(12) UK Patent Application (19) GB (11) 2 139 819 A

(43) Application published 14 Nov 1984

(21) Application No 8324605

(22) Date of filing 26 Jan 1981

Date lodged 14 Sep 1983

(30) Priority data

(31) 59306 (32) 4 Feb 1980 (33) IL
60923 26 Aug 1980

(60) Derived from Application No 8102259 under Section 15(4) of the Patents Act 1977

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(51) INT CL$^3$
**H01L 41/00**

(52) Domestic classification
**H2A** GD
**G2J** GEE
**U1S** 1915 H2A

(56) Documents cited
**GB 1526807**

(58) Field of search
**H2A**
**G2F**

# (54) Piezoelectric apparatus for positioning of optical fibres

(57) Apparatus for selectably positioning free end 28 of an optical fibre 18 along a range of positions comprises a bender assembly including at least one piezoelectric bender element 20 having a first end 26 associated with the fibre end 28 and a second end mounted on a support 22. Application of electrical energy to the piezoelectric bender element causes it to assume a selected position along the range of positions. Various embodiments of bender assemblies are described, e.g. in Fig. 3 (not shown) three bender elements are arranged to provide movement in three dimensions.

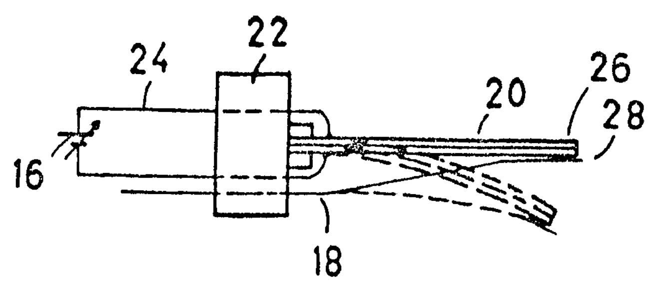


FIG 1

GB 2 139 819 A

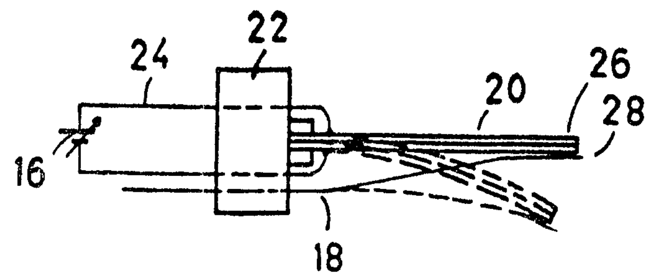


FIG 1

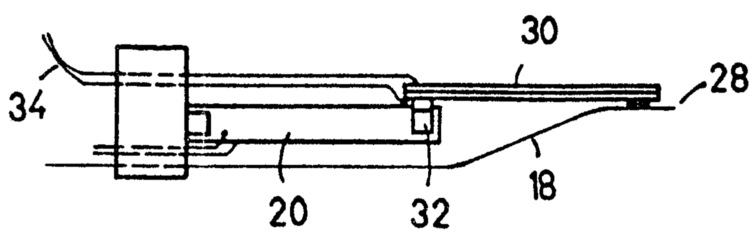


FIG 2

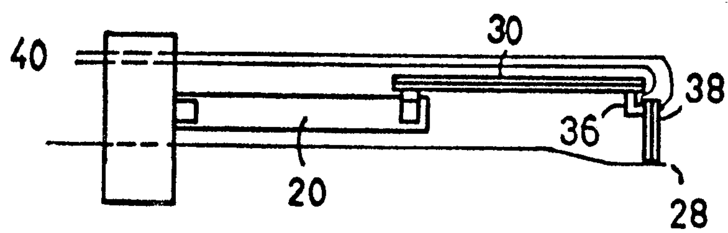


FIG 3

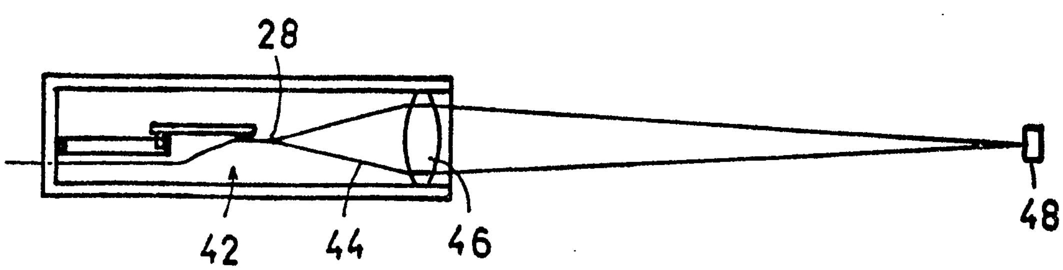


FIG 4

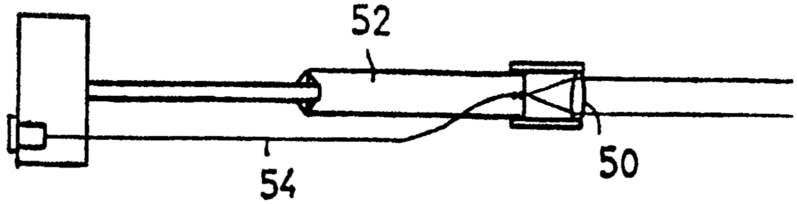


FIG 5

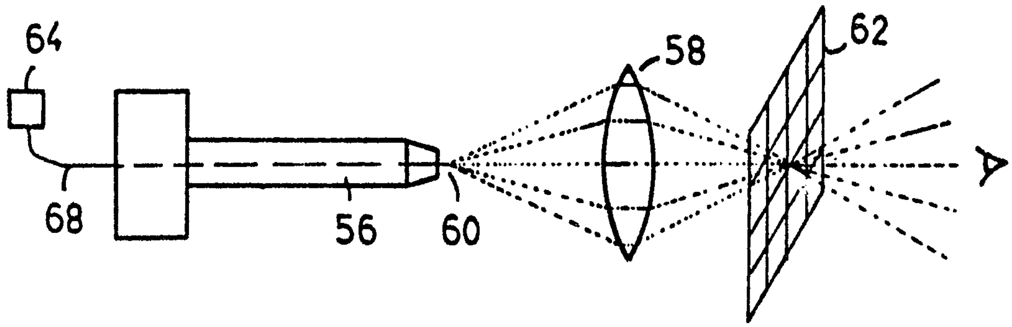


FIG 6

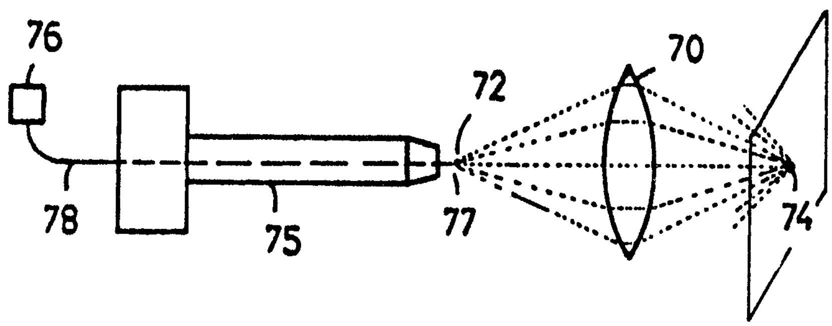


FIG 7

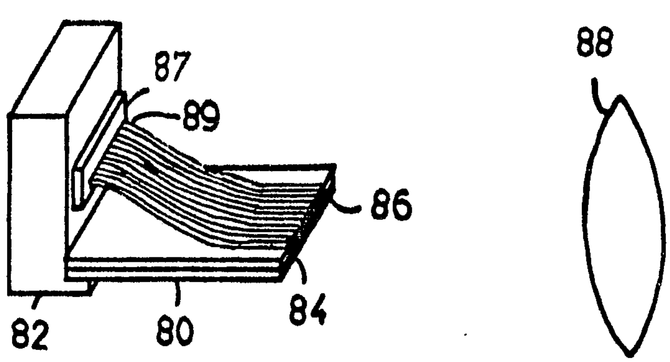


FIG 8

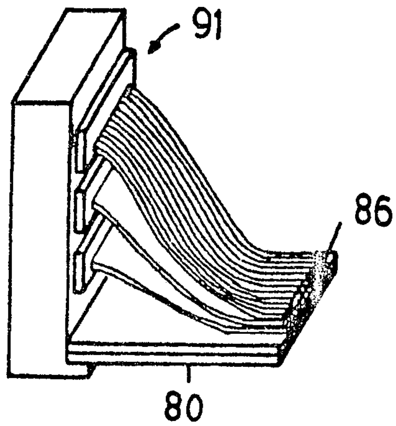


FIG 9

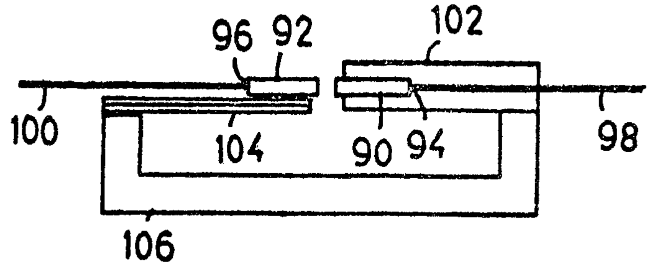


FIG 10

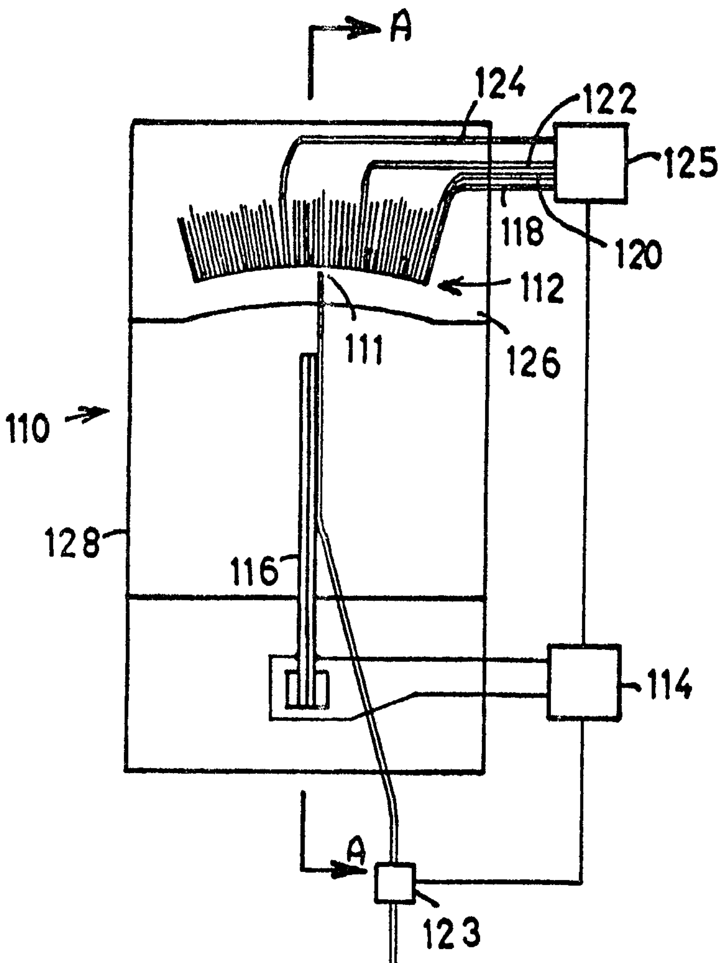


FIG 11A

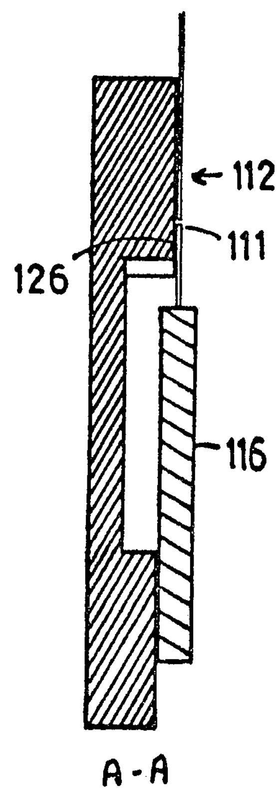


FIG 11B

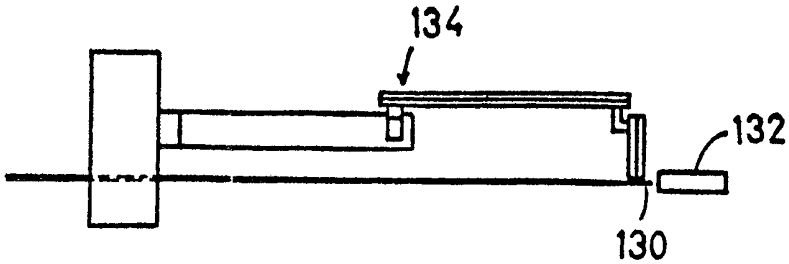


FIG 12

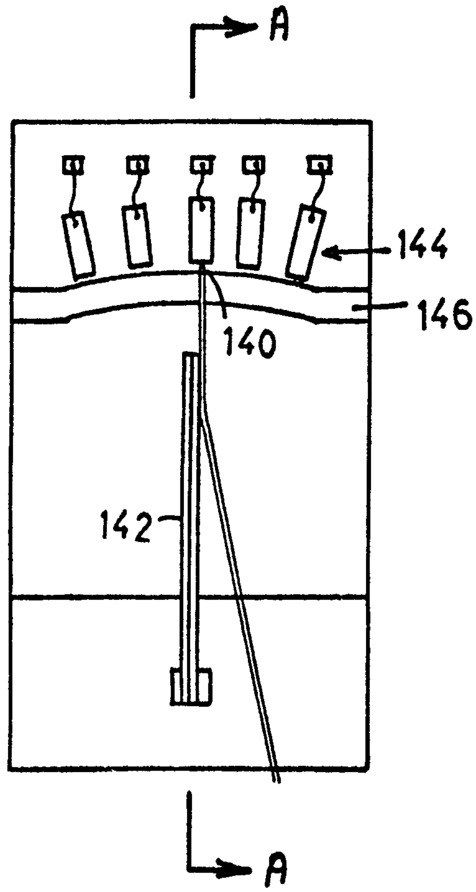


FIG 13A

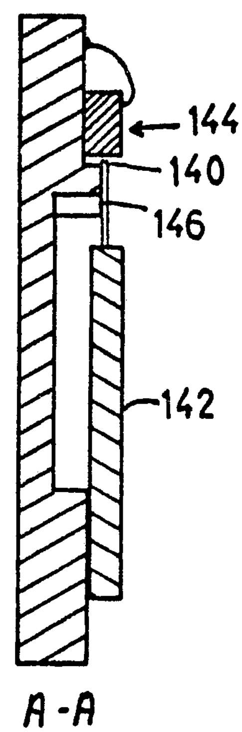


FIG 13B

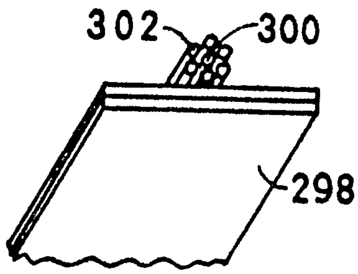


FIG 15

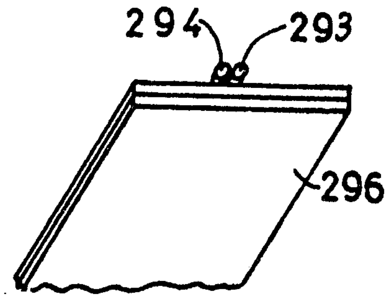


FIG 14

SPECIFICATION

**Piezoelectric apparatus for positioning of optical fibers**

*Field of the invention*

The present invention relates to optical fiber communication, and more particularly to optical fiber switching and interconnections.

*Background of the invention*

In recent years optical fibers have come into widespread use in a wide variety of applications and particularly in communications. The efficient utilization of optical fibers in many applications is dependent on the ability of associated apparatus to accurately and repeatably position optical fiber ends. Presently various mechanical devices such as x-y-z translators, concentric tubing and V-groove assemblies are employed for positioning of the optical fiber ends.

It has been proposed to employ a single piezoelectric bender element as a two position switch for an optical fiber. See Y. Ohmori & H. Ogiwara, Applied Optics, Vol. 17, No. 22, P. 3531. This reference does not contain any suggestion of using such a bender element for selectable positioning along a range of positions.

The mechanical apparatus presently used for positioning of optical fibers involves significant disadvantages in terms of cost, design limitations and reliability. The inadequacies of presently known optical fiber positioning apparatus are believed to limit the introduction of optical fiber technology into many other possible applications.

The present invention seeks to overcome the disadvantages of the prior art apparatus for positioning optical fibers which is characterized by greatly improved performance characteristics, design flexibility and economy and significantly smaller size.

As viewed from one aspect the invention provides apparatus for selectably positioning an optical fiber end comprising:

a bender assembly including at least first and second piezoelectric bender elements arranged in a series arrangement for bending motion in different directions, said bender assembly having a free end thereof arranged for association with at least one optical fiber end and a mounting end thereof located at a reference position.

As viewed from another aspect the invention provides apparatus for selectably positioning an optical fiber end at a selectable positon along a range of positions comprising:

a bender assembly including at least one piezoelectric bender element, said bender assembly having a free end thereof arranged for association with at least one optical fiber end, for selectable positioning thereof along said range of positions, and a mounting end thereof located at a reference position:

at least one optical fiber, having a free end adjacent said bender assembly and a fixed end; and

at least one radiation source arranged for selectable radiation communication with said at least one optical fiber,

and wherein said at least one radiation source comprises a plurality of radiation sources.

The present invention will be more fully understood and appreciated from the following detailed description taken in conjunction with the drawings in which:

*Figure 1* illustrates a one-dimensional optical fiber end positioning device constructed and operative in accordance with an embodiment of the present invention;

*Figures 2* and *3* illustrate respective two- and three- dimensional counterparts of the device illustrated in Figure 1;

*Figure 4* is a schematic illustration of a directable transmitter;

*Figure 5* is a schematic illustration of a transmitter constructed and operative in accordance with an alternative embodiment of the invention;

*Figure 6* illustrates display apparatus employing positioning devices of the present invention;

*Figure 7* illustrates detecting apparatus employing positioning devices of the present invention;

*Figure 8* illustrates a one-dimensional optical fiber end positioning device associated with a single array of optical fibers;

*Figure 9* illustrates a one-dimensional optical fiber end positioning device associated with a plurality of arrays of optical fibers;

*Figure 10* illustrates optical fiber positioning apparatus employing rod lenses;

*Figure 11A* illustrates a multi-position selector for coupling one optical fiber to a selected one of a plurality of optical fibers;

*Figure 11B* is a sectional view taken along lines A - A of Figure 11A;

*Figure 12 illustrates coupling of an optical fiber to a radiation transmitter.*

*Figure 13A* illustrates coupling of an optical fiber to a selected one of a plurality of radiation transmitters;

*Figure 13B* is a sectional view taken along lines A - A of Figure 13A.

*Figures 14* and *15* are pictorial illustrations of arrangements of optical fibers associated with piezoelectric bender assemblies in accordance with the present invention.

*Detailed description of the invention*

The preferred embodiment of the invention will now be described with reference to Figures 1 - 15 which illustrate a variety of constructions thereof suitable for different applications.

Referring now to Figure 1 there is seen apparatus for positioning an optical fiber end constructed and operative in accordance with a preferred embodiment of the present invention and comprising a generally elongate piezoelectric bender element 20 which is mounted at a first end thereof onto a base 22. The piezoelectric bender element 20 may be of conventional construction and manufacture such as a G-1278 Lead Zinconate-Titanate Thin Sheet piezoceramic manufactured by Gulton Industries of Metuchen, New Jersey, U.S.A. Leads 24 associated with the piezoelectric bender element may be connected to any suitable source of electrical voltage for controlling the position of the free end 26 of the bender element.

In accordance with the present invention, the free end 28 of an optical fiber 18 is attached as by glueing, a clamping or by any other suitable means onto the free end 26 of the bender element 20 or adjacent thereto for motion together therewith. Figure 1 illustrates bender element 20 in a straight orientation at rest when the bender element is de-energized and curved to one side when a voltage of a first polarity is applied to leads 24 by means of a selectable voltage source 16. It may be appreciated that normally the bender element may also be bent in an opposite direction by application of a voltage of an opposite polarity to leads 24. Furthermore any desired position intermediate the two extreme bent positions may be realized by the application of a suitable voltage to the leads 24.

It is a particular feature of the present invention that piezoelectric bender elements 20 of the type employed herein display a generally linear and repeatable position in response to voltage inputs within part of their operative range. The position-voltage characteristics can be calibrated and an open loop control may thus be employed. Relatively complex control circuitry employing microprocessor technology may be employed to take into account the hysteresis behaviour of the position voltage curve of the bender elements. Conventional technology is available for this purpose.

Referring now to Figure 2, there is seen apparatus for positioning an optical fiber end along two dimensions. The apparatus comprises the apparatus of Figure 1 to which is attached at the free end of bender element 20 a second bender element 30 which is oriented such that its plane of bending lies perpendicular to the plane of bending of bender element 20. In the illustration, the apparatus of Figure 1 is shown rotated 90 degrees from the illustration of Figure 1 and bender element 30 is attached to the free end of bender element 20 by means of a mounting element 32 formed of metal or any other suitable material. Bender element 30 is provided with leads 34 which are coupled to position control circuitry (not shown). The free end 28 of the optical fiber is mounted on the free end of bender element 30.

Figure 3 shows apparatus for positioning an optical fiber end along three dimensions and comprises the apparatus of Figure 2 to which is attached by means of a second mounting element 36 a third bender element 38 at the free end of second bender element 30. Leads 40 are associated with the third bender element 38 and are coupled to position control circuitry (not shown). In practice third bender element 38 is oriented such that its bending plane is perpendicular to the bending planes of bender elements 20 and 30 and serves to position the free end 28 of the optical fiber which is attached to its free end for focussing purposes. Bender elements 20 and 30 may be moved through their position ranges to provide a scanning function.

It is appreciated that the bender elements forming a multi-element bender assembly need not necessarily be arranged in perpendicular planes. Instead it may be sufficient that their directions of motion have respective perpendicular components.

Figure 4 shows a simplified version of a transmitter useful in the present invention and comprising a selectable position modulatable light source 42 which is substantially similar to those illustrated in Figures 1, 2 and 3. The free end 28 of the optical fiber provides a beam of electromagnetic radiation 44 which impinges on a lens 46 which focusses the beam at a location which is selected to correspond to a receiver 48. The position of the optical fiber end 28 determines the location of the impinging focused beam.

Reference is now made to Figure 5 which illustrates a transmitter substantially similar to that illustrated in Figures 1, 2 and 3 with the difference being that here the lens 50 is mounted on the free end of the bender element 52 in front of the end of the fiberoptic conduit 54 and thus moves together with the free end of the bender element. Beam directing is achieved by changing the direction of the free end of the bender element. A rod lens may be used instead of the lens 50.

Alternatively, the elements described in Figures 4 and 5 may be utilized as directable radiation detectors.

Figure 6 illustrates one of the applications of the positioning apparatus illustrated in Figures 1, 2 and 3. In Figure 6 two dimensional positioning apparatus 56, such as that illustrated in Figure 2, is associated with a lens 58 which images light emerging from the free end 60 of the optical fiber onto a screen 62. A light source 64 which communicates with the opposite end of the optical fiber 68 supplies desired radiation which may be positioned on the screen or scanned thereover as desired, similar to the raster scan of a television but slower.

The apparatus of Figure 6 is particularly suitable for use in slow scan applications in which cathode ray tubes are presently employed such as in Electrocardiographs.

A radiation detector may be constructed using the positioner of the present invention as illustrated in Figure 7. A lens 70 provides an image 72 of an object 74. Positioning apparatus 75 such as that illustrated in any of Figures 1, 2 and 3 positions the end 77 of the optical fiber 78 to the image location so as to enable light from the image to be transmitted along the optical fiber 78 to a detector 76.

In accordance with a preferred embodiment of the present invention, a plurality of images of radiation sources may be provided by lens 70. The positioning apparatus 75 is then operative to selectably and changeably position the optical fiber end at a selectable image, thus providing a directable receiver.

A multi-fiber end one dimensional scanner is illustrated in Figure 8 and comprises a relatively wide piezoelectric bender element 80 mounted on a base 82 and having associated with the free end 84 thereof a one-dimensional array of optical fiber ends 86. Oscillation of bender element 80 along one dimension provides a raster scan of a scene imaged by a lens 88. A relatively fast scan may be provided in this manner. The optical fibers may be connected at their opposite ends 89 to a linear detector array 87.

As seen in Figure 9, a plurality of arrays of optical fiber ends may be associated with a single bender element 80. In such a way a color television tyoe camera may be constructed by employing detectors 91 having different spectral responses. Similarly a color television type camera may be constructed on the basis of the apparatus illustrated in Figure 8 by employing optical fiber ends transmitting spectrally different light or detectors of different spectral response in array 87.

It may be appreciated that by replacing the detectors in the apparatus of Figures 8 and 9 with light sources, a raster scanned display may be provided.

Referring now to Figure 10 which illustrates selectable switching and coupling apparatus employing optical fiber ends, rod lenses 90 and 92 are connected to the free ends 94 and 96 of respective optical fibers 98 and 100. Rod lenses 90 and 92 are mounted on the free ends of respective piezoelectric bender elements 102 and 104 which are arranged to have perpendicular bending planes and are mounted onto a frame 106. It is noted that the bender elements are employed to selectably vary the direction of the rod lenses. In the illustrated embodiment, when the rod lenses are directed parallel, radiation transmission therebetween is permitted and when they are directed in different directions, little or no such transmission occurs.

It is noted with respect to the embodiments illustrated in Figure 10 that a plurality of bender elements arranged in series in the sense of Figures 1, 2 and 3 may be employed. Also a plurality of optical fiber ends may be mounted on each bender element.

Reference is now made to Figures 11A and 11B which illustrate an optical fiber switch 110 which is operative to selectably place an optical fiber end 111 in a desired alignment with a selectable one of an array 112 of optical fiber ends. In the illustrated construction a one-dimensional positioning device similar to that illustrated in Figure 1 is employed for positioning of optical fiber end 111 and the array 112 of optical fiber ends are arranged in the bending plane of fiber end 111 in a radial orientation, it may be appreciated that control apparatus 114 may be provided for applying a desired voltage to the bender element 116 of the positioning device to effect alignment for fiber end 111 with a desired fiber end in array 112 for radiation transmission therewith.

All optical fiber ends 111 and 112 lie on flat surface 126 of the base 128 which produces the needed alignment of fibers in the plane parallel to surface 126. Again, two dimensional benders can be utilized to eliminate the need for surface 126 and a third bender element may be used to adjust the fiber end-to-end distances. The surface 126 may be grooved in order to define discreet positions for the fiber ends 112 for precise alignment thereof with fiber end 111.

Some of the fiber ends 112 may be used for calibration purposes. Suppose that fibers 118, 120, 122 and 124 are connected to a light source 125 having different light characteristics which can be distinguished from light emerging from the other fiber ends 112, and having part of the light entering fiber end 111 detected by detector 123. By scanning the fiber end 111 from a position facing fiber 118 to a position facing the end of fiber 120, the different voltages applied to the piezoelectric element 116 may be recorded while the light of source 125 is reached peak value on detector 123. By extrapolation, the voltage needed to reach a position facing any of the fiber ends 112 may be calculated. Fibers 122 and 124 may serve to increase the accuracy of extrapolation.

The hysteresis behavior of the position-voltage characteristics of the piezoelectric element 116 will be overcome by letting the element travel a sufficient distance to have element 116 reach its linear characteristics before fiber end 111 comes to a position facing fiber 118.

Similar calibration can be achieved by replacing detector 123 with a light source and light source 125 with a detector.

Control circuitry 114 may conveniently comprise a microprocessor of conventional construction which is programmed to carry out the desired functions.

Reference is now made to Figure 12 which illustrates the selectable coupling of an optical fiber end 130 to a light source 132 such as a laser diode. The optical fiber end 130 may be conveniently mounted at the free end of a positioning device 134, typically a three dimensional positioning device of the type illustrated in Figure 3 and is positioned to face the light source 132 at a desired position relative thereto.

A further refinement of the apparatus of Figure 12 is illustrated in Figures 13A and 13B which illustrate apparatus for selectable coupling an optical fiber end 140 to a selected one of a plurality of light sources 144. Such an arrangement is particularly useful with laser diodes which are known to have limited lifetimes which are sometimes shorter than a desired servicing cycle. In such applications the operation of a bender element 142 of the type illustrated in any of Figures 1, 2 and 3 can be controlled to shift the fiber end to a new light source when the brightness of the old light source falls below a predetermined theshold.

Control of element 142 may be simply achieved by adjusting for maximum light to enter the fiber. Platform 146 is used together with a curved arrangement of lasers 144 to establish a minimum distance between the output area of the lasers and the center of the fiber end. The need for platform 146 and the arrangement of lasers 144 can be eliminated by having a two or three dimensional positioner instead of one dimensional positioner 142. The laser array 144 and platform 146 may be constructed from a unitary piece of material for production cost savings.

The preferred piezoelectric bender element is catalog number G-1278 manufactured by Gulton Industries, Inc., of New jersey and is made of Zirconate Titanate. It has a piezoelectric constant as follows: $d_{31} = -270 \times 10(-12m)/v$. The thickness of the piezolectric bender element is selected to be 0.125 mm and its length is selected to be 25 mm. Its voltage requirement is 50 volts for producing a 1 mm movement. The light source is preferably a LED and the detector is P.I.N. Silicon.

Figure 14 illustrates an arrangement of a pair of optical fibers 293 and 294 arranged on the free end of bender element 296. Preferably one of the optical fibers is a data carrying fiber while the other carries control information for assisting in accurate aiming.

Figure 15 shows a plurality of optical fibers arranged on the free end of bender element 298. A center fiber 300 carries data while the remaining fibers 302 carry control signals for providing a very high level of aiming accuracy.

It will be appreciated by persons skilled in the art that the invention is not limited to the particular examples illustrated and discussed herein. Rather the scope of the present invention is defined only by the claims which follow.

CLAIMS

1. Apparatus for selectably positioning an optical fiber end comprising:

a bender assembly including at least first and second piezolectric bender elements arranged in a series arrangement for bending motion in different directions, said bender assembly having a free end thereof arranged for association with at least one optical fiber end and a mounting end thereof located at a reference position.

2. Apparatus according to claim 1 and also comprising beam forming means for association with said at least one optical fiber end.

3. Apparatus according to claim 2 and wherein said beam forming means comprises a lens.

4. Apparatus according to claim 3 and wherein said lens comprises a rod lens attached to said at least one optical fiber end.

5. Apparatus according to any of claims 2-4 and wherein said beam forming means are arranged to receive radiation from said optical fiber end and to define a beam therefrom.

6. Apparatus according to any of claims 2-5 and wherein the position of said optical fiber end relative to said beam forming means determines the direction of a beam produced therefrom.

7. Apparatus according to claim 2 and wherein said beam forming means are arranged to receive light and to produce at least one real image thereof.

8. Apparatus according to claim 7 and wherein said bender assembly is operative to position said at least one optical fiber end at said real image.

9. Apparatus according to claim 7 and wherein said beam forming means provide a plurality of real images corresponding to a plurality of light sources and wherein said bender assembly is operative to selectably position said at least one optical fiber end at a desired one of said plurality of real images.

10. Apparatus according to any of the preceding claims and wherein said bender assembly comprises first and second bender elements having respective first and second bending planes which are arranged to lie perpendicular to each other.

11. Apparatus according to any of the preceding claims and wherein said bender assembly comprises first, second and third bender elements having respective perpendicular first, second and third bending planes.

12. Apparatus according to any of the preceding claims and wherein said at least one piezoelectric bender element comprises first, second and third bender elements arranged in a series arrangement.

13. Apparatus according to any of the preceding claims and wherein said at least one optical fiber is arranged to be coupled to a source of radiation at said fixed end.

14. Apparatus according to claim 13 and also comprising a phosphorescent display disposed in light receiving relationship with said free end of said at least one optical fiber.

15. Apparatus according to any of the preceding claims and wherein said optical fiber is arranged to be coupled to a radiation detector at said fixed end.

16. Apparatus according to claim 14 and claim 13 and also comprising means for governing the operation of said bender assembly in accordance with an information bearing signal.

17. Apparatus according to any of the preceding claims and providing a visually sensible display.

18. Apparatus according to claim 13 and wherein said radiation source comprises a data source and a source of position control signals.

19. Apparatus according to any of claims 13-15 and wherein said at least one optical fiber comprises a plurality of optical fibers.

20. Apparatus according to claim 19 and wherein at least one of said plurality of optical fibers is a data carrying fiber and at least one of said plurality of optical fibers is a position control fiber.

21. Apparatus according to any of the preceding claims and also comprising means for modulating the radiation transmitted along said optical fiber.

22. Apparatus according to claim 21 and wherein said modulation is time dependent intensity modulation.

23. Apparatus according to any of the preceding claims and also comprising bender assembly control means for supplying voltage to said bender assembly for governing the orientation of the free end thereof.

24. Apparatus according to claim 23 and wherein said control means is operative for providing a raster scan.

25. Apparatus according to claim 23 and wherein said bender assembly control means is operative for governing the orientation of the free end thereof in a time dependent sequence.

26. Apparatus according to claim 19 and wherein free ends of said plurality of optical fibers are arranged in a linear array.

27. Apparatus according to claim 26 and wherein said bender assembly is operative to provide a scanning motion of said linear array perpendicular to the axis thereof.

28. Apparatus according to claim 27 and also comprising means for providing a scanned representation of a space whose intensity as a function of time represents the radiation intensity over said space.

29. Apparatus according to any of claims 14-28 and wherein said plurality of optical fibers is

arranged in a plurality of linear arrays arranged to transmit light of different colors.

30. Apparatus according to any of claims 13-29 and also comprising at least one radiation source arranged for selectable radiation communication with said at least one optical fiber.

31. Apparatus according to claim 30 and wherein said at least one radiation source comprises a plurality of radiation sources.

32. Apparatus according to claim 31 and wherein said plurality of radiation sources are arranged for radiation communication with said at least one optical fiber in a desired sequence.

33. Apparatus according to any of the preceding claims and also comprising at least one second optical fiber end arranged for selectable radiation communication with said at least one optical fiber end by means of suitable positioning of said at least one optical fiber end for providing switching.

34. Apparatus according to claim 33 and also comprising radiation defining means arranged intermediate said first and second optical fiber ends.

35. Apparatus according to claim 33 and wherein said radiation defining means comprise beam forming means.

36. Apparatus according to claim 34 and wherein said radiation defining means comprises a rod lens.

37. Apparatus according to any of claims 33-36 and wherein said at least one second optical fiber end comprises a plurality of second optical fiber ends.

38. Apparatus according to any of claims 26-37 and also comprising means for measuring the intensity of radiation travelling along optical fibers.

39. Apparatus according to claim 38 and also comprising feedback means responsive to the intensity of radiation measured by said measuring means for governing the positioning of said at least one optical fiber end.

40. Apparatus according to any of the preceding claims and also comprising microprocessor circuitry for governing the operation of said bender assembly.

41. Apparatus for selectably positioning an optical fiber end at a selectable swtiching position along a range of switching positions comprising:

a bender assembly including at least one piezoelectric bender element, said bender assembly having a free end thereof arranged for association with at least one optical fiber end, for selectable positioning thereof along said range of positions, and a mounting end thereof located at a reference position; and

at least one optical fiber, having a free end adjacent said bender assembly and a fixed end;

and wherein:

said range of positions includes at least one position intermediate two extreme positions.

42. Apparatus according to claim 41, and wherein said at least one optical fiber includes a data carrying fiber and a position control fiber.

43. Apparatus for selectably positioning an optical fiber end at a selectable position along a range of positions comprising:

a bender assembly including at least one piezoelectric bender element, said bender assembly having a free end thereof arranged for association with at least one optical fiber end, for selectable positioning thereof along said range of positions, and a mounting end thereof located at a reference position.

at least one optical fiber, having a free end adjacent said bender assembly and a fixed end; and

at least one radiation source arranged for selectable radiation communication with said at least one optical fiber,

and wherein said at least one radiation source comprises a plurality of radiation sources.

44. Apparatus according to claim 43 and wherein said plurality of radiation sources are arranged for radiation communication with said at least one optical fiber in a desired sequence.

45. Apparatus for selectably positioning an optical fiber end at a selectable position along a range of positions comprising:

a bender assembly including at least one piezoelectric bender element, said bender assembly having a free end thereof arranged for association with at least one optical fiber end, for selectable positioning thereof along said range of positions, and a mounting end thereof located at a reference position;

at least one optical fiber, having a free end adjacent said bender assembly and a fixed end; and

at least one second optical fiber end arranged for selectable radiation communication with said at least one optical fiber end by means of suitable positioning of said at least one optical fiber end, for providing switching,

and wherein said range of positions includes at least one position intermediate two extreme positions.

46. Apparatus according to claim 45 and also comprising radiation defining means arranged intermediate said first and second optical fiber ends.

47. Apparatus according to claim 46 and wherein said radiation defining means comprise beam forming means.

48. Apparatus according to claim 47 and whrein said radiation defining means comprises a rod lens.

49. Apparatus according to any of claims 45-48 and wherein said at least one second optical fiber end comprises a plurality of second optical fiber ends.

50. Apparatus according to any of claims 41-49 and also comprising means for measuring the intensity of radiation travelling along optical fibers.

51. Apparatus according to any of claims 41-50 and also comprising feedback means responsive to the intensity of radiation measured by said measuring means for governing the positioning of said at least one optical fiber end.

52. Apparatus according to any of claims 41-51 and also comprising microprocessor circuitry for governing the operation of said bender assembly.

New claims or amendments to claims filed on 22-5-84

Superseded claims 41-52

New or amended claims:-

41. Apparatus as claimed in claim 1 for selectably positioning an optical fiber end at a selectable switching position along a range of switching positions, said bender assembly having said free end thereof arranged for association with said at least one optical fiber end for selectable positions thereof along said range of positions;

at least one optical fiber, having a free end adjacent said bender assembly and a fixed end; wherein said at least one optical fiber includes a data carrying fiber and a position control fiber;

and wherein;

said range of positions includes at least one position intermediate two extreme positions.

42. Apparatus as claimed in claim 1 for selectably positioning an optical fiber end at a selectable position along a range of positions, said bender assembly having said free end thereof arranged for association with said at least one optical fiber end for selectable positioning thereof along said range of positions;

at least one optical fiber, having a free end adjacent said bender assembly and a fixed end;

at least one radiation source arranged for selectable radiation communication with said at least one optical fiber;

and wherein said at least one radiation source comprises a plurality of radiation sources.

43. Apparatus according to claim 42 and wherein said plurality of radiation sources are arranged for radiation communication with said at least one optical fiber in a desired sequence.

44. Apparatus as claimed in claim 1 for selectably positioning an optical fiber end at a selectable position along a range of positions, said bender assembly having said free end thereof arranged for association with said at least one optical fiber end for selectable positioning thereof along said range of positions;

at least one optical fiber, having a free end adjacent said bender assembly and a fixed one;

at least one second optical fiber end arranged for selectable radiation communication with said at least one optical fiber end by means of suitable positioning of said at least one optical fiber end for providing switching;

and wherein said range of positions includes at least one position intermediate two extreme positions.

45. Apparatus according to claim 44 and also comprising radiator defining means arranged intermediate said first and second optical fiber ends.

46. Apparatus according to claim 45 and wherein said radiation defining means comprise beam forming means.

47. Apparatus according to claim 46 and wherein said radiation defining means comprises a rod lens.

48. Apparatus according to any of claims 44-47 and wherein said at least one second optical fiber end comprises a plurality of second optical fiber ends.

49. Apparatus according to any of claims 41-48 and also comprising means for measuring the intensity of radiation travelling along optical fibers.

50. Apparatus according to any of claims 41-49 and also comprising feedback means responsive to the intensity of radiation measured by said measuring means for governing the positioning of said at least one optical fiber end.

51. Apparatus according to any of claims 41-50 and also comprising microprocessor circuitry for governing the operation of said bender assembly.

Printed in the UK for HMSO, D8818935, 9/84, 7102.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.