(12) UK Patent Application (19) GB (11) 2 250 354 (13) A

(43) Date of A publication 03.06.1992

(21) Application No 9117891.3

(22) Date of filing 19.08.1991

(30) Priority data
(31) 9018184 (32) 18.08.1990 (33) GB

(71) Applicant
Eurotec Optical Fibres Limited

(Incorporated in the United Kingdom)

Farnell House, Forge Lane, Leeds, LS12 2NE, United Kingdom

(72) Inventors
St. John Alexander Burch
Clive Alexander Andrews

(74) Agent and/or Address for Service
Dibb Lupton Broomhead
117 The Headrow, Leeds, LS1 5JX, United Kingdom

(51) INT CL[5]
G02B 5/10, F21V 7/08, G02B 6/42

(52) UK CL (Edition K)
G2J JMF
U1S S1915 S1917 S1935

(56) Documents cited
GB 2153551 A GB 2151351 A GB 2098352 A
GB 1290438 A GB 1236636 A GB 1236104 A
GB 1088146 A US 5016152 A US 4860172 A
US 4710638 A

(58) Field of search
UK CL (Edition K) G2J JGEB JMF JMX
INT CL[5] G02B
WPI

(54) Light reflector

(57) In order to increase light output in an optical fibre light generating system, the invention provides a light reflector for use in such a system, having a light-reflecting surface which is substantially part ellipsoidal in shape and which extends to its open end, in a direction along the major axis of the ellipsoid of which the reflector forms a part, from that end associated with the object focus (F1) of the ellipsoid towards the other end, such that the ratio of the distance between the object focus (F1) of the ellipsoid and the point (F2) where the major axis of the ellipsoid intersects the diameter of the open end of the reflector, to the distance between the object focus (F1) and the origin (O) of the ellipsoid, is at least 0.75. The reflector is preferably so shaped as to allow insertion of a light source through the rear of the reflector.

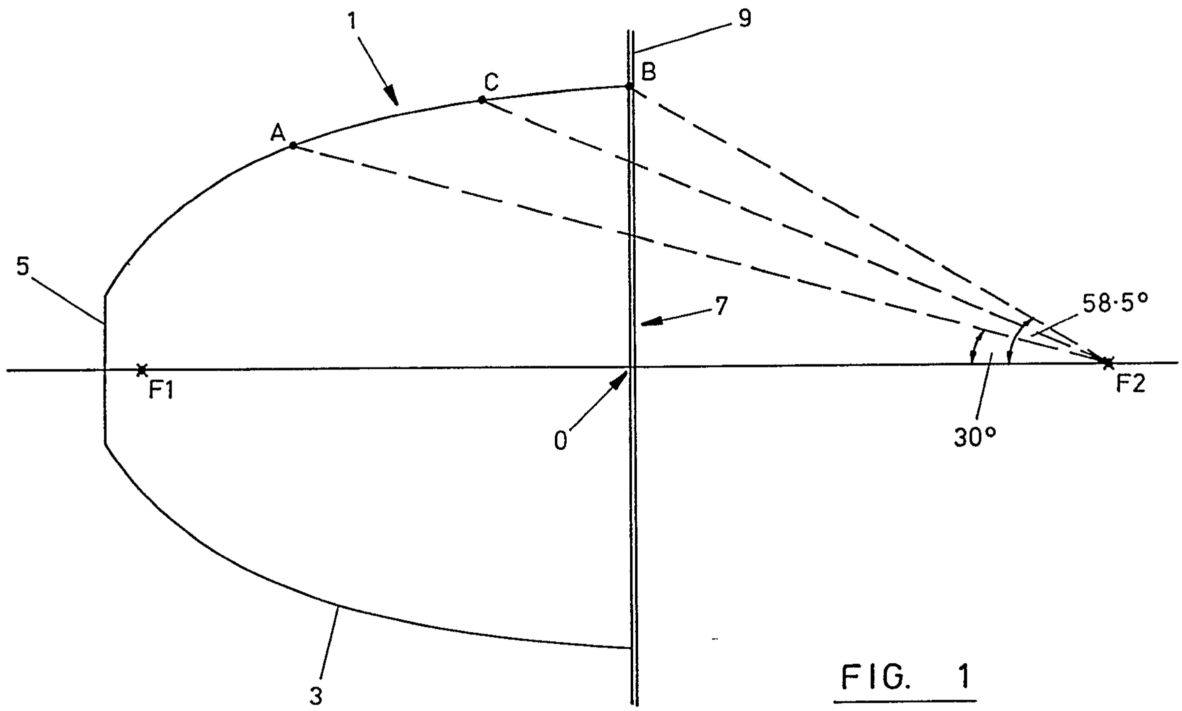

FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print incorporates corrections made under Section 117(1) of the Patents Act 1977.

GB 2 250 354 A

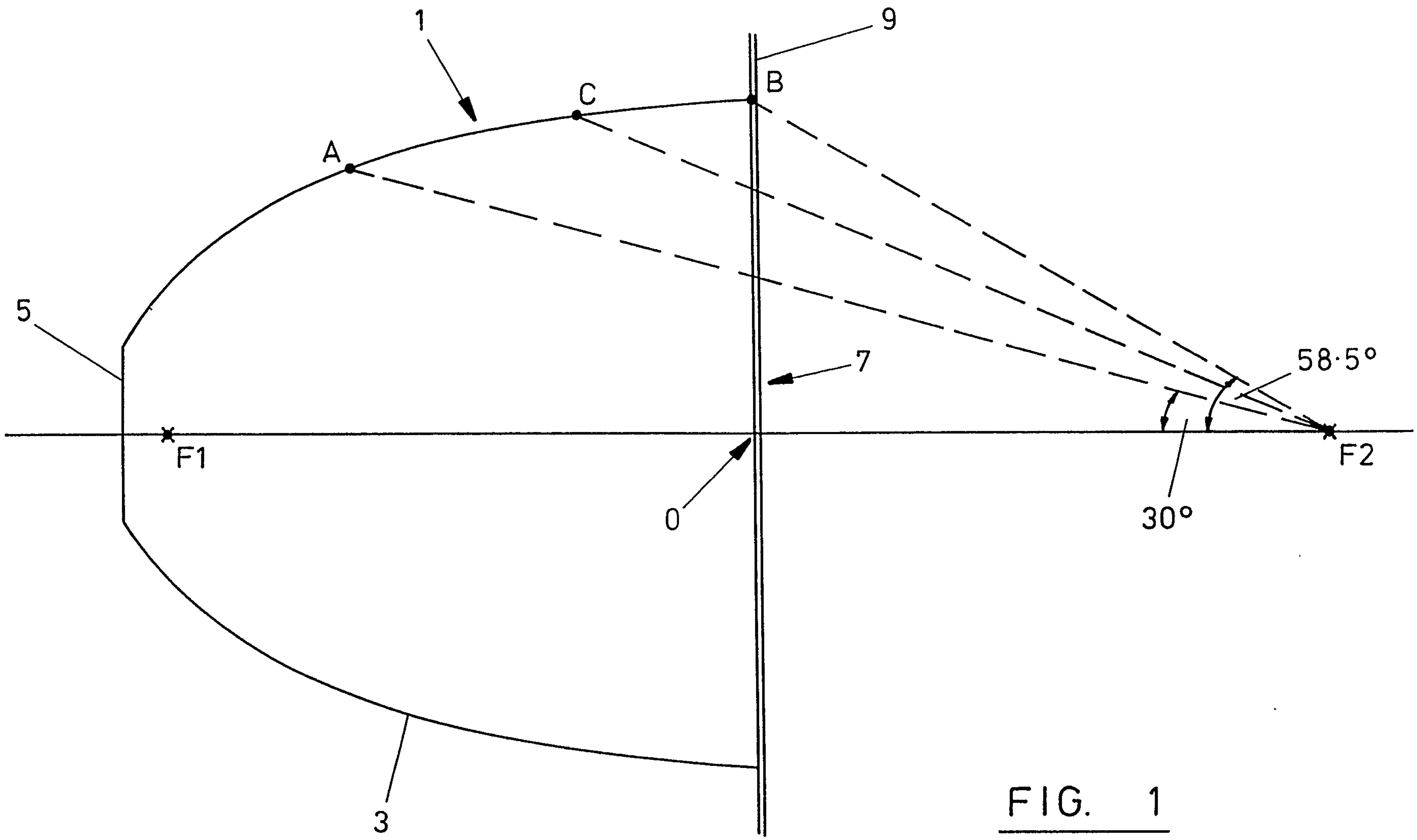

FIG. 1

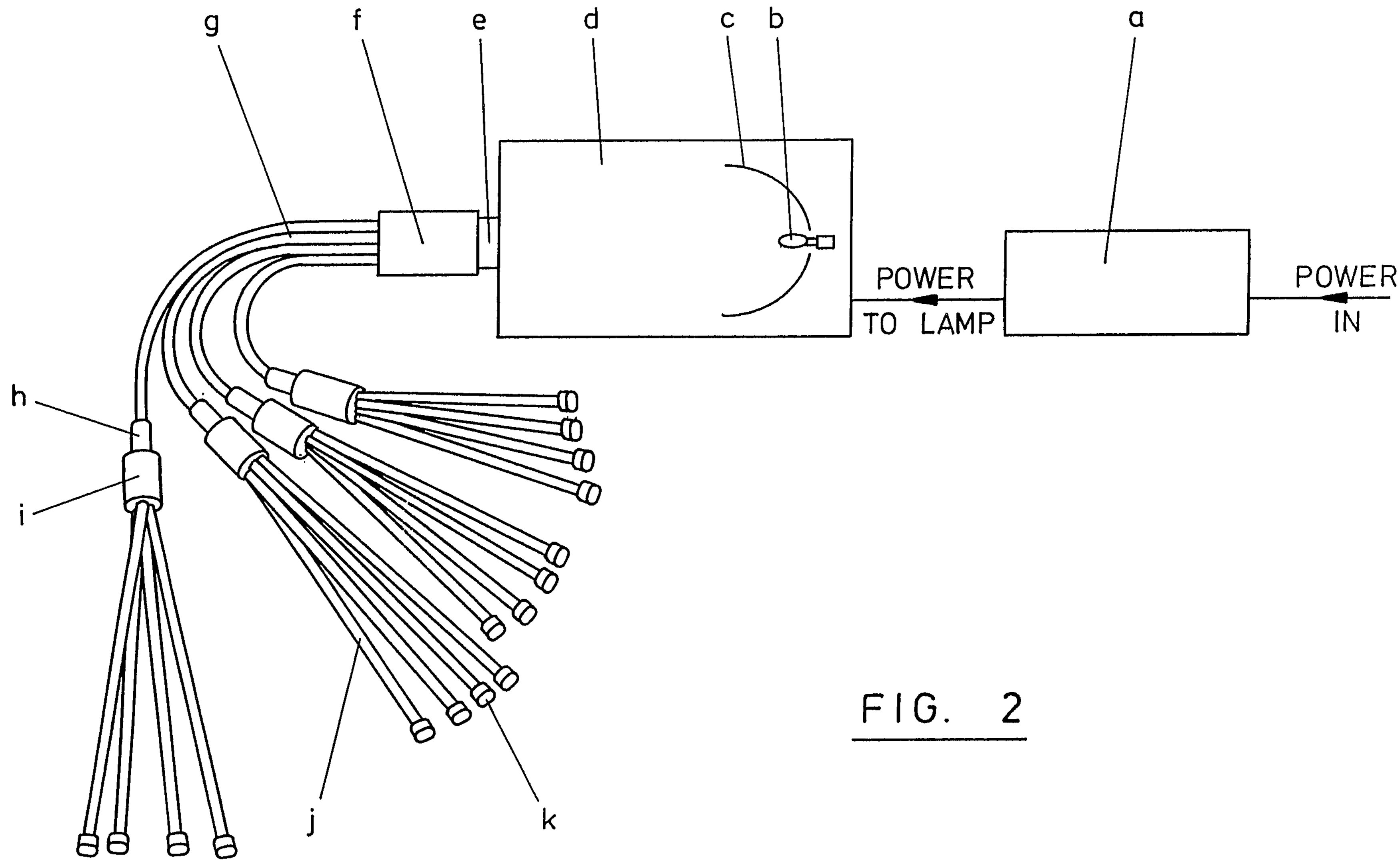

FIG. 2

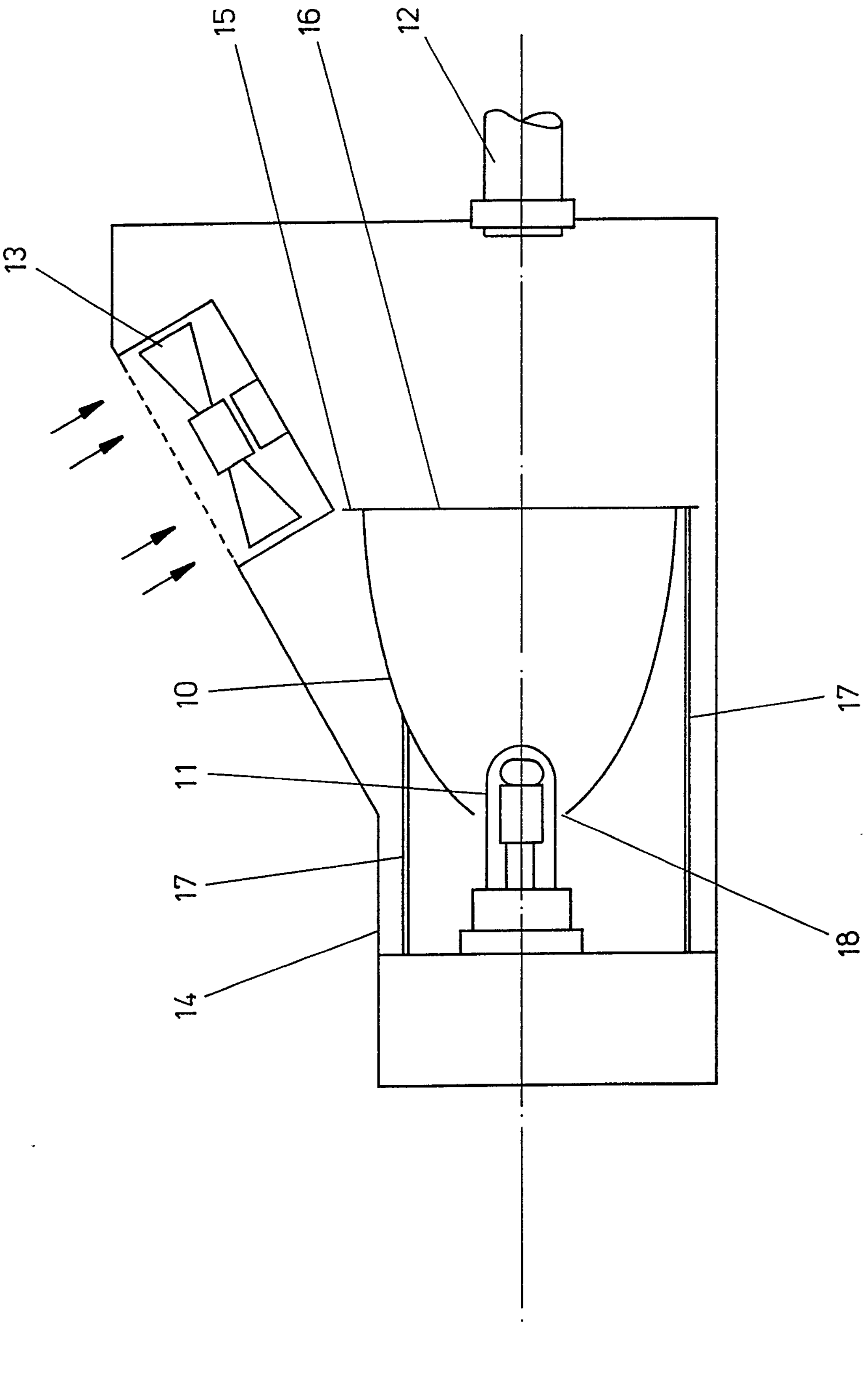

FIG. 3

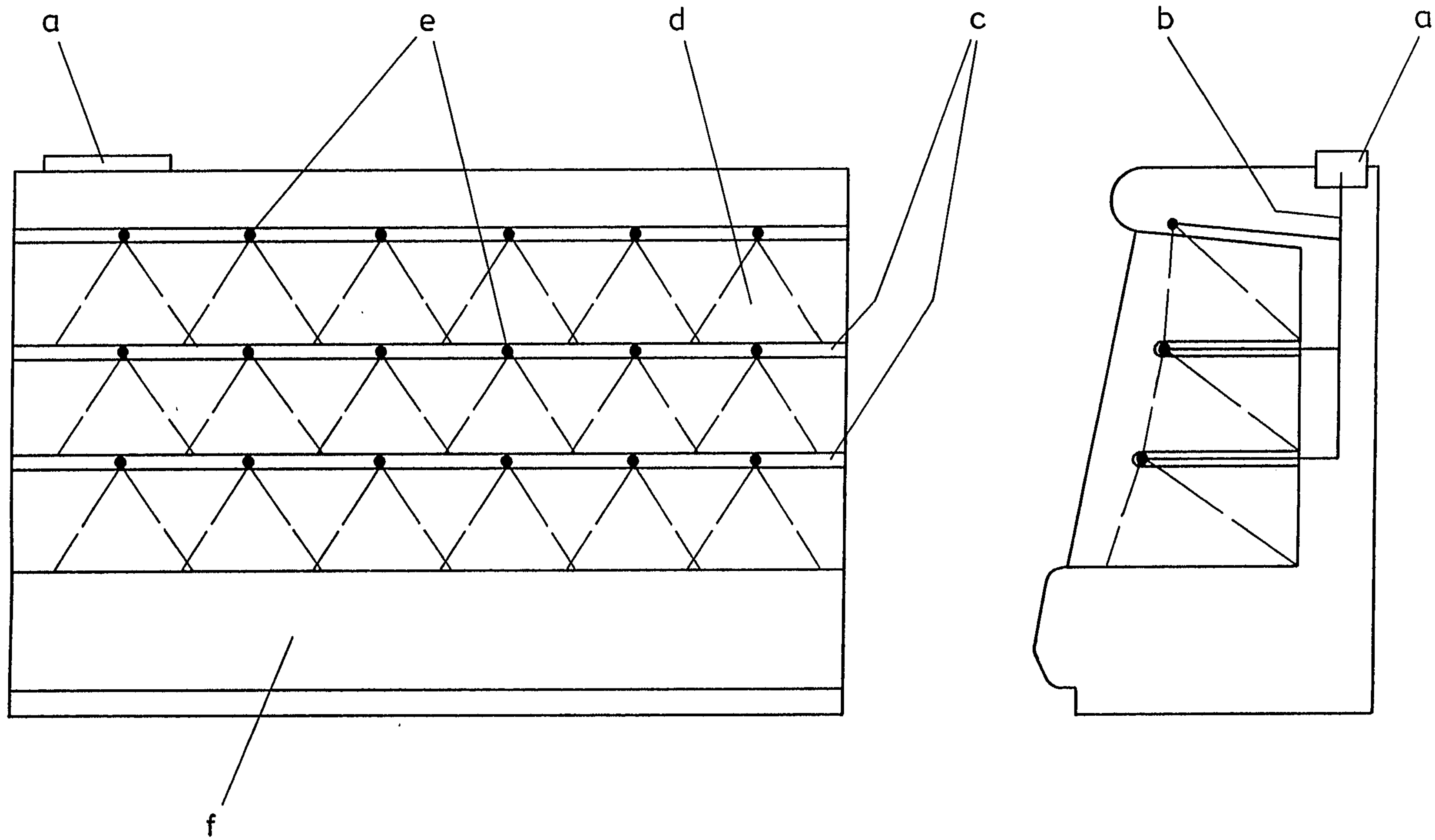

FIG. 4

2250354

LIGHT REFLECTOR

This invention relates to light reflectors and, in particular, light reflectors for use with optical fibre lighting systems.

Light reflectors for use with optical fibre lighting systems are known in which the reflector is of a substantially part ellipsoidal shape which acts to focus light, from a light source located at one focus of the ellipsoid of which the reflector forms a part, in a direction towards the second focus at which can be located the optical fibre light collector or so-called common end.

Known light reflectors are limited in length (along the major axis of the ellipsoid of which the reflector forms a part) because it has been thought that above a certain length little useful increase in light delivered to the common end could be obtained. There is also every incentive to restrict the length of the reflector, apart from light output considerations, in order to keep the cost of producing the reflector to a minimum and to keep to a minimum the overall size of the light-generating device of which the reflector forms a part. Light systems incorporating such reflectors normally require some sort of cooling arrangement to prevent over-heating and the efficacy required of the cooling system will increase as the length of the reflector increases.

Moreover, known part-ellipsoidal light reflectors are constructed to allow a reasonable amount of space between the two foci, in which optical devices such as filters, dimmers and colour wheels can be located to intercept reflected light before it reaches the second focus.

Limiting the reflector in length allows more space between the two foci, and also ease of access for installing a light source at the correct point inside the reflector, since reflectors are typically of such a design that the source has to be inserted from the front, i.e. the open end, of the reflector.

In practice, the length of the reflector has in the past always fallen far short of the reflector being a complete half-ellipsoid. If F_1 is the object focus of the ellipsoid of which the reflector forms a part (i.e. the point at which a light source is to be located), F_2 the image focus (i.e. the point onto which reflected light will be focussed), O the origin of the ellipse and X the point at which the line F_1-O-F_2 (the major axis of the ellipsoid) intersects the diameter of the open end of the reflector, then the ratio of the distances F_1-X : F_1-O has conventionally never exceeded approximately 0.72.

The acceptance cone half angle of the reflector, which is the angle between the major axis of the ellipsoid and a line drawn between the image focus (at or near which the common end is situated) and the periphery of the reflecting surface of the reflector, is an indication of the amount of light which the reflector would be expected to focus onto the image focus. This has conventionally been limited to no greater than the acceptance half angle for the optical fibre collector onto which light is to be reflected, which in turn is a measure of the amount of light which the collector would be expected to collect. The acceptance half angle for such a collector is defined by the formula:

$$\sin^{-1}\sqrt{(n_1 - n_2)}$$

where n_1, is the refractive index of the fibre core, and n_2 that of the fibre cladding.

Theoretically, the optimum acceptance cone angle (twice the acceptance cone half angle) for a reflector for use in a particular optical fibre lighting system is the same as the acceptance cone angle of the optical fibre light collector of the system. To use a reflector having a greater acceptance angle than this would theoretically provide no advantage, since the amount of reflected light collected by the optical fibre light collector would in any event be limited by its own acceptance cone angle. In order to increase acceptance angles towards this theoretical optimum, reflectors have generally been constructed as part-ellipsoids of greater width (i.e. longer minor axis), since reflector lengths are constrained by the considerations outlined above.

It has now been surprisingly found that the light output of an optical fibre light-generating system can be significantly increased by utilising a light reflector having a length greater than those previously used. This surprising result, on which the present invention is based, is thought to be at least partly due to the fact that a light source located at the focus of a reflector is never a true point light source but rather, a more diffuse "blob" having a finite area. Thus, theoretical calculations do not yield a true result as to the amount of light which can be reflected and subsequently collected.

According to the present invention, there is provided a light reflector for use in an optical fibre lighting system, the light-reflecting surface of the reflector being substantially part ellipsoidal in shape and extending to its open end, in a direction along the major axis of the ellipsoid of which the reflector forms a part, from that end associated with the object focus of the ellipsoid towards the other end, associated with the image focus, such that the ratio of the distance between the object focus of the ellipsoid and the point where the major axis of the ellipsoid intersects the diameter of the open end of the reflector, to the distance between the object focus and the origin of the ellipsoid, is at least 0.75.

By "part-ellipsoidal" is meant that the light-reflecting surface of the reflector must be of a suitable curved shape as to function in the same manner as would a true part-ellipsoid surface, i.e. to focus light, generated at one of its focal points, onto another. The reflector need not be truly part ellipsoid in shape, but will generally approximate to a part ellipsoid. It will, however, usually have a gap at its rear end (i.e. the end associated with the object focus), to allow for insertion of a suitable light source at its object focus, and to reduce the amount of light which would be reflected from such a source directly back to the source itself (which might cause the source to overheat).

The precise shape of the reflector will depend on the relative lengths of the major and minor axes of the ellipsoid of which the reflector forms a part. However, the invention is applicable to reflectors having a wide range of part-ellipsoidal shapes and, indeed, all such shapes which might, in practice, be used for reflectors of this general type.

The distance ratio referred to is preferably 1.0, such that the reflector is essentially a half-ellipsoid. Such a reflector seems capable of focussing much greater amounts of light at its image focus than would be expected from a comparison with the conventional reflector having a distance ratio of 0.72.

The invention also includes within its scope a reflector for which the distance ratio is greater than 1.0. For instance, the reflector may be more than half of an ellipsoid, such that the curved surface of the ellipsoid of which it forms a part extends beyond the minor axis of the ellipsoid. Alternatively, the reflector may comprise a half ellipsoid which extends further, beyond the minor axis of the ellipsoid, as a tube, either cylindrical or frusto-conical in section. Such designs have greater acceptance cone angles, for a given width (i.e. minor axis length) of reflector than does the simple half-ellipsoid.

The reflector is preferably of such a shape and size as to allow for further optical devices, such as filters, dimmers, colour wheels, etc., to be located, in an optical fibre light-generating system in which the reflector is used, to intercept light reflected by the reflector towards an optical fibre light collector positioned at the image focus. Whilst bearing this design constraint in mind, the reflector should nevertheless be as small as possible, so that a light-generating system containing it can be compact and portable. A minor axis of approximately 110mm, and a major axis of approximately 200mm, are, for instance, ideal values for the ellipsoid of which the reflector forms a part.

A reflector according to the invention, having a reflecting surface of greater length, reflects a much greater amount of incident light onto its image focus than would a conventional reflector, without the need to increase the width of the reflector. If designed correctly, however, it can still accommodate the extra optical devices needed in a typical optical fibre light generating system.

A reflector according to the invention is preferably so shaped as to allow insertion of a light source through the rear of the reflector (i.e. that end associated with the object focus of the ellipsoid of which the reflector forms a part). This again allows the reflector to be of greater length, since access to its open end is not needed (as would have been the case for a conventional reflector) to insert the light source. The reflector preferably has a bulb receiving aperture, at its rear end, large enough to receive a suitable light source (which will typically be a metal halide lamp, of standard construction and commonly available), such that the source can be positioned, through the aperture, at the object focus of the ellipsoid. In the case of a metal halide lamp, the bulb would be inserted through the bulb receiving aperture, and plugged into a conventional two-pin electrical socket behind the reflector.

Since the envelope of a typical metal halide bulb is narrower than its base (which will be connected to a power supply), insertion of the bulb through the rear of the reflector also means that the bulb-receiving aperture can be smaller in size than in conventional reflectors. This in turn leaves a greater surface area of the reflector, behind its object focus, available for reflecting light emanating from that focus.

A further advantage in being able to insert a light source through the rear of the reflector is that the risk of soiling the internal reflecting surface of the reflector (e.g. with finger marks) is reduced.

The acceptance cone angle for the reflector of the invention is ideally chosen to be as close as possible to, and may even be greater than, the acceptance angle of the optical fibre light collector of the light system in which the reflector is to be used.

The light reflecting surface of the reflector may be made of any suitable material, for instance, spun aluminium (preferably of a very high purity), or dichroic coated borosilicate glass. The surface may be multi-faceted.

The reflector ideally comprises an annular flange around the periphery of its open end, which acts as part of a mounting means for mounting the reflector in a light generating system. Conveniently, supporting rods (usually three, around the outside of the reflector) will be located in suitably positioned apertures in the annular flange, secured in position by means of nuts, and affixed at their free ends to an appropriate part of the system.

Incorporating this mounting flange at the front, open, end of the reflector leaves more space free behind the reflector, allowing for insertion of a light source from the rear, as described above.

The present invention also provides an optical fibre light-generating system incorporating the reflector of the invention.

Such a system will typically additionally comprise a suitable light source, such as a metal halide lamp, located at the object focus of the ellipsoid of which the reflector forms a part, and an optical fibre light collector, located at or near the image focus of the ellipsoid. The system will also preferably include a fan, used to reduce the temperature of the optical fibre light collector (common end). The fan is desirably positioned in the light generating system so as to direct cool air directly towards the light collector (the fan is not typically so positioned in known systems).

An optical fibre light-generating system incorporating a reflector of the invention may have a wide variety of applications. By way of example only, an application for such an optical fibre light-generating system is a cooled food display cabinet in which the light generator or projector is located on the outside of the cabinet, and the optical fibre light outlets are located at appropriate positions within the cabinet so as best to illuminate the food being displayed.

An embodiment of the present invention will now be described, by way of example only, and with reference to the accompanying drawings, in which:

- Fig 1 is a longitudinal section through a reflector in accordance with the present invention;
- Fig 2 is a schematic diagram of an example of an optical fibre system incorporating the reflector at Fig 1;
- Fig 3 is a plan of an alternative optical fibre system in accordance with the invention; and
- Fig 4 is a schematic diagram showing a cooled food display cabinet incorporating the optical fibre system of Fig 2.

Referring to Fig 1 of the accompanying drawings, a light reflector 1 comprises a main body portion 3 formed of a suitable material, such as dichroic coated moulded glass or high purity spun aluminium, providing a highly reflecting internal surface. Body portion 3 is half ellipsoidal in shape and, as shown in Fig 1, the ellipsoid of which the body portion 3 forms a part has focuses F1 (object) and F2 (image). Body portion 3 extends from relatively small diameter narrow rear end 5 at one side of, but close to, focus F1 to a relatively large diameter opposite open end 7 at the mid point between the two foci (i.e. level with the origin O of the ellipsoid of which reflector 1 forms a part). Extending outwards from open end 7 of body portion 3 is an integral, annular flange 9, said flange 9 being provided with three equally spaced-apart fixing holes (not shown) to enable the reflector to be mounted within a light generating system in which it is to be used.

It can be seen from Fig 1 that the ratio of the distance between F_1 and the point where the major axis of the ellipsoid (F_1-F_2) intersects the diameter of the open end 7 of the reflector, to the distance F_1-O, is 1.0 in the case of the reflector shown (i.e. the reflector is a complete half-ellipsoid).

In use, a light source, such as a metal halide lamp, is mounted at focus F1 (inserted through an aperture (not seen) in the rear end 5 of the reflector). Light emitted by this source is reflected by the internal reflecting surface of reflector 1 in a direction towards focus F2, at or near which an optical fibre light collector is located. Additional optical devices, such as filters, colour wheels, dimmers, etc., as required, may be located in the space between O and F_2.

Although a reflector according to the present invention could be of any part-ellipsoidal shape, the particular half-axis lengths which characterise the reflector shown in Fig 1 are 56.0mm for the minor axis and 114.6mm for the major axis.

Reflector 1 has an acceptance cone half angle of 29.25^{o} (full angle 58.5^{o}), which is the angle between the major axis of the ellipsoid and a line drawn between F_2 and point B on the periphery of the open end of reflector 1.

Known light reflectors, in contrast, have a light-reflecting surface extending no further than about Point A, or occasionally Point C, indicated in Fig 1.

In a comparative test, the light output of a light projector incorporating the reflector of Fig 1 was compared with that of a similar light projector having a reflector which was substantially identical to that shown in Fig 1 except that it was substantially shorter, having an acceptance cone angle of 35^{o} compared with the angle of 58.5^{o} of the reflector at Fig 1 (and therefore also a smaller distance ratio). It was found that the light output of a light projector incorporating the reflector at Fig 1 was substantially greater than that of the projector having the shorter reflector.

Although the above-described light reflector is made of spun aluminium and has a smooth internal surface, equally within the scope of the present invention are light reflectors made of other suitable materials as well as those having a faceted internal light-reflecting surface.

Referring to Fig 2 of the accompanying drawings, one specific example of an optical fibre light emitting system, in which the light reflector of Fig 1 might be used, is shown. The system includes control gear a providing electrical power to a metal halide lamp b mounted at the narrow, rear, end of reflector c which, in turn, is mounted within lamp housing d. Reflector c is that as described above with reference to Fig 1. Light is reflected by reflector c towards the common end of an optical fibre arrangement which includes ferrule mount e from which extends the primary common end ferrule f.

Primary harness g comprises a plurality of optical fibre assemblies, each of which extends from the primary common end ferrule f to a coupling h which is, in turn, connected to a secondary common end ferrule i. Secondary harness j extends from ferrule i and provides a plurality of optical fibre bundles, each of which is provided at its end with a light outlet arrangement including filter holder k and a light filter.

Fig 3 is a plan of an optical fibre light generating system which comprises reflector 10, metal halide bulb 11, common end 12 and fan 13, mounted within housing 14. Reflector 10 has the shape of a half-ellipsoid, with an integral annular flange 15 at its open end 16. To this are secured three supporting rods 17, at 120^{o} intervals around the reflector, the rods being mounted at the rear of housing 14. These rods support the reflector in position in the housing.

The reflector 10 has a bulb-receiving aperture 18 at its rear end, through which bulb 11 (part of a powered lamp) is inserted from the rear to provide a light source at the object focus of the ellipsoid of which reflector 10 is a half. Light from 11 is reflected towards the image focus, at which common end 12 is positioned.

Fan 13 is positioned so as to direct cool air directly at the common end 12 so as to keep its temperature at an acceptably low level.

It will be appreciated that a light reflector in accordance with the invention can be used in all manner of optical fibre light systems and with any appropriate light source.

Referring to Fig 4 of the accompanying drawings, a cooled food display cabinet f comprises a light projector a mounted on an upper rearward portion of the exterior of the cabinet housing. Optical fibre bundles extend from light projector a by way of harness b to a plurality of light outlets e each located on the underside of a shelf c so that emitted light d is projected towards food products displayed on the next lower shelf.

CLAIMS

1. A light reflector for use in an optical fibre light system, the light-reflecting surface of the reflector being substantially part ellipsoidal in shape and extending to its open end, in a direction along the major axis of the ellipsoid of which the reflector forms a part, from that end associated with the object focus of the ellipsoid towards the other end, associated with the image focus, such that the ratio of the distance between the object focus of the ellipsoid and the point where the major axis of the ellipsoid intersects the diameter of the open end of the reflector, to the distance between the object focus and the origin of the ellipsoid, is at least 0.75.

2. A light reflector according to Claim 1, wherein the said ratio of distances is 1.0, such that the reflector is substantially half-ellipsoidal in shape.

3. A light reflector according to Claim 1, wherein the said ratio of distances is greater than 1.0.

4. A light reflector according to Claim 3, wherein the curved surface of the ellipsoid of which the reflector forms a part extends, as a continuation of the ellipsoid, beyond the minor axis of the ellipsoid.

5. A light reflector according to Claim 3, wherein the reflector comprises a half ellipsoid which extends further, beyond the minor axis of the ellipsoid, as a cylindrical or frusto-conical tube.

6. A light reflector according to any one of the preceding claims, which is so shaped as to allow

insertion of a light source through the rear end of the reflector (i.e. that end associated with the object focus of the ellipsoid of which the reflector forms a part).

7. A light reflector according to claim 6, comprising a bulb receiving aperture at its rear end, the aperture being capable of receiving a light source to allow the source to be thus positioned at the object focus of the ellipsoid.

8. A light reflector according to any one of the preceding claims, wherein the acceptance cone angle of the reflector is substantially the same as that of the optical fibre light collector of an optical fibre light system in which the reflector is to be used.

9. A light reflector according to any one of Claims 1-7, wherein the acceptance cone angle of the reflector is greater than that of the optical fibre light collector of a light system in which the reflector is to be used.

10. A light reflector according to any one of the preceding claims, wherein the light reflecting surface of the reflector is made from high purity spun aluminium.

11. A light reflector according to any one of Claims 1-9, wherein the light reflecting surface of the reflector is made from dichroic coated moulded glass.

12. A light reflector according to any one of the preceding claims, wherein the light reflecting surface of the reflector is multi-faceted.

13. A light reflector according to any one of the preceding claims, additionally comprising an annular

flange around the periphery of its open end, for use in mounting the reflector in an optical fibre light system.

14. A light reflector according to Claim 13, wherein the annular flange is provided with one or more apertures, in which supporting rods, fixed at their free ends to an appropriate part of the optical fibre light system, can be located.

15. An optical fibre light generating system incorporating a reflector according to any one of the preceding claims.

16. An optical fibre light generating system according to Claim 15, comprising a metal halide lamp located at the object focus of the ellipsoid of which the reflector forms a part.

17. A light generating system according to Claim 15 or Claim 16, comprising an optical fibre light collector, located at or near the image focus of the ellipsoid of which the reflector forms a part, and additionally a fan to reduce the temperature of the collector, wherein the fan is positioned so as to direct cool air directly towards the light collector.

18. A display cabinet incorporating an optical fibre light generating system according to any one of Claims 15-17.

19. A light reflector substantially as herein described with reference to the accompanying illustrative drawings.

20. An optical fibre light generating system

substantially as herein described with reference to the accompanying Figures 2 and 3.

21. A display cabinet substantially as herein described with reference to the accompanying Figure 4.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

9117891.3

Relevant Technical fields

(i) UK Cl (Edition K) G2J - JMF, JMX, JGEB

(ii) Int Cl (Edition 5) GO2B

Databases (see over)

(i) UK Patent Office

(ii) WPI

Search Examiner

M J PRICE

Date of Search

24.2.92

Documents considered relevant following a search in respect of claims 1-21

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB A 2153551 (RAYCHEM) see eg Figure 3	1 at least
X	GB A 2151351 (PLESSEY) see eg Figure 1	1 at least
X	GB A 2098352 (PLESSEY) see eg Figure 1	1 at least
X	GB 1290438 (CCT) the whole document	1 at least
X	GB 1236636 (MESSER) see eg the Figures and page 3 lines 11-26	1 at least
X	GB 1236104 (MESSER) see eg Figure 1	1 at least
X	GB 1088146 (QUARZLAMPEN) see eg the Figures	1 at least
X	US 5016152 (FIBERSTARS) see eg the Figures and column 2	1 at least
X	US 4710638 (FUSION) see eg Figure 2	1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

Published 1992 at The Patent Office, Concept House, Cardiff Road, Newport, Gwent NP9 1RH. Further copies may be obtained from Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, Newport, NP1 7HZ. Printed by Multiplex techniques ltd, St Mary Cray, Kent.