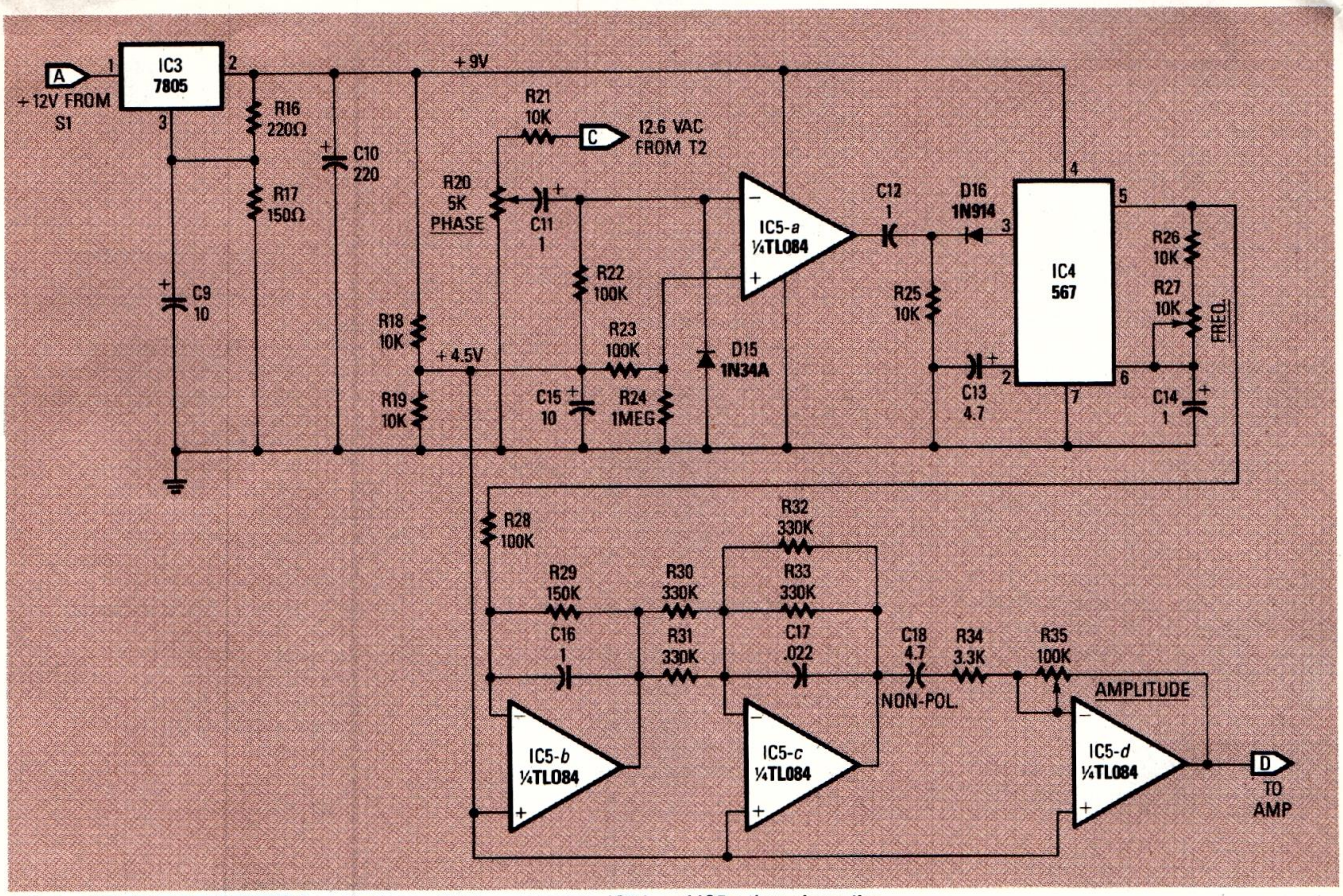


FIG. 3—THE TONE GENERATOR first develops a 60-Hz squarewave. IC5-b and IC5-c then shape the squarewave into a sinewave.

amplifier crossover distortion or clipping, and also prevents high-frequency self-oscillation.

Two of the Darlington pairs are driven in parallel by transformer T3; the other two are driven in parallel by T4. Diodes D11, D12, D13, and D14 provide a fixed DC base voltage that biases the output transistors near cutoff.

The Class-A drivers, transistors Q2 and Q3, also consist entirely of emitter followers. The necessary voltage step-up is provided by T3 and T4, which are also standard power transformers connected in reverse. Transistor Q1 drives Q2 and Q3 in parallel. The base of Q1 is directly coupled to the output of IC5-d (see Fig. 3), which is at 4.5 volts DC. Phase reversal for push-pull drive of the output stage is accomplished with proper connection of the secondaries of T3 and T4.

The sinewave generator

As shown in Fig. 3, the oscillator is built around IC4, a 567 tone detector. The IC's free-running frequency is controlled by resistors R26 and R27, and capacitor C14, and is set as close

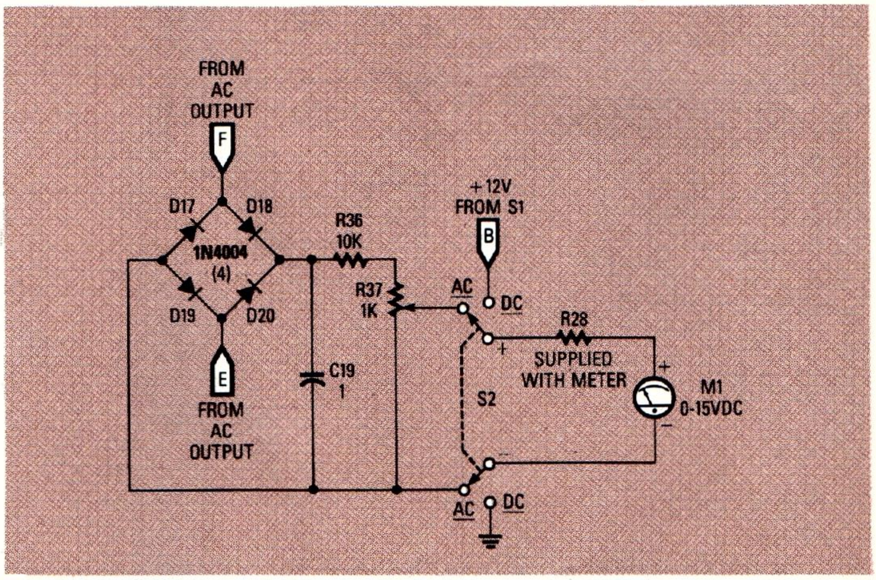


FIG. 4—THE METER CIRCUIT MEASURES both the battery voltage and the UPS output voltage. It is calibrated to the output voltage by potentiometer R37.

to 60 Hz as possible. IC4's squarewave output is converted to a triangle wave by IC5-b, which is in turn converted to a sinewave by IC5-c. Op-amp IC5-d's gain is controlled by potentiometer R35, which is used to set the AC output voltage,

Op-amp IC5-a converts the sinewave from the 12.6-volt output of T2 to a 60-Hz pulse train. D15 protects against damage that could occur if the inverting input were to go negative with respect to ground; the diode is normally reverse biased. The 60-Hz pulses, which are coupled to IC4 through C12 and D16, cause the os-

PARTS LIST

All resistors are ½-watt, 10% unless otherwise noted.
R1, R10, R11—470 ohms
R2—330 ohms
R3, R37—1000 ohm trim pot
R4, R5—3900 ohms
R6, R12, R13, R34—3300 ohms
R7, R9, R16—220 ohms
R8—1000 ohms
R14, R15—4700 ohms
R17—150 ohms
R18, R19, R21, R25, R26, R36—10,000 ohms
R20—5000 ohm trim pot
R22, R23, R28—100,000 ohms
R24—1 megohm
R27—10,000 ohms trimmer potentiometer
R29—150,000 ohms
R30, R31, R32, R33—330,000 ohms
R35—100,000 ohm potentiometer

Capacitors
C1, C2—4700 µf, 35 volts, electrolytic
C3—1000 µf, 35 volts, electrolytic
C4—100 µf, 35 volts, electrolytic
C5—.0022 µF, 250 volts
C6, C7, C10—220 µf, 35 volts, electrolytic
C8—.1 µf, 250 volts
C9, C15—10 µf, 35 volts, electrolytic
C11, C14—1 µF, 10 volts, tantalum
C12—.1 µF, 50-volts
C13—4.7 µF, 35 volt, electrolytic
C16—1 µF, 10 volts, metal film
C17—.022 µF, 10 volts
C18—4.7 µF, 10 volts, nonpolarized electrolytic
C19—1 µF, 250 volts

Semiconductors
IC1—741 op-amp
IC2—MOC3010 opto-triac coupler
IC3—7805 voltage regulator
IC4—567 tone detector
IC5—quad op-amp, TLC274, TL084 or similar
Q1—2N2222, NPN small-signal transistor
Q2–Q7—MJE34 transistor
Q8, Q9, Q10, Q11—MJ2955 transistor
D1–D5—1N5400 silicon rectifier diode
D6, D9–D14—1N4001 silicon rectifier diode
D7—5-volt Zener diode D8—9-volt Zener diode
D15—1N34A small-signal germanium diode
D16—1N914 small-signal silicon diode
D17, D18, D19, D20—1N4004 silicon rectifier diode
LED1—Light-emitting diode

Other components
CB1—2-amp, 120-volt pushbutton circuit breaker
F1—10-amp automotive-type fuse
F2—automotive-type fuse, as required for 12-VDC output
LMP1—12 volt panel lamp
J1, J2—5-way binding posts
L1, L2—choke coil, from Radio-Shack *270-030* filter kit
M1—0-15-VDC voltmeter
PL1—3-wire line cord with grounding plug
RY1—DPDT relay, 120-VAC coil, 10-amp contacts
RY2—SPST or SPDT relay, 12-VDC coil, 3-amp contacts
S1—DPDT toggle switch, center off, 20-amp contacts
S2—DPDT mini toggle switch
SO1—AC outlet, single or duplex
T1, T2—Power transformer: 120 volt primary; 25.2-volt, 2-amp secondary
T3, T4—Power transformer: 120 volt primary; 12.6-volt, 300-Ma secondary
T5—Power transformer: 120 volt primary; 12.6-volt, 3-amp secondary

Miscellaneous: Two automotive-type fuse holders, chassis mounting 12-VDC cooling fan suitable 12-volt battery cable suitable enclosure hardware

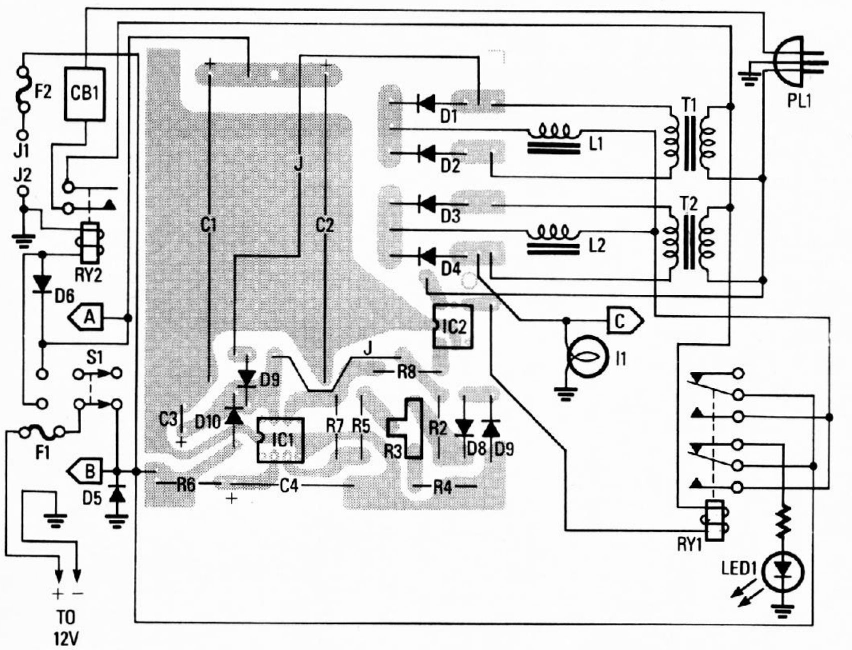


FIG. 5—THE PARTS PLACEMENT diagram for the power supply. Make certain that the parallel-wired connections of T1 and T2 are in-phase. Reversed phase will produce zero output.

cillator to lock to the powerline frequency. Some degree of control over the exact phase relationship is possible by adjusting potentiometer R20. When properly adjusted, the AC output will be in-phase with the powerline, and the unlocking and locking that occurs when the power fails and then returns will be gentle, causing very little disturbance.

The sinewave generator is supplied with clean, ripple-free 9 volt power by IC3, a 7805 5-volt regulator. Pin 3 of the regulator is held at 4 volts above ground by R16 and R17 to obtain 9 volts output.

The meter circuit

Either the battery voltage or the AC output voltage can be monitored with the meter circuit shown in Fig. 4. A bridge rectifier made up of four silicon rectifier diodes converts the AC to DC, which is filtered by C19. A DPDT switch connects a 15-volt DC voltmeter to the 12-volt supply or the voltage divider consisting of R36 and R37.

Construction

There are two important considerations to bear in mind. A considerable amount of heat is generated, particularly by Q8, Q9, Q10, and Q11. A large heatsink is required for those transistors, and a small fan is essential to keep the heatsink at a reasonable operating temperature. The physical placement of the components should allow for free movement of air through the enclosure, with the intake through the sides and the exhaust through the top. The heat-sink should be located near the fan. The power supply's rectifier diode should also be located near the fan and mounted so that the leads hold them about a half inch above the board. To protect them, Q2 and Q3 should each be fitted with a small heatsink.

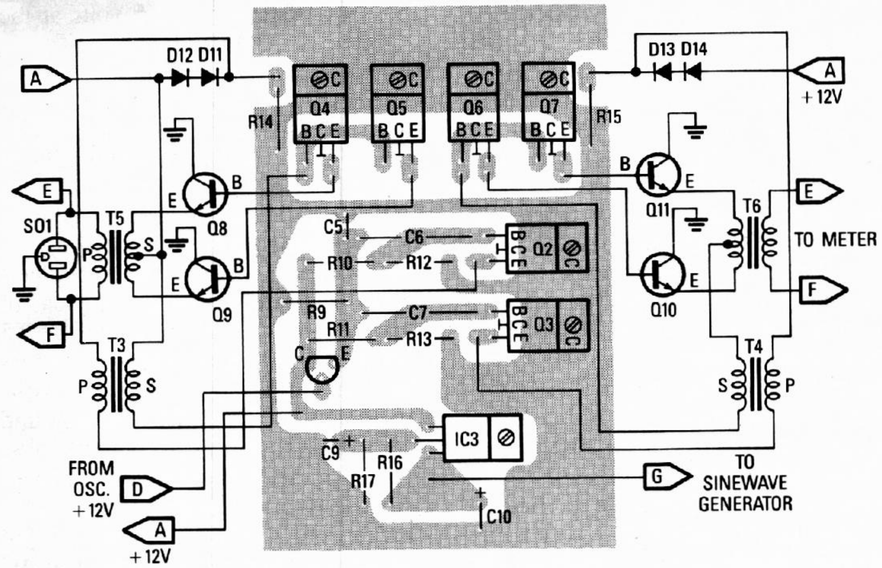


FIG. 6—THE PARTS LAYOUT FOR THE AMPLIFIER. Transistors Q8–Q11 and diodes D11–D14 must be mounted on a heatsink, as indicated by the dashed lines.

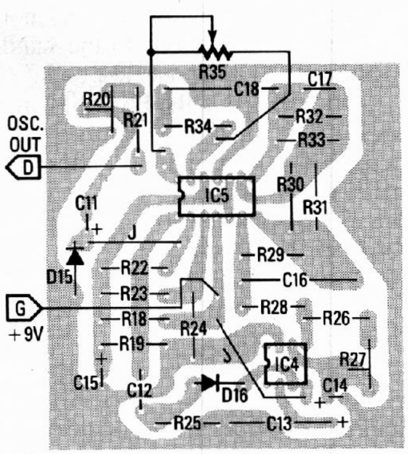


FIG. 7—THE SINEWAVE GENERATOR'S parts layout. Nothing is critical.

The amplifier draws a very high current. A fraction of a volt lost as a result of voltage drop in the power supply leads will result in several volts lost at the output, so use heavy-gauge wire for all leads from the power supply and battery to the center-taps of T5 and T6, and to the chassis ground. (12-gauge wire is recommended.)

A Radio Shack *270-238* aluminum chassis box makes an excellent heatsink. Mount the cover upside down in the bottom of the enclosure. Mount the power transistors on the other section with the leads protruding inward. The transistors' metal cases, which are connected to the collectors, should be grounded to the heatsink. Drill holes for D11, D12, D13, and D14, sized for a tight fit. Position pairs of diodes between the two transistors they affect electrically; i.e., D11 and D12 between Q8 and Q9; D13 and D14 between Q10 and Q11. Use a small amount of heat-sink compound when mounting the transistors and diodes. Insert the diodes in their mounting holes so that the leads from the anode of D11 and the cathode of D12 protrude from the top. Bend and solder the leads together to form a bar between the two diodes. Do the same with D13 and D14. Use soldering terminal strips on the underside of the heatsink for all connections.

Position the heatsink in the other half of the chassis box so that the tops of the transistors will be near the fan, then drill holes for self-tapping screws to hold the two halves together. Transformers T3 and T4, and chokes L1 and L2 will fit nicely in the lower half of the chassis box.

The large power transformers can be mounted in the base of the enclosure to either side of the heatsink. The sides of the enclosure should be vented so that cool air is (them. Depending on the used, it may be necessary t(shelf over each pair of transform... for the associated components.

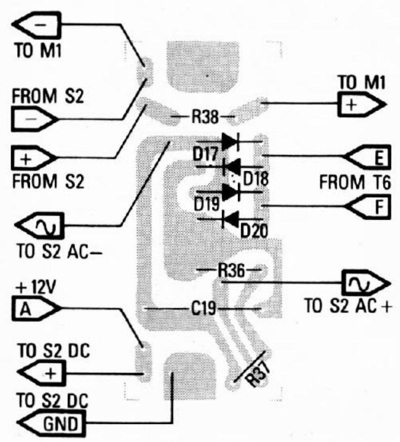


FIG. 8—THE PARTS LAYOUT for the meter board is simple, but there are many connections to other circuits; so take extra care with the interconnections.

Although printed-circuit board construction isn't required, it is recommended, and foil patterns are shown in PC Service for those who wish to use them. The corresponding parts-placement diagrams are shown in Figs. 5–8. The foil patterns can be modified to suit your needs, or the circuits can be built in a similar manner on perforated wiring board. Mounting tabs of Q2, Q3, Q4, Q5, Q6, and Q7 are their collector connections; they must be grounded by machine screws if PC board construction is used.

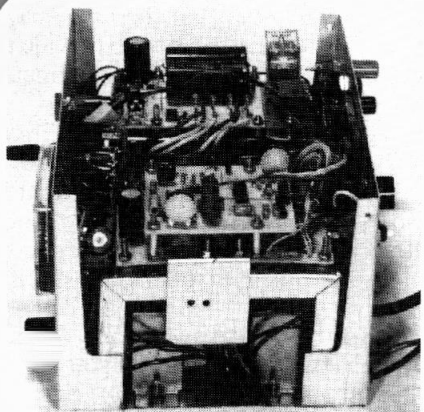
The author used a small section cut from an aluminum chassis box as a heatsink for Q2 and Q3. That heatsink is mounted against the transistor's mounting tabs with machine screws extending through holes drilled in a lip on the heatsink. The heat sink extends down over the edge of the PC board into the flow of air entering the side of the enclosure. The sinewave generator board is piggy-backed over the amplifier board using 6-32 machine screws and spacers.

The fan must operate on 12-volts DC, otherwise cooling would be lost during a power outage. Mount the fan in the top of the enclosure so that it exhausts the air. The vent should be closed except for a circle whose diameter matches that of the fan blades, so that all air must enter the enclosure through the side vents.

Testing the power supply

The power supply should be tested before the amplifier is connected. That can be done before the amplifier is even built. Set R3's wiper at the end that's connected to R4. Do not plug the linecord into an outlet yet. Connect a 12-volt storage battery to the supply and set S1 to either CHARGE or OPERATE. Relay RY2 should energize and LED1 should light. You should measure about 12 volts at pins 2 and 7 of IC1. Pin 6 should be low.

Plug the linecord into an outlet. Lamp LMP1 should light. Relay RY1 should remain deenergized and you should measure about 14 volts at its normally-open contacts. Pin 7 of IC1 should measure about 14 volts and pin 3 should measure about 11 volts. Pin 6 should remain low. Rotate R3 to its



THE UPS IS BUILT LAYER ON LAYER upwards from the base of the cabinet. Stacked mounting nuts, or spacers, at the mounting screws can be used to separate the layers.

opposite end to obtain 14 volts at pin 3; RY1 should now energize and LED1 should be dark.

You should measure about 13 volts across the battery. Rotate R3 just to the point where RY1 deenergizes.

The charger should cycle *off* and *on* as the battery voltage rises and falls. The correct setting of R3 is where, with a fully-charged battery, the charger cycles very infrequently and turns off almost as soon as it turns on. The battery potential should measure 12.5 volts with no charging current. At a lower battery voltage, the charger should cycle unless the battery is so badly discharged that the full current of the charger cannot bring the voltage back up to 12.5.

Testing the sinewave generator

The sinewave generator can be tested independently. If you build it on a PC board without the 9-volt regulator, you can use a 9-volt transistor battery or an external power supply for the test. Set R20's wiper to its ground end. A scope should show a squarewave at pin 5 of IC4. With a 60-hertz sinewave driving the scope's horizontal sweep, set R27 for a frequency of 60 Hz—which will produce a rectangular Lissajous pattern. The frequency need not be exact. A slowly changing pattern is acceptable.

With the scope set for a normal 60-Hz sweep, you should observe a triangle wave at the output of IC5-b and a sinewave at the output of IC5-c. A sinewave should also be present at the output of IC5-d, varying in amplitude as R35 is adjusted. If any of those tests are negative, check for 4.5 volts DC at all input and output pins.

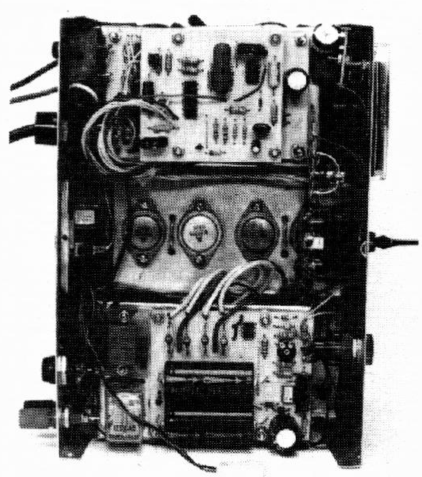
With 12.6-volts AC connected to R21, rotate R20 until the scope shows output pulses from IC5-a: The oscillator should be locked to the line frequency. Set up the scope for a Lissajous display as before and observe the output from IC5-d. It should be an oval that is nearly closed. It should be possible to adjust R20 so that the display is very nearly a sloping straight line, indicating that the output signal is in-phase with the powerline. If the AC signal is removed by unplugging the linecord, the pattern should begin a slow change to an oval that opens and closes. Readjust potentiometer R27 in order to minimize the rate of change. When the AC signal is restored, the display should quickly return to the sloping line pattern.

Testing the meter circuit

The meter circuit can be tested and calibrated by connecting the rectifier to the AC powerline. With S2 in the AC position, adjust R37 for a meter reading one-tenth that of the AC line voltage as measured independently with a calibrated meter. If there is no reading, check for about 130 volts DC across C19 to see if the rectifier is properly connected. A scope will show a large ripple component since C19 has a relatively low capacitance.

Testing the amplifier

Connect the amplifier to the 12-volt power source and the sinewave generator. Set the wiper of R35 to the end connected to the output of IC5-d, which is the setting for a zero output signal. Set S1 to the OPERATE position. Check for 12.5 volts at the emitters of Q2, Q3, Q8, Q9, Q10, and Q11. Those transistors should become slightly warm, but not hot. Check for about 11 volts at the bases of Q4, Q5, Q6, and Q7, and for about 4 volts at the emitter of Q1.



THE AMPLIFIER OUTPUT TRANSISTORS (one is under the function switch) are mounted on the top of a small chassis box that serves as the heatsink. The cooling fan is positioned on the cabinet cover directly over the transistors.

During the following procedures, use the same caution in handling the output as you would with 117-volt household power. Connect one lead of each of the 120-volt windings of T5 and T6 together, leaving the others unconnected. Connect an AC voltmeter across one of the windings and set it to a range higher than 110 volts. Slowly rotate R35 until there is a measurable output voltage. If that fails, make sure that drive to the output stages are opposite in phase. The AC voltage from the base of Q4 or Q6 to the base of Q5 or Q7 should be twice the reading to ground. If it is not, reverse the connections to the windings of either T3 or T4, not both.

Next, check that the 120-volt windings of T5 and T6 are parallel-connected in-phase. Connect the voltmeter to the leads left unconnected. If the voltage is double the previous reading, the windings are connected in series. Reverse the connection of one of the windings. If no voltage is measured, connect the other two leads together. Connect a 15-watt lamp to the output. Adjust R35 for full output. The lamp should reach full brilliance and you should measure about 125 volts.

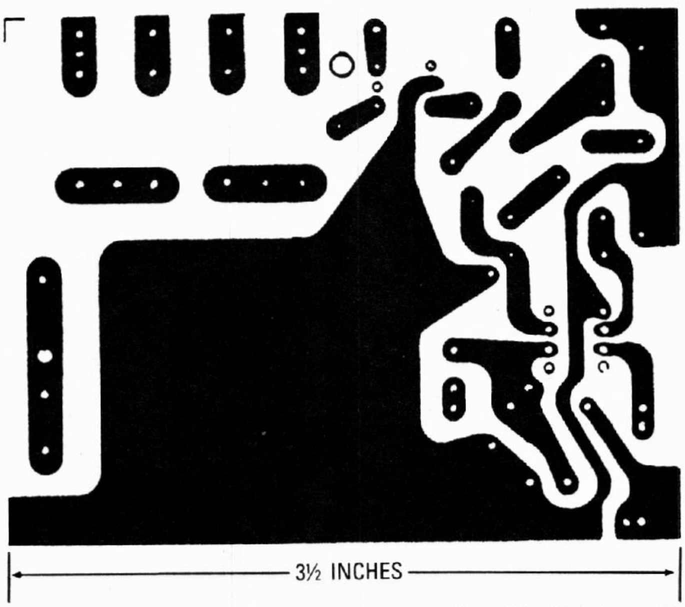
Using the UPS

In use, S1 should be set to OPERATE before the load is switched *on*. Check the AC output to be sure it is supplying at least 120 volts; the voltage will drop slightly under load. If the voltage is wavering, the oscillator is not locked in synchronization with the power line; readjust R27 and R20 after a short warm-up period. When properly adjusted, lock should occur at turn-on.

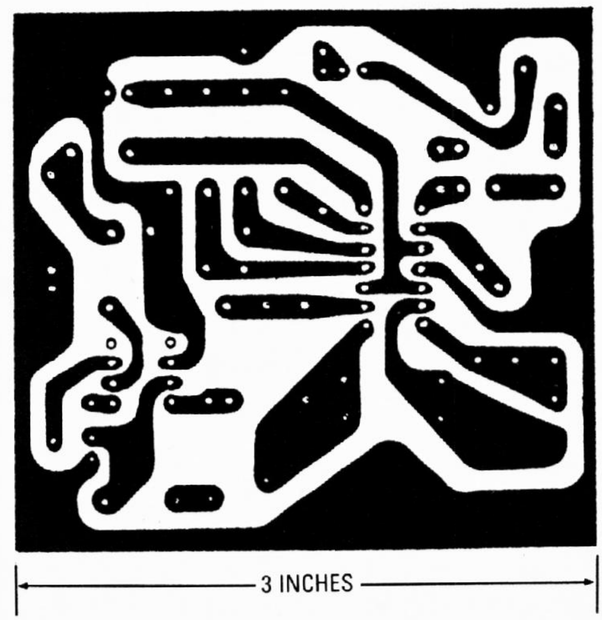
Switch the load on and recheck the voltage. It cannot be set high enough to cause harm, but it need not be set to the maximum. Some clipping will occur at the highest setting. A dip to 110 volts during operation of a discontinuous load, such as a disk drive or a printer, is acceptable.

The duration of operation during an outage will depend on the size of the battery. A motorcycle battery should allow 15 minutes of operation. **R-E**

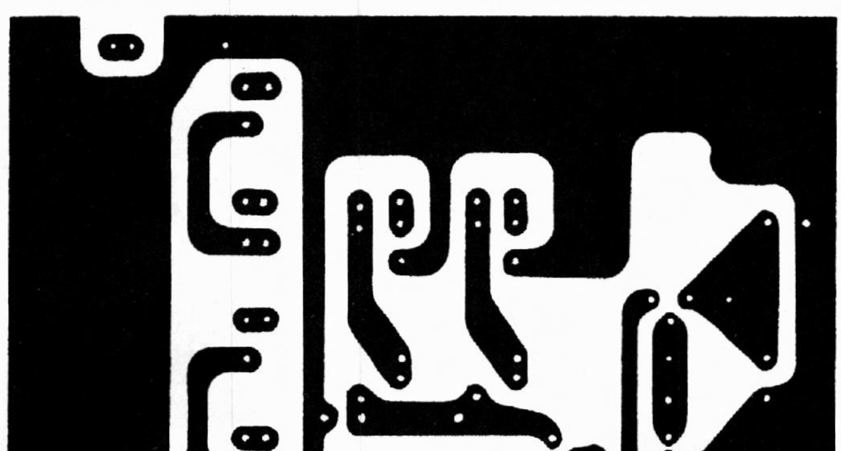
PC SERVICE



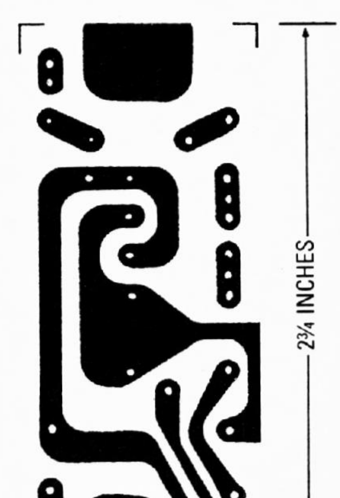
THE FOUR BOARDS on this page are used to build the Uninterruptible Power Supply. The board shown here is the power-supply board.



USE THIS BOARD to build the sine-wave generator circuit.



BUILD THE AMPLIFIER for the UPS on this board.



THE METER CIRCUIT can be built on this simple board.