



MODEL VC-M

MICROPROCESSOR-BASED
MODULAR HOT-RUNNER
TEMPERATURE CONTROLLER

INSTRUCTION MANUAL

SAFETY WARNING



WARNING!

READ THIS MANUAL BEFORE OPERATING EQUIPMENT!

The high voltage required to operate this temperature controller and the high temperatures created by its operation can cause serious injury or death, and presents a potential fire hazard.

Installation and operation of this equipment should only be performed by qualified individuals and all directions should be carefully followed. Caution should be taken to guarantee that only the rated voltage is applied to this unit and appropriate limiting control devices should be used for safe operation.

DISCONNECT THE MAIN POWER FROM THE CONTROL SYSTEM BEFORE SERVICING!

Hazardous voltage is present on the inside of the controller and mainframe system.

Standard safety procedures should be followed. Additionally, the following guidelines will help prevent personal injury and product damage:

- Do not apply a voltage greater than that specified on the product nameplates.
- Do not operate controllers or mainframe systems without appropriate supply ground connections.
- Do not insert or remove controllers into mainframe systems with power applied.
- Do not operate any controller or mainframe system without all covers in place and properly secured.
- Do not operate this product when wet or in a damp environment.
- Do not operate this product in an explosive atmosphere.

Note on EMC compliance:

Due to the processing of small analog voltages (thermocouple input) this controller is susceptible to interference caused by radiated electromagnetic fields.

Although steps have been taken to reduce upsets caused by EMI, strong signals may cause degradation of instrument accuracy. User intervention is not required to reset the controller under these circumstances. The controller will automatically recover following the removal of the interfering signal.

If continuous upsets are recognized remove the interfering signal from the process. If this is not possible consult the manufacturer for assistance with solving specific EMI interference problems.

INTRODUCTION

This manual combines graphical representation of displays with explanatory dialogue to help the user acquaint themselves with the controller features. Should further clarification be required do not hesitate to contact your nearest sales representative or distributor for assistance.

KEY FEATURES

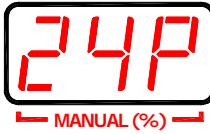
The VC-M modular temperature controller offers many user-friendly features that enable novice users to quickly become productive. These same features are key for veteran molders who desire fluent integration of the VC-M into applications where upgrade or replacement is necessary.

- The VC-M controllers are physically and electrically compatible with all †D-M-E® G-Series®, Smart Series® and similar style mainframe control systems.
- Large, highly visible LED displays simultaneously display process temperature and setpoint temperature.
- Diagnostic (Fault) Code reference label supplied with every controller provides convenient descriptions of the VC-M diagnostic codes.
- Symbolic mode and condition indicators combined with displayed mnemonics (abbreviations) clearly state operating modes or alarm conditions.
- Reliable 5-key tactile interface. The sealed construction protects the keys and circuitry from debris that typically leads to component failure.
- The front panel graphics are printed on the underside of the polycarbonate face insuring that controls will be recognizable even after many years of service.
- Time tested and proven electronics for reliable performance.
- Automatic (closed loop) and Manual (open loop) modes of control.
- Load current (Amps) monitor mode.
- Industry standard type “J” Thermocouple input (default) or selectable type “K” Thermocouple input.
- Fully automatic, adaptive tuning of PID (three-term) control variables providing smooth adaptation to any runnerless mold temperature control application with no user intervention.
- Automatic slow-start temperature ramp at start-up to ensure wet heater bake out, prolonging heater life.
- Wet heater ground fault detection at start-up that limits or disables power to avoid destructive short circuits.
- Transfer of Automatic control mode average output power (%) when switched to Manual control mode (“bumpless transfer”).
- View (monitor) display of output power (%) available when in Automatic control mode.
- View (monitor) display of load current (amps) available when in Automatic or Manual control mode.
- Boost power output mode with user selectable +25% or 100% output power to clear frozen gates.
- Anti-arc (high voltage) protection circuit to prevent electrical damage if the controller is accidentally installed or removed from the mainframe with power applied. (Circuit may be disabled).
- Automatic T/C Fault Hold transfer to manual control mode (enabled at factory). Provides for uninterrupted load power upon loss of thermocouple signal.
- Full diagnostic software to inform operator of fault conditions.
- Shorted Thermocouple diagnostic allows for user selectable (DIP switch) sample times, giving the operator greater flexibility to tailor the VC-M diagnostic to the unique thermal weight and response characteristics of a variety of control applications. (Light or heavy loads).
- Over and under temperature indication with user enabled communications output to activate external control intervention or audible and/or visual alarm. Selectable output for compatibility with †D-M-E® TAS accessory alarm modules.
- Compliant with WEEE and RoHS requirements.

CONTROLS

1. Power Switch (ON / OFF)
2. Process Temperature Display
Also Displays Diagnostic / Fault Mnemonics
3. **Setpoint Temperature Display (Shown at Right)**
In Automatic (Closed Loop) Control Mode
3. **Load Power (%) Output Display**
In Manual (Open Loop) Control Mode

POWER DISPLAY



3. **Amps (Load Current) Display**
In Amps Monitor / Display Mode

AMPS DISPLAY



4. **Increment Key**
Increment Setpoint in Automatic Mode
Increment Power Output in Manual Mode
5. **Decrement Key**
Decrement Setpoint in Automatic Mode
Decrement Power Output in Manual Mode
6. **View Key**
In Automatic Mode Displays % Power or Amps
In Manual Mode Displays Amps
7. **Automatic / Manual Control Mode Select Key**
8. **Plastic Retention / Locking Device**

INDICATORS

9. Automatic (Closed Loop) Control Mode Indicator
10. Start-Up Power Ramp Indicator
11. Load Power Indicator
12. Manual (Open Loop) Control Mode Indicator
13. Thermocouple Fault Indicator
14. Output (Power) Fault Indicator
15. Fahrenheit Temperature Scale Indicator
16. Celsius Temperature Scale Indicator
17. **User Executed Boost Power Output Mode:**
+25% to Current % Power - OR - 100% Power
User Selected via PC Board DIP Switch

BOOSTING POWER DISPLAY

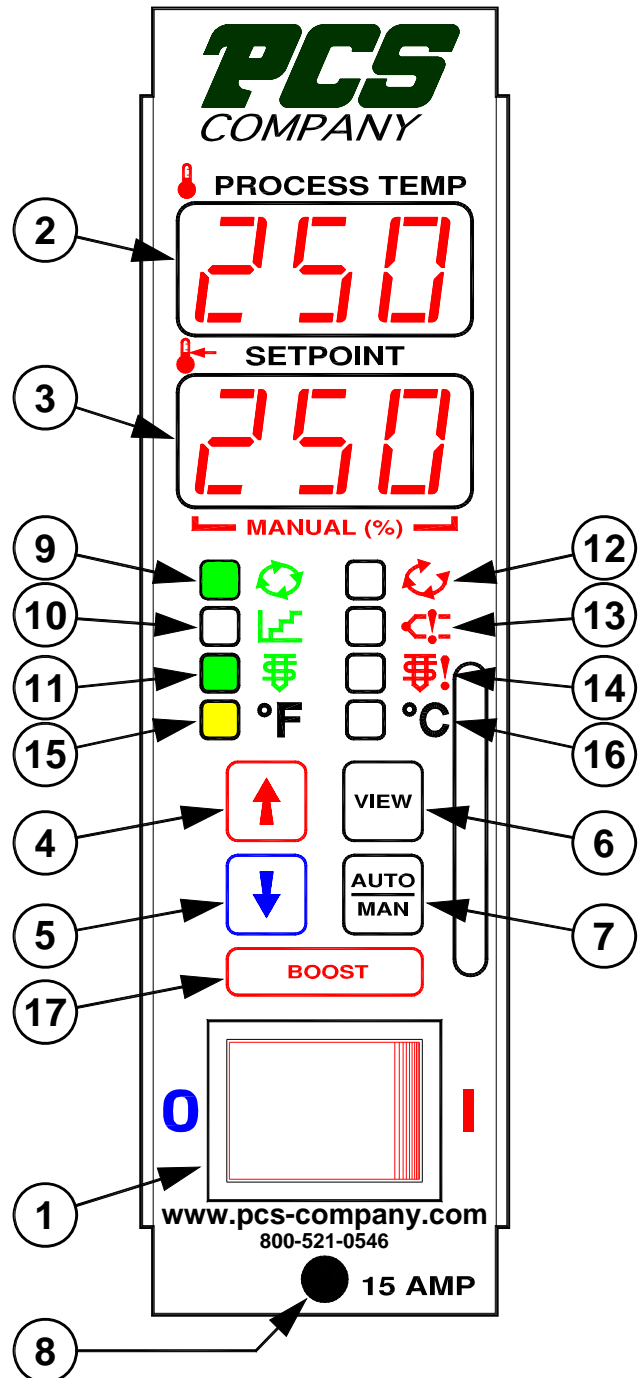


Figure 1
Controls & Indicator Placement

SPECIFICATIONS

Dimensions	2.0" Wd X 7.0" Hg X 7.8" Lg (51mm X 178mm X 198mm)
Weight	1.25lb (0.57Kg)
Operating Temp. Range	32° to 120°F (0° to 50° C)
Control Method:	
Automatic Mode	Full Scale Auto-Tuning PID (3-Term)
Manual Mode	User Selectable 0% to 99% Output Power
Temperature Reset	To Within ±1°F (±0.55°C) Of Setpoint
Power Response Time	250mS
Control Accuracy (In Auto Mode)	±1°F (±0.55°C) ** Dependant On Total Thermal System **
Slow Start Mode	From Ambient to 212°F (100°C) Low Power Application Temperature Ramp
Boost Output Power Mode	User Selectable Via PC Board Dip Switch (+25% or 100% Power)

ELECTRICAL POWER SPECIFICATIONS

Operating / Input Voltage	230 VAC ±10% (Optional 115 VAC ± 10%)
Frequency	50 / 60 Hz (Automatic)
Power Consumption	< 3 Watts (N.I.C. Load)
DC Power Supplies	Internally Generated, Regulated with Temperature Compensation
Circuit Protection ..	Dual Fast-Acting Fuse Type ABC Over-Voltage Protection via MOV
Circuit Isolation	Transformer, > 2500 Volts Triac Optically Coupled

INPUT SPECIFICATIONS

Sensor Type	Type "J" Thermocouple Selectable Type "K" (Grounded or Ungrounded)
Sampling Rate	250mS
Temperature Range	32° to 999°F (0° to 537°C)
Temperature Accuracy	±0.3% of Full Scale
Temperature Repeatability	±0.1% of Full Scale
Cold Junction Compensation	Automatic Across Operating Temperature Range
Input Impedance	22 Meg Ohms
Input Protection	Diode Clamp & Fusible Resistor
Input Isolation	Via Control Circuit Power Supply Transformer
Current (Amps) Sensor Type	Transformer
Current (Amps) Range	0-15 Amperes
Current (Amps) Accuracy / Resolution	0.1 Amp

OUTPUT SPECIFICATIONS

Output Voltage	240 VAC (Optional 120 VAC)
Load Power	3600 Watts; 15 Amps @ 240 VAC 1800 Watts; 15 Amps @ 120 VAC
Power Disconnect	16A Double Pole Switch
Power Output Control Device	Triac (Solid State – Not Mechanical)
Overload Protection	Dual Fast-Acting Fuse Type ABC
Power Line Isolation	Triac Optically Coupled

CONTROLS AND INDICATORS

Process Temperature Display	
Setpoint Temperature Display	Automatic (Closed Loop) Control Mode
Power Output (%) Display	Manual (Open Loop) Control Mode
Amps (Load Current) Display	
Boosting Output Power Display	
Setpoint / Power / Mode Control	
Display Output Power (%) & Amps	
Boost Output Power	
Automatic Mode Indication	Closed Loop LED Indicator
Manual Mode Indication	Open Loop LED Indicator
Slow Start Mode Indication	LED Indicator
Load Power Indicator	LED Indicator

DIAGNOSTICS

Diagnostics are fully automatic and require no operator intervention.

Over Temperature Indication (+30°F/+17°C)	LED Display with Accessory Alarm Output
Under Temperature Indication (-30°F/-17°C)	LED Display with Accessory Alarm Output
Open T/C Indication	LED Display with Accessory Alarm Output
Reverse T/C Indication	LED Display with Accessory Alarm Output
Shorted T/C Indication	LED Display with Accessory Alarm Output
Shorted Output Indication	LED Display with Accessory Alarm Output
Open Output Indication	LED Display with Accessory Alarm Output
Ground Fault Indication	LED Display with Accessory Alarm Output

INSPECTION

After removing the VC-M temperature controller from the shipping container immediately inspect the unit for damage resulting from mishandling in shipping. Inspect for loose components and mechanical damage such as bent sheet metal, marred front panel screen, etc. Remove the spare ABC15 fuses and mainframe zone edge connector contact (required for anti-arc circuit) and save them for later use.

Note: If the unit appears damaged or the container is missing components, contact your sales representative immediately! Use or modification of the controller or its packaging will decrease the likelihood of freight claim reimbursement.

INSTALLATION



THIS VC-M IS EQUIPPED WITH A HIGH VOLTAGE ANTI-ARC CIRCUIT! AND IS ENABLED – TO PREVENT ELECTRICAL DAMAGE TO THE CONTROLLER IF ACCIDENTALLY REMOVED FROM THE MAINFRAME WITH POWER APPLIED.

The controller **WILL NOT** apply power to the load unless mainframe zone edge connector contact #3 is installed.

Inspect each mainframe zone edge connector for the required contact. If the contact is not already installed remove the mainframe rear cover (refer to manufacturer instructions) and install the contact supplied with the VC-M. (Insure contact is locked in the connector by gently pushing on it from the front.)



Step 1: Verify installation of contact.



Step 2: If not, install provided contact

Note that the contact itself completes the triac gate (drive) circuit. No wiring, or wire connection, is required to the #3 edge connector contact.

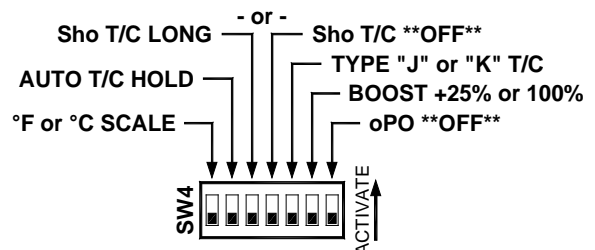
The anti-arc circuit can be disabled by installing a #22-28 AWG wire jumper into the printed circuit board jumper position P5. (Soldering is required. See Fig. 2, Component Layout.)

It is highly recommended that the anti-arc circuit not be disabled in this manner! If the controller is inadvertently installed or removed from the mainframe under power it will suffer severe damage, and possibly be destroyed. The user is encouraged to take advantage of this protective feature.

ADVANCED FEATURES

USER SELECTABLE OPTIONS

Many of the advanced features of the VC-M controller must be user selected by setting the DIP switches SW4 on the main printed circuit board. (Refer to Figure 2, Component Layout.)



USER SELECTABLE OPTIONS DIP SWITCHES

Note the following SW4 **Factory Default** settings:

- SW4:1: °F / °C Temperature Scale **set °F**
- SW4:2: Auto T/C Hold **set ON**
- SW4:3: Sho T/C Long Delay **set OFF**
- SW4:4: Sho T/C ****OFF** set OFF**
- SW4:5: Type "J" / "K" Thermocouple **set Type "J"**
- SW4:6: Boost +25% or 100% Power **set +25%**
- SW4:7: oPO (Open Output) Disable **set OFF**

Enabling or disabling (on / off) any of these features must be done before turning the controller power on (reset). A detailed explanation of these features follows below.



WARNING!

THE CONTROL SYSTEM MAINFRAME MAIN POWER DISCONNECT MUST BE IN THE "OFF" POSITION BEFORE INSERTING OR REMOVING CONTROL MODULES TO PREVENT OPERATOR INJURY AND DAMAGE TO CONTROL SYSTEM COMPONENTS!

Check the controller red power switch (Fig. 1 Item #1) insuring that it is in the "Off" (O) position. Pull the plunger of the black locking device (Fig. 1 Item #8) back into the "out" position.

Align the controller PC board top and bottom rear corners with the respective card guide rails in a mainframe control zone. Slide the controller into the frame, keeping it parallel with the frame surfaces, until it meets resistance of the edge card connector. Place thumbs on the upper and lower right corners of the controller faceplate and firmly press it into the mainframe until the backside of the faceplate meets the frame.

Gently push the plunger of the black locking device into its locked position.

OPERATION

Refer to Figure 1 to become oriented with the controller displays, indicators and user controls.

The following control events are listed in order of priority.

POWER ON

FIRST TIME USE

When the controller is turned on for the first time it will start with the following factory preset parameters:

United States: Automatic Control Mode
Setpoint = 200°F
Degree Mode = Fahrenheit

Export Models: Automatic Control Mode
Setpoint = 100°C
Degree Mode = Celsius

REPEAT USE

When power is reapplied the controller will operate using the same modes that it was using at the previous power off (unless any of the advanced feature DIP switch settings have been changed).

For example, if the controller was in *Auto Control* mode when it was turned off it will return in *Auto* mode. Likewise if the controller was shut off in *Manual Control* mode it will return in *Manual* mode.

WET HEATER GROUND FAULT

This diagnostic routine is bypassed if the process temperature is greater than 212°F (> 100°C).

When the controller is first turned on output power is disabled for 15 seconds. During this time period the controller monitors load current (amps). If the controller, with its output power off, monitors no current flow, or current (amps) less than 200 milliamperes (0.20 amps), it determines that there is no recognizable ground fault and continues in *Slow Start Control* mode as detailed below.

THIS DIAGNOSTIC ROUTINE IS PERFORMED AT START-UP IF THE CONTROLLER IS IN AUTO CONTROL MODE OR MANUAL CONTROL MODE!

If in Manual Control mode the controller will display 0% power output (disabled) until the 15-second time has elapsed. Upon completion of the test, without a ground fault, the controller will retrieve the saved (at power-off) manual power setting from memory and continue in *Manual Control* mode with that percentage of power output.

The user may increase output power during this test. However, doing so will abort the wet heater ground fault diagnostic routine and also prevent the controller from restoring the previously saved power setting!

NO THERMOCOUPLE AT START-UP

If in Auto Control mode, and a thermocouple fault is determined due to a lack of an acceptable T/C signal the controller will continue to disable the output and display the appropriate T/C diagnostic code. See *Diagnostic* modes listed below.

If the controller is set to Manual Control mode and no T/C signal is applied the wet heater ground fault diagnostic will still be active.

Note: The alarm output, if enabled (see instructions below), will not be active in this condition unless the controller is switched into *Auto Control* mode. Upon start-up in *Manual Control* mode with no T/C signal present, the VC-M controller assumes that the operator has intentionally not provided T/C input, therefore disabling the alarm output.

FAULT DETERMINED

If the controller senses current flow greater than or equal to 200 milliamperes (0.20 amps), it deduces that current is leaking to ground by a conductive path caused by moisture. In this event the following diagnostic code is displayed in the Process Temperature display window accompanied by the associated condition code LED:



DISPLAY SHOWN WITH FAULT INDICATOR

In this event the VC-M controller will also apply a signal on the mainframe communications bus (optional) that can be used to activate an audible and/or visual alarm accessory. (The operator must enable the communications output. See the *Alarm Output Selection* instructions below).

In the event of this fault the operator may continue in one of the following three ways, listed in order of precautionary weight:

1. The operator can turn the control system off and investigate the severity of the probable fault.
2. The operator can wait for controller response. The VC-M will continue to monitor the current (amps). If the current (amps) is reduced to less than 200 milliamperes (0.20 amps), **or** the Process Temperature exceeds 225°F (107°C), the controller will continue with normal operation.

If in Auto Control mode and current flow (amps) is decreased, and the temperature is lower than 225°F (107°C), it enters the *Slow Start Control* mode.

If in Manual Control mode the controller will stay at 0% output power (inhibited) until the current is reduced or the temperature exceeds 225°F (107°C). In either case the fault will be cleared and the previous power setting will be restored, and the module will operate normally.

If in Manual Control mode and **no thermocouple signal** is present the wet heater fault will continue until current flow (amps) stops, regardless of the load temperature. (Without T/C feedback the VC-M has no way to determine load temperature.)

3. The operator can override the diagnostic routine. The controller must be set in *Manual Control* mode and power must be manually increased from 0%. (See *Function Control* instructions below to change control modes).

CONTROL METHODS

SLOW START CONTROL

For Wet Heater Bake-Out

Disabled If In *Manual Control* Mode



SLOW START MODE INDICATOR

Upon start-up, the controller always enters Slow Start Control mode when all of the following conditions have been met:

1. The controller is set for *Auto Control* operation.
2. The process temperature is less than 212°F (< 100°C).
3. The wet heater diagnostic is completed without a fault condition.

Slow Start control utilizes a special power control routine designed to avoid heater destruction due to conductive paths to ground caused by moisture. While maintaining a low power setting, the VC-M controller ramps the load temperature to 212°F (100°C) at a 1-degree per second rate of rise. When 212°F (100°C) has been achieved the controller quickly reduces power to slow the temperature rise for a period of 1 minute. Upon completion the controller will continue to drive the process temperature to the setpoint.

To **disable** Slow Start Control the controller can be momentarily changed to *Manual Control* mode and then back to *Automatic Control* mode.

The **Boost** Output Power feature is **disabled** while the VC-M is in Slow Start Control Mode.

AUTOMATIC CONTROL MODE

In Automatic (Auto) Control mode the VC-M controller uses a PID algorithm to determine the required output power to hold the Process Temperature equal to the Setpoint Temperature.

This type of control is a “closed loop” system and requires a thermocouple feedback signal. The **Closed Loop** mode indicator indicates this control mode:

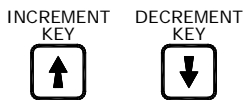


CLOSED LOOP MODE INDICATOR

The Setpoint Temperature is determined by the operator and indicated on the lower LED display:



The Setpoint can be easily adjusted up or down at any time during *Auto Control* mode operation by depressing the *Increment / Decrement* keys of the key pad:



The keys can be pressed and released one unit digit at a time, or for larger changes, the key can be held down for continuous change. In this mode the speed at which the setting is changed is ramped from slow to very fast. For example, the longer the key is held in the faster the numbers change.

AUTOMATIC PID TUNING

The VC-M controller uses a PID (three term) control algorithm to determine the required load power needed to reach and maintain the Setpoint Temperature. Every thermal system has different characteristics. To accurately control each dynamic system the VC-M must “learn” each load’s characteristics individually. In addition, every system’s variables change with temperature changes. For example, a load’s set of control variables may be different at 200° than at 350°.

To accomplish “learning” each load’s variables and to eliminate complex operator intervention the VC-M controller automatically enters a “tuning” routine when the Process Temperature reaches a point less than or equal to 80°F (45°C) below Setpoint Temperature. The controller will go through a sequence of applying different levels of power to monitor load response. The VC-M takes the information it “learned” and adjusts the PID control variables accordingly.

Note: The VC-M automatically calls this tuning routine at power-on regardless of the current Process Temperature. The controller also repeats this tuning process when the operator makes a Setpoint Temperature change greater than or equal to 100°F (55°C). **The controller will not tune if it is turned on with a process temperature greater than the setpoint.**

MANUAL CONTROL MODE

In Manual Control mode the VC-M controller regulates load power determined by the user selected Power Output setting. The power delivered is constant and will only change with user input.

This type of control is an “open loop” system and requires no thermocouple feedback signal. The **Open Loop** mode indicator indicates this control mode:

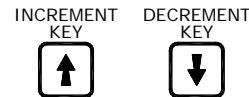


OPEN LOOP MODE INDICATOR

The Power Output setting is determined by the operator and indicated on the lower LED display:



The Power Output setting can be easily adjusted up or down at any time during *Manual Control* mode operation by depressing the *Increment / Decrement* keys of the key pad:



The keys can be pressed and released one unit digit at a time, or for larger changes, the key can be held down for continuous change. In this mode the speed at which the setting is changed is ramped from slow to very fast. For example, the longer the key is held in, the faster the numbers change.

POWER TRANSFER FROM AUTO MODE

When the VC-M controller is operating in *Auto Control* mode it records the average power setting required to maintain Setpoint Temperature. When the operator switches from *Auto Control* mode to *Manual Control* mode this power setting is automatically set for use. The operator is free to change the power setting at any time following the control mode transition.

This output power level will most likely not be able to hold the former setpoint but it will bring the load to a *constant* temperature that may or may not be close to the former setpoint value. As the controller is working in *Auto Control* mode it is continually changing output power to maintain Setpoint Temperature. The continuous changes are required to keep up with process upsets to the thermal system.

USER INTERFACE

The user makes various control mode and setting changes using the five momentary switch keypad on the controller front panel (Fig. 1 Item #4, 5, 6, 7 & 17).

The operator simply pushes and holds the desired key until the variable change is recognized on the appropriate display. For multiple keystrokes of the same key the user can hold the key in the closed position rather than entering several individual closures. In this event the controller continuously repeats the function and the input becomes more rapid the longer the key is held in.

It may be noticed that the VC-M controller does not accept quick individual key entries. The operating program has a switch closure delay time requirement that must be met before the controller will accept input as a good key and react accordingly. This precautionary measure is included to prevent the controller from reacting to environmental noise.

CAUTION: The operator should not use anything other than their finger to actuate a keypad key! The use of pens, pencils, screwdrivers or other tools will damage the keyboard assembly. Such damage is considered abuse and is not included under warranty coverage.

The individual keys are described as follows:



INCREMENT KEY

The Increment key is only active during normal *Auto and Manual Control* modes and is used to increase the Setpoint Temperature and Power Output level respectively.

The Increment key is not active in *View Amps* or *View Output Power* mode (see below).

The Increment Key will **terminate** the **Boost** function.



DECREMENT KEY

The Decrement key is only active during normal *Auto and Manual Control* modes and is used to decrease the Setpoint Temperature and Power Output level respectively.

The Decrement key is not active in *View Amps* or *View Output Power* mode (see below).

The Decrement Key will **terminate** the **Boost** function.



AUTO / MANUAL CONTROL KEY

The Auto / Manual Control Mode key switches the VC-M between *Automatic* (Closed Loop) control mode and *Manual* (Open Loop) control mode.

If the Auto / Manual key is pressed when in a View screen (see below) the controller will **terminate View** and return the controller to the default operating display. (Setpoint display in *Auto Control* and Power Output % in *Manual Control*.)

The Auto / Manual Key will **terminate** the **Boost** function.



VIEW PROCESS MODE KEY

The View Process key is active in both *Auto and Manual Control* modes. The first closure of the View key will activate:


CURRENT (AMPS) MONITOR MODE:

Whether operating in *Auto Control* mode or *Manual Control* mode the VC-M allows the operator to continuously monitor load current (amps). The monitored value is the average current (amps) being delivered to the load. Because the VC-M applies power to the load using a pattern of voltage pulses, true instantaneous current would be rapidly changing from second to second and would be difficult for the operator to interpret. The displayed average value is a much more useful quantity to the user.



CURRENT (AMPS) DISPLAY

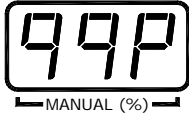



When in View AMPS mode the  of the lower LED display and the control mode LED indicator will flash.

When operating in *Auto Control* mode a second closure of the View key will activate:

AUTOMATIC CONTROL (%) OUTPUT POWER MONITOR MODE:

As stated above, when in *Auto Control* mode the VC-M controller uses a PID algorithm to determine the required output power to hold the Process Temperature equal to the Setpoint Temperature. As a result the output power is constantly changing. The operator can view the instantaneous power settings being applied to the load by using the View key.



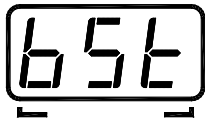
When in View POWER mode the  of the lower LED display and the control mode LED indicator will flash.

The View key is active when the **Boost** function is active.



BOOST OUTPUT KEY

When the BOOST function is active the mnemonic will alternate with the Setpoint Temperature (*Auto mode*) or Output Power (*Manual mode*) in the lower LED display:



BOOST POWER MNEMONIC

The VC-M Boost feature is active in either *Auto* or *Manual Control* modes. Boost is a function of output power regardless of what control mode is active when it is executed:

In *Auto Control* mode Boost will increase the average output power required to hold setpoint temperature by the user selected value (+25% or 100%).

Boost will remain active until it is terminated. The operator can terminate Boost by pressing any of the Boost, Auto/Manual, Increment or Decrement Keys. Or Boost will automatically terminate if the process temperature breaches the over setpoint alarm threshold of 30°F (17°C). Note that if the over setpoint alarm level is reached by Boosting output power that the external alarm signal, if enabled by the user, will not activate immediately. The VC-M will disable the alarm signal for one minute to allow the process temperature to fall below the alarm limit 30°F (17°C).

In *Manual Control* mode Boost will increase the current output power setting by the user selected value (+25% or 100%).

Boost will remain active until it is terminated. The operator can terminate Boost by pressing any of the Boost, Auto/Manual, Increment or Decrement Keys, or Boost will automatically terminate after 15 seconds.

USER SELECTABLE BOOST OUTPUT SETTING:

The operator can determine which Boost value the VC-M will use:

1. +25% to the current power output setting. (For example, the VC-M is operating @ 10% output power when Boost is executed. The Boost output power will be 10% + 25% boost = 35% output power for the duration of the Boost period.)
2. 100% (maximum) power output.

DIP switch SW4:6 must be set to the operator's choice before the VC-M controller is turned on. See USER SELECTABLE OPTIONS above or refer to Fig. 2, Component Layout.

Boost is **disabled** while the VC-M is in *Slow Start Control* mode.

Boost is **disabled** if the VC-M is TUNING for PID variables in *Auto Control* mode.

LOAD POWER INDICATION

In either *Auto Control* mode or *Manual Control* mode power being delivered to the load is indicated:



LOAD POWER INDICATOR

The indicator flashes concurrently with the firing (closing) of the load power output device (triac). Power is delivered by time proportioned preset patterns. The time interval between pulses is proportional to the power requirement. The lower the power, the slower the flash. Conversely, the higher the power the faster the flash. For example, at maximum power output (99%) the LED indicator will be on continuously. With power off (0%) the indicator will never turn on.

WARNING! The Load Power Indicator lights when the triac is turned on by the controller's MCU and is independent of voltage applied to the load! The indicator not being illuminated is not a guarantee that the control device (triac) is open. The VC-M controller will recognize a shorted triac fault (See *Diagnostic* instructions below) and will notify the operator. But, in this situation, the VC-M controller can not open or control the failed triac.

For this reason it is imperative that under a load fault condition that the operator switch the controller power disconnect switch (Fig. 1 Item #1) and also the mainframe system disconnect to the "OFF" positions before removing a controller or interconnect cabling.

TEMPERATURE SCALE INDICATION

°F - or - °C SCALE INDICATOR

The VC-M controller will operate in either the Fahrenheit or Centigrade temperature scales. DIP switch SW4:1 must be set accordingly before the VC-M controller is turned on. See USER SELECTABLE OPTIONS above or refer to Fig. 2, Component Layout.

It is not necessary to calibrate the VC-M when changing between temperature scales.

DIAGNOSTICS

The VC-M controller has the capability to diagnose a variety of unusual operating and fault conditions and alert the operator so appropriate adjustments can be made.

These conditions are described below and presented with the associated display mnemonic and *Condition Indicator*.

OVER SETPOINT ALARM INDICATION



Alarm mnemonic alternates with Process Temperature display.

When the Process Temperature exceeds the setpoint by 30°F (17°C) or more the VC-M alerts the user of an over-temperature alarm condition.

In this event the VC-M controller will also apply a signal on the mainframe communications bus (optional) that is used to activate an audible and/or visual alarm accessory. (The operator must enable the communications output. See the *Alarm Output Selection* instructions below).

UNDER SETPOINT ALARM INDICATION



Alarm mnemonic alternates with Process Temperature display.

When the Process Temperature is lower than the setpoint by 30°F (17°C) or more the VC-M alerts the user of an under-temperature alarm condition.

In this event the VC-M controller will also apply a signal on the mainframe communications bus (optional) that is used to activate an audible and/or visual alarm accessory. (The operator must enable the communications output. See the *Alarm Output Selection* instructions below).

Note: This feature is only active during normal *Auto Control* mode operation. It is disabled through *Slow Start Control* and *PID Auto Tuning* modes and initializes when the process temperature reaches setpoint.

Thermocouple Fault OPEN THERMOCOUPLE



DISPLAY SHOWN with THERMOCOUPLE FAULT INDICATOR

When the VC-M controller senses a temperature signal over range (> 999°F or 537°C) it will display the fault mnemonic on the Process Temperature display.

THE CONTROLLER WILL AUTOMATICALLY SWITCH TO MANUAL CONTROL MODE AND THE OUTPUT WILL BE IMMEDIATELY DISABLED (OUTPUT POWER = 0%) UNTIL THE OPERATOR OVERRIDES THE FAULT (Increases output power manually) **OR RESETS THE CONTROLLER.** (Turning power "OFF" and then back "ON").

UNLESS the Automatic T/C Fault Hold feature is enabled (default), in which case the VC-M will continue to output the average power required to hold setpoint temperature prior to the fault. (See the *T/C Fault Hold* instructions detailed below).

If the VC-M controller is in *Auto Control* mode and this fault occurs, a signal will be applied on the mainframe communications bus (optional) that is used to trigger an audible and/or visual alarm accessory. (The operator must enable the communications output. See the *Alarm Output Selection* instructions below).

IF THE CONTROLLER IS IN MANUAL CONTROL MODE it will continue to supply output power even though a T/C fault is indicated. (The feedback is not necessary for “open loop” control).

Thermocouple Fault **BACKWARD THERMOCOUPLE (POLARITY REVERSED)**



**DISPLAY SHOWN with
THERMOCOUPLE FAULT INDICATOR**

When the VC-M controller senses a temperature signal under range (< 32°F or 0°C) it will display the fault mnemonic on the Process Temperature display.

THE CONTROLLER WILL AUTOMATICALLY SWITCH TO MANUAL CONTROL MODE AND THE OUTPUT WILL BE IMMEDIATELY DISABLED (OUTPUT POWER = 0%) UNTIL THE OPERATOR OVERRIDES THE FAULT (Increases output power manually) **OR RESETS THE CONTROLLER.** (Turning power “OFF” and then back “ON”).

UNLESS the Automatic T/C Fault Hold feature is enabled (default), in which case the VC-M will continue to output the average power required to hold setpoint temperature prior to the fault. (See the *T/C Fault Hold* instructions detailed below).

If the VC-M controller is in *Auto Control* mode and this fault occurs, a signal will be applied on the mainframe communications bus (optional) that is used to trigger an audible and/or visual alarm accessory. (The operator must enable the communications output. See the *Alarm Output Selection* instructions below).

IF THE CONTROLLER IS IN MANUAL CONTROL MODE it will continue to supply output power even though a T/C fault is indicated. (The feedback is not necessary for “open loop” control).

Thermocouple Fault **SHORTED THERMOCOUPLE**



**DISPLAY SHOWN with
THERMOCOUPLE FAULT INDICATOR**

When the VC-M controller is applying full power to the load and senses a temperature rise no greater than 3°F (1.7°C) over the default (90 second) or the user selected (250 second) time period the fault mnemonic will be displayed on the Process Temperature display. (The mnemonic will alternate with the Process Temperature although the sensor input may not reflect the actual temperature of the load).

THE CONTROLLER WILL AUTOMATICALLY SWITCH TO MANUAL CONTROL MODE AND THE OUTPUT WILL BE IMMEDIATELY DISABLED (OUTPUT POWER = 0%) UNTIL THE OPERATOR OVERRIDES THE FAULT (Increases output power manually) **OR RESETS THE CONTROLLER.** (Turning power “OFF” and then back “ON”).

UNLESS the Automatic T/C Fault Hold feature is enabled (default), in which case the VC-M will continue to output the average power required to hold setpoint temperature prior to the fault. (See the *T/C Fault Hold* instructions detailed below).

UNLESS THE SHORTED THERMOCOUPLE (Sho) DIAGNOSTIC IS DISABLED, In which case the VC-M will remain in *Auto Control* mode applying full power. The fault mnemonic will continue to be displayed alternating with the Process Temperature and an alarm signal (if enabled) will be applied to the mainframe communications bus.

If the VC-M controller is in *Auto Control* mode and this fault occurs, a signal will be applied on the mainframe communications bus (optional) that is used to trigger an audible and/or visual alarm accessory. (The operator must enable the communications output. See the *Alarm Output Selection* instructions below).

Accidental Fault Indication may be invoked when trying to start very heavy, slow changing loads. If this is suspected the operator can override the fault by increasing the *Output Power* setting. This action should be continued until the Process Temperature is driven to or above Setpoint Temperature. Once this temperature has been reached the VC-M can be switched back into *Auto Control* mode and normal operation should commence.

If this attempt fails to increase the Process Temperature a true fault condition may exist. The operator may take the following course of action:

1. TURN OFF CONTROLLER AND MAINFRAME SYSTEM POWER and disconnect the interconnect cabling from the mold. It is now safe to thoroughly inspect the suspected faulty thermocouple and take appropriate action. Service personnel should make certain that the appropriate T/C is connected to its respective controller and inspect all associated wiring.
2. If the operator allowed the controller to run at 99% power and realized no temperature increase, and trouble shooting the control system power and T/C circuits determined no error, there could be a design problem with the mold. If the tool is being run for the first time and will not come up to temperature, the watt density of the problematic zone heater may be too low. A thorough review of the mold design by a qualified engineer may be necessary.

Additionally, low line voltage can lead to poor response from the heaters. Again, if no thermocouple errors are discovered, a full system analysis may need to be done by qualified personnel.

IF THE CONTROLLER IS IN MANUAL CONTROL MODE it will continue to supply output power even though a T/C fault is indicated. (The feedback is not necessary for "open loop" control).

USER SELECTABLE SHORTED T/C SAMPLE TIME or DISABLE

As stated above, accidental fault indication may be invoked when trying to start very heavy, slow changing loads. If this is suspected the operator can change the Shorted T/C diagnostic test sample time. The VC-M requires a temperature rise of 3°F (1.7°C) over a preset time period to not call a Sho fault. The factory default time is 90 seconds, but heavy thermal loads often require more time than this to register changes in temperature. If the user suspects such a load is being controlled the test time period may be changed to 250 seconds by activating the "Sho T/C LONG DELAY" DIP switch of SW4. (See Fig. 2). The switch bank SW4 must be set to the user's requirements as detailed in Figure 2, Component Layout.

If the user continues to experience errant fault recognition the Shorted T/C diagnostic can be disabled. In the same manner as enabling the Sho T/C long delay, the "Sho T/C *OFF*" DIP switch of SW4 must be activated as detailed in Figure 2, Component Layout.

CAUTION: IT IS STRONGLY RECOMMENDED THAT THE SHORTED T/C DIAGNOSTIC NOT BE DISABLED! Under this condition the VC-M will continue to apply full (99%) output power to a load that may have a faulty thermocouple. Under these circumstances **THE PROCESS TEMPERATURE DISPLAY IS NOT REPRESENTATIVE OF THE TRUE TEMPERATURE OF THE LOAD.** The heater may be creating an extremely high temperature that could create dangerous and volatile conditions.

To change the printed circuit board SW4 Sho DIP switches it will be necessary to turn the VC-M controller and mainframe power ****OFF**** and remove the controller from the mainframe.



THE CONTROL SYSTEM MAINFRAME MAIN POWER DISCONNECT MUST BE IN THE "OFF" POSITION BEFORE INSERTING OR REMOVING CONTROL MODULES TO PREVENT OPERATOR INJURY AND DAMAGE TO CONTROL SYSTEM COMPONENTS!

Switch SW4 is located near the top of the printed circuit board and is easily accessible without removing the VC-M side panel.

Note that if **both** the "Sho LONG" and "Sho OFF" DIP switches are accidentally selected the VC-M will recognize the errant switch selection and respond to the Shorted T/C diagnostic in the Long 250 second time period. Having both Sho DIP switches activated will be interpreted as an error by the VC-M.

Load Fault OPEN OUTPUT (LOAD OR TRIAC)



DISPLAY SHOWN with LOAD FAULT INDICATOR

When the VC-M senses load current (amps) less than or equal to 100 milliamperes (0.10 amps) while it has output power set greater than 25% this fault mnemonic will be displayed on the Process Temperature display.

There is either a failed open condition with the output control device (triac) or an open in the load power circuit, such as the interconnect cabling, mold connector or heater wiring.

THE VC-M ANTI-ARC CIRCUIT MUST BE COMPLETED! (Refer to the voltage anti-arc feature section above). *If the Anti-Arc circuit is not closed by either the mainframe edge connector contact #3 (preferred, anti-arc enabled) or by installation of PC board jumper P5 (anti-arc disabled), the VC-M MCU will not be able to turn the power output control device (triac) on!!*

The VC-M controller in the faulty zone may be swapped with another working controller to verify proper operation of the output control device (triac). If the triac fails open the controller MCU will not be able to apply power to the load.

This Load Diagnostic is active in either *Auto* or *Manual Control* modes.

The controller will remain in *Auto Control* mode with output power on until the load current (amps) exceeds 100 milliamperes (0.10 amps). If this occurs the VC-M will then continue in normal *Auto Control* mode.

In this event the VC-M controller will also apply a signal on the mainframe communications bus (optional) that is used to activate an audible and/or visual alarm accessory. (The operator must enable the communications output. See the *Alarm Output Selection* instructions below).

Disable oPO: Driving very low current loads or a high impedance input of a load switching device such as a solid state relay (SSR) could result in a false open output fault. It may be necessary to disable the oPO Open Output diagnostic by activating the “oPO *OFF*” DIP switch of SW4 as detailed in Figure 2 of the Component Layout.

To change the printed circuit board SW4 oPO DIP switch it will be necessary to turn the VC-M controller and mainframe power ****OFF**** and remove the controller from the mainframe.

Switch SW4 is located near the top of the printed circuit board and is easily accessible without removing the VC-M side panel.

Load Fault **SHORTED OUTPUT (LOAD OR TRIAC)**



**DISPLAY SHOWN with
LOAD FAULT INDICATOR**

When the VC-M senses load current (amps) greater than 100 milliamperes (0.10 amps) while it has output power turned off (0% output power) it will display this fault mnemonic on the Process Temperature display.

The controller will remain in *Auto Control* mode with output power off (0%) until the load current (amps) returns to less than or equal to 100 milliamperes (0.10 amps) If this occurs the VC-M will then continue in normal *Auto Control* mode.

WARNING!! The VC-M is not in control of the load and corrective measures should be taken immediately!

There is either a failed closed (shorted) condition with the output control device (triac) or an uncontrolled closure of the load power circuit beyond the control module that is causing the load to heat out of control.

The operator should turn VC-M controller power and the mainframe control system power “OFF” and determine the cause of the problem.

The VC-M controller in the faulty zone may be swapped with another working controller to verify proper operation of the output control device (triac). If the triac fails closed the controller MCU will not be able to turn off power to the load.

It is critical that the VC-M controller power switch be turned “OFF” before removing the VC-M controller! If the triac has failed shorted, there may be current flow through the module. Removing the controller under these circumstances can result in operator injury and controller / control system damage. **THE ENABLED VOLTAGE ANTI-ARC FEATURE WILL NOT ELLIMINATE THIS DANGER!**

This Load Diagnostic is active in either *Auto* or *Manual Control* modes.

The VC-M has set the output power to 0% (off) and if in *Manual Control* mode **the *Increment Key* will be inactive!** The VC-M will not allow the operator to increase power in this uncontrolled situation.

If the probable fault drives the Process Temperature out of range (exceeds 999°F / 537°C) the shorted output mnemonic (ShO) will alternate with the open thermocouple mnemonic (oPE). This manner of indication was selected to notify the operator that a short fault might have driven the temperature over range, rather than defaulting to only the open thermocouple indication. If these two fault conditions occur the VC-M will be forced into *Manual Control* mode with output power turned off (0%).

In this event the VC-M controller will also apply a signal on the mainframe communications bus (optional) that is used to activate an audible and/or visual alarm accessory. (The operator must enable the communications output. See the *Alarm Output Selection* instructions below).

AUTOMATIC T/C FAULT HOLD CONTROL MODE TRANSFER



PROCESS TEMP



ALTERNATING MNEMONICS

The VC-M controller has the ability to automatically switch from *Auto Control* mode to *Manual Control* mode and maintain output power in the event of T/C loss (closed loop break). When this transition is made the VC-M will continue with **output power set** to the average power required to maintain setpoint prior to the T/C fault.

When the VC-M enters this mode of operation the above detailed mnemonics will alternate on the Process Temperature display at 3-second intervals. The power setting being used will also be continuously displayed on the Setpoint / Power display.

The alternating mnemonics alarm the user of a fault condition, indicate the type of fault (reversed T/C used in the example above) and inform the operator that the VC-M automatically changed to *Manual Control* mode.

Note: This output power level will most likely not be able to hold the former setpoint but it will bring the load to a *constant* temperature that may be close to the former setpoint value. As the controller is working in *Auto Control* mode it is continually changing output power to maintain Setpoint Temperature. These continuous changes are required to keep up with process upsets to the thermal system.

ENABLING AUTO T/C FAULT HOLD

The VC-M ships from the factory with the Auto T/C Fault Hold feature **enabled**.

To disable the feature: Prior to applying power the operator must disable this function. The "AUTO T/C HOLD" DIP switch of SW4 must be changed from the factory default setting (T/C Fault Hold enabled) to the open circuit ("deactivated") position. (See the Component Layout of Figure 2.)

Once disabled the VC-M will not automatically change to *Manual Control* mode with power in the event of a T/C fault. To again enable the feature the operator must switch the DIP switch to the active, or closed, position.

TYPE "K" THERMOCOUPLE SELECTION

The VC-M can be changed to operate with type "K" Thermocouple feedback. Prior to applying power the operator must change the T/C input to type "K." The "TYPE 'K' T/C" DIP switch of SW4 must be changed from the factory default setting ("J" type) to the closed circuit position ("K" type). (See the Component Layout of Figure 2.)

The thermocouple amplifier and conditioning circuitry of the VC-M was designed to operate specifically with the industry standard type "J" thermocouple. By selecting the type "K" option, the software of the controller mathematically compensates for the difference between the type "J" and type "K" thermocouple signals and is accurate enough for most control applications. Recalibration of the VC-M in type "K" mode is not necessary.

MAINTENANCE

The VC-M controller requires very little maintenance for continuous, reliable and accurate operation. Depending on the atmosphere of the facility it may be appropriate to periodically clean the main printed circuit board assembly. This should only require blowing off dust and debris using clean and dry compressed air.

If the printed circuit board has been soiled and the air is not sufficient it is acceptable to clean the board, components and component leads using **ISOPROPYL ALCOHOL** only. Be sure that the board and components are completely dry before reapplying power to prevent unsafe and damaging short circuits.

If the faceplate / keyboard assembly needs to be cleaned use only a **DAMP RAG AND MILD DETERGENT**. Gently rub the polycarbonate overlay to remove any oil and debris. Be sure that all components are completely dry before reapplying power to prevent unsafe and damaging short circuits.

CALIBRATION

The manufacturer recommends that the VC-M controller be calibrated every 12 months to maintain accuracy and to perform within the operating specifications. Arrangements can be made with a sales representative to have the VC-M controllers calibrated using standards and equipment traceable to each region's respective governing agencies.

TEMPERATURE CALIBRATION

There are two temperature calibration potentiometers on the main printed circuit board (See Fig. 2). Pot R27 is used to set the low end of the temperature scale and pot R19 is used to set the high end of the scale.

For the highest accuracy it is recommended to calibrate the VC-M controller in the degrees Fahrenheit (°F) temperature scale.

A “J” type thermocouple calibrator (millivolt source) is required to calibrate the VC-M. The simulated T/C signal must be applied directly to the controller edge card “finger” contacts. (Fig. 2; T/C polarity is critical).

TYPE “J” T/C TEMPERATURE CALIBRATION

STEP 1: With the thermocouple input set to 200°F (93°C). Slowly turn Pot R27 (Low Cal) as required until the VC-M Process Temperature display reads the same as the simulator (200°F / 93°C).

STEP 2: Change the calibrator input to 800°F (427°C). Slowly turn Pot R19 (High Cal) as required until the VC-M Process Temperature display reads the same as the simulator (800°F / 427°C).

Turn the potentiometers slowly and STOP when resistance is met to avoid unintentional physical damage to the components!

STEP 3: Repeat steps 1-2 as many times as necessary until the low end and high end displays consistently match the simulator.

Note: It should only be necessary to repeat these steps 2-3 times to calibrate the VC-M. If calibration has not been achieved after several attempts there may be component malfunctions that need serviced. Contact your local sales representative or distributor to make arrangements to return the controller for repair by an authorized technician.

TYPE “K” T/C TEMPERATURE CALIBRATION

It is not necessary to recalibrate the VC-M using a type “K” T/C input to operate properly in type “K” Thermocouple input mode. Insure that the controller is in calibration using the standard type “J” T/C input.

CURRENT (AMPS) CALIBRATION

There is a current (amps) calibration potentiometer on the main printed circuit board (See Fig. 2). Pot R46 is used to set the load current scale.

STEP 1: Drive a known resistive load with the VC-M set in *Manual Control* mode with **output power set at 99%**. Full output power will eliminate the pulsing action of the VC-M lower output power and is the only way to accurately calibrate the current (amps) circuit.

The resistive load may be a heater less than 3600 watts. Whatever type of load is chosen must be capable of safely dissipating the supplied power of the VC-M to prevent a hazardous condition.

STEP 2: Unless it is already known, measure and record the resistance (ohms) of the load and the applied voltage, and calculate the load current. For example:

$$240 \text{ Volts (applied)} \div 41 \text{ Ohms} = \mathbf{5.8 \text{ Amps}}$$

OR

If the power (watts) of the load is known, calculate the load current using the applied voltage. For example:

$$1400 \text{ Watt Heater} \div 240 \text{ Volts (applied)} = \mathbf{5.8 \text{ Amps}}$$

STEP 3: Switch the VC-M into *Current (Amps) Monitor* mode.

STEP 4: Adjust pot R46 until the *Current (amps)* Display of the VC-M displays the correct calculated load current (amps). From the examples above, 5.8 amps.

Turn the potentiometer slowly and STOP when resistance is met to avoid unintentional physical damage to the components!

**AUTOMATIC T/C FAULT HOLD
SELECTOR SWITCH**

TURN SWITCH OFF FOR
AUTO T/C FAULT HOLD DISABLED
FACTORY DEFAULT
AUTO T/C HOLD **ENABLED**

FACTORY DEFAULT
°F SCALE
ACTIVATE SWITCH FOR
°C SCALE

**°F / °C TEMP SCALE
SELECTOR SWITCH**

**TEMPERATURE and
CURRENT (AMPS)
CALIBRATION
POTENTIOMETERS**
REFER TO CALIBRATION
INSTRUCTIONS DETAILED
IN THE **USER'S MANUAL**

**BOOST POWER OUTPUT VALUE
SELECTOR SWITCH**

FACTORY DEFAULT
BOOST = +25% TO CURRENT POWER
ACTIVATE SWITCH FOR
BOOST = **100% POWER**

**SHORTED THERMOCOUPLE
SAMPLE TIME SELECTOR SWITCH**

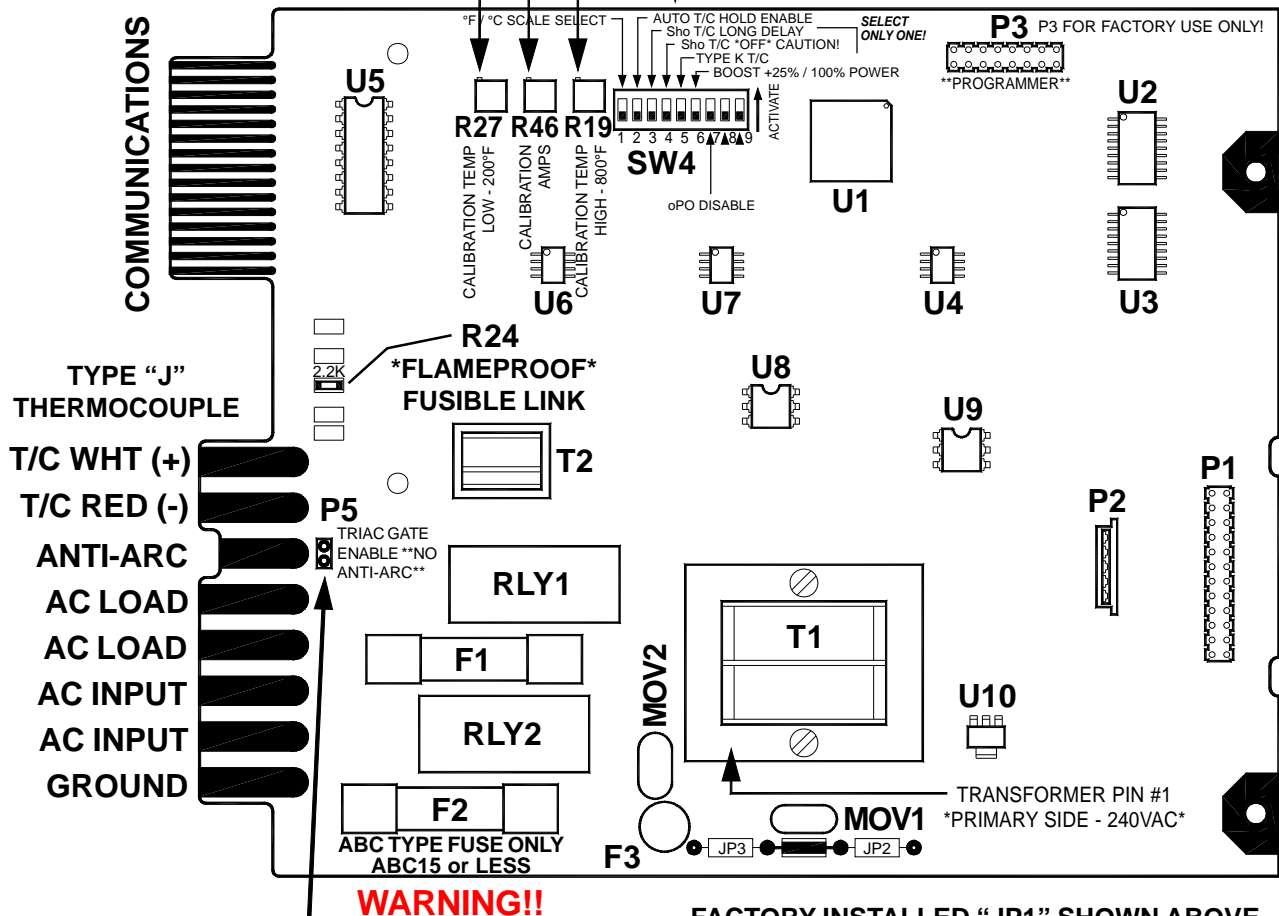
FACTORY DEFAULT
90 SECOND SAMPLE / DELAY TIME
ACTIVATE SWITCH FOR
LONG - 250 SECOND SAMPLE / DELAY TIME
ACTIVATE SWITCH FOR
SHORTED T/C (Sho) **DISABLED** **CAUTION**

**THERMOCOUPLE TYPE
(J / K) SELECTOR SWITCH**

FACTORY DEFAULT
TYPE "J" THERMOCOUPLE SELECTED
ACTIVATE SWITCH FOR
TYPE "K" THERMOCOUPLE
*** REQUIRES RECALIBRATION ***

OPEN OUTPUT (oPO) DISABLE SWITCH

ACTIVATE SWITCH FOR
OPEN OUTPUT (oPO) DISABLED



**ANTI-ARC PROTECTION
TRIAC GATE CUT-OFF JUMPER**

FACTORY DEFAULT
ANTI-ARC FEATURE **ENABLED**
INSTALL JUMPER FOR
ANTI-ARC FEATURE **DISABLED**
SOLDER INSTALL #22-#28 AWG WIRE JUMPER

**FACTORY INSTALLED "JP1" SHOWN ABOVE
*** 240 VAC *****

ALTERNATE SETTING "JP2" & "JP3"
120 VAC

INPUT VOLTAGE JUMPERS

**Figure 2
Component Layout**

REPLACEMENT PARTS

It is recommended that the VC-M controller be returned to an authorized representative for repair and calibration service.

Warning: VC-M service by unauthorized personnel may void warranty coverage!

Some component failures are easily recognized and can be quickly repaired in the field by qualified maintenance personnel. The following list of replacement parts identifies these components that are readily available through local sales representatives and distributors.

DESIG.	DESCRIPTION	PART NO.
F1, F2	FUSE – 15 AMP 250VAC **Type ABC15 only**	143-004
F3	FUSE – 40Ma 250VAC	143-047
SW1	POWER SWITCH 16A 250VAC	158-001
T1	TRANSFORMER 240/120VAC PRIMARY	154-001
T2	TRANSFORMER CURRENT SENSING	154-011
Q1	TRIAC 40 AMP 600VAC	162-100
R24	RESISTOR FUSE – 2.2K **Flameproof Type Only**	152-504
U2	IC – DISPLAY DRIVER	164-500
U3	IC – DISPLAY DRIVER	164-501
U5	IC – QUAD OPTOCOUPLER	163-508
U9	IC – OPTOCOUPLER	163-500
U8	IC – TRIAC DRIVER	163-502
U10	IC - +5VDC REGULATOR	163-503
U6, U7	IC – AMPLIFIER	163-501
U4	IC – EEPROM MEMORY	164-502
MOV1	MOV – 200 VOLT SURGE (OVER VOLTAGE) PROTECTOR	159-015
MOV2	MOV – 390 VOLT SURGE (OVER VOLTAGE) PROTECTOR	159-016
----	KEYBOARD ASSEMBLY Includes new front panel	158-103

Refer to the Component Layout (Fig. 2)

DISCLAIMER

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LIMITED WARRANTY

The manufacturer warrants that this product will be free from defects in materials and workmanship for a period of **two years** from the date of shipment.

The manufacturer, at its discretion, may or may not grant warranty service if it is determined that this product has been abused, used in a system or application which it was not designed for, altered or tampered with by unauthorized personnel.

If warranty service is applicable the manufacturer, at its option, may either repair the damaged product without charge for parts and labor or provide a replacement product in exchange for the defective unit.

This warranty excludes fuses. Appropriate arrangements must be made with a sales agent prior to the return of any material.

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