND ((coupl\$3 WITH (first near2 (beam OR ray OR light OR input OR wavelength))) WITH ((inner OR inside OR first OR primary OR center OR central OR centre) near2 core)) AND ((coupl\$3 WITH (second near2 (beam OR ray OR light OR input OR wavelength))) WITH ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 core))					
--	--	--	--	--	--	--	--



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/387,089	11/06/2023	Rudolph Huber	15540-0370006	7969
26161 7590 09/10/2024 FISH & RICHARDSON P.C. (BO) P.O. BOX 1022 MINNEAPOLIS, MN 55440-1022			EXAMINER CONNELLY, MICHELLE R	
			ART UNIT	PAPER NUMBER
			2874	
			NOTIFICATION DATE	DELIVERY MODE
			09/10/2024	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PATDOCTC@fr.com

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Priority

Receipt is acknowledged of certified copies of papers required by 37 CFR 1.55 in parent application 13/639,401.

Information Disclosure Statement

The prior art documents submitted by applicant in the Information Disclosure Statement filed on April 10, 2024 have all been considered and made of record (note the attached copy of form PTO-1449).

Drawings

Five (5) sheets of drawings were filed on November 6, 2023 and have been accepted by the examiner.

Specification

Applicant's cooperation is requested in correcting any errors of which applicant may become aware in the specification.

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference

claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP § 2146 *et seq.* for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The filing of a terminal disclaimer by itself is not a complete reply to a nonstatutory double patenting (NSDP) rejection. A complete reply requires that the terminal disclaimer be accompanied by a reply requesting reconsideration of the prior Office action. Even where the NSDP rejection is provisional the reply must be complete. See MPEP § 804, subsection I.B.1. For a reply to a non-final Office action, see 37 CFR 1.111(a). For a reply to final Office action, see 37 CFR 1.113(c). A request for reconsideration while not provided for in 37 CFR 1.113(c) may be filed after final for consideration. See MPEP §§ 706.07(e) and 714.13.

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The actual filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/apply/applying-online/eterminal-disclaimer.

Claims 28-33, 36, 38-43, and 46 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1 and 2 of U.S. Patent No. 10,281,565 B2. Although the claims at issue are not identical, they are not patentably distinct from each other because claims 1 and 2 of U.S. Patent No. 10,281,565 B2 at least disclose or suggest all of the limitations of claims 28-33, 36, 38-43, and 46.

Regarding claim 28; U.S. Patent No. 10,281,656 B2 claims a system for generating a laser beam with different beam profile characteristics (the elements of the system are obvious since the method involves the use of the elements; see claims 1 and 2 of U.S. Patent No. 10,281,656 B2), the system comprising:

- a multi-clad fiber (optical fiber having an inner fiber core and outer ring core, wherein multi-clad is inherent to a fiber having an inner core and an outer ring core, wherein each core is inherently surrounded by a clad, thereby forming a multi-clad fiber; the examiner notes that an outer layer of air may be considered an air-clad; should applicant disagree that the

multiple cladding layers are inherent to the fiber having an inner fiber core and an outer ring core, then the examiner notes that one of ordinary skill in the art would have found it obvious to form the multiple cladding layers to confine light within the cores, as this is elementary in the art) having

- an inner fiber core (inner fiber core) and
 - at least one outer ring core (outer ring core); and
- a first optical fiber (first optical input fiber; see claim 1 of U.S. 10,281,656 B2) configured to guide a first input laser beam (first input laser beam) to the multi-clad fiber (optical fiber having an inner fiber core and an outer ring core); and
- a second optical fiber (second optical input fiber; see claim 2 of U.S. 10,281,656) configured to guide a second input laser beam to the multi-clad fiber (optical fiber having an inner fiber core and an outer ring core),
- wherein the system is configured to couple at least one of:
 - the first input laser beam (first input laser beam) at least into the inner fiber core of the multi-clad fiber (coupling the first input beam to the inner fiber core only; see claim 1 of U.S. 10,281,656), or
 - the second input laser beam (second input laser beam) at least into the at least one outer ring core of the multi-clad fiber (coupling the second input beam into the outer ring core only; see claim 1 of U.S. 10,281,656).

Regarding claim 38; claims 1 and 2 of U.S. 10,281,656 B2 discloses a method of generating a laser beam with different beam profile characteristics, the method comprising (see claims 1 and 2):

- guiding a first input laser beam (first input laser beam; see claim 1 and 2 of U.S. 10,281,656 B2) by a first optical fiber (first optical input fiber; see claim 2 of U.S. 10,281,656 B2) to a fiber end of a multi-clad fiber (optical fiber having an inner fiber core and outer ring core, wherein multi-clad is inherent to a fiber having an inner core and an outer ring core, wherein each core is inherently surrounded by a clad, thereby forming a multi-clad fiber; the examiner notes that an outer layer of air may be considered an air-clad; should applicant disagree that the multiple cladding layers are inherent to the fiber having an inner fiber core and an outer ring core, then the examiner notes that one of ordinary skill in the art would have found it obvious to form the multiple cladding layers to confine light within the cores, as this is elementary in the art), wherein the multi-clad fiber has an inner fiber core (inner fiber core) and at least one outer ring core (outer ring core);
- guiding a second input laser beam (second input laser beam (see claims 1 and 2 of U.S. Patent No. 10,281,656 B2) by a second optical fiber (second input optical fiber (see claim 2 of U.S. Patent 10,281,656 B2) to the fiber end of the multi-clad fiber;
- coupling the first input laser beam (first input laser beam) and the second input laser beam (second input laser beam) into the fiber end of the multi-

clad fiber (optical fiber having an inner fiber core and an outer ring core),
comprising at least one of:

- coupling the first input laser beam at least into the inner fiber core of the multi-clad fiber (see limitation “a.” of claim 1), or
- coupling the second input laser beam at least into the at least one outer ring core of the multi-clad fiber (see limitation “b.” of claim 1); and
- generating an output laser beam by interaction of the first input laser beam and the second input laser beam with the multi-clad fiber (see claim 1 of U.S. Patent 10,281,656 B2), wherein a beam profile characteristic of the output laser beam differs depending upon the coupling of the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber (i.e. different output beam characteristics; see claim 1 of U.S. Patent 10,281,656 B2).

Regarding claims 29 and 39; U.S. Patent No. 10,281,656 B2 claims the system of claim 28 (see claims 1 and 2 of U.S. Patent No. 10,281,656 B2), wherein the system is configured to couple the first input laser beam only into the inner fiber core of the multi-clad fiber (see claim 1, limitation “a.” of U.S. Patent No. 10,281,656 B2).

Regarding claims 30 and 40; U.S. Patent No. 10,281,656 B2 claims the system of claim 28 (see claims 1 and 2 of U.S. Patent No. 10,281,656 B2), wherein the system is configured to couple the second input laser beam only into the at least one outer ring

core of the multi-clad fiber (see claim 1, limitation “b.” of U.S. Patent No. 10,281,656 B2).

Regarding claims 31 and 41; U.S. Patent No. 10,281,656 B2 claims the system of claim 28 (see claims 1 and 2 of U.S. Patent No. 10,281,656 B2), wherein the multi-clad fiber comprises one or more claddings respectively around the inner fiber core and the at least one outer ring core (the one or more claddings is inherent as discussed above with respect to 28; or alternatively obvious because it's elementary in the art to surround each core with cladding layers of lower refractive index to confine light by Snell's law within the core), and wherein the system is configured such that no laser beam is coupled into the one or more claddings (see limitations a and b of claim 1, which thereby imply that no light is coupled into the claddings).

Regarding claims 32, 33, 42 and 43; given the limitations of claims 1 and 2 of U.S. Patent No. 10,281,656 B2, it is within the level of ordinary skill in the art to select a core diameter, outer ring diameter, inner cladding thickness, and refractive index values of the inner core, inner cladding, outer core, and outer cladding that fall within the claimed ranges for the purpose of obtained desired optical transmission with minimized loss for desired wavelengths of light.

Regarding claims 36 and 46; given the limitations of claims 1 and 2 of U.S. Patent No. 10,281,656 B2, it is within the level of ordinary skill in the art to configure the system to generate a laser beam of any desired power acceptable for the intended application, including a power of at least 1kW for the purpose of providing sufficient power for an intended use.

Allowable Subject Matter

Claims 28-33, 36, 38-43, and 46 would be allowable if the non-statutory double patenting rejection set forth above was overcome.

Claims 34, 35, 37, 44, 45, and 47 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

The following is a statement of reasons for the indication of allowable subject matter: The prior art of record, which is the most relevant prior art known, does not disclose or render obvious:

- A system for generating a laser beam with different beam profile characteristics as defined by claim 28, the system comprising:
 - a multi-clad fiber having an inner fiber core and at least one outer ring core; and
 - ***a first optical fiber configured to guide a first input laser beam to the multi-clad fiber; and***
 - ***a second optical fiber configured to guide a second input laser beam to the multi-clad fiber,***
 - ***wherein the system is configured to couple at least one of:***
 - ***the first input laser beam at least into the inner fiber core of the multi-clad fiber, or***
 - ***the second input laser beam at least into the at least one outer ring core of the multi-clad fiber; or***

- A method of generating a laser beam with different beam profile characteristics as defined by claim 38, the method comprising:
 - ***guiding a first input laser beam by a first optical fiber to a fiber end of a multi-clad fiber, wherein the multi-clad fiber has an inner fiber core and at least one outer ring core;***
 - ***guiding a second input laser beam by a second optical fiber to the fiber end of the multi-clad fiber;***
 - ***coupling the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber, comprising at least one of:***
 - ***coupling the first input laser beam at least into the inner fiber core of the multi-clad fiber, or***
 - ***coupling the second input laser beam at least into the at least one outer ring core of the multi-clad fiber;*** and
 - generating an output laser beam by interaction of the first input laser beam and the second input laser beam with the multi-clad fiber, wherein a beam profile characteristic of the output laser beam differs depending upon the coupling of the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber.

Claims 29-37 depend from claim 28, and claims 39-47 depend from claim 38.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MICHELLE R CONNELLY whose telephone number is (571)272-2345. The examiner can normally be reached Monday-Friday, 9 AM to 5 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Uyen-Chau Le can be reached on 571-272-2397. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: <https://patentcenter.uspto.gov>. Visit <https://www.uspto.gov/patents/apply/patent-center> for more information about Patent Center and <https://www.uspto.gov/patents/docx> for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHELLE R CONNELLY/
Primary Examiner, Art Unit 2874

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875				Application or Docket Number 18/387,089		Filing Date 11/06/2023		☐ To be Mailed			
ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO											
APPLICATION AS FILED - PART I											
		(Column 1)		(Column 2)							
FOR		NUMBER FILED		NUMBER EXTRA		RATE (\$)		FEE (\$)			
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))		N/A		N/A		N/A					
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))		N/A		N/A		N/A					
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))		N/A		N/A		N/A					
TOTAL CLAIMS (37 CFR 1.16(i))		minus 20 = *				x \$100 =					
INDEPENDENT CLAIMS (37 CFR 1.16(h))		minus 3 = *				x \$480 =					
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))		If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).									
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))											
* If the difference in column 1 is less than zero, enter "0" in column 2.						TOTAL					
APPLICATION AS AMENDED - PART II											
		(Column 1)		(Column 2)		(Column 3)					
AMENDMENT	12/10/2024	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR		PRESENT EXTRA		RATE (\$)		ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0			x \$100 =		0	
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0			x \$480 =		0	
	☐ Application Size Fee (37 CFR 1.16(s))										
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))										
								TOTAL ADD'L FEE		0	
		(Column 1)		(Column 2)		(Column 3)					
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR		PRESENT EXTRA		RATE (\$)		ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))	*	Minus	**	=			x \$0 =			
	Independent (37 CFR 1.16(h))	*	Minus	***	=			x \$0 =			
	☐ Application Size Fee (37 CFR 1.16(s))										
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))										
								TOTAL ADD'L FEE			
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.								LIE			
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".								/VICTORIA JOHNSON/			
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".											
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.											

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.



UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/387,089

RECEIPT DATE / TIME
12/10/2024 10:12:12 AM Z ET

ATTORNEY DOCKET #
15540-0370006

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	7969	FILED BY	Cheryl Forrest
PATENT CENTER #	68300351	FILING DATE	11/06/2023
CUSTOMER #	26161	FIRST NAMED INVENTOR	Rudolph Huber
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Yunbo Guo

Documents

TOTAL DOCUMENTS: 3

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
ReplytoOA.pdf		8	-	91 KB
ReplytoOA-A....pdf	(1-1)	1	Amendment/Request for Reconsideration-After Non-Final Rejection	65 KB
ReplytoOA-CLM.pdf	(2-6)	5	Claims	79 KB
ReplytoOA-REM.pdf	(7-8)	2	Applicant Arguments/Remarks Made in an Amendment	71 KB

Digest

DOCUMENT

MESSAGE DIGEST(SHA-512)

ReplytoOA.pdf	C13FFB18CC3D6D1AE367D17AEAF0BD913EC42A2A8F2B04B 5A4445649D361B74C9D981BAD4C6BC0CC97E7DB5CF7A11E2 347B44B25F6AA06B9B41B046885183210
ReplytoOA-A....pdf	E0C4128D7E0348E44FDD3F21F4768DAD26B4FCF60A372793E 5C449BE2362AC8BADF67CB05C3C5DC01021D16BC94FA38A F62EF281DA17CDEAA3B81E2A07F7702E
ReplytoOA-CLM.pdf	39150A9D3975FD51CFAAF3BD39035BFD5A5675169DD9BE76 475F1B3296476EC6EE439129DC1F5EE663A3C0ADD7AD4B94 10B2F101216B98A26370FDD065BACD26
ReplytoOA-REM.pdf	F3691A72BD601B389BD5D50291F5897D8501F7E921F0796BE E2B36EE927FCCABD49DF8D5503C091ED0E33B48BB98BA0E B1ECC226141EF87D865208C53228AA0C

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Rudolph Huber	Art Unit :	2874
Application No. :	18/387,089	Examiner :	Michelle R. Connelly
Filed :	November 6, 2023	Conf. No. :	7969
Title :	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

Mail Stop Amendment

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY TO ACTION OF SEPTEMBER 10, 2024

Please consider the following reply.

LIST OF THE CLAIMS

This listing of claims replaces all prior versions and listings of claims in the application:

1. – 27. (Cancelled).

28. (Previously Presented) A system for generating a laser beam with different beam profile characteristics, the system comprising:

a multi-clad fiber having an inner fiber core and at least one outer ring core; and
a first optical fiber configured to guide a first input laser beam to the multi-clad fiber; and
a second optical fiber configured to guide a second input laser beam to the multi-clad fiber,

wherein the system is configured to couple at least one of:

the first input laser beam at least into the inner fiber core of the multi-clad fiber, or
the second input laser beam at least into the at least one outer ring core of the multi-clad fiber.

29. (Previously Presented) The system of claim 28, wherein the system is configured to couple the first input laser beam only into the inner fiber core of the multi-clad fiber.

30. (Previously Presented) The system of claim 28, wherein the system is configured to couple the second input laser beam only into the at least one outer ring core of the multi-clad fiber.

31. (Previously Presented) The system of claim 28, wherein the multi-clad fiber comprises one or more claddings respectively around the inner fiber core and the at least one outer ring core, and

wherein the system is configured such that no laser beam is coupled into the one or more claddings.

32. (Previously Presented) The system of claim 28, wherein the multi-clad fiber is configured to have at least one of:

the inner fiber core with a diameter of no greater than 200 μm ,
the at least one outer ring core with a diameter of no greater than 600 μm , or
an inner cladding with a thickness of no greater than 10 μm , the inner cladding being between the inner fiber core and the at least one outer ring core.

33. (Previously Presented) The system of claim 28, wherein the multi-clad fiber comprises the inner fiber core with a refractive index n_1 , a first cladding with a refractive index n_2 , and an outer ring core with a refractive index n_3 , and the first cladding surrounds the inner fiber core and is between the inner fiber core and the outer ring core, and
wherein $n_1 = n_3$ and $n_1 > n_2$.

34. (Previously Presented) The system of claim 33, wherein the multi-clad fiber further comprises a second cladding surrounding the outer ring core, and
wherein a refractive index n_4 of the second cladding is identical to the refractive index of the first cladding n_2 .

35. (Previously Presented) The system of claim 28, wherein the multi-clad fiber comprises two or more outer ring cores, and the system is configured to couple two or more corresponding input laser beams into the two or more outer ring cores.

36. (Previously Presented) The system of claim 28, wherein the system is configured to generate an output laser beam with a power of at least 1 kW.

37. (Previously Presented) The system of claim 28, further comprising a switchable device coupled between the first and second optical fibers and the multi-clad fiber,
wherein the switchable device is configured to electively couple the first input laser beam at least into the inner fiber core of the multi-clad fiber and the second input laser beam at least into the at least one outer ring core of the multi-clad fiber.

38. (Previously Presented) A method of generating a laser beam with different beam profile characteristics, the method comprising:

guiding a first input laser beam by a first optical fiber to a fiber end of a multi-clad fiber, wherein the multi-clad fiber has an inner fiber core and at least one outer ring core;

guiding a second input laser beam by a second optical fiber to the fiber end of the multi-clad fiber;

coupling the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber, comprising at least one of:

coupling the first input laser beam at least into the inner fiber core of the multi-clad fiber, or

coupling the second input laser beam at least into the at least one outer ring core of the multi-clad fiber; and

generating an output laser beam by interaction of the first input laser beam and the second input laser beam with the multi-clad fiber, wherein a beam profile characteristic of the output laser beam differs depending upon the coupling of the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber.

39. (Previously Presented) The method of claim 38, wherein coupling the first input laser beam at least into the inner fiber core of the multi-clad fiber comprises:

coupling the first input laser beam only into the inner fiber core of the multi-clad fiber.

40. (Previously Presented) The method of claim 38, wherein coupling the second input laser beam at least into the at least one outer ring core of the multi-clad fiber comprises:

coupling the second input laser beam only into the at least one outer ring core of the multi-clad fiber.

41. (Previously Presented) The method of claim 38, wherein the multi-clad fiber comprises one or more claddings respectively around the inner fiber core and the at least one outer ring core, and

wherein coupling the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber comprises:

coupling no laser beam into the one or more claddings.

42. (Previously Presented) The method of claim 38, wherein the multi-clad fiber comprises an inner cladding between the inner fiber core and the at least one outer ring core, and

wherein the multi-clad fiber is configured to have at least one of:

the inner fiber core with a diameter of no greater than 200 μm ,

the at least one outer ring core with a diameter of no greater than 600 μm , or

the inner cladding with a thickness of no greater than 10 μm .

43. (Previously Presented) The method of claim 38, wherein the multi-clad fiber comprises the inner fiber core with a refractive index n_1 , a first cladding with a refractive index n_2 , and an outer ring core with refractive index n_3 , and the first cladding surrounds the inner fiber core and is between the inner fiber core and the outer ring core, and

wherein $n_1 = n_3$ and $n_1 > n_2$.

44. (Previously Presented) The method of claim 43, wherein the multi-clad fiber further comprises a second cladding surrounding the outer ring core, and

wherein a refractive index n_4 of the second cladding is identical to the refractive index of the first cladding n_2 .

45. (Previously Presented) The method of claim 38, wherein the multi-clad fiber comprises two or more outer ring cores, and the method comprises:

coupling two or more corresponding input laser beams into the two or more outer ring cores.

46. (Previously Presented) The method of claim 38, wherein the output laser beam has a power of at least 1 kW.

47. (Previously Presented) The method of claim 38, wherein coupling the first input laser beam and the second input laser beam into the fiber end of the multi-clad fiber comprises:

electively coupling, by a switchable device coupled between the first and second optical fibers and the fiber end of the multi-clad fiber, one of

the first input laser beam at least into the inner fiber core of the multi-clad fiber and
the second input laser beam at least into the at least one outer ring core of the multi-clad fiber.

REMARKS

Applicant(s) (hereinafter, "Applicant") submits this reply in light of the Non-Final Office Action, dated on September 10, 2024. Claims 28-44 were pending, of which claims 28-33, 36, 38-43 and 46 were rejected, and claims 34-35, 37, 44-45 and 47 were objected to. In light of the following remarks, Applicant respectfully requests reconsideration and favorable action in this matter.

Non-Statutory Double Patenting Rejection

Claims 28-33, 36, 38-43, and 46 stand rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1 and 2 of U.S. Patent No. 10,281,565 B2.

Applicant notes that the Examiner listed the patent to disclaim as 10,281,565 above. However, throughout the remainder of the Office Action, the Examiner refers to the patent to disclaims as 10,281,656. It is our belief that the original reference above has a typographical error and that the correct patent to disclaim is 10,281,656. Thus, we are filing an e-Terminal Disclaimer disclaiming to U.S. patent no. 10,281,656, and respectfully requests the rejection be withdrawn.

Allowable Subject Matter

Applicant thanks the Examiner for identifying that claims 28-33, 36, 38-43, and 46 and claims 34, 35, 37, 44, 45, and 47 are allowable.

Applicant has addressed all the rejections and respectfully requests a notice of allowance.

Request for Interview

If the present Application is not allowed and/or if one or more of the rejections is maintained, Applicant hereby requests a telephone conference with the Examiner and further request that the Examiner contact the undersigned representative to schedule the telephone conference.

First Named Inventor : Rudolph Huber
Application No. : 18/387,089
Filed : November 6, 2023
Page : 8 of 8

Attorney Docket No.: 15540-0370006 / 18.01127;
DS10502

CONCLUSION

Applicant has made an earnest attempt to place this case in condition for allowance, and respectfully requests such a Notice. However, the absence of a reply to a specific rejection, issue, or comment does not signify agreement with or concession of that rejection, issue, or comment. In addition, because the arguments made above may not be exhaustive, there may be reasons for patentability of any or all pending claims (or other claims) that have not been expressed. Finally, nothing in this paper should be construed as intent to concede any issue with regard to any claim, except as specifically stated in this paper, and the amendment of any claim does not necessarily signify concession of unpatentability of the claim prior to its amendment.

Applicant respectfully requests consideration of any filed IDSs not previously considered, by initialing and returning each Form PTO-1449.

No fees are believed to be due. However, please apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: 12/10/2024

/Yunbo Guo/

Yunbo Guo, Reg. No. 70,538

Customer Number 26161
Fish & Richardson P.C.
Telephone: +1 (512) 226-8108
Facsimile: (877) 769-7945

24431373.doc



UNITED STATES
PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

APPROVAL LETTER

APPLICATION #
18/387,089

FILING DATE
11/06/2023

APPLICANT/PATENT UNDER REEXAMINATION
Rudolph Huber

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM
PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Electronic terminal disclaimer filed on 12/10/2024



Approved

This patent is subject to a Terminal Disclaimer

Approved / Disapproved by: Electronic Terminal Disclaimer automatically approved

UNITED STATES
PATENT AND TRADEMARK OFFICEP.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov**ELECTRONIC ACKNOWLEDGEMENT RECEIPT**APPLICATION #
18/387,089RECEIPT DATE / TIME
12/10/2024 11:37:36 AM Z ETATTORNEY DOCKET #
15540-0370006**Title of Invention**METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM
PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER**Application Information**APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 7969

FILED BY Cheryl Forrest

PATENT CENTER # 68279255

FILING DATE 11/06/2023

CUSTOMER # 26161

FIRST NAMED
INVENTOR Rudolph HuberCORRESPONDENCE
ADDRESS -

AUTHORIZED BY Yunbo Guo

Documents**TOTAL DOCUMENTS: 2**

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
petition-request.pdf	3	Terminal Disclaimer-Filed (Electronic)	44 KB
grantLetter.pdf	1	Terminal Disclaimer-Electronic- Approved	18 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
petition-request.pdf	246D6A48575DDDFBE515545AC8445C308632E66A0E6404A2B4 9059FFD6A735E0D8432B95EDB022F4B214F99EF00DED612F3 27F522F2F1307957501C8345386B5B

grantLetter.pdf

92953A8C1420611AFE5195B86BF54C33A993F46F9184AB1DF
FC6996B1D7EDCD4E6683370E790A4A47CC9FAA219856368E
07C232022E0855C2F6B43A5AE237EC3

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A PRIOR PATENT

APPLICATION #	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET #
18387089	11/06/2023	Rudolph Huber	15540-0370006

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER



Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action



This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent interest
TRUMPF Laser- und Systemtechnik GmbH	100%
Total	100%

The owner(s) of percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of any patent granted on pending reference Application Number(s)

Application #	Filing Date
---------------	-------------

as the term of any patent granted on said reference application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending reference application. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and any patent granted on the reference application are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term of any patent granted on said reference application, "as the term of any patent granted on said reference application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending reference application," in the event that any such patent granted on the pending reference application: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims canceled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as shortened by any terminal disclaimer filed prior to its grant.

The owner(s) of percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s)

Patent #

10281656

as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:

- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.



Terminal disclaimer fee under 37 CFR 1.20(d) included with Electronic Terminal Disclaimer request.

Applicant claims the following entity status:

Regular Undiscounted

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I certify, in accordance with 37 CFR 1.4(d)(4) that I am: An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application

Signature

Name

Registration #

/Yunbo Guo/

Yunbo Guo

70538

* Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner). Form PTO/SB/96 may be used for making this certification. See MPEP 324.



UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #
18/387,089

RECEIPT DATE / TIME
12/10/2024 11:37:36 AM Z ET

ATTORNEY DOCKET #
15540-0370006

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	7969	FILED BY	Cheryl Forrest
PATENT CENTER #	68279255	AUTHORIZED BY	Yunbo Guo
CUSTOMER #	26161	FILING DATE	11/06/2023
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Rudolph Huber

Payment Information

PAYMENT METHOD DA / 061050	PAYMENT TRANSACTION ID E2024B0B37509003	PAYMENT AUTHORIZED BY Yunbo Guo
-------------------------------	--	------------------------------------

FEE CODE	DESCRIPTION	ITEM PRICE(\$)	QUANTITY	ITEM TOTAL(\$)
1814	STATUTORY DISCLAIMER, INCLUDING TERMINAL DISCLAIMER	170.00	1	170.00
TOTAL AMOUNT:				\$170.00

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/387,089	12/18/2024 11:22:44 AM Z ET	15540-0370006

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	7969	FILED BY	Matthew O'Brien
PATENT CENTER #	68421060	AUTHORIZED BY	Yunbo Guo
CUSTOMER #	26161	FILING DATE	11/06/2023
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Rudolph Huber

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
DA / 061050	E2024BHB24025701	Matthew O'Brien

FEE CODE	DESCRIPTION	ITEM PRICE(\$)	QUANTITY	ITEM TOTAL(\$)
1806	SUBMISSION OF AN INFORMATION DISCLOSURE STATEMENT	260.00	1	260.00
TOTAL AMOUNT:				\$260.00

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Notice

This translation is machine-generated. It cannot be guaranteed that it is intelligible, accurate, complete, reliable or fit for specific purposes. Critical decisions, such as commercially relevant or financial decisions, should not be based on machine-translation output.

ABSTRACT KR20060048214A

[]

¹⁴ The present invention relates to a multi-optical connector assembly, which enables a plurality of multi-ferrules to be reliably connected, and allows only a defective multi-ferrule to be replaced. The first guide mechanism is formed by the internal shape of the mating portion of the plug housing and the external shape of the mating portion of the receptacle housing that is guided and inserted into the mating portion. The second guide mechanism is formed by a guide post and a guide hole. A third guide mechanism is formed by the internal shape of the coupling portion of the receptacle housing and the external shape of the first multi-core ferrule of the plug side optical connector inserted into the coupling portion of the receptacle housing. The fourth guide mechanism is formed with a guide pin opening for accommodating a guide pin of the second multi-core ferrule and the guide pin of the first multi-core ferrule. During mating of the receptacle-side optical connector and the plug-side optical connector, the first guide mechanism, the second guide mechanism, the third guide mechanism, and the fourth guide mechanism are operated in the above order.

²⁸ Optical connector assemblies, fiber optic cables, multi-core ferrules, plug housings

(19)대한민국특허청(KR)
(12) 공개특허공보(A)

(51) Int. Cl. (11) 공개번호 10-2006-0048214
G02B 6/38 (2006.01) (43) 공개일자 2006년05월18일

(21) 출원번호 10-2005-0048246
(22) 출원일자 2005년06월07일

(30) 우선권주장 JP-P-2004-00168857 2004년06월07일 일본(JP)

(71) 출원인 타이코 일렉트로닉스 에이애플 케이.케이.
일본, 213-8535, 가나가와, 가와사키, 다카츠, 히사모토, 3-5-8, 타이코 일렉트로닉스 에이애플 케이.케이. 내

(72) 발명자 오쓰, 노부아키
일본국, 213-8535, 가나가와-젠, 가와사키-시, 다카쓰-구, 히사모토, 3-5-8, 타이코 일렉트로닉스 에이애플 케이.케이., 내
하야시, 타케히로
일본국, 213-8535, 가나가와-젠, 가와사키-시, 다카쓰-구, 히사모토, 3-5-8, 타이코 일렉트로닉스 에이애플 케이.케이., 내
코바야시, 시게루
일본국, 213-8535, 가나가와-젠, 가와사키-시, 다카쓰-구, 히사모토, 3-5-8, 타이코 일렉트로닉스 에이애플 케이.케이., 내

(74) 대리인 신영무

참사청구 : 없음

(54) 다중 코어 광학 커넥터 어셈블리

요약

본 발명은 다중 광학 커넥터 어셈블리에 관한 것으로, 복수의 다중 패들들을 확실하게 연결할 수 있도록 하며, 결합이 있는 다중 패들만을 교체할 수 있도록 한다. 제1 가이드 메커니즘은 플러그 하우징의 결합부의 내부 형상 및 상기 결합부 내로 가이드되고 삽입되는 리셉터를 하우징의 결합부의 외부 형상으로 형성된다. 제2 가이드 메커니즘은 가이드 지주 및 가이드 홀로 형성된다. 제3 가이드 메커니즘은 상기 리셉터를 하우징의 상기 결합부의 상기 내부 형상 및 상기 리셉터를 하우징의 상기 결합부 내로 삽입되는 상기 플러그 측 광학 커넥터의 제1 다중 코어 패들의 상기 외부 형상으로 형성된다. 제4 가이드 메커니즘은 제2 다중 코어 패들의 가이드 핀 및 상기 제1 다중 코어 패들의 상기 가이드 핀을 수용하기 위한 가이드 핀 개구로 형성된다. 리셉터를 측 광학 커넥터 및 플러그 측 광학 커넥터의 결합 동안, 상기 제1 가이드 메커니즘, 제2 가이드 메커니즘, 제3 가이드 메커니즘, 제4 가이드 메커니즘은 상기 순서대로 작동된다.

대표도

도 13

색인어

광학 커넥터 어셈블리, 광섬유 케이블, 다중 코어 페룰, 플러그 하우징

명세서

도면의 간단한 설명

도 1은 본 발명의 다중 코어 광학 커넥터 어셈블리의 외관을 도시한 사시도,

도 2는 도 1의 다중 코어 광학 커넥터 어셈블리에 사용된 플러그 측 광학 커넥터의 하우징 및 리셉터를 측 광학 커넥터의 하우징의 분리된 상태를 도시한 사시도,

도 3은 도 2의 플러그 측 광학 커넥터의 커버 하우징은 제거하고 하부 하우징만을 도시한 사시도,

도 4는 도 3의 상기 하우징에 사용되는 가이드 부재를 도시한 사시도,

도 5는 상기 플러그 측 광학 커넥터를 결합면에서 본 정면도,

도 6은 내부에 다중 코어 페룰이 배치된 상기 플러그 측 광학 커넥터를 도시한 부분 확대 수직 단면도,

도 7은 상기 리셉터를 측 광학 커넥터를 결합부측에서 본 정면도,

도 8은 상기 리셉터를 측 광학 커넥터의 확대 수직 단면도,

도 9는 광섬유 케이블 설치 어셈블리의 분해 사시도,

도 10은 도 1의 상기 광학 커넥터 어셈블리에 사용되는 튜브 및 상기 튜브 내에 위치한 다중 코어 페룰을 도시한 개략도,

도 11은 상기 플러그 측 광학 커넥터 및 상기 리셉터를 측 광학 커넥터의 결합 초기 상태를 도시한 부분 확대 수직 단면도,

도 12는 결합이 진행하여 가이드 지주가 가이드되는 상태를 도시한 부분 확대 수직 단면도,

도 13은 결합이 더 진행하여 상기 다중 코어 페룰이 가이드되는 상태를 도시한 부분 확대 수직 단면도,

도 14는 상기 다중 코어 페룰의 가이드 핀이 가이드되는 상태를 도시한 부분 확대 수직 단면도,

도 15는 결합이 완성된 상태를 도시한 다중 코어 광학 커넥터의 부분 확대 수직 단면도.

<도면의 주요부분에 대한 부호의 설명>

1 : 다중 코어 광학 커넥터 어셈블리 2 : 플러그측 광학 커넥터

4 : 하우징 6 : 튜브

6a : 내경 8, 108 : 결합부

26, 112 : 만곡면(제1 가이드 기구) 50 : 제1 다중 코어 페룰

55 : 외면(제3 가이드 기구) 60 : 가이드 지주(제2 가이드 기구)

72 : 가이드 핀 개구(제4 가이드 기구) 80 : 광섬유 케이블

80b : 광섬유 100 : 리셉터를 측 광학 커넥터

102 : 하우징 116 : 가이드 지주 홀(제2 가이드 기구)
 120 : 제2 다중 코어 페룰 122 : 가이드 핀(제4 가이드 기구)
 132 : 테이퍼(제3 가이드 기구) 140a : 내면(제3 가이드 기구)
 148 : 플립(지지부재) 160 : 지지부
 162 : 압 166 : 래치 돌출부
 168 : 광섬유 케이블 168b : 광섬유

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

본 발명은 다중 코어 광학 커넥터 어셈블리에 관한 것이다. 본 발명은 특히, 광섬유 케이블의 단부를 지지하는 다수의 페룰(ferrules)을 서로 연결하는 다중 코어 광학 커넥터 어셈블리에 관한 것이다.

일본 미심사청구 특허 공개 번호 No. 2002-148486에 공지된 바와 같은, 주지된 다중 코어 광학 커넥터 어셈블리가 있다 (도 1, 도 4). 상기 다중 코어 광학 커넥터 어셈블리는 제1 하우징 및 상기 제1 하우징의 외부에 대한 가이드 하우징으로 구성되는 플러그 측 광학 커넥터; 제2 하우징으로 구성되는 리셉터클(receptacle) 측 광학 커넥터를 포함한다. 상기 제1 하우징은, 페룰 가이드 핀을 갖는 다수의 다중 코어 페룰을 수용하고, 또한 가이드 핀을 가진다. 상기 제2 하우징은, 페룰 가이드 개구를 갖는 다수의 다중 코어 페룰을 수용하고, 또한 상기 제1 하우징의 상기 가이드 핀을 수용하기 위한 가이드 개구를 갖는다. 상기 하우징들의 정렬은 두 단계로 이루어진다. 먼저, 상기 가이드 하우징과 상기 리셉터클 측 광학 커넥터의 상기 제2 하우징이 결합된다. 이후에, 상기 제1 하우징의 상기 가이드 핀이 상기 제2 하우징의 상기 가이드 개구로 삽입된다.

전술한 주지의 다중 코어 광학 커넥터 어셈블리에 있어서, 상기 다중 코어 페룰의 위치 정확도는 상기 다중 코어 페룰의 외부 치수 및 상기 다중 코어 페룰을 수용하는 상기 제1 하우징 및 제2 하우징의 상기 개구부의 치수에 종속된다. 따라서 상기 제1 하우징의 상기 가이드 핀이, 상기 제2 하우징의 상기 가이드 개구에 삽입되어 정렬될지라도, 서로에 대한 상기 다중 코어 페룰의 정렬은 보장되지 않는다. 즉, 상기 하우징의 상기 멀티 코어 페룰의 외측 치수와 상기 개구의 치수에 의해, 최종 가이드 역할을 하는 상기 페룰 가이드 핀이 상기 페룰 가이드 개구 내로 삽입되지 않을 수도 있다.

발명이 이루고자 하는 기술적 과제

본 발명은 전술한 상황에 착안하여 도출된 것으로, 본 발명의 목적은, 다수의 다중 코어 페룰을 서로 확실히 연결할 수 있는 다중 코어 광학 커넥터 어셈블리를 제공하는데 있다.

본 발명의 또 다른 목적은 결합 있는 다중 코어 페룰만을 교체할 수 있는 다중 코어 광학 커넥터 어셈블리를 제공하는데 있다.

발명의 구성 및 작용

본 발명에 따른 다중 코어 광학 커넥터 어셈블리는:

플러그 하우징을 갖는 플러그 측 광학 커넥터;

상기 플러그 하우징과 결합하는 리셉터클 하우징을 갖는 리셉터클 측 광학 커넥터;

상기 플러그 하우징은 다수의 제1 다중 코어 패들 및 전방으로 접하는 가이드 지주를 갖고, 상기 리셉터를 하우징은 다수의 제2 다중 코어 패들 및 상기 가이드 지주를 수용하기 위한 가이드 지주 홀을 갖고, 상기 제1 다중 코어 패들 및 제2 다중 코어 패들은 상호 연결되기 위한 광섬유 케이블의 말단을 지지함;

상기 플러그 하우징의 결합부의 내부 형상 및, 상기 플러그 하우징의 상기 결합부 내로 가이드되고 삽입되는 상기 리셉터를 하우징의 결합부의 외부 형상에 의해 형성되는 제1 가이드 메커니즘;

상기 가이드 지주 및 상기 가이드 지주 홀에 의해 형성되는 제2 가이드 메커니즘;

상기 리셉터를 하우징의 상기 결합부의 상기 내부 형상 및, 상기 리셉터를 하우징의 상기 결합부로 삽입되는 상기 제1 플러그 측 다중 코어 패들의 상기 외부 형상에 의해 형성되는 제3 가이드 메커니즘; 및

상기 제1 다중 코어 패들 또는 제2 다중 코어 패들의 가이드 핀 및 상기 제2 다중 코어 패들 또는 제1 코어 패들의 상기 가이드 핀을 수용하기 위한 가이드 핀 개구에 의해 형성되는 제4 가이드 메커니즘; 을 포함하며,

상기 리셉터를 측 광학 커넥터 및 상기 플러그 측 광학 커넥터를 결합하는 동안 상기 제1 가이드 메커니즘, 제2 가이드 메커니즘, 제3 가이드 메커니즘, 제4 가이드 메커니즘을 상기 순서대로 작동하는 특징이 있다.

상기 다중 코어 패들은 단일 열 또는 다수의 열에서 상기 광섬유 케이블의 상기 말단을 지지할 수 있다.

상기 플러그 하우징 및 상기 리셉터를 하우징 중 적어도 하나는 후단부에 설치된 가요성 튜브를 더 포함하고;

상기 튜브의 내부 지수는 상기 광섬유 케이블이 부착된 상기 다중 코어 패들 및 상기 일단의 광섬유 케이블이 통과할 수 있는 크기인 구조가 채용될 수 있다.

상기 리셉터를 측 광학 커넥터의 상기 리셉터를 하우징은 상기 다중 코어 패들을 지지하기 위한 지지부재를 더 포함하고;

상기 지지부재는 상기 다중 코어 패들의 후면부를 지지하기 위한 지지부 및 상기 지지부로부터 후면으로 연장하는 암들(arms)을 포함하고; 및

상기 암들에는 통상 상태의 상기 리셉터를 하우징과 결합하고 상기 암들의 만곡에 의해 상기 리셉터를 하우징으로부터 분리되는 결합부가 형성되는 구조가 채용될 수 있다.

"상기 다중 코어 패들을 지지" 라는 구문은 상기 지지부재가 다른 부재를 통해 상기 다중 코어 패들을 지지하는 경우, 부가적으로 상기 지지부재가 상기 다중 코어 패들을 직접 지지하는 경우를 포함한다.

상기 지지부재의 상기 지지부는 평면이고;

상기 암들은 상기 지지부재의 양측으로부터 연장하는 한쌍으로 형성되며; 및

상기 결합부는 각각의 상기 암들 상에 형성되는 구조가 채용될 수 있다.

상기 지지부재는 금속 플레이트로 형성된다. 상기 결합부는 상기 금속 플레이트를 자르고 만곡하여 형성되는 래치 돌기부(latch protrusions)일 수 있다.

이하에서는 본 발명에 따른 상기 다중 코어 광학 커넥터 어셈블리의 실시예를 상기 첨부된 도면을 참조하여 자세하게 설명할 것이다. 도 1은 본 발명의 다중 코어 광학 커넥터 어셈블리(1; 이하 간단히 "어셈블리"라 한다)의 외관을 도시한 사시도이다. 도 1에 도시한 바와 같이, 어셈블리(1)는 플러그 측 광학 커넥터(2) 및 리셉터를 측 광학 커넥터(100)로 구성된다. 플러그 측 광학 커넥터(2)는, 다이 캐스트 알루미늄(die cast aluminim)으로 형성되거나 전도성 수지(conductive resin)로 주조된 하우징[4; 플러그 하우징(plug housing)]을 갖는다. 금속 튜브(6)는 하우징(4)에 연결될 수 있다. 광섬유 케이블들은 튜브(6) 내에 제공된다. 따라서, 튜브(6)는 가요성이 있도록 제조되지만, 파손을 방지하도록 충분히 견고하다. 장방향 결합부(8)는 하우징(4) 상에 형성된다. 결합부(8)는 리셉터를 측 광학 커넥터(100)에 연결된다.

도 1에 도시한 바와 같이, 리셉터클 측 광학 커넥터(100)는 대체로 장방형 형상인 하우징(102; 장방형 하우징)을 갖는다. 후술하는 다중 코어 패들(50)이 설치되는 장방형 개구(104)는, 하우징(102)의 길이 방향을 따라 미리 계산된 간격으로 하우징(102)의 중심부에 형성된다. 도 1에서, 리셉터클 측 광학 커넥터(100)는 플러그 측 광학 커넥터(2)의 결합부(8)에 가까이 인접하여, 즉 이들이 서로 접근함으로써 상기 둘 사이의 연결이 가능할 수 있는 상태로 위치된다. 도 1에 유의하면, 후술할 광섬유 설치 어셈블리(144; 도 9 참조)는 단지 최좌측 개구(104)에 부착된다. 실제로, 광섬유 설치 어셈블리(144)는 모든 개구(104)에 부착된다.

여기에, 전술한 튜브(6) 및 다중 코어 패들(50) 사이의 관계는 도 10을 참조하여 설명할 것이다. 도 10은 튜브(6) 및 튜브(6) 내에 위치한 다중 코어 패들(50)을 도시한 개략도이다. 튜브(6)의 내경(6a)은 다중 코어 패들(50) 외형 치수, 즉 후면부(50b)를 대각선(50c)보다 크다. 즉, 튜브(6)의 내경(6a)은, 광섬유 케이블(80)(도 3 참조)이 부착된 다중 코어 패들(50)이 통과하여 지나갈 수 있는 크기이다. 게다가, 튜브(6)의 내경(6a)은 일단의 광섬유 케이블(80)이 통과하여 지나갈 수 있는 크기이다. 이에 의하여, 어셈블리(1)의 제조 또는 사용시 하나 이상의 광섬유 케이블에서 파손과 같은 결합이 발생한다면, 다중 코어 패들(50) 및 일단의 광섬유 케이블(80)은 튜브(6)를 통해 제거되고 교체될 수 있다.

다음으로, 하우징(4) 및 하우징(102)은 도 2를 참조하여 더욱 구체적으로 설명될 것이다. 도 2는 플러그 측 광학 커넥터(2)의 하우징(4) 및 리셉터클 측 광학 커넥터(100)의 하우징(102)의 서로 분리된 상태를 도시한 사시도이다. 하우징(2)은, 상하 방향으로 분리될 수 있는, 하부 하우징(10) 및 커버 하우징(12)으로 구성되는 선행부(2a) 및 만곡부(2b)로 구성된다. 하부 하우징(10) 및 커버 하우징(12)은 나사로 서로 고정된다. 도 2에서 참조번호(14)로 표시된 상기 홀은 상기 나사가 설치되는 곳이다. 전술한 튜브(6)가 설치되는 원형 개구(16)는, 결합부(8)의 하우징(4) 맞은편 단부(후단부)에서, 하부 하우징(10) 및 커버 하우징(12)에 의해 함께 형성된다.

상기 결합부(8)는 또한 두개의 컴포넌트 구조이다. 상부(8a)는 커버 하우징(12)과 일체로 형성되고, 하부(8b)는 하부 하우징(10)과 일체로 형성된다. 상부(8a) 및 하부(8b)에 의해 회전 가능하도록 지지되는 결합 나비나사(18; thumb screws)는 결합부(8)의 양측에 제공된다. 리셉터클 측 광학 커넥터(100) 및 플러그 측 광학 커넥터(2)가 결합될 때, 결합 나비나사(18)는 이들 사이에 결합된 상태를 유지한다. 원판상의 손잡이(20; knob)는 각각의 결합 나비나사(18)의 후단부에 일체로 형성된다. 손잡이(20)는, 상기 광학 커넥터들이 서로 고정되도록 리셉터클 측 광학 커넥터(100)의 나사산 개구(106)로 결합하는 나비나사(18)의 단부가 삽입되도록 회전한다.

전면을 향해 개방된 결합 리세스(22)는 결합부(8) 내에 형성된다. 결합 리세스(22)를 전면에서 본다면, 결합리세스(22)는 상하로 비대칭 형상이고, 이에 의해 리셉터클 측 광학 커넥터(100)의 잘못된(상하로 반전된) 삽입을 방지한다. 결합 리세스(22)를 밀봉하는 개방/폐쇄가능한 셔터(24; shutter)는 일반적으로 결합부(8)에 부착된다. 셔터(24)는, 결합 리세스(22)의 상부 및 하부에 반반씩 제공되며, 수평으로 연장하는 한쌍의 하프 셔터(24a, 24b)로 구성된다. 하프 셔터(24a, 24b)는 통상 상태에서 결합 리세스(22)를 폐쇄하기 위하여 비틀림 스프링(27a; torsion springs)(도 5 참조)으로 가압된다. 리셉터클 측 광학 커넥터(100)와 결합시, 결합부(108)가 결합 리세스(22)의 내부를 향해 회전하도록 하프 셔터(24a, 24b)를 가압함으로써, 결합 리세스(22)는 개방된다. 셔터(24)는 운전자의 눈으로 돌발적인 빛의 유입을 방지하기 위하여 광섬유 케이블(80)(도 3 참조)로부터 방출되는 빛을 차폐함으로써 운전자의 눈을 보호하도록 제공된다.

다음으로, 하우징(4)은 도 3을 참조하여 더욱 자세히 설명될 것이다. 도 3은 커버 하우징(12)을 제거하고, 단지 하부 하우징(10)만 도시된 하우징(4)의 사시도이다. 아치형 표면(26)은 세로 방향으로 결합 리세스(22)의 양쪽 단부에 형성된다. 만곡 가이드 표면(26a)은 결합부(8)의 하부(8b)의 전면에 형성된다. 즉, 만곡 가이드 표면(26a)은 아치형 표면(26)을 따라 결합면(28)과 연속하여 형성된다. 가이드 표면(26a)은 만곡면 대신에 테이퍼면(tapered surfaces)이 될 수 있는 것에 유의한다. 결합 리세스(22)는 결합 리세스(22)가 폐쇄 상태일 때 셔터(24)(도 2 참조)가 위치되는 단부(30; step); 단부(30)와 연속되는 수직면(31); 수직면(31)과 연속되는 경사부(32); 개방 상태일 때 경사부(32) 상부에 위치되는 셔터(24)를 수용하기 위한 단부(34); 단부(34) 상부에 위치한 평탄부(36)를 포함한다. 셔터(24)의 회전축(25)(도 5 참조)이 부착되는 개구(25a)들은, 결합 리세스(22)의 하부에서 양끝단에 길이 방향으로 제공된다.

결합 리세스(22)의 내부에는 상기 커넥터들의 삽입/인출 방향(38)으로 연장하는 다수의 격벽(40)이, 상하로 연장하여 하부면(10c)과 일체로 형성된다. 수직으로 연장하는 리브(42, 44; rib)는 각각의 격벽(40)의 전면 및 후면에 일체로 형성된다. 격벽(40) 및 리브(42, 44)는, 다중 코어 패들(50)(제1 다중 코어 패들)이 내부에 배열되는 다수의 중공(52)을 구성한다. 다중 코어 패들(50)이 돌출하는 개구(46)는 중공(52)의 앞측에 형성되고, 광섬유 케이블(80)이 인출되는 슬롯(48)은 중공(52)의 뒷측에 형성된다. 중공(52)의 상부는 개방되지만, 커버 하우징(12)이 하부 하우징(10)에 고정될 때 커버 하우징(12)(도 2 참조)에 의해 밀폐된다.

전술한 결합 나비나사(18)를 수용하기 위한 홈(54)은, 결합부(8)의 하부(8b)의 양단에 형성된다. 도 3은 결합 나비나사(18) 중의 하나가 홈(54) 중의 하나에 제공된 상태를 명확하게 도시한다. 전면 및 상부를 향하여 개방된 리세스(56)는 좌측 및 좌우측 공동(52) 근방에 형성된다. 가이드 부재(58)는 리세스(56)내에서 제공된다. 전면을 향하여 개방된 슬롯(62)은 리세스(56)내에서 형성된다. 가이드 부재(58)로써 기능하는 가이드 지주(60)는 슬롯(62)으로부터 돌출한다. 가이드 지주(60)의 말단은 결합 리세스(22)내에 위치되고, 따라서 외부 요소로부터 보호된다. 하부(8b)의 상부면(64)으로부터 하방으로 연장하는 한쌍의 홈(66)은 슬롯(62) 인근의 각각의 리세스(56)내에 형성된다. 리세스(56)내에 제공되는 가이드 부재(58)는 이후에 더욱 상술될 것이다.

공동(52) 내에서 배열되는 각각의 다중 코어 패들(50)은: 개구(46)보다 다소간 협소한 폭을 갖는 평행육면체인 전면부(50a); 개구(46)보다 다소간 넓은 폭을 갖는 평행육면체인 후면부(50b)를 포함한다. 상기 구조로 인하여, 전면으로 접하는 전부(53)(도 6 참조)는 각각의 다중 코어 패들(50)의 후면부(50b)의 전체 외주의 둘레에 형성된다. 부가적으로, 후면부(50b)는 공동(52)내에서 제공되는 압축 코일 스프링(78; compression coil springs)(도 6 참조)에 의해 전방으로 가압된다. 따라서, 단지 전면부(50a)만이 개구(46)를 통해 돌출하고, 전부(53)는 이들이 립(42)과 접촉하는 상태로 유지된다. 또한, 압축 코일 스프링(78)은 도 3에서 생략되어 있다.

결합부(8)의 후면으로 향하는 하부 하우징(10)의 내부는 벽체(10a, 10b)에 의해 한정되는 공간(68)이다. 다중 코어 패들(50)로부터 연장하는 광섬유 케이블(80)은 공간(68)내에서 제공된다. 도 3에는 단일 광섬유 케이블(80)이 도시되어 있다. 측면을 갖는 리세스(70)는 개구(16)와 연속하는 하부 하우징(10)의 하부 벽체(10c)에 형성된다. 튜브(6)의 말단은 리세스(70)에 배열된다.

다음으로, 가이드 부재(58)는 도 4를 참조하여 기술될 것이다. 도 4는 가이드 부재(58)를 도시한 사시도이다. 가이드 부재(58)는: 구면(60a)에서 말단이 되는 테이퍼 말단을 갖는 원통형 가이드 지주(60); 가이드 지주(60)의 후단부에 위치된 원반형 플랜지(63; discoid flange); 얇은 축부(61a)를 거쳐 플랜지(63) 후방에 형성된 원통형 통제부(61)를 포함한다. 통제부(61)는 리세스(56)(도 3 참조)내에서 위치되고, 플랜지(63)는 홈(66) 내에 격납된다. 통제부(61)의 직경은 리세스(56)를 한정하는 격벽들 사이의 간격과 대체적으로 동일하고, 따라서 리세스(56) 내에서의 좌우 이동이 통제된다. 부가적으로, 플랜지(63) 및 홈(66) 사이의 상기 결합은 삽입/인출 방향(38)으로의 가이드 부재(58) 이동을 통제한다. 이와 같이, 가이드 부재(58)는, 삽입/인출 방향(38)으로 정렬되는 이들의 축과 함께, 리세스(56)내에서 고정된다.

도 5는 결합면(28)의 측면에서 본, 상술한 구조의 플러그 측 광학 커넥터(2)를 도시한 정면도이다. 도 5는 결합 리세스(22)의 상하로 비대칭인 형상을 명확하게 도시한다. 또한 도 5는 8개의 다중 코어 패들(50)이 결합 리세스(22)내에서 제공되는 것을 도시한다. 돌출부(74, 76)는 하부(8b)의 홈(54) 및 슬롯(62)과 대응하는 위치에서 커버 하우징(12) 상에 제공된다. 돌출부(74, 76)는, 결합 나비나사(18) 및 가이드 지주(60)를 지지하기 위한 홈(54) 및 슬롯(52)과 협력한다.

참조 번호 (25)로 표시된 부분은, 결합 리세스(22) 내의 양단에서 상기 하우징을 고정하는, 하프 셔터(24a, 24b)의 회전축이다. 다수의 베어링(27)은 수지 셔터(24; resin shutter) 상에서 일체로 형성되고, 회전축(25)은 베어링(27)을 관통하여 삽입된다. 부가적으로 비틀림 스프링(27a)은, 폐쇄 방향으로 셔터(24)를 가압하기 위하여, 길이 방향으로 회전축의 중심부 주위에 권선된다. 가이드 핀 개구(72)는 다중 코어 패들(50)의 전면(51)에서 상하 배열된 쌍으로 형성되고, 8개의 광섬유(80b)의 단부면(81)(도 6 참조)은 각각 한쌍의 가이드 핀 개구(72) 사이에서 노출된다. 단부면(81)의 세로줄은 직선으로 도시된다. 상기 구조의 설명은 하기에 기술될 것이다.

도 6은 내부에 제공된 다중 코어 패들(50)을 갖는 플러그 측 광학 커넥터(2)를 도시한 부분 확대 수직 단면도이다. 다중 코어 패들(50)은, 상부(8a)의 개구(46) 및 리브(9)에 인접한 전부(53)에 의해 공동(52) 내에서 고정된다. 또한 도 6에는 압축 코일 스프링(78)이 다중 코어 패들(50)을 전방으로 가압하는 상태가 명확하게 도시된다. 8개의 광섬유 경로(73)는 가이드 핀 개구(72, 72)사이에 형성된다. 이들의 덮개(80a)가 제거된 광섬유(80b)는, 세로 방향의 단일 열(single column)로 광섬유 경로(73) 내에서 지지된다. 다중 코어 패들(50)의 전면(51) 및 광섬유(80b)의 단부면(81)은 동일평면상에 있다. 셔터(24)를 가압하는 비틀림 스프링(27a)은 도 6에서 생략되어 있다.

다음으로, 리셉터클 측 광학 커넥터(100)가 상술될 것이다. 도 7은 결합부(108) 면에서 본, 리셉터클 측 광학 커넥터(100)의 정면도이다. 도 8은 리셉터클 측 광학 커넥터(100)의 확대 수직 단면도이다. 광섬유 설치 어셈블리(144)의 단면 형상은 도 8에서 개략적으로 도시되어 있다. 이하에서는, 도 7 및 도 8을 참조하여 설명될 것이다. 도 7에 도시된 바와 같이, 결합부(108)의 외부 형상은 플러그 측 광학 커넥터(2)의 결합 리세스(22)의 내부 형상과 상보적이고, 또한 상하로 비대칭이다. 즉, 결합부(108)는 평탄상부면(110) 및 양단에 만곡면(112)을 갖는 하부면(114)을 포함한다.

다중 코어 패들(120)(제2 다중 코어 패들)은 플러그 측 광학 커넥터(2)의 다중 코어 패들(50)에 대응하는 위치에서 결합부(108)내에 제공된다. 가이드 핀(122)은 다중 코어 패들(50)의 가이드 핀 개구(72)에 대응하는 위치에서 다중 코어 패들(120) 상에 제공되며, 가이드 핀(122) 사이에는 광섬유(80b)에 대응하는 위치에 광섬유(160b)열이 제공된다. 가이드 지주홀(116)은 플러그 측 광학 커넥터(2)의 가이드 지주(60)에 대응하는 위치에서 결합부(108)의 양단부에서 제공된다. 결합 나비나사(18)가 삽입되기 위한, 나사산이 형성된 개구(106)는 하우징(102)의 양단에 형성된다.

다음으로, 도 8을 참조하여 더욱 상세한 설명이 기술될 것이다. 도 8에 도시된 바와 같이, 후면에서 개구(104)와 통하는 장방향 전면 개구(128)는 결합부(108)에 형성된다. 전면 개구(128) 및 개구(104) 사이의 공간은 패들 하우징 경로(140)이다. 내부에 접하는 테이퍼(130)는 결합부(108)의 말단에서 외면에 형성되고, 외부에 접하는 테이퍼(132)는 전면 개구(128)의 상부 및 하부 내면(140a)과 연속하여 형성된다. 후방으로 접하는 단부(134)는 전면 개구(128) 및 개구(104) 사이의 결합부(108)에서 형성된다. 장방향 결합 개구(142)는 하우징(102)의 상부면(136)에서 패들 하우징 경로(140)까지 및, 하우징(102)의 하부면(138)에서 패들 하우징 경로(140)까지 형성된다. 결합 개구(142)는 패들 하우징 경로(140)와 직각으로 형성된다.

이들의 전단에서 외향으로 접하는 테이퍼(141a)를 갖는, 상하로 분리된 용기부(141)는 패들 하우징 경로(140)의 측벽(140b) 상에 형성된다. 따라서, 총 4개의 용기부(141)가 좌측벽 및 우측벽(140b)상에 형성된다. 용기부(141)는 패들 하우징 경로(140) 내에서 측방으로 다중 코어 패들(120)을 위치시킨다.

다음으로, 패들 하우징 경로(140)에 제공되는 광섬유 설치 어셈블리(144)는 도 9를 참조하여 합체되어 설명될 것이다. 도 9는 광섬유 설치 어셈블리(144)의 분해 사시도이다. 광섬유 설치 어셈블리(144)는 다중 코어 패들(120); 한 쌍의 가이드 핀(122) 및 가이드 핀(122)이 부착된 베이스(146)로 구성되는 가이드 핀 어셈블리(156); 베이스(146) 후방에 위치되고 베이스(146)를 지지하는 클립(148; clip)(지지 부재)를 포함한다.

다중 코어 패들(120)은 다중 코어 패들(50)과 유사한 형상이며, 전면부(120a) 및 후면부(120b)를 포함한다. 전방으로 접하는 견부(150)는 후면부(120b)의 외주 둘레에 형성된다. 가이드 핀 개구(152) 및 광섬유 경로(154) 또한, 다중 코어 패들(50)과 유사한 형상으로, 다중 코어 패들(120)에 형성된다. 도 8에 도시된 바와 같이, 광섬유 케이블(168)은 리셉터를 측 광학 커넥터(100)에 연결된다. 광섬유 케이블(168)의 말단에서 커버(168a)가 제거된 광섬유(168b)는, 각각의 광섬유 경로(154)에 삽입된다. 광섬유 케이블(168)은 도 9에서 생략된다.

가이드 핀 어셈블리(156)는 원형 단면을 갖는 금속선으로 형성되는 가이드 핀(122) 및, 가이드 핀(122)이 형철(swaging) 또는 동등물에 의해 고정되는 베이스(146)로 구성된다. 가이드 핀 어셈블리(156)는 적절하게 스테인레스 스틸(stainless steel)재를 사용하여 형성된다. 베이스(146)는 한쌍의 장방향 프레임(146b) 및 2개의 프레임(146b)를 연결하는 평면 링크(146a)를 포함한다. 개별 가이드 핀(122)은 각각의 프레임(146b)에 부착된다. 광섬유 케이블(168)은 2개의 프레임(146b) 사이에 제공된다. 가이드 핀 어셈블리(156)의 가이드 핀(122)은 다중 코어 패들(120)의 후면으로부터 가이드 핀 개구(152)로 삽입되고, 베이스(146)는 후면으로부터 다중 코어 패들(120)의 후면부(120b)를 지지한다. 가이드 핀 어셈블리(156) 및 다중 코어 패들(120)은 이들이 서로 조립된 상태에서 다중 코어 패들 어셈블리(158)로 표시된다. 가이드 핀(122)은, 가이드 핀 어셈블리(156)가 다중 코어 패들(120)(도 8 참조)상에 설치된 상태에서 다중 코어 패들(120)의 전면(121)으로부터 돌출한다. 그러나, 가이드 핀(122)의 말단은 결합부(108)의 내부 내에 위치되고, 따라서 이들은 외부 요소로부터 보호된다.

클립(148)은 스포팅과 유사한 특성을 갖는 단일 금속 플레이트를 타공하고 만곡함으로써 형성된다. 클립(148)은 베이스(146)를 지지하기 위한 평면 지지부(160); 지지부(160)의 양단으로부터 후방으로 연장하는 한쌍의 암(162; arms)을 포함한다. 광섬유 케이블(168)이 통과하기 위한 절취부(160a; cutout)는 지지부(160)에 형성된다. 암(162)은 지지부(160)를 향해 대체로 평행하게 연장하는 전면부(162a); 외향으로 개방된 단부(164)를 거쳐 평행하게 연장하는 후면부(162b)를 포함한다. 후방에 접하는 정지면(166a)을 갖는 래치 돌출부(166; latch protrusions)(결합부)는 전면부(162a)를 자르고 만곡하여 형성된다. 지지부(160) 및 베이스(146)는 접착 또는 서로 간단히 접함으로써 서로 고정될 수 있다.

상술된 바와 같은 구조를 갖는 광섬유 설치 어셈블리(144)가 후방에서부터 패들 하우징 경로(140)로 삽입될 때, 다중 코어 패들(120)의 견부(150)는 패들 하우징 경로(140)내에서 단부(134)와 접한다. 래치 돌출부(166)의 정지면(166a)은 하우징(102)의 결합 개구(142)와 결합하고, 광섬유 설치 어셈블리(144)는 하우징(102) 내에서 고정된다. 이 때, 클립(148)의 후면부(162b)는 하우징(102)으로부터 후방으로 돌출한다. 광섬유 설치 어셈블리(144)가 교체를 위해 제거되는 경우, 후면부(162b)는 서로 접근하도록 그림된다(gripped). 이후에, 전면부(162a)는 래치 돌출부(166) 및 결합 개구(142)를 제거하기 위해 안으로 만곡하고, 광섬유 설치 어셈블리(144)는 간단히 인출될 수 있다.

다음으로, 상술된 바와 같은 구조의 리셉터클 측 광학 커넥터(100) 및 플러그 측 광학 커넥터(2)가 결합되는 방법은 도 11 내지 도 15를 참조하여 설명될 것이다. 도 11은 결합 초기 단계인 2개의 커넥터(2, 100)의 부분 확대 수직 단면도이다. 도 12는 결합이 진행하여 상기 가이드 지주가 가이드되는 상태를 도시한 부분 확대 수직 단면도이다. 도 13은 결합이 더 진행하여 상기 다중 코어 패들이 가이드되는 상태를 도시한 부분 확대 수직 단면도이다. 도 14는 상기 다중 코어 패들의 상기 가이드 핀이 가이드되는 상태를 도시한 부분 확대 수직 단면도이다. 도 15는 결합이 완성된 상태의 부분 확대 수직 단면도이다. 상기 도면에서 상기 광섬유 설치 어셈블리(144)의 상기 단면은 도 8과 같은 방식으로 개략적으로 도시된다.

먼저 도 11을 참조하면, 리셉터클 측 광학 커넥터(100)의 결합부(108)는 셔터(24)가 개방하도록 가압하고, 플러그 측 광학 커넥터(2)의 결합 리세스(22)내로 삽입된다. 이 때, 결합부(108)의 말단에서 테이퍼(130)는, 삽입을 용이하게 하기 위하여 결합 리세스(22)의 만곡 가이드면(26a)(도 3 참조)에 의해 가이드된다. 결합부(108)는 결합 리세스(22)에 의해 한정되는 만곡면(26)(도 3 참조)에 의해 결합 리세스(22)로 가이드되어 결합부(108)의 만곡면(112) 및 상부면(110)이 결합 리세스(22)로 미끄러져 들어간다. 상기 방식으로, 결합 리세스(22) 및 결합부(108)는 제1 가이드 메커니즘을 구성한다.

다음으로, 도 12에 도시된 바와 같이, 결합부(108)가 결합 리세스(22) 내에 더 삽입할 때, 서로에 대하여 상기 커넥터들의 위치를 정렬하기 위하여 플러그 측 광학 커넥터(2)의 가이드 지주(60)는 리셉터클 측 광학 커넥터(100)의 가이드 지주 홀(116)에 삽입한다. 가이드 지주(60) 및 가이드 지주 홀(116)은 제2 가이드 메커니즘을 구성한다.

이 후에, 도 13에 도시된 바와 같이, 결합이 더 진행할 때, 다중 코어 패들(50)의 상기 말단은 결합부(108) 내부에 더 삽입한다. 이 때, 결합부(108)에 대하여 다중 코어 패들(50)의 위치를 정렬하기 위하여, 결합부(108)의 전면 개구(128)의 테이퍼(132)는 다중 코어 패들(50)의 상기 말단을 가이드한다. 이 후에, 결합부(108) 전단부의 공동 내의 내면(140a)은 다중 코어 패들(50)을 계속하여 가이드한다. 내면(140a)에 의한 상기 가이드는, 하기의 가이드 핀(122)에 의한 가이드까지 계속될 수 있다. 선택적으로, 내면(140a)에 의한 가이드 없이, 가이드 핀(122)에 의한 가이드는 테이퍼(132)에 의해 가이드된 후 바로 계속될 수 있다. 여기서 중요한 점은 결합부(108)의 내부 형상은 다중 코어 패들(50)의 외부 형상을 가이드 한다는 점이다. 테이퍼(132), 내부면(140a), 다중 코어 패들(50)의 외면(55)은 제3 가이드 메커니즘을 구성한다.

이후에, 도 14에 도시된 바와 같이 결합이 계속 진행할 때, 다중 코어 패들(120)의 가이드 핀(122)은 다중 코어 패들(50)의 가이드 핀 개구(72)에 삽입한다. 다중 코어 패들(50)은 결합부(108) 내에서 이미 상당부분 위치해 있기 때문에, 가이드 핀(122) 및 가이드 핀 개구(72) 사이의 상기 결합은 확고히 수행된다. 상기 방식으로, 가이드핀(122) 및 가이드 핀 개구(72)는 제4 가이드 메커니즘을 구성한다.

최종적으로, 커넥터들(2, 100)이 완전히 결합될 때, 도 15에 도시된 바와 같이 다중 코어 패들(50, 120)의 전면(51, 121)은 서로 접하고, 광섬유(80b, 168b)는 서로 연결된다. 상기 방식으로, 각각의 일단의 광섬유(80b, 168b)는 리셉터클 측 광학 커넥터(100) 및 플러그 측 광학 커넥터(2)의 결합에 의해 간단하게 서로 연결된다. 따라서, 미연결(blind connections)이 상당히 경감될 수 있다.

본 발명의 적절한 실시예는 상기에 기술되었다. 그러나, 본 발명은 상기 실시예에 한정되지 않고, 다양한 변화 및 변형이 가능하다. 예를 들면, 광섬유(80b)의 단부면(81)의 배열은 단일 열에 한정되지 않고, 단부면(81)은 다수의 열로 배열될 수 있다. 부가하여, 단일 열에 제공되는 광섬유(80b)의 갯수는 9개 또는 그 이상일 수 있다. 게다가, 광학 커넥터 어셈블리(1) 내에서 경로를 따라 광섬유(80, 168)를 커버하는 부분은 비전도성 물질일 수가 있다. 그러나, 본 실시예에서와 같이, 전도성 물질이 전자파 장애(EMI; Electro Magnetic Interference)에 대해 방어하도록 사용되는 것이 바람직하다.

상술한 다중 코어 패들(50, 120)은 에폭시(epoxy)와 같은 열경화성 수지, 또는 폴리페닐렌 설파이드(polyphenylene sulfide)와 같은 열가소성 수지로 구조될 수 있고 상업적으로 입수가능하다. 또한, 가이드 핀은 상기 플러그 측 광학 커넥터의 다중 코어 패들(50) 상에 제공될 수 있고, 가이드 핀 개구는 리셉터클 측 광학 커넥터(100)의 상기 다중 코어 패들(120) 내에 제공될 수 있다.

발명의 효과

본 발명에 따른 상기 다중 코어 광학 커넥터 어셈블리는 상기 플러그 하우징을 갖는 상기 플러그 측 광학 커넥터; 상기 리셉터클 하우징을 갖는 상기 리셉터클 측 광학 커넥터를 포함한다. 본 발명에 따른 상기 다중 코어 광학 커넥터 어셈블리는 상기 플러그 하우징의 결합부의 내부 형상 및, 상기 플러그 하우징의 상기 결합부 내로 가이드되고 삽입되는 상기 리셉터클 하우징의 결합부의 외부 형상에 의해 형성되는 상기 제1 가이드 메커니즘; 상기 가이드 지주 및 상기 가이드 지주 홀에 의해 형성되는 상기 제2 가이드 메커니즘; 상기 리셉터클 하우징의 상기 결합부의 상기 내부 형상 및, 상기 리셉터클 하우

장의 상기 결합부로 삽입되는 상기 제1 플러그 측 다중 코어 패들의 상기 외부 형상에 의해 형성되는 상기 제3 가이드 매커니즘; 및 상기 제1 다중 코어 패들 또는 제2 다중 코어 패들의 가이드 핀 및, 상기 제2 다중 코어 패들 또는 제1 다중 코어 패들의 상기 가이드 핀을 수용하기 위한 가이드 핀 개구에 의해 형성되는 제4 가이드 매커니즘을 더 포함한다. 상기 리셉터를 측 광학 커넥터 및 상기 플러그 측 광학 커넥터를 결합하는 동안 상기 제1 가이드 매커니즘, 제2 가이드 매커니즘, 제3 가이드 매커니즘, 제4 가이드 매커니즘을 상기 순서대로 작동한다. 따라서, 다음의 유익한 효과가 획득된다.

즉, 상기 제1 하우징 및 제2 하우징은 상기 제1 가이드 매커니즘에 의해 서로에 대해 위치되고, 따라서 상기 제2 가이드 매커니즘에 의해 삽입/인출 방향으로 더욱 정밀하게 정렬된다. 상기 플러그 측 광학 커넥터의 상기 다중 코어 패들 및 상기 리셉터를 측 광학 커넥터의 상기 결합부의 상기 내면은 상기 제3 가이드 매커니즘에 의해 서로에 대해 정확하게 위치된다. 상기 다중 코어 패들은 상기 제4 가이드 매커니즘에 의해 서로에 대해 정확하게 위치된다. 따라서, 광섬유 케이블은 서로 정확하게 연결될 수 있고, 시각적인 확인 없이 용이하게 상기 광학 커넥터를 서로 결합할 수 있다.

상기 플러그 하우징 및 상기 리셉터를 하우징 중 적어도 하나는 후단부에 설치된 가요성 튜브를 더 포함하고; 상기 튜브의 내경은, 상기 광섬유 케이블이 부착된 상기 다중 코어 패들 및 상기 일단의 광섬유 케이블이 통과할 수 있는 크기인 구조가 채택될 수 있다. 상기의 경우, 상기 다수의 다중 코어 패들 중에서 단지 결합있는 다중 코어 패들만이, 상기 튜브를 통해 분리되어 인출되고 교체될 수 있다.

상기 리셉터를 측 광학 커넥터의 상기 리셉터를 하우징은 상기 다중 코어 패들을 지지하기 위한 지지부재를 더 포함하고; 상기 지지부재는 상기 다중 코어 패들의 후면부를 지지하기 위한 지지부 및 상기 지지부로부터 후방으로 연장하는 암들을 포함하고; 통상 상태에서 상기 리셉터를 하우징과 결합하고 상기 암들의 탄력에 의해 상기 리셉터를 하우징으로부터 분리되는, 결합부가 상기 암들 상에 형성되는 구조가 채택될 수 있다. 이러한 경우, 상기 다중 코어 패들은 교체되는 동안 용이하게 제거될 수 있고, 작업능률이 향상된다.

(37) 청구의 범위

청구항 1.

다중 코어 광학 커넥터 어셈블리에 있어서,

플러그 하우징을 갖는 플러그 측 광학 커넥터;

상기 플러그 하우징과 결합하는 리셉터를 하우징을 갖는 리셉터를 측 광학 커넥터;

- 상기 플러그 하우징은 다수의 제1 다중 코어 패들 및 전방으로 접하는 가이드 지주를 갖고, 상기 리셉터를 하우징은 다수의 제2 다중 코어 패들 및 상기 가이드 지주를 수용하기 위한 가이드 지주 홀을 갖고, 상기 제1 다중 코어 패들 및 제2 다중 코어 패들은 상호 연결되기 위한 광섬유 케이블의 말단을 지지함 -

상기 플러그 하우징의 결합부의 내부 형상 및, 상기 플러그 하우징의 상기 결합부 내로 가이드되고 삽입되는 상기 리셉터를 하우징의 결합부의 외부 형상에 의해 형성되는 제1 가이드 매커니즘;

상기 가이드 지주 및 상기 가이드 지주 홀에 의해 형성되는 제2 가이드 매커니즘;

상기 리셉터를 하우징의 상기 결합부의 상기 내부 형상 및, 상기 리셉터를 하우징의 상기 결합부로 삽입되는 상기 제1 플러그 측 다중 코어 패들의 상기 외부 형상에 의해 형성되는 제3 가이드 매커니즘; 및

상기 제1 다중 코어 패들 또는 제2 다중 코어 패들의 가이드 핀 및, 상기 제2 다중 코어 패들 또는 제1 다중 코어 패들의 상기 가이드 핀을 수용하기 위한 가이드 핀 개구에 의해 형성되는 제4 가이드 매커니즘;을 포함하며,

상기 리셉터를 측 광학 커넥터 및 상기 플러그 측 광학 커넥터를 결합하는 동안 상기 제1 가이드 매커니즘, 제2 가이드 매커니즘, 제3 가이드 매커니즘, 제4 가이드 매커니즘을 상기 순서대로 작동하는 것을 포함하는 다중 코어 광학 커넥터 어셈블리.

청구항 2.

제1항에 있어서,

상기 플러그 하우징 및 상기 리셉터를 하우징 중 적어도 하나는 후단부에 설치된 가요성 튜브를 더 포함하고;

상기 튜브의 내부 치수는, 상기 광섬유 케이블이 부착된 상기 다중 코어 패를 및 상기 일단의 광섬유 케이블이 통과할 수 있는 크기인 것을 특징으로 하는 다중 코어 광학 커넥터 어셈블리.

청구항 3.

제1항에 있어서,

상기 리셉터를 측 광학 커넥터의 상기 리셉터를 하우징은 상기 다중 코어 패를을 지지하기 위한 지지부재를 더 포함하고;

상기 지지부재는 상기 다중 코어 패를의 후면부를 지지하기 위한 지지부 및 상기 지지부로부터 후방으로 연장하는 암들을 포함하고; 및

상기 암들에는 통상 상태에서 상기 리셉터를 하우징과 결합하고 상기 암들의 만곡에 의해 상기 리셉터를 하우징으로부터 분리되는 결합부가 형성되는 것을 특징으로 하는 다중 코어 광학 커넥터 어셈블리.

청구항 4.

제2항에 있어서,

상기 리셉터를 측 광학 커넥터의 상기 리셉터를 하우징은 상기 다중 코어 패를을 지지하기 위한 지지부재를 더 포함하고;

상기 지지부재는 상기 다중 코어 패를이 후면부를 지지하기 위한 지지부 및 상기 지지부로부터 후방으로 연장하는 암들을 포함하고; 및

상기 암들 상에는 통상 상태에서 상기 리셉터를 하우징과 결합하고, 상기 암들의 만곡에 의해 상기 리셉터를 하우징으로부터 분리되는 결합부가 형성되는 것을 특징으로 하는 다중 코어 광학 커넥터 어셈블리.

청구항 5.

제3항에 있어서,

상기 지지부재의 상기 지지부는 평면이고;

상기 암들은 상기 지지부의 양측으로부터 연장하는 한쌍으로 형성되며; 및

상기 결합부는 각각의 상기 암들 상에 형성되는 것을 특징으로 하는 다중 코어 광학 커넥터 어셈블리.

청구항 6.

제4항에 있어서,

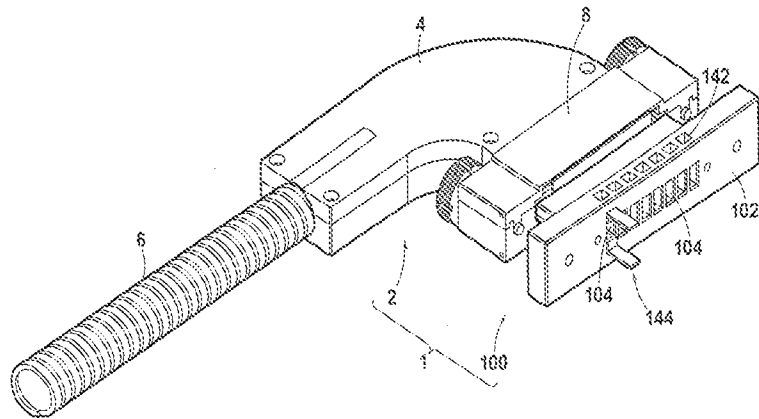
상기 지지부재의 상기 지지부는 평면이고;

상기 압들은 상기 지지부의 양측으로부터 연장하는 한쌍으로 형성되며; 및

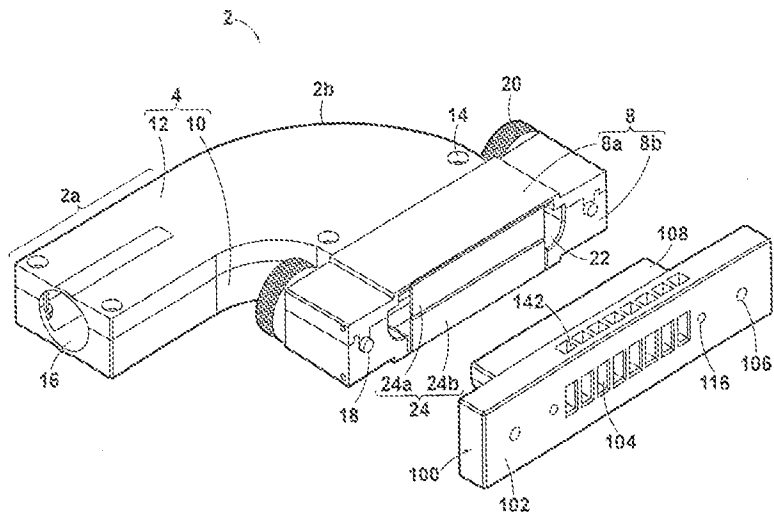
상기 결합부는 각각의 상기 압들 상에 형성되는 것을 특징으로 하는 다중 코어 광학 커넥터 어셈블리.

도면

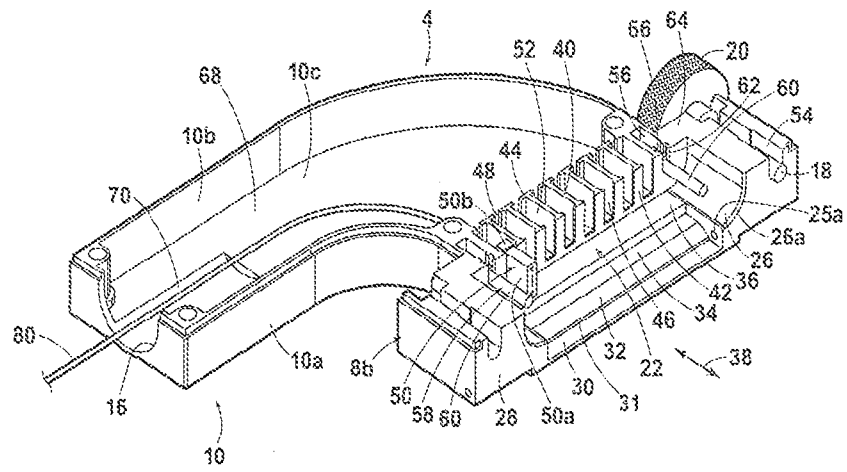
도면1



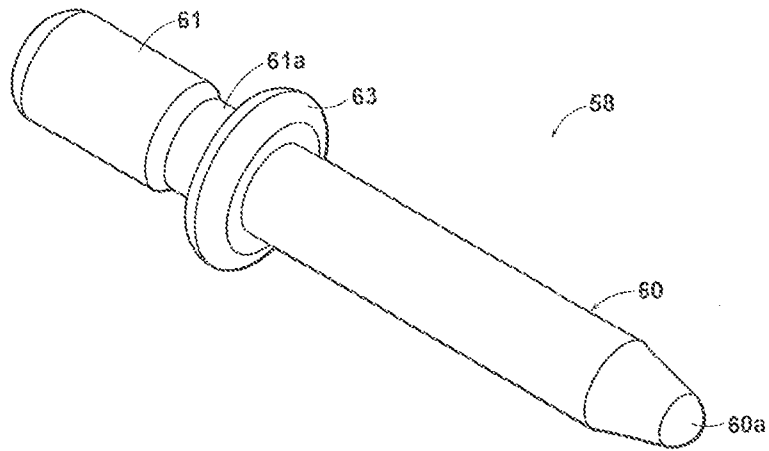
도면2



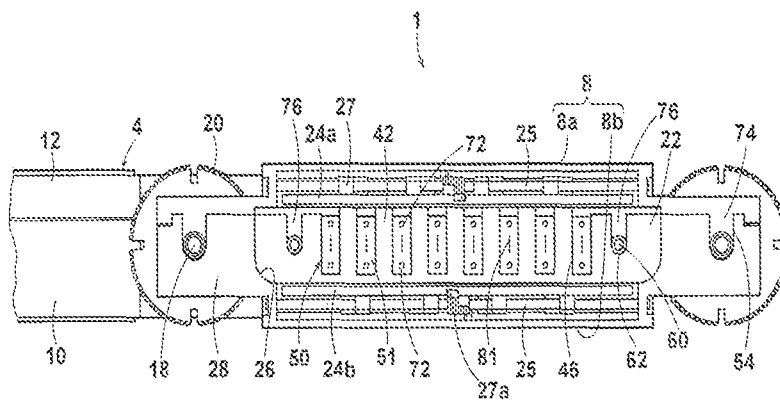
도면3



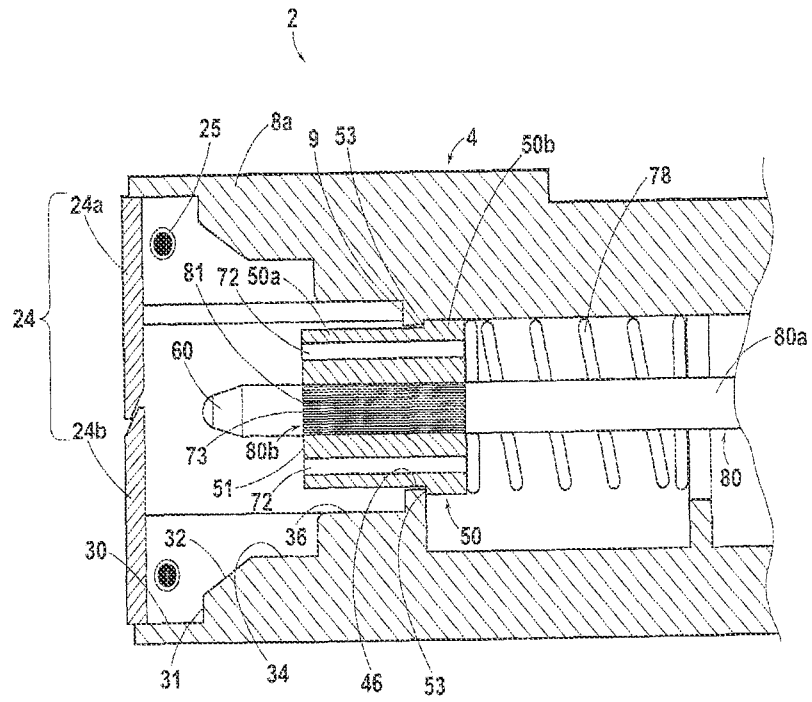
도면4



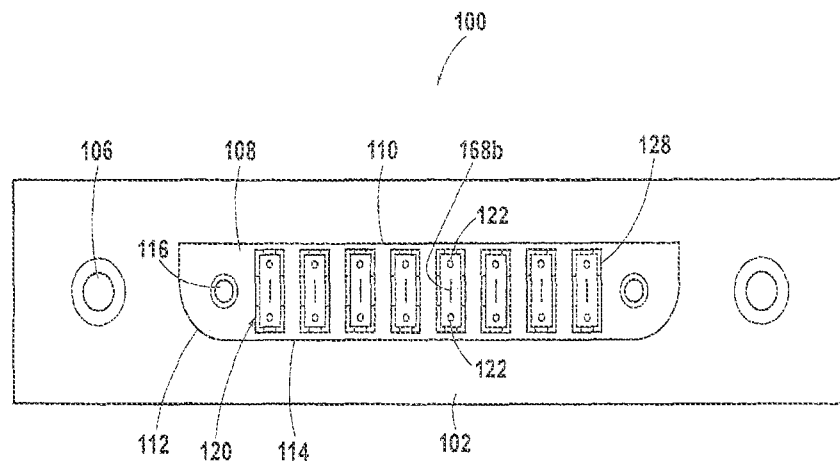
도면5



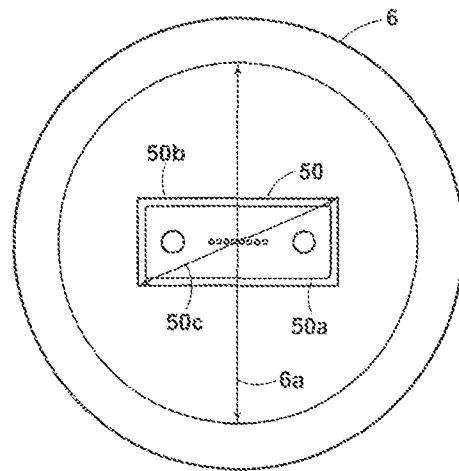
도면6



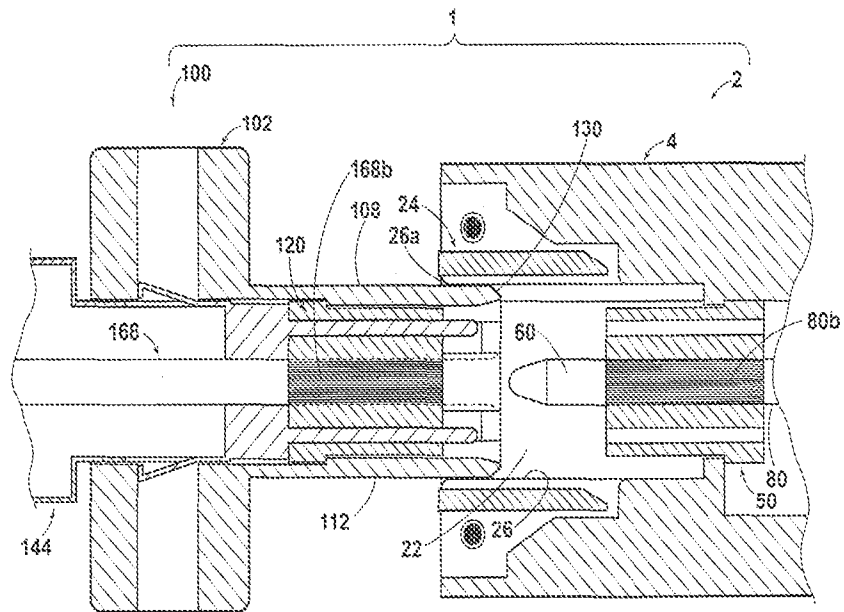
도면7



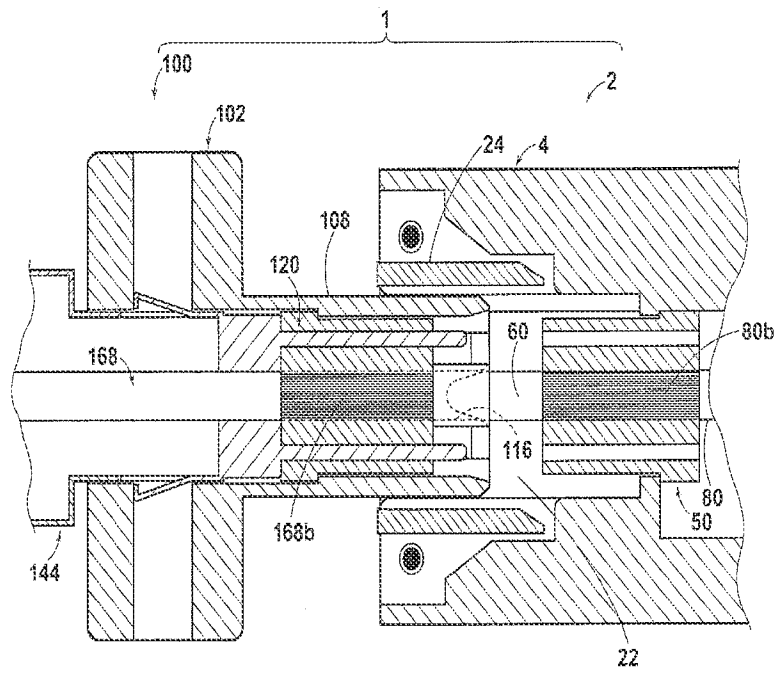
도면10



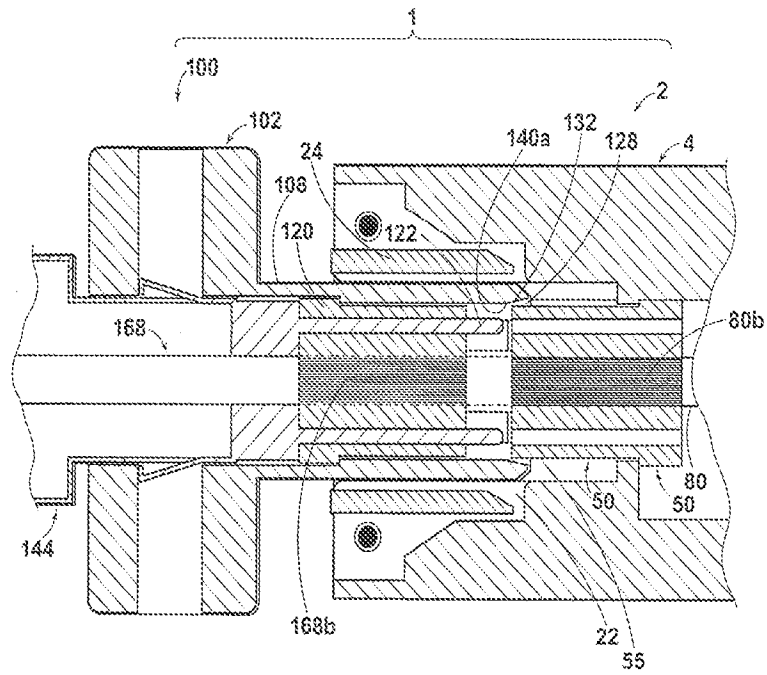
도면11



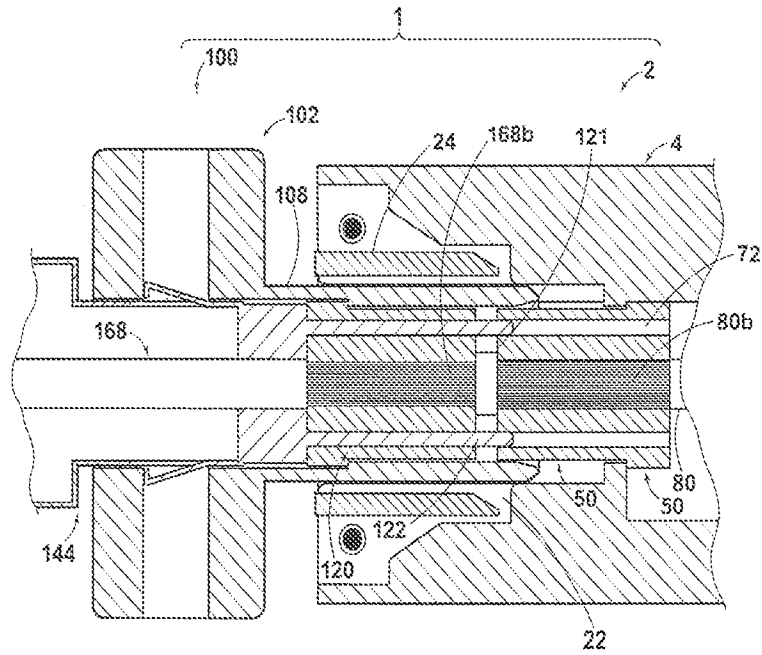
도면 12



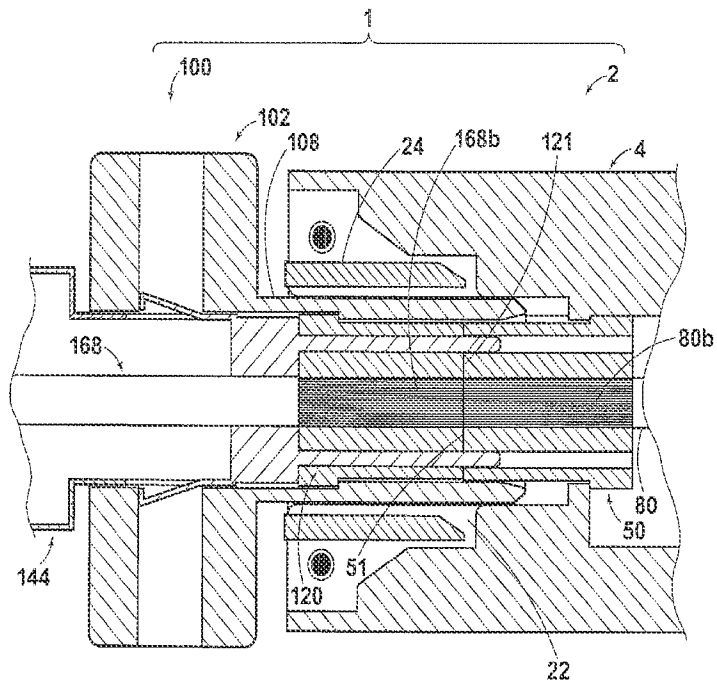
도면 13



도면 14



도면 15



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor : Rudolph Huber Art Unit : 2874
Application No. : 18/387,089 Examiner : Michelle R. Connelly
Filed : November 6, 2023 Conf. No. : 7969
Title : METHOD AND ARRANGEMENT FOR GENERATING A LASER
BEAM HAVING A DIFFERING BEAM PROFILE
CHARACTERISTIC BY A MULTI-CLAD FIBER

MAIL STOP AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT

Please consider the documents listed on the disclosure form submitted with this statement. Copies of the documents are being submitted with this statement to the extent required under 37 C.F.R. § 1.98(a)(2).

As provided by 37 C.F.R. § 1.97(h), this filing is not an admission that any of the submitted information is, or is considered to be, material to patentability as defined in 37 C.F.R. § 1.56(b). Further, the filing of this statement should not be construed to mean that a search has been conducted or that no other material documents or information exists.

This statement is being filed after a first action on the merits, but before the mailing of a final action or a notice of allowance.

Apply any necessary charges or credits applicable under 37 C.F.R. § 1.17(p) to deposit account 06-1050, referencing the above attorney docket number.

Please contact the undersigned if there are any questions regarding this statement.

Respectfully submitted,

Date: 12/18/2024

/Yunbo Guo/

Yunbo Guo, Reg. No. 70,538

Customer Number 26161
Fish & Richardson P.C.
Telephone: +1 (512) 226-8108
Facsimile: (877) 769-7945

63579014.doc

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 15540-0370006	Application No. 18/387,089
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant TRUMPF Laser- und Systemtechnik GmbH	
		Filing Date 11/6/2023	Group Art Unit 2874

U.S. Patent Documents							
Examiner Initial	Cite No.	Document Number	Publication Date	Patentee	Filing Date If Appropriate	Class	Subclass

Foreign Patent Documents or Published Foreign Patent Applications							
Examiner Initial	Cite No.	Document Number	Publication Date	Country or Patent Office	Translation	Class	Subclass
	I.	KR 20060048214 A	5/18/2006	KR	English Abstract		

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Cite No.	Document

Examiner Signature	Date Considered
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form



UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/387,089

RECEIPT DATE / TIME
12/18/2024 11:22:44 AM Z ET

ATTORNEY DOCKET #
15540-0370006

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 7969

FILED BY Matthew O'Brien

PATENT CENTER # 68421060

FILING DATE 11/06/2023

CUSTOMER # 26161

FIRST NAMED
INVENTOR Rudolph Huber

CORRESPONDENCE
ADDRESS -

AUTHORIZED BY Yunbo Guo

Documents

TOTAL DOCUMENTS: 2

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
IDS.pdf	2	Information Disclosure Statement (IDS) Form (SB08)	130 KB
Warning: This is not a USPTO supplied IDS fillable form. Data in the form cannot be automatically loaded to other USPTO systems.			
FOR_KR20060048214A.pdf	18	Foreign Reference	3127 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
IDS.pdf	CA9941AF290B76FCB6D6F72AC7B51BFA26F022F19D6C211D 7C5B51AE08BEE2E051326BA211182AFAD69FA4F0DC8372C6

C55AAA7D3E10A71148D6AF7AB7233BB2

FOR_KR20060048214A.pdf

855C295B61FBEB724A242810C79483F5F1FDFFAF0BC82381B
F2223D31E2DF5987589B26FE79ABBD3960DFC5C4BAAF57A8
D46B6A5393532136F56054889E983BD

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Issue Classification 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

CPC						
Symbol					Type	Version
B23K	/	26	/	064	F	2013-01-01
B23K	/	26	/	073	I	2013-01-01
G02B	/	6	/	03644	I	2013-01-01
G02B	/	6	/	262	I	2013-01-01
G02B	/	6	/	4206	I	2013-01-01
G02B	/	6	/	4296	I	2013-01-01
G02B	/	6	/	02042	I	2013-01-01
G02B	/	6	/	35	I	2013-01-01
G02B	/	6	/	3508	I	2013-01-01
B23K	/	26	/	067	I	2013-01-01
B23K	/	2103	/	06	A	2018-08-01

CPC Combination Sets				
Symbol	Type	Set	Ranking	Version
/				

NONE (Assistant Examiner) _____ (Date) _____		Total Claims Allowed: 20	
/MICHELLE R CONNELLY/ Primary Examiner, Art Unit 2874 (Primary Examiner) _____ (Date) 14 December 2024		O.G. Print Claim(s) 1	O.G. Print Figure 6

Issue Classification 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

INTERNATIONAL CLASSIFICATION					
CLAIMED					
B23K26/064	/	26	/	064	
B23K26/073	/	26	/	073	
G02B6/036	/	6	/	036	
G02B6/26	/	6	/	26	
G02B6/02	/	6	/	02	
B23K26/067	/	26	/	067	
NON-CLAIMED					
	/		/		

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/MICHELLE R CONNELLY/ Primary Examiner, Art Unit 2874	14 December 2024	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	6

Issue Classification 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☒ T.D. ☐ R.1.47															
CLAIMS															
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
-	1	-	10	-	19	1	28	10	37	19	46				
-	2	-	11	-	20	2	29	11	38	20	47				
-	3	-	12	-	21	3	30	12	39						
-	4	-	13	-	22	4	31	13	40						
-	5	-	14	-	23	5	32	14	41						
-	6	-	15	-	24	6	33	15	42						
-	7	-	16	-	25	7	34	16	43						
-	8	-	17	-	26	8	35	17	44						
-	9	-	18	-	27	9	36	18	45						

NONE	Total Claims Allowed:	
(Assistant Examiner)	(Date)	20
/MICHELLE R CONNELLY/ Primary Examiner, Art Unit 2874	14 December 2024	O.G. Print Claim(s)
(Primary Examiner)	(Date)	1
		O.G. Print Figure
		6

<i>Search Notes</i> 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

CPC - Searched*		
Symbol	Date	Examiner
G02B6/3508 OR B23K26/067 OR B23K26/064 OR G02B6/02042 OR G02B6/35 OR B23K26/073 OR G02B6/03644 OR G02B6/262 OR G02B6/4206 OR G02B6/4296	09/07/2024	/MC/

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
G02B6/3508 OR B23K26/067 OR B23K26/064 OR G02B6/02042 OR G02B6/35 OR B23K26/073 OR G02B6/03644 OR G02B6/262 OR G02B6/4206 OR G02B6/4296 limited with text (see attached text search strategy)	09/07/2024	/MC/
Inventor & Assignee search	09/07/2024	/MC/
PE2E SEARCH (see attached text search strategy)	09/07/2024	/MC/
PE2E SEARCH (see attached text search strategy)	12/14/2024	/MC/

/MICHELLE R CONNELLY/ Primary Examiner, Art Unit 2874	
--	--

<i>Search Notes</i> 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
PE2E SEARCH	(see attached text search strategy)	12/14/2024	/MC/

/MICHELLE R CONNELLY/ Primary Examiner, Art Unit 2874	
--	--

<i>Index of Claims</i> 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☒ T.D. ☐ R.1.47										
CLAIM		DATE								
Final	Original	09/07/2024	12/14/2024							
	1	-	-							
	2	-	-							
	3	-	-							
	4	-	-							
	5	-	-							
	6	-	-							
	7	-	-							
	8	-	-							
	9	-	-							
	10	-	-							
	11	-	-							
	12	-	-							
	13	-	-							
	14	-	-							
	15	-	-							
	16	-	-							
	17	-	-							
	18	-	-							
	19	-	-							
	20	-	-							
	21	-	-							
	22	-	-							
	23	-	-							
	24	-	-							
	25	-	-							
	26	-	-							
	27	-	-							
1	28	✓	=							
2	29	✓	=							
3	30	✓	=							
4	31	✓	=							
5	32	✓	=							
6	33	✓	=							
7	34	O	=							
8	35	O	=							
9	36	✓	=							
10	37	O	=							
11	38	✓	=							
12	39	✓	=							
13	40	✓	=							
14	41	✓	=							
15	42	✓	=							

<i>Index of Claims</i> 	Application/Control No. 18/387,089	Applicant(s)/Patent Under Reexamination Huber et al.
	Examiner MICHELLE R CONNELLY	Art Unit 2874

CLAIM		DATE								
Final	Original	09/07/2024	12/14/2024							
16	43	✓	=							
17	44	○	=							
18	45	○	=							
19	46	✓	=							
20	47	○	=							

Bibliographic Data

Application No: 18/387,089

Foreign Priority claimed: ☒ Yes ☐ No

35 USC 119 (a-d) conditions met: ☒ Yes ☐ No ☐ Met After Allowance

Verified and Acknowledged:

/MICHELLE R CONNELLY/

Examiner's Signature

Initials

Title:

METHOD AND ARRANGEMENT FOR GENERATING A LASER
BEAM HAVING A DIFFERING BEAM PROFILE
CHARACTERISTIC BY A MULTI-CLAD FIBER

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/06/2023	385	2874	
RULE			

APPLICANTS

TRUMPF Laser- und Systemtechnik GmbH,

INVENTORS

Rudolph Huber, Aldingen-Aixheim, GERMANY

Wolfgang Andreasch, Weinstadt, GERMANY

Martin Huonker, Dietingen, GERMANY

CONTINUING DATA

This application is a CON of 17552455 12/16/2021 PAT 11806804

17552455 is a DIV of 16398362 04/30/2019 PAT 11215761

16398362 is a CON of 15279781 09/29/2016 PAT 10281656

15279781 is a CON of 14300138 06/09/2014 PAT 9482821

14300138 is a CON of 13639401 12/20/2012 PAT 8781269

13639401 is a 371 of PCT/EP2011/055484 04/08/2011

FOREIGN APPLICATIONS

GERMANY DE102010003750.8 04/08/2010

IF REQUIRED, FOREIGN LICENSE GRANTED**

11/24/2023

STATE OR COUNTRY

GERMANY

ADDRESS

FILING FEE RECEIVED

\$1,980

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	1	16/398,362	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 03:40 PM
L2	8	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and laser and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:17 PM
L3	0	("2020/0310055").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L4	3	("2019/0258009").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L5	0	("2017/0031105").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L6	24	("2015/0293306").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L7	46	("2013/0223792").URP N.	(USPAT)	OR	ON	ON	2021/04/15 05:18 PM
L8	37	("20020071647" "20020168139" "20020172485" "20050031261" "20060251367" "20060263024" "20110305249" "20130064706" "20150217402" "20150378184"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/04/15 05:19 PM

L9	43	"3941670" "3975082" "4475788" "4575181" "5461692" "5475704" "5684642" "6819815" "7372877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902" "7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269" "9482821").PN. OR ("10281656").URPN. ("20020071647" "20020168139" "20020172485" "20050031261" "20060251367" "20060263024" "20130064706" "3941670" "3975082" "4475788" "4575181" "5461682" "5461692" "5684642" "7372877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902" "7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269").PN. OR ("9482821").URPN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/04/15 05:19 PM
L10	55	("20020071647" "20020168139" "20020172485" "20060251367" "20060263024" "3941670" "4475788" "4575181" "5684642" "7372877" "7379237" "7379648" "7720340" "7738166" "7809225" "7839902" "7933479" "8076632" "8094370" "8456523").PN. OR ("8781269").URPN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/04/15 05:19 PM
L11	92	(L3 or L4 or L5 or L6 or L7 or L8 or L9 or L10)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/04/15 05:19 PM
L12	9	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:20 PM

L13	186	G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:20 PM
L14	5	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:22 PM
L15	1	L12 not L2	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:22 PM
L16	5	((laser adj beam) and coupl\$3 and fiber and	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	ON	2021/04/15 05:24 PM

		(multiclad or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam) and divid\$3).clm.	JPO; DERWENT; IBM_TDB)				
L17	4	((laser adj beam) and coupl\$3 and fiber and (multiclad or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam) and divid\$3 and different).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/15 05:27 PM
L18	59	"8781269"	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/19 10:58 AM
L19	1	("8781269").PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2021/04/19 10:59 AM
L20	79	((("HUBER") near3 ("Rudolph")) OR (("ANDREASCH") near3 ("Wolfgang")) OR (("HUONKER") near3 ("Martin"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2021/04/19 11:01 AM
L21	54	((("TRUMPF") near3 ("LASER-") near3 ("UND") near3 ("SYSTEMTECHNIK") near3 ("GMBH"))).AS,AANM.	(USPAT)	OR	ON	ON	2021/04/19 11:01 AM
L22	7	(L20 or L21) and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclad or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/04/19 11:01 AM
L23	3	("2019/0258009").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:58 PM
L24	1	16/398,362	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:58 PM
L25	9	(G02B6/3508 or B23K26/067 or	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	ON	2021/08/28 07:58 PM

		B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and laser and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam)	JPO; DERWENT; IBM_TDB)				
L26	0	("2020/0310055").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:58 PM
L27	3	("2019/0258009").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L28	0	("2017/0031105").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L29	24	("2015/0293306").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L30	47	("2013/0223792").URP N.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L31	37	("20020071647" "20020168139" "20020172485" "20050031261" "20060251367" "20060263024" "20110305249" "20130064706" "20150217402" "20150378184" "3941670" "3975082" "4475788" "4575181" "5461692" "5475704" "5684642" "6819815" "7372877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902" "7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/08/28 07:59 PM

L32	43	"9482821").PN. OR ("10281656").URPN. ("20020071647" "20020168139" "20020172485" "20050031261" "20060251367" "20060263024" "20130064706" "3941670" "3975082" "4475788" "4575181" "5461682" "5461692" "5684642" "7372877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902" "7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269").PN. OR ("9482821").URPN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/08/28 07:59 PM
L33	55	("20020071647" "20020168139" "20020172485" "20060251367" "20060263024" "3941670" "4475788" "4575181" "5684642" "7372877" "7379237" "7379648" "7720340" "7738166" "7809225" "7839902" "7933479" "8076632" "8094370" "8456523").PN. OR ("8781269").URPN.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/08/28 07:59 PM
L34	93	(L26 or L23 or L28 or L29 or L30 or L31 or L32 or L33)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2021/08/28 07:59 PM
L35	10	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre- optic\$3 or fiberoptic\$3 or fiber-optic\$3) same	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM

L36	199	(multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam) (G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L37	5	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam)).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L38	1	L35 not L25	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L39	5	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam) and divid\$3).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L40	4	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM

L41	62	near2 core) and (subbeam or sub-beam) and divid\$3 and different).clm. "8781269"	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L42	1	("8781269").PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2021/08/28 07:59 PM
L43	80	((("HUBER") near3 ("Rudolph")) OR ((("ANDREASCH") near3 ("Wolfgang"))) OR ((("HUONKER") near3 ("Martin"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2021/08/28 07:59 PM
L44	58	((("TRUMPF") near3 ("LASER-") near3 ("UND") near3 ("SYSTEMTECHNIK") near3 ("GMBH"))).AS,AANM.	(USPAT)	OR	ON	ON	2021/08/28 07:59 PM
L45	7	(L43 or L44) and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 07:59 PM
L46	18	(L23 or L24 or L25 or L26 or L27 or L28 or L29 or L30 or L31 or L32 or L33 or L34 or L35 or L36 or L37 or L38 or L39 or L40 or L41 or L42 or L43 or L44 or L45) and @pd>"20210419"	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/08/28 08:05 PM
L54	7	((("10795090") or ("10197741") or ("9778422") or ("9354402") or ("8992095") or ("8845205") or ("8382382")).PN.	(US-PGPUB; USPAT; USOCR)	OR	OFF	OFF	2021/08/29 09:36 PM
L55	1	((US-20190258009-A1).did. AND PGPB.dbnm.)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY,	OR	ON	ON	2022/09/19 11:41 AM

			CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L56	3	("2019/0258009").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:42 AM
L57	30	(michelle near2 connelly).xp. AND (beam near2 profile)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:43 AM
L58	21	("5012069" "5449881" "5684642" "8399803" "9620925" "10310201" "10807190" "20020198622" "20060219673" "20070170157" "20090211700" "20110127697" "20110240617" "20130073071" "20130148925" "20130223792" "20140010508" "20150372444" "20180147661" "20190118299").pn. OR ("11022747").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:44 AM
L59	67	("2013/0148925").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:46 AM
L60	3	("2019/0258009").urpn. AND (PGPB USPT USOC).dbnm.L56	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/09/19 11:58 AM
L61	45	("10281656" OR "11215761" OR "20020071647" OR "20020168139" OR "20020172485" OR "20050031261" OR "20060219673" OR "20060251367" OR "20060263024" OR "20110305249" OR	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/19 12:07 PM

		"20130064706" OR "20130223792" OR "20150217402" OR "20150293306" OR "20150378184" OR "20170031105" OR "20190025502" OR "20190118299" OR "20190258009" OR "3941670" OR "3975082" OR "4475788" OR "4575181" OR "5461692" OR "5475704" OR "5684642" OR "6819815" OR "7372877" OR "7379237" OR "7379648" OR "7592568" OR "7720340" OR "7738166" OR "7809225" OR "7839902" OR "7933479" OR "8008600" OR "8076632" OR "8094370" OR "8326099" OR "8456523" OR "8781269" OR "8861910" OR "9482821" OR "9755739").pn.					
L62	45	("10281656" OR "11215761" OR "20020071647" OR "20020168139" OR "20020172485" OR "20050031261" OR "20060219673" OR "20060251367" OR "20060263024" OR "20110305249" OR "20130064706" OR "20130223792" OR "20150217402" OR "20150293306" OR "20150378184" OR "20170031105" OR "20190025502" OR "20190118299" OR "20190258009" OR "3941670" OR "3975082" OR "4475788" OR	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/19 03:32 PM

		"4575181" OR "5461692" OR "5475704" OR "5684642" OR "6819815" OR "7372877" OR "7379237" OR "7379648" OR "7592568" OR "7720340" OR "7738166" OR "7809225" OR "7839902" OR "7933479" OR "8008600" OR "8076632" OR "8094370" OR "8326099" OR "8456523" OR "8781269" OR "8861910" OR "9482821" OR "9755739").pn.					
L63	23	((US-20190258009-A1 OR US-20190118299- A1 OR US- 20180147661-A1 OR US-20150372444-A1 OR US-20130223792- A1 OR US- 20130148925-A1 OR US-20060219673-A1 OR US-20190025502- A1 OR US- 20170031105-A1 OR US-20150293306-A1 OR US-20150217402- A1).did. AND PGPB.dbnm.) OR ((US- 10916911-B2 OR US- 11215761-B2 OR US- 11022747-B2 OR US- 10807190-B2 OR US- 9620925-B2 OR US- 11435538-B2 OR US- 10281656-B2 OR US- 9755739-B1 OR US- 9482821-B2 OR US- 8781269-B2 OR US- 7592568-B2 OR US- 5461692-A).did. AND USPT.dbnm.)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/09/19 08:36 PM
L65	1	("20060219673").pn.	(US-PGPUB)	OR	ON	ON	2022/09/19 09:36 PM
L66	109	(L23 OR L24 OR L25 OR L26 OR L27 OR L28 OR L29 OR L30	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2022/09/20 11:52 AM

L67	3	OR L31 OR L32 OR L33 OR L34 OR L35 OR L36 OR L37 OR L38 OR L39 OR L40 OR L41 OR L42 OR L43 OR L44 OR L45) AND @pd>"20210415" "20060219673"	IBM_TDB) (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/01/14 11:38 AM
L68	287	(mov\$3 near3 laser) SAME (mov\$3 near3 fib\$3) SAME ((rotat\$3 OR mov\$3) near3 (lens OR mirror OR microlens OR micromirror OR micro-lens OR micro-mirror OR optics))	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/01/14 11:59 AM
L69	10	(mov\$3 near3 laser) SAME (mov\$3 near3 fib\$3) SAME ((rotat\$3 OR mov\$3) near3 (lens OR mirror OR microlens OR micromirror OR micro-lens OR micro-mirror OR optics)) SAME (angl\$3 near3 inciden\$4)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/01/14 12:00 PM
L70	38	(L2 OR L11) AND	(US-PGPUB; USPAT;	OR	ON	ON	2023/06/26

		@pd>"20210415"	USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				07:55 AM
L71	196	(L12 OR L13 OR L14 OR L16 OR L17 OR L22) AND @pd>"20210415"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 07:58 AM
L72	1114	((("HUBER") near3 ("Rudolph")) OR (("ANDREASCH") near3 ("Wolfgang")) OR (("HUONKER") near3 ("Martin"))).INV.) OR (((("TRUMPF") near3 ("LASER-") near3 ("UND") near3 ("SYSTEMTECHNIK") near3 ("GMBH"))).AS,AANM.)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 08:01 AM
L73	14	L25 AND @pd>"20210828"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO,	OR	ON	ON	2023/06/26 08:01 AM

L74	92613	(G02B6/3508 OR B23K26/067 OR B23K26/064 OR G02B6/02042 OR G02B6/35 OR B23K26/073 OR G02B6/03644 OR G02B6/262 OR G02B6/4206 OR G02B6/4296).cpc.	NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB) (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 08:02 AM
L75	11	L72 AND (((laser OR light OR optic\$3 OR photonic) near3 ((beam OR spot) near2 profile))) AND (((optic\$3 near2 fib\$3) OR opticalfib\$3 OR optical-fib\$3 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$3 OR fibre-optic\$3 OR fiberoptic\$3 OR fiber-optic\$3) SAME (multi-clad OR multiclad OR multicore OR multi-core OR (multiple ADJ core) OR (plural\$3 near2 core))) AND (divid\$3 WITH (light OR beam OR input)) AND (subbeam OR sub-beam))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 08:04 AM
L76	32	L74 AND (((laser OR light OR optic\$3 OR photonic) near3 ((beam OR spot) near2 profile))) AND (((optic\$3 near2 fib\$3) OR opticalfib\$3 OR optical-fib\$3 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$3 OR fibre-optic\$3 OR fiberoptic\$3 OR fiber-optic\$3) SAME (multi-clad OR multiclad OR multicore OR multi-	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO;	OR	ON	ON	2023/06/26 08:05 AM

L77	396	core OR (multiple ADJ core) OR (plural\$3 near2 core))) AND (divid\$3 WITH (light OR beam OR input)) AND (subbeam OR sub-beam)) L46 AND @pd>"20210828"	JPO; DERWENT; IBM_TDB) (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/06/26 08:07 AM
L78	5	("11806804" "11215761" "10281656" "9482821" "8781269").pn.	(USPAT)	OR	ON	ON	2024/09/07 12:21 PM
L79	1	("20060219673").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2024/09/07 12:36 PM
L80	52	("2006/0219673").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/07 12:37 PM
L81	6	("2013180295").pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 12:42 PM
L82	40	(Artificial Intelligence) More like doc: <u>JP-2013180295-A</u> Text: (JP-2013176800-A OR WO-2013133128-A1 OR TW-201825217-A OR JP-2020513325-A	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV,	OR	ON	ON	2024/09/07 12:43 PM

		OR US-11022747-B2 OR EP-3551372-A1 OR US-20190383998-A1 OR WO-2010123068- A1 OR JP-6887502-B2 OR TW-I758365-B OR JP-WO2010123068-A1 OR EP-3551372-B1 OR KR-102636850-B1 OR KR-20190093622-A OR CN-110087817-A OR CN-110087817-B OR JP-2018043256-A OR JP-5639046-B2 OR JP- 2018043257-A OR WO- 2012063348-A1).did.	MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L83	34	((US-20190258009-A1 OR US-20190118299- A1 OR US- 20180147661-A1 OR US-20150372444-A1 OR US-20130223792- A1 OR US- 20130148925-A1 OR US-20060219673-A1 OR US-20190025502- A1 OR US- 20170031105-A1 OR US-20150293306-A1 OR US-20150217402- A1 OR US- 20220179153-A1 OR US-20200310055-A1 OR US-20190383998- A1).did. AND PGPB.dbnm.) OR ((US- 10916911-B2 OR US- 11215761-B2 OR US- 11022747-B2 OR US- 10807190-B2 OR US- 9620925-B2 OR US- 11435538-B2 OR US- 10281656-B2 OR US- 9755739-B1 OR US- 9482821-B2 OR US- 8781269-B2 OR US- 7592568-B2 OR US- 5461692-A OR US- 11351633-B2).did. AND USPT.dbnm.) OR ((JP- 3645013-B2 OR CN- 113568089-B OR KR- 102498030-B1 OR KR- 102636850-B1 OR EP- 3551372-B1).did. AND FTDB.dbnm.) OR ((DE- 102010003750-A1).did.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 12:45 PM

L84	52	AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.) ("2006/0219673").urpn. AND (PGPB USPT USOC).dbnm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/07 12:47 PM
L85	97	(outer near2 core) AND connelly.xp.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/07 12:51 PM
L86	34	((US-20190258009-A1 OR US-20190118299-A1 OR US-20180147661-A1 OR US-20150372444-A1 OR US-20130223792-A1 OR US-20130148925-A1 OR US-20060219673-A1 OR US-20190025502-A1 OR US-20170031105-A1 OR US-20150293306-A1 OR US-20150217402-A1 OR US-20220179153-A1 OR US-20200310055-A1 OR US-20190383998-A1).did. AND PGPB.dbnm.) OR ((US-10916911-B2 OR US-11215761-B2 OR US-11022747-B2 OR US-10807190-B2 OR US-9620925-B2 OR US-11435538-B2 OR US-10281656-B2 OR US-9755739-B1 OR US-9482821-B2 OR US-8781269-B2 OR US-7592568-B2 OR US-5461692-A OR US-11351633-B2).did. AND USPT.dbnm.) OR ((JP-3645013-B2 OR CN-113568089-B OR KR-102498030-B1 OR KR-102636850-B1 OR EP-3551372-B1).did. AND FTDB.dbnm.) OR ((DE-102010003750-A1).did. AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 12:56 PM
L87	61	("3777150" "4467168" "5028118" "5220149"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/07 12:57 PM

L88	14	"5231464" "5237150" "5469292" "5570384" "5609781" "5684617" "5747771" "5877890" "5956447" "6018533" "6118097" "6288363" "6288835" "6376797" "6423928" "6487340" "6614975" "6687046" "7215858" "7259907" "20020080832" "20020088784" "20020153360" "20020181512" "20040104202").pn. OR ("7592568").urpn. AND (PGPB USPT USOC).dbnm. ("3833992").pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 12:59 PM
L89	14	("1580865").pn.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 01:01 PM
L90	2	("3941670" "3975082").pn.	(USPAT)	OR	ON	ON	2024/09/07 01:01 PM
L91	11	("4200587").pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2024/09/07 01:02 PM

L92	8	("2009155536").pn.	CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 01:03 PM
L93	35	((US-20190258009-A1 OR US-20190118299-A1 OR US-20180147661-A1 OR US-20150372444-A1 OR US-20130223792-A1 OR US-20130148925-A1 OR US-20060219673-A1 OR US-20190025502-A1 OR US-20170031105-A1 OR US-20150293306-A1 OR US-20150217402-A1 OR US-20220179153-A1 OR US-20200310055-A1 OR US-20190383998-A1).did. AND PGPB.dbnm.) OR ((US-10916911-B2 OR US-11215761-B2 OR US-11022747-B2 OR US-10807190-B2 OR US-9620925-B2 OR US-11435538-B2 OR US-10281656-B2 OR US-9755739-B1 OR US-9482821-B2 OR US-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 01:04 PM

L94	40	8781269-B2 OR US-7592568-B2 OR US-5461692-A OR US-11351633-B2).did. AND USPT.dbnm.) OR ((JP-3645013-B2 OR CN-113568089-B OR KR-102498030-B1 OR KR-102636850-B1 OR EP-3551372-B1).did. AND FTDB.dbnm.) OR ((DE-102010003750-A1).did. AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.) OR ((DE-3833992-C2).did. AND FPRS.dbnm.) (Artificial Intelligence) More like doc: JP-2013180295-A Text: (JP-2013176800-A OR WO-2013133128-A1 OR TW-201825217-A OR JP-2020513325-A OR US-11022747-B2 OR EP-3551372-A1 OR US-20190383998-A1 OR WO-2010123068-A1 OR JP-6887502-B2 OR TW-I758365-B OR JP-WO2010123068-A1 OR EP-3551372-B1 OR KR-102636850-B1 OR KR-20190093622-A OR CN-110087817-A OR CN-110087817-B OR JP-2018043256-A OR JP-5639046-B2 OR JP-2018043257-A OR WO-2012063348-A1).did.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 01:04 PM
L95	3856	((optic\$3 near2 fib\$3) WITH ((ring OR outer near2 core)) SAME ((radius OR diameter) WITH (microns OR micrometers OR µm))	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2024/09/07 01:39 PM

L96	475	((optic\$3 near2 fib\$3) WITH ((ring OR outer) near2 core)) SAME ((radius OR diameter) WITH (microns OR micrometers OR µm))	IBM_TDB) (USPAT)	OR	ON	ON	2024/09/07 01:40 PM
L97	223	((optic\$3 near2 fib\$3) WITH ((ring OR outer) near2 core)) SAME ((radius OR diameter) WITH (microns OR micrometers OR µm)) AND @pd<"20110101"	(USPAT)	OR	ON	ON	2024/09/07 01:40 PM
L98	55	"4200587"	(USPAT)	OR	ON	ON	2024/09/07 03:22 PM
L99	11	("4200587").pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:22 PM
L100	36	((US-20190258009-A1 OR US-20190118299-A1 OR US-20180147661-A1 OR US-20150372444-A1 OR US-20130223792-A1 OR US-20130148925-A1 OR US-20060219673-A1 OR US-20190025502-A1 OR US-20170031105-A1 OR US-20150293306-A1 OR US-20150217402-A1 OR US-20220179153-A1 OR US-20200310055-A1 OR US-20190383998-A1).did. AND PGPB.dbnm.) OR ((US-10916911-B2 OR US-11215761-B2 OR US-11022747-B2 OR US-10807190-B2 OR US-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:25 PM

L101	258	9620925-B2 OR US-11435538-B2 OR US-10281656-B2 OR US-9755739-B1 OR US-9482821-B2 OR US-8781269-B2 OR US-7592568-B2 OR US-5461692-A OR US-11351633-B2 OR US-7773845-B2).did. AND USPT.dbnm.) OR ((JP-3645013-B2 OR CN-113568089-B OR KR-102498030-B1 OR KR-102636850-B1 OR EP-3551372-B1).did. AND FTDB.dbnm.) OR ((DE-102010003750-A1).did. AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.) OR ((DE-3833992-C2).did. AND FPRS.dbnm.) (L70 OR L71 OR L72 OR L73) AND @pd>"20230626"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:29 PM
L102	271	(L75 OR L76 OR L77) AND @pd>"20230626"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:32 PM
L103	82	laser AND ((optic\$2	(US-PGPUB; USPAT;	OR	ON	ON	2024/09/07

		near2 fib\$2) OR opticalfib\$2 OR optical-fib\$2 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$2 OR fiberoptic\$2 OR fibre-optic\$2 OR fiber-optic\$2) SAME ((inner OR inside OR first OR primary OR center OR central OR centre) near2 core) AND ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 core) AND ((inner OR inside OR first OR primary OR center OR central OR centre) near2 clad\$4) AND ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 clad) AND ((coupl\$3 WITH (first near2 (beam OR ray OR light OR input OR wavelength))) WITH ((inner OR inside OR first OR primary OR center OR central OR centre) near2 core)) AND ((coupl\$3 WITH (second near2 (beam OR ray OR light OR input OR wavelength))) WITH ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 core))	USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)				03:38 PM
L106	16	((("3940670" "3975082" "4475788" "4575181" "5461692" "5475704" "5684642" "6819815" "7373877" "7379237" "7379648" "7592568" "7720340" "7738166" "7809225" "7839902").pn.)	(USPAT)	OR	ON	ON	2024/09/07 03:44 PM
L107	10	("7933479" "8008600" "8076632" "8094370" "8326099" "8456523" "8781269" "8861910" "9482821" "9755739").pn.	(USPAT)	OR	ON	ON	2024/09/07 03:45 PM
L109	21	((("10281656"	(US-PGPUB; USPAT)	OR	ON	ON	2024/09/07

		"11215761" "11806804" "20020071647" "20020168139" "20020172485" "20050031261" "20060219673" "20060251367" "20060263024" "20110305249" "20130064706" "20130223792" "20150217402" "20150293306" "20150378184" "20170031105" "20190025502" "20190118299" "20190258009" "20220179153").pn.)					03:47 PM
L110	81	("3833993" "4200587" "0362466" "2284892" "2499689" "100750511" "2009155536" "2010009101").pn.	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2024/09/07 03:49 PM
L111	38	((US-20190258009-A1 OR US-20190118299- A1 OR US- 20180147661-A1 OR US-20150372444-A1 OR US-20130223792- A1 OR US- 20130148925-A1 OR US-20060219673-A1 OR US-20190025502- A1 OR US- 20170031105-A1 OR US-20150293306-A1 OR US-20150217402- A1 OR US- 20220179153-A1 OR US-20200310055-A1 OR US-20190383998- A1).did. AND PGPB.dbnm.) OR ((US- 10916911-B2 OR US- 11215761-B2 OR US- 11022747-B2 OR US- 10807190-B2 OR US-	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:53 PM

		9620925-B2 OR US-11435538-B2 OR US-10281656-B2 OR US-9755739-B1 OR US-9482821-B2 OR US-8781269-B2 OR US-7592568-B2 OR US-5461692-A OR US-11351633-B2 OR US-7773845-B2).did. AND USPT.dbnm.) OR ((JP-3645013-B2 OR CN-113568089-B OR KR-102498030-B1 OR KR-102636850-B1 OR EP-3551372-B1).did. AND FTDB.dbnm.) OR ((DE-102010003750-A1 OR DE-4200587-C1).did. AND DWPI.dbnm.) OR ((JP-2013180295-A).did. AND JPAB.dbnm.) OR ((DE-3833992-C2 OR DE-3833993-A1).did. AND FPRS.dbnm.)					
L112	7	L111 AND @pd<"20100408"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/09/07 03:54 PM
L113	0	L83 AND @pd>"20240906"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2024/12/14 03:07 PM

L114	2	(L84 OR L85 OR L86) AND @pd>"20240906"	IBM_TDB) (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/12/14 03:08 PM
L115	37	(L93 OR L95 OR L96 OR L97 OR L98) AND @pd>"20240906"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/12/14 03:08 PM
L116	49	(L99 OR L100 OR L101 OR L102) AND @pd>"20240906"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/12/14 03:10 PM
L117	1	(L103) AND @pd>"20240906"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS,	OR	ON	ON	2024/12/14 03:11 PM

L118	2	("10281656" "10281565").pn.	IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB) (USPAT)	OR	ON	ON	2024/12/14 03:17 PM
------	---	--------------------------------	---	----	----	----	------------------------

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N47	9	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and laser and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical- fib\$3 or opticfib\$3 or optic-fib\$3 or fiberoptic\$3 or fibre- optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi- core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub- beam)	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:05 PM
N48	10	(G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:05 PM

N49	194	or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input)) and (subbeam or sub-beam) (G02B6/3508 or B23K26/067 or B23K26/064 or G02B6/02042 or G02B6/35 or B23K26/073 or G02B6/03644 or G02B6/262 or G02B6/4206 or G02B6/4296).cpc. and (((optic\$3 near2 fib\$3) or opticalfib\$3 or optical-fib\$3 or opticfib\$3 or optic-fib\$3 or fibreoptic\$3 or fibre-optic\$3 or fiberoptic\$3 or fiber-optic\$3) same (multi-clad or multiclاد or multicore or multi-core or (multiple adj core) or (plural\$3 near2 core))) and (divid\$3 with (light or beam or input))	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:05 PM
N50	5	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:06 PM
N51	5	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and (subbeam or sub-beam) and divid\$3).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:06 PM
N52	4	((laser adj beam) and coupl\$3 and fiber and (multiclاد or multi-clad) and (inner near2 core) and ((outer or ring) near2 core) and	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:06 PM

N53	194	(subbeam or sub-beam) and divid\$3 and different).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2021/08/28 08:08 PM
N54	29	(N48 OR N48 OR N49 OR N50 OR N51 OR N52) AND @pd>"20210415"	(US-PGPUB; USPAT)	OR	ON	ON	2022/09/20 11:50 AM
N55	11	((G02B6/3508 OR B23K26/067 OR B23K26/064 OR G02B6/02042 OR G02B6/35 OR B23K26/073 OR G02B6/03644 OR G02B6/262 OR G02B6/4206 OR G02B6/4296).cpc.) AND (((laser OR light OR optic\$3 OR photonic) near3 ((beam OR spot) near2 profile))) AND (((optic\$3 near2 fib\$3) OR opticalfib\$3 OR optical-fib\$3 OR opticfib\$3 OR fibreoptic\$3 OR fibre-optic\$3 OR fiberoptic\$3 OR fiber-optic\$3) SAME (multi-clad OR multiclاد OR multicore OR multi-core OR (multiple ADJ core) OR (plural\$3 near2 core))) AND (divid\$3 WITH (light OR beam OR input)) AND (subbeam OR sub-beam))	(US-PGPUB; USPAT)	OR	ON	ON	2023/06/26 08:05 AM
N56	14	(((((laser OR light OR optic\$3 OR photonic) near3 ((beam OR spot) near2 profile))) AND (((optic\$3 near2 fib\$3) OR opticalfib\$3 OR optical-fib\$3 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$3 OR fibre-optic\$3 OR fiberoptic\$3 OR fiber-optic\$3) SAME (multi-clad OR multiclاد OR multicore OR multi-core OR (multiple ADJ core) OR (plural\$3 near2	(US-PGPUB; USPAT)	OR	ON	ON	2023/06/26 08:06 AM

N57	13	core))) AND (divid\$3 WITH (light OR beam OR input)) AND (subbeam OR sub-beam))	(US-PGPUB; USPAT)	OR	ON	ON	2023/06/26 08:36 AM
N58	17	(N47 OR N48 OR N49 OR N50 OR N51 OR N52) AND @pd>"20220920"	(US-PGPUB; USPAT)	OR	ON	ON	2024/09/07 03:27 PM
N59	37	laser AND ((optic\$2 near2 fib\$2) OR opticalfib\$2 OR optical-fib\$2 OR opticfib\$3 OR optic-fib\$3 OR fibreoptic\$2 OR fiberoptic\$2 OR fibre-optic\$2 OR fiber-optic\$2) SAME ((inner OR inside OR first OR primary OR center OR central OR centre) near2 core) AND ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 core) AND ((inner OR inside OR first OR primary OR center OR central OR centre) near2 clad\$4) AND ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 clad) AND ((coupl\$3 WITH (first near2 (beam OR ray OR light OR input OR wavelength))) WITH ((inner OR inside OR first OR primary OR center OR central OR centre) near2 core)) AND ((coupl\$3 WITH (second near2 (beam OR ray OR light OR input OR wavelength))) WITH ((outer OR outside OR radial\$2 OR secondary OR peripheal OR second) near2 core))	(US-PGPUB; USPAT)	OR	ON	ON	2024/09/07 03:41 PM
N60	4	(N58 OR N59) AND @pd>"20240906"	(US-PGPUB; USPAT)	OR	ON	ON	2024/12/14 03:11 PM



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

26161 7590 12/27/2024
FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

EXAMINER

CONNELLY, MICHELLE R

ART UNIT

PAPER NUMBER

2874

DATE MAILED: 12/27/2024

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/387,089	11/06/2023	Rudolph Huber	15540-0370006	7969

TITLE OF INVENTION: METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1200	\$0.00	\$0.00	\$1200	03/27/2025

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 40% the amount of undiscounted fees, and micro entity fees are 20% the amount of undiscounted fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

26161 7590 12/27/2024
FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/387,089	11/06/2023	Rudolph Huber	15540-0370006	7969

TITLE OF INVENTION: METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1200	\$0.00	\$0.00	\$1200	03/27/2025

EXAMINER	ART UNIT	CLASS-SUBCLASS
CONNELLY, MICHELLE R	2874	385-016000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

1 _____

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required)

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☐ Electronic Payment via the USPTO patent electronic filing system ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/387,089	11/06/2023	Rudolph Huber	15540-0370006	7969
26161 7590 12/27/2024 FISH & RICHARDSON P.C. (BO) P.O. BOX 1022 MINNEAPOLIS, MN 55440-1022				
EXAMINER CONNELLY, MICHELLE R				
ART UNIT			PAPER NUMBER	
2874				
DATE MAILED: 12/27/2024				

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. The United States Patent and Trademark Office (USPTO) collects the information in this record under authority of 35 U.S.C. 2. The USPTO's system of records is used to manage all applicant and owner information including name, citizenship, residence, post office address, and other information with respect to inventors and their legal representatives pertaining to the applicant's/owner's activities in connection with the invention for which a patent is sought or has been granted. The applicable Privacy Act System of Records Notice for the information collected in this form is COMMERCE/PAT-TM-7 Patent Application Files, available in the Federal Register at 78 FR 19243 (March 29, 2013).

<https://www.govinfo.gov/content/pkg/FR-2013-03-29/pdf/2013-07341.pdf>

Routine uses of the information in this record may include disclosure to:

- 1) law enforcement, in the event that the system of records indicates a violation or potential violation of law;
- 2) a federal, state, local, or international agency, in response to its request;
- 3) a contractor of the USPTO having need for the information in order to perform a contract;
- 4) the Department of Justice for determination of whether the Freedom of Information Act (FOIA) requires disclosure of the record;
- 5) a Member of Congress submitting a request involving an individual to whom the record pertains, when the individual has requested the Member's assistance with respect to the subject matter of the record;
- 6) a court, magistrate, or administrative tribunal, in the course of presenting evidence, including disclosures to opposing counsel in the course of settlement negotiations;
- 7) the Administrator, General Services Administration (GSA), or their designee, during an inspection of records conducted by GSA under authority of 44 U.S.C. 2904 and 2906, in accordance with the GSA regulations and any other relevant (i.e., GSA or Commerce) directive, where such disclosure shall not be used to make determinations about individuals;
- 8) another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c));
- 9) the Office of Personnel Management (OPM) for personnel research purposes; and
- 10) the Office of Management and Budget (OMB) for legislative coordination and clearance.

If you do not furnish the information requested on this form, the USPTO may not be able to process and/or examine your submission, which may result in termination of proceedings, abandonment of the application, and/or expiration of the patent.

Notice of Allowability	Application No. 18/387,089	Applicant(s) Huber et al.	
	Examiner MICHELLE R CONNELLY	Art Unit 2874	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to Applicant's Amendment filed December 10, 2024.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on ____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on ____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 28-47. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a) ☒ All b) ☐ Some* c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☒ Certified copies of the priority documents have been received in Application No. 13/639,401.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: ____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date ____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)	5. ☐ Examiner's Amendment/Comment
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date ____.	6. ☒ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material ____.	7. ☐ Other ____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. ____.	

/MICHELLE R CONNELLY/ Primary Examiner, Art Unit 2874	
--	--

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Terminal Disclaimer

The terminal disclaimer filed on December 10, 2024 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of **U.S. Patent No. 10,281,656** has been reviewed and is accepted. The terminal disclaimer has been recorded.

Response to Amendment

Applicant's Amendment filed December 10, 2024 has been fully considered and entered.

Allowable Subject Matter

Claims 28-47 are allowed.

The following is an examiner's statement of reasons for allowance: Claims 28-47 remain allowable over the prior art of record, which is the most relevant known prior art, for the reasons stated in the Office action mailed September 10, 2024.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MICHELLE R CONNELLY whose telephone number is (571)272-2345. The examiner can normally be reached Monday-Friday, 9 AM to 5 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Uyen-Chau Le can be reached on 571-272-2397. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: <https://patentcenter.uspto.gov>. Visit <https://www.uspto.gov/patents/apply/patent-center> for more information about Patent Center and <https://www.uspto.gov/patents/docx> for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHELLE R CONNELLY/
Primary Examiner, Art Unit 2874



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/387,089	11/06/2023	Rudolph Huber	15540-0370006	7969
26161	7590	01/07/2025		
FISH & RICHARDSON P.C. (BO)			EXAMINER	
P.O. BOX 1022			CONNELLY, MICHELLE R	
MINNEAPOLIS, MN 55440-1022				
			ART UNIT	PAPER NUMBER
			2874	
			NOTIFICATION DATE	DELIVERY MODE
			01/07/2025	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PATDOCTC@fr.com

Corrected Notice of Allowability	Application No. 18/387,089	Applicant(s) Huber et al.	
	Examiner MICHELLE R CONNELLY	Art Unit 2874	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to the IDS filed December 18, 2024.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 28-47. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a) ☒ All b) ☐ Some* c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☒ Certified copies of the priority documents have been received in Application No. 13/639,401.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892) 2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____ 3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____ 4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____	5. ☐ Examiner's Amendment/Comment 6. ☐ Examiner's Statement of Reasons for Allowance 7. ☐ Other _____
--	--

/MICHELLE R CONNELLY/ Primary Examiner, Art Unit 2874	
--	--

Attorney Docket No.: 15540-0370006 / 18.01127; DS10502

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor : Rudolph Huber Art Unit : 2874
Application No. : 18/387,089 Examiner : Michelle R. Connelly
Filed : November 6, 2023 Conf. No. : 7969
Title : METHOD AND ARRANGEMENT FOR GENERATING A LASER
BEAM HAVING A DIFFERING BEAM PROFILE
CHARACTERISTIC BY A MULTI-CLAD FIBER

MAIL STOP AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT

Please consider the documents listed on the disclosure form submitted with this statement. Copies of the documents are being submitted with this statement to the extent required under 37 C.F.R. § 1.98(a)(2).

As provided by 37 C.F.R. § 1.97(h), this filing is not an admission that any of the submitted information is, or is considered to be, material to patentability as defined in 37 C.F.R. § 1.56(b). Further, the filing of this statement should not be construed to mean that a search has been conducted or that no other material documents or information exists.

This statement is being filed after a first action on the merits, but before the mailing of a final action or a notice of allowance.

Apply any necessary charges or credits applicable under 37 C.F.R. § 1.17(p) to deposit account 06-1050, referencing the above attorney docket number.

Please contact the undersigned if there are any questions regarding this statement.

Respectfully submitted,

Date: 12/18/2024

/Yunbo Guo/

Yunbo Guo, Reg. No. 70,538

Customer Number 26161
Fish & Richardson P.C.
Telephone: +1 (512) 226-8108
Facsimile: (877) 769-7945

63579014.doc

Sheet 1 of 1

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 15540-0370006	Application No. 18/387,089
Information Disclosure Statement by Applicant (Use several sheets if necessary) (37 CFR §1.98(b))		Applicant TRUMPF Laser- und Systemtechnik GmbH	
		Filing Date 11/6/2023	Group Art Unit 2874

U.S. Patent Documents							
Examiner Initial	Cite No.	Document Number	Publication Date	Patentee	Filing Date If Appropriate	Class	Subclass

Foreign Patent Documents or Published Foreign Patent Applications							
Examiner Initial	Cite No.	Document Number	Publication Date	Country or Patent Office	Translation	Class	Subclass
/M.R.C/	I.	KR 20060048214 A	5/18/2006	KR	English Abstract		

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Cite No.	Document

Examiner Signature /MICHELLE R CONNELLY/	Date Considered 12/31/2024
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form



UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/387,089

RECEIPT DATE / TIME
01/21/2025 04:47:39 PM Z ET

ATTORNEY DOCKET #
15540-0370006

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	7969	FILED BY	Cheryl Forrest
PATENT CENTER #	68848784	FILING DATE	11/06/2023
CUSTOMER #	26161	FIRST NAMED INVENTOR	Rudolph Huber
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Yunbo Guo

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ReplytoNOA.pdf	3	Issue Fee Payment (PTO-85B)	180 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
ReplytoNOA.pdf	8B5B34C0431E9683A2FE0E06B98F9A43746E1974279B8E8910 46AA9EE031364D9C35651F71D929981B75D14732409C702F56 EB6A6497E40973D88CE6B4179863

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Rudolph Huber	Art Unit :	2874
Application No. :	18/387,089	Examiner :	Michelle R. Connelly
Filed :	November 6, 2023	Confirmation No. :	7969
		Notice of Allowance Date:	December 27, 2024
Title :	METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER		

MAIL STOP ISSUE FEE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY TO NOTICE OF ALLOWANCE

In response to the Notice of Allowance dated December 27, 2024, enclosed is a completed Part B - Fee(s) Transmittal.

The issue fee is being paid with this reply on the USPTO patent electronic filing system. Apply that fee and any other necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

COMMENTS ON EXAMINER'S REASONS FOR ALLOWANCE

It is recognized that, in accordance with M.P.E.P. § 1302.14, the Examiner's reasons for allowance need not set forth all of the details as to why the claims are allowed. In the above-referenced application, it is not conceded that the Examiner's stated reasons for allowance are the only reasons for which the claims are allowable. The Examiner's reasons for allowance indicate that particular claim elements are not disclosed or suggested by the prior art of record, yet the claims may be patentable for other reasons as well, including the inventive combination of all of the recited claim elements. It is not conceded that the specific limitations identified by the Examiner are necessary to distinguish the art of record or to satisfy the requirements of 35 U.S.C. § 112. Moreover, the Examiner does not assert, and it would not be conceded, that the Examiner's reasons have any bearing on the patentability of claims in any other applications directed to the disclosed subject matter.

First Named Inventor : Rudolph Huber
Application No. : 18/387,089
Filed : November 6, 2023
Page : 2 of 2

Attorney Docket No.: 15540-0370006 / 18.01127;
DS10502

In addition, each dependent claim stands on its own and may be allowable on its own merits. In particular, each dependent claim may be allowable on the basis of a combination of some of the features recited in the dependent claim and its base claim(s), which combination of features may not include all of the limitations identified in the Examiner's reasons for allowance.

Respectfully submitted,

Date: 01/21/2025

/Yunbo Guo/

Yunbo Guo, Reg. No. 70,538

Customer Number 26161
Fish & Richardson P.C.
Telephone: +1 (512) 226-8108
Facsimile: (877) 769-7945

1798511.doc

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22314-1450

By fax, send to: (571) 273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize expediency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

26161 7590 12/27/2024

FISH & RICHARDSON P.C.
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

Cheryl A. Forrest	(Typed or printed name)
/Cheryl A. Forrest/	(Signature)
January 21, 2025	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/387,089	11/06/2023	Rudolph Huber	15540-0370006	7969

TITLE OF INVENTION: METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	LARGE	\$1200	\$0	\$0	\$1200	03/27/2025
EXAMINER		ART UNIT	CLASS-SUBCLASS			
CONNELLY, MICHELLE R.		2874	385-016000			

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

- (1) The names of up to 3 registered patent attorneys or agents OR, alternatively, 1 Fish & Richardson P.C.
- (2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed. 2 _____
- 3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE
TRUMPF Laser- und Systemtechnik GmbH(B) RESIDENCE: (CITY and STATE OR COUNTRY)
Ditzingen, GermanyPlease check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government4a. Fees Submitted: ☒ Issue Fee ☐ Publication Fee (if required)

4b. Method of Payment (Please first reapply any previously paid fee shown above):

☒ Electronic Payment via the USPTO patent electronic filing system ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account No. 06-1050

5. Change of Entity Status (from status indicated above)

- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
- ☐ Applicant asserting small entity status. See 37 CFR 1.27.
- ☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid Certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken as a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken as a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Yunbo Guo/Date 01/21/2025Typed or printed name Yunbo GuoRegistration No. 70,538



UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION # 18/387,089	RECEIPT DATE / TIME 01/21/2025 04:47:39 PM Z ET	ATTORNEY DOCKET # 15540-0370006
------------------------------------	---	---

Title of Invention

METHOD AND ARRANGEMENT FOR GENERATING A LASER BEAM HAVING A DIFFERING BEAM PROFILE CHARACTERISTIC BY A MULTI-CLAD FIBER

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	7969	FILED BY	Cheryl Forrest
PATENT CENTER #	68848784	AUTHORIZED BY	Yunbo Guo
CUSTOMER #	26161	FILING DATE	11/06/2023
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Rudolph Huber

Payment Information

PAYMENT METHOD DA / 061050	PAYMENT TRANSACTION ID E20251KG48228811	PAYMENT AUTHORIZED BY Cheryl Forrest
-------------------------------	--	---

FEE CODE	DESCRIPTION	ITEM PRICE(\$)	QUANTITY	ITEM TOTAL(\$)
1501	UTILITY ISSUE FEE	1200.00	1	1200.00
TOTAL AMOUNT:				\$1,200.00

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage

submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/387,089	03/04/2025	12240054	15540-0370006	7969

26161 7590 02/12/2025
FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

ISSUE NOTIFICATION

The projected patent number and issue date are specified above. The patent will issue electronically. The electronically issued patent is the official patent grant pursuant to 35 U.S.C. § 153. The patent may be accessed on or after the issue date through Patent Center at <https://patentcenter.uspto.gov/>. The patent will be available in both the public and the private sides of Patent Center. Further assistance in electronically accessing the patent, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-888-217-9197.

The USPTO is implementing electronic patent issuance with a transition period, during which period the USPTO will mail a ceremonial paper copy of the electronic patent grant to the correspondence address of record. Additional copies of the patent (i.e., certified and presentation copies) may be ordered for a fee from the USPTO's Certified Copy Center at <https://certifiedcopycenter.uspto.gov/index.html>. The Certified Copy Center may be reached at (800)972-6382.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Center (<https://patentcenter.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PATENT CENTER site <https://patentcenter.uspto.gov> for additional inventors):

Rudolph Huber, Aldingen-Aixheim, GERMANY;

Wolfgang Andreasch, Weinstadt, GERMANY;

Martin Huonker, Dietingen, GERMANY;

APPLICANT(s) (Please see PATENT CENTER site <https://patentcenter.uspto.gov> for additional applicants):

TRUMPF Laser- und Systemtechnik GmbH, Ditzingen, DE;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit [SelectUSA.gov](https://selectusa.gov).



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/387,089	11/06/2023	Rudolph Huber	15540-0370006	7969
26161	7590	03/04/2025		
FISH & RICHARDSON P.C. (BO)			EXAMINER	
P.O. BOX 1022			CONNELLY, MICHELLE R	
MINNEAPOLIS, MN 55440-1022				
			ART UNIT	PAPER NUMBER
			2874	
			NOTIFICATION DATE	DELIVERY MODE
			03/04/2025	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PATDOCTC@fr.com

APPLICATION NO.	ISSUE DATE	PATENT NO.
18/387,089	04-Mar-2025	12240054

FISH & RICHARDSON P.C. (BO)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

EGRANT NOTIFICATION

Your electronic patent grant (eGrant) is now available, which can be accessed via Patent Center at <https://patentcenter.uspto.gov>

The electronic patent grant is the official patent grant under 35 U.S.C. 153. For more information, please visit <https://www.uspto.gov/electronicgrants>