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| APPLICATION NO. | ISSUE DATE | PATENT NO. | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|------------|------------|---------------------|------------------|
| 12/965,019      | 02/26/2013 | 8382327    | AEII-172-H          | 5912             |

48980 7590 02/06/2013  
YOUNG BASILE  
3001 WEST BIG BEAVER ROAD  
SUITE 624  
TROY, MI 48084

## ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

### **Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)** (application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

Jos Timmermans, Ortonville, MI;  
Jean C. Raymond, Nominique, CANADA;  
John Ivey, Farmington Hills, MI;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit [SelectUSA.gov](http://SelectUSA.gov).

|                                                                                                     |                          |  |                        |                |                      |
|-----------------------------------------------------------------------------------------------------|--------------------------|--|------------------------|----------------|----------------------|
| <b>INFORMATION DISCLOSURE<br/>STATEMENT BY APPLICANT</b><br>( Not for submission under 37 CFR 1.99) | Receipt date: 12/05/2012 |  | Application Number     | 12965019       | 12965019 - GAU: 2821 |
|                                                                                                     |                          |  | Filing Date            | 2010-12-10     |                      |
|                                                                                                     |                          |  | First Named Inventor   | Jos Timmermans |                      |
|                                                                                                     |                          |  | Art Unit               | 2821           |                      |
|                                                                                                     |                          |  | Examiner Name          | A. Minh D      |                      |
|                                                                                                     |                          |  | Attorney Docket Number | AEII-172-H     |                      |

|                                                   |    |                                 |    |            |                  |  |
|---------------------------------------------------|----|---------------------------------|----|------------|------------------|--|
| /MA/                                              | 53 | 6068383                         |    | 2000-05-30 | Robertson et al. |  |
| Change(s) applied to document, /M.H.E./ 1/12/2013 | 54 | <del>5824784</del><br>5,924,784 |    | 1999-07-20 | Chliwnyj et al.  |  |
| /MA/                                              | 55 | 5813753                         |    | 1998-09-29 | Vriens et al.    |  |
| /MA/                                              | 56 | 4661890                         |    | 1987-04-28 | Watanabe et al.  |  |
| /MA/                                              | 57 | 5018054                         |    | 1991-05-21 | Ohashi et al.    |  |
| /MA/                                              | 58 | 5303124                         |    | 1994-04-12 | Wrobel           |  |
| /MA/                                              | 59 | 5921660                         |    | 1999-07-13 | Yu               |  |
| /MA/                                              | 60 | 6305821                         | B1 | 2001-10-23 | Hsieh et al.     |  |
| /MA/                                              | 61 | 6252350                         | B1 | 2001-06-26 | Alvarez          |  |
| /MA/                                              | 62 | 4607317                         |    | 1986-08-19 | Lin              |  |
| /MA/                                              | 63 | 4597033                         |    | 1986-06-24 | Meggs et al.     |  |

Please enter when you have a chance. Thanks,  
/Minh D A/ Date 1/23/13

Our Reference: AEII-172-H

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Jos Timmermans et al.  
Serial Number: 12/965,019  
Filing Date: December 10, 2010  
Examiner/Art Group Unit: A. Minh D/2821  
Title: LIGHT TUBE AND POWER SUPPLY CIRCUIT

**AMENDMENT UNDER 37 CFR 1.312**

M.S. Issue Fee  
Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

Sir:

If any charges or fees must be paid in connection with the following communication, they may be paid out of our Deposit Account No. 25-0115.

In response to the Notice of Allowance mailed December 20, 2012, please make the amendments shown in the attached papers in this application in the:

- ☐ **Amendments to the Abstract.**
- ☒ **Amendments to the Specification.**
- ☐ **Amendments to the Claims.**
- ☐ **Amendments to the Drawings.**



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| APPLICATION NO.                                                          | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO.             | CONFIRMATION NO.            |
|--------------------------------------------------------------------------|-------------|----------------------|---------------------------------|-----------------------------|
| 12/965,019                                                               | 12/10/2010  | Jos Timmermans       | AEII-172-H                      | 5912                        |
| 48980                                                                    | 7590        | 01/29/2013           |                                 |                             |
| YOUNG BASILE<br>3001 WEST BIG BEAVER ROAD<br>SUITE 624<br>TROY, MI 48084 |             |                      | EXAMINER<br>A, MINH D           |                             |
|                                                                          |             |                      | ART UNIT<br>2821                | PAPER NUMBER                |
|                                                                          |             |                      | NOTIFICATION DATE<br>01/29/2013 | DELIVERY MODE<br>ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docketing@youngbasile.com  
audit@youngbasile.com



|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                               |                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|------------------------------------------|
| <b>Response to Rule 312 Communication</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Application No.</b><br>12/965,019          | <b>Applicant(s)</b><br>TIMMERMANS ET AL. |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Examiner</b><br>MINH D. A                  | <b>Art Unit</b><br>2821                  |
| <p align="center"><b>-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --</b></p> <p>1. <input checked="" type="checkbox"/> The amendment filed on <u>10 January 2013</u> under 37 CFR 1.312 has been considered, and has been:</p> <p>a) <input type="checkbox"/> entered.</p> <p>b) <input checked="" type="checkbox"/> entered as directed to matters of form not affecting the scope of the invention.</p> <p>c) <input type="checkbox"/> disapproved because the amendment was filed after the payment of the issue fee.<br/> Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.</p> <p>d) <input type="checkbox"/> disapproved. See explanation below.</p> <p>e) <input type="checkbox"/> entered in part. See explanation below.</p> |                                               |                                          |
| Date 1/23/13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | /MINH D A/<br>Primary Examiner, Art Unit 2821 |                                          |

# PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail** **Mail Stop ISSUE FEE**  
**Commissioner for Patents**  
**P.O. Box 1450**  
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**or Fax (571)-273-2885**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

48980 7590 12/20/2012  
**YOUNG BASILE**  
**3001 WEST BIG BEAVER ROAD**  
**SUITE 624**  
**TROY, MI 48084**

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

## Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

|                    |
|--------------------|
| (Depositor's name) |
| (Signature)        |
| (Date)             |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|-------------|----------------------|---------------------|------------------|
| 12/965,019      | 12/10/2010  | Jos Timmermans       | AEII-172-H          | 5912             |

TITLE OF INVENTION: LIGHT TUBE AND POWER SUPPLY CIRCUIT

| APPLN. TYPE    | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE   |
|----------------|--------------|---------------|---------------------|----------------------|------------------|------------|
| nonprovisional | NO           | \$1770        | \$300               | \$0                  | \$2070           | 03/20/2013 |

| EXAMINER  | ART UNIT | CLASS-SUBCLASS |
|-----------|----------|----------------|
| A, MINH D | 2821     | 362-249020     |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a **Customer Number is required.**

2. For printing on the patent front page, list

- (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
- (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Young Basile  
 2  
 3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE  
 iLumisys, Inc.

(B) RESIDENCE: (CITY AND STATE OR COUNTRY)  
 Troy, MI

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

- ☒ Issue Fee
- ☒ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies \_\_\_\_\_

4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above)

- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 25-0115 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature Michelle L. Knight  
 Typed or printed name Michelle L. Knight

Date January 10, 2013  
 Registration No. 47711

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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## Electronic Patent Application Fee Transmittal

|                                                |                                     |          |        |                      |
|------------------------------------------------|-------------------------------------|----------|--------|----------------------|
| <b>Application Number:</b>                     | 12965019                            |          |        |                      |
| <b>Filing Date:</b>                            | 10-Dec-2010                         |          |        |                      |
| <b>Title of Invention:</b>                     | LIGHT TUBE AND POWER SUPPLY CIRCUIT |          |        |                      |
| <b>First Named Inventor/Applicant Name:</b>    | Jos Timmermans                      |          |        |                      |
| <b>Filer:</b>                                  | Michelle L. Knight/Joan Leighton    |          |        |                      |
| <b>Attorney Docket Number:</b>                 | AEII-172-H                          |          |        |                      |
| Filed as Large Entity                          |                                     |          |        |                      |
| <b>Utility under 35 USC 111(a) Filing Fees</b> |                                     |          |        |                      |
| Description                                    | Fee Code                            | Quantity | Amount | Sub-Total in USD(\$) |
| <b>Basic Filing:</b>                           |                                     |          |        |                      |
| <b>Pages:</b>                                  |                                     |          |        |                      |
| <b>Claims:</b>                                 |                                     |          |        |                      |
| <b>Miscellaneous-Filing:</b>                   |                                     |          |        |                      |
| <b>Petition:</b>                               |                                     |          |        |                      |
| <b>Patent-Appeals-and-Interference:</b>        |                                     |          |        |                      |
| <b>Post-Allowance-and-Post-Issuance:</b>       |                                     |          |        |                      |
| Utility Appl issue fee                         | 1501                                | 1        | 1770   | 1770                 |
| Publ. Fee- early, voluntary, or normal         | 1504                                | 1        | 300    | 300                  |

| Description        | Fee Code | Quantity | Amount | Sub-Total in USD(\$) |
|--------------------|----------|----------|--------|----------------------|
| Extension-of-Time: |          |          |        |                      |
| Miscellaneous:     |          |          |        |                      |
| Total in USD (\$)  |          |          |        | 2070                 |

## Electronic Acknowledgement Receipt

|                                             |                                     |
|---------------------------------------------|-------------------------------------|
| <b>EFS ID:</b>                              | 14667872                            |
| <b>Application Number:</b>                  | 12965019                            |
| <b>International Application Number:</b>    |                                     |
| <b>Confirmation Number:</b>                 | 5912                                |
| <b>Title of Invention:</b>                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |
| <b>First Named Inventor/Applicant Name:</b> | Jos Timmermans                      |
| <b>Customer Number:</b>                     | 48980                               |
| <b>Filer:</b>                               | Michelle L. Knight/Joan Leighton    |
| <b>Filer Authorized By:</b>                 | Michelle L. Knight                  |
| <b>Attorney Docket Number:</b>              | AEII-172-H                          |
| <b>Receipt Date:</b>                        | 10-JAN-2013                         |
| <b>Filing Date:</b>                         | 10-DEC-2010                         |
| <b>Time Stamp:</b>                          | 15:59:49                            |
| <b>Application Type:</b>                    | Utility under 35 USC 111(a)         |

### Payment information:

|                                          |                 |
|------------------------------------------|-----------------|
| Submitted with Payment                   | yes             |
| Payment Type                             | Deposit Account |
| Payment was successfully received in RAM | \$ 2070         |
| RAM confirmation Number                  | 2960            |
| Deposit Account                          | 250115          |
| Authorized User                          |                 |

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

# File Listing:

| Document Number              | Document Description                                | File Name            | File Size(Bytes)/<br>Message Digest      | Multi Part /.zip | Pages (if appl.) |
|------------------------------|-----------------------------------------------------|----------------------|------------------------------------------|------------------|------------------|
| 1                            |                                                     | AEI172H_312Amd.pdf   | 35594                                    | yes              | 7                |
|                              |                                                     |                      | 97fe4ac30e98e474c68358b90e46b5d58192d532 |                  |                  |
|                              | Multipart Description/PDF files in .zip description |                      |                                          |                  |                  |
|                              | Document Description                                |                      | Start                                    | End              |                  |
|                              | Amendment after Notice of Allowance (Rule 312)      |                      | 1                                        | 1                |                  |
|                              | Specification                                       |                      | 2                                        | 2                |                  |
|                              | Claims                                              |                      | 3                                        | 6                |                  |
|                              | Applicant Arguments/Remarks Made in an Amendment    |                      | 7                                        | 7                |                  |
| Warnings:                    |                                                     |                      |                                          |                  |                  |
| Information:                 |                                                     |                      |                                          |                  |                  |
| 2                            | Issue Fee Payment (PTO-85B)                         | AEI172H_IssueFee.pdf | 29066                                    | no               | 1                |
|                              |                                                     |                      | 9d2c6b9c2b5012d54fe8aa99d543ee3b356aba46 |                  |                  |
| Warnings:                    |                                                     |                      |                                          |                  |                  |
| Information:                 |                                                     |                      |                                          |                  |                  |
| 3                            | Fee Worksheet (SB06)                                | fee-info.pdf         | 32117                                    | no               | 2                |
|                              |                                                     |                      | 678b4f7d905f567d75e852f408a761eca6340fcf |                  |                  |
| Warnings:                    |                                                     |                      |                                          |                  |                  |
| Information:                 |                                                     |                      |                                          |                  |                  |
| Total Files Size (in bytes): |                                                     |                      | 96777                                    |                  |                  |

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Our Reference: AEII-172-H

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Jos Timmermans et al.  
Serial Number: 12/965,019  
Filing Date: December 10, 2010  
Examiner/Art Group Unit: A. Minh D/2821  
Title: LIGHT TUBE AND POWER SUPPLY CIRCUIT

**AMENDMENT UNDER 37 CFR 1.312**

M.S. Issue Fee  
Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

Sir:

If any charges or fees must be paid in connection with the following communication, they may be paid out of our Deposit Account No. 25-0115.

In response to the Notice of Allowance mailed December 20, 2012, please make the amendments shown in the attached papers in this application in the:

- ☐ **Amendments to the Abstract.**
- ☒ **Amendments to the Specification.**
- ☐ **Amendments to the Claims.**
- ☐ **Amendments to the Drawings.**



**Amendments to the Specification:**

Please replace paragraph [0001] of the specification with the following paragraph:

[0001] This application is a continuation of U.S. Patent Application No. 11/085,744, filed March 21, 2005 ~~PAT~~ and issued as U.S. Patent No. 8,247,895 on August 21, 2012, which is a continuation of U.S. Patent Application No. 09/782,375, filed February 12, 2001 and issued as U.S. Patent No. 7,049,761 on May 23, 2006, which claims the benefit of U.S. Provisional Application No. 60/181,744, filed February 11, 2000.

**Listing of the Claims:**

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

fixture having a light tube socket, the improvement comprising:

a plurality of light emitting diodes disposed along a length of ~~the~~ a bulb portion between a first end cap and a second end cap mounted on opposite ends of the bulb portion, wherein the plurality of light emitting diodes is mounted on only one side of a circuit board in a light emitting direction;

an electrical circuit for illuminating in response to electrical current to be received from the fluorescent light fixture; and

opaque side walls extending above the one side of the circuit board in the light emitting direction on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap to confine an entirety of light emitted from the replacement light tube to an included angle of less than about 180°.

6. (Canceled).

7. (Canceled).

8. (Previously amended) The improvement of claim 5 wherein each of the plurality of light emitting diodes is a white light emitting diode.

9. (Previously added) The improvement of claim 5, further comprising:  
a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes above a nominal variation of 120 to 100 Hz.

10. (Previously added) The improvement of claim 5, further comprising:  
a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes to provide a visible on and off cycle.

11. (Previously added) The improvement of claim 5 wherein at least one of the

first end cap and the second end cap includes an inductive receiver.

12. (Canceled).

13. (Previously amended) The improvement of claim 5 wherein the radiation pattern of light from each of the plurality of light emitting diodes is centered at a 90° angle relative to the circuit board.

14. (Previously added) The improvement of claim 5 wherein the plurality of light emitting diodes is arranged substantially continuously along the length of the bulb portion.

15. (Previously added) The light device of claim 1 wherein each of the plurality of light emitting diodes is a white light emitting diode.

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

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

18. (Previously added) The light device of claim 1 wherein at least one of the first end cap and the second end cap includes an inductive receiver.

19. (Canceled).

20. (Previously added) The light device of claim 1 wherein the plurality of

light emitting diodes is arranged substantially continuously between the opposite ends of the bulb portion.

21. (Previously added) An LED lighting unit for replacing a conventional fluorescent tube between the opposed electrical receptacles of a conventional fluorescent lighting fixture comprising:

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

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

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

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

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

22. (Previously added) The improvement of claim 5 wherein the electrical circuit includes at least a rectifier and a current-limiting circuit.

**REMARKS**

In the Notice of Allowance mailed December 20, 2012, the Examiner makes an amendment to the first paragraph to update the priority information for this application. Applicants submit this Amendment to make a further change to the priority information. No claims are added, canceled or amended.

It is submitted that this Amendment has antecedent basis in the Application as originally filed, including the specification, claims and drawings, and that this Amendment does not add any new subject matter to the application. Applicants further submit that this Amendment conforms to the provisions of 37 C.F.R. § 1.312 and respectfully request entry under the provisions therein.

If the Examiner has any comments or questions regarding this Amendment, the Examiner is invited to contact the undersigned at the telephone number listed below.

Respectfully submitted,  
YOUNG BASILE  
HANLON & MACFARLANE, P.C.

/Michelle L. Knight/

Michelle L. Knight  
Registration No. 47711  
(248) 649-3333

3001 West Big Beaver Rd., Ste. 624  
Troy, Michigan 48084-3107



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

## NOTICE OF ALLOWANCE AND FEE(S) DUE

48980 7590 12/20/2012  
YOUNG BASILE  
3001 WEST BIG BEAVER ROAD  
SUITE 624  
TROY, MI 48084

EXAMINER

A, MINH D

ART UNIT

PAPER NUMBER

2821

DATE MAILED: 12/20/2012

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|-------------|----------------------|---------------------|------------------|
| 12/965,019      | 12/10/2010  | Jos Timmermans       | AEII-172-H          | 5912             |

TITLE OF INVENTION: LIGHT TUBE AND POWER SUPPLY CIRCUIT

| APPLN. TYPE    | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE   |
|----------------|--------------|---------------|---------------------|----------------------|------------------|------------|
| nonprovisional | NO           | \$1770        | \$300               | \$0                  | \$2070           | 03/20/2013 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

### HOW TO REPLY TO THIS NOTICE:

#### I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.**

# **PART B - FEE(S) TRANSMITTAL**

**Complete and send this form, together with applicable fee(s), to: Mail Mail Stop ISSUE FEE  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
or Fax (571)-273-2885**

**INSTRUCTIONS:** This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

48980 7590 12/20/2012  
YOUNG BASILE  
3001 WEST BIG BEAVER ROAD  
SUITE 624  
TROY, MI 48084

## **Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

|                    |
|--------------------|
| (Depositor's name) |
| (Signature)        |
| (Date)             |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|-------------|----------------------|---------------------|------------------|
| 12/965,019      | 12/10/2010  | Jos Timmermans       | AEII-172-H          | 5912             |

TITLE OF INVENTION: LIGHT TUBE AND POWER SUPPLY CIRCUIT

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|----------------|--------------|---------------|---------------------|----------------------|------------------|------------|
| nonprovisional | NO           | \$1770        | \$300               | \$0                  | \$2070           | 03/20/2013 |

| EXAMINER  | ART UNIT | CLASS-SUBCLASS |
|-----------|----------|----------------|
| A, MINH D | 2821     | 362-249020     |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

- (1) the names of up to 3 registered patent attorneys or agents OR, alternatively, 1 \_\_\_\_\_
- (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed. 2 \_\_\_\_\_
- 3 \_\_\_\_\_

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

- ☐ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies \_\_\_\_\_

4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above)

- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number \_\_\_\_\_ (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature \_\_\_\_\_ Date \_\_\_\_\_

Typed or printed name \_\_\_\_\_ Registration No. \_\_\_\_\_

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.





# UNITED STATES PATENT AND TRADEMARK OFFICE

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www.uspto.gov

| APPLICATION NO.                                                          | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|--------------------------------------------------------------------------|-------------|----------------------|---------------------|------------------|
| 12/965,019                                                               | 12/10/2010  | Jos Timmermans       | AEII-172-H          | 5912             |
| 48980                                                                    | 7590        | 12/20/2012           | EXAMINER            |                  |
| YOUNG BASILE<br>3001 WEST BIG BEAVER ROAD<br>SUITE 624<br>TROY, MI 48084 |             |                      | A, MINH D           |                  |
|                                                                          |             |                      | ART UNIT            | PAPER NUMBER     |
|                                                                          |             |                      | 2821                |                  |

DATE MAILED: 12/20/2012

## Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

## Privacy Act Statement

**The Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

|                                             |                        |                     |  |
|---------------------------------------------|------------------------|---------------------|--|
| <b>Examiner-Initiated Interview Summary</b> | <b>Application No.</b> | <b>Applicant(s)</b> |  |
|                                             | 12/965,019             | TIMMERMANS ET AL.   |  |
|                                             | <b>Examiner</b>        | <b>Art Unit</b>     |  |
|                                             | MINH D. A              | 2821                |  |

All participants (applicant, applicant's representative, PTO personnel):

(1) MINH D. A. (3) \_\_\_\_\_.

(2) Michelle L. Knight. (4) \_\_\_\_\_.

Date of Interview: 05 December 2012.

Type: ☒ Telephonic ☐ Video Conference  
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.  
If Yes, brief description: \_\_\_\_\_.

Issues Discussed ☐101 ☐112 ☐102 ☐103 ☒Others  
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: claim 13.

Identification of prior art discussed: None.

#### Substance of Interview

(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Examiner contacted applicant's representative, Michelle L. Knight on 12/05/12 for discussing about a proposed amendment and an agreement was reached, therefore, the application has been amended as follows:

In specification, paragraph [0001], line 2, deleted "2005" and inserted ---2005 PAT 8,247,985---.  
Claim 13, line 1, deleted "claim 6" and inserted ---claim 5---.

Prior art of record fails to disclose or fairly suggest, a light device for illumination by a power supply circuit and particularly including wherein the arrangement of the circuit board and the bulb portion is such that substantially the entire light output of the light device is emitted away from the one surface and is confined to an included angle by sidewalls extending to a height above the one surface on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap in combination with the remaining claimed limitations as recited in claim 1.

Prior art of record fails to disclose or fairly suggest, in a replacement light tube for a fluorescent light fixture having a light tube socket, the improvement comprising: a plurality of light emitting diodes disposed along a length of a bulb portion between a first end cap and a second end cap mounted on opposite ends of the bulb portion and particularly including "opaque side walls extending above the one side of the circuit board in the light emitting direction on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap to confine an entirety of light emitted from the replacement light tube to an included angle of less than about 180°" in combination with the remaining claimed limitations as recited in claim 5

Prior art of record fails to disclose or fairly suggest, alone or in combination, an LED lighting unit for replacing a conventional fluorescent tube between the opposed electrical receptacles of a conventional fluorescent lighting fixture comprising: a rigid, substantially cylindrical structure having a first end and a second end opposite said first end, and particularly including "the combination of said support structure and said bulb portion is such that substantially the entire light output of said lighting unit device is emitted away from said surface and is confined to the included angle by sidewalls extending to a height above said surface on opposing sides of said plurality of LEDs between the first end and the second end" in combination with the remaining claimed limitations as recited in claim 21.

**Applicant recordation instructions:** It is not necessary for applicant to provide a separate record of the substance of interview.

**Examiner recordation instructions:** Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/Minh D A/

Date 12/05/12

|                               |                        |                     |  |
|-------------------------------|------------------------|---------------------|--|
| <b>Notice of Allowability</b> | <b>Application No.</b> | <b>Applicant(s)</b> |  |
|                               | 12/965,019             | TIMMERMANS ET AL.   |  |
|                               | <b>Examiner</b>        | <b>Art Unit</b>     |  |
|                               | MINH D. A              | 2821                |  |

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--**

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to the amendment filed on 9/20/12.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on \_\_\_\_; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are 1, 3, 5, 8-11, 13-18, 20-22. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see [http://www.uspto.gov/patents/init\\_events/pph/index.jsp](http://www.uspto.gov/patents/init_events/pph/index.jsp) or send an inquiry to [PPHfeedback@uspto.gov](mailto:PPHfeedback@uspto.gov).
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
  - a) ☐ All    b) ☐ Some\*    c) ☐ None    of the:
    1. ☐ Certified copies of the priority documents have been received.
    2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_.
    3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

\* Certified copies not received: \_\_\_\_.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.

**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
 

☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date \_\_\_\_\_.

**Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

- |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> <li>1. <input type="checkbox"/> Notice of References Cited (PTO-892)</li> <li>2. <input checked="" type="checkbox"/> Information Disclosure Statements (PTO/SB/08),<br/>Paper No./Mail Date <u>12/05/12, 12/07/12</u></li> <li>3. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit of Biological Material</li> <li>4. <input checked="" type="checkbox"/> Interview Summary (PTO-413),<br/>Paper No./Mail Date <u>12/05/12</u>.</li> </ol> | <ol style="list-style-type: none"> <li>5. <input checked="" type="checkbox"/> Examiner's Amendment/Comment</li> <li>6. <input checked="" type="checkbox"/> Examiner's Statement of Reasons for Allowance</li> <li>7. <input type="checkbox"/> Other _____.</li> </ol> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

/MINH D A/

Primary Examiner, Art Unit 2821

Date 12/10/12

***DETAILED ACTION***

This Office Action is a response to Applicant's Amendment filed on 09/20/12. By virtue of this amendment, claims 2, 4, 6-7, 12 and 19 were cancelled, claims 21-22 are newly added; thus, claims 1, 3, 5, 8-11, 13-18 and 20-22 are currently presented in the instant application.

***Terminal Disclaimer***

1. The terminal disclaimer filed on 12/07/12 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of U.S. Patent No: 5,510,299 has been reviewed and is accepted. The terminal disclaimer has been recorded.

***EXAMINER'S AMENDMENT***

2. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Michelle L. Knight on 12/05/12.

The application has been amended as follows:

In specification, paragraph [0001], line 2, deleted "2005" and inserted ---2005 PAT 8,247,985---.

Claim 13, line 1, deleted "claim 6" and inserted ---claim 5---.

***Allowable Subject Matter***

3. Claims 1, 3, 5, 8-11, 13-18 and 20-22 are allowed.
4. The following is an examiner's statement of reasons for allowance:

Prior art of record fails to disclose or fairly suggest, alone or in combination, a light device for illumination by a power supply circuit comprising: a bulb portion, a pair of end caps disposed at opposite ends of the bulb portion, the pair of end caps including a first end cap disposed at one end of the bulb portion; and a second end cap disposed at an end of bulb portion opposite the first end cap and particularly including "wherein the arrangement of the circuit board and the bulb portion is such that substantially the entire light output of the light device is emitted away from the one surface and is confined to an included angle by sidewalls extending to a height above the one surface on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap", in combination with the remaining claimed limitations as recited in claim 1 (claims 3, 15-18 and 20 are allowed, since they are dependent on claim 1).

Prior art of record fails to disclose or fairly suggest, alone or in combination, in a replacement light tube for a fluorescent light fixture having a light tube socket, the improvement comprising: a plurality of light emitting diodes disposed along a length of a bulb portion between a first end cap and a second end cap mounted on opposite ends of the bulb portion: wherein the plurality of light emitting diodes is mounted on only one side of a circuit board in a light emitting direction and particularly including "opaque side walls extending above the one side of the circuit board in the light emitting direction on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap to confine an entirety of light emitted from the replacement light tube to

Art Unit: 2821

an included angle of less than about 180° in combination with the remaining claimed limitations as recited in claim 5 (claims 8-11, 13-14 and 22 are allowed, since they are dependent on claim 5).

Prior art of record fails to disclose or fairly suggest, alone or in combination, an LED lighting unit for replacing a conventional fluorescent tube between the opposed electrical receptacles of a conventional fluorescent lighting fixture comprising: a rigid, substantially cylindrical structure having a first end and a second end opposite said first end, the cylindrical structure including a support structure and a bulb portion; and particularly including “the combination of said support structure and said bulb portion is such that substantially the entire light output of said lighting unit device is emitted away from said surface and is confined to the included angle by sidewalls extending to a height above said surface on opposing sides of said plurality of LEDs between the first end and the second end” in combination with the remaining claimed limitations as recited in claim 21.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled “Comments on Statement of Reasons for Allowance.”

### ***Inquiry***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Minh Dieu A whose telephone number is (571) 272-1817. The examiner can normally be reached on M-F (8:00AM to 5:00PM).



If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Douglas W Owens can be reached on (571) 272-1662. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/Minh D A/

Primary Examiner

Art Unit 2821

Date 12/10/12

|                                                                                                                        |                                                |                                                                         |
|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------------------|
| <b><i>Index of Claims</i></b><br><br> | <b>Application/Control No.</b><br><br>12965019 | <b>Applicant(s)/Patent Under Reexamination</b><br><br>TIMMERMANS ET AL. |
|                                                                                                                        | <b>Examiner</b><br><br>MINH D A                | <b>Art Unit</b><br><br>2821                                             |

|   |                 |   |                   |   |                     |   |                 |
|---|-----------------|---|-------------------|---|---------------------|---|-----------------|
| ✓ | <b>Rejected</b> | - | <b>Cancelled</b>  | N | <b>Non-Elected</b>  | A | <b>Appeal</b>   |
| = | <b>Allowed</b>  | ÷ | <b>Restricted</b> | I | <b>Interference</b> | O | <b>Objected</b> |

| <input type="checkbox"/> Claims renumbered in the same order as presented by applicant |          |            |            | <input type="checkbox"/> CPA |  |  |  | <input checked="" type="checkbox"/> T.D. |  |  |  | <input type="checkbox"/> R.1.47 |  |  |  |
|----------------------------------------------------------------------------------------|----------|------------|------------|------------------------------|--|--|--|------------------------------------------|--|--|--|---------------------------------|--|--|--|
| CLAIM                                                                                  |          | DATE       |            |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| Final                                                                                  | Original | 04/08/2012 | 12/10/2012 |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 1                                                                                      | 1        | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
|                                                                                        | 2        | -          | -          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 2                                                                                      | 3        | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
|                                                                                        | 4        | -          | -          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 8                                                                                      | 5        | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
|                                                                                        | 6        | ✓          | -          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
|                                                                                        | 7        | -          | -          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 9                                                                                      | 8        | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 10                                                                                     | 9        | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 11                                                                                     | 10       | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 12                                                                                     | 11       | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
|                                                                                        | 12       | ✓          | -          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 13                                                                                     | 13       | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 14                                                                                     | 14       | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 3                                                                                      | 15       | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 4                                                                                      | 16       | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 5                                                                                      | 17       | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 6                                                                                      | 18       | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
|                                                                                        | 19       | ✓          | -          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 7                                                                                      | 20       | ✓          | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 16                                                                                     | 21       |            | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |
| 15                                                                                     | 22       |            | =          |                              |  |  |  |                                          |  |  |  |                                 |  |  |  |

Receipt date: 12/07/2012

Doc code: IDS

Doc description: Information Disclosure Statement (IDS) Filed

12965019 - GALL:2821

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|                                                                                                     | Filing Date            |                | 2010-12-10 |  |
|                                                                                                     | First Named Inventor   | Jos Timmermans |            |  |
|                                                                                                     | Art Unit               | 2821           |            |  |
|                                                                                                     | Examiner Name          | A. Minh D      |            |  |
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| /MA/                     | 1       | H11-162234                           | JP                        | A                      | 1999-06-18       | Matsushita Electric Works Ltd.                  |                                                                        | <input checked="" type="checkbox"/> |
| /MA/                     | 2       | H11-260125                           | JP                        | A                      | 1999-09-24       | Omron Tateisi Electronics Co.                   |                                                                        | <input checked="" type="checkbox"/> |

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|                                                                                                     |                          |  | Filing Date            | 2010-12-10     |                      |
|                                                                                                     |                          |  | First Named Inventor   | Jos Timmermans |                      |
|                                                                                                     |                          |  | Art Unit               | 2821           |                      |
|                                                                                                     |                          |  | Examiner Name          | A. Minh D      |                      |
|                                                                                                     |                          |  | Attorney Docket Number | AEII-172-H     |                      |

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|                                                                                                     | Filing Date            |                | 2010-12-10                         |
|                                                                                                     | First Named Inventor   | Jos Timmermans |                                    |
|                                                                                                     | Art Unit               | 2821           |                                    |
|                                                                                                     | Examiner Name          | A. Minh D      |                                    |
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| Name/Print | Michelle L. Knight   | Registration Number | 47711      |

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| <b>Search Notes</b><br><br> | <b>Application/Control No.</b><br><br>12965019 | <b>Applicant(s)/Patent Under Reexamination</b><br><br>TIMMERMANS ET AL. |
|                                                                                                              | <b>Examiner</b><br><br>MINH D A                | <b>Art Unit</b><br><br>2821                                             |

| SEARCHED |                                                      |        |          |
|----------|------------------------------------------------------|--------|----------|
| Class    | Subclass                                             | Date   | Examiner |
| 315      | 146, 246, 185R, 185S, 312, 291, 307,                 | 4/7/12 | MA       |
| 362      | 488, 240, 800, 543, 544, 545, 249.01, 249.02, 249.03 | 4/7/12 | MA       |

| SEARCH NOTES                                          |          |          |
|-------------------------------------------------------|----------|----------|
| Search Notes                                          | Date     | Examiner |
| Text search "East", see search print out              | 4/7/12   | MA       |
| Inventor's name search "East" print out               | 4/7/12   | MA       |
| Text search "East", see search print out              | 4/8/12   | MA       |
| Updated inventor's name search "East" print out       | 12/05/12 | MA       |
| Text search "East", see search print out              | 12/05/12 | MA       |
| Interference text search "East", see search print out | 12/05/12 | MA       |

| INTERFERENCE SEARCH |          |          |          |
|---------------------|----------|----------|----------|
| Class               | Subclass | Date     | Examiner |
| 362                 | 249.02   | 12/05/12 | MA       |
| 315                 | 224      | 12/05/12 | MA       |

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|                                                                                                     | Attorney Docket Number | AEII-172-H     |            |

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|                                                                                                     |                          |  | Attorney Docket Number | AEII-172-H     |                      |

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|                                                                                                     |                          |  | Examiner Name          | A. Minh D      |                      |
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|                                                                                                     |                          |  | Examiner Name          | A. Minh D      |                      |
|                                                                                                     |                          |  | Attorney Docket Number | AEII-172-H     |                      |

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|                                                                                                     |                          |  | Examiner Name          |  | A. Minh D      |                      |
|                                                                                                     |                          |  | Attorney Docket Number |  | AEII-172-H     |                      |

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|                                                                                                     |                          |  | Art Unit               | 2821           |                      |
|                                                                                                     |                          |  | Examiner Name          | A. Minh D      |                      |
|                                                                                                     |                          |  | Attorney Docket Number | AEII-172-H     |                      |

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|                                                                                                                                            | Art Unit               |                | 2821       |                      |
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|                                                                                                                                            | Attorney Docket Number |                | AEII-172-H |                      |

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| /MA/ | 2 | 20020048174 | A1 | 2002-04-25 | Pederson        |  |
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| /MA/ | 2 | 196 24 087 | DE | A1 | 1997-12-18 | Wendelin Pimpl                    |  | <input checked="" type="checkbox"/> |
| /MA/ | 3 | 0 632 511  | EP | A2 | 1995-01-04 | Mitsubishi Cable Industries, Inc. |  | <input type="checkbox"/>            |
| /MA/ | 4 | H8-162677  | JP |    | 1996-06-21 | Nireco Corp.                      |  | <input checked="" type="checkbox"/> |
| /MA/ | 5 | H6-54103   | JP |    | 1994-07-22 | Takadate Co., Ltd.                |  | <input checked="" type="checkbox"/> |
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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

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| Name/Print | Michelle L. Knight   | Registration Number | 47711      |

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| L2    | 4    | (bulb and cap\$1 and (LED\$1 or light near4 emitting or light near4 source\$1) same board and surface\$1 and wall\$1).clm.                                           | US-PGPUB | OR               | ON      | 2012/12/05 13:31 |
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|-----|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|----|-----|---------------------|
| L11 | 514   | 362/543.ccls.                                                                                                                                                 | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:04 |
| L12 | 708   | 362/544.ccls.                                                                                                                                                 | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:04 |
| L13 | 1280  | 362/545.ccls.                                                                                                                                                 | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:05 |
| L14 | 1900  | 362/249.01.ccls.                                                                                                                                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:05 |
| L15 | 203   | 362/249.03.ccls.                                                                                                                                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:05 |
| L17 | 12886 | (cap\$1 or socket\$1) same (end\$1 or<br>terminal\$1) and (light near4 source\$1<br>or LED\$1 or light near emitting or<br>lamp\$1) with (substrate or board) | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:13 |
| L18 | 3162  | l17 and @pd<="20000211"                                                                                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:13 |
| L19 | 0     | l18 and l1                                                                                                                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:14 |
| L20 | 0     | l18 and l2                                                                                                                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:14 |
| L21 | 1     | l18 and l3                                                                                                                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:14 |
| L22 | 1     | l18 and l4                                                                                                                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:14 |
| L23 | 2     | l18 and l5                                                                                                                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |



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| L24 | 7      | I18 and I6      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L25 | 6      | I18 and I7      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L26 | 2      | I18 and I8      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L27 | 36     | I18 and I9      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L28 | 51     | I18 and I10     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L29 | 1      | I18 and I11     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L30 | 7      | I18 and I12     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L31 | 4      | I18 and I13     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L32 | 14     | I18 and I14     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L33 | 1      | I18 and I15     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:15 |
| L35 | 103219 | "315"/\$7.ccls. | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:16 |
| L36 | 142509 | "362"/\$7.ccls. | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:16 |

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| L37 | 122  | I18 and I35                                                                                                                | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:16 |
| L38 | 692  | I18 and I36                                                                                                                | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>10:16 |
| S1  | 39   | "7049761"                                                                                                                  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:18 |
| S2  | 382  | (Jos near4 Timmermans or Jean near4 Raymond or John near4 Ivey).inv.                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:34 |
| S3  | 17   | cap\$1 same bulb near4 portion and socket and power near4 supply and (LEDs or light near4 emitting near4 diodes) and board | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:35 |
| S4  | 5    | S1 and S3                                                                                                                  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:36 |
| S5  | 7    | S2 and S3                                                                                                                  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:36 |
| S6  | 308  | 315/146.ccls.                                                                                                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:36 |
| S7  | 1464 | 315/246.ccls.                                                                                                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:36 |
| S8  | 657  | 315/185R.ccls.                                                                                                             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S9  | 388  | 315/185S.ccls.                                                                                                             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S10 | 1490 | 315/312.ccls.                                                                                                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |

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| S11 | 5787   | 315/291.ccls.                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S12 | 3875   | 315/307.ccls.                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S13 | 407    | 362/488.ccls.                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S14 | 1392   | 362/240.ccls.                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S15 | 2942   | 362/800.ccls.                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:38 |
| S16 | 491    | 362/543.ccls.                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:39 |
| S17 | 688    | 362/544.ccls.                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:39 |
| S18 | 1220   | 362/545.ccls.                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:39 |
| S19 | 1784   | 362/249.01.ccls.                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:41 |
| S20 | 1447   | 362/249.02.ccls.                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:41 |
| S21 | 163    | 362/249.03.ccls.                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:41 |
| S22 | 927084 | (cap\$1 or socket\$1) same (end\$1 or<br>terminal\$1) | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:42 |

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| S23 | 7613   | S22 and (LEDs or light near4 emitting near4 diodes) and board | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:43 |
| S24 | 3282   | mount\$1 and S23                                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:43 |
| S25 | 204886 | predetermin\$3 with pattern                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:44 |
| S26 | 130    | S24 and S25                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:44 |
| S27 | 14     | S26 and @pd<="20000211"                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:44 |
| S28 | 869    | S23 and @pd<="20000211"                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:45 |
| S29 | 0      | S6 and S28                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S30 | 1      | S7 and S28                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S31 | 1      | S8 and S28                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S32 | 0      | S9 and S28                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S33 | 0      | S10 and S28                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S34 | 2      | S11 and S28                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |

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| S35 | 1      | S12 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S36 | 2      | S13 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S37 | 9      | S14 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S38 | 39     | S15 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S39 | 0      | S16 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S40 | 0      | S17 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S41 | 6      | S18 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S42 | 3      | S19 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S43 | 1      | S20 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S44 | 1      | S21 and S28     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S45 | 100857 | "315"/\$7.ccls. | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S46 | 138182 | "362"/\$7.ccls. | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |

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| S47 | 14   | S45 and S28                                                                                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:48 |
| S48 | 94   | S46 and S28                                                                                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:48 |
| S49 | 513  | predetermin\$3 and S28                                                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:51 |
| S50 | 9705 | rectif\$3 and current near4 limit\$3<br>near4 circuit                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>01:50 |
| S51 | 359  | S50 and (LEDs or light near4 emitting<br>near4 diodes) and board                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>01:51 |
| S52 | 65   | S51 and @pd<="20000211"                                                                                  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>01:51 |
| S53 | 122  | "6158882"                                                                                                | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>11:08 |
| S54 | 41   | "4748545"                                                                                                | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>11:08 |
| S55 | 5    | "11085744"                                                                                               | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>11:55 |
| S56 | 43   | voltage near4 converter same rectif\$3<br>same' (LEDs or light near4 emitting<br>near4 diodes) and board | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>13:09 |
| S57 | 3    | S56 and @pd<="20000211"                                                                                  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>13:09 |
| S59 | 122  | voltage near4 converter same rectif\$3<br>same (LEDs or light near4 emitting<br>near4 diodes)            | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>13:10 |

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| S61 | 10     | S59 and @pd<="20000211"                                                                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>13:10 |
| S62 | 71031  | socket\$1 same (end\$1 or cap\$1) same<br>(tube or lamp\$12 or flourescent)                                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:49 |
| S63 | 4585   | socket\$1 same (end\$1 or cap\$1) same<br>(tube or lamp\$12 or flourescent)same<br>(LED\$1 or light near4 emitting)                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:49 |
| S64 | 1320   | socket\$1 same (end\$1 or cap\$1) same<br>(tube or lamp\$12 or flourescent)same<br>(LED\$1 or light near4 emitting)same<br>(circuit or board) | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:50 |
| S65 | 954    | S64 and @pd<="20000211"                                                                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:50 |
| S66 | 520    | S65 and surface                                                                                                                               | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:51 |
| S67 | 122    | "6158882"                                                                                                                                     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:09 |
| S68 | 4      | S67 and "120" near4 Hz                                                                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:09 |
| S69 | 4      | S67 and "120" near4 Hz                                                                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:10 |
| S70 | 41     | "4748545"                                                                                                                                     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:10 |
| S71 | 3      | S70 and "120" near4 Hz                                                                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:10 |
| S72 | 927084 | (cap\$1 or socket\$1) same (end\$1 or<br>terminal\$1)                                                                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:12 |

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| S73 | 82    | S72 and (LEDs or light near4 emitting near4 diodes) and board and "120" near4 Hz | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:12 |
| S74 | 7     | S73 and @pd<="20000211"                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:12 |
| S75 | 4     | "5463380"                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:13 |
| S76 | 0     | S75 and Hz                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:13 |
| S77 | 9207  | inductive with antenna                                                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:47 |
| S78 | 505   | (LEDs or light near4 emitting near4 diodes) and S77                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:47 |
| S79 | 29    | S78 and @pd<="20000211"                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:48 |
| S80 | 88    | "6362578"                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:55 |
| S81 | 15054 | inductive same antenna                                                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:56 |
| S82 | 839   | (LEDs or light near4 emitting near4 diodes) and S81                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:56 |
| S83 | 34    | S82 and @pd<="20000211"                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:56 |
| S84 | 1     | S67 and @pd<="20000211"                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>20:18 |



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| S85 | 19  | S70 and @pd<="20000211"                                                                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>20:18 |
| S86 | 395 | (Jos near4 Timmermans or Jean near4 Raymond or John near4 Ivey).inv.                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/04<br>12:21 |
| S87 | 395 | (Jos near4 Timmermans or Jean near4 Raymond or John near4 Ivey).inv.                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>08:20 |
| S88 | 9   | cap\$1 and socket and power near4 supply and (LEDs or light near4 emitting near4 diodes) and board and surface\$1 and S87 | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>08:32 |
| S89 | 46  | cap\$1 and (LEDs or light near4 emitting near4 diodes) and board and surface\$1 and S87                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/12/05<br>08:47 |

12/ 5/ 2012 1:09:35 PM  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |                                                                           |                                 |                                                              |                                         |                                             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------|--------------------------------------------------------------|-----------------------------------------|---------------------------------------------|
| <b>SERIAL NUMBER</b><br>12/965,019                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>FILING or 371(c)<br/>DATE</b><br>12/10/2010<br><b>RULE</b>                                                     | <b>CLASS</b><br>315                                                       | <b>GROUP ART UNIT</b><br>2821   | <b>ATTORNEY DOCKET NO.</b><br>AEII-172-H                     |                                         |                                             |
| <b>APPLICANTS</b><br>Jos Timmermans, Ortonville, MI;<br>Jean C. Raymond, Nominique, CANADA;<br>John Ivey, Farmington Hills, MI;<br><b>** CONTINUING DATA *****</b><br>This application is a CON of 11/085,744 03/21/2005 PAT 8,247,985<br>which is a CON of 09/782,375 02/12/2001 PAT 7,049,761<br>which claims benefit of 60/181,744 02/11/2000<br><b>** FOREIGN APPLICATIONS *****</b><br><b>** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **</b><br>12/22/2010 |                                                                                                                   |                                                                           |                                 |                                                              |                                         |                                             |
| Foreign Priority claimed <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No<br>35 USC 119(a-d) conditions met <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No<br>Verified and Acknowledged /MINH D A/<br>Examiner's Signature                                                                                                                                                                                                 |                                                                                                                   | <input checked="" type="checkbox"/> Met after Allowance<br>MA<br>Initials | <b>STATE OR COUNTRY</b><br>MI   | <b>SHEETS DRAWINGS</b><br>9                                  | <b>TOTAL CLAIMS</b><br>16 <del>17</del> | <b>INDEPENDENT CLAIMS</b><br>3 <del>2</del> |
| <b>ADDRESS</b><br>YOUNG BASILE<br>3001 WEST BIG BEAVER ROAD<br>SUITE 624<br>TROY, MI 48084<br>UNITED STATES                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                   |                                                                           |                                 |                                                              |                                         |                                             |
| <b>TITLE</b><br>LIGHT TUBE AND POWER SUPPLY CIRCUIT                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                   |                                                                           |                                 |                                                              |                                         |                                             |
| <b>FILING FEE RECEIVED</b><br>1220                                                                                                                                                                                                                                                                                                                                                                                                                                 | FEES: Authority has been given in Paper<br>No. _____ to charge/credit DEPOSIT ACCOUNT<br>No. _____ for following: |                                                                           |                                 | <input type="checkbox"/> All Fees                            |                                         |                                             |
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |                                                                           |                                 | <input type="checkbox"/> 1.17 Fees (Processing Ext. of time) |                                         |                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |                                                                           |                                 | <input type="checkbox"/> 1.18 Fees (Issue)                   |                                         |                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |                                                                           |                                 | <input type="checkbox"/> Other _____                         |                                         |                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |                                                                           | <input type="checkbox"/> Credit |                                                              |                                         |                                             |



|                                                                                                                |                                              |                                                                     |  |
|----------------------------------------------------------------------------------------------------------------|----------------------------------------------|---------------------------------------------------------------------|--|
| <b>Application Number</b><br> | <b>Application/Control No.</b><br>12/965,019 | <b>Applicant(s)/Patent under Reexamination</b><br>TIMMERMANS ET AL. |  |
|                                                                                                                |                                              |                                                                     |  |

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|                                |                                                                |                                             |
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| <b>TERMINAL<br/>DISCLAIMER</b> | <input checked="" type="checkbox"/> <b>APPROVED</b>            | <input type="checkbox"/> <b>DISAPPROVED</b> |
| Date Filed : 12/07/12          | <b>This patent is subject<br/>to a Terminal<br/>Disclaimer</b> |                                             |

|                                 |
|---------------------------------|
| <b>Approved/Disapproved by:</b> |
| Angie Walker                    |

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**TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING  
REJECTION OVER A "PRIOR" PATENT**Docket Number (Optional)  
AEII-172-H

In re Application of: Jos Timmermans

Application No.: 12/965,019

Filed: December 10, 2010

For: LIGHT TUBE AND POWER SUPPLY CIRCUIT

The owner\*, ILumisys, Inc., of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent No. 7,510,299 as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:

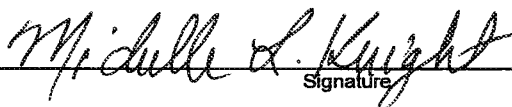
- expires for failure to pay a maintenance fee;
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- is found invalid by a court of competent jurisdiction;
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- has all claims canceled by a reexamination certificate;
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- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☒ The undersigned is an attorney or agent of record. Reg. No. 47711

  
Signature

December 7, 2012  
Date

Michelle L. Knight  
Typed or printed name

248-649-3333  
Telephone Number

- ☒ Terminal disclaimer fee under 37 CFR 1.20(d) included.

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
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|                                                                                                     |                        |                |            |  |
|-----------------------------------------------------------------------------------------------------|------------------------|----------------|------------|--|
| <b>INFORMATION DISCLOSURE<br/>STATEMENT BY APPLICANT</b><br>( Not for submission under 37 CFR 1.99) | Application Number     |                | 12965019   |  |
|                                                                                                     | Filing Date            |                | 2010-12-10 |  |
|                                                                                                     | First Named Inventor   | Jos Timmermans |            |  |
|                                                                                                     | Art Unit               | 2821           |            |  |
|                                                                                                     | Examiner Name          | A. Minh D      |            |  |
|                                                                                                     | Attorney Docket Number | AEII-172-H     |            |  |

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|                                                                                                            | 1       | H11-162234                           | JP                          | A                      | 1999-06-18                                      | Matsushita Electric Works Ltd.                                         |                                                                        | <input checked="" type="checkbox"/> |
|                                                                                                            | 2       | H11-260125                           | JP                          | A                      | 1999-09-24                                      | Omron Tateisi Electronics Co.                                          |                                                                        | <input checked="" type="checkbox"/> |
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| <b>INFORMATION DISCLOSURE<br/>STATEMENT BY APPLICANT</b><br>( Not for submission under 37 CFR 1.99) | Application Number     |                | 12965019   |
|                                                                                                     | Filing Date            |                | 2010-12-10 |
|                                                                                                     | First Named Inventor   | Jos Timmermans |            |
|                                                                                                     | Art Unit               |                | 2821       |
|                                                                                                     | Examiner Name          | A. Minh D      |            |
|                                                                                                     | Attorney Docket Number |                | AEII-172-H |

| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T <sup>5</sup>           |
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| Examiner Signature |  | Date Considered |  |
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\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

<sup>1</sup> See Kind Codes of USPTO Patent Documents at [www.USPTO.GOV](http://www.USPTO.GOV) or MPEP 901.04. <sup>2</sup> Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). <sup>3</sup> For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. <sup>4</sup> Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. <sup>5</sup> Applicant is to place a check mark here if English language translation is attached.



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|                                                                                                     | Filing Date            |                | 2010-12-10 |
|                                                                                                     | First Named Inventor   | Jos Timmermans |            |
|                                                                                                     | Art Unit               |                | 2821       |
|                                                                                                     | Examiner Name          | A. Minh D      |            |
|                                                                                                     | Attorney Docket Number |                | AEII-172-H |

### CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

### SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

|            |                      |                     |            |
|------------|----------------------|---------------------|------------|
| Signature  | /Michelle L. Knight/ | Date (YYYY-MM-DD)   | 2012-12-07 |
| Name/Print | Michelle L. Knight   | Registration Number | 47711      |

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

(51) Int.Cl.<sup>8</sup>  
F 2 1 S 5/00

識別記号

F I  
F 2 1 S 5/00H  
Z

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(21) 出願番号 特願平10-62437

(22) 出願日 平成10年(1998) 3月13日

(71) 出願人 000002945

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(74) 代理人 弁理士 板谷 康夫

(54) 【発明の名称】 光源モジュール

(57) 【要約】

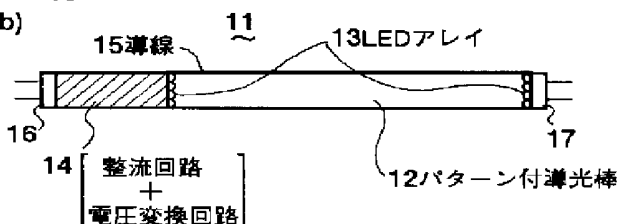
【課題】 光源モジュールにおいて、従来の照明用の光源と形・サイズ・電源との接続方法・光の出射特性がほぼ同じである光源をLEDによって作ることで、従来の照明装置に容易に取って代わる。

【解決手段】 従来の蛍光灯又は白熱灯用照明装置の電極差し込み口に、そのまま光源モジュール11の電源を取り込む電極16, 17を差し込み、使用することができるようにした。

(a)



(b)



【特許請求の範囲】

【請求項 1】 L E D を光源とする照明部と、外部から電源供給を受けて、前記光源を駆動する電源回路部とから成り、前記電源回路部へ電源を取り込む電極が、蛍光灯又は白熱灯用照明装置の電極差し込み口に差し込み可能な形状であることを特徴とする光源モジュール。

【請求項 2】 入射された光を導く導光棒と、上記導光棒に光が入射するように設置された L E D と、上記導光棒を導波する光を外に取り出す光取り出し手段と、前記 L E D を駆動するための電源回路部とから成り、前記電源回路部へ電源を取り込む電極は、蛍光灯用照明装置の電極差し込み口に差し込み可能な形状であることを特徴とする光源モジュール。

【請求項 3】 前記電源回路部が、整流回路と電圧変換回路を含み、これらが一体にモジュール化されていることを特徴とする請求項 1 又は請求項 2 に記載の光源モジュール。

【請求項 4】 上記構成要素各部の組み合わせ、又は、構成要素各部を収納したケースの大きさ及び形状が、蛍光灯とほぼ同じであることを特徴とする請求項 2 に記載の光源モジュール。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、室内（屋内）照明用の光源モジュールに係り、特に、発光ダイオードを光源としたモジュールに関するものである。

【0002】

【従来の技術】従来、室内用の照明装置の光源としては、白熱灯や蛍光灯が主として用いられているが、これらの光源に代えて、半導体を用いた固定発光素子である発光ダイオード（L E D）を室内照明用の光源として利用することが考えられている。すなわち、L E D は、小型、高輝度および長寿命といった特徴より、将来の照明手段として期待される。現在は、その変換効率が一般的な蛍光灯の約 1／6 程度とあまり良くないため、照明分野での利用は少ないが、上記の特徴および L E D の持つ可能性を考慮すると、近い将来、L E D が照明の主流となることも考えられる。

【0003】

【発明が解決しようとする課題】しかしながら、上記のような従来の L E D が照明の主流となるには、下記の問題が考えられる。

（１）現在の照明装置、特に屋内の蛍光灯は建物に埋め込まれていることが多い。また、埋め込まれていなくても、取り外しが困難であったり、照明装置をインテリアとして用いて、部屋の構成要素の一つとして用いる場合もある。そのため、照明装置ごと置き換えることはかなりの困難を伴う。

（２）現在の照明でも、効率が悪い点を除けば、ユーザによっては使用上の不都合は余りない。また、その効率の悪さも国家レベルや地球全体といったレベルでみると、改善の必要があるが、個々のユーザとしては、電気料金が若干変わる程度であり、そう問題にはならない。

【0004】よって、L E D の効率が向上したとしても、L E D が照明装置の光源として普及するには、建物が改装される時期や、照明装置の買い替えの時期を待つことになるので、非常に時間がかかる。

【0005】本発明は、上述した問題点を解決するためになされたものであり、従来の照明用の光源と形・サイズ・電源との接続方法・光の出射特性がほぼ同じである光源を L E D によって作ること、従来の照明装置に容易に取って代わり得る光源モジュールを提供することを目的とする。

【0006】

【課題を解決するための手段】上記目的を達成するために請求項 1 の発明は、L E D を光源とする照明部と、外部から電源供給を受けて、光源を駆動する電源回路部とから成り、電源回路部へ電源を取り込む電極が、蛍光灯又は白熱灯用照明装置の電極差し込み口に差し込み可能な形状である光源モジュールである。この構成においては、従来の蛍光灯又は白熱灯用照明装置の電極差し込み口に、そのまま本光源モジュールの電源を取り込む電極を差し込み、使用することができる。

【0007】また、請求項 2 の発明は、入射された光を導く導光棒と、導光棒に光が入射するように設置された L E D と、導光棒を導波する光を外に取り出す光取り出し手段と、L E D を駆動するための電源回路部とから成り、電源回路部へ電源を取り込む電極は、蛍光灯用照明装置の電極差し込み口に差し込み可能な形状である光源モジュールである。この構成においては、導光棒から光を外に取り出すことが、光取り出し手段のパターンの密度や形状によって任意にコントロールでき、効果的な拡散作用を得ることができる。

【0008】また、請求項 1 又は請求項 2 に記載の光源モジュールにおいて、電源回路部が、整流回路と電圧変換回路を含み、これらが一体にモジュール化されているものであってもよい。この構成においては、電源回路部のモジュールを照明部とは別個に形成したものとすることができ、寿命に応じて個別に交換することができる。

【0009】また、請求項 2 に記載の光源モジュールにおいて、構成要素各部の組み合わせ、又は、構成要素各部を収納したケースの大きさ及び形状が、蛍光灯とほぼ同じであるものである。この構成においては、従来の蛍光灯用照明装置に取って代わって、本光源モジュールを使用することができる。

【0010】

【発明の実施の形態】以下、本発明を具体化した一実施形態を図面を参照して説明する。図 1（a）は従来の照

明用の蛍光灯を、(b)は本実施形態による蛍光灯型LED照明用の光源モジュールを示す。本実施形態による光源モジュール11は、LEDを用いて、従来の蛍光灯1とほぼ同等の形・サイズ・電源との接続方法・光の出射特性を持たせるものとする。光源モジュール11は、表面にパターンを設けた導光棒12と、その両端面に設けられ導光棒12に光を入射させるLEDアレイ(光源)13と、光源を駆動する電源回路部14と、両側のLEDアレイ13を接続する導線15と、導光棒12の一端と電源回路部14の他端の両サイドに配置され外部から電源供給を受けるための口金である電極16、17とから構成される。LEDアレイ13から成る光源と導光棒12とで照明部が構成されている。

【0011】導光棒12の表面に設けたパターン(光取り出し手段)により、導波光を取り出し、蛍光灯と同じ棒状の光源を作る。また、蛍光灯には交流が直接印加されるが、LEDは直流に変換した電圧を印加する必要があるため、電源回路部14には、整流回路と、必要な電圧に変換するための電圧変換回路が必要となる。そして、電源を取り込む電極16、17は、従来の蛍光灯1又は白熱灯用照明装置の電極16、17の差し込み口に差し込み可能な形状とされている。また、導光棒12は円柱、多角柱、厚めの板状の部材、円筒、角筒等であってもよい。

【0012】図2に、蛍光灯1の基本的な駆動回路を示す。蛍光灯1は初期状態では、点灯回路4に電流が流れ、蛍光灯1のフィラメント2、3を熱する。ある程度フィラメントが温まったなら、点灯回路4を切り、蛍光灯1に電圧を印加して放電を生じさせ、点灯させる。よって、点灯時は蛍光灯1によって回路がつながった状態になっている。

【0013】図3に、本実施形態による蛍光灯型LED照明装置の駆動回路を示す。破線で囲んだ領域が、本発明でいう光源モジュール11であり、ここには、電源回路部14の整流回路14aと電圧変換回路14b、LEDアレイ13を含むが、それ以外の回路は、従来の蛍光灯の駆動回路と同じである。よって、本モジュール11を従来の蛍光灯と置き換えるだけで、LED照明が実現できる。このとき、点灯回路4は使用しない。

【0014】光源モジュール11は、図4に示すように、整流回路14aと電圧変換回路14bを含んだ回路部分11Aと、LEDアレイ13と導光棒12からなる光源部分11Bが一体になったときのサイズ及び形が、蛍光灯とほぼ同じになっていればよい。しかし、回路部分11Aと光源部分11Bは、寿命がそれぞれ異なるため、両者を一体化して一方の寿命に合わせて使い捨てる

のは、効率的でない。そこで、回路部分11Aと光源部分11Bとは、図示のように、それぞれ分離したモジュールとなっていることが望ましい。このようなモジュールによって、従来の蛍光灯用の照明装置で、蛍光灯を本モジュールに置き換えるだけで、容易にLED照明を使用することが可能になる。

【0015】また、本モジュールの導光棒12から出射する光は、パターンの密度や形状によって自由にコントロールできるので、本モジュールに置き換えることで、その照明装置を効果的な拡散効果を発揮する光源とすることができる。よって、現在までに確立された照明装置の種々の効果も十分に活かした、効率の良いLED照明が可能となる。

【0016】なお、本発明は上記実施形態の構成に限られず種々の変形が可能である。例えば、上記実施形態では、直線状の導光棒を示したが、丸型のものでも、屈曲型のものでも同様に適用可能である。また、室内照明用に、各色のLEDを組み合わせたアレイを用いて、白色その他任意の照明色を出すことも可能である。

【0017】

【発明の効果】以上のように本発明の光源モジュールによれば、従来の蛍光灯又は白熱灯用照明装置の電極差し込み口にそのまま電極を差し込んで使用することができるので、従来の照明用の光源に取って代わって使用でき、LEDを用いた照明照明への転換を容易に行うことが可能となる。また、導光棒から光を外に取り出す光取り出し手段のパターンの密度や形状を任意にコントロールすることが可能で、それによって、効果的な拡散作用を得て、照明効果を上げることができる。

【図面の簡単な説明】

【図1】(a)は従来の照明用の蛍光灯を示す図、(b)は本実施形態による蛍光灯型LED照明用の光源モジュールを示す図である。

【図2】蛍光灯の基本的な駆動回路を示す図である。

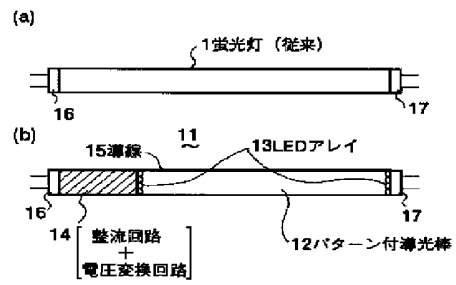
【図3】本実施形態による蛍光灯型LED照明装置の駆動回路図である。

【図4】本実施形態による光源モジュールの構成例を示す図である。

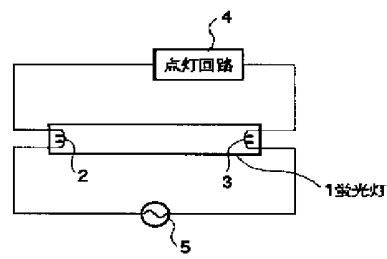
【符号の説明】

- 11 光源モジュール
- 12 導光棒
- 13 LEDアレイ
- 14 電源回路部
- 14a 整流回路
- 14b 電圧変換回路
- 16, 17 電極

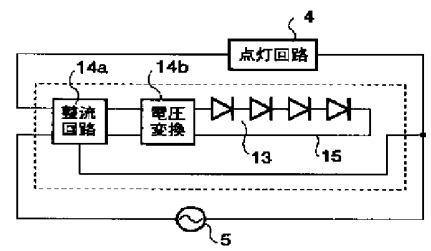
【図 1】



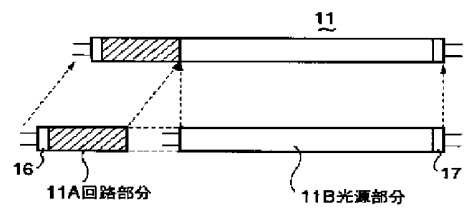
【図 2】



【図 3】



【図 4】





## Espacenet

**Bibliographic data: JP11260125 (A) — 1999-09-24**

## LIGHT SOURCE MODULE

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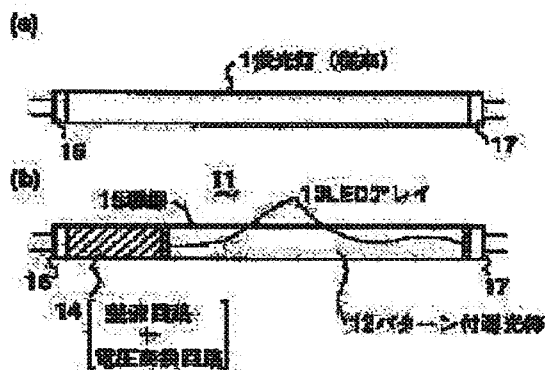
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**Classification:** - international: *F21S2/00*; (IPC1-7): F21S5/00  
- European:

**Application** JP19980062437 19980313  
**number:**

Priority number JP19980062437 19980313  
(s):

### Abstract of JP11260125 (A)



**PROBLEM TO BE SOLVED:** To easily convert to the illumination using LED by providing an electrode for taking the power source into a power source circuit portion, with the shape insertable into an electrode inserting port of a lighting system for a fluorescent lamp or an incandescent lamp. **SOLUTION:** A light source module 11 provides a shape, size, connection method with a power source and the outgoing characteristic of light almost equal to a fluorescent lamp 1, by using an LED. In the light source module 11, the light guide wave is obtained from a pattern on a surface of a light guide rod with pattern 12 to make a linear light source same as the fluorescent lamp 1. An illuminating portion comprises an LED array 13 and the light guide rod with pattern 12. Since the voltage converted into DC is to be applied to the LED, the power source circuit portion 14 must comprise a rectifying circuit and a voltage converting circuit. The electrodes 16, 17 for taking the power source are provided with the shape insertable into the inserting ports of the power source 16, 17 of the lighting system for the fluorescent lamp 1 or the incandescent lamp.

Last updated: 04.12.2012 Worldwide Database 5.7.44.6; 92p



Published 1999

#### **Detailed description of the invention**

[0001]

The present invention relates to a light source module for indoor (room) lighting, in particular, to modules which employ light emitting diodes as the light source.

[0002]

#### **Prior Art Technology**

Conventionally, as the light source for lighting device for use indoors, mainly white incandescent bulbs and fluorescent bulbs were employed, but it is conceivable to employ solid state light emission elements employing semiconductors which are light emission diodes (LEDs) as the light source for indoor lighting instead of these light sources. In other words, LEDs are characterized by being small, with high luminous intensity and long life, and are expected to play a role as lighting means in the future. Currently, because their conversion efficiency is poor at the order of 1/6 that of fluorescent bulbs, they are rarely used in the field of lighting, but in consideration of the characteristics described above and the possibilities of using LEDs, it is conceivable that LEDs will become the mainstream of lighting in the future.

[0003]

#### **Problems to be solved by the invention**

However, for the conventional LEDs described above to become the mainstream of lighting, the following problems need to be addressed:

- (1) The current lighting devices, in particular fluorescent bulbs are incorporated in the fabric of buildings. Moreover, even if not physically recessed in the buildings, it is difficult to remove them, and the lighting devices form part of the interior décor, and the form part of the configuration elements of the rooms in many cases. Because of this, there are many problems associated with replacing each and every one of the lighting devices.
- (2) Even with the current lighting, leaving aside the point about operational efficiency, there are few inconveniences from the perspective of the users. Moreover, when that poor efficiency is viewed from a national and global resource perspective, while there is a need for the improvement thereof, from the perspective of individual users, depending on the degree to which the electricity tariffs would vary, it is not such a big problem.

[0004]

Therefore, even if the efficiency of LEDs were to be improved, in order for LEDs to be widely adopted as the light source of lighting devices, because it would have to await the timing of the refurbishment of interiors, or the timing of the replacement of the lighting devices, this would be a very slow process.

[0005]

The present invention was conceived of in consideration of a resolution to these issues, and by creating light sources from LEDs which have almost the same shape, size, electrical connectivity and light emission characteristics as the conventional light sources for illumination, it has as its objective the provision of light source modules enabling easy replacement of the conventional lighting devices.

[0006]

#### **Summary of the Invention**

In order to achieve the objectives described above, the invention of claim 1 is a light source module comprised of a lighting means which has LEDs as the light source, and an electrical power source circuit means driving said light source which is in receipt of electrical power

supply from the exterior, characterized by the electrodes uptaking the electrical power to said electrical power source circuit means being of a shape enabling the insertion thereof into the electrode insertion apertures of a fluorescent lamp or incandescent lamp. In this configuration, this light source module enables the electrodes for the uptake of the power source to be inserted as is in the electrode insertion sockets of lighting devices for use with conventional fluorescent bulbs or incandescent bulbs and used therein.

[0007]

Moreover, the invention of claim 2 is a light source module comprised of a light guiding rod leading the light which is incident thereon, and LED provided so as to cause light to be incident on said light guiding rod, and a light extraction means extracting the inducted waves of light of said light guiding rod to the exterior, and an electrical power source circuit means in order to drive said LED, characterized by the electrodes uptaking the electrical power to said electrical power source circuit means being of a shape enabling the insertion thereof into the electrode insertion apertures of a fluorescent lamp. In this configuration, the extraction of light from the light guiding rod to the exterior is enabled by the free control of the pattern density or shape of the light extraction means, enabling the derivation of effective diffusion effects.

[0008]

In the light source modules claimed in claims 1 and 2, the electrical power source circuit means includes a rectifier circuit and a voltage conversion circuit, and they may be included in a unitary module. In this configuration, the module of the electrical source circuit means may be enabled separately from the illumination means, enabling the individual replacements thereof in correspondence with the respective lifetimes thereof.

[0009]

Moreover, in the light source modules claimed in claim 2 the assembly of all the constituent element means described above, or the size and shape of the case storing each of the constituent element means is almost the same as that of a fluorescent bulb. In this configuration, this light source module can be employed instead in the lighting devices which employed conventional fluorescent bulbs.

[0010]

#### **Embodiment of the invention**

Hereafter, one specific embodiment of the present invention is explained while referring to the figures. FIG. 1 (a) shows a prior art fluorescent bulb for use in lighting, while (b) shows the light source module for fluorescent bulb shaped LED lighting by means of the embodiment. The light source module 11 by means of this embodiment employs LEDs, and is one where the shape, size and connection method to the power source and the light output characteristics are almost equivalent to the prior art fluorescent lamp 1. The light source module 11 is configured from a light guide bar 12 with a surface pattern provided thereon, an LED array (Light source) 13 provided on both terminal surfaces causing light to be incident on the light guide bars 12, and lead wires 15 connecting both sides of the LED array 13, and electrodes 16 and 17 which are sockets for the receipt of electrical power supply from the exterior disposed on both sides [which are] one terminal of the light guide bar 12 and the other terminal of the power source circuit means 14. The light source comprised of the LED array 13 and the light guide bar 12 configure the lighting means.

[0011]

The wave guided light is extracted by means of the pattern (Light extraction means) provided on the surface of the light guide 12 and a bar shaped light source which has the same shape as a fluorescent bulb is created. Moreover, in the fluorescent bulbs, the alternating current is applied directly thereto, but because the LEDs require the voltage to be converted to direct current for application thereto, in the electrical source circuit means 14 there is a need for a

rectifier circuit, and a voltage conversion circuit for the conversion to a suitable voltage. Then, the electrodes 16 and 17 which uptake the electrical [power] source are of a shape enabling insertion to the electrode 16 and 17 insertion sockets of conventional fluorescent bulb or incandescent bulb lighting devices. Moreover, the light guide bar 12 may be a circular bar, a polygonal bar, a thick panel shaped member, a cylinder or square tube,

[0012]

FIG. 2 shows a drive circuit drawing of the fluorescent bulb 1 of this embodiment. In the initial state of the fluorescent bulb 1, current flows to the starter circuit 4, and the filaments 2 and 3 of the fluorescent lamp 1 are heated. When the filament are heated to some extent, the starter circuit 4 is switched off, and the voltage is applied to the fluorescent bulb 1 to generate an electrical discharge and light the bulb. Therefore, the circuit is caused to be in a connected state by the lighting of the fluorescent bulb 1.

[0011]

FIG. 3 is a drawing showing the drive circuit diagram of the fluorescent bulb shaped LED lighting device of this embodiment. The domain surrounded by the broken line is the light source module 11 of the invention, and here the rectifier circuit 14a and the voltage conversion circuit 14b of the power source circuit means 14 as well as the LED array 13 are included, but other circuits are the same as the conventional fluorescent bulb drive circuits. Therefore, by merely replacing the conventional fluorescent bulb with this module 11, LED illumination is enabled. On this occasion the starter circuit 4 is not employed.

[0011]

The light source module 11, as shown in FIG. 4, has an integrated size and shape comprising the circuit means 11a including the rectifier circuit 14a and voltage conversion circuit 14b, and the light source means 11 comprising the LED array 13 and the light guide bar 12, such that it may be almost identical to a fluorescent bulb. However, because the circuit means 11A and the light source means 11B may each have different respective lifetimes, the use and disposal thereof with both integrated in a unit is not efficient. In that respect, the circuit means 11A and the light source means 11B, as shown in the figure, are preferably comprised of separate modules. By enabling these types of modules, [when used in] in a conventional fluorescent lighting device, by replacing the fluorescent bulb with this module, the easy use of LED lighting is enabled.

[0011]

Moreover, because the light emitted from the light guide bar 12 of this module can be controlled freely by means of the pattern density and shape, by replacement with this module, a light source is enabled which emits light with a diffused effect enabled by that lighting device. Therefore, the various effects of the installed base of lighting devices to date can be availed of, enabling efficient LED lighting.

[0016]

Now, the present invention can be embodied in a variety of forms not limited to the configuration of the embodiment described above. For example, in the embodiment described above, a linear light geode bar was represented, but it may also be a circular shape, or a bent shape while still enabling similar applications. Moreover, for the purposes of indoor lighting, an array combining every color of LED may be employed, enabling the emission of white or any other color of lighting.

[0017]

#### **Effects of the invention**

By means of the light source modules as described above, because the electrode insertion sockets of the conventional fluorescent bulbs or incandescent bulbs of lighting devices can be employed, as is, the easy conversion of lighting to use LEDs by the employment thereof instead of the conventional light sources for use in lighting is enabled. Moreover, because the

free control of pattern density and shape of the light guide bars extracting the light as the light extraction means is enabled, by this means an effective diffusion effect is enabled, enabling increased lighting effectiveness.

#### Brief Description of the Drawings

FIG. 1 (a) is a drawing showing a prior art fluorescent bulb for use in lighting, (b) is a drawing showing the light source module of the fluorescent bulb type LED for use in lighting of this embodiment.

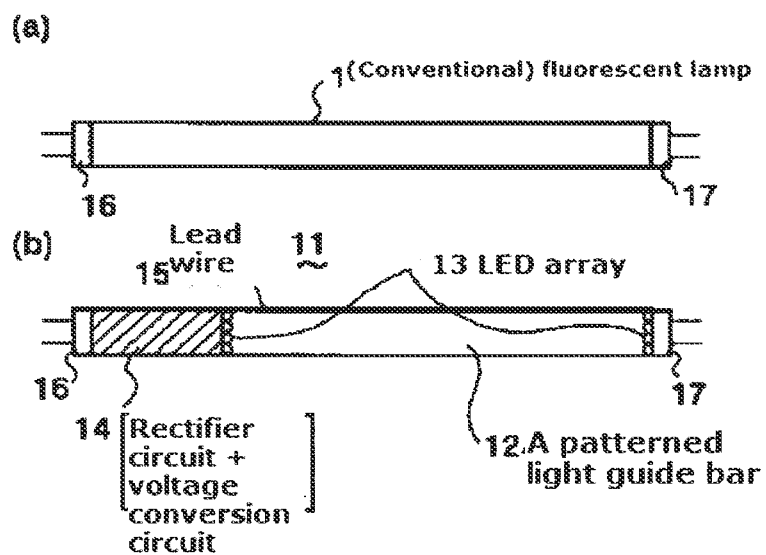


FIG. 2 A drive circuit drawing of the fluorescent bulb type LED lighting device of this embodiment

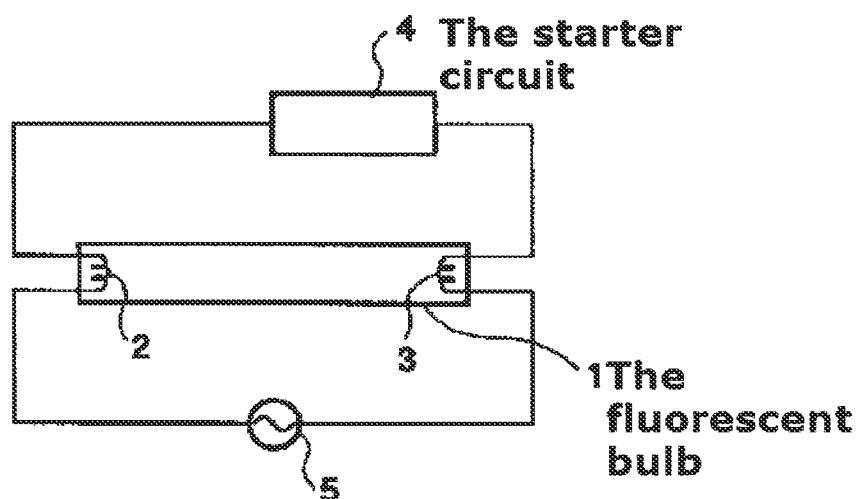


FIG. 3 is a drawing showing the drive circuit diagram of the light source module of the embodiment.

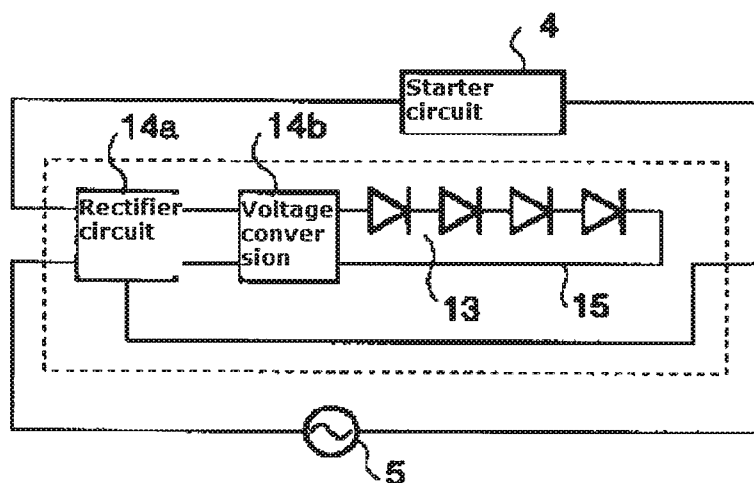
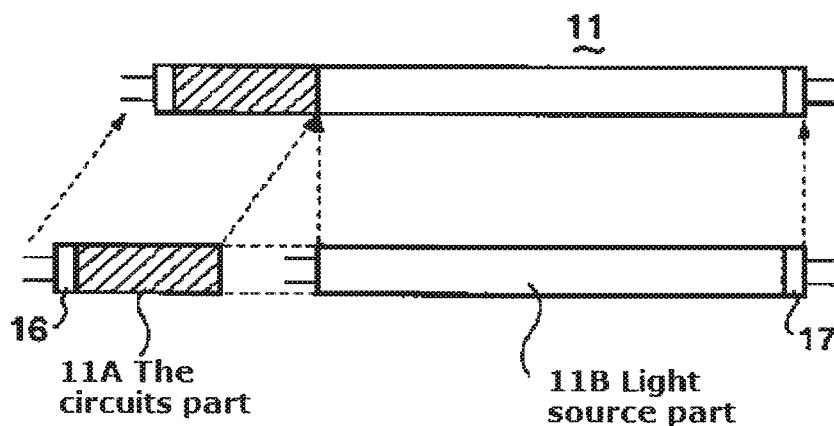


FIG. 4 is a drawing showing a configuration embodiment of the light source module of the embodiment.



#### Reference Numerals

- 11 The light source module
- 12 The light guide bar
- 13 The LED array
- 14 The light source circuit means
- 14a The rectifier circuit
- 14b The voltage conversion circuit
- 16, 17 Electrodes

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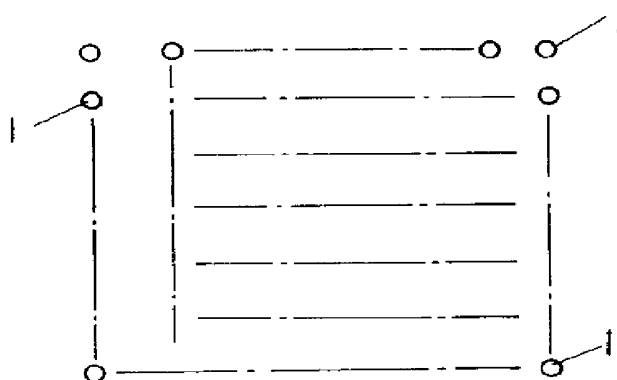
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(54) 【発明の名称】 発光ダイオードを用いた光源

(57) 【要約】

【課題】 光源自身で各種の配光を得ることができ、また面光源を容易に構成することができるようにする。

【解決手段】 複数の発光ダイオード素子1を配光設計に応じた配置密度で配列する。複数の発光ダイオード素子1を配列していることによって面光源を容易に得ることができる。また、配光設計に応じて発光ダイオード素子1の配列密度を設定しているから、光源自身で配光設計に対応することができる。



1 発光ダイオード素子

【特許請求の範囲】

【請求項 1】 複数の発光ダイオード素子が配光設計に応じた配置密度で配列されていることを特徴とする発光ダイオードを用いた光源。

【請求項 2】 発光ダイオード素子はベアチップであることを特徴とする請求項 1 記載の発光ダイオードを用いた光源。

【請求項 3】 照射面の照度を一定とするように発光ダイオード素子の配列範囲の中心部の配列密度を周辺部よりも小さくしたことを特徴とする請求項 1 記載の発光ダイオードを用いた光源。

【請求項 4】 発光ダイオード素子の配列範囲の中心部の配列密度を周辺部よりも大きくしたことを特徴とする請求項 1 記載の発光ダイオードを用いた光源。

【請求項 5】 複数の発光ダイオード素子が複数のグループを構成するように各発光ダイオード素子がグループごとに接続され、各発光ダイオード素子の点灯状態がグループごとに制御可能であることを特徴とする発光ダイオードを用いた光源。

【請求項 6】 複数の発光ダイオード素子と、放電灯用の点灯回路の出力に接続され前記発光ダイオード素子を点灯させる駆動回路とを備えることを特徴とする発光ダイオードを用いた光源。

【請求項 7】 前記駆動回路は、点灯回路に接続される整流回路を含んだ電源部と、前記電源部から前記発光ダイオード素子に通電される電流を制限する限流要素とを備えることを特徴とする請求項 6 記載の発光ダイオードを用いた光源。

【請求項 8】 前記駆動回路は、点灯回路に接続される整流回路および力率改善手段を含む電源部と、前記電源部から前記ダイオード素子に通電される電流を制限する限流要素とを備え、電源部の入力特性は放電灯の負荷特性を模擬することを特徴とする請求項 6 記載の発光ダイオードを用いた光源。

【請求項 9】 前記負荷特性は放電灯の安定点灯時の電流電圧特性であることを特徴とする請求項 8 記載の発光ダイオードを用いた光源。

【請求項 10】 前記放電灯は蛍光灯であることを特徴とする請求項 9 記載の発光ダイオードを用いた光源。

【請求項 11】 複数の発光ダイオード素子が複数のグループを構成するように各発光ダイオード素子がグループごとに接続され、各発光ダイオード素子の点灯状態がグループごとに制御可能であることを特徴とする請求項 8 記載の発光ダイオードを用いた光源。

【請求項 12】 板状体の周面に対向して配置した光源から導入された光を表裏の少なくとも一面から漏光させる導光板と、前記光源となる発光ダイオード素子とを備えることを特徴とする発光ダイオードを用いた光源。

【請求項 13】 発光ダイオード素子は導光板の周面に対向して複数個配列されていることを特徴とする請求項

12 記載の発光ダイオードを用いた光源。

【請求項 14】 複数の発光色の発光ダイオード素子が配列されていることを特徴とする請求項 13 記載の発光ダイオードを用いた光源。

【請求項 15】 導光板の表裏の少なくとも一面に表示パターンを設けた照明装置に用いられ、表示パターンにおける透過光量の多い部位ほど導光板からの漏光量が多くなるように発光ダイオード素子を配列したことを特徴とする請求項 13 記載の発光ダイオードを用いた光源。

【請求項 16】 導光板の表裏の少なくとも一面に表示パターンを設けた照明装置に用いられ、表示パターンにおける着色部の色と導光板から漏光する光色とを一致させるように複数の発光色の発光ダイオード素子を配列したことを特徴とする請求項 13 記載の発光ダイオードを用いた光源。

【請求項 17】 各発光ダイオード素子の光出力が調光手段により調光されることを特徴とする請求項 13 記載の発光ダイオードを用いた光源。

【請求項 18】 複数の発光ダイオード素子が複数のグループを構成するように各発光ダイオード素子がグループごとに接続され、各発光ダイオード素子の点灯状態がグループごとに制御可能であることを特徴とする請求項 13 記載の発光ダイオードを用いた光源。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、照明用や表示用に適した発光ダイオードを用いた光源に関するものである。

【0002】

【従来の技術】一般に、照明用に用いる光源は点光源または線光源であって、たとえば点光源は図 16 のような配光特性を有している。図 16 の横軸は点光源の鉛直下方にとった基準点からの水平距離を、光源から基準点までの距離で除算することにより規格化して表している。

【0003】図 16 から明らかなように、光源のみで照明を行なうと照射面の照度分布が均一にならないから、反射板やレンズなどの配光制御要素を備える器具に光源を取り付けることによって照明装置を構成するのが一般的である。また、表示用に用いる光源としては表示内容が明確に認識できるような面光源が必要であるが、点光源や線光源のように容易に入手できる面光源はなく、また、点光源や線光源では表示内容の全体を均一な明るさとしたり、表示内容に応じて表示面の領域ごとに明るさに変化を付けたりするのが困難である。

【0004】

【発明が解決しようとする課題】しかして、照明装置では上述のように配光制御要素を備える器具が必要であるから、比較的大型の器具が必要であるという問題がある。また、配光を変更しようとするれば照明装置を取り替えるか照明装置の位置を変更しなければならず、照明装

置を一旦設置した後に照明設計を変更するのは容易ではない。

【0005】また、上述したように面光源は一般に普及しておらず、照明用、表示用ともに安価な面光源が要望されている。本発明は上記事由に鑑みて為されたものであり、その目的は、光源自身で各種の配光を得ることが可能であり、また面光源を容易に構成することができる発光ダイオードを用いた光源を提供することにある。

【0006】

【課題を解決するための手段】請求項1の発明は、複数の発光ダイオード素子が配光設計に応じた配置密度で配列されているものである。この構成によれば、発光ダイオード素子を配列していることによって面光源を容易に得ることができ、しかも配光設計に応じて発光ダイオード素子の配列密度を設定していることにより、光源自身で配光設計に対応することができる。つまり、配光制御要素を備える器具がほとんど不要であるから、比較的小型の照明装置を構成することができ、しかも、発光ダイオード素子の配列密度の異なる光源に取り替えれば、施工後であっても配光を容易に変更することができる。さらに、発光ダイオード素子は白熱電球や蛍光灯のような一般に用いられている光源に比較して寿命が同等か長いものであるから交換回数が少なくなる。

【0007】請求項2の発明は、請求項1の発明において、発光ダイオード素子をベアチップとしたものである。この構成によれば、発光ダイオード素子の配置密度を大きくして輝度の高い光源を得ることが可能になる。請求項3の発明は、請求項1の発明において、照射面の照度を一定とするように発光ダイオード素子の配列範囲の中心部の配列密度を周辺部よりも小さくしたものである。この構成によれば、照射面の照度がほぼ均一になる。

【0008】請求項4の発明は、請求項1の発明において、発光ダイオード素子の配列範囲の中心部の配列密度を周辺部よりも大きくしたものである。この構成によれば、照射面の照度が直下付近で大きくなり部分的に照度を高めた照明が可能になる。つまり、ダウンライトやスポットライトのような部分照明が可能になる。請求項5の発明は、複数の発光ダイオード素子が複数のグループを構成するように各発光ダイオード素子をグループごとに接続し、各発光ダイオード素子の点灯状態をグループごとに制御可能としたものである。この構成によれば、グループごとに点灯や調光を行なうことによって、配光を変化させることが可能になる。

【0009】請求項6の発明は、複数の発光ダイオード素子と、放電灯用の点灯回路の出力に接続され前記発光ダイオード素子を点灯させる駆動回路とを備えるものである。この構成によれば、蛍光灯のような通常の放電灯に用いている照明器具を流用して光源のみを差し替えれば発光ダイオード素子による照明が可能になる。つま

り、点灯回路の出力を駆動回路に与えることにより、発光ダイオード素子に過電圧が印加されたり過電流が流れたりすることなく発光ダイオード素子を安定に点灯させることができる。

【0010】請求項7の発明は、請求項6の発明において、前記駆動回路が、点灯回路に接続される整流回路を含んだ電源部と、前記電源部から前記発光ダイオード素子に通電される電流を制限する限流要素とを備えるものである。この構成によれば、電源部に整流回路を備えるから、点灯回路の出力が直流でも交流でも用いることができる。しかも、限流要素によって発光ダイオード素子に過電流が流れるのを防止することができる。

【0011】請求項8の発明は、請求項6の発明において、前記駆動回路が、点灯回路に接続される整流回路および力率改善手段を含む電源部と、前記電源部から前記ダイオード素子に通電される電流を制限する限流要素とを備え、電源部の入力特性が放電灯の負荷特性を模擬するものである。この構成によれば、電源部の入力特性が放電灯の負荷特性を模擬するから、放電灯に差し替えて用いても点灯回路に支障が生じない。また、電源部に整流回路を設けていることにより、点灯回路の出力が直流でも交流でも用いることができ、さらには力率改善回路を設けているから、点灯回路の出力が交流であるときの電力の利用効率が高いものである。さらに、限流要素によって発光ダイオード素子に過電流が流れるのを防止することができる。

【0012】請求項9の発明は、請求項8の発明において、前記負荷特性を放電灯の安定点灯時の電流電圧特性としたものである。この構成によれば、点灯回路は放電灯を安定点灯させているときと同様に動作することになり、点灯回路へのストレスが少ないものである。請求項10の発明は、請求項9の発明において、前記放電灯を蛍光灯としたものである。この構成によれば、一般の照明でもっとも多く用いられている放電灯である蛍光灯を模擬することになるから、蛍光灯との置き換えによって高い経済効果を生むことになる。

【0013】請求項11の発明は、請求項8の発明において、複数の発光ダイオード素子が複数のグループを構成するように各発光ダイオード素子をグループごとに接続し、各発光ダイオード素子の点灯状態をグループごとに制御可能としたものである。この構成によれば、グループごとに点灯や調光を行なうことによって、配光を変化させることが可能になる。

【0014】請求項12の発明は、板状体の周面に対向して配置した光源から導入された光を表裏の少なくとも一面から漏光させる導光板と、前記光源となる発光ダイオード素子とを備えるものである。この構成によれば、導光板と発光ダイオード素子との組み合わせによって比較的安価な面光源を提供することができる。請求項13の発明は、請求項12の発明において、発光ダイオード



素子が導光板の周面に対向して複数個配列されているものである。この構成によれば、発光ダイオード素子の配置や点灯制御によって導光板の各領域の明るさに変化を付けることが可能になる。

【0015】請求項14の発明は、請求項13の発明において、複数の発光色の発光ダイオード素子が配列されているものである。この構成によれば、発光ダイオード素子の発光色および配置に応じて導光板の発光色を変えることができる。請求項15の発明は、請求項13の発明において、導光板の表裏の少なくとも一面に表示パターンを設けた照明装置に用いられ、表示パターンにおける透過光量の多い部位ほど導光板からの漏光量が多くなるように発光ダイオード素子を配列したものである。この構成によれば、表示パターンにおいて透過光量の多い部分ほど導光板からの漏光量が多くなるようにしているから、表示パターンの明るい部分と暗い部分とのコントラストを強調して表示パターンが認識しやすくなる。

【0016】請求項16の発明は、請求項13の発明において、導光板の表裏の少なくとも一面に表示パターンを設けた照明装置に用いられ、表示パターンにおける着色部の色と導光板から漏光する光色とを一致させるように複数の発光色の発光ダイオード素子を配列したものである。この構成によれば、着色された表示パターンにおいて色のコントラストを強調することができるから表示パターンが認識しやすくなる。

【0017】請求項17の発明は、請求項13の発明において、各発光ダイオード素子の光出力が調光手段により調光されるものである。この構成によれば、発光ダイオード素子の調光によって導光板の光量を調節することができる。請求項18の発明は、複数の発光ダイオード素子が複数のグループを構成するように各発光ダイオード素子をグループごとに接続し、各発光ダイオード素子の点灯状態をグループごとに制御可能としたものである。この構成によれば、グループごとに点灯や調光を行なうことによって、配光を変化させることが可能になる。

#### 【0018】

【発明の実施の形態】（実施形態1）本実施形態は、図1に示すように、拡散的な配光特性を有する発光ダイオード素子1を一平面上に複数個配列したものである（図1における一点鎖線は発光ダイオード素子1が配列されていることを意味する）。発光ダイオード素子1はレンズ付きのものでもベアチップでもよい。発光ダイオード素子1は配置範囲の各領域で配列密度に変化が生じるように正弦的規則に従って配列してある。ここで、正弦的規則とは、発光ダイオード素子1の配置範囲の中心からの距離を $x$ とするとときに、発光ダイオード素子1の密度を、 $a + \sin(x/b \cdot \pi)$ が満たされるように設定することである。ここに $a$ 、 $b$ は定数である。この場合の配光は図2の実線のようにになる。図2は発光ダイオード素

子1を配列した面に平行である照射面までの距離を単位距離とし、照射面内で発光ダイオード素子1の配置範囲の中心に対向する基準点からの距離を単位距離で除算して横軸に示したものである。

【0019】図2では発光ダイオード素子1の配置範囲を $\pm 2$ の範囲とし、 $a = 1.5$ 、 $b = 4$ としている。このとき、 $\pm 1.5$ の範囲では照度差が小さく、 $\pm 2.5$ の範囲外では照度が急に減少することがわかった。つまり、照射面内で基準点からの距離が所定範囲内である場所では均一な照度を得ることができる。比較例として、発光ダイオード素子1を一平面上に均一な密度で配列した場合の配光を図2に破線で示す。発光ダイオード素子1を上述の構成と同様に $\pm 2$ の範囲に配置したとき、上述の構成で $\pm 2.5$ の位置で得られた照度以上の照度は $\pm 3.5$ の範囲内で得られる。しかしながら、上述の構成に比較して距離による照度差が大きくなる。

【0020】以上の説明から明らかなように、照射面の目的範囲内で均一な照度を得るためには、本実施形態のように発光ダイオード素子1を正弦的規則に従って配列するのが望ましいと言える。また、発光ダイオード素子1を密接するように配置した場合には、発光ダイオード素子1の発熱により中央部の温度が周辺部よりも高くなる可能性があるが、中央部の配置密度を周辺部よりも小さくすることで中央部と周辺部とでの温度差を小さくすることができる。このような配列は上述のように正弦的規則でも得ることができる。しかし、発光ダイオード素子1は温度が上昇すると発光特性が変化したり、場合によっては破壊に至ることもあるが、上述のように配置範囲における中央部と周辺部との温度差を小さくすることにより発光特性のばらつきが少なくなり、また信頼性が高くなる。

【0021】（実施形態2）実施形態1では発光ダイオード素子1として拡散的な配光特性を有するものを用いたが、本実施形態では点光源的な配光特性を有する発光ダイオード素子1を用いている。この種の発光ダイオード素子1を実施形態1と同様に配列した場合の配光を図3に示す。図3における実線は正弦的規則に従って配列した本実施形態の配光、破線は均一な密度で配置した比較例の配光を示す。

【0022】図3によれば、本実施形態と比較例とで照度の均一性に大きな差はないが、本実施形態のほうが特定範囲外での照度の減衰率が大きいため、特定範囲のみを均一な照度で照明するような用途では本実施形態を用いるのが望ましい。他の構成は実施形態1と同様である。なお、本実施形態のように局所的に照度を高めるような光源を得るには、発光ダイオード素子1の配置範囲の中央部の配列密度を周辺部よりも大きくしてもよい。

【0023】（実施形態3）本実施形態は、図4に示すように、発光ダイオード素子1を図4に一点鎖線で示すような同心円上に配列し、同円周上に配置されている発

光ダイオード素子 1 を共通に接続することによって、各円周上の発光ダイオード素子 1 をそれぞれグループ G 1, G 2, ……に分けたものである。ここに、発光ダイオード素子 1 としては拡散的な配光特性を有するものを用いている。

【0024】発光ダイオード素子 1 の点灯状態は、制御回路 2 によりグループ G 1, G 2, ……ごとに制御される。発光ダイオード素子 1 の点灯状態とは、点灯・消灯の別および調光を意味し、点灯状態をグループ G 1, G 2, ……ごとに各別に制御することにより、配光を変化させることが可能になる。たとえば、配置範囲の中央部の発光ダイオード素子 1 の光出力を周辺部の発光ダイオード素子 1 よりも小さくすると、中央部の配置密度を周辺部よりも小さくしたことと等価になる。したがって、制御回路 2 によって発光ダイオード素子 1 の光出力を制御するだけで、実施形態 1 において図 2 に実線で示した配光と破線で示した配光とを得ることが可能になる。なお、発光ダイオード素子 1 として実施形態 2 と同様に点光源的な配光特性を有するものを用いれば、図 3 に実線で示した配光と破線で示した配光とを得ることが可能である。また、発光ダイオード素子 1 の点灯状態は制御回路 2 によって任意に変化させることができるから、図 2、図 3 に示した配光以外の配光に設定することも可能である。

【0025】（実施形態 4）本実施形態は、図 5 に示すように、既製の蛍光灯と同形状・同寸法に形成した円筒状の管体 3 に複数個の発光ダイオード素子 1 を収納したものである。管体 3 の両端部には蛍光灯用のソケットに着脱することができる口金 4 が設けられる。つまり、外観上は既製の蛍光灯と同様に形成される。管体 3 の内部には発光ダイオード素子 1 とともに、図 6 に示すような駆動回路が収納される。駆動回路は、蛍光灯用の点灯回路の出力によって発光ダイオード素子 1 を点灯させることができるように構成されている。つまり、ダイオードブリッジよりなる整流回路 R E を電源部として備え、整流回路 R E の直流出力端間に限流要素としての抵抗 R と複数個の発光ダイオード素子 1 との直列回路が接続されている。整流回路 R E の交流入力端は管体 3 の各端に設けた口金 4 の各 1 本の端子ピン 5 にそれぞれ接続される。つまり、各口金 4 に設けた 2 本の端子ピン 5 のうちの 1 本ずつを給電用に用いている。

【0026】このような構成によって、従来の蛍光灯用の照明装置に対して蛍光灯に代えて用いることができる。また、発光ダイオード素子 1 を直列接続し、かつ抵抗 R を直列接続しているから、降圧回路を設けることなく発光ダイオード素子 1 を点灯させることができる。しかも、抵抗 R により限流されるから、整流回路 R E の交流入力端間に比較的高い電圧が印加されても発光ダイオード素子 1 に過電流が流れることがない。さらに、整流回路 R E を設けているから、給電される電源が直流電源

か交流電源かにかかわらず使用することが可能である。また、整流回路 R E が全波整流回路であるから無極性化されており、直流電源を用いる場合でも電源の極性が問題にならない。

【0027】（実施形態 5）本実施形態は、図 7 に示すように、駆動回路として整流回路および力率改善回路を含む電源部 6 と限流要素としての抵抗 R を設けたものである。電源部 6 を構成する整流回路は、実施形態 4 と同様にダイオードブリッジよりなる全波整流回路であり、力率改善回路はたとえばチョップパ回路により構成され、直流電圧を出力するものである。チョップパ回路の構成はとくに限定しないが、直列接続される発光ダイオード素子 1 の個数に応じて降圧型、昇圧型、極性反転型などの各種チョップパ回路を用いることができる。この種のチョップパ回路は、形式にかかわらずインダクタとスイッチング素子との直列回路を含み、スイッチング素子を高周波でオン・オフさせることによって整流回路の出力をインダクタに高周波的に流す構成を有しているから、交流電源を接続した場合には入力電流を高周波的に流して入力電流歪の増加を防止し、しかも入力電流の包絡線を入力電圧に比例させることができるから、入力力率が高くなるのである。

【0028】この電源部 6 の出力端間に抵抗 R および複数の発光ダイオード素子 1 の直列回路が接続しており、電源部 6 の入力端は実施形態 4 と同様に各口金 4 の 1 本ずつの端子ピン 5 に接続してある。ところで、電源部 6 に上述のような構成の力率改善回路を設けているから、スイッチング素子を適宜に制御することによって入力特性を変化させることが可能である。そこで、本実施形態では、電源部 6 の入力特性が放電灯の負荷特性を模擬するように設計されている。とくに、本実施形態は蛍光灯に代えて用いるものであるから蛍光灯の負荷特性に合わせてあり、とくに蛍光灯の安定点灯時（定格点灯時）の電流電圧特性に一致させてある。他の構成および動作は実施形態 4 と同様である。

【0029】なお、実施形態 4、実施形態 5 において実施形態 3 と同様に発光ダイオード素子 1 をグループに分け、グループごとに点灯状態を制御するようにしてもよい。また、上述した各実施形態において、発光色の異なる発光ダイオード素子 1 を用い混色したり、白色発光ダイオード（青色光を黄色発光の蛍光体に照射して白色光を放射するものがある）を用いたりすることにより、白色系の発光色を得るのが望ましい。

【0030】（実施形態 6）本実施形態は、主として表示用に用いるものであって、図 8 に示すように、平板状の導光板 7 の端面に対向するように複数個の発光ダイオード素子 1 r, 1 g, 1 b を配列してある。発光ダイオード素子 1 r, 1 g, 1 b とては赤色、緑色、青色のものを用いている。このように発光色の異なる発光ダイオード素子 1 r, 1 g, 1 b を用いることによって混

色光がほぼ白色になるようにしてある。導光板7は透明板であって端面から導入された光の一部を反射させながら導光するとともに残りを表裏の少なくとも一面から漏光させるように形成されている。したがって、導光板7において漏光させる面には拡散透過性を有する拡散板を設けて漏光を補助し、漏光させない面には反射板を設けている。反射板は拡散反射性を有する小面積の小反射板の裏面側に鏡面を重ね合わせたものであり、小反射板は導光板7の場所によらずに漏光量がほぼ均一になるように面積および配置が考慮されている。要するに、発光ダイオード素子1r、1g、1bの近傍では単位面積当たりの小反射板の面積を小さくし、発光ダイオード素子1r、1g、1bからの距離が大きいほど単位面積当たりの小反射板の面積を大きくするのである。

【0031】図8に示した例では導光板7の端面に発光ダイオード素子1r、1g、1bを一行に配列しているが、図9のようにさらに多数の発光ダイオード素子1r、1g、1bを配列すれば、高輝度で発光させることができる。また、図10に示すように、導光板7のすべての端面に発光ダイオード素子1（1r、1g、1b）を配列することによって輝度を高めるとともに輝度の均一性を高めることができる。

【0032】本実施形態における発光ダイオード素子1r、1g、1bは、各発光色ごとにグループとして直列接続し、図11に示すように、各色の発光ダイオード素子1r、1g、1bの直列回路ごとにスイッチングトランジスタQr、Qg、Qbのコレクターエミッタ間に直列接続してある。スイッチングトランジスタQr、Qg、Qbは制御回路2により各別に制御される。したがって、スイッチングトランジスタQr、Qg、Qbのオン・オフのデューティを変化させることによって各発光ダイオード素子1r、1g、1bの輝度を調節することができる。つまり、各色の混色率を変化させて色色を変化させたり全体の輝度を変化させたりすることができる。つまり、制御回路2を調光手段および調色手段として用いることが可能である。

【0033】（実施形態7）実施形態6で説明した導光板7を用いて表示を行なうには、図12に示すように、表示パターンを設けた表示パネル8を導光板7に重ねて配置する。図12では導光板7を表示パネル8と反射板9とにより挟んである。反射板9は実施形態6で説明したものと同様である。

【0034】本実施形態では表示パネル8を重ねた導光板7の一面が均一な明るさとなるように、発光ダイオード素子1を実施形態1と同様に正弦的規則で配列してある。つまり、導光板7の端面の長手方向における中央部での配置密度を周辺部よりも小さくしてある。このような構成を採用することによって、導光板7の表面の明るさの均一性を高めることが可能である。また、発光ダイオード素子1を複数のグループに分け、グループごとに

点灯状態を制御してもよい。この場合には、導光板7の各領域の明るさに差を設けることができる。ここに、発光ダイオード素子1の点灯状態の制御には実施形態6の制御回路2と同様の構成を採用することで、制御回路2を調光手段として用いることができる。

【0035】なお、図13に示すように、蛍光灯と同様に配置した端子ピン5を設けることで、通常の蛍光灯用のソケットを用いることが可能になる。つまり、蛍光灯と導光板とを用いた表示装置に置き換えて使用することが可能になる。他の構成および動作は実施形態6と同様である。

（実施形態8）実施形態7のように表示パネル8を設けているときに表示パターンをより認識させやすくするために、表示パターンのコントラストを高めることが考えられる。コントラストを高める技術としては、表示パターンにおいて透過光量の多い部位ほど導光板7からの漏光量が多くなるように発光ダイオード素子1を配列するのが望ましい。なお、漏光量の増減は反射板9によっても制御することが可能である。

【0036】また、図14に示すように、表示パターンが着色されている場合には（図示例では領域Dr、Dg、Dbがそれぞれ赤色、緑色、青色に着色されているものとする）、図15に示すように、各領域Dr、Dg、Dbの近傍にその領域Dr、Dg、Dbと同系色の発光色である発光ダイオード素子1r、1g、1bを配置するのが望ましい。この構成によって、表示パターンの着色部位の色が明確になり、色のコントラストが強調されて表示パターンの認識性を高めることができる。なお、この構成は必要に応じて適用すればよい。

【0037】

【発明の効果】請求項1の発明は、複数の発光ダイオード素子が配光設計に応じた配置密度で配列されているものであり、発光ダイオード素子を配列していることによって面光源を容易に得ることができ、しかも配光設計に応じて発光ダイオード素子の配列密度を設定することにより、光源自身で配光設計に対応することができるという利点がある。つまり、配光制御要素を備える器具がほとんど不要であるから、比較的小型の照明装置を構成することができ、しかも、発光ダイオード素子の配列密度の異なる光源に取り替えれば、施工後であっても配光を容易に変更することができるという利点がある。さらに、発光ダイオード素子は白熱電球や蛍光灯のような一般に用いられている光源に比較して寿命が同等か長いものであるから交換回数が少なくなるという利点もある。

【0038】請求項2の発明のように、発光ダイオード素子をベアチップとしたものでは、発光ダイオード素子の配置密度を大きくして輝度の高い光源を得ることが可能になるという利点がある。請求項3の発明のように、照射面の照度を一定とするように発光ダイオード素子の

配列範囲の中心部の配列密度を周辺部よりも小さくした  
ものでは、照射面の照度がほぼ均一になるという利点がある。

【0039】請求項4の発明のように、発光ダイオード素子の配列範囲の中心部の配列密度を周辺部よりも大きくしたものでは、照射面の照度が直下付近で大きくなり部分的に照度を高めた照明が可能になるという利点がある。請求項5の発明は、複数の発光ダイオード素子が複数のグループを構成するように各発光ダイオード素子をグループごとに接続し、各発光ダイオード素子の点灯状態をグループごとに制御可能としたものであり、グループごとに点灯や調光を行なうことによって、配光を変化させることが可能になるという利点を有する。

【0040】請求項6の発明は、複数の発光ダイオード素子と、放電灯用の点灯回路の出力に接続され前記発光ダイオード素子を点灯させる駆動回路とを備えるものであり、蛍光灯のような通常の放電灯に用いている照明器具を流用して光源のみを差し替えれば発光ダイオード素子による照明が可能になるという利点がある。つまり、点灯回路の出力を駆動回路に与えることにより、発光ダイオード素子に過電圧が印加されたり過電流が流れたりすることなく発光ダイオード素子を安定に点灯させることができるという利点がある。

【0041】請求項7の発明のように、前記駆動回路が、点灯回路に接続される整流回路を含んだ電源部と、前記電源部から前記発光ダイオード素子に通電される電流を制限する限流要素とを備えるものでは、電源部に整流回路を備えるから、点灯回路の出力が直流でも交流でも用いることができるという利点がある。しかも、限流要素によって発光ダイオード素子に過電流が流れるのを防止することができるという利点がある。

【0042】請求項8の発明のように、前記駆動回路が、点灯回路に接続される整流回路および力率改善手段を含む電源部と、前記電源部から前記ダイオード素子に通電される電流を制限する限流要素とを備え、電源部の入力特性が放電灯の負荷特性を模擬するものでは、電源部の入力特性が放電灯の負荷特性を模擬するから、放電灯に差し替えて用いても点灯回路に支障が生じないという利点があり、また、電源部に整流回路を設けていることにより、点灯回路の出力が直流でも交流でも用いることができ、さらには力率改善回路を設けているから、点灯回路の出力が交流であるときの電力の利用効率が高いという利点がある。さらに、限流要素によって発光ダイオード素子に過電流が流れるのを防止することができるという効果もある。

【0043】請求項9の発明のように、前記負荷特性を放電灯の安定点灯時の電流電圧特性としたものでは、点灯回路が放電灯を安定点灯させているときと同様に動作することになり、点灯回路へのストレスが少なく、また別途に点灯回路を設計する必要がなく、既製の照明器具

の光源として用いることが可能になる。請求項10の発明のように、前記放電灯を蛍光灯としたものでは、一般の照明でもっとも多く用いられている放電灯である蛍光灯を模擬することになるから、蛍光灯との置き換えによって高い経済効果を生むことになる。

【0044】請求項11の発明のように、複数の発光ダイオード素子が複数のグループを構成するように各発光ダイオード素子をグループごとに接続し、各発光ダイオード素子の点灯状態をグループごとに制御可能としたものでは、グループごとに点灯や調光を行なうことによって、配光を変化させることが可能になるという利点を有する。

【0045】請求項12の発明は、板状体の周面に対向して配置した光源から導入された光を表裏の少なくとも一面から漏光させる導光板と、前記光源となる発光ダイオード素子とを備えるものであり、導光板と発光ダイオード素子との組み合わせによって比較的安価な面光源を提供することができるという利点がある。請求項13の発明のように、発光ダイオード素子が導光板の周面に対向して複数個配列されているものでは、発光ダイオード素子の配置や点灯制御によって導光板の各領域の明るさに変化を付けることが可能になるという利点がある。

【0046】請求項14の発明のように、複数の発光色の発光ダイオード素子が配列されているものでは、発光ダイオード素子の発光色および配置に応じて導光板の発光色を変えることができるという利点がある。請求項15の発明のように、導光板の表裏の少なくとも一面に表示パターンを設けた照明装置に用いられ、表示パターンにおける透過光量の多い部位ほど導光板からの漏光量が多くなるように発光ダイオード素子を配列したものは、表示パターンにおいて透過光量の多い部分ほど導光板からの漏光量が多くなるようにしているから、表示パターンの明るい部分と暗い部分とのコントラストを強調して表示パターンが認識しやすくなるという利点がある。

【0047】請求項16の発明のように、導光板の表裏の少なくとも一面に表示パターンを設けた照明装置に用いられ、表示パターンにおける着色部の色と導光板から漏光する光色とを一致させるように複数の発光色の発光ダイオード素子を配列したものは、着色された表示パターンにおいて色のコントラストを強調することができるから表示パターンが認識しやすくなるという利点がある。

【0048】請求項17の発明のように、各発光ダイオード素子の光出力が調光手段により調光されるものでは、発光ダイオード素子の調光によって導光板の光量を調節することができるという利点がある。請求項18の発明は、複数の発光ダイオード素子が複数のグループを構成するように各発光ダイオード素子をグループごとに接続し、各発光ダイオード素子の点灯状態をグループご

とに制御可能としたものであり、グループごとに点灯や調光を行なうことによって、配光を変化させることが可能になるという利点を有する。

【図面の簡単な説明】

【図 1】 実施形態 1 を示す概略構成図である。

【図 2】 同上の動作説明図である。

【図 3】 実施形態 2 の動作説明図である。

【図 4】 実施形態 3 を示す概略構成図である。

【図 5】 実施形態 4 を示す斜視図である。

【図 6】 同上の回路図である。

【図 7】 実施形態 5 を示す回路図である。

【図 8】 実施形態 6 を示す斜視図である。

【図 9】 実施形態 6 の他例を示す要部斜視図である。

【図 10】 実施形態 6 の別例を示す要部斜視図である。

【図 11】 同上の回路図である。

【図 12】 実施形態 7 を示す平面図である。

【図 13】 同上の正面図である。

【図 14】 実施形態 8 を示す分解斜視図である。

【図 15】 同上の斜視図である。

【図 16】 従来例を示す動作説明図である。

【符号の説明】

1 発光ダイオード素子

1 r, 1 g, 1 b 発光ダイオード素子

2 制御回路

3 管体

4 口金

5 端子ピン

6 電源部

7 導光板

8 表示パネル

9 反射板

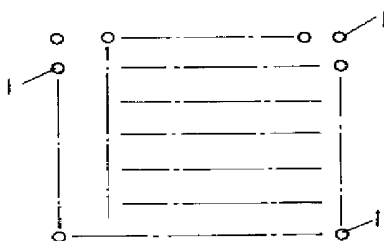
D r, D g, D b 領域

G 1, G 2, …… グループ

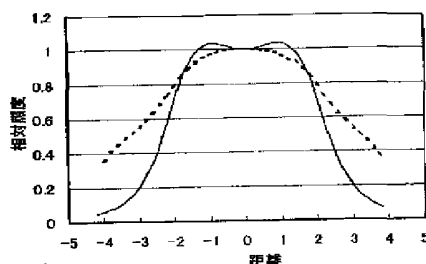
R 抵抗

R E 整流回路

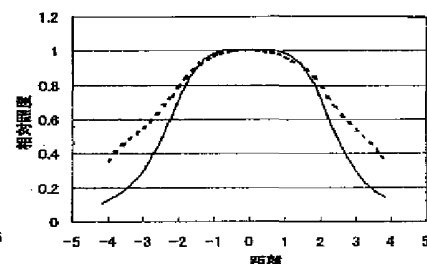
【図 1】



【図 2】



【図 3】

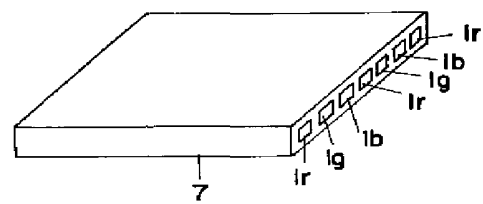
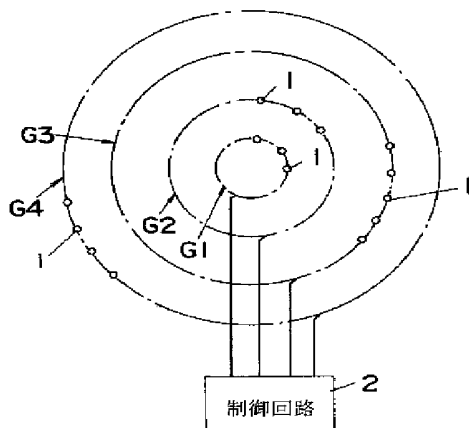
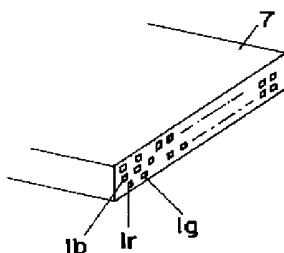


【図 4】

【図 8】

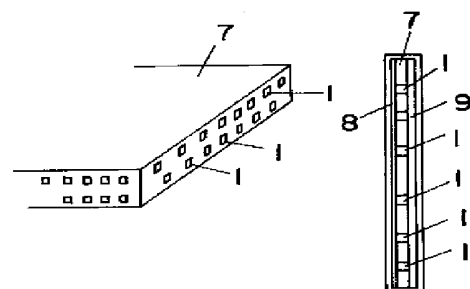
1 発光ダイオード素子

【図 9】

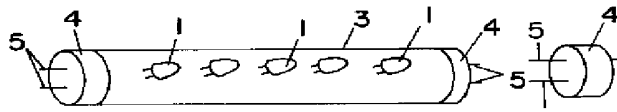


【図 10】

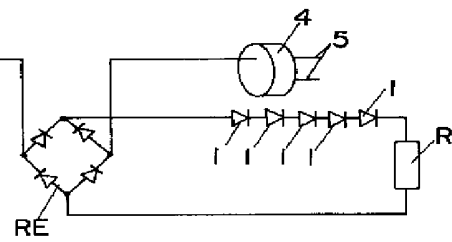
【図 12】



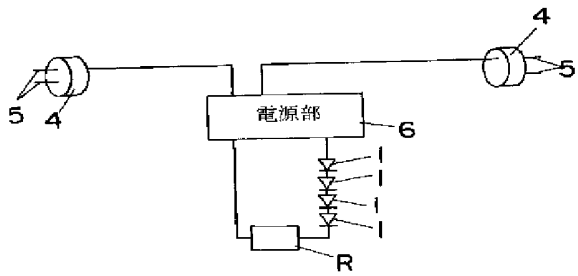
【図 5】



【図 6】

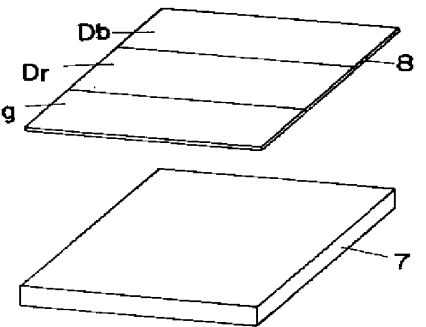
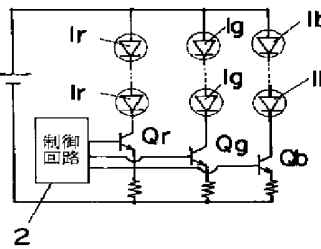


【図 7】

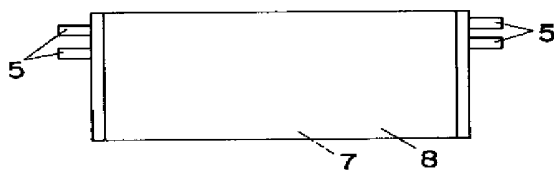


【図 11】

【図 14】

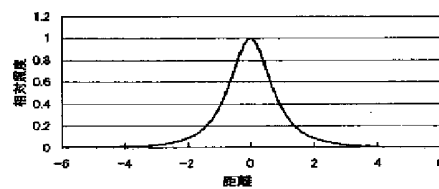
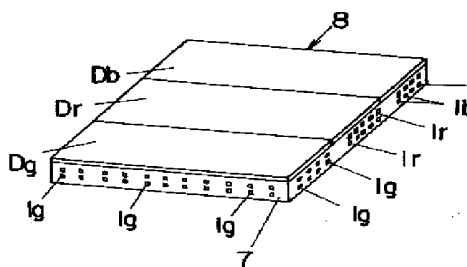


【図 13】



【図 15】

【図 16】



フロントページの続き

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**Espacenet****Bibliographic data: JP11162234 (A) — 1999-06-18**

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**LIGHT SOURCE USING LIGHT EMITTING DIODE**

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**Classification:** - International: F21V19/00; F21V8/00; H01L33/50; H05B37/02;  
F21Y101/02; (IPC1-7): F21V19/00; F21V8/00;  
H01L33/00; H05B37/02

- European:

**Application** JP19970340796 19971125  
**number:**

**Priority** JP19970340796 19971125  
**number(s):**

**Abstract of JP11162234 (A)**

**PROBLEM TO BE SOLVED:** To provide various light distributions by a light source itself and to easily constitute a surface light source. **SOLUTION:** A plurality of light emitting diode elements 1 are arranged with an arrangement density according to a light distribution design. A surface light source can be easily provided by arranging the light emitting diodes 1. Further, since the arrangement density of the light emitting diode elements 1 is set according to the light distribution design, the light source itself is conformable to the light distribution design. The light emitting diode is desirably a bare chip.



## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] The present invention relates to the light source using a light emitting diode suitable for the object for lighting, or a display.

[0002]

[Description of the Prior Art] Generally, the light source used for lighting is the point light source or the line light source, for example, the point light source has a lighting distribution characteristic like Fig.16. The horizontal axis of Fig.16 standardizes and expresses with the distance from a light source to a reference point the horizontal distance from the reference point taken to the method of directly under [ lead ] of the point light source by doing division.

[0003] Since the illuminance distribution of an irradiation surface will not become uniform if it illuminates only with a light source so that clearly from Fig.16, it is common by attaching a light source to an instrument provided with control-light-distribution elements, such as a light reflector and a lens, to constitute a lighting system. Although the surface light source which display information can recognize clearly as a light source used for a display is required, It is difficult for there to be no surface light source which can be easily obtained like the point light source or the line light source, and to make the whole display information into a uniform luminosity in the point light source or the line light source, or to give change to a luminosity for every region of a display surface according to display information.

[0004]

[Problem to be solved by the invention] A deer is carried out, and in a lighting system, since the instrument provided with a control-light-distribution element as mentioned above is required, there is a problem that a comparatively large-sized instrument is required. If it is going to change a light distribution, once having to exchange a lighting system, or having to change the position of a lighting system and installing a lighting system, it is not easy to change a lighting design.

[0005] As mentioned above, generally the surface light source does not spread, but the surface light source with inexpensive object for lighting and object for a display is demanded. Succeeding in the present invention in view of the

above-mentioned reason, the purpose is to provide the light source using the light emitting diode which it is possible to obtain various kinds of light distributions for light source itself, and can constitute the surface light source easily.

[0006]

[Means for solving problem]Invention of Claim 1 is arranged with the arrangement density [ light emitting diode elements / two or more ] according to a light-distribution design. According to this composition, by having arranged the light emitting diode element, the surface light source can be acquired easily and it can respond to a light-distribution design for light source itself by moreover having set up the arrangement density of a light emitting diode element according to a light-distribution design. That is, since the instrument provided with a control-light-distribution element is almost needlessness, a comparatively small lighting system can be constituted, and if it moreover exchanges to the light source in which the arrangement densities of a light emitting diode element differ, even if it is after construction, a light distribution can be changed easily. Since the life of a light emitting diode element is equivalent as compared with a light source like a filament lamp or a fluorescent lamp generally used or it is long, its turnover rate decreases.

[0007]Invention of Claim 2 uses a light emitting diode element as a bare chip in invention of Claim 1. According to this composition, it becomes possible to carry out arrangement density of a light emitting diode element largely, and to obtain a light source with high luminosity. In invention of Claim 1, invention of Claim 3 makes arrangement density of the central part of the arrangement range of a light emitting diode element smaller than a periphery so that it may set the illumination of an irradiation surface constant. According to this composition, the illumination of an irradiation surface becomes substantially uniform.

[0008]Invention of Claim 4 carries out more largely than a periphery arrangement density of the central part of the arrangement range of a light emitting diode element in invention of Claim 1. According to this composition, the illumination of an irradiation surface becomes largely near directly under, and the lighting which raised illumination partially is attained. That is, partial lighting like a downlight or a spotlight is attained. Invention of Claim 5 connects each light emitting diode element for every group so that two or more light emitting diode elements may constitute two or more groups, and it makes controllable lighting status of each light emitting diode element for every group. According to this composition, it becomes possible by performing lighting and

dimming for every group to change a light distribution.

[0009]Invention of Claim 6 is provided with two or more light emitting diode elements and the drive circuit which is connected to the output of the light circuit for electric discharge lamps, and makes the aforementioned light emitting diode element turn on. If the light which is used for a usual electric discharge lamp like a fluorescent lamp according to this composition is diverted and only a light source is substituted, the lighting by a light emitting diode element will be attained. That is, a light emitting diode element can be made to turn on stably by giving the output of a light circuit to a drive circuit, without applying excess voltage to a light emitting diode element, or an over-current flowing.

[0010]Invention of Claim 7 is provided with the power supply section where the aforementioned drive circuit included the rectification circuit connected to a light circuit, and the \*\* style element which restricts the current energized from the aforementioned power supply section to the aforementioned light emitting diode element in invention of Claim 6. According to this composition, since a power supply section is equipped with a rectification circuit, the output of a light circuit can also use a direct current or exchange. And an over-current can be prevented from flowing into a light emitting diode element by a \*\* style element.

[0011]The power supply section where the aforementioned drive circuit contains the rectification circuit and power-factor-improvement means which are connected to a light circuit in invention of Claim 6 in invention of Claim 8, It has a \*\* style element which restricts the current energized from the aforementioned power supply section to the aforementioned diode element, and the input characteristics of a power supply section imitate the load characteristic of an electric discharge lamp. According to this composition, since the input characteristics of a power supply section imitate the load characteristic of an electric discharge lamp, even if it substitutes and uses for an electric discharge lamp, trouble does not arise in a light circuit. Since the output of a light circuit can also use a direct current or exchange and is providing the power factor improvement circuit further by providing the rectification circuit to the power supply section, the utilization efficiency of electric power in case the output of a light circuit is exchange is high. An over-current can be prevented from flowing into a light emitting diode element by a \*\* style element.

[0012]Invention of Claim 9 makes the aforementioned load characteristic the current potential characteristic at the time of stable lighting of an electric discharge lamp in invention of Claim 8. According to this composition, the light

circuit will operate like the time of carrying out stable lighting of the electric discharge lamp, and there is little stress to a light circuit. Invention of Claim 10 uses the aforementioned electric discharge lamp as a fluorescent lamp in invention of Claim 9. According to this composition, since the fluorescent lamp which is an electric discharge lamp most used with common lighting will be imitated, a high economic effect will be induced by replacement with a fluorescent lamp.

[0013]In invention of Claim 8, invention of Claim 11 connects each light emitting diode element for every group so that two or more light emitting diode elements may constitute two or more groups, and it makes controllable lighting status of each light emitting diode element for every group. According to this composition, it becomes possible by performing lighting and dimming for every group to change a light distribution.

[0014]Invention of Claim 12 is provided with the light guide plate to which the light leak of the light introduced from the light source which opposed to the peripheral surface of the plate and has been arranged is carried out from the first [ at least ] page of a rear surface, and the light emitting diode element used as the aforementioned light source. According to this composition, the comparatively inexpensive surface light source can be provided with the combination of a light guide plate and a light emitting diode element. In invention of Claim 12, a light emitting diode element opposes to the peripheral surface of a light guide plate, and two or more invention of Claim 13 is arranged. According to this composition, it becomes possible to give change to the luminosity of each region of a light guide plate by arrangement and light control of a light emitting diode element.

[0015]As for invention of Claim 14, in invention of Claim 13, the light emitting diode element of two or more luminescent color is arranged. According to this composition, according to the luminescent color of a light emitting diode element, and arrangement, the luminescent color of a light guide plate is changeable. Invention of Claim 15 is used for the lighting system which provided the display pattern to the first [ at least ] page of the rear surface of a light guide plate in invention of Claim 13, and a light emitting diode element is arranged as a part with many transmitted light amounts in a display pattern so that the amount of light leaks from a light guide plate may increase. According to this composition, since he is trying for the amount of light leaks from a light guide plate to increase in a display pattern as a portion with many transmitted light amounts, the contrast of the bright portion of a display pattern and a dark portion is emphasized, and it becomes easy to recognize a display pattern.

[0016]In invention of Claim 13, invention of Claim 16 is used for the lighting system which provided the display pattern to the first [ at least ] page of the rear surface of a light guide plate, and it arranges the light emitting diode element of two or more luminescent color so that the light color which carries out a light leak from the color and light guide plate of a coloring section in a display pattern may be made to correspond. According to this composition, since the contrast of a color can be emphasized in the colored display pattern, it becomes easy to recognize a display pattern.

[0017]As for invention of Claim 17, in invention of Claim 13, the light of the optical power of each light emitting diode element is modulated by the control means. According to this composition, the light volume of a light guide plate can be adjusted by dimming of a light emitting diode element. Invention of Claim 18 connects each light emitting diode element for every group so that two or more light emitting diode elements may constitute two or more groups, and it makes controllable lighting status of each light emitting diode element for every group. According to this composition, it becomes possible by performing lighting and dimming for every group to change a light distribution.

[0018]

[Mode for carrying out the invention](Embodiment 1) This embodiment arranges two or more light emitting diode elements 1 which have a diffusion lighting distribution characteristic on 1 plane, as shown in Fig.1 (the alternate long and short dash line in Fig.1 means that the light emitting diode element 1 is arranged). A thing or a bare chip with a lens may be sufficient as the light emitting diode element 1. The light emitting diode element 1 is arranged in accordance with the sine rule so that change may arise in arrangement density in each region of the arrangement range. Here, a sine rule is setting up the density of the light emitting diode element 1 so that  $a + \sin(x/b - \pi/s)$  may be filled, when setting distance from the center of the arrangement range of the light emitting diode element 1 to x. a and b are constants here. The light distribution in this case becomes like the solid line of Fig.2. Fig.2 makes unit distance distance to an irradiation surface parallel to the surface which arranged the light emitting diode element 1, does division of the distance from the reference point which opposes to the center of the arrangement range of the light emitting diode element 1 in an irradiation surface by unit distance, and it is shown on a horizontal axis.

[0019]In Fig.2, the arrangement range of the light emitting diode element 1 is made into the range of  $\pi/2$ , and it is being referred to as  $a = 1.5$  and  $b = 4$ . At this time, in  $\pi/1.5$ , illuminance difference was small and it turned out that

illumination decreases suddenly out of the range of  $\pm 2.5$ . That is, the illumination whose distance from a reference point is uniform at the place which is in a prescribed range can be obtained in an irradiation surface. As a comparative example, a dashed line shows the light distribution at the time of arranging the light emitting diode element 1 by uniform density on 1 plane to Fig.2. When the light emitting diode element 1 has been arranged in the range of  $\pm 2$  like above-mentioned composition, the illumination more than the illumination obtained in the position of 2.5 [  $\pm$  ] by above-mentioned composition is obtained within the limits of  $\pm 3.5$ . However, as compared with above-mentioned composition, the illuminance difference by distance becomes largely.

[0020]In order to obtain uniform illumination by purpose within the limits of an irradiation surface so that clearly from the above description, it can be said that it is desirable to arrange the light emitting diode element 1 in accordance with a sine rule like this embodiment. When it has arranged so that it may be close in the light emitting diode element 1, the temperature of a central part may become higher than a periphery by generation of heat of the light emitting diode element 1, but the temperature gradient in a central part and a periphery can be made small by making arrangement density of a central part smaller than a periphery. Such arrangement can be acquired also under a sine rule as mentioned above. A deer is carried out, emitting properties may change, or the light emitting diode element 1 may result in destruction depending on the case, when temperature rises, but by making small a temperature gradient with the central part and periphery in the arrangement range as mentioned above, dispersion in emitting properties decreases and reliability becomes high.

[0021](Embodiment 2) Although what has a diffusion lighting distribution characteristic was used as the light emitting diode element 1 in Embodiment 1, the light emitting diode element 1 which has a point light source lighting distribution characteristic is used in this embodiment. The light distribution at the time of arranging this kind of light emitting diode element 1 like Embodiment 1 is shown in Fig.3. The light distribution of this embodiment which arranged the solid line in Fig.3 in accordance with the sine rule, and a dashed line show the light distribution of the comparative example arranged by uniform density.

[0022]According to Fig.3, although there is no big difference to the homogeneity of illumination at this embodiment and a comparative example, since the way of this embodiment has the large extinction ratio of the illumination outside the specific range, it is desirable to use this embodiment

for a use which illuminates only a specific range with uniform illumination. Other composition is the same as that of Embodiment 1. In order to obtain a light source which raises illumination locally like this embodiment, arrangement density of the arrangement midrange part of the light emitting diode element 1 may be carried out more largely than a periphery.

[0023](Embodiment 3) This embodiment by arranging on a concentric circle as shows the light emitting diode element 1 to Fig.4 with an alternate long and short dash line, and connecting in common the light emitting diode element 1 arranged on the circumference, as shown in Fig.4. The light emitting diode element 1 on each circumference is divided into the group G1, G2, and ...., respectively. As the light emitting diode element 1, what has a diffusion lighting distribution characteristic is used here.

[0024]The lighting status of the light emitting diode element 1 is controlled by the control circuit 2 by the group G1, G2, and every .... It becomes possible by the lighting status of the light emitting diode element 1 meaning the exception of lighting and putting out lights, and dimming, and controlling lighting status according to each to the group G1, G2, and every .... to change a light distribution. For example, if optical power of the light emitting diode element 1 of an arrangement midrange part is made smaller than the light emitting diode element 1 of a periphery, it will become equivalent to having made arrangement density of the central part smaller than a periphery. Therefore, it becomes possible to obtain the light distribution shown in Fig.2 as the solid line in Embodiment 1, and the light distribution shown with the dashed line only by controlling the optical power of the light emitting diode element 1 by the control circuit 2. If what has a point light source lighting distribution characteristic like Embodiment 2 is used as the light emitting diode element 1, it is possible to obtain the light distribution shown in Fig.3 as the solid line and the light distribution shown with the dashed line. Since the lighting status of the light emitting diode element 1 can be arbitrarily changed by the control circuit 2, it can also be set to light distributions other than the light distribution shown in Fig.2 and Fig.3.

[0025](Embodiment 4) This embodiment stores two or more light emitting diode elements 1 to the cylindrical shell 3 formed in ready-made fluorescent lamps, and the shape of isomorphism and the dimension, as shown in Fig.5. The cap 4 which can be detached and attached to the socket for fluorescent lamps is provided by the both ends of the shell 3. That is, it is formed like

ready-made fluorescent lamps for the reason of appearance. Inside the shell 3, a drive circuit as shown in Fig.6 with the light emitting diode element 1 is stored. The drive circuit is constituted so that the light emitting diode element 1 can be made to turn on with the output of the light circuit for fluorescent lamps. That is, it has the rectification circuit RE which consists of diode bridges as a power supply section, and the series circuit of the resistance R as a \*\* style element and two or more light emitting diode elements 1 is connected between the dc output ends of the rectification circuit RE. The ac input end of the rectification circuit RE is connected to the one terminal pin 5 each of the cap 4 provided at each end of the shell 3, respectively. That is, every one of the two terminal pins 5 provided to each cap 4 is used for electric supply.

[0026]By such composition, it can replace with and use for a fluorescent lamp to the lighting system for the conventional fluorescent lamps. The light emitting diode element 1 can be made to turn on, since the series connection of the light emitting diode element 1 is carried out and the series connection of the resistance R is carried out, without providing a pressure-lowering circuit. And since a \*\* style is carried out by the resistance R, even if comparatively high voltage is applied between the ac input ends of the rectification circuit RE, an over-current does not flow into the light emitting diode element 1. Since the rectification circuit RE is provided, the power supply to which electric power is supplied is able to use it irrespective of DC power supply or AC power supply. Since the rectification circuit RE is a full wave rectifier circuit, it is nonpolarity-ized, and even when using DC power supply, the polarity of a power supply does not become a problem.

[0027](Embodiment 5) This embodiment provides the resistance R as the power supply section 6 which includes a rectification circuit and a power factor improvement circuit as a drive circuit, and a \*\* style element, as shown in Fig.7. The rectification circuit which constitutes the power supply section 6 is a full wave rectifier circuit which consists of diode bridges like Embodiment 4, and a power factor improvement circuit is constituted by chopper circuits, and outputs direct current voltage. Although the composition in particular of chopper circuits is not limited, according to the number of the light emitting diode element 1 by which a series connection is carried out, various chopper circuits, such as lowered type of the pressure, a pressure-up type, and a polarity-reversals type, can be used. This kind of chopper circuits include the series circuit of an inductor and a switching element irrespective of form, Since it has the composition which passes the output of a rectification circuit in high frequency to an inductor by making a switching element turn on and turn off by



high frequency, Since an input current can be sent in high frequency, the increase in input current distortion can be prevented and the envelope curve of an input current can moreover be proportioned in input voltage when AC power supply is connected, an input power factor becomes high.

[0028]The series circuit of the resistance R and two or more light emitting diode elements 1 is connected between the outgoing ends of this power supply section 6, and the input terminal of the power supply section 6 is connected to the terminal pin 5 of each cap 4 per like Embodiment 4. By the way, since the power factor improvement circuit of the above composition is provided to the power supply section 6, it is possible by controlling a switching element suitably to change input characteristics. So, in this embodiment, it is designed so that the input characteristics of the power supply section 6 may imitate the load characteristic of an electric discharge lamp. Since especially this embodiment is replaced with and used for a fluorescent lamp, there is in accordance with the load characteristic of a fluorescent lamp, and it is made to have corresponded to the current potential characteristic at the time of stable lighting of a fluorescent lamp (at the time of rated lighting) especially. Other composition and operations are the same as that of Embodiment 4.

[0029]In Embodiment 4 and Embodiment 5, the light emitting diode element 1 is divided into a group like Embodiment 3, and it may be made to control lighting status for every group. In each embodiment mentioned above, it is desirable to obtain the luminescent color of a white system by carrying out mixed colors or using a white light emitting diode (there are some which irradiate the fluorescent substance of yellow light with blue glow, and emit white light) using the light emitting diode element 1 from which the luminescent color differs.

[0030](Embodiment 6) This embodiment is mainly used for a display, and as shown in Fig.8, it has arranged two or more light emitting diode elements 1r, 1g, and 1b so that it may oppose to the end face of the plate-like light guide plate 7. If it is considered as the light emitting diode elements 1r, 1g, and 1b, red and what green and blue are used. Thus, it is made for mixed-colors light to have become substantially white by using the light emitting diode elements 1r, 1g, and 1b from which the luminescent color differs. The light guide plate 7 is formed so that the light leak of the remainder may be carried out from the first [ at least ] page of a rear surface, while carrying out a light guide, reflecting a part of light which is a transparent sheet and was introduced from the end face. Therefore, the diffusion board which has diffusional permeability is

provided in the surface which carries out a light leak in the light guide plate 7, and the light reflector is provided in the surface which assist the light leak of the light leak and does not carry out it. A light reflector lays a mirror plane on top of the back surface side of the small light reflector of the small area which has diffuse reflection nature, and area and arrangement are considered as the amount of light leaks becoming substantially uniform, without a small light reflector calling at the place of the light guide plate 7. In short, near the light emitting diode elements 1r, 1g, and 1b, area of the small light reflector per unit area is made small, and area of the small light reflector per unit area is largely carried out, so that the distance from the light emitting diode elements 1r, 1g, and 1b is large.

[0031]If the many light emitting diode elements 1r, 1g, and 1b are further arranged like Fig.9, light can be made to emit with high-intensity, although the light emitting diode elements 1r, 1g, and 1b are arranged to the end face of the light guide plate 7 at the single tier in the example shown in Fig.8. The homogeneity of luminosity can be improved while raising luminosity by arranging the light emitting diode element 1 (1r, 1g, 1b) to all the end faces of the light guide plate 7, as shown in Fig.10.

[0032]The light emitting diode elements 1r, 1g, and 1b in this embodiment, A series connection is carried out as a group for every luminescent color, and as shown in Fig.11, the series connection is carried out between the switching transistor Qr and the collector emitter of Qg.Qb for every series circuit of the light emitting diode elements 1r, 1g, and 1b of each color. The switching transistor Qr and Qg.Qb are controlled by the control circuit 2 according to each. Therefore, the luminosity of each light emitting diode element 1r, 1g, and 1b can be adjusted by changing the duty of ON/OFF of the switching transistor Qr and Qg.Qb. That is, the rate of mixed colors of each color can be changed, and a light color can be changed, or the whole luminosity can be changed. That is, it is possible to use the control circuit 2 as a control means and a toning means.

[0033](Embodiment 7) In order to display using the light guide plate 7 described by Embodiment 6, as shown in Fig.12, the display panel 8 which provided the display pattern is arranged in piles to the light guide plate 7. In Fig.12, the light guide plate 7 is inserted with the display panel 8 and the light reflector 9. The light reflector 9 is the same as that of what was described by Embodiment 6.

[0034]At this embodiment, the light emitting diode element 1 is arranged under the sine rule like Embodiment 1 so that the whole surface of the light guide

plate 7 on which the display panel 8 was put may serve as a uniform luminosity. That is, arrangement density in the central part in the longitudinal direction of the end face of the light guide plate 7 is made smaller than a periphery. By adopting such composition, it is possible to improve the homogeneity of the luminosity of the surface of the light guide plate 7. The light emitting diode element 1 may be divided into two or more groups, and lighting status may be controlled for every group. In this case, a difference can be provided to the luminosity of each region of the light guide plate 7. The control circuit 2 can be used for control of the lighting status of the light emitting diode element 1 as a control means here by adopting the same composition as the control circuit 2 of Embodiment 6.

[0035]As shown in Fig.13, it becomes possible to use the socket for the usual fluorescent lamps by providing the terminal pin 5 arranged like a fluorescent lamp. That is, it becomes possible to use it, replacing to the display device using a fluorescent lamp and a light guide plate. Other composition and operations are the same as that of Embodiment 6.

(Embodiment 8) While providing the display panel 8 like Embodiment 7, in order to carry out that it is easier to make a display pattern recognize, it is possible to raise the contrast of a display pattern. It is desirable to arrange the light emitting diode element 1 in a display pattern, as technology which raises contrast, as a part with many transmitted light amounts so that the amount of light leaks from the light guide plate 7 may increase. The change in the amount of light leaks can be controlled also by the light reflector 9.

[0036]As shown in Fig.14, when the display pattern is colored, as it is shown in (the region Dr, Dg, and Db consider it as red and the thing currently colored green and blue in an illustrated example, respectively), and Fig.15.It is desirable to arrange the light emitting diode elements 1r, 1g, and 1b which are the luminescent color of the region Dr, Dg, Db, and similar colors near each region Dr, Dg, and the Db. By this composition, the color of the coloring part of a display pattern becomes clear, the contrast of a color is emphasized, and the recognition nature of a display pattern can be improved. What is necessary is just to apply this composition if needed.

[0037]

[Effect of the Invention]Invention of Claim 1 is that by which two or more light emitting diode elements are arranged with the arrangement density according to a light-distribution design, By having arranged the light emitting diode element, the surface light source can be acquired easily and there is an advantage that it can respond to a light-distribution design for light source itself,

by moreover having set up the arrangement density of a light emitting diode element according to a light-distribution design. That is, since the instrument provided with a control-light-distribution element is almost needlessness, a comparatively small lighting system can be constituted, and if it moreover exchanges to the light source in which the arrangement densities of a light emitting diode element differ, even if it is after construction, there is an advantage that a light distribution can be changed easily. Since the life of a light emitting diode element is equivalent as compared with a light source like a filament lamp or a fluorescent lamp generally used or it is long, it also has the advantage that a turnover rate decreases.

[0038]Like invention of Claim 2, there is an advantage of becoming possible to carry out arrangement density of a light emitting diode element largely, and to obtain a light source with high luminosity, by some which used the light emitting diode element as the bare chip. In some which made arrangement density of the central part of the arrangement range of a light emitting diode element smaller than a periphery like invention of Claim 3 so that the illumination of an irradiation surface might be set constant, there is an advantage that the illumination of an irradiation surface becomes substantially uniform.

[0039]Like invention of Claim 4, by some which carried out more largely than a periphery arrangement density of the central part of the arrangement range of a light emitting diode element, the illumination of an irradiation surface becomes largely near directly under, and there is an advantage that the lighting with which illumination was raised partially is attained. Invention of Claim 5 connects each light emitting diode element for every group so that two or more light emitting diode elements may constitute two or more groups, It has the advantage of becoming possible to change a light distribution, by making controllable lighting status of each light emitting diode element for every group, and performing lighting and dimming for every group.

[0040]Invention of Claim 6 is a thing provided with two or more light emitting diode elements and the drive circuit which is connected to the output of the light circuit for electric discharge lamps, and makes the aforementioned light emitting diode element turn on, If the light used for a usual electric discharge lamp like a fluorescent lamp is diverted and only a light source is substituted, there is an advantage that the lighting by a light emitting diode element is attained. That is, there is an advantage of the ability to make a light emitting diode element turn on stably, without applying excess voltage to a light emitting diode element, or an over-current flowing by giving the output of a light

circuit to a drive circuit.

[0041]The power supply section where the aforementioned drive circuit included the rectification circuit connected to a light circuit like invention of Claim 7, In a thing provided with the \*\* style element which restricts the current energized from the aforementioned power supply section to the aforementioned light emitting diode element, since a power supply section is equipped with a rectification circuit, there is an advantage that the output of a light circuit can also use a direct current or exchange. And there is an advantage that an over-current can be prevented from flowing into a light emitting diode element by a \*\* style element.

[0042]The power supply section where the aforementioned drive circuit contains the rectification circuit and power-factor-improvement means which are connected to a light circuit like invention of Claim 8, Have a \*\* style element which restricts the current energized from the aforementioned power supply section to the aforementioned diode element, and the input characteristics of a power supply section in what imitates the load characteristic of an electric discharge lamp, By the advantage that trouble does not arise being in a light circuit, even if it substitutes and uses for an electric discharge lamp, and providing the rectification circuit to the power supply section, since the input characteristics of a power supply section imitate the load characteristic of an electric discharge lamp, Since the output of a light circuit can also use a direct current or exchange and is providing the power factor improvement circuit further, there is an advantage that the utilization efficiency of electric power in case the output of a light circuit is exchange is high. It is effective in the ability to prevent an over-current from flowing into a light emitting diode element by a \*\* style element.

[0043]By what was made into the current potential characteristic at the time of stable lighting of an electric discharge lamp, the aforementioned load characteristic like invention of Claim 9, It will operate like the time of a light circuit carrying out stable lighting of the electric discharge lamp, the stress to a light circuit does not need to design a light circuit that it is few and separately, and it becomes possible to use as a light source of ready-made lights. Like invention of Claim 10, by what used the aforementioned electric discharge lamp as the fluorescent lamp, since the fluorescent lamp which is an electric discharge lamp most used with common lighting will be imitated, a high economic effect will be induced by replacement with a fluorescent lamp.

[0044]Like invention of Claim 11, each light emitting diode element is connected for every group so that two or more light emitting diode elements

may constitute two or more groups, In what made controllable lighting status of each light emitting diode element for every group, it has the advantage of becoming possible to change a light distribution, by performing lighting and dimming for every group.

[0045]The light guide plate to which the light leak of the light introduced from the light source which invention of Claim 12 opposed to the peripheral surface of the plate, and has been arranged is carried out from the first [ at least ] page of a rear surface, It has a light emitting diode element used as the aforementioned light source, and there is an advantage that the comparatively inexpensive surface light source can be provided with the combination of a light guide plate and a light emitting diode element. In some which a light emitting diode element opposes to the peripheral surface of a light guide plate, and are arranged like invention of Claim 13, there is an advantage of becoming possible to give change to the luminosity of each region of a light guide plate by arrangement and light control of a light emitting diode element.

[0046]Like invention of Claim 14, there is an advantage that the luminescent color of a light guide plate is changeable according to the luminescent color of a light emitting diode element and arrangement, by some by which the light emitting diode element of two or more luminescent color is arranged. It is used for the lighting system which provided the display pattern to the first [ at least ] page of the rear surface of a light guide plate like invention of Claim 15, In that in which the light emitting diode element was arranged as the part with many transmitted light amounts in a display pattern so that the amount of light leaks from a light guide plate might increase, Since he is trying for the amount of light leaks from a light guide plate to increase in a display pattern as a portion with many transmitted light amounts, there is an advantage of emphasizing the contrast of the bright portion of a display pattern and a dark portion, and becoming easy to recognize a display pattern.

[0047]It is used for the lighting system which provided the display pattern to the first [ at least ] page of the rear surface of a light guide plate like invention of Claim 16, Since the contrast of a color can be emphasized in the colored display pattern in what arranged the light emitting diode element of two or more luminescent color so that the light color which carries out a light leak from the color and light guide plate of a coloring section in a display pattern may be made to correspond, there is an advantage of becoming easy to recognize a display pattern.

[0048]Like invention of Claim 17, there is an advantage that the light volume of a light guide plate can be adjusted by dimming of a light emitting diode element,

by some in which the light of the optical power of each light emitting diode element is modulated by the control means. Invention of Claim 18 connects each light emitting diode element for every group so that two or more light emitting diode elements may constitute two or more groups, It has the advantage of becoming possible to change a light distribution, by making controllable lighting status of each light emitting diode element for every group, and performing lighting and dimming for every group.

## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is a schematic structure figure showing Embodiment 1.

[Drawing 2] It is an explanatory view of operation same as the above.

[Drawing 3] It is an explanatory view of Embodiment 2 of operation.

[Drawing 4] It is a schematic structure figure showing Embodiment 3.

[Drawing 5] It is a perspective view showing Embodiment 4.

[Drawing 6] It is a circuit diagram same as the above.

[Drawing 7] It is a circuit diagram showing Embodiment 5.

[Drawing 8] It is a perspective view showing Embodiment 6.

[Drawing 9] It is an essential part perspective view showing the other examples of Embodiment 6.

[Drawing 10] It is an essential part perspective view showing example of another of Embodiment 6.

[Drawing 11] It is a circuit diagram same as the above.

[Drawing 12] It is a plan view showing Embodiment 7.

[Drawing 13] It is a front view same as the above.

[Drawing 14] It is an exploded perspective view showing Embodiment 8.

[Drawing 15] It is a perspective view same as the above.

[Drawing 16] It is an explanatory view of operation showing a conventional example.

[Explanations of letters or numerals]

1 Light emitting diode element

1r, 1g, 1b light emitting diode element

2 Control circuit

3 Shell

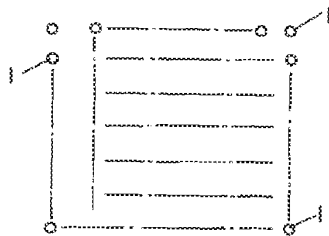
4 Cap

5 Terminal pin

6 Power supply section

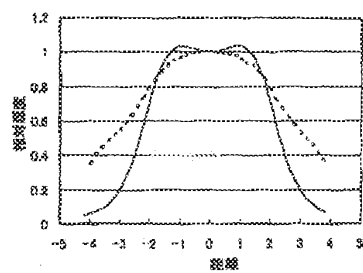
7 Light guide plate  
 8 Display panel  
 9 Light reflector  
 Dr, Dg, and Db Region  
 G1, G2 .... Group  
 R Resistance  
 RE Rectification circuit

[Drawing 1]



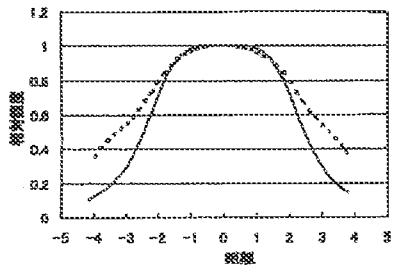
1 発光ダイオード素子

[Drawing 2]

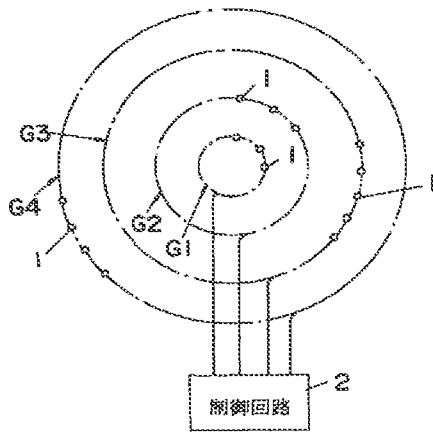


[Drawing 3]

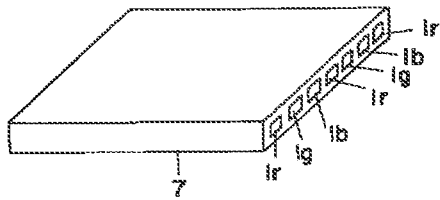




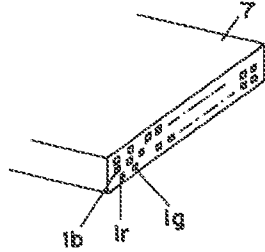
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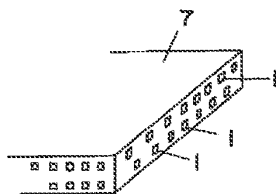
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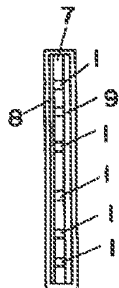
[Drawing 9]



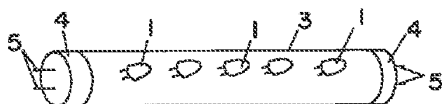
[Drawing 10]



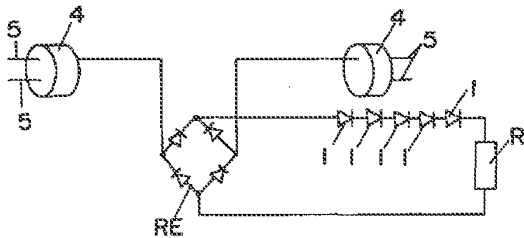
[Drawing 12]



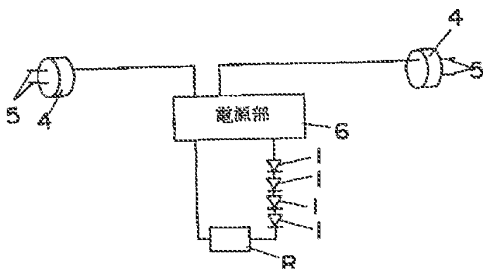
[Drawing 5]



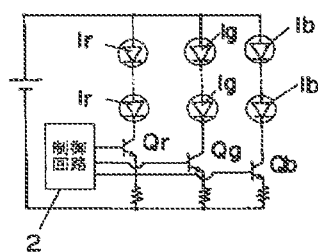
[Drawing 6]



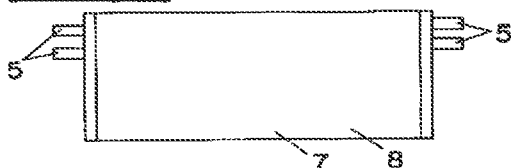
[Drawing 7]



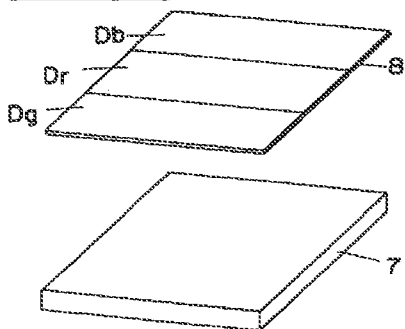
[Drawing 11]



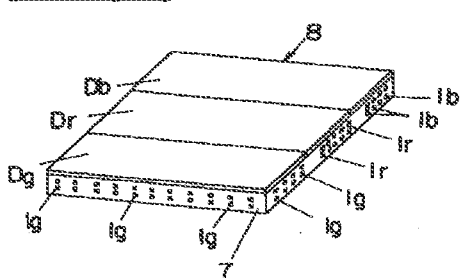
[Drawing 13]



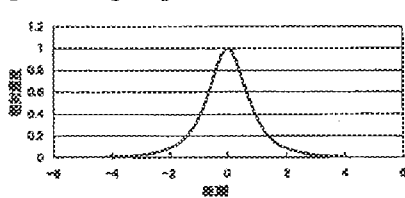
[Drawing 14]



[Drawing 15]



[Drawing 16]



| Electronic Patent Application Fee Transmittal |          |                                     |        |                      |
|-----------------------------------------------|----------|-------------------------------------|--------|----------------------|
| Application Number:                           |          | 12965019                            |        |                      |
| Filing Date:                                  |          | 10-Dec-2010                         |        |                      |
| Title of Invention:                           |          | LIGHT TUBE AND POWER SUPPLY CIRCUIT |        |                      |
| First Named Inventor/Applicant Name:          |          | Jos Timmermans                      |        |                      |
| Filer:                                        |          | Michelle L. Knight/Joan Leighton    |        |                      |
| Attorney Docket Number:                       |          | AEII-172-H                          |        |                      |
| Filed as Large Entity                         |          |                                     |        |                      |
| Utility under 35 USC 111(a) Filing Fees       |          |                                     |        |                      |
| Description                                   | Fee Code | Quantity                            | Amount | Sub-Total in USD(\$) |
| Basic Filing:                                 |          |                                     |        |                      |
| Pages:                                        |          |                                     |        |                      |
| Claims:                                       |          |                                     |        |                      |
| Miscellaneous-Filing:                         |          |                                     |        |                      |
| Petition:                                     |          |                                     |        |                      |
| Patent-Appeals-and-Interference:              |          |                                     |        |                      |
| Post-Allowance-and-Post-Issuance:             |          |                                     |        |                      |
| Extension-of-Time:                            |          |                                     |        |                      |

| Description                             | Fee Code | Quantity | Amount | Sub-Total in USD(\$) |
|-----------------------------------------|----------|----------|--------|----------------------|
| <b>Miscellaneous:</b>                   |          |          |        |                      |
| Submission- Information Disclosure Stmt | 1806     | 1        | 180    | 180                  |
| Statutory or terminal disclaimer        | 1814     | 1        | 160    | 160                  |
| <b>Total in USD (\$)</b>                |          |          |        | <b>340</b>           |

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|                                             |                                     |
|---------------------------------------------|-------------------------------------|
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| <b>Application Number:</b>                  | 12965019                            |
| <b>International Application Number:</b>    |                                     |
| <b>Confirmation Number:</b>                 | 5912                                |
| <b>Title of Invention:</b>                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |
| <b>First Named Inventor/Applicant Name:</b> | Jos Timmermans                      |
| <b>Customer Number:</b>                     | 48980                               |
| <b>Filer:</b>                               | Michelle L. Knight/Joan Leighton    |
| <b>Filer Authorized By:</b>                 | Michelle L. Knight                  |
| <b>Attorney Docket Number:</b>              | AEII-172-H                          |
| <b>Receipt Date:</b>                        | 07-DEC-2012                         |
| <b>Filing Date:</b>                         | 10-DEC-2010                         |
| <b>Time Stamp:</b>                          | 15:55:29                            |
| <b>Application Type:</b>                    | Utility under 35 USC 111(a)         |

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|                                          |                 |
|------------------------------------------|-----------------|
| Submitted with Payment                   | yes             |
| Payment Type                             | Deposit Account |
| Payment was successfully received in RAM | \$ 340          |
| RAM confirmation Number                  | 2650            |
| Deposit Account                          | 250115          |
| Authorized User                          |                 |

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## File Listing:

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| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                                |                                                    |                  |                  |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                    |                                |                                                    |                  |                  |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Information Disclosure Statement (IDS) Form (SB08) | AEI172H_IDS_20121207.pdf       | 614017<br>94c82fd096360f53a727cc179549003e4595d257 | no               | 4                |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                                |                                                    |                  |                  |
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| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                    |                                |                                                    |                  |                  |
| 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Foreign Reference                                  | JP11162234.pdf                 | 994703<br>0b97a11fd002635752c2efc38cb336db08b730   | no               | 10               |
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| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                    |                                |                                                    |                  |                  |
| 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Foreign Reference                                  | JP11162234_translation.pdf     | 1065289<br>6545a229fe7284483ee0befc0acd855b07886a8 | no               | 20               |
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| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                    |                                |                                                    |                  |                  |
| 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Fee Worksheet (SB06)                               | fee-info.pdf                   | 31936<br>506d8bf18a9c8a25df2de932cd0e4fad2436612b  | no               | 2                |
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|                                                                                                     | Filing Date            |                | 2010-12-10 |
|                                                                                                     | First Named Inventor   | Jos Timmermans |            |
|                                                                                                     | Art Unit               | 2821           |            |
|                                                                                                     | Examiner Name          | A. Minh D      |            |
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|                                                                                                     | Examiner Name          | A. Minh D      |            |
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| <b>INFORMATION DISCLOSURE<br/>STATEMENT BY APPLICANT</b><br>( Not for submission under 37 CFR 1.99) | Application Number     |                | 12965019   |
|                                                                                                     | Filing Date            |                | 2010-12-10 |
|                                                                                                     | First Named Inventor   | Jos Timmermans |            |
|                                                                                                     | Art Unit               | 2821           |            |
|                                                                                                     | Examiner Name          | A. Minh D      |            |
|                                                                                                     | Attorney Docket Number | AEII-172-H     |            |

|   |                                                                                                                                                    |                          |
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**INFORMATION DISCLOSURE  
STATEMENT BY APPLICANT**  
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| Attorney Docket Number | AEII-172-H     |

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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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☐ See attached certification statement.

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☒ A certification statement is not submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

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| Signature  | /Michelle L. Knight/ | Date (YYYY-MM-DD)   | 2012-12-03 |
| Name/Print | Michelle L. Knight   | Registration Number | 47711      |

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⑬ BUNDESREPUBLIK  
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**F21 S 1/00**  
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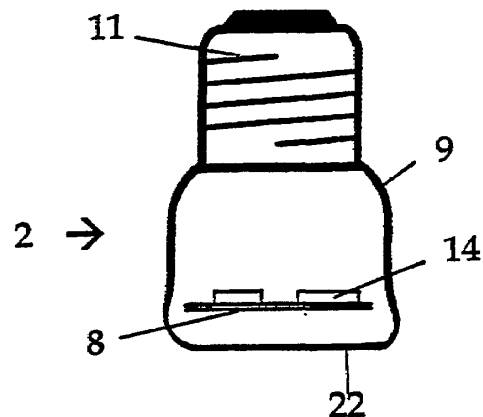
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⑤④ Leuchte mit geringem Stromverbrauch

⑤⑦ Eine Leuchte zur gleichmäßigen Beleuchtung von Flächen oder Räumen verfügt über eine elektronische Baugruppe 3 mit mindestens drei Halbleiterelementen bzw. Leuchtdioden 4, 5, 6, die eine Lichtstärke von jeweils wenigstens 0,2 cd erzeugen und jeweils Licht in mindestens drei unterschiedlichen Wellenlängenbereichen emittieren. Die Baugruppe 3 ist mit einer elektrischen Schaltung und Stromversorgung 14 ausgerüstet, über die die einzelnen Leuchtdioden 4, 5, 6 gleichzeitig angesteuert werden können. Derartige Leuchten 1 haben eine extrem hohe Lebensdauer und einen verringerten Stromverbrauch. Gekennzeichnet sind sie weiter durch günstige Baugrößen selbst bei hoher Lichtintensität.



DE 196 51 140 A 1

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

BUNDESDRUCKEREI 04. 97 702 025/586

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Die Erfindung betrifft eine Leuchte mit einer künstlichen Lichtquelle zum gleichmäßigen Beleuchten von Flächen und Räumen, die von mehreren, eine Baugruppe darstellenden Halbleiterelement gebildet ist, die Licht in unterschiedlichen Wellenlängenbereichen emittieren.

Üblicherweise werden Wohn-, Verwaltungs-, Behandlungs- und Verkaufsräume sowie Sportstätten oder sonstige Außenanlagen mittels Glüh- oder Halogenlampen, Leuchtstofflampen und anderen Entladungslampen beleuchtet. Auch im Bereich Fotooptik oder Bühnentechnik werden die vorgenannten Leuchtmittel bzw. Lichtquellen zur Ausleuchtung bzw. zum Anstrahlen von Personen, Flächen und Gegenständen verwendet. Allgemeine Anforderungen wie an die Gleichmäßigkeit der Beleuchtung, die Miniaturisierung der Leuchten selbst, die gute Farbwiedergabe, die gute Blendungsbegrenzung sowie einen variablen Ausstrahlungswinkel bei hoher Lichtausbeute haben dazu geführt, daß für die vorgenannten Zwecke vorwiegend NV-Halogenlampen oder Leuchtstofflampen verwendet werden. Diese Leuchtmittel bzw. Lichtquellen werden in der Regel durch Reflektoren oder Reflektorsysteme ergänzt, um die gewünschte Beleuchtungsaufgabe zu erfüllen. Es ist allen herkömmlichen Leuchten gemeinsam, daß deren Leuchtmittel in Fassungen gehalten werden oder über die jeweilige Fassung mit dem erforderlichen Strom versorgt werden, der mittels Vorschaltgeräten wie Drosseln oder Transformatoren in der geeigneten Form bereit gestellt wird. Nachteilig bei diesem Stand der Technik ist, daß die Lebensdauer der Lichtquellen relativ niedrig ist und bestenfalls 8000 Betriebsstunden bei Leuchtstofflampen beträgt. Daraus folgen hohe Betriebskosten der Leuchten, nämlich hohe Ersatzteilkosten, als auch hohe Wartungskosten für den Arbeitsaufwand beispielsweise beim Auswechseln der Lichtquelle selbst. Mindestens ebenso nachteilig wirkt sich der schlechte Wirkungsgrad der vorgenannten Lichtquellen aus, weil ein Großteil der elektrischen Energie anstatt in sichtbares Licht, in Konvektionswärme sowie in die unsichtbare Infrarot- und Ultraviolettstrahlung umgewandelt wird, welche überdies auch noch gesundheitsschädlich sein kann. Weitere Nachteile der herkömmlichen Leuchten ergeben sich daraus, daß die Baugröße der Leuchten, welche wesentlich durch den erforderlichen Reflektor mitbestimmt wird, relativ groß ist und über die die Farbe des ausgestrahlten Lichtes nicht beeinflußt werden kann.

Weiter ist bekannt, Lumineszenzdiode einzusetzen. In der Regel handelt es sich dabei um Halbleiterdioden, die bei Stromfluß in Durchlaßrichtung elektromagnetische Strahlung emittieren. Die Wellenlänge der emittierten Strahlung wird im wesentlichen durch das verwendete Halbleitermaterial bestimmt und ist aufgrund der elektronischen Übergänge, die für die Emission ursächlich sind, auf einen schmalen Wellenlängenbereich begrenzt. Als Lumineszenzdiode sind auch LED's mit zwei, drei oder vier Halbleiterelementen bekannt, die je nachdem, welche Anschlußpins, die jeweils zu den unterschiedlichen Halbleiterelementen innerhalb der LED führen, angesteuert werden, unterschiedlich farbiges Licht emittieren. Zur Signalisierung von Meßdaten wird je nach Schaltungszustand die ein oder andere Farbe jeweils einzeln erzeugt. Im Stand der Technik ist die Verwendung von LED's im wesentlichen auf den Einsatz in Signalelementen, Lichtschranken, Lochkartenle-

segeräten, bei der IR-Fernsteuerung und in Fotodetektoren beschränkt. Auch zur Hinterleuchtung von Displays oder Anzeigen werden Licht emittierende Halbleiterelemente eingesetzt. Aufgrund der zur Verfügung stehenden Lichtausbeute werden LED's heute auch am Automobil als Positions-, Brems- oder Richtungsänderungsleuchten eingesetzt (DE-A1-42 28 895). Beim Einsatz in Fahrzeugscheinwerfern soll jede Halbleiterlichtquelle nur Licht einer Farbe abstrahlen, wobei durch Überlagerung des von sämtlichen Halbleiterquellen abgestrahlten Lichtes ein Licht einheitlicher Farbe austreten soll. Die DE-A1-38 27 083 beschreibt ebenfalls lichtstarke Halbleiterelemente, die in der Farbe rot in einem spitzen Ausstrahlungswinkel 1—3 cd erzeugen. Bei all diesen bekannten Anwendungen von Halbleiterelementen als Lichtquelle ist von Nachteil, daß keine leistungsfähigen Leuchten zu verwirklichen sind und das notwendige Weißlicht nicht ohne weiteres zu erreichen ist.

Der Erfindung liegt daher die Aufgabe zugrunde, eine Leuchte mit kleinen Baumaßen aber hohem Wirkungsgrad und hoher Lebensdauer zu schaffen.

Die Aufgabe wird gemäß der Erfindung dadurch gelöst, daß die elektronische Baugruppe als integrierter, die einzelnen lichtemittierenden Halbleiterelemente aufnehmender Chip/Schaltkreis ausgebildet ist, daß die Leuchtdioden eine Lichtstärke von jeweils mindestens 0,2 cd aufweisen und daß der Ausstrahlungswinkel der Leuchtdioden so groß ist, daß sich aus kurzer Distanz im wesentlichen weißes Licht auf dem auszuleuchtenden Objekt ergibt.

Derartige Baugruppen sind beispielsweise nach der SMD-Technik herstellbar, wobei die einzelnen Halbleiterelemente in den Chip bzw. Schaltkreis integriert sind. Dieser Chip kann beispielsweise herkömmliche Steckverbindungsanschlüsse aufweisen, wobei die gleichmäßige Beleuchtung durch die Verwendung entsprechender Halbleiterelemente möglich ist, die eine Lichtstärke von mindestens 0,2 cd erzeugen und Licht in mindestens drei unterschiedlichen Wellenlängenbereichen emittieren. Durch additive Überlagerung der Wellenlängenbereich bzw. durch einen entsprechenden Ausstrahlungswinkel der Leuchtdioden bzw. Halbleiterelemente ist sichergestellt, daß im wesentlichen weißes Licht das zu beleuchtende Objekt bestrahlt. Durch Einsatz entsprechender Leuchtdioden und ihrer Anordnung und Integrierung in den Schaltkreis erreicht man die angestrebten kostengünstigen Leuchten mit kleinem Baumaß und hohem Wirkungsgrad.

Nach einer zweckmäßigen Ausbildung der Erfindung ist vorgesehen, daß der Schaltkreis mit einer in die Lichtquelle integrierten Stromversorgung und Ansteuerung für die Leuchtdioden ausgerüstet ist, die vorzugsweise eine Lichtstärke von jeweils 1 cd erzeugend ausgebildet sind. Da erfindungsgemäß je nach Baugruppe unterschiedliche Halbleiterelemente mit unterschiedlichen Mindestspannungen Verwendung finden können, ist eine auf das jeweilige Halbleiterelement abgestimmte Stromversorgung mit der entsprechenden Spannung von erheblichem Vorteil. Die jeweilige Stromversorgung kann bevorzugt auch ein Regelkreis für die Versorgungsspannung nach Art eines Potentiometers integriert sein, der die Helligkeit des jeweiligen Halbleiterelementes steuert. Erfindungsgemäß werden Halbleiterelemente eingesetzt, die gleichzeitig die drei Grundfarben rot, grün und blau erzeugen. Die aufwendige Anordnung und Ansteuerung unterschiedlicher Halbleiterelemente wird dann überflüssig. Bei Leuchtdioden mit 1



od kann die Zahl der zum Einsatz kommenden Leuchtdioden bzw. Halbleiter vorteilhaft reduziert werden, so daß die Leuchten noch kleiner bauen.

Eine weitere zweckmäßige Ausführung sieht vor, daß die Lichtquelle ein geschlossenes Gehäuse mit Kunststoff- und/oder Glaskörper aufweist und über den Sockel bzw. die Fassung an das Stromnetz anschließbar ist. Hierbei sind die Halbleiterelemente direkt in einen Chip integriert und reduzieren nicht nur die Baugröße, sondern verhindern auch eine Gesundheitsbeeinträchtigung, weil UV-Strahlung oder IR-Strahlungen nicht ausgesendet werden. Da die erfindungsgemäße Lichtquelle bei hoher Lichtausbeute nur niedrige Temperaturen hervorruft, ist eine Integrierung in ein geschlossenes Gehäuse aus Kunststoff oder Glas problemlos möglich, wobei dann die übliche Anschlußtechnik über Sockel oder Fassung wie bei üblichen Lichtquellen bekannt Verwendung finden kann. Dies hat den vor allem großen Vorteil, daß derartige Lichtquellen bzw. auch insgesamt Leuchten vom Verkehr schnell angenommen werden.

Um derartige Lichtquellen als Komplettlichtversorgung zu verwirklichen, ist vorgesehen, daß die Stromversorgung und Ansteuerung für die Leuchtdioden in das geschlossene Gehäuse der Lichtquelle integriert ist. Durch entsprechende Anschlüsse üblicher Bauart an das Stromnetz ist eine Anwendung derartiger Lichtquellen praktisch überall möglich.

Die Vielseitigkeit der Erfindung wird auch dadurch deutlich, daß gemäß einer Weiterbildung vorgesehen ist, daß das Gehäuse aus brennbarem Material wie Pappe, Textilstoff oder Kunststoff besteht. Damit ist aufgrund der günstigen Bauform und der niedrigen Temperaturen, die an den Halbleiterelementen bzw. Leuchtdioden und an der Stromversorgung anliegen, erstmals die Möglichkeit gegeben, dem Gehäuse selbst, d. h. also der Lichtquelle diese für die Optik wichtigen Materialien direkt zuzuordnen. Es ergeben sich damit völlig neue Effekte und Anwendungsmöglichkeiten, ohne daß dadurch irgendwelche Gefahren entstehen. Die Wirkung der einzelnen Lichtquelle und damit der Leuchte wird gezielt dadurch erhöht, daß gemäß der Erfindung der Chip auf der Seite mit den Halbleiterelementen verspiegelt ausgebildet ist.

Weiter oben ist bereits erwähnt, daß die Stromversorgung und Ansteuerung für die Leuchtdioden in das geschlossene Gehäuse der Lichtquelle integriert ist. Dabei ist eine den Platzverhältnissen optimal anzupassende Verwirklichung die, bei der die Stromversorgung und Transformation von AC/DC- und DC/DC-Wandlern gebildet ist. Derartige Bauteile können vorteilhaft in den Chip bzw. in das Gehäuse der Lichtquelle mit integriert werden, so daß sie geschützt angeordnet sind und immer voll wirksam werden und darüber hinaus die Möglichkeit bieten, derartige Lichtquellen bzw. Leuchten an übliche Wechselstromversorger anzuschließen.

Nach einer zweckmäßigen Weiterbildung der erfindungsgemäßen Leuchte ist vorgesehen, daß den Leuchtdioden ein optisches Bauelement zur Homogenisierung der Lichtfarbe und der Lichtstärkenverteilung zugeordnet ist. Bei diesem Bauelement handelt es sich zweckmäßigerweise um eine Linse oder Streuscheibe, wobei Linsen beliebiger Bauform eingesetzt werden können. Über die Bündelung der unterschiedlichen Lichtwellen erfolgt eine zielgerichtete Beeinflussung in der beschriebenen Form.

Aufgrund des sehr niedrigen Stromverbrauches des Schaltkreises bzw. der einzelnen Leuchtdioden eignet

sich die Erfindung besonders für den Einsatz der Solarenergie. Erfindungsgemäß ist dementsprechend vorgesehen, daß der Schaltkreis bzw. die Stromversorgung mit Solarzellen verbindbar ausgebildet ist. Damit ist auch in größerem Umfang der Einsatz von Solarzellen und fotovoltaischen Elementen für Außenleuchten oder auch Innenraumleuchten möglich, die in Kombination mit der Nutzung von Tageslicht eingesetzt werden. Hierbei wird das Tageslicht in Strom umgewandelt, der Akkus auflädt und nach Auflösung eines Impulses die gespeicherte Energie für die Stromversorgung der Halbleiterelemente freigibt. Da sich dieser Prozeß ausschließlich im Bereich von Gleichstrom abspielt, fallen vorteilhaft keine Transformationsverluste an. Dabei ist es vorteilhaft, wenn der Schaltkreis bzw. das Gehäuse einen Dämmerungs- oder Zeitschalter aufweist, weil darüber sichergestellt werden kann, daß der Stromverbrauch erst einsetzt, wenn dies aufgrund der Lichtverhältnisse erforderlich wird. Verhindert ist damit, daß aufgrund einer zu geringen Speicherung in den Akkus die Stromversorgung zu früh ausfällt.

Die Erfindung zeichnet sich insbesondere dadurch aus, daß eine gleichmäßige Beleuchtung bei Einsatz der erfindungsgemäßen Lichtquelle bzw. der Leuchte möglich ist, da die Halbleiterelemente, die eine Lichtstärke von jeweils wenigstens 0,2 cd erzeugen und Licht in mindestens drei unterschiedlichen Wellenlängenbereichen emittieren, mittels einer elektrischen Schaltung gleichzeitig einzeln angesteuert werden und dann durch additive Überlagerung der Wellenlängenbereiche im wesentlichen weißes Licht auf das beleuchtete Objekt abgeben. Da die Leuchtdioden eine Lebensdauer von 100 000 Stunden bei einem nur 25%igen Leistungsabfall aufweisen, ist hier der besondere Vorteil zu verzeichnen, daß ein Austauschen des Leuchtmittels sich quasi vollständig erübrigt. Da die Leuchtdioden darüber hinaus nur eine sehr geringe Baugröße aufweisen, läßt sich eine sehr geringe Baugröße der Gesamtleuchte bei hoher Lichtintensität verwirklichen. UV-Strahlung und IR-Strahlung werden vermieden, so daß eine Gesundheitsbeeinträchtigung nicht auftreten kann. Die niedrige Bauform und die niedrigen Temperaturen, die an den Halbleiterelementen und an der Stromversorgung anliegen, gestatten die Verwendung von leicht brennbaren Materialien auch als Gehäusematerial. Dadurch ergeben sich sehr viele neue Applikations- und Designmöglichkeiten. Es werden mindestens drei Halbleiterelemente verwendet, bevorzugt zur Erzielung einer möglichst gleichmäßigen Lichtfarbe auf dem beleuchteten Objekt, mindestens neun, besonders bevorzugt 27. Es ist auch die Möglichkeit, durch Verknüpfung mehrerer kleinerer Elementbaugruppen eine entsprechend große Baugruppe vorzugeben. Die Anzahl der Halbleiterelemente ist nach oben nur durch die Baugröße der Elemente und die maximale Größe der Leuchte begrenzt. Der Lichtaustrittswinkel der verschiedenfarbig strahlenden Halbleiterelemente ist derart groß und die Elemente sind entsprechend angeordnet, so daß das Licht der unterschiedlichen Wellenlängenbereich sich derart überlagert, daß sich im wesentlichen weißes Licht ergibt. Es ist auch möglich, dem weißen Licht durch entsprechende Einstellung der an den jeweiligen Halbleiterelementen anliegenden Versorgungsspannungen oder durch die Wahl der Halbleiterelemente selbst eine Färbung zu geben, falls dies aus beleuchtungstechnischen Gründen gewünscht ist. Vorteilhaft ist weiter, daß die Möglichkeit gegeben ist, die erfindungsgemäße Leuchte mit dem Einsatz von Solarenergie zu koppeln,

zumal dadurch Transformationsverluste vermieden werden können und damit eine noch bessere Ausbeute der vorhandenen Energie. Die Integrierung aller Teile einschließlich der Schaltung, der Stromversorgung und der Ansteuerung in ein komplettes geschlossenes Gehäuse gibt darüber hinaus die vorteilhafte Möglichkeit, derartige Lichtquellen mit handelsüblichen Sockeln oder Fassungen zu versehen und damit die Verwendung wesentlich zu erleichtern. Schließlich ist durch Einsatz von Akkus oder Batterien die Möglichkeit gegeben, auch transportable Einheiten zu verwirklichen.

Weitere Einzelheiten und Vorteile des Erfindungsgegenstandes ergeben sich aus der nachfolgenden Beschreibung der zugehörigen Zeichnung, in der ein bevorzugtes Ausführungsbeispiel mit den dazu notwendigen Einzelheiten und Einzelteilen dargestellt ist. Es zeigen:

Fig. 1a in perspektivischer Darstellung eine Mehrzahl von Leuchtdioden auf einer Platine,

Fig. 1b in der Draufsicht eine Mehrzahl von Leuchtdioden auf einer Platine,

Fig. 2 in schematischer Darstellung eine Mehrzahl von Leuchtdioden auf einer Platine mit einer Sammellinse als optisches Bauelement,

Fig. 3 ein Chip, in den 25 Halbleiterelemente direkt integriert sind,

Fig. 4 ein geschlossenes Gehäuse, in dem der Chip mit den Halbleiterelementen und die Stromversorgung mit Ansteuerung eingebaut sind und

Fig. 5 ein weiteres Gehäuse, in dem eine Platine mit Leuchtdioden und Stromversorgung und Ansteuerung integriert sind.

Fig. 1a zeigt einen einfachen Aufbau einer Leuchte 1 bzw. einer Lichtquelle 2, die hier lediglich aus einer Platine 10 mit einer Baugruppe 3 verschiedener Halbleiter 4 bzw. Leuchtdioden 5, 6 besteht. Die Leuchtdioden 4, 5, 6 sind durch eine hier nicht erkennbare separate Stromversorgung angesteuert.

Fig. 1b zeigt eine Draufsicht auf die Platine 10 mit der Vielzahl von Leuchtdioden 4, 5, 6, die hier symmetrisch angeordnet sind.

Fig. 2 zeigt eine Platine 10, der ein optisches Bauelement 16 vorgelagert ist, das die einzelnen Strahlengänge 18, 19, 20 und Farbanteile in einem Brennpunkt 17 überlagert und mischt.

Fig. 3 zeigt einen Chip bzw. einen Schaltkreis 8, der direkt mit Halbleiterelementen bzw. Leuchtdioden 4, 5, 6 bestückt ist und aufgrund seiner Bauform sich für den Einbau in verschiedenste Lichtquellen 2 bzw. Leuchten 1 eignet.

Die Fig. 4 und 5 verdeutlichen, daß die erforderlichen Komponenten wie z. B. der Chip bzw. Schaltkreis 8 oder die Platine 10 mit den Leuchtdioden 4, 5, 6 einem geschlossenen Gehäuse 9 zugeordnet werden können. Dieses geschlossene Gehäuse 9 weist nach Fig. 4 die angenäherte Form einer Glühbirne auf, wobei der integrierte Schaltkreis 8 im Inneren des Gehäuses 9 erkennbar ist. Ebenfalls integriert ist die Stromversorgung 14, die nicht erkennbare Ansteuerung. Der untere Teil 22 des Gehäuses 9 stellt eine geschlossene Einheit dar und kann auch mit brennbaren Materialien wie Pappe, Stoff oder Kunststoffen beschichtet sein, weil die im Inneren des Gehäuses 9 entstehenden Temperaturen unbeachtlich sind.

An den oberen Teil 22 des Gehäuses 9 angeformt ist ein Sockel 11, der ein Einschrauben in eine korrespondierende Fassung beispielsweise einer Lampe oder Leuchte 1 ermöglicht, um die vorhandene Technik

benutzen zu können. Damit ist ein direkter Anschluß an die Netzversorgung möglich, wobei über die Stromversorgung 14 und die Ansteuerung eine Versorgung und Steuerung der Leuchtdioden 4, 5, 6 möglich ist.

Nach Fig. 5 kann das Gehäuse 9 auch eine andere Form aufweisen. Hier ist das Gehäuse 9 mit einem Sockel 12 mit Steckelementen 13 ausgerüstet, so daß auch hier der Einsatz beispielsweise in Halogenleuchten möglich wird, wobei dann eine vereinfachte Stromversorgung 14 zum Einsatz kommen kann, da in der Regel Transformatoren in der Leuchte 1 bereits vorhanden sind. Das Gehäuse 9 ist über ein Schutzglas 21 ähnlich wie bei der Ausführung nach Fig. 4 abgeschlossen, so daß ein insgesamt geschützter Innenraum 23 vorhanden ist. Zur Erhöhung der Lichtintensität kann die Seite 15 der Platine 10 bzw. des Chips 8 mit den Leuchtdioden 4, 5, 6 verspiegelt ausgebildet werden.

Alle genannten Merkmale, auch die den Zeichnungen allein zu entnehmenden, werden allein und in Kombination als erfindungswesentlich angesehen.

#### Patentansprüche

1. Leuchte (1) mit einer künstlichen Lichtquelle (2) zum gleichmäßigen Beleuchten von Flächen und Räumen, die von mehreren, eine Baugruppe (3) darstellenden Halbleiterelemente (4) gebildet ist, die Licht in unterschiedlichen Wellenlängenbereichen emittieren, **dadurch gekennzeichnet**, daß die elektronische Baugruppe (3) als integrierter, die einzelnen Lichtemittierenden Halbleiterelemente (4, 5, 6) aufnehmender Chip/Schaltkreis (8) ausgebildet ist, daß die Halbleiterelemente (4, 5, 6) eine Lichtstärke von jeweils mindestens 0,2 cd aufweisen und daß der Ausstrahlwinkel der Halbleiterelemente (4, 5, 6) so groß ist, daß sich aus kurzer Distanz im wesentlichen weißes Licht auf dem auszuleuchtenden Objekt ergibt.
2. Leuchte nach Anspruch 1, **dadurch gekennzeichnet**, daß der Schaltkreis (8) mit einer in die Lichtquelle (2) integrierten Stromversorgung (14) und Ansteuerung für die Halbleiterelemente (4, 5, 6) ausgerüstet ist, die vorzugsweise eine Lichtstärke von jeweils 1 cd erzeugend ausgebildet sind.
3. Leuchte nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet**, daß die Lichtquelle (2) ein geschlossenes Gehäuse (9) mit Kunststoff- und/oder Glaskörper aufweist und über den Sockel (11) bzw. die Fassung (12) an das Stromnetz anschließbar ist.
4. Leuchte nach Anspruch 2 und Anspruch 3, **dadurch gekennzeichnet**, daß die Stromversorgung (14) und Ansteuerung für die Halbleiterelemente (4, 5, 6) in das geschlossene Gehäuse (9) der Lichtquelle (2) integriert ist.
5. Leuchte nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet**, daß das Gehäuse (9) aus brennbarem Material wie Pappe, Textilstoff oder Kunststoff besteht.
6. Leuchte nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet**, daß der Chip (8) auf der Seite (15) mit den Halbleiterelemente (4, 5, 6) verspiegelt ausgebildet ist.
7. Leuchte nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet**, daß die Stromversorgung (14) und Transformation von AC/DC- und DC/DC-Wandlern gebildet ist.
8. Leuchte nach einem der vorhergehenden An-

sprüche, dadurch gekennzeichnet, daß den Leuchtdioden (4, 5, 6) ein optisches Bauelement (16) zur Homogenisierung der Lichtfarbe und der Lichtstärkenverteilung zugeordnet ist.

9. Leuchte nach Anspruch 8, dadurch gekennzeichnet, daß das optische Bauelement (16) eine Linse oder Streuscheibe ist. 5

10. Leuchte nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der Schaltkreis (8) bzw. die Stromversorgung (14) mit Solarzellen verbindbar ausgebildet ist. 10

11. Leuchte nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß dem Schaltkreis (8) bzw. dem Schaltkreis (8), Stromversorgung (14) und Ansteuerung für die Halbleiterelemente (4, 5, 6) aufnehmenden Gehäuse (9) ein Akku oder eine Batterie zugeordnet ist. 15

12. Leuchte nach Anspruch 11, dadurch gekennzeichnet, daß der Schaltkreis (8) bzw. das Gehäuse (9) einen Dämmerungs- oder Zeitschalter aufweist. 20

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Hierzu 2 Seite(n) Zeichnungen

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- Leerseite -

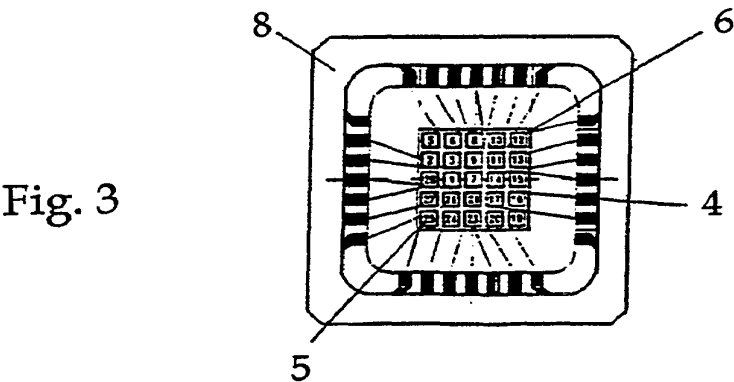
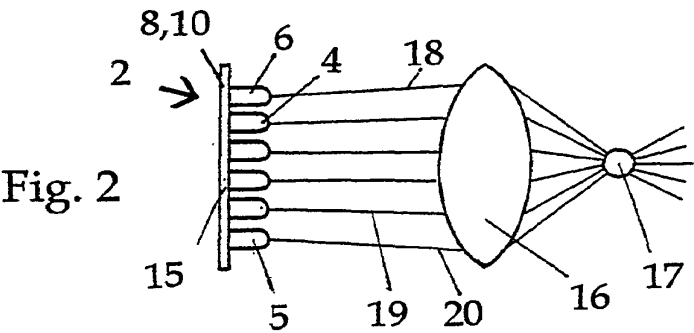
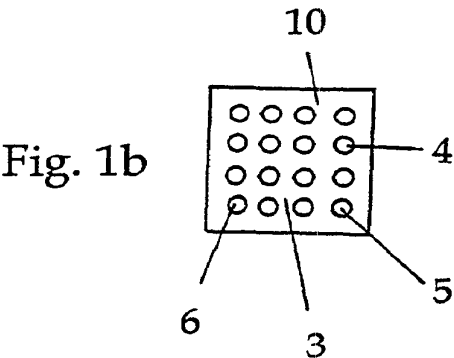
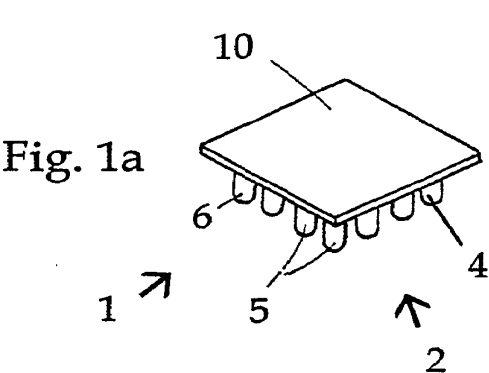


Fig. 4

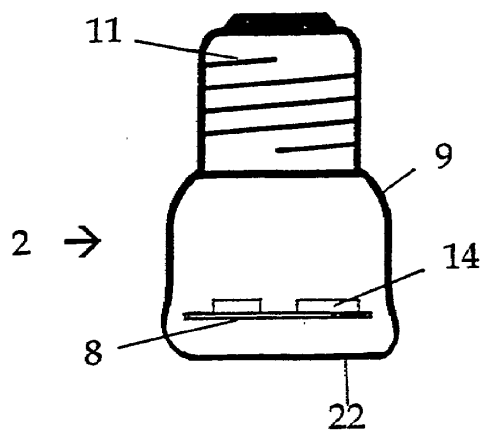
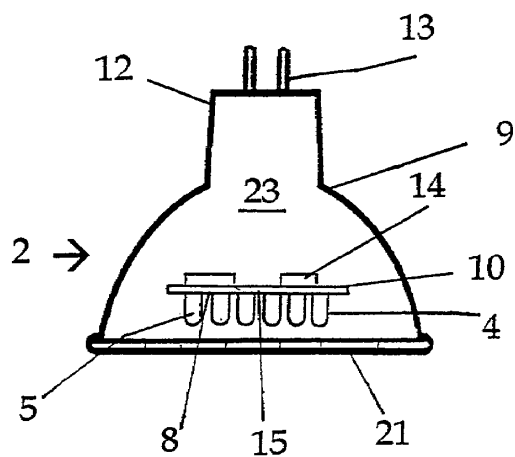


Fig. 5





**Espacenet**

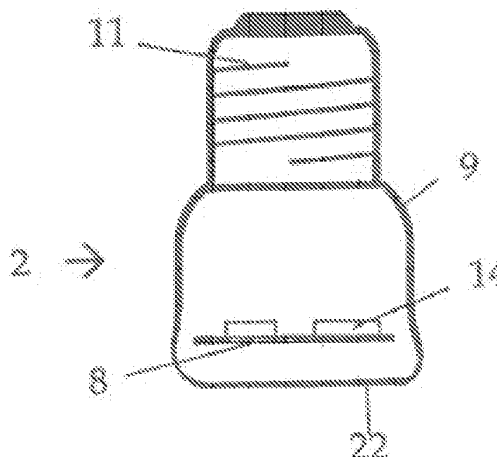
## Bibliographic data: DE 19651140 (A1)

Leuchte mit geringem Stromverbrauch

**Publication date:** 1997-06-19  
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**Classification:**  
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 - European: F21K99/00S  
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### Abstract of DE 19651140 (A1)

The invention concerns a lamp for uniformly lighting areas or rooms, the lamp having an electronic subassembly (3) which comprises at least three semiconductor elements or light-emitting diodes (4, 5, 6), each of which generates a luminous intensity of at least 0.2 cd and emits light in at least three different wave ranges. The subassembly (3) is equipped with an electrical circuit and power supply (14) via which the individual light-emitting diodes (4, 5, 6) can be controlled simultaneously. Lamps (1) of this type have an extremely long useful life and reduced current consumption. They are further characterized by favourable sizes even when their luminous intensity is high.



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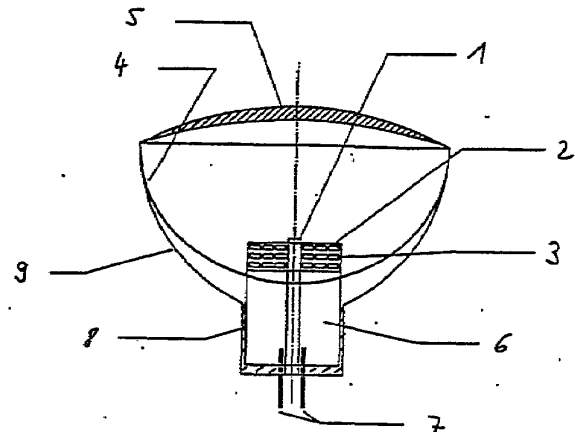
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54 Beleuchtungsvorrichtung

- 57 Die Erfindung schafft eine Beleuchtungsvorrichtung mit einer Mehrzahl von im wesentlichen punktförmigen Lichtquelleneinrichtungen, die jeweils Licht in einer bevorzugten Richtung abstrahlen, einer Halteeinrichtung, um diese punktförmigen Lichtquelleneinrichtungen in einer im wesentlichen vorgegebenen räumlichen Zuordnung zueinander zu halten, wobei diese räumliche Zuordnung derart gewählt ist, daß wenigstens zwei dieser punktförmigen Lichtquelleneinrichtungen ihr Licht in unterschiedliche Richtungen abstrahlen, und einer optischen Einrichtung, welche die Charakteristik des von diesen punktförmigen Lichtquelleneinrichtungen abgestrahlten Lichts verändert. Die erfindungsgemäße Beleuchtungsvorrichtung kann Licht mit höherer Strahlleistung und/oder breitbandigeres Licht erzeugen.



DE 196 24 087 A 1

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

BUNDESDRUCKEREI 10. 97 702 051/374

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## Beschreibung

Die vorliegende Erfindung betrifft eine Beleuchtungsanordnung und insbesondere eine Beleuchtungsanordnung mit einer Mehrzahl von im wesentlichen punktförmigen Lichtquelleneinrichtungen, die jeweils Licht in einer bevorzugten Richtung abstrahlen.

Des weiteren betrifft die vorliegende Erfindung die Verwendung der erfindungsgemäßen Beleuchtungsanordnung, ein Verfahren zum Betreiben der erfindungsgemäßen Beleuchtungsanordnung und ein Farblichtsystem mit der erfindungsgemäßen Beleuchtungsanordnung.

Obwohl sich die nachfolgende Beschreibung auf Leuchtdioden (LEDs) beschränkt, können jegliche punktförmigen Lichtquellen zum Aufbau der erfindungsgemäßen Beleuchtungsanordnung verwendet werden, insbesondere andere punktförmige Halbleiterlichtquellen, wie z. B. Halbleiterlaser oder weitere Halbleiteranordnungen, die Lumineszenzeffekte aufweisen, wie beispielsweise die jüngst bekannt gewordenen Anordnungen aus amorphem Silizium.

Leuchtdioden, welche auch als Lumineszenzdioden bezeichnet werden, sind als optoelektronisches Halbleiterbauelement verwendete pn-Dioden, bei denen am pn-Übergang Elektrolumineszenz auftritt. Dabei handelt es sich in den meisten Fällen um sichtbares Licht bzw. Infrarotlicht.

Fig. 18 zeigt drei typische geometrische Formen A, B und C von Leuchtdioden nach dem Stand der Technik, die üblicherweise in Epitaxieverfahren hergestellt werden.

Die Form A in Fig. 18 ist eine Schichtanordnung aus einer p-GaAs-Schicht 101 und einer n-GaAs-Schicht 102, auf deren Ober- und Unterseite Kontakte 103 angebracht sind. Der Kontakt auf der Oberseite weist im Mittelbereich eine Öffnung auf, welche den Lichtstrahl in Richtung des Pfeils austreten läßt.

Die Form B in Fig. 18 ist eine der Form A ähnliche Schichtanordnung, bei der zusätzlich eine n-GaAs-Kugel 102 auf der Lichtstrahlaustrittsöffnung vorgesehen ist. Diese zusätzliche n-GaAs-Kugel 102 dient zur Fokussierung des in Richtung des Pfeils emittierten Lichts.

Die Form C in Fig. 18 ist eine der Form A ähnliche Schichtanordnung, bei der der Kontakt auf der Oberseite keine Öffnung aufweist und dementsprechend der Lichtstrahl seitlich in Richtung des Pfeils austritt.

Die Leuchtdiode wird beim Betrieb in Durchlaßrichtung vorgespannt, so daß die Ladungsträgerkonzentrationen größer als die Gleichgewichtskonzentrationen sind. Die bei der auftretenden Rekombination freiwerdende Energie wird in Form von Licht abgestrahlt.

Leuchtdioden gibt es in verschiedenen Farben, und zwar insbesondere in Infrarot, Rot, Orange, Gelb, Grün und Blau.

Es ist auch möglich, das von einer Leuchtdiode emittierte Licht farblich zu ändern, indem man dieses Licht zur Anregung einer photolumineszierenden Substanz verwendet. So kann man z. B. von GaAs-Leuchtdioden emittiertes Infrarotlicht in grünes Licht verwandeln. Dabei ist die Leuchtdiode vorteilhafterweise unmittelbar mit der photolumineszierenden Substanz überzogen.

Eine spezielle Modifikation der Leuchtdiode ist der Halbleiterlaser, bei dem Rekombinationseffekte nach vorheriger Überbesetzung des Leitungsbandes stimuliert werden.

Leuchtdioden werden beispielsweise als Anzeigebaulemente und als Bestandteile integrierter Festkörperlaser bezeichnet. Halbleiterlaser finden in Laserdisplays und vor allem in Laserdruckern ihre Anwendung. Bei allen diesen Anwendungen von bekannten Halbleiterlichtquellen steht ihre Eigenschaft als punktförmige Lichtquelle im Vordergrund.

Fig. 19 zeigt den typischen Aufbau einer Leuchtdiode in einem Plastikgehäuse als punktförmige Lichtquelle nach dem Stand der Technik.

In Fig. 19 bezeichnen Bezugszeichen 104 einen Anodenanschluß, 105 einen Kathodenanschluß, 106 einen Anschlußdraht, 107 einen Leuchtdiodenchip mit beispielsweise der Form A von Fig. 18, 108 eine Reflektorwanne und 109 ein Plastikgehäuse.

In den letzten Jahren seit etwa 1990 hat die LED-Technik Fortschritte hin zu höherer Leuchteffizienz (Lumen/Watt) vor allem im Bereich sichtbarer Wellenlängen gemacht.

Im Vergleich mit herkömmlichen Lichtquellen, wie z. B. Glühlampen mit oder ohne Edelgasfüllung, erreichen sogenannte superhelle LEDs eine wesentlich höhere Leuchteffizienz. Diese superhellen LEDs gibt es auf dem Markt insbesondere in den Farben Rot, Gelb, Hellgrün, Grün und Blau. Entwicklungen superheller LEDs werden momentan für blaues bis grünes Licht mit GaN und für gelbes bis rotes Licht mit AlInGaP intensiv betrieben.

Die Strahlleistung einer einzelnen LED ist jedoch begrenzt, und als Obergrenze lassen sich einige Watt angeben. Außerdem strahlen LEDs nur Licht in einem relativ schmalen Wellenlängenbereich ab, d. h. mit einer LED kann nur annähernd monochromatisches Licht mit relativ geringer Strahlleistung erzeugt werden.

Aus der DE-OS 23 15 709 ist eine Strahlung abgebende ebene Halbleiteranordnung mit hoher Strahlleistung bekannt. Diese bekannte Halbleiteranordnung weist einen Gehäusesockel, der zumindest an der der Halbleiteranordnung zugewandten Oberflächenseite isolierend ist, sowie eine strahlungsdurchlässige, die Halbleiteranordnung bedeckende Kunststofflinse auf. Auf dem Gehäusesockel ist eine größere Anzahl von Strahlung abgebenden Halbleiterbauelementen angeordnet, die entweder sämtlich hintereinander oder parallel zueinander geschaltet sind.

Aus der EP-A-0 390 479 ist eine LED-Clustereinheit für eine Anzeigeeinrichtung bekannt. Diese bekannte LED-Clustereinheit enthält eine Matrixanordnung von LEDs auf einer Platine, auf deren Rückseite Steckverbindungen angebracht sind. Auf der Abstrahlseite der LEDs ist eine röhrenförmige Abschirmungseinrichtung vorgesehen, um die LED-Cluster vor seitlich einfallendem Licht abzuschirmen, damit der Betrachter ein scharfes Bild von dem LED-Cluster wahrnehmen kann. Weiterhin soll die Abschirmungseinrichtung die LED-Cluster vor Verschmutzung und Beschädigung schützen.

Aufgabe der vorliegenden Erfindung ist es, eine verbesserte Beleuchtungsvorrichtung zu schaffen, welche Licht mit höherer Strahlleistung und/oder breitbandigeres Licht erzeugen kann.

Erfindungsgemäß wird die obige Aufgabe durch den Gegenstand des Anspruchs 1 gelöst.

Weiterhin sieht die vorliegende Erfindung die Verwendung der erfindungsgemäßen Beleuchtungsvorrichtung gemäß Anspruch 45 bis 48, 50 bis 53 und 55 vor.

Zusätzlich schafft die vorliegende Erfindung ein Verfahren zum Betreiben erfindungsgemäßen Beleuchtungsvorrichtung gemäß Anspruch 56.

Ferner liefert die vorliegende Erfindung ein Farblichtsystem mit der erfindungsgemäßen Beleuchtungsvorrichtung nach Anspruch 57.

Zu bevorzugende Weiterbildungen sind Gegenstand der jeweiligen Unteransprüche.

Die der vorliegenden Erfindung zugrundeliegende Idee besteht darin, eine Licht mit höherer Strahlleistung und/oder breitbandigeres Licht erzeugende Beleuchtungsvorrichtung aus mehreren punktförmigen Lichtquellen dadurch zu schaffen, daß die punktförmigen Lichtquellen ihr Licht in mindestens zwei unterschiedliche Richtungen abstrahlen, und dieses abgestrahlte Licht effizient gerichtet und/oder farblich gemischt wird. Dadurch können weitaus höhere optische Wirkungsgrade (Lumen/Watt), auch als Leuchteffizienz bezeichnet, als bei den oben genannten üblichen Beleuchtungsvorrichtungen erzielt werden.

Besonders vorteilhaft an der erfindungsgemäßen Beleuchtungsvorrichtung sind die hohe Lebensdauer, die hohe Leuchteffizienz, die geringe Temperaturerhöhung gegenüber der Umgebung, die Farboptimierbarkeit, die Modularität des abgestrahlten Lichts und die Einfachheit der Verpackung.

Im folgenden werden Ausführungsbeispiele der vorliegenden Erfindung unter Bezugnahme auf die begleitende Zeichnung näher beschrieben werden.

In der Zeichnung zeigen:

Fig. 1 eine Vorderansicht eines LED-Strahlers gemäß einer ersten bevorzugten Ausführungsform der vorliegenden Erfindung;

Fig. 2 eine Draufsicht des LED-Strahlers gemäß der ersten bevorzugten Ausführungsform der vorliegenden Erfindung;

Fig. 3 eine Vorderansicht einer beispielhaften LED-Haltestruktur für die erste bevorzugte Ausführungsform der vorliegenden Erfindung;

Fig. 4 eine Draufsicht der beispielhaften LED-Haltestruktur für die erste bevorzugte Ausführungsform der vorliegenden Erfindung;

Fig. 5 bis 7 beispielhafte Anordnungen der LED-Strahlerplatten im LED-Strahler gemäß der ersten bevorzugten Ausführungsform der vorliegenden Erfindung;

Fig. 8 eine Vorderansicht eines LED-Strahlrohrs gemäß einer zweiten bevorzugten Ausführungsform der vorliegenden Erfindung;

Fig. 9 eine Draufsicht des LED-Strahlrohrs gemäß der zweiten bevorzugten Ausführungsform der vorliegenden Erfindung;

Fig. 10 bis 13 beispielhafte Anordnungen der LED-Strahlerplatten im LED-Strahlrohr gemäß der zweiten bevorzugten Ausführungsform der vorliegenden Erfindung;

Fig. 14 eine Vorderansicht eines LED-Strahlers gemäß einer dritten bevorzugten Ausführungsform der vorliegenden Erfindung, bei dem das LED-Strahlrohr gemäß der zweiten bevorzugten Ausführungsform in einem Reflektor eingesetzt ist;

Fig. 15 eine Darstellung zur Flächenabschätzung für die Strahlerplatten der erfindungsgemäßen Beleuchtungsvorrichtung unter Verwendung von handelsüblichen LED-Chips;

Fig. 16 ein Farblichtelement eines Farblichtsystems gemäß einer vierten bevorzugten Ausführungsform der vorliegenden Erfindung mit einer Teilausschnittsvergrößerung der Draufsicht und des Querschnitts;

Fig. 17 ein elektrisches Blockschaltbild für das Farblichtsystem gemäß der vierten bevorzugten Ausführungsform der vorliegenden Erfindung;

Fig. 18 drei typische geometrische Formen A, B und C von Leuchtdioden nach dem Stand der Technik, die üblicherweise in Epitaxieverfahren hergestellt werden; und

Fig. 19 den typischen Aufbau einer Leuchtdiode in einem Plastikgehäuse als Punktlichtquelle nach dem Stand der Technik.

In den Figuren bezeichnen gleiche Bezugszeichen gleiche Komponenten, wovon eine wiederholte Beschreibung unterlassen wird.

Fig. 1 zeigt eine Vorderansicht eines LED-Strahlers gemäß einer ersten bevorzugten Ausführungsform der vorliegenden Erfindung.

In Fig. 1 bezeichnet Bezugszeichen 1 einen Strahlerplattenhalter, an dem eine oder mehrere Strahlerplatten 2 mit einer Vielzahl von darauf angebrachten LEDs 3 gehalten sind. Diese Anordnung befindet sich in einem Reflektor 4 zur homogenen Strahlmischung. Die LEDs 3 sind so in einer dreidimensionalen Anordnung auf der oder den Strahlerplatten 2 verteilt, daß das von ihnen emittierte Licht auf den Reflektor 4 auftrifft.

Der Reflektor 4 richtet das Licht der LEDs 3 zu seiner Austrittsöffnung, welche vorteilhafterweise eine lichtdurchlässige Abdeckung 5 aufweist.

Die LEDs 3 können gleiche oder unterschiedliche Wellenlängen aufweisen. Bei unterschiedlichen Wellenlängen der LEDs 3 kann durch entsprechende Ausgestaltung des Reflektors 4 als Diffusor zusätzlich eine homogene Farbmischung des Lichts mit unterschiedlichen Wellenlängen erreicht werden, um somit beispielsweise weißes Licht aus den drei Grundfarben Rot, Grün und Blau zu erhalten. Entsprechend der Verteilung der verschiedenen Wellenlängen sind auch beliebige andere Farbmischungen denkbar.

Die lichtdurchlässige Abdeckung 5 kann vorteilhafterweise eine Sammellinse zur Bündelung oder eine Zerstreuungslinse zur Zerstreuung der Lichtstrahlung und zur Einstellung des Abstrahlwinkels enthalten.

Der Reflektor 4 ist seinerseits in einem Reflektorkörper 5 gehalten. Am Fuß des Reflektorkörpers 5 ist vorzugsweise ein Reglerplatinenteil 6 mit sich nach außerhalb des Reflektorkörpers 5 erstreckenden Stromzufuhrkontakten 7 in einer Vergußmasse 8 eingebettet.

Die gesamte Gestalt des LED-Strahlrohrs gemäß der ersten bevorzugten Ausführungsform der vorliegenden Erfindung ist somit ähnlich wie die eines üblichen Halogenstrahlers.

Die Stromzufuhr kann über einen Strom- oder Spannungsregler, einen Gleichrichter bei Wechselstromanschluß, eine Transientenschutzschaltung oder eine Impulsansteuerschaltung erfolgen. Sämtliche derartige Regel- oder Steuerschaltungen können entweder auf dem Reglerplatinenteil 6 integriert oder separat außerhalb des LED-Strahlers vorgesehen sein.

Werden die LEDs 3 mit Strom versorgt, so fällt das von ihnen emittierte Licht auf den Reflektor 4 und wird homogen auf die Austrittsöffnung gerichtet bzw. zusätzlich farblich gemischt und gebündelt, so daß für den Betrachter des vom LED-Strahler abgestrahlten Lichtstrahls nicht mehr erkennbar ist, daß das Licht ursprünglich von einzelnen punktförmigen Halbleiterlichtquellen, z. B. den LEDs 3, herrührt.

Es gibt zahlreiche Möglichkeiten, verschiedene Untergruppen der Vielzahl der LEDs 3 elektrisch so anzusteuern, daß unterschiedliche Helligkeits-, Farb- oder Leuchtfrequenz-Modulationseffekte erzielt werden können, auf die weiter unten detailliert eingegangen werden wird.

Auch können die einzelnen LEDs mechanisch durch eine entsprechende Einrichtung in ihrer Anordnung verstellbar sein, um derartige Modulationseffekte zu erhalten.

Der LED-Strahler mit der dreidimensionalen LED-Anordnung gemäß der ersten bevorzugten Ausführungsform der vorliegenden Erfindung strahlt Licht mit höherer Strahlleistung und/oder breitbandigeres Licht als die bekannten Vorrichtungen mit flächigen LED-Anordnungen ab, und das Erfordernis großer Abstrahlflächen für große Strahlleistungen ist somit beseitigt.

Die nachstehende Tabelle 1 zeigt eine Übersicht über für die einzelnen Komponenten des LED-Strahlers gemäß der ersten bevorzugten Ausführungsform der vorliegenden Erfindung, der in Fig. 1 und 2 dargestellt ist, verwendbaren Materialien.

Tabelle 1: Materialien für die Komponenten des LED-Strahlers gemäß der ersten bevorzugten Ausführungsform der vorliegenden Erfindung

| Komponente               | Material                                                                                                                                                                     |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Reflektorkörper 9        | Kunststoffe, wie z.B. Plexiglas, Polycarbonat, Glas                                                                                                                          |
| Reflektor 4, Diffusor    | aufgedampfte Metalle, reflektierender Lack                                                                                                                                   |
| Abdeckung 5, Sammellinse | klare Kunststoffe, wie z.B. Plexiglas, Glas                                                                                                                                  |
| Platinenhalter 12        | Kunststoffe, Glas, Keramik (grüne Keramik ist gut bearbeitbar), Metalle                                                                                                      |
| Platine 10               | glasfaserverstärkter Kunststoff kupferbeschichtet (Surface-Mount-Technology), Keramik, z.B. $Al_2O_3$ (Dickschichttechnik), Glas mit Metallbeschichtung (Dünnschichttechnik) |

Fig. 2 zeigt eine Draufsicht des LED-Strahlers gemäß der ersten bevorzugten Ausführungsform der vorliegenden Erfindung.

Wie aus Fig. 2 erkennbar, befindet sich der Strahlerplattenhalter 1 bevorzugterweise an der Längsachse des Reflektors 4. Die Strahlerplatten 2 sind vorzugsweise eben und tragen an beiden zum Reflektor 4 gerichteten Wänden eine Vielzahl von LEDs 3, um so die dreidimensionale LED-Anordnung zu bilden.

Fig. 3 zeigt eine Vorderansicht einer beispielhaften LED-Haltestruktur für die erste bevorzugte Ausführungsform der vorliegenden Erfindung.

Die auf der Strahlerplatte 2 angebrachten LEDs 3 befinden sich ihrerseits auf handelsüblichen Platinen 10, worauf sie in Serienschaltung, Parallelschaltung oder einer Mischschaltung verschaltet sind. Die Platinen 10 sind mit der Regler-Elektronik und dem Anschluß-Platinenteil verbunden.

Fig. 4 zeigt eine Draufsicht der beispielhaften LED-Haltestruktur für die erste bevorzugte Ausführungsform der vorliegenden Erfindung.

Wie aus Fig. 4 ersichtlich, besteht die Strahlerplatte 2 bevorzugterweise aus einem plattenförmigen Platinenhalter 12, an dem beidseitig Platinen 10 mit den LEDs 3 mittels einer geeigneten Klebmasse 13 befestigt sind. Der

plattenförmige Platinenhalter 12 ist seinerseits mit dem Strahlerplattenhalter 1 auf eine geeignete Art und Weise, beispielsweise durch im Strahlerplattenhalter 1 vorgesehene Steckschlitzte, verbunden.

Auch der Reglerplatinenteil 6 kann genauso wie die Platinen 10 am plattenförmigen Platinenhalter 12 angebracht sein.

Die Fig. 5 bis 7 zeigen beispielhafte Anordnungen der LED-Strahlerplatten 2 im LED-Strahler gemäß der ersten bevorzugten Ausführungsform der vorliegenden Erfindung. 5

Die Anordnung gemäß Fig. 5 sieht zwei Strahlerplatten 2 mit jeweils zwei Platinen vor, welche in einem Winkel von  $180^\circ$  zueinander angeordnet sind. Berücksichtigt man, daß auch eine punktförmige Lichtquelle wie eine LED einen endlichen Strahlwinkel aufweist, so ermöglicht bereits diese einfach Anordnung, nahezu die gesamte Innenoberfläche des Reflektors 4 auszuleuchten. Allerdings ist die so erzielbare Strahlleistung des LED-Strahlers noch relativ gering. 10

Die Anordnung gemäß Fig. 6 sieht drei Strahlerplatten 2 mit jeweils zwei Platinen vor, welche in einem Winkel von  $120^\circ$  zueinander angeordnet sind. Eine derartige Anordnung bietet eine höhere Strahlleistung, denn hierbei wird die Innenoberfläche des Reflektors 4 stärker ausgeleuchtet.

Eine noch stärkere Ausleuchtung bietet die Anordnung gemäß Fig. 7, die vier Strahlerplatten 2 mit jeweils zwei Platinen vorsieht, welche in einem Winkel von  $90^\circ$  zueinander angeordnet sind. 15

Die Ausleuchtung läßt sich durch entsprechende Verkleinerung des Winkels zwischen den einzelnen Strahlerplatten 2 weiter steigern, doch muß man darauf achten, daß bei immer kleineren Winkeln störende optische und thermische Wechselwirkungen zwischen den einzelnen LEDs auftreten können.

Fig. 8 zeigt eine Vorderansicht eines LED-Strahlrohrs gemäß einer zweiten bevorzugten Ausführungsform der vorliegenden Erfindung. 20

In Fig. 8 bezeichnet Bezugszeichen 20 eine Platine mit einer Vielzahl von darauf angebrachten LEDs 3. Mehrere Platinen 20 mit den LEDs 3 sind so in einer dreidimensionalen Anordnung, die von einem Hüllrohr 24 umgeben ist, vorgesehen, daß das von ihnen emittierte Licht auf das Hüllrohr 24 auftrifft. Das Hüllrohr 24 läßt das Licht der LEDs 3 durch seinen lichtdurchlässigen Austrittsbereich nach außen durchtreten. 25

Vorteilhafterweise ist das Hüllrohr 24 zylinderförmig, und der Austrittsbereich verläuft ringsum auf dem Zylindermantel. Axial oberhalb und unterhalb der Platinen 20 ist bei dieser Anordnung vorzugsweise jeweils eine Reflektorscheibe 25 vorgesehen, die das Licht der LEDs 3 zum Austrittsbereich des Hüllrohrs 24 richtet.

Die LEDs 3 können gleiche oder unterschiedliche Wellenlängen aufweisen. Bei unterschiedlichen Wellenlängen der LEDs 3 kann durch entsprechende Ausgestaltung des Hüllrohrs 24 als Diffusor zusätzlich eine homogene Farbmischung des Lichts mit unterschiedlichen Wellenlängen erreicht werden, um somit beispielsweise weißes Licht aus den drei Grundfarben Rot, Grün und Blau zu erhalten. Entsprechend der Verteilung der verschiedenen Wellenlängen sind auch beliebige andere Farbmischungen denkbar. 30

Am oberen Ende des Hüllrohrs 24 ist vorzugsweise ein Hüllrohrdeckel vorgesehen, wobei die obere Reflektorscheibe 25 gleichzeitig diese Funktion übernehmen kann. 35

Am unteren Ende des Hüllrohrs 24 ist vorzugsweise ein Sockel 26 angebracht, der z. B. ein Schraub- oder Stecksockel ist. Im Sockel 26 ist vorzugsweise ein Reglerplatinenteil 27 mit sich zur Oberfläche des Sockels 26 erstreckenden Stromzufuhrkontakten 28 in einer Vergußmasse eingebettet.

Die gesamte Gestalt des LED-Strahlrohrs gemäß der zweiten bevorzugten Ausführungsform der vorliegenden Erfindung ist somit ähnlich wie die einer üblichen Glühbirne. 40

Die elektrische Ansteuerung und mechanische Verstellung des LED-Strahlrohrs gemäß der zweiten bevorzugten Ausführungsform der vorliegenden Erfindung können genauso wie bei der ersten Ausführungsform erfolgen.

Fig. 9 zeigt eine Draufsicht des LED-Strahlrohrs gemäß der zweiten bevorzugten Ausführungsform der vorliegenden Erfindung. 45

Wie aus Fig. 9 ersichtlich, ist an der Rückseite der Platinen 20 mit den LEDs 3 ein Platinenhalter 29 vorgesehen. Im hier gezeigten Beispiel sind vier Platinen 20 mit zum Austrittsbereich des Hüllrohrs 24 weisenden LEDs 3 im Winkel von  $90^\circ$  zueinander am entlang der Längsachse des Hüllrohrs 24 verlaufenden Platinenhalter 29 angebracht.

Die nachstehende Tabelle 2 zeigt eine Übersicht über für die einzelnen Komponenten des LED-Strahlers gemäß der zweiten bevorzugten Ausführungsform der vorliegenden Erfindung, der in Fig. 8 und 9 dargestellt ist, verwendbaren Materialien. 50

55

60

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Tabelle 2: Materialien für die Komponenten des LED-Strahlers gemäß der zweiten bevorzugten Ausführungsform der vorliegenden Erfindung

| Komponente            | Material                                                                                                                                  |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Hüllrohrdeckel        | Keramik, Glas, Metalle                                                                                                                    |
| Reflektorscheibe 25   | aufgedampfte Metalle, reflektierender Lack                                                                                                |
| Hüllrohr 24, Diffusor | Plexiglas, Glas                                                                                                                           |
| Platinenhalter 29     | Kunststoffe, Glas, Keramik (grüne Keramik ist gut bearbeitbar), Metalle                                                                   |
| Platinen 20           | GFK kupferbeschichtet (SMT), Keramik, z.B. $\text{Al}_2\text{O}_3$ (Dickschichttechnik), Glas mit Metallbeschichtung (Dünnschichttechnik) |

Fig. 10 bis 13 zeigen beispielhafte Anordnungen der LED-Strahlerplatten im LED-Strahlrohr gemäß der zweiten bevorzugten Ausführungsform der vorliegenden Erfindung.

Die Anordnung gemäß Fig. 10 sieht zwei Platinen 20 vor, welche in einem Winkel von  $180^\circ$  mit zueinander weisenden Rückseiten an einem flachen Platinenhalter 29 befestigt sind. Berücksichtigt man, daß auch eine punktförmige Lichtquelle wie eine LED einen endlichen Strahlwinkel aufweist, so ermöglicht bereits diese einfache Anordnung, nahezu die gesamte Innenoberfläche des Hüllrohrs 24 auszuleuchten. Allerdings ist die so erzielbare Strahlleistung des LED-Strahlers noch relativ gering.

Die Anordnung gemäß Fig. 11 sieht drei Platinen 20 vor, welche in einem Winkel von  $120^\circ$  mit zueinander weisenden Rückseiten an einem dreieckigen Platinenhalter 29 befestigt sind. Eine derartige Anordnung bietet eine höhere Strahlleistung, denn hierbei wird die Innenoberfläche des Hüllrohrs 24 stärker ausgeleuchtet.

Eine noch stärkere Ausleuchtung bietet die Anordnung gemäß Fig. 12, die vier Platinen 20 vorsieht, welche in einem Winkel von  $90^\circ$  mit zueinander weisenden Rückseiten an einem viereckigen Platinenhalter 29 befestigt sind.

Eine noch stärkere Ausleuchtung bietet die Anordnung gemäß Fig. 13, die acht Platinen 20 vorsieht, welche sternförmig mit zueinander weisenden Rückseiten an einem kreuzförmigen Platinenhalter 29 befestigt sind.

Ebenso wie bei der ersten Ausführungsform läßt sich die Ausleuchtung durch entsprechende Verkleinerung des Winkels zwischen den einzelnen Strahlerplatten 2 weiter steigern, doch muß man darauf achten, daß bei immer kleineren Winkeln störende optische und thermische Wechselwirkungen zwischen den einzelnen LEDs auftreten können.

Fig. 14 zeigt eine Vorderansicht eines LED-Strahlers gemäß einer dritten bevorzugten Ausführungsform der vorliegenden Erfindung, bei dem das LED-Strahlrohr gemäß der zweiten bevorzugten Ausführungsform, das in Fig. 8 und 9 dargestellt ist, in einen Reflektor eingesetzt ist.

In Fig. 14 bezeichnet Bezugszeichen 30 allgemein das LED-Strahlrohr gemäß der zweiten bevorzugten Ausführungsform, das in Fig. 8 und 9 dargestellt ist. Das LED-Strahlrohr 50, welches im gezeigten Beispiel vier quadratisch angeordnete Platinen mit LEDs enthält, ist in einen Reflektor 31 eingesetzt. Der Reflektor 31 weist dazu an seinem Fuß einen entsprechenden Reflektorkörper 32 auf, in den das LED-Strahlrohr 30 vorzugsweise eingeschraubt oder eingesteckt ist.

Wie bei der ersten Ausführungsform richtet der Reflektor 31 das Licht des LED-Strahlrohrs 30 zu seiner Austrittsöffnung, welche vorteilhafterweise eine lichtdurchlässige Abdeckung 33 aufweist.

Die lichtdurchlässige Abdeckung 33 kann vorteilhafterweise eine Sammellinse zur Bündelung oder eine Zerstreuungslinse zur Zerstreuung der Lichtstrahlung und zur Einstellung des Abstrahlwinkels enthalten.

Die Stromversorgung des LED-Strahlrohrs 30 erfolgt über Stromzufuhrkontakte 34 an der Unterseite des Reflektorkörpers 32.

Bei der dritten Ausführungsform gemäß Fig. 14 kann der Strahl nach dem Mischen der Farbkomponenten am Hüllrohr erneut ausgerichtet werden, was die Homogenität des Strahls noch weiter verbessert.

Die elektrische Ansteuerung und mechanische Verstellung des LED-Strahlrohrs gemäß der dritten bevorzugten Ausführungsform der vorliegenden Erfindung kann genauso wie bei der ersten und zweiten Ausführungsform erfolgen.

Fig. 15 zeigt eine Darstellung zur Flächenabschätzung für die Strahlerplatten der erfindungsgemäßen Beleuchtungsvorrichtung unter Verwendung von handelsüblichen LED-Chips.

Unter Verwendung von handelsüblichen LED-Chips mit Abmessungen von größer  $0,5 \text{ mm} \times 0,5 \text{ mm}$  kann eine lineare Anordnung von drei LED-Chips (Nr. 1–3) mit zugehörigen Leiterbahnen auf einer Fläche von ca.  $8,50 \text{ mm} \times 4,55 \text{ mm}$  untergebracht werden.

Zwei derartige nebeneinanderliegende lineare Anordnungen von  $2 \times 3$  LED-Chips (Nr. 1–3 und 4–6) benötigen eine Fläche von ca.  $8,50 \text{ mm} \times 7,55 \text{ mm}$ , und drei derartige nebeneinanderliegende lineare Anordnungen

gen von  $3 \times 3$  LED-Chips (Nr. 1—3, 4—6 und 7—9) benötigen eine Fläche von ca. 8,50 mm  $\times$  11,20 mm.

Je nach vorhandenem Platz können die Strahlerplatinen sowohl verbreitert als auch verlängert werden und die Strahlleistung erhöht werden. Allerdings wird man eine Erweiterung in der dritten Dimension, wenn möglich, vorziehen, um kein Einbußen an Kompaktheit hinnehmen zu müssen.

Die nachstehende Tabelle 3 zeigt Techniken zur Herstellung von Strahlerplatinen für verschiedene Bauformen von LEDs.

Tabelle 3: Techniken zur Herstellung von Strahlerplatinen für verschiedene Bauformen von LEDs

| Bauform der LED                       | Herstellungstechnik                                                                     |
|---------------------------------------|-----------------------------------------------------------------------------------------|
| Chip-LED (nicht gekapselt)            | Chip- and Wire-Technik (Kleben der Chips mit Leitleber und Anschließen mit Bondtechnik) |
| SM-Chip-LED und SM-Lampen (gekapselt) | Kupfer-SM-Technik und Dickschichttechnik auf Keramiksubstrat, Reflowlöten               |

Die überragenden Vorteile der erfindungsgemäßen Beleuchtungsvorrichtung gegenüber herkömmlichen Glühfadenlampen eröffnen ihr eine große Reihe von zukünftigen Einsatzmöglichkeiten.

Zu den Einsatzmöglichkeiten zählen insbesondere batteriegetriebene Leuchten, wie z. B. Taschenlampen, Studiostrahler (bisher Halogenstrahler), Scheinwerfer oder sonstige Leuchten von Kraftfahrzeugen und Fahrrädern, UV- und Infrarot-Leuchten.

Des weiteren sind auch Verwendungen als gepulste Leuchten für Blaulicht, Gelblicht etc. von Einsatzfahrzeugen und für Blitzlampen in der Phototechnik oder Stroboskopie denkbar.

Der Stand der Technik in der LED-Herstellung und insbesondere die günstige Preisentwicklung von roten, gelben, grünen und blauen LEDs in Großserienherstellung lassen Anwendungen

- für den Einsatz im KFZ-Bereich als Brems- und Rücklicht oder Blinkerlicht;
- für den Einsatz im Straßenverkehr als Ampel- oder Warnlicht; und
- für den Einsatz in der optischen Datenspeichertechnik und Datenübertragungstechnik

als unmittelbar bevorstehend erscheinen.

Durch integrierte Steuerschaltungstechnik in Verbindung mit LEDs on Chip wird die Kombination LEDs plus Steuerelektronik zu höchster Baugruppenminiaturisierung führen und neue Maßstäbe in der Beleuchtungssystemtechnik setzen.

Beispielsweise eignet sich die erfindungsgemäße Beleuchtungsvorrichtung hervorragend als Bestandteil eines Farblichtsystems zur dynamischen Farblichtgestaltung in Räumen.

Fig. 16 zeigt ein Farblichtelement eines solchen Farblichtsystems gemäß einer vierten bevorzugten Ausführungsform der vorliegenden Erfindung mit einer Teilausschnittsvergrößerung der Draufsicht und des Querschnitts.

Im gezeigten Beispiel sind der Strahlerplatinenhalter und die Strahlerplatinen in einem Keramikblock 40 mit viereckigem Querschnitt integriert, auf dessen vier Seitenflächen die LEDs 43 angebracht und die Leiterbahnen 45 für die Verbindungen aufgebracht sind.

Auf jeder Seitenfläche des Keramikblocks 40 ist eine Lochplatte 42 mit vorzugsweise runden Löchern derart angebracht, daß in den so entstehenden seitlichen Vertiefungen jeweils ein Rot-Grün-Blau-LED-Tripel, das mit R, G, B bezeichnet ist, eingesetzt ist. Die Vertiefungen können zum Schutz der sich darin befindlichen LEDs und Leiterbahnen mit einem transparenten Kunststoff 47 ausgegossen sein.

Die einzelnen LED-Chips sind elektrisch so angeschlossen, daß Rot, Grün und Blau getrennt anzusteuern sind, und zwar entweder für jedes LED-Tripel oder zumindest für alle farblich einander entsprechenden LEDs. Der so aufgebaute Rot-Grün-Blau-LED-Strahler braucht deshalb mindestens vier elektrische Anschlüsse, nämlich je einen für Rot, Grün, Blau und Masse.

Das Licht der angesteuerten LEDs fällt wie bei der ersten Ausführungsform auf einen den Keramikblock 40 mit den LEDs umgebenden Reflektor 44, welcher das Licht zu seiner vorzugsweise mit einer lichtdurchlässigen Abdeckung 45 versehenen Austrittsöffnung richtet.

Die lichtdurchlässige Abdeckung 45 kann vorteilhafterweise eine Sammellinse zur Bündelung oder eine Zerstreuungslinse zur Zerstreuung der Lichtstrahlung und zur Einstellung des Abstrahlwinkels enthalten.

Der Keramikblock 40 ragt in einen unterhalb des Reflektors 44 vorgesehenen Sockel 46, welcher mehrere Funktionen aufweisen kann.

Zunächst haltet der Sockel 46 den so aufgebauten Rot-Grün-Blau-LED-Strahler, und weiterhin enthält er vorteilhafterweise die Elektronik des Farblichtelements, welche im Zusammenhang mit Fig. 17 weiter unten näher erläutert werden wird.

Die Teilausschnittsvergrößerung zeigt in einer Draufsicht und im Querschnitt die LED-Chip-Tripel Nr. 1, 2

und 3 und deren Leiterbahnen 45 in vergrößerter Darstellung. Die Dezimalzahlen in der Teilausschnittsvergrößerung geben typische Größenordnungen der LED-Chips, der Vertiefungen und der Dicke der Lochplatte in Millimetern wieder.

- Fig. 17 zeigt ein elektrisches Blockschaltbild für das Farblichtsystem gemäß der vierten bevorzugten Ausführungsform der vorliegenden Erfindung.

In Fig. 17 ist der Sockel 46 mit seinen externen Signalleitungen, der in ihm beinhalteten Elektronik und dem darauf angebrachten Rot-Grün-Blau-LED-Strahler dargestellt. Zur Vereinfachung sei hier angenommen, daß alle farblich einander entsprechenden LEDs seriell geschaltet sind.

- Extern werden dem Sockel 46 beispielsweise eine Gleichstrom- und eine Wechselstrom-Versorgungsspannungsleitung 50 bzw. 51, eine Busleitung 52 zur Verbindung mit einer zentralen Prozeessoreinheit, eine Infrarot-Steuerleitung 53 von einem daran angebrachten Infrarot-Empfänger zur separaten drahtlosen Umschaltung der Programme eines Farbprozessors 56 und eine Sensoranschlußleitung 54, z. B. für ein Mikrofon, zugeführt.

- Intern enthält der Sockel 46 einen Spannungswandler 55 für Wechselstromanschluß, den Farbprozessor 56, einen einseitigen Analog-/Digital-Wandler 57 zum Umwandeln der Signale, die über die Sensoranschlußleitung 54 übermittelt werden, drei Digital-/Analog-Wandler 61, 62, 63 mit optionell drei sich daran anschließenden Stromtreibern 64, 65, 66 zur Ansteuerung der drei LED-Serienschaltungen entsprechend den drei Grundfarben Rot, Grün und Blau.

Kernstück der sich im Sockel 46 befindlichen Elektronik ist der Farbprozessor 56. Er führt die Steuerung des R,G,B-LED-Strahlers mittels der ihm zugeführten Signale und seinen eigenen Programmen durch.

- Als Basissteuerfunktion erfolgt beispielsweise ein gepulster Strombetrieb mit auf die verwendeten LEDs optimiertem Tastverhältnis. Dies bewirkt, daß der optische Wirkungsgrad der LEDs gegenüber dem Dauerstrombetrieb verbessert wird und schützt sie außerdem vor Überlastung.

Der Basissteuerfunktion können unterschiedliche programmierbare Funktionen überlagert werden, und zwar beispielsweise

- einzelne LED-Farben Ein- und Ausschalten;
- Verändern der Pulsrate einer oder mehrerer LED-Serienschaltungen;
- zeitliche Helligkeits-, Farb- oder Frequenzmodulationen.

- Über die Busleitung 52 oder die Infrarot-Steuerleitung 53 können die im Farbprozessor gespeicherten Programme extern ein- und ausgeschaltet werden oder sogar modifiziert werden.

Die Sensorleitung 54 ermöglicht beispielsweise zeitliche Helligkeits-, Farb- oder Frequenzmodulationen in Abhängigkeit von durch das Mikrofon aufgenommenen Signalen (Lichtorgelprinzip).

- Die nachstehende Tabelle 4 listet einige steuerbare Funktionen des erfindungsgemäßen R, G, B-LED-Strahlers auf.

Tabelle 4: einige steuerbare Funktionen des erfindungsgemäßen R, G, B-LED-Strahlers

| Funktion                                                                                                                  |
|---------------------------------------------------------------------------------------------------------------------------|
| feststehende R, G, B - Farben                                                                                             |
| feststehende Mischfarben aus R, G, B gemischt                                                                             |
| langsam (fließend) sich ändernde Mischfarben aus R, G, B gemischt                                                         |
| schnell (abrupt) sich ändernde Mischfarben aus R, G, B gemischt                                                           |
| pulsierende R, G, B -Farben                                                                                               |
| pulsierende Mischfarben aus R, G, B gemischt                                                                              |
| Wiederholung speziell gewählter Farben                                                                                    |
| veränderliche Helligkeit                                                                                                  |
| durch externe Sensorsignale (z.B. Mikrofon) gesteuerte Modulation (z.B. Klang-/Farb-Zuordnung oder Lautstärken-Zuordnung) |

- Einzelne R, G, B-LED-Strahler können mit unterschiedlichen Ansteuerungsmöglichkeiten zu einem zentralgesteuerten Farblichtsystem zusammengefaßt werden. Dabei können den einzelnen R, G, B-LED-Strahlern spezielle Funktionen im System zugeordnet werden. Die Steuerung kann extern sowohl über die Busleitung als über eine Fernbedienung erfolgen.

Vorzugsweise werden über die Busleitung Programmbefehle des Zentralprozessors an die einzelnen R, G, B-LED-Strahler übermittelt, und mit der Fernbedienung werden einzelne Funktionen bestimmter Farbprozessoren aktiviert oder deaktiviert.

Ein solches Farblichtsystem läßt vielseitige Verwendungsmöglichkeiten erkennen, denn jeder R, G, B-LED-Strahler ist eine komplette Funktionseinheit.

Bespielsweise können mit dem erfindungsgemäßen elektronischen, prozessorgesteuerten Farblichtsystem ohne zusätzlichen mechanischen Aufwand Objekte in Räumen oder Räume an sich in den verschiedensten Arten angestrahlt oder ausgeleuchtet werden.

Anwendungsmöglichkeiten finden sich insbesondere in

- Ausstellungsräumen für Kunstgegenstände, z. B. Bildergalerien oder Museen;
- Ausstellungsräumen für technische oder kommerzielle Gegenstände, z. B. Messen;
- technisch genutzten Räumen, z. B. Fotolabors; und
- in Studios und Wohnräumen zur individuellen Farblichtgestaltung.

Das erfindungsgemäße Farblichtsystem macht bisher verwendete aufwendige Farbfiltersteuerungen, welche bei den üblichen Farblichtsystemen, die Farblicht aus Weißlicht gewinnen, vollkommen überflüssig und trägt somit wesentlich zur Rationalisierung derartiger Systeme bei.

#### Patentansprüche

##### 1. Beleuchtungsanordnung mit:

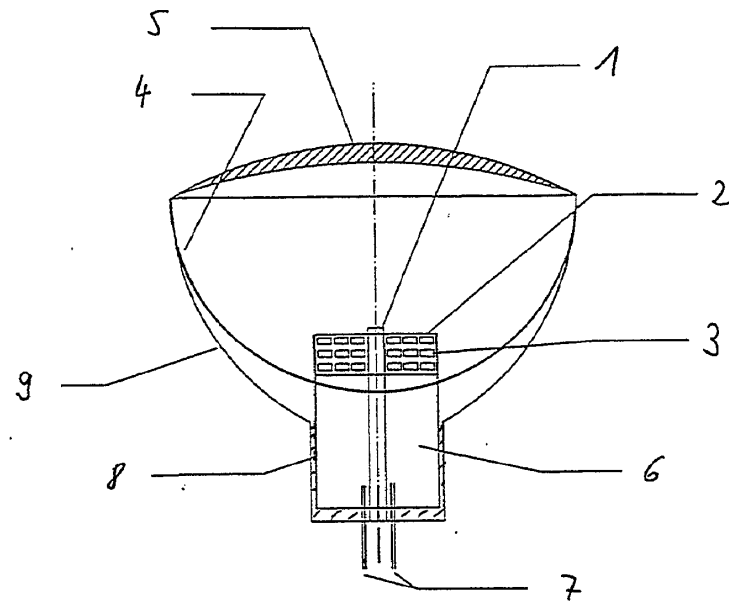
- a) einer Mehrzahl von im wesentlichen punktförmigen Lichtquelleneinrichtungen, die jeweils Licht in einer bevorzugten Richtung abstrahlen;
  - b) einer Halteinrichtung, um diese punktförmigen Lichtquelleneinrichtungen in einer im wesentlichen vorgegebenen räumlichen Zuordnung zueinander zu halten, wobei diese räumliche Zuordnung derart gewählt ist, daß wenigstens zwei dieser punktförmigen Lichtquelleneinrichtungen ihr Licht in unterschiedliche Richtungen abstrahlen; und
  - c) einer optischen Einrichtung, welche die Charakteristik des von diesen punktförmigen Lichtquelleneinrichtungen abgestrahlten Lichts verändert.
2. Beleuchtungsanordnung nach Anspruch 1, dadurch gekennzeichnet, daß die optische Einrichtung eine Richteinrichtung enthält, die das von den punktförmigen Lichtquelleneinrichtungen ausgestrahlte Licht in eine vorbestimmte Richtung richtet.
3. Beleuchtungsanordnung nach Anspruch 2, dadurch gekennzeichnet, daß die Richteinrichtung das von den punktförmigen Lichtquelleneinrichtungen ausgestrahlte Licht durch Reflexion in die vorbestimmte Richtung richtet.
4. Beleuchtungsanordnung nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, daß die optische Einrichtung eine Mischeinrichtung enthält, die das von den punktförmigen Lichtquelleneinrichtungen ausgestrahlte Licht farblich mischt.
5. Beleuchtungsanordnung nach Anspruch 4, dadurch gekennzeichnet, daß die Mischeinrichtung das von den punktförmigen Lichtquelleneinrichtungen ausgestrahlte Licht durch diffuse Transmission mischt.
6. Beleuchtungsanordnung nach Anspruch 4 oder 5, dadurch gekennzeichnet, daß die Mischeinrichtung das von den punktförmigen Lichtquelleneinrichtungen ausgestrahlte Licht durch diffuse Reflexion mischt.
7. Beleuchtungsanordnung nach einem der vorhergehenden Ansprüche, gekennzeichnet durch eine Bündelungseinrichtung zum Bündeln des durch die optische Einrichtung veränderten Lichts.
8. Beleuchtungsanordnung nach einem der vorhergehenden Ansprüche, gekennzeichnet durch eine Zerstreuungseinrichtung zum Zerstreuen des durch die optische Einrichtung veränderten Lichts.
9. Beleuchtungsanordnung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß jeweils eine Mehrzahl der punktförmigen Lichtquelleneinrichtungen ihr Licht in die gleiche Richtung abstrahlt.
10. Beleuchtungsanordnung nach Anspruch 9, dadurch gekennzeichnet, daß eine jeweilige Mehrzahl von punktförmigen Lichtquelleneinrichtungen, die ihr Licht in die gleiche Richtung abstrahlt, auf einer ebenen Platte angebracht ist.
11. Beleuchtungsanordnung nach Anspruch 10, dadurch gekennzeichnet, daß eine Mehrzahl von ebenen Platten mit einer jeweiligen Mehrzahl von punktförmigen Lichtquelleneinrichtungen vorgesehen ist.
12. Beleuchtungsanordnung nach Anspruch 11, dadurch gekennzeichnet, daß eine Gruppe von zwei ebenen Platten vorgesehen ist, die so Rücken an Rücken an einem Träger angeordnet sind, daß die darauf angebrachten punktförmigen Lichtquelleneinrichtungen ihr Licht in zwei entgegengesetzte Richtungen abstrahlen.
13. Beleuchtungsanordnung nach Anspruch 12, dadurch gekennzeichnet, daß mehrere winkelmäßig gegeneinander versetzte Gruppen von jeweils zwei ebenen Platten vorgesehen sind, wobei die zwei Platten einer Gruppe jeweils so Rücken an Rücken an einem Träger angeordnet sind, daß die darauf angebrachten punktförmigen Lichtquelleneinrichtungen ihr Licht in zwei entgegengesetzte Richtungen abstrahlen.
14. Beleuchtungsanordnung nach Anspruch 13, dadurch gekennzeichnet, daß zwei Gruppen vorgesehen sind, die um 180° winkelmäßig gegeneinander versetzt sind.
15. Beleuchtungsanordnung nach Anspruch 13, dadurch gekennzeichnet, daß drei Gruppen vorgesehen sind, die um 120° winkelmäßig gegeneinander versetzt sind.
16. Beleuchtungsanordnung nach Anspruch 13, dadurch gekennzeichnet, daß vier Gruppen vorgesehen sind, die um 90° winkelmäßig gegeneinander versetzt sind.
17. Beleuchtungsanordnung nach Anspruch 13, dadurch gekennzeichnet, daß n Gruppen vorgesehen sind, die um 360°/n winkelmäßig gegeneinander versetzt sind, wobei n eine natürliche Zahl größer als vier ist.



18. Beleuchtungsvorrichtung nach Anspruch 11, dadurch gekennzeichnet, daß drei ebene Platten vorgesehen sind, die so an einem dreieckigen Träger angeordnet sind, daß die darauf angebrachten punktförmigen Lichtquelleneinrichtungen ihr Licht in eine von drei um 120° winkelmäßig versetzte Richtungen abstrahlen.
19. Beleuchtungsvorrichtung nach Anspruch 11, dadurch gekennzeichnet, daß vier ebene Platten vorgesehen sind, die so an einem quadratischen Träger angeordnet sind, daß die darauf angebrachten punktförmigen Lichtquelleneinrichtungen ihr Licht in eine von vier um 90° winkelmäßig versetzte Richtungen abstrahlen.
20. Beleuchtungsvorrichtung nach Anspruch 11, dadurch gekennzeichnet, daß acht ebene Platten vorgesehen sind, die so an einem sternförmigen Träger angeordnet sind, daß die darauf angebrachten punktförmigen Lichtquelleneinrichtungen ihr Licht in eine von acht entsprechenden Richtungen abstrahlen.
21. Beleuchtungsvorrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die optische Einrichtung eine Reflektoreinrichtung enthält, die das von den punktförmigen Lichtquelleneinrichtungen abgestrahlte Licht reflektiert.
22. Beleuchtungsvorrichtung nach Anspruch 21, dadurch gekennzeichnet, daß die Reflektoreinrichtung das von den punktförmigen Lichtquelleneinrichtungen abgestrahlte Licht diffus reflektiert.
23. Beleuchtungsvorrichtung nach Anspruch 21 oder 22, dadurch gekennzeichnet, daß die Reflektoreinrichtung gekrümmt ist und die punktförmigen Lichtquelleneinrichtungen innerhalb des konkaven Bereichs der Krümmung angeordnet sind.
24. Beleuchtungsvorrichtung nach einem der Ansprüche 21 bis 23, dadurch gekennzeichnet, daß die Bündelungseinrichtung oder Zerstreuungseinrichtung eine in der Abstrahlöffnung der Reflektoreinrichtung angebrachte Linseneinrichtung ist.
25. Beleuchtungsvorrichtung nach einem der Ansprüche 21 bis 24, dadurch gekennzeichnet, daß die Reflektoreinrichtung in einer Reflektorhalterung untergebracht ist.
26. Beleuchtungsvorrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß eine Regel- und/oder Steuerelektronik vorgesehen ist.
27. Beleuchtungsvorrichtung nach Anspruch 26, dadurch gekennzeichnet, daß die Regel- und/oder Steuerelektronik in der Reflektorhalterung untergebracht ist.
28. Beleuchtungsvorrichtung nach Anspruch 26 oder 27, dadurch gekennzeichnet, daß sich die Regel- und/oder Steuerelektronik auf einer Platine befindet, die mit einer Vergußmasse vergossen ist.
29. Beleuchtungsvorrichtung nach Anspruch 28, dadurch gekennzeichnet, daß die Platine über sich durch die Reflektorhalterung nach außen erstreckende Stromzufuhrkontakte mit einer Stromquelle verbindbar ist.
30. Beleuchtungsvorrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die optische Einrichtung eine lichtdurchlässige Hülleinrichtung enthält, die die punktförmigen Lichtquelleneinrichtungen umgibt.
31. Beleuchtungsvorrichtung nach Anspruch 30, dadurch gekennzeichnet, daß die lichtdurchlässige Hülleinrichtung das von den punktförmigen Lichtquelleneinrichtungen abgestrahlte Licht diffus durchläßt.
32. Beleuchtungsvorrichtung nach Anspruch 30 oder 31, dadurch gekennzeichnet, daß die lichtdurchlässige Hülleinrichtung rohrförmig ist.
33. Beleuchtungsvorrichtung nach Anspruch 32, dadurch gekennzeichnet, daß in der Hüllrohreinrichtung axial oberhalb und/oder axial unterhalb der punktförmigen Lichtquelleneinrichtungen eine Reflektoreinrichtung vorgesehen ist.
34. Beleuchtungsvorrichtung nach Anspruch 32 oder 33, dadurch gekennzeichnet, daß auf einer Seite der Hülleinrichtung ein Hüllrohrdeckel vorgesehen ist.
35. Beleuchtungsvorrichtung nach einem der Ansprüche 32 bis 34, dadurch gekennzeichnet, daß auf einer Seite der Hülleinrichtung eine Anschlußsocketeinrichtung vorgesehen ist.
36. Beleuchtungsvorrichtung nach Anspruch 35, dadurch gekennzeichnet, daß die Regel- und/oder Steuerelektronik in der Anschlußsocketeinrichtung untergebracht ist.
37. Beleuchtungsvorrichtung nach Anspruch 35 oder 36, dadurch gekennzeichnet, daß die Anschlußsocketeinrichtung einen Schraubsockel enthält.
38. Beleuchtungsvorrichtung nach Anspruch 35 oder 36, dadurch gekennzeichnet, daß die Anschlußsocketeinrichtung einen Stecksockel enthält.
39. Beleuchtungsvorrichtung nach einem der Ansprüche 30 bis 38, dadurch gekennzeichnet, daß die Hülleinrichtung mit den von ihr umgebenden punktförmigen Lichtquelleneinrichtungen in einer gekrümmten Reflektoreinrichtung innerhalb des konkaven Bereichs der Krümmung angebracht ist.
40. Beleuchtungsvorrichtung nach Anspruch 39, dadurch gekennzeichnet, daß die Bündelungseinrichtung oder Zerstreuungseinrichtung eine an der Abstrahlöffnung der gekrümmten Reflektoreinrichtung angebrachte Linseneinrichtung ist.
41. Beleuchtungsvorrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die punktförmigen Lichtquelleneinrichtungen Halbleiterlichtquellen sind.
42. Beleuchtungsvorrichtung nach Anspruch 41, dadurch gekennzeichnet, daß die Halbleiterlichtquellen Leuchtdioden umfassen.
43. Beleuchtungsvorrichtung nach Anspruch 41 oder 42, dadurch gekennzeichnet, daß die Halbleiterlichtquellen Halbleiterlaser umfassen.
44. Beleuchtungsvorrichtung nach einem der vorhergehenden Ansprüche, gekennzeichnet durch eine Zuordnungs-Änderungseinrichtung zum Ändern der vorgegebenen räumlichen Zuordnung der punktförmigen Lichtquelleneinrichtungen.
45. Verwendung einer Beleuchtungsvorrichtung nach einem der Ansprüche 1 bis 44 in einer batteriegetriebenen Leuchte.

46. Verwendung einer Beleuchtungsanordnung nach einem der Ansprüche 1 bis 44 in einem Studiostrahler.  
 47. Verwendung einer Beleuchtungsanordnung nach einem der Ansprüche 1 bis 44 in einem Kraftfahrzeug.  
 48. Verwendung einer Beleuchtungsanordnung nach einem der Ansprüche 1 bis 44 an einem Fahrrad.  
 49. Verwendung nach Anspruch 47 oder 48 als Scheinwerfer, als Rücklicht, als Blinklicht, als Instrumentenlicht oder als Einsatzlicht. 5  
 50. Verwendung einer Beleuchtungsanordnung nach einem der Ansprüche 1 bis 44 in einer UV- oder Infrarot-Leuchte.  
 51. Verwendung einer Beleuchtungsanordnung nach einem der Ansprüche 1 bis 44 in einer Blitzleuchte.  
 52. Verwendung einer Beleuchtungsanordnung nach einem der Ansprüche 1 bis 44 in einer Stroboskopie-Leuchte. 10  
 53. Verwendung einer Beleuchtungsanordnung nach einem der Ansprüche 1 bis 44 in einer Verkehrsleuchte.  
 54. Verwendung nach Anspruch 53 als Ampellicht oder als Warnlicht.  
 55. Verwendung einer Beleuchtungsanordnung nach einem der Ansprüche 1 bis 44 in der Datenspeichertechnik oder Datenübertragungstechnik. 15  
 56. Verfahren zum Betreiben einer Beleuchtungsanordnung nach einem der Ansprüche 1 bis 44 mit mindestens einem der Schritte:  
     i) selektives elektrisches Ansteuern vorbestimmter punktförmiger Lichtquelleneinrichtungen zum Erzielen einer Helligkeitsmodulation;  
     ii) selektives elektrisches Ansteuern vorbestimmter punktförmiger Lichtquelleneinrichtungen zum Erzielen einer Farbmodulation; 20  
     iii) selektives elektrisches Ansteuern vorbestimmter punktförmiger Lichtquelleneinrichtungen zum Erzielen einer Leuchtfrequenzmodulation.  
 57. Farblichtsystem mit mindestens einer Beleuchtungsanordnung gemäß einem der Ansprüche 1 bis 44 und einer Steuerelektronik zum Ausführen mindestens einer der Funktionen: 25  
     i) selektives elektrisches Ansteuern vorbestimmter punktförmiger Lichtquelleneinrichtungen zum Erzielen einer Helligkeitsmodulation;  
     ii) selektives elektrisches Ansteuern vorbestimmter punktförmiger Lichtquelleneinrichtungen zum Erzielen einer Farbmodulation;  
     iii) selektives elektrisches Ansteuern vorbestimmter punktförmiger Lichtquelleneinrichtungen zum Erzielen einer Leuchtfrequenzmodulation. 30  
 58. Farblichtsystem nach Anspruch 57, dadurch gekennzeichnet, daß jede einzelne Beleuchtungsanordnung über eine eigene darin integrierte Steuerelektronik verfügt.  
 59. Farblichtsystem nach Anspruch 58, dadurch gekennzeichnet, daß die jeweilige Steuerelektronik einen Farbprozessor enthält. 35  
 60. Farblichtsystem nach Anspruch 59, dadurch gekennzeichnet, daß die Farbprozessoren über eine Busleitung mit einem Zentralprozessor verbunden sind.  
 61. Farblichtsystem nach Anspruch 59 oder 60, dadurch gekennzeichnet, daß die Farbprozessoren drahtlos ansteuerbar sind. 40

Hierzu 9 Seite(n) Zeichnungen



\* Fig. 1

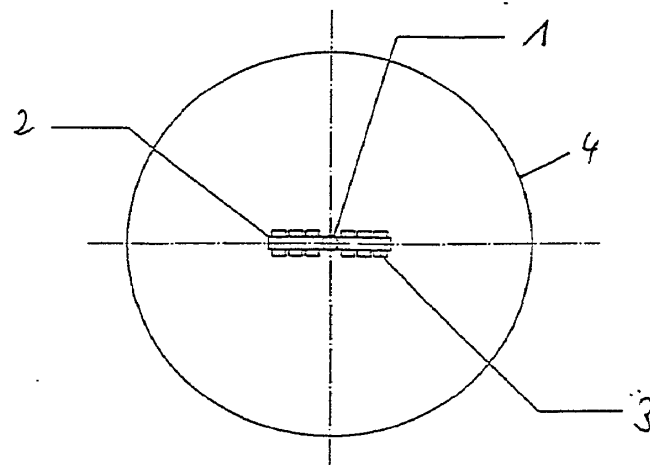


Fig. 2

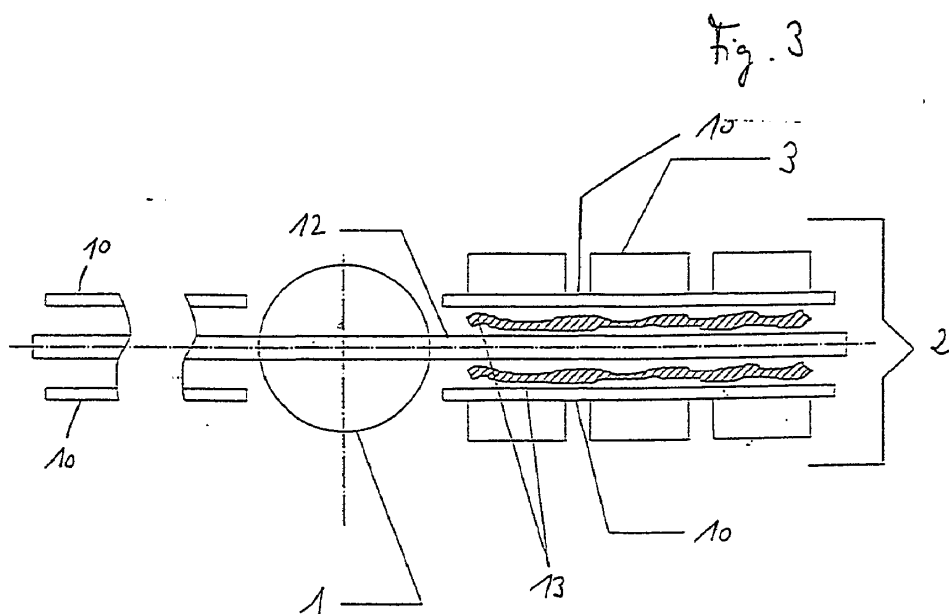
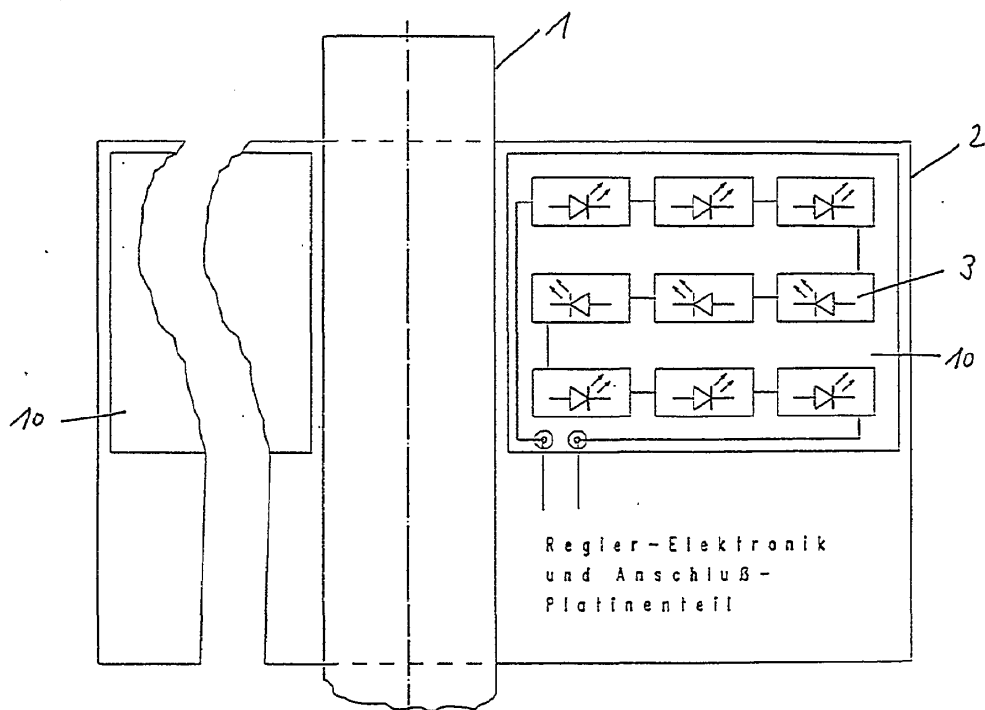


Fig. 4

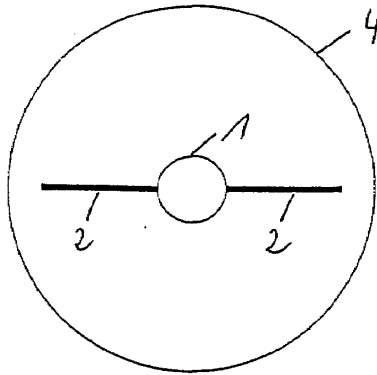


Fig. 5

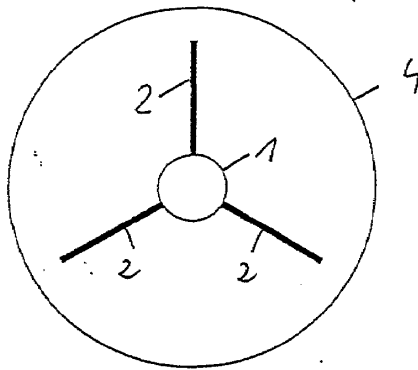


Fig. 6

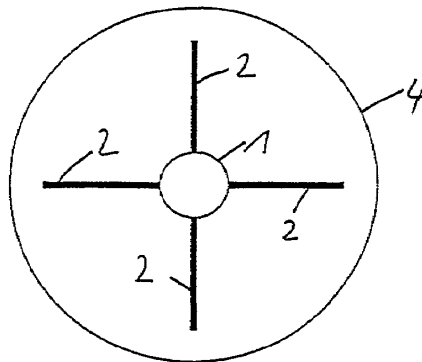
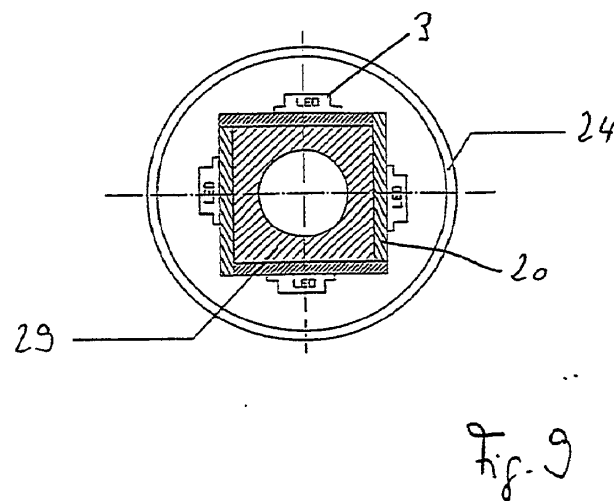
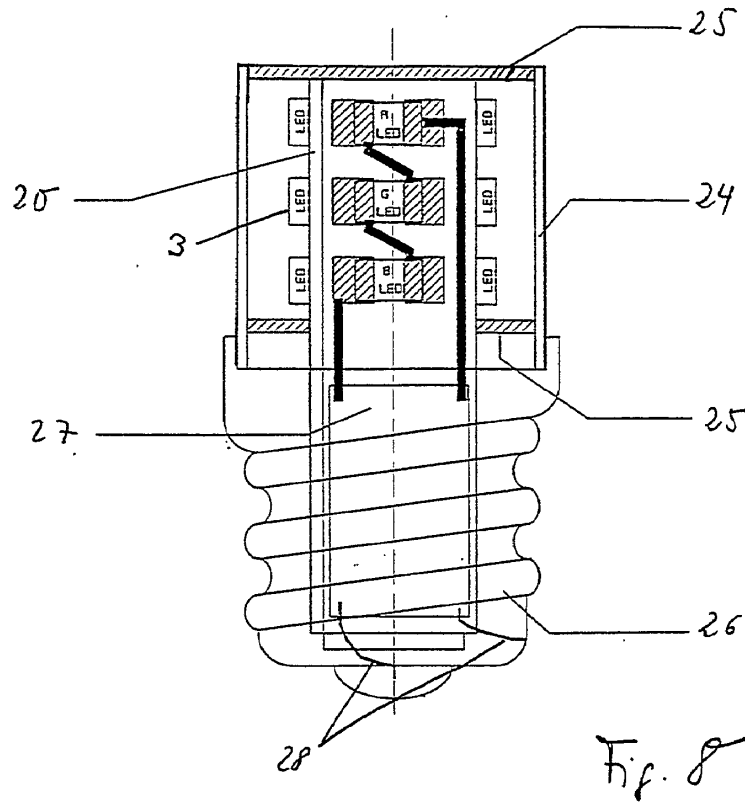


Fig. 7



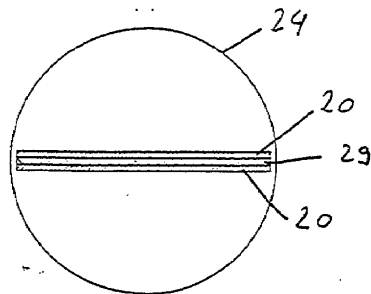


Fig. 10

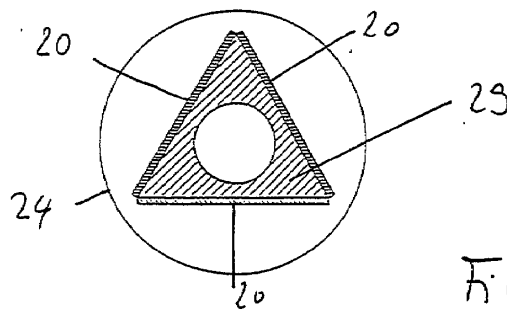


Fig. 11

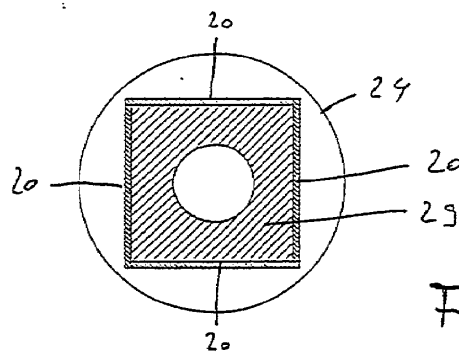


Fig. 12

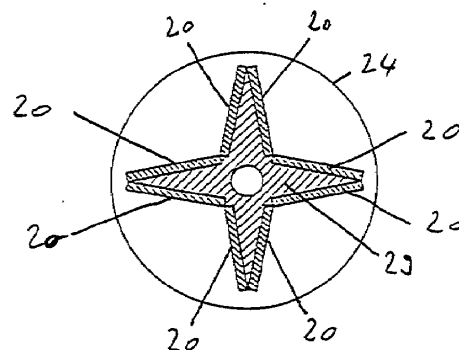


Fig. 13

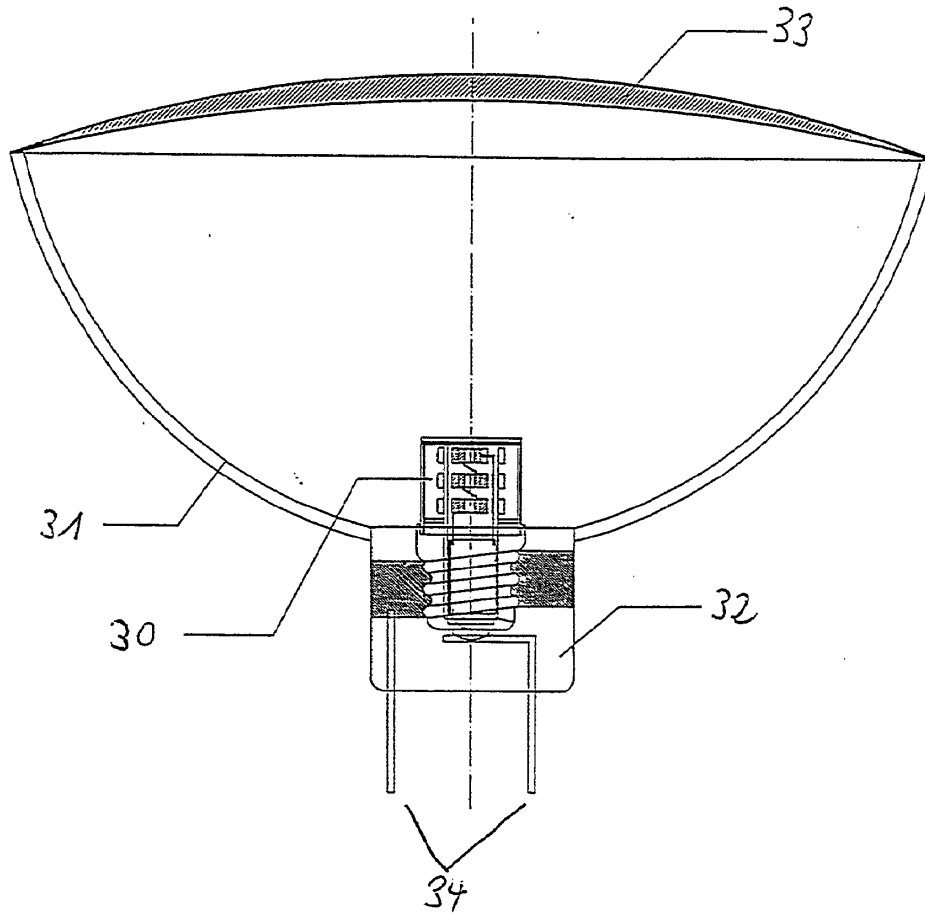


Fig. 14

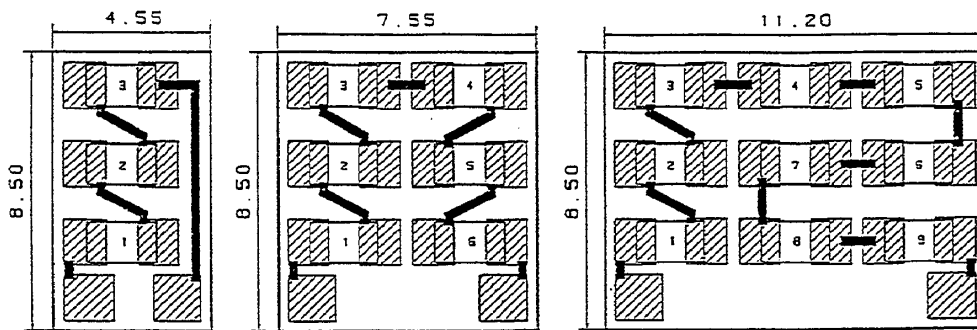


Fig. 15

702 051/374



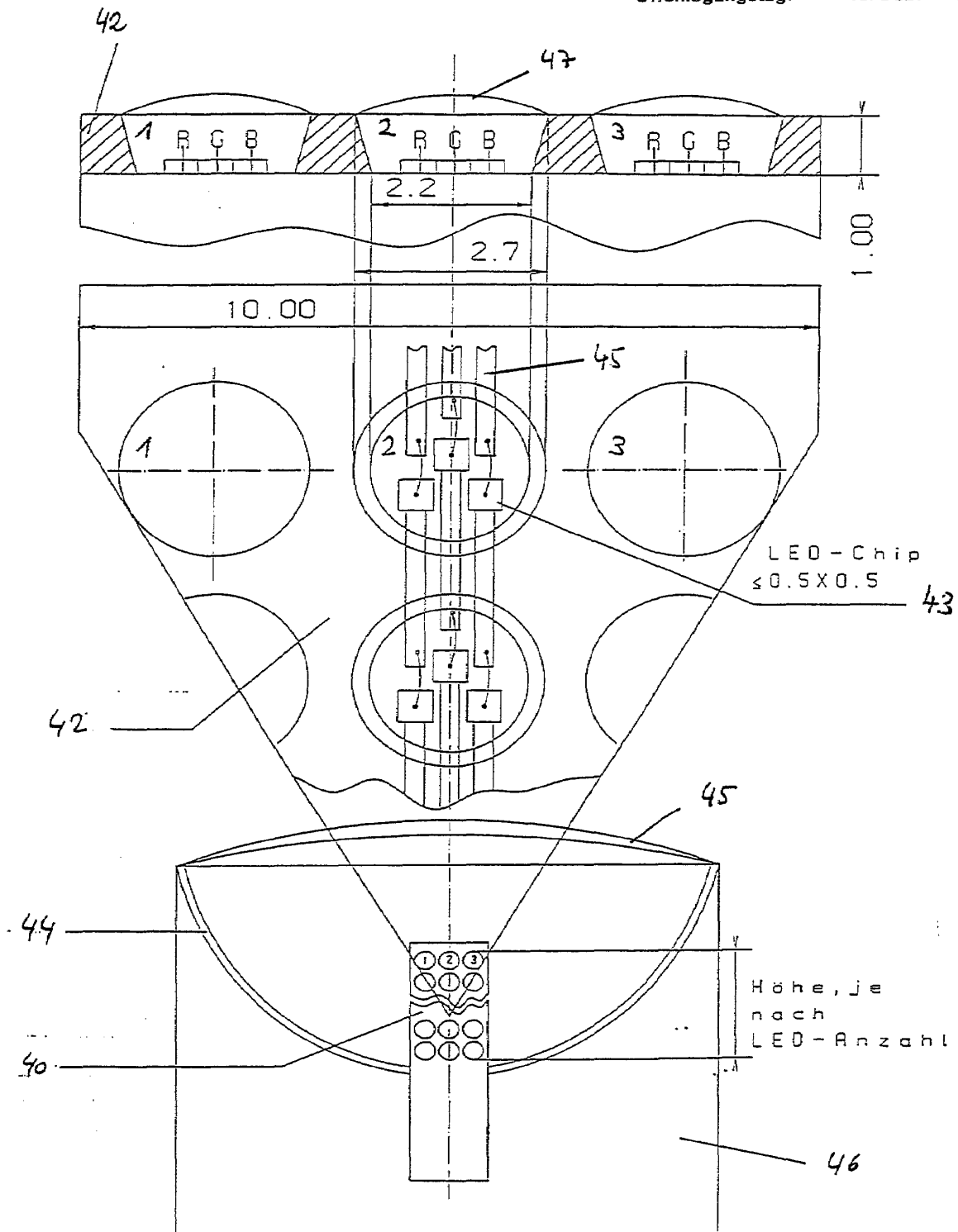


Fig. 16

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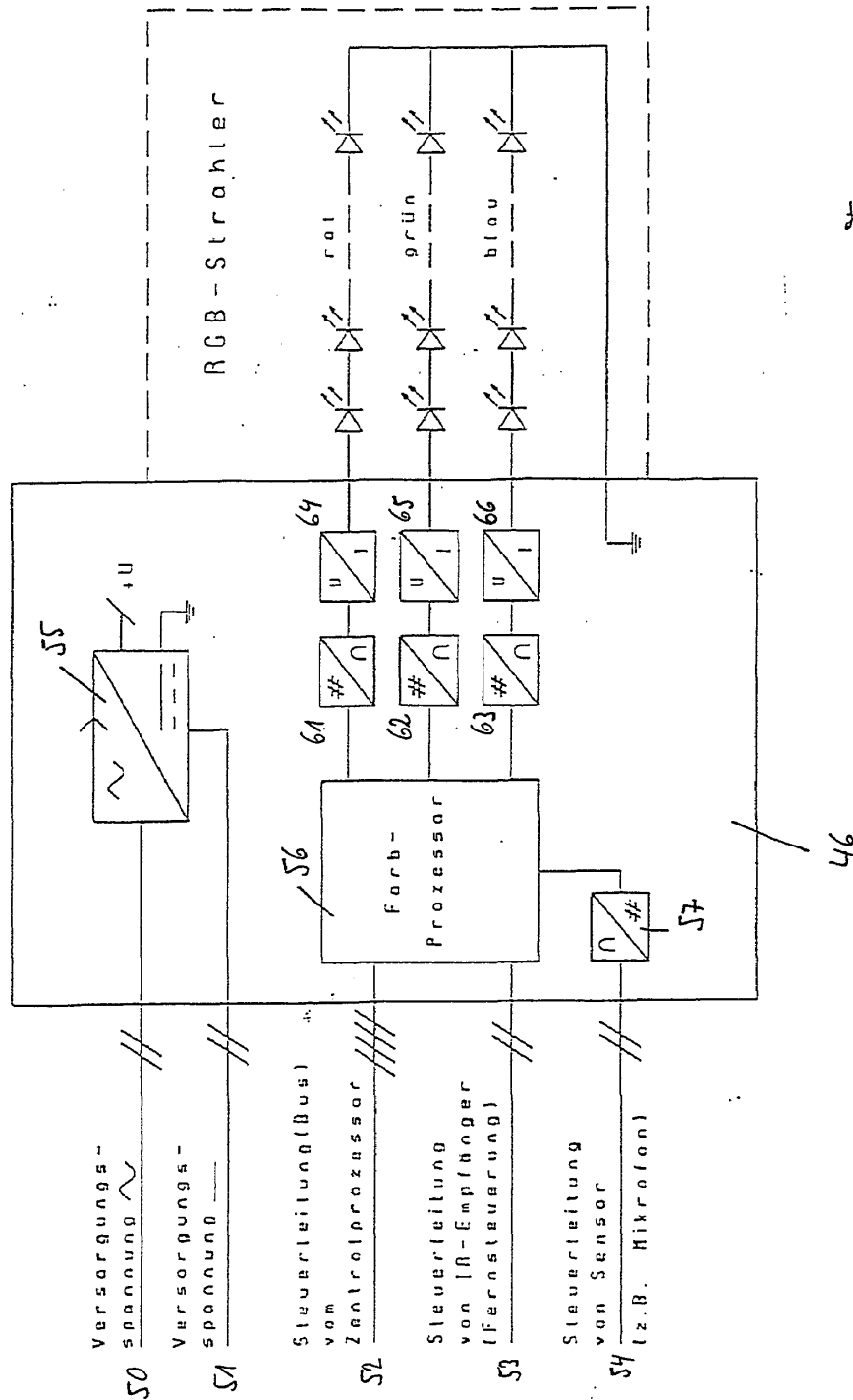
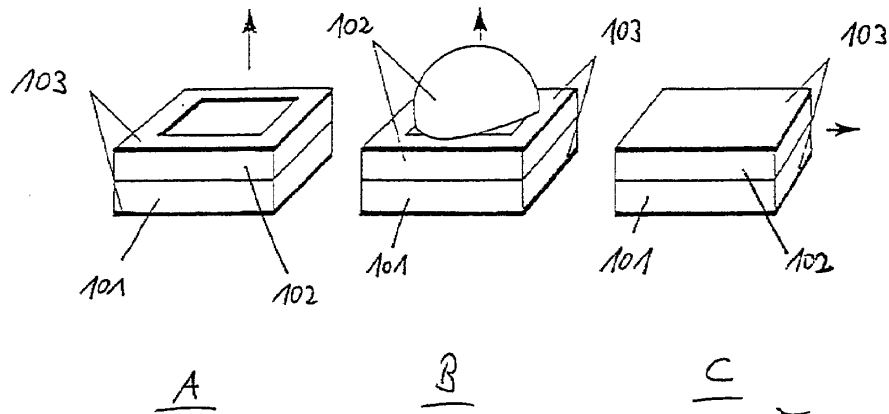


Fig. 17



C Fig. 18

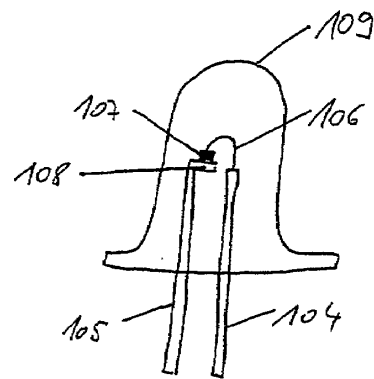


Fig. 19



**Espacenet**

## Bibliographic data: DE 19624087 (A1)

LED illumination apparatus for colour system

**Publication date:** 1997-12-18

**Inventor(s):** PIMPL WENDELIN [DE] +

**Applicant(s):** PIMPL WENDELIN [DE] +

**Classification:**

- **international:** **B60Q1/26; F21K99/00;** (IPC1-7): B62J6/00; F21M7/00; F21Q3/00; F21S1/00; F21S5/00; G03B15/02; H01L33/00; H05B33/00
- **European:** B60Q1/26L; F21K99/00S

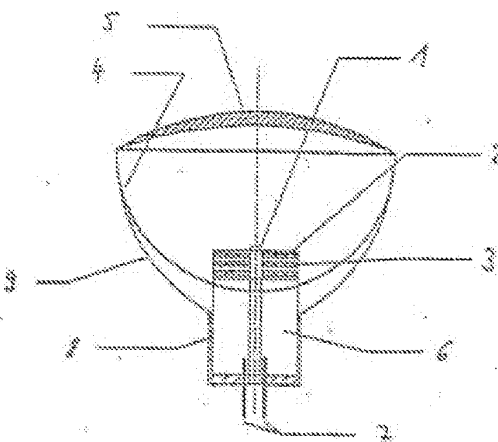
**Application number:** DE19961024087 19960617

**Priority number(s):** DE19961024087 19960617

**Cited documents:** DE3436154 (C2) DE4321823 (A1) DE4311937 (A1) DE3929477 (A1) [View all](#)

### Abstract of DE 19624087 (A1)

The apparatus includes several punctiform light sources and a holder. The sources are formed by LEDs, each radiating light in a preferred direction. The LEDs are held in a preset spatial arrangement by a holder, which secures that at least two LEDs radiate the light in different directions. An optical device changes the characteristic of the light radiated by the LEDs. It contains a light directioning device for the LED light, using preferably reflection for light directioning in a preset direction. The optical device may comprise a mixer for mixing the colour of the radiated light by diffuse transmission.



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European Patent Office  
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Publication number: **0 632 511 A2**

(12)

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**H01L 25/16**

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**30.06.93 JP 35786/93**  
**30.06.93 JP 162262/93**

(43) Date of publication of application:  
**04.01.95 Bulletin 95/01**

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**Arita-shi,**  
**Wakayama 649-03 (JP)**

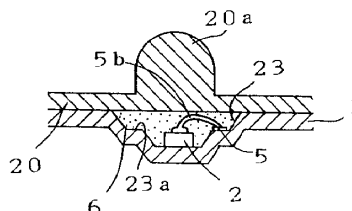
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(54) **A light emitting diode aggregate module and a method for manufacturing a light emitting diode aggregate module.**

(57) A light emitting diode aggregate module comprises a metallic base printed circuit board (1), light emitting diode chips (2) each of which is mounted on a bottom section of each hollow section (23) formed on the metallic base printed circuit board (1), electronic parts (3) which are mounted on the metallic base printed circuit board (1) and outside of the hollow sections (23), bonding wires (5b) each of which interconnects the light emitting diode (2) and each land section (5) which is formed in the hollow section (23), soft resin layers (6) each of which covers corresponding light emitting diode chip (2) and corresponding bonding wire (5b), and a lens board (20) which is formed in one body on the metallic base printed circuit board (1) by insert molding of translucent resin and has lens sections

(20a) each of which corresponds to each light emitting diode chip (2).

FIG. 23



EP 0 632 511 A2

## Background of The Invention

The present invention relates to a light emitting diode (hereinafter referred to as LED) aggregate module and a method for manufacturing an LED aggregate module. More particularly, the present invention relates to an LED aggregate module which includes a printed circuit board on which LED chips are mounted, and lens sections made of translucent resin each of which is disposed in correspondence to each LED chip, and a method for manufacturing the LED aggregate module.

## Description of The Related Arts

From the past, an  $n \times n$  matrix type LED aggregate module or  $1 \times n$  line type LED aggregate module, both LED aggregate module including a printed circuit board on which LED chips are mounted and a lens board having plural lenses which lens board is stuck to the printed circuit board with adhesive agent and the like, for example, are known as LED aggregate modules.

When the LED aggregate module having the above-mentioned arrangement is manufactured, after mounting the LED chips and electronic parts on the printed circuit board, the lens board is stuck to the printed circuit board by interposing the adhesive agent and the like therebetween. Therefore, bubbles are highly possible to be contained in an adhesive layer made of the adhesive agent and the like. Further, a special matching operation is necessary, of optical axes of light emitting sections each section has the LED chip as a main portion and of the lens sections of the lens board, when the lens board is stuck to the printed circuit board. Therefore, sticking operation requires much labor, and it is raised its possibility that matching of optical axes is not performed with sufficiently high accuracy. Furthermore, the lens board is resin shrinked after the forming thereof. Therefore, warp is generated in the LED aggregate module based upon a difference between thermal expansion of the printed circuit board and thermal expansion of the lens board, when the lens board is stuck to the printed circuit board.

To eliminate the disadvantages above-mentioned, a method for manufacturing an LED aggregate module is thought, to omit sticking of the lens board using the adhesive agent and the like by mounting the LED chips and electric parts on the printed circuit board, thereafter forming the lens board by insert molding in which the printed circuit board is set in a die having lens cavities each corresponding to each LED chip, and molten resin is inserted in the die.

When the LED aggregate module is manufactured using the method above-mentioned, the in-

ventors have found that peeling has occurred of land sections of a printed circuit from the printed circuit board, each of the land section being electrically connected the electric parts, and that breaking of the printed circuit caused by the peeling has occurred, and that yield of the LED aggregate module is lowered. More particularly, a force applied to the LED chip caused by the flow of the resin is not so great because a cross-sectional area is great of flowing of the resin concerning to the LED chip being rightly opposite to the lens portion of the lens board, that is the LED chip being located at a position which is covered by the lens cavity portion of the die. But, a force applied to the electric parts such as resistor caused by the flow of the resin is remarkably great because a cross-sectional area is extremely small of flowing of the resin in relationship to the electric parts being mounted at a position not to influence optical characteristics of the LED chip and lens section. Especially, when the electric parts is large in size, the force becomes especially great, peeling of the land section from the printed circuit board has occurred at a fairly high possibility, and breaking of a printed circuit pattern has occurred at peripheral portion of resist layer for covering the printed circuit pattern with respect to the printed circuit pattern extending from the land section in a direction at a nearly right angle to a flowing direction of the resin.

Also, when the LED aggregate module is manufactured employing the method to omit sticking of the lens board using the adhesive agent and the like by mounting the LED chips and electric parts on the printed circuit board, thereafter forming the lens board by the insert molding, the inventors have found that a part of electric parts (most of electric parts in the worst case) are damaged, and that yield of the LED aggregate module is lowered.

Further, when the method for manufacturing an LED aggregate module is executed, to omit sticking of the lens board using the adhesive agent and the like by mounting the LED chips and electric parts on the printed circuit board, thereafter forming the lens board by the insert molding, depression generated in case that the resin for insert forming is cooled so as to be solidified (shrinkage of the resin generated in case that the resin for insert molding is cooled so as to be solidified) applies pulling force to a bonding wire so that connection of the bonding wire with the land section and/or the LED chip is obstructed in the worst case. Therefore, plural hollows are formed on the printed circuit board, each LED chip is mounted in each hollow, silicon resin for protecting the bonding wire is previously (prior to insert molding) stored in the hollows so as to cover the whole extent of the bonding wire which interconnects the LED chip and the land section.

When the LED aggregate module is manufactured by forming the lens board in one body by the insert molding above-mentioned, as is illustrated in Fig. 25, a top face of the silicon resin 116 for protecting the bonding wire cannot be a flat face concerning to a part of the bonding wire 115 being projected upward from a surface of the printed circuit board 111, central portion (exactly speaking, a portion corresponding to a portion of the bonding wire locating at the uppermost position) of the top face of the silicon resin 116 becomes upward projecting condition, so that the silicon resin 116 itself has lens characteristics. Consequently, lens characteristics of the finally obtained LED aggregate module cannot be determined to be predetermined lens characteristics, because the lens characteristics of the silicon resin 116 is superimposed to the lens characteristics of the lens section 117a of the lens board 117, even when design of the forming die, selection of the resin for insert molding and the like are performed so that the lens section 117a of the lens board 117 having a desired lens characteristics, the lens board 117 being formed in one body by the insert molding. Meanwhile, the lens characteristics of the silicon resin 116 vary depending upon the degree of curvature, the projecting distance upward from the top face of the printed circuit board 111, and the like of the bonding wire 115, therefore, it is almost impossible that the lens characteristics of the lens section 117a of the lens board 117 formed in one body is designed by previously taking the lens characteristics of the silicon resin 116 into consideration. Consequently, the lens characteristics of the finally obtained LED aggregate module cannot be determined to be the desired lens characteristics.

Though, the silicon resin 116 is partially projected upward, the depression of the resin for insert molding is easily concentrated at the upward projecting portion of the silicon resin 116, so that a space 116a is formed at the concentrated portion of the depression which space 116a cannot be ignored in optical characteristics (refer to Fig. 26). And, at the boundary of the space 116a and the silicon resin 116, difference of index of refraction differs from the designed value to some degree, so that a part of emitted light from the LED chip 113 is reflected at the boundary face causing intensity of the emitted light from the LED aggregate module to be decreased.

Further, a method for manufacturing the LED aggregate module is known in which method the electric parts mounted on the printed circuit board are molded in one body with the printed circuit board (refer to Japanese Patent Publication Tokukouhei 3-60189). Fig. 27 is a cross-section view schematically illustrating a conventional molding method to the mounted LED chip on the print-

ed circuit board as an example of the electric parts. As is illustrated in Fig. 27, in the conventional method for molding, a pair of through holes 118a and 118b are formed in the printed circuit board 111 in neighbouring of each LED chip 113 mounted on one face 111a of the printed circuit board 111, the LED chips 113 together with the printed circuit board 111 are surrounded by an upper die 124b which has plural cavities 124c each having predetermined lens shape and corresponding to each LED chip 113, and a lower die 124a which has cavities 124d each acting as basin corresponding to each cavity 124c in the other face 111b side of the printed circuit board 111. Resin 119 for molding is injected from the cavity 124d side of the lower die 124a, the injected synthetic resin 119 is guided interior the cavities 124c having the lens shape via the through holes 118a and 118b so as to mold the LED chips 113 in one body.

Though the method for molding injects the resin 119 from rear side ward of the printed circuit board, and the resin 119 flows into the cavities 124c at the lens side via the two through holes 118a and 118b, the resin 119 is confluent in an effective portion of the lens so as to generate line shaped nonuniformity (weld line) w, as is illustrated in Fig. 28. The weld line causes defectiveness in penetration characteristics of light, defectiveness in appearance and the like.

On the contrary to the method, when the resin 119 is directly injected from the cavity 124c side for lens, the resin 119 strongly contacts the side face of the cavities 124c so as to generate a flow mark of the resin remaining in line shape in the effective portion of the lens which is similar to the weld line, and so as to be filled the resin in strap shape and in buckling condition so that a surface structure which is in strap shape and in squeezed condition (jetting) is generated. Therefore, disadvantages as similar as of the above-mentioned arise.

Further, the  $n \times n$  matrix type LED aggregate module is manufactured, for example, as is illustrated in Fig. 29, by mounting  $n \times n$ -number of LED chips on the printed circuit board in matrix pattern. In the LED aggregate module illustrated in Fig. 29, all land sections for electrically connecting each LED chip with printed circuit on the printed circuit board are disposed in right side with respect to the corresponding LED chip. Therefore, bonding wires each interconnecting each LED chip and the corresponding land section extend in the right side with respect to corresponding LED chips.

The  $1 \times n$  line type LED aggregate module is manufactured, for example, as is illustrated in Fig. 30, by mounting  $n$ -number of LED chips on the printed circuit board in line pattern. In the LED

aggregate module illustrated in Fig. 30, all land sections for electrically connecting each LED chip with printed circuit on the board are disposed in this side with respect to the corresponding LED chips. Therefore, bonding wires each interconnecting each LED chip and the corresponding land section extend in this side with respect to corresponding LED chips.

When the LED aggregate modules having the above-mentioned arrangement are employed, though relative positions of the land sections with respect to corresponding LED chips are constant, moving patterns for bonding are made uniform when each LED chip and the corresponding land section is interconnected by the bonding wire using an industrial robot and the like, so that the LED aggregate modules can be manufactured easily.

In the LED aggregate modules having the arrangement above-mentioned, though directions of the bonding wires with respect to corresponding LED chips are the same to one another, a part of light outgone in the same direction (a direction in which bonding wires exist) to one another among the light outgone from all LED chips is screened by the bonding wires, so that luminous intensity distribution characteristics of the LED aggregate module as a whole is spoiled.

Specifically, when the LED aggregate module is stood vertically, and on a plane which is apart from the center of the LED aggregate module by 3 meters in horizontal direction, locations 5° and 10° upward from the center of the LED aggregate module with respect to the horizontal line, locations 5° and 10° downward from the center of the LED aggregate module with respect to the horizontal line, locations 5° and 10° rightward from the center of the LED aggregate module with respect to the horizontal line, locations 5° and 10° leftward from the center of the LED aggregate module with respect to the horizontal line are selected, and luminosity at each location is measured, luminous energy at locations 5° and 10° rightward are smaller than that of at locations 5° and 10° leftward with the LED aggregate module illustrated in Fig. 29 employed, while luminous energy at locations 5° and 10° downward are smaller than that of at locations 5° and 10° upward with the LED aggregate module illustrated in Fig. 30 employed.

Therefore, it is difficult in the LED aggregate module which is required functioning as plane illuminant that the LED aggregate module is functioned as a plane illuminant with sufficiently uniformity in a higher level.

#### Summary of The Invention

It is an object of this invention to improve yield of LED aggregate module.

It is another object of this invention to form a lens board directly on a printed circuit board by forming in one body of resin and to decrease breakage of electronic parts to zero.

It is a further object of this invention to extremely decrease peeling of a land section to which the electronic parts is electrically connected, from the printed circuit board, and breaking of a printed circuit pattern.

It is still another object of this invention to facilitate fitting of the lens board to the printed circuit board, and to improve reliability by lessening warp of the printed circuit board.

It is a still further object of this invention to improve quality of lens sections of the lens board which is formed in one body to the printed circuit board.

It is yet another object of this invention to obtain a predetermined lens characteristics, and to suppress lowering of outgone light intensity.

It is an yet further object of this invention to function the LED aggregate module as a plane illuminant with sufficiently uniformity in a higher level.

An LED aggregate module according to this invention comprises;

a metallic base printed circuit board having plural hollows thereon, a predetermined printed pattern, LED chips each mounted in a bottom portion of the hollow, and electronic parts each mounted at a location which is different from a mounted location of the LED chip,

a soft resin layer for surrounding peripheral portion of the LED chips,

a protection layer made of resin for covering a part or entirety of the electronic parts, and

a lens board which is formed by injection of translucent resin into a molding die and is disposed in contact on a surface of the printed circuit board, the lens board covering the plural LED chips and the electronic parts, and having lens sections projecting forward at a location corresponding to each LED chip.

As to the LED aggregate module, a light radiated from the LED chip is effectively guided forward by the hollow and the lens section. And, disadvantages are prevented by the soft resin layer from occurring, the disadvantages possibly being applied to the LED chips when the lens sections are formed. Further, a force is escaped by the protection layer, the force possibly be applied to the electronic parts when the translucent resin is injected in the molding die. Furthermore, though adhesive agent is no need, bubbles are not possibly contained between the printed circuit board and the lens board, and no special matching operation is needed, of optical axes of light emitting sections each section having the LED chip as a main portion



and of the lens sections.

It is preferable that a rectangular shaped printed circuit board is employed, claw sections are formed in one body at edge sections excluding corner sections of the lens board, and fixation of the printed circuit board and the lens board is performed by the claws. In this case, shrinking force of the lens board in its diagonal direction after forming is released at the corner sections of the lens board, so that the warp of the LED aggregate module is suppressed.

It is also preferable that the printed circuit board further has through holes, and fixation of the printed circuit board and the lens board is performed by going round the resin for lens board to the opposite face side of the printed circuit board through the through holes. In this case, incorporation of the lens board and the printed circuit board in one body is performed simultaneously with the manufacturing of the lens board. In this case, it is more preferable that the through holes are formed in neighbouring of the mounted section of each LED chip, and the LED chips are substantially surrounded by the resin for lens board.

Also, it is preferable that the protection layer for the electronic parts is formed in a shape which reduces resistance against the flowing of the translucent resin for lens board when the translucent resin is injected in the molding die. In this case, resistance is reduced when the translucent resin for lens board is injected so that the injection of the translucent resin in the molding die is smoothly performed, and that the electronic parts are extremely decreased the degree of influence caused by the flowing of the translucent resin.

Further, it is preferable that the printed circuit extending from the land section among the printed circuit on the printed circuit board, is provided in a direction of flowing of the translucent resin when the translucent resin is injected in the molding die, the land section being electrically connected the electronic parts at least. In this case, even when a force in peeling direction is applied to the land section by being influenced by the flowing of the translucent resin when the translucent resin is injected in the molding die, a twisting force is prevented from functioning to the printed circuit so that the possibility of breaking of the printed circuit is extremely reduced.

Furthermore, it is preferable that the soft resin layer for covering peripheral portion of the LED chip is housed in the hollow so as to make the surface of the soft resin flat and coincident with the surface of the printed circuit board. In this case, depression generated when the translucent resin for lens board is solidified, is prevented from locally concentrating, so that a disadvantage is prevented from occurring that the lens characteristics

is degraded by the depression. In this case, it is further preferable that a step section is provided in a predetermined location of each hollow.

Furthermore, it is preferable that the land sections on the printed circuit board each is connected to an upper electrode of each LED chip by a bonding wire are provided, extending directions of the bonding wire with respect to the LED chip are determined at least two directions, a number of the bonding wires extending in each direction is determined nearly equal to one another, for preventing the LED aggregate module from not obtaining sufficient plane luminance characteristics caused by shielding the light radiated from the LED chips by the bonding wires. In this case, relative location (relative direction) of the radiated light from the LED chip, influenced by the bonding wire is determined based upon the extending direction of the bonding wire, and the ratio of each relative location becomes nearly equal to one another. Therefore, on an illuminated plane which receives influence of light radiated from all LED chips almost nearly to one another, influence of the bonding wires is not locally accentuated so that the LED aggregate module functions as a sufficiently uniform plane illuminant in a higher level.

A method for manufacturing an LED aggregate module comprises the steps of;

a step for housing a printed circuit board on which LED chips are mounted in a molding die which has plural cavities for lens corresponding to a front face side of the printed circuit board, and

a step for injecting translucent resin for lens board in the molding die through one or more injection gates and runners which are provided in the molding die so that the translucent once collides against the front face of the printed circuit board, then the translucent resin flows into the cavities along the front face of the printed circuit board.

In this case, adhesive agent and the like is not needed at all, therefore bubbles are not possibly contained between the printed circuit board and the lens board, and no special matching operation is necessary, of optical axes of light emitting sections each section has the LED chip as a main portion and of the lens sections of the lens board. Consequently, operability for manufacturing LED aggregate modules is improved.

It is preferable that the method further comprises a step for forming through holes in the printed circuit board at locations each of which is near the mounted section of each LED chip, and is located at a position which is covered by each cavity for lens, and

wherein the step for housing the printed circuit board in the molding die is a step for housing the printed circuit board on which the LED chips are

mounted in the molding die which has plural cavities for lens corresponding to the front face side of the printed circuit board and plural cavities for fixing lens corresponding to rear face side of the printed circuit board, each cavity for fixing lens facing to corresponding cavity for lens, and

the step for injecting the translucent resin for lens board is a step for injecting the resin for lens board to flow into the cavities for lens and for injecting the resin for lens board to flow into the cavities for fixing lens through the cavities for lens and the through holes

In this case, incorporation of the lens board and the printed circuit board in one body is performed simultaneously with the manufacturing of the lens board. Also, the lens board is strongly united with the printed circuit board.

It is preferable that the method further comprises a step for forming protection layers made of soft resin on the surface of LED chips mounted on the printed circuit board prior to housing the printed circuit board in the molding die. In this case, disadvantages are prevented by the soft resin layers from occurring, the disadvantages being possibly applied to the LED chips when the lens sections are formed. In this case, it is more preferable that the method further comprises a step for forming plural hollows in the printed circuit board, and wherein each of the LED chips is mounted at a bottom portion of each hollow. In this case, it is further preferable that the method further comprises a step for forming step sections each being in a predetermined location of each hollow.

It is preferable that the method further comprises a step for mounting electronic parts on the printed circuit board, and

a step for covering a part or entirety of each mounted electronic parts to form a protection layer thereon.

In this case, a force is escaped by the protection layer, the force possibly functioning to the electronic parts when the translucent resin is injected in the molding die.

It is preferable that the method further comprises a step for mounting LED chips on the printed circuit board in an arranged in matrix pattern condition, and wherein a plurality of injection gates are formed in the molding die, a number of injection gates corresponding to a mounted number of the LED chips and each injection gate being located at nearly central position of more than two mounted LED chips on the front face of the printed circuit board, and the translucent resin for lens is injected from each injection gate, respectively.

In this case, the method is suitable for molding the lens board for the large sized LED aggregate module having a plurality of LED chips, for instance, and performs the injection of the translu-

cent resin into all cavities for lens smoothly and almost uniformly.

It is preferable that the method further comprises a step for forming the soft resin layers each covering all surface of each LED chip, and surface of each soft resin layer being flat and coincident with the surface of the printed circuit board.

In this case, depression generated when the translucent resin for lens board is solidified, is prevented from locally concentrating, so that a disadvantage is prevented from occurring that the lens characteristics is degraded by the depression.

#### Brief Description of The Drawings

Figure 1 is a vertical cross sectional view schematically illustrating an embodiment of a manufacturing method of an LED aggregate module;

Figure 2 is a schematic perspective view illustrating an embodiment of an LED aggregate module;

Figure 3 is an enlarged vertically cross sectional view taken along a line III-III in Fig. 2;

Figure 4 is a schematic perspective view of another embodiment of an LED aggregate module;

Figure 5 is a schematic rear view of the LED aggregate module in Fig. 4;

Figure 6 is a partially enlarged vertical cross sectional view illustrating an engaged condition of a printed circuit board at an engagement section;

Figure 7 is a partially enlarged vertical cross sectional view illustrating an engaged condition of the printed circuit board at another engagement section;

Figures 8(A) to 8(C) are vertical cross sectional views of another embodiment of a manufacturing method of the LED aggregate module;

Figure 9 is a schematic view explaining a relationship of an electronic parts and a protection layer;

Figure 10 is a schematical view illustrating insert molding;

Figure 11 is a vertical cross sectional view illustrating a further embodiment of an LED aggregate module;

Figure 12 is a perspective view schematically illustrating mounted condition of an electronic parts;

Figure 13 is a perspective view schematically illustrating mounted condition of an electronic parts in still another embodiment of an LED aggregate module;

Figure 14 is a plan view illustrating a still further embodiment of an LED aggregate module;

Figure 15 is a cross sectional view taken along an XV-XV line in Fig. 14;

Figure 16 is a graph showing a luminous intensity distribution characteristics measurement result of the LED aggregate module in Fig. 14;

Figure 17 is a plan view illustrating a conventional LED aggregate module;

Figure 18 is a graph showing a luminous intensity distribution characteristics measurement result of the LED aggregate module in Fig. 17;

Figure 19 is a plan view illustrating an embodiment of a 1 X n line type LED aggregate module;

Figure 20 is a plan view illustrating another embodiment of a 1 X n line type LED aggregate module;

Figure 21 is a plan view illustrating an embodiment of an n X n matrix type LED aggregate module;

Figure 22 is a plan view illustrating a main portion of yet another embodiment of an LED aggregate module;

Figure 23 is a vertical sectional view of the LED aggregate module in Fig. 22;

Figures 24(A)-(E) are vertical sectional views explaining a further embodiment of a manufacturing method of an LED aggregate module;

Figure 25 is a vertical sectional view illustrating a main portion of a conventional LED aggregate module;

Figure 26 is a vertical sectional view illustrating a main portion of a conventional LED aggregate module;

Figure 27 is a vertical sectional view illustrating a conventional manufacturing method of an LED aggregate module;

Figure 28 is a vertical sectional view illustrating a disadvantage raised by the conventional manufacturing method of an LED aggregate module;

Figure 29 is a plan view illustrating a conventional n X n matrix type LED aggregate module; and

Figure 30 is a plan view illustrating a conventional 1 X n line type LED aggregate module.

#### Detailed Description of The Preferred Embodiments

Figure 1 is a vertical cross sectional view schematically illustrating a molding method according to this invention. As is illustrated in Fig. 1, the molding method is a method for molding LED chips 2 by molding synthetic resin coverage layer 20 which surrounds in one body the LED chips 2 and rear face portions 11b of a printed circuit board 1, via through holes 11 of the printed circuit board 1, each through hole 11 being formed in the neighbouring of the LED chip 2 mounted on the printed circuit board 1, and is a method for forming one or more injection gates 17 which direct against a front

face portions 11a of the printed circuit board 1, each injection gate neighbouring a cavity 4c existing in an LED chip mounted side, flowings of source resin 8 injected from the injection gates 17 are once collided against the front face portions 11a of the printed circuit board 1, then the source resin is flowed in the cavities 4c existing in the LED chip mounted side. Further, reference numeral 4d indicates a rear side cavity. The rear side cavity 4d is communicated with the cavity 4c via the through holes 11.

Location of each injection gate 17 with respect to the cavity 4c may be any location which enables the flowing of the source resin once colliding against the front face of the printed circuit board 1. It is preferable that the injection gates 17 are formed at least 1-2 mm apart from an edge portion of the cavity 4c by taking influence into consideration of the source resin to flowing path after collision against the front face of the printed circuit board 1. If circumstances require, the resin flowing path may be extended from one cavity to another cavity, and the another cavity is filled with the source resin after the one cavity has been filled with the source resin.

A solidified synthetic resin corresponding to a resin flowing path 17b from the injection gate to the cavity (hereinafter referred to as a runner) according to this embodiment may be remained on the printed circuit board as a finished goods, or may be removed therefrom.

The runner 17b is preferably formed by employing the front face 11a of the printed circuit board 1 as a part of side walls of the runner 17 so that the source resin flows to the cavity 4c along the front face 11a of the printed circuit board 1. But, the runner 17b may be a runner which flows the source resin apart from the printed circuit board 1 after collision of the source resin against the printed circuit board 1.

A path of the runner 17b beginning from the injection gate 17 and ending to the cavity 4c is preferably formed to be the shortest route except bypassing obstacles such as circuits on the printed circuit board 1. But, the runner 17 may be formed as a runner path which turns by a predetermined number of times to avoid a simple straight line path by taking problems into consideration such as deformation of lens caused by shrinking, depression and the like of the resin.

A section shape of the runner 17b is a known shape such as a semicircle shape, trapezoid shape and the like when the runner contacts the printed circuit board 1 as usual, and such as a circle shape and the like when it is required.

A section area in diameter direction of the runner 17b is determined to be a proper value based upon molding condition such as species,

temperature of the translucent resin for lens board, temperature of the molding die, injection pressure, injection speed, injection time and the like, and other various condition such as appearance when the runner is remained in the manufactured goods. But, a section area may be continuously varied from the injection gate 17 towards the cavity 4c so as to control the flowing speed, pressure and the like of the translucent resin.

A location uniting the runner 17b with the cavity 4c is preferably determined so that the translucent resin flows in the cavity so as to fill the cavity 4c, and then the translucent resin flows in the rear face side of the printed circuit board, by taking the location relationship with the through holes 11 into consideration.

Further, the runner may be a runner as a special example, which forms a translucent resin layer covering a part or its entirety of the front face side which is the mounting side of the printed circuit board, and which does not provide a runner extending along a special path.

In this embodiment, the LED chips are mounted on the printed circuit board which is to be a display panel, the translucent resin coverage layer is formed thereto using the molding method according to this invention, then quality of effective portion of the lens is recognized.

Polycarbonate is employed as the translucent resin for molding, the translucent resin is injected by an outlet pressure of 1500kgf/cm<sup>2</sup> of an extruding machine from the injection gate 17 which is provided at intermediate portion of two cavities 4c and 4c as is illustrated in Fig. 1. The LED chips 2 and the rear face portion of the printed circuit board 1 corresponding to the LED chips are formed in one body via the through holes 11 by molding, so that the LED aggregate module having the translucent coverage layer as lens board is obtained. When quality of lens portions of the LED aggregate module is evaluated, the LED aggregate module being obtained by the experimental method for manufacturing, no generation of weld lines, flow marks, jetting and the like was made in the effective portion of the lens portion, and the translucent resin is filled up to 100% both in front and rear portions of the printed circuit board 1, so that it is recognized that the LED aggregate module has good quality.

From the experimental method for manufacturing, it is recognized that the molding method of this invention is effective to the formation of lenses each corresponding to the LED chip mounted on the printed circuit board 1.

## Second Embodiment

Figure 2 is a schematic perspective view illustrating an embodiment of an LED aggregate module. In Fig. 2, the reference character M indicates an LED aggregate module, and a printed circuit board 1 on which LED chips (not illustrated) are mounted is engaged with engagement sections 21 formed in a lens board 20.

Figure 3 is an enlarged cross sectional view taken along a line III-III in fig. 2, and illustrates an engagement condition at the engagement section 21. The printed circuit board 1 on which the LED chips 2 are mounted, is engaged with engagement sections 21 formed in the lens board 20 having lens sections 20a.

The engagement sections 21 are formed in edge portions excluding corner portions of the lens board 20. The edge portions excluding the corner portions are meant portions each aparting from corresponding apex portions 22 by a distance d of at least 2 mm, preferably by a distance d of 4-30 mm. Further, a size of the engagement section 21 varies depending upon the size of the LED aggregate module. A width w and a length l of the engagement section 21, as is illustrated in Fig. 2, are proper to be in sizes of about more than 0.5 mm, respectively, in usual case.

In this embodiment, it is not preferable that the width w or the length l is lesser than 0.5 mm, because the printed circuit board 1 and the lens board 20 may not stably be fixed to one another.

Further, the width w and a length l of the engagement section 21 are preferable that they are as large as possible in size so as to securely fix the printed circuit board, when they are within an extent that they are not too large with respect to the size of the LED aggregate module, and that a disadvantage does not arise in greatly increasing in the amount of the translucent resin for lens board used.

Further, in this embodiment, the engagement sections 21 are formed at least one location, preferably at two locations interposing each apex 22 of the lens board 20, per each side of the lens board 20. When the length of the engagement sections 21 is short, the engagement sections 21 may be formed more than three locations per each edge of the lens board 20.

Mode of the engagement sections 21 is not specially limited as possible as fixing the printed circuit board 1 and the lens board 20. But, the engagement section 21 is preferable to be a claw shaped engagement section 21 as is illustrated in the cross sectional view of Fig. 3.

The method for forming the lens board 20 is not specially limited, but is preferable to employ insert molding which enables forming in one body

of the claw shaped engagement sections 21 with the lens board 20 easily.

The lens board 20 is made of resin having high translucency. The resin is exemplified with epoxy resin, silicon resin, acrylate resin, polycarbonate and the like.

A usually employed printed circuit board is employed as the printed circuit board 1. The printed circuit board 1 is exemplified with a metallic based printed circuit board which is made by painting or adhered in film shape of insulation material such as epoxy resin, polyethylene, polyimide, polyester and the like on a surface of a metallic board such as aluminium, copper, iron, stainless steel, nickel and the like.

As to the arrangement above-mentioned, though the printed circuit board 1 on which the LED chips 2 are mounted is engaged by the engagement sections 21 formed in one body in the lens board 20 when the lens board 20 is formed, adhesive agent which is required in the conventional LED aggregate module is not needed at all. Also, disadvantage in containing bubbles in the adhesive agent layer when the printed circuit board 1 and the lens board 20 are adhered to one another, and labor for assembling the printed circuit board 1 and the lens board 20 such as matching operation of optical axes of light emitting sections each section has the LED chip as a main portion and of the lens sections of the lens board 20 are eliminated. Consequently, the LED aggregate module is manufactured easily. Further, in this embodiment, though the engagement sections 21 are formed in one body in the edge portions excluding the corner portions of the lens board 20, shrinking forces in diagonal directions of the lens board 20 after formation of the lens board 20 are dispersed and released.

As a result, warp of the LED aggregate module caused by resin shrinking of the lens board 20 immediately after forming is prevented from occurring, for example.

### Third Embodiment

Figure 4 is a schematic perspective view of another embodiment of an LED aggregate module. In Fig. 4, the reference character M indicates an LED aggregate module which has an arrangement that a printed circuit board 1 on which LED chips 2 are mounted is covered by a lens board 20 which is divided into multiple number of lens boards 20b, 20c, 20d and 20e each having a small area.

Figure 5 is a schematic bottom view of the LED aggregate module. In Fig. 5, a reference numeral 21a indicates engagement sections formed in one body in the lens board 20. The engagement sections 21a are formed in edge portions excluding

corner portions 22 of the lens board 20, the corner portions 22 each corresponding to each apex of the printed circuit board 1 on which the LED chips 2 are mounted. Also, the reference numeral 21b indicates engagement sections formed in one body in the lens board 20. The engagement sections 21b are formed in corner sections each locating in diagonal direction with respect to each corner section 22 of the lens board 20. Figure 6 is a partially enlarged vertical cross sectional view illustrating an engaged condition of a printed circuit board 1 at the engagement section 21a of the lens board 20. In Fig. 6, the printed circuit board 1 is engaged its outer side edge portions by the engagement sections 21a formed in one body in the lens board 20 which covers the front face of the printed circuit board 1 on which the LED chips 2 are mounted.

Further, Figure 7 is a partially enlarged vertical cross sectional view illustrating an engaged condition of the printed circuit board 1 at the engagement section 21b of the lens board 20. In Fig. 7, the engagement section 21b is formed by that the translucent resin for lens board passes through the through holes 11 so as to be filled in the rear face side of the printed circuit board 1, the through holes 11 penetrating the printed circuit board 1 in its thickness direction on which the LED chips 2 are mounted. The engagement sections 21b engage the central portions of the printed circuit board 1.

The LED aggregate module of this embodiment is manufactured by partitioning the printed circuit board 1 which is housed interior a cavity of a forming die into multiple numbered small portions, and by insert molding the lens board 20 in every partition independently. At the same time, the engagement sections 21a and 21b are formed in one body.

The lens board 20 is formed in a condition that the partitioned portions have area of 200-3000 mm<sup>2</sup>, respectively. Each partitioned portion preferably has an area of 600-800 mm<sup>2</sup>. When the area of the partitioned portion exceeds 3000 mm<sup>2</sup>, the degree of resin shrinking becomes great in each of the partitioned portions so that influence to the printed circuit board becomes great, while the lens board 20 is more fractionated than the lens board 20 needs so that its formation and fixation to the printed circuit board 1 become difficult when the area of the partitioned portion is lesser than 200 mm<sup>2</sup>.

The arrangement of the engagement section 21a is the same as the engagement section 21 in the second embodiment.

Mode of the engagement sections 21b is not specially limited as possible as fixing the printed circuit board 1 and the lens board 20. But, the engagement section 21b is preferable to be a rivet

shape which is formed by that the forming resin passes through the through holes 11 penetrating the printed circuit board 1 in the thickness direction so that the forming resin is filled in the rear face side of the printed circuit board, as is illustrated in the cross sectional view of Fig. 7.

In this case, a shape of the through hole 11 is possible to be a circle shape, a square shape and the like. But, the shape of the through hole 11 is not limited to these shapes.

Further, a size of the through hole 11 varies depending upon the size of the LED aggregate module. For example, the size of the through hole 11 is preferable to be about 1-30 mm<sup>2</sup> in an usual case, when the LED aggregate module has a shape of parallelogram of 60 mm X 60 mm. In this case, when the size of the through hole 11 is lesser than 1 mm<sup>2</sup>, the printed circuit board 1 and the lens board 20 are not stably fixed to one another. While, when the size of the through hole 11 exceeds 30 mm<sup>2</sup>, the force caused by resin shrinking is not dispersed so that warp is generated in the LED aggregate module M. Thereby, it is not preferable that the size of the through hole 11 is determined to be outside the range of 1-30 mm<sup>2</sup>.

Further, it is preferable that each engagement sections 21b is formed at a location apart by a distance of 0.5-10mm, respectively, from two edges uniting the corner section which locates in diagonal direction from the corner section 22 of the lens board 20 which corner section 22 locates corresponding to each apex of the printed circuit board 1, because the lens board 20 is stably fixed to the printed circuit board 1.

A number and locations of the engagement sections 21a and 21b are not limited to the locations illustrated in Fig. 5. The number of the engagement sections 21a and 21b is sufficiently to be two points, and the locations of the engagement sections 21a and 21b are sufficiently to have at least a distance to some degree therebetween.

As to the arrangement above-mentioned, though multiple number of lens board 20 are formed each having the small area for covering the printed circuit board on which the LED chips 2 are mounted, and the printed circuit board 1 on which the LED chips 2 are mounted is engaged and held by the engagement sections 21a and 21b, the engagement section 21a being formed in one body in each edge portion excluding the corner section 22 of the lens board 20 corresponding to the apex of the printed circuit board 1, and the engagement section 21b being formed in the corner section locating in diagonal direction with respect to the corner section 22, the resin shrinking of the lens board 20 partially occurs as that an internal stress is decreased. Though the internal stress is decreased, as is described in the foregoing, warp of

the LED aggregate module is greatly suppressed.

As is described in detail in the foregoing, as to the LED aggregate module according to this embodiment, though the printed circuit board 1 on which the LED chips 2 are mounted is engaged by the engagement sections 21a and 21b formed in one body in the lens board 20 when the lens board 20 is formed, adhesive agent which is required in the conventional LED aggregate module is not needed at all. Also, disadvantage in containing bubbles in the adhesive agent layer when the printed circuit board 1 and the lens board 20 are adhered to one another, and labor for assembling the printed circuit board 1 and the lens board 20 such as matching operation of optical axes of light emitting sections each section has the LED chip as a main portion and of the lens sections of the lens board 20 are eliminated.

Further, though the engagement section 21a is formed in the edge portion excluding the corner sections of the lens board 20, shrinking forces in diagonal directions of the lens board 20 after formation of the lens board 20 are released. And though the lens board is divided into plural number of lens boards 20 each having a small area, and the lens boards 20 are formed on the printed circuit board 1, the resin shrinking of the lens board 20 is partially generated so that the internal stress decreases. As a result, warp of the LED aggregate module is suppressed.

Therefore, by employing this embodiment, the LED aggregate module is obtained which is easy in fixation of the printed circuit board 1 and the lens board 20, and has small warp of the printed circuit board 1 caused by the resin shrinking of the lens board 20, and has high reliability. Especially, fixing ability of the printed circuit board 1 and the lens board 20 is satisfactory when the LED aggregate module is large in size.

#### Fourth Embodiment

Figures 8(A) to 8(C) are vertical cross sectional views of another embodiment of a method for manufacturing the LED aggregate module. As is illustrated in Fig. 8(A), LED chips 2 and electronic parts 3 such as resistor and the like mounted and fixed in one body by soldering and the like on a printed circuit board 1 on which printed circuit having a predetermined pattern is formed. The printed circuit board 1 is, for example, a printed circuit board performing high radiating performance which is obtained by forming an insulation layer on a surface of an aluminium board and the like, then the printed circuit is formed on a surface of the insulation layer. In this case, mounting condition of the electronic parts 3 is determined so that central axis of the electronic parts 3 as many as possible is

orthogonal to a flowing direction of translucent synthetic resin for forming a lens board 20 which is described later.

In this condition, a protection layer 3a is formed with a synthetic resin having a higher melting temperature than that of the translucent synthetic resin so as to cover edge portions of each electronic parts 3 in the flowing direction of the translucent synthetic resin, as is illustrated in Fig. 8(B). Thereafter, the lens board 20 is formed in one body with the printed circuit board 1 by insert molding the lens board 20, on which printed circuit board 1 the LED chips 2 and the electronic parts 3 are mounted, as is illustrated in Fig. 8(C).

Further in this case, the employed electronic parts 3 is preferable to be an electronic parts having a column-like outer shape, but electronic parts having a rectangular cross sectional shape and electronic parts having an arbitrary shape may be employed.

Therefore, containing of bubbles is reduced to almost zero when the lens board 20 is formed in one body with the printed circuit board 1 in comparison to the case that adhesive agent is used to fix the lens board to the printed circuit board. Also, necessity is reduced to zero for special matching operation of the optical axes of light emitting sections each section has the LED chip as a main portion and of the lens sections of the lens board 20.

Further, the shape of the protection layer 3a is preferably determined to be a shape, as is illustrated in Fig. 9 for example, which shape has a smooth surface shape for acting resistance against the flow of the synthetic resin for inset molding (refer to an arrow in Fig. 9) as little as possible. The protection layer 3a may be formed so as to cover the whole extent of the electronic parts 3.

As to the method for manufacturing an LED aggregate module above-mentioned, when not only the LED chips 2 but also the electronic parts 3 are mounted on the printed circuit board 1, each of the protection layers 3a is formed on each electronic parts 3, and then the printed circuit board 1 is set in a molding die for insert molding the lens board 20, a cross sectional area for flowing the synthetic resin for insert molding is great thereby a pressure caused by the flowing of the synthetic resin does not increase so much, because the LED chips 2 are mounted at locations each of which is covered by each lens section of the lens board 20. Therefore, a disadvantage scarcely arise in that the LED chips 2 are broken following the injection of the synthetic resin for insert molding. On the other hand, the electronic parts 3 are mounted on the printed circuit board 1 at locations not for influencing to the optical characteristics of the LED chips 2 and the lens sections, that is at locations each of

which is not covered by each lens section, thereby a cross sectional area for flowing the synthetic resin for insert molding is extremely small. Therefore, a pressure caused by the flowing of the synthetic resin remarkably increases. But, a disadvantage is prevented from occurring that the pressure is concentrated a part of the electronic parts 3, because the protection layer 3a is formed at the edge portions of the electronic parts 3 in the flowing direction of the synthetic resin. Consequently, a disadvantage is prevented from occurring that the electronic parts 3 are broken, in spite of the pressure being remarkably great caused by the flowing of the synthetic resin. Thereby, yield of the LED aggregate module is greatly improved.

#### Specific Example

Resistors 3 as the electronic parts are previously soldered at four locations to the printed circuit board 1 having a rhomboid shape, and 6 X 6 number of LED chips 2 are previously mounted in matrix pattern on the printed circuit board 1. And, the printed circuit board 1 on which the LED chips 2 and the resistors 3 are mounted is inserted and positioned in a gap between an upper die 4b and a lower die 4a, as is illustrated in Fig. 10. The lower die 4a supports the printed circuit board 1, the upper die 4b has cavities 4c at locations each corresponding to each LED chip 2, the cavity 4c has a shape matching to the shape of lens section which is to be formed, and the lower die 4a and the upper die 4b are disposed in opposing condition. Then, polycarbonate is injected with a predetermined resin pressure and flowing velocity from a resin injection opening of an insert molding die 4 comprising the upper die 4b and the lower die 4a. Thereafter, an LED aggregate module is obtained by solidifies the polycarbonate.

In this case, column-shaped resistors are employed as the resistors 3, and percent defective is measured in a case that the protection layers 3a are formed, and in a case that no protection layers are formed. In the former case, percent breakage of the resistor 3 and of the soldered section are both 0%, while in the latter case, percent breakage of the resistor 3 and of the soldered section are 0% and 33%, respectively. When rectangular resistors are employed as the resistors 3, and percent defective is measured in a case that the protection layers 3a are formed, and in a case that no protection layers are formed. In the former case, percent breakage of the resistor 3 and of the soldered section are 16% and 0%, respectively, while in the latter case, percent breakage of the resistor 3 and of the soldered section are 33% and 25%, respectively. Further, the measurement of percent breakage is carried out by manufacturing 10 number of

LED aggregate modules by the method for manufacturing above-mentioned, and by detecting breakage of the 10 number of LED aggregate modules.

#### Fifth Embodiment

Figure 11 is a vertical cross sectional view illustrating a further embodiment of an LED aggregate module, while Figure 12 is a perspective view schematically illustrating mounted condition of an electronic parts.

LED chips 2 and electronic parts 3 such as resistor are mounted at predetermined locations on a printed circuit board 1 on which a predetermined printed pattern is formed, and are fixed in one body to the printed circuit board 1 by soldering them to land sections on the printed circuit board 1. And, a relative location of the printed circuit 5a with respect to the land section 5 is determined so that the printed circuit 5a extends from the land section 5 in a downstream side in a flowing direction of synthetic resin for a lens board 20.

In this condition, the lens board 20 is formed in one body to the printed circuit board 1 on which the LED chips 2 and the electronic parts 3 are mounted, by insert molding the lens board 20.

In this case, the electronic parts 3 is preferable to have a column-like outer shape, but the electronic parts 3 may have a rectangular cross sectional shape, or an arbitrary shape. Also, it is preferable that synthetic resin injection openings are formed at every predetermined distance corresponding to one edge of the printed circuit board 1 for the purpose of seizing the flowing direction of the synthetic resin, so that the flowing direction of the synthetic resin is almost constant to its entirety. It is possible that a number of synthetic resin injection openings is determined to be one, in this case, it is sufficient that the flowing direction of the synthetic resin with respect to each electronic parts is previously obtained by fluid analysis and the like, for example.

As to the LED aggregate module having the arrangement above-mentioned, a force caused by the flowing of the synthetic resin acts on the electronic parts 3 when the synthetic resin for insert molding is injected in a die, thereby there is possibility that the land sections 5 are peeled from the printed circuit board 1 to some degree. But, the peeling of the land sections 5 is scarcely occurred in connection to the printed circuit 5a, therefore cutting of the printed circuit 5a is securely prevented even when the peeling of the land sections 5 has occurred. Of course, though the lens board 20 finally covers the printed circuit board 1 in its entirety, small peeling of the land sections 5 never badly influence the characteristics of the LED aggregate module.

Further in this case, cutting of the printed circuit 5a is more securely prevented by determining a proportion of the width of the printed circuit 5a with respect to that of the land section 5 to gradually decrease following apart from the land section 5, as is illustrated in Fig. 13.

Furthermore, the printed circuit 5a may be determined to extend in the upstream side in the flowing direction of the synthetic resin with respect to the land section 5, cutting of the printed circuit 5a is almost securely prevented.

#### Specific Example

Resistors 3 as the electronic parts are previously soldered at four locations to the printed circuit board 1 having rhomboid shape, and 6 X 6 number of LED chips 2 are previously mounted in matrix pattern on the printed circuit board 1. And, the printed circuit board 1 on which the LED chips 2 and the resistors 3 are mounted is inserted and positioned in a gap between an upper die 4b and a lower die 4a, as is illustrated in Fig. 10. The lower die 4a supports the printed circuit board 1, the upper die 4b has cavities 4c at locations each corresponding to LED chip 2, the cavity 4c has a shape matching to the shape of lens section which is to be formed, and the lower die 4a and the upper die 4b are disposed in opposing condition. Then, polycarbonate is injected with a predetermined resin pressure and flowing velocity from a resin injection opening of an insert molding die 4 comprising the upper die 4b and the lower die 4a. Thereafter, an LED aggregate module is obtained by solidifies the polycarbonate.

In the LED aggregate module obtained by such manufacturing method, there are scarce cutting of the printed circuit.

#### Sixth Embodiment

Figure 14 is a plan view illustrating a still further embodiment of an LED aggregate module, while Figure 15 is a cross sectional view taken along the XV-XV line in Fig. 14.

2 X 24 number of LED chips 2 are mounted in matrix pattern on a printed circuit board 1 having a rectangular shape and on which printed circuit is formed. And, the LED chips 2 are virtually partitioned in blocks of 1 X 24 number of LED chips 2 (refer to a dot-and-chain line in Fig. 14). With respect to the LED chips 2 belonging to one partition 3a (refer to upper half in Fig. 14), land sections 5 are disposed in the upper side in Fig. 14 each of which is connected to corresponding LED chip 2 with a bonding wire 5b. On the contrary, with respect to the LED chips 2 belonging to the other partition 3b (refer to lower half in Fig. 14), land



sections 5 are disposed in the lower side in Fig. 14 each of which is connected to corresponding LED chip 2 with a bonding wire 5b. Further, each section indicated with a circle surrounding each LED chip 2 in Fig. 14 is a hollow section 23 for mounting the LED chip 2. The hollow section 23 is a hollow 23 having a reverse truncated cone shape. The hollow 23 enables the LED chip 2 being mounted not to project upward from a surface of non-hollow portion of the printed circuit board 1, and efficiently guide light outgone from the LED chip 2 to a lens section which is described later. Thereby, the inner entire face of the hollow section 23 is like a mirror.

Further, a lens board 20 is formed by insert molding so as to cover the upper face of the printed circuit board 1, and an optical axis of each of lens sections 20a of the lens board 20 is matched with an optical axis of corresponding LED chip 2 so that both optical axes are coincident to one another. Furthermore, synthetic resin for insert molding is exemplified with thermoplastic resin such as polycarbonate, polymethylmethacrylate (PMMA), polypropylene, 4-methylpentene-1 polymer and the like.

As to the LED aggregate module having the arrangement above-mentioned, light outgone from the LED chips 2 belonging to the one partition 3a is screened by bonding wires 5b in the upper side in Fig. 14, so that quantity of outgone light in this portion becomes smaller than that of the other portion. On the contrary, light outgone from the LED chips 2 belonging to the other partition 3b is screened by bonding wires 5b in the lower side in Fig. 14, so that quantity of outgone light in this portion becomes smaller than that of the other portion. That is, in each partition, when it is observed partially, the light outgone from the LED chip 2 is partially screened by the bonding wire 5b, so that dispersion is occurred to some degree in light distribution characteristics. But, the LED aggregate module functions in its entirety as a plane illuminant. On an illuminated face which receives influence of the both partitions nearly uniformly, the light distribution characteristics different from one another are overlapped to one another, so that dispersion in light distribution characteristics is greatly decreased.

Specifically, when the light distribution characteristics are measured using the LED aggregate modules having the arrangement illustrated in Fig. 14 and Fig. 15, measurement result illustrated in Fig. 16 is obtained. In this measurement, an LED chip made of GaAlAs, having a length, width and height of 300  $\mu\text{m}$ , 300  $\mu\text{m}$  and 180  $\mu\text{m}$ , respectively, and having output of 30 milli-candela (mcd) is employed as the LED chip 2, a bonding wire having a diameter of 30  $\mu\text{m}$  is employed as the

bonding wire 5b. Also, a diameter of an opening section of the hollow section 23 is determined to be 1.4 mm, a diameter of a bottom section of the hollow section 23 is determined to be 0.6 mm, a depth of the hollow section 23 is determined to be 0.4 mm, and an inclination angle of a side face of the hollow section 23 is determined to be 45°. Further, a lens board made of polycarbonate and has aspherical lenses of  $\phi 6\text{mm}$  is employed as the lens board 7. And, luminosity at plural points on a measurement plane is measured in a condition that a center of the LED aggregate module having the arrangement illustrated in Figs. 14 and 15 is coincident to a location which is apart from a cross point of a horizontal axis H and a vertical axis V of the measurement plane by 3 m in a direction vertical to the measurement plane, and that the LED aggregate module is kept vertically. Further, in Fig. 16, 10°U indicates a location on the measurement plane which is upward by 10° from the center of the LED aggregate module with respect to the horizontal direction. 5°U indicates a location on the measurement plane which is upward by 5°, similarly. Further, characters "D", "R", and "L" added after a value indicating an angle indicate downward, rightward, and leftward, respectively.

As a comparison example, as is illustrated in Fig. 17, an LED aggregate module is used for light distribution characteristics measurement in which land sections are formed in a lower side in Fig. 17 with respect to all 2 X 24 number of LED chips in matrix pattern disposition, and all bonding wires extend to downward in Fig. 17. Then, measurement result illustrated in Fig. 18 is obtained.

When the both light distribution characteristics measurement results are compared to one another, in the light distribution characteristics in Fig. 18, the quantity of light in a region of 5°D is lower to some degree in comparison with the quantity of light in a region of 5°U, and the quantity of light in a region of 10°D is remarkably lower in comparison with the quantity of light in a region of 10°U. Over against this, in the light distribution characteristics in Fig. 16, the quantity of light in a region of 5°D is nearly equal to the quantity of light in a region of 5°U, and the quantity of light in a region of 10°D is nearly equal to the quantity of light in a region of 10°U.

Therefore, by partitioning the LED chips into two partitions, and by determining the relative positioning of the land sections with respect to corresponding LED chip in each partition in reverse positioning to one another, dispersion in light distribution characteristics is greatly decreased so that the LED aggregate module functions as sufficiently homogenous plane illuminant.

Further, this invention is not limited to the above-mentioned embodiment. For example, as is

illustrated in Fig. 19, it is possible that a partitioning unit of a line type LED aggregate module is determined to be one LED chip, and that the land sections 5 are alternately provided in upper side and lower side with respect to corresponding LED chips 2. As is illustrated in Fig. 20, it is possible that the land sections 5 are sequentially provided in lower side, right side, upper side, and left side. Further as is illustrated in Fig. 21, it is possible that a partitioning unit of a matrix type LED aggregate module is determined to be one LED chip, and that the land sections 5 are suitably provided in different direction with respect to corresponding LED chip 2. It is possible that a non-metallic printed circuit board is employed, and that a printed circuit board having no hollow sections is employed. Various modifications are applicable within an extent not varying the scope of this invention.

#### Seventh Embodiment

Figure 22 is a plan view illustrating a main portion of yet another embodiment of an LED aggregate module, while Figure 23 is a vertical sectional view of the LED aggregate module in Fig. 22.

In an LED aggregate module illustrated in Fig. 22, hollow sections 23 are formed at every predetermined distance on a surface of a printed circuit board 1 on which a printed circuit is formed, and an LED chip 2 is mounted on a bottom face of each hollow section 23 interposing a land section which is not illustrated. And, the hollow section 23 is formed to be a shape of reverse truncated cone having a step section. The step section 23a is determined to be a plane in parallel to a printed circuit formed face of the printed circuit board 1. A land section 5 connected to the LED chip 2 with a bonding wire 5b is formed on a predetermined location of the step section 23a. And, the bonding wire 5b bonded to the LED chip 2 and the land section 5 in a condition that the bonding wire 5b to its entirety is positioned lower than the printed circuit formed face of the printed circuit board 1. Bonding the bonding wire 5b in such manner is performed easily by taking a condition into consideration that the upper face of the LED chip 2 and the land section 5 both are positioned lower than the printed circuit formed face of the printed circuit board 1. Further, silicon resin 6 for protecting the bonding wire 5b is housed in the hollow section 23 so as to make the upper face of the silicon resin flat and coincident with the printed circuit formed face of the printed circuit board 1. Furthermore, a lens board 20 is formed in one body by insert molding on the printed circuit board 1.

As to the LED aggregate module having the arrangement above-mentioned, though the upper face of the silicon resin 6 is flat and coincident with

the printed circuit formed face of the printed circuit board 1, the silicon resin 6 has no lens characteristics. Thereby, only lens sections 20a of the lens board 20 have the lens characteristics. Though the lens characteristics of the lens section 20a is determined based upon the species of synthetic resin for insert molding, and a shape of the lens section 20a, an LED aggregate module having the optical characteristics according to a design is easily obtained. Further, influence of depression of the synthetic resin for insert molding never concentrate locally, therefore influence of inner reflection of outgoing light from the LED chip caused by the depression is greatly decreased so that lowering of outgoing light intensity is greatly suppressed. Of course, interconnection of the LED chip 2 and the land section 5 with the bonding wire 5b is not damaged at all.

#### Eighth Embodiment

Figures 24(A)-(E) are vertical sectional views explaining a further embodiment of a method for manufacturing an LED aggregate module.

Hollow sections 23 having a shape of a reverse truncated cone having a step section are formed in predetermined locations of a printed circuit board 1 by applying drawing and the like to the printed circuit board 1 {refer to Fig. 24(A)}.

Then, a printed circuit which is not illustrated is formed on a surface of the printed circuit board 1, and simultaneously, land sections 5 are formed on a bottom face and the step section 23a of each hollow section 23, then an LED chip 2 is mounted on the land section formed on the bottom face of each hollow section 23 {refer to Fig. 24(B)}.

Thereafter, the LED chip 2 and the land section 5 formed on the step section 23a are interconnected with a bonding wire 5b {refer to Fig. 24(C)}. In this condition, length and degree of curvature of the bonding wire 5b is determined so that the uppermost portion of the bonding wire 5b is positioned lower than the printed circuit formed face of the printed circuit board 1. Though, the step section 23a has a face which is parallel to the surface (printed circuit formed face) of the printed circuit board 1 and the land section 5 is formed on the face, bonding of the bonding wire 5b to the land section 5 is easily and securely performed.

After the interconnection with the bonding wire 5b is performed, a silicon resin 6 for protecting the bonding wire is housed in the hollow section 23 so that the upper face of the silicon resin is made flat and coincident with the printed circuit formed face of the printed circuit board 1 {refer to Fig. 24(D)}.

Finally, a lens board 20 is formed in one body on the printed circuit board 1 by insert molding so that an LED aggregate module is obtained {refer to

Fig. 24(E)}.

Therefore, by executing the method for manufacturing an LED aggregate module, an LED aggregate module is easily obtained which has the optical characteristics according to a design and greatly suppresses lowering of outgone light intensity.

Further, this invention is not limited to the above-mentioned embodiment. It is possible that a reverse truncated elliptical cone shape and the like is employed as a shape of the hollow section 23 instead of the reverse truncated cone shape. It is possible that the step section 23a is formed in only a local portion. Various modifications are applicable within the extent without varying the scope of this invention.

#### Claims

1. A light emitting diode aggregate module in which lenses (20a) formed with translucent resin are disposed on a surface of a printed circuit board (1) on which plural light emitting diode chips (2) are mounted, each of the lenses (20a) corresponding to each light emitting diode chip (2), the light emitting diode aggregate module being characterized in comprising;

a metallic base printed circuit board (1) having plural hollows (23) thereon, a predetermined printed pattern, light emitting diode chips (2) each mounted in a bottom portion of each hollow (23), and electronic parts (3) each mounted at a location which is different from a mounted location of the light emitting diode chip (2),

a soft resin layer (6) for surrounding peripheral portion of the light emitting diode chip (2),

a protection layer (3a) made of resin for covering a part or entirety of the electronic parts (3), and

a lens board (20) which is formed by injection of translucent resin into a die and is disposed in contact on a surface of the printed circuit board (1), the lens board (20) covering the plural light emitting diode chips (2) and the electronic parts (3), and having lens sections (20a) projecting forward at a location corresponding to each light emitting diode chip (2).

2. A light emitting diode aggregate module as set forth in claim 1, wherein the printed circuit board (1) has a rectangular shape, and further comprises claw sections (21)(21a) which are formed in one body at edge sections excluding corner sections (22) of the lens board (20) so that fixation of the printed circuit board (1) and

the lens board (20) is performed by the claw sections (21)(21a).

3. A light emitting diode aggregate module as set forth in claim 1 or 2, further comprising through holes (11) in the printed circuit board (1) so that fixation of the printed circuit board (1) and the lens board (20) is performed by going round the resin for lens board to an opposite face side of the printed circuit board (1) through the through holes (11).
4. A light emitting diode aggregate module as set forth in claim 3, wherein the through holes (11) are provided in vicinity of the light emitting diode mounting portion, and the light emitting diode (2) is substantially surrounded with the resin for the lens board (20).
5. A light emitting diode aggregate module as set forth in one of claims 1 to 4, wherein the protection layer (3a) for the electronic parts (3) is formed in a shape which reduces resistance against the flowing of the translucent resin for lens board (20) when the translucent resin is injected in a molding die (4).
6. A light emitting diode aggregate module as set forth in one of claims 1 to 5, further comprising a printed circuit (5a) and land sections (5) formed on the printed circuit board (1), and wherein the printed circuit (5a) extending from the land section (5) among the printed circuit on the printed circuit board (1), is provided in a direction of flowing of the translucent resin when the translucent resin is injected in a molding die (4), the land section (5) being electrically connected the electronic parts (3) at least.
7. A light emitting diode aggregate module as set forth in one of claims 1 to 6, further comprising a soft resin layer (6) for covering peripheral portion of the light emitting diode chip (2), the soft resin layer (6) being housed in the hollow (23) so as to make a surface of the soft resin layer (6) flat and coincident with the surface of the printed circuit board (1).
8. A light emitting diode aggregate module as set forth in one of claims 1 to 7, further comprising a step section (23a) which is provided in a predetermined location of each hollow (23).
9. A light emitting diode aggregate module as set forth in one of claims 1 to 8, wherein the land section (5) on the printed circuit board (1) is connected to an upper electrode of the light

emitting diode chip (2) by a bonding wire (5b), extending directions of the bonding wire (5b) with respect to the light emitting diode chip (2) are determined at least two directions, a number of the bonding wires (5b) extending in each direction is determined nearly equal to one another, for preventing the light emitting diode aggregate module from not obtaining sufficient plane luminance characteristics caused by screening of light radiated from the light emitting diode chips (2) by the bonding wires (5b).

10. A method for manufacturing a light emitting diode aggregate module in which lenses (20a) formed with translucent resin are disposed on a surface of a printed circuit board (1) on which plural light emitting diode chips (2) are mounted, each of the lenses (20a) corresponding to each light emitting diode chip (2), the method being characterized in comprising the steps of;

a step for housing a printed circuit board (1) on which light emitting diode chips (2) are mounted in a molding die (4) which has plural cavities (4c) for lens corresponding to a front face side of the printed circuit board (1), and

a step for injecting translucent resin for lens board in the molding die (4) through one or more injection gates (17) and runners (17b) which are provided in the molding die (4) so that the translucent resin once collides against the front face of the printed circuit board (1), then the translucent resin flows into the cavities (4c) along the front face of the printed circuit board (1).

11. A method as set forth in claim 10, further comprising a step for forming through holes (11) in the printed circuit board (1) at locations each of which is near the mounted section of each light emitting diode chip (2), and is opposite to each cavity (4c) for lens, and

wherein the step for housing the printed circuit board (1) in the molding die (4) is a step for housing the printed circuit board (1) on which the light emitting diode chips (2) are mounted in the molding die (4) which has the plural cavities (4c) for lens corresponding to the front face side of the printed circuit board (1) and plural cavities (4d) for fixing lens corresponding to rear face side of the printed circuit board (1), each of the cavities (4d) facing to corresponding cavity (4c) for lens, and

the step for injecting the translucent resin for lens board is a step for injecting the translucent resin for lens board to flow into the cavities (4c) for lens and for injecting the trans-

lucent resin for lens board to flow into the cavities (4d) for fixing lens through the cavities (4c) for lens and the through holes(11).

12. A method as set forth in claim 10 or 11, further comprising a step for forming protection layers (6) made of soft resin on the surface of light emitting diode chips (2) mounted on the printed circuit board (1) prior to housing the printed circuit board (1) in the molding die (4).

13. A method as set forth in one of claims 10 to 12, further comprising a step for forming plural hollow sections (23) on the printed circuit board (1), and a step for mounting each of the light emitting diode chips (2) on a bottom portion of each hollow section (23).

14. A method as set forth in one of claims 10 to 13, further comprising a step for forming step sections (23a), each of which being in a predetermined location of each hollow section (23).

15. A method as set forth in one of claims 10 to 14, further comprising a step for mounting electronic parts (3) on the printed circuit board (1), and

a step for covering a part or entirety of each mounted electronic parts (3) with a protection layer

16. A method as set forth in one of claims 10 to 15, further comprising a step for mounting light emitting diode chips (2) on the printed circuit board (1) in an arranged in matrix pattern condition, and

wherein plural injection gates (17) are formed in the molding die (4), a number of injection gates (17) corresponding to a mounted number of the light emitting diode chips (2) and each injection gate (17) being located at nearly central position of more than two mounted light emitting diode chips (2) on the front face of the printed circuit board (1), and the translucent resin for lens is injected from each injection gate (17), respectively.

17. A method as set forth in one of claims 10 to 16, further comprising a step for forming a soft resin layer (6) which covers all surface of each light emitting diode chip (2), and surface of which is determined to be flat and coincident with the surface of the printed circuit board (1).



FIG. 2

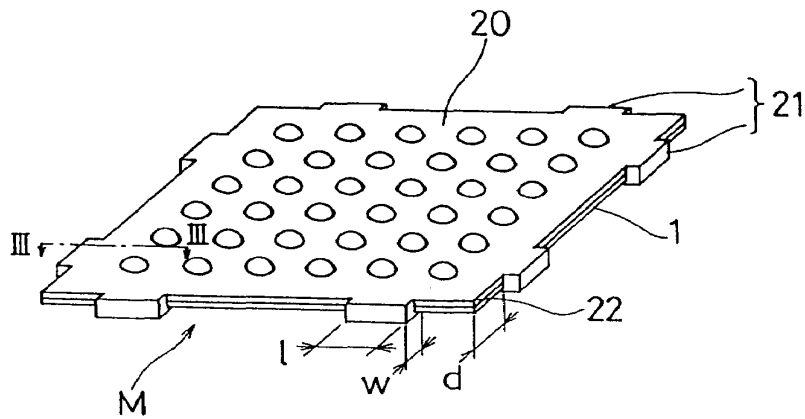


FIG. 3

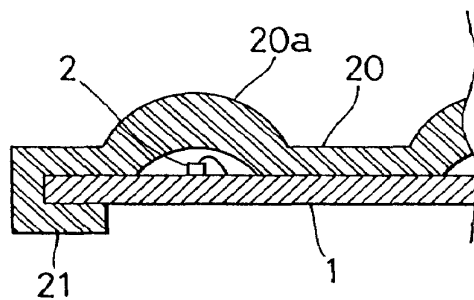


FIG. 4

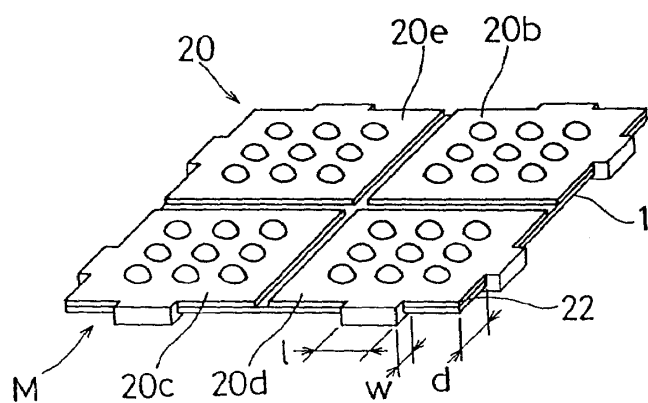


FIG. 5

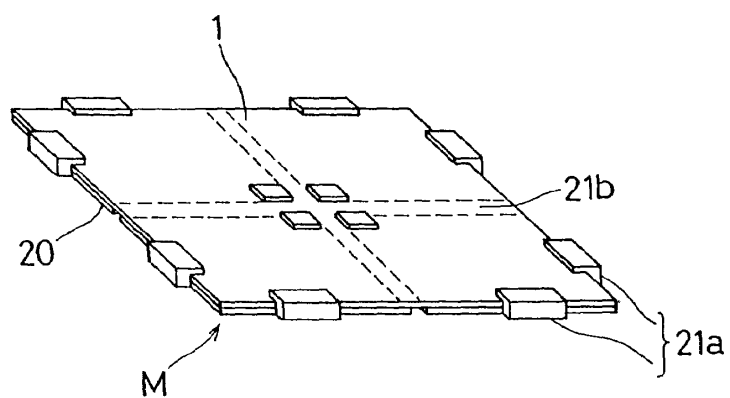


FIG. 6

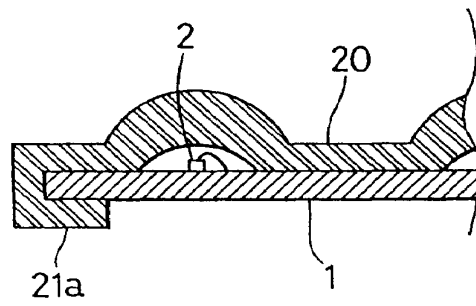


FIG. 7

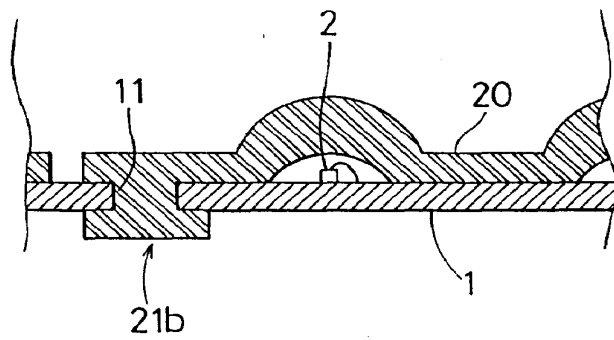




FIG. 8 (A)

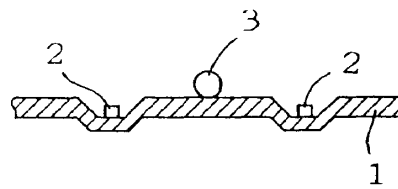


FIG. 8 (B)

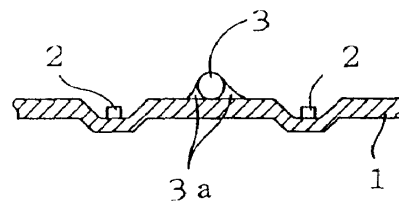


FIG. 8 (C)

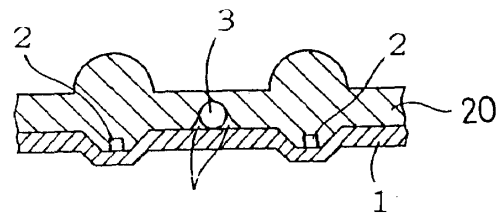
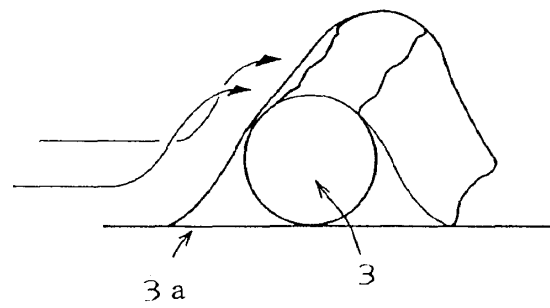
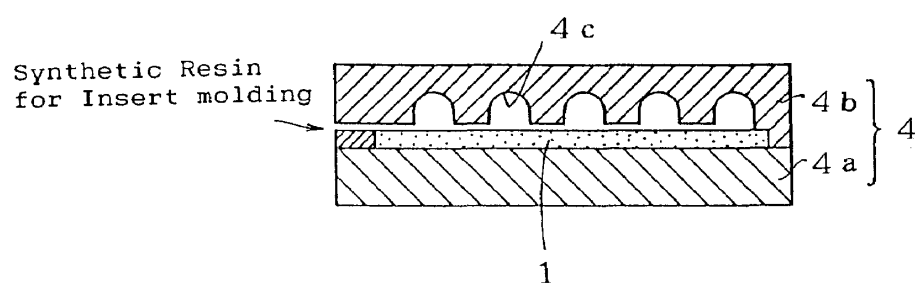


FIG. 9



F I G. 1 0



F I G. 1 1

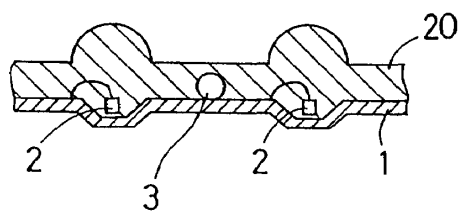


FIG. 12

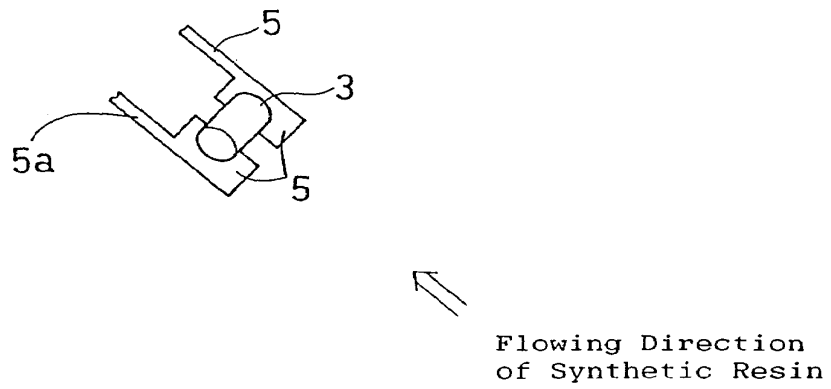


FIG. 13

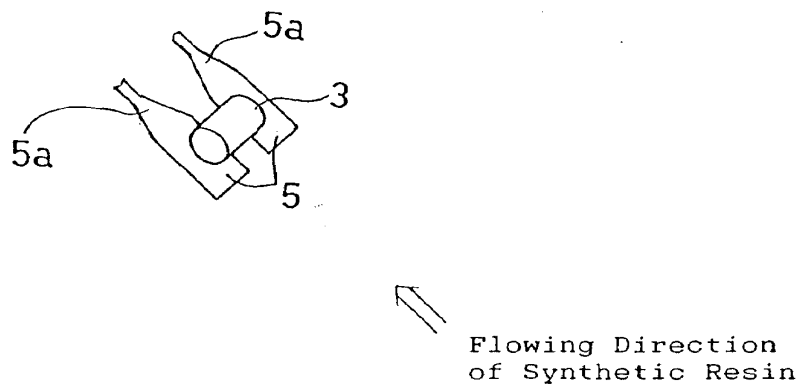


FIG. 14

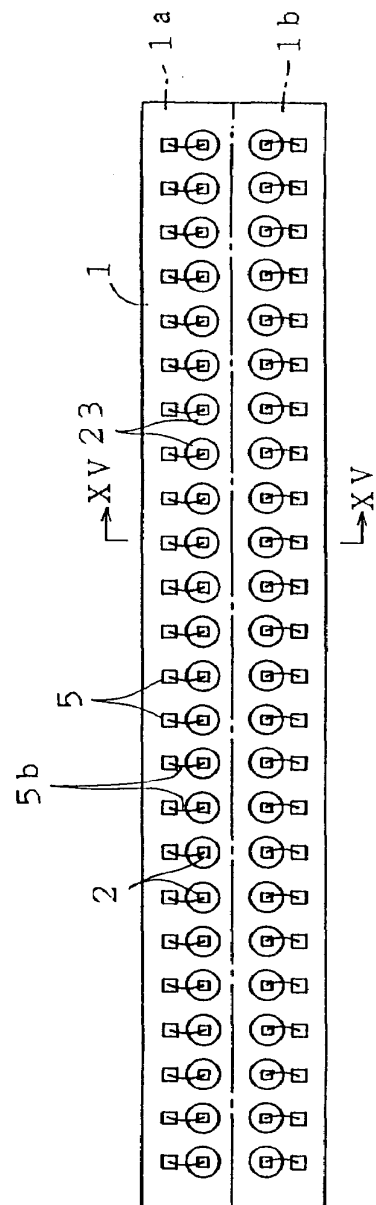


FIG. 15

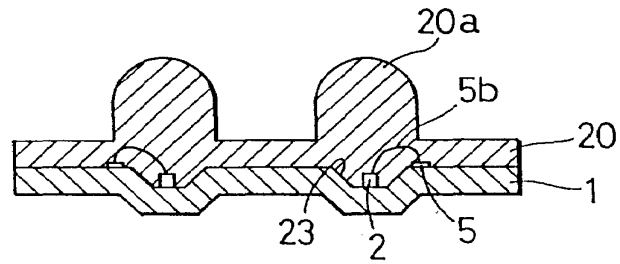


FIG. 16

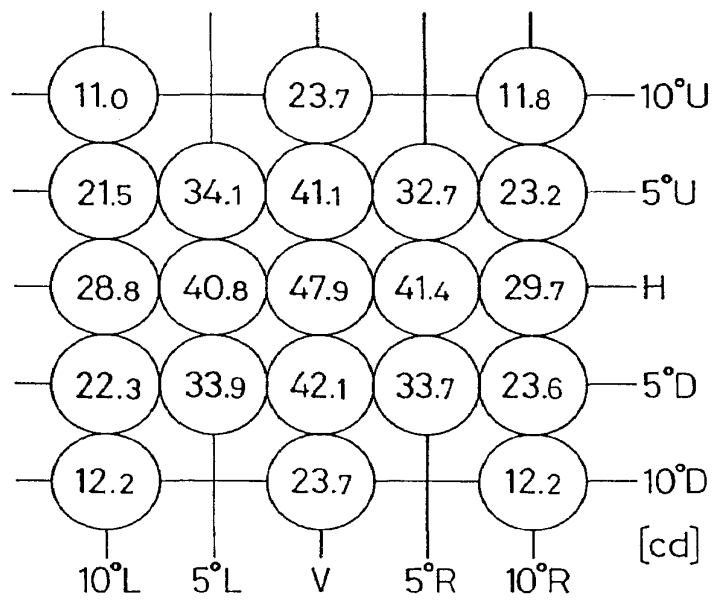


FIG. 17

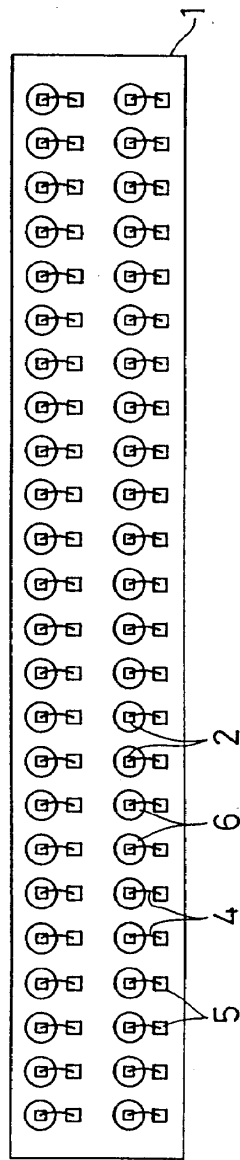


FIG. 18

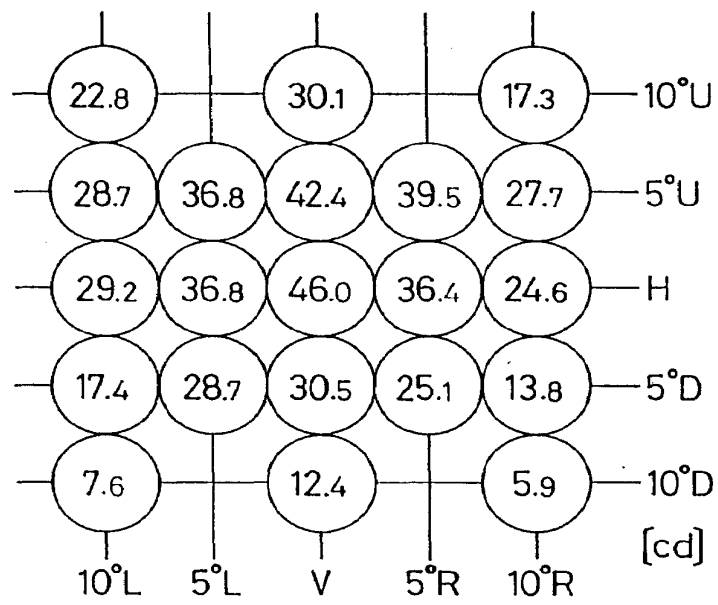


FIG. 19

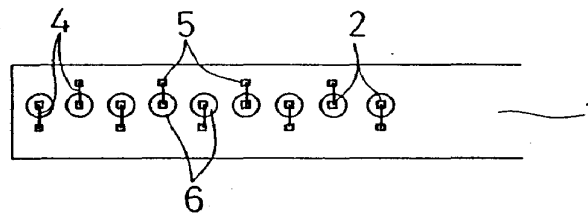


FIG. 20

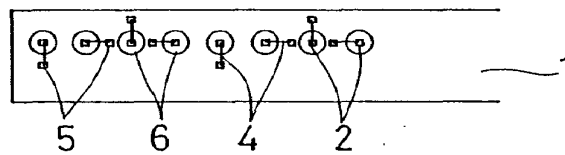


FIG. 21

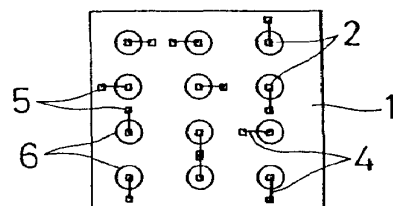




FIG. 22

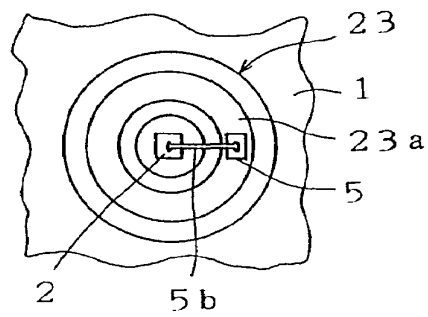
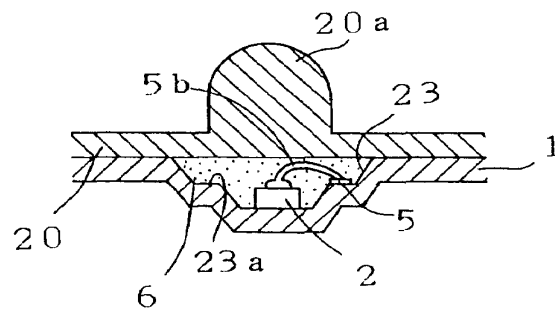


FIG. 23



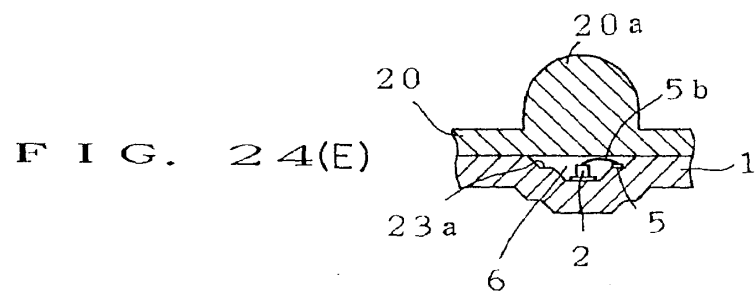
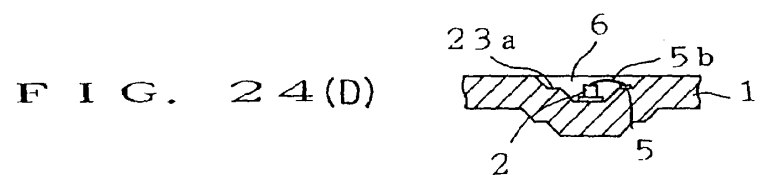
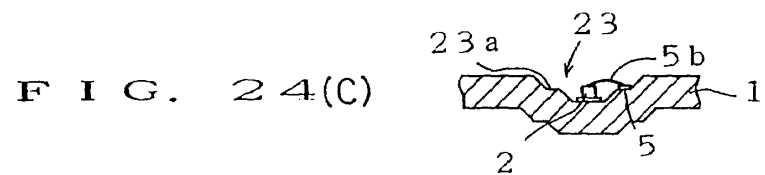
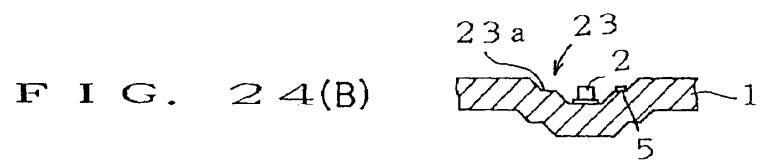
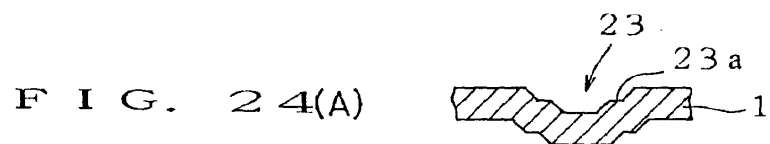


FIG. 25

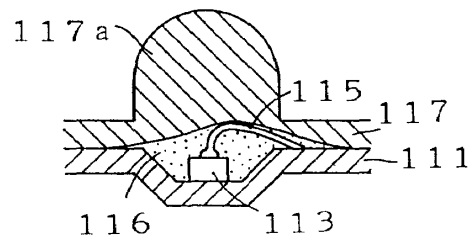


FIG. 26

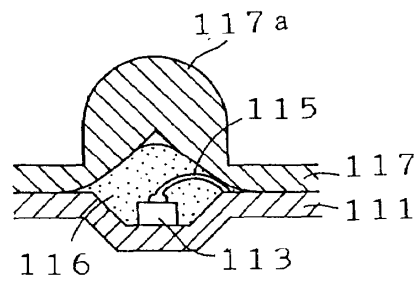


FIG. 27

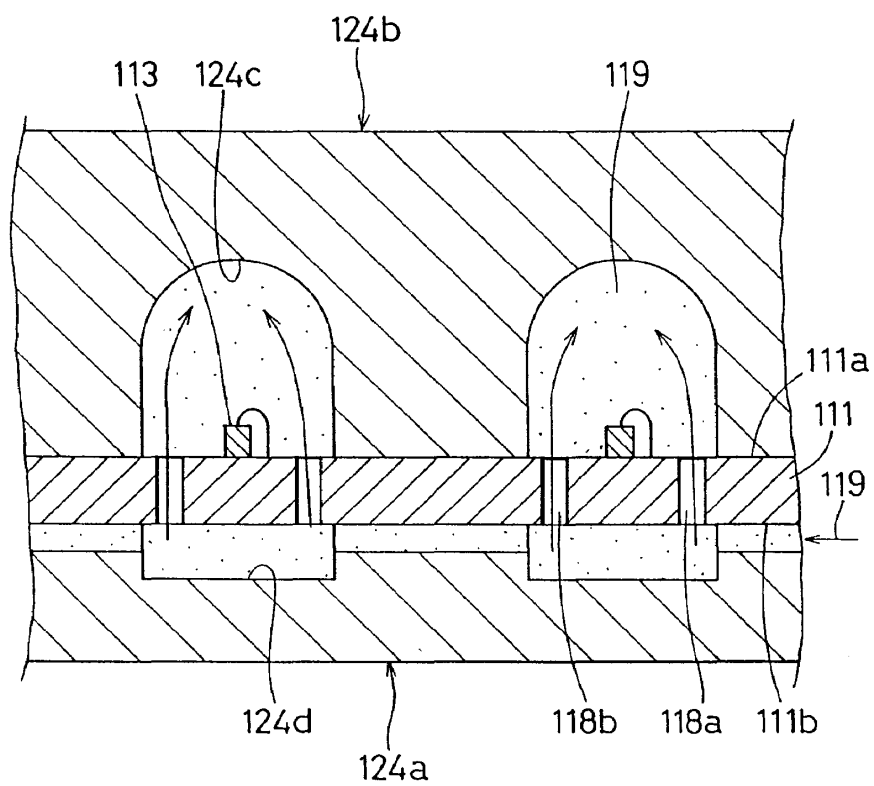


FIG. 28

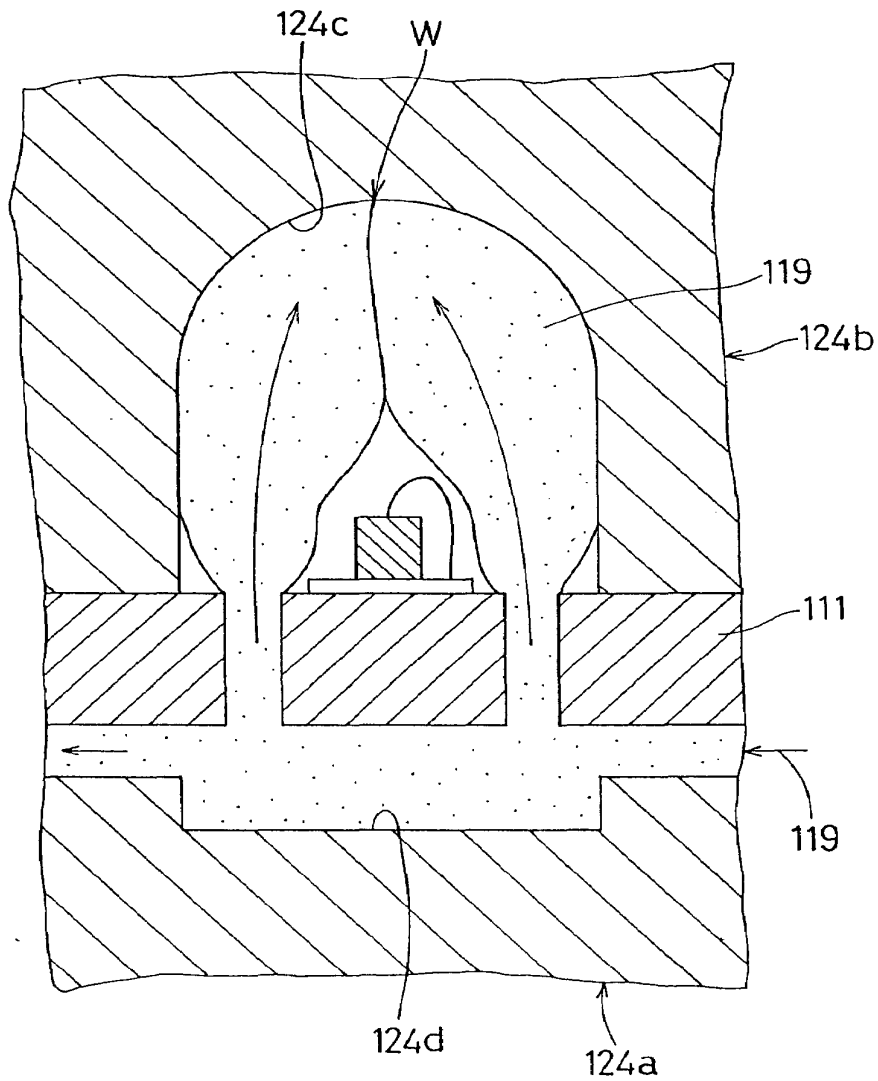


FIG. 29

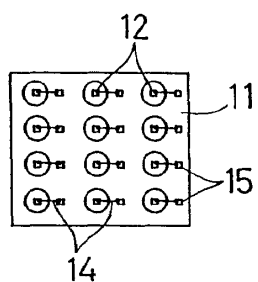
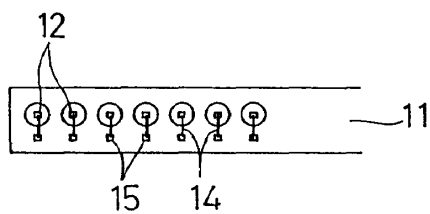


FIG. 30



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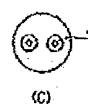
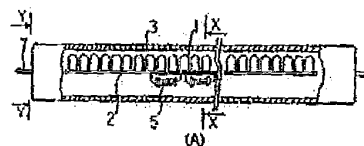
|           |                 |          |                                           |
|-----------|-----------------|----------|-------------------------------------------|
| (21) 出願番号 | 特願平8-300816     | (71) 出願人 | 000135254<br>株式会社ニレコ<br>東京都八王子市石川町2561番地4 |
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(54) 【発明の名称】 発光ダイオードを用いた細長光源

(57) 【要約】

【目的】 長寿命でかつ既存の蛍光灯と互換性ある細長光源を得る。

【構成】 発光ダイオード1を直線状にプリント基板2に配置し、これを標準的な直線状蛍光灯と同一寸法の円管3内に設置し、円管3の両端には蛍光灯の電気接続金物と同一寸法の電気接続金物7を設ける。



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【特許請求の範囲】

【請求項1】 発光ダイオードを直線状に並べたプリント基板と、このプリント基板を内部に取り付ける標準寸法の直線状蛍光灯と同一寸法で光を透過する円管と、該円管の両端に取り付けられた標準の直線状蛍光灯の電気接続金物と同一寸法の電気接続金具とを備えたことを特徴とする発光ダイオードを用いた細長光源。

【請求項2】 前記円管内壁には前記プリント基板の幅方向両辺をそれぞれ上下より挟む支持材が設けられていることを特徴とする請求項1記載の発光ダイオードを用いた細長光源。

【請求項3】 前記円管は光を拡散させる拡散材により構成されていることを特徴とする請求項1または2記載の発光ダイオードを用いた細長光源。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 本発明は、かみ、フォイル、ストリップ等ウェブのエッジ位置などを測定する光学式検出器に用いられる検光用の発光ダイオードを用いた細長光源に関する。

【0002】

【従来の技術】 紙、フォイルなどを連続印刷する場合、またストリップを圧延工程で圧延する場合、これらウェブのエッジ位置や中央位置を検出し、ウェブがロールにより適正に送られてゆくよう制御がなされる。またウェブの幅の検出も行われる。図4はこのようなウェブのエッジ位置や幅の検出方法を示す図である。走行するウェブ10の下面に細長い光源を有する検光器11をその長さ方向がウェブ10の幅方向になるように配置し、ウェブ10の上部からイメージセンサ12によりウェブ10のエッジを検出する。光源からの光がウェブ10で遮断される検目の位置がエッジを表すので、この位置をイメージセンサ12の撮像した画像より検出することによりエッジを検出できる。(A)はこのようにしてエッジを検出する方法を示し、(B)はウェブ10の幅方向両端のエッジを検出することにより、エッジ間の長さであるウェブ10の幅を検出する方法を示す。

【0003】 このようにウェブのエッジや幅、また幅の中央位置などを測定する測定用検出器に広範囲な検出長を要求されることが多く、従って使用する検光光源の投光長も数100mmから1m前後と長いものが要求される。このため、投光長が長く、輝度も均一性がある光源として蛍光灯が広く使用されている。

【0004】

【発明が解決しようとする課題】 光源として蛍光灯を使用する場合、一定のしきい値より暗くなる位置をエッジ位置としてエッジ位置を検出する。アナログ検出方式では、光源の輝度が経時劣化するため、検出誤差が徐々に増大する。またデジタル検出方式では、光源が老化しても明レベルとしきい値に差があれば特性変動はなく、

2

またしきい値を設定変更することにより特性変動を防止できるので、経時劣化の影響はある程度防ぐことができるが、使用可能期間が短いという寿命の問題があり、何れの方法の場合も寿命が短いため、定期的に交換しなければならず、保守上の支障をきたしていた。しかし蛍光灯は細長光源として広く用いられており、エッジ等の測定用検出器は蛍光灯が装備されるように製作されているので、このように既存の検出器にも容易に装備できる細長光源が必要となる。

10 【0005】 本発明は上述の問題点に鑑みてなされたもので、発光ダイオードを直線状に並べて細長光源とすることにより長寿命の光源を得ることを目的とし、さらに外形および電気接続金具を蛍光灯と同一とすることにより、既存の装置にも使用できる細長光源とすることを目的とする。

【0006】

【課題を解決するための手段】 上記目的を達成するため、請求項1の発明では、発光ダイオードを直線状に並べたプリント基板と、このプリント基板を内部に取り付ける標準寸法の直線状蛍光灯と同一寸法で光を透過する円管と、該円管の両端に取り付けられた標準の直線状蛍光灯の電気接続金物と同一寸法の電気接続金具とを備える。

【0007】 請求項2の発明では、前記円管内壁には前記プリント基板の幅方向両辺をそれぞれ上下より挟む支持材が設けられている。

【0008】 請求項3の発明では、前記円管は光を拡散させる拡散材により構成されている。

【0009】

30 【作用】 請求項1の発明によれば、発光ダイオードを直線状に並べることにより、細長光源が得られる。光源の長さは、発光ダイオードの数を増加させることにより所望の長さとすることができる。発光ダイオードは寿命が蛍光灯より十分長く輝度も安定しているので、長寿命で輝度の安定した光源が得られる。発光ダイオードを並べたプリント基板を既存の検出器に使われている標準寸法の直線状蛍光灯と同一寸法で光を透過する円管に入れ、かつ電気接続金具を蛍光灯のものと同じとするので、蛍光灯を光源としている既存の装置にも細長光源として使用できる。

40 【0010】 請求項2の発明によれば、円管内壁には発光ダイオードを直線状に並べたプリント基板の幅方向両辺をそれぞれ上下より挟む支持材が設けられているので、プリント基板を円管に挿入するときのガイドになり、またプリント基板を振動に対し十分支持し、かつ円管の補強となっている。

【0011】 請求項3の発明によれば、円管を拡散板により構成するので、発光ダイオードからの光を散乱させ輝度が均一化される。

【0012】

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【実施例】以下、本発明の実施例について図面を参照して説明する。図1は実施例の細長光源の構成図を示し、(A)が縦断面図、(B)は(A)のX-X断面、(C)は(A)のY-Y矢視図である。発光ダイオード1は赤色LEDを使用することが多いが、発光対象によっては黄、緑、青、赤外LEDを用いてもよい。発光ダイオード1はプリント基板2の上に1列に互いの間隔を密にして配置される。プリント基板2はアクリル製の円管3の直径上に配置され、両端は円管壁に取り付けられた上、下2枚の支持材4で拘束される。この支持材4は、プリント基板2を円管3内に挿入するときの案内にもなる。さらにプリント基板2を振動等に対し十分強固に支持し、円管3の振動も兼ねた構造としている。抵抗5、コンデンサ6は発光ダイオード1に供給する電流の全波整流及び平滑回路を構成する部品である。電気接続金具7は円管3の両端に設けられ、円管3の外径、長さおよび電気接続金具7は既存の換気器に使われているJISC7601の直線状蛍光灯と同じ寸法、配置とし、JISC7709のG13またはR17aの口金と同じ寸法としている。これらの換気器では30W用、32W用、40W用の出力の蛍光灯がよく使われ、これらは、出力に応じて長さのみ長くなっている。

【0013】プリント基板2は基準寸法の基準基板からなり、1つの基準基板には発光ダイオード1を33個設けている。30W用にはこの基準基板を3個長さ方向に配置し、32W用は4個、40W用は6個配置している。円管3はアクリル材の無色透明なものを用いられる。しかし、長さ方向にわたって細度の均一性を向上させるために乳白色の不透明体にしてもよい。また、円管3は透明体とし、本光源を収納する投光器ケースの発光用窓ガラスを乳白色または不透明材にするか、すりガラスを用いるようにしてもよい。なお円管3はアクリル材以外にポリカーボネイト等のプラスチック材が用いられるが、蛍光灯と同様ガラスとしてもよい。

【0014】図2は本実施例の細長光源の点灯回路ブロック図である。本図は32W用、40W用の場合を示したもので、32W用はプリント基板2の基準基板が4枚、40W用は6枚と抵抗枚から構成されているので、2分路回路としている。30W用は基準基板が3枚と奇数なので、3分路回路としている。電気接続金具7には蛍光灯に用いられる安定器からの交流電源が印加され、全波整流・平滑回路8の全波整流回路により全波整流さ

れ、整流平滑回路を経て、直列に接続された多数の発光ダイオード1に定電流源内に制限した電流を流し、各発光ダイオード1が等電流に点灯するようにしている。

【0015】図3は投光器に入っている既存の蛍光灯を本実施例の細長光源に交換する説明図である。蛍光灯を使用した既存の投光器11の場合、投光器15として使用されている既存の蛍光灯を本実施例の細長光源に交換すると共に蛍光灯のグローランプ16を取り外す。蛍光灯の安定器17はそのまま使えるので残しておく。このようにして交換された投光器15を投光器ケース18に入れる。投光器ケース18の発光用窓19はガラスまたはアクリルなどの覆い板20で覆われているが、本実施例の細長光源の円管3が透明な場合、この覆い板20を乳白色または不透明な板20とする。なお、円管3が乳白色等で光を散乱する場合は覆い板20は透明のガラスまたはプラスチックでよい。この投光器11は図4に示した光源として用いられる。

【0016】

【発明の効果】以上の説明から明らかなように、本発明は光源として発光ダイオードを使用することにより、寿命を極めて長くすることができ、交換などの保守作業を少なくし、かつ細度の経年劣化も少ないのでエッジなどの換気器に用いることにより換気精度の劣化を防止することができる。また、標準的な蛍光灯と同じ寸法および同一の電気接続金具を用いているので、光源として蛍光灯を使用している既存の設備に容易に使用することができ、

【図面の簡単な説明】

【図1】本実施例の構成を示し、(A)は縦断面図、

(B)はX-X断面図、(C)はY-Y矢視図である。

【図2】実施例の電気回路図である。

【図3】蛍光灯との交換および投光器への取り付けを示す図である。

【図4】細長光源がウェブのエッジや板縁の換出に使用されている例を示す図である。

【符号の説明】

1 発光ダイオード

2 プリント基板

3 円管

4 支持材

7 電気接続金具

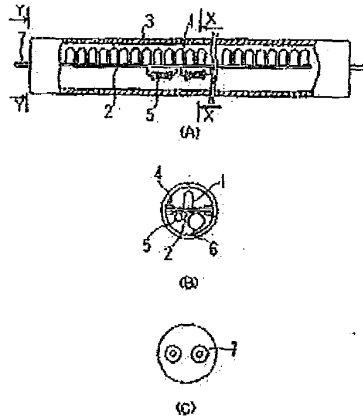
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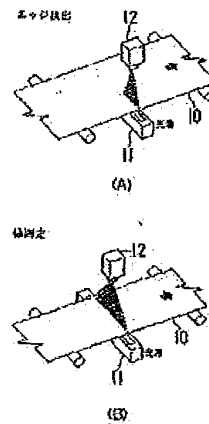
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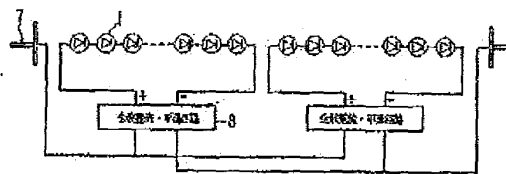
【図1】



【図4】



【図2】



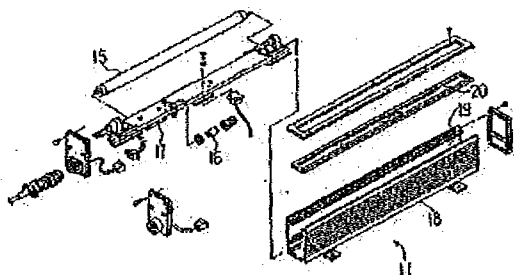
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(5)

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(図3)



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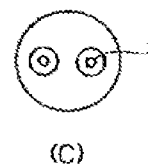
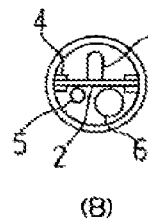
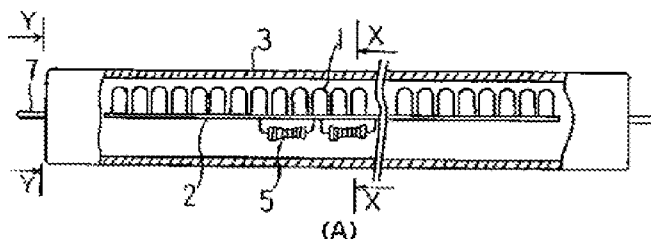
| Review Request                                                             | No request | Number of claims 3                                                                           | OL | (Total 5 pages) |
|----------------------------------------------------------------------------|------------|----------------------------------------------------------------------------------------------|----|-----------------|
| (21) Application No.: P 6-300846                                           |            | (71) Applicant: 000135254<br>Nireco Co., Ltd.<br>2951-4, Ishikawa-machi, Hachioji, Tokyo     |    |                 |
| (22) Application Date: 6 <sup>th</sup> Year of Heisei December 5<br>(1994) |            | (72) Inventor: Shinsuke Iino<br>2951-4, Ishikawa-machi, Hachioji, Tokyo<br>Nireco Co., Ltd.  |    |                 |
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|                                                                            |            | (74) Agent: Attorney Shigeru Nara                                                            |    |                 |

(54) **[Name of Invention]** Slender light source using LED

(57) **[Abstract]**

[Objective] To obtain a slender light source that has longer life and is interchangeable with the existing fluorescent lamp.

[Structure] LEDs 1 mounted linearly on a PCB 2 are set in a circular tube 3 that has the same size as the standard linear fluorescent lamp. At both ends of the circular tube 3, electric connection metal fittings 7 are set in the same size as those of a fluorescent lamp.



**What is claimed is:**

1, A slender light source which uses LED, consisting of a PCB which is linearly paratactic with LED and is mounted in a circular tube that has the same size as the standard linear fluorescent lamp, and the electric connection metal fittings which have the same size as those of the standard linear fluorescent lamp and are mounted respectively at both ends of the circular tube.

2, A slender light source with LED mentioned in Claim 1, which has support material set in the circular tube to respectively clamp both sides from top to bottom along the width of PCB.

3, A slender light source with LED mentioned in Claim 1 or Claim 2, of which the circular tube is made of diffusion material, thus allowing the light's penetration.

**[Description of the Invention]**

[0001]

**[Industrial Application]** This invention relates to the slender light source with LED, an optical detector emitting light, which is used for detecting the edge of a paper, foil, strips, and other types of connecting plates.

[0002]

**[Description of the Prior Art]** When carrying out continuous printing of paper, foil, etc., and when rolling a strip, the edge position and the middle position of these connecting plates are detected, and control is made so that a connecting plate may be properly set within a roll. The detection of the width of the connecting plate is also performed. Figure 4 is a figure showing the method detecting the edge position and the width of such a connecting plate. On the undersurface of the web 10, width-wise, mount the floodlight 11 which has a slender light source. From the upper surface, the edge of the connecting plate 10 is continuously photographed by the image sensor 12. Since the light from the light source is indicated at the joint of the connecting plate 10 and shielded by the edge, it can be detected by the images photographed by the image sensor 12. A indicates such edge detection method, and B indicates the detection of the width of the connecting plate 10 through the detection of edges at both ends of the width direction of the connecting plate 10.

[0003] The detector for the detection of the edge, width, central position of width, etc. of the connecting plate usually requires a wide range of detection lengths, so the floodlighting length of the used light source, from several hundred millimeters to one meter, is also required. To this end, the fluorescent lamp which has even floodlighting length and brightness is widely used as a light source.

[0004]

**[Problem to be Solved by the Invention]** When a fluorescent lamp is used as a light source, the position which becomes darker due to the fixed critical value is taken as an edge position and is detected. As the analogy method is applied, the ageing of the brightness

of the light source is caused and the detection error gradually increases. Thanks to digital detection, regardless of the ageing of the light source or the difference between the brightness and the critical value, the characteristic fluctuation can be prevented; therefore, to some extent, the influence of ageing can be prevented. However, the problem of the short life still exists, and the fluorescent lamp needs to be replaced periodically, regardless of any conditions. The fluorescent lamps are widely used as a slender light source, and the edge detectors are manufactured just like fluorescent lamps, so if needed, a slender light source can be easily mounted on the existing detectors. [0005] Considering the above problem, the invention takes LED as a linear slender light source and obtains a long-life light source. In addition, the similar shape and electric connector as those of fluorescent lamp makes it possible to use a slender light source on the existing device.

[0006]

**[Methods]** In order to attain the above-mentioned purpose, the invention in Claim 1 has a PCB which arranges LEDs linearly. The PCB is set in a circular tube that has the same size as the standard linear fluorescent lamp, and at both ends of the circular tube, electric connection metal fittings, the same size as those of a standard linear fluorescent lamp, are set in.

[0007] In the invention in Claim 2, the support material is set in the circular tube to respectively clamp, from top to bottom, both sides along the width of PCB.

[0008] In the invention in Claim 3, the above-mentioned circular tube is made of the diffusion material which can diffuse light.

[0009]

**[Function]** According to the invention in Claim 1, a slender light source is obtained by linearly arranging LEDs. The desired length of the light source can be obtained by increasing the number of LEDs. Since LED has a longer life than a fluorescent lamp and its brightness is also stable, a long-lasting light source whose brightness is stable can be obtained. The PCB is set in a circular tube that has the same size as the standard linear fluorescent lamp, and the electric connection metal fittings have the same size as those of a standard linear fluorescent lamp. So, the fluorescent lamp used as the light source can also be used on the existing device as a slender light source.

[0010] According to the invention in Claim 2, the support material which is inserted into the circular tube to clamp, from top to bottom, both sides of the PCB which is arranged linearly paratactic with LED, therefore becomes a waveguide, completely supports PCB against the vibration, and reinforces the circular tube.

[0011] According to the invention in Claim 3, the circular tube comprised of the diffuser plate makes the brightness of light from LED uniformed.

[0012]

**[Working Example]** The working example of this invention is described with reference to the figures. Figure 1 shows the structural figure of the slender light source of a working example. A is vertical section, B is X-X section of A, and C is Y-Y view figure of A. LEDs 1 often use red color, but depending on the object for detection, yellow, green, blue, and infrared LEDs can also be used. LEDs 1 are arranged on PCB 2 in a dense row. PCB 2 is arranged on the diameter of the circular tube 3 made from propylene, and both ends are mounted on the base of the tube wall, able to be locked by the two lower sheets of support material 4. This support material 4 also becomes a waveguide when PCB 2 is inserted into the circular tube 3. Furthermore, it can completely and firmly support PCB 2 against the vibration and reinforce the circular tube 3. The resistance 5 and the capacitor 6 are parts of the full wave rectification and the smoothing (filtering) circuit which supplies the current to LED 1. The electric connection metal fittings 7 are set at both ends of the circular tube 3, and the outer diameter and length of the circular tube 3, and the electric connection metal fittings 7 are consistent with the size of the linear fluorescent lamp of JISC7601 used on the existing detector. The size is also the same as the tube base for G13 or R17d of JISC7709. In these detectors, 30W, 32W, and 40W fluorescent lamps are often used, and only the length increases according to the output.

[0013] The standard PCB 2 has a regular size. 33 LEDs 1 are set on a standard PCB. For 30W, three standard PCBs are set at the length direction, for 32W, four PCBs are set and for 40W, six PCBs are set. In order to increase the uniformity of the brightness, a milky opaque body can also be used. The circular tube 3 is transparent, and the windowpane of the floodlight case containing the light source is of milky or opaque material, or ground glass. The circular tube 3 can be made of plastic material besides propylene, such as polycarbonate, but it can also be of glass, the same as a fluorescent lamp.

[0014] Figure 2 is the frame diagram of the lighting circuit of the slender light source. The figure is for 32W and 40W. As to the former, four standard PCBs 2 are arranged and for the latter six PCBs are used as two separated circuits. For 30W, the three PCBs are used as three separated circuits. In the electric connection metal fittings 7, AC power supply from the ballast used by the fluorescent lamp is attached. In the full-wave rectification smoothing (filtering) circuit 8,

the current within rated value goes through the serial LEDs, and each LED gives light with equal brightness.

[0015] Figure 3 is an explanatory figure of exchanging the existing fluorescent lamp included in a floodlight for the slender light source of this example. In the case of the existing floodlight 11 which uses a fluorescent lamp, the existing fluorescent lamp currently used as the floodlighting pipe 15 is exchanged for the slender light source of this example, and at the same time the bulb 16 of the fluorescent lamp is removed. Since the ballast 17 of the fluorescent lamp can be used as before, it is reserved. The exchanged floodlighting pipe 15 is put into the floodlight case 18. The lighting window 19 of the floodlight case 18 is covered with glass or propylene sheathings 20, but if the circular tube 3 of the slender light source of this example is transparent, this sheathing 20 can be milky or of opaque diffusion board. When the circular tube 3 shows opalescence, transparent glass or plastics may be sufficient as the sheathing 20. This floodlight 11 is used as a light source shown in figure 4.

[0016]

**[Effect of the Invention]** As specified in the above statement, the LED used as a light source in this invention can extremely prolong its life and reduce the maintenance needed, such as replacement. In addition, because it can reduce the ageing of brightness, the edge detector can prevent the deterioration of the detection accuracy. Besides, due to the same size as the standard fluorescent lamp and the same electric connection metal fittings, it is easy to apply it in the existing fluorescent lamp used as a light source.

#### **[Brief Description of the Drawings]**

FIG. 1 is the structure of the working example, A is vertical section, B is X-X section, and C is Y-Y view figure.

FIG. 2 is an electric circuit diagram of the working example.

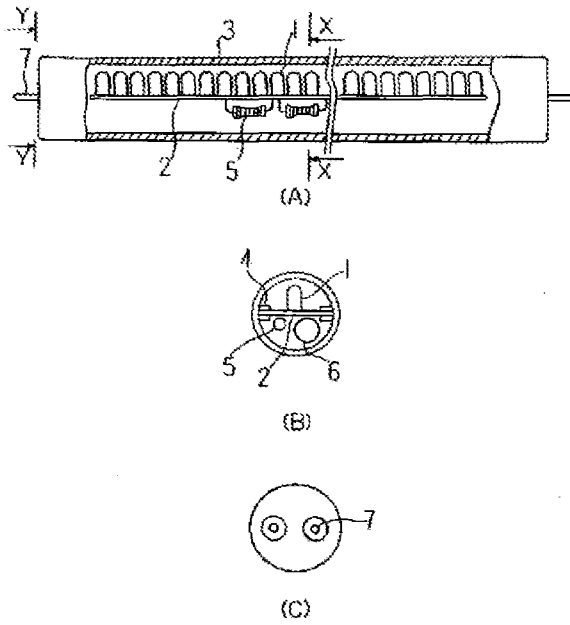
FIG. 3 shows the exchange with a fluorescent lamp and the installation of a floodlight.

FIG. 4 shows an example of slender light source used for detecting the edge and board width of the connecting plate.

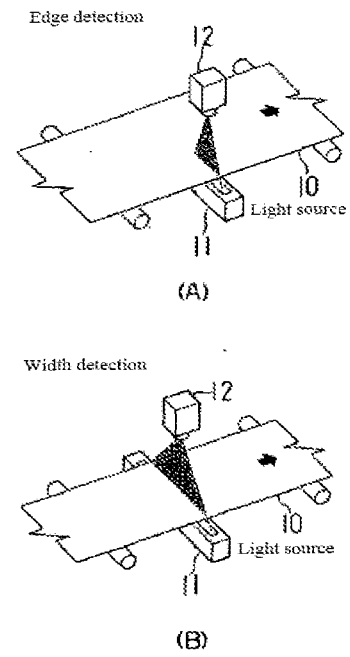
#### **[Explanations of Symbols]**

1. LED (Light emitting diode)
2. PCB (Printed circuit board)
3. Circular tube
4. Support material
7. Electric connection metal fittings.

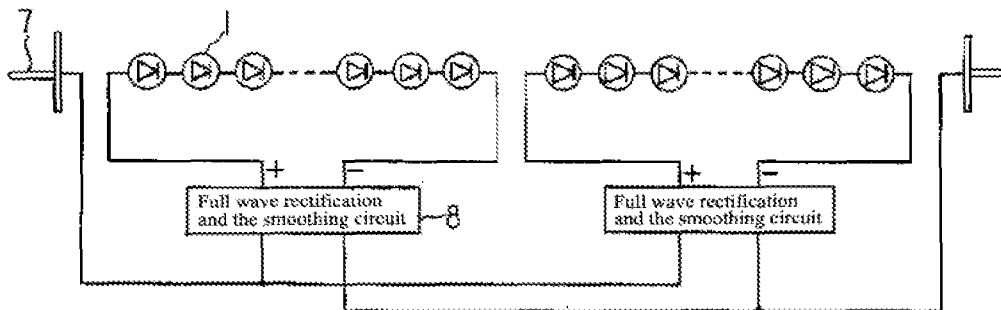
[Fig. 1]



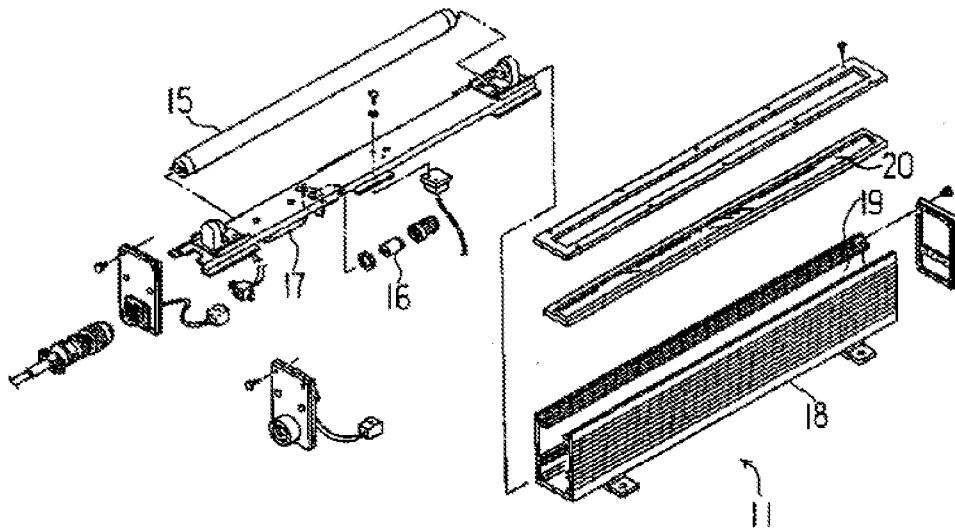
[Fig. 4]



[Fig. 2]



[Fig. 3]





## CERTIFIED TRANSLATION

I, Fazuya Naoki, a professional translator, certify that the foregoing is to the best of my knowledge and belief an accurate translation into English of Japanese patent JP08162677A, titled "Slender light source using LED."

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Date

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| H 0 1 L 33/00            |      | J 7370-4M |     |        |
|                          |      | H 7370-4M |     |        |
|                          |      | N 7370-4M |     |        |

審査請求 未請求 請求項の数 1 (全 2 頁)

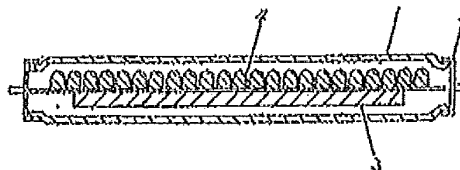
|          |                |         |                                          |
|----------|----------------|---------|------------------------------------------|
| (21)出願番号 | 実開平4-25528     | (71)出願人 | 591057658<br>高立株式会社<br>東京都中野区南台 2丁目19番1号 |
| (22)出願日  | 平成4年(1992)3月0日 | (72)考案者 | 植田 典則<br>東京都中野区南台二丁目19番1号高立株式<br>会社内     |

(64)【考案の名称】 蛍光灯型LED投光器

(57)【要約】

【目的】すでに設置されている蛍光灯器具に装着することによって、他の設備を必要とする事無く、LEDを点灯し、投光することのできる投光器を供給することを目的とする。

【構成】すなわち、管1および口金2によって、たとえばJIS C 7001に定められた蛍光灯と同じ形状となるようにし、蛍光灯器具に接続できるようにする。蛍光灯器具に装着することによって、電力は口金2を経てLEDを点灯する回路3に供給され、ここでLEDを点灯するのに適した電力に変えられ、LED4に供給され、LED4を点灯する。



(2)

実開平B-54103

1

2

【実用新案登録請求の範囲】

【請求項1】 蛍光灯器具に接続できる機構を有し、LEDおよび商用電源によってLEDを点灯する回路を内蔵し、蛍光灯器具に装着することによってLEDを点灯し、投光する投光器。

【図面の簡単な説明】

【図1】 本考案による蛍光灯型LED投光器の望ましい一例の断面図である。

＊【図2】 「図1」に示した蛍光灯型LED投光器の回路のブロック図である。

【符号の説明】

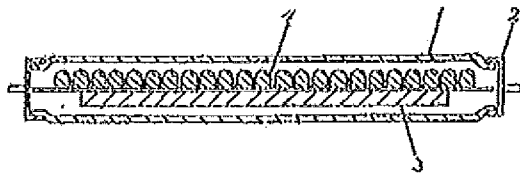
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2・・・口金

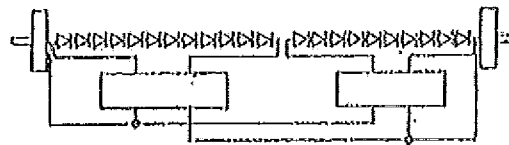
3・・・LEDを点灯する回路

4・・・LED

（図1）



（図2）



## 【考案の詳細な説明】

## 【産業上の利用分野】

【0001】 本考案は、LED投光器の構成にかかわり、蛍光灯器具に接続できる機構を有し、LEDおよび商用電源によってLEDを点灯する回路を内蔵し、蛍光灯器具に装着することによって、他の設備を必要とする事無く、LEDを点灯し、投光することを特長とする投光器に関する。

## 【従来の技術】

【0002】 従来より、たとえば鋼板の圧延において、鋼板の下に蛍光灯を設置し、鋼板の上に受光素子をならべたものを設置して、散受光素子に光が到達するか否かで、鋼板の位置を検出する設備が用いられてきた。

【0003】 また一部では、上記の蛍光灯の代わりに、LEDをならべたものを投光器として使用しているところもある。

## 【考案が解決しようとする課題】

【0004】 ところで上記のような従来の蛍光灯を設置した設備では蛍光ランプの寿命が短いため、頻繁に蛍光ランプを交換せざるをえず、そのたびに圧延装置を停止するなど負担の大きいものであった。

【0005】 また、投光器としてLEDをならべたものを使用するには、すでに設置されている蛍光灯器具を撤去し代わりにLEDを点灯する回路を設けるなどの負担の大きいものであった。

【0006】 本考案は上記従来の難点に鑑みなされたもので、すでに設置されている蛍光灯器具に装着することによって、他の設備を必要とする事無く、LEDを点灯し、投光することのできる投光器を供給することを目的とする。

## 【課題を解決するための手段】

【0007】 本考案による蛍光灯型LED投光器の構造は、蛍光灯器具に接続できる機構を有し、LEDおよび商用電源によってLEDを点灯する回路を内蔵し、すでに設置されている蛍光灯器具に装着することによって、他の設備を必要とする事無く、LEDを点灯し、投光することを特長とする。

## 【作用】

【0008】 この蛍光灯型LED投光器では、すでに設置されている蛍光

灯器具に装着することによって、他の設備を必要とする事無く、投光できるため、従来蛍光灯を用いていたところでは何ら設備の変更なしに、単に使用している蛍光灯の交換の時期に、この蛍光灯型LED投光器に交換するだけで、寿命の長いLED投光器とすることができる。

【実施例】

【0009】 以下に本考案による蛍光灯型LED投光器の望ましい実施例を図面に基づき説明する。

【0010】 第一図は本考案による蛍光灯型LED投光器の望ましい一例の断面図であり、第2図は同じ蛍光灯型LED投光器の回路のブロック図である。

【0011】 すなわち、管1および口金2によって、たとえばJISC7601に定められた蛍光灯と同じ形状となるようにし、蛍光灯器具に接続できるようにする。蛍光灯器具に装着することによって、電力は口金2を経てLEDを点灯する回路3に供給され、ここでLEDを点灯するのに適した電力に変えられ、LED4に供給され、LED4を点灯する。

【考案の効果】

【0012】 上記の説明からも明らかなように、本考案による蛍光灯型LED投光器を用いれば、すでに設置されている蛍光灯器具に装着することによって、他の設備を必要とする事無く、投光することができるLED投光器を供給することができる。

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**(12) Publication of Unexamined Utility Model Application (U)**

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(43) Publication Date of Unexamined Utility Model Application: July 22, 1994  
Request for Examination: Not yet submitted  
Number of Claims: 1  
Total Pages: 2

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| (51) Int.Cl. <sup>5</sup> | Identification Symbol | JPO File Number | FI |
|---------------------------|-----------------------|-----------------|----|
| F 2 1 M 1/00              | M                     | 9249-3K         |    |
| H 0 1 L 33/00             | J                     | 7376-4M         |    |
|                           | H                     | 7376-4M         |    |
|                           | N                     | 7376-4M         |    |

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(54) Title of Device: Fluorescent Lamp Type LED Projector

(21) Utility Model Application No.: H4-25528

(22) Utility Model Application Date: March 6, 1992

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**(54) [Title of Device]** Fluorescent Lamp Type LED Projector

**(57) [Abstract]**

**[Objective]** The objective is to provide a projector that can illuminate an LED (and) emit light by installing it in an already existing fluorescent lamp fixture without having to use any other equipment.

**[Constitution]** In other words, a configuration that is similar to, for example, the fluorescent lamp specified in JIS C7601, is made so as to be connectable to a fluorescent lamp fixture using a tube, 1, and base metal, 2. Electric power is supplied to an LED-illuminating circuit, 3, via base metal 2, converted to electric power that is capable of LED-illuminating, supplied to the LED, 4, and it illuminates LED 4.

**[Registered Utility Model Claims]**

**[Claim 1]** A projector that has the feature of having the capability to be connected to a fluorescent lamp fixture, has an LED and a circuit for LED illumination with a commercial electric power source, and turns on the LED and projects light by being installed in a fluorescent lamp fixture.

**[Brief Explanation of the Drawings]**

**[Fig. 1]** A cross section of a preferred example of the fluorescent lamp-type LED projector of this device.

**[Fig. 2]** A block diagram of the circuit of the fluorescent lamp-type LED projector shown in Fig. 1.

**[Explanation of Symbols]**

- (1) ..... Tube
- (2) ..... Base metal
- (3) ..... Circuit for LED illuminating
- (4) ..... LED

Figure 1

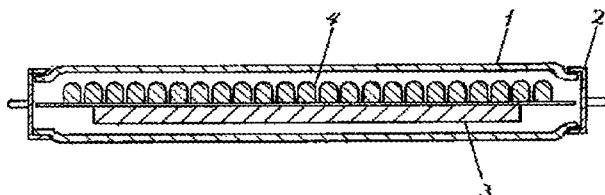
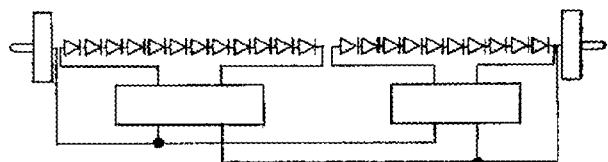


Figure 2



**[Detailed Explanation of the Device]****[Industrial Field of Application]**

**[0001]** This device is related to the structure of an LED projector, and is related to a projector that has the feature of being capable of connecting to a florescent lamp fixture and is characterized by having an LED and an LED lighting circuit for a commercial electric power source, being capable of turning on the LED and projecting light by being installed in a florescent lamp fixture without the use of any other equipment.

**[Prior Art]**

**[0002]** In a steel sheet rolling mill, as an example, equipment where fluorescent lamps are placed underneath the steel sheet and light sensing elements are arranged over the steel sheet for steel sheet position detection by judging whether or not light is sensed by said light sensing elements has been conventionally used.

**[0003]** Also, in some places a set of LEDs is used as the projector instead of the aforementioned fluorescent lamps.

**[Problems the Device is to Solve]**

**[0004]** However, with the equipment using conventional fluorescent lamps as described in the above, the life of the fluorescent lamps is short, frequent fluorescent lamp changes are needed, and having to stop the steel rolling mill every time (the lamps have to be changed) is a burden.

**[0005]** Also, for use of a set of LEDs as a projector, existing fluorescent lamp fixtures have to be removed and a (new) circuit for LED lighting has to be provided which is also a great burden.

**[0006]** This device considers the above mentioned problems and its objective is to present a projector that can be installed in an already existing fluorescent lamp fixture, and can turn on an LED and project light without the use of any other equipment.

**[0007]** The structure of the fluorescent lamp-type LED projector of this device has the feature of being capable of being connected to a fluorescent lamp fixture and is characterized by having an LED and an LED lighting circuit for a commercial electric power source, and by being capable of turning on an LED and projecting light by installation in an already existing fluorescent lamp fixture without the use of any other equipment.



### **[Operation of the Device]**

**[0008]** Since this fluorescent type LED projector can project light by being installed in an already existing fluorescent lamp fixture without the use of any other equipment, in such an area where conventional fluorescent lamps have been used, a long-life LED projector can be made by only changing it into this fluorescent lamp-type LED projector at the time of fluorescent lamp changing without changing any other equipment.

### **[Working Example]**

**[0009]** A preferred working example of the fluorescent type LED projector of this device is explained below based on the drawings.

**[0010]** Figure 1 is a cross section of one preferred example of the fluorescent lamp-type LED projector of this device, and Fig. 2 is a block diagram of the circuit for the same fluorescent lamp-type LED projector.

**[0011]** That is, a configuration that is similar to the fluorescent lamp that is specified in JIS C7601 as an example is made using tube 1 and base metal 2 for connection to a fluorescent lamp fixture. By installation in a fluorescent lamp fixture, electric power is supplied to circuit 3 for LED lighting via base metal 2, and (the power) is converted here to electric power that is capable of LED lighting, and is supplied to LED 4, and turns on LED 4.

### **[Effect(s) of the Device]**

**[0012]** As shown in the above explanation, when the fluorescent lamp-type LED projector of this device is used, an LED projector can be presented that can project light by being installed in an already existing fluorescent lamp fixture without the use of any other equipment.

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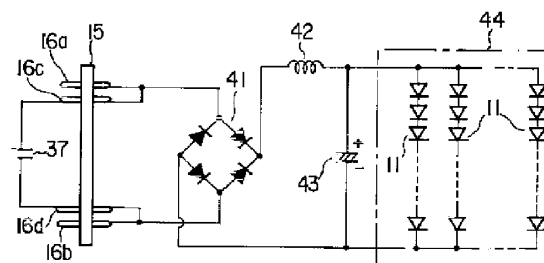
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(54)【発明の名称】 LED照明装置

(57)【要約】

【課題】インバータ形安定器を備えた照明器具に使用するLED照明装置で、平滑回路に使用するコンデンサの容量を小さくし、このコンデンサに流入するリップル電流を抑制し、LEDを確実に連続点灯させる。

【解決手段】インバータ安定器からの高周波を整流する全波整流回路41と、この整流回路にインダクタ素子42を介して接続した平滑コンデンサ43と、この平滑コンデンサに接続した $n \times m$ 個のLED11を配列したLEDユニット44からなり、LEDが点灯開始するときの電流を $I_{min}$ .アンペア、電圧降下を $V_{min}$ .ボルト、LEDの最大定格順方向電流を $I_{max}$ .アンペア、電圧降下を $V_{max}$ .ボルトとすると、平滑コンデンサはLED点灯時に出力電圧が常に $n V_{min}$ .よりも高く、 $n V_{max}$ .よりも低い電圧値を維持する容量に設定し、インダクタ素子は安定器からの周波数の2倍で十分なインピーダンスを有する値に設定する。



## 【特許請求の範囲】

【請求項1】 照明用インバータ安定器からの高周波電力を整流する整流回路と、この整流回路の出力端子にインダクタ素子を介して接続した平滑回路と、この平滑回路に接続した発光ダイオード群とからなり、

前記発光ダイオード群は、 $n$ 個の発光ダイオードを直列に接続した発光ダイオードアレイを $m$ 個並列に接続した発光ダイオードアレイ群からなり、

前記平滑回路は、平滑コンデンサを備え、この平滑コンデンサは、前記発光ダイオードアレイ群の各発光ダイオードが点灯し始めるときに流れる順方向電流を $I_{min}$ .アンペア、そのときの各発光ダイオードの電圧降下を $V_{min}$ .ボルト、また、各発光ダイオードの最大定格順方向電流を $I_{max}$ .アンペア、そのときの各発光ダイオードの電圧降下を $V_{max}$ .ボルトとしたとき、前記各発光ダイオードの点灯時に前記平滑回路出力電圧が常に $n V_{min}$ .よりも高く、かつ、 $n V_{max}$ .よりも低い電圧値を維持する容量に設定し、

前記インダクタ素子は、前記照明用インバータ安定器からの高周波の周波数からこの周波数の2倍の周波数の範囲において充分なインピーダンスを有する値に設定したことを特徴とするLED照明装置。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は、通常の蛍光灯を点灯する高周波インバータ安定器を備えた照明器具を使用して点灯ができるLED照明装置に関する。

## 【0002】

【従来の技術】通常の照明器具は白熱電球や蛍光灯を照明用に使用している。特に、蛍光灯は白熱電球に比べて消費電力、発熱などの点で優れており一般的に使用されている。しかしながら、蛍光灯の寿命は器具に使用している安定器に比べて短い。そこで、近年、蛍光灯に比べて寿命が長く、発熱も少ないランプとして発光ダイオードが使用されつつある。そして、発光ダイオードを使用した照明装置として、蛍光灯照明器具を共通に使用できるものが開発されている。

【0003】例えば、実開平6-54103号公報のものは、図9の(a)に示すように蛍光灯と同じ形状の管1と口金2を備え、その内部に複数の発光ダイオード(以下、LEDと称する。)3と点灯回路4を収納し、口金2を蛍光灯照明器具に装填することで図9の(b)に示すように点灯回路4がLED3を点灯動作するようになっている。

## 【0004】

【発明が解決しようとする課題】ところで、このLED照明装置をチョークコイル形安定器を使用した照明器具で点灯させる場合、点灯回路4にはチョークコイル形安定器から電源が供給されることになる。点灯回路4は、通常、交流を脈流に変換する整流回路やこの整流回路で

整流された脈流を疑似的な直流に変換する平滑回路からなる。例えば、点灯回路を整流回路のみで構成すると、50Hz又は60Hzの交流が100Hz又は120Hzの脈流に変換され、これによりLEDが駆動されることになる。一方、LEDは図10に示すように、印加電圧がある電圧 $V_{min}$ .以上でなければ発光しないという電圧-電流特性を持っており、図11の(a)に示す50Hz又は60Hzの電源周波数を図11の(b)に示す100Hz又は120Hzの脈流に変換して使用する場合、図中斜線の部分が消灯領域となるため100Hz又は120Hzの周期で点滅するという問題が生じ照明には適さない。

【0005】そこで、点灯回路を整流回路と平滑回路で構成すると、整流回路で100Hz又は120Hzの脈流に変換された電圧は平滑回路によって疑似的な直流に変換されることになる。しかし、この場合において平滑回路に使用するコンデンサの容量が小さいと、図12に示すように充分な平滑ができないので、図中斜線で示すように消灯領域が生じ、やはり点滅するという問題が生じる。これを解決するには、使用するコンデンサの容量を大きくすれば図13に示すように充分な平滑ができ、常に電圧が $V_{min}$ .以上となってLEDを連続点灯させることができるが、しかし、容量の大きなコンデンサを使用することは点灯回路が大形化、大重量化し、また、コストも高くなり、蛍光灯の代わりに使用する照明装置としては新たな問題が生じる。

【0006】また、このようなLED照明装置をインバータ形安定器を使用している照明器具に使用すると、チョークコイル形安定器の出力が50Hz又は60Hzの低周波であるのに対し、インバータ形安定器の出力は図14に示すようにある程度平滑された100Hz又は120Hzの包絡波形aに約50KHz～60KHzの高周波bが載った波形となり、これを容量の大きな平滑コンデンサを使用して平滑すれば図15に示すように略直線に近い充分な平滑ができ、LEDを連続点灯させることができる。しかし、この場合も容量の大きなコンデンサを使用することになり、点灯回路が大形化、大重量化し、また、コストも高くなり、蛍光灯の代わりに使用する照明装置としては新たな問題が生じる。また、インバータ形安定器からの高周波により平滑回路のコンデンサに流入するリップル電流が多くなってコンデンサの寿命を短くし、その結果、照明装置としての寿命が短くなるという問題が生じる。

【0007】そこで請求項1記載の発明は、インバータ形安定器を備えた照明器具に使用するものにおいて、平滑回路に使用するコンデンサの容量を極力小さくでき、また、このコンデンサに流入するリップル電流を抑制してコンデンサの長寿命化を図ることができ、しかもLEDを確実に連続点灯させることができるLED照明装置を提供する。

## 【0008】

【課題を解決するための手段】請求項1記載の発明は、照明用インバータ安定器からの高周波電力を整流する整流回路と、この整流回路の出力端子にインダクタ素子を介して接続した平滑回路と、この平滑回路に接続した発光ダイオード群とからなり、発光ダイオード群は、 $n$ 個の発光ダイオードを直列に接続した発光ダイオードアレイを $m$ 個並列に接続した発光ダイオードアレイ群とからなり、平滑回路は、平滑コンデンサを備え、この平滑コンデンサは、発光ダイオードアレイ群の各発光ダイオードが点灯し始めるときに流れる順方向電流を $I_{min}$ 、アンペア、そのときの各発光ダイオードの電圧降下を $V_{min}$ 、ボルト、また、各発光ダイオードの最大定格順方向電流を $I_{max}$ 、アンペア、そのときの各発光ダイオードの電圧降下を $V_{max}$ 、ボルトとしたとき、各発光ダイオードの点灯時に平滑回路出力電圧が常に $n V_{min}$ よりも高く、かつ、 $n V_{max}$ よりも低い電圧値を維持する容量に設定し、インダクタ素子は、照明用インバータ安定器からの高周波の周波数からこの周波数の2倍の周波数の範囲において充分なインピーダンスを有する値に設定したものである。

## 【0009】

【発明の実施の形態】本発明の実施の形態を図面を参照して説明する。

(第1の実施の形態)図1はLED照明装置の構成を示し、(a)は一部切欠した平面図、(b)は一部切欠した側面図、(c)は(b)のA-A断面図、(d)は(b)の矢印B方向から見た図である。複数のLED11を基板12の一面側にこの基板12の面に対して略垂直方向に発光指向性を示すようにして縦横に整列して配置している。なお、この場合、各LED11の個々の配置を発光強度分布を考慮して行えば、より配光面の光強度分布品質を高めることができる。

【0010】前記基板12の他面側に前記各LED11の点灯回路13を配置している。そして、各LED11及び点灯回路13を配置した基板12をカバーである断面小判形状の透明な耐熱性のアクリル管14内に挿入し、前記基板12及びアクリル管14の一端を口金15内に固定している。前記口金15の外面には4本の口金ピン16を突出させて設けている。前記各LED11としては白色光を発光するLEDを使用している。なお、LEDとして、赤色、青色、黄色、緑色の発光を行うLEDを使用してもよい。

【0011】前記アクリル管14の外寸、口金15及び口金ピン16の外寸、配置は、既存のコンパクト形蛍光ランプ、例えば、蛍光ランプFPL27EXの外寸、配置に合わせている。これにより、このLED照明装置は蛍光ランプFPL27EXが取付けられることのできる照明器具に対してこの蛍光ランプに代えて使用することができる。なお、ここでは蛍光ランプFPL27EXと同一

構成にしたが必ずしもこれに限定するものではなく、JISC 7601及びこの付属書1に規定される蛍光ランプの外寸、JISC 7709及びこの付属書1に規定される口金、口金ピンの外寸、配置になっていればよい。

【0012】また、ここでは指向性、配光面強度を重視しカバーとして透明な耐熱性のアクリル管14を使用した必ずしもこれに限定するものではなく、ポリカーボネイトなど他の透明な耐熱性の高いプラスチック材、あるいはガラスでもよい。また、透明材ではなく、出射光輝度の均一、指向性の緩和、演色性の向上のために白色又はその他の色でもよく、透明材に各色の塗料、フィルタの使用も可能である。さらに、LEDとして紫外線発光型LEDを用いた場合には、カバーに蛍光体を塗布又はカバーの部材に蛍光体を混合させることにより紫外線を可視光に変換する構造でもよい。

【0013】図2は照明用インバータ安定器を備えた照明器具にこのLED照明装置を取付けた状態での全体の回路構成を示すブロック図で、照明器具は、商用電源21に整流回路22を介して平滑回路23を接続し、この平滑回路23にインバータ回路24を接続して構成している。そして、前記インバータ回路24の出力端子にLED照明装置25を接続している。

【0014】前記インバータ回路24は、図3に示すように、前記平滑回路23の出力端子間に第1のインダクタ素子31とNPN形スイッチングトランジスタ32との直列回路を接続している。前記第1のインダクタ素子31に共振用コンデンサ33を並列に接続してLC並列共振回路を構成している。前記トランジスタ32にダイオード34を図示極性にして並列に接続している。そして、前記第1のインダクタ素子31の一端(トランジスタ32との非接続端)を第2のインダクタ素子35を介して前記LED照明装置25の口金ピン16の1つ16aに接続し、前記第1のインダクタ素子31の他端(トランジスタ32との接続端)をコンデンサ36を介して前記LED照明装置25の口金ピン16の他の1つ16bに接続している。前記LED照明装置25の口金ピン16の残りの2つ16c、16dの間にはコンデンサ37を接続している。

【0015】前記LED照明装置25の回路は、図4に示すように、4つの口金ピン16a～16dのうち、16aと16cを共通に接続し、16bと16dを共通に接続し、口金ピン16a、16cの接続点をダイオードブリッジ全波整流回路41の一方の入力端子に接続し、口金ピン16b、16dの接続点を前記全波整流回路41の他方の入力端子に接続している。前記全波整流回路41を構成する各ダイオードとして、例えば、逆回復時間が数十ns～数 $\mu$ sの高速整流用ダイオードを使用している。これにより、インバータ安定器に対してダイオードの発熱が抑えられ、その結果、商用電源のみでな

く、インバータ回路24の出力の高周波電源に対してもダイオードの発熱が抑えられ照明装置の短命化を防止できる。なお、全波整流回路41に代えて半波整流回路を使用してもよい。

【0016】前記全波整流回路41の出力端子間に第3のインダクタ素子42を介して平滑回路を構成する平滑コンデンサ43を接続している。そして、前記平滑コンデンサ43に $n$ 個のLED11を直列に接続した発光ダイオードアレイを $m$ 個並列に接続した発光ダイオードアレイ群をLEDユニット44として接続している。

【0017】図5は前記LEDユニット44の電圧-電圧特性の一例を示すもので、このLEDユニット44は $V_{min.}$ 以上の電圧を印加しなければ電流が流れず点灯しない。このときの電圧 $V_{min.}$ は、LEDユニット44が点灯し始める最少の順方向電流 $I_{min.}$ が流れる際のLEDユニット44の両端電圧である。また、LEDユニット44に流れる順方向最大定格電流 $I_{max.}$ の際のLEDユニット44の両端電圧が $V_{max.}$ となる。このLEDユニット44に $I_{max.}$ を越える電流を流すと定格オーバーとなり、動作は保証されず、最悪の場合LED11が破壊する。従って、前記LEDユニット44は、図中斜線で示す正常点灯領域の電流と電圧の関係で動作させる。

【0018】従って、前記平滑コンデンサ43として、出力が $V_{min.}$ 以上で、 $V_{max.}$ 以下の電圧値を常に維持できる容量に設定すれば、LEDユニット44は常に正常点灯領域で動作することになり、発光にちらつきのない連続点灯ができる。よって、各LED11の点灯時の電圧降下が $V$ ボルト、電流が $I$ アンペアであったとすると、 $I_{min.} \leq mI \leq I_{max.}$ で、かつ、 $V_{min.} \leq nV \leq V_{max.}$ を満足するように $m$ 、 $n$ を決定すればLEDユニット44は正常に点灯することになる。

【0019】このような構成においては、LED照明装置25を照明器具に装着して電源を投入すると、インバータ回路24が発振動作を開始し、このインバータ回路24からの高周波電力がLED照明装置25の全波整流回路41を介し、さらに、第3のインダクタ素子42を介して平滑コンデンサ43に供給される。ここで、第3のインダクタ素子42として、インバータ回路24からの高周波電力の周波数からこの周波数の2倍の周波数の範囲、例えば、高周波電力の周波数の2倍の周波数に対して充分なインピーダンスを有する値に設定すれば、全波整流回路41から第3のインダクタ素子42を介して平滑コンデンサ43に流入する電流の周波数はインバータ回路24からの高周波電力の周波数の2倍の周波数となっているので、平滑コンデンサ43に流入する電流に対して第3のインダクタ素子42のインピーダンスが十分に作用し、平滑コンデンサ43に流入するリップル電流を抑制する。

【0020】すなわち、平滑コンデンサ43は、通常、電解コンデンサを使用しており、第3のインダクタ素子

42が無ければ平滑コンデンサ43に流入するリップル電流が多くなってコンデンサの短命化を招くが、第3のインダクタ素子42の作用により平滑コンデンサ43へのリップル電流の流入を抑制するので、平滑コンデンサ43の寿命を延命化できる。従って、LED照明装置25の寿命を延命化できる。また、同時にLEDユニット44の各LED11に流入する電流のリップルも抑えることができ、各LED11の発光品質を向上できる。

【0021】平滑コンデンサ43は印加される電圧を平滑化してLEDユニット44に印加する。そして、平滑コンデンサ43の容量は、LEDユニット44の $n \times m$ 個のLED11に対して、印加電圧 $nV$ が、 $V_{min.} \leq nV \leq V_{max.}$ を満足し、流入する電流 $mI$ が、 $I_{min.} \leq mI \leq I_{max.}$ を満足するように設定しているので、LEDユニット44の各LED11は正常点灯領域で動作し、確実に連続点灯するようになる。しかも、平滑コンデンサ43の容量をこのように設定することで、容量を極力小さくでき、点灯回路を小形化、軽量化できる。

【0022】(第2の実施の形態)なお、前述した第1の実施の形態と同一の部分には同一の符号を付し異なる部分について述べる。図6はLED照明装置の構成を示し、(a)は一部切欠した側面図、(b)は(a)のC-C断面図である。前述した第1の実施の形態では複数のLED11を基板12の一面側に配置して片面のみに発光指向性を持たせたものであったが、この実施の形態では、さらに、複数のLED11を基板121の一面側にこの基板121の面に対して略垂直方向に発光指向性を示すようにして縦横に整列して配置し、前記基板12の他面側と前記基板121の他面側との間に前記LEDの点灯回路13を配置している。そして、各LED11により一方の面への発光指向性を持たせ、各LED11により他方の面への発光指向性を持たせている。なお、LED照明装置の回路構成は図4と同様である。このような構成においても前述した第1の実施の形態と同様の作用効果を奏するものである。

【0023】(第3の実施の形態)なお、前述した第1の実施の形態と同一の部分には同一の符号を付し異なる部分について述べる。図7はLED照明装置の構成を示し、(a)は一部切欠した平面図、(b)は一部切欠した側面図である。前述した各実施の形態では点灯回路を基板の他面側に配置したが、ここでは各LED11を配置した基板122と点灯回路131とを分離して配置している。すなわち、点灯回路131をアクリル管14内の口金15側に配置し、基板122をアクリル管14内の先端側に配置している。なお、LED照明装置の回路構成は図4と同様である。このような構成においても前述した第1の実施の形態と同様の作用効果を奏するものである。なお、口金15の形状を大きくして点灯回路131を口金15内に収納し、アクリル管14内に基板122のみを配置するようにしてもよい。

【0024】（第4の実施の形態）なお、前述した第1の実施の形態と同一の部分には同一の符号を付し異なる部分について述べる。前述した各実施の形態では図4に示すように、全波整流回路41の出力端子に第3のインダクタ素子42を介して平滑コンデンサ43並びにLEDユニット44を接続したが、この実施の形態では図8に示すように、全波整流回路41の出力端子に第3のインダクタ素子42を介して平滑コンデンサ43を接続するとともに前記全波整流回路41の出力端子にLEDユニット44を直接接続している。すなわち、第3のインダクタ素子42を平滑コンデンサ43の充放電路のみに直列に挿入している。

【0025】この実施の形態では、LEDユニット44の各LED11に流入する電流のリップルを抑えるという点では前述した実施の形態に比べて劣るが、その他については第1の実施の形態と同様の作用効果を奏するものである。

【0026】

【発明の効果】請求項1記載の発明によれば、インバータ形安定器を備えた照明器具に使用するLED照明装置において、平滑回路に使用するコンデンサの容量を極力小さくでき、また、このコンデンサに流入するリップル電流を抑制してコンデンサの長寿命化を図ることができる。しかも、LEDを確実に連続点灯させることができる。

【図面の簡単な説明】

【図1】本発明の第1の実施の形態におけるLED照明装置の構成を示す図。

【図2】同実施の形態における全体の回路構成を示すブロック図。

【図3】同実施の形態におけるインバータ回路の回路構成を示す図。

成を示す図。

【図4】同実施の形態におけるLED照明装置の回路構成を示す図。

【図5】同実施の形態におけるLEDユニットの電流－電圧特性の一例を示す図。

【図6】本発明の第2の実施の形態におけるLED照明装置の構成を示す図。

【図7】本発明の第3の実施の形態におけるLED照明装置の構成を示す図。

【図8】本発明の第4の実施の形態におけるLED照明装置の回路構成を示す図。

【図9】従来例を示す図。

【図10】LEDの電圧－電流特性を示す図。

【図11】従来の課題を説明するための電圧波形図。

【図12】従来の課題を説明するための電圧波形図。

【図13】従来の課題を説明するための電圧波形図。

【図14】インバータ形安定器の出力波形例を示す図。

【図15】インバータ形安定器出力を平滑コンデンサで平滑した場合の出力波形例を示す図。

【符号の説明】

11…LED（発光ダイオード）

13…点灯回路

14…アクリル管

15…口金

24…インバータ回路

25…LED照明装置

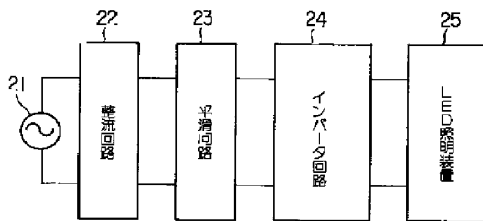
41…ダイオードブリッジ全波整流回路

42…第3のインダクタ素子

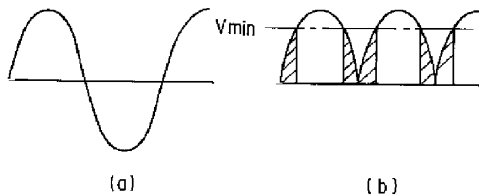
43…平滑コンデンサ

44…LEDユニット

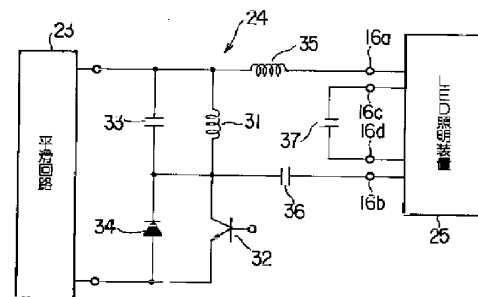
【図2】



【図11】



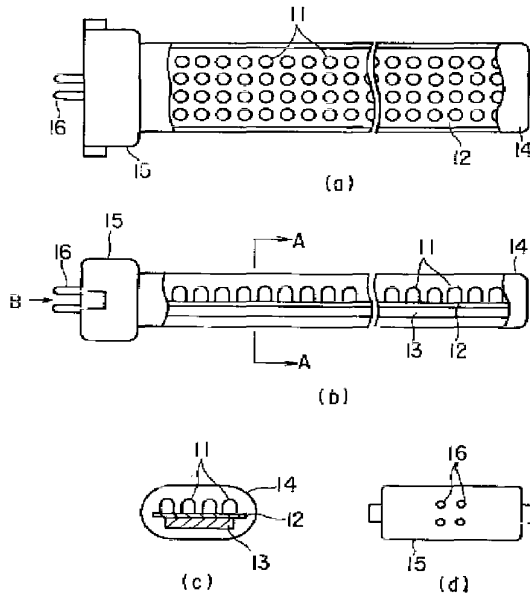
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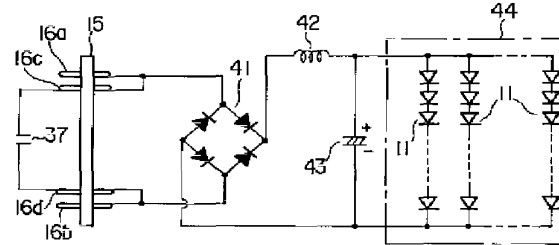
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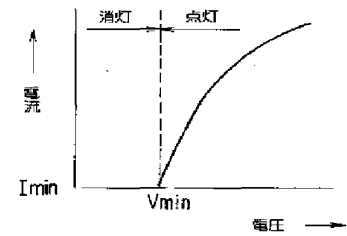
【図1】



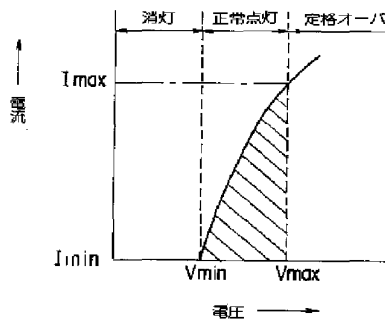
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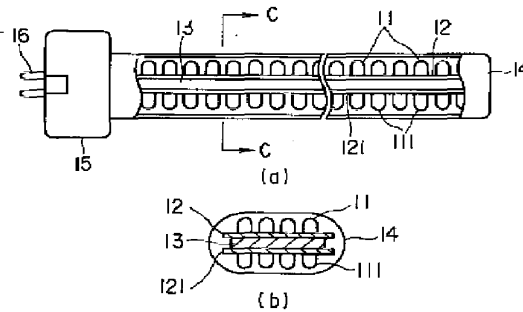
【図10】



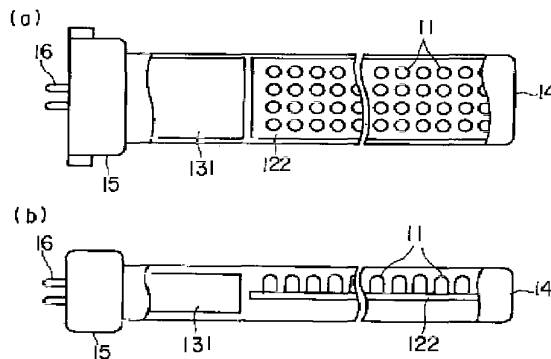
【図5】



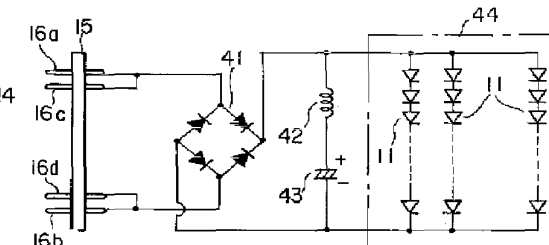
【図6】



【図7】



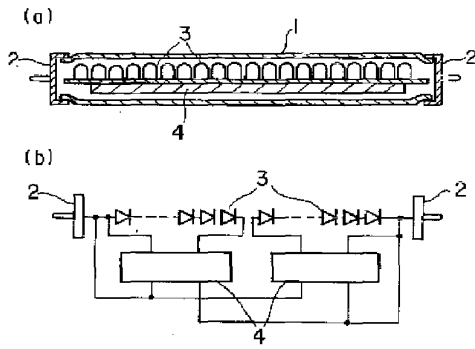
【図8】



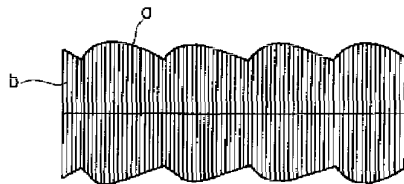
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【図 9】



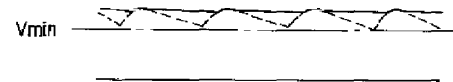
【図 1 4】



【図 1 3】



【図 1 5】





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| (51) Int.Cl. <sup>6</sup> | Identification Symbol | FI              |
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| H 0 1 L 33/00             |                       | H 0 1 L 33/00 Z |
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(54) Title of Invention: LED Lighting System

(21) Patent Application No.: H9-298777

(22) Patent Application Date: October 30, 1997

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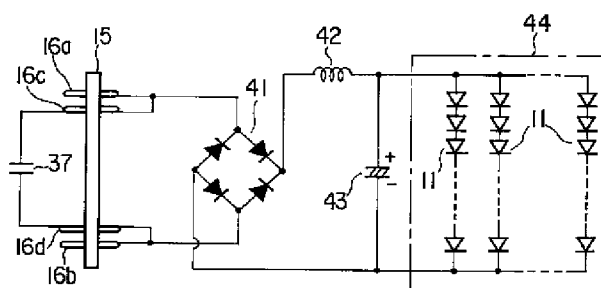
(74) Agent: Suzue Takehiko, Patent Attorney (and 6 others)

**(54) [Title of the Invention]** LED Lighting System

**(57) [Abstract]**

**[Subject]** An LED lighting system that is to be used with a lighting fixture that is equipped with an inverter-type ballast, which can make the capacity of the capacitor to be used in the smoothing circuit small, suppress the ripple current that flows to this capacitor, and which can assure continuous lighting of an LED.

**[Solution Means]** (An LED lighting system that is) composed of a full-wave rectification circuit, 41, that rectifies the high frequency wave from an inverter ballast, a smoothing capacitor, 43, that is connected to this rectification circuit via an inductor element, 42, and an LED unit, 44, where  $n \times m$  number of LEDs, 11, are arranged in lines, which is connected to this smoothing capacitor; and the smoothing capacitor is set so that the output voltage at the time of LED lighting is always higher than  $nV_{\min}$  and lower than  $nV_{\max}$ , and the inductor element is set to have sufficient impedance for 2-times the frequency coming from the ballast, where  $I_{\min}$  (ampere) is the minimum current when the LEDs can light,  $V_{\min}$  (volt) is voltage drop (at that time),  $I_{\max}$  (ampere) the maximum rated forward direction current of the LEDs, and  $V_{\max}$  (volt) is the voltage drop (at that time).



**[Claim(s)]**

**[Claim 1]** An LED lighting system which is composed of a rectification circuit that rectifies the high frequency power of an inverter ballast (used) for illumination purposes, a smoothing circuit that is connected to the output terminals of this rectification circuit via inductor element(s), and a light-emitting diode group that is connected to this smoothing circuit; where the aforementioned light-emitting diode group is characterized by having “m” parallel arranged light-emitting diode arrays, each array having “n” light-emitting diodes in series, and the aforementioned smoothing circuit is characterized by having a smoothing capacitor whose capacity is set so that the aforementioned

smoothing circuit output voltage is always higher than  $nV_{min}$  and lower than  $nV_{max}$  at the illumination period of the aforementioned all light-emitting diodes, (where  $I_{min}$  (ampere) is the minimum forward-direction current that flows when all the light-emitting diodes of the aforementioned light-emitting diode array group can light,  $V_{min}$  (volt) is the voltage drop of each light-emitting diode at that time,  $I_{max}$  (ampere) is the maximum rated forward-direction current in each light emitting diode, and  $V_{max}$  (volt) is the voltage drop of each light-emitting diode at that time), and the aforementioned inductor element is characterized by being set to a sufficient impedance between the frequency number of the high frequency waves from the aforementioned inverter ballast (used) for illumination purposes and two-times that frequency number.

**[Detailed Explanation of the Invention]**

**[0001]**

**[Technology Field to which the Invention Belongs]** This invention is related to an LED lighting system which can illuminate using a lighting fixture that is equipped with a high frequency inverter ballast that illuminates an ordinary fluorescent lamp.

**[0002]**

**[Prior Art]** An ordinary lighting fixture uses an incandescent light bulb or a fluorescent lamp for illumination purposes. In particular, a fluorescent lamp is superior to an incandescent light bulb in terms of electric power consumption and heat generation and is in wide use. However, the life of a fluorescent lamp is shorter than that of the ballast that is used in the fixture. Therefore, in recent years, light emitting diodes whose life is longer than that of a fluorescent lamp and whose heat generation is also less are being used. Consequently, a lighting system which uses light emitting diodes, that can commonly use a fluorescent lamp lighting fixture, is being developed.

**[0003]** For instance, the one shown in Unexamined Utility Model Application No. H6-54103 is equipped with a tube, 1, and base metal, 2, that have the same shapes as that for a fluorescent lamp as shown in Fig. 9(a), and is provided internally with multiple light emitting diodes, 3, (LED, hereafter) and a lighting circuit, 4, so that insertion of base metal 2 into the fluorescent lamp lighting fixture makes lighting circuit 4 activate illumination of LEDs 3 as shown in Fig. 9(b).

**[0004]**

**[Problems the Invention is to Solve]** However, when this LED lighting system is illuminated by a

lighting fixture that uses a choke coil type ballast, power is supplied from the choke coil type ballast to lighting circuit 4. Lighting circuit 4 is normally composed of a rectification circuit that converts alternate current to pulsation current, and a smoothing circuit that converts pulsation current, which is rectified by the rectification circuit, into pseudo-direct current. For example, when a lighting circuit is structured only with a rectification circuit, an alternate current of 50 Hz or 60 Hz is converted to a pulsation current of 100 Hz or 120 Hz, and the LEDs are supposed to be driven by this (pulsation current). Meanwhile, an LED has a voltage current characteristic where illumination is done only when an applied voltage is at  $V_{min}$  or over as shown in Fig. 10, and when the pulsation current of 100 Hz or 120 Hz shown in Fig 11(b) was converted from a power frequency of 50 Hz or 60 Hz shown in Fig. 11(a), the shaded area in the figure becomes an extinguished (no-illumination) domain, and flashing at 100 Hz or 120 Hz will occur, therefore it is not sufficient for illumination.

**[0005]** Then, when a lighting circuit is composed of a rectification circuit and a smoothing circuit, a pulsation current of 100 Hz or 120 Hz that has been converted at the rectification circuit will be converted into a pseudo-direct current at the smoothing circuit. But if the capacity of the capacitor in the smoothing circuit is small, sufficient smoothing cannot be done as shown in Fig. 12, and non-illuminating domains will be created as shown by the shaded areas in the figure, also causing flashing. As a means to solve this problem, if the capacity of the capacitor to be used is increased, sufficient smoothing can be done as shown in Fig. 13, and the voltage can always be at  $V_{min}$  or over for continuous lighting of the LEDs. But use of a capacitor with a large capacity makes the lighting circuit large, heavy, and expensive. This creates another problem for use of a new lighting system that can replace a fluorescent lamp.

**[0006]** Also, if such LED lighting system is used with a lighting fixture where an inverter type ballast is used, compared with the 50 Hz or 60 Hz output of a choke coil type ballast, the output of the inverter type ballast becomes, as shown, in Fig. 14, somewhat smoothed enveloping waveforms of 100 Hz or 120 Hz (Fig. 14a) with a high frequency waveform of approximately 50 KHz to 60 KHz (Fig. 14b). When this is smoothed with a large capacity smoothing capacitor, as shown in Fig. 15, smoothing with a nearly flat line is possible and continuous lighting of the LEDs can be done. Also, in this case, a large capacity capacitor is needed and the lighting circuit will become large, heavy, and expensive; thus, use of this lighting system instead of a fluorescent lamp is a problem. Also, the high frequency waves from

the inverter type ballast increase the ripple current into the capacitor of the smoothing circuit which shortens the life of the capacitor and, thus, the life of the lighting system is shortened as a result. This is another problem.

**[0007]** Then, the invention described in Claim 1 presents an LED lighting system which uses a lighting fixture that is equipped with an inverter type ballast; it can make the capacity of the capacitor used in the smoothing circuit as small as possible, it can suppress the ripple current that flows into this capacitor, lengthening the life of this capacitor and, thus, it assures continuous lighting of the LEDs.

**[0008]**

**[Means of Solving the Problems]** The invention described in Claim 1 is composed of a rectification circuit that rectifies the high frequency power of an inverter ballast (used) for illumination purposes, a smoothing circuit that is connected to the output terminals of this rectification circuit via inductor element(s), and a light-emitting diode group that is connected to this smoothing circuit, where the light-emitting diode group is characterized by having “m” parallel arranged light-emitting diode arrays, each array having “n” light-emitting diodes in series, and the smoothing circuit is characterized by having a smoothing capacitor whose capacity is set so that the smoothing circuit output voltage is always higher than  $nV_{min}$  and lower than  $nV_{max}$  at the illumination period of all light-emitting diodes, (where  $I_{min}$  (ampere) is the minimum forward-direction current that flows when all the light-emitting diodes of the light-emitting diode array group can light,  $V_{min}$  (volt) is the voltage drop of each light-emitting diode at that time,  $I_{max}$  (ampere) is the maximum rated forward-direction current in each light emitting diode, and  $V_{max}$  (volt) is the voltage drop of each light-emitting diode at that time), and the inductor element is characterized by being set to a sufficient impedance between the frequency number of the high frequency waves from the inverter ballast (used) for illumination purposes and two-times that frequency number.

**[0009]**

**[Working Forms of the Invention]** Working forms of this invention are explained using illustrations as references.

**(No. 1 Working Form)** Figure 1 shows the structure of the LED lighting system; (a) is a plan view where one portion of it is cut out, (b) is a side view where one portion of it is cut out, (c) is A-A cross section of (b), and (d) is the view from the Arrow B direction. Multiple LEDs 11 are arranged

in line in the longitudinal direction and lateral direction on one side of a base plate, 12, so that the lights are oriented nearly perpendicular to the plate. Incidentally, if the arrangement of each LED is made in consideration of the light intensity distribution, the light intensity distribution quality of the illumination surface can be improved.

**[0010]** A lighting circuit, 13, for the aforementioned LEDs 11 is provided on the other side of aforementioned base plate 12. Then, base plate 12 with LEDs 11 and lighting circuit 13 on it is inserted into a cover, i.e. a transparent and heat-resisting acrylic tube, 14, which has an oblong cross section, and one end of aforementioned base plate 12 and acrylic tube 14 are secured into the base metal, 15. Four base pins, 16, are provided on the outer surface of aforementioned base metal 15 in a protruding manner. LEDs that emit white light are used for aforementioned LEDs 11. Incidentally, LEDs that emit red, blue, yellow, and green colors can also be used as the LEDs.

**[0011]** The outer dimensions of aforementioned acrylic tube 14 and the outer dimensions and layout of base metal 15 and base pins 16 are made to match the outer dimensions and layout of an existing compact type fluorescent lamp, such as FPL 27 EX. Thus, this LED lighting system can be used instead of a fluorescent lamp with a lighting fixture where fluorescent lamp FPL 27 EX can be used. Incidentally, the same structure as that of fluorescent lamp FPL 27 EX was used here but it is not limited to this and the outer dimensions of the fluorescent lamps that are specified in JIS C 7601 and Appendix 1 and the outer dimensions and layout that are specified in JIS C 7709 and Appendix 1 can be used.

**[0012]** Also, the (light) orientation and illumination surface intensity were seriously considered and, thus, a transparent and heat-resisting acrylic tube 14 was used. But it is not limited to this and other transparent and heat-resisting plastic materials such as polycarbonate or glass can also be used. Also, instead of transparent materials, white or other colors can be chosen for purposes of brightness homogeneity of the emitted lights, relaxation of orientation, and improvement of color rendering property. Also, (adding) a painting material to transparent material or use of filters is possible. Further, when an ultraviolet ray emitting type LED is used as the LED, ultraviolet rays can be structurally converted into visible radiation by coating a cover with a fluorescent material or by mixing a fluorescent material into the cover materials.

**[0013]** Figure 2 is a block diagram of an entire circuit structure in a state where this LED lighting system

is attached to a lighting fixture that is equipped with an inverter ballast for lighting purposes. Here, the lighting fixture is structured such that a smoothing circuit, 23, is connected to a commercial power source, 21, via a rectification circuit, 22, and an inverter circuit, 24, is connected to this smoothing circuit 23. Then, the LED lighting system, 25, is connected to the output terminals of aforementioned inverter circuit 24.

**[0014]** As shown in Fig. 3, aforementioned inverter circuit 24 has a series circuit (consisting) of No. 1 inductor element 31 and a NPN-type switching transistor, 32, between the output terminals of aforementioned smoothing circuit 23. An LC parallel resonance circuit is constructed by connecting a resonance capacitor, 33, to aforementioned No. 1 inductor element 31 in a parallel manner. Diode 34 is connected to aforementioned transistor 32 in a parallel manner having polarity as shown in the figure. Then, one end (end not connecting with transistor 32) of aforementioned No. 1 inductor element 31 is connected to one of base pins 16, 16a, of aforementioned LED lighting system 25 via No. 2 inductor element 35, and the other end (connecting end with transistor 32) of aforementioned No. 1 inductor element 31 is connected to one of the other base pins 16, 16b, of aforementioned LED lighting system 25 via capacitor 36. Capacitor 37 is connected between the two remaining base pins 16, i.e. 16c and 16d, of aforementioned LED lighting system 25.

**[0015]** In the circuit of aforementioned LED lighting system 25, as shown in Fig. 4, base pins 16a and 16c of the four base pins 16a ~ 16d are connected to each other, and 16b and 16d are connected to each other. The connection point of base pins 16a and 16c is connected to one input terminal of diode bridge full-wave rectification circuit 41, and the connection point of base pins 16b and 16d is connected to the other input terminal of aforementioned full-wave rectification circuit 41. For the diodes in aforementioned full-wave rectification circuit 41, high-speed rectification diodes with an inverse recovery time of, for instance, several tens of ns to several  $\mu$ s, are used. Thus, heat generation in the diodes, relative to the inverter ballast, is suppressed and, as a result, heat generation in the diodes is suppressed not only with a commercial power source but also with the high frequency power that is the output of inverter circuit 24, thus, life-shortening of the lighting system can be prevented. Incidentally, a half-wave rectification circuit can be used instead of full-wave rectification circuit 41.

**[0016]** A smoothing capacitor, 43, is connected via No. 3 inductor element 42 between the output terminals of aforementioned full-wave rectification circuit 41 to construct a smoothing circuit. Then,

LED unit 44, i.e. a light emitting diode array group which has “m” light emitting diode arrays arranged in a parallel manner where each array has “n” LEDs 11 in series, is connected to aforementioned smoothing capacitor 43.

**[0017]** Figure 5 shows one example of the current – voltage characteristics of aforementioned LED unit 44. Electric current does not flow into this LED unit 44 for lighting if voltage that is equal to or above  $V_{min}$  is not applied. This voltage,  $V_{min}$ , is the voltage between two end terminals of LED unit 44 when the minimum forward-direction current  $I_{min}$  flows for lighting. Also,  $V_{max}$  is the voltage between two end terminals of LED 44 when the forward-direction maximum rated current  $I_{max}$  flows into LED unit 44. If a current exceeding  $I_{max}$  flows into this LED unit 44, i.e. at a current over the rating, functioning can not be assured and, in the worst case, LEDs 11 will break down. Therefore, aforementioned LED unit 44 is to be operated at the current and voltage relationship shown in the normal lighting domain shown by the shaded area in the figure.

**[0018]** Therefore, when aforementioned smoothing capacitor 43 can always assure maintaining an output voltage over  $V_{min}$  and below  $V_{max}$ , LED unit 44 always functions in the normal lighting domain, assuring continuous lighting without flickering. Thus, letting  $V$  be voltage drop in each LED 11 at a lighting period, and  $I$  be current (A), and if “m” and “n” satisfy relationships  $I_{min} \leq mI \leq I_{max}$ , and  $V_{min} \leq nV \leq V_{max}$ , LED unit 44 will normally light.

**[0019]** When LED lighting system 25 is structured as described in the above and is installed in a lighting fixture and the power is turned on, inverter circuit 24 starts an oscillation function, and high-frequency power from this inverter circuit 24 is supplied to smoothing capacitor 43 via full-wave rectification circuit 41 of LED lighting system 25 and further via No. 3 inductor element 42. Here, if No. 3 inductor element 42 is set to a sufficient impedance for the frequency range between the frequency number of high-frequency power from inverter circuit 24 and two-times this frequency number, or for example, especially for two-times the frequency number of the high-frequency power, the frequency of the current that flows from full-wave rectification circuit 41 to smoothing capacitor 43 via inductor element 42 is two-times the frequency of the high-frequency power from inverter circuit 24, thus the impedance of No. 3 inductor element 42 is sufficient to function with the current to smoothing capacitor 43, and suppresses the ripple current that flows into smoothing capacitor 43.

**[0020]** In other words, an electrolytic capacitor is ordinarily used as smoothing capacitor 43. If there



is no No. 3 inductor element 42, ripple current to smoothing capacitor 43 will be significant and will shorten the life of the capacitor. But, since the function of No. 3 inductor element 42 suppresses the flow of ripple current to smoothing capacitor 43, the life of smoothing capacitor 43 can be extended. Therefore, the life of LED lighting system 25 can be extended. Also, at the same time, current ripple to each LED 11 of LED unit 44 can be suppressed and the lighting quality of each LED can be improved.

**[0021]** Smoothing capacitor 43 smoothes the incoming voltage before supplying it to LED unit 44. Then, since the capacity of smoothing capacitor 43 is set to satisfy the conditions where applied voltage  $nV$  to  $n \times m$  number of LEDs 11 of LED unit 44 is to be  $V_{\min} \leq nV \leq V_{\max}$ , and current  $mI$  is to be  $I_{\min} \leq mI \leq I_{\max}$ , each LED 11 of LED unit 44 functions in the normal lighting domain and certain continuous lighting is assured. Moreover, by setting the capacity of smoothing capacitor 43 in this way, the capacity can be reduced to this extent and the lighting circuit can be made compact and light in weight.

**[0022] (No. 2 Working Form)** Incidentally, for the same parts as in No. 1 Working Form, the same symbols are assigned and (only) parts that are different are explained. Fig. 6 shows the structure of an LED lighting system; (a) is a partially cut-out side view and (b) is a C-C cross section of (a). In the previously explained No. 1 Working Form, multiple LEDs 11 were arranged on only one surface of base plate 12 for lighting orientation in only one direction but in this (No. 2) Working Form, multiple LEDs 111 are arranged on one surface of base plate 121 in longitudinal and lateral lines having a lighting orientation nearly perpendicular to the surface; aforementioned LED lighting circuit 13 is arranged between the other surface of aforementioned base plate 12 and the other surface of aforementioned base plate 121. Then, LEDs 11 on one surface have a lighting orientation in one direction and LEDs 111 have a lighting orientation in the other direction. Incidentally, the circuit structures of the LED lighting system are the same as in Fig. 4. With a structure such as this, functions similar to the No. 1 Working Form can be obtained.

**[0023] (No. 3 Working Form)** Incidentally, for the same parts as in No. 1 Working Form, the same symbols are assigned and (only) parts that are different are explained. Fig. 7 shows the structure of the LED lighting system; (a) is a partially cut-out plan view and (b) is a partially cut-out side view. In the previously described working forms, the lighting circuit was arranged on the other side (of the base

plate from the LEDs) but in this form, base plate 122, on which LEDs 11 are arranged, and lighting circuit 131 are separated from each other. That is, lighting circuit 131 is arranged on the base metal 15 side inside acrylic tube 14, and base plate 122 is arranged on the front end side inside acrylic tube 14. Incidentally, the circuit structures of the LED lighting system are similar to those in Fig. 4. With a structure such as this, functions similar to the previously discussed No. 1 Working Form can be obtained. Incidentally, the shape of base metal 15 can be enlarged to accommodate lighting circuit 131 inside it, and only base plate 122 can be arranged inside acrylic tube 14.

**[0024] (No. 4 Working Form)** Incidentally, for the same parts as in No. 1 Working Form, the same symbols are assigned and (only) parts that are different are explained. In each working form previously explained, as shown in Fig. 4, smoothing capacitor 43 and LED unit 44 were connected to the output terminal of full-wave rectification circuit 41 via No. 3 inductor element 42, but in this working form, as shown in Fig. 8, smoothing capacitor 43 is connected to the output terminal of full-wave rectification circuit 41 via No. 3 inductor element, and LED unit 44 is directly connected to the output terminal of aforementioned full-wave rectification circuit 41. In other words, No. 3 inductor element 42 is inserted only into the charge-discharge line of smoothing capacitor 43 in a series manner.

**[0025]** This working form is inferior to the other working forms in terms of its capability to suppress ripples of current to LEDs 11 but, other than that, a function similar to that of the other working forms can be obtained.

**[0026]**

**[Effect(s) of the Invention]** According to the invention described in Claim 1, for an LED lighting system that is used in a lighting fixture where an inverter type ballast is provided, the capacity of the capacitor to be used in a smoothing circuit can be made extremely small. Also, ripple current to this capacitor can be suppressed and (it can) lengthen the life of the capacitor and, further, the LEDs can assuredly be continuously lit.

**[Brief Explanation of the Drawings]**

**[Fig. 1]** A drawing that shows the structure of the LED lighting system in No. 1 Working Form of this invention.

**[Fig. 2]** A block diagram that shows the entire circuit structure in the same working form.

**[Fig. 3]** A drawing that shows the circuit structure of the inverter circuit in the same working form.

[Fig. 4] A drawing that shows the circuit structure of the LED lighting system in the same working form.

[Fig. 5] A drawing that shows one example of the current-voltage characteristics of the LED unit in the same working form.

[Fig. 6] A drawing that shows the structure of the LED lighting system in No. 2 Working Form of this invention.

[Fig. 7] A drawing that shows the structure of the LED lighting system in No. 3 Working Form of this invention.

[Fig. 8] A drawing that shows the circuit structure of the LED lighting system in No. 4 Working Form of this invention.

[Fig. 9] A drawing that shows a conventional example.

[Fig. 10] A drawing that shows the LED voltage-current characteristic.

[Fig. 11] A voltage waveform that explains a conventional problem.

[Fig. 12] A voltage waveform that explains a conventional problem.

[Fig. 13] A voltage waveform that explains a conventional problem.

[Fig. 14] A drawing that shows the output waveform of the inverter-type ballast.

[Fig. 15] A drawing that shows the output waveform when an inverter-type ballast output is smoothed by a smoothing capacitor.

#### **[Explanation of Reference Numerals]**

11 .... LED (Light Emitting Diode)

13 .... Lighting circuit

14 .... Acrylic tube

15 .... Base metal

24 .... Inverter circuit

25 .... LED lighting system

41 .... Diode bridge full-wave rectification circuit

42 .... No. 3 inductor element

43 .... Smoothing capacitor

44 .... LED unit

Figure 1

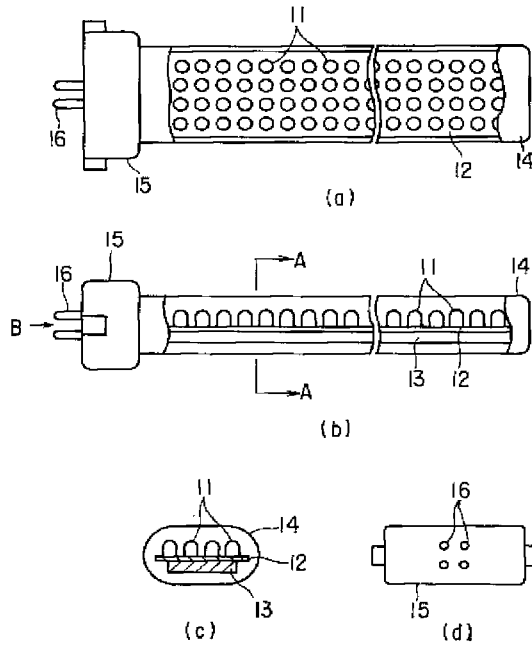


Figure 4

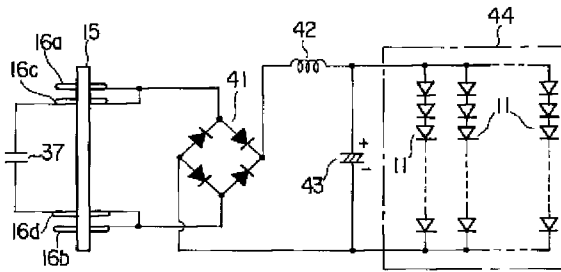


Figure 10

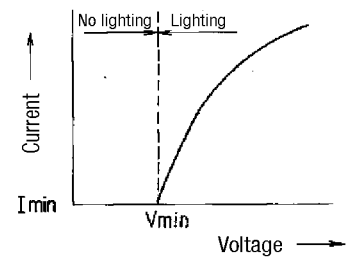


Figure 5

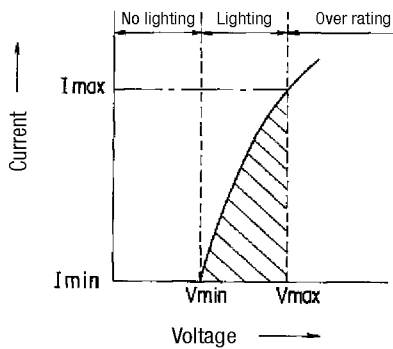


Figure 6

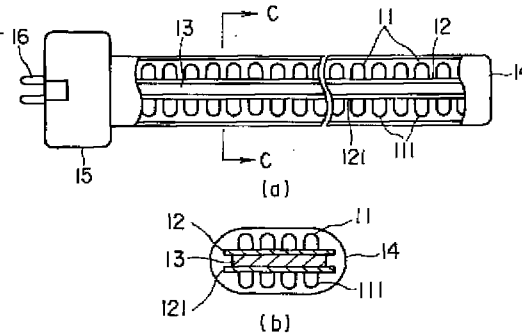


Figure 7

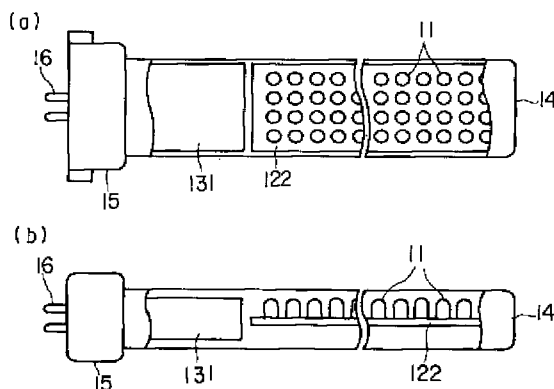


Figure 8

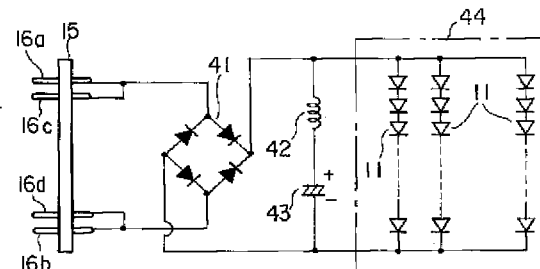


Figure 2

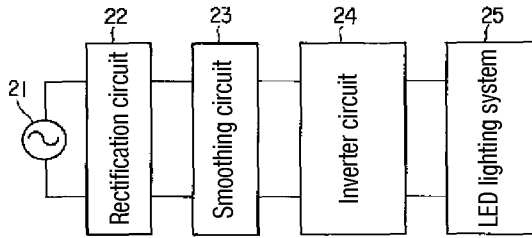


Figure 11

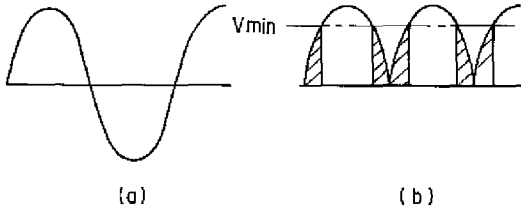


Figure 3

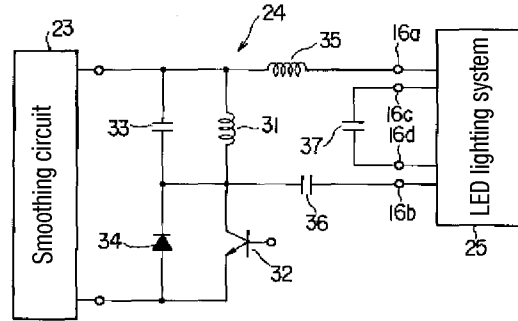


Figure 12



Figure 9

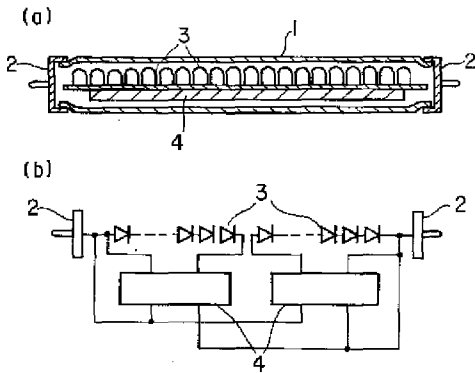


Figure 13



Figure 14

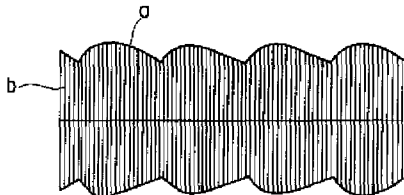


Figure 15

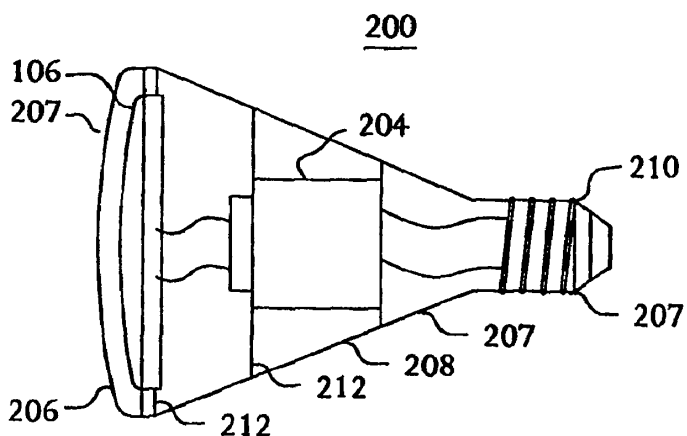


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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| <b>(21) International Application Number:</b> PCT/US99/09723<br><b>(22) International Filing Date:</b> 4 May 1999 (04.05.99)<br><br><b>(30) Priority Data:</b><br>60/084,172 4 May 1998 (04.05.98) US<br>09/122,311 24 July 1998 (24.07.98) US<br><br><b>(71) Applicant:</b> FIBER OPTIC DESIGNS, INC. [US/US]; 704 Floral Vale Boulevard, Yardley, PA 19067 (US).<br><b>(72) Inventor:</b> ALLEN, Mark, R.; 1257 Silverado Street, La Jolla, CA 92037 (US).<br><b>(74) Agents:</b> WEISER, Gerard, J. et al.; Weiser & Associates, P.C., Suite 500, 230 S. 15th Street, Philadelphia, PA 19102 (US).                                                                                                                                                                                                                      |           | <b>(81) Designated States:</b> CN, JP, KP, KR, MX, SG, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).<br><br><b>Published</b><br><i>With international search report.</i> |
| <b>(54) Title:</b> A LAMP EMPLOYING A MONOLITHIC LED DEVICE<br><br><b>(57) Abstract</b><br><p>A lamp including one or more monolithic LED devices, each having an array of LED dies (104) rather than pre-packaged, discrete LEDs providing light sources. Each monolithic LED device may have the LED dies wired in block series-parallel form in order to optimize size and cost of voltage converter (204), if employed. The LED dies are coupled as the array on the substrate and then encapsulated in a light conducting medium to form a lens (106) on the array of LED dies. LED dies may be controlled such that its individual color components, e.g., red, green, and blue when employed are either variable or fixed.</p>  |           |                                                                                                                                                                                                                                                                                                                                                                                                             |

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## A LAMP EMPLOYING A MONOLITHIC LED DEVICE

### BACKGROUND OF THE INVENTION

#### Field of the Invention

5           The present invention relates to a lamp having an array of LED dies, and, in particular, to a lamp employing a monolithic LED device.

#### Cross-Reference to Related Applications

10           This application claims the benefit of the filing date of U.S. provisional application no. 60/084,172, filed on May 4, 1998 as attorney docket no. 1009.001PROV.

#### Description of the Related Art

15           Employing light emitting diodes (LEDs) as a basic lighting source is increasingly attractive for applications such as complex backlighting, outdoor signage and signaling, and even simple replacement light bulbs or lamps. Lamps employing LEDs have the following advantages: (1) as a device, LEDs have much longer lifespan than other standard light sources, such as fluorescent and incandescent light sources, with typical LED lifespan being at least 200,000 hours as measured by 30% loss of light output degradation over time; (2) LEDs have several favorable physical properties, including ruggedness, low operating temperature, ability to operate under a wide temperature variation, and safe low-voltage power requirements; (3) LEDs are increasingly more efficient, as measured by light output versus power consumed, with newer, more sophisticated doping technologies, allowing typical power efficiencies for LEDs to be better by a factor of ten than power efficiencies of comparable incandescent lighting sources; (4) increased consumer demand, costs of LEDs are reduced and, therefore, LEDs are becoming increasingly cost effective for many applications; (5) new blue LEDs allow color and adjustable color lighting from a red/green/blue (RGB) combination; (6) new wideband "white" LEDs and related phosphoring technologies allow white light of good color rendering index without having to use an RGB mixture; and (7) recent invention of multilayer, multicolor LED die-on-substrate growing techniques enables fabrication of full color (RGB) monolithic LED devices at increasingly low cost.

20           LEDs are commonly provided as prepackaged dies, known as a "bulb" form or as a "discrete LED."  
30           Discrete LED packages include a tiny LED die, often called a LED "chip", a wire frame, and leads soldered between the wire frame and the LED. The die, wire frame and part of the leads are encapsulated in a light conducting medium, typically an epoxy compound, via injection molding into the shape of a tiny bulb. This manufacturing process accounts for much of the cost associated with a discrete LED. For example, a discrete LED that costs several cents each (in large quantity) may incorporate a LED die that costs a fraction of a  
35           cent.



LEDs as a light source for lamps are known in the art. For example, U.S. Patent 4,211,955 to Ray describes using discrete LEDs mounted in a transparent or translucent case. Further, US Patent number 5,726,535 to Yan for "LED Retrofit Lamp for Exit Signs," and US patent number 5,640,792 to Smith et al. for "Lighting Fixtures" are examples of LED light sources for particular types of applications. In these and all other related patents, a colored light bulb is described using prepackaged, discrete LEDs, and the equivalent-light incandescent power requirement is limited to a maximum of approximately 20 Watts. Three characteristics of these LED light bulbs of the prior art limit light or LED output power: (1) a large number of discretely packaged LEDs must be used to achieve practical light output, which may not be practical for certain common lamp package types due to the size of the discrete LEDs; (2) these lamps of the prior art may be expensive to manufacture due to the large number of prepackaged discrete LEDs required and due to high individual cost of the discrete LEDs; and (3) the typical application of the prior art, such as for exit signs or backlighting, requires only a relatively low light output power.

More recently, several LED sub-dies have been grown together on a substrate for the purpose of providing multiple color combinations of Red, Green, and Blue (RGB) LED light. These RGB sub-die combinations are described in, for example, U.S. Patent 5,459,337 to Ito et al for SEMICONDUCTOR DISPLAY DEVICE WITH RED, GREEN, AND BLUE EMISSION, and U.S. Patent 5,424,560 to Norman et al for INTEGRATED MULTICOLOR ORGANIC LED ARRAY, and these patents are incorporated herein by reference for their teachings of RGB die combinations grown on silicon substrates, as well as for their teachings of control of individual RGB sub-dies for adjusting output light color.

### SUMMARY OF THE INVENTION

A lamp comprising a lamp body; an electrical interface mounted in the lamp body and adapted to interface with a standard voltage supply; and a monolithic LED device electrically coupled to the electrical interface and comprising: i) an array of electrically coupled LED dies mounted on a substrate, and ii) a package having a lens, the substrate encapsulated in the package with the lens over the array.

### BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the present invention will become more fully apparent from the following detailed description, the appended claims, and the accompanying drawings in which:

FIG. 1A shows a top view of a monolithic LED device in accordance with the present invention having block series-parallel wiring.

FIG. 1B shows a side view of a monolithic LED device in accordance with the present invention having block series-parallel wiring.

FIG.2 shows an exemplary wiring diagram for a monolithic LED device in accordance with the present invention constructed of individual red, green, and blue sub-die arrays coupled in a block series-parallel configuration.

FIG. 3A shows a top view of an exemplary embodiment of the present invention employed in a  
5 "R-type" lamp configuration.

FIG. 3B shows a side view of an exemplary embodiment of the present invention employed in a "R-type" lamp configuration.

FIG. 4A shows one exemplary circuit for the voltage converter of FIGs. 2A and 2B having a step-down transformer in accordance with the present invention to convert power and effect control of the  
10 monolithic LED device.

FIG. 4B shows another exemplary circuit for the voltage converter of FIGs. 2A and 2B having a low-pass capacitor followed by a step-down resistor to convert power and effect control of the monolithic LED device.

FIG. 5 shows a block diagram of an exemplary controller that receives an output signal of the voltage converter of FIGs. 4A and 4B and controls each variable resistor and so effects control of each color  
15 component.

FIG. 6A shows a top view of an exemplary embodiment of the present invention employed in an "A-type" screw-in hemispherical lamp configuration.

FIG. 6B shows a side view of an exemplary embodiment of the present invention employed in an  
20 "A-type" screw-in hemispherical lamp configuration.

FIG. 7A shows a top view of an exemplary embodiment of the present invention employed in a low-voltage, push/screw type lamp configuration.

FIG. 7B shows a bottom view of an exemplary embodiment of the present invention employed in a low-voltage, push/screw type lamp configuration.

FIG. 7C shows a side view of an exemplary embodiment of the present invention employed in a low-voltage, push/screw type lamp configuration.  
25

FIG. 8A shows a top view of an exemplary embodiment of the present invention employed in a 110 VAC fluorescent-type, plug-in tube lamp configuration having two transformer-based power supplies.

FIG. 8B shows a side view of an exemplary embodiment of the present invention employed in a 110  
30 VAC fluorescent-type, plug-in tube lamp configuration having two transformer-based power supplies.

DETAILED DESCRIPTION

In accordance with the present invention, a lamp includes one or more monolithic LED devices, each LED device having an array of LED dies rather than prepackaged discrete LEDs. The monolithic LED device may be formed using multilayer crystal fabrication, or assembled by soldering together or otherwise connecting individual prefabricated LED dies, onto a substrate. The array of LED dies of the monolithic LED device may be wired in a block series-parallel fashion to optimize, for example, either the size and cost of the step-down transformer or the efficiency of the step-down resistor, of exemplary embodiments of lamps in accordance with the present invention including a voltage converter. The array of LED dies may comprise a mixture of RGB sub-dies or "white dies" or a mixture of both types of dies. Intermediate colors in addition to RGB (e.g. yellow) may also be used to obtain better color rendering index. White dies may be, for example, blue dies with phosphorescent coating to produce a wideband spectrum. Wiring in such embodiments may be such that the output is either adjustable or fixed.

A monolithic LED device employed in a lamp in accordance with the present invention may allow: (1) much greater light density than lamps of the prior art; (2) much lower production cost when an array of LED dies is employed when compared to arrays of discrete LEDs as employed in the art; (3) more efficient heat dissipation; and (4) greater design freedom for covering geometric surfaces with light output power.

A monolithic LED device employing numerous, for example hundreds, of dies wired in an array on a substrate may form a lamp component of a predetermined light output power, and different lamps may be constructed employing multiple lamp components.

Referring to FIGs. 1A and 1B, there are shown top and side views, respectively, of an exemplary monolithic LED device 100 having an array of LED dies, as may be wired for a light source or lamp in accordance with the present invention. FIGs. 1A and 1B show five series blocks 108, each block 108 consisting of six LED dies 104. However, the configuration of FIGs. 1A and 1B is exemplary only and does not imply that the invention is so limited to such configuration. The monolithic LED device 100 consists of a substrate 102, such as rigid printed circuit board (PCB) or silicon, a plurality of LED dies 104, and a lens 106 formed over the array of LED dies 104. An encapsulation, using a light conducting medium, such as epoxy, for example, may be used as a package for lens 106 as well as for a body of monolithic LED device 100. Lens 106, as shown in FIG. 1B is planar, but other shapes may be employed. Each LED die 104 may be a set of RGB sub-dies, where the red, green, and blue sub-die components form adjacent linear subarrays along the monolithic LED device 100 in, for example, an alternating order to balance the resulting light such that a desired color, for example, a white color temperature, is achieved.

In accordance with one embodiment of the present invention, the monolithic LED device 100 may either be constructed by growing LED dies 104 on the substrate 102, such as silicon, where electrical

coupling of internal LED dies in a block series-parallel configuration is incorporated into a semiconductor chip making process. In accordance with another embodiment, the monolithic LED device may be constructed by mounting individual, prefabricated LED dies 104, which also may emit having more than one color, on the substrate 102, such as PCB or silicon, where the LED dies 104 are then electrically coupled together in block series-parallel on the monolithic LED device 100 through a standard process, such as wave soldering. For either of these cases, the monolithic LED device 100 is then encapsulated as described previously, generally using an injection molding process similar to that used for individual LED packaging, with a light-conducting material, so as to form lens 106 on front of device 100 to having one of many possible specific focusing properties.

The monolithic LED device 100 may be formed having various shapes and sizes. A light output power of the LED dies 104 of the monolithic LED device 100 may be operated by individually controlling each RGB sub-die LED die 104; operated by controlling each subarray of LED dies individually, such as by control of the individual RGB sub-die color components together; or operated by controlling the entire monolithic LED device 100 at once. Moreover, multiple monolithic LED devices 100 may be coupled in parallel to produce geometric configurations: for example, a hemispherical radiation pattern may be constructed by employing planar-shapes for monolithic LED device 100 which are oriented along each geometric axis of a lamp. For typical lamp applications, control of the array of LED dies 104 is normally achieved so as to cause the light output power to have either a variable color component or fixed color component.

For a monolithic LED device 100 of a lamp in accordance with the present invention, the preferred embodiment includes block series-parallel coupling of LED dies 104. Block series-parallel coupling of LED dies 104 allows a maximal number of dies to be wired in series so as to matching the maximum input voltage of the monolithic LED device 100. Each series set is then wired in parallel to provide a desired lumens, electroluminescent, or light output power for the desired input voltage. Block series-parallel coupling allows for matching of input voltage of LED device 100 with the supply voltage to minimize the size and cost of a voltage converter described subsequently with respect to FIG. 3B. For common lamps with a low-voltage DC supply voltage, such as 12 VDC commonly used in outdoor lighting or automobiles; block series-parallel coupling may also be used to eliminate the voltage converter converting between different DC voltage levels. Note that the series block in the block series-parallel wiring may be as small as one die, resulting in a pure parallel circuit, in which case series wiring is not necessary.

A monolithic LED device 100 in accordance with the present invention may have several advantages in heat dissipation. Each LED die 104 is mounted directly on substrate 102 and substrate 102 may, in turn, typically be mounted on a heat sink to dissipate heat generated by monolithic LED device 100. Since a path of heat conduction to the heat sink is only through substrate 102, rather than through additional packaging for each discrete LED as in the prior art, more heat may be dissipated through a heat sink than discrete LED

arrays. Operating monolithic LED device 100 with such a heat sink may extend an operating life of each LED die 104.

FIG. 2 shows an exemplary wiring diagram for a monolithic LED device 100 in accordance with the present invention constructed of individual red, green and blue sub-die arrays coupled in a block series-parallel configuration. As shown in FIG. 2, each block 302, 304 and 306 may be connected in parallel for each block 310, 320 and 330, with each sub-array controlled by respective voltage applied across RED, BLU and GRN rails to ground potential GND.

In FIGs. 3A and 3B there are shown top and side views, respectively, of an exemplary embodiment of a lamp 200 in accordance with the present invention as may be employed in, for example, a standard 110 VAC "R-type" floodlight or spotlight configuration. Lamp 200 includes monolithic LED device 100 as shown in FIG. 1, lamp housing 207 including front face 206, mounting brackets 212 and side 208, voltage converter 204 and base 210.

Lens 106 may be employed to provide focusing properties. In alternative embodiments, focusing of light from monolithic LED device 100 may either be performed by lens 106, or by a front face 206 of the lamp housing 207, or by both. Monolithic LED device 100 is electrically coupled to a supply voltage by a voltage converter 204, which may be a transformer, such as step-down transformer, series resistor, or other type of voltage converter employed in the art to convert from a supply voltage such as an AC or DC supply followed by a bridge rectifier circuit. A voltage regulator (not shown) following the bridge rectifier may also be employed, but for preferred embodiments, the voltage regulator is not necessarily employed since it is desired for the lamp 200 to be dimmable and since common power surges may be handled by a simple varistor. The supply voltage is electrically coupled to the lamp 200 by an electrical interface shown as base 210 and optional voltage converter 204. Base 210 may be formed as a screw-in plug for a candelabra, an intermediate, or medium base, for example.

The voltage converter 204 of FIGs. 3A and 3B is employed to connect the supply voltage to a desired input voltage to the monolithic LED device 100. For a case having equivalent supply voltage and input voltage, the voltage converter 204 may be omitted.

Lamp housing 207 may be manufactured so as to appear in any standard configuration, such as an ordinary R-type lamp configuration shown in FIG. 2, as may be desired for audience appeal in mass marketing. The electrical interface in accordance with the present invention, having base 210 and optional voltage converter 204, provides the monolithic LED device 100 with an input voltage from the supply voltage. Lamp housing 207 may be constructed from several parts, with some parts being opaque, such as the funnel-shaped side 208, and other parts being transparent or frosted, such as the front face 206. In all the implementations shown in FIGs. 3A and 3B and FIGs. 6A through 8B, these parts may desirably be fastened or glued together in a hermetically sealed fashion to prevent moisture damage. The monolithic LED

device 100 and voltage converter 204 are supported in the housing by means of internal mounting supports 212, which may be either opaque or transparent, and may be, for example, either separate glued-in components or molded as a part of other components of bulb housing 207. In both cases, for the exemplary embodiments shown in FIGs. 3A and 3B and FIGs. 6A-8B, the housing may be made using a rigid, durable plastic such as polycarbonate.

For embodiments of the present invention adapted to interface a monolithic LED device 100 with a high AC supply voltage, such as 100/220 VAC, the voltage converter 204 (FIG. 3B) may employ the exemplary embodiments as shown in FIGs. 4A and 4B. FIG. 4A shows a first embodiment of voltage converter 204 comprising step-down transformer 407 and FIG. 4B shows a second embodiment which includes a low-pass capacitor 406 followed by a step-down resistor 407. Both voltage converters as shown in FIGs. 4A and 4B employ an optional varistor 403 for surge protection, a bridge rectifier 404 for full-wave conversion of the AC supply voltage to a DC voltage and an optional variable resistor 405 for each positive output lead. FIGs. 4A and 4B show three output of supply leads, one for each of the RGB sub-die color components. More leads may be required if intermediate colors are used, for example, to increase color rendering index (CRI). If only white dies or dies of a single color are employed, the variable resistor may not be necessary, and the output may have one lead.

Variable resistor(s) 405 in the voltage converter of FIGs. 4A and 4B may be employed to regulate power available for each sub-die color component. Variable resistors 405 may be controlled by a variety of activators, such as a simple set of external slides or knobs that the user may manually adjust to a sophisticated controller having a processor that may blink, change color, or adjust color in a continuous, a periodic, or a random way, depending on specific desired applications. FIG. 5 shows color adjustment controller 500 as employed in accordance with the present invention that may adjust color emitted by LED die 104 in a continuous fashion, or to maintain approximately the same color, for example, white color temperature when the lamp 200 is dimmed. Color adjustment controller 500 includes an analog-to-digital converter (A/D) 501 Read Only Memory (ROM) 502 and Switching Network (SW-NET) 503.

Referring to FIG. 5, for each color component, the positive output of the bridge rectifier 404 (FIGs. 4A and 4B) is provided to A/D 501 as well as into SW-NET 503. The A/D 501 converts the voltage level into a digital signal, shown in FIG. 5 as a 3-bit digital value yielding eight discrete values. These voltage values are converted by ROM 502 into signals that actuate the SW-NET 503 in a predefined way. The SW-NET 503 controls the variable resistor 405 (FIGs. 4A and 4B) through a set of internal taps, not shown, corresponding to minimal, maximal, and intermediate levels of resistance, or equivalently, attenuation to the sub-die color component output of LED die 104.

Providing a maximum voltage input to the monolithic LED device 100 minimizes the required current, allowing a reduction of wire gauge in the step-down transformer of voltage converter 204 and, more

desirably, a turn-ratio in a step-down transformer for transformer 407 may be minimized. For example, using a 110 VAC supply voltage and a monolithic LED device 100 having one hundred LED dies 104 and each LED die 104 drawing 20 mA at 2 VDC, if LED dies 104 are wired in parallel such that an input voltage to device 100 is 2 VDC, a total current drawn by the monolithic LED device may be approximately 2  
5 Amperes and a turn ratio of the step-down transformer may be approximately 55:1. With one hundred LED dies 104 in the device 100 wired in accordance with a block series-parallel configuration, each block comprising five LED dies 104, the input voltage provided to device 100 is 10 VDC, the total current is 0.4 Amperes, and a turn-ratio of the step-down transformer of voltage converter 204 is 11:1. In either case the total power consumption is the same at 4 Watts, with 100% efficiency, but the block series-parallel  
10 configuration results in a lamp 200 which is smaller and less costly to produce.

For an alternative embodiment, the voltage converter 204 employs a step-down resistor 407 and step-down capacitor 406 as shown in FIG. 4B, as may be most useful for very small light bulbs where size limitations are severe, instead of a step-down transformer 402 as shown in FIG. 4A. The use of a maximum voltage input to the monolithic LED device 100 not only minimizes the monolithic LED device current  
15 requirement, hence minimizing the size and cost of the step-down resistor 407, but also maximizes the efficiency of the lamp by minimizing power loss through the step-down resistor 407. For example, using, as above, a 110 VAC supply voltage and a monolithic LED device 100 consisting of one hundred LED dies 104, each LED die 104 drawing 20 mA at 2 VDC, if the array of LED dies 104 were wired purely in parallel such that its input voltage is 2 VDC, the total current drawn by the monolithic LED device 100 would be 2  
20 Amperes and its resistance would be 100 Ohms. The step-down resistor 407 for this case would be 5,500 Ohms and the total power consumed would be 220 Watts, which compared with 4 Watts of the example described results in only 1.8% efficiency and considerable heat dissipation through the step-down resistor 407. With the same number of dies in the monolithic LED device 100 wired with a block series-parallel configuration, where each block consists of, for example, five dies 104, the resulting input voltage of  
25 monolithic LED device 100 may be 10 VDC, the total current may be reduced to only 0.4 Amperes and the monolithic LED device resistance may be 500 Ohms. The step-down resistor 407 in this case would be reduced to 1,100 Ohms and the total power consumed would be reduced to 44 Watts, which compared with 4 Watts of the example above results in 9% efficiency which is a five-fold increase in efficiency over the purely parallel wiring case with five-fold less heat generated. With recent introduction of 110 VDC LEDs,  
30 voltage conversion other than from AC to DC (using bridge rectifier) may not be necessary.

FIGs. 3A and 3B and the following FIGs. 6A-8B illustrate exemplary embodiments of the present invention as used in typical light bulb configurations. The preferred embodiment spans any light bulb application involving the use of one or more monolithic LED devices 100, and the exemplary embodiments of FIGs. 3A and 3B and FIGs. 6A-8B may be a set of common lamp configurations for 110 VAC screw-in,  
35 12 VDC (low voltage) push/screw, and 110 VAC fluorescent-type, plug-in applications, respectively. As

such, lamps employing the monolithic LED device **100** described for these applications preferably include either a set of white dies or a set of colored RGB dies for LED dies **104** that produce light output power of desired color temperature. These sets of dies are wired together in a block series-parallel configuration described previously with either maximum series block size or a size of block **108** having the input voltage matched to a low-voltage supply voltage, such as 12 VDC. With a typical drive voltage of 2V for each LED die **104**, these two requirements may be the same or similar; i.e., the maximal block size, which may be six, may result in a 12 V monolithic LED device **100**.

For example, for the four exemplary lamp embodiments described with respect to FIG. 3A and 3B and FIGs. 6A to 8B, it may be desirable to form monolithic LED device **100** as a lamp component for the purpose of convenience and low manufacturing costs. The light output power of the monolithic LED device **100** constructed as a lamp component may have light output power equivalent to an incandescent power of 20 Watts, or approximately 200 lumens. Using such a component monolithic LED device **100**, five monolithic LED devices **100** may be wired together in parallel, for example, to form a lamp equivalent to a 100 Watt lamp having approximately 1000 lumen light output.

In the preferred exemplary embodiments shown in FIGs. 3A-3B and FIGs. 6A-8B, the lamps are shown having array of LED dies **104** controlled either through its primary RGB sub-die color components or all at once, resulting in a reduced number of possible leads to the monolithic LED device. These exemplary embodiments are so shown for clarity only and the invention herein is not so limited, encompassing much general approach of all possible sizes of monolithic LED devices **100**, array dies of LED dies **104**, and sets wiring variations as described previously. For a monochromatic or white light bulb using monochromatic or white dies for LED dies **104**, the preferred embodiment would involve only two leads, whereas if white light is produced using a RGB monolithic LED die array device, up to four leads may be required, particularly if a variable resistor is used to vary the current to each color as a function of applied input voltage, to account for differences between each of the three color components light output versus power characteristic curve, in order for the output light to maintain the same whiteness characteristic; i.e., color temperature, when dimmed, or for the user to produce a desired continuous color or color sequence. In addition, intermediate color LED dies **104** may be employed to better match the spectrum of daylight, as commonly indicated by color rendering index, with CRI = 100 being a "perfect" match.

FIGs. 6A and 6B show top and side views of a standard 110 VAC "A-type" hemispherical lamp configuration based on a set of five planar monolithic LED devices **100**. For this embodiment, each monolithic LED device **100** may have an equivalent light output incandescent power requirement of 20 Watts (200 lumens), forming a replacement for an equivalent 100 Watt incandescent bulb. The mounting **212** supporting the five monolithic LED devices **100** is preferably transparent or translucent, whereas the mounting **212** that supports the voltage converter **204** is preferably opaque. Accordingly, the parts of the bulb housing **207** forming the globular front face **206** and form the sides up to the mounting support for the



power supply is likely to be transparent or frosted, whereas the remaining parts of the housing 207 forming the base 210 are preferably opaque. Variations of this lamp configuration employed with dies providing red, green or yellow may be preferred for traffic light applications.

In FIGs. 7A, 7B and 7C, there are shown conceptual top, bottom and side views of a low-voltage (e.g., 12 VDC input) lamp configuration based on a single monolithic LED device 100 with light output equivalent to an output of incandescent power 20 Watts (200 lumens). Low-voltage supply voltage such as 12 VDC may be common for outdoor safety/decorative lighting or automotive lighting. Base 210 may be a push/screw connector as is employed in a standard outdoor low-voltage lamps, as is the shape of the housing 207. Since the monolithic LED device is wired in block series-parallel form such that its operating voltage is matched to the supply voltage (e.g., 12 VDC), the monolithic LED device 100 may be coupled to the base 210, eliminating the need for voltage manipulation or regulation, and so eliminating voltage converter 204, thereby reducing manufacturing cost. In this embodiment of FIGs. 7A-7C, the front face 206 of the housing 207 would be either transparent or frosted, and possibly have a focusing lens molded in, whereas an area from the mounting support 212 to base 210 is preferably opaque.

In the exemplary embodiment as shown in FIGs. 8A and 8B, the lamp 200 may be formed as a 110 VAC fluorescent-type tube lamp configuration based on, for example, a set of ten monolithic LED devices 100 arranged along a line and spaced evenly across a, for example, four foot long mounting support 212. With ten such monolithic LED devices 100, each having light output equivalent to an incandescent output of 20 Watts (200 lumens), the total light output may be equivalent to a 40 Watt fluorescent bulb (2000 lumens). The plug-in connector for bases 210 is purposely drawn to duplicate that of a fluorescent-type tube bulb, as is the shape of the housing 207. In this case, the housing 207 may be such that an area from front face 206 to the mounting support 212 is either transparent or frosted, and the remaining areas may be opaque. Depending on a size and cost of voltage converter 204, it may be desirable to use two power supplies, with one at either end directly connected to the respective base 210, and with each transformer and bridge rectifier of voltage converter 204 supplying half of the monolithic LED devices 100, for example, wired in parallel. In this embodiment, it may also be desirable to mould the mounting support 212 into a bottom portion of housing 207.

These embodiments shown in FIGs. 3A and 3B and FIGs. 6A through 8B are exemplary only, and do not comprise the totality of possible implementations claimed herein. Many other forms of lighting fixtures may be constructed employing the monolithic LED device in accordance with the present invention, including low-voltage lighting, automotive lighting, street lighting, emergency lighting, flashlights, and decorative lights such as track lights, for example. In addition, embodiments having various forms of die array control wiring for the monolithic LED device to control and adjust light intensity, as described previously. More sophisticated control features may also be included for decorative lighting designs, such as random or periodic or random blinking and/or color changing.

It will be further understood that various changes in the details, materials, and arrangements of the parts which have been described and illustrated in order to explain the nature of this invention may be made by those skilled in the art without departing from the principle and scope of the invention as expressed in the following claims.

CLAIMS

What is claimed is:

1           1. A lamp comprising:

2                 a lamp body;

3                 an electrical interface mounted in the lamp body and adapted to interface with a standard voltage  
4 supply;

5                 a monolithic LED device electrically coupled to the electrical interface and comprising:

6                     i) an array of electrically-coupled LED dies mounted on a substrate, and

7                     ii) a package having a lens, the substrate encapsulated in the package with the lens over the  
8 array.

1           2. The invention as recited in claim 1, wherein the electrical interface comprises a voltage  
2 converter, the voltage converter adapted to convert a first voltage potential of the standard voltage supply  
3 to a second voltage potential, and the electrical interface couples the array of electrically-coupled LEDs  
4 across the second voltage potential of the voltage converter.

1           3. The invention as recited in claim 2, wherein the voltage converter is a transformer, the voltage  
2 transformer being either a step-down transformer or a low-pass capacitor with step-down resistor circuit.

1           4. The invention as recited in claim 1, wherein the monolithic LED device includes at least one set  
2 of at least two arrays of electrically-coupled LED dies, each array having series-connected LED dies, and  
3 the at least two arrays coupled in parallel forming a discrete block.

1           5. The invention as recited in claim 4, wherein each array of series-connected LED dies is voltage-  
2 matched to a predetermined voltage potential.

1           6. The invention as recited in claim 5, wherein sets of one or more discrete blocks are coupled in  
2 parallel, thereby to form the monolithic LED device having a standard light output power.

1           7. The invention as recited in claim 2, wherein at least one LED die of the array of electrically-  
2 coupled LED dies is a white die.

1           8. The invention as recited in claim 7, wherein the electrical interface includes an actuator, each  
2 array of electrically coupled LED dies includes a variable resistor having a resistance responsive to the  
3 actuator, thereby to adjust a luminance of each LED die.

1           9. The invention as recited in claim 8, wherein the actuator is manually adjusted.

1           10. The invention as recited in claim 8, wherein the actuator includes a controller, the controller  
2     adjusting the resistance of the variable resistor to provide a predetermined luminance sequence of the lamp.

1           11. The invention as recited in claim 8, wherein the electrical interface comprises a voltage  
2     converter, the converter adapted to convert a first voltage potential of the standard voltage supply to a second  
3     voltage potential, and the actuator includes a bridge rectifier coupled in parallel across the second voltage  
4     potential, an output signal of the bridge rectifier related to at least one stored value, the stored value  
5     employed to adjust the resistance of the variable resistor.

1           12. The invention as recited in claim 2, wherein at least one LED die of the array of electrically-  
2     coupled LED dies is a multi-color die having at least two of a red sub-die, a green sub-die and a blue sub-die.

1           13. The invention as recited in claim 12, wherein the electrical interface includes an actuator, each  
2     array of electrically-coupled LEDs includes a separate set of series-connected red sub-dies, series-connected  
3     green sub-dies and series-connected blue sub-dies, each separate set having a variable resistor having a  
4     resistance responsive to the actuator, thereby to adjust a luminance of each sub-die of the set.

5           14. The invention as recited in claim 12, the multi-color die further comprising at least one  
6     intermediate color die, the intermediate color die operated so as to adjust a color rendering index of the  
7     multi-color die.

8           15. The invention as recited in claim 1, wherein the array of electrically-coupled LEDs emit a light  
9     output having a single color.

10          16. The invention as recited in claim 1, wherein the array of electrically-coupled LED dies is  
11     mounted on the substrate by either growing each LED die on the substrate or mounting pre-fabricated dies  
12     on the substrate.

1           17. The invention as recited in claim 14, wherein the substrate is either a printed circuit board,  
2     ceramic substrate or a silicon-based crystal.

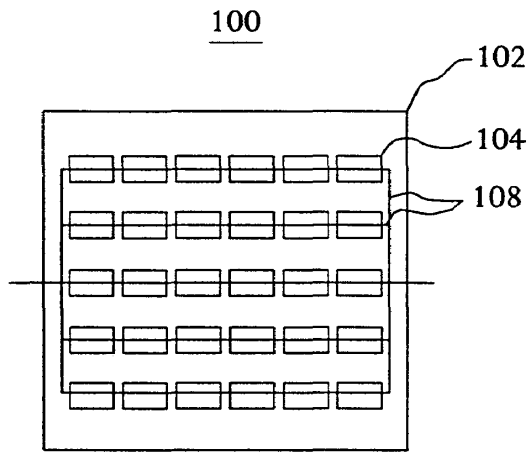


FIG. 1A

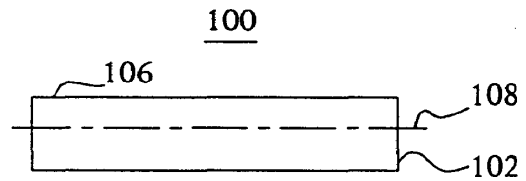


FIG. 1B

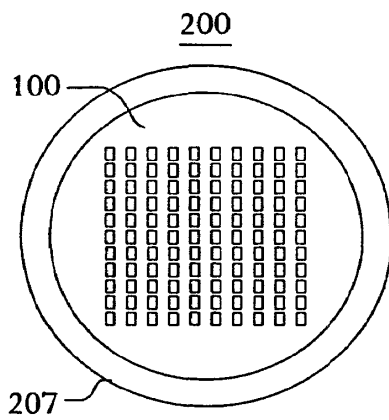


FIG. 3A

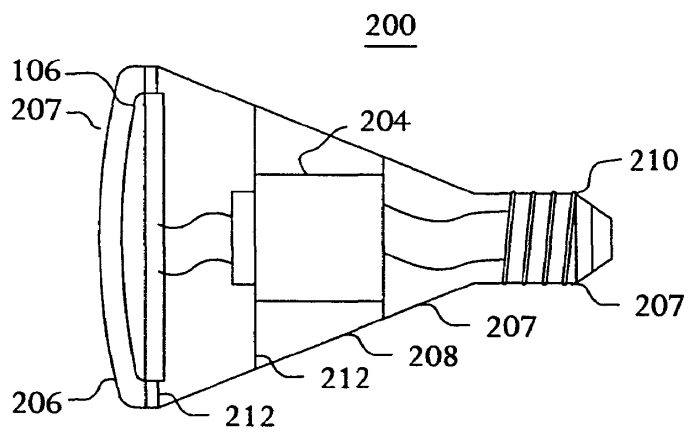


FIG. 3B

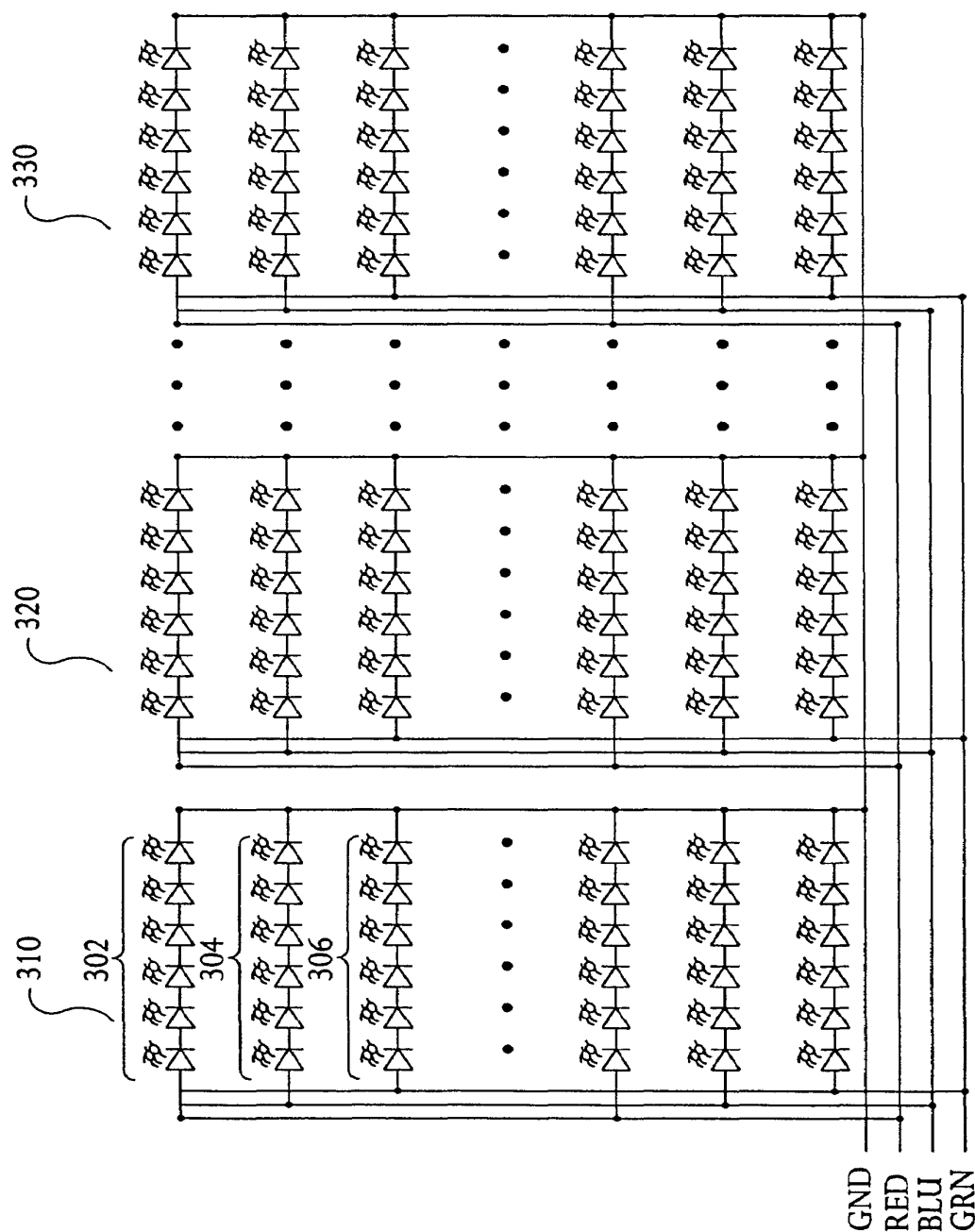


FIG. 2

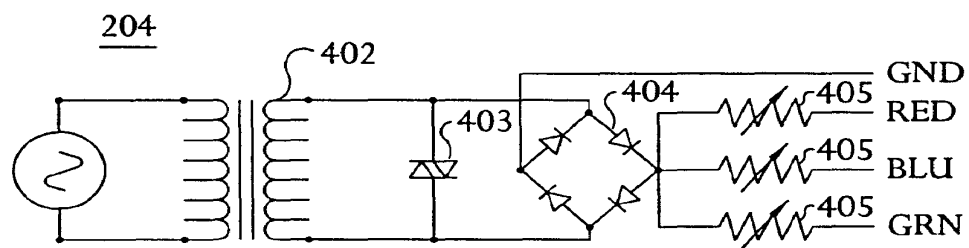


FIG. 4A

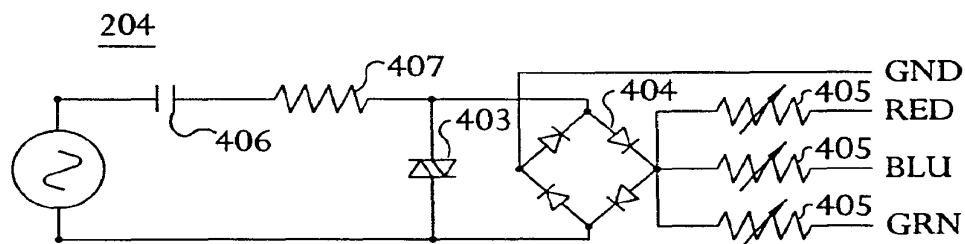


FIG. 4B

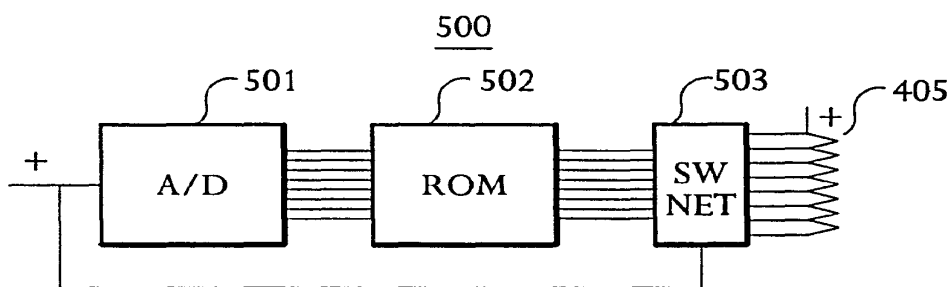


FIG. 5

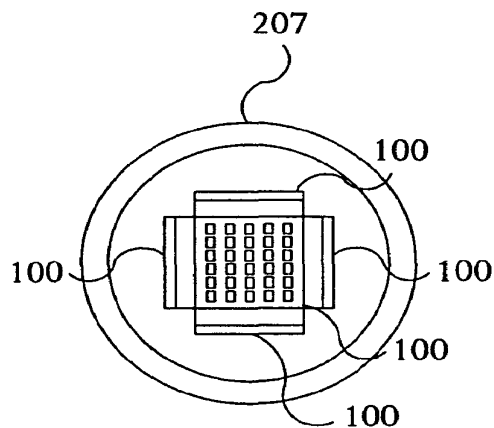


FIG. 6A

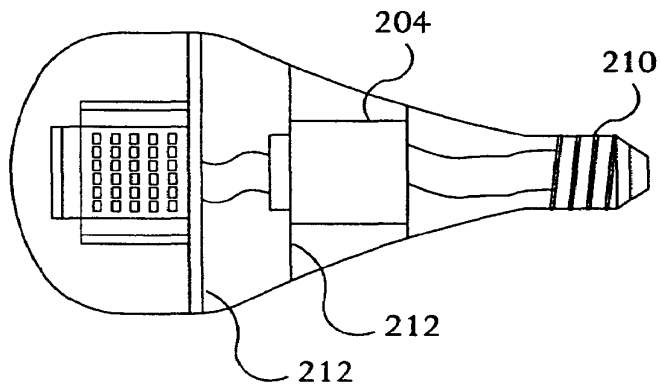


FIG. 6B

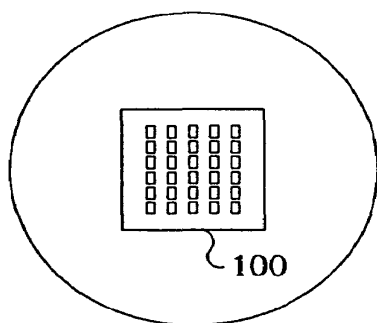


FIG. 7A

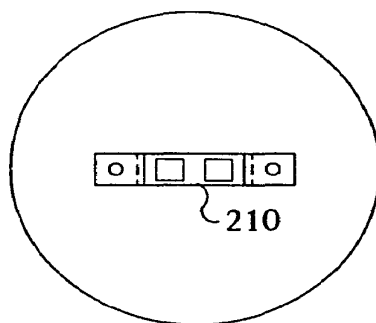


FIG. 7B

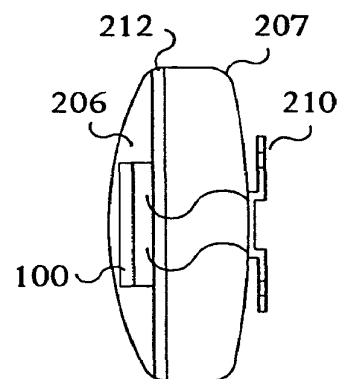


FIG. 7C



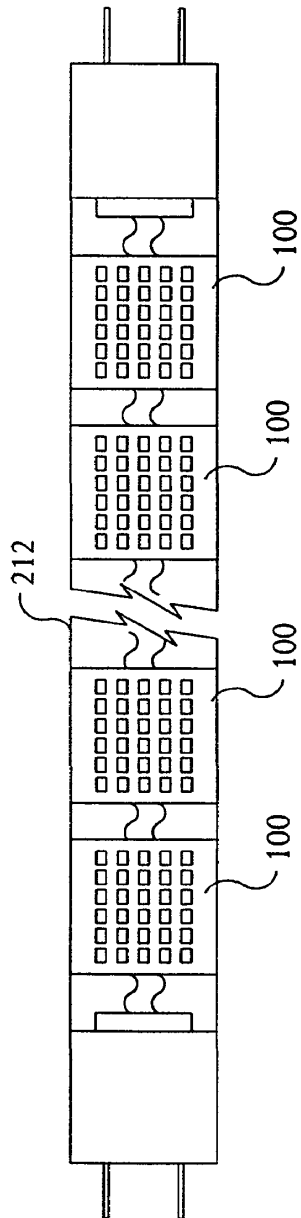


FIG. 8A

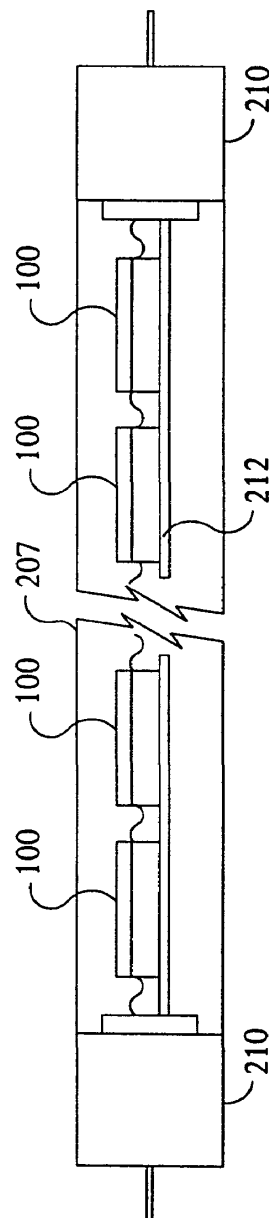


FIG. 8B

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US99/09723

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H05B 37/00

US CL :315/77, 291, 149, 312, 326, 363

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 315/77, 291, 149, 312, 326, 363

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
none

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

U.S. PTO APS, LED#, LIGHT EMITTING DIODE#, LENS, LIGHT# OR LAMP#, TRANSFORMER#, PACKAGE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| A         | US, 4,912,454 A (SOLOW) 27 MARCH 1990, (27/03/90) SEE<br>WHOLE DOCUMENT            | 1-17                  |



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

24 JUNE 1999

Date of mailing of the international search report

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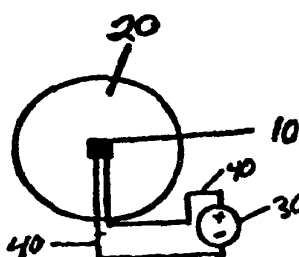
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>(51) International Patent Classification <sup>6</sup> :</b><br><b>F21M 3/14</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>A1</b> | <b>(11) International Publication Number:</b> <b>WO 99/45312</b><br><b>(43) International Publication Date:</b> 10 September 1999 (10.09.99)                                                                                                                                                                                                                                                                                                                           |
| <b>(21) International Application Number:</b> PCT/US99/04927<br><b>(22) International Filing Date:</b> 4 March 1999 (04.03.99)<br><b>(30) Priority Data:</b><br>60/076,840 4 March 1998 (04.03.98) US<br><b>(71)(72) Applicant and Inventor:</b> SCIANNA, Carlo [US/US];<br>1110 Wexford Court, Des Plaines, IL 60016 (US).<br><b>(74) Agents:</b> SWEENEY, James, R. et al.; Lee, Mann, Smith,<br>McWilliam, Sweeney & Ohlson, P.O. Box 2786, Chicago,<br>IL 60690-2786 (US).                                                                |           | <b>(81) Designated States:</b> AL, AM, AU, AZ, BA, BB, BG, BR, BY,<br>CA, CN, CU, CZ, EE, GD, GE, GH, GM, HU, ID, IL, IN,<br>IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LV,<br>MD, MG, MK, MN, MW, MX, NO, NZ, PL, RO, RU, SD,<br>SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN,<br>YU, ZW, European patent (AT, BE, CH, CY, DE, DK, ES,<br>FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).<br><br><b>Published</b><br><i>With international search report.</i> |
| <b>(54) Title:</b> OMNIDIRECTIONAL LIGHTING DEVICE<br><br><b>(57) Abstract</b><br><p>A light modifying material composed of ethylene/butene-1 copolymer or propylene homopolymer or a combination of the two, and lighting devices using the material in a light transmitting cover (20). It is preferred that the light source (10) for the devices is a semiconductor or light emitting diode (LED), to produce an energy efficient light source.</p>  |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

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| BG | Bulgaria                 | HU | Hungary                                  | MN | Mongolia                                     | TT | Trinidad and Tobago      |
| BJ | Benin                    | IE | Ireland                                  | MR | Mauritania                                   | UA | Ukraine                  |
| BR | Brazil                   | IL | Israel                                   | MW | Malawi                                       | UG | Uganda                   |
| BY | Belarus                  | IS | Iceland                                  | MX | Mexico                                       | US | United States of America |
| CA | Canada                   | IT | Italy                                    | NE | Niger                                        | UZ | Uzbekistan               |
| CF | Central African Republic | JP | Japan                                    | NL | Netherlands                                  | VN | Viet Nam                 |
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| CH | Switzerland              | KG | Kyrgyzstan                               | NZ | New Zealand                                  | ZW | Zimbabwe                 |
| CI | Côte d'Ivoire            | KP | Democratic People's<br>Republic of Korea | PL | Poland                                       |    |                          |
| CM | Cameroon                 | KR | Republic of Korea                        | PT | Portugal                                     |    |                          |
| CN | China                    | KZ | Kazakhstan                               | RO | Romania                                      |    |                          |
| CU | Cuba                     | LC | Saint Lucia                              | RU | Russian Federation                           |    |                          |
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| DE | Germany                  | LK | Sri Lanka                                | SE | Sweden                                       |    |                          |
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**OMNIDIRECTIONAL LIGHTING DEVICE**

5

**Background of the Invention**

The Applicant claims priority based on U.S. Provisional Patent Application Serial No. 60/076,840 filed March 4, 1998. This application incorporates co-pending and co-owned U.S. patent application 08/802,526 in its entirety.

10 The present invention relates broadly to light transmission media and to associated lighting devices and improvements in lighting devices incorporating light emitting diodes as light sources, particularly the use of an ethylene/butene-1 copolymer or a propylene homopolymer to serve as a modifier to deliver a more uniform light output across the lighting device which allows the light to be diffused and magnified.

Light emitting diodes (LEDs) have been used for many purposes for many years. 15 Generally they have been used as indicator lights and in arrays to form information displays. The light emitting diodes have the advantages of operating at a low voltage, approximately three volts, and energy efficiency, generating approximately 25 lumens of light per watt. The disadvantage of this type of lighting is that the light is unidirectional, that is, the light is directed only in the direction of the axis of the light emitting diode. The light does not diffuse 20 to the sides. Typical LEDs provide light less than 40° from the axis of the diode. If the LED is being used in a warning light to alert the public to a danger, a person approaching the warning light from the side will not have their attention drawn to the peril.

The light from an LED is also concentrated, appearing to emanate from a small point. Currently many warning and signal lights constructed with LEDs do not meet specifications 25 set by the Institute of Transportation Engineers. This is because the LEDs emit a highly

concentrated intense unidirectional light causing a "hot" spot in the center of the signal face and the testing standard measures the light intensity over an area  $\pm 10^\circ$  from the optical center. In some cases an array of LEDs is used to provide a larger signal area, but such arrays are wasteful as they require more LEDs, increasing production costs and requiring  
5 more energy to operate.

Presently, incandescent light sources are widely used in existing lighting devices. Examples of these products are exit lights, flashing yellow barrier lights, lighted exit signs required in buildings, Christmas lights, hand held signal lights such as those used by traffic police, and instrument panel display lights. Because these devices use incandescent light  
10 bulbs, they are inefficient. They are also susceptible to vibration, which may cause a failure or a shortening of the bulbs useful life. The mean time between failure for a typical incandescent device is less than 5000 hours. A typical LED has a mean time between failure of 100,000 hours.

The following table summarizes the comparison of current designs using various light  
15 sources:

20

It is an object of this invention to provide a reduced power light source for warning devices, signs, and other illuminated articles. It is also an object of this invention to provide an omnidirectional LED light source and a device that gives a more uniform light output across the face of the device compared to the unidirectional concentrated light of traditional LED light devices.

This invention need not be restricted to LEDs as the light source. It can also utilize any light source, both visible and invisible such as infra-red, such as an incandescent, fluorescent, or neon bulb, or lasers.

#### **Disclosure of the Invention**

The device of this invention is an omni-directional light assembly that emits light from the side as well as in the direction of the axis of the light source. The light is dispersed and magnified by a light transmitting material herein disclosed so that persons approaching such a device from the side would clearly see the emitted light. More particularly, the invention is directed towards an omni-directional light assembly utilizing a non omnidirectional light source, such as an LED.

The invention, when utilizing LEDs or other semiconductors, further provides the benefit of reduced power consumption over incandescent bulbs. The invention may further gain energy efficiency by utilizing solid state circuitry to pulse at a rate sufficiently high so as to appear to be steadily on, or in the alternative, pulse with a desired rate to create a flashing light. Such a circuit is disclosed in co-owned U.S. Patent Application 08/802,526.

The invention has application in areas such as traffic safety barriers, logos or emblems, hand held light signals, exit or other warning and signal lights, safety articles as disclosed in U.S. Patent Application 08/802,526, as well as instrumentations lighting.

The apparatus of the present invention comprises the LED itself with a cover made of a plastic material such as ethylene or propylene. The cover can be clear or it can contain color. It may also be translucent or opaque, depending upon the formulation and method of production. Since the normal LED is small, a cover having a diameter in the range of about 3 inches would be satisfactory to cover the emitted light from the LED and provide the omni-directional condition for a warning light. The specific dimension of any article will vary with the application. It should be obvious that the cover can be made to any shape and size. As the size increases one may desire to use multiple LEDs.

The spatial relationship of the cover and the light source may vary. The cover may be spaced from the light source, as is the common design of typical incandescent lights and associated lenses. Alternatively, the light source can be placed against or in contact with the cover. An extension of this design is embedding the light source in the cover material. The LED light source lends itself well to this arrangement since it is small and gives off negligible heat.

The cover is made from a plastic material, preferably from a polyolefin and more preferably a polyolefin in either a rigid or semi-rigid state. The polyolefin is mixed with a hydrocarbon material to create a matte look. Broad ranges of hydrocarbons can be used for this purpose. A clarifying agent may also be added. An example of such an agent is Millad 3988 made by Milliken Chemical Company which is added at about 0.25% by weight of the polyolefin material. The cover is generally molded or blow molded from the polyolefin material in a conventional manner using heat or it may be extruded.

A particular polyolefin material which has been found useful in the invention is a propylene homopolymer designed for injection molding applications. This particular



propylene homopolymer has a melt flow rate of 32 grams per 10 minutes, a density of .90 grams per cm<sup>3</sup>, a melting point of 147°C, a tensile strength of 5.0 kpsi, an elongation of 16% and a flexural modulus of 200 kpsi. Such a compound is manufactured and sold by Exxon Chemical under the trademark ACHIEVE 1625.

5           A particular ethylene/butene-1 copolymer material which has been found useful in the invention is a copolymer designed for injection molding applications. Such a compound is manufactured and sold by Exxon Chemical under the trademark EXACT 4049.

          The EXACT 4049 material is flexible and milky in color. The flexibility allows the lighting device made from the material to be easily bent or shaped into desired  
10 configurations. The ACHIEVE material is rigid and also milky in color. The ACHIEVE material is appropriate for applications where a rigid cover is desired. The two materials are compatible and may be mixed in any combination to result in a cover of desired rigidity or flexibility.

          The ACHIEVE material is normally milky in color and transparent. The addition of a  
15 material known as Millad Concentrate 8C41-10, manufactured by Milliken chemical of Inman South Carolina, and belonging to the chemical family of sorbitol acetal in polyolefin blend, is known to act as a clarifying agent if added in a ratio of 25% by weight of the polyolefin material. One skilled in the art will readily recognize that other clarifying agents may be used.

20           The EXACT 4049 material may also be rendered clear by rapidly chilling the product immediately upon extrusion or molding. When the material is extruded or molded, it is typically at a temperature of 140° to 200° F. If allowed to cool at room temperature, the material will have a milky but translucent appearance. If the material is rapidly cooled

however, the resulting product will be clear. The preferred way to cool the material is to bathe the product in chilled water just after it is extruded or molded and is still above 140° F. While there are many ways to accomplish the cooling, the preferred way is to spray chilled water upon the product. The water should be at a temperature just above freezing for the best results.

The cover described in this application is useable with numerous different kinds of LEDs. When the LED itself is not circular in its upper dimension the cover of this invention can be molded in different forms so that it is useful with any kind of an LED.

The cover may be shaped or molded into any number of desired shapes. Also, the LED may be placed anywhere within or at the surface of the cover. More than one LED may be used as a light source if the face of the device is large or if higher intensity light is desired.

The lights source and cover combination has many uses. For instance, the cover may be used with an incandescent bulb and suitable power source to from a signal or warning light, such as those commonly seen in highway construction zones. While the cover of the present invention would perform well with an incandescent light source, it would be preferable to utilize a light source of lower power consumption and longer life, such as an LED. LEDs have not been used in the past for barrier warning lights because of the unidirectional and concentrated nature of the light emitted. The cover modifies the concentrated light of the LED and spreads it out across the surface of the cover, resulting in an omnidirectional uniform lighting effect. Thus the cover allows use of an LED or an array of LEDs where incandescent lights were the preferred source. Suitable electronic circuitry may be electrically connected to the light source and power source to cause the light to flash at a desired time interval. Such circuits are well known to those skilled in the art.

The cover and LEDs and can be combined with a standard incandescent bulb base to create a replacement bulb for the incandescent bulb. Such a replacement bulb utilizing LEDs as a light source instead of a filament can provide a operational cost advantage.

### **Brief Description of the Drawings**

5           Figure 1 is a side elevational view of a typical LED which may be used in connection with the cover of this invention.

Figure 2 is a sectional view of the cover of this invention which is designed to fit over the LED shown in Figure 1. The cover is made of the plastic material already described and will when light is emitted from the LED, disperse and magnify the light.

10           Figure 3 is front view of a traffic barrier warning light utilizing a single LED light source embedded in a cover of light modifying plastic.

Figure 4 is a front view of a generic signal light utilizing a plurality of LED light sources embedded in the cover of light modifying plastic.

15           Figure 5 is a front view of any exit sign utilizing a plurality of LED light sources positioned at the edge of the light modifying plastic.

Figure 6 is a front view of an instrument panel utilizing plurality of LED light sources positioned within the cover of light modifying plastic.

Figure 7 is a perspective view of lighted logo or emblem design utilizing a plurality of Led light sources.

20           Figure 8 is a side view of a hand held light signal utilizing an LED embedded in a light modifying plastic cover.

Figure 8a is a side view of the device of Figure 8 utilizing a plurality of LEDs.

Figure 9 is a front view of a shaped hand held light signal utilizing a plurality of LEDs embedded on a light modifying plastic cover.

Figure 10 is a side view of a LED bulb suitable to replace an incandescent bulb.

5

### **Best Modes of Carrying out the Invention**

Referring to Figures 1 and 2, the invention in its basic form includes a light source, such as an LED 10, and a cover 20. The LED 10 may be of any type depending upon the application. For applications requiring the most visibility, a high intensity LED may be selected. For applications requiring a low power consumption, an LED of low power can be selected. As is obvious to one skilled in the art, the LED 10 is electrically connected to a power source 30 by the conductors 40. In the preferred embodiment, the conductors 40 are length of wire, but could easily be any other suitable electrically conductive material.

The cover 20 is constructed of a substantially transparent polyolefin material. In the preferred embodiment, the cover 20 can be constructed of a material known as EXACT 4049, a material known as Acheive 1625, or a combination the two. The cover 20 may be of any color desired. Exact 4049 and Acheive 1625 materials are normally milky in color, but can be rendered clear by the methods described in this application.

The preferred construction for a warning light is shown in Figure 3. The LED 10 is placed generally in the center of the cover 20. The conductors 40 and the LED 10 are embedded in the cover 20 material. It is obvious to one skilled in the art how to connect the conductors to an appropriate power source for powering the LED 10. While it is preferred that the LED 10 be embedded in the cover 20, it is not necessary for the functioning of the invention. The LED 10 may be located at a surface of the cover 10, or located remotely from

the surface. For instance, the cover 20 shown in Figure 3 could be hollow, as would be the case if the cover 20 were produced by means of blow molding, thus defining a plenum in which the LED 10 could reside.

As shown in Figure 4, multiple LEDs 10 may be used in constructing the lighting device. The plurality of LEDs 10 can be located anywhere within the cover 20 depending upon the lighting effect desired. As disclosed above, it is not necessary that the LEDs 10 be embedded in the cover 20. Location is a choice dependant upon the design, use, and desired effect of the lighting device. For instance, for illumination of an exit sign constructed of the polyolefin materials disclosed, it may be desirable to locate the LEDs 10 at the perimeter of the cover. It is also obvious to one skilled in the art how to use the conductors 30 to electrically connect the LEDs 10 to one another and to a power source or other electronic circuitry.

The preferred construction of an exit sign is shown in Figure 5. The cover 20 is generally rectangular in shape and approximately 8 inches by 14 inches by 3/4 inches, but the dimensions can vary. The word "EXIT" can be formed on the cover by paint or other means commonly used in the art. A plurality of LEDs 10 are placed at the surface of the perimeter of the cover 20, although they may also be embedded in the cover material. Electrically connecting the LEDs to a power source is obvious to one skilled in the art.

Figure 6 shows an example of automobile instrument panel indicators constructed using the light transmitting material disclosed herein. The cover 20 is used to transmit the light from the LEDs 10 to the mask carrying the indicia of the instrument panel so that the message of the indicia can be observed by the operator.

Figure 7 shows an example of a lighted emblem or logo to be attached to an article of clothing. The cover 20 will generally be as thin as 1/16 inches and 3 inches diameter, but dimensions will vary with the design. The emblem may employ a single or multiple LEDs 10, which need not be the same. The LEDs 10 are placed in contact or embedded in the cover 20 material. The cover 20 may bear an indicia of source, such as ACME in the example. The power source 30 is preferably a small button cell battery so as not to add bulk.

Figure 8 shows a hand held light signal using a single LED 10 embedded in the cover 20. The handle and cover 20 are generally cylindrical in shape and the size of a 2 cell flashlight, but the shape and dimensions may be varied to any convenient design. The power source 30 is contained in the handle and the LED 10 is electrically connected by the conductors 30. A tube of retroreflective material 60, as described in U.S. patent application 08/802,526, may be placed over the cover to further enhance the transmission of light from the LED 10. A plurality of LEDs 10 can be contained within the cover 20 for the length of the cover 20 as shown in figure 8a.

Figure 9 shows a shaped lighting device using a plurality of LEDs 10 within the cover 20.

Figure 10 shows a replacement bulb utilizing a plurality LEDs 10 as the light source instead of a filament. The cover 20 is attached to a base 50 as is commonly used for incandescent bulbs. The LEDs 10 are electrically connected to the base 50 by the conductors 30. The cover 20 is hollow and the LEDs 10 reside within the plenum defined by the surfaces of the cover 20. The number of LEDs 10 may be varied as dictated by the design.

Various features of the invention have been particularly shown and described in connection with the illustrated embodiments of the invention. However, it must be understood that these particular arrangements, and their method of manufacture, do not limit but merely illustrate, and that the invention is to be given its fullest interpretation within the

5 terms of the appended claims.

I claim:

1) A lighting device comprising:

a power source;

a light source;

5 a light transmitting cover made from a polyolefin.

2) The lighting device of claim 1 wherein the cover is composed of a polyolefin from the group consisting of ethylene\butene-1 copolymer and propylene homopolymer.

10 3) The lighting device of claim 1 wherein the cover is composed of a polyolefin composed from a combination of ethylene\butene-1 copolymer and propylene homopolymer.

4) The lighting device of claim 2 wherein the cover is clear.

15 5) The lighting device of claim 2 wherein the cover is additionally composed of a clarifying agent.

6) The lighting device of claim 5 wherein the clarifying agent is a sorbitol acetal in polyolefin blend.

20

7) A lighting device comprising:

a light source;



a cover made from a plastic from a group comprising ethylene/butene-1 copolymer and propylene homopolymer;

a power source; and

an electronic circuit to cause the light source to flash when electrically connected to  
5 the power source and light source.

8) The lighting device of claim 7 wherein the light source is surrounded by the cover.

9) The lighting device of claim 7 wherein the light source is a semiconductor device.

10

10) The lighting device of claim 7 wherein the cover is in contact with the light source.

11) A light bulb comprising:

a base;

an LED;

15

a cover;

wherein said base is attached to said cover, forming a bulb, and said LED is electrically connected to said base and contained within the bulb.

20

12) The lighting device of claim 11 where in the cover is composed of a polyolefin from the group consisting of ethylene/butene-1 copolymer and propylene homopolymer.

13) The lighting device of claim 12 wherein the cover is composed of a polyolefin composed from a combination of ethylene/butene-1 copolymer and propylene homopolymer.

14) The lighting device of claim 12 wherein the cover is clear.

15) The lighting device of claim 12 wherein the cover is additionally composed of a clarifying agent.

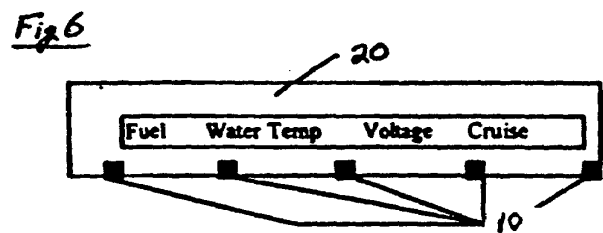
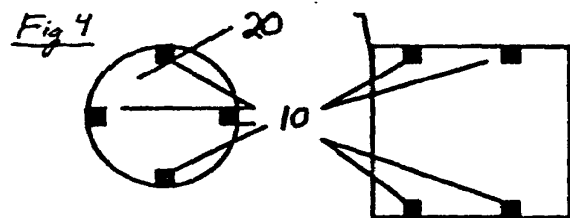
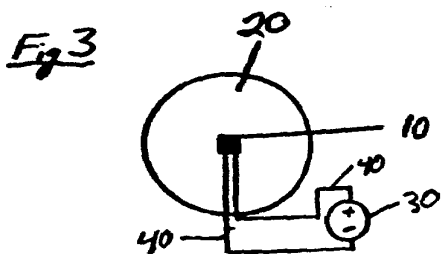
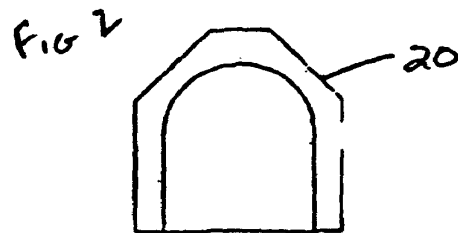
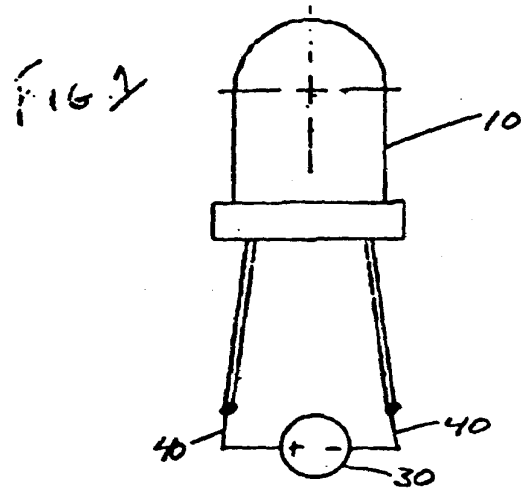
5

16) The lighting device of claim 15 wherein the clarifying agent is a sorbitol acetal in polyolefin blend.

17) A clear light transmitting material formed by heating a ethylene\butene material above 140 degrees F, and rapidly cooling said material by bathing the material in cold water.

10 18) The material in claim 17 wherein the water is approximately 34 degrees F.

19) A light transmitting material composed of a combination of an ethylene/butene-1 copolymer and a propylene homopolymer.



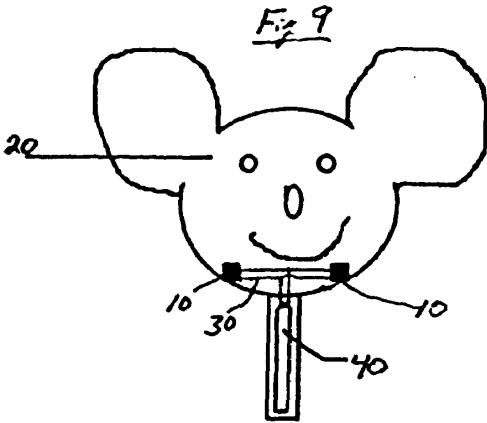
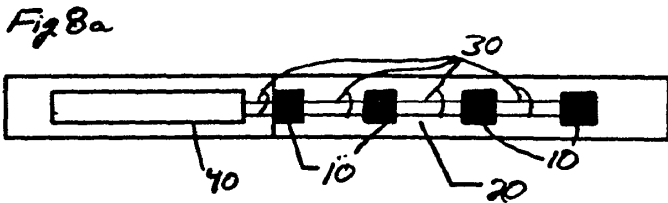
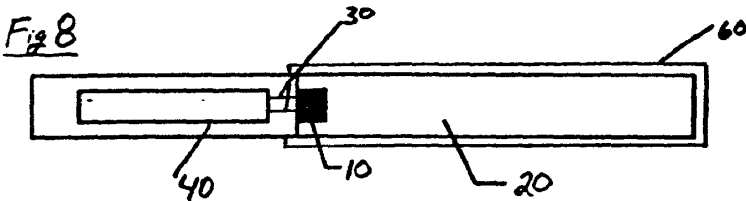
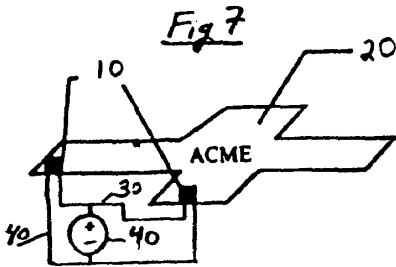
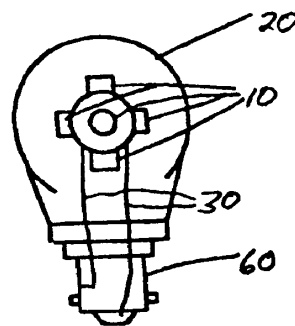


Fig 10



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US99/04927

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :F21M 3/14

US CL :362/255, 800

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 362/255, 800, 256, 293, 311

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
NONE

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------|-----------------------|
| X         | US 5,143,443 A (MADSEN) 01 September 1992, (01/09/92) col.1, lines 55-59 and Fig. 1. | 1,2,7,8,10,19         |
| --        |                                                                                      | -----                 |
| Y         |                                                                                      | 9,11,12               |
| Y         | US 5,463,502 A (SAVAGE,Jr.) 31 October 1995, (31/10/95) see Fig.3.                   | 9,11,12               |

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

|                                                                                                                                                                         |                                                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * Special categories of cited documents:                                                                                                                                | *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention                                              |
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Date of the actual completion of the international search  
19 MAY 1999

Date of mailing of the international search report  
**28 MAY 1999**

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
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Washington, D.C. 20231

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Authorized officer

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| Electronic Patent Application Fee Transmittal |          |                                     |        |                      |
|-----------------------------------------------|----------|-------------------------------------|--------|----------------------|
| Application Number:                           |          | 12965019                            |        |                      |
| Filing Date:                                  |          | 10-Dec-2010                         |        |                      |
| Title of Invention:                           |          | LIGHT TUBE AND POWER SUPPLY CIRCUIT |        |                      |
| First Named Inventor/Applicant Name:          |          | Jos Timmermans                      |        |                      |
| Filer:                                        |          | Michelle L. Knight/Joan Leighton    |        |                      |
| Attorney Docket Number:                       |          | AEII-172-H                          |        |                      |
| Filed as Large Entity                         |          |                                     |        |                      |
| Utility under 35 USC 111(a) Filing Fees       |          |                                     |        |                      |
| Description                                   | Fee Code | Quantity                            | Amount | Sub-Total in USD(\$) |
| Basic Filing:                                 |          |                                     |        |                      |
| Pages:                                        |          |                                     |        |                      |
| Claims:                                       |          |                                     |        |                      |
| Miscellaneous-Filing:                         |          |                                     |        |                      |
| Petition:                                     |          |                                     |        |                      |
| Patent-Appeals-and-Interference:              |          |                                     |        |                      |
| Post-Allowance-and-Post-Issuance:             |          |                                     |        |                      |
| Extension-of-Time:                            |          |                                     |        |                      |

| Description                             | Fee Code | Quantity | Amount | Sub-Total in USD(\$) |
|-----------------------------------------|----------|----------|--------|----------------------|
| <b>Miscellaneous:</b>                   |          |          |        |                      |
| Submission- Information Disclosure Stmt | 1806     | 1        | 180    | 180                  |
| <b>Total in USD (\$)</b>                |          |          |        | <b>180</b>           |



## Electronic Acknowledgement Receipt

|                                             |                                     |
|---------------------------------------------|-------------------------------------|
| <b>EFS ID:</b>                              | 14390700                            |
| <b>Application Number:</b>                  | 12965019                            |
| <b>International Application Number:</b>    |                                     |
| <b>Confirmation Number:</b>                 | 5912                                |
| <b>Title of Invention:</b>                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |
| <b>First Named Inventor/Applicant Name:</b> | Jos Timmermans                      |
| <b>Customer Number:</b>                     | 48980                               |
| <b>Filer:</b>                               | Michelle L. Knight/Joan Leighton    |
| <b>Filer Authorized By:</b>                 | Michelle L. Knight                  |
| <b>Attorney Docket Number:</b>              | AEII-172-H                          |
| <b>Receipt Date:</b>                        | 05-DEC-2012                         |
| <b>Filing Date:</b>                         | 10-DEC-2010                         |
| <b>Time Stamp:</b>                          | 15:21:24                            |
| <b>Application Type:</b>                    | Utility under 35 USC 111(a)         |

### Payment information:

|                                          |                 |
|------------------------------------------|-----------------|
| Submitted with Payment                   | yes             |
| Payment Type                             | Deposit Account |
| Payment was successfully received in RAM | \$ 180          |
| RAM confirmation Number                  | 2060            |
| Deposit Account                          | 250115          |
| Authorized User                          |                 |

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

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Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

## File Listing:

| Document Number     | Document Description                               | File Name                       | File Size(Bytes)/<br>Message Digest                  | Multi Part /.zip | Pages (if appl.) |
|---------------------|----------------------------------------------------|---------------------------------|------------------------------------------------------|------------------|------------------|
| 1                   | Transmittal Letter                                 | AEII172H_IDSLetter_20121203.pdf | 27178<br>8f303114d83fd1aad1f15265a4557c281bc3f96b    | no               | 3                |
| <b>Warnings:</b>    |                                                    |                                 |                                                      |                  |                  |
| <b>Information:</b> |                                                    |                                 |                                                      |                  |                  |
| 2                   | Information Disclosure Statement (IDS) Form (SB08) | AEII172H_IDS_20121203.pdf       | 617568<br>4d82060af2236563f6cc25cefaddf8051a1030dc   | no               | 14               |
| <b>Warnings:</b>    |                                                    |                                 |                                                      |                  |                  |
| <b>Information:</b> |                                                    |                                 |                                                      |                  |                  |
| 3                   | Foreign Reference                                  | DE19651140A1.pdf                | 519355<br>3f39c4c60fac0ecfa8c0dbd78013f3cbf34983be   | no               | 8                |
| <b>Warnings:</b>    |                                                    |                                 |                                                      |                  |                  |
| <b>Information:</b> |                                                    |                                 |                                                      |                  |                  |
| 4                   | Foreign Reference                                  | DE19651140A1_Eng_Abstract.pdf   | 45438<br>e0d1fdbbfa4c1490761531fcd9cdfd51ef4aff406   | no               | 1                |
| <b>Warnings:</b>    |                                                    |                                 |                                                      |                  |                  |
| <b>Information:</b> |                                                    |                                 |                                                      |                  |                  |
| 5                   | Foreign Reference                                  | DE19624087A1.pdf                | 1264967<br>8c3d8fc2f66c093db498b923743243325de4e23e  | no               | 20               |
| <b>Warnings:</b>    |                                                    |                                 |                                                      |                  |                  |
| <b>Information:</b> |                                                    |                                 |                                                      |                  |                  |
| 6                   | Foreign Reference                                  | DE19624087A1_Eng_Abstract.pdf   | 47914<br>df7a159e19e8461ae6295b422a10ef881d43157e    | no               | 1                |
| <b>Warnings:</b>    |                                                    |                                 |                                                      |                  |                  |
| <b>Information:</b> |                                                    |                                 |                                                      |                  |                  |
| 7                   | Foreign Reference                                  | EP0632511A2.pdf                 | 1919902<br>243287ce62fb6289c2e1f147e5bfbf25946148f26 | no               | 34               |
| <b>Warnings:</b>    |                                                    |                                 |                                                      |                  |                  |
| <b>Information:</b> |                                                    |                                 |                                                      |                  |                  |
| 8                   | Foreign Reference                                  | JP08162677.pdf                  | 279134<br>b5216e174a22b36690lbb6ce23e880b6831bd83cd  | no               | 5                |
| <b>Warnings:</b>    |                                                    |                                 |                                                      |                  |                  |

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| Information: |                       |                                       |                                          |    |    |
| 9            | Foreign Reference     | JP08162677_translation.pdf            | 270912                                   | no | 6  |
|              |                       |                                       | 9cf111d18e36364e650fba4741b95dd7b3937c8  |    |    |
| Warnings:    |                       |                                       |                                          |    |    |
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| 10           | Foreign Reference     | JPH06054103.pdf                       | 161283                                   | no | 4  |
|              |                       |                                       | ff14cdfb63eb7e7ef0ad9b7c434f7fab917b2ebc |    |    |
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| 11           | Foreign Reference     | JPH06054103_translation.pdf           | 112931                                   | no | 4  |
|              |                       |                                       | 7720a3e73661c76743d6cdd4de78fc76d55f5995 |    |    |
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| 12           | Foreign Reference     | JPH11135274A.pdf                      | 327922                                   | no | 7  |
|              |                       |                                       | 97a50c0a0b2144ddd29d999189fcd9b1989705a0 |    |    |
| Warnings:    |                       |                                       |                                          |    |    |
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| 13           | Foreign Reference     | JPH11135274_translation.pdf           | 185173                                   | no | 13 |
|              |                       |                                       | 9d505b6716de6514139bcd9be489b6ab1901ff1b |    |    |
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| 14           | Foreign Reference     | WO9957945A1.pdf                       | 940102                                   | no | 21 |
|              |                       |                                       | 3c81519dbf56fd9f5958307a29f4d640e40d620  |    |    |
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| 15           | Foreign Reference     | WO9945312A1.pdf                       | 617922                                   | no | 20 |
|              |                       |                                       | 91267ebb820fbc8af1309ede29155fe7dc6bcca8 |    |    |
| Warnings:    |                       |                                       |                                          |    |    |
| Information: |                       |                                       |                                          |    |    |
| 16           | Non Patent Literature | AEII172C_Invalidity_Contentions1.pdf  | 1569258                                  | no | 54 |
|              |                       |                                       | 10b10281f3a6e378ebb9db02e7786157c082938a |    |    |
| Warnings:    |                       |                                       |                                          |    |    |
| Information: |                       |                                       |                                          |    |    |
| 17           | Non Patent Literature | AEII172C_FedCirDecision_201103091.pdf | 112059                                   | no | 12 |
|              |                       |                                       | 72372368a912bbdc0cc4c8afd6f6e36aa2a458ed |    |    |
| Warnings:    |                       |                                       |                                          |    |    |

|                              |                       |                                  |                                          |    |   |
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| 18                           | Non Patent Literature | AEII172E_NPL_Trucklite_led14.pdf | 83315                                    | no | 1 |
|                              |                       |                                  | 0539789dda7749148bab5b43b8bf8ba6771ef7be |    |   |
| Warnings:                    |                       |                                  |                                          |    |   |
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| 19                           | Non Patent Literature | AEII172F_NPL_Trucklite_led2.pdf  | 85516                                    | no | 1 |
|                              |                       |                                  | f1f657a7c4fd573358dbe1a139f173ce2c8eceda |    |   |
| Warnings:                    |                       |                                  |                                          |    |   |
| Information:                 |                       |                                  |                                          |    |   |
| 20                           | Non Patent Literature | AEII172F_NPL_Trucklite_led4.pdf  | 85543                                    | no | 1 |
|                              |                       |                                  | 6410e3f80adce08530defedba88b5c050496be37 |    |   |
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| Information:                 |                       |                                  |                                          |    |   |
| 21                           | Non Patent Literature | AEII172E_NPL_Telecite.pdf        | 104927                                   | no | 1 |
|                              |                       |                                  | 2b5476409ee179d16215106682bcdbc7f4941575 |    |   |
| Warnings:                    |                       |                                  |                                          |    |   |
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| 22                           | Non Patent Literature | AEII172E_NPL_Dialight.pdf        | 107969                                   | no | 1 |
|                              |                       |                                  | 8a1b1c97637957ef2db6aa8f72b0a931bd08ed56 |    |   |
| Warnings:                    |                       |                                  |                                          |    |   |
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| 23                           | Non Patent Literature | AEII172E_NPL_Ledlights.pdf       | 86450                                    | no | 1 |
|                              |                       |                                  | 995c44c21a1abae986b941fc443f34617bc9fd0e |    |   |
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| Information:                 |                       |                                  |                                          |    |   |
| 24                           | Non Patent Literature | AEII172F_NPL_LEDTRONICS_Cat.pdf  | 552085                                   | no | 2 |
|                              |                       |                                  | c1454a90c4d9669d3047aff1e0a5f0f55ae5136b |    |   |
| Warnings:                    |                       |                                  |                                          |    |   |
| Information:                 |                       |                                  |                                          |    |   |
| 25                           | Fee Worksheet (SB06)  | fee-info.pdf                     | 30473                                    | no | 2 |
|                              |                       |                                  | 3c9fe3b2323002ea223b03f5e45812f2b90f6bd9 |    |   |
| Warnings:                    |                       |                                  |                                          |    |   |
| Information:                 |                       |                                  |                                          |    |   |
| Total Files Size (in bytes): |                       |                                  | 10155296                                 |    |   |

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Our Reference: AEII-172-H

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Jos Timmermans et al.  
Serial Number: 12/965,019  
Filing Date: December 10, 2010  
Examiner/Art Group Unit: A. Minh D/2821  
Title: LIGHT TUBE AND POWER SUPPLY CIRCUIT

**SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT  
PURSUANT TO 37 C.F.R. § 1.97**

M.S. Amendment  
Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

Sir:

Attached please find an Information Disclosure Statement in the subject application.

Applicants provide notice to the Examiner of the following proceedings involving related patents/applications and note the current status of these matters for the Examiner's information. The present Application is a continuation of U.S. Pat. Appln. No. 11/085,744, filed March 21, 2005, now U.S. Pat. No. 8,247,985, issued August 21, 2012, which is a continuation of U.S. Pat. Appln. No. 09/782,375, filed February 12, 2001, now U.S. Pat. No. 7,049,761, issued May 23, 2006 (hereinafter the '761 patent).

1) Application Serial No. 11/925,037 is a continuation of U.S. Pat. Appln. No. 11/085,744, filed March 21, 2005, which is a continuation of the application that became the '761 patent. Application Serial No. 11/925,037 issued on March 31, 2009 as U.S. Pat. No. 7,510,299 (hereinafter the '299 patent). Further to the previous Assignee's request for reexamination of the '299 patent on August 13, 2009, Control No. 90/010,644 was assigned, and a reexamination certificate issued as US 7,510,299 C1 on November 9, 2010.

{YB:00034164.DOC }

2) A third party filed a request for reexamination of the '299 patent on October 4, 2010, which was assigned Control No. 90/011,261. A reexamination certificate issued as US 7,510,299 C2 on May 24, 2011.

3) A third party filed a request for reexamination of the '299 patent on June 27, 2011, which was assigned Control No. 90/011,762. A reexamination certificate issued at US 7,7510,299 C3 on July 17, 2012.

4) Litigation involving the '761 patent, Altair Engineering, Inc. v. LEDdynamics, Civil Case No. 07-CV-13150 (E.D. Mich.) (J. Steeh) ended with a judgment of non-infringement and was appealed to the Court of Appeals for the Federal Circuit on June 4, 2009. The Federal Circuit affirmed-in-part and reversed-in-part and remanded the case to the district court. Altair Engineering, Inc. v. LEDdynamics, Docket No. 2010-1118 (Fed. Cir., March 9, 2011). Applicants have attached that decision with the attached Form SB/08. Upon return to the district court, an Order Dismissing Case was signed July 25, 2011 due to a settlement between the parties.

5) Litigation involving the '299 patent was filed on March 31, 2009. Altair Engineering, Inc. v. LEDdynamics, Civil Case No. 2:09-CV-11207 (E.D. Mich.) (J. Steeh). A Stipulated Order Dismissing Case was signed by the Judge on July 25, 2011 due to a settlement between the parties.

6) Litigation involving both the '761 and the '299 patents was filed on August 26, 2010. Altair Engineering, Inc. v. LEDs America, Inc., Civil Case No. 2:10-CV-13424 (E.D. Mich.) (J. O'Meara). The Defendant filed invalidity contentions, which are included with the attached Form SB/08. An Order staying the case pending reexamination of both patents was entered on May 31, 2011.

7) The assignee was sued for a declaratory judgment of non-infringement and invalidity of each of the '761 patent and the '299 patent on February 4, 2011. Green Ray LED, LLC v. Altair Engineering, Inc., Civil Case No. 3:11-CV-00549-EMC (N.D. Cal.) (J. Chen). A consent Judgment and Order Dismissing Case was signed and filed by the Judge on July 20, 2011 due to a settlement between the parties.

8) Application Serial No. 11/007,417 is a continuation-in-part of the application that issued as the '761 patent. It issued on January 10, 2012 as U.S. Pat. No. 8,093,823 (hereinafter the '823 patent).

9) Application Serial No. 12/242,033, which is a continuation of the application that issued as the '823 patent, is currently undergoing substantive examination with Examiner Vu, also in Art Unit 2821.

Publications of each of the patents described above are referenced in the attached Form SB/08.

Respectfully submitted,

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/Michelle L. Knight/

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Our Reference: AEII-172-H

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Jos Timmermans et al.  
Serial Number: 12/965,019  
Filing Date: December 10, 2010  
Examiner/Art Group Unit: A. Minh D/2821  
Title: LIGHT TUBE AND POWER SUPPLY CIRCUIT

**AMENDMENT**

M.S. Amendment  
Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

Sir:

If any charges or fees must be paid in connection with the following communication, they may be paid out of our Deposit Account No. 25-0115.

In response to the Office Action mailed April 20, 2012, please make the amendments shown in the attached papers in this application in the:

- ☐ **Amendments to the Abstract.**
- ☐ **Amendments to the Specification.**
- ☒ **Amendments to the Claims.**
- ☐ **Amendments to the Drawings.**

### **Listing of the Claims:**

1. (Currently amended) A light device for illumination by a power supply circuit comprising:

a bulb portion,

a pair of end caps disposed at opposite ends of the bulb portion, the pair of end caps including a first end cap disposed at one end of the bulb portion, and a second end cap disposed at an end of bulb portion opposite the first end cap, wherein the bulb portion and the pair of end caps are dimensioned to be mounted in a fluorescent light tube socket; and

a plurality of light emitting diodes disposed inside the bulb portion along one surface of a circuit board extending between the ~~pair of end caps~~ first end cap and the second end cap for illuminating in response to electrical current to be received from the power supply circuit; ~~and wherein each of the plurality of light emitting diodes is mounted at an angle with respect to surface of the circuit board to establish a predetermined radiation pattern of light emitted from the bulb portion between the pair of end caps; and~~

wherein the arrangement of the circuit board and the bulb portion is such that substantially the entire light output of the light device is emitted away from the one surface and is confined to an included angle by sidewalls extending to a height above the one surface on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap.

2. (Canceled).

3. (Previously amended) The light tube of claim 1 wherein each of the pair of end caps includes an electrical bi-pin connector.

4. (Canceled).

5. (Currently amended) In a replacement light tube for a fluorescent light fixture having a light tube socket, the improvement comprising:

a plurality of light emitting diodes disposed along a length of ~~the~~ a bulb portion between a first end cap and a second end cap mounted on opposite ends of the bulb portion, wherein the plurality of light emitting diodes is mounted on only one side of a circuit board in a light emitting direction; and

an electrical circuit for illuminating in response to electrical current to be received from the fluorescent light fixture, ~~the electrical circuit including at least a rectifier and a current-limiting circuit; and~~

opaque side walls extending above the one side of the circuit board in the light emitting direction on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap to confine an entirety of light emitted from the replacement light tube to an included angle of less than about 180°.

6. (Canceled).

7. (Canceled).

8. (Currently amended) The improvement of claim ~~6~~ 5 wherein each of the plurality of light emitting diodes is a white light emitting diode.

9. (Previously added) The improvement of claim 5, further comprising:  
a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes above a nominal variation of 120 to 100 Hz.

10. (Previously added) The improvement of claim 5, further comprising:  
a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes to provide a visible on and off cycle.

11. (Previously added) The improvement of claim 5 wherein at least one of the

first end cap and the second end cap includes an inductive receiver.

12. (Canceled).

13. (Previously added) The improvement of claim 6 wherein the radiation pattern of light from each of the plurality of light emitting diodes is centered at a 90° angle relative to the circuit board.

14. (Previously added) The improvement of claim 5 wherein the plurality of light emitting diodes is arranged substantially continuously along the length of the bulb portion.

15. (Previously added) The light device of claim 1 wherein each of the plurality of light emitting diodes is a white light emitting diode.

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

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

18. (Previously added) The light device of claim 1 wherein at least one of the first end cap and the second end cap includes an inductive receiver.

19. (Canceled).

20. (Previously added) The light device of claim 1 wherein the plurality of

light emitting diodes is arranged substantially continuously between the opposite ends of the bulb portion.

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

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

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

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

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

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

22. (New) The improvement of claim 5 wherein the electrical circuit includes at least a rectifier and a current-limiting circuit.

### **REMARKS**

In the Office Action mailed April 20, 2012, the Examiner rejects claims 1, 3, 5, 6 and 8-20 on the ground of nonstatutory obviousness-type double patenting. The Examiner rejects claims 11, 12, 18 and 19<sup>1</sup> under 35 U.S.C. § 112, second paragraph, and rejects claims 1, 3, 5, 6 and 8-20 under 35 U.S.C. § 103(a). With this Amendment, Applicants have amended claims 1, 5 and 8. Claims 6, 12 and 19 are canceled without prejudice or disclaimer, and claims 21 and 22 are added. After entry of this Amendment, claims 1, 3, 5, 8-11, 13-18 and 20-22 are pending in the Application. Reconsideration of the Application as amended is respectfully requested.

#### *Response to rejections based on nonstatutory obviousness-type double patenting*

Claims 1, 3, 5, 6 and 8-20 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-26 of U.S. Patent No. 7,049,761 (hereinafter the '761 patent).<sup>2</sup> While the rejection states that a side by side comparison table between each pending claim and the existing claims is included in the rejection, only claims 1, 3 and 5 of the pending Application are compared. Applicants have amended each of claims 1 and 5. Claim 1 now includes the feature "wherein the arrangement of the circuit board and the bulb portion is such that substantially the entire light output of the light device is emitted away from the one surface and is confined to an included angle by sidewalls extending to a height above the one surface on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap." Claim 5 now includes the features of claim 6 and the feature of "opaque side walls extending above the one side of the circuit board in the light emitting direction on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap to confine an entirety of light emitted from the replacement light tube to an included angle of less than about 180°." Claim 6 is canceled. Applicants respectfully submit that the amendments to claims 1 and 5 render the nonstatutory obviousness-type double patenting

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<sup>1</sup> The Office Action refers to claims 11, 12, 17 and 18, but the rejection clearly refers to claims 11, 12, 18 and 19. (Office Action, pg. 7)

<sup>2</sup> The Office Action also refers to U.S. Patent No. 7,560,873 B2 (see pg. 3), but that patent is unrelated to the present inventors and is not prior art to the present invention.

rejection based on the '761 patent moot.

Claim 1 is rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claim 1 of the '761 patent. As described above, Applicants respectfully submit that the amendments to claim 1 render this rejection moot.

Claim 5 is rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claim 13 of the '761 patent in view of Johnson (U.S. Patent No. 5,463,280). Applicants respectfully submit that the amendments to claim 5 render this rejection moot.

*Response to rejections under 35 U.S.C. § 112*

Claims 11, 12, 18 and 19 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants regard as the invention. The Examiner states that it is unclear whether first and second end caps include an "antenna for receive and transmitter frequency signal." The Examiner cites FIG. 10 as showing "inductive for transmitter and receiver from power or voltage from a power source." (Office Action, pg. 7).

With regard to claim 11 and claim 18, neither of these claims recites an antenna. Instead, these claims each recite that "at least one of the first end cap and the second end cap includes an inductive receiver." Accordingly, the rejection does not apply to these claims. Withdrawal of the rejection under 35 U.S.C. § 112, second paragraph, is respectfully requested.

With regard to claim 12 and claim 19, as described in paragraph [0036] of the Substitute Specification, "at least one end cap includ[es] an inductive receiver or antenna 72." As the Examiner knows, an inductive coupling is formed by an electromagnetic field generated between two objects. More specifically, this coupling is formed where two conductors are arranged so that a change in current flow through one induces a voltage across the other using electromagnetic induction. When the light tube 20 of FIG. 10 is mounted in socket 40, for example, "the at least one inductive receiver 72 in the light tube 20 is disposed adjacent to the at least one inductive transmitter 70 in the light tube socket 40." (§ [0036]). As is known in the art,

the conductors are often wound into induction coils and thus may at times be referred to as antennas. Nonetheless, Applicants have canceled claims 12 and 19 to further prosecution.

*Response to rejections under 35 U.S.C. § 103*

Claims 1, 3 and 20 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Bischoff, Jr. (U.S. Patent No. 6,158,882) in view of Schmitt (U.S. Patent No. 4,748,545). Applicants disagree with the rejection but have amended claim 1 to further prosecution. Namely, claim 1 now includes the feature “wherein the arrangement of the circuit board and the bulb portion is such that substantially the entire light output of the light device is emitted away from the one surface and is confined to an included angle by sidewalls extending to a height above the one surface on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap.” Neither of the cited references teaches or suggests at least this feature of claim 1. Accordingly, claim 1 and its dependent claims are allowable over Bischoff, Jr. and Schmitt, either alone or in any permissible combination.

Claims 5, 6, 8 and 13-15 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Bischoff, Jr. in view of Schmitt and further in view of Johnson (U.S. Patent No. 5,463,280). Applicants disagree with the rejection but have amended claim 5 to further prosecution. Claim 6 is canceled. Claim 5 now includes the feature of “opaque side walls extending above the one side of the circuit board in the light emitting direction on opposing sides of the plurality of light emitting diodes between the first end cap and the second end cap to confine an entirety of light emitted from the replacement light tube to an included angle of less than about 180°.” None of the cited references teaches or suggests at least this feature of claim 5. Accordingly, claim 5 and its dependent claims are allowable over Bischoff, Jr., Schmitt and Johnson, either alone or in any permissible combination.

Claims 9-12 and 16-19 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Bischoff, Jr. in view of Schmitt and Johnson and further in view of Swanson et



al. (U.S. Patent No. 5,463,280). Claims 12 and 19 are canceled. The remaining claims depend either directly or indirectly from independent claim 1 or independent claim 5. Swanson et al. fails to cure the deficiencies in the rejection of the independent claims described above, so claims 9-11 and 16-18 are thus allowable at least based on their dependence from an allowable independent claim.

In addition to the foregoing, Applicants respectfully submit that the cited art fails to teach or suggest the feature in each of claims 11 and 18 wherein “at least one of the first end cap and the second end cap includes an inductive receiver.” The rejection cites the bi-pins of FIG. 8 of Schmitt. (Office Action, pgs. 11-12). However, the bi-pins do not form an *inductive* coupling with a power source and cannot be inductive receivers. Instead, they are male electrical connectors that fit into female receivers to form a direct (that is, wired) electrical connection. The transfer of power is not made through electromagnetic induction. For this additional reason, claims 11 and 18 are allowable over the cited references.

#### *New claim*

Claims 21 and 22 are new. Applicants respectfully submit that independent claim 21 includes features not taught, suggested or described in any of the cited references. Claim 22 depends from claim 5 and includes features removed from that claim. Claim 22 is allowable at least based on its dependence from an allowable claim. Examination and allowance of claims 21 and 22 are respectfully requested.

#### *Conclusion*

It is submitted that this Amendment has antecedent basis in the Application as originally filed, including the specification, claims and drawings, and that this Amendment does not add any new subject matter to the application. Reconsideration of the Application as amended is requested. It is respectfully submitted that this Amendment places the Application in suitable condition for allowance; notice of which is requested.

If the Examiner feels that prosecution of the present Application can be expedited by way of an Examiner's amendment, the Examiner is invited to contact the undersigned at the telephone number listed below.

Respectfully submitted,  
YOUNG BASILE  
HANLON & MACFARLANE P.C.

/Michelle L. Knight/

Michelle L. Knight  
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3001 West Big Beaver Rd., Ste. 624  
Troy, Michigan 48084-3107

| Electronic Patent Application Fee Transmittal |          |                                     |        |                      |
|-----------------------------------------------|----------|-------------------------------------|--------|----------------------|
| Application Number:                           |          | 12965019                            |        |                      |
| Filing Date:                                  |          | 10-Dec-2010                         |        |                      |
| Title of Invention:                           |          | LIGHT TUBE AND POWER SUPPLY CIRCUIT |        |                      |
| First Named Inventor/Applicant Name:          |          | Jos Timmermans                      |        |                      |
| Filer:                                        |          | Michelle L. Knight/Joan Leighton    |        |                      |
| Attorney Docket Number:                       |          | AEII-172-H                          |        |                      |
| Filed as Large Entity                         |          |                                     |        |                      |
| Utility under 35 USC 111(a) Filing Fees       |          |                                     |        |                      |
| Description                                   | Fee Code | Quantity                            | Amount | Sub-Total in USD(\$) |
| Basic Filing:                                 |          |                                     |        |                      |
| Pages:                                        |          |                                     |        |                      |
| Claims:                                       |          |                                     |        |                      |
| Miscellaneous-Filing:                         |          |                                     |        |                      |
| Petition:                                     |          |                                     |        |                      |
| Patent-Appeals-and-Interference:              |          |                                     |        |                      |
| Post-Allowance-and-Post-Issuance:             |          |                                     |        |                      |
| Extension-of-Time:                            |          |                                     |        |                      |
| Extension - 2 months with \$0 paid            | 1252     | 1                                   | 560    | 560                  |

| Description       | Fee Code | Quantity | Amount | Sub-Total in USD(\$) |
|-------------------|----------|----------|--------|----------------------|
| Miscellaneous:    |          |          |        |                      |
| Total in USD (\$) |          |          |        | 560                  |

## Electronic Acknowledgement Receipt

|                                             |                                     |
|---------------------------------------------|-------------------------------------|
| <b>EFS ID:</b>                              | 13797416                            |
| <b>Application Number:</b>                  | 12965019                            |
| <b>International Application Number:</b>    |                                     |
| <b>Confirmation Number:</b>                 | 5912                                |
| <b>Title of Invention:</b>                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |
| <b>First Named Inventor/Applicant Name:</b> | Jos Timmermans                      |
| <b>Customer Number:</b>                     | 48980                               |
| <b>Filer:</b>                               | Michelle L. Knight/Joan Leighton    |
| <b>Filer Authorized By:</b>                 | Michelle L. Knight                  |
| <b>Attorney Docket Number:</b>              | AEII-172-H                          |
| <b>Receipt Date:</b>                        | 20-SEP-2012                         |
| <b>Filing Date:</b>                         | 10-DEC-2010                         |
| <b>Time Stamp:</b>                          | 15:35:55                            |
| <b>Application Type:</b>                    | Utility under 35 USC 111(a)         |

### Payment information:

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| Submitted with Payment                   | yes             |
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### File Listing:

| Document Number | Document Description | File Name                | File Size(Bytes)/<br>Message Digest                    | Multi Part /.zip | Pages (if appl.) |
|-----------------|----------------------|--------------------------|--------------------------------------------------------|------------------|------------------|
| 1               |                      | AEI172H_Amd_20120420.pdf | 57354<br><br>72a344e49653bd4d3301240c3287f7942bdd57ab9 | yes              | 10               |

|  |                                                            |  |              |            |
|--|------------------------------------------------------------|--|--------------|------------|
|  | <b>Multipart Description/PDF files in .zip description</b> |  |              |            |
|  | <b>Document Description</b>                                |  | <b>Start</b> | <b>End</b> |
|  | Amendment/Req. Reconsideration-After Non-Final Reject      |  | 1            | 1          |
|  | Claims                                                     |  | 2            | 5          |
|  | Applicant Arguments/Remarks Made in an Amendment           |  | 6            | 10         |

### Warnings:

### Information:

|   |                      |              |                                                       |    |   |
|---|----------------------|--------------|-------------------------------------------------------|----|---|
| 2 | Fee Worksheet (SB06) | fee-info.pdf | 30474<br><br>dbf2ba628bc8f6f12f2d264b7375be89a3512912 | no | 2 |
|---|----------------------|--------------|-------------------------------------------------------|----|---|

### Warnings:

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|                                     |  |  |       |
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| <b>Total Files Size (in bytes):</b> |  |  | 87828 |
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### New Applications Under 35 U.S.C. 111

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

### National Stage of an International Application under 35 U.S.C. 371

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

### New International Application Filed with the USPTO as a Receiving Office

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**



# UNITED STATES PATENT AND TRADEMARK OFFICE

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| APPLICATION NO.                                                          | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO.             | CONFIRMATION NO.            |
|--------------------------------------------------------------------------|-------------|----------------------|---------------------------------|-----------------------------|
| 12/965,019                                                               | 12/10/2010  | Jos Timmermans       | AEII-172-H                      | 5912                        |
| 48980                                                                    | 7590        | 04/20/2012           |                                 |                             |
| YOUNG BASILE<br>3001 WEST BIG BEAVER ROAD<br>SUITE 624<br>TROY, MI 48084 |             |                      | EXAMINER<br>A, MINH D           |                             |
|                                                                          |             |                      | ART UNIT<br>2821                | PAPER NUMBER                |
|                                                                          |             |                      | NOTIFICATION DATE<br>04/20/2012 | DELIVERY MODE<br>ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docketing@youngbasile.com  
audit@youngbasile.com

|                              |                        |                     |  |
|------------------------------|------------------------|---------------------|--|
| <b>Office Action Summary</b> | <b>Application No.</b> | <b>Applicant(s)</b> |  |
|                              | 12/965,019             | TIMMERMANS ET AL.   |  |
|                              | <b>Examiner</b>        | <b>Art Unit</b>     |  |
|                              | MINH D. A              | 2821                |  |

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --**

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☐ Responsive to communication(s) filed on \_\_\_\_.
- 2a) ☐ This action is **FINAL**.                      2b) ☒ This action is non-final.
- 3) ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on \_\_\_\_; the restriction requirement and election have been incorporated into this action.
- 4) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 5) ☒ Claim(s) 1,3,5,6 and 8-20 is/are pending in the application.
- 5a) Of the above claim(s) \_\_\_\_ is/are withdrawn from consideration.
- 6) ☐ Claim(s) \_\_\_\_ is/are allowed.
- 7) ☒ Claim(s) 1,3,5,6 and 8-20 is/are rejected.
- 8) ☐ Claim(s) \_\_\_\_ is/are objected to.
- 9) ☐ Claim(s) \_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 10) ☐ The specification is objected to by the Examiner.
- 11) ☐ The drawing(s) filed on \_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
     Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
     Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 12) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All    b) ☐ Some \* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- |                                                                                                            |                                                                                         |
|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)                                | 4) <input type="checkbox"/> Interview Summary (PTO-413)<br>Paper No(s)/Mail Date. ____. |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)                       | 5) <input type="checkbox"/> Notice of Informal Patent Application                       |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)<br>Paper No(s)/Mail Date ____. | 6) <input type="checkbox"/> Other: ____.                                                |



### ***DETAILED ACTION***

This is a response to the Applicants' filing on 12/10/10. In virtue of this filing, claims 1, 3, 5-6, 8-20 are currently presented in the instant application.

### ***Double Patenting***

1. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

2. Claims 1, 3, 5-6, 8-20 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-26 of U.S. Patent No. 7,049,761. Although the conflicting claims are not identical, they are not patentably distinct from each other because the double patenting is shown in the side by side comparison table below between claims 1, 3, 5-6, 8-20 of the instant application and claims 1-26 of U.S. Patent No. 7, 560,873 B2.

| <b>Instant application: 12/965,019</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Patent No: 7,049,761</b>                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Claim 1. A light device for illumination by a power supply circuit comprising: a bulb portion, a pair of end caps disposed at opposite ends of the bulb portion, the pair of end caps including: a first end cap disposed at one end of the bulb portion; and a second end cap disposed at an end of bulb portion opposite the first end cap, wherein the bulb portion and the pair of end caps are dimensioned to be mounted in a flourescent light tube socket; and a | 1. A light device for illumination by a power supply circuit comprising: a bulb portion, a first end cap disposed at one end of the bulb portion, a second end cap disposed at an end of bulb portion opposite the first end cap, the first and second end caps forming a pair of end caps on opposite ends of the bulb portion; and wherein the bulb portion and the pair of end caps are dimensioned to be mounted in a |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>plurality of light emitting diodes disposed inside the bulb portion along one surface of a circuit board extending between the pair of end caps for illuminating in response to electrical current to be received from the power supply circuit; and wherein each of the plurality of light emitting diodes is mounted at an angle with respect to surface of the circuit board to establish a predetermined radiation pattern of light emitted from the bulb portion between the pair of end caps.</p> <p>Claim 3. The light tube of claim 1, wherein each of the pair of end caps includes an electrical bi-pin connector.</p> <p>5. In a replacement light tube for a fluorescent light fixture having a light tube socket, the improvement comprising: a plurality of light emitting diodes disposed along a length of the bulb portion between a first end cap and a second end cap</p> | <p>fluorescent light tube socket, and a plurality of light emitting diodes disposed inside the bulb portion, the light emitting diodes in electrical communication with the end cap for illuminating in response to electrical current received from the power supply circuit, and wherein the plurality of light emitting diodes is mounted an at least one circuit board; and wherein each of the</p> <p>13. In a replacement light tube for a fluorescent light fixture having a light tube socket and a power supply circuit, the improvement comprising: a plurality of closely-spaced light emitting diodes disposed inside a bulb</p> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| mounted on opposite ends of the bulb portion; and an electrical circuit for illuminating in response to electrical current to be received from the fluorescent light fixture, the electrical circuit including at least a rectifier and a current-limiting circuit. | portion of the light tube and in electrical communication with a pair of end caps coupled to opposed ends of the bulb portion and engageable with the light tube socket, the plurality of light emitting diodes operable to illuminate in response to electrical current delivered by the fluorescent light fixture wherein the electric current is a direct current signal; a rectifier for converting an alternating current signal from the fluorescent light fixture to the direct current signal; and a pulse-width modulating circuit for receiving the direct current signal and supplying a resulting modulated signal to the plurality of light emitting diodes. |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

3. Claim 1 is rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claim 1 of U.S. Patent No. 7,049,761. Although the conflicting claims are not identical, they are not patentably distinct from each other because (i) the inventions of the two groups of claims are directed to a common

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inventive matter, (ii) the limitation "along one surface of a circuit board extending between the pair of end caps" recited in lines 11-12 of claim 1 of the instant application would have regarded as an obvious intended use to a person skilled in the art.

4. Claim 5 is rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claim 13 of U.S. Patent No. 7,049,761 in view of Johnson (US Patent No: 5,463,280).

Regarding claim 51, claim 13 of Patent disclose all of the claimed subject matter, as expressly recited in claim 1, except for mentioning the a current limiting circuit.

Johnson disclose, in figure 1 that , a light emitting diode retrofit lamp comprising a current limiting device as shown in capacitor (20) for functions to limit current within the circuit(18), col.4, lines 62-67 for limit current within the circuit (18).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the circuit of Patent by employing the limit current circuit as taught by Johnson for the purpose of limiting current for the light emitting diode, since this configuration for the stated purpose would have been deemed obvious as evidenced by the teaching of Johnson (See col.4, lines 62-67).

### ***Claim Rejections - 35 USC § 112***

3. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Claims 11-12 and 17-18 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Regarding claims 11-12 and 17-18, the limitations "wherein at least one of the first end cap and the second end cap includes an inductive receiver and wherein the inductive receiver is an antenna" renders the claim indefinite because it is unclear the first end and second end cap include an antenna for receive and transmitter frequency signal, for example, Figure 10 shows inductive for transmitter and receiver from power or voltage from a power source.

***Claim Rejections - 35 USC § 103***

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

6. Claims 1, 3 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over by Bischoff, JR (US Patent No: 6,158,882) in view of Schmitt (US Patent No: 4,748,545).

Regarding claim 1, Bischoff, JR disclose, in figures 1, 2a and 3b-3c that, a light device for illumination by a power supply circuit(see figure 3b or 3 c for power circuit) comprising: a bulb portion (figure 1, tube(12)), a pair of end caps(first and second ends(18,20) disposed at opposite ends of the bulb portion(12), the pair of end caps including: a first end cap(18) disposed at one end of the bulb portion; and a second end cap(20) disposed at an end of bulb portion opposite the first end cap, and a plurality of light emitting diodes (40) disposed inside the bulb portion (12)along one surface of a

circuit board (see figure 2a) extending between the pair of end caps(18,20) for illuminating in response to electrical current to be received from the power supply circuit(figures 3b-3c); and wherein each of the plurality of light emitting diodes(40) is mounted at an angle with respect to surface of the circuit board(circuit board (29) or rigid circuit board(30) to establish a predetermined radiation pattern of light emitted from the bulb portion between the pair of end caps(18, 20).Col.3, lines 59-67 to col.5. lines 1-24.

Bischoff, JR do not clearly disclose that, wherein the bulb portion (12) and the pair of end caps (18,20) are dimensioned to be mounted in a fluorescent light tube socket. However, note that, Bischoff, JR disclose, the light emitting diodes (40) are connected to a wire (44) and a connector (45) as shown in figures 2a-2d.

Schmitt discloses, in figures 9-10 that, wherein the bulb portion (housing (122)) and the pair of end caps (128, 130) are dimensioned to be mounted in a fluorescent light tube socket(S and S2) and also extend electrical bi-pins(130,132).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the bulb portion of Bischoff by employing a fluorescent light tube socket (S1 and S2) and electrical bi-pins(130,132) as taught by Schmitt for the purpose of replacing existing fluorescent lamp and replacing the ballast needed for the fluorescent tubes, since this configuration for the stated purpose would have been deemed obvious as evidenced by the teaching of Schmitt (See col.2, lines 37-40).

Regarding claim 3, combination Bischoff, JR and Schmitt disclose each of the pair of end caps includes an electrical bi-pin connector(130,132)(figure 8 of Schmitt)

Regarding claim 20, combination Bischoff, JR and Schmitt disclose wherein the plurality of light emitting diodes is arranged substantially continuously between the opposite ends of the bulb portion. Figures 1 or 2a.

7. Claims 5-6, 8, 13-15 are rejected under 35 U.S.C. 103(a) as being unpatentable over by Bischoff, JR (US Patent No: 6,158,882) in view of Schmitt (US Patent No: 4,748,545) and further in view of Johnson (US Patent No: 5,463,280).

Regarding claim 5, combination Bischoff and Schmitt disclose all of the claimed subject matter, as expressly recited in claim 1, that, a replacement light tube for a fluorescent light fixture having a light tube socket, the improvement comprising: a plurality of light emitting diodes disposed along a length of the bulb portion between a first end cap and a second end cap mounted on opposite ends of the bulb portion; and an electrical circuit for illuminating in response to electrical current to be received from the fluorescent light fixture, the electrical circuit including a current-limiting circuit(current limiting resistor(36).

Combination Bischoff and Schmitt do not disclose the electrical circuit including at least a rectifier.

Johnson disclose a light emitting diode retrofit lamp comprising a current limiting device as shown in capacitor (20) for functions to limit current within the circuit(18), col.4, lines 62-67 for limit current within the circuit (18) and also includes a rectifier(46) as shown in figure 1.



It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the circuit of combination Bischoff and Schmitt by employing a rectifier and the limit current circuit as taught by Johnson for the purpose of converting AC to DC voltage and limiting current for the light emitting diode, since this configuration for the stated purpose would have been deemed obvious as evidenced by the teaching of Johnson (See col.4, lines 62-67 and figure 1 for a rectifier).

Regarding claim 6, combination Bischoff, Schmitt and Johnson disclose wherein the plurality of light emitting diodes are mounted on only one side of a circuit board. See figure 2a of Bischoff for installing LEDs on one side of board.

Regarding claim 8, combination Bischoff Schmitt and Johnson disclose wherein each of the plurality of light emitting diodes is a white light emitting diode. See claim 4 of Bischoff.

Regarding claim 13, combination Bischoff, Schmitt and Johnson disclose wherein the radiation pattern of light from each of the plurality of light emitting diodes is centered at a 90° angle relative to the circuit board. Figure 2a of Bischoff.

Regarding claim 14, combination Bischoff, Schmitt and Johnson disclose wherein the plurality of light emitting diodes is arranged substantially continuously along the length of the bulb portion. Figures 1 or 2a of Bischoff.

Regarding claim 15, combination Bischoff, Schmitt and Johnson disclose wherein each of the plurality of light emitting diodes is a white light emitting diode. Claim 4 of Bischoff.

8. Claims 9-12 and 16-19 are rejected under 35 U.S.C. 103(a) as being unpatentable over by Bischoff, JR (US Patent No: 6,158,882) in view of Schmitt (US Patent No: 4,748,545) and Johnson (US Patent No: 5,463,280) as applied to claim 5 above, and further in view of Swanson et al (USP. 6,362,578).

Regarding claims 9-10 and 16-17, combination Bischoff Jr. and Schmitt and Johnson teaches every feature in the claimed invention excepting the plurality of LEDs to emit light at a frequency higher than 120 Hz and a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes above a nominal variation of 120 to 100 Hz.

Swanson et al disclose in Fig. 1, an IC chip driver (12) including a pulse-width modulating circuit (38) receiving DC power from said battery (74) and supplying modulated power to said plurality of LEDs (20) (Swanson, Fig. 1, Col. 3, Line 53); one or more current-limiting resistor (62, 64, 66) coupled between said pulse-width modulating circuit (38) and said plurality of LEDs (14, 16, 18) (Swanson, Fig. 1, Col. 3, Line 45); the plurality of LEDs to emit light at a frequency higher than 120 Hz (Swanson, Col. 6, Line 62); and the plurality of LEDs to cyclically flash light from the LED lighting unit on and off (Col. 6, Line 60).

It would have been obvious to incorporate the Swanson's teaching into Bischoff, Schmitt and Johnson's teaching for increasing LEDs lifetime in order to provide a full range of dimming capability.

Regarding claims 11-12 and 18-19 with the best understood, combination Bischoff Jr. and Schmitt and Johnson disclose wherein at least one of the first end cap

and the second end cap includes an inductive receiver. See figure 8 of Schmitt includes bi-pins for receiving or transmitting voltage or power from power source.

***Citation of relevant prior art***

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Prior art Shaffer (U.S. Patent No. 5,813,751) discloses device for permanent installation of Christmas lighting.

Prior art Bischoff, Jr (US. Patent No. 6,158,882) discloses LED semiconductor lighting system.

***Inquiry***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Minh Dieu A whose telephone number is (571) 272-1817. The examiner can normally be reached on M-F (9:00AM to 6:00PM).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Douglas W Owens can be reached on (571) 272-1662. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you

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have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Examiner /Minh A/

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Date 4/8/12

|                                   |                                       |  |                                                              |             |
|-----------------------------------|---------------------------------------|--|--------------------------------------------------------------|-------------|
| <b>Notice of References Cited</b> | Application/Control No.<br>12/965,019 |  | Applicant(s)/Patent Under Reexamination<br>TIMMERMANS ET AL. |             |
|                                   | Examiner<br>MINH D. A                 |  | Art Unit<br>2821                                             | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * |   | Document Number<br>Country Code-Number-Kind Code | Date<br>MM-YYYY | Name                   | Classification |
|---|---|--------------------------------------------------|-----------------|------------------------|----------------|
| * | A | US-6,158,882                                     | 12-2000         | Bischoff, Jr., A. John | 362/488        |
| * | B | US-5,813,751                                     | 09-1998         | Shaffer, Robert G.     | 362/249.08     |
| * | C | US-6,158,882                                     | 12-2000         | Bischoff, Jr., A. John | 362/488        |
| * | D | US-5,463,280                                     | 10-1995         | Johnson, James C.      | 315/187        |
| * | E | US-4,748,545                                     | 05-1988         | Schmitt, Lawrence O.   | 362/219        |
|   | F | US-                                              |                 |                        |                |
|   | G | US-                                              |                 |                        |                |
|   | H | US-                                              |                 |                        |                |
|   | I | US-                                              |                 |                        |                |
|   | J | US-                                              |                 |                        |                |
|   | K | US-                                              |                 |                        |                |
|   | L | US-                                              |                 |                        |                |
|   | M | US-                                              |                 |                        |                |

**FOREIGN PATENT DOCUMENTS**

| * |   | Document Number<br>Country Code-Number-Kind Code | Date<br>MM-YYYY | Country | Name | Classification |
|---|---|--------------------------------------------------|-----------------|---------|------|----------------|
|   | N |                                                  |                 |         |      |                |
|   | O |                                                  |                 |         |      |                |
|   | P |                                                  |                 |         |      |                |
|   | Q |                                                  |                 |         |      |                |
|   | R |                                                  |                 |         |      |                |
|   | S |                                                  |                 |         |      |                |
|   | T |                                                  |                 |         |      |                |

**NON-PATENT DOCUMENTS**

| * |   | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|-------------------------------------------------------------------------------------------|
|   | U |                                                                                           |
|   | V |                                                                                           |
|   | W |                                                                                           |
|   | X |                                                                                           |

\*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)  
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

|                                                                                                                        |                                                |                                                                         |
|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------------------|
| <b><i>Index of Claims</i></b><br><br> | <b>Application/Control No.</b><br><br>12965019 | <b>Applicant(s)/Patent Under Reexamination</b><br><br>TIMMERMANS ET AL. |
|                                                                                                                        | <b>Examiner</b><br><br>MINH D A                | <b>Art Unit</b><br><br>2821                                             |

|   |                 |   |                   |   |                     |   |                 |
|---|-----------------|---|-------------------|---|---------------------|---|-----------------|
| ✓ | <b>Rejected</b> | - | <b>Cancelled</b>  | N | <b>Non-Elected</b>  | A | <b>Appeal</b>   |
| = | <b>Allowed</b>  | ÷ | <b>Restricted</b> | I | <b>Interference</b> | O | <b>Objected</b> |

| <input type="checkbox"/> Claims renumbered in the same order as presented by applicant |          | <input type="checkbox"/> CPA |  | <input type="checkbox"/> T.D. |  | <input type="checkbox"/> R.1.47 |  |  |  |
|----------------------------------------------------------------------------------------|----------|------------------------------|--|-------------------------------|--|---------------------------------|--|--|--|
| CLAIM                                                                                  |          | DATE                         |  |                               |  |                                 |  |  |  |
| Final                                                                                  | Original | 04/08/2012                   |  |                               |  |                                 |  |  |  |
|                                                                                        | 1        | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 2        | -                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 3        | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 4        | -                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 5        | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 6        | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 7        | -                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 8        | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 9        | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 10       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 11       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 12       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 13       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 14       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 15       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 16       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 17       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 18       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 19       | ✓                            |  |                               |  |                                 |  |  |  |
|                                                                                        | 20       | ✓                            |  |                               |  |                                 |  |  |  |

EAST Search History

EAST Search History (Prior Art)

| Ref # | Hits   | Search Query                                                                    | DBs                                                | Default Operator | Plurals | Time Stamp          |
|-------|--------|---------------------------------------------------------------------------------|----------------------------------------------------|------------------|---------|---------------------|
| L2    | 122    | "6158882"                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:09 |
| L3    | 4      | L2 and "120" near4 Hz                                                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:09 |
| L4    | 4      | L2 and "120" near4 Hz                                                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:10 |
| L5    | 41     | "4748545"                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:10 |
| L6    | 3      | L5 and "120" near4 Hz                                                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:10 |
| L7    | 927084 | (cap\$1 or socket\$1) same (end\$1 or terminal\$1)                              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:12 |
| L8    | 82     | L7 and (LEDs or light near4 emitting near4 diodes) and board and "120" near4 Hz | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:12 |
| L9    | 7      | l8 and @pd<="20000211"                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:12 |
| L10   | 4      | "5463380"                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:13 |
| L11   | 0      | l10 and Hz                                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR               | OFF     | 2012/04/08<br>19:13 |

|     |       |                                                                                                                            |                                                    |    |     |                     |
|-----|-------|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|----|-----|---------------------|
| L12 | 9207  | inductive with antenna                                                                                                     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:47 |
| L13 | 505   | (LEDs or light near4 emitting near4 diodes) and I12                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:47 |
| L14 | 29    | I13 and @pd<="20000211"                                                                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:48 |
| L15 | 88    | "6362578"                                                                                                                  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:55 |
| L16 | 15054 | inductive same antenna                                                                                                     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:56 |
| L17 | 839   | (LEDs or light near4 emitting near4 diodes) and I16                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:56 |
| L18 | 34    | I17 and @pd<="20000211"                                                                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>19:56 |
| L26 | 1     | L2 and @pd<="20000211"                                                                                                     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>20:18 |
| L27 | 19    | L5 and @pd<="20000211"                                                                                                     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>20:18 |
| S1  | 39    | "7049761"                                                                                                                  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:18 |
| S2  | 382   | (Jos near4 Timmermans or Jean near4 Raymond or John near4 Ivey).inv.                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:34 |
| S3  | 17    | cap\$1 same bulb near4 portion and socket and power near4 supply and (LEDs or light near4 emitting near4 diodes) and board | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:35 |



|     |      |                |                                                    |    |     |                     |
|-----|------|----------------|----------------------------------------------------|----|-----|---------------------|
| S4  | 5    | S1 and S3      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:36 |
| S5  | 7    | S2 and S3      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:36 |
| S6  | 308  | 315/146.ccls.  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:36 |
| S7  | 1464 | 315/246.ccls.  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:36 |
| S8  | 657  | 315/185R.ccls. | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S9  | 388  | 315/185S.ccls. | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S10 | 1490 | 315/312.ccls.  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S11 | 5787 | 315/291.ccls.  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S12 | 3875 | 315/307.ccls.  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S13 | 407  | 362/488.ccls.  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S14 | 1392 | 362/240.ccls.  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:37 |
| S15 | 2942 | 362/800.ccls.  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:38 |

|     |        |                                                                  |                                                    |    |     |                     |
|-----|--------|------------------------------------------------------------------|----------------------------------------------------|----|-----|---------------------|
| S16 | 491    | 362/543.ccls.                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:39 |
| S17 | 688    | 362/544.ccls.                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:39 |
| S18 | 1220   | 362/545.ccls.                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:39 |
| S19 | 1784   | 362/249.01.ccls.                                                 | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:41 |
| S20 | 1447   | 362/249.02.ccls.                                                 | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:41 |
| S21 | 163    | 362/249.03.ccls.                                                 | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:41 |
| S22 | 927084 | (cap\$1 or socket\$1) same (end\$1 or<br>terminal\$1)            | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:42 |
| S23 | 7613   | S22 and (LEDs or light near4 emitting<br>near4 diodes) and board | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:43 |
| S24 | 3282   | mount\$1 and S23                                                 | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:43 |
| S25 | 204886 | predetermin\$3 with pattern                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:44 |
| S26 | 130    | S24 and S25                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:44 |
| S27 | 14     | S26 and @pd<="20000211"                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:44 |

|     |     |                         |                                                    |    |     |                     |
|-----|-----|-------------------------|----------------------------------------------------|----|-----|---------------------|
| S28 | 869 | S23 and @pd<="20000211" | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:45 |
| S29 | 0   | S6 and S28              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S30 | 1   | S7 and S28              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S31 | 1   | S8 and S28              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S32 | 0   | S9 and S28              | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S33 | 0   | S10 and S28             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S34 | 2   | S11 and S28             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S35 | 1   | S12 and S28             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S36 | 2   | S13 and S28             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S37 | 9   | S14 and S28             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S38 | 39  | S15 and S28             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |
| S39 | 0   | S16 and S28             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:46 |

|     |        |                                                                  |                                                    |    |     |                     |
|-----|--------|------------------------------------------------------------------|----------------------------------------------------|----|-----|---------------------|
| S40 | 0      | S17 and S28                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S41 | 6      | S18 and S28                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S42 | 3      | S19 and S28                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S43 | 1      | S20 and S28                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S44 | 1      | S21 and S28                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S45 | 100857 | "315"/\$7.ccls.                                                  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S46 | 138182 | "362"/\$7.ccls.                                                  | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:47 |
| S47 | 14     | S45 and S28                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:48 |
| S48 | 94     | S46 and S28                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:48 |
| S49 | 513    | predetermin\$3 and S28                                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/07<br>09:51 |
| S50 | 9705   | rectif\$3 and current near4 limit\$3<br>near4 circuit            | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>01:50 |
| S51 | 359    | S50 and (LEDs or light near4 emitting<br>near4 diodes) and board | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>01:51 |

|     |       |                                                                                                                                                  |                                                    |    |     |                     |
|-----|-------|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|----|-----|---------------------|
| S52 | 65    | S51 and @pd<="20000211"                                                                                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>01:51 |
| S53 | 122   | "6158882"                                                                                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>11:08 |
| S54 | 41    | "4748545"                                                                                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>11:08 |
| S55 | 5     | "11085744"                                                                                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>11:55 |
| S56 | 43    | voltage near4 converter same rectif\$3<br>same' (LEDs or light near4 emitting<br>near4 diodes) and board                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>13:09 |
| S57 | 3     | S56 and @pd<="20000211"                                                                                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>13:09 |
| S59 | 122   | voltage near4 converter same rectif\$3<br>same (LEDs or light near4 emitting<br>near4 diodes)                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>13:10 |
| S61 | 10    | S59 and @pd<="20000211"                                                                                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>13:10 |
| S62 | 71031 | socket\$1 same (end\$1 or cap\$1)<br>same (tube or lamp\$12 or<br>flourescent)                                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:49 |
| S63 | 4585  | socket\$1 same (end\$1 or cap\$1)<br>same (tube or lamp\$12 or<br>flourescent)same (LED\$1 or light<br>near4 emitting)                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:49 |
| S64 | 1320  | socket\$1 same (end\$1 or cap\$1)<br>same (tube or lamp\$12 or<br>flourescent)same (LED\$1 or light<br>near4 emitting)same (circuit or<br>board) | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:50 |
| S65 | 954   | S64 and @pd<="20000211"                                                                                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:50 |

EAST Search History

|     |     |                 |                                                    |    |     |                     |
|-----|-----|-----------------|----------------------------------------------------|----|-----|---------------------|
| S66 | 520 | S65 and surface | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS; EPO;<br>JPO | OR | OFF | 2012/04/08<br>15:51 |
|-----|-----|-----------------|----------------------------------------------------|----|-----|---------------------|

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C:\ Users\ ma\ Documents\ EAST\ Workspaces\ 12965019.wsp

|                                                                                                              |                                                |                                                                         |
|--------------------------------------------------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------------------|
| <b>Search Notes</b><br><br> | <b>Application/Control No.</b><br><br>12965019 | <b>Applicant(s)/Patent Under Reexamination</b><br><br>TIMMERMANS ET AL. |
|                                                                                                              | <b>Examiner</b><br><br>MINH D A                | <b>Art Unit</b><br><br>2821                                             |

| SEARCHED |                                                      |        |          |
|----------|------------------------------------------------------|--------|----------|
| Class    | Subclass                                             | Date   | Examiner |
| 315      | 146, 246, 185R, 185S, 312, 291, 307,                 | 4/7/12 | MA       |
| 362      | 488, 240, 800, 543, 544, 545, 249.01, 249.02, 249.03 | 4/7/12 | MA       |

| SEARCH NOTES                             |        |          |
|------------------------------------------|--------|----------|
| Search Notes                             | Date   | Examiner |
| Text search "East", see search print out | 4/7/12 | MA       |
| Inventor's name search "East" print out  | 4/7/12 | MA       |
| Text search "East", see search print out | 4/8/12 | MA       |

| INTERFERENCE SEARCH |          |      |          |
|---------------------|----------|------|----------|
| Class               | Subclass | Date | Examiner |
|                     |          |      |          |

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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|--------------------|-----------------------|-----------------------|------------------------|
| 12/965,019         | 12/10/2010            | Jos Timmermans        | AEII-172-H             |

**CONFIRMATION NO. 5912**  
**POA ACCEPTANCE LETTER**

48980  
YOUNG BASILE  
3001 WEST BIG BEAVER ROAD  
SUITE 624  
TROY, MI 48084



Date Mailed: 04/20/2012

**NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY**

This is in response to the Power of Attorney filed 04/12/2012.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/vvan/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



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**POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO**

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:



Practitioners associated with the Customer Number:

48980

OR



Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

| Name | Registration Number | Name | Registration Number |
|------|---------------------|------|---------------------|
|      |                     |      |                     |
|      |                     |      |                     |
|      |                     |      |                     |
|      |                     |      |                     |
|      |                     |      |                     |
|      |                     |      |                     |

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:



The address associated with Customer Number:

OR

|                                                  |       |     |  |
|--------------------------------------------------|-------|-----|--|
| <input type="checkbox"/> Firm or Individual Name |       |     |  |
| Address                                          |       |     |  |
| City                                             | State | Zip |  |
| Country                                          |       |     |  |
| Telephone                                        | Email |     |  |

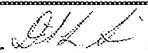
Assignee Name and Address:

ilumisys, Inc.  
1820 East Big Beaver Road  
Troy, Michigan 48083-2031

**A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.**

**SIGNATURE of Assignee of Record**

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

|           |                                                                                     |           |                       |
|-----------|-------------------------------------------------------------------------------------|-----------|-----------------------|
| Signature |  | Date      | March 9, 2012         |
| Name      | David L. Simon                                                                      | Telephone | 248-614-2400 ext. 332 |
| Title     | President                                                                           |           |                       |

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

## Electronic Acknowledgement Receipt

|                                             |                                     |
|---------------------------------------------|-------------------------------------|
| <b>EFS ID:</b>                              | 12531000                            |
| <b>Application Number:</b>                  | 12965019                            |
| <b>International Application Number:</b>    |                                     |
| <b>Confirmation Number:</b>                 | 5912                                |
| <b>Title of Invention:</b>                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |
| <b>First Named Inventor/Applicant Name:</b> | Jos Timmermans                      |
| <b>Customer Number:</b>                     | 48980                               |
| <b>Filer:</b>                               | Andrew R. Basile/Janet Zuk          |
| <b>Filer Authorized By:</b>                 | Andrew R. Basile                    |
| <b>Attorney Docket Number:</b>              | AEII-172-H                          |
| <b>Receipt Date:</b>                        | 12-APR-2012                         |
| <b>Filing Date:</b>                         | 10-DEC-2010                         |
| <b>Time Stamp:</b>                          | 17:16:48                            |
| <b>Application Type:</b>                    | Utility under 35 USC 111(a)         |

### Payment information:

|                        |    |
|------------------------|----|
| Submitted with Payment | no |
|------------------------|----|

### File Listing:

| Document Number | Document Description                              | File Name                       | File Size(Bytes)/<br>Message Digest                | Multi Part /.zip | Pages (if appl.) |
|-----------------|---------------------------------------------------|---------------------------------|----------------------------------------------------|------------------|------------------|
| 1               | Assignee showing of ownership per 37 CFR 3.73(b). | AEII172H_Statement_20120412.pdf | 458048<br>8d5814bad920a41e877450b5626ef9e3a0b784c6 | no               | 2                |

### Warnings:

### Information:

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                   |                                 |                                                     |    |   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------|-----------------------------------------------------|----|---|
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Power of Attorney | ilumisys_ExecutedGeneralPOA.pdf | 2287829<br>16dede5a861b988dda552b2c043d7d251389143d | no | 1 |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                   |                                 |                                                     |    |   |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                   |                                 |                                                     |    |   |
| <b>Total Files Size (in bytes):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                   |                                 | 2745877                                             |    |   |
| <p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b><br/> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b><br/> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b><br/> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p> |                   |                                 |                                                     |    |   |

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**STATEMENT UNDER 37 CFR 3.73(b)**Applicant/Patent Owner: ilumisys, Inc.Application No./Patent No.: 12/965,019Filed/Issue Date: 12/10/2010Titled: Light Tube and Power Supply Circuitilumisys, Inc., a Michigan corporation

(Name of Assignee)

(Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that it is:

1. ☒ the assignee of the entire right, title, and interest in;
2. ☐ an assignee of less than the entire right, title, and interest in  
(The extent (by percentage) of its ownership interest is \_\_\_\_\_ %); or
3. ☐ the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)  
the patent application/patent identified above, by virtue of either:

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy therefore is attached.

**OR**

B. ☒ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Jos Timmermans, Jean Raymond, John Ivey To: Altair Engineering, Inc.

The document was recorded in the United States Patent and Trademark Office at  
Reel 025901, Frame 0733, or for which a copy thereof is attached.

2. From: Altair Engineering, Inc. To: ilumisys, Inc.

The document was recorded in the United States Patent and Trademark Office at  
Reel 027971, Frame 0632, or for which a copy thereof is attached.

3. From: \_\_\_\_\_ To: \_\_\_\_\_

The document was recorded in the United States Patent and Trademark Office at  
Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Nadine N. Mustafa/

April 12, 2012

Signature

Date

Nadine N. Mustafa

Attorney of Record

Printed or Typed Name

Title

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

## Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.



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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|--------------------|-----------------------|-----------------------|------------------------|
| 12/965,019         | 12/10/2010            | Jos Timmermans        | AEII-172-H             |

CONFIRMATION NO. 5912

PUBLICATION NOTICE

48980  
YOUNG BASILE  
3001 WEST BIG BEAVER ROAD  
SUITE 624  
TROY, MI 48084



**Title:**LIGHT TUBE AND POWER SUPPLY CIRCUIT

**Publication No.**US-2011-0156608-A1

**Publication Date:**06/30/2011

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at [www.uspto.gov](http://www.uspto.gov). The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at [www.uspto.gov](http://www.uspto.gov) using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <http://pair.uspto.gov/>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

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Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|--------------------|-----------------------|-----------------------|------------------------|
| 12/965,019         | 12/10/2010            | Jos Timmermans        | AEII-172-H             |

48980  
YOUNG BASILE  
3001 WEST BIG BEAVER ROAD  
SUITE 624  
TROY, MI 48084

**CONFIRMATION NO. 5912**  
**POA ACCEPTANCE LETTER**



Date Mailed: 03/31/2011

**NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY**

This is in response to the Power of Attorney filed 03/24/2011.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/s/brahim/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



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| APPLICATION<br>NUMBER | FILING or<br>371(c) DATE | GRP ART<br>UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|-----------------------|--------------------------|-----------------|---------------|----------------|------------|------------|
| 12/965,019            | 12/10/2010               | 2875            | 1220          | AEII-172-H     | 17         | 2          |

CONFIRMATION NO. 5912

UPDATED FILING RECEIPT



OC000000046595309

48980  
YOUNG BASILE  
3001 WEST BIG BEAVER ROAD  
SUITE 624  
TROY, MI 48084

Date Mailed: 03/24/2011

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

**Applicant(s)**

Jos Timmermans, Ortonville, MI;  
Jean C. Raymond, Nominique, CANADA;  
John Ivey, Farmington Hills, MI;

**Assignment For Published Patent Application**

ALTAIR ENGINEERING, INC., Troy, MI

**Power of Attorney:** None

**Domestic Priority data as claimed by applicant**

This application is a CON of 11/085,744 03/21/2005  
which is a CON of 09/782,375 02/12/2001 PAT 7,049,761  
which claims benefit of 60/181,744 02/11/2000

**Foreign Applications** (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.)

**If Required, Foreign Filing License Granted:** 12/22/2010

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/965,019**

**Projected Publication Date:** 06/30/2011

**Non-Publication Request:** No

**Early Publication Request:** No



**Title**

LIGHT TUBE AND POWER SUPPLY CIRCUIT

**Preliminary Class**

362

**PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES**

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

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| <b>PATENT APPLICATION FEE DETERMINATION RECORD</b><br>Substitute for Form PTO-875                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                               |                                  |            |                                    |               | Application or Docket Number<br>12/965,019 |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------------|------------------------------------|---------------|--------------------------------------------|--------------------|
| <b>APPLICATION AS FILED - PART I</b>                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
| (Column 1)                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                               | (Column 2)                       |            | SMALL ENTITY                       |               | OTHER THAN SMALL ENTITY                    |                    |
| FOR                                                                                                                                                                                                                                                                                                                                                                                                        | NUMBER FILED                                                                                                                                                                                                                  | NUMBER EXTRA                     | RATE(\$)   | FEE(\$)                            |               | RATE(\$)                                   | FEE(\$)            |
| BASIC FEE<br>(37 CFR 1.16(a), (b), or (c))                                                                                                                                                                                                                                                                                                                                                                 | N/A                                                                                                                                                                                                                           | N/A                              | N/A        |                                    |               | N/A                                        | 330                |
| SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m))                                                                                                                                                                                                                                                                                                                                                                | N/A                                                                                                                                                                                                                           | N/A                              | N/A        |                                    |               | N/A                                        | 540                |
| EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q))                                                                                                                                                                                                                                                                                                                                                           | N/A                                                                                                                                                                                                                           | N/A                              | N/A        |                                    |               | N/A                                        | 220                |
| TOTAL CLAIMS<br>(37 CFR 1.16(i))                                                                                                                                                                                                                                                                                                                                                                           | 17                                                                                                                                                                                                                            | minus 20 = *                     |            |                                    | OR            | x 52 =                                     | 0.00               |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h))                                                                                                                                                                                                                                                                                                                                                                     | 2                                                                                                                                                                                                                             | minus 3 = *                      |            |                                    |               | x 220 =                                    | 0.00               |
| APPLICATION SIZE FEE<br>(37 CFR 1.16(s))                                                                                                                                                                                                                                                                                                                                                                   | If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$270 (\$135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). |                                  |            |                                    |               |                                            | 0.00               |
| MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            | 0.00               |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               |                                  | TOTAL      |                                    |               | TOTAL                                      | 1090               |
| * If the difference in column 1 is less than zero, enter "0" in column 2.                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
| <b>APPLICATION AS AMENDED - PART II</b>                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
| AMENDMENT A                                                                                                                                                                                                                                                                                                                                                                                                | (Column 1)                                                                                                                                                                                                                    |                                  | (Column 2) |                                    | (Column 3)    |                                            | SMALL ENTITY       |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               | CLAIMS REMAINING AFTER AMENDMENT |            | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA |                                            | RATE(\$)           |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Total<br>(37 CFR 1.16(i))                                                                                                                                                                                                     | *                                | Minus      | **                                 | =             |                                            | ADDITIONAL FEE(\$) |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Independent<br>(37 CFR 1.16(h))                                                                                                                                                                                               | *                                | Minus      | ***                                | =             |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Application Size Fee (37 CFR 1.16(s))                                                                                                                                                                                         |                                  |            |                                    |               |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            | FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               |                                  |            |                                    |               | TOTAL<br>ADD'L FEE                         |                    |
| AMENDMENT B                                                                                                                                                                                                                                                                                                                                                                                                | (Column 1)                                                                                                                                                                                                                    |                                  | (Column 2) |                                    | (Column 3)    |                                            | SMALL ENTITY       |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               | CLAIMS REMAINING AFTER AMENDMENT |            | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA |                                            | RATE(\$)           |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Total<br>(37 CFR 1.16(i))                                                                                                                                                                                                     | *                                | Minus      | **                                 | =             |                                            | ADDITIONAL FEE(\$) |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Independent<br>(37 CFR 1.16(h))                                                                                                                                                                                               | *                                | Minus      | ***                                | =             |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Application Size Fee (37 CFR 1.16(s))                                                                                                                                                                                         |                                  |            |                                    |               |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            | FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               |                                  |            |                                    |               | TOTAL<br>ADD'L FEE                         |                    |
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3.<br>** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".<br>*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".<br>The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1. |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO**

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:

☐ Practitioners associated with the Customer Number:

48980

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

| Name | Registration Number | Name | Registration Number |
|------|---------------------|------|---------------------|
|      |                     |      |                     |
|      |                     |      |                     |
|      |                     |      |                     |
|      |                     |      |                     |
|      |                     |      |                     |
|      |                     |      |                     |

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:

☒ The address associated with Customer Number:

48980

OR

|                                                  |       |     |  |
|--------------------------------------------------|-------|-----|--|
| <input type="checkbox"/> Firm or Individual Name |       |     |  |
| Address                                          |       |     |  |
| City                                             | State | Zip |  |
| Country                                          |       |     |  |
| Telephone                                        | Email |     |  |

Assignee Name and Address:

Altair Engineering, Inc.  
1820 E. Big Beaver Rd., Troy, MI 48063-2031

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

**SIGNATURE of Assignee of Record**

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

|           |                         |           |              |
|-----------|-------------------------|-----------|--------------|
| Signature | <i>Tom M. Perrin</i>    | Date      | 10-24-07     |
| Name      | Tom Perrin              | Telephone | 248-614-2400 |
| Title     | Chief Operating Officer |           |              |

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

## Electronic Acknowledgement Receipt

|                                             |                                     |
|---------------------------------------------|-------------------------------------|
| <b>EFS ID:</b>                              | 9727817                             |
| <b>Application Number:</b>                  | 12965019                            |
| <b>International Application Number:</b>    |                                     |
| <b>Confirmation Number:</b>                 | 5912                                |
| <b>Title of Invention:</b>                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |
| <b>First Named Inventor/Applicant Name:</b> | Jos Timmermans                      |
| <b>Customer Number:</b>                     | 48980                               |
| <b>Filer:</b>                               | Andrew R. Basile/Janet Zuk          |
| <b>Filer Authorized By:</b>                 | Andrew R. Basile                    |
| <b>Attorney Docket Number:</b>              | AEII-172-H                          |
| <b>Receipt Date:</b>                        | 24-MAR-2011                         |
| <b>Filing Date:</b>                         | 10-DEC-2010                         |
| <b>Time Stamp:</b>                          | 09:05:44                            |
| <b>Application Type:</b>                    | Utility under 35 USC 111(a)         |

### Payment information:

|                        |    |
|------------------------|----|
| Submitted with Payment | no |
|------------------------|----|

### File Listing:

| Document Number | Document Description                              | File Name                      | File Size(Bytes)/<br>Message Digest                | Multi Part /.zip | Pages (if appl.) |
|-----------------|---------------------------------------------------|--------------------------------|----------------------------------------------------|------------------|------------------|
| 1               | Assignee showing of ownership per 37 CFR 3.73(b). | AEII172H_ExecutedStatement.pdf | 428019<br>65271ab4ce741152b59d6940c460f4f7487d11e9 | no               | 2                |

### Warnings:

### Information:

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                   |                                  |                                                    |    |   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------|----------------------------------------------------|----|---|
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Power of Attorney | AEI10_GeneralPowerOfAttorney.pdf | 100547<br>6608de79f2fc41febd5f862a6118df809e45a186 | no | 1 |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                   |                                  |                                                    |    |   |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                   |                                  |                                                    |    |   |
| <b>Total Files Size (in bytes):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                   |                                  | 528566                                             |    |   |
| <p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b><br/> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b><br/> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b><br/> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p> |                   |                                  |                                                    |    |   |

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**STATEMENT UNDER 37 CFR 3.73(b)**Applicant/Patent Owner: ALTAIR ENGINEERING, INC.Application No./Patent No.: 12/965,019Filed/Issue Date: December 10, 2011

Titled:

LIGHT TUBE AND POWER SUPPLY CIRCUIT

ALTAIR ENGINEERING, INC.

, a corporation

(Name of Assignee)

(Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that it is:

1. ☒ the assignee of the entire right, title, and interest in;
2. ☐ an assignee of less than the entire right, title, and interest in  
(The extent (by percentage) of its ownership interest is \_\_\_\_\_ %); or
3. ☐ the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)  
the patent application/patent identified above, by virtue of either:

A. ☒ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 025901, Frame 0733, or for which a copy therefore is attached.

**OR**

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: \_\_\_\_\_ To: \_\_\_\_\_

The document was recorded in the United States Patent and Trademark Office at

Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

2. From: \_\_\_\_\_ To: \_\_\_\_\_

The document was recorded in the United States Patent and Trademark Office at

Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

3. From: \_\_\_\_\_ To: \_\_\_\_\_

The document was recorded in the United States Patent and Trademark Office at

Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Andrew R. Basile, Sr./

March 23, 2011

Signature

Date

Andrew R. Basile, Sr.

Authorized Agent

Printed or Typed Name

Title

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

## Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.



Atty. Doc. No. AEII-172-H

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Jos Timmermans et al.  
Serial Number: 12/965,019  
Filing Date: December 10, 2010  
Examiner/Art Group Unit: Unknown/2875  
Title: LIGHT TUBE AND POWER SUPPLY CIRCUIT

RESPONSE TO NOTICE TO FILE MISSING PARTS  
OF NONPROVISIONAL APPLICATION

M.S. Missing Parts  
Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

Sir:

In response to the Notice to File Missing Parts dated December 28, 2010, Applicants herewith enclose executed Declarations. Further, Applicants hereby enclose nine (9) Replacement sheets for the drawing figures in the subject application. These Replacement sheets replace the original nine (9) drawing sheets. There are no substantive changes to any other drawing figure as compared to those originally filed.

The undersigned hereby authorizes the U.S. Patent and Trademark Office to charge our Deposit Account No. 25-0015 any fees associated with the filing of this Response.

03/15/2011 MTEKLEMI 00000026 250115 12965019  
01 FC:1251 130.00 DA

Respectfully submitted,

YOUNG BASILE  
HANLON & MACFARLANE P.C.

/Michelle L. Knight/

Michelle L. Knight  
Registration No. 47,711  
(248) 649-3333

3001 West Big Beaver Rd., Ste. 624  
Troy, Michigan 48084-3107  
Date: March 8, 2011

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Jos Timmermans et al.  
Serial Number: 12/965,019  
Filing Date: December 10, 2010  
Examiner/Art Group Unit: Unknown/2875  
Title: LIGHT TUBE AND POWER SUPPLY CIRCUIT

RESPONSE TO NOTICE TO FILE MISSING PARTS  
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M.S. Missing Parts  
Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

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Respectfully submitted,

YOUNG BASILE  
HANLON & MACFARLANE P.C.

/Michelle L. Knight/

Michelle L. Knight  
Registration No. 47,711  
(248) 649-3333

3001 West Big Beaver Rd., Ste. 624  
Troy, Michigan 48084-3107  
Date: March 8, 2011

Doc Code: Oath

Document Description: Oath or declaration filed

PTO/SB/01 (04-09)

Approved for use through 09/30/2010. OMB 0651-0032  
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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|                                                                                       |                           |                                                                                                                                  |               |         |
|---------------------------------------------------------------------------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------------------|---------------|---------|
| <b>DECLARATION FOR UTILITY OR<br/>DESIGN<br/>PATENT APPLICATION<br/>(37 CFR 1.63)</b> | Attorney Docket<br>Number | AEII-172-H                                                                                                                       |               |         |
|                                                                                       | First Named Inventor      | Jos Timmermans                                                                                                                   |               |         |
|                                                                                       | COMPLETE IF KNOWN         |                                                                                                                                  |               |         |
|                                                                                       | Application Number        | 12/965,019                                                                                                                       |               |         |
|                                                                                       | Filing Date               | December 10, 2010                                                                                                                |               |         |
|                                                                                       | Art Unit                  | Unknown                                                                                                                          |               |         |
| <input type="checkbox"/> Declaration<br>Submitted<br>With Initial<br>Filing           | OR                        | <input checked="" type="checkbox"/> Declaration<br>Submitted After Initial<br>Filing (surcharge<br>(37 CFR 1.16(f))<br>required) | Examiner Name | Unknown |

I hereby declare that: (1) Each inventor's residence, mailing address, and citizenship are as stated below next to their name; and (2) I believe the inventor(s) named below to be the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention titled:

LIGHT TUBE AND POWER SUPPLY CIRCUIT

(Title of the Invention)

the application of which

☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY) 12/10/2010 as United States Application Number or PCT International

Application Number 12/965,019 and was amended on (MM/DD/YYYY) (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified application, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

#### Authorization To Permit Access To Application by Participating Offices

☐ If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the above-identified patent application is filed access to the above-identified patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the above-identified patent application is filed to have access to the above-identified patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the above-identified patent application with respect to: 1) the above-identified patent application-as-filed; 2) any foreign application to which the above-identified patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the above-identified patent application; and 3) any U.S. application-as-filed from which benefit is sought in the above-identified patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing the Authorization to Permit Access to Application by Participating Offices.

[Page 1 of 3]

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

## DECLARATION — Utility or Design Patent Application

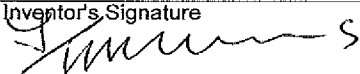
### Claim of Foreign Priority Benefits

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application<br>Number(s) | Country | Foreign Filing Date<br>(MM/DD/YYYY) | Priority<br>Not Claimed  | Certified Copy Attached? |                          |
|----------------------------------------|---------|-------------------------------------|--------------------------|--------------------------|--------------------------|
|                                        |         |                                     |                          | YES                      | NO                       |
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|                                        |         |                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

☐ Additional foreign application number(s) are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

## DECLARATION — Utility or Design Patent Application

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                                                                                                                     |                                                                               |                                                          |  |
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| Direct all correspondence to: <input checked="" type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |       | The address associated with Customer Number: <span style="border: 1px solid black; padding: 2px 20px;">48980</span> |                                                                               | OR <input type="checkbox"/> Correspondence address below |  |
| Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                                                                                                                     |                                                                               |                                                          |  |
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| Country                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       | Telephone                                                                                                           |                                                                               | Email                                                    |  |
| <b>WARNING:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                                                                                                                     |                                                                               |                                                          |  |
| <p>Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available. Petitioner/applicant is advised that documents which form the record of a patent application (such as the PTO/SB/01) are placed into the Privacy Act system of records DEPARTMENT OF COMMERCE, COMMERCE-PAT-7, System name: <i>Patent Application Files</i>. Documents not retained in an application file (such as the PTO-2038) are placed into the Privacy Act system of COMMERCE/PAT-TM-10, System name: <i>Deposit Accounts and Electronic Funds Transfer Profiles</i>.</p> <p>I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.</p> |       |                                                                                                                     |                                                                               |                                                          |  |
| NAME OF SOLE OR FIRST INVENTOR:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                                                                                                                     | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                                                          |  |
| Given Name (first and middle [if any])                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                                                                                     | Family Name or Surname                                                        |                                                          |  |
| Jos                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |       |                                                                                                                     | Timmermans                                                                    |                                                          |  |
| Inventor's Signature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                                                                                                                     | Date                                                                          |                                                          |  |
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| Residence: City                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | State | Country                                                                                                             | Citizenship                                                                   |                                                          |  |
| Ortonville                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | MI    | US                                                                                                                  | NL                                                                            |                                                          |  |
| Mailing Address                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                                                                                                                     |                                                                               |                                                          |  |
| c/o Altair Engineering, Inc., 1820 East Big Beaver Rd.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                                                                                                                     |                                                                               |                                                          |  |
| City                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | State | Zip                                                                                                                 | Country                                                                       |                                                          |  |
| Troy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | MI    | 48084                                                                                                               | US                                                                            |                                                          |  |
| <input checked="" type="checkbox"/> Additional inventors or a legal representative are being named on the <u>1</u> supplemental sheet(s) PTO/SB/02A or 02LR attached hereto                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |                                                                                                                     |                                                                               |                                                          |  |

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

|                    |                                                     |
|--------------------|-----------------------------------------------------|
| <b>DECLARATION</b> | <b>ADDITIONAL INVENTOR(S)</b><br>Supplemental Sheet |
| Page 1 of 1        |                                                     |

|                                                        |                 |                                                                               |                   |
|--------------------------------------------------------|-----------------|-------------------------------------------------------------------------------|-------------------|
| Name of Additional Joint Inventor, if any:             |                 | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                   |
| Given Name (first and middle (if any))                 |                 | Family Name or Surname                                                        |                   |
| Jean                                                   |                 | Raymond                                                                       |                   |
| Inventor's Signature                                   |                 | Date                                                                          |                   |
| Nominique<br>Residence: City                           | Quebec<br>State | CA<br>Country                                                                 | CA<br>Citizenship |
| c/o Altair Engineering, Inc., 1820 East Big Beaver Rd. |                 |                                                                               |                   |
| Mailing Address                                        |                 |                                                                               |                   |
| Troy<br>City                                           | MI<br>State     | 48084<br>Zip                                                                  | US<br>Country     |
| Name of Additional Joint Inventor, if any:             |                 | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                   |
| Given Name (first and middle (if any))                 |                 | Family Name or Surname                                                        |                   |
| John                                                   |                 | Ivey                                                                          |                   |
| Inventor's Signature                                   |                 | Date                                                                          |                   |
| Farmington Hills<br>Residence: City                    | MI<br>State     | US<br>Country                                                                 | US<br>Citizenship |
| Mailing Address                                        |                 |                                                                               |                   |
| City                                                   | State           | Zip                                                                           | Country           |
| Name of Additional Joint Inventor, if any:             |                 | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                   |
| Given Name (first and middle (if any))                 |                 | Family Name or Surname                                                        |                   |
|                                                        |                 |                                                                               |                   |
| Inventor's Signature                                   |                 | Date                                                                          |                   |
| Residence: City                                        | State           | Country                                                                       | Citizenship       |
| Mailing Address                                        |                 |                                                                               |                   |
| City                                                   | State           | Zip                                                                           | Country           |

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

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## DECLARATION – Supplemental Priority Data Sheet

[illegible]

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: **Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.*

Doc Code: Oath

Document Description: Oath or declaration filed

PTO/SB/01 (04-09)

Approved for use through 09/30/2010. OMB 0651-0032  
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

|                                                                                                                                                                                                                      |  |                           |                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|---------------------------|-------------------|
| <b>DECLARATION FOR UTILITY OR<br/>DESIGN<br/>PATENT APPLICATION<br/>(37 CFR 1.63)</b>                                                                                                                                |  | Attorney Docket<br>Number | AEII-172-H        |
|                                                                                                                                                                                                                      |  | First Named Inventor      | Jos Timmermans    |
| <input type="checkbox"/> Declaration<br>Submitted<br>With Initial<br>Filing      OR <input checked="" type="checkbox"/> Declaration<br>Submitted After Initial<br>Filing (surcharge<br>(37 CFR 1.16(f))<br>required) |  | COMPLETE IF KNOWN         |                   |
|                                                                                                                                                                                                                      |  | Application Number        | 12/965,019        |
|                                                                                                                                                                                                                      |  | Filing Date               | December 10, 2010 |
|                                                                                                                                                                                                                      |  | Art Unit                  | Unknown           |
|                                                                                                                                                                                                                      |  | Examiner Name             | Unknown           |

I hereby declare that: (1) Each inventor's residence, mailing address, and citizenship are as stated below next to their name; and (2) I believe the inventor(s) named below to be the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention titled:

**LIGHT TUBE AND POWER SUPPLY CIRCUIT**

*(Title of the Invention)*

the application of which

☐ Is attached hereto

OR

☒ was filed on (MM/DD/YYYY) 12/10/2010 as United States Application Number or PCT International

Application Number 12/965,019 and was amended on (MM/DD/YYYY) \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified application, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

#### Authorization To Permit Access To Application by Participating Offices

☐ If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the above-identified patent application is filed access to the above-identified patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the above-identified patent application is filed to have access to the above-identified patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the above-identified patent application with respect to: 1) the above-identified patent application-as-filed; 2) any foreign application to which the above-identified patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the above-identified patent application; and 3) any U.S. application-as-filed from which benefit is sought in the above-identified patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing the Authorization to Permit Access to Application by Participating Offices.

[Page 1 of 3]

This collection of information is required by 35 U.S.C. 116 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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## DECLARATION — Utility or Design Patent Application

### Claim of Foreign Priority Benefits

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT International application having a filing date before that of the application on which priority is claimed.

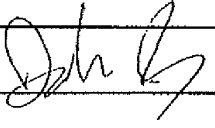
| Prior Foreign Application<br>Number(s) | Country | Foreign Filing Date<br>(MM/DD/YYYY) | Priority<br>Not Claimed  | Certified Copy Attached? |                          |
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|                                        |         |                                     |                          | YES                      | NO                       |
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|                                        |         |                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

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## DECLARATION — Utility or Design Patent Application

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| Direct all correspondence to: <input checked="" type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  | The address associated with Customer Number: <span style="border: 1px solid black; padding: 2px 20px;">48980</span> |           | OR <input type="checkbox"/>                                                   |      | Correspondence address below |  |
| Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |                                                                                                                     |           |                                                                               |      |                              |  |
| Address                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  |                                                                                                                     |           |                                                                               |      |                              |  |
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| I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                                                                                                     |           |                                                                               |      |                              |  |
| NAME OF SOLE OR FIRST INVENTOR:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |                                                                                                                     |           | <input type="checkbox"/> A petition has been filed for this unsigned inventor |      |                              |  |
| Given Name (first and middle (if any))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                     |           | Family Name or Surname                                                        |      |                              |  |
| Jos                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  |                                                                                                                     |           | Timmermans                                                                    |      |                              |  |
| Inventor's Signature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |                                                                                                                     |           |                                                                               | Date |                              |  |
| Residence: City                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | State                                                                                                               |           | Country                                                                       |      | Citizenship                  |  |
| Ortonville                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  | MI                                                                                                                  |           | US                                                                            |      | NL                           |  |
| Mailing Address                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |                                                                                                                     |           |                                                                               |      |                              |  |
| c/o Altair Engineering, Inc., 1820 East Big Beaver Rd.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                     |           |                                                                               |      |                              |  |
| City                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  | State                                                                                                               |           | Zip                                                                           |      | Country                      |  |
| Troy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  | MI                                                                                                                  |           | 48084                                                                         |      | US                           |  |
| <input checked="" type="checkbox"/> Additional inventors or a legal representative are being named on the <u>1</u> supplemental sheet(s) PTO/SB/02A or 02LR attached hereto                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |                                                                                                                     |           |                                                                               |      |                              |  |

|                    |                                                     |
|--------------------|-----------------------------------------------------|
| <b>DECLARATION</b> | <b>ADDITIONAL INVENTOR(S)</b><br>Supplemental Sheet |
|                    | Page <u>1</u> of <u>1</u>                           |

|                                                                                                         |                 |                                                                               |                    |
|---------------------------------------------------------------------------------------------------------|-----------------|-------------------------------------------------------------------------------|--------------------|
| Name of Additional Joint Inventor, If any:                                                              |                 | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                    |
| Given Name (first and middle (if any))                                                                  |                 | Family Name or Surname                                                        |                    |
| Jean                                                                                                    |                 | Raymond                                                                       |                    |
| Inventor's Signature                                                                                    |                 |                                                                               | Date               |
| Nominque<br>Residence: City                                                                             | Quebec<br>State | CA<br>Country                                                                 | CA<br>Citizenship  |
| c/o Allair Engineering, Inc., 1820 East Big Beaver Rd.                                                  |                 |                                                                               |                    |
| Mailing Address                                                                                         |                 |                                                                               |                    |
| Troy<br>City                                                                                            | MI<br>State     | 48064<br>Zip                                                                  | US<br>Country      |
| Name of Additional Joint Inventor, If any:                                                              |                 | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                    |
| Given Name (first and middle (if any))                                                                  |                 | Family Name or Surname                                                        |                    |
| John                                                                                                    |                 | Ivey                                                                          |                    |
| Inventor's Signature  |                 |                                                                               | Date <u>2/2/11</u> |
| Farmington Hills<br>Residence: City                                                                     | MI<br>State     | US<br>Country                                                                 | US<br>Citizenship  |
| Mailing Address                                                                                         |                 |                                                                               |                    |
| City                                                                                                    | State           | Zip                                                                           | Country            |
| Name of Additional Joint Inventor, If any:                                                              |                 | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                    |
| Given Name (first and middle (if any))                                                                  |                 | Family Name or Surname                                                        |                    |
|                                                                                                         |                 |                                                                               |                    |
| Inventor's Signature                                                                                    |                 |                                                                               | Date               |
| Residence: City                                                                                         | State           | Country                                                                       | Citizenship        |
| Mailing Address                                                                                         |                 |                                                                               |                    |
| City                                                                                                    | State           | Zip                                                                           | Country            |

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

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### **DECLARATION – Supplemental Priority Data Sheet**

**Foreign applications:**

[illegible]

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

*If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.*

Doc Code: Oath

Document Description: Oath or declaration filed

PTO/SB/01 (04-09)

Approved for use through 09/30/2010. OMB 0851-0032  
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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|                                                                                                                                                                                                                      |  |                           |                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|---------------------------|-------------------|
| <b>DECLARATION FOR UTILITY OR<br/>DESIGN<br/>PATENT APPLICATION<br/>(37 CFR 1.63)</b>                                                                                                                                |  | Attorney Docket<br>Number | AEI-172-H         |
|                                                                                                                                                                                                                      |  | First Named Inventor      | Jos Timmermans    |
| <input type="checkbox"/> Declaration<br>Submitted<br>With Initial<br>Filing      OR <input checked="" type="checkbox"/> Declaration<br>Submitted After Initial<br>Filing (surcharge<br>(37 CFR 1.16(f))<br>required) |  | COMPLETE IF KNOWN         |                   |
|                                                                                                                                                                                                                      |  | Application Number        | 12/965,019        |
|                                                                                                                                                                                                                      |  | Filing Date               | December 10, 2010 |
|                                                                                                                                                                                                                      |  | Art Unit                  | Unknown           |
|                                                                                                                                                                                                                      |  | Examiner Name             | Unknown           |

I hereby declare that: (1) Each inventor's residence, mailing address, and citizenship are as stated below next to their name; and (2) I believe the inventor(s) named below to be the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention titled:

LIGHT TUBE AND POWER SUPPLY CIRCUIT

(Title of the invention)

the application of which

☐ Is attached hereto

OR

☒ was filed on (MM/DD/YYYY) 12/10/2010 as United States Application Number or PCT International  
Application Number 12/965,019 and was amended on (MM/DD/YYYY) (If applicable).

I hereby state that I have reviewed and understand the contents of the above identified application, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT International filing date of the continuation-in-part application.

#### Authorization To Permit Access To Application by Participating Offices

☐ If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the above-identified patent application is filed access to the above-identified patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the above-identified patent application is filed to have access to the above-identified patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the above-identified patent application with respect to: 1) the above-identified patent application-as-filed; 2) any foreign application to which the above-identified patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the above-identified patent application; and 3) any U.S. application-as-filed from which benefit is sought in the above-identified patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing the Authorization to Permit Access to Application by Participating Offices.

[Page 1 of 3]

This collection of information is required by 35 U.S.C. 116 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1460, Alexandria, VA 22313-1460. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1460, Alexandria, VA 22313-1460.

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## DECLARATION — Utility or Design Patent Application

### Claim of Foreign Priority Benefits

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT International application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application<br>Number(s) | Country | Foreign Filing Date<br>(MM/DD/YYYY) | Priority<br>Not Claimed  | Certified Copy Attached? |                          |
|----------------------------------------|---------|-------------------------------------|--------------------------|--------------------------|--------------------------|
|                                        |         |                                     |                          | YES                      | NO                       |
|                                        |         |                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|                                        |         |                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|                                        |         |                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|                                        |         |                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

☐ Additional foreign application number(s) are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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## DECLARATION — Utility or Design Patent Application

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |                                                                                 |           |                                                                               |       |                              |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|---------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------|-------|------------------------------|--|
| Direct all correspondence to: <input checked="" type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  | The address associated with Customer Number: <input type="text" value="48980"/> |           | OR <input type="checkbox"/>                                                   |       | Correspondence address below |  |
| Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |                                                                                 |           |                                                                               |       |                              |  |
| Address                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |                                                                                 |           |                                                                               |       |                              |  |
| City                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |                                                                                 |           | State                                                                         |       | Zip                          |  |
| Country                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |                                                                                 | Telephone |                                                                               | Email |                              |  |
| <p><b>WARNING:</b></p> <p>Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available. Petitioner/applicant is advised that documents which form the record of a patent application (such as the PTO/SB/01) are placed into the Privacy Act system of records DEPARTMENT OF COMMERCE, COMMERCE-PAT-7, System name: <i>Patent Application Files</i>. Documents not retained in an application file (such as the PTO-2038) are placed into the Privacy Act system of COMMERCE/PAT-TM-10, System name: <i>Deposit Accounts and Electronic Funds Transfer Profiles</i>.</p> <p>I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.</p> |  |                                                                                 |           |                                                                               |       |                              |  |
| NAME OF SOLE OR FIRST INVENTOR:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |                                                                                 |           | <input type="checkbox"/> A petition has been filed for this unsigned inventor |       |                              |  |
| Given Name (first and middle (if any))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |                                                                                 |           | Family Name or Surname                                                        |       |                              |  |
| Jos                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                                                                 |           | Timmermans                                                                    |       |                              |  |
| Inventor's Signature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |                                                                                 |           | Date                                                                          |       |                              |  |
| Residence: City                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | State                                                                           |           | Country                                                                       |       | Citizenship                  |  |
| Ortonville                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  | MI                                                                              |           | US                                                                            |       | NL                           |  |
| Mailing Address                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |                                                                                 |           |                                                                               |       |                              |  |
| c/o Altair Engineering, Inc., 1820 East Big Beaver Rd.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |                                                                                 |           |                                                                               |       |                              |  |
| City                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  | State                                                                           |           | Zip                                                                           |       | Country                      |  |
| Troy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  | MI                                                                              |           | 48084                                                                         |       | US                           |  |
| <input checked="" type="checkbox"/> Additional inventors or a legal representative are being named on the <u>1</u> supplemental sheet(s) PTO/SB/02A or 02LR attached hereto                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |                                                                                 |           |                                                                               |       |                              |  |

[Page 3 of 3]

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|--------------------|-----------------------------------------------------|
| <b>DECLARATION</b> | <b>ADDITIONAL INVENTOR(S)</b><br>Supplemental Sheet |
|                    | Page <u>1</u> of <u>1</u>                           |

|                                                        |              |                                                                               |                |
|--------------------------------------------------------|--------------|-------------------------------------------------------------------------------|----------------|
| Name of Additional Joint Inventor, if any:             |              | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                |
| Given Name (first and middle (if any))                 |              | Family Name or Surname                                                        |                |
| Jean C.                                                |              | Raymond                                                                       |                |
| Inventor's Signature <i>[Signature]</i>                |              | Date <i>02/02/2011</i>                                                        |                |
| Residence: City                                        | Quebec State | CA Country                                                                    | CA Citizenship |
| c/o Altair Engineering, Inc., 1820 East Big Beaver Rd. |              |                                                                               |                |
| Mailing Address                                        |              |                                                                               |                |
| Troy City                                              | MI State     | 48064 Zip                                                                     | US Country     |
| Name of Additional Joint Inventor, if any:             |              | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                |
| Given Name (first and middle (if any))                 |              | Family Name or Surname                                                        |                |
| John                                                   |              | Ivey                                                                          |                |
| Inventor's Signature                                   |              | Date                                                                          |                |
| Farmington Hills Residence: City                       | MI State     | US Country                                                                    | US Citizenship |
| Mailing Address                                        |              |                                                                               |                |
| City                                                   | State        | Zip                                                                           | Country        |
| Name of Additional Joint Inventor, if any:             |              | <input type="checkbox"/> A petition has been filed for this unsigned inventor |                |
| Given Name (first and middle (if any))                 |              | Family Name or Surname                                                        |                |
|                                                        |              |                                                                               |                |
| Inventor's Signature                                   |              | Date                                                                          |                |
| Residence: City                                        | State        | Country                                                                       | Citizenship    |
| Mailing Address                                        |              |                                                                               |                |
| City                                                   | State        | Zip                                                                           | Country        |

This collection of information is required by 35 U.S.C. 116 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

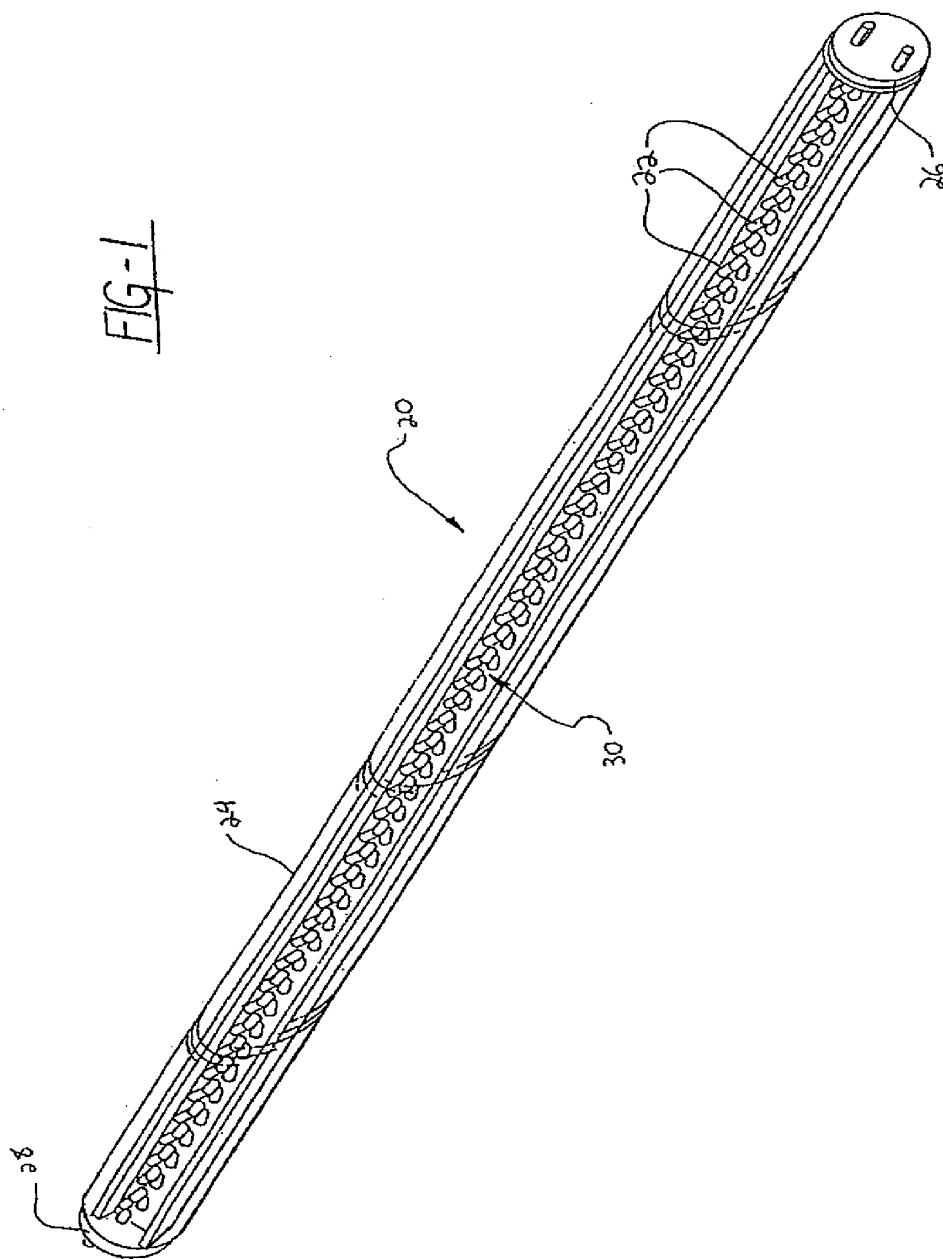


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[illegible]

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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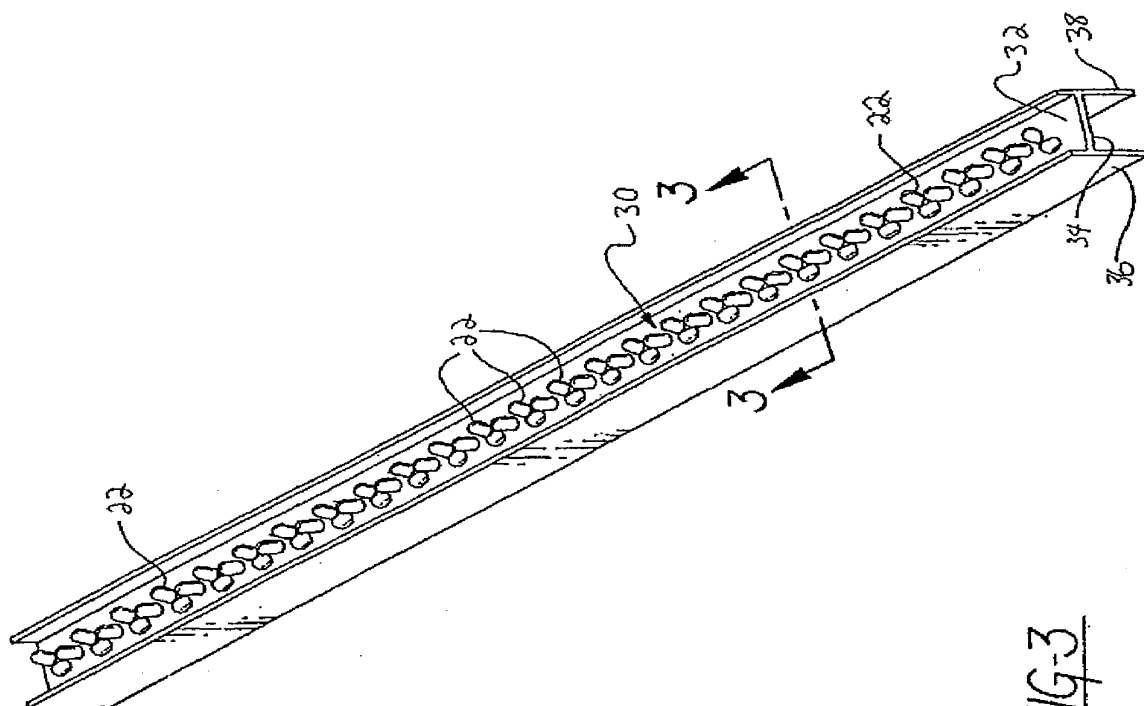


FIG-2

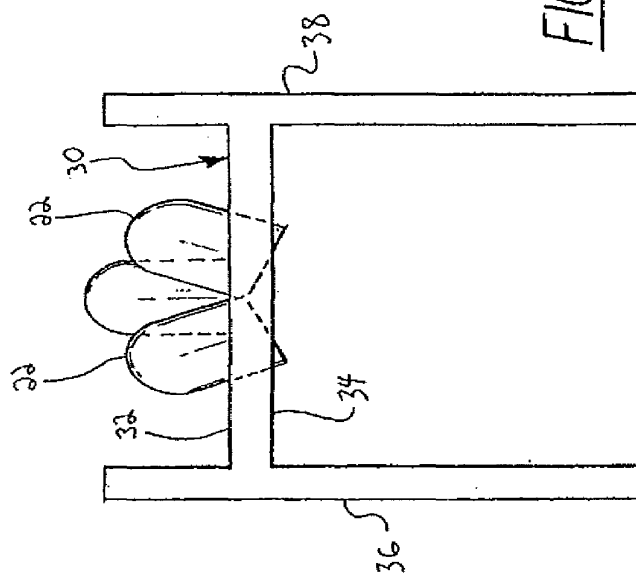
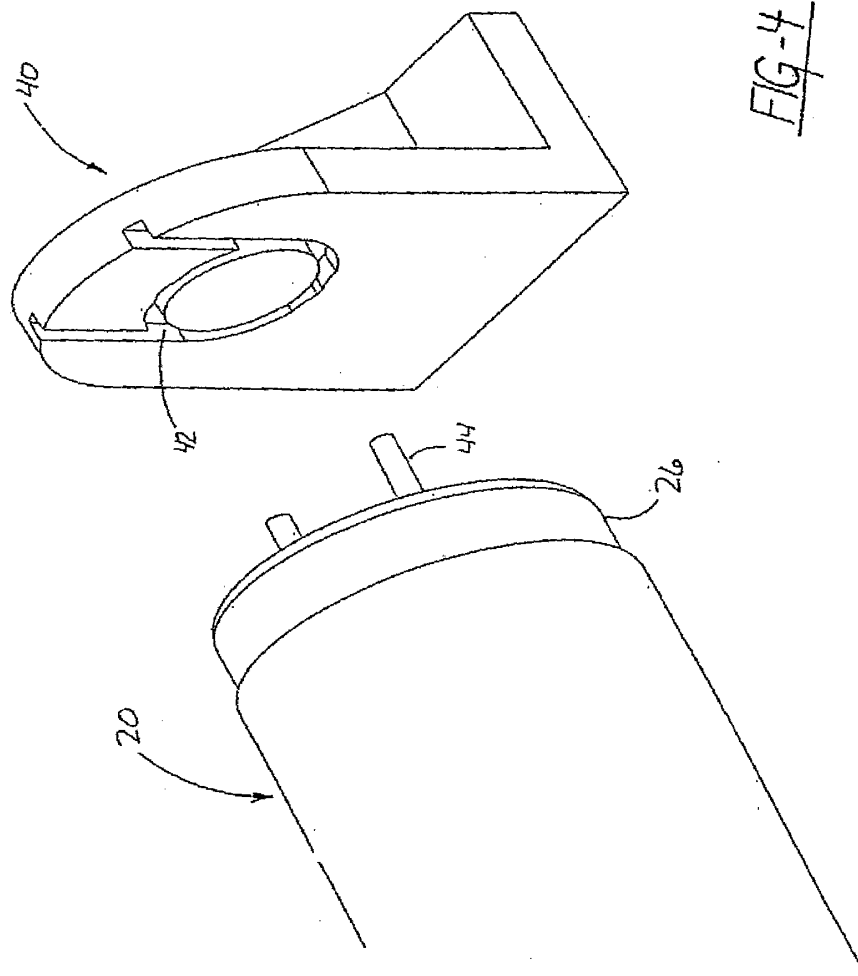


FIG-3



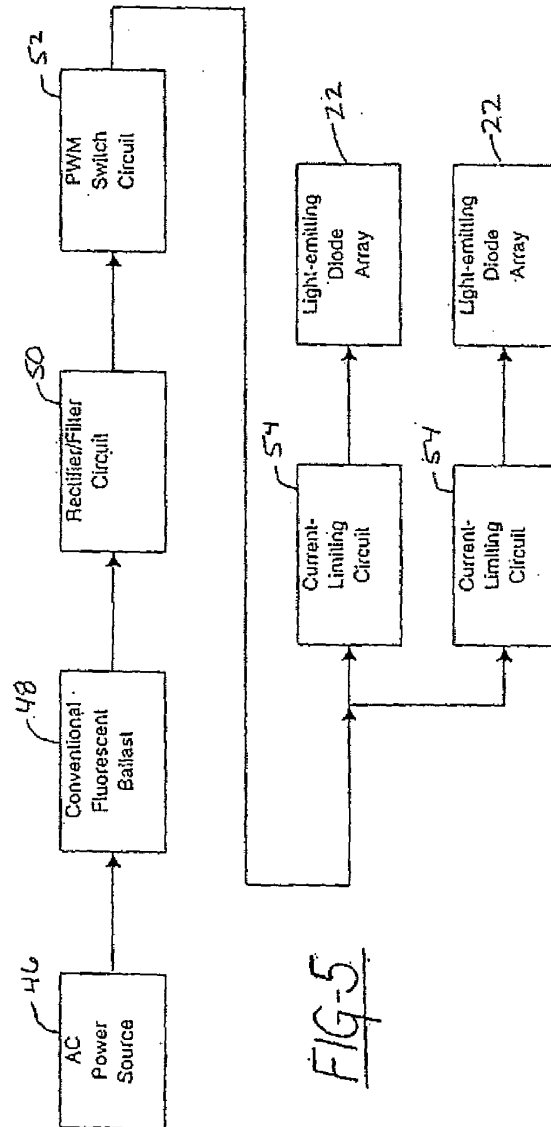
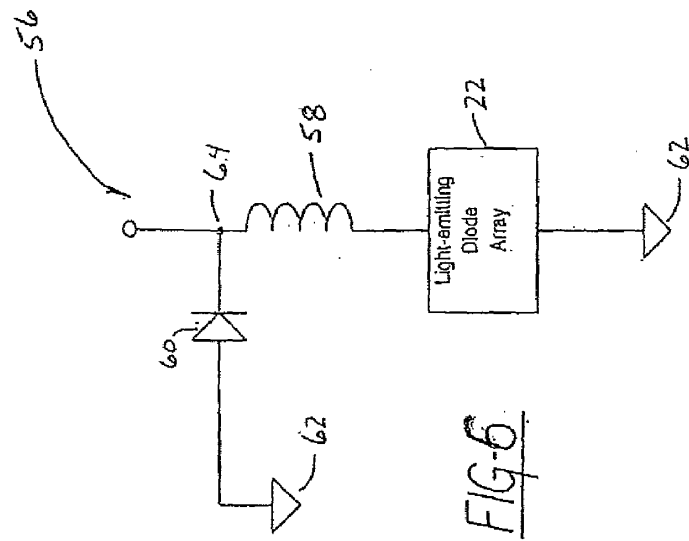
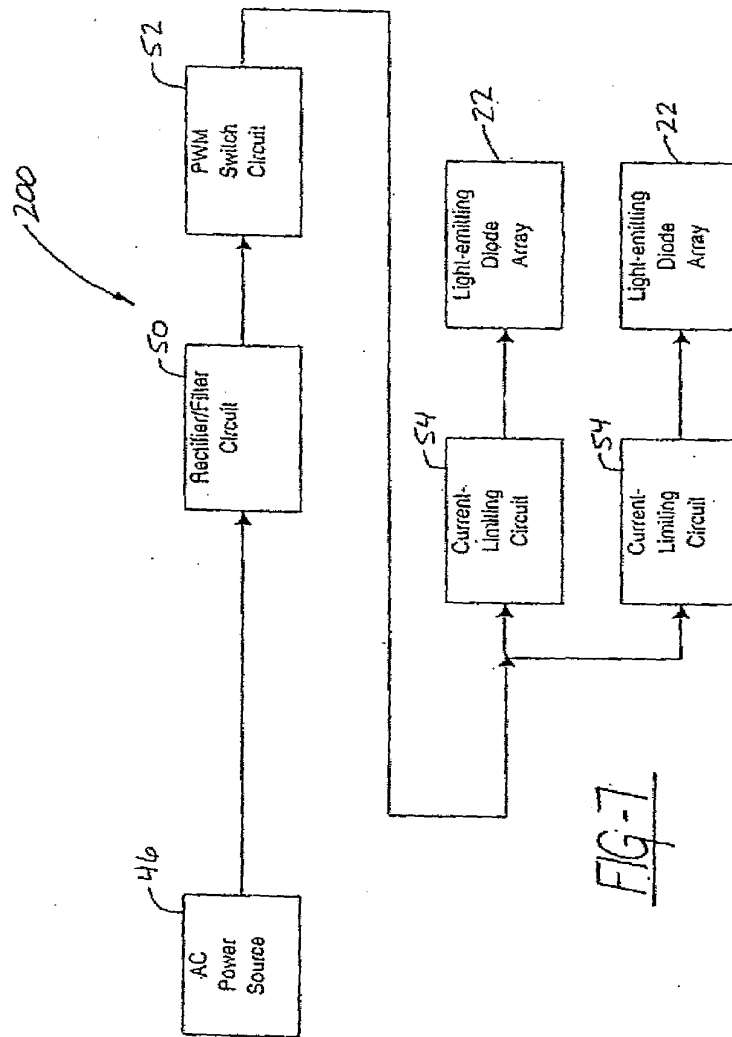
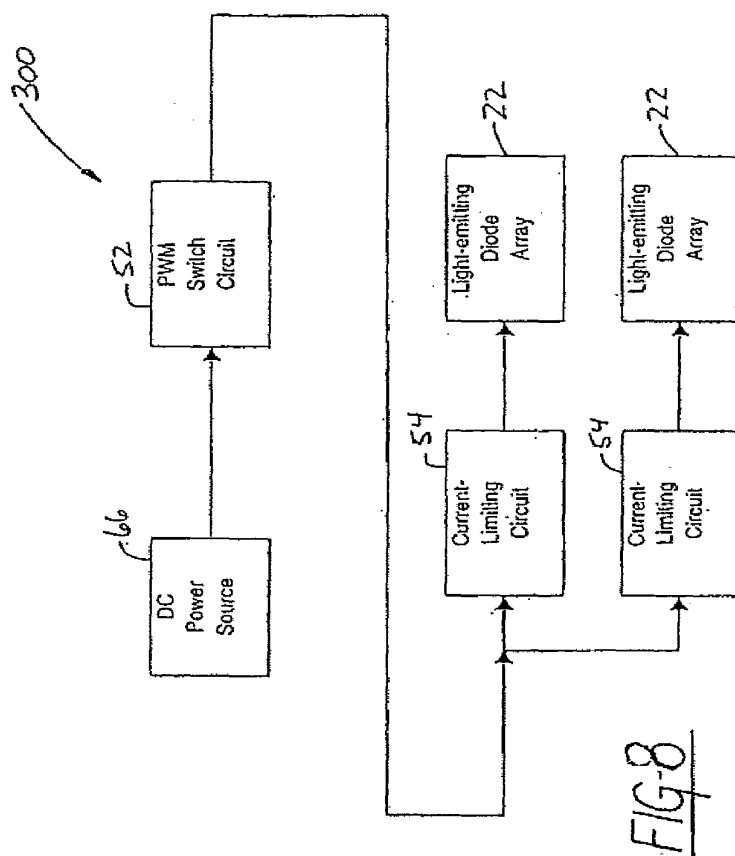


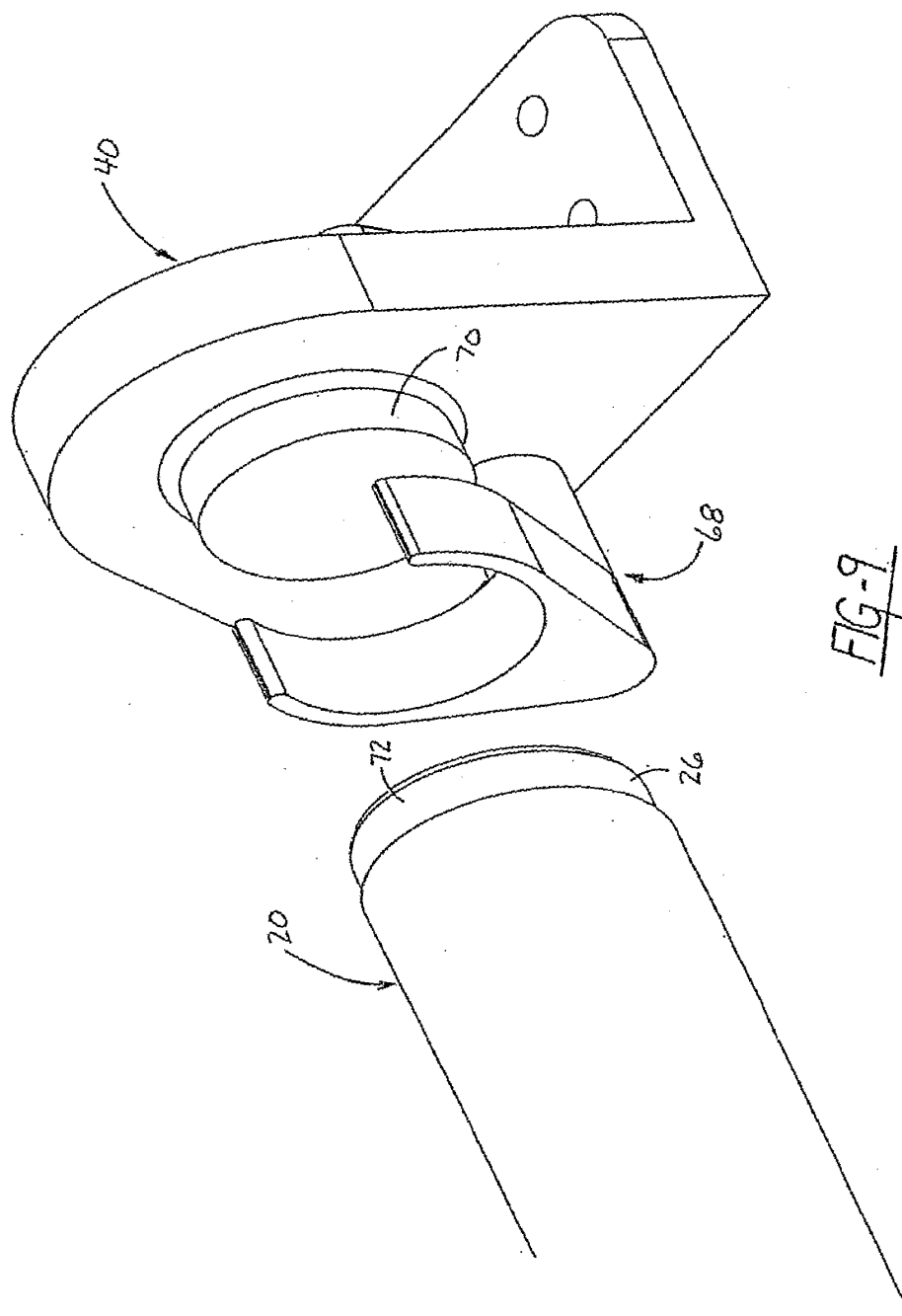
FIG-5











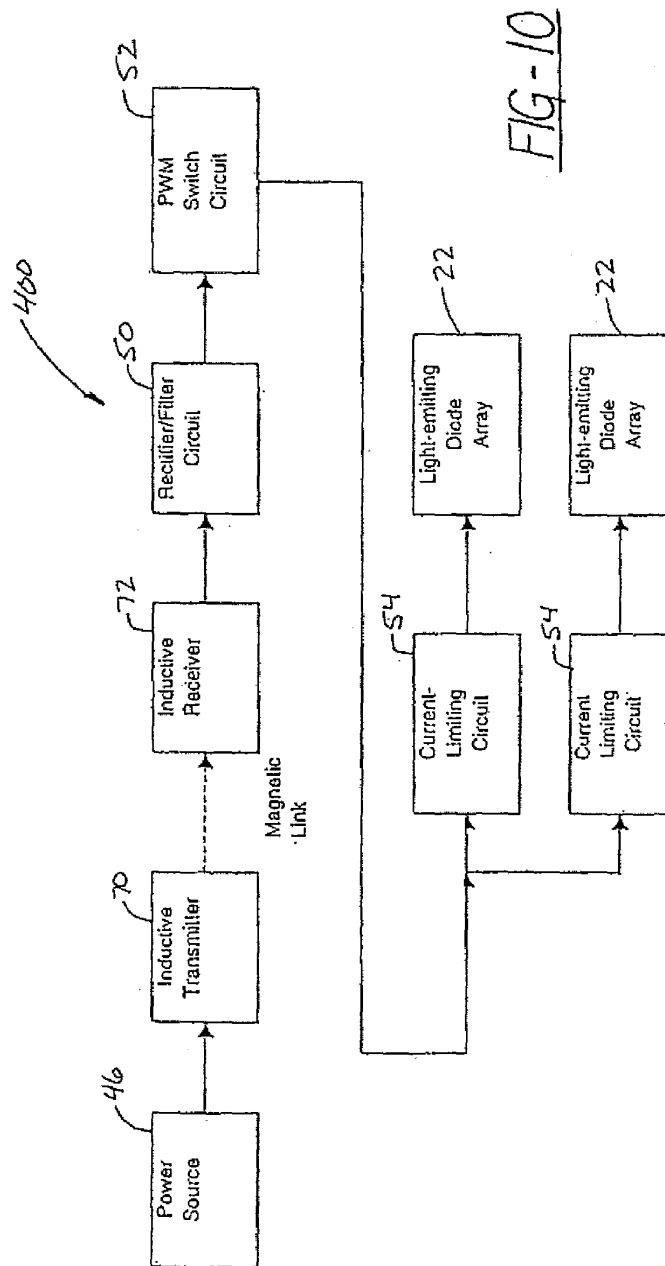


FIG-10

| Electronic Patent Application Fee Transmittal |          |                                     |        |                      |
|-----------------------------------------------|----------|-------------------------------------|--------|----------------------|
| Application Number:                           |          | 12965019                            |        |                      |
| Filing Date:                                  |          | 10-Dec-2010                         |        |                      |
| Title of Invention:                           |          | LIGHT TUBE AND POWER SUPPLY CIRCUIT |        |                      |
| First Named Inventor/Applicant Name:          |          | Jos Timmermans                      |        |                      |
| Filer:                                        |          | Michelle L. Knight/Joan Leighton    |        |                      |
| Attorney Docket Number:                       |          | AEII-172-H                          |        |                      |
| Filed as Large Entity                         |          |                                     |        |                      |
| Utility under 35 USC 111(a) Filing Fees       |          |                                     |        |                      |
| Description                                   | Fee Code | Quantity                            | Amount | Sub-Total in USD(\$) |
| Basic Filing:                                 |          |                                     |        |                      |
| Pages:                                        |          |                                     |        |                      |
| Claims:                                       |          |                                     |        |                      |
| Miscellaneous-Filing:                         |          |                                     |        |                      |
| Late filing fee for oath or declaration       | 1051     | 1                                   | 130    | 130                  |
| Petition:                                     |          |                                     |        |                      |
| Patent-Appeals-and-Interference:              |          |                                     |        |                      |
| Post-Allowance-and-Post-Issuance:             |          |                                     |        |                      |
| Extension-of-Time:                            |          |                                     |        |                      |

| Description       | Fee Code | Quantity | Amount | Sub-Total in USD(\$) |
|-------------------|----------|----------|--------|----------------------|
| Miscellaneous:    |          |          |        |                      |
| Total in USD (\$) |          |          |        | 130                  |

## Electronic Acknowledgement Receipt

|                                             |                                     |
|---------------------------------------------|-------------------------------------|
| <b>EFS ID:</b>                              | 9610681                             |
| <b>Application Number:</b>                  | 12965019                            |
| <b>International Application Number:</b>    |                                     |
| <b>Confirmation Number:</b>                 | 5912                                |
| <b>Title of Invention:</b>                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |
| <b>First Named Inventor/Applicant Name:</b> | Jos Timmermans                      |
| <b>Customer Number:</b>                     | 48980                               |
| <b>Filer:</b>                               | Michelle L. Knight/Joan Leighton    |
| <b>Filer Authorized By:</b>                 | Michelle L. Knight                  |
| <b>Attorney Docket Number:</b>              | AEII-172-H                          |
| <b>Receipt Date:</b>                        | 08-MAR-2011                         |
| <b>Filing Date:</b>                         | 10-DEC-2010                         |
| <b>Time Stamp:</b>                          | 14:43:23                            |
| <b>Application Type:</b>                    | Utility under 35 USC 111(a)         |

### Payment information:

|                                          |                 |
|------------------------------------------|-----------------|
| Submitted with Payment                   | yes             |
| Payment Type                             | Deposit Account |
| Payment was successfully received in RAM | \$ 130          |
| RAM confirmation Number                  | 1076            |
| Deposit Account                          | 250115          |
| Authorized User                          |                 |

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

| File Listing:                |                                                   |                                   |                                          |                  |                  |
|------------------------------|---------------------------------------------------|-----------------------------------|------------------------------------------|------------------|------------------|
| Document Number              | Document Description                              | File Name                         | File Size(Bytes)/ Message Digest         | Multi Part /.zip | Pages (if appl.) |
| 1                            | Applicant Response to Pre-Exam Formalities Notice | AEII172H_MissingPartsResponse.pdf | 11946                                    | no               | 1                |
|                              |                                                   |                                   | 21ccc1d8260cbc315b3f5699033bfa80f5a3eafb |                  |                  |
| Warnings:                    |                                                   |                                   |                                          |                  |                  |
| Information:                 |                                                   |                                   |                                          |                  |                  |
| 2                            | Oath or Declaration filed                         | AEII172H_ExecutedTimmermanDec.pdf | 318802                                   | no               | 5                |
|                              |                                                   |                                   | 92a9e1c9066e15de2f6fa0f3fdae2c1faf3f6974 |                  |                  |
| Warnings:                    |                                                   |                                   |                                          |                  |                  |
| Information:                 |                                                   |                                   |                                          |                  |                  |
| 3                            | Oath or Declaration filed                         | AEII172H_ExecutedIveyDec.pdf      | 325806                                   | no               | 5                |
|                              |                                                   |                                   | 17b4cec26dcf0d29f91a95f606b2ff50db01c21a |                  |                  |
| Warnings:                    |                                                   |                                   |                                          |                  |                  |
| Information:                 |                                                   |                                   |                                          |                  |                  |
| 4                            | Oath or Declaration filed                         | AEII172H_ExecutedRaymondDec.pdf   | 339555                                   | no               | 5                |
|                              |                                                   |                                   | bac663b7525d96cdf08a5a6ee6152cfc6119c69e |                  |                  |
| Warnings:                    |                                                   |                                   |                                          |                  |                  |
| Information:                 |                                                   |                                   |                                          |                  |                  |
| 5                            | Drawings-only black and white line drawings       | AEII172H_Dwgs4.pdf                | 263948                                   | no               | 9                |
|                              |                                                   |                                   | ab0d371ae686d629796644dc399d721dbdf521e9 |                  |                  |
| Warnings:                    |                                                   |                                   |                                          |                  |                  |
| Information:                 |                                                   |                                   |                                          |                  |                  |
| 6                            | Fee Worksheet (PTO-875)                           | fee-info.pdf                      | 30126                                    | no               | 2                |
|                              |                                                   |                                   | a14f9230f8080ddc459ff5f4d64082830bbac963 |                  |                  |
| Warnings:                    |                                                   |                                   |                                          |                  |                  |
| Information:                 |                                                   |                                   |                                          |                  |                  |
| Total Files Size (in bytes): |                                                   |                                   | 1290183                                  |                  |                  |

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**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|--------------------|-----------------------|-----------------------|------------------------|
| 12/965,019         | 12/10/2010            | Jos Timmermans        | AEII-172-H             |

48980  
YOUNG BASILE  
3001 WEST BIG BEAVER ROAD  
SUITE 624  
TROY, MI 48084

**CONFIRMATION NO. 5912**  
**FORMALITIES LETTER**



Date Mailed: 12/28/2010

**NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION**

**FILED UNDER 37 CFR 1.53(b)**

*Filing Date Granted*

**Items Required To Avoid Abandonment:**

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is missing.

*A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.*

*Note: If a petition under 37 CFR 1.47 is being filed, an oath or declaration in compliance with 37 CFR 1.63 signed by all available joint inventors, or if no inventor is available by a party with sufficient proprietary interest, is required.*

The application is informal since it does not comply with the regulations for the reason(s) indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- Replacement drawings in compliance with 37 CFR 1.84 and 37 CFR 1.121(d) are required. The drawings submitted are not acceptable because:
  - The drawings must be reasonably free from erasures and must be free from alterations, overwriting, interlineations, folds, and copy marks. See Figure(s) all.

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- A surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.16(f) of \$**130** for a non-small entity, must be submitted.



**SUMMARY OF FEES DUE:**

Total fee(s) required within **TWO MONTHS** from the date of this Notice is **\$130** for a non-small entity  
• **\$130** Surcharge.

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|                                                                                                                                |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
|--------------------------------------------------------------------------------------------------------------------------------|----------|--------|--------------------------|--------|---------------------------|--------|---------------------------------------------------|-------|-------------|-------|--------|-------|--------|
| <b>MULTIPLE DEPENDENT CLAIM<br/>FEE CALCULATION SHEET</b><br><br>Substitute for Form PTO-1360<br>(For use with Form PTO/SB/06) |          |        |                          |        |                           |        | Application Number<br><b>12965019</b>             |       | Filing Date |       |        |       |        |
|                                                                                                                                |          |        |                          |        |                           |        | Applicant(s) <b>Jos Timmermans</b>                |       |             |       |        |       |        |
|                                                                                                                                |          |        |                          |        |                           |        | * May be used for additional claims or amendments |       |             |       |        |       |        |
| CLAIMS                                                                                                                         | AS FILED |        | AFTER FIRST<br>AMENDMENT |        | AFTER SECOND<br>AMENDMENT |        |                                                   | *     |             | *     |        | *     |        |
|                                                                                                                                | Indep    | Depend | Indep                    | Depend | Indep                     | Depend |                                                   | Indep | Depend      | Indep | Depend | Indep | Depend |
| 1                                                                                                                              | 1        |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 2                                                                                                                              | ---      | ---    |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 3                                                                                                                              | 1        |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 4                                                                                                                              | ---      | ---    |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 5                                                                                                                              |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 6                                                                                                                              |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 7                                                                                                                              | ---      | ---    |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 8                                                                                                                              |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 9                                                                                                                              |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 10                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 11                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 12                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 13                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 14                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 15                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 16                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 17                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 18                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 19                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 20                                                                                                                             |          | 1      |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 21                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 22                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 23                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 24                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 25                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 26                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 27                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 28                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 29                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 30                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 31                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 32                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 33                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 34                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 35                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 36                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 37                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 38                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 39                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 40                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 41                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 42                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 43                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 44                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 45                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 46                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 47                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 48                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 49                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 50                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| Total Indep                                                                                                                    | 2        |        | 0                        |        | 0                         |        |                                                   |       |             |       |        |       |        |
| Total Depend                                                                                                                   | 15       | ↙      | 0                        | ↙      | 0                         | ↙      |                                                   |       |             |       |        |       |        |
| Total Claims                                                                                                                   | 17       |        | 0                        |        | 0                         |        |                                                   |       |             |       |        |       |        |
| 51                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 52                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 53                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 54                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 55                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 56                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 57                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 58                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 59                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 60                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 61                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 62                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 63                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 64                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 65                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 66                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 67                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 68                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 69                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 70                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 71                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 72                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 73                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 74                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 75                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 76                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 77                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 78                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 79                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 80                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 81                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 82                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 83                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 84                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 85                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 86                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 87                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 88                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 89                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 90                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 91                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 92                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 93                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 94                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 95                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 96                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 97                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 98                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 99                                                                                                                             |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |
| 100                                                                                                                            |          |        |                          |        |                           |        |                                                   |       |             |       |        |       |        |

| <b>PATENT APPLICATION FEE DETERMINATION RECORD</b><br>Substitute for Form PTO-875                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                               |                                  |            |                                    |               | Application or Docket Number<br>12/965,019 |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------------|------------------------------------|---------------|--------------------------------------------|--------------------|
| <b>APPLICATION AS FILED - PART I</b>                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
| (Column 1)                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                               | (Column 2)                       |            | SMALL ENTITY                       |               | OTHER THAN SMALL ENTITY                    |                    |
| FOR                                                                                                                                                                                                                                                                                                                                                                                                        | NUMBER FILED                                                                                                                                                                                                                  | NUMBER EXTRA                     | RATE(\$)   | FEE(\$)                            |               | RATE(\$)                                   | FEE(\$)            |
| BASIC FEE<br>(37 CFR 1.16(a), (b), or (c))                                                                                                                                                                                                                                                                                                                                                                 | N/A                                                                                                                                                                                                                           | N/A                              | N/A        |                                    |               | N/A                                        | 330                |
| SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m))                                                                                                                                                                                                                                                                                                                                                                | N/A                                                                                                                                                                                                                           | N/A                              | N/A        |                                    |               | N/A                                        | 540                |
| EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q))                                                                                                                                                                                                                                                                                                                                                           | N/A                                                                                                                                                                                                                           | N/A                              | N/A        |                                    |               | N/A                                        | 220                |
| TOTAL CLAIMS<br>(37 CFR 1.16(i))                                                                                                                                                                                                                                                                                                                                                                           | 17                                                                                                                                                                                                                            | minus 20 = *                     |            |                                    | OR            | x 52 =                                     | 0.00               |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h))                                                                                                                                                                                                                                                                                                                                                                     | 2                                                                                                                                                                                                                             | minus 3 = *                      |            |                                    |               | x 220 =                                    | 0.00               |
| APPLICATION SIZE FEE<br>(37 CFR 1.16(s))                                                                                                                                                                                                                                                                                                                                                                   | If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$270 (\$135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). |                                  |            |                                    |               |                                            | 0.00               |
| MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            | 0.00               |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               |                                  | TOTAL      |                                    |               | TOTAL                                      | 1090               |
| * If the difference in column 1 is less than zero, enter "0" in column 2.                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
| <b>APPLICATION AS AMENDED - PART II</b>                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
| AMENDMENT A                                                                                                                                                                                                                                                                                                                                                                                                | (Column 1)                                                                                                                                                                                                                    |                                  | (Column 2) |                                    | (Column 3)    |                                            | SMALL ENTITY       |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               | CLAIMS REMAINING AFTER AMENDMENT |            | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA |                                            | RATE(\$)           |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Total<br>(37 CFR 1.16(i))                                                                                                                                                                                                     | *                                | Minus      | **                                 | =             |                                            | ADDITIONAL FEE(\$) |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Independent<br>(37 CFR 1.16(h))                                                                                                                                                                                               | *                                | Minus      | ***                                | =             |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Application Size Fee (37 CFR 1.16(s))                                                                                                                                                                                         |                                  |            |                                    |               |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            | FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               |                                  |            |                                    |               | TOTAL<br>ADD'L FEE                         |                    |
| AMENDMENT B                                                                                                                                                                                                                                                                                                                                                                                                | (Column 1)                                                                                                                                                                                                                    |                                  | (Column 2) |                                    | (Column 3)    |                                            | SMALL ENTITY       |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               | CLAIMS REMAINING AFTER AMENDMENT |            | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA |                                            | RATE(\$)           |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Total<br>(37 CFR 1.16(i))                                                                                                                                                                                                     | *                                | Minus      | **                                 | =             |                                            | ADDITIONAL FEE(\$) |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Independent<br>(37 CFR 1.16(h))                                                                                                                                                                                               | *                                | Minus      | ***                                | =             |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Application Size Fee (37 CFR 1.16(s))                                                                                                                                                                                         |                                  |            |                                    |               |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            | FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               |                                  |            |                                    |               | TOTAL<br>ADD'L FEE                         |                    |
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3.<br>** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".<br>*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".<br>The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1. |                                                                                                                                                                                                                               |                                  |            |                                    |               |                                            |                    |



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|-----------------------|--------------------------|-----------------|---------------|----------------|------------|------------|
| 12/965,019            | 12/10/2010               | 2875            | 1090          | AEII-172-H     | 17         | 2          |

CONFIRMATION NO. 5912

FILING RECEIPT



OC00000045102774

48980  
YOUNG BASILE  
3001 WEST BIG BEAVER ROAD  
SUITE 624  
TROY, MI 48084

Date Mailed: 12/28/2010

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

**Applicant(s)**

Jos Timmermans, Ortonville, MI;  
Jean Raymond, Nominique, CANADA;  
John Ivey, Farmington Hills, MI;

**Assignment For Published Patent Application**

ALTAIR ENGINEERING, INC., Troy, MI

**Power of Attorney:** None

**Domestic Priority data as claimed by applicant**

This application is a CON of 11/085,744 03/21/2005  
which is a CON of 09/782,375 02/12/2001 PAT 7,049,761  
which claims benefit of 60/181,744 02/11/2000

**Foreign Applications**

**If Required, Foreign Filing License Granted:** 12/22/2010

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/965,019**

**Projected Publication Date:** To Be Determined - pending completion of Missing Parts

**Non-Publication Request:** No

**Early Publication Request:** No

**Title**

LIGHT TUBE AND POWER SUPPLY CIRCUIT

**Preliminary Class**

362

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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Our Reference: AEII-172-H

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Jos Timmermans et al.  
Serial Number: Unknown  
Filing Date: Herewith  
Examiner/Art Group Unit: Unknown  
Title: LIGHT TUBE AND POWER SUPPLY CIRCUIT

**PRELIMINARY AMENDMENT**

Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

Sir:

If any charges or fees must be paid in connection with the following communication, they may be paid out of our Deposit Account No. 25-0115.

Before the calculation of fees and before examination, please make the amendments shown in the attached papers in this application in the:

- ☐ Amendments to the Abstract.
- ☒ Amendments to the Specification.
- ☒ Amendments to the Claims.
- ☐ Amendments to the Drawings.

Application Serial No. Unknown  
Preliminary Amendment  
Dated: December 10, 2010

Page 2 of 6

**Amendments to the Specification:**

Please enter the attached Substitute Specification in the subject application.



**Listing of the Claims:**

1. (Currently amended) A light ~~tube~~ device for illumination by a power supply circuit comprising:
  - a bulb portion,
  - a pair of end caps disposed at opposite ends of the bulb portion, the pair of end caps including:
    - a first end cap disposed at one end of the bulb portion; and
    - a second end cap disposed at an end of bulb portion opposite the first end cap, wherein the bulb portion and the pair of end caps are dimensioned to be mounted in a flourescent light tube socket; and
  - a plurality of light emitting diodes disposed inside the bulb portion ~~and in electrical communication with~~ along one surface of a circuit board extending between the pair of end caps for illuminating in response to electrical current to be received from the power supply circuit; and wherein each of the plurality of light emitting diodes is mounted at an angle with respect to surface of the circuit board to establish a predetermined radiation pattern of light emitted from the bulb portion between the pair of end caps.
2. (Canceled).
3. (Currently amended) The light tube of claim 2-1 wherein each of the pair of end caps ~~are includes an electrical bi-pin-connectors~~ connector.
4. (Canceled).
5. (Currently amended) In a replacement light tube for a flourescent light fixture having a light tube socket ~~and a power supply circuit~~, the improvement comprising:
  - a plurality of light emitting diodes disposed ~~inside a~~ along a length of the bulb portion between a first end cap and a second end cap mounted on opposite ends of

the bulb portion; and

in an electrical communication with a pair of end caps circuit for  
illuminating in response to electrical current to be received from the fluorescent light  
fixture, the electrical circuit including at least a rectifier and a current-limiting circuit.

6. (Currently amended) The improvement of claim 5 wherein the plurality of light emitting diodes are mounted ~~to~~ on only one side of a circuit board.

7. (Canceled).

8. (New) The improvement of claim 6 wherein each of the plurality of light emitting diodes is a white light emitting diode.

9. (New) The improvement of claim 5, further comprising:  
a circuit that modulates a frequency of light emitted from the plurality of light emitting diodes above a nominal variation of 120 to 100 Hz.

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

11. (New) The improvement of claim 5 wherein at least one of the first end cap and the second end cap includes an inductive receiver.

12. (New) The improvement of claim 11 wherein the inductive receiver is an antenna.

13. (New) The improvement of claim 6 wherein the radiation pattern of light from each of the plurality of light emitting diodes is centered at a 90° angle relative to the circuit board.

14. (New) The improvement of claim 5 wherein the plurality of light emitting diodes is arranged substantially continuously along the length of the bulb portion.

15. (New) The light device of claim 1 wherein each of the plurality of light emitting diodes is a white light emitting diode.

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

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

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

19. (New) The light device of claim 18 wherein the inductive receiver is an antenna.

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

**REMARKS**

With this Preliminary Amendment, Applicants have amended claims 1, 3, 5 and 6. Claims 2, 4 and 7 are canceled, and claims 8-20 are added. After entry of this Amendment, claims 1, 4, 5, 6 and 8-20 are pending in the Application. Consideration of the Application is respectfully requested.

Applicants have amended the first paragraph of the specification to provide a description of the priority claims for this Application. This change is included in the enclosed Substitute Specification. A version of the specification as originally filed showing this change is also submitted.

It is respectfully submitted that this Preliminary Amendment has antecedent basis in the application as originally filed, including the specification, claims and drawings, and that this Preliminary Amendment does not add any new subject matter to the application. Applicants respectfully request examination and allowance of the subject application.

If the Examiner believes that prosecution of this case would be advanced by an Examiner's amendment, the Examiner is invited to contact the undersigned at the telephone number listed below.

Respectfully submitted,

YOUNG BASILE  
HANLON & MACFARLANE P.C.

/Michelle L. Knight/

Michelle L. Knight  
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**SPECIFICATION WITH MARKINGS TO SHOW CHANGES MADE**  
**LIGHT TUBE AND POWER SUPPLY CIRCUIT**

**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001].....This application is a continuation of U.S. Patent Application No. 11/085,744, filed March 21, 2005, which is a continuation of U.S. Patent Application No. 09/782,375, filed February 12, 2001 and issued as U.S. Patent No. 7,049,761 on May 23, 2006, which claims the benefit of U.S. Provisional Application No. 60/181,744 filed February 11, 2000.

**FIELD OF THE INVENTION**

[0002].....The present invention relates to a light tube illuminated by LEDs (light emitting diodes) which are packaged inside the light tube and powered by a power supply circuit.

**BACKGROUND OF THE INVENTION**

[0003].....Conventional fluorescent lighting systems include fluorescent light tubes and ballasts. Such lighting systems are used in a variety of locations, such as buildings and transit buses, for a variety of lighting purposes, such as area lighting or backlighting. Although conventional fluorescent lighting systems have some advantages over known lighting options, such as incandescent lighting systems, conventional fluorescent light tubes and ballasts have several shortcomings. Conventional fluorescent light tubes have a short life expectancy, are prone to fail when subjected to excessive vibration, consume high amounts of power, require a high operating voltage, and include several electrical connections which reduce reliability. Conventional ballasts are highly prone to fail when subjected to excessive vibration. Accordingly, there is a desire to provide a light tube and power supply circuit which overcome the shortcomings of conventional fluorescent lighting systems. That is, there is a desire to provide a light tube and power supply circuit which have a long life expectancy, are resistant to vibration failure, consume low amounts of power,

operate on a low voltage, and are highly reliable. It would also be desirable for such a light tube to mount within a conventional fluorescent light tube socket.

#### SUMMARY OF THE INVENTION

[0004] A light tube for illumination by a power supply circuit including a bulb portion and a pair of end caps disposed at opposite ends of the bulb portion. A plurality of light emitting diodes are disposed inside the bulb portion and in electrical communication with the pair of end caps for illuminating in response to electrical current to be received from the power supply circuit.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0006] Figure 1 is a line drawing showing a light tube, in perspective view, which in accordance with the present invention is illuminated by LEDs packaged inside the light tube;

[0007] Figure 2 is a perspective view of the LEDs mounted on a circuit board;

[0008] Figure 3 is a cross-sectional view of Figure 2 taken along lines 3-3;

[0009] Figure 4 is a fragmentary, perspective view of one embodiment of the present invention showing one end of the light tube disconnected from one end of a light tube socket;

[00010] Figure 5 is an electrical block diagram of a first power supply circuit for supplying power to the light tube;

[00011] Figure 6 is an electrical schematic of a switching power supply type current limiter;

[00012] Figure 7 is an electrical block diagram of a second power supply circuit for supplying power to the light tube;

[00013] Figure 8 is an electrical block diagram of a third power supply circuit for supplying power to the light tube;

[00014] Figure 9 is a fragmentary, perspective view of another embodiment of the present invention showing one end of the light tube disconnected from one end of the light tube socket; and

[000151] Figure 10 is an electrical block diagram of a fourth power supply circuit for supplying power to the light tube.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

[000161] Figure 1 is a line drawing showing a light tube 20 in perspective view. In accordance with the present invention, the light tube 20 is illuminated by LEDs 22 packaged inside the light tube 20. The light tube 20 includes a cylindrically shaped bulb portion 24 having a pair of end caps 26 and 28 disposed at opposite ends of the bulb portion. Preferably, the bulb portion 24 is made from a transparent or translucent material such as glass, plastic, or the like. As such, the bulb material may be either clear or frosted.

[000171] In a preferred embodiment of the present invention, the light tube 20 has the same dimensions and end caps 26 and 28 (e.g. electrical male bi-pin connectors, type G13) as a conventional fluorescent light tube. As such, the present invention can be mounted in a conventional fluorescent light tube socket (not shown).

[000181] The line drawing of Figure 1 also reveals the internal components of the light tube 20. The light tube 20 further includes a circuit board 30 with the LEDs 22 mounted thereon. The circuit board 30 and LEDs 22 are enclosed inside the bulb portion 24 and the end caps 26 and 28.

[000191] Figure 2 is a perspective view of the LEDs 22 mounted on the circuit board 30.

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

[000201] Figure 3 is a cross-sectional view of Figure 2 taken along lines 3-3. To provide structural strength along the length of the light tube 20, the circuit board 30 is designed with a H-shaped cross-section. To produce a predetermined radiation pattern or dispersion of light from the light tube 20, each LED 22 is mounted at an angle relative to adjacent LEDs and/or the mounting surface 32. The total radiation pattern of light from the light tube 20 is effected by (1) the mounting angle of the LEDs 22 and (2) the radiation pattern of light from each LED. Currently, white LEDs having a viewing range between 6° and 45° are commercially available.

[000211] Figure 4 is a fragmentary, perspective view of one embodiment of the present invention showing one end of the light tube 20 disconnected from one end of a light tube socket 40. Similar to conventional fluorescent lighting systems and in this embodiment of the present invention, the light tube socket 40 includes a pair of electrical female connectors 42 and the light tube 20 includes a pair of mating electrical male connectors 44.

[000221] Within the scope of the present invention, the light tube 20 may be powered by one of four power supply circuits 100, 200, 300, and 400. A first power supply circuit includes a power source and a conventional fluorescent ballast. A second power supply circuit includes a power source and a rectifier/filter circuit. A third power supply circuit includes a DC power source and a PWM (Pulse Width Modulation) circuit. A fourth power supply circuit powers the light tube 20 inductively.

[000231] Figure 5 is an electrical block diagram of a first power supply circuit 100 for supplying power to the light tube 20. The first power supply circuit 100 is particularly adapted to operate within an existing, conventional fluorescent lighting system. As such, the first power supply circuit 100 includes a conventional fluorescent light tube socket 40 having two electrical female connectors 42 disposed at opposite ends of the socket. Accordingly, a light tube 20 particularly adapted for use with the first power supply circuit 100 includes two end caps 26 and 28, each end cap having the form of an electrical male connector 44 which mates with a corresponding electrical female connector 42 in the socket 40.

[000241] The first power supply circuit 100 also includes a power source 46 and a conventional magnetic or electronic fluorescent ballast 48. The power source 46 supplies power to the conventional fluorescent ballast 48.



[000251].....The first power supply circuit 100 further includes a rectifier/filter circuit 50, a PWM circuit 52, and one or more current-limiting circuits 54. The rectifier/filter circuit 50, the PWM circuit 52, and the one or more current-limiting circuits 54 of the first power supply circuit 100 are packaged inside one of the two end caps 26 or 28 of the light tube 20.

[000261].....The rectifier/filter circuit 50 receives AC power from the ballast 48 and converts the AC power to DC power. The PWM circuit 52 receives the DC power from the rectifier/filter circuit 50 and pulse-width modulates the DC power to the one or more current-limiting circuits 54. In a preferred embodiment of the present invention, the PWM circuit 52 receives the DC power from the rectifier/filter circuit 50 and cyclically switches the DC power on and off to the one or more current-limiting circuits 54. The DC power is switched on and off by the PWM circuit 52 at a frequency which causes the white light emitted from the LEDs 22 to appear, when viewed with a "naked" human eye, to shine continuously. The PWM duty cycle can be adjusted or varied by control circuitry (not shown) to maintain the power consumption of the LEDs 22 at safe levels.

[000271].....The DC power is modulated for several reasons. First, the DC power is modulated to adjust the brightness or intensity of the white light emitted from the LEDs 22 and, in turn, adjust the brightness or intensity of the white light emitted from the light tube 20.

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

[000281].....The one or more current-limiting circuits 54 receive the pulse-width modulated or switched DC power from the PWM circuit 52 and transmit a regulated amount

of power to one or more arrays of LEDs 22. Each current-limiting circuit 54 powers a bank of one or more white LEDs 22. If a bank of LEDs 22 consists of more than one LED, the LEDs are electrically connected in series in an anode to cathode arrangement. If brightness or intensity variation between the LEDs 22 can be tolerated, the LEDs can be electrically connected in parallel.

[000291].....The one or more current-limiting circuits 54 may include (1) a resistor, (2) a current-limiting semiconductor circuit, or (3) a switching power supply type current limiter.

[000301].....Figure 6 is an electrical schematic of a switching power supply type current limiter 56. The limiter 56 includes an inductor 58, electrically connected in series between the PWM circuit 52 and the array of LEDs 22, and a power diode 60, electrically connected between ground 62 and a PWM circuit/inductor node 64. The diode 60 is designed to begin conduction after the PWM circuit 52 is switched off. In this case, the value of the inductor 58 is adjusted in conjunction with the PWM duty cycle to provide the benefits described above. The switching power supply type current limiter 56 provides higher power efficiency than the other types of current-limiting circuits listed above.

[000311].....Figure 7 is an electrical block diagram of a second power supply circuit 200 for supplying power to the light tube 20. Similar to the first power supply circuit 100, the second power supply circuit 200 includes a conventional fluorescent light tube socket 40 having two electrical female connectors 42 disposed at opposite ends of the socket 40. Accordingly, a light tube 20 particularly adapted for use with the second power supply circuit 200 includes two end caps 26 and 28, each end cap having the form of an electrical male connector 44 which mates with a corresponding electrical female connector 42 in the socket 40.

[000321].....In the second power supply circuit 200, the power source 46 supplies power directly to the rectifier/filter circuit 50. The rectifier/filter circuit 50, the PWM circuit 52, and the one or more current-limiting circuits 54 operate as described above to power the one or more arrays of LEDs 22. The rectifier/filter circuit 50, the PWM circuit 52, and the one or more current-limiting circuits 54 of the second power supply circuit 200 are preferably packaged inside the end caps 26 and 28 or the bulb portion 24 of the light tube 20 or inside the light tube socket 40.

[000331] Figure 8 is an electrical block diagram of a third power supply circuit 300 for supplying power to the light tube 20. Similar to the first and second power supply circuits 100 and 200, the third power supply circuit 300 includes a conventional fluorescent light tube socket 40 having two electrical female connectors 42 disposed at opposite ends of the socket 40. Accordingly, a light tube 20 particularly adapted for use with the third power supply circuit 300 includes two end caps 26 and 28, each end cap having the form of an electrical male connector 44 which mates with a corresponding electrical female connector 42 in the socket 40.

[000341] The third power supply circuit 300 includes a DC power source 66, such as a vehicle battery. In the third power supply circuit 300, the DC power source 66 supplies DC power directly to the PWM circuit 52. The PWM circuit 52 and the one or more current-limiting circuits 54 operate as described above to power the one or more arrays of LEDs 22. In the third power supply circuit 300, the PWM circuit 52 is preferably packaged in physical location typically occupied by the ballast of a conventional fluorescent lighting system while the one or more current-limiting circuits 54 and LEDs 22 are preferably packaged inside the light tube 20, in either one of the two end caps 26 or 28 or the bulb portion 24.

[000351] Figure 9 is a fragmentary, perspective view of another embodiment of the present invention showing one end of the light tube 20 disconnected from one end of the light tube socket 40. In this embodiment of the present invention, the light tube socket 40 includes a pair of brackets 68 and the light tube 20 includes a pair of end caps 26 and 28 which mate with the brackets 68.

[000361] Figure 10 is an electrical block diagram of a fourth power supply circuit 400 for supplying power to the light tube 20. Unlike the first, second, and third power supply circuits 100, 200, and 300 which are powered through direct electrical male and female connectors 44 and 42, the fourth power supply circuit 400 is powered inductively. As such, the fourth power supply circuit 400 includes a light tube socket 40 having two brackets 68 disposed at opposite ends of the socket 40. At least one bracket 68 includes an inductive transmitter 70. Accordingly, a light tube 20 particularly adapted for use with the fourth power supply circuit 400 has two end caps 26 and 28 with at least one end cap including an inductive receiver or antenna 72. When the light tube 20 is mounted in the light tube socket

40, the at least one inductive receiver 72 in the light tube 20 is disposed adjacent to the at least one inductive transmitter 70 in the light tube socket 40.

1000371.....The fourth power supply circuit 400 includes the power source 46 which supplies power to the at least one inductive transmitter 70 in the light tube socket 40. The at least one transmitter 70 inductively supplies power to the at least one receiver 72 in one of the end caps 26 and/or 28 of the light tube 20. The at least one inductive receiver 72 supplies power to the rectifier/filter circuit 50. The rectifier/filter circuit 50, PWM circuit 52, and the one or more current-limiting circuits 54 operate as described above to power the one or more arrays of LEDs 22. In this manner, the light tube 20 is powered without direct electrical connection.

**SUBSTITUTE SPECIFICATION**

**LIGHT TUBE AND POWER SUPPLY CIRCUIT**

**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application is a continuation of U.S. Patent Application No. 11/085,744, filed March 21, 2005, which is a continuation of U.S. Patent Application No. 09/782,375, filed February 12, 2001 and issued as U.S. Patent No. 7,049,761 on May 23, 2006, which claims the benefit of U.S. Provisional Application No. 60/181,744 filed February 11, 2000.

**FIELD OF THE INVENTION**

[0002] The present invention relates to a light tube illuminated by LEDs (light emitting diodes) which are packaged inside the light tube and powered by a power supply circuit.

**BACKGROUND OF THE INVENTION**

[0003] Conventional fluorescent lighting systems include fluorescent light tubes and ballasts. Such lighting systems are used in a variety of locations, such as buildings and transit buses, for a variety of lighting purposes, such as area lighting or backlighting. Although conventional fluorescent lighting systems have some advantages over known lighting options, such as incandescent lighting systems, conventional fluorescent light tubes and ballasts have several shortcomings. Conventional fluorescent light tubes have a short life expectancy, are prone to fail when subjected to excessive vibration, consume high amounts of power, require a high operating voltage, and include several electrical connections which reduce reliability. Conventional ballasts are highly prone to fail when subjected to excessive vibration. Accordingly, there is a desire to provide a light tube and power supply circuit which overcome the shortcomings of conventional fluorescent lighting systems. That is, there is a desire to provide a light tube and power supply circuit which have a long life expectancy, are resistant to vibration failure, consume low amounts of power,

operate on a low voltage, and are highly reliable. It would also be desirable for such a light tube to mount within a conventional fluorescent light tube socket.

### SUMMARY OF THE INVENTION

[0004] A light tube for illumination by a power supply circuit including a bulb portion and a pair of end caps disposed at opposite ends of the bulb portion. A plurality of light emitting diodes are disposed inside the bulb portion and in electrical communication with the pair of end caps for illuminating in response to electrical current to be received from the power supply circuit.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0006] Figure 1 is a line drawing showing a light tube, in perspective view, which in accordance with the present invention is illuminated by LEDs packaged inside the light tube;

[0007] Figure 2 is a perspective view of the LEDs mounted on a circuit board;

[0008] Figure 3 is a cross-sectional view of Figure 2 taken along lines 3-3;

[0009] Figure 4 is a fragmentary, perspective view of one embodiment of the present invention showing one end of the light tube disconnected from one end of a light tube socket;

[00010] Figure 5 is an electrical block diagram of a first power supply circuit for supplying power to the light tube;

[00011] Figure 6 is an electrical schematic of a switching power supply type current limiter;

[00012] Figure 7 is an electrical block diagram of a second power supply circuit for supplying power to the light tube;

[00013] Figure 8 is an electrical block diagram of a third power supply circuit for supplying power to the light tube;

[00014] Figure 9 is a fragmentary, perspective view of another embodiment of the present invention showing one end of the light tube disconnected from one end of the light tube socket; and

[00015] Figure 10 is an electrical block diagram of a fourth power supply circuit for supplying power to the light tube.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

[00016] Figure 1 is a line drawing showing a light tube 20 in perspective view. In accordance with the present invention, the light tube 20 is illuminated by LEDs 22 packaged inside the light tube 20. The light tube 20 includes a cylindrically shaped bulb portion 24 having a pair of end caps 26 and 28 disposed at opposite ends of the bulb portion. Preferably, the bulb portion 24 is made from a transparent or translucent material such as glass, plastic, or the like. As such, the bulb material may be either clear or frosted.

[00017] In a preferred embodiment of the present invention, the light tube 20 has the same dimensions and end caps 26 and 28 (e.g. electrical male bi-pin connectors, type G13) as a conventional fluorescent light tube. As such, the present invention can be mounted in a conventional fluorescent light tube socket (not shown).

[00018] The line drawing of Figure 1 also reveals the internal components of the light tube 20. The light tube 20 further includes a circuit board 30 with the LEDs 22 mounted thereon. The circuit board 30 and LEDs 22 are enclosed inside the bulb portion 24 and the end caps 26 and 28.

[00019] Figure 2 is a perspective view of the LEDs 22 mounted on the circuit board 30.

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

[00020] Figure 3 is a cross-sectional view of Figure 2 taken along lines 3-3. To provide structural strength along the length of the light tube 20, the circuit board 30 is designed with a H-shaped cross-section. To produce a predetermined radiation pattern or dispersion of light from the light tube 20, each LED 22 is mounted at an angle relative to adjacent LEDs and/or the mounting surface 32. The total radiation pattern of light from the light tube 20 is effected by (1) the mounting angle of the LEDs 22 and (2) the radiation pattern of light from each LED. Currently, white LEDs having a viewing range between 6° and 45° are commercially available.

[00021] Figure 4 is a fragmentary, perspective view of one embodiment of the present invention showing one end of the light tube 20 disconnected from one end of a light tube socket 40. Similar to conventional fluorescent lighting systems and in this embodiment of the present invention, the light tube socket 40 includes a pair of electrical female connectors 42 and the light tube 20 includes a pair of mating electrical male connectors 44.

[00022] Within the scope of the present invention, the light tube 20 may be powered by one of four power supply circuits 100, 200, 300, and 400. A first power supply circuit includes a power source and a conventional fluorescent ballast. A second power supply circuit includes a power source and a rectifier/filter circuit. A third power supply circuit includes a DC power source and a PWM (Pulse Width Modulation) circuit. A fourth power supply circuit powers the light tube 20 inductively.

[00023] Figure 5 is an electrical block diagram of a first power supply circuit 100 for supplying power to the light tube 20. The first power supply circuit 100 is particularly adapted to operate within an existing, conventional fluorescent lighting system. As such, the first power supply circuit 100 includes a conventional fluorescent light tube socket 40 having two electrical female connectors 42 disposed at opposite ends of the socket. Accordingly, a light tube 20 particularly adapted for use with the first power supply circuit 100 includes two end caps 26 and 28, each end cap having the form of an electrical male connector 44 which mates with a corresponding electrical female connector 42 in the socket 40.

[00024] The first power supply circuit 100 also includes a power source 46 and a conventional magnetic or electronic fluorescent ballast 48. The power source 46 supplies power to the conventional fluorescent ballast 48.



[00025] The first power supply circuit 100 further includes a rectifier/filter circuit 50, a PWM circuit 52, and one or more current-limiting circuits 54. The rectifier/filter circuit 50, the PWM circuit 52, and the one or more current-limiting circuits 54 of the first power supply circuit 100 are packaged inside one of the two end caps 26 or 28 of the light tube 20.

[00026] The rectifier/filter circuit 50 receives AC power from the ballast 48 and converts the AC power to DC power. The PWM circuit 52 receives the DC power from the rectifier/filter circuit 50 and pulse-width modulates the DC power to the one or more current-limiting circuits 54. In a preferred embodiment of the present invention, the PWM circuit 52 receives the DC power from the rectifier/filter circuit 50 and cyclically switches the DC power on and off to the one or more current-limiting circuits 54. The DC power is switched on and off by the PWM circuit 52 at a frequency which causes the white light emitted from the LEDs 22 to appear, when viewed with a "naked" human eye, to shine continuously. The PWM duty cycle can be adjusted or varied by control circuitry (not shown) to maintain the power consumption of the LEDs 22 at safe levels.

[00027] The DC power is modulated for several reasons. First, the DC power is modulated to adjust the brightness or intensity of the white light emitted from the LEDs 22 and, in turn, adjust the brightness or intensity of the white light emitted from the light tube 20.

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

[00028] The one or more current-limiting circuits 54 receive the pulse-width modulated or switched DC power from the PWM circuit 52 and transmit a regulated amount

of power to one or more arrays of LEDs 22. Each current-limiting circuit 54 powers a bank of one or more white LEDs 22. If a bank of LEDs 22 consists of more than one LED, the LEDs are electrically connected in series in an anode to cathode arrangement. If brightness or intensity variation between the LEDs 22 can be tolerated, the LEDs can be electrically connected in parallel.

[00029] The one or more current-limiting circuits 54 may include (1) a resistor, (2) a current-limiting semiconductor circuit, or (3) a switching power supply type current limiter.

[00030] Figure 6 is an electrical schematic of a switching power supply type current limiter 56. The limiter 56 includes an inductor 58, electrically connected in series between the PWM circuit 52 and the array of LEDs 22, and a power diode 60, electrically connected between ground 62 and a PWM circuit/inductor node 64. The diode 60 is designed to begin conduction after the PWM circuit 52 is switched off. In this case, the value of the inductor 58 is adjusted in conjunction with the PWM duty cycle to provide the benefits described above. The switching power supply type current limiter 56 provides higher power efficiency than the other types of current-limiting circuits listed above.

[00031] Figure 7 is an electrical block diagram of a second power supply circuit 200 for supplying power to the light tube 20. Similar to the first power supply circuit 100, the second power supply circuit 200 includes a conventional fluorescent light tube socket 40 having two electrical female connectors 42 disposed at opposite ends of the socket 40. Accordingly, a light tube 20 particularly adapted for use with the second power supply circuit 200 includes two end caps 26 and 28, each end cap having the form of an electrical male connector 44 which mates with a corresponding electrical female connector 42 in the socket 40.

[00032] In the second power supply circuit 200, the power source 46 supplies power directly to the rectifier/filter circuit 50. The rectifier/filter circuit 50, the PWM circuit 52, and the one or more current-limiting circuits 54 operate as described above to power the one or more arrays of LEDs 22. The rectifier/filter circuit 50, the PWM circuit 52, and the one or more current-limiting circuits 54 of the second power supply circuit 200 are preferably packaged inside the end caps 26 and 28 or the bulb portion 24 of the light tube 20 or inside the light tube socket 40.

[00033] Figure 8 is an electrical block diagram of a third power supply circuit 300 for supplying power to the light tube 20. Similar to the first and second power supply circuits 100 and 200, the third power supply circuit 300 includes a conventional fluorescent light tube socket 40 having two electrical female connectors 42 disposed at opposite ends of the socket 40. Accordingly, a light tube 20 particularly adapted for use with the third power supply circuit 300 includes two end caps 26 and 28, each end cap having the form of an electrical male connector 44 which mates with a corresponding electrical female connector 42 in the socket 40.

[00034] The third power supply circuit 300 includes a DC power source 66, such as a vehicle battery. In the third power supply circuit 300, the DC power source 66 supplies DC power directly to the PWM circuit 52. The PWM circuit 52 and the one or more current-limiting circuits 54 operate as described above to power the one or more arrays of LEDs 22. In the third power supply circuit 300, the PWM circuit 52 is preferably packaged in physical location typically occupied by the ballast of a conventional fluorescent lighting system while the one or more current-limiting circuits 54 and LEDs 22 are preferably packaged inside the light tube 20, in either one of the two end caps 26 or 28 or the bulb portion 24.

[00035] Figure 9 is a fragmentary, perspective view of another embodiment of the present invention showing one end of the light tube 20 disconnected from one end of the light tube socket 40. In this embodiment of the present invention, the light tube socket 40 includes a pair of brackets 68 and the light tube 20 includes a pair of end caps 26 and 28 which mate with the brackets 68.

[00036] Figure 10 is an electrical block diagram of a fourth power supply circuit 400 for supplying power to the light tube 20. Unlike the first, second, and third power supply circuits 100, 200, and 300 which are powered through direct electrical male and female connectors 44 and 42, the fourth power supply circuit 400 is powered inductively. As such, the fourth power supply circuit 400 includes a light tube socket 40 having two brackets 68 disposed at opposite ends of the socket 40. At least one bracket 68 includes an inductive transmitter 70. Accordingly, a light tube 20 particularly adapted for use with the fourth power supply circuit 400 has two end caps 26 and 28 with at least one end cap including an inductive receiver or antenna 72. When the light tube 20 is mounted in the light tube socket

40, the at least one inductive receiver 72 in the light tube 20 is disposed adjacent to the at least one inductive transmitter 70 in the light tube socket 40.

[00037] The fourth power supply circuit 400 includes the power source 46 which supplies power to the at least one inductive transmitter 70 in the light tube socket 40. The at least one transmitter 70 inductively supplies power to the at least one receiver 72 in one of the end caps 26 and/or 28 of the light tube 20. The at least one inductive receiver 72 supplies power to the rectifier/filter circuit 50. The rectifier/filter circuit 50, PWM circuit 52, and the one or more current-limiting circuits 54 operate as described above to power the one or more arrays of LEDs 22. In this manner, the light tube 20 is powered without direct electrical connection.

| Electronic Patent Application Fee Transmittal |          |                                     |        |                      |
|-----------------------------------------------|----------|-------------------------------------|--------|----------------------|
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| Filing Date:                                  |          |                                     |        |                      |
| Title of Invention:                           |          | LIGHT TUBE AND POWER SUPPLY CIRCUIT |        |                      |
| First Named Inventor/Applicant Name:          |          | Jos Timmermans                      |        |                      |
| Filer:                                        |          | Michelle L. Knight/Joan Leighton    |        |                      |
| Attorney Docket Number:                       |          | AEII-172-H                          |        |                      |
| Filed as Large Entity                         |          |                                     |        |                      |
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| Description                                   | Fee Code | Quantity                            | Amount | Sub-Total in USD(\$) |
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| Utility application filing                    | 1011     | 1                                   | 330    | 330                  |
| Utility Search Fee                            | 1111     | 1                                   | 540    | 540                  |
| Utility Examination Fee                       | 1311     | 1                                   | 220    | 220                  |
| Pages:                                        |          |                                     |        |                      |
| Claims:                                       |          |                                     |        |                      |
| Miscellaneous-Filing:                         |          |                                     |        |                      |
| Petition:                                     |          |                                     |        |                      |
| Patent-Appeals-and-Interference:              |          |                                     |        |                      |

| Description                       | Fee Code | Quantity | Amount | Sub-Total in USD(\$) |
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| Post-Allowance-and-Post-Issuance: |          |          |        |                      |
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| <b>Confirmation Number:</b>                 | 5912                                |
| <b>Title of Invention:</b>                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |
| <b>First Named Inventor/Applicant Name:</b> | Jos Timmermans                      |
| <b>Customer Number:</b>                     | 48980                               |
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## File Listing:

| Document Number | Document Description                                | File Name               | File Size(Bytes)/<br>Message Digest      | Multi Part /.zip | Pages (if appl.) |
|-----------------|-----------------------------------------------------|-------------------------|------------------------------------------|------------------|------------------|
| 1               |                                                     | AEI172H_Application.pdf | 50442                                    | yes              | 13               |
|                 |                                                     |                         | 51e070d6f4e1287460abb27dbb75a183e843250f |                  |                  |
|                 | Multipart Description/PDF files in .zip description |                         |                                          |                  |                  |
|                 | Document Description                                |                         | Start                                    | End              |                  |
|                 | Specification                                       |                         | 1                                        | 10               |                  |
|                 | Claims                                              |                         | 11                                       | 12               |                  |
|                 | Abstract                                            |                         | 13                                       | 13               |                  |
| Warnings:       |                                                     |                         |                                          |                  |                  |
| Information:    |                                                     |                         |                                          |                  |                  |
| 2               | Drawings-only black and white line drawings         | AEI172H_Dwgs2.pdf       | 196697                                   | no               | 9                |
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| 3               | Application Data Sheet                              | AEI172H_ADS.pdf         | 1036085                                  | no               | 5                |
|                 |                                                     |                         | d227d5d87863b9197fa3ace4477bd9c2a8d9b284 |                  |                  |
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| 4               |                                                     | AEI172H_Prelim_Amd.pdf  | 31422                                    | yes              | 6                |
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|                 | Multipart Description/PDF files in .zip description |                         |                                          |                  |                  |
|                 | Document Description                                |                         | Start                                    | End              |                  |
|                 | Preliminary Amendment                               |                         | 1                                        | 1                |                  |
|                 | Specification                                       |                         | 2                                        | 2                |                  |
|                 | Claims                                              |                         | 3                                        | 5                |                  |
|                 | Applicant Arguments/Remarks Made in an Amendment    |                         | 6                                        | 6                |                  |
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| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                        |                                                       |    |   |
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| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                        |                                                       |    |   |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                        |                                                       |    |   |
| 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Fee Worksheet (PTO-875)                          | fee-info.pdf                           | 32972<br><br>a79c815b081e6b428efb00fd43654239da03c739 | no | 2 |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                        |                                                       |    |   |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                        |                                                       |    |   |
| <b>Total Files Size (in bytes):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                        | 1434677                                               |    |   |
| <p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b><br/> <b>If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</b></p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b><br/> <b>If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</b></p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b><br/> <b>If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</b></p> |                                                  |                                        |                                                       |    |   |

Our Reference: AEI-172B

**LIGHT TUBE AND POWER SUPPLY CIRCUIT**

CROSS-REFERENCE TO RELATED APPLICATIONS

5           This application claims the benefit of U.S.  
Provisional Application No. 60/181,744 filed February 11,  
2000.

FIELD OF THE INVENTION

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

BACKGROUND OF THE INVENTION

15           Conventional fluorescent lighting systems include  
fluorescent light tubes and ballasts. Such lighting systems  
are used in a variety of locations, such as buildings and  
transit buses, for a variety of lighting purposes, such as  
area lighting or backlighting. Although conventional  
fluorescent lighting systems have some advantages over known  
20           lighting options, such as incandescent lighting systems,  
conventional fluorescent light tubes and ballasts have several  
shortcomings. Conventional fluorescent light tubes have  
a short life expectancy, are prone to fail when subjected  
to excessive vibration, consume high amounts of power, require  
25           a high operating voltage, and include several electrical  
connections which reduce reliability. Conventional ballasts  
are highly prone to fail when subjected to excessive vibration.

          Accordingly, there is a desire to provide a light tube and  
power supply circuit which overcome the shortcomings of  
30           conventional fluorescent lighting systems. That is, there  
is a desire to provide a light tube and power supply circuit  
which have a long life expectancy, are resistant to vibration  
failure, consume low amounts of power, operate on a low voltage,  
and are highly reliable. It would also be desirable for  
35           such a light tube to mount within a conventional fluorescent  
light tube socket.

### SUMMARY OF THE INVENTION

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

10

### BRIEF DESCRIPTION OF THE DRAWINGS

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

15

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

20

Figure 2 is a perspective view of the LEDs mounted on a circuit board;

25

Figure 3 is a cross-sectional view of Figure 2 taken along lines 3-3;

30

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

35

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

Figure 6 is an electrical schematic of a switching power supply type current limiter;

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

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

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

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

DESCRIPTION OF THE PREFERRED EMBODIMENT

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

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

The line drawing of Figure 1 also reveals the internal components of the light tube 20. The light tube 20 further includes a circuit board 30 with the LEDs 22 mounted

thereon. The circuit board 30 and LEDs 22 are enclosed inside the bulb portion 24 and the end caps 26 and 28.

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

Figure 3 is a cross-sectional view of Figure 2 taken along lines 3-3. To provide structural strength along the length of the light tube 20, the circuit board 30 is designed with a H-shaped cross-section. To produce a predetermined radiation pattern or dispersion of light from the light tube 20, each LED 22 is mounted at an angle relative to adjacent LEDs and/or the mounting surface 32. The total radiation pattern of light from the light tube 20 is effected by (1) the mounting angle of the LEDs 22 and (2) the radiation pattern of light from each LED. Currently, white LEDs having a viewing range between 6° and 45° are commercially available.

Figure 4 is a fragmentary, perspective view of one embodiment of the present invention showing one end of

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

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

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

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

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

The rectifier/filter circuit 50 receives AC power  
10 from the ballast 48 and converts the AC power to DC power. The PWM circuit 52 receives the DC power from the rectifier/filter circuit 50 and pulse-width modulates the DC power to the one or more current-limiting circuits 54.

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

25 The DC power is modulated for several reasons. First, the DC power is modulated to adjust the brightness or intensity of the white light emitted from the LEDs 22 and, in turn, adjust the brightness or intensity of the white light emitted from the light tube 20. Optionally, the  
30 brightness or intensity of the white light emitted from the light tube 20 may be adjusted by a user. Second, the DC power is modulated to improve the illumination efficiency of the light tube 20 by capitalizing upon a phenomenon in which short pulses of light at high brightness or intensity  
35 to appear brighter than a continuous, lower brightness or intensity of light having the same average power. Third,

the DC power is modulated to regulate the intensity of light emitted from the light tube 20 to compensate for supply voltage fluctuations, ambient temperature changes, and other such factors which effect the intensity of white light emitted by the LEDs 22. Fourth, the DC power is modulated to raise the variations of the frequency of light above the nominal variation of 120 to 100 Hz thereby reducing illumination artifacts caused by low frequency light variations, including interactions with video screens. Fifth, the DC power may optionally be modulated to provide an alarm function wherein light from the light tube 20 cyclically flashes on and off.

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

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

Figure 6 is an electrical schematic of a switching power supply type current limiter 56. The limiter 56 includes an inductor 58, electrically connected in series between the PWM circuit 52 and the array of LEDs 22, and a power diode 60, electrically connected between ground 62 and a PWM circuit/inductor node 64. The diode 60 is designed to begin conduction after the PWM circuit 52 is switched off. In this case, the value of the inductor 58 is adjusted in conjunction with the PWM duty cycle to provide the benefits



described above. The switching power supply type current limiter 56 provides higher power efficiency than the other types of current-limiting circuits listed above.

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

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

              Figure 8 is an electrical block diagram of a third power supply circuit 300 for supplying power to the light  
30 tube 20. Similar to the first and second power supply circuits 100 and 200, the third power supply circuit 300 includes a conventional fluorescent light tube socket 40 having two electrical female connectors 42 disposed at opposite ends of the socket 40. Accordingly, a light tube 20 particularly  
35 adapted for use with the third power supply circuit 300 includes two end caps 26 and 28, each end cap having the form of an

electrical male connector 44 which mates with a corresponding electrical female connector 42 in the socket 40.

5 The third power supply circuit 300 includes a DC power source 66, such as a vehicle battery. In the third power supply circuit 300, the DC power source 66 supplies DC power directly to the PWM circuit 52. The PWM circuit 52 and the one or more current-limiting circuits 54 operate as described above to power the one or more arrays of LEDs 22. In the third power supply circuit 300, the PWM circuit 10 52 is preferably packaged in physical location typically occupied by the ballast of a conventional fluorescent lighting system while the one or more current-limiting circuits 54 and LEDs 22 are preferably packaged inside the light tube 20, in either one of the two end caps 26 or 28 or the bulb 15 portion 24.

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

25

Figure 10 is an electrical block diagram of a fourth power supply circuit 400 for supplying power to the light tube 20. Unlike the first, second, and third power supply circuits 100, 200, and 300 which are powered through direct 30 electrical male and female connectors 44 and 42, the fourth power supply circuit 400 is powered inductively. As such, the fourth power supply circuit 400 includes a light tube socket 40 having two brackets 68 disposed at opposite ends of the socket 40. At least one bracket 68 includes an inductive transmitter 70. Accordingly, a light tube 20 particularly 35 adapted for use with the fourth power supply circuit 400

has two end caps 26 and 28 with at least one end cap including an inductive receiver or antenna 72. When the light tube 20 is mounted in the light tube socket 40, the at least one inductive receiver 72 in the light tube 20 is disposed adjacent to the at least one inductive transmitter 70 in the light tube socket 40.

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

What is claimed is:

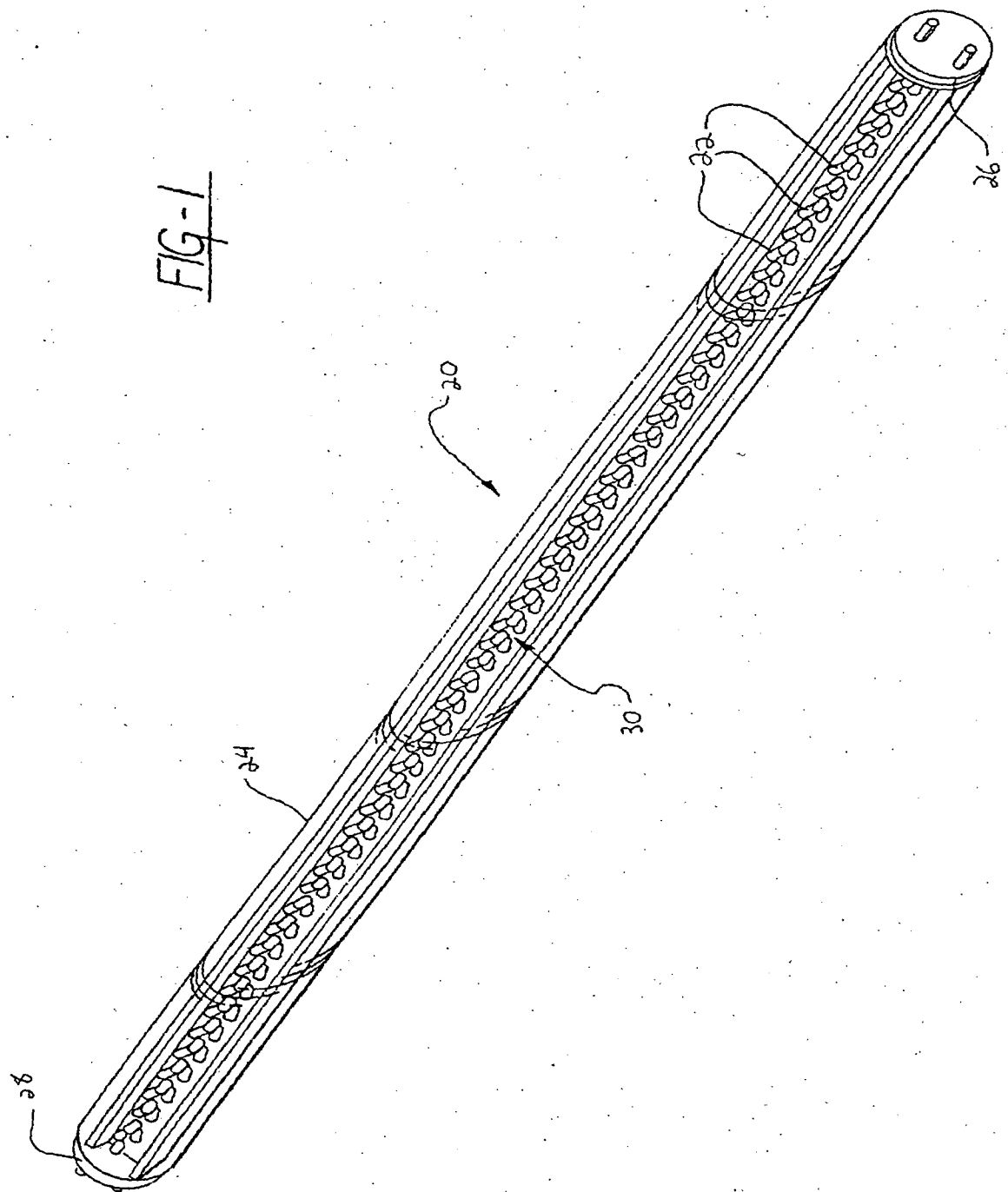
- 1           1.    A light tube for illumination by a power supply  
2 circuit comprising:  
3           a bulb portion,  
4           a pair of end caps disposed at opposite ends of  
5 the bulb portion, and  
6           a plurality of light emitting diodes disposed inside  
7 the bulb portion and in electrical communication with the  
8 pair of end caps for illuminating in response to electrical  
9 current to be received from the power supply circuit.
- 1           2.    The light tube of claim 1 wherein the pair  
2 of end caps are shaped to be coupled with a fluorescent light  
3 tube socket.
- 1           3.    The light tube of claim 2 wherein the pair  
2 of end caps are electrical bi-pin connectors.
- 1           4.    The light tube of claim 1 wherein the bulb  
2 portion and the pair of end caps are dimensioned to be mounted  
3 in a fluorescent light tube socket.
- 1           5.    In a replacement light tube for a fluorescent  
2 light fixture having a light tube socket and a power supply  
3 circuit, the improvement comprising:  
4 a plurality of light emitting diodes disposed inside a bulb  
5 portion and in electrical communication with a pair of end  
6 caps for illuminating in response to electrical current to  
7 be received from the fluorescent light fixture.
- 1           6.    The improvement of claim 5 wherein the  
2 plurality of light emitting diodes are mounted to a circuit  
3 board.

1           7.    The improvement of claim 5 wherein the  
2    plurality of light emitting diodes are mounted at a angular  
3    off-set to establish a predetermined radiation pattern of  
4    light.

ABSTRACT OF THE DISCLOSURE

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

5



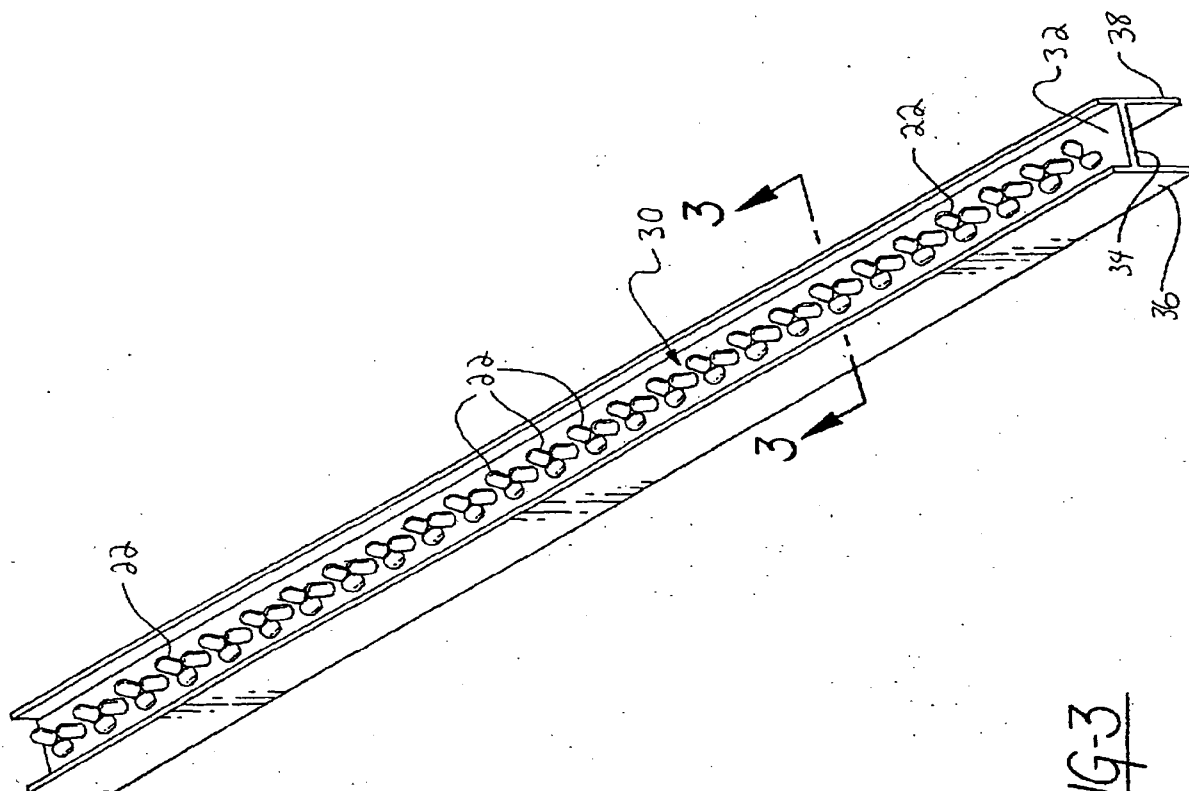


FIG-2

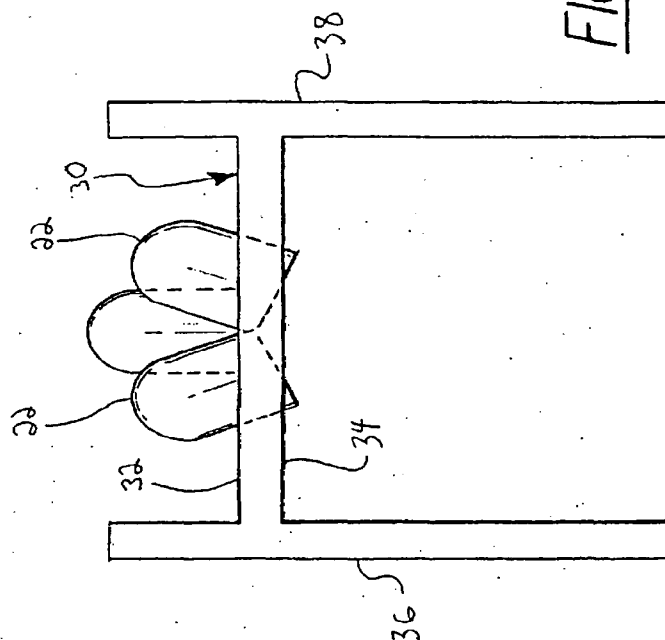


FIG-3



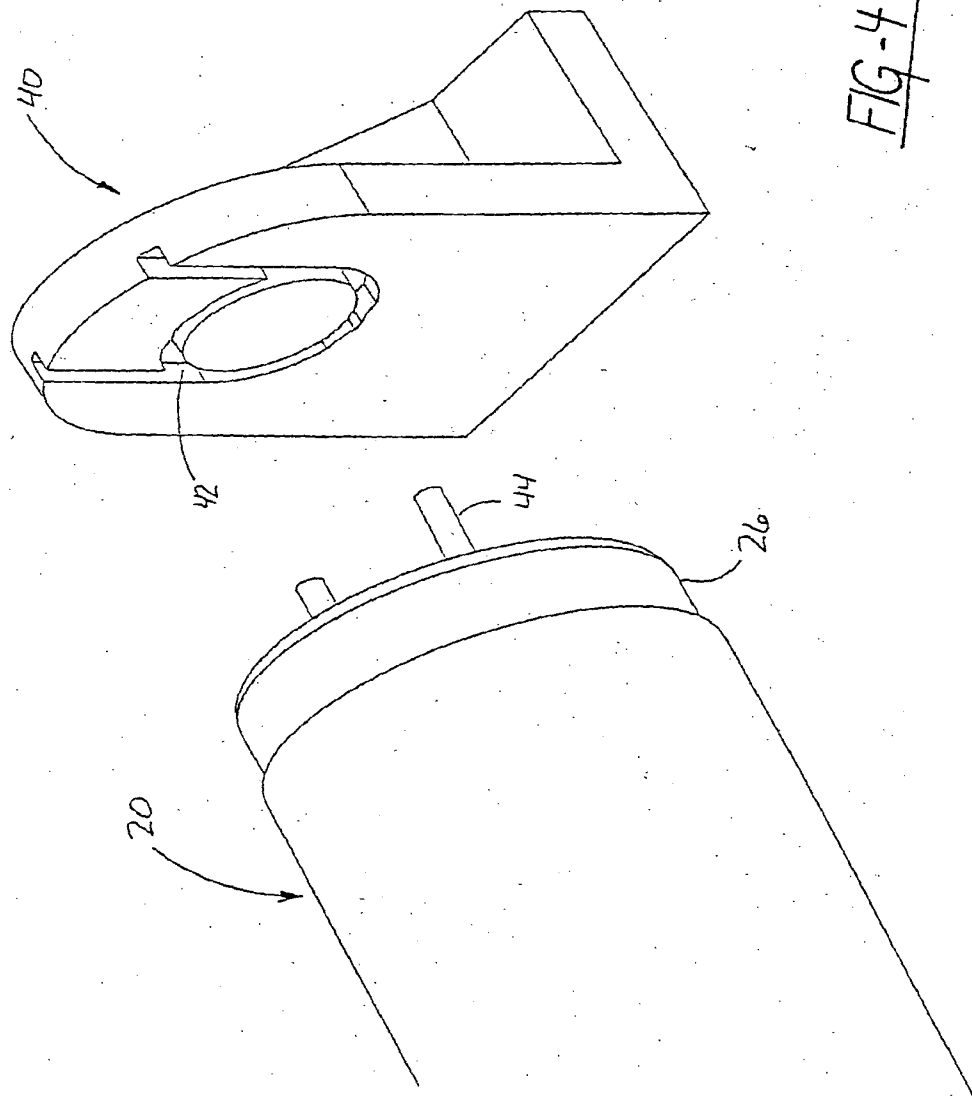


FIG-4

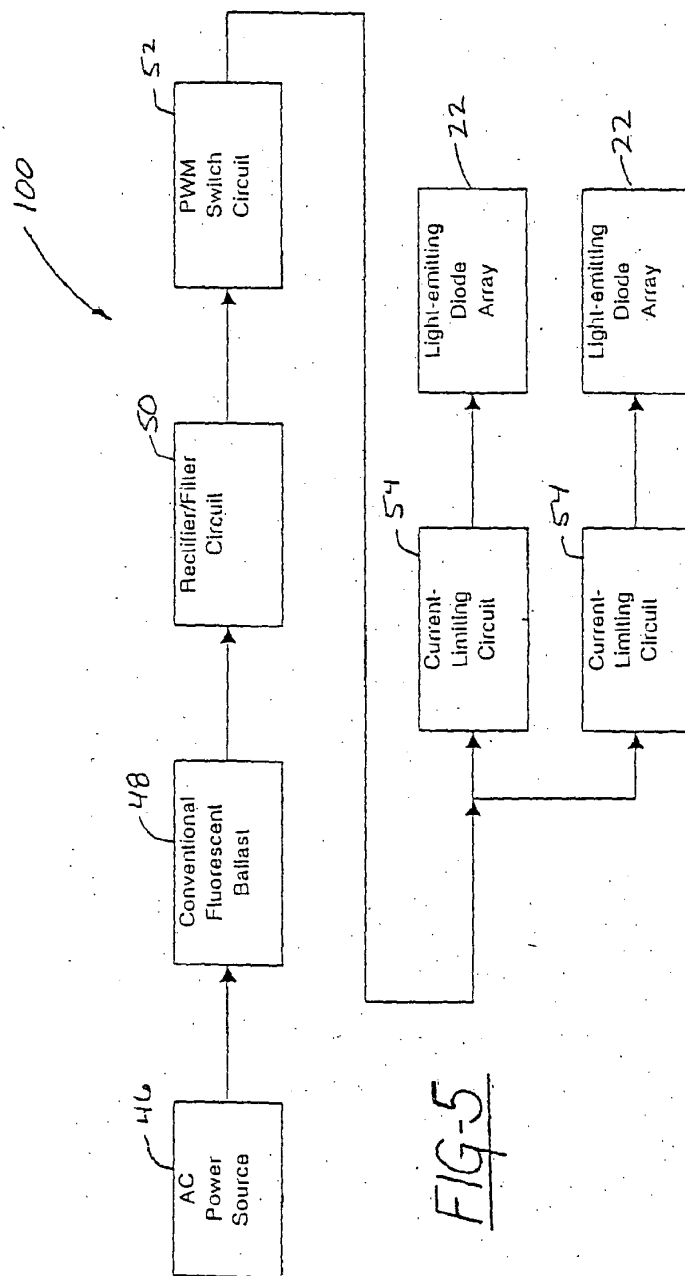


FIG-5

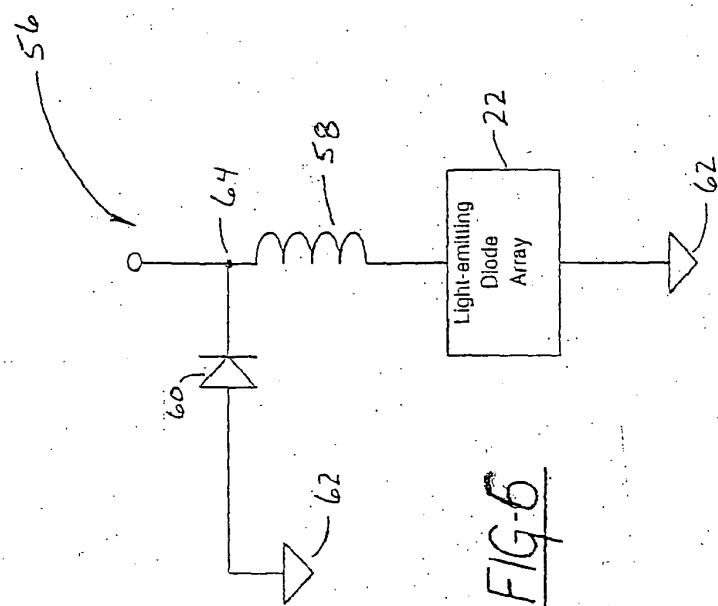


FIG-6

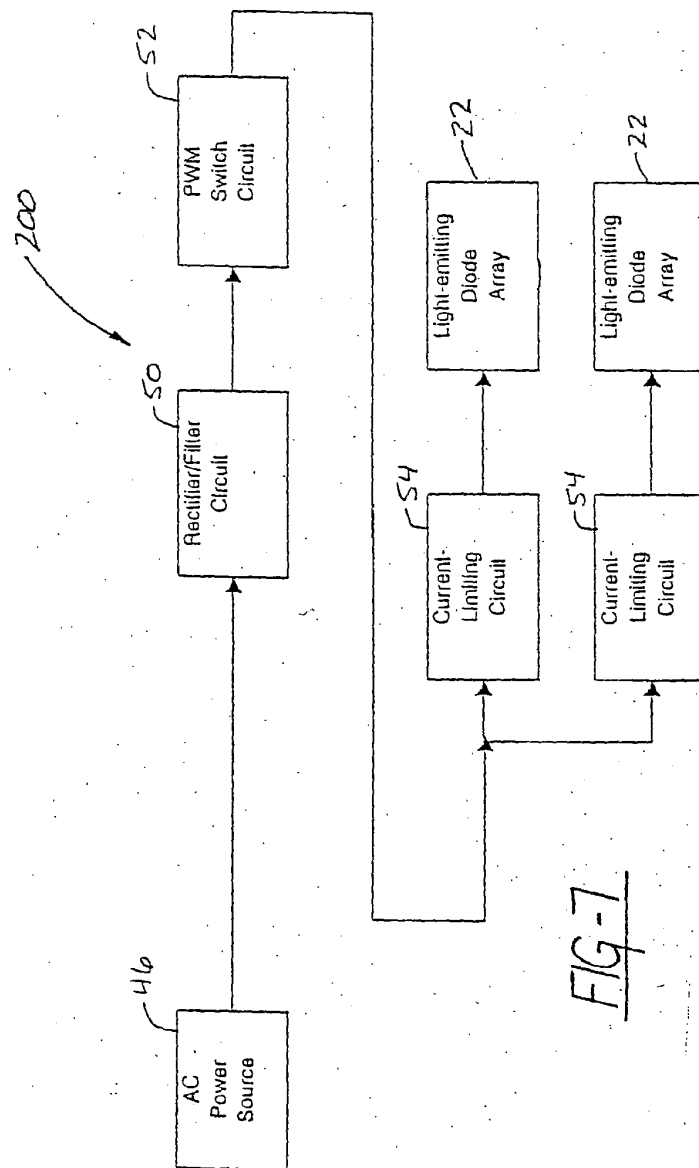


FIG-7

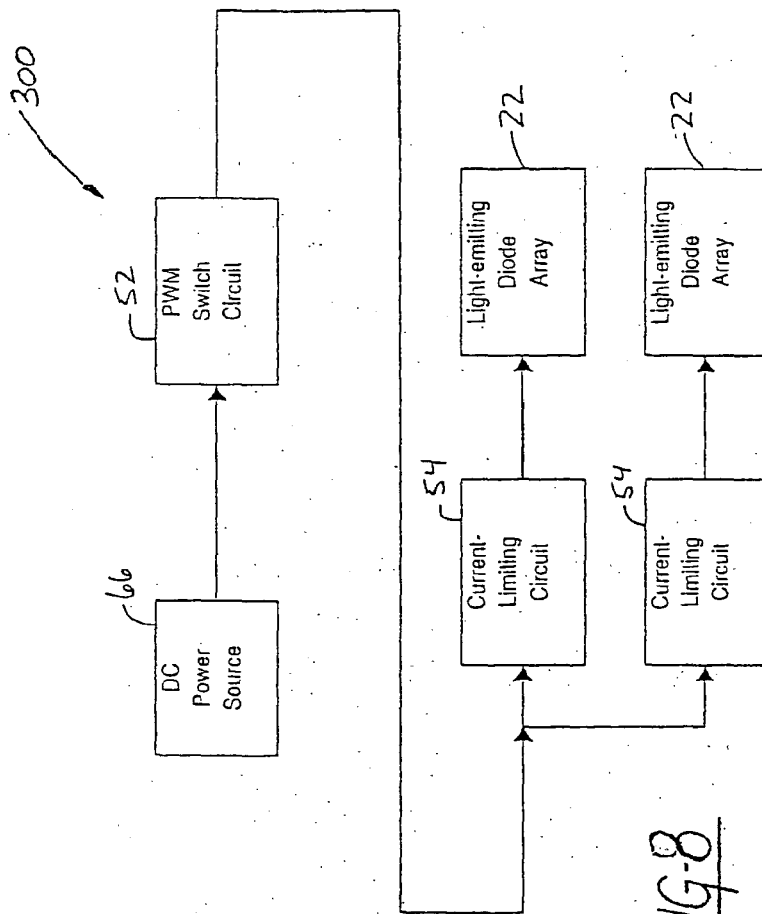


FIG-8

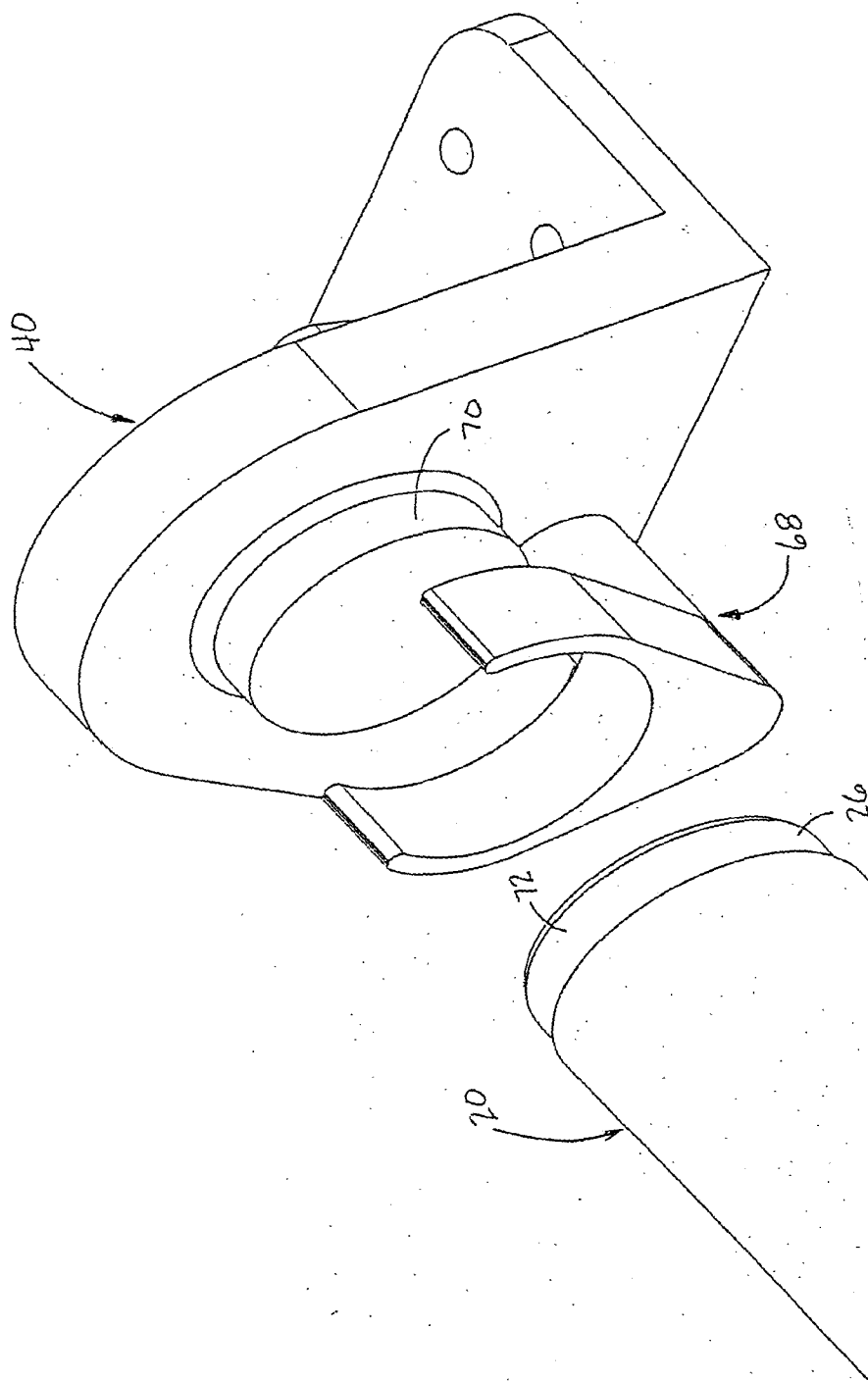


FIG-9

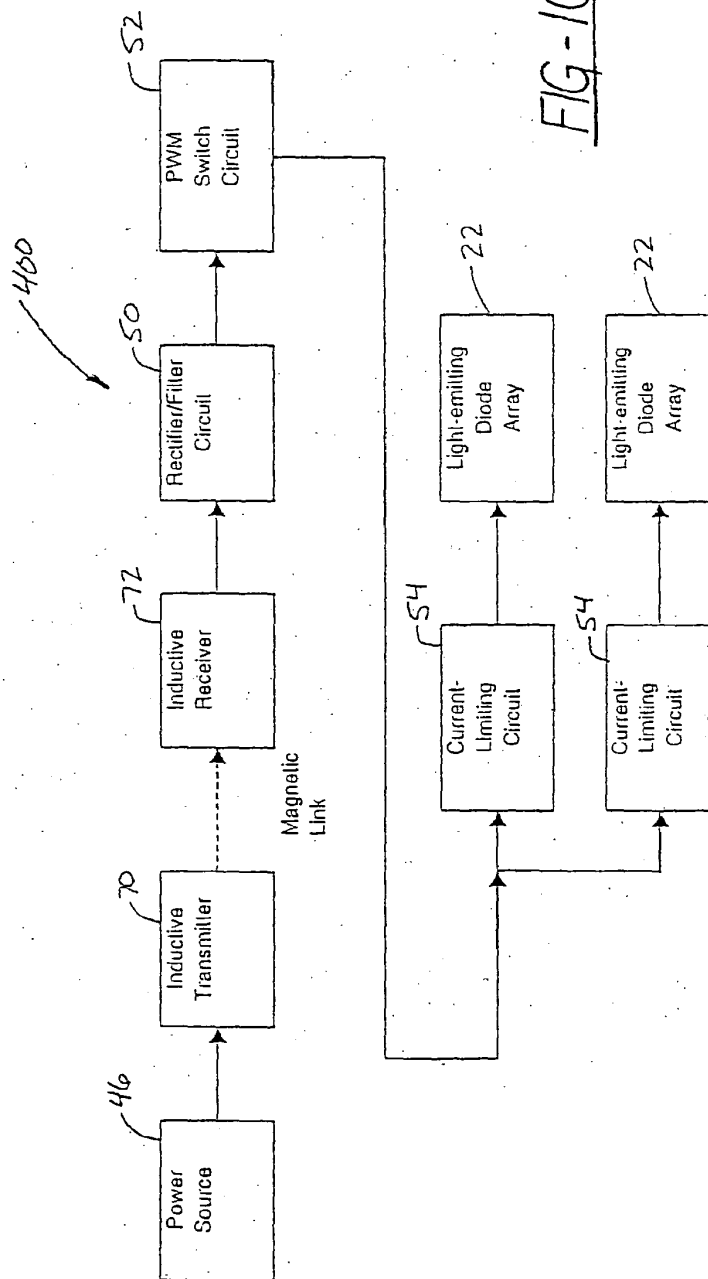


FIG-10

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                     |                        |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------------------------|------------|
| <b>Application Data Sheet 37 CFR 1.76</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                     | Attorney Docket Number | AEII-172-H |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                     | Application Number     |            |
| Title of Invention                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |                        |            |
| <p>The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.</p> <p>This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.</p> |                                     |                        |            |

**Secrecy Order 37 CFR 5.2**

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

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| <b>Prefix</b>                             | <b>Given Name</b> | <b>Middle Name</b>                            |    | <b>Family Name</b>                                             |    | <b>Suffix</b>                                               |  |
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| <b>Citizenship under 37 CFR 1.41(b) i</b> |                   | NL                                            |    |                                                                |    |                                                             |  |
| <b>Mailing Address of Applicant:</b>      |                   |                                               |    |                                                                |    |                                                             |  |
| <b>Address 1</b>                          |                   | c/o Altair Engineering, Inc.                  |    |                                                                |    |                                                             |  |
| <b>Address 2</b>                          |                   | 1820 East Big Beaver Rd.                      |    |                                                                |    |                                                             |  |
| <b>City</b>                               | Troy              | <b>State/Province</b>                         |    | MI                                                             |    |                                                             |  |
| <b>Postal Code</b>                        |                   | 48083-2031                                    |    | <b>Country<sup>i</sup></b>                                     | US |                                                             |  |
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| <b>Prefix</b>                             | <b>Given Name</b> | <b>Middle Name</b>                            |    | <b>Family Name</b>                                             |    | <b>Suffix</b>                                               |  |
|                                           | Jean              |                                               |    | Raymond                                                        |    |                                                             |  |
| <b>Residence Information (Select One)</b> |                   | <input type="radio"/> US Residency            |    | <input checked="" type="radio"/> Non US Residency              |    | <input type="radio"/> Active US Military Service            |  |
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| <b>Mailing Address of Applicant:</b>      |                   |                                               |    |                                                                |    |                                                             |  |
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| <b>Address 2</b>                          |                   | 1820 East Big Beaver Rd.                      |    |                                                                |    |                                                             |  |
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| <b>Applicant Authority</b>                |                   | <input checked="" type="radio"/> Inventor     |    | <input type="radio"/> Legal Representative under 35 U.S.C. 117 |    | <input type="radio"/> Party of Interest under 35 U.S.C. 118 |  |
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|                                           | John              |                                               |    | Ivey                                                           |    |                                                             |  |
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| <b>City</b>                               | Farmington Hills  | <b>State/Province</b>                         | MI | <b>Country of Residence i</b>                                  |    | US                                                          |  |



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|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------------------------|------------|------------------------------------|
| <b>Application Data Sheet 37 CFR 1.76</b>                                                                                                   |                                     | Attorney Docket Number | AEII-172-H |                                    |
|                                                                                                                                             |                                     | Application Number     |            |                                    |
| Title of Invention                                                                                                                          | LIGHT TUBE AND POWER SUPPLY CIRCUIT |                        |            |                                    |
| Citizenship under 37 CFR 1.41(b) i                                                                                                          |                                     | US                     |            |                                    |
| <b>Mailing Address of Applicant:</b>                                                                                                        |                                     |                        |            |                                    |
| Address 1                                                                                                                                   | c/o Altair Engineering, Inc.        |                        |            |                                    |
| Address 2                                                                                                                                   | 1820 East Big Beaver Rd.            |                        |            |                                    |
| City                                                                                                                                        | Troy                                | State/Province         | MI         |                                    |
| Postal Code                                                                                                                                 | 48083                               | Country <sup>i</sup>   |            |                                    |
| All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the <b>Add</b> button. |                                     |                        |            | <input type="button" value="Add"/> |

### Correspondence Information:

|                                                                                                                                       |                           |                                          |                                             |
|---------------------------------------------------------------------------------------------------------------------------------------|---------------------------|------------------------------------------|---------------------------------------------|
| Enter either Customer Number or complete the Correspondence Information section below.<br>For further information see 37 CFR 1.33(a). |                           |                                          |                                             |
| <input type="checkbox"/> An Address is being provided for the correspondence Information of this application.                         |                           |                                          |                                             |
| Customer Number                                                                                                                       | 48980                     |                                          |                                             |
| Email Address                                                                                                                         | docketing@youngbasile.com | <input type="button" value="Add Email"/> | <input type="button" value="Remove Email"/> |

### Application Information:

|                                         |                                     |                                           |                          |
|-----------------------------------------|-------------------------------------|-------------------------------------------|--------------------------|
| Title of the Invention                  | LIGHT TUBE AND POWER SUPPLY CIRCUIT |                                           |                          |
| Attorney Docket Number                  | AEII-172-H                          | Small Entity Status Claimed               | <input type="checkbox"/> |
| Application Type                        | Nonprovisional                      |                                           |                          |
| Subject Matter                          | Utility                             |                                           |                          |
| Suggested Class (if any)                |                                     | Sub Class (if any)                        |                          |
| Suggested Technology Center (if any)    |                                     |                                           |                          |
| Total Number of Drawing Sheets (if any) | 9                                   | Suggested Figure for Publication (if any) | 1                        |

### Publication Information:

|                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <input type="checkbox"/> Request Early Publication (Fee required at time of Request 37 CFR 1.219)                                                                                                                                                                                                                                                                                                                      |
| <input type="checkbox"/> <b>Request Not to Publish.</b> I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application <b>has not and will not</b> be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing. |

### Representative Information:

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                              |                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|----------------------------------------------|---------------------------------------------------------|
| Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing. |                                                  |                                              |                                                         |
| Please Select One:                                                                                                                                                                                                                                                                                                                                                                                                                                              | <input checked="" type="radio"/> Customer Number | <input type="radio"/> US Patent Practitioner | <input type="radio"/> Limited Recognition (37 CFR 11.9) |

|                                           |                                     |                        |            |
|-------------------------------------------|-------------------------------------|------------------------|------------|
| <b>Application Data Sheet 37 CFR 1.76</b> |                                     | Attorney Docket Number | AEII-172-H |
|                                           |                                     | Application Number     |            |
| Title of Invention                        | LIGHT TUBE AND POWER SUPPLY CIRCUIT |                        |            |
| Customer Number                           | 48980                               |                        |            |

## Domestic Benefit/National Stage Information:

|                                                                                                                                                                                                                                                                                                                                                                                                        |                    |                          |                          |               |                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------------|--------------------------|---------------|-------------------------|
| This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification. |                    |                          |                          |               |                         |
| Prior Application Status                                                                                                                                                                                                                                                                                                                                                                               | Pending            |                          | <a href="#">Remove</a>   |               |                         |
| Application Number                                                                                                                                                                                                                                                                                                                                                                                     | Continuity Type    | Prior Application Number | Filing Date (YYYY-MM-DD) |               |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                        | Continuation of    | 11085744                 | 2005-03-21               |               |                         |
| Prior Application Status                                                                                                                                                                                                                                                                                                                                                                               | Patented           |                          | <a href="#">Remove</a>   |               |                         |
| Application Number                                                                                                                                                                                                                                                                                                                                                                                     | Continuity Type    | Prior Application Number | Filing Date (YYYY-MM-DD) | Patent Number | Issue Date (YYYY-MM-DD) |
| 11085744                                                                                                                                                                                                                                                                                                                                                                                               | Continuation of    | 09782375                 | 2001-02-12               | 7049761       | 2006-05-23              |
| Prior Application Status                                                                                                                                                                                                                                                                                                                                                                               | Abandoned          |                          | <a href="#">Remove</a>   |               |                         |
| Application Number                                                                                                                                                                                                                                                                                                                                                                                     | Continuity Type    | Prior Application Number | Filing Date (YYYY-MM-DD) |               |                         |
| 09782375                                                                                                                                                                                                                                                                                                                                                                                               | non provisional of | 60181744                 | 2000-02-11               |               |                         |
| Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the <b>Add</b> button.                                                                                                                                                                                                                                                                                  |                    |                          |                          |               | <a href="#">Add</a>     |

## Foreign Priority Information:

|                                                                                                                                                                                                                                                                                                             |                      |                                 |                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------------------------|---------------------------------------------------------------|
| This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a). |                      |                                 |                                                               |
| <a href="#">Remove</a>                                                                                                                                                                                                                                                                                      |                      |                                 |                                                               |
| Application Number                                                                                                                                                                                                                                                                                          | Country <sup>i</sup> | Parent Filing Date (YYYY-MM-DD) | Priority Claimed                                              |
|                                                                                                                                                                                                                                                                                                             |                      |                                 | <input checked="" type="radio"/> Yes <input type="radio"/> No |
| Additional Foreign Priority Data may be generated within this form by selecting the <b>Add</b> button.                                                                                                                                                                                                      |                      |                                 | <a href="#">Add</a>                                           |

## Assignee Information:

|                                                                                                                                                                                                 |                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office. |                          |
| <b>Assignee 1</b>                                                                                                                                                                               | <a href="#">Remove</a>   |
| If the Assignee is an Organization check here. <input checked="" type="checkbox"/>                                                                                                              |                          |
| Organization Name                                                                                                                                                                               | Altair Engineering, Inc. |

|                                           |                                     |                        |            |
|-------------------------------------------|-------------------------------------|------------------------|------------|
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|                                                                                                                                                                    |    |                          |                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|--------------------------|-------------------|
| <b>Mailing Address Information:</b>                                                                                                                                |    |                          |                   |
| Address 1                                                                                                                                                          |    | 1820 East Big Beaver Rd. |                   |
| Address 2                                                                                                                                                          |    |                          |                   |
| City                                                                                                                                                               |    | Troy                     | State/Province MI |
| Country                                                                                                                                                            | US | Postal Code              | 48083             |
| Phone Number                                                                                                                                                       |    | Fax Number               |                   |
| Email Address                                                                                                                                                      |    |                          |                   |
| Additional Assignee Data may be generated within this form by selecting the <b>Add</b> button. <span style="border: 1px solid black; padding: 2px 5px;">Add</span> |    |                          |                   |

**Signature:**

|                                                                                                                                                              |                      |           |        |                     |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------|--------|---------------------|------------|
| A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature. |                      |           |        |                     |            |
| Signature                                                                                                                                                    | /Michelle L. Knight/ |           |        | Date (YYYY-MM-DD)   | 2010-12-10 |
| First Name                                                                                                                                                   | Michelle L.          | Last Name | Knight | Registration Number | 47711      |

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

## Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.