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SP200 Series

Microprocessor-controlled syringe pumps

www.wpiinc.com

INSTRUCTION MANUAL

Serial No._____

082701

World Precision Instruments

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DECLARATION OF CONFORMITY

We: World Precision Instruments, Inc.
175 Sarasota Center Boulevard
Sarasota FL 34240-9258
USA

as the distributor of the apparatus listed, declare that the products:

Title: SP200i Infusion Pump, SP210iw Infusion/Withdrawal Pump, SP220i Infusion Pump, SP230iw Infusion/Withdrawal Pump, SP250i Infusion Pump, SP260p and SP210c Push-Pull Pumps

to which this declaration relates are in conformity with the following standards or other normative documents:

Emissions/Immunity: EN 61326:1997 w/A1:1998 and A2:2001
EN 61000-4-2:1995
EN 61000-4-3:1996
EN 61000-4-4:1995
EN 61000-4-5:1995
EN 61000-4-6:1996
EN 61000-4-8:1994
EN 61000-4-11:1994
EN 61000-3-2:2000
EN 61000-3-3:1997

Safety: EN61010-1, 2nd Edition (2001)

and therefore conform with the protection requirements of Council Directives 89/336/EEC relating to electromagnetic compatibility and 73/23/EEC relating to safety.

Issued on: May 4, 2007

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Warranty

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of one year* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

Claims and Returns

• Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within 10 days after receipt of shipment. Claims for lost shipments must be made within 30 days of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim settles. In some instances, photographic documentation may be required. Some items are time sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container.

• WPI cannot be held responsible for items damaged in shipment en route to us. Please enclose merchandise in its original shipping container to avoid damage from handling. We recommend that you insure merchandise when shipping. The customer is responsible for paying shipping expenses including adequate insurance on all items returned.

• Do not return any goods to WPI without obtaining prior approval and instructions (RMA#) from our returns department. Goods returned unauthorized or by collect freight may be refused. The RMA# must be clearly displayed on the outside of the box, or the package will not be accepted. Please contact the RMA department for a request form.

• Goods returned for repair must be reasonably clean and free of hazardous materials.

• A handling fee is charged for goods returned for exchange or credit. This fee may add up to 25% of the sale price depending on the condition of the item. Goods ordered in error are also subject to the handling fee.

• Equipment which was built as a special order cannot be returned.

• Always refer to the RMA# when contacting WPI to obtain a status of your returned item.

• For any other issues regarding a claim or return, please contact the RMA department.

Warning: This equipment is not designed or intended for use on humans.

** Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*

General Safety Summary

Please read the following safety precautions to ensure proper use of your syringe pump. To avoid potential hazards and product damage, use this product only as instructed in this manual. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

To Prevent Hazard or Injury

Use Proper Power Supply

The pump is supplied with an approved power supply and line cord.

Use Proper Line Cord

Use only the line cord shipped with the product and make sure line cord is certified for country of use.

Ground the Product

This product is grounded through the grounding conductor of the power cord. To avoid electric shock, use only approved line cord with the product and insure it is connected to earth ground.



Protective Ground Terminal

Make Proper Connections

Make sure all connections are made properly and securely.

Orient Equipment Properly

Do not position the equipment such that it is difficult to reach the disconnecting device.

Observe all Terminal Ratings

Review the operating manual to learn the ratings on all connections.

Avoid Exposed Circuitry

Do not touch any electronic circuitry inside of the product.

Do Not Operate with Suspected Failures

If damage is suspected on or to the product do not operate the product. Contact qualified service personnel to perform inspection.



CAUTION

Refer to Manual

Avoid Pinch Hazard

A pinch hazard may exist between the Pusher Block and End Blocks. Avoid placing fingers between these points while the pump is running.

Observe all Warning Labels on Product

Read all labels on product to ensure proper usage.

NOTE: This pump is not registered with the FDA and is not for clinical use on human or veterinary patients. It is intended for research use only.

General Description

This manual applies to infusion pumps **SP200i**, **SP220i**, **SP250i**; infusion/withdrawal pumps **SP210iw** and **SP230iw**; push/pull pump **SP260p**; and continuous cycle pump **SP210c**.

Most features are common to all pumps. However, the infusion/withdrawal models, **SP210iw** and **SP230iw** have additional modes and related RS232 commands not available in infusion-only models.

Operation of the pumps is simplified by using a keypad to select features from a menu on the alphanumeric display.

All control functions are performed automatically by the pump microcontroller and are based on the syringe diameter and linear motion of the pusher block to deliver a known volume. After entering the syringe diameter, either directly or from a table in memory, a dispense volume and flow rate can be entered, and then all calibration and control functions are performed by the pump automatically.

Model	No. of Syringes	infusion	Withdrawal	Push/Pull
SP200i	2	X		
SP210iw	2	X	X	
SP210c	4			X
SP220i	10	X		
SP230iw	10	X	X	
SP250i	4	X		
SP260p	4			X

Specifications

SP200i, SP210c, 210iw, SP220i, SP230iw, SP250i, SP260p

Syringe Size	10 µL to 140 mL
Electrical Rating	US model 115 V~, 0.25 A CE model 230 V~, 0.16 A
Fuse	5 x 20 mm, 250 V~, Slow Blow, 0.25 A
Voltage Operating Range	US model 110-120 V~, 50/60 Hz CE model 200-240 V~, 50/60 Hz
Drive Mechanism	Microprocessor controlled stepper motor 1/2 - 1/16 microstepping, driving a leadscrew through a belt and pulley drive mechanism
Pusher Advance per Microstep ($^1/_{16}$ step)	0.165 micron (0.0000064 inch)
Volume per Microstep ($^1/_{16}$ step)	with 60 mL BD syringe - 0.0919 µL
Max. Stepping Rate	1600 (half-step) /sec
Min. Step Rate	1 ($^1/_{16}$-step) /120 secs
Linear Travel Rate	Min: 4.95 x10-4 cm/hr Max: 12.67 cm/min
Flowrate Range	2.757 µL/hr to 70.56 mL/min (60 mL syringe)
Nominal Linear Force	35 lb
Dimensions	11 x 9 x 5.5 inch (28 x 23.5 x 14 cm)
Weight	9 lb (4 kg)
Atmospheric Specifications Temperature Humidity	 5°C - 40°C (41°F - 104°F) 20% - 80% RH
Mode of Operation	Continuous
Classification	Class I
Pollution	Degree 2
Installation	Category II
Output	N/A
Physiological Effects	N/A
Cooling Conditions	No special considerations
Mechanical Stability	No special considerations
Protective Packaging	No special considerations
Earth Terminals	No external connections required
Removable Protective Means	N/A

Table 2 Flow Rates

Syringe	Diameter*	Minimum	Maximum
10 µL	0.46 mm	0.001 µL/h	21.10 µL/min
25 µL	0.73 mm	0.003 µL/h	53.15 µL/min
50 µL	1.03 mm	0.005 µL/h	105.8 µL/min
100 µL	1.46 mm	0.009 µL/h	212.6 µL/min
250 µL	2.3 mm	0.021 µL/h	527.6 µL/min
500 µL	3.26 mm	0.042 µL/h	1060 µL/min
1 mL	4.61 mm	0.083 µL/h	2119 µL/min
2.5 mL	7.28 mm	0.207 µL/hr	5286 µL/min
3 mL	8.59 mm	0.288 µL/hr	7360 µL/min
5 mL	10.3 mm	0.414 µL/hr	634 mL/hr
10 mL	14.57 mm	0.828 µL/hr	1270 mL/hr
20 mL	19.05 mm	1.414 µL/hr	2171 mL/hr
30 mL	21.59 mm	1.817 µL/hr	2789 mL/hr
50 mL	28.9 mm	3.277 µL/hr	4998 mL/hr
60 mL	26.6 mm	2.757 µL/hr	4234 mL/hr
100 mL	34.9 mm	4.746 µL/hr	7289 mL/hr
140 mL	38.4 mm	5.746 µL/hr	8824 mL/hr

Syringes from different manufacturers can have slightly different limits.

*__NOTE__: This is a reference diameter used to compute the flow rate. The specific diameter should be entered for your syringe type.

Features

Syringe identification

Look up Table — The pump contains a table of standard syringes arranged by manufacturer, material and size. Once the syringe is identified in the table the pump automatically enters the appropriate diameter.

Direct Entry — If the syringe used is not included in the table, the internal diameter of the syringe barrel can be measured in millimeters and entered directly from the keypad.

Infusion and refill rates

The infusion rate and, where applicable, the withdrawal rate can be set independently and can be changed while the pump is running. After the operating mode selection is made the program will prompt *only* for the relevant rates associated with that mode.

Volume

A target volume can be entered for infusion and refill independently, and the pump automatically stops when this volume is reached. The pump displays an initial volume of zero and increases as the dispense process proceeds to the target volume. The target volume can be reviewed or changed as the pump continues to operate.

Modes of operation

Infusion — Rate and volume settings: pump infuses to the set volume and stops. Rate setting only: pump runs until manually stopped or stalls.

Withdrawal — Rate and volume settings similar to above.

Infusion/ withdrawal — Infusion automatically followed by withdrawal. Rate and volume settings can be made independently for infusion and withdrawal, hence the pump can infuse at one rate and volume and then change to a different withdrawal flow rate and volume setting.

Withdrawal/ infusion — Withdrawal immediately followed by infusion. Separate settings for rate and volume can be made for withdrawal and infusion.

Continuous operation — The pump cycles from infusion to withdrawal continuously. The volume is identical in infuse and withdrawal directions.

Note: The displayed menu which prompts the operator for Rate and Volume settings changes with Mode selection. For convenience, only the relevant settings associated with the selected mode are prompted. For example, in the Withdrawal / Infusion mode the menu prompts for withdraw and then infuse volumes, followed by withdraw and infuse rates. In Infusion only mode, the menu prompts only for infusion volume and infusion

rate. In the Continuous mode only one volume is prompted for followed by infusion and withdrawal flow rates.

RS232C interface

Multiple pumps can be controlled in a "daisy chain" by a single PC. Programming is reduced to a small number of simple commands.

TTL

Input and output controls are available, such as, direction change, run indicator, footswitch or timer control, and valve or relay actuation.

Stall detection

The motor is monitored by an optical encoder to confirm the programmed movement. If the back pressure increases due to jamming or flow restriction the motor may stall. Stall detection by the encoder results in a pump shutdown. The display will read "Stalled". The stall message can be cleared with the **select** key.

Power disruption

When power is returned after a temporary power disruption the pump can be programmed to resume operation or remain stopped. However, if a dispense volume is set then the pump always remains stopped.

Non-volatile memory

All operational settings are stored in non-volatile memory for convenience and are used to set the pump when first switched on.

Selection of rate and volume units

Units of volume (µL or mL) and flowrate (µL or mL per min or hr) can be changed if required.

7. Scientific Glass Engineering
SGE

25 µL	0.73 mm
50	1.03
100	1.46
250	2.30
500	3.26
1 mL	4.61 mm
2.5	7.28
5	10.30
10	14.57

8. Sherwood - Monojet Plastic

1 cc	4.65 mm
3	8.94
6	12.70
12	15.90
20	20.40
35	23.80
50	26.60

9. Terumo

1 cc	4.73 mm
3	9.00
5	13.04
10	15.79
20	20.18
30	23.36
60	29.45

10. Unimetrics
Series 9000

10 µL	0.46 mm
25	0.73
50	1.03
100	1.46
250	2.30
500	3.26
1000	4.61

Table 1 – Syringe Diameters

1. "Air-Tite" All Plastic

1 cc	4.70 mm
2.5	9.70
5.0	12.48
10	15.89
20	20.00
30	22.50
50	28.90

2. Becton Dickinson

Interim, WW design, Plastipak

1 cc	4.70 mm
3	8.59
5	11.99
10	14.48
20	19.05
30	21.59
60	26.60

3. Becton Dickson

Glass - all types

0.5 cc	4.64 mm
1	4.64
2.5	8.66
5	11.86
10	14.34
20	19.13
30	22.70
60	28.60

4. Hamilton

1000-Series Gastight

10 µL	0.46 mm
25	0.73
50	1.03
100	1.46
250	2.30
500	3.26
1 mL	4.61 mm
2.5	7.28
5	10.30
10	14.57
25	23.03
50	32.57

5. Popper & Sons, Inc.

Perfektum glass

0.25	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

6. Ranfac

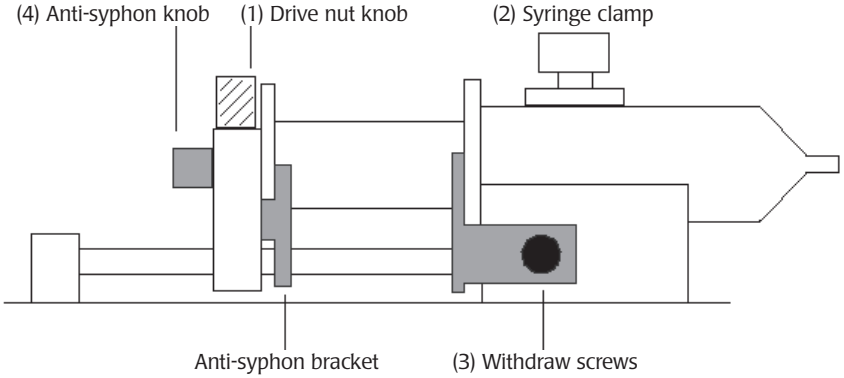
2 cc	9.12 mm
5	12.34
10	14.55
20	19.86
30	23.20
50	27.60

Operating Instructions

Power Switch

The power switch is located on the right corner of the rear panel.

Syringe Loading



To simplify syringe loading, the pusher block can be disengaged from the leadscrew by turning the knob(1) and manually moved along the guide rods. Alternately, the Fast forward, Fast reverse feature can be used (press Run and respective Arrow key simultaneously).

Knob (1) is rotated to release the drive nut from the leadscrew. When the white line on the knob is facing toward the syringe barrel the drive nut is engaged and when the white line faces the keypad the nut is disengaged.

Raise and rotate the spring loaded retaining arm (2) and place the syringe barrel in the "V" of the syringe holder. With the syringe in place release the retaining arm so that it clamps down on the barrel and holds it securely in place.

Release the pusher block mechanism and slide the block along the guide rods until the block presses firmly against the syringe plunger. Rotate the knob (1) to re-engage the drive nut.

SP210iw and SP230iw Withdrawal Operation

For withdrawal, or refill operation, the syringe plunger and barrel flange must be secured by additional brackets.

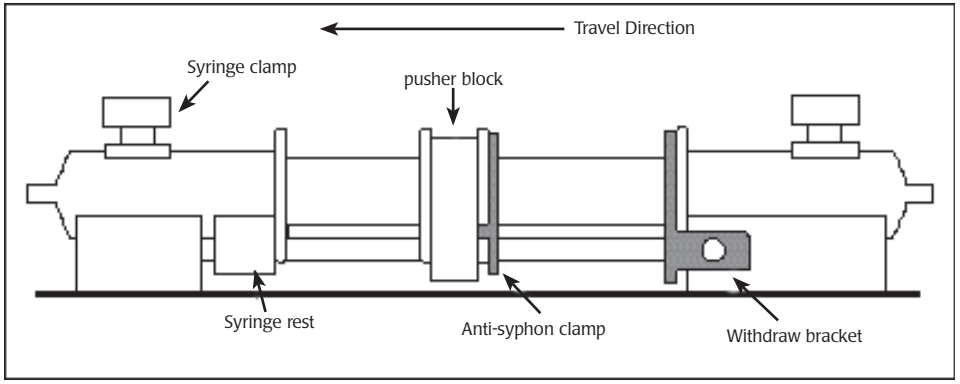
Loosen screws (3) on the syringe holder and, after loading the syringe, press the

retaining bracket against the barrel flange to secure the flange between the bracket and syringe holder. Tighten screws (3).

To restrain the plunger, rotate knob (4) to release the retaining bracket and position the syringe plunger between the pusher block and retaining bracket. Turn knob (4) clockwise to tighten the retaining bracket and then re-engage the drive nut knob (1).

The mechanism is designed to accommodate a wide range of syringe sizes however, there are some syringes which require additional attention (see page 10).

SP260p Push-Pull Syringe Pump



Push-Pull operation: Operate in Withdraw Mode.

Large volume dispenses using large syringes may not require the use of the syringe rest. Increase travel is possible if the infusion syringe is retained in the left syringe holder without use of the syringe rest.

SP260p has all the features of a model **SP210iw** and, for the push-pull operation the Withdrawal Mode should be selected from the menu. In this mode the pusher block will travel from right to left, as shown above.

Menu Features

When the pump is first turned on the LCD will display the last Rate or Volume setting. Pressing select repeatedly will always return the display to the main menu. The main menu consists of seven variables, three of which are displayed at all times. The center variable pulses to indicate that this option can be reviewed or changed. The menu acts as a continuous loop and the **arrow keys**, ← → are used to move around the loop. The variable to be changed can be selected with the **select** key.

← → DIA ← → TABLE ← → RATE ← → VOL ← → MODE ← → RS232 ← → PWR UP ← →

Maintenance

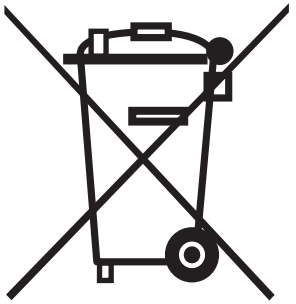
Maintenance is required only for the moving mechanical parts, which should be kept clean and lubricated. Occasionally, a small amount of light machine oil should be applied to the guide rods and a small amount of grease or oil to the leadscrew.

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

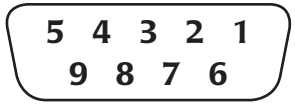
Disposal

Do not dispose of this device with municipal waste — special collection/disposal is required.

The instrument may be returned to WPI for proper recycling and disposal.



TTL Specifications



As viewed from rear of pump.

Pin		
3	Vss , ground ref.	
1,6	Controllable output with Programmable models could be used for relay or valve control (low: infusing; high: refilling)	
8	Trigger	Falling edge starts /stops pump, *e.g.* footswitch
4	Gate	Change from high to low — starts when running stays low, change to high, stops, *e.g.* footswitch, timer
2	Directional Output	high: infuse; low: refill (stays high when stopped)
5	Undefined Input or Output	
7	Run Indicator	high: running; low: stopped
9	Reverse Direction	Normally high; connect to ground (pin 3) reverses direction (only applies to infuse/withdraw mode)

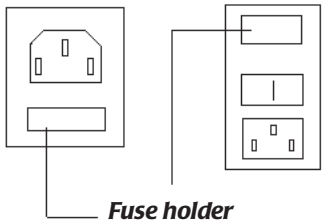
logic low 0 - 0.5V, max 2ma current sink

logic high 2V - 5V

Fuses

The fuses are located in the power entry module on the rear panel. The linecord must be removed first to gain access to the fuse holder.

Fuse 5 x 20 mm, 250V~ slow blow, 0.25 A



Voltage Selector (CE version only)

If it is necessary to change the input voltage selection, disconnect the line cord from the entry module on the rear panel. Use a flat bladed screwdriver to open the Fuse Holder access door. Remove the Fuse Holder, flip over, and install. Close the access door. The new input voltage selection should be visible through the door window. Intall a proper line cord certified for the country of use.

Keypad Functions

A keypad is used for selection of features from the displayed menu and numerical entries.

← →	These keys move the displayed menu left and right, respectively.
select	Used to select the highlighted menu feature (flashing).
enter	Used to select features and, when the numerical parameters of the feature selected are set, then **enter** places all the settings in memory ready for operation. All settings are stored in non-volatile memory and will be used next time the pump is operated.
0 - 9, **.**	Numerical and decimal entry keys.
run / stop	Starts and stops the motor. Acts as a pause during a dispense.

Fast Forward, Fast Reverse

Keys **run** and ← or → pressed simultaneously causes the pump to run at maximum speed. This feature can be used for loading, purging and reversing out of a stall condition.

Syringe Diameter Entry

The pump must be calibrated by identifying the internal diameter of the syringe used. Once entered this data is stored in non-volatile memory and need be modified only when a different syringe is used.

Table

Use the **arrow** keys to move TABLE to the center of the display and press **select** to select this feature. The display now reads abbreviated names of syringe manufacturers and the type of syringe (plastic or glass).

Use the **arrow** and **select** keys to scroll through the list and select the manufacturer's name of the syringe used. The display now lists the size of syringe. Again, use the **arrow** and **select** keys to identify and enter the syringe used.

Diameter

If the syringe used is not listed in the table of syringes then the internal diameter of the syringe must be measured and entered directly. Scroll through the main menu and select **DIA**. The display now prompts for entry of the syringe barrel internal diameter measured in **millimeters**. Enter by using the numerical keys and **enter**.

NOTE: If the diameter is changed, the volume and rate settings are set to zero.

Volume Setting

Volume can be reached directly from the main menu or will be prompted after mode selection.

Volume prompt: Vol: 00.00 mL >

1. Enter target volume from the numerical keypad.
2. If the units and value displayed are correct, **enter**.

The underlined display, or pulsing display segment, indicates that this parameter can be changed. The arrow symbol signifies direction of travel (**<** indicates withdrawal) and pulses when the pump is running.

When dispensing, the volume display increments in units of the last significant figure of the volume entered. Therefore, to increment by 0.01 the volume should be set at 1.00. Similarly, if the volume is set at 1.000 then the volume increments by 0.001.

Volume setting = 0.0

*Infusion or Withdrawal mode*s. Volume = 0 is interpreted as no volume and the pump will run until manually stopped or a stall occurs. The LCD will display the rate setting.

Infusion/withdrawal, Withdrawal/infusion and Continuous modes. A volume setting must be entered. If no volume is entered the display returns to the mode selection menu to select the appropriate mode.

Units Setting

prompt: Vol: 00.00 mL **<**

The units displayed can be changed if required.

1. Use the **RIGHT** arrow key to move the pulsing indicator to the units displayed.
2. Continue to use the **RIGHT** arrow key to scroll through the possible units.
3. The **LEFT** arrow key will move the active display back to the numerical value.
4. When the correct value and units are displayed press **enter**.

Possible units are:

µL and mL (microliter and milliliter)

µL/m, µL/h and mL/m, mL/h (µL or mL per minute or hour)

Rate Setting

Display reads: Rate 00.00 mL/h **>**

1. Enter the flow rate value required with the numerical keypad.
2. If necessary, change the units using the ➔ key to move to and scroll through the possible units.

rateb 1 mlm	Withdraw rate set to 1.0 mL/minute.
ratef 1 mlm	Finish rate 1 mL/min.
loop y	Select a loop
loopto 3	After step 4 will loop back to and repeat step 3.
loopcnt 1	Will repeat loop one time.
save	
done	completes and saves program

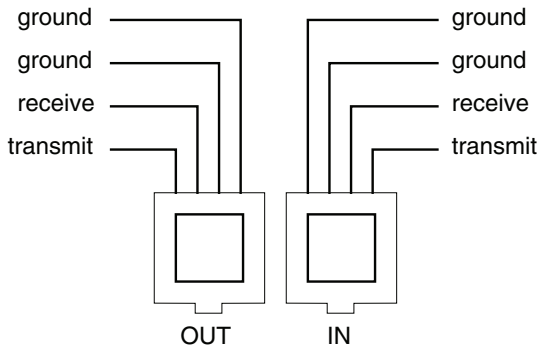
Queries:

a. loops?	S2:1 S4:1	loop in step 2, loop count is 1; loop in step 4, count 1
b. step 3 portout?	HH	Portout set in step 1 and remained unchanged
c. step 1 ratef?	1 mL/m	Finish rate in step 1 is 1.0 ml/minute

RS232 Format

8 data bits
No parity
1 stop (can use 2 stops)

Pump uses simple three wire communications — ground, transmit, and receive. No flow control. No handshaking.



PC with 9-pin connector		PC with 25-pin connector	
receive	pin 2	transmit	pin 2
transmit	pin 3	receive	pin 3
ground	pin 5	ground	pin 7

Program Example

Syringe selected, 4.70 mm diameter

RS232 programming

mode prgm	Select Program mode
Number 4	Sets number of steps in the program
Step 1	Selects Step 1 for programming
time 00:00:10	Step 1 time duration is 10 seconds
travel I	Infusion selected
rateb 0 mlm	Step 1 beginning rate is 0 mL/minute
ratef 1 mlm	Step 1 finishing rate is 1 mL/minute
portout hh	Output pins 1 and 6 set at high/high
pause n	Pause inactive
loop n	No loops
save	Save step settings
Step 2	Ready to program step 2
time 00:00:15	Set time duration to 15 seconds
rateb 1 mlm	Assumes previous travel direction (infusion), and sets step 2 beginning rate 1 mL/minute.
ratef 0.1 mlm	Finishing rate 0.1 mL/minute
loop y	Select a loop
loopto 1	Program will loop back to step 1 after completeing step 2
loopcnt 1	Will repeat the loop one time
save	
step 3	Ready to program step 3
time 00:00:20	Time of step 3 is 20 seconds
rateb .3 mlm	Sets begin rate to 0.3 mL/min. Assumes no direction change.
ratef 0 mlm	Sets finish rate to 0 mL/min.
save	
Step 4	Program step 4
time 00:00:12	Time duration 12 seconds
travel w	Change direction to withdrawal

3. When the displayed settings are correct press **select** or **enter**.

If the number entered exceeds the maximum flow rate possible then the pump displays the maximum feasible rate. To continue enter a rate smaller than the maximum.

To check the maximum possible rate, enter 9's to the required decimal position. For example, enter 99.9 and the maximum displayed is 12.3 whereas if 99.99 is entered, the the maximum displayed is 12.34.

Power Up run or stop

This option is only applicable when **no dispense volume** is selected. When power returns after an interruption the pump can resume operation (select RUN) or remain stopped (select STOP).

If the pump resumes operation the rate display will flash to indicate that a power interruption has occurred. Press **select** to clear the display to resume normal operation.

Run/Stop

After all settings are made the pump can be started or stopped by a single press of the **run/stop** key. During a volume dispense, **stop** acts as a "pause" and **run** will resume the dispense.

Change or Review Volume Setting While Running

While the pump continues to run, press **select** to return to the main menu. Scroll through the menu and select Volume to display the set dispense volume.

no volume change — Press **select**. The display returns to the incrementing display volume.

volume change — Make the changes with the numerical keypad and **enter**. The display moves to RATE, permitting a change if required. Use the numerical keypad and **enter** to make changes. The pump immediately changes to the new flow rate and the volume continues to increment, uninterrupted by the review process, to the new target dispense volume when it will stop automatically.

If the volume is changed to a volume smaller than the volume already accumulated then the pump will stop as soon as the new, smaller target volume is entered.

Mode Selection

Mode selection is available only on infusion/withdrawal models.

Select **MODE** from the main menu and then scroll through the options displayed and select the mode required. (For bidirectional modes a volume is required.)

infusion — Pump infuses at the set rate and stops automatically when the target volume is reached. The pump can be manually stopped and restarted at any

time; that is, the dispense is paused and, when restarted, will continue to the set dispense volume.

withdrawal — Pump withdraws at the set rate to the set volume.

infusion / withdrawal — The pump first infuses and when the target volume is reached it immediately changes direction and withdraws. *The volume settings for infusion and withdrawal can be different, as can the infusion and withdrawal flow rates.*

withdrawal / infusion — The pump runs first in the withdrawal direction and then automatically changes to the infusion direction. Different setting of rate and volume for withdraw and infusion are permitted.

continuous — The pump first infuses and then withdraws, and then cycles continuously. Only one volume setting for infusion and withdrawal is permitted. Different flow rates can be set for infuse and withdraw. If the pump is matched to a valve, which is actuated by a TTL pulse from the pump, this mode can be used to infuse and then refill the pump for continuous operation.

The menu now prompts for volume and rate settings relevant to the mode selected.

Manual Stall Setting and Microliter Syringes

A movable collar, located on the rear guide rod of infusion only pumps, can be set to limit travel of the pusher block. The block moves until stalled against the collar when the electrooptical sensor detects the stall and stops the pump.

Damage to the fine wire plungers of microliter syringes caused by forcing the plunger into the end of the syringe barrel can be prevented by careful adjustment of the collar position.

Glass Syringes

In the withdrawal mode the retaining bracket on the pusher block clamps on the head of the plunger. With some glass syringes the corners of the plunger head are rounded and this may cause the head to ride up out of the retaining bracket. Similarly, in the infusion mode the rounded corners of the syringe barrel flange cause a tendency for the syringe barrel to ride up out of the syringe holder.

To give a more secure, flatter surface to clamp against, an O-ring or metal collar can be placed over the barrel and pressed against the flange.

Clearing a Stall Condition

Should a stall occur the pump motor is stopped to prevent damage.

To clear the display press **select**.

To move the stalled mechanism use the **fast forward** or **fast reverse** to move the pusher

travel?	queries direction of travel in programmable step (not active step) Response: **I** or **W** where I is infusion, and W is withdrawal. Note: Prompts > or < indicate direction of active step.
rateb?	queries beginning rate Response: nnnnn uuu where nnnn is . , 0 to 9; uuu is µL/m, µL/h, mL/m. mL/h
ratef?	sets finish rate Response: nnnnn uuu where nnnnn is . , 0 to 9 uuu are units µL/m , µL/h, mL/m, mL/h.
portout?	queries status of output TTL pins 1 and 6 Response HH, HL, LH, LL
pause?	queries whether pause Response: **Y** or **N** where Y is yes, N is no
loops?	queries whether loops in program Response: Sn:x Sn:x where **Sn** is the step number containing a loop; **x** is the number of loops remaining to be executed (counts down)
loop?	queries loop status in the step Response: **Y** or **N** where Y is yes, N is no
loopto?	queries step number to which program loops (not available if no loops) Response: n where n = 1 to 7
loopcnt?	queries number of loop repeats (not available if no loops programmed) Response: n where n = 1 to 100

NOTE

a. It is important to save each step before programming next step.

b. Only two loops are permitted, therefore recommend to query number of loops in an existing program before modifying the program. If loops are present it will be necessary to delete an existing loop before a new loop can be programmed.

time xx:xx:xx	sets time duration of step to be programmed. hr:min:sec
travel i (w)	sets direction to infusion (withdrawal)
rateb nnnnn uuu	sets step beginning rate nnnnn is . , 0 to 9; uuu are units µLm, µLh, mLm, mLh. If set rate is out of range then response is NA; rate is set at zero.
ratef nnnnn uuu	sets step finish rate nnnnn is . , 0 to 9; uuu are units µlm, µlh, mlm, mlh. If set rate is out of range then response is NA; rate is set at zero.
portout p	sets status of output pins 1 and 6 where p is HH (1=high, 6=high) HL (1=high, 6=low) LH (1=low, 6=high) LL (1=low, 6=low)
pause y or n	sets status of pause y = active; n = inactive
loop y or n	sets loop status y = yes; n = no
loopto n	sets step number to loop to where n = 1 to 8
loopcnt b	sets number of loops to be repeated where b = 1 to 100
save	saves step settings *important that each step is saved*
done	saves all programmed steps *important that "done" is entered after all steps saved*
wait	stops pump (pauses), but can be restarted
continue	restarts pump after "wait" command, program continues
nextstep	causes program to jump to the next step
mode?	query mode. Response PGM
activestep?	queries step running Response: **n** where n = 1 to 8
timeleft?	queries time remaining in active step Response: xx:xx:xx where hr:min:sec
number?	queries number of steps in program Response: n where n = 1 to 8
step?	queries step being programmed (Not the active step) Response: n where n = 1 to 8
time?	queries time in program step (Not the active step) Response: xx:xx:xx where hr:min:sec

block. Using the fast forward or fast reverse feature is not only the most simple way to deal with the stall, it also reduces potential damage to the mechanism which could be caused by using the cam to release the halfnut from the leadscrew.

NV RAM Failure

If the settings in the non-volatile memory become corrupted the display will read "NV Ram Failure" and the pump will not operate. To recover from this condition, the pump must be powered down and then turned on again after a few seconds' delay. The pump will be re-initialized to the default settings and can now be programmed as normal.

If the above fails to work, the "NV Ram Failure" message can also be cleared by pressing select and programming a new flow rate. The pump should then be turned off and on to save the settings.

RS232C Connections

The RS232 connections are made through two modular telephone connectors, labelled IN and OUT, located on the rear panel.

A single PC can control up to 100 pumps via a "daisy chain" using the IN and OUT connectors. When using the daisy chain each pump must be assigned an address and set to the same baud rate. A splitter may be required with greater than 50 pumps.

When controlled via RS232 the pump will still respond to keypad commands but will not respond to keypad and RS232 commands simultaneously. All RS232 command settings, similar to keypad settings, are stored in non-volatile memory.

Select RS232 from the main menu.

BAUD RATE	300, 1200, 2400, 4800, 9600 The available baud rates will now be displayed and can be selected using the **arrow** and **select** keys. The display now prompts for assignment of a pump address.
ADDRESS	If no address is assigned then the pump defaults to a 0 setting. All pumps with the same address respond simultaneously to the same commands. Use the arrow key to enter an address, 0 - 99, and press **select** to return to the main menu.

RS232C Commands

RS232 is used for remote computer control of up to 100 pumps, identified with an address from 0 to 99 and set to the correct baud rate. Each pump can be controlled either from the keypad or via RS232 at all times but the pump can only respond to one command at a time. When under RS232 control the display reads "REMOTE". All settings made via RS232 are stored in nonvolatile memory.

To move the pump from Remote (RS232) to keypad control press **select**.

After each command is received and executed by the pump, the pump responds with a message and a prompt.

Commands are not case sensitive. Abbreviations used below: carriage return <CR>; line feed <LF>; space <SP>; and no space <NSP>.

Command: Address<SP>command<CR><LF>

Response: <CR><LF>address<NSP>prompt

For example:

Query pump 2 for withdrawal flow rate (which is 0.2 ml/minute)

command: 2<SP>ratew?<CR><LF>

response: 0.2<SP>ml/m<CR><LF>2:

Query a single pump for infusion flow rate (which is 0.2 ml/minute)

command: ratei?<CR><LF>

response: 0.2<SP>ml/m<CR><LF>:

Prompts

>	running in infusion direction
<	withdrawing
:	stopped
NA	not applicable
E	error (see error? command)
<CR>	All pumps in the chain interpret this as a stop command.

pump address, <CR> Pump with the specified address responds with a prompt.

pump address (optional), command, <CR>
Pump at the address executes the command and then responds with a prompt.

If there are multiple pumps in the daisy chain and a pump address is not used, then all pumps will respond to the non-specific command and return prompts. Multiple prompts results in a communications breakdown.

Pump Commands and Responses

Note that mode selection and withdrawal and continuous mode commands are recognized only by the infusion/withdrawal models.

run	Starts pump running to present settings, returns prompt > or <. If already running, command is ignored.
stop	Stops pump if running, otherwise is ignored. Returns prompt :

Changes to program parameters cannot be made when the pump is running therefore parameter setting commands, such as, step, travel, rate etc. are not applicable [NA] when the program is running.

When the pump is running all queries are disallowed except activestep?, timeleft?, and loops?

Commands are not case sensitive.

After each command is received and executed the pump responds with prompt sequence:

Query commands:

<CR> <LF> text <CR> <LF> 1 or 2 digit address, prompt

Other commands:

<CR> <LF> 1 or 2 digit address, prompt

Prompts

>	running in infusion direction
<	withdrawing
:	stopped
NA	not applicable
E	error (see error? command)
P	pump is paused
<CR>	All pumps chain interpret this as a stop command

pump address <CR> Pump with the specified address responds with a prompt

pump address (optional), command, <CR>
Pump at the address executes the command and then responds with a prompt.

Note: If there are multiple pumps in the daisy chain and a pump address is not used then all pumps will respond to the non-specific command and return prompts. Multiple prompts results in a communications breakdown.

Note that withdrawal and continuous mode commands are recognized only by the infusion/withdrawal models.

mode prgm	sets pump in program mode. Response :
number n	sets number of steps in program. n = 1 - 8
step n	sets step number to be programmed. n = 1 - 8 Step number must be set before entering program settings

Running the Program

Run

The Run key starts the program; the displayed time counts down and the direction arrow flashes.

Hold / Continue

If the Run/Stop key is pressed while running a program, the pump is stopped but gives an option to end the program, or restart the pump and continue the program to its end.

Program changes when operating

Once a step has commenced no changes are possible in that step. However, while dispensing changes are permitted to steps still to be executed.

Syringe size changes

If the pump was previously used in Program Mode the pump will be initialized in Program Mode when it is switched on. For convenience, it is possible to enter a new syringe size, either from the stored Table or DIA, without leaving the Program Mode.

Note: If a syringe change is made this will change all program values to the default settings and will require reprogramming. A diameter change causes the pump to stop; resets the "number" of steps to 1; resets the "activestep" to 1; and all values will be set to the initial default settings. The initialization of the new settings takes approximately two seconds.

Stall Condition

The Fast Forward & Fast Reverse features do not work in Program Mode. Should a stall occur then go to Infusion Mode where the Fast Forward/Fast Reverse features works, and use these features to end the stall condition.

By going to the infusion mode the program is still saved in memory.

RS232 Commands and Responses

All commands and responses in standard pumps remain the same, however, the program mode does have additional commands and responses.

Each pump can be controlled either from the keypad or via RS232 at all times, but the pump can only respond to one command at a time. When under RS232 control the display reads "REMOTE". All settings made via RS232 are stored in non-volatile memory.

To move the pump from Remote (RS232) to keypad control press select.

dia nn.nn	Sets syringe diameter in millimeters n = 0 to 9
run?	Queries run status, returns prompt
del?	Queries delivered volume (requires a dispense volume to be set) *Response*: nnnnn<SP>u nnnnn is ., 0 to 9 and u is units (µL or mL)
dia?	Requests present diameter setting. *Response*: nn.nn n = 0 to 9 (units always millimeters)
ratei?	Queries infusion rate *Response*: nnnnn<SP>u/u nnnnn is ., 0 to 9 u/u are units µL/m, µL/h, mL/m, or mL/h
ratew?	Queries withdrawal rate Response: nnnnn<SP>u/u nnnnn is ., 0 to 9 and u/u is rate unit
ratei nnnnn u/u	Sets infusion rate nnnnn is ., 0 to 9, and u/u are units Units required but if not specified then defaults to automatic setting based on syringe diameter.
ratew nnnnn u/u	Sets withdrawal rate
voli nnnnn uu	Sets infusion target volume n = 0 to 9, and uu are units µL or mL If units not specified, defaults to automatic setting.
volw nnnnn uu	Sets withdrawal target volume
voli?	Queries volume setting *Response* **nnnnn<SP>uu** nnnnn is ., 0 to 9, and u are units µL or mL
mode i	Sets mode to infusion
mode w	Sets mode to withdrawal
mode i / w	Sets mode to infusion / withdrawal *(dispense volume required)*
mode w / i	Sets mode to withdrawal / infusion *(dispense volume required)*
mode con	Sets mode to continuous *(dispense volume required)*
mode?	Query mode. *Response*: I, W, I/W, W/I, CON

dir rev Changes direction of running pump. (If pump is not running, command is ignored.) Available only in Infusion and Withdrawal modes.

dir? Queries direction.
Response: I (infusion) or W (withdrawal).
Not applicable in infusion-only models.

error? Queries for error type after E prompt.
Response: 0 = no error
1 = RS232 communication error
2 = stall
3 = RS232 error + stall
4 = serial overrun
5 = serial error + serial overrun
6 = stall + serial overrun
7 = stall + serial error + serial overrun
Errors 8 - 15 only occur if using pressure switch.
8 = overpressure
9 = serial error overpressure
10 = stall + overpressure
11 = stall + serial overrun + overpressure
12 = serial overrun + overpressure
13 = serial error + serial overrun + overpressure
14 = stall + serial overrun + overpressure
15 = stall + serial error + serial overrun + overpressure

Note: sending a query also clears all errors.

A serial error indicates a command that is too long for the input buffer.

A serial overrun indicates that a command has been sent before the prior command has been processed.

A stall error indicates that a stall condition has occurred.

After each command you must wait for the prompt (indicating that the command has been executed) before sending the next command.

The prompt will indicate whether or not the command has been executed successfully.

prom? Queries software version
Response: number 2100.0xx or 2101.0xx or similar.

a. LOOP to STEP

The menu now prompts for the Step # the program Loop should return to. For example, if the program is at step 5 and the loop step selected is #3, then the program executes step 3, 4 and 5 again.

Loop to Step ?

The step number is entered from the numerical keypad followed by

ENTER or SELECT.

NOTE: Maximum number of loops is two. Once both loops are entered the loop option will NOT be displayed in menu. To change loops, if two are already entered, one loop must be cancelled before the new loop can be programmed.

b. LOOP COUNT

After setting the initial step number of the loop, the menu will prompt for the "loop count", the number of times the loop will be repeated.

Maximum repeat number is 100.

Display reads: **# Loop Count: x**

The number of loops to be executed, x is entered from the numerical keypad followed by ENTER.

NOTE: It is possible to have a loop running within a loop.

9. Saving the Step

As there are many options in each step the program gives one more option, "Redo" to make changes before storing the Step.

menu prompts: **# Step: Save Redo**

The arrow keys are used to highlight the required option which can be saved with ENTER or SELECT.

10. Program End

After saving the step the program prompts: **# Next Step Done**

"Next Step" is selected, unless all steps are completed, and the above process is repeated for the number of steps required, up to 8. When all steps are programmed "Done" should be entered, with SELECT or ENTER to complete the programming.

The pump and display will now move to Step 1 ready to start the programmed dispense.

display: **Stp 1 xx:xx:xx ➔**

b. #End: xxxxx uuu

xxxxx numerical and uuu units of flowrate

c. Options:

if R1=R2=0

Pump is stopped — no flowrate.

if R1<R2

Flowrate increases LINEARLY from R1 to R2 over the step duration.

if R1>R2

Flowrate decreases LINEARLY from R1 to R2 over the step time.

6. Pin Out

Pins 1 and 6 on the 9-pin TTL connector can be controlled to set levels high (H) or low (L). This change in status of an output pin can be used to trigger another external event.

The display reads: **# Pinout: 1= H, 6= H**

Options: HH, HL, LH, LL

The arrow keys are used to toggle through the options. Select and Enter are used to save the settings.

7. Pause

If the Pause option is selected in a step, the pump completes the step and pauses at the end of the step.

The display reads: Paused @ end of n where n is the step number.

The pump is programmed but stopped, waiting to be actuated, either by:

a. Run/Stop key

b. "RUN" command via RS232

c. TTL input, Pin 8 ; level change from High to Low.

The display reads: **# Pause: Inactive Active**

Use the arrow key and SELECT to save.

8. LOOP

A loop permits the program to return to and execute a previous step, or steps, and repeat these steps a specified number of times (up to 100).

The menu first prompts for a loop selection: **# Loop?: Yes No**

Loop selection is made using the arrow keys to move to Yes or No. SELECT to save.

Programmable Option

General Information

KEYPAD PROGRAMMABLE PUMPS

The "program mode" is available on all Series 200 models and permits multistep dispenses without the need for computer control.

From the pump keypad, a custom program can be entered, which will control the pump from seconds to days; permit the flowrate to be changed for discrete time periods; repeat dispenses; control output TTL signals to coordinate with other laboratory instruments (or valves); or respond to inputs from other devices, such as switches or relays, and to perform loops, where dispense sequences are repeated.

The program is divided into time periods called STEPS, each of which can be up to 12 hours long. Each step is automatically numbered and, to simplify programming, a menu prompts the user to select the options available in each STEP.

The flowrate can be ramped up or down, or kept constant for a defined time period for a volume dispense. The initial and final flowrate for each period is entered and the pump automatically makes rate changes over the time period. No need to enter increments for a ramp up or down; the pump automatically ramps the rate linearly.

The pump can be paused and then restarted, either by a time delay or by a TTL input. Both TTL inputs and outputs can be controlled by the pump. The pump can therefore, respond to switch closures or send out signals to actuate valve, or other relays, switches, etc.

Two separate loops can be programmed so that steps can be repeated. The number of repeat operations is controlled by the "loop count". For example, this is helpful when a volume dispense is required repeatedly, triggered by a switch.

The two loops can be "nested" so that the program can run for days and complex dispenses can be repeated many times.

Features

PARAMETERS WHICH CAN BE PROGRAMMED IN EACH STEP

Time duration
Infuse or withdraw
Start flowrate
End flowrate
TTL output settings
Pause, wait for TTL input actuation
Loops to repeat previous steps

To simplify the programming, previously programmed settings are stored in non-volatile memory and are displayed when Program Mode is selected. Whenever possible, options are displayed with the "active" option flashing. If flashing, this parameter can be selected or changed.

The pump can be programmed by first selecting MODE on the mainline menu and then selecting Program (PRGM).

DISPLAY AND PROGRAMMING SEQUENCE

After selecting Program Mode, display reads:

Table Dia Step Mode

DIA and TABLE

If the pump was previously used in Program Mode the pump will be initialized in Program Mode when it is switched on. For convenience, should a syringe change be required, it is possible to enter a new syringe size, either from the stored Table or DIA, without leaving the Program Mode.

If a syringe size change is made however, this will change all program values to defaults and will require reprogramming.

It is possible to review the syringe size in "Dia" or "Table" without changing the programmed settings.

In "Table" review the settings but select "QUIT", do not enter a diameter.

In "Dia" the settings will not change if there is no change to the diameter entered.

MODE

Mode selection reverts back to other pump operations.

STEP

Step selection starts the programming sequence

Menu Operation

After selecting MODE and then PROGRAM the display will show STEP which leads into editing the program.

1. **Number of STEPS**

   Menu prompts " NUM of Steps". Enter total number of program steps using numerical keypad and press SELECT or ENTER to save a maximum of 8.

2. **Edit STEP #**

   The menu automatically increments the step number, however, it is possible to enter a different number. If the step number displayed (flashing) is required then press SELECT to save and continue editing.

3. **Time**

   Step # Time xx:xx:xx.

   Time xx:xx:xx in hours, minutes and seconds.

   Use the ➔ key to move from left to right and enter the time using the numerical keypad. When the correct time is displayed press ENTER to load this time into memory.

4. **Infusion/ Withdraw**

   The direction of travel for each step must be selected. Initially, " Infusion " direction will be flashing. The direction keys, ← and ➔ are used to switch between directions. SELECT key is then used to load the direction into memory.

5. **Rate**

   The program requires the initial rate (Start), the ending rate (End), and the units.

   a. Display reads: **#Start: xxxxx uuu**

   # is step number, automatically assigned.

   xxxxx is the numerical flowrate. Enter from the numerical keypad.

   uuu is flowrate unit.

   Use the arrow key ➔to select units (displayed flashing). Repeat to move through the unit options. Options are: µl/m or µl/h, ml/m or ml/h

   The ← key is used to move back to the numerical display.

   Press ENTER to save.

   The menu now prompts for the final rate which is entered in the same manner.

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