Stirred Reactors and Pressure Vessels

Designing and Building Quality Pressure Apparatus for Over 100 Years

Chapter 4

This pdf is chapter four of our Catalog 4500. Please refer to all five chapters to make the proper equipment choice for your needs.

Controllers

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Temperature Controllers

4842 PID Temperature Controller with Expansion Options

Microprocessor technology has brought dramatic improvements to the field of temperature control in recent years. Yesterday's on/off and current proportioning controllers have been replaced with entry level controllers with 3-mode, PID, control.

PID Control

PID (Proportional - Integral - Derivative) control can rapidly bring a system to a desired temperature with little or no overshoot and smooth, continuous regulation. These controllers are now self-tuning so that they can set the proportional band, compensate for any offset and adjust the proportional action to ensure that the temperature in the controlled system will be held at the set point with minimal deviation.

Prior to the advent of these modern controllers, heating baths, block heaters, special thermocouple placements and similar hardware and techniques were required to produce acceptable control for many applications. But with the anticipatory and adaptive nature of these modern controls, special heaters and special control systems are now reserved for only the most unusual and difficult control applications.

Ramp and Soak Programming

This control option allows the operator to program a time and temperature profile into the controller for automatic execution. This can consist of a series of different temperature settings and the length of time each is to be held. The rate of change from one setting to another can also be controlled if the changes are within the capability of the heating and/or cooling system. An additional feature provides for control of the approach to a critical temperature when over-shoots cannot be tolerated. A visual display prompts for all programming and timing functions.

Cascade Control

This control option utilizes two temperature sensors: One internal and one external to provide superior performance in difficult control systems. It is particularly effective for heating systems with large thermal lags, such as thick walled vessels or vessels with glass or PTFE liners. Cascade control is also for systems where the contents of the vessel have a small heat capacity when compared with the vessel itself. By monitoring both the internal and external temperatures a cascade controller prevents the external temperature from exceeding the internal temperature by a margin large enough to induce significant over-shoots.

Separate Heating and Cooling Control Loops

Parr controllers actually have two separate PID control loops; one for heating and a second one for cooling. The second loop with its own self-tuning parameters can be used to activate a solenoid valve to control the flow of coolant through an installed cooling coil.

Series 4840 Modular Controllers

The Series 4840 Modular Controllers are offered in three different models from which the user can select either a simple temperature controller or an expanded control system. Various enhancement modules can be added for monitoring and controlling the temperature, pressure and stirring speed in Parr reactors.

Model 4842 PID Controller

The 4842 Controller is a full feature, microprocessor based fully digital temperature control system offering PID control loops for both heating and cooling.

Model 4843 Ramp and Soak Controller

The 4843 Controller adds Ramp and Soak temperature profile programming to the features of the 4842 Controller.

Model 4844 Cascade Controller

The 4844 Controller is a dual element controller equipped with the Cascade control algorithm in addition to PID control loops to handle very difficult control applications. Parr does not recommend selection of this controller without first discussing your application with a Parr technical representative.

Model 4843 Temperature Controller, PID, Ramp and Soak, with Expansion Modules

Control Module Specifications	
All Parr control modules share the following specifications*	
Operating Range**	0-600° C
Digital Readout Resolution	1° C
Digital Set point Resolution	1° C
System Accuracy	+/-2° C
High Limit Alarm	Digital
Thermocouple Burnout Protection	Yes
Thermocouple**	Type J
Optional Communications Module***	RS232C
Size	1/8 DIN Horizontal

*In order to provide our customers with the best available technology in a rapidly changing market, Parr reserves the right to change meters and specifications where appropriate.

**Other ranges and other sensors including Type K, Type T thermocouples or RTD sensors are available on special order.

*** For primary temperatures only.

Series 4840 Modular Controllers, Continued...

Connection Panel Series 4840 Controller, 230 volt

Connection Panel Series 4840 Controller, 115 volt

In addition to the primary temperature control module, all series 4840 controllers provide:

- **Load Relay.** This relay is rated for heater loads up to 25 amps.
- **Motor Speed Control.** This control module drives the variable speed DC motors used in Parr series 4500, 5100, and 5500 reactors. A rheostat is provided on the front of the controller for setting the stirring speed. Potentiometers are provided on the control board to set the maximum stirring speed and the maximum current delivered to the motor.
- **3-Way Heater Circuit.** In addition to full power and shut off, this circuit allows the operator to select 50% power output for better control at lower operating temperatures.
- **Lock Out Relay and Reset.** This relay interrupts power to the heater should an alarm condition be sensed in the primary control module or in the high temperature or pressure display modules.
- **Expansion Modules.** Up to four expansion modules can be installed and integrated into the controller.
- **Plug In Connections.** Sockets are provided for quick coupling of both the reactor heater and the solenoid valve module (optional) for control of cooling water.
- **Switches, Fuses, Breakers and Connectors.** These are provided for full protection and easy operation of the reactor.

Enhancement Options

Option 1
TDM

Option 2
PDM

Option 3
HTM

Option 4
AMM

In addition to a choice of three individual temperature controllers in the 4840 series, there are various enhancement modules which can be added to these controllers to monitor and/or control the temperature, pressure and stirring speed in Parr reactors. These modules will be installed at the factory if specified when the controller is ordered, or they can be installed later by the user in pre-cut openings in the cabinet that otherwise are closed with blank covers. All necessary fittings and mounting hardware are furnished with each module.

Option 1—TDM Tachometer Display Module

This module provides a means for continuously monitoring the stirring speed in Parr reactors, offering a particularly valuable feature since all reactors are normally equipped with variable speed motors. It consists of a bright digital readout to be installed in the controller cabinet and connected to an optical wheel and sensor mounted on the driven pulley assembly in the overarm. The digital display will show the stirring speed with 1 rpm resolution and +/- 5 rpm accuracy. When ordering this option for field installation be sure to provide the model number and serial number of the reactor on which the tachometer is to be installed so that the proper hardware can be furnished.

Option 2—PDM Pressure Display and Cut-off Module

This module provides a digital readout for continuously monitoring the pressure within the reactor, plus a back-up safety feature which will shut down the heater if a pre-set maximum pressure is reached. Pressure is displayed with 1 psi resolution and 10 psi accuracy on a bright LED digital readout, normally calibrated from 0 to 2000 psig. Higher or lower ranges are available by special order. The safety cut-off feature offers excellent protection against accidental over-pressurization by allowing the user to set a maximum pressure which, if reached, will activate a lock out relay and shut down the system heater immediately.

The signal for the pressure display is generated by a transducer in a stainless steel housing mounted on the reactor near the Bourdon tube pressure gage. For applications involving environments corrosive to stainless steel, users should consult with the Parr engineering staff regarding possible corrosion protection arrangements. When ordering this option separately or installed in a Series 4840 Controller, always specify the reactor on which the transducer will be installed so that the proper hardware can be furnished.

Option 3—HTM High Temperature Cut-off Module

This module provides a completely redundant high temperature safety cut-off which will shut down the heater in case of an unusual malfunction in the primary control system. Each Series 4840 Controller has a high temperature safety cut-off built into the control system, but this feature depends upon the proper functioning of the primary sensing thermocouple and the temperature measuring circuitry. To guard against any possible malfunction in this primary system, the optional high temperature cut-off module offers a completely independent secondary (on/off) controller operating with its own thermocouple, digital display and wiring, which will shut down the system if an operator-set maximum temperature is reached.

When used with any Parr micro or mini reactor, this module requires a dual thermocouple consisting of two thermocouples sealed within a single sheath and installed in the single thermocouple opening. For all other Parr reactors the module operates from a second thermocouple inserted into the thermowell together with the basic control thermocouple. When ordering this option separately or installed in a Series 4840 Controller, always specify the reactor on which it will be used so that a thermocouple of the proper style and length can be furnished.

The HTM option also provides a means for measuring additional temperatures in the reactor system, multiple HTMs can be installed.

Enhancement Options, continued...

Option 4—AMM Ammeter Display Module

This module provides a means for continuously monitoring the current being drawn by the stirrer motor. Since the motor speed control will provide a constant stirring speed at any given setting, changes in the current drawn by the motor will correspond to changes in the viscosity of the reactants in the vessel. This will be a useful option for users who want to monitor the progress of a polymerization reaction in which there is a viscosity change as the reaction proceeds.

Option 5—(A) Analog Outputs

Analog outputs for recording the measured data are available for the tachometer, pressure, high temperature and ammeter modules as well as for the main temperature control modules. Multiple ranges can be provided for each output, giving the user a choice of either 0-5 volt, 0-10 volt, or 4-20 mA linear signal. If this feature is desired, it must be specified when ordering any of the above modules or controllers.

Parr can also furnish controllers made by other manufacturers if a user has a preference for a particular brand, or if he requires a controller with special functions not available in a Parr unit.

Inquiries are always welcome.

Option 6—CM Communications Module

This option is available for the primary temperature controllers. It adds a RS232C digital communications port to only the primary temperature control module within the controller. This digital communications link can be used to set or change all parameters within the temperature control module and to transmit the temperature to an attached computer. It does not communicate with any of the expansion modules (tachometer, pressure display, ammeter or high temperature cut-off) which may be installed in the controller. It is the user's responsibility to write all code for the RS232C communication. As described in the previous section, an analog output can be provided for users who wish to record temperature data from the primary control module.

Option 7—SVM Solenoid Valve Module

This module provides a solenoid valve and all parts needed to assemble an automatic flow control system for controlling the flow of coolant through a cooling coil in any reactor. It usually is installed in a cold water line with a flow connection to the cooling coil and an electrical connection to an output socket provided at the back of the 4840 controller. This connection is driven by its own PID control loop. This system is particularly advantageous for controlling exothermic reactions, holding temperatures below 150° C or cooling the reactor at the end of an experiment.

Ordering Information

	Catalog No.	Voltage
Model 4842 Controller with PID Control	4842EB / 4842EE	115 v.a.c. / 230 v.a.c.
Model 4843 Controller with Ramp and Soak Control	4843EB / 4843EE	115 v.a.c. / 230 v.a.c.
Model 4844 Controller with Cascade Control	4844EB / 4844EE	115 v.a.c. / 230 v.a.c.

Enhancement options for the above controllers are identified by the symbols shown below. When ordered with a controller, add the symbol(s) for the option(s) to the catalog number for the controller (e.g. 4842EB-TDM-PDM). When ordered separately, use the symbol as the catalog number.

TDM	Tachometer Display Module
PDM	Pressure Display Module
HTM	High Temperature Cut-off Module
AMM	Ammeter Display Module
SVM	Solenoid Valve Module
CM(A)	Communications Module Analog
CM(D)	Communications Module Digital RS-232C

The suffix (A) indicates the module is eqiupped with an analog output. Specify either 0-5 V, 0-10 V, or 4-20 mA.

All Series 4840 Controllers require an A472E, Type J thermocouple with an A470E2 extension wire which are furnished with each Parr laboratory reactor.

Series 4830 Temperature Controller

Parr now offers a compact temperature controller which can be used on Series 4560 Mini Reactors, Series 4590 Micro Reactors, Series 3910 and 3920 Shaker type Hydrogenation Apparatus as well as the Series 5500 High Pressure Compact Reactors for which it was developed.

These controllers provide dual PID (proportional-integral-derivative) heating and cooling control. The control module is 1/16 DIN in size. The controller includes a load relay suitable for switching heater loads of up to 1000 watts. A motor speed control suitable for either 1/8 or 1/4 hp motors is included along with the speed control rheostat. Output sockets for both heating and cooling control are provided. A lock-out relay is included to disable the heater if the high temperature alarm is tripped.

Catalog number 4835 identifies the set-point version of this compact controller. Catalog number 4836 identifies the model with Ramp and Soak programming capabilities. Users who wish to program their reactor to automatically step through a preset temperature profile will want to select the 4836 controller.

There are five principal differences between the Series 4830 Controllers and the Series 4840 Controllers. These are:

1. The Series 4840 Controllers use a large 1/8 DIN controller with a larger display.
2. The Series 4830 Controller are limited to heating loads of 1000 watts or less. The 4840 Controller can handle heating loads up to 3500 watts.
3. The Series 4830 Controllers can accommodate only one expansion module whereas the 4840 Controllers can accept up to four. For the 4830 Controllers this will usually be a tachometer display module.
4. Communications modules are not available for the 4830 Controllers. An analog output is available for the 4836 Temperature Controller and the optional expansion module.
5. The 50% heater output is not available for the Series 4830 Controllers.

Series 4846 Data Acquisition System

This PC based data logger system targeted at users of the 4840 Series Controller, which incorporates modules providing analog outputs of temperature, pressure and stirring speed. It can accommodate up to 8 analog inputs (0-5 VDC only) and uses a 12-bit A/D converter.

The PC based software provided with this unit will operate on current systems running the Microsoft Windows operating systems. The software provides the following features:

- A real time display of up to 8 channels. Each channel can be scaled by the user-provided slope and intercept values. User definable text is used to identify each channel reading.
- Two strip chart panels are provided for the real time trending of key channels. The user can define both the y-axis scale and the x-axis time base.
- Data logging to a disk file. All channels can be logged to a disk file at a user specified time interval. The file is formatted in a comma-delimited manner that makes it easy to import into any spreadsheet program for further analysis or reporting.
- Four totalizing type channels are provided. These channels can be used to integrate or accumulate the value of any of the 8 input channels over time. This feature is useful on systems incorporating mass flow meters or controllers for gases. The total amount of gas passing through the device can be displayed and logged.

One BNC patch cable (P/N: A1335E) is required for each input channel to be used. The patch cord (10 feet long) is connected between the analog output at the rear of the 4840 Series Controller and the break out box of the data logger system.

A demonstration program illustrating these features is available. The data logging system is CE compliant.

4870 Process Controllers

4870 Process Controller with 4875 Power Controller and PC

The Parr model 4870 Process Controller has been developed to provide an integrated stand alone control system for controlling either a single reactor with multiple feed and product controls or multiple reactors operating independently or in parallel.

The Parr 4870 Process Controller combines into a single turnkey system the following component parts:

1. Honeywell UMC-800 universal multi-loop controller.
2. SpecView Plus SCADA software.
3. Power controllers for handling heating, cooling, safety and motor control devices.
4. System set up with graphical user interface configured to individual requirements.

Control Module

The control module of the Parr 4870 Process Controller is a Honeywell UMC-800 universal multi-loop controller.

Input / Output

The control chassis has been designed to accept up to 16 input or output modules. Depending upon the type, each module contains between 4 and 6 individual inputs or outputs, fully isolated from one another. The modules available to tailor the controller to the users application include:

Input Modules. The analog inputs are of universal type and are most commonly used for thermocouple or RTD temperature sensors, strain gage type pressure transducers, motor current monitoring and similar devices with mV, V, or resistance inputs. Input isolation, cold junction compensation, and burnout protection are incorporated into the circuitry.

The digital inputs can be logic inputs or contact closures. These are typically used for sensing valve positions or conditions of safety devices.

Module Type	*Individual I/O per module*	*Maximum Number of Modules*	
Analog Input (AI)	4	16	*16 Combined Maximum*
Analog Output (AO)	4	4	
Digital Input (DI)	6	16	
Digital Output (DO)	6	8	

Output Modules. The analog outputs are 0/4-20 mA. A suitable dropping resistor can be used to convert this to 0-5 or 0-10 VDC. Analog outputs are commonly used to set stirrer motor operating speeds, position control valves, or drive mass flow controllers or pumps.

The digital outputs are open collector type, capable of sinking up to 300 mA. They are commonly used to control heaters, solenoid valves for cooling or other flow control, system safety shut down, visual and/or audible alarms, and similar devices.

Control Loops

The controller can provide 8 PID or ON/OFF control loops in its standard configuration. These can be expanded to 16 in the extended control version.

The PID control algorithm includes auto-tuning and fuzzy logic overshoot suppression for each control loop. For heating and cooling control, the PID control loops provide time proportioning of the associated digital output.

Many temperature control applications utilize two separate time proportioning outlets with one PID controller; one for heating and one for cooling.

Control loops can be linked together to provide cascade, feed forward or ratio control for difficult or advanced control applications.

Both high and low limit values can be entered for each control loop to sound alarms or initiate safety control schemes.

Set Point Programming

Recipes for controlling the entire process of a reactor can be written using the setpoint profiler incorporated into the control firmware. A single profile may be from 2 to 50 segments in length. A typical profile might be a ramp and soak of the reactor temperature but, in addition, the analog and digital outputs can be tied to the basic profile to start and stop flows, activate stirrers or accessories, or change alarms. Any of the setpoints within the profile can be protected with the setpoint guarantee function that assures that the process variable will be within the entered limits before the profile can proceed.

Up to four separate profiles can be running independently (4 reactors each on their own program, for example) at one time.

While a maximum of 70 profiles can be stored in the controller itself, an unlimited number can be stored in the operator's PC for rapid transfer to the controller.

In addition to the setpoint profiling capability, the controller is also equipped with a setpoint scheduling function. This feature can operate up to 8 profiles operating on a common time base. Under this scheduler, up to 8 reactors can be operated in parallel on a single program.

Screenshot of typical 4870 Controller user interface main screen.

Communications Channels.

Each 4870 controller is equipped with a RS-232 and a RS-485 Modbus communication port. The RS-232 port is used to establish fundamental control logic. The RS-485 port provides communication with the host PC when using the SpecView GUI program. Multiple controllers, each with a unique address, can be daisy-chained on the RS-485 interface with a single connection to the PC.

The 4870 series controllers are available with an Ethernet 10BaseT interface that is used instead of the RS-485 serial interface. This interface is implemented using a special Modbus/TCP to Modbus/RS-485 bridge card in the controller. The principal advantage of the Ethernet interface is that it allows the user to use an existing network infrastructure to connect the controller to the PC. As a result, one can operate the controller over the network from anywhere within your facility. Additionally, Internet access from remote locations becomes possible. This type of connectivity offers unique possibilities, for example, related to remote diagnostics and system troubleshooting.

4870 Process Controllers, continued...

4875 Power Controller Rear View

PC Requirements

- Windows 95/98/NT/2k/XP PC with at least 10 MB free hard disk space to allow for data logging and the configuration files.
- The display resolution should be set up for 1024 x 768 pixels and at least 16-bit color.

Third Generation Technology

The 4870 Controller is the third generation of process control Parr has offered to its customers for integrated process control. Starting with the terminal based 4850 introduced in 1989 and the graphical based 4860 introduced in 1998 we have developed a good appreciation of the requirements for integrated process controllers.

The combination of the Honeywell 800 UMC controller with the SpecView software system provides a major step forward in the capabilities, flexibility, ease of programming and adaptability of these controllers for small to moderate size systems.

4875 Power Controller

- A CD-ROM drive for program installation and at least one RS-232 COM port is required to communicate with the controller.
- If the alternate Ethernet interface is used, the PC must be setup to participate on an Ethernet network using TCP/IP protocol.

Operator Interface

In most laboratory and pilot plant applications, a PC will be used for the operator interface. For plant or production applications, an industrial type user interface box with a color graphic LCD is available.

User Interface Software

SpecView describes their product as "Software for people with other jobs". That seems to be an excellent description of this software package used with the 4870 controller to:

- Configure the control package.
- Develop the graphical screen layout.
- Establish the data logging profiles.
- Prepare custom reports.
- Create bar graphs.
- Generate time trend graphs.
- Monitor alarms.
- Create flexible recipes.
- Retrieve and replace logged data.
- Operate the reactor system(s).

The full software package, not just a run-time version, is supplied with 4870 controller so operators can enhance their system as they get familiar with it or expand / change their applications.

Demonstration versions of the SpecView software can be downloaded at:

www.specview.com.

Configuration

An integral part of the Honeywell UMC Controller is the control builder software. This is the "Drag and Drop" software that enables Parr to rapidly establish the controller's internal logic and adapt it to individual systems requirements.

The user can employ this same software to change or enhance the fundamental logic of the controller as additional components are added to the system or as functions need to change.

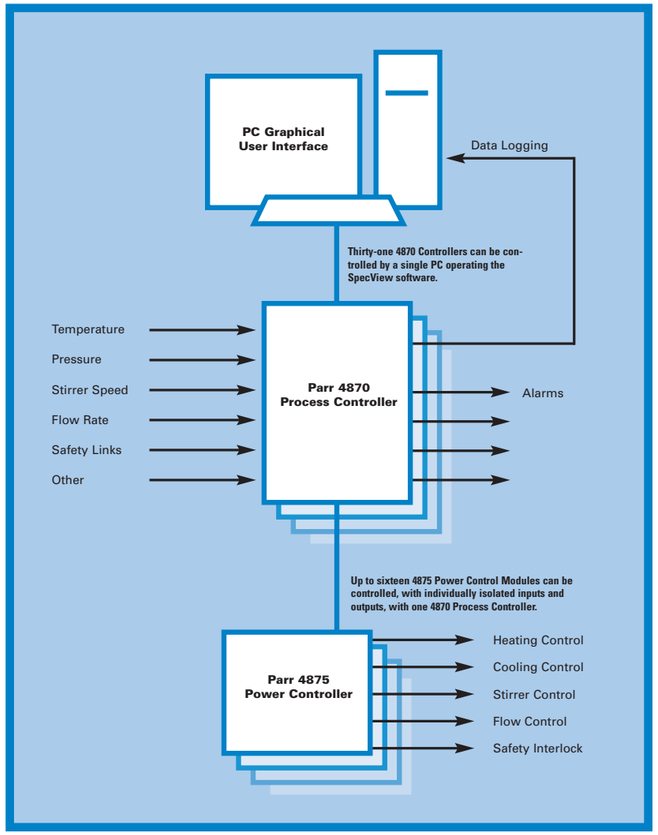
Power Controllers

Parr designs, builds and furnishes power controllers to adapt the analog and digital outputs from the 4870 controllers to the reactors or systems being controlled. These power controllers handle all of the high current power circuits so that the control circuitry is isolated from these loads. This also makes it possible to install the controller in a control room some distance from the system being controlled.

The power controller or controllers will be designed for each individual system, but as an example, a 4875 power controller includes:

1. A solid-state relay sized to handle the current drawn by the vessel heater. This is commonly a 25-amp relay with its protective fuses.
2. A solid-state relay sized to drive a solenoid valve to control the flow of cooling water to the vessel.
3. A motor speed controller that converts the analog output signal from the controller to the electrical signal required to drive the specific stirrer motor. A circuit breaker for the motor is also provided.
4. A lockout relay to shut down the heater circuit should an alarm condition be detected.
5. Status lights for the principal functions.
6. Connections of appropriate style for the power input and device outputs.

Note: One model 4875 Power controller is required for each reactor in a parallel system.



4870 Process Controller Input/Output Diagram

Expansion Capabilities

If any of the input, output, control or programming limits described here for a single controller are a limitation in building a control system, up to 31 controllers can be linked together in a multi-drop network to a single host PC.

Some users will find the advanced capabilities of the Honeywell 900 incorporated into the Parr 4871 Controller attractive.

Current Industrial Standards

Modbus, Ethernet, auto-tuning, auto-configuring, fuzzy logic, man machine interface (MMI), supervisory control and data acquisition (SCADA), multi-loop control; these are a few of the terms and capabilities designed into the hardware and software incorporated into the Parr 4870 controller.

This is a very modern and powerful package that enables us to offer turnkey systems ready to run within weeks of order at very attractive prices compared with custom programmed systems previously available.

Series 4870 Process Controller Selection Guide

Each 4870 controller will be specified and assembled to match the users intended application. These applications can vary from a single reactor with full process control to eight reactors operating in parallel.

There are three basic parts to this configuration process.

1. Basic Controller

The base model includes all of the components that will be required for any system:

- Control chassis with Honeywell CPU
- Communication module to PC
- Power supply
- Cabinet
- Connection cable to PC
- Operating and configuration software

2. Input and Output Modules

These are the analog and digital inputs and outputs required to receive the signals from the sensors (thermocouples, pressure transducers, position switches, safety interlocks, etc.) installed on the system and to drive the control devices (motors, heaters, control valves, coolant flow, etc) which operate the system. In addition to the circuit boards installed in the control chassis, these modules also include the connection cables to the I / O devices:

- Analog Input (AI) 4 / module
- Digital Input (DI) 6 / module
- Analog Output (AO) 4 / module
- Digital Output (DO) 6 / module

3. Power Controller

The load carrying components are mounted separately from the data processing components mounted in the controller cabinet. Typically the components mounted in a power controller would include:

- Solid state load relay for heater control
- Solid state load relay for cooling control
- Motor speed controller
- Fuses and circuit breakers for the above

A Model 4875 Power Controller includes a complement of heating, cooling and motor control to operate a single reactor. Each reactor being controlled by the Model 4870 Controller will require its own power controller. Power controllers can be custom designed to meet unique requirements with additional control features for more expanded systems.

Please contact the customer service department for assistance in configuring Model 4870 Controllers.

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