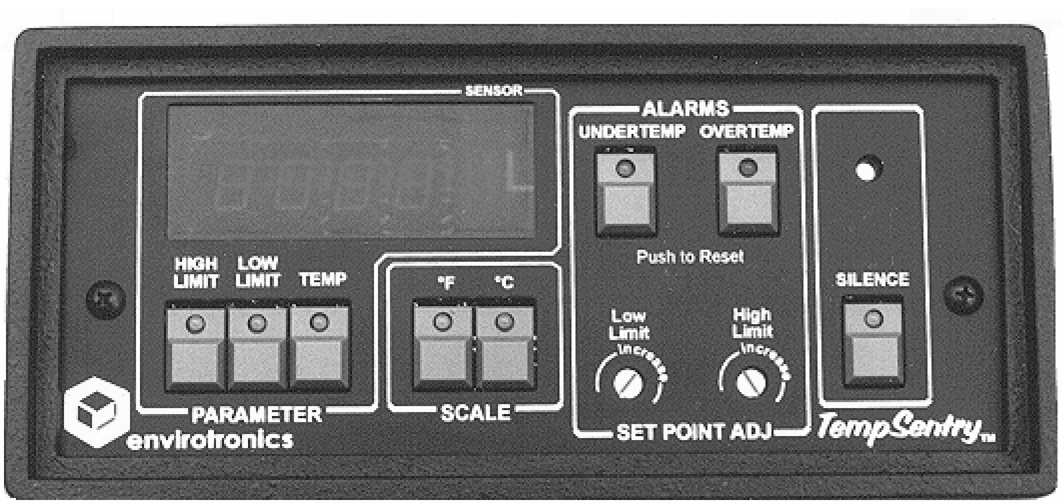
# TECHNICAL MANUAL

# *"TempSentry"*

Bi-Directional Temperature Limit Controller




Sixth Edition
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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, an output switches to the "off" state to disable either the heating system or the cooling system. A third "auxiliary" output may be used either to operate remote alarm devices, or to remove power from equipment under test within the chamber. 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).

## 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,
- indicating HIGH LIMIT, LOW LIMIT, and TEMP indicator mode selector switches,
- indicating °F or °C indicator scale selector switches,
- a SENSOR fault indicator,
- recessed HIGH LIMIT and LOW LIMIT adjustments,
- indicating HIGH LIMIT and LOW LIMIT reset switches,
- 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 flashing "0" temperature indication, 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 +/-.5%.

The outputs of the controller consist of three mechanical 1P2T relay contacts, rated 10-amps @ 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 see the diagrams on the following page**

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 in the sketch, the controller normally protrudes 6-1/4" behind the face of the mounting panel; an additional 1-1/2" clearance behind the unit will be required for the relay output board and its associated wiring.

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

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

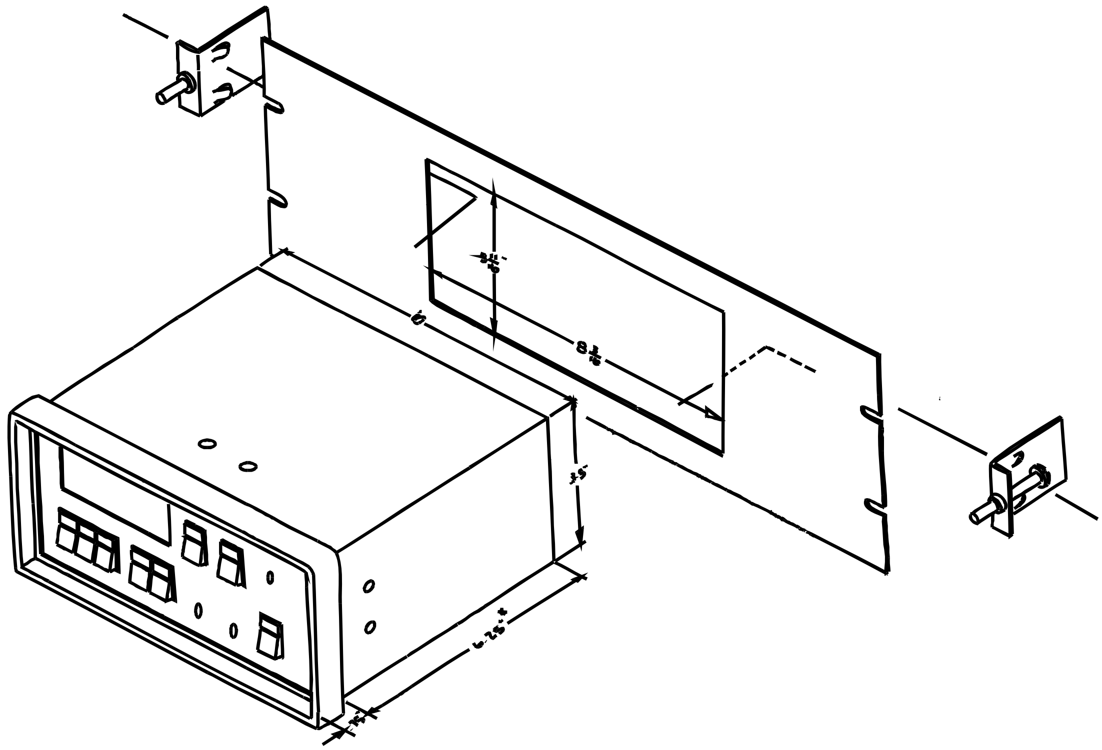
| 110/120vac circuits | 208/240vac circuits |
|---|---|
| Line to terminals L1 & x1<br>Com to terminals x2 & L2<br>Ground to terminal “GND" | L1 to terminal L1<br>jumper to terminals x1 & x2<br>L2 to terminal L2<br>Ground to terminal "GND" |

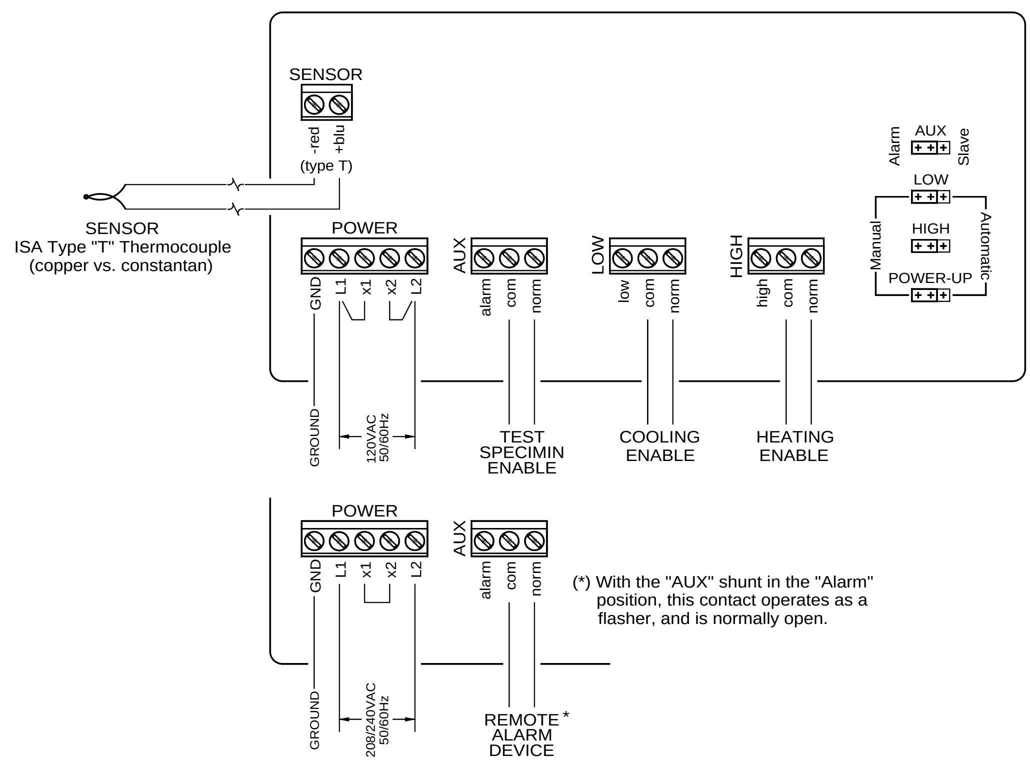
Shunts on the relay output board permit user-selection certain operating characteristics. The AUX relay may be used to control power to test specimens, or to operate remote alarms. To pulse a remote alarm device, move the AUX jumper to the “Alarm” position. If the controller is used in the manually reset mode, it will normally start-up in the "tripped" condition. If the equipment can be permitted to restart itself when power is restored, move the POWER-UP jumper to the “Automatic” position. 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 this jumper at the "Manual" position. The HIGH and LOW alarm channels may be independently set for either “Automatic” or “Manual” reset (selecting automatic reset also necessarily provides for automatic reset at power-up).

The controller's relay outputs are plainly marked ...

| | |
|---|---|
| **AUX:** | ALARM/COM/NORM, |
| **LOW LIMIT:** | LOW/COM/NORM |
| **HIGH LIMIT:** | HIGH/COM/NORM. |

These SPDT contacts will handle up to 10-amps at 250vac. During periods of normal operation, these contacts will be closed (COM → NORM). When out-of-limits conditions occur, the appropriate contacts will switch to the opposite state (ALARM ← COM), (LOW ← COM), or (HIGH ← COM). Use these contacts to signal remote alarm devices, to disable cooling and heating systems, to shut-off power to “live loads”, etc.




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

## OPERATION

The limit temperatures can be set by depressing either the HIGH LIMIT or LOW LIMIT display select button, then turning the respective set point adjustment as necessary to provide the desired indication. When either limit display button is pressed, the selected parameter will be held for approximately 30-seconds, then the display will automatically return to the temperature-indicating mode. The indicator can be manually returned to the measured temperature by pressing the TEMP button.

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 can be selected via a jumper on the output board. When the 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 outputs. 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 can be turned off by depressing the SILENCE button.

Independent automatic reset operation is available for both the HIGH and LOW channels, via shunts on the output board. 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 the schematic diagram on pages 6 and 7**

### Measuring Circuit

The controller's temperature measuring circuit, U3a 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 U3-11, the input of this amplifier. The input compensation network C67, R136 and R137 provides a high level of RFI rejection, particularly at cellular frequencies. The controller is 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 the 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 U3-13. To achieve this, the gain of the amplifier is set by R6, R8 and R9 at 424.

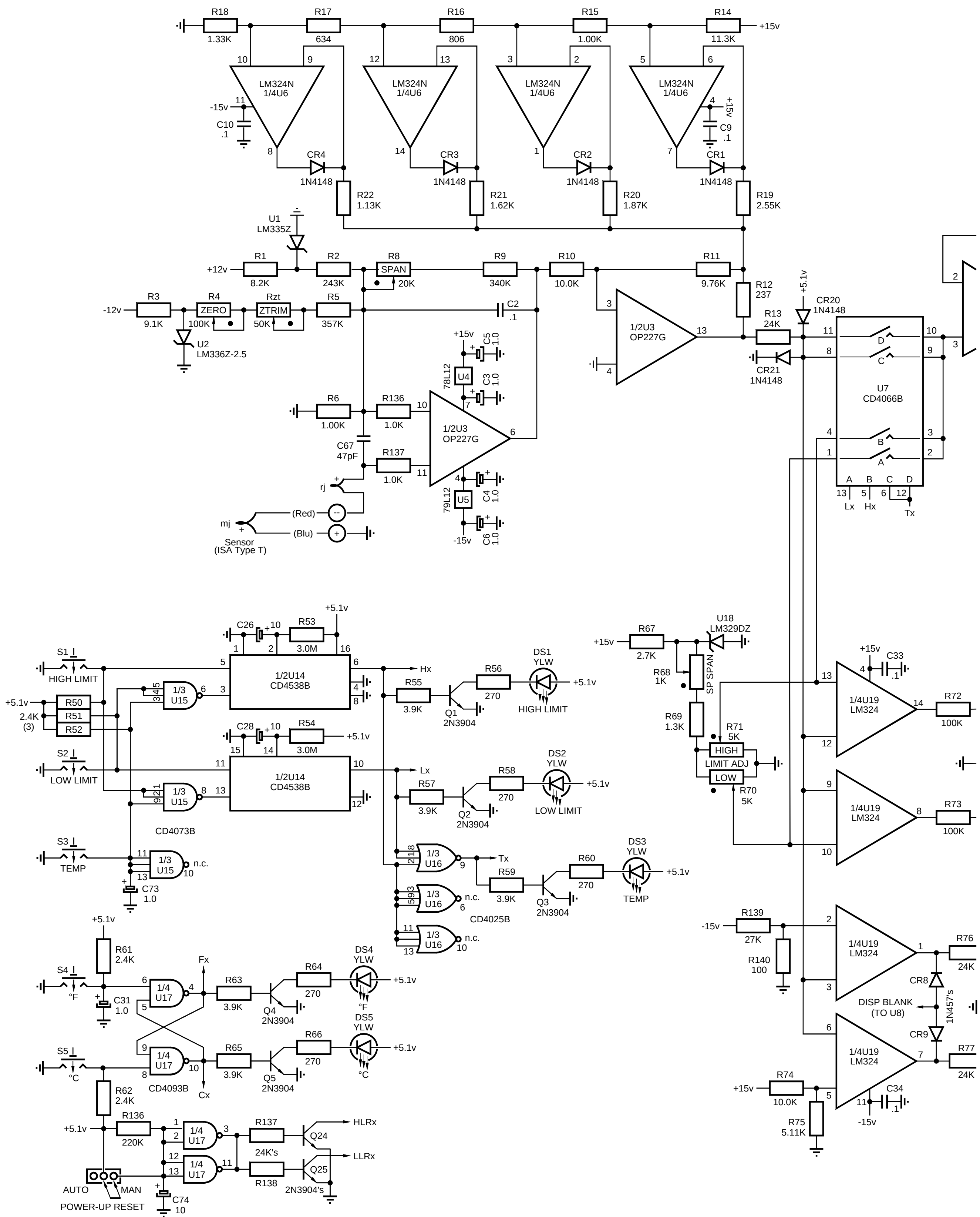
This non-inverting amplifier will always settle at the point where the potential at its inverting input, U3-10, is exactly equal to its input, U3-11. This condition is established by a feedback current, passed from the output, U3-6, through R8 and R9 to the amplifier's inverting input. For a given input, the magnitude of the feedback current required to establish this balance is a function of R6. Having established that, the magnitude of the amplifier's output voltage then becomes a function of the feedback resistors, R8 and R9. 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.

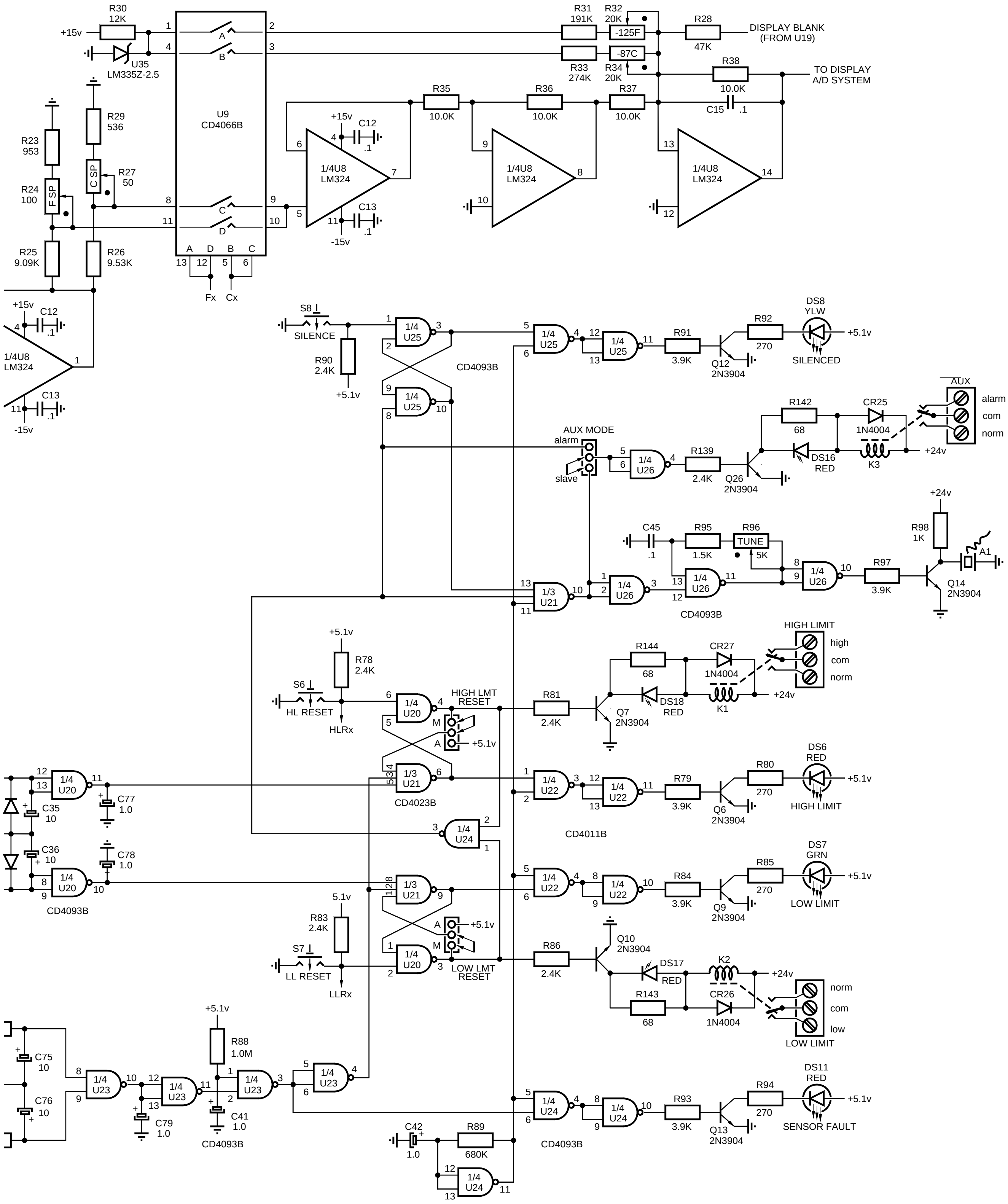
Thermocouple circuits necessarily involve a second junction, sometimes called the "reference junction". This junction, shown as "rj" on the schematic, has the same "emf vs. temperature" characteristic as the sensor. It occurs in series with the sensor's emf, with the opposite polarity. The emf produced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

U1, R1 and R2 provide reference junction compensation, which minimizes errors due to variations in ambient temperature. U1 is an integrated circuit temperature sensor, which produces an output proportional to its absolute temperature. This output varies 10mV/°C, and is scaled by R2 to produce a feedback current through R8 and R9 which will be approximately equal and opposite to that being caused by the influence of the reference junction. 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 R1. A 1°C ambient temperature change will also result in a 10mV variation at U1. This will produce a -41nA change in the total feedback current, which approximately cancels out the shift produced by rj.

U2, R3, R4, $R_{zt}$ and R5 provide a means of shifting the amplifier's output to zero with a -125°F input at "mj". U2 is a precision voltage reference integrated circuit, which provides a stable +6.9v at its junction with R3 and R4. 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 U3-6.

Meanwhile, the voltage at the U1, R1 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 U3-6 of about -5.2 volts.


R18
1.33K
R17
634
R16
806
R15
1.00K
R14
11.3K
+15v
LM324N
1/4U6
-15v
C10
.1
C9
.1
CR4
CR3
CR2
CR1
1N4148
R22
1.13K
R21
1.62K
R20
1.87K
R19
2.55K
U1
LM335Z
R1
8.2K
R2
243K
R8
SPAN
20K
R9
340K
R10
10.0K
R11
9.76K
R12
237
+12v
-12v
R3
9.1K
R4
ZERO
100K
Rzt
ZTRIM
50K
R5
357K
C2
.1
U2
LM336Z-2.5
1/2U3
OP227G
R13
24K
+5.1v
CR20
1N4148
CR21
1N4148
U7
CD4066B
Lx
Hx
Tx
C5
1.0
78L12
U4
C3
1.0
R6
1.00K
R136
1.0K
C67
47pF
R137
1.0K
79L12
U5
C4
1.0
C6
1.0
rj
mj
(Red)
(Blu)
Sensor
(ISA Type T)
C26
10
R53
3.0M
1/2U14
CD4538B
S1
HIGH LIMIT
1/3
U15
R50
R51
R52
2.4K
(3)
S2
LOW LIMIT
C28
R54
S3
TEMP
CD4073B
C73
1.0
n.c.
R55
3.9K
R56
270
Q1
2N3904
DS1
YLW
HIGH LIMIT
R57
3.9K
R58
270
Q2
2N3904
DS2
YLW
LOW LIMIT
1/3
U16
CD4025B
R59
3.9K
R60
270
Q3
2N3904
DS3
YLW
TEMP
R67
2.7K
U18
LM329DZ
R68
1K
SP SPAN
R69
1.3K
R71
5K
HIGH
LIMIT ADJ
LOW
R70
5K
1/4U19
LM324
C33
.1
R72
100K
R73
100K
R139
27K
R140
100
R76
24K
CR8
DISP BLANK
(TO U8)
1N457's
CR9
R77
24K
R74
10.0K
R75
5.11K
C34
.1
S4
°F
R61
2.4K
C31
1.0
1/4
U17
Fx
R63
3.9K
R64
270
Q4
2N3904
DS4
YLW
S5
°C
R62
2.4K
CD4093B
Cx
R65
3.9K
R66
270
Q5
2N3904
DS5
YLW
R136
220K
R137
24K's
R138
HLRx
LLRx
Q24
Q25
2N3904's
AUTO
MAN
POWER-UP RESET
C74
10


R30 12K
+15v
U35 LM335Z-2.5
U9 CD4066B
R29 536
R23 953
R27 50
R24 100
F SP
C SP
R25 9.09K
R26 9.53K
Fx
Cx
R31 191K
R32 20K
-125F
-87C
R33 274K
R34 20K
R28 47K
DISPLAY BLANK (FROM U19)
R38 10.0K
TO DISPLAY A/D SYSTEM
R35 10.0K
R36 10.0K
R37 10.0K
C15 .1
C12 .1
C13 .1
-15v
1/4U8 LM324
S8
SILENCE
R90 2.4K
+5.1v
1/4 U25
CD4093B
R91 3.9K
R92 270
DS8 YLW
SILENCED
Q12 2N3904
AUX
alarm
com
norm
R142 68
CR25 1N4004
DS16 RED
K3
+24v
AUX MODE
alarm
slave
1/4 U26
R139 2.4K
Q26 2N3904
C45 .1
R95 1.5K
R96 TUNE 5K
R98 1K
A1
R97 3.9K
Q14 2N3904
1/3 U21
HIGH LIMIT
high
R144 68
CR27 1N4004
DS18 RED
K1
R78 2.4K
S6
HL RESET
HLRx
1/4 U20
HIGH LMT RESET
R81 2.4K
Q7 2N3904
1/4 U22
CD4023B
CD4011B
R79 3.9K
R80 270
DS6 RED
Q6 2N3904
C35 10
C36 10
C77 1.0
C78 1.0
1/4 U24
R84 3.9K
R85 270
DS7 GRN
LOW LIMIT
Q9 2N3904
R83 2.4K
5.1v
S7
LL RESET
LLRx
LOW LMT RESET
R86 2.4K
Q10 2N3904
DS17 RED
K2
R143 68
CR26 1N4004
low
C75 10
C76 10
1/4 U23
R88 1.0M
C79 1.0
C41 1.0
C42 1.0
R89 680K
R93 3.9K
R94 270
DS11 RED
SENSOR FAULT
Q13 2N3904

U3 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, R4 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 accessible from the back of the unit, as a means of correcting slight zero offsets in the field without removing the unit from service.

## 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, U3b and U6 converts the nonlinear measuring circuit output (U3-6) to a linear analog at U3-13. 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 U3-6 into five segments. The apparent gain of the inverting buffer, U3b, is readjusted as necessary to produce a linear 10mV/°F slope within each segment. For example, the non-inverting input, U6-5, is held at +3.752 volts by the voltage divider R14 - R18. With the R11/R12 node at any higher level, U6-7, and all the other outputs of U6, will be at the negative saturation limit. Because of the diodes CR1 through CR4, U6 makes no contribution to the output under these circumstances.

As the temperature decreases, the R11/R12 node drops below the +3.752 volt threshold (U3-13 = +3.843v), U6-7 swings to +3.752 volts plus the diode drop, acting like a dc buffer which sets U6-6 at +3.752 volts. This produces a small current in R19. Since the other three linearizer stages are still off, this current is provided from the output U3-13, through R12. In order to provide this additional current, U3-13 drops to a slightly less positive level than would otherwise be required to satisfy the normal R10 feedback requirement.

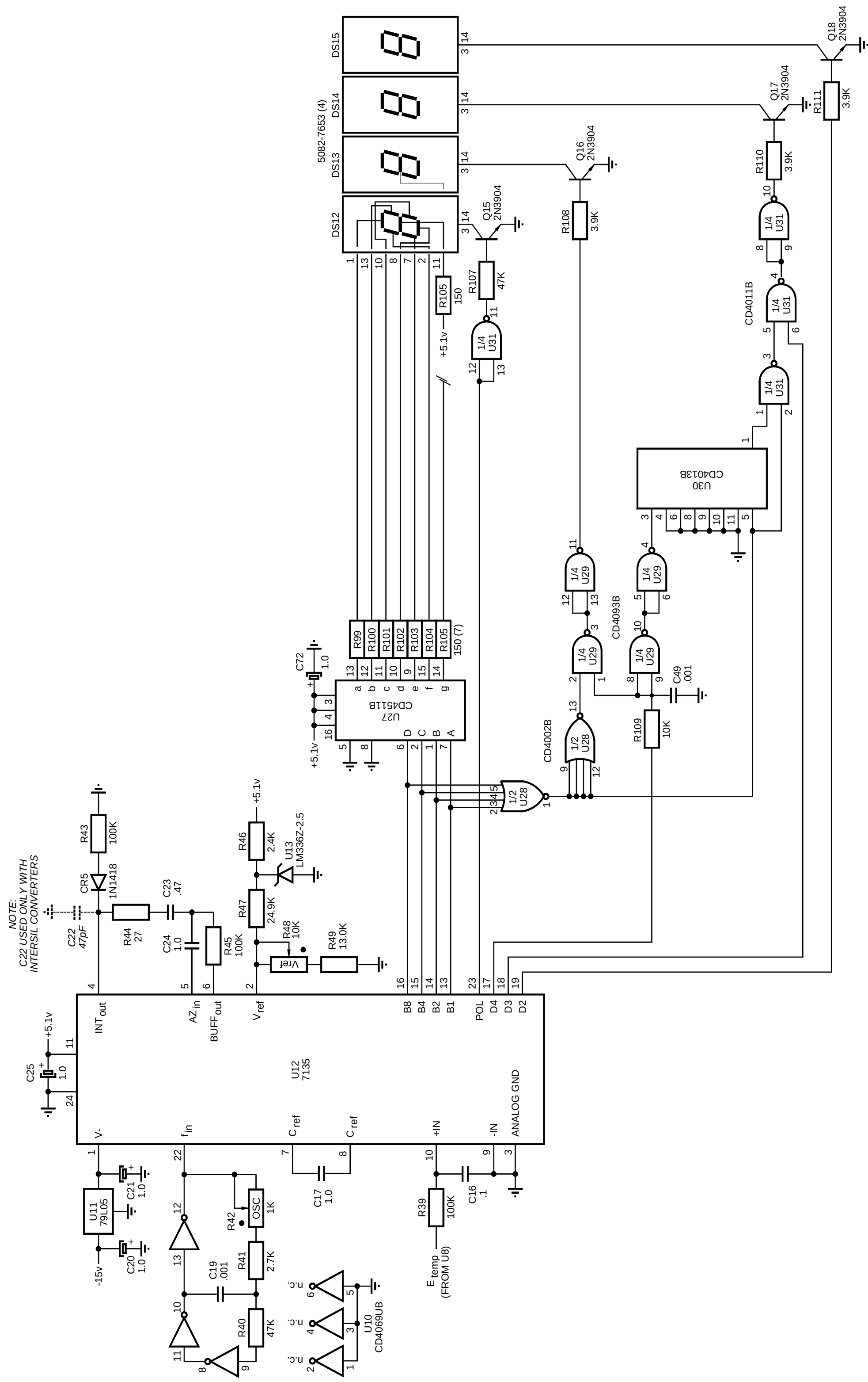
As the temperature continues to fall, the voltage at the R11/R12 node decreases. This increases the linearizer current, which increases the resulting offset factor in the U3-13 output. When the R11/R12 node falls to +2.757 volts, the next linearizer stage is enabled, increasing the rate of curve correction. 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.

## Scaling Circuit

The indicator A/D converter is basically a digital millivolt meter. The 0/+5.00v output provided at U3-13, and the limit set point analog voltages from R70 and R71, 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 Celsius (°C) values.

Analog switch U7 multiplexes the analogs into buffer input U8-3. The output of this buffer is connected to two voltage dividers. The R23 - R25 divider converts the 5-volt analog to a 0/500mV analog, representing the 500°F span. The R26 - R29 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 U9, is buffered, then applied to R35, an input to an inverting unity gain amplifier. The inverted output, U8-8, is then applied to R37, the input of a second inverting buffer.


DS12
DS13
DS14
DS15
5082-7653 (4)
Q15 2N3904
Q16 2N3904
Q17 2N3904
Q18 2N3904
U27 CD4511B
U30 CD4013B
CD4093B
CD4011B
CD4002B
U12 7135
U11 79L05
U13 LM336Z-2.5
U10 CD4069UB
NOTE: C22 USED ONLY WITH INTERSIL CONVERTERS
E temp (FROM U8)
ANALOG GND

At this circuit, the analog is summed with an offsetting voltage selected by two additional sections of U9. In the "°F" display mode, R31 and R32 injects +12.5uA into the feedback node, which shifts the output at U8-14 in the negative direction by exactly 125mV. This provides a "-125" read-out when the analog is at zero volts. In the "°C" display mode, an offsetting current of +8.72uA is provided by R33 and R34, to provide -87.2mV at U8-14 (-125°F = -87.2°C).

The "display blank" input to R28 is taken from the CR8/CR9 junction at U19, and is normally open since the diodes are normally reverse biased. Certain sensor faults cause U19 to forward bias one of these diodes, imposing a -13.3v potential on R28. This forces U8-14 to at least +2.5v, which activates the over-range function of the A/D converter, producing a flashing "0" display.

### DVM Circuit

The DVM circuit is shown separately on page 9. The scaled and level-shifted analog voltage at U8-14 is applied to the input of DVM circuit, U12, through low pass filter R39 and C16. U12 is a dual-slope 4-1/2 digit A/D converter which provides a multiplexed BCD output to operate a digital display system. The least significant digit, D1, is not used in this application. Peripheral circuitry includes U10, which provides a 100kHz reference frequency for the converter, U11 which provides a -5v supply for the DVM chip, and U13, which provides a +1.000v reference voltage.

The BCD, digit and polarity outputs from U12 are connected to the display circuitry. The BCD inputs to U27, a BCD/7-segment converter, are set up as required to display the appropriate number in each digit position, while the display digits are simultaneously scanned from D4 to D2 (D1 is not used).

U28 through U31 provide a zero-blanking function for the first two digits, while the LSD is driven directly with no blanking provisions. One degree is therefore displayed as "1", rather than "001". When all the BCD lines are at zero, U28-1 will be high. U28-13 will therefore be low, preventing the "D4" pulse from being gated through U29-3. If any BCD line is high, these logic levels will be reversed. When D4 goes high, U29-11 goes high, which enables digit driver transistor, Q16. D4 is also gated into U30-3, clocking this D-type flip-flop circuit. If the BCD lines are all zero for D4, a high logic level is clocked through to the Q output, U30-1. Then, if the lines are also all zero for D3, U31-3 will be low, preventing the D3 pulse from being gated through to the digit driver transistor, Q17. Again, if any one of the BCD lines is high during the D3 time, the second digit will be enabled.

### Display Mode Selector Circuitry

The digital display system (see page 6) 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 U14 through U17.

U14 is a dual timer. When the high limit display button is pressed, its timer is triggered and provides a high output (Hx) at U14-6. This enables the "High Limit" indicator, DS1, and analog gate U7-3. If the low limit timer was active when the high limit button was pressed, it will be reset by U15-9. A high output from either timer disables the temperature display line (Tx) by forcing U16-9 to go low. The timers will hold the display for 30-seconds, after which the display automatically returns to the measured temperature.

U17 is a simple manual set-reset flip-flop, which selects either the °F or °C range, operating the analog gates of U9 in the scaling circuit accordingly.

## Alarm Circuitry

U19 provides a system of comparators which monitors the measured temperature with respect to high and low limit settings, and for "reasonableness".  U18 provides a precision +6.9v reference for the limit set points, R70 and R71.  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 U19-14 and U19-8 will be low.  U20-11 and U20-10 will therefore be high.

Furthermore, when the analog voltage is greater than -0.06v, but less than +5.06v (i.e., temperature within the range of -131°F to 381°F), U19-1 and U19-7 will both be high, and U23-4 will therefore also be high.

Pressing both reset buttons, S6 and S7, forces U20-4 and U20-3 high.  With all three inputs high, U21-6 and U21-9 go low.  This disables both the high limit and low limit indicators, and latches U20-4 and U20-3 at the high level, enabling the output transistors, Q7 and Q10.  This is the normal operating status.

In the event that the 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 U24-11.

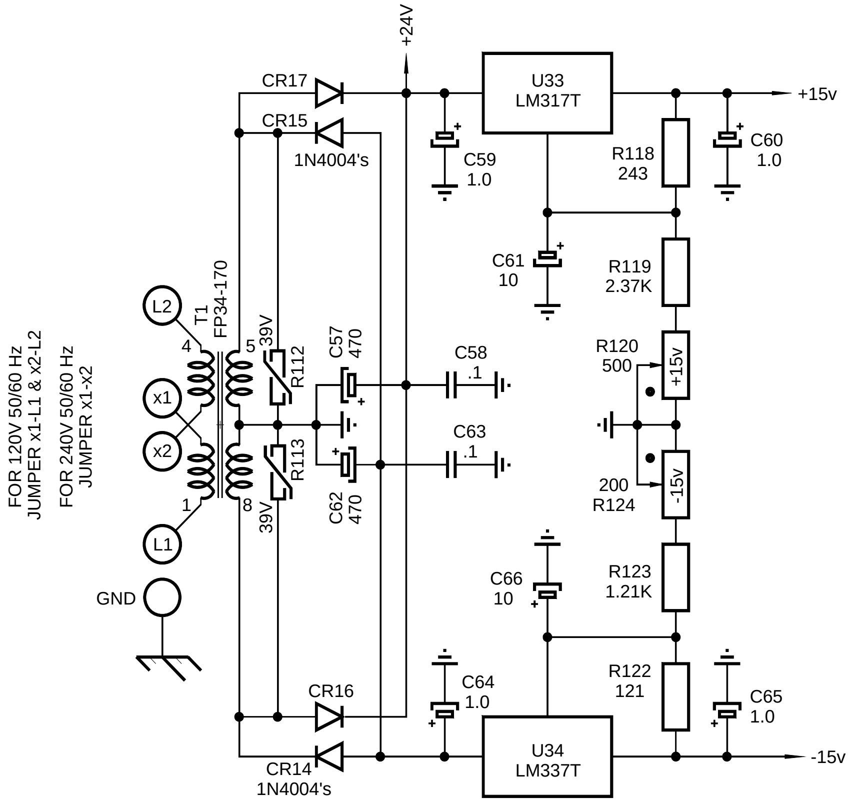
When neither limit is tripped, U24-3 will be low.  U26-10 and U25-11 will therefore both be low, holding both the audible warning device (beeper) and the SILENCED indicator off.  When either on (or both) of the limits are tripped, U24-3 goes high.  This enables the audible warning device, but not the SILENCED indicator.  Pressing S8 forces U25-3 high.  U25-10 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.

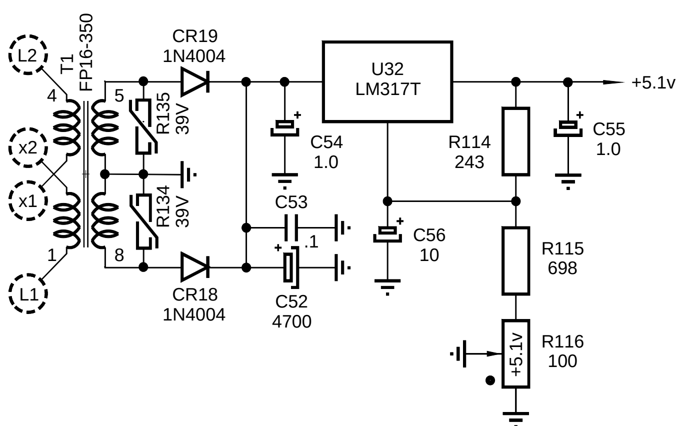
At power on, U23-1 is initially held low as C41 begins to charge. This trips both limits and toggles the sensor fault indicator.  A momentary loss of power will therefore trip both limits.  An open sensor connection will cause the measuring circuit to provide abnormal analog voltage levels and toggle either U19-1 or U19-7.  A flashing SENSOR warning signal via Q13, and both limits will also be tripped.

## Power Supply Circuits

As seen on the separate diagram on page 12, power for the controller can be taken from either 110/120vac or 208/240vac, 50/60 Hz lines.

The controller circuit uses +15v, -15v and +5.1v dc voltages.  The +/-15v levels are provided by T1 and its associated bilateral full-wave rectifier circuit.  Regulators U33 and U34 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 T2 and regulator U32.  All three of these supplies are adjustable, and are set precisely at the 15v and 5.1v levels.




## Output Circuitry

The Q7, Q10 and Q26 open-collector outputs are connected to operate mechanical relays K1, K2 and K3, and their associated LED indicators on the relay output board. These relays provide separate 1P2T contacts capable of switching 10-amps at 250vac. The relays are de-energized by abnormal operating conditions (AUX <- COM), (LOW <- COM) and (HIGH <- COM).

## Handling Electrical Interference

When used in the manually reset mode, this device becomes a latching mechanism. Momentary bursts of stray electrical energy, which would normally constitute nothing more than a minor transient disturbance for other non-latching electronic instruments, may cause this device to latch its load circuits off. Electrical interference, or "noise", is therefore a matter for special attention in the application of latching electronic limit controllers.

Although this control has been designed to provide a relatively high level of immunity to stray electrical energy, it is not possible to provide for 100% rejection of any noise frequency, waveshape or amplitude. A few application hints are therefore offered for cases where noise problems occur, or are anticipated:

1. Never ground the sensor, or use grounded-sheath type sensors.

2. If possible, do not run the sensor cable through conduits or cable trays with switched current-carrying conductors. If it is not possible to separate sensor cables and power wiring, used shielded thermocouple extension cable, connecting the shield to ground (the electrical panel) at the controller's chassis (do not ground the shield on the sensor end).

3. Transient electrical signals can be conducted into the controller through its power wiring. It is therefore good practice to take power for this device directly from the source (typically the control power step-down transformer), rather than from a "daisy chain" bus connection. As with the sensor cable, the power supply leads can also pick up stray electrical signals from adjacent wiring serving switched inductances (relay coils, etc.). If the controller can not be mounted close enough to the power source to permit a short, separate hook-up, twisting its "line" and "common" hook-up wires is recommended as a means of minimizing such pick-up. In extreme cases, use two-wire shielded control cable for the power connection.

4. As a general rule, electrical interference is best treated at its source. A simple RC snubber network (typically .047uF in series with 100Ω) connected across the terminals of a troublesome switch, relay coil or motor, will provide an easy and totally effective solution, whereas it may be next to impossible to achieve the same result by altering the controller's hook-up wiring or internal circuitry.

## Field Calibration Procedure

A ZERO TRIM potentiometer is provided on the back of the controller (see page 28) to permit easy compensation for minor offsets due to aging and sensor anomalies. Most calibration problems will be zero offsets which are correctable here.

The regular ZERO and SPAN are provided on the controller's top circuit board (see page 20), and are accessible through ports in the internal cover plate.

To trim these adjustments, disconnect the sensor cable and connect a portable potentiometer or millivolt source to the (+) and (-) terminals.

Set the input at "-125°F" or its equivalent emf. Adjust the ZERO trimmer (R4) to provide an indication of exactly "-125°F" or "-87°C" on the digital display.

Likewise, set the input at "+375°F" or its equivalent emf, and adjust the SPAN trimmer (R8) to provide a digital indication of exactly "+375°F" or "+191°C".

This procedure normally results in a calibration accuracy of +/-1% of Span, which will normally be sufficient for limit switch operation. For closer calibration, refer to the more detailed bench procedure, which follows.

## Test Bench Calibration Procedure

Remove the internal cover panel to gain access to the various trimmers referred to below, then refer to circuit board layout on page 20 and perform the following adjustments.

**Please allow at least 10-minutes after applying power for circuit temperatures to stabilize prior to final calibration. Also please note that unrestricted air flow through and around the unit may produce abnormal temperature gradients in the measuring circuitry, which can degrade the accuracy of the calibration effort (viz., avoid drafts).**

1. Connect a digital voltmeter (DVM) between the right-hand pin of U34, and ground on the (+) (or front) side of C66. Adjust the "-15v" trimmer, R124, to provide an indication of exactly -15.0v.

2. Connect the DVM (+) lead to the center pin of U33. Adjust the "+15v" trimmer, R120, to provide an indication of exactly +15.0v

3. Connect the (+) lead to U9-14. 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. Reset and trip the limits to provide an audible warning. Adjust the "Tune" trimmer, R96 on the bottom board (accessible through the hole in the top board) to find the peak audible output.

5. Connect the (+) lead to the left-hand end of R47. Adjust the "Vref" trimmer, R48, to provide an indication of exactly +1.000v.

6. Connect a frequency counter between U12-22 ("*" position) and ground. Adjust the "Osc" trimmer, R42, to provide a clock frequency of exactly 100kHz (period = 10.000µS).

7. Turn the low limit all the way counterclockwise, and the high limit fully clockwise. Connect the DVM (+) lead to U8-1. Select the LOW LIMIT display mode, then adjust the "-125°F" trimmer, R32, for a read-out of exactly -125°F, and the "-87°C" trimmer for an indication of exactly -87°C.

8. Select the HIGH LIMIT display mode, then adjust the "SP Span" trimmer, R68, to provide an indication of exactly +5.00v. Next, adjust the "F Span" trimmer, R24, to provide a display indication of exactly 375°F, then adjust the "C Span" trimmer, R27 to display exactly 191°C.

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 U8-1 and ground, center $R_{zt}$ on the back of the unit and adjust the "Zero" trimmer, R4, to provide a DVM indication of exactly 0.00v.

10. Set the input at "+375F" or +8.787mV, and adjust the "Span" trimmer, R8, to provide an indication of exactly +5.00v.

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.

12. When properly calibrated, the average indication accuracy for all points within the range of -125°F/+375°F (-87°C/+191°C) should be within +/-0.25% of Span.

13. When complete, replace the internal cover panel and outer cover.

## 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: 012011
Drawing Number: 470606 (see Page 3)

**"*TempSentry*"** BI-DIRECTIONAL TEMPERATURE LIMIT CONTROLLER

| PART # | DESC | MFGR | MFGR'S NO | QTY | UM |
|---|---|---|---|---|---|
| 048048 | ANALOG PCB ASSY, FRT | WRNR | 048048/470582 | 1 | EA |
| 048049 | DIGITAL PCB ASSY, FRT | WRNR | 048049/470583 | 1 | EA |
| 048050 | DVM PCB ASSY, FRT | WRNR | 048050/470584 | 1 | EA |
| 048051 | CONTROL PANEL PCB ASSY, FRT | WRNR | 048051/470585 | 1 | EA |
| 048070 | RELAY OUTPUT PCB ASSY | WRNR | 048070/470734 | 1 | EA |
| 142001 | FILTER, RED DISPLAY | WRNR | 470509 | 1 | EA |
| 251018 | INSULATOR, FRT | WRNR | 251018/470683 | 1 | EA |
| 266002 | STICK MOUNT, GRN | MEIJ | | 1 | EA |
| 271026 | SCREW, BDR HD 6-32x.250 | SSUP | | 7 | EA |
| 2710258 | SCREW, BDR HD 6-32x.500 | SSUP | | 2 | EA |
| 271259 | SCREW, TRUS HD 6-32x.250 | | | 8 | EA |
| 272041 | WASHER, NYLON PLAIN #6 REG | KEYS | 3163 | 1 | EA |
| 279022 | SPACER, M-F TYPE 6-32x1.25 | KYST | 1955 | 5 | EA |
| 279024 | SPACER, M-F TYPE 6-32x.313 | SMTH | 8249 | 2 | EA |
| 351030 | BEZEL, FRT | WRNR | 351030/470590 | 1 | EA |
| 351048 | CHASSIS, FRT | WRNR | 351048/470738 | 1 | EA |
| 352052 | MOUNTING CLAMP | WRNR | 352052/470602 | 2 | EA |
| 352056 | COVER PLATE, INTERNAL | WRNR | 352056/470694 | 1 | EA |
| 353056 | COVER, FRT | WRNR | 353026/470694 | 1 | EA |

Part Number: 048048
Drawing Number: 470582 (see Page 20)

***"TempSentry"*** ANALOG PCB ASSY

| PART # | DESC | | MFGR | MFGR'S NO | QTY | UM |
|---|---|---|---|---|---|---|
| 051035 | RESISTOR, COMP 1/4W 5% | 27Ω | ROHM | RC07GF270J | 1 | EA |
| 051049 | RESISTOR, COMP 1/4W 5% | 100Ω | ROHM | RC07GF101J | 1 | EA |
| 051073 | RESISTOR, COMP 1/4W 5% | 1.0K | ROHM | RCO7GF102J | 2 | EA |
| 051076 | RESISTOR, COMP 1/4W 5% | 1.3K | ROHM | RC07GF132J | 1 | EA |
| 051082 | RESISTOR, COMP 1/4W 5% | 2.4K | ROHM | RC07GF242J | 1 | EA |
| 051083 | RESISTOR, COMP 1/4W 5% | 2.7K | ROHM | RC07GF272J | 2 | EA |
| 051095 | RESISTOR, COMP 1/4W 5% | 8.2K | ROHM | RC07GF822J | 2 | EA |
| 051096 | RESISTOR, COMP 1/4W 5% | 9.1K | ROHM | RC07GF912J | 1 | EA |
| 051099 | RESISTOR, COMP 1/4W 5% | 12k | ROHM | RC07GF123J | 1 | EA |
| 051106 | RESISTOR, COMP 1/4W 5% | 24K | ROHM | RC07GF243J | 3 | EA |
| 051107 | RESISTOR, COMP 1/4W 5% | 27K | ROHM | RC07GF273J | 1 | EA |
| 051113 | RESISTOR, COMP 1/4W 5% | 47K | ROHM | RC07GF473J | 2 | EA |
| 051121 | RESISTOR, COMP 1/4W 5% | 100K | ROHM | RC07GF104J | 5 | EA |
| 052209 | RESISTOR, FILM 1/8W 1% | 121Ω | ROHM | RN55D1210F | 1 | EA |
| 052237 | RESISTOR, FILM 1/8W 1% | 237Ω | ROHM | RN55D2370F | 1 | EA |
| 052238 | RESISTOR, FILM 1/8W 1% | 243Ω | ROHM | RN55D2430F | 1 | EA |
| 052271 | RESISTOR, FILM 1/8W 1% | 536Ω | DIGI | 536X | 1 | EA |
| 052278 | RESISTOR, FILM 1/8W 1% | 634Ω | ROHM | RN55D6340F | 1 | EA |
| 052288 | RESISTOR, FILM 1/8W 1% | 806Ω | ROHM | RN55D8060F | 1 | EA |
| 052295 | RESISTOR, FILM 1/8W 1% | 953Ω | ROHM | RN55D9530F | 1 | EA |
| 052301 | RESISTOR, FILM 1/8W 1% | 1.00K | DIGI | 1.0KX | 2 | EA |
| 052306 | RESISTOR, FILM 1/8W 1% | 1.13K | ROHM | RN55D1131F | 1 | EA |
| 052309 | RESISTOR, FILM 1/8W 1% | 1.21K | ROHM | RN55D1211F | 1 | EA |
| 052313 | RESISTOR, FILM 1/8W 1% | 1.33K | ROHM | RN55D1331F | 1 | EA |
| 052321 | RESISTOR, FILM 1/8W 1% | 1.62K | DIGI | 1.62KX | 1 | EA |
| 052327 | RESISTOR, FILM 1/8W 1% | 1.87K | ROHM | RN55D1871F | 1 | EA |
| 052337 | RESISTOR, FILM 1/8W 1% | 2.37K | ROHM | RN55D2371F | 1 | EA |
| 052340 | RESISTOR, FILM 1/8W 1% | 2.55K | ROHM | RN55D2551F | 1 | EA |
| 052369 | RESISTOR, FILM 1/8W 1% | 5.11K | ROHM | RN55D5111F | 1 | EA |
| 052393 | RESISTOR, FILM 1/8W 1% | 9.09K | DIGI | 9.09KX | 1 | EA |
| 052395 | RESISTOR, FILM 1/8W 1% | 9.53K | ROHM | RN55D9531F | 1 | EA |
| 052396 | RESISTOR, FILM 1/8W 1% | 9.76K | ROHM | RN55D9761F | 1 | EA |
| 052401 | RESISTOR, FILM 1/8W 1% | 10.0K | ROHM | RN55D1002F | 6 | EA |
| 052406 | RESISTOR, FILM 1/8W 1% | 11.3K | ROHM | RN55D1132F | 1 | EA |
| 052412 | RESISTOR, FILM 1/8W 1% | 13.0K | ROHM | RN55D1302F | 1 | EA |
| 052439 | RESISTOR, FILM 1/8W 1% | 24.9K | ROHM | RN55D2492F | 1 | EA |
| 052528 | RESISTOR, FILM 1/8W 1% | 191K | ROHM | RN55D1913F | 1 | EA |
| 052538 | RESISTOR, FILM 1/8W 1% | 243K | ROHM | RN55D2433F | 1 | EA |
| 052543 | RESISTOR, FILM 1/8W 1% | 274K | ROHM | RN55D2743F | 1 | EA |
| 052552 | RESISTOR, FILM 1/8W 1% | 340K | ROHM | RN55D3403F | 1 | EA |
| 052554 | RESISTOR, FILM 1/8W 1% | 357K | DIGI | 357KX | 1 | EA |
| 054003 | POTENTIOMETER, TRIM 1T-3/8 | 50 | BRNS | 3386P-1-500 | 1 | EA |
| 054004 | POTENTIOMETER, TRIM 1T-3/8 | 100 | BRNS | 3386P-1-101 | 1 | EA |

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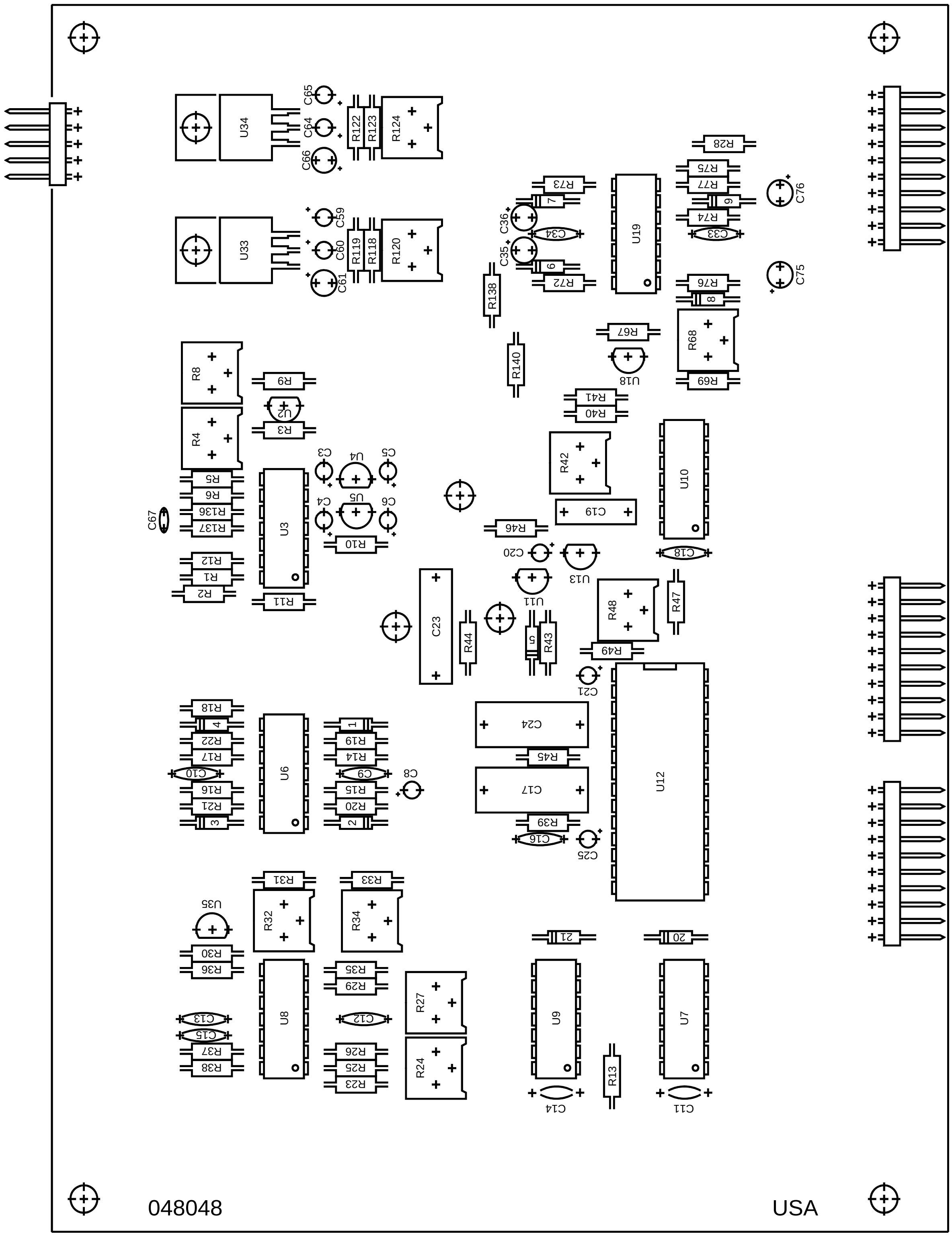
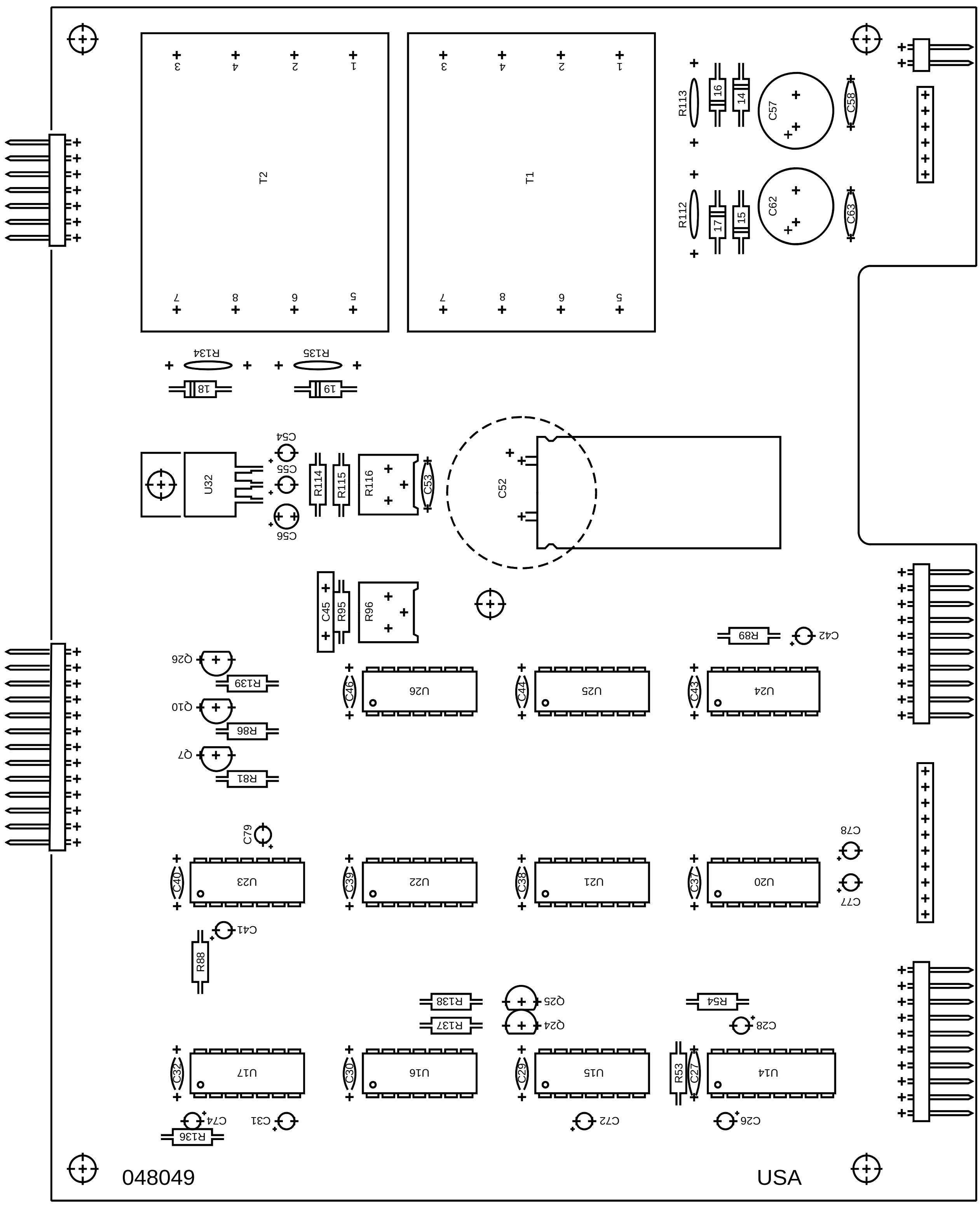

048048
USA

Part Number: 048048
Drawing Number: 470582 (see Page 20)

***"TempSentry"*** ANALOG PCB ASSY (Continued)

| PART # | DESC | | MFGR | MFGR'S NO | QTY | UM |
|---|---|---|---|---|---|---|
| | ... continuing | | | | | |
| 054005 | POTENTIOMETER, TRIM 1T-3/8 | 200 | BRNS | 3386P-1-201 | 1 | EA |
| 054006 | POTENTIOMETER, TRIM 1T-3/8 | 500 | BRNS | 3386P-1-501 | 1 | EA |
| 054007 | POTENTIOMETER, TRIM 1T-3/8 | 1K | BRNS | 3386P-1-102 | 2 | EA |
| 054010 | POTENTIOMETER, TRIM 1T-3/8 | 10K | BRNS | 3386P-1-103 | 1 | EA |
| 054011 | POTENTIOMETER, TRIM 1T-3/8 | 20K | BRNS | 3386P-1-203 | 3 | EA |
| 054013 | POTENTIOMETER, TRM 1T-3/8 | 100K | BRNS | 3386P-1-104 | 1 | EA |
| 062016 | CAPACITOR. CRMC 25V | 47pF | PANA | P4008 | 1 | EA |
| 062060 | CAPACITOR, CRMC 25V | .01uF | MOUS | 25FG010 | 3 | EA |
| 062067 | CAPACITOR, CRMC 25V | 0.1uF | SPRG | HY-850 | 9 | EA |
| 063013 | CAPACITOR, TANT 35V | 1.0uF | MOUS | 551-1.0M35 | 13 | EA |
| 063045 | CAPACITOR, TANT 25V | 10uF | MOUS | 551-10M25 | 6 | EA |
| 067054 | CAPACITOR, FILM 100V | 0.47uF | THOM | 581-MC474K1F | 1 | EA |
| 067058 | CAPACITOR, FILM 100V | 1.0uF | THOM | 581-MC105K1H | 2 | EA |
| 067069 | CAPACITOR, FILM 400V | 0.001uF | WEST | 160/.001/K/1k/C | 1 | EA |
| 081001 | DIODE, SIG | | MOUS | 333-1N4148 | 9 | EA |
| 081015 | DIODE, SIGNAL LOW iR | | SPC | 1N457 | 2 | EA |
| 091002 | IC, HEX INVERTER | | RCA | 570-CD4069UBE | 1 | EA |
| 091013 | IC, QUAD BILATERAL SWITCH | | RCA | 570-CD4066BE | 2 | EA |
| 093002 | IC, QUAD OP AMP | | SGS | 511-LM324N | 2 | EA |
| 093010 | IC, ADJ POS 1.5A REGULATOR | | SGS | 511-LM317T | 1 | EA |
| 093011 | IC, +12V 100mA REGULATOR | | NEC | 551-UPC78L12 | 1 | EA |
| 093012 | IC, -12V 100mA REGULATOR | | NS | LM79L12ACZ | 1 | EA |
| 093013 | IC, ADJ NEG 1.5A REGULATOR | | NS | LM337T | 1 | EA |
| 093016 | IC, PRECISION 6.9V REFERENCE | | NS | LM329DZ | 1 | EA |
| 093017 | IC, PRECISION 2.5V REFERENCE | | NS | LM336Z-2.5 | 3 | EA |
| 093026 | IC, -5V 100mA REGULATOR | | NS | LM79L05ACZ | 1 | EA |
| 093030 | IC, DUAL PRECISION OP AMP | | LT | OP227GN | 1 | EA |
| 093032 | IC, PRECISION QUAD OP AMP | | LT | LT1014DN | 1 | EA |
| 094001 | IC, DISPLAY D/A CONVERTER | | ITSL | ICL7135CPI | 1 | EA |
| 173003 | HEADER, RA/SR MALE 36-W | | APT | 929835-01-36 | 33 | EA |
| 175002 | SOCKET, IC, 14 PIN SOLDER TAIL | | TIC | 8914-01 | 7 | EA |
| 175005 | SOCKET, IC 28-PIN SOLDER TAIL | | DIGI | C8928 | 1 | EA |
| 271014 | SCREW, BDR HD 4-40x.250 | | SSUP | | 2 | EA |
| 273002 | LOCKWASHER, HELIC #4 REG | | SSUP | | 2 | EA |
| 274002 | NUT, HEX 4-40 | | SSUP | | 2 | EA |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T1
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R112
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14
17
15
C57
C62
C58
C63
R134
R135
18
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C55
C56
R114
R115
R116
C53
C52
C45
R95
R96
R89
C42
Q26
R139
Q10
R86
Q7
R81
U26
U25
U24
C46
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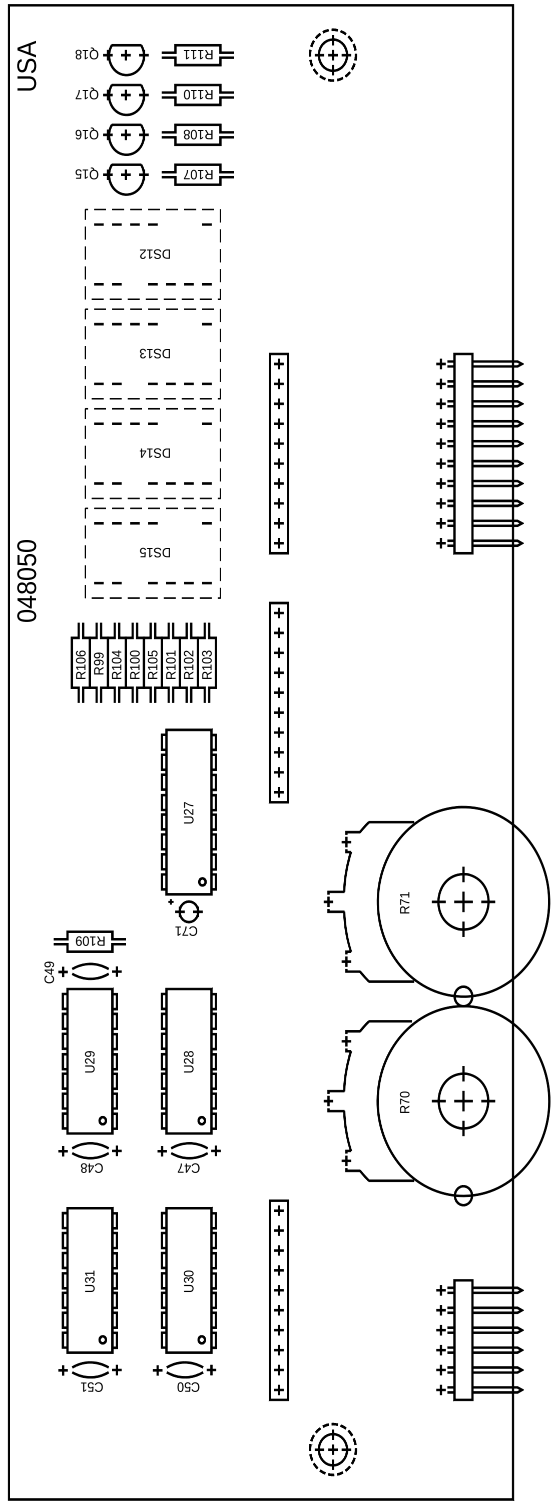
U20
C40
C39
C38
C37
C78
C77
C41
R88
R138
R137
Q25
Q24
R54
C28
U17
U16
U15
U14
C32
C30
C29
C27
R53
C74
C31
C72
C26
R136
048049
USA

Part Number: 048049
Drawing Number: 470583 (see Page 22)

***"TempSentry"*** DIGITAL PCB ASSY

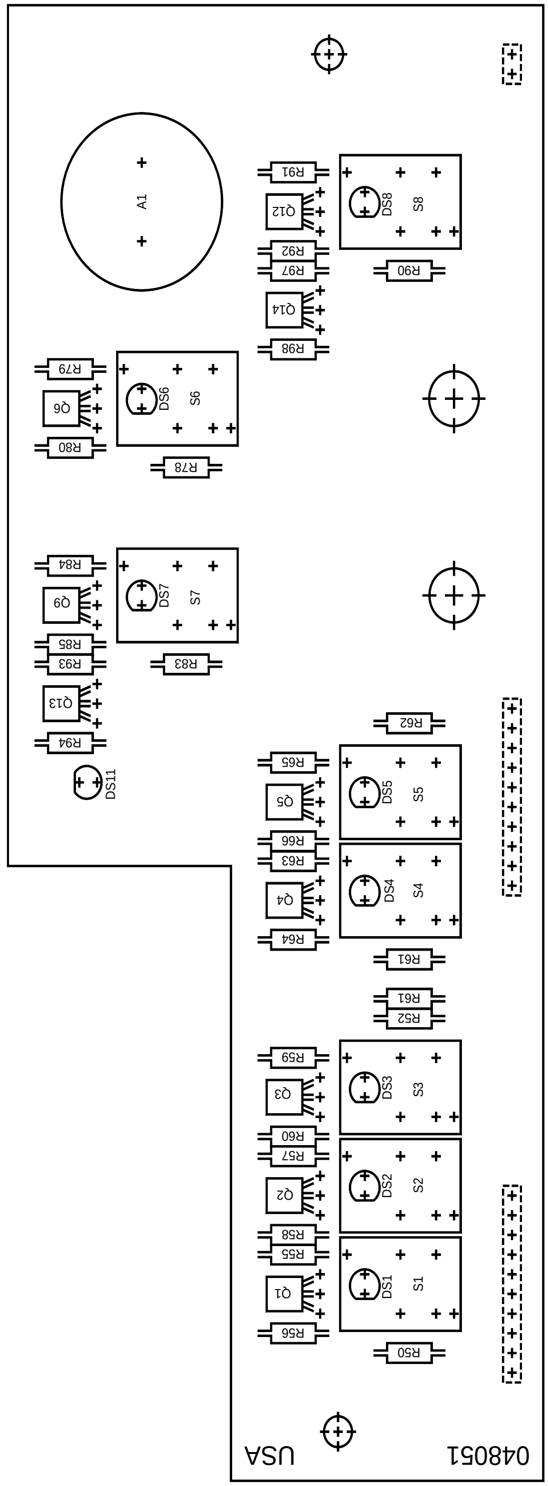
| PART # | DESC | | MFGR | MFGR'S NO | QTY | UM |
|---|---|---|---|---|---|---|
| 051082 | RESISTOR, COMP 1/4W 5% | 2.4K | MOUS | 29SJ250-2.4K | 3 | EA |
| 051077 | RESISTOR, COMP 1/4W 5% | 1.5K | MOUS | 29SJ250-1.5K | 1 | EA |
| 051106 | RESISTOR, COMP 1/4W 5% | 24K | MOUS | 29SJ250-24K | 2 | EA |
| 051129 | RESISTOR, COMP 1/4W 5% | 220K | MOUS | 29SJ250-220K | 1 | EA |
| 051141 | RESISTOR, COMP 1/4W 5% | 680K | ROHM | RC07GF684J | 1 | EA |
| 051145 | RESISTOR, COMP 1/4W 5% | 1.0M | MOUS | 29SJ250-1.0MEG | 1 | EA |
| 051156 | RESISTOR, COMP 1/4W 5% | 3.0 M | ROHM | RC07GF305J | 2 | EA |
| 052238 | RESISTOR, FILM 1/8W 1% | 243Ω | ROHM | RN55D2430F | 1 | EA |
| 052282 | RESISTOR, FILM 1/8W 1% | 698Ω | ROHM | RN55D6980F | 1 | EA |
| 054004 | POTENTIOMETER, TRIM 1T | 100Ω | BRNS | 3386P-1-101 | 1 | EA |
| 054042 | POTENTIOMETER, CONT 1T-5/8 | 5K | A-B | 73N1N056S502W | 2 | EA |
| 056001 | VARISTOR, 31VDC 180MJ | | GE | V39MA2B | 4 | EA |
| 062060 | CAPACITOR, CRMC 25V | .01uF | MOUS | 21FG010 | 10 | EA |
| 062067 | CAPACITOR, CRMC 25V | 0.1uF | MOUS | 21FG100 | 4 | EA |
| 063013 | CAPACITOR, TANT 35V | 1.0uF | MOUS | 551-1.0M35 | 9 | EA |
| 063045 | CAPACITOR, TANT 25V | 10uF | MOUS | 551-10M25 | 4 | EA |
| 064004 | CAPACITOR, ELEC 35V | 470uF | PANA | P6255 | 2 | EA |
| 064016 | CAPACITOR, ELEC 16V | 4700uF | PANA | P6900 | 1 | EA |
| 062072 | CAPACITOR, MONO 100V | .1uF | TECA | 92R2A104K | 1 | EA |
| 071005 | TRANSFORMER, PWR | 34vct/170MA | SGNL | LP34-170 | 1 | EA |
| 071006 | TRANSFORMER, PWR | 16vct/350MA | SGNL | LP16-350 | 1 | EA |
| 081002 | DIODE, RECT 200V 1A | | MOUS | 333-1N4002 | 6 | EA |
| 083021 | TRANSISTOR, NPN GENL PURPOSE | | | MOUS 333-KN3904 | 5 | EA |
| 091001 | IC, QUAD SCHMIT NAND | | RCA | 570-CD4093BE | 6 | EA |
| 091008 | IC, QUAD 2-INPUT NAND GATE | | RCA | 570-CD4011BE | 1 | EA |
| 091011 | IC, TRIPLE 3-INPUT NAND GATE | | RCA | 570-CD4023BE | 1 | EA |
| 091012 | IC, TRIPLE 3-INPUT NOR GATE | | RCA | 570-CD4025BE | 1 | EA |
| 091016 | IC, TRIPLE 3-INPUT AND GATE | | RCA | 570-CD4073BE | 1 | EA |
| 092005 | IC, DUAL MONOSTABLE | | RCA | 570-CD4538BE | 1 | EA |
| 093010 | IC, ADJ POS 1.5A REGULATOR | | SGS | 551-LM317T | 1 | EA |
| 173003 | HEADER, RA/SR MALE 36-W | | APT | 929648-01-36 | 42 | EA |
| 173006 | RECEPTACLE, STR/SR 36-W | | APT | 929850-01-35 | 16 | EA |
| 175002 | SOCKET, IC, 14 PIN SOLDER TAIL | | TI | C8914 | 10 | EA |
| 175003 | SOCKET, IC 16-PIN SOLDER TAIL | | TI | C8916-01 | 1 | EA |
| 271015 | SCREW, BDR HD 4-40x.375 | | | | 1 | EA |
| 273002 | LOCKWASHER, HELIC #4 REG | | | | 1 | EA |
| 274002 | NUT, HEX 4-40 | | | | 1 | EA |


USA
048050
Q15
Q16
Q17
Q18
R107
R108
R110
R111
DS12
DS13
DS14
DS15
R106
R99
R104
R100
R105
R101
R102
R103
U27
C71
R71
R70
R109
C49
U29
U28
C48
C47
U31
U30
C51
C50

Part Number: 048050
Drawing Number: 470584 (see Page 24)

***"TempSentry"*** DVM PCB ASSY

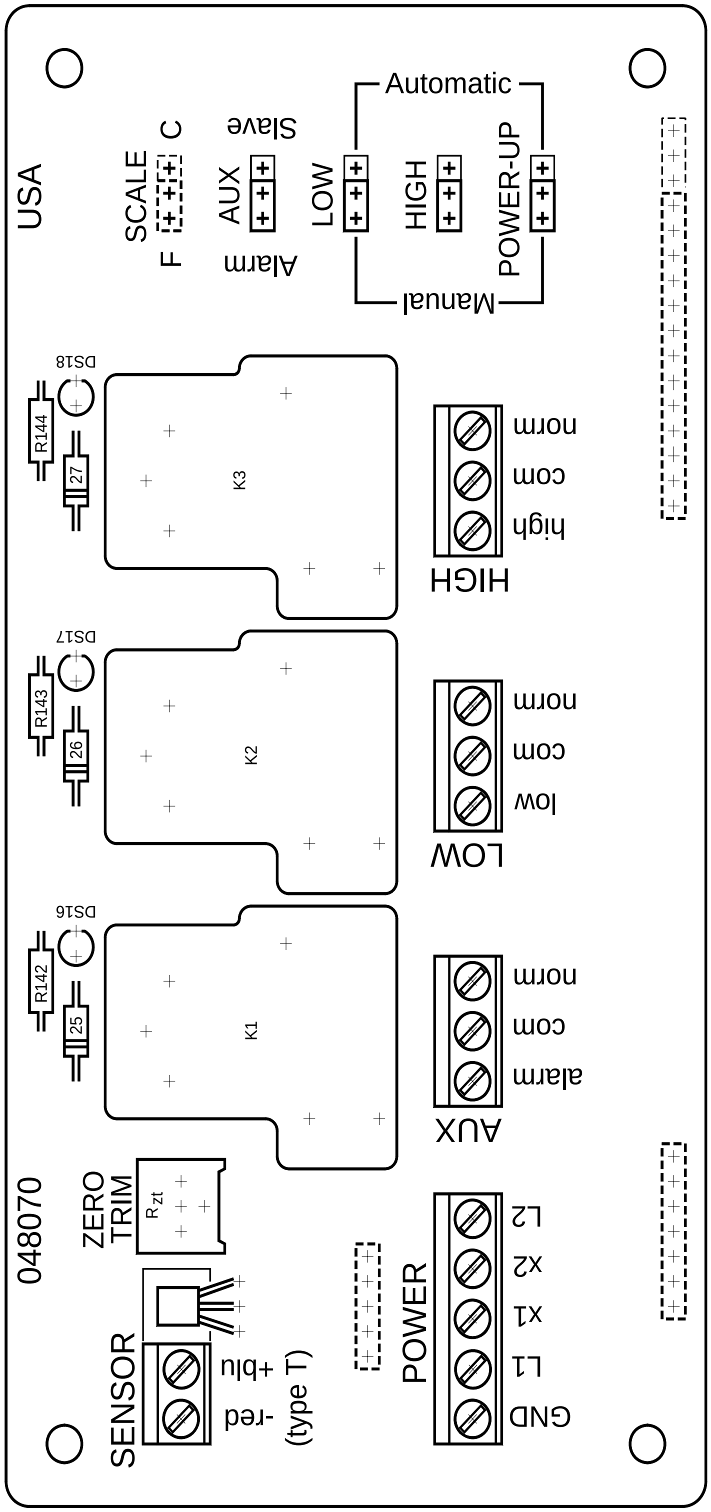
| PART # | DESC | | MFGR | MFGR'S NO | QTY | UM |
|---|---|---|---|---|---|---|
| 051053 | RESISTOR, COMP 1/4W 5% | 150Ω | ROHM | RC07GF151J | 8 | EA |
| 051087 | RESISTOR, COMP 1/4W 5% | 3.9K | ROHM | RC07GF392J | 3 | EA |
| 051097 | RESISTOR, COMP 1/4W 5% | 10K | ROHM | RC07GF103J | 1 | EA |
| 051113 | RESISTOR, COMP 1/4W 5% | 47K | ROHM | RC07GF473J | 1 | EA |
| 054041 | POTENTIOMETER, CONT | 10K | ALPH | V24PV25SB10K | 2 | EA |
| 062041 | CAPACITOR, DISC 1000V | 0.001uF | SPRG | 5GA-D10 | 1 | EA |
| 062060 | CAPACITOR, CRMC 25V | .01uF | MOUS | 21FG010 | 4 | EA |
| 063013 | CAPACITOR, TANT 35V | 1.0uF | SPRG | 199D105X0035AA1 | 1 | EA |
| 083021 | TRANSISTOR, NPN | 2N3904 | NS | KN3904 | 4 | EA |
| 091001 | IC, QUAD SCHMIT NAND | | RCA | 570-CD4093BE | 1 | EA |
| 091008 | IC, QUAD 2-INPUT GATE | | RCA | 570-CD4011BE | 1 | EA |
| 091009 | IC, DUAL 4-INPUT NOR GATE | | RCA | 570-CD4002BE | 1 | EA |
| 091010 | IC, DUAL D FILP/FLOP | | RCA | 570-CD4013BE | 1 | EA |
| 092011 | IC, BCD/7-S DECODER/DRIVER | | RCA | 570-CD4511BE | 1 | EA |
| 125001 | DISPLAY, .43" DIGIT RED (CC) | | NS | 5082-7653 | 4 | EA |
| 173003 | HEADER, RA/SR MALE 36-W | | APT | 929648-01-36 | 16 | EA |
| 173006 | RECEPTACLE, STR/SR 36-W | | APT | 929850-01-36 | 30 | EA |
| 175002 | SOCKET, IC, 14 PIN SOLDER TAI | | TI | C8914 | 4 | EA |
| 175003 | SOCKET, IC 16-PIN SOLDER TAIL | | TI | C8916-01 | 1 | EA |
| 279001 | STANDOFF, SWAGE TYPE 6-32x1/4 | | KYST | 1591-2 | 2 | EA |


A1
R91
Q12
DS8
S8
R92
R97
R90
Q14
R98
R79
Q6
DS6
S6
R80
R78
R84
Q9
DS7
S7
R85
R93
R83
Q13
R94
DS11
R62
R65
Q5
DS5
S5
R66
R63
Q4
DS4
S4
R64
R61
R52
R59
Q3
DS3
S3
R60
R57
Q2
DS2
S2
R58
R55
Q1
DS1
S1
R56
R50
USA
048051

Part Number: 048051
Drawing Number: 470585 (see Page 26)

***"TempSentry"*** CONTROL PCB ASSY

| PART # | DESC | | MFGR | MFGR'S NO | QTY | UM |
|---|---|---|---|---|---|---|
| 051059 | RESISTOR, COMP 1/4W 5% | 270Ω | MOUS | 29SJ250-270 | 9 | EA |
| 051073 | RESISTOR, COMP 1/4W 5% | 1.0K | ROHM | RC07GF102J | 1 | EA |
| 051082 | RESISTOR, COMP 1/4W 5% | 2.4K | ROHM | RC07GF242J | 8 | EA |
| 051087 | RESISTOR, COMP 1/4W 5% | 3.9K | MOUS | 29SJ250-3.9K | 10 | EA |
| 083021 | TRANSISTOR, NPN | 2N3904 | MOUS | KN3904 | 10 | EA |
| 102010 | SWITCH, PB PCB | | SHDW | 200130 | 8 | EA |
| 109005 | KEY CAP, GRY 1-LED | | SHDW | 71077 | 8 | EA |
| 121003 | LED, MIN RED DIFF T1 | | ROHM | SLH-34-VR3 | 2 | EA |
| 121009 | LED, MIN YLW DIFF T1 | | ROHM | SLH-34-YY3 | 6 | EA |
| 121003 | LED, MIN RED DIFF T1 | | ROHM | SLH-34-MG3 | 1 | EA |
| 124001 | SOUND TRANSDUCER | | MURA | PKM22EPP-4001 | 1 | EA |
| 173006 | RECEPTACLE, STR/SR 36-W | | APT | 929850-01-36 | 22 | EA |


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

Part Number: 048053
Drawing Number: 470734 (see Page 28)

***"TempSentry"*** RELAY OUTPUT PCB ASSY

| PART # | DESC | | MFGR | MFGR'S NO | QTY | UM |
|---|---|---|---|---|---|---|
| 051047 | RESISTOR, CFLM 1/4W 5% | 68Ω | MOUS | 29SJ250-68 | 3 | EA |
| 054012 | POTENTIOMETER, TRM 1T-3/8 | 50K | BRNS | 3386P-1-503 | 1 | EA |
| 081003 | DIODE, RECT 400V 1A | | SPC | 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, T1 MIN DIFF | RED | ROHM | SLR-33 UR3 | 3 | EA |
| 173002 | SHUNT, 2-CKT .1 CTRS | | APT | 929950-00 | 4 | EA |
| 173005 | HEADER, STR MALE 3-W | | AMP | 4-103321-0 | 4 | EA |
| 176006 | TERMINAL BLOCK, PCB 3-W | | PHNX | 1715035 | 4 | EA |
| 176007 | TERMINAL BLOCK, PCB 2-W | | PHNX | 1715022 | 2 | EA |

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WARNER INSTRUMENTS

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