TECHNICAL MANUAL

"ChamberMate"

Bi-directional Temperature Limit Controller

Fourth Edition
June 20, 1998

ChamberMate™ is a tradename of Warner Instruments. This product is also manufactured under the proprietary tradenames of other manufacturers, including ***TempSentry II*** and ***SafeGuard.***

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PURPOSE

This device is designed as a precision hi/lo temperature limit switch for environmental and reliability test chambers. Whenever the measured temperature strays above or below a preset “normal" range, a "high" or "low" relay contact switches to the "off" state to disable either the heating system or the cooling system. Visual LIMIT indications and an audible warning signal are provided, and the output is held off until manually reset by the user (automatic reset is a user-selected option).

An "auxiliary" contact is also provided. This third contact may be slaved to the "high" and "low" outputs (switching off when either limit is exceeded) to control power to live loads, or it may be configured to pulse remote alarm devices.

DESCRIPTION

This device is packaged as a single, panel-mounted component, consisting of printed circuit assemblies housed in a painted and anodized aluminum case. Front panel controls and indicators include :

- a precision digital temperature indicator,
- a SENSOR fault indicator,
- indicating HIGH LIMIT and LOW LIMIT reset switches which, when pressed, also cause the indicator to display the limit setting,
- recessed HIGH LIMIT and LOW LIMIT adjustments,
- an audible warning device (beeper), and
- an indicating audible warning "SILENCE" switch.

The controller is designed for use with ISA type T (copper vs constantan) thermocouples, with a measuring range of -125°F to +375°F. Electronic cold junction compensation is provided, and the input is unaffected by sensor leadwire resistance. In the event of an open sensor circuit, the controller will produce a blank display, and a flashing SENSOR warning. A special fail-safe circuit also disables both the heating and cooling outputs, assuring that both systems will remain inoperative until protection is restored. The indicating accuracy of the controller is ±.25%. The switching accuracy is mainly a function of its setability; about ±1%.

The outputs of the controller consist of three mechanical 1P2T relay contacts, rated 10-amps at 250vac maximum. These relays are energized during all periods of normal operation, and drop out whenever a limit is exceeded, or when power is removed from the equipment.

Input power requirements are 3.5VA max. at 110/120vac or 208/240vac, 50/60 Hz. All connections are made at terminal blocks on the back of the unit.

INSTALLATION & WIRING

Please refer to Drawing No. 470684.

Install the controller at a location which is convenient to system wiring, reasonably free of vibration and temperature extremes, and accessible to equipment operators. The controller is normally panel-mounted in a 3-11/16" x 8-3/16" cutout, using special mounting clamps (p/n 352052). As shown on Drawing No. 470684, the controller normally protrudes 7-3/16" behind the face of the mounting panel.

Connect an ISA type T thermocouple to the SENSOR terminal block in the upper right-hand corner of the controller, observing the RED (-) and BLU (+) color code. Use only type "XT" (copper vs constantan) thermocouple extension wire between the sensor and this terminal block. The controller is not affected by leadwire resistances less than 1000-ohms.

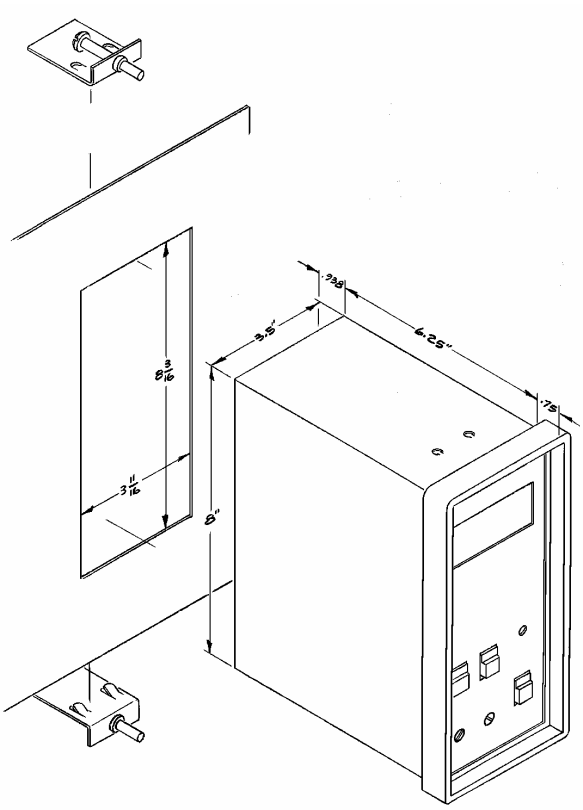
Connect the input power to the terminal block in the lower right-hand corner, as follows:

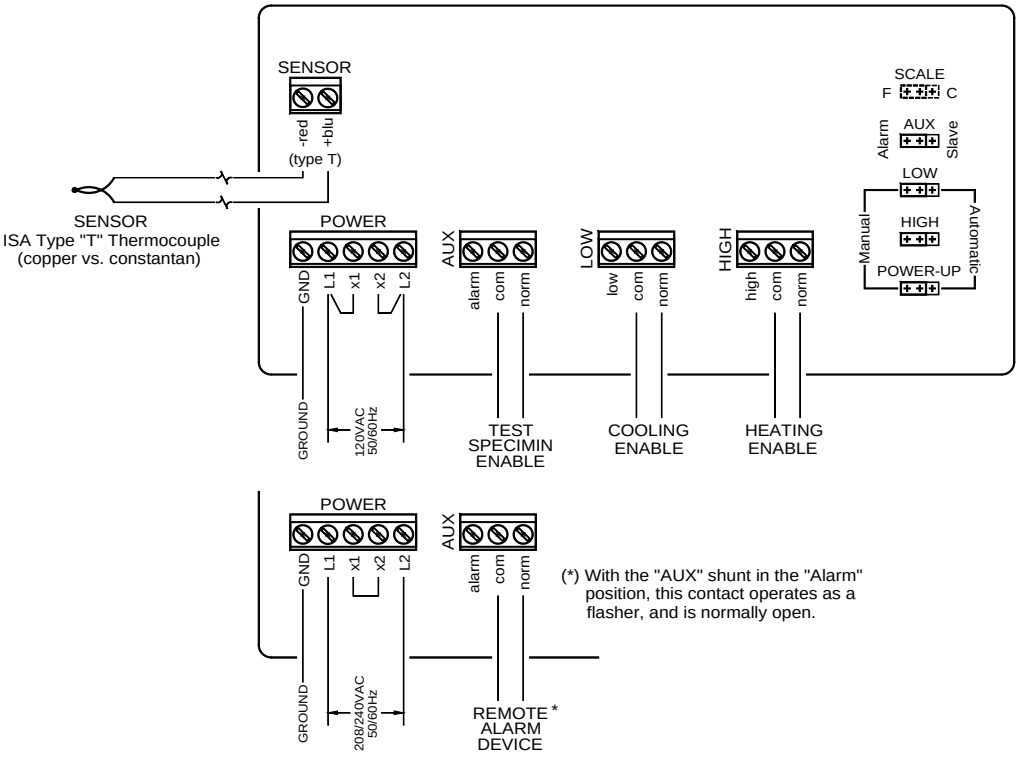
110/120vac circuits	208/240vac circuits
Line to terminals 1 & 2 Com to terminals 3 & 4 Ground to terminal 5 ("GND")	L1 to terminal 1 jumper to terminals 2 & 3 L2 to terminal 4 Ground to terminal 5 ("GND")

An indicator LED is provided on the back of the unit adjacent to each output relay. These lights will be on whenever their associated relay is energized. The relays are energized during all periods of normal operation (exception for K3 noted below), opening when limits are exceeded, or when power is removed from the unit. Whenever these relays are energized, their normally open contact set will connect COM to NORM at their associated terminal block.

The output connections are marked HIGH/COM/NORM, LOW/COM/NORM and ALARM/COM/NORM. During normal operation, COM will be connected to NORM. When a high or low limit is exceeded, COM switches to HIGH or LOW, as the case may be. Control power for the heating and cooling systems will therefore normally be wired through the COM and NORM terminals.

The operation of the auxiliary "ALARM" contact varies with the mode selected. In the slaved mode, COM will be connected to NORM until either limit is tripped, at which time COM switches to ALARM. Control power to live loads will therefore normally be wired through the COM and NORM terminals. In the alarm mode, this relay is normally off (COM to ALARM), and is pulsed on (COM to NORM) and off whenever a limit has been exceeded and the SILENCE button on the front of the unit has not been pressed (problem having not been attended to). Power to remote alarm devices will therefore also normally be wired through the COM and NORM terminals.


3.5"
6.25"
.75"
8"
3 1/16
3 1/16


SENSOR
-red +blu
(type T)
SENSOR
ISA Type "T" Thermocouple
(copper vs. constantan)
POWER
GND L1 x1 x2 L2
GROUND
120VAC 50/60Hz
AUX
alarm com norm
TEST SPECIMIN ENABLE
LOW
low com norm
COOLING ENABLE
HIGH
high com norm
HEATING ENABLE
SCALE
F C
AUX
Alarm Slave
LOW
HIGH
POWER-UP
Manual Automatic
POWER
GND L1 x1 x2 L2
GROUND
208/240VAC 50/60Hz
AUX
alarm com norm
REMOTE * ALARM DEVICE
(*) With the "AUX" shunt in the "Alarm" position, this contact operates as a flasher, and is normally open.

SELECTION OF OPTIONAL OPERATING MODES

Jumpers on the back of the unit permit the user to configure the operating mode of the unit. Two of these jumpers provide for the selection of either manual or automatic reset operation on the "High" and "Low" limit channels. If the controller is used in the manual reset mode, it will normally start-up in the "tripped" condition. A third jumper therefore provides for the selection of automatic reset on power-up, when desired. If the alarms should trip on power failures, but not in connection with routine on-off switching, connect the instrument to the main power buss, just ahead to the equipment's on/off switch, and set the third jumper at the "normal" position.)

The third "Auxiliary" contact may be slaved to the "High Limit" and "Low Limit" outputs, switching off when either limit is tripped. Or the "Aux." output may be set to pulse on and off when either limit is tripped, to operate remote alarm devices. Set the "AUX" jumper to provide the desired alternative.

Finally, a fifth jumper provides for the selection of either the Celsius or Fahrenheit indicator temperature range.

These jumpers and the above options are also illustrated on Dwg No 470684. As shipped from the factory, these jumpers are set to provide manual reset, manual power-up reset, alarm operation of the auxiliary contact, and Fahrenheit temperature indications.

OPERATION

The limit temperatures can be set by pressing either the HIGH LIMIT or LOW LIMIT reset button, then turning the respective set point adjustment as necessary to provide the desired indication.

When power is first applied, the controller will start-up in the "LIMIT" mode. Its red HIGH LIMIT and green LOW LIMIT indicators will flash on and off, and the audible alarm will sound. To start the equipment, press both RESET buttons. If the measured temperature is within the set limits, the indicators and audible alarm will be switched off, and the outputs will be enabled (units set for automatic reset will start up automatically).

If desired, automatic power-up reset operation may be selected via a jumper on the back of the unit. When this feature is used, the limit indicators will flash on momentarily when power is first applied, and will then automatically assume the normal reset condition.

During all periods of normal operation, the alarm indicators and the audible warning device will remain off, and the system will be enabled by the controller's output contacts. If the measured temperature ever exceeds a limit setting, the controller will immediately switch to the LIMIT mode. The flashing red or green indicator will then be enabled, the audible warning will sound, and the associated output will be disabled. When the temperature has returned to an acceptable level, press the lighted reset button to return to normal operation. In the meantime, the audible warning signal (and remote alarm devices, if used) can be turned off by pressing the SILENCE button.

Independent automatic reset operation is available for both the HIGH and LOW channels, via jumpers on the back of the unit. When used, the alarms will return to the normal status as soon as the measured temperature returns to within limits. Note that the selection of automatic reset inherently provides power-up reset for that channel. It is not possible to set the jumpers to provide automatic reset on both limit channels, with manual reset on power-up.

CIRCUIT ANALYSIS

Please refer to schematic diagram, Drawing No. 470665.

Measuring Circuit

The controller's temperature measuring circuit, the first half of U8 and its associated circuitry, converts the low level thermocouple input to a scaled and compensated high level analog voltage. The sensor, "mj" (measuring junction) is connected to U8-11, the input of this amplifier. C17 provides low pass filtering for this input. Standard units are designed to measure temperatures over the range of -125°F to +375°F, using a type T (copper vs constantan) thermocouple. Over this temperature range, this sensor produces emf's ranging from -3.006mV to +8.787mV. This input is amplified and scaled to provide a 0v to -5.0v analog output at U8-6. To achieve this, the gain of the amplifier is set by R17, R18 and R19 at 424.

This non-inverting amplifier will always settle at the point where the potential at its inverting input, U8-10, is exactly equal to its input, U8-11. This condition is established by a feedback current, passed from the output, U8-6, through R18 and R17 to the amplifier's inverting input. For a given input, the magnitude of the feedback current required to establish this balance is a function of R19. Having established that, the magnitude of the amplifier's output voltage then becomes a function of the feedback resistors, R17 and R18. The resistor values used permit the gain to be set exactly at 423.98, with a calibration range of about ±2% to accommodate all tolerances.

Thermocouple circuits necessarily involve a second junction, sometimes called the "reference junction". This junction, shown as "rj" on the schematic, has the same "emf vs temperature" characteristic as the sensor. It occurs in series with the sensor's emf, with the opposite polarity. The emf produced by the "rj" junction is algebraically summed with the sensor emf, so any variation of the ambient temperature directly affects the measurement.

U5, R20 and R21 provide reference junction compensation, which minimizes errors due to variations in ambient temperature. U5, which is located at the (-) end of the SENSOR terminal block, is an integrated circuit temperature sensor, which produces an output proportional to its absolute temperature. This output varies 10mV/°C, and is scaled by R21 to produce a feedback current through R17 and R18 which will be approximately equal and opposite to that being caused by the influence of the reference junction emf. At room temperature, the emf produced at rj varies about 40.7uV/°C which, in turn, produces a feedback current of about 40.7nA through R21. A 1°C ambient temperature change will also result in a 10mV variation at U5. This will produce a -41nA change in the total feedback current, which approximately cancels out the shift produced by rj.

U4, R14, R15 R_{zt} and R16 provide a means of shifting the amplifier's output to zero with a -125°F input at "mj". U4 is a precision voltage reference integrated circuit, which provides a stable +6.9v at its junction with R14 and R15. At -125°F, the mj input will be -3.006mV. Assuming a 25°C ambient temperature, the emf produced by rj will be about +0.992mV, so the net input will be about +3.998mV, producing an offset of about +1.7 volts at U8-6.

Meanwhile, the voltage at the U5, R20 node varies with absolute temperature by 10mV/°K, and will therefore be about +2.98v (0°C = 273°K). This produces a compensator-related offset at U8-6 of about -5.2 volts.

U8 is a precision op amp, with negligible offsets, so the total value of the offsets is therefore about -3.5 volts. To shift the output level back to zero, R16 is adjusted so that the zero network injects a current into the feedback node which is about equal and opposite to that caused by the total offsets; about -3.5v/422.98°K = -8.3uA. R_{zt} is a “zero trim” adjustment, and is located on the back of the unit next to the sensor input terminals.

Linearizer Circuit

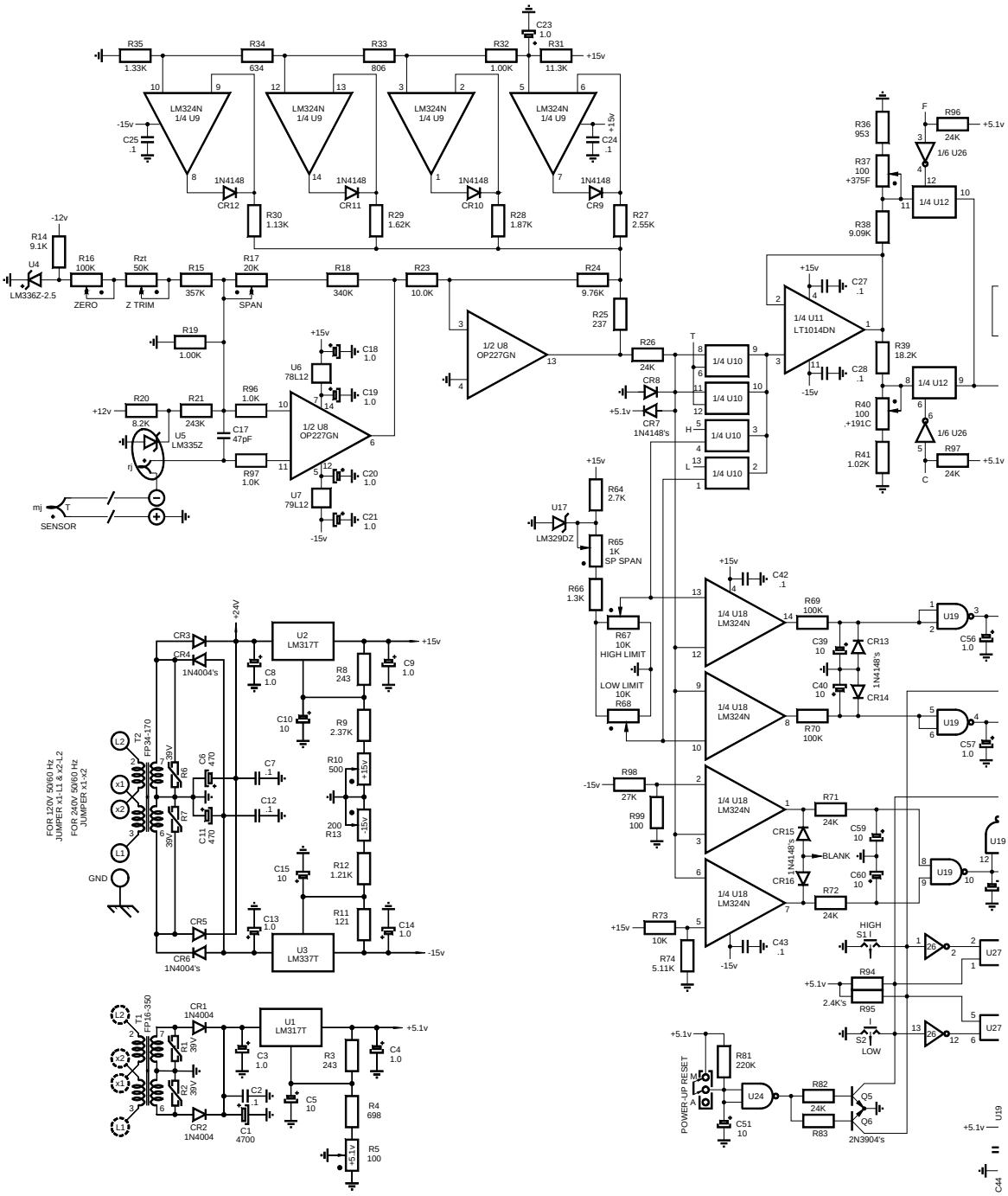
The "emf vs. temperature" response of the thermocouple temperature sensor is highly nonlinear, varying from 16.6uV/°F at -125°F to 29.2uV/°F at +375°F. To provide a highly accurate digital temperature read-out, U8 and U9 convert the nonlinear 0/-5.00v measuring circuit output (U8-6) to a linear analog at U8-13. The linear analog has a range of 0/+5.00v (slope = 10mV/°F).

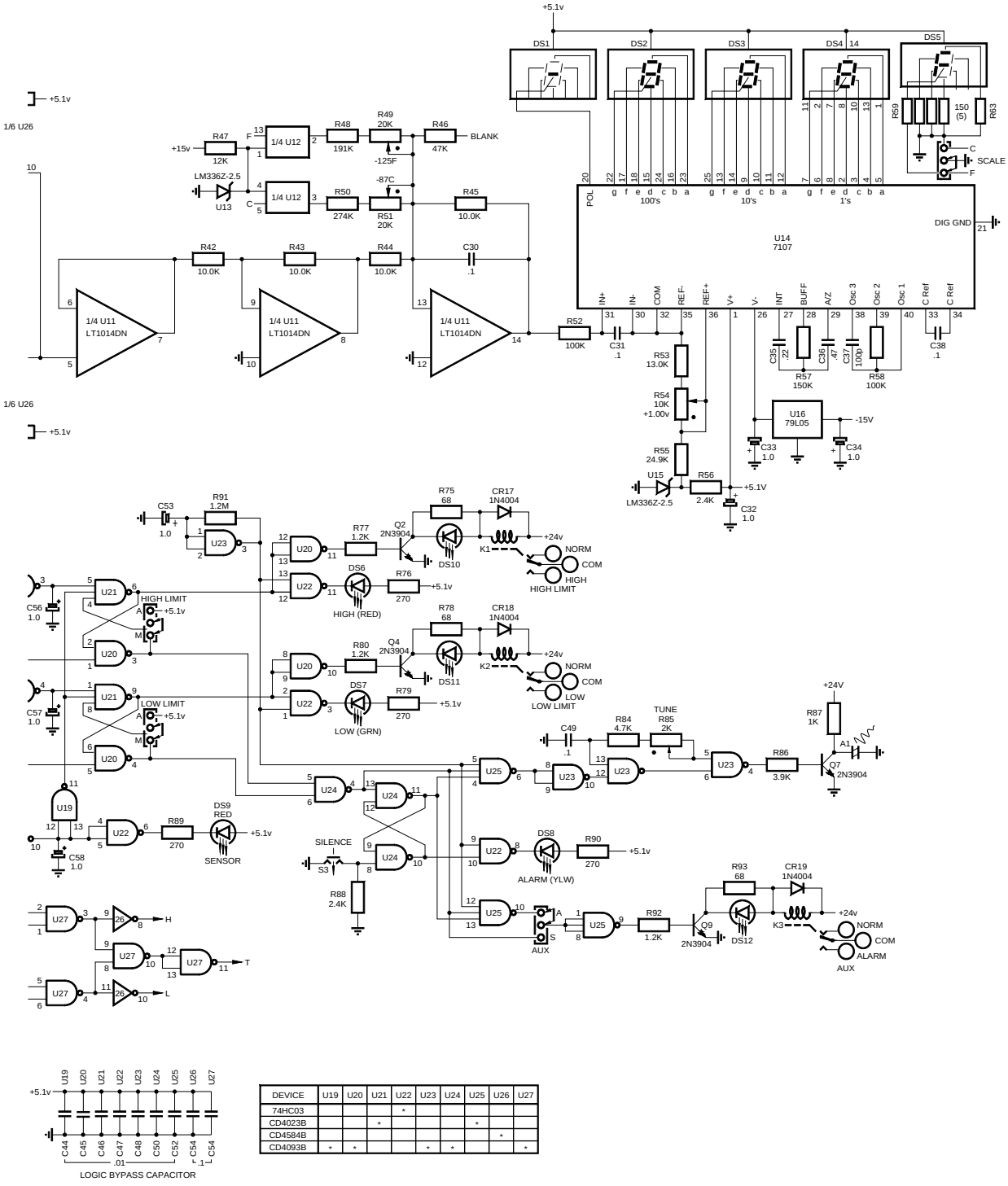
A "piecewise" linearizing strategy is used, which breaks down the output at U8-6 into five segments. The apparent gain of the inverting buffer, U8's second half, is readjusted as necessary to produce a linear 10mV/deg slope within each segment. For example, the non-inverting input at U9-5 is held at +3.752 volts by the voltage divider R31 - R35. With the R24/R25 node at any higher level, U9-7, and all the other outputs of U9, will be at the negative saturation limit. Because of the diodes CR9 through CR12, U9 makes no contribution to the output under these circumstances.

As the temperature decreases, the R24/R25 node drops below the +3.752 volt threshold (U8-13 = +3.843v), U9-7 swings to +3.752 volts plus the diode drop, acting like a dc buffer which holds U9-6 at +3.752 volts as the voltage at U8-13 continues to decrease. This produces a small current in R27. Since the other three linearizer stages are still off, this current is provided from the output U8-13, through R25. In order to provide this additional current, U8-13 drops to a slightly less positive level than would otherwise be required to satisfy the normal R23 feedback requirement.

As the temperature continues to fall, the voltage at the R24/R25 node decreases. This increases the linearizer current, which increases the resulting offset factor in the U8-13 output. When the R24/R25 node falls to +2.757 volts, the next linearizer stage is enabled, increasing the rate of curve correction. By increasing the slope-compensating action as the measured temperature decreases, the linearizer converts the sensor's "curve" to a constant 10mV/°F slope.

Without linearization, measuring errors as large as 33.3°F could result. The theoretical maximum error of this linearization scheme is -1.7°F occurring at -76°F.


LM324N 1/4 U9
1N4148
LM336Z-2.5
ZERO
Z TRIM
SPAN
SENSOR
1/2 U8 OP227GN
LT1014DN
1/4 U10
1/4 U18 LM324N
LM329DZ
SP SPAN
HIGH LIMIT
LOW LIMIT
1N4148's
BLANK
HIGH
LOW
POWER-UP RESET
2N3904's
FOR 120V 50/60 Hz JUMPER X1-L1 & X2-L2
FOR 240V 50/60 Hz JUMPER X1-X2
LM317T
LM337T
1N4004's
GND


+5.1v
DS1
DS2
DS3
DS4
DS5
1/6 U26
R47
12K
+15v
1/4 U12
R48
191K
R49
20K
-125F
R46
47K
BLANK
LM336Z-2.5
U13
-87C
R50
274K
R51
20K
R45
10.0K
R42
10.0K
R43
10.0K
R44
10.0K
C30
.1
1/4 U11
LT1014DN
U14
7107
POL
100's
10's
1's
DIG GND
R52
100K
C31
.1
R53
13.0K
R54
10K
+1.00v
R55
24.9K
R56
2.4K
C32
1.0
U15
LM336Z-2.5
C35
.22
R57
150K
C36
.47
C37
100p
R58
100K
C38
.1
U16
79L05
-15V
C33
1.0
C34
1.0
R59
150
(5)
R63
C
SCALE
F
C53
1.0
R91
1.2M
U23
R77
1.2K
Q2
2N3904
R75
68
CR17
1N4004
DS10
K1
NORM
COM
HIGH
HIGH LIMIT
U20
U21
U22
DS6
HIGH (RED)
R76
270
HIGH LIMIT
C56
1.0
R78
68
CR18
1N4004
R80
1.2K
Q4
2N3904
DS11
K2
LOW
LOW LIMIT
DS7
LOW (GRN)
R79
270
C57
1.0
C49
.1
R84
4.7K
TUNE
R85
2K
R86
3.9K
R87
1K
Q7
2N3904
A1
+24v
U24
U25
U19
DS9
RED
R89
270
SENSOR
C58
1.0
SILENCE
S3
R88
2.4K
DS8
ALARM (YLW)
R90
270
AUX
R92
1.2K
Q9
2N3904
R93
68
CR19
1N4004
DS12
K3
ALARM
U27
H
T
L
DEVICE
U19
U20
U21
U22
U23
U24
U25
U26
U27
74HC03
CD4023B
CD4584B
CD4093B
C44
C45
C46
C47
C48
C50
C52
C54
C54
.01
.1
LOGIC BYPASS CAPACITOR

Scaling Circuit

The indicator A/D converter is basically a digital millivolt meter. The 0/+5.00v output provided at U8-13, and the limit set point analog voltages from R67 and R68, must therefore be converted to -125mV/+375mV to provide a "-125°F" to "+375°F" display. The scaling circuit also converts these analog voltages to equivalent "°C" values.

Analog switch U10 multiplexes the analogs into buffer input U11-3. The output of this buffer is connected to two voltage dividers. The R36 - R38 divider converts the 5-volt analog to a 0/500mV analog, representing the 500°F span. The R39 - R41 divider converts the 5-volt analog to a 0/278mV analog, representing the equivalent 278°C span. Either the "F" or the "C" analog is selected by U12, is buffered, then applied to R42, an input to a unity gain inverter. The inverted output, U11-8, is then applied to R44, one input of a unity gain summing circuit.

At this circuit, the analog is summed with an offsetting voltage selected by two additional sections of U12. In the "F" display mode, R48 and R49 injects +12.5uA into the feedback node, which shifts the output at U11-14 in the negative direction by exactly 125mV. This provides a "-125" read-out when the measuring circuit analog is at zero volts. In the "C" display mode, an offsetting current of +8.72uA is provided by R50 and R51, to provide -87.2mV at U11-14 (-125°F = -87.2°C).

The "display blank" input to R46 is taken from the CR15/CR16 junction at U18, and is normally open since the diodes are normally reverse biased. Certain sensor faults cause U18 to forward bias one of these diodes, imposing a -13.3v potential on R46. This forces U11-14 to at least +2.5v, which activates the over-range function of the A/D converter, producing a blank display.

DVM Circuit

The scaled and level-shifted analog voltage at U11-14 is applied to the input of DVM circuit, U14, through low pass filter R52 and C31. U14 is a dual-slope 3-1/2 digit A/D converter which provides 7-segment outputs to operate the digital display system. The most significant digit is not used in this application, and zero-blanking is not provided.

U14 does the A/D conversion in three phases. First, the converter is internally zeroed. Next, the input voltage is applied to an integrator, the output of which increases from zero at a linear rate until stopped at the end of this precisely timed period. Since the integrator's output slope is a function of its input voltage, its output at the end of this (integrate) phase is directly proportional to the input voltage. In the third and final (de-integrate) phase, the precision +1.000v reference voltage is applied to the integrator to drive its output back to zero at a known rate, while a counter system measures the time required to do so. The resulting count is therefore proportional to the magnitude of the input voltage, and is converted from binary to 7-segment code for display purposes.

Peripheral circuitry includes U15, which provides a +1.000v reference voltage, and U16, which provides a -5v supply for the DVM chip. The DVM chip handles all other necessary

functions internally. A jumper on the back of the unit permits the selection of either a "F" or "C" character for display purposes. Two gates of U26 buffer the choice to analog switch U12 in the scaling circuitry.

Display Mode Selector Circuitry

The digital display system is used to read-out the high and low limit set points as well as the measured temperature value, and can display all values in either °F or °C. The display mode is selected by the circuitry composed of U26 and U27.

When the high limit reset button is pressed, U26-8 goes high and enables U10-3 to connect the high limit analog to the scaling circuit at U11-3. At the same time, U27-11 is forced low, which disconnects the measuring circuit analog from U11-3. The low limit setting is selected in a similar manner. The circuit is rather straightforward, and tracing the logic is left as an exercise for the reader.

Alarm Circuitry

U18 provides a system of comparators which monitors the measured temperature with respect to high and low limit settings, and for "reasonableness". U17 provides a precision +6.9v reference for the limit set points, R67 and R68. These set point outputs provide one input to their respective comparator circuits, while the 0/+5.00v temperature analog voltage is connected to the other inputs. When the analog voltage is less than the high limit set point, and greater than the low limit set point, both U18-14 and U18-8 will be low. U19-3 and U19-4 will therefore be high.

Furthermore, when the analog voltage is greater than -50mV, but less than +5.07v, fail-safe detector outputs U18-1 and U18-7 will both be high, and U19-10 will therefore be low.

Pressing both reset buttons, S1 and S2, forces U20-3 and U20-4 high. With all three inputs high, U21-6 and U21-9 go low. This disables both the high limit and low limit indicators, enables the output transistors, Q2 and Q4,and latches U20-3 and U20-4 at the high level. With both of its inputs high, U24-4 will be low, which turns off Q7 and DS-8 and turns on Q9 (in the "slave" mode). This is the normal operating status.

If the measured temperature strays outside of the set range, either the high limit or low limit will be tripped, and the above status for that limit will be reversed; the indicator will be on and output transistor off. The indicators are gated by a flasher signal provided from U23-3.

When neither limit is tripped, U24-4 will be low. U23-4 and U22-8 will therefore both be low, holding both the audible warning device (beeper) and the "SILENCED" indicator off.

When either one(or both) of the limits are tripped, U24-4 goes high. This enables the audible warning device, but not the "SILENCED" indicator. Pressing S3 forces U24-10 high. U24-11 then goes low, which latches the beeper off, and the "SILENCED" indicator on. Both the beeper and the "SILENCED" indicator are also modulated by the flasher signal.

At power-on, U18-7 is initially held low as C41 begins to charge. This trips both limits and toggles the sensor fault indicator. A momentary loss of power will therefore trip both limits. An open sensor connection will cause the measuring circuit to provide abnormal analog voltage levels and toggle either U18-1 or U18-7. A flashing "SENSOR" warning signal via U22-6, and both limits will also be tripped. U24-3, Q5 and Q6 comprise a power-up reset timer.

Power Supply Circuits

Power for the controller can be taken from either 110/120vac or 208/240vac, 50/60 Hz lines. The controller circuitry uses +15v, -15v and +5.1v dc voltages. The +/-15v levels are provided by T2 and its associated bilateral full-wave rectifier circuit. Regulators U2 and U3 stabilize these supply voltages at the required +15v and -15v levels. A separate +5.1v supply is provided for the controller's logic and display circuitry by T1 and regulator U1. All three of these supplies are adjustable, and are set precisely at the 15v and 5.1v levels. The 15v potentials are re-stabilized at +/-12v for use at the low level measuring circuit, U8.

Output Circuitry

Separate 1P2T contacts capable of switching 10-amps ant 250vac are provided for each of the three outputs. A LED indicator is provided near, and operates with, each relay. The relays are de-energized by abnormal operating conditions (COM to HIGH or COM to LOW and COM to ALARM).

CALIBRATION PROCEDURE

Please refer to analog circuit board layout Drawing No. 470668 (page 18) and perform the following adjustments.

NOTE: allow at least 10-minutes after applying power for circuit temperatures to stabilize prior to final calibration.

1. Connect a digital voltmeter between the right-hand pin of U3, and ground ([-] side of C13, C14 or C15). Adjust the "-15v" trimmer, R13, for an indication of exactly -15.0v.

2. Connect the DVM (+) lead to the center pin of U2. Adjust the "+15v" trimmer, R10, to provide an indication of exactly +15.0v

3. Connect the (+) lead to U12-14. Adjust the "+5.1v" trimmer on the bottom board (accessible through the hole in the top board) to provide an indication of exactly +5.1v

4. Trip the limits to provide an audible warning. Adjust the "tone" trimmer, R85 on the bottom board (accessible through the hole in the top board) to find the peak audible output.

5. Connect the (+) lead to the wire loop by the trimmer on the DVM board. Adjust "Vref" trimmer, R54, to provide an indication of exactly +1.000v (see Dwg No 470671, page 24).

6. Turn the low limit all the way counterclockwise, and the high limit fully clockwise. Connect the DVM (+) lead to U11-1. Select the LOW LIMIT display mode. Adjust the "-125F" trimmer, R49, for a read-out of exactly -125F, and the "-87C" trimmer, R51, for an indication of exactly -87C.

7. Select the HIGH LIMIT display mode, then adjust the "SP Span" trimmer, R65, to provide a DVM indication of exactly +5.00v.

8. With the HIGH LIMIT still selected, adjust the "F Span" trimmer, R37, to provide a display indication of exactly 375F, then adjust the "C Span" trimmer, R40 to display 191C.

9. Disconnect the sensor, and connect a compensated portable potentiometer or precision mV source to the input terminals of the controller. Set the input at "-125°F" or -3.006mV. With the DVM still connected between U11-1, and ground, center the Rzt adjustment and adjust the "Zero" trimmer, R16, to provide a DVM indication of exactly 0.00v.

10. Set the input at "+375°F" or +8.787mV, and adjust the "Span" trimmer, R17, to provide an indication of exactly +5.00v. ***Large span adjustments will effect the zero adjustment somewhat; therefore repeat Steps 9 and 10 if a large span adjustment was required.***

11. Check the limit accuracy, and the operation of the associated lights and relay contacts. Set the input at about "+300°F", and slowly reduce the HIGH LIMIT setting. When the displayed setting falls just below "300", the high limit alarm should trip. Press the SILENCE button and observe that the audible warning is canceled. Reset the high limit, and check the LOW LIMIT in a similar manner.

REPLACEMENT PARTS LIST

This section of the handbook includes parts lists for each major assembly and repairable subassembly. This lists are arranged by part number, as indicated in the table of contents. Each list includes a component layout drawing, which physically located most items.

Every item used in an assembly is identified in its parts list. The various parts are listed by part number. The six-digit part numbering system has a logical order, which is summarized as follows:

Class Codes	*Items Covered*
000000 - 049000	Major Assemblies & Subassemblies
050000 - 099000	Electronic Component Parts
100000 - 139000	Electromechanical Parts
140000 - 169000	Optical Parts, Sensors
170000 - 199000	Wiring & Wiring Hardware
200000 - 209000	Printed Circuit Boards
210000 - 259000	Electrical Parts & Hardware
260000 - 289000	Mechanical Hardware
290000 - 329000	Fluidic (Pneumatic) Parts & Hardware
330000 - 399000	Mechanical & Structural Parts
400000 - up	Drawings, Publications & Literature

Since the manufacturer's name and part number are often printed on purchased parts, this information is included in the parts lists to help you properly identify the item in question. Purchased parts are often provided by alternate sources however, so this information should be taken as representative, rather than absolute.

Part Number: 012019
Drawing Number: 470665

"*ChamberMate*" BI-DIRECTIONAL TEMPERATURE LIMIT CONTROLLER

PART #	DESC	MFGR	MFGR'S NO	QTY	UM
048062	ANALOG PCB ASSY, TLC-II	WRNR	048062/470668	1	EA
048063	DIGITAL PCB ASSY, TLC-II	WRNR	048063/470669	1	EA
048064	CONTROL PCB ASSY, TLC-II	WRNR	048064/470670	1	EA
048065	DVM PCB ASSY, TLC-II	WRNR	048065/470671	1	EA
048066	RELAY PCB ASSY, TLC-II	WRNR	048066/470672	1	EA
142003	FILTER, RED DISPLAY 1.5"x3.0"	WRNR	142003	1	EA
251018	INSULATOR, TLC-II	WRNR	251018/470683	1	EA
266002	STICK MOUNT, GREEN	MEIJ	`	1	EA
271026	SCREW, BDR HD 6-32x.250			8	EA
271028	SCREW, BDR HD 6-32x.500			4	EA
271136	SCREW, FIL HD 10-32x1.00			2	EA
271259	SCREW, TRUS HD 6-32x.250 BLK			8	EA
272038	WASHER, NYLON PLAIN #4 REG	KEYS	3358	1	EA
272041	WASHER, NYLON PLAIN #6	KEYS	3163	1	EA
279001	STANDOFF, SWAGE 6-32x.250	RAF	3047-B-632-B	9	EA
279004	STUD, CAPTIVE 4-40x.250	CFC	CH-440-10-C	4	EA
279007	CAP NUT, 10-32	CFC	CF74-1032	2	EA
279009	THREADED INSERT, 6-32x.063 SSC	CFC	CLF-632-1	8	EA
279022	SPACER, M-F TYPE 6-32x1.25	EFJ	J217	5	EA
279024	SPACER, M-F TYPE 6-32x.375	SMTH	8249	1	EA
279026	SPACER, MM-F TYPE 6-32x.250	KEYS	8717	1	EA
351030	BEZEL, FRT	WRNR	351030/470698	1	EA
351042	CHASSIS, TLC-II	WRNR	351042/470694	1	EA
352052	MOUNTING CLAMP	WRNR	352052/470602	2	EA
352056	COVER PLATE, INTERNAL	WRNR	352056/470694	1	EA
353026	COVER, FRT	WRNR	353026/4706995	1	EA

Part Number: 048062
Drawing Number: 470668

"*ChamberMate*" ANALOG PCB ASSY

PART #	DESC		MFGR	MFGR'S NO	QTY	UM
051049	RESISTOR, CFLM 1/4W 5%	100	DIGI	100Q	1	EA
051076	RESISTOR, CFLM 1/4W 5%	1.3K	MOUS	29SJ250-1.3K	1	EA
051083	RESISTOR, CFLM 1/4W 5%	2 7K	MOUS	29SJ250-2.7K	1	EA
051095	RESISTOR, CFLM 1/4W 5%	8.2K	MOUS	29SJ250-8.2K	1	EA
051096	RESISTOR, CFLM 1/4W 5%	9.1K	MOUS	29SJ250-9.1K	1	EA
051099	RESISTOR, CFLM 1/4W 5%	12K	MOUS	29SJ250-12K	1	EA
051106	RESISTOR, CFLM 1/4W 5%	24K	MOUS	29SJ250-24K	3	EA
051107	RESISTOR, CFLM 1/4W 5%	27K	DIGI	27KQ	1	EA
051113	RESISTOR, CFLM 1/4W 5%	47K	MOUS	29SJ250-47K	1	EA
051121	RESISTOR, CFLM 1/4W 5%	100K	MOUS	29SJ250-100K	2	EA
052209	RESISTOR, MFLM 1/4W 1%	121	NIC	121X	1	EA
052237	RESISTOR, MFLM 1/4W 1%	237	NIC	237X	1	EA
052238	RESISTOR, MFLM 1/4W 1%	243	NIC	243X	1	EA
052278	RESISTOR, MFLM 1/4W 1%	634	NIC	634X	1	EA
052288	RESISTOR, MFLM 1/4W 1%	806	NIC	806X	1	EA
052295	RESISTOR, MFLM 1/4W 1%	953	NIC	953X	1	EA
052301	RESISTOR, MFLM 1/4W 1%	1.00K	NIC	1.00KX	2	EA
052302	RESISTOR, MFLM 1/4W 1%	1.02K	NIC	102KX	1	EA
052306	RESISTOR, MFLM 1/4W 1%	1.13K	NIC	1.13KX	1	EA
052309	RESISTOR, MFLM 1/4W 1%	1.21K	NIC	1.21KX	1	EA
052313	RESISTOR, MFLM 1/4W 1%	1.33K	NIC	1.33KX	1	EA
052321	RESISTOR, MFLM 1/4W 1%	1.62K	NIC	1.62KX	1	EA
052327	RESISTOR, MFLM 1/4W 1%	1.87K	NIC	1.87KX	1	EA
052337	RESISTOR, MFLM 1/4W 1%	2.37K	NIC	2.37KX	1	EA
052340	RESISTOR, MFLM 1/4W 1%	2.55K	NIC	2.55KX	1	EA
052369	RESISTOR, MFLM 1/4W 1%	5.11K	NIC	5.11KX	1	EA
052393	RESISTOR, MFLM 1/4W 1%	9.09K	IC	9.09KX	1	EA
052396	RESISTOR, MFLM 1/4W 1%	9.76K	NIC	9.76KX	1	EA
052401	RESISTOR, MFLM 1/4W 1%	10.0K	NIC	10.0KX	6	EA
052406	RESISTOR, MFLM 1/4W 1%	11.3K	NIC	11.3KX	1	EA
052426	RESISTOR, MFLM 1/4W 1%	18.2K	NIC	18.2KX	1	EA
052528	RESISTOR, MFLM 1/4W 1%	191K	NIC	191KX	1	EA
052538	RESISTOR, MFLM 1/4W 1%	243K	NIC	243KX	1	EA
052543	RESISTOR, MFLM 1/4W 1%	274K	NIC	274KX	1	EA
052552	RESISTOR, MFLM 1/4W 1%	340K	NIC	340KX	1	EA
052554	RESISTOR, MFLM 1/4W 1%	357K	NIC	357KX	1	EA
054004	POTENTIOMETER, TRIM 1T-3/8	100	PANA	0FA12	2	EA
054005	POTENTIOMETER, TRIM 1T-3/8	200	PANA	0FA22	1	EA
054006	POTENTIOMETER, TRIM 1T-3/8	500	PANA	0FA52	1	EA
054007	POTENTIOMETER, TRIM 1T-3/8	1K	PANA	0FA13	1	EA
054011	POTENTIOMETER, TRIM 1T-3/8	20K	PANA	0FA24	3	EA
054013	POTENTIOMETER, TRM 1T-3/8	100K	PANA	0FA15	1	EA

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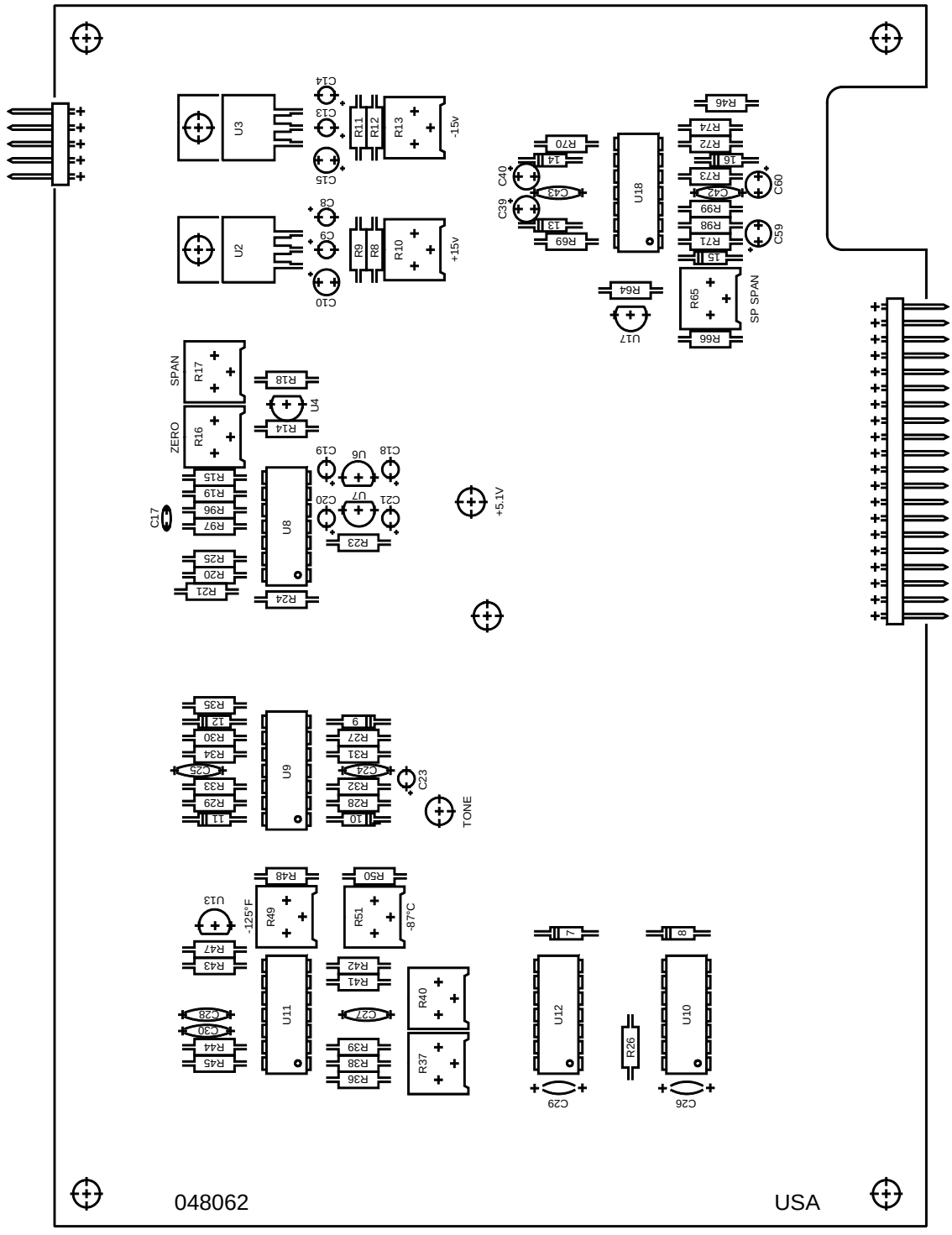
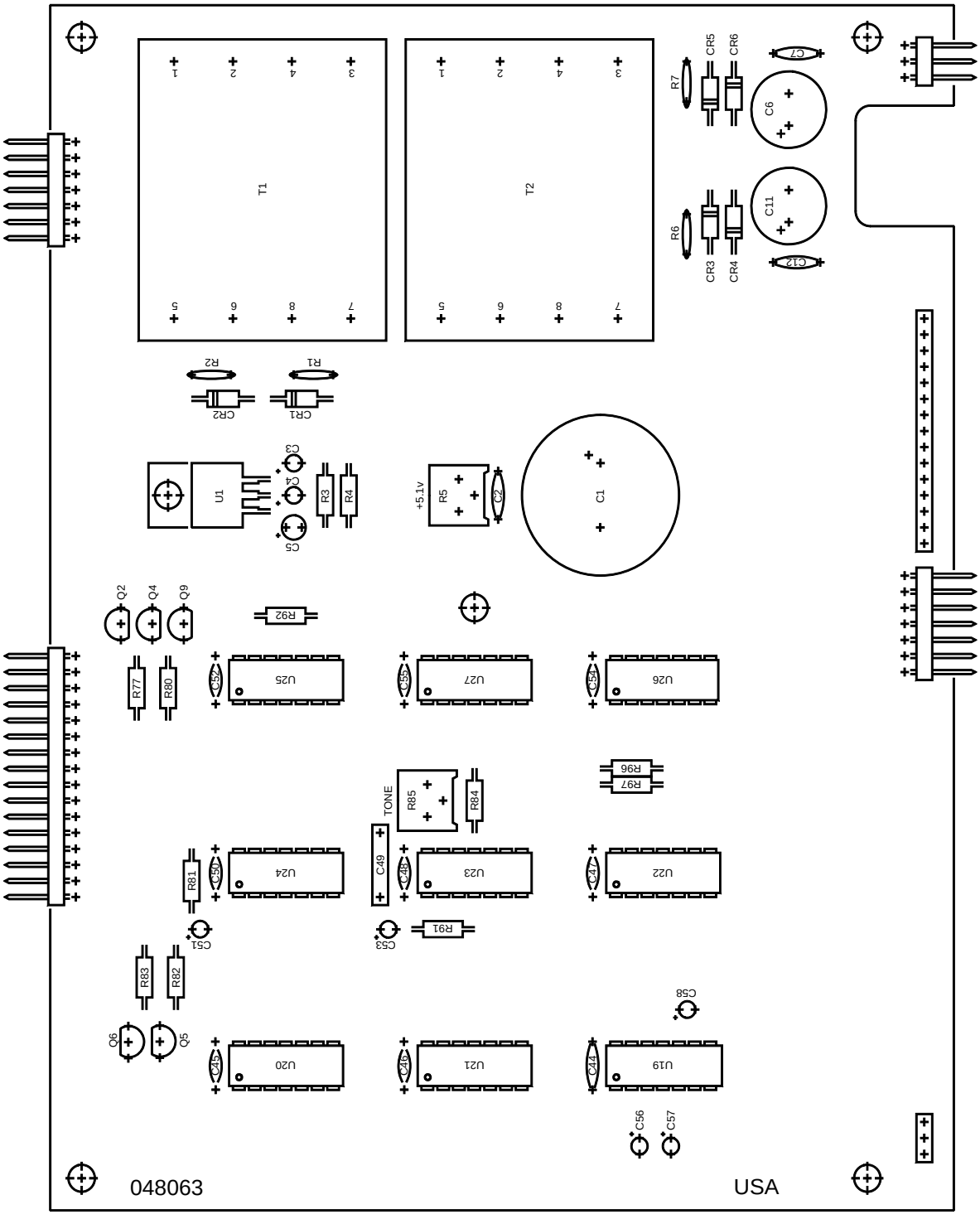

048062
USA
SPAN
ZERO
SP SPAN
TONE
-15v
+15v
+5.1V
-125°F
-87°C

Part Number: 048062
Drawing Number: 470668

"ChamberMate" ANALOG PCB ASSY (continued)

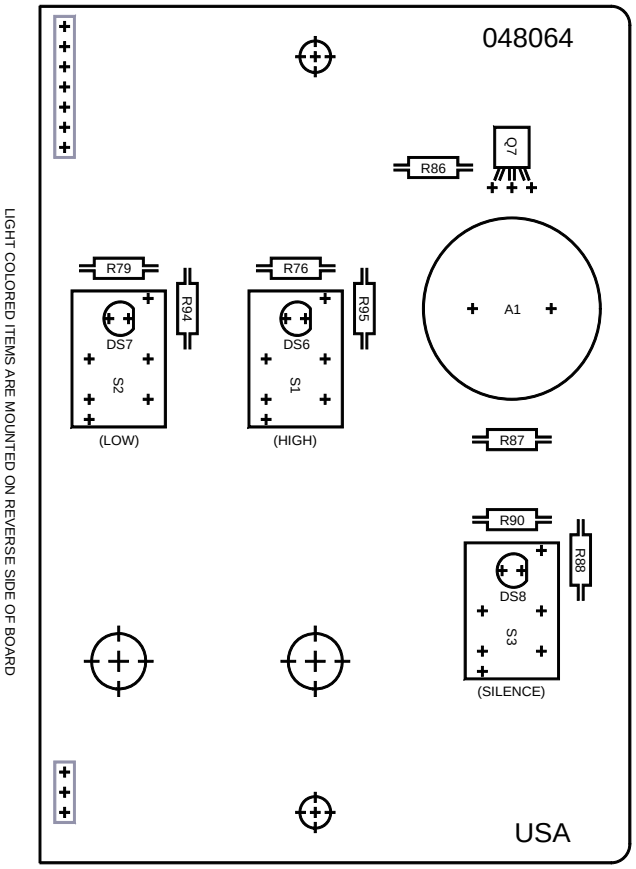
PART #	DESC	MFGR	MFGR'S NO	QTY	UM
	... continuing				
062060	CAPACITOR, CRMC 25V .01uF	NIC	NCD.01M25MX5U	2	EA
063013	CAPACITOR, TANT 35V 1.0uF	NEC	1.0M35	10	EA
062067	CAPACITOR, CRMC 50V 1uF	NIC	NCD.1M50MX5U	7	EA
063045	CAPACITOR, TANT 25V 10uF	NEC	10M25	6	EA
081001	DIODE, SIG	MOUS	1N4148	8	EA
081015	DIODE, SIGNAL LOW iR	SPC	1N457	2	EA
091013	IC, QUAD BILATERAL SWITCH	RCA	CD4066BE	2	EA
093002	IC, QUAD OP AMP	NS	LM324N	2	EA
093010	IC, ADJ POS 1.5A REGULATOR	NS	LM317T	1	EA
093011	IC, +12V 100mA REGULATOR	NEC	UPC78L12	1	EA
093012	IC, -12V 100mA REGULATOR	PANA	AN79L12	1	EA
093013	IC, ADJ NEG 1.5A REGULATOR	NEC	UPC337H	1	EA
093016	IC, PRECISION 6.9V REFERENCE	NS	LM329DZ	1	EA
093017	IC, PRECISION 2.5V REFERENCE	NS	LM336Z-2.5	2	EA
093030	IC, DUAL PRECISION OP AMP	LTEC	OP227GN	1	EA
093032	IC, PRECISION QUAD OP AMP	LTEC	LT1014DN	1	EA
173003	HEADER, RA/SR MALE 36-W GOLD		APT 929648-01-36	25	EA
175002	SOCKET, IC 14-PIN SOLDER TAIL	AMP	A9314	6	EA
201073	PTD CKT BOARD, TLC-II ANALOG	WRNR	201073/470673	1	EA
271014	SCREW, BDR HD 4-40x.250			2	EA
273002	LOCKWASHER, HELIC #4 REG			2	EA
274002	NUT, HEX 4-40			2	EA


T1
T2
R7
CR5
CR6
C7
C6
R6
CR3
CR4
C11
C12
R2
R1
CR2
CR1
C3
C4
C5
U1
R3
R4
+5.1v
R5
C2
C1
Q2
Q4
Q9
R92
R77
R80
C52
U25
C55
U27
C54
U26
R96
R97
TONE
R85
R84
R81
C50
U24
C49
C48
U23
C47
U22
C51
C53
R91
R83
R82
C58
Q6
Q5
C46
U20
C45
U21
C44
U19
C56
C57
048063
USA

Part Number: 048063
Drawing Number: 470669

"ChamberMate" DIGITAL PCB ASSY

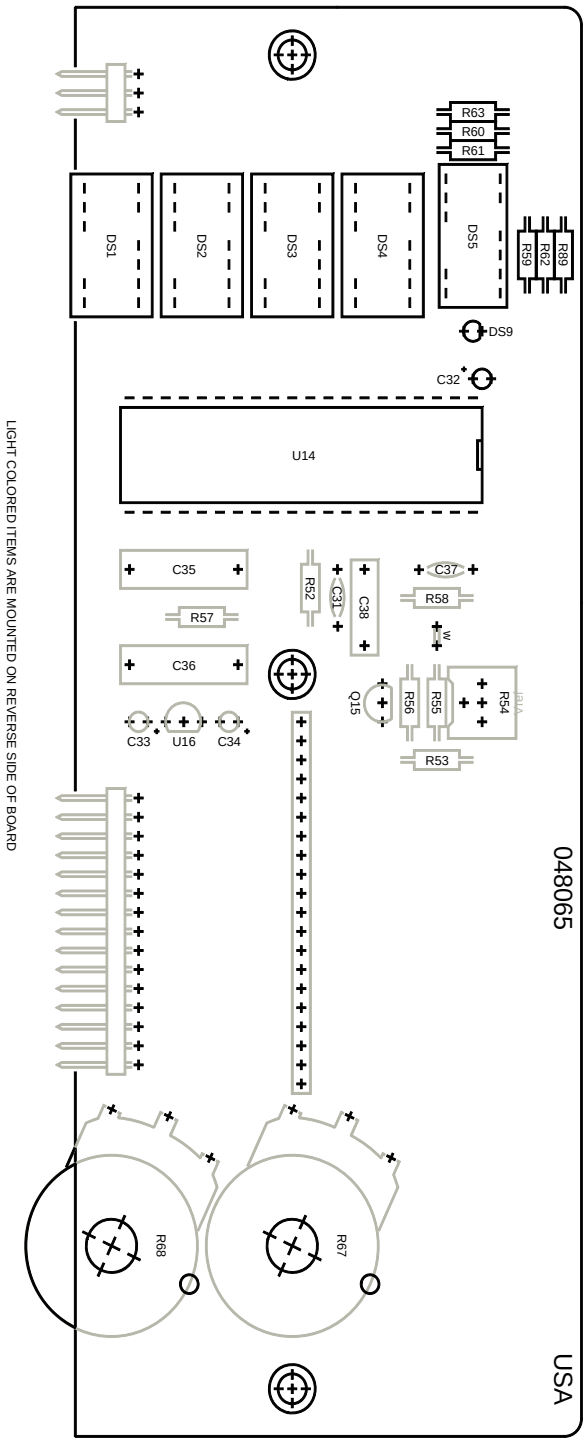
PART #	DESC	MFGR	MFGR'S NO	QTY	UM
051075	RESISTOR, CFLM 1/4W 5% 1.2K	MOUS	29SJ250-1.2K	3	EA
051089	RESISTOR, CFLM 1/4W 5% 4.7K	MOUS	29SJ250-4.7K	1	EA
051106	RESISTOR, CFLM 1/4W 5% 24K	MOUS	29SJ250-24K	4	EA
051129	RESISTOR, CFLM 1/4W 5% 220K	MOUS	29SJ250-220K	1	EA
051147	RESISTOR, CFLM 1/4W 5% 1.2MEG	MOUS	29SJ250-1.2M	1	EA
052238	RESISTOR, MFLM 1/8W 1% 243	NIC	243X	1	EA
052282	RESISTOR, MFLM 1/8W 1% 698	NIC	698X	1	EA
054004	POTENTIOMETER, TRIM 1T-3/8 100	PANA	0FA12	1	EA
054008	POTENTIOMETER, TRIM 1T-3/8 2K	PANA	0FA23	1	EA
056001	VARISTOR, 180mJ 31VDC	PANA	P7020	4	EA
062060	CAPACITOR, CRMC 25V .01uF	NIC	NCD.01M25MX5U	7	EA
062067	CAPACITOR, CRMC 50V .1uF	NIC	NCD.1M50MX5U	5	EA
063013	CAPACITOR, TANT 35V 1.0uF	NEC	1.0M35	6	EA
063045	CAPACITOR, TANT 25V 10uF	NEC	10M25	2	EA
064004	CAPACITOR, ELEC 35V 470uF	PANA	P6255	2	EA
064016	CAPACITOR, ELEC 16V 4700uF	PANA	P6900	1	EA
067046	CAPACITOR, FILM 100V .1uF	MLRY	160104J100C	1	EA
071005	TRNSFORMER, PWR 34VCT@170MA	SGNL	LP34-170	1	EA
071006	TRNSFORMER, PWR 16VCT@350MA	SGNL	LP16-350	1	EA
081002	DIODE, RECT 200V 1A	MOT	1N4002	6	EA
083021	TRANSISTOR, NPN GENL PURPOSE	MOUS	KN3904	5	EA
091001	IC, QUAD 2-INPUT SCHMIT NAND	RCA	CD4093BE	5	EA
091011	IC, TRIPLE 3-INPUT NAND GATE	RCA	CD4023BE	2	EA
091018	IC, QUAD 2-INPUT NAND (OC)	RCA	CD74HC03E	1	EA
091019	IC, HEX SCHMITT INVERTER	RCA	CD74HC14	1	EA
093010	IC, ADJ POS 1.5A REGULATOR	NS	LM317T	1	EA
173003	HEADER, RS/SR MALE 36-W GOLD	APT	929648-01-36	30	EA
173006	RECEPTACLE, STR/SR PCB 36-W GD	APT	929850-01-36	18	EA
175002	SOCKET, IC 14-PIN SOLDER TAIL	AMP	A9314	9	EA
201074	PTD CKT BOARD, TLC-II DIGITAL	WRNR	470674	1	EA
271014	SCREW, BDR HD 4-40x.250			1	EA
273002	LOCKWASHER, HELIC #4 REG			1	EA
274002	NUT, HEX 4-40			1	EA


048064
Q7
R86
R79
R94
DS7
S2
(LOW)
R76
R95
DS6
S1
(HIGH)
A1
R87
R90
R88
DS8
S3
(SILENCE)
USA
LIGHT COLORED ITEMS ARE MOUNTED ON REVERSE SIDE OF BOARD

Part Number: 048064
Drawing Number: 470670

"ChamberMate" CONTROL PCB ASSY

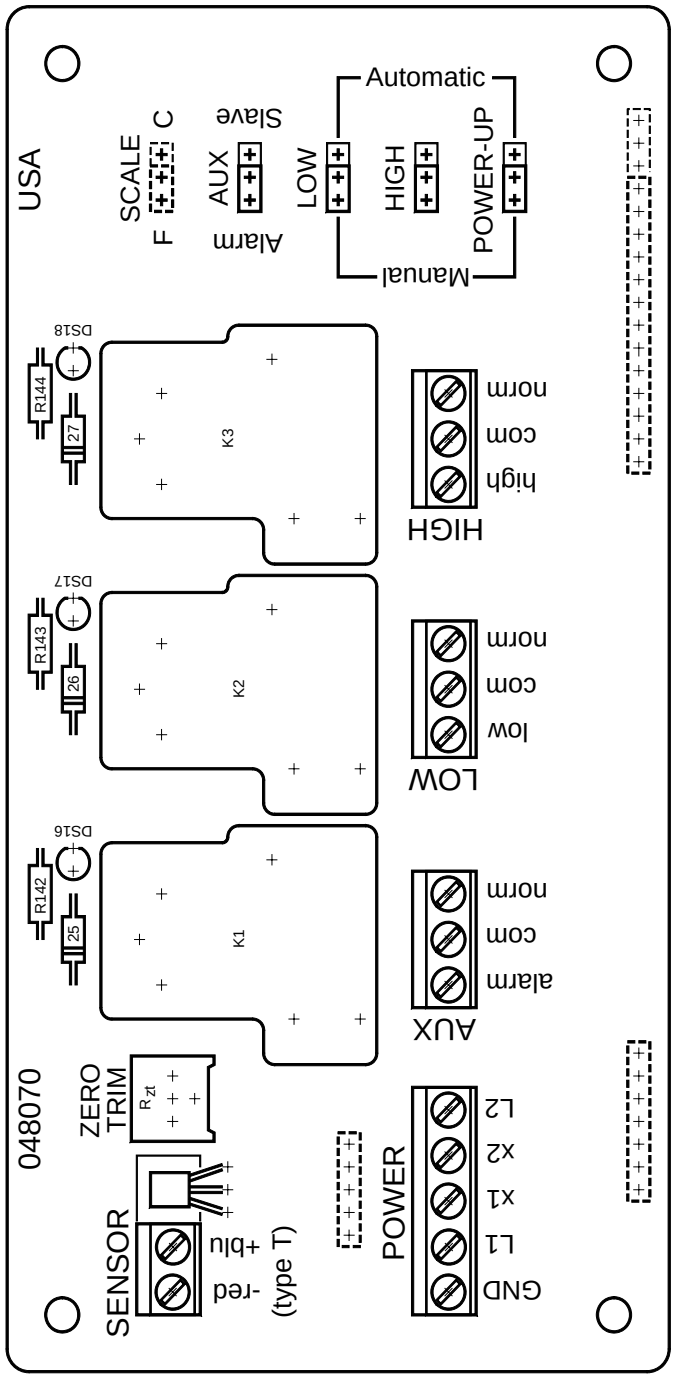
PART #	DESC		MFGR	MFGR'S NO	QTY	UM
051059	RESISTOR, CFLM 1/4W 5%	270	MOUS	29SJ250-270	3	EA
051073	RESISTOR, CFLM 1/4W 5%	1.0K	MOUS	29SJ250-1.0K	1	EA
051082	RESISTOR, CFLM 1/4W 5%	2.4K	MOUS	29SJ250-2.4K	3	EA
051087	RESISTOR, CFLM 1/4W 5%	3.9K	MOUS	29SJ250-3.9K	1	EA
083021	TRANSISTOR, NPN		MOUS	KN3904	1	EA
102010	SWITCH, PB PCB		SHDW	200130	3	EA
109005	KEY CAP, GRY 1-LED		SHDW	71077	3	EA
121003	LED, T1 MIN DIFF	RED	ROHM	SLR-34 VR3	1	EA
121009	LED, T1 MIN DIFF	YLW	ROHM	SLR-34 YY3	1	EA
121010	LED, T1 MIN DIFF	GRN	ROHM	SLR-34 MG3	1	EA
124001	SOUND TRANSDUCER		BELL	MS-1	1	EA
173006	RECEPTACLE, STR/SR PCB 36-W GD		929850-01-35		10	EA
201075	PTD CKT BOARD, TLC-II CONTROL		WRNR	470675	1	EA


LIGHT COLORED ITEMS ARE MOUNTED ON REVERSE SIDE OF BOARD
R63
R60
R61
DS1
DS2
DS3
DS4
DS5
R59
R62
R89
DS9
C32
U14
C35
R57
C36
C33
U16
C34
R52
C31
C38
C37
R58
R56
R55
R54
R53
Q15
R68
R67
048065
USA

Part Number: 048065
Drawing Number: 470671

"ChamberMate" DVM PCB ASSY

PART #	DESC	MFGR	MFGR'S NO	QTY	UM
051059	RESISTOR, CFLM 1/4W 5% 270	MOUS	29SJ250-270	1	EA
051061	RESISTOR, CFLM 1/4W 5% 330	MOUS	29SJ250-330	5	EA
051082	RESISTOR, CFLM 1/4W 5% 2.4K	MOUS	29SJ250-2.4K	1	EA
051121	RESISTOR, CFLM 1/4W 5% 100K	MOUS	29SJ250-100K	2	EA
051125	RESISTOR, CFLM 1/4W 5% 150K	MOUS	29SJ250-150K	1	EA
052412	RESISTOR, MFLM 1/4W 5% 13.0K	DIGI	13.0KX	1	EA
052439	RESISTOR, MFLM 1/4W 5% 24.9K	DIGI	24.9KX	1	EA
054010	POTENTIOMETER, TRIM 1T-3/8 10K	BRNS	3386P-1-103	1	EA
054042	POTENTIOMETER, CONT 1T 5K	ALPH	31VC401	2	EA
062067	CAPACITOR, CRMC 50V .1uF	NIC	P4164-ND	1	EA
063013	CAPACITOR, TANT 35V 1.0uF	NEC	1.0M35	3	EA
067046	CAPACITOR, FILM 400V .1uF	THOM	MC104K1C	1	EA
067050	CAPACITOR, FILM 100V .22uF	THOM	MC224K1D	1	EA
067054	CAPACITOR, FILM 63V .47uF	THOM	MC474K1F	1	EA
067087	CAPACITOR, POLY 25V 100pF	PANA	ECQ-P1H101JZ	1	EA
093017	IC, 2.5V REFERENCE	NS	LM336Z-2.5	1	EA
093026	IC, -5V 100mA REGULATOR	NS	LM79L05ACZ	1	EA
094002	IC, D/A DISPLAY CONVERTERTLDN	TSC7107CPL		1	EA
121003	LED, T1 MIN DIFF RED	ROHM	SLR-34 UR3	1	EA
125003	DISPLAY, .43" DIGIT RED (CA)	PANA	LN514OA	4	EA
125004	DISPLAY, .30" DIGIT RED (CA)	PANA	LN513OA	1	EA
173003	HEADER, RA/SR MALE 36-W GOLD	APT	929648-01-36	18	EA
173006	RECEPTACLE, STR/SR PCB 36-W GD	APT	929850-01-36	20	EA
175017	SOCKET, IC 40-PIN SOLDER TAIL	AMP	A9340	1	EA
201076	PTD CKT BOARD, TLC-II DVM	WRNR	470676	1	EA
274009	NUT, HEX 3/8-24	A-B	w/054042	2	EA
279001	STANDOFF, SWAGE TYPE 6-32x.250	RAF	3047-B-632-B-0	2	EA
279032	STANDOFF, SWAGE TYPE 6-32x.375	KEYS	1561B	1	EA


USA
SCALE
F
C
AUX
Alarm
Slave
LOW
HIGH
POWER-UP
Automatic
Manual
DS18
R144
27
K3
high
com
norm
HIGH
DS17
R143
26
K2
low
com
norm
LOW
DS16
R142
25
K1
alarm
com
norm
AUX
048070
ZERO
TRIM
SENSOR
-red
+blu
(type T)
POWER
GND
L1
x1
x2
L2

Part Number: 048066
Drawing Number: 470734

"ChamberMate" RELAY OUTPUT PCB ASSY

PART #	DESC	MFGR	MFGR'S NO	QTY	UM
051045	RESISTOR, CFLM 1/4W 5% 68	MOUS	29SJ250-68	3	EA
054012	POTENTIOMETER, TRIM 1T-3/850K	BRNS	3386P-1-503	1	EA
081003	DIODE, RECT 400V 1A	MOT	1N4004	3	EA
093029	IC, TEMP SENSOR	NS	LM335Z	1	EA
111004	COVER, MIN PCB RELAY	P&B	35C620	3	EA
111005	RELAY, MIN PCB 24V 1P2T	P&B	T90N5D1224	3	EA
121003	LED, MIN RED DIFF T1	ROHM	SLR-34 VR3	3	EA
173002	SHUNT 2-W	APT	929950-00	5	EA
173005	HEADER, MALE PCB STR 3-W	APT	4-103321-0	5	EA
173006	RECEPTACLE, SSTR/SR PCB 36-W	APT	929850-01-36	26	EA
176006	TERMINAL STRIP, PCB 3-W	MOUS	ME153-2103	4	EA
176007	TERMINAL STRIP, PCB 2-W	MOUS	ME153-2102	2	EA
201077	PTD CKT BOARD, TLC-II RELAY	WRNR	470677	1	EA

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Phone: (616) 843-5342
e-mail: *info1@fireright.com*