Wood Stove Heat Distribution

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Grade 6

List of Figures

Purpose

The purpose of this experiment is to find out how to distribute the heat from a wood stove (fireplace) through out the room evenly.

Background Research

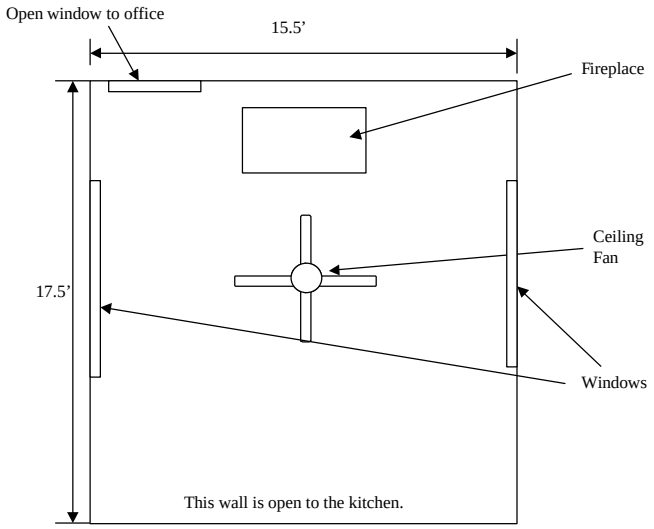


Figure 1.
Explanatory Figure Showing the Layout of the Family Room Where the Measurements Were Taken.

Figure 1 shows the layout of the family room, which is where the measurements were taken. It is very important to know where drafts may enter the room. The fireplace is a Waterford Trinity MKII Woodstove[1] that has a heat exchanger fan built into it. It can have a maximum of 55000 BTU's (British Thermal Units; the amount of energy needed to raise the heat of one pound of water one degree Fahrenheit[2]) per hour. The ceiling fan is a Hunter Model #: 23710 [3]. The shape of the room looking at it from the kitchen is a pentagon where the top is a lopsided "V". The very top is 16'. The ceiling fan hangs slightly lower then 12' off of the ground.

I didn't find any other web pages that had actual temperature measurements for the ceiling fan and the heat exchanger combination. We all know warm air rises. Air that is heated becomes less dense. The air that is not heated has more pressure then the heated air, causing the cold air to become heavier[4]. This causes the cold air to sink and the warm air to rise. Usually, references do not measure the before and after temperatures of the effect of the ceiling fan. Sometimes they state that the thermostat can be lowered by 5-10 degrees[5].

[1] See http://www.waterfordstoves.com/pages/trinity.shtml
[2] see http://www.jafi.org.il/newsite/aliyah/heat.htm
[3] see http://www.hunterfan.com/showroom/fans_detail.tmpl?SKU=0%2049694%2023710%201
[4] pg 479, Focus on Earth Science, Prentice Hall Inc.
[5] see http://www.regencyfan.com/press/pdf/comfort.pdf

Other references talk about using ceiling fans with a temperature difference between the ceiling and the floor being greater then 5 degrees Fahrenheit[6].

Figure 2. Heat Exchanger

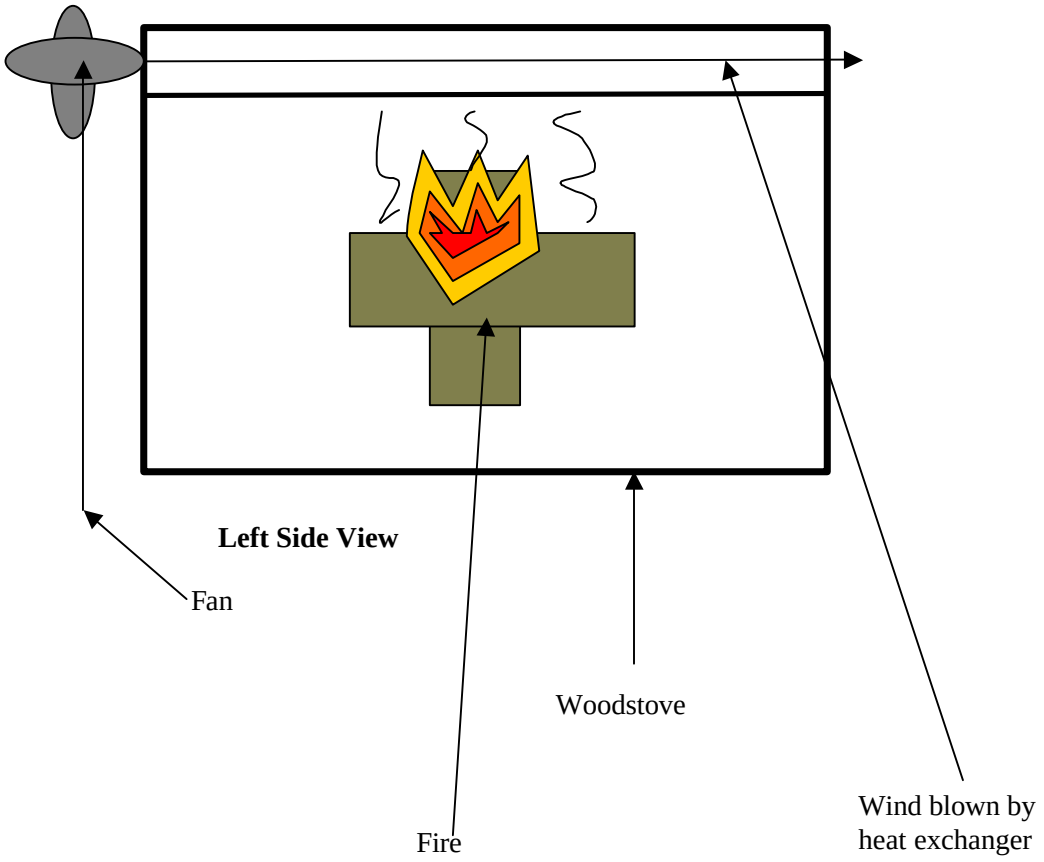


Figure 2 shows how the heat exchanger works. The fan blows clean air over the top of the woodstove. The top of the woodstove is the hottest and heats the air. This greatly increases the amount of heat transferred into the room.[7]

Hypothesis

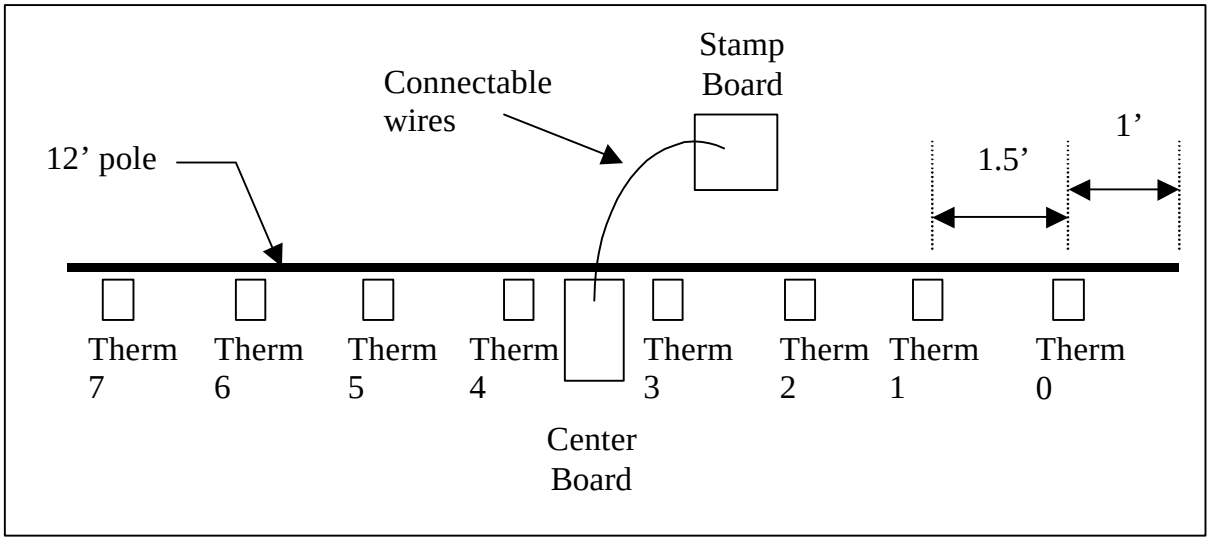
If a lot of the heat generated from the wood stove is lost by the heat rising, then the ceiling fan shall push it back down and help more then the other fan to distribute the heat.

[6] http://www.nrel.gov/docs/fy00osti/28129.pdf, pg 3, Sheila J. Hayter, Paul A. Torcellini, A Case Study of the Energy Design Process Used for A Retail Application, August 2000, NREL
[7] For references see section Research References

Materials

For my experiment I built a test apparatus to automatically measure the temperature from 8 evenly spaced thermometers. As shown in figure 3 the thermometers are spaced 1.5 feet from each other attached to a twelve-foot stick. The thermometers are integrated circuits, each on their own printed circuit board. The top 4 thermometers (0-3) and the bottom 4 thermometers (4-7) are each individually wired to the center circuit board. The whole mission is carried out by a microprocessor called a Stamp. The Stamp reads the temperatures and stores the values in a memory. When done the Stamp can be disconnected from the apparatus and hooked up to a PC so that the data can be transferred and plotted.

Figure 3.
Test Apparatus.



THE STAMP

A Stamp is a microprocessor that may be used to control minor tasks by being programmed. I first learned how to program these microcomputers late last summer. I found it not only easy to use, but intriguing. Stamps are made by a company called *Parallax* [8]

[8] Their web site may be found at www.parallaxinc.com, "BASIC stamp is a registered trademark of Parallax, Inc. Other brand and product names are trademarks or registered trademarks of their respective holders."

Stamps are programmed in a language called BASIC. In order to program it, you need a PC. For the stamp, you write the program on the PC and press run and it will start executing immediately. Once you have pressed run, it will save the program in the stamp so that to run it again you only have to press the reset button. This reset button is located on the stamp board. On the stamp board there are 16 pins that are used to communicate to the other chips or other hardware. It was through these pins that I connected the thermometers, the switches, and the memory chip.

Figure 4 is a list of BASIC commands for the BS2P stamp which I used. Figure 5 is a list of all the operators and functions.[9] This is pretty much a complete list of all the stamp commands that can be used in a program.

The BS2P stamp has more commands then some of the earlier stamps. It has advanced commands to read and write to the thermometers, memory, and LCD display that I used in my project. SHIFTIN and SHIFTOUT are the commands that I used for the thermometers. The I2CIN and I2COUT are used to read and write to memory. LCDCMD and LCDOUT are used to write to the LCD.

There are sample stamp programs that you can find on the net and in books for all of the parts that I used. One really nice website is Stamps In Class.[10] They have books for teaching kids how to use the stamp. For using the thermometers, there is a student workbook called **Earth Measurements** that I found helpful. Chapter 1 explains how the DS1620 digital thermometers work and provides sample programs and schematics.

DS1620

The DS1620 (the thermometer) has 8 pins and is made by Dallas Semiconductor. It has a resolution of 0.5 Deg C. The value that is read is 2 * Deg C. Data is read or written through a 3 wire serial port. The same data wire and clock wire may be connected together to all the thermometers. The third pin is used to select which thermometer is being used.

The thermometer chip has some intelligence built in. Once the stamp tells the thermometer to read the temperature, it will do so once every second. The thermometer reads the temperature every second and writes to its own memory this value, but it is only sent to the stamp when the stamp tells it to. The stamp is the master and the thermometer is the slave.

[9] Taken from kclass Stamp lecture.
[10] www.stampsinclass.com, Teachers see this website, please!

Figure 4. BS2P Stamp BASIC Commands

Branching	
IF…THEN	Compare and conditionally branch.
BRANCH	Branch to address specified by offset.
GOTO	Branch to address.
GOSUB	Branch to subroutine address
RETURN	Return from subroutine.
RUN	Switch execution to another program page
POLLRUN	Polled interrupt call
Looping	
FOR…NEXT	Establish a FOR-NEXT execution loop.
EEPROM Access	
DATA	Data storage in EEPROM.
READ	Read EEPROM byte into variable
WRITE	Write byte to EEPROM
STORE	Switch program slot for access
RAM Access	
GET	Read Scratch Pad RAM byte into variable
PUT	Write byte to Scratch Pad RAM
Numeric	
LOOKUP	Lookup data in a table
LOOKDOWN	Table match to variable
RANDOM	Generate a pseudo-random number.
Digital I/O	
INPUT	Make an I/O pin an input.
OUTPUT	Make an I/O pin an output.
REVERSE	Reverse the direction of a pin.
LOW	Force an I/O pin low.
HIGH	Force an I/O pin high.
TOGGLE	Toggle an I/O pin output value.
PULSIN	Measure an input I/O pin pulse.
PULSOUT	Output a pulse on an I/O pin.
BUTTON	Debounce button and branch on value.
COUNT	Count the cycles on a pin.
XOUT	Output a X-10 home automation command.
AUXIO	Activate auxiliary I/O pin group.

Digital I/O (cont.)	
MAINIO	Activate main I/O pin group.
IOTERM	Activate specified I/O pin group.
POLLOUT	Specify pin for polled interrupt.
POLLMODE	Specifies the polled interrupt mode.
Asynchronous Serial I/O	
SERIN	Input asynchronous serial data.
SEROUT	Output asynchronous serial data.
OWIN	Input data from a one wire device.
OWOUT	Output data to a one wire device.
Synchronous Serial I/O	
SHIFTIN	Input synchronous serial data.
SHIFTOUT	Output synchronous serial data.
I2CIN	Input data from a I2C device.
I2COUT	Output data to a I2C device.
Parallel I/O	
LCDCMD	Writes a command to an LCD.
LCDIN	Reads data from an LCD.
LCDOUT	Writes data to a LCD.
Analog I/O	
PWM	Output pulse width modulation.
RCTIME	Measure RC charge/discharge time.
Time	
PAUSE	Pause execution for specified milliseconds
POLLWAIT	Pause until a polled interrupt occurs.
Sound	
FREQOUT	Generate 1 or 2 sine wave frequency outputs.
DTMFOUT	Generate DTMF telephone tones.
Power Control	
NAP	Nap for a period to conserve power.
SLEEP	Sleep for the specified seconds to conserve power.
END	Sleep until the power cycles or the PC connects.
Program Debugging	
DEBUG	Print values back to the PC for debugging.

Figure 5. Stamp BASIC Operators and Functions

Expression Operators

+	Addition
-	Subtraction
*	Multiplication
**	Multiplication (returns upper 16 bits)
*/	Multiply by 8-bit integer, 8 bit fraction
/	Division
//	Modulus (remainder of division)
MIN	Limits a value to a specified low
MAX	Limits a value to a specified high
DIG	Returns a specified digit of a number
<<	Shift bits left by specified amount
>>	Shift bits right by specified amount
REV	Reverse specified number of bits
&	Bitwise AND
|	Bitwise OR
^	Bitwise XOR

Unary Operators

ABS	Returns absolute value
COS	Returns cosine in two's compliment binary radians
DCD	2^n-power decoder
~	Inverse
-	Negative
NCD	Priority encoder of a 16-bit value
SIN	Returns sine in two's compliment binary radians
SQR	Returns square root of value

Variable Modifiers

LOWBYTE	low byte of a word
HIGHBYTE	high byte of a word
BYTE0	byte 0 (low byte) of a word
BYTE1	byte 1 (high byte) of a word
LOWNIB	low nibble of a word or a byte
HIGHNIB	high nibble of a word or byte
NIB0	nibble 0 of a word or byte
NIB1	nibble 1 of a word or byte
NIB2	nibble 2 of a word
NIB3	nibble 3 of a word
LOWBIT	low bit of a word, byte, or nibble
BIT0...BIT3	bit 0 through bit 3 of a word, byte, or nibble
BIT4...BIT7	bit 4 through bit 7 of a word or byte
BIT8…BIT15	bit 8 through bit 15 of a word

RAM Organization

word	byte	nibbles
INS	INL	INA, INB
	INH	INC, IND
OUTS	OUTL	OUTA, OUTB
	OUTH	OUTC, OUTD
DIRS	DIRL	DIRA, DIRB
	DIRH	DIRC, DIRD
W0	B0	
	B1	
…<same for W1, W2, W3, etc through W12>		
W12	B24	
	B25	

24LC32A

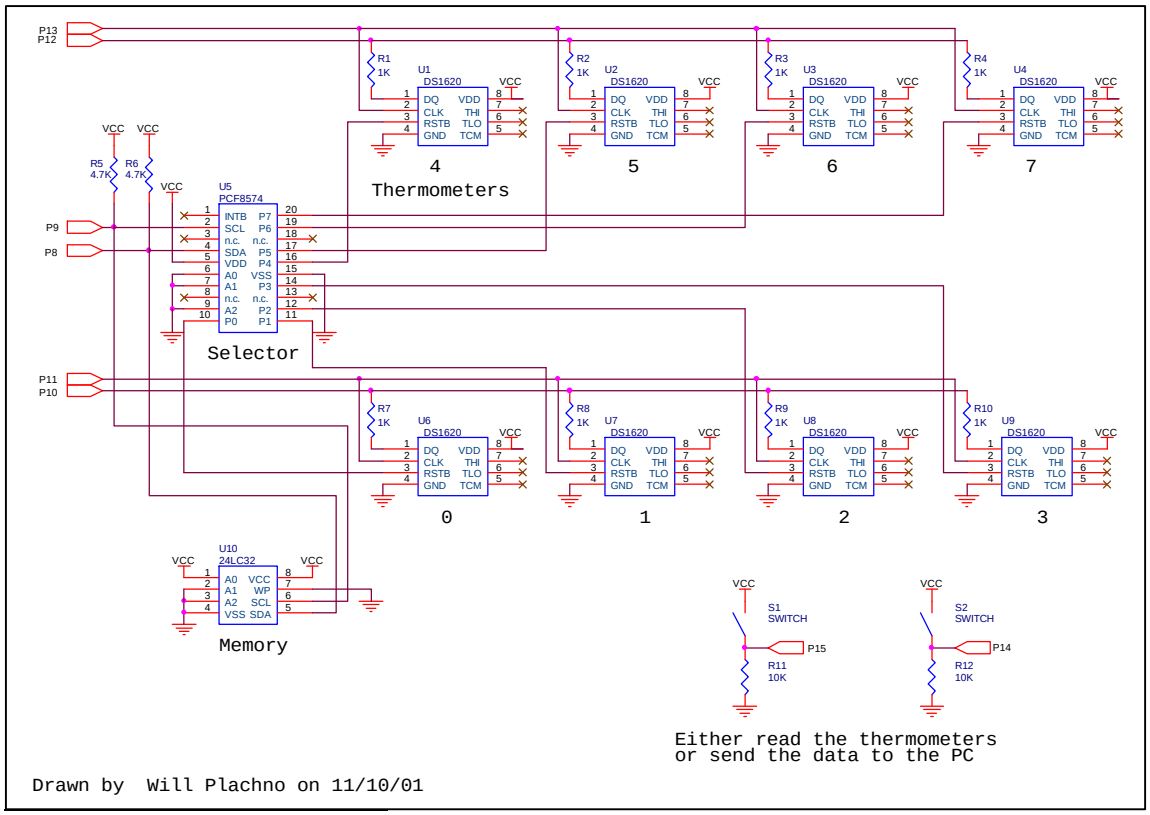
This is the memory chip that was used. This memory is called an EEPROM, which really means that it will remember the data even after the power is off. It is made be MicroChip Inc. This is a 4K x 8-memory chip. 4K does not mean 4,000. K really means 2^{10} or 1024 so 4K really means 4,096. Every temperature reading is 8 bits or a byte, so I can store up to 4,096 temperature readings. Actually I only store 4000 temperature readings since I measure 8 different thermometers at 500 different points in time.

This communicates to the stamp through a two-wire interface also called an I^2C interface[11]. There is still a data and still a clock wire but there is no selector wire. This chip has three address pins: a2 a1 a0, which I set to 001. There is another I^2C part (the selector) but its address is 000.

PCF8574

This is the selector chip. This chip is an I^2C part just like the memory, so they share the same data and clock pins. All this chip does is it gives you 8 additional programmable pins. I used these pins to select which thermometer is being read. These outputs are the third wire of the DS1620 third wire interface.

Figure 6. Schematic



[11] I^2C is a trademark of Phillips Corporation.

Hardware Design

Shown in figure 6 is the schematic. Thermometers 0-3 are on a different three-wire bus then 4-7. If all eight thermometers were on the same bus (data/clock wires) it would weigh too much (too much capacitance) and it might severely slow it down.

Figure 7. Switch Positions

(P15) switch 1	(P14) switch 2	Description.
On	On/Off	you upload to the PC
Off	On	Taking the temperature (and putting it into memory)
Off	Off	Reading but not storing the value

Figure 7 says that there are 2 switches and what they do in each position.

The connection to the LCD display is not shown in the schematic. The stamp board has a built in connecter for the LCD so I didn't have to wire anything to that.

Figure 8. Stamp pin connections

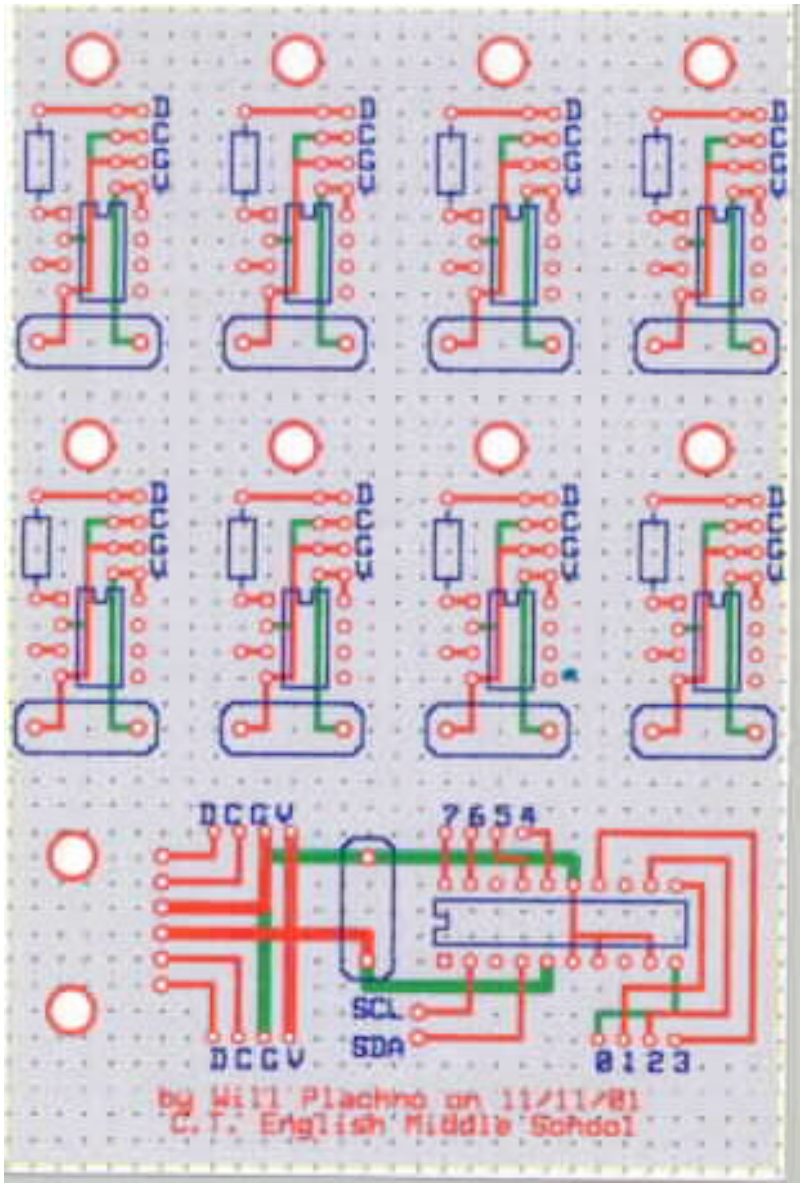
Stamp pin	Connection	Stamp pin	Connection
15	Upload switch	7	D3 LCD
14	Temp Read switch	6	D2 LCD
13	Clock 4-7	5	D1 LCD
12	Data 4-7	4	D0 LCD
11	Clock 0-3	3	Reg Select LCD
10	Data 0-3	2	R/W LCD
9	Clock I^2C	1	Enable LCD
8	Data I^2C	0	Unused

Figure 8 shows all the connections to the stamp pins.

The Printed Circuit Board

I had to make a center board and 8 thermometer boards. Using ExpressPCB[12] I put them all on one board and cut them out. The red lines are the metal connections on the top of the board and the green wires are the connections on the bottom of the board.

Figure 9. Printed Circuit Board



[12] See www.expresspcb.com , You can download free software from their website to draw your PC board .

Each board has a hole for a #6 woodscrew to attach it to the apparatus. There are other holes in the board for soldering the wires. These holes are labeled D, C, G, or V. D is for the data wire, C is the clock wire, G is the ground wire, and V stands for voltage supply. All of them are passed on to the center board by wiring each letter to its counterpart.

I added capacitors across the power supply. Capacitors don't want the voltage across them to change. Thus, these capacitors keep the V and G wires quiet.

There are 8 holes in the center board to connect wires to the stamp. There are also 8 blue wires that connect from the selector to each thermometer board.

Figure 10.
One of the Thermometer Boards.

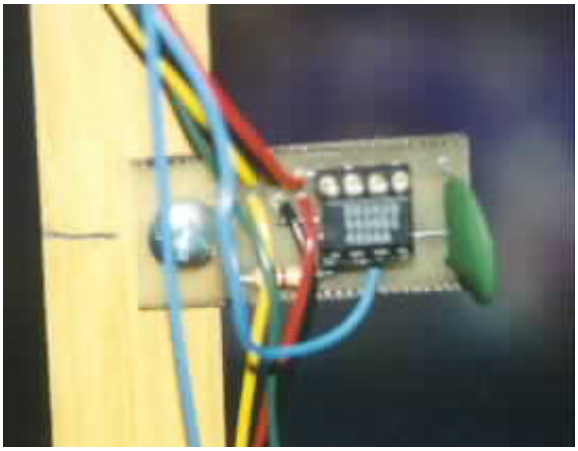
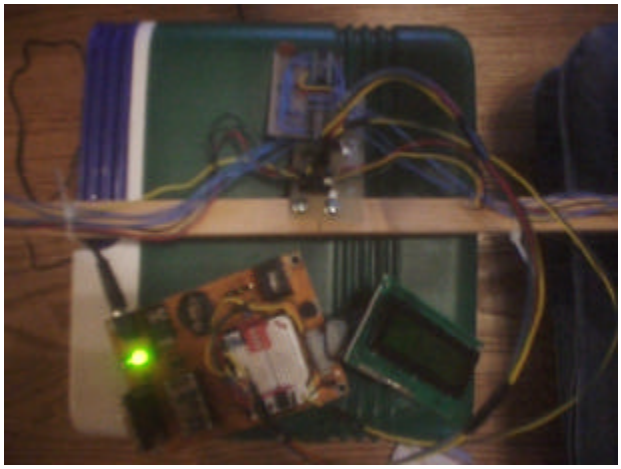


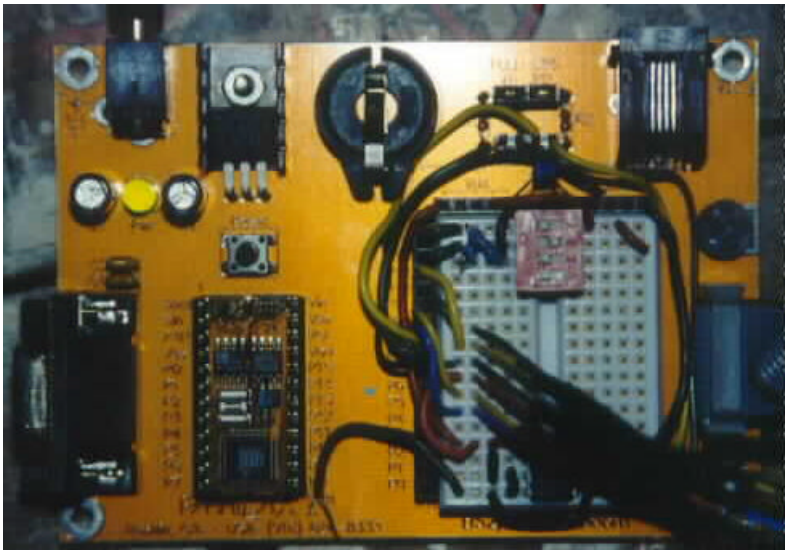
Figure 11.
The Stamp Board Hooked up to the Center Board



The Stamp Board

The stamp board I used is the BS2p demo board. It contains a little bread board that can be used to hook the stamp up to a component. The bread board for this experiment only has 2 things on it: the switches and the memory. To upload data, you have to have the switches (so that you can tell it to upload) and the memory (to get the data from).

Figure 12.
The Stamp Board with the Switches Set to 01



Material List

Figure 13. List of Materials

Quantity	Name
1	BS2p Basic Stamp
8	DS1620
1	24LC32A
1	PCF8574
1	4 switch DIP switch
1	Parallel LCD display
1	BS2p demo board
2	10K resistors
8	1K resistors
10	0.1uF disc capacitors
1	12’ pole

The Software Program

The program is done on Windows (on a PC) with a program called Stampw[13]. You have to connect the stamp with a serial port to the PC. It is programmed in BASIC. The software has three main parts, the header, the main program, and the subroutines.

The header is not made up of step by step instructions like you usually see. It consists of details the rest of the program needs. It contains three sections, the constants, pin direction settings, and variable declarations. The constants are basically only putting a name on the addresses used for the memory chip or the selector chip. The next section tells which of the stamp's 16 pins are inputs or outputs. The variable definitions are next. This defines whether a variable is a byte or a word. The max number a byte can use is 255. To have a variable of 500, you need to use a word, which is 16 bits.

There are 9 different subroutines, select, deselect, writeto, redf, getth, gettl, lcdtime, lcddata, and innit. Using the subroutines makes the main program more readable because it handles all the difficulties of reading and writing the chips.

Getth and Gettl

They both are used to get the temperature. The only reason they are not the same is because of the way the apparatus is built, with 4 on the top and 4 on the bottom. The thermometer reads the temperature every second, but the stamp tells it when to send what the temperature is. The shiftout instruction is a command to the DS1620 to tell it to send the temperature value. The shiftin instruction reads the data. This was taken from an example from Earth Measurements[14].

Select and Deselect

These two subroutines write to the selector chip, PCF8574. The select command selects one of the eight thermometers. Deselect makes sure none of the thermometers are selected. Figure 14 shows how the thermometers are selected. The variable nthm tells you which blue wire should be set to 1. The instruction line "j = 1 << nthm" generates the values for this table. It shifts the value 1, nthm number of times (example= if nthm = 3, j = 00001000).

The instructions for writing the PCF8574 were taken from a sample program on the Internet.[15]

[13] Download it free at www.parallaxinc.com!
[14] Page 16 Earth Measurements Student Version 1.2
[15] pg 17-18 Parallax, Inc BS2p "Plus Pack" (#45184)

Figure 14. Thermometer Selection

Nthm	Therm 7	Therm 6	Therm 5	Therm 4	Therm 3	Therm 2	Therm 1	Therm 0
0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	1	0
2	0	0	0	0	0	1	0	0
3	0	0	0	0	1	0	0	0
4	0	0	0	1	0	0	0	0
5	0	0	1	0	0	0	0	0
6	0	1	0	0	0	0	0	0
7	1	0	0	0	0	0	0	0

Writeto and Redf

These read and store values in the memory. An address is where in a memory you want to store it. The 24LC32A can store up to 4,096 bytes. This was also taken from an example on the Internet.[16] After the temperature is taken, it needs a pause to store it in memory. There is an option not to take the temperature if the switches are set to 00.

LCDtime and LCDdata

These output the temperature and the time point to the LCD. For each thermometer, the command LCDdata has to calculate where to put the temperature. The LCD I'm using has 16 characters on two lines. Figure 15 shows the addresses for the characters with the locations of the time point and thermometer values shaded.

Figure 15. LCD Display Locations

128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207

The time point is located at 128 as a decimal value 3 characters wide. For the thermometer values, if its on the first line you start on address 128 or if it is on the second line you start on 192. Then you skip over 5 values to get to the first thermometer. Then the following are spaced 3 from the one in front of it. Each temperature value is output as a decimal value 2 characters wide.

Sample program instructions for the LCD display was taken from Basic Stamp Manual Version 2.0.[17]

[16] pg 28 Parallax Inc. BS2p "Plus Pack"
[17] pg 159-176 BASIC Stamp Manual 2.0b

Innit

This subroutine initializes all the chips. The initialization for the LCD I got from examples off the Internet.[18] They said not to change anything, so I didn't.

The 8 thermometers also require initialization. They must be told to start taking the temperature.[19]

The plot software will also be initialized, but well talk about that later. This subroutine also sets 2 variables to their initial values. The memory address must be set to 0. Also the default is not to write to memory.

The Main Program

There are three sections, the switches, reading the thermometers, and uploading the data.

Switches and Reading Them

If the first switch is on, upload the data to the PC. If the first is off and the second is on then it will read the temperature. For the switch pins, you have a resistor connecting to ground, and the switch connecting to 5v. If the switch is off, then the resistor pulls it to ground, a logical 0. If the switch is on, the pin is forced to 5v, a logical 1, completely over-powering the resistor. In the program, "in15" is pin 15, and "in14" is pin 14. "if in15 = 1 then datat", this says that if the top switch equals 1, then it will transfer the data to the PC.

Reading the Thermometers

Figure 16. Code for Reading the Thermometers

```
thermr:
' This reads the data from the therms. Read 8 therms every 15 seconds.
' 500 total time points. 8 x 500 = 4000 data points.

for x = 0 to 499            ' loop through 500 time points
    gosub lcdtime           ' display time point x on LCD
    for nthm = 0 to 3       ' do bottom 4 therms
        gosub gettl         ' read temp
        gosub writeto       ' writes to memory
        gosub lcddata       ' display temp on LCD
    next
    for nthm = 4 to 7       ' do top 4 therms
        gosub getth         ' read temp
        gosub writeto       ' writes to memory
        gosub lcddata       ' display temp on LCD
    next
    pause 14200             ' pause 15 seconds
next
```

[18] pg 6 Parallax Inc BS2p "Plus Pack".
[19] Pg16 Earth Measurements Student Guide

Thermr reads the thermometers and writes the values to memory. The for-next statements create loops. Loops repeat the commands that are located between the for and the next a specified number of times. You need to create two loops, one for the top 4 and one for the bottom 4 thermometers because each have there own subroutines. Since I take the temperature every 15 seconds, I have to tell it to wait 15 seconds before the next time point. The pause instruction will wait the specified number in milliseconds. It only says 14200 milliseconds because of the wait to write the values to memory, which is 100 milliseconds. You might have noticed that 14200 + 100 is only 14300, but you have to do this (100 x *8*) + 14200 = 15000, or 15 seconds.

Uploading the Data

I used a program called StampPlot Pro[20] to transfer the data to the PC and plot it out. After you're done taking measurements, move it to the PC and hook it up. Then start up the StampPlot Pro program and click the handshake icon.

Instead of having StampPlot Pro calculate the x-axis, I had to use an optional feature called "historical data". This needs all 8 thermometers to be transferred on one line with the data separated by commas.

Figure 17. Code for Uploading the Data.

```
datat:
' Transfers data to PC
' Stamp is connected to the PC through the serial port
' Stamp outputs to serial port using the debug command
' Stampplot Pro is the program on the PC
' It requires the 8 temps on 1 line separated by commas

for x = 0 to 499              ' loop through 500 time points
    debug "!HISD 15"          ' Historical data 15 seconds apart
    for nthm = 0 to 7         ' do all therms on one line
        gosub redf            ' reads from memory
        degC = t / 2          ' converts reading into degree C
        debug ", ", dec degC  ' output decimal value
        i= t & %00000001      ' looks only at last digit (in binary)
        if i = 0 then tdone   ' if last digit is 0 then done
           debug ".5"         ' if last digit is 1 then output .5
        tdone:
    next
    debug cr                  ' output end of line
```

The BASIC stamp command "debug" is used to write to the PC. I used multiple debug commands to write one line and then finish the line with a "CR" or carriage return. One problem I had was that the temperature value is 2 x DegC. I had to translate this whole value into a floating-point number in degree Celsius. First you divide by 2 then if bit 0 of the byte is 1 then print ".5".

[20] S-Plot and StampPlot are trademarks of SelmaWare Solutions, see http:/www.selmaware.com

In my BASIC stamp program you can send commands to the plot software. These commands are in the innit subroutine.

Figure 18. Code for Initialization of the Plot Software

```
Innitialize plot software
debug "!RSET",cr          ' reset the plot
debug "!Plot on",cr
debug "!TITL 8 Thermometer Plot",cr
debug "!YLBL Temp = degree C", cr
debug "!XLBL Minutes", cr
debug "!AMAX 40",cr       ' maximum y value
debug "!AMIN 10",cr       ' minimum y value
debug "!TDIV 60",cr       ' time in minutes
debug "!TMAX 125",cr      ' maximum x value
debug "!COLR G9",cr       ' change grid color
debug "!PNTS 5000",cr     ' 5000 data points max
debug "!HISS" cr          ' historical data format
```

I set the minimum of the y axis to 10 and the maximum to 40 degree Celsius. For those people who like Fahrenheit more then Celsius, I have provided a conversion table.

Figure 19. Temperature Conversions[21]

Deg Celsius	Deg Fahrenheit
40	104
35	95
30	86
25	77
20	68
15	59
10	50

[21] I used Uncle Ron's program *Convert1* to convert to Fahrenheit.

Complete BASIC Stamp Program Listing

```
'{$STAMP BS2p}

' Written by Will Plachno
' Subroutines written on 11/4/01
' Will goes to Loma Preita, C.T. English,
' Science teacher is Juli Seigrist



''''''''''''''''''''''''''''''''''''''''
' I/O pin definitions and other constants
''''''''''''''''''''''''''''''''''''''''

I2Cpin    con    8     ' SDA = 8, SCL = 9
Wr8574    con    $40   ' 8574 address at 000
Rd8574    con    $41
dir8574   con    $00   ' all I/O pins are outputs
Wr2432    con    $A2   ' 2432 address at 001
Rd2432    con    $A3



''''''''''''''''''''''''''''
' I/O pin direction settings
''''''''''''''''''''''''''''

input  15 'switch for transfering data
input  14 'switch for reading therms
output 13 'DS1620 clock therms 4-7
output 12 'DS1620 data  therms 4-7
output 11 'DS1620 clock therms 0-3
output 10 'DS1620 data  therms 0-3
output  9 'I2C clock
output  8 'I2C data


''''''''''''''''''''''''
' Variable declarations
''''''''''''''''''''''''

t        var byte           ' temp
degC     var byte           ' temperature in Celsius
x        var word           ' time points 0-499
nthm     var byte           ' therm number 0-7
i        var byte           ' gen purpose variable
j        var byte           ' gen purpose variable
k        var byte           ' gen purpose variable
addr     var word           ' 2432 EEPROM address 0-3999
addrHi   var addr.HighByte  ' high byte of mem address
addrLo   var addr.LowByte   ' low byte of mem address
no_write var byte           ' flag for not writing memory



''''''''''''''''''''''
' Main Program
''''''''''''''''''''''

gosub innit                 ' do initialization
if in15=1 then datat        ' if switches = 1x transfer data
if in14=0 then thermr       ' if switches = 00 read therms, no write
no_write = 0                ' if switches = 01 read therms, write



thermr:
' This reads the data from the therms. Read 8 therms every 15 seconds.
```

```
' 500 total time points. 8 x 500 = 4000 data points.

for x = 0 to 499            ' loop through 500 time points
    gosub lcdtime           ' display time point x on LCD
    for nthm = 0 to 3       ' do bottom 4 therms
        gosub gettl         ' read temp
        gosub writeto       ' writes to memory
        gosub lcddata       ' display temp on LCD
    next
    for nthm = 4 to 7       ' do top 4 therms
        gosub getth         ' read temp
        gosub writeto       ' writes to memory
        gosub lcddata       ' display temp on LCD
    next
    pause 14200             ' pause 15 seconds
next
stop



datat:
' Transfers data to PC
' Stamp is connected to the PC through the serial port
' Stamp outputs to serial port using the debug command
' Stampplot Pro is the program on the PC
' It requires the 8 temps on 1 line separated by commas

for x = 0 to 499              ' loop through 500 time points
    debug "!HISD 15"          ' Historical data 15 seconds apart
    for nthm = 0 to 7         ' do all therms on one line
        gosub redf            ' reads from memory
        degC = t / 2          ' converts reading into degree C
        debug ", ", dec degC  ' output decimal value
        i= t & %00000001      ' looks only at last digit (in binary)
        if i = 0 then tdone   ' if last digit is 0 then done
           debug ".5"         ' if last digit is 1 then output .5
        tdone:
    next
    debug cr                  ' output end of line
next
stop



' Subroutine select
' This selects 1 of the 8 thermometers
' This requires the variable nthm
' nthm is the thermometer number 0-7
' Temporary variable j is also used

select:
j= 1 << nthm
i2cout  I2Cpin, Wr8574, dir8574, [j]
return



' Subroutine deselect
' This deselects all 8 thermometers
' This does not require any input variables

deselect:
i2cout  I2Cpin, Wr8574, dir8574, [0]
return



' Subroutine writeto
```

```
' This stores a value in memory
' This requires variable t
' t is the temperature value stored in memory
' You also need the address addr

writeto:
if no_write = 1 then xwrite
i2cout  I2Cpin, Wr2432, addrHi\addrLo, [t]
addr = addr + 1
pause 100
xwrite:
return



' Subroutine redf
' This reads a value from memory
' This requires variable t
' t is the temperature value read from memory
' You also need the address addr

redf:
i2cin  I2Cpin, Rd2432, addrHi\addrLo, [t]
addr = addr + 1
return



' Subroutine getth
' This reads a value from a thermometer (4-7)
' This requires variable t and the nthm
' t is the temperature value read
' nthm is the number of the thermometer
' DS1620 Data pin is 12
' DS1620 Clock pin is 13

getth:
gosub select
shiftout  12, 13, lsbfirst, [170]  'ask for data
shiftin   12, 13, lsbpre, [t]      'read data
gosub deselect
return



' Subroutine gettl
' This reads a value from a thermometer (0-3)
' This requires variable t and the nthm
' t is the temperature value read
' nthm is the number of the thermometer
' DS1620 Data pin is 10
' DS1620 Clock pin is 11

gettl:
gosub select
shiftout  10, 11, lsbfirst, [170]  'ask for data
shiftin   10, 11, lsbpre, [t]      'read data
gosub deselect
return



' Subroutine lcdtime
' This outputs the time point to the LCD
' This requires variable x
' x is the time point your measurement is on (0-500)
```

```
lcdtime:
lcdout 0, 128, [dec3 x]
return



' Subroutine lcddata
' This outputs the temperature to the LCD
' This requires variable t and the nthm
' t is the temperature value written
' nthm is the number of the thermometer
' Temporary variable j is also used
' Temporary variable k is also used

lcddata:
k= nthm
j= 128      ' starting position of the first line
if nthm<4 then thrmspc
   j= 192   ' starting position of the second line
   k= nthm -4  'the k'th data online
thrmspc:
k=k*3    '3 digits per thermometer
j=j+5+k  '+5 from beginning of the line
lcdout 0, j, [dec2 t]
return



' Subroutine innit
' This initializes all the chips

innit:
' This is the LCD display initialization
pause 1000
lcdcmd 0, %00110000    ' 1st wake up
pause 10
lcdcmd 0, %00110000    ' 2nd wake up
pause 1
lcdcmd 0, %00110000    ' 3rd wake up
pause 1
lcdcmd 0, %00100000    ' 4 bit data bus
pause 1
lcdcmd 0, %00001100    ' display on, no cursor or blink
pause 1
lcdcmd 0, %00101100    ' 2 display lines, 5x10 font
pause 1
lcdcmd 0, %00000001    ' clear display, move cursor home

' This is the thermometer innitialization
for nthm=0 to 3
   gosub select
   shiftout  10, 11, lsbfirst, [238]  'start taking temperature
next
for nthm=4 to 7
   gosub select
   shiftout  12, 13, lsbfirst, [238]  'start taking temperature
next
gosub deselect
pause 2000               ' wait for first temp reading

' Innitialize plot software
debug "!RSET",cr          ' reset the plot
debug "!Plot on",cr
debug "!TITL 8 Thermometer Plot",cr
debug "!YLBL Temp = degree C", cr
debug "!XLBL Minutes", cr
debug "!AMAX 40",cr       ' maximum y value
debug "!AMIN 10",cr       ' minimum y value
debug "!TDIV 60",cr       ' time in minutes
```

```
debug "!TMAX 125",cr      ' maximum x value
debug "!COLR G9",cr       ' change grid color
debug "!PNTS 5000",cr     ' 5000 data points max
debug "!HISS",cr          ' historical data format

no_write = 1              ' default is no write to mem
addr = 0                  ' start at mem address 0

return
end
```

Procedure

1. Position the thermometer apparatus, set switches to 00
2. start fire in the fireplace
3. set switches to 10, hit reset (starts taking measurements)
4. on measurement 175, turn on heat exchanger
5. on measurement 350, turn on ceiling fan
6. set switches on 00 disconnect power
7. take memory to PC, connect cable
8. set switches to 01, press connect on Stamplot Pro
   (this transfers the measurements to the PC)
9. save data to a file, copy plot to report

Repeat above procedure for both the horizontal and vertical positions.

Figure 20.

Horizontal position

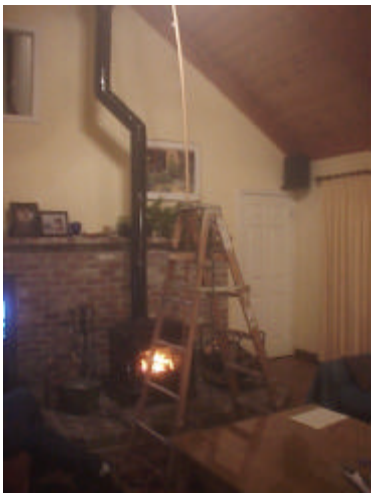


Figure 21.

First Vertical position

Results

For the first experiment, the apparatus was positioned horizontally with thermometer 0 closest to the furnace.

Figure 22. First Experiment Activity

Time Point	Minutes	Activity
0	0	Started measurements and the fire
137	34.5	Put another log in the fire
175	44	Turned on the Heat Exchanger fan
223	56	Put another log in the fire
343	86	Put in another log in the fire
352	88.25	Turned on the Ceiling Fan
420	105.25	Put another log in the fire
472	118.25	Pushed all the wood together

Figure 23. The Graph of the Horizontal Position Measurements

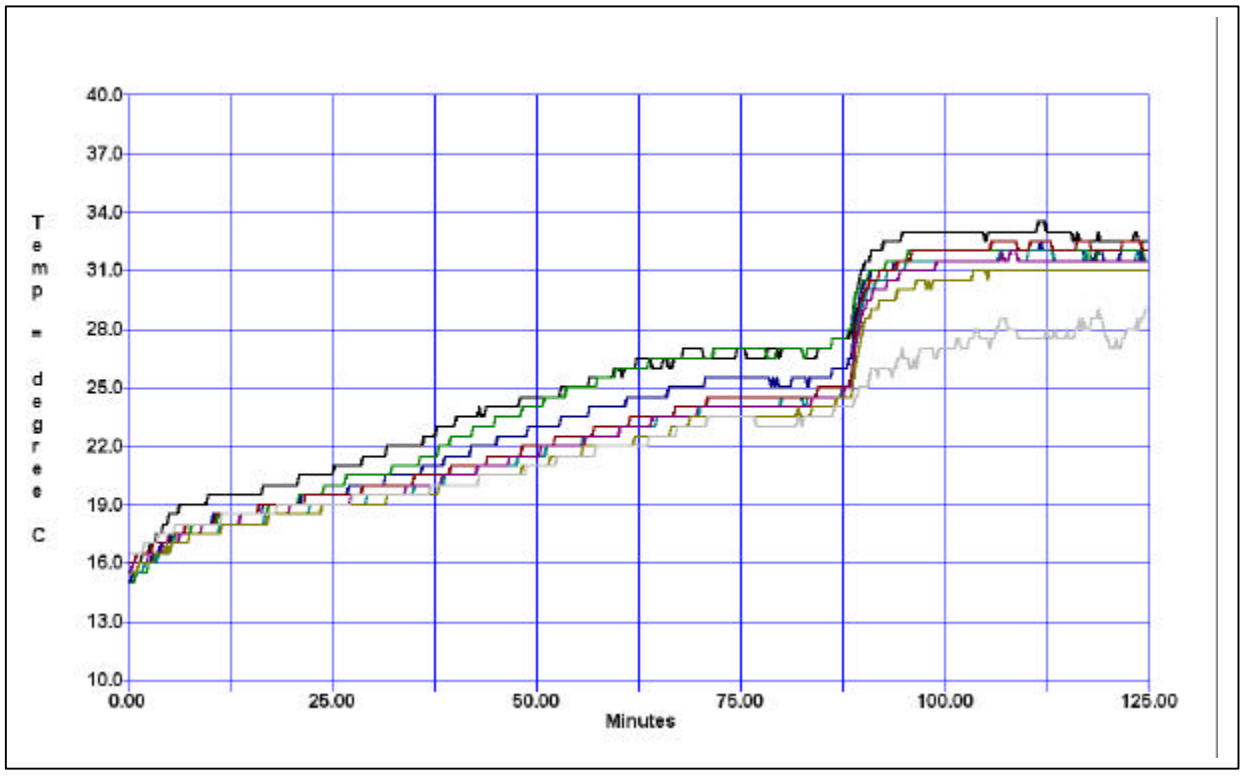


Figure 24.

Plot Color Legend

Thermometer	Color	Thermometer	Color
0	Black	4	Dark Red
1	Dark Blue	5	Purple
2	Dark Green	6	Gold
3	Turquoise	7	Grey

Figure 25.
Horizontal run results. Time is in minutes. Temperature is in Celsius.

x	time	thermometers 0,1,2,3,4,5,6,7
000	0.25	15.5, 15, 15, 15.5, 16, 15.5, 15.5, 16.5
001	0.50	16, 15.5, 15, 15.5, 16, 16, 15.5, 16.5
002	0.75	16, 15.5, 15, 15.5, 16, 16, 15.5, 16.5
003	1.00	16, 15.5, 15.5, 15.5, 16.5, 16, 15.5, 16.5
004	1.25	16, 15.5, 15.5, 15.5, 16.5, 16, 16, 16.5
005	1.50	16, 15.5, 15.5, 15.5, 16.5, 16, 16, 16.5
006	1.75	16.5, 15.5, 15.5, 15.5, 16.5, 16, 16, 16.5
007	2.00	16.5, 16, 15.5, 16, 16.5, 16, 16, 17
008	2.25	16.5, 16, 15.5, 16, 16.5, 16, 16, 17
009	2.50	16.5, 16, 16, 16, 16.5, 16.5, 16, 17
010	2.75	17, 16, 16, 16, 16.5, 16.5, 16, 17
011	3.00	17, 16.5, 16, 16, 17, 16.5, 16, 17
012	3.25	17, 16.5, 16, 16, 17, 16.5, 16.5, 17
013	3.50	17.5, 16.5, 16.5, 16, 17, 16.5, 16.5, 17
014	3.75	17.5, 16.5, 16.5, 16.5, 17, 16.5, 16.5, 17.5
015	4.00	17.5, 17, 16.5, 16.5, 17, 16.5, 16.5, 17.5
016	4.25	18, 17, 16.5, 16.5, 17, 17, 16.5, 17.5
017	4.50	18, 17, 16.5, 16.5, 17, 17, 16.5, 17.5
018	4.75	18, 17, 17, 16.5, 17, 17, 17, 17.5
019	5.00	18.5, 17, 17, 16.5, 17.5, 17, 16.5, 17.5
020	5.25	18.5, 17.5, 17, 17, 17.5, 17, 17, 17.5
021	5.50	18.5, 17.5, 17, 17, 17.5, 17, 17, 17.5
022	5.75	18.5, 17.5, 17.5, 17, 17.5, 17, 17, 18
023	6.00	18.5, 17.5, 17.5, 17, 17.5, 17, 17, 18
024	6.25	19, 17.5, 17.5, 17, 17.5, 17.5, 17, 18
025	6.50	19, 17.5, 17.5, 17, 17.5, 17.5, 17, 18
026	6.75	19, 17.5, 17.5, 17, 17.5, 17.5, 17, 18
027	7.00	19, 18, 17.5, 17, 18, 17.5, 17, 18
028	7.25	19, 18, 17.5, 17, 18, 17.5, 17, 18
029	7.50	19, 18, 17.5, 17.5, 18, 17.5, 17.5, 18
030	7.75	19, 18, 18, 17.5, 18, 17.5, 17.5, 18
031	8.00	19, 18, 18, 17.5, 18, 17.5, 17.5, 18

032	8.25	19,	18,	18,	17.5,	18,	17.5,	17.5,	18
033	8.50	19,	18,	18,	17.5,	18,	17.5,	17.5,	18
034	8.75	19,	18,	18,	17.5,	18,	17.5,	17.5,	18
035	9.00	19,	18,	18,	17.5,	18,	18,	17.5,	18
036	9.25	19,	18,	18,	17.5,	18,	18,	17.5,	18
037	9.50	19,	18,	18,	17.5,	18,	18,	17.5,	18
038	9.75	19.5,	18,	18,	17.5,	18,	18,	17.5,	18
039	10.00	19.5,	18,	18,	17.5,	18,	18,	17.5,	18
040	10.25	19.5,	18,	18,	17.5,	18,	18,	17.5,	18
041	10.50	19.5,	18.5,	18,	17.5,	18,	18,	17.5,	18
042	10.75	19.5,	18.5,	18,	17.5,	18.5,	18,	17.5,	18
043	11.00	19.5,	18.5,	18.5,	17.5,	18.5,	18,	17.5,	18
044	11.25	19.5,	18.5,	18.5,	18,	18.5,	18,	17.5,	18
045	11.50	19.5,	18.5,	18.5,	18,	18.5,	18,	18,	18.5
046	11.75	19.5,	18.5,	18.5,	18,	18.5,	18,	18,	18.5
047	12.00	19.5,	18.5,	18.5,	18,	18.5,	18,	18,	18.5
048	12.25	19.5,	18.5,	18.5,	18,	18.5,	18,	18,	18.5
049	12.50	19.5,	18.5,	18.5,	18,	18.5,	18,	18,	18.5
050	12.75	19.5,	18.5,	18.5,	18,	18.5,	18,	18,	18.5
051	13.00	19.5,	18.5,	18.5,	18,	18.5,	18,	18,	18.5
052	13.25	19.5,	18.5,	18.5,	18,	18.5,	18,	18,	18.5
053	13.50	19.5,	18.5,	18.5,	18,	18.5,	18,	18,	18.5
054	13.75	19.5,	18.5,	18.5,	18,	18.5,	18.5,	18,	18.5
055	14.00	19.5,	18.5,	18.5,	18,	18.5,	18.5,	18,	18.5
056	14.25	19.5,	18.5,	18.5,	18,	18.5,	18.5,	18,	18.5
057	14.50	19.5,	18.5,	18.5,	18,	18.5,	18.5,	18,	18.5
058	14.75	19.5,	18.5,	18.5,	18,	18.5,	18.5,	18,	18.5
059	15.00	19.5,	18.5,	18.5,	18,	18.5,	18.5,	18,	18.5
060	15.25	19.5,	18.5,	18.5,	18,	18.5,	18.5,	18,	18.5
061	15.50	19.5,	18.5,	18.5,	18,	18.5,	18.5,	18,	18.5
062	15.75	19.5,	18.5,	18.5,	18,	18.5,	18.5,	18,	18.5
063	16.00	19.5,	18.5,	18.5,	18,	19,	18.5,	18,	18.5
064	16.25	19.5,	18.5,	18.5,	18,	19,	18.5,	18,	18.5
065	16.50	20,	19,	18.5,	18,	19,	18.5,	18,	18.5
066	16.75	20,	19,	18.5,	18.5,	19,	18.5,	18,	18.5
067	17.00	20,	19,	18.5,	18.5,	19,	18.5,	18,	18.5
068	17.25	20,	19,	19,	18.5,	19,	18.5,	18.5,	18.5
069	17.50	20,	19,	19,	18.5,	19,	18.5,	18.5,	18.5
070	17.75	20,	19,	19,	18.5,	19,	18.5,	18.5,	18.5
071	18.00	20,	19,	19,	18.5,	19,	18.5,	18.5,	18.5
072	18.25	20,	19,	19,	18.5,	19,	18.5,	18.5,	19
073	18.50	20,	19,	19,	18.5,	19,	18.5,	18.5,	19
074	18.75	20,	19,	19,	18.5,	19,	18.5,	18.5,	19
075	19.00	20,	19,	19,	18.5,	19,	18.5,	18.5,	19
076	19.25	20,	19,	19,	18.5,	19,	18.5,	18.5,	19
077	19.50	20,	19,	19,	18.5,	19,	18.5,	18.5,	19

078	19.75	20,	19,	19,	18.5,	19,	19,	18.5,	19
079	20.00	20,	19,	19,	18.5,	19,	19,	18.5,	19
080	20.25	20,	19,	19,	18.5,	19,	19,	18.5,	19
081	20.50	20,	19,	19,	18.5,	19,	19,	18.5,	19
082	20.75	20,	19,	19,	18.5,	19,	19,	18.5,	19
083	21.00	20.5,	19,	19.5,	18.5,	19,	19,	18.5,	19
084	21.25	20.5,	19.5,	19.5,	18.5,	19,	19,	18.5,	19
085	21.50	20.5,	19.5,	19.5,	18.5,	19,	19,	18.5,	19
086	21.75	20.5,	19.5,	19.5,	18.5,	19.5,	19,	18.5,	19
087	22.00	20.5,	19.5,	19.5,	18.5,	19.5,	19,	18.5,	19
088	22.25	20.5,	19.5,	19.5,	19,	19.5,	19,	18.5,	19
089	22.50	20.5,	19.5,	19.5,	19,	19.5,	19,	18.5,	19
090	22.75	20.5,	19.5,	19.5,	19,	19.5,	19,	18.5,	19
091	23.00	20.5,	19.5,	19.5,	19,	19.5,	19,	18.5,	19
092	23.25	20.5,	19.5,	19.5,	19,	19.5,	19,	18.5,	19
093	23.50	20.5,	19.5,	19.5,	19,	19.5,	19,	18.5,	19
094	23.75	20.5,	19.5,	19.5,	19,	19.5,	19,	19,	19
095	24.00	20.5,	19.5,	20,	19,	19.5,	19,	19,	19
096	24.25	20.5,	19.5,	20,	19,	19.5,	19,	19,	19
097	24.50	20.5,	19.5,	20,	19,	19.5,	19,	19,	19
098	24.75	20.5,	19.5,	20,	19,	19.5,	19,	19,	19
099	25.00	20.5,	19.5,	20,	19,	19.5,	19,	19,	19
100	25.25	21,	19.5,	20,	19,	19.5,	19,	19,	19
101	25.50	21,	19.5,	20,	19,	19.5,	19,	19,	19
102	25.75	21,	19.5,	20,	19,	19.5,	19,	19,	19
103	26.00	21,	19.5,	20,	19,	19.5,	19,	19,	19
104	26.25	21,	19.5,	20,	19,	19.5,	19,	19,	19
105	26.50	21,	19.5,	20,	19,	19.5,	19,	19,	19
106	26.75	21,	19.5,	20.5,	19,	19.5,	19,	19,	19
107	27.00	21,	20,	20.5,	19,	19.5,	19,	19,	19
108	27.25	21,	20,	20.5,	19,	19.5,	19.5,	19,	19
109	27.50	21,	20,	20.5,	19,	19.5,	19.5,	19,	19.5
110	27.75	21,	20,	20.5,	19,	19.5,	19.5,	19,	19.5
111	28.00	21,	20,	20.5,	19,	19.5,	19.5,	19,	19.5
112	28.25	21,	20,	20.5,	19,	19.5,	19.5,	19,	19.5
113	28.50	21,	20,	20.5,	19,	19.5,	19.5,	19,	19.5
114	28.75	21.5,	20,	20.5,	19,	20,	19.5,	19,	19.5
115	29.00	21.5,	20,	20.5,	19,	20,	19.5,	19,	19.5
116	29.25	21.5,	20,	20.5,	19.5,	20,	19.5,	19,	19.5
117	29.50	21.5,	20,	20.5,	19.5,	20,	19.5,	19,	19.5
118	29.75	21.5,	20,	20.5,	19.5,	20,	19.5,	19,	19.5
119	30.00	21.5,	20,	20.5,	19.5,	20,	19.5,	19,	19.5
120	30.25	21.5,	20,	20.5,	19.5,	20,	19.5,	19,	19.5
121	30.50	21.5,	20,	20.5,	19.5,	20,	19.5,	19,	19.5
122	30.75	21.5,	20,	20.5,	19.5,	20,	19.5,	19,	19.5
123	31.00	21.5,	20,	20.5,	19.5,	20,	19.5,	19,	19.5

124	31.25	21.5,	20,	20.5,	19.5,	20,	19.5,	19,	19.5
125	31.50	21.5,	20.5,	20.5,	19.5,	20,	19.5,	19,	19.5
126	31.75	22,	20.5,	20.5,	19.5,	20,	19.5,	19.5,	19.5
127	32.00	22,	20.5,	20.5,	19.5,	20,	19.5,	19.5,	19.5
128	32.25	22,	20.5,	21,	19.5,	20,	19.5,	19.5,	19.5
129	32.50	22,	20.5,	21,	19.5,	20,	19.5,	19.5,	19.5
130	32.75	22,	20.5,	21,	19.5,	20,	19.5,	19.5,	19.5
131	33.00	22,	20.5,	21,	19.5,	20,	19.5,	19.5,	19.5
132	33.25	22,	20.5,	21,	19.5,	20,	19.5,	19.5,	19.5
133	33.50	22,	20.5,	21,	19.5,	20,	19.5,	19.5,	19.5
134	33.75	22,	20.5,	21,	19.5,	20,	19.5,	19.5,	19.5
135	34.00	22,	20.5,	21,	19.5,	20,	20,	19.5,	19.5
136	34.25	22,	20.5,	21,	19.5,	20,	20,	19.5,	19.5
137	34.50	22,	20.5,	21,	19.5,	20,	20,	19.5,	19.5
138	34.75	22,	20.5,	21,	19.5,	20,	20,	19.5,	19.5
139	35.00	22,	20.5,	21,	20,	20.5,	20,	19.5,	19.5
140	35.25	22,	20.5,	21,	20,	20.5,	20,	19.5,	19.5
141	35.50	22,	20.5,	21,	20,	20.5,	20,	19.5,	19.5
142	35.75	22,	20.5,	21.5,	20,	20.5,	20,	19.5,	19.5
143	36.00	22,	21,	21.5,	20,	20.5,	20,	19.5,	19.5
144	36.25	22.5,	21,	21.5,	20,	20.5,	20,	19.5,	19.5
145	36.50	22.5,	21,	21.5,	20,	20.5,	20,	19.5,	19.5
146	36.75	22.5,	21,	21.5,	20,	20.5,	20,	19.5,	19.5
147	37.00	22.5,	21,	21.5,	20,	20.5,	20,	19.5,	20
148	37.25	22.5,	21,	21.5,	20,	20.5,	20,	19.5,	20
149	37.50	22.5,	21,	21.5,	20,	20.5,	20,	19.5,	20
150	37.75	23,	21,	21.5,	20,	20.5,	20,	19.5,	20
151	38.00	23,	21,	22,	20,	20.5,	20,	20,	20
152	38.25	23,	21,	22,	20,	20.5,	20,	20,	20
153	38.50	23,	21,	22,	20,	20.5,	20.5,	20,	20
154	38.75	23,	21.5,	22,	20.5,	20.5,	20.5,	20,	20
155	39.00	23,	21.5,	22,	20.5,	20.5,	20.5,	20,	20
156	39.25	23,	21.5,	22,	20.5,	20.5,	20.5,	20,	20
157	39.50	23,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
158	39.75	23,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
159	40.00	23,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
160	40.25	23.5,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
161	40.50	23.5,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
162	40.75	23.5,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
163	41.00	23.5,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
164	41.25	23.5,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
165	41.50	23.5,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
166	41.75	23.5,	21.5,	22.5,	20.5,	21,	20.5,	20,	20
167	42.00	23.5,	22,	22.5,	20.5,	21,	20.5,	20,	20
168	42.25	23.5,	22,	23,	20.5,	21,	20.5,	20,	20
169	42.50	23.5,	22,	23,	20.5,	21,	20.5,	20,	20

170	42.75	23.5, 22, 23, 21, 21, 21, 20, 20
171	43.00	24, 22, 23, 21, 21, 21, 20.5, 20.5
172	43.25	23.5, 22, 23, 21, 21, 21, 20.5, 20.5
173	43.50	23.5, 22, 23, 21, 21, 21, 20.5, 20.5
174	43.75	24, 22, 23, 21, 21, 21, 20.5, 20.5
175	44.00	24, 22, 23, 21, 21.5, 21, 20.5, 20.5
176	44.25	24, 22, 23, 21, 21.5, 21, 20.5, 20.5
177	44.50	24, 22, 23, 21, 21.5, 21, 20.5, 20.5
178	44.75	24, 22, 23, 21, 21.5, 21, 20.5, 20.5
179	45.00	24, 22, 23.5, 21, 21.5, 21, 20.5, 20.5
180	45.25	24, 22.5, 23.5, 21, 21.5, 21, 20.5, 20.5
181	45.50	24, 22.5, 23.5, 21, 21.5, 21, 20.5, 20.5
182	45.75	24, 22.5, 23.5, 21, 21.5, 21, 20.5, 20.5
183	46.00	24, 22.5, 23.5, 21, 21.5, 21, 20.5, 20.5
184	46.25	24, 22.5, 23.5, 21, 21.5, 21, 20.5, 20.5
185	46.50	24, 22.5, 23.5, 21, 21.5, 21, 20.5, 20.5
186	46.75	24, 22.5, 23.5, 21, 21.5, 21.5, 20.5, 20.5
187	47.00	24, 22.5, 23.5, 21, 21.5, 21.5, 20.5, 20.5
188	47.25	24, 22.5, 23.5, 21, 21.5, 21.5, 20.5, 20.5
189	47.50	24, 22.5, 23.5, 21, 21.5, 21.5, 20.5, 20.5
190	47.75	24, 22.5, 23.5, 21.5, 21.5, 21.5, 20.5, 20.5
191	48.00	24.5, 22.5, 23.5, 21.5, 21.5, 21.5, 20.5, 20.5
192	48.25	24.5, 22.5, 24, 21.5, 22, 21.5, 21, 20.5
193	48.50	24.5, 22.5, 24, 21.5, 22, 21.5, 21, 20.5
194	48.75	24.5, 22.5, 24, 21.5, 22, 21.5, 21, 21
195	49.00	24.5, 23, 24, 21.5, 22, 21.5, 21, 21
196	49.25	24.5, 23, 24, 21.5, 22, 21.5, 21, 21
197	49.50	24.5, 23, 24, 21.5, 22, 21.5, 21, 21
198	49.75	24.5, 23, 24, 21.5, 22, 21.5, 21, 21
199	50.00	24.5, 23, 24, 21.5, 22, 21.5, 21, 21
200	50.25	24.5, 23, 24, 21.5, 22, 21.5, 21, 21
201	50.50	24.5, 23, 24, 21.5, 22, 22, 21, 21
202	50.75	24.5, 23, 24, 21.5, 22, 22, 21, 21
203	51.00	24.5, 23, 24.5, 21.5, 22, 22, 21, 21
204	51.25	24.5, 23, 24.5, 22, 22, 22, 21, 21
205	51.50	24.5, 23, 24.5, 22, 22, 22, 21, 21
206	51.75	24.5, 23, 24.5, 22, 22, 22, 21.5, 21
207	52.00	24.5, 23, 24.5, 22, 22, 22, 21.5, 21
208	52.25	24.5, 23, 24.5, 22, 22.5, 22, 21.5, 21
209	52.50	24.5, 23, 24.5, 22, 22.5, 22, 21.5, 21.5
210	52.75	24.5, 23, 24.5, 22, 22.5, 22, 21.5, 21.5
211	53.00	25, 23.5, 24.5, 22, 22.5, 22, 21.5, 21.5
212	53.25	25, 23.5, 24.5, 22, 22.5, 22, 21.5, 21.5
213	53.50	25, 23.5, 24.5, 22, 22.5, 22, 21.5, 21.5
214	53.75	25, 23.5, 25, 22, 22.5, 22, 21.5, 21.5
215	54.00	25, 23.5, 25, 22, 22.5, 22, 21.5, 21.5

216	54.25	25,	23.5,	25,	22,	22.5,	22,	21.5,	21.5
217	54.50	25,	23.5,	25,	22,	22.5,	22,	21.5,	21.5
218	54.75	25,	23.5,	25,	22,	22.5,	22,	21.5,	21.5
219	55.00	25,	23.5,	25,	22,	22.5,	22,	21.5,	21.5
220	55.25	25,	23.5,	25,	22,	22.5,	22,	21.5,	21.5
221	55.50	25,	23.5,	25,	22,	22.5,	22,	21.5,	21.5
222	55.75	25,	23.5,	25,	22.5,	22.5,	22,	22,	21.5
223	56.00	25,	23.5,	25,	22.5,	22.5,	22.5,	22,	21.5
224	56.25	25,	23.5,	25,	22.5,	22.5,	22.5,	22,	21.5
225	56.50	25.5,	24,	25,	22.5,	22.5,	22.5,	22,	21.5
226	56.75	25.5,	24,	25,	22.5,	22.5,	22.5,	22,	21.5
227	57.00	25.5,	24,	25,	22.5,	23,	22.5,	22,	21.5
228	57.25	25.5,	24,	25,	22.5,	23,	22.5,	22,	22
229	57.50	25.5,	24,	25.5,	22.5,	23,	22.5,	22,	22
230	57.75	25.5,	24,	25.5,	22.5,	23,	22.5,	22,	22
231	58.00	25.5,	24,	25.5,	22.5,	23,	22.5,	22,	22
232	58.25	25.5,	24,	25.5,	22.5,	23,	22.5,	22,	22
233	58.50	25.5,	24,	25.5,	22.5,	23,	22.5,	22,	22
234	58.75	25.5,	24,	25.5,	22.5,	23,	22.5,	22,	22
235	59.00	25.5,	24,	25.5,	22.5,	23,	22.5,	22,	22
236	59.25	25.5,	24,	25.5,	22.5,	23,	22.5,	22,	22
237	59.50	26,	24,	25.5,	22.5,	23,	22.5,	22,	22
238	59.75	26,	24,	26,	22.5,	23,	22.5,	22,	22
239	60.00	26,	24,	26,	22.5,	23,	22.5,	22,	22
240	60.25	26,	24,	26,	23,	23,	23,	22,	22
241	60.50	25.5,	24,	26,	23,	23,	23,	22,	22
242	60.75	26,	24,	26,	23,	23,	23,	22,	22
243	61.00	26,	24.5,	26,	23,	23,	23,	22,	22
244	61.25	26,	24.5,	26,	23,	23,	23,	22,	22
245	61.50	26,	24.5,	26,	23,	23.5,	23,	22,	22
246	61.75	26,	24.5,	26,	23,	23.5,	23,	22,	22
247	62.00	26,	24.5,	26,	23,	23.5,	23,	22.5,	22
248	62.25	26.5,	24.5,	26,	23,	23.5,	23,	22.5,	22
249	62.50	26.5,	24.5,	26,	23,	23.5,	23,	22.5,	22
250	62.75	26.5,	24.5,	26,	23,	23.5,	23,	22.5,	22
251	63.00	26.5,	24.5,	26,	23,	23.5,	23,	22.5,	22
252	63.25	26.5,	24.5,	26,	23,	23.5,	23,	22.5,	22
253	63.50	26.5,	24.5,	26,	23,	23.5,	23,	22.5,	22
254	63.75	26.5,	24.5,	26.5,	23,	23.5,	23,	22.5,	22.5
255	64.00	26.5,	24.5,	26.5,	23,	23.5,	23,	22.5,	22.5
256	64.25	26,	24.5,	26.5,	23,	23.5,	23.5,	22.5,	22.5
257	64.50	26,	24.5,	26.5,	23,	23.5,	23.5,	22.5,	22.5
258	64.75	26,	24.5,	26.5,	23.5,	23.5,	23.5,	22.5,	22.5
259	65.00	26,	24.5,	26.5,	23.5,	23.5,	23.5,	22.5,	22.5
260	65.25	26,	24.5,	26.5,	23.5,	23.5,	23.5,	22.5,	22.5
261	65.50	26.5,	24.5,	26.5,	23.5,	23.5,	23.5,	22.5,	22.5

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263	66.00	26.5, 24.5, 26.5, 23.5, 23.5, 23.5, 22.5, 22.5
264	66.25	26, 25, 26.5, 23.5, 23.5, 23.5, 22.5, 22.5
265	66.50	26, 25, 26.5, 23.5, 23.5, 23.5, 23, 22.5
266	66.75	26.5, 25, 26.5, 23.5, 23.5, 23.5, 23, 22.5
267	67.00	26.5, 25, 26.5, 23.5, 24, 23.5, 23, 22.5
268	67.25	26.5, 25, 26.5, 23.5, 24, 23.5, 23, 23
269	67.50	26.5, 25, 26.5, 23.5, 24, 23.5, 23, 23
270	67.75	26.5, 25, 26.5, 23.5, 24, 23.5, 23, 23
271	68.00	27, 25, 26.5, 23.5, 24, 23.5, 23, 23
272	68.25	27, 25, 26.5, 23.5, 24, 23.5, 23, 23
273	68.50	27, 25, 26.5, 23.5, 24, 23.5, 23, 23
274	68.75	27, 25, 26.5, 23.5, 24, 23.5, 23.5, 23
275	69.00	27, 25, 26.5, 23.5, 24, 23.5, 23.5, 23
276	69.25	27, 25, 26.5, 23.5, 24, 23.5, 23.5, 23
277	69.50	27, 25, 26.5, 23.5, 24, 23.5, 23.5, 23
278	69.75	27, 25, 26.5, 23.5, 24, 24, 23.5, 23
279	70.00	27, 25, 26.5, 24, 24, 24, 23.5, 23
280	70.25	27, 25, 26.5, 24, 24, 24, 23.5, 23
281	70.50	26.5, 25, 26.5, 24, 24, 24, 23.5, 23
282	70.75	26.5, 25.5, 26.5, 24, 24, 24, 23.5, 23
283	71.00	26.5, 25.5, 26.5, 24, 24.5, 24, 23.5, 23.5
284	71.25	26.5, 25.5, 26.5, 24, 24.5, 24, 23.5, 23.5
285	71.50	26.5, 25.5, 26.5, 24, 24.5, 24, 23.5, 23.5
286	71.75	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
287	72.00	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
288	72.25	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
289	72.50	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
290	72.75	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
291	73.00	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
292	73.25	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
293	73.50	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
294	73.75	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
295	74.00	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
296	74.25	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
297	74.50	27, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
298	74.75	27, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
299	75.00	27, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
300	75.25	27, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
301	75.50	27, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
302	75.75	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
303	76.00	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
304	76.25	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
305	76.50	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
306	76.75	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23.5
307	77.00	26.5, 25.5, 27, 24, 24.5, 24, 23.5, 23

308	77.25	26.5,	25.5,	27,	24,	24.5,	24,	23.5,	23				
309	77.50	26.5,	25.5,	27,	24,	24.5,	24,	23.5,	23				
310	77.75	26.5,	25.5,	27,	24,	24.5,	24,	23.5,	23				
311	78.00	26.5,	25.5,	27,	24,	24.5,	24,	23.5,	23				
312	78.25	27,	25.5,	26.5,	24,	24.5,	24,	23.5,	23				
313	78.50	27,	25.5,	26.5,	24,	24.5,	24,	23.5,	23				
314	78.75	27,	25,	26.5,	24,	24.5,	24,	23.5,	23				
315	79.00	27,	25.5,	26.5,	24,	24.5,	24,	23.5,	23				
316	79.25	27,	25,	26.5,	24,	24.5,	24,	23.5,	23				
317	79.50	27,	25.5,	27,	24,	24.5,	24,	23.5,	23				
318	79.75	26.5,	25,	27,	24,	24.5,	24,	23.5,	23				
319	80.00	27,	25,	27,	24.5,	24.5,	24,	23.5,	23				
320	80.25	27,	25,	27,	24.5,	24.5,	24,	23.5,	23				
321	80.50	27,	25,	27,	24.5,	24.5,	24,	23.5,	23				
322	80.75	27,	25,	27,	24.5,	24.5,	24,	23.5,	23				
323	81.00	27,	25,	27,	24.5,	24.5,	24,	23.5,	23				
324	81.25	27,	25.5,	27,	24.5,	24.5,	24,	23.5,	23				
325	81.50	27,	25.5,	27,	24.5,	24.5,	24,	23.5,	23				
326	81.75	27,	25.5,	27,	24.5,	24.5,	24,	23.5,	23				
327	82.00	27,	25.5,	27,	24.5,	24.5,	24,	24,	23.5				
328	82.25	27,	25.5,	27,	24.5,	24.5,	24,	23.5,	23.5				
329	82.50	27,	25.5,	27,	24.5,	24.5,	24,	23.5,	23				
330	82.75	26.5,	25.5,	26.5,	24,	24.5,	24,	23.5,	23.5				
331	83.00	26.5,	25.5,	26.5,	24,	24.5,	24,	23.5,	23.5				
332	83.25	26.5,	25,	27,	24.5,	24.5,	24,	23.5,	23.5				
333	83.50	26.5,	25.5,	27,	24.5,	24.5,	24,	23.5,	23.5				
334	83.75	26.5,	25.5,	27,	24.5,	24.5,	24.5,	24,	23.5				
335	84.00	26.5,	25.5,	27,	24.5,	24.5,	24.5,	24,	23.5				
336	84.25	26.5,	25.5,	27,	24.5,	24.5,	24.5,	24,	23.5				
337	84.50	27,	25.5,	27,	24.5,	25,	24.5,	24,	23.5				
338	84.75	27,	25.5,	27,	24.5,	25,	24.5,	24,	23.5				
339	85.00	27,	25.5,	27,	24.5,	25,	24.5,	24,	23.5				
340	85.25	27,	25.5,	27,	24.5,	25,	24.5,	24,	23.5				
341	85.50	27,	25.5,	27,	24.5,	25,	24.5,	24,	23.5				
342	85.75	27,	25.5,	27,	24.5,	25,	24.5,	24,	23.5				
343	86.00	27,	25.5,	27,	24.5,	25,	24.5,	24,	23.5				
344	86.25	27.5,	26,	27.5,	24.5,	25,	24.5,	24,	23.5				
345	86.50	27.5,	26,	27.5,	24.5,	25,	24.5,	24,	24				
346	86.75	27.5,	26,	27.5,	24.5,	25,	24.5,	24.5,	24				
347	87.00	27.5,	26,	27.5,	24.5,	25,	24.5,	24.5,	24				
348	87.25	27.5,	26,	27.5,	24.5,	25,	24.5,	24.5,	24				
349	87.50	27.5,	26,	27.5,	25,	25,	24.5,	24.5,	24				
350	87.75	27.5,	26,	27.5,	25,	25,	25,	24.5,	24				
351	88.00	27.5,	26,	27.5,	25,	25,	25,	24.5,	24				
352	88.25	27.5,	26.5,	28,	25,	25,	25,	24.5,	24				
353	88.50	28,	26.5,	28,	25,	25.5,	25,	24.5,	24				

354	88.75	29, 27.5, 28.5, 26, 26.5, 25.5, 25, 24
355	89.00	29.5, 28.5, 29.5, 27, 27.5, 27, 26, 24.5
356	89.25	30, 29, 30, 28, 28.5, 27.5, 26.5, 24.5
357	89.50	30.5, 29.5, 30, 28.5, 29, 28, 27, 25
358	89.75	31, 30, 30, 29, 29.5, 28.5, 27.5, 25
359	90.00	31, 30, 30.5, 29.5, 29.5, 29, 28, 25
360	90.25	31.5, 30.5, 30.5, 29.5, 30, 29, 28.5, 25
361	90.50	31.5, 30.5, 30.5, 30, 30, 29.5, 28.5, 25
362	90.75	31.5, 30.5, 31, 30, 30.5, 29.5, 28.5, 25.5
363	91.00	32, 31, 31, 30, 30.5, 29.5, 29, 26
364	91.25	32, 31, 31, 30, 30.5, 30, 29, 26
365	91.50	32, 31, 31, 30.5, 30.5, 30, 29, 26
366	91.75	32, 31, 31, 30.5, 30.5, 30, 29, 25.5
367	92.00	32, 31, 31, 30.5, 31, 30, 29.5, 26
368	92.25	32, 31, 31, 30.5, 31, 30, 29.5, 26
369	92.50	32.5, 31, 31, 30.5, 31, 30, 29.5, 26
370	92.75	32.5, 31, 31.5, 30.5, 31, 30, 29.5, 26
371	93.00	32.5, 31, 31.5, 31, 31, 30.5, 29.5, 26
372	93.25	32.5, 31, 31.5, 31, 31, 30.5, 29.5, 26
373	93.50	32.5, 31, 31.5, 31, 31, 30.5, 29.5, 25.5
374	93.75	32.5, 31.5, 31.5, 31, 31, 30.5, 29.5, 26
375	94.00	32.5, 31.5, 31.5, 31, 31, 30.5, 29.5, 26
376	94.25	32.5, 31.5, 31.5, 31, 31.5, 30.5, 30, 26.5
377	94.50	32.5, 31.5, 31.5, 31, 31.5, 31, 30, 26.5
378	94.75	33, 31.5, 31.5, 31, 31.5, 31, 30, 27
379	95.00	33, 31.5, 31.5, 31, 31.5, 31, 30, 26.5
380	95.25	33, 31.5, 31.5, 31.5, 31.5, 31, 30, 26.5
381	95.50	33, 32, 32, 31.5, 31.5, 31, 30, 26.5
382	95.75	33, 32, 32, 31.5, 31.5, 31, 30, 26
383	96.00	33, 32, 32, 31.5, 32, 31, 30, 26
384	96.25	33, 32, 32, 31.5, 32, 31, 30, 26.5
385	96.50	33, 32, 32, 31.5, 32, 31, 30.5, 26
386	96.75	33, 32, 32, 31.5, 32, 31, 30.5, 26.5
387	97.00	33, 32, 32, 31.5, 32, 31, 30.5, 27
388	97.25	33, 32, 32, 31.5, 32, 31, 30.5, 27
389	97.50	33, 32, 32, 31.5, 32, 31, 30.5, 27
390	97.75	33, 32, 32, 31.5, 32, 31, 30, 27
391	98.00	33, 32, 32, 31.5, 32, 31, 30.5, 27
392	98.25	33, 32, 32, 31.5, 32, 31, 30, 27
393	98.50	33, 32, 32, 31.5, 32, 31, 30.5, 27
394	98.75	33, 32, 32, 31.5, 32, 31, 30.5, 26.5
395	99.00	33, 32, 32, 31.5, 32, 31.5, 30.5, 26.5
396	99.25	33, 32, 32, 31.5, 32, 31.5, 30.5, 27
397	99.50	33, 32, 32, 31.5, 32, 31.5, 30.5, 27
398	99.75	33, 32, 32, 31.5, 32, 31.5, 30.5, 27
399	100.00	33, 32, 32, 31.5, 32, 31.5, 30.5, 27

400	100.25	33,	32,	32,	31.5,	32,	31.5,	30.5,	27
401	100.50	33,	32,	32,	31.5,	32,	31.5,	30.5,	27
402	100.75	33,	32,	32,	31.5,	32,	31.5,	30.5,	27
403	101.00	33,	32,	32,	31.5,	32,	31.5,	30.5,	27
404	101.25	33,	32,	32,	31.5,	32,	31.5,	30.5,	27
405	101.50	33,	32,	32,	31.5,	32,	31.5,	30.5,	27.5
406	101.75	33,	32,	32,	31.5,	32,	31.5,	30.5,	27.5
407	102.00	33,	32,	32,	31.5,	32,	31.5,	30.5,	27
408	102.25	33,	32,	32,	31.5,	32,	31.5,	30.5,	27
409	102.50	33,	32,	32,	31.5,	32,	31.5,	30.5,	27
410	102.75	33,	32,	32,	31.5,	32,	31.5,	30.5,	27
411	103.00	33,	32,	32,	31.5,	32,	31.5,	30.5,	27.5
412	103.25	33,	32,	32,	31.5,	32,	31.5,	30.5,	27.5
413	103.50	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
414	103.75	33,	32,	32,	31.5,	32,	31.5,	31,	28
415	104.00	33,	32,	32,	31.5,	32,	31.5,	31,	28
416	104.25	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
417	104.50	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
418	104.75	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
419	105.00	32.5,	32,	32,	31.5,	32,	31.5,	31,	27.5
420	105.25	33,	32,	32,	31.5,	32,	31.5,	30.5,	27.5
421	105.50	33,	32,	32,	31.5,	32,	31.5,	31,	27
422	105.75	33,	32,	32,	31.5,	32.5,	31.5,	31,	27.5
423	106.00	33,	32,	32,	31.5,	32.5,	31.5,	31,	27.5
424	106.25	33,	32,	32,	31.5,	32.5,	31.5,	31,	28
425	106.50	33,	32,	32,	31.5,	32.5,	31.5,	31,	28
426	106.75	33,	32,	32,	32,	32.5,	31.5,	31,	28.5
427	107.00	33,	32,	32,	32,	32.5,	32,	31,	28.5
428	107.25	33,	32,	32,	32,	32.5,	31.5,	31,	28.5
429	107.50	33,	32,	32,	32,	32.5,	31.5,	31,	28.5
430	107.75	33,	32,	32,	32,	32.5,	31.5,	31,	28
431	108.00	33,	32,	32,	32,	32.5,	32,	31,	28
432	108.25	33,	32,	32,	32,	32.5,	32,	31,	28
433	108.50	33,	32,	32,	32,	32.5,	32,	31,	28
434	108.75	33,	32,	32,	32,	32.5,	32,	31,	28
435	109.00	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
436	109.25	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
437	109.50	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
438	109.75	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
439	110.00	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
440	110.25	33,	32,	32,	32,	32,	31.5,	31,	27.5
441	110.50	33,	32,	32,	32,	32.5,	31.5,	31,	27.5
442	110.75	33,	32,	32,	32,	32.5,	31.5,	31,	27.5
443	111.00	33,	32,	32,	32,	32.5,	31.5,	31,	27.5
444	111.25	33,	32,	32,	32,	32.5,	31.5,	31,	27.5
445	111.50	33.5,	32,	32,	32,	32.5,	31.5,	31,	27.5

446	111.75	33.5,	32.5,	32,	32,	32.5,	31.5,	31,	27.5
447	112.00	33.5,	32,	32,	32,	32.5,	31.5,	31,	27.5
448	112.25	33.5,	32,	32,	32,	32.5,	31.5,	31,	27.5
449	112.50	33,	32,	32,	32,	32.5,	31.5,	31,	28
450	112.75	33,	32,	32,	32,	32.5,	31.5,	31,	27.5
451	113.00	33,	32,	32,	32,	32.5,	31.5,	31,	27.5
452	113.25	33,	32,	32,	32,	32,	31.5,	31,	27.5
453	113.50	33,	32,	32,	31.5,	32,	31.5,	31,	28
454	113.75	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
455	114.00	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
456	114.25	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
457	114.50	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
458	114.75	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
459	115.00	33,	32,	32,	31.5,	32,	31.5,	31,	28
460	115.25	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
461	115.50	33,	32,	32,	31.5,	32,	31.5,	31,	27.5
462	115.75	32.5,	32,	32,	31.5,	32,	31.5,	31,	27.5
463	116.00	32.5,	32,	32,	31.5,	32,	31.5,	31,	28
464	116.25	33,	32,	32,	31.5,	32.5,	31.5,	31,	28
465	116.50	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	28.5
466	116.75	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	28
467	117.00	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	28.5
468	117.25	32.5,	31.5,	32,	32,	32.5,	31.5,	31,	28
469	117.50	32.5,	31.5,	32,	31.5,	32.5,	31.5,	31,	28
470	117.75	32.5,	31.5,	32,	31.5,	32.5,	31.5,	31,	28
471	118.00	32.5,	31.5,	31.5,	31.5,	32,	31.5,	31,	28.5
472	118.25	32.5,	31.5,	31.5,	31.5,	32,	31.5,	31,	28.5
473	118.50	32.5,	32,	31.5,	31.5,	32,	31.5,	31,	28.5
474	118.75	33,	32,	32,	31.5,	32,	31.5,	31,	29
475	119.00	32.5,	32,	32,	31.5,	32,	31.5,	31,	28.5
476	119.25	32.5,	32,	32,	31.5,	32,	31.5,	31,	28.5
477	119.50	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	28
478	119.75	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	27.5
479	120.00	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	27.5
480	120.25	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	27
481	120.50	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	27
482	120.75	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	27
483	121.00	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	27.5
484	121.25	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	27
485	121.50	32.5,	32,	32,	31.5,	32,	31.5,	31,	27
486	121.75	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	27.5
487	122.00	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	27.5
488	122.25	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	28
489	122.50	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	28
490	122.75	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	28
491	123.00	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	28

492	123.25	33,	32,	32,	31.5,	32.5,	31.5,	31,	28
493	123.50	33,	32,	32,	32,	32.5,	31.5,	31,	28.5
494	123.75	32.5,	32,	32,	32,	32.5,	31.5,	31,	28
495	124.00	32.5,	32,	32,	31.5,	32.5,	31.5,	31,	28.5
496	124.25	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	28.5
497	124.50	32.5,	31.5,	31.5,	31.5,	32,	31.5,	31,	29
498	124.75	32.5,	31.5,	31.5,	31.5,	32,	31.5,	31,	29
499	125.00	32.5,	31.5,	32,	31.5,	32,	31.5,	31,	29

For the second experiment, the apparatus was positioned vertically with thermometer 0 closest to the floor about 2 feet in front of the wood stove.

Figure 26. Second Experiment Activity

Time Point	Minutes	Activity
0	0	Started measurements and the fire
46	11.75	Put another log in the fire
160	40.25	Put another log in the fire
175	44	Turned on the Heat Exchanger fan
214	53.75	Put in another log in the fire
350	87.75	Turned on the Ceiling Fan
436	109.25	Put another log in the fire
489	122.5	Put another log in the fire

Figure 27. The Graph of the First Vertical Position Measurements

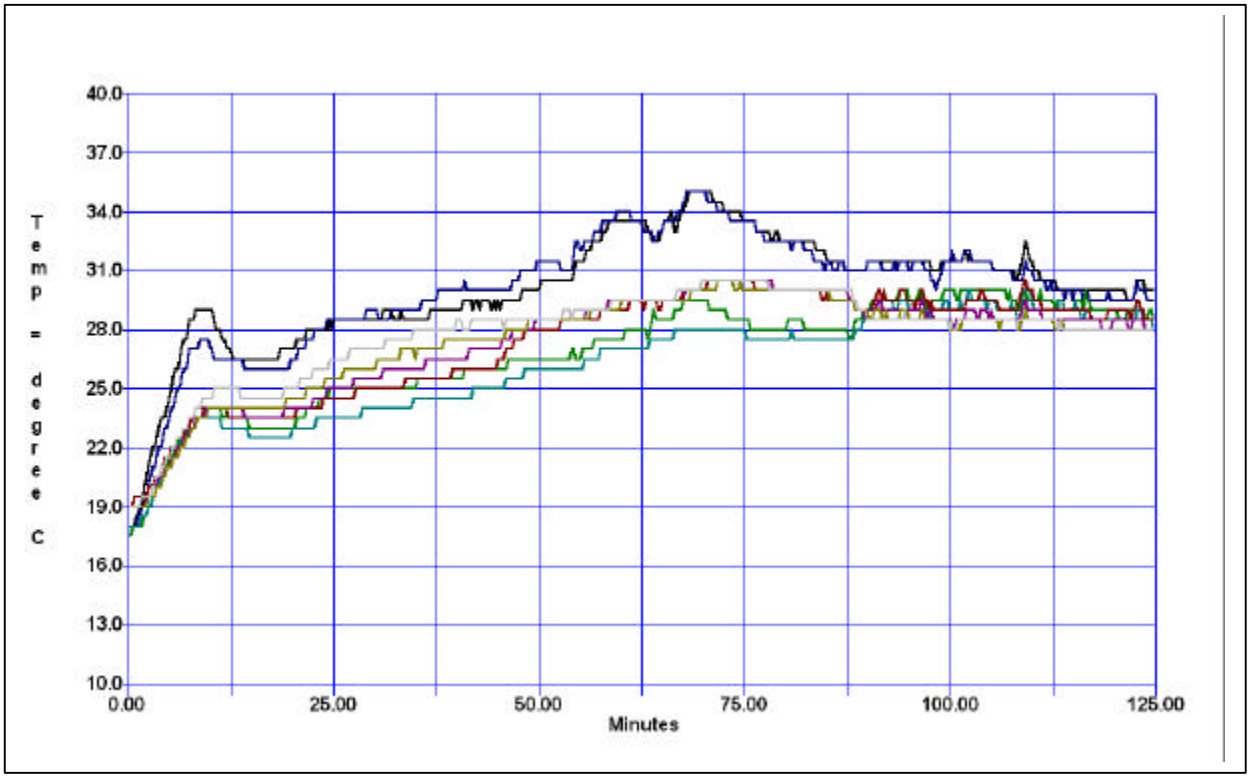

Figure 28.
First Vertical run results. Time is in minutes. Temperature is in Celsius.

x	time	thermometers 0,1,2,3,4,5,6,7
000	0.25	18, 18, 17.5, 18, 19, 19, 19, 19
001	0.50	18, 18, 18, 18, 19, 19, 19, 19
002	0.75	18, 18, 18, 18, 19.5, 19, 19, 19
003	1.00	18.5, 18, 18, 18, 19.5, 19, 19, 19
004	1.25	18.5, 18.5, 18, 18, 19.5, 19, 19, 19
005	1.50	19, 18.5, 18, 18, 19.5, 19, 19, 19
006	1.75	19, 19, 18, 18.5, 19.5, 19, 19, 19.5
007	2.00	20, 19, 18.5, 18.5, 19.5, 19, 19, 19.5
008	2.25	20.5, 19.5, 18.5, 18.5, 19.5, 19.5, 19, 19.5
009	2.50	21, 20, 19, 19, 20, 19.5, 19.5, 19.5
010	2.75	21.5, 20.5, 19, 19, 20, 19.5, 19.5, 19.5
011	3.00	22, 21, 19.5, 19.5, 20, 20, 19.5, 20
012	3.25	22, 21, 19.5, 19.5, 20.5, 20, 19.5, 20
013	3.50	22.5, 21.5, 20, 20, 20.5, 20, 20, 20.5
014	3.75	23, 22, 20, 20, 20.5, 20.5, 20, 20.5
015	4.00	23.5, 22, 20.5, 20.5, 21, 20.5, 20, 21
016	4.25	23.5, 22.5, 20.5, 20.5, 21, 20.5, 20.5, 21
017	4.50	23.5, 23, 21, 21, 21.5, 21, 20.5, 21
018	4.75	24, 23, 21, 21, 21.5, 21, 21, 21.5
019	5.00	24.5, 23.5, 21.5, 21, 21.5, 21, 21, 21.5
020	5.25	25, 24, 21.5, 21.5, 22, 21.5, 21, 21.5
021	5.50	25.5, 24, 21.5, 21.5, 22, 21.5, 21.5, 22
022	5.75	26, 24.5, 22, 21.5, 22, 21.5, 21.5, 22
023	6.00	26, 25, 22, 22, 22.5, 22, 21.5, 22.5
024	6.25	26.5, 25, 22.5, 22, 22.5, 22, 22, 22.5
025	6.50	27, 25.5, 22.5, 22.5, 22.5, 22, 22, 22.5
026	6.75	27.5, 26, 22.5, 22.5, 22.5, 22.5, 22, 23
027	7.00	27.5, 26, 23, 22.5, 23, 22.5, 22.5, 23
028	7.25	28, 26.5, 23, 23, 23, 22.5, 22.5, 23
029	7.50	28.5, 27, 23.5, 23, 23, 23, 22.5, 23.5
030	7.75	28.5, 27, 23.5, 23, 23.5, 23, 23, 23.5
031	8.00	28.5, 27, 23.5, 23, 23.5, 23, 23, 23.5
032	8.25	29, 27, 24, 23.5, 23.5, 23.5, 23, 24
033	8.50	29, 27, 24, 23.5, 23.5, 23.5, 23.5, 24
034	8.75	29, 27.5, 24, 23.5, 23.5, 23.5, 23.5, 24
035	9.00	29, 27.5, 24, 23.5, 23.5, 23.5, 23.5, 24.5
036	9.25	29, 27.5, 24, 23.5, 24, 23.5, 23.5, 24.5
037	9.50	29, 27.5, 24, 23.5, 24, 24, 23.5, 24.5
038	9.75	29, 27.5, 24, 23.5, 24, 24, 24, 24.5
039	10.00	29, 27, 24, 23.5, 24, 24, 24, 24.5

040	10.25	29,	27,	24,	23.5,	24,	24,	24,	24.5
041	10.50	28.5,	26.5,	24,	23.5,	24,	24,	24,	25
042	10.75	28,	26.5,	24,	23.5,	24,	24,	24,	25
043	11.00	28,	26.5,	24,	23.5,	24,	24,	24,	25
044	11.25	28,	26.5,	24,	23.5,	24,	24,	24,	25
045	11.50	27.5,	26.5,	23.5,	23,	24,	24,	24,	25
046	11.75	27.5,	26.5,	23.5,	23,	24,	24,	24,	25
047	12.00	27,	26.5,	24,	23,	24,	24,	24,	25
048	12.25	27,	26.5,	23.5,	23,	23.5,	24,	24,	25
049	12.50	27,	26.5,	23.5,	23,	23.5,	24,	24,	25
050	12.75	26.5,	26.5,	23.5,	23,	23.5,	24,	24,	25
051	13.00	26.5,	26.5,	23.5,	23,	23.5,	24,	24,	25
052	13.25	26.5,	26.5,	23.5,	23,	23.5,	24,	24,	25
053	13.50	26.5,	26.5,	23.5,	23,	23.5,	24,	24,	25
054	13.75	26.5,	26.5,	23.5,	23,	23.5,	24,	24,	24.5
055	14.00	26.5,	26.5,	23.5,	23,	23.5,	24,	24,	24.5
056	14.25	26.5,	26,	23.5,	23,	23.5,	23.5,	24,	24.5
057	14.50	26.5,	26,	23.5,	23,	23.5,	23.5,	24,	24.5
058	14.75	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
059	15.00	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
060	15.25	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
061	15.50	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
062	15.75	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
063	16.00	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
064	16.25	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
065	16.50	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
066	16.75	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
067	17.00	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
068	17.25	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
069	17.50	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
070	17.75	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
071	18.00	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
072	18.25	26.5,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
073	18.50	27,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
074	18.75	27,	26,	23,	22.5,	23.5,	23.5,	24,	24.5
075	19.00	27,	26,	23,	22.5,	23.5,	24,	24,	25
076	19.25	27,	26,	23,	22.5,	23.5,	24,	24.5,	25
077	19.50	27,	26,	23,	22.5,	23.5,	24,	24.5,	25
078	19.75	27,	26.5,	23,	22.5,	23.5,	24,	24.5,	25
079	20.00	27,	26.5,	23,	23,	23.5,	24,	24.5,	25
080	20.25	27,	26.5,	23,	23,	23.5,	24,	24.5,	25
081	20.50	27.5,	26.5,	23.5,	23,	24,	24,	24.5,	25
082	20.75	27.5,	27,	23.5,	23,	24,	24,	24.5,	25
083	21.00	27.5,	27,	23.5,	23,	24,	24,	24.5,	25.5
084	21.25	27.5,	27,	23.5,	23,	24,	24,	24.5,	25.5
085	21.50	27.5,	27,	23.5,	23,	24,	24,	24.5,	25.5

086	21.75	28, 27.5, 24, 23, 24, 24, 25, 25.5
087	22.00	28, 27.5, 24, 23, 24, 24, 25, 25.5
088	22.25	28, 27.5, 24, 23, 24, 24, 25, 25.5
089	22.50	28, 27.5, 24, 23, 24, 24.5, 25, 26
090	22.75	28, 28, 24, 23, 24, 24.5, 25, 26
091	23.00	28, 28, 24, 23.5, 24, 24.5, 25, 26
092	23.25	28, 28, 24.5, 23.5, 24, 24.5, 25, 26
093	23.50	28, 28, 24.5, 23.5, 24, 24.5, 25, 26
094	23.75	28, 28, 24.5, 23.5, 24.5, 24.5, 25, 26
095	24.00	28, 28, 24.5, 23.5, 24.5, 24.5, 25.5, 26
096	24.25	28, 28.5, 24.5, 23.5, 24.5, 25, 25.5, 26
097	24.50	28.5, 28.5, 25, 23.5, 24.5, 25, 25.5, 26.5
098	24.75	28, 28.5, 25, 23.5, 24.5, 25, 25.5, 26.5
099	25.00	28.5, 28.5, 25, 23.5, 24.5, 25, 25.5, 26.5
100	25.25	28.5, 28.5, 25, 23.5, 24.5, 25, 25.5, 26.5
101	25.50	28.5, 28.5, 25, 23.5, 24.5, 25, 25.5, 26.5
102	25.75	28.5, 28.5, 25, 23.5, 24.5, 25, 25.5, 26.5
103	26.00	28.5, 28.5, 25, 23.5, 24.5, 25, 25.5, 26.5
104	26.25	28.5, 28.5, 25, 23.5, 24.5, 25, 26, 26.5
105	26.50	28.5, 28.5, 25, 23.5, 24.5, 25, 26, 26.5
106	26.75	28.5, 28.5, 25, 23.5, 24.5, 25, 26, 26.5
107	27.00	28.5, 28.5, 25, 23.5, 24.5, 25, 26, 27
108	27.25	28.5, 28.5, 25, 23.5, 24.5, 25, 26, 27
109	27.50	28.5, 28.5, 25, 23.5, 24.5, 25.5, 26, 27
110	27.75	28.5, 28.5, 25, 23.5, 25, 25.5, 26, 27
111	28.00	28.5, 28.5, 25, 23.5, 25, 25.5, 26, 27
112	28.25	28.5, 28.5, 25, 23.5, 25, 25.5, 26, 27
113	28.50	28.5, 28.5, 25, 24, 25, 25.5, 26, 27
114	28.75	28.5, 28.5, 25, 24, 25, 25.5, 26, 27
115	29.00	28.5, 29, 25, 24, 25, 25.5, 26, 27
116	29.25	28.5, 29, 25, 24, 25, 25.5, 26, 27
117	29.50	28.5, 29, 25, 24, 25, 25.5, 26, 27
118	29.75	28.5, 29, 25, 24, 25, 25.5, 26, 27
119	30.00	28.5, 29, 25, 24, 25, 25.5, 26, 27
120	30.25	28.5, 29, 25, 24, 25, 25.5, 26.5, 27
121	30.50	28.5, 28.5, 25, 24, 25, 25.5, 26.5, 27
122	30.75	28.5, 28.5, 25, 24, 25, 25.5, 26.5, 27
123	31.00	29, 28.5, 25, 24, 25, 26, 26.5, 27
124	31.25	29, 28.5, 25, 24, 25, 26, 26.5, 27.5
125	31.50	29, 28.5, 25, 24, 25, 26, 26.5, 27.5
126	31.75	29, 28.5, 25, 24, 25, 26, 26.5, 27.5
127	32.00	29, 29, 25, 24, 25, 26, 26.5, 27.5
128	32.25	28.5, 29, 25, 24, 25, 26, 26.5, 27.5
129	32.50	28.5, 29, 25, 24, 25, 26, 26.5, 27.5
130	32.75	28.5, 29, 25, 24, 25, 26, 26.5, 27.5
131	33.00	28.5, 29, 25, 24, 25, 26, 26.5, 27.5

132	33.25	29,	29,	25,	24,	25,	26,	27,	27.5
133	33.50	28.5,	29,	25,	24,	25,	26,	27,	27.5
134	33.75	28.5,	29,	25,	24,	25.5,	26,	27,	27.5
135	34.00	28.5,	29,	25,	24,	25.5,	26,	27,	27.5
136	34.25	28.5,	29,	25,	24,	25.5,	26,	27,	27.5
137	34.50	28.5,	29,	25,	24,	25.5,	26,	27,	27.5
138	34.75	28.5,	29,	25,	24.5,	25.5,	26,	27,	28
139	35.00	28.5,	29,	25,	24.5,	25.5,	26,	26.5,	28
140	35.25	28.5,	29,	25.5,	24.5,	25.5,	26,	27,	28
141	35.50	28.5,	29,	25.5,	24.5,	25.5,	26,	27,	28
142	35.75	28.5,	29.5,	25.5,	24.5,	25.5,	26,	27,	28
143	36.00	28.5,	29.5,	25.5,	24.5,	25.5,	26,	27,	28
144	36.25	28.5,	29.5,	25.5,	24.5,	25.5,	26.5,	27,	28
145	36.50	28.5,	29.5,	25.5,	24.5,	25.5,	26.5,	27,	28
146	36.75	29,	29.5,	25.5,	24.5,	25.5,	26.5,	27,	28
147	37.00	29,	29.5,	25.5,	24.5,	25.5,	26.5,	27,	28
148	37.25	29,	29.5,	25.5,	24.5,	25.5,	26.5,	27,	28
149	37.50	29,	29.5,	25.5,	24.5,	25.5,	26.5,	27,	28
150	37.75	29,	30,	25.5,	24.5,	25.5,	26.5,	27,	28
151	38.00	29,	30,	25.5,	24.5,	25.5,	26.5,	27,	28
152	38.25	29,	30,	25.5,	24.5,	25.5,	26.5,	27,	28
153	38.50	29,	30,	25.5,	24.5,	25.5,	26.5,	27.5,	28
154	38.75	29,	30,	25.5,	24.5,	25.5,	26.5,	27.5,	28
155	39.00	29,	30,	25.5,	24.5,	25.5,	26.5,	27.5,	28
156	39.25	29,	30,	25.5,	24.5,	25.5,	26.5,	27.5,	28
157	39.50	29,	30,	25.5,	24.5,	26,	26.5,	27.5,	28
158	39.75	29,	30,	25.5,	24.5,	26,	26.5,	27.5,	28
159	40.00	29,	30,	25.5,	24.5,	26,	26.5,	27.5,	28.5
160	40.25	29,	30,	25.5,	24.5,	26,	26.5,	27.5,	28.5
161	40.50	29,	30,	25.5,	24.5,	26,	26.5,	27.5,	28.5
162	40.75	29.5,	30,	25.5,	24.5,	26,	26.5,	27.5,	28
163	41.00	29.5,	30.5,	26,	24.5,	26,	26.5,	27.5,	28
164	41.25	29.5,	30,	26,	24.5,	26,	26.5,	27.5,	28
165	41.50	29.5,	30,	26,	24.5,	26,	27,	27.5,	28
166	41.75	29.5,	30,	26,	24.5,	26,	27,	27.5,	28.5
167	42.00	29,	30,	26,	25,	26,	27,	27.5,	28.5
168	42.25	29.5,	30,	26,	25,	26,	27,	27.5,	28.5
169	42.50	29.5,	30,	26,	25,	26,	27,	27.5,	28.5
170	42.75	29,	30,	26,	25,	26,	27,	27.5,	28.5
171	43.00	29.5,	30,	26,	25,	26,	27,	27.5,	28.5
172	43.25	29.5,	30,	26,	25,	26,	27,	27.5,	28.5
173	43.50	29.5,	30,	26,	25,	26,	27,	27.5,	28.5
174	43.75	29.5,	30,	26,	25,	26,	27,	27.5,	28.5
175	44.00	29.5,	30,	26,	25,	26,	27,	27.5,	28.5
176	44.25	29,	30,	26,	25,	26,	27,	27.5,	28.5
177	44.50	29.5,	30,	26,	25,	26,	27,	27.5,	28.5

178	44.75	29, 30, 26, 25, 26, 27, 27.5, 28.5
179	45.00	29.5, 30, 26, 25, 26.5, 27, 27.5, 28.5
180	45.25	29, 30, 26, 25, 26.5, 27, 27.5, 28.5
181	45.50	29.5, 30, 26, 25, 26.5, 27.5, 27.5, 28.5
182	45.75	29.5, 30, 26, 25, 26.5, 27.5, 27.5, 28
183	46.00	29.5, 30, 26, 25.5, 27, 27.5, 28, 28.5
184	46.25	29.5, 30, 26.5, 25.5, 27, 27.5, 28, 28.5
185	46.50	29.5, 30, 26.5, 25.5, 27, 27.5, 28, 28.5
186	46.75	29.5, 30.5, 26.5, 25.5, 27, 28, 28, 28.5
187	47.00	29.5, 30.5, 26.5, 25.5, 27.5, 28, 28, 28.5
188	47.25	29.5, 30.5, 26.5, 25.5, 27.5, 28, 28, 28.5
189	47.50	29.5, 30.5, 26.5, 25.5, 27.5, 28, 28, 28.5
190	47.75	29.5, 31, 26.5, 25.5, 27.5, 28, 28, 28.5
191	48.00	30, 31, 26.5, 25.5, 27.5, 28, 28, 28.5
192	48.25	30, 31, 26.5, 26, 28, 28, 28, 28.5
193	48.50	30, 31, 26.5, 26, 28, 28, 28, 28.5
194	48.75	30, 31, 26.5, 26, 28, 28, 28.5, 28.5
195	49.00	30, 31, 26.5, 26, 28, 28, 28.5, 28.5
196	49.25	30, 31, 26.5, 26, 28, 28, 28.5, 28.5
197	49.50	30, 31, 26.5, 26, 28, 28.5, 28.5, 28.5
198	49.75	30, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
199	50.00	30, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
200	50.25	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
201	50.50	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
202	50.75	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
203	51.00	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
204	51.25	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
205	51.50	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
206	51.75	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
207	52.00	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
208	52.25	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
209	52.50	30.5, 31.5, 26.5, 26, 28, 28.5, 28.5, 28.5
210	52.75	30.5, 31, 26.5, 26, 28.5, 28.5, 28.5, 28.5
211	53.00	30.5, 31, 26.5, 26, 28.5, 28.5, 28.5, 29
212	53.25	30.5, 31, 26.5, 26, 28.5, 28.5, 28.5, 29
213	53.50	30.5, 31, 26.5, 26, 28.5, 28.5, 28.5, 29
214	53.75	30.5, 31, 26.5, 26, 28.5, 28.5, 28.5, 29
215	54.00	30.5, 31, 27, 26, 28.5, 28.5, 28.5, 28.5
216	54.25	31, 32, 27, 26, 28.5, 28.5, 28.5, 29
217	54.50	31.5, 32.5, 26.5, 26, 28.5, 28.5, 28.5, 29
218	54.75	31.5, 32.5, 26.5, 26, 28.5, 28.5, 28.5, 29
219	55.00	31.5, 32, 26.5, 26, 28.5, 28.5, 28.5, 29
220	55.25	31.5, 32, 27, 26, 28.5, 28.5, 28.5, 29
221	55.50	31.5, 32.5, 27, 26.5, 28.5, 28.5, 28.5, 29
222	55.75	32, 32.5, 27, 26.5, 28.5, 29, 28.5, 29
223	56.00	32, 32.5, 27, 26.5, 28.5, 29, 28.5, 29

224	56.25	32,	32.5,	27,	26.5,	28.5,	29,	29,	29
225	56.50	32.5,	32.5,	27,	26.5,	28.5,	29,	29,	29
226	56.75	32.5,	33,	27.5,	26.5,	28.5,	29,	29,	29
227	57.00	32.5,	33,	27.5,	26.5,	28.5,	29,	29,	29
228	57.25	32.5,	33,	27.5,	26.5,	28.5,	29,	29,	29
229	57.50	32.5,	33,	27.5,	27,	29,	29,	29,	29
230	57.75	33,	33.5,	27.5,	27,	29,	29,	29,	29
231	58.00	33,	33.5,	27.5,	27,	29,	29,	29,	29
232	58.25	33,	33.5,	27.5,	27,	29,	29,	29,	29
233	58.50	33.5,	33.5,	27.5,	27,	29,	29.5,	29,	29
234	58.75	33.5,	33.5,	27.5,	27,	29,	29.5,	29,	29.5
235	59.00	33.5,	33.5,	27.5,	27,	29,	29.5,	29,	29.5
236	59.25	33.5,	33.5,	27.5,	27,	29,	29.5,	29,	29.5
237	59.50	33.5,	34,	27.5,	27,	29,	29.5,	29,	29.5
238	59.75	33.5,	34,	27.5,	27,	29,	29.5,	29,	29.5
239	60.00	33.5,	34,	27.5,	27,	29,	29.5,	29.5,	29.5
240	60.25	33.5,	34,	27.5,	27,	29,	29.5,	29.5,	29.5
241	60.50	33.5,	34,	28,	27,	29,	29.5,	29.5,	29.5
242	60.75	33.5,	34,	28,	27,	29,	29.5,	29.5,	29.5
243	61.00	33.5,	34,	28,	27,	29.5,	29.5,	29.5,	29.5
244	61.25	33.5,	33.5,	28,	27,	29.5,	29.5,	29.5,	29.5
245	61.50	33.5,	33.5,	28,	27,	29.5,	29.5,	29.5,	29.5
246	61.75	33.5,	33.5,	28,	27,	29.5,	29.5,	29.5,	29.5
247	62.00	33.5,	33.5,	28,	27,	29.5,	29.5,	29.5,	29.5
248	62.25	33.5,	33.5,	28,	27,	29.5,	29.5,	29.5,	29.5
249	62.50	33.5,	33.5,	28,	27,	29.5,	29.5,	29.5,	29.5
250	62.75	33.5,	33,	28,	27,	29,	29.5,	29.5,	29.5
251	63.00	33.5,	33,	28,	27,	29.5,	29.5,	29.5,	29.5
252	63.25	33,	33,	27.5,	27,	29.5,	29.5,	29.5,	29.5
253	63.50	33,	33,	28,	27.5,	29.5,	29.5,	29.5,	29.5
254	63.75	32.5,	33,	28.5,	27.5,	29.5,	29.5,	29.5,	29.5
255	64.00	32.5,	32.5,	29,	27.5,	29.5,	29.5,	29.5,	29.5
256	64.25	32.5,	32.5,	28.5,	27.5,	29.5,	29.5,	29.5,	29.5
257	64.50	32.5,	33,	28.5,	27.5,	29,	29.5,	29.5,	29.5
258	64.75	33,	33,	28.5,	27.5,	29,	29.5,	29.5,	29.5
259	65.00	33,	33,	28.5,	27.5,	29.5,	29.5,	29.5,	29.5
260	65.25	33.5,	33.5,	28.5,	27.5,	29.5,	29.5,	29.5,	29.5
261	65.50	33.5,	33.5,	28.5,	27.5,	29.5,	29.5,	29.5,	29.5
262	65.75	33.5,	33.5,	28.5,	27.5,	29.5,	29.5,	29.5,	29.5
263	66.00	34,	33.5,	28.5,	27.5,	29.5,	29.5,	29.5,	29.5
264	66.25	34,	33.5,	28.5,	27.5,	29.5,	29.5,	29.5,	29.5
265	66.50	33,	33.5,	29,	28,	29.5,	29.5,	29.5,	29.5
266	66.75	33,	34,	29,	28,	29.5,	29.5,	29.5,	30
267	67.00	33.5,	34,	29,	28,	29.5,	29.5,	29.5,	30
268	67.25	34,	34,	29,	28,	29.5,	29.5,	29.5,	30
269	67.50	34,	34.5,	29.5,	28,	30,	29.5,	29.5,	30

270	67.75	34.5,	34.5,	29.5,	28,	30,	30,	29.5,	30
271	68.00	34.5,	35,	29.5,	28,	30,	30,	29.5,	30
272	68.25	35,	35,	29.5,	28,	30,	30,	29.5,	30
273	68.50	35,	35,	29.5,	28,	30,	30,	30,	30
274	68.75	35,	35,	29.5,	28,	30,	30,	30,	30
275	69.00	35,	35,	29.5,	28,	30,	30,	30,	30
276	69.25	35,	35,	29.5,	28,	30,	30,	30,	30
277	69.50	35,	35,	29.5,	28,	30,	30,	30,	30
278	69.75	35,	35,	29.5,	28,	30,	30.5,	30,	30.5
279	70.00	35,	35,	29.5,	28,	30,	30.5,	30,	30.5
280	70.25	35,	35,	29.5,	28,	30,	30.5,	30,	30.5
281	70.50	35,	34.5,	29.5,	28,	30.5,	30.5,	30,	30.5
282	70.75	35,	34.5,	29,	28,	30.5,	30.5,	30,	30.5
283	71.00	35,	34.5,	29,	28,	30.5,	30.5,	30,	30.5
284	71.25	34.5,	34.5,	29,	28,	30.5,	30.5,	30,	30.5
285	71.50	34.5,	34.5,	29,	28,	30.5,	30.5,	30,	30.5
286	71.75	34.5,	34,	29,	28,	30.5,	30.5,	30.5,	30.5
287	72.00	34.5,	34,	29,	28,	30.5,	30.5,	30.5,	30.5
288	72.25	34.5,	34,	29,	28,	30.5,	30.5,	30.5,	30.5
289	72.50	34,	34,	29,	28,	30.5,	30.5,	30.5,	30.5
290	72.75	34,	34,	29,	28,	30.5,	30.5,	30.5,	30.5
291	73.00	34,	34,	28.5,	28,	30.5,	30.5,	30.5,	30.5
292	73.25	34,	33.5,	28.5,	28,	30.5,	30.5,	30.5,	30.5
293	73.50	34,	33.5,	28.5,	28,	30.5,	30.5,	30.5,	30.5
294	73.75	34,	33.5,	28.5,	28,	30.5,	30.5,	30,	30.5
295	74.00	34,	33.5,	28.5,	28,	30.5,	30.5,	30,	30.5
296	74.25	34,	33.5,	28.5,	28,	30.5,	30.5,	30,	30.5
297	74.50	34,	33.5,	28.5,	28,	30.5,	30.5,	30.5,	30.5
298	74.75	33.5,	33.5,	28.5,	28,	30.5,	30.5,	30,	30.5
299	75.00	33.5,	33.5,	28.5,	28,	30.5,	30.5,	30,	30.5
300	75.25	33.5,	33.5,	28.5,	27.5,	30.5,	30.5,	30,	30.5
301	75.50	33.5,	33.5,	28.5,	27.5,	30.5,	30.5,	30,	30.5
302	75.75	33.5,	33.5,	28,	27.5,	30.5,	30.5,	30,	30.5
303	76.00	33.5,	33.5,	28,	27.5,	30.5,	30.5,	30,	30.5
304	76.25	33.5,	33.5,	28,	27.5,	30,	30.5,	30,	30.5
305	76.50	33,	33,	28,	27.5,	30,	30.5,	30,	30.5
306	76.75	33,	33,	28,	27.5,	30,	30.5,	30,	30.5
307	77.00	33,	33,	28,	27.5,	30,	30.5,	30,	30.5
308	77.25	33,	33,	28,	27.5,	30,	30.5,	30,	30.5
309	77.50	33,	32.5,	28,	27.5,	30,	30.5,	30,	30.5
310	77.75	33,	32.5,	28,	27.5,	30,	30.5,	30,	30.5
311	78.00	33,	32.5,	28,	27.5,	30,	30.5,	30,	30
312	78.25	32.5,	32.5,	28,	27.5,	30,	30.5,	30,	30
313	78.50	32.5,	32.5,	28,	27.5,	30,	30,	30,	30
314	78.75	33,	32.5,	28,	27.5,	30,	30,	30,	30
315	79.00	33,	32.5,	28,	27.5,	30,	30,	30,	30

316	79.25	32.5,	32.5,	28,	27.5,	30,	30,	30,	30
317	79.50	32.5,	32.5,	28,	27.5,	30,	30,	30,	30
318	79.75	32.5,	32.5,	28,	27.5,	30,	30,	30,	30
319	80.00	32.5,	32.5,	28,	27.5,	30,	30,	30,	30
320	80.25	32.5,	32.5,	28.5,	27.5,	30,	30,	30,	30
321	80.50	32.5,	32.5,	28.5,	27.5,	30,	30,	30,	30
322	80.75	32.5,	32,	28.5,	28,	30,	30,	30,	30
323	81.00	32.5,	32.5,	28.5,	27.5,	30,	30,	30,	30
324	81.25	32.5,	32.5,	28.5,	27.5,	30,	30,	30,	30
325	81.50	32.5,	32.5,	28.5,	27.5,	30,	30,	30,	30
326	81.75	32.5,	32.5,	28.5,	27.5,	30,	30,	30,	30
327	82.00	32.5,	32.5,	28.5,	27.5,	30,	30,	30,	30
328	82.25	32.5,	32,	28,	27.5,	30,	30,	30,	30
329	82.50	32.5,	32,	28,	27.5,	30,	30,	30,	30
330	82.75	32.5,	32,	28,	27.5,	30,	30,	30,	30
331	83.00	32.5,	32,	28,	27.5,	30,	30,	30,	30
332	83.25	32.5,	32,	28,	27.5,	30,	30,	30,	30
333	83.50	32.5,	31.5,	28,	27.5,	30,	30,	30,	30
334	83.75	32,	31.5,	28,	27.5,	30,	30,	30,	30
335	84.00	32,	31.5,	28,	27.5,	30,	30,	30,	30
336	84.25	32,	31.5,	28,	27.5,	30,	30,	30,	30
337	84.50	32,	31.5,	28,	27.5,	29.5,	30,	30,	30
338	84.75	32,	31,	28,	27.5,	29.5,	30,	30,	30
339	85.00	31.5,	31.5,	28,	27.5,	30,	30,	30,	30
340	85.25	31.5,	31.5,	28,	27.5,	29.5,	30,	30,	30
341	85.50	31.5,	31.5,	28,	27.5,	29.5,	30,	29.5,	30
342	85.75	31.5,	31,	28,	27.5,	29.5,	30,	29.5,	30
343	86.00	31.5,	31,	28,	27.5,	29.5,	30,	29.5,	30
344	86.25	31.5,	31,	28,	27.5,	29.5,	30,	29.5,	30
345	86.50	31.5,	31.5,	28,	27.5,	29.5,	30,	29.5,	30
346	86.75	31.5,	31.5,	28,	27.5,	29.5,	30,	29.5,	30
347	87.00	31.5,	31.5,	28,	27.5,	29.5,	30,	29.5,	30
348	87.25	31,	31,	28,	27.5,	29.5,	30,	29.5,	30
349	87.50	31,	31,	28,	27.5,	29.5,	30,	29.5,	30
350	87.75	31,	31,	27.5,	27.5,	29.5,	29.5,	29.5,	30
351	88.00	31,	31,	27.5,	27.5,	29.5,	29.5,	29.5,	30
352	88.25	31,	31,	28,	27.5,	29.5,	29.5,	29.5,	29.5
353	88.50	31,	31,	28.5,	28,	29.5,	29.5,	29,	29.5
354	88.75	31,	31,	28.5,	28,	29,	29,	29,	29
355	89.00	31,	31,	28.5,	28,	29,	29,	29,	29
356	89.25	31,	31,	28.5,	28,	29,	29,	29,	29
357	89.50	31,	31,	29,	28.5,	29,	29,	29,	29
358	89.75	31,	31,	29,	28.5,	29,	28.5,	29,	29
359	90.00	31.5,	31.5,	29,	28.5,	29,	29,	29,	28.5
360	90.25	31.5,	31.5,	29,	28.5,	29,	29,	28.5,	28.5
361	90.50	31.5,	31.5,	29.5,	28.5,	29,	29,	28.5,	28.5

362	90.75	31.5,	31.5,	29.5,	29,	29.5,	29,	29,	28.5
363	91.00	31.5,	31.5,	29.5,	29,	29.5,	29,	29,	28.5
364	91.25	31.5,	31.5,	29.5,	29.5,	30,	29.5,	29,	28.5
365	91.50	31.5,	31.5,	29.5,	29.5,	30,	29.5,	29,	28.5
366	91.75	31.5,	31,	29.5,	29.5,	29.5,	29,	28.5,	28.5
367	92.00	31.5,	31,	29.5,	29.5,	30,	29,	28.5,	28.5
368	92.25	31.5,	31,	29.5,	29.5,	29.5,	29,	29,	28.5
369	92.50	31.5,	31,	29.5,	29.5,	29.5,	29,	28.5,	28.5
370	92.75	31.5,	31,	29.5,	29.5,	29.5,	29,	28.5,	28.5
371	93.00	31.5,	31,	29.5,	29.5,	29.5,	29,	28.5,	28.5
372	93.25	31.5,	31.5,	29.5,	29,	29.5,	29,	28.5,	28.5
373	93.50	31.5,	31,	29.5,	29,	29.5,	29,	28.5,	28.5
374	93.75	31.5,	31.5,	30,	29.5,	29.5,	29,	28.5,	28.5
375	94.00	31.5,	31.5,	30,	29.5,	30,	29,	29,	28.5
376	94.25	31.5,	31.5,	30,	29.5,	30,	29,	29,	28.5
377	94.50	31.5,	31.5,	30,	29.5,	30,	29,	29,	29
378	94.75	31.5,	31.5,	30,	29.5,	29.5,	29,	29,	28.5
379	95.00	31.5,	31,	29.5,	29,	29.5,	29,	28.5,	28.5
380	95.25	31.5,	31,	29.5,	29,	29.5,	29,	28.5,	28.5
381	95.50	31.5,	31.5,	29.5,	29,	29.5,	29,	28.5,	28.5
382	95.75	31.5,	31.5,	29.5,	29,	29,	29,	28.5,	28.5
383	96.00	31.5,	31.5,	29.5,	29,	29.5,	29,	28.5,	28.5
384	96.25	31.5,	31.5,	30,	29,	29.5,	29,	28.5,	28.5
385	96.50	31.5,	31.5,	30,	29.5,	30,	29.5,	29,	28.5
386	96.75	31.5,	31.5,	29.5,	29.5,	30,	29.5,	29,	28.5
387	97.00	31.5,	31,	29.5,	29,	29.5,	29,	28.5,	28.5
388	97.25	31.5,	31,	29,	29,	29.5,	28.5,	28.5,	28.5
389	97.50	31.5,	31,	29,	28.5,	29,	29,	28.5,	28.5
390	97.75	31,	30.5,	29.5,	29,	29.5,	29,	28.5,	28.5
391	98.00	31,	30.5,	29.5,	29,	29,	28.5,	28.5,	28.5
392	98.25	31,	30,	29.5,	29,	29,	28.5,	28.5,	28.5
393	98.50	31,	30.5,	29.5,	29,	29,	28.5,	28.5,	28.5
394	98.75	31,	30.5,	29.5,	29,	29,	28.5,	28.5,	28.5
395	99.00	31.5,	31,	29.5,	29,	29,	28.5,	28.5,	28.5
396	99.25	31.5,	31.5,	30,	29.5,	29,	28.5,	28.5,	28.5
397	99.50	31.5,	31.5,	30,	29.5,	29,	28.5,	28.5,	28.5
398	99.75	31.5,	31.5,	30,	29.5,	29,	28.5,	28.5,	28.5
399	100.00	31.5,	31.5,	30,	29,	29,	28.5,	28,	28
400	100.25	31.5,	32,	30,	29,	29,	28.5,	28,	28.5
401	100.50	31.5,	31.5,	30,	29,	29,	28,	28,	28
402	100.75	31.5,	31.5,	29.5,	29,	29,	28.5,	28,	28
403	101.00	31.5,	31.5,	29.5,	29,	29,	28.5,	28,	28.5
404	101.25	31.5,	31.5,	30,	29.5,	29,	28.5,	28,	28.5
405	101.50	31.5,	31.5,	30,	29,	29,	28.5,	28.5,	28.5
406	101.75	32,	32,	30,	29,	29,	28.5,	28.5,	28.5
407	102.00	32,	32,	30,	29.5,	29.5,	29,	28.5,	28.5

408	102.25	31.5,	32,	30,	30,	29.5,	29,	28.5,	28.5
409	102.50	32,	32,	30,	30,	29.5,	29,	28.5,	28.5
410	102.75	31.5,	31.5,	30,	29.5,	29.5,	29,	28.5,	28.5
411	103.00	31.5,	31.5,	30,	29.5,	29.5,	29,	28.5,	28.5
412	103.25	31.5,	31.5,	30,	29.5,	29.5,	28.5,	28.5,	28.5
413	103.50	31.5,	31.5,	30,	29.5,	29.5,	28.5,	28.5,	28.5
414	103.75	31.5,	31.5,	30,	29.5,	30,	29,	28.5,	28.5
415	104.00	31.5,	31.5,	30,	29.5,	30,	29,	28.5,	28.5
416	104.25	31.5,	31.5,	30,	29.5,	29.5,	29,	28.5,	28.5
417	104.50	31.5,	31.5,	30,	29,	29.5,	29,	28.5,	28.5
418	104.75	31.5,	31.5,	30,	29.5,	29.5,	28.5,	28.5,	28.5
419	105.00	31.5,	31.5,	30,	29.5,	29.5,	29,	28.5,	28.5
420	105.25	31,	31,	30,	29.5,	29.5,	28.5,	28.5,	28.5
421	105.50	31,	31,	30,	29.5,	29.5,	28.5,	28.5,	28.5
422	105.75	31,	31,	30,	29,	29.5,	28.5,	28.5,	28.5
423	106.00	31,	31,	30,	29,	29,	28.5,	28,	28.5
424	106.25	31,	31,	30,	29,	29,	28.5,	28.5,	28.5
425	106.50	31,	31,	30,	29,	29,	28.5,	28.5,	28.5
426	106.75	31,	31,	30,	29,	29,	28.5,	28.5,	28.5
427	107.00	31,	31,	29.5,	29,	29,	28.5,	28.5,	28.5
428	107.25	31,	31,	30,	29,	29,	28.5,	28.5,	28.5
429	107.50	31,	31,	29.5,	29.5,	29,	28.5,	28.5,	28.5
430	107.75	31,	30.5,	29.5,	29,	29,	28.5,	28.5,	28.5
431	108.00	30.5,	30.5,	29.5,	29,	29,	28.5,	28.5,	28.5
432	108.25	30.5,	30.5,	29,	28.5,	29,	28.5,	28,	28
433	108.50	31,	30.5,	29,	28.5,	29.5,	28.5,	28,	28.5
434	108.75	31.5,	30.5,	29.5,	29,	30,	29,	28.5,	28.5
435	109.00	32,	31,	30,	30,	30.5,	29.5,	28.5,	28.5
436	109.25	32.5,	31.5,	30,	30,	30.5,	29.5,	29,	28.5
437	109.50	32,	31,	29.5,	30,	30,	29,	28.5,	28.5
438	109.75	31.5,	31,	29.5,	30,	30,	29,	28.5,	28.5
439	110.00	31.5,	31,	29.5,	29.5,	30,	29,	28.5,	28.5
440	110.25	31,	30.5,	29.5,	29,	29.5,	29,	28.5,	28.5
441	110.50	31,	30.5,	29.5,	29,	29.5,	29,	28.5,	28.5
442	110.75	31,	30.5,	29.5,	29,	29.5,	29,	28.5,	28.5
443	111.00	30.5,	30.5,	30,	29,	29.5,	29,	28.5,	28.5
444	111.25	30.5,	30.5,	29.5,	29,	29,	28.5,	28.5,	28.5
445	111.50	30.5,	30.5,	29.5,	29,	29,	28.5,	28.5,	28.5
446	111.75	30.5,	30,	29.5,	29,	29,	28.5,	28.5,	28.5
447	112.00	30.5,	30,	29.5,	29,	29,	28.5,	28.5,	28.5
448	112.25	30.5,	30.5,	29.5,	29,	29,	28.5,	28.5,	28.5
449	112.50	30.5,	30,	29.5,	29,	29,	28.5,	28.5,	28.5
450	112.75	30.5,	30,	29,	29,	29,	28.5,	28,	28.5
451	113.00	30,	30,	29.5,	29,	29,	28.5,	28,	28.5
452	113.25	30,	30,	29.5,	29.5,	29,	28.5,	28,	28
453	113.50	30,	30,	29.5,	29.5,	29,	28.5,	28.5,	28.5

454	113.75	30,	30,	29.5,	29.5,	29,	28.5,	28.5,	28
455	114.00	30,	29.5,	29,	29,	29,	28.5,	28,	28
456	114.25	30,	30,	29,	29,	29,	28.5,	28,	28
457	114.50	30,	30,	29,	29,	29,	28.5,	28,	28
458	114.75	30,	30,	29,	29,	29,	28.5,	28,	28
459	115.00	30,	29.5,	29,	29,	29,	28.5,	28,	28
460	115.25	30,	30,	29.5,	29.5,	29,	28.5,	28,	28
461	115.50	30,	30,	29.5,	29,	29,	28.5,	28,	28
462	115.75	30,	30,	29.5,	29,	29,	28.5,	28,	28
463	116.00	30,	30,	29.5,	28.5,	29,	28.5,	28,	28
464	116.25	30,	29.5,	29,	28.5,	29,	28.5,	28,	28
465	116.50	30,	30,	30,	29,	29,	28.5,	28,	28
466	116.75	30,	30,	29.5,	29,	29,	28.5,	28,	28
467	117.00	30,	29.5,	29.5,	29,	29,	28.5,	28,	28
468	117.25	30,	29.5,	29,	28.5,	28.5,	28.5,	28,	28
469	117.50	30,	29.5,	29,	28.5,	28.5,	28.5,	28,	28
470	117.75	30,	29.5,	29,	28.5,	28.5,	28.5,	28,	28
471	118.00	30,	29.5,	29,	28.5,	28.5,	28.5,	28,	28
472	118.25	30,	29.5,	29,	28.5,	28.5,	28.5,	28,	28
473	118.50	30,	29.5,	29,	28.5,	28.5,	28,	28,	28
474	118.75	30,	29.5,	29,	28.5,	28.5,	28,	28,	28
475	119.00	30,	29.5,	29,	28.5,	28.5,	28,	28,	28
476	119.25	30,	30,	29,	28.5,	29,	28,	28,	28
477	119.50	30,	29.5,	29,	28.5,	29,	28,	28,	28
478	119.75	30,	29.5,	29,	28.5,	29,	28.5,	28,	28
479	120.00	30,	29.5,	29,	28.5,	29,	28.5,	28,	28
480	120.25	30,	29.5,	29,	28.5,	29,	28.5,	28,	28
481	120.50	30,	29.5,	28.5,	28.5,	29,	28.5,	28,	28
482	120.75	30,	29.5,	28.5,	28.5,	29,	28.5,	28,	28
483	121.00	30,	29.5,	28.5,	28.5,	29,	28.5,	28,	28
484	121.25	30,	29.5,	28.5,	28.5,	29,	28.5,	28,	28
485	121.50	29.5,	29.5,	29,	28.5,	29,	28.5,	28,	28
486	121.75	29.5,	29.5,	29,	28.5,	29,	28,	28,	28
487	122.00	29.5,	29.5,	29,	28.5,	28.5,	28,	28,	28
488	122.25	29.5,	29.5,	29,	28.5,	29,	28.5,	28,	28
489	122.50	30,	30,	29,	28.5,	29,	28.5,	28,	28
490	122.75	30.5,	30.5,	29.5,	29,	29.5,	28.5,	28,	28
491	123.00	30.5,	30,	29.5,	29,	29.5,	28.5,	28,	28
492	123.25	30.5,	30,	29,	29,	29,	28.5,	28,	28
493	123.50	30.5,	30,	29,	28.5,	29,	28.5,	28,	28
494	123.75	30,	30,	28.5,	28.5,	28.5,	28,	28,	28
495	124.00	30,	29.5,	28.5,	28.5,	28.5,	28,	28,	28
496	124.25	30,	29.5,	29,	28.5,	28.5,	28,	28,	28
497	124.50	30,	29.5,	29,	28.5,	28.5,	28,	28,	28
498	124.75	30,	29.5,	28.5,	28,	28.5,	28,	28,	28
499	125.00	30,	29.5,	29,	28.5,	28.5,	28,	28,	28

For the third experiment, the apparatus was positioned vertically with thermometer 0 closest to the floor about 8.5 feet away from the wood stove. The pole was farther away from the wood stove than the second experiment, which was only 2 feet from the wood stove.

Figure 29. Third Experiment Activity

Time Point	Minutes	Activity
0	0	Started measurements and the fire
140	35.25	Put another log in the fire
181	45.50	Turned on the Heat Exchanger fan
257	64.5	Put in another log in the fire
350	87.75	Turned on the Ceiling Fan
450	112.75	Put another log in the fire

Figure 30. The Graph of the 2nd Vertical Position Measurements (third experiment)

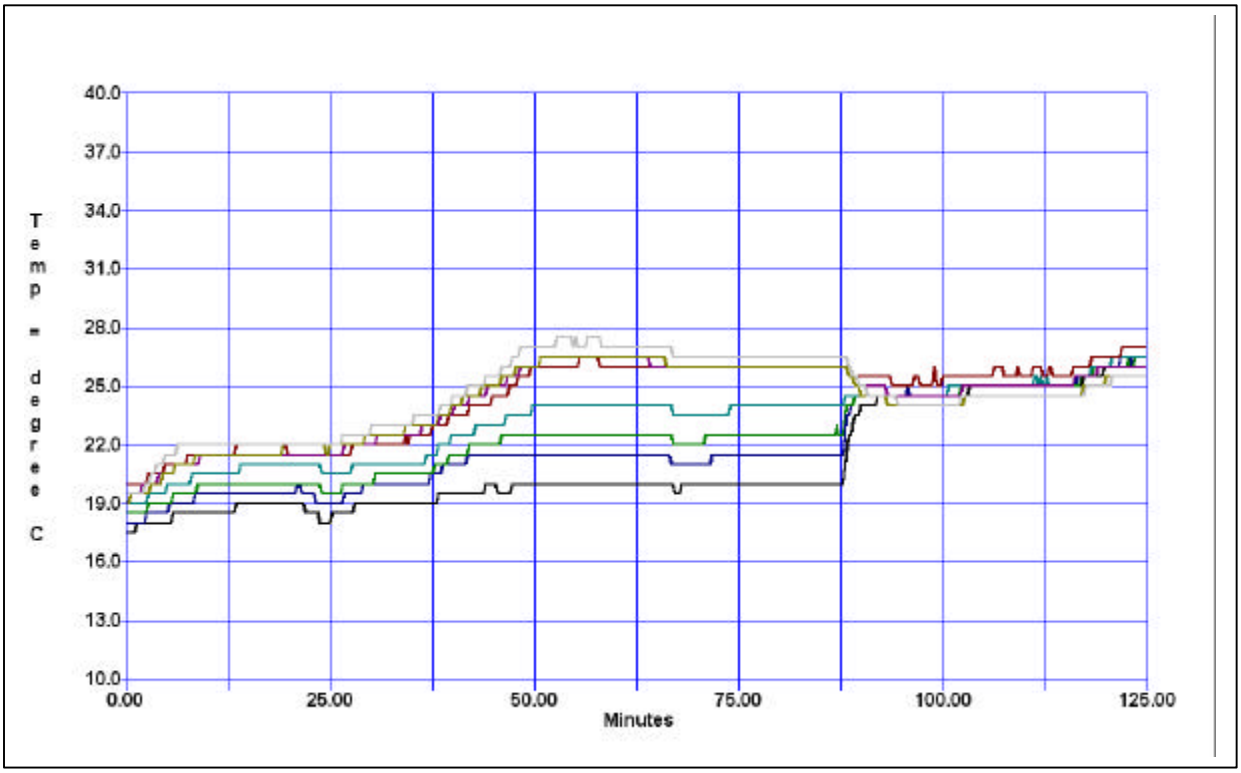

Figure 31.

Second Vertical run results. Time is in minutes. Temperature is in Celsius.

x	time	thermometers 0,1,2,3,4,5,6,7
000	0.25	17.5, 18, 18.5, 19, 20, 19.5, 19, 19.5
001	0.50	17.5, 18, 18.5, 19, 20, 19.5, 19.5, 19.5
002	0.75	17.5, 18, 18.5, 19, 20, 19.5, 19.5, 19.5
003	1.00	17.5, 18, 18.5, 19, 20, 19.5, 19.5, 19.5
004	1.25	18, 18, 18.5, 19, 20, 19.5, 19.5, 19.5
005	1.50	18, 18, 18.5, 19, 20, 19.5, 19.5, 19.5
006	1.75	18, 18, 18.5, 19, 20, 19.5, 19.5, 19.5
007	2.00	18, 18, 18.5, 19, 20, 20, 19.5, 19.5
008	2.25	18, 18, 18.5, 19, 20, 20, 19.5, 20
009	2.50	18, 18.5, 18.5, 19, 20, 20, 19.5, 20
010	2.75	18, 18.5, 19, 19.5, 20.5, 20, 19.5, 20
011	3.00	18, 18.5, 19, 19.5, 20.5, 20, 20, 20.5
012	3.25	18, 18.5, 19, 19.5, 20.5, 20, 20, 20.5
013	3.50	18, 18.5, 19, 19.5, 20.5, 20, 20, 20.5
014	3.75	18, 18.5, 19, 19.5, 20.5, 20, 20, 21
015	4.00	18, 18.5, 19, 19.5, 20.5, 20.5, 20, 21
016	4.25	18, 18.5, 19, 19.5, 20.5, 20.5, 20, 21
017	4.50	18, 18.5, 19, 19.5, 20.5, 20.5, 20.5, 21
018	4.75	18, 18.5, 19, 19.5, 21, 20.5, 20.5, 21.5
019	5.00	18, 18.5, 19, 20, 21, 20.5, 20.5, 21.5
020	5.25	18, 19, 19, 20, 21, 20.5, 20.5, 21.5
021	5.50	18, 19, 19, 20, 21, 20.5, 20.5, 21.5
022	5.75	18.5, 19, 19.5, 20, 21, 20.5, 20.5, 21.5
023	6.00	18.5, 19, 19.5, 20, 21, 21, 21, 21.5
024	6.25	18.5, 19, 19.5, 20, 21, 21, 21, 22
025	6.50	18.5, 19, 19.5, 20, 21, 21, 21, 22
026	6.75	18.5, 19, 19.5, 20, 21, 21, 21, 22
027	7.00	18.5, 19, 19.5, 20, 21, 21, 21, 22
028	7.25	18.5, 19, 19.5, 20, 21, 21, 21, 22
029	7.50	18.5, 19, 19.5, 20, 21.5, 21, 21, 22
030	7.75	18.5, 19, 19.5, 20, 21.5, 21, 21, 22
031	8.00	18.5, 19, 19.5, 20.5, 21.5, 21, 21, 22
032	8.25	18.5, 19, 19.5, 20.5, 21.5, 21, 21, 22
033	8.50	18.5, 19.5, 19.5, 20.5, 21.5, 21, 21.5, 22
034	8.75	18.5, 19.5, 20, 20.5, 21.5, 21, 21.5, 22
035	9.00	18.5, 19.5, 20, 20.5, 21.5, 21.5, 21.5, 22
036	9.25	18.5, 19.5, 20, 20.5, 21.5, 21.5, 21.5, 22
037	9.50	18.5, 19.5, 20, 20.5, 21.5, 21.5, 21.5, 22
038	9.75	18.5, 19.5, 20, 20.5, 21.5, 21.5, 21.5, 22
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042	10.75	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
043	11.00	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
044	11.25	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
045	11.50	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
046	11.75	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
047	12.00	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
048	12.25	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
049	12.50	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
050	12.75	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
051	13.00	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
052	13.25	18.5,	19.5,	20,	20.5,	21.5,	21.5,	21.5,	22
053	13.50	19,	19.5,	20,	20.5,	22,	21.5,	21.5,	22
054	13.75	19,	19.5,	20,	20.5,	22,	21.5,	21.5,	22
055	14.00	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
056	14.25	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
057	14.50	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
058	14.75	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
059	15.00	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
060	15.25	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
061	15.50	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
062	15.75	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
063	16.00	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
064	16.25	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
065	16.50	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
066	16.75	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
067	17.00	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
068	17.25	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
069	17.50	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
070	17.75	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
071	18.00	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
072	18.25	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
073	18.50	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
074	18.75	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
075	19.00	19,	19.5,	20,	21,	22,	21.5,	21.5,	22
076	19.25	19,	19.5,	20,	21,	22,	21.5,	22,	22
077	19.50	19,	19.5,	20,	21,	22,	21.5,	22,	22
078	19.75	19,	19.5,	20,	21,	21.5,	21.5,	22,	22
079	20.00	19,	19.5,	20,	21,	21.5,	21.5,	22,	22
080	20.25	19,	19.5,	20,	21,	21.5,	21.5,	22,	22
081	20.50	19,	19.5,	20,	21,	21.5,	21.5,	22,	22
082	20.75	19,	19.5,	20,	21,	21.5,	21.5,	22,	22
083	21.00	19,	20,	20,	21,	21.5,	21.5,	22,	22
084	21.25	19,	20,	20,	21,	21.5,	21.5,	22,	22
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096 24.25 18, 19, 19.5, 20.5, 21.5, 21.5, 22, 22
097 24.50 18, 19, 19.5, 20.5, 21.5, 21.5, 21.5, 22
098 24.75 18, 19, 19.5, 20.5, 21.5, 21.5, 21.5, 22
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133	33.50	19,	20,	20.5,	21,	22,	22.5,	22.5,	23
134	33.75	19,	20,	20.5,	21,	22,	22.5,	22.5,	23
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136	34.25	19,	20,	20.5,	21,	22.5,	22.5,	23,	23
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138	34.75	19,	20,	20.5,	21,	22.5,	22.5,	23,	23
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141	35.50	19,	20,	20.5,	21,	22.5,	22.5,	23,	23.5
142	35.75	19,	20,	20.5,	21,	22.5,	22.5,	23,	23.5
143	36.00	19,	20,	20.5,	21,	22.5,	22.5,	23,	23.5
144	36.25	19,	20,	20.5,	21,	22.5,	23,	23,	23.5
145	36.50	19,	20,	20.5,	21,	22.5,	23,	23,	23.5
146	36.75	19,	20,	20.5,	21.5,	22.5,	23,	23,	23.5
147	37.00	19,	20,	20.5,	21.5,	22.5,	23,	23,	23.5
148	37.25	19,	20.5,	20.5,	21.5,	22.5,	23,	23,	23.5
149	37.50	19,	20.5,	20.5,	21.5,	23,	23,	23,	23.5
150	37.75	19,	20.5,	21,	21.5,	23,	23,	23,	23.5
151	38.00	19,	20.5,	21,	21.5,	23,	23,	23,	23.5
152	38.25	19.5,	20.5,	21,	22,	23,	23,	23.5,	23.5
153	38.50	19.5,	20.5,	21,	22,	23,	23.5,	23.5,	24
154	38.75	19.5,	21,	21,	22,	23,	23.5,	23.5,	24
155	39.00	19.5,	21,	21,	22,	23,	23.5,	23.5,	24
156	39.25	19.5,	21,	21,	22,	23,	23.5,	23.5,	24
157	39.50	19.5,	21,	21.5,	22,	23.5,	23.5,	23.5,	24
158	39.75	19.5,	21,	21.5,	22.5,	23.5,	23.5,	24,	24
159	40.00	19.5,	21,	21.5,	22.5,	23.5,	23.5,	24,	24.5
160	40.25	19.5,	21,	21.5,	22.5,	23.5,	24,	24,	24.5
161	40.50	19.5,	21,	21.5,	22.5,	23.5,	24,	24,	24.5
162	40.75	19.5,	21,	21.5,	22.5,	23.5,	24,	24,	24.5
163	41.00	19.5,	21,	21.5,	22.5,	23.5,	24,	24,	24.5
164	41.25	19.5,	21,	21.5,	22.5,	23.5,	24,	24.5,	24.5
165	41.50	19.5,	21,	21.5,	22.5,	23.5,	24,	24.5,	24.5
166	41.75	19.5,	21.5,	21.5,	22.5,	23.5,	24,	24.5,	25
167	42.00	19.5,	21.5,	22,	22.5,	24,	24.5,	24.5,	25
168	42.25	19.5,	21.5,	22,	22.5,	24,	24.5,	24.5,	25
169	42.50	19.5,	21.5,	22,	22.5,	24,	24.5,	24.5,	25
170	42.75	19.5,	21.5,	22,	23,	24,	24.5,	24.5,	25
171	43.00	19.5,	21.5,	22,	23,	24,	24.5,	24.5,	25
172	43.25	19.5,	21.5,	22,	23,	24,	24.5,	24.5,	25
173	43.50	19.5,	21.5,	22,	23,	24,	24.5,	25,	25
174	43.75	19.5,	21.5,	22,	23,	24,	24.5,	25,	25
175	44.00	20,	21.5,	22,	23,	24,	24.5,	25,	25.5
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180	45.25	20, 21.5, 22, 23, 24.5, 25, 25, 25.5
181	45.50	19.5, 21.5, 22, 23, 24.5, 25, 25, 25.5
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183	46.00	19.5, 21.5, 22.5, 23, 24.5, 25, 25.5, 26
184	46.25	19.5, 21.5, 22.5, 23, 24.5, 25, 25.5, 26
185	46.50	19.5, 21.5, 22.5, 23.5, 24.5, 25, 25.5, 26
186	46.75	19.5, 21.5, 22.5, 23.5, 24.5, 25.5, 25.5, 26
187	47.00	19.5, 21.5, 22.5, 23.5, 25, 25.5, 25.5, 26
188	47.25	20, 21.5, 22.5, 23.5, 25, 25.5, 25.5, 26.5
189	47.50	20, 21.5, 22.5, 23.5, 25, 25.5, 25.5, 26.5
190	47.75	20, 21.5, 22.5, 23.5, 25, 25.5, 26, 26.5
191	48.00	20, 21.5, 22.5, 23.5, 25.5, 25.5, 26, 26.5
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193	48.50	20, 21.5, 22.5, 23.5, 25.5, 26, 26, 27
194	48.75	20, 21.5, 22.5, 23.5, 25.5, 26, 26, 27
195	49.00	20, 21.5, 22.5, 23.5, 25.5, 26, 26, 27
196	49.25	20, 21.5, 22.5, 23.5, 25.5, 26, 26, 27
197	49.50	20, 21.5, 22.5, 23.5, 26, 26, 26, 27
198	49.75	20, 21.5, 22.5, 24, 26, 26, 26, 27
199	50.00	20, 21.5, 22.5, 24, 26, 26, 26, 27
200	50.25	20, 21.5, 22.5, 24, 26, 26, 26, 27
201	50.50	20, 21.5, 22.5, 24, 26, 26, 26, 27
202	50.75	20, 21.5, 22.5, 24, 26, 26.5, 26.5, 27
203	51.00	20, 21.5, 22.5, 24, 26, 26.5, 26.5, 27
204	51.25	20, 21.5, 22.5, 24, 26, 26.5, 26.5, 27
205	51.50	20, 21.5, 22.5, 24, 26, 26.5, 26.5, 27
206	51.75	20, 21.5, 22.5, 24, 26, 26.5, 26.5, 27
207	52.00	20, 21.5, 22.5, 24, 26, 26.5, 26.5, 27
208	52.25	20, 21.5, 22.5, 24, 26, 26.5, 26.5, 27
209	52.50	20, 21.5, 22.5, 24, 26, 26.5, 26.5, 27
210	52.75	20, 21.5, 22.5, 24, 26, 26.5, 26.5, 27.5
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223	56.00	20, 21.5, 22.5, 24, 26.5, 26.5, 26.5, 27

224	56.25	20,	21.5,	22.5,	24,	26.5,	26.5,	26.5,	27
225	56.50	20,	21.5,	22.5,	24,	26.5,	26.5,	26.5,	27.5
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237	59.50	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
238	59.75	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
239	60.00	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
240	60.25	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
241	60.50	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
242	60.75	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
243	61.00	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
244	61.25	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
245	61.50	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
246	61.75	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
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248	62.25	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
249	62.50	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
250	62.75	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
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252	63.25	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
253	63.50	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
254	63.75	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
255	64.00	20,	21.5,	22.5,	24,	26,	26.5,	26.5,	27
256	64.25	20,	21.5,	22.5,	24,	26,	26,	26.5,	27
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258	64.75	20,	21.5,	22.5,	24,	26,	26,	26.5,	27
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262	65.75	20,	21.5,	22.5,	24,	26,	26,	26.5,	27
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265	66.50	20,	21.5,	22.5,	24,	26,	26,	26,	27
266	66.75	20,	21,	22.5,	24,	26,	26,	26,	27
267	67.00	20,	21,	22,	23.5,	26,	26,	26,	26.5
268	67.25	19.5,	21,	22,	23.5,	26,	26,	26,	26.5
269	67.50	19.5,	21,	22,	23.5,	26,	26,	26,	26.5

270	67.75	19.5,	21,	22,	23.5,	26,	26,	26,	26.5
271	68.00	20,	21,	22,	23.5,	26,	26,	26,	26.5
272	68.25	20,	21,	22,	23.5,	26,	26,	26,	26.5
273	68.50	20,	21,	22,	23.5,	26,	26,	26,	26.5
274	68.75	20,	21,	22,	23.5,	26,	26,	26,	26.5
275	69.00	20,	21,	22,	23.5,	26,	26,	26,	26.5
276	69.25	20,	21,	22,	23.5,	26,	26,	26,	26.5
277	69.50	20,	21,	22,	23.5,	26,	26,	26,	26.5
278	69.75	20,	21,	22,	23.5,	26,	26,	26,	26.5
279	70.00	20,	21,	22,	23.5,	26,	26,	26,	26.5
280	70.25	20,	21,	22,	23.5,	26,	26,	26,	26.5
281	70.50	20,	21,	22,	23.5,	26,	26,	26,	26.5
282	70.75	20,	21,	22,	23.5,	26,	26,	26,	26.5
283	71.00	20,	21,	22.5,	23.5,	26,	26,	26,	26.5
284	71.25	20,	21,	22.5,	23.5,	26,	26,	26,	26.5
285	71.50	20,	21,	22.5,	23.5,	26,	26,	26,	26.5
286	71.75	20,	21.5,	22.5,	23.5,	26,	26,	26,	26.5
287	72.00	20,	21.5,	22.5,	23.5,	26,	26,	26,	26.5
288	72.25	20,	21.5,	22.5,	23.5,	26,	26,	26,	26.5
289	72.50	20,	21.5,	22.5,	23.5,	26,	26,	26,	26.5
290	72.75	20,	21.5,	22.5,	23.5,	26,	26,	26,	26.5
291	73.00	20,	21.5,	22.5,	23.5,	26,	26,	26,	26.5
292	73.25	20,	21.5,	22.5,	23.5,	26,	26,	26,	26.5
293	73.50	20,	21.5,	22.5,	23.5,	26,	26,	26,	26.5
294	73.75	20,	21.5,	22.5,	23.5,	26,	26,	26,	26.5
295	74.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
296	74.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
297	74.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
298	74.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
299	75.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
300	75.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
301	75.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
302	75.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
303	76.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
304	76.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
305	76.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
306	76.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
307	77.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
308	77.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
309	77.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
310	77.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
311	78.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
312	78.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
313	78.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
314	78.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
315	79.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5

316	79.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
317	79.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
318	79.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
319	80.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
320	80.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
321	80.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
322	80.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
323	81.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
324	81.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
325	81.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
326	81.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
327	82.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
328	82.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
329	82.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
330	82.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
331	83.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
332	83.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
333	83.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
334	83.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
335	84.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
336	84.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
337	84.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
338	84.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
339	85.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
340	85.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
341	85.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
342	85.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
343	86.00	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
344	86.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
345	86.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
346	86.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
347	87.00	20,	21.5,	23,	24,	26,	26,	26,	26.5
348	87.25	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
349	87.50	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
350	87.75	20,	21.5,	22.5,	24,	26,	26,	26,	26.5
351	88.00	21,	22.5,	23.5,	24.5,	26,	26,	26,	26.5
352	88.25	21.5,	23.5,	24,	24.5,	26,	26,	26,	26.5
353	88.50	22.5,	23.5,	24,	24.5,	26,	25.5,	25.5,	26
354	88.75	22.5,	24,	24,	24.5,	26,	25.5,	25.5,	26
355	89.00	23,	24,	24,	24.5,	25.5,	25.5,	25.5,	25.5
356	89.25	23.5,	24.5,	24.5,	24.5,	25.5,	25,	25,	25.5
357	89.50	23.5,	24.5,	24.5,	24.5,	25.5,	25,	25,	25.5
358	89.75	23.5,	24.5,	24.5,	24.5,	25.5,	25,	25,	25
359	90.00	24,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	25
360	90.25	24,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	25
361	90.50	24,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	25

362	90.75	24,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
363	91.00	24,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
364	91.25	24,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
365	91.50	24,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
366	91.75	24,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
367	92.00	24.5,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
368	92.25	24.5,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
369	92.50	24.5,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
370	92.75	24.5,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
371	93.00	24.5,	24.5,	24.5,	24.5,	25.5,	25,	24.5,	24.5
372	93.25	24.5,	24.5,	24.5,	24.5,	25.5,	24.5,	24,	24.5
373	93.50	24.5,	24.5,	24.5,	24.5,	25.5,	24.5,	24,	24.5
374	93.75	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24.5
375	94.00	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24.5
376	94.25	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24.5
377	94.50	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
378	94.75	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
379	95.00	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
380	95.25	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
381	95.50	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
382	95.75	24.5,	25,	24.5,	24.5,	25,	24.5,	24,	24
383	96.00	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
384	96.25	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
385	96.50	24.5,	24.5,	24.5,	24.5,	25.5,	24.5,	24,	24
386	96.75	24.5,	24.5,	24.5,	24.5,	25.5,	24.5,	24,	24
387	97.00	24.5,	24.5,	24.5,	24.5,	25.5,	24.5,	24,	24
388	97.25	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
389	97.50	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
390	97.75	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
391	98.00	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
392	98.25	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
393	98.50	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
394	98.75	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
395	99.00	24.5,	24.5,	24.5,	24.5,	26,	24.5,	24,	24
396	99.25	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
397	99.50	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
398	99.75	24.5,	24.5,	24.5,	24.5,	25,	24.5,	24,	24
399	100.00	24.5,	24.5,	24.5,	24.5,	25.5,	24.5,	24,	24
400	100.25	24.5,	24.5,	24.5,	24.5,	25.5,	24.5,	24,	24
401	100.50	24.5,	24.5,	24.5,	24.5,	25.5,	24.5,	24,	24
402	100.75	24.5,	24.5,	24.5,	25,	25.5,	24.5,	24,	24
403	101.00	24.5,	24.5,	24.5,	25,	25.5,	24.5,	24,	24
404	101.25	24.5,	24.5,	24.5,	25,	25.5,	24.5,	24,	24
405	101.50	24.5,	24.5,	24.5,	25,	25.5,	24.5,	24,	24
406	101.75	24.5,	24.5,	24.5,	25,	25.5,	24.5,	24,	24
407	102.00	24.5,	24.5,	24.5,	25,	25.5,	24.5,	24,	24

408	102.25	24.5,	25,	25,	25,	25.5,	24.5,	24,	24.5
409	102.50	24.5,	25,	25,	25,	25.5,	25,	24,	24.5
410	102.75	24.5,	25,	25,	25,	25.5,	25,	24.5,	24.5
411	103.00	24.5,	25,	25,	25,	25.5,	25,	24.5,	24.5
412	103.25	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
413	103.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
414	103.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
415	104.00	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
416	104.25	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
417	104.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
418	104.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
419	105.00	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
420	105.25	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
421	105.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
422	105.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
423	106.00	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
424	106.25	25,	25,	25,	25,	26,	25,	24.5,	24.5
425	106.50	25,	25,	25,	25,	26,	25,	24.5,	24.5
426	106.75	25,	25,	25,	25,	26,	25,	24.5,	24.5
427	107.00	25,	25,	25,	25,	26,	25,	24.5,	24.5
428	107.25	25,	25,	25,	25,	26,	25,	24.5,	24.5
429	107.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
430	107.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
431	108.00	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
432	108.25	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
433	108.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
434	108.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
435	109.00	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
436	109.25	25,	25,	25,	25,	26,	25,	24.5,	24.5
437	109.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
438	109.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
439	110.00	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
440	110.25	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
441	110.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
442	110.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
443	111.00	25,	25,	25,	25,	26,	25,	24.5,	24.5
444	111.25	25,	25,	25,	25.5,	26,	25,	24.5,	24.5
445	111.50	25,	25,	25,	25.5,	26,	25,	24.5,	24.5
446	111.75	25,	25,	25,	25,	26,	25,	24.5,	24.5
447	112.00	25,	25,	25,	25.5,	26,	25,	24.5,	24.5
448	112.25	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
449	112.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
450	112.75	25,	25,	25,	25.5,	25.5,	25,	24.5,	24.5
451	113.00	25,	25,	25,	25,	26,	25,	24.5,	24.5
452	113.25	25,	25,	25,	25,	26,	25,	24.5,	24.5
453	113.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5

454	113.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
455	114.00	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
456	114.25	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
457	114.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
458	114.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
459	115.00	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
460	115.25	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
461	115.50	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
462	115.75	25,	25,	25,	25,	25.5,	25,	24.5,	24.5
463	116.00	25,	25,	25,	25,	26,	25,	24.5,	24.5
464	116.25	25,	25,	25,	25.5,	26,	25.5,	24.5,	24.5
465	116.50	25,	25.5,	25,	25.5,	26,	25.5,	24.5,	24.5
466	116.75	25,	25.5,	25,	25.5,	26,	25.5,	24.5,	24.5
467	117.00	25,	25.5,	25.5,	25.5,	26,	25.5,	24.5,	24.5
468	117.25	25.5,	25.5,	25.5,	25.5,	26,	25.5,	25,	24.5
469	117.50	25.5,	25.5,	25.5,	25.5,	26,	25.5,	25,	25
470	117.75	25.5,	25.5,	25.5,	25.5,	26,	25.5,	25,	25
471	118.00	25.5,	25.5,	25.5,	25.5,	26,	25.5,	25,	25
472	118.25	25.5,	26,	25.5,	26,	26.5,	25.5,	25,	25
473	118.50	25.5,	26,	26,	26,	26.5,	25.5,	25,	25
474	118.75	25.5,	26,	26,	26,	26.5,	25.5,	25,	25
475	119.00	25.5,	26,	26,	26,	26.5,	26,	25,	25
476	119.25	25.5,	26,	26,	26,	26.5,	26,	25,	25
477	119.50	25.5,	26,	26,	26,	26.5,	26,	25,	25
478	119.75	26,	26,	26,	26,	26.5,	26,	25,	25
479	120.00	26,	26,	26,	26,	26.5,	26,	25.5,	25
480	120.25	26,	26,	26,	26,	26.5,	26,	25.5,	25
481	120.50	26,	26,	26,	26,	26.5,	26,	25.5,	25
482	120.75	26,	26,	26,	26.5,	26.5,	26,	25.5,	25.5
483	121.00	26,	26,	26,	26.5,	26.5,	26,	25.5,	25.5
484	121.25	26,	26,	26,	26.5,	26.5,	26,	25.5,	25.5
485	121.50	26,	26,	26,	26.5,	26.5,	26,	25.5,	25.5
486	121.75	26,	26.5,	26,	26.5,	26.5,	26,	25.5,	25.5
487	122.00	26,	26.5,	26,	26.5,	27,	26,	25.5,	25.5
488	122.25	26,	26.5,	26,	26.5,	27,	26,	25.5,	25.5
489	122.50	26,	26.5,	26,	26.5,	27,	26,	25.5,	25.5
490	122.75	26,	26.5,	26.5,	26.5,	27,	26,	25.5,	25.5
491	123.00	26,	26.5,	26,	26.5,	27,	26,	25.5,	25.5
492	123.25	26,	26,	26,	26.5,	27,	26,	25.5,	25.5
493	123.50	26,	26.5,	26.5,	26.5,	27,	26,	25.5,	25.5
494	123.75	26,	26.5,	26.5,	26.5,	27,	26,	25.5,	25.5
495	124.00	26,	26.5,	26.5,	26.5,	27,	26,	25.5,	25.5
496	124.25	26,	26.5,	26.5,	26.5,	27,	26,	25.5,	25.5
497	124.50	26,	26.5,	26.5,	26.5,	27,	26,	25.5,	25.5
498	124.75	26,	26.5,	26.5,	26.5,	27,	26,	25.5,	25.5
499	125.00	26,	26.5,	26.5,	26.5,	27,	26,	25.5,	25.5

Interpretation of Data

I did three experiments, two vertical, and one horizontal. The vertical experiments should show the temperature difference between the ceiling fan and the floor, while the horizontal experiment shall show more the heat distribution at the level where people sit.

The first vertical experiment didn't turn out well. The test apparatus pole is 12' long and hits the ceiling fan. For the first vertical experiment, I placed the apparatus between the ceiling fan and the fireplace. The bottom thermometer got a lot more heat then the others because it was right in front of the fireplace so the measurements didn't show the correct temperature difference between the ceiling and the floor. For the second vertical experiment I placed the apparatus on the other side of the ceiling fan, away from the woodstove.

It is interesting to look at the temperature difference between the ceiling and the floor for the second vertical experiment. Shown in figure 32 is the difference between the ceiling and the floor at the end of the no fan, heat exchanger, and the ceiling fan sections.

Figure 32. Ceiling to Floor Temperature Difference

Section	Time Point	Floor Thermometer	Ceiling Thermometer	Temperature Difference
No fan	180	20	25.5	5.5
Heat exchanger	349	20	26.5	6.5
Ceiling fan	499	26	25.5	0.5

At the end of the heat exchanger section, there was 6.5 deg Celsius difference between the ceiling and the floor temperature or 11.7 deg Fahrenheit. After the ceiling fan turned on, it basically equalized the temperature (within the accuracy of the temperature reading).

Looking at the graph of the horizontal experiment, I see several different things. To me, it appears that there are 6 different rates of rising.

Figure 33.

Temp Change Rate for the Horizontal Run

Area Description	**Rate** Deg C per min
High rate after start of the fire	0.44
No fans are on	0.1
Heat Exchanger first introduced to room	0.13
Heat Exchanger gets old and rates plateau	0
Ceiling fan becomes a celebrity when started	2.3
Ceiling fan becomes ancient and again plateaus	0

Figure 33 shows that the Heat Exchanger has an increased rate on the graph then when there are no fans. However, the ceiling fan shows a DRAMATICALLY increased rate.

The other thing that I see from this data is the differences of the min and max temp of all 8 thermometers. The Heat Exchanger, instead of heating up the room evenly, heated up the closest thermometers more than the thermometers that were farther away. With the exception of the last thermometer (it is the color gray on the graph). The ceiling fan did a very good job of evening out the temperature of through out the room. The last thermometer wasn't effected by the ceiling fan because it wasn't really *inside* of the room.

A possible source of error in my experiment is the thermometers. They supposedly have an accuracy of 0.5 degree Celsius. *I don't think so.* However this error does not effect the trends I have observed above. Some of the air in the thermometer readings in the horizontal experiment may have to do to just poor air circulation. The test apparatus was laying on some pillows which may have effected some of the thermometer readings.

Conclusion

The ceiling fan had the highest rate and even equalized the temperature the best. That supports my hypothesis because the ceiling fan pushed the warm air (that raised up, remember?) down from the ceiling.

A summary of what I have learned is that the ceiling fan does the best job of distributing the heat. Also the Heat Exchanger does better then without any fans, but its not as good as I thought it would be.

Ideas for Future Experiments

For all three experiments, I had the fan blowing air downward. My mother does not like the fan on because it makes her cold even though the thermometers say the temperature is hotter. This is because of the “wind chill factor”. As wind blows on your skin, it evaporates water. The energy required for the evaporation is heat taken away from the skin. To avoid this I should have reversed the direction of the ceiling fan so that the air blows up instead of down. I should repeat the experiment with the fan reversed to see if it does as good a job equalizing the temperature.

Another possible idea is to do another horizontal experiment where the test apparatus is positioned with each end next to a window to see if there are any drafts from the windows.

Application for society

This shall help people keep warm and comfortable through the winter. So it is very beneficial to have a ceiling fan put in a room with a fireplace.

Research References

Joseph D. Exline, Fred Holtzclaw, Linda Cronin Jones, Steve Miller, Barbara Brooks Simons, Carole Garbuny Vogel, Thomas R. Wellnitz. Focus on Earth Science., Upper Saddle River, New Jersey: Prentice Hall Inc., 2001.

Tracy Allen. Earth Meaasurements Student Guide Version 1.2, Rocklin, California: Parallax Inc., 1999.

BASIC Stamp Manuel Version 2.0, Rocklin, California: Parallax Inc., 2000.

BS2p "Plus Pack" Appkit (#45184), Parallax Inc., October 2001, http://www.parallaxinc.com/downloads/Documentation/BS2P/BS2p%20Plus%20Pack.pdf

"The Waterford Trinity Wood Stove", 12/8/2001, http://www.waterfordstoves.com/pages/trinity.shtml

"To Heat or Not To Heat" 11/3/2001 http://www.jafi.org.il/newsite/aliyah/heat.htm

"1896 Art Nouveau™ Hunter Fan Showcase" 12/8/2001 http://www.hunterfan.com/showroom/fans_detail.tmpl?SKU=0%2049694%2023710%201

Del Wenzlick, "Ceiling fans key in winter comfort, efficiency" Regency Fans Press Release, 11/3/2001 http://www.regencyfan.com/press/pdf/comfort.pdf

Sheila J. Hayter, Paul A. Torcellini, "A Case Study of the Energy Design Process Used for A Retail Application", Presented at the American Soler Energy Society (ASES) conference Madison Wisconsin June 2000, 11/3/2001, http://www.nrel.gov/docs/fy00osti/28129.pdf

"Home of the Stamp and the SX-Key",10/9/2001, http://www.parallaxinc.com/

Robert Plachno, "Stamps", Kclass Lectures, 9/1/2001, stamp.doc

"Stamps in Class", 12/9/01, http://www.stampsinclass.com/

"ExpressPCB"11/11/2001, http://www.expresspcb.com/

"S-Plot Pro, Selmaware Solutions" 11/13/2001, http://www.selmaware.com/

What I Have Learned

- I learned how important the ceiling fan is.
- I learned how the heat exchanger works.
- This is the first time I made a complete BASIC stamp program.
- This, in my case, required me to make my first loop.
- I learned how to write subroutines.
- I learned many BASIC commands and instructions.
- This is the first time I have made a schematic of a board with integrated circuits.
- It is the first time I made a design of a Printed Circuit Board.
- This is the first time I have soldered an integrated circuit.
- First time I have soldered on a Printed Circuit Board.
- First time I have written a report longer then 20 pages.
- I learned how to write faster.
- I learned how to use footnotes.

Name Plate

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