



(51) International Patent Classification:
G02B 6/24 (2006.01)

(21) International Application Number:
PCT/US2011/032885

(22) International Filing Date:
18 April 2011 (18.04.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/324,893 16 April 2010 (16.04.2010) US

(71) Applicant (for all designated States except US): **AFL TELECOMMUNICATIONS LLC** [US/US]; P.O. Box 3127, Spartanburg, South Carolina 29304-3127 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **KUBO, Toshiki** [US/US]; 104 Hadrian Lane, Greer, South Carolina 29650 (US).

(74) Agents: **PELLEGRINI, Carl J.** et al.; Sughrue Mion, PLLC, 2100 Pennsylvania Avenue, NW, Suite 800, Washington, District of Columbia 20037-3213 (US).

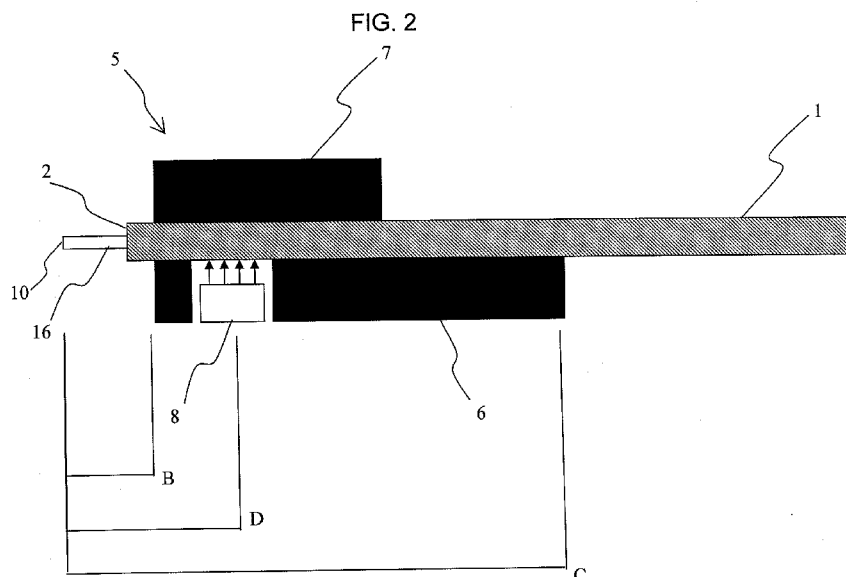
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: METHOD AND APPARATUS FOR ALIGNMENT OF OPTICAL FIBER



(57) Abstract: Methods and apparatuses for aligning and splicing optical fibers. Optical fibers are placed in a holder. The holder holds the fiber between a first position close to the end of the fiber to be spliced, and a second position farther from the end of the fiber to be spliced. A light source is placed at a location between the first position and the second position, and illuminates the fiber.

METHOD AND APPARATUS FOR ALIGNMENT OF OPTICAL FIBER

BACKGROUND

[01] This application claims priority from U.S. Provisional Application No. 61/324,893, filed on April 16, 2010, the disclosure of which is incorporated herein by reference in its entirety.

1. Field

[02] The following description relates to optical fibers, and more particularly to methods and apparatuses for alignment of optical fibers.

2. Related Art

[03] Optical fibers are widely used for a number of applications, including but not limited to fiber optics communications, fiber optic sensors, laser generations, optical signal amplification, and even decoration. When long runs of fiber optical cables are needed, it becomes necessary to splice two cable together, often through fusion splicing. This splicing often requires careful alignment of the two fiber optic cables.

[04] Polarization-maintaining (PM) fibers are widely used for many types of photonic assemblies. See for example, Yamauchi, R, "Specialty fibers", Lasers and Electro-Optics Society Annual Meeting, 1994. LEOS '94 Conference Proceedings. IEEE, Vol 2, pp.228 – 229, 31 Oct.-3 Nov. 1994, and Segi, T.; Ouchi, Y.; Nishiwaki, K.; Sakai, T.; Nishide, K.; Wada, A, "Polarization-maintaining EDFA for optical sensing application, composed of panda fiber based

low loss and low cross-talk optical components,” Optical Fiber Sensors Conference Technical Digest, pp. 289 - 292 vol.1 6-10 May 2002.

[05] Generally, PM fibers are optical fibers which maintain the polarization of their guided light through a strong built-in birefringence. So long as the light launched into the fiber has polarization aligned with the one of the birefringent axes, the polarization of the of the guided light will be preserved, even if the fiber is bent.

[06] Yet, if the polarized light is to be transmitted over long distances, it will often be necessary to splice more than one length of PM fiber together. Accordingly, the birefringent axes of the spliced fibers must be aligned in order to ensure that the polarization of the guided light is maintained between the spliced fibers.

[07] Fully automatic alignment and splicing has been possible for most PM fibers by existing methods. However, each existing method has its limitations and drawbacks. Furthermore, there has been a proliferation of new specialized PM fibers in recent years for sensor and fibers laser applications that are difficult to align by any previous method. See for example, Carter, A.; Samson, B., “Panda-style fibers move beyond telecom”, Nufern Article, http://www.nufern.com/article_detail.php/20, Aug. 2, 2004.

[08] The Profile Alignment System (PAS) observes the side view of the PM fiber using a CCD camera. See for example, Itoh, K; Yoshinuma, N; Suzuki,

N; Yamada, T; Taya, H, "Method of fusion-splicing polarization maintaining optical fibers," United States Patent 5013345, May 7, 1991. Collimated light from an LED is bent by the difference in the index of refraction between air and glass as it enters a panda fiber cladding and at any point inside the fiber where there is a difference in refractive index between elements of the fiber structure such as at the interface of the fiber cladding and the low-index stress rods. The PAS focal plane intersects the fiber on the side near the camera. At this position the collimated light is focused inward into a bright region, and the brightness intensity yields a detailed profile. The Panda fiber is rotated until two specific points have the same height on the brightness intensity profile. This works well for most panda fibers and some bow-tie fibers, however other PM fibers cannot be aligned by this method. Also, while the PAS system has typically offered the greatest accuracy for panda alignment, many low-contrast panda fibers developed recently lack sufficient refractive index contrast between the stress rods and the cladding to be aligned by PAS.

[09] The optical system for the POL (Polarization Observation by Lens Effect) method is similar to that of the PAS system, but the focal plane is outside of the fiber at a point where the collimated light from the LED has been concentrated together by the fiber lens effect. See for example, W. Zheng, "Automated Fusion-Splicing of Polarization Maintaining Fibers," J. Lightwave Technol. 15, 125-134, 1997, and W. Zheng, "Automated alignment and splicing

of different PM-fiber types.” Fiber Optic Gyros: 20th Anniversary Conference, Denver, 1996. Because all of the light is concentrated together, there is no detail in the brightness intensity profile as in the PAS case. Only a single factor (the contrast between the strong center peak and the dark outer region) can be discerned from the POL image. This cannot by itself be used to align a PM fiber. However, for most PM fibers if the fiber is rotated while the contrast is observed, a characteristic profile of the contrast versus rotational position can be developed. When splicing two identical PM fibers, these contrast profiles are synchronized by rotating one or both fibers. If different PM fibers are spliced together, it is necessary to identify the position of the fast or slow axis on the contrast profile. While POL is applicable to more PM fibers than PAS, it is not as accurate as PAS for some fibers, and POL cannot align some fibers such as the low-contrast types.

[10] A third automated PM alignment method is end-view. See for example, Itoh, K; Yamada, T; Onodera, T; Yoshinuma, M; Kato, Y. “Apparatus for fusion-splicing a pair of polarization maintaining optical fibers,” United States Patent 5147434, Sept. 15, 1992. In this system end-view mirrors are located between the end of two PM fibers during alignment in order to direct reflected images of the cleaved fiber ends through a lens and into a camera. Image analysis enables fiber alignment. The mirrors must be withdrawn prior to splicing in order to permit the two fibers to be joined. The end-view system can be applied to PM fibers of every type, but cannot align all PM fibers either due to limitations of

end-view illumination, or due to the specific nature of the fiber. A PM fiber with low contrast presents a problem whether the optical system observes a transverse fiber image or an end image, since the illumination position is too far away from the fiber end. Most of low contrast fiber types are also double cladding, this make it even more difficult to illuminate the fiber properly.

[11] An example of a conventional method is shown in FIG. 1. FIG. 1 depicts one fiber being aligned accordingly to a conventional method, though a person of ordinary skill in the art would understand that the a second fiber would undergo a similar process in order to complete the slicing of the two fibers. According to the conventional method, a length C of fiber 1 is placed in a holder 5. The fiber 1 includes end 10 be spliced to the second fiber (not depicted). The holder 5 includes a block 6 and a clamp 7, between which the fiber 1 is held such that end 10 is on one side of holder 5. On the other side of holder 5, a light source 8 is provided to illuminate the fiber. In the conventional method, the light source 8 will be at a distance from end 10 that is at least as long as holder 5, and will almost surely be longer due to practical considerations in constructing the device. The distance from the light source 8 to end 10 of the fiber 1 results in low illumination at end 10, making aligning the fiber difficult.

[12] The difficulties in aligning optical fibers are not limited to PM fibers. For example, accordingly to the related methods and apparatuses, view both claddings in a double clad fiber can be very difficult.

SUMMARY

[13] Accordingly, exemplary embodiments provide a method of splicing an optical fiber, including placing a fiber in a holder, the holder holding the fiber between a first position and a second position; illuminating the fiber from a third position, the third position located between the first position and the second position; aligning the end of the fiber according to the illuminating.

[14] In another exemplary embodiment, the illumination includes illuminating the fiber using a light emitting diode (LED).

[15] In other exemplary embodiments, methods where illuminating the fiber includes placing a light source in a hole in the holder at the third position.

[16] Exemplary embodiments further include methods of aligning the fiber through an end-view alignment.

[17] Exemplary embodiments are directed to methods for aligning polarization maintaining fibers. Other exemplary embodiments are directed to aligning panda fibers, aligning bow-tie fibers, and aligning elliptical clad fiber.

[18] Yet other exemplary embodiments are directed to aligning fibers including a cladding and a core; fibers including an inner cladding and an outer cladding, aligning erbium doped fibers, aligning single mode fibers, and aligning multimode fibers.

[19] According to exemplary embodiments, the second position is between 35 mm and 75 mm from the end of the fiber. In other exemplary embodiments, the second position is between 50 and 60 mm from the end of the fiber. Exemplary embodiments are also directed to methods in which the third position is between 10 and 30 mm from the end of the fiber. While in other exemplary embodiments, the third position is between 15 and 25 mm from the end of the fiber.

[20] Exemplary embodiments are also directed to apparatuses for aligning and splicing an optical fiber, the apparatuses including a fiber holder holding a fiber between a first position and third position; a light source illuminating the fiber from a third position between the first position and the second position.

[21] In other exemplary embodiments, the holder includes a block and a clamp.

[22] In exemplary embodiments, the light source includes a light emitting diode (LED).

[23] In some exemplary embodiments, the light source is placed in a hole in the block. Yet, in other exemplary embodiments, the light source is placed in a hole in the clamp. In yet other exemplary embodiments, the light placed outside of the holder.

[24] BRIEF DESCRIPTION OF THE DRAWINGS

[25] FIG. 1 is a schematic representation of a related art device for aligning an optical fiber.

[26] FIG. 2 is a schematic representation of an exemplary embodiment of an apparatus for aligning an optical fiber.

[27] FIG. 3 is a schematic representation of a second exemplary embodiment of an apparatus for aligning an optical fiber.

[28] FIG. 4 is a schematic representation of a third exemplary embodiment of an apparatus for aligning an optical fiber.

[29] FIG. 5 is a schematic representation of a fourth exemplary embodiment of an apparatus for aligning an optical fiber.

[30] FIG. 6 is a schematic representation of a fifth exemplary embodiment of an apparatus for aligning an optical fiber.

[31] FIG. 7 is a schematic representation of a sixth exemplary embodiment of an apparatus for aligning an optical fiber.

[32] FIGS. 8a and 8b are a side-by-side comparison of the end of an optical fiber as illuminated by a conventional method, and as illuminated by an exemplary embodiment.

[33] FIGS. 8a and 8b are a side-by-side comparison of the end of another optical fiber as illuminated by a conventional method, and as illuminated by an exemplary embodiment.

DETAILED DESCRIPTION

[34] The following detailed description is provided to assist the reader in gaining a comprehensive understanding of the methods, apparatuses and/or systems described herein. Various changes, modifications, and equivalents of the systems, apparatuses and/or methods described herein will suggest themselves to those of ordinary skill in the art. Descriptions of well-known functions and structures are omitted to enhance clarity and conciseness.

[35] Hereinafter, the exemplary embodiments will be described with reference to accompanying drawings.

[36] To splice one fiber optic cable to another, it is necessary to align the core of the first optical fiber with core the second optical fiber. In the case of polarization maintaining (PM) fibers, the birefringent axes of the fibers need to be aligned as well. FIG. 2 is a schematic representation of a device according to an exemplary embodiment capable of aligning cores of the optical fibers that also provides for aligning the birefringent axis of PM fibers, for splicing.

[37] When one wishes to align fiber 1, it will be placed in holder 5. As depicted in FIG. 2, holder 5 is comprised of a block 6 and a clamp 7, but other methods of securing a fiber 1 in a holder are within the scope of the claims, as would be understood by one of ordinary skill in the art. Fiber end 10 will be spliced to a another optical fiber (not depicted). As illustrated in FIG. 2, outer coating 2 has been removed from end 10 to expose the outer cladding 16 of fiber

1. The fiber 1 is held in the holder between a first position B and second position C, where the first position B is closer to fiber end 10 than the second position C.

[38] In the related art device of FIG. 1, a light source 8 is positioned farther from the fiber end 10 than the second position C. Yet, in the exemplary embodiment of FIG. 2, the light source 8 is positioned at a third position D which is closer to the fiber end 10 than the second position C. Accordingly, with the light source 8 located closer to the fiber end 10, it is possible to provide more illumination to fiber end 10, easing the alignment process.

[39] It is preferable that the second position C be between 35 and 75 mm from the end 10. It is more preferable that the second position C be between 50 and 60 mm from the fiber 10. It is also preferable that the third position D be between 10 and 30 mm from fiber end 10, and more preferably between 15 and 25 mm from fiber end 10. Yet, as would be understood by a person of ordinary skill in the art, these values may vary depending on the sizes and materials used for the fiber and the fiber aligning apparatus.

[40] In the exemplary embodiment of FIG. 2, an LED is used as the light source 8 to illuminate the fiber. Yet, a person of ordinary skill in the art would understand that alternative light sources may be used. For example, incandescent light bulbs, lasers, ambient or sun light, and other light sources known to those skilled in the art could be used as the light source. Furthermore,

while light in the visible spectrum is preferable, the device is not limited to visible light.

[41] According to the exemplary embodiment of FIG. 2, the LED light source 8 has been positioned in a hole in block 6 to facilitate locating the light source closer to fiber end 10 than second position C. Yet, exemplary embodiments are not limited the device as depicted in FIG. 2. For example, FIG. 3 depicts a second exemplary embodiment in which the light source 8 has been provided in a hole 12 in clamp 7. Similarly, FIG. 4 depicts an exemplary embodiment in which light source 8 is positioned farther from fiber end 10 than clamp 7, but still closer to fiber end 10 than second position C.

[42] In FIG. 5, the light source 8 itself is not positioned at the third position D. Instead, a light guide 13, such as an optical fiber, guides the light from light source 8 to illuminate the fiber 1 at the third position D.

[43] Additionally, as depicted in FIGS. 6 and 7, the light source can be embedded in the holder. When the light source is embedded in the holder, a power source, such as a dry battery, may be similarly embedded in the holder.

[44] FIG. 8a depicts a panda fiber end 10a as illuminated by a related art method, while FIG. 8b depicts a panda fiber end 10b as illuminated by an exemplary embodiment. As clearly seen in the figures, the core 14 and stress members 15a, 15b are clearly more visible in FIG. 8b than in FIG. 8a. For example, in one exemplary embodiment, using a 50mA white LED, the brightness

at the fiber end increased from 60 to 170 by moving the light source from 60mm away from the end of the fiber to 20 mm away from the end of the fiber.

[45] Additionally, while the fiber depicted in FIGS. 8a and 8b is a panda PM fiber, exemplary embodiments are directed to any optical fiber. For example, FIG. 9a depicts a double clad fiber with an outer cladding 16 and an inner cladding 17 as illuminated by a related art method, while FIG. 9b depicts a double clad fiber as illuminated by an exemplary embodiment. When illuminated by related art methods, it is extremely difficult to differentiate between the inner cladding 17 and the outer cladding 16. Yet, when illuminated according to exemplary embodiments, the inner cladding 17 and the outer cladding 16 are very easily differentiated.

[46] In addition to the panda fibers depicted in FIGS. 8a and 8b, and the double clad fibers depicted in FIGS. 9a and 9b, exemplary embodiments can be directed to devices for aligning any type of fiber comprising a cladding and a core. For example, exemplary embodiments can be directed to single mode fibers, multimode fibers, single clad fibers, double clad fibers, doped fibers including Erbium doped fibers, bow tie PM fibers, elliptical clad PM fibers, and other optical fibers known to those skilled in the art.

[47] As would be plain to one of ordinary skill in the art, numerous benefits can be achieved with exemplary embodiments. For example, the alignment of the fibers can be accomplished with less power consumption as less

light is needed to clearly illuminate the fiber ends. Furthermore, exemplary embodiments require shorter fiber lengths than related art embodiments.

Additionally, exemplary embodiments can be applied to conventional splicing machines and methods.

[48] As would be plain to one of ordinary skill in the art, the ability to more easily determine the location of stress members 15a and 15b provides immense benefits when aligning and splicing PM optical fibers. As the stress members of two fibers being spliced together need to be aligned in order to ensure the polarization is maintained through the splice, being able to more easily identify the stress member will simplify the process, and decrease the time needed to splice two PM fibers.

[49] While the above described benefits may be achieved by exemplary embodiments, additional benefits may also be achieved. On the other hand, none of the above-described benefits need to be achieved by embodiments of the following claims.

[50] Although a few exemplary embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

LISTING OF CLAIMS

What is claimed:

1. A method of aligning an optical fiber, comprising:
placing a fiber in a holder, the holder holding the fiber between a first position and a second position;
illuminating the fiber from a third position, the third position located between the first position and the second position; and
aligning an end of the fiber according to the illuminating..
2. The method according to claim 1, wherein the illumination comprises illuminating the fiber using a light source.
3. The method according to claim 2, wherein the illuminating the fiber using the light source comprises placing the light source in a hole in the holder at the third position.
4. The method according to claim 1, wherein the aligning comprises an end-view alignment.
5. The method according to claim 1, wherein the fiber comprises a polarization maintaining (PM) fiber.

6. The method according to claim 1, wherein the fiber comprises a panda fiber.
7. The method according to claim 1, wherein the fiber comprises a bow-tie fiber.
8. The method according to claim 1, wherein the fiber comprises a elliptical clad fibers.
9. The method according to claim 1, wherein the fiber comprises a cladding and a core.
10. The method according to claim 9, wherein the cladding comprises an inner cladding and an outer cladding.
11. The method according to claim 1, wherein the fiber comprises an erbium doped fiber.
12. The method according to claim 1, wherein the fiber comprises a single mode fiber.

13. The method according to claim 1, wherein the fiber comprises a multimode fiber.
14. The method according to claim 1, wherein the second position is between 35 and 75 mm from the end of the fiber.
15. The method according to claim 1, wherein the second position is between 50 and 60 mm from the end of the fiber.
16. The method according to claim 1, wherein the third position is between 10 and 30 mm from the end of the fiber.
17. The method according to claim 1, wherein the third position is between 15 and 25 mm from the end of the fiber.
18. The method according to claim 1, further comprising splicing the fiber.
19. An apparatus for aligning an optical fiber, comprising:

a fiber holder holding a fiber between a first position and a second position;

a light source illuminating the fiber from a third position between the first position and the second position.

20. The apparatus according to claim 19, wherein the holder comprises a block and a clamp.

21. The apparatus according to claim 19, wherein the light source comprises a light emitting diode (LED).

22. The apparatus according to claim 19, wherein the light source is placed in a hole in the block.

23. The apparatus according to claim 19, wherein the light source is placed in a hole in the clamp.

24. The apparatus according to claim 19, wherein the fiber comprises a polarization maintaining (PM) fiber.

25. The apparatus according to claim 19, wherein the fiber comprises a panda fiber.

26. The apparatus according to claim 19, wherein the fiber comprises a bow-tie fiber.

27. The apparatus according to claim 19, wherein the fiber comprises a elliptical clad fibers.

28. The apparatus according to claim 19, wherein the fiber comprises an outer cladding and an inner cladding.

29. The apparatus according to claim 19, wherein the fiber comprises a cladding and a core.

30. The apparatus according to claim 19, wherein the cladding comprises an inner cladding and an outer cladding.

31. The apparatus according to claim 19, wherein the fiber comprises an erbium doped fiber.

32. The apparatus according to claim 19, wherein the fiber comprises a single mode fiber.

33. The apparatus according to claim 19, wherein the fiber comprises a multimode fiber.

34. The apparatus according to claim 19, wherein the second position is between 35 and 75 mm from the end of the fiber.

35. The apparatus according to claim 19, wherein the second position is between 50 and 60 mm from the end of the fiber.

36. The apparatus according to claim 19, wherein the third position is between 10 and 30 mm from the end of the fiber.

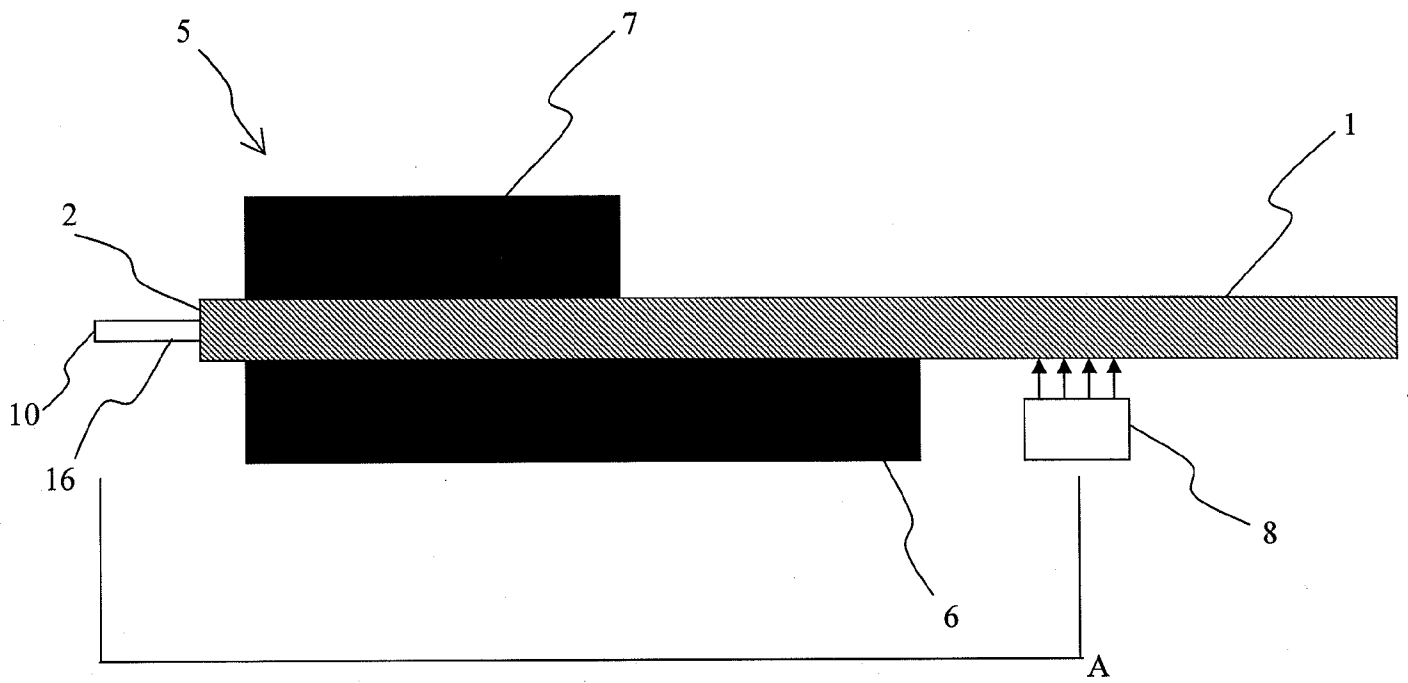
37. The apparatus according to claim 19, wherein the third position is between 15 and 25 mm from the end of the fiber.

38. The apparatus according to claim 19, further comprising a light guide guiding illumination from the light source to the third position.

39. The apparatus according to claim 19, wherein the light source is embedded in the holder.

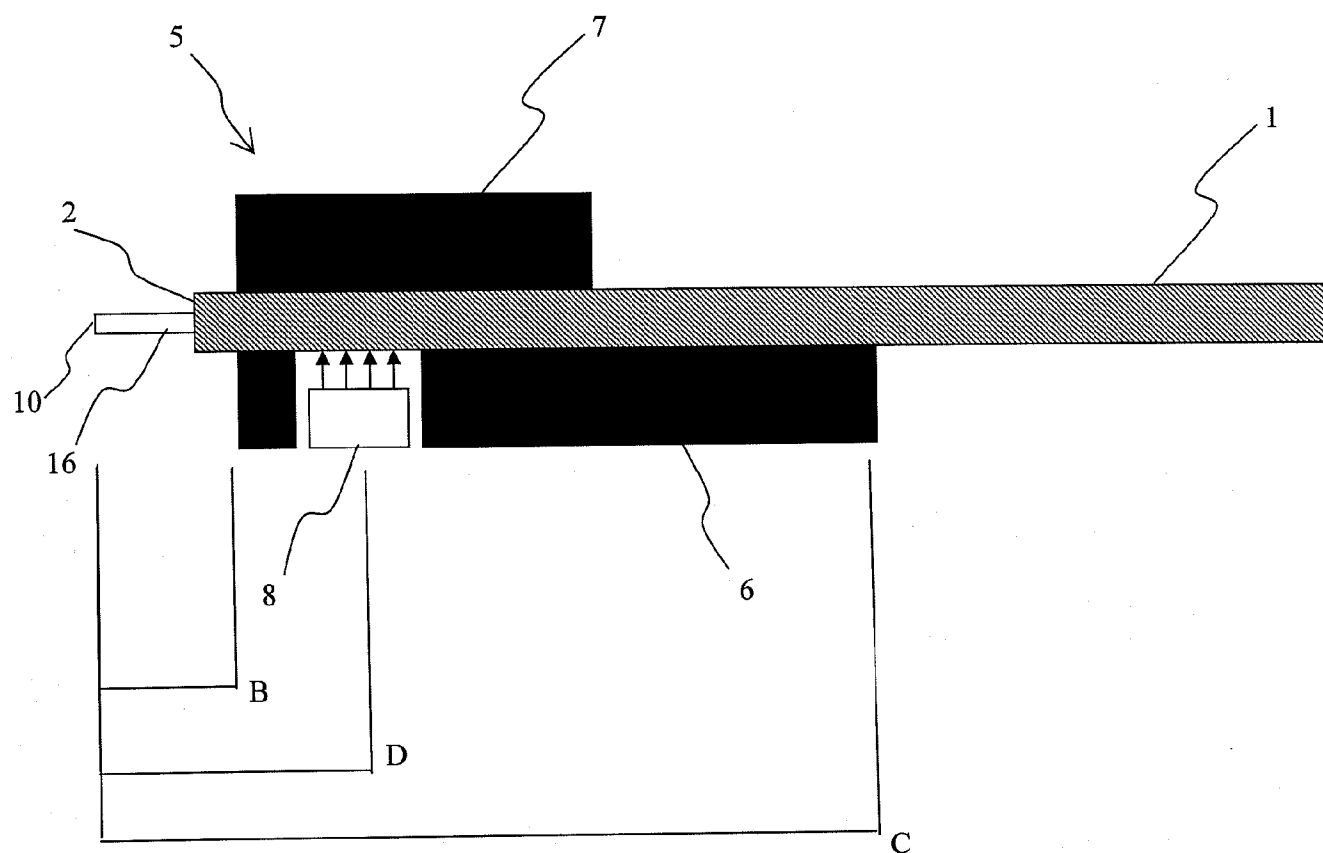
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FIG. 1
Related Art



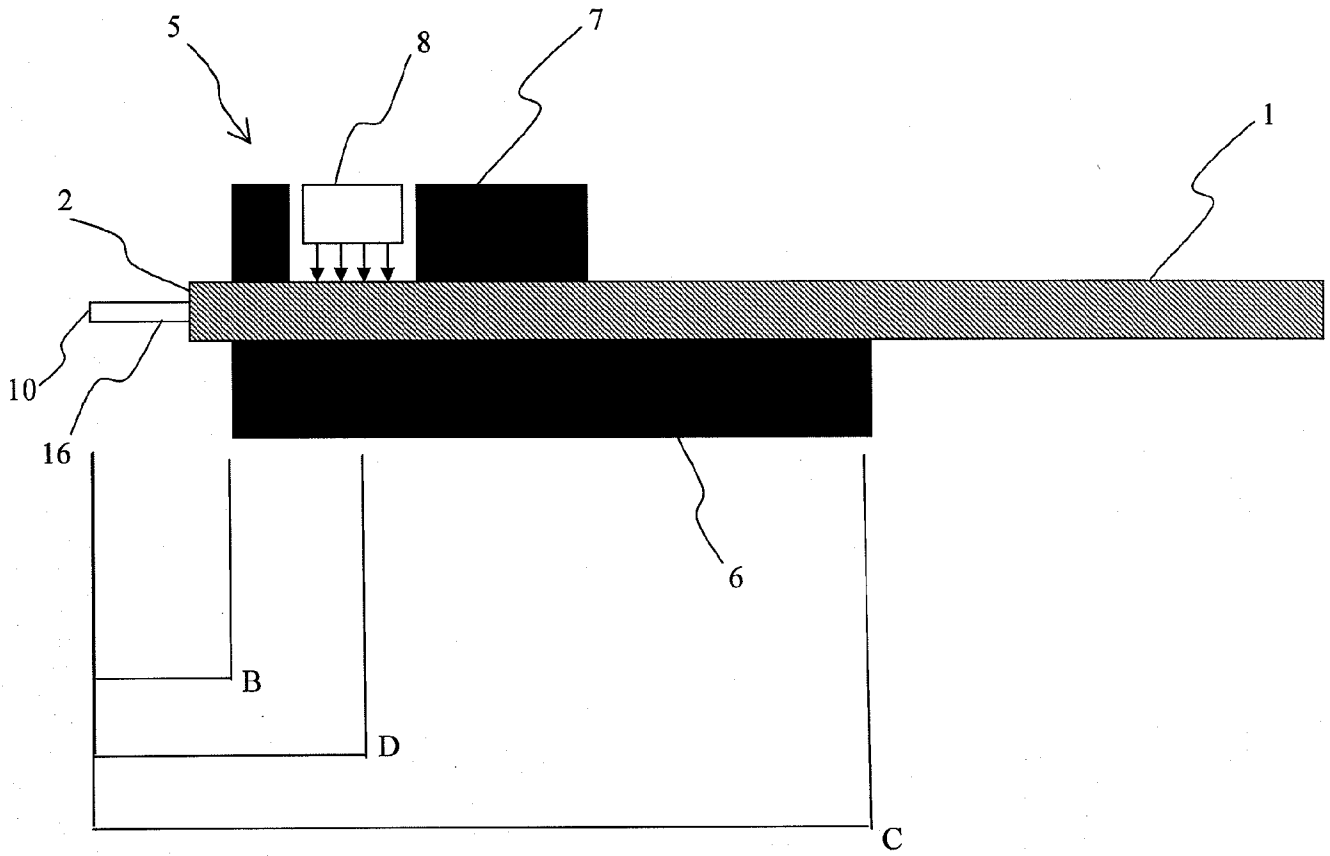
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FIG. 2



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FIG. 3



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FIG. 4

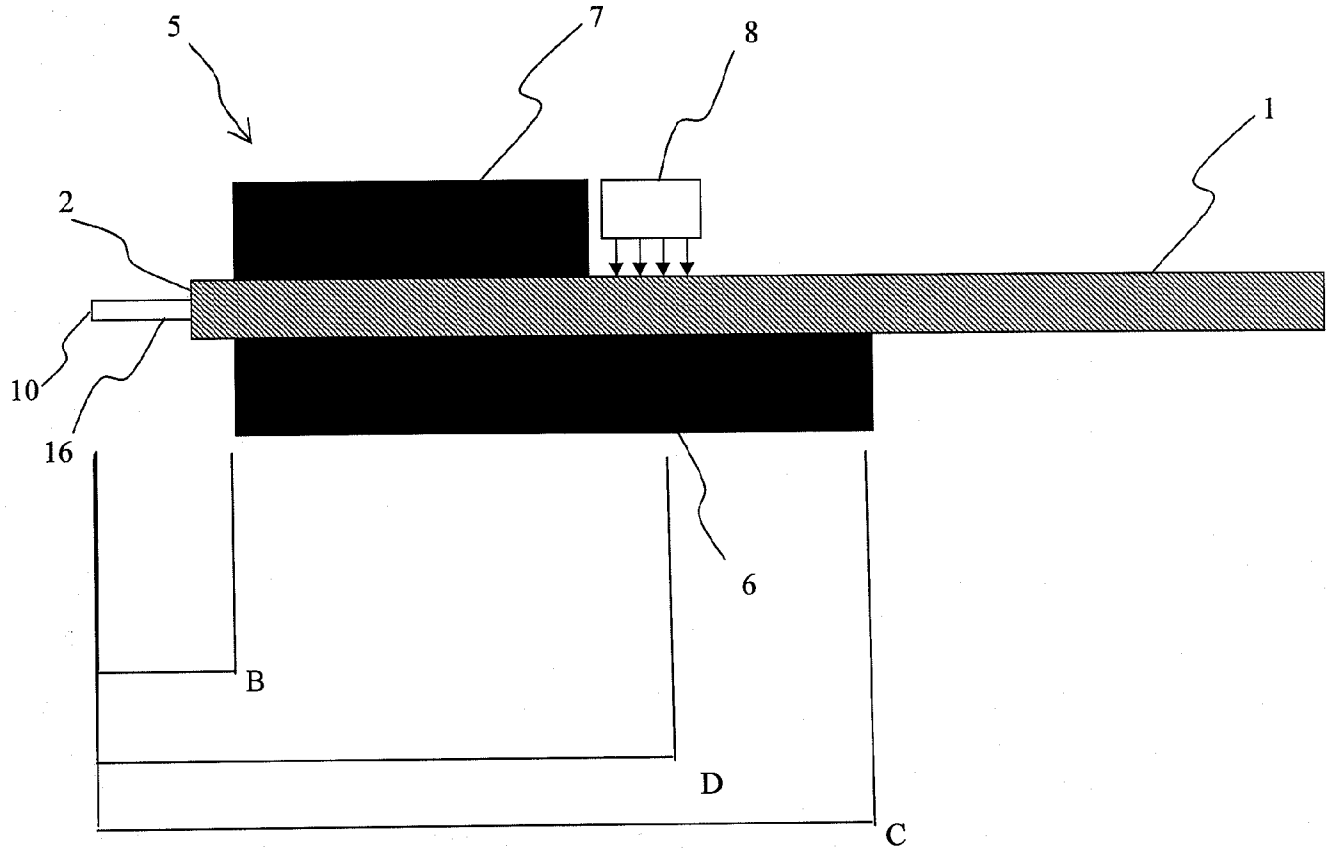


FIG. 5^{5/8}

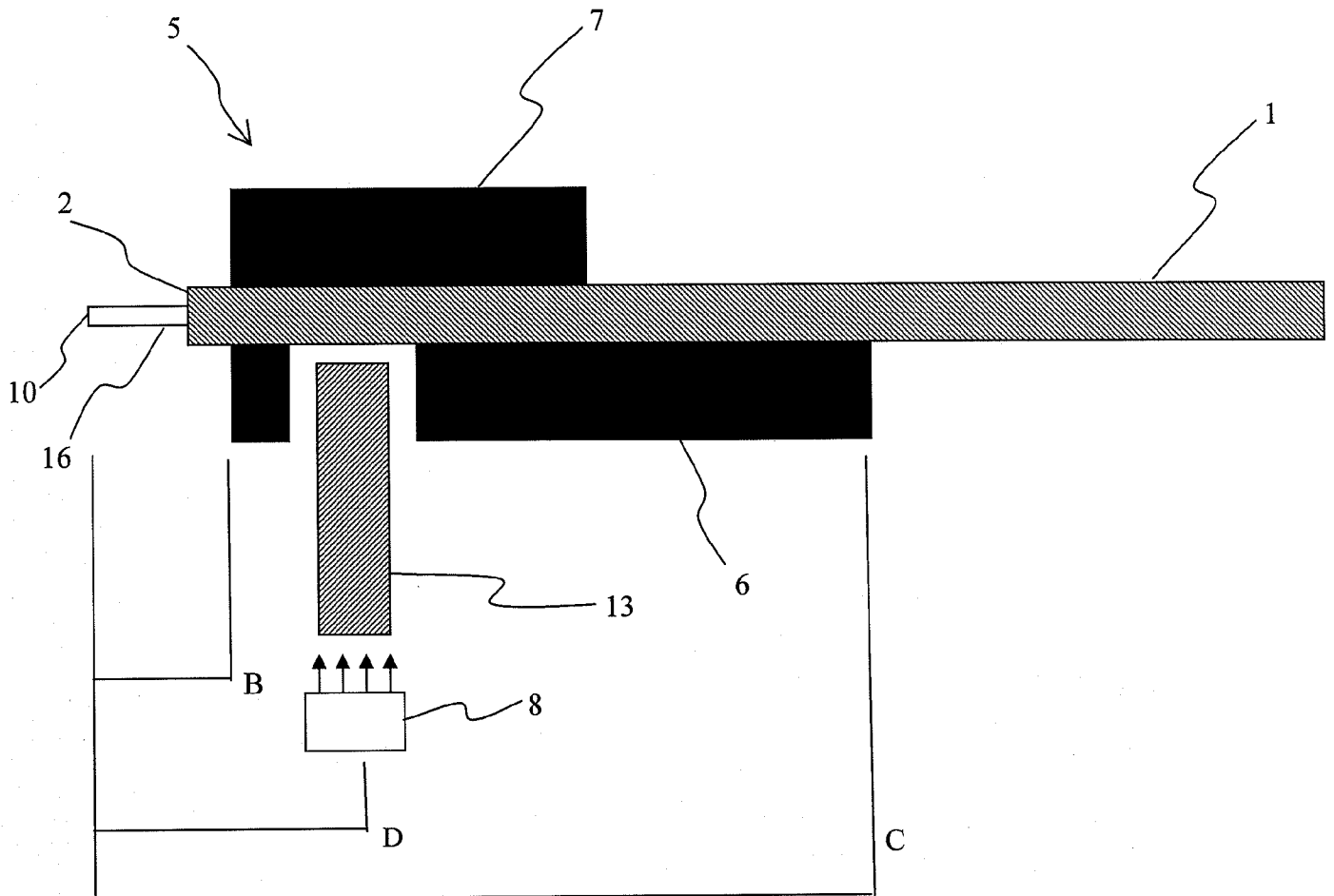
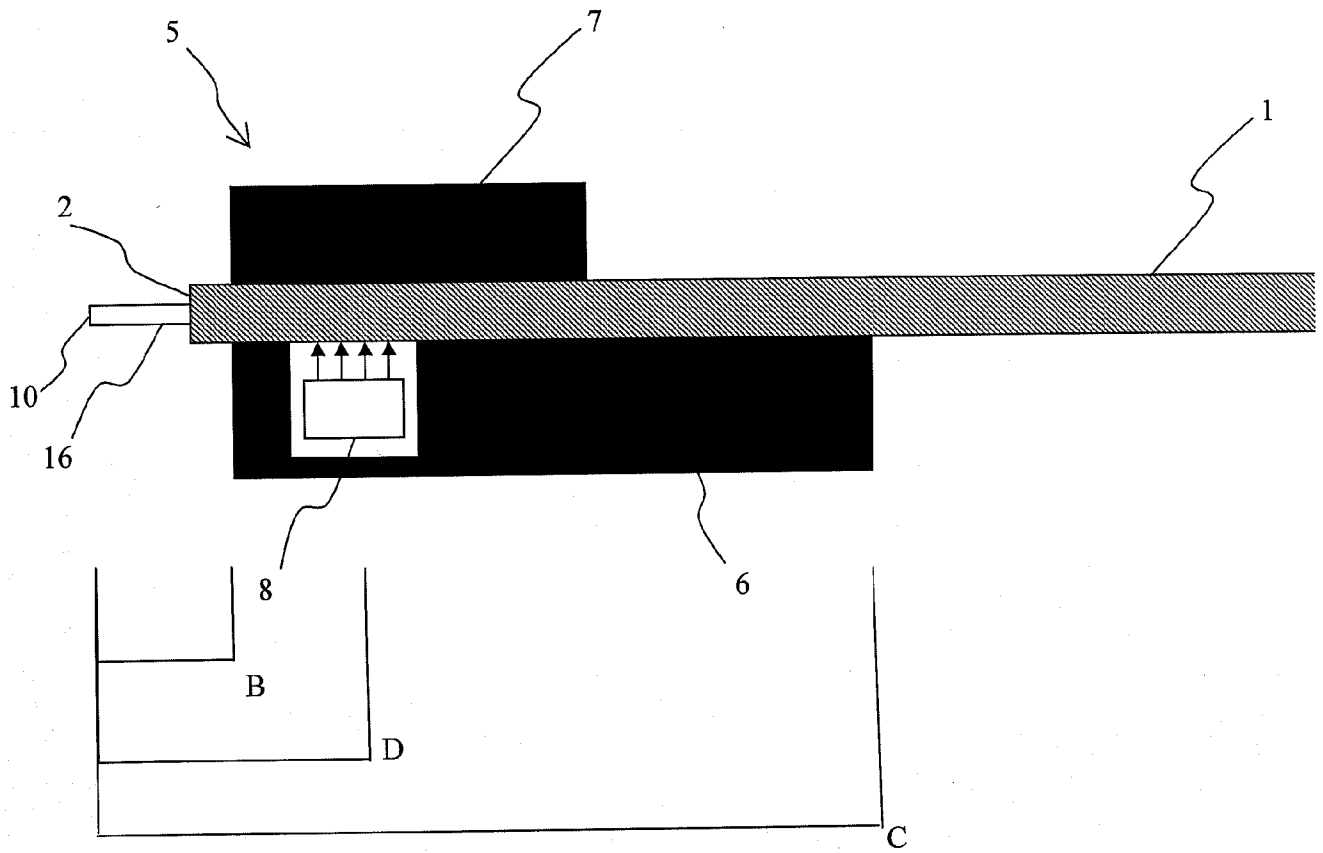


FIG. 6^{6/8}



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FIG. 7

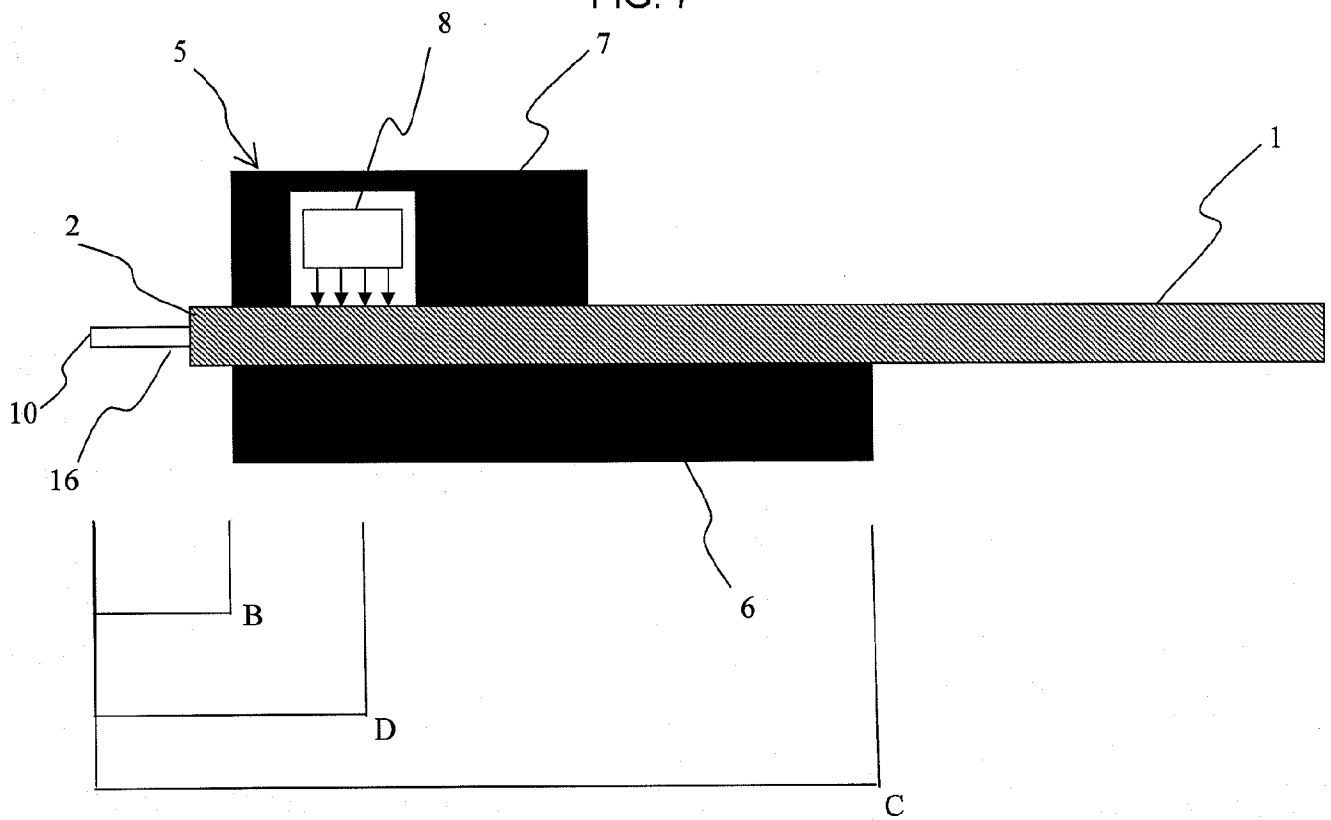


FIG. 8A

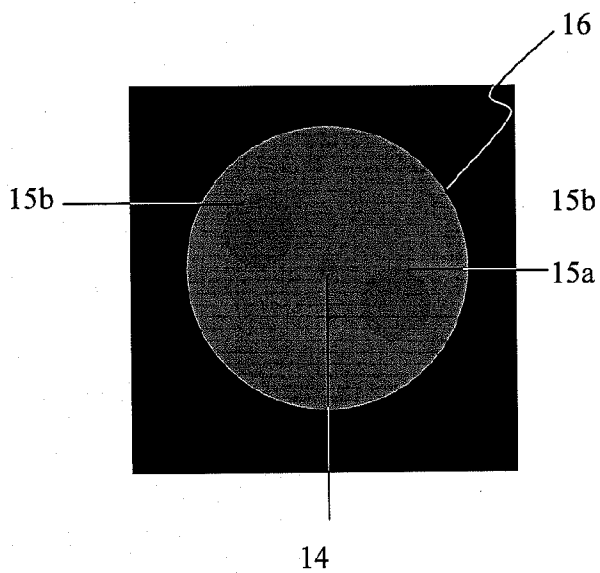


FIG. 8B

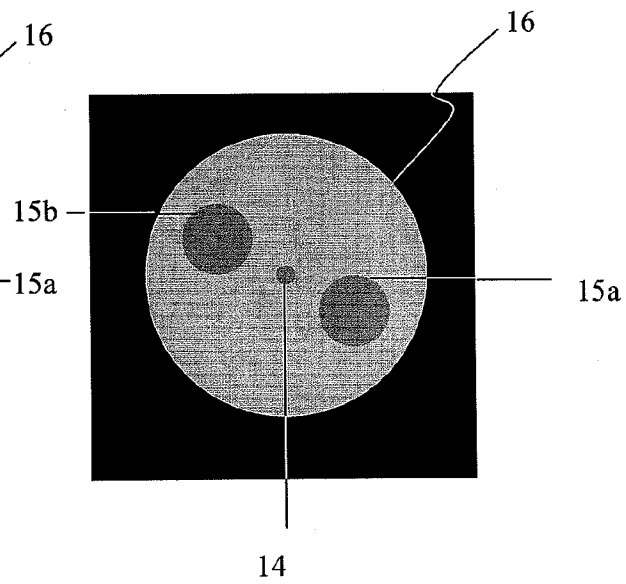


FIG. 9A

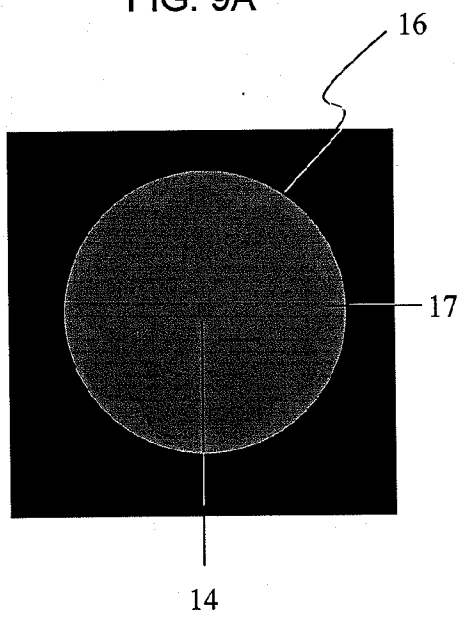
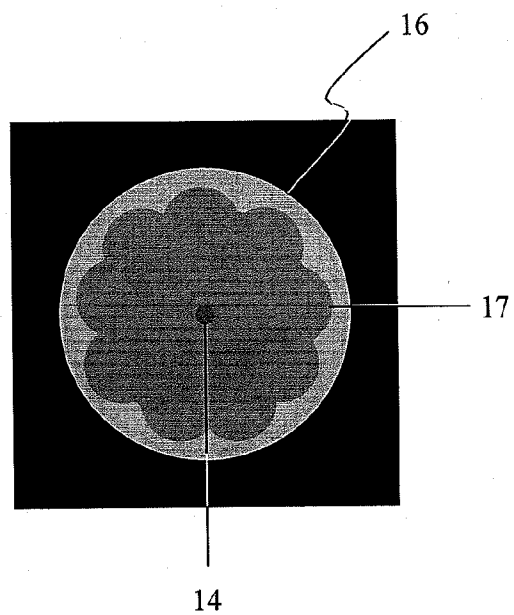


FIG. 9B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/032885

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G02B 6/24 (2011.01)

USPC - 356/508

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - G01B 11/00; G02B 6/24, 26, 38, 255 (2011.01)

USPC - 65/407, 501; 356/508; 385/15, 52, 97, 98

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005/0254754 A1 (HUANG et al) 17 November 2005 (17.11.2005) entire document	1-39
Y	WO 2010/039951 A1 (ZHENG et al) 08 April 2010 (08.04.2010) entire document	1-39
Y	US 3,808,549 A (MAURER) 30 April 1974 (30.04.1974) entire document	10,12,13,28,30,32,33
Y	US 5,013,345 A (ITOH et al) 07 May 1991 (07.05.1991) entire document	20,22,23,38

☐ Further documents are listed in the continuation of Box C.

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22 June 2011

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