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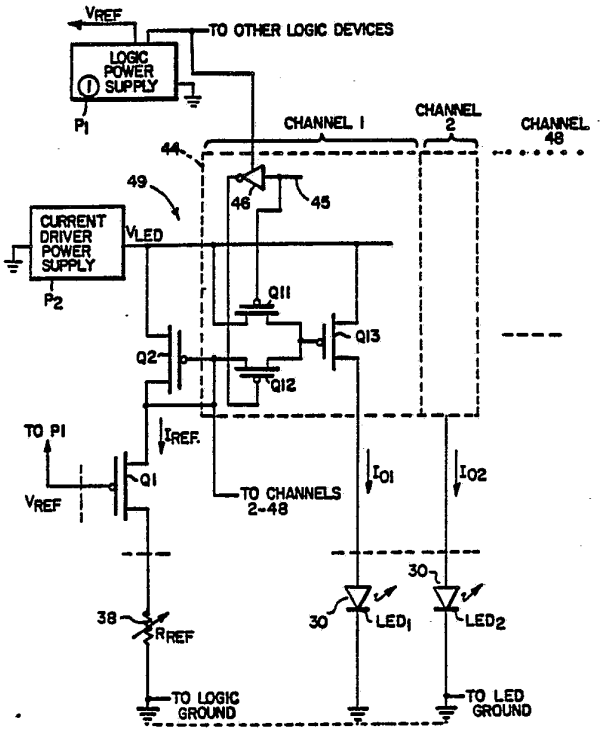
(57) Abstract

An improved printer apparatus (20) includes a series of point-like radiation sources (30), such as LED's, arranged in a row for exposing a recording medium. Logic means (43) is provided for determining which of the point-like radiation sources are to be selected for energization. A current driver means (49) includes means (44) responsive to the logic means (43) to provide electrical current to the radiation sources (30) selected. The current driver means (49) includes a current mirror having a master circuit (Q2, q1, 38) for generating a reference current (I_{REF}) and a plurality of slave circuits (Q13, 30) for providing respective driver currents to the radiation sources (30) selected for energization. The master circuit includes a resistor (38) of the type that at least prior to adjustment permits for substantially continuous adjustment of driver current over a range of resistance values. Two independent power supplies (P_1, P_2) are provided to the print head. One power suppply (P_1) provides electrical energy for the logic device at a fixed voltage suitable for the logic devices. A second power supply (P_2) provides the electrical energy for illuminating the point-like radiation sources. Thus, power to the logic devices is isolated from noise generated during energization of the point-like radiation sources. An adjustable variable voltage is provided by this second power supply to permit for flexibility in adjustment of the currents to the point-like radiation sources. This variable voltage may be adjusted in response to aging of the LED's or temperature of the print head.



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PRINTER APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to recording apparatus for recording images on a moving radiation sensitive member and, more particularly, to printer apparatus for use therewith.

In the prior art as exemplified by U.S. Patent No. 4,571,602 printer apparatus is described which comprises a multiplicity of individually addressable and energizable point-like radiation sources, such as LED's, arranged in rows for exposing points upon a photoreceptor during movement thereof relative to and in a direction normal to the rows. Driver circuits are provided for simultaneously energizing the radiation sources responsive to respective data bit input signals applied to the driver circuits during an information line period. The print or recording head includes a support upon which are mounted chips placed end to end and upon each of which are located a group of LED's. The driver circuits are incorporated in chips and located to each side of the linear array of LED chips. The driver circuits in this apparatus include a shift register for serially reading-in data-bit signals and for driving respective LED's in accordance with the data signals.

Associated with each driver chip is an input pad onto which a current-level control signal is applied. The signal determines the mean current that is produced by a driver into its corresponding LED's. Reference is made to mean current because, due to fabrication tolerances of drivers and LED's, the actual current through an LED may be up to e.g. 10% larger or smaller than the desired nominal

value. In order to set the control signal, four resistors in series are provided between a line carrying a five volt DC voltage and the driver chip. By shorting out one or more of the four different resistors, 15 different possible combinations of current control signals can be made. The current control signal fixed for that driver chip is not fed to the LED's but is instead used to generate a larger actual current that passes through the LED's selected to be energized by the data signals.

A problem with the apparatus described in the aforementioned patent is that 15 levels of control provide an undesirable design limitation. A mean current to one group of LED's that is higher than that to an adjacent group of LED's in the same row will provide reproductions with varying patterns of lines. The eye is very sensitive in detecting low frequency pattern lines in reproductions. While differences in light output between adjacent LED's may not be significant to the eye, differences of mean light output between adjacent groups of LED's tend to degrade image quality, particularly in reproductions of pictorial information.

A further disadvantage of the apparatus of the prior art is that of lacking the ability to provide for easy and preferably automatic maintenance of LED light output to correct for changes in light output resulting from aging or other changes to the print head.

A further disadvantage over the apparatus of the prior art is the offsetting of adjacent LED's into staggered rows and the requirement that circuitry be provided for illuminating the rows at staggered times.

It is, therefore, an object of the invention to provide an improved printer apparatus and print head for use therewith which overcomes the problems of the prior art.

SUMMARY OF THE INVENTION

The improved printer apparatus of the invention is realized by a printing apparatus including a series of point-like radiation sources arranged in a row for exposing a radiation sensitive recording medium; means providing data signals representing data to be printed; logic means responsive to the data signals for determining which of the point-like radiation sources are to be selected for energization; current driver means responsive to the logic means for providing electrical current to the radiation sources selected for energization; characterized by:

the current driver means including a current mirror circuit means including a master circuit for generating a reference current and a plurality of slave circuits for providing respective driver currents to the radiation sources selected for energization; the master circuit including a resistor of the type that at least prior to adjustment permits for substantially continuous adjustment of driver currents over a range of resistance values.

An improved printer apparatus is also realized by apparatus including a series of point-like radiation sources arranged in a row for exposing a radiation sensitive recording medium, the series of point-like radiation sources comprised of a plurality of sub-groups of said point-like radiation sources; current driver means for providing electrical current to the radiation sources; characterized by:

the current driver means including for each

sub-group of radiation sources a current mirror circuit means including a master circuit for generating a reference current and a plurality of slave circuits for providing respective driver currents to the radiation emitters selected for energization; the master circuit for each sub-group including a respective voltage responsive reference current controlling circuit and a resistance means of respective resistance value for establishing a respective reference current in the master circuit; the respective resistance values for at least two of said sub-groups being substantially different to establish different respective reference current levels in their respective master circuits;

means for coupling the respective voltage responsive reference current controlling circuits to a common reference voltage source; the respective resistance values of the resistance means being set such that a relatively small change in reference voltage causes a change in reference current that is approximately the same for each master circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic of a recording apparatus, including printer apparatus, made in accordance with the invention;

FIG. 2 is a block diagram of circuitry used in forming the printer apparatus of FIG. 1 in accordance with the invention;

FIG. 3 is a block diagram of a driver circuit for use in the printer apparatus of FIG. 2;

FIG. 4 is a schematic of a current driving circuit for the driver circuit of FIG. 3;

FIG. 5 is a graph illustrating a preferred range of parameters for operating the circuit of FIG. 4.

FIG. 6a and 6b are schematics of alternate circuits for use with the apparatus of FIG. 1.

FIG. 7a and 7b are flowcharts for a program for operating the print apparatus in accordance with certain aspects of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Apparatus of the preferred embodiments will be described in accordance with an electrophotographic recording medium. The invention, however, is not limited to apparatus for creating images on such a medium, as other media such as photographic film, etc. may also be used with the invention.

Because electrophotographic reproduction apparatus are well known, the present description will be directed in particular to elements forming part of or cooperating more directly with the present invention. Recording apparatus not specifically shown or described herein are selectable from those known in the prior art.

With reference now to FIG. 1, an electrophotographic reproduction apparatus 10 includes a radiation sensitive recording medium such as a photoconductive web 11 or other photosensitive or radiation sensitive medium that is trained about three transport rollers 12, 13 and 14, thereby forming an endless or continuous web. Roller 12 is coupled to a driver motor M in a conventional manner. Motor M is connected to a source of potential when a switch (not shown) is closed by a logic and control unit (LCU) 15. When the switch is closed, the roller 12 is driven by the motor M and moves the web 11 in a clockwise direction as indicated by arrow A. This movement causes successive image areas of the web 10 to sequentially pass a series of electrophotographic work stations of the reproduction apparatus.

For the purposes of the instant exposure, several work stations are shown along the web's path. These stations will be briefly described.

First, a charging station 17 is provided at which the photoconductive surface 16 of the web 11 is sensitized by applying to such surface a uniform electrostatic primary charge of a predetermined voltage. The output of the charger may be controlled by a grid connected to a programmable power supply (not shown). The supply is in turn controlled by the LCU 15 to adjust the voltage level Vo applied onto the surface 16 by the charger 17.

At an exposure station 18 an electrostatic image is formed by modulating the primary charge on an image area of the surface 16 with selective energization of point-like radiation sources in accordance with signals provided by a data source 19. The point-like radiation sources are supported in a printer apparatus (print head) 20 to be described in more detail below.

A development station 21 includes developer which may consist of iron carrier particles and electroscopic toner particles with an electrostatic charge opposite to that of the latent electrostatic image. Developer is brushed over the photoconductive surface 16 of the web 11 and toner particles adhere to the latent electrostatic image to form a visible toner particle, transferable image. The development station may be of the magnetic brush type with one or two rollers. Alternatively, the toner particles may have a charge of the same polarity as that of the latent electrostatic image and develop the image in accordance with known reversal development techniques.

The apparatus 10 also includes a transfer station 25 shown with a corona charger 22 at which the toner image on web 11 is transferred to a copy sheet S; and a cleaning station 28, at which the photoconductive surface 16 of the web 11 is cleaned of any residual

toner particles remaining after the toner images have been transferred. After the transfer of the unfixed toner images to a copy sheet S, such sheet is transported to a heated pressure roller fuser 27 where the image is fixed to the copy sheet S.

As shown in FIG. 1, a copy sheet S is fed from a supply 23 to driver rollers 24, which then urge the sheet to move forward onto the web 11 in alignment with a toner image at the transfer station 25.

To coordinate operation of the various work stations 17, 18, 21, and 25 with movement of the image areas on the web 11 past these stations, the web has a plurality of indicia such as perforations along one of its edges. These perforations generally are spaced equidistantly along the edge of the web 11. At a fixed location along the path of web movement, there is provided suitable means 26 for sensing web perforations. This sensing produces input signals into the LCU 15 which has a digital computer, preferably a microprocessor. The microprocessor has a stored program responsive to the input signals for sequentially actuating, then de-actuating the work stations as well as for controlling the operation of many other machine functions. Additional encoding means may be provided as known in the art for providing more precise timing signals for control of the various functions of the apparatus 10.

Programming of a number of commercially available microprocessors is a conventional skill well understood in the art. This disclosure is written to enable a programmer having ordinary skill in the art to produce an appropriate control program for the one or more microprocessors used in this apparatus. The particular details of any such program would, of

course, depend on the architecture of the designated microprocessor.

With reference to FIGS. 1 and 2, the printer apparatus (print head) 20, as noted, is provided with a multiplicity of energizable point-like radiation sources 30, preferably light-emitting diodes (LED's). Optical means 29 may be provided for focusing light from each of the LED's onto the photoconductive surface. The optical means preferably comprises an array of optical fibers such as sold under the name Selfoc, a trademark for a gradient index lens array sold by Nippon Sheet Glass, Limited. Due to the focusing power of the optical means 29, a row of emitters will be imaged on a respective transverse line on the recording medium.

With reference to FIG. 2, the print head 20 comprises a suitable support with a series of LED chips 31 mounted thereon. Each of the chips 31 includes in this example 96 LED's arranged in a single row. Chips 31 are also arranged end-to-end in a row and where twenty-seven LED chips are so arranged, the print head will extend across the width of the web 11 and include 2592 LED's arranged in a single row. To each side of this row of LED's there are provided twenty-seven identical driver chips 40. Each of these driver chips include circuitry for addressing the logic associated with each of 48 LED's to control whether or not the LED should be energized as well as to determine the level of current to each of the LED's controlled by that driver chip 40. Two driver chips 40 are thus associated with each chip of 96 LED's. Each of the two driver chips will be coupled for driving of alternate LED's. Thus, one driver chip will drive the odd numbered LED's of the 96 LED's and the other will drive the even numbered

LED's of these 96 LED's. The driver chips 40 are electrically connected in parallel to a plurality of lines 34-37 providing various electrical control signals. These lines provide electrical energy for operating the various logic devices and current drivers 49 in accordance with their voltage requirements. A series of lines 36 (indicated by a single line in Fig. 2) provide clock signals and other pulses for controlling the movement of data to the LED's in accordance with known techniques. As may be noted in Figure 2, external to each driver chip 40 is a variable resistor 38 that is schematically illustrated and will be described in greater detail below. A data line 33 is also provided for providing data signals in the form of either a high or low logic level. The driver chips each include a data in and data out port so that they serially pass data between them.

With reference now to FIG. 3, the architecture for each driver chip 40 includes a 48 bit bidirectional shift register 41. A logic signal carried over line R/LB determines the direction data will flow down this register. Assume that this chip is enabled to cause data to flow down the register from left to right as shown in FIG. 3. Data thus enters shift register 41 over line 33 through the driver chip's data-in port at the left from say the data-out port of a driver chip immediately to the left or from the LCU if the driver chip 40 is the first chip for data to enter. Data exits from this chip at the data-out port to be input to the next adjacent driver chip to the right of driver chip 40. In operation for each line of image to be exposed in the main scanning direction, i.e., transverse to that of movement of the recording medium 11 data from the

data source suitably rasterized, in accordance with known techniques, streams serially through the shift registers under control of clock pulses provided by the LCU over line 36a. When 2592 bits of data (1's or 0's) are stored by the shift registers of all of the driver chips, a latch signal is provided over line 36b to latch this data into latch registers 42 so that the shift registers 41 may commence filling with data signals for the next line of exposure. Forty-eight latch registers 42 are provided in each driver chip to receive the data shifted out in parallel fashion from the shift register 41. Each latch register is associated with a particular LED and adjacent latch registers are associated with every other LED. A logic AND gate 43 is associated with each latch register and has one input coupled to the output of its respective latch register and its other input coupled to a line 36c for providing a strobe or timing pulse from the LCU. This strobe pulse determines when to trigger the LED's to turn on in relation to the position of the recording medium and the duration for which the LED's are turned on. All the AND gates have one of their inputs connected to this strobe line. The output of each of the AND gates is coupled to a logic or switching circuit that is part of a constant current driver circuit 44.

With reference now to FIG. 4, the output of each AND gate is fed over line 45 to a logic circuit that includes a logic inverter and three p-channel enhancement mode MOSFET's (metal-oxide semiconductor field-effect transistors) Q11, Q12, and Q13. Transistor Q11 has its gate terminal connected to the input of the inverter and its drain-source current conducting channel connected to the line labeled V_{LED} carrying a voltage of, say, 4.5 volts. Current conducting channels of transistors Q11 and

Q12 are both connected to the gate terminal of transistor Q13. The output of the inverter 46 is connected to the gate terminal of transistor Q12. The current conducting channel of transistor Q12 is connected to the gate of a similar type transistor Q2. Transistor Q2 has its current conducting channel coupled to the line V_{LED}. A terminal of transistor Q2 is coupled to one terminal of the current conducting channel of an n-channel enhancement mode transistor Q1. The gate terminal of Q2 is also connected to the connection between transistors Q2 and Q1. A variable voltage source V_{REF} is coupled to the gate terminal of transistor Q1 and the current conducting channel of transistor Q1 is coupled to ground through the variable resistor R_{REF}, previously described. The circuit described comprises a current mirror in that current I_{REF}, through a master circuit that includes the line carrying V_{LED}, transistor Q2, transistor Q1 and R_{REF} to ground, is mirrored or proportionally maintained in each of the identical slave circuits, one of which shown comprises the line carrying V_{LED}, transistor Q13, an LED, and ground.

The operation of this current mirror will now be described. It will be appreciated that each slave circuit forming a part of this current driver circuit 49 will behave in the same manner, assuming a same logic signal is provided. With a "high" logic level signal provided by the AND gate 43 to the input of inverter 46, the output of the inverter is such as to render transistor Q12 conductive and causes current I_{01} to flow through LED_1 by rendering transistor Q13 conductive. Current I_{01} is proportional to current I_{REF} flowing through the master circuit due to transistors Q2 and Q13 having approximately the same

biasing potentials. Transistor Q1 controls the level of I_{REF} in accordance with the input voltage V_{REF} at its gate terminal. The level of current I_{REF} is also controlled by the value of the resistor R_{REF} that is in series with transistors Q2 and Q1. As noted above, the output of the inverter 46 goes to a "low" logic level due to the concurrence of a logic "high" input signal on the AND gate's 43 data terminal and a logic "high" strobe or trigger pulse signal on its other input terminal. When the strobe pulse drops down to a logic "low" level, the output of AND gate 43 goes "low" and the output of inverter 46 goes to a logic "high" level and turns off transistor Q12 and turns on transistor Q11. This removes the needed bias for transistor Q13 to operate and it, too, turns off or ceases to conduct, thereby preventing any current from flowing to LED_1. Thus, the on-time for exposing each pixel on the recording medium is determined by the strobe signal and the amount of current controlling the brightness of this LED is controlled by the level of the current I_{01}.

An important feature of the invention is having R_{REF} be adjustable over a continuous range of resistance values. During calibration of the print head, measurements are taken of the mean or average light output of the forty-eight LED's driven by a respective driver chip and compared with the light output needed or specified for proper exposure of the recording medium. The reference voltage, V_{REF}, may be set at 3.0 volts during this measurement. The reference resistor R_{REF} is of the known laser trimmable type wherein portions may be vaporized off so that while measurements of light output are taken, the resistance is adjusted until the light output

measured matches that specified. In resistors of this type, the material vaporized results in reduction of the effective cross-sectional area for the resistor thereby affecting its conductivity.

Each of the groups of 48 LED's is calibrated in a similar manner so that their respective resistor R_{REF} is adjusted accordingly. The resistors and driver chips may now be encapsulated to prevent further adjustment. With the print head mounted as shown in FIG. 1, adjustments for variation in light output due to aging and/or environmental conditions will now be described. As shown in FIG. 6a, a logic device power supply 50 outputs a calibrated voltage V. A voltage divider circuit is provided in which one of the resistors, R_T, is a positive temperature coefficient thermistor attached to the print head at a location that is reasonably representative of the temperature of the LED's. The LED's used in this print head have decreased light output with elevation in temperature. To compensate for this, the resistance R_T will increase, thereby, providing an increase to the reference voltage used to drive transistor Q1. This affects the master current level I_{ref} as shown in FIG. 5. As may be noted in this figure, the preferred operating range for each driver chip 40 is in the range indicated by the somewhat parallelogram-shaped figure having the vertices A, B, C and D. In one embodiment of a print head, values of R_{REF} might range from 100 to 160 ohms. V_{LED} can be maintained constant at 4.5 volts. V_{REF} could be thus adjusted over the range from 2.6 volts to 3.6 volts. It will be noted that providing the type of operating range as shown in FIG. 5 has important advantages in making adjustments to maintain the appropriate level of illumination output

by the LED's. In this example, assuming V_{REF} is 2.6 volts, the currents to the various subgroups of LED's will range from 5ma to 7ma or each LED of any subgroup of LED's will receive a current indicated by some point on line AD. Line AD thus represents the locus of points for the currents to the LED's at the selected V_{REF} of 2.6 volts. It will be noted that as V_{REF} increases towards 3.6 volts, the locus, x y, of similar points but for a different V_{REF} shifts upwardly but does not change the relative differentials in current received by the LED's. Thus, LED's in a subgroup having a driver chip with an R_{REF} of 160 ohms might have a current of 5.2 amps for a V_{REF} of 2.6 volts (point D), while another subgroup having a driver chip with an R_{REF} of 100 ohms might have a current of 7.1 ma (point A). The difference in current between a respective LED in each of these subgroups is 1.9ma per LED. With a need for a change of V_{REF} to say 3.0 volts due to a need to compensate for aging or thermal affects upon light outputs by the LED's, the operating parameters of the LED's have shifted generally uniformly both upwardly and to the right on this graph. The new current locus, x y, indicates that the subgroup of LED's formerly operating at point A now has 8.1 ma of current that will pass through each LED of that subgroup while that operating at point D will now have a current of 6.2 ma. The difference in current between respective LED's remains at 1.9 ma. The circuit described thus provides in addition a simplification to calibration since with adjustments of a parameter such as V_{REF} the expected respective currents to the LED's can be readily calculated. This facilitates also the providing of different reference voltages, V_{REF},

for compensating for different "ages" of the LED's. The "age" of an LED may be defined by the number of times it has been used rather than its chronological age.

With reference now to FIG 6b, an alternate circuit for adjusting V_{REF} is shown. In this embodiment, changes in resistance of thermistor R_T due to temperature changes of the print head 20 cause corresponding changes in voltage V_T. The voltage V_T is sensed by analog to digital (A/D) converter 60 and fed to the LCU 15. The LCU would include input buffers for temporarily storing inputs from the A/D converter until such inputs can be handled by the LCU's central processor. Associated with the central processor are program memory units and temporary memory units. In the program memory a subroutine program can be provided for determining adjustments to V_{REF} in response to readings of V_T. One approach as indicated in the flowchart of Fig. 7a is to have a program which includes a table memory for comparing predetermined stored relationships between V_T and V_{REF}. The program will thus compare the sensed value for V_T with that in the table and select an appropriate V_{REF}. An output driver 62 then adjusts V_{REF} to each driver chip in accordance with the value stored in memory. Another approach is to provide a mathematical equation between the values of V_{REF} and V_T and have the LCU calculate V_{REF}. More than one thermistor may be used in the event there are temperature differences between driver chips so as to provide a thermistor at the most appropriate place for measuring the temperature of a number of driver chips.

In the flowchart of Fig. 7b, age of a driver chip is also accounted for as well as thermal affects.

This flowchart will also be described with regard to the circuit of Fig. 6b. As noted above, the LCU 15 controls the flow of data to the shift registers. Since this form of data is in the form of binary digits (1's or 0's) the data for use in enabling an LED for each main scan line may be noted by registers in the LCU and a count maintained of the number of times each LED is enabled. Periodically, a calculation may be made by the LCU to determine the average or mean number (or count) of firings for the LED's of that subgroup driven by a particular driver chip. This average number along with updated sensings of V_T may be compared with a table memory listing comparing these variables with appropriate values V_{REF}. A selected appropriate V_{REF} is then outputted by the series of up to 54 drivers 62 to each of the driver chips in accordance with print head temperatures and average age of that subgroup. Thus, for any driver chip the current to the subgroup of LED's driven by that driver chip have their current adjusted in accordance with the temperature of the print head and the average age of the LED's in that subgroup.

As may be noted in the schematic of FIG. 4, two separate power supplies with separate ground or return lines are provided to the print head. One power supply P_1 is used to provide the energy needed to run the logic devices such as inverters 46 (and AND gates, registers and latches etc. shown in FIG. 3). It will be appreciated that an inverter 46 is provided for each of the slave circuits and thus for each LED. The second power supply P_2 is used for providing the electrical energy for powering the current driver circuit; i.e. V_{LED}. As may be noted a variable adjustable tap may be provided at power

supply P_1 to allow an operator to adjust V_{REF} as an alternative to automatic adjustment in response to print head temperature. In this way, the large transients or noise created by energization of the LED's during commencement and termination of printing of each line are effectively isolated from the logic devices to thereby immunize them from specious signals. Power consumption is also minimized by running the various devices at their optimum levels. Thus, the LED's may have their driver voltage V_{LED} made lower than the 5 volts used to drive the logic devices.

While the invention has been described with regard to LED's, other emitters known in the art may also be employed.

The printer apparatus thus described provides for improved control of current to the radiation emitters, thereby ensuring improved reproduction of pictorial information. There is also facilitated the ability to provide equal changes of the electrical currents to the various emitters should such change be necessary.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

We Claim:

1. A printer apparatus (20) including a series of point-like radiation sources (30) arranged in a row for exposing a radiation sensitive recording medium; means (41, 42) providing data signals representing data to be printed; logic means (43) responsive to the data signals for determining which of the point-like radiation sources are to be selected for energization; current driver means (49) responsive to the logic means (43) for providing electrical current to the radiation sources (30) selected for energization; characterized by:

the current driver means (49) including a current mirror circuit means including a master circuit (Q2, Q1, 38) for generating a reference current and a plurality of slave circuits (Q13, 30) for providing respective driver currents to the radiation sources selected for energization; the master circuit including a resistor (38) of the type that at least prior to adjustment permits for substantially continuous adjustment of driver currents over a range of resistance values.

2. The apparatus of Claim 1 and wherein the master circuit includes a variable voltage source for adjusting the levels of driver currents.

3. The apparatus of Claim 1 or 2 and including automatic adjustment means for sensing the need for adjustment of driver currents and for providing adjustment in said currents by changing the output voltage of the voltage source.

4. The apparatus of Claim 3 and wherein the automatic adjustment means includes means for sensing the temperature of the apparatus.

5. The apparatus of Claim 2 and wherein the variable voltage source is provided by a power supply independent of a power supply for the logic means.

6. The apparatus of Claims 1, 2 or 5 and wherein the apparatus includes a support; and wherein a group of point-like radiation sources are arranged on a chip; groups of chips are mounted on the support with the point-like radiation sources aligned in a single line; and wherein a respective different current driver is coupled to a sub-group of point-like radiation sources on each chip.

7. The apparatus of Claim 6 and wherein the sub-group comprises every other point-like radiation source.

8. A printer apparatus including a series of point-like radiation sources (30) arranged in a row for exposing a radiation sensitive recording medium, the series of point-like radiation sources comprised of a plurality of sub-groups of said point-like radiation sources; current driver means (49) for providing electrical current to the radiation sources; characterized by:

the current driver means (49) including for each sub-group of radiation sources a current mirror circuit means including a master circuit (Q2, Q1, 38) for generating a reference current and a plurality of slave circuits (Q13, 30) for providing respective driver currents to the radiation emitters selected for energization; the master circuit for each sub-group including a respective voltage responsive reference current controlling circuit (Q1) and a resistance means (38) of respective resistance value for establishing a respective reference current in the master circuit; the respective resistance values for at least two of said sub-groups being substantially different to establish different respective reference current levels in their respective master circuits;

means for coupling the respective voltage responsive reference current controlling circuits to a common reference voltage source; the respective resistance values of the resistance means being set such that a relatively small change in reference voltage causes a change in reference current that is approximately the same for each master circuit.

9. The apparatus of Claim 8 in combination with a voltage source that is adjustable for adjusting the levels of driver currents.

10. The apparatus of Claim 9 and including automatic adjustment means for sensing the need for adjustment of driver currents and for providing adjustment in said currents by changing the output voltage of the voltage source.

11. The apparatus of Claim 10 and wherein the automatic adjustment means includes means for sensing the temperature of the apparatus.

12. The apparatus of Claim 9 and wherein the voltage source is provided by a power supply independent of a power supply for the logic means.

13. The apparatus of Claims 1, 2 or 8 and wherein the apparatus includes a support; and wherein a group of point-like radiation sources are arranged on a chip; groups of chips are mounted on the support with the point-like radiation sources aligned in a single line; and wherein at least two sub-groups of point-like radiation sources are on each chip and a sub-group on a chip comprises every other point-like radiation source.

14. The apparatus of Claims 1, 2 or 8 and wherein the point-like radiation sources are light emitting diodes.

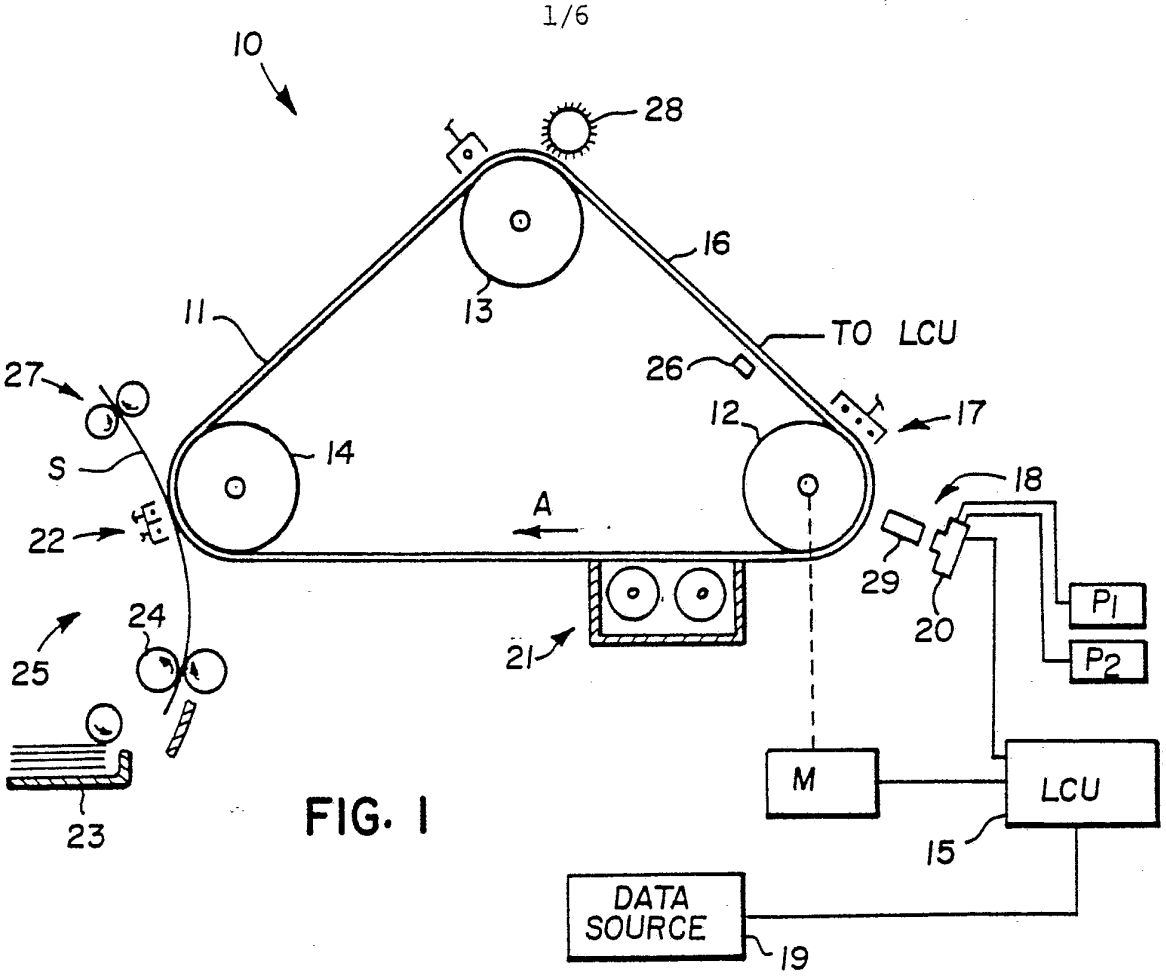
10
28
16
13
11
TO LCU
27
26
12
17
S
14
18
A
22
29
P1
24
20
P2
25
21
M
LCU
15
DATA SOURCE
19
23

FIG. 1

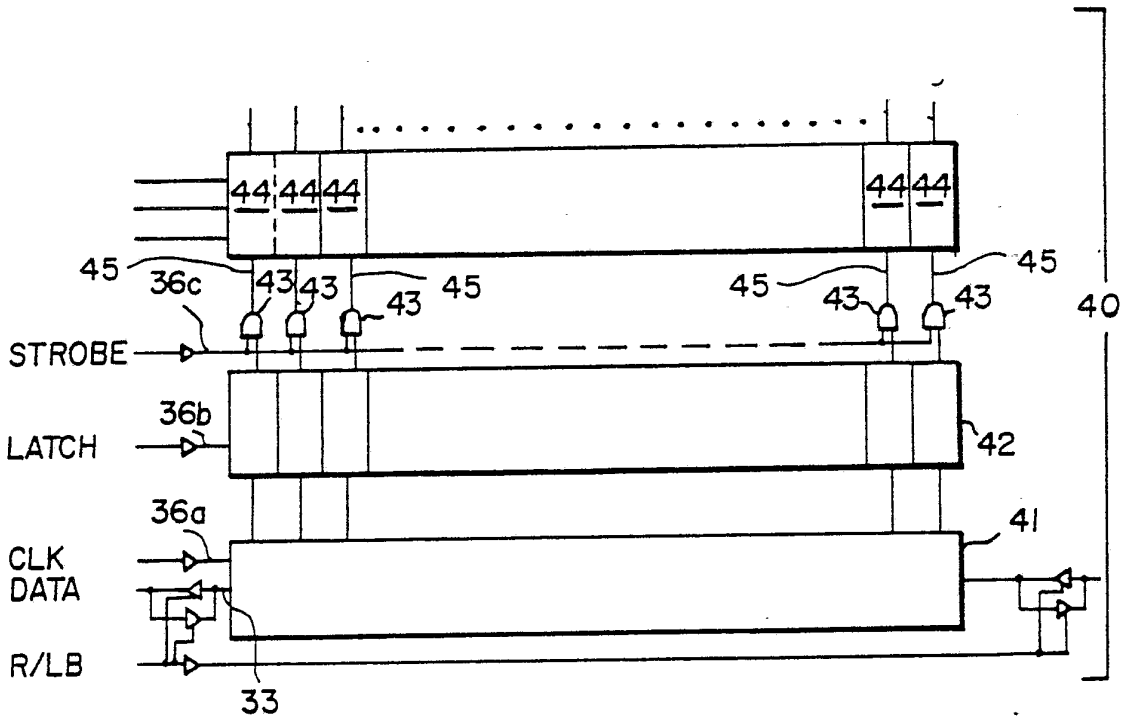
44 44 44
44 44
45
36c
43
43
43
45
45
43
43
45
40
STROBE
36b
LATCH
42
36a
41
CLK
DATA
R/LB
33

FIG. 3

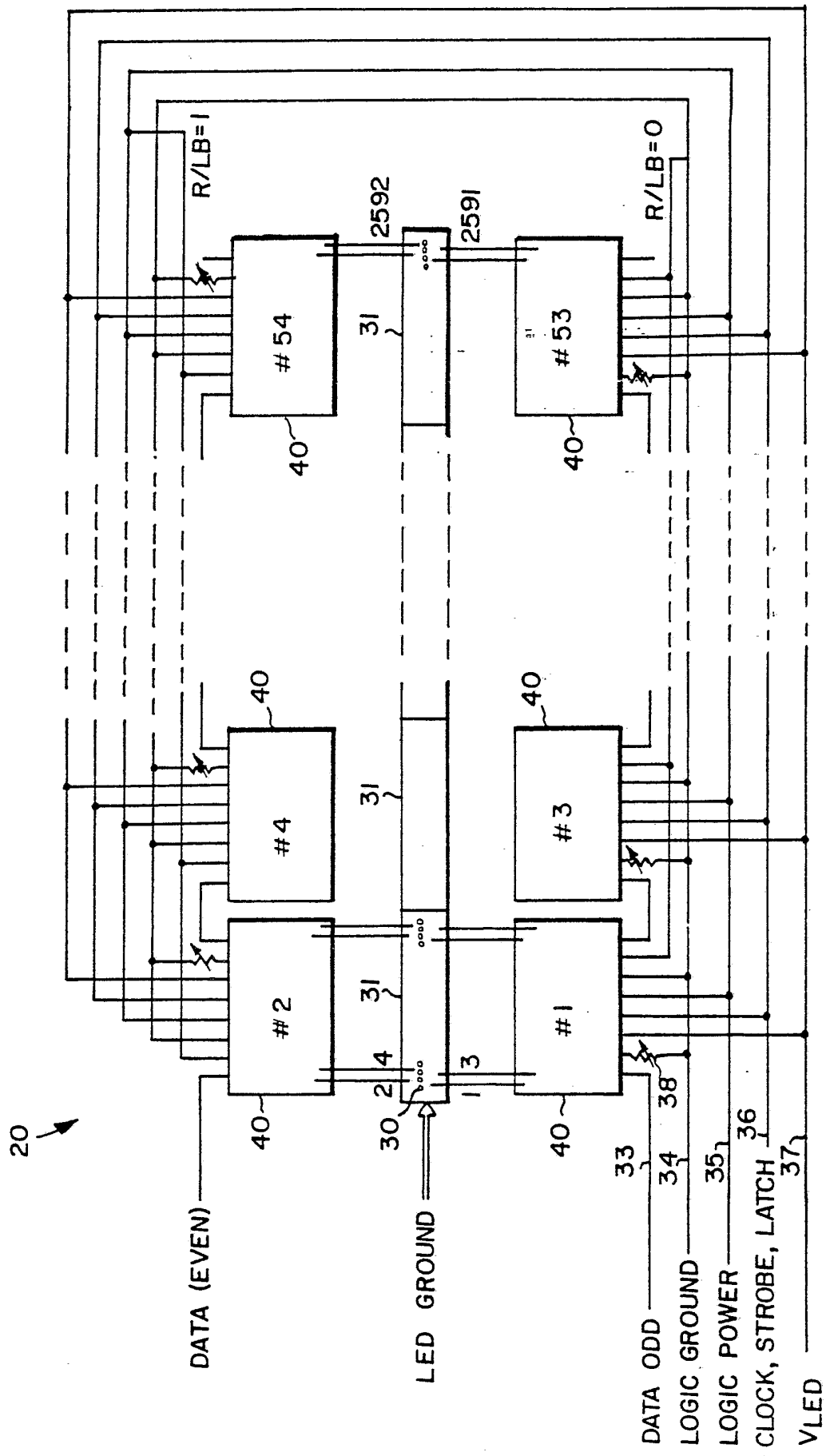
20
R/LB=1
R/LB=0
2592
2591
#54
#53
#4
#3
#2
#1
31
40
4
3
2
1
30
38
33
34
35
36
37
DATA (EVEN)
LED GROUND
DATA ODD
LOGIC GROUND
LOGIC POWER
VREF CLOCK, STROBE, LATCH
VLED

FIG. 2

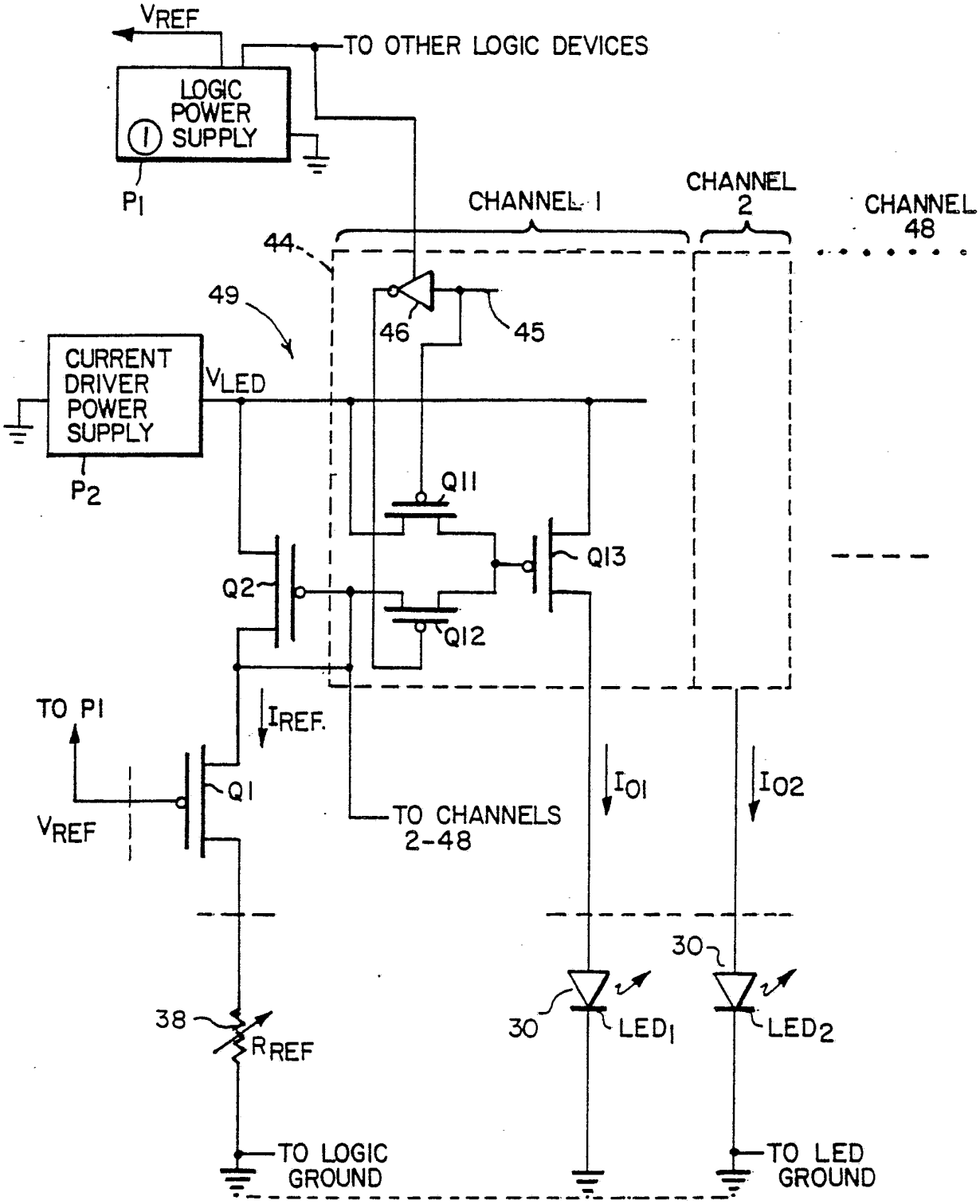
VREF
TO OTHER LOGIC DEVICES
LOGIC POWER SUPPLY
1
P1
CHANNEL 1
CHANNEL 2
CHANNEL 48
44
49
46
45
CURRENT DRIVER POWER SUPPLY
VLED
P2
Q11
Q13
Q2
Q12
TO P1
IREF.
Q1
VREF
TO CHANNELS 2-48
IO1
IO2
30
38
RREF
LED1
LED2
TO LOGIC GROUND
TO LED GROUND

FIG. 4

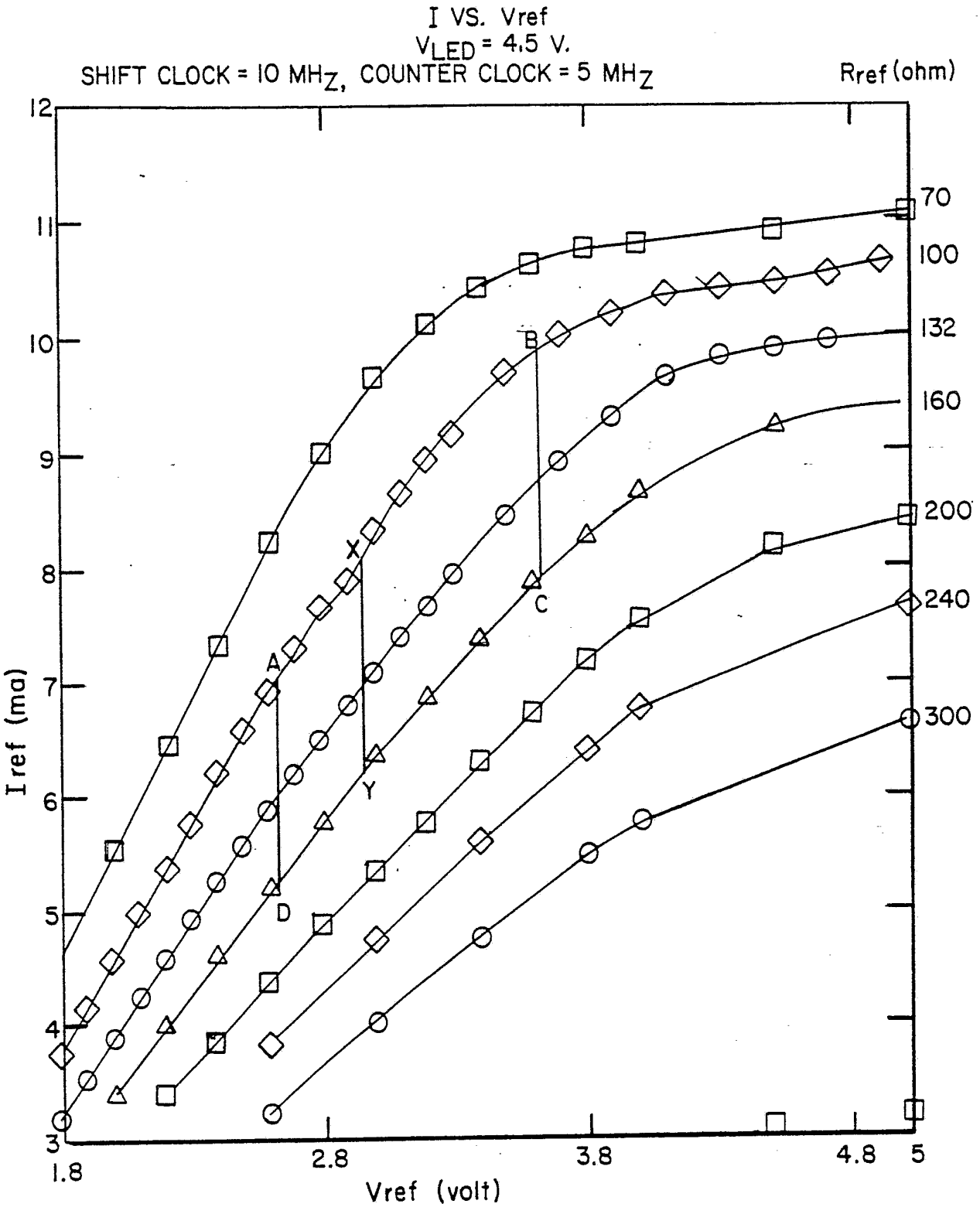
I VS. Vref
VLED = 4.5 V.
SHIFT CLOCK = 10 MHz, COUNTER CLOCK = 5 MHz
Rref (ohm)
70
100
132
160
200
240
300
A
B
C
D
X
Y
Iref (ma)
12
11
10
9
8
7
6
5
4
3
1.8
2.8
3.8
4.8
5
Vref (volt)

FIG. 5

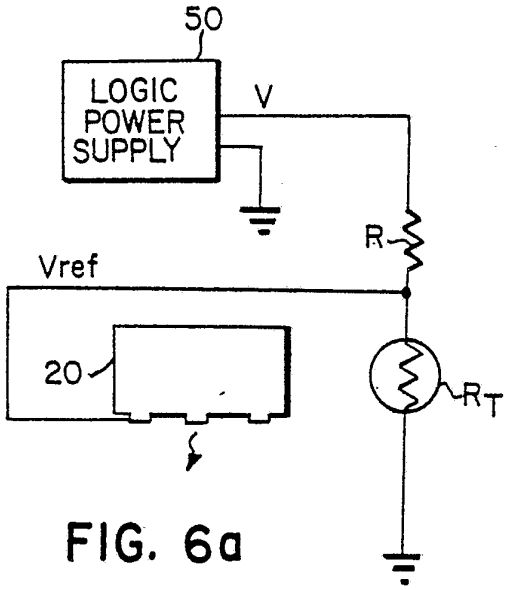
50
LOGIC POWER SUPPLY
V
R
Vref
20
R_T

FIG. 6a

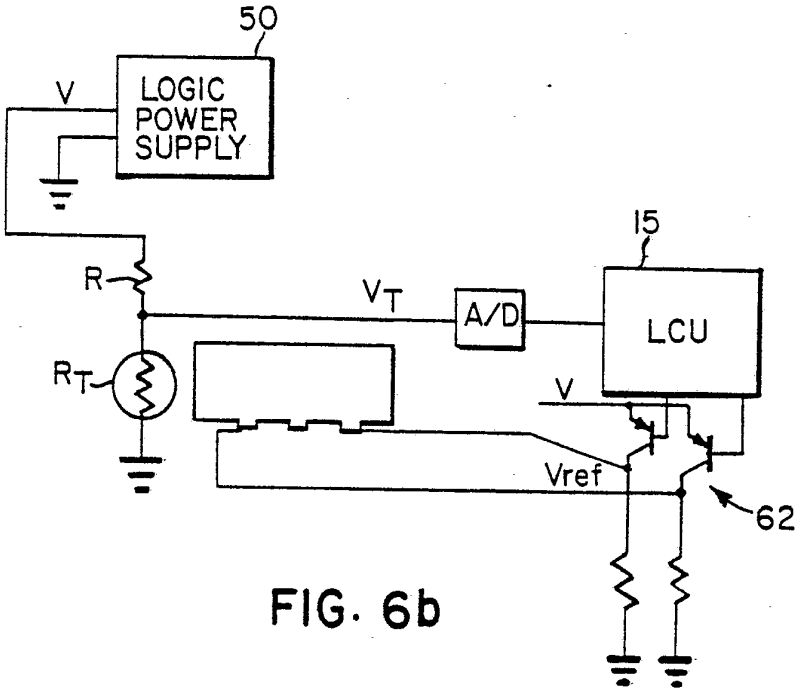
50
V
LOGIC POWER SUPPLY
15
R
V_T
A/D
LCU
R_T
V
Vref
62

FIG. 6b

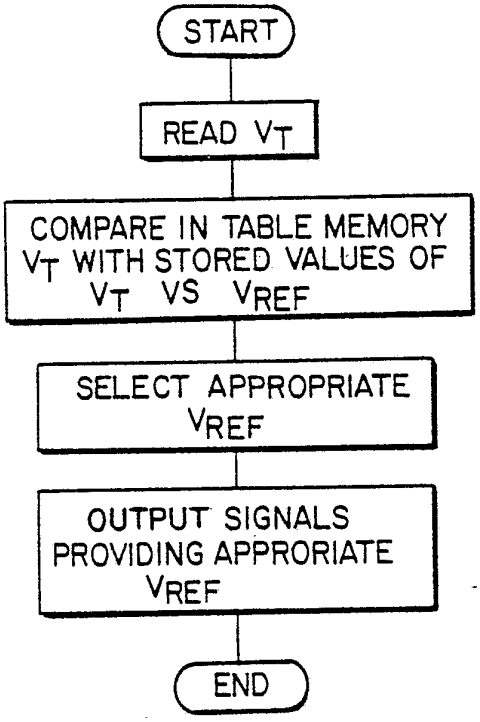
START
READ V_T
COMPARE IN TABLE MEMORY V_T WITH STORED VALUES OF V_T VS V_{REF}
SELECT APPROPRIATE V_{REF}
OUTPUT SIGNALS PROVIDING APPRORIATE V_{REF}
END

FIG. 7a

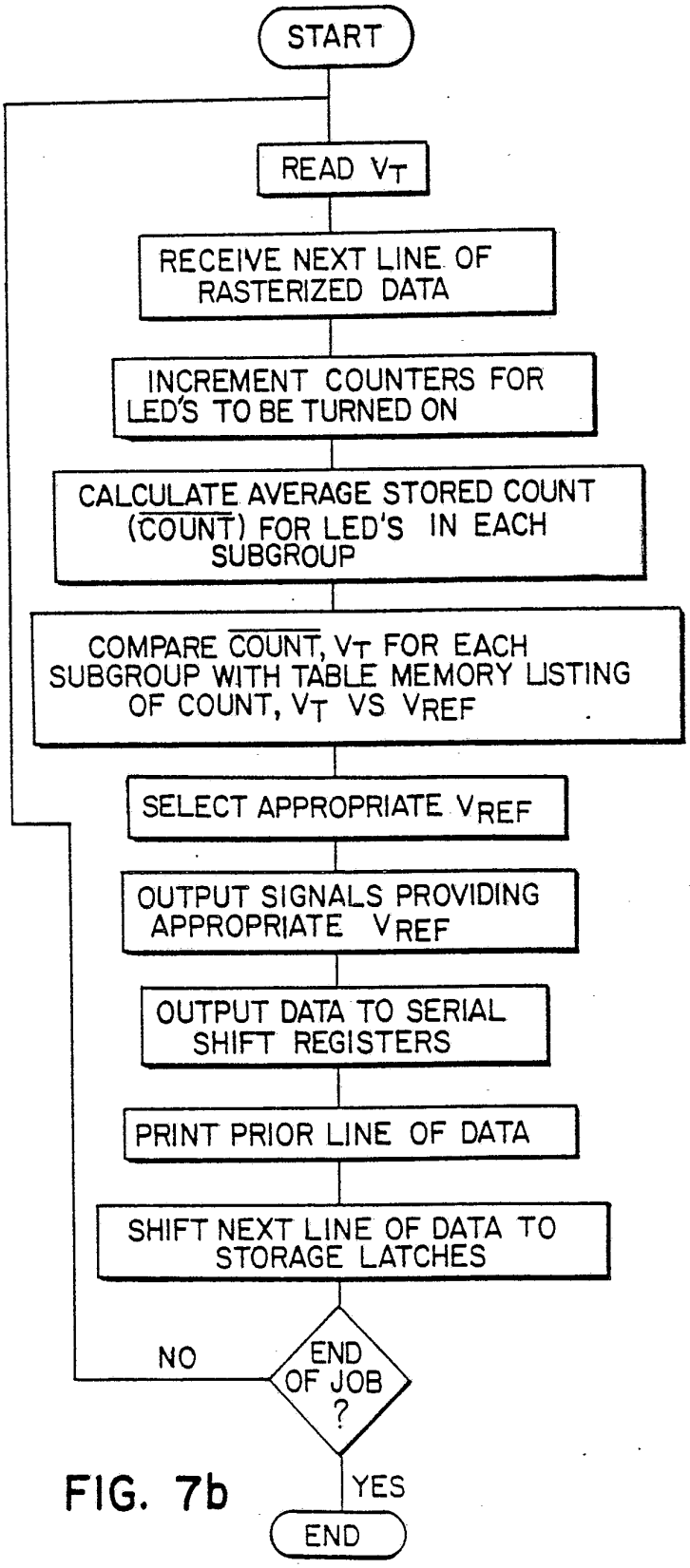
START
READ V_T
RECEIVE NEXT LINE OF RASTERIZED DATA
INCREMENT COUNTERS FOR LED'S TO BE TURNED ON
CALCULATE AVERAGE STORED COUNT ($\overline{COUNT}$) FOR LED'S IN EACH SUBGROUP
COMPARE $\overline{COUNT}$, V_T FOR EACH SUBGROUP WITH TABLE MEMORY LISTING OF COUNT, V_T VS V_{REF}
SELECT APPROPRIATE V_{REF}
OUTPUT SIGNALS PROVIDING APPROPRIATE V_{REF}
OUTPUT DATA TO SERIAL SHIFT REGISTERS
PRINT PRIOR LINE OF DATA
SHIFT NEXT LINE OF DATA TO STORAGE LATCHES
END OF JOB ?
NO
YES
END

FIG. 7b

REVISED VERSION

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 88/00958

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: G 06 K 15/12

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	G 06 K; B 41 J; H 04 N; G 03 G

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	IEEE Transactions on Consumer Electronics, volume CE-32, no. 1, February 1986, IEEE, (New York, US), J. Burkhart et al.: "A monolithically integrated 128 LED-driver and its application", pages 26-31 see figures 3,4; page 28, left-hand column, line 6 - page 29, left-hand column, line 19 --	1,2
A	DE, A, 3422907 (CANON) 3 January 1985 see figures 3,7,10-15; page 1, line 1 - page 2, line 17 --	1,8
A	GB, A, 2104266 (PITNEY BOWES) 2 March 1983 see figures 3,4; page 3, lines 15-70; page 3, lines 8-68 --	1,6,8
A	US, A, 4571602 (DE SCHAMPHELAERE et al.) 18 February 1986 cited in the application -- ./.	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1st February 1989	10 FEB 1989
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
P,A	WO, A, 87/02162 (SIEMENS) 9 April 1987 see figures 1-3; page 7, line 9 - page 10, line 5	1-14

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US 8800958 SA 21832

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 08/02/89
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A- 3422907	03-01-85	JP-A- 60006471	14-01-85
		US-A- 4596995	24-06-86
		JP-A- 60006472	14-01-85
		JP-A- 60005387	11-01-85
GB-A- 2104266	02-03-83	FR-A,B 2511532	18-02-83
		DE-A- 3230226	03-03-83
		AU-A- 8713782	17-02-83
		JP-A- 58078476	12-05-83
		US-A- 4455562	19-06-84
		CA-A- 1182512	12-02-85
		GB-A,B 2154776	11-09-85
		AU-B- 551563	01-05-86
US-A- 4571602	18-02-86	None	
WO-A- 8702162	09-04-87	DE-A- 3534338	02-04-87
		JP-T- 63501003	14-04-88
		EP-A- 0275254	27-07-88
		US-A- 4780731	25-10-88