

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
16 April 2009 (16.04.2009)

PCT

(10) International Publication Number
WO 2009/046548 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/CA2008/002169

(22) International Filing Date:
15 December 2008 (15.12.2008)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant and

(72) Inventor: WILLIAMSON, Michael, Herbert [CA/CA];
1395 Charlotte Rd., North Vancouver, British Columbia
V7J 1 H1 (CA).

(74) Agent: KAUFMAN, Frederick; 1937 Pendrell Street,
Suite 403, Vancouver, British Columbia V6G 1T4 (CA).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA,
CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE,
EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID,

IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK,
LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW,
MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT,
RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ,
TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,
NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG,
CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

- upon request of the applicant, before the expiration of the
time limit referred to in Article 21(2)(a)
- without international search report and to be republished
upon receipt of that report
- without classification; title and abstract not checked by the
International Searching Authority

(54) Title: METHOD AND ASSEMBLY USING EMITTING DIODED (LEDs) FOR PLANT-GROWING

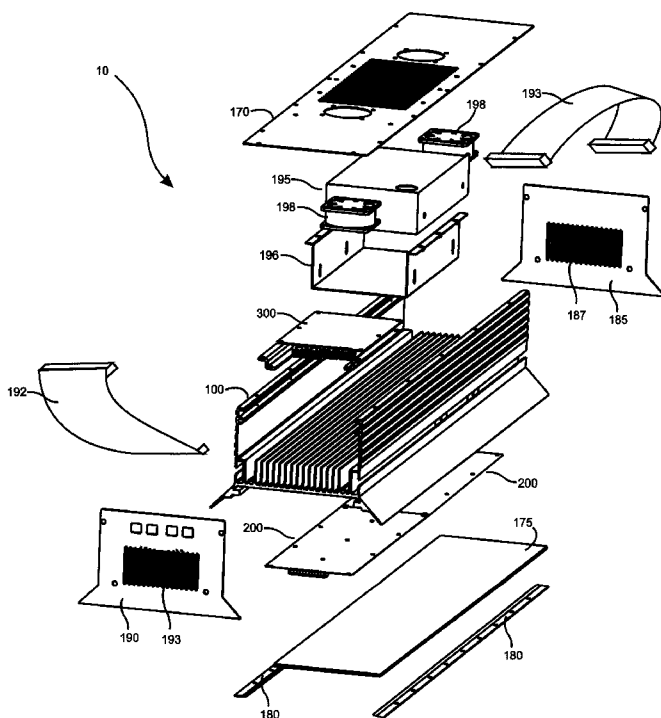


FIG. 1

(57) Abstract: A method and assembly for growing plants, the method comprising the following operations: providing a white light spectrum incorporating a blue component and a color temperature in a range of 5000-6000K and a luminous flux proper to white (W) LEDs; providing a red light spectrum having a luminous flux proper to red (R) LEDs and a dominant wavelength basically of 625 nm; and providing an amber light spectrum having a luminous flux proper to amber (A) LEDs and a dominant wavelength basically of 590 nm. The assembly includes a subassembly for housing, a subassembly for lighting and a subassembly for controlling the assembly for lighting. The lighting subassembly comprises a base and three LED modules attached to the base. Each of the three LEDs modules includes LEDs providing basically the following color spectra: white, red and amber.

Method and Assembly Using Emitting Diodes (LEDs) for Plant-Growing

I. BACKGROUND OF THE INVENTION

1. Definition of the Invention

The present invention refers, in general, to lighting systems providing selectable colors, and, more particularly, to a method and an assembly using light emitting diodes (LEDs) for plant-growing.

2. Description of the State of Art

An electric light source for plants must not only provide an adequate intensity of light but also provide light of the proper spectral characteristics to meet the plant's requirements. A further important consideration of an electric light source pertains to the efficiency of conversion of the electricity to light with the required spectral characteristics.

With LEDs comes the possibility of strongly monochromatic light and chroma-specific lighting fixtures. Photosynthetic plants make use of specific of specific wavelengths i.e. colors of light as their energy source and for various types of stimulation. The wavelength requirements of the plants are determined by the specific light receptors and physiological needs present in the plant. LEDs have no excess heat problem, hence they can be arranged relatively close to the cultured plant and, thus, reduce the necessary space. Supplementally, LEDs present the advantage of long life span and lower power consumption.

Attempts have been made to develop artificial light apparatuses using light emitting diodes as light source for young plants, especially plantlets growing in tissue culture vessels. For example, United States Patent No. 7,033,060 granted to Dubuc on Apr. 25, 2006 for a "Method and Apparatus for Irradiation of Plants Using Light Emitting Diodes" discloses the use of high-energy LEDs to supplement natural or artificial light. In one embodiment, LEDs have a peak

emission of 435 nm, in another embodiment, LEDs have a peak emission of 455 nm. No mention is made concerning the use of different color spectra, which each has a specific and essential role in plant growing. Another example is United States Patent No. 6,921,182 granted on Jul. 26, 2005 to Anderson, Jr. et al. for an “Efficient LED lamp for Enhancing Commercial and Home Plant Growth” describes the use of a first set of orange LEDs with a peak wavelength emission of about 612 nm, a second set of red light emitting LEDs with a peak wavelength of about 660 nm, and blue light LEDs. Two main disadvantages characterize the foregoing patent: without a wavelength of 590 nm the plants do not properly process nitrogen, do not develop strong stems, and the red-blue balance leads to stretching. Yet another example is United States Patent No. 6,725,598 granted on Apr. 27, 2004 to Yoneda et al. for a “Plant Cultivator and Control System therefor” discloses a cultivator provided with a LED illumination element and LED control means that control the LED illumination element. Use is made of a growth detection sensor. The main shortcoming of this patent resides in the fact that there is no teaching as to the spectral distribution or balance of intensities among colors, which can lead to the stress or damage of the plants.

II. SUMMARY OF THE INVENTION

There is a need for a plant growing system (method and apparatus), which uses LEDs to supply the required light intensity and/or wavelength, in such a manner, as to optimize the plant growing.

The forthcoming objectives are set by the inventor:

A basic objective of the present invention is to develop a method and an assembly to carry out the method to provide specified power spectra in the distribution of artificial light for enhancing or inhibiting budding, for enhancing or inhibiting flowering, for enhancing germination, for enhancing leafiness of the plant, for obtaining a strong and/or lengthy stem, for having a stronger plant, for getting a bigger harvest, and/or for advancing or restraining ripening of a fruit or vegetable.

Another important objective of the present invention is to ensure reproducibility of the operations and, consequently, of the results.

Yet another objective of the present invention is to develop an apparatus environmentally friendly.

Yet another objective of the present invention is to use heat conductive means to maximize efficiency and life expectancy of the assembly.

Broadly stating, the method using light emitting diodes (LEDs) for plant-growing, according to the present invention, is carried out by one or more assemblies, wherein each one of the one or more assemblies comprises

- a housing subassembly used for attaching all other means of the assembly using light emitting diodes for plant- growing, the housing subassembly incorporating a base situated in its interior and a printed circuit board connected to the base;

- a lighting subassembly attached to the base and facing towards a bottom of the housing subassembly; and
- a light controller subassembly for controlling the lighting subassembly.

The method using light emitting diodes for plant-growing includes the following operations:

- providing a white light spectrum incorporating a blue component and defined by a color temperature generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market;
- providing a red light spectrum having a luminous flux proper to red (R) LEDs and a dominant wavelength basically of 625 nm; and
- providing an amber light spectrum having a luminous flux proper to amber (A) LEDs and a dominant wavelength basically of 590 nm.

In one aspect, the above described method, further comprises the following operations:

- providing a blue light spectrum having a luminous flux proper to blue (B) LEDs and a dominant wavelength basically of 460 nm; and
- providing a cyan light spectrum having a luminous flux proper to cyan (C) LEDs and a dominant wavelength basically of 505 nm.

In one specific aspect, the method using light emitting diodes (LEDs) for plant-growing, includes the following operations:

- providing basically white (W), red (R) and amber (A) spectra, the lighting subassembly including at least one LEDs module; the at least one LEDs module incorporates, when

- a) a $N = 8$ white (W) LEDs are used, b) $3N/8$ red (R) LEDs and $3N/8$ amber (A) LEDs;
- displaying by each N white (W) LEDs a white light spectrum incorporating a blue component and defined by a color temperature generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market;
 - displaying by each said $3N/8$ red (R) LEDs, a red light spectrum generally providing 70% of said luminous flux of each said white (W) LEDs available on the market and, basically, a dominant wavelength of 625 nm; and
 - displaying by each said $3N/8$ amber (A) an amber light spectrum generally providing a luminous flux equal to 90% of said luminous flux of each said N white (W) LEDs, and, basically, a dominant wavelength of 590 nm.

In another aspect, the above method, when uses at least one module, further comprises $N/8$ cyan (C) LEDs and $N/8$ blue (B) LEDs, so that the N white (W) LEDs constitutes 50% of a total number of LEDs used by that at least one LEDs module; b) the $3N/8$ red (R) LEDs constitutes 18.75 of the total number of LEDs used by that at least one LEDs module; the $3N/8$ amber (A) LEDs constitutes 18.75 of the total number of LEDs used by that at least one LEDs module; the $N/8$ cyan (C) constitutes 6.25 of the total number of LEDs used by that at least one LEDs module; and the $N/8$ blue (B) LEDs constitutes 6.25 of the total number of LEDs used by that at least one LEDs module.

The method further includes the operations of:

- displaying by each $N/8$ cyan (C) LEDs, a cyan light spectrum providing 60% of the luminous flux of each N (white) LEDs and, basically, having a dominant wavelength of 505nm; and

- displaying by each N/8 blue (B) LEDs, 20% of the luminous flux of the N (white) LEDs and, basically, having a dominant wavelength of 460nm.

Broadly stating, the assembly using light emitting diodes (LEDs) for plant-growing comprising

- a housing subassembly used for attaching all other means of the assembly; the housing subassembly incorporates a base situated in its interior and a printed circuit board connected to the base;
- a lighting subassembly attached to the base and facing towards a bottom of the housing subassembly; and
- light controller subassembly for the lighting subassembly.

The assembly using light emitting diodes for plant-growing includes

- LEDs for providing a white light spectrum incorporating a blue component and defined by a color temperature generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market;
 - LEDs means for providing a red light spectrum having a luminous flux proper to red (R) LEDs and a dominant wavelength basically of 625 nm; and
 - LEDs means for providing an amber light spectrum having a luminous flux proper to amber (A) LEDs and a dominant wavelength basically of 590 nm; and
- when more than one assemblies are coupled together, their synchronization is necessary.

In one aspect, the above assembly further comprises:

- LEDs for providing a blue light spectrum having a luminous flux proper to blue (B) LEDs and

a dominant wavelength basically of 460 nm; and

- LEDs for providing a cyan light spectrum having a luminous flux proper to cyan (C) LEDs and a dominant wavelength basically of 505 nm.

In one aspect the assembly using light emitting diodes (LEDs) for plant-growing comprises:

- the subassembly for housing used for attaching all other subassemblies of the assembly using artificial light for plant- growing; the subassembly for housing incorporates a base situated in its interior and a printed circuit board connected to said base;

- the subassembly for lighting attached to the base and facing towards a bottom of the subassembly for housing;

the subassembly for lighting including at least one LEDs module, basically for providing white (W), red (R) and amber (A) spectra; the at least one LEDs module incorporating, when

a) a $N = 8$ white (W) LEDs are used, b) $3N/8$ red (R) LEDs are used; and $3N/8$ amber (A) LEDs are used; said N white (W) LEDs display a white light spectrum incorporating a blue component and defined by a color temperature generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market; the $3N/8$ red (R) LEDs, each displaying a red light spectrum generally providing 70% of said luminous flux of each said white (W) LEDs available on the market and, basically, a dominant wavelength of 625 nm; and the $3N/8$ amber (A), each displaying an amber light spectrum generally providing a luminous flux equal to 90% of the luminous flux of each the N white (W) LEDs, and, basically, a dominant wavelength of 590 nm; and

- a subassembly for controlling the subassembly for lighting.

In another aspect, the assembly using artificial light for plant-growing as defined in claim 4, wherein said at least one module further comprises $N/8$ cyan (C) LEDs and $N/8$ blue (B) LEDs, so that said N white (W) LEDs constitute 50% of a total number of LEDs used by said at least one LEDs module; b) said $3N/8$ red (R) LEDs constitute 18.75 of the total number of LEDs used by said at least one LEDs module; said $3N/8$ amber (A) LEDs constitute 18.75 of the total number of LEDs used by said at least one LEDs module; said $N/8$ cyan (C) constitutes 6.25 of the total number of LEDs used by said at least one LEDs module; and said $N/8$ blue (B) LEDs constitutes 6.25 of the total number of LEDs used by said at least one LEDs module; said $N/8$ cyan (C) LED, each displaying a cyan light spectrum providing 60% of said luminous flux of each said N (white) LEDs and, basically, a dominant wavelength of 505nm, while said $N/8$ blue (B) LEDs providing each 20% of said luminous flux of said N (white) LEDs and, basically, a dominant wavelength of 460nm.

-

- providing a white light spectrum incorporating a blue component and defined by a color temperature in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market;
- providing a red light spectrum having a luminous flux proper to red (R) LEDs available on the market and a dominant wavelength basically of 625 nm; and
- providing an amber light spectrum having a luminous flux proper to amber (A) LEDs available on the market and a dominant wavelength basically of 590 nm.

III. Brief Description of the Drawings.

The subject matter of the invention is particularly pointed out and distinctively claimed in the concluding portion of the specification. The invention, however, both in structure and operation may be better understood by reference to the following description taken in conjunction with the subjoined claims and the accompanying drawings of which:

Figure 1 illustrates an exploded view of the assembly using artificial light for plant-growing of the present invention;

Figure 2 is a perspective view of the housing subassembly of the assembly using artificial light for plant-growing;

Figure 3 is a top diagrammatic view of the lighting subassembly;

Figure 4 is an exploded view of light controller subassembly;

Figure 5 is a block diagram of light controller;

Figure 6 is a block diagram of FPGA operation section; and

Figure 7 is a block diagram of LED driver section.

IV. Description of the Preferred Embodiment.

An assembly using artificial light for plant-growing 10 is shown in Fig. 1.

It is to be agreed, that terms such as “upper”, “lower”, “inward”, “outward”, “rearward”, “front”, “back”, “side”, “top”, “bottom”, “left” and “right” are conventionally used in the present specification with reference to the normal position in which assembly using artificial light for plant-growing 10 would be used.

The assembly using artificial light for plant-growing 10 comprises:

A housing subassembly 100 (see Fig 2);

A transparent window 175 located and attached at the bottom of housing subassembly using artificial light for plant-growing 100;

A top cover 170 located and attached at the top of housing subassembly using artificial light for plant-growing 100;

A pair of straps 180 for securing transparent window 175 to housing subassembly 100;

A back cover 185 for closing the rear end of housing subassembly 100;

A front cover 190 for closing the front end of housing subassembly 100;

A front electric flat cable 192 located in the interior of housing subassembly 100, close to its front end;

A back electric flat cable 193 located in the interior of housing subassembly 100, close to its back end;

A switching power supply 195 located in the middle of housing subassembly 100;

A power supply support 196 connected to switching power supply 195;

Cooling fans 198 located in housing subassembly 100, under top cover 170 ;

A lighting subassembly 200 attached in the interior of housing subassembly 100 and facing transparent window 175; and

A lighting controller subassembly 300 inserted in the interior of housing subassembly 100 and located in a front zone of the latter.

HOUSING SUBASSEMBLY 100

Housing subassembly 100 has a unitary structure, made by extrusion from aluminum, and incorporates a horizontally disposed support 105.

A plurality of vertical fins 110, equally spaced, extend along horizontally disposed support 105.

Two internally threaded sleeves 115 extend horizontally and inwardly from each longitudinal extremity of horizontally disposed support 105. Each internally threaded sleeve 115 is located between two adjacent vertical fins 110 of the plurality of vertical fins 110.

Horizontally disposed support 105 is flanked longitudinally by two C-shaped, outwardly open channels 120 and is traversed by a multiplicity of threaded openings 125.

A pair of walls 130 extends upwardly along longitudinal extremities of the two C-shaped, outwardly open channels 120. Each wall 130 extends, along its upper end, into a strip 135 that projects inwardly and horizontally.

A guiding channel G is bordered upwardly by strip 135, laterally by an upper portion of an adjacent wall 130 and downwardly by an internally threaded socket 140. The latter extends at each longitudinal extremity of guiding channel G. Two guiding channels G are formed; they are oppositely disposed and used to receive a lighting controller subassembly using artificial light for plant-growing 300 and power supply 195.

Each strip 135 incorporates several threaded perforations 145 spaced along its length.

Two slanted wings 150 extends downwardly and outwardly from each C-shaped, outwardly open channels 120. A relatively narrow, stepped wall 155 extends horizontally and inwardly along an internal surface of each one of the two slanted wings 150. Stepped wall 155 is approximately located at midway of each one of two slanted wings 150 width.

A horizontal inwardly projecting stepped 160 of stepped wall 155 is provided along its length

with several threaded holes 165.

Housing subassembly 100 includes, as well, a plate-cover 170 made of aluminum. Plate cover 170 is superimposed on the top of strips 135, so, as to cover entirely an upper part of housing 100. Conventional screws (not shown) are tightened in threaded holes 145 in order to secure plate-cover 170 to strips 135.

Housing subassembly 100 further includes a panel 175 made of transparent material. Panel 175 is placed on horizontal inwardly projecting step 160 of stepped wall 155, via two straps 180.

Each strap 180 is attached to each horizontal inwardly projecting step 160 by screws (not shown).

Housing subassembly 100 includes a rear cover 185 placed perpendicularly at the rear of lateral walls 130 and kept in place by screws (not shown) inserted into internally threaded sockets 115 and 140.

Housing subassembly 100 includes a front cover 190 placed perpendicularly at the front of lateral walls 130 and kept in place by screws (not shown) inserted into internally threaded sockets 115 and 140.

The lighting subassembly using artificial light for plant-growing 200 is attached by screws (not shown) to the base 105.

The lighting controller subassembly 300 is inserted in the housing subassembly 100 by sliding the extremities of the light controller support 392 (see later in the description of light controller subassembly 300) in opposite internally threaded sockets 140. The light controller support 392 is secured by screws (not shown) to front cover 190.

An electrical connection is made by using flat cables 192, 193, of the same type as those used in

computer hardware. Flat cable 192 is connected to the positive polarity of the light subassembly 200 via a pins header 208 (see later in the description of light subassembly 200). Flat cable 193 is connected to the negative polarity of the light subassembly 200 via a pins header 210.

Power supply 195 of a conventional type converts the electric energy from the electric public grid to a lower voltage of 32V DC and a power of 300 watts.

Power supply unit 195 is inserted in a metallic support 196 and kept in place by screws (not shown). The whole power supply subassembly using artificial light for plant-growing is inserted into housing channels 140. Two 16 AWG electric wires (not shown) are used to deliver the power to the light controller subassembly 300. Public grid electricity is transported by a conventional three wires cable (not shown) from a standard outlet receptacle to the power supply 195.

A cooling device is used to control the heat in the housing subassembly 100 via two fans 198 that direct an outside cool air towards internal fins 110. Exhaust grills 187, 193, provided in rear and front covers 185,190, allow the hot air pressured by fans 198 to escape outside.

LIGHTING SUBASSEMBLY 200

Lighting subassembly 200 (Fig. 3) comprises a base 202; and three identical LED modules 204 (incorporating high power LEDs – further called merely LEDs) mounted on and secured to base 202.

Base 202 incorporates a printed circuit board on an aluminum substrate.

Basically, said light subassembly 200 incorporates LEDs for providing the following color spectra:white (W), red (R), and amber (A).

White (W) light spectrum incorporates a blue component and is defined by a color temperature

generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market.

Red (R) light spectrum has a luminous flux proper to red (R) LEDs and a dominant wavelength basically of 625 nm.

Amber (A) light spectrum has a luminous flux proper to amber (A) LEDs and a dominant wavelength basically of 590 nm.

Basically, the method using light emitting diodes for plant-growing includes the following operations:

- providing a white light spectrum incorporating a blue component and defined by a color temperature generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market;
- providing a red light spectrum having a luminous flux proper to red (R) LEDs and a dominant wavelength basically of 625 nm; and
- providing an amber light spectrum having a luminous flux proper to amber (A) LEDs and a dominant wavelength basically of 590 nm.

In another variant, the foregoing method further incorporates the following steps:

- providing a blue light spectrum having a luminous flux proper to blue (B) LEDs and a dominant wavelength basically of 460 nm; and
- providing a cyan light spectrum having a luminous flux proper to cyan (C) LEDs and a dominant wavelength basically of 505 nm.

In a specific embodiment described in the present invention, each of the three identical LED modules 204 includes 16 LEDs 206, which provide the following color spectra: white (W), red

(R), amber (A), cyan (C) and blue (B).

The foregoing color spectra are included in each of the three identical LEDs modules 204, generally as follows (N representing the number of white (W) LEDs 206 in different embodiments; in the present embodiment $N=8$):

N white (W) LEDs 206 constituting 50 % of a total of 16 LEDs 206;

$3N/8$ red (R) LEDs 206 constituting 18,75 % of the total of 16 LEDs 206;

$3(N/8 \times 3)$ amber (A) LEDs 206 constituting 18,75 % of the total of 16 LEDs 206;

1 (N/8) cyan (C) LEDs 206 constituting 6.25 % of the total of 16 LEDs 206; and

1 (N/8) blue (B) LEDs 206 constituting 6.25 % of the total of 16 LEDs 206.

8 (N) white (W) LEDs 206 provide a light spectrum incorporating a blue component and defined by a color temperature generally of a range of 5000-6000K and a luminous flux corresponding to white LEDs available on the market;

$3(N/8 \times 3)$ red (R) LEDs 206, each of them basically displaying a red light spectrum providing 70% of the luminous flux of each white (W) LED available on the market and a dominant wavelength basically of 625nm;

$3(N/8 \times 3)$ amber (A) LEDs 206, each of them providing an amber light spectrum having a luminous flux equal to 90% of said luminous flux of each said N white (W) LEDs and a dominant wavelength basically of 590nm;

1 cyan (C) LEDs 206 provide an cyan light spectrum having a luminous flux corresponding to cyan LEDs available on the market and a dominant wavelength basically of 505nm; and

1 blue (B) LEDs 206 provide an blue light spectrum corresponding to blue LEDs available on the market and a dominant wavelength basically of 460nm.

A basic system of growing plants can be limited to white, red, amber spectra.

Obviously, when more than one assembly using artificial light for plant-growing is used, the latter must be synchronized in time.

Left and right connectors 208 and 210 are secured to base 202.

Starting from left connector 208, each LED 206 of a color incorporated in one of the three identical LEDs modules 204 is connected in series with a corresponding, successive LEDs of other modules 204 and finally to the right connectors 210.

LIGHT CONTROLLER SUBASSEMBLY 300

Light controller subassembly 300 (Fig 4) comprises:

a printed circuit board 301;

a controller unit 305;

a LED driver unit 330;

a synchronization unit 340;

a memory card unit 360;

an user interface unit 370;

a power supply unit 380;

LED output connectors 385, 386;

a heat sink unit 390;

a thermal pad 391 and

a metallic support 392.

LIGHT CONTROL SUBASSEMBLY 300 DESCRIPTION (FIG. 5).

Controller unit 305 includes a microcontroller 307, such as, for example, ATMEGA 128 manufactured by ATMEL. This microcontroller 307 has a FLASH ROM of 128KB, several input-output ports, serial communication ports, analog to digital converter and can reach a speed of 20 MHz;

A Field Programmable Gate Array (further called FPGA) 310 (see FIG. 6), for example Spartan 3 made by Xilinx, comprises a current controller 311 and pulsation controller 312 connected to a LED drivers 330. The FPGA 310 receives commands from microcontroller 307 via a SPI serial bus 313.

FPGA 310 comprises an external clock signal 310a of 100MHz that synchronizes the entire internal operation of FPGA 310. A reset signal 310b supplied by microcontroller 307 re-initializes to a default value for each registers 310 (g-m). A serial communication bus 310c is connected to microcontroller 307. Serial data from the serial communication bus 310c are converted to parallel data 310e by a Synchronizing Serial I/O block 310d. Parallel data 310d are decoded and routed to each specific registers by the Address Decoder and Data Multiplexer block 310f. Each registers having its own independent address, can be controlled individually by microcontroller 307. A current control function device 311 comprises a Fixed Prescaler 310g that reduces the frequency of external clock signal 310a to a lower frequency, about one hundred of KHz. This lower frequency incrementally increases the value of 8 Bit Binary Counter register 310h, which value will be correlated by comparators 310i to a value of a Current Adjust Register 310j. When the value of the 8 Bit Binary Counter register 310h is less than the value in the Current Adjust Register 310j, the digital signal 310p is at its lower state. When the value of the 8

Bit Binary Counter register 310h is higher than the value in the Current Adjust Register 310j, the digital signal 310p is at its higher state. A digital signal 310o is a pulsation at a fixed frequency and varies in duty cycle that serves to adjust the amount of current in each of several LED channels 311a-p. A similar function is applied to the digital signal 310p that serves to control the LED pulsation in variable frequency and variable duty cycle in each of several LED channels 312a-p. To reach that, a Programmable Prescaler 310k adjusts a frequency signal, according to a user preference, that increments an 8 bit Binary Counter 310l. A value in the Binary Counter 310l is compared to a value in the Pulse Width Register 310m by a comparator 310n that generate an output signal. The same concept is also applied to all of the remaining 15 channels.

The microcontroller 307, for monitoring the temperature, uses analog input ports 314 and read a voltage provided by a thermistor 315 located on light subassembly using artificial light for plant-growing 200. The temperature is compared to a maximum threshold value. During a normal operation, the microcontroller 307 activates fans 198, mounted inside housing 100, to cool down the light subassembly 200. If a temperature passes the threshold value, the microcontroller 307 automatically turns off light subassembly 200 and activates an over temperature indicator, incorporated in LED indicators 370.

LED drivers 330 (see FIG. 7) comprise of 4 LED drivers IC 330a of the type LT3476, made by Linear Technologies, and include 4 constant current outputs per LED drivers IC 330a of channels 1-16 (reference number 331). A digital to analog conversion circuit 330c, made by a second order low-pass filter, extracts an average DC voltage 310b from a pulsation signal 310d, provided by a current control 311 embedded in FPGA 310. A voltage 330b adjusts proportionally a current for each channel 331. A pulsation signal 330e, provided by a pulsation control 312

embedded in FPGA 310, alternates between on and off in each channels 331, thereby providing energy saving and a beneficial dark period.

Each channel 331 is driven by a constant current switching power supply (not shown). A switching element (incorporated within LED driver IC 330a and not shown) controls the amount of current passing through each channel 331 via a current sense circuit 330f. A buck type topology constituted by an inductor 330g and a diode 330h converts the energy supplied to lighting subassembly using artificial light for plant-growing 200.

A multi-fixture synchronization unit 340 allows a synchronization signal 341 from a preceding lighting subassembly using artificial light for plant-growing 200 (when several lighting subassemblies are used) to be successively conveyed to the next lighting subassembly using artificial light for plant-growing 200 in a daisy chain configuration. Synchronization signal 341 acts on all lighting subassemblies 200 to turn on and off simultaneously. The first lighting subassembly using artificial light for plant-growing 200 in the chain initiates the pulsation of the other lighting subassemblies 200. Synchronization signal 341 is the type of Low Voltage Differential Signal (LVDS). A simple twisted-pair cable (not shown) interconnects different lighting subassemblies 200. Signal LVDS is converted to a required level by a TTL 342 via a signal level translator 345. TTL 342 signal is attached to microcontroller 307.

A memory card interface 360 is connected to microcontroller 310 via a serial communication bus 365. A memory card 361, similar to SD card type, contains information on a specific program adapted to various plant types according to the color, time, pulse and frequency.

LED indicators 370 display several system components status of temperature, master and slave units and power.

Power supply DC-DC converter 380 transforms the main 32V DC source to different DC voltages, required by electronic components. A conventional DC to DC converter (not shown) is used. The latter achieves up to 90% of efficiency and, thus, reduces the amount of released heat.

As required, a detailed embodiment of the present invention is disclosed herein; however, it is to be understood that the disclosed embodiment is merely exemplary of the invention which may embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed structure.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

Claim 1. A method using light emitting diodes (LEDs) for plant-growing, method carried out by one or more assemblies, wherein each of said one or more assemblies comprises

- means for housing used for attaching all other means of said assembly using artificial light for plant- growing, said means for housing incorporating a base situated in its interior and a printed circuit board connected to said base;
- means for lighting attached to said base and facing towards a bottom of said means for housing;
- and
- means for controlling said means for lighting.

said method using light emitting diodes for plant-growing includes the following operations:

- providing a white light spectrum incorporating a blue component and defined by a color temperature generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market;
- providing a red light spectrum having a luminous flux proper to red (R) LEDs and a dominant wavelength basically of 625 nm; and
- providing an amber light spectrum having a luminous flux proper to amber (A) LEDs and a dominant wavelength basically of 590 nm.

Claim 2. The method of claim 1 further comprising the following operations:

- providing a blue light spectrum having a luminous flux proper to blue (B) LEDs and a

dominant wavelength basically of 460 nm; and

- providing a cyan light spectrum having a luminous flux proper to cyan (C) LEDs and a dominant wavelength basically of 505 nm.

Claim 3. The method of claim 1 or claim 2, wherein when two or more assemblies are used, a synchronization between the assemblies is required.

Claim 4. A method using light emitting diodes (LEDs) for plant-growing, method carried out by one or more assemblies, wherein each of said one or more assemblies comprises

- means for housing used for attaching all other means of said assembly using artificial light for plant- growing, said means for housing incorporating a base situated in its interior and a printed circuit board connected to said base;

- means for lighting attached to said base and facing towards a bottom of said means for housing;
- and

- means for controlling said means for lighting;

said method using light emitting diodes for plant-growing including the following operations:

- providing basically white (W), red (R) and amber (A) spectra, said means for lighting including at least one LEDs module; said at least one LEDs module incorporating, when

a) a $N = 8$ white (W) LEDs are used, b) $3N/8$ red (R) LEDs and $3N/8$ amber (A) LEDs;

- displaying by each said N white (W) LEDs a white light spectrum incorporating a blue component and defined by a color temperature generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market;

- displaying by each said $3N/8$ red (R) LEDs, a red light spectrum generally providing 70% of

said luminous flux of each said white (W) LEDs available on the market and, basically, a dominant wavelength of 625 nm; and

- displaying by each said 3N/8 amber (A) an amber light spectrum generally providing a luminous flux equal to 90% of said luminous flux of each said N white (W) LEDs, and, basically, a dominant wavelength of 590 nm.

Claim 5. The method using light emitting diodes (LEDs) for plant-growing, as defined in claim 4, wherein said at least one module further comprises N/8 cyan (C) LEDs and N/8 blue (B) LEDs, so that said N white (W) LEDs constituting 50% of a total number of LEDs used by said at least one LEDs module; b) said 3N/8 red (R) LEDs constituting 18.75 of the total number of LEDs used by said at least one LEDs module; said 3N/8 amber (A) LEDs constituting 18.75 of the total number of LEDs used by said at least one LEDs module; said N/8 cyan (C) constituting 6.25 of the total number of LEDs used by said at least one LEDs module; and said N/8 blue (B) LEDs constitutes 6.25 of the total number of LEDs used by said at least one LEDs module; said method further including the operations of:

- displaying by each said N/8 cyan (C) LEDs, a cyan light spectrum generally providing a luminous flux equal to 60% of said luminous flux of each said N white (W) LEDs and, basically, having a dominant wavelength of 505nm; and

- displaying by each said N/8 blue (B) LEDs, a blue light spectrum generally providing a luminous flux equal to 20% of said luminous flux of said N (white) LEDs and, basically, having a dominant wavelength of 460nm.

Claim 6. An assembly using light emitting diodes (LEDs) for plant-growing comprising

- means for housing used for attaching all other means of said assembly using light emitting diodes (LEDs) for plant- growing, said means for housing incorporating a base situated in its interior and a printed circuit board connected to said base;
- means for lighting attached to said base and facing towards a bottom of said means for housing;
- and
- means for controlling said means for lighting.

said assembly using light emitting diodes for plant-growing including

- LEDs means for providing a white light spectrum incorporating a blue component and defined by a color temperature generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market;
- LEDs means for providing a red light spectrum having a luminous flux proper to red (R) LEDs and a dominant wavelength basically of 625 nm; and
- LEDs means for providing an amber light spectrum having a luminous flux proper to amber (A) LEDs and a dominant wavelength basically of 590 nm; and

when more than one assemblies are coupled together, their synchronization is necessary.

Claim 7. The assembly, as defined in claim 6, further comprising:

- LEDs means for providing a blue light spectrum having a luminous flux proper to blue (B) LEDs and a dominant wavelength basically of 460 nm; and
- LEDs means for providing a cyan light spectrum having a luminous flux proper to cyan (C) LEDs and a dominant wavelength basically of 505 nm.

Claim 8. An assembly using light emitting diodes (LEDs) for plant-growing comprising:

- means for housing used for attaching all other means of said assembly using artificial light for plant- growing, said means for housing incorporating a base situated in its interior and a printed circuit board connected to said base;
- means for lighting attached to said base and facing towards a bottom of said means for housing; said means for lighting including at least one LEDs module, basically for providing white (W), red (R) and amber (A) spectra; said at least one LEDs module incorporating, when
 - a) a $N = 8$ white (W) LEDs are used, b) $3N/8$ red (R) LEDs are used; and $3N/8$ amber (A) LEDs are used; said N white (W) LEDs display a white light spectrum incorporating a blue component and defined by a color temperature generally in a range of 5000-6000K and a luminous flux proper to white (W) LEDs available on the market; said $3N/8$ red (R) LEDs each displaying a red light spectrum generally providing 70% of said luminous flux of each said white (W) LEDs available on the market and, basically, a dominant wavelength of 625 nm; and said $3N/8$ amber (A), each displaying an amber light spectrum generally providing a luminous flux equal to 90% of said luminous flux of each said N white (W) LEDs, and, basically, a dominant wavelength of 590 nm; and
- means for controlling said means for lighting.

Claim 9. The assembly using artificial light for plant-growing as defined in claim 4, wherein said at least one module further comprises $N/8$ cyan (C) LEDs and $N/8$ blue (B) LEDs, so that said N white (W) LEDs constitute 50% of a total number of LEDs used by said at least one LEDs module; b) said $3N/8$ red (R) LEDs constitute 18.75 of the total number of LEDs used by said at least one LEDs module; said $3N/8$ amber (A) LEDs constitute 18.75 of the total number of LEDs

used by said at least one LEDs module; said N/8 cyan (C) constitutes 6.25 of the total number of LEDs used by said at least one LEDs module; and said N/8 blue (B) LEDs constitutes 6.25 of the total number of LEDs used by said at least one LEDs module; said N/8 cyan (C) LED, each displaying a cyan light spectrum providing 60% of said luminous flux of each said N (white) LEDs and, basically, a dominant wavelength of 505nm, while said N/8 blue (B) LEDs providing each 20% of said luminous flux of said N (white) LEDs and, basically, a dominant wavelength of 460nm.

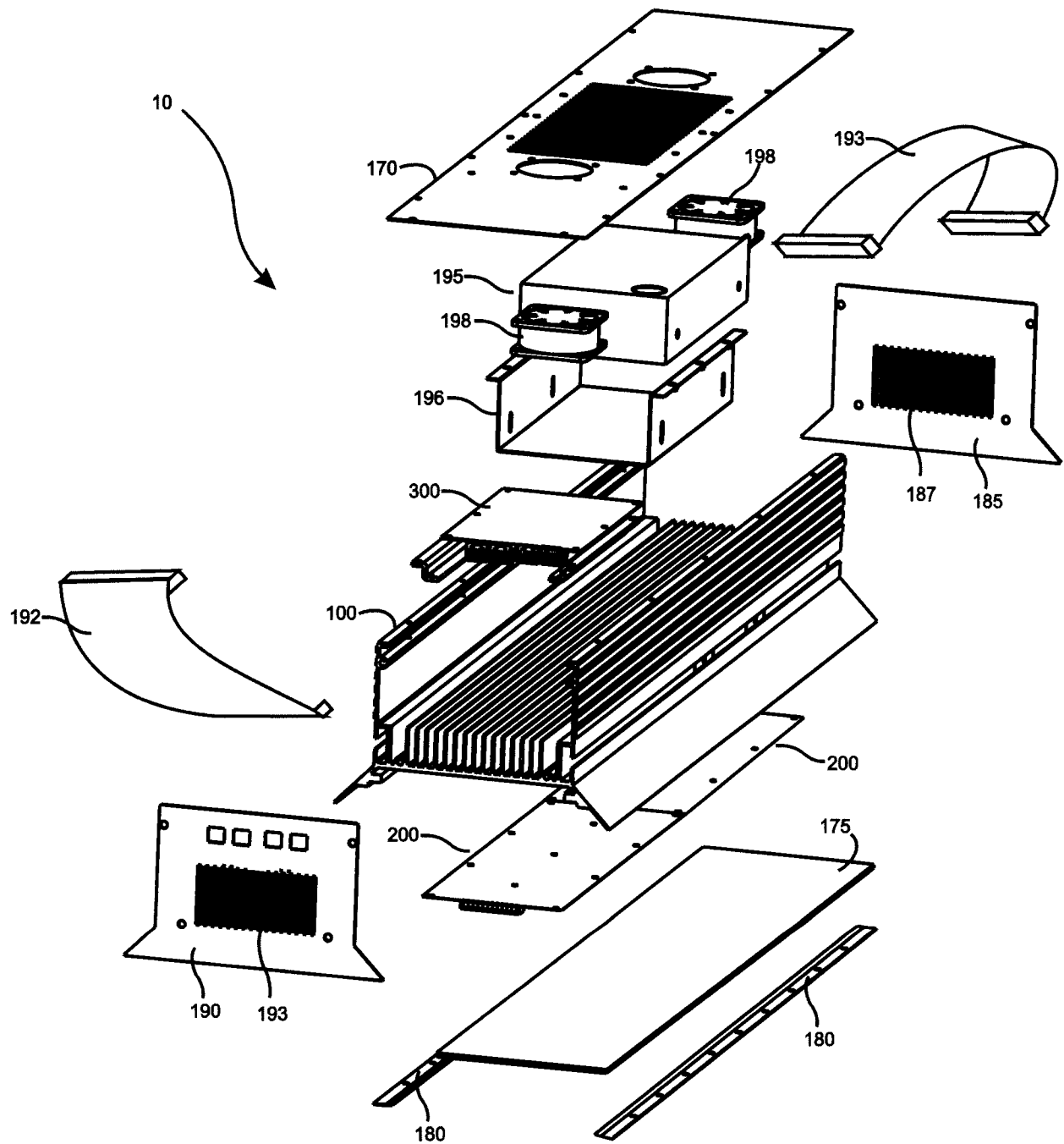


FIG. 1

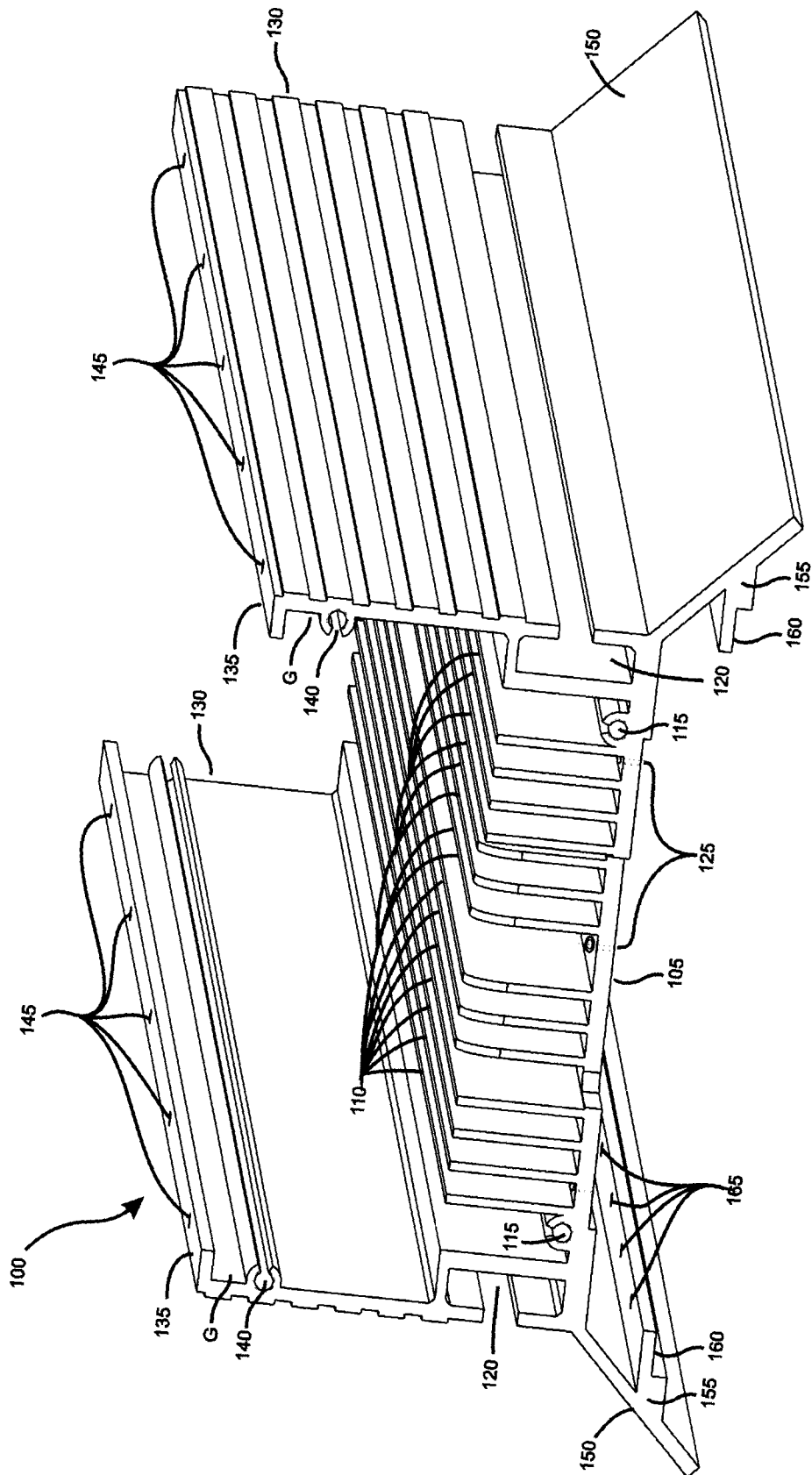


FIG. 2

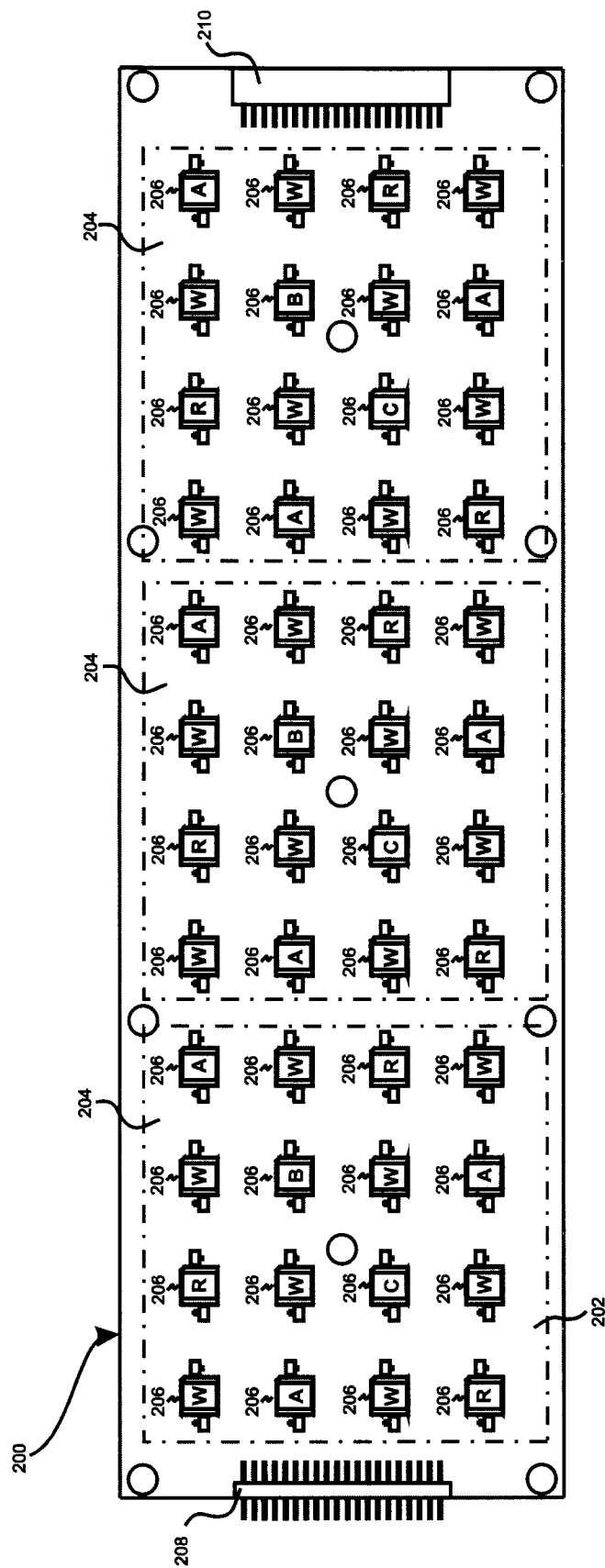
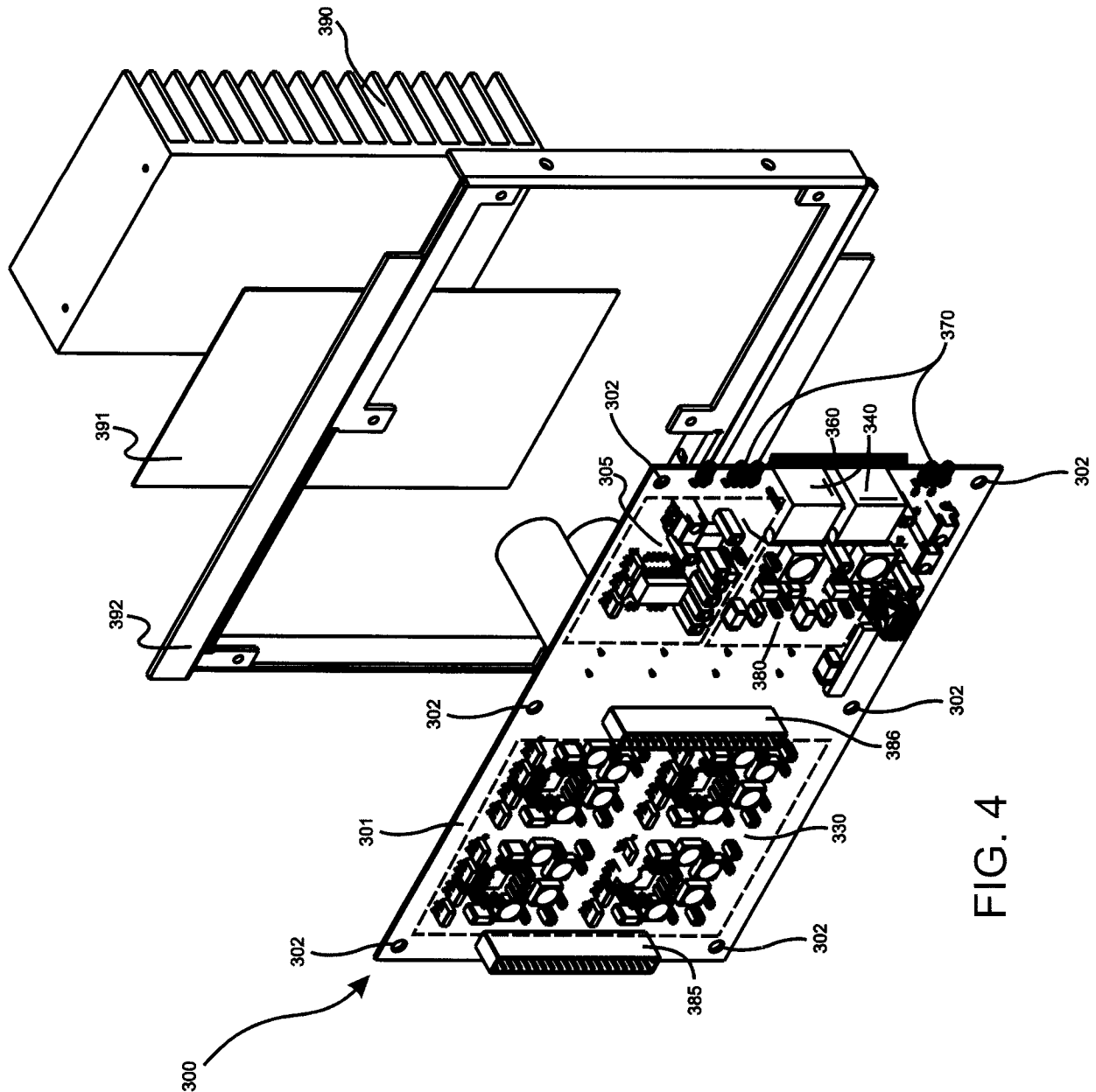


FIG. 3



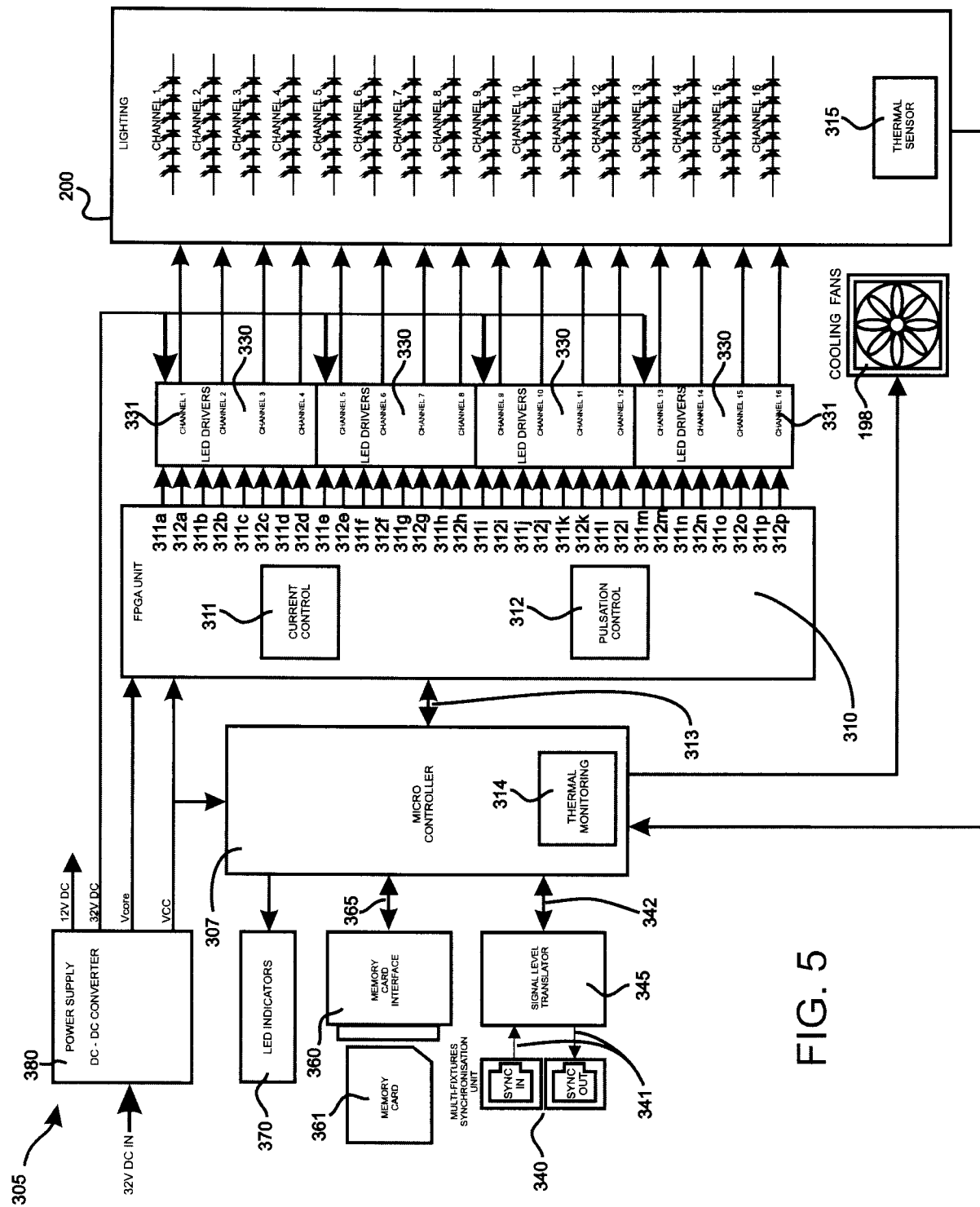
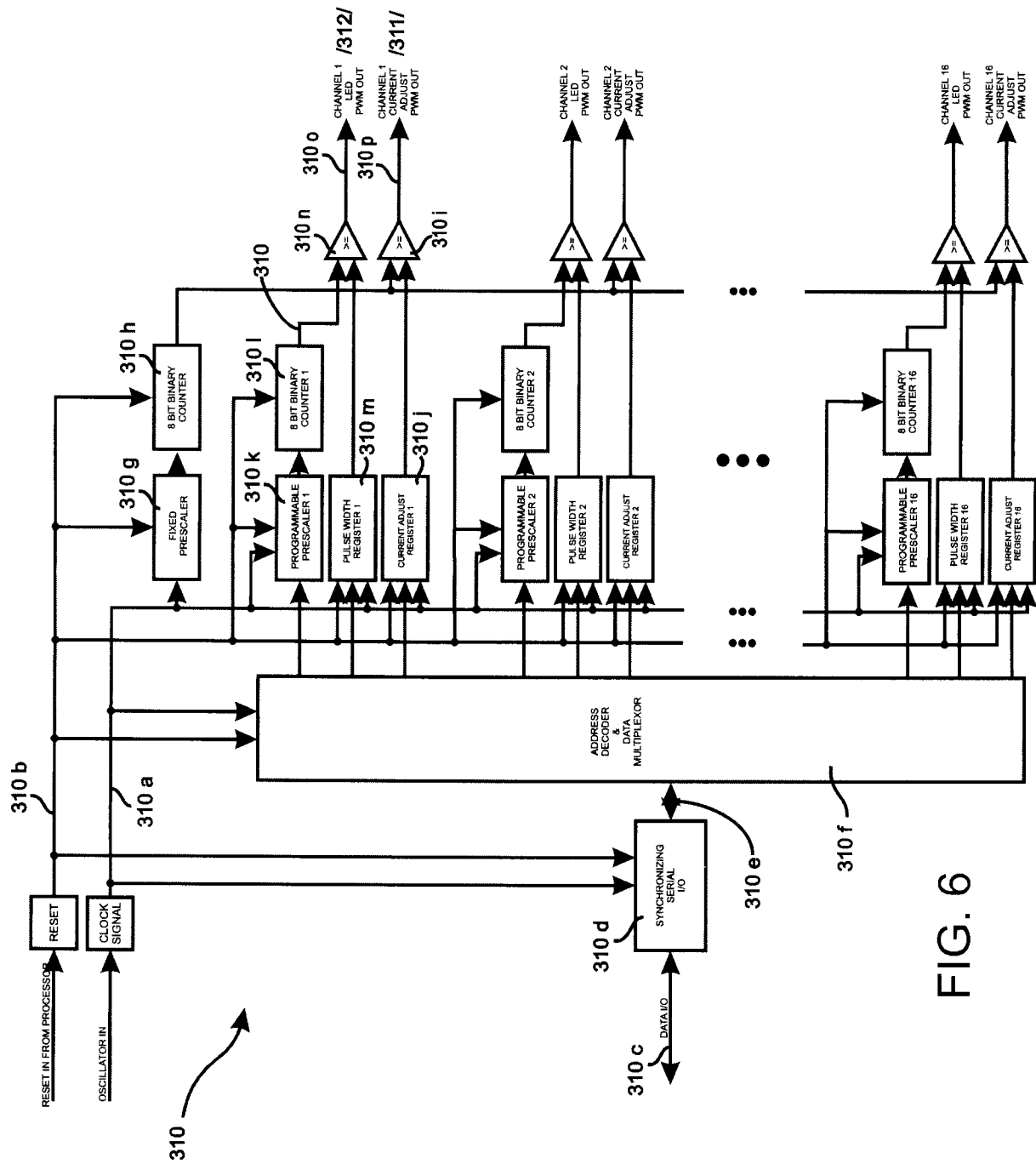


FIG. 5



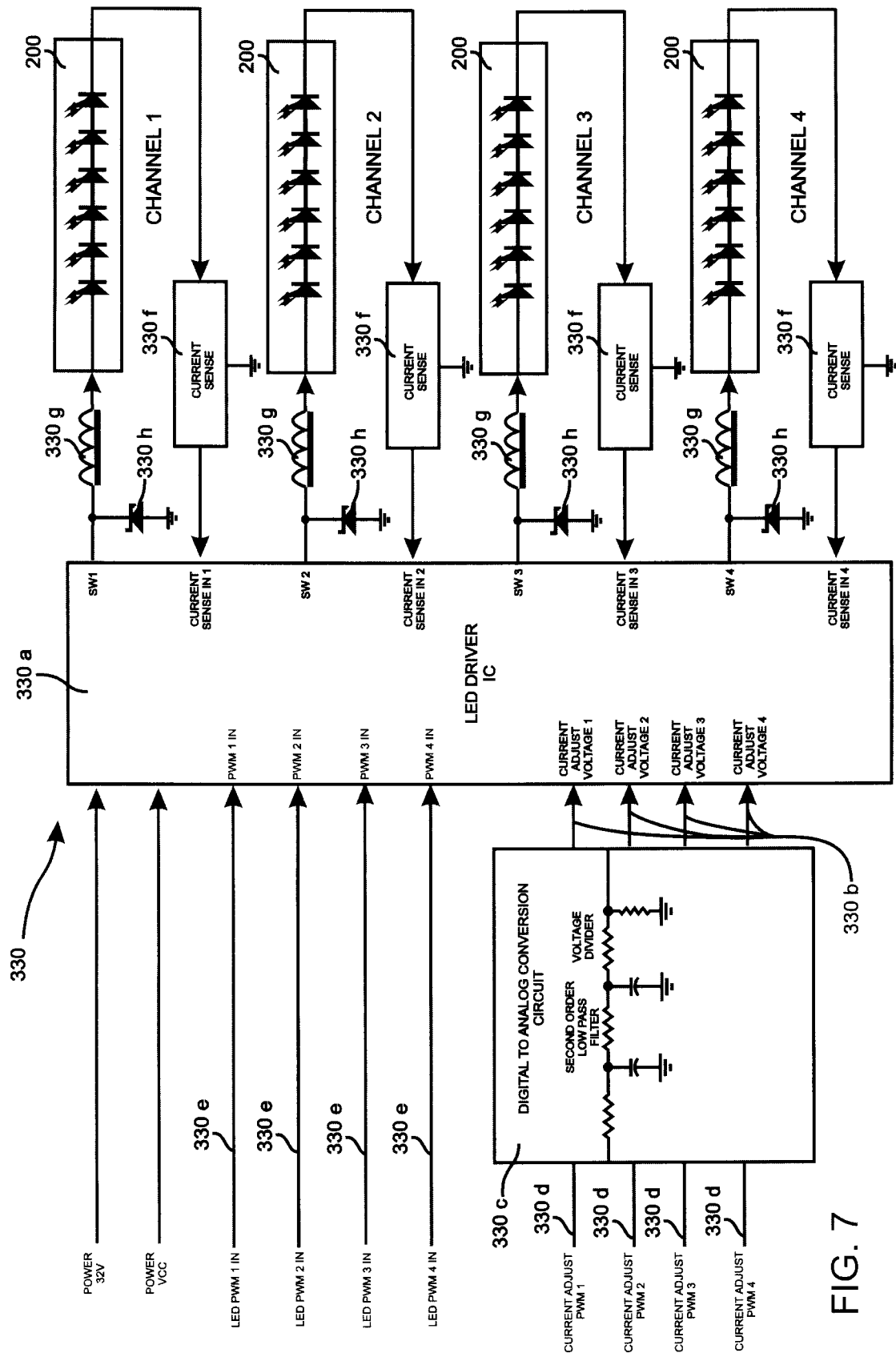


FIG. 7