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ABSTRACT

A micro-optical device for combining optical signals of similar or different wavelengths is described wherein, an array of light sources are collimated, directed to propagate along a similar path, and coupled into an optical fiber through a single lens. The optical coupling module can be constructed in various ways to achieve the desired configuration. One example is a single plastic-injection molded part, containing all of the mechanical alignment features, an array of collimating lenses, and a fiber coupling lens housed within a fiber optic connector ferrule.

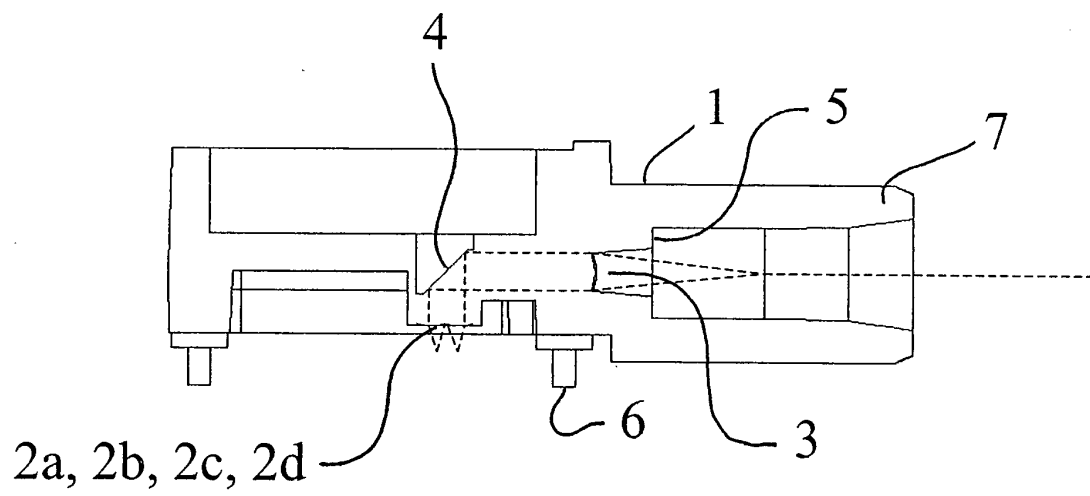


Fig. 1

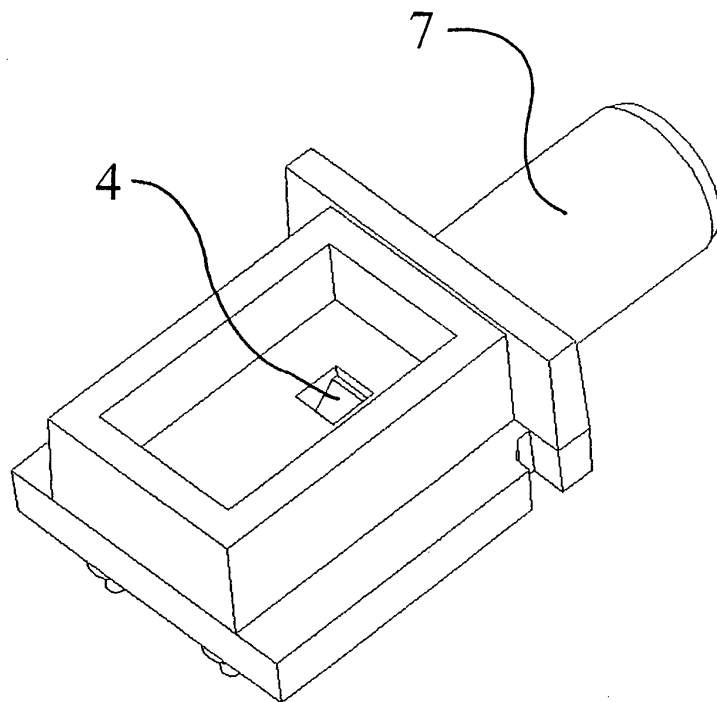


Fig. 2

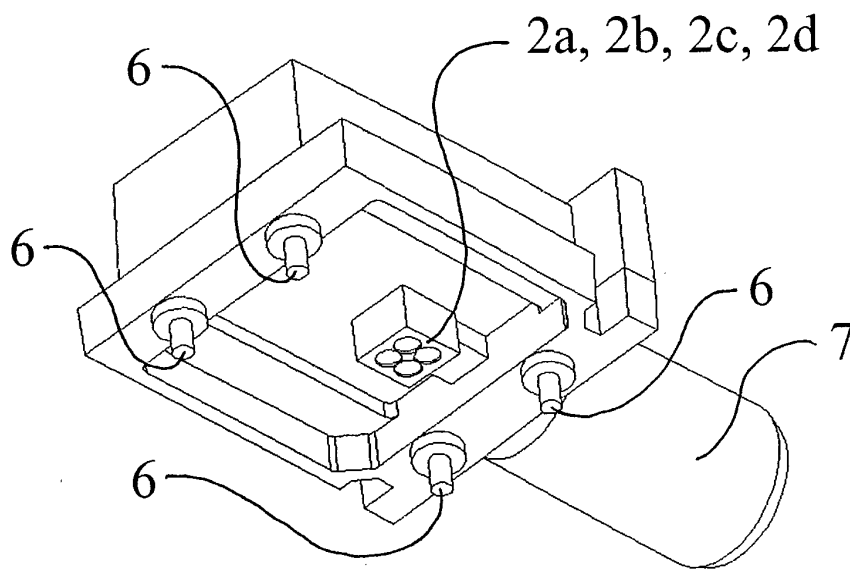


Fig. 3

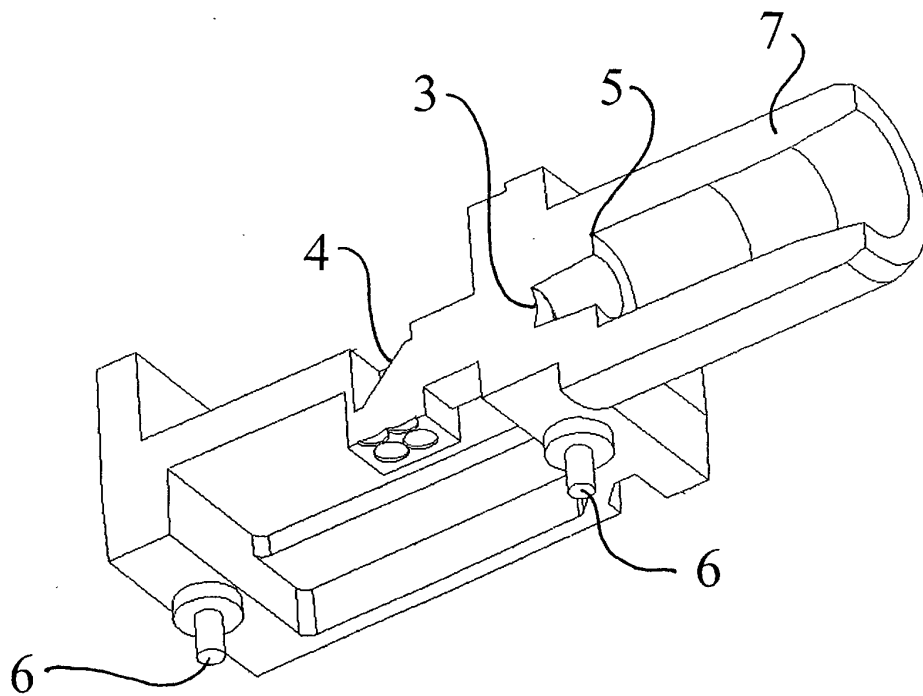


Fig. 4

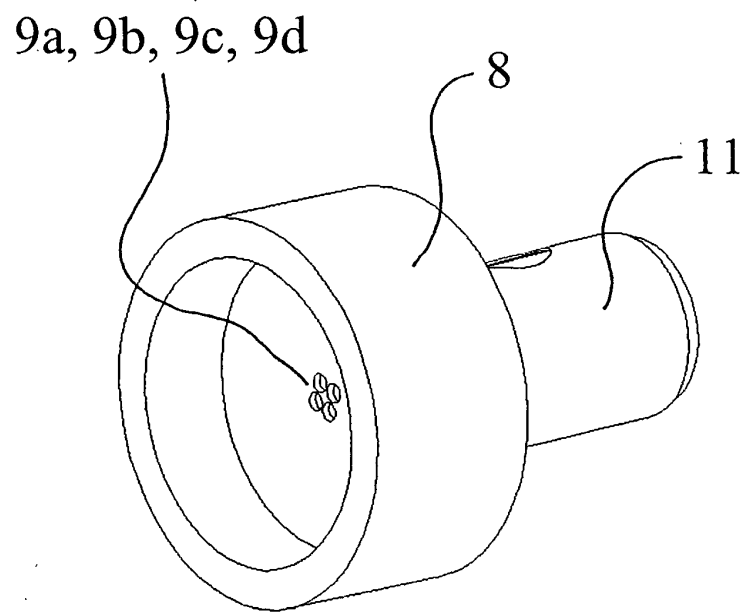


Fig. 5

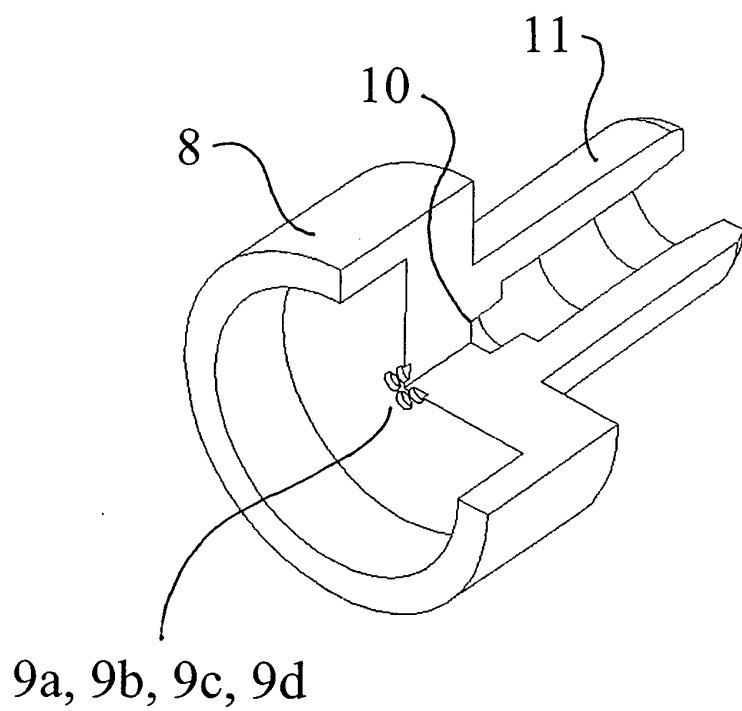


Fig. 6

1 MICRO-OPTICAL COMBINER DEVICE

2 PROBLEM THE INVENTION OVERCOMES

3 Most combiner devices are used as wavelength division multiplexers. Current
4 wavelength division multiplexed (WDM) devices are designed using dielectric filters or
5 expensive waveguides. The combiner/WDM device described herein utilizes plastic-mold
6 injection to create a compact device capable of combining multiple optical signals into a single
7 optical fiber. While a single molded device can be constructed to create the present
8 invention, two or more parts can be combined to accomplish the same function, and may be
9 necessary to achieve certain environmental conditions.

10 DETAILED DESCRIPTION OF THE INVENTION

11 Background of the Invention

12 1. Field of the Invention

13 The present invention pertains to optical communications. More particularly, this
14 invention relates to an optical multiplexing device which spatially combines multi-wavelength
15 light from a plurality of lasers into an optical fiber. In certain preferred embodiments, the
16 improved multiplexing device of the present invention is particularly suited for wavelength
17 division multiplexing systems for the fiber-optic data-communications and telecommunications
18 systems.

19 2. Description of the Related Art

20 In wavelength division multiplexed optical communication systems, many different
21 optical wavelength carriers provide independent communication channels in a single optical
22 fiber. Future computation and communication systems place ever-increasing demands upon
23 communication link bandwidth. It is generally known that optical fibers offer much higher
24 bandwidth than conventional coaxial communications; furthermore a single optical channel
25 in a fiber waveguide uses a small fraction of the available bandwidth of the fiber (typically a
26 few GHz out of several tens of THz). By transmitting several channels at different optical

1 wavelengths into a fiber (i.e., wavelength division multiplexing, or WDM), this bandwidth may
2 be more efficiently utilized.

3 An optical multiplexing device combines or separates multiple light signals with varying
4 optical wavelengths. The optical multiplexing device has applications for both dense and
5 coarse wavelength division multiplexing (DWDM & CWDM) for both multi-mode and signal-
6 mode fiber optic data communications and telecommunications. Multiple wavelength light
7 sources are combined into a single optical path for transmission.

8 SUMMARY OF THE INVENTION

9 One of the key features of the present invention is to provide a compact and cost
10 effective optical multiplexer for both single-mode or multimode fiber optic communication
11 systems.

12 Another feature of the present invention is to minimize optical loss due to divergence
13 of light between the source coupling optics and the fiber optic connector coupling optics.

14 Another feature of the present invention is to minimize reflections directly back to the
15 same focal position they were emitted from.

16 Another feature of the present invention to integrate a fiber optic connector within the
17 optical module, to passively align an optical fiber to the coupling optic.

18 The present invention is comprised of a plastic molded coupling module consisting of
19 a plurality of lenses, one lens for focusing several geometrically placed collimated beams onto
20 the fiber and one or more lenses for collimating light from lasers or fibers and a means for
21 geometrically arranging the plurality of collimated beams for maximum coupling efficiency into
22 the fiber.

23 The plastic molded coupling module is formed by integrating an aspherical on-axis,
24 offset collimating lens array, a redirectional mirror, a coupling lens, a fiber optic connector,
25 and mechanical features for alignment of the optical part to either an array of light sources or
26 an optical fiber array, all within a single part.

1 BRIEF DESCRIPTION OF THE DRAWINGS

2 Fig. 1 shows a cross-section side view of the WDM optical multiplexer;

3 Fig. 2 shows an isometric top view of the WDM device;

4 Fig. 3 shows an isometric bottom view of the WDM device;

5 Fig. 4 shows a cross-sectional isometric side view of the WDM device;

6 Fig. 5 shows an isometric view of an alternative embodiment of the WDM device; and

7 Fig. 6 shows an isometric cross-sectional view of an alternative embodiment of the
8 WDM device.

9 DETAILED DESCRIPTION OF THE INVENTION

10 Figs. 1 - 4 show an optical combiner 1 that illustrates an embodiment of the present
11 invention. The combiner 1 in this embodiment shows four input collimating lenses 2a, 2b, 2c,
12 2d and output focusing lens 3. Light sources are located at the focal points of the four input
13 lenses and the light is collimated, reflected off a prism 4 and focused by the focusing lens 3
14 onto a spot at which a fiber is stopped 5. Pins 6 are located to aid in affixing the combiner
15 device 1 to the light sources. The integrated ferrule 7 enables one to place a fiber optic cable
16 into the pre-aligned connector.

17 This combiner device has the ability to combine individual light signals into a single
18 optical path that can be directed towards an optical fiber. Matching the NA of the larger lens
19 3 and the NA of the fiber inserted at the fiber stop 5, as well as the spot size of the focused
20 beam being made smaller than the fiber core couples a maximum amount of the collimated
21 light into the fiber. Similarly, by arranging four (in this embodiment) collimating lenses 2a, 2b,
22 2c, 2d of a size small enough to fit inside the diameter of the focusing beam, and matching
23 their NA to the light sources, the maximum amount of light will couple into the collimated
24 beam.

25 Figs. 5 and 6 show an alternative embodiment for combining multiple optical signals
26 8, which does not include a prism for translating the optical beams from one axis to another.

1 This particular embodiment is beneficial for mating to a standard "TO" style laser chip
2 package. Similar to the embodiment described in Figs. 1-4, the embodiment shown here
3 utilizes a two-dimensional array of lenses 9a, 9b, 9c, 9d for collimating the input light signals,
4 a single focusing lens 10, and a fiber connector 11 that allows one to place a fiber optic cable
5 into the pre-aligned connector.

6 Unique and Key Features:

7 Manufacturing throughput Replication procedures are extremely fast, thus reducing
8 the overall cost of the manufactured device.

9 Passive Alignment All of the optical components within the multiplexer could utilize
10 passive alignment mechanisms.

11 Monolithic Coupling Optics Each optical coupling and redirection component is
12 integrated within a single monolithic plastic-molded device.

13 Cost Reduction Fewer parts are required such as filters and reflector blocks

14 Offset Launch Spots may be focused on a section of the fiber which is offset from the
15 center of the fiber, thus creating an offset launch condition, which is known by those skilled
16 in the art to produce a better condition for resisting modal partition noise.

17 Possible Alternative Versions:

18 Potential applications:

- 19 1) Wavelength division multiplexing/demultiplexing (WDM)
- 20 2) Optical signal routing
- 21 3) Spectroscopy
- 22 4) Biological and chemical integrated optical sensors
- 23 5) Optical computing

24 The foregoing description of the invention has been presented for purposes of
25 illustration and description and is not intended to be exhaustive or to limit the invention to the
26 precise form disclosed. Modifications and variations are possible in light of the above

1 teaching. The embodiments were chosen and described to best explain the principles of the
2 invention and its practical application to thereby enable others skilled in the art to best use
3 the invention in various embodiments and with various modifications suited to the particular
4 use contemplated.

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