ENERGY MISER

For Air Conditioners

You can cut your air-conditioning bills—while still staying comfortable—by using this device to control the cycling time of your central air-conditioning system.

BILL OWEN

MANY PEOPLE DREAD THE SUMMER months. It's not because of the heat—it's because of what happens to utility bills once the air conditioner starts running. But as we'll show you, you can keep your bills down while still staying cool. The only requirements are that you have central air conditioning and that the air conditioning uses 24-volt DC control circuits.

When we say we feel hot or cold, we are really describing how comfortable we feel—not necessarily the air temperature. That's because the human body is a poor thermometer: Along with the temperature, it responds to humidity, air movement, and fresh air. For example, we've all heard of the wind-chill factor (a formula which takes into account the effects of air movement on how cold we feel). And all of us have experienced being uncomfortably hot when it's 79°F, and muggy (humid) but quite comfortably cool when it's 78° and dry. (And we've all heard too many times—and we're bound to hear it many more times as the weather heats up—the expression "It's not the heat, it's the humidity.)

Problems with a thermostat

Air conditioning equipment is controlled by a thermostat which, unlike us, can respond *only* to changes in air temperature. If we attempt to economize by increasing the thermostat setting, we will save money. But we'll also reduce the amount of time that the compressor runs, increase humidity, reduce air movement, and allow room air to grow stale. The device that we'll describe uses the proven principal of *time cycling* to keep a comfortable effective air temperature while reducing the actual air-conditioner operating time. It cycles the air conditioner more frequently to reduce humidity, increase air movement and remove stale air. Comfort is maintained with reduced compressor operating-time, resulting in significant savings.

Another problem with a thermostat is that it can respond only to changes in temperature near its location. Because of that, it often cannot provide fine control—it permits the room temperature to vary from uncomfortably cold to uncomfortably hot with no in-between. However, with the flexible COOLING CYCLE control of the device that we'll build, the exact amount of cooling can be easily programmed.

The device that we'll build is effective (and most efficient) when used in conjunction with a ceiling fan. When used that way, you can program the air conditioner to run for minimum-length cycles (to introduce dry, fresh air as needed) but you can still stay comfortable because of the increased air movement that the ceiling fan provides.

Another application for the device is in humid areas where it is necessary to run air conditioning when you are away from home to prevent mildew and damage to furniture, carpets, drapes and artwork. The extended-cycle feature is ideal for unoccupied homes or buildings. In that setting, the "energy mizer" will cycle the air conditioner on for 5 minutes, followed by 30-minute off period. Valuable furnishings and possessions will be protected because the air conditioner will run at regular, predictable, and economical intervals, where as a thermostat may or may not operate depending upon temperature variations.

A feature normally found only in expensive energy management systems is the fan run-on timer. Normally, when the air conditioner's compressor shuts down, the fan motor stops as well. That leaves cool air trapped in the duct work and cold compressor-coils. However, the fan run-on timer of the device that we'll build lets the fan run for 90 seconds after the compressor stops—allowing the fan to pull cool air into the living space. That feature alone can help you realize significant energy savings, and thus saving you enough money so that you can recoup your investment in a very short time.

A look at the circuit

Figure 1 is the schematic of the cycling-time control circuit. Three monostable timers (IC1, IC2, and IC3) correspond to the three timed intervals. The first timer, IC1, controls the fan-on time—the amount of time that the fan runs on after the compressor shuts off. The second timer, IC2, controls the compressor-on time and the third timer, IC3, controls the compressor-off time. Let's take a look at how it works.

When power is initially applied, the R4-C1 time constant keeps the trigger input (pin 2) of IC2 (which controls the compressor-on time) low enough to ensure triggering. The output from IC2 switches high for a period of time determined by the parallel combination of capacitors C4 and C5 and series resistors R1 and R7. Depending upon the position of control R1 (the COOLING-CYCLE control), the compressor-on time will be between 5 minutes and 20 minutes.

At the end of the on cycle, IC2 pin 3 switches low, triggering IC1 (pin 2) through capacitor C9. Pin 3 of IC1 switches high for 90 seconds (as determined by C11 and R13). At the end of the 90-second fan-on period, IC1 pin 3 switches low, triggering IC3. The output of IC3 (which controls the compressor-off time) will go high for a time interval that is selected by S1. In the CYCLE 1 position, that compressor-off interval is 15 minutes, as determined by C6 and R6. In the CYCLE 2 position, the compressor-off interval is 30 minutes, as determined by C6 and the series combination of R3 and R6.

During the compressor-on interval, IC2 pin 3 is high, which turns on transistor Q1, energizing relay RY1 and the associated LED indicator. Relay RY1 completes the 24-volt control circuit for the compressor-motor contactor. Similarly, during the fan-on interval, relay RY2 and its LED indicator are energized through transistor Q2. During the compressor-off interval, IC2 pin 3 is in its low state, and LED1, the COMPRESSOR-OFF LED, is lighted.

The three timers continue in sequence (compressor on, fan on, compressor off) until power is interrupted. When power is reapplied, the compressor-on timer will begin the sequence.

We don't have to build a power supply for our cycling controller—it obtains its power from the control-voltage transformer inside the air conditioner. One side of that 24-volt AC secondary is brought out directly to the thermostat and is (usually) labeled R. (See Table 1 for some common thermostat markings.) The other side of the secondary is available indirectly through the heater contactor-coil (labeled W).

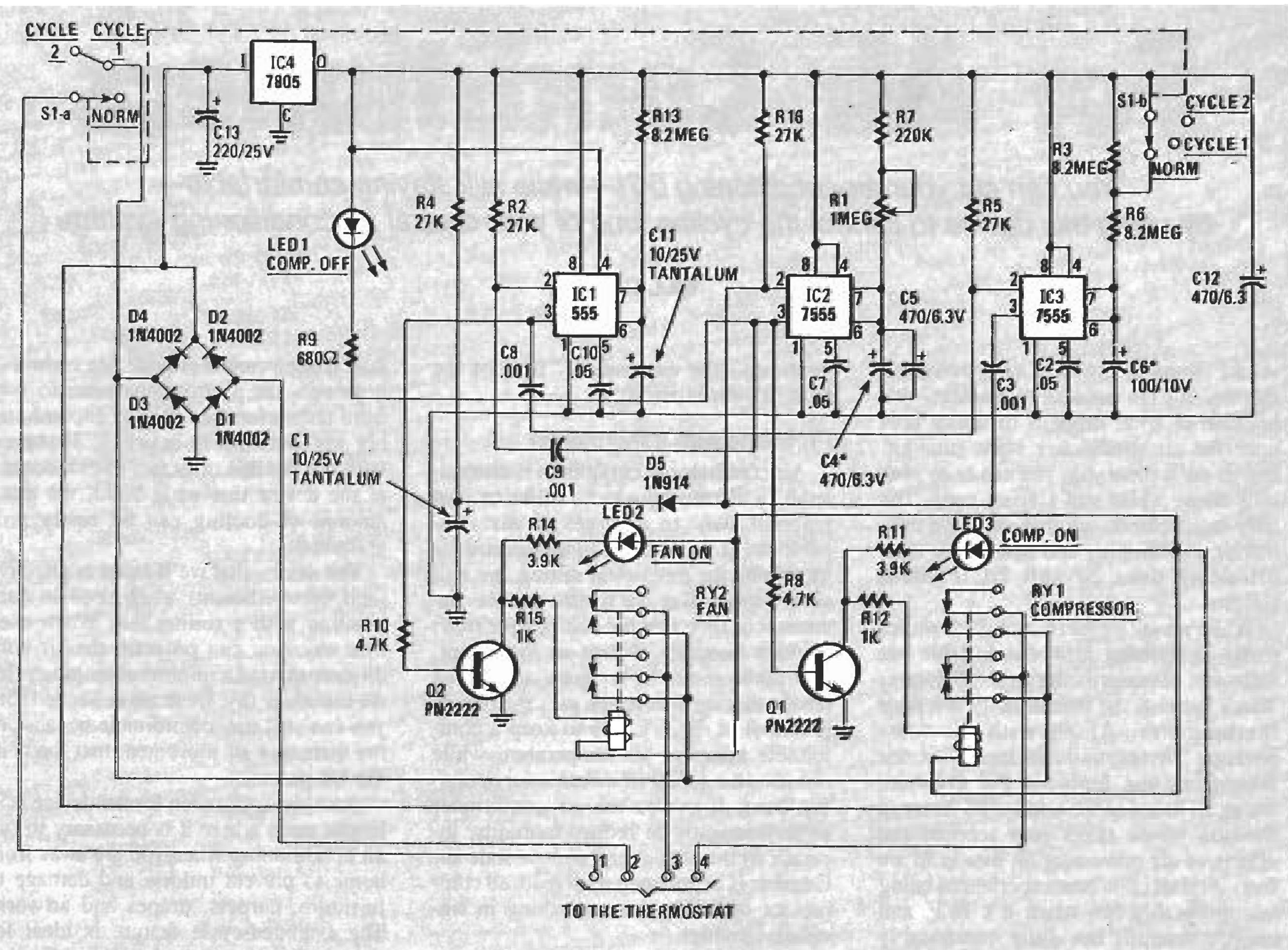

FIG. 1—THREE TIMERS ARE USED to provide compressor-on, compressor-off, and fan-on intervals. Two of the timers are 7555 types because of the long time constants required. Note that the capacitors marked with an asterisk (*) are low-leakage electrolytics.

TABLE 1—HOOKUP

Cable/Color	Possible thermostat-terminal markings				
1/Red	R5	R	RH	4	M
2/White	4	W	W	W	H
3/Green	G	G	G	G	F
4/Yellow	Y6	Y	Y	Y	C

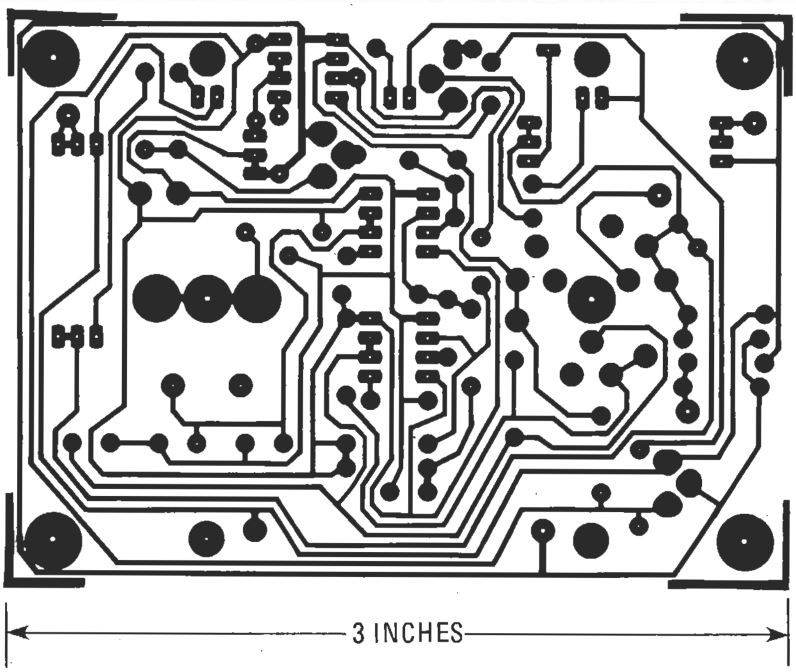

FIG. 2—FOIL PATTERN for a single-sided board is shown full size.

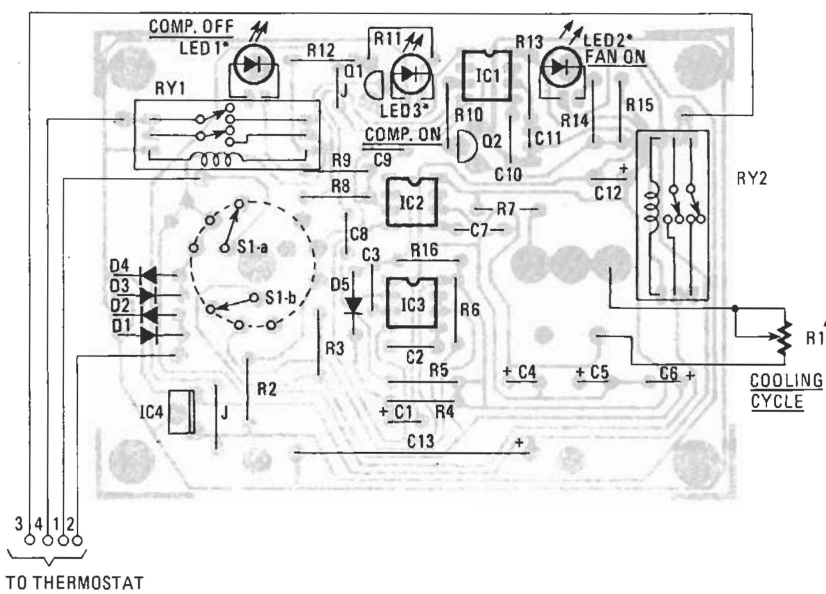

FIG. 3—PARTS-PLACEMENT diagram. The three LED's (marked by *) are mounted on the foil side of the board, as is R1, the COOLING-CYCLE control.

Since the "energy miser" will not be used during reverse-cycle or heat-cycle operation of the air conditioner, we can use a small amount of current (about 50 mA) through the heater contactor (relay) coil. (If more current were drawn through the heater contactor- coil, it might energize the contactor.) Of course, you can use a small transformer instead. Diodes D1 through D4 form a full-wave bridge rectifier. The "R" line from the thermostat is connected to the pole of S1-a (through line 1) and is applied to one bridge input through the switch. The "W" thermostat line is connected to the other bridge input through line 2. The DC output-voltage is filtered by C13 and regulated to five volts by IC4.

PARTS LIST

All resistors ¼-watt, 5% unless otherwise noted.
R1—1 megohm, potentiometer
R2,R4,R5,R16—27,000 ohms
R3,R6,R13—8.2 megohms
R7—220,000 ohms
R8,R10—4700 ohms
R9—680 ohms
R11,R14—3900 ohms
R12,R15—1000 ohms
Capacitors
C1,C11—10 μF, 25 volts, tantalum
C2,C7,C10—.05 μF, ceramic disc
C3,C8,C9—.001 μF, ceramic disc
C4,C5,C12—470 μF, 6.3 volts, low-leakage electrolytic
C6—100 μF, 10 volts, low-leakage electrolytic
C13—220 μF, 25 volts, electrolytic
Semiconductors
IC1—555 timer
IC2,IC3—7555 timer (CMOS version of 555)
IC4—7805 5-volt regulator
D1–D4—1N4002
D5—1N914 or 1N4148
Q1,Q2—PN2222
RY1,RY2—reed-type relay
S1—PC-mount, 3P3T
LED1–LED3—miniature red LED's
Miscellaneous—PC board, cabinet, knobs, machine screws, hookup wire, IC sockets, etc.
The following is available from NRG Electronics, P.O. Box 24138, Ft. Lauderdale, FL 33307; drilled and etched PC board, $9.95; complete kit, $29.95; wired and tested unit, $49.95. Include $1.50 to cover postage and handling and $2.00 for C.O.D. orders.

Assembly

You can easily build this energy-saving device by using a printed circuit board. A PC board isn't essential—point-to-point wiring can be used—but a board is recommended, if only for its neatness and ease of troubleshooting. A suitable foil pattern is shown in Fig. 2. To assemble the project, simply follow the parts-placement diagram of Fig. 3. However, if you plan to mount the board in a cabinet (and that's surely recommended), you should prepare the cabinet before you start soldering. You'll want to mark the locations of R1, S1, and the three LED's on the front panel. Then drill the front panel at those points to fit your components.

Make sure to use good quality rosin-core solder and a fine-tipped pencil-type soldering iron. Place and solder the resistors and diodes first followed by the IC sockets, capacitors and transistors. Be sure to observe polarity with the dipped tantalum and electrolytic capacitors, the transistors, and the diodes. Place and solder potentiometer R1 on the foil side of the PC board. Mount switch S1 on the component side of the PC board and solder. (Figure 4 shows the component side of the

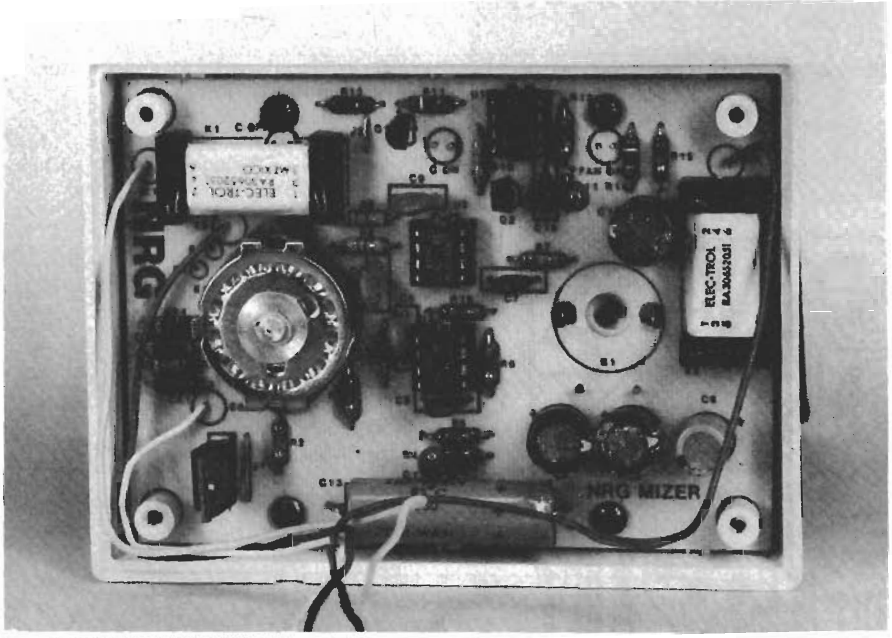

FIG. 4—COMPONENT SIDE. Although the unit is small (about 3×4 inches), the components aren't densly packed.

FIG. 5—USING A PLASTIC case for the project allows you to simply use double stick foam tape to mount it to the wall.

completely assembled PC board.) Next install the three LED's on the foil side of the PC board. Note that the LED's must be polarized correctly. Temporarily fit the PC assembly into the cabinet top and push the LED's into the holes in the cabinet. Clinch the LED leads and carefully remove the PC assembly from the cabinet and—without changing their adjustment—solder the LED leads to the foil. Relays can now be placed at RY1 and RY2 and soldered.

Use excess component leads as wire jumpers and solder at the locations marked "J" on the parts-placement diagram. Finally, install the four wires that you'll use to hook up the device to your thermostat. The leads should be color-coded: The leads marked 1, 2, 3, and 4 on the schematic and parts-placement diagram should be red, white, green, and yellow respectively.

Before installing the unit, it's a good idea to check its operation. Let's now see how to go about doing that:

With controls R1 and S1 set at MIN and NORMAL, connect the red and white wires to an 18-24 volt AC or DC source. (If none is available, two 9-volt transistor radio batteries in series will suffice.) Switch to CYCLE 1 and note that the COMPRESSOR-ON lamp will light.

The proper LED-lighting sequence will start with COMPRESSOR ON, which will stay lit for between 5 and twenty minutes (depending on the setting of the COOLING-CYCLE control) That will be followed by the lighting of the FAN-ON LED for 2 minutes while at the same time "COMPRESSOR OFF" is lit for 15 minutes (in CYCLE 1) or 30 minutes (in CYCLE 2). After IC3 times out, the cycle will begin again when IC2 is triggered again. Remember that those times are approximate and will vary from unit to unit.

If that test shows that something is wrong, you can troubleshoot the unit by "manually triggering" its operating modes. Remove the integrated circuits and, with power applied, make the following jumps using fine gauge wire in the IC sockets. Jumpering IC2 pin 3 to IC2 pin 1, you can test the compressor-off operation and by jumpering IC2 pin 3 to IC2 pin 4, you can test compressor-on operation. To test fan-on operation, jumper IC1 pin 3 to IC1 pin 4.

Installation

During installation, **remove power to the air conditioner at the circuit-breaker panel**. Install the device next to the thermostat. Double-stick foam tape will easily hold the unit on a wall as shown in Fig. 5. Remove the thermostat cover to expose the wire terminals on or behind the wall mounting plate. Cut the wires from the unit to a convenient length and make the connections to the thermostat indicated in Table 1. (It may be necessary to trim some plastic from the thermostat cover or base to allow for wire passage. Switch the "energy mizer" to NORMAL and restore power to the air conditioner. Set the air conditioner to "cool," and the fan to "auto" and set the thermostat high enough so that it does not come on. Set the "energy mizer" to MIN and CYCLE 1. When that's done, the air conditioner should come on and the COMPRESSOR-ON LED should light.

Tips

The thermostat acts as a high limit and will override the device if the room temperature rises above the set temperature. When using the heat cycle, switch the "energy mizer" to NORMAL.

The CYCLE 2 mode provides an extended-off period (about 30 minutes) that is useful for unattended dwellings for humidity control. If the unit is set to MIN and CYCLE 2, the air conditioner compressor will run for 5 minutes followed by a 30 minute off period.

The most economical operation is achieved by setting the fan on auto rather than continuously on. The fan-on timer will keep the fan running for about two minutes after the compressor stops to purge cool air from the duct work and compressor coils. **R-E**