US008382327B2

(12) United States Patent
Timmermans et al.

(10) **Patent No.: US 8,382,327 B2**

(45) **Date of Patent: *Feb. 26, 2013**

(54) **LIGHT TUBE AND POWER SUPPLY CIRCUIT**

(75) Inventors: **Jos Timmermans**, Ortonville, MI (US); **Jean C. Raymond**, Nominique (CA); **John Ivey**, Farmington Hills, MI (US)

(73) Assignee: **iLumisys, Inc.**, Troy, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/965,019**

(22) Filed: **Dec. 10, 2010**

(65) **Prior Publication Data**

US 2011/0156608 A1 Jun. 30, 2011

Related U.S. Application Data

(63) Continuation of application No. 11/085,744, filed on Mar. 21, 2005, now Pat. No. 8,247,985, which is a continuation of application No. 09/782,375, filed on Feb. 12, 2001, now Pat. No. 7,049,761.

(60) Provisional application No. 60/181,744, filed on Feb. 11, 2000.

(51) **Int. Cl.**
H05B 41/24 (2006.01)
H05B 37/02 (2006.01)

(52) **U.S. Cl.** **362/249.02**; 315/224

(58) **Field of Classification Search** .... 315/146, 315/246, 185 R, 185 S, 312, 291, 307; 362/488, 362/240, 800, 543, 544, 545, 249.01, 249.02, 362/249.03

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,612,855	A	10/1971	Juhnke	
3,993,386	A	11/1976	Rowe	
4,102,558	A	7/1978	Krachman	
4,107,581	A	8/1978	Abernethy	
4,189,663	A	2/1980	Schmutzer et al.	
4,211,955	A	7/1980	Ray	
4,581,687	A	4/1986	Nakanishi	
4,597,033	A	6/1986	Meggs et al.	
4,607,317	A	8/1986	Lin	
4,661,890	A	4/1987	Watanabe et al.	
4,698,730	A	10/1987	Sakai et al.	
4,748,545	A *	5/1988	Schmitt	362/219
4,758,173	A	7/1988	Northrop	
4,810,937	A	3/1989	Havel	
4,912,371	A	3/1990	Hamilton	
4,941,072	A	7/1990	Yasumoto et al.	
4,943,900	A	7/1990	Gartner	

(Continued)

FOREIGN PATENT DOCUMENTS

DE	196 51 140 A1	6/1997
DE	196 24 087 A1	12/1997

(Continued)

OTHER PUBLICATIONS

Defendant's *Invalidity Contentions in Altair Engineering, Inc.* v. *LEDS America, Inc.*, Civil Case No. 2:10-CV-13424 (E. D. Mich) (J. O'Meara) (Feb. 4, 2011).

(Continued)

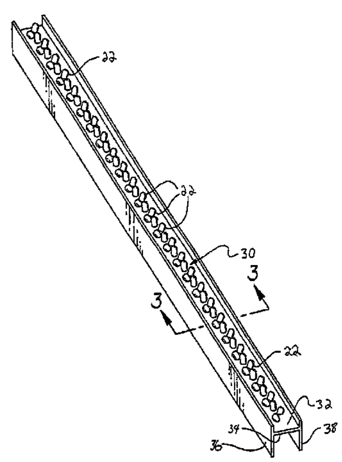
Primary Examiner — Minh D A

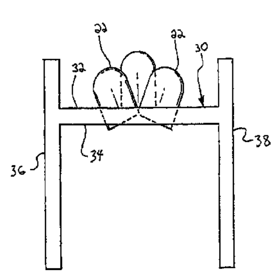
(74) *Attorney, Agent, or Firm* — Young Basile

(57) **ABSTRACT**

The present invention provides a light tube for illumination by a power supply circuit including a bulb portion and a pair of end caps disposed at opposite ends of the bulb portion. A plurality of light emitting diodes are disposed inside the bulb portion and in electrical communication with the pair of end caps for illuminating in response to electrical current to be received from the power supply circuit.

16 Claims, 9 Drawing Sheets





U.S. PATENT DOCUMENTS

5,018,054	A		5/1991	Ohashi et al.
5,027,037	A		6/1991	Wei
5,036,248	A		7/1991	McEwan et al.
5,103,382	A		4/1992	Kondo et al.
5,136,483	A		8/1992	Schoniger et al.
5,140,220	A		8/1992	Hasegawa
5,151,679	A		9/1992	Dimmick
5,303,124	A		4/1994	Wrobel
5,321,593	A		6/1994	Moates
5,365,411	A		11/1994	Rycroft et al.
D354,360	S		1/1995	Murata
5,388,357	A		2/1995	Malita
5,404,094	A		4/1995	Green et al.
5,463,280	A	*	10/1995	Johnson 315/187
5,463,502	A		10/1995	Savage, Jr.
5,561,346	A		10/1996	Byrne
5,575,459	A		11/1996	Anderson
5,581,158	A		12/1996	Quazi
5,607,227	A		3/1997	Yasumoto et al.
5,608,290	A		3/1997	Hutchisson et al.
5,622,423	A		4/1997	Lee
5,655,830	A		8/1997	Ruskouski
5,661,645	A		8/1997	Hochstein
5,684,523	A		11/1997	Satoh et al.
5,688,042	A		11/1997	Madadi et al.
5,697,695	A		12/1997	Lin et al.
5,726,535	A		3/1998	Yan
5,731,759	A		3/1998	Finucan
5,803,579	A		9/1998	Turnbull et al.
5,803,580	A		9/1998	Tseng
5,803,729	A		9/1998	Tsimerman
5,810,463	A		9/1998	Kawahara et al.
5,813,751	A	*	9/1998	Shaffer 362/249.08
5,813,753	A		9/1998	Vriens et al.
5,825,051	A		10/1998	Bauer et al.
5,850,126	A		12/1998	Kanbar
5,865,529	A		2/1999	Yan
5,890,794	A		4/1999	Abtahi et al.
5,917,287	A		6/1999	Haederle et al.
5,921,660	A		7/1999	Yu
5,924,784	A		7/1999	Chliwnyj et al.
5,943,802	A		8/1999	Tijanic
5,949,347	A		9/1999	Wu
5,998,928	A		12/1999	Hipp
6,007,209	A		12/1999	Pelka
6,028,694	A		2/2000	Schmidt
6,030,099	A		2/2000	McDermott
6,056,420	A		5/2000	Wilson et al.
6,068,383	A		5/2000	Robertson et al.
6,072,280	A		6/2000	Allen
6,135,620	A		10/2000	Marsh
6,149,283	A		11/2000	Conway et al.
6,158,882	A	*	12/2000	Bischoff, Jr. 362/488
6,217,190	B1		4/2001	Altman et al.
6,227,679	B1		5/2001	Zhang et al.
6,238,075	B1		5/2001	Dealey, Jr. et al.
6,252,350	B1		6/2001	Alvarez
6,268,600	B1		7/2001	Nakamura et al.
6,305,109	B1		10/2001	Lee
6,305,821	B1		10/2001	Hsieh et al.
6,325,651	B1		12/2001	Nishihara et al.
6,362,578	B1		3/2002	Swanson et al.
6,371,637	B1		4/2002	Atchinson et al.
6,394,623	B1		5/2002	Tsui
6,471,388	B1		10/2002	Marsh
6,528,954	B1		3/2003	Lys et al.
6,568,834	B1		5/2003	Scianna
6,577,072	B2		6/2003	Saito et al.
6,577,794	B1		6/2003	Currie et al.
6,582,103	B1		6/2003	Popovich et al.
6,621,222	B1		9/2003	Hong
6,682,205	B2		1/2004	Lin
6,712,486	B1		3/2004	Popovich et al.
6,762,562	B2		7/2004	Leong
6,853,151	B2		2/2005	Leong et al.
7,014,336	B1		3/2006	Ducharme et al.
7,049,761	B2		5/2006	Timmermans et al.
7,161,313	B2		1/2007	Piepgras et al.
7,510,299	B2		3/2009	Timmermans et al.
8,093,823	B1		1/2012	Ivey et al.
8,247,985	B2		8/2012	Timmermans et al.
2002/0048174	A1		4/2002	Pederson
2003/0076281	A1		4/2003	Morgan et al.
2004/0085219	A1		5/2004	Pederson
2004/0145490	A1		7/2004	Pederson
2004/0212993	A1		10/2004	Morgan et al.
2005/0041424	A1		2/2005	Ducharme
2005/0099317	A1		5/2005	Pederson
2007/0030683	A1		2/2007	Popovich et al.

FOREIGN PATENT DOCUMENTS

EP	0 632 511	A2	1/1995
JP	H6-54103		7/1994
JP	H8-162677		6/1996
JP	H11-135274		5/1999
JP	H11-162234	A	6/1999
JP	H11-260125	A	9/1999
WO	99/45312	A1	9/1999
WO	99/57945	A1	11/1999

OTHER PUBLICATIONS

Decision in *Altair Engineering, Inc.* v. *LEDdynamics* (Fed. Cir. Mar. 9, 2011).

Web page at http://trucklite.com/leds_14.htm printed on Nov. 13, 2000

Web page at http://trucklite.com/leds_2.htm printed on Nov. 13, 2000.

Web page at http://trucklite.com/leds_4.html printed on Jan. 13, 2000.

Web page at http://www.telecite.com/en/products/options_en.htm printed on Jan. 13, 2000.

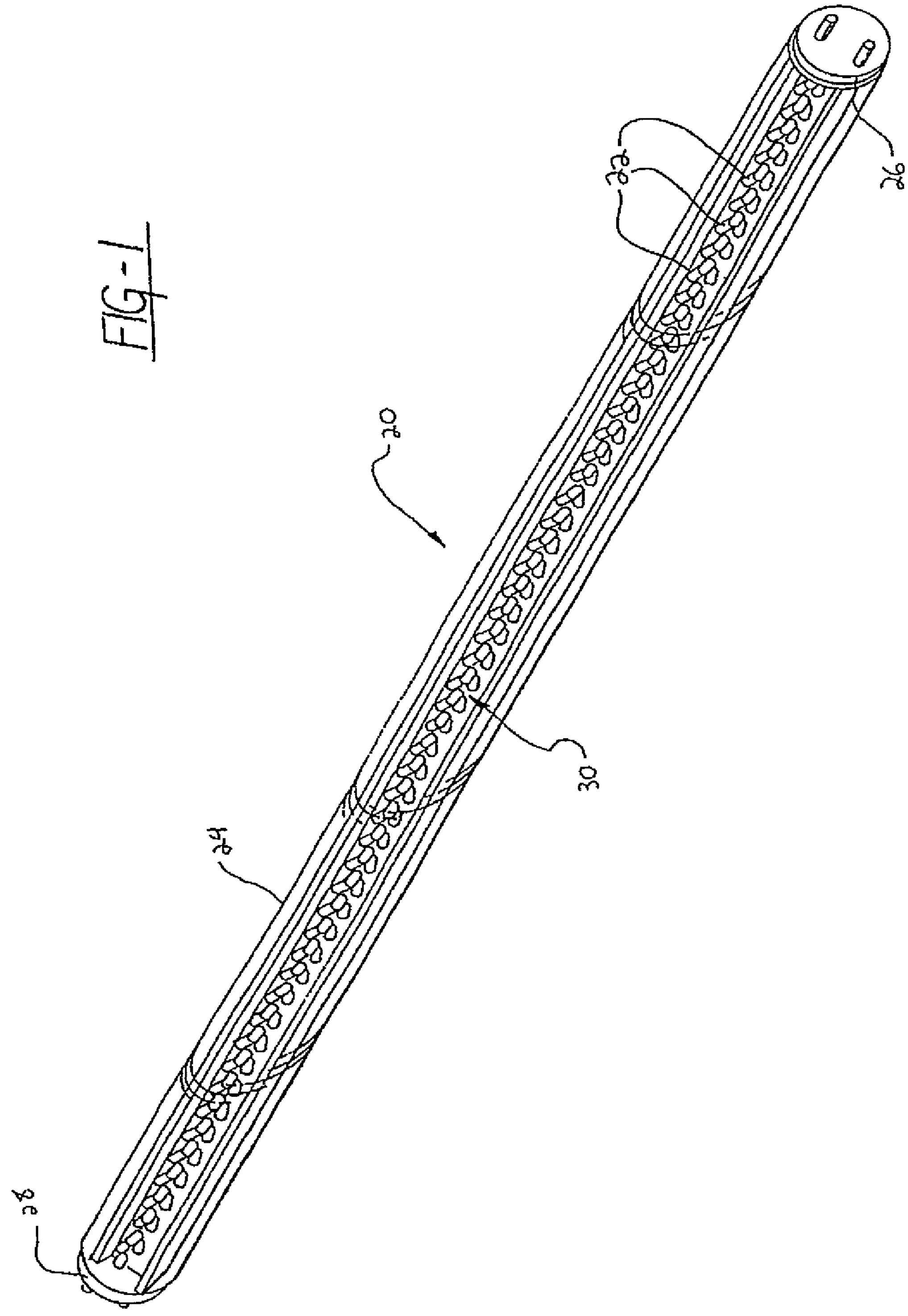
Web page at http://www.dialight.com/trans.htm printed on Jan. 13, 2000.

Web page at http://www.ledlight.com/replac.htm printed on Jan. 13, 2000.

LEDTRONICS, apparently 1996 Catalog, apparently cover page and p. 10.

* cited by examiner

FIG-1



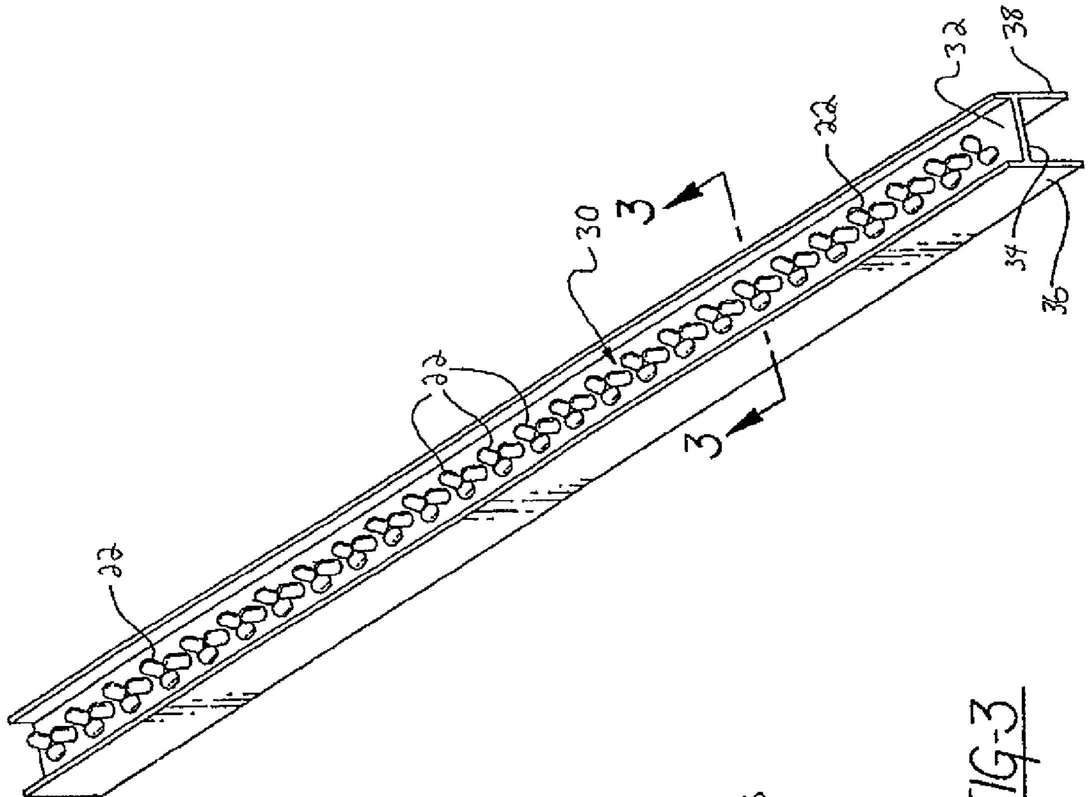


FIG-2

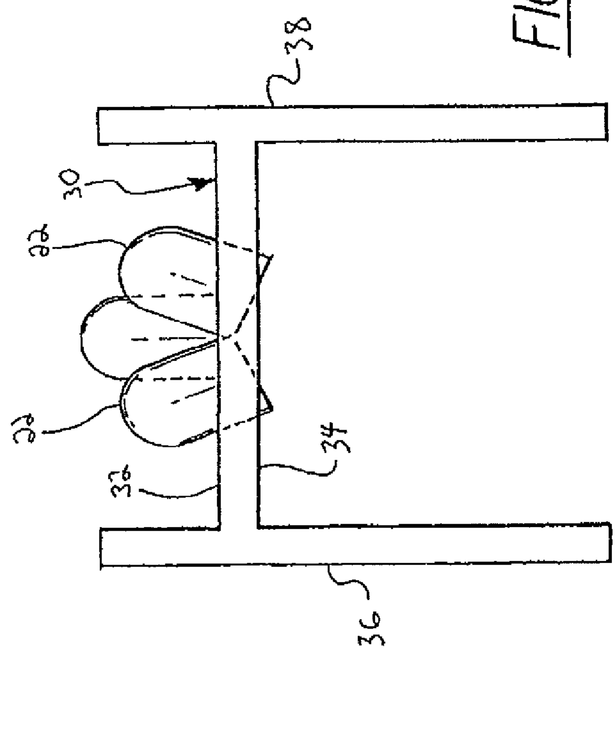


FIG-3

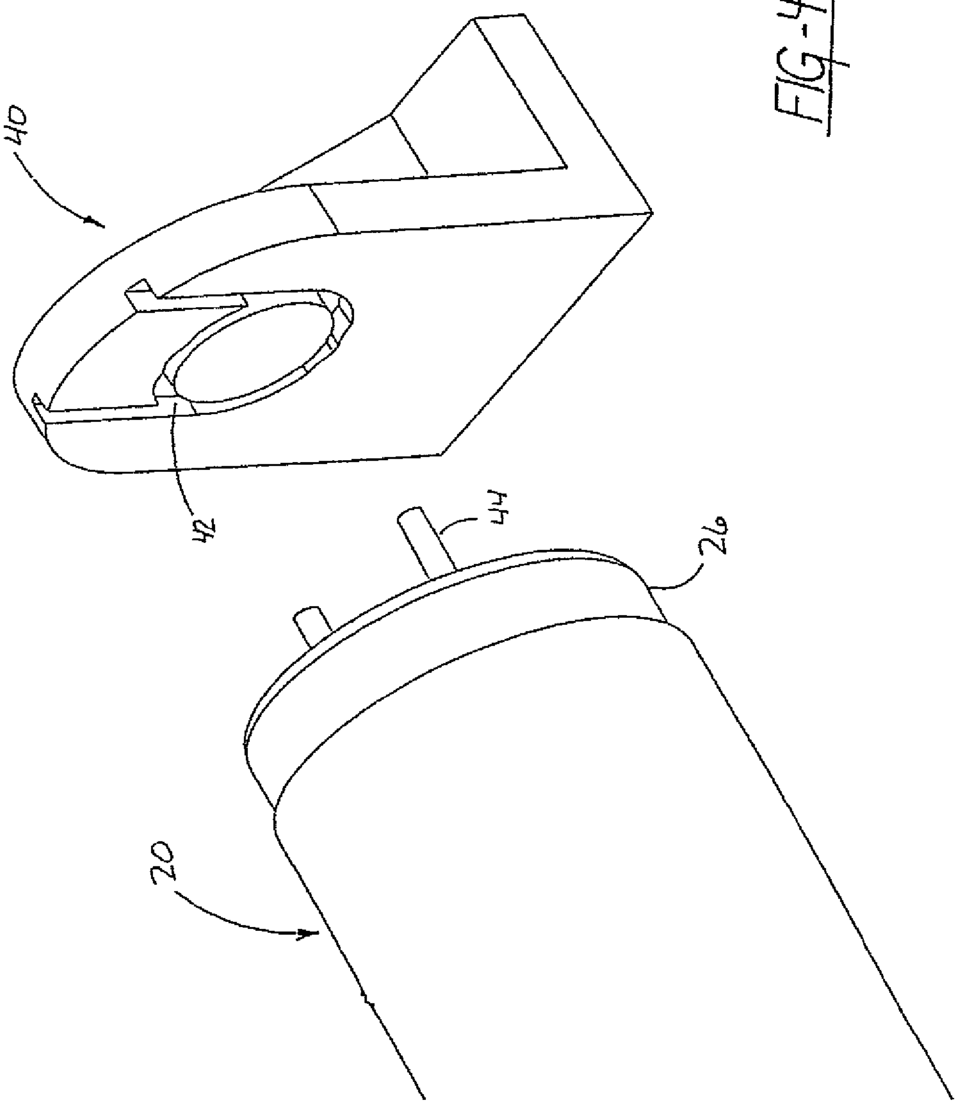


FIG-4

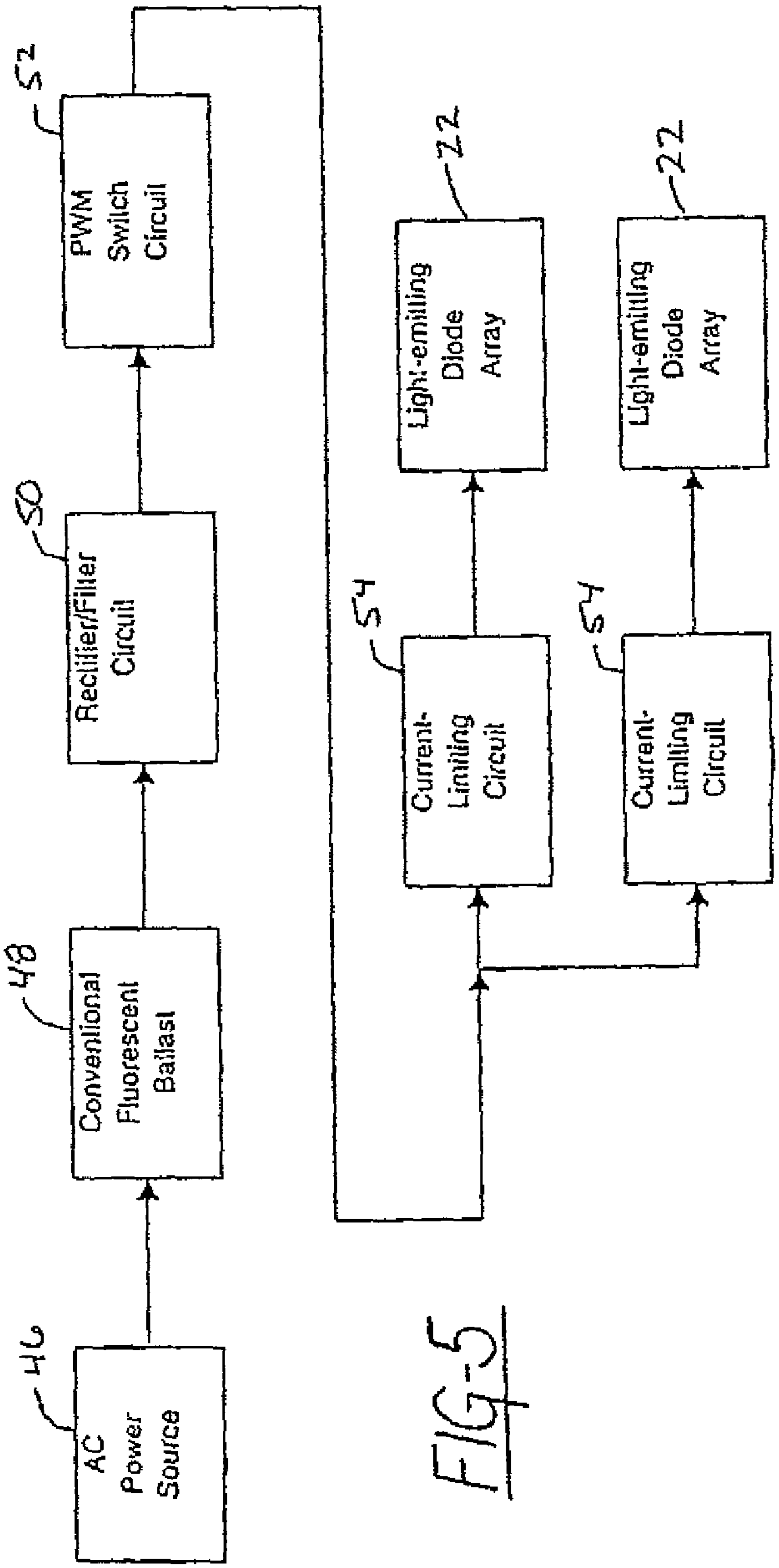

AC Power Source
46
Conventional Fluorescent Ballast
48
Rectifier/Filter Circuit
50
PWM Switch Circuit
52
Current-Limiting Circuit
54
Current-Limiting Circuit
54
Light-emitting Diode Array
22
Light-emitting Diode Array
22

FIG-5

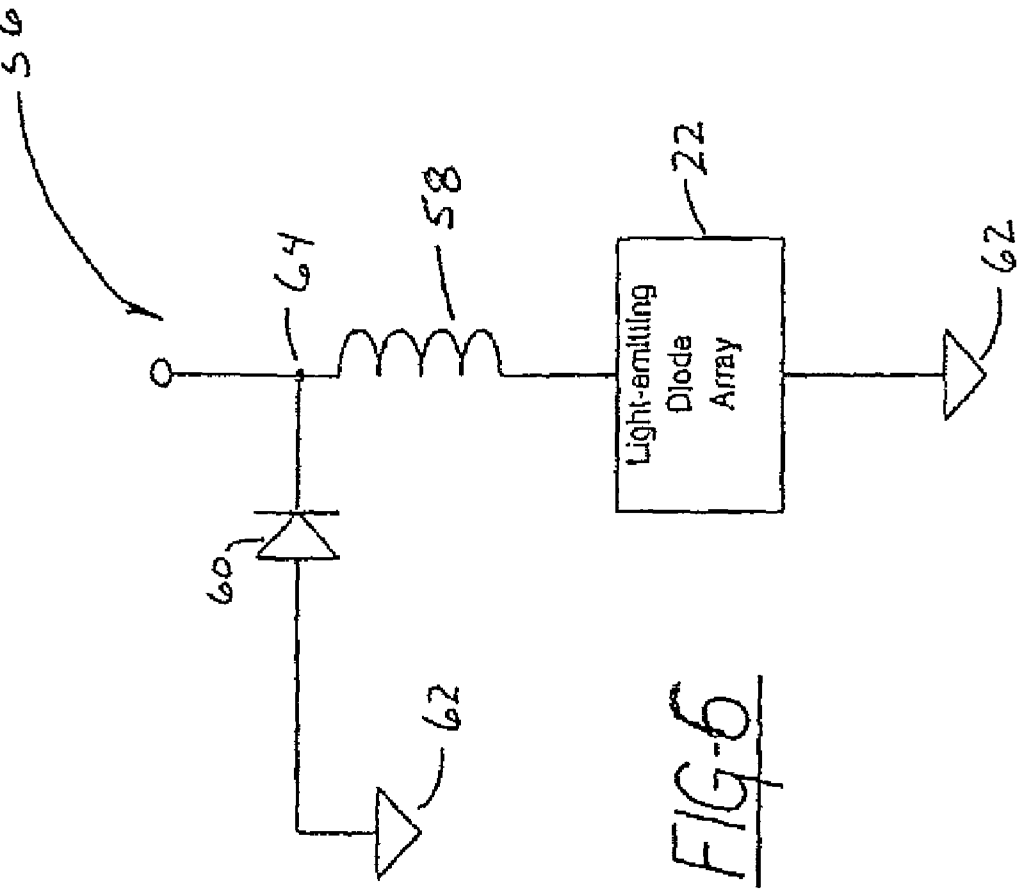


FIG-6

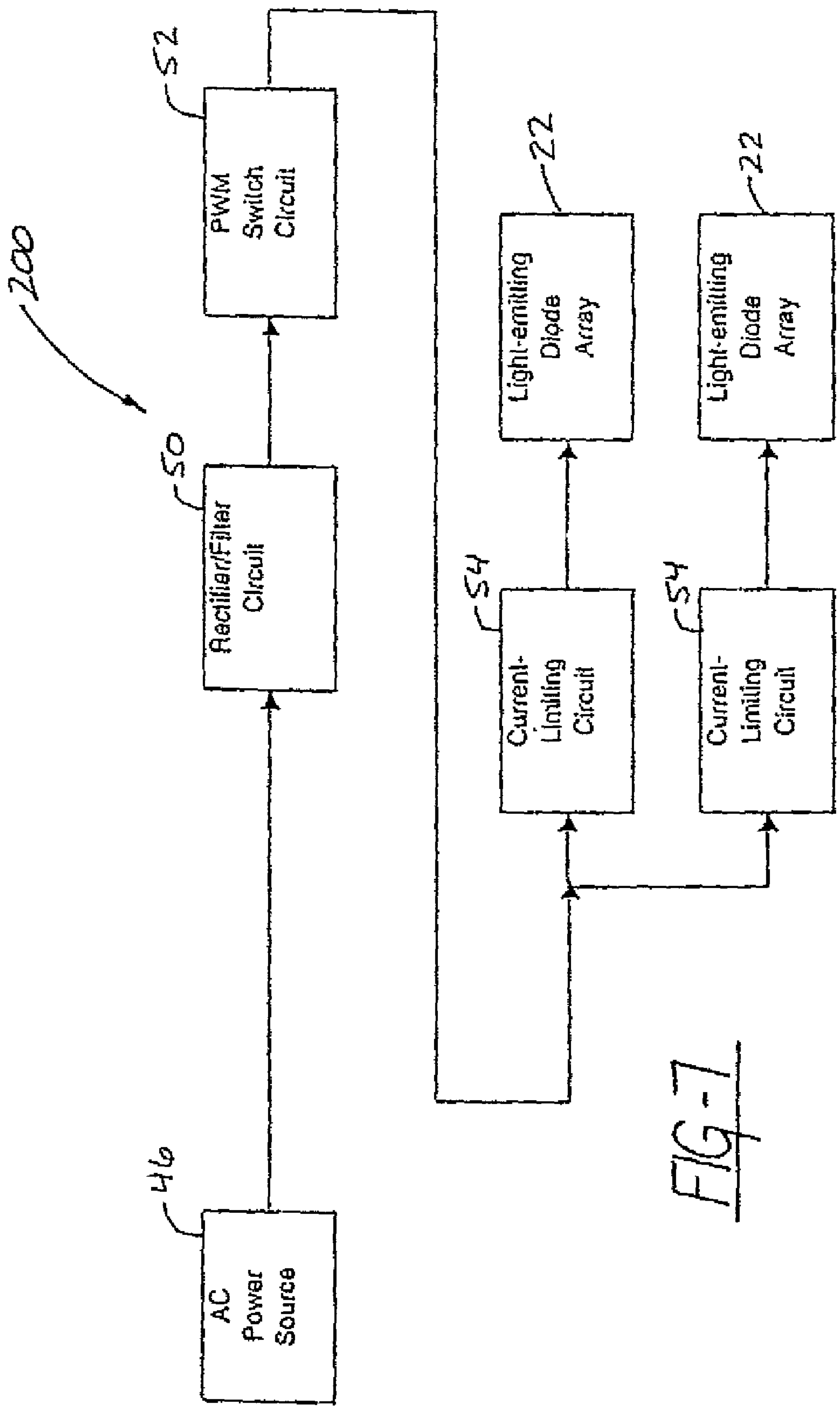

200
AC Power Source
46
Rectifier/Filter Circuit
50
PWM Switch Circuit
52
Current-Limiting Circuit
54
Current-Limiting Circuit
54
Light-emitting Diode Array
22
Light-emitting Diode Array
22

FIG-7

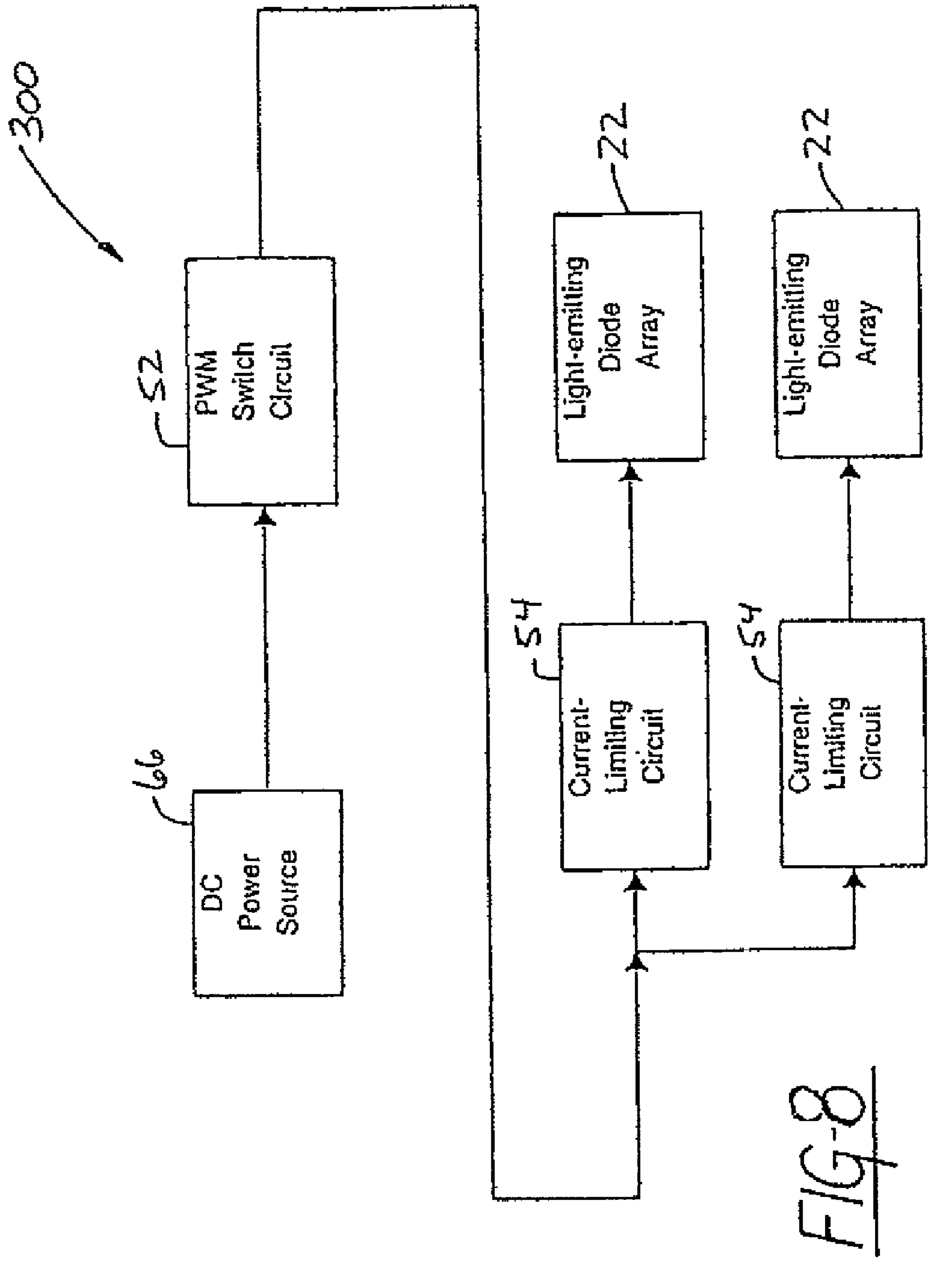

300
52
PWM Switch Circuit
66
DC Power Source
22
Light-emitting Diode Array
22
Light-emitting Diode Array
54
Current-Limiting Circuit
54
Current-Limiting Circuit

FIG-8

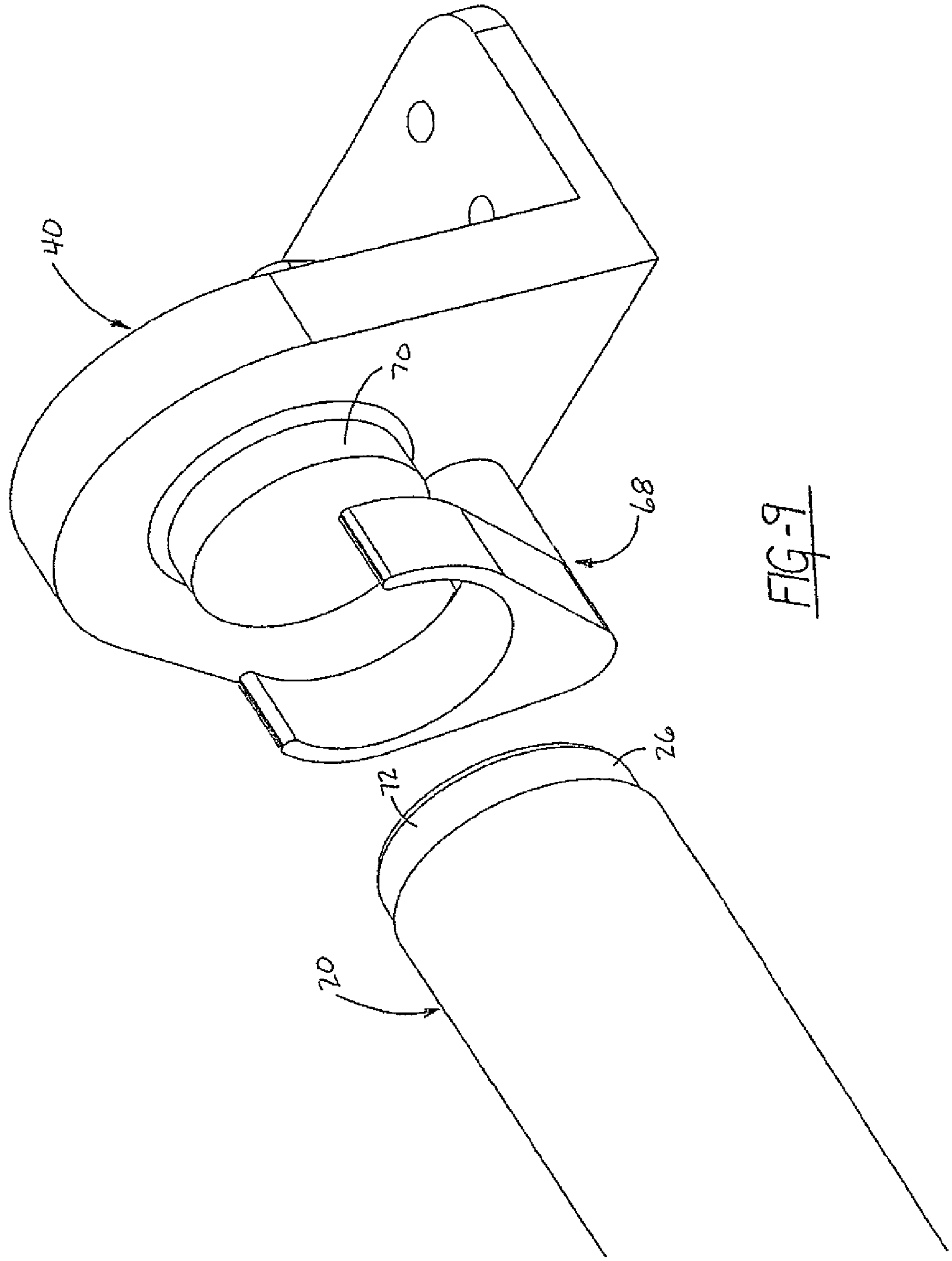


FIG-9

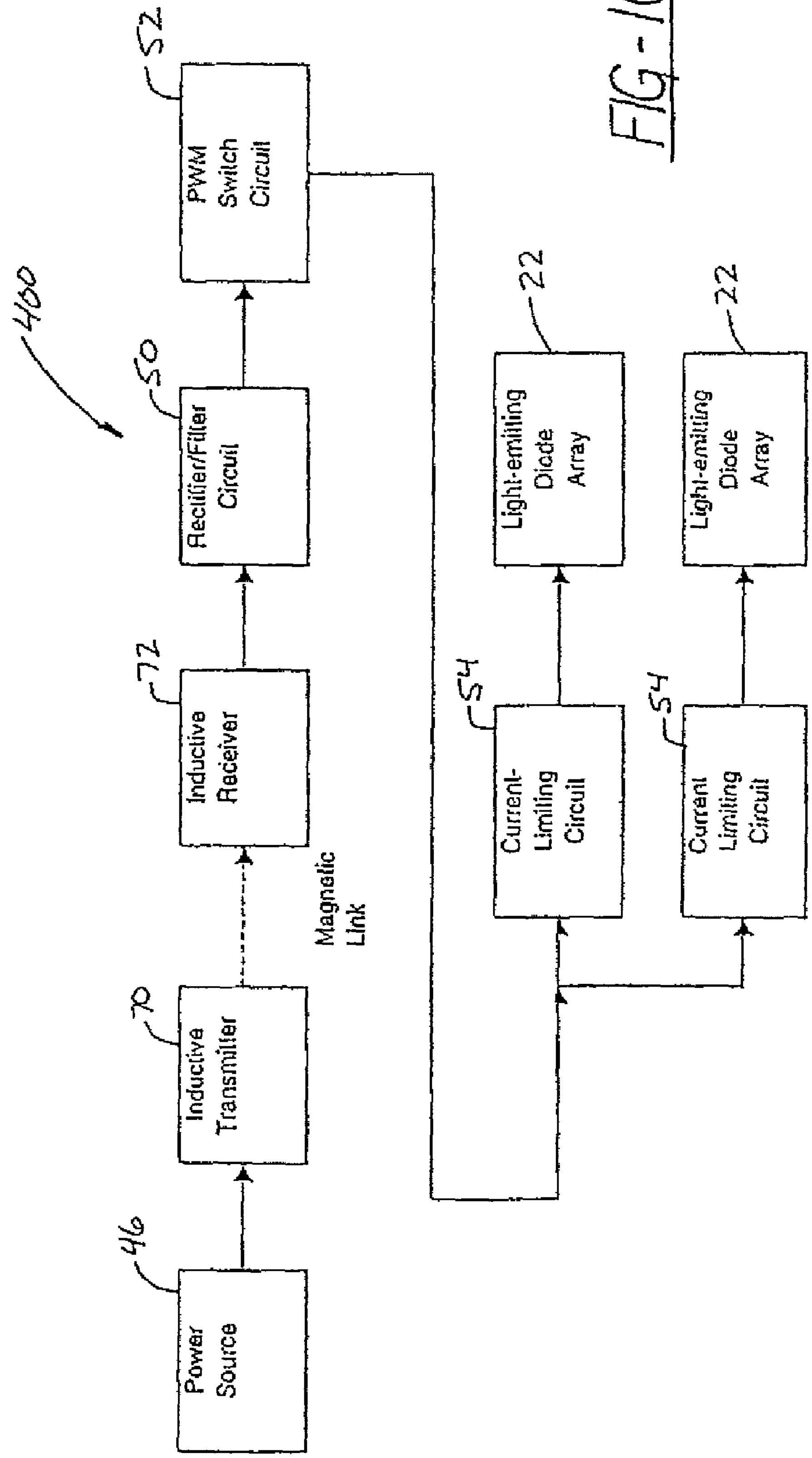

400
46
Power Source
70
Inductive Transmitter
Magnetic Link
72
Inductive Receiver
50
Rectifier/Filter Circuit
52
PWM Switch Circuit
54
Current-Limiting Circuit
54
Current Limiting Circuit
22
Light-emitting Diode Array
22
Light-emitting Diode Array

FIG-10

LIGHT TUBE AND POWER SUPPLY CIRCUIT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 11/085,744, filed Mar. 21, 2005 and issued as U.S. Pat No. 8,247,985, on Aug. 21, 2012, which is a continuation of U.S. patent application Ser. No. 09/782,375, filed Feb. 12, 2001 and issued as U.S. Pat. No. 7,049,761 on May 23, 2006, which claims the benefit of U.S. Provisional Application No. 60/181,744, filed Feb. 11, 2000.

FIELD OF THE INVENTION

The present invention relates to a light tube illuminated by LEDs (light emitting diodes) which are packaged inside the light tube and powered by a power supply circuit.

BACKGROUND OF THE INVENTION

Conventional fluorescent lighting systems include fluorescent light tubes and ballasts. Such lighting systems are used in a variety of locations, such as buildings and transit buses, for a variety of lighting purposes, such as area lighting or backlighting. Although conventional fluorescent lighting systems have some advantages over known lighting options, such as incandescent lighting systems, conventional fluorescent light tubes and ballasts have several shortcomings. Conventional fluorescent light tubes have a short life expectancy, are prone to fail when subjected to excessive vibration, consume high amounts of power, require a high operating voltage, and include several electrical connections which reduce reliability. Conventional ballasts are highly prone to fail when subjected to excessive vibration. Accordingly, there is a desire to provide a light tube and power supply circuit which overcome the shortcomings of conventional fluorescent lighting systems. That is, there is a desire to provide a light tube and power supply circuit which have a long life expectancy, are resistant to vibration failure, consume low amounts of power, operate on a low voltage, and are highly reliable. It would also be desirable for such a light tube to mount within a conventional fluorescent light tube socket.

SUMMARY OF THE INVENTION

A light tube for illumination by a power supply circuit including a bulb portion and a pair of end caps disposed at opposite ends of the bulb portion. A plurality of light emitting diodes are disposed inside the bulb portion and in electrical communication with the pair of end caps for illuminating in response to electrical current to be received from the power supply circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

FIG. **1** is a line drawing showing a light tube, in perspective view, which in accordance with the present invention is illuminated by LEDs packaged inside the light tube;

FIG. **2** is a perspective view of the LEDs mounted on a circuit board;

FIG. **3** is a cross-sectional view of FIG. **2** taken along lines **3-3**;

FIG. **4** is a fragmentary, perspective view of one embodiment of the present invention showing one end of the light tube disconnected from one end of a light tube socket;

FIG. **5** is an electrical block diagram of a first power supply circuit for supplying power to the light tube;

FIG. **6** is an electrical schematic of a switching power supply type current limiter;

FIG. **7** is an electrical block diagram of a second power supply circuit for supplying power to the light tube;

FIG. **8** is an electrical block diagram of a third power supply circuit for supplying power to the light tube;

FIG. **9** is a fragmentary, perspective view of another embodiment of the present invention showing one end of the light tube disconnected from one end of the light tube socket; and

FIG. **10** is an electrical block diagram of a fourth power supply circuit for supplying power to the light tube.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** is a line drawing showing a light tube **20** in perspective view. In accordance with the present invention, the light tube **20** is illuminated by LEDs **22** packaged inside the light tube **20**. The light tube **20** includes a cylindrically shaped bulb portion **24** having a pair of end caps **26** and **28** disposed at opposite ends of the bulb portion. Preferably, the bulb portion **24** is made from a transparent or translucent material such as glass, plastic, or the like. As such, the bulb material may be either clear or frosted.

In a preferred embodiment of the present invention, the light tube **20** has the same dimensions and end caps **26** and **28** (e.g. electrical male bi-pin connectors, type G13) as a conventional fluorescent light tube. As such, the present invention can be mounted in a conventional fluorescent light tube socket (not shown).

The line drawing of FIG. **1** also reveals the internal components of the light tube **20**. The light tube **20** further includes a circuit board **30** with the LEDs **22** mounted thereon. The circuit board **30** and LEDs **22** are enclosed inside the bulb portion **24** and the end caps **26** and **28**.

FIG. **2** is a perspective view of the LEDs **22** mounted on the circuit board **30**. A group of LEDs **22**, as shown in FIG. **2**, is commonly referred to as a bank or array of LEDs. Within the scope of the present invention, the light tube **20** may include one or more banks or arrays of LEDs **22** mounted on one or more circuit boards **30**. In a preferred embodiment of the present invention, the LEDs **22** emit white light and, thus, are commonly referred to in the art as white LEDs. In FIGS. **1** and **2**, the LEDs **22** are mounted to one surface **32** of the circuit board **30**. In a preferred embodiment of the present invention, the LEDs **22** are arranged to emit or shine white light through only one side of the bulb portion **24**, thus directing the white light to a predetermined point of use. This arrangement reduces light losses due to imperfect reflection in a convention lighting fixture. In alternative embodiments of the present invention, LEDs **22** may also be mounted, in any combination, to the other surfaces **34**, **36**, and/or **38** of the circuit board **30**.

FIG. **3** is a cross-sectional view of FIG. **2** taken along lines **3-3**. To provide structural strength along the length of the light tube **20**, the circuit board **30** is designed with a H-shaped cross-section. To produce a predetermined radiation pattern or dispersion of light from the light tube **20**, each LED **22** is mounted at an angle relative to adjacent LEDs and/or the mounting surface **32**. The total radiation pattern of light from the light tube **20** is effected by (1) the mounting angle of the

LEDs **22** and (2) the radiation pattern of light from each LED. Currently, white LEDs having a viewing range between 6° and 45° are commercially available.

FIG. **4** is a fragmentary, perspective view of one embodiment of the present invention showing one end of the light tube **20** disconnected from one end of a light tube socket **40**. Similar to conventional fluorescent lighting systems and in this embodiment of the present invention, the light tube socket **40** includes a pair of electrical female connectors **42** and the light tube **20** includes a pair of mating electrical male connectors **44**.

Within the scope of the present invention, the light tube **20** may be powered by one of four power supply circuits **100**, **200**, **300**, and **400**. A first power supply circuit includes a power source and a conventional fluorescent ballast. A second power supply circuit includes a power source and a rectifier/filter circuit. A third power supply circuit includes a DC power source and a PWM (Pulse Width Modulation) circuit. A fourth power supply circuit powers the light tube **20** inductively.

FIG. **5** is an electrical block diagram of a first power supply circuit **100** for supplying power to the light tube **20**. The first power supply circuit **100** is particularly adapted to operate within an existing, conventional fluorescent lighting system. As such, the first power supply circuit **100** includes a conventional fluorescent light tube socket **40** having two electrical female connectors **42** disposed at opposite ends of the socket. Accordingly, a light tube **20** particularly adapted for use with the first power supply circuit **100** includes two end caps **26** and **28**, each end cap having the form of an electrical male connector **44** which mates with a corresponding electrical female connector **42** in the socket **40**.

The first power supply circuit **100** also includes a power source **46** and a conventional magnetic or electronic fluorescent ballast **48**. The power source **46** supplies power to the conventional fluorescent ballast **48**.

The first power supply circuit **100** further includes a rectifier/filter circuit **50**, a PWM circuit **52**, and one or more current-limiting circuits **54**. The rectifier/filter circuit **50**, the PWM circuit **52**, and the one or more current-limiting circuits **54** of the first power supply circuit **100** are packaged inside one of the two end caps **26** or **28** of the light tube **20**.

The rectifier/filter circuit **50** receives AC power from the ballast **48** and converts the AC power to DC power. The PWM circuit **52** receives the DC power from the rectifier/filter circuit **50** and pulse-width modulates the DC power to the one or more current-limiting circuits **54**. In a preferred embodiment of the present invention, the PWM circuit **52** receives the DC power from the rectifier/filter circuit **50** and cyclically switches the DC power on and off to the one or more current-limiting circuits **54**. The DC power is switched on and off by the PWM circuit **52** at a frequency which causes the white light emitted from the LEDs **22** to appear, when viewed with a "naked" human eye, to shine continuously. The PWM duty cycle can be adjusted or varied by control circuitry (not shown) to maintain the power consumption of the LEDs **22** at safe levels.

The DC power is modulated for several reasons. First, the DC power is modulated to adjust the brightness or intensity of the white light emitted from the LEDs **22** and, in turn, adjust the brightness or intensity of the white light emitted from the light tube **20**. Optionally, the brightness or intensity of the white light emitted from the light tube **20** may be adjusted by a user. Second, the DC power is modulated to improve the illumination efficiency of the light tube **20** by capitalizing upon a phenomenon in which short pulses of light at high brightness or intensity to appear brighter than a continuous, lower brightness or intensity of light having the same average power. Third, the DC power is modulated to regulate the intensity of light emitted from the light tube **20** to compensate for supply voltage fluctuations, ambient temperature changes, and other such factors which effect the intensity of white light emitted by the LEDs **22**. Fourth, the DC power is modulated to raise the variations of the frequency of light above the nominal variation of 120 to 100 Hz thereby reducing illumination artifacts caused by low frequency light variations, including interactions with video screens. Fifth, the DC power may optionally be modulated to provide an alarm function wherein light from the light tube **20** cyclically flashes on and off.

The one or more current-limiting circuits **54** receive the pulse-width modulated or switched DC power from the PWM circuit **52** and transmit a regulated amount of power to one or more arrays of LEDs **22**. Each current-limiting circuit **54** powers a bank of one or more white LEDs **22**. If a bank of LEDs **22** consists of more than one LED, the LEDs are electrically connected in series in an anode to cathode arrangement. If brightness or intensity variation between the LEDs **22** can be tolerated, the LEDs can be electrically connected in parallel.

The one or more current-limiting circuits **54** may include (1) a resistor, (2) a current-limiting semiconductor circuit, or (3) a switching power supply type current limiter.

FIG. **6** is an electrical schematic of a switching power supply type current limiter **56**. The limiter **56** includes an inductor **58**, electrically connected in series between the PWM circuit **52** and the array of LEDs **22**, and a power diode **60**, electrically connected between ground **62** and a PWM circuit/inductor node **64**. The diode **60** is designed to begin conduction after the PWM circuit **52** is switched off. In this case, the value of the inductor **58** is adjusted in conjunction with the PWM duty cycle to provide the benefits described above. The switching power supply type current limiter **56** provides higher power efficiency than the other types of current-limiting circuits listed above.

FIG. **7** is an electrical block diagram of a second power supply circuit **200** for supplying power to the light tube **20**. Similar to the first power supply circuit **100**, the second power supply circuit **200** includes a conventional fluorescent light tube socket **40** having two electrical female connectors **42** disposed at opposite ends of the socket **40**. Accordingly, a light tube **20** particularly adapted for use with the second power supply circuit **200** includes two end caps **26** and **28**, each end cap having the form of an electrical male connector **44** which mates with a corresponding electrical female connector **42** in the socket **40**.

In the second power supply circuit **200**, the power source **46** supplies power directly to the rectifier/filter circuit **50**. The rectifier/filter circuit **50**, the PWM circuit **52**, and the one or more current-limiting circuits **54** operate as described above to power the one or more arrays of LEDs **22**. The rectifier/filter circuit **50**, the PWM circuit **52**, and the one or more current-limiting circuits **54** of the second power supply circuit **200** are preferably packaged inside the end caps **26** and **28** or the bulb portion **24** of the light tube **20** or inside the light tube socket **40**.

FIG. **8** is an electrical block diagram of a third power supply circuit **300** for supplying power to the light tube **20**. Similar to the first and second power supply circuits **100** and **200**, the third power supply circuit **300** includes a conventional fluorescent light tube socket **40** having two electrical female connectors **42** disposed at opposite ends of the socket **40**. Accordingly, a light tube **20** particularly adapted for use with the third power supply circuit **300** includes two end caps

26 and 28, each end cap having the form of an electrical male connector 44 which mates with a corresponding electrical female connector 42 in the socket 40.

The third power supply circuit 300 includes a DC power source 66, such as a vehicle battery. In the third power supply circuit 300, the DC power source 66 supplies DC power directly to the PWM circuit 52. The PWM circuit 52 and the one or more current-limiting circuits 54 operate as described above to power the one or more arrays of LEDs 22. In the third power supply circuit 300, the PWM circuit 52 is preferably packaged in physical location typically occupied by the ballast of a conventional fluorescent lighting system while the one or more current-limiting circuits 54 and LEDs 22 are preferably packaged inside the light tube 20, in either one of the two end caps 26 or 28 or the bulb portion 24.

FIG. 9 is a fragmentary, perspective view of another embodiment of the present invention showing one end of the light tube 20 disconnected from one end of the light tube socket 40. In this embodiment of the present invention, the light tube socket 40 includes a pair of brackets 68 and the light tube 20 includes a pair of end caps 26 and 28 which mate with the brackets 68.

FIG. 10 is an electrical block diagram of a fourth power supply circuit 400 for supplying power to the light tube 20. Unlike the first, second, and third power supply circuits 100, 200, and 300 which are powered through direct electrical male and female connectors 44 and 42, the fourth power supply circuit 400 is powered inductively. As such, the fourth power supply circuit 400 includes a light tube socket 40 having two brackets 68 disposed at opposite ends of the socket 40. At least one bracket 68 includes an inductive transmitter 70. Accordingly, a light tube 20 particularly adapted for use with the fourth power supply circuit 400 has two end caps 26 and 28 with at least one end cap including an inductive receiver or antenna 72. When the light tube 20 is mounted in the light tube socket 40, the at least one inductive receiver 72 in the light tube 20 is disposed adjacent to the at least one inductive transmitter 70 in the light tube socket 40.

The fourth power supply circuit 400 includes the power source 46 which supplies power to the at least one inductive transmitter 70 in the light tube socket 40. The at least one transmitter 70 inductively supplies power to the at least one receiver 72 in one of the end caps 26 and/or 28 of the light tube 20. The at least one inductive receiver 72 supplies power to the rectifier/filter circuit 50. The rectifier/filter circuit 50, PWM circuit 52, and the one or more current-limiting circuits 54 operate as described above to power the one or more arrays of LEDs 22. In this manner, the light tube 20 is powered without direct electrical connection.

What is claimed is:

1. A light device for illumination by a power supply circuit comprising:
 a bulb portion,
 a pair of end caps disposed at opposite ends of the bulb portion, the pair of end caps including a first end cap disposed at one end of the bulb portion, and a second end cap disposed at an end of bulb portion opposite the first end cap, wherein the bulb portion and the pair of end caps are dimensioned to be mounted in a flourescent light tube socket; and
 a plurality of light emitting diodes disposed inside the bulb portion along one surface of a circuit board extending between the first end cap and the second end cap for illuminating in response to electrical current to be received from the power supply circuit; wherein each of the plurality of light emitting diodes is mounted with respect to surface of the circuit board to establish a radiation pattern of light emitted from the bulb portion; and
 wherein the arrangement of the circuit board and the bulb portion is such that substantially the entire light output of the light device is emitted away from the one surface and is confined to an included angle by sidewalls extending to a height above the one surface on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap.

2. The light tube of claim 1 wherein each of the pair of end caps includes an electrical bi-pin connector.

3. The light device of claim 1 wherein each of the plurality of light emitting diodes is a white light emitting diode.

4. The light device of claim 1, further comprising:
 a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes above a nominal variation of 120 to 100 Hz.

5. The light device of claim 1, further comprising:
 a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes to provide a visible on and off cycle.

6. The light device of claim 1 wherein at least one of the first end cap and the second end cap includes an inductive receiver.

7. The light device of claim 1 wherein the plurality of light emitting diodes is arranged substantially continuously between the opposite ends of the bulb portion.

8. In a replacement light tube for a flourescent light fixture having a light tube socket, the improvement comprising:
 a plurality of light emitting diodes disposed along a length of a bulb portion between a first end cap and a second end cap mounted on opposite ends of the bulb portion, wherein the plurality of light emitting diodes is mounted on only one side of a circuit board in a light emitting direction;
 an electrical circuit for illuminating in response to electrical current to be received from the flourescent light fixture; and
 opaque side walls extending above the one side of the circuit board in the light emitting direction on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap to confine an entirety of light emitted from the replacement light tube to an included angle of less than about 180°.

9. The improvement of claim 8 wherein each of the plurality of light emitting diodes is a white light emitting diode.

10. The improvement of claim 8, further comprising:
 a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes above a nominal variation of 120 to 100 Hz.

11. The improvement of claim 8, further comprising:
 a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes to provide a visible on and off cycle.

12. The improvement of claim 8 wherein at least one of the first end cap and the second end cap includes an inductive receiver.

13. The improvement of claim 8 wherein the radiation pattern of light from each of the plurality of light emitting diodes is centered at a 90° angle relative to the circuit board.

14. The improvement of claim 8 wherein the plurality of light emitting diodes is arranged substantially continuously along the length of the bulb portion.

15. The improvement of claim 8 wherein the electrical circuit includes at least a rectifier and a current-limiting circuit.

16. An LED lighting unit for replacing a conventional fluorescent tube between the opposed electrical receptacles of a conventional fluorescent lighting fixture comprising:

a rigid, substantially cylindrical structure having a first end and a second end opposite said first end, the cylindrical structure including a support structure and a bulb portion;

a first end cap disposed upon said first end of said cylindrical structure and a second end cap disposed upon said second end of said cylindrical structure;

a pair of parallel, fluorescent light fixture receptacle connectors extending from each said end cap and configured for installing within the opposed electrical receptacles of the lighting fixture; and

a plurality of LEDs disposed along a surface of said support structure in electrical contact with one another and with at least one pair of said pair of connectors extending from said end caps, whereby light is divergently emitted along the length of said lighting unit in an included angle of less than about 180°;

wherein the combination of said support structure and said bulb portion is such that substantially the entire light output of said lighting unit device is emitted away from said surface and is confined to the included angle by sidewalls extending to a height above said surface on opposing sides of said plurality of LEDs between the first end and the second end.

* * * * *