An Experimenter's Power Supply

An adaptable multi-voltage supply.

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After you have built a special project and want to power it up, you connect the completed project to your power supply. But what do you do when the project requires special voltages, different from the normal 12 VDC power supply, like +9 and +5 and -5 and -9 VDC? You say to yourself, "I need a multi-voltage power supply that also has negative voltages, and I have to be able to set the voltages to accommodate different projects."

Switching Supplies vs. Standard Transformer Power Supplies

There have been a number of articles on power supplies over the past years. Most of these have been single- or dual-voltage.

Switching power supplies have a lot to offer. They provide higher efficiency at higher currents than transformer supplies. Switching supplies are smaller and weigh much less than transformer supplies. An 8-amp transformer supply could weigh six to 10 pounds, while a switching supply could be as light as two pounds. Switching supplies are easier to filter and offer better regulation.

Why haven't there been published construction articles on switching power supplies? Because switching power supplies are much harder to design and it's difficult to keep the radiation down. Without a large amount of RFI filtering and shielding, you could never operate a radio near a switching power supply.

Switching power supplies are not as reliable as conventional transformer power supplies, though the commercial supplies are becoming as reliable as their transformer counterparts. The weakest links in switching supplies are the switching devices (transistors or FETs), due to the Di/Dt transients under load conditions. The biggest reason why standard transformer power supplies are still popular with us builders and experimenters is the availability of parts and the ease of building a supply. With the availability of transformers, regulator ICs (ie. the 723, 78xx series and 317/337 devices), and capacitors, it is easy to build a transformer power supply.

We wanted to make a supply that was simple, yet versatile enough to fit all low power multi-voltage applications. The supply we came up with has six outputs that can be independently adjusted. We set the outputs to +12, +9, +5, -5, -9, and -12 VDC.

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Circuit Description

The power supply is made up of two independent circuits, the positive and the negative voltage sections. Diodes D1-4 and D5-8 rectify the AC voltage and C1 and C2 filter the DC voltage for the positive and negative sections. Capacitors C3, 5, 7, 9, 11, and 14 are placed at the input of each of the regulator ICs for regulator stability; C4, 6, 8, 10, 12, and 13 are placed at the output of each regulator for improved transient response, i.e. to improve the output voltage overshoot and undershoot response when a load is applied or removed from the output. The negative and positive sections are divided into three separate regulator circuits. The LM317T and LM337T regulator ICs, chosen because of their availability, require only two external parts, can be configured as variable regulators, and are rated at 1.5 amps (with proper heat-sinking). The voltage adjust resistor was chosen as 5k, but lower values could be used to increase the adjustment sensitivity and to lower the maximum adjusted output voltage.

The data book (Note 1) gives the equation for the output voltage as:

$$V_{out} = V_{ref}(1 + R2/R1) + I_{adj}\,R2$$

V_{ref} is a constant 1.25 volt that is maintained between the output and adjust terminals by the regulator. Thus, the lowest voltage that can be achieved from the LM300 series regulators is 1.25 volts. Using the above equation, the adjustable resistor value is 2,244 ohms for a 13.8 volt output. Using a 1k pot would yield an output voltage range of 1.25 to 6.8 volts. Depending on where the output voltage of the individual regulator is set, the LED current-limiting resistor should be adjusted to keep the LED current in a safe operating range, as specified by the LED manufacturer. We like to keep the LED current between 10 and 20 milliamps.

To calculate the LED current for the output voltage setting you want, use the formula:

$$R_{LED} = (V_{out} - 0.7) / 0.015$$

The 0.7 is the LED voltage drop and 0.015 is the LED current of 15 milliamperes. For example, for V_{out} of 12 volts, the current-

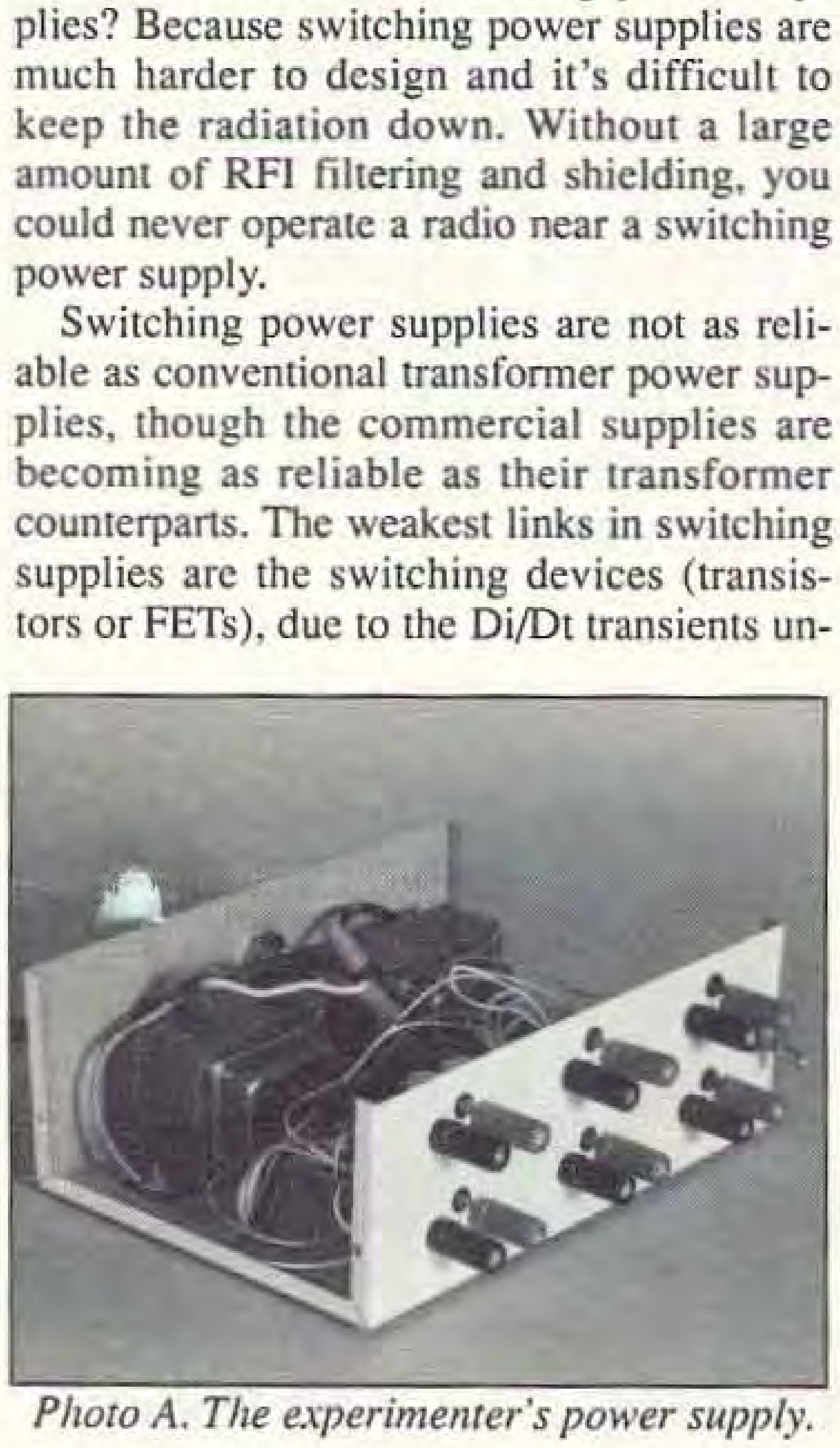

Photo A. The experimenter's power supply.

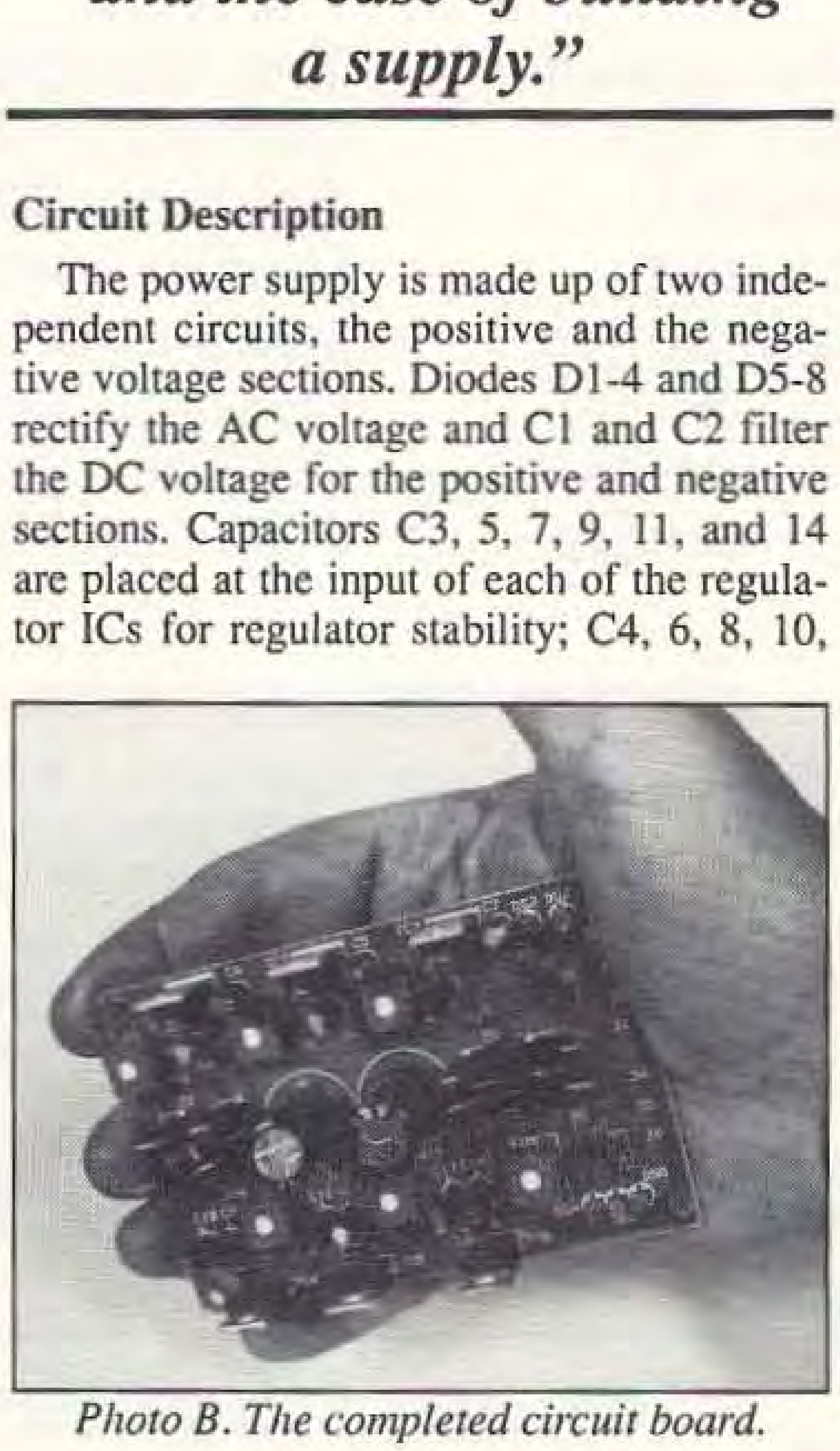

Photo B. The completed circuit board.

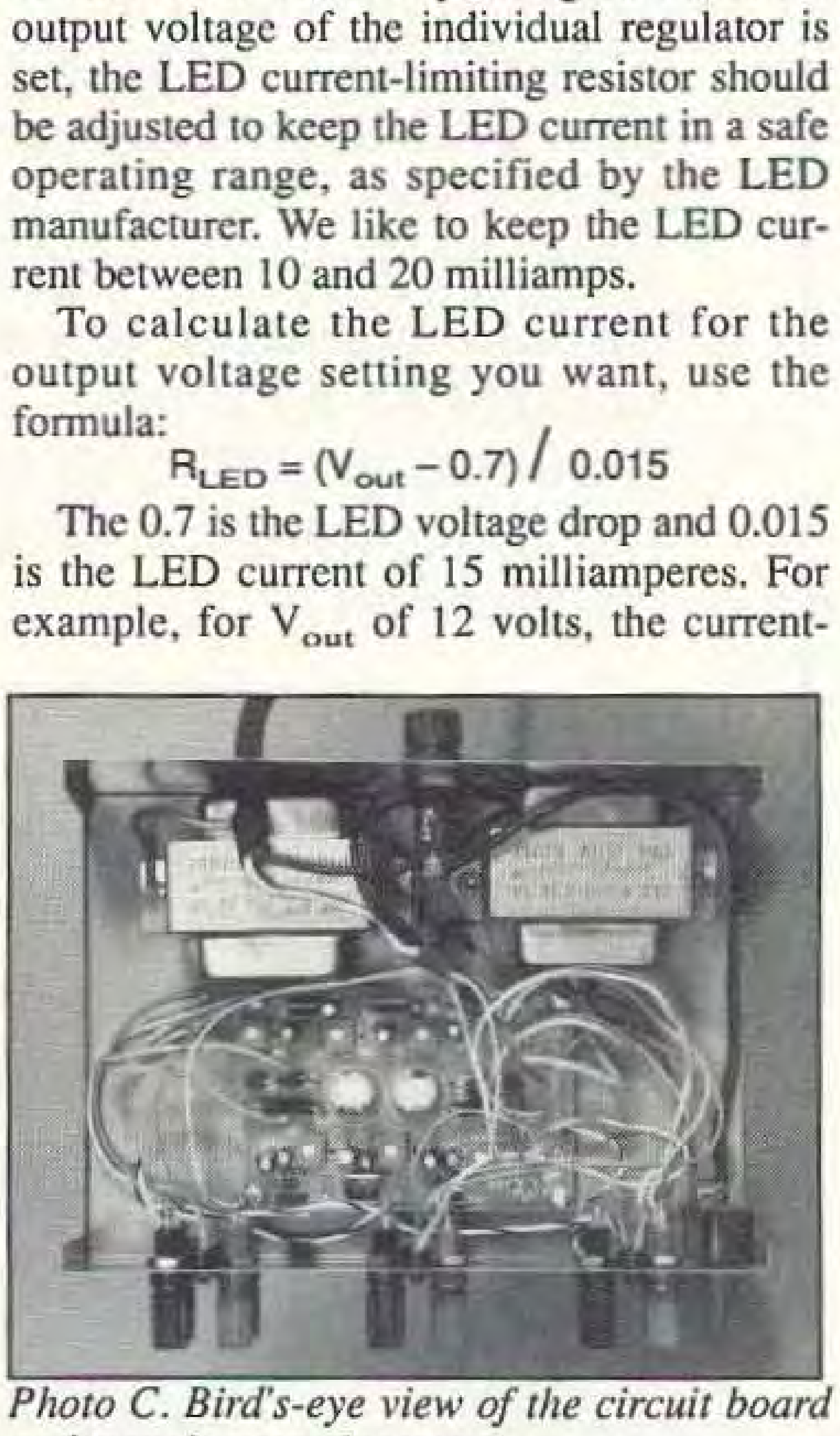

Photo C. Bird's-eye view of the circuit board and transformer placement.

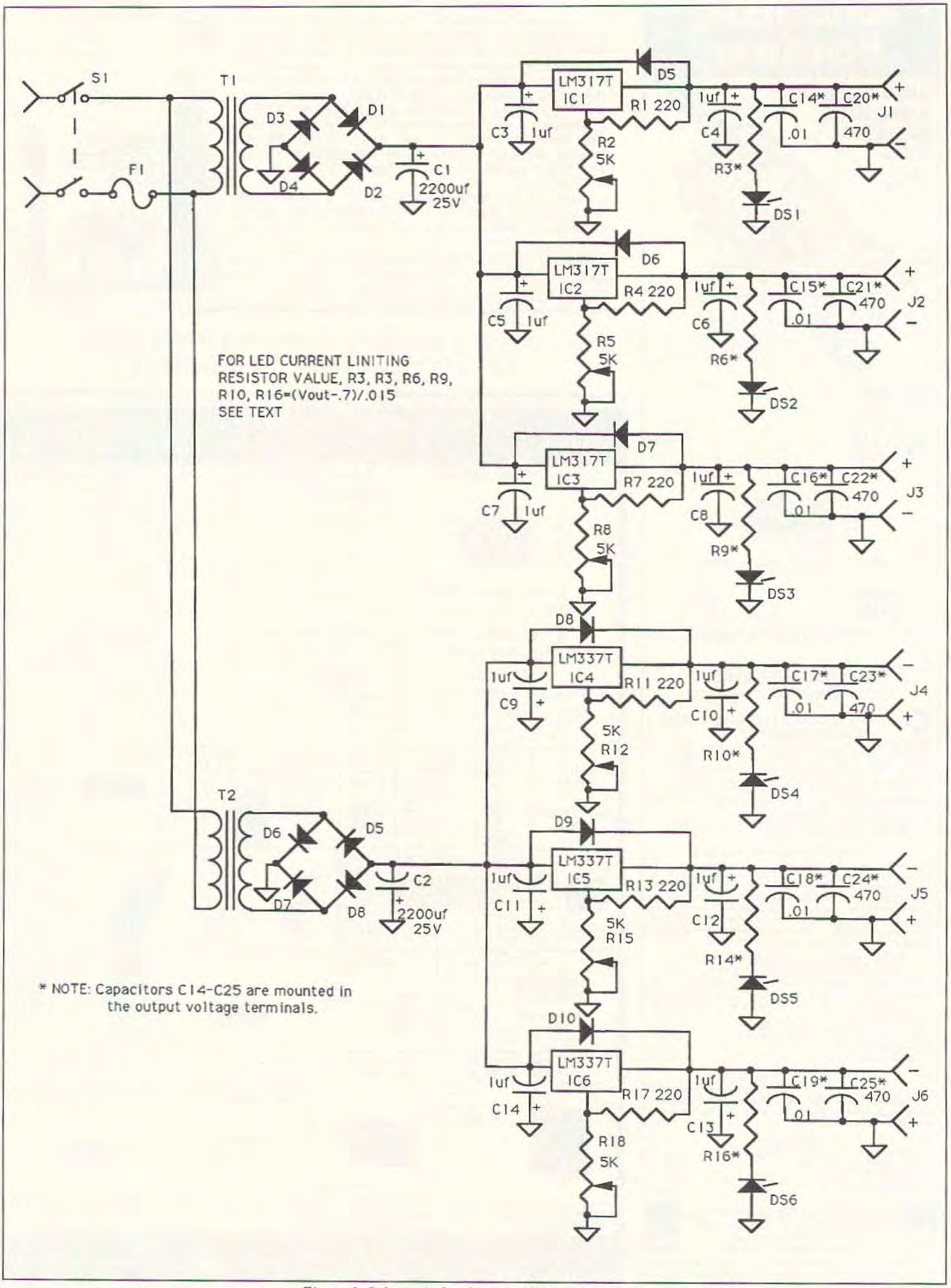

Figure 1. Schematic for the switching power supply.

limiting resistor should be 750 ohms. A 680 or 820 would also work, keeping the current in the 13.78 to 16.6 milliamperes range. For a lower value of V_{out} of 5V, a 270 or 330 ohm resistor will do the job. We used a 680 ohm LED current-limiting resistor. This kept the LEDs in a safe operating limit at the higher voltages and still allowed the LED to light dimly when the output voltage was adjusted to 5 volts.

We chose a 3 amp transformer because of its availability and current rating. The available 3 amp source current is divided between the three regulator circuits. Two separate transformers were used for the AC to keep the positive and negative voltages isolated. We mounted the transformers off the PC board.

A Word About RFI

All active regulated power supplies work great until you use them to power up the transmitter project you just finished. Have you ever wondered why the voltage drops or increases drastically when you key the transmitter? This is due to RF getting back into the regulator of the power supply. To prevent this, put 0.01 and 560 pF or 470 pF capacitors across the voltage output terminals.

A word of caution: The LM317s and LM337s like to have a load on them at all times. If the LEDs are not installed, and with no load on the regulator, the output voltage could float up to the input unregulated voltage. The LED current is sufficient to keep the output voltage from floating up.

Construction

The project is assembled in a Radio Shack box #270-250. A bigger box may be required if heat sinks and/or front panel adjustments are used. The AC power switch should be a DPDT type which disconnects both sides of the line when the power supply is turned off. The fuse should be in the high side of the power line and use a three-prong AC plug on the end of the power cord. The regulator ICs are rated at 1.5 amperes but will require heat sinks for the lower voltage applications that draw more current. For example, if the output is adjusted to 5V and the load current is 0.75 milliamps, there will be almost 10 watts of power dissipated into heat in that regulator IC. We did not show the heat sink in the power supply pictured in this article. When adding the heat sink, remember that the tabs on the LM337Ts are connected to the input voltage and the tab on the LM317T is connected to the output voltage. Mica insulating hardware (such as Digi-Key 4671K-ND or 4672K-ND, or Newark 46F7847 with insulating shoulder washers) must be used to isolate the tabs of the regulators from each other. The power supply is assembled on a nice 4" x 2.75" PC board with a screened legend for easy assembly. The board is available from FAR Circuits (Note 3). The transformer is external to the board and connects to the T1 and T2 points on the board. 73

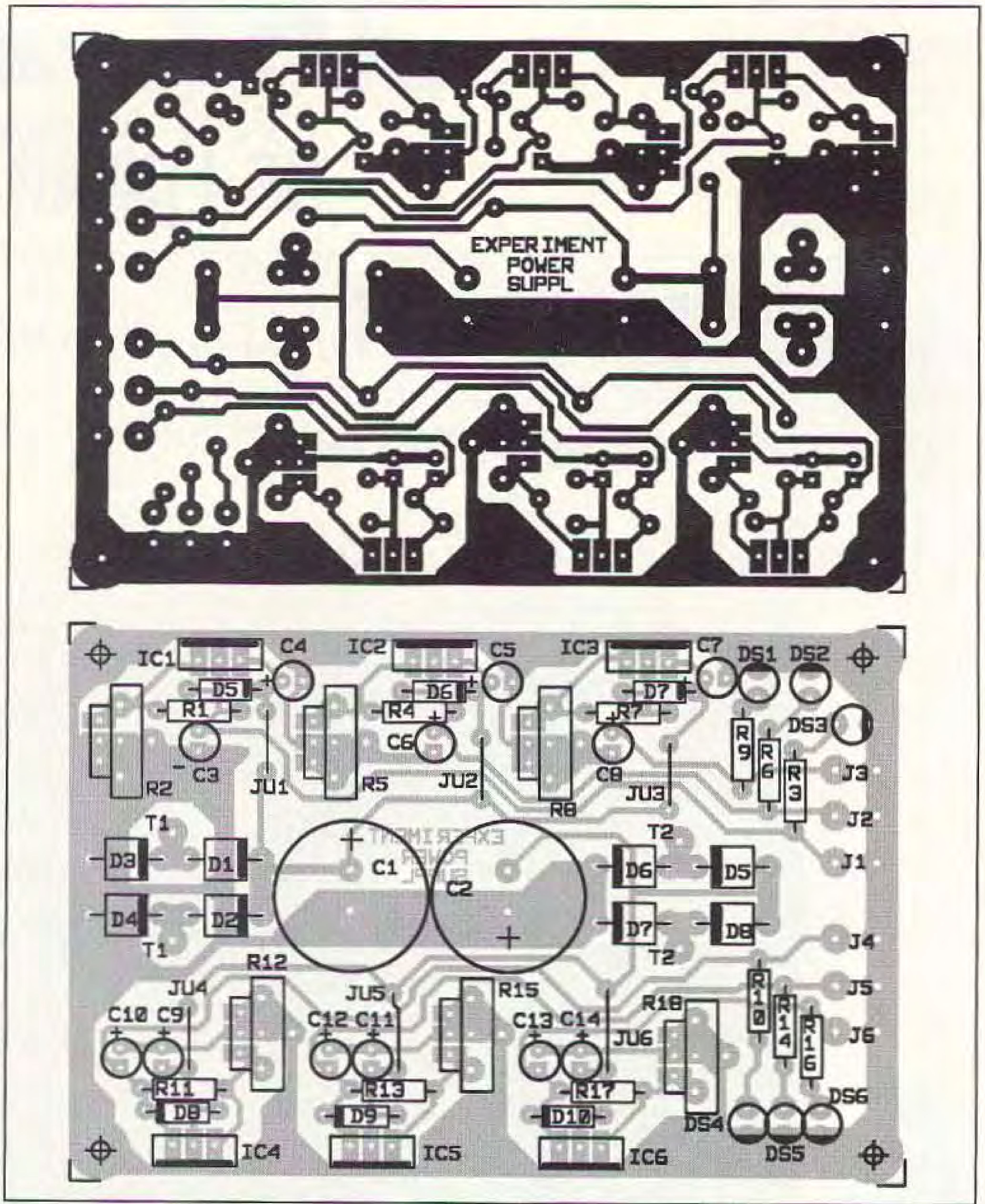

Figure 2. PC board pattern and parts placement for the switching power supply.

Parts List

IC1-IC3	LM317T (RS276-1778, All Electronics, Mouser #595-SG317P or 511-LM317T)
IC4-IC6	LM337T (All Electronics, Mouser #595-SG337AP or 511-LM337SP)
C1, C2	2200µF 25V (All Electronics, Mouser #140-LLR25V2200)
C3-C13	1µF 35µF Tantalums (RS272-1434, All Electronics, Mouser #540-0.1m35)
C14-C19	0.01µF disc capacitor (RS272-131)
C20-C25	470 pF disc capacitor (RS272-125)
D1-D8	1N5402s (RS276-1143, All Electronics, Mouser #333PG5402 or 333-PG5402)
D5-D10	1N4001 diode (RS276-1101, All Electronics, Mouser)
DS1-DS6	Red LED T3/4 (RS276-041, All Electronics LED-10, Mouser)
T1, T2	12.6V CT 3.OA Transformer (RS273-1511, All Electronics TX-123, Mouser #41 ILG030)
S1	Toggle switch 3A 125 VAC, DPDT (RS275-666) or DPST (All Electronics STS-14, Mouser #10TE002)
J1-J6	Binding post, red and black, (RS274-661 set of six, All Electronics 5-BP-B and 5-BP-R, Mouser)
F1	Fuse Holder (All Electronics FHPM-6, Mouser #504-HJM)
R1, R4, R7, R11, R13, R17	220 1/4 watt
R2, R5, R8, R12, R15, R18	5k pot (RS271-217, All Electronics STOP5K, Mouser #320-1510-5K)
R3, R6, R9, R10, R14, R16	See text
Box	Radio Shack #270-250 or Mouser #40UB103

The above part numbers are only suggestions and are not the only part that the listed companies have available that will work in the circuit. All Electronics: 800-826-5432; Mouser: 800-346-6873

Note 1. *Motorola Linear and Interface Integrated Circuits*, DL128, Rev 2.

Note 2. *Fred Reimers Storehouse of Knowledge*, 1946 Ed.

Note 3. A drilled and etched PC board is available for $6.00 plus $1.50 S & H per order from FAR Circuits, 18N640 Field Ct., Dundee IL 60118.