MICROCOMPOUNDER

OPERATION MANUAL

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DACA instruments

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WARNINGS

High operating temperatures and moving parts of DACA Instruments' processing instruments are potentially dangerous; therefore the user should observe the following safety precautions and be aware of the possible dangers at all times.

OPERATOR SAFETY

Users who are to install and operate the equipment should study this Operation Manual and all referenced documentation prior to installation and/or operation of the equipment. Carefully read installation instructions and operating instructions; observe all WARNINGS and CAUTIONS.

Ensure that the equipment setup and the actual use do not present a hazard to personnel. Common sense and good judgment are the best safety precautions.

GENERAL SAFETY

The following statements apply to all users of DACA Instruments' processing instruments.

1. HIGH SPEEDS AND FORCES

Be aware at all times of moving components which are potentially dangerous due to high speeds and forces. Do not permit anyone to operate a processing system who is unaware of its function or unskilled in its use.

2. SUPPLY VOLTAGES EXCEEDING 50V

DACA Instruments designs do not permit the operator to be exposed to voltages exceeding 50V under normal operation of the instrument. However, if any covers are removed from the instrument, all safety precautions should be strictly observed when carrying out servicing procedures. Also, always disconnect the instrument from the main power source whenever checking or changing fuses.

3. ROTATING MACHINERY

The source of power for rotating machinery is electrical. Always disconnect the test instrument or equipment from the power source before removing any cover which gives access to rotating machinery, (e.g., belts, gears, screws or shafts).

4. MEDIUM AND HIGH TEMPERATURE COMPONENTS

It is essential to display a WARNING notice concerning high temperature operation whenever high temperature equipment is in use; always use special handling gear and protective clothing under these conditions. High temperature refers to all equipment with a temperature exceeding 60°C (165°F). Note that the hazard from high temperature can extend beyond the immediate area of the instrument.

5. HIGH PRESSURE COMPRESSED AIR

The MicroCompounder uses compressed air for cooling. High pressure compressed air is potentially dangerous. Always follow the operating instructions. Before releasing an air connection, disconnect the air supply and reduce to zero any system pressure and stored pressure.

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INTRODUCTION

GENERAL DESCRIPTION

This apparatus is a small (micro-) scale batch mixer originally developed by a group of scientists, designers, and machinists at DSM, The Netherlands. This equipment is of particular importance in that it allows:
1) accelerated research and development of new polymer blends, and
2) efficient studies of the effects of additives on polymers.
Its small scale allows the rapid and economical testing of the various parameters which affect the properties of the final blends.

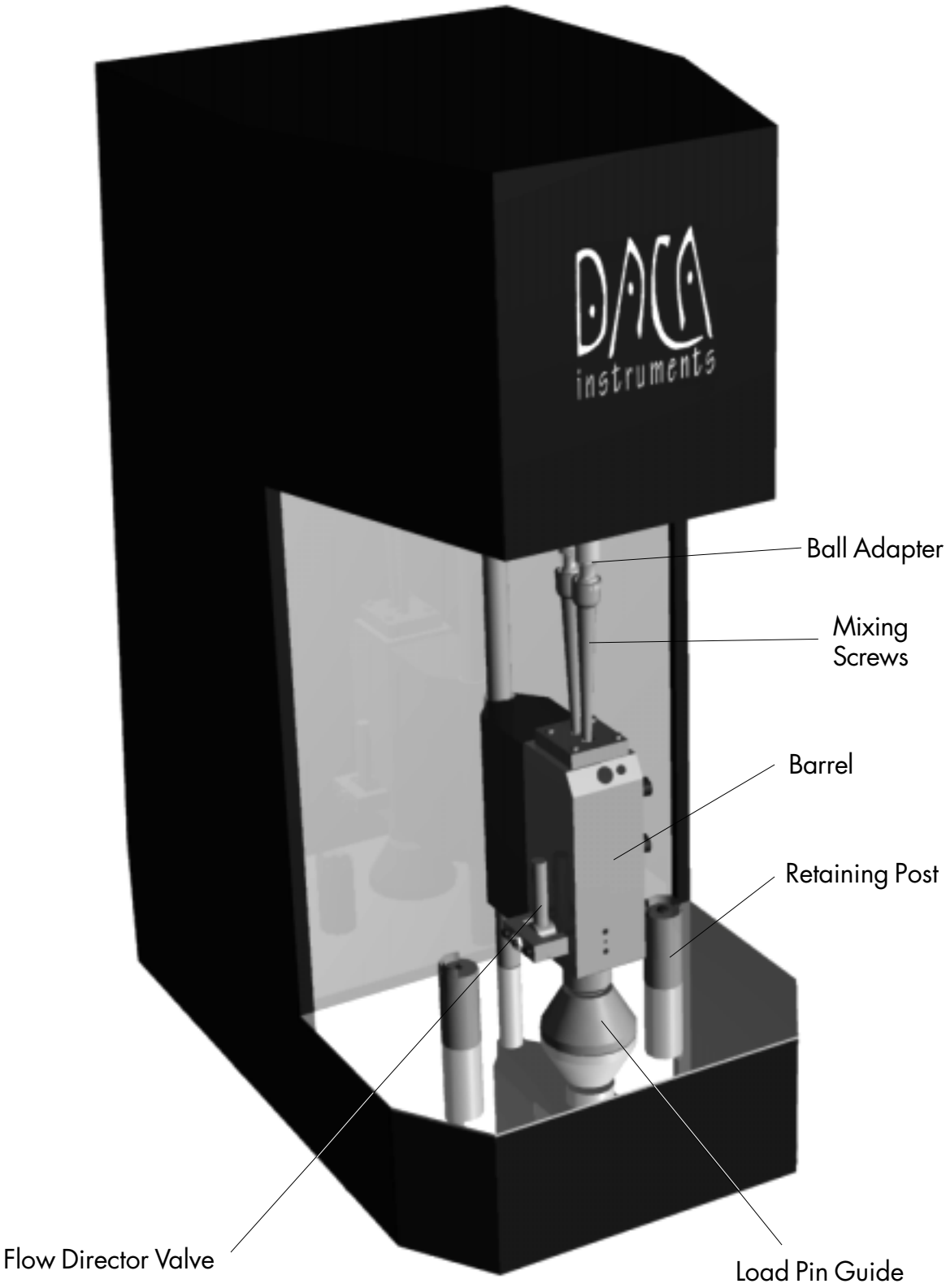
The equipment is designed to mimic the behavior of large production compounding machines. It offers excellent control of mixing temperature and speed and provides for uncoupled residence time. Residence time in commercial machines is determined by the screw length, and limited by mechanical constraints. By contrast, a unique design allows DACA Instruments' mixer to recirculate stock indefinitely.

Potentially, this equipment can be used by any polymer research facility investigating polymer blends, polymer additives, polymer compounding, or the processing of highly viscous liquids. This equipment will be of particular interest to those working with costly or hard-to-produce compounds.

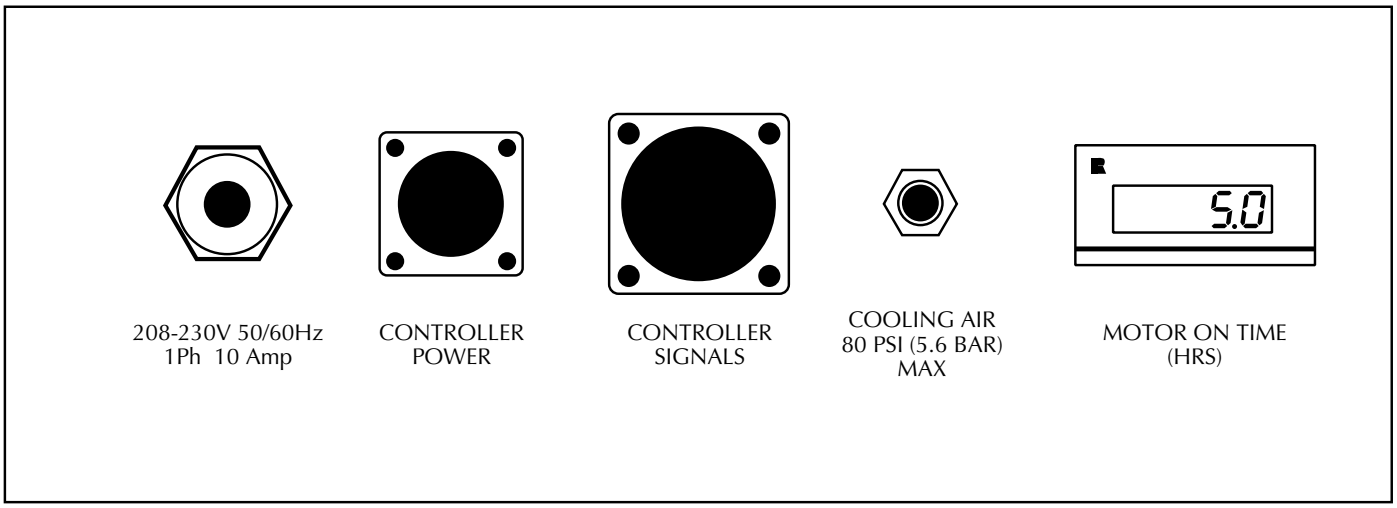
SPECS & SCHEMATICS

MIXING VOLUMES	Sample size	4.5 cc max
	Min. Unextruded	0.4 cc
HEATERS	Barrel heaters (ea. side)	400°C, (4x150 W), 220V AC
	Temperature Controls	EUROTHERM 94: Digital auto tune PID closed loop
	Thermocouples	Type K
MOTOR AND MOTION CONTROL	Motor	Baldor 1/3 hp DC gearmotor (5:1)
	Armature Voltage	180 VDC
	Speed Control	Digital control, 1 RPM increment
	SpeedRange	10-360 RPM
ADDITIONAL SENSORS	Load Sensor	0–5000 N, Limit alarm at 4500N
	Torque Display	0-6.2 N•m
ELECTRICAL	Voltage	220V AC
	Frequency	50/60 Hz
	Max. current	10A
	Phase	1
PHYSICAL	Dimensions Compounder	30 cm W x 53.5 cm D x 70 cm H
	Weight Compounder	75 Kg
	Dimensions Controller	30.5 cm W x 26 cm D x 18 cm H
	Weight Controller	4.3 Kg

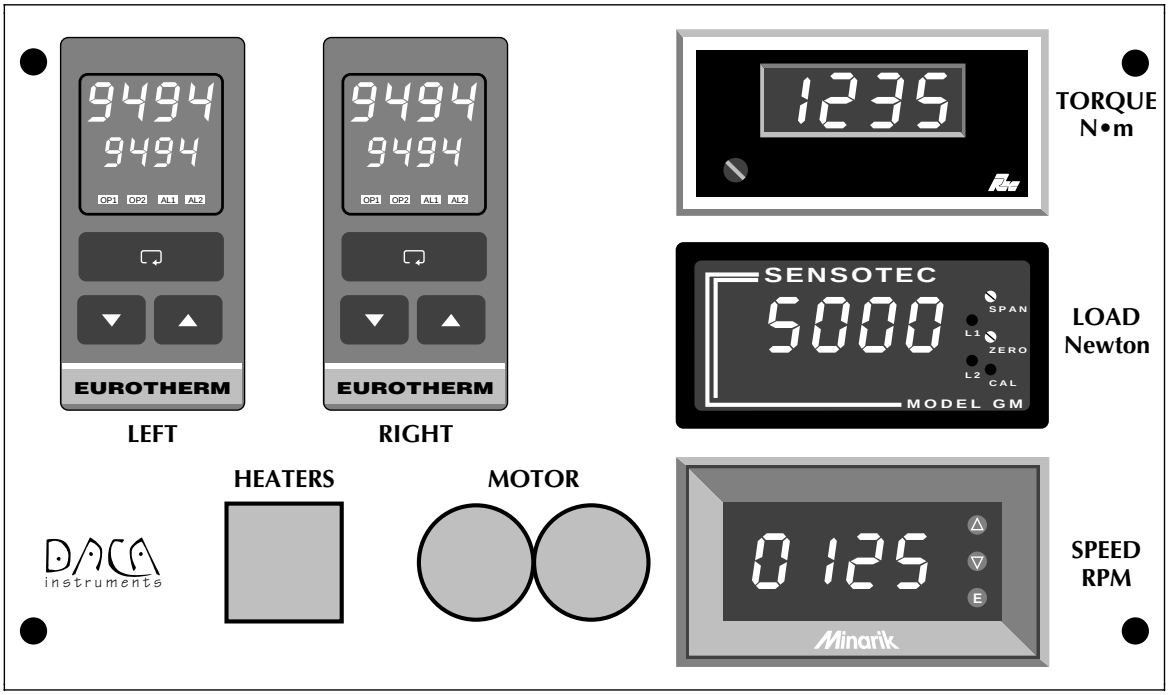
GENERAL SCHEMATIC



SCHEMATIC OF CONNECTOR PANEL



SCHEMATIC OF CONTROLLER



INSTALLATION

UNPACKING

SHIPMENT DAMAGE

Merchandise shipped is carefully packed in compliance with carrier requirements. Claims for loss or damage in transit must be made with the carrier by the customer. All shipments should be unpacked and inspected immediately upon receipt. If damage is concealed and does not become apparent until shipment is unpacked, the customer must make a request for inspection by the carrier's agent and file a claim with the carrier. Any external evidence of loss or damage must be noted on the freight bill or carrier's receipt and signed by the carrier's agent. Failure to do this will result in the carrier refusing to honor the claim. For the customer's protection, DACA Instruments' billings include insurance for damage or loss in transit.

The wooden crate should contain the following items:

- 1 MicroCompounder
- 1 Controller
- 1 Bag with 1 Kg of purging compound
- 1 Plastic package:
  - This Operation Manual
  - Quick Operation Card
  - Registration Card
  - 1 Set of interconnecting cables
  - 1 Pair of mixing screws (might be installed in the barrel)
- 1 Toolbox containing
  - 2 Filling Tools
  - 1 Tool for operating the flow directing valve
  - 1 Reverse Ring-type pliers for opening the barrel when hot
  - 1 Drill bit with handle for cleaning the exit channel
  - 1 Set Metric Hex wrenches
  - 1 Metric Hex screwdriver 6 mm
  - 1 10 mm combination wrench
  - 6 Brass brushes for cleaning the Barrel and screws:
    - 2 large, 2 small, 2 round

If any of these items is missing, please contact DACA Instruments immediately so that we may ship replacements.

INSTALLATION

LOCATION

The MicroCompounder should be set up on a leveled, sturdy table or bench. The normal operating temperature of the MicroCompounder can be as high as 400 °C (750 °F); therefore, the instrument should be placed away from other heat-sensitive equipment and high traffic areas where people might accidentally come in contact with the hot instrument.

ELECTRICAL

The MicroCompounder requires an electrical connection. The instrument operates with 220V 50/60Hz, 10Amp, single phase. The power cord has been fitted with a standard 220V plug for operation in the United States. For proper operations outside the U.S. the plug might have to be replaced with a different one.Consult your local electrical code. The wires inside the plug have been labeled for easier connection to a different plug.

OPERATOR INTERFACE

A separate controller box contains the temperature and speed controllers. This box also contains the displays for motor torque, and compounder load displays. An interconnecting cable is supplied to connect the controller to the Micro-Compounder. The cable is composed of two armored cables joined together in several places by cable ties. One of the cables carries power to the controller the other carries all the signal wires to and from the controller. The end connectors of the two cables are different to prevent misconnection.
The cables must be connected to the MicroCompounder and the controller before turning the power on. The cable is 1.5 meters long to allow placement of the controller box at a convenient location next to the compounder. The controller might also be placed on top of the compounder.

COOLING AIR SUPPLY

A fixture is provided on the back of the compounder to connect a compressed air line used for cooling the barrel. The air must be dry in order to prevent corrosion of the internal components. The normal operating pressure should be 2.8 BAR (40 PSIG). The supply line must have a valve to control the flow rate through the system and provide emergency shut off. The maximum pressure of the air must not exceed 5.5 BAR (80 PSIG). Excessive pressure will cause damage to the gas lines and solenoids inside the instrument.

General Operation

The general procedure for operating the MicroCompounder is described below. The detailed description of each step is provided in the following pages.

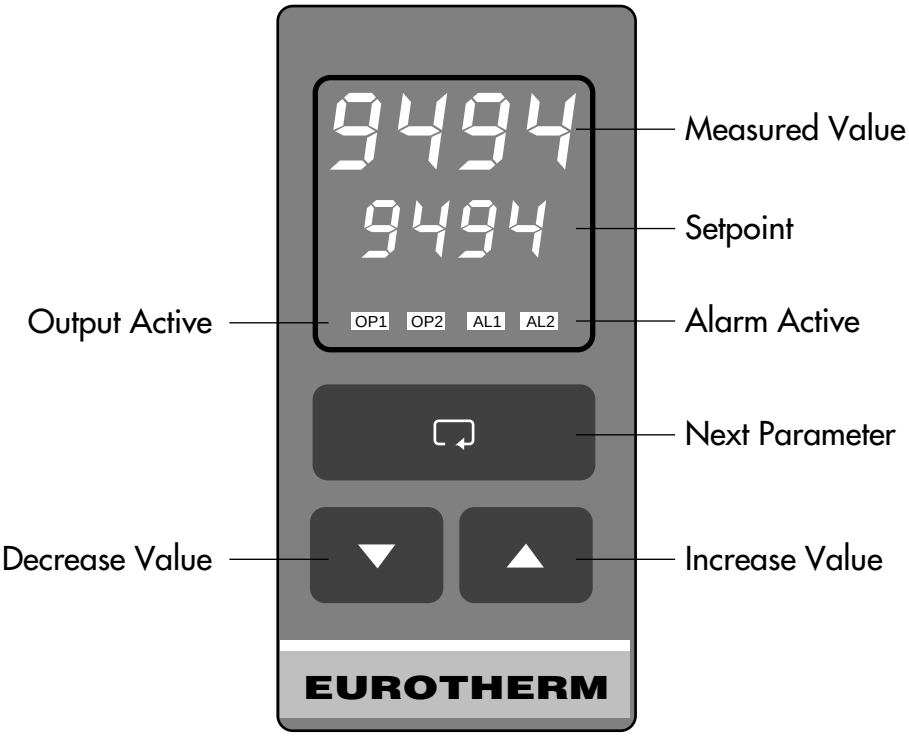
- Turn on the MicroCompounder
- Turn on and set the temperature controllers to the desired compounding temperature.
- Without turning the motor on, set the speed controller to the desired compounding speed (100 RPM recomended).
- After placing the two mixing screws in place, close the two halves of the barrel and lightly tighten the 6 locking screws using the 6 mm hex screwdiver.
- After the compounder has achieved its operating temperature, further tighten the locking screws to 34 N•m (25 ft•lb) using the long, 6 mm hex wrench provided. This will prevent leakage of the sample from the barrel during processing.
- Unscrew the supporting pin of the load sensor until the load indicator reads ≥ 50 N. **The motor will NOT start unless the load value is ≥ 50 N.**
- Close the output valve (back position). Turn on the motor and begin filling up the compounder using one of the filling tools provided.
- Compound the material for the desired length of time.
- Open the output valve (front position) and empty out the compounder.
- Open the compounder and clean out the material remaining in the compounder using the brass brushes provided. If the material compounded is too sticky (e.g. Nylon, PET) run a charge of cleaning compound through the compounder to remove the sticky material first. Any remaining cleaning compound will be easier to remove from the barrel and screws.
- Begin a new test.

TEMPERATURE CONTROL

TEMPERATURE CONTROL

Portions © EUROTHERM CONTROLS Inc.

Temperature of the barrel is controlled by two independent EUROTHEM model 94 temperature controllers. A separate power switch has been provided for the temperature controllers. The two controllers allow for independent adjustment of the temperature for each side of the barrel. However, the two temperatures must be set to the same value for proper operation of the Micro-Compounder.



The controllers have been pre-configured as follows:

Maximum Allowable Set Point: 400°C

Measured Temperature Unit: °C

Heat and Cool Control: PID control on both channels

The controller configuration and parameter values are stored in non-volatile EPROM. This memory provides data retention for the life of the controller with or without power applied. When the controller is powered up, it performs a self test to verify that all the memories and internal electronics are operating properly before controlling the temperature.

START UP AND PARAMETER SECURITY

SELF DIAGNOSTIC MESSAGES

MESSAGE*	DISPLAY CONDITION	USER ACTION/COMMENTS
tESt **1111**	Internal self test upon power up.	Replace unit if all four **1**'s do not light up or fails to go to "**8888**" Do not touch front panel during self test.
8888 **8888**	Display test after above self test. Lasts for approximately 3 seconds.	User should verify that all digits and lamps light up to prevent erroneous readings.
E E **FAIL**	Memory corruption.	Verify and correct all parameter and configuration values. If display persists, replace unit.

***** The two lines in the message box refer to what will be displayed in the upper and lower display lines of the controller. *measured value* refers to the temperature currently measured by the controller. *param. mnemonic* refers to the 2-4 letter code used for a particular parameter such as **AL** for alarm.

BASIC OPERATION

SETPOINT CHANGE

To light up the buttons: touch any key on the front panel.
To modify the set point: press ▲ or ▼ to increase or decrease the set point respectively.

PROCESS RELATED SAFETY FEATURES

MEASURED VALUE ALARM

The temperature controller has been configured for one HI temperature alarm condition:

Alarm 1: HI temperature alarm (>360°C)

When the Alarm 1 condition is reached (measured temperature = 360°C), a red annunciation LED –AL1– on the controller lights up to indicate the over temperature condition. This alarm condition is non-latching and when the temperature drops below 360°C the AL1 LED turns off.

SENSOR BREAK ALARM AND SHUTDOWN

If the controller detects that the sensor circuit (thermocouple) has failed, then the output power level is forced to 0% and the annunciation **SnSr FAIL** is displayed. Upon reinstatement of the input sensor, the controller resumes controlling with the same output power level used at the moment of the break.

A failed sensor is detected if:

- the input signal is out of the selected sensor's range
- the input is open circuit
- the controller's operating temperature is outside of the specified operating range (thermocouple inputs only)

LOOP BREAK ALARM

The temperature controller can detect if there is a break in the control loop due to a fuse burn out, heater burn out, faulty output device or loose wiring. The operator is warned by the message **LP.br.** The message is latching; resetable by touching any button on the front panel. During a loop break alarm condition, the controller output is determined by the control algorithm.

LOOP STATUS MESSAGES

MESSAGE*	DISPLAY CONDITION	USER ACTION/COMMENTS
Sn Sr FAIL	Sensor fail. Input open or reversed; measured value outside of configured range.	Vefity input sensor and connections. Message disappears when input signal is reinstated
measured value **LP.br**	Break detected in control loop.	Verify output device, fuses, wiring and heater. Check that input wiring is not shorted. Acknowledge by touching any key.
measured value **SP.rr**	Setpoint ramping in progress.	Setpoint and "SP.rr" parameter still user-adjustable during ramping.
measured value **SP 2**	Setpoint 2 selected.	Setpoint 1 may be adjusted in protected list
HHHH setpoint	Measured value greater than high sensor limit.	Unit should not be used in this range.
LLLL setpoint	Measured value less than low sensor limit.	Unit should not be used in this range
param. mnemonic **LLLL or HHHH**	Parameter value out of range. May have resulted from change of configuration code	In general, check (and reset if required) parameter values after reconfiguration

TUNING AND ADJUSTMENTS

SELF-TUNING GENERAL INFORMATION

The temperature controllers incorporate a self-tuning algorithm that automatically determines values for the PID parameters for the heating and cooling loops. The algorithm is operative when changing the setpoint or upon start-up. A unique feature of the algorithm minimizes overshoot when the tuning operation is started with the barrel at ambient temperature.

The operator can simply select tuning from the controller. The algorithm does not require that the operator load any initial PID parameter values to initialize the procedure. During the tuning operation, the message **tunE** is displayed alternately with the setpoint. When the algorithm has successfully finished tuning the loop, **tunE** is no longer displayed and the calculated parameter values are loaded into memory. These results can be inspected by the operator.

If selected, the self-tuner can automatically determine values for the overshoot inhibition parameters (high and low cutback), as well as the time setting for the loop break alarm.

The controller has been pre-tuned at the factory for optimal operation at 200 °C. If you feel that the response of the system is not adequate, it is easy to autotune the controller to recalculate the PID parameters at anytime. It might also be necessary to perform the tuning procedure to compensate for differences in the cooling air flow rate between the factory and your location.

PID SELF-TUNING PROCEDURE

USE THIS PROCEDURE WHEN THE INSTRUMENT HAS COOLED TO ROOM TEMPERATURE.

- After turning the controllers ON, dial the setpoint temperature to 180 °C (or your normal operating temperature)
- press ↵ until **tunE** shows up in the upper display
- press ▲ or ▼ until **Ht.CI** shows up in the lower display and pause
- the **tunE** message will flash in the lower display
- wait for the tuning operation to finish: **tunE** will no longer be displayed

SELF–TUNE MESSAGES

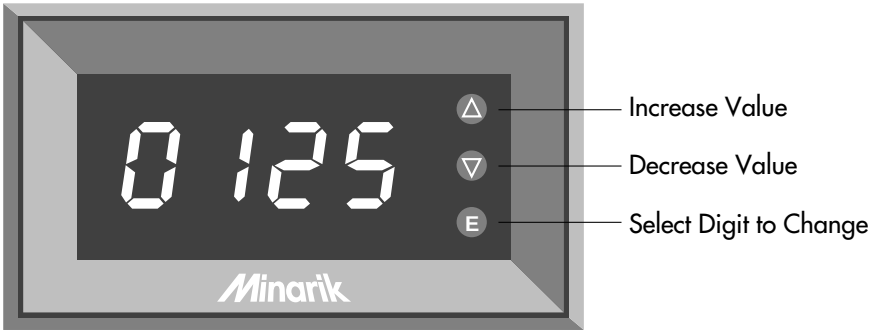
MESSAGE	DISPLAY CONDITION	USER ACTION/COMMENTS
measured value **tunE**	Self tuning in progress.	Annunciation only. Adjustment of setpoint and PID values inhibited during self tuning
tunE **FAIL**	Self tuning operation has failed because controller cannot maintain setpoint.	Acknowledge by touching any key. Remove cause of failure: e g heater fuse blown, etc.
LinE **FAIL**	Loss of controller power during self-tuning operation renders sampled data questionable.	Acknowledge by touching any key. Verify power supply Reinitiate self tuning procedure.

SPEED CONTROL

MIXING SPEED CONTROL

Portions © MINARIK Electric

The speed of the motor is governed by a MINARIK DLC400 Digi-Lok™ converter which uses a closed-loop digital system capable of controlling the motor speed precisely and reproducibly. The Digi-Lok™ converter receives a feedback signal generated by a magnetic pickup sensor that monitors a precision gear mounted on the motor belt pulley. The converter reads the velocity dependent feedback signal and corrects its analog output to bring the motor back to the set speed.



As received, the MicroCompounder has its speed set to 0000. As soon as AC power is turned on, the speed controller will be operating. When the speed controller is in its operating mode, press the ENTER push-button (**E**) once to get into the speed setting mode. Only in this mode do the digits in the display flash on and off. Flashing indicates which of the digits is able to be changed to a new value or have its value 'ENTER'ed before proceeding to the next digit.

Upon entering the speed setting mode, the leftmost digit will be flashing. Use the UP/DOWN (▲▼) buttons to set that particular digit to the desired value. Press the ENTER push-button (**E**) once again. Now the second digit from the left will be flashing. Set that digit to the desired value. Continue in this manner until all four digits have been set. When you press ENTER after setting the fourth digit, the display will hold the speed setting momentarily.

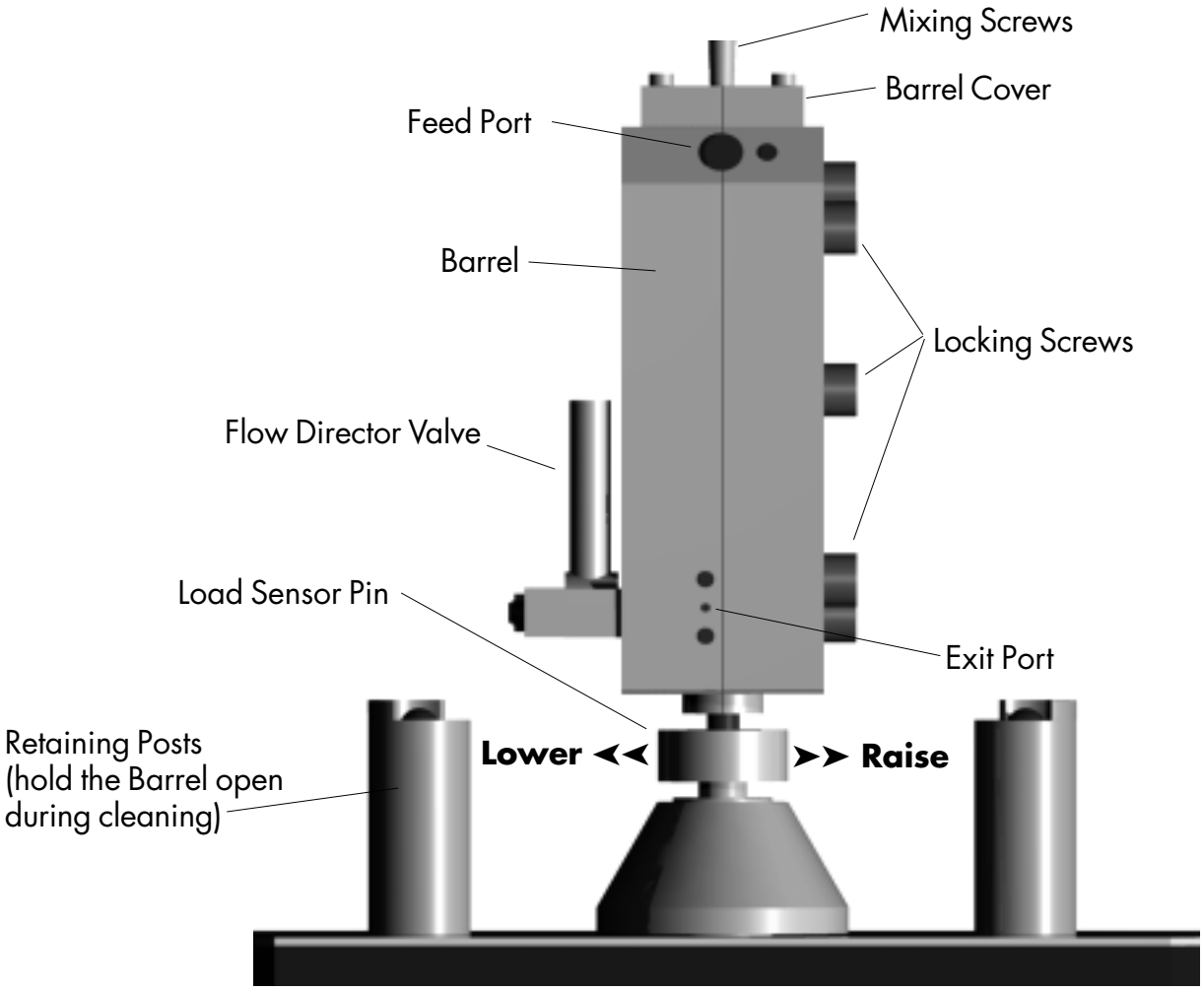
If you need to correct an entry error, press ENTER immediately again. You will once again see the leftmost digit flashing. This allows you to stay in the speed-setting mode. Scroll to the incorrect digit using the ENTER push-button and make the necessary corrections.

You can only leave the speed setting mode by pressing ENTER when the fourth (least significant) digit is flashing. Wait momentarily for the speed controller to signal its return to normal operating mode by displaying the actual speed. The digits do not flash when the speed controller is in its normal operating mode.

NOTE: Although the speed can be set to any value from 0000 to 9999, the operating range for the motor used in the MicroCompounder is 10 to 360 RPM. The motor will not operate any faster than 360 RPM regardless of the value entered. If the value is less than 10, the motor might behave erratically since a constant speed cannot be maintained below 10 RPM (20 RPM if there is no load on the mixing screws). For most experiments it is recomended to use 100 RPM.

To start the motor press the green, round button next to the speed controller. To stop the motor, press the red button. Note that there might be a slight delay between the time the green button is pressed and when the motor starts moving. This delay is particularly noticeable at very slow speeds.

The speed of the motor may be changed, using the method described above, while the motor is in operation.



MIXING AND CLEANING

WARNING! The barrel and all metal parts in contact with the barrel will be very hot during operation. Wear appropriate protective gloves and clothing to prevent injury.

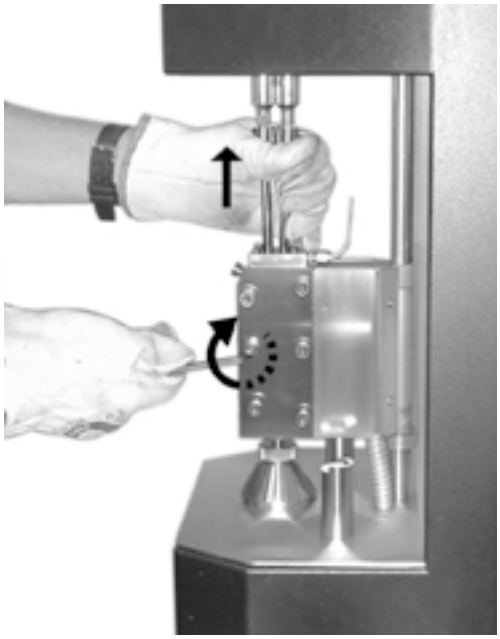
SCREWS AND BARREL SET-UP

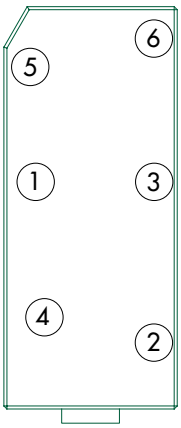
Once the processing temperature and speed have been set and the barrel has reached the desired operation temperature, the screws and barrel can be assembled to begin operation. The procedure consists of three steps:

- Installing the mixing screws onto the ball adapter.
- Closing the barrel and tightening the six screws that hold it together.
- Setting the initial value for the load sensor.

The conical mixing screws provided with the MicroCompounder have been designed to be interchangeable. The two mixing screws are identical and can be placed in the front or rear ball adapter. These mixing screws will be held on the ball adapter by a retaining ring. After the mixing screws are in place, bring their tips together and close the two halves of the barrel.

There is a small amount of free play when the mixing screws are attached to the ball adapters and it is important to keep the mixing screws at their highest position while tightening the barrel. Hold the screws and pull them up towards the top of the machine before tightening the first locking screw. If the mixing screws are too low when the barrel is tighten, the barrel might clamp on the screws and prevent their rotation.



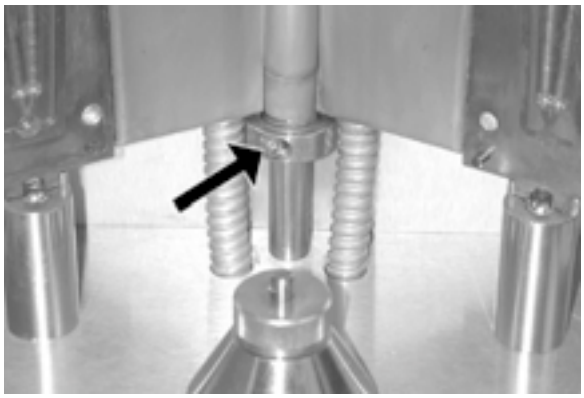


If it is difficult to close the barrel, the position of the load sensor pin might be too high. Lower the load pin by turning it clock wise (CW). After closing the barrel, tighten the six screws around the barrel to seal the compounding chamber. If the barrel is cold or just heating, use the hex screw driver to lightly tighten the screws. Once the barrel has stabilized at the desired compounding temperature, tighten the screws to a 34 N•m (25 ft•lb) using the hex wrench provided to complete the seal of the barrel. The bolts should be tightened in a cross pattern to insure a proper seal.

VERY IMPORTANT! Before loading the material to be mixed into the compounder, set the initial value of the load sensor to read ≥ 50 Newtons by turning the load sensor pin counter clock wise (CCW). This is extremely important in order to provide proper support to the barrel and minimize wear of components. The motor wil NOT start unless the load is ≥ 50 N.

HIGH TEMPERATURE OPERATION

There is a collar that maintains the proper position of the barrel on the support shaft. The position is set at the factory to allow that barrel to work properly under common operation conditions. However, at very high temperatures (>300°C) thermal expansion can cause the barrel and the mixing screws to grind against each other even when there is polymer inside the instrument. At these temperatures it might be necessary to readjust the height of the barrel. Open the barrel and let it rest against the retaining posts. Loosen the screw on the shaft collar (see photo) and lower the collar 2-3 mm (0.08-0.12") and tighten the collar screw. This position of the shaft collar will accommodate the thermal expansion of the barrel at high temperature. However, it will place the barrel lower than the top of the retaining posts. Consequently, the barrel will have to be lifted onto the post for cleaning. Please be aware that at these high temperatures fingers and skin burn very fast. Use protective clothing and high temperature gloves to operate the instrument at elevated temperatures.



LOADING THE POLYMER INTO THE COMPOUNDER

After the barrel is set up and the temperature has stabilized, the material to be compounded can be loaded in to the mixer. The MicroCompounder is capable of mixing many high viscosity materials such as molten polymers, waxes, pastes, and gels. The seal of the two halves of the barrel, when properly set, prevents leakage of any material (including liquids) loaded into the compounder. This feature is useful for dissolving polymers into solvents at high temperatures and mixing the resulting high-viscosity solution. However, in order to have the material circulate through the compounder during mixing, it must be viscous enough to develop pressure at the end of the barrel. This pressure will push the mixed material through the recirculation channel.

CAPACITY

The MicroCompounder has a maximum capacity of 4.5 cc of material (3.5-5 g depending on viscosity). For most efficient mixing, it is preferable to fill the compounder to capacity. Of this material, a minimum of 0.4 cc cannot be extruded from the barrel after compounding because it will remain trapped in the recirculation and exit channels. In addition a small amount will remain attached to the screws and walls of the compounder. Most of this remaining material can be recovered once the barrel is opened for cleaning.

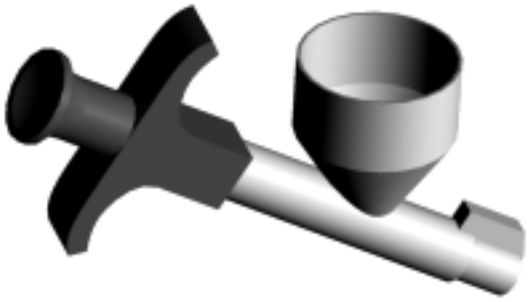
FILLING

Make sure the flow directing valve is turned to the recirculate position (back). Turn the motor on before introducing any material into the compounder. Solid polymers, particularly pellets, should be fed SLOWLY into the compounder to allow them to completely melt before they reach the bottom of the

barrel. Pellets, in general, need to melt where they first contact the mixing screws in order to be conveyed down the barrel.

If bending unmeltable powders into polymers, it is important that the two components are added to the MicroCompounder simultaneously at the desired final ratio i.e. premixed in the solid state. This is particularly important if the concentration of the unmeltable solid is high (>40% by vol). The blended material needs to flow at all stages. If a glob of unmeltable powder reaches the return channel before is blended into the polymer, the compacted powder will block the channel and the MicroCompounder will not work properly. This situation might also cause an quick raise of the load or torque and the machine will stop. Increasing the mixing speed (>200 RPM) and introducing the components slowly into the compounder will also help the processing of highly loaded blends.

Two filling tools have been provided to aid introducing material into the compounder. The tool with an attached funnel is used to introduce pellets and powders into the compounder. The funnel tool can be loaded with powder or pellets prior to attaching it to the compounder. Once the tool is into the feeding port it can be locked into place using the locking screw. This will prevent the filling tool from coming out of the filling port when the material is being pushed into the compounder.



The tool without the funnel is useful for pastes and waxes. In the latter case, the paste can be loaded into the tool using a spatula and then “injected” into the compounder.

NOTE: As the material is introduced into the compounder, the force measured by the load pin will increase. The final load will depend on the viscosity and amount of material. If the load exceeds 4900 N at any time, a safety alarm in the load sensor will automatically stop the motor. This safety mechanism will prevent damage to the bearings in the gear box due to excessive load. In addition, if the viscosity becomes high enough to exceed the torque rating of the motor, another safety device will reduce the motor output. In this case, the motor will automatically resume operation when the viscosity is reduced. If any of these two conditions is encountered, stop the experiment and manually remove the material from the compounder (see instructions for cleaning).

Once all the material has been introduced into the mixer, remove the filling tool from the entry port and cover the port with the filling plug. This plug will push any material remaining in the filling channel into the compounder and will prevent any material from coming out of the filling port during mixing.

NOTE: The filling port plug has been machined to precisely fit the inner curvature of the barrel at the insertion point. It is machined together with the barrel and cannot be replaced without replacing the barrel. DO NOT LOSE IT.

MIXING

The design of the MicroCompounder allows unlimited residence time of the material during compounding. Usually 5 minutes mixing time is enough to compound most materials. At the end of the compounding time, turn the flow

director valve to the outflow position (front) and collect the compounded material from the exit port. After the material has been extruded from the compounder, stop the motor and clean the barrel.

WARNING!

It is recommended that cleaning of the screws and barrel be performed while the compounder is at the processing temperature for the resin. WEAR PROTECTIVE GLOVES, PROTECTIVE CLOTHING, AND SAFETY GLASSES to prevent injuries.

CLEANING

Cleaning the screws and barrel of the compounder can be accomplished by:

- opening the barrel and manually cleaning the screws and barrel walls, or
- running purging compound or clean resin through the compounder.

If cross-contamination between tests does not affect the results of the experiments, cleaning is not required and the second sample can be loaded into the compounder after the first one is extruded. Carefully load the second sample. Slightly less material will be needed due to the small residue left in the compounder from the previous experiment.

If it is important not to cross-contaminate the material being compounded from one experiment to the next, it is necessary to open up the barrel and manually remove any unextruded material from the return channel, the barrel walls, and the screws. As mentioned previously, a *minimum* of 0.4 cc of material will remain trapped in the return and exit channels and will not be extruded from the compounder. Additional material will remain in the compounder if the resin is particularly sticky or the screws are worn out. To remove this remaining material by hand, begin by removing the six screws that hold the barrel closed and open the barrel until the halves are held firmly in place by the two retaining posts. A tool (ring-type plier) is provided to facilitate opening the barrel while it is hot.

Remove the screws from the ball adapters and clean them with the brass brush provided. Do not use steel or other brushes made of hard metals since they will scratch the surfaces of the screws and barrel thus reducing their lifetime. Remove the major portions of leftover material from the return channel and barrel using a small pair of tweezers. The rest can be removed by using the brass brushes provided. Use the smaller (softer) brushes when possible.

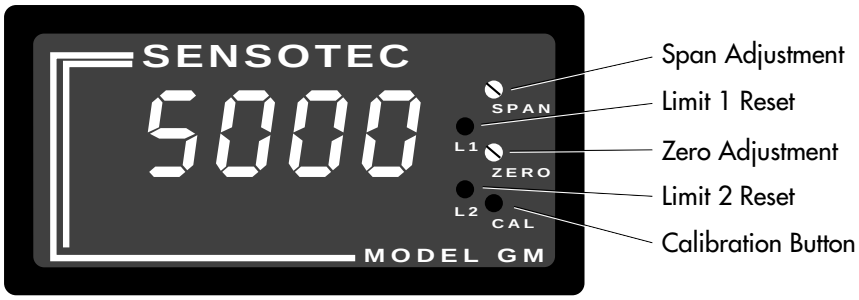
Pay particular attention to the bottom of the barrel near the flow director valve and the feeding port. The exit port can be cleaned using the provided small drill bit with the brass handle. Carefully push the drill bit from the exit hole towards the flow valve while rotating clockwise to “drill” out any material remaining in the channel.

If the material compounded is very sticky, it is easier to remove it from the compounder by running one or two charges of purging compound through the mixer. After the compounded material has been extruded, close the flow director valve (back position) and fill the compounder with purging compound. Mix this material for five minutes and extrude it as described above. If the processing temperature of the material being tested is > 250 °C, introduce the purging compound at the processing temperature then lower the temperature of the compounder to 180 °C to increase the cleaning efficiency of the purging material. Mix at the lower temperature for five minutes and extrude. After the purging compound is extruded, open the barrel and manually clean it as described above.

OTHER INDICATORS

LOAD INDICATOR

Because of the conical design of the MicroCompounder, high pressures will be generated at the narrow end of the mixer during operation. For a constant volume of material compounded, the pressure generated will be proportional to the viscosity of the material and to the processing speed. This pressure creates a downward force that pushes the barrel down and away from the mixing screws. This force is monitored using a load sensor placed at the end of the supporting pin and is displayed in the LOAD indicator in the controller box. The force is measured and displayed in Newtons and it has a range of 0–5000 N. The load sensor is also a safety device which monitors the process load and cuts power to the motor if the load exceeds 5000 N. The main purpose of this limit is to protect the instrument, particularly the bearings inside the gear box.



BASIC OPERATION

- After closing the barrel and tightening the locking screws, unscrew the supporting pin of the load sensor until the load indicator reads 40N. This minimum load insures proper contact of the supporting pin with the barrel, and minimum displacement of the barrel during the test.
- Proceed with the experiment as described in the general operation section.

SAFETY LIMITS

Two limits are preprogrammed into the indicator.

L2 (Low limit):

This limit has been programmed to activate at 50 N. Once activated, a light will turn on below the L2 reset button to indicate that the motor can be turned on.

L1 (High limit):

This limit has been programmed to activate at 4500 N. Once activated, the **motor will stop,** thus ending the test. In addition, a warning light will turn on below the L1 reset button. After the test stops, the load will drop resetting the limit. Two conditions will cause the load to exceed the allowed setting:

- the viscosity of the material being compounded is too high.
- the return channel is blocked preventing proper recirculation of the material through the mixer.

In either case, the barrel should be opened and manually emptied before continuing with other tests. Do NOT continue to compound the material which triggered the alarm since damage to the compounder will occur.

CALIBRATION

Some adjustments might be necessary from time to time to maintain the load indicator working within the proper parameters. These include adjusting the FINE ZERO and FINE SPAN if they have changed. Allow the instrument to warm up for 15 minutes before making any adjustments.

FINE ZERO ADJUSTMENT

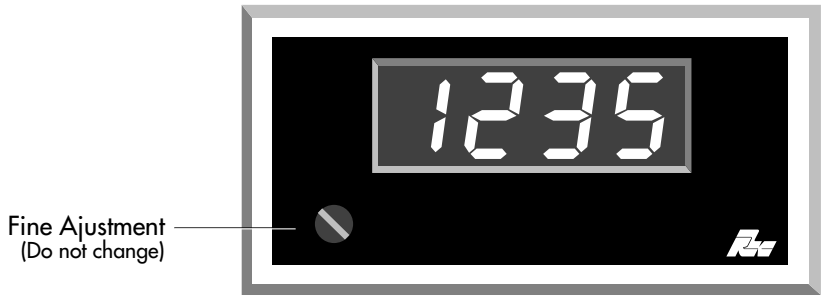
The load transducer usually has a small amount of zero drift as a result of temperature change at the transducer itself. If the indicator does not read zero when the barrel is open and no load is placed on the load pin, the transducer can be readjusted to zero by changing the position of the ZERO adjustment screw with a small screwdriver.

FINE SPAN ADJUSTMENT

After the FINE ZERO is readjusted, press the CAL button to determine if the span is correct. With the CAL button pressed, the indicator should read _____. If the reading is different change the position of the SPAN adjustment screw with a small screwdriver until the display reads _____. Release the CAL button and verify that the display returns to zero. Repeat both steps if necessary.

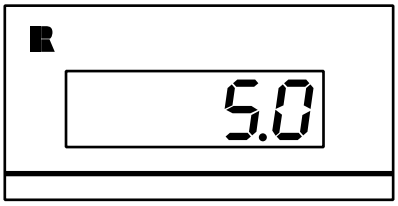
TORQUE INDICATOR

Another useful parameter to monitor during processing is the torque output by the motor since it gives an indication of the mechanical energy put into the system. The torque indicator used for the standard model MicroCompounder gives a close approximation of the motor's torque output by monitoring the current drawn by the motor and converting it to a torque reading. For the DC motor used the torque output is proportional to the current used by the motor. The speed of the motor is controlled by the voltage applied to the motor. The indicator is set to display 6.2 N•m (max. motor torque) when the current drawn by the motor is 2 Amps. In addition to being an approximation, this reading does not take into account any mechanical losses due to the drive geometry, or the gear box.



MOTOR ON TIME INDICATOR

An hour meter has been included in the back of the compounder to keep track of the time that the motor is on. This information is useful to time oil changes of the gear box and perform other regular maintenance of the MicroCompounder.



MAINTENANCE

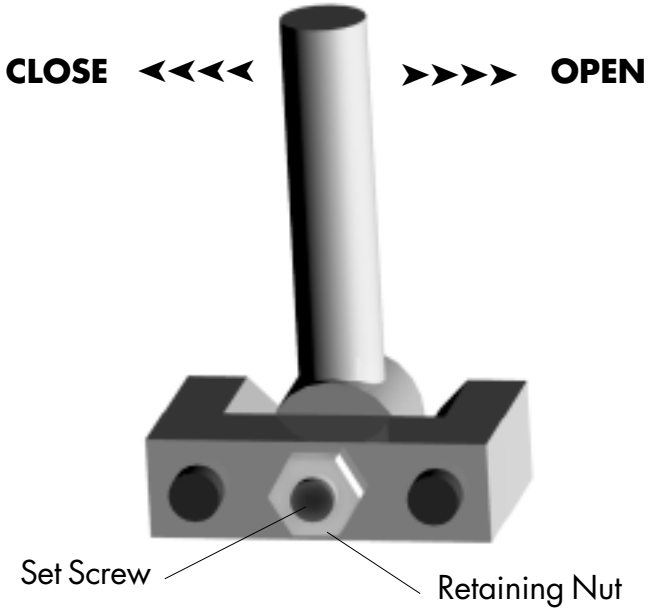
Maintenance of the MicroCompounder is relatively simple. There are only four general maintenance areas:

- cleaning of body and screws
- lubrication of screw coupling
- lubrication of gear box
- replacement of brushes in the motor

CLEANING

Periodically the barrel should be cleaned thoroughly to remove all polymer particles attached to any of the surfaces and screw holes. Use the brass brushes provided to aid with the cleaning. Steel tools (except brushes) may be used taking extreme care not to scratch the surfaces.

If the flow directing valve becomes hard to operate at any temperature, polymer residue might be trapped in the cavity of the valve. The valve can be removed for cleaning by first removing the bracket that holds the valve in place. The valve should be removed by pulling it out of the barrel while gently rotating it back and forth. It is easier to remove a sticky valve by heating the barrel to the melting temperature of the polymer trapped in the channel.



WARNING: DO NOT PUSH THE VALVE FROM INSIDE. Doing so will damage the inner surface of the valve and allow the sample to leak through the exit port during tests.

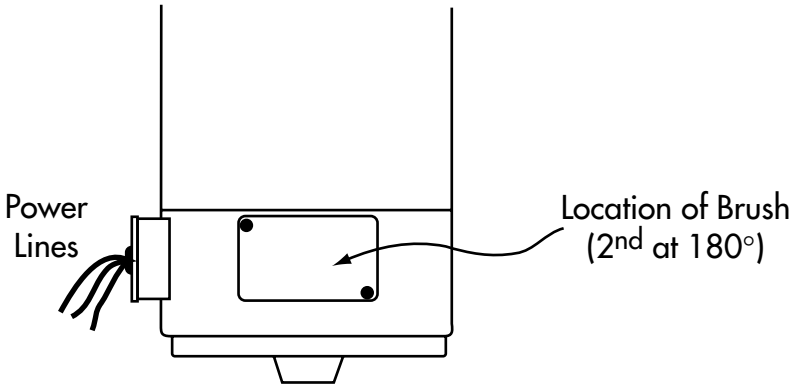
After cleaning and reassembly, the closing force of the valve might have to readjusted to prevent leakage of polymer from the exit port during a test. To adjust the valve, the set screw that maintains the exact position of the valve must be tightened. Loosen the retaining nut and tighten the set screw. For this adjustment, it is helpful to run a test sample of polyethylene and observe for leakage as the set screw pressure is increased. Do not overtighten the set screw. After the valve is properly set, retighten the retaining nut of the set screw. If the leakage persists, the valve might be worn out and need replacing.

MIXING SCREWS

The coupling between the screw and the ball adapter must be lubricated to insure proper operation of the coupling. Use a high temperature grease such as Lubriplate™ when the existing lubrication has been removed.

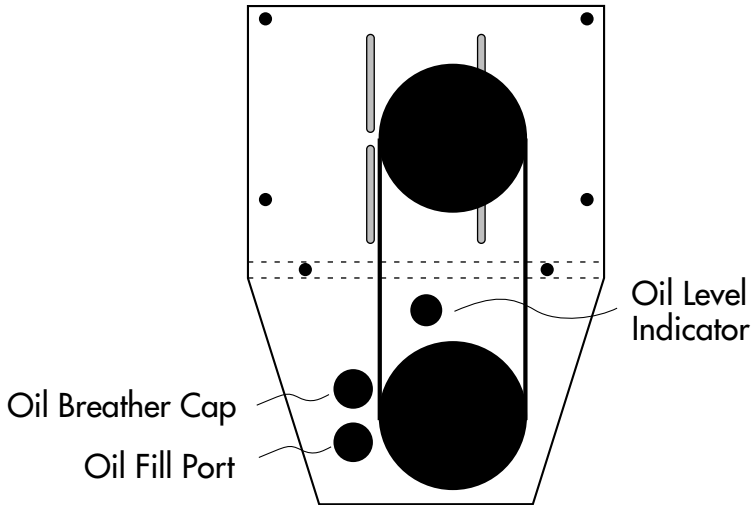
ELECTRICAL MOTOR

The brushes for the motor should be checked every six months to determine their wear status. Because of the position of the motor, only one of the brushes can be checked easily. Remove the back cover of the MicroCompounder and disconnect the cable to the fan. Remove the small rectangular cover at the bottom of the motor and remove the brush. If the brush is less than 7 mm long, replace BOTH brushes.
BRUSH TYPE: AB01
Please contact DACA Instruments for replacement brushes and additional instructions.



GEAR BOX

The gear box is filled with lubricating oil. This oil should be replaced after 4000 hr of motor ON time. The level of the oil should be checked regularly using the indicator located on top of the MicroCompounder near the drive belt. Open the rear cover and disconnect the fan. Locate the indicator as shown in the figure and pull out the cap. Verify that the oil level about 35 mm (1.4") from the top of the tube. If the oil level is low, add oil through the oil fill port.



Additional oil might be obtained through DACA Instruments. To replace the oil the chassis must be removed to access the drain plug in front of the gear box. For instructions contact DACA Instruments.

RECOMMENDED OILS:
USA: Mobilgear 630 (Mobil)
Europe: Mobilgear 630 (Mobil), Omala Oil220 (Shell), Spartan EP220 (Esso), Energol GR-XP200 (BP).
Other countries:
Lubrication Oil: CLP 220 DIN 51517 (mineral oil)
Viscosity according to: ISO VG220 DIN 51519
Capacity: 1.3 liters

TROUBLESHOOTING

If you experience any problem with the MicroCompounder, please contact DACA Instruments for assistance.

DACA Instruments
P.O. Box 991
Goleta, CA 93116
Phone: +1 (805) 967-6959
FAX: +1 (805) 967-4331

MOTOR PROBLEMS

The drive system for the MicroCompounder is comprised of several components. Power is provided by a permanent magnet, DC gear motor. The motor is rated at 1/3 Hp with a base speed of 1725 RPM. A 5:1 gear reducer coupled to the motor reduces the top speed to 360 RPM. The current to the motor is controlled by a Pulse Width Modulated (PWM) driver. This small electronic component is located inside the mixer chassis. A speed controller, located on the control box, uses a speed feedback signal from a magnetic RPM transducer and regulates the voltage supplied by the driver to the motor. The output shaft of the motor is coupled to the parallel shaft gear box by means of an 8 mm pitch timing belt and pulleys. The parallel shaft gear box converts the single input from the motor to two parallel, co-rotating shafts that drive the mixing screws. There is a small speed increase in this gear box but it is compensated by the way the speed is read at the motor timing pulley.

Most problems, if they do occur, will appear at initial start-up of the speed controller system. The more common problems are described below.

If your speed controller fails to operate as it should after you have followed the suggestions found in this list, contact DACA Instruments for technical assistance.

IF THE MOTOR WILL NOT RUN:

1. Verify that the load sensor pin has been adjusted to display ≥ 50 N on the load indicator before turning on the motor. (see page 20.)

2. Check that the screws are not clamped by the barrel. Loosen the locking screws and press the start button. (The Load must be ≥ 50N). If the instrument operates this way, follow the instructions on page 19 before re-tightening the locking screws.

3. Check the fuse located in the PWM driver. The driver is located to the left of the base of the motor.

4. Check the status of the brushes in the motor.

5. The speed control may be damaged. Disconnect the speed controller from the driver. Connect a 10 KΩ speed adjust potentiometer to the driver. Check whether the motor runs properly. (Contact DACA instruments for further instructions.)

6. The motor may be defective. Test system with another motor.

IF THE MOTOR WILL NOT LOCK INTO SPEED:

1. Confirm that the pickup sensing tip of the speed sensor is directly over the center of the gear teeth and is no farther than 0.3 mm above the teeth.

Extensive shaft runout is the most common cause of this type of problem.

2. Check continuity and shielding of pickup leads. Electrical noise can cause the speed controller to attempt corrections that are not justified.

IF MOTOR RUNS AT TOP SPEED REGARDLESS OF THE SET SPEED:

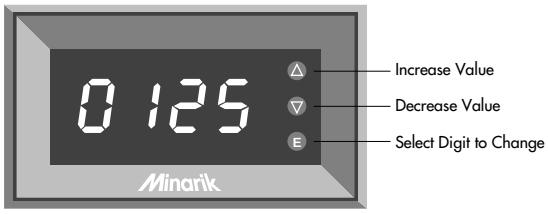
1. There may be an electromechanical defect in the pickup, a break in the pickup leads, or in the leads from any sensor. Also, check the alignment of the pickup over the gear. Without accurate feedback information fed to the speed controller, the system cannot be expected to operate correctly.

2. The driver may be defective. Replace the speed controller with the speed potentiometer and check whether the motor runs properly.

IF MOTOR RUNS AT A FIXED MULTIPLE OF THE SET SPEED (OVER OR UNDER):

If the motor runs at a fixed multiple of the set speed, i.e. motor set at 100 RPM but runs at 25 and set at 200 runs at 50, the parameters of the speed controller have been changed. To set the correct parameters:

A) Turn off the MicroCompounder.
B) Press and hold the button **E** on the DLC400 and turn on the instrument.



When the machine is turned on a sequence of numbers will be shown on the controller. To see a particular number of the sequence release the **E** button. Now every time you push the **E** button one of the four parameters will be shown and can be adjusted. The main difference of the four parameter (in addition to their value) is the number of periods in the parameter. The correct values for the four parameters are:

0026.
000.7.
00.2.6.
0.0.0.0.

C) The periods cannot be changed (i.e. 00026. cannot be converted into 00.2.6.). If the value of any of the parameters has changed you can use the ▲ or ▼ key to adjust it.

D) To return to normal operation after all the parameters are correct, press and hold the **E** key an then press the ▲ key. You will be in the speed setting mode at this point with one of the digits blinking. Set the desired speed (page 17) and turn on the motor.

HEATERS AND TEMPERATURE CONTROLLER PROBLEMS

HEATERS

If either side of the barrel fails to heat up after turning on the temperature controllers, check the fuses located inside the MicroCompounder in positions 5 and 6 of the terminal barrier. The fuses are rated 4 Amps, fast blow.

Under normal operating conditions, the barrel (closed with mixing screws in place and no polymer) should heat from room temperature to 180°C in 7-8 min. If the heating time is several minutes longer it is possible that one or more of the heaters is damaged. Another good indicator of heater damage is uneven heating of the two sides of the barrel. Because the two sides are turned on at the same time, they should reach the final temperature almost at the same time (unless the two set points are not the same). The message **LP.br** should be displayed on the temperature controller if one of the heaters is faulty.

The temperature controllers can detect if there is a break in the control loop due to a fuse burnout, heater burnout, faulty output device or loose wiring. The operator is warned by the message **LP.br.** The message is latching, resettable by touching any button on the front panel. The controller assumes a break in the control loop if the output to the heaters remains at 0% or 100% and the measured value moves less than 1/2 of the **ProP** setting (proportional band) towards the setpoint within the setting of **LP.br** (loop break time). These two values are determined during the autotune procedure.

CAUSES:	SOLUTIONS:
Fuse Burnout	Check the appropriate fuse inside the compounder. Replace if necessary.
Heater damaged or burned out	Replace heater. Contact DACA Instruments for instructions.

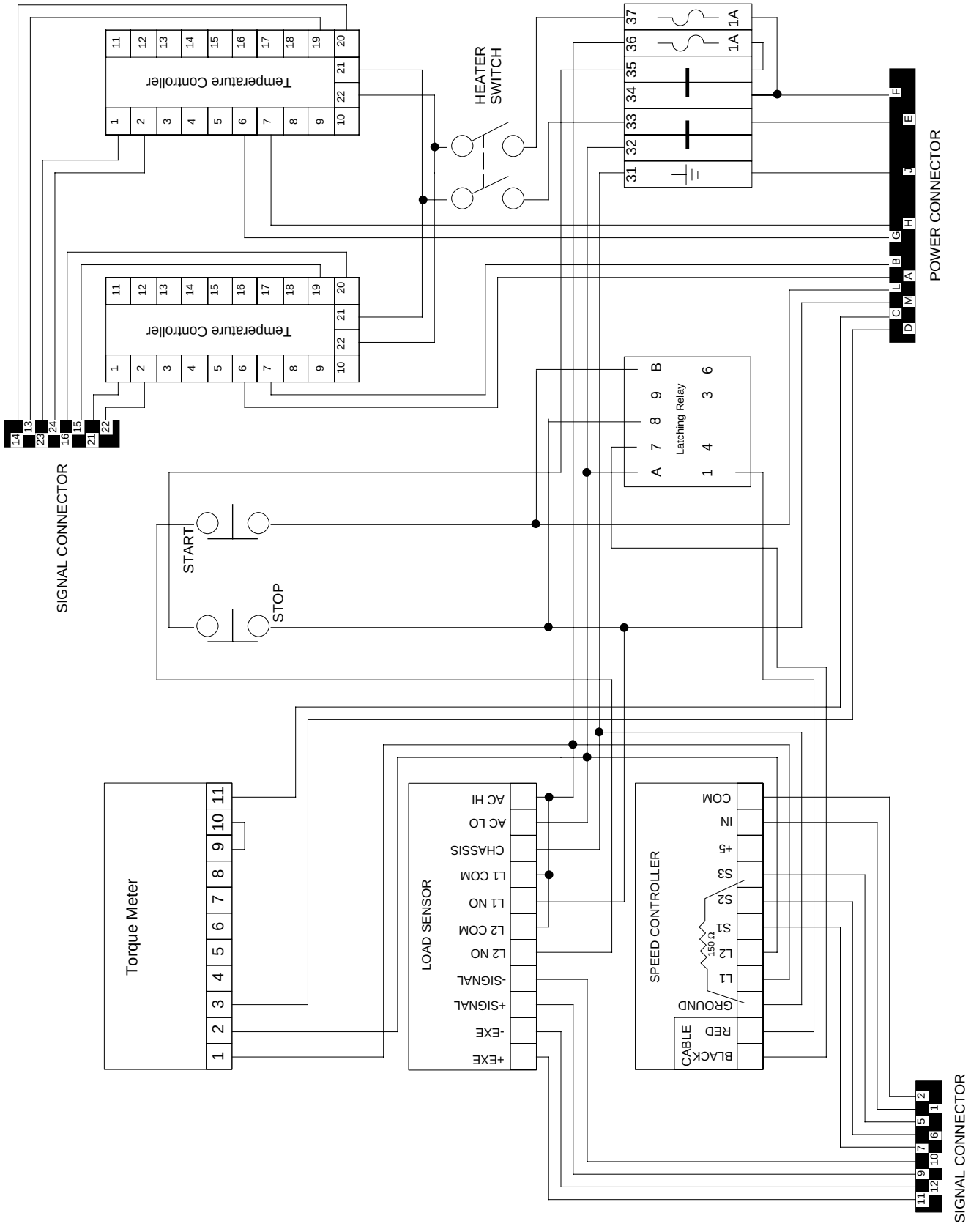
TEMPERATURE CONTROLLER

If the temperature controllers do not turn on when the front panel switch is pressed, check the fuse located inside the controller box in position 57 of the terminal block. The fuse is rated 1 Amp, fast blow.

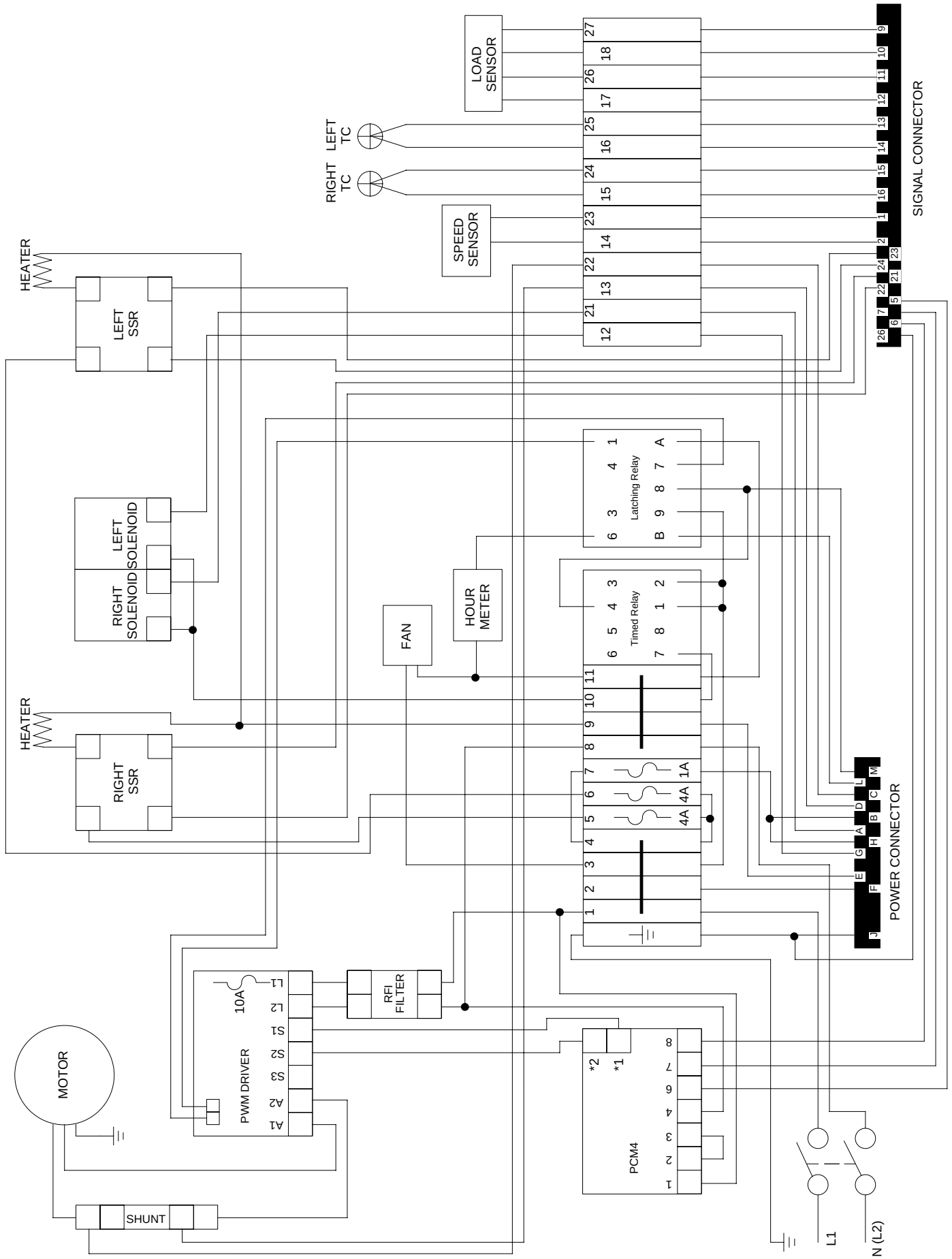
Please refer to the tables in the temperature control section for descriptions of the messages that might show up on the temperature controller during faulty operation.

APPENDICES

APPENDIX A: SCHEMATICS OF THE ELECTRICAL WIRING



COMPOUNDER


LOAD SENSOR
LEFT TC
RIGHT TC
SPEED SENSOR
SIGNAL CONNECTOR
HEATER
LEFT SSR
LEFT SOLENOID
RIGHT SOLENOID
HEATER
RIGHT SSR
FAN
HOUR METER
Latching Relay
Timed Relay
4A
4A
1A
POWER CONNECTOR
MOTOR
PWM DRIVER
10A
RFI FILTER
PCM4
SHUNT
L1
N (L2)

APPENDIX B: WARRANTY

Our Pledge

It is the goal of DACA Instruments to have every article bearing the DACA name give you, the Customer, complete satisfaction. To achieve this end, we maintain the highest standards for our workmanship and materials, and for the inspection of our products. If the article you have purchased should experience any problem during its lifetime, contact us and we will do all we can to fix the problem. (We will fix it almost for free during the first year.) However, if you abuse the article or accidentally "drop it on your foot," it's your problem!

PLEASE COMPLETE AND RETURN THE WARRANTY CARD WHICH IS INCLUDED WITH YOUR INSTRUMENT SHIPMENT. Although it is not a requirement to validate the warranty, it will allow us to send you (and not the purchasing department) information about new products, as well as modifications to the product you purchased.

LIMITED WARRANTY

DACA Instruments warrants this equipment to be free of defects in materials and workmanship for a period of thirteen (13) months from date of shipment. DACA's Warranty adds an additional one (1) month grace period to the normal one (1) year product warranty to cover handling, shipping and set-up time. This ensures that our customers receive maximum coverage on each product. Our liability under this warranty is limited to the repair and replacement, at our expense, of any defective item or part thereof with a similar item or part thereof free from defect. This warranty does not apply to any equipment altered by Customer or which malfunctions because of Customer's fault or negligence or to components which experience normal wear. If during the warranty period the equipment malfunctions and the Customer contacts DACA Instruments, describing the problem being encountered, DACA Instruments will analyze the problem to the extent possible and either advise of corrective action that the Customer can perform or request the return of the equipment to DACA Instruments for factory repair. If factory repair is required, Customer will return the equipment in accordance with DACA Instruments' instructions at Customer's expense. Upon receipt, DACA Instruments shall either repair the equipment or replace it with an equivalent unit(s), and return such equipment to Customer at DACA Instruments' expense. THE WARRANTIES CONTAINED IN THIS PARAGRAPH ARE IN LIEU OF ALL OTHER WARRANTIES, AND NO OTHER WARRANTIES WHATSOEVER, EXPRESS OR IMPLIED, INCLUDING THE WARRANTIES OF MERCHANTABILITY OR FITNESS, APPLY TO THIS EQUIPMENT, AND NO EXPRESS WARRANTY OR GUARANTY, EXCEPT AS MENTIONED ABOVE, GIVEN BY ANY PERSON, FIRM OR CORPORATION WITH RESPECT TO THIS EQUIPMENT, SHALL BIND DACA INSTRUMENTS.

This warranty gives the Customer specific legal rights, and the Customer may also have other rights that vary from state to state, province to province, or country to country.

LIABILITY

These units are inherently dangerous and are intended to be installed and used only by qualified personnel. Our liability is conditioned upon the installation, operation, maintenance, storage, service and repair of the item in accordance with written plans and instructions prepared or approved by us. In no event will DACA Instruments be liable for any damages, including any lost revenue or other indirect, incidental, special, consequential, punitive or exemplary damages arising out of the use or inability to use equipment purchased from DACA Instruments. By accepting this equipment, the Customer will assume all liability for any damages which may result from its use or misuse by the purchaser, his/hers/its employees or by others. No warranty extended herein will apply if such unit is installed or used by unqualified personnel. Further, the customer agrees that any liability of DACA Instruments for all claims if any shall not exceed the amount actually paid by customer.

Further, the Customer and/or its End Users shall indemnify and hold harmless DACA Instruments from all loss, damage, costs and expenses of whatever nature, including

attorney's fees, arising from or in any way connected with any injury to person or damage to property resulting from an unauthorized modification or alteration of the Product.

PATENTS: The sale of any product or products by DACA Instruments pursuant to this order does not convey to the Purchaser any license, by implication, estoppel, or otherwise, respecting any patent, trademark or trade name claims or rights of DACA Instruments covering said product or products or any combination thereof with or without other devices or elements.

MODIFICATIONS TO THE TERMS OF SALE: No addition to, deletion from, nor modification of any of the provisions of the Terms & Conditions of Sale of this order shall be binding upon DACA Instruments unless acknowledged and accepted in writing by DACA Instruments. Any change made by DACA Instruments will be deemed accepted by Customer unless, within ten (10) days from written notice of such change, Customer notifies DACA Instruments. Any waiver of the Terms & Conditions of Sale shall not be deemed to be a continuing waiver or a waiver of any other default or of any other of these Terms & Conditions of Sale, but shall apply solely to the instance to which the waiver is directed. Any agreed upon modifications shall be specified on both the Customer's purchase order and DACA's order acknowledgement document.

MISCELLANEOUS PROVISIONS: This Agreement is entered into, shall be governed by, and is to be construed according to the laws of the State of California.Any dispute, controversy, or claim arising out of or relating to the enforcement, interpretation, or alleged breach of this Agreement shall be submitted to and resolved by binding arbitration in the Santa Barbara County, California before one (1) neutral arbitrator appointed in accordance with the Commercial Arbitration Rules of the American Arbitration Association and judgment upon the award may be entered in and enforceable by any court having jurisdiction. In the event that any matter respecting this Agreement is submitted to arbitration or if either party hereto files suit to enforce and/or interpret this Agreement, the prevailing party in such proceedings shall be entitled to reasonable attorney's fees and costs. In addition, jurisdiction and venue of any claim filed to enforce and/or interpret this Agreement shall lie with the appropriate State of California court in the County of Santa Barbara

The parties hereto agree that if any provision of this Agreement or the application thereof is held to be invalid, then such invalidity shall not effect any other provisions of this Agreement or the application thereof and to this end the provisions of this Agreement are declared severable.

This Agreement contains the entire agreement of the parties concerning any and all matters described herein, and supersedes any prior or contemporaneous agreements with respect thereto.

DACA instruments

NOTES