BUILD A "HOME-BREW" TEMPERATURE CONTROLLER

DAVID W. BOERTJES

One of the secrets of successful home brewing of wines and beers is a constant temperature. Our temperature-controlled heater will keep the temperature of your brews precise and even!

Home brewing can be a very rewarding hobby. Not only is it less expensive to brew wine and beer at home, but depending on how much time and effort one puts into each batch, beverages of excellent quality can be produced.

All home brewers have their own secrets to success, which they may not be willing to share. Two details that most budding brewers tend to overlook have to do with temperature and light. The bacteria responsible for the fermenting process work best at temperatures between 68° and 75°F. Although it is a matter of opinion as to what exact temperature is best, most brewers agree that once a temperature is chosen it should remain constant.

The effect of light on fermentation has been debated among brewers for the longest time. It is the author's opinion that it is best to brew in the dark—especially for wine. The obvious location for brewing under those conditions is a dark basement.

Unfortunately, most basements are also too cold for effective fermentation. Some form of controlled heater would then be needed. One method that has been tried is a small cabinet just large enough to hold the carboy (the 6-gallon glass jug used for brewing), a household thermostat, and a 60-watt light bulb. The thermostat controls the light, which heats the inside of the cabinet. Unfortunately, there are a couple of drawbacks to this. For one, the bulb gives off light. You could wrap the bulb in aluminum foil to cut down on the light, but that would decrease the bulb's life. Even more of a concern is the fact that a household thermostat usually has a "swing" of several degrees—perfectly fine for a comfortable home, but not nearly accurate enough for proper brewing.

The solution to those dilemmas is the Home-Brew Temperature Controller presented here. This project is relatively easy and inexpensive to build. The parts can be purchased for about $70 if you don't have anything on hand already. The electronics are simple enough that the circuit can be constructed on perfboard.

Designing a Heater. While the circuitry for a heater with temperature feedback might seem to be an almost trivial matter, there are several finer points to keep in mind when devising such a circuit. The set point should be adjustable over a temperature range of 68°–75°F. The maintained temperature should be within 1 or 2 degrees of the set point so that the system does not "chatter" from rapid switching of the heater's power supply. Whatever switching method is chosen should be flexible enough to control different types of loads such as fans or lights. Choosing low-cost and readily-available components will help

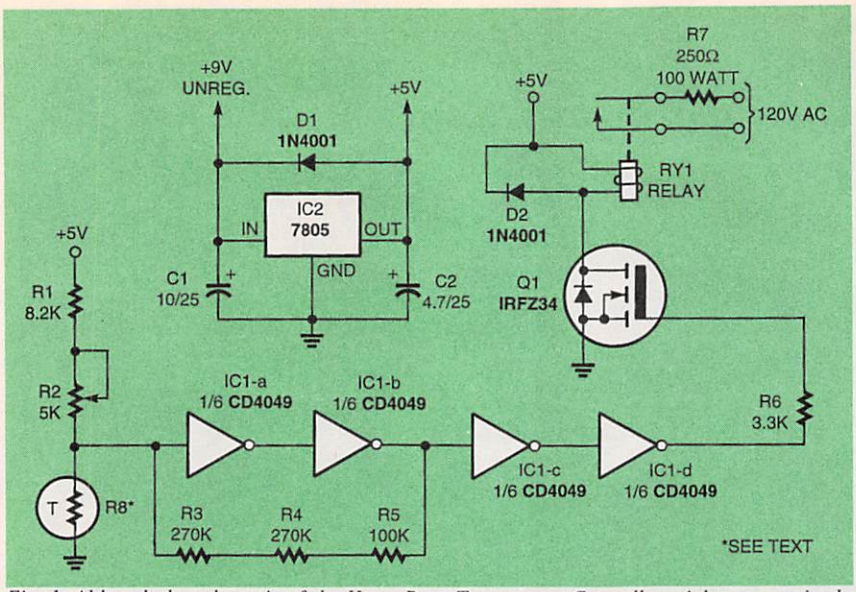

Fig. 1. Although the schematic of the Home-Brew Temperature Controller might appear simple, some sophisticted design work can be seen in the temperature-sensing portion of the circuit. For safety considerations, the "hot" side of the supply line for the heater should be connected to RY1 and the neutral is connected to R7.

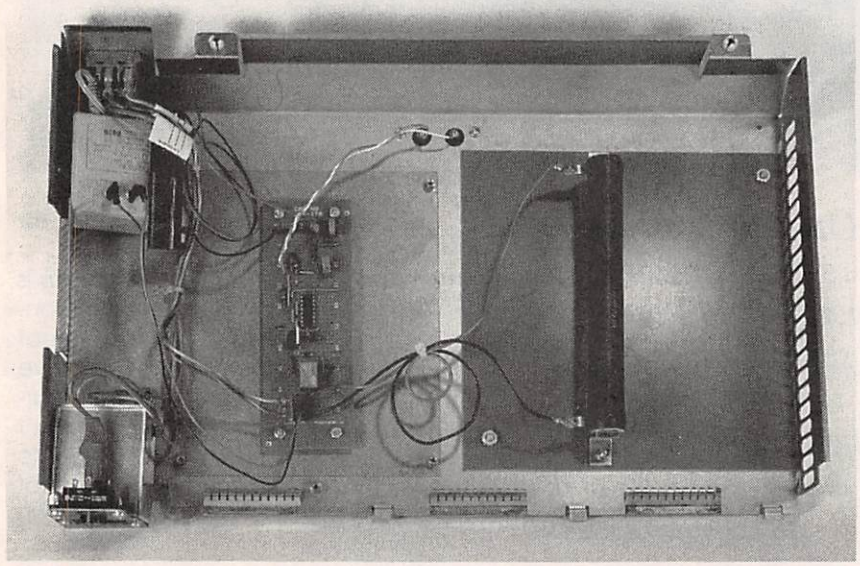

Fig. 2. Here is an inside view of the author's Home-Brew Temperature Controller. Note the use of a fiberglass PC board to insulate the large heating resistor from the metal case. The heating resistor has also been placed near some ventilation holes and is located as far away from the rest of the circuit as possible.

keep expenses to a reasonable level.

For the accuracy needed in this project, a thermistor will be used to sense temperature. That device is inexpensive and small, and different units can be selected depending on the temperature range needed. The one we will be using has a negative thermal coefficient. That means that as the temperature increases, the thermistor's resistance will decrease. The thermistor's resistances at some of the temperatures that we are interested in are listed in Table 1.

The thermistor will be used in a resistor network so that the temperature of the thermistor will generate a variable voltage. To provide the "hysteresis" so that the circuit does not chatter, we'll put an additional resistance in parallel with the thermistor's resistor network. That parallel resistor will be switched so that it is either electrically across the thermistor or across the adjustable set resistor. When placed across the thermistor, the apparent temperature of the thermistor will be higher because of Ohm's Law of resistors in parallel. When placed in parallel with the set-point resistor, the apparent setting will be changed in a similar fashion. The values for the resistors will be chosen so that the circuit will switch off when the temperature is 1°F above the set point and switch on when the temperature drops to 1°F below the set point.

With a digital signal that switches when additional head is called for, the rest of the circuit is simply a relay that turns a heating element on and off as needed.

Circuit Description. The schematic of the Home-Brew Temperature Controller is shown in Fig. 1. The temperature-sensing thermistor is R8, with R2 being the adjustment for the temperature-set point. The values for the combination of R1 and R2 let the set point be adjusted between 8200 ohms and 13,200 ohms—covering the temperature range in which we are interested. Resistors R3, R4, and R5 make up the hysteresis resistance that will be switched between R8 and R2. The 640,000-ohm value of the hysteresis resistors will change the apparent temperature being sensed by the circuit by 1°F. An unusual design point is the use of a CMOS inverter gate in its linear mode. The gate chosen for IC1 switches between its logic-low and logic-high outputs when the input voltage is *exactly* one-half of the device's supply voltage. The outputs can also be very close to the actual supply-voltage values.

The output of IC1-d drives Q1 so that enough current can be supplied to RY1. When the relay switches on, line current is supplied to R7, a 100-watt power resistor, which acts as the heating element. Power for the circuit is supplied by IC2, a 5-volt regulator.

Building the Heater. There are many options when building any circuit, even a relatively simple project such as the Home-Brew Temperature Controller. However, a few cautions are in order. Care must always be taken when using 120 volts AC in any project. With the Home-Brew Temperature Controller,

PARTS LIST FOR THE HOME-BREW TEMPERATURE CONTROLLER

SEMICONDUCTORS

IC1—CD4049 Hex CMOS inverter, integrated circuit
IC2—7805 5-volt regulator, integrated circuit
D1, D2—1N4001, silicon diode
Q1—IRFZ34, MOSFET transistor

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—8200-ohm
R2—5000-ohm, potentiometer
R3, R4—270,000-ohm
R5—100,000-ohm
R6—3300-ohm
R7—250-ohm, 100-watt
R8—Thermistor, 10,000-ohm@25° C (RadioShack 271-110 or similar)

CAPACITORS

C1—10-µF, 25-WVDC, electrolytic
C2—4.7-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

RY1—Single-pole, double-throw relay, 5-volt
9-volt DC wall adapter, case, line cord, brackets for R7, wire, hardware, etc.

however, there is also an element that will become hot. Take some extra time to think about the placement of the heating resistor within the chassis. Any plastic part or wire insulation that gets too close to the heating resistor could melt. Also make sure that all of the high-voltage connections are isolated in a safe manner. It is also a good idea that the unit's metal chassis be grounded and that a 1-amp fuse be wired into the power line.

An example of the author's arrangement is shown in Fig. 2. A ventilated metal chassis that measures 17 inches by 11 inches by 3 inches houses the circuit. Heating resistor R7 is located on one side of the cabinet, with the rest of the circuitry located on the other side. The resistor is also mounted on a sheet of single-sided PC board material. The board's fiberglass is a good insulator for both electricity and heat. The heat insulation helps prevent the top of the case from getting too hot and becoming a burn hazard. It can be seen that R7 is also mounted with brackets that let air circulate all around the resistor.

The temperature-set resistor, R2, is a PC-mounted trimpot. However, it can also be a panel-mounted potentiometer on the outside of the case. With that arrangement, adjusting the temperature becomes much easier. Unfortunately, accidentally bumping the control can just as easily change the temperature setting, so some type of protection or "lock-out" method would be needed.

Electrical power for the circuit is provided by a 9-volt, 500-mA wall adapter that has been tucked into one corner of the case. Using a surplus adapter can be less expensive in terms of cost and construction time over using a standard transformer, bridge rectifier, and filter capacitor.

The thermistor probe is best made by soldering a pair of twisted wires onto the device and shielding the connections and thermistor leads with two pieces of heat-shrink tubing. A suitable connector on the other end of the wires should mate with a jack mounted on the case. One way to do that is to use spade lugs on the probe wires and a dual-screw terminal on the case

To set up the Home-Brew Temperature Controller, fill a carboy with water and place an accurate thermometer in it. Set the carboy on the heater in a room where the temperature is always lower than the temperatures you will be needing—an unheated basement will do. Turn on the heater. Over a period of several days, the water will stabilize at a particular temperature. Small changes in the setting of R2 will change the temperature that the heater will maintain. If you used a panel-mounted potentiometer for R2, you could mark the settings for various temperatures. Once you have set R2 for a particular temperature you'd like to brew at, you're ready to mix your first batch of temperature-controlled brew.

With the addition of the Home-Brew Temperature Controller, the quality and consistency of your batches might improve. It will also give you a warm feeling to know that the heater is faithfully doing its job! Ω

TABLE 1

Temperature	Thermistor Resistance
68°F	12,100 ohms
69°F	11,900 ohms
70°F	11,600 ohms
71°F	11,400 ohms
72°F	11,200 ohms
73°F	10,900 ohms
74°F	10,700 ohms