Automated
Econo System

Instruction
Manual

For Technical Service in the U.S. Call

1-800-4BIORAD

(1-800-424-6723)

BIO-RAD

Warranty

Model _____

Serial Number _____

Date of Delivery _____

Warranty Period _____

Unless otherwise specified, instruments sold by Bio-Rad Laboratories are warranted for 1 year against defects in materials and workmanship.

If any defects should occur during this warranty period, Bio-Rad will replace the defective parts without charge. However, the following defects are specifically excluded:

1. Defects caused by improper operation.

2. Repair or modification done by anyone other than Bio-Rad Laboratories or an authorized agent.

3. Use with tubings or fittings not specified by Bio-Rad Laboratories for use with this system.

4. Deliberate or accidental misuse.

5. Damage caused by disaster.

6. Damage due to use of improper solvents or samples.

7. Damage due to spills.

This warranty does not apply to tubing, fittings, and fuses.

For inquiry or request for repair service, contact Bio-Rad Laboratories after confirming the model and serial number of your instrument.
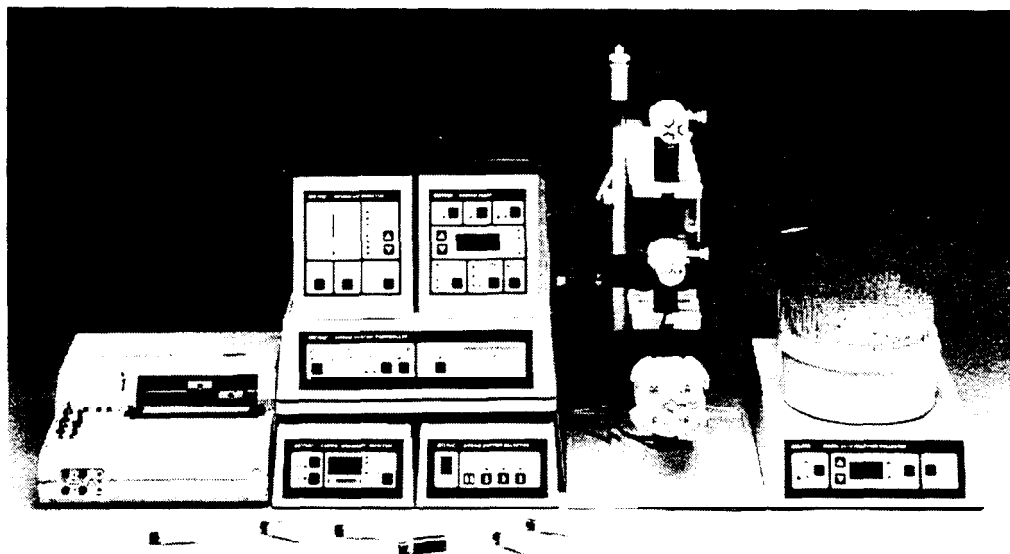
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Section 1
Introduction

Fig. 1.1. The Automated Econo System

1.1 Overview

The Automated Econo System consists of a series of free-standing chromatography instruments which can be integrated to form a system. System components include a complete line of chromatography columns, prepacked cartridges, fittings, tubing, and valves. Each component has its own stand-alone features in addition to its role in the system.

The Model ES-1 Econo System Controller integrates the individual components into a low pressure chromatography system. The Econo System controller provides the following functions:

- Gradient proportioning and mixing

- Peak detection by threshold or time windows

- Programmed control of up to 5 solutions

- Waste/collect diverter valve

- 6-port manual injector valve

- Solvent ice bath

These functions supplement those provided by the Model EP-1 Econo Pump, Model EM-1 Econo UV Monitor, Model EG-1 Econo Gradient Monitor, Model EV-1 Econo Buffer Selector, and Model 2 I 10 Fraction Collector. This manual contains the necessary information for setting up and running the system. In some sections, references will be made to information

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provided in the component manuals. A binder is provided to help organize the information.

1.2 System Components

The complete Automated Econo System consists of the following components:

- Model EP-1 Econo Pump
- Model EM-1 Econo UV Monitor
- Model ES-l Econo System Controller
- Model EV-1 Econo Buffer Selector
- Model EG- 1 Econo Gradient Monitor
- Model 2 110 Fraction Collector
- Econo Rack
- Econo System Organizer
- Model SV-3 Diverter Valve
- Model MV-6 6-port Injection Valve
- Model 1325 Econo Recorder (optional)
- Model 1326 Econo (Dual-Pen) Recorder (optional)

For the Econo System controller to function, it must be connected to the Model EP- 1 Econo Pump. For automated control of more than 2 buffers, the Model EV-1 Econo Buffer Selector must be connected to the Econo System controller. Aside from these requirements, UV and gradient monitors, fraction collectors, and chart recorders from other manufacturers can be used with the system. See Appendix A for details.

Section 2
Unpacking

2.1 Unpacking Instructions

Start by removing the solvent bath, which contains the tubing, fittings kit, and. sample injection valve. Next, remove the system controller, by lifting under the base of the instrument. Do not pull on the ribbon cables. Carefully remove the plastic bag, and check for any obvious damage or problems with the instrument. Packed next to the instrument is a bag containing the connection cables, injector valve, and diversion valve. Figure 2.1 shows all the parts included with the Econo System controller. Check off all parts against the sup-

plied packing list. Other components of the Automated Econo System (Model EP-1 Econo Pump, Model EM-1 Econo UV Monitor, etc.) are packaged separately.

If any parts are missing or damaged, contact Bio-Rad Laboratories immediately. Refer to Figure 2.1 for the proper designation of the missing or damaged part(s).

Tubing

Fittings Starter Kit

Fraction Collector Cable

Diverter Valve

Injection Valve

Chart Recorder Cable

Model ES-1 Econo System Controller

Also includes:
    Solvent Reservoir
    Instruction Manual w/ Binder
    Drain Tube
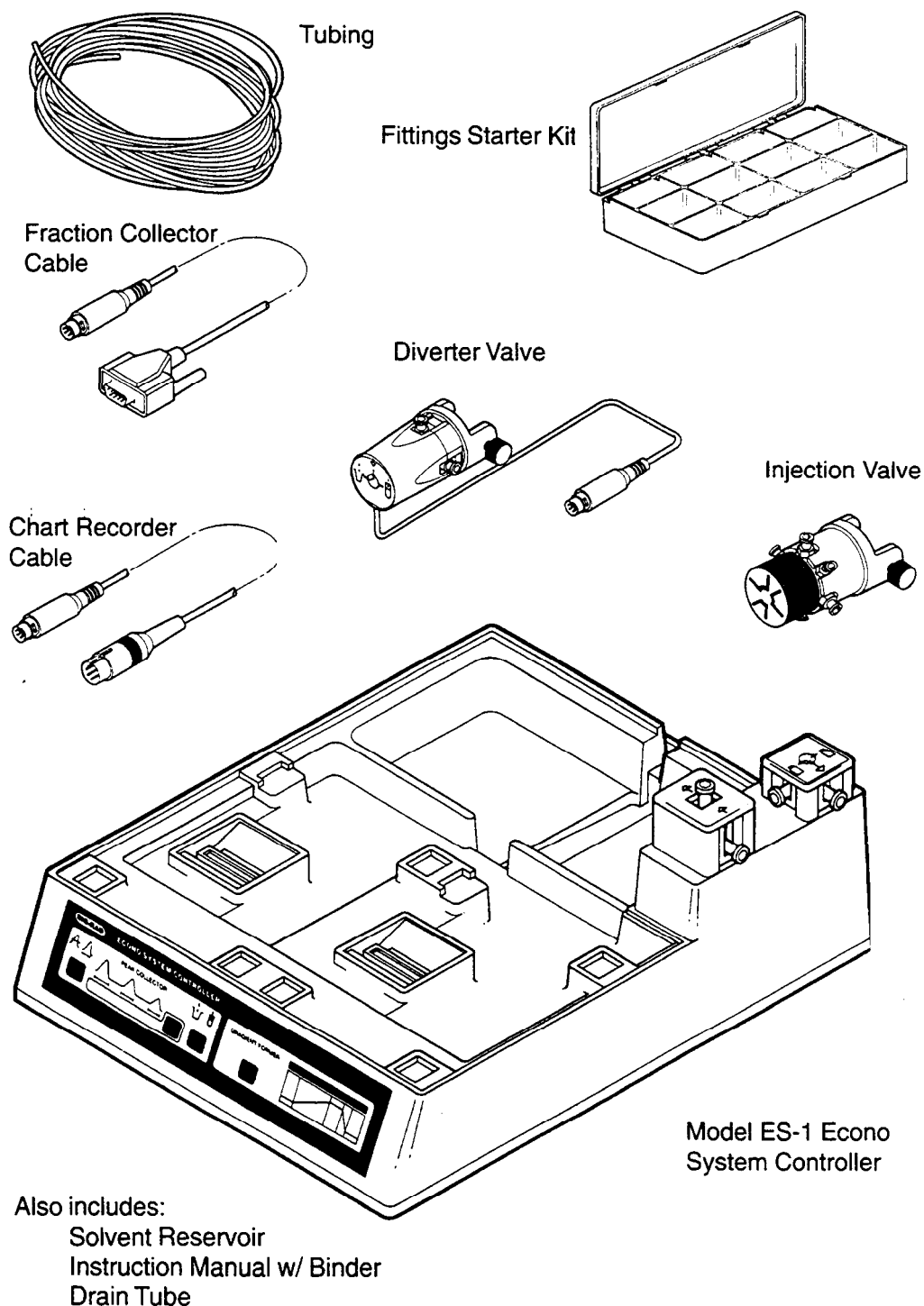
Fig. 2.1. Parts included with the Model ES-I Econo System Controller.

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2.2 Voltage Considerations

The Econo System controller receives its power from the Model EP-1 Econo Pump, which is shipped in the 120 V or 220 V configuration. For details on voltage conversions to 100 V or 240 V configurations, refer to the Model EP-1 Econo Pump manual.

2.3 Safety Considerations

The Econo System controller receives power from the Model EP- 1 Econo Pump through a ribbon connector shown in Figures 3.3 and 4.2. Do not insert any objects into this connector.

Section 3
Econo System Controller:
Physical Description and Control Features

3.1 Front Panel Functions
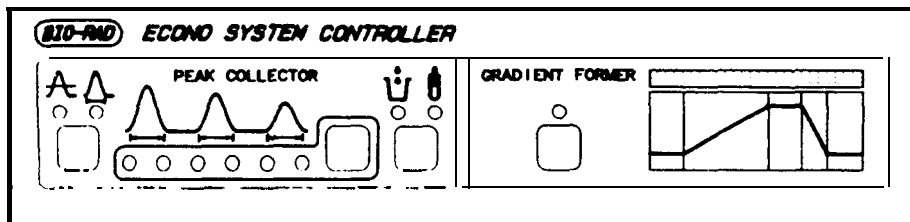
Fig. 3.1. Front panel controls.

Display		Function
	Gradient Former	This control is used to program binary gradient methods consisting of up to five steps in tandem with the integral proportioning valve and mixer. The gradient LED display gives quick identification of gradient progression.
	Peak Separator Key	This key is used to select between the two peak separation methods, threshold detection and time windows.
	Time Window Display and Key	This key is used to select up to three time windows for peak separation. During each time window, the diverter valve is routed to the fraction collector for collection of eluant.

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Diverter Valve Indicator and Key

This display will indicate the position of the Model SV-3 Diverter Valve, used in fraction collection and peak separation programs. Diverter valve position can be overridden using the Diverter Valve key.

3.2 Rear Panel Functions
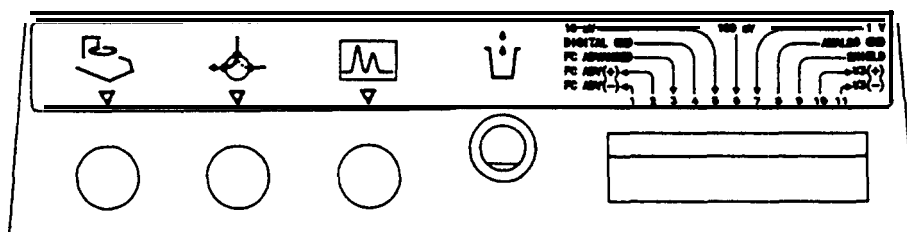
Fig. 3.2. Rear panel functions.

Display	Function
Fraction Collector Output	This 8-pin mini-DIN socket is used for sending an advance signal to the Model 2 110 Fraction Collector via cable #1.
Diverter Valve Output	This 8-pin mini-DIN socket sends a signal to the diverter valve, thus diverting flow from a fraction collector or collection device to another receptacle (waste), or vice versa.
Chart Recorder Output	This 8-pin mini-DIN socket is used for connection of the Model 1325 Econo Chart Recorder. The Econo System controller will control the pen lift and paper feed functions of the Model 1325 Econo Chart Recorder.

Waste Port

All spills on the top of the Econo System controller are led to a central waste/collection port. From this port, a drain tube passes out through the rear of the case.

I/O Connector
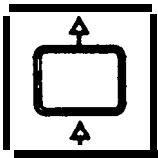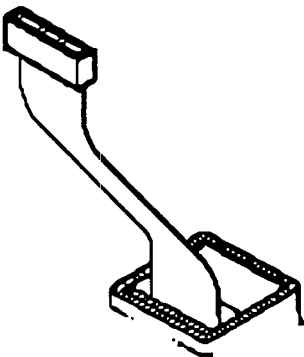
This 1 1-pin connector is used for sending valve control signals to the Model EV- 1 Econo Buffer Selector via Econo System Cable #10. Refer to the Econo Buffer Selector manual for details.

This connector is also used for connecting non-Econo System components including fraction collectors, UV monitors, and chart recorders to the Econo System. See Appendix A for details.

3.3 Topside Functions
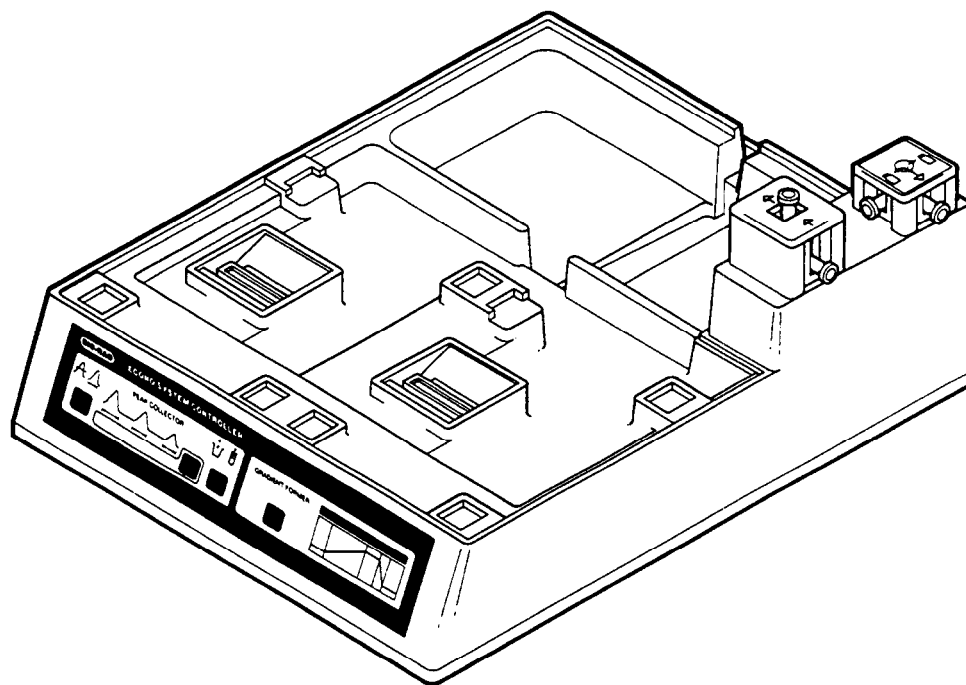
Fig. 3.3 Top view of the Econo System controller.

Display	Function
Gradient Proportioning Valve	This valve is used for proportioning two solvents for the purpose of forming linear gradients, as dictated by the Gradient Former control.
Mixer	Dynamic mixer for the rapid mixing of two solutes.
Ribbon Cables	These 34- and 40-pin ribbon connectors are for connecting the Model EM-l Econo UV Monitor and Model EP- 1 Econo Pump, respectively, to the Econo System controller. Power is supplied to the system controller through the 40-pin Econo Pump connector.

Section 4
Econo System Controller Connections and Set Up

The Econo System can be set up in a variety of locations, including 4 °C cold rooms or cold boxes. The orientation of the system is up to the user. The Econo System Rack is designed to hold the Model EM-l Econo UV Monitor optics module, diverter valve, and sample injection valve. The Econo System Organizer is designed to lift up the Econo System Controller for placement of the Model EG-1 Econo Gradient Monitor and Model EV-1 Econo Buffer Selector underneath. For this reason, it is recommended that the Econo Rack and Econo System Organizer be set up before proceeding.

The Model EP- 1 Econo Pump and the Model EM- 1 Econo UV Monitor have two connection modes. In both the stand-alone and the system configuration, the power connections are made from the back of each instrument. The system controller receives its power from the Model EP-1 Econo Pump. To access system functions provided by the Econo System controller, ribbon cables on the top of the system controller are used for connection to the underside of the pump and UV monitor. See Figures 4.1 and 4.2 for details.
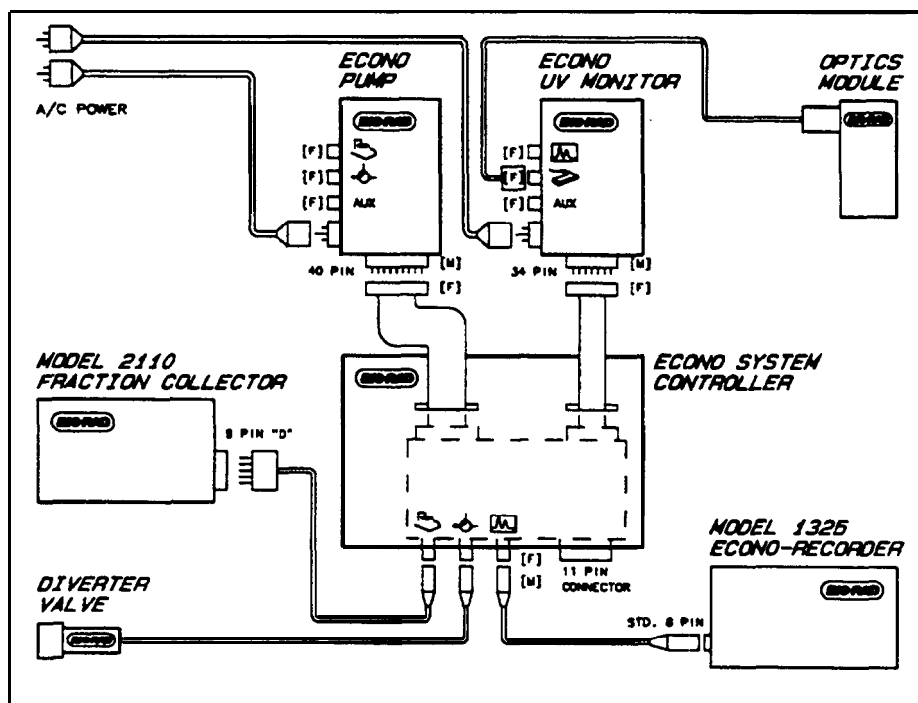
Fig. 4.1. Econo System external connections.

4.1 Model EP-1 Econo Pump

When connecting the Model EP-1 Econo Pump to the system controller, the connector on the bottom of the pump is used.

1.' Gently pull the exposed connector out of the recessed area labeled "pump". Do not pull more than 20 cm of cable out of the system controller.

2. Holding the connector in one hand, lean the pump forward with the other hand and make the connection shown in Figure 4.2.

3. Set the pump on the system controller, placing the feet in the areas indicated in Figure 4.2. Make sure the cable feeds back into the system controller. No other connection is required between the pump and system controller.
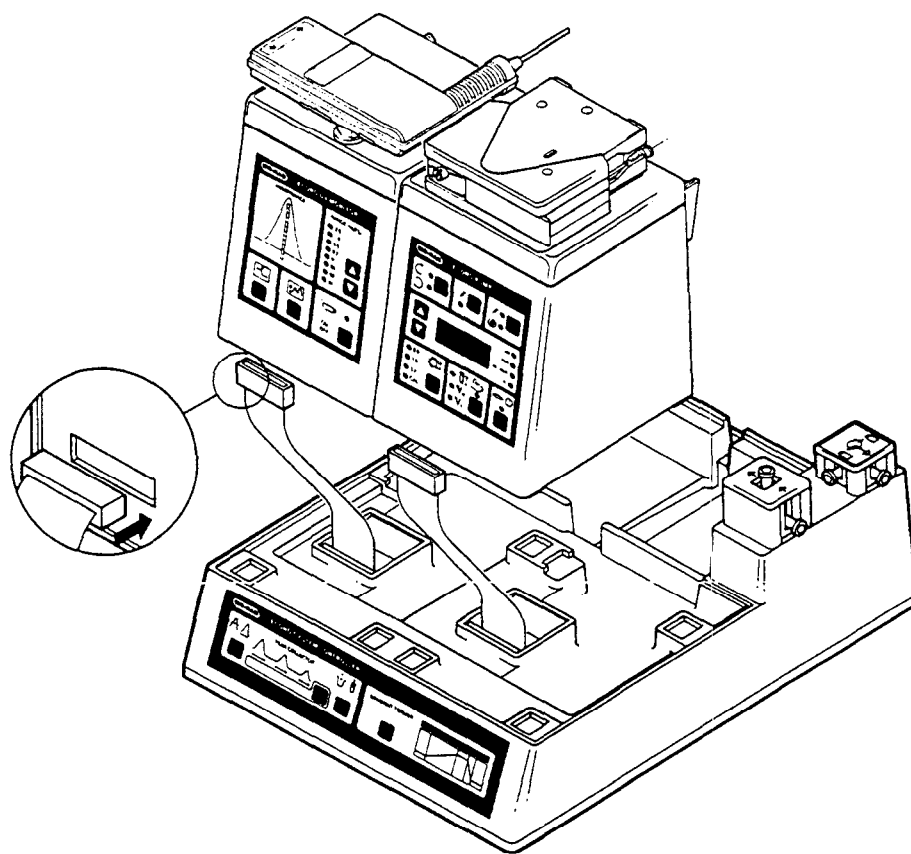
Fig. 4.2. Connection of Model EP-1 Econo Pump and Model EM-1 Econo UV Monitor to Econo System controller.

4.2 Model EM-1 Econo UV Monitor and Optics Module

When connecting the Model EM-l Econo UV Monitor to the system controller, the connector on the bottom of the monitor is used. If a non-Econo System UV monitor will be used, skip this section and refer to Appendix A.

1. Remove the rubber boot from the recessed area on the system controller, labeled "UV Monitor".

2. Follow steps 2 and 3 in Section 4.1.

3. Connect the portable optics module to the rear of the Model EM-l Econo UV Monitor through the 8-pin circular socket labeled with the optics module icon.

4. The optics module can be attached, using its feet, to the top of the UV monitor or to the rack.

4.3 Model EV-1 Econo Buffer Selector and Model SV-5 Valve Pod

The Model EV-1 Econo Buffer Selector connects directly to the Econo System Controller via Econo System Cable #10. Place the Econo Buffer Selector control unit underneath the Econo System Controller (if the Econo System Organizer is used) or beside the Econo System Controller. Use cable #10 (supplied with the Econo Buffer Selector) to connect the Econo System socket on the rear panel of the Econo Buffer Selector to the 1 l-pin I/O connector on the rear panel of the Econo System Controller.

The Model SV-5 Valve Pod can be mounted to the Econo Rack or the lip of the Solvent Reservoir in a variety of locations. For best results, minimize the length of tubing between the valve pod, the mixer on the Econo System Controller, and the buffer reservoirs. See the Econo Buffer Selector manual for details.

Connect the valve pod's Signal Cable to the Valve Pod socket on the rear panel of the Model EV-1 Econo Buffer Selector control unit.

4.4 Model EG-1 Econo Gradient Monitor

The Model EG-1 Econo Gradient Monitor connects only to the chart recorder. If a non-Econo Recorder is to be used, refer to the Model EG-1 Econo Gradient Monitor manual for details.

The Econo Gradient Monitor connects to the Model 1325 Econo (Single-Pen) Recorder via Econo System Cable #2. Use cable #2 (supplied with the Econo Gradient Monitor) to connect the standard DIN connector on the Model 1325 Recorder to the 8-pin mini-DIN socket labelled with the chart recorder icon on the rear panel of the Econo Gradient Monitor.

If both UV and conductivity are to be monitored, the Model 1326 (Dual-Pen) Chart Recorder (or other dual-channel recording device) must be used. Use Econo System Cable #2 (supplied with the Econo Gradient Monitor) to connect the standard DIN connector labelled Channel #2 on the Model 1326 Recorder to the 8-pin mini-DIN socket labelled with the chart recorder icon on the rear panel of the Econo Gradient Monitor.

4.5 Model 2110 Fraction Collector

Interfacing between the Model 2110 Fraction Collector and system controller is achieved by connecting the 9-pin I/O connector on the back of the Model 2110 Fraction Collector to the 8-pin mini-DIN socket labeled with the fraction collector icon on the rear panel of the system controller (refer to Figure 3.2). Cable #1 is used to make this connection, and is supplied with the system controller. The fraction collector can also be connected to the

8-pin mini-DIN socket labeled with the fraction collector icon on the rear of the Model EP-1 Econo Pump. To connect a non Econo System fraction collector, refer to Appendix A.

4.6 Model SV-3 Diverter Valve

The Model SV-3 Diverter Valve (Figure 4.3) can be attached to the rack in a variety of locations depending upon the application. The ports on the valve are labeled to allow them to be oriented in the directions they will be plumbed. The cable for the diverter valve is attached to the back of the system controller using the 8-pin mini-DIN socket labeled with the diverter valve icon (refer to Figure 3.2). The diverter valve can also be connected to the 8-pin mini-DIN socket labeled with the Diverter Valve icon on the rear of the Model EP-1 Econo Pump.
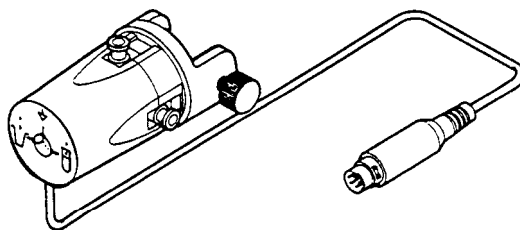
Fig. 4.3. Model SV-3 Diverter Valve.

4.7 Solvent Reservoir

The solvent reservoir sits in the impression in the system controller behind the pump and UV monitor. Be careful not to trap cables under the reservoir.

4.8 Model 1325 Econo (Single-Pen) Recorder

The Model 1325 Econo Recorder has been designed for use with the Econo System. Through one connection, the system controller will output the analog data signal, pen drop, and start command to the recorder. Refer to the recorder instruction manual for operating details. To connect the Model 1325 Econo Recorder to the system controller, use cable #2 supplied with the system controller to connect the standard DIN connector on the Model 1325 Econo Recorder to the 8-pin mini-DIN socket labeled with the chart recorder icon on the rear panel of the system controller (see Figure 3.2). Set all top panel controls of the Model 1325 Econo Recorder to their green settings for automatic control.

4.9 Model 1326 (Dual-Pen) Econo Recorder

The Model 1326 Econo Recorder has been designed for use with the Econo System. Through one connection, the system controller will output the analog data signal, pen drop, and start command to the recorder. Refer to the recorder instruction manual for operating details. To connect the Model 1326 Econo Recorder to the system controller, use Econo System Cable #2 (supplied with the system controller) to connect the standard DIN connector labelled Channel #1 on the Model 1326 Econo Recorder to the 8-pin mini-DIN socket labeled with the chart recorder icon on the rear panel of the system controller (See Figure 3.2).

4.10 Data Acquisition Systems

The system controller takes into account the use of the Econo System with data acquisition systems, such as the Model 3396A Integrator, or other instruments. The ⚡ 8-pin mini-DIN socket on the rear panel of the Model EM-1 Econo UV Monitor will output a non-scaled analog signal, accessible through Econo System cable #7. Alternatively, if the Econo Buffer Selector is not connected to the System Controller, the 11 -pin connector on the rear panel of the system controller can be used. See Appendix A for signal specifications.

Section 5
Plumbing the System

· The Econo System can be plumbed quickly and easily. Five meters of Tygon® tubing and a starter tubing fittings kit are included with the system. The kit contains compatible luer fittings for quick tubing connections. Figure 5.1 shows a typical plumbing diagram for the Automated Econo System. Figure 5.2 shows a typical plumbing diagram for the Econo System without the Econo Buffer Selector and Econo Gradient Monitor.
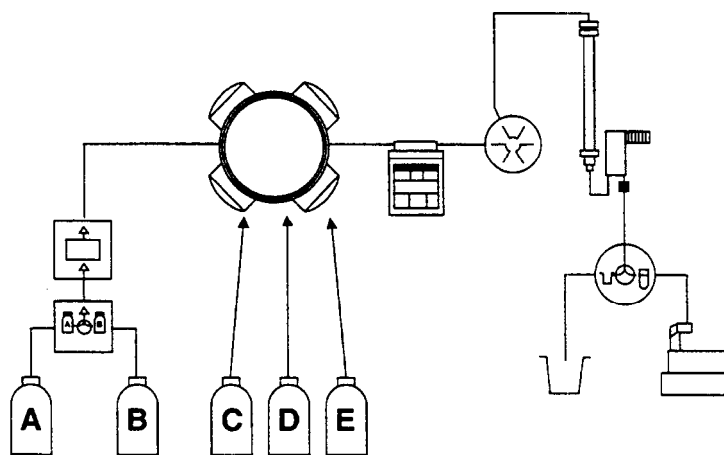
Fig. 5.1. Plumbing diagram for the Automated Econo System
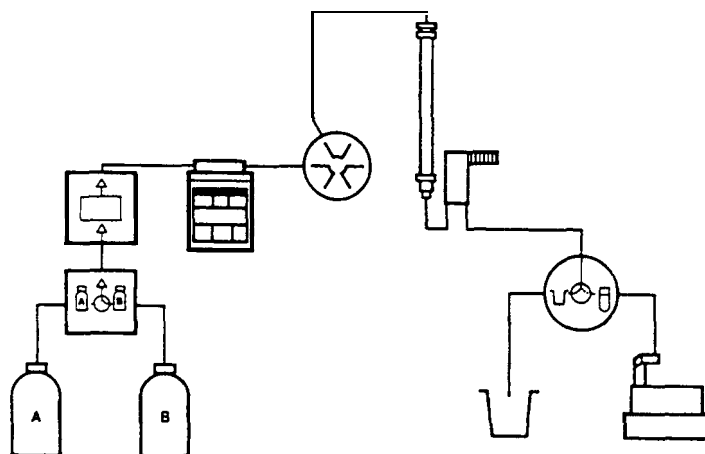
Fig. 5.2. Plumbing diagram for the Econo System (without Econo Buffer Selector and Econo Gradient Monitor).

The plumbing arrangement described in this section is by no means the only way to connect the system. The additional tubing and fittings are supplied to allow the system to be customized for specific applications.

5.1 Tubing and Fittings

The Econo System can be conveniently plumbed with most tubing having inner diameters less than or equal to 3.2 mm (⅛"). The Tygon tubing supplied in the plumbing kit is 1.6 mm ID. This should suffice for most applications. When using 3.2 mm tubing in the pump for increased pump output, the proportioning valve and mixer should also be plumbed with 3.2 mm tubing to maintain adequate flow. (Refer to the Model EP-1 Econo Pump manual for tubing compatibilities with the pump.) Figure 5.3 summarizes the more commonly used fittings.

Male luer for system tubing connections

Female luer for pump tubing

Female 't' connector

Male-to-male connector

Fig. 5.3. Fittings for system tubing connections.

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Note: Tubing lock-rings are used only for plumbing the Model EP-1 Econo Pump and are not needed for system tubing connections.

5.2 Gradient Proportioning Valve and Mixer

The length of tubing between the buffer bottles and the proportioning valve is not critical; however, it is important to clearly label which bottles will be designated buffer A and buffer B.

1. Insert the barbed end of a male luer fitting into one end of the tubing. Connect the male luer fitting to the female luer fitting on the proportioning valve. Make sure that the line from buffer A is connected to the A port on the proportioning valve. Repeat this process for buffer line B. Do not over-tighten the luer fittings.

2. The connection between the proportioning valve and mixer should be made with a piece of tubing less than 10 cm long. This is to maintain the accuracy of the gradients formed by the proportioning valve. Affix male luer fittings to both ends of the tubing as described above, and connect the outlet of the proportioning valve with the inlet of the mixer (see Figure 5.1).

5.3 Model EP-1 Econo Pump

Installation of the tubing in the pump head is described in the Model EP-1 Econo Pump manual. Pre-cut silicone tubing and fittings are supplied with the pump. To make these tubing sections yourself with Tygon, or other tubing, refer to the following procedure. Note that tubing length varies with tubing composition. This is to accommodate tubing prestretch, which affects flow rate calibration and flow reproducibility.

Warning: If using tubing other than the type supplied by Bio-Rad, make sure the wall thickness is not greater then 0.8 mm. Using tubing with a greater wall thickness can damage the pump and void your warranty.

1. Cut the tubing to a length described below. Make sharp, perpendicular cuts.

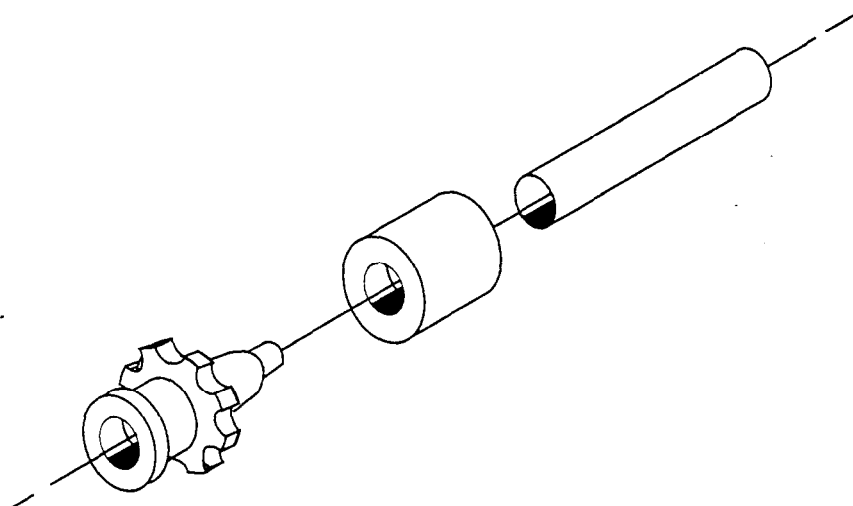| Tubing	Length
Tygon, Norprene	179 mm +/- 1.3 (7.04" +/- 0.05)
Silicone	17 1 mm +/- 1.3 (6.75" +/- 0.05)

2. Slip a color-coded lock-ring specific for that size of tubing onto one end of the tubing (see below). Install the female luer fittings by inserting the barbed end of the fitting into the tubing, and clamp the luer fitting into place by sliding the lock-ring over the barbed fitting (see Figure 5.3). Repeat on the other end of the tubing.

Note: Lock-rings are required only for high pressure applications.

Lock-Ring Color	Size
Red	0.8 mm ($\frac{1}{32}$")
Orange	1.6 mm ($\frac{1}{16}$")
Yellow	3.2 mm ($\frac{1}{8}$")

If a Model EV- 1 Econo Buffer Selector is not being used, the connection between the pump and the mixer should be made with a section of tubing less then 15 cm long to maintain accuracy of gradients. Affix male luer fittings to both ends as described above, and connect to the female luer fittings on both the pump outlet and the mixer.

If a Model EV-1 Econo Buffer Selector is to be used, do not connect the mixer to the pump. Continue with Section 5.4 for plumbing the Model SV-5 Valve Pod.

Fig. 5.4. Attachment of tubing fittings.

5.4 Valve Pod

The Model SV-5 Valve Pod should be positioned as close as possible to the mixer on the Econo System controller and the Econo Pump. The length of tubing should be of minimal length and inner diameter. Buffers A and B should already be plumbed through the proportioning valve and mixer on the Econo System Controller. Connect tubing from the outlet of the mixer on the Econo System controller to the A/B inlet port on the Model SV-5 Valve Pod. Connect tubing from each buffer/sample reservoir (C, D, E) to the corresponding valve port on the Model SV-5 Valve Pod. Connect tubing from the outlet port of the valve pod to the Model EP-1 Econo Pump.

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5.5 Manual Sample Injection Valve and Chromatography Column

Samples can be introduced into the flow path of the Econo System in a variety of ways. Two methods for manual sample injection are described below using the Model MV-6 Injector Valve. One uses preset injection volumes with a classical injection loop system, post-pump; the other allows variable injection volumes, pre-pump. The MV-6 injector valve can be used in both configurations. Alternatively, a three-way valve can be inserted in-line between the pump and the column inlet or between the pump and mixer to provide a simple injection port. See Section 7.8 for details on automated sample injection.

Post-Pump Injection with a Sample Loop

1. The Model MV-6 Injector Valve can be installed in a variety of locations on the rack. Use the screw fitting on the injector valve housing to secure the valve.

2. Cut a section of tubing long enough to connect the pump and the injector port. Affix male luer fittings as described above.

3. An injection loop of a desired volume can be formed by using a section of tubing of a length which corresponds to a desired volume. Table 5.1 provides the tubing lengths that correspond to several common loop volumes.

4. Attach a female luer-fitting to each end of the sample loop tube.

5. Connect the inlet line from the pump, sample loop, and outlet line to the column as shown in Figure 5.4. Arrow indicates rotation direction of valve.

Sample Loop

Waste
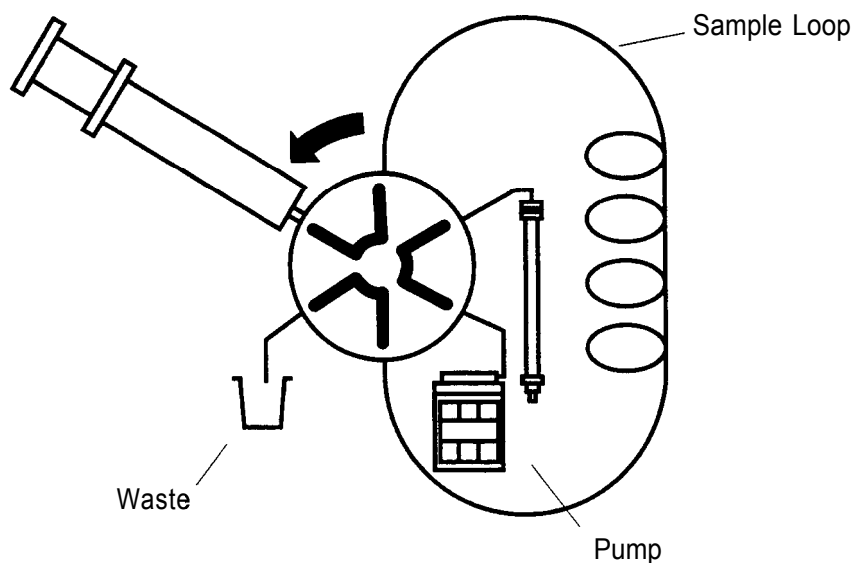
Pump

Fig. 5.4. Tubing connection for post-pump injector valve placement.

Pre-Pump Injection

1. Install the injector valve on the rack in a location close to the mixer.

2. Disconnect the tubing between the pump and mixer.

3. Connect the mixer to the injector valve, and the injection valve to the pump, as shown in Figure 5.5. Arrow indicates rotation direction of valve.
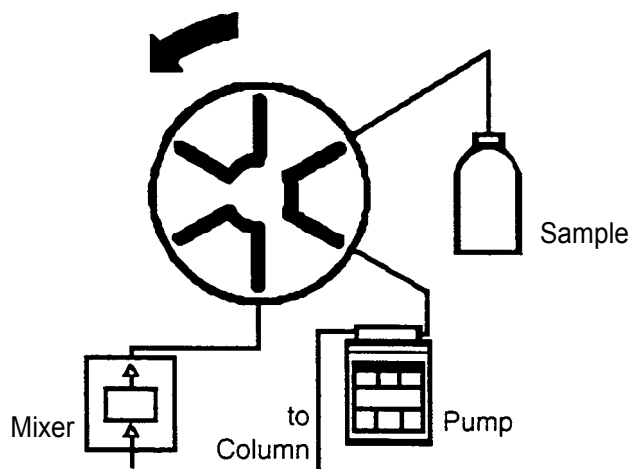
Fig. 5.6. Tubing connection for pre-pump injector valve placement

Table 5.1 Sample Injection Loop Volumes by Tubing ID

Tubing ID	Loop Volume	Tubing Length
0.8 mm	100 µl	20 cm
0.8 mm	200 µl	40 cm
1.6 mm	200 µl	10 cm
1.6 mm	500 µl	25 cm
1.6 mm	1 ml	5C cm
3.2 mm	500 µl	6.25 cm
3.2 mm	1 ml	12.4 cm
3.2 mm	2 ml	24.8 cm
3.2 mm	5 ml	62.6 cm

5.6 UV Optics Module and Gradient Monitor Flow Cell

The Model EM-l Econo UV Monitor optics module should be coupled as close to the column outlet as possible, to minimize mixing of the separated sample prior to detection- The tubing end used to connect the outlet of the chro-

matography column should have a female luer fitting attached. Arrows on the top of the optics module are used to indicate flow direction. The tubing ends to be connected to the inlet and outlet lines of the UV monitor should be affixed with a male luer fitting. It is important to minimize the length and inner diameter of this section of tubing.

Connect the gradient monitor flow cell directly to the inlet or outlet port of the UV optics module for optimal conductivity detection.

Warning: Do not overtighten the luer fittings.

5.7 Model SV-3 Diverter Valve

The Model SV-3 Diverter Valve should be coupled as close as possible to the UV monitor outlet. The length of tubing used should be of minimal length and inner diameter. Connect two sections of tubing with a male luer fitting on one end and connect to both the collect and waste ports of the diverter valve. Direct the tubing from the waste port to an appropriate waste container or suitable collection device. Connect the tubing from the collector port to a fraction collector or suitable collection device as described in Section 5.8.

5.8 Fraction Collector

To connect the diverter valve to the Model 2110 Fraction Collector, affix a male luer fitting to one end of a length of tubing, and attach this connector to the female luer fitting to the collection port of the flow diverter valve. Place the other end of the tubing into the rubber ferrule of the fraction collector drop forming arm. See the Model 2110 Fraction Collector instruction manual for details on this connection. Minimizing the length of tubing used for this connection will improve the accuracy with which peaks are collected.

Section 6
Getting Started

After the Econo System is connected and plumbed, it can be powered up. It is important that the input voltage match the voltage on the power entry module. Refer to Section 2.2 if it does not match.

6.1 Power Up

The following line cords need to be connected to power up the system.

1. Model EP- 1 Econo Pump

2. Model EM-l Econo UV Monitor

3. Model EV-1 Econo Buffer Selector (requires power adaptor)

4. Model EG-1 Econo Gradient Monitor (requires power adaptor)

5. Model 2110 Fraction Collector

6. Model 1325 or Model 1326 Econo Recorder (optional)

The Model EP-1 Econo Pump will supply the power for the system controller when the ribbon cable has been connected to the pump base. The Model EM-l Econo UV Monitor is plugged directly into an appropriately grounded power source, as is the gradient monitor, buffer selector, chart recorder and fraction collector. The UV monitor is powered up with the lamp on. Insure that the optics module is plugged into the appropriate socket on the rear panel of the UV monitor. The UV lamp LED will flash during the first minute or two. Allow at least 15 minutes for the UV lamp, and 10 minutes for the gradient monitor to warm up.

6.2 System Check

Before proceeding, it is advisable to check the system for leaks or other problems. To carry out the test, place buffer lines for buffer A and B into a reservoir containing water. Disconnect any chromatography column during the test.
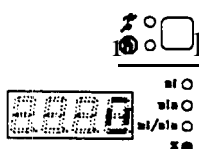
1. Press the Run/Stop key on the pump front panel. The run and % light will come on, and the pump display will read 0.

2. Press the Waste/Collect key on the system controller front panel until the waste light is lit. When the valve cycles between waste and collect, a click should be heard. If not, check the connection with the system controller.
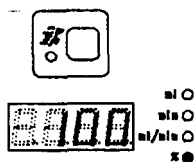
3. Using the scroll keys on the pump, increase the pump output to 25%. The pump head should begin to turn.

4. Over the next 10 minutes, watch for any leaks or air bubbles. If leaks or excessive bubbles are encountered, press Run/Stop to stop the pump, and repair the leak and remove air bubbles. Restart the pump.

5. Press the Purge key on the pump front panel and let pump operate at 100% maximum output (25 rpm) of buffer A for several minutes. Again, check for any leaks in the system. When'purging, the diverter valve should be in the waste position.

6. To prime with 100% buffer B, press the Gradient Former key (see Figure 3.1) while in the Purge mode. The Gradient Former indicator light will flash and the pump display will show a flashing "b" to indicate 100% buffer B output.

   Note: To prime the buffer lines for buffers C, D, and E (if the Econo Buffer Selector is being used), the system must be configured in the Enhanced mode (See Section 7.1). Buffers A through E can then be selected by depressing the Gradient Former key. Release the key when the desired buffer is displayed on the Econo Buffer Selector display. The valves will not change until the key is released.

   Press the Run/Stop key to stop the pump, or the Purge key once more to put the pump into Run mode.

Section 7
Programming the System

The Econo System components function in the system configuration much the same way they do in the stand-alone configuration. For more specific details on the operation of the individual components, refer to the manuals supplied with them. This section summarizes the function of the system in various separation strategies, and various levels of complexity.

7.1 Getting Started: Verification of Econo System Software Version

The Model EP-1 Econo Pump must have software version 2.01 or higher to control the Model EV-1 Econo Buffer Selector. If your system does not include a Model EV-1 Econo Buffer Selector, See Section 7.2. If your system does include a Model EV-1 Econo Buffer Selector, check the software version of your system before proceeding:

Simultaneously press and hold the Direction Key and the "down" Arrow key on the front panel of the Model EP-1 Econo Pump. The four digit LED display on the front panel of the Econo Pump should display: "**v2.01**"

If your Econo Pump disnlays a number lower than 2.01, it must be upgraded. An EP-1 ROM Replacement Kit is included with the Buffer Selector for this purpose. Disconnect the Econo Pump from all connections and replace the ROM following the directions in the ROM Replacement Kit. The ROM replacement procedure takes about 15 minutes. If you do not wish to perform the ROM replacement, please contact your local Bio-Rad representative.

If your pump currently features software version 2.01 or higher, or if the ROM upgrade has already been completed, ensure that all connections between the Econo Pump, Econo System Controller and Econo Buffer Selector have been completed and the system power is on.

7.2 Econo System Software Mode Selection

Software version 2.01 and higher features two user-selectable programming modes, Standard and Enhanced. The "Enhanced" software mode is required to use the Model EV-1 Econo Buffer Selector and is the mode of choice whenever more than two buffers will be controlled, methods longer than 5 steps or automated sample injection is desired. The "Standard" software mode is the mode of choice for methods requiring l-2 buffers, and l-5 steps, including simple binary gradient methods.

To choose the software mode of operation:
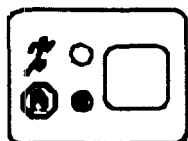
1. Stop the pump.
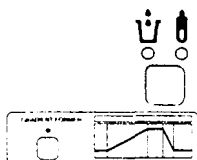
2. While depressing the Diverter Valve Key, press and hold the Gradient Former Key on the front panel of the Econo System Controller for approximately 3 seconds. The indicator lights on the front panel of the Econo Pump will flash and the four-digit LED display on the pump will display either "Std" for Standard Mode or "Enh" for Enhanced Mode. (This will not work if you were previously programming a method and did not exit prior to pressing the keys

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mentioned above. In this case, press the Gradient Former key until the Gradient Former indicator light is off. Repeat Step 2.

3. To choose a mode, press the Arrow Keys to choose between "Std" and "Enh".
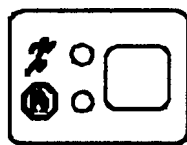
4. To accept the selected mode, ensure that it is displayed on the four-digit LED display, and press the Run/Stop Key on the front panel of the Econo Pump. The system will remain in the mode selected until a different mode is selected (even after power-down.)

The Standard and Enhanced modes have separate memories. Methods programmed in one mode do not affect the other.

## 7.3 Isocratic (Single-buffer) Methods

To run the system in a simple isocratic mode (use of one buffer component) using only the buffer A inlet, use the following procedure.

1. Insure that both the Model EP-1 Econo Pump and Model EM- 1 Econo UV Monitor are plugged into a grounded power source. The pump will power up in the Stop mode, and the UV monitor with the lamp on. Allow at least 15 minutes warm-up time for the UV lamp.

2. Configure the system in the "Std" software mode. Refer to Section 7.2 for instructions.
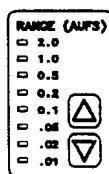
3. Set the desired UV sensitivity using the arrow keys on the UV monitor front panel. See the UV monitor manual for details.

4. When using the system in an isocratic fashion, make sure that solvent line A is being used, and is properly connected to the proportioning valve.
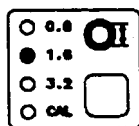
5. Calibrate the pump by either choosing one of three pre-selected tubing sizes, or user-calibrating any tubing. See pump manual, for detailed calibration procedures.

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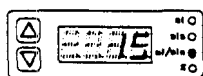
6. With the tubing in place, set the desired pump speed in ml/min using the arrow keys. Pressing the keys will increase or decrease the pump speed more quickly.
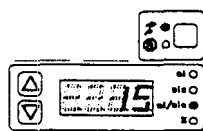
7. To initiate flow, press the Run/Stop key. To stop flow, press once more. Flow rate will be displayed in ml/min. Change the flow to the desired speed while the pump is running by pressing the arrow keys.

8 Eluant can be directed to suitable collection devices using the two-way diverter valve key located on the system controller, if the diverter valve has been plumbed. Simply press the key to light the indicator light below the figure correspond-ing to either waste or collect. The default position of the valve is in the waste position.

Tip: The gradient former can be used to provide automatic shut-off of the isocratic run. This can be done by entering a 0 for the % B values called for in the gradient programming scheme. See Section 7.2 for details on programming the gradient former. Alternatively, programming a total run volume (V,) and setting fraction size to zero will cause the pump to shut off once the total run volume has been delivered. For detail, see **Tip** in the following section.

Isocratic Time Based Collection
with the Model 2110 Fraction Collector

The isocratic run described in Section 7.1 can be stopped automatically by invoking the fraction collection feature of the Model EP-1 Econo Pump. Use of this feature requires calibration of flow. See Section 5.2 of the Model EP-1 Econo Pump manual for details. To enable the Model 2110 Fraction Collector:

1. Connect the fraction collector to the system con-troller or Model EP- 1 Econo Pump using cable # 1.
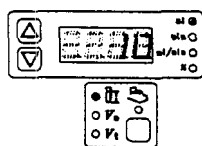
2. Press the Fraction Collector key on the Model EP- 1 Econo Pump front panel to enter the fraction col-lector edit mode. In the edit mode, only the flashing keys are active. Note that the Fraction Size and ml indicator lights are flashing, prompting entry of frac-tion size. Enter the fraction size in 0.1 ml increments using the Arrow keys. After the fraction size is

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entered, press the Fraction Collector key once more to confirm the fraction size.
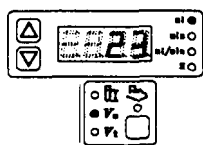
3. Enter a void volume (V_o) in 1 ml increments using the Arrow keys. See the Model EP-1 Econo Pump manual for details on the Void Volume (V_o) function. Press the Fraction Collector key to confirm this value and enter the Total Run Volume (V,) edit mode. If a void volume is not desired, set V_o to zero.
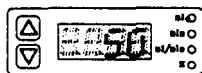
4. Enter the Total Run Volume (V,) in 1 ml increments using the Arrow keys. If zero is entered and confirmed, the fraction collection scheme is disabled. To resume data entry, start at Step 2 above. All values previously entered remain in the memory until other values are entered to replace them.
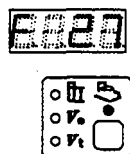
5. After entering a V_t value, press the flashing Fraction Collection key to confirm the value. The flashing LED multi-display shows the estimated number of fractions to be collected.
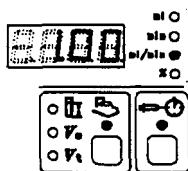
6. Press the flashing Fraction Collection key once more to enable the fraction collector. Pump output is displayed in ml/min. To actuate the fraction collector, press the Program Run key after starting the pump, if it was not already running. (The fraction collector can be programmed with the pump running or stopped.) After the fraction collection program is initiated, the LED multi-display shows the progression of the fraction collection scheme in minutes, to the nearest tenth of a minute.

Note: Insure that sample has been injected into the column before starting a program.

7. For options while running a method, see Section 7.9.

8. To stop the fraction collection scheme at any time during the program, press the Run/Stop key twice. The pump will stop, and the LED display will read OFF, indicating abortion of the fraction collection program.
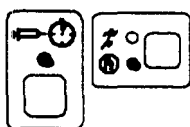
9. To place a collection program that has begun on hold, press the lit Program Run key once. To resume the collection program, press once again. Pressing the Run/Stop key while the program is on hold will abort the fraction collection scheme.

**TIP:** The fraction collection control feature of the Model EP-1 Econo Pump can be used to turn off the pump even if a fraction collector is not connected. Simply enter zero for fraction size. After confirming the V_t value entered, start the pump, if not already running, then press the flashing Program Run key. The pump will stop automatically when the total run volume has been delivered.

7.4 Binary Gradient Formation

The Econo System gradient former functions with the Model EP- 1 Econo Pump and the integral proportioning valve and mixer to form a binary gradient consisting of up to five time segments. Note: the graphic display of a gradient on the front panel of the system controller is provided as a guide, and is by no means the only way to format a five segment gradient.
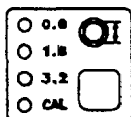
1. The pump must be calibrated in order to form gradients. See Section 5.2 of the Model EP- 1 Econo Pump manual for details.

2. Configure the system in the "Std" software mode, if not already done. Refer to Section 7.2 for instructions.

3. The gradient profile can be constructed in the following way:

Inflection Point	Time Elapsed	%B
1	0	B1
2	T2	B2
3	T3	B3
4	T4	B4
5	T5	B5
6	T6	B6

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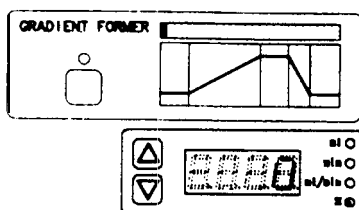
4. Press the gradient key once. The **min** light on the pump and the pump display will flash **"0"**, to indicate time=0. Press the gradient key once more. The % light on the pump will flash, along with the light above the first gradient point on the gradient display. The pump display reads 0, or the most recently entered value for % of buffer B. Enter a new value for initial % B (B 1) using the Arrow keys. Confirm entry by pressing the Gradient Former key.
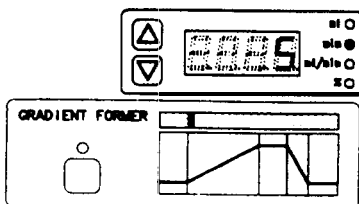
5. The gradient point indicator will then advance to the next gradient inflection point. Note the flashing min indicator light on the pump. Enter the time desired for the first gradient step (T2), or leave the previously entered value unchanged. Confirm this value by pressing the Gradient Former key.

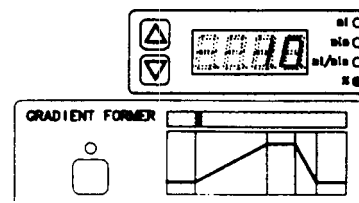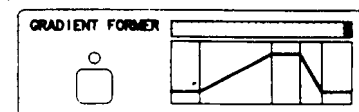6. The flashing % LED indicator light prompts entry of a % B value for this inflection point (B2). Enter the new value, and press the Gradient Former key to confirm this entry and advance to the next gradient inflection point.

7. Follow steps 2-5 for the remaining gradient points.
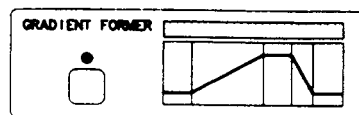
8. If using fewer than the six inflection points allowed, scroll through the time and % points for the remaining gradient inflection points by pressing the Gradient Former key, without changing the values showing.
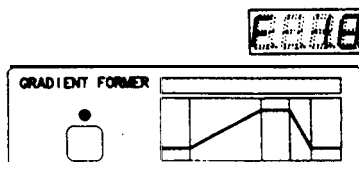
9. After the last % B value has been selected (or left unchanged) and confirmed, the gradient former will be enabled, as indicated by the lit Gradient Former key.
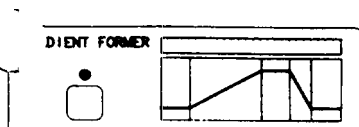
10. If a fraction collection program has been entered previously (note light under the fraction collector icon on pump front panel), the number of fractions to be collected will be re-estimated and displayed at this time. Press the flashing Gradient Former key a final time to confirm the gradient program.

11. At this point, the gradient former is set up for gradient formation. If the gradient is not desired, press the Gradient Former key one more time to turn off the gradient former indicator light.

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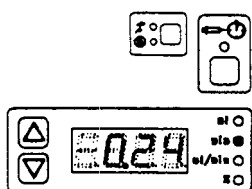
12. To begin the gradient scheme, press the Run/Stop key to get the pump running at the initial gradient condition, B 1 (you will hear the partitioning valve operating at the starting conditions). To start the program, press the flashing Program Run key on the pump. The gradient will begin, with the LED display showing minutes progressed. To observe the other parameters of the program, scroll through with the Arrow keys as described in 'Section 7.9.

Note: Insure that sample has been injected into the column before starting a program.

13. For options while running a method, see Section 7.9.

Binary Gradient Time-Based Collection with the Model 2110 Fraction Collector

The system should be configured in the "Std" mode, if not already done. See Section 7.2 for instructions.
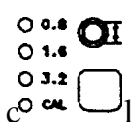
1. Calibrate the Model EP- 1 Econo Pump as described in the pump manual, Section 5.2.
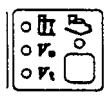
2. Initialize the Model 2110 Fraction Collector as described in Section 7.1. See Appendix A for connection of other fraction collectors.
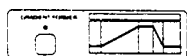
3. Program a gradient as described previously.
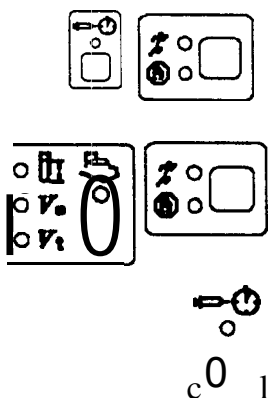
4. Start the pump to begin the gradient at initial conditions (% B 1). Start the binary gradient time-based collection by pressing the flashing Program Run key.

To discontinue collection only, press the Run/Stop key twice, and turn off the fraction collector by pressing the Fraction Collector key. Then press Run/Stop once more to start the pump, and the Program Run key to start the gradient at initial conditions.

6. For options while running a method, see Section 7.9.

Note: After the gradient former program has been entered. the total volume (V,) and estimated number of fractions to be collected will be adjusted based on the total gradient time and flow rate. Scroll through the Fraction Collection program to view the adjusted V_t and fraction number values.

7.5 Peak Detection and Collection

The peak detection and separation functions of the Econo System allow the user to discriminate among various chromatographic peaks using either a minimum threshold value set with the Model EP-1 Econo Pump in tandem with the Model EM-1 Econo UV Monitor, or with time windows, where peaks falling within selected time windows are separated out. Both features are accessible using the Peak Collector key, a five-way switch with an enter and confirm position for both threshold detection and time windows, and an off position (see Figure 7.1). Both methods of peak collection operate using the diverter valve, which functions to divert the eluant stream from a waste line to a collection line. This collection line can be directed into a fraction collector for more precise peak breakdown, or into any suitable collection device. A fraction collection program, gradient former, or auto shutoff must be used with the peak collection function. Peak detection and collection features may be used in either "Std" or "Enh" software modes.
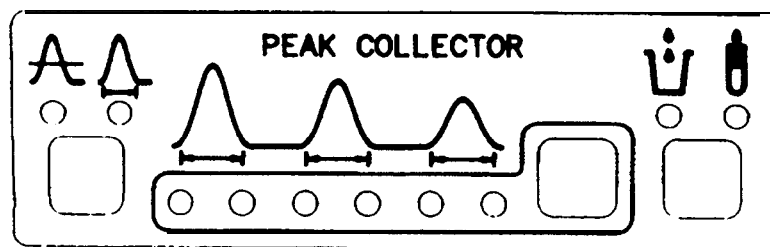
Fig. 7.1. Peak detection and collection features.

Peak Collection by Threshold

Peak collection on the basis of threshold detection allows for the diversion of peaks to a fraction collector, while directing non-peak eluant to a waste container or other collection vessel. This is accomplished by selecting a peak threshold value in percent full scale UV absorbance.
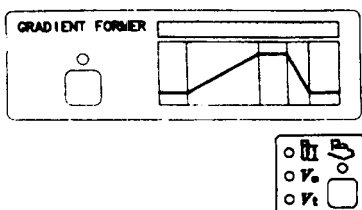
1. To operate the threshold detection function of the Econo System, a fraction collection, V_t timer, or gradient formation program must be enabled. See Section 7.3 and 7.4 for details.
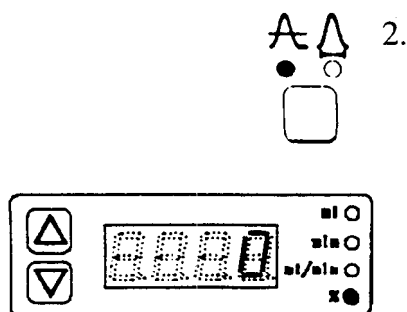
2. Press the Peak Collector key until the indicator light below the threshold icon is flashing. The Pump LED will read %, prompting entry of a threshold value for percentage of full-scale absorbance. Use the Arrow keys to scroll up or down. For reference purposes, each green light on the absorbance display of the Model EM-1 Econo UV Monitor equals 10% of full scale (five lights lit = 50% of full scale).
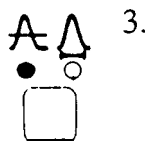
3. After entry of this threshold value, press the Peak Collection key once more to enable threshold detection. The light below the threshold icon will be lit.
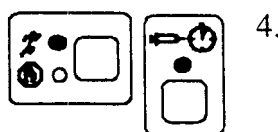
4. To start the peak detection program, press the Run/Stop key, followed by the flashing Program Run key. To Stop the program, press the Run/Stop key twice within 1 second.
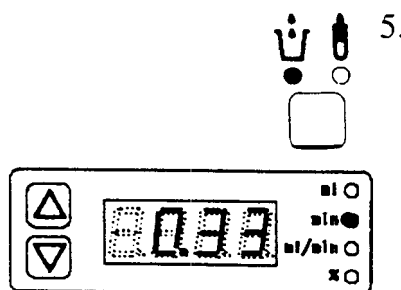
5. When Peak Collection is enabled, the diverter valve is in the Waste position, with the light under the waste icon lit. The pump LED display reads minutes progressed. When the selected threshold value is reached, the diverter valve will switch to Collect, and a mark will be superimposed on the chart recorder tracing.
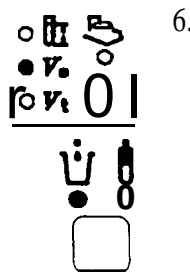
6. If a void volume has been programmed, the valve will remain in the waste position for the duration of the void. At the end of this time period, if the absorbance is above the selected threshold value, the valve will revert to collect, then back to waste after the absorbance drops back below the set threshold value. With each valve change, a mark will be superimposed on the recorder tracing.
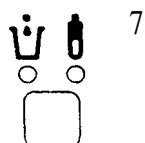
7. The Diverter Valve key allows the user to toggle back and forth between waste and collect. The Peak Collection function will override the manual placement of the diverter valve. That: is, if the diverter valve has been manually placed into the collect position prior to a peak, when that peak is detected, the valve will stay in the collect position, then switch to waste on the tail end of the peak when the absorbance drops below the set value.

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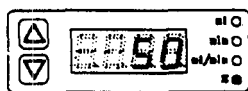
8. To change the threshold value during a run, press the Peak Collection key to enter the edit mode for threshold detection, indicated by a flashing light under the threshold icon. The pump LED display indicator lights will now show %, prompting entry of a threshold value in % full-scale absorbance. To confirm this value, press the Peak Collection key once more. The pump will continue to run when changing the threshold setting.

9. If the new threshold value is greater than the absorbance value currently seen by the UV monitor, the diverter valve will switch from collect to waste, and vice versa if the new value is less than the current value.
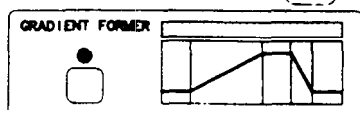
10. The threshold detection feature can be run in tandem with the gradient former to optimize chromatographic isolation and collection. Simply program the gradient former as described above prior to starting the threshold detection program.

11 To terminate the threshold collection program, press the Run/Stop key twice within 1 second. To place the program on hold, press the Program Run key. Press once again to resume, or press the flashing Run/Stop key to terminate the program.

Peak Collection by Time Windows

Peak collection on the basis of time windows will simplify collection of material known to elute at a specific time. The user can select the starting and ending times for three peaks, as indicated by the six indicator lights located beneath the three representative peaks (see Figure 7.1). To operate the time windows method of peak collection, the fraction collection, V_t timer, or gradient formation feature must be enabled.

1. To enter the edit mode for time windows collection, press the Peak Collection key, and continue pressing until the light below the time window icon flashes.
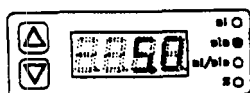
2. Enter a time value for the starting point for the first peak in 0.1 min increments using the Arrow keys on the pump.

3. To confirm the time window starting point and advance to that time window end point, press the Time Windows key.
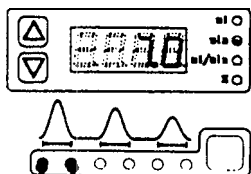
4. Enter the time window endpoint value in 0.1 min increments using the Arrow keys. Advance to the next time window starting point by pressing the Time Windows key.

5. Repeat steps 2-4 for the remaining two windows, or confirm entry of that time window and enable the time window collection feature by pressing the Peak Collector key. The light beneath the Time Windows icon will be lit solid, indicating activation of the time windows feature.

6. To start the Time Windows program, press the Run/Stop key followed by the flashing Program Run key.
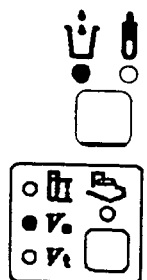
7. The diverter valve will reside in the waste position until a time window is reached. At that point, the valve will switch over to the collect position. The valve can be manually switched using the Diverter Valve key. The position determined by the programmed time window feature will override any manual positioning of the valve. However, if V_o is superimposed over a time window, the diverter valve will be in the waste position. To cancel V_o, press the Fraction Collector key.
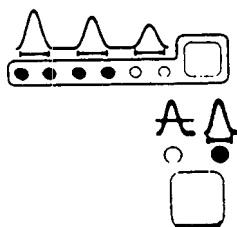
8. Changes to the window's start and end points can be made by stopping the program, scrolling through the time windows with the Time Windows key, and entering and confirming the new values as described in Steps 2-4. Pressing the Peak Selector key without changing any of the time points will confirm all previously entered values and invoke Time Windows.
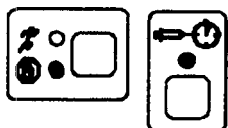
9. To terminate the Time Windows program, press the Run/Stop key twice within 1 second. To place the program on hold, press the Program Run key. Press again to resume, or press the flashing Run/Stop key to terminate the program.
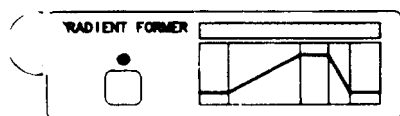
10. The Time Windows detection function can be run in tandem with the gradient former to optimize chromatographic isolations and collection. Simply program the gradient former as described above prior to invoking the time windows collection function.

7.6 Programming Multi-Step Methods (Using the Econo Buffer Selector)

Note: The Econo System must be configured in the Enhanced software mode for automated valve control using the Econo Buffer Selector. If you are not familiar with programming the Standard Econo System, please review Sections 7.1 - 7.5 of this manual before proceeding.

Inflection	Elapsed time	Valve/Buffer
1	0	A
2	10	B
3	13	C
4	23	D
5	33	E
6	43	A
7	55	A
8	55	A
9	5 5	End

where: A = Loading Buffer
B = Sample
C = Elution Buffer #1
D = Elution Buffer #2
E = Regeneration Buffer

Table 7.5. A Typical Method Table for a Multi-Step Method. The method outlined consists of 4 buffers, 1 sample, and 6 steps (7 inflection points).

Programming methods in the Enhanced software mode involves a method table with a maximum of 9 inflection points (equivalent to 8 steps) (See Table 5.4 and Table 5.4.b.). Each inflection point is defined by an elapsed

(cumulative) time and a buffer/valve position. Any buffer/valve position may be selected at each inflection point.

A multi-step method is a method which consists of a sequence of steps from one buffer to another. The Model EV-1 Econo Buffer Selector can control up to 5 different buffers (one of which could be a sample) and a method can consist of up to 8 steps (created by 9 inflection points).
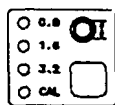
1. The Econo Pump must be calibrated. Calibrate the Model EP-1 Econo Pump as described in the Model EP-I Econo Pump manual, Section 5.2.

2. Press the Run/Stop key to stop the pump.
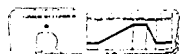
3. Press the Gradient Former key once. The pump display will flash 0, indicating time = 0. The single digit display on the Buffer Selector will flash **1,** indicating the first inflection point: in the method.

Note: The Stop indicator light on the pump will flash at every step during programming to indicate that this key may be pressed at any time tc exit the edit mode. Upon exit, any changes made to the method are automatically saved.
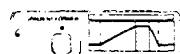
4. Press the Gradient Former key again. The single-digit display on the Buffer Selector will still be flashing **1** for inflection point #1. The % light on the pump will flash, and a letter (**A,b,C,d,E,L**) will appear in the left digit of the pump display. (L is used for binary gradient steps and is explained in Section 5.4.b.)

5. Use the Arrow keys to select a valve position. Confirm the entry by pressing the Gradient Former key.
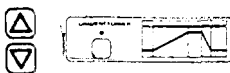
6. **The min** indicator light on the pump will flash and the single-digit display on the Buffer Selector will flash 2, indicating inflection point #2. Using the Arrow keys, enter the elapsed time desired for the second inflection point. Confirm entry by pressing the Gradient Former key.

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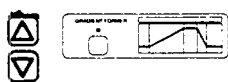
7. The % light on the pump will flash, and a letter **(A,b,C,d,E,L)** will appear on the pump display. Use the Arrow keys to select a new valve position. Press the Gradient Former key to confirm the entry and advance to the next inflection point.

8. Repeat steps 6-7 for the remaining inflection points.
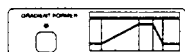
9. If using fewer than the maximum of 9 inflection points, scroll through the time and % points for the remaining method inflection points by pressing the Gradient Former key, without changing the values showing, or, exit the edit mode by pressing the Run/S top key.

    *If the edit mode is exited, data points from any previously entered method are not automatically erased. Ensure that the data points in the remaining programming steps will not interfere with the current method.

10. After the last elapsed time point has been entered and confirmed (inflection point #9 as displayed by the Buffer Selector), the pump display will flash **"End".** Press the Gradient Former key once more to enable the method. The Gradient Former indicator light should be lit.

11. If a fraction collection program was previously entered (the Fraction Collector indicator light on the pump front panel will be lit), the estimated number of fractions to be collected in the method entered will be re-estimated and the pump display will flash **"F ###"**. Press the flashing Gradient Former key to confirm the gradient program. The Gradient Former indicator light should be lit.

12. To begin the method, press the Run/Stop key to start the pump running at the initial gradient condition. To start the method program, press the flashing Program Run key on the pump.

13. The pump display will show a flashing **"n"**. "n" = the number of times the method should automatically repeat. Use the Arrow keys to enter a value from 1 to 999. The default for n = 1.

If a manual sample injection is necessary for the method, ensure that sample has been injected into the column before starting the program.

14. Press the Program Run key to confirm the entry. The method will begin and an event mark will appear on the chart paper.

7.7 Programming Step Methods Which Include a Binary Gradient (Using the Econo Buffer Selector)

A multi-step method which includes a binary gradient is one of the most common types of chromatography methods used. For example, such a method could include:

- column equilibration with a Buffer (buffer A)

- automatic injection of a sample (buffer C, >5 ml volume)

- a linear gradient (from 0% buffer B to 100% buffer B)

- column washing with a regeneration buffer (buffer D)

- column washing with a buffer appropriate for column storage (buffer E)

When programming a method, any buffer/valve position may be selected at each inflection point. The relationship between valve positions and buffers is:

Valve Position:	L	C	d	E
Buffer:	Ab	C	d	E

The **L** (for "linear") is one choice for the buffer/valve position at each inflection point. *L is identical to the S-step method that is programmed in the Standard software mode.* Because buffers A and B are plumbed through the proportioning and mixing valves on the Econo System Controller before connecting to the Valve Pod A/B inlet port, L is the only valve position in which a linear binary gradient may be formed. L can be programmed at any step in the Enhanced method table, and it can be used only once per method (See Table .).

Inflection Point	Elapsed time (min)	Valve/Buffer
1	0	A
2	5	C
3	10	A
4	15	L
6	50	D
7	60	E
8	75	A
9	70	End

where: A = Loading Buffer
B = Elution Buffer
C = Sample
D = Regeneration Buffer
E = Column Storage Buffer

STEP "L"

Inflection Point	Elapsed time (min)	%B
1	15	0
2	30	50
3	35	50
4	35	100
5	45	100
6	45	0

Table 7.6. A Typical Method Table for a Multi-Step Method Which Includes A Binary Gradient. The method tables outline a method which consists of 4 buffers, 1 sample, 7 steps (8 inflection points), and a binary linear gradient (Step L).

7.8 Programming Automated Sample Injection

·   The Model EV-1 Econo Buffer Selector can be used to automate injection of samples. The recommended minimum sample volume is 5 ml. However, is is feasible to load samples as small as 1 ml using a flow rate of 1 ml/min. This is not recommended since sample loss may occur due to tubing volumes.

Samples smaller than 1 ml should be diluted to 1 ml, or loaded manually using the Model MV-6 Sample Injection Valve. Always keep tubing connections as short as possible to avoid excessive loss of sample.

For the automated injection of samples (injection programmed within a method):

1. Calculate the amount of time necessary to pull the sample into the system based on the sample volume and method's flow rate. This calculated time will be the duration of the injection step, programmed in the method.

2. Prime the tubing connecting the Model SV-5 Valve Pod and the sample reservoir with either the appropriate "binding" buffer for the column, or with sample itself. Plumb the sample reservoir to either valve port C, D, or E. Minimize the tubing length between the valve pod and the sample reservoir as much as possible. If excessive lengths of tubing are used, the amount of sample delivered to the column may differ from the amount used in the calculations in step #1.

3. For very large volume samples and especially when automatically repeating injections by self-looping methods, ensure that the actual volume of sample plumbed to the system matches the calculated volume of sample to be injected by the method program.

7.9 Options While Running A Method

The following options are available while running a method in either the Standard or Enhanced software mode.

1. While a method is running, the following information can be displayed by pressing the Arrow keys on the pump. The units for the data displayed are indicated by the indicator lights to the right of the display. The following is an example:

Information	Display	Indicator Light	Meaning
Volume	" 30"	ml	30 ml of solution has been delivered in the current run
Elapsed time	" 123"	min	Time elapsed in current run is 123 minutes
Flow rate	" 10"	ml/min	The flow rate is 10 ml/min
Inflection point and buffer	"7—A"	%	Method on step #7, valve port A is selected
% B	"b 50"	%	System currently forming 50%B of A/B binary gradient
Repeat #	"n 3"		The third run of the method is being run

2. After method initiation:
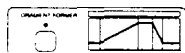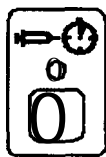
- <u>To hold the method with Dump <u>stopped</u>,</u> press the Program Run key. The pump display will show **"Hold".** To continue, press the Program Run key once more.

- <u>To hold the method with pump running</u> (holding the current valve port or proportional rate of the gradient former constant), press the Gradient Former key. The Gradient Former indicator light on the system controller and the pump display will flash.

  The fraction advance and UV threshold level detector (if enabled) are still active. Fractions will continue to be collected on a volume basis. If Time Windows is enabled, fractions will continue to be collected only if the system is collecting at the time the method is held.

  While holding the method with the pump running, run-time parameters can still be viewed on the pump display by pressing the Arrow keys. To stop the pump, but continue holding the method, press the Program Run key. Press the Program Run key to start the pump again.
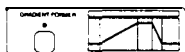
  To resume the method, press the Gradient Former key.

3. To terminate the method at any time (e.g. stop the pump and the method):
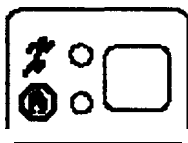
   Press the Run/Stop key twice within 1 second. The pump display will show "Off".

4. To change a program, exit the method (See Step 3.) and re-enter the edit mode:
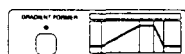
   Press the Gradient Former key to enter the edit mode. Scroll through the method to the point where a change is desired. Make desired changes and exit by pressing the Run/Stop key.

5. At each valve change during a method, an event mark will be superimposed on the chromatogram trace.

Once entered, a method is retained in memory even if the power is switched off. Standard and Enhanced modes have separate memories, so methods entered in one mode do not affect the other.

If the system is turned off, methods are retained in memory for at least 10 hours.

Section 8
Storage and Maintenance

The Econo System requires very little maintenance to assure reliable operation. Following are general procedures for maintenance of the Econo System and components.

Econo System component cases, carousel, and rack: During normal operation, spills and splashes may result in precipitates forming on the component cases, fraction collector carousel, and rack. Use a squirt bottle and soapy water to wash down the rack and outer cases of the instruments. The instruments are resistant to spills. Liquid draining off the cases of the pump and UV monitor will run onto the system controller, where it will drain out the back of the case through the drainage tube. The Model 10 fraction collector also has a drain out the back of the unit.

Model EP-1 Econo Pump: Check tubing regularly for signs of cracking and wear. If any exist, replace the tubing to help prevent leakage of fluids into the pump's electronics. When not in use, tubing should be removed from the pump to prevent deformation of the tubing. Remove the platen and relax the tubing by unhooking one end of the tubing from the tubing bracket. To prevent the formation of precipitates around the pump head and on the membrane key panel, promptly remove any spills.

Model EM-1 Econo UV Monitor and Model EG-1 Econo Gradient Monitor: Clean the outside surfaces of the Econo UV Monitor, Econo Gradient Monitor, UV optics module, and flow cell as described above. The 280 nm and 254 nm filters in the UV optics unit should be cleaned only when necessary with a dry lens tissue and replaced in the optics module. Use of a dilute ethanol or isopropanol solution will assist in the removal of contaminants. When the UV optics module or gradient monitor flow cell is not in use, disconnect and clean out dissolved salts or protein using a syringe filled with distilled water. To prevent the formation of salt crystals and solute deposits, do not allow the flow cell to dry out. Store the flow cell in a dilute solution (10-25%) of ethanol or isopropanol to prevent microbial growth.

Model 2110 Fraction collector: Clean the instrument case and carousel as described above. The drop sensor's optical window should be cleaned periodically with a cotton swab moistened with water.

Proportioning, mixing, and diverter valves: These valves require essentially no maintenance other than to flush salt solutions out after use with a syringe filled with distilled water. Storing the valves dry will not affect their operation. If salt solutions are spilled onto the valves, rinse, as described above, with soapy water.

Model SV-5 Valve Pod: *Solutions containing dissolved solids should never be allowed to dry inside the valve pod.* The valve ports should be flushed out periodically with deionized water.

For long-term storage, store the valve pod by injecting a dilute solution (15-25%) of ethanol or isopropanol into the ports to prevent microbial growth. Use the end caps provided to seal all ports.

Prior to long-term storage of the Econo System, flush out all valves and system tubing with distilled water. Power down the system by turning off the power switches on the bottom panel of the pump and UV monitor, and rear panels of all other components.

Section 9
Troubleshooting

This section contains a brief troubleshooting guide to help you quickly locate the cause of any problems you might encounter in the operation of the Econo System and suggest possible remedies. In all cases, do not hesitate to refer to the pertinent component instructions for more detailed information. Check the following before calling Bio-Rad Chromatography Technical Service:

- Check the connection of the power cables to the Model EP-1 Econo Pump, Model EM-l Econo UV Monitor, Model 2110 Fraction Collector, and the Model 1325 Econo Recorder, if used. Ensure that power is supplied to these components.

- Check the connection of the ribbon cables between the base of the pump and UV monitor to the system controller.

- If you are using a non Econo System UV monitor, fraction collector, chart recorder, or other component, insure that each instrument is connected with the proper cable to the Econo System.

- Check the tubing routed throughout the system for indications of leaking solvent. Insure that all valves are operating properly and are free of blockages.

- Check for air bubbles within the system lines. Disconnect column and purge to remove. Isolate and seal possible air inlets. Use degassed solvents to reduce the possibility of air bubble formation.

Problem: Faulty numeric pump LED display upon power up.
Action: 1. Insure that the 40-pin connector between the Model EP-1 Econo Pump and system controller is properly affixed. Check power connection to the pump.

2. Turn pump off, then back on again.

3. Unplug power cord to pump. Simultaneously press both the downward arrow and the tubing calibration key on the pump front panel, while plugging the pump back in. Press until display clears.

4. Call Bio-Rad Instrument Service.

Problem: No peaks are observed on the chromatogram.
Action: 1. Be sure proper sample was injected properly.

2. Insure that baseline has not drifted out, off the bottom of chart paper.

3. Full scale of graph set too high. Decrease AUFS setting on the UV monitor. Insure that chart recorder input range setting is set at 1 V full scale.

4. Detector malfunction. Use detector's Auto Zero adjustment to verify proper operation.

Problem: UV Peaks are clipped or squared off.
Action: 1. Graph scale is too low. Readjust the AUFS setting on the UV monitor.

2. Detector overrange. Use a lower concentration of sample or less injection volume.

Problem: Retention times vary between injections of same material.
Action: 1 . Column clogged. Remove obstruction or replace/repour column.

2. Flow rate is not reproducible. Check tubing for signs of wear. Replace damaged or worn tubing. Check that pump is functioning properly.

For the Econo System Controller to function, it must be connected to the Model EP-1 Econo Pump. For automated valve control, the Model EV-1 Econo Buffer Selector must be connected to the Econo System Controller. Aside from this requirement, non Econo System components such as UV monitors, fraction collectors, chart recorders, RI monitors, and conductivity monitors can be connected to the system through output sockets on the rear panel of the Econo System controller (see Figure 3.2). In addition to the three 8-pin mini-DIN connectors, an 1 l-pin I/O connector is available to access a variety of signals. All output signals are TTL compatible. To use these signals, you must insure that the circuit external to the Econo System controller does not draw more than 15 milliamperes of current. Following is a description of the Econo System controller signal outputs.

'I. Fraction Collector Output
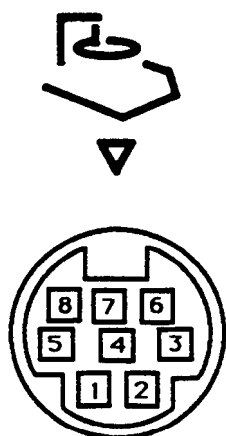
Pinout	Signal Type
*	Shield
1	Fraction Advance (low going output)
2	No Contact
3	No Contact
4	No Contact
5	Fraction Advance (high going output)
6	No Contact
7	Ground
8	Fraction Marks to Recorder (low going input)

A fraction collector can be connected to this socket using an 8-pin mini-DIN to bare wire cable (cable #7). Connect the fraction collector to the bare wires on cable #7 to access the functions listed above..

2. Diverter Valve Output

This 8-pin mini-DIN socket is for connection of the Model SV-3 Diverter Valve only.

3. Chart Recorder Output

Pinout	Signal Type
*	Shield
1	Start/Enable (output)
2	No Contact
3	Mark A (output)
4	No Contact
5	No Contact
6	Pen (output)
7	Ground
8	Mark B (output)
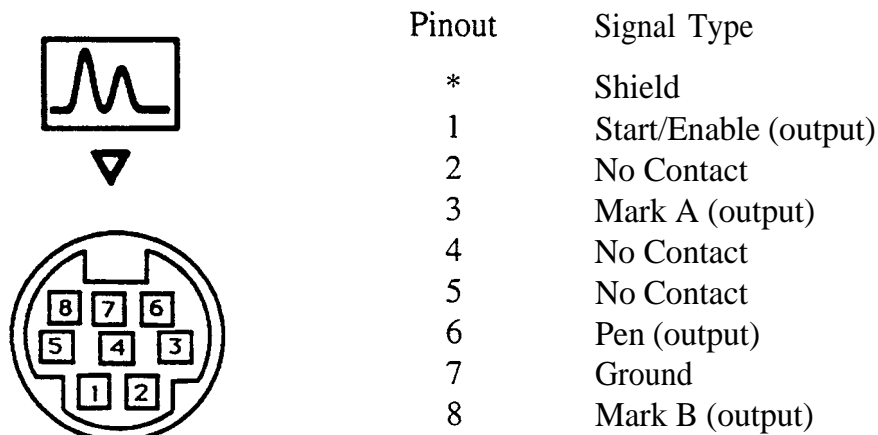
A chart recorder can be connected to this socket using breakout cable #7 as described in the Fraction Collector Output section.

4. Eleven Pin I/O Connector

The 1 1-pin connector described below is used for connection of the Econo Buffer Selector to the System Controller. It may also be used for the connection of other manufacturer's instruments including fraction collectors, UV monitors, and conductivity monitors. The 11 screw-terminal pinouts are readily available for connection to bare leads from the instruments Following is a description of the pinouts.

Pinout	Signal Type	Pinout	Signal Type
1	Fraction Collector Advance (low going output)	7	1 V Input
2	Fraction Collector Advance (high gong output)	8	Analog Ground
3	Fraction Advanced (signal input)	9	Shield
4	Digital Ground	10	Buffer Selector
5	10 mV Input	11	Buffer Selector
6	100 mV Input		

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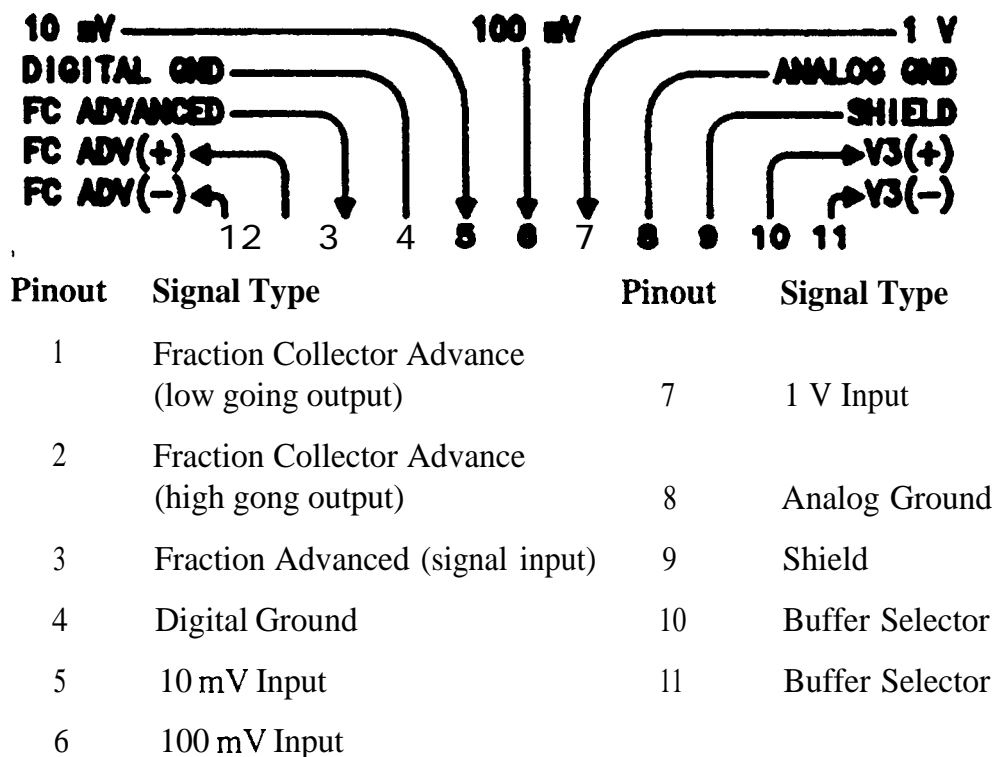
To connect a non Econo System UV monitor which has a 1 volt signal output, the leads from the monitor can be connected directly to the 1 volt input and analog ground terminals. If a non Econo System UV monitor is being used, a chart recorder must be connected to it rather than to the system controller. Diverter valve and peak selection marks will not appear on a chart recorder tracing if a non Econo System monitor is connected.

To access the fraction advance signal for a non Econo System fraction collector, the leads from the collector can be connected to the fraction advance and digital ground screw terminals. The signal type (high or low) depends upon the fraction collector being used. Connecting the collector's fraction advanced signal lead to pin # 3 will allow fraction advance marks to be sent to a chart recorder.

Appendix B
System Specifications

Following are specifications as they relate to the Econo System controller. For specifications related to individual Econo System components, refer to the specific manuals.

Gradient former	5-time segment (6-point) gradient capability I-9999 min.
	O-100 % buffer partitioning via a 3-way solenoid proportioning valve
Gradient accuracy	Within 1 %
Gradient linearity	3 % full scale
Mixing valve volume	475 dynamic mixer
Peak detection	Threshold or time windows
Threshold	O-99 % of selected AUFS range
Time windows	Maximum 3 time windows, in minutes
Diverter valve µl	Three-way solenoid valve in solvent resistant housing
Sample injector valve	Six-way PTFE valve with ¼ x 28 to female luer fittings (6)
Buffer reservoir	21.8 x 15.2 x 15.0 cm (W x D x H) (for two 1 L bottles, incl. ice)
Component connectors	Econo pump: 40-pin ribbon cable
(signal outputs)	Econo UV monitor: 34-pin ribbon cable
	Fraction collector: 8-pin mini-DIN
	Diverter valve: 8-pin mini-DIN
	Chart recorder: 8-pin mini-DIN

	Auxiliary: 11 -pin Combecon con-nector
Signals	TTL logic
Operating temperature	4-40 °C
Dimensions	32.3 x 40.6 x 16.0 cm (W x D x H)
Weight	2.95 kg
Material of construction	Noryl

Appendix C
Ordering Information

Model EP-1
Econo Pump

Catalog Number	**Product Description**
731-8140	**Model EP-1 Econo Pump,** 110 V (USA power cord), with tubing set and starter fittings kit
731-8142	**Model EP-1 Econo Pump,** 220 V (no power (cord), with tubing set and starter fittings kit
731-8145	**Model EP-1 Pumphead Assembly**

Model EM-1
Econo UV Monitor

731-8160 ,	**Model EM-1 Econo UV Monitor,** 110 V (USA power cord), with starter fittings kit
731-8162	**Model EM-I Econo UV Monitor,** 220 V (no power cord), with starter fittings kit
731-8165	**Model EM-I Flow Cell**
731-8166	**Model EM-I Lamp**
731-8167	**Model EM-1 Filter Assembly** (280/254 nm)
731-8168	**Model EM-1 Optics Module Assembly**

Model EV-1
Econo Buffer Selector

The Model EV-1 Econo Buffer Selector requires a power adaptor.

731-8170	**Econo Buffer Selector, Model EV-1,** requires power adaptor, includes valve pod (catalog no. 731-8236)

Catalog Number	Product Description
731-8171	**Econo Buffer Selector, Model EV-1,** with 100-l 20V power adaptor (catalog no. 731-8270), and valve pod (catalog no. 73 1-8236)
731-8236	**Econo Valve Pod, Model SV-5,** 1
731-8270	**Power Adaptor, 100-l 20V, for USA, Canada, Japan, Mexico, Taiwan, Latin America**
731-8271	**Power Adaptor, 220-240 V, for Europe (Except the UK) and other countries not specifically listed**
73 l-8272	**Power Adaptor, 220-240V, for UK, Australia, New Zealand**

Model EG-1
Econo (Gradient Monitor

The Model EG-1 Econo Gradient Monitor requires a power adaptor.

731-8150	**Econo Gradient Monitor, Model EG-1,** without power adaptor, includes flow cell (catalog no.731 -8155)
731-8151	**Econo Gradient Monitor, Model EG-1,** with USA power adaptor (catalog no.731-8270) and flow cell (catalog no. 731-8155)
731-8155	**Flow Cell, Model EG-1,** 1 cell
731-8270	**Power Adaptor, 100-120V, for USA, Canada, Japan, Mexico, Taiwan, Latin America**
731-8271	**Power Adaptor, 220-240V, for Europe (Except the UK) and other countries not specifically listed**
731-8272	**Power Adaptor, 220-240V, for UK, Australia, New Zealand**

Model 1 325
Econo Recorder

731-8190	**Model 1325 Econo Recorder,** with US power adaptor, includes dust cover, paper roll (1), fiber tip pen (1), spare fuse (1), banana cables (1 set), US power adaptor (1)
731-8192	**Model 1325 Econo Recorder,** without US power adaptor, includes dust cover, paper roll (1), fiber tip pen (1), spare fuse (1), banana cables (1 set)
731-8194	**Power Adaptor for USA, Canada, Japan, Mexico, Taiwan, Latin America**
731-8195	**Power Adaptor for UK, Commonwealth (Except Canada, Australia, and New Zealand)**

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Catalog Number	Product Description
731-8196	**Power Adaptor for Australia and New Zealand**
731-8197	**Power Adaptor for Europe (Except the UK) and Other Countries Not Specifically Listed**
731-8198	**Chart Paper, 2** rolls: 10 cm x 1300 cm
167-02 15	**Disposable Fiber Tip Pens,** 3 pens, each good for approximately 1,000 m

Model 1326
Econo (Dual-Pen) Recorder

The Model 1326 Econo Recorder is a dual pen recorder which does not require a power adaptor.

731-8191	**Model 1326 Econo Recorder,** dual-pen, 90-132 V. Includes **1** roll chart paper, 2 fiber tip pens (red and blue), spare fuses, 2 sets banana cables.
731-8193	**Model 1326 Econo Recorder,** dual-pen, 180-265 V. Includes 1 roll chart paper, 2 fiber tip pens (red and blue), spare fuses, 2 sets banana cables.
731-8199	**Chart Paper,** 2 rolls: 120 cm x 13 m
167-0218	**Red Fiber Tip Pens, 3**
167-0219	**Blue Fiber Tip Pens, 3**

Econo System Controller

731-8180	**Model ES-I Econo System Controller,** with Model SV-3 Diverter Valve, MV-6 injection valve, fraction collector cable, UV monitor cable, starter fittings kit, and 1.6 mm Tygon tubing, 5 m
731-8185	**Model ES-I Proportioning Valve**
731-8186	**Model ES-1 Mixer Assembly**

Complete Econo System

731-8104	**Automated Econo System, 100-120 V,** includes the Model EP-1 Econo Pump, Model EM-I Econo UV Monitor, Model ES-I Econo System Controller, Model EG-1 Econo Gradient Monitor, Model EV-1 Econo Buffer Selector, Model 2110 Fraction Collector, Econo Rack, Econo System Organizer, Model 1326 Econo Chart Recorder, diverter and injection valves, starter fittings kit, 5 M of 1.6 mm Tygon tubing, and all necessary cables.
731-8105	**Automated Econo System, 220-240 V,** same as 731-8104.

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Catalog Number	Product Description
731-8100	**Econo System,** includes Model EP-1 Econo Pump, 110 V, Model EM-I Econo UV Monitor, Model ES-I Econo System Controller, Model 2110 Fraction Collector, rack, diverter valve, and injection valve, fraction collector cable, UV monitor cable, starter fittings kit, and 1.6 mm Tygon tubing, 5 m
731-8102	**Econo System,** includes Model EP-1 Econo Pump, 220 V, Model EM-I Econo UV Monitor, Model ES-I Econo System Controller, Model 2110 Fraction Collector, rack, diverter valve, and injection valve, with starter fittings kit and 1.6 mm Tygon tubing, 5 m
73 I-8200	**Econo System Rack,** (assembled) includes: base, 4 vertical supports, 2 horizontal supports, 8 column clips, 1 test tube rack; extra parts include 2 vertical and 1 horizontal support
731-8201	**Econo System Organizer, with 110V power strip**
731-8206	**Econo System Organizer, without power strip**

Valves

731-8237	**Model MV-6 6-Port Injection Valve**
731-8235	**Model SV-3 Diverter Valve**

Tubing

731-8210	**Silicone Tubing, 0.8** mm ID, 0.8 mm wall, 10 m
731-8211	**Silicone Tubing,** 1.6 mm ID, 0.8 mm wall, 10 m
731-8212	**Silicone Tubing, 3.2** mm ID, 0.8 mm wall, 10 m
731-8214	**Tygon Tubing,** 0.8 mm ID, 0.8 mm wall, 10 m
731-8215	**Tygon Tubing,** 1.6 mm ID, 0.8 mm wall, 10 m
731-8217	**Norprene Tubing, 0.8** mm ID, 0.8 mm wall, 10 m
731-8218	**Norprene Tubing,** 1.6 mm ID, 0.8 mm wall, 10 m
731-821'9	**Norprene Tubing, 3.2** mm ID, 0.8 mm wall, 10 m

Tubing Kits

731-8240	**Silicone Tubing,** 0.8 mm, 17.1 cm, 20; 4 red lock-rings, 4 female luer-fittings, 4 male luer-fittings

Catalog Number	Product Description
731-8241	**Silicone Tubing,** 1.6 mm, 17.1 cm, 20; 4 orange lock-rings, 4 female her-fittings, 4 male her-fittings
731-8242	**Silicone Tubing,** 3.2 mm, 17.1 cm, 20; 4 yellow lock-rings, 4 female luer-fittings, 4 male luer-fittings
73 l-8244	**Norprene Tubing,** 0.8 mm, 17.9 cm, 20; 4 red lock-rings, 4 female her-fittings, 4 male her-fittings
73 l-8245	**Norprene Tubing,** 1.6 mm, 17.9 cm, 20; 4 orange lock-rings, 4 female her-fittings, 4 male her-fittings
731-8246	**Norprene Tubing,** 3.2 mm, 17.9 cm, 20; 4 yellow lock-rings, 4 female luer-fittings, 4 male her-fittings

Fittings

732-8220	**Low Pressure Fittings Kit,** includes over 250 male and female luer connectors, 2- and 3-way stopcocks, and tubing connectors
731-8221	**Female Luer with Barb for 0.8 mm ID Tubing, 25**
731-8222	**Female Luer with Barb for 1.6 mm ID Tubing, 25**
73 1-8223	**Female Luer with Barb for 3.2 mm ID Tubing, 25**
731-8224	**Male Luer with Barb for 0.8 mm ID Tubing, 25**
73 l-8225	**Male Luer with Barb for 1.6 mm ID Tubing, 25**
73 l-8226	**Male Luer with Barb for 3.2 mm ID Tubing, 25**
731-8228	**Female-to-Female Luer, 10**
731-8229	**Female-to-Female-to-Female Luer,** 10
731-8230	**Male-to-Male Luer,** 10
731-8232	**Female Luer Plugs, 25**
731-8233	**Male Luer Plugs, 25**
732-8 102	**2-way Polycarbonate Stopcock,** 10
732-8103	**3-way Polycarbonate Stopcock,** 10
732-8107	**3-way Nylon Stopcock,** 10
732-8300	**Straight-through Connector, 25**
732-8302	**T-connector, 25**

Catalog Number	Product Description

Econo System Cables

731-8261   **Cable #1,** 8-pin mini-DIN to DB-9 connector. For connection of Model 2110 Econo Fraction Collector to the Econo Pump, Econo UV Monitor, or Econo System Controller

73 I-8262   **Cable #2,** 8-pin mini-DIN to 8-pin standard DIN. For connection of Econo Recorders to the Econo UV Monitor, Econo Pump, Econo Gradient Monitor, or Econo System Controller

73 1-8263   **Cable #3,** 8-pin mini-DIN to 8-pin mini DIN. Connects the Econo Pump to the Econo UV Monitor in the absence of the System Controller

73 I-8264   **Cable #4,** 8-pin mini-DIN to banana cable. To connect Econo UV Monitor to most non-Bio-Rad chart recorders

73 I-8265   **Break-out cable #5,** DB-9 connector to bare wires. For connection of Model 2110 Econo Fraction Collector to non-Econo System components

73 I-8266   **Break-out cable #6,** 8-pin standard DIN to bare wires. To connect Econo Recorder to non-Econo System detectors

73 I-826:7   **Break-out cable #7,** 8-pin mini-DIN to bare wires. To connect Econo Pump, Econo UV Monitor, or Econo System Controller to non-Econo System components

73 I-82613   **Cable #8,** 8-pin standard DIN to DB-9 connector. For connection of Econo Recorders to Econo Fraction Collector

73 1-8269   **Cable #9,** 8-pin mini-DIN to Pharmacia Frac-100. For connection of Pharmacia Frac-100 fraction collector to the Econo System

731-8281   **Cable #10,** 8-pin mini-DIN to Isco DB-9 connector For connection of Isco Retriever II collector to the Econo System

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