Battery Monitor and Charger Controller

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Many hams have a 12-volt automobile battery under the operating table for a variety of uses. There is a continuing need to know the battery voltage and to keep it charged. A hassle-free means of solving these two problems is offered by the battery monitor and charger controller described in this article.

This unit displays the battery voltage on a 10-segment bar LED in increments of 0.5 volts over the range of 10.0 to 14.5 volts. When the battery voltage drops to 12.0 volts the unit automatically enables the 110 VAC line to the charger and begins charging the battery. As the battery voltage rises to 14.0 volts, the unit disables the 110 VAC line, turning off the charger. A discrete LED provides a visual indication of the on-off state of the charger. The 110 VAC line control is all solid state, eliminating mechanical relays and the inevitable pitting and dirty relay contacts. The circuit automatically switches to the "Charge" condition upon application of 12 VDC to the unit.

A printed circuit board layout is provided (see Figures 2 and 3) for builders who desire to make their own. Etched and drilled boards are available from FAR Circuits (see the Parts List) as well. The circuit is simple enough to be easily built on perf board, as a prototype was. It is easy to build and has no tricky circuits or difficult adjustments. All components are readily available at most of the mail order supply houses such as Digi-Key, or from "Peg Board" sources such as JimPaks. The unit is configured to occupy minimal shelf space on a crowded operating table, while presenting the display for easy visibility and power connections near the rear of the table. This results in the long, narrow configuration shown in the photos.

The Circuit

The schematic for the battery monitor and charger controller is shown in Figure 1. The circuit senses the 12V battery voltage and applies it to the input of the LM3914. The LM3914 converts the analog input voltage to 10 discrete outputs, each of which drives a segment of the bar LED. The LM3914 in this unit is wired as an expanded-scale voltmeter so that the first LED lights when the input is 10.0 volts and the last LED lights when the input is 14.5 volts. Thus, the various LEDs light following the battery voltage as it discharges and is recharged. The bar LED provides the battery voltage monitoring function.

The 4011B quad gate is wired as a set-reset flip-flop. The "set" input is connected to the "12.0V" LED pin of the LM3914, so that the 4011B output is set high when the 12.0V LED lights. The "reset" input is similarly connected to the "14.0V" LED pin of the LM3914. When the battery voltage reaches 14.0 volts the 4011B output is reset low. The 4011B output drives the MOC 3010 optoisolator, turning it on and off as the battery voltage ranges between 12.0 and 14.0 volts. The MOC 3010 in turn operates the triac, which switches the 110 VAC on and off to the battery charger. Two gates of the 4011B are wired to control a discrete "charge" indicator LED, in an identical set-reset manner. Note that the 4011B has inputs and outputs wired

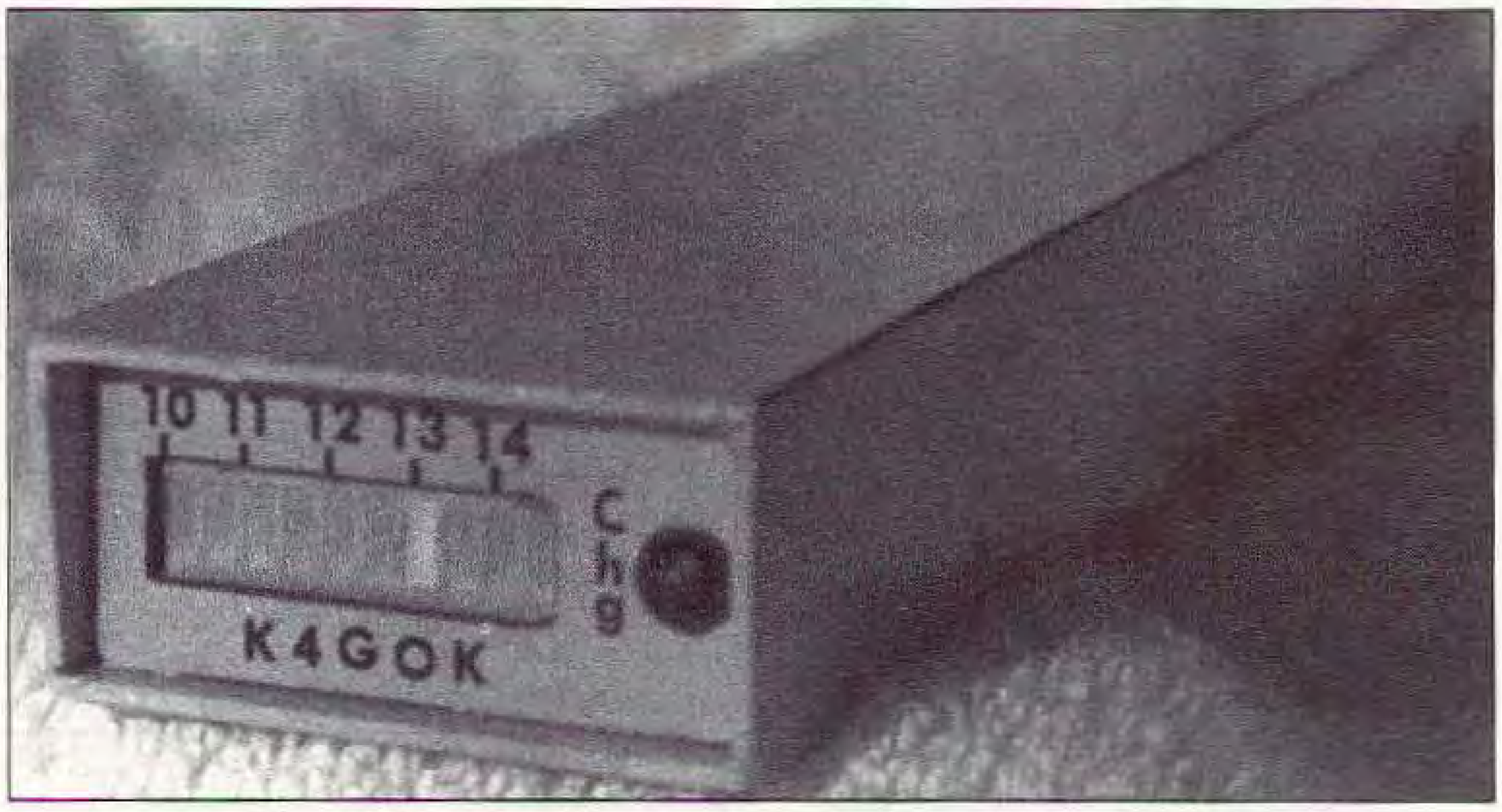


Photo A. Completed battery monitor and charge controller unit.

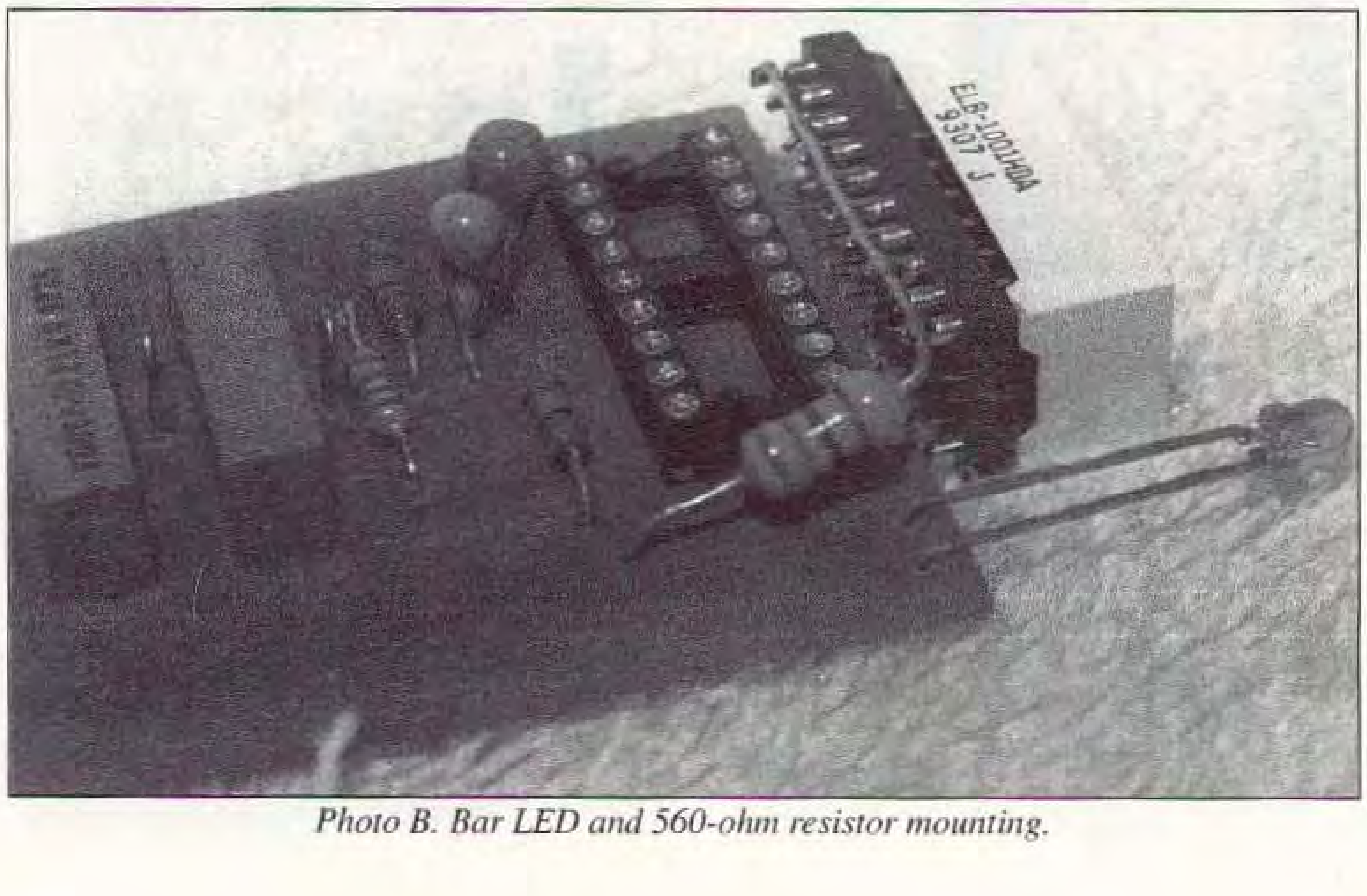
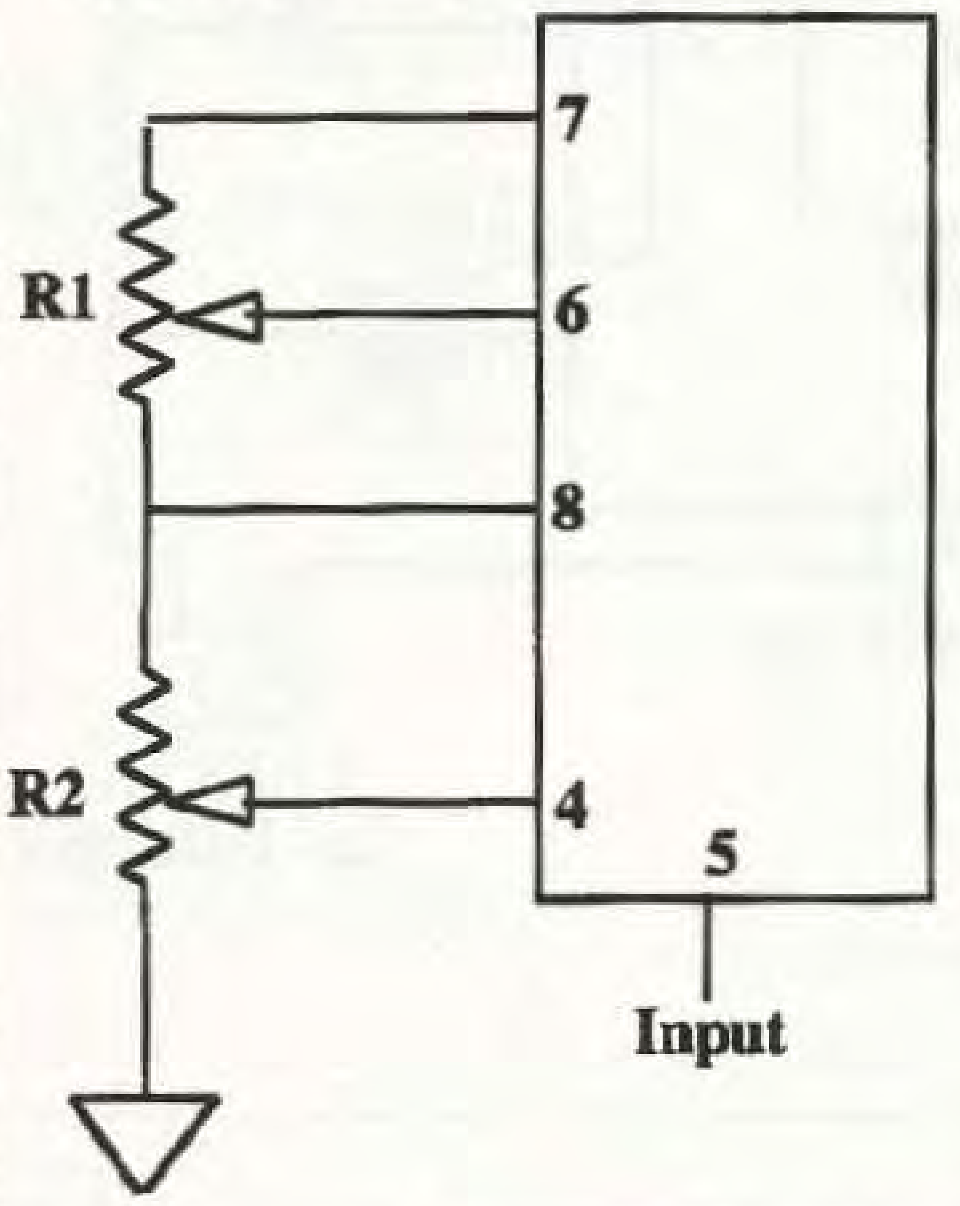


Photo B. Bar LED and 560-ohm resistor mounting.

Design Equations And Principles For The LM3914, 15, & 16 Chips

Reference Circuit 1



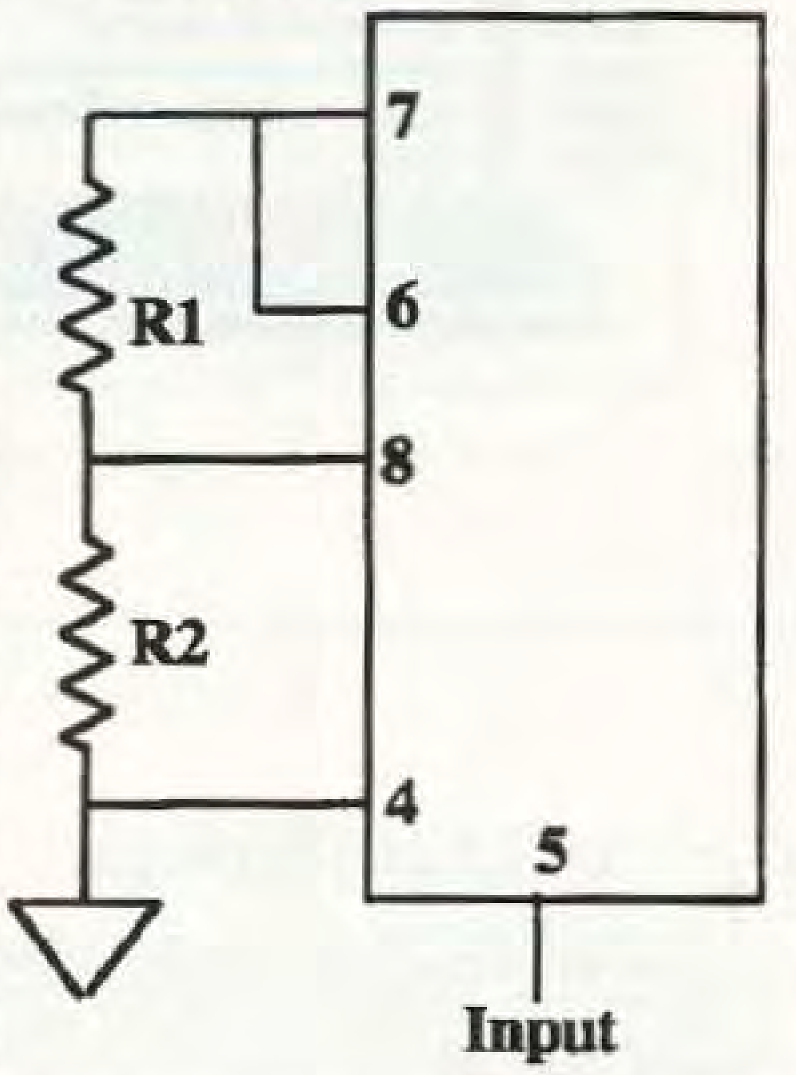
Principles:

1. The chip maintains a constant 1.25V across pins 7 and 8.
2. The current thru each LED is determined by the resistance between pins 7 and 8.
   Current =12.5/R1
3. Current thru R2 is the same (close) as R1.
4. Pin 6 is the top of an internal precision resistor chain, and pin 4 is the low end. This chain is connected to the internal comparators, and is compared with the voltage at pin 5 for determining which LED to light.
5. The #10 LED lights when pin 5 voltage is that on pin 6. The #0 LED lights when pin 5 voltage is that on pin 4.

Design Notes:

1. The voltage across R1 is always $1.25 \pm .03$
2. The voltage across R2 is always...
   $V_{R2} = (R2/R1)(1.25)$
3. The sum of voltage across R1 and R2 can't exceed the supply voltage, naturally!
4. Maximum voltage at pin 6 (wiper at top) is $V_{R1} + V_{R2}$
5. Minimum voltage at pin 6 (wiper at bottom) is V_{R2}
6. Maximun voltage at pin 4 is V_{R2}
7. Minimum voltage at pin 4 is zero (ground).
8. Chip to chip variations cause minor voltage variations

Reference Circuit 2



Design Example - Circuit 1

R1 = 1.0K, R2 = 5.0K
LED current = 12.5/1.0K = 12.5 ma
Max V_4 = (5.0/1.0)(1.25) = 6.25 volts
Min V_6 = 6.25 volts (same as above)
Max V_6 = 6.25 + 1.25 = 7.50 volts

Design Example - Circuit 2

Zero to 5 Volt Meter (V_6 = 5.0, V_4 = 0.0)
LED Current = 10ma
R1 = 12.5/.010 = 1.25K
V_{R2} = 5.0-1.25 = 3.75
R2 = (3.75)(1.25)/1.25K = 3.75K

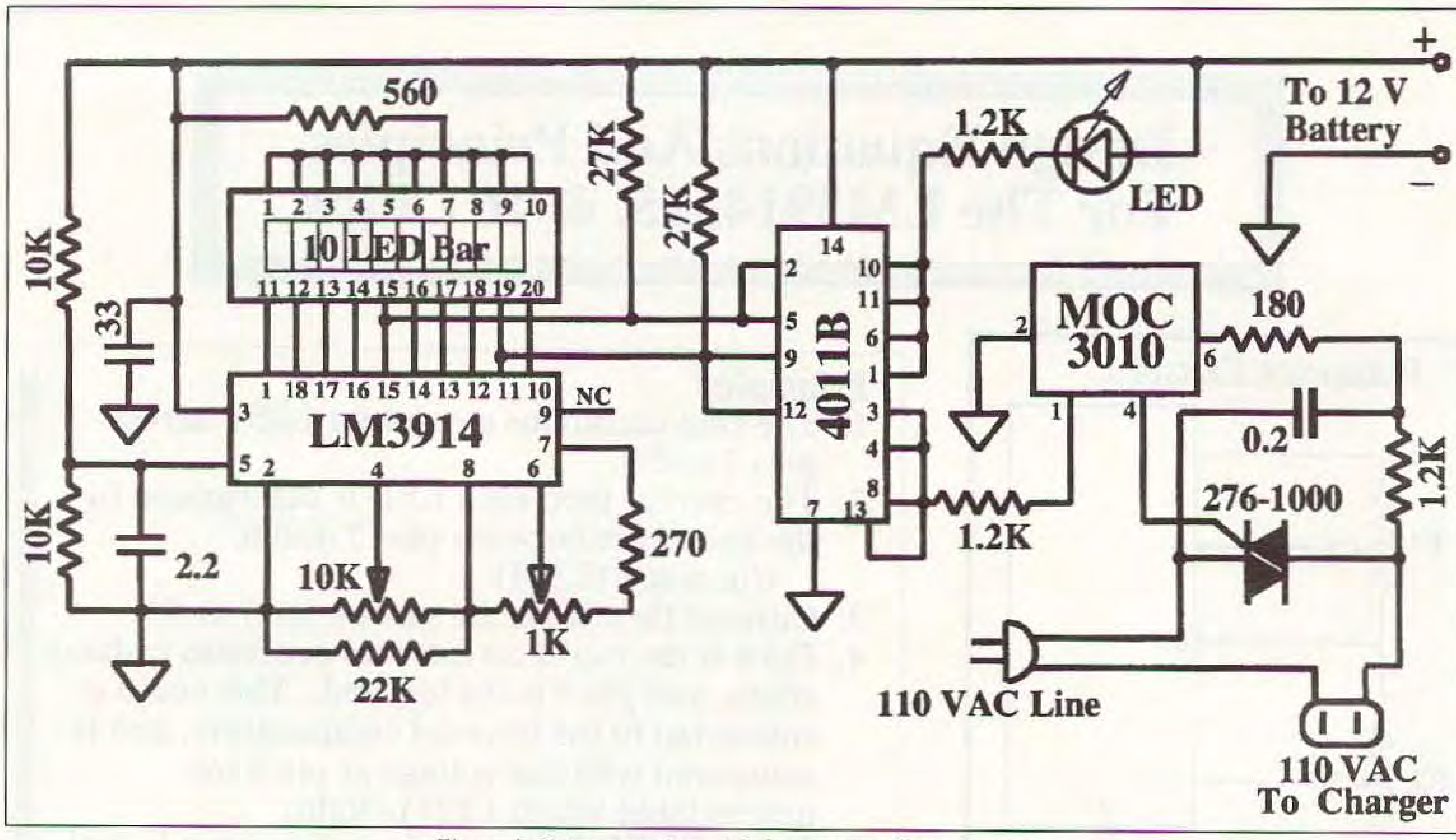


Figure 1. Battery monitor and charge controller schematic.

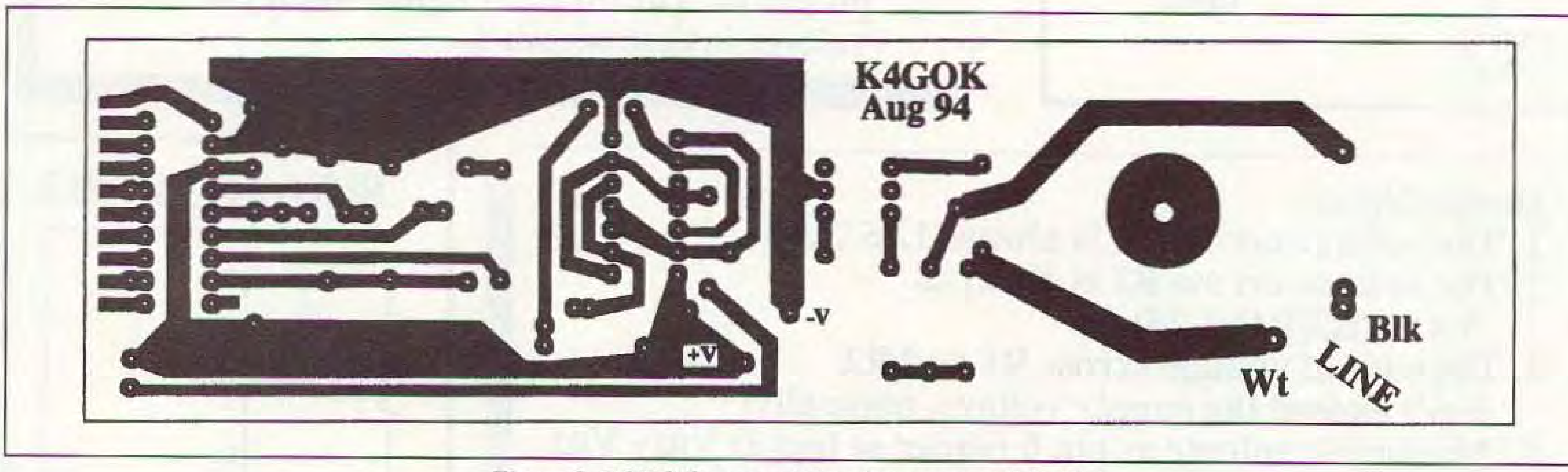


Figure 2. PCB foil pattern (view from copper foil side).

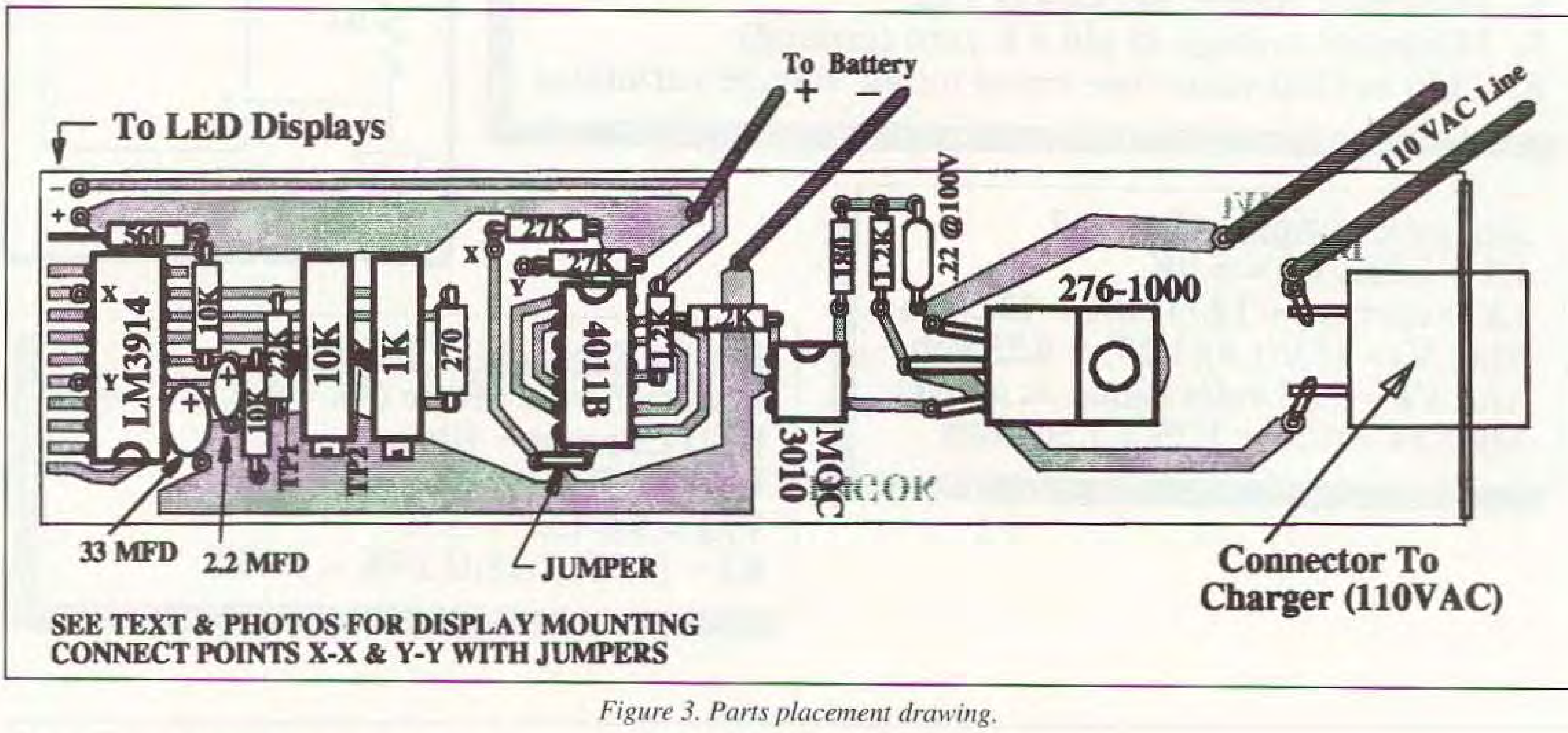


Figure 3. Parts placement drawing.

in parallel to provide the necessary drive to the other circuit elements.

Construction and Checkout

Construction is rather straightforward when using the PCB. The PCB foil pattern is shown in Figure 2. Install all the IC sockets, resistors and caps as shown on the parts placement drawing, Figure 3, except for the 560-ohm resistor. Sockets are recommended for all of the ICs except the triac, which should be soldered in place. Bolt the triac to the PCB for good thermal conduction. Observe proper polarity when installing the 2.2 and 33 MFD tant caps. Note that there are three jumpers on this PCB. One is near pin 7 of the 4011B and is installed from the component side of the board. The other two are installed on the foil side of the board, and go between the points marked Y-Y and X-X, as shown on the parts placement drawing.

The LEDs should be installed next. A socket for the 10-segment bar LED is recommended. Note that the bar LED socket is mounted 90 degrees to the PCB surface. Solder the socket directly to the edge of the PCB. The resistor lead should be soldered to all the socket pins along one edge, as shown. Study the photo to see how the socket and the 560-ohm resistor are mounted. Solder in place the "charge" LED with lead lengths so that it will extend through the front panel.

At this point the PCB should be carefully inspected for solder bridges. Check that all points that should be connected to 12V are, and that everything that should be connected to ground is. Verify that there is no short between 12V and ground. Be careful checking this circuit because potentially dangerous voltages will be present before checkout is completed. Make sure no 110 VAC is connected for the moment. Remove any voltage on the two caps by temporarily shorting across them at the cap leads. Connect an ohmmeter between test point 1 and ground, and adjust the 10k pot for a reading of 4.9k. Adjust the 1k pot for an ohmmeter reading of 7.2k between test point 2 and ground. Pay careful attention to the proper orientation of the ICs and install them. Briefly apply 12 VDC power and verify that the "charge" LED lights. One segment of the bar LED should also light at this time.

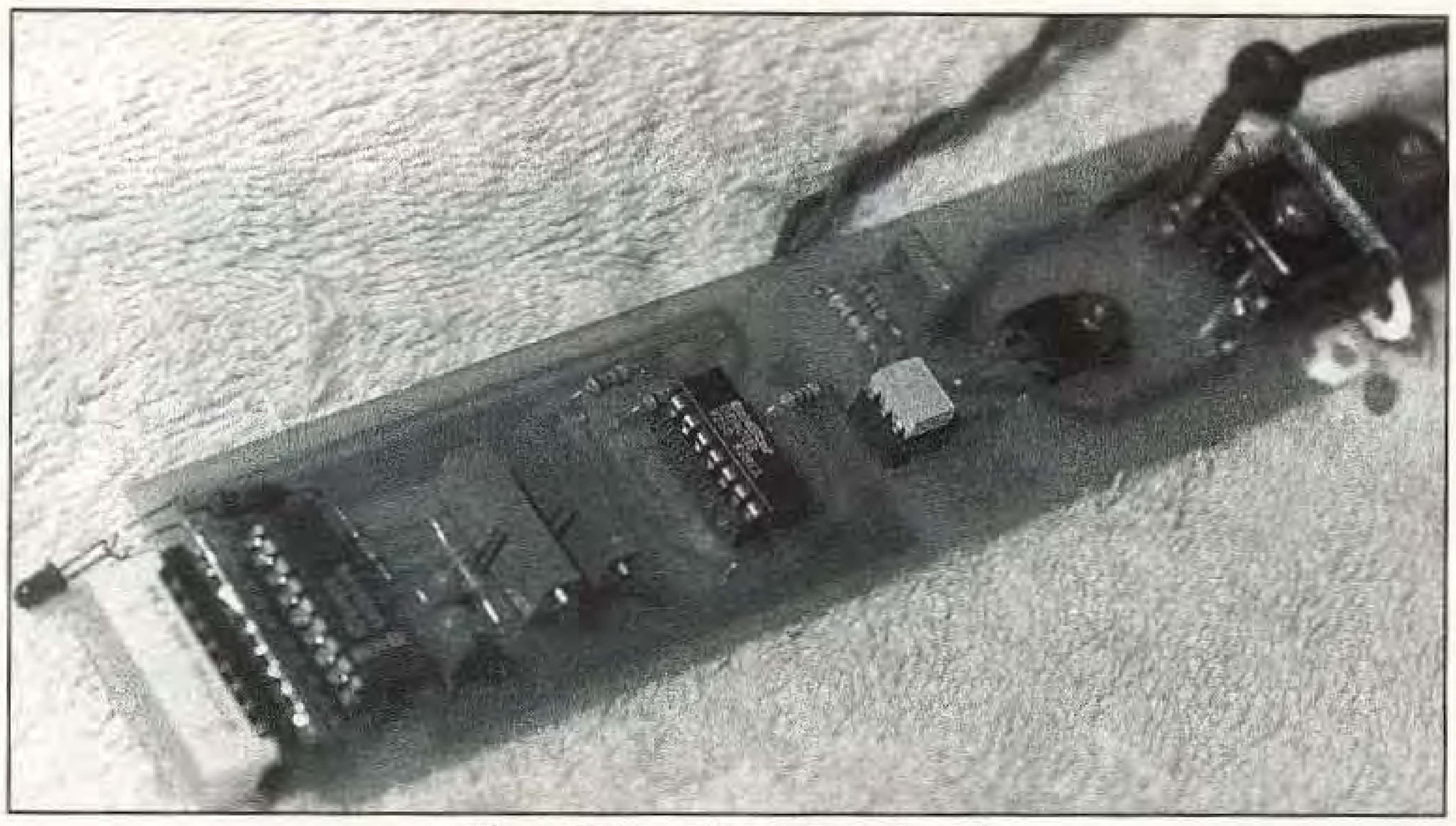


Photo C. Completed circuit board.

Next power the PCB with a variable voltage DC supply that will cover the range from 9 to 15 volts. Set the power supply at about 12 VDC. Adjust the 10k pot for 4.90 volts at test point 1 (TP1), then adjust the 1k pot for 7.25 volts at TP2. Set the power supply to 14.5 volts output, and fine-tune the 1k pot so that the "14.5V" LED just lights. The "14.5V" LED will be the rightmost one when the PCB is component-side-down. Then set the power supply to 10.0V and fine-trim the 10k pot so that the "10.0V" LED just lights (the leftmost LED with the PCB upside down). Repeat these adjustments until the "14.5V" LED lights just as the supply voltage rises to 14.5 volts, and that the "10.0V" LED lights just as the supply voltage falls to 10.0 volts. Note that there may be some interaction between these two adjustments.

During the above calibration, the "charge" LED should light when the voltage falls to 12.0 volts, and should go off when the voltage rises to 14.5. It is necessary to apply 110 VAC to make the next checks. Use appropriate caution. Connect your charger or a 110V low-wattage light bulb to the unit. Connect the unit to the 110 VAC line. Vary the DC power supply voltage and verify that the charger or lamp come on and go off at 12.0 and 14.0 volts, respectively. Remove the 110 VAC and check for heating of the components. Nothing in this unit should be hot after operating for several minutes. *Do not* check for temperature effects with 110 VAC applied to the unit.

This completes checkout of the unit. It is ready for mounting in a small container. A container can be made from copper-clad PCB material. It is important that the PCB be mounted in the container with the components downward for proper reading of the LED display. The "charge" LED will be on the right when the board is properly mounted. Figure 4 shows how the battery monitor and charger controller are connected to the battery and charger. Note that the 12V battery connections for the monitor and charger controller should be connected directly to the battery terminals as shown. The sidebar on page 33 contains design principles and equations for readers who might want to apply the LM3914 in other applications.

Conclusion

The battery monitor and charger controller has been in use at this QTH for many months. It serves its intended purpose well. The automobile battery under the operating table stays charged automatically, and battery voltage is obvious at a glance. Others are encouraged to build a duplicate unit and enjoy the hassle-free benefits it provides.

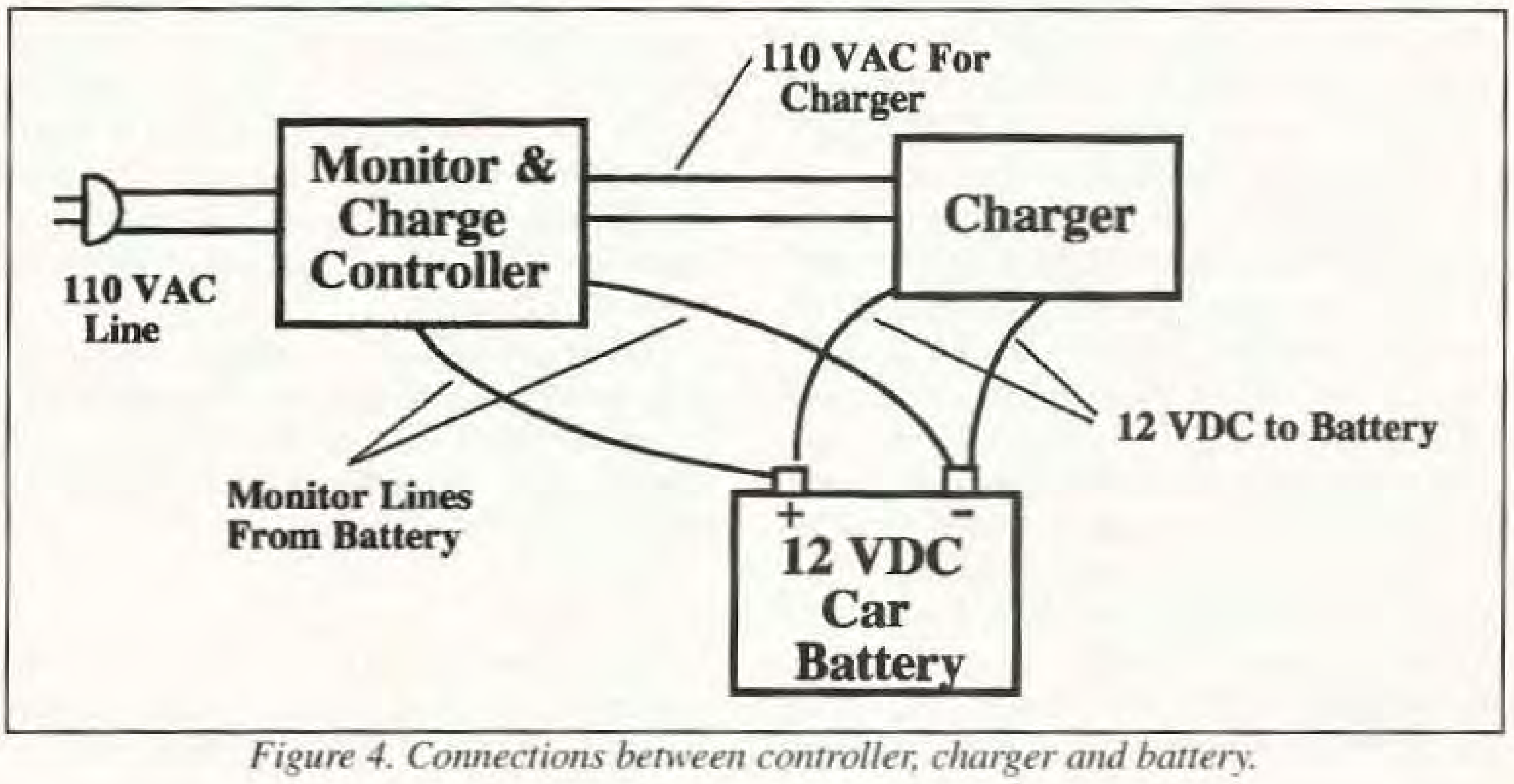


Figure 4. Connections between controller, charger and battery.

Parts List

Resistors
1 each 270, 560, 820, 22k
2 each 10k, 27k
3 each 1.2k
1 each Pot 1k, 10k

Capacitors
1 each 0.1 @ 200V
1 each 2.2, 30 µF @25V

ICs
1 each LM3914, 4011B, MOC3010, RS276-1000

LEDs
1 each 10-segment bar LED, mini LED

Misc. connectors, sockets, etc.

PCB available from FAR Circuits, 18N640 Field Court, Dundee IL 60118 ($6.25 plus $1.50 S&H per order).