ANALOG SETPOINT TEMPERATURE CONTROL MODULES

D-M-E high performance temperature control modules are fully time proportioning closed loop feedback units capable of precise control over a wide range of operating conditions. They incorporate all of the superior temperature control and safety features that have been developed and proven by D-M-E through past practical experience.

Fully solid state, employing the latest state of the art integrated circuit technology and using no mechanical relays, these modules are completely self-contained units which can hold temperature to ±.5°F/±.3°C in a properly designed system. Zero crossover AC power switching, selection of automatic or manual control and automatic power shutdown in the event of thermocouple break are a few of the standard features.

Ease of operation with a minimum of operator controls, as well as greater control accuracy, reliability and safety are hallmarks of the new D-M-E G-Series temperature control modules.

FEATURES:

- Advanced circuitry for reliable and precise temperature control
- Zero crossing triac triggering for minimum RFI
- Automatic thermocouple break power shutdown
- Automatic or Manual control mode
- Automatic thermocouple cold junction compensation
- Plug in design for module interchangeability
- 100% solid state circuitry, no mechanical relays
- Complete self contained, no external power supplies, triac switches etc. required
- Fully fused and grounded
- Electrically isolated with grounded front panel for operator safety
- Simple operation
- Compatible with all G-Series Main Frames

ADDITIONAL FEATURES:

- Thermocouples may be grounded or ungrounded
- Deviation meter operational in Manual mode as long as thermocouple is intact
- High impedance potentiometric input allows long thermocouple wiring
- Fast cycle time for rapid temperature correction
- Analog setpoint dial equipped with dial lock
- Power supplies and circuitry fully temperature compensated
- Pilot lights to define module functions
- 240/120 Volt operation, 240 Volts is standard
- Oversize heat sink for cool, reliable operation
- Transient and dv/dt suppression included
- Type "J" thermocouple is standard
- Calibrated "0" center deviation meter
- Fahrenheit or Celsius module available
**PERFORMANCE SPECIFICATIONS:**

Control Mode, Auto. and Manual
Temperature Range °F/°C
Control Accuracy
Temperature Stability
Calibration Accuracy
Proportional Bandwidth
Cycle Time

**INPUT SPECIFICATIONS:**

Thermocouple Sensor
External Thermocouple Resistance
Thermocouple Isolation
Cold Junction Compensation
Thermocouple Break Protection
Input Type
Input Impedance
Input Protection
Input Amplifier Stability
Input Dynamic Range
Common Mode Rejection Ratio
Power Supply Rejection Ratio

**OUTPUT SPECIFICATIONS:**

Voltage
Power Capability
Power Switch
Overload Protection
Transient Protection
Power Line Isolation

**CONTROLS AND INDICATORS:**

Setpoint Control
Manual Power Control
Reset Adjustment
Power ON-OFF
Automatic/Manual
Temperature Deviation Meter
Power "ON" Indicator
Power to Load Indicator

**ELECTRICAL POWER SPECIFICATIONS:**

Input Voltage
Frequency
DC Power Supplies
Module Power Usage
Dimensions

**ORDERING INFORMATION:**

CATALOG NUMBERS
For 240 VAC (Standard)
FC10AG
FC15AG
For 120 VAC (Special Order)
FC10AG1
FC15AG1
CELSIUS, ADD X AFTER FC IN CATALOG NUMBER.

**FUSE REQUIREMENTS**

For 10 ampere module
For 15 ampere module

**MODULE/FRAME USE CHART:**

<table>
<thead>
<tr>
<th>G-Series Main Frame</th>
<th>MF 2</th>
<th>MF 2</th>
<th>MF</th>
<th>MFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Operation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Manual Only</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Compatible with Accessory Modules

**Note:** G-Series modules will fit into all G-Series frames. The above chart indicates what module operations can be utilized in any particular frame.

---

**FOR ADDITIONAL INFORMATION, CALL YOUR NEAREST D-M-E SERVICE CENTER**

**D-M-E COMPANY**
A Fairchild Industries Company

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**D-M-E SERVICE CENTERS**

**UNITED STATES and CANADA**

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ATLANTA, GA 30331
(404) 451-2674

562 Brookpark Road
CLEVELAND, OH 44109
(216) 741-9202

2143 Joe Field Road, Suite 200
DALLAS, TX 75228
(214) 262-1480

83 Keystone Dr.
* LEONINGTON, MA 01453
(617) 537-4716

1551 W. 69th Street
FORT LAUDERDALE, FL 33309
(305) 874-4220

1217 Central Avenue
MILLISSE NEWARK, NJ 07105
(201) 355-3500

1175 N. 17th Avenue
MELROSE PARK (CHICAGO), IL 60180
(312) 620-2800

558 Lee Street
BAYTON, GA 30304
(513) 461-3903

816 Wayzata Blvd.
* MINNEAPOLIS, MN 55416
(612) 946-5591

12035 Westline Industrial Dr.
ST. LOUIS, MO 63141
(314) 432-2233

11849 WYOMING (GRAND RAPIDS), MI 49509
(616) 331-9720

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**LITHO IN U.S.A.**

TCMA-1/25M/282
POWER CONTROL MODULES
WITH REGULATED OUTPUT

These D-M-E power control modules have been designed for use with systems that do not require closed loop control. Incorporated are all the superior control and safety features that have been developed and proven by D-M-E through past practical experience.

They are simple to use, require no thermocouple and, due to the special electronic circuits involved, provide constant power to the load, even with wide power line variations.

Fully solid state, employing the latest state of the art integrated circuit technology and using no mechanical relays, these modules are completely self-contained units which provide excellent power regulation. Zero AC power switching, time proportioning operation, including a standby/warmup heat function are a few of the standard features.

FEATURES:
- Automatic power compensation for AC line voltage variations
- Maintains constant heater power
- Open loop operation requires no thermocouple
- Standby heat mode for constant low output power
- 100% output power mode if required, instant return to setpoint
- Linear percent power control
- Calibrated percent power meter for 208, 220, 240 VAC
- Completely self contained, no external power supplies, triac switches etc. required
- Plug in design for module interchangeability
- Fully fused and grounded
- Electrically isolated with grounded front panel for operator safety
- Simple operation
- Compatible with all G-Series Main Frames

ADDITIONAL FEATURES:
- 100% solid state circuitry, no mechanical relays
- Power supplies and circuitry fully temperature compensated
- Pilot lights to define module functions
- 240/120 volt operation, 240 volts is standard
- Oversize heat sink for cool, reliable operation
- Transient and dv/dt suppression included
- Zero crossing triac triggering for minimum RFI
- D'Arsonval type meter with jeweled bearings
- Both sides of the AC line are high speed fused

TECHNICAL SPECIFICATIONS LISTED ON REVERSE SIDE
PERFORMANCE SPECIFICATIONS:
- Power Regulation: ±3% of the set output power for line voltage variation of 190 to 280 VAC (±20% of 240 VAC)
- Power Setpoint Resolution: 5% of maximum power
- Control Mode: Variable time proportioning
- Cycle Time: Fixed at 0.3 second
- Temperature Stability: ±1.5% of full scale over the ambient range of 32 to 140°F/0 to 60°C
- Calibration Accuracy: Better than 5% of full scale
- Standby Heat Output Power: 10-15% of maximum power

OUTPUT SPECIFICATIONS:
- Voltage: 240 VAC nominal, single phase, 120 VAC available
- Power Capability: 10 amperes, 2400 watts @ 240 VAC, 1200 watts @ 120 VAC
- Power Control Range: 0 to 100% of maximum output power
- Power Switch: Internal solid state triac, triggered by zero AC crossing pulses
- Overload Protection: Triac and load use high speed fuses. Both sides of AC line are fused
- Transient Protection: dw/dt and transient pulse suppression included

CONTROLS AND INDICATORS:
- Percentage Power Control: Linear single turn potentiometer
- Power ON-OFF: Three position rocker switch. 100%-OFF-ON
- Normal/Standby Heat: Miniature toggle switch
- Percent Power Meter: Analog, D’Arsonval jeweled movement
- Power "ON" Indicator: Calibrated 0-100% for 208, 220, 240 VAC
- Power to Load Indicator: Amber neon light
- Standby Heat Indicator: Red LED

ELECTRICAL POWER SPECIFICATIONS:
- Input Voltage: 240 VAC ±20%
- Frequency: 46 to 62 Hz
- DC Power Supplies: Internally generated, regulated and temperature compensated
- Module Power Usage: Less than 5 watts
- Dimensions: 2"W x 7"H x 7¼"D

ORDERING INFORMATION:
- Catalog Numbers:
  - For 240 VAC (Standard):
    - PMR10G: 10 amperes, 2400 watts
    - PMR15G: 15 amperes, 3600 watts
  - For 120 VAC (Special Order):
    - PMR10G: 10 amperes, 1200 watts
    - PMR15G: 15 amperes, 1800 watts
- Fuse Requirements:
  - For 10 ampere module: (1) ABC-10 and (1) 13X-10 fuse
  - For 15 ampere module: (1) ABC-15 and (1) 13X-15 fuse

MODULE/FRAME USE CHART:

<table>
<thead>
<tr>
<th>G-Series Main Frame</th>
<th>MF 2</th>
<th>MFF 2</th>
<th>MF</th>
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</tr>
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<tbody>
<tr>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Manual Only</td>
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<td></td>
<td></td>
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<tr>
<td>Compatible with Accessory Modules</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: G-Series modules will fit into all G-Series frames. The above chart indicates what module operations can be utilized in any particular frame.

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A Fairchild Industries Company

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(617) 557-4716

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MADISON HEIGHTS (WORLD HEADQUARTERS)
(586) 293-6000

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MILWAUKEE, WI 53203
(414) 386-2800

6116 Woodgate Blvd.
MINNEAPOLIS, MN 55416
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6710 Northwest Drive
MIDDLETOWN, OH 45042
(513) 877-5370

103 Monterey Pass Road
MONTEVERDE, CA 95036
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11826 Westline Industrial Dr.
ST. LOUIS, MO 63141
(314) 432-2233

4263 Clyde Park
GRAND RAPIDS, MI 49509
(616) 531-9700

* D-M-E MINI BRANCHES

LITHO IN U.S.A.
TECHNICAL SERVICE MANUAL

FC-10G/FC-15G SERIES

TEMPERATURE CONTROLLERS

D-M-E Company
29111 Stephenson Highway
Madison Heights, Michigan  48071
GENERAL DESCRIPTION

The FC10G/FC15G series is a family of modular closed-loop temperature controllers designed for plug-in installation in a group of standard main frames. These controllers are available with either 10 or 15 ampere capability and with a variety of optional operating features. These controllers are supplied calibrated in degrees Fahrenheit unless an "X" appears in the model number which denotes degrees Celsius calibration (e.g. FCX10AG).

The basic models that are available are:

- FC10AG/FC15AG: Analog setpoint controller
- FC10ASG/FC15ASG: Analog setpoint controller with SloStart option
- FC10DG/FC15DG: Digital setpoint controller
- FC10DSG/FC15DSG: Digital setpoint controller with SloStart option

ELECTRICAL SPECIFICATIONS

INPUT: 120/240 VAC ±20%, 48 to 62 Hz (240 VAC normal)

OUTPUT: FC10G-10 amperes, 2400 watts, single phase
- FC15G-15 amperes, 3600 watts, single phase

TEMPERATURE RANGE: 200°F to 800°F (Fahrenheit units)
- 100°C to 400°C (Celsius units)

TEMPERATURE SENSOR: Type J thermocouple

TEMPERATURE SET CONTROL: Analog units - Single turn potentiometer with calibrated dial
- Digital units - 3-digit thumbwheel switch

RESOLUTION: Analog units ±2 degrees Fahrenheit
- Digital units ±1 degree Fahrenheit

ACCURACY: Better than 0.5 degrees Fahrenheit

MANUAL POWER CONTROL: Single turn with calibrated scale

MANUAL POWER RANGE: 0 to 100%

TEMPERATURE DEVIATION METER: Analog zero center type ±40°F and ±20°C scale

SloStart DURATION: 5.3 minutes ±5%

SloStart MODE OUTPUT POWER: 50% of maximum power

CONTROL MODE: Time proportioning

OVERLOAD PROTECTION: Fused on both sides of AC line. Load and triac protected by high speed fuse.
INSTALLATION

The model FC10G/FC15G Series Temperature Controller is ready to use as shipped from the factory. No special unpacking procedures are required prior to installation into a main frame.

CAUTION: Never insert or remove a controller from a main frame with the AC power on. Disconnect AC power before servicing system to avoid damaging the controller and main frame.

HAZARDOUS POTENTIALS EXIST ON COMPONENTS INSIDE OF CONTROLLER. NEVER SERVICE EQUIPMENT WITH POWER APPLIED.

To install a controller into a main frame, release the locking device on the lower edge of the module's front panel by gently pulling the plunger away from the panel. Align the upper and lower edges of the printed circuit board on the controller with their respective card guides on the main frame and slide the unit all the way into the frame until the rear connector is completely engaged. Lock the controller into the frame by depressing the plunger on the locking device.

120V/240V OPERATION

Unless otherwise specified, temperature controllers are shipped from the factory wired for 240 VAC operation. To convert for 120 VAC operation, it is necessary to cut a copper land on the printed circuit board and insert two jumper wires. Refer to the schematic diagram for the location of these connections.

OPERATION

The following items refer to front panel controls and indicators on the FC10G/FC15G Temperature Controller. The purpose of this section is to familiarize you with the function of each of the indicators and adjustments provided.

1. MODULE ON-OFF SWITCH
   Applies AC power to the module. This switch must be in the OFF position when removing or inserting module.

2. A.C. POWER ON LAMP
   Amber neon lamp indicates that power is applied to the controller when the power switch is ON and the fuses are good.

3. TEMPERATURE SETPOINT DIAL
   Analog or digital, is used to adjust the desired setpoint or operating temperature of the controller.
4. **TEMPERATURE OFFSET METER**
   Zero center scale meter indicates the temperature differential between the thermocouple and the temperature setpoint dial.

5. **POWER TO LOAD LAMP**
   Red neon lamp lights to indicate when the controller is supplying power to the load.

6. **RESET ADJUSTMENT**
   Will move the proportional band so that the temperature deviation is reduced to zero. Adjust if necessary ONLY AFTER system has stabilized.

7. **MANUAL/ AUTOMATIC SWITCH**
   In "AUTO" position the module operates in closed-loop mode with thermocouple control.

   "MAN" position allows operation of % power control, night or weekend heat. To return to automatic operation, restore switch to "AUTO" position.

8. **% POWER CONTROL**
   This control is used for manually adjusting the power level when AUTO/MAN switch is in the MAN position. The WARM section of the calibrated dial is used for nighttime or weekend low power setting. MAN/AUTO switch must be in the MAN position.

9. **SloStart SWITCH (optional)**
   Turns SloStart operation ON. The module will automatically switch to normal operation after SloStart period is complete. The SloStart cycle time is fixed at approximately five minutes. If the SloStart feature is not desired, turn switch to the OFF position.

10. **SloStart LAMP (optional)**
    This lamp will blink to indicate that the module is in the SloStart mode of operation. The lamp will extinguish when the SloStart period is over.

**THEORY OF OPERATION**

A type J thermocouple is used to sense the temperature of the heater. Referring to the block diagram, the thermocouple voltage is applied to the input of U3, a precision operational amplifier. The output of U3 is a signal 101 times that of the thermocouple. Provisions added at the input of U3 generate a high temperature output when the thermocouple is broken.

CR4, U2D, and the associated circuitry generate a voltage to cancel or compensate for the voltage developed by the thermocouple cold junction at the input of U3. The amplified thermocouple signal and the cold junction compensating voltages are added and then compared with the set temperature, specified by R29 and U2C. The output of U2C is called the temperature error or deviation. An analog meter is provided for monitoring that temperature deviation continuously.
The temperature error is also applied to U2B where offset and manual control signals are introduced. Offset voltage is set by R36 and manual control signal is set by R35.

Q1, Q2 and the associated circuitry generate a linear sawtooth signal. U2A compares the sawtooth voltage level with the U2B output voltage level. If the sawtooth voltage is higher than the output of U2B, then the comparator output is low; otherwise it is high. A high comparator output indirectly turns on AC power to the heater load, while a low comparator output turns off AC power to the load.

A series of 120 Hz pulses is generated by the circuit of U1A and U1B. Each pulse generated coincides with the zero crossing of the AC line. This feature is essential for minimizing RFI generated when a triac is turned on. The 120 Hz pulses are gated by the signal at the output of U2A. If the output of U2A is high, the Triac Enable Circuit passes the 120 Hz pulses to the Triac Trigger Circuit, otherwise the 120 Hz pulses are blocked.

The Triac Trigger Circuit is an optically coupled thyristor. Such a device offers an exceptionally high isolation, more than 2500 volts between the AC mains and the control circuit ground. When the Triac Trigger output is activated, triac Q4 is turned on, connecting the heater load across the mains. Q4 turns itself off automatically at each zero-volt crossing of the mains.

The SloStart Circuit is an optional feature of the controller. If included the SloStart logic reduces the initial rate of temperature rise. Furthermore, the temperature will be held below 175°F during the SloStart active period.

When the controller AC power is first turned on and the SloStart function is selected, the Clock Oscillator Circuit starts generating a stable 26 Hz square wave. The SloStart logic also forces the controller to deliver 50% power to the heater load. When the 8192th square wave is received by U7, in approximately 5 minutes, the SloStart function terminates.

During the active SloStart period, the Temperature Limit Circuit, U10B, monitors the thermocouple temperature continuously. Should the temperature rise above 175°F, the SloStart Enable Circuit inhibits the heater power to prevent further temperature rise. The Temperature Limit Circuit also includes an override feature. This feature inhibits the SloStart function when the temperature is above 250°F prior to turning the power on.

MAINTENANCE

The appendix of this manual includes an electrical parts list, a schematic diagram and a parts location diagram to facilitate the servicing of the temperature control module.

All electrical and electronic parts are listed in the sequence of their circuit designation numbers as shown on the schematic diagram.
We recommend that all parts be ordered directly from the factory. The commercial equivalents of many parts have wide parameter tolerances and may not be suitable for direct replacement purposes. This is especially true with semiconductor devices, since manufacturers are continually modifying their products. Substituting "equivalent" devices may affect the performance of the temperature controller; since they may have different gains, operating voltage levels or frequency response. We can assure compliance with the original specifications if replacement parts are ordered directly from the factory.

When ordering replacement parts, please identify the temperature controller as thoroughly as possible giving the model number and serial number if available.

The replacement parts you receive may not have the same part number as that shown on the electrical parts list. This can be due to several factors:

(A) The original vendor has discontinued manufacture of the item or can no longer manufacture it to the original specifications.

(B) A better device for use in a particular circuit has been substituted.

(C) Tighter controls for interchangeability have provided greater assurance of reliability with the replacement part.

CALIBRATION

All temperature controllers are factory calibrated and the adjustment trimpots sealed prior to shipment. Recalibration is not normally required unless critical components which may affect calibration accuracy are replaced.

Field calibration of temperature controllers is not recommended, since it requires the use of precision laboratory type test equipment. We suggest that controllers be returned to the factory for recalibration.

The following procedure should only be performed by qualified technical service personnel, since instrumentation accuracy and ambient temperature will affect the results.

**Equipment Required:**
1) 4½ Digit Digital Voltmeter
2) Accurate Adjustable Millivolt Source
3) Digital Counter/Timer
4) Card Extender or Extension Cable
5) Thermometer
6) Type "G" Main Frame and Load
PRELIMINARY

Connect temperature controller to main frame by means of a card extender or extension cable to allow access to internal controls with the power ON.

Connect a load to the zone under test on the main frame. Turn AC power switch ON.

A/D CONVERTER CALIBRATION (Digital Units Only)

1. Connect Digital Voltmeter so that the NEGATIVE lead goes to ground and the POSITIVE lead goes to pin 10 of U12.

2. Set thumbwheel setpoint switch to "000".

3. Adjust RG1 until DVM indicates zero.

4. Disconnect DVM from U12.

TEMPERATURE CALIBRATION

1. Place setpoint control at 200°F or 100°C. Set reset control on front panel fully clockwise to prevent cycling.

2. Connect millivolt source to thermocouple input of controller under test. Monitor the output of the millivolt source with DVM.

3. Adjust millivolt source to 3.83mv at ambient temperature of 70°F for 200°F calibration point. (For 100°C calibration point, adjust millivolt source to 4.19mv at 70°C ambient temperature.) Refer to calibration chart for millivolt settings at other ambient temperatures.

4. Adjust R21 until deviation meter on front panel indicates zero.

5. Place setpoint control to 800°F or 425°C.

6. Adjust millivolt source to 22.24mv at an ambient temperature of 70°F at 800°F calibration point. (For 425°C calibration point, adjust millivolt source to 22.15mv at 70°F ambient temperature.) Refer to calibration chart for millivolt settings at other ambient temperatures.

7. Adjust R27 until deviation meter on front panel indicates zero.

8. Repeat steps 1 through 7 until calibration accuracy is achieved at both ends of scale.
ROOM AMBIENT (°F)

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>68</th>
<th>69</th>
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<th>71</th>
<th>72</th>
<th>73</th>
<th>74</th>
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<td>3.83</td>
<td>3.80</td>
<td>3.77</td>
<td>3.74</td>
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<td>22.12</td>
<td>22.09</td>
<td>22.06</td>
<td>22.03</td>
</tr>
</tbody>
</table>

Figure 1
Calibration Chart

CHECK SloStart OPERATION

1. Set millivolt source to zero.

2. Turn SloStart switch ON. Observe that SloStart lamp blinks and that Load Lamp cycles at approximately 50% duty cycle.

3. Increase millivolt source to point where LOAD cycle lamp turns OFF.

4. Set setpoint control to center Deviation Meter. The control should be between 149 - 185°F. (65 - 85°C).

5. Continue to increase output of millivolt source until the SloStart lamp turns OFF.

6. Set the setpoint control to zero the Deviation Meter. The control should be between 239 - 275°F. (115 - 135°C)

7. Turn the controller OFF and then back ON. Time the SloStart cycle using the counter/timer. The duration of the SloStart cycle should be 5 minutes ±20 seconds.
ELECTRICAL PARTS LIST

The FC10G and FC15G series of temperature controllers consist of a family of similar models, each having different operating features. The following electrical parts list is applicable to all types. Components may be deleted or values changed, as indicated, from model to model.

<table>
<thead>
<tr>
<th>CIRCUIT NUMBER</th>
<th>DESCRIPTION</th>
<th>PART NUMBER</th>
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<td>B1</td>
<td>Neon Lamp Ass'y, Amber</td>
<td>2910S20-AMB</td>
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<tr>
<td>B2</td>
<td>Neon Lamp Ass'y, Red</td>
<td>2910S20-RED</td>
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<td>C8,C9</td>
<td>Capacitor, Electrolytic, 10uf/16VDC</td>
<td>PDA10M16</td>
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<td>Capacitor, Electrolytic, 100uf/16VDC</td>
<td>KSET100-16</td>
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<td>Capacitor, Electrolytic, 1uf/50VDC</td>
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<td>Capacitor, Tantalum 10uf/16VDC</td>
<td>DPA1M16</td>
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<td>M1</td>
<td>Meter, Deviation, Edgewise</td>
<td>IM36</td>
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<tr>
<td>Q1</td>
<td>Transistor, NPN</td>
<td>2N4401</td>
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<td>Q2</td>
<td>Transistor, PNP</td>
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<td>Q3,Q5</td>
<td>Transistor, Unijunction</td>
<td>2N6028</td>
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<td>Q4</td>
<td>Triac, 25A</td>
<td>Q4025P</td>
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<tr>
<td>R64</td>
<td>Resistor, Carbon Film 470ohm, 5%, 1/8W</td>
<td>RAB.25J471</td>
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<tr>
<td>R30</td>
<td>Resistor, Carbon Film 560ohm, 5%, 1/8W</td>
<td>RAB.25J561</td>
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<tr>
<td>R39</td>
<td>Resistor, Carbon Film 680ohm, 5%, 1/8W</td>
<td>RAB.25J681</td>
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<tr>
<td>R48</td>
<td>Resistor, Carbon Film 1kohm, 5%, 1/8W</td>
<td>RAB.25J102</td>
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<tr>
<td>R4,R7</td>
<td>Resistor, Carbon Film 1.5kohm, 5%, 1/8W</td>
<td>RAB.25J152</td>
</tr>
<tr>
<td>R15,34,37,52</td>
<td>Resistor, Carbon Film 2.2kohm, 5%, 1/8W</td>
<td>RAB.25J222</td>
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<tr>
<td>R56</td>
<td>Resistor, Carbon Film 3.3kohm, 5%, 1/8W</td>
<td>RAB.25J332</td>
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<tr>
<td>R5,R55</td>
<td>Resistor, Carbon Film 6.8kohm, 5%, 1/8W</td>
<td>RAB.25J682</td>
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<tr>
<td>R8,13,38</td>
<td>Resistor, Carbon Film 10kohm, 5%, 1/8W</td>
<td>RAB.25J103</td>
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<tr>
<td>R57,62,63</td>
<td>Resistor, Carbon Film 10kohm, 5%, 1/8W</td>
<td>RAB.25J103</td>
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<tr>
<td>R9,R54</td>
<td>Resistor, Carbon Film 22kohm, 5%, 1/8W</td>
<td>RAB.25J223</td>
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<tr>
<td>R65-R76</td>
<td>Resistor, Carbon Film 33kohm, 5%, 1/8W</td>
<td>RAB.25J333</td>
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<tr>
<td>R31,40,53</td>
<td>Resistor, Carbon Film 47kohm, 5%, 1/8W</td>
<td>RAB.25J473</td>
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<tr>
<td>R1,32,33</td>
<td>Resistor, Carbon Film 100kohm, 5%, 1/8W</td>
<td>RAB.25J104</td>
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<tr>
<td>R60</td>
<td>Resistor, Carbon Film 120kohm, 5%, 1/8W</td>
<td>RAB.25J124</td>
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<tr>
<td>R3</td>
<td>Resistor, Carbon Film 220kohm, 5%, 1/8W</td>
<td>RAB.25J224</td>
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<tr>
<td>R10,11,12</td>
<td>Resistor, Carbon Film 1megohm, 5%, 1/8W</td>
<td>RAB.25J105</td>
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</tbody>
</table>

*For FC15G Triac, 40A Q4040P
R26,58,59 Resistor, Carbon Film, 1megohm, 5%, 1/4W RAB.25J105
R2 Resistor, Carbon Film, 2.2megohm, 5%, 1/4W RAB.25J225
R44,45,51 Resistor, Carbon Film, 470kohm, 5%, 1/4W RAB.25J474
R14,R50 Resistor, Composition, 22megohm, 10% 1/4W RAD.25K226
R41,R43 Resistor, Composition, 100ohm, 10% 1/4W RAD.5K101
R16 Resistor, Precision, 2.21kohm, 1%, 1/8W RAN.25F2211D
R22,46,47 Resistor, Precision, 10.0kohm, 1%, 1/8W RAN.25F1002D
*R28 Resistor, Precision, 10.0kohm, 1%, 1/8W RAN.25F1002D
R28 Resistor, Precision, 15.0kohm, 1%, 1/8W RAN.25F1502D
R18 Resistor, Precision, 47.5kohm, 1%, 1/8W RAN.25F4752D
R19,20,24,25 Resistor, Precision, 100kohm, 1%, 1/8W RAN.25F1003D
R23 Resistor, Precision, 205kohm, 1%, 1/8W RAN.25F2053D
R17 Resistor, Precision, 221kohm, 1%, 1/8W RAN.25F2213D
**R29 Resistor, Variable, 5kohm, 2W AW20498VC
R35 Resistor, Variable, 10kohm, 3/4W BM5693
*R27 Resistor, Trimmer, 50kohm 3386X-1-503.
R27 Resistor, Trimmer, 100kohm 3386X-1-104
R21 Resistor, Trimmer, 100kohm 3386X-1-104
R36,R61 Resistor, Trimmer, 10kohm 3386X-1-103

S1 Switch, Rocker, DPDT 2600-13E
S2 Switch, Toggle, DPDT Miniature ST2-1
*S3 Switch, Thumbwheel BCD 44011S
S4 Switch, Toggle, SPDT Miniature ST1-1

T1 Transformer, Power F24-07.5-F-N

U1 Integrated Ckt, Digital CD4070BE
U2 Integrated Ckt, Linear LM324N
U3 Integrated Ckt, Linear OP-07DP
U4 Integrated Ckt, Opto-coupler 4N40
U5 Integrated Ckt, Linear LM79L05AC
U6 Integrated Ckt, Digital CD4093BE
U7 Integrated Ckt, Digital CD4020BE
U8 Integrated Ckt, Digital MC14001BCP
U9 Integrated Ckt, Digital CD4016BE
U10 Integrated Ckt, Linear LF353N
U11 Integrated Ckt, Digital AD7525KN
U12 Integrated Ckt, Linear LM747CN

VR1 Varistor, Metal Oxide V250LA15A

NOTES: *indicates that item is used only on digital units
**indicates that item is used only on Celsius units

All electrical parts do not appear on all units. Components may be added or deleted to provide specific operating features depending on the model number. Refer to the schematic diagram to identify the components related to each function.
ADDENDA TO PARTS LIST

The following items are replaceable mechanical parts for the model FC10/FC15G Series Temperature Controllers. Although it is unlikely that these parts will require replacement during the normal life of the unit, the following information is provided for servicing convenience.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PART NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knob, Setpoint, Fahrenheit</td>
<td>PS95TS-5124-2</td>
</tr>
<tr>
<td>Knob, Setpoint, Celsius</td>
<td>PS95TS-5124-3</td>
</tr>
<tr>
<td>Knob, % Power</td>
<td>PK50-B-1/8</td>
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<tr>
<td>Handle</td>
<td>A-1594-2</td>
</tr>
<tr>
<td>Nylatch Plunger</td>
<td>HN3P-33-4-1</td>
</tr>
<tr>
<td>Nylatch Grommet</td>
<td>HN3G-33-1</td>
</tr>
<tr>
<td>Analog Dial Lock Thumbscrew</td>
<td>2366</td>
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<tr>
<td>Dial Lock Nylon Flatwasher</td>
<td>5610-37-040</td>
</tr>
<tr>
<td>Dial Lock Shoulder Washer</td>
<td>5607-79</td>
</tr>
<tr>
<td>Meter Retaining Spring Clip</td>
<td>670-403A</td>
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</tbody>
</table>
FC-10 AG SERIES

To convert from 240V to 120V

1. Cut trace (copper etching) where indicated by X
2. Solder jumpers (2) where indicated by A & B

Inset view

(Solder side)