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X-5850C/5851
March, 1983
Issue 1

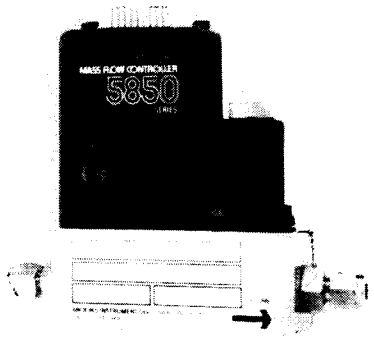
INSTRUCTIONS

BROOKS INSTRUMENT DIVISION
EMERSON ELECTRIC CO.
HATFIELD, PENNSYLVANIA 19440

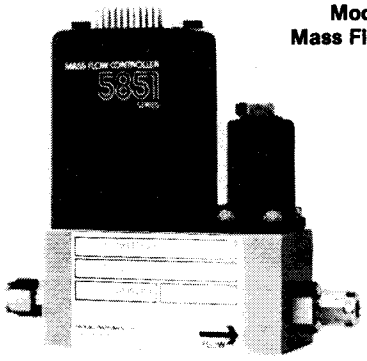
EMERSON®

INSTALLATION AND OPERATING INSTRUCTIONS

Brooks Mass Flow Controller
Models 5850C and 5851



Model 5850C
Mass Flow Controller



Model 5851
Mass Flow Controller

CAUTION

It is recommended that this publication be read in its entirety before performing any operation. Failure to understand and follow these instructions could result in serious personal injury and/or damage to the equipment.

Dear Customer:

The Brooks Instrument Division, Emerson Electric Co., Mass Flow Controller you have just received is of the highest quality available, offering superior performance to the user. This controller provides the finest degree of accuracy, repeatability, and widest operating parameters available for extremely reliable gas measurement and control of mass flow rate.

Because of the wide variety of applications for mass flow controllers, we have expressly designed this instrument to provide user selectable functions in a single instrument to meet ever changing process conditions. Additionally, this "state-of-the-art" design has been packaged and materials selected to permit application to a variety of often corrosive and hostile conditions.

To realize the full potential of the inherent design flexibility and ease of maintenance, may we suggest you review this manual in its entirety.

Should you need additional information concerning the 5850C or 5851 Series Mass Flow Controllers, please feel free to contact your local Brooks Instrument Division Sales Office, Representative, or our Hatfield, Pennsylvania factory. We are pleased to have this opportunity of servicing you for your gas measurement and control needs.

Sincerely,

BROOKS INSTRUMENT DIVISION
Emerson Electric Co.

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Section 1 INTRODUCTION

1-1 Purpose

The Brooks Models 5850C and 5851 Flow Controllers are mass flow measurement devices designed for accurately measuring and controlling flows of gases.

1-2 Description

The Brooks Models 5850C and 5851 consist of three basic units: a flow sensor, a control valve and an integral electronic control system. This combination produces a stable gas flow, selectable overshoot protection and eliminates the need for continuous monitoring and readjustment of gas pressures.

Standard user selectable features include: soft-start, valve override, and external valve control.

— SOFT START provides a valve ramping function that effectively reduces gas-flow overshoot and undershoot to a negligible value. Refer to Section 2-7.

—VALVE OVERRIDE permits the user to fully open and close the control valve independent of the command setting. Refer to Section 2-9.

—EXTERNAL VALVE CONTROL permits the user flexibility to provide an external valve control source independent of the standard 50:1 control function incorporated within the standard configuration. Refer to Section 2-10.

Card edge or 'D' type connectors, preselected by the user, are available.

1-3 Specifications (Refer to Table 1-1)

Caution: Do not operate instruments in excess of specifications listed in Table 1-1.

Section 2 INSTALLATION

2-1 Receipt of Equipment

When the equipment is received, the outside packing case should be checked for any damage incurred during shipment. If the packing case is damaged, the local carrier should be notified at once regarding his liability. A report should be submitted to the Product Service Department, Brooks Instrument Div., Emerson Electric Co., Hatfield, PA 19440.

Table 1-1 Specifications

PERFORMANCE	Model 5850C	Model 5851
Standard Ranges:	sccm: 0-10 0-20 0-50 0-100 0-200 0-500 0-1000 0-2000 0-5000 0-10000 0-20000	slpm: 0-10 0-20 0-50 0-100 0-150 (helium) 0-200 (hydrogen)
Accuracy:	±1.0% full scale indicating linearity @ 70°F (21.0°C) ±10°F, (±6°C) and 25 psig (±15 psi variation in gas operating conditions)	±1.0% full scale indicating linearity @ 70°F (21.0°C) ±10°F, (±6°C) and 25 psig (±15 psi variation in gas operating conditions)
Repeatability:	±0.25% of rate	±0.25% of rate
Response Time:	15 seconds max. to within 98% of set point	15 seconds max. to within 98% of set point
Power Requirements:	+15 Vdc, 250 mA dc -15 Vdc, 10 mA dc	+15 Vdc, 250 mA dc -15 Vdc, 200 mA dc
Operating Temperature Limits:	40°F to 150°F (4.4°C to 65°C)	40°F to 150°F (4.4°C to 65°C)
Ambient Temperature Limits:	40°F to 150°F (4.4°C to 65°C)	40°F to 150°F (4.4°C to 65°C)
Maximum Working Pressure:	1500 psi full automatic control with differential pressure of 5 to 50 psi (3000 without valve)	1500 psi full automatic control with differential pressure of 5 to 50 psi (3000 without valve)
Output Signal:	0-5 Vdc into 1000 ohms or greater; 3 mV rms maximum ripple	0-5 Vdc into 1000 ohms or greater; 3 mV rms maximum ripple
Regulation:	0.2% indicating repeatability and environmental effects	0.2% indicating repeatability and environmental effects
Control Range:	50 to 1	50 to 1
Electrical Connection:	Edge card or optional "D" type	Edge card or optional "D" type

Remove the envelope containing the packing list. Carefully remove the equipment from the packing case. Make sure spare parts are not discarded with the packing material. Inspect for damaged or missing parts.

2-2 Return Shipment

Do not return any assembly or part without a Return Material Report. The Return Material Report is available from all District Sales Offices and the Product Service Department, Hatfield, PA. Information describing the problem, corrective action, if any, and the work to be accomplished at the factory must be included.

2-3 Recommended Storage Practice

If intermediate or long-term storage is required for equipment, as supplied by Brooks Instrument Div., it is recommended that said equipment be stored in accordance with the following:

a. Within the original shipping container.
b. Storer in a sheltered area, preferably a warm, dry, heated warehouse.
c. Ambient termperature 70°F (21.0°C) nominal 90°F max./45°F min. (32.1°C max./7.1°C min.)
d. Relative humidity 45% nominal 60% max./25% min.

Upon removal from storage, a visual inspection should be conducted to verify the condition of equipment is "as received". If the equipment has been in storage for an excess of ten (10) months or in conditions in excess of those recommended, all pressure boundary seals should be replaced and the device subjected to a pneumatic pressure test in accordance with applicable vessel codes.

2-4 Gas Connections

Standard inlet and outlet connections supplied on the Model 5850C are 1/4" Swagelok*. The standard connections on the Model 5851 are 3/8" Swagelok.

Optional VCO and VCR connections are available upon request. Prior to installation, make certain all piping is clean and free of obstructions. Install the piping in such a manner that permits easy removal if the instrument is to be removed for cleaning or test bench troubleshooting.

2-5 Installation (Refer to Figure 2-1 and 2-2)

Caution: When installing the controller, care should be taken that no foreign materials enter the inlet or outlet of the instrument.

Recommended installation procedures:

a. The Models 5850C and 5851 should be located in a clean dry atmosphere relatively free of shock and vibration.
b. Leave sufficient room for access to the electrical components.
c. Install in such a manner that permits easy removal if the instrument requires cleaning.
d. Horizontal installation within ±2° is recommended, however, attitude insensitive devices (if specified at time of order) may be mounted in any position.

Caution: When mounting the flow controller in other than a horizontal position factory calibration will be affected. (Refer to Table 1-1 for accuracy specification)

Note: The control valve in the Models 5850C and 5851 provides precision control and is not designed for positive shut-off.
If positive shut-off is required, it is recommended a separate shut-off valve be installed in the line downstream from the controller.

2-6 In Line Filter

It is recommended an in-line type filter be installed upstream from the flow sensor to prevent the possibility of any foreign material entering the flow sensor or control valve. The filtering element should be periodically replaced or may be ultrasonically cleaned. Refer to Table 2-1.

Table 2-1 Recommended Filter Size

Flow Rate (sccm)	Recommended Filter Size
0 - 100	1 micron
100 - 500	2 micron
1000 - 5000	10 micron
5000 - 10000	10 micron
10000 - 20000	10 micron

2-7 Soft Start - Standard Option; User Selectable

To enable soft start, place shorting plug on the printed circuit board (figures 3-7 and 3-8) at J4.

To disable, place shorting plug at J3. Refer to figures 3-4, 3-5, 3-7 and 3-8.

2-8 Remote Programming - Standard Option; User Selectable

If the controller is to be programmed by an external 0-5 Vdc command voltage, the command potentiometer is not used.

Remote programming hook-up for the mass controller with edge card connector is as follows:

a. Connect the external command voltage to pin 3 (command input for remote programming) and to pin 17 (command return for remote programming). Refer to Figure 2-3 and 2-5 for hook-up diagram.

Remote programming hook-up for the mass controller with "D" type connector is as follows:

a. Connect the external command voltage to pin 8 (command input for remote programming) and to pin 1 (command return for remote programming). Refer to figures 2-4, and 2-6 for hook-up diagram.

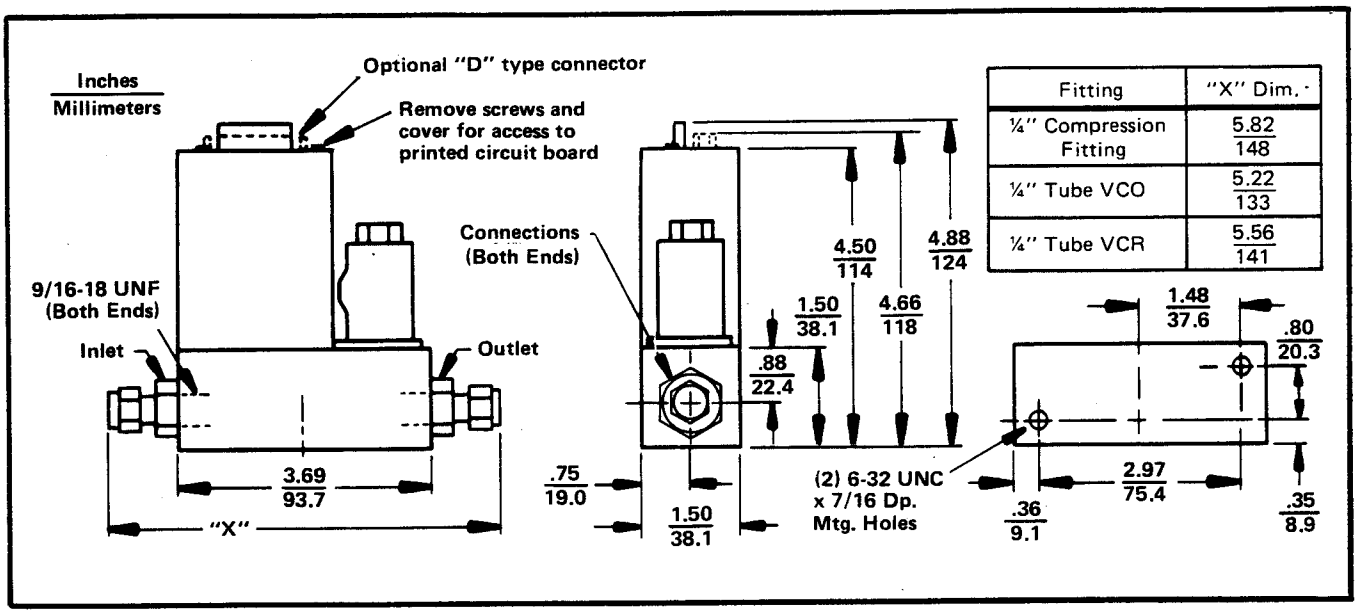


Figure 2-1 Model 5850C Dimensions

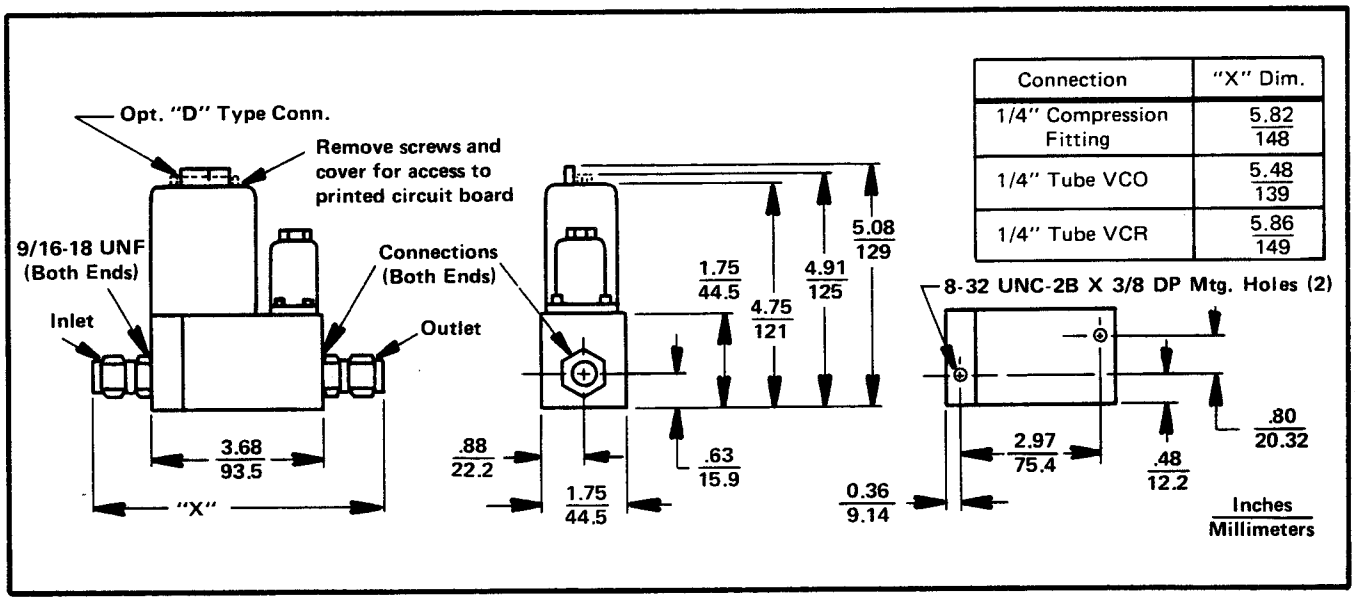


Figure 2-2 Model 5851 Dimensions

2-9 Valve Override - Standard Option; User Selectable (refer to Figures 2-3, 2-4, 2-5 and 2-6)

The valve override function allows full opening and closing of the valve independent of the command setting.

Valve override for the mass controller with edge card connector is as follows;
a. To open valve connect +15 V to pin 20.
b. To close valve connect -15 V to pin 20.

Valve override for the mass controller with "D" type connector is as follows:
a. To open valve connect +15 V to pin 12.
b. To close valve connect -15 V to pin 12.

Note: For normal operation, pins 12 ("D" type connector) and 20 (edge card connector) are left open (floating).

2-10 External Valve Control - Standard Option; User Selectable

The external valve control allows the user to drive the valve using an external control circuit. Refer to Figures 2-3, 2-4, 2-5, 2-6, 3-7 and 3-8.

Caution: The valve drive signals must be of the polarity given and must not exceed 24 V or damage to the unit may result.

To enable external valve control:
a. Remove J5 and insert J6.
b. Mass controller with edge card connector: Valve signal to pin 5 and 13 (external valve control input) pins 14 and 16 (external valve control return).
c. Mass controller with "D" type connector: Valve signal to pin 7 (external valve control input) and pin 3 (external valve control return).

PIN NO	FUNCTION	COLOR CODE
1	Flow signal output	Brown
2	+15 Vdc supply	Red
3	Cmd. pot "S" or cmd. input for remote programming	Orange
4	+15 Vdc supply	Yellow
5	External valve control input	Green
6	+15 Vdc supply	Blue
7	Flow signal return	Violet
8	+15 Vdc supply	Gray
9	Supply common	White
10	-15 Vdc supply	Black
11	Supply common	Brown
12	-15 Vdc supply	Red
13	External valve control input	Orange
14	Supply common or external valve control return	Yellow
15	Not used	Green
16	Supply common or external valve control return	Blue
17	Cmd. pot "CCW" or cmd. return for remote programming	Violet
18	Command pot "CW", +5V ref.	Gray
19	Chassis ground	White
20	Valve override	Black

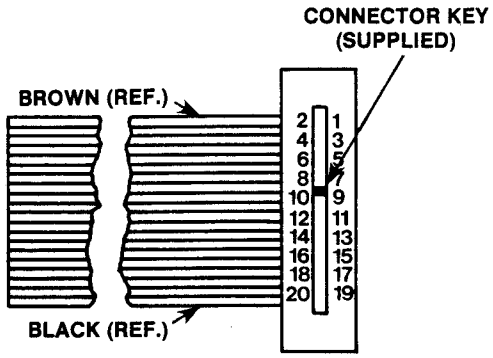
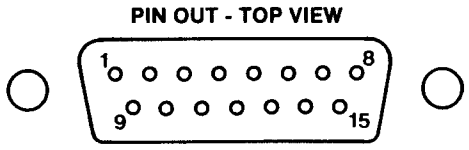


Figure 2-3 Customer Hook-Up Edge Card Connector 5850C

PIN NO	FUNCTION	COLOR CODE
1	Cmd. pot "CCW" or cmd. return for remote programming	Black
2	Flow signal output	White
3	Supply common or external valve control return	Red
4	Not used	Green
5	+15 Vdc supply	Orange
6	-15 Vdc supply	Blue
7	External valve control input	Wht/Blk
8	Cmd. pot "S" or cmd. input for remote programming	Red/Blk
9	Supply common	Grn/Blk
10	Flow Signal Return	Org/Blk
11	Command pot "CW", +5V ref.	Blu/Blk
12	Valve override	Blk/Wht
13	+15 Vdc Supply	Red/Wht
14	Chassis Ground	Grn/Wht
15	Not used	Blu/Wht



NOTE: CABLE SHIELD TIED TO CHASSIS GROUND IN METER CONNECTOR. MAKE NO CONNECTION ON CUSTOMER END.

Figure 2-4 Customer Hook-Up "D" Type Connector 5850C

PIN NO	FUNCTION	COLOR CODE
1	Flow signal output	Brown
2	+15 Vdc supply	Red
3	Cmd. pot "S" or cmd. input for remote programming	Orange
4	+15 Vdc supply	Yellow
5	External valve control input	Green
6	+15 Vdc supply	Blue
7	Flow signal return	Violet
8	+15 Vdc supply	Gray
9	Supply common	White
10	-15 Vdc supply	Black
11	Supply common	Brown
12	-15 Vdc supply	Red
13	External valve control input	Orange
14	-15 V supply or external valve control return	Yellow
15	Not used	Green
16	-15 V supply or external valve control return	Blue
17	Cmd. pot "CCW" or cmd. return for remote programming	Violet
18	Command pot "CW", +5V ref.	Gray
19	Chassis ground	White
20	Valve override	Black

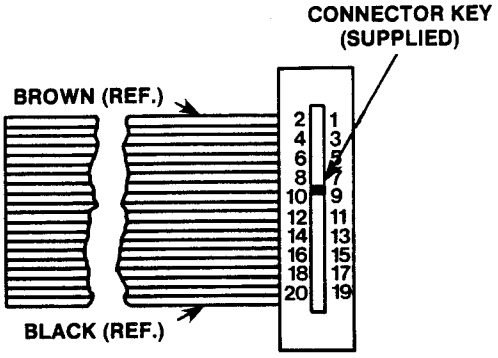
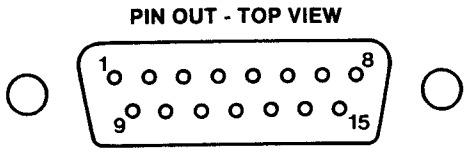


Figure 2-5 Customer Hook-Up Edge Card Connector 5851

PIN NO	FUNCTION	COLOR CODE
1	Cmd. pot "CCW" or cmd. return for remote programming	Black
2	Flow signal output	White
3	-15 V supply or external valve control return	Red
4	Not used	Green
5	+15 Vdc supply	Orange
6	-15 Vdc supply	Blue
7	External valve control input	Wht/Blk
8	Cmd. pot "S" or cmd. input for remote programming	Red/Blk
9	Supply common	Grn/Blk
10	Flow Signal Return	Org/Blk
11	Command pot "CW", +5V ref.	Blu/Blk
12	Valve override	Blk/Wht
13	+15 Vdc Supply	Red/Wht
14	Chassis Ground	Grn/Wht
15	Not used	Blu/Wht



NOTE: CABLE SHIELD TIED TO CHASSIS GROUND IN METER CONNECTOR. MAKE NO CONNECTION ON CUSTOMER END.

Figure 2-6 Customer Hook-Up "D" Type Connector 5851

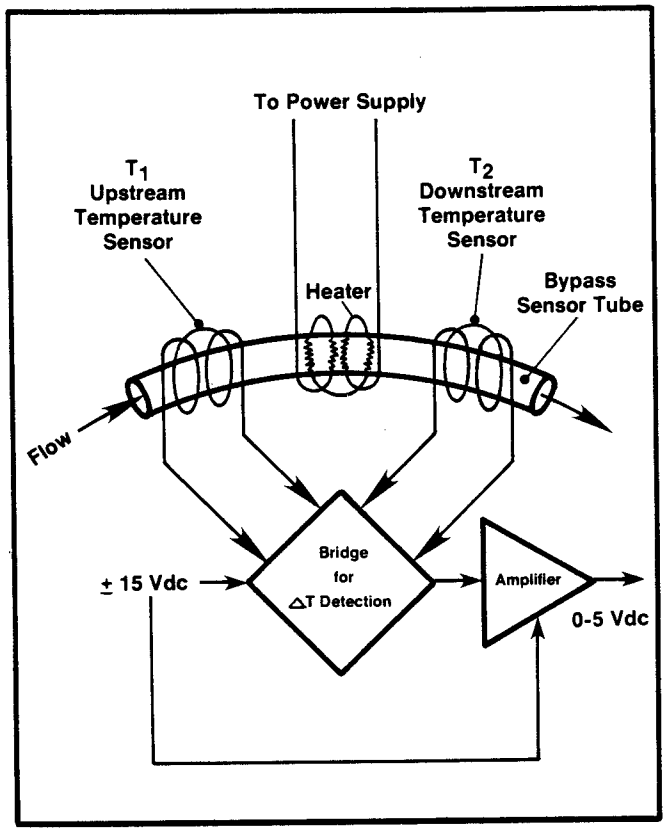


Figure 3-1 Flow Sensor Operational Diagram

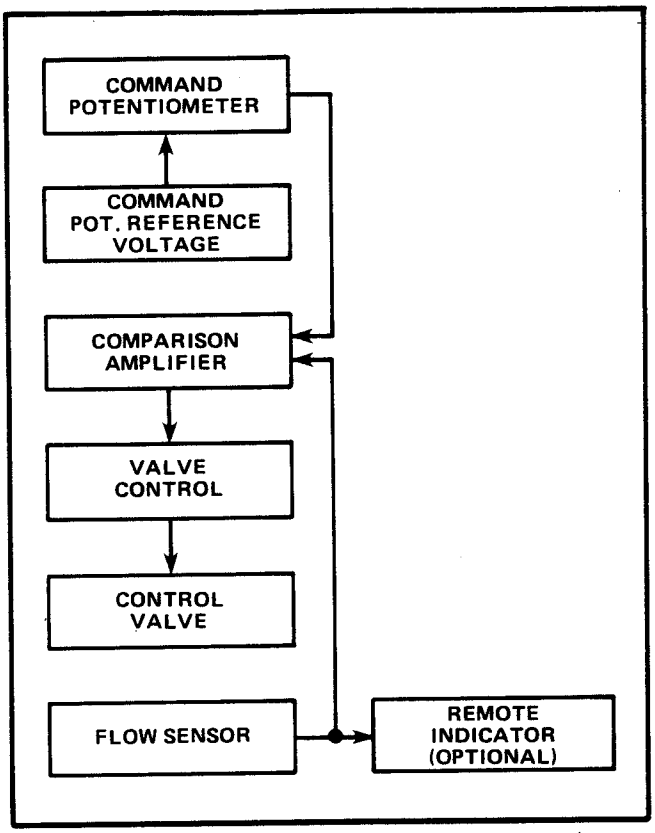


Figure 3-2 Flow Control System Block Diagram

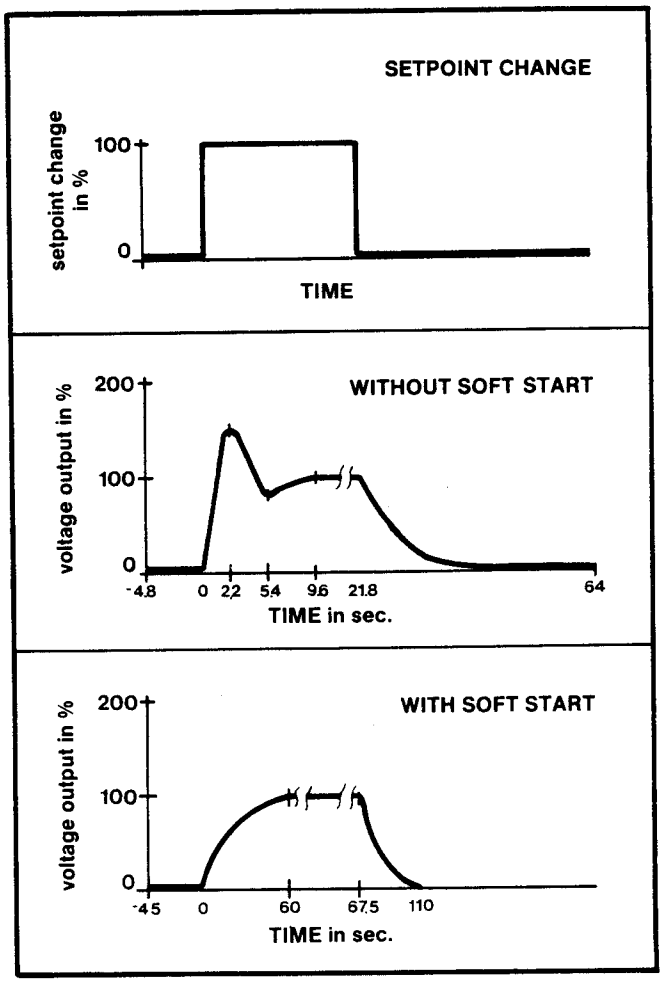


Figure 3-3 Soft Start Response Time

Section 3 OPERATION

3-1 Theory of Operation (Refer to Figures 3-1, 3-2, 3-4 and 3-5)

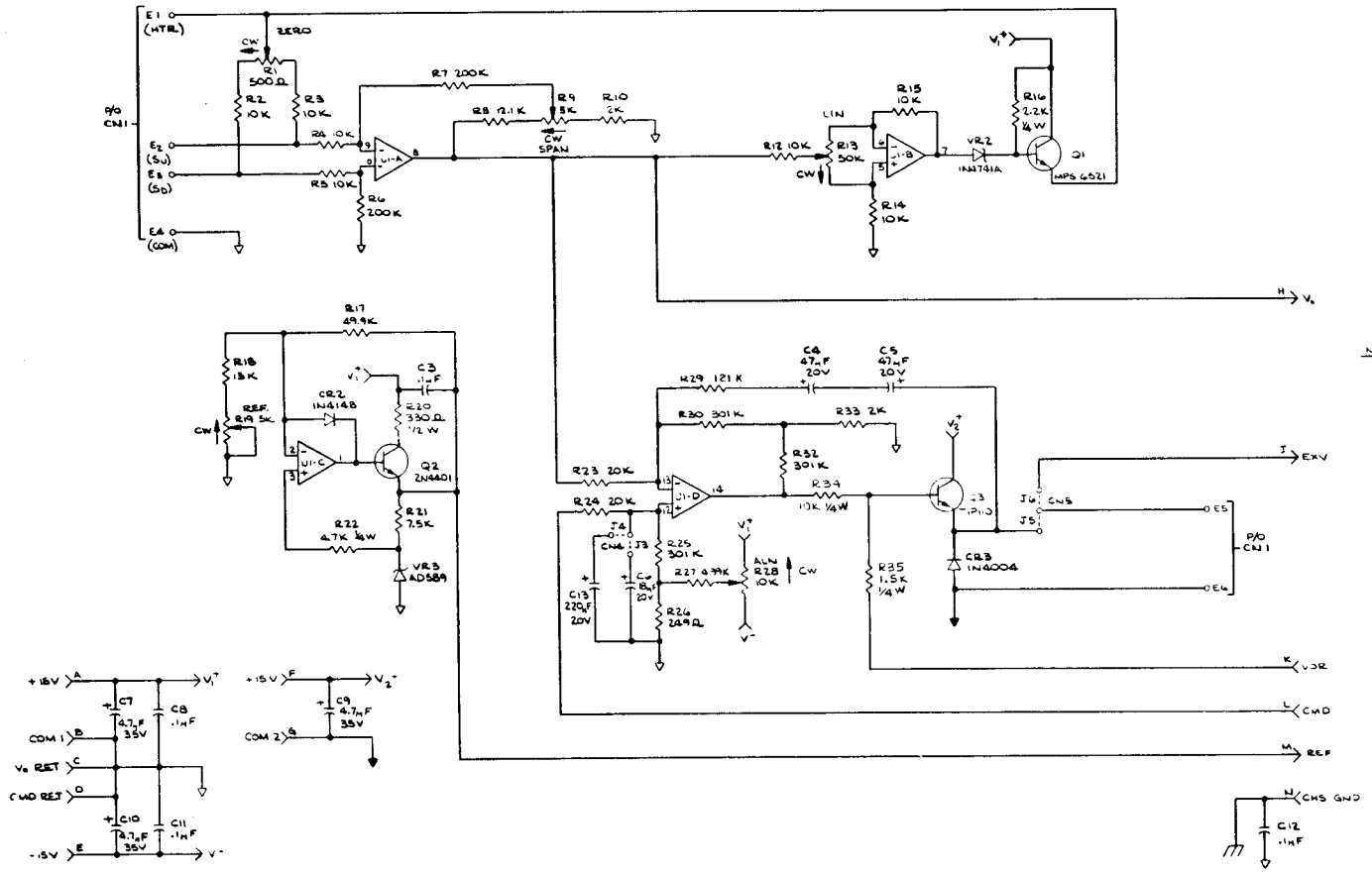
A heater coil uniformly heats the gas flow stream. As a result, both the upstream and downstream sensor coils are heated equally at zero flow. Refer to Figure 3-1.

At zero, or no flow, a balanced bridge circuit is established to provide a zero or no flow output signal. As gas flows within the sensor, a temperature differential is created between the upstream and downstream sensor coils. This difference is directly proportional to the mass flow rate.

The resulting voltage differential is applied to the input of the differential amplifier, U1-A (pins 9 and 10). The amplifier generates a dc voltage output at U1-A (pin 8) directly proportional to the mass flow rate. This voltage is seen at voltage output P1, (on card edge connector controllers) or P2 (on "D" type connector controllers) for remote indication and is presented at U1-D (pin 13) through a resistor, for use in the control circuit.

The automatic control feature consists of the following two units in addition to the flow sensor:

a. Flow control valve — located adjacent to and downstream of the flow sensor. It responds to an error signal and increases or decreases the mass flow until the measured flow equals the required flow.



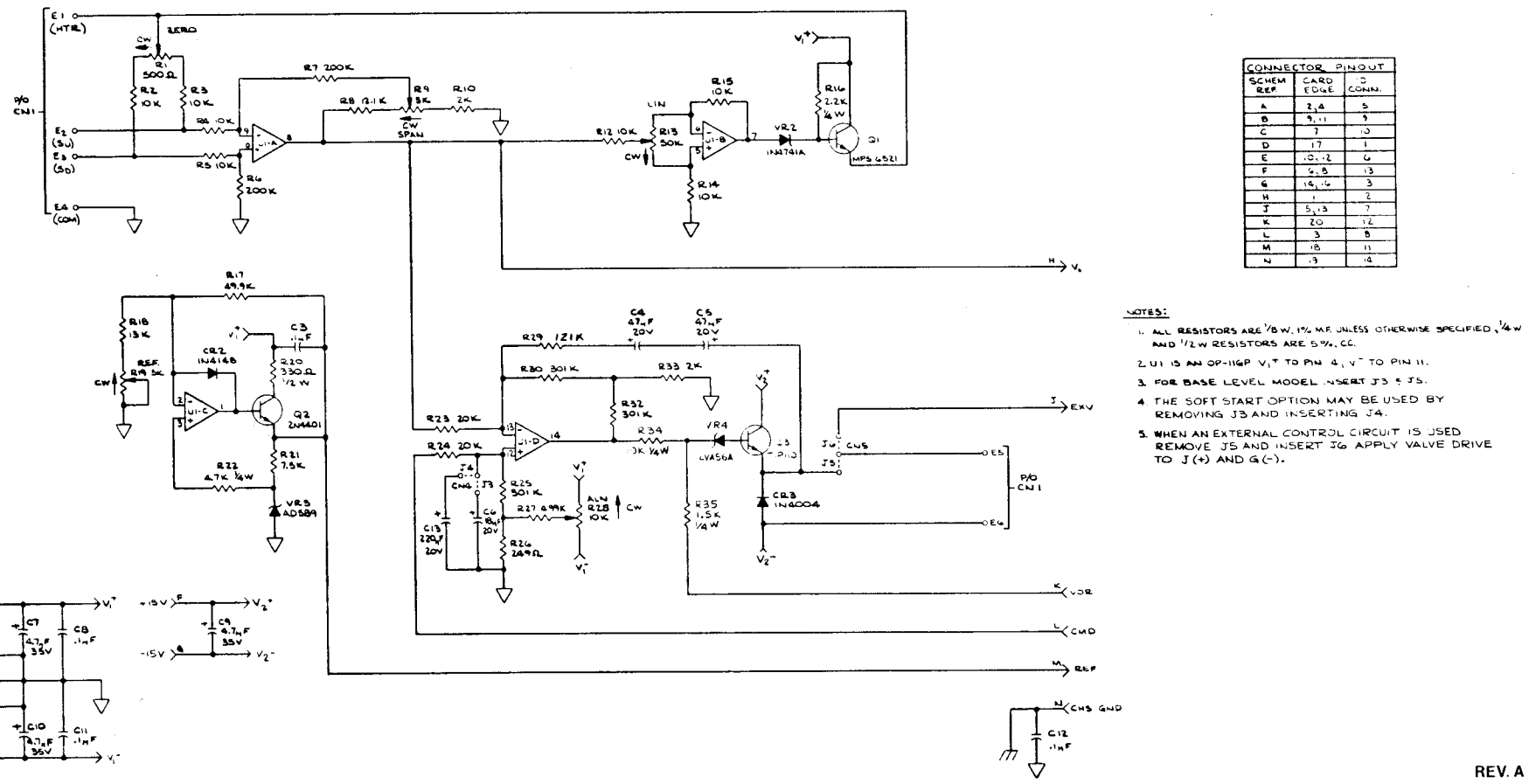
CONNECTOR PINOUT		
SCHEM REF.	CARD EDGE	D CONN.
A	2,4	5
B	9,11	9
C	7	13
D	17	1
E	20,12	6
F	4,8	13
G	14,16	3
H	1	2
J	5,13	7
K	20	12
L	3	8
M	18	11
N	19	14

NOTES:

1. ALL RESISTORS ARE 1/8 W, 1% M.F. UNLESS OTHERWISE SPECIFIED, ¼ W AND ½ W RESISTORS ARE 5%, C.C.
2. U1 IS AN OP-11GP V_1^+ TO PIN 4, V^- TO PIN 11.
3. FOR BASE LEVEL MODEL INSERT J3 & J5.
4. THE SOFT START OPTION MAY BE USED BY REMOVING J3 AND INSERTING J4.
5. WHEN AN EXTERNAL CONTROL CIRCUIT IS USED REMOVE J5 AND INSERT J6 APPLY VALVE DRIVE TO J(+) AND G(-).

REV. B

Figure 3-4 Schematic Diagram 5850C



CONNECTOR PINOUT		
SCHEM REF.	CARD EDGE	D CONN.
A	2,4	5
B	9,11	9
C	7	10
D	17	1
E	10,12	6
F	6,8	13
G	14,16	3
H	1	2
J	5,13	7
K	20	12
L	3	8
M	18	11
N	19	14

NOTES:

1. ALL RESISTORS ARE ⅛W, 1% M.F. UNLESS OTHERWISE SPECIFIED, ¼W AND ½W RESISTORS ARE 5%, C.C.
2. U1 IS AN OP-116P V_1^+ TO PIN 4, V^- TO PIN 11.
3. FOR BASE LEVEL MODEL INSERT J3 & J5.
4. THE SOFT START OPTION MAY BE USED BY REMOVING J3 AND INSERTING J4.
5. WHEN AN EXTERNAL CONTROL CIRCUIT IS USED REMOVE J5 AND INSERT J6 APPLY VALVE DRIVE TO J(+) AND G(-).

REV. A

Figure 3-5 Schematic Diagram 5851

b. Command (set point) potentiometer — a precision 10-turn 1K ohm potentiometer with integral turns counting dial permitting repeatable adjustments of the mass flow to 1 part in 1000.

The voltage derived from U1-C (pin 1) and the emitter of Q2 is a precision reference voltage used to drive the command potentiometer.

The voltage presented to the wiper by voltage divider action and applied to noninverting U1-D (pin 12), the comparison amplifier, turns on the valve transistor, Q3. This causes current to flow through the solenoid valve.

The comparison amplifier throttles back on the valve control transistor to establish equilibrium by closing the valve when the flow signal, U1-D (pin 13) is greater than the command signal, U1-D (pin 12) and opening the valve when the flow signal is less than the command signal. Potentiometer, R28, (ALN) is used to null shift the offset of the comparison amplifier.

The output, at P1 voltage output (or P2 on "D" type connector controllers), may be connected to an indicator or instruments requiring an 0 to 5 volt dc input.

3-2 Principle of Operation - Soft Start

A user selectable Soft Start function is a standard feature. This feature, when enabled, virtually eliminates overshoot and undershoot to a negligible value.

Many processes, particularly those requiring injection of a volatile or reactive gas, require a slow injection of the fluid as protection to the process. A valve ramping function is included within the standard electronics package and is user selectable. Refer to Section 2-7.

Caution: Since the Model 5850C/5851 control valve is not a positive shut-off, a separate solenoid valve may have been installed for that purpose. It should be noted that a small amount of gas may be trapped between the downstream side of the Mass Flow Controller and this solenoid resulting in a surge upon actuation of the controller. This surge can be reduced in magnitude by locating the controller and solenoid close together or moving the solenoid upstream of the controller.

3-3 Operating Procedure

a. Apply power to the controller and allow approximately 15 minutes (45 minutes for attitude insensitive controller) for the instrument to warm up and stablize.

b. Turn on gas supply.

c. Command 0% flow and observe the controller's output signal. Output should be slightly positive (approximately +10 mV dc).

d. Set command for desired flow rate to assume normal operation.

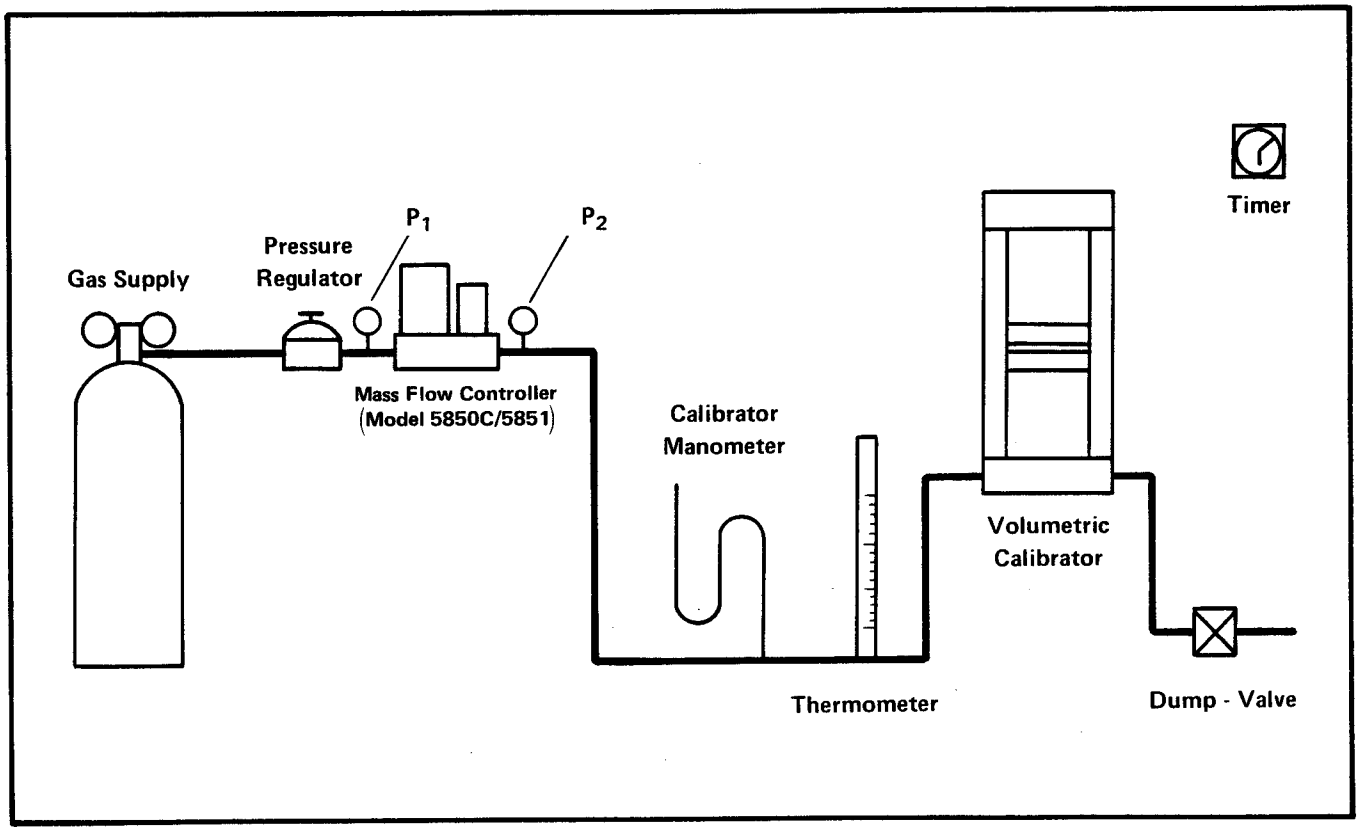


Figure 3-6 Typical Calibration Installation

3-4 Calibration Procedure (Refer to Figures 3-6, 3-7, and 3-8)

Note: Calibration of the Model 5850C or 5851 requires the use of a digital voltmeter (DVM) and a volumetric calibrator. It is recommended calibration be performed only by trained and qualified service personnel.

1. With the meter level and installed in a unpressurized gas line, apply power and allow to warm-up approximately 15 minutes (45 minutes for attitude insensitive controller).

2a. Reference (REF) adjustment for mass controllers with edge card connectors. Connect DVM positive lead to command potentiometer terminal CW (pin 18, gray) and DVM negative to common (pin 7); adjust REF (R19) for 5.000 V.

2b. Reference (REF) adjustment for mass controllers with "D" type connectors: connect DVM positive lead to command potentiometer terminal CW (pin 11) and DVM negative to common (pin 10). Adjust REF (R19) for 5.000 V.

3a. Zero adjustment for mass controllers with edge card connectors. Connect DVM positive to the output (pin 1); adjust zero (R1) for 15 mV ±2 mV.

3b. Zero adjustment for mass controllers with "D" type connectors. Connect DVM positive to the output (pin 2); adjust zero (R1) for 15 mV ±2 mV.

4a. Alignment (ALN) adjustment for mass controllers with card edge connectors. Set Command potentiometer to 100% flow (5.000V). With DVM positive connected to the output, pin 1; adjust ALN (R28) for 5.000 V.

4b. Alignment (ALN) adjustments for mass controllers with "D" type connectors. Set command potentiometer to 100% flow (5.000 V). With DVM positive connected to the output, pin 2; adjust ALN (R28) for 5.000 V.

5. Set command potentiometer to 10% of flow (.500 V). Check and record output reading. The difference (in millivolts) between the command and output is "total error".

6. Adjust ALN (R-28) to minus one-half of error.

7. Linear (LIN) adjustment. Set command potentiometer to 100% of flow with digital DVM connected to E1 on the sensor lead connector. Adjust LIN (R-13) for 11.0 V.

8. Span adjustment - with command potentiometer at 100% of flow, using suitable volumetric calibration equipment, adjust span (R-9) for proper full scale flow.

9. Set command potentiometer to 0% of flow. Connect DVM positive to output and readjust zero (R-1) for 15 mV ±2 mV.

10. Set command potentiometer to 50% of flow (2.500 V) and measure the flow rate using suitable volumetric calibration equipment. Calculate the error as a % of full scale.

$$\text{Full Scale} = 100\% \frac{(\text{measured/desired flow rate})}{\text{full scale flow rate}}$$

Example: What is the percent of full scale error when F.S = 100 sccm?

Measured flow rate = 51.5 sccm

Desired flow rate = 50.0 sccm

$$\text{F.S. error} = \frac{100\ (51.5 - 50)}{100}$$

$$= 1.5\%$$

Note: If the result of the percent of error calculation is negative, be sure the "negative" percent of error is used when calculating the E1 voltage.

11. Set command potentiometer to 100% of flow. Note the voltage at E1. Calculate the new E1 voltage: the error from Step 10 times (-0.178 V/%) plus the old E1 voltage.

Example:

If Step 10 error = 1.5%
and E1 voltage = 11.000 V
Then the new E1 = 1.5% x (-0.178 V/%)† + 11 V
= -0.267 V + 11 V
= 10.733 V

† A linearity adjustment factor units = volts/percent

12. Adjust LIN (R-13) for new E1 voltage.

13. Repeat Steps 8, 9, and 10. If the error from Step 10 is less than 0.5%, then calibration is complete. If not, then repeat Steps 11, 12, and 13.

Section 4 MAINTENANCE

4-1 General

No routine maintenance is required to be performed on the Models 5850C and 5851 other than an occasional cleaning. It is recommended Freon be used for cleaning the flow sensor and control valve. Flush in both directions and air dry thoroughly. If an in-line filter is used, the filtering element should periodically be replaced or ultrasonically cleaned.

4-2 Control Valve

The control valve may be disassembeled in the field by the user for cleaning or servicing. Disassemble the valve as follows:

a. Remove the jam nut on top of the valve assembly.
b. Remove the screws and cover of the controller.
c. Remove the valve housing.
d. Remove screws holding the retaining plate.
e. Remove retaining plate.

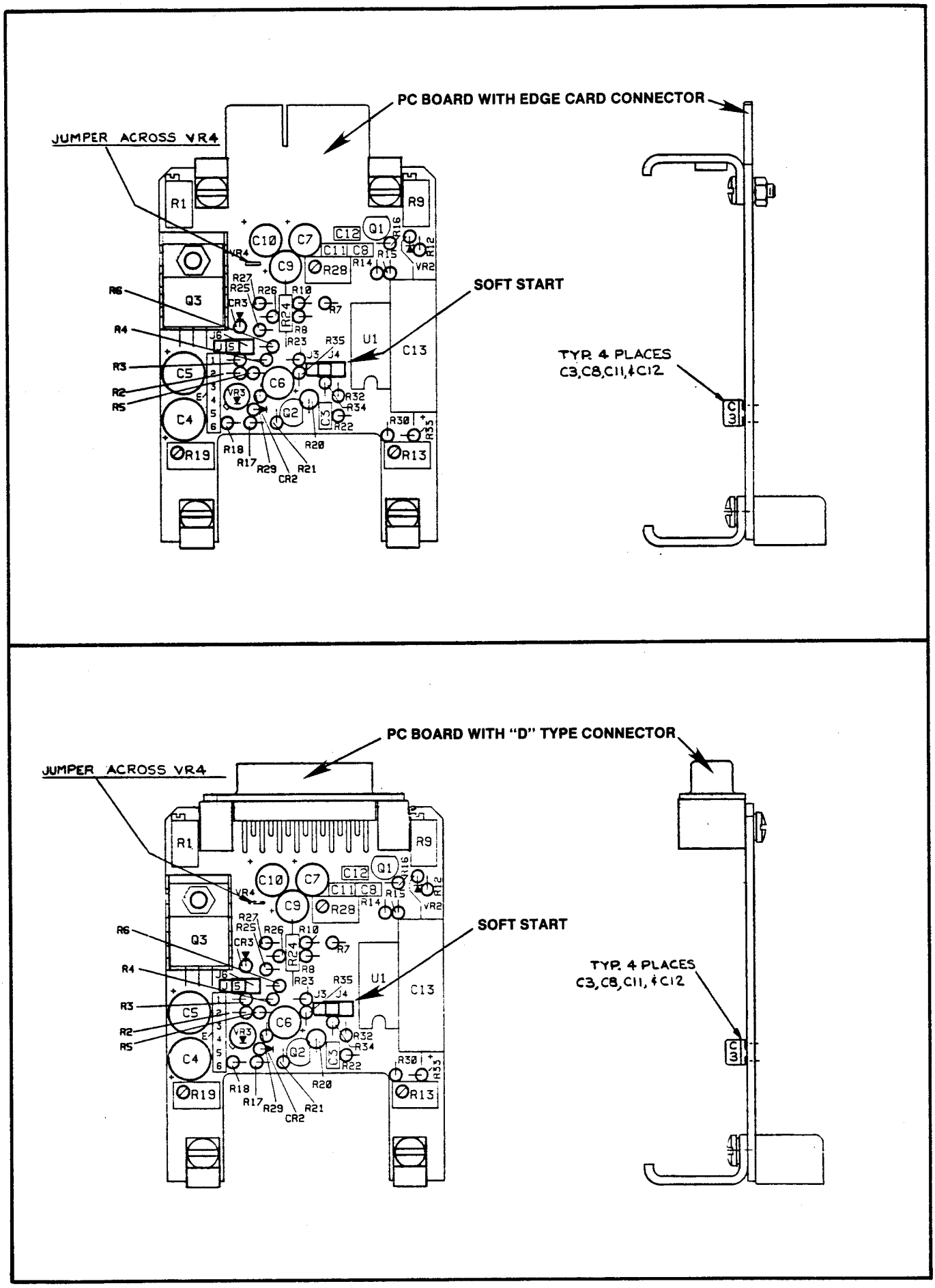
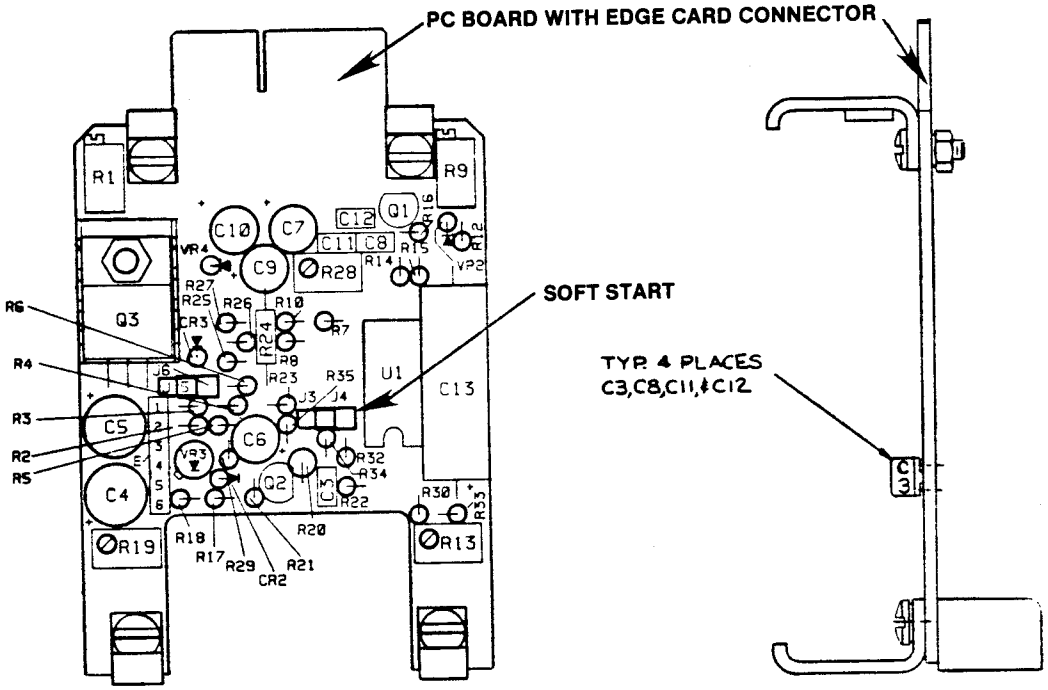


Figure 3-7 P.C. Board Assemblies 5850C



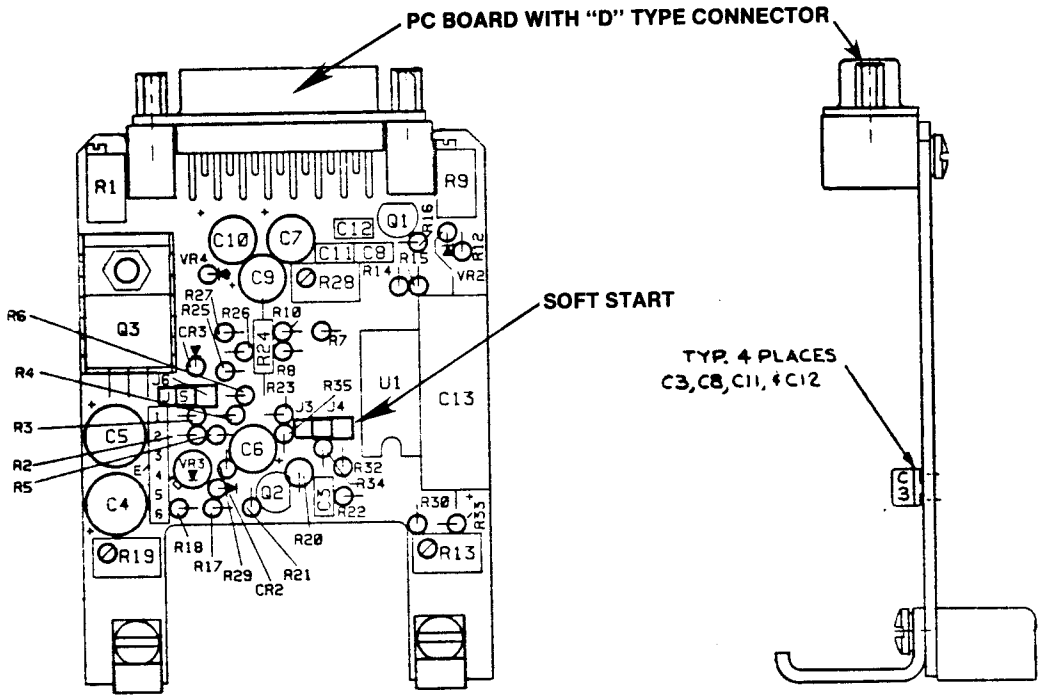


Figure 3-8 P.C. Board Assemblies 5851

Table 4-1 Troubleshooting

Trouble	Possible Cause	Comments
No output	No power in	1. Check for ±15 Vdc
	Obstruction in sensor	1. Flush sensor in both directions with non-residuous solvent. Air dry thoroughly. Do not attempt to service or disassemble sensor. 2. Return to factory.
	P.C. board failure	1. Replace P.C. board
Will not zero	Gas leak	1. Check downstream gas connections 2. Return to factory
	P.C. board failure	1. Replace P.C. board
Out of calibration	Gas leak	1. Check all gas connections
	Dirty sensor	1. Flush with non-residuous solvent. Air dry thoroughly. Do not attempt to service or disassemble sensor. 2. Return to factory
	Change in composition of metered gas	1. Refer to Table 4-2 for conversion factor. 2. Return to factory
	P.C. board failure	1. Replace P.C. board
	Clogged restrictor	1. Ultrasonically clean 2. Replace restrictor

If any of the above services are performed, it is recommended calibration of the unit be verified using suitable volumetric calibration equipment.

f. Carefully unscrew and lift out the stem assembly, keeping it vertical to avoid damaging the lower guide spring.
g. Remove plunger assembly.
h. Remove orifice.

Clean parts and carefully assemble in reverse of the above procedure. It is recommended that all o-rings be replaced upon reassembly of the valve.

4-3 Troubleshooting (Refer to Table 4-1)

Caution: It is important this instrument be serviced only by properly trained and qualified personnel.

4-4 Use of the Conversion Table

The Conversion Table 4-2 is used to calculate the flow rate for gases other than the preselected gas.

The flow controller is factory set to a preselected gas, pressure and flow range. To change to a new gas, multiply the output reading by the ratio of the gas factor for the desired gas to the gas factor for the calibration gas.

Actual gas flow rate = Output reading

$$\times \frac{\text{factor calibrated gas}}{\text{factor new gas}}$$

or for example:

The controller is calibrated for nitrogen.
The desired gas is carbon dioxide.
The output reading is 75 sccm.

Then $75 \frac{1}{0.77} = 57.75$ sccm

Table 4-2 Conversion Factors

GAS	FACTOR
Acetylene (C_2H_2)	0.66
Air	1.00
Ammonia (NH_3)	0.79
Argon (Ar)	1.39
Butadiene (C_4H_6)	0.38
Butane (C_4H_{10})	0.31
Carbon Dioxide (CO_2)	0.77
Carbon Monoxide (CO)	1.00
Dichlorosilane ($Si H_2 CL_2$)	0.47
Ethane (C_2H_6)	0.56
Ethylene (C_2H_4)	0.68
Helium (He)	1.40
Hydrogen (H_2)	1.00
Hydrogen Sulfide (H_2S)	0.85
Methane (CH_4)	0.82
Neon (Ne)	1.40
Nitric Oxide (NO)	0.99
Nitrogen (N_2)	1.00
Nitrogen Dioxide (NO_2)	0.76
Nitrous Oxide (N_2O)	0.75
Oxygen (O_2)	0.99
Propane (C_3H_8)	0.41
Propylene (C_3H_6)	0.47
Silane ($Si H_4$)	0.68
Sulfur Dioxide (O_2)	0.73

Conversion Factors (Air = 1.0)

*TRADEMARKS
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