



US008444292B2

(12) **United States Patent**
Ivey et al.

(10) **Patent No.:** **US 8,444,292 B2**
(45) **Date of Patent:** **May 21, 2013**

(54) **END CAP SUBSTITUTE FOR LED-BASED TUBE REPLACEMENT LIGHT**

(75) Inventors: **John Ivey**, Farmington Hills, MI (US);
David L Simon, Grosse Pointe Woods, 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 720 days.

(21) Appl. No.: **12/573,233**

(22) Filed: **Oct. 5, 2009**

(65) **Prior Publication Data**

US 2010/0103673 A1 Apr. 29, 2010

Related U.S. Application Data

(60) Provisional application No. 61/108,345, filed on Oct. 24, 2008.

(51) **Int. Cl.**

F21S 4/00 (2006.01)
B29C 65/00 (2006.01)
B23P 6/00 (2006.01)

(52) **U.S. Cl.**

USPC **362/225**; 362/249.02; 156/60; 29/402.08

(58) **Field of Classification Search**

USPC 362/225, 217, 116
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

D54,511 S 2/1920 Owen
D58,105 S 6/1921 Poritz
D79,814 S 11/1929 Hoch

D80,419 S 1/1930 Kramer
D84,763 S 7/1931 Stange
D119,797 S 4/1940 Winkler et al.
D125,312 S 2/1941 Logan
2,909,097 A 10/1959 Alden et al.
3,272,977 A 9/1966 Holmes
3,318,185 A 5/1967 Kott
3,561,719 A 2/1971 Grindle
3,586,936 A 6/1971 McLeroy

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1584388 A 2/2005
CN 2766345 Y 3/2006

(Continued)

OTHER PUBLICATIONS

Wolsey, Robert. Interoperable Systems: The Future of Lighting Control, Lighting Research Center, Jan. 1, 1997, vol. 2 No. 2, Rensselaer Polytechnic Institute, Troy, New York [online]. Retrieved Lighting Research Center Web Page using Internet <URL: http://www.lrc.rpi.edu/programs/Futures/LF-BAS/index.asp>.

(Continued)

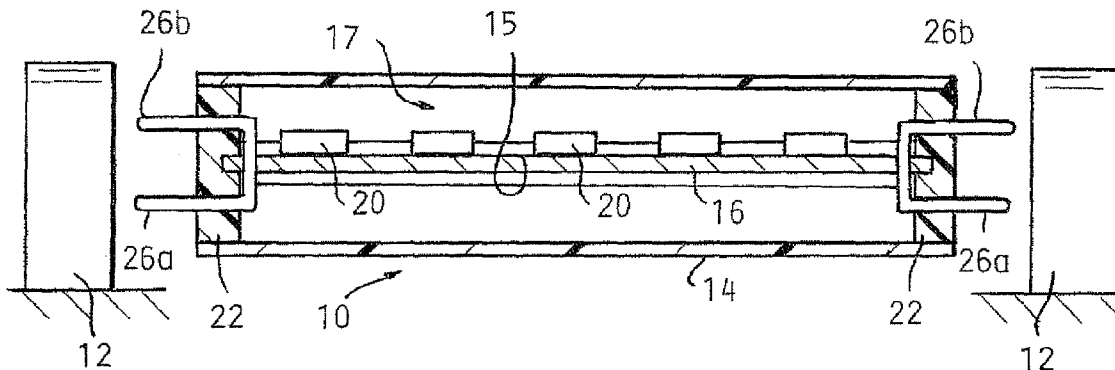
Primary Examiner — Tracie Y Green

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

(57) **ABSTRACT**

Disclosed herein is a replacement light for a fluorescent tube usable in a fluorescent fixture. The light includes a housing having a first end and a second end opposite the first end. A support structure is disposed within the housing. At least one LED is positioned within the housing and is arranged on the support structure. A first seal has at least one aperture and is disposed within the first end of the housing. The first seal is configured to conform to an inner circumference of the first end of the housing. At least one electrical connector extends through the at least one aperture and is connectable to the fluorescent fixture.

26 Claims, 1 Drawing Sheet



U.S. PATENT DOCUMENTS					
3,601,621 A	8/1971	Ritchie	4,851,972 A	7/1989	Altman
3,612,855 A	10/1971	Juhnke	4,857,801 A	8/1989	Farrell
3,643,088 A	2/1972	Osteen et al.	4,863,223 A	9/1989	Weissenbach et al.
3,746,918 A	7/1973	Drucker et al.	4,870,325 A	9/1989	Kazar
3,818,216 A	6/1974	Larraburu	4,874,320 A	10/1989	Freed et al.
3,832,503 A	8/1974	Crane	4,887,074 A	12/1989	Simon et al.
3,858,086 A	12/1974	Anderson et al.	4,894,832 A	1/1990	Colak
3,909,670 A	9/1975	Wakamatsu et al.	4,901,207 A	2/1990	Sato et al.
3,924,120 A	12/1975	Cox, III	4,912,371 A	3/1990	Hamilton
3,958,885 A	5/1976	Stockinger et al.	4,922,154 A	5/1990	Cacoub
3,974,637 A	8/1976	Bergey et al.	4,934,852 A	6/1990	Havel
3,993,386 A	11/1976	Rowe	4,941,072 A	7/1990	Yasumoto et al.
4,001,571 A	1/1977	Martin	4,943,900 A	7/1990	Gartner
4,054,814 A	10/1977	Fegley et al.	4,962,687 A	10/1990	Belliveau et al.
4,070,568 A	1/1978	Gala	4,965,561 A	10/1990	Havel
4,082,395 A	4/1978	Donato et al.	4,973,835 A	11/1990	Kurosu et al.
4,096,349 A	6/1978	Donato	4,979,081 A	12/1990	Leach et al.
4,102,558 A	7/1978	Krachman	4,980,806 A	12/1990	Taylor et al.
4,107,581 A	8/1978	Abernethy	4,992,704 A	2/1991	Stinson
4,189,663 A	2/1980	Schmutzer et al.	5,003,227 A	3/1991	Nilssen
4,211,955 A	7/1980	Ray	5,008,595 A	4/1991	Kazar
4,241,295 A	12/1980	Williams, Jr.	5,008,788 A	4/1991	Palinkas
4,271,408 A	6/1981	Teshima et al.	5,010,459 A	4/1991	Taylor et al.
4,271,458 A	6/1981	George, Jr.	5,018,054 A	5/1991	Ohashi et al.
4,272,689 A	6/1981	Crosby et al.	5,027,037 A	6/1991	Wei
4,273,999 A	6/1981	Pierpoint	5,027,262 A	6/1991	Freed
4,298,869 A	11/1981	Okuno	5,032,960 A	7/1991	Katoh
4,329,625 A	5/1982	Nishizawa et al.	5,034,807 A	7/1991	Von Kohorn
4,339,788 A	7/1982	White et al.	5,036,248 A	7/1991	McEwan et al.
4,342,947 A	8/1982	Bloyd	5,038,255 A	8/1991	Nishihashi et al.
4,367,464 A	1/1983	Kurahashi et al.	5,065,226 A	11/1991	Kluitmans et al.
D268,134 S	3/1983	Zurcher	5,072,216 A	12/1991	Grange
4,382,272 A	5/1983	Quella et al.	5,078,039 A	1/1992	Tulk et al.
4,388,567 A	6/1983	Yamazaki et al.	5,083,063 A	1/1992	Brooks
4,388,589 A	6/1983	Molldrem, Jr.	5,088,013 A	2/1992	Revis
4,392,187 A	7/1983	Bornhorst	5,089,748 A	2/1992	Ihms
4,394,719 A	7/1983	Moberg	5,103,382 A	4/1992	Kondo et al.
4,420,711 A	12/1983	Takahashi et al.	5,122,733 A	6/1992	Havel
4,455,562 A	6/1984	Dolan et al.	5,126,634 A	6/1992	Johnson
4,500,796 A	2/1985	Quin	5,128,595 A	7/1992	Hara
4,581,687 A	4/1986	Nakanishi	5,130,909 A	7/1992	Gross
4,597,033 A	6/1986	Meggs et al.	5,134,387 A	7/1992	Smith et al.
4,600,972 A	7/1986	MacIntyre	5,140,220 A	8/1992	Hasegawa
4,607,317 A	8/1986	Lin	5,142,199 A	8/1992	Elwell
4,622,881 A	11/1986	Rand	5,151,679 A	9/1992	Dimmick
4,625,152 A	11/1986	Nakai	5,154,641 A	10/1992	McLaughlin
4,635,052 A	1/1987	Aoike et al.	5,161,879 A	11/1992	McDermott
4,647,217 A	3/1987	Havel	5,161,882 A	11/1992	Garrett
4,656,398 A	4/1987	Michael et al.	5,164,715 A	11/1992	Kashiwabara et al.
4,661,890 A	4/1987	Watanabe et al.	5,184,114 A	2/1993	Brown
4,668,895 A	5/1987	Schneiter	5,194,854 A	3/1993	Havel
4,675,575 A	6/1987	Smith et al.	5,198,756 A	3/1993	Jenkins et al.
4,682,079 A	7/1987	Sanders et al.	5,209,560 A	5/1993	Taylor et al.
4,686,425 A	8/1987	Havel	5,220,250 A	6/1993	Szuba
4,687,340 A	8/1987	Havel	5,225,765 A	7/1993	Callahan et al.
4,688,154 A	8/1987	Nilssen	5,226,723 A	7/1993	Chen
4,688,869 A	8/1987	Kelly	5,254,910 A	10/1993	Yang
4,695,769 A	9/1987	Schweickardt	5,256,948 A	10/1993	Boldin et al.
4,698,730 A	10/1987	Sakai et al.	5,278,542 A	1/1994	Smith et al.
4,701,669 A	10/1987	Head et al.	5,282,121 A	1/1994	Bornhorst et al.
4,705,406 A	11/1987	Havel	5,283,517 A	2/1994	Havel
4,707,141 A	11/1987	Havel	5,287,352 A	2/1994	Jackson et al.
D293,723 S	1/1988	Buttner	5,294,865 A	3/1994	Haraden
4,727,289 A	2/1988	Uchida	5,298,871 A	3/1994	Shimohara
4,740,882 A	4/1988	Miller	5,301,090 A	4/1994	Hed
4,748,545 A	5/1988	Schmitt	5,303,124 A	4/1994	Wrobel
4,753,148 A	6/1988	Johnson	5,307,295 A	4/1994	Taylor et al.
4,758,173 A	7/1988	Northrop	5,321,593 A	6/1994	Moates
4,771,274 A	9/1988	Havel	5,323,226 A	6/1994	Schreder
4,780,621 A	10/1988	Bartleucci et al.	5,329,431 A	7/1994	Taylor et al.
4,794,383 A	12/1988	Havel	5,344,068 A	9/1994	Haessig
4,810,937 A	3/1989	Havel	5,350,977 A	9/1994	Hamamoto et al.
4,818,072 A	4/1989	Mohebban	5,357,170 A	10/1994	Luchaco et al.
4,824,269 A	4/1989	Havel	5,371,618 A	12/1994	Tai et al.
4,837,565 A	6/1989	White	5,374,876 A	12/1994	Horibata et al.
4,843,627 A	6/1989	Stebbins	5,375,043 A	12/1994	Tokunaga
4,845,481 A	7/1989	Havel	D354,360 S	1/1995	Murata
4,845,745 A	7/1989	Havel	5,381,074 A	1/1995	Rudzewicz et al.
			5,388,357 A	2/1995	Malita

5,402,702 A	4/1995	Hata	5,813,751 A	9/1998	Shaffer
5,404,282 A	4/1995	Klinke et al.	5,813,753 A	9/1998	Vriens et al.
5,406,176 A	4/1995	Sugden	5,821,695 A	10/1998	Vilanilam et al.
5,410,328 A	4/1995	Yoksza et al.	5,825,051 A	10/1998	Bauer et al.
5,412,284 A	5/1995	Moore et al.	5,828,178 A	10/1998	York et al.
5,412,552 A	5/1995	Fernandes	5,836,676 A	11/1998	Ando et al.
5,420,482 A	5/1995	Phares	5,848,837 A	12/1998	Gustafson
5,421,059 A	6/1995	Leffers, Jr.	5,850,126 A	12/1998	Kanbar
5,430,356 A	7/1995	Ference et al.	5,851,063 A	12/1998	Doughty et al.
5,432,408 A	7/1995	Matsuda et al.	5,852,658 A	12/1998	Knight et al.
5,436,535 A	7/1995	Yang	5,854,542 A	12/1998	Forbes
5,436,853 A	7/1995	Shimohara	RE36,030 E	1/1999	Nadeau
5,450,301 A	9/1995	Waltz et al.	5,859,508 A	1/1999	Ge et al.
5,461,188 A	10/1995	Drago et al.	5,865,529 A	2/1999	Yan
5,463,280 A	10/1995	Johnson	5,890,794 A	4/1999	Abtahi et al.
5,463,502 A	10/1995	Savage, Jr.	5,896,010 A	4/1999	Mikolajczak et al.
5,465,144 A	11/1995	Parker et al.	5,907,742 A	5/1999	Johnson et al.
5,475,300 A	12/1995	Havel	5,912,653 A	6/1999	Fitch
5,489,827 A	2/1996	Xia	5,921,660 A	7/1999	Yu
5,491,402 A	2/1996	Small	5,924,784 A	7/1999	Chliwnyj et al.
5,493,183 A	2/1996	Kimball	5,927,845 A	7/1999	Gustafson et al.
5,504,395 A	4/1996	Johnson et al.	5,934,792 A	8/1999	Camarota
5,506,760 A	4/1996	Giebler et al.	5,943,802 A	8/1999	Tijanac
5,513,082 A	4/1996	Asano	5,946,209 A	8/1999	Eckel et al.
5,519,496 A	5/1996	Borgert et al.	5,949,347 A	9/1999	Wu
5,530,322 A	6/1996	Ference et al.	5,952,680 A	9/1999	Strite
5,544,809 A	8/1996	Keating et al.	5,959,547 A	9/1999	Tubel et al.
5,545,950 A	8/1996	Cho	5,962,989 A	10/1999	Baker
5,550,440 A	8/1996	Allison et al.	5,962,992 A	10/1999	Huang et al.
5,559,681 A	9/1996	Duarte	5,963,185 A	10/1999	Havel
5,561,346 A	10/1996	Byrne	5,974,553 A	10/1999	Gandar
D376,030 S	11/1996	Cohen	5,980,064 A	11/1999	Metroyanis
5,575,459 A	11/1996	Anderson	5,998,925 A	12/1999	Shimizu et al.
5,575,554 A	11/1996	Guritz	5,998,928 A	12/1999	Hipp
5,581,158 A	12/1996	Quazi	6,007,209 A	12/1999	Pelka
5,592,051 A	1/1997	Korkala	6,008,783 A	12/1999	Kitagawa et al.
5,592,054 A	1/1997	Nerone et al.	6,011,691 A	1/2000	Schreffler
5,600,199 A	2/1997	Martin, Sr. et al.	6,016,038 A	1/2000	Mueller et al.
5,607,227 A	3/1997	Yasumoto et al.	6,018,237 A	1/2000	Havel
5,608,290 A	3/1997	Hutchisson et al.	6,019,493 A	2/2000	Kuo et al.
5,614,788 A	3/1997	Mullins et al.	6,020,825 A	2/2000	Chansky et al.
5,621,282 A	4/1997	Haskell	6,025,550 A	2/2000	Kato
5,621,603 A	4/1997	Adamec et al.	6,028,694 A	2/2000	Schmidt
5,621,662 A	4/1997	Humphries et al.	6,030,099 A	2/2000	McDermott
5,622,423 A	4/1997	Lee	6,031,343 A	2/2000	Recknagel et al.
5,633,629 A	5/1997	Hochstein	D422,737 S	4/2000	Orozco
5,634,711 A	6/1997	Kennedy et al.	6,056,420 A	5/2000	Wilson et al.
5,640,061 A	6/1997	Bornhorst et al.	6,068,383 A	5/2000	Robertson et al.
5,640,141 A	6/1997	Myllymaki	6,069,597 A	5/2000	Hansen
5,642,129 A	6/1997	Zavracky et al.	6,072,280 A	6/2000	Allen
5,655,830 A	8/1997	Ruskouski	6,084,359 A	7/2000	Hetzel et al.
5,656,935 A	8/1997	Havel	6,086,220 A	7/2000	Lash et al.
5,661,374 A	8/1997	Cassidy et al.	6,091,200 A	7/2000	Lenz
5,661,645 A	8/1997	Hochstein	6,092,915 A	7/2000	Rensch
5,673,059 A	9/1997	Zavracky et al.	6,095,661 A	8/2000	Lebens et al.
5,682,103 A	10/1997	Burrell	6,097,352 A	8/2000	Zavracky et al.
5,688,042 A	11/1997	Madadi et al.	6,116,748 A	9/2000	George
5,697,695 A	12/1997	Lin et al.	6,121,875 A	9/2000	Hamm et al.
5,701,058 A	12/1997	Roth	6,127,783 A	10/2000	Pashley et al.
5,712,650 A	1/1998	Barlow	6,132,072 A	10/2000	Turnbull et al.
5,721,471 A	2/1998	Begemann et al.	6,135,604 A	10/2000	Lin
5,725,148 A	3/1998	Hartman	6,139,174 A	10/2000	Butterworth
5,726,535 A	3/1998	Yan	6,149,283 A	11/2000	Conway et al.
5,731,759 A	3/1998	Finucan	6,150,774 A	11/2000	Mueller et al.
5,734,590 A	3/1998	Tebbe	6,151,529 A	11/2000	Batko
5,751,118 A	5/1998	Mortimer	6,153,985 A	11/2000	Grossman
5,752,766 A	5/1998	Bailey et al.	6,158,882 A	12/2000	Bischoff, Jr.
5,765,940 A	6/1998	Levy et al.	6,166,496 A	12/2000	Lys et al.
5,769,527 A	6/1998	Taylor et al.	6,175,201 B1	1/2001	Sid
5,784,006 A	7/1998	Hochstein	6,175,220 B1	1/2001	Billig et al.
5,785,227 A	7/1998	Akiba	6,181,126 B1	1/2001	Havel
5,790,329 A	8/1998	Klaus et al.	6,183,086 B1	2/2001	Neubert
5,803,579 A	9/1998	Turnbull et al.	6,183,104 B1	2/2001	Ferrara
5,803,580 A	9/1998	Tseng	6,184,628 B1	2/2001	Ruthenberg
5,803,729 A	9/1998	Tsimerman	6,196,471 B1	3/2001	Ruthenberg
5,806,965 A	9/1998	Deese	6,203,180 B1	3/2001	Fleischmann
5,808,689 A	9/1998	Small	6,211,626 B1	4/2001	Lys et al.
5,810,463 A	9/1998	Kawahara et al.	6,215,409 B1	4/2001	Blach
5,812,105 A	9/1998	Van de Ven	6,217,190 B1	4/2001	Altman et al.

6,219,239	B1	4/2001	Mellberg et al.	6,624,597	B2	9/2003	Dowling et al.
6,227,679	B1	5/2001	Zhang et al.	D481,484	S	10/2003	Cuevas et al.
6,238,075	B1	5/2001	Dealey, Jr. et al.	6,634,770	B2	10/2003	Cao
6,241,359	B1	6/2001	Lin	6,634,779	B2	10/2003	Reed
6,250,774	B1	6/2001	Begemann et al.	6,636,003	B2	10/2003	Rahm et al.
6,252,350	B1	6/2001	Alvarez	6,639,349	B1	10/2003	Bahadur
6,252,358	B1	6/2001	Xydis et al.	6,641,284	B2	11/2003	Stopa et al.
6,268,600	B1	7/2001	Nakamura et al.	6,659,622	B2	12/2003	Katogi et al.
6,273,338	B1	8/2001	White	6,660,935	B2	12/2003	Southard et al.
6,275,397	B1	8/2001	McClain	6,666,689	B1	12/2003	Savage, Jr.
6,283,612	B1	9/2001	Hunter	6,667,623	B2	12/2003	Bourgault et al.
6,292,901	B1	9/2001	Lys et al.	6,674,096	B2	1/2004	Sommers
6,293,684	B1	9/2001	Riblett	6,676,284	B1	1/2004	Willson
6,297,724	B1	10/2001	Bryans et al.	6,679,621	B2	1/2004	West et al.
6,305,109	B1	10/2001	Lee	6,681,154	B2	1/2004	Nierlich et al.
6,305,821	B1	10/2001	Hsieh et al.	6,682,205	B2	1/2004	Lin
6,307,331	B1	10/2001	Bonasia et al.	6,683,419	B2	1/2004	Kriparos
6,310,590	B1	10/2001	Havel	6,700,136	B2	3/2004	Guida
6,315,429	B1	11/2001	Grandolfo	6,712,486	B1	3/2004	Popovich et al.
6,323,832	B1	11/2001	Nishizawa et al.	6,717,376	B2	4/2004	Lys et al.
6,325,651	B1	12/2001	Nishihara et al.	6,717,526	B2	4/2004	Martineau et al.
6,334,699	B1	1/2002	Gladnick	6,720,745	B2	4/2004	Lys et al.
6,340,868	B1	1/2002	Lys et al.	6,726,348	B2	4/2004	Gloisten
6,354,714	B1	3/2002	Rhodes	6,741,324	B1	5/2004	Kim
6,361,186	B1	3/2002	Slayden	D491,678	S	6/2004	Piepgas
6,369,525	B1	4/2002	Chang et al.	D492,042	S	6/2004	Piepgas
6,371,637	B1	4/2002	Atchinson et al.	6,744,223	B2	6/2004	Lafamme et al.
6,379,022	B1	4/2002	Amerson et al.	6,748,299	B1	6/2004	Motoyama
D457,667	S	5/2002	Piepgas et al.	6,762,562	B2	7/2004	Leong
D457,669	S	5/2002	Piepgas et al.	6,774,584	B2	8/2004	Lys et al.
D457,974	S	5/2002	Piepgas et al.	6,777,891	B2	8/2004	Lys et al.
6,388,393	B1	5/2002	Illingworth	6,781,329	B2	8/2004	Mueller et al.
6,394,623	B1	5/2002	Tsui	6,787,999	B2	9/2004	Stimac et al.
D458,395	S	6/2002	Piepgas et al.	6,788,000	B2	9/2004	Appelberg et al.
6,400,096	B1	6/2002	Wells et al.	6,788,011	B2	9/2004	Mueller et al.
6,404,131	B1	6/2002	Kawano et al.	6,791,840	B2	9/2004	Chun
6,411,022	B1	6/2002	Machida	6,796,680	B1	9/2004	Showers et al.
6,422,716	B2	7/2002	Henrici et al.	6,801,003	B2	10/2004	Schanberger et al.
6,428,189	B1	8/2002	Hochstein	6,803,732	B2	10/2004	Kraus et al.
D463,610	S	9/2002	Piepgas et al.	6,806,659	B1	10/2004	Mueller et al.
6,445,139	B1	9/2002	Marshall et al.	6,814,470	B2	11/2004	Rizkin et al.
6,448,550	B1	9/2002	Nishimura	6,815,724	B2	11/2004	Dry
6,448,716	B1	9/2002	Hutchison	6,846,094	B2	1/2005	Luk
6,459,919	B1	10/2002	Lys et al.	6,851,816	B2	2/2005	Wu et al.
6,469,457	B2	10/2002	Callahan	6,851,832	B2	2/2005	Tieszen
6,471,388	B1	10/2002	Marsh	6,853,150	B2	2/2005	Clauberg et al.
6,472,823	B2	10/2002	Yen	6,853,151	B2	2/2005	Leong et al.
6,473,002	B1	10/2002	Hutchison	6,853,563	B1	2/2005	Yang et al.
D468,035	S	12/2002	Blanc et al.	6,857,924	B2	2/2005	Fu et al.
6,488,392	B1	12/2002	Lu	6,860,628	B2	3/2005	Robertson et al.
6,495,964	B1	12/2002	Muthu et al.	6,866,401	B2	3/2005	Sommers et al.
6,527,411	B1	3/2003	Sayers	6,869,204	B2	3/2005	Morgan et al.
6,528,954	B1	3/2003	Lys et al.	6,871,981	B2	3/2005	Alexanderson et al.
6,528,958	B2	3/2003	Hulshof et al.	6,874,924	B1	4/2005	Hulse et al.
6,538,375	B1	3/2003	Duggal et al.	6,879,883	B1	4/2005	Motoyama
6,548,967	B1	4/2003	Dowling et al.	6,882,111	B2	4/2005	Kan et al.
6,568,834	B1	5/2003	Scianna	6,883,929	B2	4/2005	Dowling
6,573,536	B1	6/2003	Dry	6,883,934	B2	4/2005	Kawakami et al.
6,577,072	B2	6/2003	Saito et al.	6,888,322	B2	5/2005	Dowling et al.
6,577,080	B2	6/2003	Lys et al.	6,897,624	B2	5/2005	Lys et al.
6,577,512	B2	6/2003	Tripathi et al.	6,909,239	B2	6/2005	Gauna
6,577,794	B1	6/2003	Currie et al.	6,909,921	B1	6/2005	Bilger
6,578,979	B2	6/2003	Truttman-Battig	6,918,680	B2	7/2005	Seeberger
6,582,103	B1	6/2003	Popovich et al.	6,921,181	B2	7/2005	Yen
6,583,550	B2	6/2003	Iwasa et al.	6,936,968	B2	8/2005	Cross et al.
6,583,573	B2	6/2003	Bierman	6,936,978	B2	8/2005	Morgan et al.
6,585,393	B1	7/2003	Brandes et al.	6,940,230	B2	9/2005	Myron et al.
6,586,890	B2	7/2003	Min et al.	6,948,829	B2	9/2005	Verdes et al.
6,590,343	B2	7/2003	Pederson	6,957,905	B1	10/2005	Pritchard et al.
6,592,238	B2	7/2003	Cleaver et al.	6,963,175	B2	11/2005	Archenhold et al.
6,596,977	B2	7/2003	Muthu et al.	6,964,501	B2	11/2005	Ryan
6,598,996	B1	7/2003	Lodhie	6,965,197	B2	11/2005	Tyan et al.
6,608,453	B2	8/2003	Morgan et al.	6,965,205	B2	11/2005	Piepgas et al.
6,608,614	B1	8/2003	Johnson	6,967,448	B2	11/2005	Morgan et al.
6,609,804	B2	8/2003	Nolan et al.	6,969,179	B2	11/2005	Sloan et al.
6,612,712	B2	9/2003	Nepil	6,969,186	B2	11/2005	Sonderegger et al.
6,612,717	B2	9/2003	Yen	6,969,954	B2	11/2005	Lys
6,621,222	B1	9/2003	Hong	6,975,079	B2	12/2005	Lys et al.
6,623,151	B2	9/2003	Pederson	6,979,097	B2	12/2005	Elam et al.

6,982,518	B2	1/2006	Chou et al.	7,217,012	B2	5/2007	Southard et al.
6,995,681	B2	2/2006	Pederson	7,217,022	B2	5/2007	Ruffin
6,997,576	B1	2/2006	Lodhie et al.	7,218,056	B1	5/2007	Harwood
7,004,603	B2	2/2006	Knights	7,218,238	B2	5/2007	Right et al.
D518,218	S	3/2006	Roberge et al.	7,220,015	B2	5/2007	Dowling
7,008,079	B2	3/2006	Smith	7,220,018	B2	5/2007	Crabb et al.
7,014,336	B1	3/2006	Ducharme et al.	7,221,104	B2	5/2007	Lys et al.
7,015,650	B2	3/2006	McGrath	7,221,110	B2	5/2007	Sears et al.
7,018,063	B2	3/2006	Michael et al.	7,224,000	B2	5/2007	Aanegola et al.
7,021,799	B2	4/2006	Mizuyoshi	7,226,189	B2	6/2007	Lee et al.
7,021,809	B2	4/2006	Iwasa et al.	7,228,052	B1	6/2007	Lin
7,024,256	B2	4/2006	Krzyzanowski et al.	7,228,190	B2	6/2007	Dowling et al.
7,031,920	B2	4/2006	Dowling et al.	7,231,060	B2	6/2007	Dowling et al.
7,033,036	B2	4/2006	Pederson	7,233,115	B2	6/2007	Lys
7,038,398	B1	5/2006	Lys et al.	7,233,831	B2	6/2007	Blackwell
7,038,399	B2	5/2006	Lys et al.	7,236,366	B2	6/2007	Chen
7,042,172	B2	5/2006	Dowling et al.	7,237,924	B2	7/2007	Martineau et al.
7,048,423	B2	5/2006	Stepanenko et al.	7,237,925	B2	7/2007	Mayer et al.
7,049,761	B2	5/2006	Timmermans et al.	7,239,532	B1	7/2007	Hsu et al.
7,052,171	B1	5/2006	Lefebvre et al.	7,241,038	B2	7/2007	Naniwa et al.
7,053,557	B2	5/2006	Cross et al.	7,242,152	B2	7/2007	Dowling et al.
7,064,498	B2	6/2006	Dowling et al.	7,246,926	B2	7/2007	Harwood
7,064,674	B2	6/2006	Pederson	7,246,931	B2	7/2007	Hsieh et al.
7,067,992	B2	6/2006	Leong et al.	7,248,239	B2	7/2007	Dowling et al.
7,077,978	B2	7/2006	Setlur et al.	7,249,269	B1	7/2007	Motoyama
7,080,927	B2	7/2006	Feuerborn et al.	7,249,865	B2	7/2007	Robertson
7,086,747	B2	8/2006	Nielson et al.	D548,868	S	8/2007	Roberge et al.
7,088,014	B2	8/2006	Nierlich et al.	7,252,408	B2	8/2007	Mazzochette et al.
7,088,904	B2	8/2006	Ryan, Jr.	7,253,566	B2	8/2007	Lys et al.
7,102,902	B1	9/2006	Brown et al.	7,255,457	B2	8/2007	Ducharme et al.
7,113,541	B1	9/2006	Lys et al.	7,255,460	B2	8/2007	Lee
7,114,830	B2	10/2006	Robertson et al.	7,256,554	B2	8/2007	Lys
7,114,834	B2	10/2006	Rivas et al.	7,258,458	B2	8/2007	Mochiachvili et al.
7,118,262	B2	10/2006	Negley	7,258,467	B2	8/2007	Saccomanno et al.
7,119,503	B2	10/2006	Kemper	7,259,528	B2	8/2007	Pilz
7,121,679	B2	10/2006	Fujimoto	7,262,439	B2	8/2007	Setlur et al.
7,122,976	B1	10/2006	Null et al.	7,264,372	B2	9/2007	Maglica
7,128,442	B2	10/2006	Lee et al.	7,267,467	B2	9/2007	Wu et al.
7,128,454	B2	10/2006	Kim et al.	7,270,443	B2	9/2007	Kurtz et al.
D532,532	S	11/2006	Maxik	7,271,794	B1	9/2007	Cheng et al.
7,132,635	B2	11/2006	Dowling	7,273,300	B2	9/2007	Mrakovich
7,132,785	B2	11/2006	Ducharme	7,274,045	B2	9/2007	Chandran et al.
7,132,804	B2	11/2006	Lys et al.	7,274,160	B2	9/2007	Mueller et al.
7,135,824	B2	11/2006	Lys et al.	D553,267	S	10/2007	Yuen
7,139,617	B1	11/2006	Morgan et al.	7,285,801	B2	10/2007	Eliashevich et al.
7,144,135	B2	12/2006	Martin et al.	7,288,902	B1	10/2007	Melanson
7,153,002	B2	12/2006	Kim et al.	7,296,912	B2	11/2007	Beauchamp
7,161,311	B2	1/2007	Mueller et al.	7,300,184	B2	11/2007	Ichikawa et al.
7,161,313	B2	1/2007	Piepgas et al.	7,300,192	B2	11/2007	Mueller et al.
7,161,556	B2	1/2007	Morgan et al.	D556,937	S	12/2007	Ly
7,164,110	B2	1/2007	Pitigoi-Aron et al.	D557,854	S	12/2007	Lewis
7,164,235	B2	1/2007	Ito et al.	7,303,300	B2	12/2007	Dowling et al.
7,165,863	B1	1/2007	Thomas et al.	7,306,353	B2	12/2007	Popovich et al.
7,165,866	B2	1/2007	Li	7,307,391	B2	12/2007	Shan
7,167,777	B2	1/2007	Budike, Jr.	7,308,296	B2	12/2007	Lys et al.
7,168,843	B2	1/2007	Striebel	7,309,965	B2	12/2007	Dowling et al.
D536,468	S	2/2007	Crosby	7,318,658	B2	1/2008	Wang et al.
7,178,941	B2	2/2007	Roberge et al.	7,319,244	B2	1/2008	Liu et al.
7,180,252	B2	2/2007	Lys et al.	7,319,246	B2	1/2008	Soules et al.
D538,950	S	3/2007	Maxik	7,321,191	B2	1/2008	Setlur et al.
D538,952	S	3/2007	Maxik et al.	7,326,964	B2	2/2008	Lim et al.
D538,962	S	3/2007	Elliott	7,327,281	B2	2/2008	Hutchison
7,186,003	B2	3/2007	Dowling et al.	7,329,031	B2	2/2008	Liaw et al.
7,186,005	B2	3/2007	Hulse	D563,589	S	3/2008	Hariri et al.
7,187,141	B2	3/2007	Mueller et al.	7,345,320	B2	3/2008	Dahm
7,190,126	B1	3/2007	Paton	7,348,604	B2	3/2008	Matheson
7,192,154	B2	3/2007	Becker	7,350,936	B2	4/2008	Ducharme et al.
7,198,387	B1	4/2007	Gloisten et al.	7,350,952	B2	4/2008	Nishigaki
7,201,491	B2	4/2007	Bayat et al.	7,352,138	B2	4/2008	Lys et al.
7,201,497	B2	4/2007	Weaver, Jr. et al.	7,352,339	B2	4/2008	Morgan et al.
7,202,613	B2	4/2007	Morgan et al.	7,353,071	B2	4/2008	Blackwell et al.
7,204,615	B2	4/2007	Arik et al.	7,358,679	B2	4/2008	Lys et al.
7,204,622	B2	4/2007	Dowling et al.	7,358,929	B2	4/2008	Mueller et al.
7,207,696	B1	4/2007	Lin	7,374,327	B2	5/2008	Schexnaider
7,210,818	B2	5/2007	Luk et al.	7,385,359	B2	6/2008	Dowling et al.
7,210,957	B2	5/2007	Mrakovich et al.	7,391,159	B2	6/2008	Harwood
7,211,959	B1	5/2007	Chou	7,396,146	B2	7/2008	Wang
7,213,934	B2	5/2007	Zarian et al.	7,401,935	B2	7/2008	VanderSchuit
7,217,004	B2	5/2007	Park et al.	7,401,945	B2	7/2008	Zhang

7,427,840	B2	9/2008	Morgan et al.	2003/0102810	A1	6/2003	Cross et al.
7,429,117	B2	9/2008	Pohlert et al.	2003/0133292	A1	7/2003	Mueller et al.
7,434,964	B1	10/2008	Zheng et al.	2003/0137258	A1	7/2003	Pieppgras et al.
7,438,441	B2	10/2008	Sun et al.	2003/0185005	A1	10/2003	Sommers et al.
D580,089	S	11/2008	Ly et al.	2003/0185014	A1	10/2003	Gloisten
D581,556	S	11/2008	To et al.	2003/0189412	A1	10/2003	Cunningham
7,449,847	B2	11/2008	Schanberger et al.	2003/0222587	A1	12/2003	Dowling, Jr. et al.
D582,577	S	12/2008	Yuen	2004/0003545	A1	1/2004	Gillespie
D584,428	S	1/2009	Li et al.	2004/0012959	A1	1/2004	Robertson et al.
7,476,002	B2	1/2009	Wolf et al.	2004/0036006	A1	2/2004	Dowling
7,476,004	B2	1/2009	Chan	2004/0037088	A1	2/2004	English et al.
7,478,924	B2	1/2009	Robertson	2004/0052076	A1	3/2004	Mueller et al.
D586,484	S	2/2009	Liu et al.	2004/0062041	A1	4/2004	Cross et al.
D586,928	S	2/2009	Liu et al.	2004/0075572	A1	4/2004	Buschmann et al.
7,490,957	B2	2/2009	Leong et al.	2004/0080960	A1	4/2004	Wu
7,497,596	B2	3/2009	Ge	2004/0090191	A1	5/2004	Mueller et al.
7,507,001	B2	3/2009	Kit	2004/0090787	A1	5/2004	Dowling et al.
7,510,299	B2	3/2009	Timmermans et al.	2004/0105261	A1	6/2004	Ducharme et al.
7,520,635	B2	4/2009	Wolf et al.	2004/0105264	A1	6/2004	Spero
7,521,872	B2	4/2009	Bruning	2004/0113568	A1	6/2004	Dowling et al.
7,524,089	B2	4/2009	Park	2004/0116039	A1	6/2004	Mueller et al.
D593,223	S	5/2009	Komar	2004/0124782	A1	7/2004	Yu
7,534,002	B2	5/2009	Yamaguchi et al.	2004/0130909	A1	7/2004	Mueller et al.
7,549,769	B2	6/2009	Kim et al.	2004/0141321	A1	7/2004	Dowling et al.
7,556,396	B2	7/2009	Kuo et al.	2004/0155609	A1	8/2004	Lys et al.
7,572,030	B2	8/2009	Booth et al.	2004/0160199	A1	8/2004	Morgan et al.
7,575,339	B2	8/2009	Hung	2004/0178751	A1	9/2004	Mueller et al.
7,579,786	B2	8/2009	Soos	2004/0189218	A1	9/2004	Leong et al.
7,583,035	B2	9/2009	Shteynberg et al.	2004/0189262	A1	9/2004	McGrath
7,602,559	B2	10/2009	Jang et al.	2004/0212320	A1	10/2004	Dowling et al.
7,619,366	B2	11/2009	Diederiks	2004/0212321	A1	10/2004	Lys et al.
7,635,201	B2	12/2009	Deng	2004/0212993	A1	10/2004	Morgan et al.
7,639,517	B2	12/2009	Zhou et al.	2004/0223328	A1	11/2004	Lee et al.
D612,528	S	3/2010	McGrath et al.	2004/0240890	A1	12/2004	Lys et al.
7,690,813	B2	4/2010	Kanamori et al.	2004/0257007	A1	12/2004	Lys et al.
7,710,047	B2	5/2010	Shteynberg et al.	2005/0013133	A1	1/2005	Yeh
7,712,918	B2	5/2010	Siemiet et al.	2005/0024877	A1	2/2005	Frederick
7,828,471	B2	11/2010	Lin	2005/0030744	A1	2/2005	Ducharme et al.
7,843,150	B2	11/2010	Wang et al.	2005/0035728	A1	2/2005	Schanberger et al.
2001/0033488	A1	10/2001	Chliwnyj et al.	2005/0036300	A1	2/2005	Dowling et al.
2001/0045803	A1	11/2001	Cencur	2005/0040774	A1	2/2005	Mueller et al.
2002/0038157	A1	3/2002	Dowling et al.	2005/0041161	A1	2/2005	Dowling et al.
2002/0044066	A1	4/2002	Dowling et al.	2005/0041424	A1	2/2005	Ducharme
2002/0047569	A1	4/2002	Dowling et al.	2005/0043907	A1	2/2005	Eckel et al.
2002/0047624	A1	4/2002	Stam et al.	2005/0044617	A1	3/2005	Mueller et al.
2002/0047628	A1	4/2002	Morgan et al.	2005/0047132	A1	3/2005	Dowling et al.
2002/0048169	A1	4/2002	Dowling et al.	2005/0047134	A1	3/2005	Mueller et al.
2002/0057061	A1	5/2002	Mueller et al.	2005/0062440	A1	3/2005	Lys et al.
2002/0060526	A1	5/2002	Timmermans et al.	2005/0063194	A1	3/2005	Lys et al.
2002/0070688	A1	6/2002	Dowling et al.	2005/0078477	A1	4/2005	Lo
2002/0074559	A1	6/2002	Dowling et al.	2005/0099824	A1	5/2005	Dowling et al.
2002/0078221	A1	6/2002	Blackwell et al.	2005/0107694	A1	5/2005	Jansen et al.
2002/0101197	A1	8/2002	Lys et al.	2005/0110384	A1	5/2005	Peterson
2002/0113555	A1	8/2002	Lys et al.	2005/0116667	A1	6/2005	Mueller et al.
2002/0130627	A1	9/2002	Morgan et al.	2005/0128751	A1	6/2005	Roberge et al.
2002/0145394	A1	10/2002	Morgan et al.	2005/0141225	A1	6/2005	Striebel
2002/0145869	A1	10/2002	Dowling	2005/0151489	A1	7/2005	Lys et al.
2002/0152045	A1	10/2002	Dowling et al.	2005/0151663	A1	7/2005	Tanguay
2002/0152298	A1	10/2002	Kikta et al.	2005/0154494	A1	7/2005	Ahmed
2002/0153851	A1	10/2002	Morgan et al.	2005/0174473	A1	8/2005	Morgan et al.
2002/0158583	A1	10/2002	Lys et al.	2005/0174780	A1	8/2005	Park
2002/0163316	A1	11/2002	Lys et al.	2005/0184667	A1	8/2005	Sturman et al.
2002/0171365	A1	11/2002	Morgan et al.	2005/0201112	A1	9/2005	Machi et al.
2002/0171377	A1	11/2002	Mueller et al.	2005/0206529	A1	9/2005	St.-Germain
2002/0171378	A1	11/2002	Morgan et al.	2005/0213320	A1	9/2005	Kazuhiro et al.
2002/0176259	A1	11/2002	Ducharme	2005/0213352	A1	9/2005	Lys
2002/0179816	A1	12/2002	Haines et al.	2005/0213353	A1	9/2005	Lys
2002/0195975	A1	12/2002	Schanberger et al.	2005/0218838	A1	10/2005	Lys
2003/0011538	A1	1/2003	Lys et al.	2005/0218870	A1	10/2005	Lys
2003/0028260	A1	2/2003	Blackwell	2005/0219860	A1	10/2005	Schexnaider
2003/0031015	A1	2/2003	Ishibashi	2005/0219872	A1	10/2005	Lys
2003/0057884	A1	3/2003	Dowling et al.	2005/0225979	A1	10/2005	Robertson et al.
2003/0057886	A1	3/2003	Lys et al.	2005/0231133	A1	10/2005	Lys
2003/0057887	A1	3/2003	Dowling et al.	2005/0236029	A1	10/2005	Dowling
2003/0057890	A1	3/2003	Lys et al.	2005/0236998	A1	10/2005	Mueller et al.
2003/0076281	A1	4/2003	Morgan et al.	2005/0248299	A1	11/2005	Chemel et al.
2003/0085710	A1	5/2003	Bourgault et al.	2005/0253533	A1	11/2005	Lys et al.
2003/0095404	A1	5/2003	Becks et al.	2005/0259424	A1	11/2005	Zampini, II et al.
2003/0100837	A1	5/2003	Lys et al.	2005/0265019	A1	12/2005	Sommers et al.

2005/0275626	A1	12/2005	Mueller et al.	2007/0195527	A1	8/2007	Russell
2005/0276051	A1	12/2005	Caudle et al.	2007/0195532	A1	8/2007	Reisenauer et al.
2005/0276053	A1	12/2005	Nortrup et al.	2007/0205712	A1	9/2007	Radkov et al.
2005/0276064	A1	12/2005	Wu et al.	2007/0206375	A1	9/2007	Piepgras et al.
2005/0285547	A1	12/2005	Piepgras et al.	2007/0211463	A1	9/2007	Chevalier et al.
2006/0002110	A1	1/2006	Dowling et al.	2007/0228999	A1	10/2007	Kit
2006/0012987	A9	1/2006	Ducharme et al.	2007/0235751	A1	10/2007	Radkov et al.
2006/0012997	A1	1/2006	Catalano et al.	2007/0236156	A1	10/2007	Lys et al.
2006/0016960	A1	1/2006	Morgan et al.	2007/0237284	A1	10/2007	Lys et al.
2006/0022214	A1	2/2006	Morgan et al.	2007/0240346	A1	10/2007	Li et al.
2006/0028155	A1	2/2006	Young	2007/0241657	A1	10/2007	Radkov et al.
2006/0028837	A1	2/2006	Mrakovich	2007/0242466	A1	10/2007	Wu et al.
2006/0034078	A1	2/2006	Kovacik et al.	2007/0247842	A1	10/2007	Zampini et al.
2006/0050509	A9	3/2006	Dowling et al.	2007/0247847	A1	10/2007	Villard
2006/0050514	A1	3/2006	Opolka	2007/0247851	A1	10/2007	Villard
2006/0076908	A1	4/2006	Morgan et al.	2007/0258231	A1	11/2007	Koerner et al.
2006/0092640	A1	5/2006	Li	2007/0258240	A1	11/2007	Ducharme et al.
2006/0098077	A1	5/2006	Dowling	2007/0263379	A1	11/2007	Dowling
2006/0104058	A1	5/2006	Chemel et al.	2007/0274070	A1	11/2007	Wedell
2006/0109648	A1	5/2006	Trenchard et al.	2007/0281520	A1	12/2007	Insalaco et al.
2006/0109649	A1	5/2006	Ducharme et al.	2007/0285926	A1	12/2007	Maxik
2006/0109661	A1	5/2006	Coushaine et al.	2007/0285933	A1	12/2007	Southard et al.
2006/0126325	A1	6/2006	Lefebvre et al.	2007/0290625	A1	12/2007	He et al.
2006/0126338	A1	6/2006	Mighetto	2007/0291483	A1	12/2007	Lys
2006/0132061	A1	6/2006	McCormick et al.	2007/0296350	A1	12/2007	Maxik et al.
2006/0132323	A1	6/2006	Grady, Jr.	2008/0003664	A1	1/2008	Tysoe et al.
2006/0146531	A1	7/2006	Reo et al.	2008/0007945	A1	1/2008	Kelly et al.
2006/0152172	A9	7/2006	Mueller et al.	2008/0012502	A1	1/2008	Lys
2006/0158881	A1	7/2006	Dowling	2008/0012506	A1	1/2008	Mueller et al.
2006/0170376	A1	8/2006	Piepgras et al.	2008/0013316	A1	1/2008	Chiang
2006/0192502	A1	8/2006	Brown et al.	2008/0013324	A1	1/2008	Yu
2006/0193131	A1	8/2006	McGrath et al.	2008/0018261	A1	1/2008	Kastner
2006/0197661	A1	9/2006	Tracy et al.	2008/0037245	A1	2/2008	Chan
2006/0198128	A1	9/2006	Piepgras et al.	2008/0037284	A1	2/2008	Rudisill
2006/0208667	A1	9/2006	Lys et al.	2008/0062680	A1	3/2008	Timmermans et al.
2006/0221606	A1	10/2006	Dowling et al.	2008/0089075	A1	4/2008	Hsu
2006/0221619	A1	10/2006	Nishigaki	2008/0092800	A1	4/2008	Smith et al.
2006/0232974	A1	10/2006	Lee et al.	2008/0093615	A1	4/2008	Lin et al.
2006/0262516	A9	11/2006	Dowling et al.	2008/0093998	A1	4/2008	Dennery et al.
2006/0262521	A1	11/2006	Piepgras et al.	2008/0094837	A1	4/2008	Dobbins et al.
2006/0262544	A1	11/2006	Piepgras et al.	2008/0130267	A1	6/2008	Dowling et al.
2006/0262545	A1	11/2006	Piepgras et al.	2008/0151535	A1	6/2008	de Castris
2006/0273741	A1	12/2006	Stalker, III	2008/0158871	A1	7/2008	McAvoy et al.
2006/0274529	A1	12/2006	Cao	2008/0158887	A1	7/2008	Zhu et al.
2006/0285325	A1	12/2006	Ducharme et al.	2008/0164826	A1	7/2008	Lys
2007/0035255	A1	2/2007	Shuster et al.	2008/0164827	A1	7/2008	Lys
2007/0040516	A1	2/2007	Chen	2008/0164854	A1	7/2008	Lys
2007/0041220	A1	2/2007	Lynch	2008/0175003	A1	7/2008	Tsou et al.
2007/0047227	A1	3/2007	Ducharme	2008/0180036	A1	7/2008	Garrity et al.
2007/0053182	A1	3/2007	Robertson	2008/0186704	A1	8/2008	Chou et al.
2007/0053208	A1	3/2007	Justel et al.	2008/0192436	A1	8/2008	Peng et al.
2007/0064419	A1	3/2007	Gandhi	2008/0211419	A1	9/2008	Garrity
2007/0070621	A1	3/2007	Rivas et al.	2008/0224629	A1	9/2008	Melanson
2007/0070631	A1	3/2007	Huang et al.	2008/0224636	A1	9/2008	Melanson
2007/0081423	A1	4/2007	Chien	2008/0253125	A1	10/2008	Kang et al.
2007/0086754	A1	4/2007	Lys et al.	2008/0258647	A1	10/2008	Scianna
2007/0086912	A1	4/2007	Dowling et al.	2008/0285257	A1	11/2008	King
2007/0097678	A1	5/2007	Yang	2008/0285266	A1	11/2008	Thomas
2007/0109763	A1	5/2007	Wolf et al.	2008/0290814	A1	11/2008	Leong et al.
2007/0115658	A1	5/2007	Mueller et al.	2008/0291675	A1	11/2008	Lin et al.
2007/0115665	A1	5/2007	Mueller et al.	2008/0315773	A1	12/2008	Pang
2007/0120594	A1	5/2007	Balakrishnan et al.	2008/0315784	A1	12/2008	Tseng
2007/0127234	A1	6/2007	Jervey, III	2009/0002995	A1	1/2009	Lee et al.
2007/0133202	A1	6/2007	Huang et al.	2009/0016063	A1	1/2009	Hu
2007/0139938	A1	6/2007	Petroski et al.	2009/0046473	A1	2/2009	Tsai et al.
2007/0145915	A1	6/2007	Roberge et al.	2009/0052186	A1	2/2009	Xue
2007/0147046	A1	6/2007	Arik et al.	2009/0067182	A1	3/2009	Hsu et al.
2007/0152797	A1	7/2007	Chemel et al.	2009/0086492	A1	4/2009	Meyer
2007/0153514	A1	7/2007	Dowling et al.	2009/0091938	A1	4/2009	Jacobson et al.
2007/0159828	A1	7/2007	Wang	2009/0140285	A1	6/2009	Lin et al.
2007/0165402	A1	7/2007	Weaver, Jr. et al.	2009/0175041	A1	7/2009	Yuen et al.
2007/0165405	A1	7/2007	Chen	2009/0185373	A1	7/2009	Grajcar
2007/0173978	A1	7/2007	Fein et al.	2009/0195186	A1	8/2009	Guest et al.
2007/0177382	A1	8/2007	Pritchard et al.	2009/0196034	A1	8/2009	Gherardini et al.
2007/0182387	A1	8/2007	Weirich	2009/0213588	A1	8/2009	Manes
2007/0188114	A1	8/2007	Lys et al.	2009/0273926	A1	11/2009	Deng
2007/0188427	A1	8/2007	Lys et al.	2009/0303720	A1	12/2009	McGrath
2007/0189026	A1	8/2007	Chemel et al.	2009/0316408	A1	12/2009	Villard
2007/0195526	A1	8/2007	Dowling et al.	2010/0008085	A1	1/2010	Ivey et al.

2010/0019689 A1 1/2010 Shan
 2010/0027259 A1 2/2010 Simon et al.
 2010/0033095 A1 2/2010 Sadwick
 2010/0033964 A1 2/2010 Choi et al.
 2010/0096998 A1 4/2010 Beers
 2010/0109550 A1 5/2010 Huda et al.
 2010/0109558 A1 5/2010 Chew

FOREIGN PATENT DOCUMENTS

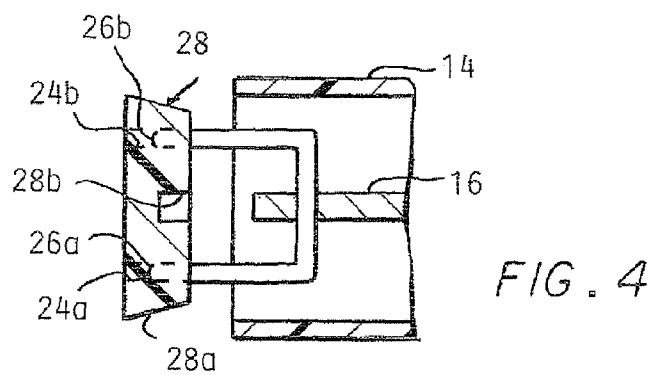
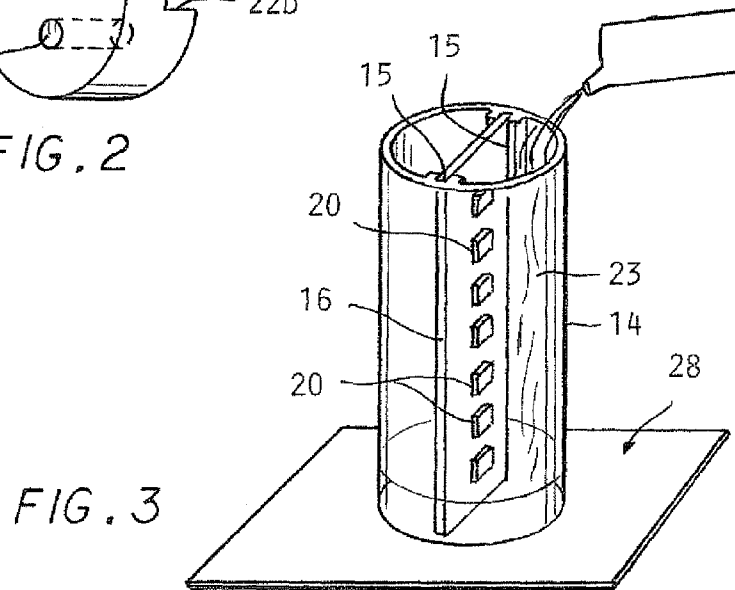
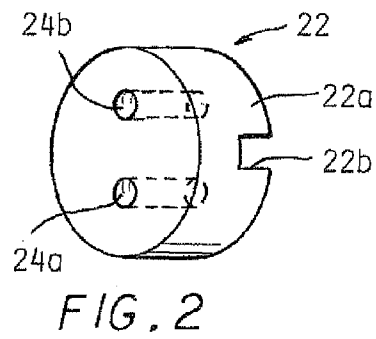
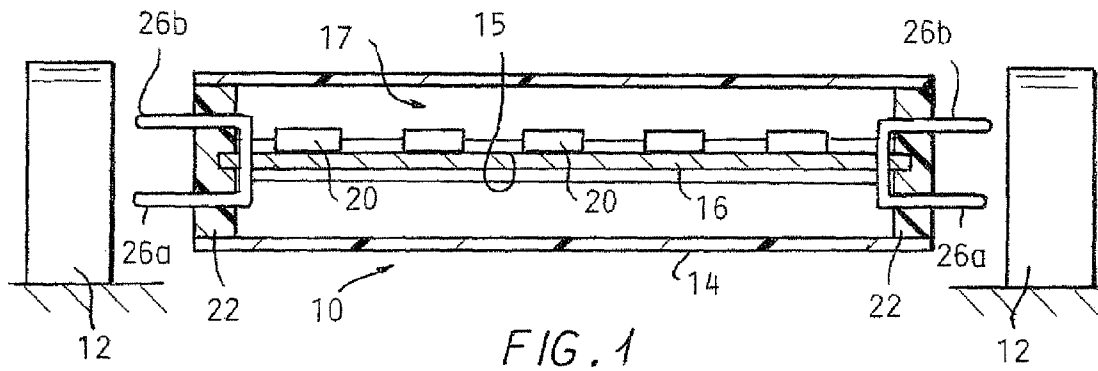
CN 2869556 Y 2/2007
 EP 0013782 B1 3/1983
 EP 0091172 A2 10/1983
 EP 0124924 B1 9/1987
 EP 0174699 B1 11/1988
 EP 0197602 B1 11/1990
 EP 0214701 B1 3/1992
 EP 0262713 B1 6/1992
 EP 0203668 B1 2/1993
 EP 0272749 B1 8/1993
 EP 0337567 B1 11/1993
 EP 0390262 B1 12/1993
 EP 0359329 B1 3/1994
 EP 0403011 B1 4/1994
 EP 0632511 A2 1/1995
 EP 0432848 B1 4/1995
 EP 0403001 B1 8/1995
 EP 0525876 B1 5/1996
 EP 0714556 B1 1/1999
 EP 0889283 A1 1/1999
 EP 0458408 B1 9/1999
 EP 0578302 B1 9/1999
 EP 0723701 B1 1/2000
 EP 0787419 B1 5/2001
 EP 1195740 A2 4/2002
 EP 1016062 B1 8/2002
 EP 1195740 A3 1/2003
 EP 1149510 B1 2/2003
 EP 1056993 B1 3/2003
 EP 0766436 B1 5/2003
 EP 0924281 B1 5/2003
 EP 0826167 B1 6/2003
 EP 1147686 B1 1/2004
 EP 1142452 B1 3/2004
 EP 1145602 B1 3/2004
 EP 1422975 A1 5/2004
 EP 0890059 B1 6/2004
 EP 1348319 B1 6/2005
 EP 1037862 B1 7/2005
 EP 1346609 B1 8/2005
 EP 1321012 B1 12/2005
 EP 1610593 A2 12/2005
 EP 1415517 B1 5/2006
 EP 1415518 B1 5/2006
 EP 1438877 B1 5/2006
 EP 1166604 B1 6/2006
 EP 1479270 B1 7/2006
 EP 1348318 B1 8/2006
 EP 1399694 B1 8/2006
 EP 1461980 B1 10/2006
 EP 1110120 B1 4/2007
 EP 1440604 B1 4/2007
 EP 1047903 B1 6/2007
 EP 1500307 B1 6/2007
 EP 0922305 B1 8/2007
 EP 0922306 B1 8/2007
 EP 1194918 B1 8/2007
 EP 1048085 B1 11/2007
 EP 1763650 B1 12/2007
 EP 1776722 B1 1/2008
 EP 1873012 A1 1/2008
 EP 1459599 B1 2/2008
 EP 1887836 A2 2/2008
 EP 1579733 B1 4/2008
 EP 1145282 B1 7/2008
 EP 1157428 B1 9/2008
 EP 1337784 B1 6/2009
 FR 2813115 A1 2/2002
 GB 2215024 A 9/1989
 GB 2324901 A 11/1998

JP 6-54103 U 7/1994
 JP H6-54103 7/1994
 JP 7-249467 9/1995
 JP 08-162677 6/1996
 JP 11-135274 A 5/1999
 JP 2001-238272 A 8/2001
 JP 2002-141555 A 5/2002
 JP 3098271 U 2/2004
 JP 2004-335426 11/2004
 JP 2005-158363 A 6/2005
 JP 2005-166617 A 6/2005
 JP 2005-347214 A 12/2005
 JP 2006-507641 A 3/2006
 JP 3139714 U 2/2008
 JP 2008-258124 A 10/2008
 KR 10-2004-0008244 A 1/2004
 KR 20-0430022 Y1 11/2006
 KR 10-0781652 B1 12/2007
 TW M337036 7/2008
 WO 9906759 A1 2/1999
 WO 99/10867 A1 3/1999
 WO 99/31560 A2 6/1999
 WO 9945312 A1 9/1999
 WO 00/01067 A2 1/2000
 WO 02/25842 A2 3/2002
 WO 02/061330 A2 8/2002
 WO 02/069306 A2 9/2002
 WO 02/091805 A2 11/2002
 WO 02/098182 A2 12/2002
 WO 02/099780 A2 12/2002
 WO 03/026358 A1 3/2003
 WO 03/055273 A2 7/2003
 WO 03/067934 A2 8/2003
 WO 03/090890 A1 11/2003
 WO 03/096761 A1 11/2003
 WO 2004/021747 A2 3/2004
 WO 2004/023850 A2 3/2004
 WO 2004/032572 A2 4/2004
 WO 2004/100624 A2 11/2004
 WO 2005031860 A2 4/2005
 WO 2005/052751 A2 6/2005
 WO 2005/060309 A2 6/2005
 WO 2005/084339 A2 9/2005
 WO 2005/089293 A2 9/2005
 WO 2005/089309 A2 9/2005
 WO 2006/023149 A2 3/2006
 WO 2006044328 A1 4/2006
 WO 2006056210 A1 6/2006
 WO 2006/093889 A2 9/2006
 WO 2006/127666 A2 11/2006
 WO 2006/127785 A2 11/2006
 WO 2006/133272 A2 12/2006
 WO 2006137686 A1 12/2006
 WO 2007/081674 A1 7/2007
 WO 2007/094810 A2 8/2007
 WO 2007090292 A1 8/2007
 WO 9957945 A1 9/2009

OTHER PUBLICATIONS

Experiment Electronic Ballast. Electronic Ballast for Fluorescent Lamps [online], Revised Fall of 2007. [Retrieved on Sep. 1, 1997]. Retrieved from Virginia Tech Web Page using Internet <URL: <http://www.ece.vt.edu/ece3354/labs/ballast.pdf>>.
 Truck-Lite, LEDSelect—LED, Model 35, Clearance & Marker Lighting, [online], [retrieved on Jan. 13, 2000] Retrieved from Truck-Lite Web Page using Internet <URL: <http://trucklite.com/leds14.html>>.
 Truck-Lite, LEDSelect—LED, Super 44, Stop, Turn & Tail Lighting, [online], [retrieved on Jan. 13, 2000] Retrieved from Truck-Lite Web Page using Internet <URL: <http://trucklite.com/leds2.html>>.
 Truck-Lite, LEDSelect—LED, Model 45, Stop, Turn & Tail Lighting [online], [retrieved on Jan. 13, 2000] Retrieved from Truck-Lite Web Page using Internet <URL: <http://trucklite.com/leds4.html>>.
 Telecite Products & Services—Display Options, [online], [retrieved on Jan. 13, 2000] Retrieved from Telecite Web page using Internet <URL: http://www.telecite.com/en/products/options_en.htm>.
 Traffic Signal Products—Transportation Products Group, [online],

- [retrieved on Jan. 13, 2000] Retrieved from the Dialight Web Page using Internet <URL: <http://www.dialight.com/trans.htm>>.
- LED Lights, Replacement LED lamps for any incandescent light, [online], [retrieved on Jan. 13, 2000] Retrieved from LED Lights Web Page using Internet <URL: <http://www.ledlights.com/replac.htm>>.
- Ledtronics, Ledtronics Catalog, 1996, p. 10, Ledtronics, Torrance, California.
- Piper. The Best Path to Efficiency. Building Operating Management, Trade Press Publishing Company May 2000 [online], [retrieved on Jan. 17, 2008]. Retrieved from Find Articles Web Page using Internet <URL:http://findarticles.com/p/articles/mi_qu3922/is_200005/ai_n8899499/>.
- Henson, Keith. The Benefits of Building Systems Integration, Access Control & Security Systems Integration, Oct. 1, 2000, Penton Media. [online], [retrieved on Oct. 24, 2008] Retrieved from Security Solutions Web page using Internet <URL: http://securitysolutions.com/mag/security_benefits_building_systems/>.
- Phason Electronic Control Systems, Light Level Controller (LLC) case study. Nov. 30, 2004. 3 pages, Phason Inc., Winnipeg, Manitoba, Canada.
- Airport International. Fly High With Intelligent Airport Building and Security Solutions [online], [retrieved on Oct. 24, 2008]. Retrieved from Airport International web page using Internet <URL: <http://www.airport-int.com/categories/airport-building-and-security-solutions/fly-high-with-intelligent-airport-building-and-security-solutions.html>>.
- D.N.A.-III, [online], [retrieved Mar. 10, 2009] Retrieved from the PLC Lighting Web Page using Internet <URL: http://www.plclighting.com/product_info.php?cPath=1&products_id=92>.
- E20116-18 Larmes Collection, [online], [retrieved on Jul. 10, 2010] Retrieved from ET2 Contemporary Lighting using Internet <URL: <http://www.et2online.com/proddetail.aspx?ItemID=E20116-18>>.
- E20112-22 Starburst Collection, [online], [retrieved on Jul. 10, 2010] Retrieved from ET2 Contemporary Lighting using Internet <URL: <http://www.et2online.com/proddetail.aspx?ItemID=E20112-22>>.
- E20524-10 & E20525-10 Curva Collection, [online], [retrieved on Jul. 10, 2010] Retrieved from ET2 Contemporary Lighting using Internet <URL: <http://www.et2online.com/proddetail.aspx?ItemID=E20524-10&E20525-10>>.
- E22201-44 Esprit Collection, [online], [retrieved on Jul. 10, 2010] Retrieved from ET2 Contemporary Lighting using Internet <URL: <http://www.et2online.com/proddetail.aspx?ItemID=E22201-44>>.
- E20743-09 Stealth Collection, [online], [retrieved on Jul. 10, 2010] Retrieved from ET2 Contemporary Lighting using Internet <URL: <http://www.et2online.com/proddetail.aspx?ItemID=E20743-09>>.
- Spencer, Eugene. High Sales, Low Utilization. Green Intelligent Buildings, Feb. 1, 2007. [online]. Retrieved from Green Intelligent Buildings web page using Internet <URL: http://www.greenintelligentbuildings.com/CDA/IBT_Archive/BNP_GUID_9-5-2006_A_1000000000000056772>.
- Sensor Switch, nLight Lighting Control System, [online], [retrieved on Jan. 11, 2008] Retrieved from Sensor Switch web page using Internet <URL: <http://www.sensorswitch.com>>.
- Six Strategies, [online], [retrieved on Jan. 11, 2008] Retrieved from Encelium Technologies Inc. Web Page using Internet <URL: <http://www.encelium.com/products/strategies.html>>.
- Lawrence Berkeley National Laboratory. Lighting Control System—Phase Cut Carrier. University of California, [online] [retrieved on Jan. 14, 2008] Retrieved from Lawrence Berkeley National Laboratory web page using Internet <URL: <http://www.lbl.gov/tt/techs/lbnl1871.html>>.
- Best Practice Guide—Commercial Office Buildings—Central HVAC System. [online], [Retrieved on Jan. 17, 2008] Retrieved from Flex Your Power Organization web page using Internet <URL: <http://www.fypower.org/bpg/module.html?b=offices&m+Central+HVAC+Systems&s=Contr..>>.
- Cornell University. Light Canopy—Cornell University Solar Decathlon, [online], [retrieved on Jan. 17, 2008] Retrieved from Cornell University web page using Internet <URL: <http://cusd.cornell.edu/cusd/web/index.php/page/show/section/Design/page/controls>>.
- Written Opinion and International Search Report of the International Search Authority May 24, 2010 from the corresponding International Application No. PCT/US2009/060087 filed Oct. 9, 2009.
- Extended European Search Report for related case EP09822425, mailed Aug. 22, 2012, 9 pgs.



1

END CAP SUBSTITUTE FOR LED-BASED TUBE REPLACEMENT LIGHT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application Ser. No. 61/108,345, filed Oct. 24, 2008, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

The present invention relates in general to LED replacements for fluorescent lights.

BACKGROUND

LED-based lights shaped to replace conventional fluorescent tubes have appeared in recent years. Typically, such lights include a hollow tube with two end caps, one at each longitudinal end of the tube. The end caps generally include molded plastic cup-shaped bodies that slide over the ends of the tube to secure the end caps to the tube. End caps can seal ends of the tube to prevent contaminants from interfering with operation of the light. Additionally, each end cap can include one or more pins for compatibility with standard fluorescent fixtures. For example, many end caps carry two pins for compatibility with fixtures designed to receive standard-sized tubes, such as T5, T8, or T12 tubes.

SUMMARY

Embodiments of a replacement light for a fluorescent tube usable in a fluorescent fixture are disclosed herein. In one such embodiment, the light includes a housing having a first end and a second end opposite the first end. A support structure is disposed within the housing. At least one LED is positioned within the housing and is arranged on the support structure. A first seal has at least one aperture and is disposed within the first end of the housing. The first seal is configured to conform to an inner circumference of the first end of the housing. At least one electrical connector extends through the at least one aperture and is connectable to the fluorescent fixture.

In another such embodiment, the light includes a housing having a first end and a second end opposite the first end. A support structure is disposed within the housing. At least one LED is positioned within the housing and arranged on the support structure. Sealing means for replacing a conventional end cap are disposed within the first end of the housing.

Embodiments of a method of manufacturing a seal for a fluorescent tube replacement light containing at least one LED are also disclosed herein. In one such embodiment, the method includes providing a housing having a first end and a second end opposite the first end. A hardenable material is introduced to at least the first end of the housing. The hardenable material is hardened such that it conforms to an inner circumference of the first end.

These and other embodiments will be described in additional detail hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-section of an example of a light tube according to one embodiment of the present invention;

FIG. 2 is a perspective view of an example of the end cap replacing seal of FIG. 1;

2

FIG. 3 is a perspective view of material being poured into a housing to form an end cap replacing seal; and

FIG. 4 is an exploded side view of an end cap replacing seal being inserted into a housing.

5

DESCRIPTION

Examples of LED-based lights including end cap replacing seals for use instead of plastic cup-shaped end caps and other types of end caps are discussed below with reference to FIGS. 1-4. FIG. 1 illustrates a light 10 sized for placement in a fixture 12 designed to receive standard-sized tubes. The fixture 12 can be, for example, of the type for accepting a T5, T8, T12 or any other suitable tube. Alternatively, the fixture 12 can be of the type for accepting another light, such as a halogen light or an incandescent bulb.

The light 10, as shown in FIG. 1, includes a tubular housing 14, a circuit board 16, multiple LEDs 20, and two end cap replacing seals 22. The tubular housing 14 defines a through-bore 17. The housing 14 can be made from polycarbonate, acrylic, glass or another light transmitting material (i.e., the housing 14 can be transparent or translucent). For example, a translucent housing 14 can be made from a composite, such as polycarbonate with particles of a light refracting material interspersed in the polycarbonate. While the illustrated housing 14 is cylindrical, housing having a square, triangular, polygonal, or other cross sectional shape can alternatively be used. Similarly, while the illustrated housing 14 is linear, housing having an alternative shape, e.g., a U-shape or a circular shape can alternatively be used. Additionally, the housing 14 need not be a single piece as shown in FIG. 1. Instead, another example of a housing can be formed by attaching multiple individual parts, not all of which need be light transmitting. For example, a housing formed by attaching multiple individual parts can include an opaque lower portion and a lens or other transparent cover attached to the lower portion to cover the LEDs 20. The housing 14 as shown in FIG. 1 can be manufactured to include light diffusing or refracting properties, such as by surface roughening or applying a diffusing film to the housing 14. For compatibility with the fixture 12 as discussed above, the housing 14 can have a length such that the light 10 is approximately 48" long, and the housing 14 can have a 0.625", 1.0", or 1.5" diameter. Of course, housing 14 can have other suitable dimensions. Additionally, the housing 14 can define a groove 15 for slidably receiving the circuit board 16.

The circuit board 16, as illustrated in FIG. 1, is an elongate printed circuit board. Multiple circuit board sections can be, for example, joined by bridge connectors to create the circuit board 16. The circuit board 16 is slidably engaged with the groove 15 of the housing 14, though the circuit board 16 can alternatively be clipped, adhered, snap- or friction-fit, screwed or otherwise connected to the housing 14. For example, the circuit board 16 can be mounted on a heat sink that is attached to the housing 14. As another example, the circuit board 16 can be secured by the seals 22 as is discussed below in greater detail. Also, other types of circuit boards may be used, such as a metal core circuit board. Or, instead of a circuit board 16, other types of electrical connections (e.g., wires) can be used to electrically connect the LEDs 20 to a power source. Additional electrical components, such as a rectifier and filter, can also be mounted on the circuit board 16.

The LEDs 20 can be surface-mount devices of a type available from Nichia, though other types of LEDs can alternatively be used. For example, although surface-mounted LEDs 20 are shown, one or more organic LEDs can be used in

65

place of or in addition thereto. The LEDs 20 can be mounted to the circuit board 16 by solder, a snap-fit connection, or other means. The LEDs 20 can produce white light. However, LEDs that produce blue light, ultra-violet light or other wavelengths of light can be used in place of white light emitting LEDs 20.

The number of LEDs 20 can be a function of the desired power of the light 10 and the power of the LEDs 20. For a 48" light, such as the light 10, the number of LEDs 20 can vary from about five to four hundred such that the light 10 outputs approximately 500 to 3,000 lumens. However, a different number of LEDs 20 can alternatively be used, and the light 10 can output a different amount of lumens. The LEDs 20 can be evenly spaced along the circuit board 16, and the spacing of the LEDs 20 can be determined based on, for example, the light distribution of each LED 20 and the number of LEDs 20.

As shown in FIG. 1, the seals 22 can be positioned in opposing ends of the housing 14 (i.e., in opposing ends of the through-bore 17 defined by the housing 14). The seals 22 can be made from a variety of materials, such as an epoxy or other resin-based substance, rubber, cork, gel, concrete, glass, clay, wax, a polymer, silicone, or another material. The seals 22 can prevent the unintended entry of objects to the interior of the housing 14. The seals 22 can also perform additional functions as described below.

Each seal 22 can have a perimeter 22a shaped to conform to an inner circumference of the housing 14. As such, each seal 22 can have a perimeter 22a substantially identical to an inner circumference of the housing 14 such that the seal 22 can plug an end of the housing 14. For example, each seal 22 can be generally disc-shaped if the housing 14 is cylindrical. Alternatively, the seals 22 can be shaped to contact only portions of the inner circumference of the housing 14 when fit into ends of the housing 14. Thus, while the seals 22 can serve to prevent the unintended entry of an object to the interior of the housing 14, the seals 22 need not necessarily be air-tight or water-tight.

The thickness of the seals 22 (i.e., the distance that each seal 22 extends longitudinally from an end of the housing 14 toward a center of the housing 14) can be based on multiple factors. A large thickness can allow the seals 22 to strengthen the housing 14, can be more securely engaged with the housing 14, and/or can enhance the ability of the seals 22 to prevent unintended entry of an object to the interior of the housing 14. However, a seal 22 with a large thickness can require more material to produce, can be more difficult to install in the housing 14, and can limit the length of the housing 14 through which light can be produced. These factors, among others, can be considered to determine a proper seal shape. Additionally, the seals 22 can protrude from ends of the housing 14 (i.e., the seals 22 need not be fully contained within the housing 14 or flush with ends of the housing 14).

Each seal 22 can also define two apertures 24a and 24b to allow pins 26a and 26b to communicate between the socket 12 and circuit board 16. The apertures 24a and 24b can be circular, with diameters as large as or larger than diameters of the pins 26a and 26b. However, apertures 24a and 24b can have alternative shapes, such as shapes that allow the pins 26a and 26b to pass through the seal 22. The apertures 24a and 24b can also physically support the pins 26a and 26b. For example, each seal 22 can hold the pins 26a and 26b in position via a friction fit between the apertures 24a and 24b and the pins 26a and 26b, respectively. If the seals 22 are made from a material that is not electrically insulating, a rubber O-ring or other insulator can be included between the seal 22 and the pins 26a and 26b.

The pins 26a and 26b can physically and electrically connect the light 10 to the fixture 12. The pins 26a and 26b can be the sole physical connection between the light 10 and the fixture 12, though ends of the housing 14 and/or portions of the seals 22 can also contact the fixture 12. The pins 26a and 26b can be directly electrically connected to the circuit board 16 as shown in FIG. 1 to provide power to the LEDs 20 from the fixture 12, or the pins 26a and 26b can be coupled to another structure that in turn is electrically connected to the circuit board 16. Of the four total pins 26a and 26b, two of the total four pins 26a and 26b can be "dummy pins" that do not provide an electrical connection. Alternatively, instead of pairs of pins 26a and 26b, other types of electrical connectors depending on the type of fixture 12 can extend through the seals 22 or otherwise past the seals 22 into the housing 14. For example, a single pin can be used instead of two pins 26a and 26b for compatibility with a single pin fixture. Alternatively, three of the four total pins 26a and 26b can be "dummy pins" that do not provide an electrical connection, thereby permitting only one of the pins to electrically connect with the fixture 12.

A variety of methods can be used to manufacture the seals 22. In a first example, the seals 22 are formed from a liquefied or viscous material that is introduced to the housing 14, and then hardened in the position shown in FIG. 1. The liquefied or viscous material can be an epoxy prior to setting or mixing with a hardener, concrete prior to hardening, a polymer heated to above its melting point, melted wax, or another liquefied or viscous material. Several different processes can be used to form the seals 22 from the liquefied or viscous material depending on the characteristics of the material. For example, as shown in FIG. 3, the circuit board 16 can be engaged with the housing 14, and one end of the housing 14 can be sealed with a non-stick mat 28 or other structure while liquefied material 23 is poured into the top of the bore 17 of the housing 14. The seal 22 can be formed when the material 23 dries or cures, and the apertures 24a and 24b can be drilled in the seal 22 for the insertion of pins 26a and 26b. However, prior to inserting the pins 26a and 26b into the apertures 24a and 24b, the housing 14 can be rotated 180° and the seal 22 forming process can be repeated at the other end by pouring liquefied material 23 through one of the apertures 24a or 24b. Finally, the pins 26a and 26b can be inserted into the apertures 24a and 24b in each seal 22 and electrically connected to the circuit board 16. Alternatively, the circuit board 16 can be supported without being attached to the housing 14 during the seal 22 forming process, in which case the seals 22, once hardened or cured, can each define a groove 22b as shown in FIG. 2 for receiving and/or securing the circuit board 16.

As another example of manufacturing the seals 22, the housing 14 can be inserted into a pool of liquefied or viscous material, and the material can be allowed to harden to form the seal 22. The insertion can occur with the pins 26a and 26b already coupled to the housing 14 such that the seals 22 are formed to include apertures 24a and 24b without drilling, in which case sleeves can be installed over the portions of the pins 26a and 26b that engage the fixture 12 during insertion of the housing 14 into the pool of material in order to avoid getting material on the pins 26a and 26b.

If the material is too viscous to be poured into the housing 14, the material can be packed into an end of the housing 14. For example, pliable clay can be packed in an end of the housing 14 and then be allowed to dry, or silicone sealant can be applied in the end of the housing 14.

In yet another example, seals 28 as shown in FIG. 4 can be shaped prior to insertion into the housing 14. For example, each seal 28 can be made from an elastic material such as

5

rubber or cork, and each seal **28** can be shaped to have a perimeter **28a** transitioning from slightly smaller than an inner circumference of the housing **14** to slightly larger than the inner circumference of the housing **14**, allowing the seal **28** to be press fit into the housing **14** as shown in FIG. 4. If made from a less elastic material, each seal **28** can be shaped to have a perimeter slightly smaller than an inner circumference of the housing and a rubber O-ring or similar elastic strip can circumscribe the seal **28**. By using O-rings, the seals **28** can be inserted into the housing **14** without substantially deforming the seals **28**. Also, each seal **28** can define a groove **28b** for receiving and/or securing the circuit board **16** similar to the groove **22b** in the seal **22**.

Also, regardless of the elasticity of the seals **28**, installation of the seals **28** can include inserting the pins **26a** and **26b** through the apertures **24a** and **24b** in the seals **28** prior to the pins **26a** and **26b** being physically attached to the circuit board **16**. For example, the pins **26a** and **26b** can be coupled by flexible wires to the circuit board **16**, then inserted into the apertures **24a** and **24b** of the seals **28**, and then the seals **28** can be press-fit into the housing **14**. As another example, the pins **26a** and **26b** can be coupled to the circuit board **16** with the circuit board **16** disconnected from the housing **14**. The pins **26a** and **26b** can then be inserted into the apertures **24a** and **24b**. Then, the circuit board **16** can be slid into the housing **14** until the seal **28** is press-fit into the housing **14**, in which case the circuit board **16** is supported by the seals **28** instead of directly by the housing **14**.

Additionally, structures other than seals **22** or seals **28** can be used instead of plastic end caps. For example, tape can be applied over ends of the housing **14**, or the housing **14** can be formed of a solid rod that is drilled to accommodate pins **26a** and **26b** without end caps.

The above-described embodiments have been described in order to allow easy understanding of the invention and do not limit the invention. On the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structure as is permitted under the law.

What is claimed is:

1. A replacement light for a fluorescent tube usable in a fluorescent fixture, comprising:

a housing having a first end and a second end opposite the first end;

a support structure disposed within the housing;

at least one LED positioned within the housing and arranged on the support structure;

at least one electrical connector connected to the at least one LED; and

a first seal having at least one aperture shaped to receive the at least one electrical connector and disposed within the first end of the housing, the first seal configured to conform to an inner circumference of the first end of the housing and an outer surface of the at least one electrical connector

wherein the at least one electrical connector extends through the at least one aperture and is connectable to the fluorescent fixture.

2. The light of claim 1 wherein the at least one electrical connector is a first connector, further comprising:

a second seal having at least one aperture shaped to receive a second electrical connector and disposed within the second end of the housing, the second seal configured to

6

conform to an inner circumference of the second end of the housing and an outer surface of the second electrical connector.

3. The light of claim 1, wherein the first seal is made of at least one of epoxy, rubber, cork, gel, concrete, glass, clay, wax, a polymer and silicone.

4. The light of claim 1, wherein the first seal has a perimeter that is substantially equal to the inner circumference of the first end.

5. The light of claim 1, wherein the housing has a cylindrical cross-section and the first seal is generally disc-shaped such that the first seal is configured to contact substantially the entire inner circumference of the first end.

6. The light of claim 1, wherein the first seal contacts only a portion of the inner circumference of the first end.

7. The light of claim 1, wherein the first seal has a proximal end and a distal end opposite the proximal end, the proximal end one of flush with the first end and outwardly protruding from the first end.

8. The light of claim 7, wherein the distal end has a groove configured to engage one end of the support structure.

9. The light of claim 1, wherein the at least one aperture is shaped to secure the at least one electrical connector by a friction fit.

10. The light of claim 1, further comprising: a rubber O-ring disposed around and configured to insulate the at least one electrical connector.

11. A method of manufacturing a seal for a fluorescent tube replacement light for a fluorescent fixture containing at least one LED, comprising:

providing at least one electrical connector;

providing a housing having a first end and a second end opposite the first end;

introducing a hardenable material to at least the first end of the housing;

and hardening the hardenable material such that it conforms to an inner circumference of the first end and an outer surface of the at least one electrical connector to form at least one aperture; and

extending the at least one electrical connector through that at least one aperture.

12. The method of claim 11, wherein the hardenable material is one of an epoxy without a hardener, liquid concrete, a polymer heated to above its melting point and melted wax.

13. The method of claim 11, wherein introducing a hardenable material to the first end of the housing further comprises:

sealing the first end of the housing to a non-stick surface; and

pouring the hardenable material into the second end of the housing.

14. The method of claim 13, further comprising:

forming at least one aperture into the hardened material of the first end of the housing;

sealing the second end of the housing to the non-stick surface; and

pouring the hardenable material into the at least one aperture; and

hardening the hardenable material so that it conforms to an inner circumference of the second end.

15. The method of claim 14, further comprising: inserting the at least one electrical connector through the at least one aperture.

16. The method of claim 11, wherein introducing a hardenable material further comprises:

inserting the first end of the housing into a pool of the hardenable material.

7

17. The method of claim 16, wherein the housing includes a support structure disposed therein and the at least one electrical connector electrically engaged with the support structure, further comprising:

installing a sleeve over the at least one electrical connector. 5

18. The method of claim 11, wherein introducing a hardenable material further comprises:

packing the hardenable material into the first end of the housing.

19. A replacement light for a fluorescent tube usable in a fluorescent fixture, comprising: 10

a housing having a first end and a second end opposite the first end;

a support structure disposed within the housing;

at least one LED positioned within the housing and arranged on the support structure; and 15

sealing means for replacing a conventional end cap disposed within the first end of the housing wherein the sealing means includes at least one aperture shaped to receive at least one electrical connector. 20

20. The light of claim 19, further comprising:

at least one electrical connector extending through the sealing means and connectable to the fluorescent fixture.

21. A method of replacing a conventional end-cap for a fluorescent tube replacement light containing at least one LED, comprising; 25

8

providing a housing having a first end and a second end opposite the first end;

providing a first seal;

inserting the first seal into one of the first end and the second end of the housing; and

conforming the first seal at the first end in such a manner to include an aperture shaped for receiving at least one electrical connector.

22. The method of claim 21 wherein the first seal is configured to conform to an inner circumference of the first end of the housing. 10

23. The method of claim 21, further comprising:

forming at least one aperture into the first seal of the housing; and

inserting an electrical connector into the at least one aperture. 15

24. The method of claim 23, further comprising:

shaping the first seal prior to insertion into the housing.

25. The method of claim 24, wherein the first seal has a proximal end and a distal end opposite the proximal end, and wherein the first seal is shaped have a perimeter transitioning from slightly smaller at the proximal end than an inner circumference of the housing to slightly larger at the distal end than the inner circumference of the housing. 20

26. The method of claim 21, wherein the first seal is press-fit into the housing. 25

* * * * *