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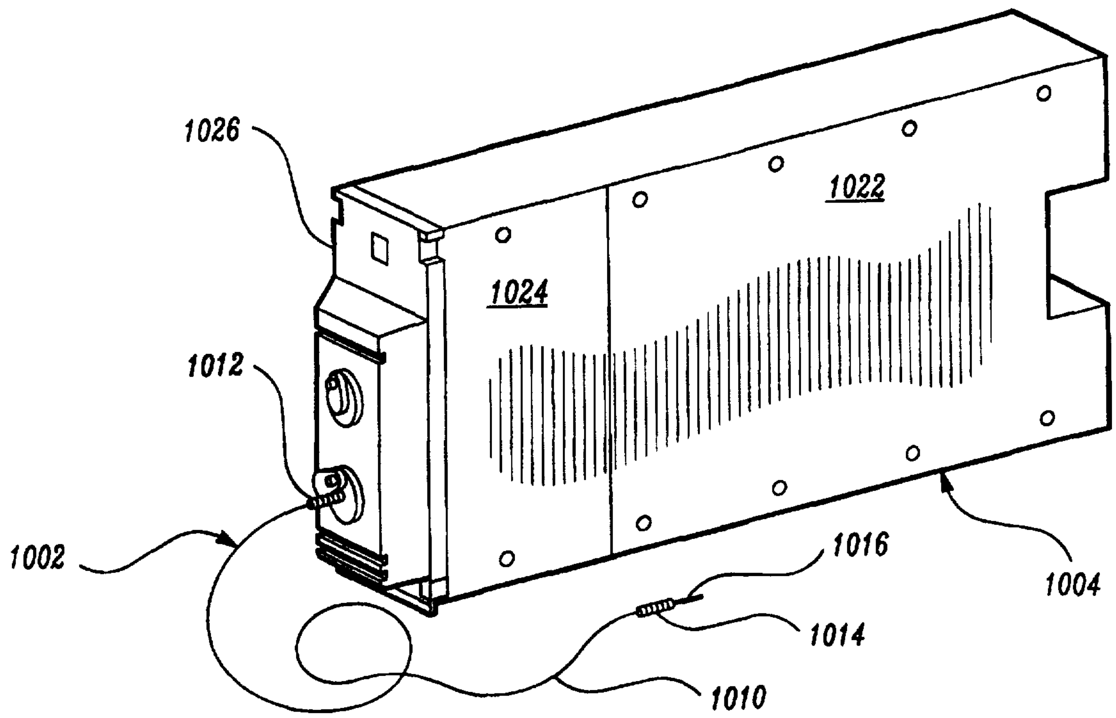


(57) Abstract

A system for controlling a plurality of ophthalmic microsurgical instruments is disclosed. Particularly, an endo-illuminator system (1000) for such ophthalmic systems is described for illuminating a posterior portion of a patient's eye during ophthalmic surgery. The novel endo-illuminator system (1000) includes a lamp system (1004), providing a high color temperature light which is shieleded for use with plastic lamp connections without melting.

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# OPHTHALMIC MICROSURGICAL SYSTEM

## Technical Field

This invention relates generally to microsurgical and ophthalmic systems and, particularly, to an endo-illuminator system for such ophthalmic systems for illuminating a posterior portion of a patient's eye during ophthalmic surgery.

## Background of the Invention

Present day ophthalmic microsurgical systems provide one or more surgical instruments connected to a control console. The instruments are often electrically or pneumatically operated and the control console provides electrical or fluid pressure control signals for operating the instruments. The control console usually includes several different types of human actuable controllers for generating the control signals supplied to the surgical instruments. Often, the surgeon uses a foot pedal controller to remotely control the surgical instruments.

Various ophthalmological procedures require posterior portions of a patient's eye (i.e., behind the iris) to be illuminated. Typically, an incision is made in the sclera (i.e., the white of the eye) and a small endo-illuminator is inserted through the incision into the vitreous body of the eye. The endo-illuminator comprises a single fiberoptic filament having a connector at one end for connection to a high intensity light source. The other end of the filament is supported by a handpiece which is used to insert the filament into the vitreous body. When the light source is energized, light is transmitted through the filament and projected through the vitreous body onto the ocular feature of interest.

Due to the heat generated by most prior art light sources, endo-illuminator connectors may be made of metal so they can withstand heat. However, this dramatically increases costs because endo-illuminators are only used once before being disposed. To permit use of plastic connectors and thereby reduce costs, some light sources have filters for removing heat. However, filters reduce the intensity of the light emitted, which reduces the effectiveness of the system.

Incandescent lamps are frequently used in light sources. In order to produce light having sufficient illuminance (i.e., intensity of illumination) to travel through the endo-illuminator and project onto the posterior portion of the eye, 150 watt bulbs are typically used in incandescent light sources. The illuminance and color temperature of light emitted by incandescent lamps are so low that the interior features of the eye may not be optimally illuminated. Although the power input to the lamp and the lamp size may be increased to increase the illuminance, doing so increases the power consumption and heat output of the lamp and shortens its life.

In order to alleviate the problems associated with incandescent lamps, xenon arc lamps have been used in some light sources. Unlike incandescent lamps which are susceptible to unpredictable catastrophic failure, arc lamps generally fail only during ignition thereby permitting failed lamps to be replaced prior to surgery. However, xenon arc lamps have very high illuminance and color temperatures which can damage the eye if the light is not sufficiently filtered. Yet, filtering is inefficient and is particularly undesirable with xenon lamps as they consume relatively high power (175-300 watt lamps are generally used). Further, xenon arc lamps produce significant amounts of heat which can melt the endo-illuminators if they are not shielded or otherwise adapted to endure the temperatures. Because arc lamps are designed for use with constant voltage power supplies, moveable screens are generally employed to vary the intensity of the light emitted. These screens have different size openings and/or different opening spacings in different areas which can be selectively aligned with the light to vary the intensity. The screens also provide the advantages of a heat filter, but change the angular distribution of light entering the endo-illuminator. As a result, different intensity light beams have different characteristics.

## Disclosure of Invention

Among the several objects and features of the present invention may be noted the provision of an endo-illuminator system for illuminating a posterior portion of a patient's eye during ophthalmic surgery; the provision of such a system which produces light having a high color temperature; the provision of such a system which is capable of use with fiberoptic endo-illuminators having plastic connectors; and the provision of such a system having a heat shield for conducting heat away from the fiberoptic endo-illuminator.

Briefly described, an endo-illuminator system embodying aspects of the invention illuminates a posterior portion of a patient's eye during ophthalmic surgery. The system comprises a fiberoptic endo-illuminator having opposite first and second ends. The endo-illuminator is adapted to transmit light entering the first end to the second end. The second end is sized for insertion into the patient's eye so that light transmitted to the second end from the first end is projected onto the posterior portion of the patient's eye. The system also comprises a metal halide arc discharge lamp for producing a focused beam of light and a mount for holding the first end of the fiberoptic endo-illuminator relative to the lamp so that the first end is positioned within the focused light beam produced by the lamp. The mount also holds the first end of the endo-illuminator and is aligned so light produced by the lamp enters the first end and is transmitted to the second end.

In another embodiment, the invention is an endo-illuminator light source for use in combination with a fiberoptic endo-illuminator to illuminate a posterior portion of a patient's eye during ophthalmic surgery. The light source comprises a metal halide arc discharge lamp for producing a focused beam of light having a color temperature in a range of between 5000° and 6000° K and a mount for holding a first end of a fiberoptic endo-illuminator in the focused light beam produced by the lamp so that the endo-illuminator transmits light to a second end of the endo-illuminator opposite the first end.

In yet another embodiment, the present invention is an endo-illuminator light source for use in combination with a fiberoptic endo-illuminator to illuminate a posterior portion of a patient's eye during ophthalmic surgery. The light source comprises an arc discharge lamp for producing a focused beam of light and a cooling fan for producing a stream of air. The fan is positioned so that the air stream is directed toward the lamp in a transverse direction relative to the beam of light produced by the lamp thereby cooling the lamp by convective heat transfer. The light source also comprises a mount for holding a first end of a fiberoptic endo-illuminator within the focused beam of light produced by the lamp so that the endo-illuminator delivers light to a second end of the endo-illuminator opposite the first end. The mount is configured to hold the fiberoptic endo-illuminator so that the first end extends into the stream of air produced by the cooling fan thereby cooling the endo-illuminator first end by convective heat transfer.

In still another embodiment, the invention is an endo-illuminator light source for use in combination with a fiberoptic endo-illuminator to illuminate a posterior portion of a patient's eye during ophthalmic surgery. The light source comprises a lamp for producing a focused beam of light and a one-piece mount having a lamp holder shaped to hold the lamp in a fixed position within the mount and an endo-illuminator holder for holding a first end of a fiberoptic endo-illuminator in a fixed position relative to the lamp. The first end of the endo-illuminator is positioned within the focused beam of light produced by the lamp so that the endo-illuminator delivers light to a second end of the endo-illuminator opposite the first end. The mount has a passage for permitting air to pass through the mount to cool the lamp and the endo-illuminator first end by convective heat transfer.

In yet another embodiment, the invention is an endo-illuminator light source for use in combination with a fiberoptic endo-illuminator to illuminate a posterior portion of a patient's eye during ophthalmic surgery. The light source comprises an arc discharge lamp for producing a focused beam of light and a mount for holding a connector at a first end of a fiberoptic endo-illuminator to position the first end within the focused beam of light so that the endo-illuminator delivers light to a second end of the endo-illuminator opposite the first end. The light source also comprises a stationary heat shield positioned between the lamp and the first end of the fiberoptic endo-illuminator to shield the endo-illuminator connector from heat and conduct heat away from the endo-illuminator to a heat sink spaced from the endo-illuminator connector. The heat shield has an aperture sized to permit light to enter the first end of the fiberoptic endo-illuminator.

These and other goals and advantages of the invention will be in part apparent and in part pointed out herein below and in the attached drawings.

## Brief Description of Drawings

Fig. 1 is a perspective view of a microsurgical control system for use with ophthalmic microsurgical instruments and having a plurality of control modules utilizing a variety of surgical instruments or handpieces in accordance with the present invention;

Fig. 2 is a perspective of an endo-illuminator system of the present invention;

Fig. 3 is a fragmentary side elevation of an endo-illuminator light source of the system of Fig. 2;

Fig. 4 is a front elevation of the light source;

Fig. 5 is a rear elevation of the light source;

Fig. 6 is a fragmentary bottom plan of the light source;

Fig. 7 is a fragmentary view in partial section taken in the plane of line 7-7 of Fig. 3;

Fig. 8 is a view similar to Fig. 7 showing a second embodiment having a heat shield; and

Fig. 9 is a perspective of the heat shield shown in Fig. 8.

**Mode(s) for Carrying Out the Invention**

Referring to the accompanying drawings in which like reference numbers indicate like elements, Fig. 1 illustrates a microsurgical control system, generally designated 1, according to a preferred embodiment of the present invention. As shown, the system 1 includes a computer unit 3 having a flat panel display 5, a base unit 7 housing a plurality of modules 13, and peripherals such as a foot control assembly 15 and a motorized intravenous (IV) pole assembly 17 (each of which is generally indicated by its respective reference numeral). Each of the modules 13 housed in the base unit 7 controls at least one ophthalmic microsurgical instrument 19 for use by a surgeon in performing various ophthalmic surgical procedures. As is well known in the art, ophthalmic microsurgery involves the use of a number of different instruments 19 for performing different functions. These instruments 19 include vitrectomy cutters, phacoemulsification or phacofragmentation handpieces, electric microscissors, fiber optic illumination instruments, coagulation handpieces and other microsurgical instruments known in the art. To optimize performance of instruments 19 during surgery, their operating parameters differ according to, for example, the particular procedure being performed, the different stages of the procedure, the surgeon's personal preferences, whether the procedure is being performed in the anterior or posterior portion of the patient's eye, and so on.

As shown in Fig. 1, an instrumentation cart, generally designated 21, supports system 1. Preferably, the cart 21 includes a surgical, or Mayo, tray 25, the automated IV pole assembly 17, a storage compartment 27 for stowing the foot control assembly 15, disposable packs and other items, an opening 33 to house an expansion base unit (not shown in Fig. 1), and rotating casters 35. Base unit 7 and computer unit 3 preferably sit on top of instrumentation cart 21 as shown in Fig. 1 and the Mayo tray 25 is mounted on an articulating arm (not shown) preferably attached to the top of instrumentation cart 21, directly beneath base unit 7. Instrumentation cart 21 also holds a remote control transmitter, generally indicated 39, for use in remotely controlling system 1.

The modules 13 in base unit 7 house control circuits for the various microsurgical instruments 19 so that the system's user is able to configure system 1 for optimizing its use by the surgeon. Modules 13 include connections or ports by which one or more microsurgical instruments 19 connect to each module 13 and house the necessary control circuitry for controlling operation of the particular instrument or instruments 19 connected thereto. Thus, the user, by inserting the desired modules 13 in base unit 7, configures system 1 to meet a particular surgeon's preference, to control each of the instruments 19 needed for a particular surgical procedure, or to otherwise optimize system 1 for use by the surgeon.

Referring now to Fig. 2, an endo-illuminator system is indicated in its entirety by the reference numeral 1000. The endo-illuminator system 1000 includes a fiberoptic endo-illuminator (generally indicated at 1002) and a light source (generally indicated at 1004). Although other light source configurations are contemplated as being within the scope of the present invention, the light source 1004 of the preferred embodiment is a modular unit which plugs into a larger housing with other surgical instrument control modules. In a preferred embodiment, the endo-illuminator 1002 is one of the instruments 19 for use with the microsurgical system 1.

The endo-illuminator 1002 is a conventional instrument used to illuminate a posterior portion of a patient's eye during ophthalmic surgery. Although other endo-illuminators are envisioned as being within the scope of the present invention, the endo-illuminator of the preferred embodiment is an MVS1011 endo-illuminator sold by Storz Ophthalmics Inc. of St. Louis, Missouri. The endo-illuminator 1002 includes a single fiberoptic filament 1010 which is approximately 0.030 inches in diameter and about six feet long. A plastic sheath surrounds the filament to protect it and inhibit light transmission through the side of the filament. A conventional American College of Medical Informatics (ACMI) connector 1012 is attached to the filament 1010 at a first end. The connector 1012 is plastic to keep material cost low since the endo-illuminator 1002 is intended to be disposed after a single use. A handpiece 1014 is attached to the filament 1010 at a second end opposite the first end, and a stainless steel tube 1016 extends outward from the handpiece to support the filament adjacent its second end. The tube 1016 is sized so it may be inserted into an incision made in a patient's eye. For example, the tube 1016 of the preferred embodiment has a twenty-gauge diameter and is about 1.5 inches long. Although the endo-illuminator 1002 of the preferred embodiment consists of a single fiberoptic filament, fiberoptic bundles comprising a plurality of filaments are also envisioned as being within the scope of this invention.

As further shown in Fig. 2, the light source 1004 is enclosed in a housing 1020 having side access panels 1022, 1024 and a molded front cover 1026 having two endo-illuminator connection ports 1028 (Fig. 7). Referring to Fig. 3 which shows the light source 1004 with the forward access panel 1022 removed and the rearward access panel 1024 fragmented, the light source also comprises two mounts 1030, two metal halide arc lamps 1032, two starter ballasts 1034, one control board 1036 and one cooling fan 1038. The light source 1004 of the preferred embodiment has two mounts 1030, lamps 1032 and ballasts 1034 so a single endo-illuminator 1002 may be switched from one connection port 1028 to the other in the unlikely event either lamp or ballast fails. In addition, this configuration permits two endo-illuminators 1002 to be used at the same time.

Electrical connectors 1040 connect each of the lamps 1032 to a pair of leads 1042 which extend to one of the starter ballasts 1034. Each of the leads 1042 is threaded through a bead 1044 to cancel electromagnetic interference (EMI) caused by current travelling through the lead. Due to the proximity of the leads 1042 to various electronic components within the light source housing 1020 and beyond, elimination of EMI is necessary to ensure proper operation of the components.

Each starter ballast 1034 delivers a voltage spike to a respective lamp 1032 to initiate the arc during start-up. Although other ballasts are envisioned as being within the scope of the present invention, each of the starter ballasts 1034 of the preferred embodiment is a Model B21N001, non-regulated ballast made by Welch Allyn, Inc. and is specifically intended for use in combination with the lamps 1032 of the preferred embodiment. Each ballast 1034 delivers 21 watts of power at sixty volts when energized by a fifteen-volt input. At start-up, the ballast 1034 produces a 3000-4000 volt spike within one second after being energized to initiate the arc in a respective lamp 1032.

Additional leads 1046 connect each of the starter ballasts 1034 to the control board 1036. These leads 1046 are also threaded through beads 1048 to cancel EMI.

As its name implies, the control board 1036 controls the lamps 1032 and other components of the light source 1004 and communicates with various external modules (not shown). For instance, the control board 1036 may include means for reducing the intensity of the light beam in response a signal from the computer unit 3 by varying the voltage delivered to the ballasts 1034. When the voltage input to the ballasts 1034 is varied, the voltage output from the ballasts, and therefore, the voltage delivered to the lamps is varied. Although the lamps 1032 were initially designed to deliver constant illuminance light, it has been found that the intensity of light emitted from the lamps 1032 varies with voltage input. For example, a decrease in voltage input to about 75 percent of the design voltage, decreases the light output from the lamps by approximately 50 percent without causing a significant color shift (a shift greater than 600°K) in the light output. Further, unlike prior art light sources which used screens to vary the output light intensity, the variable voltage method used in the light source of the preferred embodiment does not change the angular distribution of the emitted light. Although it is envisioned that the control board 1036 could be adapted to change the illumination over a continuous range, the control board 1036 of the preferred embodiment includes a digital to analog converter which is adapted to provide five discrete power levels, level 5 (100%), level 4 (75%), level 3 (50%), level 2 (38%) and level 1 (25%), output illumination levels. Other means for reducing the intensity of the light beam emitted by the light source are also envisioned as being within the scope of the present invention. These means include conventional variable resistance circuits which may comprise potentiometers, varistors, and/or voltage dividers.

The control board 1036 includes an 18-pin electrical connector 1052 which protrudes through an opening 1054 (Fig. 5) in the rear of the housing 1020 for connecting the light source 1004 to a backplane (not shown) having a power bus for supplying power from an external regulated power source (not shown) and a data communications bus for communicating with the other system modules. Together the power source, the control 1036 and ballasts 1034 constitute a power supply for producing electrical current to energize the lamps 1032.

The rearward access panel 1022 includes a wall portion 1056 which extends into the housing midway between its forward and rearward ends and segregates the housing into forward and rearward compartments. The forward access panel 1024 can be removed to replace failed lamps.

As shown in Fig. 4, two shutters 1060 are pivotably attached to the front cover 1026 by fasteners 1062 so that they cover the connection ports 1028. Thus, light only passes through the connection ports 1028 when the connectors 1012 are plugged into them. The shutters 1060 may be pivoted about the fasteners 1062 to expose the connection ports 1028 (Fig. 7) for inserting the connector 1012 as shown in Fig. 2. Returning to Fig. 4, a light emitting diode 1064 is also positioned on the front cover 1026. A lead 1066 (Fig. 3) connects the diode 1064 to the control board 1036. The control board 1036 powers the diode 1064 to indicate when the light source 1004 is energized.

Turning to Fig. 5, an exhaust port 1074 is provided in the rear wall of the housing 1020 adjacent the fan 1038 and above the 18-pin electrical connector 1052. As illustrated in Figs. 104 and 105, two parallel slots 1076 are formed in the bottom of the housing 1020 for mounting the light source 1004 on rails (not shown) within a housing or rack (not shown) of the aforementioned base unit 7 (Fig. 1). As also shown in Fig. 6, a recess 1078 is formed near the bottom of the front cover 1026 so the light source 1004 may be gripped to slide it into and out of the rack. An opening 1080 in the housing 1020 allows air to be drawn into the housing by the fan 1038 for cooling the lamps 1032 and other system components. Because the opening 1080 is located on the bottom of the housing 1020, the possibility of liquid entering the housing 1020 is reduced thereby making the housing spill-resistant. A deflector 1082 angled into the housing 1020 from the opening 1080 deflects air entering the housing toward the front cover 1026. The wall portion 1056 (Fig. 3) of the rearward access panel 1022 directs the air upward past the mounts 1030 and lamps 1032 before allowing it to turn toward the fan 1038 at the top of the wall.

As shown in Fig. 7, each lamp 1032 includes an elliptical reflector 1090 for focussing the light toward a focal point F. The focal "point" of the lamps 1032 of the preferred embodiment is a sphere having a diameter of approximately 0.040 inches. A tight tolerance collar 1092 holds the rim of the reflector 1090 in a fixed position to ensure that the reflector is precisely aimed toward the desired focal point F. A tube 1094 positioned inside the reflector contains two electrodes 1096a, 1096b in an atmosphere comprising mercury vapor and a metal halide. Pin connectors 1098 are connected to the electrodes for supplying the lamp 1032 with electricity from a respective ballast 1034. When a sufficient voltage is applied to the connectors 1098, an arc passes between the electrodes 1096a, 1096b. The light generated by the arc is focused by the reflector as previously explained. Although other lamps are envisioned as being within the scope of the present invention, each of the lamps 1032 of the preferred embodiment is a Model M21E001, Hi-Lux™ metal halide arc discharge lamp. Hi-Lux is a trademark of Welch Allyn, Inc. of Skaneateles Falls, New York. In contrast to prior art incandescent lamps which typically operate at 150 watts or xenon lamps which typically operate at between 175 and 300 watts, the lamps 1032 of the preferred embodiment operate at approximately 21 watts while producing a beam of light nearly as bright as xenon lights and brighter than incandescent lights.

As further shown in Fig. 7, the mount 1030 is fastened to the front cover 1026 of the housing 1020 by screws 1100. A cover plate 1102 is positioned over the heads of the screws 1100 and is held in place by a fastener (not shown). The mount 1030 extends rearward from the front cover 1026 at an angle of approximately 15° from perpendicular. This causes the endo-illuminator connector 1012 to be angled with respect to the lamp reflector so that the reflector axis $A_1$ is angled with respect to the endo-illuminator 1002 axis $A_2$.

Due to catadioptric effects, there is a faint shadow near the center of any light beam projected from a reflector. By angling the endo-illuminator relative to the lamp, the shadow at the center of the reflected light beam is offset from the axis of the endo-illuminator. The intensity of light emitted from any radius of a fiberoptic filament is the average of the intensities of light rays entering the filament at that radius. Because the shadow enters the filament at an angle, it is averaged with normal intensity light entering the filament at the same radius. Thus, the shadow is blended and virtually made unnoticeable by angling the endo-illuminator with respect to the reflector. However, as the angle between the lamp and the endo-illuminator axis is increased, the intensity of light emitted from the endo-illuminator is attenuated. Thus, there is an optimal angle between the lamp and endo-illuminator at which the overall intensity is maximized and the catadioptric shadow effect is minimized. Experiments have shown this angle is approximately 15°.

Referring now to Fig. 7, the mount 1030 is a generally cylindrical member, preferably formed (e.g., machined) from a single block of suitable material, such as aluminum, to have a flat forward face which is inclined relative to the central axis of the cylinder at the aforementioned 15° angle. A bore is formed in the rearward end of the mount to provide a cylindric outer shell 1108 with an enlarged inner diameter 1110 and an annular shoulder 1112 defining a lamp holder. The collar 1092 of the lamp seats within the inner diameter 1110 and against the shoulder 1112 to hold the lamp in a fixed position in the mount 1030. A pin (not shown) extends radially outward from the lamp collar 1092 and engages an axial slot (not shown) in the lamp holder to align the lamp 1032 in the inner diameter 1110. A spring clip 1114 (Fig. 3) engages circumferential slots 1116 in the lamp holder to retain the lamp 1032 in place within the holder.

A filter holder, generally designated by 1120, is positioned within the outer shell of the mount 1030. The filter holder 1120 also comprises a cylinder having an annular shoulder 1122 formed in its inner diameter. A groove 1124 formed in the inner diameter rearward of the shoulder 1122 receives an O-ring 1126 to hold a filter 1128 against the shoulder. The filter 1128 reduces ultra-violet and infrared radiation emitted by the system to ensure that most of the light transmitted to the patient has a spectral content between 500 and 750 nm.

A hole 1130 sized to hold the endo-illuminator connector 1012 extends through the front part of the mount 1030, and a resilient ball spring 1132 is positioned in a groove surrounding the hole. The spring 1132 is receivable in a notch 1134 in the endo-illuminator connector 1012 for releasably holding the connector in the hole. Together the hole 1130 and ball spring 1132 form an endo-illuminator holder for holding the end of the endo-illuminator in a fixed position with the end of the filament 1010 positioned at the focal point F of the lamp 1032. Because the mount 1030 is formed as one part, close tolerances may be maintained between the endo-illuminator holder and the lamp holder. Thus, the position of the endo-illuminator connector is tightly controlled relative to the lamp, and the light output from the endo-illuminator is highly predictable.

A first pair of racetrack-shaped openings 1140 are provided in the top and bottom of the outer shell 1108 of the lamp holder, and a second pair of racetrack-shaped openings 1142 are provided in the top and bottom of the annular wall forming the filter holder 1120 to permit air to pass through the mount to cool the lamp 1032, connector 1012 and endo-illuminator filament 1010. The openings 1140, 1142 form part of a cooling passage extending though the housing 1020 from the opening 1080 in the bottom of the housing to the exhaust port 1074 at the rear of the housing. Air is drawn through the housing 1020 by the cooling fan 1038 mounted adjacent the rearward end of the passage. The air passes through the mount 1030 from the lower opening 1140 to the upper opening 1140 in a transverse direction relative to the beam of light to cool the lamp 1032 by convective heat transfer. The air flow through the openings 1140 is sufficiently high to cool the tip of the lamp tube 1094 during operation. A portion of the air also travels through openings 1142 into the filter holder 1120 where it also cools the end of the endo-illuminator 1002 by convective heat transfer. In fact, the endo-illuminator 1002 is sufficiently cooled that the connector 1012 may be made of plastic thereby reducing the endo-illuminator cost. After passing through the mount 1030, the air continues upward and passes the top of the wall portion 1056 (Fig. 3) of the rearward access panel 1022 before turning rearward to cool the other components of the endo-illuminator system 1000.

The assembly shown in Fig. 8 is identical to that of Fig. 7 except a heat shield 1150 is included between the lamp 1032 and endo-illuminator connector 1012 for shielding the connector from heat and conducting heat away from the endo-illuminator. The heat shield 1150 extends through one of the openings 1142 and is secured (e.g., brazed) to the rearward face of the mount 1030 which acts as a heat sink for absorbing thermal energy from the shield 1150. An aperture 1152 (Fig. 9) in the heat shield is sized (e.g., about 0.045-0.055 inches) to permit light to enter the first end of the fiberoptic endo-illuminator 1002 while preventing heat transfer to the connector 1012. Although it is envisioned that the heat shield may be made of any thermally conductive material which can withstand the temperatures, in the preferred embodiment the heat shield 1150 is made of a beryllium-copper alloy sheet material having a thickness of approximately 0.010 inches. The shield 1150 is spaced from the end of the connector 1012 by approximately 0.010-0.015 inches so the connector is thermally insulated.

To operate the endo-illuminator system 1000 of the present invention, the light source 1004 is installed in a housing of the base unit 7 (Fig. 1) so the electrical connector 1052 engages a backplane having power and data communications buses. An endo-illuminator connector 1012 is installed in one or both of the connection ports 1028. In response to a data signal from the computer unit 3 or other module 13, the control board 1036 starts the cooling fan 1038 and delivers about fifteen volts to the starter ballasts 1034. Within about one second, the ballasts deliver a 3000-4000 volt spike to the lamps 1032 to initiate the arc. After the lamps are warm, the user may select a 50%, 75%, or 100% illuminance level. In response to this selection, the control board 1036 varies the voltage delivered to the ballasts 1034 as previously discussed in a range of between about ten and fifteen volts to vary the illuminance of the light emitted by the lamps. Regardless of the intensity of light emitted, the lamps 1032 focus the light onto the connector end of the endo-illuminator filament 1010. The light is transmitted through the filament 1010 and projected out the tube end of the endo-illuminator 1002 to illuminate the ocular feature at which the endo-illuminator is aimed.

As will be appreciated by the previous description, the endo-illuminator system 1000 of the present invention delivers a high illuminance light which is sufficiently bright for illuminating a posterior portion of a patient's eye during ophthalmic surgery. Further, the system 1000 is highly efficient and uses very little power. In addition, the system 1000 produces light having a high color temperature and is capable of use with fiberoptic endo-illuminators having plastic connectors.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

## Claims

1. An endo-illuminator system for illuminating a posterior portion of a patient's eye during ophthalmic surgery, the system comprising:

a fiberoptic endo-illuminator having opposite first and second ends, the endo-illuminator being adapted to transmit light entering said first end to said second end, said second end being sized for insertion into the patient's eye so that light transmitted to said second end from said first end is projected onto the posterior portion of the patient's eye;

a metal halide arc discharge lamp for producing a focused beam of light; and

a mount for holding said first end of the fiberoptic endo-illuminator relative to the lamp so that said first end is positioned within said focused light beam produced by the lamp and aligned so light produced by the lamp enters said first end and is transmitted to said second end.

2. An endo-illuminator light source for use in combination with a fiberoptic endo-illuminator to illuminate a posterior portion of a patient's eye during ophthalmic surgery, the light source comprising:

a metal halide arc discharge lamp for producing a focused beam of light having a color temperature in a range of between 5000° and 6000° K; and

a mount for holding a first end of a fiberoptic endo-illuminator in said focused light beam produced by the lamp so that the endo-illuminator transmits light to a second end of the endo-illuminator opposite said first end.

3. An endo-illuminator light source as set forth in claim 2 further comprising means for reducing an intensity

of the light beam by more than forty percent without decreasing the color temperature by more than 600° K.

4. An endo-illuminator light source as set forth in claim 2 wherein said light beam transmitted through the fiberoptic endo-illuminator has an angular distribution and the light source further comprises means for varying an intensity of the light beam without affecting the angular distribution of the light beam.

5. An endo-illuminator light source as set forth in claim 4 wherein the means for varying said light beam intensity includes a control for varying voltage supplied to the lamp to thereby vary the intensity of the light beam.

6. An endo-illuminator light source for use in combination with a fiberoptic endo-illuminator to illuminate a posterior portion of a patient's eye during ophthalmic surgery, the light source comprising:

a lamp for producing a focused beam of light; and

a one-piece mount having a lamp holder shaped to hold the lamp in a fixed position within the mount and an endo-illuminator holder for holding a first end of a fiberoptic endo-illuminator in a fixed position relative to the lamp wherein said first end is positioned within said focused beam of light produced by the lamp so that said endo-illuminator delivers light to a second end of the endo-illuminator opposite said first end, the mount having a passage for permitting air to pass through the mount to cool the lamp and said endo-illuminator first end by convective heat transfer.

7. An endo-illuminator light source as set forth in claim 6 further comprising a cooling fan for producing a stream of air, the fan being positioned so that said air stream is directed through the mount passage thereby cooling

the lamp and said endo-illuminator first end by convective heat transfer.

8. An endo-illuminator light source as set forth in claim 7 wherein said passage extends transverse to the beam of light produced by the lamp.

9. An endo-illuminator light source as set forth in claim 6 further comprising a filter positioned between the lamp and said first end of the endo-illuminator.

10. An endo-illuminator light source as set forth in claim 9 wherein the filter reduces ultra-violet light transmitted from the lamp to said first end of the endo-illuminator.

11. An endo-illuminator light source as set forth in claim 6 wherein the mount holds said first end of the endo-illuminator at an angle relative to said light beam.

12. An endo-illuminator light source as set forth in claim 11 wherein the mount holds said first end of the endo-illuminator at an angle of approximately 15° relative to said light beam.

13. An endo-illuminator light source for use in combination with a fiberoptic endo-illuminator to illuminate a posterior portion of a patient's eye during ophthalmic surgery, the light source comprising:

an arc discharge lamp for producing a focused beam of light;

a cooling fan for producing a stream of air, the fan being positioned so that said air stream is directed toward the lamp in a transverse direction relative to the beam of light produced by the lamp thereby cooling the lamp by convective heat transfer; and a mount for holding a first end of a fiberoptic endo-illuminator within said focused beam of light produced by the lamp so that said endo-illuminator delivers light to a second end of the endo-illuminator opposite said first end, the mount being configured to hold the fiberoptic endo-illuminator so that said first end extends into said stream of air produced by the cooling fan thereby cooling said endo-illuminator first end by convective heat transfer.

14. An endo-illuminator light source as set forth in claim 13 further comprising a housing for enclosing the lamp, the fan and the mount, the housing having a passage extending in the transverse direction relative to the beam of light produced by the lamp to direct said air stream toward the lamp, the housing having first and second openings at opposite ends of the passage, the fan being mounted within the passage.

15. An endo-illuminator light source as set forth in claim 14 wherein said first housing opening is positioned in a bottom face of the housing and said second housing opening is positioned on a rear face of the housing, and the fan is oriented to draw air through said first opening and exhaust air through said second opening.

16. An endo-illuminator light source as set forth in claim 15 wherein the fan is positioned adjacent said second housing opening.

17. An endo-illuminator light source as set forth in claim 6 further comprising a cooling fan for producing a stream of air, the fan being positioned so that said air stream is directed through the mount passage thereby cooling the lamp and said endo-illuminator first end by convective heat transfer.

18. An endo-illuminator light source as set forth in claim 17 wherein said passage extends transverse to the beam of light produced by the lamp.

19. An endo-illuminator light source as set forth in claim 6 further comprising a filter positioned between the lamp and said first end of the endo-illuminator.

20. An endo-illuminator light source as set forth in claim 19 wherein the filter reduces ultra-violet light transmitted from the lamp to said first end of the endo-illuminator.

21. An endo-illuminator light source as set forth in claim 6 wherein the mount holds said first end of the endo-illuminator at an angle relative to said light beam.

22. An endo-illuminator light source as set forth in claim 21 wherein the mount holds said first end of the endo-illuminator at an angle of approximately 15° relative to said light beam.

23. An endo-illuminator light source for use in combination with a fiberoptic endo-illuminator to illuminate a posterior portion of a patient's eye during ophthalmic surgery, the light source comprising:

an arc discharge lamp for producing a focused beam of light;

a mount for holding a connector at a first end of a fiberoptic endo-illuminator to position said first end within said focused beam of light so that the endo-illuminator delivers light to a second end of the endo-illuminator opposite said first end; and

a stationary heat shield positioned between the lamp and said first end of the fiberoptic endo-illuminator to shield the endo-illuminator connector from heat and conduct heat away from the endo-illuminator to a heat sink spaced from said endo-illuminator connector, the heat shield having an aperture sized to permit light to enter the first end of the fiberoptic endo-illuminator.

24. An endo-illuminator light source as set forth in claim 23 wherein the heat sink is integrally formed with the mount.

25. An endo-illuminator light source as set forth in claim 23 further comprising a cooling fan for producing a stream of air, the fan being positioned so that said air stream is directed across the heat sink thereby cooling the heat sink.

26. An endo-illuminator light source as set forth in claim 6 wherein the mount holds said first end of the endo-illuminator at an angle relative to said light beam.

27. An endo-illuminator light source as set forth in claim 26 wherein the mount holds said first end of the endo-illuminator at an angle of approximately 15° relative to said light beam.

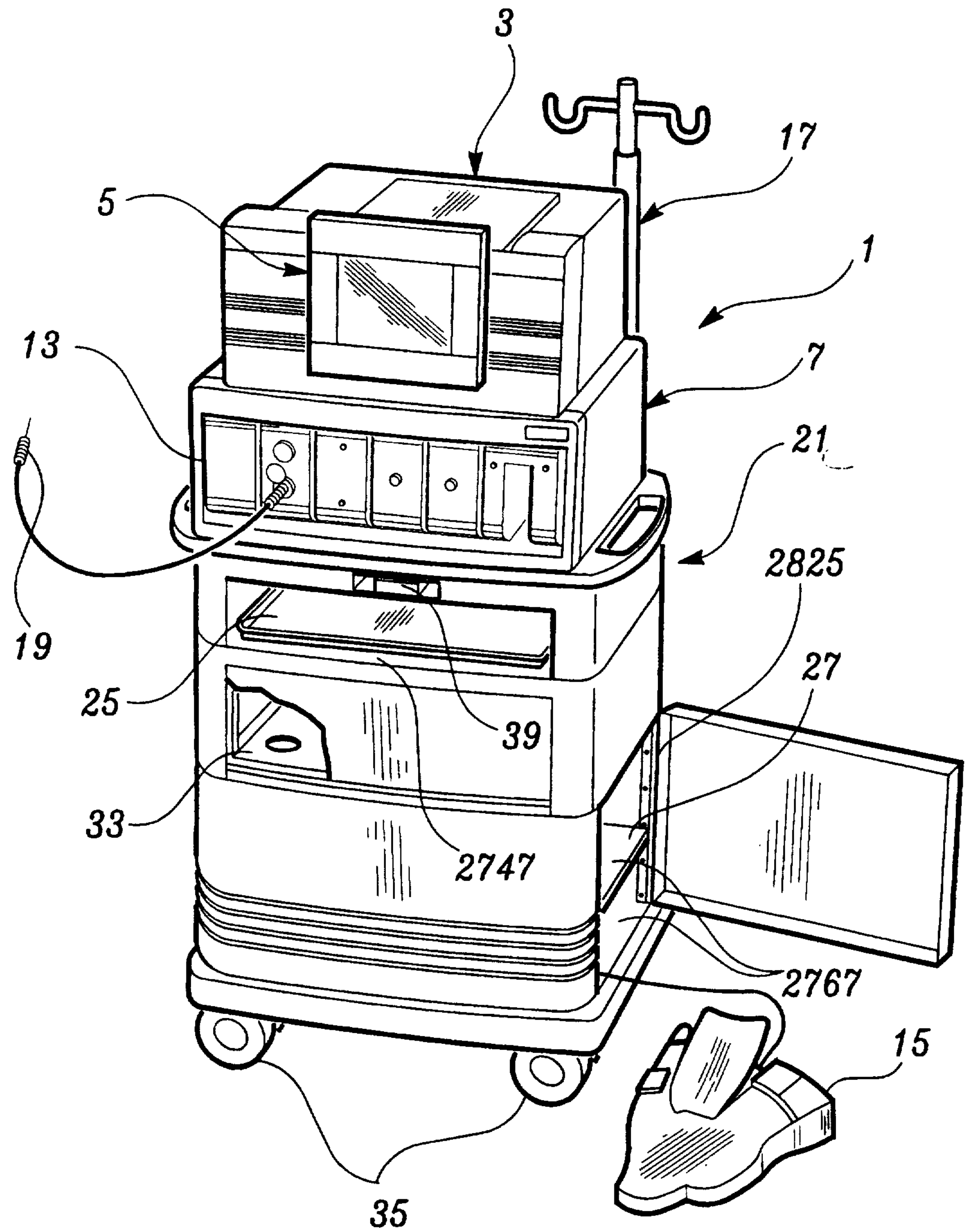


figure 1

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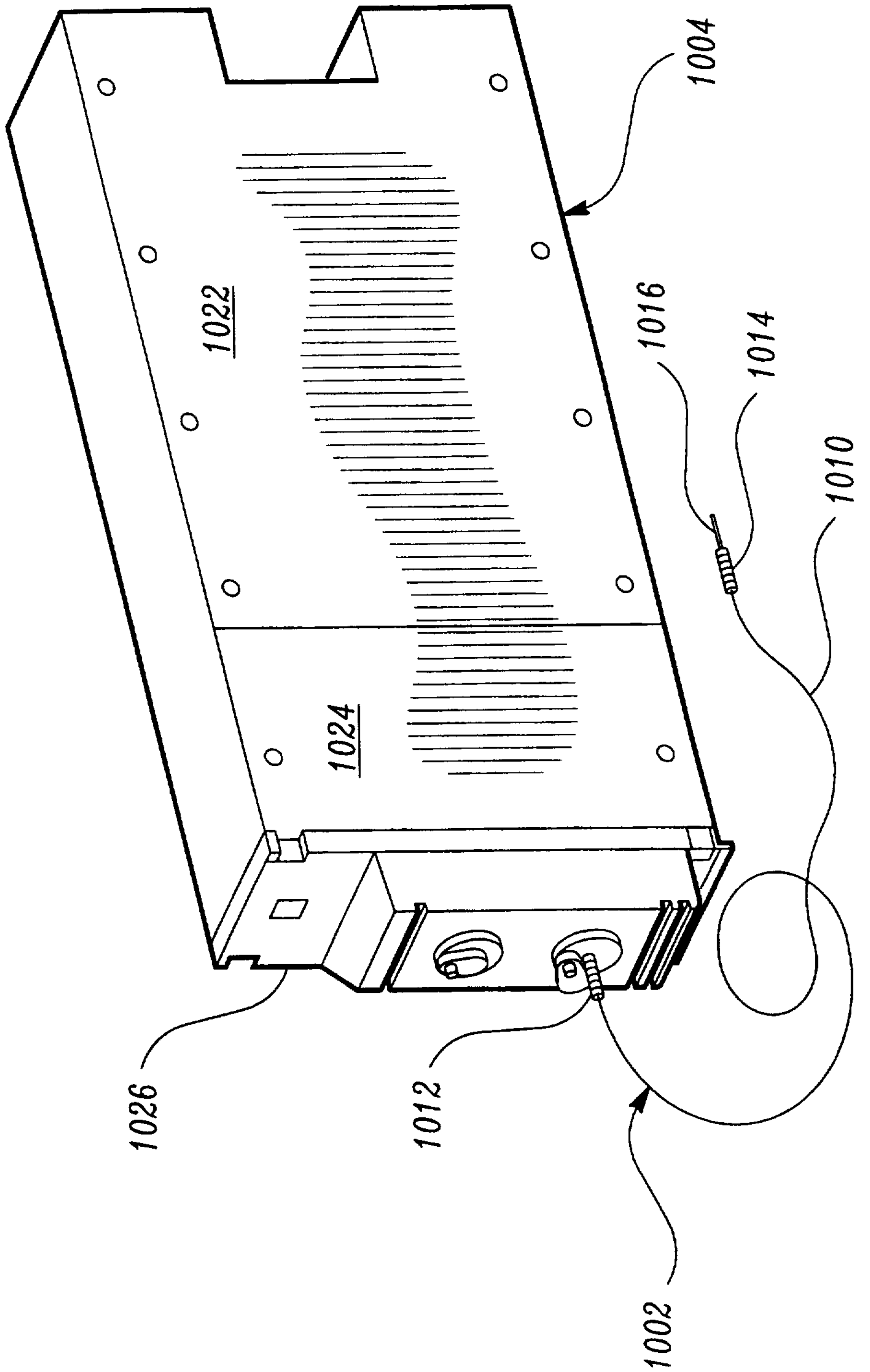


figure 2

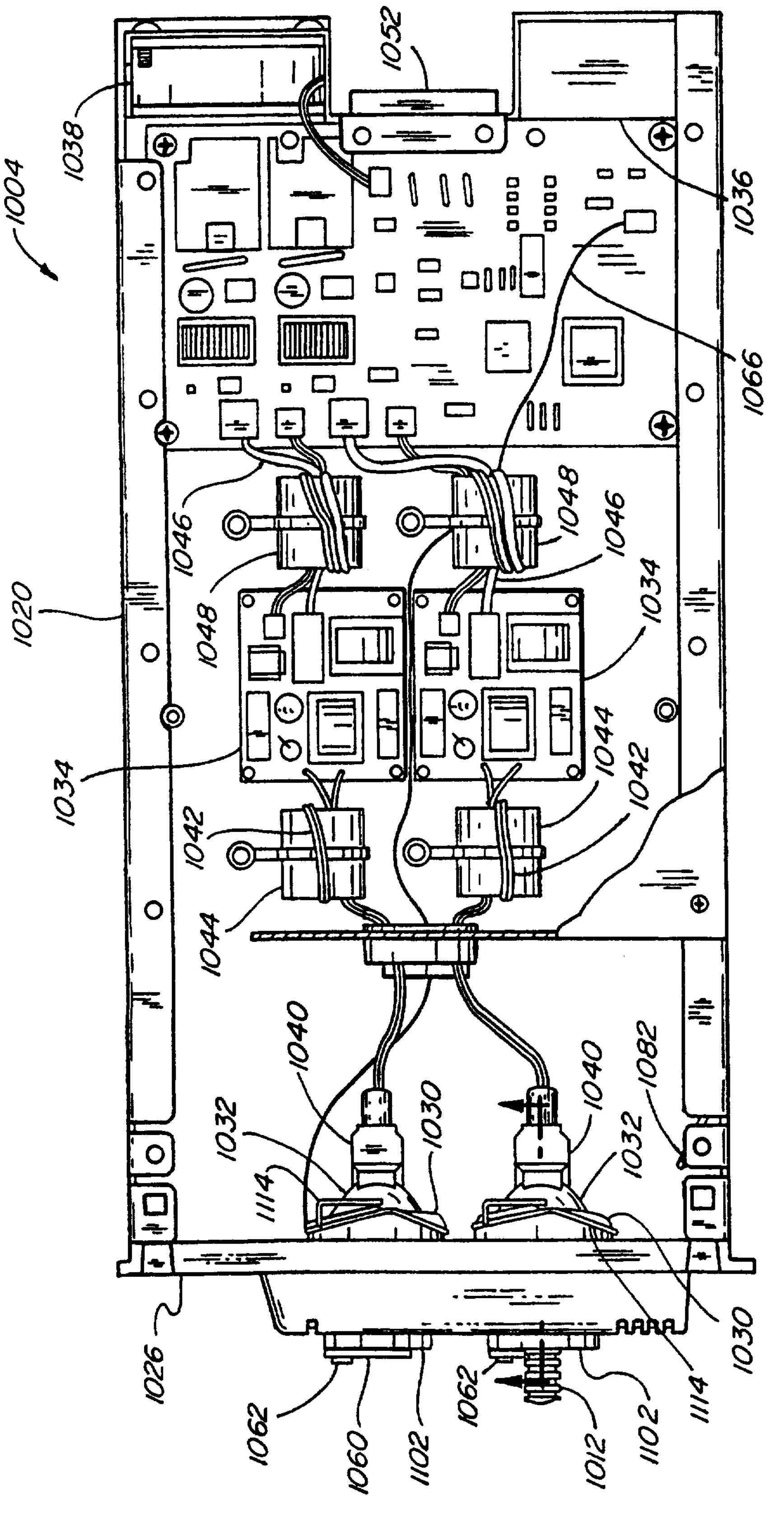
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figure 3

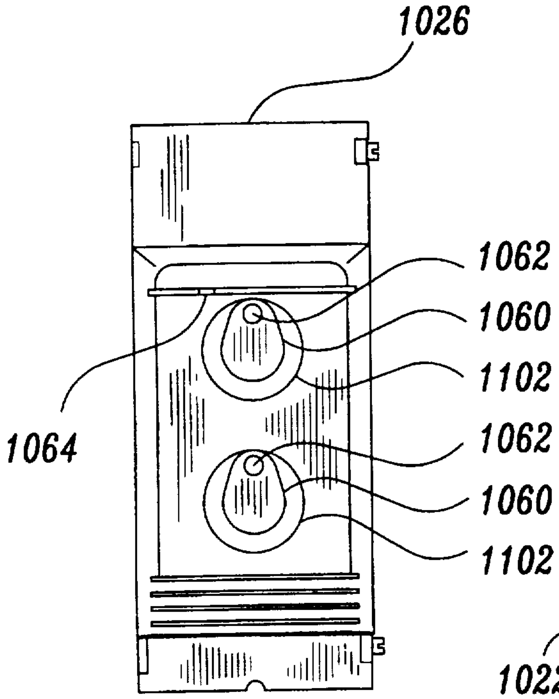


figure 4

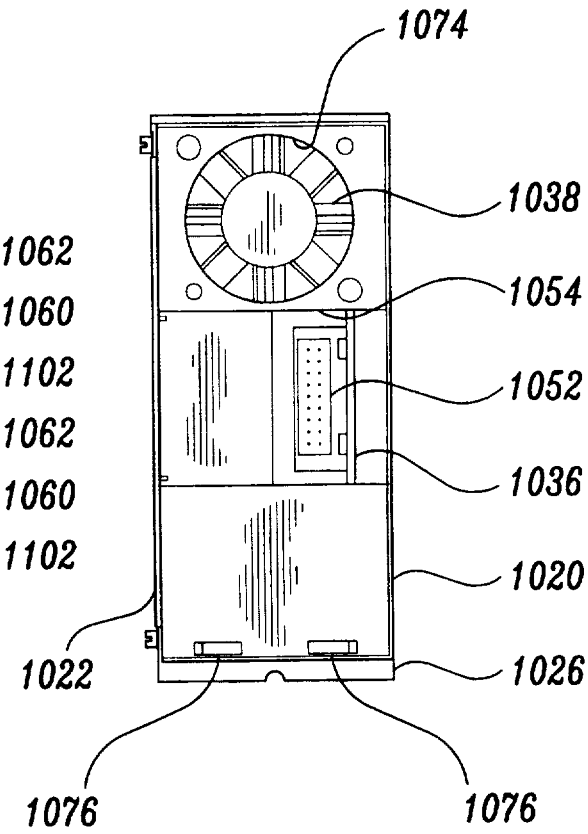


figure 5

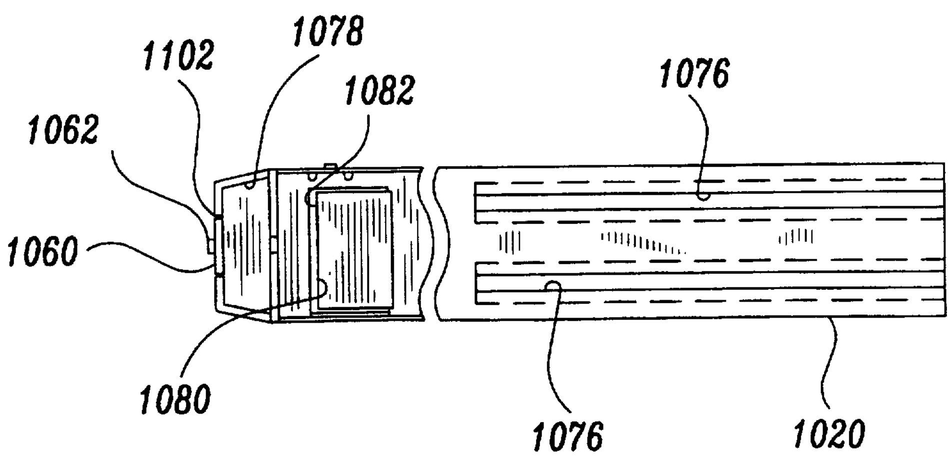


figure 6

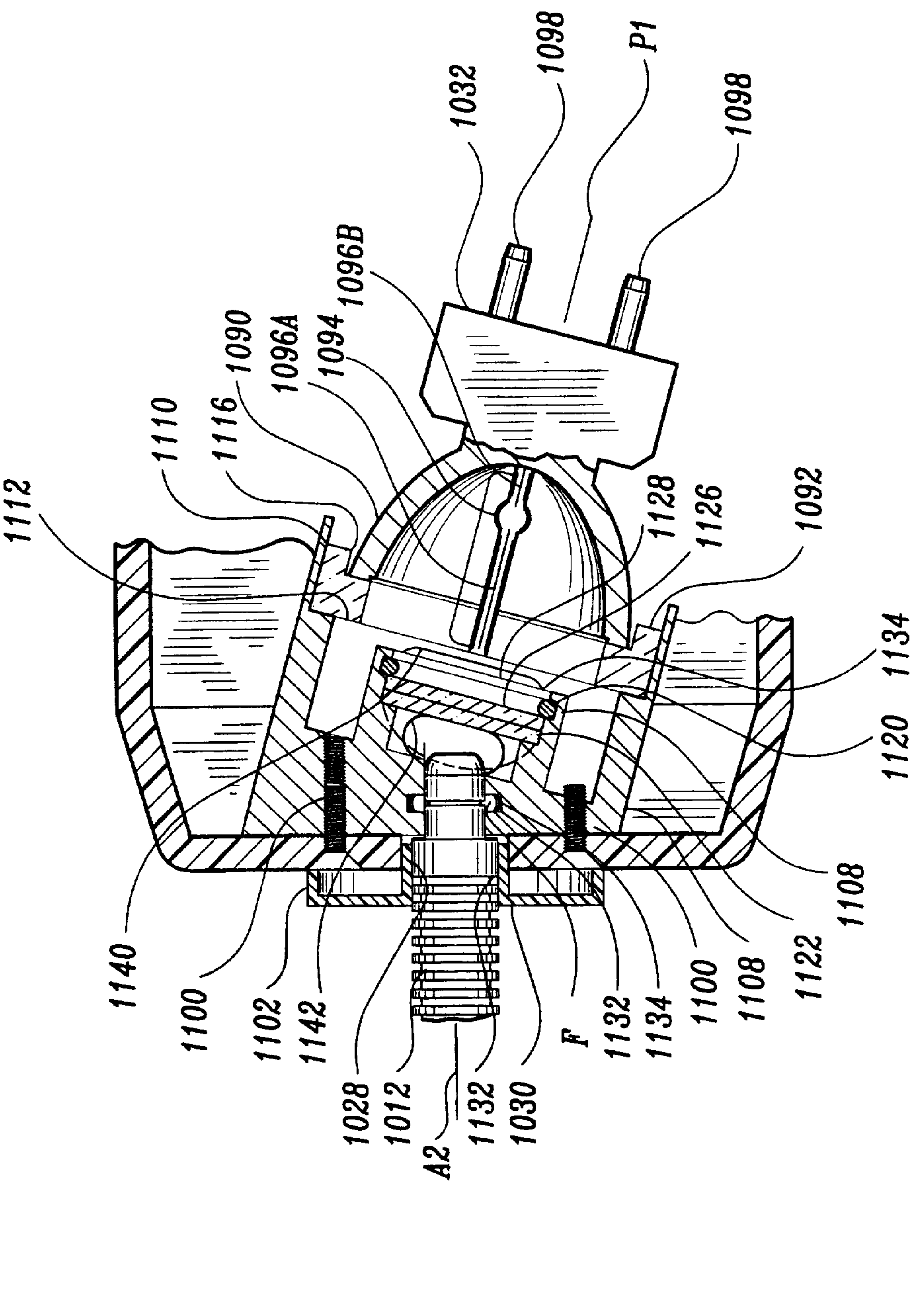
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figure 7

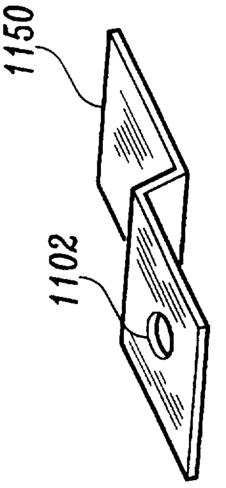


figure 9

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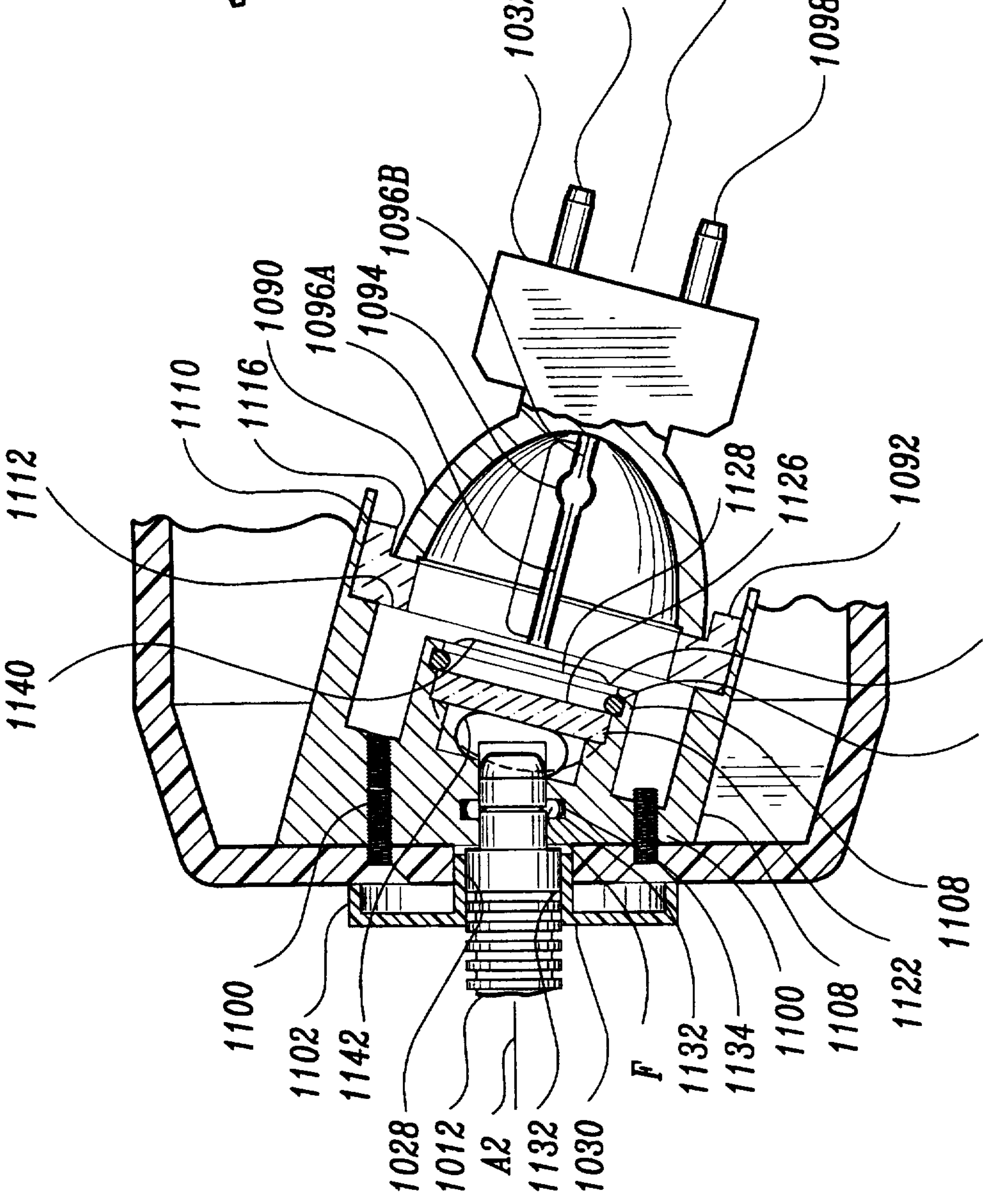


figure 8

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/15182

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : A61B 17/20
US CL : 604/22
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. : 604/22; 606/5,161,166

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y, P | US 5,591,185 A (KILMER et al.) 07 January 1997, entire patent. | 1-27 |
| Y | US 5,170,193 A (McMILLAN et al.) 08 December 1992, entire document. | 1-27 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"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

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"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

"&" document member of the same patent family

Date of the actual completion of the international search

17 NOVEMBER 1997

Date of mailing of the international search report

22 DEC 1997

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