(12) UK Patent Application (19) GB (11) 2 053 462 A

(21) Application No **8018467**
(22) Date of filing **5 Jun 1980**
(30) Priority data
(31) **54/069968**
(32) **6 Jun 1979**
(33) **Japan (JP)**
(43) Application published
4 Feb 1981
(51) INT CL[3]
H04B 9/00
(52) Domestic classification
G1A AB C4 G14 G6 G8 P10 P17 P6 P7 P9 R7 S10 S4 S5
(56) Documents cited
None
(58) Field of search
G1A
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(54) A light source assembly, primarily for an optical communication system

(57) The operational reliability of an optical system, particularly an optical communication system, can be greatly improved by means of a light source assembly which comprises plurality of light sources S_1—S_4 each of which provides light at a different wavelength (λ_1—λ_4) from the others. An electrical switch enables only one of the light sources to be actuated at any time and is controlled so that when a fault is detected in the actuated light source a different light source is actuated in its place. Optical multiplexer 13 is coupled to receive the output from each light source so that the light from the actuated source is transmitted by the multiplexer into an optical fibre cable. In another embodiment there are pairs of light sources, the sources in each pair providing light at the same wavelength, but each pair providing different wavelength light from the others.

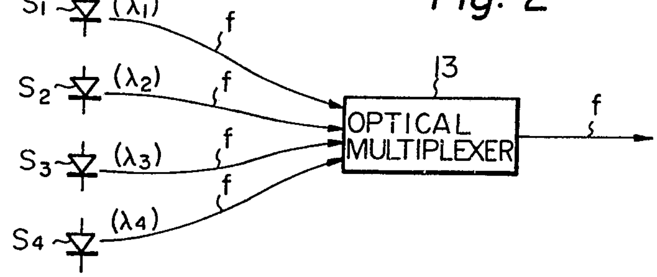

Fig. 2

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Fig. 1

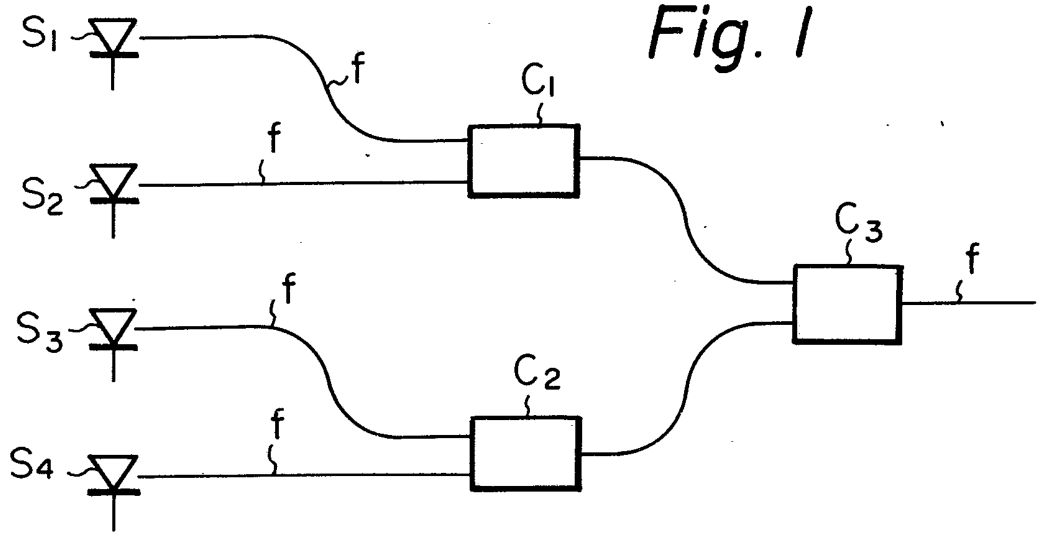

Fig. 2

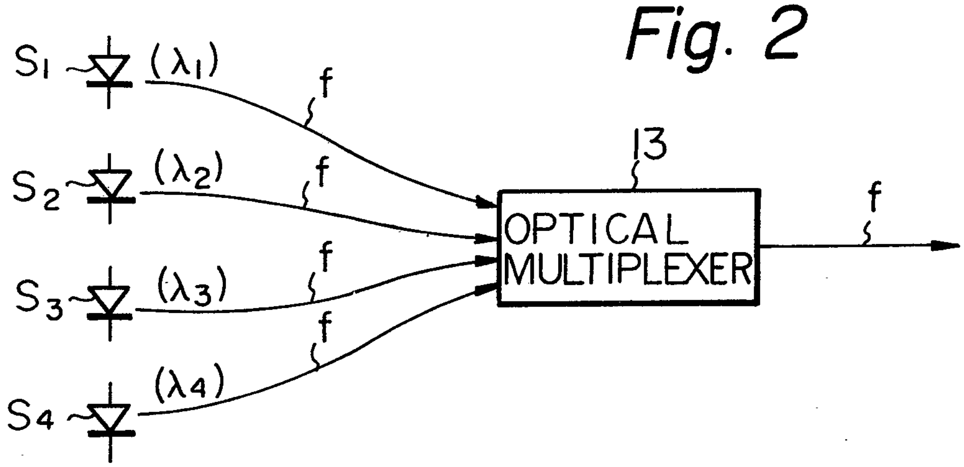

Fig. 3

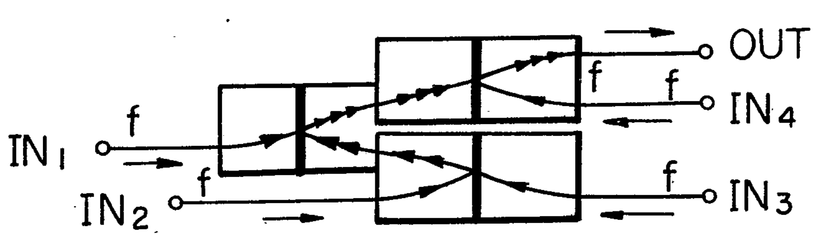

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Fig. 4

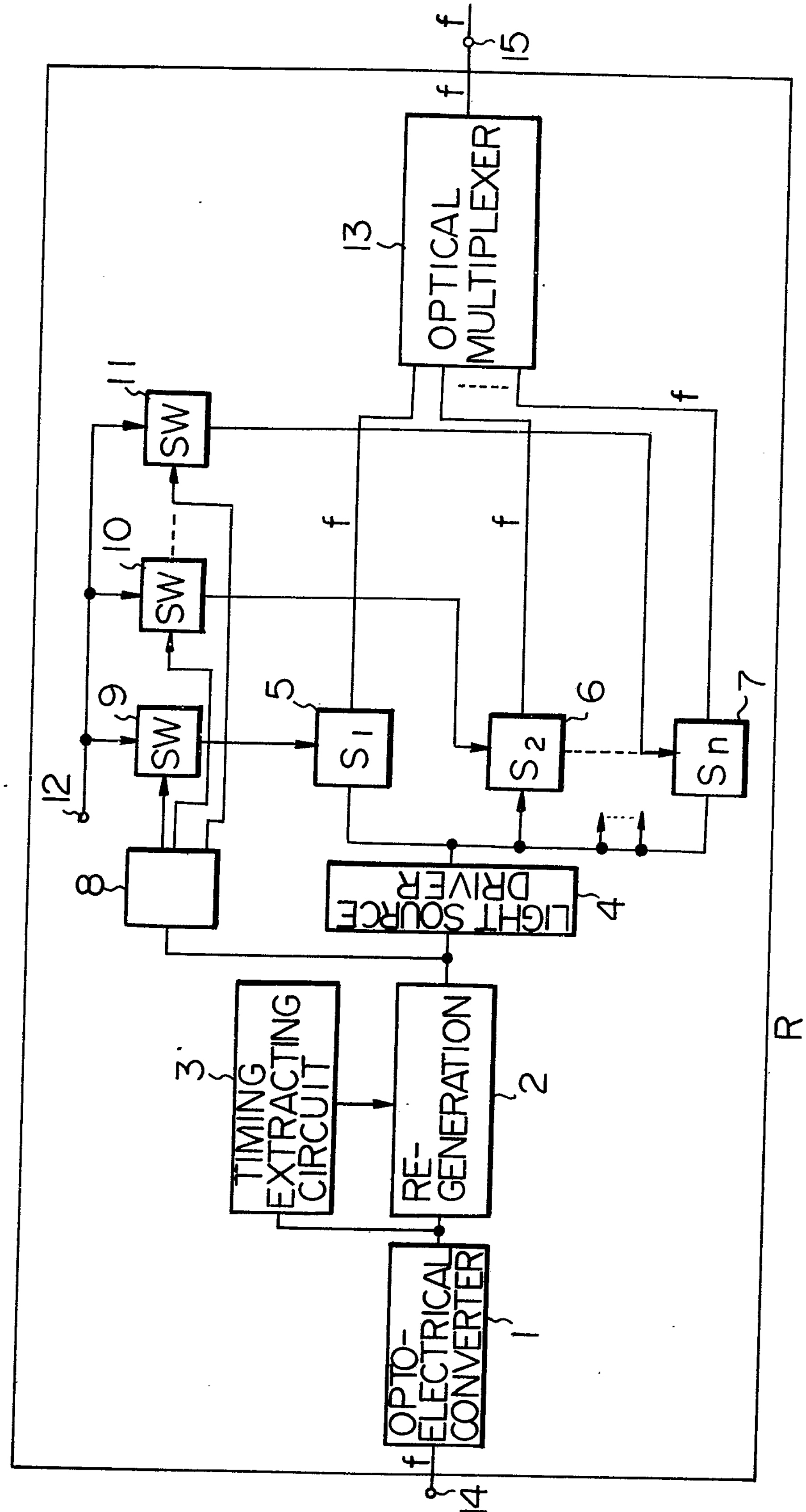
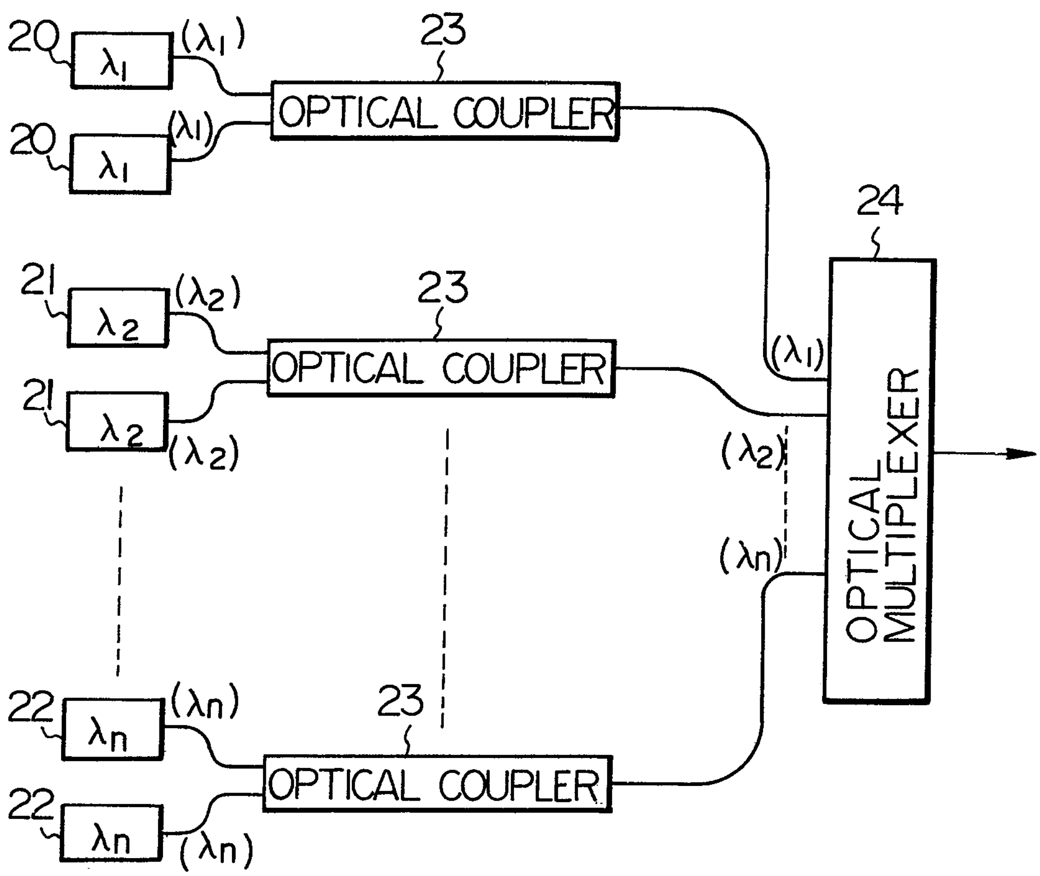


Fig. 5


20
λ1
(λ1)
20
λ1
(λ1)
23
OPTICAL COUPLER
21
λ2
(λ2)
21
λ2
(λ2)
23
OPTICAL COUPLER
22
λn
(λn)
22
λn
(λn)
23
OPTICAL COUPLER
24
OPTICAL MULTIPLEXER
(λ1)
(λ2)
(λn)

SPECIFICATION

A light source assembly, primarily for an optical communication system

The present invention relates to an optical light source assembly, primarily for use in an optical communication systém having an optical fibre transmission cable.

In a long distance optical communication system, for example having an intercontinental communication line, the optical fibre cable is provided with a number of optical repeaters at intervals along its length, and the operational reliability of the system must be extremely high compared with that of a system having a short communication line because of the time and cost of repairing any fault which develops in a long distance system. The most important element affecting the operational reliability of an optical communication system having an optical fibre cable and a plurality of optical repeaters is the optical light source installed in each optical repeater for converting a repeated and/or amplified electrical signal to an optical signal which is to be relayed by the optical fibre cable to the next repeater, since the operational reliability of the light source is relatively low compared with that of electrical components installed in the optical repeater.

It has been proposed, therefore, to improve the operational reliability of an optical repeater in an optical communications system by providing the repeater with a back-up system of light sources which enables a light source which develops a fault to be replaced immediately with a new light source. Such a light source assembly is described in the Japanese laid open specification No. 37023/80, and is illustrated diagrammatically in Figure 1 of the accompanying drawings. In this system S_1, S_2, S_3 and S_4 represent light sources which are arranged to provide the same wavelength of optical energy as one another, and C_1, C_2 and C_3 are optical couplers each of which comprises a rod lens or a simple connection of optical fibres. Each optical light source S_1 to S_4 comprises a light emitting diode (LED) or a laser diode, which is energized by an electrical circuit including an automatic power control (APC), a bias circuit, and a driving circuit (not shown). The symbols (f) represent optical fibres. The light sources S_1 to S_4 are selectively actuated so that only one is operative at a time, and when this light source is degraded, it is switched off and another one is brought into operation.

However, the light source assembly of Figure 1 has the disadvantage that the insertion loss of an optical coupler is rather high. Generally, each optical coupler C_1, C_2, C_3 has an insertion loss of approximately 3 dB, and since pairs of optical couplers C_1, C_3, and C_2, C_3 are connected in series, the total insertion loss between the operational light source and the optical fibre cable is 6 dB. This large insertion loss by the optical couplers shortens the possible spacing between repeaters in the transmission cable, and even when many light sources and many optical couplers are utilized, the operational reliability of the communication system as a whole is not significantly improved.

The aim of the present invention is to overcome the disadvantages and limitations of the light source assembly described above and to provide an assembly which has a back-up system of light sources with low insertion loss and providing high operational reliability in an optical system incorporating the assembly.

According to the invention a light source assembly, primarily for use in an optical communication system, comprises a plurality of light sources each of which is arranged to supply light at a different wavelength from the others, electrical switch means by which only one of the light sources is actuated at any time and which is controlled so that when a fault is detected in the actuated light source a different light source is actuated, and an optical multiplexer which is optically coupled to all of the light sources whereby, in use, the light supplied from whichever light source is actuated is transmitted by the multiplexer to an optical fibre cable.

Examples of the assembly in accordance with the present invention will now be described with reference to Figures 2 to 5 of the accompanying drawings, in which:—

Figure 2 is a diagrammatic illustration of one example of the light source assembly in accordance with the present invention;

Figure 3 illustrates one form of the optical multiplexer which is used in the example of Figure 2;

Figure 4 is a block diagram of an optical repeater incorporating a light source assembly in accordance with the present invention; and

Figure 5 is a view similar to that of Figure 2, but illustrating a different example.

Figure 2 shows a light source assembly suitable for use in an optical repeater. In the Figure, the symbols S_1 to S_4 are light sources which are arranged to generate light at the different wavelengths λ_1 to λ_4, respectively, only one of these light sources being activated by an electrical signal at any one time. The symbols f represent optical fibres, and 13 is an optical multiplexer which multiplexes wavelengths. In order to operate the actuated light source, a driving circuit, a bias circuit, and an APC (automatic power control) circuit are necessary, but these circuits are not shown in the drawing for the sake of simplicity. The insertion loss of an optical multiplexer 13 is approximate 3 dB in the case of four wavelengths as shown in Figure 2, and it will be appreciated that the insertion loss of 3 dB in the assembly of Figure 2 is smaller than that of Figure 1, which gives a loss of 6 dB in the case of four light sources. The optical multiplexer 13 may be of conventional form, for example, a beam focusing type rod lens, a prism, a diffraction grating, a dielectric thin-film filter, or an internal reflection film type focusing rod lens.

Figure 3 shows an example of an optical

multiplexer which is an internal reflection film type focusing rod lens capable of taking four wavelengths. The symbols IN_1, IN_2, IN_3 and IN_4 represent optical input terminals for the wavelengths λ_1, λ_2, λ_3, and λ_4, respectively, and the symbol OUT is the optical output terminal of the multiplexer. The arrows in Figure 3 indicate the path of optical beams through the multiplexer. Although Figure 3 shows a four wavelength device, it should be noted that similar devices are available capable of multiplexing more than five wavelengths. More details of internal reflection film type focusing rod lenses can be found in the article S3—13 entitled "An internal reflection film type micro-optic circuit" presented to the general meeting in 1978 organized by the Institute of Electronics and Communication in Japan.

In a preferred embodiment of the present example, the wavelengths λ_1, λ_2, λ_3, and λ_4 are 0.74 μm, 0.82 μm, 0.89 μm and 1.06 μm, respectively.

Figure 4 is a block diagram of an optical repeater R having an optical light source assembly in accordance with the present invention. In the optical repeater R, the reference numeral 1 is an optoelectrical converter including an amplifier and an equalizer, 2 is a regenerator of a digital signal, 3 is a timing signal extracting circuit, 4 is a light source driver, and 5, 6 and 7 are optical generators each including a light source, a bias circuit, and an APC circuit, and it should be noted that each of the light sources generates a light beam at a different wavelength from the others. The reference numeral 8 is a detector of a light source switching control signal, 9, 10 and 11 are electrical switches, 12 is an electrical terminal for providing a bias current the light sources via the switches, 13 is an optical multiplexer, 14 is the optical input terminal of the optical repeater, and 15 is the optical output terminal of the repeater.

The operation of the optical repeater R is as follows. The optical signal received at the input terminal 14 is converted to an electrical signal by the opto-electrical converter 1, and the output of the converter 1 is applied to the regenerator 2 and the timing signal extracting circuit 3, which regenerate a digital pulse train. The regenerated digital signal is applied to the light source driver 4, and the driver 4 operates whichever one of the optical generators 5 to 7 is energised. If the first optical generator 5 is energized, that generator 5 converts the regenerated digital signal in an electrical form to an optical form, and the resulting light beam signal is relayed back into the optical fibre cable through the optical multiplexer 13 and the output terminal 15. The energised optical generator 5 is connected to the terminal 12 through the switch 9 to receive a bias current for the light source.

When there is something wrong with the energised optical generator 5, a terminal station on land (not shown) sends a light source switching control signal to all the optical repeaters in the transmission cable, and this signal is detected by detector 8 of the designated repeater. Upon detection of the switching control signal, the detector 8 opens the switch 9, and closes one of the switches 10 and 11, thereby connecting the bias current at the terminal 12 to either the optical generator 6 or the optical generator 7 depending on which of the switches 10 and 11 is closed. Thus the generator 5 is de-energised and one of the generators 6 and 7 is energised in its place, and the optical transmission system is maintained operational.

The embodiment shown in Figure 4 may be modified in various ways. For example, the light source switching control signal may be obtained at the output of either the converter 1 or the timing signal extracting circuit 3, instead of at the output of the regenerator 2. Further, a fault in the energised light source of a repeater may be detected automatically in the repeater itself by measuring the operation of the APC circuit, and upon detection of the fault, the light source may be switched automatically without the operation of a terminal station as in the embodiment of Figure 4. Also, the electrical switches 9, 10 and 11 may be connected to the output of the light source driver 4, and a light source driver 4 may be provided for each optical generator. Further, all the optical generators may have a common APC circuit, instead of each having its own individual APC circuit as described.

When a plurality of repeaters R are inserted in an optical fibre cable, each repeater will receive the light beam signal at a wavelength which depends upon the energised light source of the upstream repeater. Therefore, the opto-electrical converter 1 of each repeater R must cover a wide range of wavelengths so that that converter 1 can receive the light from any of the light sources in the upstream repeater. In this respect, an opto-electrical converter or a photo-cell which covers a wide range of wavelengths suitable for optical communication is readily available.

Figure 5 shows another embodiment of the present invention, in which the number of wavelengths available are limited and the number of light sources desired is more than those available wavelengths.

In Figure 5, the reference numerals 20, 21 and 22 are optical generators providing light at the wavelengths λ_1, λ_2 and λ_3 respectively, 23 is an optical coupler or an optical switch, and 24 is an optical multiplexer. The form of the optical coupler or optical switch 23 is described in the Japanese laid open Patent specification No. 37023/80. It should be noted that when the required number of optical generators is n, the available number of wavelengths is simply n/2 in the example shown. In this embodiment the nature of an optical coupler and the nature of an optical multiplexer are combined. Some alternatives to the arrangement shown in Figure 5 are possible of course. For example, as already mentioned, the optical coupler 23 may be replaced by an optical switch. Also, when the number of input terminals of the optical multiplexer 24 are limited, the wavelengths may be preliminarily multiplexed by inserting an optical switch before an optical coupler 23. The number of wavelengths available are thus increased.

Although we have described the application of the present invention to an optical repeater, it should be realised that the invention can also be applied to other fields, such as to an optical generator in a terminal station of an optical communication system, or to an optical generator in an optical measurement equipment.

CLAIMS

1. A light source assembly, primarily for use in an optical communication system, the assembly comprising a plurality of light sources each of which is arranged to supply light at a different wavelength from the others, electrical switch means by which only one of the light sources is activated at any time and which is controlled so that when a fault is detected in the actuated light source a different light source is actuated, and an optical multiplexer which is optically coupled to all of the light sources whereby, in use, the light supplied from whichever light source is actuated is transmitted by the multiplexer to an optical fibre cable.

2. A light source assembly according to Claim 1, in which the optical multiplexer is an internal reflection film type focusing rod lens.

3. A light source assembly according to Claim 1 or Claim 2, in which there are more than three light sources.

4. A light source assembly according to Claim 3, in which there are four light sources.

5. A light source assembly according to Claim 1, in which at least two of the light sources are coupled to the optical multiplexer through an optical switch and an optical coupler.

6. A light source assembly according to Claim 1, substantially as described with reference to Figures 2 and 3, or to Figure 5 of the accompanying drawings.

7. An optical repeater for use in an optical communication system and including a light source assembly according to Claim 1, the repeater being substantially as described with reference to Figure 4 of the accompanying drawings.

8. An optical communication system comprising an optical fibre transmission cable interrupted at intervals along its length by optical repeaters each including a light source assembly according to any one of Claims 1 to 6.

9. An optical communication system comprising an optical fibre transmission cable and a transmitting terminal station at at least one end, the terminal station including a light source assembly according to any one of Claims 1 to 6.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.