



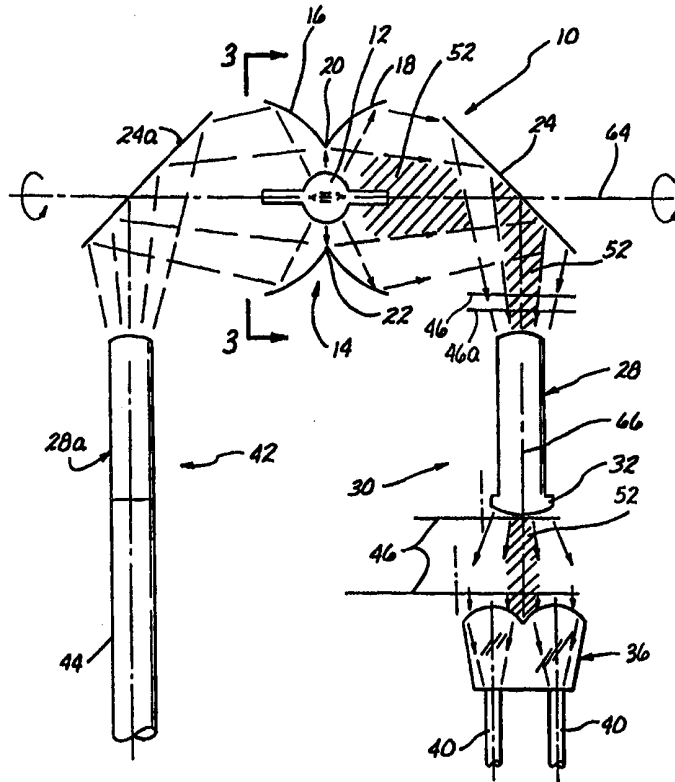
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<p>(21) International Application Number: PCT/US98/03172 (22) International Filing Date: 18 February 1998 (18.02.98) (71) Applicant: REMOTE SOURCE LIGHTING INTERNATIONAL, INC. [US/US]; 32961 Calle Perfecto, San Juan Capistrano, CA 92675 (US). (72) Inventors: RISER, Andrew, P.; 35262 Camino Capistrano #207, Capistrano Beach, CA 92624 (US). MATHIS, Ronald, F.; 17632 Rancho de Carole Road, Ramona, CA 92065 (US). LIU, David, H.; 18409 Mescal Street, Rowland Heights, CA 91748 (US). (74) Agent: STOUT, Donald, E.; 100 Pacifica #210, Irvine, CA 92618 (US).</p>	<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report.</i></p>	

(54) Title: MULTIPORT ILLUMINATOR FOR LIGHT GUIDES

(57) Abstract

A light guide illumination system having a metal-halide double-ended illumination source is disclosed. The light guide illumination system includes at least one light guide (42, 28, 28a) and two curved reflectors (14) disposed in proximity to the double-ended illumination source. The two curved reflectors (14) are adapted to reflect the emitted light from the double-ended illumination source (12) into the light guide (42, 28, 28a). The light guide illumination system further includes at least one multi-sector lens (38) adapted to receive light from the light guide and at least one output light guide. The multi-sectored lens (38) is adapted to receive the reflected light from the light guide and to focus the light into the output light guide (40).



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MULTIPOINT ILLUMINATOR FOR LIGHT GUIDES

This application is related to U.S. Patent Number 5,661,828, issued on August 26, 1997 and entitled REFLECTOR FOR ILLUMINATION SYSTEM; and U.S. Patent Number 5,682,448, issued on October 28, 1997 and
5 entitled REFLECTOR AND ILLUMINATION SYSTEM, both of which are commonly assigned and the contents of which are expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

10 The present invention relates generally to reflectors and, more particularly, to reflectors for coupling light from a light source into one or more light guides.

2. Description of Related Art

15 Large diameter fiber optics, often referred to as "flexible light guides", are well known in the art, and typically comprise a single, solid core light guide which is surrounded by a cladding layer and a sheath or shielding layer. The core is the portion of
20 a light guide which transmits light, and typically has a diameter of about 2 to 12 mm. It is formed of a very soft, semi-liquid plastic material, such as OPTIFLEX®, which is manufactured by Rohm & Haas Corporation, of Philadelphia, Pennsylvania. The

cladding layer typically comprises polytetrafluoroethylene (PTFE or TEFLON®), or the like, while the outer sheath is fabricated of a material such as polyvinylchloride (PVC). Unlike
5 small diameter light guides, which are typically used to transmit information in relatively complex control systems, these large diameter "light guides" are typically employed in a variety of illumination systems where direct lighting is difficult to
10 maintain, dangerous, or subject to vandalism. Examples include architectural lighting, display cases, pools and spas (to eliminate electrical connections near water), hazardous material zones (to eliminate the need for sealed lighting), and jail
15 cells. Large diameter light guides are particularly advantageous in that only a single centralized illumination system must be maintained, rather than a plurality of individual lights.

There are problems, however, in implementing
20 state of the art light guide illumination systems because of the difficulty of illuminating a plurality of light guides from a single illumination source, as is discussed in U.S. Patent No. 5,559,911, which is expressly incorporated by reference herein. According
25 to one prior art configuration, the light guides are bundled as closely as possible, to ensure the maximum ratio of core area (the part of each light guide which actually transmits light) to total area. However, bundling the large diameter light guides together in
30 order to illuminate them from the single illumination source is difficult to do efficiently. The individual light guides are round and thus have a great deal of space between them due to the cladding and shielding

layers. To obtain maximum efficiency, it is desirable to illuminate only the core of each of the bundled light guides, but this is impossible using state of the art bundling techniques. Necessarily, if the
5 light from the source of illumination is spread across the array of light guides, it will illuminate not only the cores of the light guides, but also the cladding layers and shielding layers. Furthermore, the voids between the light guides, which are inevitable because
10 of the light guides' round dimensions, also are impacted by the light from the illumination source. All of the light falling upon any element other than the cores is wasted, and becomes an efficiency loss, since it will not be transmitted by the light guides.
15 Additionally, packing the light guides closely together may create problems such as mechanical difficulties in configuring and accommodating the illumination system and difficulties encountered in attempting to replace one of the individual bundled
20 light guides. This design also may result in color variation between light guides unless techniques are specifically employed to prevent this problem.

One prior art solution to this problem has been to eliminate the sheathing and cladding layers about
25 each light guide, in order to reduce the area across the bundled array of light guides which does not transmit light. However, there is still a packing factor problem because the light guides are round, and there are other physical disadvantages in eliminating
30 those layers. Thus, this solution is unsatisfactory for most applications.

A number of prior art approaches use reflectors for focussing light from a source of illumination into

one or more light guides. U.S. Patent No. 5,222,793 and U.S. Patent No. 5,259,056, both to Davenport et al., disclose lighting systems which use a single reflector assembly for illuminating light transmissive elements. U.S. Patent No. 5,396,571 to Saadatmanesh et al. discloses a multi-segmented lens which divides light from a light beam into four separate beams, each of which is focussed onto a separate optical fiber. U.S. Patent No. 4,912,605 to Whitehead discloses an electric light source mounted between two reflectors, each of which directs light into a corresponding light guide. U.S. Patent No. 5,469,337 to Cassarly et al. discloses a light source and a plurality of curved reflectors for focussing light into lenses and then into a plurality of light guides. The use of reflectors and multi-segmented lenses by the prior art for coupling light into light guides has represented some advancement over the prior art bundled light guides, but the need for a proper and efficient coupling of a light source to a plurality of light guides still remains.

Another problem associated with prior art designs is the large number of optical components associated with these designs. Reducing the number of parts of any optical design would appear to be advantageous to any system.

SUMMARY OF THE INVENTION

This invention efficiently couples the light originating from an arc lamp, or similar source, into a multiplicity of flexible macroscopic light guides. Such a system is to be used in transmitting illumination from a central source to a variety of

remote locations. The combination of the several elements of the inventive system results in a very efficient transfer of the energy of the light source to the light guides. The system also provides a very flexible mechanical means for distributing the energy to the light guides and to the remote locations at which the light is used.

The invention, together with additional features and advantages thereof may best be understood by reference to the following description taken in conjunction with the accompanying illustrative drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1a and 1b are schematic top views of optical systems according to the present invention;

Figure 2 is an enlarged schematic view of the lamp and right portion of the dual reflector illustrated in Figure 1;

Figure 3 is an end view of the dual reflector, taken along lines 3-3 in Figure 1;

Figure 4 is schematic side view illustrating the multi-sector lens which forms a part of the optical system shown in Figure 1;

Figure 5 is an end view of the multi-sector lens shown in Figure 4;

Figure 6 is a schematic top view of an inventive light guide illumination unit, illustrating a housing containing the system elements shown in Figure 1;

Figure 7 is a schematic side view of the unit illustrated in Figure 6;

Figure 8 is a schematic front view of the unit illustrated in Figures 6 and 7;

Figures 9a and 9b are perspective views of the optical assembly 10 in a partially disassembled state, according to the presently preferred embodiment;

5 Figure 10 illustrates an exploded view of the light guide illumination unit, according to the presently preferred embodiment;

Figure 11a illustrates an exploded view of the optical assembly of a side module, according to the presently preferred embodiment;

10 Figures 11b and 11c illustrate perspective views of the optical assembly shown in Figure 11a;

Figure 12a illustrates a partially disassembled view of the dual curved reflector and the light source, according to the presently preferred
15 embodiment;

Figures 12b and 12c illustrate perspective views of the dual curved reflector and the light source, according to the presently preferred embodiment;

20 Figures 13a-13d illustrate various views of the light source, according to the presently preferred embodiment;

Figure 14a illustrates a partially disassembled view of the fan and electrical assembly of the center source module, according to the presently preferred
25 embodiment;

Figures 14b and 14c illustrate perspective views of the fan and power assembly shown in Figure 14a, according to the presently preferred embodiment;

30 Figures 15a-15c illustrate various perspective views of the front and rear shields, according to the presently preferred embodiment;

Figures 16a-16c illustrate various views of the left and right shields, according to the presently preferred embodiment; and

Figures 17a and 17b illustrate perspective views of the light guide illumination unit in an assembled configuration, according to the presently preferred embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning to Figure 1a, an optical system 10 is illustrated which includes a compact light source 12, which may comprise an arc lamp or any other conventional means for emitting light. This light source 12 is placed at the focus of a dual curved reflector 14, which comprises two reflector portions 16 and 18 which are disposed in a back-to-back fashion. In each reflector portion 16, 18, the center or vertex region of the reflector has been removed, as illustrated, and the two reflector portions are joined at intersection points 20 and 22.

Light emitted from the light source 12 is reflected by the dual reflector 14, as illustrated by the lines of incidence shown in Figure 1a, in two opposing directions, and is then directed through an angle of approximately 90 degrees (or any other desired angle) by each of two flat reflectors or fold mirrors 24 and 24a, respectively. The fold mirrors function to reflect heat generated by the light source 12, and to re-direct the light emitted from light source 12 to output light guides 40. Alternatively, particularly in a linear system using a dual reflector, as illustrated in Figure 1b, ultra-violet (UV) and/or infrared (IR) radiation blocking coatings

may be placed on the exit lens faces 32, since the fold mirrors 24 and 24a are not used, or hot mirrors 24' may be used for reflecting UV and IR radiation. The hot mirrors 24' may be placed at any stage between
5 the light source and the output light guides and, further, may be placed at perpendicular or off-axis orientations.

Each focussed beam of light impinges on a respective one of the circular mixing rods 28, 28a.
10 Although each mixing rod preferably comprises a circular cross-section, other cross-sections, such as rectangular, for example, may also be used. Each of the two circular light pipes 28, 28a preferably
15 comprises a transparent material, such as glass or clear plastic, and is adapted to integrate the light beam by means of multiple reflections within the mixing rod. The mixing rods may be omitted in alternative embodiments of the present invention.

On the right side of the system, or right channel
20 30, as illustrated in Figure 1a, the light beam emerges from the mixing rod 28 at the exit lens face 32. The diverging beam from the mixing rod 28 is then focussed and split into a number of separate focussed
25 beams by means of a multi-sector lens 36 (Figures 1a, 4, and 5). Each of the lens sectors 38 (Figure 5) focusses onto the core of a corresponding output light guide 40. If an electrodeless lamp or a very high
30 lumen output lamp is to be used, the light guides preferably comprise light guides which are rated for the proper lumen output. For high-lumen output cases, the light guides will often comprise a non-plastic material.

In a conventional optical design, a focussing lens would likely be required between the circular mixing rod 28 and the multi-sectored lens 36. The multi-sectored lens 36 of the present invention, however, is modified over conventional lenses to obviate any need for a focussing lens. For example, the multi-sectored lens 36 is larger than would be required with a conventional focussing lens between the multi-sectored lens 36 and the circular mixing rod 28. Alternatively, a conventional focussing lens may be used with the multi-sectioned lens 36.

The optical system for the left beam of Figure 1a focussed by the dual reflector 14 through the left channel 42 can be essentially the same as that described with respect to the right channel 30, or some different features may be incorporated into the left channel. For example, the right channel 30 may have a sector lens accommodating ten output light guides, while the left channel 42 may only couple to a single large light guide or multi-light guide bundle 44. In the embodiment of Figure 1b, the focussing lens 45 focusses light from the second reflector portion 18 to the circular mixing rod 28. The focussing lens 45 may be used instead of, or in addition to, either of the fold mirrors 24 and 24a in the right and left channels 30 and 42, respectively, according to design parameters.

A useful feature of the invention, as illustrated in Figure 1a, is to incorporate two rotating color wheels 46 and 46a at the entrance of the mixing rod 28. The rotating color wheels 46, 46a can be disposed at the exit of the mixing rod 28 or, alternatively, in front of the sector lens 36. With the color wheels

46, 46a at the mixing rod exit, the color of the light to all of the light guides is the same and changes simultaneously as the wheels rotate. With the wheels near the entrance to the sector lens 36, the colors to
5 each light guide are different and can change at different rates depending on the pattern of the wheels. These various color controls are useful in pool lighting, signs, and other applications.

The high efficiency of this illumination system
10 derives from the special design of a number of its elements working singly and in combination. The reflector 14 consists of two axially symmetrical curved halves or portions 16 and 18, with the lamp centered at their matching plane. This arrangement
15 makes use of the very efficient collection properties of the low magnification section of the ellipsoidal (or near ellipsoidal) reflector shape. The large hole 48 in the center of each reflector-half (Figure 3) results
20 in a focussed light beam with a ring-shaped cross section. The light entering the hole in the reflector is not lost but passes into the opposite reflector-half and is focussed into the second focussed beam. This reflector arrangement efficiently generates a
25 ring cross-section beam which is very useful in reducing the radial aperture required of each of the sector lenses 38. Figure 2 shows a section through the right portion 18 of the dual reflector 14 indicating how the ring-shaped beam 50 is generated.
30 The ring-shaped beam 50, wherein the darkened center portion 52 is represented by cross-hatching, is preserved through the mixing rod 28.

As shown best in Figure 4, the ring-shaped beam impinges on the sector lens 36 as well, and it can be seen that the outer boundary 54 of the beam 50 and the inner boundary 56 thereof, define the lens aperture in the radial direction. The ring beam thus very usefully limits the required lens aperture and permits lenses of relatively short focal length to be used. This ability to use short focal length lenses permits much more efficient coupling into small diameter light guides, thus unexpectedly increasing the efficiency of the system. The minimum light guide diameter is controlled by the need to match the angular extent of the output beam to the numerical aperture of the light guide.

Another important feature of the invention is the orientation of the light source 12. As illustrated particularly in Figure 2, the light source 12 is shown at the focal point of the dual reflector 14. The presently preferred embodiment of the light source 12, however, comprises a double-ended lamp, as is discussed below with reference to Figures 9-17. Continuing with the general theoretical description of the invention with reference to Figure 2, the long dimension of the arc discharge of the light source 12, as defined by the position of the electrodes 58, is oriented so as to be substantially parallel and coincident with the reflector symmetry axis 60. The efficiency of transmission of the optical system is greatly influenced by the arc orientation with respect to the reflector because of the high length-to-diameter ratio (typically about five times) of the arc. By aligning the light source 12 as described, the small dimension 62 of the arc (Figure 3) becomes

the controlling parameter in defining the minimum permissible output light guide diameter for efficient coupling. Small output light guide diameter is usually desired in most applications. A design for a small light guide will also, in general, provide efficient coupling to larger light guides provided the numerical aperture of the larger light guide is the same or larger than the smaller light guide. In the presently preferred embodiment, the output light guide core diameter is nominally one half inch. This large diameter may be desired because the high output power of the light source can burn smaller light guides in some cases. Additionally, the sector lens of the present invention, which obviates any need for a focussing lens, has an aspheric shape that can be specified using standard optical equations.

Although six equal lens sectors 38 are illustrated in Figure 5, the sector lens 36 can have as few as two and up to twelve or more sectors. Also, the sectors need not be equal in area, since in some applications it may be desirable to deliver different amounts of light to different locations. The presently preferred embodiment, which is illustrated in Figures 9-17, comprises four equal area sectors. The sector lens as a means of splitting the incident beam has a major advantage over currently used bundled light guides in that the sector lens array separates the light guides from each other (Figures 4 and 5), thereby permitting easy installation and removal of individual light guides.

As previously mentioned, the fold reflectors 24, 24a may serve a multiple function of folding mirror and heat rejecting mirror. As a folding mirror, they

may be used with or without a hot light source 12, and provide the ability of rotating the entire output optical system around a mechanical axis 64, as best shown in Figure 1a. This feature is very useful in
5 allowing great flexibility in positioning the direction in which the light guides emerge from the unit. Independent rotation of the fold mirrors 24 and 24a on either side of the light source 12 provides additional flexibility of output light guide location.

10 As described above, the circular light pipe 28 (as well as light pipe 28a) is used to integrate the angular distribution of the light around the rod axis 66. This is advantageous since it allows the light output of each light guide to be identical (which is
15 usually desired), because the angular light distribution from the light source 12 is not generally uniform. Additionally, the light source 12 will often have some color differences in the angular distribution which also needs to be integrated out in
20 order to avoid undesirable color differences in output between light guides. Mechanically, the field lens portion 32 of the mixing rod is larger in diameter than the rod section itself in order to provide a loss-free means of mounting the mixing rod 28.
25 Anything touching the mixing rod surface will bleed off some of the internally reflected light unless the rod is clad, which is a disadvantageous approach since it reduces its numerical aperture and increases its cost. Each mixing rod may be coated with a low-index
30 material according to one embodiment of the present invention.

The field lens portion 32 in conjunction with each individual lens sector 38 comprises a relay lens

system that roughly images the output end of the mixing rod onto the light guide port. The lens sectors may have aspheric shapes to reduce aberrations and improve efficiency, and are preferably given a thickness such that the output beam is focussed on the rear surface of the lens sector. This allows the soft core of the usual type of light guide to "wet" the lens surface, thereby reducing reflection losses at this interface. In another embodiment of the present invention, air gaps can be maintained between the light guides 40 and the lens sector 38 surfaces.

An exemplary complete light guide illumination unit 68 having a modular dual-port construction, is illustrated schematically in Figures 6 through 8. The center module 70 of the unit contains the light source 12 and its dual reflector 14, together with a power supply 72, cooling fan 74, and all other associated electrical wiring, etc. Two side modules 76 and 78 preferably contain the fold mirrors 24 and 24a, the mixing rods 28 and 28a, and the collimating lens 34 and 34a and sector lens assemblies 36 and 36a that feed into the light guides 40 and 40a. As discussed in connection with Figure 1a, although the two modules 76 and 78 are substantially identical, there is no requirement that they be so. Having different sector lenses on either side allows coupling to a different number of light guides on the two sides. Advantageously, the side modules 76 and 78 do not contain any electrical wiring and therefore can be detached easily from the center source module 70, using ordinary mechanical fasteners. The side modules can be rotated about the mechanical axis 64, as

discussed in connection with Figure 1 and shown in Figure 7, in order to allow convenient placement of the light guide output ports. This feature permits great flexibility for lighting installations with
5 tight space restraints, in building utility closets and the like.

Figures 9a and 9b illustrate two perspective views of the optical system 10, in a partially disassembled state, according to the presently
10 preferred embodiment. The optical system 10 comprises a fan and power assembly 80. The fan and power assembly 80 comprises a fan housing and a power supply 84. The fan housing 82 and the power supply 84 are preferably assembled into a single unit, and then
15 secured within the center module 70. The right channel optical assembly 30 is shown in an assembled state, comprising a fold mirror 24, at least one color wheel 46, a light pipe 28, a lens face 32, a spring 33, a multi-sectored lens 36, and a ferrule housing
20 assembly 37.

Although the left channel optical assembly was illustrated in Figure 1, comprising a lens end 26a, a light pipe 28a and a multi-light guide bundle 44, the left channel optical assembly 42 may be configured
25 similarly to the right channel optical assembly 30 shown in Figure 9a. For example, the left channel optical assembly 42 in Figure 9a may comprise optical components similar to those of the right channel optical assembly 30 of Figure 9a, disposed between the
30 fold mirror 24a and the ferrule housing assembly 37a. As presently embodied, each of the left channel optical assembly and the right channel optical assembly comprises an optical assembly, which may be

secured together, before placement within the corresponding side module 76, 78. In addition to a preassembled fan and power assembly 80, and preassembled optical assemblies 30, 42, the presently preferred embodiment further comprises an electrical assembly 86. The electrical assembly 86 is illustrated in Figure 9b in an assembled state, secured to the optical system 10.

Figure 10 illustrates an exploded view of the optical system 10, which may comprise the left channel optical assembly 42, the fan and power assembly 80, the dual-curved reflector 14, a rear housing 90, an intermediate housing 93, a front housing 95, a top shield 97, and a left shield 99. The disassembled illustration of Figure 10 does not show the right channel optical assembly 30, the bottom shield, and the right shield.

Figure 11a discloses the right channel optical assembly 30 in a partially disassembled configuration. A color wheel nut assembly 105 secures the color wheel 46 to a color wheel shaft, which is driven by a motor. Figures 11b and 11c disclose perspective views of the right channel optical assembly 30. As can be seen from Figure 11b, for example, an additional color wheel may be secured onto the color wheel shaft 107 with a color wheel nut assembly (not shown), which is similar to the color wheel nut assembly 105.

The color wheels are adapted for use in either the first side module 76, the second side module 78, or both. As presently embodied, the use of the first color wheel 46 and a second color wheel (not shown) provides a number of special functions. The two color wheels are preferably used together to allow for a

total of ten cells for placement of color filters. Accordingly, more colors are available with use of both of the color wheels. The two color wheels overlap in front of the mixing rod 28, for example.

5 One of the color filters is preferably an aluminum shutter, which alternates the passage of light therethrough. The shutter can be adjusted over the light beam to provide dimming, for example. The two color wheels together allow for mixing of colors.

10 The spring 33 is positioned between the multi-sectored lens 36 and the lens face 32. The spring 33 pushes against the multi-sectored lens 36 and the lens face 32. These lenses 32 and 36 may have grooves cut into them so they can interface with the spring 33 and
15 fit into a round cut-out in the sheet metal. By pressing on the lenses as shown in Figure 11a, for example, the lenses 32 and 36 are retained in the metal base without any screws or adhesive.

Figure 12a illustrates a perspective view of the
20 dual-curved reflector 14 and a partially disassembled view of the light source 12, according to the presently preferred embodiment. As presently embodied, the light source 12 comprises a metal halide lamp, model BA 575 GS, which is manufactured by
25 Sylvania. This metal halide lamp preferably comprises a 575 watt lamp, which is adapted for emitting approximately 49,000 lumens at a color temperature of between 4,000 and 6,000 degrees Kelvin. As can be seen from Figure 12a, for example, the metal halide
30 lamp comprises a first end 111 and a second end 113. A first electrode 115 and a second electrode 117 feed from opposite ends of the metal halide lamp 12.

The metal halide lamp 12 provides a greater distribution of illumination within the dual-curved reflector 14, and allows for more efficient operation. An ignitor 121 (Figure 9) is used to drive the metal halide lamp 12. As presently embodied, the dual-curved reflector 14 is cast molded. The dual-curved reflector 14 also preferably comprises reflective metal inserts (not shown). It may also be made of molded glass with a metal support structure (not shown). The dual-curved reflector 14 is illustrated comprising two mounting webs 123 and 125. Each of the mounting webs 123, 125 comprises a mounting aperture 127, 129, respectively. Mounting brackets 132 and 133 comprise cups 135 and 137, respectively. A first cup 135 accommodates a first electrode 115 and the first end 111, and a second cup 137 accommodates the second electrode 117 and the second end 113. The brackets 132 and 133 preferably comprise ceramic. Plastic may also be used, but sufficient ventilation must be maintained to control the temperature within the optical system 10 in this embodiment. If the optical system 10 is used outdoors and is covered with leaves, for example, sufficient ventilation may be prevented by the accumulation of leaves over exterior vents of the optical system 10. In such a case, the brackets 132 and 133, if made of plastic, may become deformed from excessive heat. The holding of the illumination source 12 by the two brackets 132 and 133 has been found to be advantageous over prior art illumination source brackets. The two brackets 132 and 133 are adapted to be secured to the large-diameter, circular distal ends of the dual reflector. This securing to the distal ends of the

dual reflector, as distinguished from prior art brackets which are secured to proximal or middle ends of the dual reflector, does not interrupt the interior reflective surfaces of the dual reflector where the intensity of light is the greatest. Thus, the brackets 132 and 133 of the present invention facilitate greater reflection of light from the illumination source out of the reflector, since the interior reflective surfaces closest to the illumination source are not used to hold the illumination source.

The central mount 140 is adapted for accommodating a conventional light source 12, which may comprise an arc lamp, for example. Clips 142 fit onto opposing ends of the brackets 132, 133, and also fit into recesses 144 within the dual-curved reflector 14, to thereby secure the light source 12 within the dual-curved reflector 14. Figures 12b and 12c illustrate perspective views of the dual-curved reflector 14 with the light source 12 secured therein.

Figures 13a-13d illustrate various views of the light source 12 and mounting brackets 132, 133. As presently embodied, a cylindrical metal insert (not shown) is inserted within the cup 135, and another cylindrical cap 146 is inserted within the metal insert. The metal insert may be glued to the cup 135 and the cap 146. As presently preferred, the metal insert is spring loaded between the cup 135 and the cap 146. As shown in the cross-sectional view of Figure 13c, the first illuminated end 111 comprises a diameter which is substantially smaller than an inner diameter of the cup 135. This difference in diameter provides a space for accommodating the cap 146 and the

optional metal insert, which is preferably spring loaded. Other means for securing the light source 12 between the two mounting brackets 132, 133, however, may be implemented within the scope of the present invention.

Figures 14a-14c illustrate various views of the fan and power assembly 80, which is preferably preassembled before being secured within the central source module 70. The fan and power assembly 80 comprises the fan housing 82, the power supply 84, a fan mount bracket 149, and a number of electrical components. More particularly, a DMX card and PCA display 151, transformer 153, power switch 155, power entry module 157, DMX connectors 159 and moisture seal 161 are all additionally assembled onto a frame member 165 of the fan and power assembly 80.

Figures 15a-15c illustrate various views of the top shield 97, and Figures 16a-16c illustrate various views of the left shield 99. The bottom shield (not shown) and right shield (not shown) are preferably configured similarly to the top shield 97 and the left shield 99, respectively. As shown in Figure 15a, for example, the shield 97 comprises a shield portion 170 and a screen portion 172. Similarly, the left shield 99 preferably comprises a shield portion 178 and a screen portion 180. Figures 17a and 17b illustrate perspective views of the optical system 10 in an assembled configuration.

Although exemplary embodiments of the invention have been shown and described, many other changes, modifications and substitutions, in addition to those set forth in the above paragraphs, may be made by one

having ordinary skill in the art without necessarily departing from the spirit and scope of this invention.

What is Claimed is:

1. A light guide illumination system,
comprising:
a double-ended illumination source adapted to
emit light;
5 at least one multi-sectored lens; and
a dual reflector disposed in proximity to the
double-ended illumination source, the dual reflector
being adapted to reflect the emitted light from the
double-ended illumination source into the at least one
10 multi-sectored lens.
2. The light guide illumination system as
recited in Claim 1, the double-ended illumination
source comprising a metal-halide lamp.
3. The light guide illumination system as recited
in Claim 2, the double-ended illumination source
comprising an 575 Watt lamp.
4. The light guide illumination system as
recited in Claim 1, further comprising at least one
output light guide, the at least one multi-sectored
lens being adapted to receive the reflected light from
5 the dual reflector and to focus the light into the at
least one output light guide.
5. The light guide illumination system as
recited in Claim 4, the at least one multi-sectored
lens comprising four lenses, and
the at least one output light guide comprising
5 four output light guides, the four lens being adapted

to receive the reflected light from the dual reflector and to focus the light into the four output light guides.

6. The light guide illumination system as recited in Claim 1, further comprising a mixing rod adapted to receive light from the double-ended illumination source.

7. The light guide illumination system as recited in Claim 6, further comprising a fold mirror disposed between the double-ended illumination source and the mixing rod.

8. The light guide illumination system as recited in Claim 1, further comprising a focusing lens disposed between the double-ended illumination source and the light guide.

9. A light guide illumination system, comprising:

a double-ended illumination source adapted to emit light;

5 at least one color wheel;

a dual reflector disposed in proximity to the double-ended illumination source, the dual reflector being adapted to reflect the emitted light from the double-ended illumination source into the at least one color wheel;

10

at least one multi-sectored lens adapted to receive light from the at least one color wheel; and

at least one output light guide adapted to receive the reflected light from the multi-sectored lens.
15

10. The optical light guide illumination system as recited in Claim 9, the dual reflector comprising two curved surfaces which are disposed in a back-to-back fashion, each of the two curved surfaces comprising an aperture disposed at a center of the curved surface.
5

11. The light guide illumination system as recited in Claim 10, the double-ended illumination source being disposed at the centers of the two curved surfaces.

12. The light guide illumination system as recited in Claim 11, the double-ended illumination source being placed at a focus of the two curved surfaces.

13. The light guide illumination system as recited in Claim 12, the double-ended illumination source comprising a metal-halide lamp.

14. The light guide illumination system as recited in Claim 13, the double-ended illumination source comprising an 575 Watt lamp.

15. An illumination source bracket for mounting an illumination source on a curved reflector, the curved reflector having a proximal end adapted to receive the illumination source in close proximity

5 thereto and at least one distal end where a majority
of light from the illumination source can exit the
curved reflector, the illumination source bracket
comprising:

an arm adapted to contact and hold an
10 illumination source near the proximal end of the
curved reflector; and

means for securing the arm to the at least one
distal end of the curved reflector.

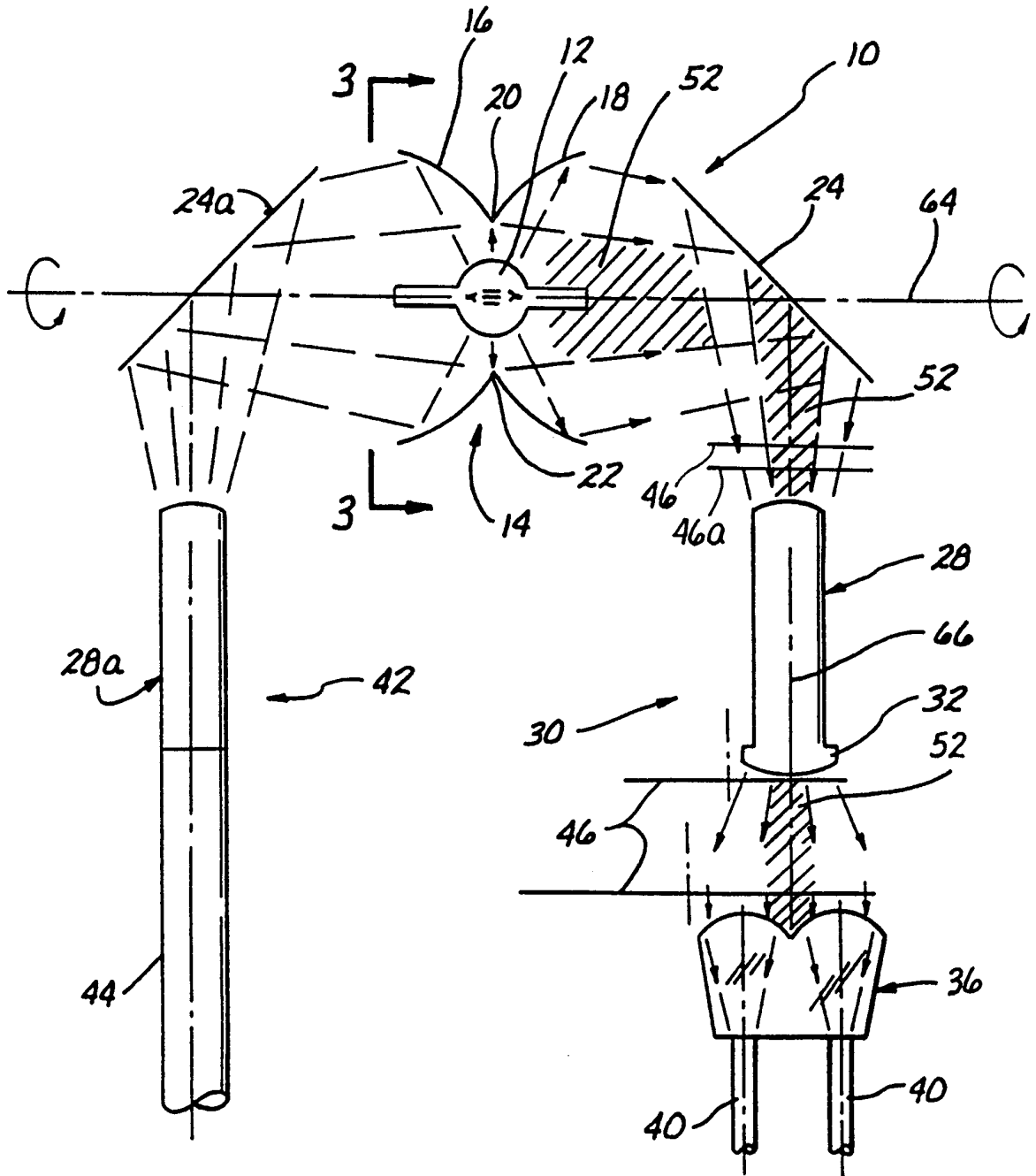


FIG. 1a

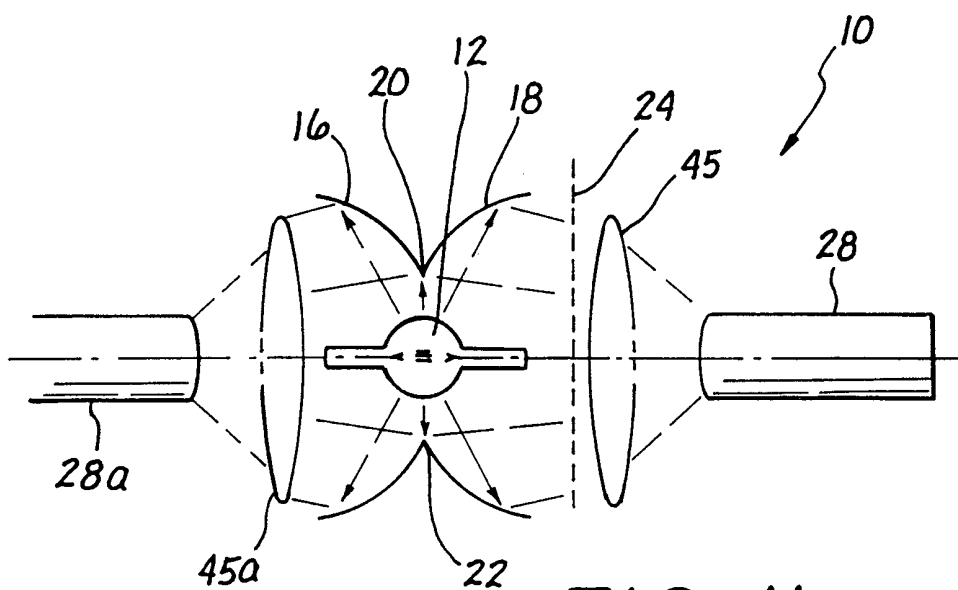


FIG. 1b

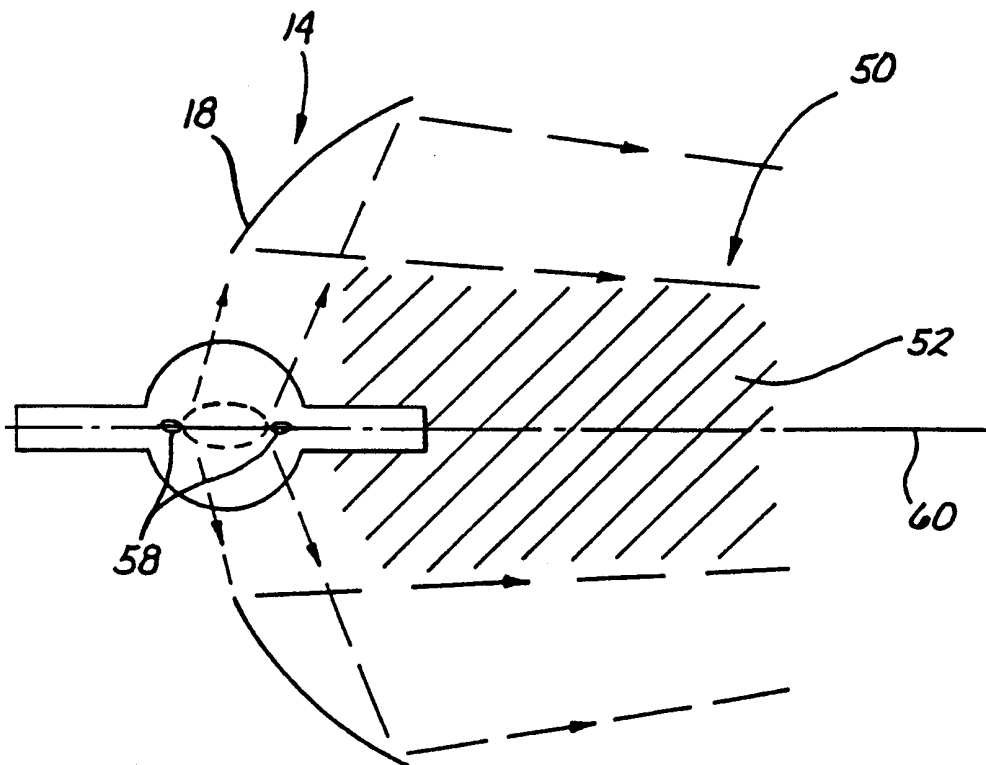


FIG. 2

FIG. 3

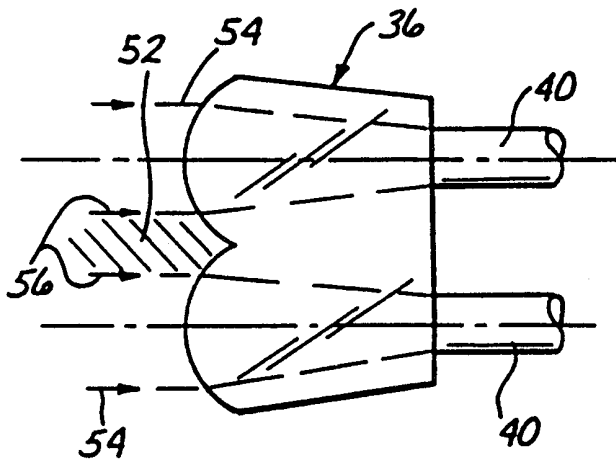
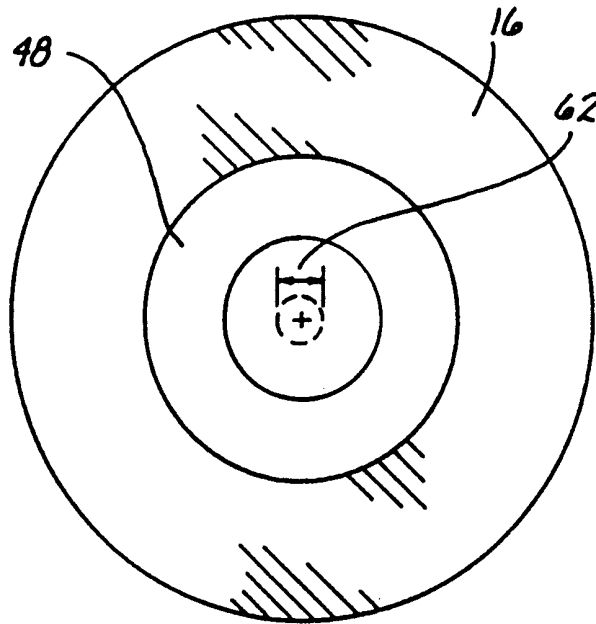


FIG. 4

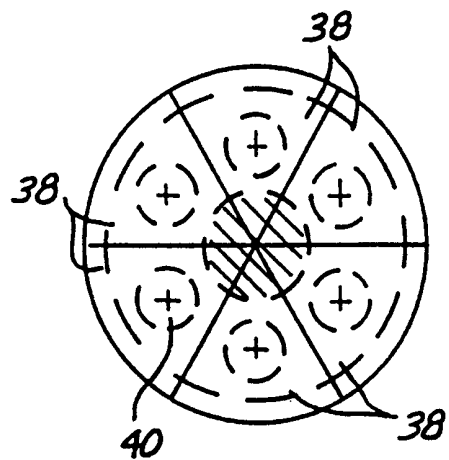


FIG. 5

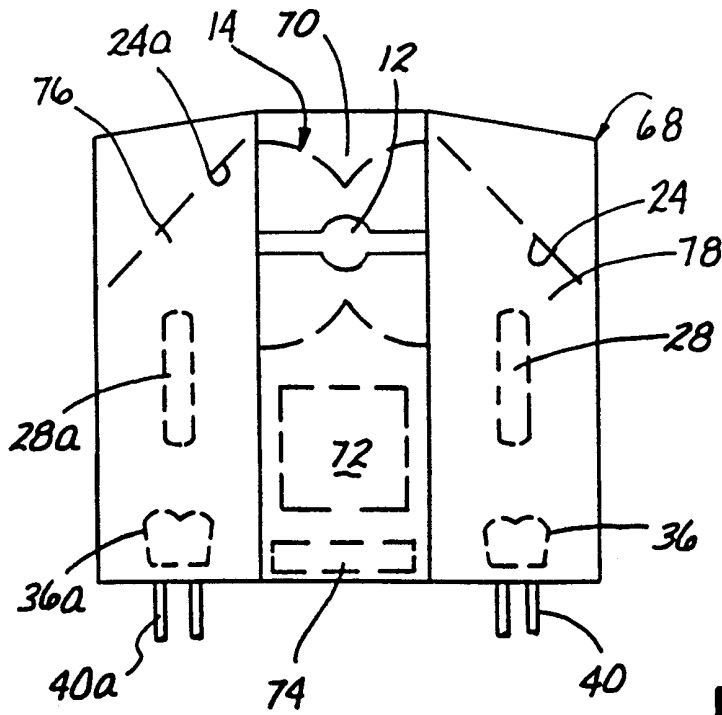


FIG. 6

FIG. 7

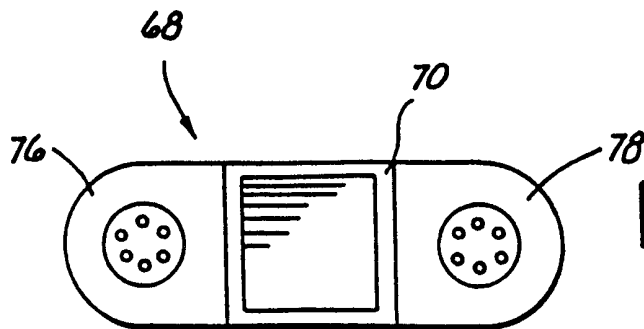
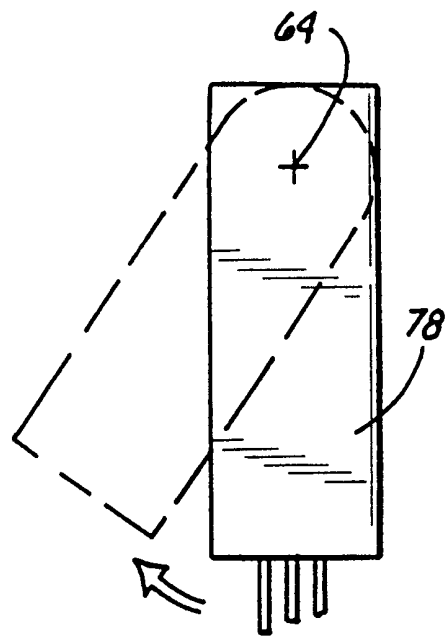
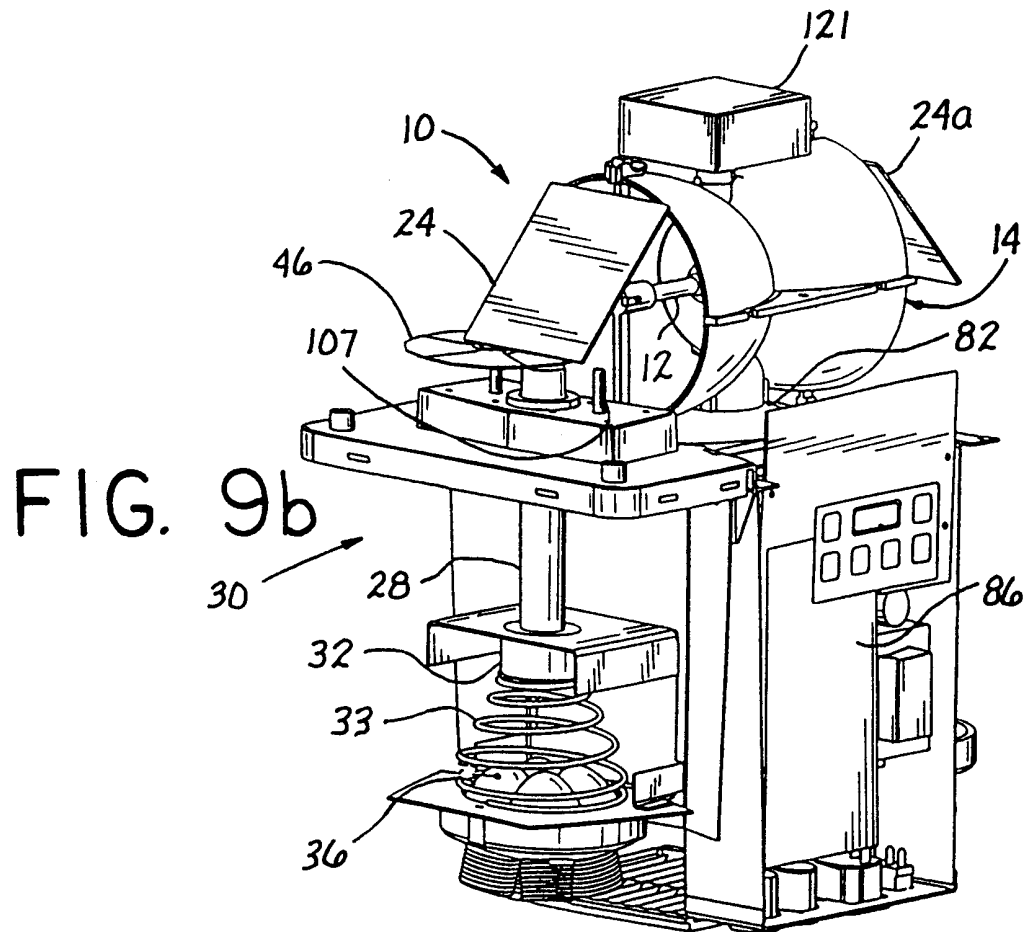
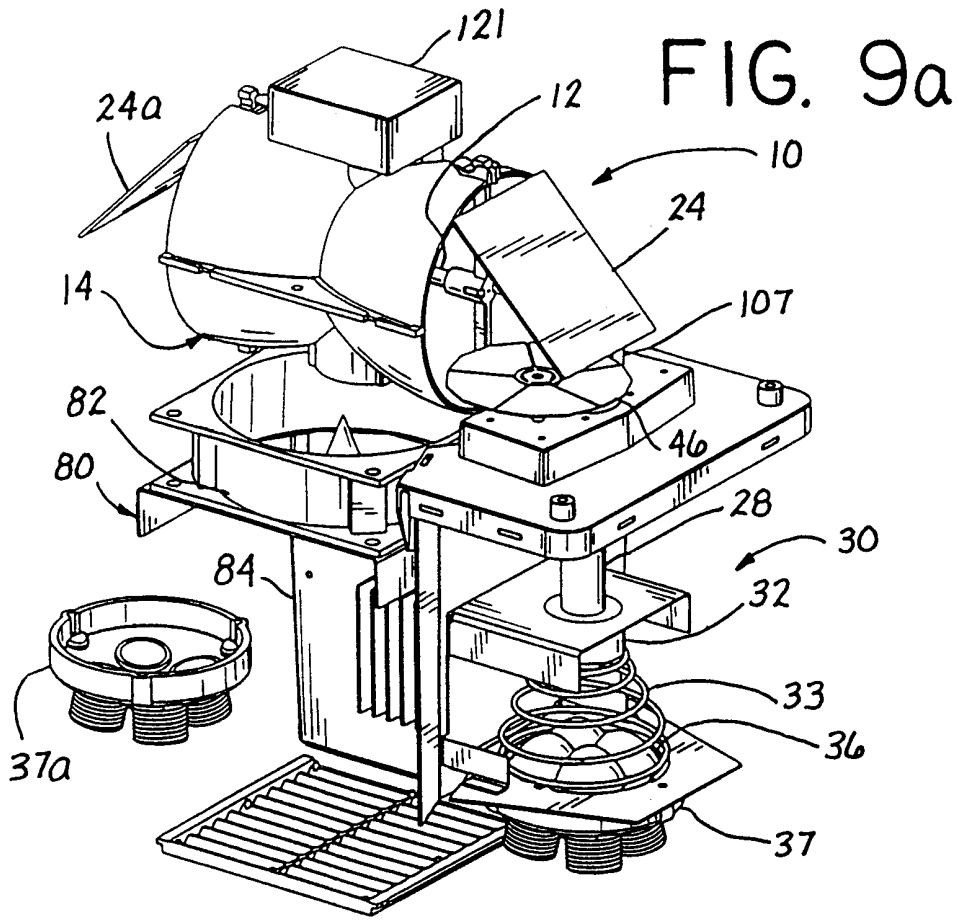


FIG. 8



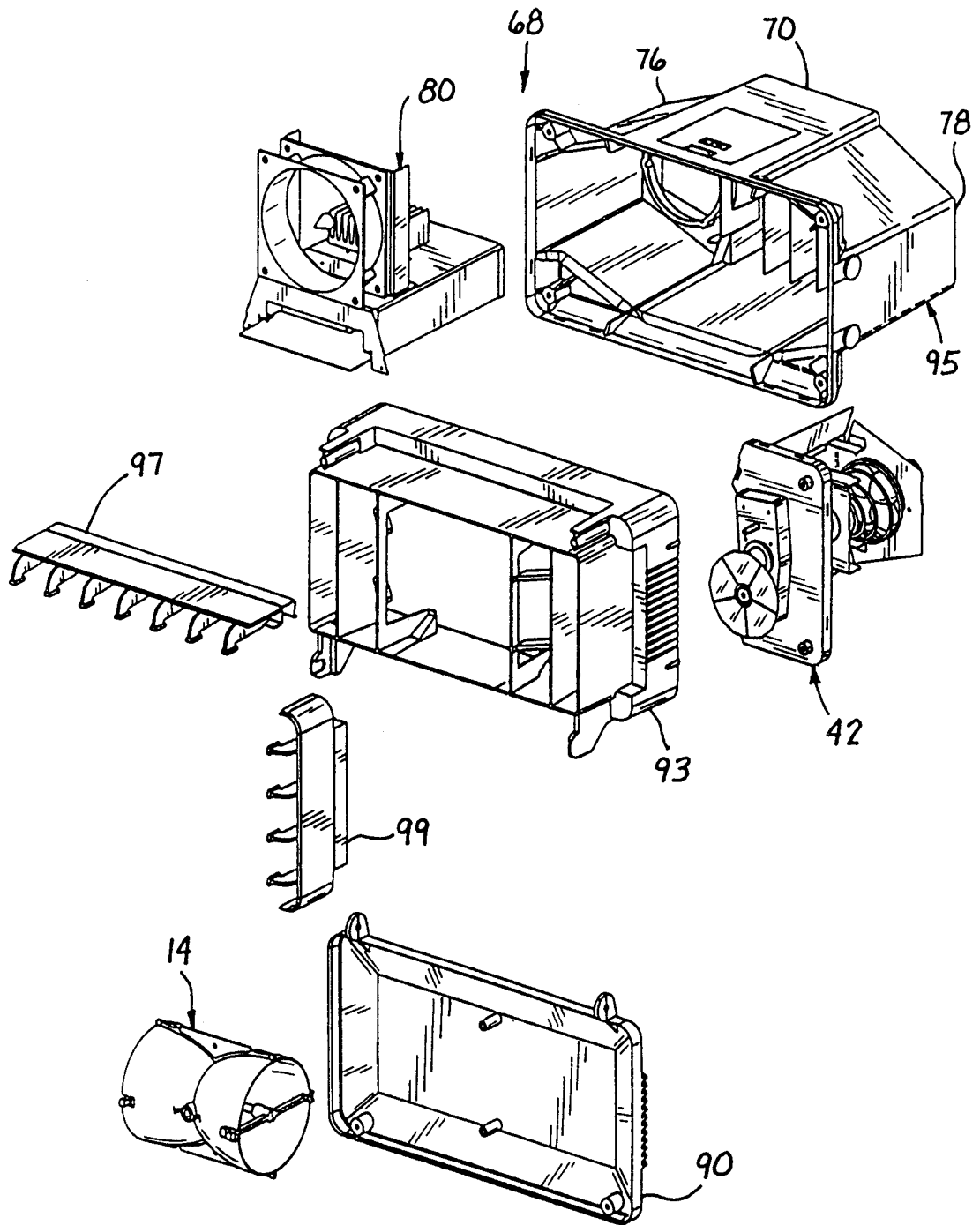


FIG. 10

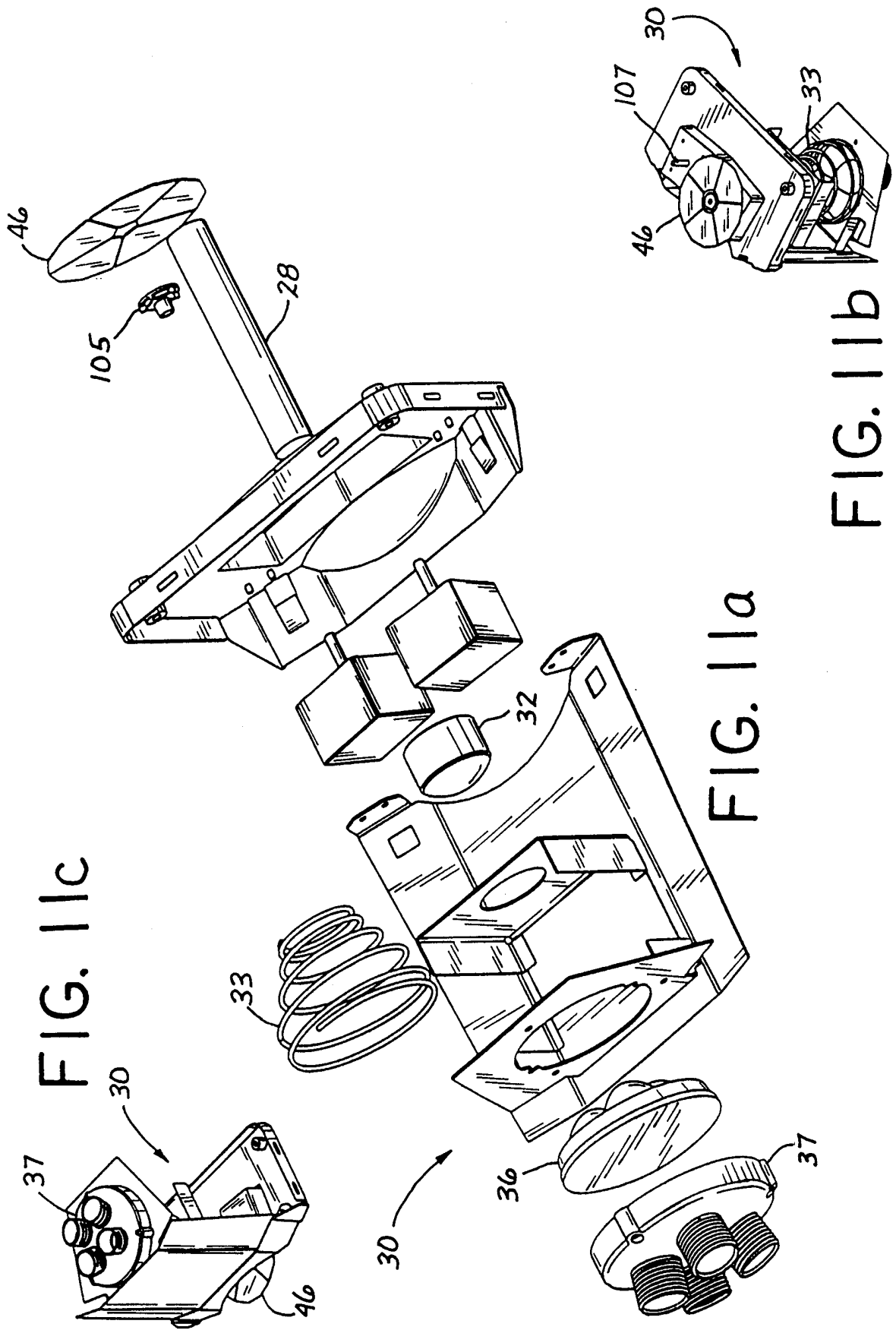


FIG. 11c

FIG. 11a

FIG. 11b

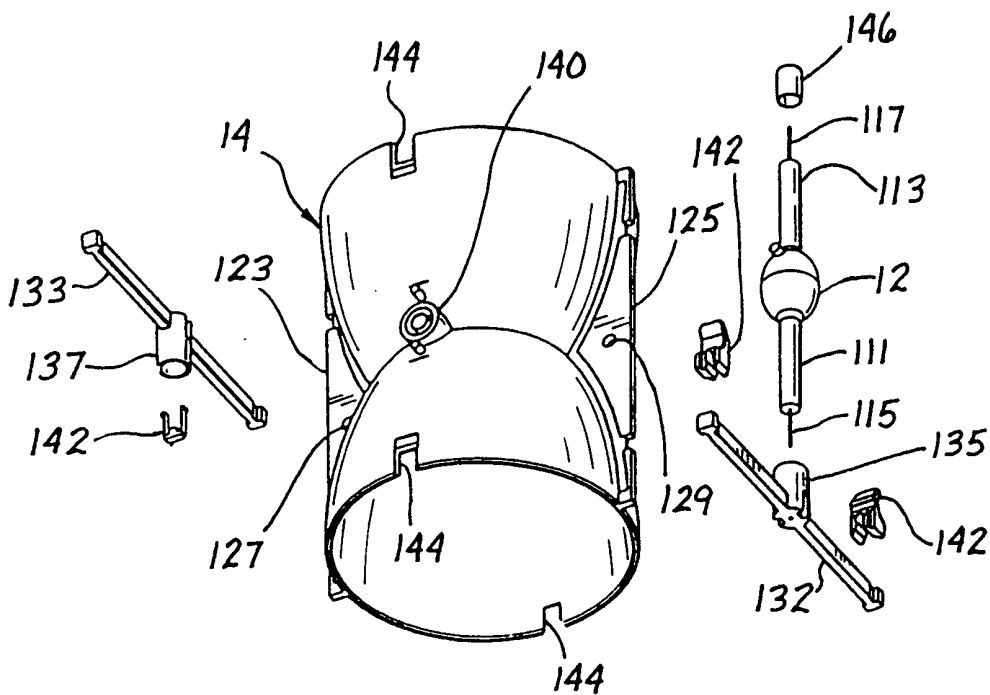


FIG. 12a

FIG. 12b

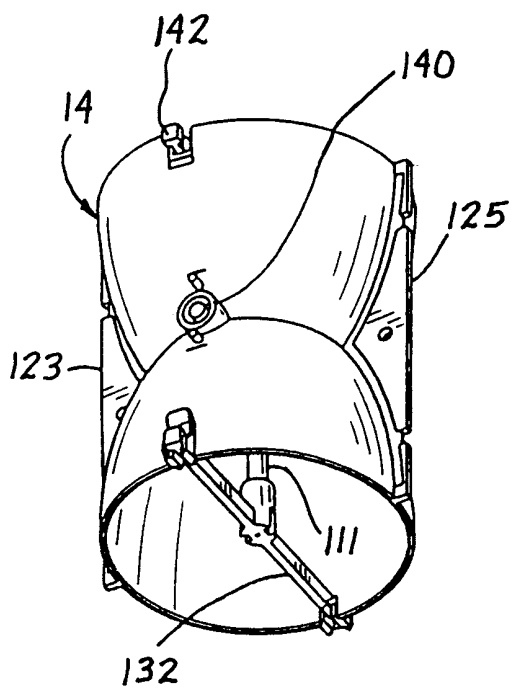
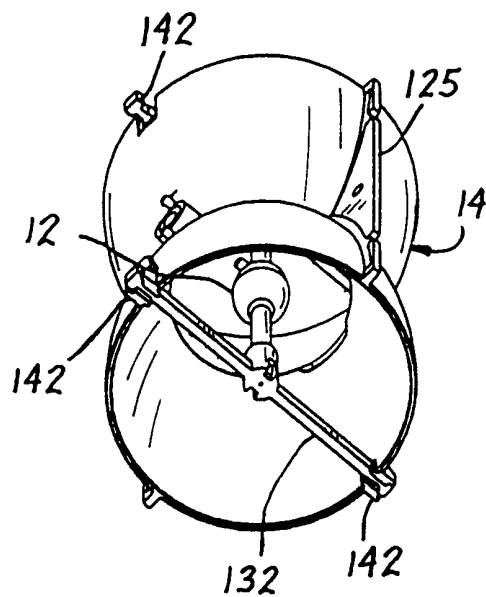


FIG. 12c



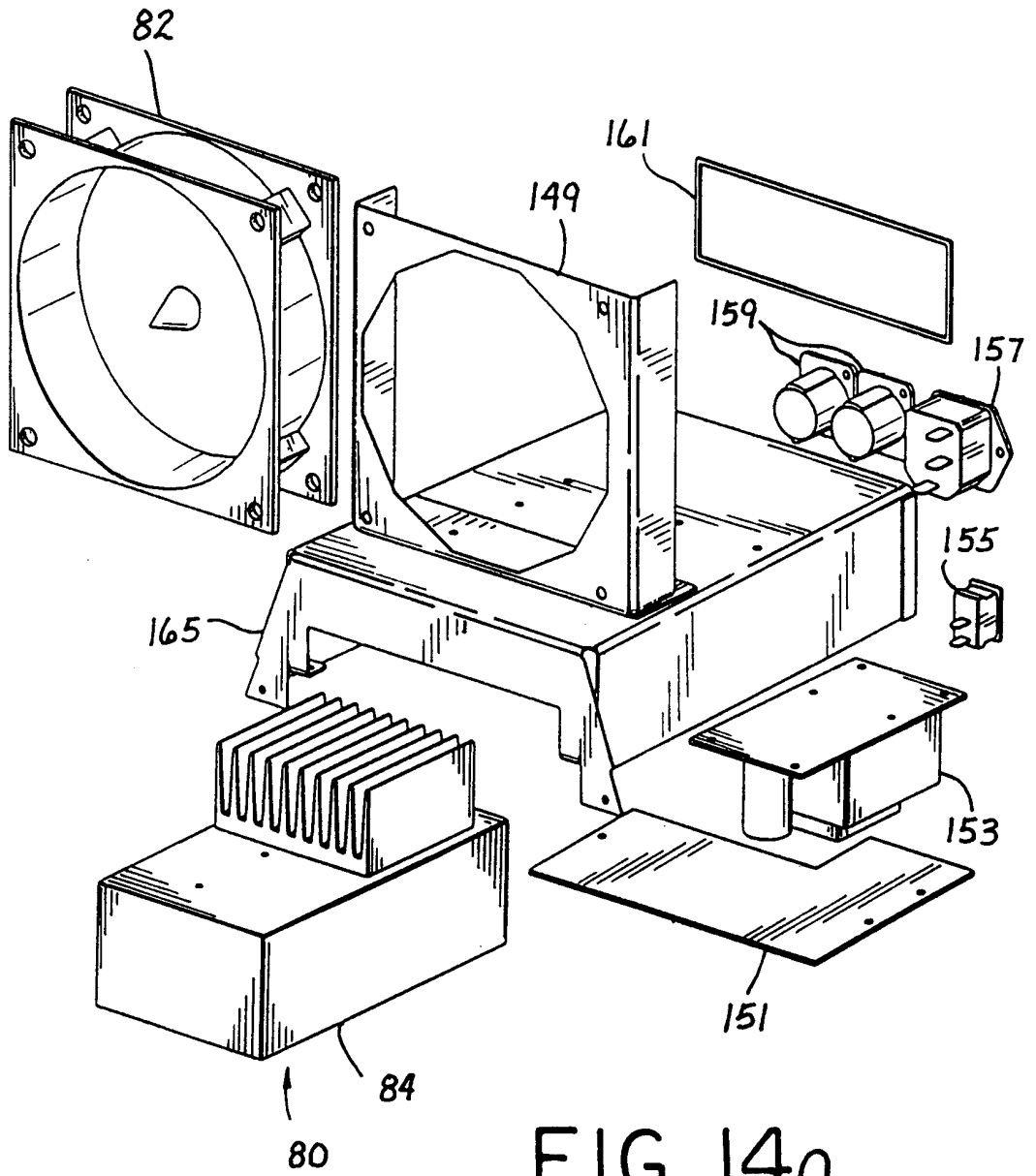


FIG. 14a

FIG. 14b

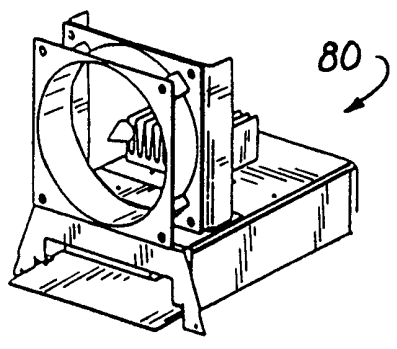


FIG. 14c

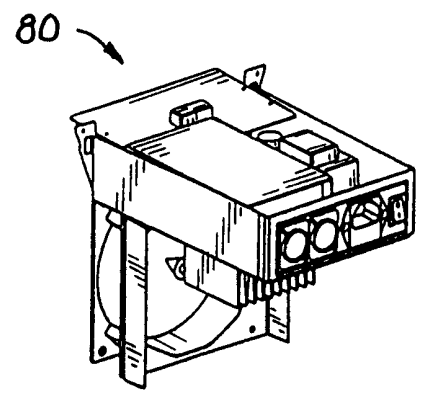


FIG. 15a

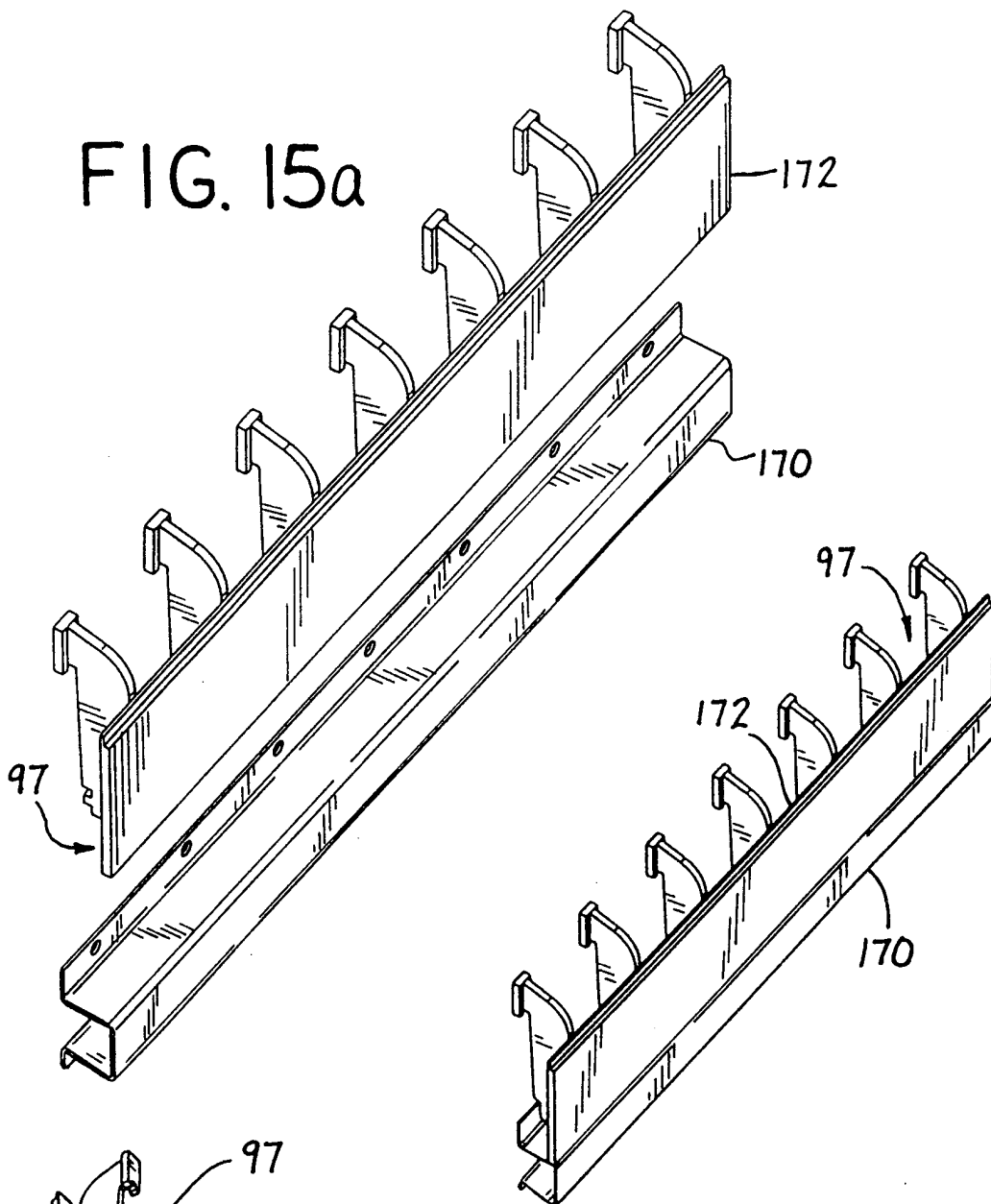


FIG. 15c

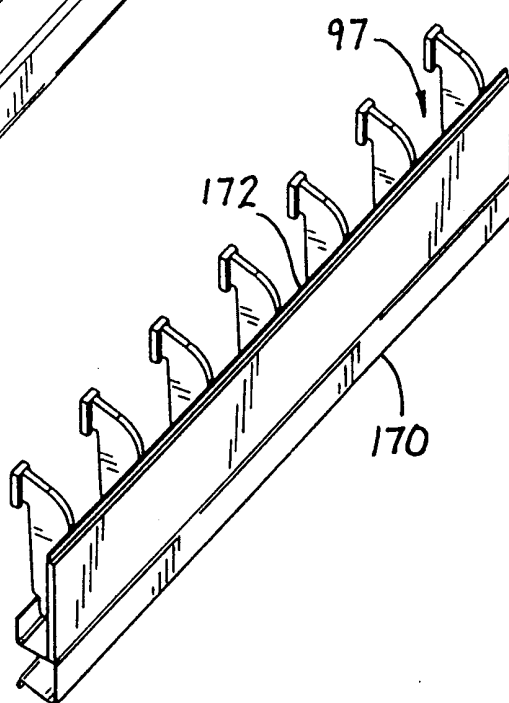
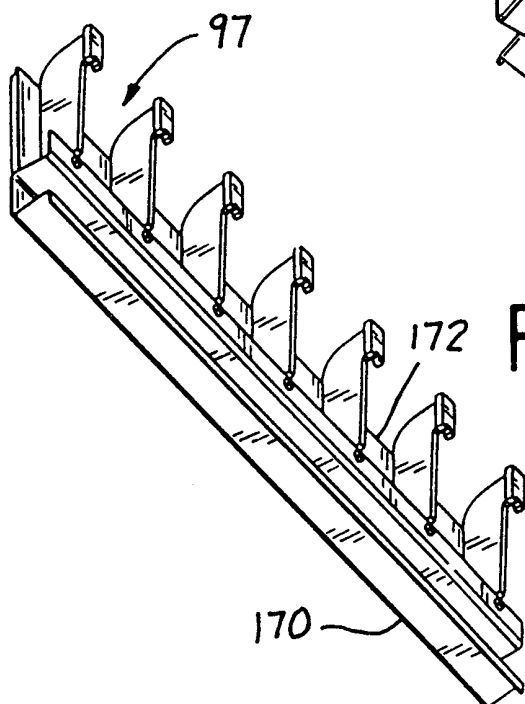


FIG. 15b



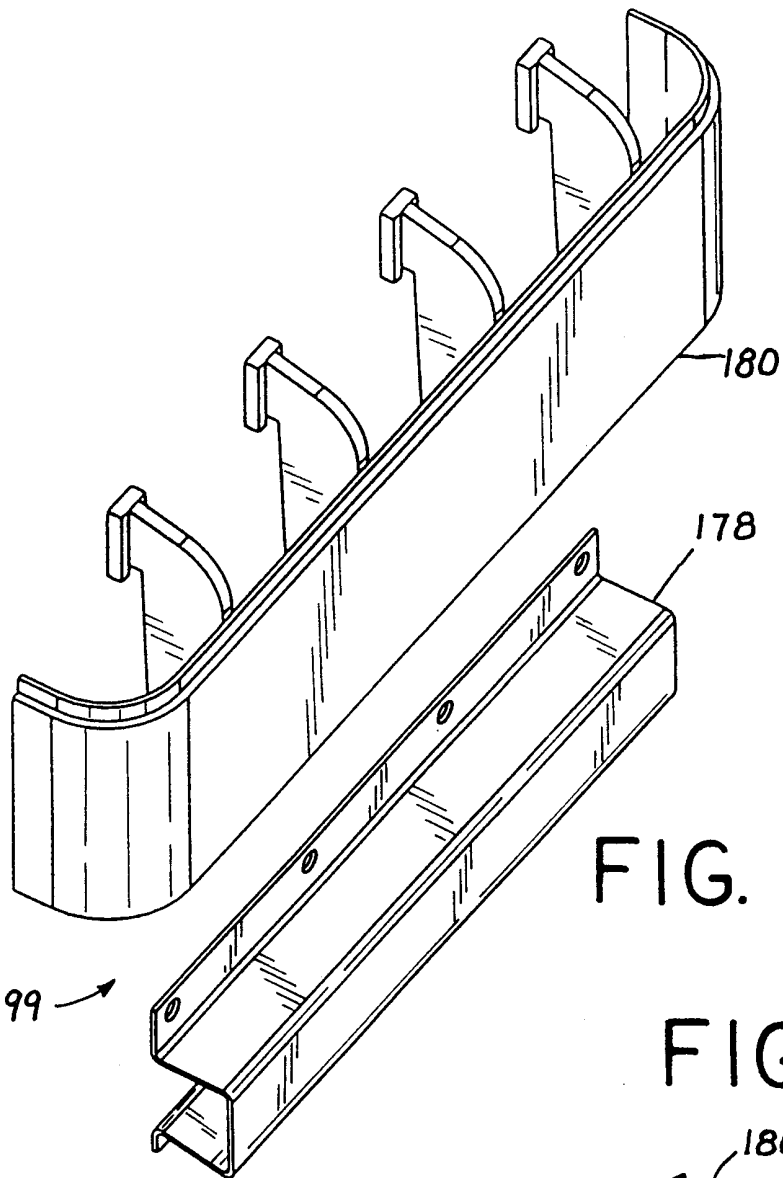


FIG. 16a

FIG. 16c

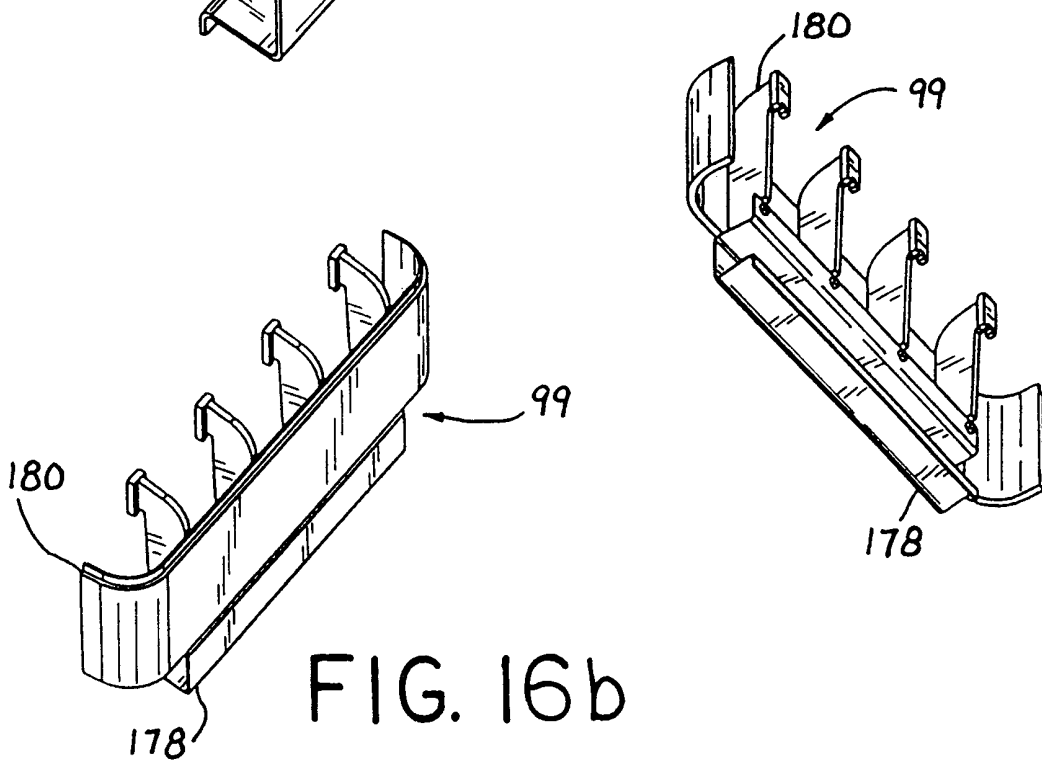
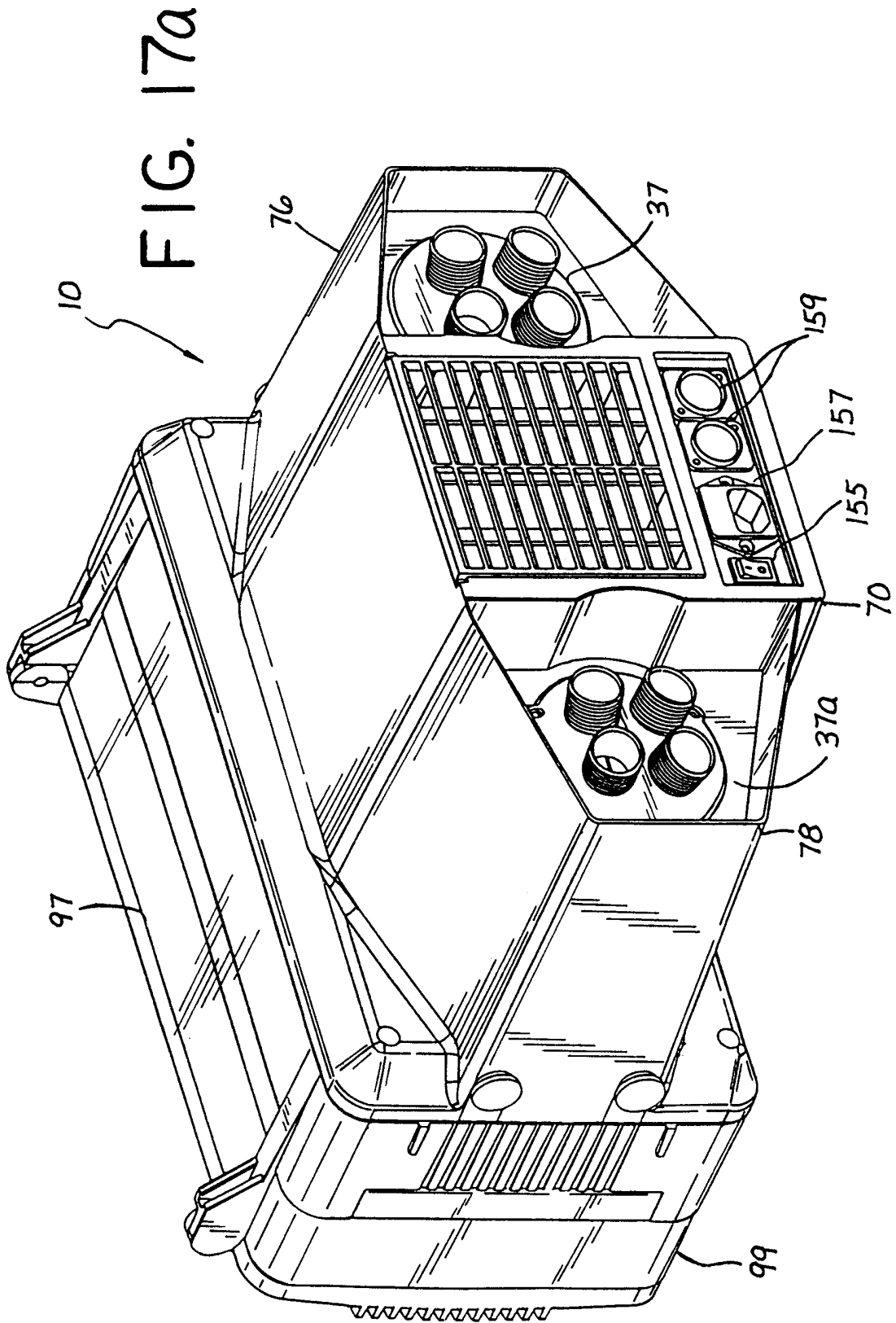


FIG. 16b



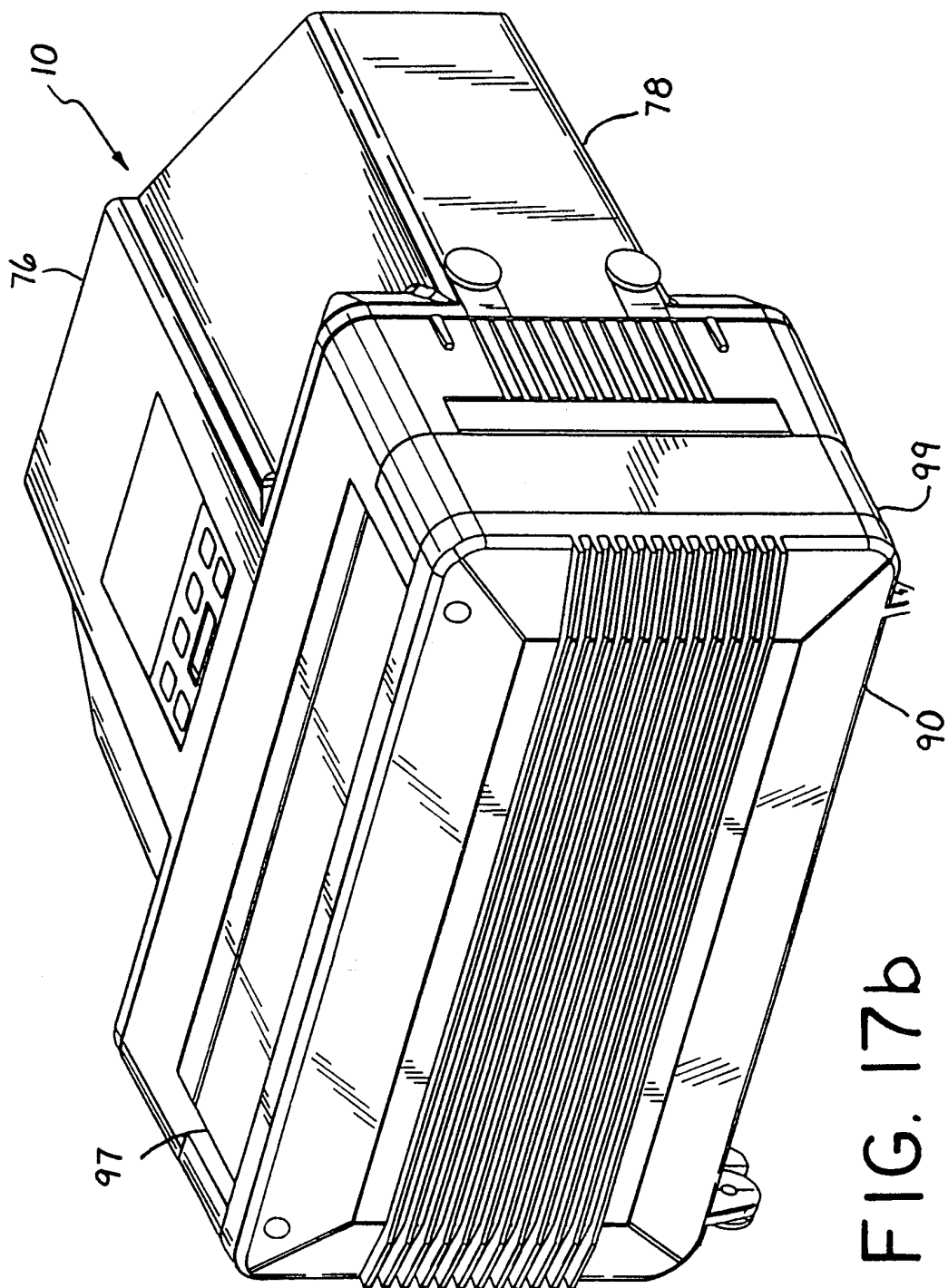


FIG. 17b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/03172

A. CLASSIFICATION OF SUBJECT MATTER		
IPC(6) :G02B 6/26 US CL :385/31 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) U.S. : 385/31		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched NONE		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) SEARCHED APS search terms: optic?(2A)(fiber? or fibre?) and doubl?(2A)reflector? and sector?(2A)lens? and illuminat?(2A)system?		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,559,911 A (FORKNER ET. AL.) 24 SEPTEMBER 1996 (24/09/96) PLEASE NOTE FIGS.12 -14 AND COL. 7, LINES 15-60	1,2,4,5,7 AND 8
A	US 5,396,571 A (SAADATMANESH ET. AL.) 07 MARCH 1995 (07/03/95) NOTE ENTIRE DOCUMENT	1-15
A	US 4,912,605 A (WHITEHEAD) 27 MARCH 1990 (27/03/90) NOTE ENTIRE DOCUMENT	1-15
A	US 5,222,793 A (DAVENPORT ET. AL.) 29 JUNE 1993 (29/06/93) NOTE ENTIRE DOCUMENT	1-15
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 22 JUNE 1998	Date of mailing of the international search report 23 JUL 1998	
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer <i>Brian Healy</i> BRIAN HEALY Telephone No. (703) 308-2693	