Model '44'

Syringe Pump Series

User's Manual

Model '44' Programmable 55-1144

HARVARD
APPARATUS

Table of Contents

Serial Numbers

All inquires concerning our product should refer to the serial number of the unit. Serial numbers are located on the rear of the chassis.

Calibrations

All electrical apparatus is calibrated at rated voltage and frequency. While the flow will stay calibrated, the peak will vary.

Warranty

Harvard Apparatus warranties this instrument for a period of one year from date of purchase. At its option, Harvard Apparatus will repair or replace the unit if it is found to be defective as to workmanship or material.

This warranty does not extend to damage resulting from misuse, neglect or abuse, normal wear and tear, or accident.

This warranty extends only to the original customer purchaser.

IN NO EVENT SHALL HARVARD APPARATUS BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. Some states do not allow exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you. **THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR USE, OR OF ANY OTHER NATURE.** Some states do not allow this limitation on an implied warranty, so the above limitation may not apply to you.

If a defect arises within the one-year warranty period, promptly contact ***Harvard Apparatus, Inc. 84 October Hill Road, Building 7, Holliston, Massachusetts 01746-1371*** using our toll free number 1-800-272-2775. Goods will not be accepted for return unless an RMA (returned materials authorization) number has been issued by our customer service department. The customer is responsible for shipping charges. Please allow a reasonable period of time for completion of repairs, replacement and return. If the unit is replaced, the replacement unit is covered only for the remainder of the original warranty period dating from the purchase of the original device.

This warranty gives you specific rights, and you may also have other rights which vary from state to state.

Repair Facilities and Parts

Harvard Apparatus stocks replacement and repair parts. When ordering, please describe parts as completely as possible, preferably using our part numbers. If practical, enclose a sample or drawing. We offer a complete reconditioning service.

CAUTION !

This pump is not registered with the FDA and is not for clinical use on human patients.

CAUTION
NOT FOR CLINICAL USE
ON HUMAN PATIENTS

Pump '44' Specifications

Type	Single Syringe Infusion/Withdrawal
Size	257 x 289 x 152 mm (10.1 x 11.4 x 6 in)
Weight	7.25 kg (16 lb)
Power	115/230 VAC, 50/60 Hz via selector switch, 65 W
Fuse	3AG 1/2 AMP 250 V SLO-BLO
Leakage to Ground	Typically < 10 µA
Ground Resistance	Typically < 0.05
Voltage Operating Range	95 to 130 VAC, 220 to 260 VAC
Drive Motor	1.8° stepper
Motor Drive Circuitry	Microprocessor controlled from 1/2 to 1/32 microstepping
Timing Belt Drive	2:1
Lead Screw Pitch	24 threads/in
Motor Steps per One Revolution of Lead Screw	From 800 to 12,800 dependent on rate
Step Rate:	
Minimum	27.3 sec/step
Maximum	416.7 µsec/step
Minimum Pusher Advance/Step	0.082 µm
Pusher Travel Rate:	
Minimum	0.18 µm/min
Maximum	190.676 mm/min
Dynamic Speed Range	1,059,311 to 1
Maximum Force	193 lb
Maximum Pressure	1500 psi with an 8 ml stainless steel syringe
Accuracy	±1%
Reproducibility	±0.1%

Pump '44' Specifications

Calibration	Enter syringe dia. from table, any size, any make up to 50 mm dia.
Syringe Size:	
Minimum	0.5 µl
Maximum	140 ml
Flow Rate Range:	
Minimum	0.0001 µl/hr (0.5 µl syringe)
Maximum	220.82 ml/min (140 ml syringe)
Display	20 character alphanumeric vacuum fluorescent; 5 LED indicators
RS-232 Interface	Multiplexed dual bidirectional ports
Non-Volatile Memory	Storage of all settings

Pressure and Speed

Pump '44' can deliver up to 220.82 ml/mm with a 140 ml syringe and is capable of pressures up to 1500 PSI with an 8 ml stainless steel syringe. (See Appendix C).

Built-in Syringe Table and Custom Syringes

If a *non-standard* syringe is to be used, enter the inside diameter in millimeters.

If a *standard* syringe is to be used, select your syringe using the pump's built-in syringe table. Syringes are arranged according to manufacturer and material, and then according to size. The pump will look up and use the diameter for the syringe you select. (See Appendix A for standard syringes).

Infusion and Refill Rates

Specify independent rates for infusing and refilling. This allows a slow infusion rate then a fast refill.

Auto Fill

Auto Fill automatically activates an externally attached solenoid and refills the syringe when it is empty. This permits infusions to be virtually independent of syringe capacity.

Modes of Operation

Pump – Runs continuously, infuse or refill, until stopped

Volume – Runs until a specified volume has been pumped or refilled

Program – Pump operates according to a specified sequence of instructions

(Note: All modes interact with Auto Fill feature)

External Connections

TTL – Allows pump operations to be synchronized with external devices or by a person at a distance from the pump. Direction of pump travel can be set via a TTL pin. Also, a TTL pin is used to control an external valve for refilling. Additional TTL pins are available for general use.

RS-232 – Multiple pumps can be "daisy chained" together and remotely controlled from a computer or any device communicating via RS-232.

A scale can be attached, enabling the pump to infuse by weight instead of by volume.

A printer can be attached to record final volumes or weights whenever the pump stops. In addition the program entered for the program mode can be listed on an attached printer.

Nonvolatile Memory

All operational data entered into the pump from the keypad or from a computer will be stored, including the program. On power up, the display will blink until the pump receives its first command and all settings from when it was powered down will be recalled. If in an unlikely event a failure to properly recall the data occurs, the settings will be reset and the display will read: SETTINGS RESET.

Stall Detection

An optical detector is used to verify expected movement of the motor. If the motor is prevented from turning due to jamming or kinking of the tubing, the pump will stop and the display will read: PUMP STALLED.

Theory of Operation

Pump '44' employs a microcontroller which controls a small step angle stepping motor that drives a lead screw and half nut. Microstepping techniques are employed to further reduce the step angle, making flow pulsation negligible. A key pad is used for entry of operating data to the pump. Data can also be entered via RS-232. The microcontroller calculates the cross-sectional area of the syringe selected and calibrates the flow rate and volume accumulation. The numerous features of the Pump '44' result from the use of microcontroller technology.

Initial Set-Up

1. Read the manual.

2. Locate the voltage selector switch on the rear panel of the pump and set it to the voltage being used. If other than 110 V, 60 Hz is being used, the plug must be cut off and an appropriate plug installed, observing the polarity of the international line cord used:

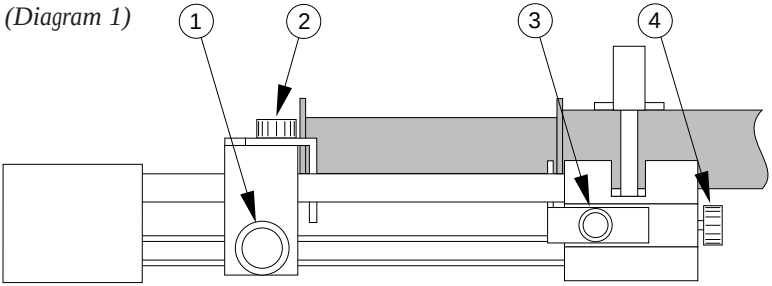
Brown	–	live
Blue	–	neutral
Green	–	ground

3. Turn on main power switch located directly above the line cord on the rear panel. The display will now illuminate indicating that the power connections are correct. The flashing display indicates that power has just been applied.

4. Load syringe, see next page.

Loading Syringes

(Diagram 1)



- The syringe holder and pusher block are fitted with movable retaining brackets which hold firmly the syringe barrel and plunger when refilling. When loading the syringe into the pump it is necessary to adjust these brackets. The pusher block is fitted with a mechanism to release the drive nut from the leadscrew so that the block can be moved freely to facilitate loading the syringe.

- Loosen the screws on the syringe block and pusher block to free the retaining brackets (2 & 3, Diag. 1).

- To free the pusher block from the leadscrew, turn the knob on the front of the block (1) until the pin in the knob slips into the hole in the block.

- The syringe clamp locking screw on the right side of the syringe block (4) should be loosened and the clamp rotated to the side.

- Place the syringe barrel on the syringe holder block and move the pusher block to accommodate the plunger.

- Make sure the syringe barrel flange and the plunger flange are held by the retaining clamps. Press the retaining brackets firmly against the flanges and tighten the retaining screws.

- Rotate the syringe clamp and press down firmly on the syringe barrel. Secure in place by tightening the locking screw (4).

User Interface

The user interface consists of a display area and a keypad. The display consists of a 20 character alphanumeric vacuum fluorescent display and 5 LED indicators. The display will show one of three types of messages: *default display, setting display, or an informational message.*

The default display is divided into three sections. The first consists of the delivered volume, or time interval remaining in an operation, expressed with 5 digits plus a decimal point. Next is the units of the previous number expressed as "ml" for milliliters, "g" for grams, if a scale is attached, or "time" for a time interval. Third is the pumping direction, either "INFUSE" or "REFILL", or the current operating state of the pump. A diamond symbol in the last character of the display indicates pump chain communication has been received.

Setting displays are used to facilitate entering control information and data into the pump. Data entry will be discussed in detail.

Informational messages occur at various times to indicate such items as a data setting out of range, or a detected problem, such as the pump stalling. Pressing any key clears the message from the display.

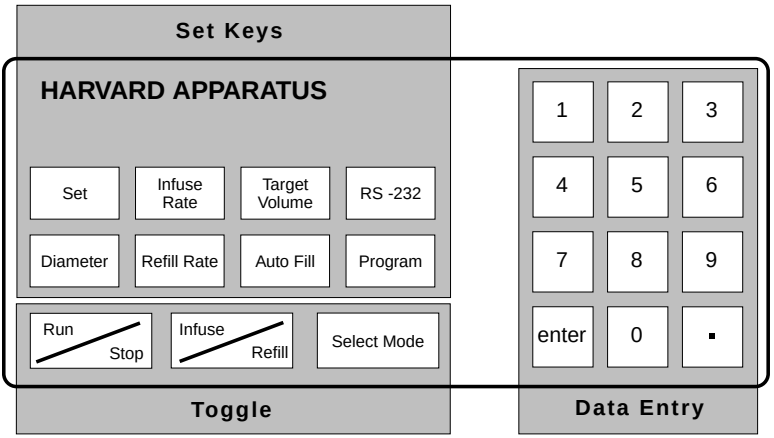
The LED indicators have the following meanings when lit:

Pump Mode	–	Indicates Pump run mode
Vol. Mode	–	Indicates Target Volume run mode
Prog. Mode	–	Indicates Program run mode
Auto Fill	–	Indicates Auto Fill feature is on
Run	–	Indicates motor is running

Description of Keys

The keypad consists of 23 keys used for entering control information and data into the pump. These keys are grouped into 3 sections (see Diagram 2): set keys, toggle keys, and data entry keys.

(Diagram 2)



Set Keys

SET – Allows modification of a data item in this group of keys. To modify a data item, press the relevant key after pressing the SET key.

INFUSE RATE – Displays/sets current infuse rate. Scrolls through rate units when setting. Displays current programmed rate while running in program mode.

REFILL RATE – Displays/sets current refill rate. Scrolls through rate units when setting.

DIAMETER – Displays/sets current syringe diameter. When held down during setting, enters built-in syringe table.

TARGET VOLUME – Displays/sets current volume mode target volume.

RS-232 – Displays/sets current RS-232 device(s) attached.

AUTO FILL – Turns Auto Fill feature setting on/off. Also, displays/sets syringe refill volume.

PROGRAM – Displays current sequence number of program. Held down, with a printer attached and the pump stopped, prints a program listing.

Description of Keys (Contd)

Toggle Keys

SELECT MODE – Toggles between PUMP/DISPENSE/PROGRAM run modes with each press of the key. LED indicators display current mode. Pump must be stopped.

INFUSE/REFILL – Changes direction of syringe travel for Pump and Volume modes. Pump must be stopped or in pump mode.

RUN/STOP – Starts/stops–interrupts pump.

Data Entry Keys

1, 2, 3, 4, 5, 6, 7, 8, 9, 0, – Used to facilitate the entering of numeric data values.

ENTER – Stores displayed data value when setting a data item.

Entering Data

Set Keys

The yellow keys in this group are used to modify or review settings of the pumps control data. To review the current setting of a control data item, simply hold down the relevant key and the data setting will appear in the display. In the case of the PROGRAM key, the data will be sent to the printer if one is attached.

To modify a data setting, first press then release the green SET key. The display should then read "SET WHAT?". Press the key in the SET key group whose data is to be modified. The display will display the current setting. Data is entered into the pump by either entering a numerical value or by scrolling through a menu of choices. Always press ENTER to terminate each data request by the pump.

If you are to enter a numerical value, the far left of the display will show "ENTER" followed by the units of the number to be entered. Using the numerical keys on the right side of the keypad (see diagram) enter the new data value. Up to five digit numbers are accepted, including up to four decimal places.

Entering more than five digits will clear the previous five digits in the display. Press the green ENTER key when the desired data value is displayed.

If the far left of the display does not show "ENTER", then a menu of choices is being displayed. Pressing the relevant key, according to the choices being displayed, selects successive menu entries. When the desired selection is displayed, press the green ENTER key.

If the data value entered is outside the pump's operating parameters, the display will read "OUT OF RANGE". Pressing any key will restore the display with the original data value. Enter another data value within the pump's parameters or just press ENTER to reuse the original data value.

The data value entered can be reviewed as described above. Note: Certain data items have multiple settings. For these, after the ENTER key is pressed, the display will prompt you for the additional information. Various rules apply to when, what and how data can be set at various times. See the relevant section for further details.

Toggle Keys

The keys in this group, when permitted, select successive states of the keys' function when pressed.

Because of the wide range of functions that the Pump '44' is capable of performing, certain information about your application must be entered into the pump. At minimum, the pump needs to know the diameter of your syringe, the infusion rate and direction of travel. This is the only information needed to operate the pump in the Pump Mode. If not specified, the Refill Rate will default to the Infuse Rate. The pump will need additional information to utilize its more advanced features. See the section on User interface for general information on data entry.

Diameter

If the inside diameter of the syringe being used is known, enter the value in millimeters. Otherwise, access the built-in syringe table and select your syringe. After a new diameter is entered, directly or via the built-in table, the Infuse Rate and Refill Rate are set to 0 and the Auto Fill feature is turned off. This is done for reasons of safety. The maximum diameter is 50 mm.

To access the built-in syringe table, after pressing the SET key then the DIAMETER key, hold down the DIAMETER key for about one second. Using the DIAMETER key, find the manufacturer and material, if applicable, of your syringe. Press the ENTER key to enter your selection. Now, using the DIAMETER key again, find the size of your syringe, in CC or UL, as indicated on the display. Pressing the ENTER key will select the size of the syringe and look up and store the diameter.

The diameter will be displayed until the ENTER key is released. Thereafter, pressing the DIAMETER key will display the selected diameter. In addition, the syringe size selected becomes the default Refill Volume when the Auto Fill feature is turned on. See Appendix A for a listing of the built-in syringe table and their respective diameters.

Infuse Rate

The Infuse Rate is the rate of pumping while infusing in the Pump or Volume modes. Also, the Infuse Rate is used as a starting rate for the program mode if one is not specified in the program, regardless of pumping direction.

When entering the Infuse Rate, the INFUSE RATE key is used to scroll through the allowable units of rate. The allowable units are: ml/mn, ml/hr, µl/mn, µl/hr.

While running in the Pump or Volume modes, the Infuse Rate can be changed. If the new rate is valid, it will take effect when the ENTER key is pressed.

The minimum and maximum rates permitted vary depending on the diameter of the syringe. If an "OUT OF RANGE" message is displayed when entering a rate, try using a different syringe for your application.

Refill Rate

The Refill Rate is the rate of pumping while refilling in the Pump or Volume Modes or during Auto Fill. If the Refill Rate hasn't been set (rate is 0), the Refill Rate will default to the Infuse Rate.

When entering the Refill Rate, the REFILL RATE key is used to scroll through the allowable units of rate. The allowable units are: ml/mn, ml/hr, µl/mn, µl/hr.

While running in the Pump or Volume modes, the Refill Rate can be changed. If the new rate is valid, it will take effect when the ENTER key is pressed.

The minimum and maximum rates permitted vary depending on the diameter of the syringe. If an "OUT OF RANGE" message is displayed when entering a rate, try using a different syringe.

Auto Fill

While setting, use the AUTO FILL key to toggle between Auto Fill "on" and "off". If Auto Fill is set to "on", the pump will next request the volume of the syringe in milliliters. The volume of the syringe is used as the refill volume of the syringe.

When set to "on", the syringe is assumed to be empty. Auto Fill continuously monitors the volume of the syringe according to the volume pumped. When the pump determines that the syringe is empty, the operation in progress is suspended and Auto Fill is activated. The pumping direction is then reversed and the pump runs at the refill rate. During the Auto Fill operation, the display will indicate the volume in the syringe.

When the volume in the syringe reaches the set syringe volume, Auto Fill will stop, and the previous operation of the pump will resume. Auto Fill continues to monitor the volume of the syringe. TTL direction output is toggled on during refill. Refill Rate defaults to Infuse Rate if not set.

Note: Auto Fill will only activate while infusing, (i.e., if the pump direction is set to Refill, the pump will not stop when the syringe is full.) Also, if the syringe plunger is manually moved, the pump will lose track of the true syringe volume.

Selecting the Run Mode

After entering any necessary operating data into the pump, select the pumping mode that will be used when the pump is operated. Pressing the SELECT MODE key advances the LED run mode indicator. Advance the run mode indicator to the desired mode, either Pump Mode, Volume Mode or Program Mode.

(1) Pump Mode - The pump will continuously pump, infusing or refilling, until stopped. While running, the Infuse and Refill Rates can be changed. The new rate, for the relevant pumping direction, takes effect when the ENTER key is pressed. Also, the pumping direction can be changed by pressing the INFUSE/REFILL key.

(2) Volume Mode - The pump will run, infusing or refilling, until a specified target volume is pumped or refilled. The TARGET VOLUME key is used to enter the Volume Mode pumping target. Used in conjunction with Auto Fill, the target volume can be greater than the volume of the syringe. While running, the Target Volume, Infuse and Refill Rates can be changed. The new rate, for the relevant pumping direction, takes effect when the ENTER key is pressed.

(3) Program Mode - In the Program Mode the pump can make complex dispenses including changes in rate and target volume. These complex dispenses are easily programmed from the keypad and are detailed in the Program Mode and the Programming Tutorial sections.

Running the Pump

Pressing the RUN/STOP key starts the pump. The pump will operate according to the relevant data entered as interpreted by the selected run mode. Pressing the RUN/STOP key while the pump is running stops the pump and the right side of the display will indicate "INTERRUPT" plus a ">" for infusing or a "<" for refilling. This indicates that the pumping operation has been suspended and can be continued. Pressing the RUN/STOP key again will continue the pumping operation at the point that it was interrupted. Changing any of the settings, including the pumping direction and the run mode, cancels the interrupted operation and resets the volume delivered display to 0.0000 ml. The pump can also be started and stopped from a remote source.

Program Description

A program is made up of a set of sequences. Each sequence being a set of operating instructions for the pump to follow. When the pump is started in the PROGRAM run mode, the pump will start at sequence 1 and execute the operating instructions in that sequence. When the pump has completed the instructions for a sequence, it will go to the next, or specified, sequence and execute the instructions in that sequence. Presently, up to nine sequences may be entered. The pump continues this process until it either has reached a "STOP" operation, the pump is manually or remotely stopped, or the last sequence has completed.

A sequence consists of a sequence number, indicating the order of the sequence; a mode, indicating what operation the sequence will be performing; and the actual data for the operation, such as rates and volumes. The necessary data specified for each sequence will depend on the strategy used.

One of two strategies may be chosen for a sequence's target. Strategy 1 pumps until a target volume is reached, while Strategy 2 pumps until a target time interval has lapsed. When Strategy 1 is used, enter a time interval of 0:00:00, then you will be prompted for the target volume. See the Programming Tutorial for example programs.

Entering a Program

It is advisable to plan out your program prior to entering the program into the pump. Press SET then PROGRAM to begin entering a program.

The following is a list of possible data that can be requested when entering a program and instructions on entering the data.

Sequence Operation

Use the PROGRAM key to select the sequence's operation. Operations that can be selected are: Profile, Increment, Decrement, Dispense, Pump, Event, Go To, TTL Out, Pause, Restart, Stop.

When the required operation is displayed press ENTER. Additional information may be requested.

Rate

Enter the rate, using the INFUSE RATE key to change units. Note: If the rate entered is invalid, an error message *will not* be given at the immediate time of entry. An "OUT OF RANGE" error message will be given during the running of the program.

Delta Rate

Enter the rate increment or decrement. The units of the rate cannot be specified. Units will be the same as the units of the current pumping rate at the time the sequence is executed.

Target Volume

Enter the delivered target volume of the sequence. For increment and decrement sequences, the target volume is an incremental target. An incremental target is added to the delivered volume at the start of the sequence.

Time Interval

Enter the time duration of the sequence in the form: "hours : minutes : seconds". If sequence Strategy 1 is used, enter 0:00:00 for the time target. The maximum time interval is 9:99:99.

Number of Repetitions

Enter the number of times the sequence is to be repeated. The repetition number can be from 1 to 99,999.

Pumping Direction

Each sequence that specifies a pumping operation, also specifies a pumping direction. Use the INFUSE/REFILL key to change the pumping direction.

Pin Level

Select either HI or LOW for the logic level of the programmable output pin 4. Use the PROGRAM key to change the setting.

Go to sequence number

Enter the destination sequence to continue operation of the program. Valid sequence numbers are 1 to 9.

Profile

Runs at specified rate until target volume is pumped or a time interval has elapsed. Travel direction is as specified.

Data Specified:

Strategy 1:	Rate	Strategy 2:	Rate
	Target volume		Time interval
	Pumping direction		Pumping direction

Incr

Increments current rate by specified value and pumps until the target volume is pumped or a time interval has elapsed. Units of rate will be that of the current rate of the pump or the infusion rate's units, if first sequence.

Sequence is repeated the specified number of times. Travel direction is as specified.

Data Specified:

Strategy 1:	Delta rate	Strategy 2:	Delta rate
	Volume increment		Time interval
	Number of repetitions		Number of repetitions
	Pumping direction		Pumping direction

Decr

Same as INCR except rate is decremented.

Dispense

Repeatedly dispense specified volume. Runs at specified rate until a volume is pumped or a time interval has elapsed, then pump will stop. If no time interval was specified (Strategy 1), the display will show "TRIGGER" and the next dispense will begin after an external or keyboard run command. Otherwise, the sequence will pause for specified time interval. Sequence is repeated the specified number of times.

Travel direction is as specified:

Strategy 1:	Rate	Strategy 2:	Rate
	Target volume		Target volume
	Number of repetitions		Time interval
	Pumping direction		Number of repetitions
			Pumping direction

Event

Program Events – A program event is an external event defined as a high to low transition on TTL pin-9. Within a program, a one time event trigger can be set which watches for and acts upon the external event. The triggered event causes an immediate continuation of the program at the specified sequence and the operation of the pump will be according to this sequence.

Data Specified: Go to sequence number

Go To

Causes the program to immediately continue operation at the sequence specified.

Data Specified: Go to sequence number

Pause

Pump stops for specified time then continues with next programmed sequence. Current program rate set to 0, with no change in units.

Data Specified: Time interval

Pump

Runs the pump continuously at the specified rate without any pumping target. This mode can provide a background flow rate while waiting for an external event to trigger a new sequence specified by the EVENT operation.

Data Specified: Rate

Pumping direction

Restart

Immediately restart program from the first sequence.

Data Specified: None

TTL Out

Programmable TTL Pin
TTL output Pin 4 can be set to a HIGH or LOW level from within a program

Data Specified: TTL pin level

Stop

Stops pump and terminates program.

Data Specified: None

Program Printout

If a printer is attached and the pump is stopped, a program listing can be obtained by pressing the PROGRAM key for about one second. "PRINTING PROGRAM" will be displayed while data is being sent.

Program Run Time Error Messages

If while running a program an operation is requested that cannot be performed, the pump will stop and an error message will be displayed. Error messages will be displayed with the following format:

SEQ n: message

Where "n" is the sequence number where an error was detected, and "message" is the indicated error as follows:

INFINITE LOOP
A GO TO sequence cannot specify the current sequence.

INVALID GO TO
The target of the GO TO specified an invalid sequence number.

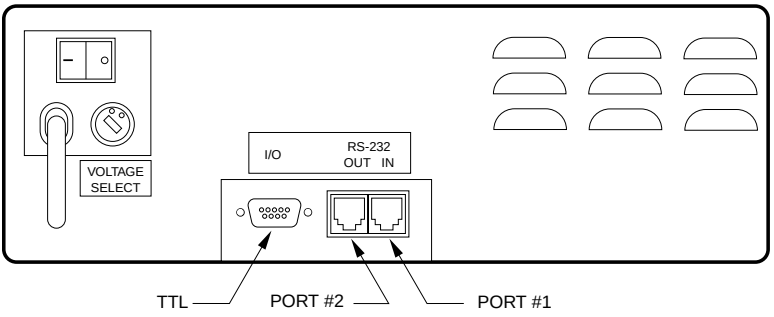
RATE UNDERFLOW
A decrement sequence decremented a rate to less than or equal to 0.

RATE OVERFLOW
An increment sequence caused an arithmetic overflow.

OUT OF RANGE
Specified or calculated rate is beyond the pumps capabilities with the specified syringe.

VOL TGT ERROR
A sequence with a volume target cannot follow a sequence with a time target, unless the volume delivered is zero or the pump is stopped at the start of the sequence.

External devices that can be attached to the Pump 44 are categorized into either RS-232 devices or TTL devices. Pump Chains, Scales and Printers are RS-232 devices, all other devices are TTL devices. See the appropriate appendixes for specification details on attaching devices.



RS-232 Devices

On the back of the pump are two telephone jack type connectors. These are the RS-232 ports. Looking at the back of the pump, the connector on the right is port 1 and the left is port 2. Attach the RS-232 connectors in the appropriate port according to the following chart:

Device	***Port Number***
Pump Chain computer side	1
Pump Chain pump side	2
Scale	1
Printer	2

Configuring the Pump for RS-232 devices

Press SET, then use the RS-232 key to scroll through the menu of allowable RS-232 configurations.

Possible configurations are:

Pump Chain
Scale
Printer
Scale & Printer

After entering the RS-232 configuration, additional information may be requested:

Pump Chain

- Enter the 2-digit address assigned to the pump. Note: Each pump in the chain needs a unique address. After entering the address, the baud rate will be requested. Use the RS-232 key to toggle between the supported baud rates: 300, 1200, 2400 and 9600. Note: Each pump in the chain must have same baud rate. See the section on Pump Chain Commands for pump chain control information.

Scale

- Use the RS-232 key to toggle between the supported manufacturers: Mettler, Sartorius and Ohaus. When a scale is attached, the weight will be read from the scale and used as the delivered volume whenever the pumping direction of the pump is set to infuse. When refilling, the syringe diameter is used for volume calculations. When the scale weight is displayed, the units will be grams.

Printer

- No additional information requested when entering. With a printer attached, the pump will print the delivered volume whenever the pump stops or the direction of pumping changes, except before and after Auto Fill of the syringe. If the pump stops due to the pump stalling, an asterik (*) will be appended to the volume printed.

  In addition, the entered pump program can be listed on the printer by pressing the PROGRAM key for about one second, with the pump stopped.

TTL Devices

- The pump does not need to be configured to attach a TTL device. Simply plug the device into the 9-pin connector on the rear of the pump. See Appendix F for wiring specifications.

Foot Switch or Relay

- Used to start and stop the pump. Pressing the footswitch performs the same function as pressing the RUN/STOP key on the keyboard. The footswitch connector allows remote or automated operation of the pump.

Timer

- Opening the timer input starts the pump. Closing the timer input stops the pump. The timer input allows for an externally controlled pumping interval.

Pumping Direction

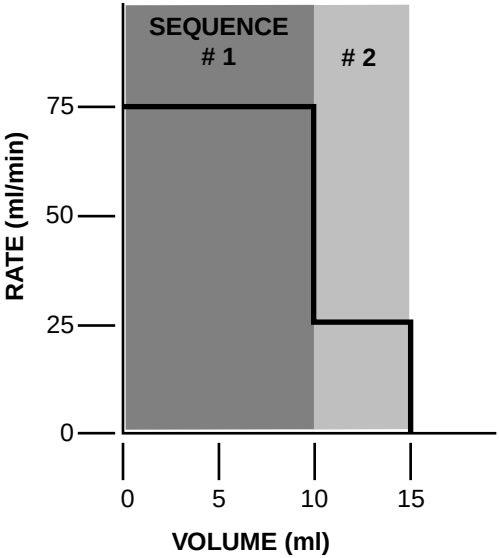
- Sets the direction of pumping. Opening the directional input sets the pump to infuse. Closing the directional input sets the pump to refill. The pumping direction input is recognized only in the situations that the INFUSE/REFILL key would be recognized, i.e., when the pump is stopped or running in the Pump Mode.

Valve Control

- The valve control output is an indicator of the direction of pump travel. When the output is a logical high, the pump is set to refill. A logical low indicates infuse.

In the following examples, the diameter is 26.7 mm and the infuse rate is 50 ml/mn. To run a program after entering it, select Program Mode using the SELECT MODE key and press the RUN/STOP key.

Example 1



The following program will instruct the pump to infuse according to the above graph. The program instructs the pump to infuse 10 ml at 75.000 ml/mn then infuse another 5 ml at 25 ml/mn then stop, for a total of three sequences. Since this graph is Rate vs. Volume, Strategy 1 will be used when entering the program.

Programming Tutorial (Contd)

SEQUENCE 1:

Key Presses	***Explanation***
SET, PROGRAM	Allows program entry
PROGRAM	Press until PROFILE selected
ENTER	Enters selection
75	Enter rate of 75.000 ml/mn
INFUSE RATE	Press until units are ml/mn
ENTER	Enters rate
0, ENTER	Enter 0 for the time, this indicates Strategy 1
10, ENTER	10 ml is the first target volume
INFUSE/REFILL	Toggles direction to infuse
ENTER	Enters sequence's pumping direction

SEQUENCE 2:

Key Presses	***Explanation***
PROGRAM	Press until PROFILE selected
ENTER	Enters selection
25	Enter rate of 25.000 ml/mn
INFUSE RATE	Press until units are ml/mn
ENTER	Enters rate
0, ENTER	Enter 0 for the time, this indicates Strategy 1
5, ENTER	5 ml is the second target volume
INFUSE/REFILL	Toggles direction to infuse
ENTER	Enter sequence's pumping direction

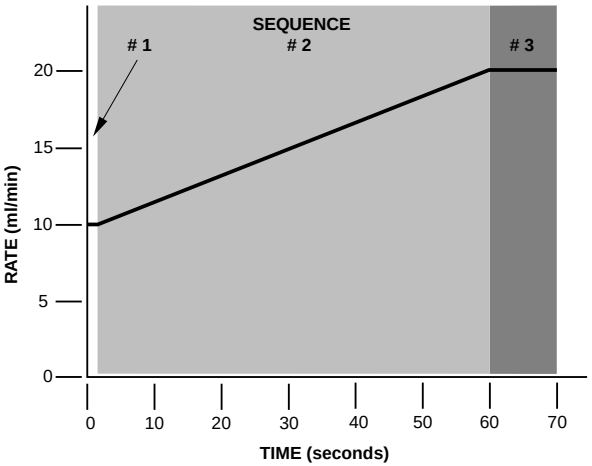
SEQUENCE 3:

Key Presses	***Explanation***
PROGRAM	Press until STOP selected
ENTER	Enters selection and ends program entry

PROGRAM PRINTOUT

```
SEQ 1:  PROFILE
75.000 ml/mn
10.000 ml
INFUSE
SEQ 2:  PROFILE
25.000 ml/mn
5.0000 ml
INFUSE
SEQ 3:  STOP
```

Example 2



In this example, the pump will ramp up from 10 ml/mm to 20 ml/mn over 60 seconds, then continue to run at 20 ml/min for another 10 seconds. This is a Strategy 2 Program requiring four sequences:

(1) Specify the initial rate as a profile of 10 ml/mn for one second.

(2) Specify the ramp up to 20 ml/mn. Since the minimum resolution of an increment is one second, it will take 59 steps to reach the target rate. Sequence 2 starts at time 1 second and ends at time 60 seconds, giving it a duration of 59 seconds. At one second a step, 59 seconds divided by one second per step equals 59 steps. The increase per step will by 20 ml/mn minus 10 ml/mn, divided by 59 steps or 0.1695 rounded to four decimal places.

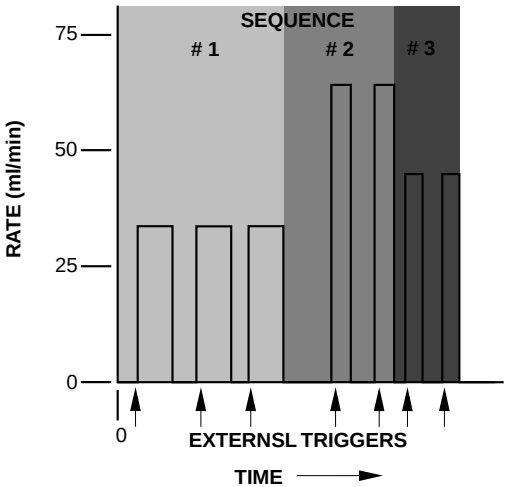
(3) Continue running at 20 ml/mn for 10 seconds with a profile operation.

(4) Stop the pump.

PROGRAM PRINTOUT

```
SEQ 1:  PROFILE
10.000 ml/mn
0:00:01 INTERVAL
INFUSE
SEQ 2:  INCR
0.1695 INCR
0:00:01 INTERVAL
INFUSE
59 REPEAT
SEQ 3:  PROFILE
20.000 ml/mn
0:00:10 INTERVAL
INFUSE
SEQ 4:  STOP
10.000 ml
```

Example 3



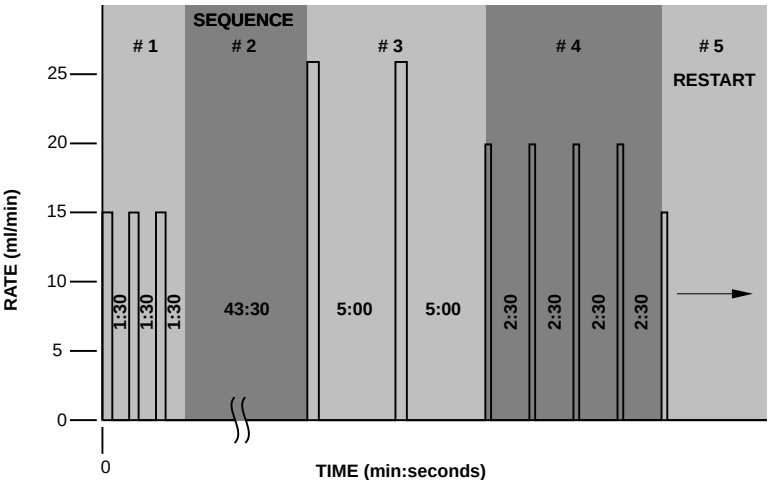
Here, a series of dispenses are programmed. Each dispense is started by a trigger, such as pressing the RUN/STOP key or pressing an attached foot switch. Seven dispenses are programmed: three of 15 ml at 35 ml/mn, two of 25 ml at 65 ml/mn, and two of 17 ml at 45 ml/mn. The pump's display will show "TRIGGER" when it is waiting for a run trigger and the Run LED will be off.

This is a Strategy 1 dispense. A time interval of 0 is specified when entering a Strategy 1 dispense. Since the total volume to be dispensed is 129 ml and the syringe volume is 50 ml, the Auto Fill feature would be very useful with this program.

PROGRAM PRINTOUT

```
SEQ 1:  DISPENSE
35.000 ml/mn
15.000 ml
3.  REPEAT
INFUSE
SEQ 2:  DISPENSE
65.000 ml/mn
25.000 ml
2. REPEAT
INFUSE
SEQ 3:  DISPENSE
45.000 ml/mn
17.000 ml
2. REPEAT
INFUSE
SEQ 4:  STOP
```

Example 4



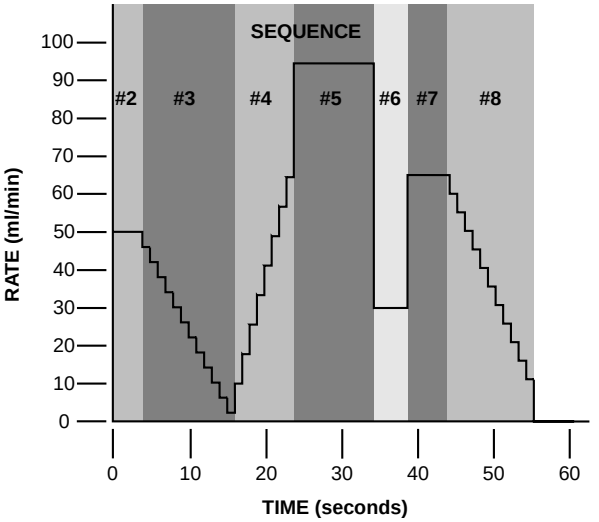
This is an example of a series of periodic dispenses of varying volumes and intervals. For this application, Strategy 2 dispenses are used. Note that between the third and fourth dispenses is a 45 minute interval. Each dispense in the first sequence is separated by a pause interval of 1:30. Since after the third dispense there already will be a 1:30 pause, an additional pause of 43:30 is used to extend the pause to the desired 45:00. Sequence 5 is a RESTART command, causing the series of dispenses to be continuously repeated until the pump is stopped.

PROGRAM PRINTOUT

```
SEQ 1:  DISPENSE
15.000 ml/mn
3.5000 ml
0:01:30 INTERVAL
3. REPEAT
INFUSE
SEQ 2:  PAUSE
0:43:30 INTERVAL
SEQ 3:  DISPENSE
25.700 ml/mn
6.7500 ml
0:05:00 INTERVAL
2.  REPEAT
INFUSE
SEQ 4:  DISPENSE
20.000 ml/mn
4.3000 ml
0:02:30 INTERVAL
4.  REPEAT
INFUSE
SEQ 5:  RESTART
```

Programming Tutorial (Contd)

Example 5



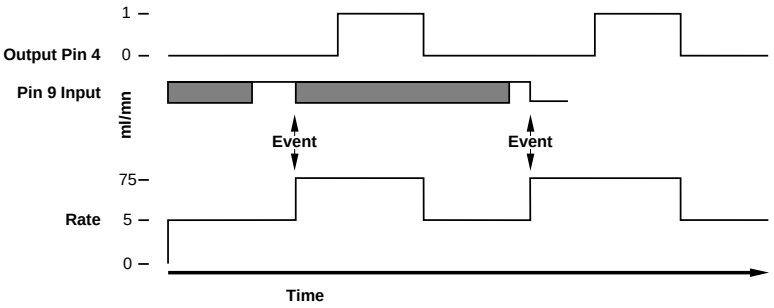
Here is an example of a more complex profile program. Each "run" of the infusion has been determined to pump 43.155 ml. The first sequence refills the syringe with the volume to be infused then the infusion profile is started, after which the syringe is refilled and the infusion is repeated until the pump is stopped.

PROGRAM PRINTOUT

```
SEQ 1:  PROFILE
75.000 ml/mn
43.155 ml
REFILL
SEQ 2:  PROFILE
50.000 ml/mn
0:00:04 INTERVAL
INFUSE
SEQ 3:  DECR
4.0000 DECR
0:00:01 INTERVAL
12.  REPEAT
INFUSE
SEQ 4:  INCR
8.0000 INCR
0:00:01 INTERVAL
8.  REPEAT
INFUSE
```

```
SEQ 5:  PROFILE
95.000 ml/mn
0:00:10 INTERVAL
INFUSE
SEQ 6:  PROFILE
30.000 ml/mn
0:00:05 INTERVAL
INFUSE
SEQ 7:  PROFILE
65.000 ml/mn
0:00:05 INTERVAL
INFUSE
SEQ 8:  DECR
5.0000 DECR
0:00:01 INTERVAL
11.  REPEAT
INFUSE
SEQ 9:  RESTART
```

Example 6

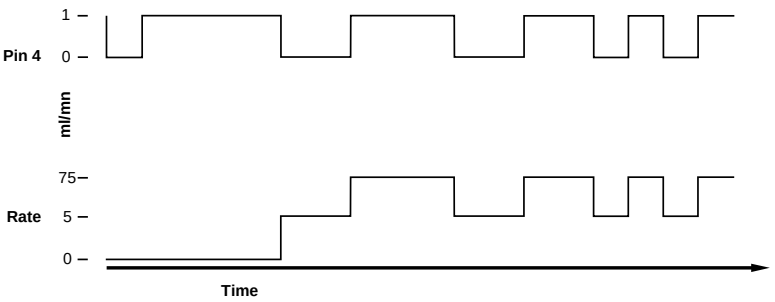


This is an example of the Pump 44 working interactively with other laboratory equipment. The pump will continuously pump at 300 ml/hr until an external event, a high to low transition at pin 9, possibly produced by another Pump 44, causes the pump to deliver a 15 ml bolus at 75 ml/mn. After delivering 5 ml of the bolus, output pin 4 is set to a logic high for the duration of the bolus after which it is dropped. This output pin can be attached to the timer input of another pump, such as a Harvard Pump 22, to create a precise mixture during the bolus. After the bolus is completed, the Pump 22 would be stopped and the Pump 44 would return to delivering its background rate of 300 ml/hr, waiting for another external event.

PROGRAM PRINTOUT

```
SEQ 1:  TTL OUT
OFF
SEQ 2:  EVENT
GO TO 4
SEQ 3:  PUMP
300.00 ml/hr
INFUSE
SEQ 4:  PROFILE
75.000 ml/mn
5.0000 ml
INFUSE
SEQ 5:  TTL OUT
ON
SEQ 6:  PROFILE
75.000 ml/mn
10.0000 ml
INFUSE
SEQ 7:  RESTART
```

Example 7



Before the pumping flow begins, the pump sends a TTL signal to another piece of equipment for 5 seconds, but first verifies that the TTL line is low by turning it off for 1 second, then turns it on.

The pumping process itself consists of an alternation of pumping 3 ml's at 53 ml/mn then pumping 5 ml's at 75 ml/mn. The pump uses the TTL output to signal to another device which sequence it is executing by lowering the TTL line before sequence 5 and raising the line before sequence 8.

PROGRAM PRINTOUT

```
SEQ 1:  TTL OUT
OFF
SEQ 2:  PAUSE
0:00:01 INTERVAL
SEQ 3:  TTL OUT
ON
SEQ 4:  PAUSE
0:00:01 INTERVAL
SEQ 5:  TTL OUT
OFF
SEQ 6:  PROFILE
53.000 ml/mn
3.0000 ml
INFUSE
SEQ 7:  TTL OUT
ON
SEQ 8:  PROFILE
75.000 ml/mn
5.0000 ml
INFUSE
SEQ 9:  GO TO
GO TO 5
```

Example 8

This is an example of the Pump 44 being operated from a remote location. When the pump is powered on, the position of the pusher block is unknown and must be homed to a known position.

At the syringe full position, a limit switch is placed such that it is tripped by the pusher block when the syringe is full. The limit switch is connected to pins 4 and 9, programmable output and the event input, on the TTL connector.

When the pump receives a start signal, it first refills the syringe and stops when the limit switch is sensed. The pump then waits for a start trigger and performs a dispense then refills the syringe and waits again for the next start trigger.

PROGRAM PRINTOUT

```
SEQ 1:  EVENT
GO TO 7
SEQ 2:  TTL OUT
ON
SEQ 3:  PAUSE
0:00:01 INTERVAL
SEQ 4:  TTL OUT
OFF
SEQ 5:  PAUSE
00:00:01 INTERVAL
SEQ 6:  PUMP
75.000 ml/mn
SEQ 7:  DISPENSE
10.000 ml/mn
0.0001 ml
1. REPEAT
REFILL
SEQ 8:  PUMP
75.000 ml/mn
10.000 ml
INFUSE
SEQ 9:  RESTART
```

Pump Chain Commands

The Pump Chain RS-232 interface is used to enhance the control applications of the Pump '44'. This interface allows all control information, including a program, to be entered into the pump from an external source such as a computer. In addition, this interface allows up to 100 Pump 44's and, in certain cases, other RS-232 devices to be controlled from a single RS-232 communication port on a computer.

Assign each pump in the pump chain a unique address from 0 to 99. This address is used to identify which pump is to receive a command and which pump is responding. Configure each pump with its assigned address and the baud rate being used (See External Control & Interfaces).

When a pump is sent a command, or a request is made for its prompt, a diamond appears on the far right of the default display indicating that it is receiving RS-232 commands. The diamond remains on the default display until the pump is turned off or SET RS-232 is entered on the keyboard, indicating a change in the RS-232 configuration.

A pump will not respond to pump chain communication while it is in a setting mode (entered when user presses the SET key). The pump can still be controlled from the keyboard while it is in a pump chain. Control data that is changed via RS-232 will be stored in the pump's non-volatile memory.

After each command is received and executed, the pump terminates its responses with a prompt. A prompt is a string of ascii characters sent by a pump.

Each command sent to the pump chain is a string of ascii characters, with leading zero's on numbers and all spaces optional. Numbers are a maximum of five digits. The following symbols are used in describing the commands:

Symbol	***Meaning***
[. . .]	optional
{. . .}	select one
|	either/or
f	digits 0 – 9 or a decimal point
d	digits 0 – 9
<cr>	carriage return (ascii 13)
<lf>	line feed (ascii 10)
<float>	f f f f f f
<integer>	ddddd
<time>	d:dd:dd
<text>	any string of ascii characters

Command Format	***Meaning***
<cr>	Stops all pumps. All pumps on the pump chain interpret this as a stop command.
pump address, <cr>	Request for prompt The pump with the indicated address responds with its prompt
optional pump address, command, <cr>	Send a command to a pump. The pump with the indicated address executes the command then responds with its prompt. The optional pump address, if not specified, will default to pump address 0.

After each command is received and executed, the pump acknowledges the command with a prompt. Preceding the prompt may be some additional text responses. The additional text will be one or more lines of ascii text, each preceded by a line feed and terminated by a carriage return:

<lf>, <text>, <cr>

A prompt is a string of ascii characters sent by a pump indicating the pumps address and its present state:

<lf>, 1 or 2 digit address, prompt character

Prompt Characters	***Meaning***
:	Pump stopped
>	Pump infusing
<	Pump refilling
/	Pause interval (pump stopped)
*	Pumping interrupted (pump stopped)
^	Dispense trigger wait (pump stopped)

RUN

Starts pumping according to the present setting of the pump. If pump is already pumping, a "Not Applicable" response will be given.

STP

Stops pump if it was running. If pump was already stopped, a "Not Applicable" response will be given.

DEL

Request for volume delivered, in ml.
Response is of the following format:
space, space, f f f f f f

CLD

Request to zero volume delivered. If the pump was interrupted, it will cancel the interrupted condition. If the pump is running, request will not be accepted and a "Not Applicable" response will be given. Otherwise, no response is given.

RAT [<float> [<units>]]

Request to set or query infusion rate setting.
Set infusion rate:
RAT rate
Set infusion rate and units:
RAT rate units
Rate is of format: f f f f f f
Units are one of:

	Definition
UM	µl/mn
UH	µl/hr
MM	ml/mn
MH	ml/hr

If rate is accepted and valid, rate will become the new infusion rate.
If the rate is invalid, an "Out Of Range" response will be given.
Command will not be accepted if the pump is running in the Program Mode and a "Not Applicable" response will be given.

Query infusion rate: RAT
Response is of the following format:
space, space, f f f f f f units
Where units is one of the following:
ml/mn
ul/mn
ml/hr
ul/hr

RFR [<float> [<units>]]

Request to set or query refill rate setting.
Set refill rate:
RFR rate
Set refill rate and units:
RFR rate units
Rate is of format: f f f f f f
Units are one of:

	Definition
UM	µl/mn
UH	µl/hr
MM	ml/mn
MH	ml/hr

If rate is accepted and valid, rate will become the new refill rate.
If the rate is invalid, an "Out Of Range" response will be given.
Command will not be accepted if the pump is running in the Program Mode and a "Not Applicable" response will be given.

Query refill rate: RFR
Response is of the following format:
space, space, f f f f f f units
Where units is one of the following:
ml/mn
ul/mn
ml/hr
ul/hr

PGR

Request for the rate of pumping set during the running of a program.
Response is of the following format:
space, space, f f f f f f units
Where units is one of the following:
ml/mn
ul/mn
ml/hr
ul/hr

DIA [<float>]

Request to set or query syringe diameter setting.
Set diameter:
DIA diameter
Diameter is of format: f f f f f f
Units are MM.

INFUSE and REFILL rates will be set to zero and AUTO FILL will be set to off.

If diameter is accepted and valid, diameter will become the new diameter. Diameter will not be accepted if the pump is running and a "Not Applicable" response will be given.
If the diameter is invalid, an "Out Of Range" response will be given.

Query diameter: DIA
Response is of the following format:
space, space, f f f f f f
Units are MM.

TGT [<float>]

Request to set or query target volume setting.
Set target volume:
TGT volume
Volume is of format: f f f f f f
Units are ML.
If volume is accepted and valid, volume will become the new target volume. Volume will not be accepted if the pump is running and a "Not Applicable" response will be given.
If the volume is invalid, an "Out Of Range" response will be given.

Query volume: TGT
Response is of the following format:
space, space, f f f f f f
Units are ML.

MOD [{PMP|VOL|PGM}]

Request to set or query pumping mode
Set: MOD PMP (Puts pump in Pump Mode)
MOD VOL (Puts pump in Volume Mode)
MOD PGM (Puts pump in Program Mode)
Command will not be accepted if the pump is running and a "Not Applicable" response will be given.

Query: MOD
If mode is PUMP, response will be:
PUMP
If mode is VOLUME, response will be:
VOLUME
If mode is PROGRAM response will be:
PRGRAM

DIR [{INF|REF|REV}]

Request to set or query pumping direction
Set: DIR INF (sets pumping direction to infusion)
DIR REF (sets pumping direction to refill)
DIR REV (reverses current pumping direction)

Command will not be accepted if the pump is running in volume or program modes and a "Not Applicable" response will be given.

Query: DIR
If pump direction is infusion, response will be:
INFUSE
If pump direction is refill, response will be:
REFILL

AF [{ON|OFF}]

Request to set or query auto fill setting
Set: AF ON (turns Auto Fill feature on)
Note: The syringe volume is also needed for auto fill to operate. (See SYR command)
AF OFF (turns Auto Fill function off)
Command will not be accepted if the pump is running and a "Not Applicable" response will be given.

Query: AF
If Auto Fill function is ON, response will be:
ON
If Auto Fill function if OFF, response will be:
OFF

SYR [<float>]

Request to set or query syringe volume setting for auto fill.
Used in conjunction with Auto Fill feature. (See AF command).
Set syringe volume: SYR volume
Volume is of format: f f f f f f
Units are ML.
If volume is accepted and valid, volume will become the new syringe Auto Fill volume. Volume will not be accepted if the pump is running and a "Not Applicable" response will be given.
If the volume is invalid, an "Out Of Range" response will be given.

Query syringe volume: SYR
Response is of the following format:
space, space, f f f f f f

IN d

Request to read the TTL logic level of the specified pin on the external 9 pin D-SUB connector.
Valid pin numbers for input are:
6, 7, 8 and 9
If the pin specified is valid and if the pin level is high, response will be:
ON
If the pin level is low, response will be:
OFF

If the pin specified is invalid:
An "Out Of Range" response will be given

OUT d = <ON|OFF>

Request to set the TTL logic level at the specified pin on the external 9 pin D-SUB connector.
Valid pin number for output is: 4
If the pin specified is invalid:
An "Out Of Range" response will be given
Example:
Set pin 4 high:
OUT 4 = ON
Set pin 4 low:
OUT 4 = OFF

SEQ [<integer>} [<entry>]

Request to set or query programming sequences. <integer> is sequence number. Default is Sequence 1. Command only applicable while pump is stopped. Valid sequence numbers, "n", are 1 to 9. "n" defaults to 1 wherever it is optional. See program examples.

Query entire program: SEQ
Example response:

```
SEQ 1:  DISPENSE
75.000 ml/mn
43.155 ml
0:00:01 INTERVAL
                    3 REPEAT
INFUSE
SEQ 2:  PROFILE
100.00 ml/mn
150.00 ml
REFILL
SEQ 3:  RESTART
```

Query program sequence n: SEQ n
Example response to the command "SEQ 2" with the previous example's program:

SEQ 2: PROFILE
100.00 ml/mn
150.00 ml
REFILL

Query program sequence n's mode: SEQ [n] MOD Response will be according to the following table:

Response	Description	Response	Description
STP	stop	RST	restart
PRO	profile	GOT	go to
INC	increment	EVN	event
DEC	decrement	PMP	pump
DIS	dispense	OUT	TTL out
PAS	pause		

Query data item of program sequence n:

Command	Description
SEQ [n] RAT	Query rate Response: f f f f f f units Where units is one of the following: ml/mn ul/mn ml/hr ul/hr
SEQ [n] GOT	Query go to sequence number Response: <n>
SEQ [n] TGT	Query target volume Response: <float>
SEQ [n] INT	Query time interval Response: <time>
SEQ [n] RPT	Query repetition count Response: <float>
SEQ [n] OUT	Query output pin level setting Response: <ON/OFF>
SEQ [n] DIR	Query pumping direction Possible responses: INFUSE REFILL

Set mode of program sequence n:
SEQ [n] MOD mode
Where mode is as follows:

Mode	Description	Mode	Description
STP	stop	RST	restart
PRO	profile	EVN	event
INC	increment	GOT	go to
DEC	decrement	OUT	set output pin
DIS	dispense	PMP	pump
PAS	pause		

Set data item of program sequence n:
Set sequence's rate:
SEQ [<n>] RAT <float> [<units>]
Rate is of format: f f f f f f

Units are one of :	***Description***
UM	µl/mn
UH	µl/hr
MM	ml/mn
MH	ml/hr

Set sequence's go to sequence number
SEC [<n>] GOT <n>

Set sequence's target volume:
SEQ [<n>] TGT <float>

Set sequence's time or target:
SEQ [<n>] INT <time>

Set sequence's repetition number:
SEQ [<n>] RPT <integer>

Set sequence's pumping direction:
SEQ [<n>] DIR <INF|REF>

Set sequence's output pin level
SEQ [<n>] OUT <ON|OFF>

VER

Request for version of pumps embedded software.
Response for the present version will be:
space, space, 44V2.3

Pump Chain Error Messages

Error messages are in the format:
<lf>, space, space, <message>, <cr>,

Where <message> is one of the following:

?	Syntax error in a received command
NA	Command not applicable at this time
OOR	Control data is out of the operating range of the pump

Appendix A (Syringe Diameter in mm)

Stainless Steel

Size	Diameter
8 cc	9.525 mm
20 cc	19.130
50 cc	28.600
100 cc	34.900

Becton Dickinson Plastic "Plasticpak"

Size	Diameter
1 cc	4.78 mm
3	8.66
5	12.06
10	14.50
20	19.13
30	21.70
50/60	26.70

Air–Tite "All Plastic"

Size	Diameter
2.5 cc	9.60 mm
5.0	12.45
10	15.90
20	20.05
30	22.50
50	29.00

Unimetrics Series 4000 & 5000

Size	Diameter
10 µl	0.460 mm
25	0.729
50	1.031
100	1.460
250	2.300
500	3.260
1000	4.610

Terumo

Size	Diameter
3 cc	8.95 mm
5	13.00
10	15.80
20	20.15
30	23.10
60	29.10

Sherwood–Monoject Plastic

Size	Diameter
1 cc	4.65 mm
3	8.94
6	12.70
12	15.90
20	20.40
35	23.80
60	26.60
140	38.40

Popper & Sons, Inc. "Perfektum" Glass

Size	Diameter
0.25 cc	3.45 mm
0.5	3.45
1	4.50
2	8.92
3	8.99
5	11.70
10	14.70
20	19.58
30	22.70
50	29.00
100	35.70

SGE Scientific Glass Engineering

Size	Diameter
25 µl	0.73 mm
50	1.03
100	1.46
250	2.30
500	3.26
1.0 ml	4.61 mm
2.5	7.28
5	10.30
10	14.57

Hamilton–Microliter Series Gastight

Size	Diameter
.5 µl	0.103 mm
1	0.1457
2	0.206
5	0.3257
10	0.460
25	0.729
50	1.031
100	1.46
250	2.3
500	3.26
1.0 ml	4.61 mm
2.5	7.28
5	10.3
10	14.57
25	23.0
50	32.6

Appendix B

Nominal Minimum & Maximum Flow Rates

Various Syringes

(Actual Limits Will Vary Depending on Manufacturer)

Pump 44

nominal syringe size	µl/hr		µl/min		ml/hr		ml/min	
	min	max	min	max	min	max	min	max
0.5 µl	.0001	95.33						
1.0 µl	.0002	190.74						
2.0 µl	.0004	381.30						
5.0 µl	.0010	953.17						
10.0 µl	.0019					1.9013		
25.0 µl	.0046					4.7752		
50.0 µl	.0092					9.5511		
100.0 µl	.0183					19.153		
250.0 µl	.0454					47.532		
1000.0 µl			.0031			190.95		
1.0 ml			.0033			205.30		
2.0 ml			.0119			747.35		
2.5 ml			.0108			476.21		
3.0 ml			.0108					11.231
5.0 ml			.0208					21.781
10.0 ml			.0301					31.486
20.0 ml			.0523					54.804
30.0 ml			.0673					70.518
50.0 ml			.1019					106.76
100.0 ml			.1740					182.40
140.0 ml			.2106					220.82

Appendix C

Pressure & Force Specifications

Rate ml/min	Starting PSI	Stall PSI	Stall Force Lbs.	Stall Force (Kg)
10	110	115	170	77
20	120	120	178	81
30	120	130	193	88
50	110	130	193	88
70	110	125	185	84
90	110	120	178	81
110	85	115	170	77
130	70	100	148	67
150	45	90	133	60
170	25	75	111	50
180	10	65	96	43

Rate

This is the rate indicated with a Harvard Apparatus 100 ml stainless steel syringe. Diameter 34.9 mm, cross-sectional area 1.48 square inches.

Starting PSI

This is the back pressure at which the pump would reliably start. At higher pressures, the pump may stall.

Stall PSI

This is the back pressure that finally stalls the pump.

Stall Force

This is the force coressponding to the stall PSI. The same force applied to different size syringes will generate correspondingly higher or lower pressures and flow rates.

Appendix D

Pump Chain Command Summary

All spaces in command are ignored.

Maximum 5 digits per integer, float or time data.

		Description
Command =>	[<adr>] [<cmd>] <cr>	
adr =>	[d] d	1 or 2 digit address
cmd =>	RUN	start pump
	STP	stop/interrupt pump
	DEL	query volume delivered
	CLD	clear volume delivered
	RAT [<float> [<units>]]	set/query infusion rate
	RFR [<float> [<units>]]	set/query refill rate
	PGR	query current program rate
	DIA [<float>]	set/query syringe diameter
	TGT [<float>]	set/query target volume
	MOD [{PMP|VOL|PGM}]	set/query pumping mode
	DIR [{INF|REF|REV}]	set/query pumping direction
	SEQ [<integer>] [<entry>]	set/query program sequences
	AF [{ON|OFF}]	set/query auto fill setting
	SYR [<float>]	set/query syringe refill volume
	IN <d>	read TTL pin d
	OUT <d> = {ON|OFF}	output TTL pin d
	VER	query software version
entry =>	MOD [{PRO|INC|DEC|GOT|OUT|EVN|PMP|DIS|PAS|RST|STP}]	set/query seq mode
	RAT [<float> [<units>]]	set/query seq rate
	TGT [<float>]	set/query seq dispense volume
	INT [<time>]	set/query seq interval
	RPT [<integer>]	set/query seq repetition
	DIR [{INF|REF}]	set/query seq pumping direction
	OUT [{ON|OFF}]	set/query TTL pin setting
	GOT [d]	set/query go to sequence
units =>	{UM|UH|MM|MH}	µl/min, µl/hr, ml/min, ml/hr

Appendix D (Contd)

Command Response Output Format

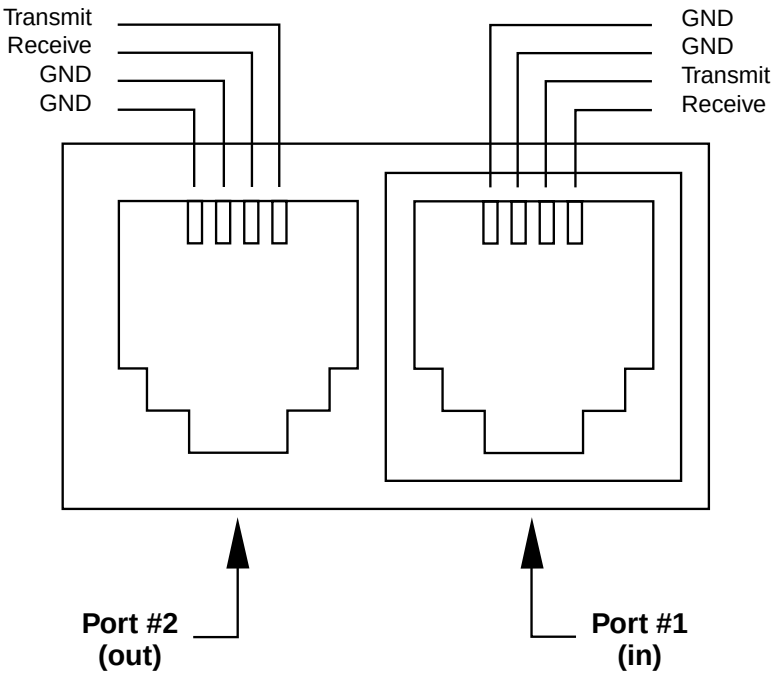
		Description
output =>	[<response>] <prompt>	
response =>	<response> <response> <lf> <message> <cr>	
prompt =>	<lf> <adr>:	stopped
	<lf> <adr>>	infusing
	<lf> <adr> <	withdrawing
	<lf> <adr>/	pause interval (stopped)
	<lf> <adr> *	pumping interrrupted (stopped)
	<lf> <adr> ^	dispense trigger wait (stopped)
adr =>	[d]d	1 or 2 digit pump address
message =>	bb?	unrecognized command
	bb NA	command not presently applicable
	bb OOR	entered value out of range
	bb <text>	
	<integer>	
	<float>	
	<time>	

Legend

<...>	non-terminal	
upper case	terminals	
[...]	optional	
{...}	select one	
|	either-or	
=>	non-terminal expansion	
float	**=>**	ffffff
f	**=>**	d|**.**
integer	**=>**	ddddd
time	**=>**	d:dd:dd
d	**=>**	0|1|2|3|4|5|6|7|8|9
b	**=>**	(space)
cr	**=>**	(ascii 13)carriage return
1f	**=>**	(ascii 10)line feed
text	**=>**	(any string of ascii characters)

Appendix E

RS-232 Specifications



Pump Chain

Pump Port 1	–	Computer control side
Pump Port 1	–	Computer control side
Pump Port 2	–	Connection for remainder of pump chain
Baud Rate	–	300, 1200, 2400 or 9600
Word Size	–	8
Parity	–	none
Stop Bits	–	2

Scale

Connect scale to Pump Port 1
Supported scales:

Appendix E (Contd)

Mettler

Baud Rate – 2400
Word Size – 7
Parity – even
Stop Bits – 1
Pause – 0

Sartorius

Baud Rate – 2400
Word Size – 7
Parity – even
Stop Bits – 1

Code Settings:

311 – Weigh only (models with PLUS performance package)
211 – External print command without stability
225 – 2400 baud
234 – Even Parity
432 – Beeper off

Ohaus

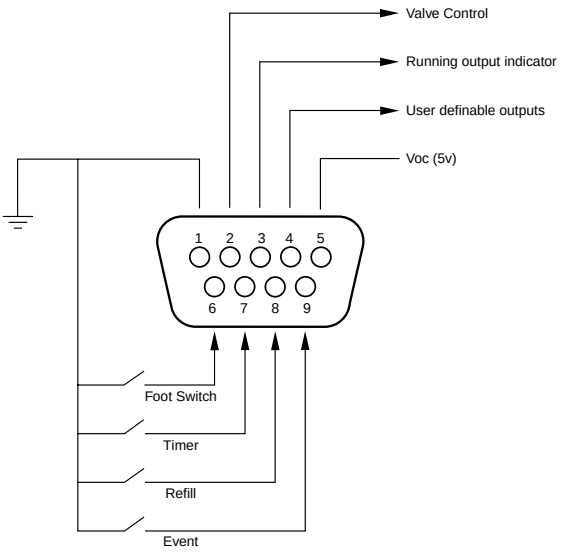
Baud Rate – 2400
Word Size – 8
Parity – even
Stop Bits – 1
Auto print feature – off
Stable data only – off
Serial data frame selection – Fr.7

Printer

Serial printer with print buffer

Baud Rate – 2400
Word Size – 8
Parity – none
Stop Bits – 2

TTL Connector Specifications



TTL Connections are via a 9 pin D-sub type connector. All inputs are internally pulled up to a logic high.

Pin Assignments:

1 Vss (Ground reference, logic low)

2 Valve control output:
Low – Infusing
High – Refilling

3 Running Output Indicator
Low - Pumped stopped
High - Pump running

4 Programmable output

5 Vcc (logic high reference)

6 Foot switch input
Falling edge starts/stops pump

7 Timer Input
Rising edge starts pump
Falling edge stops pump

8 Directional control input
Rising edge sets pump to infuse
Falling edge sets pump to refill

9 Event input
Falling edge triggers program event

Logic Low: 0 V – 0.5 V
Maximum 2 mA current sink

Logic High: 2 V – 5 V
Maximum 400 µA current source

Maintenance

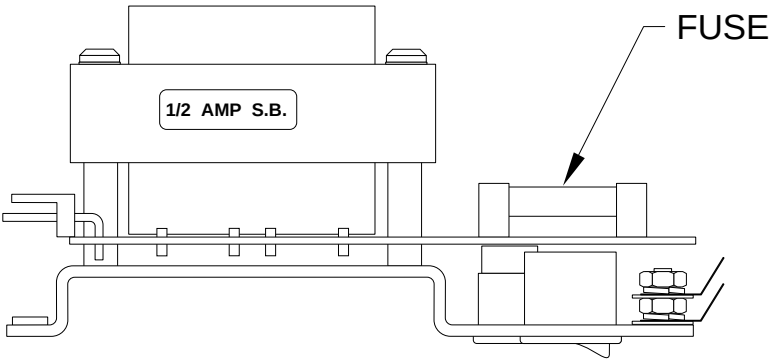
Pump '44' requires no special maintenance other than keeping it clean by avoiding accidental spills of pumped material.

The two guide rods and the lead screw should be sparingly lubricated periodically with the Magnalube-G R grease provided with the pump. This Teflon R based grease is available either from Harvard Apparatus or Carleton-Stuart Corp. 13-02 44th Ave., Long Island City, NY 11101

Solvents of any type should never be used to clean the pump. A mild detergent solution may be used to clean the key pad.

Fuse Replacement

Make sure power cord is disconnected from main supply before replacing fuse. Remove bottom cover on pump by removing four (4) rubber feet and three (3) screws. Remove two (2) nuts retaining aluminium shield. Locate fuse on power supply module. Remove fuse from fuse clip. Use caution not to break the fuse when removing. Replace fuse, shield, bottom cover, screws and rubber feet. For continued fire protection replace fuse only with specified type and rating. (3AG 1/2 AMP 250V SLO-BLO)



WARNING: USE IN MANNER NOT SPECIFIED BY THE MANUFACTURER MAY IMPAIR THE PROTECTION PROVIDED BY THE EQUIPMENT.

Appendix H

Troubleshooting

RS-232 Difficulties

Verify that the baud rates and data framing parameters on all devices are the same. With the pump chain, a "Communication timeout" error on a computer is usually caused by the computer errantly handshaking on the RTS, CTS and DSR lines. Verify pins 4, 5 and 6, on the 25 pin connector, are jumpered on the computer side of the cable.

Pump '44' Display Messages

PUMP STALLED

This indicates that the pusher block travel has been impeded. This may be caused by the syringe plunger hitting bottom, a kink in the tubing, syringe plunger binding or any situation requiring more force to the head of the syringe than the pump is capable of delivering. To restart the pump, remove the cause of stalling and press RUN. The pump will continue the interrupted procedure where it stopped. Also note, a large increase in the pumping rate could also stall the motor.

OUT OF RANGE

A value was entered or encountered in a pump program that was beyond the pump's limits. Also, verify that the Infuse Rate is not 0. Note that rates must be less than 42949. Express larger rates using different units.

SETTINGS RESET

The values stored in the non-volatile memory have been lost. This should never occur under normal operation.

REPLACE NOVRAM

The non-volatile memory has failed. This should never occur under normal operation.

Accessories

Auto Fill Accessory

To operate the Auto Fill feature, either the low pressure or high pressure valve assembly is required. Each assembly contains the solenoid valve, connector cable, power cable, and tubing and fittings to connect to the syringe. Operates at 115/230 VAC, 50/60 Hz via a selector switch.

Catalog No.	***Product***
55-1146	Low pressure Auto Fill Accessory
55-1145	High Pressure Auto Fill Accessory

Additional Accessories

Catalog No.	***Product***
55-4144	Foot Switch for '44' Pump
55-7760	Pump Chain Cable for connecting two or more '44' Pumps
55-4145	RS-232C Connector Cable for IBM and compatible personal computers
55-4146	RS-232C Connector Cable for other than IBM and compatible personal computers

Appendix J

Custom Applications

The Harvard '44' Programmable Syringe Pump lends itself to a multitude of OEM industrial applications.

For all types of custom pumping or pilot plant applications, the pump's programming capabilities can be enhanced. Please contact the Harvard Development Group if we can be of help.

Pump '44' Variations

98-0759 – Multi-Syringe Pump, with up to 10 Syringes, (20 ml - .5 µl)
– Multi-Syringe Pump, with up to 6 Syringes, (30 ml - 140 ml)

98-0782 – Higher Pressure Single Syringe Pump - 250 lbs. of Force,

98-0774 – Remote Single Syringe Pump - 250 lbs. of Force.

Appendix K: 'Auto Fill' Valves

Two models are available:

55-1146	Supplied with 1/8 inch I.D., 1/4 inch O.D. silastic tubing and a connector to the syringe.
55-1145	Supplies with 1/4 inch O.D. 304 stainless steel tubing with Swagelok fittings.

Setting Up the Valve

Set up consist of three phases: Voltage selection (110 or 220v), Pump to valve electrical connection and Valve tubing to syringe hook up.

1. Voltage Selection

Valves are shipped from the factory with an American line cord with three wire molded power connector and the pump set for 115 - 125 VAC.

For 220 - 240 VAC operation the molded power connector must be cut off and replaced with an appropriate type. The line cord is color coded in International standard colors:

Brown	-	High
Blue	-	Neutral
Green	-	Ground

Observe the polarities when installing the new connector.

To adjust the valve for 220 - 240 volt operation an international voltage selector switch must be set.

Remove the top panel by removing eight screws, four on each enc of the valve. Identify the voltage selector switch located directly below. Using a screw driver turn the switch from 110 to 220.

The pump is now set up for 220 volt operation.

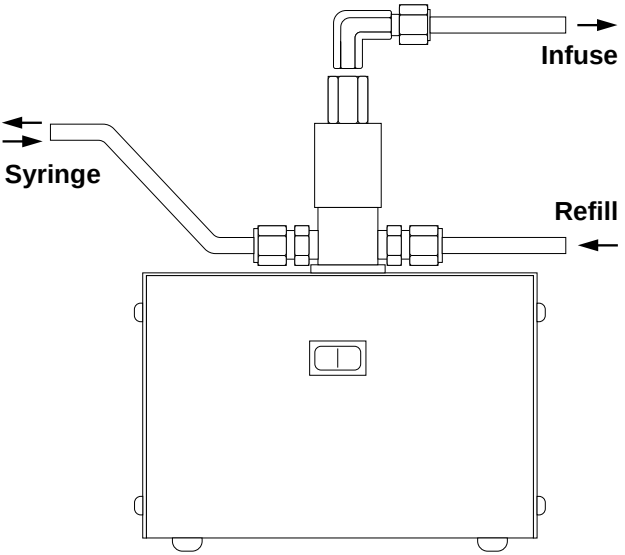
2. Pump to Valve Electrical Connection

The cable fitted with a male 9 pin D-sub connector must be connected to the female D-sub connector on the rear of the Model '44' Syringe Pump.

Power can now be switched on with the illuminated power On/Off switch on the front valve housing.

3. Pump to Valve Tubing Connection

Swagelok fitting should be finger tight plus 1 1/4 turn. Tubing is 304 stainless steel 1/4 inch O.D. wall thickness 0.035 inch.



Silicon tubing 1.4 inch O.D., 1/8 inch I.D.