Feedstock Processing Controller

User Manual

Release 1.1

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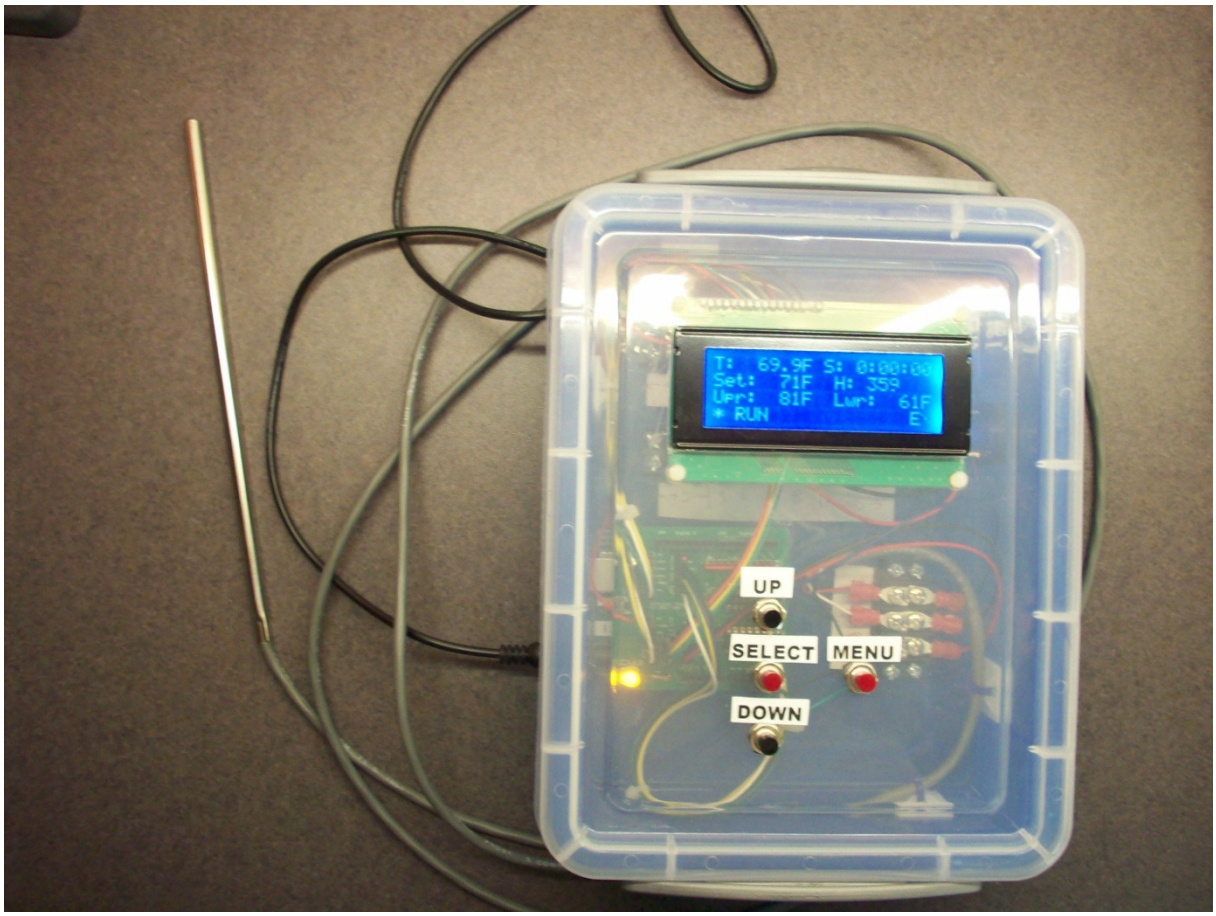

Instructions for use and operation of a controller for feedstock processing.

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- Open Source Controller hardware, including the box design, Test Board, and the Shield Board.
- Open Source Controller software, including Controller Test Software, all libraries and the Arduino development environment software.
- Open Source Controller documentation, including the instruction manual, "read_me" files, box cover template, and parts list.
- Feedstock Processing Controller hardware, software and documentation, including this manual.

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1 Introduction.

The Feedstock Processing Controller (Controller) uses the hardware, libraries and construction/test documentation from the Open Source Controller, by Bob Glicksman and Curbie. Software has been written to utilize this Controller to support feedstock processing experimentation and operations.

The Controller monitors a process' temperature and includes a countdown "stop watch" timer. The basic processing functions supported, then, are temperature and time monitoring. The Controller is intended for use in feedstock processing experimentation where a batch of feedstock, with enzymes and other chemical agents added, must be "cooked", i.e. held within a specific temperature range, for some pre-specified period of time.

The Controller removes the burden of the user monitoring temperature and time in critical processing steps. The user sets upper and lower alarm limits on temperature and the Controller will monitor the temperature continuously and alarm the user if the temperature goes above or below the user specified limits. Additionally, the Controller can act as a thermostat to turn a heat source on and off to maintain a user-preset temperature automatically while accumulating the time that the heater is on as an aide in determining cooking energy.

The Controller monitors process temperature via a temperature probe. The probe may be of any design that uses a Maxim/Dallas Semiconductor DS18B20 temperature sensor chip. A stainless steel temperature probe from Brewers Hardware (http://www.brewershardware.com/BrewTroller-Straight-Mount-Sensors/) is recommended, but not mandatory.

The Controller removes the burden of the user monitoring the time of a process step via an internal countdown "stop watch" timer. The time is set by the user for each process step and when the Controller is placed into RUN mode, the timer counts down and alerts the user when the time has expired via an audible beeping sequence. The Controller does not use time to enable or disable automatic thermostat heater control, as feedstock processing steps often require that the heat be maintained between process steps.

The Controller uses the Open Source Controller's front panel LCD display and 4 pushbuttons to monitor the process temperature and time and to allow the user to set up the temperature and time limits and other Controller functions (e.g. enable or disable the heater control). The Controller software contains several features to allow rapid setting of the most important Controller values, "short circuit" setup of values that need not be changed, and protect the user from forgetting to move the Controller to the RUN mode after setting some process monitoring and control values. The Controller display and the user setting modes and operation are explained in the sections that follow. Appendix A contains information about connecting the Controller to automatically control a heat source for the process (an optional feature).

2 Connecting the Temperature Probe to the Controller.

The Controller requires a temperature probe in order to monitor process temperature. The Controller supports any temperature probe that uses the Maxim/Dallas Semiconductor DS18B20 temperature sensor. A stainless steel temperature probe from Brewers Hardware (http://www.brewershardware.com/BrewTroller-Straight-Mount-Sensors/) is recommended, but not mandatory.

The temperature probe connects to the "one-wire bus" terminal strip inside of the Controller, as shown in figure 2-1.

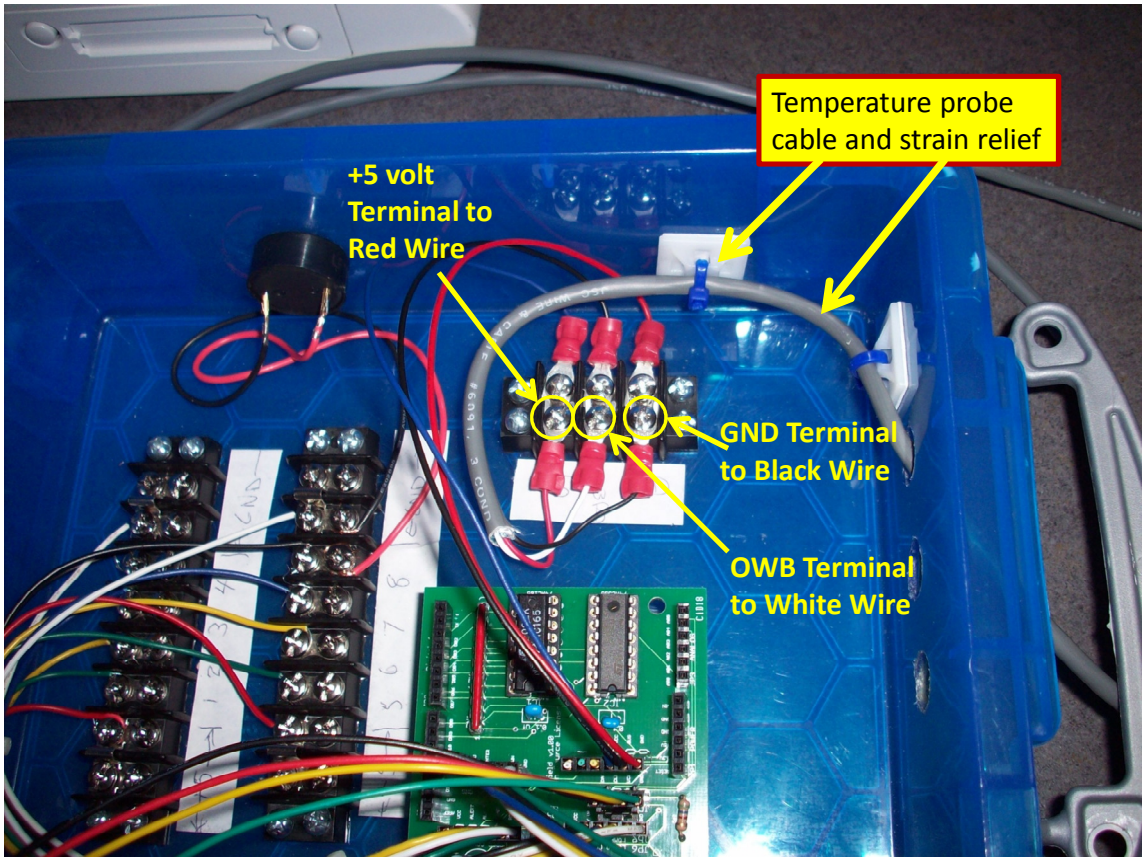

Figure 2-1. Temperature Probe Connection to Controller

The RED wire in the cable connects to the +5 volt terminal, the WHITE wire to the "OWB" (one-wire bus) terminal and the BLACK wire to the GND (ground) terminal. The cable shield wire (bare wire) is not necessary and does not need to be connected (clip it off).

Figure 2-2 shows the pin connections directly to the DS18B20 chip. Use this figure as a guide in the event that you use a different probe with different wire colors.

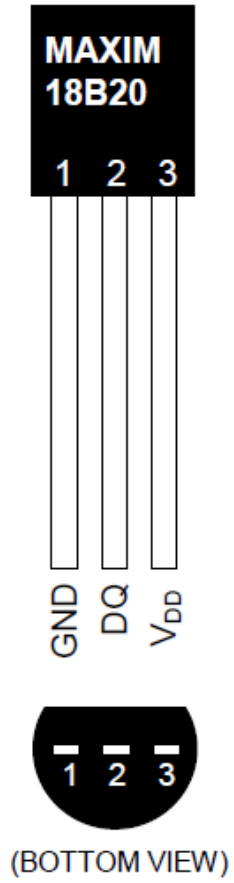

Figure 2-2. DS18B20 Chip Pin-out.

I recommend using cable ties and stick on cable tie mounts for dressing the temperature probe cable inside of the Controller box and for providing strain relief, as shown in figure 2-1.

3 Controller Front Panel Display.

Figure 3-1 shows the front panel LCD display for the Controller. The components of the display are indicated.

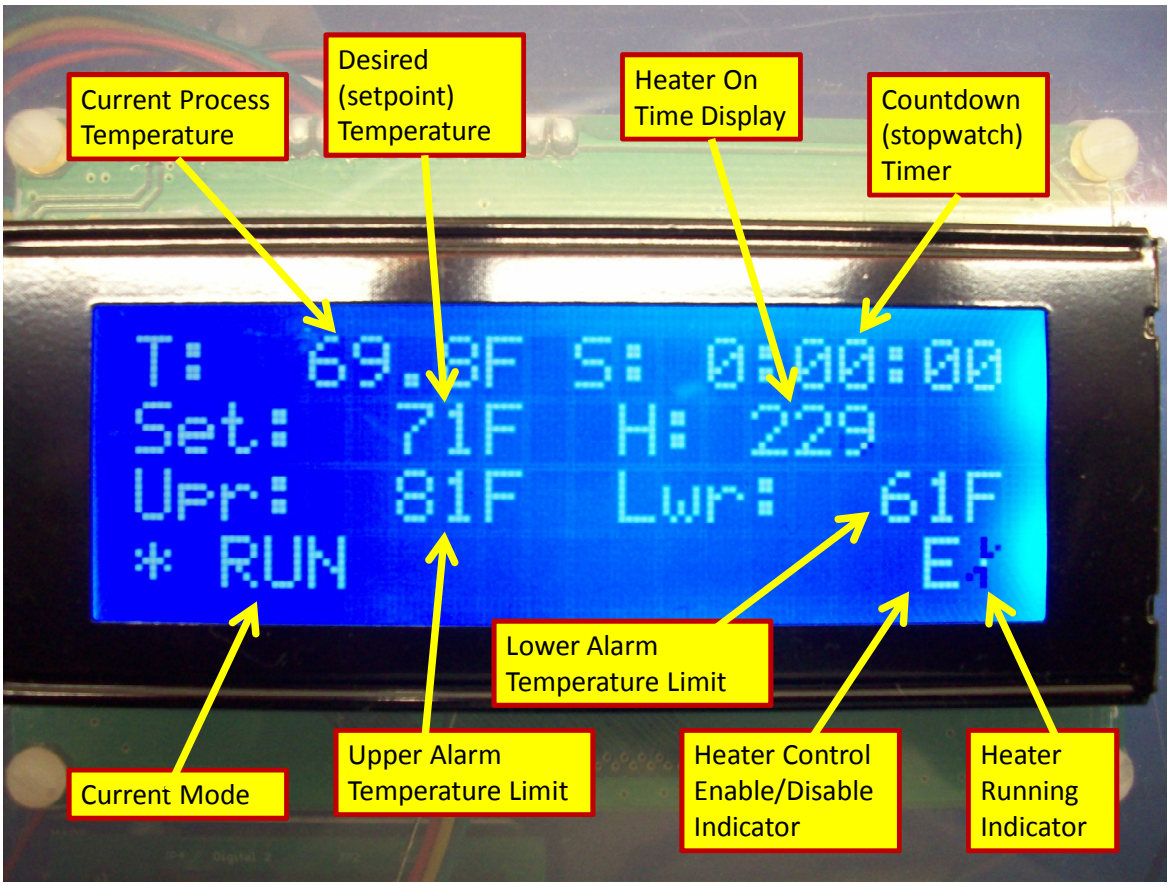

Figure 3-1. Feedstock Processing Controller LCD Display.

The front panel LCD display of the Controller presents the following information to the user:

- CURRENT PROCESS TEMPERATURE. This is a continuously updated display of the process temperature as reported to the Controller by the temperature probe. The current process temperature is updated every 750 milliseconds, which is the conversion time of the sensor in the probe. The temperature is displayed to one decimal place. The default temperature is displayed in Fahrenheit (it can be changed to display in Centigrade by changing a constant in the software and reloading the software to the Controller).

- COUNTDOWN TIMER. When the Controller is placed into the RUN mode, the time begins counting down from whatever time has been set by the user. When the countdown time reaches zero, the alert beeps 5 times. When the Controller is placed into a setup mode (mode other than RUN), the timer stops counting down to make this less confusing

to the user. The countdown timer can be set to as much as 9 hours and as little as one minute. The readout format is H:MM:SS with one second resolution.

- DESIRED TEMPERATURE. This is a user setting, indicating the temperature that the user desires the Controller to monitor and, optionally, to control. When used to monitor temperature, changing this setting also changes the upper and lower alarm temperature limits (by default, the upper alarm is 10 degrees higher than this setting and the lower alarm is 10 degrees lower than this setting). When the Controller is used to thermostatically control a heater, the Controller will turn the heater ON if the process temperature goes lower than one-half of one degree below this desired temperature and turn the heater off when the process temperature goes higher than one-half of one degree above this desired temperature. The +/- 10 degree defaults on the alarm temperature limits and the +/- one-half degree thermostatic "dead-band" are software defined constants and can be changed only by altering the software and reloading it to the Controller. If the software-defined constant is changed from Fahrenheit to Centigrade, the display will change to Centigrade but the limits will remain the same and will not be automatically rescaled.

- HEATER ON TIME DISPLAY: This is a continuous display of the number of seconds that the Controller has turned on an external heater. The on-time counter accumulates until the user manually resets it. This information can be used to provide an estimate of the energy utilized in an experiment consisting of a number of steps where the temperature and cooking time are altered, as is typical in processing starchy material down into fermentable sugars. The total energy utilized in the experiment can be determined by multiplying the wattage of the heater by the number of seconds of accumulated on-time to yield the total energy in watt-seconds. This feature is only valid if the Controller is used in the thermostatic mode to control an external heater.

- UPPER ALARM TEMPERATURE LIMIT. This is a user setting, indicating the temperature at which the user wants the Controller to sound an alarm if exceeded on the high side. In addition to the default set by setting the desired temperature, the upper limit can be independently set by the user to any value, in one degree increments.

- LOWER ALARM TEMPERATURE LIMIT. This is a user setting, indicating the temperature at which the user wants the Controller to sound an alarm if exceeded on the low side. In addition to the default set by setting the desired temperature, the lower limit can be independently set by the user to any value, in one degree increments.

- MODE. The current mode of the Controller is displayed. The mode is either RUN or some user setting condition, as described in the next section. Temperature monitoring

and control is continuous, regardless of the mode of the Controller. However, the limit alarm will only sound when the Controller is placed in the RUN mode. Likewise, the countdown timer will only begin counting down when the Controller is in the RUN mode.

- HEATER CONTROL INDICATOR AND HEATER RUNNING INDICTOR. The heater control indicator displays "E" when the control heater is enabled and "D" when the heater control is disabled. The heater control is enabled by default, on the assumption that if a heater is connected to the Controller, it would usually be controlled by the Controllers' thermostatic function. However, the heater can be disabled by the user, as described in the next section. The heater running indicator displays an "X" when the heater is not running (turned off by the Controller) and displays a "spinning" figure when the heater is running (turned on by the Controller). If the heater is disabled by the user, it running indicator will always be an "X".

4 Setting Controller Values and Controller Operation.

The four pushbutton switches on the front of the Controller allow the user to set time, desired temperature, upper and lower temperature limits for alarming, enable/disable the heater control function, and to reset the accumulated heater on time.

The Controller is intended to be set up by the user for each step in a feedstock processing recipe. Consequently, the design of the user interface has given a high priority to rapid and reliable user setup. The following general principles have been used in this design:

a) The most likely values to change from step to step are the first menu options in sequence.

b) "Short circuiting" allows the user to exit to the RUN mode at any point in the setup sequence. Combined with "a", above, this means that the user can generally set only what they need and immediately return to the RUN mode.

c) Defaults are established for likely settings. For example, setting the desired temperature also sets the upper and lower temperature alarm limits to "most likely" values of 10 degrees above and below the desired temperature, respectively. In combination with short circuiting, the defaults allow the user to skip settings where the default values are acceptable.

d) "Fail safe" operation ensures that the Controller performs the most important functions even if the user forgets to do something. For example, if the user forgets to return to the RUN mode after making some settings, the Controller automatically returns to the RUN mode after 20 seconds of no user activity (no pushing of buttons). If the user MUTEs the alarm, the alarm mute is automatically reset whenever the process temperature returns to within the upper and lower temperature limits.

e) Fast setting of values. In order to set Controller values such as time and temperature with a minimum of button pushes, the modes of operation include course and fine settings, e.g. "set temperature x10" increments or decrements the desired temperature setting by 10 degrees for each depression of the UP or DOWN button. The "set temperature x1" may be used to "fine tune" the temperature by increments/decrements of one degree.

The Controller's modes of operation are listed below. The MENU button toggles into and out of the RUN mode, providing the "short circuit" operation described above. The SELECT button advances the Controller, in sequence, through its modes. The UP and DOWN buttons are used to add or subtract the indicated amount from the indicated setting.

The following functions operate in all Controller modes of operation:

- The current process temperature (temperature probe reading) is continually monitored and displayed on the LCD.

- If the thermostatic control of a heater function is enabled, the Controller will turn the heat on and off in response to the process temperature reading, and will accumulate the total time that the heater has been turned on.

- Muting of the alarm will automatically reset (re-arm the alarm) whenever the process temperature is between the upper and lower alarm temperature limits.

- The Controller will automatically return to the RUN mode, from any mode other than RUN, if no button is pushed for a period of 20 seconds.

Modes of operation:

- RUN: when in the RUN mode, the Controller counts down the stop watch time and alerts the user when the time has expired. The alarm will sound if the process temperature goes out of bounds (is above the upper limit temperature or below the lower limit temperature).

- SET HOURS X1: pressing UP will increment the stop watch time by 1 hour, pressing DOWN will decrement the stop watch time by 1 hour.

- SET MINS X15: pressing UP will increment the stop watch time by 15 minutes, pressing DOWN will decrement the stop watch time by 15 minutes.

- SET MINS X1: pressing UP will increment the stop watch time by 1 minute, pressing DOWN will decrement the stop watch time by 1 minute.

- SET TEMP X10: pressing UP will increment the desired (set point) temperature by 10 degrees, pressing DOWN will decrement the desired (set point) temperature by 10 degrees. The upper alarm temperature limit will follow, 10 degrees higher and the lower alarm temperature limit will follow, 10 degrees lower.

- SET TEMP X1: pressing UP will increment the desired (set point) temperature by 1 degree, pressing DOWN will decrement the desired (set point) temperature by 1 degree. The upper alarm temperature limit will follow, 10 degrees higher, and the lower alarm temperature limit will follow, 10 degrees lower.

- SET U LIMIT X10: pressing UP will increment the upper alarm temperature limit by 10 degrees, pressing DOWN will decrement the upper alarm temperature limit by 10 degrees.

- SET U LIMIT X1: pressing UP will increment the upper alarm temperature limit by 1 degree, pressing DOWN will decrement the upper alarm temperature limit by 1 degree.

- SET L LIMIT X10: pressing UP will increment the lower alarm temperature limit by 10 degrees, pressing DOWN will decrement the lower alarm temperature limit by 10 degrees.

- SET L LIMIT X1: pressing UP will increment the lower alarm temperature limit by 1 degree, pressing DOWN will decrement the lower alarm temperature limit by 1 degree.

- HEATER ENABLE: pressing UP will enable thermostatic control of the heater, pressing DOWN will disable thermostatic control of the heater.

- HEAT TIME RESET: pressing DOWN will reset the heater on time accumulator to zero.

Button operation:

The following is a summary of the operation of each of the Controller pushbuttons:

- MENU: when in RUN mode, toggles out of RUN into stop watch time setting. When not in RUN mode, depressing MENU always immediately returns the Controller to the RUN mode, "short circuiting" other setup functions.

- SELECT: toggles though all modes of the Controller: RUN, set hours X1, set minutes x15, set minutes x1, set temperature x10, set temperature x1, set upper limit x10, set upper limit x1, set lower limit x10, set lower limit x1, enable/disable the heater, reset the heater on time accumulator, and then back to RUN.

- UP: does nothing in RUN mode. In a value setting mode, increases the parameter indicated by the mode by the value indicated (15, 10, 1, etc.). In the HEATER ENABLE mode, enables the heater thermostat function.

- DOWN: in the RUN mode, depressing DOWN will mute the temperature out-of-limits alarm. The alarm will remain muted until the process temperature returns to within the upper and lower temperature limits. In a value setting mode, decreases the parameter indicated by the mode by the value indicated (15, 10, 1, etc.). In HEATER ENABLE

mode, disables the heater thermostat function. In the HEAT TIME RESET mode, resets the heater on time accumulator.

Appendix A. Controlling an External Heater.

The Controller provides a "thermostat" like control on Digital Output #1 of the Controller. This is a "dead zone" type of control system, like a thermostat. When the heater function is enabled, the Controller will activate the heat source (setting Digital Output #1 to +5 volts) when the process temperature falls one degree below the desired (set point) temperature, and the Controller will deactivate the heat source (setting Digital Output #1 to 0 volts) when the process temperature rises one degree above the desired (set point) temperature.

The digital outputs from the Controller are logic level signals capable of driving a solid state relay or similar device. In order to control an electric heater, an electromechanical or solid state relay (SSR) should be used to control the AC power to the heater. A simple and safe device for doing this is the "Power Switch Tail" (http://powerswitchtail.com/default.aspx), which is shown in figure A-1.

Figure A-1. Power Switch Tail Device.

The Power Switch Tail is like an extension cord with a relay built into it. No high voltage AC is exposed. Simply run a wire (#22 AWG stranded wire is recommended) from the Digital Output #1 terminal strip connection to the "+in" terminal on the Power Switch Tail and run another wire (same type) from the GND terminal strip connection to the "-in" terminal on the Power Switch Tail. Plug the AC plug into any 110VAC outlet and plug an electric stove or heater (up to 1200

watts) into the AC socket and the Controller will control the temperature of any process that is heated by the stove/heater and whose temperature is monitored by the Controller's temperature probe. A candidate electric stove is the Proctor-Silex model #34101 "Fifth Burner", as shown in figure A-2.

Figure A-2. Typical Single Burner Electric Stove.

This stove is available from Amazon.com at:

http://www.amazon.com/Proctor-Silex-34101-Proctor-Silex-Burner/dp/B000690WNU/ref=sr_1_2?ie=UTF8&qid=1329871503&sr=8-2