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(54) **Electro-optical terminations**

(57) An electro-optical termination is provided which enables an optical fibre to be efficiently coupled to a receiving or transmitting electrical circuit. The optical fibre may be a single strand or may consist of a large bundle of individual fibres. It is important to accurately align the optical fibre with an electro-optical converter and to facilitate this alignment, the converter is mounted on a small substrate 6, which is spaced apart by a predetermined amount from the end of a short fixed length 8 of optical fibre forming an integral part of the termination.

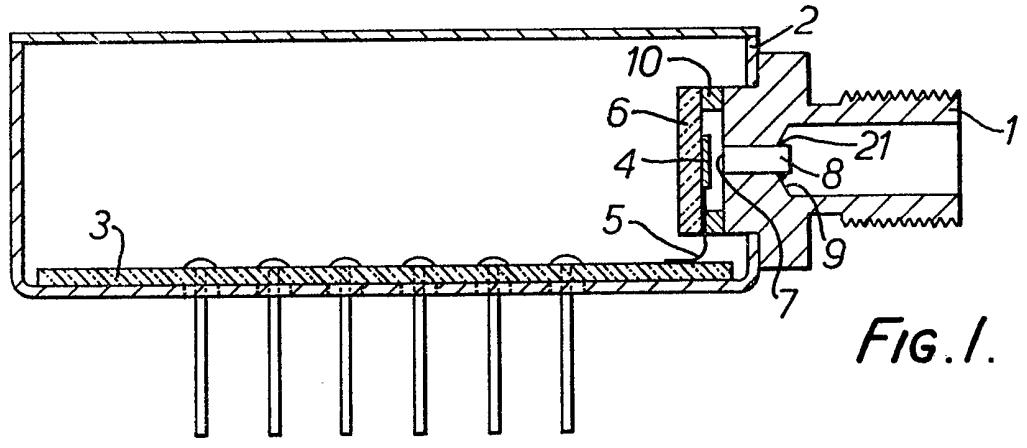

FIG. 1.

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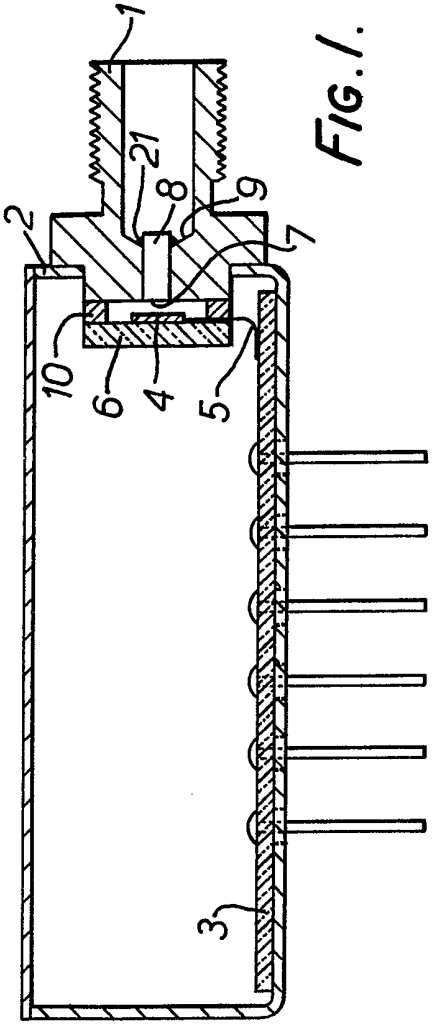
1
21
8
9
7
2
10
6
4
5
3

FIG. 1.

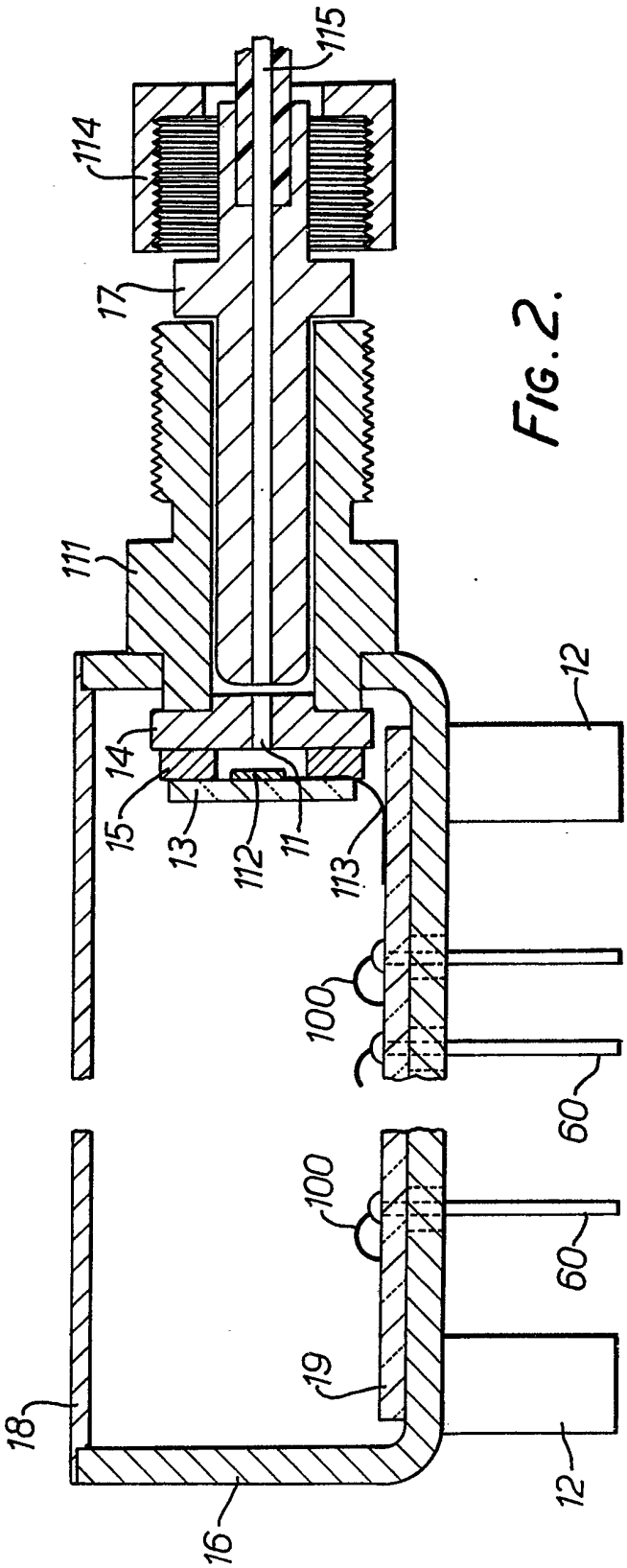
115
114
17
111
12
14
15
13
112
11
113
100
60
100
60
19
18
12
16

FIG. 2.

SPECIFICATION

Electro-optical terminations

This invention relates to electro-optical terminations and is specifically concerned with the termination of optical fibres. As is known, signals can be transmitted in optical form along thin strands of glass or glass like materials and that in certain circumstances transmission of signals in this way can be advantageous as compared with the conventional transmission of signals in electrical form. The use of optical fibres enables electrical isolation to be maintained and this can be of particular advantage in those instances when control signals are applied to very high voltage installations. Additionally, optical fibres exhibit a very wide bandwidth allowing very high frequencies and short pulses to be transmitted along them without serious degradation.

At each end of the optical transmission path, the signals are conventionally handled and processed as necessary in electrical form, and thus at each end of the transmission path it is necessary to convert the signal between its electrical and optical forms by means of suitable electro-optical terminations. This has proved difficult in practice because the very thin optical fibres must be very precisely aligned with associated electro-optical converter devices if the signal conversion is to be accomplished in an efficient manner. In previously known electro-optical terminations, it can be difficult and time consuming to achieve alignment in a regular and reliable manner. The present invention seeks to provide an improved electro-optical termination.

According to this invention an electro-optical termination includes an electro-optical device mounted on a surface of a substrate; spacer means attached to said surface and to a body having an aperture containing a length of optical fibre, the height of the spacer determining the separation of the electro-optically active surface of said device from the adjacent end of said aperture.

The electro-optical device may be such as to generate an optical signal in response to an electrical stimulation, in which case the electro-optical termination acts as a transmitter of optical signals, or alternatively, the electro-optical device may be such as to generate an electrical output signal in response to an optical stimulation received via the optical fibre and in this case the electro-optical termination acts as a receiver. In the former case, the electro-optical device conveniently takes the form of a light emissive semiconductor device such as a light emitting diode, and in the latter case, the electro-optical device could conveniently be a PIN diode.

Preferably the length of the optical fibre located in said aperture extends to and is flush with the surface of the body, which is adjacent to said device. In this way the separation of the electro-optically active surface of said device from the end of the optical fibre is determined by the height of the spacer.

The body may form an integral part of a connector for use with a detachable cable formed of optical fibre, or it may be instead attached to such a connector after the spacer and said device have been connected to it in a permanent manner.

The invention is further described by way of example with reference to the accompanying drawing.

Figures 1 and 2 show alternative embodiments of an electro-optical termination in accordance with the present invention.

The termination shown in Figure 1 is particularly suitable for use with an optical fibre having a relatively large diameter light transmissive core. The flexibility of an optical fibre is determined largely by the size of its core, and where the core is relatively large it is usually formed of a bundle of smaller fibres. In Figure 1, the connector 1 is arranged to receive a plug (not shown) which is permanently connected to the end of a relatively long and flexible optical fibre. The connector 1 is attached to part of the wall 2 of a chamber which houses an electrical circuit to which an optical signal received via the plug (not shown) is to be applied. In the present example, it is assumed that the circuit is formed in what is usually termed a hybrid circuit; that is to say, discrete components such as active devices in the form of transistors, diodes and capacitors are mounted on a rigid ceramic substrate with conductive tracks and resistors being formed by suitable metallisation of selected areas of the substrate. It is possible to make relatively complex electrical circuits in a very compact fashion using this kind of assembly. The technique is particularly applicable to very high frequency systems and in such cases, it is usual to mount the electrical circuit within an electrical conductive housing which provides the necessary degree of electrical shielding.

In Figure 1, the ceramic substrate 3 is connected to an electro-optical converter device 4 via thin flexible gold leads 5. One end of each of the leads 5 is bonded to terminal pads on the upper surface of the ceramic substrate 3, whilst the other ends are bonded to a major surface of a further ceramic substrate 6. The substrate 6 is relatively small and is typically formed of alumina. The electro-optical converter device 4 is a PIN diode, and as is known, the conductivity of such a diode is strongly dependent on the level of optical illumination falling upon it. In this case the converter device 4 is placed closely adjacent to one end 7 of a short length of optical fibre 8 which is permanently mounted in a channel formed at the inner end of the connector 1. The end 7 is flush with the surface of the connector 1, but the other end of the optical fibre 8 protrudes slightly from a collar 9, which is formed within the connector 1. In order to securely attach the fibre 8 to the connector, the outer cylindrical surface of the fibre may be initially metallised and held in place by means of solder 21 applied around the outside of its outer end. The substrate 6 is spaced apart from the end of the connector 1 by means of a spacer 10, which is in the form of a ring like

collar.

In assembling the termination, the gold tapes, 5, followed by the PIN diode 4 are first bonded to the substrate 6, and the spacer 10 is then attached to the same surface of the substrate so as to encircle the PIN diode. The short length of optical figure 8 is mounted within the connector 1 as previously described and its inner end 7 is ground flat and polished so as to be flush with the inner end face of the connector 1. The spacer 10 is then attached to the connector with its position being laterally adjusted so that the electro-optically sensitive region of the PIN diode is precisely aligned with the optical fibre 8. The lateral adjustment may be achieved by viewing the position of the PIN diode via the optical fibre 8 or alternatively the electrical output of the PIN diode can be monitored to achieve a maximum amplitude, and when alignment has been achieved, the spacer 10 is bonded permanently to the connector 1. The height of the spacer 10 is chosen in relation to the thickness of the PIN diode, so that the optically active surface of the diode is extremely close to the end of the optical fibre 8, but does not actually touch it. A similar method, using a LED, can be used for a transmitter module.

An alternative electro-optical termination is shown in Figure 2 and it takes a form in which it may be a little easier to accurately align the optical fibre with an electro-optical converter device. An electro-optical converter device 112 takes the form of a light emitting diode (in the case of a transmitter) or a photosensitive diode (in the case of a receiver) and is mounted on a small substrate 13, which has two gold tapes 113 attached to it. A small spacer 15, having typically a two millimetre diameter hole in its centre, is attached to the substrate 13, so that the converter device 112 lies within the hole. The spacer 15 is formed of alumina and is approximately .6 millimetres in thickness, and it is attached to the substrate 13 by a suitable adhesive so that the spacer, the substrate and the converter device are attached by means of an expoxy resin to an inner connector 14 which is composed of nickel plated mild steel, and the active area of the converter device 112 is aligned accurately, before the epoxy is fully cured, with a short length of optical fibre 11 mounted within a hole in the inner connector. This alignment can be achieved by viewing the active area of the converter device 112 along the optical fibre 11 and moving the converter device 112 laterally, together with the substrate 13 and spacer 15, until exact alignment is found. Typically, a concentricity of approximately five micrometres or better is required for the converter device when it forms part of a transmitter, but less accuracy is acceptable when it forms part of a receiver.

The optical fibre 11 is hermetically sealed into the central hole of the inner connector 14, so that its inner end is adjacent to the active area of the converter device 112. The device may be protected by a transparent coating, if desired. The protruding end of the optical fibre 11 is then polished flush with the face of the inner connector 14. The component parts 11, 13, 14, 15, 112 and 113 form an optical sub-unit which can be optically, electrically and mechanically tested prior to assembly into the main housing.

The housing 16 shown in Figure 2 forms part of a hybrid dual-in-line package. It is generally of a standard form, but additionally contains four relatively large fixing studs 12 and an outer optical connector 111. The connector 111 is arranged to accept a detachable optical plug 17 and the connector 111 is itself welded or brazed directly to the housing 16. The outer connector 111 and the fixing studs 12 are hermetically sealed into the housing 16 before the electro-optical converter device is fitted.

The circuit to which the converter device 112 is electrically connected conveniently takes the form of a conventional thick film circuit which is printed and assembled on a substrate 19 with two areas of conductor being positioned at one end of the substrate, so that the gold tapes 113 can be electrically connected to them. Electrically conductive epoxy or a thermo compression bonding technique may be used for this purpose. The circuit formed on the substrate 19 is designed to provide an electrical interface between the electro-optical device 112 and the output pins 60.

The termination is assembled as follows. Initially, the circuit formed on the substrate 19 is fixed into the housing 16 using a thermally conductive adhesive, such as a loaded epoxy resin. The connections from the substrate 19 are made to the pins 60 by means of thin bonded wires 100. The electro-optical converter device 112 is fixed into the housing by projection welding the optical sub-unit on to the end of the outer connector 111, and the gold tapes 113 are then fixed to their respective conductor pads on the substrate 19 as previously described. At this stage the termination can again be electrically and optically tested before the package lid 18 is hermetically sealed on to the housing 16 using a welded joint.

As before, the optical fibre which terminates at the termination may be a single fibre or a bundle of fibres. The optical fibre 115 terminates in a cylindrical plug 17 which is accurately machined so that its outer cylindrical surface fits closely into the outer connector 111. It is retained in place by means of a cap 114 which screws on to an outer thread formed on the surface of the outer connector 111.

It will be seen that accurate optical alignment is achieved in a relatively simple manner and it is necessary to machine only a very few components to an accurate standard. The dimensions which must be machined accurately comprise a) the internal bore of the outer connector 111, b) the outer diameter of the inner connector 14, which fits snugly into the bore of the outer connector 111, c) the concentricity of the hole in which the optical fibre 11 is located compared to the outer diameter of the inner connector 14, and d) the diameter of the hole in which the optical fibre 11 is fitted. It will be noted that the three major units,

which comprise the optical sub-unit, the circuit formed on the substrate 19 and the housing 16, can be fully tested before the lid 18 is finally attached. The whole termination is hermetically sealed in a manner which is capable of withstanding rigorous environmental conditions.

CLAIMS

1. An electro-optical termination including an electro-optical device mounted on a surface of a substrate; spacer means attached to said surface and to a body having an aperture containing a length of optical fibre, the height of the spacer determining the separation of the electro-optically active surface of said device from the adjacent end of said aperture.

2. A termination as claimed in claim 1 and wherein the length of the optical fibre located in said aperture extends to and is flush with the surface of the body, which is adjacent to said device.

3. A termination as claimed in claim 1 or 2 and wherein the body forms an integral part of a connector for use with a detachable cable formed of optical fibre.

4. A termination as claimed in claim 3 and wherein said connector is mounted on a housing after the electro-optical device has been attached to said body, the connector being so mounted that the said device is located within the housing.

5. A termination as claimed in claim 1 or 2 and wherein said body is attached to a connector for use with a detachable cable formed of optical fibre, the connector being mounted on a housing prior to the attachment of said body so that when said body is attached as aforesaid the electro-optical device is located within said housing.

6. A method of making an electro-optical termination including the steps of: mounting an electro-optical device on the surface of a substrate; attached spacer means to said surface; aligning said device with the end of an optical fibre located in a channel in a body; and securing said spacer means to said body when alignment has been achieved.

7. An electro-optical termination substantially as illustrated in and described with reference to Figure 1 or 2 of the accompanying drawing.

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