

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CURRENT LIGHTING SOLUTIONS, LLC D/B/A GE CURRENT

Petitioner

v.

JIAXING SUPER LIGHTING ELECTRIC APPLIANCE CO., LTD.

Patent Owner

INTER PARTES Review No. IPR2023-00269
Patent 10,560,989

DECLARATION OF DONALD E. ACKLEY, Ph.D

PETITIONER'S EXHIBIT LIST

Exhibit	Shorthand	Description
1001	'989 Patent	U.S. Patent No. 10,560,989
1002	'989 File History	Prosecution History of U.S. Patent No. 10,560,989
1003	Ackley	Declaration of Donald E. Ackley, Ph.D.
1004	Ackley CV	CV of Donald E. Ackley, Ph.D.
1005	Li	Chinese Patent Publication 103899939A to Li Certified Translation
1006	Ono	Japanese Patent Publication JP 2014-103000A to Ono et al. Certified Translation
1007	Guang	U.S. Patent No. 9,338,853 to Guang
1008	Miyamichi	U.S. Patent No. 8,779,679 to Miyamichi
1009	Xu	Chinese Patent Publication 2802892Y to Xu Certified Translation
1010	Liu	<i>LED Packaging for Lighting Applications – Design, Manufacturing and Testing</i> , Sheng Liu et al., Chemical Industry Press (2011)
1011	Garbowicz	U.S. Patent No. 5,616,990 to Garbowicz et al.
1012	Deng	Chinese Patent No. CN203797412U to Deng Certified Translation
1013	Draft Stipulation	Draft Stipulation of Invalidity Contentions, <i>Jiaxing Super Lighting Electric Appliance Co., Ltd. et al. v. Current Lighting Solutions, LLC d/b/a GE Current</i> , Civil Action No. 6:22-cv- 00534-ADA (W.D. Tex. 2022)
1014	Zhang	U.S. Patent No. 10,104,723 to Zhang
1015	Halliwell	U.S. Patent No. 9,206,970 to Halliwell et al.
1016		Omitted
1017	Litigation Scheduling Order	Scheduling Order, <i>Jiaxing Super Lighting Electric Appliance Co., Ltd. et al. v. Current</i>

Exhibit	Shorthand	Description
		<i>Lighting Solutions, LLC d/b/a GE Current,</i> Civil Action No. 6:22-cv-00534-ADA (W.D. Tex. 2022)

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I. INTRODUCTION

1. My name is Donald E. Ackley, Ph.D. I have been retained by Current Lighting Solutions, LLC d/b/a GE Current (“Current Lighting”) as an independent expert in the relevant art.

II. PROFESSIONAL BACKGROUND

2. I have a Ph.D. from Brown University in Electrical Sciences. I wrote my dissertation on my research into picosecond relaxations in amorphous semiconductors. I received my Bachelors of Science in Electrical Engineering and my Masters of Science in Electrical Sciences, both also from Brown University.

3. I have extensive experience in the design and development of LEDs, LED lamps, and LED displays. For example, I managed programs for development of LEDs at Epitaxx Inc. before the company was sold to Nippon Sheet Glass. Additionally, while I was at Siemens Corporate Research, I developed tunable LED devices. Additionally, when I worked for Lytel Inc., I managed and built an engineering team and research facilities with the goal of developing novel optoelectronic materials and components including LEDs.

4. From 1990 to 1996, I worked at Motorola Photonics Technology Center, first as a manager and then as a Chief Scientist. During this time, I worked on programs related to LED chips and OLEDs.

5. Next, from 1996 to 1999, I worked as an Executive Director of Microelectronics at Nanogen, Inc. I was responsible for directing a team of engineers, biologists, and chemists to further develop the company's DNA chip and microfluidics technology.

6. I was the Vice President of Engineering at Redeon, Inc., from 1999 to 2001 and was responsible for the engineering development of MEMS microneedle technology for transdermal drug delivery and continuous glucose monitoring. Part of this technology involved application of printed circuit board technology to create microneedle arrays.

7. I next served as President and CEO of VSK Photonics Inc. from 2001 to 2004. The company produced 10 and 40 Gb/s optical components. During my time at the company, I led the transition to LED-based TOSA modules.

8. After my time at VSK Photonics, from 2001 to 2004, I served as founder, CEO, CTO, and/or a Board Member of three different companies—Nanotrope Inc., Newton Sensors Inc., and Jaco Electronics. Since then I have been a consultant providing technical support for various technologies including superluminescent LEDs as amplifiers for LIDAR and remote sensing, single frequency optical devices, organic TFT and photodetector arrays, and biosensors.

9. I have also held academic appointments, including as an adjunct professor at the University of Illinois Department of Electrical Engineering. During

this appointment, I researched high-power InGaAs diode lasers. I also worked as a visiting scientist at Rutgers University in the Department of Materials Science and Engineering. During this time, I researched sol gel waveguide chemical sensors.

10. I am an inventor on over 75 issued and pending U.S. Patents. In particular, U.S. Patent Nos. 5,324,964; 5,563,900; 5,710,441; and 8,970,948 related to my work in LED technology.

11. I have also written over fifty articles for scientific journals and authored chapters for two books.

12. My CV, which I understand is being submitted with this declaration, includes a listing of patents applications on which I am an inventor.

13. Because of my background, training, and experience, I am qualified as an expert to explain the background of the technology encompassed by the '989 Patent as well as to opine on the validity of the claims of the '989 Patent in view of the prior art references discussed herein.

III. COMPENSATION

14. My work on this matter is being billed at my customary rate of 450.00 per hour. Also, I am being reimbursed for reasonable expenses I incur in relation to my services. I will be paid regardless of the outcome of any proceeding that my work is used in.

IV. OVERVIEW OF TASK & BASIS FOR OPINIONS

15. I have been asked to review the '989 Patent. I have been asked to provide opinions related to certain issues from the perspective of a person of ordinary skill, having knowledge of the relevant art, as of September 28, 2014, and—except where otherwise noted—the opinions stated in this declaration are from that perspective. The qualifications and abilities of such a person are described in Section V below.

16. More particularly, I have been informed that this proceeding is currently at a preliminary stage during which the Patent Trial and Appeal Board will decide whether the Petition establishes a reasonable likelihood of at least one claim of the '989 Patent being invalid.

17. My opinions are based on my education, training, and experience as well as items that I reviewed to prepare my opinions, including the documents listed in the Exhibit List included with the Petition and any other items I reference in my below analysis.

18. I understand that other issues may arise that require further explanation, and I will provide that explanation if appropriate. As a result, I respectfully reserve the right to update and supplement this declaration and the information and opinions provided herein.

V. LEVEL OF SKILL IN THE RELEVANT ART

19. I understand that the level of ordinary skill may be reflected by the prior art of record, and that a person of ordinary skill in the art (“POSITA”) to which the claimed subject matter pertains would have the capability of understanding the scientific and engineering principles applicable to the pertinent art.

20. I understand there are multiple factors relevant to determining the level of ordinary skill in the pertinent art, including (1) the levels of education and experience of persons working in the field at the time of the invention; (2) the sophistication of the technology; (3) the types of problems encountered in the field; (4) the prior art solutions to those problems; and (5) the rapidity with which innovations are made.

21. A POSITA as of September 28, 2014—the ’989 Patent’s earliest claimed priority date—would have had at least a bachelor’s degree in electrical engineering, or an equivalent field, and at least two to four years of experience (either in academia or industry) in design, development and/or testing of lighting designs, including knowledge of LEDs and related technology for driving LEDs, or the equivalent, with additional education substituting for experience and vice versa. Such a POSITA would have been familiar with the concepts and types of LED lighting technology described below.

VI. OVERVIEW OF THE TECHNICAL FIELD & PRIOR ART

22. The '989 Patent describes “[a]n LED tube lamp includes a tube having two ends, two end caps respectively at the ends of the tube, a power supply in one or both of the end caps, an LED light strip in the tube; and a plurality of LED light sources on the LED light strip.” EX1001, Abstract; *see also id.*, 1:57-60. As acknowledged by the '989 Patent, “LED lighting technology is rapidly developing to replace traditional incandescent and fluorescent lightings.” *Id.*, 1:64-65. It was well-known that LED lamps were often not compatible with traditional power systems used for fluorescent lamps. *Id.*, 2:55-65 (“[T]he driving of an LED uses a DC driving signal. The driving signal for a fluorescent lamp is a low-frequency and low-voltage AC signal as provided by an AC powerline, a high-frequency and high-voltage AC signal provided by a ballast, or even a DC signal provided by a battery for emergency lighting applications. Since the voltages and frequency spectrums of these types of signals differ significantly, simply performing a rectification to produce the required DC driving signal in an LED tube lamp is not competent at achieving the LED tube lamp's compatibility with traditional driving systems of a fluorescent lamp.”). The '989 Patent purports to provide a novel LED lamp that provided more compatibility with such power systems. *Id.*, 3:41-42.

A. Fluorescent lamps

23. Fluorescent lamps were in common use at the time of the '989 Patent. EX1001, 2:1-6. "A fluorescent lamp consists of a glass tube filled with an inert gas (usually argon) at low pressure. On each side of the glass tube is an electrode. Electricity is passed through the gas, causing an arc of illumination." EX1007, 1:22-25. "Historically, fluorescent lamps use AC power, effectively meaning that the electrode that functions as the cathode switches back and forth." *Id.*, 2:1-3.

24. "As electrical current forms an arc through the lamp, it ionizes a higher percentage of the tube's contained gas molecules. The more molecules that are ionized, the lower the resistance of the gas. If too many gas molecules are ionized, the resistance will drop to the point that an electrical short would occur." *Id.*, 2:13-18. "Therefore, the ballast [included in the fluorescent lamp] also contains electronic components that control the current, preventing the current through the lamp from rising to the point that the lamp would burn out." *Id.*, 2:18-21. "An electrical ballast is a device that intended to limit the amount of current in an electric circuit." *Id.*, 1:45-47. "The ballast is typically physically located in a box mounted near its lamp or lamps." *Id.*, 1:63-65. The electrical ballast "contains electronic components that control the current, preventing the current through the lamp from rising to the point that the lamp would burn out. Electronic ballasts use semiconductors to limit power to a fluorescent lamp." *Id.*, 2:18-22.

25. Some fluorescent lamps used magnetic ballasts instead of electronic ballast. EX1008, 1:24-29. A magnetic ballast can be as simple as series inductor as shown in EX1008, Fig. 15a, or can further comprise a glow starter as depicted in EX1008, Fig. 15a and described in 1:51-55. Alternatively, magnetic ballasts can be a rapid-start type. EX1008, FIG. 15b, 1:56-59. A rapid-start magnetic ballast includes a transformer and additional resistors and capacitors such that the LED lamp lights simultaneously with the filament pre-heat functionality.

B. Pre-heat process

26. “Fluorescent lamps often require that their filaments (electrodes) be preheated prior to lamp ignition.” EX1011, 1:12-13. “In lamps that require preheating, it is difficult to start a lamp when the filaments have not been sufficiently preheated.” *Id.*, 1:38-40. “Preheating is often controlled by an automatic switch commonly referred to as a starter.” *Id.*, 1:13-15. During preheating, “[c]urrent [] flows through the [starter’s] electrodes and lamp filaments heating the latter.” *Id.*, 1:25-26. “Once the filaments have been preheated, one or more large voltage pulses, generated by an ignitor, are applied to the fluorescent lamp filaments.” *Id.*, 1:15-17.

27. “[A] rapid start ballast is used for fluorescent lamps having a filament (two electrode pin lamp) that is used for pre-heating before the lamp is started. A rapid start ballast applies voltage and heats the two electrode pins (the cathodes) simultaneously.” EX1007, 2:41-45. “A programmed-start ballast is a more

advanced version of the rapid start ballast. ... [P]rogrammed-start [] provides precise heating of lamp filaments and controls the pre-heat time before the startup voltage is applied, thereby reducing filament stress. The programmed-start ballast applies power to the filaments first, which allows the cathodes to preheat and then applies voltage to the lamps to strike an arc.” *Id.*, 2:51-58. In contrast, “[a]n instant start ballast does not preheat the electrodes, instead using a relatively high voltage (~600 V) to initiate the discharge arc.” *Id.*, 2:30-32.

C. The Rise of LED Lamps and Issues with replacing fluorescent lamps with LED lamps

28. “[T]here has been over the past decade an enormous commercial move toward replacing both incandescent and fluorescent light fixtures with light-emitting diode (LED) lighting.” EX1007, 4:13-16. “LEDs have advantages over those prior light sources: lower energy consumption, longer life, improved robustness, smaller size, and the ability to be switched on and off faster.” EX1007, 4:20-22.

29. “Most LED fixtures drawing from AC wall receptacle power must have a driver circuitry that includes a power converter with at least a current-limiting resistor.” EX1007, 5:12-15. Therefore, replacing a traditional fluorescent lamp with an LED lamp required a different driving circuit because “[a] small change in voltage causes a large change in current. If the supplied voltage exceeds the LED's forward voltage drop by a small amount, the current rating may be exceeded by a large

amount, potentially damaging or destroying the LED. A solution is to use constant-current power supplies to keep the current below the LED's maximum current rating.” EX1007, 5:7-12. Because “a fluorescent tube lamp requires a means to limit current flow to prevent a self-destroying positive feedback loop,” “ballasted fluorescent fixtures are ubiquitous in the lighting industry.” EX1007, 5:27-31. “Replacing either an instant-start, shunted socket fluorescent lamp or a rapid-start non-shunted socket fluorescent lamp with a replacement LED tube and driver has previously required the ballast to be electrically detached or physically removed from the system, and the standard AC power wires to be attached directly to the driver's circuitry.” EX1007, 5:16-22. “Detachment can be expensive, typically requiring the services of a licensed electrician. Removal can also be time-consuming, requiring access to the ballast itself, which is often behind lamp fixture or ceiling panels.” EX1007, 5:22-26. Solutions existed allowing consumers to “plug an LED tube lamp into any size compatible fluorescent fixture (with or without ballast or shunt) and have the internal circuitry utilize the supplied energy to power the LED array.” EX1007, 5:37-40. These solutions included “using direct line voltage to power a secondary LED power supply while bypassing ballasted input power or physically removing the ballast altogether,” “us[ing] back up battery power to supply the LED array,” and creating a “self-ballasted lamp.” EX1007, 5:40-45, 5:65-6:3.

30. It was known that operation of an LED lamp generates heat, which, if not dissipated, can reduce performance and damage components of an LED lighting device. EX1010, 167/367, 201/367, 203/367. It was also known the that the components of the driver circuits, especially the electrolytic capacitors, were an important, if not the most important, factor in determining the reliability of LED lighting systems, and that elevated temperatures reduced the reliability of those components. Thus it is of interest to manage the temperature of the driver components and circuit boards. In my opinion, a POSITA was well aware of the importance of managing heat in a LED lamp. Additionally, it was also known to include openings in the end caps, such as to reduce pressure or heat within the tube. *See, e.g.*, EX1012, [0037], FIGS. 1 and 3.

D. Li (EX1005)

31. Li is titled “LED Fluorescent Lamp and Installation Method Thereof.” Li was published on July 2, 2014. I understand that Li qualifies as prior art to the ’989 Patent.

32. Li describes “An LED fluorescent lamp according to an embodiment of the invention comprises: a [red] glass inner tube; a [green] glass outer tube sleeved outside the glass inner tube; [blue] end covers enclosing two ends of the glass inner tube and provided with plugs adaptable to fluorescent lamp holders; and an [orange] LED driver power supply, comprising a strip substrate fixed inside the glass inner

tube, a plurality of LED units arranged on the [purple] strip substrate, and a drive circuit module, which is arranged at one or two ends of the strip substrate and electrically connected to the LED units and the plugs.” EX1005, Abstract; *see also id.*, [0088-0090], [0092], [0095], [0100-0101]; [0108].

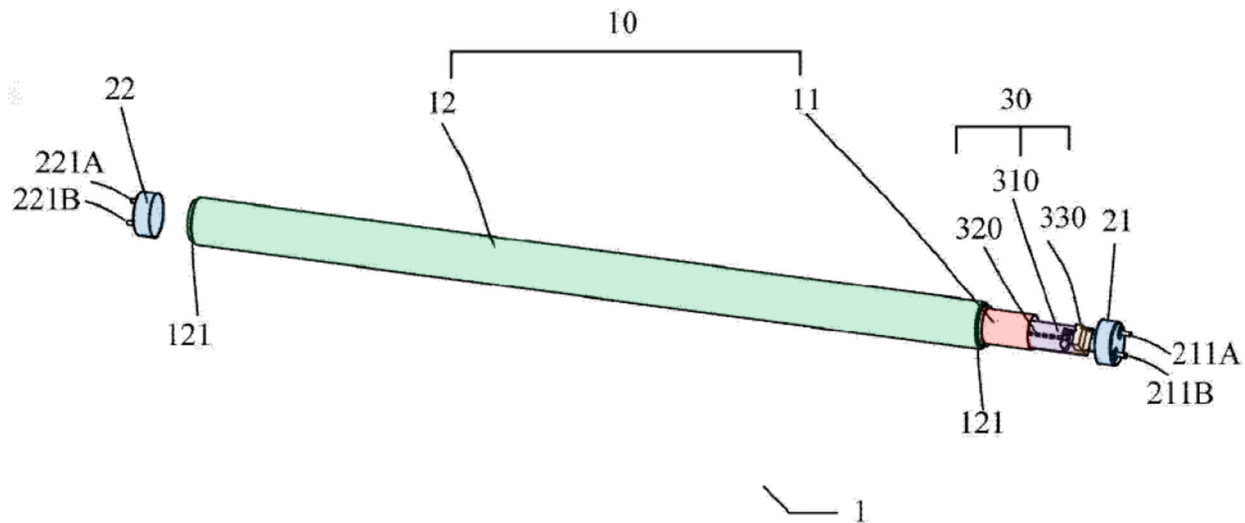


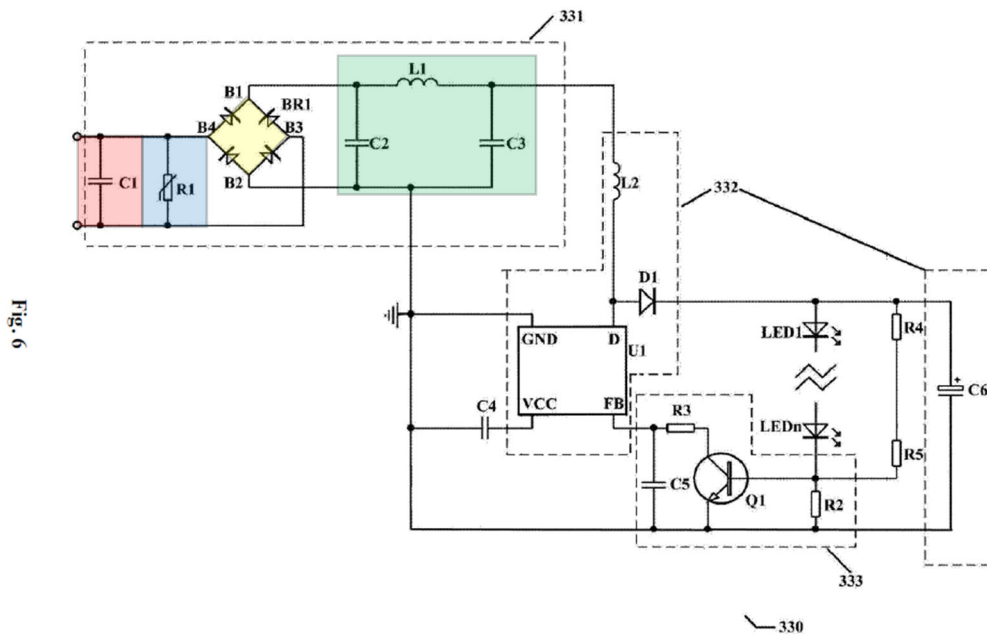
Fig. 1

Id., FIG. 1.¹

33. Li describes the drive circuit module as making the LED lamp compatible with conventional lighting fixtures. *Id.*, [0092], [0113]. “The drive circuit module 330 shown in Fig. 6 comprises a bridge rectifier filter unit 331, a DC-DC boost conversion unit 332 and a feedback unit 333.” *Id.*, [0112]. This includes “a [yellow] full-bridge rectifier BR1” and [green] “filter capacitors C2 & C3 and

¹ All colorized figures herein are annotated.

the inductor L1 form a π -shaped filter loop.” *Id.*, [0113], [0115]. “[T]he [red] filter capacitor C1 and the [blue] varistor R1 are connected in parallel between the AC input terminals B3 and B4 of the full-bridge rectifier BR1.” *Id.*, [0115]. Li describes both resistors and varistors and in Figure 6, R1 is illustrated as a variable resistor or “varistor.” A varistor is a term of art that refers to a voltage dependent resistor where the resistance of a varistor depends on the voltage applied. *See* EX1007, 10:26-30 (“A varistor is an electronic component with diode-like but nonlinear current-voltage characteristics. At low voltage it has high resistance to current, and at high voltage it changes and becomes low resistance to current. The varistor is thus a voltage-dependent variable resistor.”)



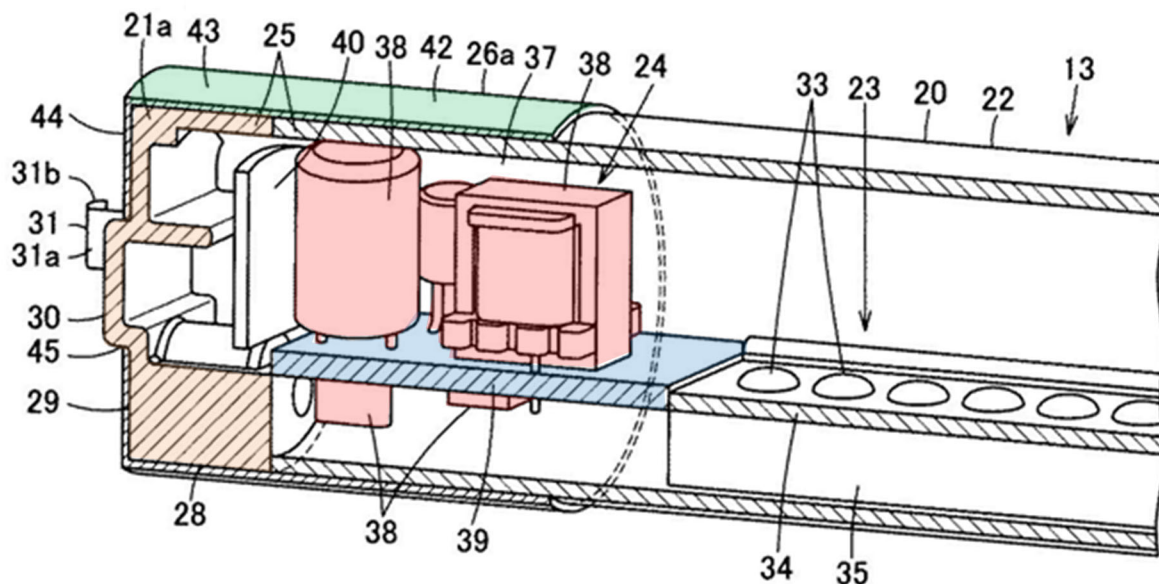
Id., FIG. 6.

E. Ono (EX1006)

34. Ono is titled “Straight Tube Lamp and Lighting Device.” Ono was published on June 5, 2014. I understand that Ono qualifies as prior art to the ’989 Patent.

35. “The straight tube lamp 13 includes a light source unit 23 having light emitting elements 33, a lighting circuit 24 for lighting the light emitting elements 33, and a lamp unit 22 housing the light source unit 23 and the lighting circuit 24. The lamp unit 22 includes a straight tube 20 that is at least partially translucent, and a cap 21a disposed on one end of the tube 20. The lighting circuit 24 is covered with an [orange] insulator 25, and the lighting circuit 24 is covered with a [green] non-combustible cover 26a via the insulator 25.” EX1006, [Solution].

[Fig. 1]

*Id.*, FIG. 1.

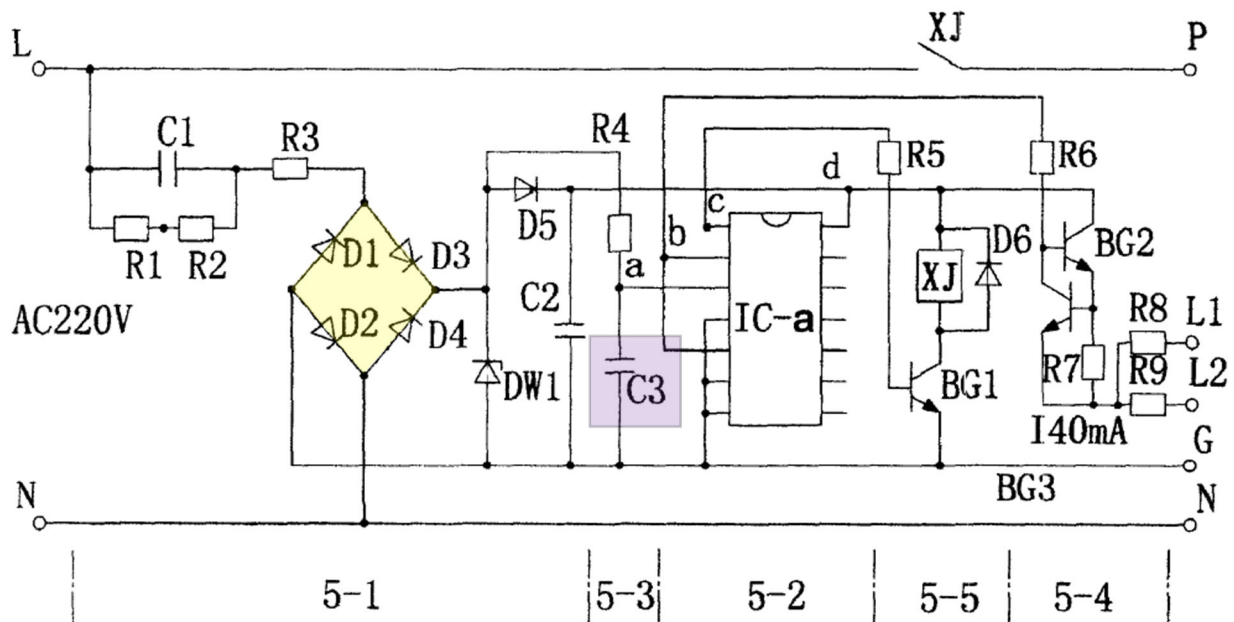
36. “The lighting circuit 24 receives commercial alternating current power from the cap 21a on one end, converts the alternating current power into direct current power for lighting the light emitting elements 33, and supplies the direct current power to the light emitting elements 33.” *Id.*, [0017]. “The lighting circuit 24 is housed inside the tube 20 on one end in a lighting circuit housing portion 37 between the light source unit 23 housed inside the tube 20 and the cap 21a attached to one end of the tube 20. The lighting circuit 24 has a [blue] circuit board 39 on which a plurality of [red] electronic components 38 have been mounted. Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39, and surface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.” *Id.*

F. Xu (EX1009)

37. Xu is titled “Multiple Light Source Lighting Device.” Xu was published on August 2, 2006. I understand that Xu qualifies as prior art to the ’989 Patent.

38. Xu discloses, in Figure 5, a “switching controller 5 [for an LED lamp] connected to the power supply through the power cord 6.” EX1009, 5/36. “[Yellow] D1-D4 is a bridge rectifier circuit.” *Id.* After the D1-D4 bridge rectifier circuit is the [purple] capacitor C3 that works in combination with the resistor R4 to create “[t]he control triggering signal circuit 5-3.” *Id.*, 5-6/36. The control triggering signal

circuit is a delay circuit that works in conjunction with the controller integrated circuit IC-a. *Id.*; *see also id.*, FIG. 5 The delay circuit is a simple RC circuit that is used to introduce a delay interval between 0.5-2 seconds with the delay being chosen by adjusting the capacitance of the capacitor C3, or optionally, resistor R4. EX1009, 6/36. “The signal from the control triggering signal circuit 5-3 is output through two circuits (one positive and one negative) of the bistable controller 5-2 to control the LED light source assembly driver 5-4.” *Id.*, 6/36.

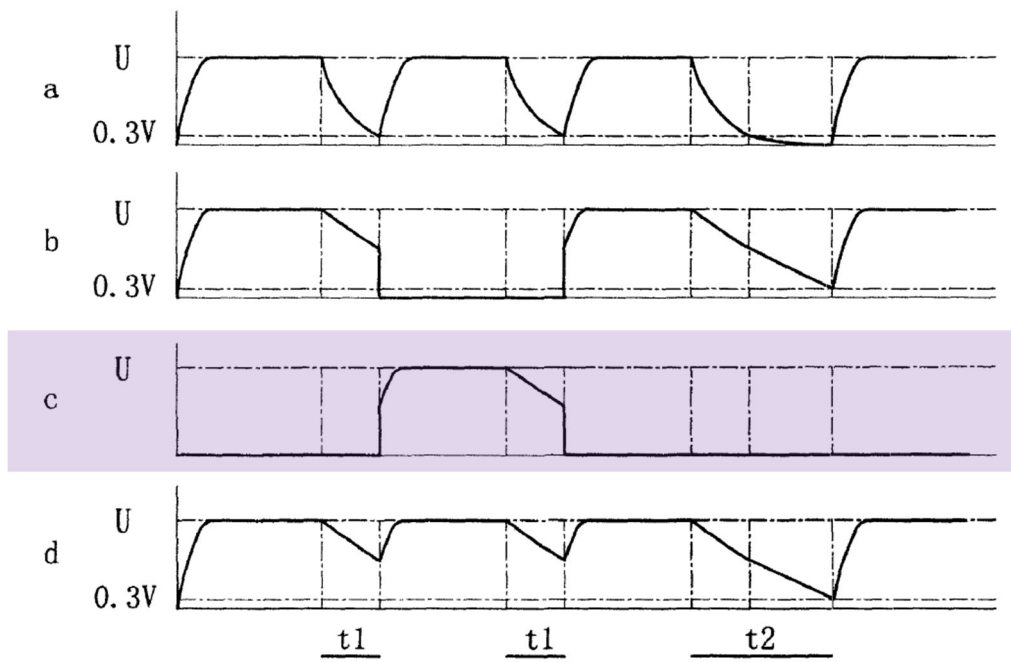


EX1009, 5/36, FIG. 5. Additionally, capacitor C2 serves as both a filter capacitor and as an additional delay element. EX1009, 5/36.

39. In Figure 6, Xu describes various timing adjustments that switching controller implements. The example in [purple] Fig. 6c is an example of a delay, where the LED lamp does not turn on until after the expiration of time period t1.

EX1009, 6/36, FIG. 6. “The time delay interval t_1 is between 0.5-2 seconds.

EX1009, 5/36.



EX1009, FIG. 6.

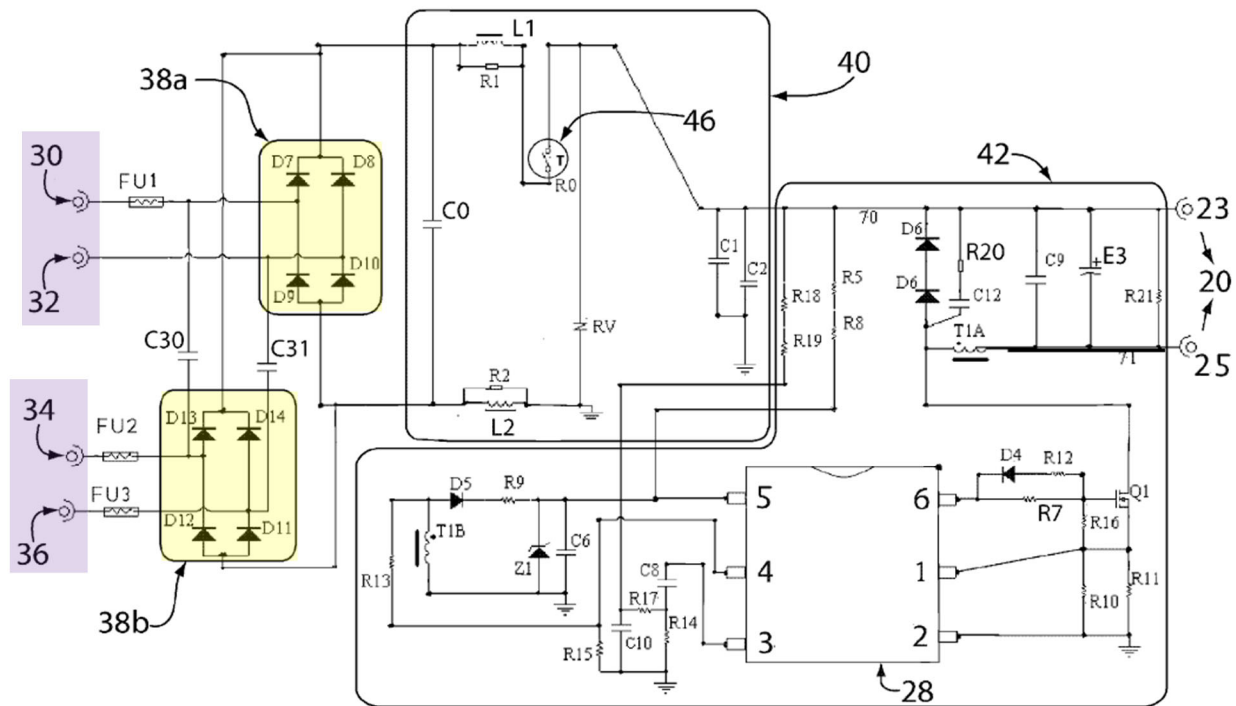
G. Guang (EX1007)

40. Guang is titled “LED Tube Driver Circuitry for Ballast and Non-Ballast Fluorescent Tube Replacement.” Guang was filed on September 17, 2014. I understand that Guang qualifies as prior art to the '989 Patent.

41. Guang discloses “[a]n LED lamp tube and driver circuit that is direct replacement for fluorescent tubes with or without ballasts, that works with standard AC high voltage current input, with high frequency pulse current input, or with lower voltage input.” EX1007, Abstract. “FIG. 2 is an electronic schematic of the power management circuitry of the Fluorescent Compatible LED Tube Lamp 10 of FIGS.

1 and 2, showing how power can be supplied through either or both pairs of [purple] electrode pins, 30, 32, or 34, 36. Incoming AC power is rectified by [yellow] parallel DC converter 38a and 38b, which then filtered by a filter circuit 40, and finally managed by a step-down constant current control circuit 40.” *Id.*, 8:67-63; *see also id.*, 9:2-8 (“[P]ower would be supplied from external fluorescent fixtures to the first pair of electrode pins 30 and 32, to the second pair of electrode pins 34 and 36, or to a combination of pins of both pairs. The power, whether arriving at the electrodes as AC or DC is passed through the respective first rectifier circuit 38a and/or second rectifier circuit 38b.”). “Each of the first and second rectifier circuits 38a and 38b has four diodes, which each pass electrical current in only one direction.” *Id.*, 9:28-30.

Fig. 2



EX1007, FIG. 2.

H. Zhang (EX1014)

42. Zhang is titled “Solid-State Lighting Apparatus With Filament Imitation for Use With Fluorescent Ballasts.” Zhang was filed on October 16, 2013. I understand that Zhang qualifies as prior art to the '989 Patent.

43. Zhang discloses that “[s]olid-state lighting devices may be attractive for retrofit/replacement applications, where devices such as LEDs may offer improved energy efficiency, reduced heat generation, extended life and desired performance characteristics, such as certain color and/or color rendering capabilities. For example, LED bulbs are commonly used to replace incandescent bulbs in down

lights and other applications to reduce energy consumption and increase time between replacements.” EX1014, 1:24-32. Zhang further describes that “LED-based replacements for fluorescent lamps have [] been developed.” EX1014, 1:33-34. Zhang discloses various filament-imitating circuits. One such circuit is shown in Figure 4 and includes “a capacitor C1 coupled to the first and second terminals 101a, 101b of the first ballast port 101 and to a LED lighting circuit 110,” as shown below. *Id.*, 4:59-62.

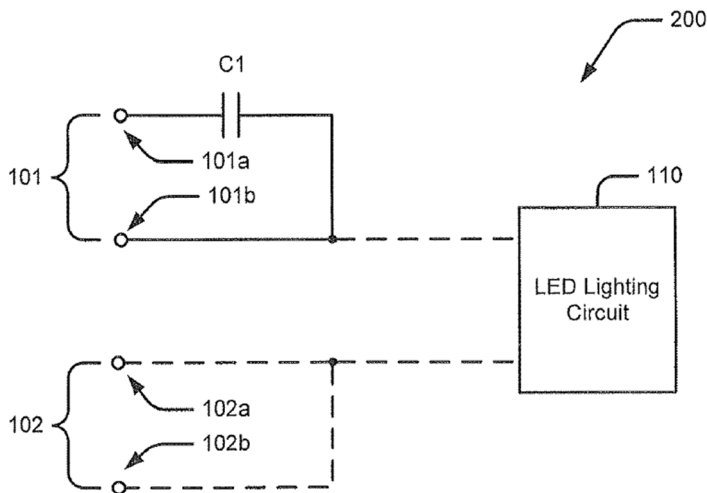


FIG. 2

Id., FIG. 2. The capacitor C1 presents an impedance in the circuit to imitate the filament impedance of a fluorescent lamp. *Id.*, 4:62-5:3.

I. Halliwell (EX1015)

44. Halliwell is titled “Linear LED Lamp Tube With Internal Driver and Interconnect to Line Voltage and Methods of Installing the Same.” Halliwell was

published on February 13, 2013. I understand that Halliwell qualifies as prior art to the '989 Patent.

45. Halliwell describes “a light emitting diode (LED) lamp tube is provided along with a method of installing the LED tube lamp into a lighting fixture.” EX1015, Abstract. The LED lamp tube includes “at least one end cap 11 [that] may comprise a small hole 111 on the end of the end cap 11.” EX1015, 8:61-63. “[T]he hole 111 acts to allow the pressure within the tube to maintain a pressure substantially similar to the ambient air pressure.” *Id.*, 8:66-9:1.

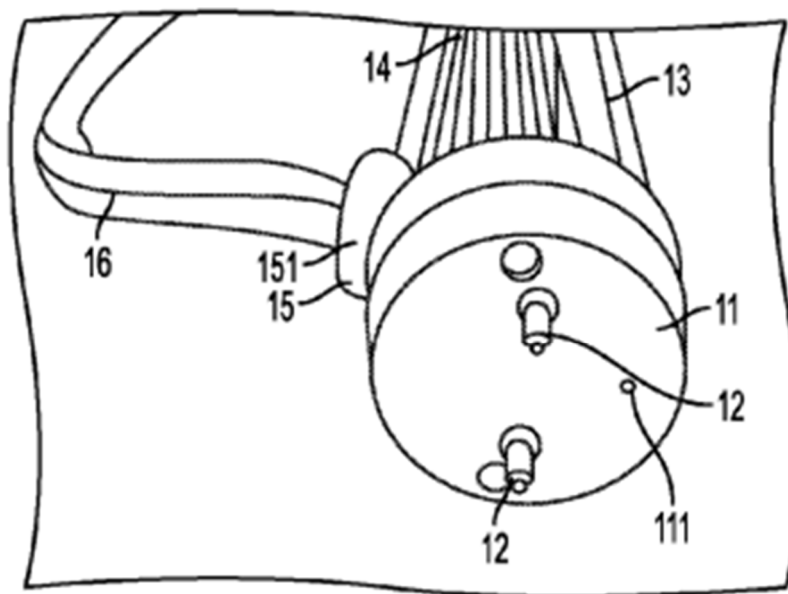


FIG. 18

EX1015, FIG. 18.

VII. THE '989 PATENT

46. The '989 Patent describes “[a]n LED tube lamp includes a [blue] tube having two ends, two [orange] end caps respectively at the ends of the tube, a [green] power supply in one or both of the end caps, an [red] LED light strip in the tube; and a [yellow] plurality of LED light sources on the LED light strip.” EX1001, Abstract; *see also id.*, 98:1-6, 98:9-15.

47. “The part of the end wall 320 which is connected to the hollow conductive pins 301 is made by an insulating material, and the other part of the end wall 320 is made by aluminum.” *Id.*, 105:29-32. “Each of the end caps 300 comprises a [purple] pair of hollow conductive pins 301 utilized for being connected to an outer electrical power source.” *Id.*, 98:43-45.

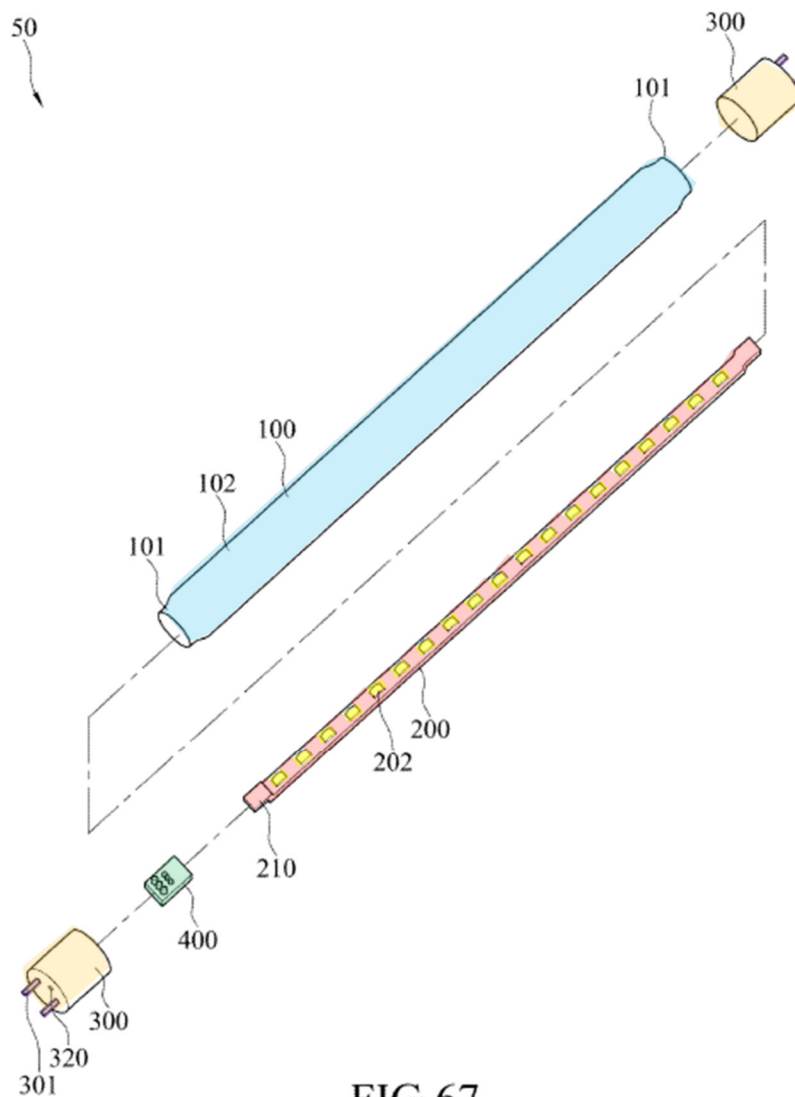


FIG. 67

Id., FIG. 67.

48. “The [blue] power supply 400 can be a module, e.g., an integrated power module. The power supply 400 may be in the form of a single integrated unit (e.g., with all components of the power supply 400 are within a body) disposed in an end cap 300 at one end of the tube 100.” *Id.*, 101:5-9.

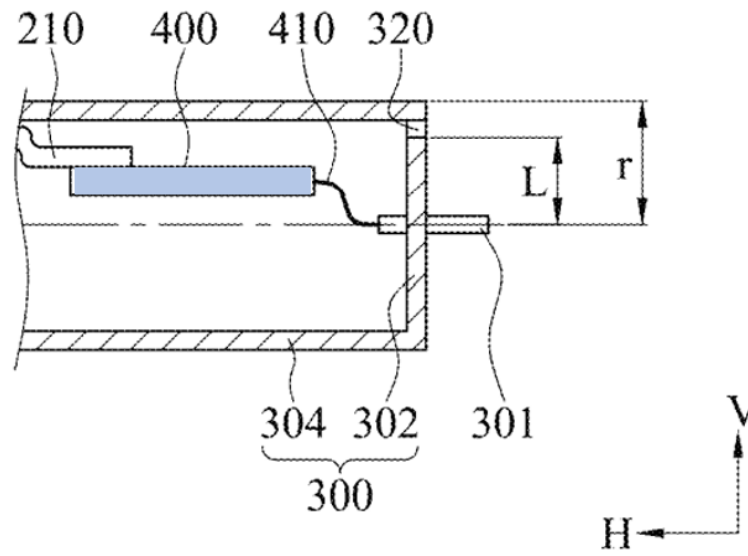


FIG. 69

Id., FIG. 69.

49. “The power supply 400 shown in FIG. 83 comprises a [blue] printed circuit board 420, one or more [red] electronic components 430, and a heat-dissipating element or driving module 440.” *Id.*, 106:53-56. The electronic components include components such as rectifying circuits, filtering circuits, resistors, capacitors, inductors, and integrated circuits. *Id.*, 4:13-15, 5:13-15.

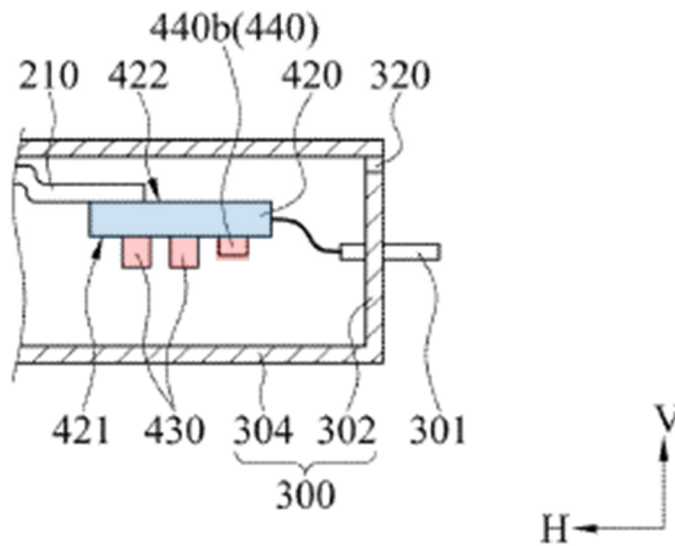


FIG. 83

Id., FIG. 83.

50. The '989 Patent describes prior art LED lamps and associated drawbacks. *Id.*, 1:64-3:19. Specifically, “existing LED tube lamps have certain drawbacks. For example, the electrical components and fuses in the LED tube lamps may not perform properly due to increasing temperature inside the LED tube lamps during the use of the LED tube lamps. Specifically, the fuses very likely incorrectly cause open circuit in responsive to high environment temperature inside the LED tube lamps instead of high electrical current flow. The electrical components operate in unexpected ways which are different from circuit design.” *Id.*, 2:17-25. Additionally, heat dissipation can also be a problem. *Id.*, 2:48-54. Further, “the driving of an LED uses a DC driving signal. The driving signal for a fluorescent

lamp is a low-frequency and low-voltage AC signal as provided by an AC powerline, a high-frequency and high-voltage AC signal provided by a ballast, or even a DC signal provided by a battery for emergency lighting applications. Since the voltages and frequency spectrums of these types of signals differ significantly, simply performing a rectification to produce the required DC driving signal in an LED tube lamp is not competent at achieving the LED tube lamp's compatibility with traditional driving systems of a fluorescent lamp.” *Id.*, 2:55-65. “[A]n LED is a nonlinear component with significantly different characteristics from a fluorescent lamp. Therefore, using an LED tube lamp with an electrical ballast impacts the resonant circuit design of the electrical ballast, causing a compatibility problem. Generally, a program-start ballast will detect the presence of a filament in a fluorescent lamp, but traditional LED driving circuits cannot support the detection and may cause a failure of the filament detection and thus failure of the starting of the LED tube lamp. Further, electrical ballast is in effect a current source, and when it acts as a power supply of a DC-to-DC converter circuit in an LED tube lamp, problems of overvoltage and overcurrent or undervoltage and undercurrent are likely to occur, resulting in damaging of electronic components in the LED tube lamp or unstable provision of lighting by the LED tube lamp.” *Id.*, 3:4-19.

51. To overcome the purported shortcomings, the '989 Patent proposes an LED tube lamp having a “ power supply circuit comprises a rectifying circuit, a

filtering circuit, an LED module and a ballast-compatible circuit.” *Id.*, 5:13-15.

“The rectifying circuit is configured to rectify the external driving signal to produce a rectified signal.” *Id.*, 5:15-17. “The filtering circuit is connected to the rectifying circuit and configured to produce a filtered signal.” *Id.*, 5:17-19. As I explained above in Section VI, it was well-known before the ’989 Patent to perform such rectifying and filtering.

A. Challenged Claims

52. I understand that Claims 1-2, 4-6, 12-13, 30-31, 37, 77, 84-86, 88, and 90 of the ’989 Patent are challenged claims. Claims 1 and 30 are independent. Claims 2, 4-6, 12-13, 88 depend from independent Claim 1 and Claims 31, 37, 77, 84-86, and 90 depend from independent Claim 30.

53. ’989 Claim 1 reads:

1[p] An LED tube lamp, comprising:

1[a] a tube having two ends;

1[b] an LED light strip attached to an inner circumferential surface of the tube;

1[c] a plurality of LED light sources mounted on the LED light strip;

1[d] a power supply module electrically connecting to the LED light strip and configured to drive the plurality of LED light sources; and

1[e] a first end cap and second end cap respectively attached at the two ends of the tube, each of the first and second end caps comprising a lateral wall and an end wall, the lateral wall substantially being coaxial with the tube and connecting to the tube, the end wall substantially being perpendicular to an axial direction of the lateral wall and connecting to an end of the lateral wall away from the tube,

1[f] wherein the power supply module comprises a printed circuit board and a plurality of electronic components mounted on the printed circuit board, the printed circuit board comprises a first surface and a second surface opposite to and substantially parallel to the first surface, and the first surface and the second surface of the printed circuit board are substantially parallel with the axial direction of the lateral wall;

1[g1] wherein at least some of the plurality of electronic components comprise a rectifying circuit having at least two input terminals and configured to rectify signal receiving from the at least two input terminals,

1[g2] at least one of the plurality of electronic components comprises a filtering circuit electrically connecting to the rectifying circuit,

1[h] wherein the plurality of electronic components comprise a resistor which is positioned closest to the end wall of the first end cap and connecting to one of the input terminals of the rectifying circuit;

1[i] wherein the end wall comprises a first portion made of an insulating material.

54. '989 Claim 2 reads:

2[a] The LED tube lamp according to claim 1, wherein each of the end caps comprises at least one conductive pin connected to the first portion, and

2[b] the resistor is electrically connected between the conductive pin and one of the input terminals of the rectifying circuit.

55. '989 Claim 4 reads:

4 The LED tube lamp according to claim 1, wherein each of the end caps comprises two conductive pins connected to the first portion, and the resistor is electrically connected between the two conductive pins.

56. '989 Claim 5 reads:

5 The LED tube lamp according to claim 1, wherein the end wall comprises at least one opening.

57. '989 Claim 6 reads:

6 The LED tube lamp according to claim 5, wherein the resistor is positioned closest to the opening.

58. '989 Claim 12 reads:

12 The LED tube lamp according to claim 1, wherein at least some of the electronic components form a first circuit electrically connected between the rectifying circuit and the filtering circuit and causes a delay before the LED tube lamp lights up.

59. '989 Claim 13 reads:

13 The LED tube lamp according to claim 12, wherein the electronic components forming the first circuit comprises a capacitor configured to be charged when an AC driving signal is provided to the LED tube lamp and cause the LED tube lamp to conduct when voltage of the capacitor exceeds a threshold trigger voltage.

60. '033 Claim 30 reads:

30[p] An LED tube lamp, comprising:

30[a] a tube having two ends;

30[b] an LED light strip attached to an inner circumferential surface of the tube;

30[c] a plurality of LED light sources mounted on the LED light strip;

30[d] a power supply module electrically connecting to the LED light strip and configured to drive the plurality of LED light sources; and

30[e] a first end cap and second end cap respectively attached at two ends of the tube, each of the first and second end caps comprising a lateral wall and an end wall, the lateral wall substantially being coaxial with the tube and connecting to the tube, the end wall substantially being perpendicular to an axial direction of the lateral wall and connecting to an end of the lateral wall away from the tube,

30[f] wherein the power supply module comprises a printed circuit board and a plurality of electronic components mounted on the printed circuit board, the printed circuit board comprises a first surface and a second surface opposite to and substantially parallel to the first surface, and the first surface and the second surface of the printed circuit board are substantially parallel with the axial direction of the lateral wall;

30[g1] wherein at least some of the electronic components comprise a rectifying circuit having at least two input terminals and configured to rectify signal receiving from the input terminals,

30[g2] at least one of the electronic components comprises a filtering circuit electrically connected to the rectifying circuit,

30[h] wherein the plurality of electronic components comprise a capacitor which is positioned closest to the end wall of the first end cap;

30[i] wherein the end wall comprises a first portion made of an insulating material.

61. '989 Claim 31 reads:

31 The LED tube lamp according to claim 30, wherein the end wall comprises at least one opening.

62. '989 Claim 37 reads:

37 The LED tube lamp according to claim 30, wherein the capacitor connects between the input terminals of the rectifying circuit.

63. '989 Claim 77 reads:

77[a] The LED tube lamp according to claim 30, wherein the rectifying circuit comprises: a first full-wave bridge rectifying circuit, having two input terminals electrically connected to two conductive pins of one of the first and the second end caps, respectively, and having a positive output terminal and a negative output terminal; and

77[b] a second full-wave bridge rectifying circuit, having two input terminals electrically connected to two conductive pins of the other one of the first and the second end caps, respectively, and having a positive output terminal and a negative output terminal,

77[c] wherein the positive output terminals of the first and the second full-wave bridge rectifying circuits are electrically connected to each other, and the negative output terminals of the first and the second full-wave bridge rectifying circuits are electrically connected to each other.

64. '989 Claim 84 reads:

84 The LED tube lamp according to claim 30, wherein at least some of the electronic components form a filament-simulating circuit

configured to conduct current during a preheat process when the LED tube lamp is powered by a ballast.

65. '989 Claim 85 reads:

85 The LED tube lamp according to claim 84, wherein the filament-simulating circuit comprises: a second capacitor, coupled between the two conductive pins of one of the first and the second end caps.

66. '989 Claim 86 reads:

86 The LED tube lamp according to claim 85, wherein the filament-simulating circuit further comprises: a resistor, coupled to the second capacitor in parallel.

67. '989 Claim 88 reads:

88 The LED tube lamp according to claim 1, wherein the tube is a glass tube.

68. '989 Claim 90 reads:

90 The LED tube lamp according to claim 30, wherein the tube is a glass tube.

B. Prosecution History

69. I have reviewed the prosecution history of the '989 Patent. The '989 Patent issued from an application filed on April 2, 2019, U.S. Patent Application No. 15/339,221.

70. The first non-final office action, issued by the Examiner on June 7, 2019, included rejections of claims 1, 16, 19-20, 34, and 42-43 and objections to claims 2-15, 17-18, 21-33, 35-41, and 44-52. EX1002, 397-401/600.

71. The Applicant responded to the Office Action on September 6, 2019. In the response, the Applicant cancelled claims 1, 16, 19, 34, and 43 and rewrote

claims 2, 21, and 35 in independent form. Additionally, the Applicant amended Claim 2 to recite “an LED light strip attached to an inner circumferential surface of the tube” instead of “an LED light strip disposed inside the tube.” *Id.*, 471-479/600. Further, the Applicant added new claims 53-96. *Id.*, 480-488/600.

72. The Examiner issued a Notice of Allowance on September 25, 2019. In the Notice, the Examiner indicated that “the prior arts of record fail to disclose or suggest wherein the end wall comprises a first portion made of an insulating material, as required in amended claims 1, 21, and 35.” The Examiner renumbered claim 2 to claim 1, claim 21 to claim 17, claim 35 to claim 28, claim 53 to claim 47, and claim 83 to claim 77. *Id.*, 509-515/600.

C. Claim Construction

73. I understand claims are to be given their ordinary and customary meaning to a POSITA in view of the claims, specification, and prosecution history. I also understand that Applicants can define their own claim terms in the specification, which will be used when interpreting the claims.

1. “electrically connected” / “electrically connecting”

74. In is my opinion that the term “electrically connected” should be construed as “connected through wires or other intervening electrical components.” “Electrically connected” is found in claims 1, 2, 4, 12, 30, 47, and 77. A POSITA would have understood that to be “electrically connected,” components do not

require a direct connection, i.e., with no intervening electrical components or modules.

75. The '989 Patent distinguishes between “electrically connected” and “directly electrically connected”:

As used herein, items described as being "electrically connected" are configured such that an electrical signal can be passed from one item to the other. . . . Moreover, items that are "directly electrically connected," to each other are electrically connected through one or more passive elements, such as, for example, wires, pads, internal electrical lines, resistors, etc. As such, directly electrically connected components do not include components electrically connected through active elements, such as transistors or diodes.

EX1001, 15:19-34. Therefore, the '989 Patent itself confirms my opinion that the construction is correct.

2. *“disposed on an inner circumferential surface of the lamp tube”*

76. In my opinion, “disposed on an inner circumferential surface of the lamp tube” means either directly disposed, with no intervening components, or indirectly disposed, with at least one intermediate component. My opinion is informed by the '989 Patent. The '989 Patent describes the LED light strip as being fixed to the inner surface of the lamp tube by an adhesive sheet. EX1001, 29:49-59. Additionally, the '989 Patent describes embodiments where the LED light strip is “directly bonded” to the inner circumferential surface of the lamp tube. *Id.*, 30:11-

15. Therefore, the patent describes both directly disposed, with no intervening components, or indirectly disposed, with at least one intermediate component.

VIII. COMPARISON OF PRIOR ART TO '989 PATENT'S CHALLENGED CLAIMS

A. Ground 1 - Claims 1, 2, 4-6, 30, 31, 37, 88, and 90 are Obvious over Li in view of Ono

1. Motivation to Combine Li and Ono

77. Li discloses an LED lamp including a drive circuit that makes the lamp compatible with standard fluorescent light fixtures. EX1005, [0092], [0113]. The drive circuit is “connected between an alternating current (AC) or direct current (DC) power supply outside the lighting device and the light emitting diode as a light source, and is used to provide the required current or voltage (e.g., constant current, constant voltage or constant power) to the light emitting diode.” *Id.*, [0082]. “[T]he components of the drive circuit module 330 are arranged at two ends of the substrate 310.” *Id.*, [0101], *see also id.*, Abstract, [0108]. Li teaches that “the driver power supply can be achieved in a modular structure” and “comprises a printed circuit board and one or more components mounted on the printed circuit board and electrically connected together by means of wiring.” EX1005, [0082]; *see also id.*, Abstract, [0100], [0108]. However, Li does not explicitly describe how the PCB would be arranged to create that modular structure.

78. To understand how to implement Li's drive circuit at the end of substrate 310 within the LED tube and on a circuit board that fits into an end cap of the LED lamp, in my opinion, a POSITA would have been motivated to look for the details Li lacks. Ono for an example of installing capacitors, resistors, and other electronic components on a printed circuit board ("PCB") and positioning that PCB in the end cap. Specifically, Ono describes a "lighting circuit 24 [that] has a circuit board 39 on which a plurality of electronic components 38 have been mounted. Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39, and surface mounted components such as resistors and switching elements are mounted on the wiring pattern surface." EX1006, [0017]. "The lighting circuit 24 is housed inside the tube 20 on one end in a lighting circuit housing portion 37 between the light source unit 23 housed inside the tube 20 and the cap 21a attached to one end of the tube 20." EX1006, [0017]. There are many reasons a POSITA would have been motivated to configure the ends of Li's lamp, including the physical format of its circuit on a PCB, with the insulator end caps within a non-combustible cover of Ono.

79. For example, in my opinion, a POSITA would have implemented Li's drive circuit on a PCB as described by Ono. Specifically, a POSITA would have been motivated to use Ono's drive circuit configuration in the lamp end as taught by Li. EX1005, Abstract, [0082], [0100], [0108]. For example, Ono describes that

arranging electronic components on different sides on a PCB provides certain advantages. Specifically, “by forming the insulator 25 from the end portion of the tube 20 and the cap 21a, a separate insulating member is not required, the number of parts can be reduced, and assembly is more efficient” and “[w]hen the lighting circuit 24 has electronic components 38 arranged only on one side of the circuit board 39, the other side of the circuit board 39 does not have to be covered with the non-combustible cover 26a. In this case, the side of the circuit board 39 on which the electronic components 38 have been arranged faces the side opposite to the mounting surface of the board 34 on which the light emitting elements 33 have been mounted, that is, the side opposite the direction in which the light from the light emitting elements 33 is emitted. In this way, a non-combustible cover 26a does not have to be arranged on the light emitting side, and light is not blocked by the non-combustible cover 26a. This improves illumination efficiency.” EX1006, [0030], [0046]. Further, Ono describes improved safety: “because [its] non-combustible cover 26a has a lighting circuit covering portion 42 that covers the periphery of the lighting circuit 24, ... covering the periphery of the lighting circuit 24, which is susceptible to heat damage, with the non-combustible cover 26a creates a reliable non-combustible structure.” *Id.*, [0031]. Thus, a POSITA would have been motivated to implement Ono’s lamp-end structure (the physical format Li’s circuit on Ono’s dual-sided circuit board and Ono’s insulator end caps) to reduce the

number of parts and improve the efficiency of assembly, as well as to improve safety due to the inclusion of a reliable non-combustible structure surrounding the power circuit.

80. It would have been obvious to a POSITA to try the PCB implementation described in Ono with Li's drive circuit to because there were a finite number of possible solutions that would have been identifiable and predictable to a POSITA. For example, Li teaches that the "the strip substrate is an aluminum substrate or double-sided printed circuit board." EX1005, [0021]. Li further describes that "[t]he driver power supply module 330 can adopt circuits with various topological structures," and "comprises a printed circuit board and one or more components mounted on the printed circuit board and electrically connected together by means of wiring." EX1005, [0082], [0109]. Ono likewise describes a "circuit board 39 on which a plurality of electronic components 38 have been mounted," such as capacitors and inductors mounted on one surface, and resistors and switches mounted on another surface. EX1006, [0017]. A POSITA would have recognized a design need for implementing Li's not fully described drive circuit and would have looked to Ono's PCB structure that also taught a double-sided PCB but with a particular arrangement of components. In doing so, a POSITA would have expected this implementation to be successful and yield predicable results based on the stability of the technology and straight-forward implementation of the technology.

81. Further, a POSITA would have found it obvious to try implementing Ono's insulating material for end caps within a non-combustible cover with Li's end covers because there were a finite number of identified, predictable solutions a POSITA would have pursued. For example, Li describes that an objective of the invention is "a simple manufacturing process." EX1005, [0006]. Ono explains that "by forming the insulator 25 from the end portion of the tube 20 and the cap 21a, a *separate insulating member is not required*, the number of parts can be reduced, and assembly is *more efficient*." EX1006, [0030]. Thus, a POSITA would have been motivated to implement Ono's known end cap structure to reduce the number of parts and improve the efficiency of assembly with a reasonable expectation of success.

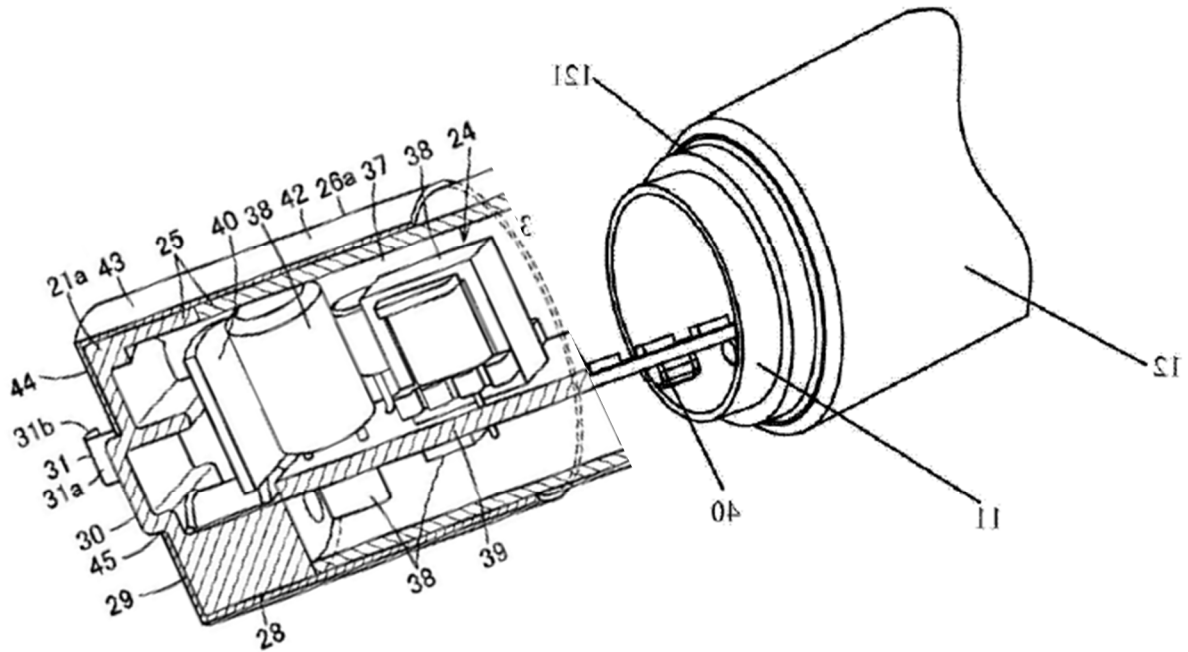
82. A POSITA would have understood that the substitution of Ono's known PCB structure for Li's drive circuit and Ono's insulating end-caps for Li's end covers would have predictable results. Li describes that its drive circuit uses a double-sided PCB (EX1005, [0021]) and Ono describes lighting circuit 24 as a double-sided PCB with a specific configuration of well-known components (EX1006, [0017]). Both Li's drive circuit and Ono's lighting circuit 24 serve the same purpose: providing power to LED lamps. EX1006, [0017]; EX1005, [0082]. Therefore, a POSITA would have understood that Ono's teachings of mounting components on a double-sided PCB would be used to implement Li's drive circuit on

a double-sided PCB. Similarly, both Li and Ono describe end caps to enclose the end of a glass tube and provide external electrical connection. EX1006, [0013]; EX1005, Abstract. Thus, a POSITA would have understood that the simple substitution of Ono's PCB structure and end caps for Li's drive circuit and end covers would have predictable results.

83. Further, a POSITA would have expected the implementation on Ono's lamp-end configuration in the ends of Li's LED lamp to be successful. Ono itself successfully implements its lamp-end configuration in LED tube lamps used to replace conventional fluorescent bulbs. This is an identical application as Li. Ono's dual-sided PCB structure is also consistent with Li's teaching that "[p]referably, ... the strip substrate is an ... double-sided printed circuited board [PCB]." EX1005, [0021]. Thus, a POSITA would have understood that Ono's lamp-end configuration could easily be incorporated into Li's LED lamp because the technology for installing electronic components on a PCB was well developed and the installation would have been straight-forward for a POSITA to implement using known technology. A POSITA would have expected the combination to be successful.

2. Modification of Li in view of Ono

84. A POSITA would have been motivated to modify the Li LED lamp with Ono's lighting circuit PCB and insulated end caps to create the Li-Ono lamp, as shown below.



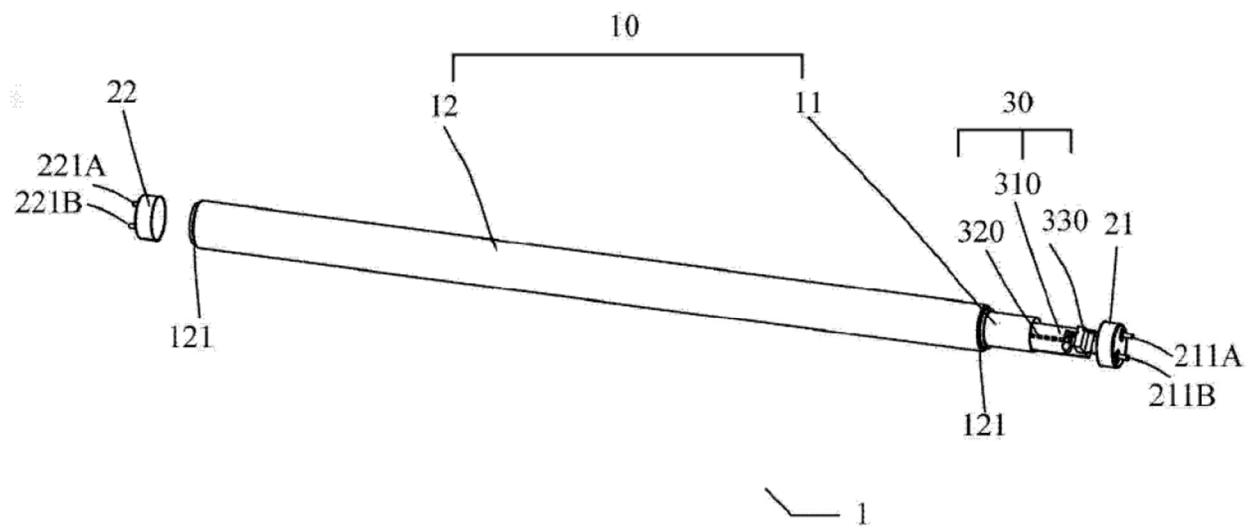
Li FIG. 3
(Modified per Li-Ono)

EX1005, FIG. 3; EX1006, FIG. 1.

3. *Element-by-Element Analysis*

Limitation 1[p]: “An LED tube lamp, comprising:”

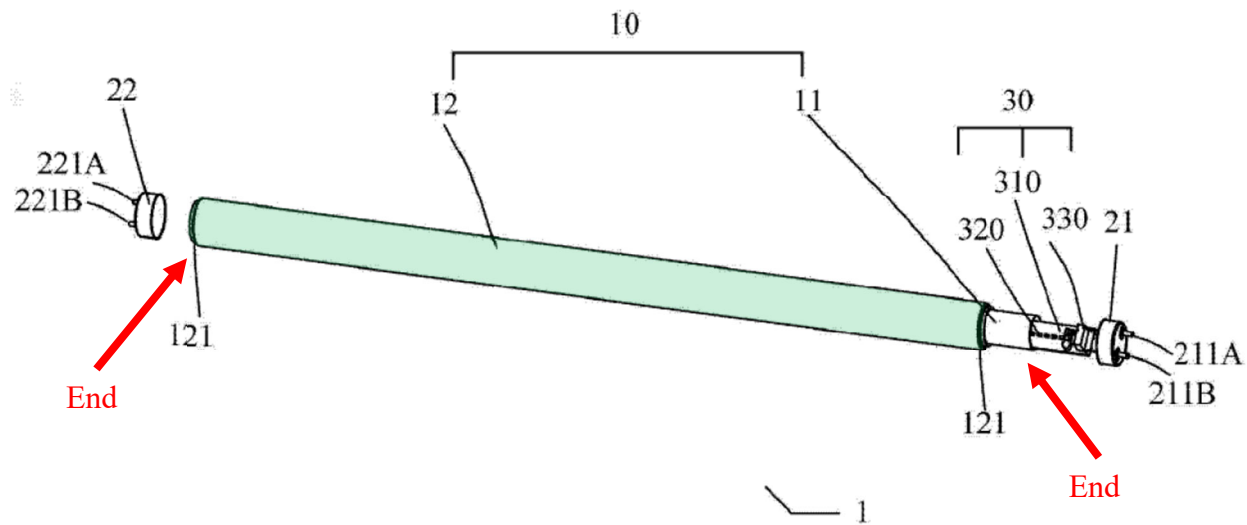
85. It is my opinion that the combination of Li and Ono renders obvious an LED tube lamp. Li describes an “LED fluorescent lamp 1 shown in Fig. 1 comprises a tube body 10, a pair of end covers 21 & 22 located at two ends of the tube body 10, and an LED driver power supply 30 located inside the tube body 10.” EX1005, [0088]. Li’s tube lamp is shown in Figure 1:

**Fig. 1**

EX1005, [0088]; FIG. 1.

Limitation 1[a]: “a tube having two ends;”

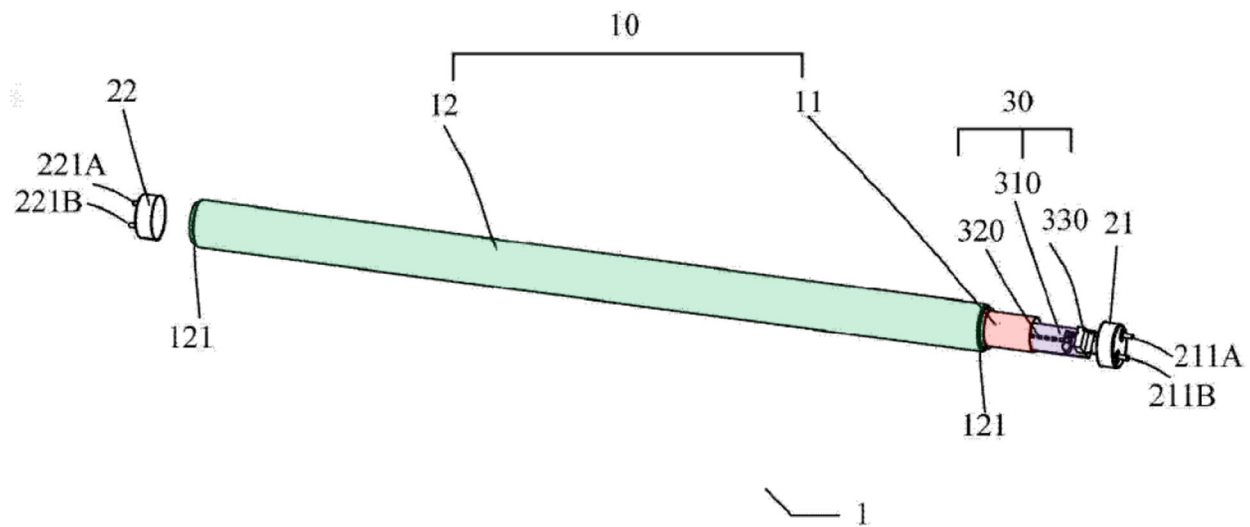
86. It is my opinion that the combination of Li and Ono renders obvious a tube with two ends. The LED lamp tube body “comprises an [red] inner tube 11 and an [green] outer tube 12 sleeved outside the inner tube 11.” EX1005, [0089]. Li’s Figure 1 shows that both the inner and outer tubes have ends.

**Fig. 1**

EX1005, [0089], FIG. 1.

Limitation 1[b]: “an LED light strip attached to an inner circumferential surface of the tube;”

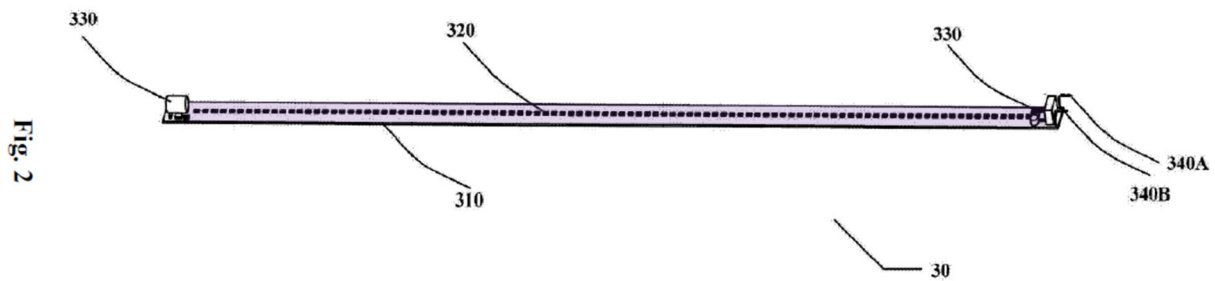
87. It is my opinion that the combination of Li and Ono renders obvious an LED light strip inside the tube. Li teaches that inside the [red] inner glass tube is “a plurality of LED units 320 are arranged longitudinally along the [purple] substrate 310.” EX1005, [0098]. “The substrate 310 of the LED power supply 30 is fixed to the inside of the inner tube 11 at ends by means of a silicone-like adhesive, for example.” *Id.*, [0097].

**Fig. 1**

Id., FIG. 1.

Limitation 1[c]: “a plurality of LED light sources mounted on the LED light strip;”

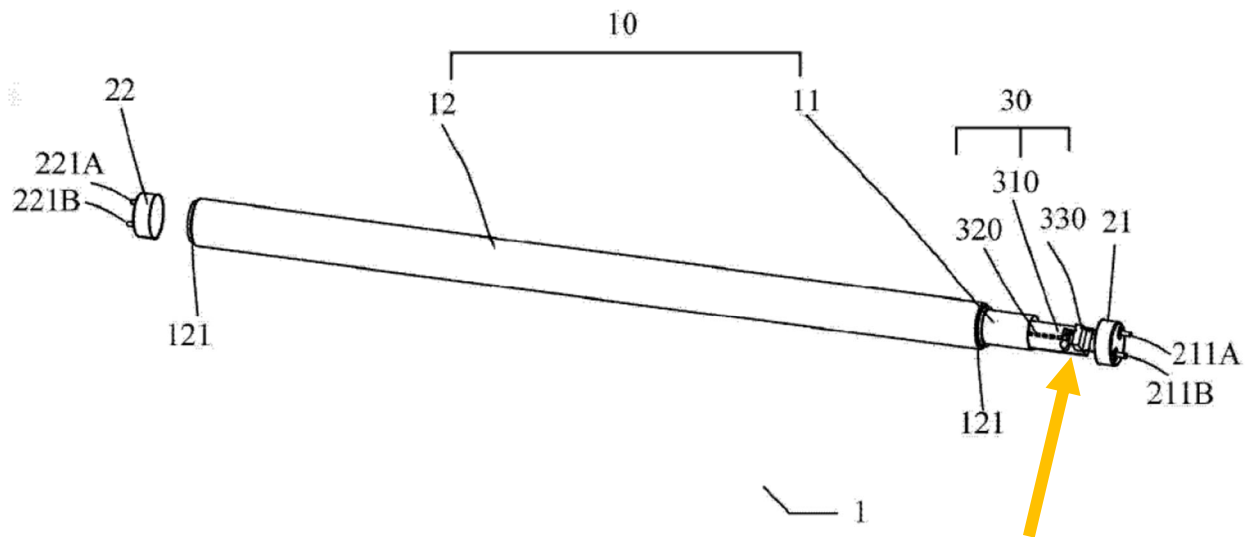
88. It is my opinion that the combination of Li and Ono renders obvious multiple LED light sources mounted on the LED light strip. Li discloses a ceramic or composite substrate that includes “a plurality of LED units 320 [] arranged longitudinally along the [purple] substrate 310.”



EX1005, [0096], [0098], FIG. 2.

Limitation 1[d]: “a power supply module electrically connecting to the LED light strip and configured to drive the plurality of LED light sources; and”

89. It is my opinion that the combination of Li and Ono renders obvious a power supply connected and providing power to the LED light sources. Li discloses “a[n] [orange] drive circuit module” in the LED light. EX1005, Abstract. The “drive circuit module, which is arranged at one or two ends of the strip substrate and electrically connected to the LED units and the plugs.” *Id.*

**Fig. 1**

Id., FIG. 1.

90. The drive circuit module is “connected between an alternating current (AC) or direct current (DC) power supply outside the lighting device and the light emitting diode as a light source, and is used to provide the required current or voltage (e.g., constant current, constant voltage or constant power) to the light emitting diode.” *Id.*, [0082]. Therefore, the drive circuit module provides power to drive the LED light sources attached to the substrate.

Limitation 1[e]: “a first end cap and second end cap respectively attached at the two ends of the tube, each of the first and second end caps comprising a lateral wall and an end wall, the lateral wall substantially being coaxial with the tube and connecting to the tube, the end wall substantially being perpendicular

to an axial direction of the lateral wall and connecting to an end of the lateral wall away from the tube,”

91. It is my opinion that the combination of Li and Ono renders obvious end caps attached to each end of the tube, each having lateral and end walls. Li's LED light includes "[blue] end covers 21 and 22 [that] enclose the two ends of the inner tube 11." EX1005, [0092]. As shown in Figure 1, the end caps have a cylindrical structure. The sides of the cylinder ("a lateral wall") are parallel (e.g., coaxial) with the length of the tube. The end of the cylinder ("an end wall") is perpendicular to the side of the cylinder.

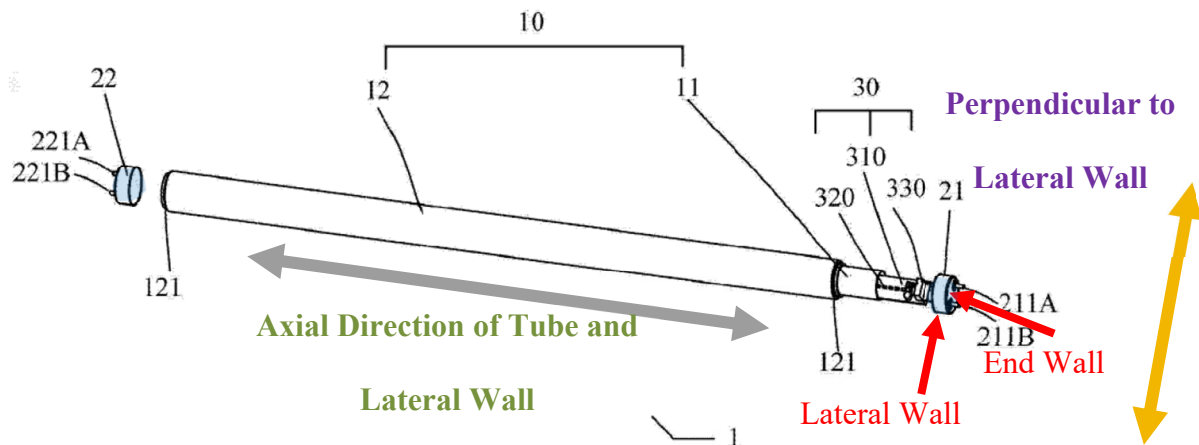


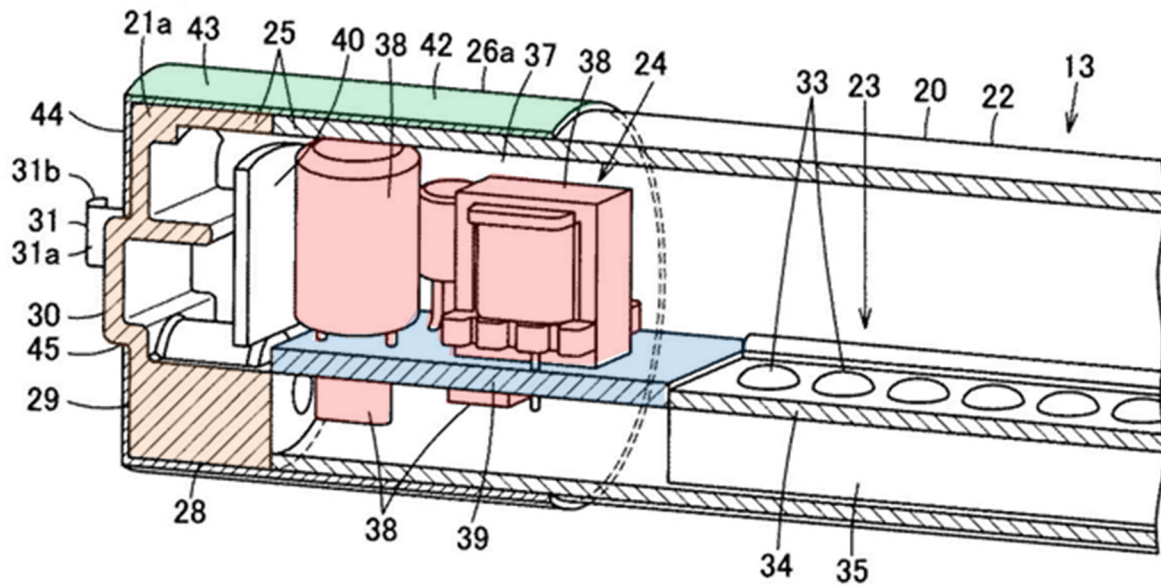
Fig. 1

EX1005, Abstract, FIGs. 1-2.

92. Ono describes an "insulator 25 is composed of a tube 20 and a cap 21a, both made of a resin material, and the lighting circuit 24 is covered by the tube 20 and the cap 21a." EX1006, [0018]; *see also id.*, [0030], [0041-0044], FIGs. 1, 7.

“The lighting circuit 24 is covered with an insulator 25, and the lighting circuit 24 is covered with a non-combustible cover 26a via the insulator 25.” *Id.*, [Solution].

[Fig. 1]



Id., FIG. 1.

Limitation 1[f]: “wherein the power supply module comprises a printed circuit board and a plurality of electronic components mounted on the printed circuit board, the printed circuit board comprises a first surface and a second surface opposite to and substantially parallel to the first surface, and the first surface and the second surface of the printed circuit board are substantially parallel with the axial direction of the lateral wall;”

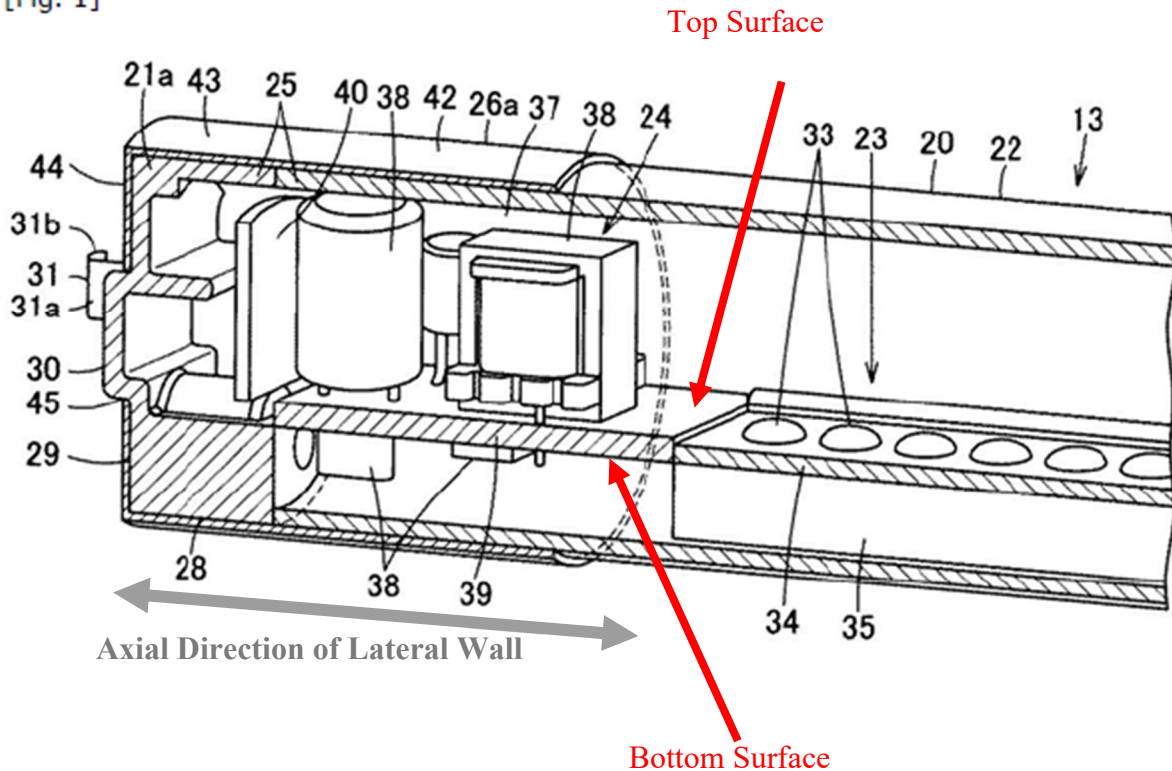
93. It is my opinion that the combination of Li and Ono renders obvious a power supply formed of a PCB having two parallel surfaces on which electronic

components are mounted and positioned parallel with the axial direction of the lateral wall of the end cap. Li discloses the LED drive circuit module 330, but does not describe the physical structure of the drive circuit beyond disclosing that “the driver power supply can be achieved in a modular structure. For example, it comprises a printed circuit board and one or more components mounted on the printed circuit board and electrically connected together by means of wiring. Examples of these components include but are not limited to LED drive controller chips, rectifier chips, resistors, capacitors and coils.” EX1005, [0082].

94. As I explained above, a POSITA would have been motivated to look to Ono to understand the physical implementation of the circuits described in Li. Specifically, Ono describes that “[t]he lighting circuit 24 has a circuit board 39 on which a plurality of electronic components 38 have been mounted. Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39, and surface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.” EX1006, [0017].

95. As shown in Figure 1, Ono’s PCBs have a top and bottom surfaces parallel to each other. EX1006, FIG. 1. The PCB is arranged in the end cap such that the PCB is substantially parallel with the axial direction of the lateral wall of the end cap. EX1006, FIG. 1.

[Fig. 1]

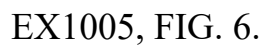


EX1006, FIG. 1.

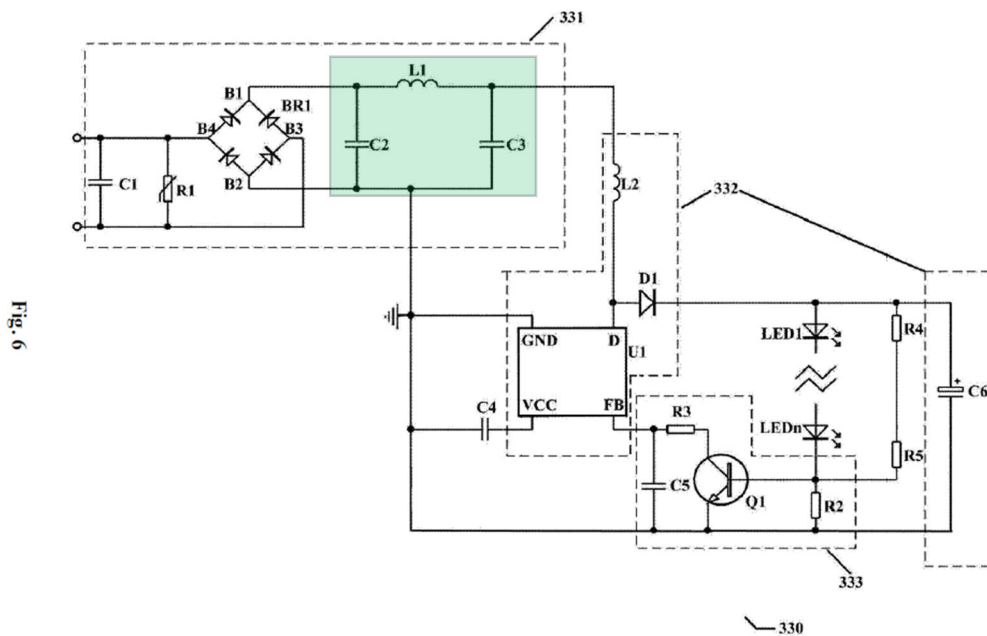
Limitation 1[g1]: “wherein at least some of the plurality of electronic components comprise a rectifying circuit having at least two input terminals and configured to rectify signal receiving from the at least two input terminals,”

96. It is my opinion that the combination of Li and Ono renders obvious a rectifying circuit with two input terminals. Li describes that “[t]he drive circuit module 330 shown in Fig. 6 comprises a bridge rectifier filter unit 331, a DC-DC boost conversion unit 332 and a feedback unit 333.” EX1005, [0112]. “[T]he bridge

Fig. 6



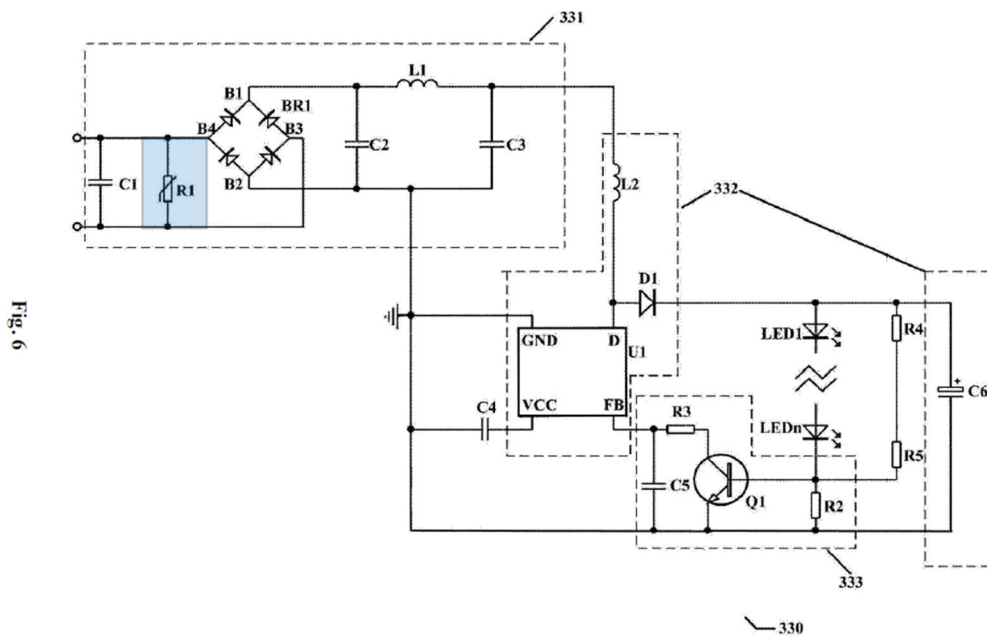
97. It is my opinion that the combination of Li and Ono renders obvious a filtering circuit electrically connected to the rectifying circuit. Li describes that “[t]he filter capacitors C2 & C3 and the inductor L1 form a π -shaped filter loop and are electrically connected between the anode terminal B1 and the cathode terminal B2 of the full-bridge rectifier BR1 to low-pass filter the pulsating voltage output from the full-bridge rectifier BR1.” EX1005, [0115]; *see also id.*, [0113].



EX1005, FIG. 6.

Limitation 1[h]: “wherein the plurality of electronic components comprise a resistor which is positioned closest to the end wall of the first end cap and connecting to one of the input terminals of the rectifying circuit;”

98. It is my opinion that the combination of Li and Ono renders obvious a resistor located closest to the end wall of an end cap and connected to an input of the rectifying circuit. Li describes that “the filter capacitor C1 and the varistor R1 are connected in parallel between the AC input terminals B3 and B4 of the full-bridge rectifier BR1, wherein the varistor R1 holds the input voltage of the full-bridge rectifier BR1 at a predetermined level by suppressing abnormal overvoltage in the circuit.” EX1005, [0115].



EX1005, [0115], FIG. 6. In my opinion, a POSITA would have understood the AC input of the drive circuit, located on the left side of Figure 6, to be the conductive pins in the end wall at one end of the tube light. Therefore, varistor R1 is close to the end wall. While in Figure 6, C1 is illustrated closer to the circuit inputs, because C1 and R1 are connected in parallel, it is my opinion that the locations of C1 and R1 can be reversed without changing the functionality of the circuit disclosed in Li. Therefore, it is my opinion that Li discloses that R1 is located closest to the end wall of the end cap.

99. My opinion that the location of the varistor R1 is closest to the end wall of the end cap is confirmed by Ono. Ono describes that “[t]he lighting circuit 24 has a circuit board 39 on which a plurality of electronic components 38 have been

mounted. Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39, and surface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.” EX1006, [0017]. Ono’s resistors are located on the bottom side (e.g., the wiring pattern surface) of the PCB 39. EX1006, [0017] (“[S]urface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.”). Ono’s capacitors are located on the top of the PCB 39 (e.g., the mounting surface). EX1006, [0017] (“Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39”). Therefore, when Li’s drive circuit is implemented in a PCB as described by Ono, the capacitor C1 is mounted on the top of the PCB and varistor R1 is mounted on the bottom and a POSITA would have understood that both the capacitor C1 and the varistor R1 are located closest to the end wall of the end cap.

100. Further, a POSITA would have understood that resistors are heat generating circuit elements. Therefore, it would have been obvious for a POSITA to place the resistor closest to the end cap such that heat would be efficiently dissipated through heat dissipating functions in the end caps, such as ventilating holes. This placement would cool the resistor as well as minimize the effects of the resistor heating up other components on the PCB and improve the lifespan of the LED lamp. As an alternative to, or in addition to ventilation holes, the PCB could

be placed in direct contact with the end cap. A POSITA would have understood that heat is transferred to the end cap through this direct connection and would have been conducted out of the LED lamp to the outside environment directly through the end wall or through the conducting pins. Thus, it would have been obvious to a POSITA to locate the (heat generating) resistor closest to the end cap.

Limitation 1[i]: “wherein the end wall comprises a first portion made of an insulating material.”

101. It is my opinion that the combination of Li and Ono renders obvious an end wall made of an insulating material. Because Li is silent on the material that forms end caps 21 and 22, as I explained above, it is my opinion that a POSITA would have been motivated to look to other LED lighting references, such as Ono, to determine the materials that could be used as end caps. Ono describes that a cap 21a is an insulator made of a resin material. EX1006, [0018]; *see also id.*, [0030], [0041]-[0044], FIGS. 1, 7.

Limitation 2[a]: “The LED tube lamp according to claim 1, wherein each of the end caps comprises at least one conductive pin connected to the first portion, and”

102. Li-Ono renders obvious a conductive pin connected to the first portion of an end wall. Li describes “pins 340A and 340B are arranged at one end of the substrate 310 as a first electrode and a second electrode of the LED drive circuit

module 330, respectively (therefore, the pins 340A and 340B are hereinafter also referred to as “electrode pins”). After assembly, the electrode pins 340A and 340B are electrically connected to the plugs 211A and 211B on the end cover 21.” EX1005, [0100].

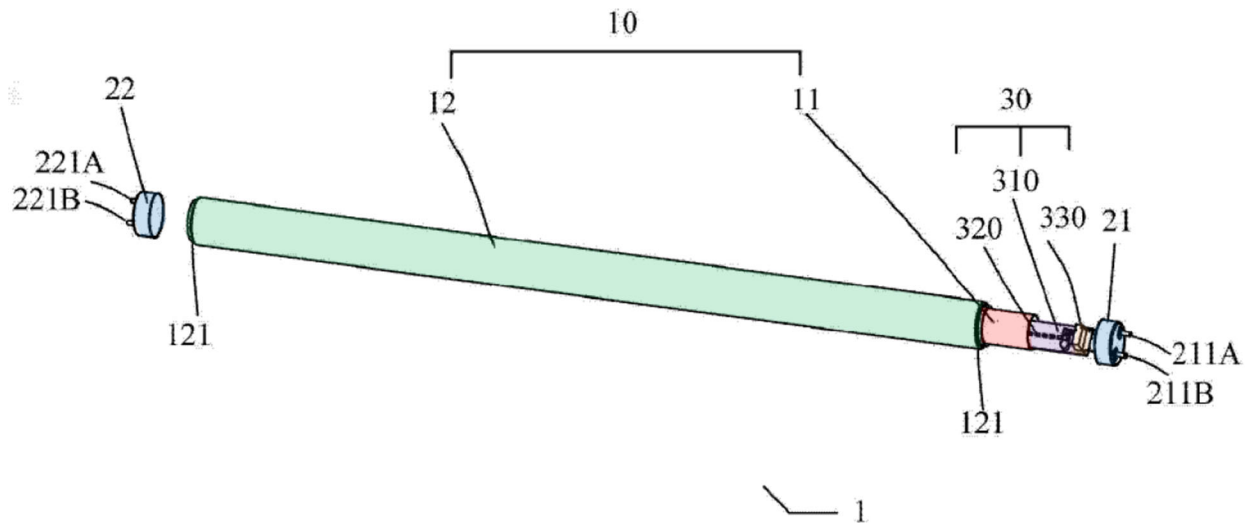


Fig. 1

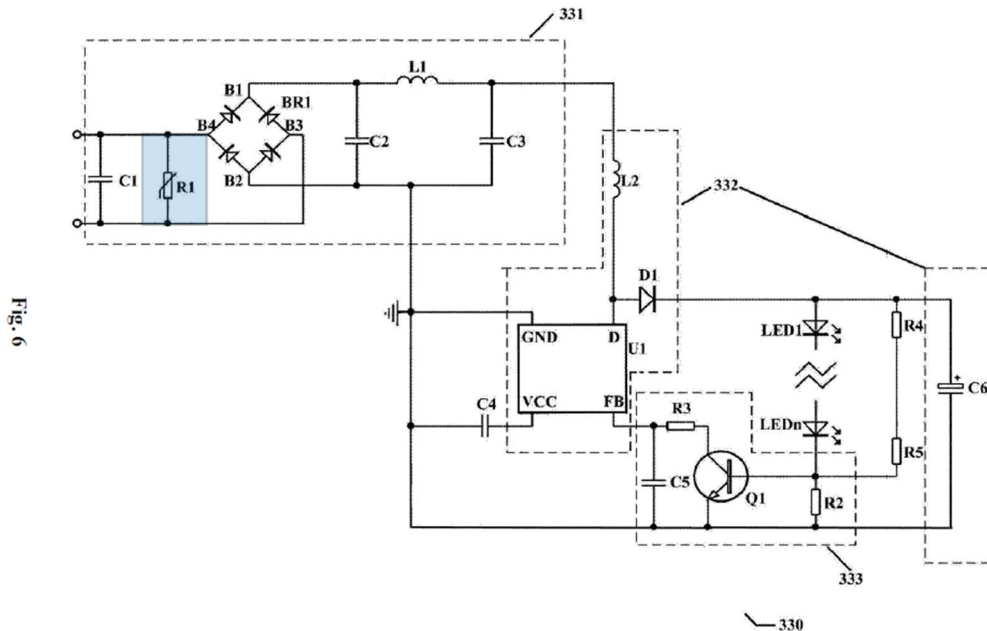
EX1005, FIG. 1.

Limitation 2[b]: “the resistor is electrically connected between the conductive pin and one of the input terminals of the rectifying circuit.”

103. It is my opinion that the combination of Li and Ono renders obvious a resistor connected between the conductive pin and an input terminal of the rectifying circuit. Li describes that “the filter capacitor C1 and the varistor R1 are connected in parallel between the AC input terminals B3 and B4 of the full-bridge rectifier

BR1, wherein the varistor R1 holds the input voltage of the full-bridge rectifier BR1 at a predetermined level by suppressing abnormal overvoltage in the circuit.”

EX1005, [0115].



EX1005, [0115], FIG. 6. In my opinion, a POSITA would have understood the AC input of the drive circuit, located on the left side of Figure 6, to be the conductive pins in the end wall at one end of the tube light. Therefore, the varistor R1 is connected between the AC input at the connective pins and an input of the rectifying circuit, specifically to input terminals B3 and B4.

Claim 4: “The LED tube lamp according to claim 1, wherein each of the end caps comprises two conductive pins connected to the first portion, and the resistor is electrically connected between the two conductive pins.”

104. It is my opinion that the combination of Li and Ono renders obvious two conductive pins connected to a first portion of the end cap and a resistor connected between the two pins. Li describes “pins 340A and 340B are arranged at one end of the substrate 310 as a first electrode and a second electrode of the LED drive circuit module 330, respectively (therefore, the pins 340A and 340B are hereinafter also referred to as “electrode pins”). After assembly, the electrode pins 340A and 340B are electrically connected to the plugs 211A and 211B on the end cover 21.” EX1005, [0100].

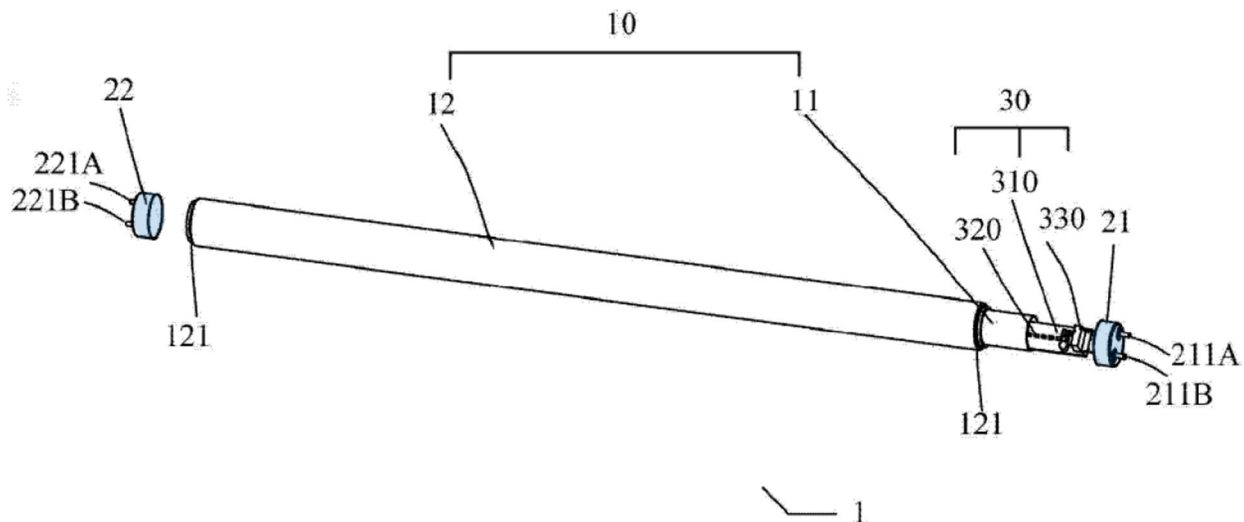
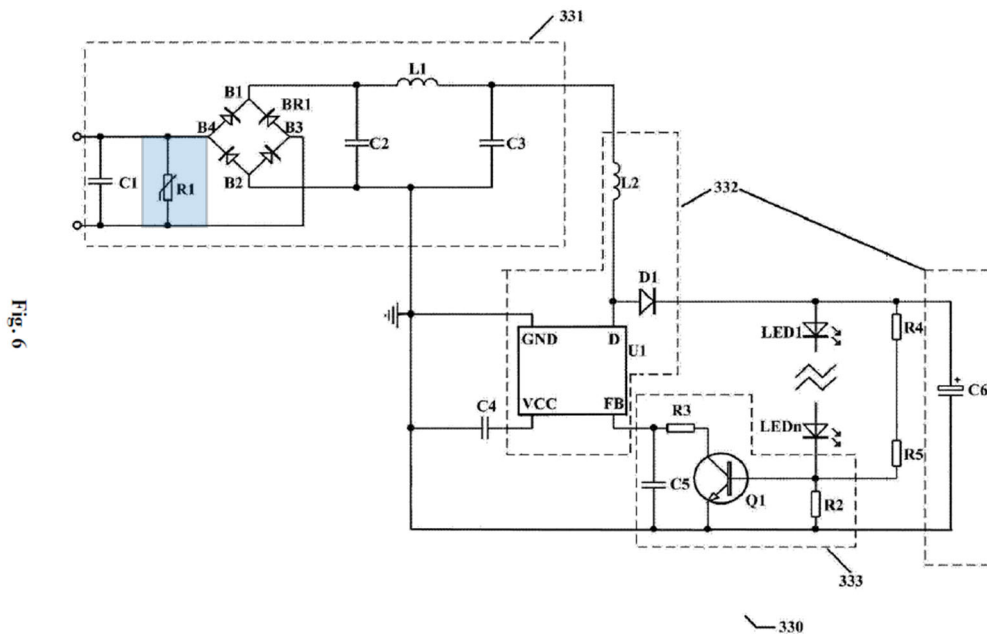


Fig. 1

EX1005, FIG. 1.

105. Li describes that “the filter capacitor C1 and the varistor R1 are connected in parallel between the AC input terminals B3 and B4 of the full-bridge rectifier BR1, wherein the varistor R1 holds the input voltage of the full-bridge rectifier BR1 at a predetermined level by suppressing abnormal overvoltage in the circuit.” EX1005, [0115]. In my opinion, a POSITA would have understood the AC input of the drive circuit, located on the left side of Figure 6, to be the conductive pins in the end wall at one end of the tube light. Therefore, the varistor R1 is connected between the AC input at the connective pins and an input of the rectifying circuit, specifically to input terminals B3 and B4.

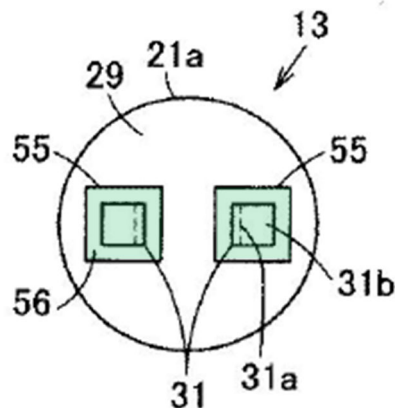


EX1005, [0115], FIG. 6.

Claim 5: “The LED tube lamp according to claim 1, wherein the end wall comprises at least one opening.”

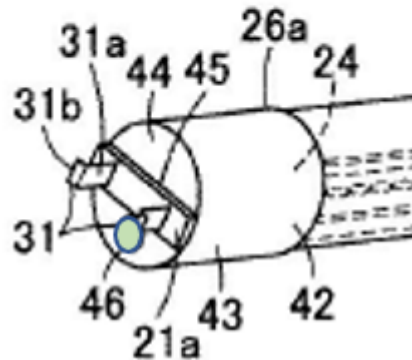
106. It is my opinion that the combination of Li and Ono renders obvious an opening in the end wall. As I explained above, because Li is silent on the design of end caps 21 and 22, in my opinion, a POSITA would have been motivated to look to other LED lighting references, such as Ono, to determine potential designs for end caps. Ono describes that end cap 21a has “a pair of [green] openings 55.”

[Fig. 8]



EX1006, [0040], FIG. 8.

107. Ono also describes “mounting holes 46 for screwing a non-combustible cover 26a, 26b into a cap 21a, 21b.” EX1006, [0019]. These are shown in green below.

[Fig. 2]

EX1006, FIG. 2.

Claim 6: “The LED tube lamp according to claim 5, wherein the resistor is positioned closest to the opening.”

108. It is my opinion that the combination of Li and Ono renders obvious a resistor positioned closest to the opening in the end wall. Li describes that “the filter capacitor C1 and the varistor R1 are connected in parallel between the AC input terminals B3 and B4 of the full-bridge rectifier BR1, wherein the varistor R1 holds the input voltage of the full-bridge rectifier BR1 at a predetermined level by suppressing abnormal overvoltage in the circuit.” EX1005, [0115]. In my opinion, a POSITA would have understood the AC input of the drive circuit, located on the left side of Figure 6, to be the conductive pins in the end wall at one end of the tube

light. Therefore, varistor R1 is close to the end wall. While in Figure 6, C1 is illustrated closer to the circuit inputs, because C1 and R1 are connected in parallel, it is my opinion that the locations of C1 and R1 can be reversed without changing the functionality of the circuit disclosed in Li. Therefore, it is my opinion that Li discloses that varistor R1 is located closest to the end wall of the end cap. Ono teaches that conductive pins extend through openings 55. EX1006, [0040]. Therefore, the varistor R1 is closest to both the end wall and the openings.

109. My opinion that the location of the varistor R1 is closest to the end wall of the end cap is confirmed by Ono. Ono describes that “[t]he lighting circuit 24 has a circuit board 39 on which a plurality of electronic components 38 have been mounted. Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39, and surface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.” EX1006, [0017]. Ono’s resistors are located on the bottom side (e.g., the wiring pattern surface) of the PCB 39. EX1006, [0017] (“[S]urface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.”). Ono’s capacitors are located on the top of the PCB 39 (e.g., the mounting surface). EX1006, [0017] (“Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39”). Therefore, when Li’s drive circuit is implemented in a PCB as described by Ono, the capacitor C1 is

mounted on the top of the PCB and varistor R1 is mounted on the bottom and a POSITA would have understood that both the capacitor C1 and the varistor R1 are located closest to the end wall of the end cap.

110. Further, a POSITA would have understood that resistors are heat generating circuit elements. Therefore, it would have been obvious for a POSITA to place the resistor closest to the end cap such that heat would be efficiently dissipated through heat dissipating functions in the end caps, such as ventilating holes. This placement would cool the resistor as well as minimize the effects of the resistor heating up other components on the PCB. Thus, it would have been obvious to a POSITA to locate the (heat generating) resistor closest to the holes in the end cap and improve the lifespan of the LED lamp.

Limitation 30[p]: “An LED tube lamp, comprising:”

111. It is my opinion that the combination of Li and Ono describes an LED tube lamp. *See* Limitation 1[p].

Limitation 30[a]: “a tube having two ends;”

112. It is my opinion that the combination of Li and Ono describes a tube with two ends. *See* Limitation 1[a].

Limitation 30[b]: “an LED light strip attached to an inner circumferential surface of the tube;”

113. It is my opinion that the combination of Li and Ono describes an LED light strip inside the tube. *See* Limitation 1[b].

Limitation 30[c]: “a plurality of LED light sources mounted on the LED light strip;”

114. Li-Ono describes multiple LED light sources mounted on the LED light strip. *See* Limitation 1[c].

Limitation 30[d]: “a power supply module electrically connecting to the LED light strip and configured to drive the plurality of LED light sources; and”

115. It is my opinion that the combination of Li and Ono describes a power supply connected and providing power to the LED light sources. *See* Limitation 1[d].

Limitation 30[e]: “a first end cap and second end cap respectively attached at two ends of the tube, each of the first and second end caps comprising a lateral wall and an end wall, the lateral wall substantially being coaxial with the tube and connecting to the tube, the end wall substantially

being perpendicular to an axial direction of the lateral wall and connecting to an end of the lateral wall away from the tube,”

116. It is my opinion that the combination of Li and Ono describes end caps attached to each end of the tube, each having lateral and end walls. *See* Limitation 1[e].

Limitation 30[f]: “wherein the power supply module comprises a printed circuit board and a plurality of electronic components mounted on the printed circuit board, the printed circuit board comprises a first surface and a second surface opposite to and substantially parallel to the first surface, and the first surface and the second surface of the printed circuit board are substantially parallel with the axial direction of the lateral wall;”

117. It is my opinion that the combination of Li and Ono describes a power supply formed of a PCB having two parallel surfaces on which electronic components are mounted and positioned parallel with the axial direction of the lateral wall of the end cap. *See* Limitation 1[f].

Limitation 30[g1]: “wherein at least some of the electronic components comprise a rectifying circuit having at least two input terminals and configured to rectify signal receiving from the input terminals, ”

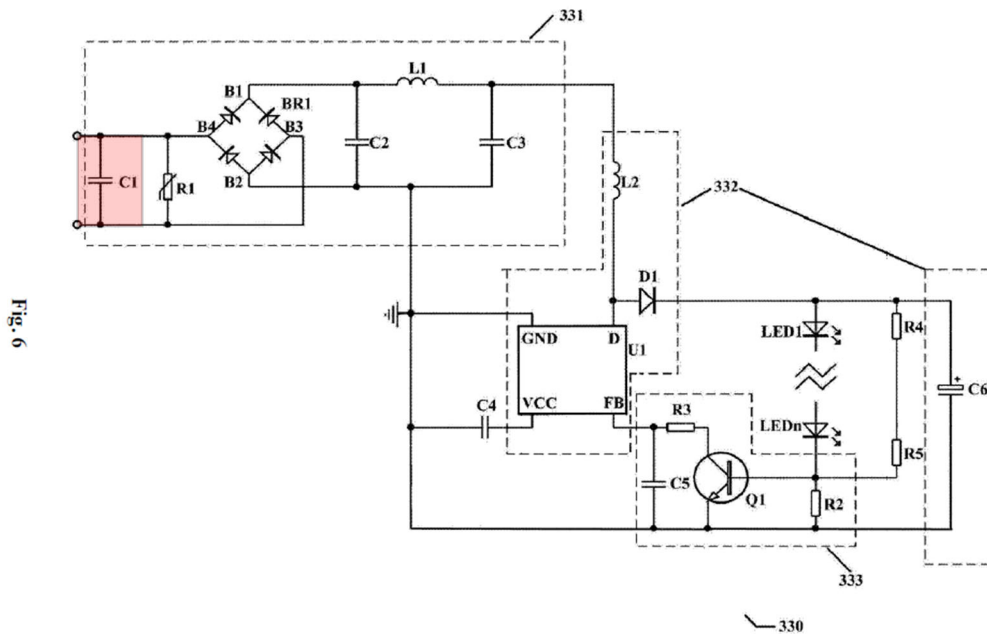
118. It is my opinion that the combination of Li and Ono describes a rectifying circuit with two input terminals. *See* Limitation 1[g1].

Limitation 30[g2]: “at least one of the electronic components comprises a filtering circuit electrically connected to the rectifying circuit,”

119. It is my opinion that the combination of Li and Ono describes a filtering circuit electrically connected to the rectifying circuit. *See* Limitation 1[g2].

Limitation 30[h]: “wherein the plurality of electronic components comprise a capacitor which is positioned closest to the end wall of the first end cap;”

120. It is my opinion that the combination of Li and Ono renders obvious a capacitor located closest to the end wall of an end cap. Li describes that “the [red] filter capacitor C1 and the varistor R1 are connected in parallel between the AC input terminals B3 and B4 of the full-bridge rectifier BR1, wherein the varistor R1 holds the input voltage of the full-bridge rectifier BR1 at a predetermined level by suppressing abnormal overvoltage in the circuit.” EX1005, [0115].



EX1005, [0115], FIG. 6. In my opinion, a POSITA would have understood the AC input terminals B3 and B4 of the bridge rectifier in the drive circuit, located on the left side of Figure 6, to correspond to the conductive pins in the end wall at one end of the tube light. Therefore, the capacitor C1 is closest to the end wall.

121. My opinion that the location of the capacitor C1 is closest to the end wall of the end cap is confirmed by Ono. Ono describes that “[t]he lighting circuit 24 has a circuit board 39 on which a plurality of electronic components 38 have been mounted. Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39, and surface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.” EX1006, [0017]. Ono’s resistors are located on the bottom side (e.g., the wiring

pattern surface) of the PCB 39. EX1006, [0017] (“[S]urface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.”). Ono’s capacitors are located on the top of the PCB 39 (e.g., the mounting surface). EX1006, [0017] (“Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39”). Therefore, when Li’s drive circuit is implemented in a PCB as described by Ono, the capacitor C1 is mounted on the top of the PCB and varistor R1 is mounted on the bottom and a POSITA would have understood that both the capacitor C1 and the varistor R1 are located closest to the end wall of the end cap.

122. Further, a POSITA would have understood that high temperatures are detrimental to the reliability of capacitors and most directly electrolytic capacitors which were often used in conjunction with bridge rectifier circuits. Thus, to ensure that the capacitor recited in Claim 30 remained cool, it would have been obvious to a POSITA to place the capacitor nearest to the end cap such that heat would be efficiently dissipated through heat dissipating functions in the end caps, such as ventilating holes, cooling the capacitor. As an alternative to, or in addition to ventilation holes, the PCB could have been placed in direct contact with the end cap. A POSITA would have understood that heat is transferred to the end cap through this direct connection and would have been conducted out of the LED lamp to the outside environment directly through the end wall or through the conducting pins.

Thus it would have been obvious to a POSITA to locate the (heat sensitive) capacitor closest to the end cap so as to efficiently transfer any heat away from the capacitor and enhance its reliability and improve the lifespan of the LED lamp.

Limitation 30[i]: “wherein the end wall comprises a first portion made of an insulating material.”

123. It is my opinion that the combination of Li and Ono describes an end wall made of an insulating material. *See* Limitation 1[i].

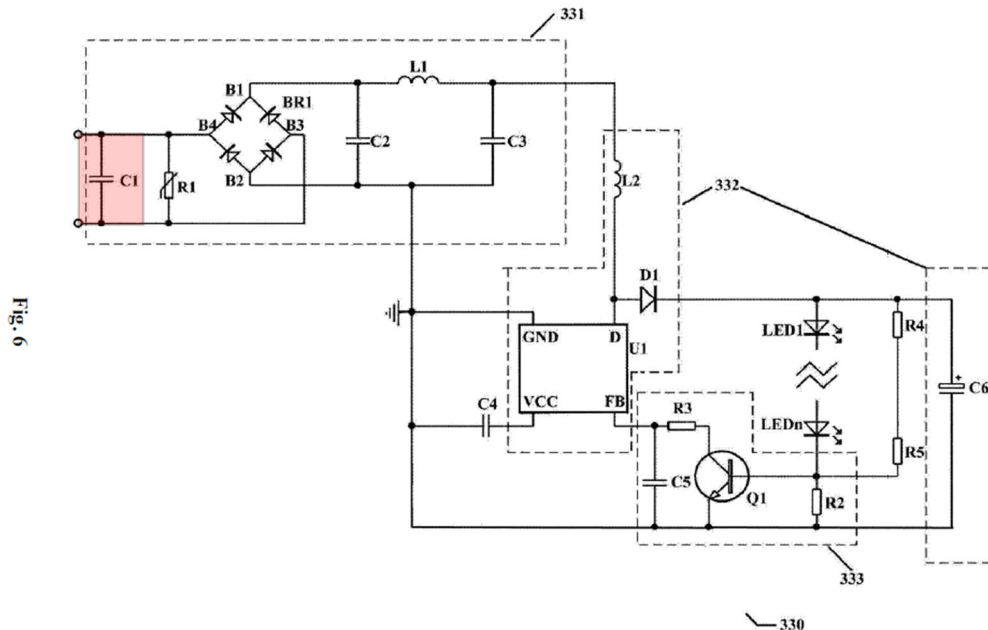
Claim 31: “The LED tube lamp according to claim 30, wherein the end wall comprises at least one opening.”

124. It is my opinion that the combination of Li and Ono describes an end wall comprising at least one opening. *See* Claim 5.

Claim 37: “The LED tube lamp according to claim 30, wherein the capacitor connects between the input terminals of the rectifying circuit.”

125. It is my opinion that the combination of Li and Ono renders obvious that a capacitor connects between the input terminals of the rectifying circuit. Li describes that “the filter capacitor C1 and the varistor R1 are connected in parallel between the AC input terminals B3 and B4 of the full-bridge rectifier BR1, wherein the varistor R1 holds the input voltage of the full-bridge rectifier BR1 at a predetermined level by suppressing abnormal overvoltage in the circuit.” EX1005,

[0115]. Therefore, the capacitor C1 is connected between the input of the rectifying circuit, specifically to input terminals B3 and B4.



EX1005, FIG. 6.

Claim 88: “The LED tube lamp according to claim 1, wherein the tube is a glass tube.”

126. It is my opinion that the combination of Li and Ono renders obvious a tube of an LED light made of glass. Li describes that “the tube body 10 comprises an inner tube 11 and an outer tube 12 sleeved outside the inner tube 11, and they may be made of a glass material.” EX1005, [0089].

Claim 90: “The LED tube lamp according to claim 30, wherein the tube is a glass tube.”

127. It is my opinion that the combination of Li and Ono describes a tube of an LED light made of glass. *See* Claim 88.

B. Ground 2 - Claims 12-14 are Obvious over Li and Ono in view of Xu

1. Motivation to Combine Li, Ono, and Xu

128. As I explained above in Ground 1, a POSITA would have been motivated to combine Li and Ono. It is also my opinion that a POSITA would have been motivated to combine Li and Ono with Xu.

129. Li describes that its LED lamp solves the drawbacks of incompatible of LED lamps with existing fluorescent lamp fixtures. EX1005, [0004-0005]. As I explained above, fluorescent light fixtures included different types of ballasts. Therefore, a POSITA would have understood that one way to increase the compatibility of LED lamps with fixtures for conventional fluorescent lamps is to ensure that the LED lamp can work with ballasts included in these fixtures. EX1008, 2:55-58. Many ballasts utilize different turn-on protocols, such as filament pre-heating, instant start, and rapid start. EX1007, 2:30-58. Therefore, in my opinion, a POSITA would have recognized the benefit of adding a delay to provide time for the electrical signal provided to an LED lamp to reach the desired voltage. *See, e.g.*, EX1008, 5:1-35. The delay would maximize efficiency and minimize the potential

for damage to the LED tube lamp. For example the LED tube lamp could be damaged by a high voltage pulse as is normally generated in the instant start turn-on protocol.

130. Specifically, Xu discloses “[t]he control triggering signal circuit 5-3 is composed of R4 and C3.” EX1009, 5-6/36. Xu teaches that the control triggering signal circuit 5-3 “control[s] the LED light assembly driver 5-4” (*id.*, 6/36, 3/36) and “energize[s] the [LED] light bulb” (*id.*, claims 2, 6). Xu teaches using a capacitor C3 to introduce a delay. EX1009, 6/36. In my opinion, using a properly positioned capacitor would have predictably achieved the benefits Xu describes with the Li-Ono LED lamp.

131. Xu describes different delays and current dumps that impact the timing of illumination of an LED lamp. EX1009, 3/36, FIG. 6. These features are “easy to implement” and “bring[] convenience to users.” EX1009, 3/36. The features also introduce the capability for the LED lamp to be used with a dimmer switch. EX1009, 3/36. Because of these features, a POSITA would have recognized that consumers desired convenience and dimmable LED lamps and would have sought to provide those capabilities in the LED lamp described by Li and Ono.

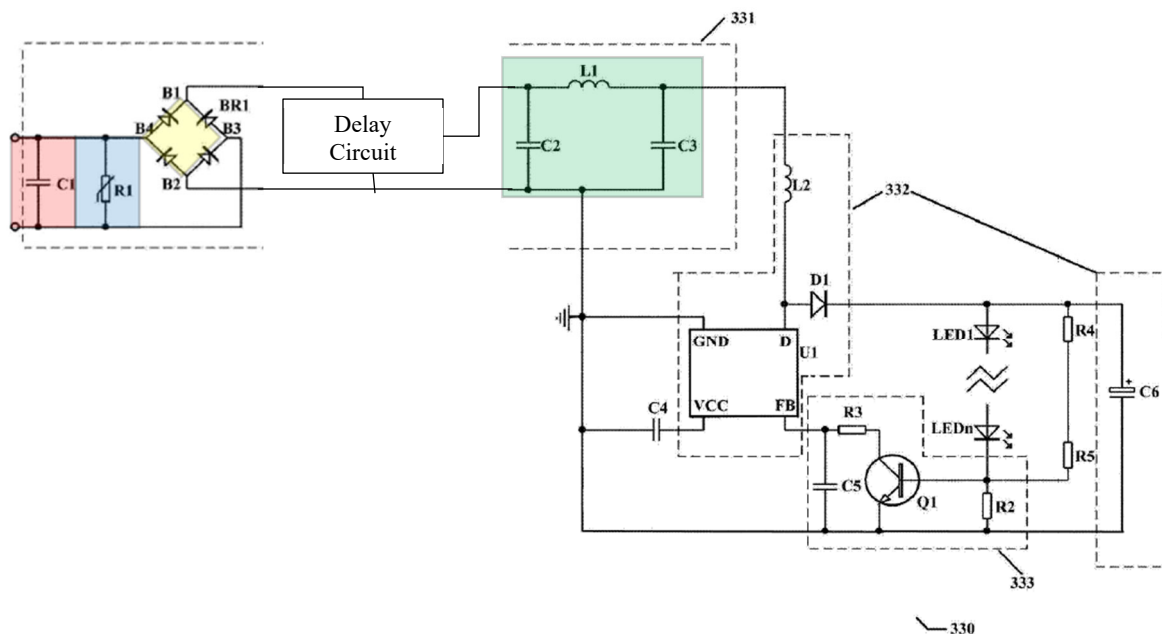
132. When a POSITA incorporated Xu’s delay capability in the Li-Ono LED lamp, the POSITA would have used existing technology to provide capability in LED lamps in a way that was well-known. A POSITA would have been very

familiar with the use of capacitors to create delays in the transmission of current to downstream components. Specifically, once the capacitor was charged to a specific threshold voltage, it might trigger a controller integrated circuit, or merely reach the required voltages to turn on the following driver components. Xu describes its capacitive delay as a “control triggering signal circuit.” EX1009, 5-6/36. A POSITA would have also had significant familiarity with the use of capacitors in conjunction with filtering circuits to further smooth the electricity provided to downstream components. Thus, when a POSITA selected a capacitor to provide an amount of delay of the LED lamp, in my opinion the POSITA would have had a reasonable expectation that such an implementation would be successful to cause a delay before the LED lamp lights up. This is at least because delay circuits were known in the art. In fact, Xu successfully uses a delay circuit in the same field to add a delay in an LED lamp. EX1009, 1/36, 5-6/36.

2. Modification of Li-Ono in view of Xu

133. A POSITA would have modified Li-Ono’s drive circuit to include Xu’s triggering signal circuit 5-3 using a capacitor for a delay before the Li-Ono lamp powers on would leave Li-Ono essentially unchanged, but implement Xu’s capacitive delay in the drive circuit between the output of bridge rectifier BR1 and the filtering circuit formed of C2, C3, and L1.

134. Xu describes a threshold control signal triggering circuit 5-3 that comprises a resistor and capacitor and is located ahead of LED light source assembly 5-4. Circuit 5-3 is additionally connected to the bridge rectifier ahead of filter capacitor C2. EX1009, 6/36, FIG. 5. A POSITA would understand that circuit 5-3 is a delay circuit, indeed Xu describes that the power off delay interval t_1 delay is controlled by capacitor C3 and resistor R4. Thus in light of Xu, a POSITA would have understood that a capacitor located after the rectifiers and ahead of the filter circuit could be used to introduce a turn-on delay into the LED tube lamp.



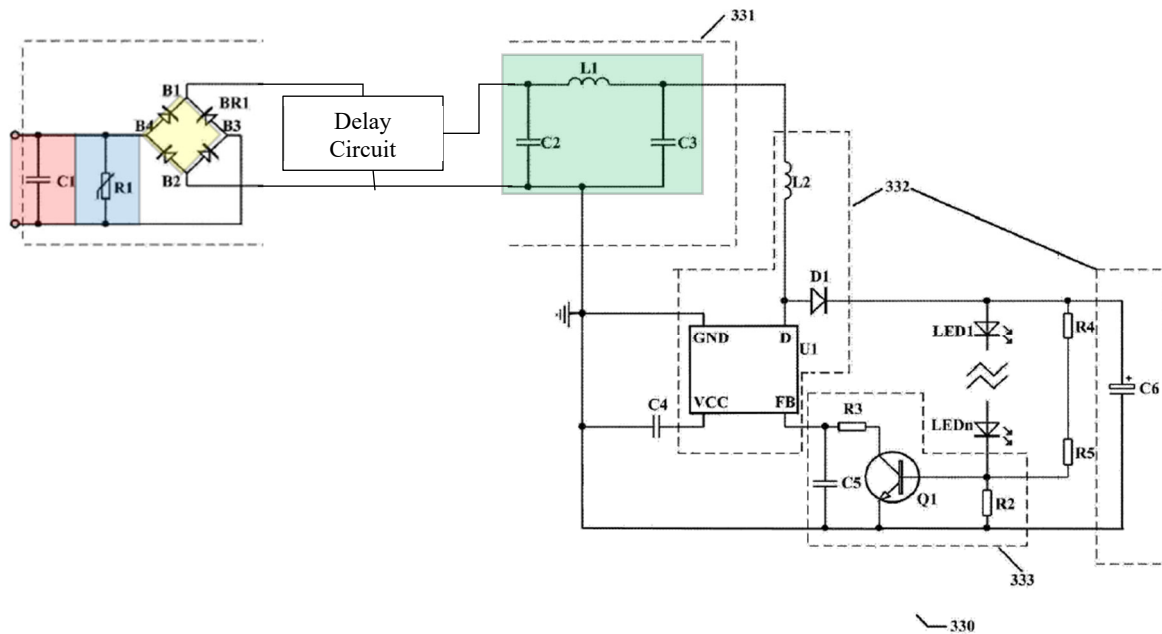
Li FIG. 6
(Modified per Li-Ono-Xu)

3. *Element-by-Element Analysis*

Claim 12: “The LED tube lamp according to claim 1, wherein at least some of the electronic components form a first circuit electrically connected between the rectifying circuit and the filtering circuit and causes a delay before the LED tube lamp lights up.”

135. It is my opinion that the combination of Li, Ono, and Xu renders obvious a circuit between the rectifying and filtering circuits that causes a delay before the LED lamp lights up. As described above, it is my opinion that a POSITA would have been motivated to include the delay circuit described in Xu in the Li-Ono LED lamp to cause a delay before the lamp lights up.

136. Xu teaches that “control triggering signal circuit 5-3” “control[s] the LED light assembly driver 5-4” (*id.*, 6/36, 3/36) and “energize[s] the [LED] light bulb” (*id.*, claims 2, 6). Specifically, the capacitor C3 and/or the resistor R3 introduces a delay. EX1009, 6/36. A POSITA would understand that circuit 5-3 is a delay circuit, indeed Xu describes that the power off delay interval t_1 delay is controlled by capacitor C3 and resistor R4. Further, as I described above a POSITA would have implemented the control triggering signal circuit 5-3 between the output of bridge rectifier BR1 and the filtering circuit formed of C2, C3, and L1 in the Li-Ono LED tube lamp.



EX1005, FIG. 6 (as modified by Xu).

137. The control triggering signal circuit 5-3 creates a delay before the LED lamp lights up because it does not output a sufficient voltage until “the power-off delay interval t_1 ,” which is “adjusted by adjusting the resistance value of R4 and the capacity value of C3.” EX1009, 6/36, FIG. 6. In my opinion, a POSITA would have understood not only that Xu’s capacitor C3 (in conjunction with resistor R4) is the delay circuit, but would have seen that it is connected between the bridge rectifier and filter capacitor C2, as I explained above in Section VIII.B.2. The length of the delay is created by selecting the capacitance of the capacitor C3 (and optionally resistor R4) to create the desired start-up delay.

Claim 13: “The LED tube lamp according to claim 12, wherein the electronic components forming the first circuit comprises a capacitor

configured to be charged when an AC driving signal is provided to the LED tube lamp and cause the LED tube lamp to conduct when voltage of the capacitor exceeds a threshold trigger voltage.”

138. It is my opinion that the combination of Li, Ono, and Xu renders obvious a delay circuit including a capacitor that is charged to a threshold voltage. As described above, it is my opinion that a POSITA would have been motivated to include the control triggering signal circuit 5-3 described in Xu in the Li-Ono LED lamp to implement a delay before the lamp starts up.

139. As explained above in Claim 12, Xu’s capacitor C3 creates a delay before the LED lamp lights up. EX1009, 5-6/36. A POSITA would have understood that a delay is created by charging a capacitor until it reaches a specified voltage, such as a threshold trigger voltage. At this point, the current is allowed to flow through the circuit beyond the capacitor to the LEDs in the LED lamp. In this way, the capacitance of the capacitor acts to control the threshold trigger voltage. In Li-Ono-Xu system, the capacitor C3 outputs a predetermined voltage after a lapse of a predetermined period of time based on the capacitance of the capacitor C3, after which the LED lamp will light up.

Claim 14: “The LED tube lamp according to claim 12, wherein the LED tube lamp is delayed to light up by 0.1 to 3 seconds.”

140. It is my opinion that the combination of Li, Ono, and Xu renders obvious a start-up delay of between 0.1-3 seconds. As described above, it is my opinion that a POSITA would have been motivated to include the control triggering signal circuit 5-3 described in Xu in the Li-Ono LED lamp to implement a delay before the lamp starts up.

141. As explained above in Claim 12, Xu discloses a capacitor C2 that creates a delay, t_1 , before the LED lamp lights up. EX1009, 5-6/36. “ $t_1 = 0.5-2$ seconds.” EX1009, 5/36.

C. Ground 3 - Claim 47 and 77 are Obvious over Li in view of Ono and Guang

1. Motivation to Combine Li, Ono, and Guang

142. For the reasons discussed throughout Ground 1, in my opinion, it would have been obvious to a POSITA to combine Li and Ono. In my opinion, a POSITA would have also been motivated to combine Guang with Li-Ono with a reasonable expectation of success for several reasons.

143. Li teaches pins at both ends of the tube lamp: Li teaches “pins 340A and 340B are arranged at one end of the substrate 310 as a first electrode and a second electrode of the LED drive circuit module 330, respectively (therefore, the pins 340A and 340B are hereinafter also referred to as “electrode pins”). After

assembly, the electrode pins 340A and 340B are electrically connected to the plugs 211A and 211B on the end cover 21.” EX1005, [0100]. Li also teaches “a pair of pins 350A and 350B electrically connected to the plugs 221A and 221B on the end cover 22, respectively, are arranged on the other end of the substrate 310.” EX1005, [0101]. Li further describes a drive circuit module on each end of the tube lamp connected to the pins 340A/340B and 350A/350B, respectively. EX1005, [0100-0101]. But Li describes that “when the electrode pins 340A and 340B are electrically connected to the jacks A and B, respectively, and the pins 350A and 350B are electrically connected to the jacks C and D, respectively, the electrode pin 340A is electrically connected to the live line L and meanwhile, as the pins 350A and 350B located at the other end of the substrate 310 are shorted.” EX1005, [0105].

144. In my opinion, a POSITA would have understood that different types of lamp holders existed and it would have been desirable to have both ends of the LED lamp able to receive power. EX1007, 8:57-67 (referring to Figure 2 “showing how power can be supplied through either or both pairs of electrode pins”). Therefore, a POSITA would have been motivated to include two full-wave bridge rectifying circuit, like what is disclosed in Guang, to receive and rectify power from both sets of conductive pins rather than just one. This would provide that the replacement LED lamp would be operable in the lamp holder no matter the orientation of the LED lamp.

145. A POSITA could have recognized the benefits provided by Guang by incorporating aspects of Guang's power management circuitry into the Li-Ono lamp.

Specifically:

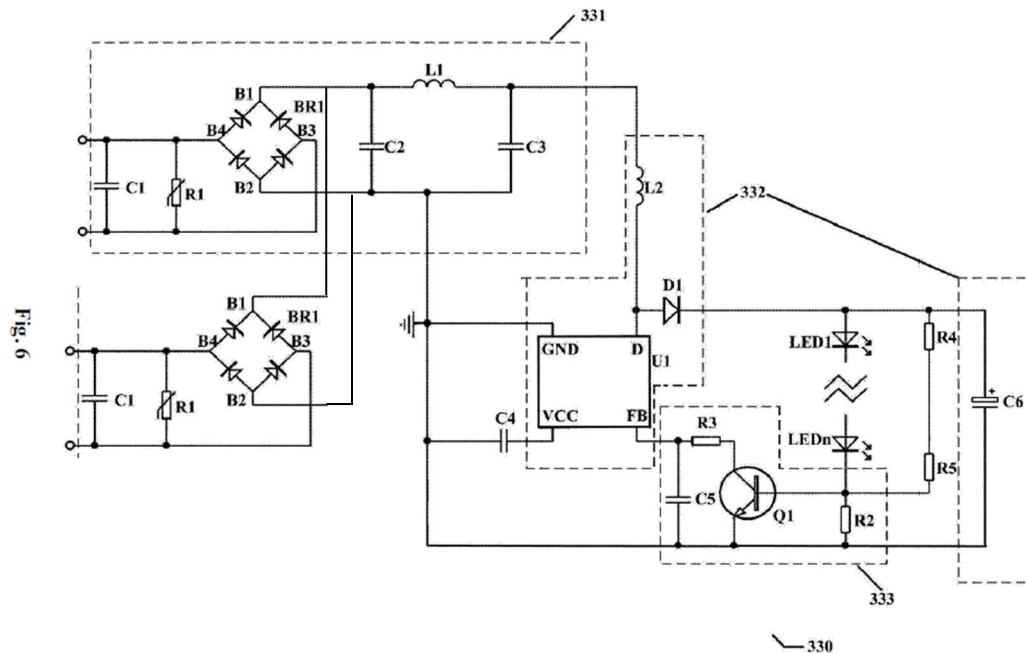
Either end of the Fluorescent Compatible LED Tube Lamp 10 can be plugged into either end of a fluorescent fixture having a tube to be replaced. The driver circuit is versatile in handling a variety of electrical current conditions present among various fluorescent lamp fixtures. It doesn't matter to the driver circuit shown in FIG. 2 whether the socket is shunted or Non-shunted. It also does not matter to the driver circuit shown in FIG. 2 whether any particular one of the various fluorescent lamp fixtures into which the Fluorescent Compatible LED Tube Lamp 10 might be plugged, has a ballast delivering modified AC current to the socket, whether there is bare line voltage (e.g. 110V AC) present at the socket, or whether there is an AC-DC transformer already wired into the fixture for a previous LED conversion. The arrangement of eight diodes D7 to D14 of the rectifier circuits 38a and 38b ensures that when power is input from any two of the electrode pins, four of the eight diodes will operate to pass DC current to the filter circuit 40, whether it is DC or AC power that is input from the electrode pins. The arrangement of eight diodes of the rectifier circuit, as shown in FIG. 2, allows that the electrode pins from which the input power is received can be any two of the tube's four electrode pins, that is, the input power can be from an electrode pin on one end of the tube in conjunction with another pin on the other end of the tube completing the input power circuit, or input power can be from an electrode pin on one end of the tube and with the other pin of the pair on the same end of the tube completing the input power circuit.

EX1007, 9:51-10:11. A POSITA would have understood that by integrating the diodes from Guang's rectifier circuit into the Li-Ono lamp by placing a full-wave bridge rectifier circuit at each set of conductive pins, the compatibility of the LED lamp with conventional lamp holders would have been increased.

146. Further, because Li already discloses a full-wave bridge rectifier circuit, BR1, in the drive power module, a POSITA would have expected that including a second full-wave bridge rectifier circuit at a second set of pins would be successful because to do so was an implementation of known components already existing in the drive power module in exactly the same way, just at a different location. In fact, Guang itself successfully implemented two full-wave bridge rectifier circuits in an LED lamp. EX1007, 9:2-21. No other changes to the circuit would be required as both full-wave bridge rectifier circuits are connected to the downstream portions of the drive circuit, i.e., the filtering circuit, DC-DC boost conversion unit 332, and feedback unit 333.

2. Modification of Li-Ono in view of Guang

147. In my opinion, the modification of Li-Ono to include Guang's two full-wave bridge rectifying circuits would duplicate the single full-wave bridge rectifying circuit of Li for both sets of conductive pins located on opposite sides of the LED tube lamp.



Li FIG. 6
(Modified per Li-Ono-Guang)

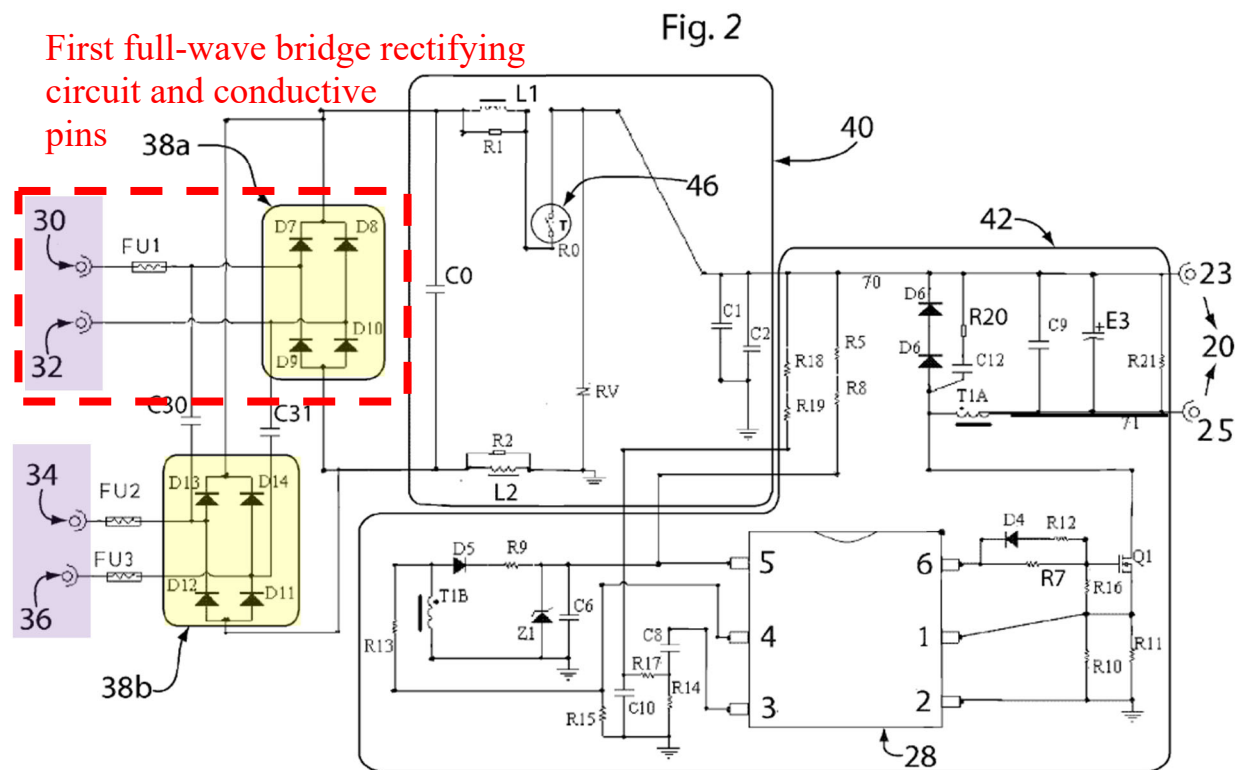
EX1005, FIG. 6; EX1007, FIG. 2.

3. *Element-by-Element Analysis*

Limitation 47[a]: “The LED tube lamp according to claim 4, wherein the rectifying circuit comprises: a first full-wave bridge rectifying circuit, having two input terminals electrically connected to the two conductive pins of one of the end caps, respectively, and having a positive output terminal and a negative output terminal; and”

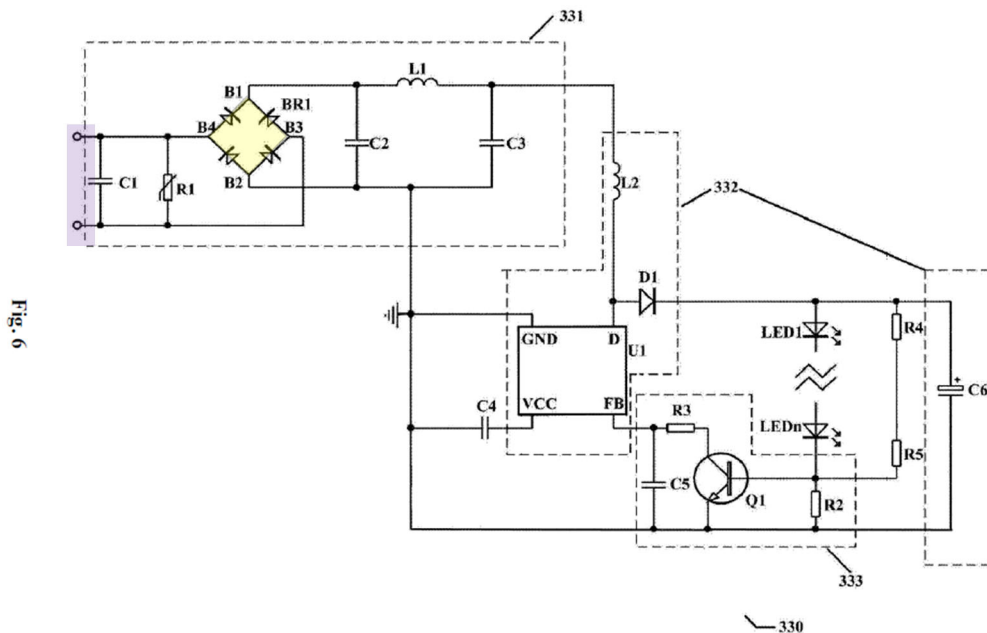
148. It is my opinion that the combination of Li, Ono, and Guang renders obvious a first full-wave bridge rectifying circuit, with positive and negative output terminals, connected to one set of conductive pins. Guang describes “[e]ach of the

[yellow] first and second rectifier circuits 38a and 38b has four diodes, which each pass electrical current in only one direction. The first and second rectifier circuits are connected in parallel as shown. Any AC current arriving via [purple] electrode pins 30 and 32 is converted to DC by diodes D7 and D8 alternately. If AC current arrives via [purple] electrode pins 34 and 36 the current is converted to DC by diodes D13 and D14 alternately.” EX1007, 9:28-35.



EX1007, 9:2-8, FIG. 2. Full-wave bridge rectifying circuit 38a has positive and negative output terminals. EX1007, 9:39-50.

149. Li also discloses a [yellow] full-wave bridge rectifying circuit, BR1, connected to a [purple] set of conductive pins, and has output positive terminal B1 and output negative terminal B2. EX1005, [0113].



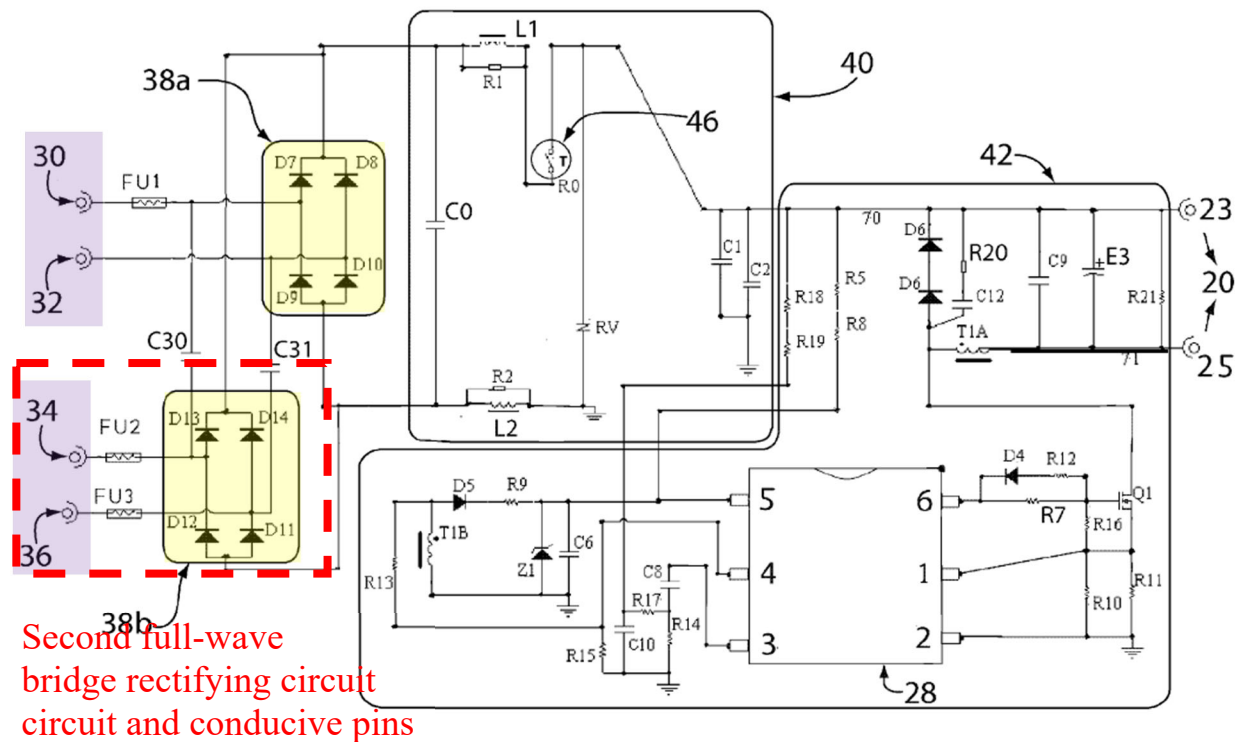
EX1005, FIG. 6.

Limitation 47[b]: “a second full-wave bridge rectifying circuit, having two input terminals electrically connected to the two conductive pins of the other one of the end caps, respectively, and having a positive output terminal and a negative output terminal,”

150. It is my opinion that the combination of Li, Ono, and Guang renders obvious a second full-wave bridge rectifying circuit, with positive and negative output terminals, connected to the other set of conductive pins. While Li does not disclose a second full-wave bridge rectifying circuit, Li does disclose a second set

of conductive pins. EX1005, [0101]. And as I explained above, it would have been obvious to a POSITA to include Guang's second full-wave bridge rectifying circuit connected to Li's second set of conductive pins. Specifically, Guang describes "[e]ach of the [yellow] first and second rectifier circuits 38a and 38b has four diodes, which each pass electrical current in only one direction. The first and second rectifier circuits are connected in parallel as shown. Any AC current arriving via [purple] electrode pins 30 and 32 is converted to DC by diodes D7 and D8 alternately. If AC current arrives via [purple] electrode pins 34 and 36 the current is converted to DC by diodes D13 and D14 alternately." EX1007, 9:28-35.

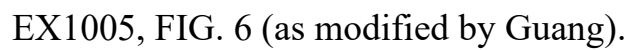
Fig. 2



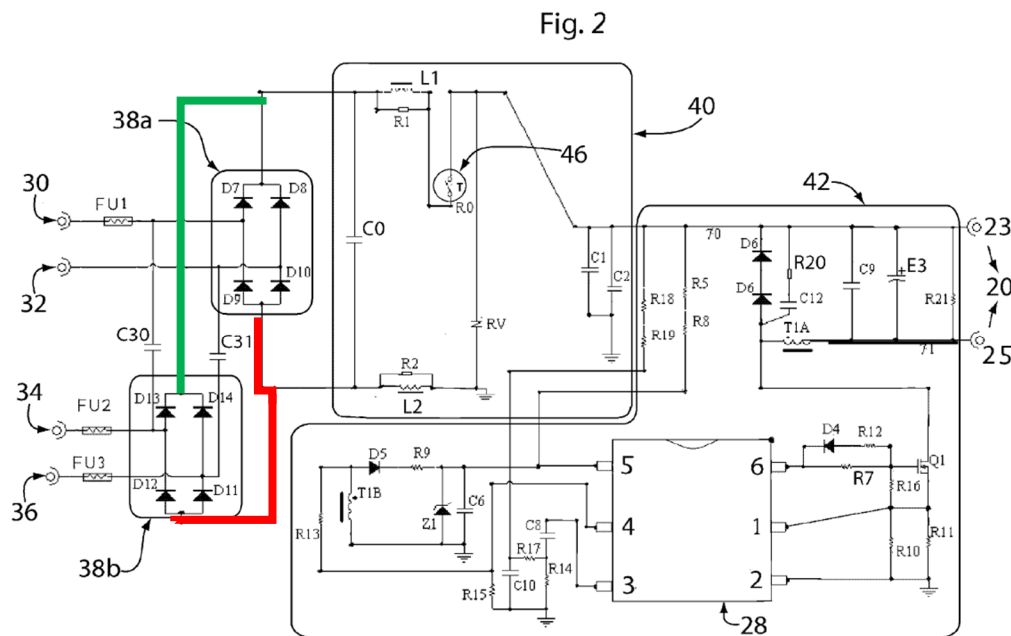
EX1007, 9:2-8, 9:28-30, 9:39-50, FIG. 2.

Limitation 47[c]: “wherein the positive output terminals of the first and the second full-wave bridge rectifying circuits are electrically connected to each other, and the negative output terminals of the first and the second full-wave bridge rectifying circuits are electrically connected to each other.”

151. It is my opinion that the combination of Li, Ono, and Guang renders obvious a circuit where the positive output terminals of the two full-wave bridge rectifying circuits are electrically connected and the negative output terminals of the two full-wave bridge rectifying circuits are electrically connected. In the Li-Ono-Guang system, the [green] positive output terminals of both full-wave bridge rectifying circuits are connected to the part of the circuit near inductor L1 and capacitor C2. The [red] negative output terminals are connected in close proximity to capacitor C2.



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EX1007, FIG. 2.

Limitation 77[a]: “The LED tube lamp according to claim 30, wherein the rectifying circuit comprises: a first full-wave bridge rectifying circuit, having two input terminals electrically connected to two conductive pins of one of the first and the second end caps, respectively, and having a positive output terminal and a negative output terminal; and”

153. It is my opinion that the combination of Li, Ono, and Guang describes a first full-wave bridge rectifying circuit, with positive and negative output terminals, connected to one set of conductive pins. *See* Limitation 47[a].

Limitation 77[b]: “a second full-wave bridge rectifying circuit, having two input terminals electrically connected to two conductive pins of the other

one of the first and the second end caps, respectively, and having a positive output terminal and a negative output terminal,”

154. It is my opinion that the combination of Li, Ono, and Guang describes a second full-wave bridge rectifying circuit, with positive and negative output terminals, connected to the other set of conductive pins. *See* Limitation 47[b].

Limitation 77[c]: “wherein the positive output terminals of the first and the second full-wave bridge rectifying circuits are electrically connected to each other, and the negative output terminals of the first and the second full-wave bridge rectifying circuits are electrically connected to each other.”

155. It is my opinion that the combination of Li, Ono, and Guang describes a circuit where the positive output terminals of the two full-wave bridge rectifying circuits are electrically connected and the negative output terminals of the two full-wave bridge rectifying circuits are electrically connected. *See* Limitation 47[c].

D. Ground 4 - Claims 84-86 are Obvious over Li in view of Ono and Zhang

1. Motivation to Combine

156. For the reasons I discussed throughout Ground 1, in my opinion, it would have been obvious to combine Li and Ono. It is also my opinion that a POSITA would have also been motivated to combine Zhang with Li-Ono with a reasonable expectation of success for several reasons.

157. Li describes that its LED lamp solves the drawbacks of incompatible of LED lamps with existing fluorescent lamp fixtures. EX1005, [0004-0005]. As I explained above, fluorescent light fixtures included ballasts. Therefore, a POSITA would have understood that one way to increase the compatibility of LED lamps with fixtures for conventional fluorescent lamps is to ensure that the LED lamp can work with ballasts included in these fixtures. A POSITA would have known that light fixtures often include ballasts used for preheating before the lamp is started. *See* EX1007, 2:41-45. When a POSITA replaced a traditional fluorescent lamp with an LED lamp, if the light fixture is not modified, the lack of filament in the LED lamp may have caused the ballast in the light fixture to erroneously determine that filaments are open-circuited or short-circuited during the pre-heating process. Because Li-Ono has the goal of increasing the compatibility of LED lamps with conventional light fixtures, a POSITA would have been motivated to solve the problem created by the absence of a filament in the LED lamp when such a lamp was installed in a conventional light fixture. In my opinion, a POSITA would have been motivated to combine Li-Ono with Zhang because doing so would have ensured that the Li-Ono LED lamp was compatible with conventional light fixtures. This would have been the case because the LED lamp would simulate the load that would typically be generated by a conventional light bulb.

158. Zhang describes that “some fluorescent lighting ballasts may be configured to detect the state of an attached lamp by monitoring the AC and/or DC impedance between terminals of pins connected to the ends of the filament, and may shut down the ballast if the impedance indicates a failed/failing lamp.” EX1014, 4:46-51. Therefore, Zhang teaches that “[t]he filament-imitating impedance may mimic the impedance of a healthy filament under such monitoring and, therefore, may prevent unwanted shutdown.” *Id.*, 4:51-54.

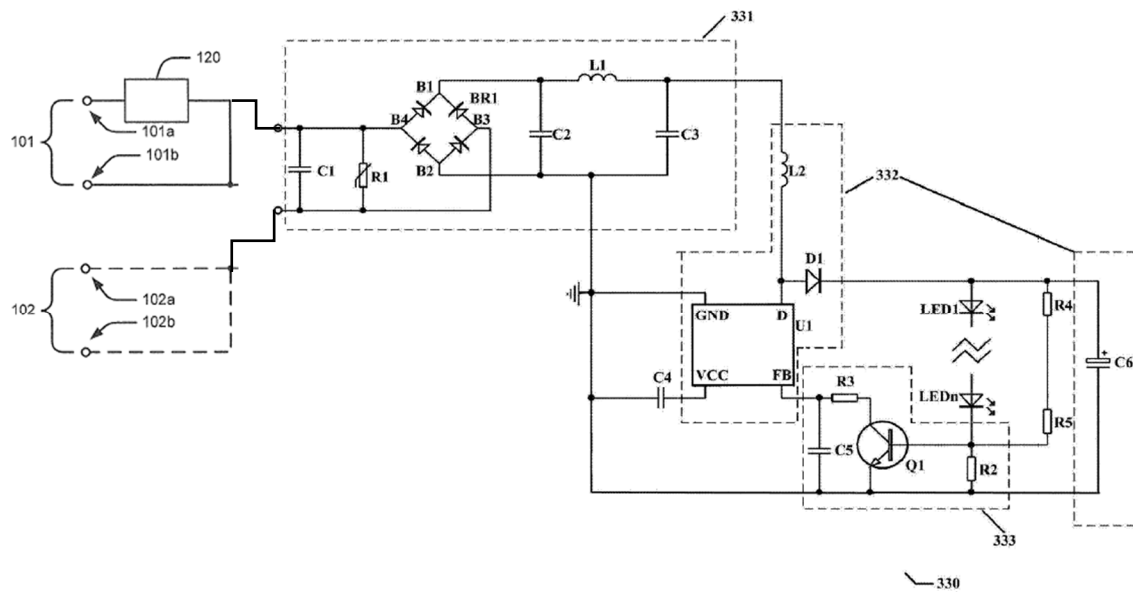
159. Therefore, Li and Zhang are directed to solving the same problem of using an LED tube lamp in an existing ballast using a similar power supply structure. A POSITA would have readily looked to both when searching for a solution. Because Li does not explicitly describe the structure of a filament-simulating circuit that could be implemented on the power supply PCB, a POSITA would have been motivated to look for examples of filament-simulating circuits for LED tube lamps to see how others had approached the design of said circuits in the past.

160. Zhang describes one such approach. EX1014, 5:11-20, FIG. 4. Zhang discloses a capacitor connected to each input pin pair. EX1014, 5:18-20, FIG. 4. The capacitor acts to simulate the presence of a filament in the LED lamp. EX1014, 4:59-5:3. Therefore, a POSITA would have been motivated to include this capacitor in Li-Ono and a POSITA would have had a reasonable expectation of success because the modification would have been the implementation of known

components, resistors and capacitors, in a conventional way to achieve conventional results. Filament-simulating circuits were well known, as described by Zhang, and it is my opinion that a POSITA would have been readily able to add such a circuit to the existing drive circuit of Li-Ono. Zhang already demonstrated to a POSITA that filament-simulating circuits could successfully be implemented in LED lamps. EX1014, Abstract, 2:23-33.

2. Modification of Li-Ono in view of Zhang

161. In my opinion, a POSITA would have modified Li-Ono such that it included a filament-simulating circuit, as described by Zhang, to add filament-simulating capability to Li-Ono's circuitry between the inputs to the Li-Ono drive circuit and the conductive pins in the end caps of the LED lamp. This modification would prevent compatibility problems when the LED lamp is used in a conventional light fixture.



Li FIG. 6
(Modified per Li-Ono-Zhang)

3. *Element-by-Element Analysis*

Claim 84: “The LED tube lamp according to claim 30, wherein at least some of the electronic components form a filament-simulating circuit configured to conduct current during a preheat process when the LED tube lamp is powered by a ballast.”

162. It is my opinion that the combination of Li, Ono, and Zhang renders obvious a filament-simulating circuit configured to conduct current during a preheat process when the LED lamp is powered by a ballast. As I described above, it is my opinion that a POSITA would have been motivated to include the filament-

simulating circuit described in Zhang in the Li-Ono LED lamp to improve the compatibility of the LED lamp with conventional light fixtures.

163. In Zhang, the filament-simulating circuit 120 is connected to the input terminals 101 of the LED lamp, as shown in the figure below.

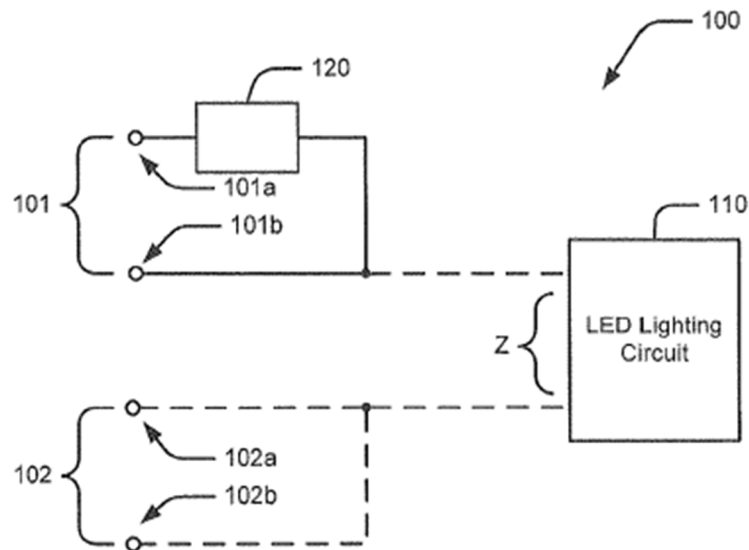


FIG. 1

Id., 4:27-28, FIG. 1.

164. Zhang discloses an LED lighting apparatus that “includes at least one ballast connection port 101 including first and second terminals 101a and 101b. The terminals 101a and 101b may comprise, for example pins that are configured to be connected to a fluorescent lamp connector (e.g. a tombstone connector) that provides electrical coupling to a fluorescent lighting ballast.” EX1014, 4:17-27, FIG. 1. A POSITA would have understood that these terminals coincide with the end terminals

of an LED replacement tube lamp designed to fit into a fluorescent light fixture which commonly utilize tombstone connectors at each end. Zhang further discloses this usage by disclosing that the apparatus “may also include a second port 102 with similar terminals 102a, 102b for use in, for example, bi-pin fluorescent tube replacement applications. *Id.*, 4:24-26. Thus a POSITA would further understand that terminals 101a and 101b would correspond to the pin terminals at one end of a replacement LED tube lamp, and that terminals 102a and 102b would correspond to the pin terminals at the other end of a fluorescent replacement LED tube lamp. This is further supported by Zhang in Fig 17, which “illustrates a fluorescent tube replacement lamp” which includes a “tubular housing 1710 which includes a translucent portion 1710 and end caps 1720” and “first and second ballast connection ports located respective ends of the housing 1710.” Zhang further discloses that the “first ballast connection port includes pins 1701a, 1701b and the second ballast connection port 1702 includes pins 1702a, 1702b.” and further comprises a string of LED lights on a substrate positioned within housing 170 and coupling circuitry 1750 which connect the LEDS to the port pins and “may include filament-imitating impedances, a low frequency blocking impedance, a rectifier circuit and a resonant matching circuit.” EX1014, 8:1-16, FIG. 17.

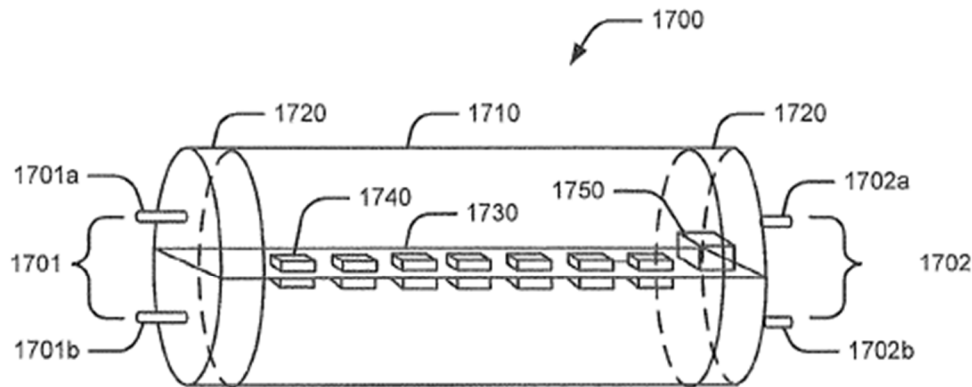


FIG. 17

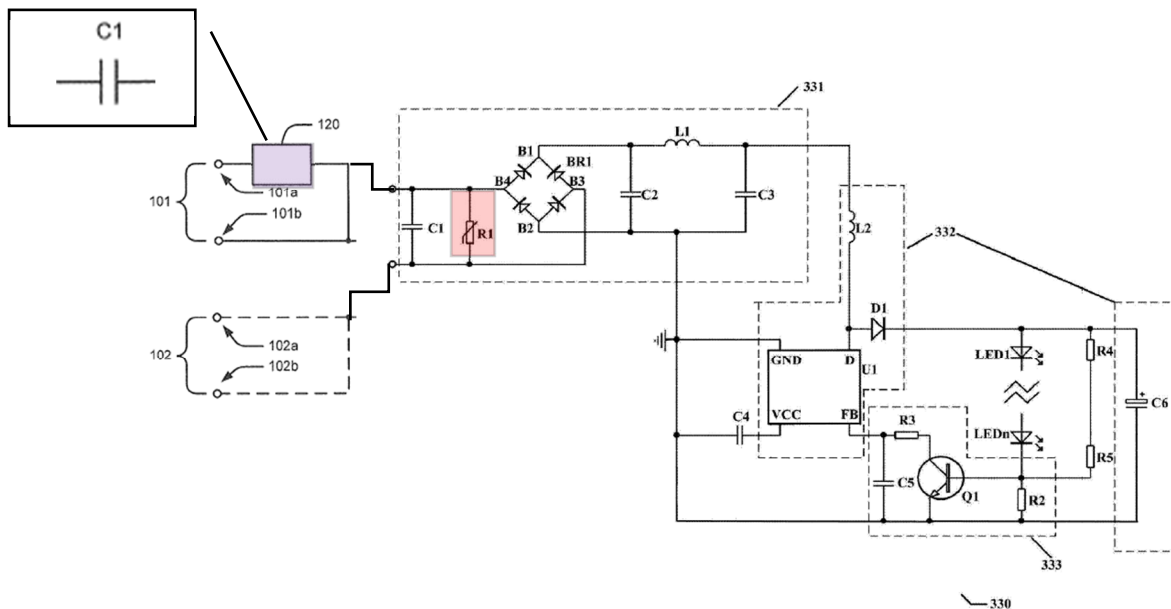
165. In one embodiment of the invention, Zhang discloses “a filament imitating impedance 120 [that] is coupled between first and second terminals 101a, 101b”, and that is further coupled to “LED lighting circuit 110 (which may include one or more LEDS and associated circuitry for driving the same” EX1014, 4:27-31, FIG. 1. Zhang further describes that “the filament-imitating impedance 120 is configured to provide and impedance mimics behavior of the filament of a fluorescent lamp.” *Id.*, 4:36-38. A POSITA would have understood that the ballast performs a filament test at start-up as part of its process to provide current and preheat the lamp.

166. Therefore, in my opinion, the filament-imitating impedance forms a filament-simulating circuit that conducts current during a preheat process while the LED lamp is powered by different types of ballast.

Claim 85: “The LED tube lamp according to claim 84, wherein the filament-simulating circuit comprises: a second capacitor, coupled between the two conductive pins of one of the first and the second end caps.”

167. It is my opinion that the combination of Li, Ono, and Zhang renders obvious a filament-simulating circuit configured to conduct current during a preheat process when the LED lamp is powered by a ballast. As I described above, it is my opinion that a POSITA would have been motivated to include the filament-simulating circuit described in Zhang in the Li-Ono LED lamp to improve the compatibility of the LED lamp with conventional light fixtures.

168. In the combined Li-Ono-Zhang system, the [red] capacitor C1 corresponds to the [first] capacitor of independent claim 30, which claims, in part, “a capacitor which is positioned closest to the end wall of the first end cap.” Additionally, the input includes a [purple] filament-imitating impedance 120. “[A] filament-imitating impedance may take the form of a [second] capacitor C1 coupled to the first and second terminals 101a, 101b.” EX1014, 4:59-62, FIG. 2.

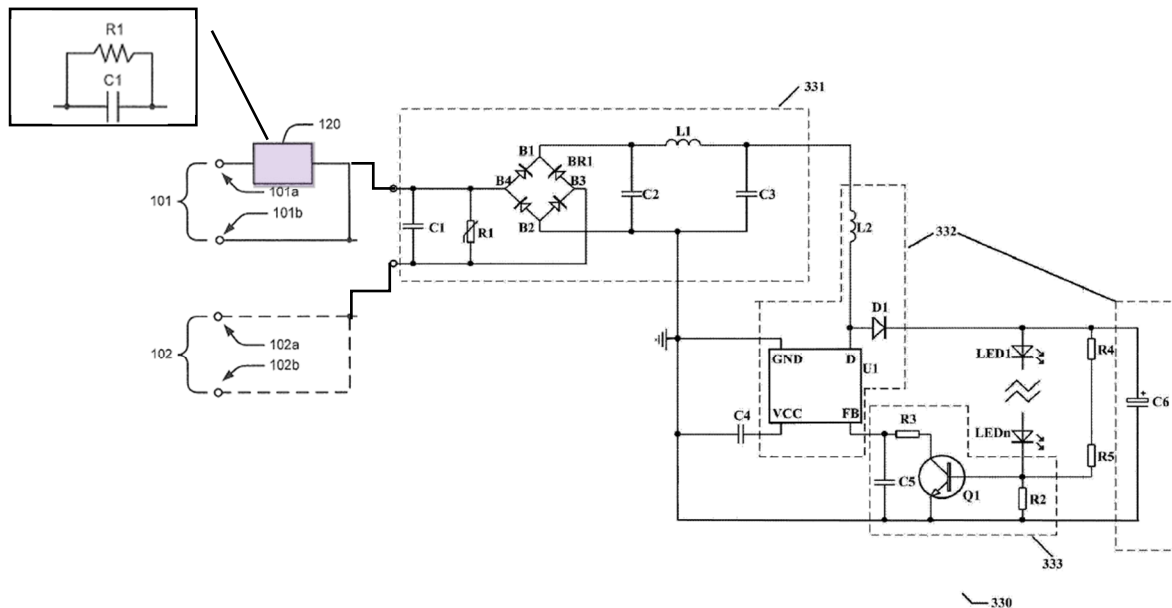


EX1005, FIG. 6; EX1014, FIGs. 1-2.

Claim 86: “The LED tube lamp according to claim 85, wherein the filament-simulating circuit further comprises: a resistor, coupled to the second capacitor in parallel.”

169. It is my opinion that the combination of Li, Ono, and Zhang renders obvious a filament-simulating circuit including a resistor coupled in parallel to the second capacitor. As I described above, it is my opinion that a POSITA would have been motivated to include the filament-simulating circuit described in Zhang in the Li-Ono LED lamp to improve the compatibility of the LED lamp with conventional light fixtures.

170. In the combined Li-Ono-Zhang system, in my opinion, the [purple] capacitor C1 forms part of the claimed filament-simulating circuit in the drive circuit module. EX1014, FIG. 4. Additionally, the input includes a [purple] filament-imitating impedance 120. A filament-imitating impedance may “include[] a capacitor C1 and a resistor R1 connected in parallel with the capacitor C1” and coupled to the first and second terminals 101a and 101b. EX1014, 5:35-38, FIG. 7.



EX1005, FIG. 6; EX1014, FIGs. 1, 7.

E. Ground 5 - Claims 5, 6, and 31 are Obvious over Li in view of Ono and Halliwell

1. Motivation to Combine

171. For the reasons I discussed throughout Ground 1, in my opinion, it would have been obvious to combine Li and Ono. It is also my opinion that a

POSITA would have also been motivated to combine Halliwell with Li-Ono with a reasonable expectation of success for several reasons.

172. Li describes that “[a]nother objective of the present invention is to provide an installation method of the foregoing LED fluorescent lamp which has an advantage of simple installation.” EX1005, [0032]. Li further describes components, such as the drive circuit located in the end caps and that, during assembly, the end caps are bonded to the tube body of the LED lamp. EX1005, [0092], [0100].

173. A POSITA would have understood that if the end caps on the LED tube lamp have features that extend into the tube, such as a plug or components in the end cap, when the LED lamp is assembled, these features reduce the interior volume of the tube as the end caps are attached to the end of the tube. This is the case with Li. Thus, it is necessary to allow air within the tube to escape during assembly to avoid compressing the interior air to a higher pressure, potentially reducing the reliability of the tube lamp. Thus, a POSITA would have been motivated to look to other solutions for preventing the Li-Ono LED lamp from suffering from a build-up of pressure inside the tube lamp. One skilled in the art would further have understood that a hole in the end cap would contribute to heat transfer by convection between the inside of the tube and the outside, although the amount of heat transfer would be determined by the size and shape of the hole.

174. A POSITA would have been well versed in the importance of equalizing the pressure within the long tube of the LED lamp so that the internal pressure equals the external pressure to prevent damage to the lamp. When the LEDs in an LED lamp are lit, the LEDs generate heat and pressure builds up inside an LED lamp. This increase can, if not addressed, result in a pressure imbalance between the interior of the tube and the ambient pressure outside the tube. If the pressure is allowed to continue to build, the pressure imbalance could result in damage to the lamp. This damages could include shattering the lamp tube, or popping off one or both end caps.

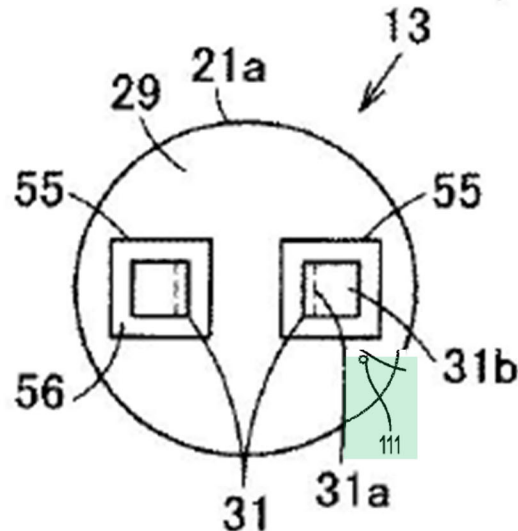
175. For example, a POSITA would have been motivated to look to a reference like Halliwell which discloses small hole 111 in the end of end cap 11, such that “hole 111 acts to allow the pressure within the tube to maintain a pressure substantially equal to the ambient air pressure.” EX1015, 8:66-9:1; FIG. 18. A POSITA would additionally have understood that the use of a larger single hole or multiple small holes would have the same beneficial effect in balancing the air pressure inside and outside the tube lamp. A POSITA would also understand that the use of single or multiple small holes could be beneficial in providing cooling air flow between the interior and exterior of the tube lamp.

176. Additionally, a POSITA would have been familiar with the use of vents to provide air flow through an LED lamp to equalize the pressure between the inside

of the lamp and the outside of the lamp. *See, e.g.*, EX1012, [0037], FIGS. 1 and 3. Because Halliwell describes a hole 111 in each end cap, a POSITA would have recognized that Halliwell's hole 111 would have provide air flow through the LED lamp and would have been motivated to improve Li-Ono with at least one hole, in addition to Ono's openings 55 to improve air flow in the LED lamp. EX1015, 8:61-63, FIG. 18. A POSITA would have been motivated to modify Li-Ono's LED lamp to include a small hole in the end cap described by Halliwell because venting for improved pressure equalization was well known and such a modification would have been a straight-forward implementation of known technology. It would have been obvious to a POSITA to try the hole described in Halliwell with Li-Ono's LED lamp to because in doing so, a POSITA would have expected this implementation to be successful based on the stability of the technology and Halliwell's implementation of the solution in its LED lamp.

2. Modification of Li with Ono and Halliwell

177. The Li-Ono-Halliwell LED lamp includes Ono's end cap as modified with the addition of Halliwell's [green] hole 111.

[Fig. 8]

Ono FIG. 8
(Modified per Li-Ono-Halliwell)

EX1006, FIG. 8; EX1015, FIG. 18.

3. Element-by-Element Analysis

Claim 5: “The LED tube lamp according to claim 1, wherein the end wall comprises at least one opening.”

178. It is my opinion that the combination of Li, Ono, and Halliwell renders obvious an opening in the end wall. As described above in Ground 1, Li-Ono discloses all limitations of Claim 1. Additionally, it is my opinion that Li-Ono teaches an opening in the end wall. However, to the extent that the patent owner may argue that Li-Ono does not disclose the claimed “opening” in the end wall,

Halliwell discloses such an opening. As I explained above, a POSITA would have been motivated to look to other LED lighting references, such as Halliwell, to determine potential designs for increasing air flow through the LED lamp.

179. Halliwell describes an LED lamp tube that includes “at least one end cap 11 [that] may comprise a small hole 111 on the end of the end cap 11.” EX1015, 8:61-9:1.

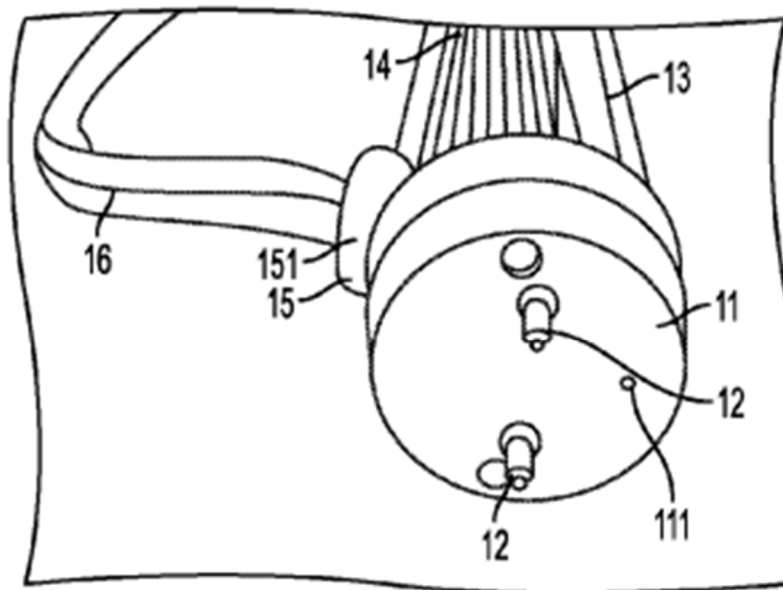


FIG. 18

EX1015, FIG. 18. As I explained above, Halliwell’s hole 111 is incorporated into the Li-Ono-Halliwell end cap.

Claim 6: “The LED tube lamp according to claim 5, wherein the resistor is positioned closest to the opening.”

180. It is my opinion that the combination of Li, Ono, and Halliwell renders obvious an opening in the end wall. As described above in Ground 1, Li-Ono discloses all limitations of Claim 1. Additionally, as I explained above, a POSITA would have been motivated to look to other LED lighting references, such as Halliwell, to determine potential designs for increasing air flow through the LED lamp.

181. A POSITA would have understood the AC input of the drive circuit to be the conductive pins in the end wall. Therefore, components closest to the conductive pins are also closest to the openings because both the conductive pins and the hole are in the end wall.

182. While in Figure 6, C1 is illustrated closer to the circuit inputs, because C1 and R1 are connected in parallel, it is my opinion that the locations of C1 and R1 can be reversed without changing the functionality of the circuit disclosed in Li. Therefore, it is my opinion that Li discloses that R1 is located closest to the end wall of the end cap.

183. My opinion that the location of the varistor R1 is closest to the end wall of the end cap is confirmed by Ono. Ono describes that “[t]he lighting circuit 24 has a circuit board 39 on which a plurality of electronic components 38 have been

mounted. Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39, and surface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.” EX1006, [0017]. Ono’s resistors are located on the bottom side (e.g., the wiring pattern surface) of the PCB 39. EX1006, [0017] (“[S]urface mounted components such as resistors and switching elements are mounted on the wiring pattern surface.”). Ono’s capacitors are located on the top of the PCB 39 (e.g., the mounting surface). EX1006, [0017] (“Lead components such as capacitors and inductors are mounted on the mounting surface of the circuit board 39”). Therefore, when Li’s drive circuit is implemented in a PCB as described by Ono, the capacitor C1 is mounted on the top of the PCB and varistor R1 is mounted on the bottom and a POSITA would have understood that both the capacitor C1 and the varistor R1 are located closest to the end wall of the end cap.

184. Further, a POSITA would have understood that resistors are heat generating circuit elements. Therefore, it would have been obvious for a POSITA to place the resistor closest to the end cap such that heat would be efficiently dissipated through heat dissipating functions in the end caps, such as ventilating holes. This placement would cool the resistor as well as minimize the effects of the resistor heating up other components on the PCB. Thus, it would have been obvious

to a POSITA to locate the (heat generating) resistor closest to the opening in the end cap and improve the lifespan of the LED lamp

Claim 31: “The LED tube lamp according to claim 30, wherein the end wall comprises at least one opening.”

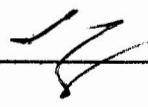
185. It is my opinion that the combination of Li, Ono, and Halliwell describes an end wall comprising at least one opening. *See* Claim 5. And as described above in Ground 1, Li-Ono discloses all limitations of Claim 1.

IX. CONCLUSION

186. All statements made herein of my own knowledge are true, all statements made herein on information and belief are believed to be true, and these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

December 14, 2022

Date


Donald E. Ackley, Ph.D.