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(54) **MULTICOLORED LED LIGHTING METHOD AND APPARATUS**

VERFAHREN UND EINRICHTUNG ZUR MEHRFARBIGEN BELEUCHTUNG DURCH LEDS  
PROCEDE ET DISPOSITIF POUR ECLAIRAGE MULTICOLORE A DIODES  
ELECTROLUMINESCENTES

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(56) References cited:  
**EP-A- 0 752 632                      FR-A- 2 640 791  
US-A- 4 887 074                      US-A- 5 410 328  
US-A- 5 420 482**

• **PATENT ABSTRACTS OF JAPAN vol. 018, no.  
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## Description

**[0001]** This application claims priority from United States Patent Application No. 08/920,156, filed August 26, 1997 and relates to an illumination apparatus comprising a plurality of light emitters of at least two different colors adapted to be coupled to a power circuit including a power source and a common potential reference, driver means for driving the plurality of light emitters, the driver means comprising at least two switches connected to the plurality of light emitters and said power circuit and corresponding to respective current paths of the at least two different color light emitters. Such an illumination apparatus is disclosed in US-A-5,420,482.

**[0002]** The present invention relates to providing light of a selectable color using light sources, such as LEDs. More particularly, the present invention concerns apparatus for providing a computer controlled multicolored illumination network capable of high performance and rapid color selection and change.

**[0003]** It is well known that combining the projected light of one color with the projected light of another color will result in the creation of a third color. It is also well known that the three most commonly used primary colors -- red, blue and green -- can be combined in different proportions to generate almost any color in the visible spectrum. The present invention takes advantage of these effects by combining the projected light from at least two light emitting diodes (LEDs) of different primary colors. It should be understood that for purposes of this invention the term "primary colors" encompasses any different colors that can be combined to create other colors.

**[0004]** Computer lighting networks are not new. U.S. Patent No. 5,420,482, issued to Phares, describes one such network that uses different colored LEDs to generate a selectable color. Phares is primarily for use as a display apparatus. However, the apparatus has several disadvantages and limitations. First, each of the three color LEDs in Phares is powered through a transistor biasing scheme in which the transistor base is coupled to a respective latch register through biasing resistors. The three latches are all simultaneously connected to the same data lines on the data bus.

This means it is impossible in Phares to change all three LED transistor biases independently and simultaneously. Also, biasing of the transistors is inefficient because power delivered to the LEDs is smaller than that dissipated in the biasing network. This makes the device poorly suited for efficient illumination applications. The transistor biasing used by Phares also makes it difficult, if not impossible, to interchange groups of LEDs having different power ratings, and hence different intensity levels.

**[0005]** U.S. Patent No. 4,845,481, issued to Havel, is directed to a multicolored display device. Havel ad-

resses some, but not all of the switching problems associated with Phares. Havel uses a pulse width modulated signal to provide current to respective LEDs at a particular duty cycle. However, no provision is made for precise and rapid control over the colors emitted. As a stand alone unit, the apparatus in Havel suggests away from network lighting, and therefore lacks any teaching as to how to implement a pulse width modulated computer lighting network. Further, Havel does not appreciate the use of LEDs beyond mere displays, such as for illumination.

**[0006]** U.S. Patent No. 5,184,114, issued to Brown, shows an LED display system. But Brown lacks any suggestion to use LEDs for illumination, or to use LEDs in a configurable computer network environment. U.S. Patent No. 5,134,387, issued to Smith et al., directed to an LED matrix display, contains similar problems. Its rudimentary current control scheme severely limits the possible range of colors that can be displayed.

**[0007]** US-A-4,887,074 discloses a computer-controlled LED display system in which the LEDs are switched on and off, using switches operated by a controller, so that the LEDs are driven by a train of light pulses operated by intervals of substantially zero light intensity. However, DI fails to disclose either a pulse width modulation technique for individually adjusting the light intensity of the LEDs of different colour, or the controller operating in response to a data stream portion identified in an input data stream as pertaining to that controller.

**[0008]** FR-A-2 640 791 discloses a lighting network having a plurality of illumination units, in which the light intensity of the LEDs is controlled by varying the magnitude of the current supplied. It does not, however, disclose the use of pulse width modulation for setting a duty cycle for the LED(s) of each colour, for varying the brightness. Furthermore, it also fails to disclose a controller that, according to its set alterable address, identifies a corresponding data stream portion used to produce PWM signals for determining the respective duty cycles of the different colour LEDs.

**[0009]** According to the invention there is provided an illumination apparatus in accordance with that as claimed in independent claim 1.

**[0010]** In one embodiment, the illumination apparatus includes a binary tree network configuration of lighting units (nodes). In another embodiment, the apparatus comprises a heat dissipating housing, made out of a heat-conductive material, for housing the lighting assembly. The heat dissipating housing contains two stacked circuit boards holding respectively the power module and the light module. The light module is adapted to be conveniently interchanged with other light modules having programmable current, and hence maximum light intensity, ratings. Such other light modules may include organic LEDs, electro-luminescent strips, and other modules, in addition to conventional LEDs.

**[0011]** Disclosed herein is a high performance computer controlled multicolored lighting network, which is

an LED lighting network.

**[0012]** Disclosed herein is a LED lighting network structure capable of both a linear chain of nodes and a binary tree configuration.

**[0013]** Disclosed herein is an illumination apparatus of the lighting network comprising a heat-dissipating housing to contain the illumination apparatus.

**[0014]** Disclosed herein is a current regulated LED illumination apparatus, wherein the apparatus contains lighting modules each having its own maximum current rating and each conveniently interchangeable with one another.

**[0015]** Disclosed herein is a computer current-controlled LED lighting assembly for use as a general illumination device capable of emitting multiple colors in a continuously programmable 24-bit spectrum.

**[0016]** The invention will be better understood by referring, by way of example, to the accompanying drawings, in which:-

Figure 1 is a stylized electrical circuit schematic of a light module included in a first embodiment of the present invention.

Figure 2 is a stylized electrical circuit schematic of the power module of the first embodiment of the present invention.

Figure 3 is an exploded view of the housing of a practical realisation of the present invention.

Figure 4 is a plan view of the LED-containing side of the light module of this embodiment.

Figure 5 is a plan view of the electrical connector side of the light module of the same embodiment.

Figure 6 is a plan view of the power terminal side of the power module of the same embodiment.

Figure 7 is a plan view of the electrical connector side of the power module of the same embodiment.

**[0017]** The structure and operation of a preferred embodiment will now be described. It should be understood that many other ways of practising the inventions herein are available, and the embodiments described herein are exemplary and not limiting, other than falling within the scope of the appended claims.

**[0018]** Turning to Figure 1, shown is an electrical schematic representation of a light module 100 of the present invention. Figures 4 and 5 show the LED-containing side and the electrical connector side of light module 100. Light module 110 is self-contained, and is configured to be a standard item interchangeable with any similarly constructed light module. Light module 100 contains a ten-pin electrical connector 110 of the general type. In this embodiment, the connector 110 contains male pins adapted to fit into a complementary ten-pin connector female assembly, to be described below. Pin 180 is the power supply. A source of DC electrical potential enters module 100 on pin 180. Pin 180 is electrically connected to the anode end of light emitting diode (LED) sets 120, 140 and 160 to establish a uniform

high potential on each anode end.

**[0019]** LED set 120 contains red LEDs, set 140 contains blue and set 160 contains green, each obtainable from the Nichia America Corporation. These LEDs are primary colors, in the sense that such colors when combined in preselected proportions can generate any color in the spectrum. While three primary colors is preferred, it will be understood that the present invention will function nearly as well with only two primary colors to generate any color in the spectrum. Likewise, while the different primary colors are arranged herein on sets of uniformly colored LEDs, it will be appreciated that the same effect may be achieved with single LEDs containing multiple color-emitting semiconductor dies. LED sets 120, 140 and 160 each preferably contains a serial/parallel array of LEDs in the manner described by Okuno in U. S. Patent No. 4,298,869, incorporated herein by reference. In the present embodiment, LED set 120 contains three parallel connected rows of nine red LEDs (not shown), and LED sets 140 and 160 each contain five parallel connected rows of five blue and green LEDs, respectively (not shown). It is understood by those in the art that, in general, each red LED drops the potential in the line by a lower amount than each blue or green LED, about 2.1 V, compared to 4.0 V, respectively, which accounts for the different row lengths. This is because the number of LEDs in each row is determined by the amount of voltage drop desired between the anode end at the power supply voltage and the cathode end of the last LED in the row. Also, the parallel arrangement of rows is a fail-safe measure that ensures that the light module 100 will still function even if a single LED in a row fails, thus opening the electrical circuit in that row. The cathode ends of the three parallel rows of nine red LEDs in LED set 120 are then connected in common, and go to pin 128 on connector 110. Likewise, the cathode ends of the five parallel rows of five blue LEDs in LED set 140 are connected in common, and go to pin 148 on connector 110. The cathode ends of the five parallel rows of five green LEDs in LED set 160 are connected in common, and go to pin 168 on connector 110. Finally, on light module 100, each LED set is associated with a programming resistor that combines with other components, described below, to program the maximum current through each set of LEDs. Between pin 124 and 126 is resistor 122, 6.2  $\Omega$ . Between pin 144 and 146 is resistor 142, 4.7  $\Omega$ . Between pin 164 and 166 is resistor 162, 4.7  $\Omega$ . Resistor 122 programs maximum current through red LED set 120, resistor 142 programs maximum current through blue LED set 140, and resistor 162 programs maximum current through green LED set 160. The values these resistors should take are determined empirically, based on the desired maximum light intensity of each LED set. In the present embodiment, the resistances above program red, blue and green currents of 70, 50 and 50  $\mu\text{A}$ , respectively.

**[0020]** With the electrical structure of light module 100 described, attention will now be given to the electrical

structure of power module 200, shown in Figure 2. Figures 6 and 7 show the power terminal side and electrical connector side of an embodiment of power module 200. Like light module 100, power module 200 is self contained. Interconnection with male pin set 110 is achieved through complementary female pin set 210. Pin 280 connects with pin 180 for supplying power, delivered to pin 280 from supply 300. Supply 300 is shown as a functional block for simplicity. In actuality, supply 300 can take numerous forms for generating a DC voltage. In the present embodiment, supply 300 provides 24 Volts through a connection terminal (not shown), coupled to pin 280 through transient protection capacitors (not shown) of the general type. It will be appreciated that supply 300 may also supply a DC voltage after rectification and/or voltage transformation of an AC supply, as described more fully in U.S. Patent No. 4,298,869.

**[0021]** Also connected to pin connector 210 are three current programming integrated circuits, ICR 220, ICB 240 and ICG 260. Each of these is a three terminal adjustable regulator, preferably part number LM317B, available from the National Semiconductor Corporation, Santa Clara, California. The teachings of the LM317 datasheet are incorporated herein by reference. Each regulator contains an input terminal, an output terminal and an adjustment terminal, labeled I, O, and A, respectively. The regulators function to maintain a constant maximum current into the input terminal and out of the output terminal. This maximum current is preprogrammed by setting a resistance between the output and the adjustment terminals. This is because the regulator will cause the voltage at the input terminal to settle to whatever value is needed to cause 1.25 V to appear across the fixed current set resistor, thus causing constant current to flow. Since each functions identically, only ICR 220 will now be described. First, current enters the input terminal of ICR 220 from pin 228. Of course, pin 228 in the power module is coupled to pin 128 in the light module, and receives current directly from the cathode end of the red LED set 120. Since resistor 122 is ordinarily disposed between the output and adjustment terminals of ICR 220 through pins 224/124 and 226/126, resistor 122 programs the amount of current regulated by ICR 220. Eventually, the current output from the adjustment terminal of ICR 220 enters a Darlington driver. In this way, ICR 220 and associated resistor 122 program the maximum current through red LED set 120. Similar results are achieved with ICB 240 and resistor 142 for blue LED set 140, and with ICG 260 and resistor 162 for green LED set 160.

**[0022]** The red, blue and green LED currents enter another integrated circuit, IC1 380, at respective nodes 324, 344 and 364. IC1 380 is preferably a high current/voltage Darlington driver, part no. DS2003 available from the National Semiconductor Corporation, Santa Clara, California. IC1 380 is used as a current sink, and functions to switch current between respective LED sets and ground 390. As described in the DS2003 datasheet,

incorporated herein by reference, IC1 contains six sets of Darlington transistors with appropriate on-board biasing resistors. As shown, nodes 324, 344 and 364 couple the current from the respective LED sets to three pairs of these Darlington transistors, in the well known manner to take advantage of the fact that the current rating of IC1 380 may be doubled by using pairs of Darlington transistors to sink respective currents. Each of the three on-board Darlington pairs is used in the following manner as a switch. The base of each Darlington pair is coupled to signal inputs 424, 444 and 464, respectively. Hence, input 424 is the signal input for switching current through node 324, and thus the red LED set 120. Input 444 is the signal input for switching current through node 344, and thus the blue LED set 140. Input 464 is the signal input for switching current through node 364, and thus the green LED set 160. Signal inputs 424, 444 and 464 are coupled to respective signal outputs 434, 454 and 474 on microcontroller IC2 400, as described below. In essence, when a high frequency square wave is incident on a respective signal input, IC1 380 switches current through a respective node with the identical frequency and duty cycle. Thus, in operation, the states of signal inputs 424, 444 and 464 directly correlate with the opening and closing of the power circuit through respective LED sets 120, 140 and 160

**[0023]** The structure and operation of microcontroller IC2 400 will now be described. Microcontroller IC2 400 is preferably a MICROCHIP brand PIC16C63, although almost any properly programmed microcontroller or microprocessor can perform the software functions described herein. The main function of microcontroller IC2 400 is to convert numerical data received on serial Rx pin 520 into three independent high frequency square waves of uniform frequency but independent duty cycles on signal output pins 434, 454 and 474. The Figure 2 representation of microcontroller IC2 400 is partially stylized, in that persons of skill in the art will appreciate that certain of the twenty-eight standard pins have been omitted or combined for greatest clarity.

**[0024]** Microcontroller IC2 400 is powered through pin 450, which is coupled to a 5 Volt source of DC power 700. Source 700 is preferably driven from supply 300 through a coupling (not shown) that includes a voltage regulator (not shown). An exemplary voltage regulator is the LM340 3-terminal positive regulator, available from the National Semiconductor Corporation, Santa Clara, California. The teachings of the LM340 datasheet are hereby incorporated by reference. Those of skill in the art will appreciate that most microcontrollers, and many other independently powered digital integrated circuits, are rated for no more than a 5 Volt power source. The clock frequency of microcontroller IC2 400 is set by crystal 480, coupled through appropriate pins. Pin 490 is the microcontroller IC2 400 ground reference.

**[0025]** Switch 600 is a twelve position dip switch that may be alterably and mechanically set to uniquely identify the microcontroller IC2 400. When individual ones

of the twelve mechanical switches within dip switch 600 are closed, a path is generated from corresponding pins 650 on microcontroller IC2 400 to ground 690. Twelve switches create 2<sup>12</sup> possible settings, allowing any microcontroller IC2 400 to take on one of 4096 different IDs, or addresses. In the preferred embodiment, only nine switches are actually used because the DMX-512 protocol, discussed below, is employed.

**[0026]** Once switch 600 is set, microcontroller IC2 400 "knows" its unique address ("who am I"), and "listens" on serial line 520 for a data stream specifically addressed to it. A high speed network protocol, preferably a DMX protocol, is used to address network data to each individually addressed microcontroller IC2 400 from a central network controller (not shown). The DMX protocol is described in a United States Theatre Technology, Inc. publication entitled "DMX512/1990 Digital Data Transmission Standard for Dimmers and Controllers," incorporated herein by reference. Basically, in the network protocol used herein, a central controller (not shown) creates a stream of network data consisting of sequential data packets. Each packet first contains a header, which is checked for conformance to the standard and discarded, followed by a stream of sequential bytes representing data for sequentially addressed devices. For instance, if the data packet is intended for light number fifteen, then fourteen bytes from the data stream will be discarded, and the device will save byte number fifteen. If as in the preferred embodiment, more than one byte is needed, then the address is considered to be a starting address, and more than one byte is saved and utilized. Each byte corresponds to a decimal number 0 to 255, linearly representing the desired intensity from Off to Full. (For simplicity, details of the data packets such as headers and stop bits are omitted from this description, and will be well appreciated by those of skill in the art.) This way, each of the three LED colors is assigned a discrete intensity value between 0 and 255. These respective intensity values are stored in respective registers within the memory of microcontroller IC2 400 (not shown). Once the central controller exhausts all data packets, it starts over in a continuous refresh cycle. The refresh cycle is defined by the standard to be a minimum of 1196 microseconds, and a maximum of 1 second.

**[0027]** Microcontroller IC2 400 is programmed continually to "listen" for its data stream. When microcontroller IC2 400 is "listening," but before it detects a data packet intended for it, it is running a routine designed to create the square wave signal outputs on pins 434, 454 and 474. The values in the color registers determine the duty cycle of the square wave. Since each register can take on a value from 0 to 255, these values create 256 possible different duty cycles in a linear range from 0% to 100%. Since the square wave frequency is uniform and determined by the program running in the microcontroller IC2 400, these different discrete duty cycles represent variations in the width of the square wave pulses.

This is known as pulse width modulation (PWM).

**[0028]** The PWM interrupt routine is implemented using a simple counter, incrementing from 0 to 255 in a cycle during each period of the square wave output on pins 434, 454 and 474. When the counter rolls over to zero, all three signals are set high. Once the counter equals the register value, signal output is changed to low. When microcontroller IC2 400 receives new data, it freezes the counter, copies the new data to the working registers, compares the new register values with the current count and updates the output pins accordingly, and then restarts the counter exactly where it left off. Thus, intensity values may be updated in the middle of the PWM cycle. Freezing the counter and simultaneously updating the signal outputs has at least two advantages. First, it allows each lighting unit to quickly pulse/strobe as a strobe light does. Such strobing happens when the central controller sends network data having high intensity values alternately with network data having zero intensity values at a rapid rate. If one restarted the counter without first updating the signal outputs, then the human eye would be able to perceive the staggered deactivation of each individual color LED that is set at a different pulse width. This feature is not of concern in incandescent lights because of the integrating effect associated with the heating and cooling cycle of the illumination element. LEDs, unlike incandescent elements, activate and deactivate essentially instantaneously in the present application. The second advantage is that one can "dim" the LEDs without the flickering that would otherwise occur if the counter were reset to zero. The central controller can send a continuous dimming signal when it creates a sequence of intensity values representing a uniform and proportional decrease in light intensity for each color LED. If one did not update the output signals before restarting the counter, there is a possibility that a single color LED will go through nearly two cycles without experiencing the zero current state of its duty cycle. For instance, assume the red register is set at 4 and the counter is set at 3 when it is frozen. Here, the counter is frozen just before the "off part" of the PWM cycle is to occur for the red LEDs. Now assume that the network data changes the value in the red register from 4 to 2 and the counter is restarted without deactivating the output signal. Even though the counter is greater than the intensity value in the red register, the output state is still "on", meaning that maximum current is still flowing through the red LEDs. Meanwhile, the blue and green LEDs will probably turn off at their appropriate times in the PWM cycle. This would be perceived by the human eye as a red flicker in the course of dimming the color intensities. Freezing the counter and updating the output for the rest of the PWM cycle overcomes these disadvantages, ensuring the flicker does not occur.

**[0029]** The network interface for microcontroller IC2 400 will now be described. Jacks 800 and 900 are standard RJ-8 network jacks. Jack 800 is used as an input

jack, and is shown for simplicity as having only three inputs: signal inputs 860, 870 and ground 850. Network data enters jack 800 and passes through signal inputs 860 and 870. These signal inputs are then coupled to IC3 500, which is an RS-485/RS-422 differential bus repeater of the standard type, preferably a DS96177 from the National Semiconductor Corporation, Santa Clara, California. The teachings of the DS96177 datasheet are hereby incorporated by reference. The signal inputs 860, 870 enter IC3 500 at pins 560, 570. The data signal is passed through from pin 510 to pin 520 on microcontroller IC2 400. The same data signal is then returned from pin 540 on IC2 400 to pin 530 on IC3 500. Jack 900 is used as an output jack and is shown for simplicity as having only five outputs: signal outputs 960, 970, 980, 990 and ground 950. Outputs 960 and 970 are split directly from input lines 860 and 870, respectively. Outputs 980 and 990 come directly from IC3 500 pins 580 and 590, respectively. It will be appreciated that the foregoing assembly enables two network nodes to be connected for receiving the network data. Thus, a network may be constructed as a daisy chain, if only single nodes are strung together, or as a binary tree, if two nodes are attached to the output of each single node.

**[0030]** From the foregoing description, one can see that an addressable network of LED illumination or display units can be constructed from a collection of power modules each connected to a respective light module. As long as at least two primary color LEDs are used, any illumination or display color may be generated simply by preselecting the light intensity that each color LED emits. Further, each color LED can emit light at any of 255 different intensities, depending on the duty cycle of PWM square wave, with a frill intensity pulse generated by passing maximum current through the LED. Further still, the maximum intensity can be conveniently programmed simply by adjusting the ceiling for the maximum allowable current using programming resistances for the current regulators residing on the light module. Light modules of different maximum current ratings may thereby be conveniently interchanged.

**[0031]** The foregoing embodiment may reside in any number of different housings. A preferred housing for an illumination unit is described. Turning now to Figure 3, there is shown an exploded view of an illumination unit of the present invention comprising a substantially cylindrical body section 10, a light module 20, a conductive sleeve 30, a power module 40, a second conductive sleeve 50, and an enclosure plate 60. It is to be assumed here that the light module 20 and the power module 40 contain the electrical structure and software of light module 100 and power module 200, described above. Screws 62, 64, 66, 68 allow the entire apparatus to be mechanically connected. Body section 10, conductive sleeves 30 and 50 and enclosure plate 60 are preferably made from a material that conducts heat, most preferably aluminum. Body, section 10 has an open end, a reflective interior portion and an illumination end, to which

module 20 is mechanically affixed. Light module 20 is disk shaped and has two sides. The illumination side (not shown) comprises a plurality of LEDs of different primary colors. The connection side holds an electrical connector male pin assembly 22. Both the illumination side and the connection side are coated with aluminum surfaces to better allow the conduction of heat outward from the plurality of LEDs to the body section 10. Likewise, power module 40 is disk shaped and has every available surface covered with aluminum for the same reason. Power module 40 has a connection side holding an electrical connector female pin assembly 44 adapted to fit the pins from assembly 22. Power module 40 has a power terminal side holding a terminal 42 for connection to a source of DC power. Any standard AC or DC jack may be used, as appropriate.

**[0032]** Interposed between light module 20 and power module 40 is a conductive aluminum sleeve 30, which substantially encloses the space between modules 20 and 40. As shown, a disk-shaped enclosure plate 60 and screws 62, 64, 66 and 68 seal all of the components together, and conductive sleeve 50 is thus interposed between enclosure plate 60 and power module 40. Once sealed together as a unit, the illumination apparatus may be connected to a data network as described above and mounted in any convenient manner to illuminate an area. In operation, preferably a light diffusing means will be inserted in body section 10 to ensure that the LEDs on light module 20 appear to emit a single uniform frequency of light.

**[0033]** From the foregoing, it will be appreciated that PWM current control of LEDs to produce multiple colors may be incorporated into countless environments, with a network.

**[0034]** While the foregoing has been a detailed description of the preferred embodiment of the invention, the claims which follow define more freely the scope of invention to which applicant is entitled.

## Claims

### 1. An illumination apparatus comprising:

a plurality of light emitters of at least two different colours adapted to be coupled to a power circuit including a power source (300) and a common potential reference (390);  
 driver means (380) for driving the plurality of light emitters, the driver means comprising at least two switches connected to the plurality of light emitters and said power circuit and corresponding to respective current paths of the at least two different colour light emitters; and  
 a controller for periodically and independently opening and closing the at least two switches, the controller having an alterable address assigned to itself such as to identify and respond

to a respective portion of an input data stream assigned thereto, which data stream portion is assigned to that controller,

**characterised by** each light emitter being an LED; and

said controller (400) being arranged to generate a plurality of PWM signals, each signal corresponding to a respective colour of the plurality of LEDs of different colours, each said PWM signal causing a respective one of the at least two switches to be opened and closed at corresponding frequencies according to respective duty cycles, and wherein said data stream portion comprises data for determining the respective duty cycles of the at least two different colour LEDs.

2. Apparatus according to claim 1, wherein the controller comprises at least two registers for the at least two different colour LEDs, respectively arranged to store respective data values of the data stream portion for the at least two different colour LEDs, the controller being arranged to use these data values for determining the respective duty cycles of the corresponding colour LEDs.

3. Apparatus according to claim 1 or 2, comprising a housing that substantially encloses the plurality of LEDs, the driver means and the controller.

4. Apparatus according to claim 1 or 2, further comprising a current regulator for controlling the respective maximum currents supplied along said current paths to the plurality of LEDs, so as to maintain the maximum currents at constant maximum values.

5. Apparatus according to claim 3, further comprising a current regulator for controlling the respective maximum currents supplied along said current paths to the plurality of LEDs, so as to maintain the maximum currents at constant maximum values, the housing substantially enclosing the current regulator in addition to the plurality of LEDs, the driver means and the controller.

6. Apparatus according to any preceding claim, wherein each LED is an organic LED.

7. Apparatus according to any preceding claim, wherein the controller is arranged to identify and respond to said respective input data stream portion in accordance with a DMX data protocol.

8. Apparatus according to any preceding claim, each input data stream portion comprises a respective byte for each LED colour, said byte containing 8 bits of data for defining the intensity of the respective LED colour within a range corresponding with the

decimal numbers 0 to 255, the controller being arranged to control the pulse width of each PWM signal in accordance with the bit content of each respective byte.

9. Apparatus according to any preceding claim, wherein said plurality of LEDs comprises red, green and blue LEDs.

10. Apparatus according to any preceding claim, wherein said plurality of LEDs comprises a serial/parallel array of LEDs.

11. A lighting network comprising:

a central controller for creating an input data stream; and

a plurality of illumination apparatus according to any preceding claim, each said apparatus being arranged to receive said data stream and having its alterable address set differently so as to respond to different portions of the input data stream.

## Patentansprüche

1. Beleuchtungsvorrichtung, umfassend:

eine Mehrzahl von Lichtstrahlern in zumindest zwei verschiedenen Farben, die darauf ausgelegt sind, an einen Stromkreis gekoppelt zu werden, der eine Stromquelle (300) und eine gemeinsame Potentialreferenz (390) enthält;

Treibermittel (380) zum Betreiben der Mehrzahl von Lichtstrahlern, die zumindest zwei mit der Mehrzahl von Lichtstrahlern und dem Stromkreis verschaltete und den jeweiligen Strompfaden der zumindest zwei verschiedenfarbigen Lichtstrahler entsprechende Schalter umfassen; und

eine Steuerung zum periodischen und unabhängigen Öffnen und Schließen der zumindest zwei Schalter, wobei die Steuerung eine sich selbst zugewiesene, veränderliche Adresse hat, um einen jeweiligen Anteil eines zugewiesenen Eingangsdatenflusses zu identifizieren und darauf zu reagieren, wobei der Datenflussteil dieser Steuerung zugewiesen ist,

**dadurch gekennzeichnet, dass** jeder Lichtstrahler eine LED ist; und

die Steuerung (400) eine Mehrzahl von PWM-Signalen erzeugt, wobei jedes Signal jeweils einer Farbe der Mehrzahl von LEDs verschiedener Farben entspricht und jedes der PWM-Signale einen entspre-

chenden der zumindest zwei Schalter zum Öffnen und Schließen mit entsprechenden Frequenzen gemäß den jeweiligen Arbeitszyklen veranlasst, und wobei der Datenflussanteil Daten zur Bestimmung der jeweiligen Arbeitszyklen der zumindest zwei verschiedenfarbigen LEDs umfasst.

2. Vorrichtung gemäß Anspruch 1, wobei die Steuerung zumindest zwei Register für die zumindest zwei verschiedenfarbigen LEDs umfasst, die jeweils zum Speichern respektiver Datenwerte des Datenflussanteils für die zumindest zwei verschiedenfarbigen LEDs eingerichtet sind, wobei die Steuerung dafür eingerichtet ist, die Datenwerte zum Bestimmen der jeweiligen Arbeitszyklen der zugehörigen Farb-LEDs zu verwenden. 10
3. Vorrichtung gemäß Anspruch 1 oder 2, die ein Gehäuse umfasst, das im wesentlichen die Mehrzahl von LEDs, die Treibermittel und die Steuerung umgibt. 15
4. Vorrichtung gemäß Anspruch 1 oder 2, weiterhin umfassend einen Stromregler zum Steuern der über die Strompfade zu der Mehrzahl von LEDs gelieferten Maximalströme, um so die Maximalströme auf konstanten Maximalwerten zu halten. 25
5. Vorrichtung gemäß Anspruch 3, weiterhin umfassend einen Stromregler zum Steuern der über die Strompfade zu der Mehrzahl von LEDs gelieferten Maximalströme, um so die Maximalströme auf konstanten Maximalwerten zu halten, wobei das Gehäuse im wesentlichen zusätzlich zur Mehrzahl von LEDs, den Treibermitteln und der Steuerung, den Stromregler umgibt. 30
6. Vorrichtung gemäß einem der vorhergehenden Ansprüche, wobei jede LED eine organische LED ist. 35
7. Vorrichtung gemäß einem der vorhergehenden Ansprüche, wobei die Steuerung zum Identifizieren und Reagieren auf den jeweiligen Eingangsdatenflussanteil in Übereinstimmung mit einem DMX-Datenprotokoll eingerichtet ist. 40
8. Vorrichtung gemäß einem der vorhergehenden Ansprüche, wobei jeder Eingangsdatenflussanteil umfasst jeweils ein Byte für jede LED-Farbe, wobei das Byte 8 Datenbits zum Festlegen der Intensität der jeweiligen LED-Farbe innerhalb eines Bereichs, der den Dezimalzahlen 0 bis 255 entspricht, enthält, und die Steuerung dafür eingerichtet ist, die Pulsweite jedes PWM-Signals in Übereinstimmung mit dem Bitinhalt des jeweiligen Bytes zu steuern. 45
9. Vorrichtung gemäß einem der vorhergehenden Ansprüche, wobei die Mehrzahl von LEDs rote, grüne

und blaue LEDs umfasst.

10. Vorrichtung gemäß einem der vorhergehenden Ansprüche, wobei die Mehrzahl von LEDs eine serielle/parallel Anordnung von LEDs umfasst.
11. Ein Beleuchtungsnetzwerk, umfassend: eine zentrale Steuerung zum Erzeugen eines Eingangsdatenflusses; und eine Mehrzahl von Beleuchtungsvorrichtungen gemäß einem der vorhergehenden Ansprüche, wobei jeder der Apparate dafür eingerichtet ist, den Datenfluss zu empfangen und seine veränderliche Adresse anders setzen zu lassen, um so auf verschiedene Anteile des Eingangsdatenflusses zu reagieren.

### Revendications

1. Dispositif d'éclairage comprenant :

une pluralité de sources de lumière possédant au moins deux couleurs différentes et adaptées pour être couplées à un circuit d'alimentation incluant une source d'alimentation (300) et une référence de potentiel commune (390) ; des moyens de commande (380) pour commander la pluralité de sources de lumière, les moyens de commande comprenant au moins deux interrupteurs connectés à la pluralité de sources de lumière et audit circuit d'alimentation et correspondant à des trajets respectifs de courant des au moins deux sources de lumière ayant des couleurs différentes; et un dispositif de commande pour ouvrir et fermer périodiquement et de façon indépendante les au moins deux interrupteurs, le dispositif de commande possédant une adresse modifiable qui lui est affectée, comme par exemple pour identifier et répondre à une partie respective d'un flux de données d'entrée qui lui est affectée, pour indiquer quelle partie de flux de données est affectée à ce dispositif de commande,

**caractérisé par le fait que** chaque source de lumière est une diode LED; et

que ledit dispositif de commande (400) est agencé de manière à produire une pluralité de signaux MID, chaque signal correspondant à une couleur respective de la pluralité de diodes LED de différentes couleurs, chacun desdits signaux MID provoquant l'ouverture et la fermeture de l'un respectif des au moins deux interrupteurs à des fréquences correspondantes conformément à des taux d'impulsions respectifs, et ladite partie de flux de données comprenant des données pour déterminer les taux d'impulsions respectifs des au moins deux diodes LED à couleurs différentes.

2. Dispositif selon la revendication 1, dans lequel le dispositif de commande comprend au moins deux registres pour les au moins deux diodes LED de couleurs différentes disposées respectivement de manière à mémoriser des valeurs de données respectives de la partie du flux de données pour les au moins deux diodes LED de couleurs différentes, le dispositif de commande étant agencé de manière à utiliser ces valeurs de données pour déterminer les taux d'impulsions respectifs des données en couleurs correspondantes.
3. Dispositif selon la revendication 1 ou 2, comprenant un boîtier qui renferme pour l'essentiel une pluralité de diodes LED, les moyens de commande et le dispositif de commande.
4. Dispositif selon la revendication 1 ou 2, comprenant en outre un régulateur de courant pour la commande des courants maximum respectifs envoyés le long dudit trajet de courant à la pluralité de diodes LED de manière à maintenir les courants maximum à des valeurs maximales constantes.
5. Dispositif selon la revendication 3, comprenant en outre un régulateur de courant pour commander les courants maximum respectifs envoyés le long desdits trajets de courant à la pluralité de diodes LED, de manière à maintenir des courants maximum à des valeurs maximales constantes, le boîtier englobant pour l'essentiel le régulateur de courant en plus de la pluralité de diodes LED, les moyens de commande et le dispositif de commande.
6. Dispositif selon l'une quelconque des revendications précédentes, dans lequel chaque diode LED est une diode LED organique.
7. Dispositif selon l'une quelconque des revendications précédentes, dans lequel le dispositif de commande est agencé de manière à identifier et répondre à ladite partie de flux de données d'entrée respective conformément à un protocole de données DMX.
8. Dispositif selon l'une quelconque des revendications précédentes, chaque partie de flux de données d'entrée comprenant un octet respectif pour chaque couleur de diode LED, ledit octet contenant 8 bits de données pour définir l'intensité de la couleur de diode LED respective dans une gamme correspondant aux nombres décimaux 0 à 255, le dispositif de commande étant agencé de manière à commander la durée d'impulsions de chaque signal MID en fonction du contenu en bits de chaque octet respectif.
9. Dispositif selon l'une quelconque des revendications précédentes, dans lequel ladite pluralité de diodes LED comprend des diodes LED rouge, verte et bleue.
10. Dispositif selon l'une quelconque des revendications précédentes, dans lequel ladite pluralité de diodes LED comprend un réseau série/parallèle de diodes LED.
11. Réseau d'éclairage comprenant :
- un dispositif central de commande pour créer un flux de données d'entrée; et
- une pluralité de dispositifs d'éclairage selon l'une quelconque des revendications précédentes, chaque dispositif étant agencé de manière à recevoir ledit flux de données et dont l'adresse modifiable est réglée différemment afin de répondre à différentes parties du flux de données.

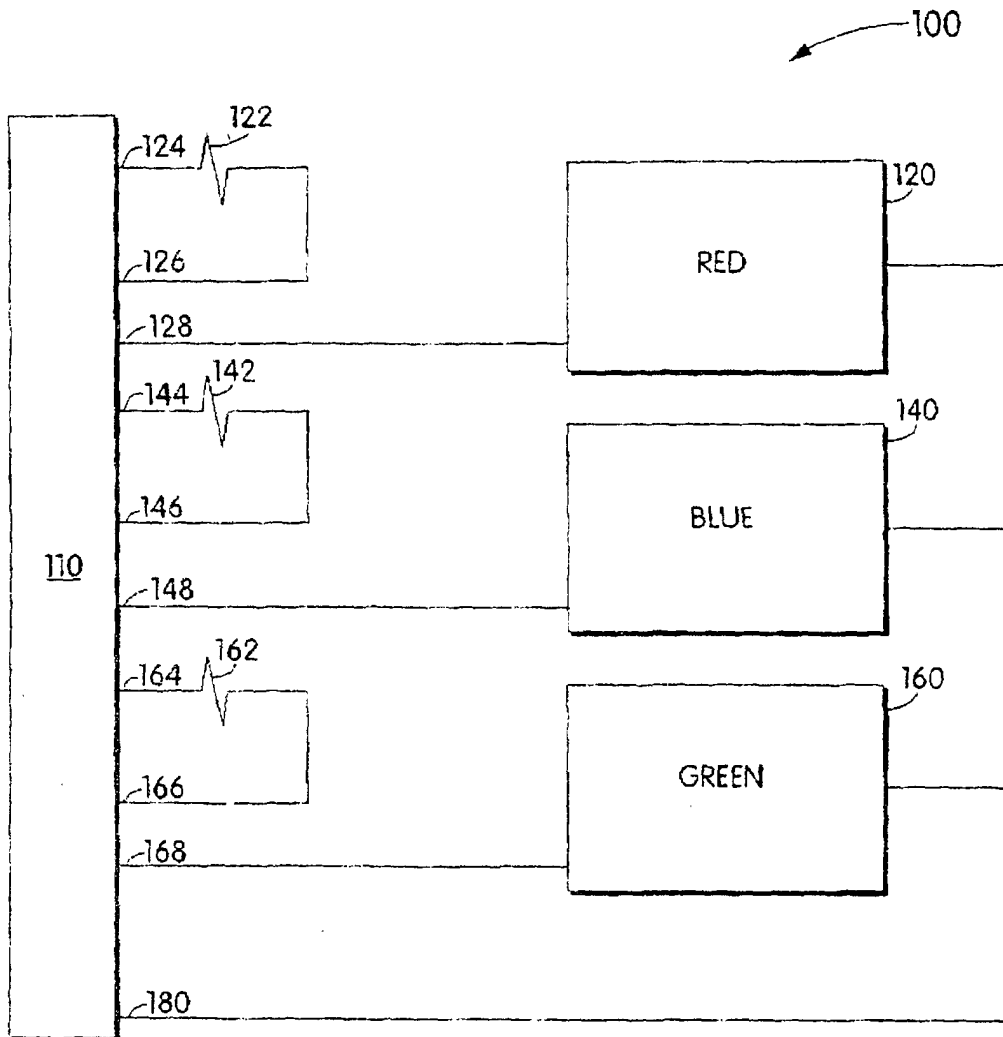


Fig. 1

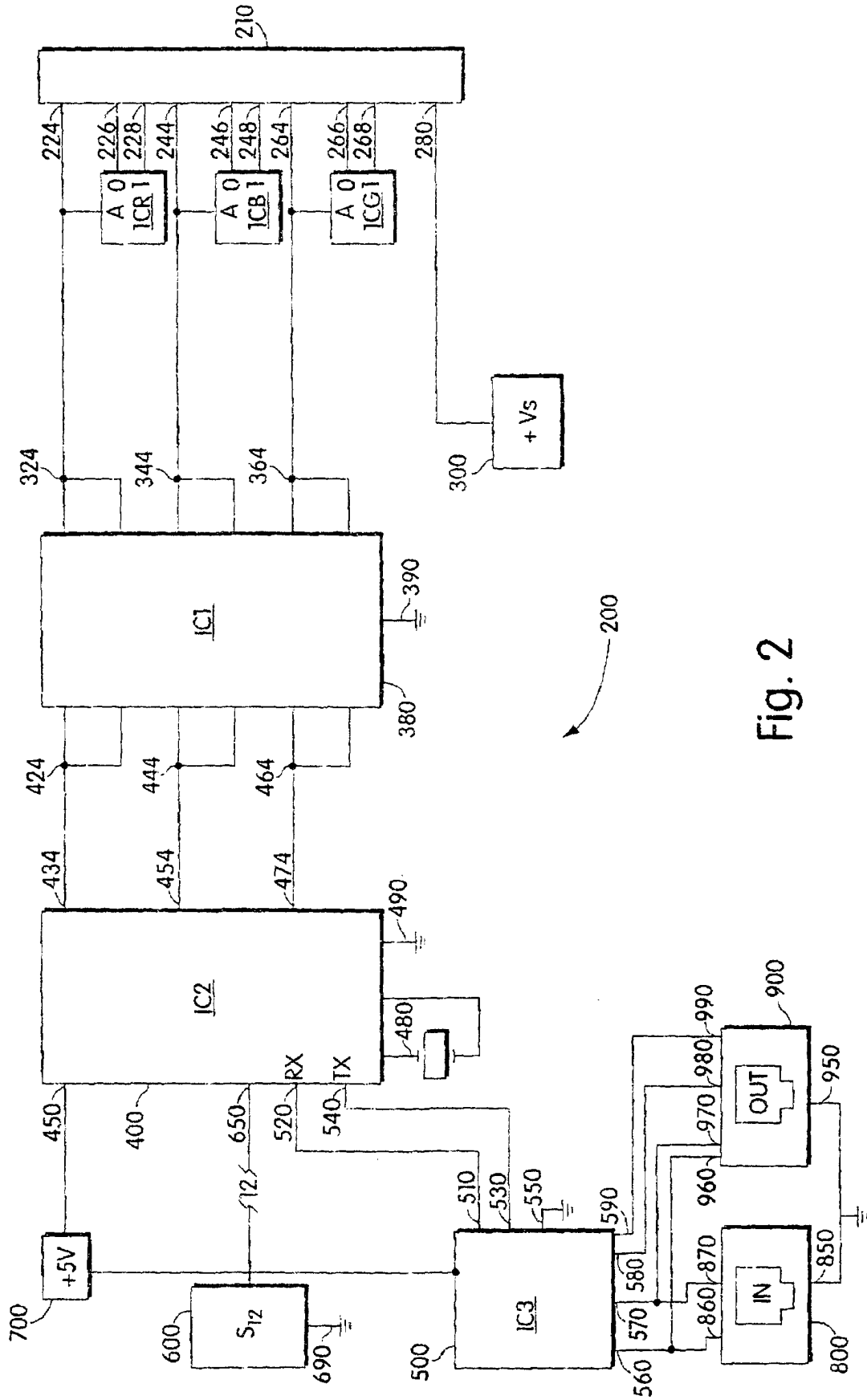


Fig. 2

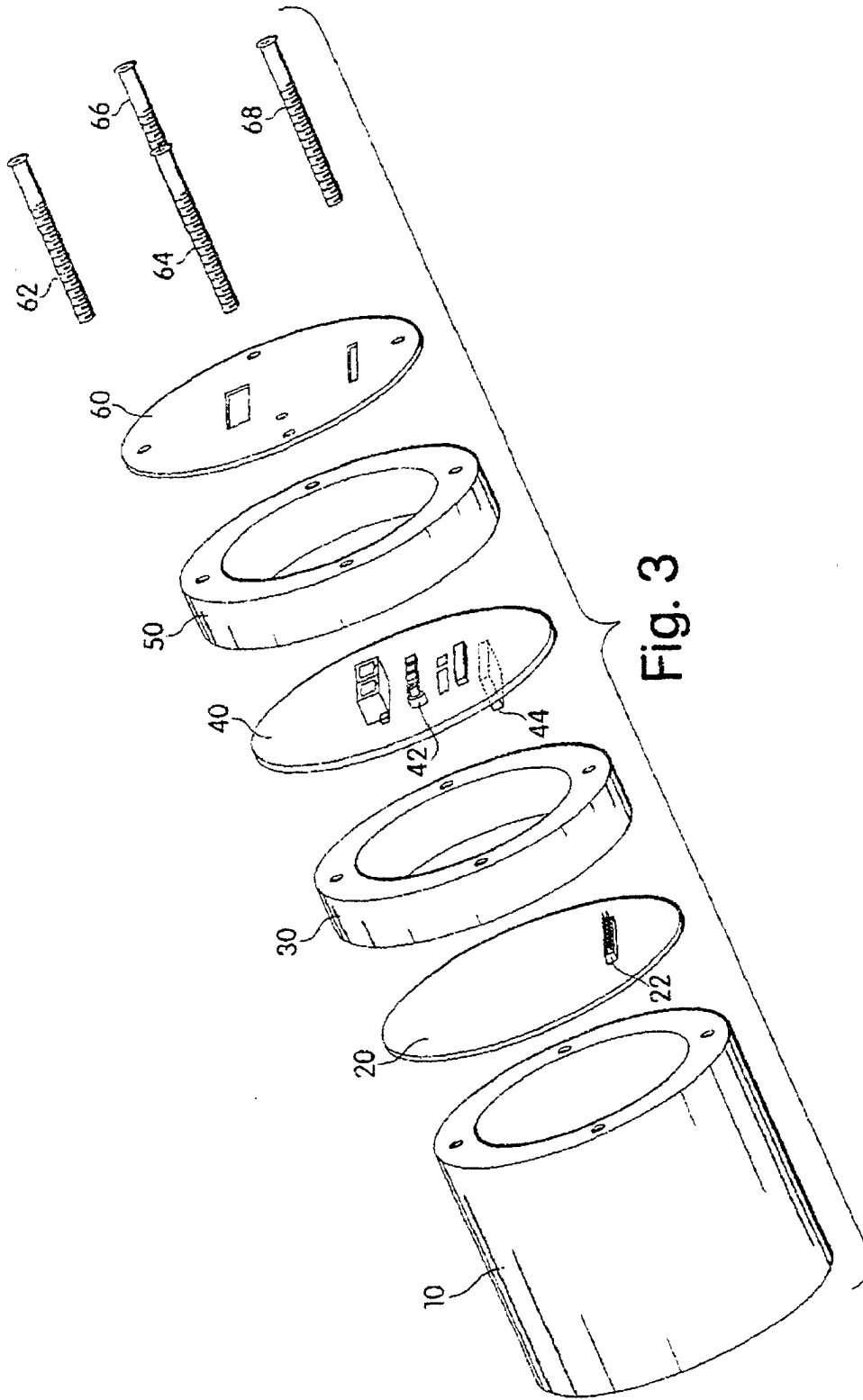


Fig. 3

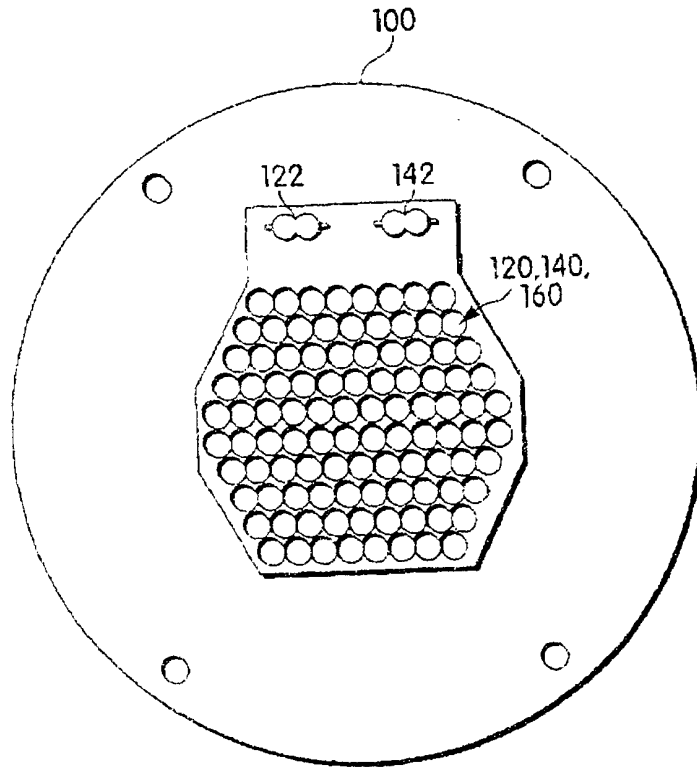


Fig. 4

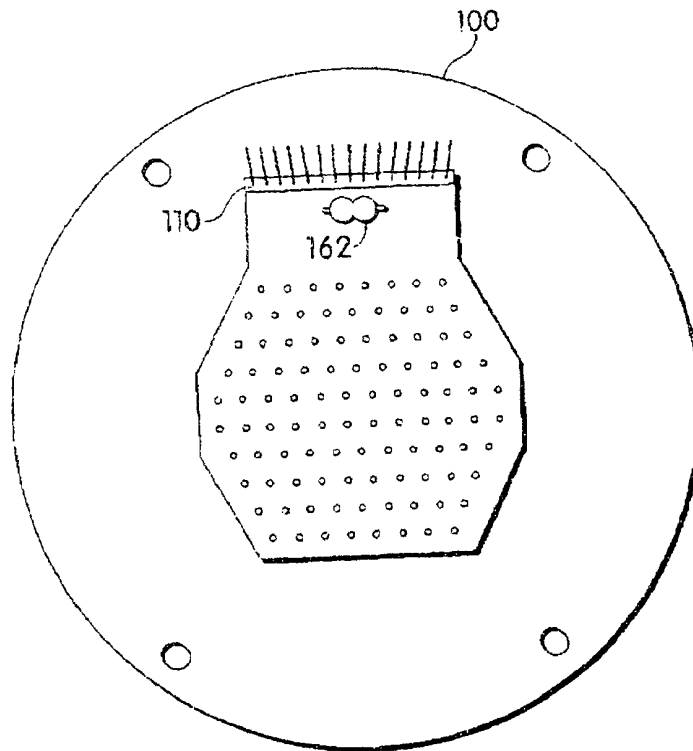


Fig. 5

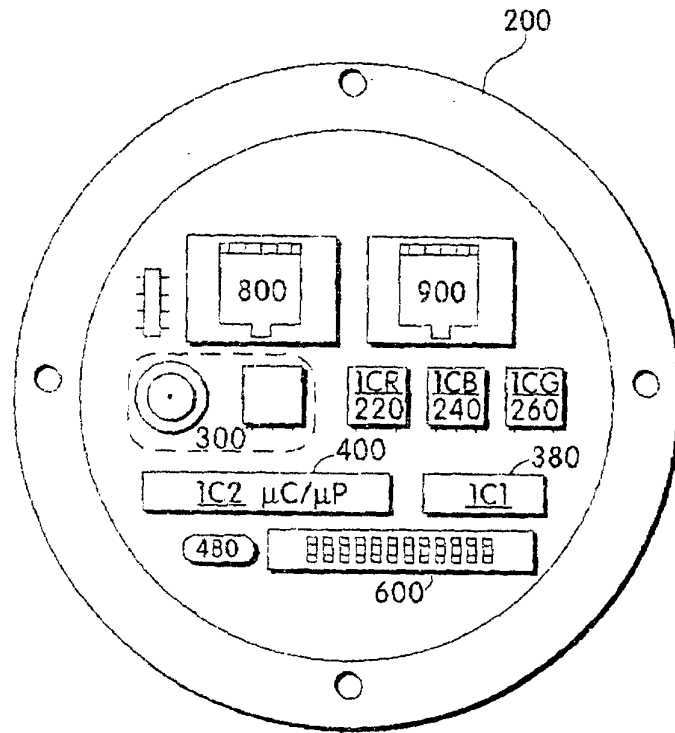


Fig. 6

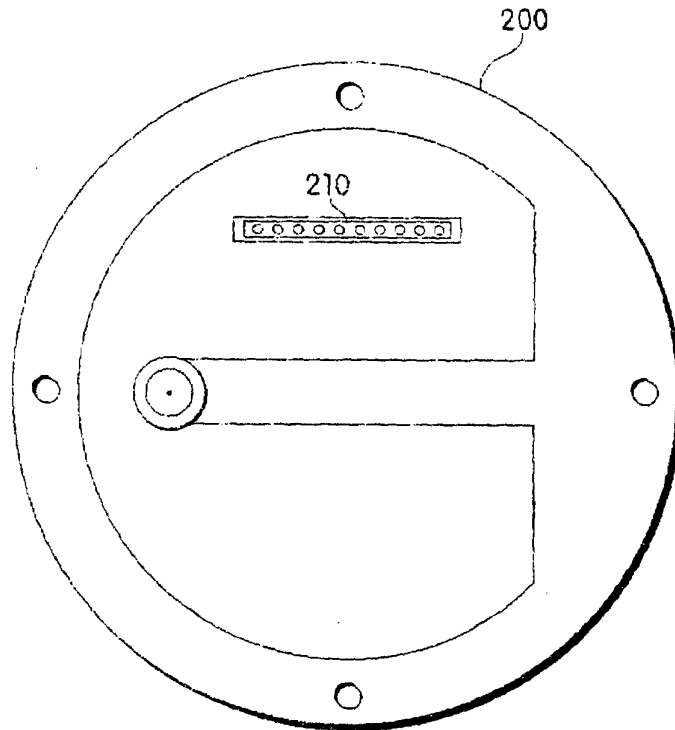


Fig. 7