

UNITED STATES PATENT AND TRADEMARK OFFICE

**BEFORE THE PATENT TRIAL AND APPEAL BOARD
CURRENT LIGHTING SOLUTIONS, LLC**

PETITIONER

v.

**JIAXING SUPER LIGHTING ELECTRIC
APPLIANCE CO., LTD.**

PATENT OWNER

**IPR2023-00979
PATENT 11,112,068**

DECLARATION OF R. JACOB BAKER, PH.D., P.E.

TABLE OF CONTENTS

I.	PROFESSIONAL BACKGROUND.....	1
A.	Industry Experience	2
B.	Academic Experience.....	6
C.	Other Relevant Experience.....	8
II.	COMPENSATION.....	9
III.	LEGAL CONSIDERATIONS.....	9
A.	Obviousness	9
B.	Claim Interpretation	10
C.	POSITA.....	11
IV.	BASIS FOR OPINIONS	13
V.	FIELD OF TECHNOLOGY.....	13
A.	LED Tube Lamps.....	13
B.	LED Light Strips	16
C.	Reflective Solder Resists.....	22
D.	LED Power Supplies	24
E.	Use of Soldering Pads to Connect LED Arrays to Power Supplies	28
F.	Soldering Techniques.....	30
VI.	THE '068 PATENT.....	40
A.	Overview of the '068 Patent.....	40
1.	LED Tube Lamp Replacements	42
2.	Issues with LED Tube Lamps	43
3.	Summary of Alleged Invention of the '068 Patent.....	43
B.	Interpretation of Certain Terms Used in the '068 Patent.....	45
1.	“electrically connected/coupled”	45
2.	“attached to an inner circumferential surface of the lamp tube”	45
3.	“adjacent to the two first openings”	46

VII.	ANALYSIS OF PRIOR ART TO THE '068 PATENT	46
A.	Takahashi	46
B.	Shimasaki.....	55
C.	Levante.....	60
1.	It Would Have Been Obvious to Modify Takahashi's LED Tube Light to Utilize Shimasaki's Resist Layer with Openings for LED Light Sources and Solder Pads.	64
2.	It Would Have Been Obvious to Solder Takahashi's LED light strip to the Power Supply PCB using Levante's soldering technique.	73
D.	Gu.....	82
1.	It Would Have Been Obvious to Include Gu's Soldering Pads on the Power Supply Module of Takahashi-Shimasaki-Levante.	84
E.	Jing.....	90
1.	It Would Have Been Obvious to Attach the LED Light Strip of Takahashi-Shimasaki-Levante to an Inner Circumferential Surface of the Lamp Tube with an Adhesive as Taught by Jing	94
F.	Takigami	96
1.	A POSITA Would Have Been Motivated to Combine Takigami's Third Openings and Recognizing Marks into LED Tube Lamps.....	100
2.	It Would Have Been Obvious to Use a Third Opening in a Resist Layer Like Takigami's in the Modified Tube Lamp.....	101
3.	It Would Have Been Obvious Use a Recognizing Mark Like Takigami's in the Modified Tube Lamp	107
XVII.	CONCLUSION	112

LIST OF DOCUMENTS CONSIDERED

Exhibit	Shorthand	Description
1001	'068 Patent	U.S. Patent No. 11,112,068
1002	Baker	Declaration of R. Jacob Baker, Ph.D.
1003	Appendix B	CV of R. Jacob Baker, Ph.D.
1004	'068 Prosecution History	Prosecution History of U.S. Patent No. 11,112,068
1005	Takahashi	U.S. Patent No. 9,271,354
1006	Shimasaki	U.S. Patent No. 8,833,965
1007	Levante	U.S. Patent No. 9,057,504
1008	Takigami	U.S. Patent No. 6,365,841
1009	Jing	Chinese Patent No. CN203036295U to Jing Certified Translation
1010	Gu	Chinese Patent App. Pub. No. CN103672530A to Gu Certified Translation
1011	Wilcox	U.S. Patent No. 9,726,330
1012	Luk	U.S. Patent No. 6,846,094
1013	Demuynck	U.S. Patent No. 9,328,874
1014	Kamada	U.S. Patent No. 7,948,001
1015	Sato	Japanese Patent App. Pub. No. JP2010-153549 to Sato Certified Translation
1016	Guang	U.S. Patent No. 9,338,853
1017	Van Der Wel	U.S. Patent No. 9,146,017
1018	Bisberg	U.S. Patent No. 8,558,255
1019	Nakamura	U.S. Patent No. 6,331,891
1020	Kawabata	U.S. Patent No. 8,591,057
1021	Kawashima	U.S. Patent App. Pub. No. 2014/0218908
1022	Wu	U.S. Patent No. 8,651,690
1023	Lerman	U.S. Patent No. 8,461,602
1024	Ono	Japanese Patent Application No. 2014-103000A to Ono Certified Translation
1025	Cho	U.S. Patent No. 7,534,966
1026	Stack Exchange forum	Declaration of Nathanael E Frank-White and certified Internet Archive of Electrical Engineering Stack Exchange forum discussion
1027	Yang	Chinese Patent No. CN203375312U to Yang Certified Translation
1028	Suen	U.S. Patent No. 8,801,228

1029		U.S. Patent No. 7,600,315
1030		U.S. Patent No. 7,834,273
1031	Gernhardt	U.S. Patent No. 7,155,815

DECLARATION OF R JACOB BAKER

1. My name is R. Jacob Baker. I am over the age of twenty-one (21) years, of sound mind, and capable of making the statements set forth in this Declaration. I am competent to testify about the matters set forth herein. All the facts and statements contained herein are within my personal knowledge and they are, in all things, true and correct.

2. I have been asked by Current Lighting Solutions, LLC to submit this declaration in support of its challenge to the validity of certain claims of U.S. Patent No. 11,112,068 (the “’068 Patent”).

I. PROFESSIONAL BACKGROUND

3. My qualifications generally are set forth in my Curriculum Vitae, which is attached as Appendix B. Appendix B also includes a list of the publications I have authored and a list of the other cases in which I have testified during the last four years.

4. I have been working as an Engineer since 1985 and I have been teaching Electrical and Computer Engineering courses since 1991. I am currently a Professor of Electrical and Computer Engineering at the University of Nevada, Las Vegas (“UNLV”). I am the named inventor on over 150 U.S. patents resulting from my industry work.

5. I received B.S. and M.S. degrees in Electrical Engineering from UNLV in 1986 and 1988, respectively. I received my Ph.D. in Electrical Engineering from the University of Nevada, Reno, in 1993.

6. My doctoral research, culminating in the award of a Ph.D., investigated the use of power MOSFETs in the design of very high peak power, and high-speed, instrumentation. I developed techniques to reliably stack power MOSFETs to switch higher voltages, that is, greater than 1,000 V and 100 Amps of current with nanosecond switching times. This work was reported in the paper entitled “Transformerless Capacitive Coupling of Gate Signals for Series Operation of Power MOSFET Devices,” published in the IEEE Transactions on Power Electronics. The paper received the Best Paper Award in 2000.

A. Industry Experience

7. I have done technical and expert witness consulting for over 200 companies and their subsidiaries since I started working as an engineer in 1985. From 1985 to 1993, I worked for EG&G Energy Measurements and the Lawrence Livermore National Laboratory designing nuclear diagnostic instrumentation for underground nuclear weapon tests at the Nevada test site. During this time, I designed, and oversaw the fabrication of, over 30 electronic and electro-optic instruments, including high-speed cable and fiber-optic receiver/transmitters, PLLs,

frame and bit-syncs, data converters, streak-camera sweep circuits, Pockel's cell drivers, micro-channel plate gating circuits, charging circuits for battery backup of equipment for recording test data, and analog oscilloscope electronics.

8. My work during this time, as one example, had a direct impact on my doctoral research work using power MOSFETs, subsequent publishing efforts, and industry designs. In addition to the 2000 Best Paper Award from the IEEE Power Electronics Society, I published several other papers in related areas while working in industry. I hold a patent, Patent No. 5,874,830, in the area of power supply design, titled, "Adaptively biased voltage regulator and operating method," which was issued on February 23, 1999. I have designed dozens of linear and switching power supplies for commercial products and scientific instrumentation.

9. I am a licensed Professional Engineer and have extensive industry experience in circuit design, fabrication, and manufacture of Dynamic Random Access Memory (DRAM) semiconductor integrated circuit chips, Phase-Change Random Access Memory (PCRAM) chips, and CMOS Image Sensors (CISs) at Micron Technology, Inc. ("MTI") in Boise, Idaho. I spent considerable time working on the development of flash memory chips while at MTI. My efforts resulted in more than a dozen patents relating to flash memory. One of my projects at MTI included the development, design, and testing of circuit design techniques for a multi-level

cell (MLC) flash memory using signal processing. This effort resulted in higher-density memories for use in solid-state drives and flash memory cards having an ATA interface that are ubiquitous in consumer electronics, including cameras and data storage systems. Further, the use of higher-density memory can result in fewer changes in the flash translation layer for logical-to-physical addressing, less need for garbage collection, and larger data segments that can improve a computing system's performance. Another project I worked on at MTI focused on the design of buffers for high-speed double-data rate DRAM, which resulted in around 10 U.S. patents in buffer design. Among many other experiences, I led the development of the delay locked loop (DLL) in the late 1990s so that MTI DRAM products could transition to the DDR memory protocol, used in mobile and non-mobile (server, desktop, cell phones, tablets, etc.) computing systems as main computer memory, for addressing and controlling accesses to memory via interprocess communications (IPC) with the memory controller (MC). I provided technical assistance with MTI's acquisition of Photobit during 2001 and 2002, including transitioning the manufacture of CIS products into MTI's process technology. Further, I did consulting work at Sun Microsystems and then Oracle on the design of memory modules during 2009 and 2010. This work entailed the design of low-power, high-speed, and wide

interconnection methods with the goal of transmitting data to/from the memory module and the MC at higher speeds.

10. I have extensive experience in the development of instrumentation and commercial products in a multitude of areas including: integrated electrical/biological circuits and systems, array (memory, imagers, and displays) circuit design, CMOS analog and digital circuit design, diagnostic electrical and electro-optic instrumentation for scientific research, CAD tool development and online tutorials, low-power interconnect and packaging techniques, design of communication/interface circuits (to meet commercial standards such as USB, firewire, DDR, PCIe, SPI, etc.), circuit design for the use and storage of renewable energy, and power electronics. For example, a part of my research at Boise State, for many years, focused on the use of Thru-Silicon-Vias (TSVs), aka Thru-Wafer Vias (TWVs), for high-density packaging. These packaging techniques were utilized in the memory module development work I did with Sun Microsystems and Oracle. As another example, I designed circuitry for use in implementing Universal Serial Bus (USB) interface circuits while I did consulting at Tower Semiconductor. I designed PCI communication circuits for IPC between a Graphics Processor Unit (GPU) and memory while consulting for Rendition, Inc.

11. My current research work is focused in part on the design of integrated circuits for wireless sensing using LIDAR (LIght Detection And Ranging). I have worked with several companies in the development of these circuits and systems including Freedom Photonics, Aerius Photonics, and FLIR. In the early 1990s, I worked on wireless systems for wideband impulse radar while at Lawrence Livermore Laboratory. Further, part of my research for several years focused on the digitization of IQ channels using delta-sigma modulation. The knowledge and experience gained from this effort are reflected in my textbook CMOS Mixed-Signal Circuit Design and a presentation, which I have presented at several universities and companies, http://cmosedu.com/jbaker/papers/talks/BP_DSM_talk.pdf.

B. Academic Experience

12. I was an adjunct faculty member in the Electrical Engineering departments of UNLV and UNR from 1991-1993. From 1993 to 2000, I served on the faculty at the University of Idaho as an Assistant Professor and then as a tenured Associate Professor of Electrical Engineering. In 2000, I joined a new Electrical and Computer Engineering program at Boise State University (“BSU”), where I served as department chair from 2004 to 2007. At BSU, I helped establish graduate programs in Electrical and Computer Engineering including, in 2006, the university’s second Ph.D. degree. In 2012, I re-joined the faculty at UNLV. Over the

course of my career as a professor, I have advised more than 100 masters and doctoral students.

13. I have been recognized for my contributions as an educator in the field. While at Boise State University, I received the President's Research and Scholarship Award (2005), Honored Faculty Member recognition (2003), and Outstanding Department of Electrical Engineering Faculty recognition (2001). In 2007, I received the Frederick Emmons Terman Award (the "Father of Silicon Valley"). The Terman Award is bestowed annually upon an outstanding young electrical/computer engineering educator in recognition of the educator's contributions to the profession. In 2011, I received the IEEE Circuits and Systems Education Award. I received the Tau Beta Pi Outstanding Electrical and Computer Engineering Professor Award every year it was awarded while I have been back at UNLV.

14. I have authored several books and papers in the electrical and computer engineering area. My published books include CMOS Circuit Design, Layout, and Simulation (Baker, R.J., Wiley-IEEE, ISBN: 9781119481515 (4th ed., 2019)) and CMOS Mixed-Signal Circuit Design (Baker, R.J., Wiley-IEEE, ISBN: 9780470290262 (2nd ed., 2009) and ISBN: 9780471227540 (1st ed., 2002)). I co-authored DRAM Circuit Design: Fundamental and High-Speed Topics (Keeth, B., Baker, R.J., Johnson, B., and Lin, F., Wiley-IEEE, ISBN: 9780470184752 (2008)),

DRAM Circuit Design: A Tutorial (Keeth, B. and Baker, R.J., Wiley-IEEE, ISBN: 0-7803-6014-1 (2001)), and CMOS Circuit Design, Layout and Simulation (Baker, R.J., Li, H.W., and Boyce, D.E., Wiley - IEEE, ISBN: 9780780334168 (1998)). I contributed as an editor and co-author on several other electrical and computer engineering books.

C. Other Relevant Experience

15. I have performed technical and expert witness consulting for more than 200 companies and their subsidiaries and given more than 50 invited talks at conferences, companies, and universities. Further, I am the author or co-author of more than 100 papers and presentations in the areas of electrical and computer engineering design, fabrication, and packaging.

16. I currently serve, or have served, as a volunteer on the IEEE Press Editorial Board (1999-2004); as editor for the Wiley-IEEE Press Book Series on Microelectronic Systems (2010-2018); as the Technical Program Chair of the 2015 IEEE 58th International Midwest Symposium on Circuits and Systems (MWSCAS 2015); on the IEEE Solid-State Circuits Society (SSCS) Administrative Committee (2011-2016); as a Distinguished Lecturer for the SSCS (2012-2015); the Technology Editor (2012-2014) and Editor-in-Chief (2015-2020) for IEEE Solid-State Circuits Magazine; and IEEE Kirchhoff Award Committee (2020-2023). These meetings,

groups, and publications are intended to allow researchers to share and coordinate research. My active participation in these meetings, groups, and publications allowed me to see what other researchers in the field have been doing.

17. In addition to the above, I am an IEEE Fellow for contributions to semiconductor memory design and a member of the honor societies Eta Kappa Nu and Tau Beta Pi.

II. COMPENSATION

18. My work on this matter is being billed at my standard hourly rate of \$655. I am also being reimbursed for reasonable expenses I incur in relation to my services. My compensation is not dependent on my testimony or the outcome of any proceeding.

III. LEGAL CONSIDERATIONS

19. I am not an attorney. My understanding of the law is based on information provided by counsel for Current.

A. Obviousness

20. I understand that a claimed invention is obvious and, therefore, not patentable if the subject matter claimed would have been obvious to a person of ordinary skill in the art at the time that the patent was filed (a “POSITA”), which I have been asked to treat as September 28, 2014. I understand that there must be

some articulated reasoning with some rational underpinning to support a conclusion of obviousness. I further understand that rationales that may support a conclusion of obviousness include:

- a) simply arranging old elements in a way in which each element performs the same function it was known to perform, and the arrangement yields expected results;
- b) merely substituting one known element for another known element in the field, and the substitution yields no more than a predictable result;
- c) combining elements in a way that was “obvious to try” because of a design need or market pressure, where there was a finite number of identified, predictable solutions;
- d) whether design incentives or other market forces in a field prompted variations in a work that were predictable to a POSITA;
- e) that some teaching, suggestion, or motivation would have led a POSITA to modify the prior art or to combine prior art references to arrive at the claimed invention, among other rationales.

B. Claim Interpretation

21. I understand that a claim term is given the meaning that the term would have to a POSITA at the time the patent is filed, which generally is the ordinary and customary meaning of the term. I further understand that the ordinary and customary

meaning of a term may be evidenced by a variety of sources, including the words of the claims themselves, the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art.

22. I understand that a patent holder is entitled to provide alternate definitions of words in common usage, but if the patent holder uses a term that is in common usage without providing an alternate definition, then that term should generally be understood as having its common meaning.

C. POSITA

23. I have been asked to provide my opinions regarding the knowledge and understanding of a POSITA at the time that the '068 Patent was filed.

24. I understand that the factors considered in determining the ordinary level of skill in the art include: (a) the type of problems encountered in the art; (b) prior art solutions to those problems; (c) the rapidity with which innovations are made; (d) the sophistication of the technology; and (e) the education level of active workers in the field.

25. I understand that a POSITA is not a specific real individual, but rather a hypothetical individual having qualities based on the factors above. This hypothetical person has knowledge of all prior art in the relevant field. I also

understand that a POSITA is a person of ordinary creativity, not an automaton. Therefore, a POSITA has and applies common sense to modify or combine references in the prior art, and can also find any teaching, suggestion, or motivation, whether to modify or combine, whether explicit or implicit.

26. As of September 28, 2014, it is my opinion that a POSITA as to the '068 Patent would have had a Bachelor's degree in electrical engineering, or an equivalent field, as well as at least 1-2 years of academic or industry experience in lighting design, including knowledge of LEDs and related technology for driving LEDs. A person of ordinary skill in the art with a higher level of education may have fewer years of academic or industry experience, or vice versa. A POSITA would have been familiar with the field of technology described in Section V below. The prior art and the '068 Patent also evidence this level of ordinary skill. Here, the background described in Section V and the prior art described herein demonstrate that a POSITA would have been familiar with various aspects of LED lighting device design.

27. With over 35 years of experience in the semiconductor circuit design field, I am well acquainted with the level of ordinary skill required to design semiconductor circuit products, including LED lighting and power supply circuitry.

I have direct experience in this field, and I am capable of rendering an informed opinion on the level of ordinary skill in the art as of September 28, 2014.

IV. BASIS FOR OPINIONS

28. My opinions are based on my education, training, and experience as well as items that I reviewed to prepare my opinions, including the '068 Patent and at least the portions cited herein of the publications listed in the table at the beginning of this declaration. All of my opinions are from the perspective of a POSITA as of September 28, 2014.

V. FIELD OF TECHNOLOGY

A. LED Tube Lamps

29. LED tube lamps are LED lighting devices which can be used in place of fluorescent tube lamps. LED light sources have been known for decades. *See generally*, E. Fred Schubert, *Light-Emitting Diodes*, Second Edition (Cambridge University Press, 2006). Consumer interest in LED lamps increased in the mid-2010s due to improved energy efficiency and longer life span. *See, e.g.*, U.S. Patent No. 9,338,853 to Guang at 4:13-62 (filed September 17, 2014) (EX1016). Accordingly, persons of ordinary skill in the art would have understood the need to continue improving the cost-effectiveness, lifespan, reliability, and energy efficiency of LED tube lamps.

30. LED light sources can be disposed inside tubes made to fit into existing fluorescent light sockets or fixtures. *See, e.g.*, Guang at 4:16-19 (“Arrays of LEDs can be fitted in tubes that are physically compatible replacement [sic] for fluorescent tubes, using the same sockets for their electrodes to fit into.”). Typically, such LED tube lamps include end caps on each end of the lamp tube with electrode pins for connecting the LED tube lamp to a lighting fixture and to an external electrical power source. *See id.* at 7:39-46.

31. LED lamp tubes can be formed with a diffusion treatment applied to the tube, and persons of ordinary skill in the art would have understood that there are several methods of diffusing light from LED tube lamps. For example, U.S. Patent No. 9,271,354 to Takahashi (EX1005), filed August 13, 2014, and discussed in greater detail below, discloses several methods of providing diffusion to a lamp tube, including providing “a light diffusion sheet or light diffusion film”, using a “lens structure”, or “printing a dot pattern to at least one of at least one of the inner surface and the outer surface of the [lamp tube]” and “applying silica, calcium carbonate, or the like to the inner surface of the [lamp tube].” Takahashi at 7:18-45. Another example of creating a diffusion layer by coating white particles on the surface of a LED cover was described in U.S. Patent No. 8,801,228 to Suen, at 5:23-6:14 (EX1028) (issued August 12, 2014). Suen teaches a diffusion layer “coated on

a surface of a diffuser cap . . . [containing] white particles that are operable to reflect and diffuse light emitted by the LED chip.” Suen at 5:38-41. Examples of white particles that can make up Suen’s coating film “include calcium sulfate, zinc oxide, barium sulfate, or titanium oxide.” Suen, 6:4-14. A POSITA would have understood that, while these methods have their differences, they all serve a similar purpose in diffusing light from LED tube lamps. The general advantage of diffusion is that it creates a uniform or smooth light output from LED tube lamps. *See, e.g.* U.S. Patent No 9,146,017 to Van Der Wel (EX1017), filed April 14, 2011 and published October 27, 2011, at 2:7-14 (teaching smooth light output as an advantage of diffusion). A POSITA would also have understood that diffusion can lessen discomfort from viewing the LED tube lamp because the light is less directed, or focused.

32. While diffusion treatment in general is advantageous for these reasons, a POSITA would have understood that diffusion films and sheets have particular advantages over other diffusion treatments, including ease of processing and manufacturing to get a precise thickness for the diffusion film, to diffuse light precisely to a given level. *See, e.g.,* Van Der Wel, 2:14-19, 6:60-7:11. A POSITA would have understood that it would be desirable for LED tube lamps to be manufactured so that each LED tube lamp in a manufacturing run would diffuse light

to the same degree, increasing manufacturing consistency. Another advantage of diffusion films is that they can be rolled into a tube and inserted into a lamp tube. Van Der Wel, 2:50-55; 6:36-39. A POSITA would have recognized that this rolled structure increases the safety of a lamp tube by providing additional insulation from electrical components (see Van Der Wel, 5:55-67, 7:16-22) and can be easier to manufacture (see Van Der Wel, 2:65-67). Diffusion films can also be manufactured and assembled inexpensively. See Van Der Wel, 1:32-34.

33. LED lighting technology presents numerous advantages over fluorescent and incandescent lighting. For example, LED lighting technology has “lower energy consumption, longer life, improved robustness, [and] smaller size” than fluorescent and incandescent lights. Guang at 4:13-62. These advantages of LED lighting can also make LED lighting technology a more cost-effective lighting solution than fluorescent and incandescent lights. See *id.* LED tube lamps also generally do not need toxic chemicals like lead or mercury to operate, unlike many fluorescent lamps. *Id.* at 4:8-10; see also Demuynck, 6:60-65 (teaching numerous LED lamp advantages, including lack of toxic chemicals).

B. LED Light Strips

34. LED light sources for use in tube lamps are typically mounted on LED light strips in arrays. These light strips can be made of any material suitable for

mounting electrical components, including traditional printed circuit board materials—rigid boards or chips made of resin or another dielectric material, with a metal foil or other thin conductor patterned into wiring paths disposed on the surface of the board. *See, e.g.*, U.S. Patent No. 8,833,965 to Shimasaki (EX1006), filed September 11, 2012, at 4:40-44 (disclosing various substrate materials and the use of foil on a substrate to form wiring layers). LED light strips can be formed on a single long substrate running the length of the tube, or on smaller substrates connected together. *See id.* at 3:11-16.

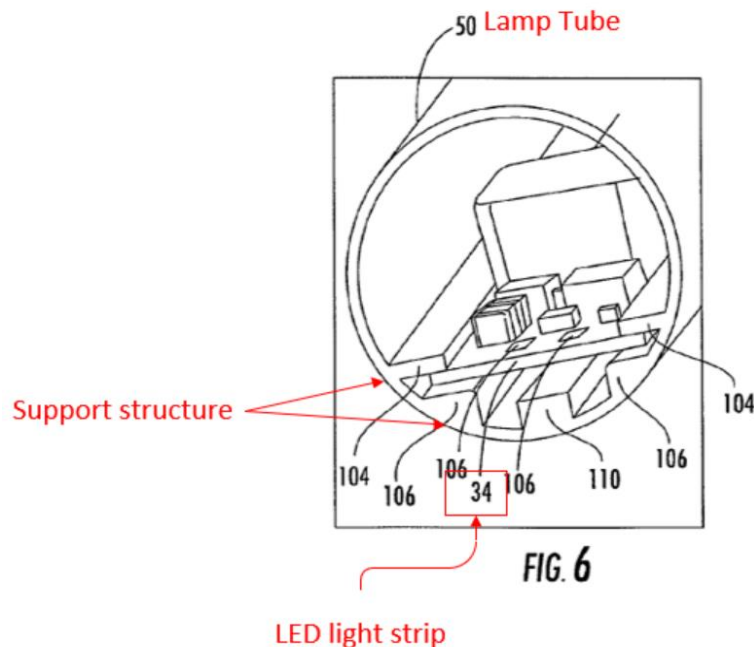
35. In addition to traditional circuit boards, a common configuration for LED light strips is for the LED light sources to be mounted onto a flexible circuit board or strip because this enables the LED light strip to be used in lighting applications with various different shapes. For example, U.S. Patent No. 6,846,094 to Luk (EX1012), issued January 25, 2005, teaches the use of a flexible LED light strip arranged in a helical structure and arranged within a flexible tube: “light-emitting diodes in different colors can be mounted onto a flexible circuit board that is twisted into a helix and inserted into a flexible tubular housing.” Luk at 1:63-66. This patent further discloses that during manufacturing, LEDs would be mounted onto the flexible circuit board arranged in a flat mode before forming the flexible light strip into a helix. *Id.* at 6:44-54. Such flexible LED light strips can be “made

of a flexible electrically non-conductive and high-temperature resistant plastic material such as, for example, polyimide.” *Id.*; *see also* U.S. Patent No. 9,328,874 to Demuynck (EX1013), filed June 30, 2014, at 7:58-61 (“The LED board 34 may comprise a flex circuit comprising a flexible layer of a dielectric material such as a polyimide, polyester or other material to which a layer of copper or other electrically conductive material is applied such as by adhesive.”); U.S. Patent No. 9,726,330 to Wilcox (EX1011), filed March 25, 2014, at 7:41-65 (disclosing a “flex circuit 20a” comprising “a flexible layer of a dielectric material such as a polyimide, . . . to which a layer of copper or other electrically conductive material is applied”). Luk lists advantages of flexible circuits including flexibility, versatility, and capability to be configured into numerous configurations. Luk at 3:13-19. From these teachings, a POSITA would have understood that flexible circuit boards for LED lighting applications were well-known in the art and provided a versatile substrate for mounting LED light sources.

36. A POSITA would have understood that LED light strips for LED tube lamps can be arranged in numerous ways within the lamp tube of the LED tube lamp. For example, LED light strips can be disposed directly on an inner circumferential surface of the lamp tube. Flexible circuit boards were known to be particularly useful for this purpose because they could be attached directly to the curved inner

surface of the tube. *See, e.g.*, Jing at ¶¶[0027]-[0028] (teaching that “when the circuit board 2 is made of flexible PCB, the circuit board 2 can be fixedly connected with the inner wall of the lamp tube 1 through the fixing layer 3.”). Wilcox similarly teaches that a “substrate 20 [LED light strip] such as the flex circuit 20a or PCB FR4 board may be mounted directly to the tube 2 [lamp tube].” Wilcox at 10:46-48. Wilcox also teaches that “the substrate 20 [LED light strip] may be mounted directly to the tube 2 using an adhesive.” *Id.* at 10:48-49. A POSITA would have understood that using an adhesive is a cost-effective way to secure an LED light strip to a surface of the light tube. *See* Jing (CN 203036295 U, published July 3, 2013) at ¶[0018] (discussed in greater detail below in paragraphs 96-104). Another example, taught by Demuynck, is that “the LED board 34 [LED light strip] may be supported on a separate support member where the support member may be made of a rigid, thermally conductive material such as aluminum that physically supports the LED board.” Demuynck at 8:9-14. The benefit of this structure is that heat from the LED light strip could be thermally conducted away from the LED light strip and that it would be supported within the tube. In another embodiment, Demuynck teaches that “the enclosure 50 [lamp tube] may be provided with a support structure 102 where the support structure supports the LED board 34 [LED light strip] in the enclosure 50.” Demuynck further teaches that “support structure 102 comprises

supports 104 and 106 that are fixed to the interior surface 50a of the enclosure 50 such that the LED board 34 may be retained by the supports 104,106 in a desired position in the enclosure 50.” Demuynck, 10:44-50; *see also* Demuynck FIG. 6 (annotated below).



37. Other methods were also known, including Luk’s helical structure discussed above in paragraph 35. Luk at 1:63-66; *see also* Van Der Wel at 6:5-39 (teaching an LED strip attached to a transparent carrier foil, rolled into a tube, and inserted into the lamp tube). From these teachings, a POSITA would have understood that there are many ways of disposing an LED light strip within and on the inner surface of a lamp tube, each with the benefit of supporting and securing the LED light strip in place. Selection of one method over another would have been

merely a simple substitution of one known technique for attaching an LED light strip to a lamp tube with another known technique for attaching an LED light strip to a lamp tube. A POSITA would further recognize the results of such a substitution would yield the predictable result of an LED tube lamp having LED light sources mounted on an interior of the lamp tube.

38. A POSITA would have been familiar with manufacturing methods for LED light strips. For example, U.S. Patent No. 8,558,255 to Bisberg (EX1018), filed May 2, 2013, and issued October 15, 2013, teaches methods of aligning and mounting LED chips to PCBs, including a “self-aligning solder reflow” process and the use of “fiducial marks” by which a human or machine vision system might align and mount LED chips to a PCB. Bisberg at 7:10-55. Bisberg teaches that a solder reflow process “is particularly effective for smaller LED chips (e.g., LED chips with length and/or width less than 250 microns),” but that alternatively, solder for mounting LED chips could be “plated, or formed by deposition and etching, onto traces.” *Id.* at 7:56-8:5. The motivation to use smaller LED chips, according to Bisberg, is that they can produce light more efficiently than larger LED chips, and produce less light per chip, which lessens discomfort from viewing the LED chips directly. *See id.* at 12:50-65. The use of small LED chips means that more chips are needed to produce the same amount of light as larger chips, which can increase

manufacturing costs, but automated processes in LED manufacturing can compensate for the increased cost. *See id.* at 1:21-45 (teaching cost concerns from larger chips); 13:14-16 (teaching automated pick and place equipment to mount LED chips). A POSITA would also have recognized that other manufacturing techniques were available. *See, e.g.*, U.S. Patent No. 6,331,891 to Nakamura (EX1019), issued December 18, 2001 (teaching a device for positioning and soldering semiconductor devices to a substrate).

C. Reflective Solder Resists

39. Solder resist layers have been used in PCB design and manufacturing for decades to protect the underlying circuit traces and elements. *See, e.g.*, U.S. Patent No. 7,600,315 (EX1029) at 2:8-9 (describing the use of solder resist layers in conventional PCB manufacturing); U.S. Patent No. 7,834,273 at 1:46-47 (“Normally, a solder resist layer to protect the conductor circuit is formed on the surface layer[.]”). In LED lighting applications, using **reflective** solder resist is a well-known technique for increasing the light output efficiency of LED lighting devices. For example, U.S. Patent No. 7,948,001 to Kamada (EX1014), issued May 24, 2011, teaches that “a resist layer 26 made of a white colored resin is also laminated on the surface of the insulating substrate 22a, opposite to the heat transfer plate 21 side, to cover part of the patterned conductors 23, 23 and to cover a portion

of the insulating substrate 22a where the patterned conductors 23, 23 are not formed (see FIG. 3). Therefore, light incident on the surface of the resist layer 26 from the side of the LED chip 10 is reflected therefrom so that absorption of the light from the LED chip 10 through the wiring board 22 surface opposite to the heat transfer plate 21 side can be prevented, which can increase the light output efficiency and thus can increase the optical output.” Kamada at 7:9-35. From these teachings, a POSITA would have understood that incorporating a reflective resist layer on the surface of an LED lighting device provides several benefits, such as improved light output efficiency and preventing light absorption through the substrate on which the LED light sources (i.e., LED chips) are disposed. A POSITA would also have understood that such a resist layer is a protective layer in that it covers patterned conductors or wiring layers and offers a degree of protection against damage and corrosion to the conductors or wiring layers. *See, e.g.*, U.S. Patent No. 8,651,690 to Wu (EX1022), filed April 24, 2012, and issued February 18, 2014, at 8:20-30 (teaching the use of “a solder mask layer 930 , i.e., a protective layer,” which “has an opening 932 to expose the first signal line 940 and a portion of the first extension line 950 for soldering the light-emitting diode 960 thereon.”).

40. A POSITA would also have understood that such a resist layer could be applied before mounting LED elements onto the wiring layers of the board,

leaving openings to expose mounting regions for the LED elements to be mounted onto. *See* Kamada at 7:36-42 (describing apertures in the resist layer through which LED chips are mounted, *i.e.*, after the apertures are formed). In many general electronics applications, solder resist layers are applied to base substrates and printed circuit boards (PCBs) before electric components, such as surface mount devices (SMDs), are mounted. *See, e.g.*, U.S. Patent No. 6,365,841 to Takigami (EX1008), filed on July 17, 1998 and issued April 2, 2002 (discussed in greater detail in Section VII.F below). In such applications, openings are formed in the resist layer to expose soldering pads (also known as lands), onto which SMDs can be soldered or otherwise mounted and electrically connected to the PCB. *See* U.S. Patent No. 7,600,315 at 2:7-10 (describing forming openings in a solder resist with a solder opening process). The solder resist prevents solder beads from forming in undesired locations or creating undesired solder bridges (electrical shorts) between component leads. A POSITA would have understood that this feature of solder resists would be desirable in LED lighting applications to enable cleaner mounting of LED chips.

D. LED Power Supplies

41. LED tube lamps, and indeed most LED lighting applications that receive external electrical power from standard AC power outlets, typically have a power supply circuit that provides power to the LED light sources. *See, e.g.*, Guang

at 5:4-15 (“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.”) Power supply circuits, also known as driver circuits, are typically needed to regulate and maintain a constant current and voltage for the LEDs because LEDs, like other diodes, experience exponential changes in current with changes in voltage, which can potentially damage or destroy LEDs. *Id.* Power supply circuits were usually built on printed circuit boards. *See, e.g.*, Guang at 8:17-28 (teaching the use of multiple PCBs for an LED power supply); U.S. Patent No. 8,591,057, to Kawabata (EX1020) at 11:36-39 (teaching “power supply substrates” made of “glass-fiber-reinforced epoxy resin” in an “elongated rectangular shape” with a wiring layer); and Japanese Patent Application No. 2014-103000A to Ono (EX1024) at ¶[0017] (“The lighting circuit 24 has a circuit board 39 on which a plurality of

[Fig. 1]

26

and a resistor). Other examples of power supply components were also known in the art. *See, e.g.*, Takahashi at 6:55-65, 13:48-56 (teaching an LED drive circuit 360 including “constant power output circuit 20, [a] selection control circuit 30, a rectifier circuit 40, [and] a filter circuit 50”); Guang at 6:26-7:6 (teaching a driver circuit including a rectifier circuit, a filter circuit with a resistor and inductor in parallel, and a step-down constant current circuit); U.S. Patent No. 9,057,504 to Levante (EX1007) at 5:22-27 (teaching “occupancy sensors, timers, dimmers, switches, diode bridges, voltage regulators and control modules”).

43. In summary then, power supplies for LED lighting were known to a POSITA before the '068 Patent to have numerous components, including AC/DC converters, (*e.g.*, rectifiers using bridge circuits), constant-current circuits, and filtering elements like capacitors or inductors.

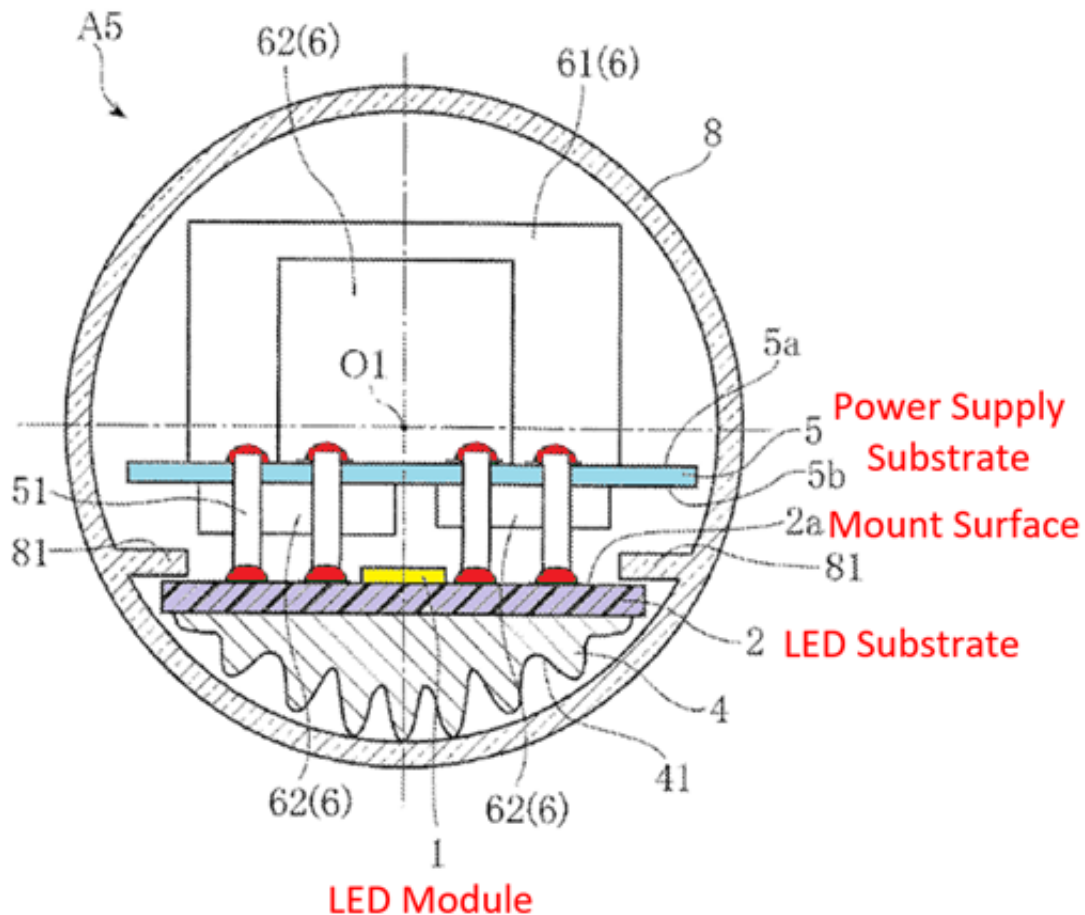
44. A POSITA would also have recognized that power supply circuits for LED tube lamps could be disposed in numerous locations according to the design needs of a given LED tube lamp (*e.g.*, so as not to obscure the light from the LEDs), including in housings, luminaires, or fixtures outside of the lamp tube (*see, e.g.*, Shimasaki at 3:39-61; U.S. Patent App. Pub. No. 2014/0218908 to Kawashima (EX1021), published August 7, 2014, at ¶[0049]), inside the lamp tube at the end of the LED strip (*see, e.g.*, Kawabata at 11:51-61 and FIGs. 7-9), or inside one or both

of the end caps (*see, e.g.*, Guang at 7:7-9; Takahashi at 8:12-19). Disposing a power supply circuit in any of these locations would have been a simple substitution of known elements from on known location to another, because in each instance the power supply would need to be electrically connected to the external electrical power and the LED light strip internally. The predictable result of this substitution would be LED tube lamps driven by power supplies.

E. Use of Soldering Pads to Connect LED Arrays to Power Supplies

45. Connecting LED arrays or light strips to a power supply using electrical connections established using soldering pads would have been well-known to a POSITA. For example, FIG. 9 of Kawabata (U.S. Patent No. 8,591,057, issued November 26, 2013) (EX1020), reproduced below with annotations, shows LED light sources (1) arranged on a mounting surface 2a of an LED substrate (i.e., an LED light strip) and connected to a power supply disposed on power supply substrate (5) via leads 51 soldered to soldering pads (shown in red) on the (purple) mount surface (2a) and the (blue) power supply substrate (5). *See* Kawabata at FIGs. 7-9, 11:6-61.

FIG.9



46. A POSITA would also have understood that soldering pads are one of multiple methods for forming electrical connections between the an LED light strip and a power supply, including pin connectors, through-holes, and couplings. For example, U.S. Patent No. 8,461,602 to Lerman, filed January 31, 2011 and issued June 11, 2013 (EX1023), teaches a that for a string of LED chips (LED light strip), there are “many ways to electrically connect to the various conductors on the

substrates.” Lerman at 23:15-16. Lerman teaches “an end of a sheet or strip . . . where the ends of conductor 314 . . . are exposed,” and further teaches that “[t]he ends of the exposed portions of the conductors 314 . . . are thickly plated with copper, gold, silver, or other suitable material to provide [red] **connection pads 317 for solder bonding or for any other form of connector** (e.g., a resilient clip connector) to electrically connect the anode and cathode of the end LED chip 56 to another string or to a power supply.” Lerman at 23:17-31 (emphasis added), FIG. 30A (reproduced below).

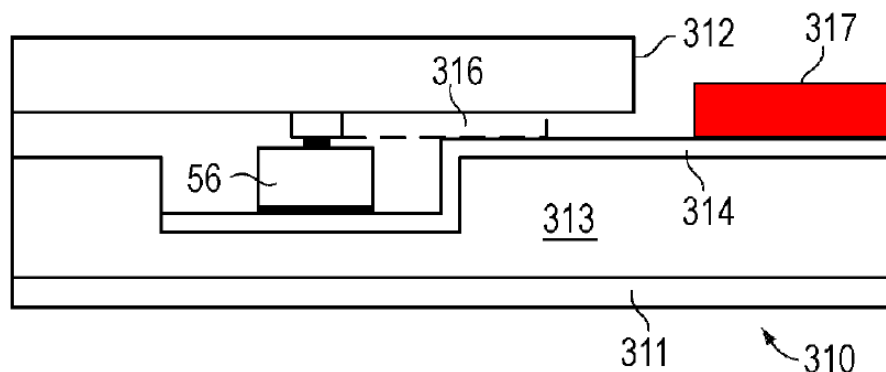


FIG. 30A

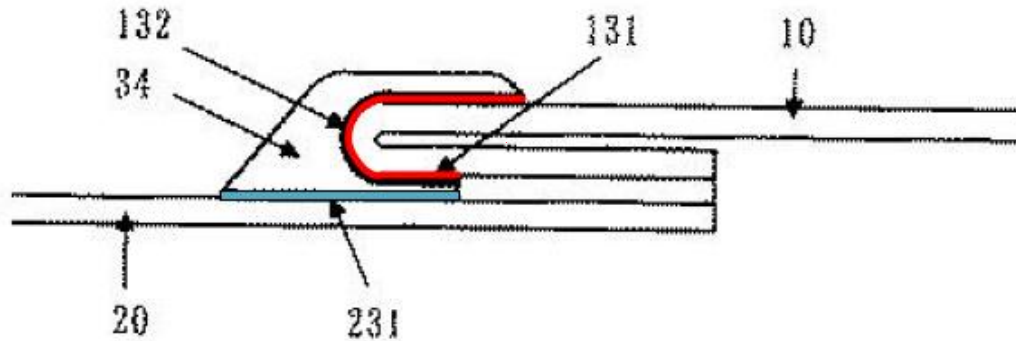
F. Soldering Techniques

47. Several soldering techniques for making connections using solder and soldering pads were well-known to a POSITA at the time of the '068 Patent. As discussed above, solder could be used to solder leads, such as Kawabata's leads 51, to soldering pads on power supply PCBs or to soldering pads on LED light strips.

Kawabata at FIGs. 7-9, 11:6-61. Another known technique is the use of solder reflow, as discussed in paragraph 38 above with reference to Bisberg, in which solder is placed onto a soldering pad on a PCB, a component (e.g., an LED, an SMD, or another PCB) is placed in contact with the solder and then the solder is heated so that when it melts, it bonds with soldering pads on both the PCB and the component. Bisberg at 7:34-55.

48. Still another well-known technique was soldering directly between two soldering pads of adjacent or overlapping PCBs or LED light strips, as was shown by Sato (Japanese Patent App. Pub. No. JP2010-153549 to Sato, Certified Translation, published July 8, 2010) (EX1015). Sato describes a method for creating a long and flexible LED strip by folding parallel strips on a flexible substrate such that the strips align lengthwise. Sato at Abstract, ¶[0008]. Soldering pads on the strips overlap at a step formed by folding, and the overlapping soldering pads are soldered together over the step. Sato at Abstract, ¶¶[0004], FIGs. 1, 2, 6. Sato FIG. 6 below shows a cross-sectional side view of a folded LED light strip 10 where solder joint 34 is disposed on a (red) solder pad on LED strip substrate 10, disposed on a (blue) soldering pad 23 on the other substrate 20, and covering the folded edge of the LED strip substrate 132.

[FIG. 6]

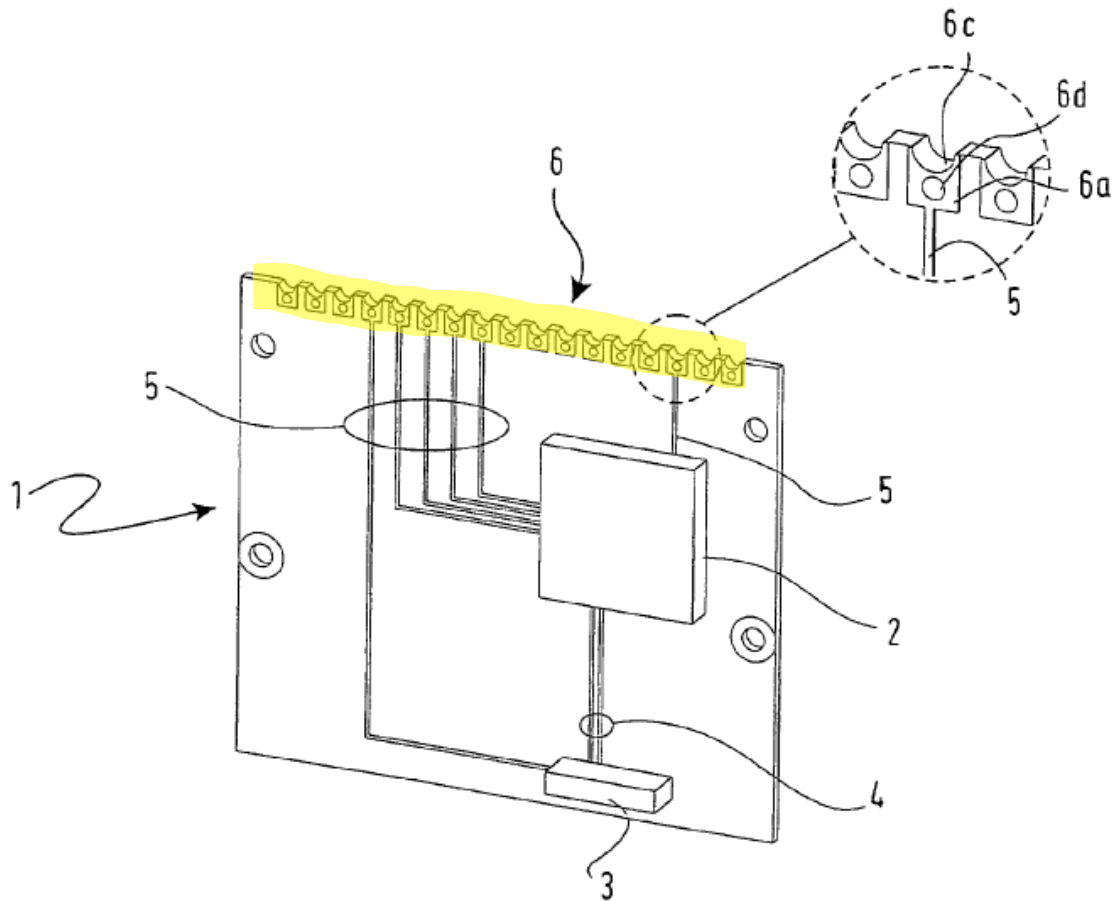


Sato, FIG. 6; *see also* Sato at ¶¶[0008]-[0011]. Sato also discloses the use of through holes to form soldered connections for LED light strips. Sato at ¶[0009]. *Id.*, ¶[0010]. Sato teaches that soldering in this manner “improv[es] the degree of contact” and “improv[es] the securing force” of the solder. *Id.* at ¶[0010]; *see also* ¶[0005] (“When soldering at the part that is a step, the area of the connecting part will be large, enabling good connecting properties for the interconnections, and enabling high-strength.”). Thus, soldering from a soldering pad on one substrate, such as an LED strip, onto a soldering pad on another substrate was known in the art to form reliable electrical connections and strong physical attachment between the soldering pads. Similar methods of soldering at the edge of an LED light strip and directly to electrical substrates (*e.g.*, PCBs) were known and taught by Levante at 7:7-20, FIG. 14, and Gu (Chinese Patent App. Pub. No. CN103672530A) (EX1010)

at ¶¶[0008]-[0009], [0015], as explained in greater detail in paragraphs 72-73, and 81-95 below.

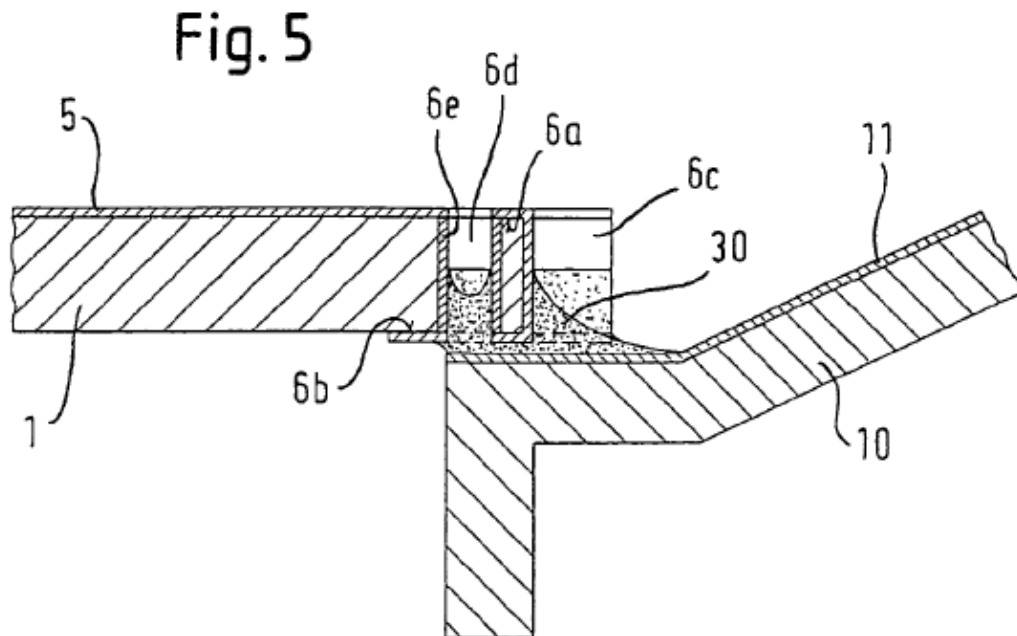
49. This technique of soldering from a soldering pad on a first PCB and onto a soldering pad of a second PCB, covering an edge of the first PCB, could also have been accomplished using castellated, or notched soldering pads. U.S. Patent No. 7,155,815 to Gernhardt, issued Jan. 2, 2007, (EX1031) shows an example of this type of soldering pad, which are labeled as 6 and highlighted in yellow in Gernhardt's Fig. 1 below.

Fig. 1



Gernhardt describes these soldering pads as “edge contacts 6 at the upper edge of the circuit board.” Gernhardt at 4:16-17. The edge contacts 6 include “contacting areas 6a and 6b” on the front and back of the board and “connected to one another both by semi-cylindrical areas 6c . . . and additionally via through-plated holes 6d.” *Id.* at 4:30-34. Gerhardt’s Fig. 5 below shows a cross section of one of these edge contacts 6 soldered to another circuit board 10 at the edge of the circuit board 1 and

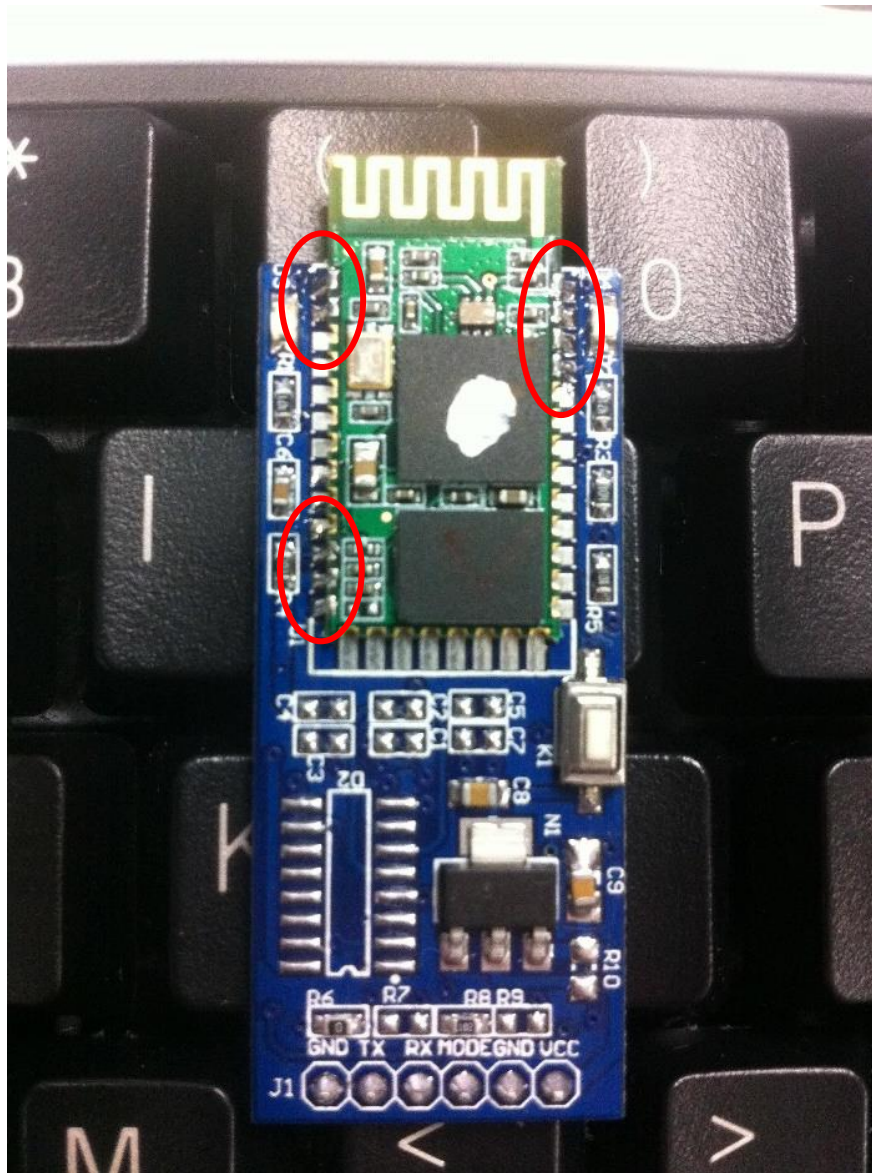
covering the lower edge of the soldering pad with solder 30. Because of capillary action, “the solder fills at least the gap between this lower contacting area 6b and the end of the printed conductor 11. Because of the capillary action, the solder 30 also rises into the hole 6d.” *Id.* at 5:30-36.



As another example, using castellated soldering pads to solder one PCB to another was discussed in 2012 on Electrical Engineering Stack Exchange,¹ a public online electronics forum. EX1026. An example image from that discussion, reproduced below (red markings added), shows a green upper PCB with castellated soldering

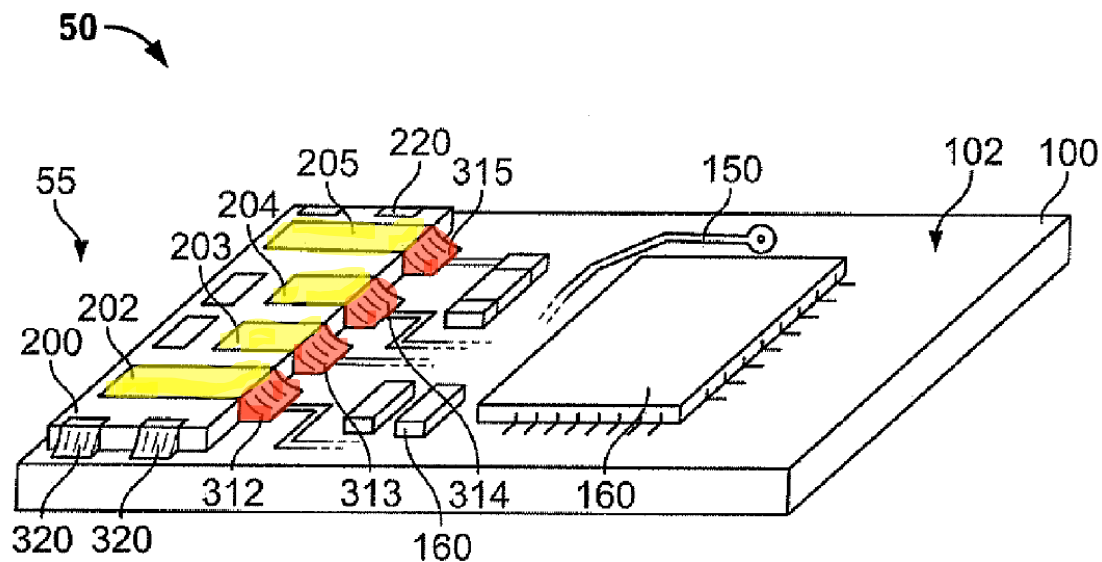
¹ Archived May 14, 2013 to the following URL:
<http://web.archive.org/web/20130514125612/https://electronics.stackexchange.com/questions/35625/soldering-pcbs-directly-together>.

pads on three sides placed above and overlapping a blue lower PCB. *Id.* at p. 6. Planar soldering pads on the lower PCB are arranged under the castellated soldering pads of the upper PCB. *Id.* Solder is disposed on several of the castellated upper soldering pads, on the planar lower soldering pads, and covering an edge of the upper PCB.



EX1026, p. 6. Public online forums such as Electrical Engineering Stack Exchange were known to a POSITA as places to obtain and share information relating to soldering and other electrical engineering concepts. *See id.* at p. 5 (“Electrical Engineering Stack Exchange is a question and answer site for electronics and electrical engineering professionals, students, and enthusiasts.”). A POSITA, exercising reasonable diligence, would have found the above identified website using customary internet searching tools available at the time.

50. Even without castellation, soldering at the edge of PCBs was well known. For example, U.S. Patent No. 7,534,966 to Cho, issued May 19, 2009, (EX1025) teaches a soldering technique at the edge of straight soldering pads. “During assembly of the PCB edge connection structure 50, the PCB contact terminal structure 200 is placed over area A of the first PCB 100 with the two sets of the soldering terminals [yellow] aligned and the soldering terminals are joined by [red] solder joints 312, 313, 314, 315.” Cho at 4:10-14.



As an aside, Cho also teaches that its PCB's insulating solder resist would "be patterned so that the soldering terminals 112, 113, 114, 115 are exposed," (Cho, 4:50-52) showing yet another example of the well-known nature of openings in solder resists.

51. The above paragraphs demonstrate several techniques known to a POSITA for soldering directly between PCBs such as LED light strips using solder and soldering pads. These examples highlight numerous benefits from using solder and soldering pads. For example, soldering typically secures and strengthens the direct contact between solder pads (see Sato, ¶¶[0005], [0011]). Soldered connections in these applications could have theoretically been replaced by a mechanical plug connector, such as those discussed above in paragraph 46 with

reference to Lerman or the pin connectors discussed in Guang at 8:45-56, but a POSITA would have viewed a soldered connection as a more reliable connection. Soldering directly eliminates an intermediate connection that would otherwise be present between a wire and a connector. For example, a POSITA would have expected soldered connections to be less susceptible to oxidation that could impede the connection between plug connectors, at least because the solder fills and surrounds the interface between the wire and the solder pad, whereas a connector—even when tight—permits air (and entrained moisture) to intrude into the interface between the pin and socket. See Shimasaki at 7:38-41 (“Spare solder 9a for preventing oxidation of the solder land sections 61c and protecting the solder land sections 61c is applied to the solder land sections 61C.”).

52. Soldering directly, rather than using lead wires or connectors can also reduce manufacturing costs. See Chinese Patent No. CN203375312U to Yang, Certified Translation (EX1027) at ¶[0016] (teaching that soldering directly to a PCB can be done “without the need to use wires . . . [and this] structure saves space in the glass tube.”). Removing lead wires or other connectors and soldering directly would remove at least the cost of those materials, which would typically still need to be soldered to PCBs. A POSITA would have also expected their removal to remove the cost in manufacturing from the manufacturing steps and tools necessary to install

such a lead wire or connector. Thus soldering provides a known and potentially cost effective means for forming secure electrical connections.

VI. THE '068 PATENT

A. Overview of the '068 Patent

53. Entitled “LED Tube Lamp,” the '068 Patent is directed to an LED tube lamp that includes “a glass tube, two end caps coupled to a respective end of the glass tube, an LED light strip attached to an inner circumferential surface of the glass tube, a protective layer disposed on a surface of the LED light strip, a plurality of LED light sources mounted on the LED light strip, two first soldering pads arranged at an end of the LED light strip, . . . a power supply module configured to drive the plurality of LED light sources.” EX1001, Abstract. “The power supply module comprises a printed circuit board comprising two second soldering pads, and each of the two first soldering pad soldered to the respective second soldering pad by a solder.” *Id.* The '068 Patent thus discloses and claims aspects of LED tube lamps to replace fluorescent tube lamps. *Id.*, 1:48-61. The annotated FIG. 22 below shows [orange] LED light strip 2 attached to the glass tube and soldered to [green] power supply module 5 at [purple] soldering pads “a” and “b.” *See id.*, 31:20-60. Note that element 21 in FIG. 22 is a “freely extending portion” of light strip 2, which can extend toward the power supply module because it is flexible. *Id.*, 31:61-32:10.

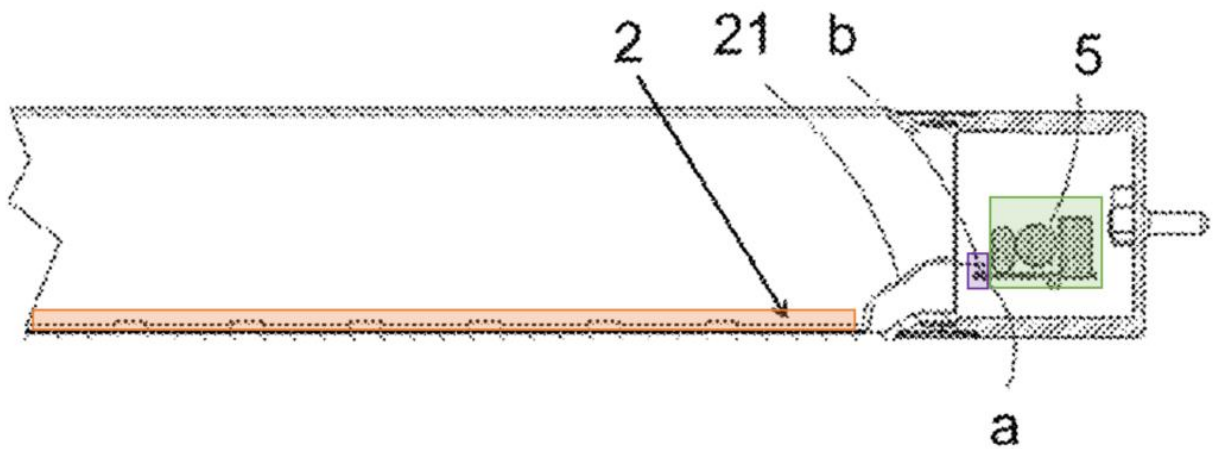


Fig. 22

'068 Patent, FIG. 22. An alternative view of the soldering pads "a" on [green] power supply module 5 and soldering pads "b" on LED light strip 2 with the soldering pads soldered together using [red] solder "g" is shown in FIG. 24.

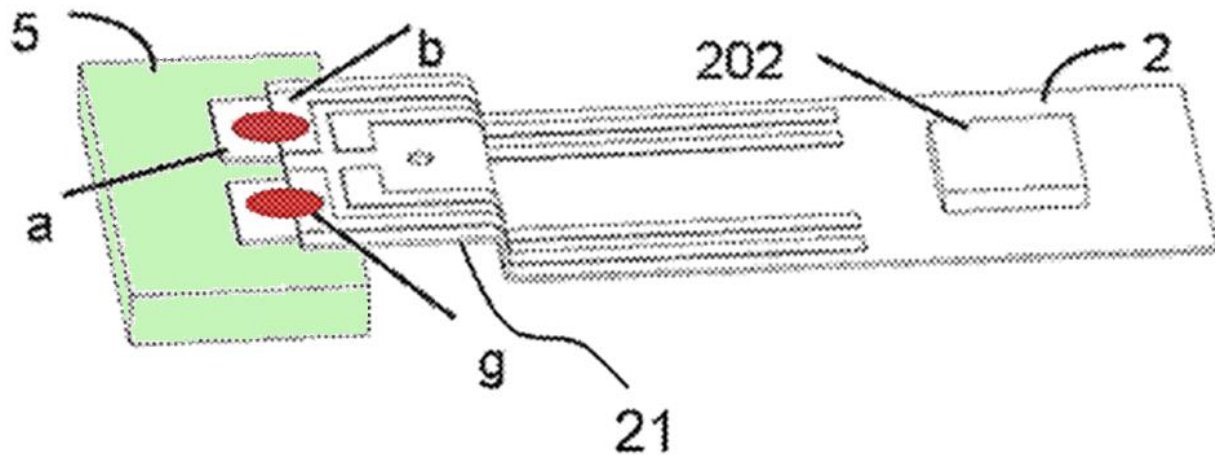


Fig. 24

1. LED Tube Lamp Replacements

54. The '068 Patent teaches that replacement of incandescent and fluorescent lighting with LED tube lamps has become increasingly common due to the benefits offered by LED tube lamps relative to incandescent and fluorescent lighting. '068 Patent at 1:48-61. For example, "LED tube lamps are mercury-free in comparison with fluorescent tube lamps that need to be filled with inert gas and mercury." *Id.* at 1:49-51. LED tube lamps also have improved durability and longevity compared to traditional incandescent and fluorescent lightings. *Id.* at 1:57-58. And LED tube lamps typically consume less energy to output the same brightness. *Id.* at 1:58-61. These factors mean that LED tube lamps are typically considered a cost effective lighting option. *Id.*

55. The '068 Patent admits that elements of LED tube lights were well known and being used to replace traditional incandescent and fluorescent lighting. '068 Patent, 1:48-65. Specifically, the '068 Patent admits that "[t]ypical LED tube lights have a lamp tube, light sources in the lamp tube, two caps connected to two ends of the lamp tube, and one power supply or two at the ends of the lamp tube." *Id.* at 1:62-65. "The caps receive external electricity and transmit it to the power supply and the light sources through a wire or wires." *Id.*, 1:65-67.

2. *Issues with LED Tube Lamps*

56. According to the '068 Patent, a drawback to LED tube lamps is that “the wires may be easily damaged and even broken due to any movement during manufacturing, transportation, and usage of the LED tube lamp and therefore may disable the LED tube lamp.” '068 Patent, 2:1-5.

3. *Summary of Alleged Invention of the '068 Patent*

57. The '068 Patent purports to solve the wire-damage problem described above by “provid[ing] an LED lamp tube” ('068 Patent at 2:9-10) that includes, alongside typical LED tube lamp elements, “at least two first soldering pads arranged at an end of the LED light strip, [and] **a protective layer disposed on a surface of the LED light strip** . . . [which] comprises at least two openings to expose the two first soldering pads.” *Id.*, 2:60-3:2 (emphasis added). According to the '068 Patent the protective layer is “made of an ink with the function of resisting soldering and increasing reflectivity.” *Id.*, 29:5-8. The protective layer may also comprise “a plurality of second openings” for disposing the LEDs on the LED strip. *Id.*, 3:11-14. Modified FIG. 25 below shows the [blue] protective layer having openings at the end of the LED light strip over the “b” solder pads, and additional openings “c” and “d” adjacent to the openings at “b.” *Id.*, 32:32-50.

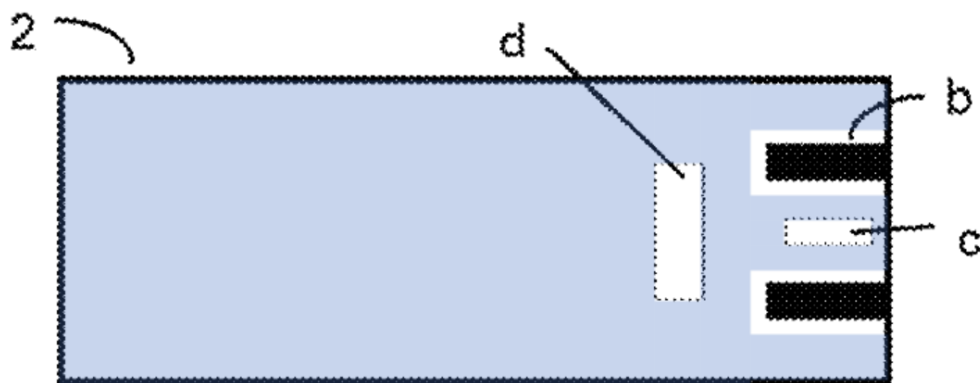


Fig. 25

58. The '068 Patent also claims as inventive various arrangements of soldering the LED strip to the power supply PCB. “The printed circuit board comprises at least two second soldering pads, each of the two first soldering pad [sic] is soldered to the respective second soldering pad by a solder.” *Id.* 3:4-7. In one arrangement, shown below in FIG. 24, “[t]he solder is disposed on the first soldering pad, the corresponding second soldering pad and covering an edge of the end of the LED light strip.” *Id.*, 3:7-10; FIG. 24.

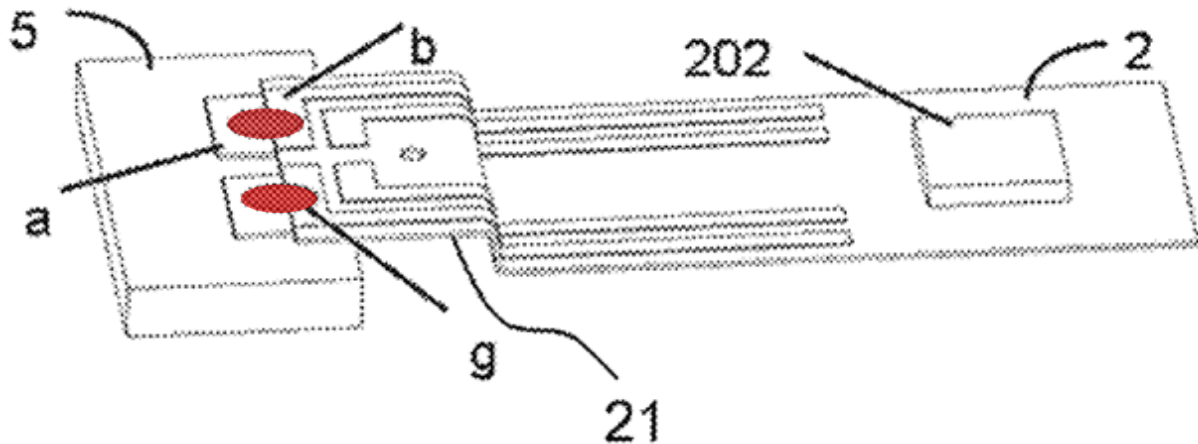


Fig. 24

B. Interpretation of Certain Terms Used in the '068 Patent

1. *“electrically connected/coupled”*

59. Petitioner does not believe this term needs explicit construction, but notes that the specification expressly indicates that the term is broad enough to cover both direct connections and indirect connections (via intervening components). EX1001, 12:30-46.

2. *“attached to an inner circumferential surface of the lamp tube”*

60. Petitioner does not believe this term needs explicit construction, but notes that the specification expressly indicates that similar terms to “attached” like “coupled to”/“connected to”/“on”/“between” are broad enough to cover both direct contact or through “intervening elements” unless direct contact is specified. EX1001, 11:29-41; *c.f.* 31:61-65 (“LED light strip 2 is attached and secured to the

inner surface”) with 52:9-17 (“LED components directly attached on the inner surface”).

3. “adjacent to the two first openings”

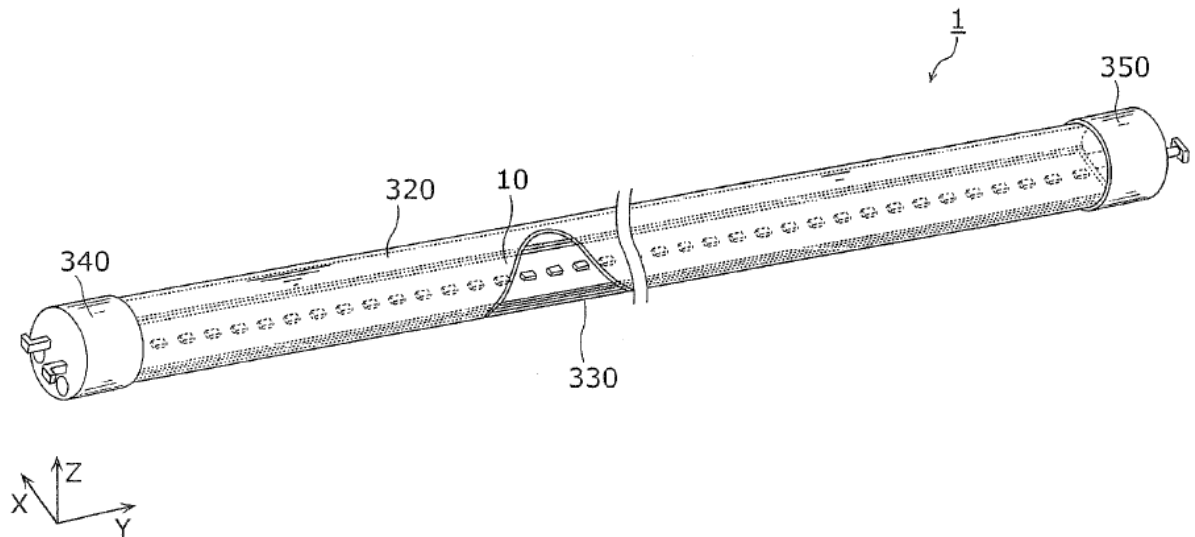
61. Petitioner does not believe this term needs explicit construction, but notes that the specification expressly indicates that “adjacent” is broad enough to cover elements being both “directly adjacent” and adjacent with “intervening elements.” EX1001, 11:29-41.

VII. ANALYSIS OF PRIOR ART TO THE ’068 PATENT

A. Takahashi

62. Takahashi is titled “Lighting Source and Lighting Apparatus.” (EX1005). Takahashi notes that “[i]n recent years, . . . semiconductor light-emitting elements such as LEDs [have] gained in popularity as a substitute for an incandescent light bulb.” Takahashi, 1:20-24. Takahashi describes a “straight tube LED lamp” that “substitutes for a conventional straight tube fluorescent lamp.” Takahashi, 6:28-31.

FIG. 1

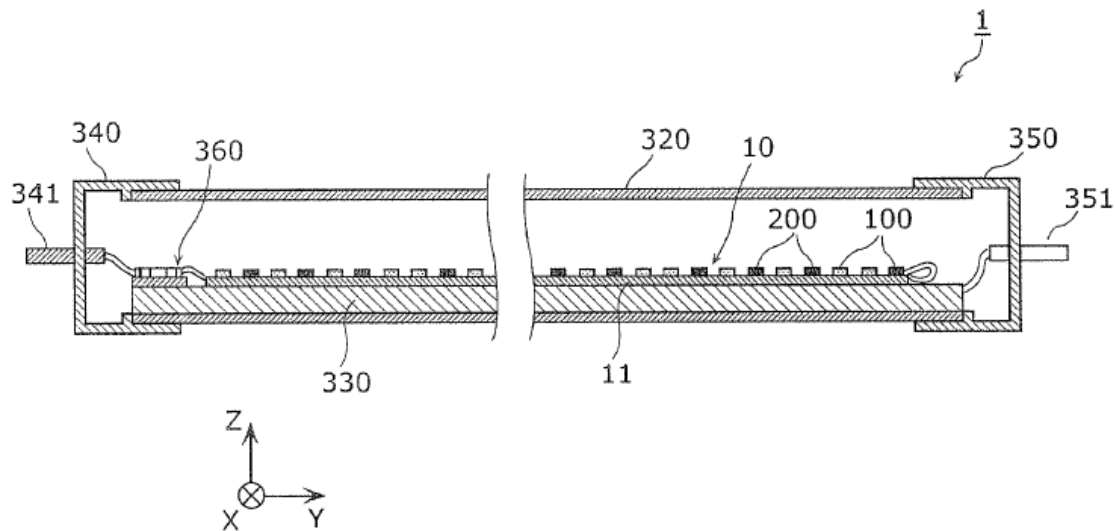


Takahashi, FIG. 1.

63. Takahashi discloses the structural elements of claim 1 of the '068 Patent. As shown in FIG. 1 above, Takahashi discloses that “the straight tube LED lamp 1 is a lighting source including: an LED module 10; “an elongated case 320” (a lamp tube), “feeding base 340” and “non-feeding base 350” (end caps coupled to the ends of the lamp tube), and “an LED module 10” (LED light strip) housed in the lamp tube, and supported by a “base platform 330.” Takahashi, 6:40-48; 7:44-63; FIG. 1. Takahashi also discloses “a feeding pin 341 and a non-feeding pin 351” for

connecting the LED tube lamp to an external socket and electrical power. Takahashi, 6:50-54. The pins 341 and 351 are illustrated in FIG. 2 below.

FIG. 2



Takahashi, FIG. 2.

64. Takahashi discloses a lamp tube with diffusion elements: “The case 320 is an elongated translucent cover covering the LED module 10 and having translucency.” Takahashi, 7:7-8. “The case 320 can be made of a transparent resin material or glass.” Takahashi, 7:11-12. Takahashi discloses a diffusion layer coated on the tube: “Diffusion treatment on an outer surface or an inner surface of the case 320 allows diffusion of light from the LED module 10. Examples of the diffusion

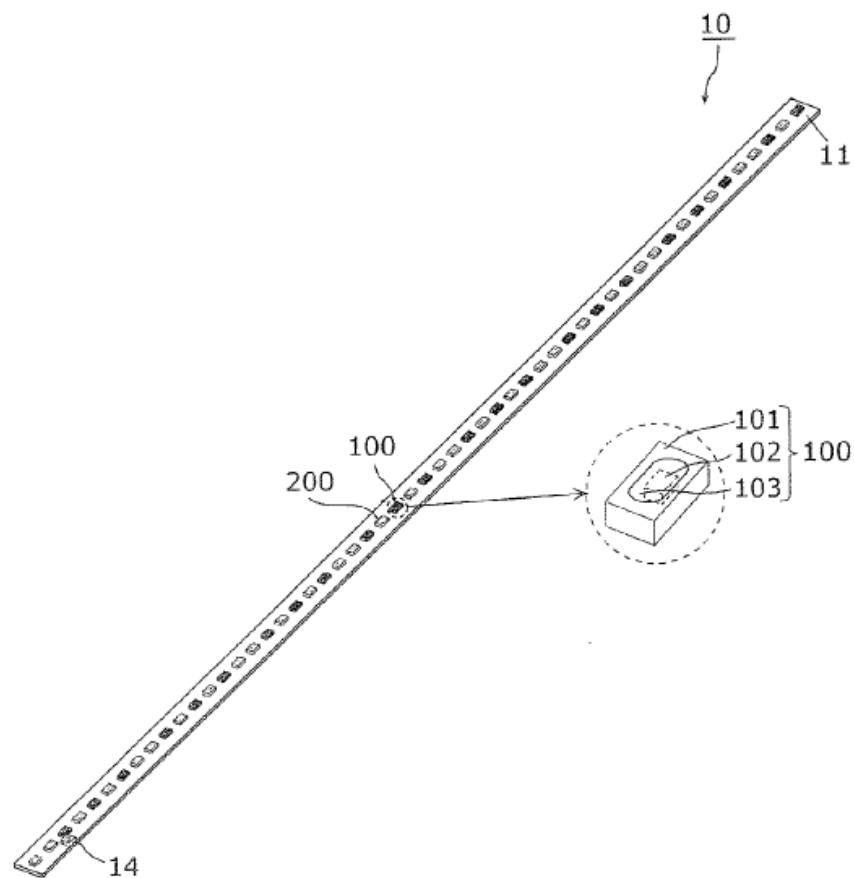
treatment include a method for applying silica, calcium carbonate, or the like to the inner surface of the case 320.” Takahashi at 7:17-22. Takahashi notes that “the case 320 may include a light diffusion unit having a light diffusion function to diffuse light from the LED module 10.” Takahashi, 7:23-25. “Examples of the light diffusion unit include a light diffusion sheet or a light diffusion film provided to at least one of the inner surface and the outer surface of the case 320.” Takahashi, 7:27-29.

65. Takahashi discloses that “the base platform 330 holds (supports) the LED module 10 and the drive circuit 360” and “is firmly fixed to the inner surface of the case 320.” Takahashi, 7:47-51. Takahashi contemplates fixing (or attaching) its LED module 10 onto base platform 330 “with an adhesive.” Takahashi at 7:65-8:4. Takahashi discloses that “the LED module 10 is elongated in a tube axis direction of the case 320, and LED elements 100 and LED elements 200 that are surface mount devices (SMDs) are mounted on a board 11.” Takahashi, 8:5-8. As illustrated in FIG. 2, Takahashi also discloses a “drive circuit 360 [which] may be disposed inside the feeding base 340 via a lead wire connected to a connection terminal on the board 11.” Takahashi, 8:17-19. “The board 11 is an LED mounting board which has at least a surface including an insulating material and on which LED elements are mounted.” Takahashi, 9:9-11. The board may be “a flexible

board including polyimide or the like and having flexibility.” Takahashi at 9:14-15.

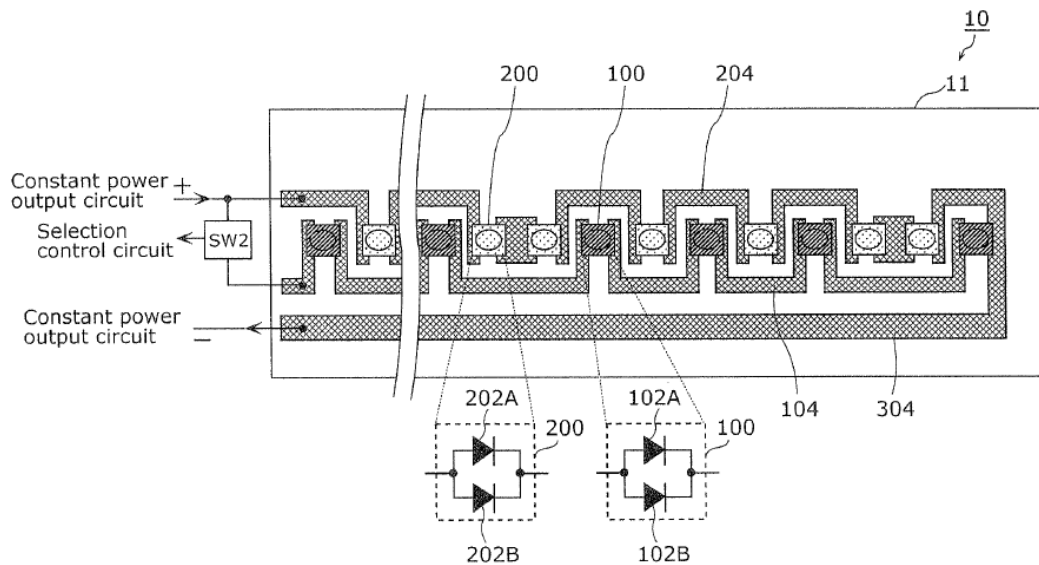
The board 11 and its wiring layers are illustrated in FIGs. 3 and 4, reproduced below.

FIG. 3



Takahashi, FIG. 3.

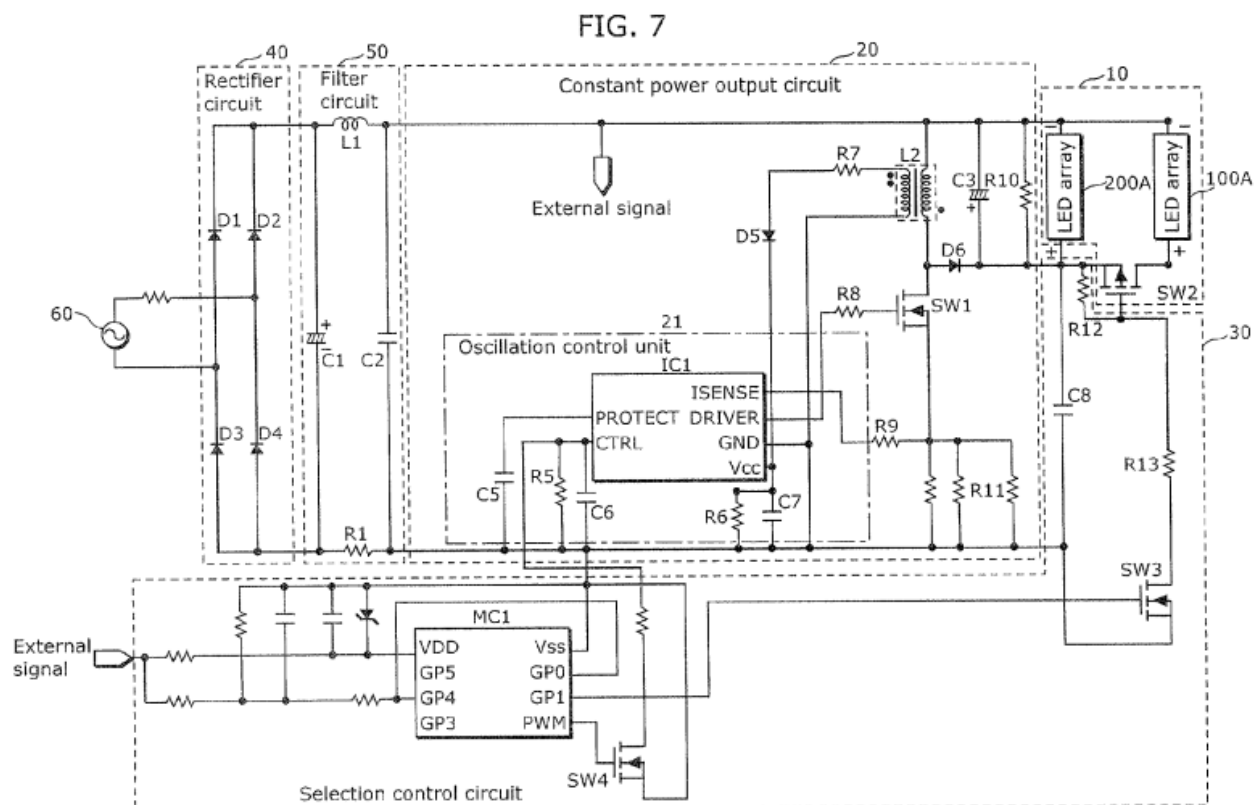
FIG. 4



Takahashi, FIG. 4.

66. Additionally, Takahashi discloses in FIG. 7, below, a “circuit configuration diagram including an LED lamp.” Takahashi, 4:33-34. “FIG. 7 illustrates the LED module 10, the constant power output circuit 20, the selection control circuit 30, a rectifier circuit 40, a filter circuit 50, and an alternating-current (AC) source 60.” *Id.*, 13:49-52. The constant power output circuit 20 and the selection control circuit 30 are included in drive circuit 360. *Id.*, 6:55-65. A POSITA would have understood that these components make up a power supply for Takahashi’s LED tube lamp for the reasons discussed above at paragraphs 41-44. A POSITA would also have recognized that a circuit, such as the drive circuit 360 of

Takahashi, would have necessarily included a printed circuit board (PCB) given the flat form factor illustrated in Takahashi's FIG. 2. It would have been obvious to a POSITA to implement Takahashi's drive circuit 360 as a PCB, at least because PCBs have been used as electronic substrates for decades, including to power LEDs. See, e.g., the power supply circuit boards of Guang, Kawabata, and Ono referenced above at paragraph 41. PCBs were known to desirably provide a compact form factor of the type necessary for placement of a drive circuit 360 in a LED tube end cap as expressly disclosed and depicted by Takahashi.

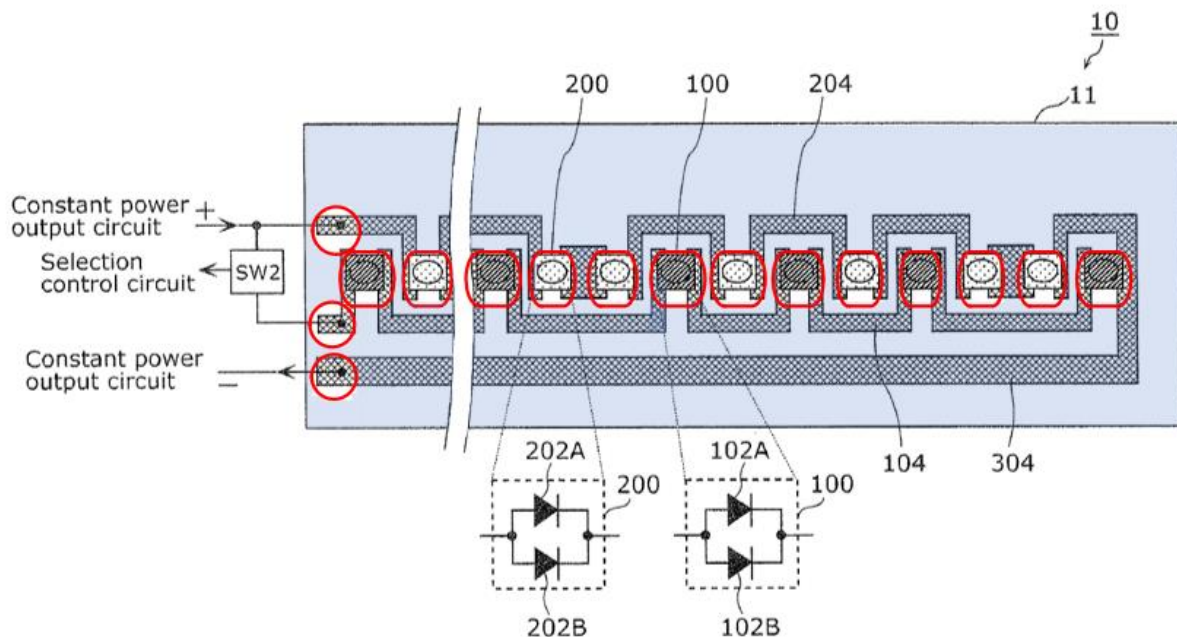


Takahashi, FIG. 7. A POSITA would have understood from these teachings and FIG. 4 that Takahashi's drive circuit 360 is connected to the board 11 via three different connections using a lead wire soldered to the connection terminal. Takahashi depicts these features in the connection between wiring layers and the constant power output circuit at the end of the LED strip depicted in FIG. 4. Thus, the end of Takahashi's light strip has at least two soldering pads for electrically connecting the LED light sources and the power supply.

67. Takahashi teaches a protective layer disposed on a surface of the LED light strip. Takahashi teaches that "to enhance reflectivity and protect wiring, a white resist may be applied to the front surface of the board 11." Takahashi, 9:20-22. From this teaching, a POSITA would have understood that the white resist in Takahashi is a protective layer—that is, it serves a protective function for the wiring it is applied to. A POSITA would have also understood that the white color of the resist would serve to enhance the reflectivity of the board 11, improving the light output of the LED module, as discussed above at paragraph 39. Takahashi does not specifically disclose the details of the white resist layer, e.g., openings to accommodate the LED light sources or solder pads for connection to the power circuit disclosed in FIGs. 4 and 7. But a POSITA would have understood that openings in the protective layer for solder pads and LED light sources would be

necessary for proper connection between the components. For example, Takahashi teaches connecting the LED light sources to wiring lines on the board and connecting the lines to a connection terminal (soldering pads) and to the drive circuit (power supply). See Takahashi, 9:27-42, FIG. 4. A POSITA would have understood that such electrical connections would be more difficult if not impossible to make if the protective layer did not have openings to accommodate those elements. Therefore, a POSITA would be motivated to include [red] openings in Takahashi's [blue] protective layer as shown in modified FIG. 4 below.

FIG. 4



Takahashi, FIG. 4.

B. Shimasaki

68. Shimasaki is titled “Light-Emitting Circuit, Luminaire, and Manufacturing Method for the Light-Emitting Circuit.” (EX1006) Shimasaki notes that “[i]n recent years, according to an increase in output and improvement of efficiency of an LED (light-emitting diode), a luminaire including the LED as a light Source and used indoor or outdoor is developed.” Shimasaki, 1:26-29. Shimasaki discloses a “direct tube type LED lamp 2 [that] has dimensions and an external shape substantially the same as those of an existing direct tube type fluorescent lamp.” Shimasaki, 4:1-4. Shimasaki specifies that “for example, the direct tube type LED lamp 2 has dimensions and an external shape substantially the same as those of 20 W and 40 W direct tube type fluorescent lamps.” Shimasaki, 4:5-9. The direct tube type LED lamp of Shimasaki is illustrated below.

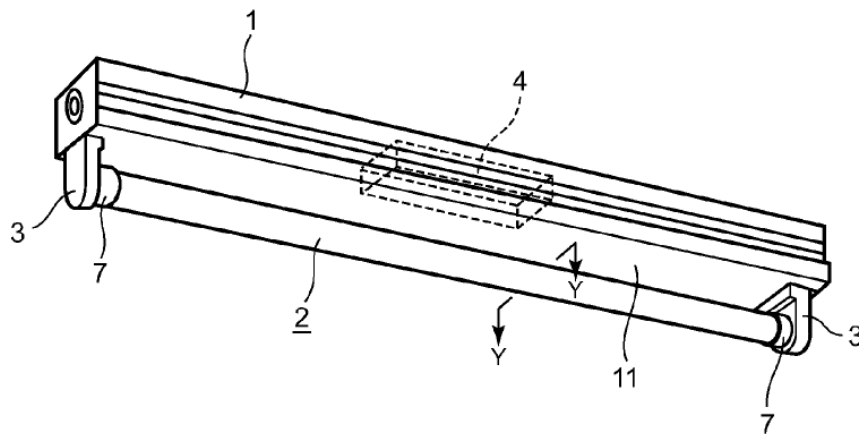


FIG. 1

Shimasaki, FIG. 1.

69. Shimasaki discloses that the structure of its direct tube type LED lamp “includes an elongated main body 5 having a substantially cylindrical shape in external appearance, a light source section 6, and cap sections 7.” Shimasaki, 4:12-14. “As shown in FIG. 2 [below], the main body 5 has an internal space.” Shimasaki, 4:15. “The main body 5 is formed in a substantially cylindrical shape and manufactured by extrusion molding from a synthetic resin material such as translucent polycarbonate resin having diffusibility.” Shimasaki, 4:16-19. “On the inner wall of the main body 5, a pair of 20 supporting rails 51 opposed to each other and projecting to the inner side is formed.” Shimasaki, 4:19-21. “An elongated attachment member 52 is supported by the supporting rails 51 and disposed along the longitudinal direction of the main body 5.” Shimasaki, 4:21-23. Shimasaki describes connecting pins, as “Power supply terminals 71 and an earth terminal 72 projecting from both ends of the direct tube type LED lamp 2 shown in FIG. 16 [which] are connected to the socket sections 3.” Shimasaki, 3:48-50.

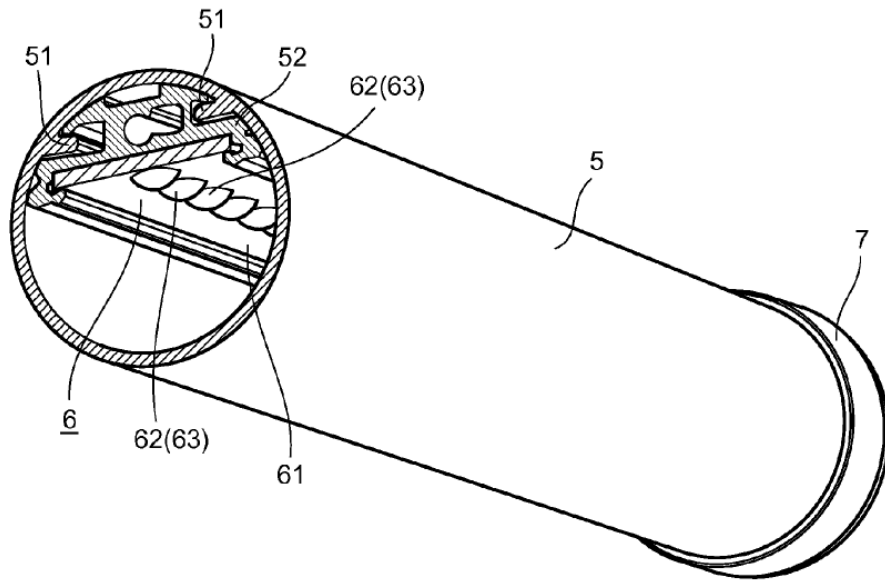


FIG. 2

Shimasaki, FIG. 2.

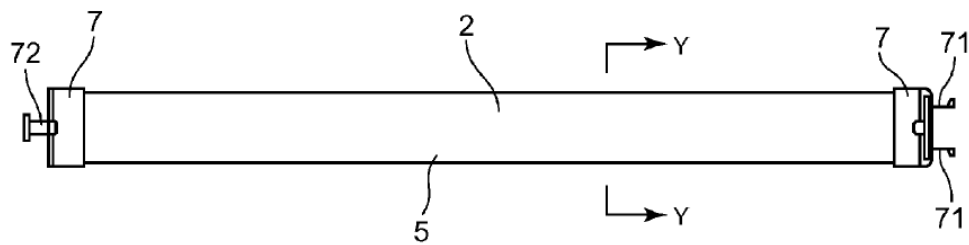


FIG. 16

Shimasaki, FIG. 16.

70. Shimasaki discloses a power supply circuit, “lighting circuit 4 housed in the luminaire main body 1” outside of the lamp tube, which connects a commercial alternating power supply to the LED tube lamp. *Id.* at 3:44-61. “The lighting circuit 4 includes a diode bridge circuit that receives electric power of the alternating-current power supply AC and generates a direct-current output.” *Id.* “The lighting circuit 4 is configured by, for example, connecting a smoothing capacitor between output terminals of the diode bridge circuit and connecting a direct-current voltage converting circuit and a current detecting section to the smoothing capacitor.” *Id.* A POSITA would have understood that the lighting circuit 4, with its diode bridge circuit, direct-current voltage converting circuit, and current detecting section, is a power supply for the reasons set out in paragraphs 41-44 above.

71. Shimasaki’s “light source section 6 includes a substrate 61, a plurality of light-emitting elements 62 linearly arranged and mounted on the substrate 61, and a phosphor layer 63 that covers the light-emitting elements 62.” Shimasaki, 4:33-39. “A plurality of the substrates 61 are arranged and disposed in the longitudinal direction of the light source section 6.” *Id.* “A wiring pattern layer 61a formed of a copper foil is formed on the front surface side of the substrate 61.” Shimasaki, 4:44-52. “A resist layer 61b is laminated on the wiring pattern layer 61a as appropriate.” *Id.* “The resist layer 61b is a white resist layer having high

reflectance.” *Id.* “The resist layer 61b is laminated over substantially the entire surface of the front layer of the substrate 61 excluding a mounting region of the light-emitting elements 62 and solder land sections 61c” *Id.* “The solder land sections 61c are a part of the wiring pattern layer 61a and are portions where the wiring pattern layer 61a, on which the resist layer 61b is not laminated, is exposed to the surface and formed in a corner-rounded rectangular shape.” Shimasaki, 6:24-30. From these teachings, and the discussion above at paragraphs 39-40, a POSITA would have understood this resist layer to be a protective layer because it covers the wiring layers. A POSITA would also have understood that the protective layer of Shimasaki explicitly included openings to accommodate the LED light sources (light emitting elements) and at least two soldering pads (solder land sections). This structure, including the openings in the resist layer for a mounting region and solder land sections, is illustrated below.

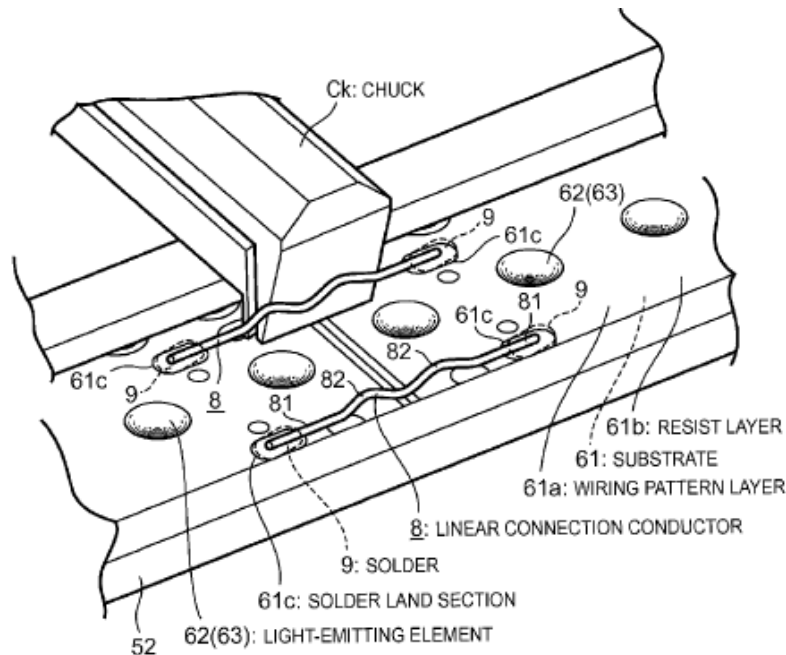


FIG. 5

Shimasaki at FIG. 5.

C. Levante

72. Levante (EX1007) is titled “LED Strip Light Connector System” and describes techniques “for providing a reliable connection between a flexible LED light strip and a connector.” Levante at Abstract. Levante describes connecting a flexible LED strip to a rigid “support member 20 . . . comprised of a printed circuit board having circuitry that electrically connects the connectors attached to the support member 20.” Levante at 5:10-15. This support PCB includes two support portions 24 and 26 “preferably comprised of unitary structure,” (*Id.*, 5:46-52) or in

other words made as part of the same PCB substrate. “With a printed circuit board used for the support member 20, the support member 20 preferably integrates system level components within the printed circuit board such as but not limited to occupancy sensors, timers, dimmers, switches, diode bridges, voltage regulators and control modules.” *Id.*, 5:22-27.

73. In addition to its solderless connector, Levante describes a soldered connection between the LED light strip and the supporting PCB. Levante at 7:7-20, FIG. 14 (reproduced below). “In the soldered connection, at least two electrical contacts 29 that are adapted to have a corresponding pair of solder joints 41 connect to the connecting end 13 of the light strip 12 as shown in FIG. 14.” *Id.*, 7:11-14. “The solder joints 41 may be applied to the contacts 14, 15 of the light strip 12 and the electrical contacts 29 of the support member 20.” *Id.*, 7:14-16. From this description and FIG. 14, A POSITA would have understood that contacts 14, 15, and 29 are soldering pads for forming electrical connections, and that solder joints 41 cover the edge of the connecting end 13 of the light strip 12.

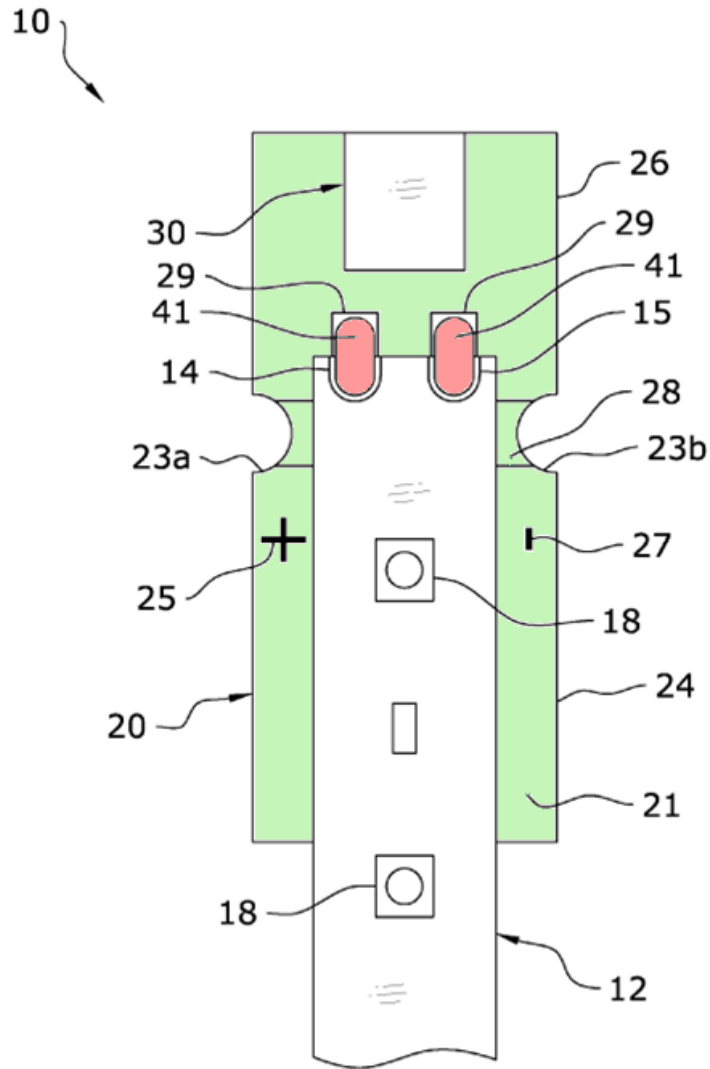
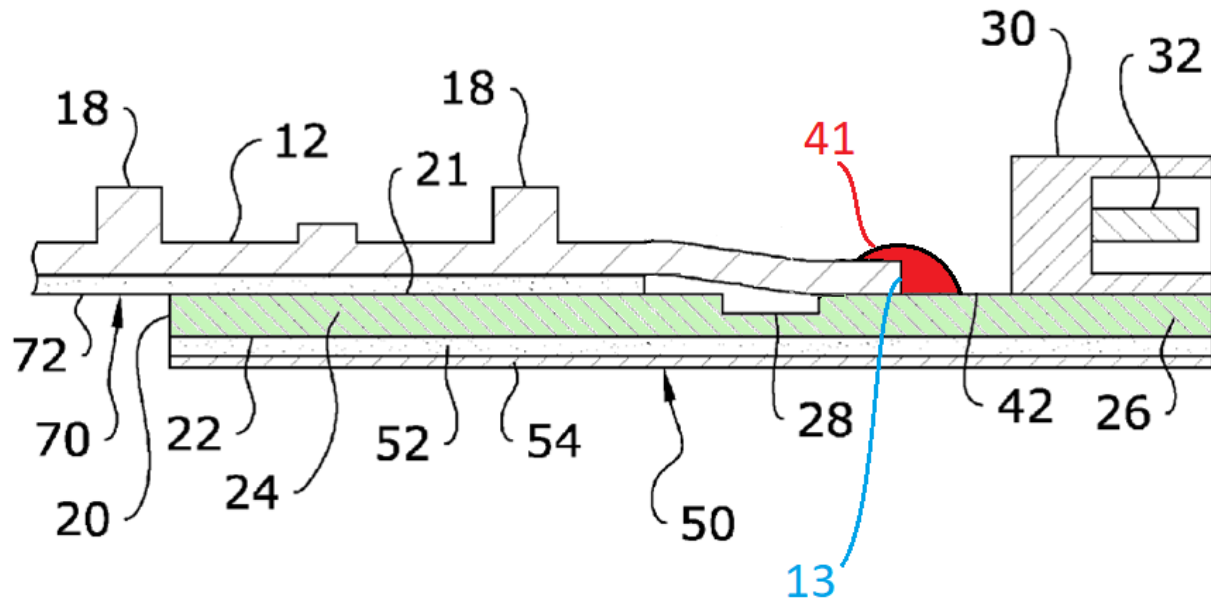


FIG. 14

Levante, FIG. 14. A POSITA would have understood that Levante's [red] soldered connection 41 covers the edge of connecting end 13 of the light strip 12, as illustrated below in a side-view figure based on Levante FIGs. 6 and 14.



Levante explains that “in FIG. 14, the light strip 12 is attached to the first support portion 24 of the support member 20 along the longitudinal axis of the support member 20 similar to the connection with a solderless connector 40.” Levante at 7:16-20. While FIG. 6 below, included for comparison, shows the use of a solderless connector 40, a POSITA would have expected that the soldered connection shown from the top in FIG. 14 would have resulted in a side view similar to that of the figure above.

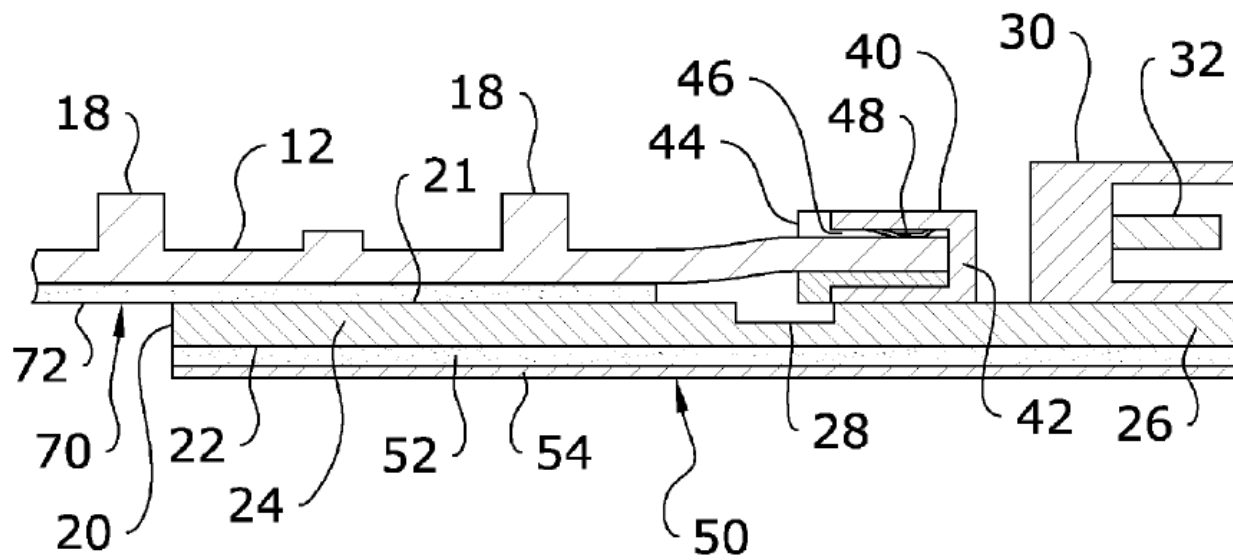


FIG. 6

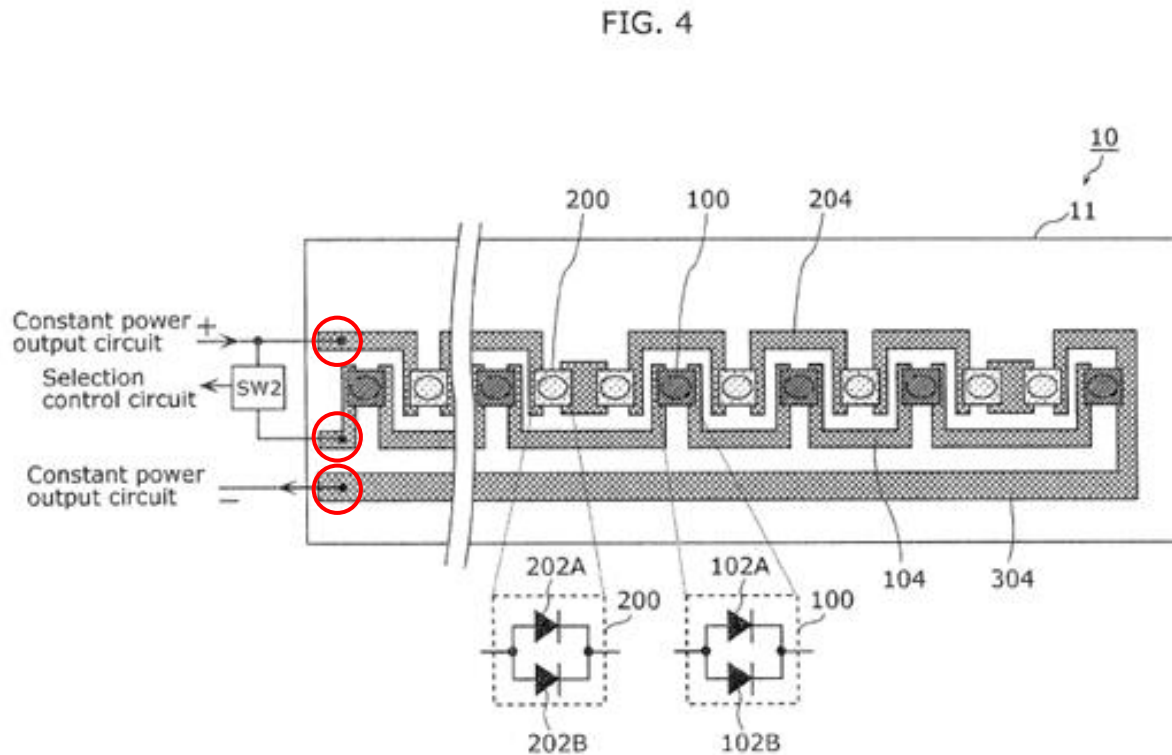
1. *It Would Have Been Obvious to Modify Takahashi's LED Tube Light to Utilize Shimasaki's Resist Layer with Openings for LED Light Sources and Solder Pads.*

74. The LED tube lamp taught by Takahashi teaches the elements recited in Claim 31 of the '068 Patent. Specifically, and as explained above at paragraphs 62-67, Takahashi teaches an LED tube lamp with a glass tube (7:11-15, FIG. 1); two end caps, each of the two end caps coupled to a respective end of the glass tube (6:40-48, FIGs. 1-2); an LED light strip attached to an inner circumferential surface of the glass tube (7:65-8:4, FIGs. 1-2); a plurality of LED light sources mounted on the LED light strip (8:5-13, FIGs. 3-4); at least two first soldering pads arranged at

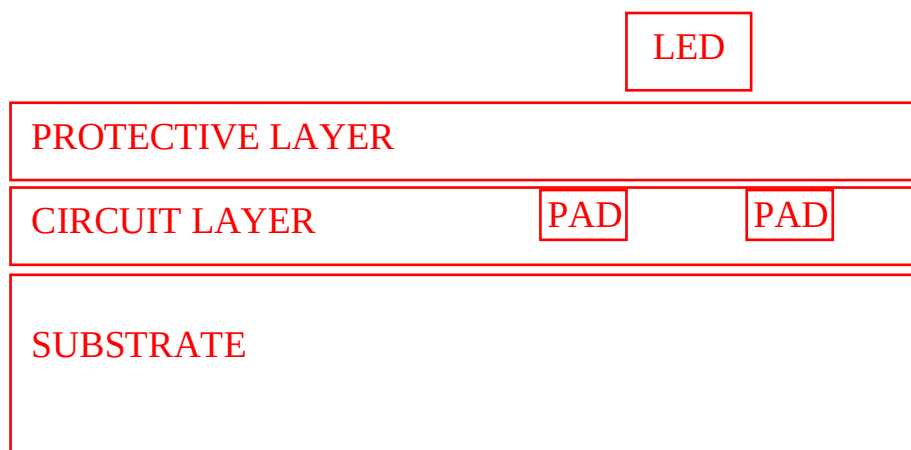
one end of the LED light strip (9:37-42, FIG. 4); a protective layer disposed on a surface of the LED light strip (9:20-22); and a power supply module comprising a printed circuit board and configured to drive the plurality of LED light sources (6:55-65, 13:48-56), wherein the power supply module at least comprises a rectifying circuit and a filtering circuit coupled to the rectifying circuit (13:48-63, FIG. 7).

75. Takahashi does not teach explicitly that the protective layer has openings to accommodate the LED light sources or its connection terminal to which “lead wire is soldered” “to be fixed to the board 11.” Takahashi, 9:40-42). But Takahashi implicitly teaches openings in the protective layer for the connection terminal and LED light sources. A POSITA would have viewed such connections—between the LEDs and the board, and between the drive circuit 360 and the connection terminal 14 of the board—to be necessary for the operation of Takahashi’s LED lamp. Because of this, a POSITA would have been motivated to include such openings through Takahashi’s “white resist” layer on “the front surface of the board 11.” *Id.* More particularly, Takahashi teaches connecting the LED light sources to wiring lines on the board and connecting the lines to a “connection terminal” (soldering pads) and to the drive circuit. *See* Takahashi at 9:27-42 and FIG. 4. A POSITA would have understood that Takahashi’s drive circuit 360 is connected to the board 11 via three different connections—one for each line—using

a lead wire soldered to soldering pads as highlighted in red in annotated FIG. 4 below.

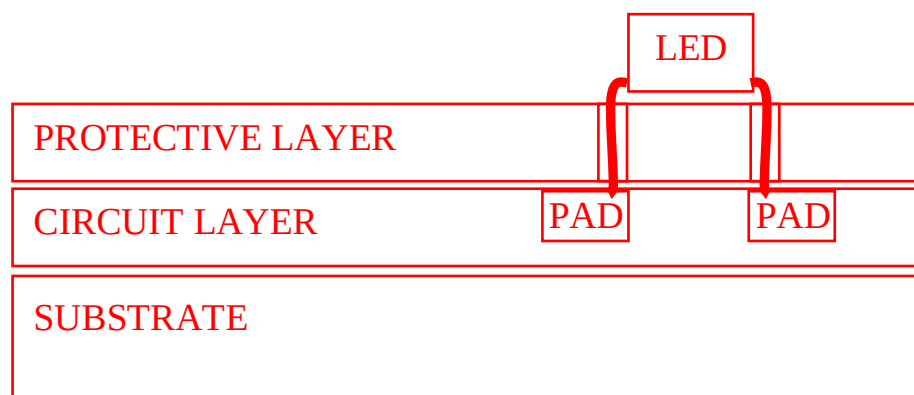


76. A POSITA would have understood that—“to ... protect wiring”—the protective layer must necessarily be above the wiring. And—“to enhance reflectivity”—the protective layer must necessarily be below the LEDs (and not over the LEDs). As illustrated conceptually below, a POSITA would have also understood that such circuit boards are typically manufactured layer-by-layer, such that the circuits would be added as a layer over a substrate, and the protective layer would be added as an additional layer over the circuits.



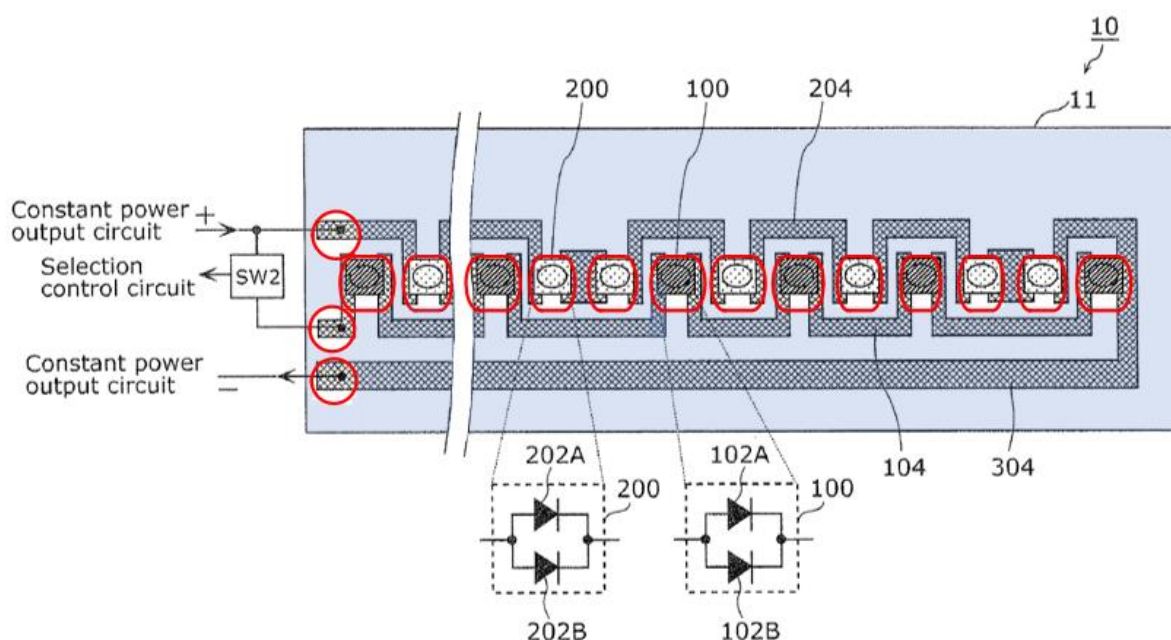
77. In this illustrated example, the circuit layer includes two solder pads for connecting the LED to receive power. Similar solder pads could be formed adjacent to an end of the LED light strip to make connections to the power supply. A POSITA would have understood that such electrical connections would be more difficult, and likely impossible, without creating openings in the protective layer through which to make the connections. To that end, in such layered circuit manufacturing, a POSITA would have expected such a protective layer to be applied over the entire area and then “etched” to remove portions of the coating where a connection is needed between layers. Alternatively, a POSITA would have understood that a mask could be applied to the circuit layer before the protective layer is applied, such that when the mask is removed, it would remove portions of the protective layer applied to the mask and similarly expose openings through which connections to the LEDs or the power supply could be made. Such masking would occur before the placement of the LEDs at least because the effectiveness of masking depends on the mask being

placed directly on the underlying layer. Otherwise, during deposition of the protective layer, material could seep under the mask, resulting in ill-defined boundaries that frustrate the purpose of masking, such that placing the mask over LEDs would be ineffective. In either option, the protective layer would be between the circuit layer and the LED, such that openings would necessarily be included for electrical connections, as indicated below.



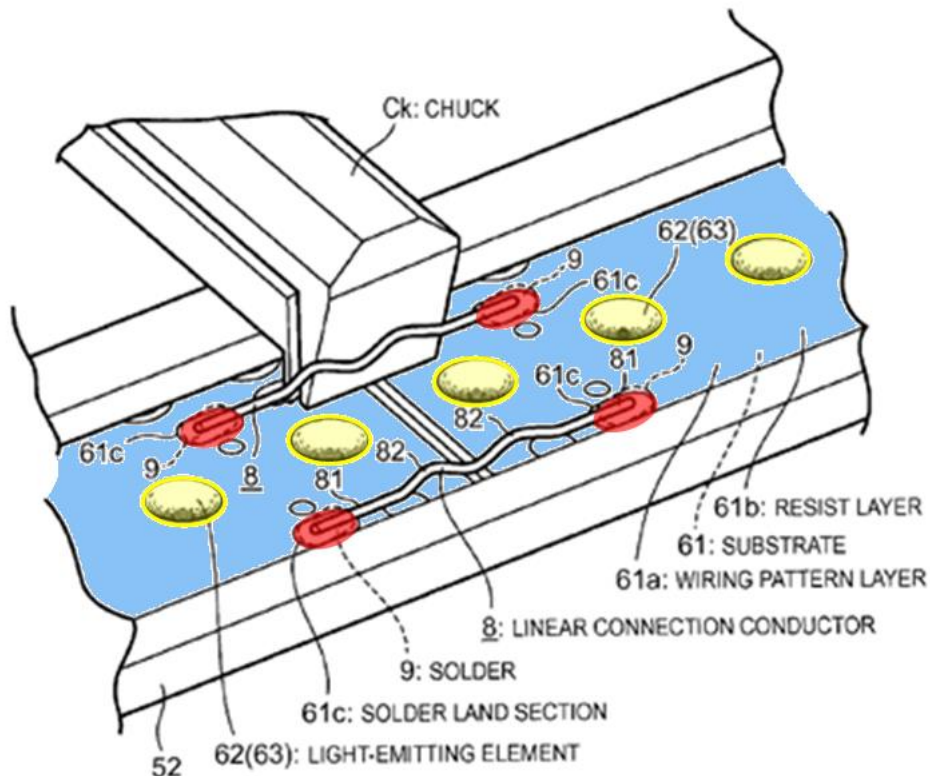
Therefore, a POSITA would have been motivated to include [red] openings in Takahashi's [blue] protective layer as shown conceptually below in annotated FIG. 4. In the absence of explicit disclosure within Takahashi, a POSITA would have also been motivated to look elsewhere for details of such openings.

FIG. 4



78. Shimasaki explicitly discloses such openings through a protective resist layer to allow for LED connections and board-level connections. See Shimasaki at 4:44-52. “A resist layer 61b is laminated on the wiring pattern layer 61a as appropriate.” *Id.* “The resist layer 61b is a white resist layer having high reflectance.” *Id.* As shown below in annotated Shimasaki FIG. 5, “The resist layer 61b [shown in blue] is laminated over substantially the entire surface of the front layer of the substrate 61 **excluding** a mounting region of the [yellow] light-emitting elements 62 and [red] solder land sections 61c.” *Id.* (emphasis added). As discussed in the introduction to Shimasaki at paragraphs 68-71, a POSITA would have understood this resist layer to be a protective layer, and the **excluding** language to

be explicitly describing openings for LED light sources and soldering pads. Furthermore, Shimasaki explicitly teaches making these openings for mounting LED light sources to the LED light strip (Shimasaki at 4:34-36, 47-50) and for soldering pads formed so connections between circuit elements, including the wiring layers and the power supply, can be made. Shimasaki at 4:47-51, 5:40-42, 10:4-7, and FIG. 5.



A POSITA would have been motivated to incorporate openings into the protective layer of Takahashi, as explicitly taught by Shimasaki, at least because such openings

would enable efficient connection of the LED light sources to the wiring used to provide power to the LED light sources while providing the advantages offered by the protective layer, such as improved light output efficiency and protection against corrosion and damage as explained above at paragraph 39.

79. Moreover, a POSITA would have been motivated to include such openings in Takahashi's "white resist" layer (EX1005, 9:20-22) to enable the soldered connections contemplated by Takahashi (*id.*, 9:40-42) because soldered connections through such openings represented one desirable option from of a finite number of options for making electrical connections. Takahashi's soldered connections could theoretically have been enabled by omitting the resist layer, but doing so would sacrifice the benefits—enhanced reflectivity and protection for wiring—taught by Takahashi (*id.*, 9:20-22). Alternatively, Takahashi's connection terminal could have theoretically been replaced by a mechanical plug connector (for example, such as the mechanical pin connectors described by Guang at 7:15-24), but a POSITA would have viewed a soldered connection as a more-reliable connection. For example, soldering typically secures and strengthens the direct contact between a wire and the solder pads, and eliminates an intermediate connection that would otherwise be present between the wire and the connector, for at least the reasons discussed above at paragraph 51. Additionally, a POSITA would have expected

soldered connections to be less susceptible to oxidation that could impede the connection between plug connectors, at least because the solder fills and surrounds the interface between the wire and the solder pad, whereas a connector—even when tight—permits air (and entrained moisture) to intrude into the interface between the pin and socket. *See* Shimasaki at 7:38-41 (“Spare solder 9a for preventing oxidation of the solder land sections 61c and protecting the solder land sections 61c is applied to the solder land sections 61C.”). And Shimasaki teaches that connectors are not used “to prevent the connectors from becoming obstacles to light emitted” from the LEDs. Shimasaki, 8:45-49. Thus, a POSITA would have preferred openings in Takahashi’s resist layer for solder pads as preferred among a small set of known options. *See* discussion above in paragraphs 45-51.

80. Finally, a POSITA would have reasonably expected to successfully incorporate such openings into Takahashi’s resist layer to allow connections through that layer, at least because such openings and connections were known in the art, and because Shimasaki successfully uses them in the same field—i.e., connection between a power circuit and an LED light strip. Thus, openings in a protective layer were known to predictably enable electrical connections for LED light strips.

2. *It Would Have Been Obvious to Solder Takahashi's LED light strip to the Power Supply PCB using Levante's soldering technique.*

81. As explained above in paragraphs 74-75, Takahashi contemplates the use of soldered connections between its LED board 11 and drive circuit 360. Takahashi at 9:40-42. Furthermore, Takahashi describes that its LED board 11 may be “a flexible board including polyimide.” Takahashi, 9:11-16. Takahashi does not explicitly describe soldering the connection terminal on the board directly to soldering pads on the power supply PCB, instead describing the use of a lead wire soldered between the strip and the PCB. Takahashi, 9:40-42. Lead wires and faulty solder joints were known to be a common failure point for LED lights. For example, Shimasaki acknowledged that “it is difficult to guarantee the reliability of the joining of the lead wire.” Shimasaki at 3:9-10. Shimasaki's solution was to manufacture lead wires “bent in a convex shape” for connecting LED strips. *Id.*, 2:63-67.

82. However, a POSITA would have understood that LED strips could be soldered directly to other PCBs using any of several known techniques, as discussed above at paragraphs 47-51. A POSITA would have known that flexible PCBs or LED strips have the advantage of being able to be positioned as needed, as discussed above at paragraph 35. A POSITA would have been motivated to take advantage of this flexibility to position the LED strip as needed within the tube, including positioning the end so as to be close and to allow direct soldering. Moreover, a

POSITA would have understood at least from the teachings of Shimasaki (*see* Shimasaki at 3:9-10) that lead wires experience weakness under stress and that a direct soldered connection could remove the lead wire element and its associated weaknesses. Levante confirms the known weakness present in LED lighting connections, noting that without a “support structure,” both “soldered and solderless . . . conventional connectors for flexible LED light strips” can fail over time due to forces acting on them. Levante at 1:66-2:8. Levante’s solution is to position its flexible LED strip to enable direct soldering of soldering pads on its LED strip to soldering pads on its PCB. *Id.*, 7:9-20. Levante’s PCB also serves “to provide support to the light strip,” preventing the failure of the solder joints. *Id.*, 5:7-10. A POSITA would have recognized that when flexible LED strips like Takahashi’s are supported as in Levante, they can be soldered reliably. A POSITA would have been motivated to combine Levante’s support and soldered connection into Takahashi’s LED lamp to address the known weakness of lead wires.

83. A POSITA would also have been motivated to use a direct soldered connection over a lead wire or connector because, as explained in paragraphs 51 and 79 above, they would have found a soldered connection more secure. Furthermore, substituting a direct soldered connection for a lead wire soldered to the LED strip would reduce the cost to manufacture the LED tube lamp by removing the additional

elements of a lead wire or a connector, as well as the manufacturing steps and tools necessary to install such a lead wire or connector. A POSITA would have understood that such a modification would have been a mere substitution of one known technique (direct soldered connection) for electrically connecting LED lighting devices for another known technique (lead wires soldered at both ends), and the results of both techniques were predictable (*e.g.*, working electrical connections suitable for receiving and distributing power from a power supply to LED light sources). Finally, Takahashi itself contemplates the use of “equivalent structures” for forming LED tube lamps. Takahashi, 18:1-6. In the absence of explicit disclosure within Takahashi, a POSITA would have been motivated to look elsewhere for a technique to form this connection.

84. Levante explicitly teaches solder disposed on soldering pads on a flexible LED strip, on soldering pads on a PCB, and covering an edge of the flexible LED strip. Levante, 7:9-20, FIG. 14. As illustrated in FIG. 14 below, Levante teaches a “soldered connection” including [red] “solder joints 41 . . . applied to the contacts 14, 15 [soldering pads] of the light strip 12 and the electrical contacts 29 [soldering pads] of the [green] support member 20 [PCB].” *Id.*, 7:14-16.

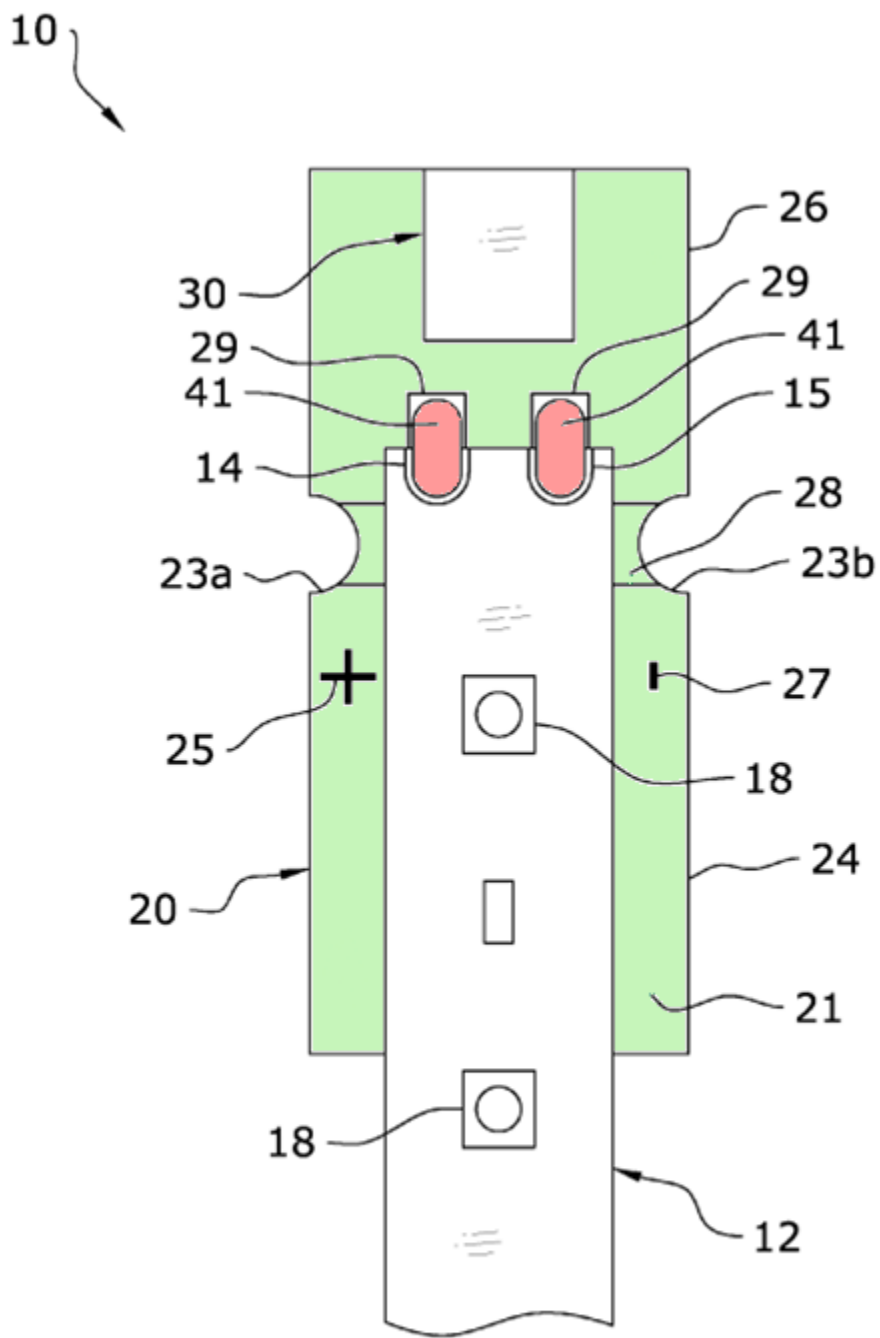
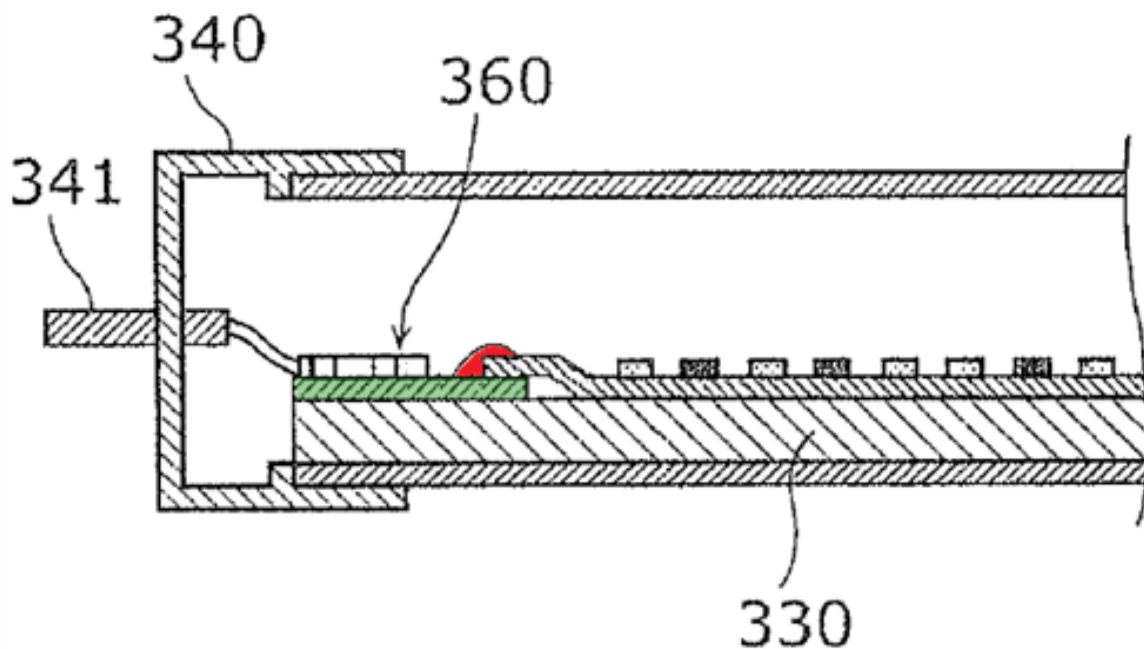


FIG. 14

85. A POSITA would have recognized that Levante's soldered connection could have been desirably incorporated into Takahashi's tube lamp in at least two ways. First, as illustrated in modified Takahashi FIG. 2 below, Levante's (red) soldered connection could connect Takahashi's LED strip directly to the (green) power supply PCB ("drive circuit 360"). This would take advantage of the flexibility of Takahashi's LED strip in forming a secure soldered connection to the power supply, while maintaining the support structure Levante teaches (Levante at 4:49-5:27).



86. Alternatively, Takahashi's power supply components, including its rectifier and filter circuits, could have been mounted to Levante's PCB 20 in a

similar way to Levante's connector 30 for use in Takahashi's LED tube lamp, as illustrated in modified Levante FIG. 14 below. In this arrangement, Levante's connector 30 could be kept on the PCB for connecting the power supply module to Takahashi's pin 34 for connecting to external electricity. Further, Levante explicitly contemplates that additional electrical components, including "switches, diode bridges, voltage regulators and control modules" would preferably be integrated onto PCB 20. EX1007, 5:22-27. As discussed above at paragraph 42, circuit components like these could be included in power supply circuits. Indeed, Takahashi explicitly teaches the use of switches and control circuits as part of its power supply circuits. See Takahashi at 13:48-14:26. Thus, a POSITA would have reasonably expected that power supply components could be successfully integrated onto Levante's PCB 20.

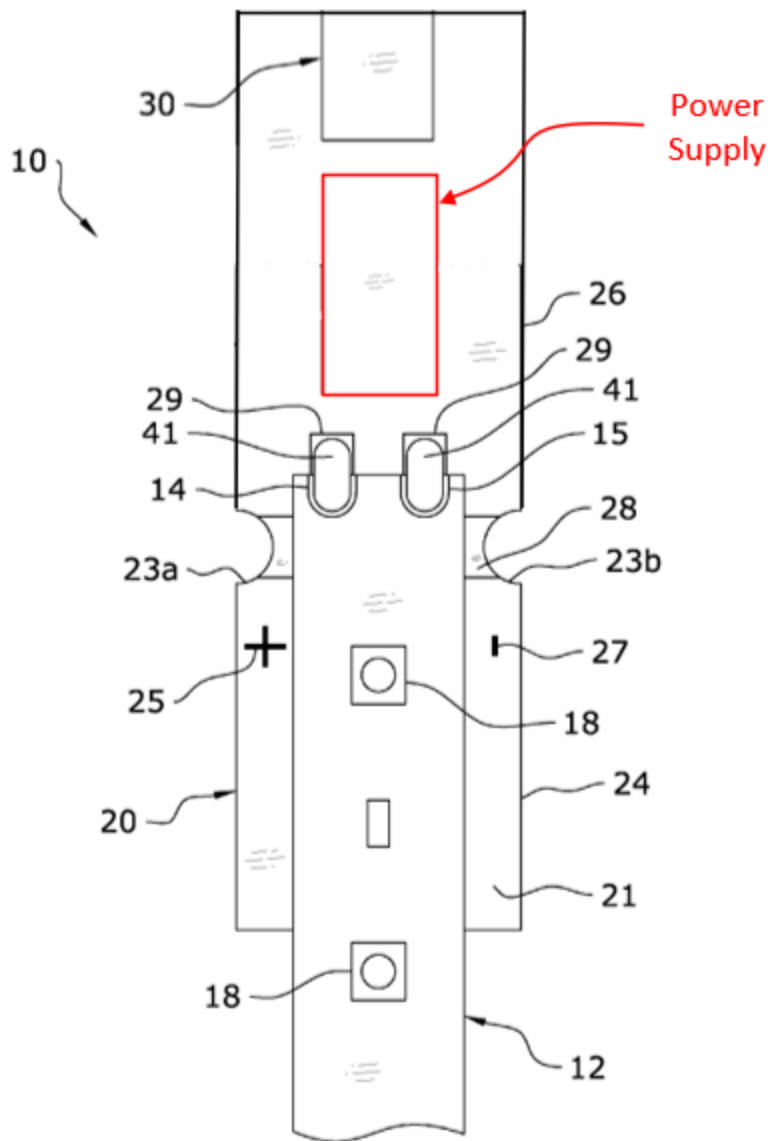


FIG. 14

87. In either configuration, a POSITA would have been motivated to use Levante's soldered connection for connecting Takahashi's flexible LED strip to the power supply PCB to take advantage of the flexibility of the LED strip and to form

a secure connection between the soldering pads. A POSITA would have recognized that there were multiple known methods for creating this direct soldered connection, as discussed above in paragraphs 47-51, including arranging the flexible LED strip above the power supply PCB and forming the soldered connection as in Levante. Using Levante's method of forming a soldered connection in Takahashi's tube lamp would necessarily require detaching the end of the LED strip from the base platform 330 so as to arrange the LED strip's soldering pads over the PCB soldering pads. Alternative methods for forming an equivalent soldered connection would include soldering between soldering pads on an LED strip arranged adjacent to the PCB, at least to the extent that the LED strip and the PCB were of comparable thicknesses, or soldering in through holes in the soldering pads. Selection from a known group of methods for forming a direct soldered connection would have been merely a matter of design choice, and the results of selecting one soldering method over another would yield predictable results (e.g., working electrical connections, formed securely by solder). A POSITA would have expected that to enable the direct soldered connection of Levante in Takahashi's end cap, the soldering pads would ideally be arranged at the end of the strip as in Levante's orientation to prevent excess LED strip substrate material, which could increase costs and potentially get in the way of soldering.

88. As discussed above in paragraphs 51, 83, substituting a lead wire soldered to Takahashi's connection terminal with a direct soldered connection would reduce costs of manufacturing by eliminating a lead wire. A POSITA would have also been motivated to utilize a direct soldered connection instead of a lead wire to support automation of manufacturing processes. For example, Shimasaki describes using automatic supply machines and techniques to manufacture LED lamps. EX1006, 5:40-7:64; 9:29-31 (describing an automatic joining processes to produce LED lighting arrays with electrical connections to soldering pads). While Shimasaki does not explicitly disclose the over-the-edge soldering technique used in Levante, a POSITA would have recognized that similar automation methods could have been used and would be desirable to form Levante's soldered connection. A POSITA would have understood that the inherent flexibility of a flexible LED strip would enable it to be used in place of a lead wire to connect to the power supply. Applying the teachings of Levante in supporting the LED strip as well as making a direct soldered connection would have allowed a POSITA to take advantage of the LED strip flexibility. A POSITA would have reasonably expected success in making this combination because Levante explains that support for the strip reduces the stress that can cause connection failure. Levante at 1:66-2:8, 4:49-5:27. Thus, a POSITA would have been motivated to use a direct soldered connection to improve

manufacturability and reduce costs for LED tube lamps. Thus, Takahashi-Shimasaki-Levante renders obvious a power supply PCB connected to a flexible LED strip with solder on soldering pads and covering an edge of the LED strip.

D. Gu

89. Titled “LED Fluorescent Lamp with an LED Substrate at the Bottom of a PC Tube,” Gu discloses an LED fluorescent lamp “comprising an LED substrate, . . . a plastic tube, end caps and power panels.” Gu, at ¶[0007]. A POSITA would have understood from the form factor of Gu’s power panels 2 as depicted in Fig. 6 below, that Gu’s power panels are formed on PCBs. For example, the power panels are depicted with cylindrical components protruding from them, which would indicate to a person of skill in the art that the power panels included components typical of LED power supplies, such as capacitors and inductors, similar to the components described above in paragraphs 41-43. Such components are usually arranged on PCBs in commercial lighting products. Even if those components are not explicitly identified as being on a PCB, it would have been obvious to a POSITA to implement Gu’s power panels as a PCB, at least because PCBs have been used as electronic substrates for decades, including to power LEDs. *See, e.g.,* the power supply PCBs of Guang, Kawabata, and Ono referenced above at paragraph 41. Gu explicitly describes soldering directly between soldering pads on the LED substrate

and the power panels: “Each of the two ends of the LED substrate is provided with a plurality of rectangular solder joints, the bottom of the side of each power panel adjacent to the end cap is provided with a plurality of rectangular solder joints, and the LED substrate is connected to the power panels by means of the solder joints.” *Id.*, ¶[0008]. “Solder faces are arranged on the upper surfaces of the two ends of the LED substrate, a solder face is arranged on the side of each power panel adjacent to the end cap, a groove is opened on each power panel, the LED substrate passes through the groove, the LED substrate solder face intersects with the power panel solder face at an angle of 90°, and the intersection surface is soldered to achieve quick electrical connection between the LED substrate and the power panel.” *Id.*, ¶[0009]. This arrangement is shown in FIGs. 6-7 below.

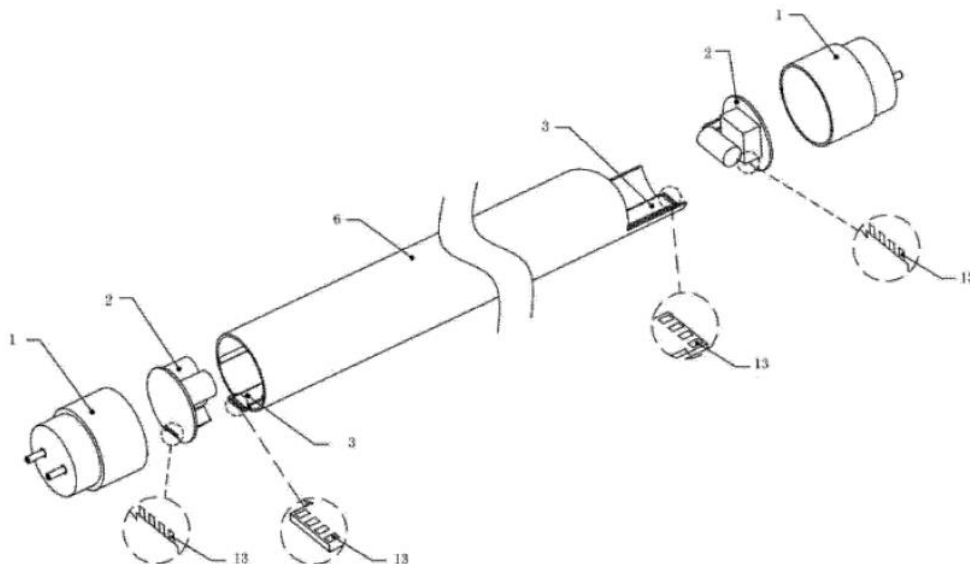


Fig. 6

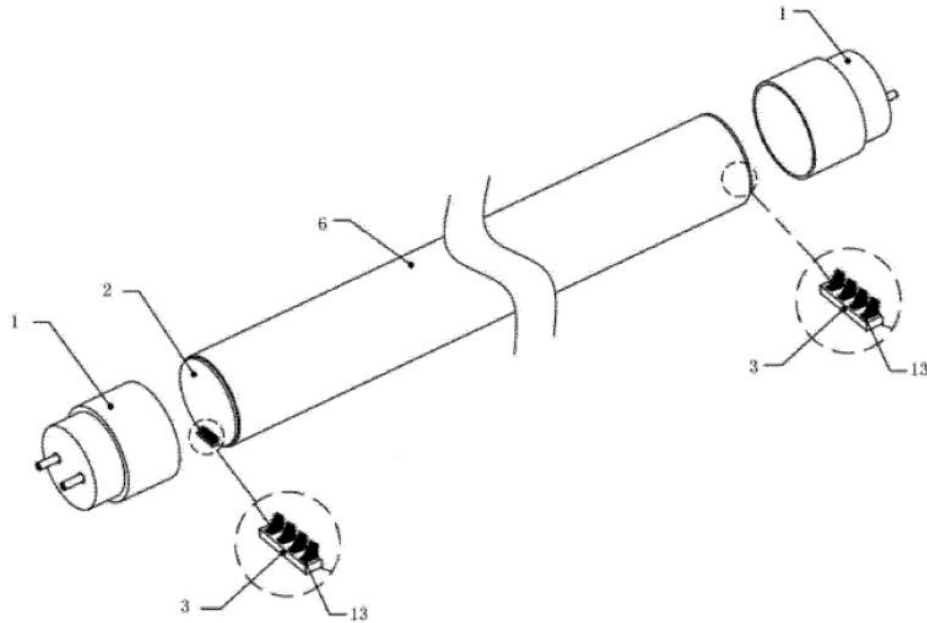


Fig. 7

EX1010, FIGs. 6-7.

90. Gu teaches that “the solder faces of the LED substrate and the power panels are directly soldered, and the adoption of this quick electrical connection method features low cost and convenient and simple assembly and is conducive to market promotion.” Gu, ¶[0015].

1. It Would Have Been Obvious to Include Gu’s Soldering Pads on the Power Supply Module of Takahashi-Shimasaki-Levante.

91. For the reasons discussed above related to the Takahashi-Shimasaki-Levante combination, see paragraphs 74-80, a POSITA would have been motivated to include soldering pads on Takahashi’s power supply PCB to enable electrical

connections between the PCB and the LED strip. Soldering pads were the obvious way to form the soldered connections contemplated by Takahashi (see Takahashi at 9:40-42), and were clearly demonstrated in Levante's soldered connection. See Levante at 7:7-20.

92. To the extent that it is argued that Takahashi does not explicitly disclose soldering pads on the power supply PCB or a direct, soldered connection between soldering pads on the power supply PCB and the LED strip, Gu renders obvious soldering pads on a power supply PCB, soldered directly to soldering pads on an LED strip.

93. As illustrated in modified FIG. 6 below, Gu teaches an LED tube lamp with LED strip 3 ("LED substrate"), power supply PCB 2 ("power panel"), and soldering pads 13 ("solder joints") on both the LED strip (depicted in green) and the power supply PCBs (depicted in blue) at each end of the tube. EX1010, ¶¶[0008]-[0009]; FIGs. 6-7.

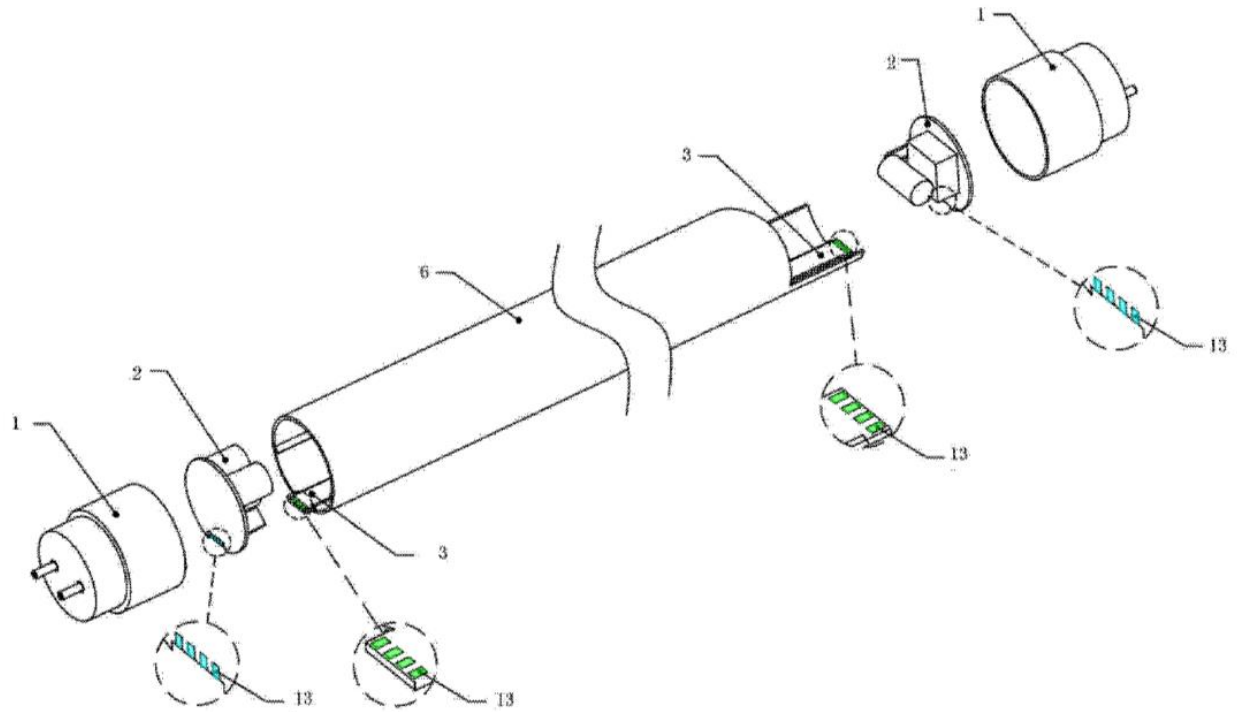


Fig. 6

94. As shown in modified FIG. 7 below, the pads are aligned adjacent to each other and (red) solder is then applied to solder the soldering pads on the power supply to the soldering pads on the LED strip.

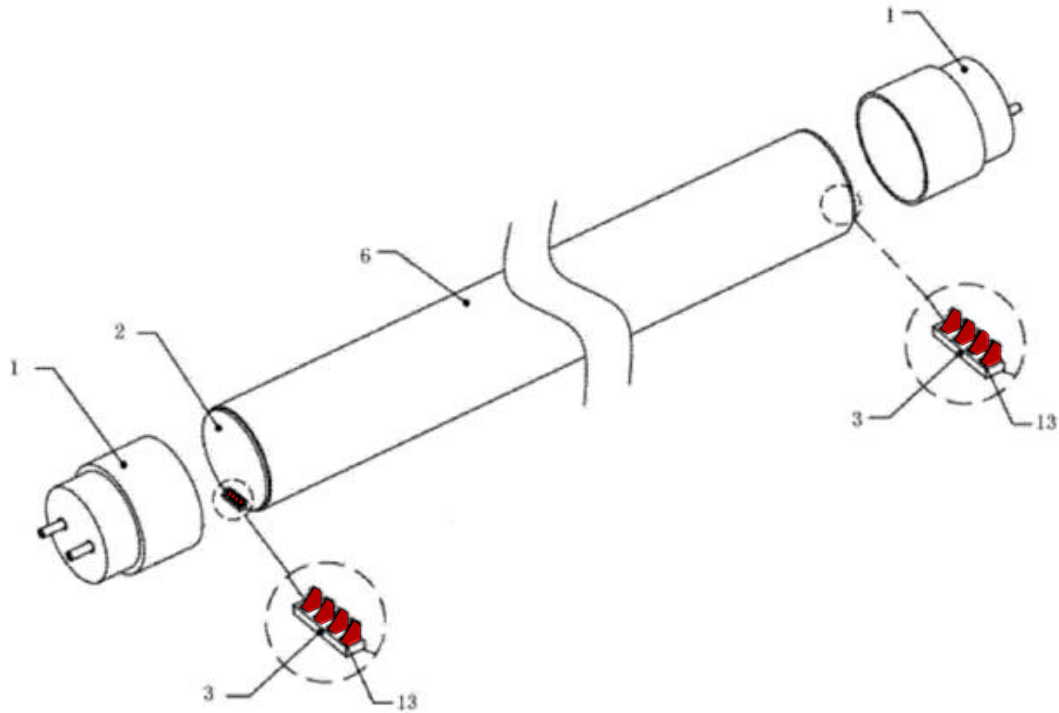


Fig. 7

95. Gu teaches that “the solder faces of the LED substrate and the power panels are directly soldered, and the adoption of this quick electrical connection method features low cost and convenient and simple assembly and is conducive to market promotion.” Gu, ¶[0015]. This is a strong motivation to use Gu’s direct soldering method in manufacturing LED tube lamps. Thus, a POSITA would have been motivated to use a direct soldered connection like in Gu, including soldering pads on a power supply PCB, in Takahashi’s LED tube lamp to simplify manufacturing and reduce costs. A POSITA would not have had to use the entire power supply disclosed by Gu to take advantage of Gu’s teaching of soldering

directly from soldering pads on the LED strip to soldering pads on the power supply. For instance, a similar soldered connection could be accomplished without rotating the power supply PCB 90° from the LED light strip. Looking again to Levante, it is clear that LED strips could be soldered directly to soldering pads on PCBs oriented in the same or roughly the same direction as an LED strip. See Levante, FIG. 14. What Gu makes clear is that soldering pads on an LED tube lamp power supplies were known and could be incorporated into LED tube lamp power supplies for advantageous reasons. A POSITA would have expected success in incorporating Gu's soldering pads into Takahashi's power supply PCB at least because Gu successfully uses soldering pads on a power supply PCB for the same purpose—i.e., connection between a power circuit and an LED light strip.

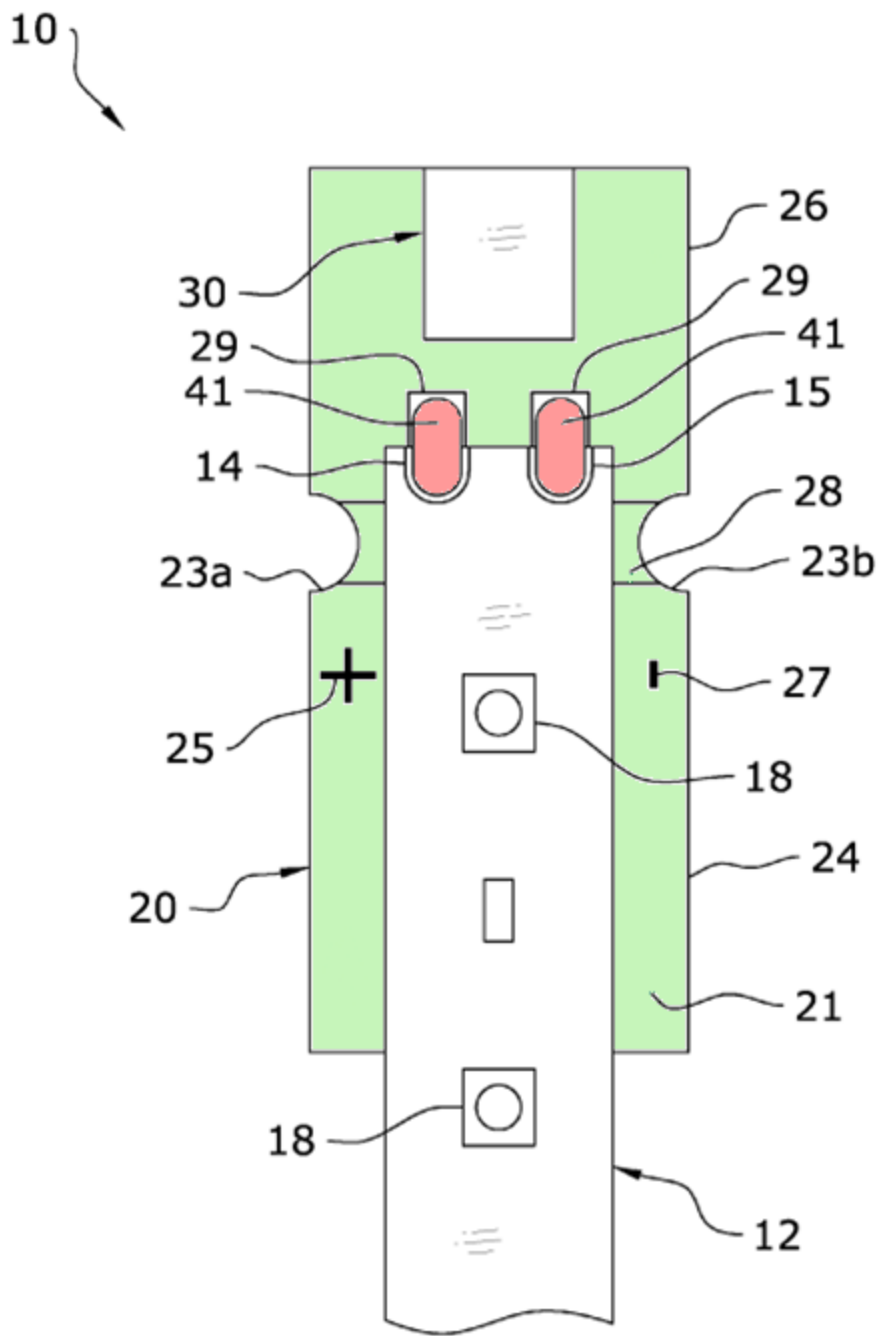
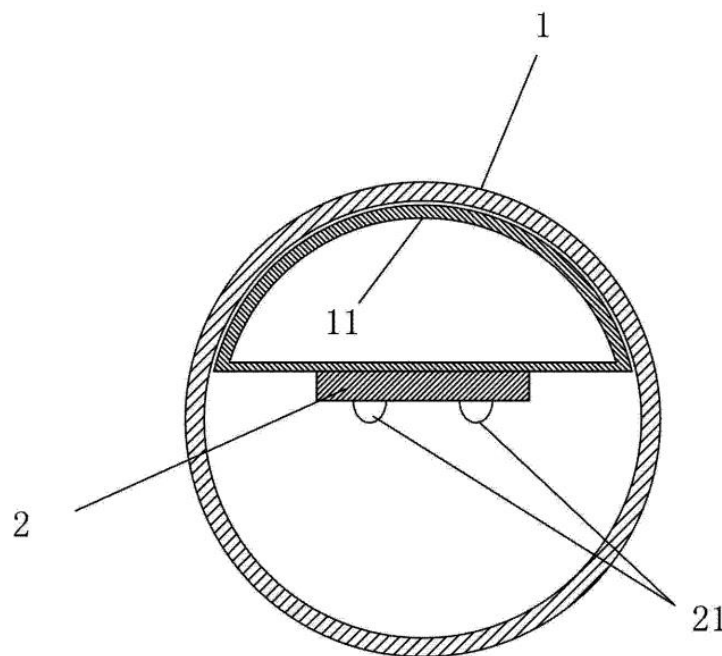


FIG. 14

E. Jing

96. Jing is titled “LED Fluorescent Lamp” (EX1009) and was published July 3, 2013. In “Background Technology,” Jing describes an “LED fluorescent lamp in the prior art is composed of a glass lamp tube 1 [and] a light emitting component arranged in the lamp tube 1 . . . The light emitting component includes a bracket 11 made of aluminum profiles extending from one end of the lamp tube to the other end, and a circuit board 2 fixed on the bracket, which extends along the axis of the lamp tube and is equipped with LED lamp beads 21.” Jing at ¶ [0002].



Jing, FIG. 1.

97. “This structure has the following shortcomings: . . . Due to the barrier of the bracket, when the LED light source in the enclosed space inside the lamp tube

works, the heat generated is transferred to the bracket through the circuit board, and then transferred from the bracket to the external space through the glass wall of the lamp tube. In this way, the heat resistance will be larger through two heat conduction exchange layers.” Jing, ¶¶ [0003]-[0005].

98. In “Invention Content,” Jing states that “[t]he technical problem to be solved is to reduce the manufacturing cost.” Jing, ¶ [0006]. “This Utility Model sets reflective film layers on the inner and outer walls of the lamp tube, so that the light emitted from the LED light source to the back of the lamp tube can be fully utilized due to reflection, thereby correspondingly enhancing the luminance of the LED fluorescent lamp.” *Id.*, ¶ [0018]. “The further improvement of the Utility Model is that the inner wall of the lamp tube 1 corresponding to the back of the circuit board 2 is coated with a film that can reflect light by electroplating, spraying or vacuum coating.” *Id.*, ¶ [0032]. Similar to the greater light output efficiency discussed above in paragraph 39 known in the art to be achieved with reflective solder resists, Jing’s reflective film works “so that the light emitted from the LED light source to the back of the lamp tube can be fully utilized due to reflection, thereby correspondingly enhancing the luminance of the fluorescent lamp.” *Id.*, at the “Summary” section on p. 1/20. A POSITA would have understood from this disclosure that reflected light would increase the light output efficiency of the lamp.

99. Jing teaches that the LED fluorescent lamp “is composed of a lamp tube 1 with a circular section and glass material, a circuit board 2 arranged in the lamp tube 1 extending along the axis, and a plug with a driver arranged on both ends of the lamp tube 1 and electrically connecting the circuit board 2 with the external power supply.” Jing, ¶ [0027]. Jing’s LED light strip may be a “flexible PCB” which “can be fixedly connected with the inner wall of the lamp tube 1 without using the tube bracket, thereby greatly reducing the manufacturing cost of the LED fluorescent lamp.” *Id.*, ¶[0028]. Jing also contemplates an embodiment with an arc-shaped aluminum or glass fiber PCB, formed to fit the circumference of the tube. *Id.*

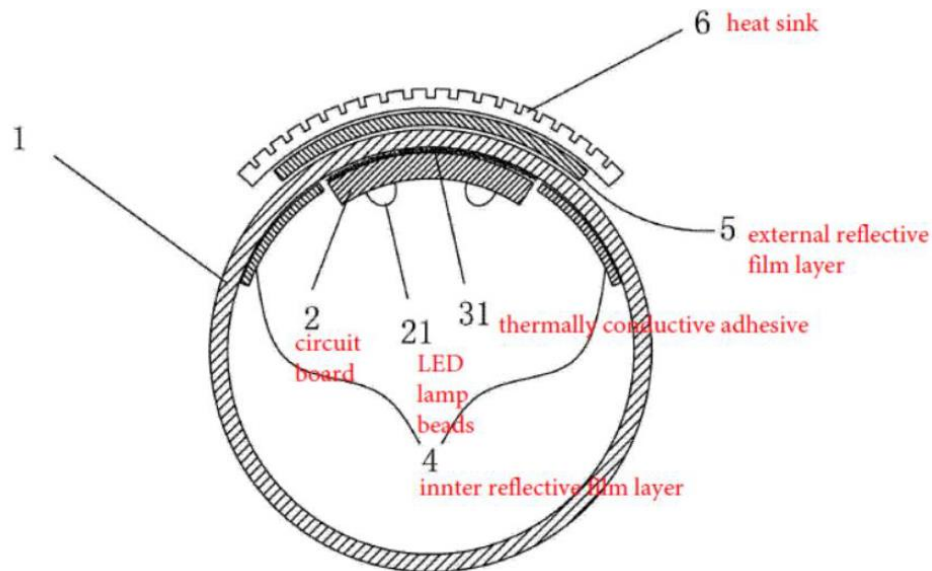
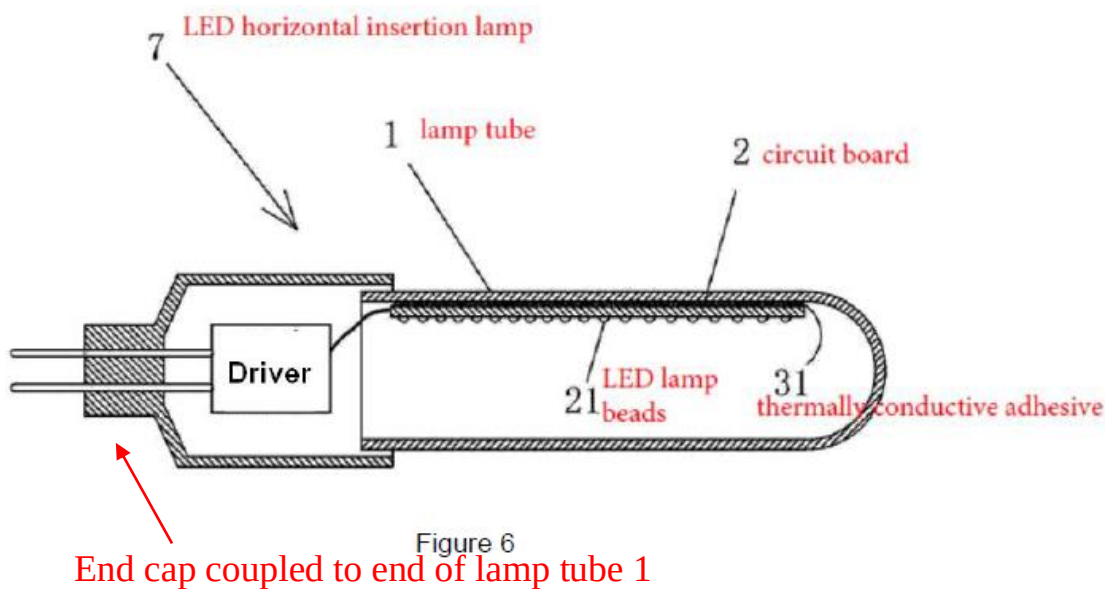


Figure 2

EX1009, FIG. 2.

100. Jing teaches an embodiment in which the LED fluorescent lamp “is composed of . . . a plug with a driver arranged on both ends of the lamp tube 1 and electrically connecting the circuit board 2 with the external power supply.” Jing, ¶ [0027]. In another embodiment, “one end is an open end, [and] the other end is a closed LED horizontal insertion lamp 7, that is, the circuit board is installed into the lamp tube through the open end of the horizontal insertion lamp tube, and then the plug with the driver electrically connected to the external power supply is blocked on the open end, as shown in Figure 6.” *Id.*



EX1009, FIG. 6.

1. *It Would Have Been Obvious to Attach the LED Light Strip of Takahashi-Shimasaki-Levante to an Inner Circumferential Surface of the Lamp Tube with an Adhesive as Taught by Jing*

101. As noted previously, consumer interest in LED lamps in the mid-2010s was high due to the increased energy efficiency, long lifespan, and reduced use of toxic materials in LED lamps, as discussed at paragraphs 29 and 33 above. A POSITA would also have understood the need for increased reliability and lower manufacturing costs of LED tube lamp designs.

102. A POSITA would have been motivated to look for examples of LED lamps using structures that could reduce manufacturing cost for the reasons described above in paragraphs 29, 33, and 36-38. Jing describes one such approach. Jing describes an LED lamp that results in reduced manufacturing cost for the LED tube, higher luminance, and better heat performance. Jing at ¶¶ [0006], [0018], [0032]. Specifically, Jing describes that a “structure that directly fixes the circuit board onto the inner wall of the lamp tube through the fixing layer **omits the metal bracket used to fix the circuit board in the LED fluorescent lamp tube in the prior art, and greatly reduces the manufacturing cost** of the LED fluorescent lamp.” Jing, ¶ [Summary]; see also ¶ [0018].

103. Importantly, Jing shows that a POSITA would have been aware of benefits from having an intervening structure for attaching LEDs within a lamp tube

(e.g., heat dissipation, supporting the LED light strip) and would have still recognized that in some instances reducing costs and/or increasing luminance (or efficiency) is more important than utilizing these benefits.

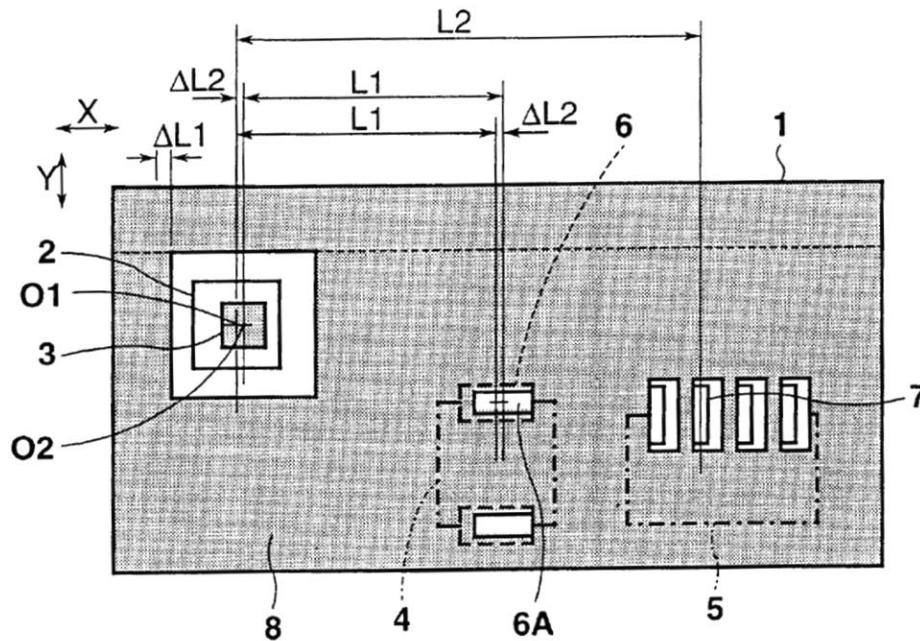
104. A POSITA would have understood that Takahashi contemplates fixing (or attaching) its LED module 10 onto base platform 330 “with an adhesive.” Takahashi at 7:65-8:4. A POSITA would have also understood that adhesive could be used to ensure “base platform 330 is fixed to the inner surface of the case 320.” See Takahashi at 7:50-51. Accordingly, a POSITA would have been motivated to modify the tube lamps of Takahashi-Shimasaki-Levante and Takahashi-Shimasaki-Levante-Gu to use Jing’s thermally conductive adhesive to securely attach the LED light strip to the inner surface of the LED tube with the predictable result of reduced manufacturing costs and increased luminance. It would have been obvious to a POSITA to try attaching the LED light strip with Jing’s adhesive to the LED tube lamps of these combinations because a POSITA would have expected this implementation to be successful in stably attaching the LED light strip to the light tube while reducing manufacturing costs. A POSITA would have understood and expected that following the teachings of Jing in modifying Takahashi’s lamp, Takahashi’s flexible LED strip would function much the same as Jing’s flexible circuit board and “be fixedly connected with the inner wall of the lamp tube.”

EX1009, ¶[0028]. In other words, a POSITA would have understood and expected that similar results could be achieved with the flexible LED PCB contemplated by Takahashi.

F. Takigami

105. Takigami is titled “Printed Circuit Board with Resist Coating Defining Reference Marks.” (EX1008) Takigami discloses that a printed circuit board (PCB) can include “a mark which is used as a recognition of an origin for mounting by a mounter.” Takigami, FIG. 2, 1:5-7. In other words, Takigami teaches the use of a recognizing mark. Takigami further discloses that a resist layer 8 (i.e., solder resist) applied to the PCB includes gaps (openings) around recognizing mark 2 and lands 6, 7 (i.e., portions of the PCB where devices are to be mounted). Takigami, 1:14-30, 3:29-59. Takigami explains that mounting errors may occur if the resist is applied over areas of the PCB where devices are to be mounted (EX1008, FIGs. 3A, 3B, 1:51-2:34) and discloses a technique for overcoming such errors, namely by including a second mark 3, made of resist and formed over, without covering mark 2, which can be used as a second origin or reference point. EX1008, FIGs. 1 and 4, 3:9-5:44.

FIG. 1

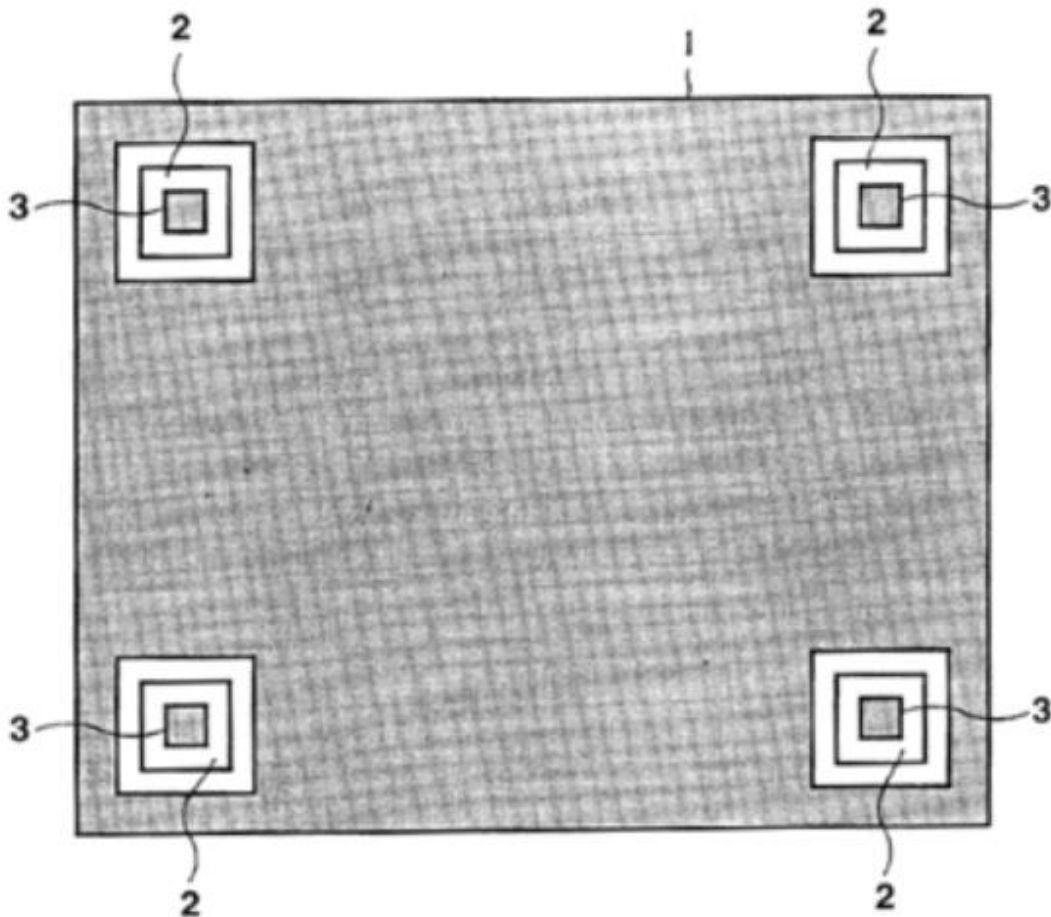


106. Takigami teaches “[a] printed circuit board includes a first mark 2 formed by a thin conductor, a second mark 3 formed by a resist 8, a land 6 which is partially coated by the resist 8 and a land 7 which is not coated by the resist 8.” Takigami, Abstract. “The second mark 3 is formed when the land 6 is partially coated by the resist 8.” *Id.* “A device 4, which corresponds to the land 6, is mounted at a position apart from a center O2 of the second mark 3 by a predetermined distance L1.” *Id.* “A device 5, which corresponds to the land 7, is mounted at a position apart from a center O1 of the first mark 2 by a predetermined distance L2.” *Id.*

“Therefor [sic], the devices 4, 5 can be properly mounted on the printed circuit board 1 in spite of a positional error of the resist 8.” *Id.*

107. As shown above in FIG. 1, Takigami discloses a solder resist layer on a printed circuit board that is masked to form openings to expose solder pads, or lands for mounting electric components. *See* Takigami, 3:29-44. Solder resists with openings were thus known in the art to persons of ordinary skill in the art. The solder resist layer includes an opening for mark 2 that can be used to position a mounter. *See* Takigami, 3:45-59. FIG. 4 below demonstrates that multiple openings exposing multiple marks 2 was also possible. *See* Takigami, 4:63-67 (“Generally, in a case that the resist 8 is rotated against the printed circuit board 1, it is very valid to form, at every corner of two or three or four corners of the printed circuit board 1, one set of the first mark 2 and the second mark 3.”). A POSITA would have understood that the use of two such marks would enable alignment in two dimensions (*e.g.*, X and Y) and the use of three marks would enable alignment in three dimensions (*e.g.*, X, Y, and rotational angle θ).

FIG. 4



108. Takigami discloses that the use of openings or other recognizing marks to position mounters was known in the art prior to its invention: “When a mounter mounts devices 4, 5 such as electric parts on the printed circuit board 10, the mark 2 is recognized and used as an origin for mounting by the mounter. The mounter is a machine which is used for mounting devices on the printed circuit board.” Takigami, 1:18-21 (describing the prior art solution being improved upon). A POSITA would

have further understood from these teachings that Takigami's marks could be used to automate the manufacturing process by providing a means for automatic alignment and soldering of components. Recognizing marks like Takigami's enable automated manufacturing of electronics by serving as reference points or origins for automated component mounting processes.

1. A POSITA Would Have Been Motivated to Combine Takigami's Third Openings and Recognizing Marks into LED Tube Lamps.

109. For the reasons discussed above in Sections VII.C.1-VII.C.2, a POSITA would have been motivated to incorporate (1) openings in the resist layer (protective layer) for LEDs and soldering pads, and (2) a soldered connection between soldering pads on the LED strip and the power supply PCB of Takahashi-Shimasaki-Levante.

110. For the reasons discussed in Section VII.D.1, a POSITA would have been motivated to incorporate soldering pads onto the power supply PCB of Takahashi-Shimasaki-Levante in view of Gu.

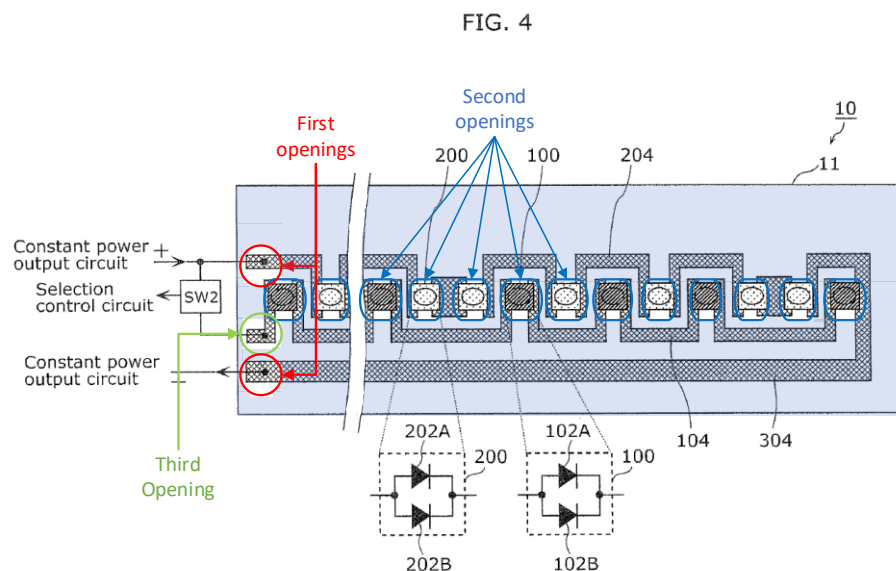
111. For the reasons discussed in Section VII.E.1, a POSITA would have been motivated to further modify Takahashi-Shimasaki-Levante and Takahashi-Shimasaki-Levante-Gu in view of Jing to directly adhere the LED light strip to the inner circumferential tube surface.

112. A POSITA would further have been motivated to further modify each of Takahashi-Shimasaki-Levante, Takahashi-Shimasaki-Levante-Gu, Takahashi-Shimasaki-Levante-Jing, and Takahashi-Shimasaki-Levante-Gu-Jing to include the reference/recognizing marks and openings therefore taught by Takigami, with a reasonable expectation of success. The motivations and benefits of including a “third opening adjacent to the two first openings” on the LED light strip are discussed below in Section VII.F.2. The motivations and benefits of including a “recognizing mark arranged adjacent to the two first openings” are discussed below in Section VII.F.3.

2. *It Would Have Been Obvious to Use a Third Opening in a Resist Layer Like Takigami’s in the Modified Tube Lamp*

113. As explained above, the combinations of Takahashi-Shimasaki-Levante, Takahashi-Shimasaki-Levante-Gu, Takahashi-Shimasaki-Levante-Jing, and Takahashi-Shimasaki-Levante-Gu-Jing rendered obvious the features of claim 31 and 32 of the '068 Patent. The combinations above also rendered claim 33 obvious. Claim 33 recites “The LED tube lamp as claimed in claim 32, wherein the protective layer further comprises a third opening adjacent to the two first openings.” There is nothing in the language of claim 33 that prevents the “third opening” in the protective layer from being an opening for a third solder pad, as shown in green in annotated FIG. 4 of Takahashi below, and as described in the '068 Patent. FIG. 4 of

Takahashi below shows three adjacent solder land sections, one for each of lines 104, 204, 304, and Shimasaki teaches that a protective layer should not be applied to the solder land sections. Takahashi, FIGs. 4, 7; Shimasaki, 4:40-52, 6:26-34 *See* '068 Patent at 32:51-65 (describing LED light strips having more than 2 solder pads). Levante similarly teaches that “[if] the light strip 12 is adapted to provide different colors of lights, then additional contacts may be included within the connecting end 13.” EX1007, 4:1-3. Thus, a POSITA would have been motivated to include a third opening for a third soldering pad.



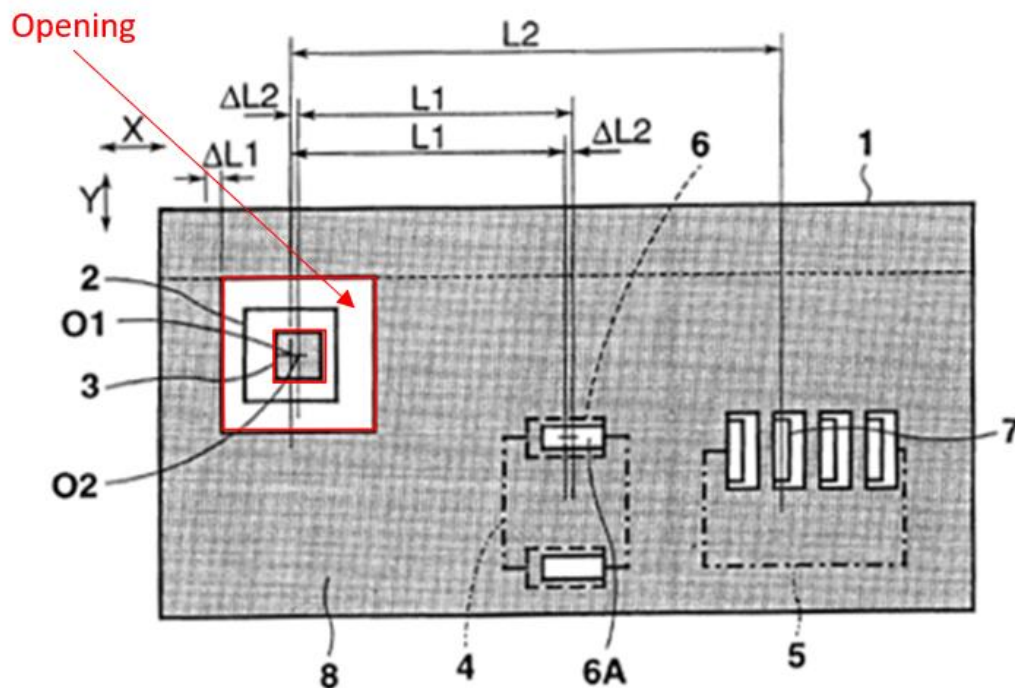
114. The '068 Patent also describes providing openings in the protective layer for elements other than soldering pads or LEDs. *See* '068 Patent at 32:44-47 (exposing a through hole on the LED light strip), 3:19-21 exposing a recognizing mark on the LED light strip); 32:47-50 (exposing an “extra positioning opening” on

the LED light strip). To the extent it is argued that Claim 33 requires the “third opening” to be related to something other than a solder pad, Takahashi-Shimasaki-Levante (alone or in any further combination with Gu and/or Jing, as described above) in further view of Takigami renders obvious “a third opening [in a protective layer] adjacent to two second openings”, as in Claim 33 of the '068 Patent.

115. Takigami discloses coating a printed circuit board with a solder resist (i.e., a protective layer) and leaving openings in the resist. Takigami at 3:11-59. Takigami explicitly discloses providing openings in the resist layer for exposing a recognizing mark (*e.g.*, a mark recognized by a mounter machine as a reference or origin) and for other purposes (*e.g.*, mounting electrical components to lands on the printed circuit board). See Takigami at FIGs. 1-4, 1:14-2:34. Illustrated in FIG. 1 below, Takigami discloses that “the resist 8 is coated on a central area of the first mark 2 [to form second mark 3] while ***enough of a gap is assured*** between the central area and a circumference of the first mark 2.” Takigami at 3:45-48 (emphasis added). Takigami also describes that “outside of the first mark 2 . . . the resist 8 is ***coated on an area sufficiently apart*** from the circumference of the first mark 2 so as to avoid the first mark 2.” Takigami, 3:55-59 (emphasis added). Thus the gap between the second mark 3 made of resist and the circumference of first mark 2 made of a conductor, plus the “extremely sufficient clearance” between mark 2 and

resist 8, form an opening on the PCB, as outlined in red in annotated FIG. 1, inset below. In the language of the '068 Patent, whether this opening is a “third” or some other opening is merely a matter of naming convention, “only used to distinguish one element . . . from another.” '068 Patent, 11:4-21.

FIG. 1



116. Further, as shown in FIG. 1, the opening exposing the recognizing mark is arranged adjacent to the soldering pad openings 6 and 7. In the language of the '068 Patent, components can be adjacent whether they are “directly adjacent” or there are “intervening elements” between the adjacent components. See '068 Patent,

11:29-41. In Takigami, the recognizing mark 2 is offset from openings 6 and 7 by distances of L1 and L2 respectively. EX1009, 4:1-21. FIG. 1 shows no intervening elements other than PCB 1 and resist 8 along distance L1 between the opening over mark 2 and the openings over land 6. Thus, the openings are adjacent.

117. A POSITA would have been motivated to include openings like those taught by Takigami in the protective layer of the LED light strip adjacent to the soldering pad openings in any of the LED tube lamp combinations identified above. This is true whether the openings were for soldering pads or for mounting LEDs, as discussed in paragraph 113, or for recognizing marks, as discussed in paragraphs 114-116. Openings in protective layers for soldering pads were known and were desired so that electrical connections could be made to wiring underneath the protective layer, as discussed in detail in paragraphs 40, and 76-77. And openings to form or expose recognizing marks would have been desirable for the reasons taught by Takigami, namely to improve alignment, which would enable automated manufacturing of LED strips, as discussed below.

118. A POSITA would have been familiar with LED manufacturing and would have understood the benefits of incorporating Takigami's marks 2 and corresponding openings in a resist (protective layer) to expose recognizing mark 2 into the LED strip of any of the combinations listed above. For instance, Takigami

teaches that recognizing marks were known to improve alignment in PCB manufacturing. This could be incorporated into automated manufacturing, and a POSITA would have expected the use of recognizing marks to be successful in that application. A POSITA would have understood that a recognizing mark like the one taught by Takigami could be utilized in manufacturing LED strips like those in Takahashi, Shimasaki, and Levante because those references describe LED light strips having LED light sources (i.e., electrical devices) mounted to and electrically connected to a wiring layer. See paragraphs 65, 67, and 71. A POSITA would have been motivated to incorporate a recognizing mark to enable a mounter, such as the mounter of Takigami, to be used to accurately mount the LED light sources to their respective lands. Accurate mounting is a key concern the invention of Takigami addresses, as its second recognizing mark 3 serves to increase component mounting accuracy and to correct for misalignment. See Takigami at 5:16-38; see also claim 13. A POSITA would further recognize that the protective layers taught by Takahashi and Shimasaki could include an opening for the recognizing mark, and would have been motivated to provide an opening in the protective layer for the recognizing mark to enable the mounter to accurately locate the recognizing mark and adjust for position errors, as taught by Takigami. A POSITA would have reasonably expected that incorporating a recognizing mark and corresponding resist-

layer opening onto an LED strip would enable a mounter to accurately mount electrical devices to a circuit board, or an LED light strip. A POSITA would have expected that other benefits of automated manufacturing enabled by openings for recognizing marks would include reducing the cost of manufacturing the LED strip and providing a more energy-efficient LED tube lamp, benefits discussed above at paragraphs 33, 38. Accordingly, a POSITA would have been motivated to incorporate a recognizing mark in an opening in the protective layer to take advantage of these benefits.

3. *It Would Have Been Obvious Use a Recognizing Mark Like Takigami's in the Modified Tube Lamp*

119. As explained above, the combinations of Takahashi-Shimasaki-Levante, Takahashi-Shimasaki-Levante-Gu, and Takahashi-Shimasaki-Jing and Takahashi-Shimasaki-Levante-Gu-Jing rendered obvious the features of claim 31 and 32 of the '068 Patent. These combinations in further view of Takigami also rendered claim 34 obvious. Claim 34 recites “The LED tube lamp as claimed in claim 32, wherein the LED light strip comprises a recognizing mark arranged adjacent to the two first openings.”

120. As discussed above related to Claim 33, Takigami teaches a recognizing mark arranged adjacent to openings in the protective layer. As

illustrated in FIG. 1, Takigami teaches a first mark 2 that is recognized by a device mounter to determine proper placement of electrical components:

(1) Before devices 4, 5 are mounted, ***the mounter detects the center O1 of the first mark 2*** made of the thin conductor and the center O2 of the second mark 3 made of the resist 8 from an output signal of a sensor such as a CCD camera.

(2) Then, the mounter initially mounts the device 4 at the distance L1 apart from the center O2 of the second mark 3 made of the resist 8, and next ***mounts the device 5 at the distance L2 apart from the center O1 of the first mark 2*** made of the thin conductor. On the other hand, the mounter initially mounts the ***device 5 at the distance L2 apart from the center O1 of the first mark 2*** made of the thin conductor, and next mounts the device 4 at the distance L1 apart from the center O2 of the second mark 3 made of the resist 8.

Takigami, 3:64-4:10. First mark 2 is a “recognizing mark” because “[b]efore devices 4, 5 are mounted, the mounter detects the center O1 of the first mark 2” to provide orientation for placement of devices 4, 5. Takigami, 3:64-65. In other words, it serves the same function as the “recognizing mark” described in the ’068 Patent. See ’068 Patent, 32:32-50. Regarding FIG. 25 below, the ’068 Patent explains that “[purple] positioning opening ‘d’ [recognizing mark] may also be

provided . . . to allow an automatic soldering machine to quickly *recognize the position* of the [green] soldering pads ‘b’.” ’068 Patent, 32:32-50.

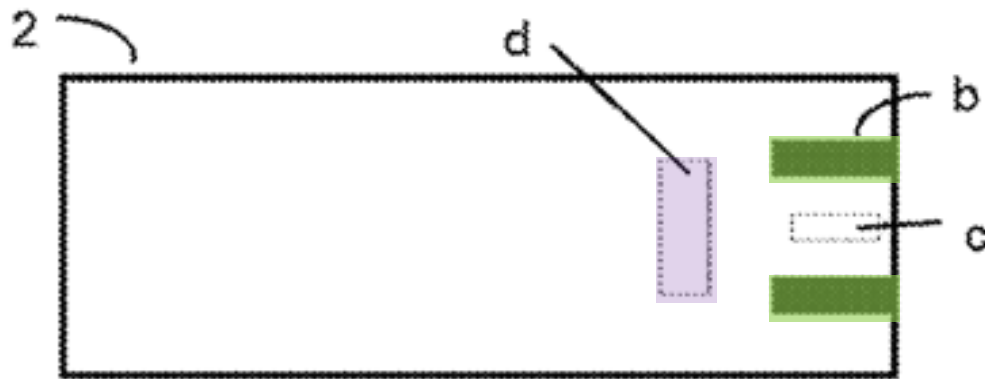
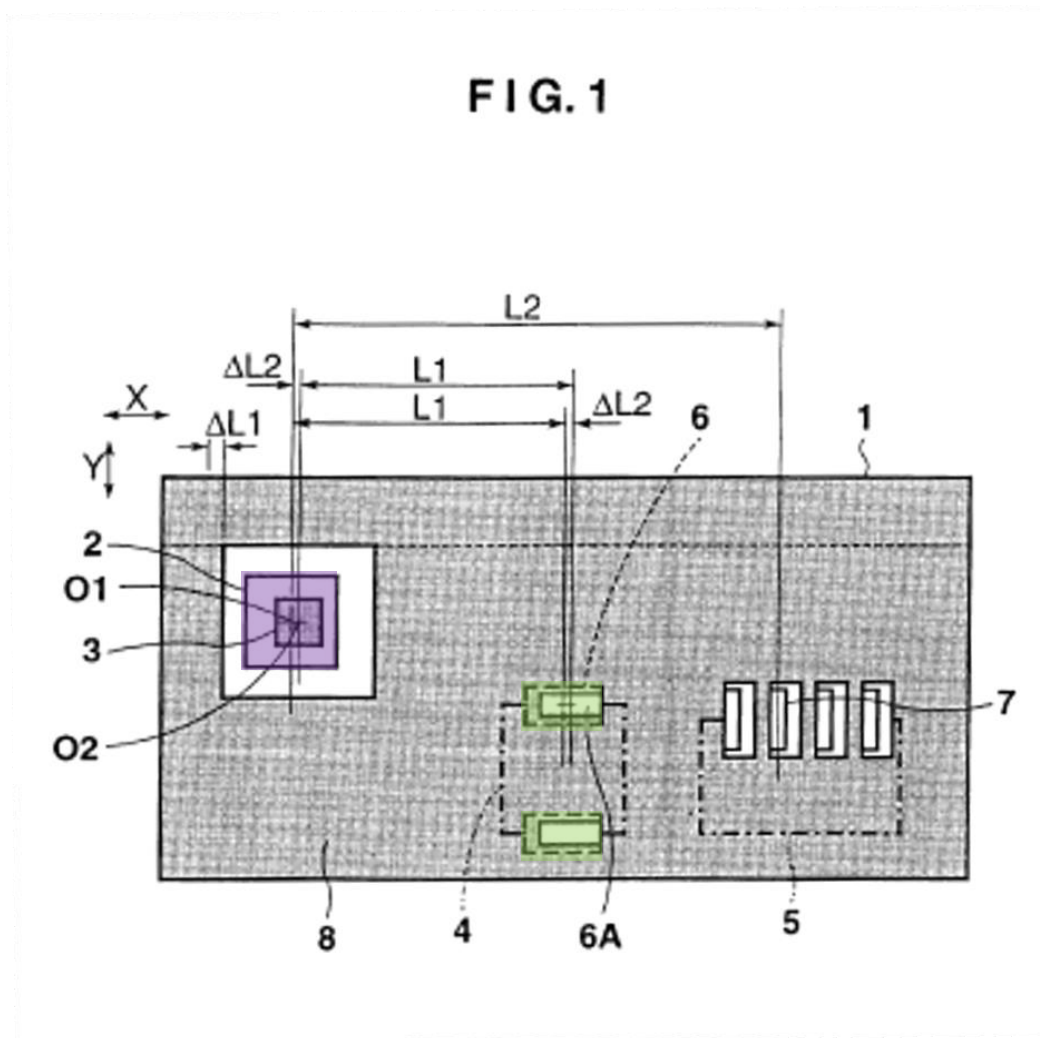


Fig. 25

121. Further, as shown in Takigami FIG. 1, the (purple) recognizing mark 2 is arranged adjacent to the (green) soldering pad openings 6. The recognizing mark 2 is offset from openings 6 and 7 by distances of L1 and L2 respectively. Takigami, 4:1-21. In the language of the ’068 Patent, components can be adjacent whether they are “directly adjacent” or there are “intervening elements” between the adjacent components. See ’068 Patent, 11:29-41. FIG. 1 shows no intervening elements other than PCB 1 and resist layer 8 along distance L1 between the opening over recognizing mark 2 and the openings over soldering pads 6 other than PCB substrate

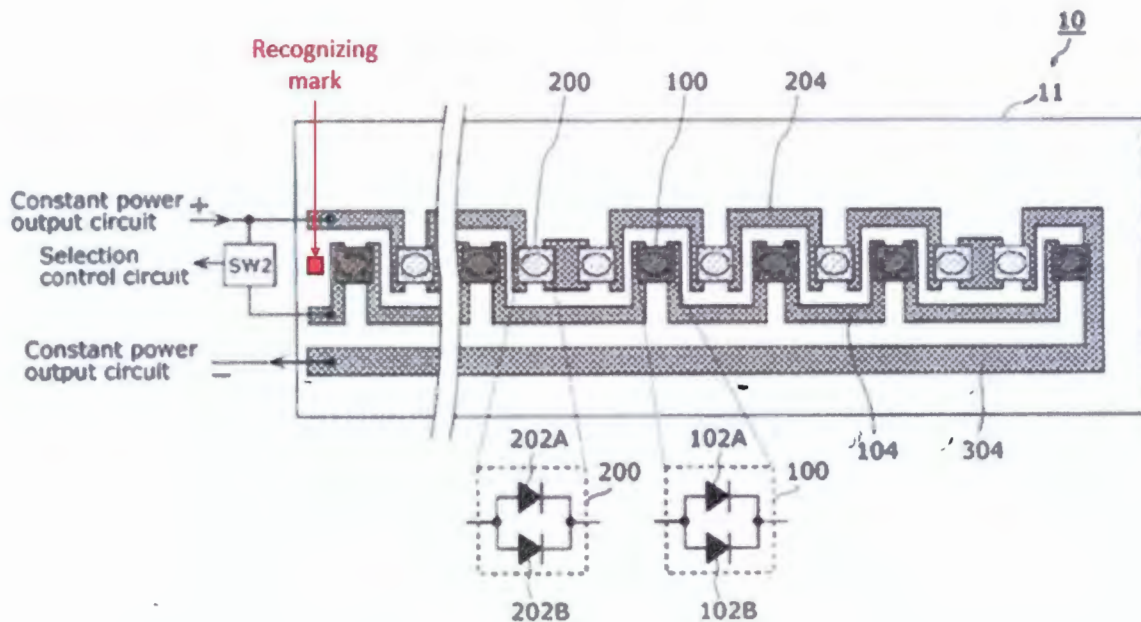
1 and resist 8. Thus, the recognizing mark is adjacent to the soldering pads. *Id.*; see '068 Patent, 11:29-41.



122. As explained above in paragraphs 62-67, and 74-88 Takahashi teaches an LED light strip with a plurality of LED light sources mounted thereon and at least two soldering pads at the end of the strip. *See* FIG. 4 below. A POSITA would have understood that a recognizing mark could be arranged adjacent to the soldering pads

at the end of the LED strip as shown in FIG. 4, and would have been motivated to position the recognizing mark in that location to simplify programming of the mounter with respect to mounting each of the LEDs to the LED strip. For example, FIG. 4 illustrates that each of the LED light sources are arranged in a row and are approximately evenly spaced. A recognizing mark arranged adjacent to the soldering pads and in line with the LEDs would enable a POSITA to program the mounter to move incremental distances in a single direction or dimension (e.g., left to right in FIG. 4) to mount each of the LEDs (e.g., mount LED₁ at location (X_{1n},Y), mount LED₂ at location (X_{2n},Y), and so on, where n represents the incremental distance to move the mounter between mounting each LED). Similar techniques could be employed for soldering the LED strip to a PCB. A POSITA would have expected that a recognizing mark like in Takigami could be successfully used in this way on the LED strip of Takahashi.

FIG. 4



XVII. CONCLUSION

123. 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.

Dated: MAY 31, 2023

R. J. Baker
R. Jacob Baker, Ph.D., P.E.