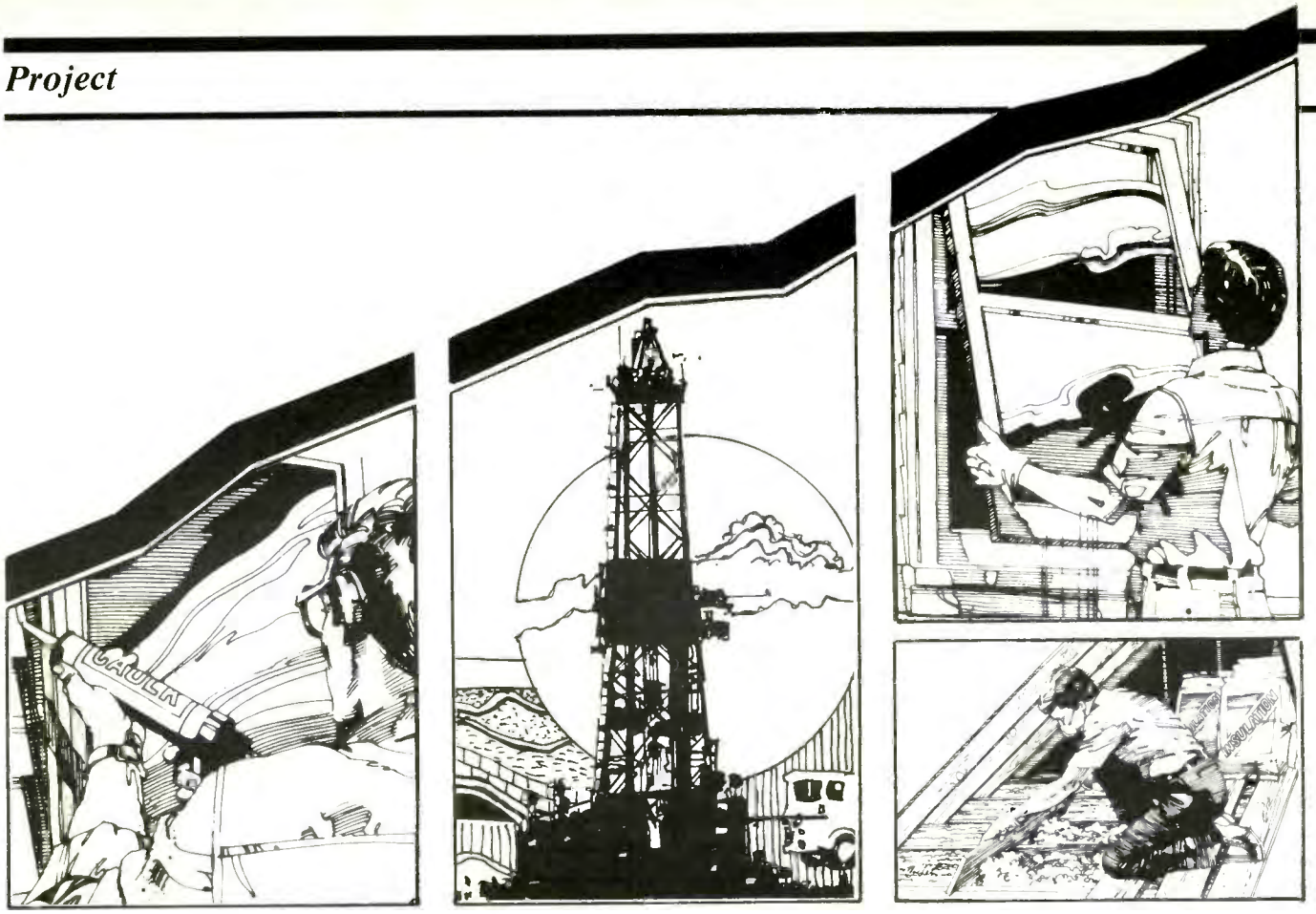


Heating Costs Too High? Try A Fuel Miser

It's easy to build, simple to install and suitable for use on either gas or oil heating systems

By Anthony J. Caristi

If you're like most of us, you've seen your home heating bills go up and up year after year, apparently with no end in sight. But there is something you can do right now to reduce your heating costs dramatically, and that's to enhance the efficiency of your present heating system.

How? By adding to it an electronic cycling device that I call a fuel miser, a remarkable little gadget that will automatically regulate your furnace with ruthless, digital precision, yet keep you just as warm and cozy as you've always been. It's also easy to build, simple to install and suitable for use on either gas or oil heating systems.

Sound too good to be true? Not at all. Let me explain.

A typical furnace, you see, operates only in an "off" or "full speed ahead" state. So when the thermostat calls for heat, your furnace instantly, automatically cranks itself up to 100 percent of capacity. It responds as if the weather outside is as cold as it's ever going to be, a figure generally set at about −10F, for much of the country.

Some of this "full speed ahead" operation is tempered by a feature called heat anticipation, which is built into your thermostat and causes the furnace to shut off shortly before the thermostat registers your desired temperature. That helps some; the fuel miser helps more.

The real problem here, it turns out, is your furnace's heat exchanger. No matter how much heat your furnace generates, no matter how long it gen-

erates it, your heat exchanger can transfer just so many BTUs of heat energy into your hot water, steam or warm air system in a given amount of time. After the heat exchanger has reached a certain temperature level, any further burner operation simply results in more heat loss up the chimney. Enter the fuel miser.

It enables you to select a "duty cycle" for your burner that can range from 10 percent to 100 percent of capacity, selectable in increments of 10 percent—nothing more. But once set, it will allow the thermostat circuit of your heating system to operate normally only for the duty cycle you have selected.

The rest of the time, your thermostat will be prevented from turning on your burner. However, residual heat from the heat exchanger will continue to flow into your heating system. The on-off cycle of the fuel miser is so fast, in fact, that the heat exchanger will always have sufficient heat, just as it would with a full-speed, lower-efficiency, non-controlled furnace.

Gas-operated furnaces respond especially well to relatively short bursts of demand. The fuel miser has thus been designed so that each 10 percent increment of heating time here is 45 seconds, with a complete cycle taking 450 seconds, or 7½ minutes.

Oil furnaces are more restrictive in their cycling requirements; each system must be permitted a short cooling period each time the burner turns off. For oil systems then, the timing cycle of the fuel miser is set at 3 minutes for each 10 percent increment of duty cycle. The total time for one complete cycle for an oil burner system is therefore 30 minutes.

The selection of either of these timing cycles is accomplished merely by connecting one jumper wire in the fuel miser's circuit board.

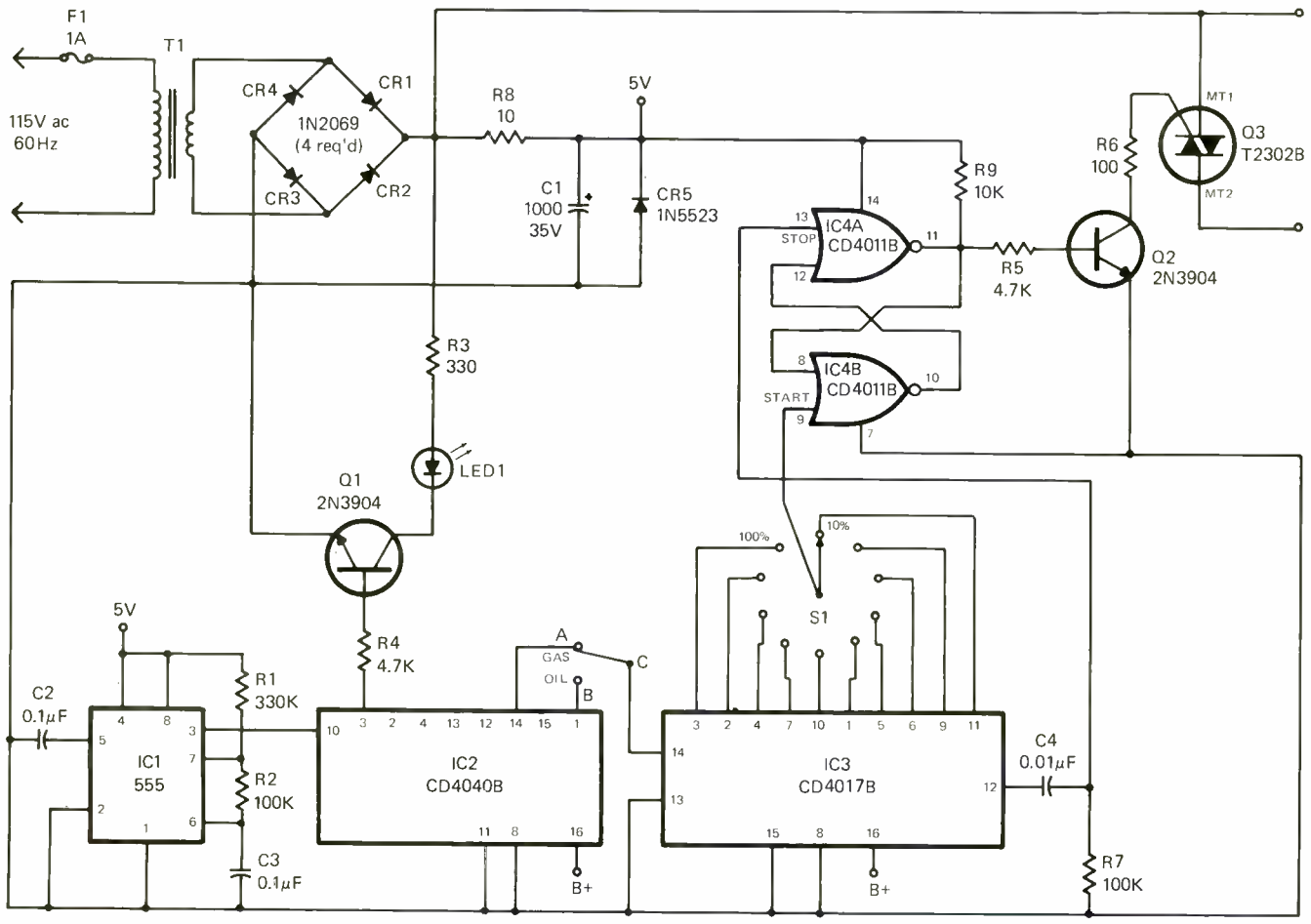
How It Works

As you can see from the schematic diagram and the timing chart shown in Figs. 1 and 2, the fuel miser is simply a clock dedicated to performing a specific task.

IC1, a 555 timer chip, operates as an astable multivibrator at a frequency of about 22.7 Hertz. This frequency is divided by IC2, a 12-stage binary divider, to provide a frequency of 0.022 Hertz for gas systems or 0.006 Hertz for oil systems. These frequencies represent periods of 45 seconds and 160 seconds (each period is the reciprocal of its frequency).

The selected output of IC2 feeds a

Fig. 1. Schematic diagram shows that Fuel Miser is simply a clock performing a specific task.



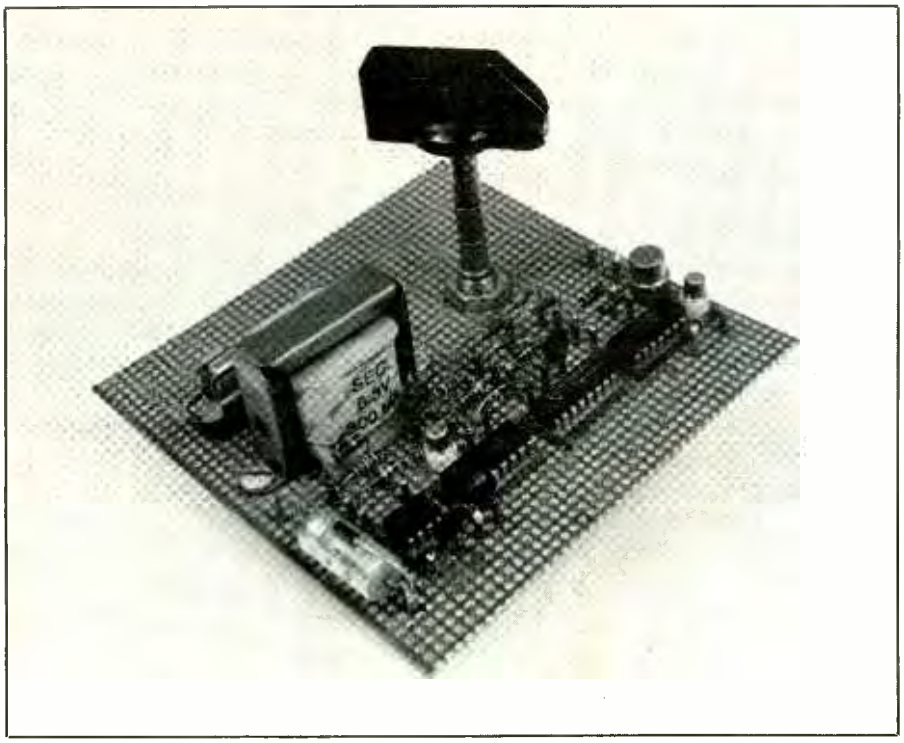


Photo of author's prototype shows project assembled on perforated board. Note the use of sockets for all ICs and transistors. All wiring is performed on under side of board. A homemade pc board can also be used.

decade Johnson counter, IC3, which counts from zero to nine over and over again. IC3 has 10 decoded outputs, one for each count, and a divide-by-10 output, pin 12, as illustrated in the timing diagram. One of the decoded outputs of IC3 is selected by the duty cycle switch and is used to trigger a latch circuit, IC4A and IC4B.

At this point the thermostat circuit of your furnace would be enabled. The divide-by-10 of IC3 is differentiated and used to reset the latch circuit. This disables the thermostat circuit.

If the output pulse of pin 4 of IC3, for example, is selected to start the sequence, the output pulse at pin 12 will stop the sequence eight decoded pulses later. Thus, the latch circuit output, pin 11 of IC4, will have a logic 1 level 80 percent of the time and a logic zero level 20 percent of the time.

This logic signal is fed to Q1, which acts as a switch to turn Triac Q2 on and off. Q2 is the controlling switch that permits your thermostat to operate or not operate in accordance with the duty cycle selected by S1. Q2 has a sufficient voltage rating and current-carrying capacity to handle both 24-volt and 115-volt thermostat circuits.

Construction

The fuel miser can be constructed on a printed or wiring circuit board measuring about 3½ by 5 inches. A printed circuit layout is illustrated full size in Fig. 3, as viewed from the copper side of the board. The parts layout, as seen from the component side of the board, is shown in Fig. 4.

The layout of this circuit is not at all critical. It would be good practice, though, to use sockets for the integrated circuits and Triac instead of soldering these components directly into the circuit, especially if the PC pattern is used. Such practice makes servicing the fule miser easy, if it's ever necessary.

It's also important to pay strict attention to the orientation of the integrated circuit chips. Pin 1 of these components is usually indicated on the top of the plastic package by a small dot or numeral 1. In Figs. 3 and 4, pin 1 of each chip is identified by a small dot.

When you have finished constructing the circuit, examine it very carefully to be sure that there are no solder splashes that might short out one copper path to another, or two adjacent IC pins. Check also the position of each diode to make sure it's placed in the circuit as shown in Fig. 4.

There is one jumper wire that must be placed in the circuit for the appropriate type of heating system that the fuel miser will control. For gas systems, connect the jumper wire between points A and B as shown in Fig.

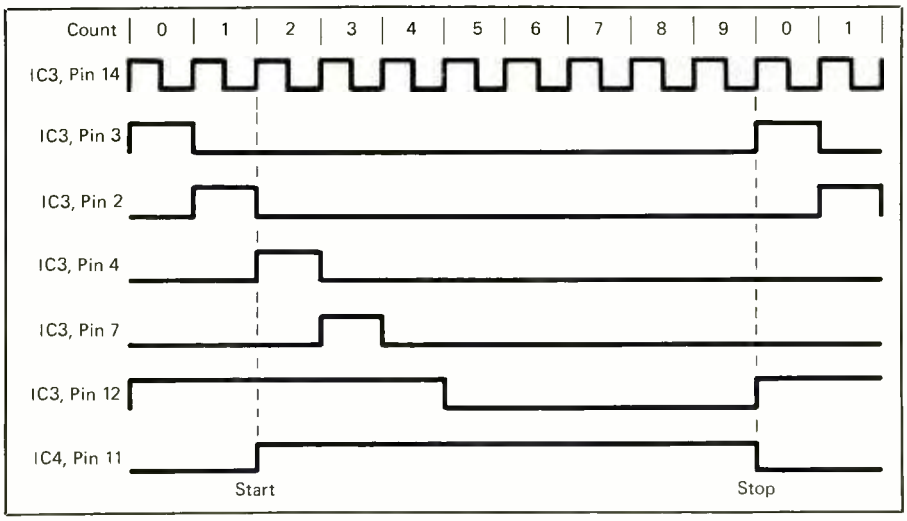


Fig. 2. Timing diagram for Fuel Miser.

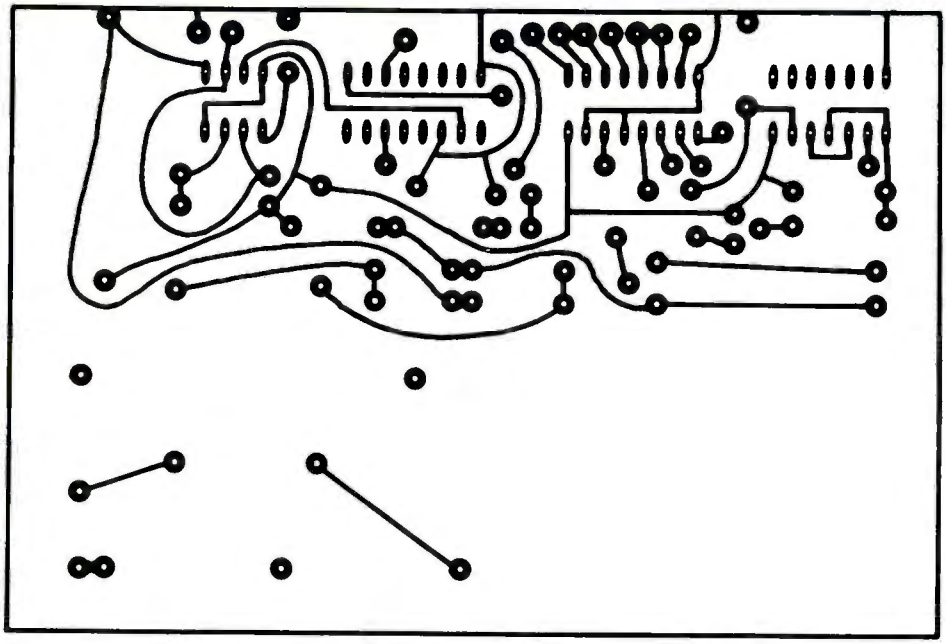


Fig. 3. Actual-size etching-and-drilling guide for Fuel Miser pc board.

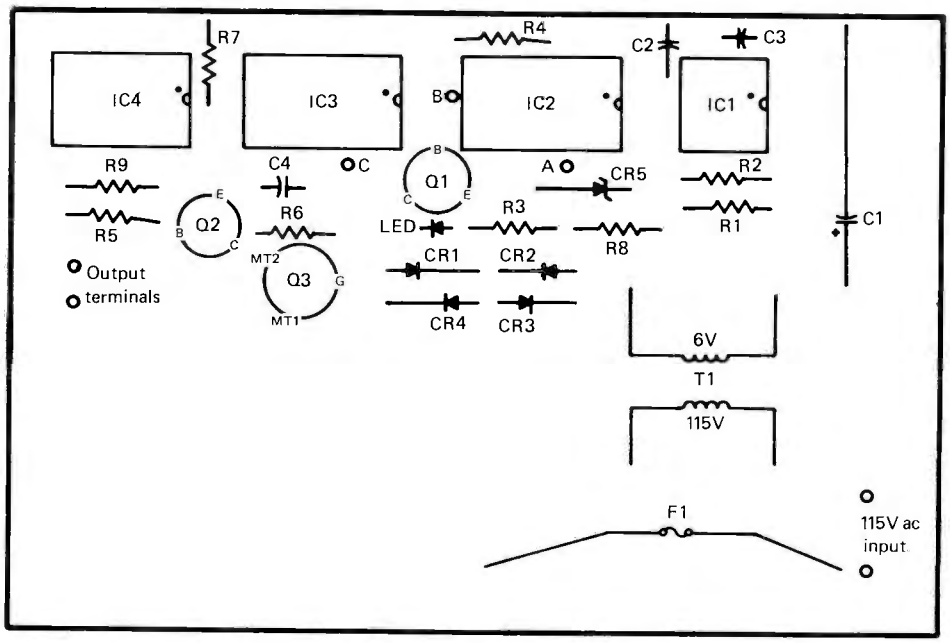


Fig. 4. Component installation guide for pc board shown above.

4. For oil burner systems, connect the jumper between points A and C. Be sure to use only one jumper wire in your circuit.

For ease of assembly into a cabinet, you may mount the duty cycle selector switch directly on the circuit board and wire it into the circuit. This will enable you to mount the board to the front of the cabinet with the switch shaft protruding through a hole drilled for that purpose. Use spacers to mount the circuit board.

Note that you may want to mount the LED on the panel of the cabinet so you can view it during operation to make sure it's working properly. After your assembly is complete, you will then want to label the switch positions, from 10 percent to 100 percent in increments of 10 percent each.

Before you connect the fuel miser into your furnace circuit, turn it on by applying 115 V of a.c. power to the transformer primary. The LED should flash about once a second. If it does, your fuel miser is probably wired correctly.

If you do not get the flashing signal from the LED, disconnect the electrical power and examine the circuit for bad solder connections or short circuits between adjacent pins on the IC chips. Also check the diodes, transistors and IC's to be sure that they are not placed backwards in the circuit. You will have to substitute new IC chips for those already in the circuit if one or more of these chips is defective.

Installation

Once completed, the fuel miser can be installed anywhere near your furnace or your thermostat. Turn off all electrical power to the furnace and the fuel miser before making the installation. For all heating systems that operate with a two-wire thermostat, all you need do to connect the fuel miser is to open one of the thermostat connections and connect the output terminals of the fuel miser in series with the thermostat. This is illustrated in Fig. 5.

In some oil burner systems, three-wire thermostats are used. These thermostats have two sets of contacts that close at slightly different temperatures and are designed so that the burner starts only when both contacts are closed.

In these systems, the thermostat is usually wired to a relay whose contacts operate the oil burner motor. This means that the fuel miser's output terminals must be connected in series with the relay coil. This is shown in Fig. 6, which illustrates a typical three-wire oil burner.

After you have made the necessary connections, whatever your system, apply power to both the fuel miser and your furnace. Set the fuel miser's switch to the 100 percent position,

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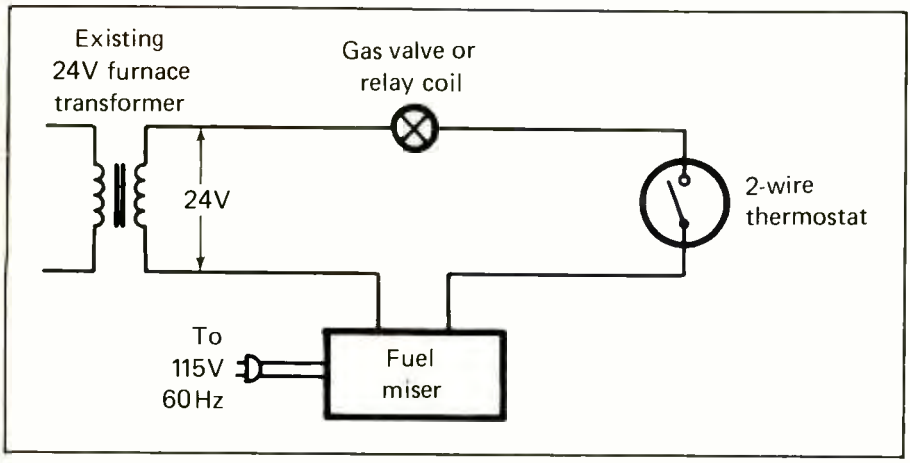

Fig. 5. Installation details for two-wire thermostat heating system.

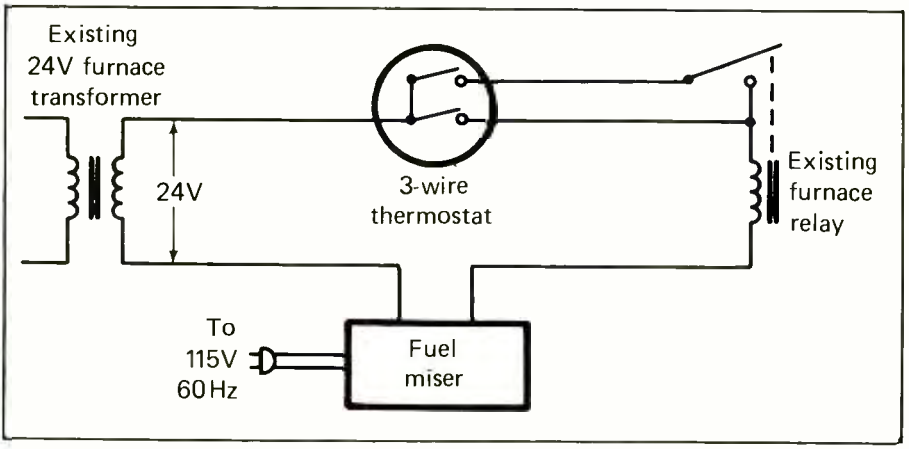

Fig. 6. Installation details for three-wire thermostat heating system.

PARTS LIST

C1—1000-μF 35-V electrolytic capacitor
C2,C3—0.1-μF ceramic capacitor
C4—0.01 μF ceramic capacitor
CR1 thru CR4 silicon diode, 1N2069 or similar.
CR5—5.1-V zene diode, 1N4733 or similar
F1—1-A fuse
IC1—555 timer
IC2—CD4040B 12-stage binary counter
IC3—CD4017B Johnson counter
IC4—CD4011B Quad 2-input, NOR gate
LED1—Light-emitting diode
Q1,Q2—2N3904 transistor or similar
Q3—T2302B triac (RCA or similar)
S1—Rotary switch, 10-position 1 pole
T1—6-V transformer
All resistors ¼-W, 10%
R1—330 ohms
R2,R7—100k
R3—330 ohms
R4,R5—4.7k
R6—100 ohms
R8—10 ohms
R9—10k

Note: The following parts are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: pc board, $4.75; triac T2302B, $3.75; CD 4040B, $3.75. Please include 50 cents for postage.

and check your furnace for normal operation when heat is called for.

Next, set the fuel miser's switch to the 10 percent position. Now set your thermostat to its highest setting and time the cycle of burner operation.

For gas systems the burner should operate about 45 seconds and be off for about 7 minutes. For oil systems, the burner should operate about 3 and be off for about 27 minutes.

When you've checked out your fuel miser, it's time, of course, to set it into operation. It is suggested that you start with a setting of 70 percent for a day or two. With some experimenting, you will quickly settle on a duty cycle that provides you with sufficient comfort while substantially reducing your heating bill.

You will probably find that during severe winter weather, your preferred setting will normally approach the higher end of your new heating scale. During milder weather, though, you'll probably find you can take full advantage of the lower settings—and lower costs. ME