ALTRONIC RESEARCH, INC.

P.O. BOX 249
YELLVILLE, ARKANSAS 72687-0249
U.S.A.

CALORIMETRY
MODEL 3500

MODEL 3500
DIGITAL CALORIMETRY

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CALORIMETRY MODEL 3500

LIMITED WARRANTY

We take pride in manufacturing products of the highest quality and we warrant them to the original purchaser to be free from defects in material and workmanship for the period of one year from date of invoice. Additionally, products of our manufacture repaired by us are warranted against defects in material and workmanship for a period of 90 days from date of invoice, with the provisions described herein.

Should a product, or a portion of a product of our manufacture prove faulty, in material or workmanship, during the life of this warranty, we hereby obligate ourselves, at our own discretion, to repair or replace such portions of the product as required to remedy such defect. If, in our judgment, such repair or replacement fails to be a satisfactory solution, our limit of obligation shall be no more than full refund of the purchase price.

This warranty is limited to products of our own manufacture. Equipment and components originating from other manufacturers are warranted only to the limits of that manufacturer's warranty to us. Furthermore, we shall not be liable for any injury, loss or damage, direct or consequential, arising out of the use, or misuse (by operation above rated capacities, repairs not made by us, or any misapplication) of the equipment. Before using, the user shall determine the suitability of the product for the intended use; and the user assumes all risk and liability whatsoever in connection therewith.

The foregoing is the only warranty of Altronic Research Incorporated and is in lieu of all other warranties expressed or implied.

Warranty returns shall first be authorized by the Customer Service Department and shall be shipped prepaid. **Warranty does not cover freight charges.**

PRECAUTIONS

CAUTION

The contact ratings of the enable relay are 200VDC, switching current +.5A current carrying 1.2A. When purchased in an Altronic Research load system, a buffer relay is provided for isolation and enhanced current carrying capacity. When purchased separately it is recommended that a buffer relay be utilized in the modification and installation.

CAUTION

1. **The LCD display life expectancy is dramatically reduced with exposure to UV radiation. Avoid direct sunlight. Exposure may cause rapid deterioration and subsequent failure.**
2. **The touch pad should only be cleaned with a damp cloth or a screen cleaner.**

INTRODUCTION

This handbook was prepared for technical personnel as an aid in understanding and performing installation procedures for the Calorimetry Model 3500. Personnel are considered to be skilled if they have the necessary knowledge and practical experience of electrical and radio engineering to appreciate the various hazards that can arise from working on radio transmitters, and to take appropriate precautions to ensure the safety of personnel.

SECTION I

DESCRIPTION AND LEADING PARTICULARS

1-1. **PURPOSE AND APPLICATION OF EQUIPMENT.** When RF energy is terminated into the broadband resistor network, it is transformed into heat by the resistors. Forced air is passed over the resistors, carrying away the heat.

Calorimetry techniques require measuring the rise in temperature between the cold (inlet air), the hot (outlet air) and by measuring the rate of airflow. (See Section IV Theory of Operation). Considerable detail has been given to insure high accuracy while still maintaining a rapid response system. The complete package is housed in a shielded enclosure.

1-2. **GENERAL DESCRIPTION.** The display, computer and interface board are located in an enclosure attached to the front of the load. The temperature sensors are mounted on the intake and exhaust sides of the load.

1-3. **COMPUTER ASSEMBLY.** The computer assembly consists of a Programmable Logic Controller which has a 4 input 4-to-20 ma. module. The program is stored in non-volatile memory. Display and interface functions are handled by a touch-screen Liquid Crystal Display. These devices operate on 24 VDC which is supplied by the AC to DC power supply.

1-4. **DATA ACQUISITION MODULE.** Data acquisition and conversion is performed by two modules: (1) the temperature module transforms the analog signals from the thermistors to a 4-to-20 ma. signal level. (2) The flow module converts the flow information to a 4-to-20 ma. signal level.

1-5. **SENSORS.** Airflow is determined by measuring the differential pressure on each side of the fan(s). This differential signal is converted to a 4-20 ma signal.

a. Temp Sensors

Altronic Research utilizes different temperature sensing devices for the various application requirements. RTD's are generally used in air loads and thermistors in water loads.

b. RTD

RTD's are linear over the wide operating ranges as experienced when utilized in an air load. They are interchangeable over extended ranges and exhibit excellent stability at high temperatures. They may be made up in any length which allows them to perform as an averaging temperature sensor. The low-level temperature signal is changed to a 4-20 ma signal by a transmitter.

c. Thermistor

Thermistors have a fast response to temperature changes and are available in very small sizes and produce high signal levels.

1-6. **SOFTWARE.** The program for the PLC is written in ladder logic and may be updated by a RS-232 connection from a PC or updated from a plug-in memory card. The program for the display may be updated from a PC or with a module which may be plugged in.

1-7. **ALARMS / INTERLOCKS.**

Alarms and alerts are not used in this version of Calorimetry. Alarms and alerts are available as add on options. Check www.altronic.com or call Altronic Research Inc. for updates.

SECTION II

DEFINITIONS

ACTUAL POWER
Calculated as follows: $\frac{K \times FLOW \times \Delta P}{14{,}330}$
FLOW = Inlet Area x Linear Flow Ft./Min. Measured in Cu.Ft / Min.
* K ≅ 9 Dependent on Temperature, Humidity, Pressure, Efficiency of load

DELTA TEMP
Hot temperature: temperature in degrees C. of the air that is exiting the load.
Cold temperature: temperature in degrees C. of the air that is entering the load.

FLOW
A quantitive measure of the volume of air that is passing through the load.

HOT OFFSET
A calibration number that may be used to correct any errors in the hot temperature sensors.

COLD OFFSET
A calibration number that may be used to correct any errors in the cold temperature sensor.

HOT GAIN
A multiplier to convert the temperature in engineering units to degrees C.

COLD GAIN
A multiplier to convert the cold temperature in engineering units to degrees C.

FLOW OFFSET
Used to calibrate the flow meter and represents the minimum flow measurement capabilities of the flow meter.

FLOW GAIN
A multiplier that is used to convert from engineering units to Cubic Feet Per Minute.

GAINMOD
A multiplier used to control the slope of the flow curve.

GAINPRIME
The operative multiplier which is varied by the computer based on flow temperature and programmable variables programmed into the computer.

RESET
Pressing of the reset push button will cause all default factory calibration numbers to be loaded into the system equations.

SCREEN
The screen button forces the display to change display screens.

SECTION III

OPERATION

3-1. THEORY OF OPERATION.

RF energy is terminated into a cermet film resistor network, housed in a broadband cavity. The electromotive energy is transformed into heat by resistive action. A medium flows over the resistor and carries away the heat. The amount of heat the medium absorbs is directly proportional to the applied energy, the amount of medium, and the temperature differences between the inlet and outlet streams. This describes the operation basics for both air and water-cooled loads.

Air calculations utilize the following equation with K representing the specific heat of air:

$$kW = \frac{9\text{GramCalories} * K * \text{Flow} * \text{Delta Temperature}}{14330\ \text{GramCalories}}$$

Altronic Research Inc. utilizes a unique approach which incorporates a data acquisition unit located in the RF hardened enclosure. This unit samples and scales the output from flow and temperature sensors.

Different temperature-sensing devices are used for the various application requirements. RTD's are generally used in air-cooled loads. The RTD's used are linear over the wide operating ranges as experienced in an air-cooled load. They are interchangeable over extended ranges and exhibit excellent stability at high temperatures. Airflow is determined by measuring the differential pressure on each side of the fan(s).

Measurements

On current models all temperature measurements are displayed in degrees Celsius. All flow measurements are displayed in cubic feet per minute. Power measurements auto range from watts to megawatts.

In the course of taking a measurement in air-cooled loads, the applied energy has to heat up the load resistors and the load itself. This takes several minutes and the displayed power lags behind the actual power. Air-cooled loads require 10 to 15 minutes for a stable reading. Some models of calorimetry do not have the projected power feature.

Options

The display and control capabilities may be remoted from the unit via radio link or dedicated line.

Optional communication interfaces are RS-232 and RS-485 formats. RS-232 signals may be remoted up to six meters. RS-485 signals can be remoted up to 2000 meters. Balanced line receivers and transmitters provide for high-level noise immunity.

3-2. INSTALLATION

The calorimetry system is self-contained and only requires connection to AC power. The temperature sensors are terminated in a junction box. The wires are connected to pin 3,4 of the level convertor module which is located inside the junction box. The positive wire from the PLC connects to pin (1) of the level convertor terminal block and the signal wire connects to pin (2). See Section IV for on-site calibration.

3-3. POWER CALCULATIONS

1Kw = 9.1 gm cal (K factor) * flow F X temp 14330 gm cal/KW
gm - cal = gram calories
FT^3 = cubic feet/minute
T = difference in temp hot - temp cold

SECTION IV

ON-SITE CALIBRATION

The performance of the calorimetric system is affected by altitude. When calibrated at a low altitude and operated at a high altitude the readings will be in slight error.

Additionally any restrictions imposed by obstacles in close proximity to the inlet or outlet grills can cause error readings.

The load should be installed with a minimum open space on each side that equals the length of the load. Failure to comply with these requirements will result in the outlet air bunching and flowing over the top back into the input side.

This 300 kW load has approximately 11,000 Cu Ft./ minute of air circulation. When operated at the maximum power there will be approximately 45 Degrees C. increase in the exhaust air over the inlet air temperature. This load will add one million BTU's of heat into the room/area where it is installed. It is recommended that the exhaust be diverted away from the load and any other equipment that would be affected by heat. Also sufficient make up air should be provided to replace the exhausted air.

The calorimetry readings are not instantaneous. They follow the natural log much like the charging of a capacitor. It takes (5) time constants to reach 95% of the final reading.

A time constant for this load is between one and two minutes. Therefore it would take about 10 minutes to reach the specified accuracy.

This load was calibrated at the factory and calibration settings were burned in to the "Factory Configuration". These numbers are specific for the altitude and confinements of installation at the factory. These default numbers may be reloaded by pressing the reset push button on the calibration screen.

Note: Because of the large thermal mass of the load, all measurements should be performed when the system is rising. Measurements made on a decreasing temperature will require an extended stabilization time.

Hot Offset	= 178	Constant based on –17.8 C. @ 0 deg F.
Cold Offset	= 178	Constant based on –17.8 C. @ 0 deg F.
Hot Gain	= 502	Converts eng units to degrees C.
Cold Gain	= 502	Converts eng units to degrees C.

The above settings are standards for the temperature sensors.

Flow Offset	= 0	
Flow Gain	= 124	Converts eng units to Cu Ft. / Minute.
Kt	= 9	Constant “Air”
GainMod	= 44	Changes the slope of the output power conversion curve
GainPrime		Variable determined by the computer based on the temp, raw flow signals, and program variable numbers.

Because the Power Curve is nonlinear, at least three points must be determined to insure correct calibration across the range from the minimum to the maximum power settings.

1. Apply 50 KW “No Modulation”. Allow 15 minutes to stabilize.

2. Using the equation flow =(kw ***14330)/(9***DeltaT)

   Note: Initially use the Factory Settings of 124 for FlowGain and 44 for the GainMod.

3. Adjust the Flow Gain Calibration Number up or down to give the proper flow indication on the display.

   i.e. 50 KW*14330 Cal= 716500 Cal
   9 * 6.8 = 61.2 Kt * DeltaT= cal/CuFt/Min
   716500/61.2 = 11707 cal/ Cal/Cu Ft/Min = Cu Ft./Min

4. Apply 100 KW “No Modulation”. Allow 15 minutes to stabilize.

5. Perform Step 2.

6. Adjust The GainMod number to give the proper flow indication on the display.

7. Apply 200 KW “No Modulation”. Allow 15 minutes to stabilize.

8. Compare displayed power with the applied power.

9. Small changes may be made at this time to FlowGain and/or GainMod.

   Note: Changes are not instant and will be delayed 2 minutes. Changes to FlowGain are directly proportional and changes to GainMod are inversely proportional. At this point the Flow is allowed to have variation. Make adjustments to correct the Displayed Power not the Flow.

10. Apply 200KW with 100 % modulation. Allow 15 minutes for system to stabilize.

11. Compare Displayed Power with Applied Power.

12. Make small changes to the FlowGain and/or GainMod as necessary.

    Note: Changes to FlowGain will have a small effect on the minimum power reading. Make adjustments to GainMod first.

13. Remove power from the load and allow the system to cool to ambient .

14. Apply Power 50 KW. Allow 10 minutes.

15. Record applied power and displayed power.

16. Apply 100 % modulation. Allow 10 minutes.

17. Multiply the applied power by 1.5 and record along with the displayed power.

18. Remove modulation.

19. Apply 100 KW. Allow 10 minutes.

20. Record applied power and displayed power.

21. Apply 100% modulation. Allow 10 minutes.

22. Multiply the applied power by 1.5 and record along with the displayed power.

23. Remove modulation.

24. Apply 200 KW power. Allow 10 minutes.

25. Record applied power and displayed power.

26. Apply 100% modulation. Allow 10 minutes.

27. Multiply the applied power by 1.5 and record along with the displayed power.

28. Remove RF power from the load.

29. Compare the recorded results of applied to display power. They should be ± 4% of each other. If not, repeat the calibration procedure. If the power settings are

within limits record the settings to the calibration screen on a separate label and save.

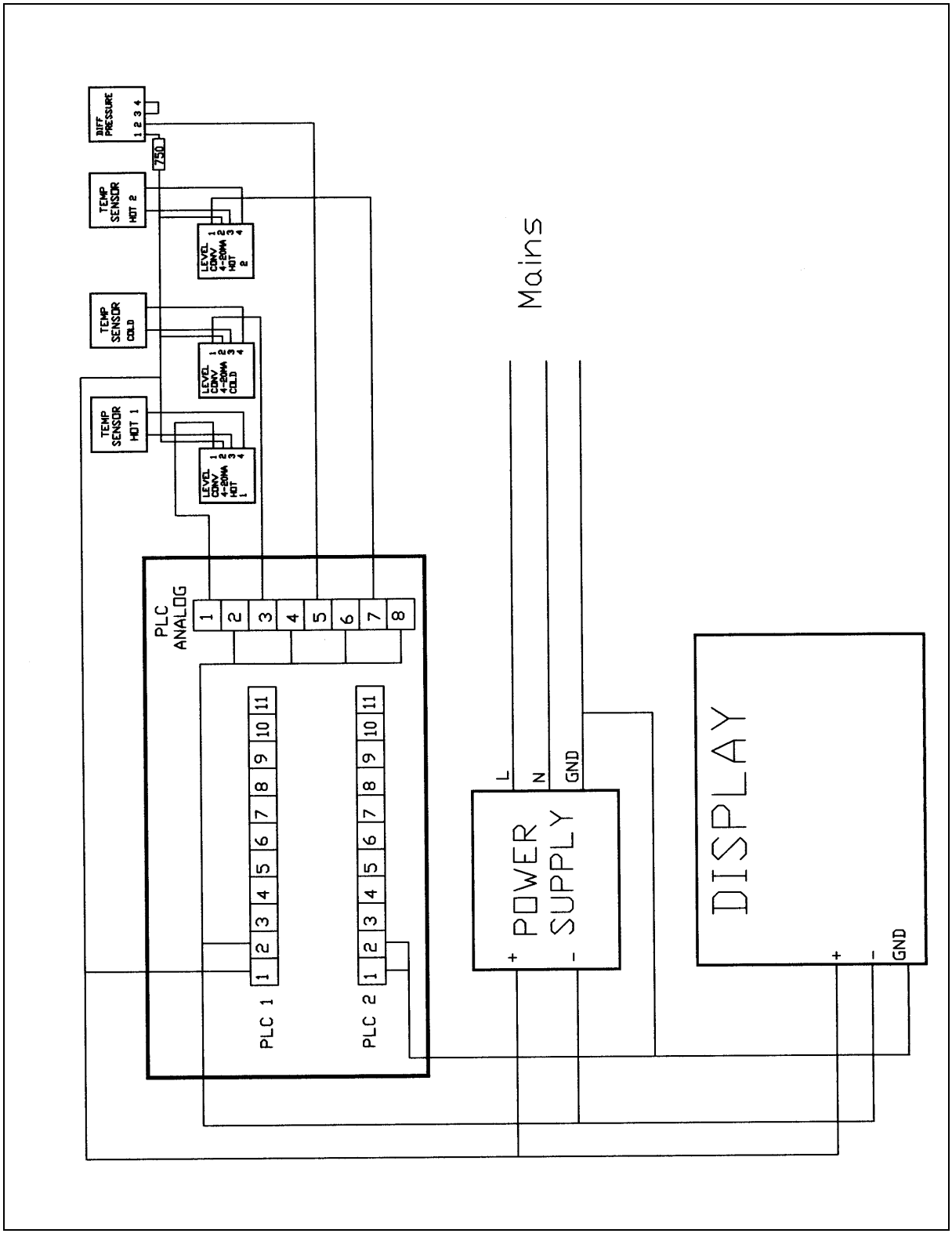
30. Should the reset button be pressed, these numbers will have to be reentered to maintain calibration.

Additional notes:

- The touch screen / display has several screens which allow programming and viewing. The first screen that is displayed only once after power on contains information for contacting Altronic Research should there be any problems.
- To advance to another screen press the start bar at the bottom of the display.
- The second screen displays the temperature, flow, and power information.
- To advance out of this screen press the screen change button at the lower left of display.
- The third screen provides an interface to enter variables into the computer.
- The data for these values is provided in the calibration section of this manual.
- At the lower left of the display is a reset button. When this button is pressed the factory settings that are burned into memory are loaded.
- When data is programmed into the individual values, they are stored into nonvolatile memory until they are reprogrammed or the reset is pressed. To exit from this screen, press the change screen button in the lower left side of the display.
- The fourth screen may be used to adjust the contrast/view angle and increment the time. To exit from this screen touch the change screen button located in the lower left of the screen.

SECTION V

SCHEMATIC



SECTION VI

SPECIFICATIONS
Calorimetry Model 3500AML

INPUT POWER

Voltage ---------- 90 - 270 VAC

Frequency Range ---------- 40 - 400 Hz

MECHANICAL VARIATIONS

ENVIRONMENTS

Operating Temperature---------- > 5°C - 40°C

Storage Temperature ---------- > - 20°

Altitude non-operating---------- <20,000 ft.

Humidity ---------- 95% R.H. (non-condensing)

Serial No. _____ **Software Revision _____**

Model 3500AML **Inspected by GLJ** **Date _____**

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SECTION VII

CALIBRATION CERTIFICATION
MODEL 3500AML Serial # 103

TEST RESULTS SHOWN ON FOLLOWING PAGES

Source power was determined utilizing voltage and current measurements with test equipment, possessing in date calibration and a total accumulated error of less than 1%.

I certify the calibration data as accurate.

Gary L. James
Altronic Research Inc.
Date: