The Brewtus Compendium

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THE AUTHOR ACCEPTS NO RESPONSIBILITY FOR ANY INJURIES OR LOSSES RESULTING FROM ANY ATTEMPT TO PERFORM THESE MODIFICATIONS.

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I would like to make it very clear from the outset that the addition of a PID controller to the Brewtus is not as simple as a Silvia; it's not insanely complex but it does require knowledge of the inner workings of the machine and the interaction of the two boilers in addition to being very familiar with the proper preparation of electrical wiring and control systems. To that end; this document is not a paint-by-number instruction sheet that gives a point to point explanation of every wiring change made to the machine; there are many ways(and places) to install controllers in the system and I am only covering how and why I did mine the way I did.

Thanks to Doug Shannon for providing assistance with the wiring for a stock machine and the parts list.
(Because I thought it would be a good idea to write this manual **after** I ripped all the wiring out of my machine.)

Thanks to Abe Carmeli and Kitt Johnson for multiple re-reads to find ~~tipos~~ ~~typas~~ typos. ☺

How the Machine Works

1.

1.1. How It All Works:

The Brewtus is a double boiler, E61 brewgroup espresso machine utilizing some very clever techniques and controls to enable 120V operation of two 1000 W boiler heaters and pump from a 15 amp service.

1.2. The Boilers:

The single feature that distinguishes this machine from the vast majority of other makes and models in both the commercial and home market place, is the double boiler system and how it handles the interaction between brew and steam boilers.

Note: *Schematic diagram of the plumbing of the machine on page 8. Item numbers on the schematic will be shown as superscripts throughout this section.*

In the center of the diagram are the two 1.7L boilers; Steam[46] and Brew[47], each Boiler has a 975W heater[16] that is screwed in from the bottom of the boiler. With the exception of a heat exchanger[42] installed in the steam boiler for brew boiler feedwater pre-heat, the construction of the two units is identical. Fittings on the boilers are BSPP thread of various sizes and consist of the following:

Brew Boiler:

- Upper feedwater from the Steam boiler HX.
- Upper supply to the Brewgroup.
- Lower return from the Brewgroup.

Steam Boiler:

- Lower inlet to HX for Brew boiler feed water from the pump.
- Lower inlet for steam boiler fill from solenoid valve.
- Lower outlet to hot water tap.
- Upper outlet from HX to brew boiler.
- Upper outlet to steam wand/Pressurestat.
- Fitting for water level sensor.[25]
- Fitting for a vacuum break assembly.

Conditions during operation:

Idle:

- Brew boiler[47] will be completely full of water including the brewgroup[35] (a very slight air gap may exist in the brewgroup). Thermosyphon action will be circulating hot water from the top of the boiler into the brewgroup[35] where it cools and exits out the bottom pipe of the group and returns to the bottom of the boiler, pulling more hot water into the top of the group as it settles.
- The steam boiler[46] is kept half-full by virtue of the electronic level control sensor[28], this allows sufficient steam for frothing and ~ 760ml of water for the hot water tap. Boiler pressure is regulated at 1.2Bar by the pressurestat[31] and the HX[42] is full of feedwater for the brew boiler. The vacuum break[23] is held closed by the steam pressure and will emit a slight hissing sound during warm-up only.

Brew:

- The Pump[3] maintains 9Bar of pressure through the HX[42] in the steam boiler[46] where the feedwater is pre-heated and then routed to the top of the brew boiler[47] that is also maintained at 9Bar during brew. This water flows out of the brew boiler to the brewgroup[35] and then out of the machine into the drip pan.
- The steam boiler[46] will drop in temperature during brewing due to the cooling effects of the incoming feedwater in the HX[42]. This cooling action will most likely cause the pressurestat[31] to call for steam boiler heat[16/46]; when this happens, the heat to the brew boiler[16/47] is put in standby until 1.2Bar is reached.
- The solenoid valve[11] is not activated at this time.

Steam boiler details:

- The steam boiler[46] will automatically refill itself when the water level drops below the bottom of the level sensor[28]. When this happens, the control module (not pictured) will activate the pump[3] and the solenoid valve[11]to fill the steam boiler[46]. The water will flow into the steam boiler[46] by virtue of the fact that the brew boiler[47] circuit is already filled with water; forcing the water to flow into the steam boiler until it reaches the level sensor[28].
- The safety relief[37] opens at approximately 1.8Bar
- The vacuum break[23] is a valve that is held closed by boiler pressure, it will hiss during warm-up until enough pressure is built up to hold it closed. This valve prevents pump operation issues and also prevents generation of a vacuum in the steam boiler[46]. A vacuum can draw contaminated water back into the boiler in the event that either the steam wand[36] or the water wand[34] are left submerged in pitchers of water/milk when the machine is turned off.

1.3. The Pump:

The "pump" consists of three distinct components:

- A 41watt Ulka or 50watt CEME vibe pump[3]
- A de-aeration valve[45] to reduce the incidence of air bubbles in the pump output.
- An Over-Pressure-Valve or OPV[5] that regulates the system brew pressure.

Some machines have shipped with an Ulka pump and others have the original CEME version. Both pumps are fine units and should give years of trouble-free service. The pump[3] inlet line is connected to a water softener[39] that is at the end of the intake hose. As the water leaves the pump[3], it passes through a de-aeration valve[45] that removes the air bubbles that may be present in the water. The de-aeration valve[45] is essentially a port with a very fine opening that allows air to pass easily, but presents a difficult path for water to pass. This port is vented back to the water reservior[38] for recovery of the water that does pass through the port.
After the water passes the de-aeration valve it comes to the OPV[5], this valve uses an adjustable, spring-loaded ball that opens when a pre-set pressure is exceeded. When the ball opens, the excess pressure (water) is vented back to the water reservoir[38] until the pressure lowers to the pre-set value. At times, this process of open-close can cause slight "moaning" noises, this is not detrimental, just noisy.
Incorporated into the outlet of the OPV is a one-way check valve[44], this valve prevents water backflow through the pump assembly.

1.4. The Electronics:

Temperature control

Temperature control of the brew boiler is maintained by a digital on/off type control. The control is a 2-digit display unit set for readout in degrees Celsius with adjustments to brew temperature in 1 degree increments. Temperature sensing is via a sensor that is inserted into a thermowell in the brew boiler and which is held in place with thermally conductive paste.

Programmed into the control is an offset between the measured boiler temperature and the displayed value on the control; this compensates for the temperature difference between the boiler and the brewgroup. Displayed value should reflect the temperature of the brewgroup.

System Control, A.K.A "The Brain Box":

Control of the overall system is performed by a small black box mounted behind the front panel, just below the temperature controller. This controller coordinates the automatic refilling of the steam boiler and the logic required for switching the pump on during brewing.

Inputs to this unit are:

- The spring-loaded switch under the reservoir for detection of an empty reservoir.
- The microswitch for the pump. (behind the brew handle)
- The level sensor in the steam boiler.

Outputs from this unit are:

- The pump.
- Heater power for the boilers.
- Solenoid valve control.

1.5. The heaters:

The heater control for the machine is actually very straightforward. The steam boiler has priority in this system and that prioritizing is performed via the pressurestat. Overall, the switch on the platform for the reservoir controls power to the boilers. This power is then routed to the pressurestat where the steam boiler is assigned priority by the SPDT switch on the pressurestat.

- When the steam pressure is below ~1.1Bar, the pressurestat switches power to the steam boiler heater through the safety thermostat (steam).
- When the pressure is above ~1.2Bar, the power is routed to the brew temperature controller and then through the safety thermostat (brew) and brew boiler heater.

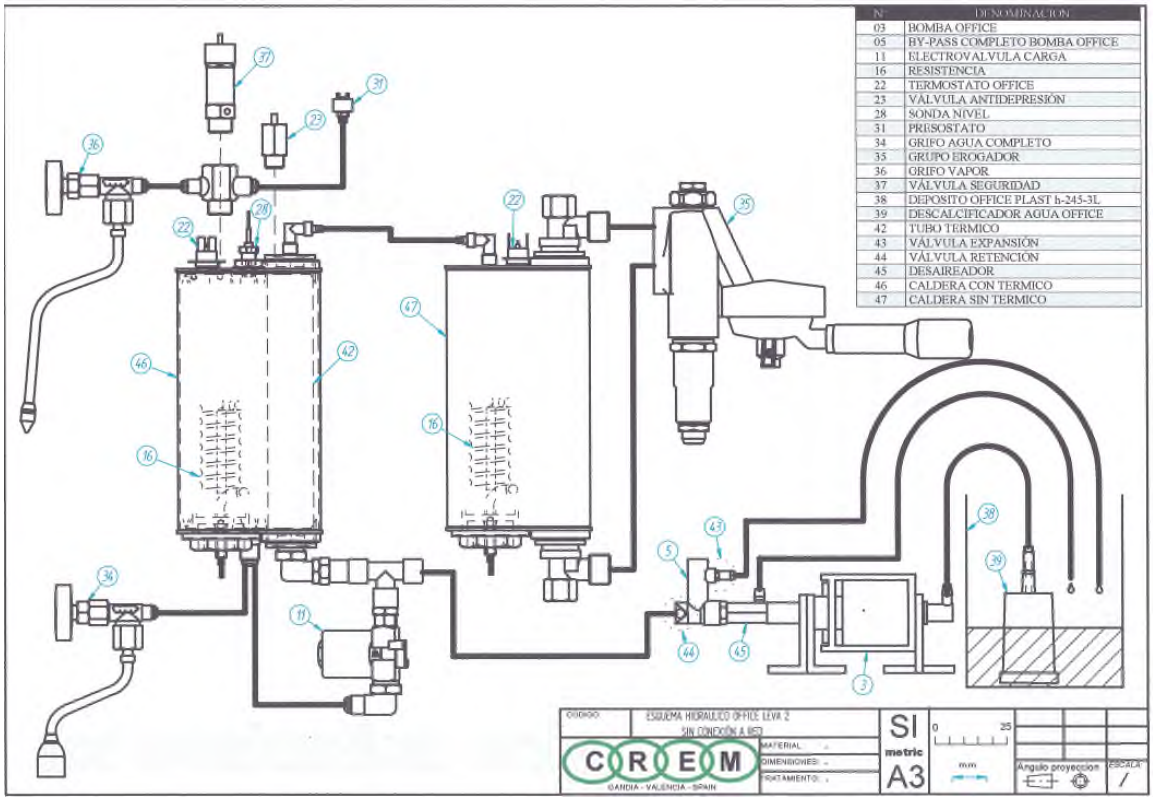
IMPORTANT:

It is possible to for the light for the steam boiler to be on at the same time that the digital temperature controller is calling for heat (small LED in the upper left hand corner of the display); keep in mind, that although the temperature controller is calling for heat, all power switching for boiler priority is done at the pressurestat and the display only reflects a "request" for heat in the brew boiler.

Notes:

a. The control can be programmed to read in degrees Fahrenheit but due to the 2 digit display limitation; it will display an E1 (out of range) error when the display rolls from 99 to 100; this will also occur if the temperature exceeds 100 degrees Celsius at any time. Normal operation will resume once the temperature displayed drops below the "100" value.

1.6. Mechanical schematic

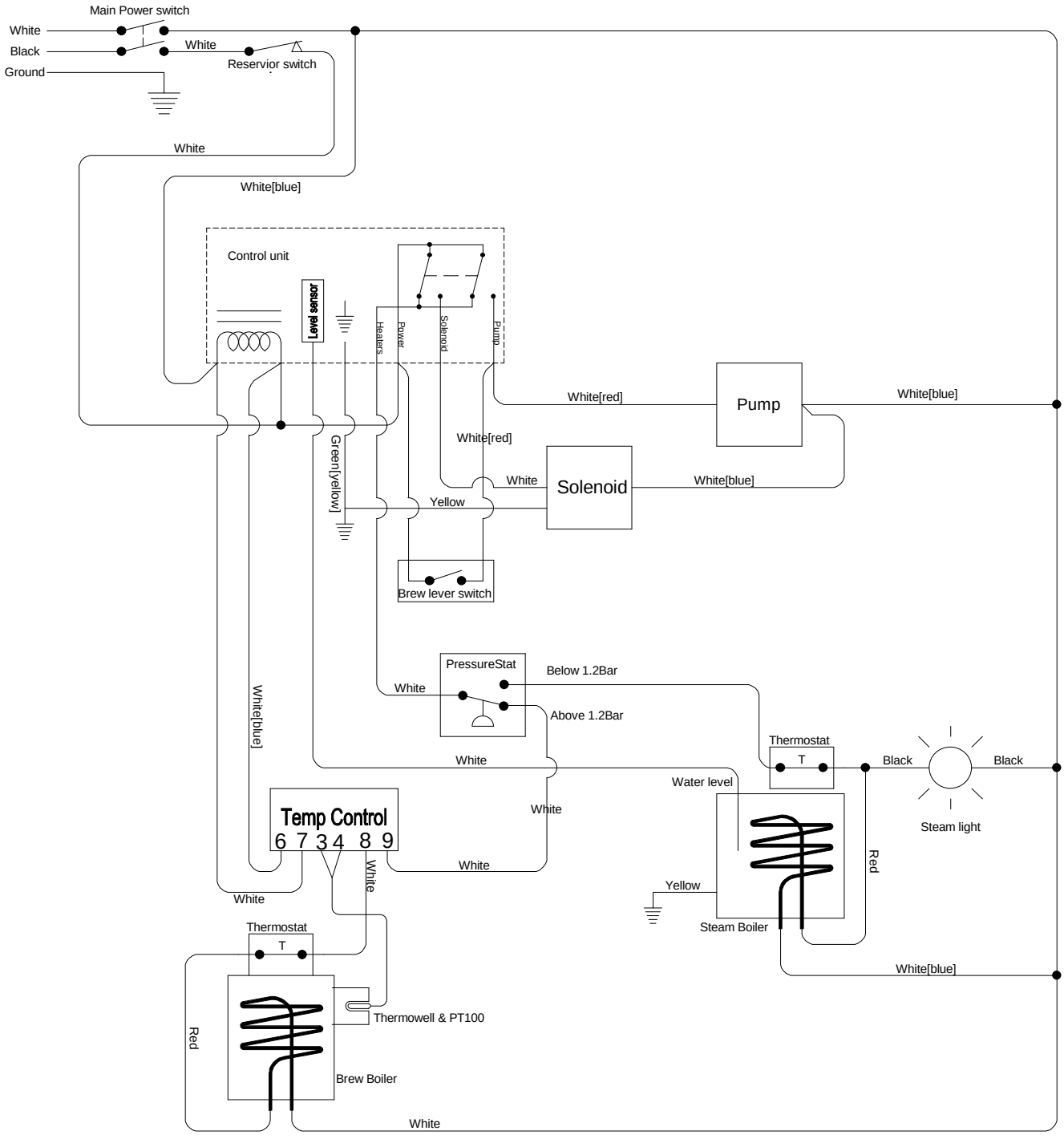


Nomenclature Translation:

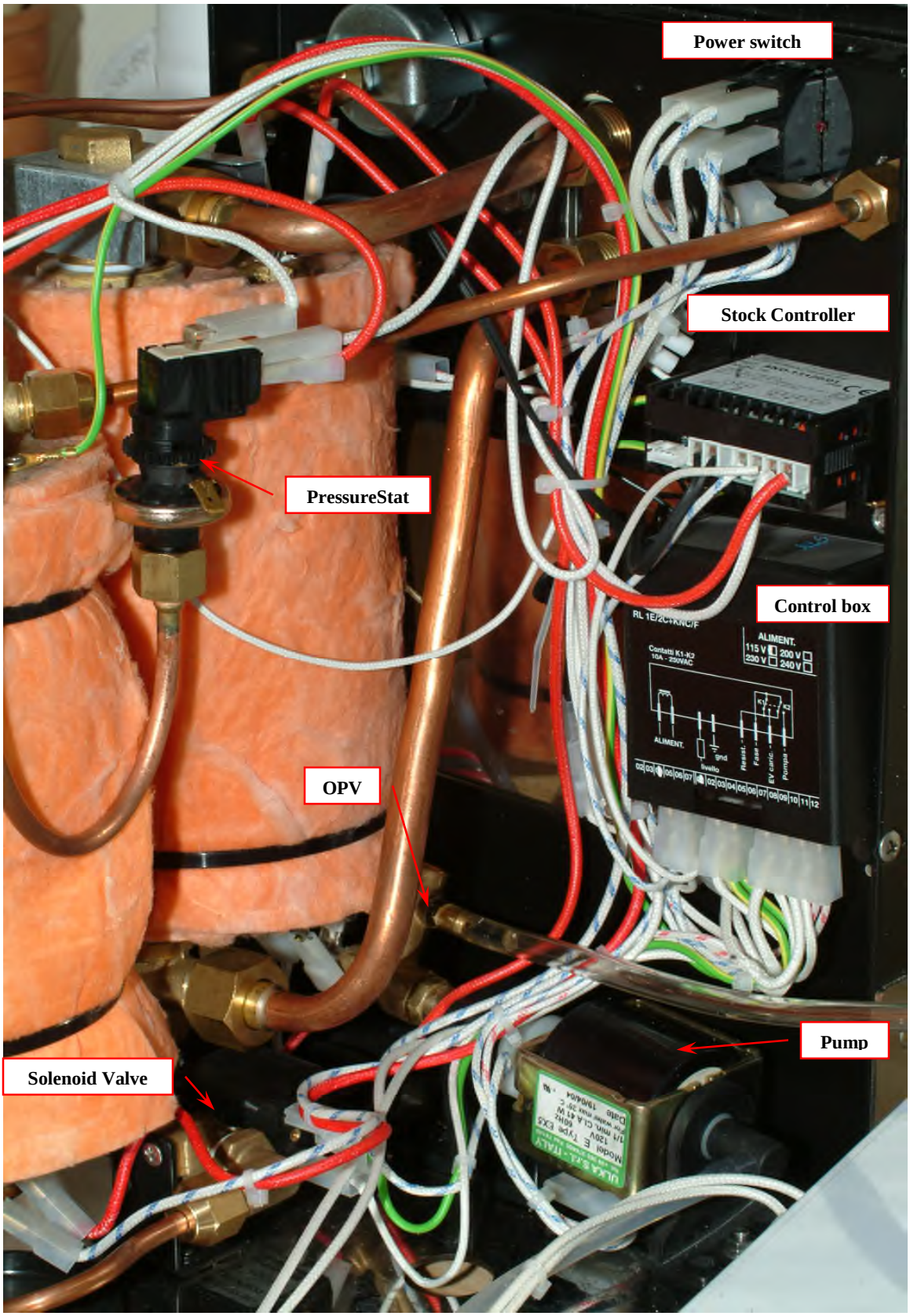
03 Pump Housing
05 Complete Pump Bypass Housing
11 Solenoid Valve
16 Heater Element (coil)
22 Thermostat Housing
23 Relief Valve
28 Water Level Sensor Valve
31 Pressure Gauge
34 Water Faucet Assembly
35 Brew Group Assembly
36 Steam Faucet Assembly
37 Safety Valve
38 Plastic Water Reservoir
39 Water Softener Orifice
42 Heat Exchanger
43 Expansion Valve
44 Retention Valve
45 Aerator Valve
46 Brew Boiler
47 Steam Boiler

2. The Electrical Components

2.1. Stock Circuit diagram

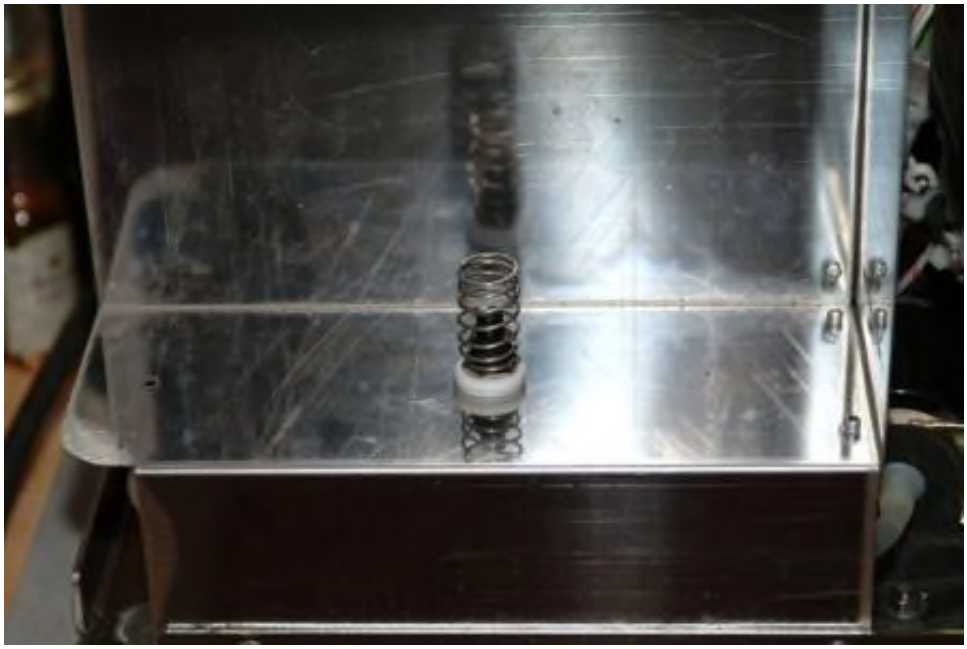


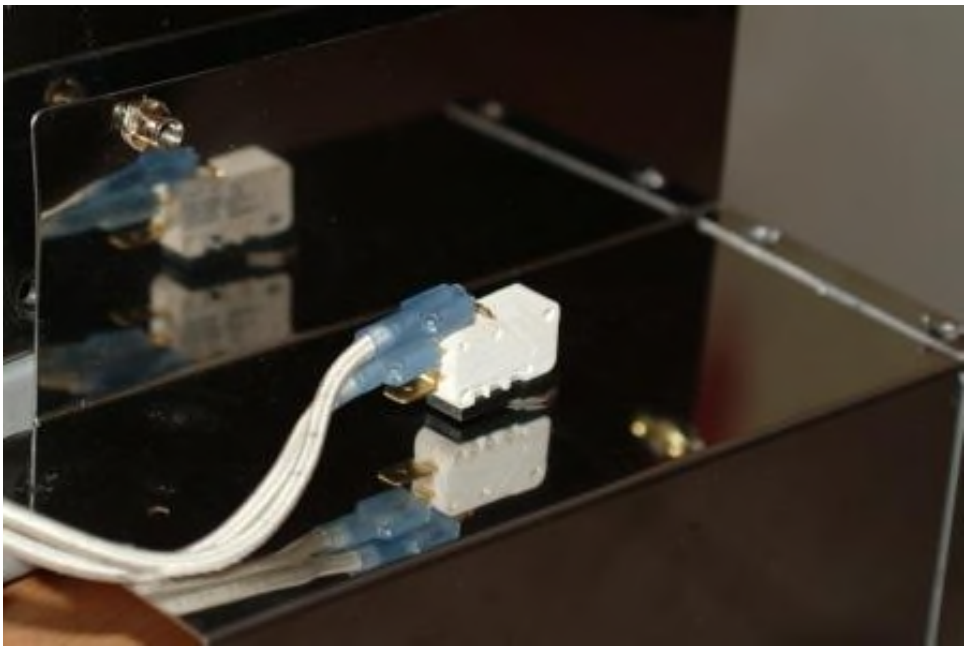
2.2 Internal overview photo:



2.3 **Main Power switch:**
Location: Front panel of machine
DPST rocker switch with indicator lamp; switches both neutral and hot leads of the incoming power.

2.4 **Reservoir switch:**
Location: Under reservoir, fastened to the stainless panel that isolates the reservoir from the boilers.

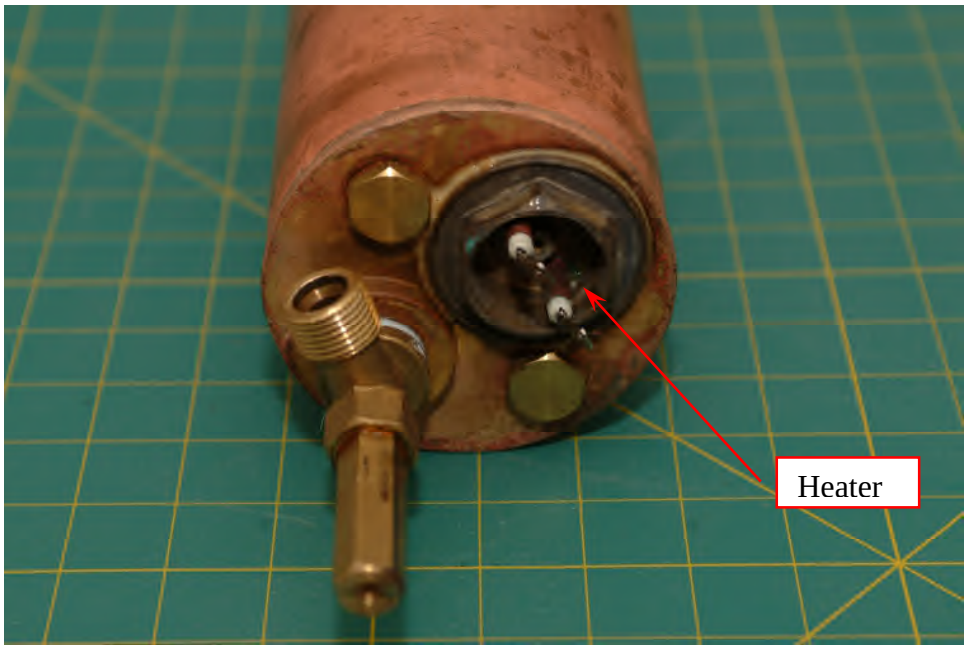




This switch is a SPDT switch that controls ALL incoming power to the unit after the main power switch. The power is wired to the Normally Open contacts (NO.) and the weight of a full water reservoir depresses the switch to a closed position. This configuration is called “Normally open held closed”, it is this way so that its normal state de-energizes the system with no water. When this switch is “OFF” all power to the machine will be interrupted with the exception of the red pilot light in the rocker switch for main power.

2.5 **Heater Circuits.**

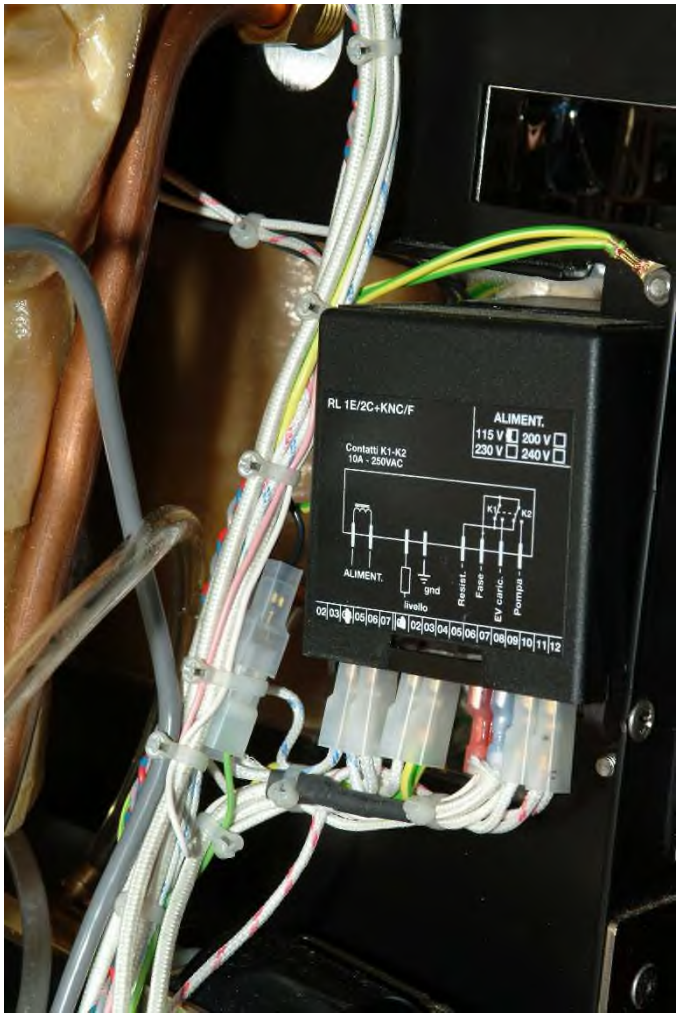
Location: Heaters are screwed into the bottom of each Boiler; each boilers safety thermostat is a small, tan, cylindrical unit held to the top of each boiler with 2 small screws.



Each boiler heater assembly is identical in operation for its relative boiler. The heaters each have an accompanying safety thermostat that is wired in series with the heater such that in the event of an over-temperature situation; the thermostat opens and interrupts power to the heater until the temperature reaches a safe level. Power to the heater circuit is supplied to one terminal of the thermostat after which it is then conveyed by a red wire to a terminal of the heater coil on the bottom of the boiler. The open terminal of the heater coil is connected to the neutral line of the power. Power should always be supplied to the thermostat first and then the heater second, this practice assures that 120V potential is removed from the heater coils in the event of an overheat situation.

2.6 **Control Box:**

Location: Small black box on the back of the front panel; below the temperature controller (OEM).



The control box provides the control logic for the automatic level control of the steam boiler and controls the supply of power to the heating elements via an internal DPDT relay. Normally closed contacts are wired together to supply the heaters; normally open contacts are wired to control the pump and the solenoid valve (on contact set per device).

Operation:

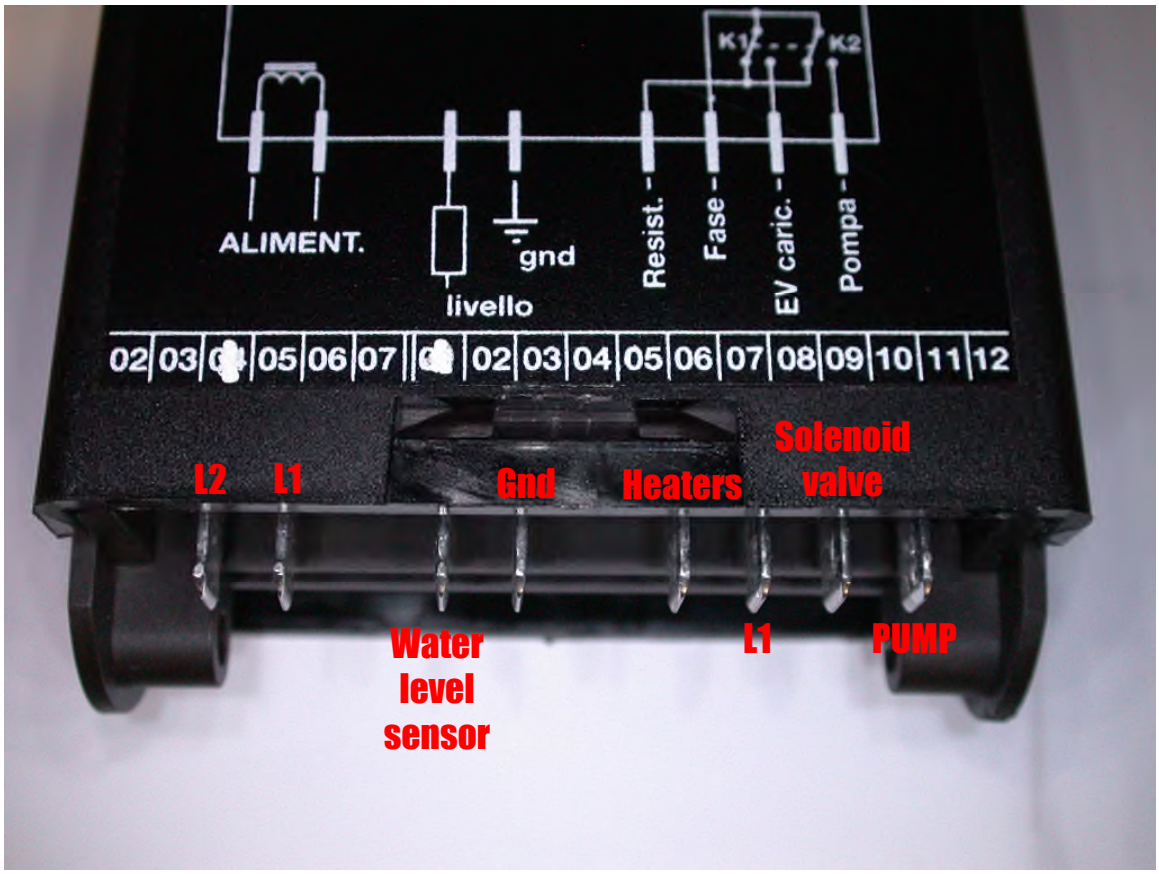
Idle:

- Power is applied to the internal transformer for the logic circuits inside the unit and the common connections for the internal relay.
- The internal relay is de-energized and power is supplied to the heater circuits via the normally closed contacts of both contact sets of the internal relay.

Steam boiler refill:

- Internal circuitry senses a drop in water in the steam boiler by an increase in resistance at the sensor.
- Internal circuits energize the power control relay inside the control box.
- Both the pump and solenoid valve are energized to generate system pressure and fill the steam boiler through the solenoid valve.
- Power to the heaters is interrupted while the relay is energized; this prevents the possibility of steam heater element burnout in the event of low water.

2.7 Control box connections



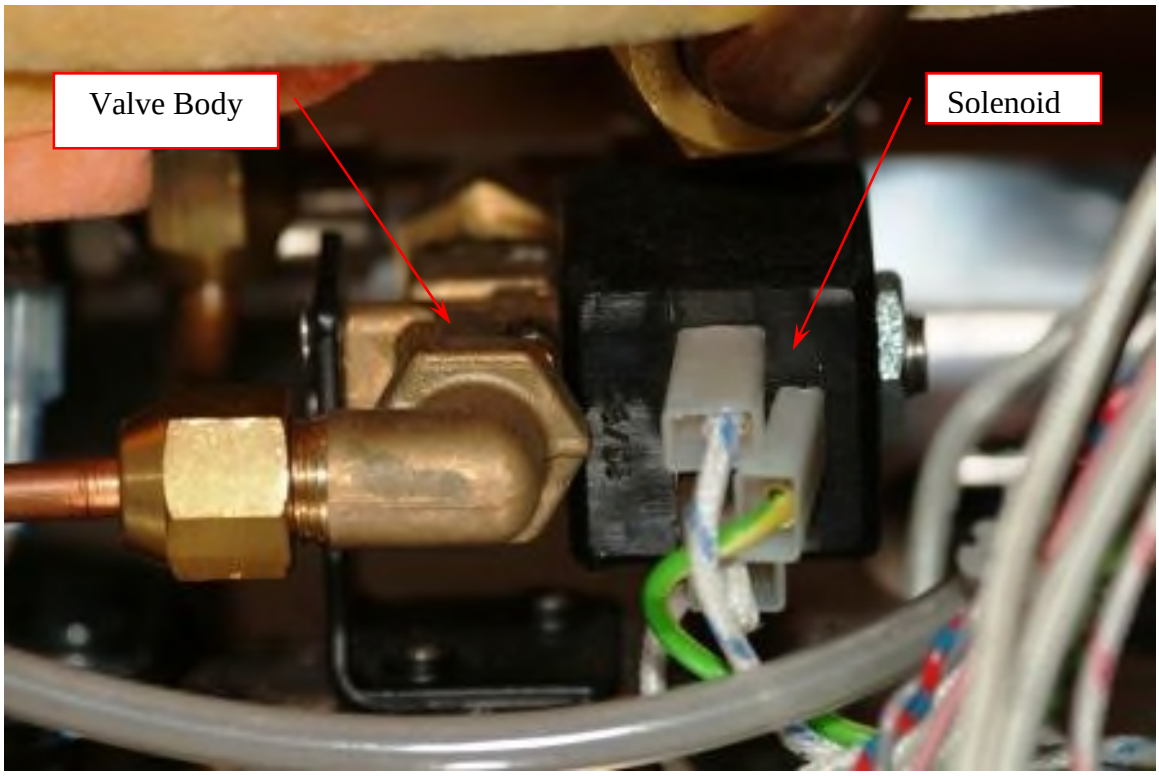
2.8 **Brew Micro-Switch:**

Location: protrudes through the front panel directly behind the brew lever. Roller operator is seen from the outside; electrical contacts are connected to the operator inside the machine.

The micro-switch is a normally open switch that is closed when the brew lever is brought to the horizontal position. When closed; the contacts bypass the control box relay that controls the pump and forces the pump to energize. When the pump is energized without the solenoid valve being energized, the water is routed to the brew boiler and subsequently the brew group.

2.9 **Solenoid valve:**

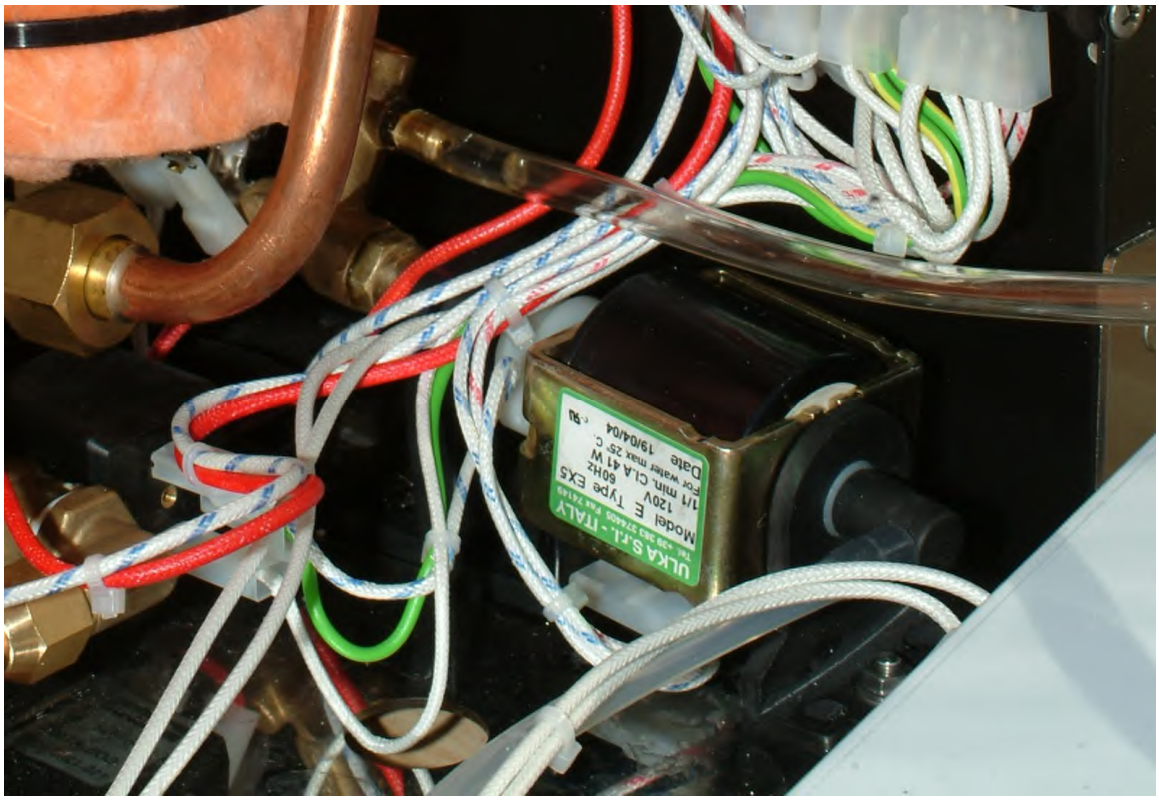
Location: Directly below the steam boiler; the valve assembly is part of the stand-off that anchors the steam boiler to the frame of the machine.



The solenoid valve is closed when de-energized; and opens when energized by the control unit relay. This valve only controls the flow of water into the steam boiler. During steam boiler refill; water flows into the boiler by virtue of the fact that the brew boiler is already full of water thereby leaving the path of least resistance for the water to flow into (steam boiler). Because of the manner in which the system works; attempting to brew while the steam boiler tries to refill is not possible because system pressure at the levels required for brewing cannot be generated while the steam boiler fills. The mechanical valve portion of the assembly is energized by the small black cube that contains an electromagnetic coil that is situated on the side of the valve facing the front of the machine. The coil assembly has 3 wires coming out of it; a ground lead and 2 power leads.

2.10 **Pump:**

Location: Directly behind the front panel of the machine; bolted the floor and slightly offset to the reservoir side of the machine.



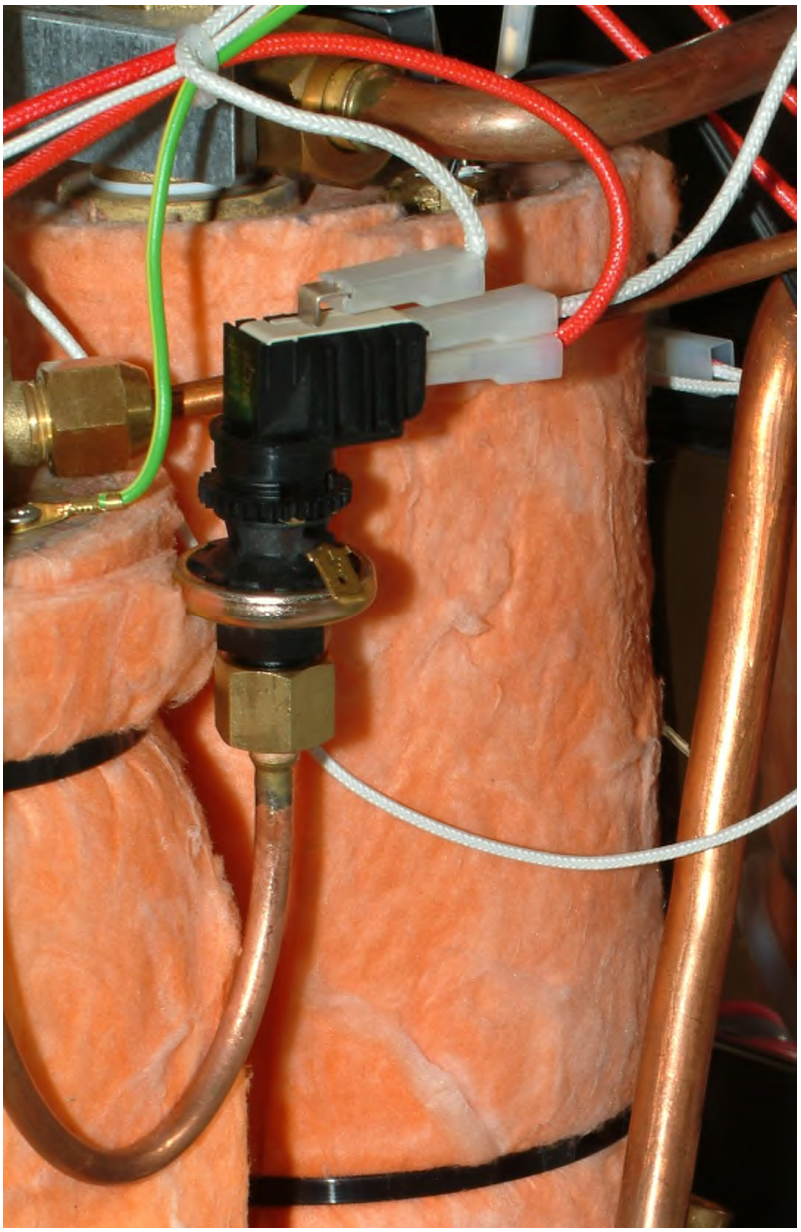
The pump in the Brewtus is either a CEME 47 Watt unit or an ULKA 41 Watt unit, either pump is fine as there are little performance differences between the two.

The pump is controlled automatically by the steam boiler level control box or manually by the brew lever micro-switch.

2.11 **Pressurestat:**

Location: Attached to the end of a “U” shaped tube that comes from a fitting in the top of the steam boiler.

All prioritization for heater power in the machine is performed at the pressure stat. the unit consists of a single pole-double throw switch that is operated by a pressure sensing diaphragm housed in the round, steel base portion of the assembly. In operation; power is supplied to the switch



common terminal and routed to the normally closed terminal when steam pressure is below 1.2Bar and to the normally open terminal when steam pressure is above 1.2Bar.

As wired in the machine:

The steam boiler heater is connected to the normally closed terminal so that it receives power whenever steam pressure drops below ~1.2Bar.

The normally open terminal of the switch supplies power to the control relay on the brew boiler temperature controller (unit with the digital display) which, in turn, performs the temperature control of the brew boiler.

Note: ***The Controller is going to be replaced but it is important to understand how it worked in the first place.***

2.12 **Temperature Controller:**

Location: Digital display mounted in the front of the control panel to the left of the brew group.

The display unit is a 2 digit, on-off type temperature controller. Wiring of the unit consists of 6 connections:

Power:

2 connections that are made in parallel with the supply power for the control box power. The only devices that control power to this unit are the main power switch and the reservoir switch.

Control output:

This is a normally open relay output (2 wires) that is closed when the control relay energizes in response to the controller sensing a need for additional heat in the brew boiler. The common terminal receives power from the N.O. terminal of the Pressure-Stat. power from the N.O. terminal of this controller goes to the brew boiler heater circuit.

Sensor:

The sensor is a 2 wire device that is connected to the controller and is located in a thermowell in the top of the brew boiler.

3 Control systems Conversion

3.1 Single PID…Dual PID; Thermocouple…Pressure Transducer; 1,2,3 SSRs; Priority…No Priority

Lots of choices here and no perfect answers, just a group of compromises, you pick the ones you can live with.

I chose the following configuration:

- Pressure Transducer for the steam boiler.
- Thermocouple for the brew boiler.
- Dual SSR for control of both the heaters in the same device.
- A secondary SSR to control the main heater power. (To bypass the control unit relay)
- Steam boiler priority during warm-up cycle.
- Both boilers operational (no priority) after system is up to operating temperature.

I used a pressure transducer to control the steam boiler because it gave me very fast response to changes in pressure; this response time aided the systems performance with regards to steaming and it had the advantage of steady pressure control regardless of water level in the steam boiler. I make an Americano in the morning and during a long draw of water for my coffee it is possible that the thermocouple is going to be out of the water…I don't like that, I also don't like the fact that to guarantee that the thermocouple is always in contact with the water I would have to place it right next to the heater element. Power for the transducer comes from the main control box in my machine(see attachments) because the level control circuitry runs on 12V as does the sensor and the control box has a 1Amp 12V regulator in it…Handy! I only need a few milliamps to run the transducer. If you don't like the thought of modifying your control box; you can install a small 12V power supply.

The brew boiler is controlled via a stainless steel .062 thermocouple that is inserted through a Swagelok® bored-through $^{1}/_{16}$" compression fitting that is threaded into the blank plug in the top of the brew boiler. The thermocouple is "wet", inserting a thermocouple in the thermowell is functional but I wanted the speed of response that a fine/wet thermocouple would give me, I also wanted the ability to be able to re-position the thermocouple in the boiler so as to find the best location for temperature control.

The single contact rating of the relay in the OEM control box is not large enough to take the heater load if one contact set fails so I decided to add another SSR to do the load switching of the heaters, in retrospect I could have used a relay of similar rating but I had the SSR so I used it. A relay would be a fine choice for the type of duty that this contact set is subject to and it would be a lot less expensive in most cases. I would make sure that the single contact rating of the device used is at least 20 Amps. The problem with splitting the load between two 10Amp contacts is that there is always some minor difference in timing between the contacts of a relay and one of the two contact sets will have to withstand full current loads during switching ….better safe than sorry.

The SSR I chose for the duty of controlling both the heaters is a dual 25Amp SSR, it has 2, 25 amp devices in 1 package that is the same size as a standard SSR….2 sets of control inputs and 2 sets of outputs. Having 2 devices in a single package necessitates the need for a heat sink and a low profile one is going to be needed if you are going to mount it inside the original case for the machine. I have a thin case under my Brewtus that I mounted all the hardware in but am in the process of converting the machine to all internal mounted hardware to clean up the appearance.

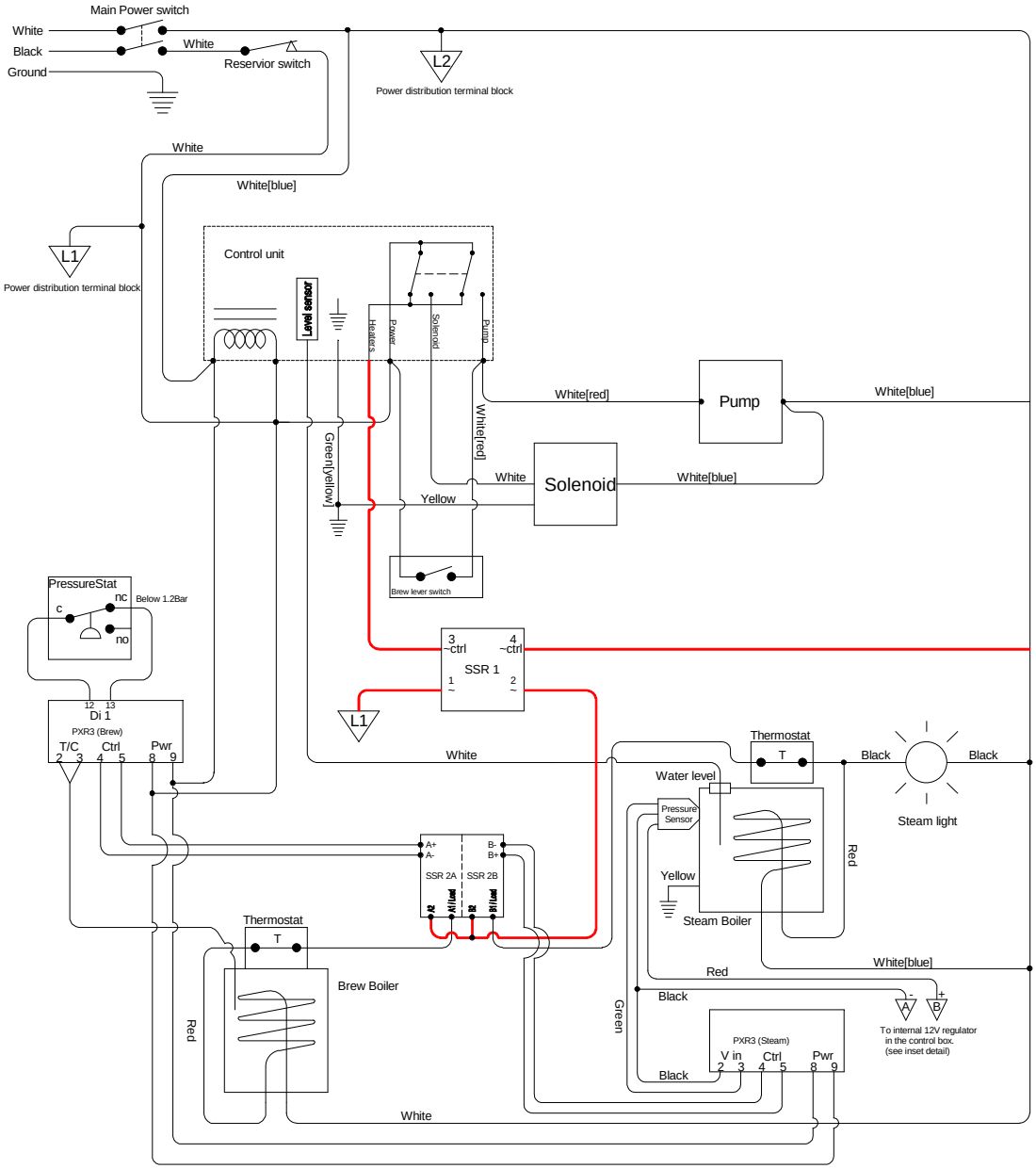
Installation of hardware:

3.2 Main power control SSR/Relay:

Because I wired my system such that both boilers are operational at the same time, I needed to add a SSR that bypasses the control relay in the OEM control box.

1. Remove the wire from the" Resist" terminal of the control box.
2. Connect terminal #3 for the power SSR to the "Resist" terminal.
3. Terminal #4 is connected to L2 (Black).
4. Terminal #1 is connected to L1 (white)
5. Terminal #2 connected to the power feeds (A2&B2) of the dual SSR for boiler control.

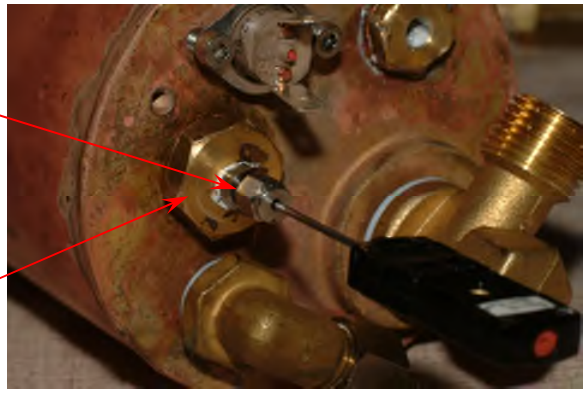
3.3 Power SSR Circuit



3.4 **Brew PID:**

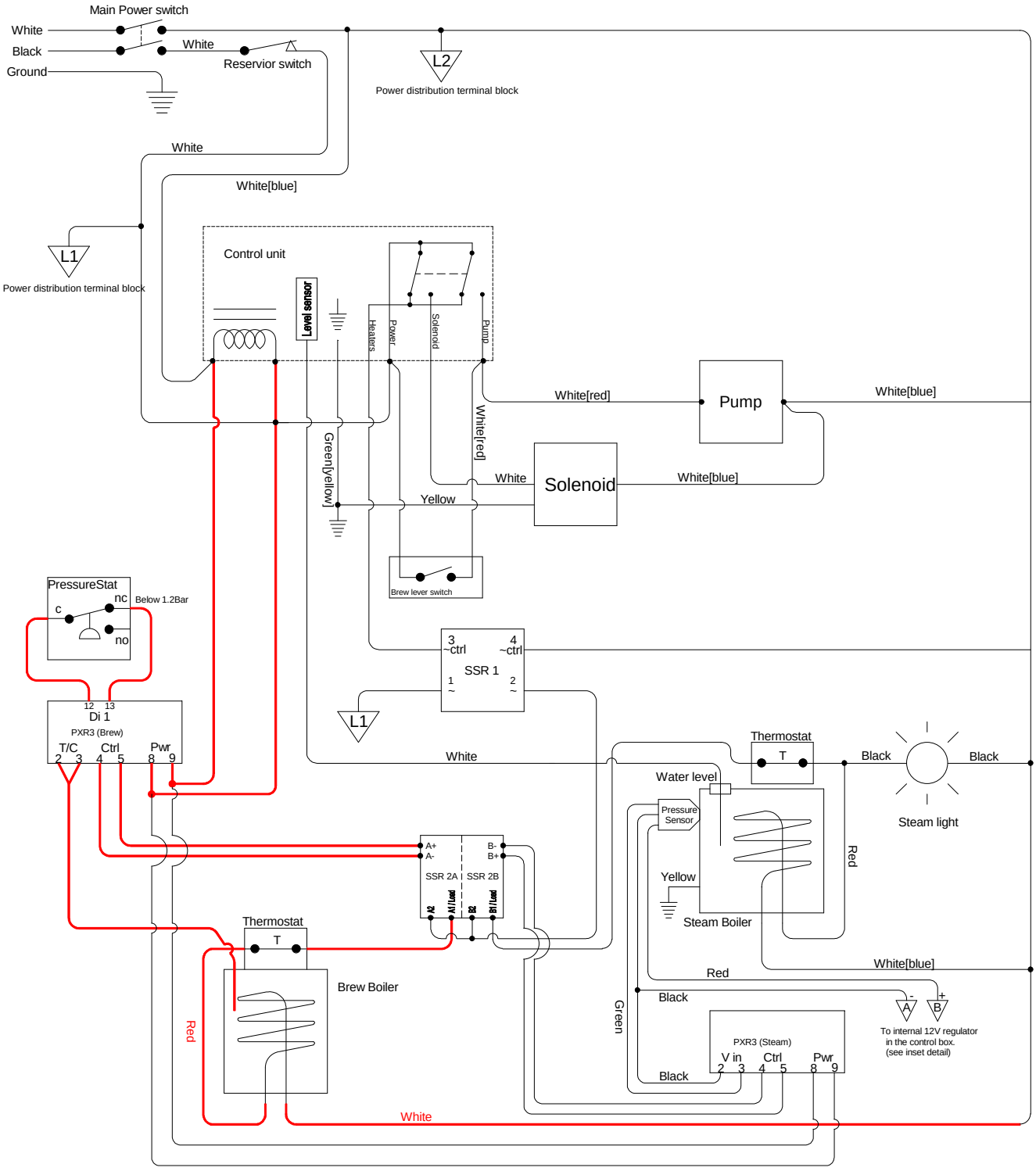
For the brew boiler PID control I used the PXR3 control that was setup for thermocouple input and a digital input configured to put the unit in standby with a contact closure. Expobar seems to daisychain a lot of their 120V connections (saves money) so I got a small terminal strip and installed it in my machine so I didn't have all these doubled up connections that were hard to change. I installed my controllers in a tray under the machine so my connections all went through the bottom of the machine. I recommend spending some time to tidy up the wiring as you go along; the payoff is big if you ever have to trace out a circuit.

1. Power for the PID control uses the same leads as the old controller, I just extended them to accommodate the remote location of my controls, keep in mind that the second control will use the same power so make provisions for a second set of wires.
2. Remove all the wires from the pressurestat and connect the controller digital input to the pressurestat switch; C to #12 and NC to #13. This provides the priority switching during warm-up so the brew boiler doesn't come on full during while the steam boiler is trying to warm up.
3. I installed the Thermocouple in my boiler using the spare pipe plug hole in the top of the boiler ; connect the thermocouple to terminals #2 and #3 on the new controller. The current thermowell has OK performance as well and does not require drilling and tapping.



4. Run control leads to the "A" side of the SSR using the 4 pin connector for .1mm pins; A- to #4, A+ to #5
5. Run a power wire from the A1/Load side of the SSR to the open terminal of the thermostat on top of the brew boiler, confirm a red wire on the other terminal of the thermostat that goes to one of the power connections of the heater of the boiler and confirm that the other lead of the heater is connected to the neutral (L2) line of incoming power.

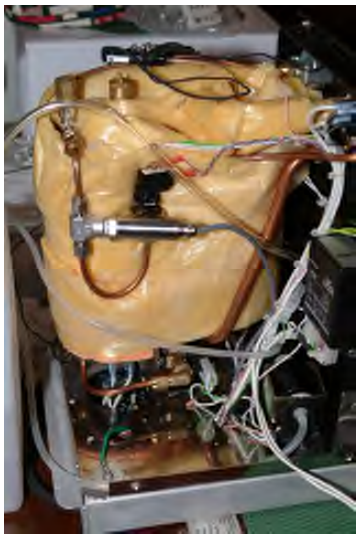
3.5 **Brew PID Circuit:**

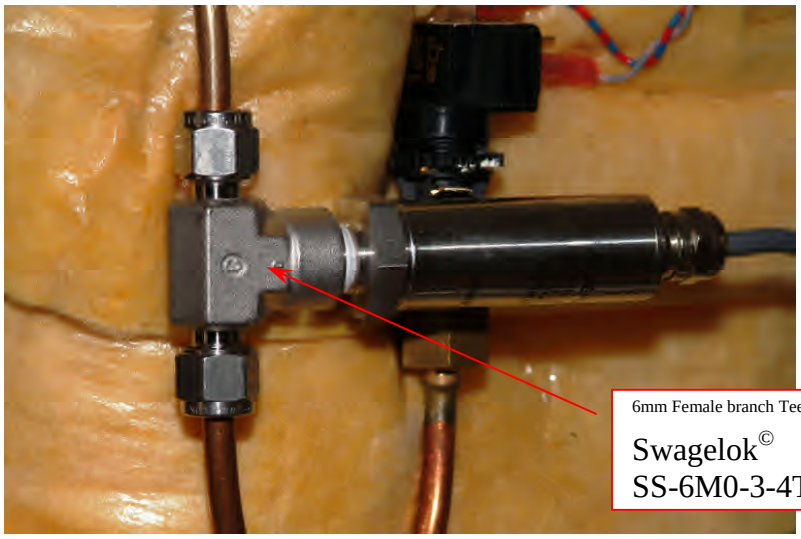


3.6 **Steam PID:**

Because of the pressure transducer needed for the steam boiler control; you will need to find a place in the existing steam line to put a Tee for the transducer. I chose the pressurestat steam line for a number of reasons, primary of which is that it was where the transducer would fit without too much trouble and it would not run as hot as in the pressure gauge line over the top of the boilers. The other issue that you may want to deal with is the scaling of the signal to the PID controller. The pressure transducer I use is 0-30 PSI at 1-5V output so 1.5Bar~3.9V output. I got a bit perturbed by this at first and put a voltage divider in to trim the voltage to 1.5 volts at 1.5 Bar; Now, I really don't care because I don't touch the adjustment and it sits at 1.5Bar all the time …again, just a big set of compromises, you chose the ones you can live with. (I have included a conversion table at the end of the manual.

1) Remove the pressurestat and steam line from the steam boiler assembly.
2) Cut the 6mm steam line across from the pressurestat such that the pressure transducer will clear the diaphragm housing when the Tee is installed





3) The signal wire of the Transducer is attached to Pin 3 (+Vin) of the steam controller.

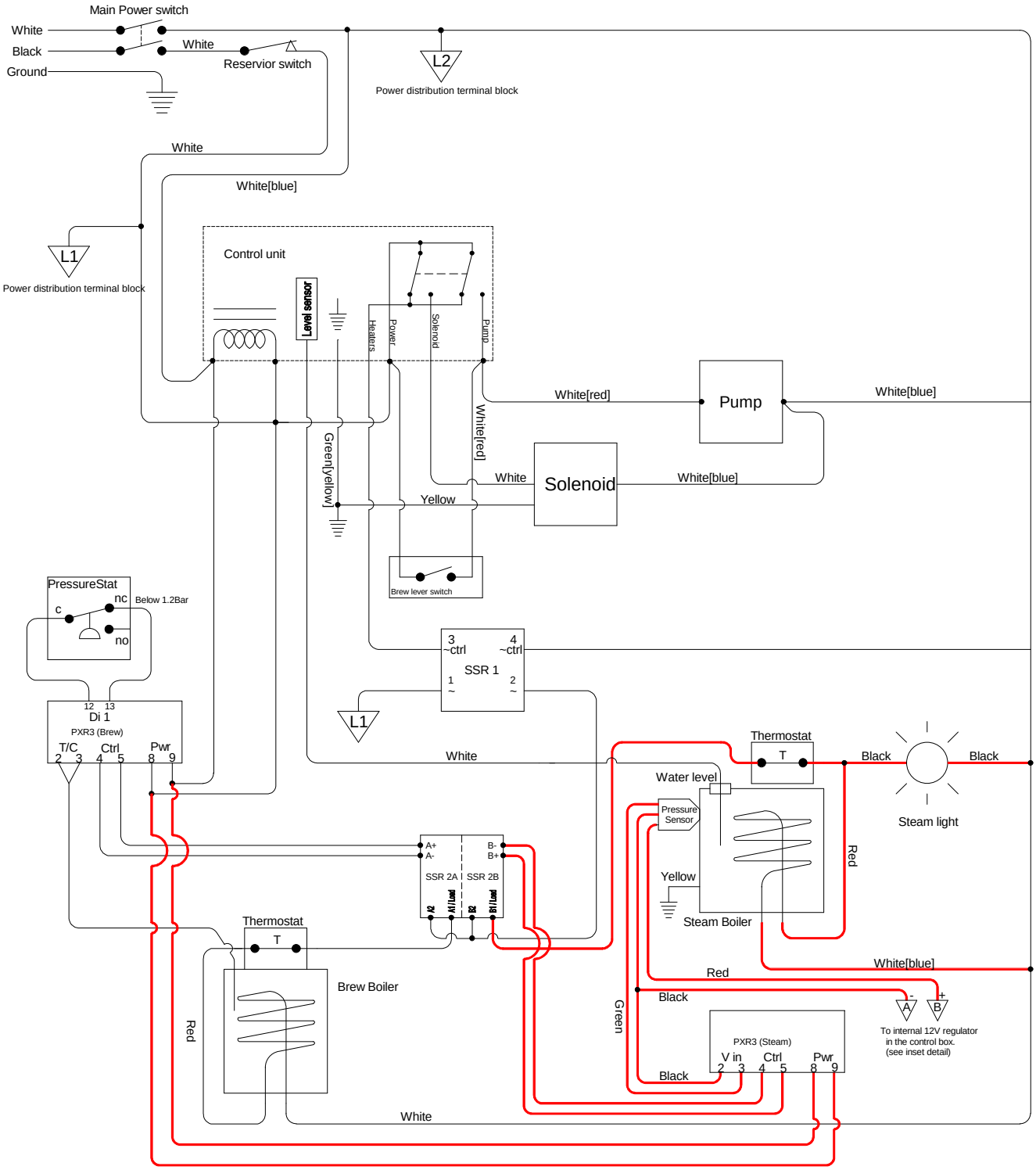
4) The Ground/Signal return wire of the Transducer is connected to Pin 2 (-Vin) of the steam controller. At this time you also need to also attach another black wire to the same pin of the controller. This wire will be the – supply lead to the transducer.

5) Depending on whether you are going to mod the control box of the machine to get the 12V required to run the Transducer.

   a) Use an extra 12V supply. This is the safest way from a standpoint where you do not want to take a chance damaging the control box on the unit by soldering on a couple of wires to get power. The transducer takes very little power so the tiniest 12V supply will do the job. I modified my control box so I have no direction here but **make it small**.
   b) Use the 12V supply inside the control box. This is the method I used and it works great. It is also the most elegant with regards to installation in the stock cabinetry. How I modified my unit is in the reference section in the back of this manual.

6) Run control leads to the "B" side of the SSR using the 4 pin connector for .1mm pins; B- to #4, B+ to #5
7) Run a power wire from the B1/Load side of the SSR to the open terminal of the thermostat on top of the steam boiler, confirm a red wire on the other terminal of the thermostat that goes to one of the power connections of the heater of the boiler and confirm that the other lead of the heater is connected to the neutral (L2) line of incoming power. Keep in mind that the pilot lamp for the steam heater also comes off the thermostat to L2; this indicator shows that the steam boiler is active.

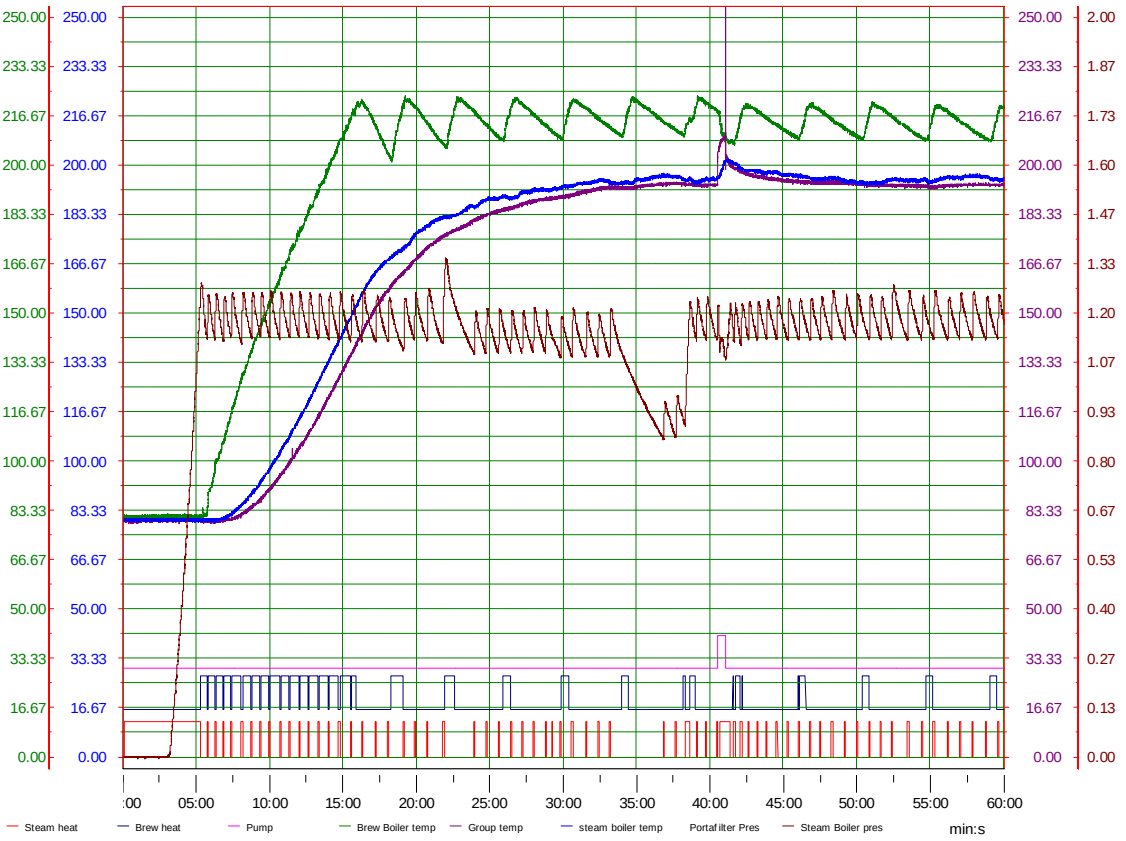
3.7 **Steam PID circuit:**



4 Performance charts

4.1 Stock performance: OEM Setup

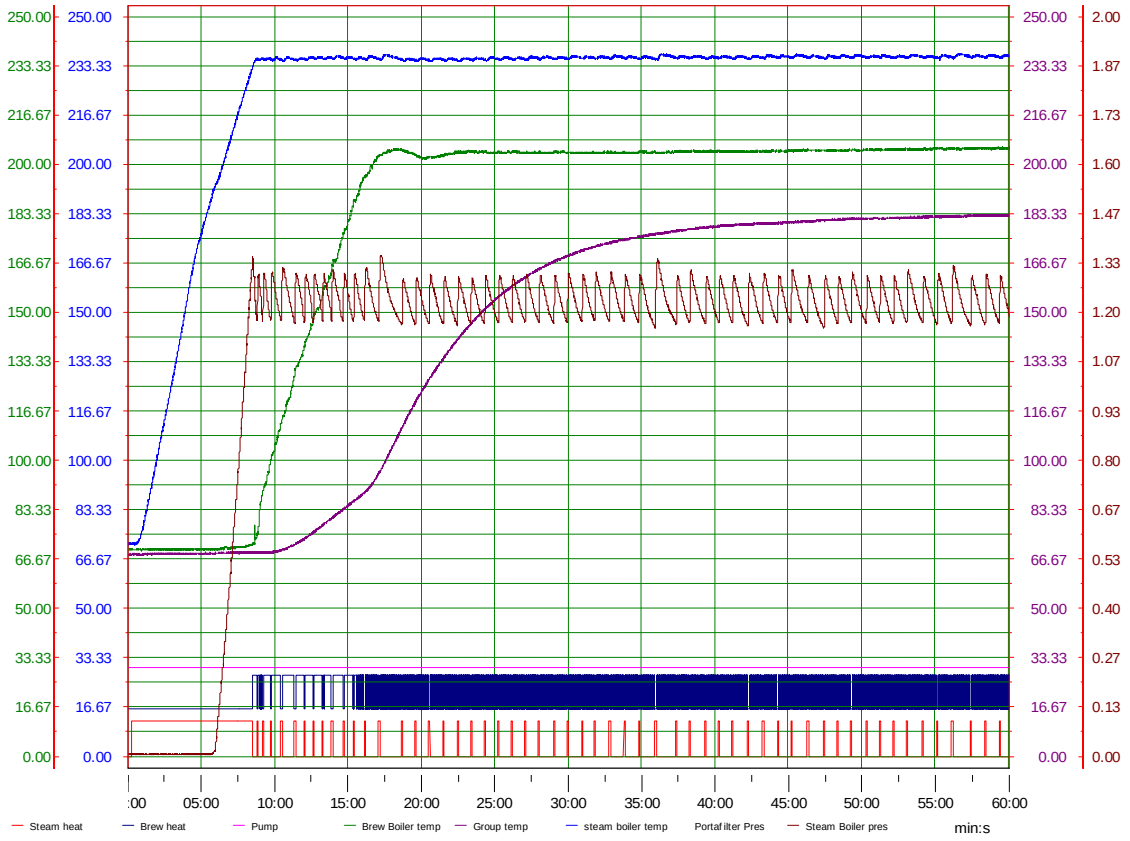
Top of chart
Green: Brew boiler Brown: steam pressure Blue: Group temp (casting) Maroon: Group temp (screen)
Bottom of chart
Pink: Pump Dk. Blue: Brew heater Red: Steam Heater



In the graph above, you will see that the brew boiler temp oscillates 5-8 degrees around the set point of the stock controller and the steam pressure oscillates between 1.1and 1.25 Bar. The variation in the steam pressure is due to pressurestat inconsistencies (sticky diaphragm) one of the problems observed in the system was the tendency for the brew temps to oscillate with off-idle performance due to the temperature swings of the boiler; these temperature oscillations were not larger than 1 degree F˚ in usage but were enough to be noticeable. Both the steam pressure and brew temps varied in response based on where in the feedback cycle the brew command came. Notice the frequency of heat cycles along the bottom of the graph. At this time the steam boiler has priority over the brew boiler for heat cycles (via pressurestat).

4.2 Single PID Performance: Brew Boiler

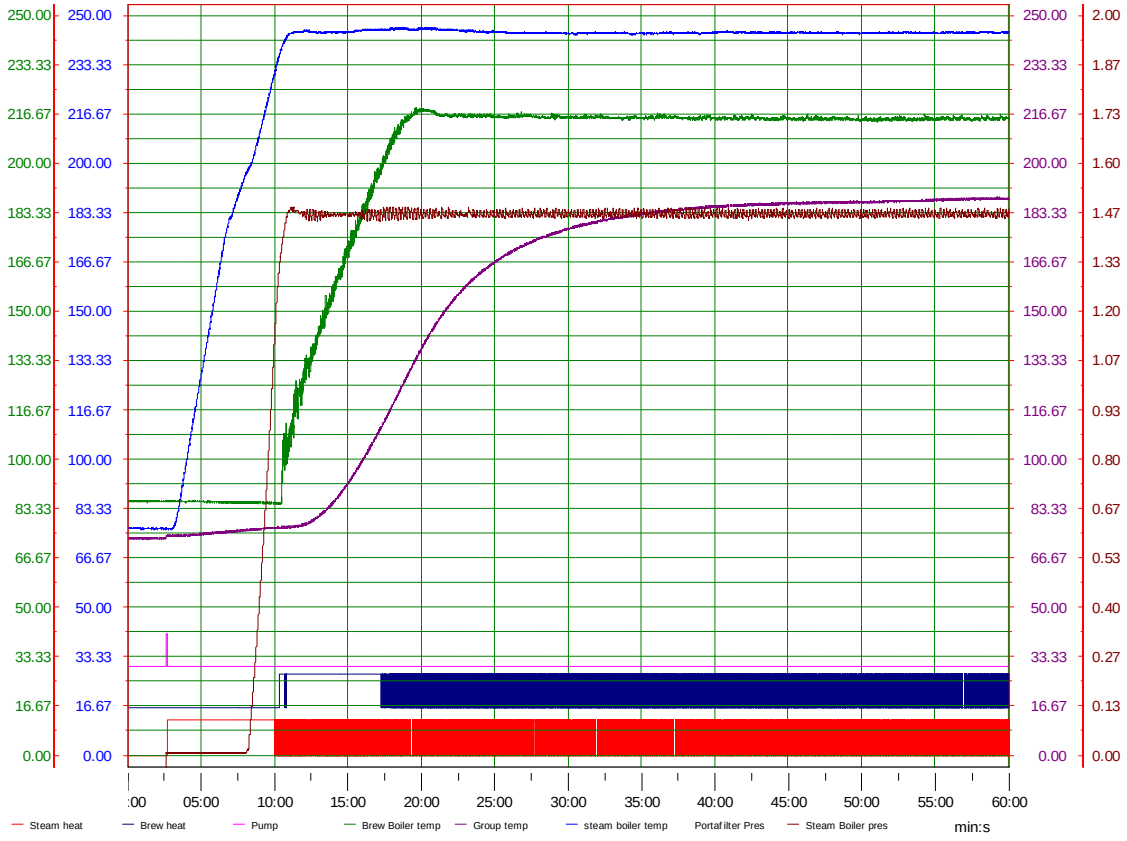
Top of chart
Green: Brew boiler | Brown: steam pressure | Blue: Steam boiler temp | Maroon: Group temp
Bottom of chart
Pink: Pump | Dk. Blue: Brew heater | Red: Steam Heater



In the above graph, a FUJI PXR3 control has been added to the brew boiler. The steam boiler is still has priority at all times (via pressurestat). Notice the magnitude of the oscillations in the steam pressure with only small changes on steam boiler temperature. Again, notice the anomalies in steam pressure due to inconsistent control in the pressurestat. Notice the increase in command frequency for the brew boiler heater (blue) at the bottom of the chart; although it appears to “on” much more, it is actually “on” for less time total in very short duration commands.

4.3 Double PID Performance: Steam and brew boilers

Top of chart
Green: Brew boiler | Brown: steam pressure | Blue: Steam boiler temp | Maroon: Group temp
Bottom of chart
Pink: Pump | Dk. Blue: Brew heater | Red: Steam Heater



This is the machine in with dual PID control. The pressurestat is configured to hold the brew boiler in standby until the steam boiler has reached 1.2Bar; at which time the steam boiler controller has started to just “tickle” the heater. This system is wired such that both steam and brew boilers are running at the same time. To support the additional load on the system, I have replaced all primary line cords with 14 gauge wiring and moved the machine to a 20 amp circuit. In the end, the 20 amp service proved to be not necessary due to the time weighted average of the current being lower than expected and the fact that warm-up current draw was kept under control via initial boiler priority shifting. As can be seen above, there is an impact on the warm-up performance of the brew boiler due to the additional load of the steam boiler cycling. In practice; the benefits of the improved temperature control outweigh any loss of warm-up performance.

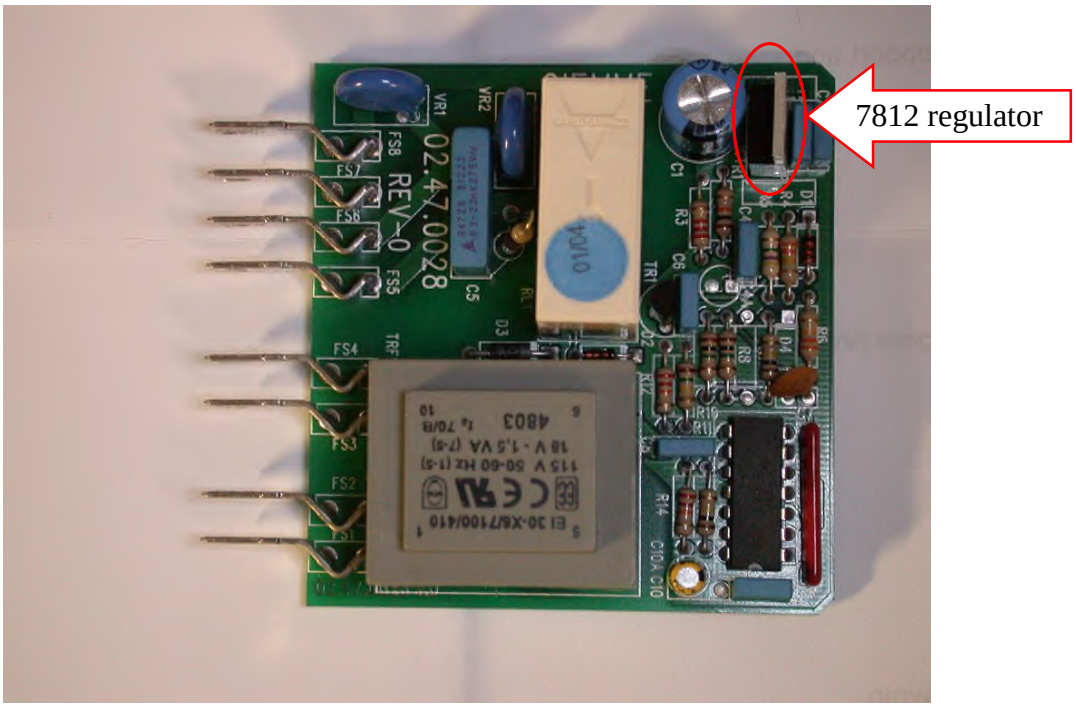
5. Reference

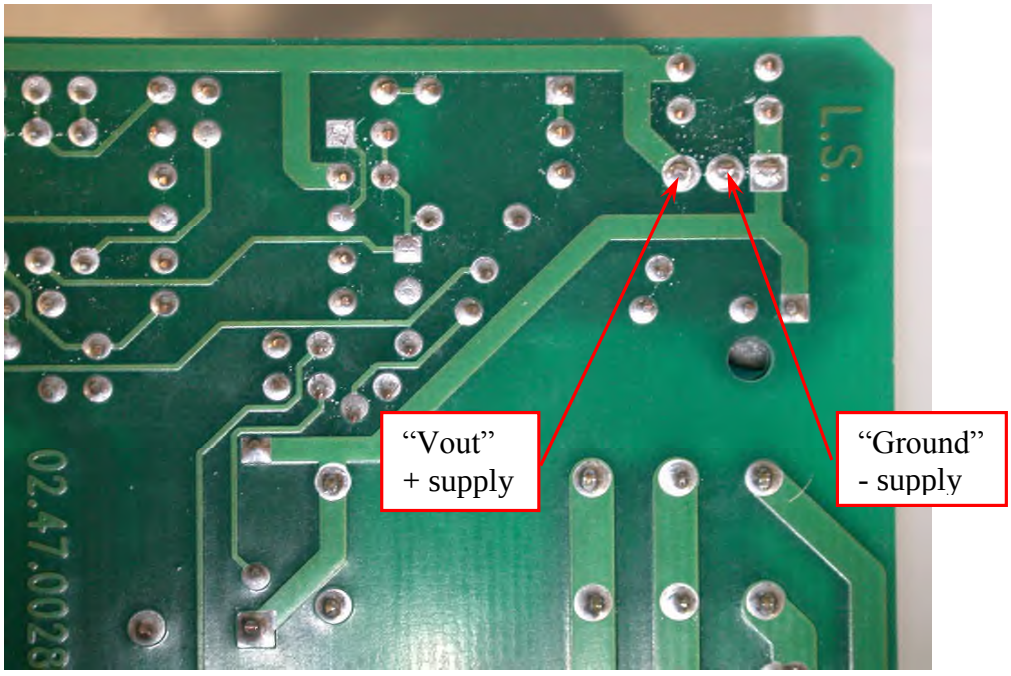
5.1 Parts List

Part	Mfr #	Stk #	Qty	Price	Get it Here
**********	*********	*****	***	******	**********
Fuji PXR3 PID (Brew)	PXR3-RCY1-4VTA1	N/A	1	$159.00	http://www.ttiglobal.com/Product.asp?Param1=PXR3&Param2=60
Fuji PXR3 PID (Steam)	PXR3-ACY1-4V0A1	N/A	1	$129.00	http://www.ttiglobal.com/Product.asp?Param1=PXR3&Param2=60
Crydom Dual DC SSR	D2425D	682-2397	1	$56.67	http://www.alliedelec.com/cart/ProductDetail.asp?SKU=682-2397&SEARCH=d2425&ID=&DESC=D2425D
Crydom Single AC SSR	A2425	682-0007	1	$32.55	http://www.alliedelec.com/Search/SearchResults.asp?SearchQuery=a2425
Honeywell Pressure Sensor	SPT4V0030PG5W02	643-0069	1	$157.36	http://www.alliedelec.com/Search/SearchResults.asp?SearchQuery=643-0069
High Temp,High Flex Wire	3431441-100-0	03F7331	1	$66.11	http://www.newark.com/NewarkWebCommerce/newark/en_US/endecaSearch/partDetail.jsp?SKU=03F7331&N=4
4-Pin Disconnect for Dual SSR	640440-4	90F4204	1	$0.20	http://www.newark.com/NewarkWebCommerce/newark/en_US/endecaSearch/partDetail.jsp?SKU=90F4204&N=4
Insulated Piggyback Disconnects	19013-0005	WM18253-ND	50	$34.70	http://www.digikey.com/
Heat Sink Compound	276-1372	N/A	1	$1.99	http://www.radioshack.com/
Screw Terminal Strip	924-2826	323-HDS/04	2	$0.83	http://www.alliedelec.com/Search/SearchResults.asp?SearchQuery=924-2826&SearchType=STANDARD
Swagelok© 1/16 Tube to 1/16 NPT bored through	SS-100-1-1BT	N/A	1	$8.00	http://www.swagelok.com/product.asp?bigp=CPH351-SH-VS.jpg
Swagelok© 6mm to ¼ NPt female branch TEE	SS-6M0-3-4TTF	N/A	1	$24.00	http://www.swagelok.com/product.asp?bigp=CPH357-SH-VS.jpg

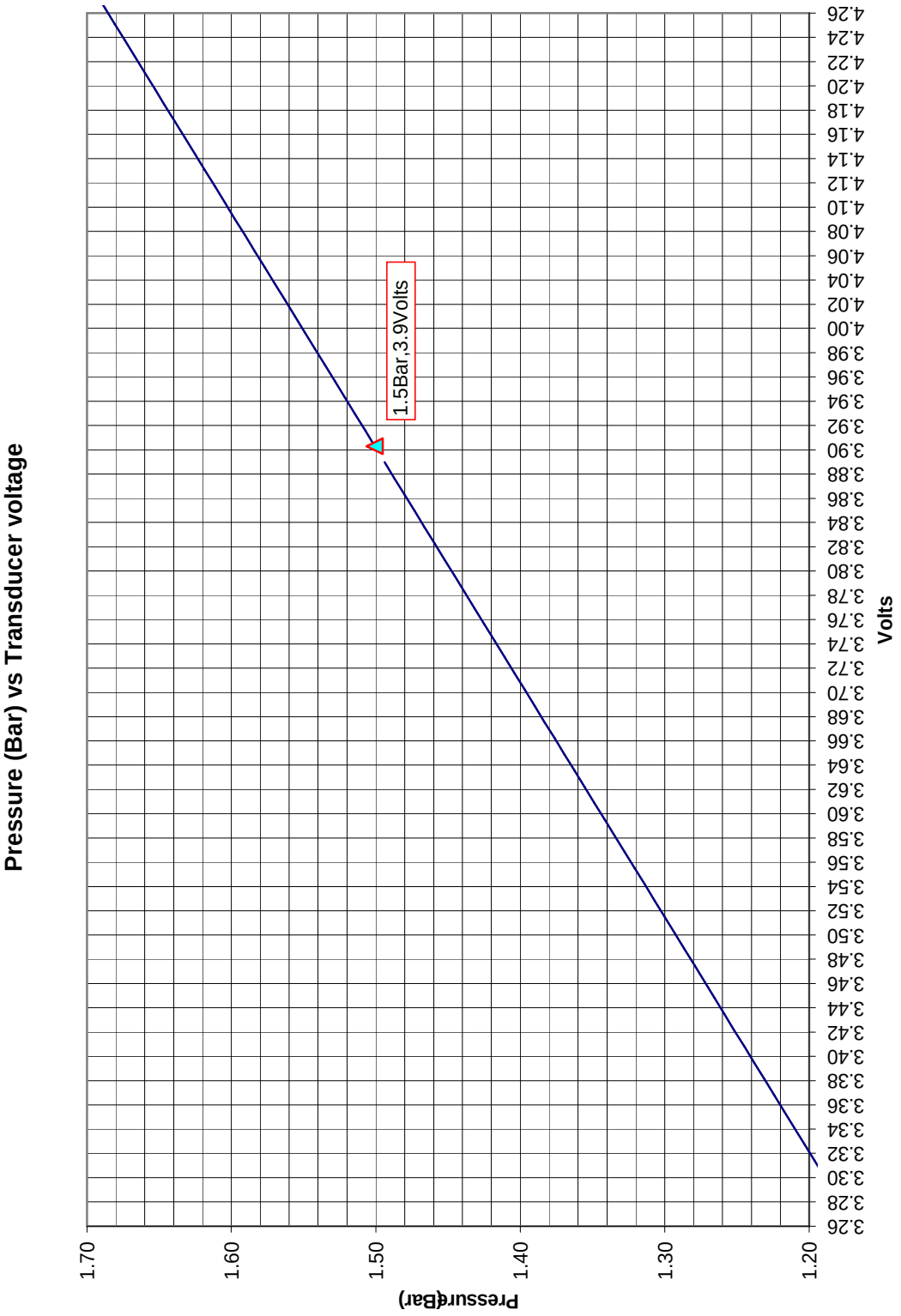
5.2 Control box mod for 12V power.

The control box uses an internal 7812 voltage regulator that has a 1Amp rating; this is plenty to supply both the control box and the transducer.

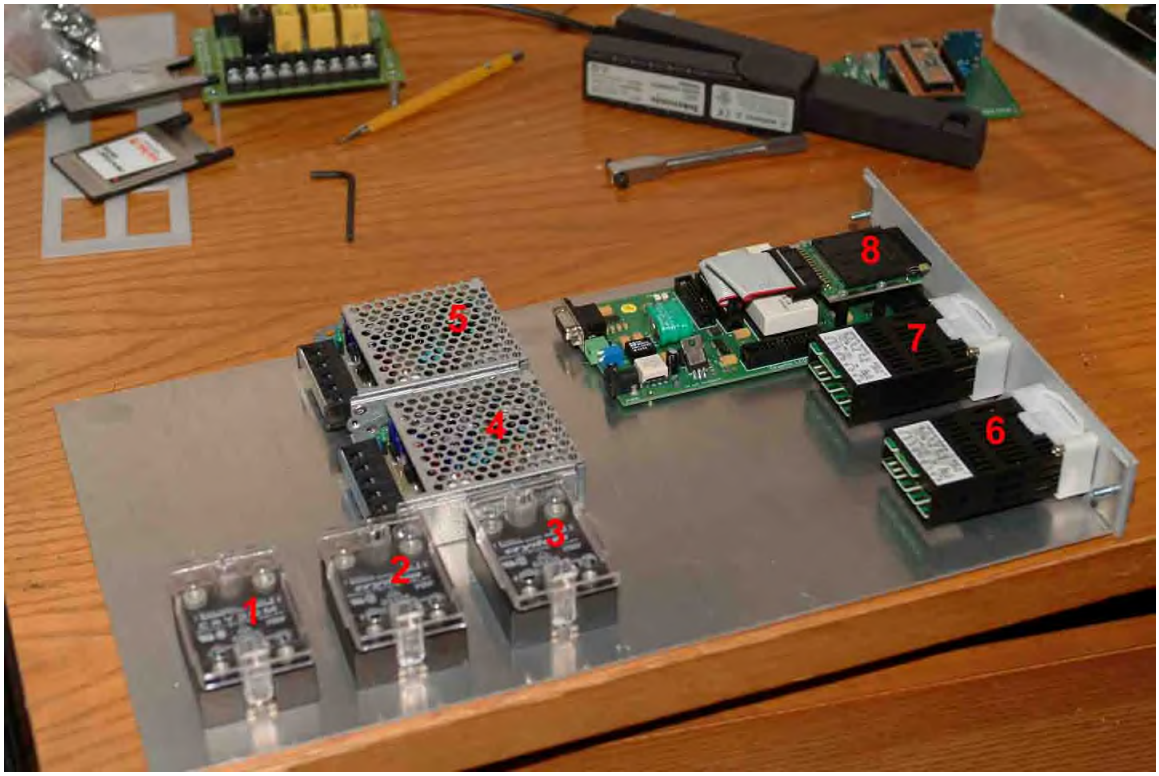




5.3


Pressure (Bar) vs Transducer voltage
1.5Bar,3.9Volts
Volts
Pressure(Bar)
4.26
4.24
4.22
4.20
4.18
4.16
4.14
4.12
4.10
4.08
4.06
4.04
4.02
4.00
3.98
3.96
3.94
3.92
3.90
3.88
3.86
3.84
3.82
3.80
3.78
3.76
3.74
3.72
3.70
3.68
3.66
3.64
3.62
3.60
3.58
3.56
3.54
3.52
3.50
3.48
3.46
3.44
3.42
3.40
3.38
3.36
3.34
3.32
3.30
3.28
3.26
1.70
1.60
1.50
1.40
1.30
1.20

6. Photos of the mounting tray



1. Power SSR
2. Steam SSR
3. Brew SSR
4. 12V supply
5. 24V supply
6. Brew PID
7. Steam PID
8. System controller/Data acquisition system

Notes

- #2 & #3 SSR' have been replaced with a single unit.
- Using the tandem SSR and internal power supply from the control box the following items have been eliminated: 2,3,4,5,8(not used anyway)