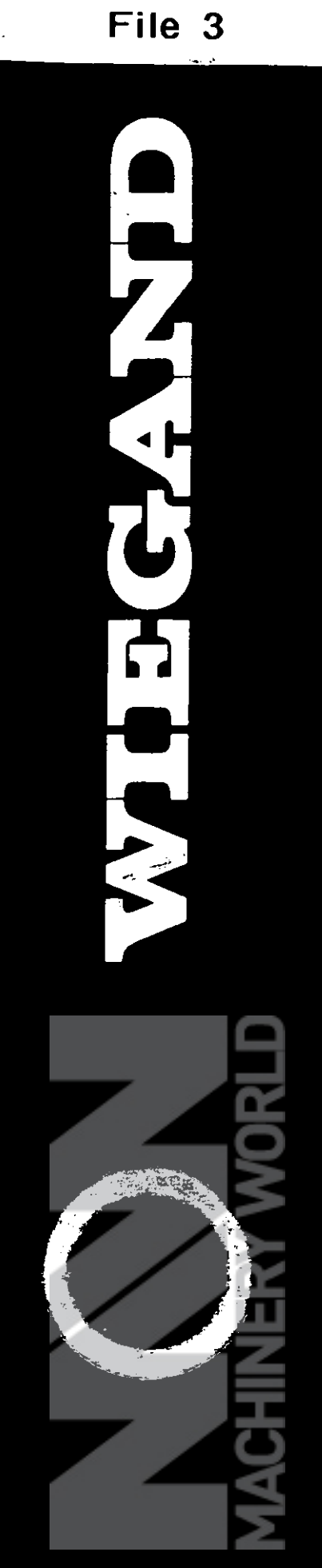
File 3



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file

WIEGAND

File 1

1 Operating Instructions Evaporation Plant
2 Erection Drawings No. 763/764/765/766-303-0
3 Flow-sheet No. 513 / 515 - 302 - 0
4 Maintenance Instructions SIHI Vacuum pump
5 Maintenance Instructions Hilge Centrifugle pumps
6 Maintenance Instructions Mono pump Nezch
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11 Installation, Assembly & commisioning of controls
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21 Maintenance Instructions Bran + Lubbe pump
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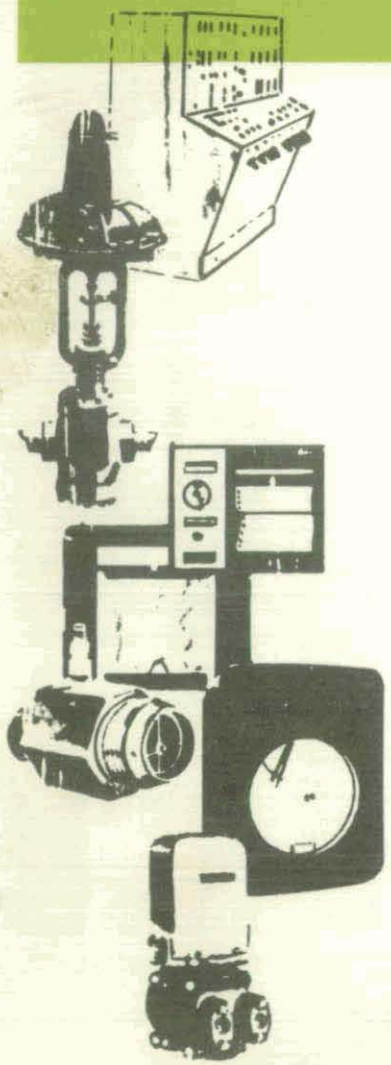
INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct installation of your Foxboro Instruments, and in their proper operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number*.

Book No. 0 2628

FOXBORO

Foxboro Yoxall
A Division of Foxboro Great Britain Limited

Redhill Surrey England
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Telex: 892852
Telegram: Yoxbri Redhill

Guarantee

The Company undertakes to replace free of charge any component of its own manufacture (which excludes electronic tubes) which, in the opinion of the Company, is not within the specified limit of calibration or is defective in material or workmanship under normal or proper use, provided that the same is returned at the customer's risk and expense to the Company's works within twelve months from the date of the despatch by the Company of the equipment to the customer.
All representations, conditions, guarantees and warranties by law or otherwise howsoever expressed or implied are hereby excluded to the intent, except as above provided, after delivery to and acceptance by the customer of any equipment or apparatus, the Company shall not be liable for any loss, damage, injury, delay or expense or consequential loss or damage howsoever arising from or in respect of the equipment or apparatus or the use thereof.

Pyrometer Thermocouples, Resistance Thermometer Bulbs, and Protection Tubes, on account of the severity of their usage, are not subject to replacement unless returned unused.

The Company shall not be liable for loss, damage, detention or delay caused by fire, strike, civil, or military authority, insurrection or riot, or for other cause beyond its reasonable control. Acceptance of apparatus by the Purchaser shall constitute a waiver of all claims for delay.

Service

The Company is anxious to be of every possible assistance to you, to ensure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service in the British Isles should be made with the Company at Redhill. In other parts of the World arrangements should be made through the nearest Representative and/or Factory listed at the end of this book.
A unique feature of Foxboro service — of particular interest to Companies which do not have Instrument Departments or enough qualified Staff to carry out regular inspection and maintenance — is the Service Contract. Under this arrangement, a Foxboro Service Engineer will call at stated intervals to check the condition and operation of all Foxboro Instruments in your Plant. The Service Contract is also used by Companies for the routine inspection and maintenance of highly technical instrumentation which requires specialised knowledge and experience.
The Company provides an expertly staffed and fully equipped Training Centre at Redhill devoted to the instruction of customers' Instrumentation Engineers and Service Men. The courses cover: theory of operation maintenance and application of the principal types of instruments. Applications from Companies in the British Isles should be made to Redhill, Surrey; from those in other parts of the world, to our nearest Representative as listed at the end of this book.

Parts

Parts Lists for Foxboro Instruments may be obtained by writing to the above address. It is strongly urged that only genuine Foxboro parts be used. Always give the serial number from the instrument data plate when requesting parts lists or ordering parts. (Those unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment, should not be permitted to undertake any major service work.)

Replacement

The Company has considerable knowledge and experience in regard to the economic life of Foxboro instrument equipment and will give advice on the desirability or otherwise, of fitting new parts into the older models. Improvements in design, materials, or methods sometimes make it more economic to replace rather than repair an instrument which has been in service for a long period of time.

Charts

To obtain the most accurate and consistent recording performance from our instruments, we strongly recommend the use of genuine Foxboro strip and circular charts.

FOXBORO

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

FOXBORO®

Instruction

MI
021-350
May 1983

896P AND 896S PULSED dc MAGNETIC FLOW TRANSMITTERS

Installation and Operation

The 896P and 896S Pulsed dc Magnetic Flow Transmitters use a dc pulse technique to drive the flux-producing coils of a 2800 Magnetic Flowtube. The standard transmitter converts the dc pulse signal from the flowtube to a standardized 4 to 20 mA signal. This signal is directly proportional to the process flow rate and is transmitted to a receiver to indicate, record, totalize, and/or control a variable.

This instruction contains installation, operation, and calibration procedures for standard transmitters, and use of the precalibrated span adjustment and the minimum signal lock options. For details of other options, refer to the applicable instruction listed on Page 12.

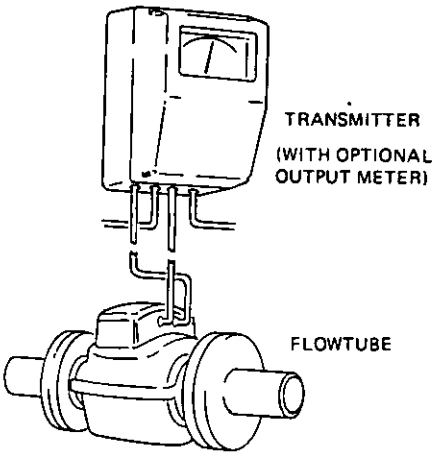

Figure 1.
896 Transmitter and 2800 Flowtube

CONTENTS . . .

STANDARD SPECIFICATIONS

Input Span Limits*: 100 µV peak pulse and 10 mV peak pulse; selected by span jumpers and a fine-span potentiometer.

Output Range**:
4 to 20 mA dc into 1000 Ω maximum

Power Requirements
Voltage: 120, 220, or 240 V ac, +10%, -15%; selected by link arrangement
Frequency Limits: 47 and 63 Hz

Power Consumption: Between 20 and 50 W (depending on options) including any 2800 Flowtube.

Ambient Temperature Limits
Normal Limits:
-25 and +55°C (-15 and +130°F)
Operative Limits:
-30 and +70°C (-25 and +160°F)

Transmitter Housing: Meets the requirements of IEC IP65 and provides the environmental protection of NEMA Type 4.

Electrical Classification: Refer to data plate.

INSTALLATION

Wiring

⚠ CAUTION

Unlike systems with ac coil excitation, ac power must not be present in the flowtube power connection box when an 896 Transmitter is used with a 2800 Flowtube. All signal and power wires must be connected as shown in Figure 3.

*Transmitter input values are based on a flowtube peak coil current of 1 A.
**Output range is given for a standard transmitter. For specifications of the various output options, refer to the applicable option instructions.

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Use the following type and size wires:

Transmitter Input Signal Wiring:
multicore, multiscreened (multiconductor, multishielded), Foxboro Part R0101ZS, or equivalent

Flowtube Coil Wiring:
2-core (2-conductor), 2.50 mm² or 14 AWG minimum; 300 V minimum rating

Power Mains Wiring:
3-core (3-conductor), 2.50 mm² or 14 AWG minimum

Output Signal and Options Wiring:
0.50 mm² or 22 AWG, or larger, recommended. Minimum size is limited by mechanical considerations.

1. If system (transmitter and flowtube) was not calibrated at factory, complete "Calibration" procedure on Pages 6 through 8 before proceeding. Otherwise, proceed to Step 2.

2. Refer to Figure 2. Unscrew the six captive screws in transmitter cover and lift off cover.

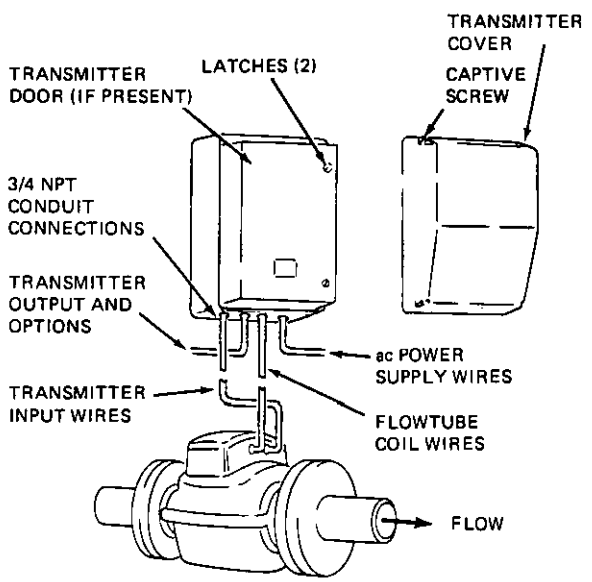


Figure 2.
Conduit Connections

3. If transmitter has a door (supplied with some options), turn the two screw-type latches on door (shown in Figure 2) 1/4 turn counterclockwise. Open door.

4. Run input signal, output signal, ac supply, and flowtube coil wires through separate conduit. Wires for minimum signal lock and other options can be run through same conduit as output wires. Use steel conduit for electromagnetic shielding. Connect conduit to transmitter as shown in Figure 2.

5. Prepare input signal cable using "Input-Signal Cable Preparation" procedure on Page 4.

6. Remove access cover from flowtube.

7. Refer to Figure 3. Connect input-signal wires to flowtube output terminal block as shown. Clamp input cable over its inner jacket with cable clamp.

8. Remove protective cover from coil-drive terminals (shown in Figure 3). If flowtube is installed with two conduit connections (see Figure 2) facing downstream, connect coil-drive wires to flowtube terminals as shown in Figure 3. If flowtube is installed with two conduit connections facing upstream, reverse coil-drive wire connections at flowtube.

9. Reinstall protective cover over coil-drive terminal. Reinstall access cover on flowtube.

10. Refer to Figure 3. Position transmitter input cable so that black wire is near transmitter terminal 2 (on left) and white wire is near terminal 4 (on right).

11. Clamp cable over its inner jacket as shown. Butt outer jacket against cable clamp.

12. Connect input wires to transmitter terminals 1 through 5 as shown in Figure 3. When connecting wires to terminals 1 through 17, insert wire in terminal slot so that wire is on top of clamp jaw as shown in Figure 4. Turn terminal screw to tighten clamp. Check that wire is secured in place after tightening clamp.

    When connecting wires to terminals C1, C2, L1, and L2, insert wire into clamp as shown in Figure 5. Then tighten terminal screw.

13. Connect wires for transmitter 4 to 20 mA output signal to terminals 6 (-) and 7 (+).

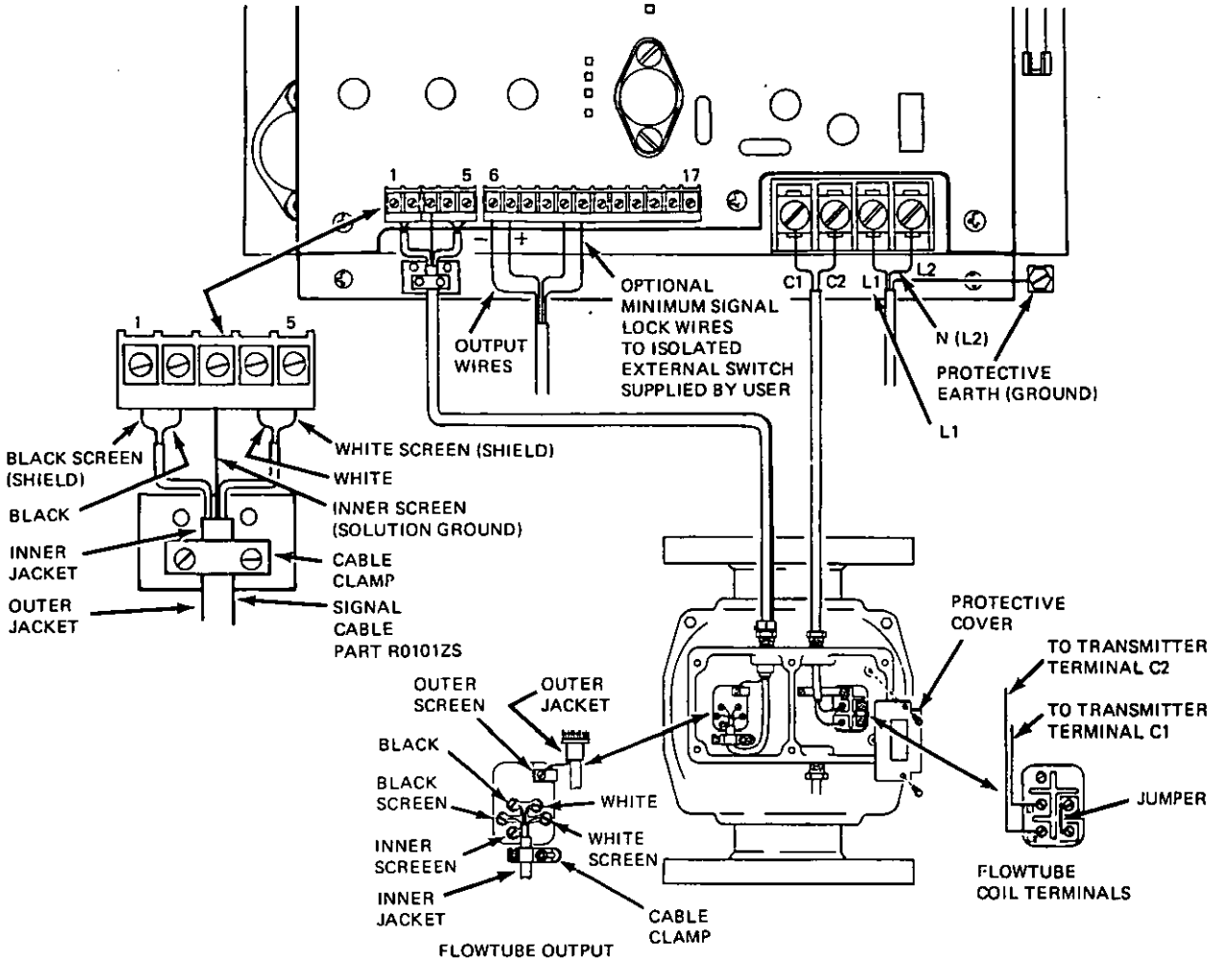


Figure 3.
Terminal Identifications

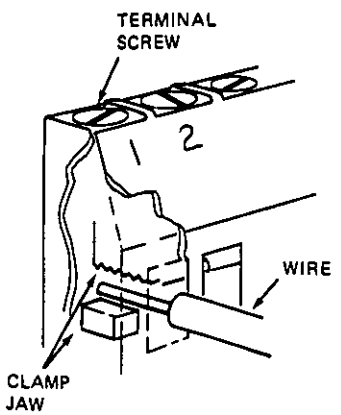


Figure 4.
Connecting Wires to Signal Terminals

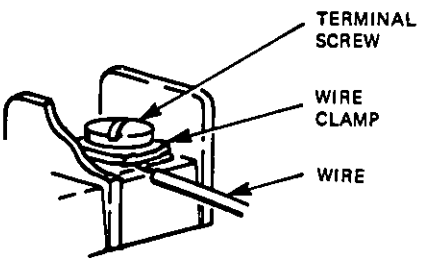


Figure 5.
Connecting Wires to
Coil and Power Terminals

NOTE
For optional pulse output wiring, refer to applicable instruction listed on Page 12. If 4 to 20 mA output is not used, leave open circuit between terminals 6 and 7.

14. Connect wires from flowtube coils to transmitter terminals C1 and C2 as shown.

15. Connect power mains wires to terminals L1, L2 (N) and earthing (grounding) post as shown.

16. To put system in operation, complete "Operation" procedure on Pages 5 and 6.

Input-Signal Cable Preparation

Termination to Flowtube

1. Trim back outer jacket and foil screen (shield) as shown in Figure 6. Do not cut screen lead.

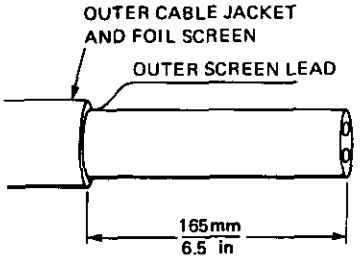


Figure 6.
Outer Jacket Trimmed Back
at Flowtube End of Signal Cable

2. Trim back inner jacket and foil screen as shown in Figure 7. Do not cut inner screen lead.

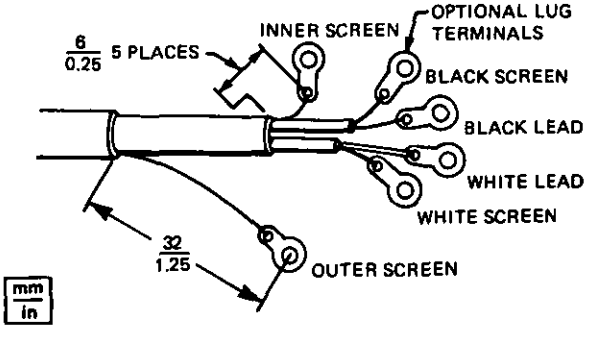


Figure 7.
Inner and Wire Jackets Trimmed
Back at Flowtube End of Signal Cable

3. Trim back wire jackets and foil screens as shown. Do not cut wire screen leads.

4. Strip insulation from black and white leads as shown.

5. If connections to terminal lugs are desired, connect lugs (supplied by user) to terminals as shown in Figure 7.

Termination to Transmitter

1. Trim back outer jacket and foil screen as shown in Figure 8. Cut screen lead flush with edge of jacket.

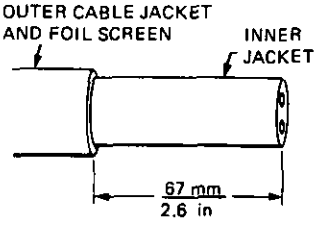


Figure 8.
Outer Jacket Trimmed Back
at Transmitter End of Signal Cable

2. Trim back inner jacket and foil screen as shown in Figure 9. Do not cut inner screen lead.

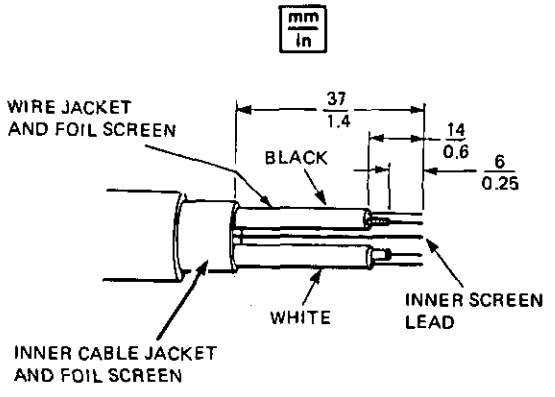


Figure 9.
Inner and Wire Jackets Trimmed
Back at Transmitter End of Signal Cable

3. Trim back wire jackets as shown. Do not cut screen leads.

4. Strip insulation from white and black leads as shown.

5. Tin the end of all five leads.

6. To connect cable between flowtube and transmitter, complete "Wiring" procedure on Pages 1 through 4.

OPERATION

Start-up Procedure

1. Before applying ac power, check that links are in correct position. For link positions, see Pages 10 and 11.

⚠ CAUTION

Damage to transmitter can result if ac power is applied while supply-voltage links are in incorrect position.

2. Apply ac power.

3. If system (transmitter and flowtube) was not calibrated at factory, complete "Calibration" procedure on Pages 6 through 8.

4. Refer to Figure 10. Connect a 0 to 1 V dc voltmeter between test points TP18 (+) and TP19 (-).

5. Start process liquid flow through flowtube. Voltmeter reading should increase. If it decreases, turn off ac power, reverse wires at coil-drive terminals C1 and C2 (see Figure 3) in transmitter, then reapply power. System is now ready for operation

Damping Adjustment

The damping adjustment is shown in Figure 10. To decrease damping, turn adjustment counterclockwise.

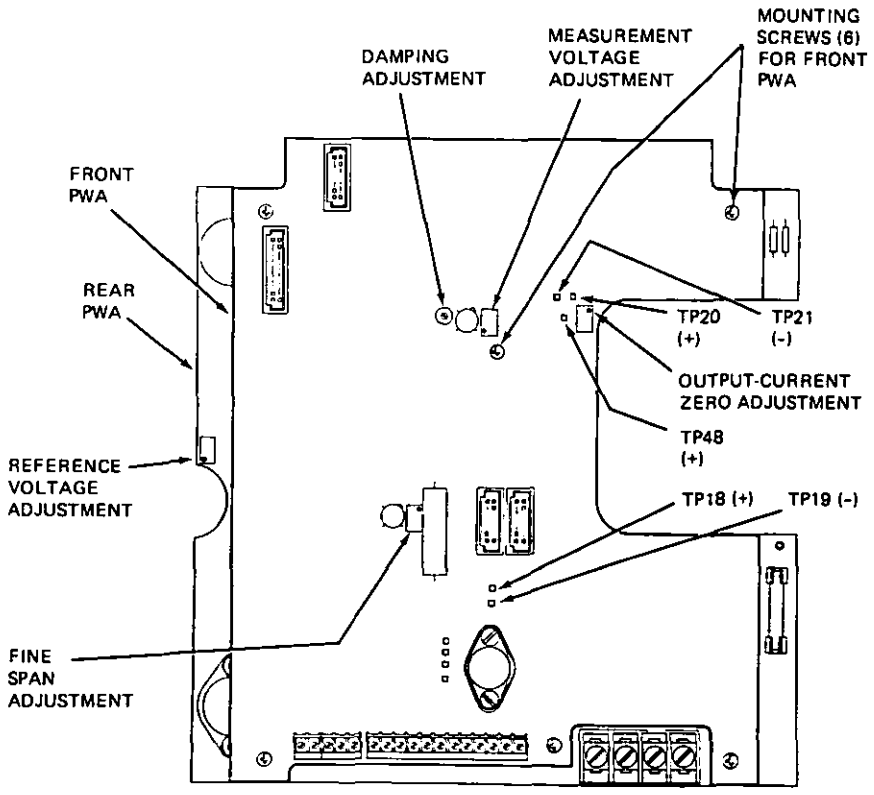


Figure 10.
Test Points and Adjustments

Optional Minimum Signal Lock

With this option, an external contact closure (supplied by user) drives the transmitter output to zero flow conditions (4 mA with analog output; no pulses with optional pulse output).

In transmitter with this option, connect wires from an isolated external switch (supplied by user) to terminals 10 and 11 as shown in Figure 11. To prevent false triggering due to pickup, use screened (shielded) cable or run wires through conduit. For wiring details, see "Wiring" procedure on Pages 1 through 4.

To activate minimum signal lock, put switch in closed position.

CALIBRATION*

This procedure includes calibration of standard transmitter and use of optional precalibrated span adjustment. Other options require additional adjustments. For details, refer to applicable instruction listed on Page 12.

Calibration Equipment

- Foxboro Model 896CAL Field Calibrator
- Digital Voltmeter (4 1/2-digit); Accuracy: ±0.05%

Standard Calibration

1. If the upper-range flow rate is not being changed, calibrate the transmitter using the millivolt (mV) value stamped on the transmitter data plate.

   If the upper-range flow rate is being changed, determine the calibration factor from the flowtube data plate. Calculate the transmitter's new upper range value (URV) in mV using the following formula:

   URV = (Flowtube Calibration Factor)(New Upper-Range Flow Rate)

   Example:
   New Upper-Range Flow Rate = 20 L/s
   Flowtube Calibration Factor = 0.098 mV/L/s
   URV = (0.098)(20) = 1.96 mV

2. Shut off ac power supply.

3. Position span jumpers as shown in "Link and Jumper Positions" on Pages 10 and 11.

4. Refer to Figure 12. Connect a jumper across transmitter terminals 6 and 7. (Jumper is not required if normal output load is already connected between these terminals.)

5. If input wires are connected to terminals 1 through 5, note arrangement (for later reconnection) and disconnect wires.

6. If coil drive wires are connected to terminals C1 and C2, note arrangement (for later reconnection) and disconnect wires.

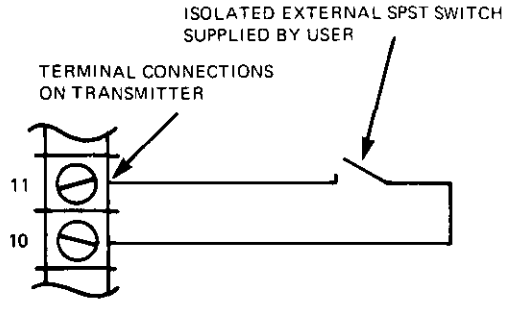
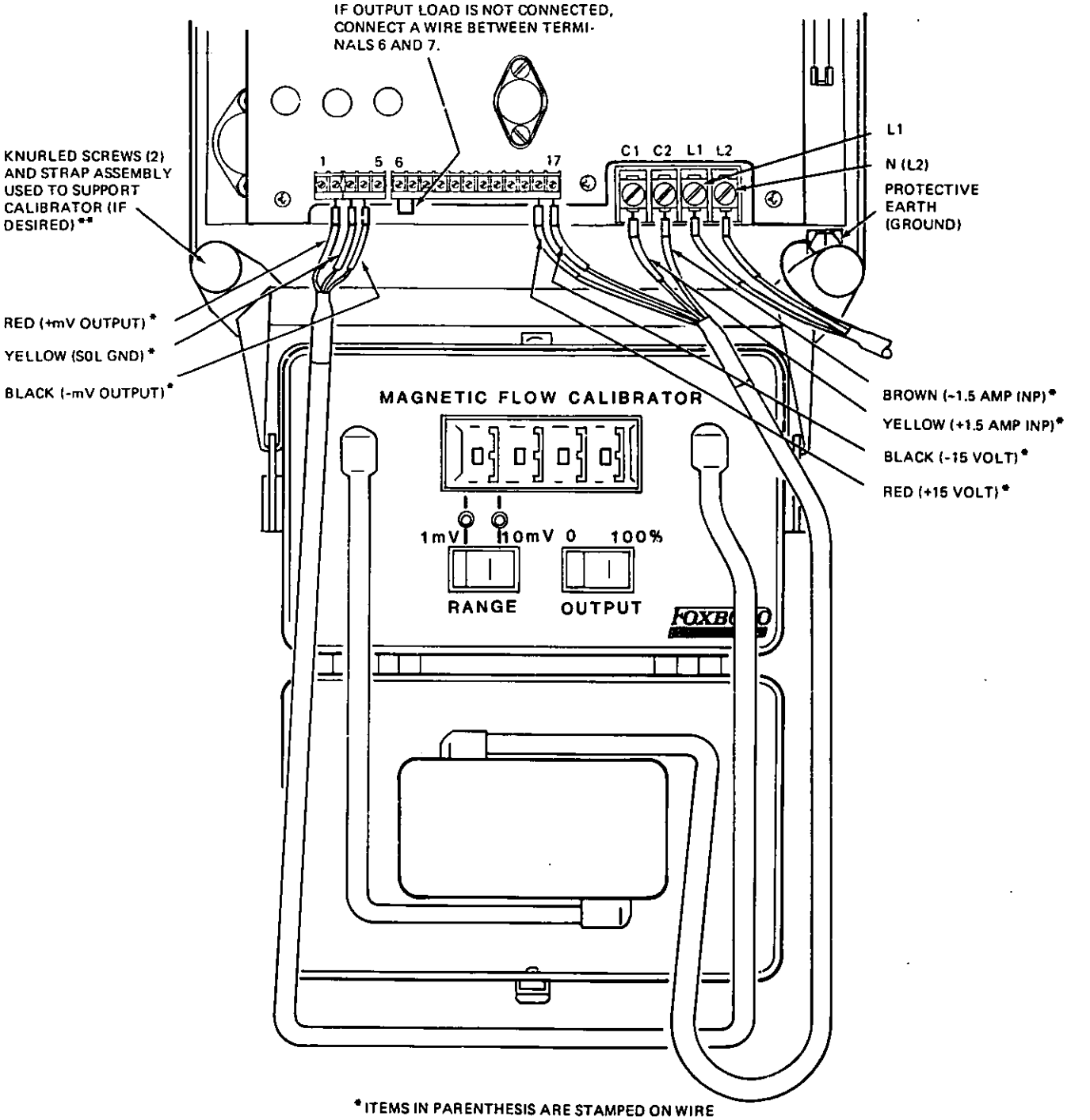


Figure 11.
Switch Connections with
Minimum Signal Lock Option

*Transmitter input values are based on a flowtube peak coil current of 1 A.



*ITEMS IN PARENTHESIS ARE STAMPED ON WIRE LABELS.
**UNSCREW TWO KNURLED SCREWS FROM SIDES OF CALIBRATOR AND SCREW INTO TRANSMITTER HOUSING AS SHOWN.

Figure 12.
Calibration Wiring

7. If desired, the 896CAL Calibrator can be supported by the transmitter during calibration. Remove the two knurled screws from the sides of the calibrator and install them in transmitter housing as shown in Figure 12. The calibrator will now be hanging by its carrying strap.

8. Connect cables from calibrator to transmitter as shown in Figure 12.

9. Adjust voltmeter to 10 V range and connect it between test terminals TP20 (+) and TP21 (-). Terminals are shown in Figure 10.

10. Position jumper J6 (shown in Figure 14) between pins P12 and P14.

11. Turn on ac power supply to transmitter. Allow 15-minute warm-up time.

12. On calibrator, adjust the 4-digit thumbwheel and the range switch to mV upper range value of transmitter (either the value given on data plate or the value calculated in Step 1, as applicable). Position the 2-position output switch at 0%.

13. On transmitter, turn reference voltage adjustment (shown in Figure 10) until voltmeter reads 10.000 V, ±5 mV.

14. Disconnect voltmeter lead from test point TP20 and connect it to TP48. Adjust voltmeter to 1 V range.

15. Turn measurement-voltage zero adjustment (shown in Figure 10) until voltmeter reads 0.000 V, ±1 mV.

16. Disconnect voltmeter from test points TP20 and TP48, and connect it to TP18 (+) and TP19 (-).

17. Turn output-current zero adjustment (shown in Figure 10) until voltmeter reads 0.1000 V, ±0.1 mV.

18. Position jumper J6 (shown in Figure 14) between pins P11 and P12.

19. On 896CAL Calibrator, position OUTPUT switch at 100%.

20. Turn fine span adjustment (shown in Figure 10) until voltmeter reading is 0.5000 V, ±0.5 mV.

NOTE

With span less than 1 mV and minimum damping, voltmeter reading may be unstable. To stabilize reading, turn damping adjustment (shown in Figure 10) 1/4 turn clockwise (increased damping). Allow about 15 seconds for reading to stabilize.

21. If transmitter has a pulse output option, complete the pulse output calibration procedure in applicable instruction listed on Page 12.

22. Turn off ac power supply. Disconnect calibrator and voltmeter from transmitter. Disconnect jumper (if previously connected) from transmitter terminals 6 and 7. Reconnect transmitter input wires to terminals 1 through 5. Reconnect coil-drive wires to terminals C1 and C2.

23. Complete "Installation" and "Operation" procedures as applicable.

Precalibrated Span Adjustment

The precalibrated span adjustment is shown in Figure 13. This adjustment consists of two settings: span multiplier and span adjustment. The maximum upper range value, in millivolts (mV), is determined by the position of the span multiplier switch. Table 1 shows the maximum upper range value for each switch position.

Table 1.
Maximum Upper Range Values (URV) with Optional Precalibrated Span Adjustment

SPAN MULTIPLIER SETTING	MAXIMUM UPPER RANGE VALUE (mV)
0.1	1
0.3	3
1	10

1. Determine upper range value of transmitter. For calculation details, see Step 1 of "Standard Calibration" procedure on Page 6.

2. Refer to Table 1. Select smallest span multiplier setting which includes upper range value of transmitter. Turn SPAN MULTIPLIER to setting which provides this adjustment range. For example, if upper range value is 1.96 mV, set SPAN MULTIPLIER to 0.3.

3. Turn span adjustment (SPAN ADJ) until dial indicates either the upper range value of transmitter or the calculated value (see note and example below).

NOTE
When the SPAN MULTIPLIER is set to 0.3, the SPAN ADJ does not provide a direct reading of the upper range value (URV). The numerical setting is determined by dividing the upper range value by 3.

Example: With a URV of 1.96 mV, the SPAN MULTIPLIER setting is 0.3. Therefore, 1.96 ÷ 3 = 0.653. And the SPAN ADJ setting = 653.

The transmitter is now fully calibrated for the new input range.

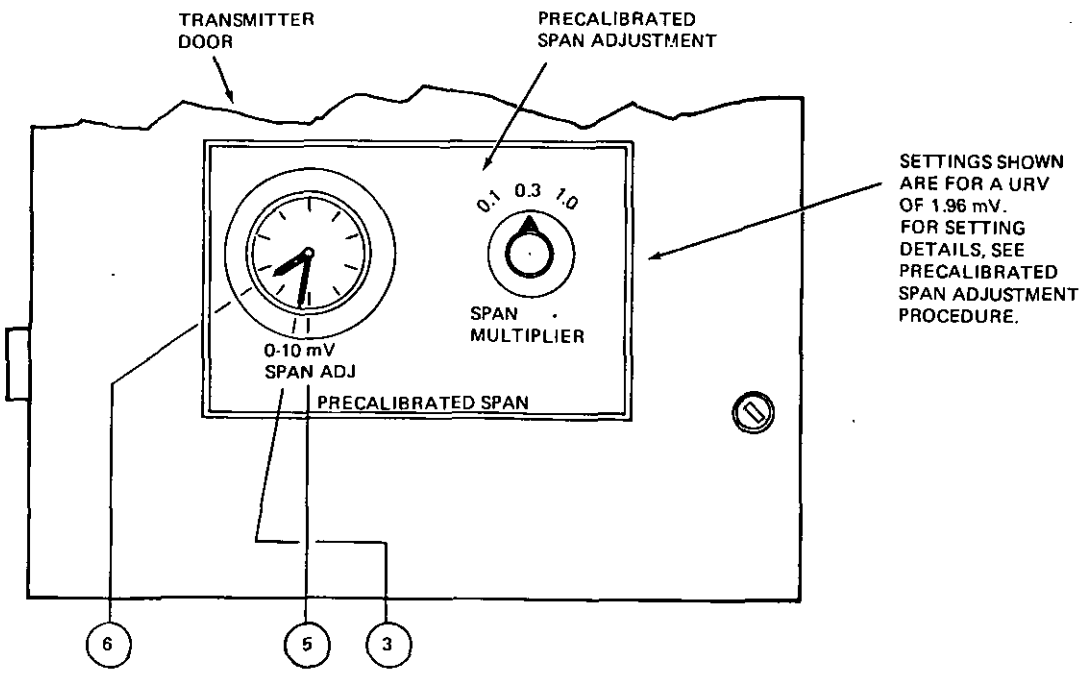


Figure 13.
Optional Precalibrated Span Adjustment

LINK AND JUMPER POSITIONS

To locate link or jumper positions used to change a particular operating mode, refer to Figure 14. Position links or jumpers as indicated in the corresponding table below or on Page 11. Mark new operating mode on data plate.

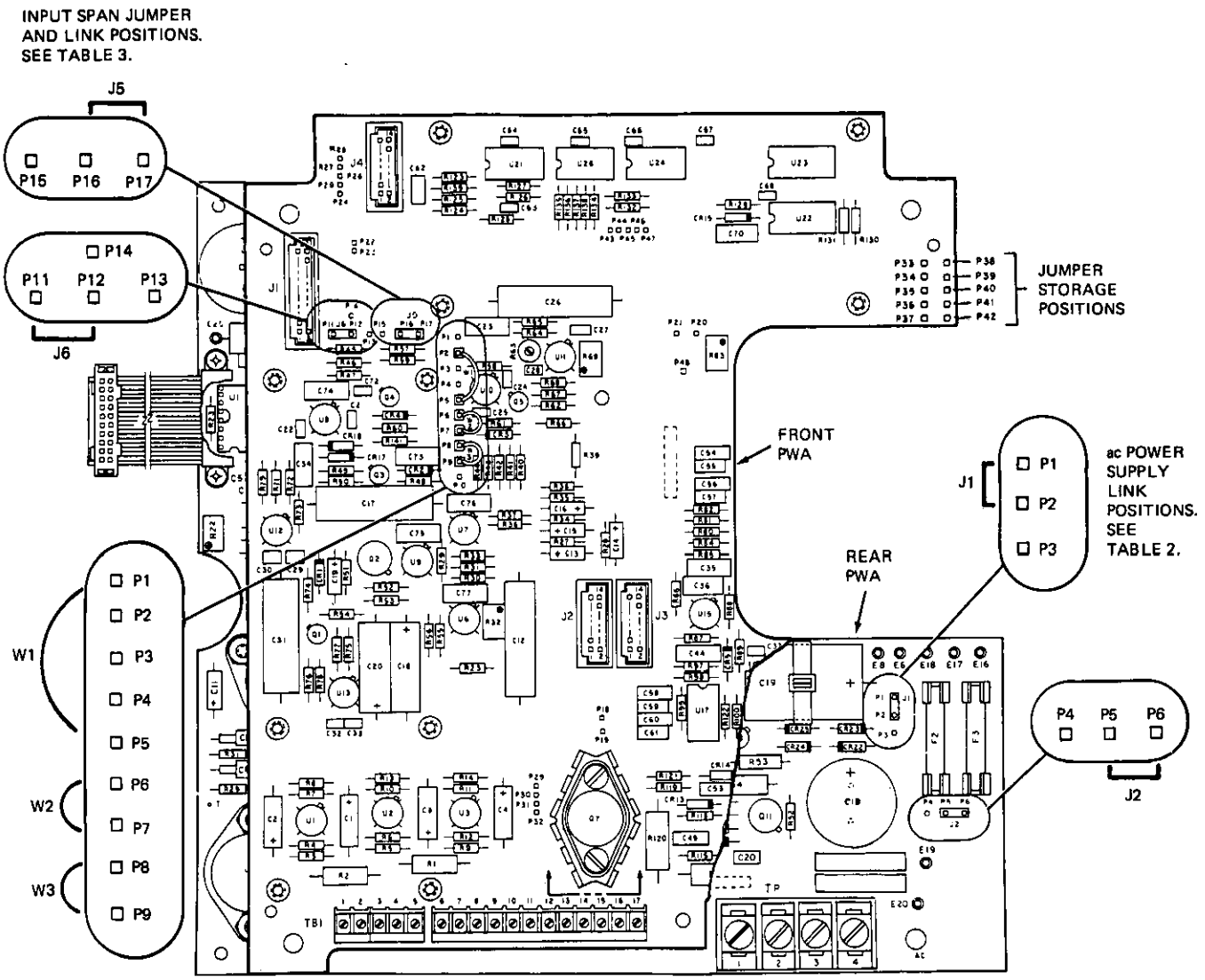


Figure 14. Link and Jumper Positions

Table 2. Supply Voltage Link Positions

SUPPLY VOLTAGE (V ac)	LINK POSITIONS	
	J1	J2
120	P2-P3	P5-P4
220	P2-P1	P5-P6
240	P2-P3	P5-P6

NOTE

To change supply voltage link positions, front printed wiring assembly (PWA) must be removed from transmitter. To remove PWA, remove the six mounting screws shown in Figure 10. If transmitter has a door (supplied with some options; shown in Figure 2), door frame will also be dismounted when four mounting screws at corners of PWA are removed. Unplug cables from PWA as required when removing assemblies. Reinstall cables after reassembling transmitter.

Table 3. Span Jumper and Link Positions

INPUT SPAN ADJUSTMENT RANGE		JUMPER AND LINK POSITIONS*				
Units	Values	W1	W2	W3	J5	J6**
µV	93 to 99	P1 and P5	S	S		
	99 to 106	P1 and P5	P8 and P9	S		
	106 to 114	P1 and P5	P7 and P8	S		
	114 to 124	P1 and P5	P7 and P9	S		
	124 to 135	P1 and P5	P6 and P7	S		
	135 to 148	P1 and P5	P6 and P7	P8 and P9		
	148 to 165	P1 and P5	P6 and P8	S		
	165 to 183	P1 and P5	P6 and P9	S		
	183 to 198	P2 and P5	S	S		
	198 to 212	P2 and P5	P8 and P9	S		
	212 to 228	P2 and P5	P7 and P8	S		
	228 to 248	P2 and P5	P7 and P9	S		
	248 to 270	P2 and P5	P6 and P7	S		
	270 to 298	P2 and P5	P6 and P7	P8 and P9	P16	
	298 to 331	P2 and P5	P6 and P8	S	and	
	331 to 367	P2 and P5	P6 and P9	S	P17	
	367 to 397	P3 and P5	S	S		
	397 to 426	P3 and P5	P8 and P9	S		
	426 to 458	P3 and P5	P7 and P8	S		
	458 to 497	P3 and P5	P7 and P9	S		
	497 to 542	P3 and P5	P6 and P7	S		
	542 to 596	P3 and P5	P6 and P7	P8 and P9		
	596 to 663	P3 and P5	P6 and P8	S		
	663 to 734	P3 and P5	P6 and P9	S		
	734 to 796	P4 and P5	S	S		
	796 to 853	P4 and P5	P8 and P9	S		
	853 to 918	P4 and P5	P7 and P8	S		
	918 to 995	P4 and P5	P7 and P9	S		
	995 to 1086	P4 and P5	P6 and P7	S		P11 and P12
mV	1.077 to 1.185	P1 and P5	P6 and P7	P8 and P9		
	1.185 to 1.316	P1 and P5	P6 and P8	S		
	1.316 to 1.457	P1 and P5	P6 and P9	S		
	1.457 to 1.597	P2 and P5	S	S		
	1.597 to 1.691	P2 and P5	P8 and P9	S		
	1.691 to 1.821	P2 and P5	P7 and P8	S		
	1.821 to 1.973	P2 and P5	P7 and P9	S		
	1.973 to 2.154	P2 and P5	P6 and P7	S		
	2.154 to 2.369	P2 and P5	P6 and P7	P8 and P9		
	2.369 to 2.633	P2 and P5	P6 and P8	S		
	2.633 to 2.918	P2 and P5	P6 and P9	S		
	2.918 to 3.163	P3 and P5	S	S		
	3.163 to 3.389	P3 and P5	P8 and P9	S	P15	
	3.389 to 3.650	P3 and P5	P7 and P8	S	and	
	3.650 to 3.955	P3 and P5	P7 and P9	S	P16	
	3.955 to 4.317	P3 and P5	P6 and P7	S		
	4.317 to 4.749	P3 and P5	P6 and P7	P8 and P9		
	4.749 to 5.277	P3 and P5	P6 and P8	S		
	5.277 to 5.848	P3 and P5	P6 and P9	S		
	5.848 to 6.339	P4 and P5	S	S		
	6.339 to 6.792	P4 and P5	P8 and P9	S		
	6.792 to 7.314	P4 and P5	P7 and P8	S		
	7.314 to 7.926	P4 and P5	P7 and P9	S		
	7.926 to 8.651	P4 and P5	P6 and P7	S		
	8.651 to 9.517	P4 and P5	P6 and P7	P8 and P9		
	9.517 to 10.576	P4 and P5	P6 and P8	S		
	10.576 to 11.877	P4 and P5	P6 and P9	S		
	With Optional Precalibrated Span Adjustment	S	S	S	P16 and P17	

*S = Put jumper in storage position.

**With optional minimum signal lock, link J6 is connected between P12 and P13.

REFERENCE INSTRUCTIONS

The precalibrated span adjustment and minimum signal lock options are covered in this instruction. For details of other options, refer to the applicable instructions listed below.

OPTION	INSTRUCTION (MI)
0.1 to 10 Hz Pulse Output	021-354
0 to 2000 Hz Pulse Output	021-355
Transistor Switch Closure Pulse Output	021-336
Span Switching	021-337
Digital Rate Meter	021-338

Printed in England

Instruction

MI
021-352
September 1983

896 PULSED dc MAGNETIC FLOW TRANSMITTER

Servicing

INTRODUCTION

This instruction assumes that the fault has been isolated to the transmitter. If the fault has not been isolated to the transmitter, refer to the system fault location procedure in Instruction MI 021-138.

For the principle of operation of the transmitter, refer to Technical Information TI 027-076.

TEST EQUIPMENT

The following equipment is sufficient to complete all tests in this instruction: Foxboro 896CAL Field Calibrator; digital multimeter; storage oscilloscope.

FAULT LOCATION TABLE

To use Table 1, find the symptom in the following list and go to the page specified. Complete the corresponding tests and applicable corrective action.

Table 1. Fault-Location Guide

SYMPTOM AND PROBABLE CAUSE	TEST	CORRECTIVE ACTION
1. NO OUTPUT CURRENT		
a. No Supply Voltage Between L1 and L2/N	Measure voltage between L1 and L2/N.	Apply correct supply voltage.
b. Defective ac Supply Fuse (F2 or F3) or Power Supply Assembly	Disconnect ac power supply and measure continuity across fuses. (See Figure 2 on Page 8.)	Replace defective fuse. If new fuse blows, install new power-supply assembly, Part M0156AV.
c. Supply-Voltage Link J1 or J2 Missing or Incorrectly Installed	Check position of links on power-supply PWA*. For link positions, see MI 021-350 (896P or 896S) or MI 021-351 (896T).	Install links in correct position.

*Printed Wiring Assembly

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Table 1. Fault-Location Guide (continued)

SYMPTOM AND PROBABLE CAUSE	TEST	CORRECTIVE ACTION
d. Open Circuit in Primary Windings of Power Transformer, or Blown Thermal Fuse in Power Transformer	Disconnect ac power supply and measure resistance between transmitter terminals L1 and L2/N. Approximate correct values are: 120 V Supply: 7 Ω 220 V Supply: 25 Ω 240 V Supply: 26 Ω	Install new power-supply assembly, Part M0156AV.
e. dc Supply Voltage not Present	1. On signal-conditioning PWA measure voltage between point P21 (ref.) and terminals 16 (+15 ±1 V) and 17 (-15 ±1 V).	Check continuity of fuses F4 and F5 on power-supply PWA (see Figure 2 on Page 8). If fuse is defective, install new fuse. Proceed to Test 2.
	2. On power-supply PWA, check for +15 V between lower lead of C8 (ref.) and points E21 and E22. Check for -15 V at both points E23 and E24 (using C8 ref. point). (For access to power-supply PWA, signal-conditioning PWA must be removed. See "Power-Supply PWA" on Page 8.)	If either +15 V or -15 V is not present, install new power-supply assembly, Part M0156AV. If both +15 V and -15 V are present, proceed to Test 3.
	3. Check continuity of of ribbon cable which is connected between power-supply PWA and signal-conditioning PWA.	If cable is defective, repair cable or install new power-supply assembly, Part M0156AV.
	4. Reinstall signal-conditioning PWA, reconnect ac power, and repeat Test 1.	If +15 V or -15 V is still not present, install new signal-conditioning PWA, Part M0156AG.
f. Isolated dc Supply Voltage not Present	On signal-conditioning PWA, check for the following voltages referenced to left lead of R107: U18, pin 7: +15 ±1 V U19, pin 7: -15 ±1 V R119, left lead: +25 ±2 V	Install new power-supply assembly, Part M0156AV.
g. Defective Reference-Voltage or Coil-Drive Circuit	1. The following test set-up is used to complete Tests 2 through 5. Connect calibrator to transmitter per Instruction MI 021-350 (896P or 896S) or MI 021-351 (896T). Check that jumpers are in correct position (per MI 021-350 or MI 021-351). Turn calibrator OUTPUT switch to 0%.	

Table 1. Fault-Location Guide (continued)

SYMPTOM AND PROBABLE CAUSE	TEST	CORRECTIVE ACTION
g. Defective Reference-Voltage or Coil-Drive Circuit (continued)	2. On signal-conditioning PWA, check for 10 V dc between points P21(ref.) and P20(+).	On power-supply PWA, turn R22 (reference voltage adjustment) for 10 V reading. If cannot adjust correctly, complete Test 3.
	3. Disconnect voltmeter from points P21 and P20. Connect oscilloscope between P21 and upper lead of R79. Correct waveform is shown in Table 2 on Page 6.	If correct waveform is present, install new signal-conditioning PWA, Part M0156AG. If correct waveform is not present, complete Test 4.
	4. Disconnect oscilloscope from point P20. Connect oscilloscope trigger input to point P43. Set oscilloscope for + external trigger. Refer to Table 2. With P21 as reference and P23 connected to trigger input, check waveforms at P43, P44, P45, and P47.	If all waveforms are correct, install new power-supply assembly, Part M0156AV. If some waveforms are correct, install new signal-conditioning PWA, Part M0156AG. If no waveforms are correct, complete Test 5.
	5. Measure ac voltage between points P22 and P23. Voltage should be between 30 and 40 V ac.	If voltage is not correct, check cable between signal-conditioning PWA and power supply PWA. Also check 20-pin contors at ends of cable. If voltage is correct, install new signal-conditioning PWA, Part M0156AG.

Table 1. Fault-Location Guide (continued)

SYMPTOM AND PROBABLE CAUSE	TEST	CORRECTIVE ACTION
h. Defective Gain or Automatic Zero Circuit	1. The following test set-up is used to complete Tests 2 through 5. Connect calibrator to transmitter per Instruction MI 021-350 (896P or 896S) or MI 021-351 (896T). Check that jumpers are in correct position (per MI 021-350 or MI 021-351). If transmitter does not have precalibrated span adjustment, set calibrator to input upper range value (URV) stamped on transmitter data plate. If transmitter has precalibrated span adjustment, set adjustment dial at 10, set multiplier dial at 0.1, and set calibrator for 1 mV signal. After adjusting calibrator either to transmitter URV or to 1 mV (as applicable), set calibrator OUTPUT switch at 0%. On signal-conditioning PWA, remove link J6 from pins P11 and P12 and connect it to pins P12 and P14.	If correct voltage cannot be obtained for any of the tests, install new signal-conditioning PWA, Part M0115AG. If all voltages are correct, transmitter is functioning correctly and defect is elsewhere in system. For system servicing, refer to Instruction MI 021-138.
	2. Connect voltmeter to points P21(ref.) and P48. Turn R69 (voltage-measurement zero adjustment) for a reading of 0 V dc.	
	3. Disconnect voltmeter from points P21 and P48 and connect it to P18(+) and P19(-). Turn R83 (output-current zero adjustment) so that voltmeter reads 0.1000 V.	
	4. Position jumper J6 between pins P11 and P12. and check that voltmeter reading remains at 0.1000 V. (With narrow spans there may be a small variation.)	
	5. Adjust calibrator for 100% input to the transmitter. Turn R32 (fine span adjustment) until voltmeter reads 0.5000 V.	

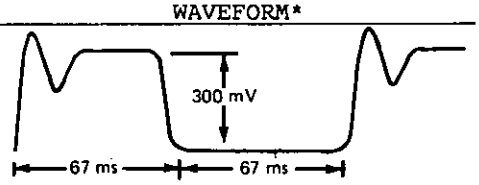
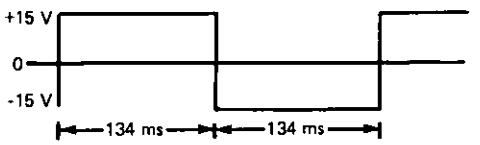
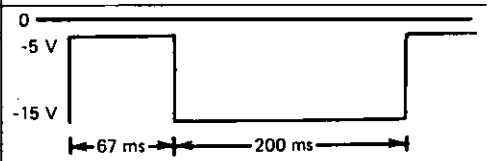
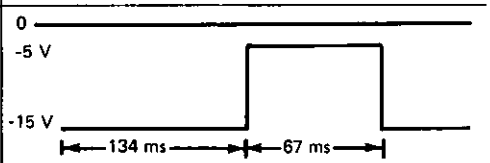
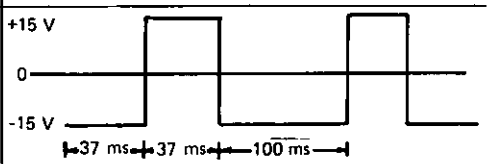
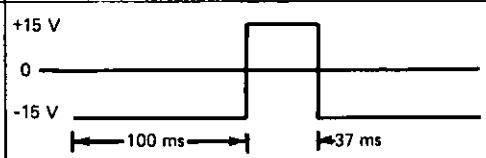
Table 1. Fault-Location Guide (continued)

SYMPTOM AND PROBABLE CAUSE	TEST	CORRECTIVE ACTION
2. OUTPUT CURRENT LOCKED AT 4 mA		
a. Defective System Wiring	Refer to system maintenance instructions (MI 021-138).	
b. Defective Gain or Automatic Zero Circuit.	Complete tests and corrective action for symptom 1h on Page 4.	
3. OUTPUT CURRENT LESS THAN 4 mA BUT GREATER THAN ZERO.		
a. Coil Wires between Transmitter and Flowtube Miswired	Refer to system maintenance instructions (MI 021-138).	
b. Defective Coil-Drive or Signal Circuit	Complete tests and corrective action for symptoms 1g and 1h on Pages 2 through 4.	
4. OUTPUT CONSTANTLY GREATER THAN 20 mA		
a. Jumpers Not Correctly Positioned. Transmitter Incorrectly Calibrated	Check jumper positions and transmitter calibration. For details refer to MI 021-350 (896P or 896S) or MI 021-351 (896T).	Reposition jumpers or recalibrate transmitter, as required.
b. Fault in Transmitter Circuit	Connect calibrator to transmitter per Instruction MI 021-350 (896P or 896S) or MI 021-351 (896T). With calibrator OUTPUT set to 0%, transmitter output should be 4 mA.	Complete tests and corrective action for symptoms 1g and 1h on Pages 2 through 4.
c. Faulty System Wiring or Defect in Flowtube	Refer to system maintenance instructions (MI 021-134).	
5. TRANSMITTER OUTPUT CANNOT BE CALIBRATED CORRECTLY, ERRATIC OR DRIFTING OUTPUT	Complete tests and corrective action for symptoms 1g and 1h on Pages 2 through 4.	

WAVEFORMS

Table 2 shows correct waveforms for points specified in Table 1.

Table 2. Waveforms

TEST POINT (Ref. to P21)	WAVEFORM*
R79, Upper Lead	
P43**	
P44**	
P45**	
P46**	
P47**	

*Time values are given for 60 Hz mains frequency; with 50 Hz frequency, multiply values by 1.2. Voltage values may vary depending an accuracy of ±15 Vdc supply.

**With "+" external trigger of oscilloscope connected to P43.

TEST-POINT AND COMPONENT LOCATIONS

Signal-Conditioning PWA

For location of test points and components on signal-conditioning PWA, refer to Figure 1.

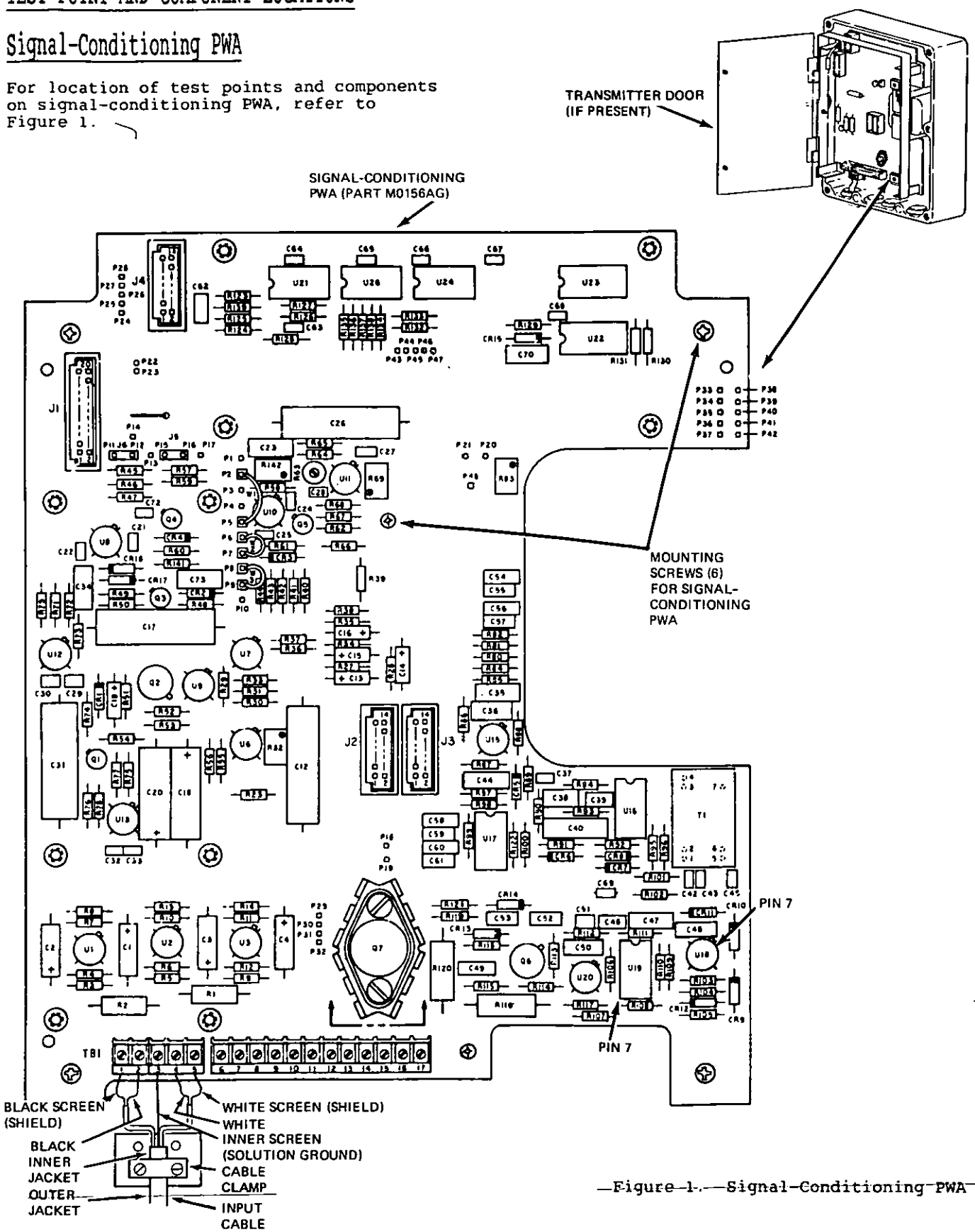


Figure 1. Signal-Conditioning PWA

Power-Supply PWA

For location of test points and components on power-supply PWA, refer to Figure 2. For access to PWA, complete Steps 1 through 4 of "Signal-Conditioning PWA" removal procedure on Page 9.

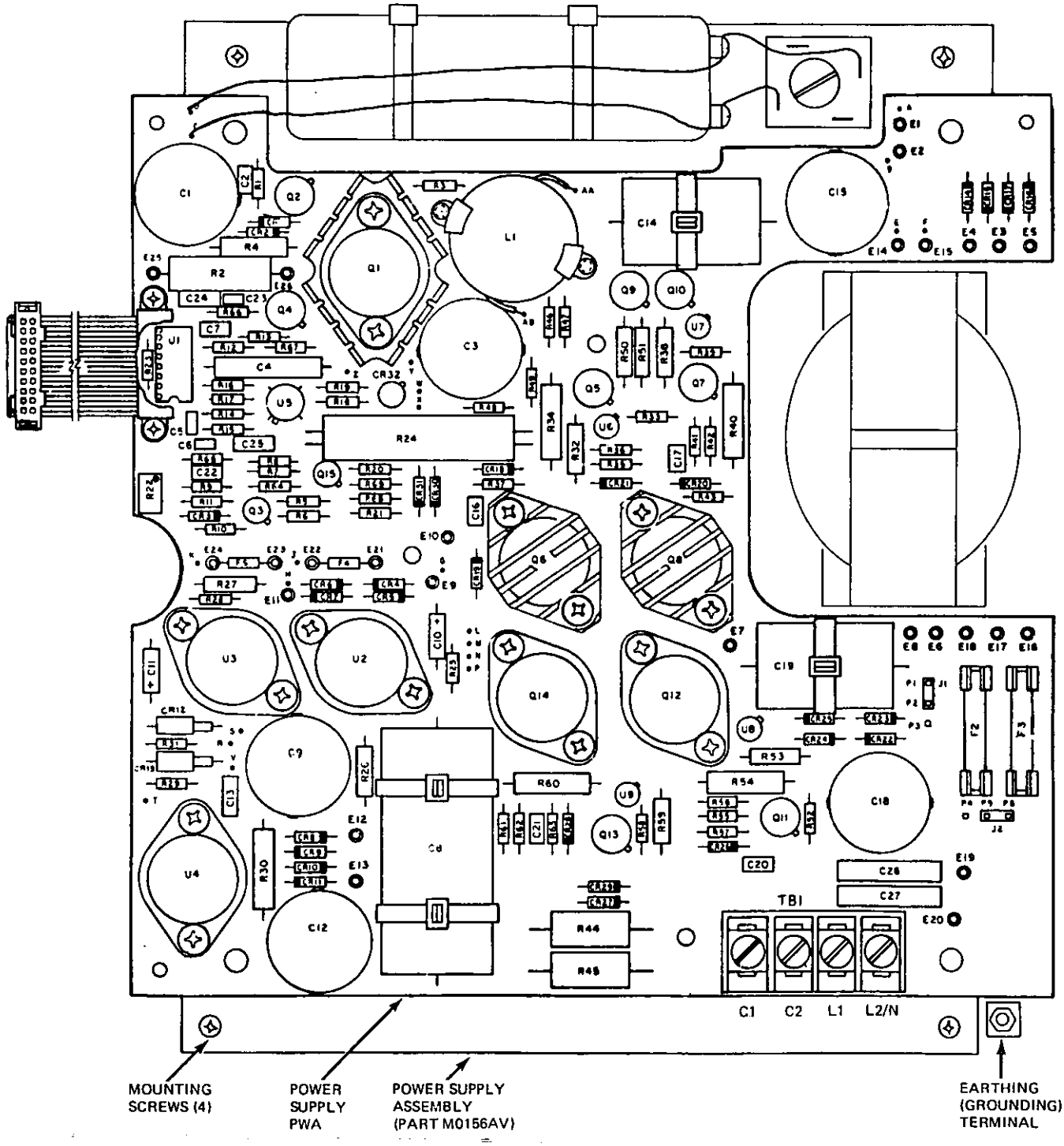


Figure 2. Power-Supply PWA

REMOVING ASSEMBLIES

Signal-Conditioning PWA

1. Turn off ac power.

2. Refer to Figure 1. If new signal-conditioning PWA is being installed, disconnect all input and output wiring from signal-conditioning PWA. Also unplug all cables from PWA. Note arrangement of wires for later reinstallation.

   If signal-conditioning PWA is being removed for access to power-supply PWA, do not disconnect any wires or cables. Unscrew cable clamp (shown in Figure 1) from input cable so that cable will be free to move when PWA is removed from transmitter.

3. Remove the 6 mounting screws (shown in Figure 1) from PWA.

   NOTE
   If transmitter has a door (supplied with some options; shown in Figure 1), door frame will also come free when four mounting screws at corners of PWA are removed.

4. Remove PWA from transmitter.

5. To reinstall PWA or to install new PWA, reverse Steps 2 through 4.

6. If new PWA was installed, complete calibration procedure in Instruction MI 021-350 (896P or 896S Transmitter) or MI 021-351 (896T Transmitter).

Power-Supply Assembly

1. For access to power-supply assembly, complete Steps 1 through 4 of "Signal-Conditioning PWA" removal procedure at left.

2. Unplug power-supply cable from connector J1 (shown in Figure 1) on signal-conditioning PWA. Remove PWA from transmitter.

3. Refer to Figure 2. Disconnect wires from terminals C1, C2, L1 and L2/N on power-supply PWA. Also disconnect wire from earthing (grounding) terminal.

4. Remove the four mounting screws (shown in Figure 2) from corners of power-supply assembly. Remove assembly from transmitter housing.

5. If new power-supply assembly is being installed, remove the two mounting screws from input-cable clamp (shown in Figure 1). Remove clamp from old power-supply assembly and install it on new assembly.

6. To install a new power-supply assembly, reverse Steps 1 through 5.

Notes

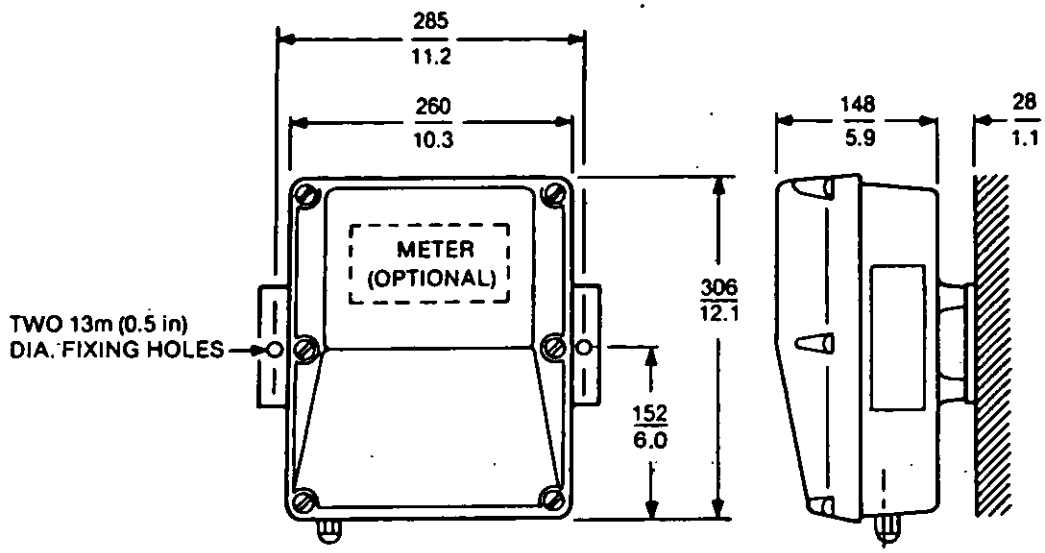
Notes

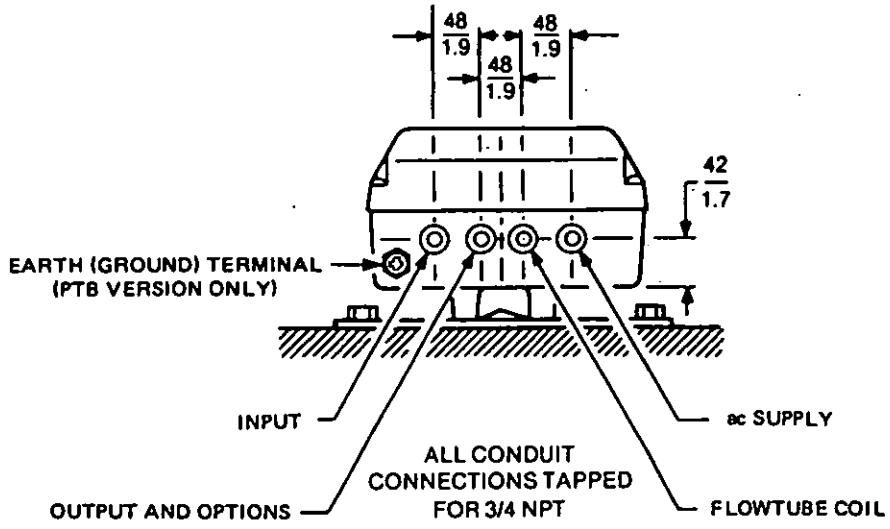
Printed in England

Dimensional Print

CDP
021-351
FEBRUARY 1983

896S MAGNETIC FLOW TRANSMITTER
SURFACE MOUNTED





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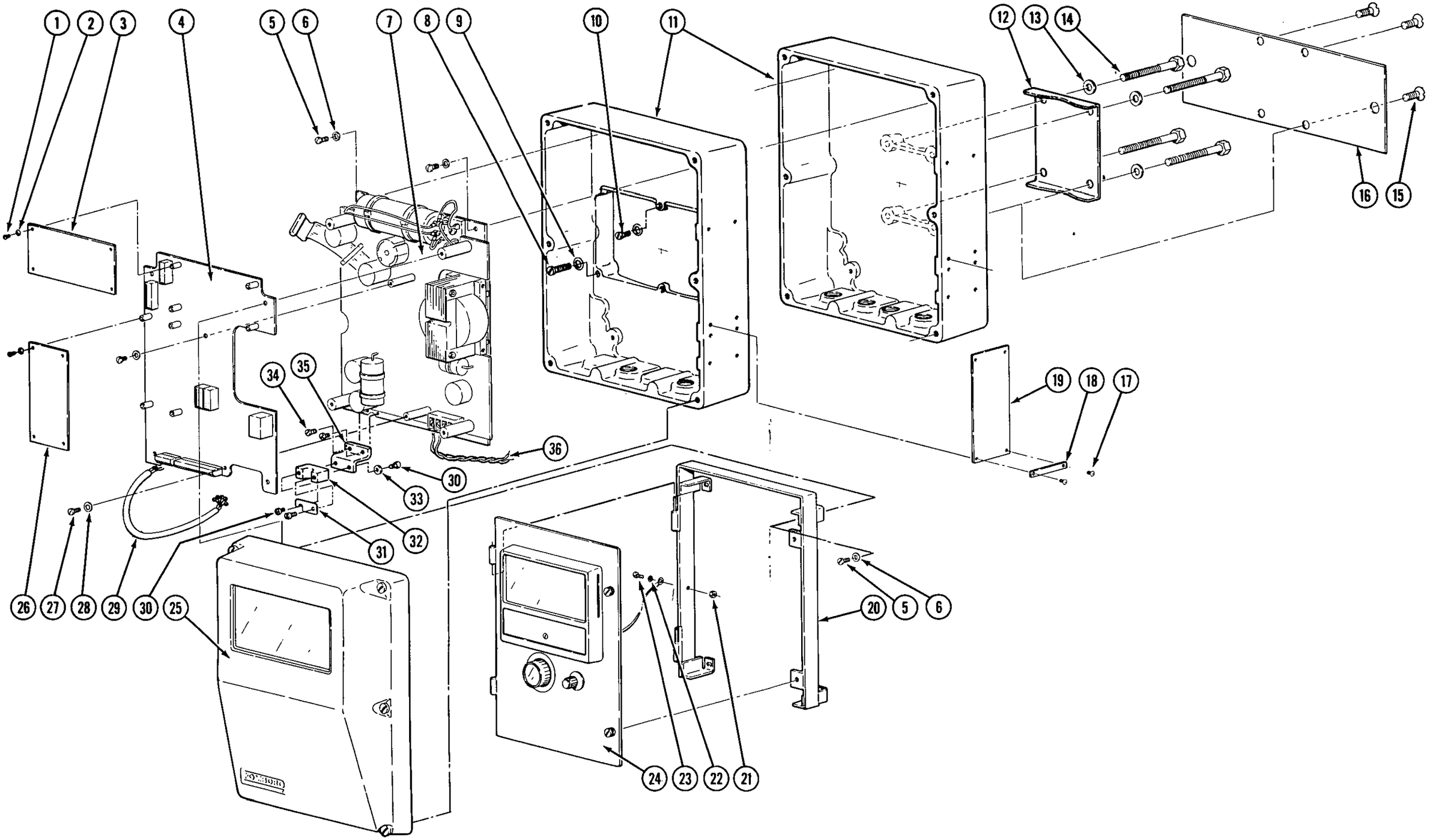

Figure R1076

896
Magnetic Flow Transmitter
Style A

Item	Part No.	Qty.	Part Name
1	A2003ZY	4-8	Screw, Pan H., 0.112-40 x 0.375
2	X0143RZ	4-8	Lockwasher
3	Below	1	PWA, Pulse
	M0156AJ		Low Rate Scaled (Codes -D, -E)
	M0156AN		High Rate Unscaled (Code -F)
	M0156AL		High Rate Scaled (Code -G)
4	M0156AG	1	PWA, Transmitter
5	X0127DE	8	Screw, Pan H., 0.190-32 x 0.437
6	X0143SC	8	Washer
7	M0156AV	1	Power Supply
8	X0128LT	4	Screw, Pan H., 0.250-20 x 1.750 (Code -T)
9	X0143QY	6	Washer (Code -T)
10	X0128LM	2	Screw, Pan H., 0.250-20 x 0.750 (Code -T)
11	Below	1	Case
	M0156AW		For Pipe or Surface Mounting (Codes -P, -S)
	M0156AY		For Flowtube Mounting (Code -T)
12	P0121SX	1	Plate, Pipe Clamp (Code -P)
13	X0143DJ	4	Washer (Code -P)
14	X0166GD	4	Screw, Hex H., 0.312-18 x 0.250 (Code -P)
15	B0119ZL	4	Screw, F.H., 0.312-18 x 0.750 (Code -S)
16	P0121SY	1	Mounting Plate (Code -S)
17	N0143WX	4	Screw, Tapping, 0.086-32 x 0.187
18	—	1	Address Plate
19	B0171CY	1	Date Plate (blank)
20	M0156BA	1	Frame Assembly
21	X0104FY	1	Nut, 0.138-32
22	X0143RK	1	Lockwasher
23	A2004EC	1	Screw, Fil. H., 0.138-32 x 0.375
24	—	1	Door Assembly (see page 5)

Item	Part No.	Qty.	Part Name
25	Below	1	Cover Assembly
	P0122TT		Blind (standard)
	P0122TQ		Window for Counter and Meter
	P0122TU		Window for Meter
—	P0122ST	1	Gasket
—	X0128LS	6	Screw, Pan H., 0.250-20 x 1.500
—	C0100CK	6	O-ring
Window parts for P0122TQ			
—	P0122QW	1	Window Gasket
—	P0122QV	1	Window
—	P0122QX	1	Window Frame
—	X0122UH	6	Screw, Pan H., 0.138-32 x 0.250
—	X0143RK	6	Lockwasher
Window Parts for P0122TU			
—	P0122MP	1	Window Gasket
—	P0122SV	1	Window
—	P0122MQ	1	Window Retainer
—	X0122UH	8	Screw, Pan H., 0.138-32 x 0.250
—	X0143RK	8	Lockwasher
26	M0156AU	1	PWA, Empty Tube Auto Zero (Code -R)
27	A2004EE	2	Screw, Pan H., 0.138-32 x 0.437
28	X0143RK	2	Washer
29	M0156CG	1	Signal Cable Assembly (Code -T)
30	X0169EN	4	Screw, Pan H., 0.138-32 x 0.312 (Codes -P, -S)
31	P0122PP	1	Clamp Plate (Codes -P, -S)
32	P0122PN	1	Clamp (Codes -P, -S)
33	X0171WX	2	Insulating Bushing (Codes -P, -S)
34	X0170VQ	2	Screw, Pan H., 0.112-40 x 0.250 (Codes -P, -S)
35	M0156BK	1	Bracket (Codes -P, -S)
36	M0156BZ	1	Lead Assembly (Code -T)

GIVE INSTRUMENT MODEL NUMBER AND STYLE LETTER WHEN ORDERING

Parts List

PL
008-596
March 1983

896
MAGNETIC FLOW TRANSMITTER

Style A

Model Code

896 = Magnetic Flow Transmitter, 4 to 20 mA Output

Mounting
-P = Pipe
-S = Surface
-T = Tube

Supply Voltage
A = 120 V 50/60 Hz
B = 220 V 50/60 Hz
C = 240 V 50/60 Hz

- = Optional Suffix
A = Precalibrated Span Adjustment
B = Output Meter, 0 to 100% Scale
C = Output Meter, Scale Per S.O.
D = Low Rate Scaled Pulse with Counter and Meter
E = ADJ. 0.1 to 10 Hz 24 V dc Pulse Output
F = 0 to 2 K Hz Unscaled Pulse Output
G = ADJ. Transistor Switch Closure Pulse Output
H = Span Switching
K = Precalibrated Span with Output Meter, 0 to 100% or Scale Per S.O.
L = Span Switch with Output Meter, 0 to 100% or Scale Per S.O.
M = Digital Rate Meter
N = Precalibrated Span with Digital Rate Meter
P = Span Switch with Digital Rate Meter
R = Empty Tube Automatic Zero

FOXBORO®

Door Assemblies
(See Page 2, Item 24)

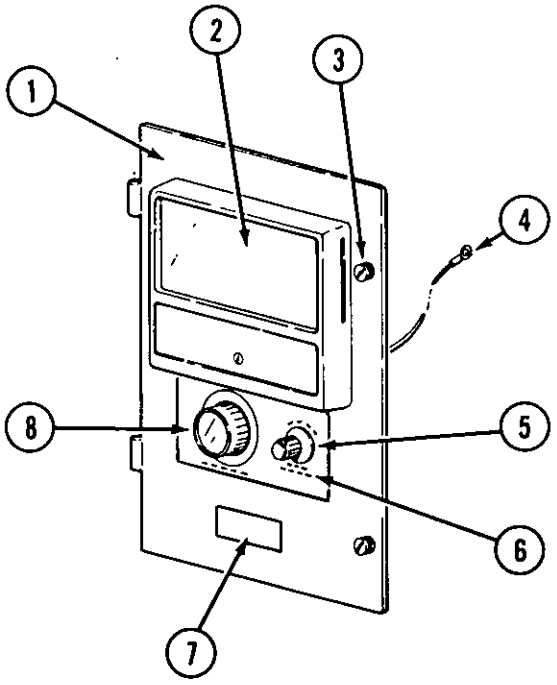

Figure R1087

Item	Part No.	Qty.	Part Name
—	Below	1	Door Assembly
	M0156DA		Precalibrated Span Adjustment (Code -A)
	M0156DB		Meter (Codes -B, -C)
	M0156DC		Meter and Counter (Code -D)
	M0156DD		Span Switch (Code -H)
	M0156DF		Meter and Precalibrated Span Adjustment (Code -K)
	M0156DG		Meter and Span Switch (Code -L)
	M0156DJ		Digital Rate Meter (Code -M)
	M0156DK		Digital Rate Meter and Precalibrated Span Adjustment (Code -N)
	M0156DL		Digital Rate Meter and Span Switch (Code -P)
1	Below	1	Door
	M0156BN		For Assemblies without Meter
	M0156BQ		For Assemblies with Meter
2	Below		Meter Assembly
	B0135CJ	1	Meter (Codes -B, -C, -K, -L)
—	M0156CT	1	Cable Assembly for Meter B0135CJ
—	N0139FR	2	Cable Tie
—	N0138EK	2	Mounting Pad
	M0156DQ	1	Digital Rate Meter (Codes -M, -N, -P)
—	X0169QJ	4	Tapping Screw
—	X0143RK	4	Lockwasher
	P0162AT	1	Meter (Code -D)
—	M0156BR	1	Bezel
—	M0156CD	1	PWA, Meter
—	M0156CU	1	Cable
—	N0139FR	2	Cable Tie
—	N0138EK	2	Cable Tie
	P0162AK	1	Counter (used with Meter P0162AT)
3	—	2	Fastner Assembly, Consisting of:
	X0167GG	2	Wear Washer
	X0167GE	2	Retainer
	X0167GM	2	Ejecter Spring
	X0170WS	2	Quarter Turn Fastner
4	M0156CC	1	Cable, Earth (Ground)
—	X0143RK	1	Lockwasher
—	X0104FY	1	Nut, 0.138-32
5	Below	—	Span Switch (position)
	M0156AQ	1	PWA, Precalibrated Span Adjustment (Codes -A, -K, -N)
	M0156AS	1	PWA, Span Switch (Codes -H, -L, -P)
	X0170TB	1	Knob (units with switch)
	M0156CA	1	Plug (units without switch)
—	X0170YR	2	Cable Clamp
—	X0143RZ	2	Washer
—	A2003ZY	2	Screw, Pan H., 0.112-40 x 0.375
6	Below	1	Label
	B0171CD		For units with Precalibrated span Adjustment (Codes -A, -K, -N)
	B0171CE		For units with Span Switch (Codes -H, -L, -P)
7	B8003KC	1	Label (Warning)
8	Below	—	Span Adjustment (position)
	E0285WZ	1	Potentiometer (units with Precalibrated Span Adjustment (Codes -A, -K, -N)
	M0156CB	1	Plug (units without Precalibrated Span Adjustment)

0383

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Instruments and Systems for Indicating, Recording, Controlling . . .

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Compression
Concentration, Solution
Conductivity, Solution
Consistency
Current — a-c, d-c
Density
Dew Point
Displacement
Drag
Flow
Force
Gas Analysis
Humidity
Interface
Ion Selection
Liquid Analysis
Liquid Level
Load
Moisture Content
Motion
Motor Load
Operation, Schedule
Operation, Time
Oxidation-Reduction Potential
pH
Position
Power, Electric
Pressure
Resistance, Electric
Sheet Moisture
Sheet Weight
Specific Gravity
Speed
Strain
Stress
Temperature
Tension
Thrust
Torque
Vacuum
Viscosity
Voltage
Weight

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

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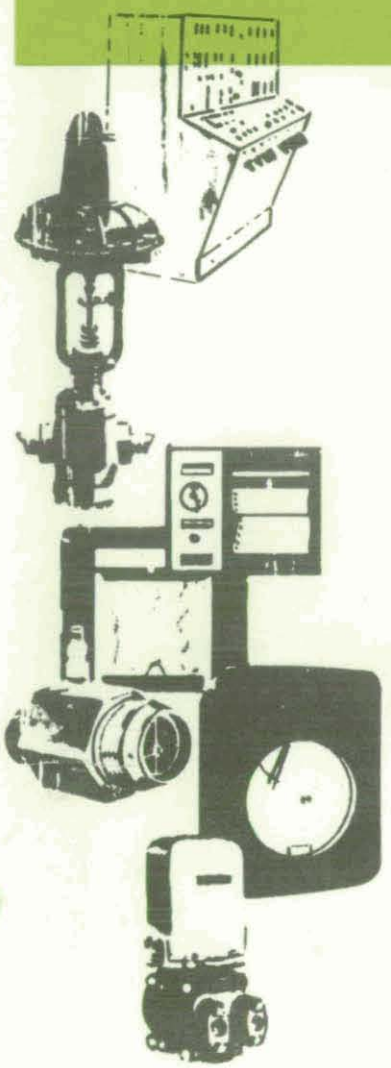
INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct installation of your Foxboro Instruments, and in their proper operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number*.

Book No. 6 1082

FOXBORO

Foxboro Yoxall
A Division of Foxboro Great Britain Limited

Redhill Surrey England
RH1 2HL
Tel: Redhill (0737) 65000
Telex: 892852
Telegram: Yoxbri Redhill

Guarantee

The Company undertakes to replace free of charge any component of its own manufacture (which excludes electronic tubes) which, in the opinion of the Company, is not within the specified limit of calibration or is defective in material or workmanship under normal or proper use, provided that the same is returned at the customer's risk and expense to the Company's works within twelve months from the date of the despatch by the Company of the equipment to the customer.
All representations, conditions, guarantees and warranties by law or otherwise howsoever expressed or implied are hereby excluded to the intent, except as above provided, after delivery to and acceptance by the customer of any equipment or apparatus, the Company shall not be liable for any loss, damage, injury, delay or expense or consequential loss or damage howsoever arising from or in respect of the equipment or apparatus or the use thereof.

Pyrometer Thermocouples, Resistance Thermometer Bulbs, and Protection Tubes, on account of the severity of their usage, are not subject to replacement unless returned unused.

The Company shall not be liable for loss, damage, detention or delay caused by fire, strike, civil, or military authority, insurrection or riot, or for other cause beyond its reasonable control. Acceptance of apparatus by the Purchaser shall constitute a waiver of all claims for delay.

Service

The Company is anxious to be of every possible assistance to you, to ensure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service in the British Isles should be made with the Company at Redhill. In other parts of the World arrangements should be made through the nearest Representative and/or Factory listed at the end of this book.
A unique feature of Foxboro service — of particular interest to Companies which do not have Instrument Departments or enough qualified Staff to carry out regular inspection and maintenance — is the Service Contract. Under this arrangement, a Foxboro Service Engineer will call at stated intervals to check the condition and operation of all Foxboro Instruments in your Plant. The Service Contract is also used by Companies for the routine inspection and maintenance of highly technical instrumentation which requires specialised knowledge and experience.
The Company provides an expertly staffed and fully equipped Training Centre at Redhill devoted to the instruction of customers' Instrumentation Engineers and Service Men. The courses cover: theory of operation maintenance and application of the principal types of instruments. Applications from Companies in the British Isles should be made to Redhill, Surrey; from those in other parts of the world, to our nearest Representative as listed at the end of this book.

Parts

Parts Lists for Foxboro Instruments may be obtained by writing to the above address. It is strongly urged that only genuine Foxboro parts be used. Always give the serial number from the instrument data plate when requesting parts lists or ordering parts. (Those unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment, should not be permitted to undertake any major service work.)

Replacement

The Company has considerable knowledge and experience in regard to the economic life of Foxboro instrument equipment and will give advice on the desirability or otherwise, of fitting new parts into the older models. Improvements in design, materials, or methods sometimes make it more economic to replace rather than repair an instrument which has been in service for a long period of time.

Charts

To obtain the most accurate and consistent recording performance from our instruments, we strongly recommend the use of genuine Foxboro strip and circular charts.

FOXBORO

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

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Maximum Signal-Cable Length

Using the graph in Figure 11, the maximum signal-cable length for specified system accuracy can be determined. Note that the graph is valid only for Foxboro cable, Part R0101ZS, or cable and connector assembly, Part N0136CC (used with 896 Transmitter or E96 Transmitter only). Maximum cable length depends on size of flowtube, conductivity of liquid, and type of instrument to which flowtube is connected.

Example:

Find the maximum signal-cable length allowed to maintain system accuracy for an 80 mm (3 in) flowtube to be used with an E96 Transmitter and a fluid conductivity of 5500 µS/m (55 µmho/cm).

Referring to Figure 11:

a. Draw a line from 5500 µS/m (55 µmho/cm) to the 50 to 100 mm (2 to 4 in) reference line.

b. From this intersection, draw a horizontal line to the E96 standard performance line.

c. From this intersection, draw a vertical line to the cable length scale where approximately 55 m (185 ft) is read.

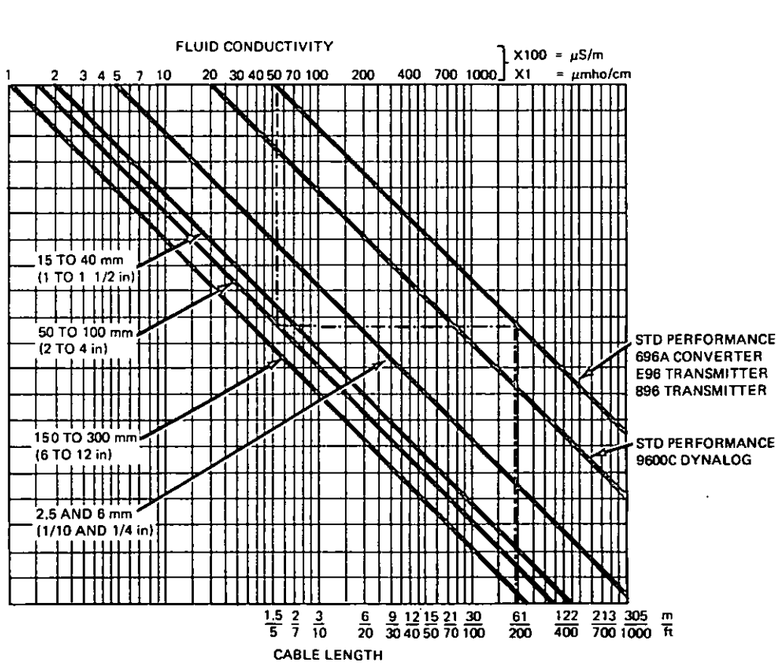

Figure 11

MAINTENANCE

If a fault is suspected in the flowtube, first make exterior checks such as wire continuity and rusted or corroded flanges and/or flange bolts. Rusted flanges and/or bolts can result in a poor process earth (ground). Use ultrasonic cleaner or low-voltage cleaning procedure, if the flowtube is so equipped, to clean electrodes.

If it becomes necessary to clean flowtube, avoid damaging the tube interior. Do not exceed temperature or pressure limits of flowtube.

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0883

Printed in England

Instruction

MI
021-120
August 1983

2800 SERIES MAGNETIC FLOWTUBES

Sizes 2.5 through 300 mm (1/10 through 12 in) With Lined Metal Metering Tube

The principle of operation of the magnetic flowtube is based on Faraday's law of electromagnetic induction: The voltage (V_o) induced in a conductor of length (D_e) is proportional to D_e multiplied by the velocity (v) of the conductor and the intensity (T) of the magnetic field. That is, $V_o = (D_e)(v)(T)$.

In this application of Faraday's law, the process fluid is the conductor. The process fluid passes through the magnetic field induced by coils built around a section of the metering tube. Two metallic electrodes are mounted in the metering tube and make contact with the flowing liquid. The voltage developed across the electrodes is directly proportional to the average velocity of the liquid passing through the magnetic field. The 2800 Series Flowtube can be used with either ac (e.g., E96 Magnetic Flow Transmitter) or pulsed dc (from the 896 Magnetic Flow Transmitter) coil excitation. The voltage signal is shielded from interference, amplified, and demodulated into a standard dc current signal by a magnetic flow transmitter.

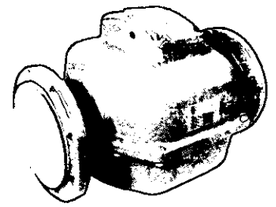

Figure 1

FLOWTUBE HANDLING

The Foxboro Magnetic Flowtube is built to be durable, but is part of a calibrated precision system and should be handled as such. Avoid dropping or otherwise subjecting it to impact particularly at the flange faces.

The flowtube is shipped from the factory in a sturdy carton and cradeled between flange covers for protection. Before removing it from the carton, move it as close as possible to its installation point. If the flowtube must be removed for receiving inspection, REINSTALL THE END COVERS AFTER INSPECTION.

Lift flowtube out of carton with rope falls, chain hoist, etc. as shown in Figure 2. In some instances it may be more convenient to insert bolts into the flange bolt holes and use hooks around the bolts for lifting (rather than tying slings around the flowtube). NEVER PUT ANYTHING THROUGH THE FLOWTUBE TO LIFT IT.

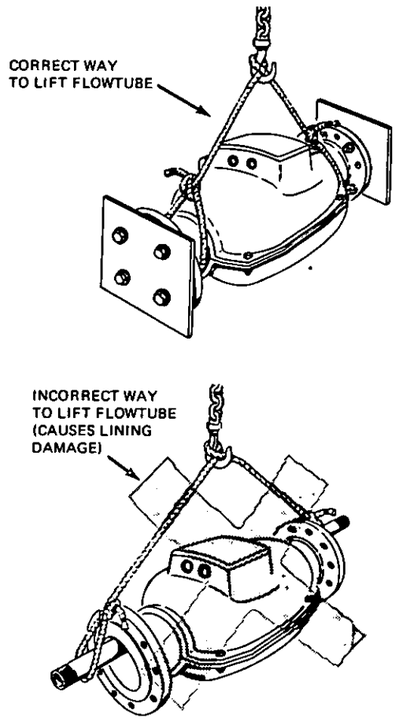

Figure 2

FOXBORO®

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STANDARD SPECIFICATIONS

Power Consumption*: Refer to PSS 1-6B5 A.
Upper Range Values (Flow Rate): Refer to PSS 1-6B5 A.
End Connections: Refer to DP 021-120.
Supply Voltage: 120 or 240 V ac +10%, -15% at 60 ±2 Hz; 120, 220, or 240 V ac +10%, -15% at 50 ±2 Hz, as specified in sales order, or pulsed dc power from an 896 Transmitter
Ambient Temperature Limits**
Normal Limits: -10 and +50°C (20 and 120°F)
Operative Limits: -30 and +60°C (-20 and +140°F)
Output Signal: ac or dc millivolts proportional to flow
Electrode Material: As specified in sales order
Mass: See Table 1.
Process Pressure and Temperature Limits
With ptfe or pfa Lining: See Figure 3.
With Polyurethane Lining: See Table 2.

Table 1. Approximate Mass

FLOWTUBE SIZE		MASS	
mm	in	kg	lb
2.5	1/10	13	35
6	1/4	13	35
15	1/2	21	46
25	1	18	40
40	1 1/2	20	45
50	2	21	47
80	3	27	60
100	4	34	76
150	6	55	122
200	8	85	188
250	10	91	200
300	12	125	275

Table 2. Process Temperature and Pressure Limits for Polyurethane Lining

FLANGE	FLOWTUBE SERIES	PRESSURE LIMITS				TEMPERATURE LIMITS	
		UPPER LIMITS			LOWER LIMIT	UPPER LIMIT	LOWER LIMIT
		MPa	psi	bar or kg/cm²			
ANSI Class 150	2802 to 2812	1.7	240	17	Full Vacuum	+70°C (+160°F)	-18°C (0°F)
ANSI Class 300	2802 to 2804	4.8	700	48			
	2806 and 2808	1.7	240	17			
PN 10	2802 to 2812	1.0	150	10			
PN 16	2802 to 2812	1.6	235	16			
PN 25	2802 to 2804	2.5	368	25			
	2806 to 2812	1.7	240	17			
PN 40	2802 to 2804	4.0	590	40			
	2806 to 2812	1.7	240	17			

*Add: 15 VA for E96 Transmitter
25 VA for 696A Converter
60 VA for 9600C DYNALOG Instrument
No additional VA is required for the 896 Transmitter

**With E96T (flowtube-mounted) Transmitter, upper temperature limits are limited to 38°C (100°F) by the transmitter

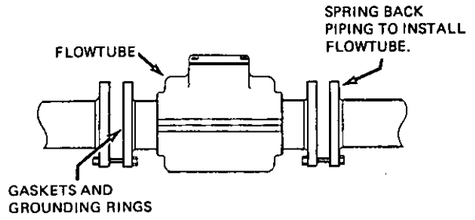


Figure 9

Field-Coil Connections

On ac systems, flowtube coils may be wired either in series or in parallel as shown in Figure 10. Although coils wired in parallel allow the lowest possible flow range, they also consume the most power. Unless otherwise specified, coils are wired in series at the factory. If coil wiring is changed to parallel in the field, multiply the stated calibration factor (mV/[L/s] or mV/[U.S. gpm]) by 2.

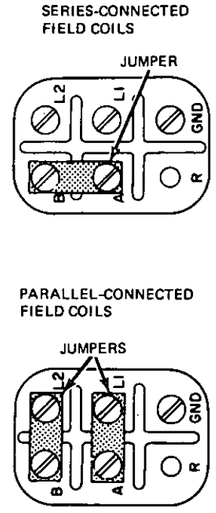


Figure 10

E96, 696A, OR 9600C	896
L1 = Live L2 = Neutral GND = Power Earth (Ground)	L1 = C1 or C2 L2 = C1 or C2 GND = Not Used

NOTE
896 Transmitter is used with series-connected field coils only.

3. If flowtube does not have ptfe lining protector (TLP option) it is recommended that adjoining spool pieces (pieces of pipe) be installed on flowtube before installation.

   If adjoining spool pieces are being installed, complete this step. Otherwise proceed to Step 4.

   a. Refer to Figure 8. Position gaskets and grounding rings (as applicable) adjacent to flowtube flanges. (For details of grounding rings, see "Flowtube Earthing (Grounding)" on Page 4.

   b. Connect spool pieces to flowtube on floor. Tighten flange bolts to specifications given in Table 4.

   c. Hoist complete assembly into position as shown in Figure 8. Align flanges and bolt into place.

4. If adjoining spool pieces are not being installed on flowtube, complete this step.

   a. Refer to Figure 9. Spring back piping to allow clearance as necessary to insert flowtube without causing damage to lining.

   b. Install gaskets and grounding rings (as applicable) adjacent to flowtube flanges. (For details of grounding rings, see "Flowtube Earthing (Grounding)" on Page 4.)

   c. Align flanges, install bolts, and position piping into place.

   d. Tighten flange bolts to specifications given in Table 4.

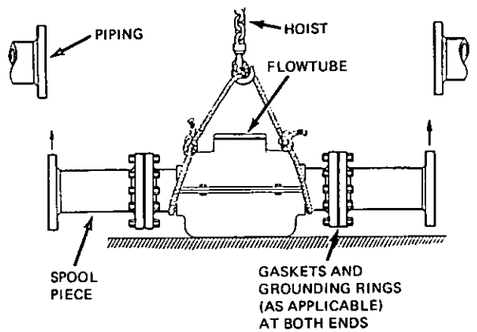
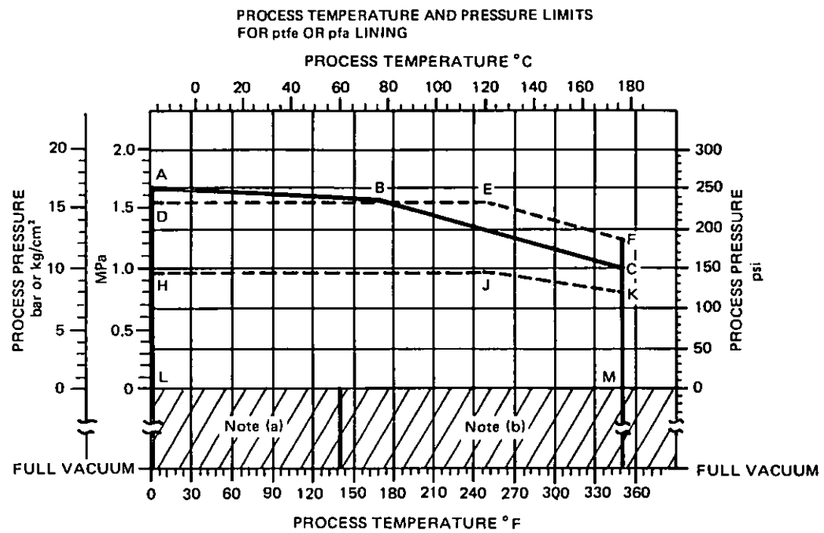


Figure 8

Table 4. Flange-Bolt Torque Specifications

FLOWTUBE SIZE		NUMBER OF BOLTS IN FLANGE	FLANGE-BOLT TORQUE			
			PTFE or PFA LINING		POLYURETHANE LINING	
mm	in		N·m	lb·ft	N·m	lb·ft
2.5	1/10	4	7	5	--	--
6	1/4	4	7	5	--	--
15	1/2	4	7	5	--	--
25	1	4	15	10	--	--
40	1 1/2	4	20	15	--	--
		8	15	10	--	--
50	2	4	35	25	55	40
		8	20	15	30	20
80	3	4	55	40	80	60
		8	35	25	55	40
100	4	8	40	30	60	45
150	6	8	80	60	120	90
		12	60	45	95	70
200	8	8	100	75	150	120
		12	80	60	120	90
250	10	12	95	70	140	110
		16	80	60	120	90
300	12	12	110	80	160	120
		16	95	70	140	110



(a) Refer to Foxboro for application in this area
(b) Application of 2891 through 2804 Series only permitted in this area

Figure 3

REFERENCE INSTRUCTIONS

For details of flowtube wiring to an 896 Transmitter, E96 Series Transmitter, 696A Series Converter, or 9600C Series DYNALOG Instrument, refer to the applicable Instruction (MI) listed below.

896P or S, Style A:	MI 021-350
896T, Style A:	MI 021-351
E96P or S, Style D:	MI 021-333
E96R, Style D:	MI 021-334
E96T, Style D:	MI 021-335
E96P or S, Styles A, B, and C:	MI 021-312
E96R, Styles A, B, and C:	MI 021-313
E96T, Styles A, B, and C:	MI 021-311
696A:	MI 021-211
9600C:	MI 021-195

GENERAL PRECAUTIONS

1. Leave end covers installed over flanges any time flowtube is put in storage.

2. Check that lead length between flowtube and transmitter is within limit for specified system accuracy. Lead-length details are given on Page 8.

3. Good piping practice should be used for the installation of all magnetic flowtubes. Gaskets are normally required. Select a gasket material which is compatible with the process liquid.

4. The flowtube lining extends outward and over the raised face of the flange.

   ⚠ CAUTION

   To avoid damage to the lining extension, do not exceed torque values specified when tightening flange bolts.

5. The flowtube lining is susceptible to damage from excessive heat. Avoid such heat sources (such as welding adjacent piping).

6. To avoid excessive lining wear and possible loss of accuracy, it is recommended that flowtube be connected in a straight section of pipe at least 5 pipe diameters upstream and 3 pipe diameters downstream.

7. For flowtube with polyurethane lining and parallel-connected coils, the temperature of the lining can rise significantly above the upper temperature limit if flow is stopped for a long period of time. To avoid possible damage to the lining from excessively high temperatures, disconnect power from the coils whenever flow is to be stopped for more than about one hour. Note that lining not filled with liquid will heat even faster than one filled with liquid.

INSTALLATION

Flowtube Earthing (Grounding)

Continuity between flowing liquid and metal metering tube is required to provide a reference for the measurement signal. With unlined metal pipe connected to the flowtube flange, continuity is provided by the pipe and the flange bolts. No additional grounding is required.

Installations in which non-metal or lined metal pipe is used require installation of earthing rings (grounding rings) on each flowtube flange as shown in Figure 4. To provide continuity, one end of a wire is connected to the grounding ring, and the other end is connected either to a flange bolt or to a hole drilled and tapped in the flange.

Grounding rings can be made from an orifice plate. To provide positive contact with process liquid, its inner diameter sould be slightly less than that of entrance to metering tube. Inside diameters of entrances to metering tube are shown in Table 3.

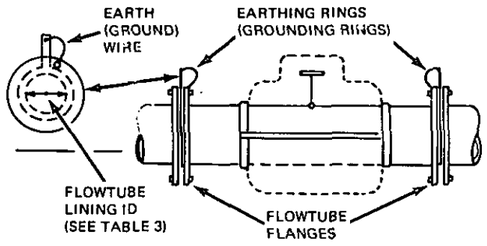


Figure 4

Protection from Abrasive Flow

In addition to providing metering tube earthing (grounding), earthing rings (grounding rings) can also be used to protect the leading edge of flowtube lining from abrasives. Inner diameter of rings should be slightly less than that of entrance to metering tube. For details, refer to "Flowtube Earthing (Grounding)" above.

Table 3. Inside Diameters of Entrances to Metering Tubes

FLOWTUBE SIZE		DIAMETER			
		PTFE or PFA LINING		POLYURETHANE LINING	
mm	in	mm	in	mm	in
2.5	1/10	7.9	0.31	--	--
6	1/4	7.9	0.31	--	--
15	1/2	12.7	0.50	--	--
25	1	24.7	0.97	--	--
40	1 1/2	39.6	1.56	--	--
50	2	51.7	2.04	--	--
80	3	78.4	3.09	63.75	2.51
100	4	103.8	4.09	82.80	3.26
150	6	155.1	6.11	136.04	5.36
200	8	203.3	8.00	186.13	7.33
250	10	256.4	10.09	289.31	9.42
300	12	306.3	12.06	289.31	11.39

Mounting Positions

The flowtube may be mounted in any position: vertical, horizontal, or at an angle. However for accurate measurement, the flowtube must be completely full. Vertical installation with flow in an upward direction, as shown in Figure 5, is generally recommended. This is particularly so in slurries with abrasive solids. If mounting flowtube in other than a vertical position, it is recommended that flowtube be turned about the flow axis shown in Figure 6 so that electrodes are horizontal. Electrodes should be horizontal to avoid contacting bubbles (at top) or sediment (at bottom) inside metering tube.

Flow through flowtube may be in either direction. However, if it is installed with the two conduit connections facing upstream, it may be necessary to rewire the flowtube signal wires. For details, refer to wiring section of applicable instruction listed on Page 3.

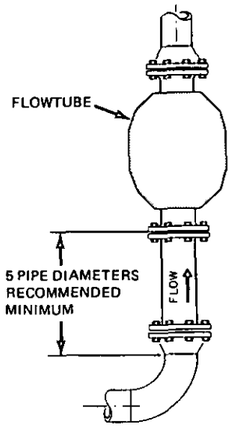


Figure 5

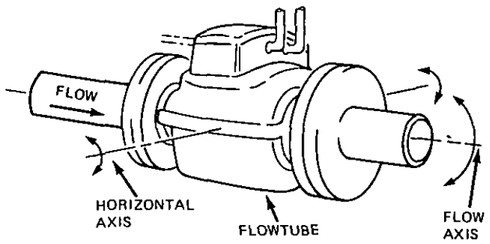


Figure 6

Mounting Procedure

⚠ CAUTION

Excessive forces during installation and operation of flowtube can crush extended ends of flowtube lining (especially ptfe or pfa lining). Some causes of these forces are excessive bolt torque, weight of vertical pipeline on lining, thermal expansion of pipeline, and misalignment of flanges. To minimize these forces, adhere to the following procedure.

1. Before installing flowtube, install and adequately support piping. If flowtube is being mounted vertically, add piping supports above and below flowtube to avoid strain to flanges and damaging lining.

   Leave space for later installation of flowtube and adjoining spool pieces (if applicable, see Step 3). Adjust piping and flanges so that flanges will be aligned and parallel with flowtube flanges when flowtube is installed. Flanges must not be forced into alignment during installation of flowtube. Correct alignment of piping is shown in Figure 7. Also allow for thermal expansion of piping during operation, as required.

   NOTE

   Piping supports must be strong enough so that addition of process fluid will not disrupt alignment of flowtube and adjacent piping. When mounting a 2.5 or 6 mm (1/10 or 1/4 in) flowtube to pipe which has less than 15 mm (1/2 in) I.D., use mounting holes on bottom of flowtube housing for additional support. These holes can either be used with self-tapping bolts or can be tapped for M8 x 20 mm or 5/16-18 x 3/4 in bolt.

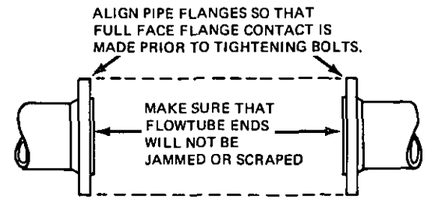


Figure 7

2. Locate and remove all foreign objects from the piping. If possible, make up and install a section of pipe (spool piece) in the space provided for the flowtube. Start up the process to help locate any foreign objects.

Instruction

MI
021-136
August 1983

2800 SERIES MAGNETIC FLOWTUBES
Sizes 350 to 900 mm (14 to 36 in)
Lined Metal Flowtube

The principle of operation of the magnetic flowtube is based on Faraday's law of electro-magnetic induction; the voltage (V_o) induced in a conductor of length (D_e) moving through a magnetic field (T) is proportional to the velocity (v) of the conductor.

$$V_o = (D_e)(v)(T)$$

In this application of Faraday's law, the process fluid is the conductor. The process fluid passes through the magnetic field induced by coils built around a section of the metering tube. The process fluid is electrically insulated from the flowtube by the lining in the tube. Two metallic electrodes are mounted in the flowtube, and a voltage is developed across these electrodes which is directly proportional to the average velocity of the fluid passing through the magnetic field. The 2800 Flowtube can be used with either ac (e.g., E96 Magnetic Flow Transmitters) or pulsed dc (from an 896 Magnetic Flow Transmitter) coil excitation. The voltage signal is shielded from interference, amplified and demodulated into a standard dc current signal by a magnetic flow transmitter.

Standard Specifications

Supply Voltage: 120 or 240 V ac +10%, -15% at 50 or 60 ±3 Hz, as specified in sales order, or pulsed dc power from an 896 Transmitter

Power Consumption*:
Mass:
Upper Range Value (Flow Rate):
Ambient Temperature Limits:
Process Temperature Limits:
Process Pressure Limits:
End Connections:
— Refer to Product Specifications Sheet PSS 1-6B5 E

*Add: 15 VA for E96 Transmitter
25 VA for 696A Converter
60 VA for 9600C DYNALOG Instrument
(For 896 Transmitter, no additional VA is required

Reference Instructions

For details of flowtube wiring to an 896 Transmitter, E96 Transmitter, 696A Converter, or 9600C DYNALOG Instrument, refer to the applicable Instruction (MI) listed below.

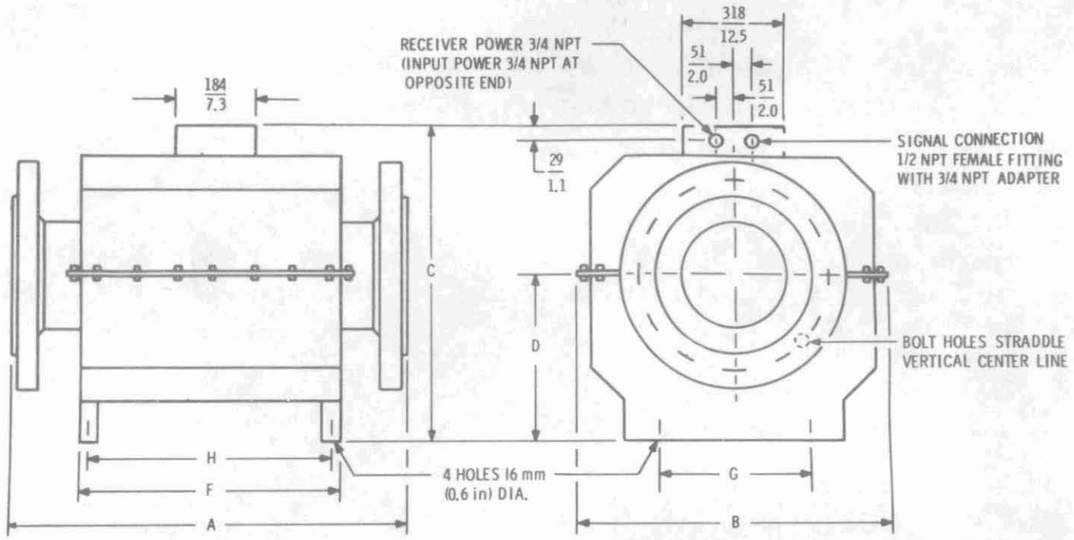
896P or S:	MI 021-350
896T:	MI 021-351
E96P or S, Style D:	MI 021-333
E96R, Style D:	MI 021-334
E96T, Style D:	MI 021-335
E96P or S, Styles A, B, and C:	MI 021-312
E96R, Styles A, B, and C:	MI 021-313
E96T, Styles A, B, and C:	MI 021-311
696A:	MI 021-211
9600C:	MI 021-195

FOXBORO®

MB 100
Printed in England
0883

Mounting Dimensions

mm / in



LINE SIZE (NOMINAL)		A	B	C	D	F	G	H
mm	in							
350	14	711 28.0	711 28.0	714 28.1	381 15.0	451 17.8	260 10.3	400 15.8
400	16	762 30.0	781 30.8	765 30.1	406 16.0	451 17.8	330 13.0	400 15.8
450	18	864 34.0	857 33.8	816 32.1	432 17.0	533 21.0	406 16.0	483 19.0
500	20	864 34.0	933 36.8	867 34.1	457 18.0	533 21.0	483 19.0	483 19.0
600	24	965 38.0	1080 42.5	968 38.1	508 20.0	616 24.3	629 24.8	565 22.3
800	30	1067 42.0	1302 51.3	1095 43.1	584 23.0	737 29.0	851 33.5	686 27.0
900	36	1219 48.0	1524 60.0	1273 50.1	660 26.0	864 34.0	1073 42.3	813 32.0

Establishing Measurement Reference
(Liquid-to-Flowtube Contact)

The flowing liquid, the metal part of the metering tube, and the measuring instrument circuit common must all be at the same measurement reference or inner shield potential. The flowing liquid must make electrical contact with the metal tube which is connected to the transmitter by means of the inner shield signal lead. A factory-wired lead connects the tube to the IN SH (inner shield) terminal in the flowtube.

The method of establishing contact between the liquid and the metal part of the metering tube is determined by the pipe adjacent to the flowtube. If the adjacent pipe is unlined metal, contact is made through the flange bolts. Attach 4 ground straps (2 on each end) in addition to the flange bolts to establish the liquid to flowtube contact. To attach the ground straps, drill and tap 4 holes 0.312-18 (2 on each end) on the adjacent flanges diametrically opposite the existing tapped holes located on the flowtube flanges. Four ground straps are supplied with a flowtube. If the adjacent pipe is nonmetal or lined metal, grounding rings are required.

NOTE: The grounding ring can be made, for example, from a blank orifice plate. The diameter of the hole in the plate should be equal to or slightly smaller than the inner diameter (ID) of the flowtube lining, so that the edge of the hole contacts the flowing liquid. For ID of flowtube lining, see Table 1 below.

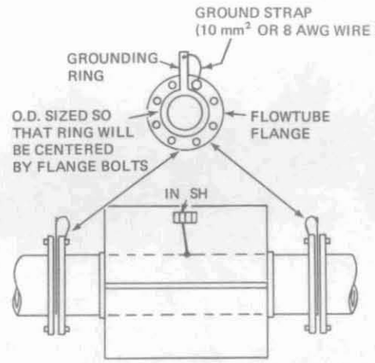


Table 1. Flowtube-Lining ID

Line Size		Neoprene Lining		Polyurethane Lining	
mm	in	mm	in	mm	in
350	14	340	13.38	337	13.25
400	16	390	15.38	387	15.25
450	18	441	17.38	438	17.25
500	20	492	19.38	490	19.25
600	24	594	23.38	584	23.00
750	30	746	29.38	737	29.00
900	36	899	32.38	889	35.00

Table 2. Flange Bolt Torques

Line Size		Number of Bolts											
		12		16		20		24		28		32	
mm	in	N•m	lb•ft	N•m	lb•ft	N•m	lb•ft	N•m	lb•ft	N•m	lb•ft	N•m	lb•ft
350	14	135	100	110	80								
400	16			135	100								
450	18			170	125	135	100						
500	20					170	125						
600	24					200	150						
750	30							200	150	200	150		
900	36									240	175	240	175

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Neoprene is a trademark of E.I. duPont de Nemours and Company.

Installing Flowtube in an EXISTING Line

Before proceeding, refer to "General Installation Precautions" below and "Establishing Measurement Reference" on Page 7.

Prior to installation, spring back the piping on either side to allow as much as is necessary for the flowtube so that its ends will not be damaged. It is necessary to align the adjacent piping to provide good full face contact to the flowtube before starting to tighten the bolts. Use the final supports on the adjacent piping to achieve good full face contact prior to tightening the bolts.

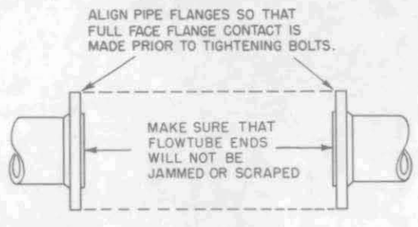
CAUTION: Do not use the bolts to force the alignment. Use a torque wrench to tighten the bolts gradually and uniformly. AVOID EXCESSIVE TIGHTENING OR THE TUBE FACE WILL BE DAMAGED. The bolt torques for the various pipe sizes are listed on Page 7 in Table 2.

Installing Flowtube in a NEW Line

Before proceeding, refer to "General Installation Precautions" below and "Establishing Measurement Reference" on Page 7.

The flowtube requires no support other than that required for an equal length of pipe. However, if the flowtube is to be vertically mounted, support the piping above and below the flowtube to avoid producing strain in the flanges and damaging the linings.

See illustration below. Square-up associated flanges and piping so that the flowtube fits into the line without scraping or tearing the lining and without bumping or warping the faces.



General Installation Precautions

1. "Good piping practice" should be used for the installation of all magnetic flowtubes. To avoid damaging the tube face, the torque specifications in Table 2 on Page 7 must not be exceeded.
2. Gaskets are normally required. Select a gasket material which is suitable for the process liquid.
3. During installation be careful not to overheat the flowtube lining from heat sources such as nearby welding.

Pressure-Temperature Limits

If flow through the flowtube is stopped for more than a few hours at a time, temperature rise of the liquid may affect the lining, so it is recommended that a flowtube with series-connected field coils be used (series-connected coils use less power and produce less heat). Otherwise, depending on ambient temperature, etc., it is recommended that power to the flowtube be turned off during no-flow periods.

POLYURETHANE LINING

Because of its abrasive resistance and high wear resistance, this lining is best suited for abrasive slurries. The lining thickness is 6.4 mm (0.250 in) and extends outward covering the raised face of the flanges.

NEOPRENE LINING

This lining is best suited for general purpose use. The lining thickness is 4.8 mm (0.188 in) and extends outward covering the raised face of the flange.

CAUTION: Do not use hydrocarbon defoamers such as kerosene or sulfonated oils as they cause Neoprene to swell.

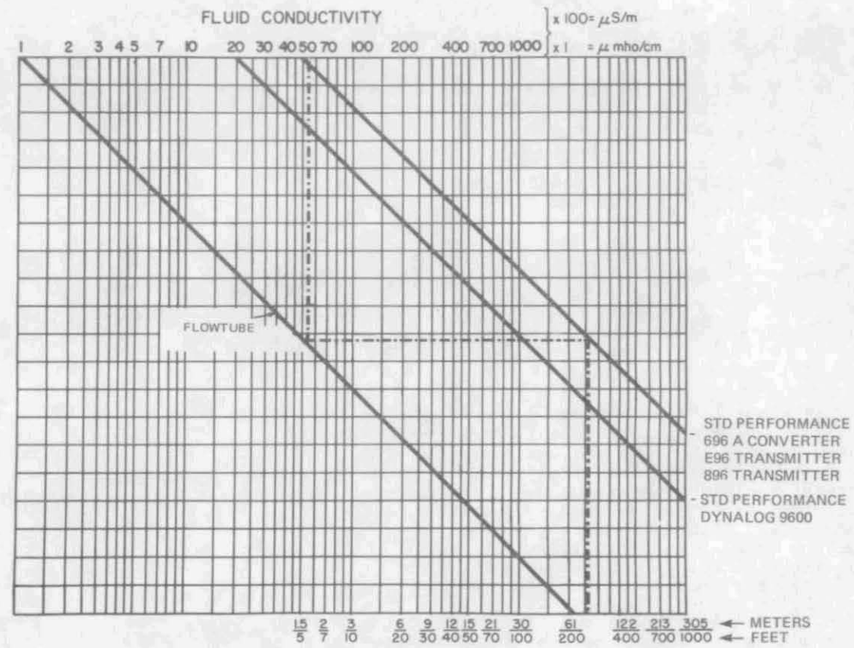
Before Startup

If possible, make up a flanged "spool piece" the same length as the flowtube. Insert it in the line before startup. On startup any foreign objects in the line, such as pieces of wood or metal, should be located and removed before the flowtube is installed. This greatly lessens the possibility of accidential damage to the flowtube.

Maximum Lead Length to Maintain Specified Accuracy
(At Reference Operating Conditions)

The graph below relates conductivity, flowtube size, and permissible signal cable length between flowtube and transmitter. It is valid only for cable recommended by and available from Foxboro, with driven screens (shields) electrically connected. The graph is used to determine:

1. Maximum cable length to obtain specified system performance for a given conductivity and flowtube size, or
2. Minimum conductivity required to obtain specified system performance for a given cable length and flowtube size.



MAXIMUM PERMISSIBLE SIGNAL - CABLE LENGTH

Example: Determine the maximum permissible signal-cable length for a 350 mm (14 in) flowtube to be used with an E96 Transmitter if the process fluid has a conductivity of 5500 μS/m (55 μmho/cm).

Refer to dotted lines on graph above.

a. Draw a vertical line at a fluid conductivity of 55 x 100 μS/m (55 μmho/cm) intersecting the flowtube reference line.

b. From this intersection draw a horizontal line to the E96 Transmitter standard (std) performance line.

c. From this intersection draw a vertical line to the cable length scale where approximately 78 m (255 ft) is read.

NOTE: The graph can be used to solve the above problem in reverse, using a desired cable length of 78 m (255 ft) with a 350 mm (14 in) flowtube to determine minimum conductivity of 5500 μS/m (55 μmho/cm) at specified system accuracy.

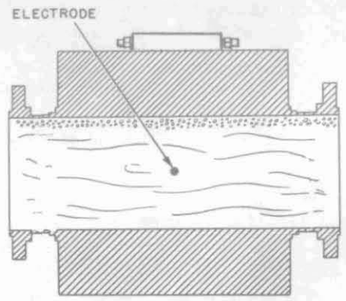
Installing Details

The flowtube may be mounted in any position: vertical, horizontal, or at an angle. Both electrodes must be in contact with the measured liquid at all times (see illustration at right). For accurate measurement, THE FLOW LINE MUST ALWAYS BE COMPLETELY FULL AND SHOULD BE MOUNTED IN A STRAIGHT SECTION (AT LEAST 5 PIPE DIAMETERS BOTH UPSTREAM AND DOWNSTREAM) OF UNOBSTRUCTED PIPE.

Locate the flowtube so there will be room to remove the top housing, if necessary. See Page 2 for mounting dimensions.

Make provisions for positive flow shutoff when checking system flow zero. Flowtube must be full.

If the flowtube is to be located underground, or in a pit that may be flooded, make provisions to prevent it from being submerged.

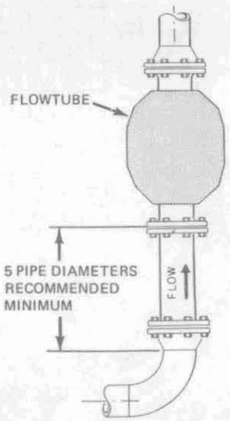


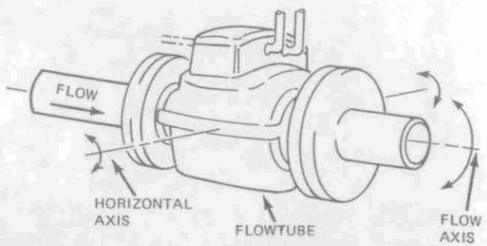
Horizontally-Mounted Flowtube Showing Correct Location of Electrodes

Typical Piping Installations

The flowtube may be mounted in any position: vertical, horizontal, or at an angle. However for accurate measurement, the flowtube must be completely full. Vertical installation with flow in an upward direction, as shown, is generally recommended. This is particularly so in slurries with abrasive solids. If mounting flowtube in other than a vertical position, it is recommended that flowtube be turned about the flow axis shown so that electrodes are horizontal. Electrodes should be horizontal to avoid contacting bubbles (at top) of sediment (at bottom) inside metering tube.

If flowtube is installed with two conduit connections facing upstream, it may be necessary to rewire signal wires. For details, refer to wiring section of applicable instruction listed on Page 1.



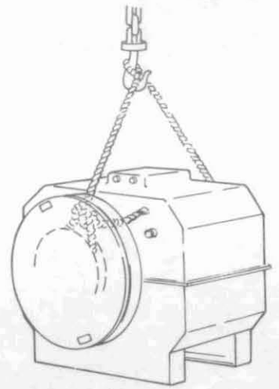


Handling the Flowtube

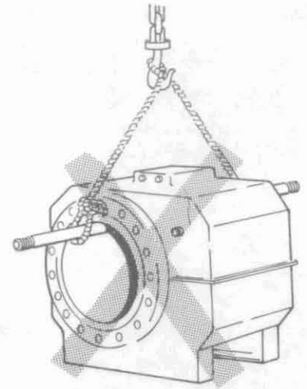
The magnetic flowtube is durable, but it is part of a precision calibrated system and should be handled as such. Avoid dropping or otherwise subjecting it to impact, particularly at the flange faces.

Remove as much of the shipping container as necessary for inspection and replace after inspection. If it must be removed from the container for receiving or inspection, see illustration at left below for proper method of lifting.

At the time of installation the flowtube should be left in the container and moved as near as possible to the installation point. Remove the top of the shipping container. Refer to illustration below. NEVER PUT ANYTHING THROUGH THE TUBE TO LIFT IT.



Lifting Flowtube for Horizontal Installation

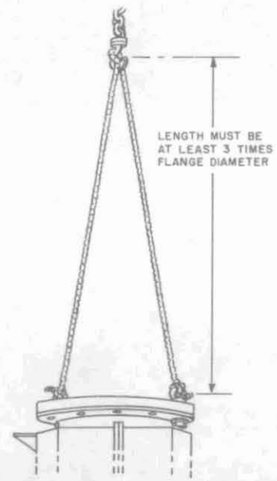


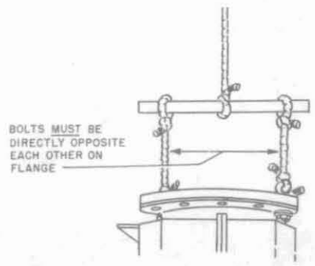
Wrong Way to Lift Flowtube

Handling the Flowtube (For vertical mounting)

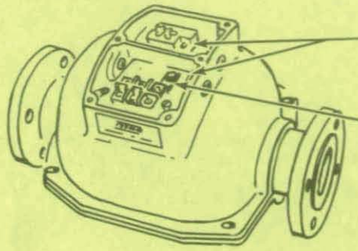
When the flowtube is to vertically mounted, precautions must be observed to avoid damaging the flanges. The illustrations at right show 2 practical methods using eye bolts in the flange to lift the flowtube into place. Both methods are intended to ensure that the lifting force is applied to the eye bolts as nearly straight upward as possible.

CAUTION: Do not use the housing to support or lift the flowtube in a vertical position.





ASSEMBLY (Continued)

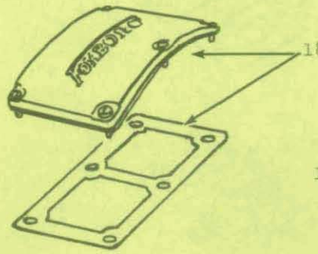


16. Put lockwashers and nuts on terminal block studs.

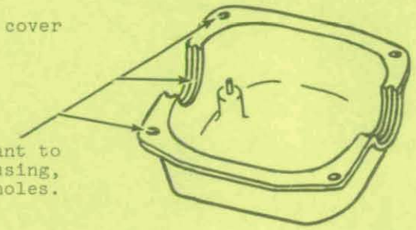
17. Connect grounding strap to power terminal block and tighten screws.

NOTE

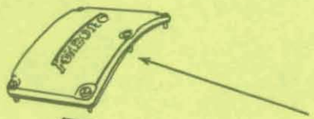
Nulling procedure should be performed at this time. It is recommended that the flowtube be installed in a pipeline with a minimum length of one pipe diameter upstream and downstream. Pipe must have a conductive surface. For nulling procedure, refer to MI 21-185.



18. Install gasket on top cover as shown.

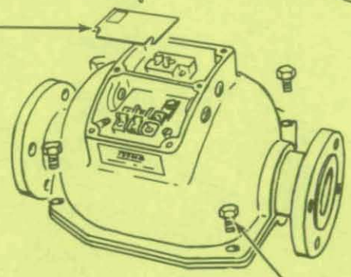


19. Apply a bead of sealant to the flange of the housing, and around the bolt holes.



20. Install shock hazard cover on power terminal block.

21. Install top cover.

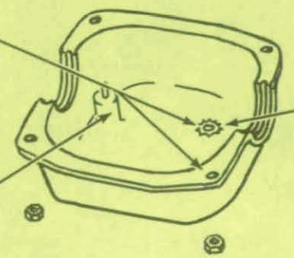


22. Push lockwasher into sealant centering it over bolt hole.

24. Install four housing bolts with washers and tighten.

NOTE

Make sure lockwasher is still in place.



23. Put housing halves together making sure locating pins are engaged in metering tube.

3/78

Printed in England

Instruction

MI
21-181
March 1978

REPLACEMENT OF METERING TUBE

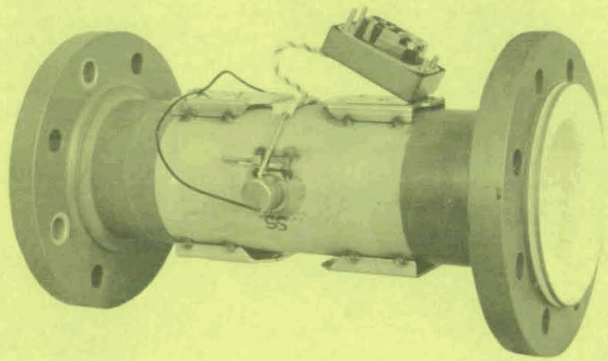
2800 Series Magnetic Flowtube

Sizes 15 to 300 mm or 1/2 to 12 in

Field replacement of a metering tube may cause some degradation of system accuracy. If a 1% system accuracy is required, the magnetic flowtube may require flow calibration.

It is recommended that the entire disassembly and assembly procedures, particularly Page 2, Step 7, be read thoroughly before replacement is attempted.

A replacement data tag, containing the sales order number and the millivolt factor of the replacement metering tube, is attached to the tube. It is recommended that the mV/GPM number on the original flowtube be blanked out to avoid later confusion.



Replacement metering tubes are available for 2800 Series Magnetic Flowtubes, sizes 15 to 300 mm or 1/2 to 12 in. The metering tube kit consists of:

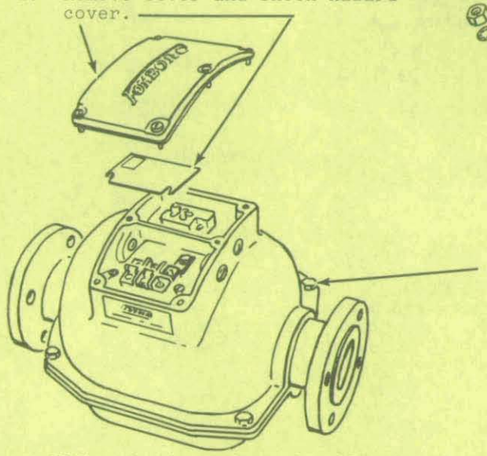
1. Tube, liner if applicable, electrodes, and connector assembly.
2. Tube of silicone sealant
3. Nulling tool
4. One band for sizes 25 to 150 mm or 1 to 6 in.
5. Gasket
6. Gasketing material
7. Thread adhesive (Loctite)

FOXBORO®

DISASSEMBLY

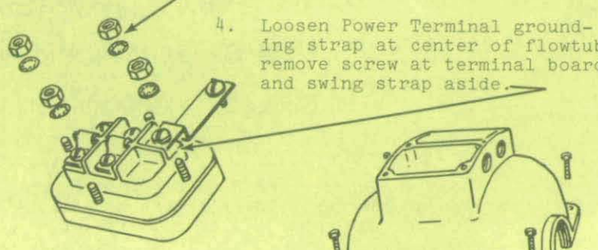
1. Remove flowtube from line. See Instructions MI 21-120 or MI 21-130 for handling.

2. Remove cover and shock hazard cover.



3. Remove nuts and lockwashers from both power and signal blocks.

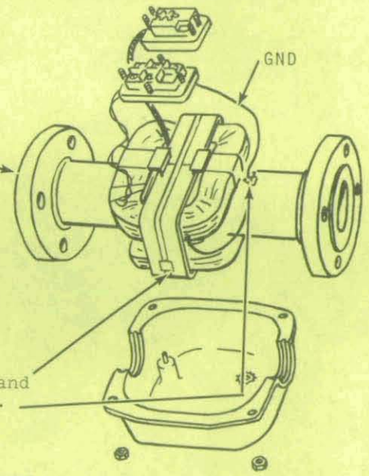
4. Loosen Power Terminal grounding strap at center of flowtube, remove screw at terminal board, and swing strap aside.



5. Remove bolts.

6. Carefully lift up top housing.

Lift metering tube and coil assembly out of bottom housing.

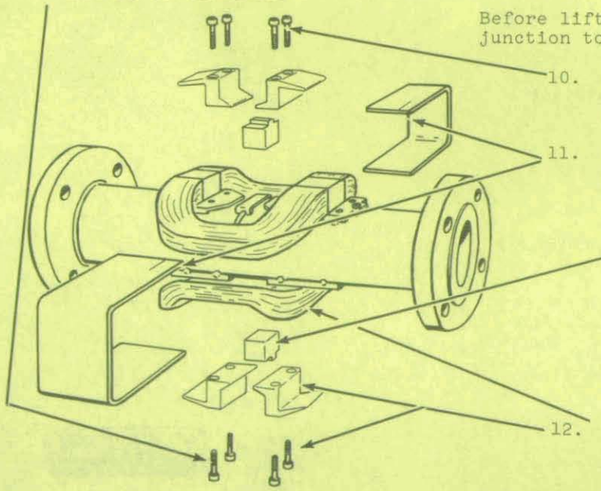


NOTE

Make sketch of arrangement of signal and power leads and identify top coil so that these parts can be correctly reassembled (Page 3, Step 1). Do NOT disconnect leads from power block unless a coil is being replaced. If leads are to be disconnected, make a sketch of connections to terminals on power block (signal block leads do not have to be disconnected).

8. Cut band at clamp and remove ground lead.

9. Loosen the bottom four screws that go through the retaining brackets holding the core halves to the coil.



NOTE

Before lifting core halves, make a mark across top junction to facilitate reassembly in same orientation.

10. Remove the four screws from the top retaining brackets. Remove retaining brackets.

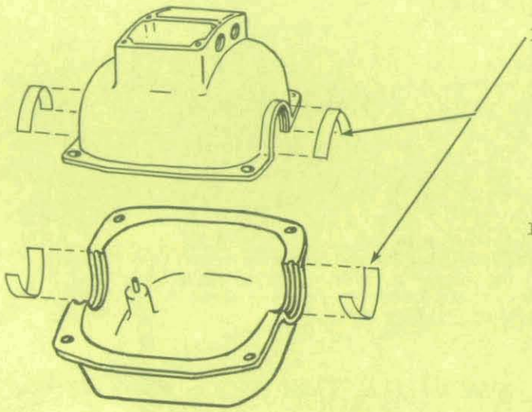
11. Slide out the core halves, using care to avoid damaging coils. Lift out the laminated assembly.

NOTE

On 50 mm or 2 in and smaller flowtubes, laminated assemblies are used in the construction. These are to be removed after the core halves have been separated. When using a 15 mm or 1/2 in flowtube, identify the top assembly, as top and bottom are not interchangeable as in the larger sizes.

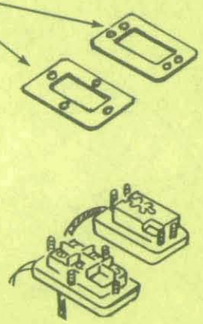
12. Remove the top coil; turn metering tube over. Remove the four retaining screws, retaining brackets, laminated assembly, and bottom coil.

ASSEMBLY (Continued)



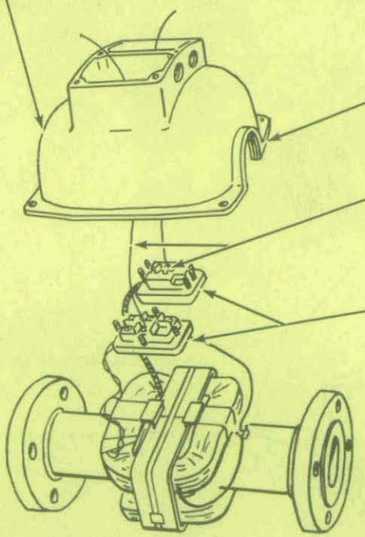
10. Cut gasketing material into four equal lengths and cement to top and bottom as shown, using a suitable adhesive. Once cement has dried, trim off excess so housings will fit together without interference.

11. Install new gaskets on signal and power blocks.



NOTE

Locating pin this end.



12. Apply a bead of sealant to the housing where it comes in contact with the tube. Repeat on other end.

13. Wrap a piece of string or wire around one screw on each terminal block so it can be pulled up through cutouts in top housing.

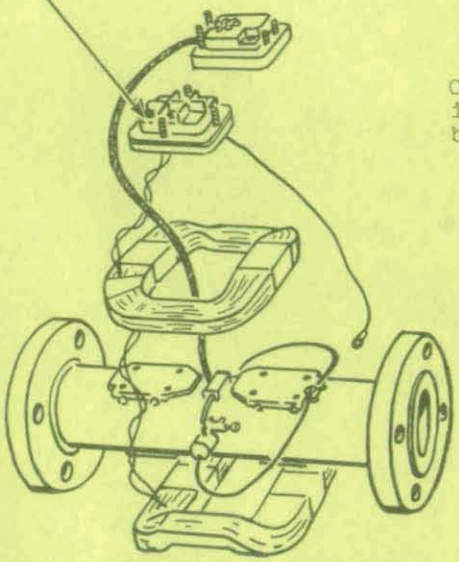
14. Place terminal blocks on top coil.

15. Carefully put top housing on, pulling terminal blocks into place. Bottom housing is assembled after nulling procedure is performed.

(Continued on Page 6)

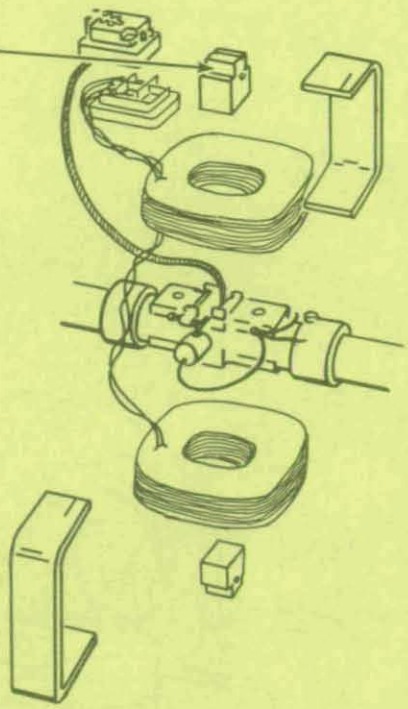
ASSEMBLY

1. Place coils on metering tube. Refer to sketch from Page 2, Step 7, for positioning power and signal leads. Connect leads to power terminal block.

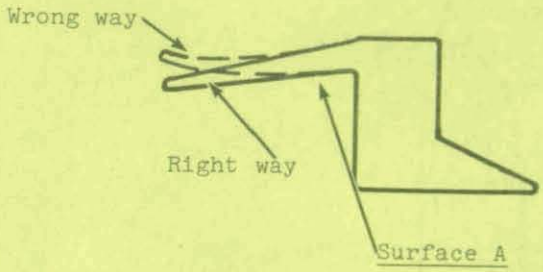


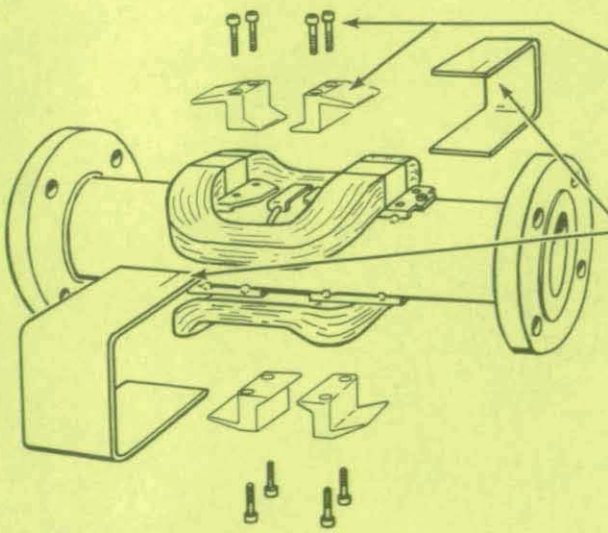
NOTE

On sizes 50 mm (2 in) and less, insert laminated assemblies in both coils with grooved side out.



2. Before installing the retaining brackets, surface A should be bent flat as shown.





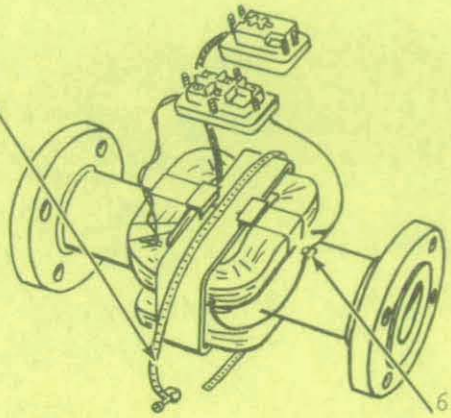
3. Place the retaining bracket on coil. After placing a drop of thread adhesive on each screw, install finger tight. Repeat for remaining three brackets.

4. Put on core halves matching up marks (Page 2, Step 9).

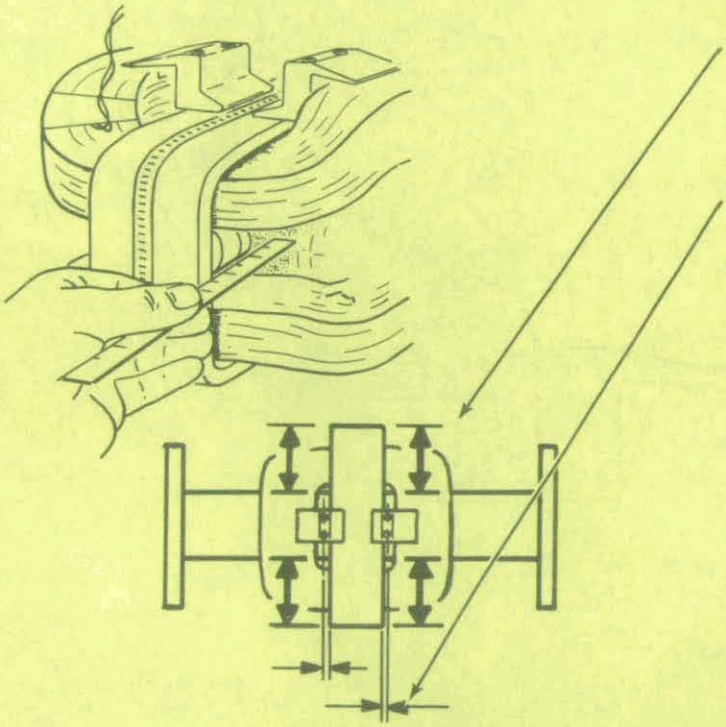
(Continued on Page 4)

ASSEMBLY (Continued)

5. Position strap around core assembly with clamp at bottom and tighten. Cut off excess strap.



6. Attach ground lead as shown.



7a. Measure from the core to the tube next to the electrode.

7b. Repeat measurements at three remaining locations shown.

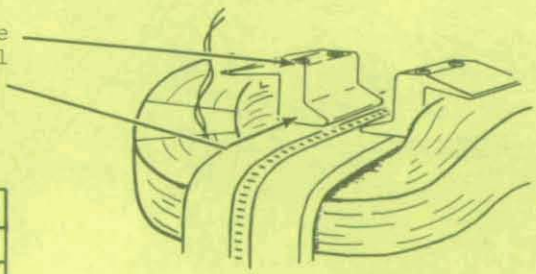
8a. Measure from the core to the retaining bracket screw.

8b. Repeat on other side as shown.

NOTE

It is essential that the core is evenly centered on the flowtube. All six measurements must be equal to within 1 mm (0.03 in). If not, reposition core on tube until measurements are within 1 mm (0.03 in).

9. Tighten retaining bracket screws to the applicable torque listed below OR until the back edge of the bracket starts to lift away from the core.



Flowtube Size		Torque	
mm	in	N·m	lb-ft
15-40	1/2-1 1/2	8.1	6
50-100	2-4	10.8	8
150-300	6-12	13.5	10

(Continued on Page 5)

MB 100

Printed in England

0681

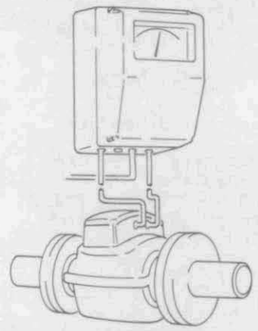
Instruction

MI
021-185
June 1981

2800 SERIES MAGNETIC FLOWTUBE
Nulling Procedure

This instruction outlines the nulling procedure required when the metering tube assembly has been replaced. The purpose is to obtain a no-flow millivolt output as near to zero as possible. The procedure covers the 2800 Series Magnetic Flowtube when used with an E96P, R, S, or T Series Transmitter, or with a 696A Series Converter.

E96P and S Series



E96R Series

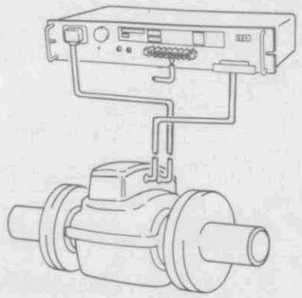
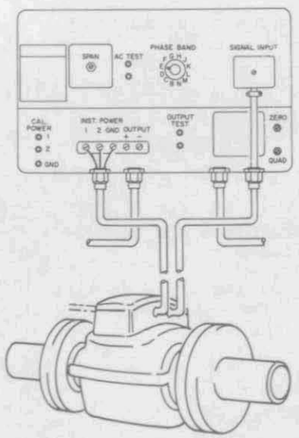
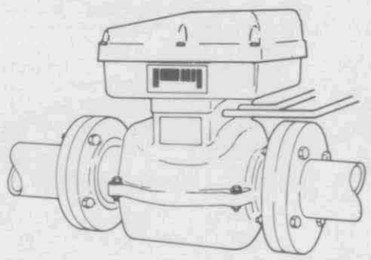


Figure 1

696A Series



E96T Series



CONTENTS . . .

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REFERENCE INSTRUCTIONS

E96P or S Transmitter, Style D:	MI 021-333
E96R Transmitter, Style D:	MI 021-334
E96T Transmitter, Style D:	MI 021-335
E96P or S Transmitter, Style A, B, or C:	MI 021-312
E96R Transmitter, Style A, B, or C:	MI 021-313
E96T Transmitter, Style A, B, or C:	MI 021-311
696A Converter:	MI 021-211
2800 Magnetic Flowtube Replacement of Metering Tube:	MI 021-181

PROCEDURE WHEN USING AN E96 SERIES TRANSMITTER

NOTE

A nulling tool is required for the following procedure.
Sizes 50 mm (2 in) and less, Part K0125KL
Sizes 80 mm (3 in) and above, Part K0125KM

1. Put Transmitter span jumper(s) in position(s) used for 1 mV span. For location of jumper position(s), refer to applicable transmitter instruction listed above.

2. Fill flowtube with process liquid or water. After filling, allow liquid to flow for a short time to remove any bubbles, then stop flow. Keep flowtube filled with liquid during this procedure.

3. For E96 Style D, refer to Figure 2. Put CAL/RUN switch in CAL position. Connect a battery-powered or earth-isolated (ground-isolated) ac voltmeter between test points TP3 and TP21. Use voltmeter having a minimum input inpedance of 5000 ohms/volt and ranges of 0-to-1.0 and 0-to-0.1 volts. Proceed to Step 4.

   For E96 Style A, B, or C, complete the following steps.

   a. Refer to Figure 3. Connect short jumpers between Input 1, Input 2, and Inner Screen (Solution Ground) terminals.

   b. Connect a battery-powered or earth-isolated (ground-isolated) ac voltmeter between test points TP6 and TP20 (shown in Figure 3). Use voltmeter having a minimum input impedance of 5000 ohms/volt and ranges of 0-to-1.0 and 0-to-0.1 volts.

   c. Turn zero adjustment (shown in transmitter instructions) for minimum reading (null) on voltmeter.

   d. Remove jumpers from Input 1, Input 2, and Inner Screen terminals.

   e. Proceed to Step 4.

4. Refer to Figure 4. Unscrew plugs from nulling-screw access holes on flowtube.

5. At the flowtube, lift black lead off terminal block and connect a short jumper from black lead (B) to INNER SHIELD.

6. With nulling tool, adjust opposite (white) nulling screw until a minimum ac voltage is read on the voltmeter. Remove jumper. Replace lead on terminal block.

7. At the flowtube, lift white lead off terminal block and connect a short jumper from white lead (W) to INNER SHIELD.

8. Adjust opposite (black) nulling screw until a minimum ac voltage is read on the voltmeter. Remove jumper. Replace lead on terminal block.

3. If the span of the converter is set above 10 millivolts, jumper the range resistor on the main board assembly. See Figure 6.

4. Set PHASE BAND switch (at upper center on front of converter) to B; note reading (approximately 1.4 V) on ac voltmeter.

5. Set PHASE BAND switch to N; note reading on ac voltmeter.

6. Adjust QUAD (lower right corner of converter) until there is no change in the ac voltage reading when the PHASE BAND switch is changed from B to N.

7. Adjust ZERO (above QUAD) until converter output equals 0.10 volt.

8. Remove calibrator from SIGNAL INPUT and CAL POWER terminals of converter and insert signal plug from flowtube.

9. Run fluid through flowtube for a short time. Shut flow off, keep flowtube full.

10. Refer to Figure 4. Remove plugs from nulling-screw access holes.

11. At the flowtube, lift black lead off terminal block and connect a short jumper from black lead (B) to INNER SHIELD.

12. With nulling tool, adjust opposite (white) nulling screw until a minimum ac voltage is read on the voltmeter. Remove jumper. Replace lead on terminal block.

13. At the flowtube, lift white lead off terminal block and connect a short jumper from white lead (W) to INNER SHIELD.

14. Adjust opposite (black) nulling screw until a minimum ac voltage is read on the voltmeter. Remove jumper. Replace lead on terminal block.

NOTE

On 50 mm or 2 in and smaller, repeat Steps 11 through 14 until minimum voltage is achieved without further adjustment.

15. Disconnect ac voltmeter.

16. Replace plugs in nulling-screw access holes.

17. Remove jumper across range resistor if connected in Step 2.

18. Adjust Zero on converter for 0.1 volt.

19. The system is now ready for operation. Refer to Instruction MI 021-181 for final assembly of housing.

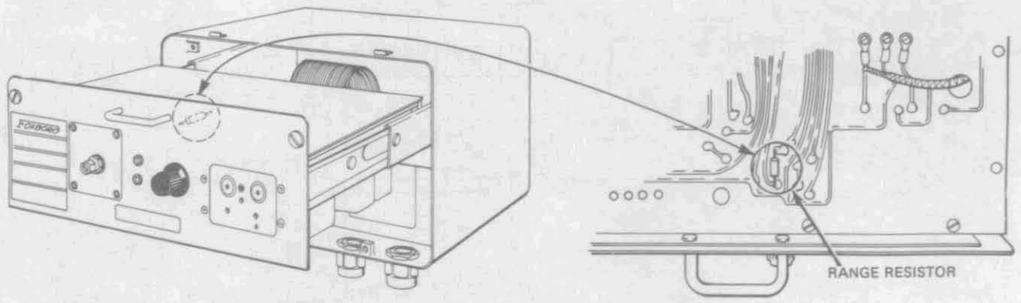


Figure 6

NOTE

On 50 mm or 2 in and smaller, repeat Steps 5 through 8 until minimum voltage is achieved without further adjustment.

9. Make final adjustment using either black or white nulling screw for total null (minimum ac voltage reading) with both black and white leads connected to flowtube.

10. Disconnect ac voltmeter.

11. Replace plugs in nulling-screw access holes.

12. The E96 Transmitter must now be reset to the correct span using the new millivolt factor supplied with the replacement metering tube. Refer to "Reference Instructions" for correct instruction.

13. The system is now ready for operation. Refer to Instruction MI 021-181 for final assembly.

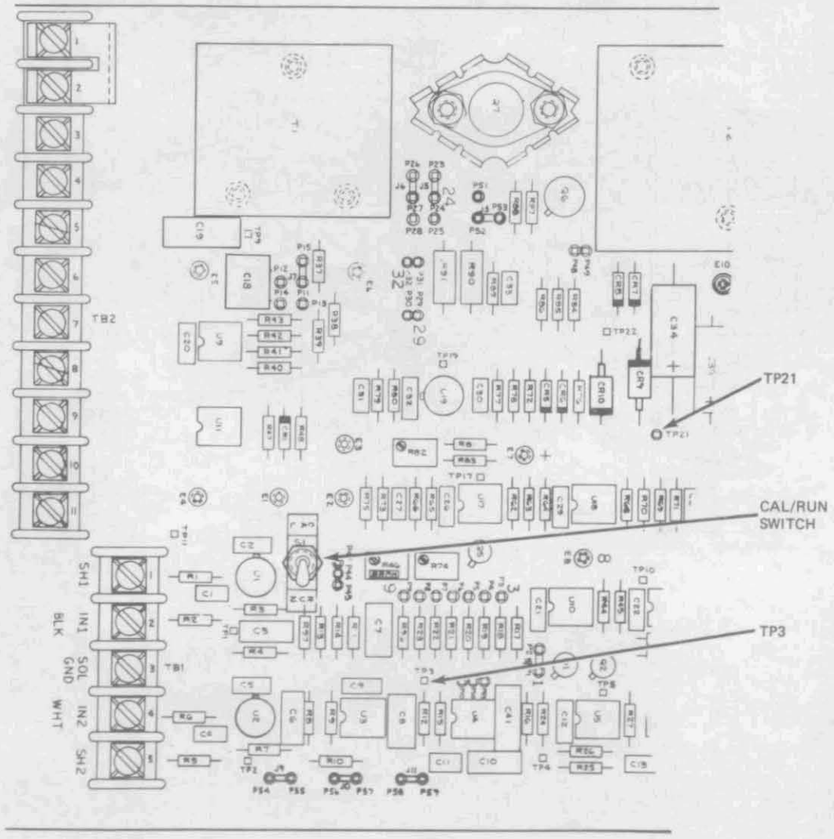


Figure 2

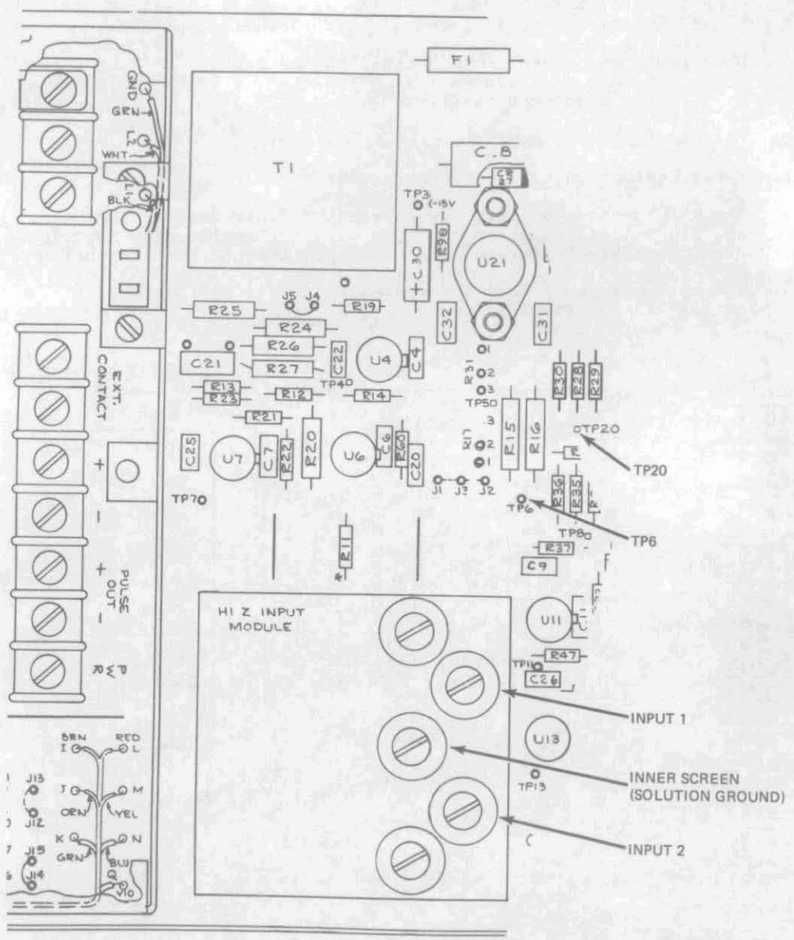


Figure 3

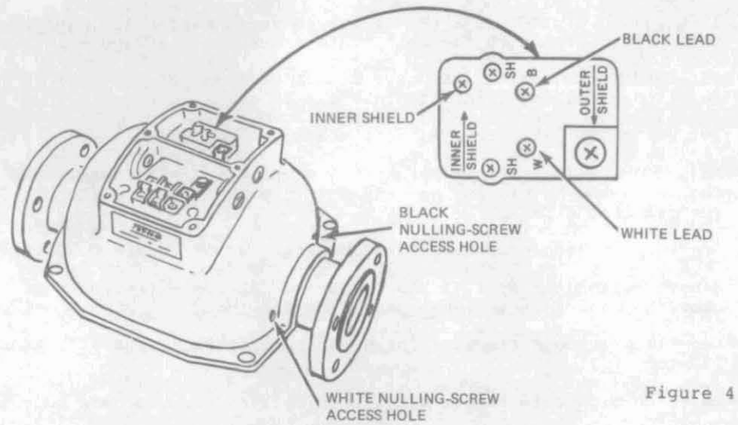


Figure 4

PROCEDURE WHEN USING A 696A SERIES CONVERTER

NOTE

A nulling tool is required for the following procedure.
Sizes 50 mm (2 in) and less, Part K0125KL
Sizes 80 mm (3 in) and above, Part K0125KM

1. Calibrate converter using new calibration factor supplied with metering tube. For calibration procedure, refer to Instruction MI 021-211.

2. Make connections as shown in Figure 5. Set calibrator PERCENT OUTPUT switch at 0.

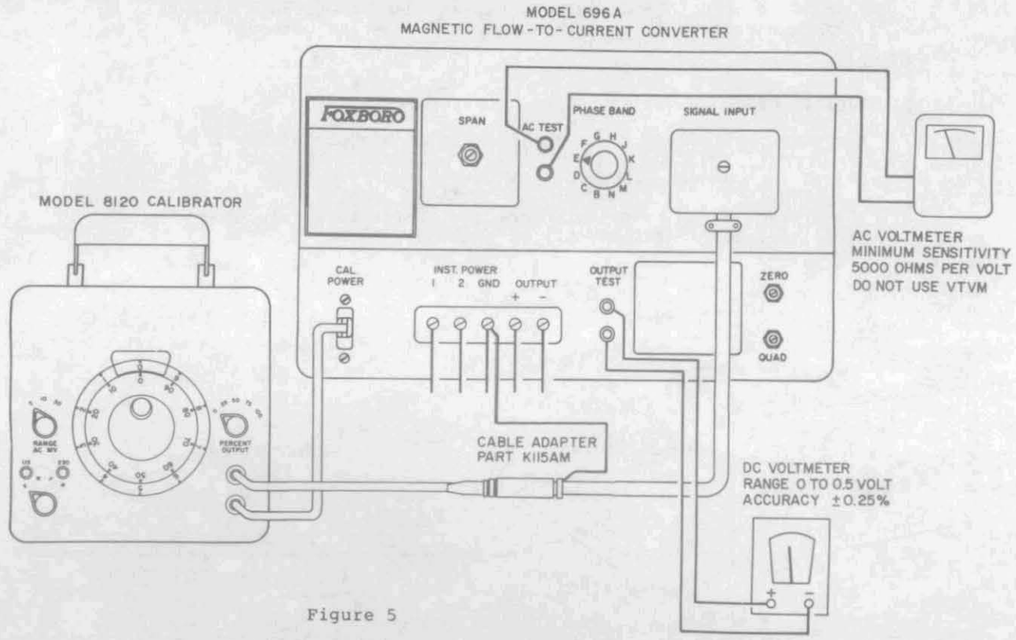
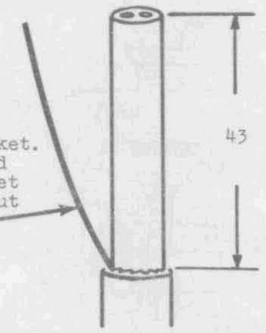


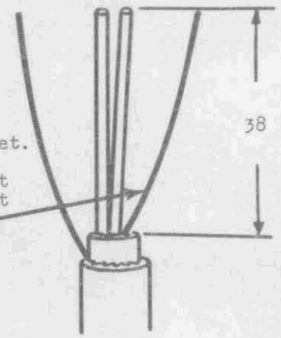
Figure 5

Model 696A Converters:
Preparation of the Converter End of the Signal Cable

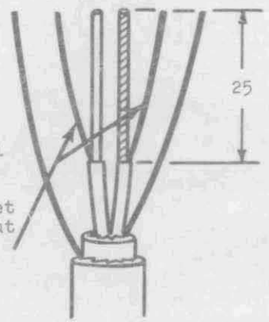
If the signal cable (Part R101ZS) or the connector (Part N136CL) is purchased separately, prepare the converter end of the cable as follows.



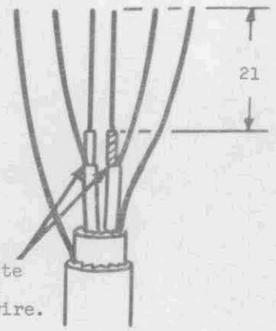
1. Strip outer jacket. Trim foil shield flush with jacket edge. Do not cut stranded outer shield lead.



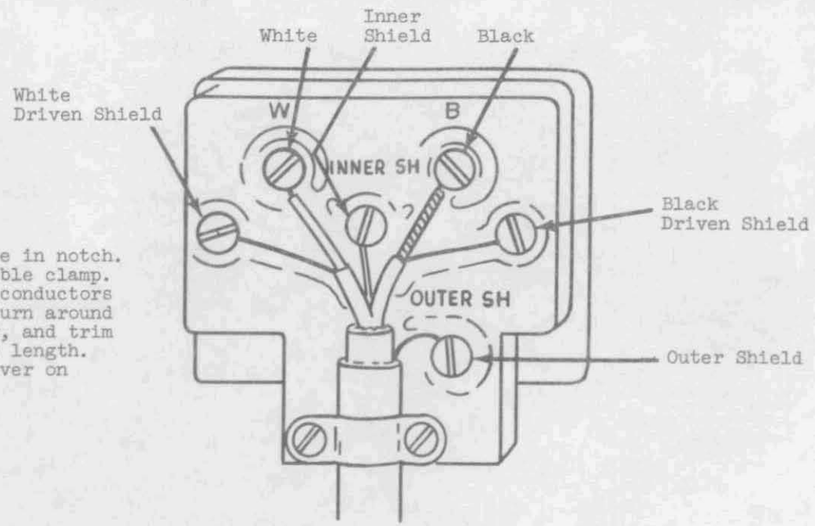
2. Strip inner jacket. Trim foil shield flush with jacket edge. Do not cut stranded inner shield lead.



3. Strip individual jackets. Trim foil shields flush with jacket edge. Do not cut stranded driven shield leads.



4. Strip black and white insulation. Do not nick the stranded wire.

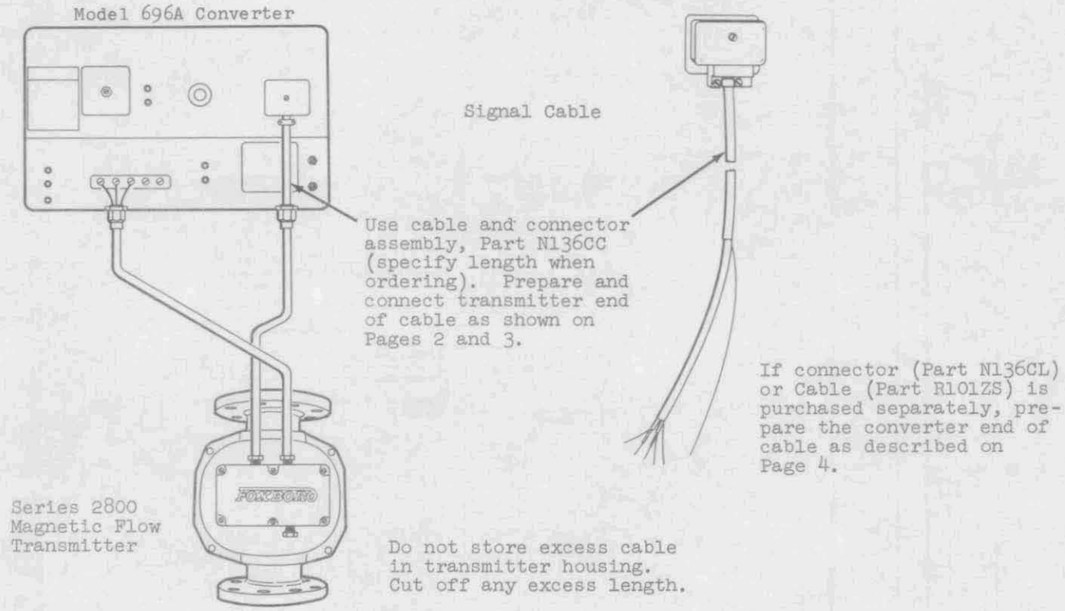


5. Place cable in notch. Tighten cable clamp. Terminate conductors with one turn around each screw, and trim off excess length. Install cover on connector.

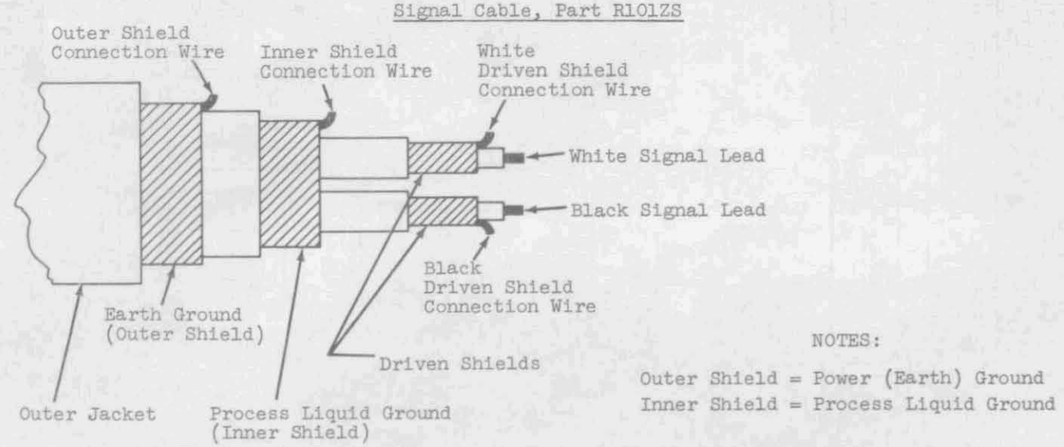
Instruction

MI
21 - 190
February 1970

SIGNAL CABLE PREPARATION AND CONNECTIONS FOR MODEL 696A MAGNETIC FLOW-TO-CURRENT CONVERTER AND SERIES 2800 MAGNETIC FLOW TRANSMITTER



Signal Cable, Part R101ZS



NOTES:
Outer Shield = Power (Earth) Ground
Inner Shield = Process Liquid Ground

Each of the two signal leads, black and white, has its own individual shield, which is "driven" by the Model 696A Converter preamplifier so that it is kept at the same voltage as the lead. With voltage between the lead and its shield at a minimum, signal attenuation due to cable capacitance is minimized.

Printed in England

FOXBORO

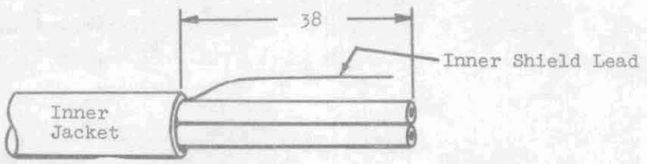
Cable Preparation for Signal Connections

(Illustrations are shown actual size to facilitate cable preparation.)

1. Strip outer jacket. Trim foil shield flush with jacket.

   Do not cut shield lead.

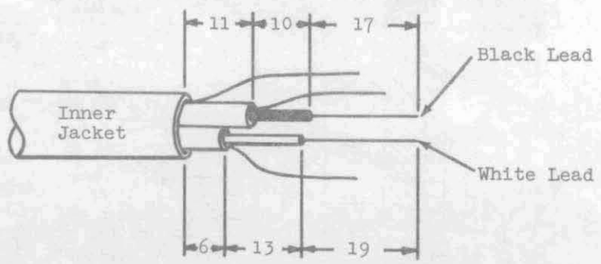
2. Strip inner jacket. Trim foil shield flush with jacket.



Dims. in mm

3. Strip individual lead jackets as shown and trim foil shields flush with jackets.

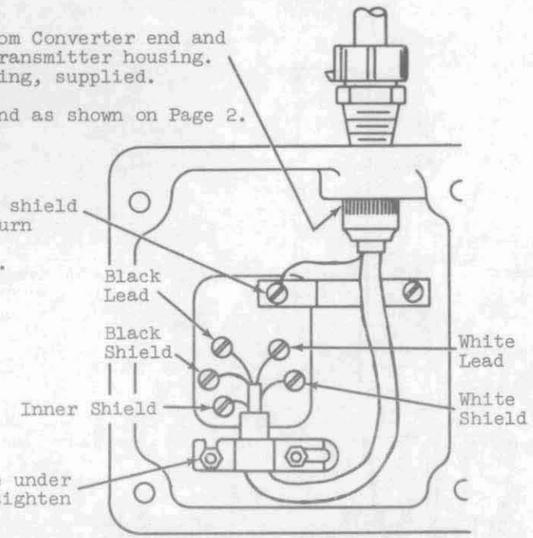
   Do not cut shield leads.



4. Strip insulation from black and white leads as shown.

Cable Installation

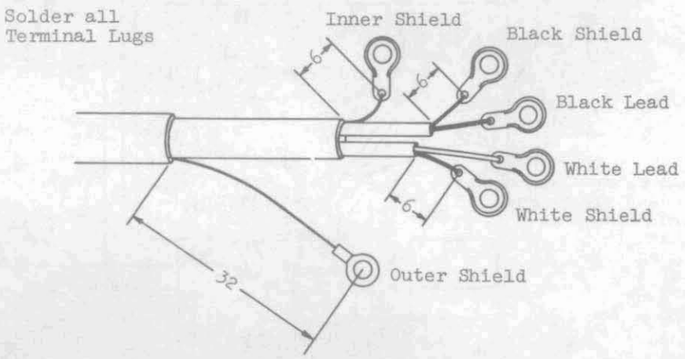
1. Insert cable from Converter end and bring it into Transmitter housing. Use rubber bushing, supplied.
2. Prepare cable end as shown on Page 2.
3. Terminate outer shield lead with one turn under screw. Trin off excess.
4. Place cable under clamp and tighten clamp.



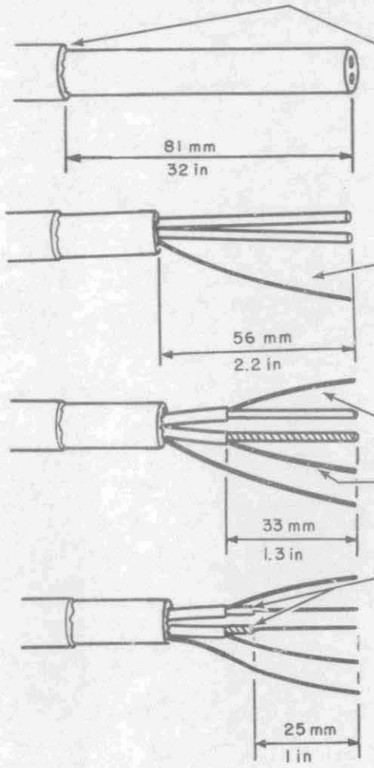
5. Terminate leads as shown by wrapping one turn clockwise under screw. Tighten screw. Trim off excess lead length.

NOTE: If soldered connections are desired, remove terminal lugs from screws. Prepare cable as shown below. Install terminal lugs on screw posts bevel side down. Replace and tighten screws.

To Attach Terminal Lugs for Soldered Connections



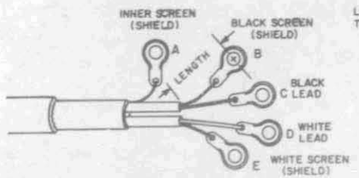
Preparation of Transmitter End of Cable
Surface and Pipe Mounted Transmitters, Models E96S and E96P



1. Strip outer jacket. Trim foil screen flush with jacket edge. Cut screen lead flush with edge of jacket.
2. Strip inner jacket. Trim foil screen flush with jacket edge. Do not cut stranded inner screen lead.
3. Strip jackets of individual leads. Trim foil screens flush with jacket edges. Do not cut stranded leads of driven screens.
4. Strip black and white insulation of individual leads. Do not nick the stranded wires.

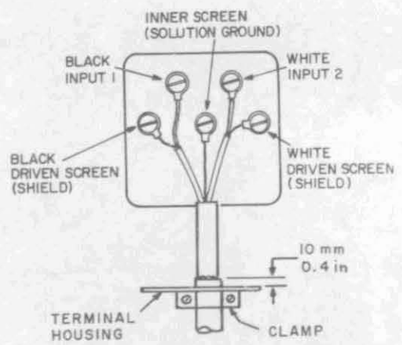
Installing Cable at Transmitter

1. Insert cable between upper and lower clamp so that approximately 10 mm (0.4 in.) of full diameter cable extends beyond the clamp. Tighten screws of clamp moderately.
2. Insert clamp assembly so that its 4 tabs fit through the 4 holes in the wall of the terminal housing.
3. Terminate each lead with one turn in a clockwise direction around each terminal and trim off any excess length. Tighten the terminal screws and the two clamp screws.



LENGTH OF SOLDERED TERMINAL LUG CONNECTIONS

A	29	1.13
B	21	.81
C	30	1.19
D	30	1.19
E	19	.75



NOTE: If connections to terminal lugs are preferred, prepare cable as shown. Install terminal lugs on screw posts bevel side down. Replace and tighten screws.

Printed in England

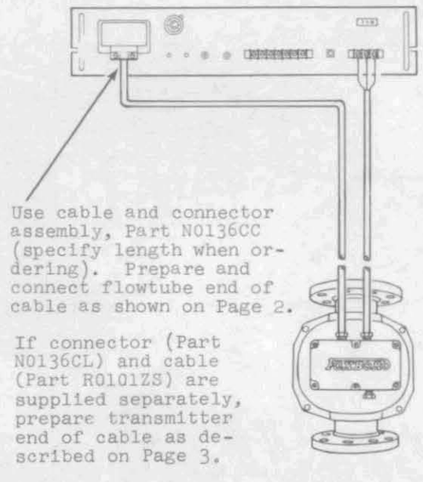
Instruction

MI
21-191
October 1979

SIGNAL CABLE PREPARATION AND CONNECTIONS

E96 Series Magnetic Flow Transmitters
Used with 2800 Series Magnetic Flowtubes

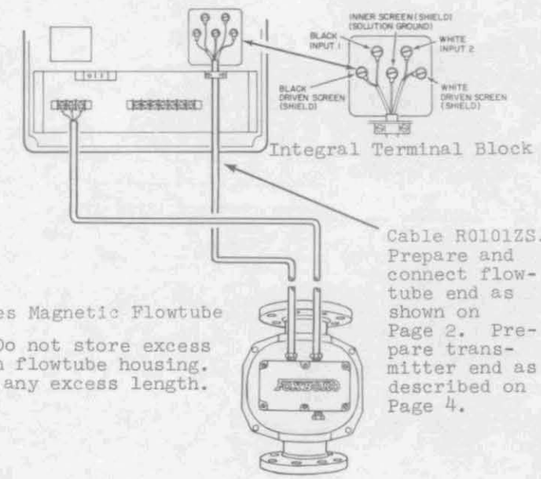
Model E96R



Use cable and connector assembly, Part N0136CC (specify length when ordering). Prepare and connect flowtube end of cable as shown on Page 2.

If connector (Part N0136CL) and cable (Part R0101ZS) are supplied separately, prepare transmitter end of cable as described on Page 3.

Models E96P and E96S



Integral Terminal Block

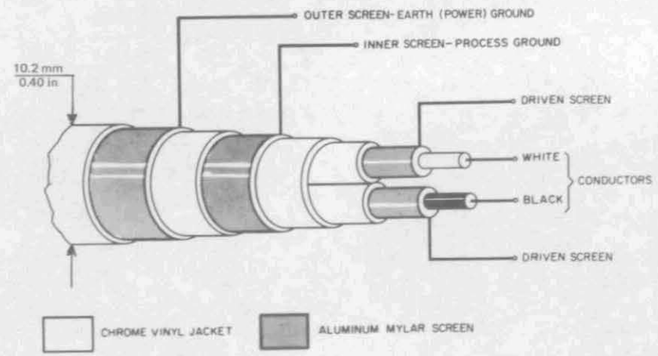
2800 Series Magnetic Flowtube

NOTE: Do not store excess cable in flowtube housing. Cut off any excess length.

Cable R0101ZS. Prepare and connect flowtube end as shown on Page 2. Prepare transmitter end as described on Page 4.

Signal Cable, Part R0101ZS

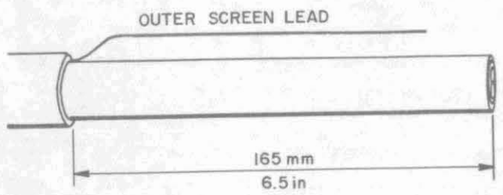
Each of the two signal leads, black and white, has its own individual screen (shield), which is "driven" by the E96 Series preamplifier so that it is kept at the same voltage as the lead. With voltage between the lead and its screen at a minimum, signal attenuation due to cable capacitance is minimized.



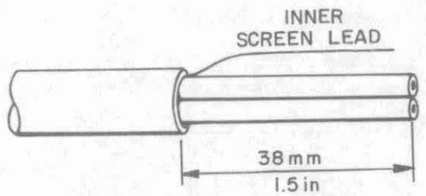
NOTE:
Outer Screen is the earth (power) ground.
Inner Screen is the process liquid ground.

FOXBORO®

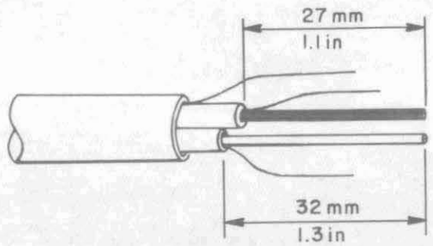
Preparation of Flowtube End of Cable



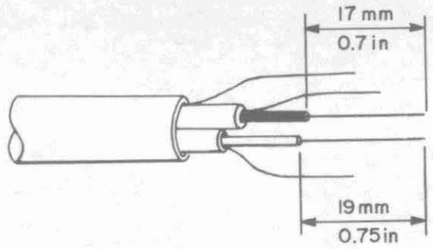
1. Strip outer jacket. Trim foil screen flush with jacket edge. Do not cut screen lead.



2. Strip inner jacket. Trim foil screen flush with jacket edge. Do not cut inner screen lead.



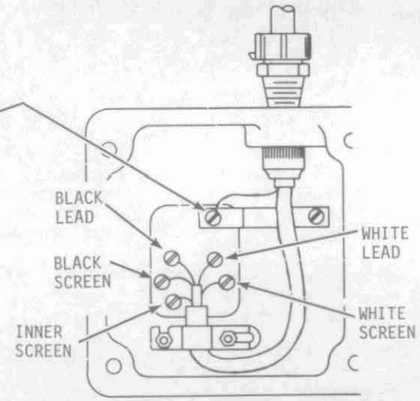
3. Strip jackets of individual leads. Trim foil screens flush with jacket edges. Do not cut screen leads.

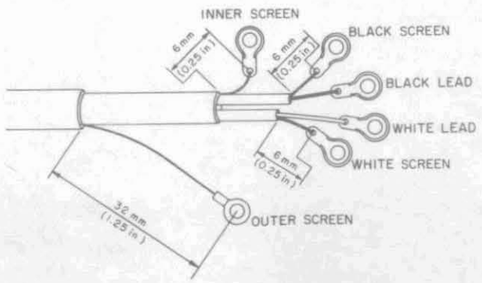


4. Strip insulation from black and white leads as shown.

Installing Cable at Flowtube

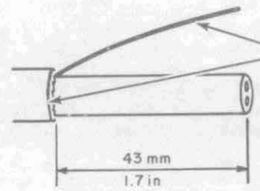
1. Bring cable into flowtube housing.
2. Prepare cable as shown above.
3. Terminate outer shield lead with one turn under screw. Trim off excess.
4. Place cable under clamp and tighten clamp.
5. Terminate leads as shown by wrapping one turn clockwise under screw. Trim off excess lead length.



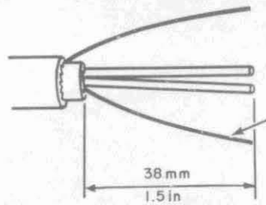


NOTE: If connections to terminal lugs are preferred, prepare cable as shown above. Install terminal lugs on screw posts bevel side down. Replace and tighten screws.

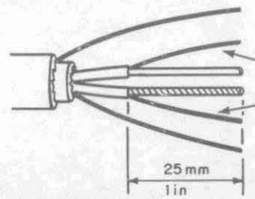
Preparation of Transmitter End of Cable
Rack Mounted Transmitter Model E96R



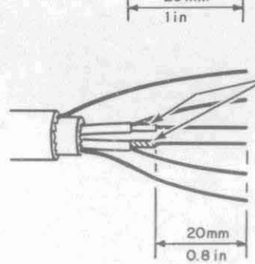
1. Strip outer jacket. Trim foil screen flush with jacket edge. Do not cut stranded outer lead.



2. Strip inner jacket. Trim foil screen flush with jacket edge. Do not cut stranded inner screen lead.

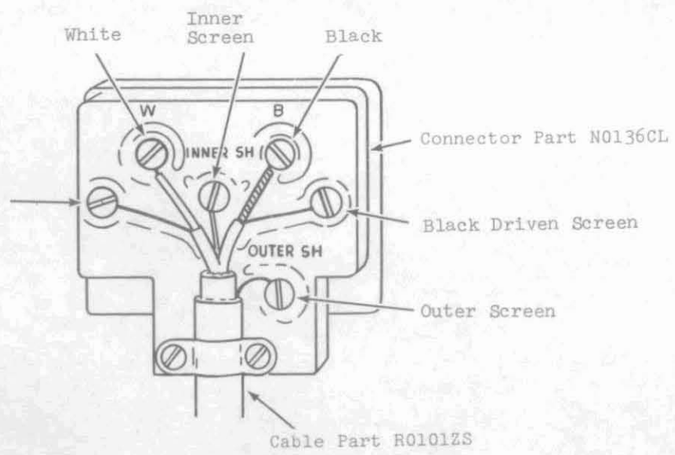


3. Strip jackets of individual leads. Trim foil screens flush with jacket edges. Do not cut stranded leads of driven screens.



4. Strip black and white insulation of individual leads. Do not nick the stranded wires.

Attaching Cable to Connector



Place cable in notch. Tighten cable clamp. Terminate conductors with one turn around each screw, and trim off excess length. Install cover on connector.

Instruction

MI
021-240
June 1981

ULTRASONIC CLEANING OSCILLATOR
For Use With 2800 Series Magnetic Flowtubes
Electrode Installation and Operation

INTRODUCTION

The Ultrasonic Cleaning Oscillator option consists of a magnetic flowtube with ultrasonic transducers installed on the electrodes and an ultrasonic oscillator with 7.5 metres (25 feet) of screened (shielded) cable that connects the oscillator to the transducers. The high frequency of the transducers causes cavitation of the process fluid. This keeps the sensitive portions of the electrodes clean, thus maintaining full sensitivity of the electrodes and greatly minimizing manual cleaning of the electrodes.

The Ultrasonic Cleaning Oscillator (stationary or portable) is designed to supply power to drive a piezoelectric transducer (electrode driver) in the nominal range of 0.5 to 4.5 W at frequencies in the ranges of 38 to 85 kHz (determined by the resonant frequency of the transducer). The power output is variable in 4 steps over a total range of about 8 to 1. The electrode transducers were designed such that their operation does not interrupt the flow signal. Continuous or periodic use does not cause loss of flow measurement.

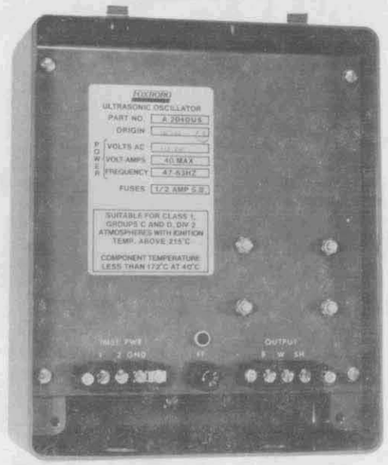


Figure 1.
Oscillator with Cover
and Terminal Guards Removed

SPECIFICATIONS—OSCILLATOR (PART A2040US OR D0138NG)

Output: 4.5 W maximum, frequency range 38 to 85 kHz
Ambient Temperature Limits: -30 and +50°C (-20 and +120°F)
ac Supply Voltage: 100, 120, 220, or 240 V, ±10% (portable cleaner; 120 V only)
Power Requirements: 23 W
Mass (approximate): 9 kg (19 lb)
Enclosure Classification: Meets IEC IP65 and provides the environmental protection of NEMA Type 4
ac Power Fuses: 1/2 A, 250 V ac, slow blow
Electrical Classification: Refer to data plate

CONTENTS . . .

MB 100

0681

Printed in England

INSTALLATION
Nominal Dimensions

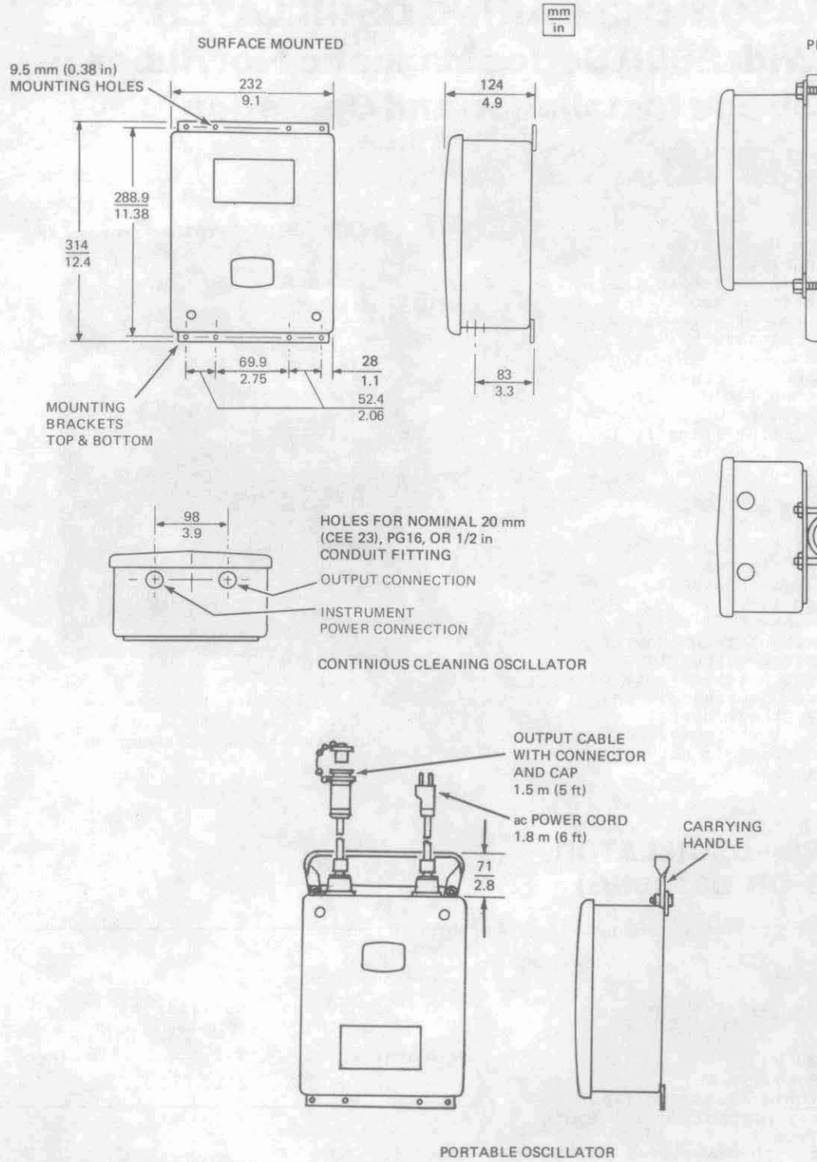


Figure 2

COMPONENT DIAGRAM

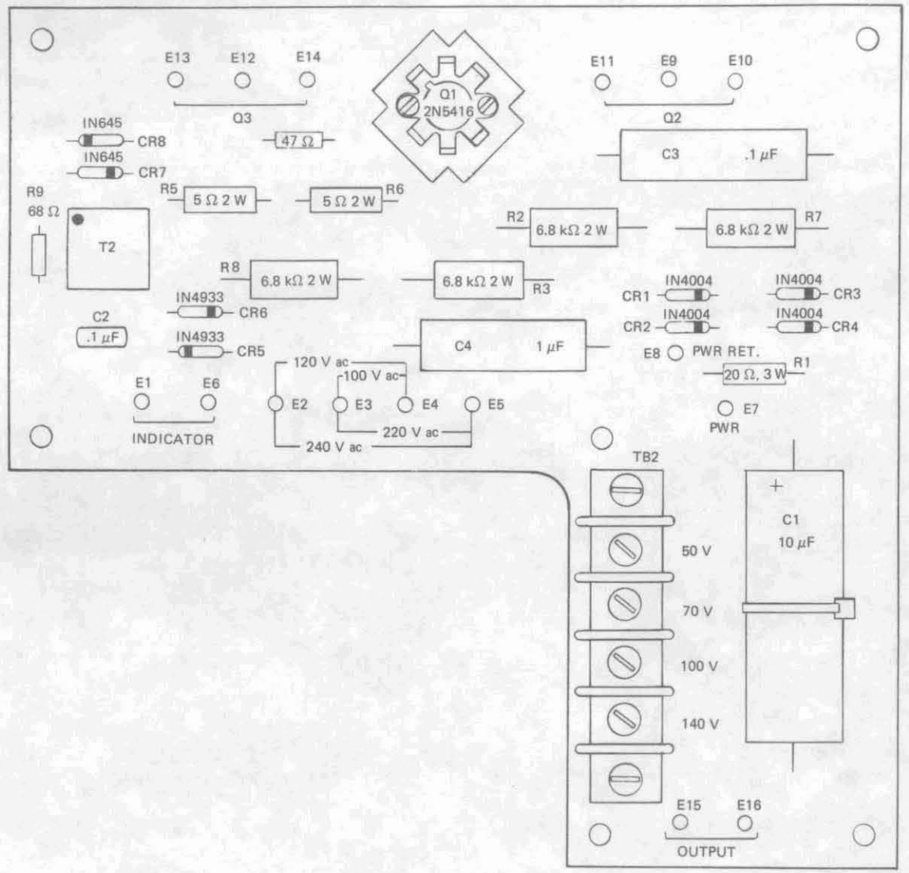


Figure 9

CIRCUIT DIAGRAM

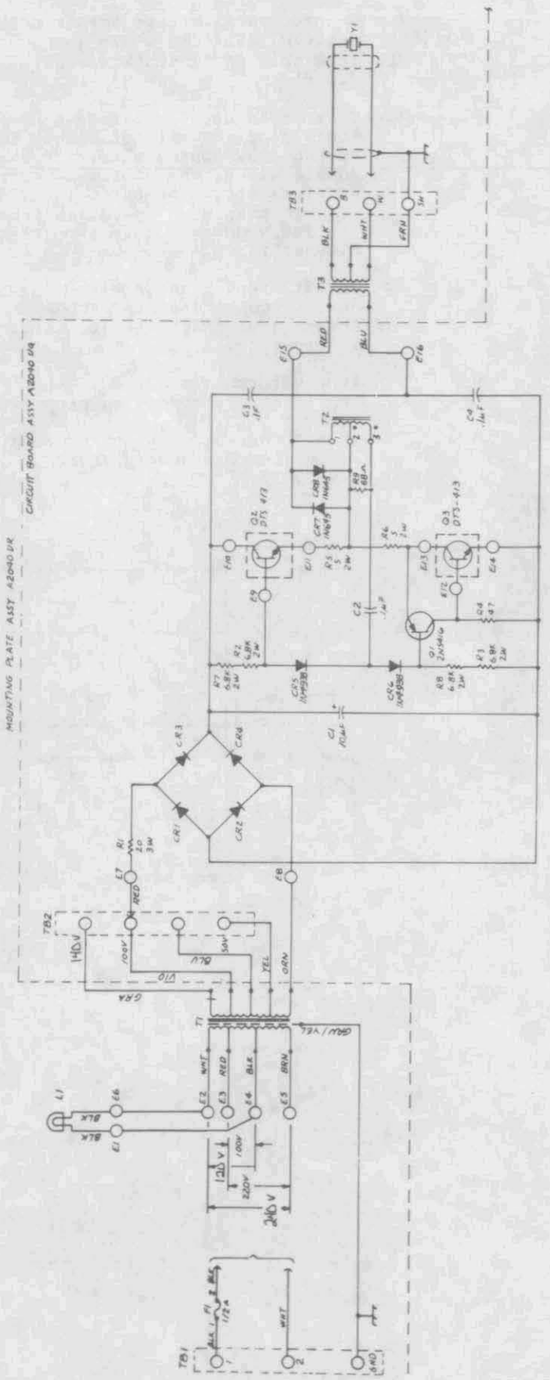


Figure 8

Circuit Diagram

Parts List

Item	Description	Part No.
CR1-CR4	Diodes, Type 1N4004	N0258DL
CR5,CR6	Diodes, Type 1N4938	N0138AL
CR7,CR8	Diodes, Type 1N645	N0258AF
Q1	Transistor, Type 2N5416	N0282EK
Q2,Q3	Transistors, Type DTS-413	N0282EL
T1	Transformer, power	N0234BE
T2	Transformer, dual winding	N0233CL
T3	Transformer, output	N0233CR
L1	Lamp, neon	N0268AT
--	Circuit Board Assembly	A2040UQ

Item	Description	Part No.
R1	Resistor, 20 Ω ±5%, 3 W, wire-wound	A2026WN
R2,R3	Resistors, 6.8 kΩ ±2%, 2 W, metal glaze	E0159KN
R4	Resistor, 47 Ω ±2%, 1/4 W, metal glaze	E0156CM
R5,R6	Resistors, 5 Ω ±5%, 2 W, wire-wound	T0124EZ
R7,R8	Resistors, 6.8 kΩ ±2%, 2 W, metal glaze	E0159KN
C1	Capacitor 10 µF ±10%, 300 V, metalized polycarbonate	H0183BQ
C2	Capacitor, 0.1 µF ±10%, 100 V, ceramic	H0111CB
C3,C4	Capacitors, 0.1 µF ±10%, 400 V, metalized polycarbonate	A2038WT
R9	Resistor, 68 Ω ±2%, 1/4 W	E0156CS

Wiring

The oscillator must be mounted closer than 7.5 m (25 ft) to the flowtube so that the 7.5 m (25 ft) screened cable supplied with the system can connect the two.

A magnetic flowtube with the Ultrasonic Cleaning Oscillator option differs in appearance from a standard flowtube by the addition of two feed-through terminals located in the power connection box (as supplied on initial order). The output cable from the Ultrasonic Cleaning Oscillator connects to these terminals (junction box in portable version).

The installation of the flowtube ac power leads is similar to a standard flowtube, except that the leads from the ac power supply and the input power leads to the transmitter must pass through the same conduit opening to the flowtube power connection box (see Figure 3 or 4).

Wall or Pipe Mounted

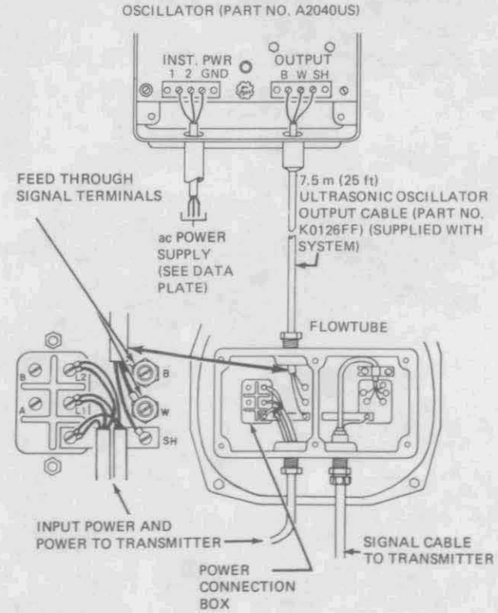


Figure 3

Portable

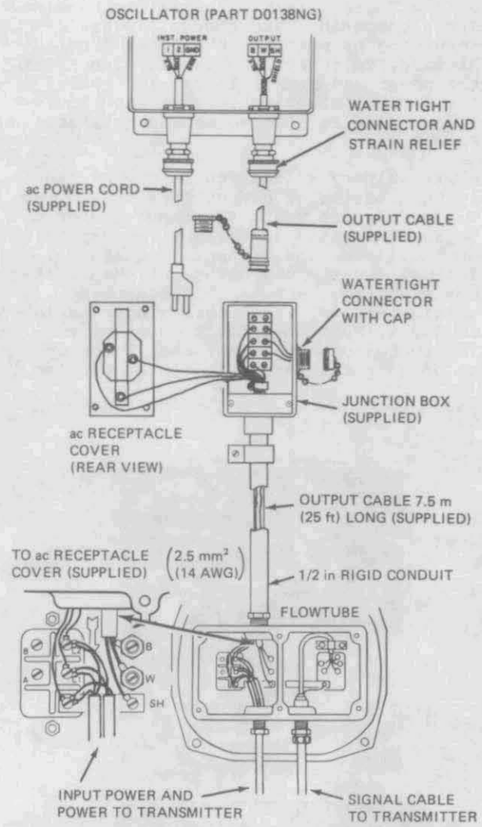


Figure 4

SERVICING

All components are mounted on the printed wiring board assembly inside the housing. These components are accessible for servicing by removing the panel from the housing. To remove the panel, disconnect the power and signal leads, and remove the 4 panel mounting screws; see Figure 6. For details of component panel, see Page 7.

A preliminary voltage check may be made at the oscillator output terminals B and W (see Figures 3 and 4). Reading should be approximately 30 to 75 V rms depending on oscillator and transducer characteristics. (Due to the nature of the ultrasonic voltage, some low impedance dc multimeters may erroneously indicate 100 to 300 V. Such an indication is more likely to suggest normal oscillator operation rather than an oscillator problem.)

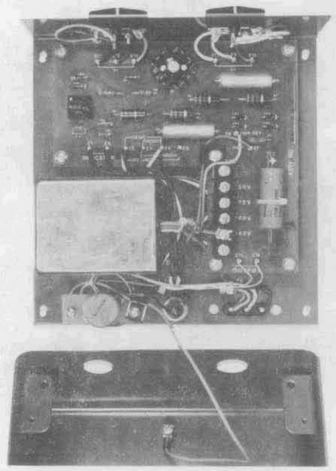


Figure 5

Oscillator Power Output

Various levels of oscillator power are available by moving a lead on terminal board TB2 located on the component panel. Refer to Page 7.

The terminal board is labeled 50 V, 70 V, 100 V, and 140 V. The instrument is shipped with the lead connected to the 140 V terminal. Decreasing the voltage level will decrease the power to the transducer.

For a 1 kW transducer, the power steps are:

rms Voltage	Approximate Power (W)
50	0.5
70	1.1
100	2.2
140	4.5

Oscillator Supply Voltage

The oscillator may be adapted to various supply voltages by moving instrument power leads on the component panel, Page 7.

NOTE

Does not apply to the portable ultrasonic cleaning oscillator.

Supply Voltage	Terminals on Component Panel
100 V ac	BLK to E3 and WHT to E4
120 V ac	BLK to E2 and WHT to E4
220 V ac	BLK to E3 and WHT to E5
240 V ac	BLK to E2 and WHT to E5

Operational Check

1. Check oscillator data plate to determine required supply voltage (100, 120, 220, or 240 V ac).
2. Set up equipment as shown (Figure 6).

NOTE

Power connections to the flowtube are shown for reference only; it is not necessary to apply power to the flowtube for this operational check.

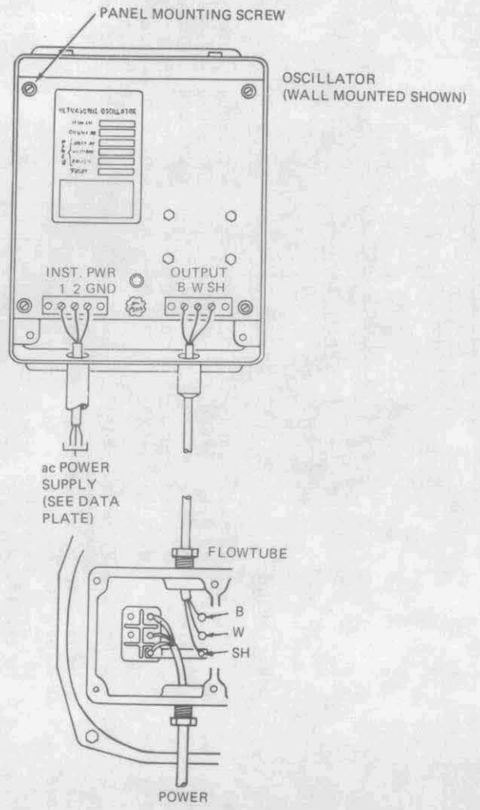
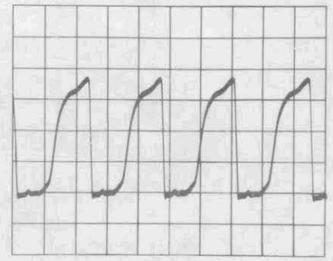


Figure 6

3. Connect oscilloscope across screen (shield) (SH) and white (W) terminals at flowtube (see Figure 6).
4. Turn on ac supply voltage to oscillator. Oscillator should start up and show approximately 70 kHz square waves. The amplitude of the waveform should be 80 to 100 V dc peak-to-peak when operating from the 140 V dc secondary tap (see Figure 7).
5. Repeat Steps 3 and 4 with oscilloscope connected across screen (SH) and black (B) terminals at flowtube.
6. If waveforms are correct, the oscillator is operating properly.
7. If not correct, replace printed wiring board assembly (Part A2040UQ).



70 kHz WAVEFORM
OSCILLOSCOPE SETTINGS:
X AXIS, 5 μs/DIVISION
Y AXIS, 25 V/DIVISION

Figure 7

Model Code

280H = 1/2 Inch Pipe Size
2801 = 1 Inch Pipe Size
281H = 1-1/2 Inch Pipe Size
2802 = 2 Inch Pipe Size
2803 = 3 Inch Pipe Size
2804 = 4 Inch Pipe Size
2806 = 6 Inch Pipe Size
2808 = 8 Inch Pipe Size
2810 = 10 Inch Pipe Size
2812 = 12 Inch Pipe Size

Tube Construction
-SA = AISI Type 304 Stainless Steel, Schedule 10
-SB = AISI Type 304 Stainless Steel, Schedule 40

End Connections
BA = ANSI Class 150 Carbon Steel Flange
BB = ANSI Class 150 Stainless Steel Flange
BD = ANSI Class 300 Carbon Steel Flange
MD = PN(ND) 10 cs Flange and Metric (DIN 1181) Sanitary Extension
RD = PN(ND) 10 cs Flange and R.J.T. (BS 1864) Sanitary Extension
TA = ANSI Class 150 cs Flange and Tri-Clover Type 14 MPW Quick-Disconnect
TB = ANSI Class 150 ss Flange and Tri-Clover Type 14 MPW Quick-Disconnect
UD = PN(ND) 10 cs Flange and I. S. (BS 4825-ISO 2853) Sanitary Extension
ZD = BS 4504—10 bar Carbon Steel Flange
ZE = BS 4504—16 bar Carbon Steel Flange
ZF = BS 4504—25 bar Carbon Steel Flange
ZG = BS 4504—40 bar Carbon Steel Flange
ZL = BS 4504—10 bar Stainless Steel Flange
ZM = BS 4504—16 bar Stainless Steel Flange
ZN = BS 4504—25 bar Stainless Steel Flange
ZP = BS 4504—40 bar Stainless Steel Flange

Liner
-A = Polyurethane (Adiprene "L")
-T = Tetrafluoroethylene (TFE)

Electrodes
B = Tantalum—Tungsten
C = 316 Stainless Steel—Conical
H = Hastelloy C
K = Hastelloy C—Conical
P = Platinum—Iridium
S = 316 Stainless Steel
T = Titanium

Coils
A = 120 V 60 Hz
B = 240 V 60 Hz
C = 120 V 50 Hz
D = 220 V 50 Hz
E = 240 V 50 Hz
F = For use unit 896 Transmitter
G = For use with 896 Transmitter and 60 Hz (dual calibration)

Housings
-A = Accidental Submergence
-G = General Purpose
-L = Corrosion Resistant
-N = Submersible

-Optional
U = Ultrasonic Electrode Cleaning Driver Assembly with Oscillator and Cable
W = Ultrasonic Driver Assembly with Cable and Junction Box for Portable Ultrasonic Electrode Cleaner
Z = Ultrasonic Driver Assembly without Oscillator and Cable

Adiprene "L" is a trademark of E. I. duPont de Nemours and Company.
Hastelloy C is a trademark of the Stellite Division of Cabot Corporation.
Loctite is a trademark of Loctite Corporation.

MB 150

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Printed in England

Parts List

PL
008-541
August 1983

2800
MAGNETIC FLOWTUBE
LINED METAL

Styles B and C

15 mm through 300 mm
(0.5 inch through 12 inch)

Model Code
(see page 6)

FOXBORO®

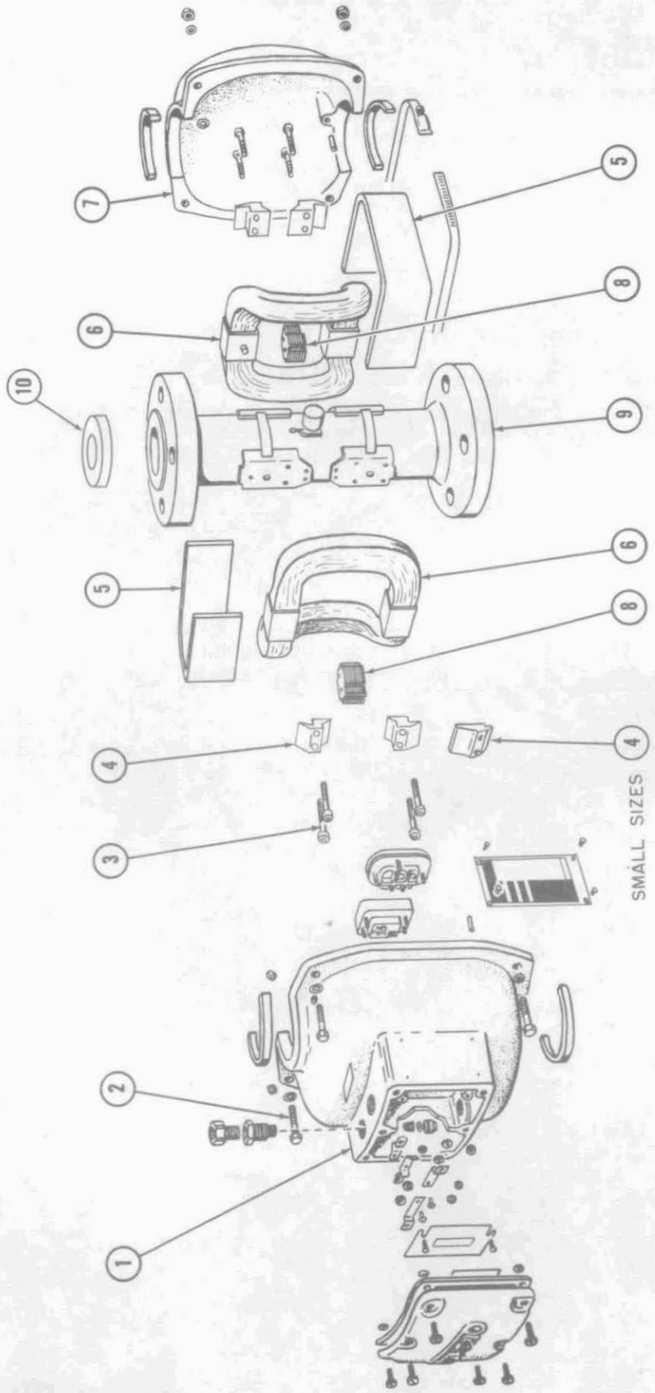


Figure E1640A

SANITARY ADAPTOR

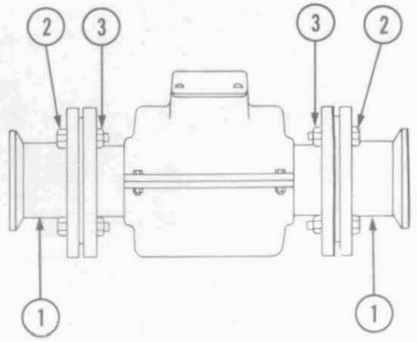


Figure E2320

Flowtube Size	Item 1 Sanitary Adapter (2 required)				Item 2 Nut (8 required)	Item 3 Bolt (8 required)
	Codes TA, TB	Code MD	Code RD	Code UD		
15 mm (0.5 in)	K0127BF	K6005RV	K6005RL	K6005RR	X0142CW K6003NA	X0140GX K6003MA
25 mm (1 in)	K0127BG	K6005RW	K6005RM	K6005RS	X0142CW K6003NA	X6000EA K6003MA
40 m (1.5 in)	K0127BH	K6005RX	K6005RN	K6005RT	X0142CW K6003NB	X0116NX K6003MB
50 mm (2 in)	K0127BJ	K6005RY	K6005RP	K6005RU	X6000AP K6003NB	X0171VT K6003MC
80 mm (3 in)	K0127BK	K6005RZ	K6005RQ	—	X6000AP K6003NB	X0171VU K6003MD

Note: End size is 1/2 inch larger than flowtube size.

OPTIONS

- Type Y Purge
  - English Units ..... Kit K0123BL
  - Metric Units ..... Kit K0123AW

  Kits include:

K0123BK	1 Relief Valve
X0171RG	1 Needle Valve
Below	1 Rotameter
D0105PF	English Unit (Kit K0123BL)
M0153YN	Metric Units (Kit K0123AW)

  Note:Installation requires purge drilling in top housing and cover, see Page 3, Item 1 and Page 4, Item 2. See MI 21-145.
- Field Addition of Optional Teflon Liner Protector ..... Kit-C-28 (Refer to Foxboro)
- Electrode Voltage Boil-off Assembly ..... Part No. D0128JW

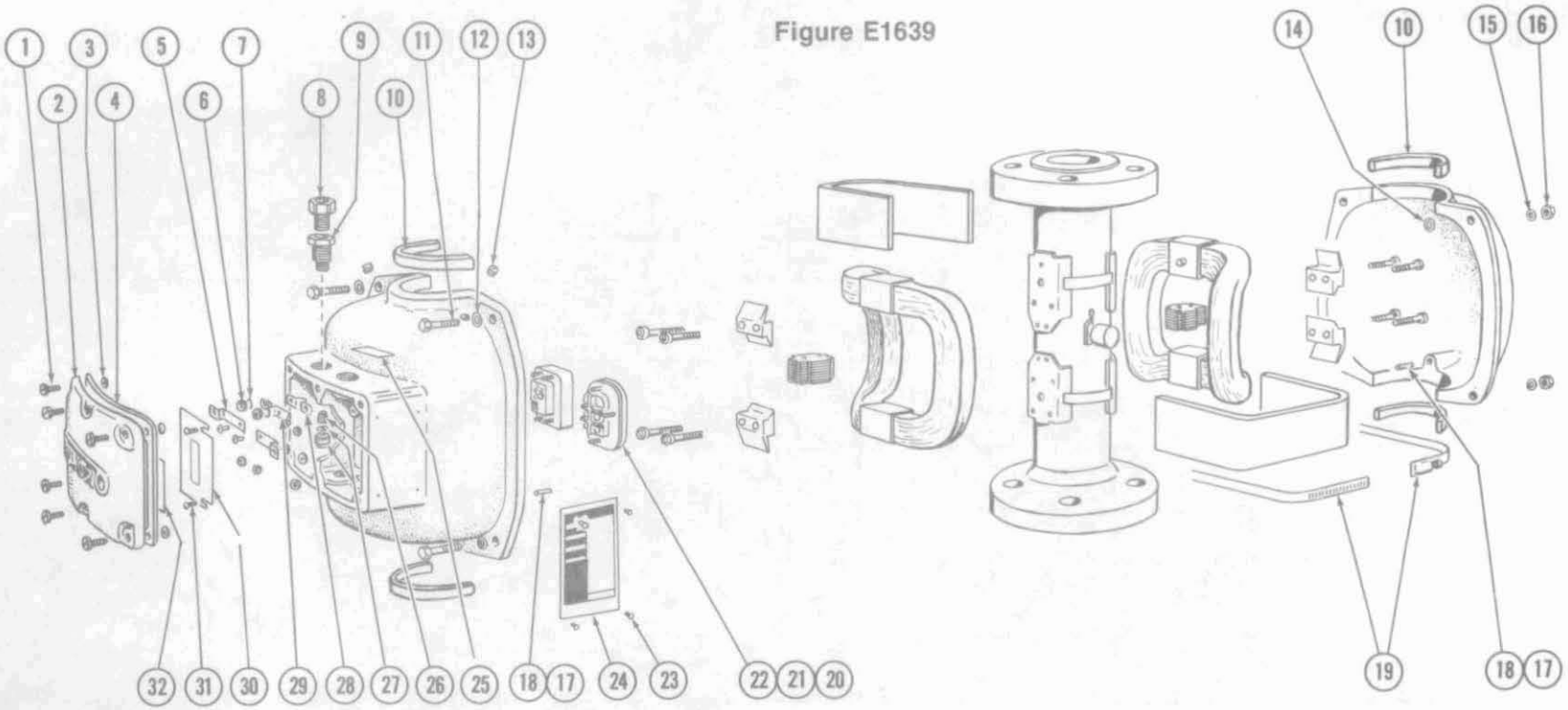
Parts are illustrated on page 2

The following items vary with flowtube size.
For items common to all 15 mm to 300 mm (0.5 to 12 in) sizes refer to page 4.

Item	Part Name	Qty.	Flowtube Size (Nominal)									
			15 mm (0.5 in)	25 mm (1 in)	40 mm (1.5 in)	50 mm (2 in)	80 mm (3 in)	100 mm (4 in)	150 mm (6 in)	200 mm (8 in)	250 mm (10 in)	300 mm (12 in)
1	Top Housing	1										
	*General Purpose		K0123PP	K0123PP	K0123PP	K0123PP	K0123SB	K0123ER	K0124BC	K0124ES	K0124KY	K0124NC
	Submersible		K0125PA	K0125PA	K0125PA	K0125PA	K0125PB	K0125PC	K0125PE	K0125PF	K0125PK	K0125PL
	Ultrasonic Cleaning		—	—	—	K0125WR	K0125WS	K0125WT	K0125WW	K0125WX	K0125WY	K0125WZ
	PTB		K6005KD	K6005KD	K6005KD	K6005KD	K6005KE	K6005KF	K6005KG	—	—	—
	Corrosion Resistant		K0125ES	K0125ES	K0125ES	K0125ES	K0125EW	K0125EY	K0125FA	K0125FC	K0125FF	K0125FL
	Type Y Purged, Div. 1 (CSA)		K0123BM	K0123BM	K0123BM	K0123BM	K0123BN	K0123BP	K0123BR	K0123BS	K0125LR	K0125LE
2	Cap Screw	4,8,10	A0101SP 0.312-18 x 1.250 Hex Head	A0101SP 0.312-18 x 1.250 Hex Head	A0101SP 0.312-18 x 1.250 Hex Head	A0101SP 0.312-18 x 1.250 Hex Head	A0101SP 0.312-18 x 1.250 Hex Head	A0101SP 0.312-18 x 1.250 Hex Head	X0100LT 0.312-18 x 1.500 Hex Head	X0118CK 0.312-18 x 1.750 Hex Head	X0118CK 0.312-18 x 1.750 Hex Head	X0118CK 0.312-18 x 1.750 Hex Head
3	Cap Screw	8	X0134BJ 0.250-28 x 3.000 Socket H.	X0134BH 0.250-28 x 2.750 Socket H.	X0134BG 0.250-28 x 2.500 Socket H.	X0134BF 0.250-28 x 2.250 Socket H.	C3286YD 0.250-28 x 1.500 Socket H.	C3286YD 0.250-28 x 1.500 Socket H.	X0134DE 0.312-24 x 1.750 Socket H.	X0134DE 0.312-24 x 1.750 Socket H.	X0134CL 0.312-18 x 1.750 Socket H.	X0134CL 0.312-18 x 1.750 Socket H.
4	Clamp	4	K0116BJ	K0116BJ	K0116BJ	K0116BK	K0116BL	K0116BM	K0116BN	K0116BP	K0116BQ	K0116BQ
5	Core	2	K0123PM	K0123PM	K0123PM	K0123PM	—	—	—	—	—	—
5	Core (pair)	1	—	—	—	—	K0123SA	K0123CA	K0124AZ	K0124EN	K0124KS	K0124MY
6	Coil	2										
	120 V 60 Hz (series or parallel) / 240 V 60 Hz (series only)		K0125MP	K0124PZ	K0124RX	K0123NP	K0123RZ	K0123LY	K0124BZ	K0124FN	—	—
	120 V 60 Hz (parallel only)		—	—	—	—	—	—	—	—	K0124MF	K0124NY
	120 V 50 Hz (series or parallel)		†K6001WG	K6001TE	†K6001TH	K6001PN	K6001MT	K6001KT	K6001QP	K6001RT	†K6001UE	†K6001VF
	220 V 50 Hz (series or parallel)		†K6001WH	K6001TD	†K6001TG	K6001PP	K6001MW	K6001KW	K6001QQ	K6001RU	†K6001UF	†K6001VG
	240 V 50 Hz (series only)		†K6001WH	K6001TD	†K6001TG	K6001PP	K6001MW	K6001KW	K6001QQ	K6001RU	†K6001UF	†K6001VG
7	Bottom Housing	1										
	*General Purpose		K0123XM	K0123XM	K0123XM	K0123XM	K0123MC	K0123EM	K0124BA	K0124EP	K0123ZT	K0123ZW
	Submersible		K0125PM	K0125PM	K0125PM	K0125PM	K0125PN	K0125PR	K0125PS	K0125PT	K0125PW	
	Corrosion Resistant		K0125ET	K0125ET	K0125ET	K0125ET	K0125EX	K0125EZ	K0125FB	K0125FE	K0125FK	K0125FM
—	Washers (used with corrosion resistant housing)	4,8,10	X0143AY	X0143AY	X0143AY	X0143AY	X0143AY	X0143AY	X0143AY	X0143AY	X0143AY	X0143AY
8	Lamination Assembly	2	K0125MS (Top) K0125NT (Bottom)	K0124SE	K0124TC	K0123NY	—	—	—	—	—	—
9	Replacement Metering Tube	1								Refer to Foxboro		
10	Gasket for flair protected Teflon lined flow tubes	2	K0126HM	K0126HN	K0126HP	K0126HQ	K0126HR	K0126HS	K0126HU	K0126HV	K0126HW	K0126HX

*Accidental Submergence
†Coils for use in Ordinary Location (General Purpose) only.
Other coils for Class I, Groups C and D, Division 2 locations.

Figure E1639

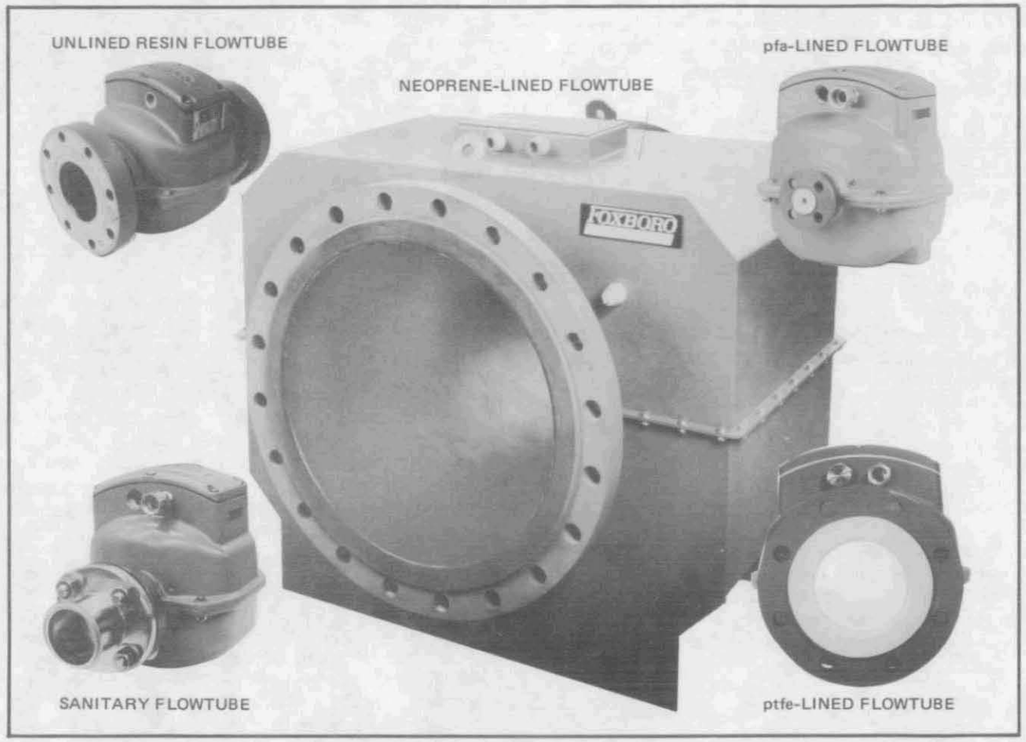


The following items are common to all 15 to 300 mm (0.5 to 12 in) flowtube sizes. For items which vary with flowtube size refer to pages 2 and 3.

Item	Part No.	Qty.	Part Name
1	K0123EX	6	Screw, Pan H., 0.250-20 x 0.812
2	Below	1	Cover
	K0123ES		General Purpose
	K0123EZ		Submersible
	K0125ER		Corrosion Resistant
	K0123BX		Type Y Purged
3	C0100CK	6	O-ring, 5.3 mm (0.21 in) ID
4	K0123EW	1	Gasket
5	K0123EZ	2	Strap
6	X0104CW	10	Nut, 0.190-32
7	0027520	8	Lockwasher
8	N0136BF	1	Reducer
9	K0123FR	1	Reducer
10	Below		Gasket (specify length)
	K0123ZP		3 mm (0.125 in) thick
	K0123ZN		1.5 mm (0.62 in) thick
11	—	—	Screw, Hex H., 0.312-18 (see page 3, item 2)
12	X0143AY	4-10	Washer
13	E0100LL	2	Plug
14	X0143SE	1	Lockwasher
15	A0101SN	4-10	Lockwasher
16	X0104CT	4-10	Nut, 0.312-18

Item	Part No.	Qty.	Part Name
17	K0123CK	1-2	Pin
18	S0106ML	—	Loctite Adhesive (as required)
19	K0125KE	1	Replacement Clamp Assembly 15-150 mm (0.5-6 in) sizes
19	K0125KE	2	Replacement Clamp Assembly 200-300 mm (8-12 in) sizes
20	K0111ZW	1	Terminal Board, Power
21	K0107RF	2	Jumper
22	X0116CY	12	Screw, Pan H., 0.190-32 x 0.312
23	B0119WM	6	Screw, Tapping
24	—	1	Data Plate (give instrument serial number)
25	—	1	Label (electrical code)
26	K0123LE	1	Bushing
27	K0123LF	1	Nut (special)
28	K0123FE	1	Clamp
29	K0123FC	1	Clamp
30	K0123LL	1	Cover Assembly
31	X0100SS	2	Screw, Pan H., 0.138-32 x 0.312
32	K0123EA	1	Label
—	X0117AX	—	RTV Sealant (as required, used between housing halves and gaskets)
—	A2040US	1	Ultrasonic Oscillator Cleaner Assembly
—	K0126FF	1	Cable Kit

MB 015 Printed in England 0383



2800 SERIES MAGNETIC FLOWTUBES

Proven dependability and versatility in use make Foxboro 2800 Series Flowtubes your first choice for measuring clean, as well as extremely difficult-to-handle, liquids.

INTRODUCTION

A magnetic flowtube is the primary in-line device in a magnetic flowmeter. It is used to measure the flow rate of electrically conductive liquids. The flowtube produces a dc or ac millivoltage. This low-level voltage is directly proportional to velocity and translatable to volumetric flow rate. It is converted into a standard transmission signal by a Foxboro magnetic flow transmitter.

Most industrial and municipal water/waste liquids can be measured by magnetic flowmeters. Acids and bases are common applications. Water and other clean liquids which can be measured by other devices, such as orifice meters, can also be measured with magnetic flowtubes to take advantage of their many desirable features. Liquids with suspended solids and certain waste flows, often impossible to meter otherwise, are dependably measured with magnetic flowtubes. The primary requirement is that the liquid have at least some minimum ability to conduct electricity.

CONTENTS . . .

FOXBORO®

PRINCIPLE OF OPERATION

The operation of a magnetic flowtube is based on Faraday's law of electromagnetic induction. Voltage (V_o) is induced in a conductor moving through a magnetic field.

The voltage is proportional to the intensity (T) of the magnetic field, multiplied by the length (D_e) and the velocity (v) of the conductor.

$$V_o = (T)(D_e)(v)$$

In a magnetic flowtube, process liquid is the conductor and the distance between electrodes (flowtube diameter) is the conductor length. Figure 1 illustrates the basic principle of operation. A magnetic field is created by coils outside the tube, and the process liquid flows through the field inside the tube. A flowtube must be built so that the generated voltage is not dissipated through the walls of the tube.

Figure 2 shows the key components of an actual magnetic flowtube. Two metal electrodes, mounted in the flowtube wall, sense the voltage induced by the flow of the process liquid. This voltage is directly proportional to the average velocity of the liquid passing through the flowtube. The flowtube coils are energized by an ac or pulsed dc power source depending upon its calibration. The magnetic field and resultant induced voltage have the same characteristics as the energizing current. The millivolt output signal is protected from interference by screens (shields) and amplified by a transmitter into a standard transmission signal.

The metering tube is basically a conduit for the process liquid. If the tube is metal, it must have a lining (which serves as an electrical insulator) on its inside wall. A pair of electrodes, extending through the wall of the tube, are essentially flush with the inside surface of the tube. The tube end connections are usually flanged for mounting in a pipeline. Flared ends for quick-disconnect clamps (sanitary flowtubes) and plain ends for Dresser couplings (largest sizes) are also used.

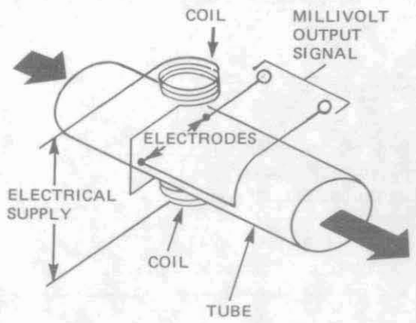


Figure 1. Operational Schematic Drawing

Mounted outside the tube are a pair of coils which create the electromagnetic field in the tube. A laminated transformer steel core mounts around the coils. This core completes the magnetic circuit and magnetically shields the measuring zone. Screened (shielded) leads connect the electrodes to terminals where the transmitter cable is attached. Except for the ends of the metering tube, the entire flowtube is enclosed by a sealed housing.

FLOWTUBE CONSTRUCTION

Metering Tubes

Basic Materials Because the magnetic field is created outside the tube, non-magnetic tube materials must be used. AISI 300 Series stainless steel—the standard for all Foxboro lined-metal flowtubes—does not limit or distort the magnetic field. It is available in the standard pipe sizes required and is a corrosion-resistant material. The four choices of lining for stainlees steel tubes are listed in Tables 1 and 2. A tabulation of tube materials and electrode metals is given in TI 27-71f. Data is included on chemical compatibility with various process liquids suitable for measurement by magnetic flowtubes.

Unlined Resin Tubes Also listed in Tables 1 and 2 are unlined glass fiber-reinforced resin flowtubes. Smaller diameter units (200 mm [8 in] and smaller) have epoxy resin as the glass bonding agent. Polyester resin is used in the larger tubes. In all sizes, the inner wall is a smooth glass-free resin surface. Measurement voltage cannot dissipate into the pipeline with these nonconductive/nonpermeable tubes. This eliminates the need for an insulating liner. Tubes of this construction are nonmagnetic. Reinforced resin flowtubes are lower in price than corresponding sizes of lined metal units, yet are suitable for a wide variety of applications.

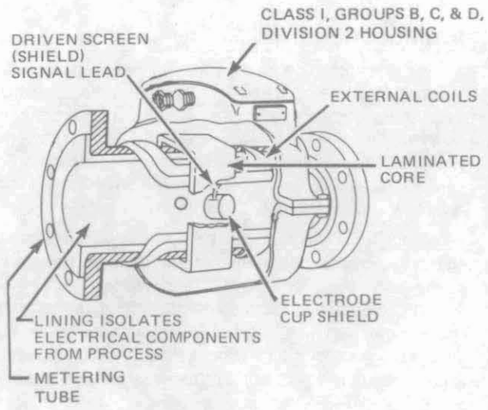


Figure 2. Cut-away View

Lining Flare Protection

In addition to spool pieces and other optional parts for flowtube flanges, a ptfe lining protection device is available. It consists of a pair of stainless steel rings which fit around the outer diameter of the flange raised faces and extend beyond the raised faces, approximately 15 mm (0.5 in) on each end. The rings are spot-welded in place. They help prevent lining damage if flange bolts are overtorqued. Also, if a prying tool is used to remove a flowtube from a pipeline, the rings help to prevent cuts in the lining flare. A pair of thick, solid ptfe gaskets are supplied to cover the lining flares (inside the rings) to effect a good flange joint seal without lining damage.

Conical Electrodes

Conical-shaped electrodes are optionally available on ptfe-lined 2800 Series Flowtubes from 25 mm (1 in) up to 300 mm (12 in) in size. There is a choice of AISI Type 316 stainless steel or Hastelloy C metal for these electrodes.

Low-Voltage Electrode Cleaning Assembly

This low-energy electrode cleaner is used to remove sludge and film deposits from the electrodes. The output of the cleaner is a nominal 24 V ac (50 or 60 Hz) through a current-limiting 5000 Ω resistor.

Ultrasonic Cleaning

To protect against the formation of insulative coatings on the flowtube electrodes (and eventual loss of measurement accuracy), an ultrasonic cleaner can be used. Foxboro offers a choice of cleaner options. With one option, the cable from the oscillator power supply is connected directly to terminals inside the flowtube housing. Another option is to have a junction box wired to the flowtube terminals. This option is used for the portable electrode cleaner. The 1.5 m (5 ft) screened (shielded) cable from the oscillator power supply is terminated with a connector which plugs into the junction box.

For most applications, the ultrasonic cleaner should be operated continuously to provide maximum protection against the formation of insulative coatings. For such cases, the direct-wired oscillator power supply is the most economical installation. When intermittent electrode cleaning is permissible, the portable ultrasonic cleaner can be used. With this option, the oscillator power supply can be easily disconnected from one flowtube and connected to another, permitting periodic cleaning of several electrodes using a single power supply.

The electrode cleaning action results from vibrations of 65 ±10 Hz impacted to the electrode surfaces. The cleaner itself consists of two main components: a pair of electrode drivers (inside the flowtube housing) and the external oscillator power supply. The drivers are mechanical assemblies of stainless steel parts and a washer-shaped piezo ceramic element. Electrostatic screening is utilized in ultrasonic cleaning assemblies to prevent any disturbance in the flow measurement. Ultrasonic cleaning is available with all 50 mm (2 in) and larger sizes of 2800 Series Flowtubes with standard housings and stainless steel electrodes. It is also available in 50 through 300 mm (2 through 12 in) flowtubes with Hastelloy C or titanium electrodes. It is not available with PTB approved versions of flowtubes.

High Calibration Accuracy for ac Systems

For 2800/E96 installations which require higher accuracy, optional system accuracy calibration can be performed in the Foxboro Flow Laboratory. This feature provides improved system accuracy because the particular flowtube and transmitter to be used together are calibrated together. These specially calibrated systems include a 2800 Series Flowtube (any size or version) with an E96 Series Transmitter and optional counter (if present). A Foxboro electronic recorder can also be included in a calibrated system.

Replaceable Metering Tube Assemblies

To enhance on-site repair capability of 2800 Series Flowtubes, precision replacement metering tubes are available. The lining and flanges are included, completely assembled with electrodes and wiring terminal blocks. A typical replacement tube assembly is illustrated in Figure 8. Other parts, such as field coils and housings, are also available as replacement items. They can be stocked and installed on site to minimize downtime. The simple replacement operation is described in Instruction MI 021-181.

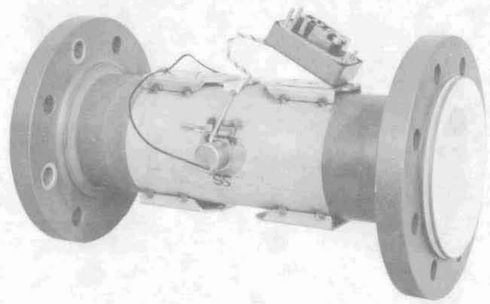


Figure 8. Replaceable Metering Tube Assembly

SUMMARY

Developed from the "know-how" of over 30 years of experience in manufacturing thousands of quality magnetic flowmeters for industry and specialized applications, Foxboro 2800 Series Magnetic Flowtubes offer excellent value. This discussion covers the proven design features of these flowtubes, and details their sturdy components and assembly techniques. Safety aspects and added versatility with optional features are also discussed. Many of the reasons are given for the high performance and dependability which make the 2800 Series Magnetic Flowtube your first choice for flow metering applications.

Piping Considerations

To avoid excessive lining wear from abrasives, and possible loss of accuracy, the upstream side of the flowtube should be mounted to a straight section of pipe which is at least five pipe diameters in length. Continuity between the flowing liquid and the flowtube is required to provide a reference for the measurement signal. With metal pipe connected to a flowtube flange, the continuity is provided by the pipe and the flange bolts. Installations in which nonmetal or lined-metal pipe is connected to the flowtube, earthing rings (grounding rings) must be used. These rings are installed between the pipe and the flowtube flanges. A wire between the grounding ring and one of the flange bolts provides the required continuity between the liquid and the metering tube. To provide positive contact with the liquid, the inner diameter of the grounding ring should be slightly less than that of the metering tube. A grounding ring is also sometimes installed in the upstream side of a lined metal flowtube to protect the inner edge of the liner from wear. This is especially true when measuring the flow of an abrasive liquid.

PRODUCT SAFETY

These flowtubes are designed to satisfy personnel safety requirements and to minimize potential shock and casualty hazards. They are also designed to be a minimum fire hazard by use of adequate insulation and separation of circuits. Standard requirements of Factory Mutual or Canadian Standards Association (FM or CSA) are generally fulfilled, as well as the concensus standards adopted by the Occupational Safety and Health Administration (OSHA). Meeting these standards generally satisfies similar requirements for use in other parts of the world.

ac Calibrated Flowtubes

For ac systems, the 2800 Series Flowtubes in sizes from 15 through 900 mm (1/2 through 24 in) are certified by FM and CSA as suitable for use in ordinary locations and in Class I, Groups B, C, and D, Division 2 hazardous locations. Sizes 2.5 and 6 mm (1/10 and 1/4 in) are certified by Foxboro for use in these same locations.

Pulsed dc Calibrated Flowtubes

For pulsed dc systems, 2800 Series Flowtubes in sizes 2.5 through 900 mm (1/4 through 24 in) are Foxboro self-certified for use in ordinary locations and in Class I, Groups B, C, and D, Division 2 hazardous locations as defined by FM or CSA.

OPTIONAL FEATURES

Hazardous Locations Installations

A Type Y purging option is available on 300 mm (12 in) and smaller sizes of pfa-, ptfe-, and polyurethane-lined flowtubes which are otherwise certified by FM or CSA for Division 2 hazardous locations. With Type Y purging, the atmosphere in the housing is maintained at Division 2 conditions in spite of a more hazardous Division 1 surrounding atmosphere. This permits operation in a Division 1 area if the outside of the housing and the purge air exhaust do not provide a possible source of ignition. The system is designed per the National Fire Protection Association (NFPA) "Purge Enclosures for Electrical Equipment" (document number 496). Prior to energizing the flowtube, there must be an initial purge equal to four times the internal housing volume. During operation, a purge flow rate indicator is required to verify purge protection.

For European use, an optional Physikalisch-Technische Bundesanstalt (PTB) approved version of ac-calibrated flowtubes is available. They can be supplied in sizes 15 mm (1/2 in) through 150 mm (6 in) with ptfe or polyurethane lining. The signal circuit is modified to meet the requirements of intrinsic safety by PTB definition for use in Group IIC, Zone 1 hazardous locations. They are PTB certified explosion-protected according to VDE 0171 protection methods "Intrinsic Safety" $(Ex)_iG5$, and "Increased Safety" $(Ex)_eG(3, 4, or 5)$. (Manufactured in The Netherlands). The flowtube must be used with the PTB certified version of the Foxboro E96 Series Transmitter. Mains connections meet PTB increased safety requirements. Among the limitations of these systems, ultrasonic cleaning and Type Y purging cannot be used. Also, field coils must be factory-wired for either series or parallel operation and cannot be changed on site.

Submersible Operation

The 2800 Series Flowtube can be encased in a watertight enclosure for continuous operation of the flowmeter when the flowtube is submerged in as much as 3 m (10 ft) of water. The housing is prepared with special RTV sealing and then pressure tested. The flowtube assembly is coated with N-55 Neoprene which provides a second moisture seal plus added protection against corrosion. An ample supply of RTV 602 potting compound is included to seal signal and power connections during installation.

Accidental Submergence

This option provides a watertight enclosure which protects the flowmeter from accidental submergence in as much as 9 m (30 ft) of water for a period of up to 24 hours. Typical use is in a municipal waste pit which could overflow during heavy rain. The housing is coated with an epoxy paint, sealed with RTV, and then pressure tested. A supply of RTV 602 potting compound is included to seal signal and power connections during installation.

Corrosion-Resistant Coating

For operation in extremely corrosive environments, a superior corrosion-resistance option is available for 300 mm (12 in) or smaller flowtubes. Applied to the housing is a chip-resistant, baked-on dispersion coating of vinylidene fluoride. It is porosity-free and nonpermeable, and it resists corrosion from most strong industrial chemicals, including hot caustic liquids.

ptfe Lined For ptfe-lined stainless steel tubes, the recommended maximum steady process temperature is 175°C (350°F). Because of this high temperature rating, and because of its inertness to a wide range of acids and bases, ptfe is the most widely used flowtube lining material. Preformed "tubes" of ptfe are mechanically fitted into the stainless steel tube, and the ptfe ends are flared out over the flowtube end connections to effectively isolate process liquid from the metallic tube.

pfa Lined Similar to the ptfe-lined flowtube, the pfa-lined stainless steel flowtube has a recommended maximum steady process temperature of 175°C (350°F) and is chemically inert to a wide range of acids and bases. Because of its moldability, pfa is used in the smallest sized flowtubes, i.e., 2.5 and 6 mm (1/10 and 1/4 in) sizes. The pfa is injection molded into the stainless steel tube and is flared over the end connections to form a gasket and isolate the process liquid from the metallic tube.

Polyurethane Lined In some applications, a ptfe flowtube lining does not have adequate abrasion resistance. Where extreme resistance to wear or erosion is required, due to solid particles in the process stream, a polyurethane lining is often the best choice. In 2800 series Flowtubes, the polyurethane lining extends over the flange raised face. Polyurethane is much more resilient and abrasion resistant, but cannot be used at high temperatures or with strong acids or bases.

Neoprene Lined Neoprene is a flowtube lining material which combines some of the resistance to chemical attack of ptfe with a good degree of abrasion resistance. In 2800 Series Flowtube construction, a Neoprene lining also extends out over the flange raised face. Neoprene-lined flowtubes, with a slightly higher temperature rating than polyurethane-lined, are general-purpose units.

Sanitary Lined A ptfe-lined flowtube, with quick-disconnect sanitary end connections, is used in consumable product processes. These sanitary flowtubes are ideally suited for use with dairy products, beer, soft drinks, coffee, molasses, and corn syrup. Processed products, such as catsup and other viscous, sticky, or otherwise difficult-to-measure liquids, are also easily measured. The sanitary flowtube, shown in Figure 3, is of crevice-free construction which permits CIP (clean-in-place) operation. It meets 3-A standards, and U.S. Food and Drug Administration regulations for food contact service.

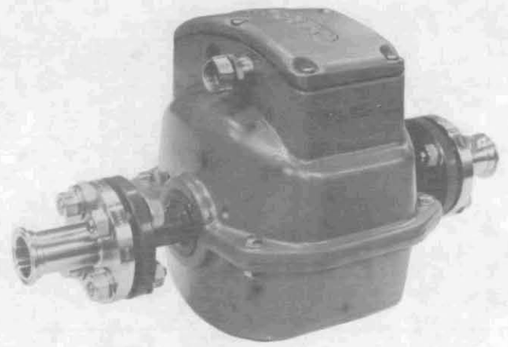


Figure 3. Sanitary Flowtube

Table 1. 2800 Series Flowtubes with ac Coil Excitation

Nominal Flowtube Size		Power Supply Frequency (Hz)	Flow Units	Nominal Upper Range Value Flow Rates[a][b]							
				ptfe or pfa Lined		Polyurethane Lined		Neoprene Lined		Unlined Glass Fiber	
mm	in			Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
2.5	1/10	50 or 60	L/s U.S. gpm	0.0050 0.080	0.038 0.60						
6	1/4	50 or 60	L/s U.S. gpm	0.032 0.50	0.25 4.0						
15	1/2	50 or 60	L/s U.S. gpm	0.14 2.2	0.75 12						
25	1	50 or 60	L/s U.S. gpm	0.50 8.0	3.0 50						
40	1 1/2	50 or 60	L/s U.S. gpm	1.25 20	7.6 120						
50	2	50 or 60	L/s U.S. gpm	2.0 32	13 200	1.4 22	7.6 120			1.8 29	10 160
80	3	50 or 60	L/s U.S. gpm	4.5 70	30 500	3.8 60	24 385			4.5 70	25 400
100	4	50 or 60	L/s U.S. gpm	8.2 130	52 820	6.4 100	41 650			8.2 130	48 750
150	6	50 or 60	L/s U.S. gpm	19 300	115 1825	16 260	110 1800			19 300	110 1770
200	8	50 or 60	L/s U.S. gpm	34 520	200 3150	30 480	210 3300			32 520	200 3120
250	10	50 or 60	L/s U.S. gpm	50 800	320 5000	48 750	340 5400			50 800	310 4900
300	12	50 or 60	L/s U.S. gpm	75 1200	450 7150	70 1100	500 7900			70 1100	445 7050
350	14	50	L/s U.S. gpm			95 1500	680 10800	95 1500	550 8800	95 1500	535 8500
		60	L/s U.S. gpm			115 1800	680 10800	115 1800	550 8800	115 1800	535 8500
400	16	50	L/s U.S. gpm			125 2000	900 14200	125 2000	720 11500	125 2000	695 11000
		60	L/s U.S. gpm			150 2400	900 14200	150 2400	720 11500	150 2400	695 11000
450	18	50	L/s U.S. gpm			160 2500	1150 18200	160 2500	930 14700	160 2500	880 14000
		60	L/s U.S. gpm			190 3000	1150 18200	190 3000	930 14700	190 3000	880 14000
500	20	50	L/s U.S. gpm			200 3150	1430 22600	200 3150	1160 18400	200 3150	1100 17500
		60	L/s U.S. gpm			240 3800	1430 22600	240 3800	1160 18400	240 3800	1100 17500
600	24	50	L/s U.S. gpm			320 5000	2050 32500	320 5000	1690 26800	320 5000	1580 25000
		60	L/s U.S. gpm			380 6000	2050 32500	380 6000	1690 26800	380 6000	1580 25000
750	30	50	L/s U.S. gpm			475 7500	3250 51500	475 7500	2670 42200	475 7500	2570 40800
		60	L/s U.S. gpm			570 9000	3250 51500	570 9000	2670 42200	570 9000	2570 40800
900	36	50	L/s U.S. gpm			660 10500	4730 75000	660 10500	3860 61200	660 10500	3720 59000
		60	L/s U.S. gpm			790 12500	4730 75000	790 12500	3860 61200	790 12500	3720 59000

[a]For all but the 2.5 mm (1/10 in) flowtube, the minimum upper range value flow rates can be reduced to 50% of the value listed. This is accomplished by using an alternate coil connection and/or voltage arrangement. Refer to PSS 1-6B5 A and PSS 1-6B5 C.
[b]Recommended limits. Flow velocities to 9 m/s (30 ft/s) are permissible but may accelerate lining wear.

In dc systems, power is wired directly to the transmitter. Flowtube coil excitation power (pulsed dc) is supplied by the 896 Transmitter. Any signal variations caused by line voltage or frequency variations are small and are compensated by the transmitter.

Minimum and Maximum Flow Rates

With an 896 Series Transmitter, the minimum process-liquid upper range value (full scale) velocity is 0.3 m/s (1 ft/s). For a particular flowtube, upper range value (full scale) flow rate can be calculated by using the applicable area-times-velocity formula. The area can be determined by using the inner diameter (ID) given in tables in the flowtube Product Specification Sheet (PSS).

With an E96 Series Transmitter, the minimum upper range value (full scale) flow rate for a particular flowtube is dictated only by what flow will generate 1 mV; i.e., a velocity of 0.50 m/s (1.65 ft/s). The reason for this is that 0 to 1 mV is the lowest span acceptable by the transmitter. For example, a 25 mm (1 in) ptfe-lined flowtube, with series-connected coils powered by 120 V ac, produces 2.00 mV per L/s (0.125 mV per U.S. gpm). These values are the published nominal calibration factors, and dividing them into 1 mV, gives the minimum upper range value flow rate: 1 × 2.00 = 0.5 L/s (1 × 0.125 = 8 U.S. gpm). However, this flow rate corresponds to a very low process liquid velocity, approximately 1.1 m/s (3.5 ft/s). When the velocity of a "dirty" liquid is this low, suspended materials tend to settle. Therefore, when the application is for a liquid known to deposit coatings inside the pipe, the flowtube should be sized for as high a velocity as possible to help keep potential coating materials moving with the stream and to scrub away previously-formed deposits. See "Buildup in Flowtubes" section.

Recommended maximum upper range value (full scale) flow rates are based upon velocities of 6.1 m/s (20 ft/s) in ptfe and Neoprene lined-metal, as well as in unlined resin tubes. In pfa and polyurethane lined-metal tubes, maximum flow rates are based on velocities of 7.6 m/s (25 ft/s). These recommendations (although based upon wear-and-tear resistance of the tube material) are somewhat arbitary, and some users choose to exceed them. There are potential problems in doing this. Primarily, accelerated wear inside the tube will shorten the life of the flowtube. Also, there is a greater chance of damaging a flowtube (especially an unlined glass fiber-reinforced resin tube) if a severe hydraulic shock (usually caused by excessively fast valve action) occurs during a period of excessively high liquid velocity. Such pressure surges ("water hammer") must be avoided, for example, above 4.5 m/s (15 ft/s) in 50 mm (2 in) size resin flowtubes, and above 1.5 m/s (5 ft/s) in 300 mm (12 in) size resin flowtubes. Apart from these considerations, magnetic flowmeters can operate satisfactorily, even when there are excursions in flow rate above recommended maximums. However, the design of Foxboro magnetic flow transmitters limits the upper range value (full scale) flow rate to a maximum of 9 m/s (30 ft/s).

Buildup in Flowtubes

Low-level voltage, generated by liquid flowing through the magnetic field, is conducted into the leads (and transmitter circuits) by the electrodes. If coatings form on the electrodes and create a very high resistance, the measurement signal can become erratic. A coating on the liner can also be troublesome in some cases.

To prevent error-causing electrode coatings, attention should first be directed to proper sizing of the flowtube. With "clean" liquids—those which do not precipitate nonconductive coatings on the electrodes—flowtube sizing is a simple matter.

It is usually assumed, that if a flowtube has the same diameter as the pipeline, it is properly sized. This is not always true with "dirty" liquids, even if the upper range value flow rate is within the published minimum and maximum for the flowtube. For instance, an expected flow rate of 5 L/s (80 U.S. gpm), in an 80 mm (3 in) ptfe-lined flowtube, amounts to approximately 1.2 m/s (3.8 ft/s) velocity. If the liquid tends to make deposits, a better choice would be a 50 mm (2 in) flowtube in which this same flow rate gives approximately 2.4 m/s (8 ft/s). If pressure drop in the pipeline is not critical, a 40 mm (1 1/2 in) flowtube could also be considered because of the much higher velocity, almost 4 m/s (14 ft/s).

In some "dirty" liquid applications, high velocity is either impractical or ineffective as a means of keeping electrodes clean. For liquids not containing abrasive particles, altering the flow profile or increasing liquid turbulence with pipe elbows or other flow conditioning devices is sometimes an adequate solution to this problem. However, if the liquid does contain abrasive particles, consideration must be given to another potential problem: impact of abrasive flow upon a lining can accelerate wear.

Standard electrodes are essentially flush with the inside surface of the flowtube. At this surface, the liquid velocity is minimal, even at high flow rates. For process liquids which leave deposits on electrode surfaces, optional conical electrodes which protrude into the flowstream, might be successfully applied. The cones extend in from the tube wall to where the liquid velocity is more likely to inhibit coating.

For applications where these techniques do not solve coating problems, Foxboro offers a unique choice of two electrode cleaning options. One of the choices, the low-voltage electrode cleaning technique, provides a means of applying a low voltage between electrodes and liquid to remove buildup. The other electrode cleaning device available on 2800 Series Flowtubes is an ultrasonic oscillation type. Ultra-high speed mechanical motion of the electrodes prevents or removes many kinds of coatings. Both of these choices are listed in "Optional Features" on Page 11.

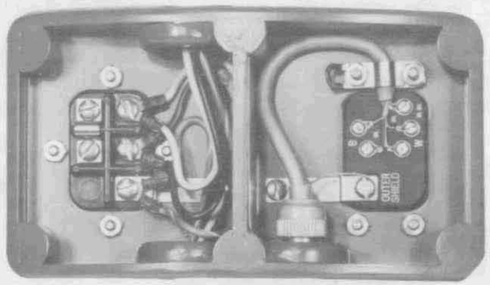


Figure 6. Connection Boxes

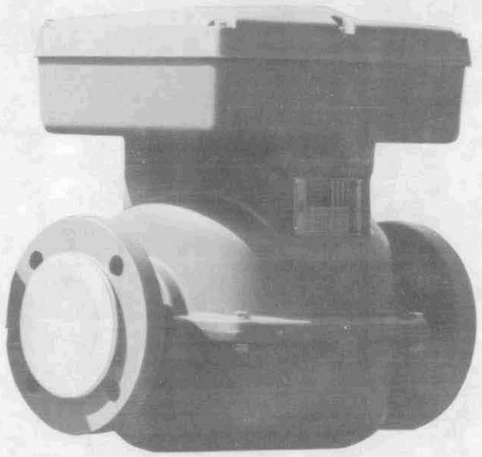


Figure 7. Transmitter Integral with Flowtube

INDUSTRIAL APPLICATIONS

Wide Areas of Use

Magnetic flowmeters are considered to be the only solution for certain difficult-to-handle (hot, corrosive, abrasive, solids-bearing, etc.) liquid or slurry metering applications. There are no differential pressure taps to become clogged or require purging. Long meter runs are normally not necessary. Magnetic flowtubes have no greater pressure drop or obstruction to flow than equivalent lengths of straight pipe. Relatively easy to install, they can be mounted at any pipeline angle. The only consideration is that the tube must be full of liquid.

Many industrial process plants necessarily have large numbers of magnetic flowtubes. In such a plant, standardization on magnetic flowtubes is an often-used means to avoid spare parts inventories for different kinds of flowtubes (and to simplify maintenance routines).

Electrical conductivity of the process liquid is the fundamental limiting factor for the application of magnetic flowmetering. Most industrial process liquids have great enough conductivity. For example, city water at 60 to 100 µS/cm or mmho/cm, or various strong acid or base solutions at as much as 10 000 µS/cm or µmho/cm. Usually, 2 µS/cm or µmho/cm, a typical value for distilled water, is regarded as the minimum. Liquids with lower conductivity values can be considered, but they must be examined on an individual basis. The lower limit in any particular application depends upon the length of cable between flowtube and transmitter.

Selecting E96 or 896 Systems

Foxboro E96/2800 magnetic flow metering systems provide accurate flow measurement for virtually all types of conductive liquids in a variety of applications.

The Foxboro 896/2800 magnetic flow metering systems provide very high accuracy flow measurement on many types of conductive liquids and range of applications. However, these systems should not be used for certain applications. For example:

- non-homogeneous liquids
- slurries with high solid content
- processes with entrained air or gases
- applications involving fast changing or pulsating flows

Process Variations

Conductivity changes in process liquids can occur due to changes in composition and other reasons. However, if the conductivity value does not drop below acceptable levels, this will not affect accurate magnetic flow measurement.

A magnetic flowmeter measures the average liquid velocity through the flowtube. Variations in liquid composition (unless they change velocity or reduce conductivity below the minimum) have no effect on the measurement. For example, viscosity or density changes do not affect magnetic flow measurements.

Also, changes in process liquid temperature or pressure have no effect. These parameters, and combinations of them, must only be maintained within the wide limits published in 2800 Series Flowtube specifications.

In ac systems, variation in line voltage or frequency will cause a change in the measurement voltage generated. Automatic compensation is made for these variations by the transmitter. For accurate, total compensation to be effective, power must be wired directly to the flowtube and supplied, in parallel, to the transmitter from terminals in the flowtube connection box. In this way, the exact voltage, phase, and frequency that excites the coils, is fed to transmitter compensation circuits. This design does not allow for wiring shortcuts. Following this procedure assures that complete, accurate compensation is made for any voltage surge or drop and any line frequency variation.

Table 2. 2800 Series Flowtubes with Pulsed dc Coil Excitation

Nominal Flowtube Size		Flow Units	Nominal Upper Range Value Flow Rates[a]							
			ptfe or pfa Lined		Polyurethane Lined		Neoprene Lined		Unlined Glass Fiber	
mm	in		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
2.5	1/10	L/s U.S. gpm	0.0025 0.040	0.038 0.60						
6	1/4	L/s U.S. gpm	0.0012 0.019	0.25 4.0						
15	1/2	L/s U.S. gpm	0.038 0.60	0.75 12						
25	1	L/s U.S. gpm	0.15 2.3	3.0 50						
40	1 1/2	L/s U.S. gpm	0.38 6.0	7.6 120						
50	2	L/s U.S. gpm	0.66 10.5	13 200	0.32 5.0	7.6 120			0.50 8.0	10 160
80	3	L/s U.S. gpm	1.5 23	30 500	0.98 22	24 385			1.3 20	25 400
100	4	L/s U.S. gpm	2.5 40	52 820	1.6 26	41 650			2.5 40	48 750
150	6	L/s U.S. gpm	5.7 90	115 1825	4.4 70	110 1800			5.7 90	110 1770
200	8	L/s U.S. gpm	10 160	160 3150	8.2 130	210 3300			10 160	200 3120
250	10	L/s U.S. gpm	16 250	320 5000	14 220	340 5400			16 250	310 4900
300	12	L/s U.S. gpm	22 350	450 7150	20 320	500 7900			22 350	445 7050
350	14	L/s U.S. gpm			27 430	680 10800	28 440	550 8800	26 420	535 8500
400	16	L/s U.S. gpm			36 570	900 14200	36 580	720 11500	35 550	695 11000
450	18	L/s U.S. gpm			46 730	1150 18200	47 740	930 14700	44 700	880 14000
500	20	L/s U.S. gpm			114 1815	1430 22600	116 1840	1160 18400	109 1730	1100 17500
600	24	L/s U.S. gpm			246 3900	2050 32500	252 4000	1690 26800	237 3750	1580 25000
750	30	L/s U.S. gpm			391 6200	3250 51500	397 6300	2670 42200	388 6150	2570 40800
900	36	L/s U.S. gpm			568 9000	4730 75000	580 9200	3860 61200	568 9000	3720 59000

[a]Recommended limits. Flow velocities to 9 m/s (30 ft/s) are permissible but may accelerate lining wear.

Electrodes The standard electrode in 2800 Series Magnetic Flowtubes is AISI Type 316L stainless steel. This metal satisfies the non-magnetic requirement, and has more than adequate corrosion resistance for many applications. Platinum–10% iridium and other more highly corrosion resistant electrode metals, including Hastelloy C, titanium, and tantalum, are optionally available on certain 300 mm (12 in) and smaller size flowtubes.

On 15 mm (1/2 in) and larger size flowtubes, the electrodes are inserted from inside the tube*. The threaded end of the electrode extends outside the tube. Flush with the tube inside wall, the head of the electrode bears against the lining surface. On lined-metal tubes, electrodes are electrically insulated from the tube. An electrode assembly for a ptfe-lined flowtube is shown in Figure 4.

Special care is given to electrode sealing. Electrodes are bonded into unlined glass fiber-reinforced resin flowtubes to assure electrode seal integrity. In polyurethane-lined flowtubes, the electrodes are molded in the liner. Equally good sealing is obtained by torquing electrodes against Neoprene linings. The characteristic cold flow property of ptfe and pfa, however, has to be overcome by more rigorous electrode sealing procedures. Electrode sealing surfaces are grooved to provide additional sealing surface and to firmly grip the lining. When installed, the electrodes are tightened firmly against the lining. The correct sealing pressure against the ptfe is maintained by a series of Belleville spring washers. With a pfa liner, the correct sealing pressure is maintained by means of a coil spring.

Pipeline Connections Flange end connections are the usual means of mounting a flowtube into a process pipeline. On 300 mm (12 in) and smaller sizes of lined-metal flowtubes, slip-on (welded) AISI Class 150 RF (raised face) or PN 10 flanges are standard. The flange material is either stainless steel [for 2.5 and 6 mm (1/10 and 1/4 in) sizes] or carbon steel [for 15 through 300 mm (1/2 through 12 in) sizes]. The larger lined-metal flowtubes are supplied with AWWA Class 125 flat face or PN 10 raised face carbon steel flanges.

Sanitary flowtubes have stainless steel extensions with quick-disconnect type connections. The extensions are bolted to the flanged ends of a ptfe-lined flowtube. Flowtube with ANSI Class 150 flange has a Tri-Clover extension which mates to a Tri-Clamp on the process piping. Flowtube with PN 10 flange has a sanitary coupling extension (DIN 11851, BS 1864, BS 4825, or ISO 2853, as specified) with an external thread. Mating clamps, connections, and gaskets are supplied by the user. Sanitary flowtubes are used with the next larger line size as listed in the table below.

Sanitary Flowtube and Corresponding Line Sizes

Nominal Flowtube Size		Nominal Line Size	
mm	in	mm	in
15	1/2	25	1
25	1	40	1 1/2
40	1 1/2	50	2
50	2	80	3
80	3	100	4

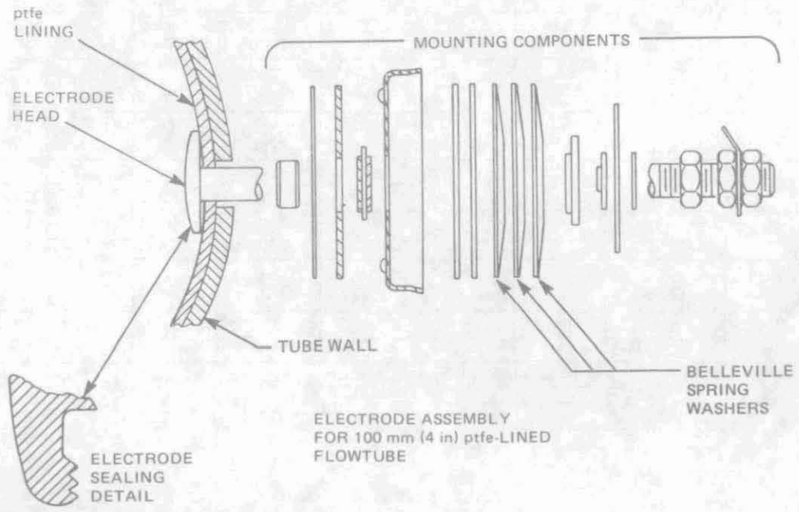


Figure 4. Electrode Assembly

*On the two smaller sizes, electrodes are inserted from outside the tube.

On unlined resin flowtubes, flat-face flanges (of the same material as the tube) are standard for 600 mm (24 in) and smaller sizes. The largest unlined resin flowtubes, 750 and 900 mm (30 and 36 in), have plain ends suitable for use with Dresser couplings.

Various optional flanges are available. Up to 200 mm (8 in) sizes of ptfe- and polyurethane-lined 2800 Series Flowtubes can be supplied with heavier flanges, ANSI Class 300 RF, PN 40, etc. Also available are AISI Type 316 stainless steel flanges with selected flowtubes.

Process Earth (Ground) The electrical continuity of the process and pipeline must be maintained. This is accomplished through the metal tube and the flange bolts (or quick-disconnect clamps). With unlined resin tubes, it is achieved by means of a metal strip on the outside of the flowtube, in contact with the flange bolts. When the flowtube is connected to a lined or non-metal pipe, earthing rings (grounding rings) are used to provide the required continuity. Use of grounding rings is discussed later in "Piping Considerations."

Coil Assembly and Lead Wires

Coils The design for the 2800 Series Flowtube coils has been enhanced by many years of experience in producing dependable industrial-grade magnetic flowtubes. High wire density (see Figure 5) allows a strong magnetic field to be generated in a minimum space with low power consumption. On ac systems, the coils can be connected in series or parallel. They are normally connected in series for minimum power consumption. When they are connected in parallel, the magnetic field is doubled, and the flowtube output signal is thus doubled. As noted in a footnote of Table 1, this permits lower minimum upper range values. Coil wires have high temperature insulation so as not to be a factor in determining high process temperature limits. Coils for 300 mm (12 in) diameter and smaller sizes, have a rectangular cross-sectional area to provide a precise, extremely sturdy assembly. All sizes of 2800 Series Flowtubes are virtually immune to shock or vibration.

Core The purpose of the core, which is mounted around the coils, is to complete the magnetic circuit and to magnetically shield the measuring zone. To minimize power waste and heat buildup from eddy currents, the core is laminated transformer steel. The core/coil/tube assembly is an extremely sturdy unit, built for dependable and accurate performance, despite heavy mechanical shock or pipeline vibration.

Lead Wires Protected by driven screens (shields), lead wires conduct the low-level measurement voltage from the electrodes out through the magnetic field to terminals for connection to a transmitter. A separate driven screen encloses each measurement lead wire. These screens are driven by the transmitter to the same potential and phase as are on the leads, providing the ultimate protection against signal loss due to capacitance. Proper positioning of the leads within the housing, in the magnetic field, minimizes spurious voltage pickup and distortion of the measurement. Access is provided on 2800 Series Flowtubes to adjust lead wires to the optimum contour. This is used when field repairs (especially replacement of a flowtube) are required.

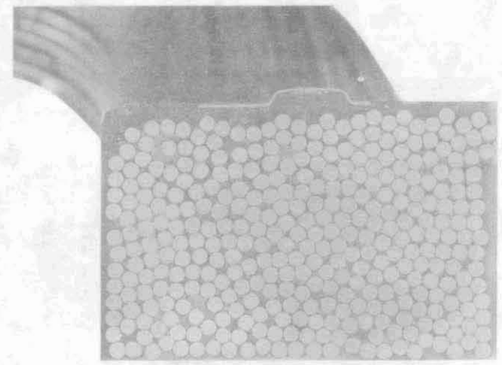


Figure 5. Field Coil Cross-section

Housings

The coils, cores, wires, etc., of 2800 Series Flowtubes are enclosed by a sealed housing for protection from moisture or other harmful external elements. Two integral but separate connection boxes, one for power and the other for measurement wiring (see Figure 6), are located at the top of the housing. When used in ac systems, jumpers in the power connection box are used to connect the coils either in series or parallel. Because magnetic flowtubes must often operate in harsh environments, housing materials must withstand a variety of corrosive atmospheres. For flowtubes 300 mm (12 in) diameter and smaller, low-copper content cast aluminum alloy is the housing material; these housings meet IEC IP65 requirements and provide the environmental protection of NEMA Type 4. Steel housings, which meet IEC IP65 and CSA 4 requirements and provide the environmental protection of NEMA Type 4, are used for larger flowtubes.

The high heat-dissipation rates of these metal enclosures contribute to lower temperature operation. All flowtube housings are made in two pieces, gasketed with silicone rubber sealants and bolted together, and are protected by a high-build epoxy paint*. Two versions of flowtube-mounted secondary magnetic flow instruments, the 896T and E96T Series Transmitters (see Figure 7), are available for use with 300 mm (12 in) diameter or smaller 2800 Series Flowtubes. The 896T requires pulsed dc flowtube calibration; the E96T requires ac flowtube calibration.

*A baked vinyl finish may be used depending on plant of manufacture.

Instruments and Systems for Indicating, Recording, Controlling . . .

Air Weight
Btu
Capacitance
Composition
Compression
Concentration, Solution
Conductivity, Solution
Consistency
Current — a-c, d-c
Density
Dew Point
Displacement
Drag
Flow
Force
Gas Analysis
Humidity
Interface
Ion Selection
Liquid Analysis
Liquid Level
Load
Moisture Content
Motion
Motor Load
Operation, Schedule
Operation, Time
Oxidation-Reduction Potential
pH
Position
Power, Electric
Pressure
Resistance, Electric
Sheet Moisture
Sheet Weight
Specific Gravity
Speed
Strain
Stress
Temperature
Tension
Thrust
Torque
Vacuum
Viscosity
Voltage
Weight

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

FOXBORO®

MS 0283

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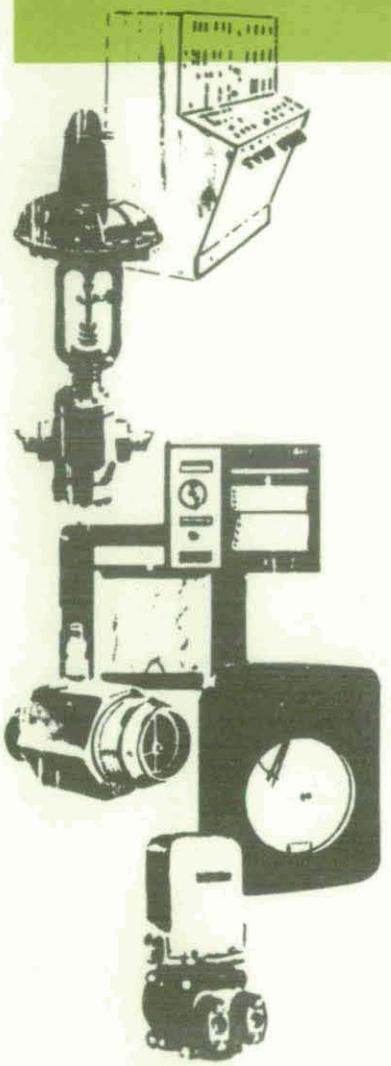
INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct installation of your Foxboro Instruments, and in their proper operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number.*

Book No. 0 2438

FOXBORO

Foxboro Yoxall
A Division of Foxboro Great Britain Limited

Redhill Surrey England
RH1 2HL
Tel: Redhill (0737) 65000
Telex: 892852
Telegram: Yoxbri Redhill

Guarantee

The Company undertakes to replace free of charge any component of its own manufacture (which excludes electronic tubes) which, in the opinion of the Company, is not within the specified limit of calibration or is defective in material or workmanship under normal or proper use, provided that the same is returned at the customer's risk and expense to the Company's works within twelve months from the date of the despatch by the Company of the equipment to the customer.
All representations, conditions, guarantees and warranties by law or otherwise howsoever expressed or implied are hereby excluded to the intent, except as above provided, after delivery to and acceptance by the customer of any equipment or apparatus, the Company shall not be liable for any loss, damage, injury, delay or expense or consequential loss or damage howsoever arising from or in respect of the equipment or apparatus or the use thereof.

Pyrometer Thermocouples, Resistance Thermometer Bulbs, and Protection Tubes, on account of the severity of their usage, are not subject to replacement unless returned unused.

The Company shall not be liable for loss, damage, detention or delay caused by fire, strike, civil, or military authority, insurrection or riot, or for other cause beyond its reasonable control. Acceptance of apparatus by the Purchaser shall constitute a waiver of all claims for delay.

Service

The Company is anxious to be of every possible assistance to you, to ensure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service in the British Isles should be made with the Company at Redhill. In other parts of the World arrangements should be made through the nearest Representative and/or Factory listed at the end of this book.
A unique feature of Foxboro service — of particular interest to Companies which do not have Instrument Departments or enough qualified Staff to carry out regular inspection and maintenance — is the Service Contract. Under this arrangement, a Foxboro Service Engineer will call at stated intervals to check the condition and operation of all Foxboro Instruments in your Plant. The Service Contract is also used by Companies for the routine inspection and maintenance of highly technical instrumentation which requires specialised knowledge and experience.
The Company provides an expertly staffed and fully equipped Training Centre at Redhill devoted to the instruction of customers' Instrumentation Engineers and Service Men. The courses cover: theory of operation maintenance and application of the principal types of instruments. Applications from Companies in the British Isles should be made to Redhill, Surrey; from those in other parts of the world, to our nearest Representative as listed at the end of this book.

Parts

Parts Lists for Foxboro Instruments may be obtained by writing to the above address. It is strongly urged that only genuine Foxboro parts be used. Always give the serial number from the instrument data plate when requesting parts lists or ordering parts. (Those unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment, should not be permitted to undertake any major service work.)

Replacement

The Company has considerable knowledge and experience in regard to the economic life of Foxboro instrument equipment and will give advice on the desirability or otherwise, of fitting new parts into the older models. Improvements in design, materials, or methods sometimes make it more economic to replace rather than repair an instrument which has been in service for a long period of time.

Charts

To obtain the most accurate and consistent recording performance from our instruments, we strongly recommend the use of genuine Foxboro strip and circular charts.

FOXBORO

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

FOXBORO®

MB 100

Printed in England

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Instruction

MI
020-336
January 1983

821GM SERIES
GAUGE PRESSURE TRANSMITTER

INTRODUCTION

Figure 1

The 821GM Series Gauge Pressure Transmitter uses the resonant wire principle to measure pressure. The transmitter transforms this measurement to a proportional electric signal.

The output of the pressure sensor is a frequency signal. In the milliampere-output transmitter, the frequency signal is converted, within the transmitter, to a milliampere signal. In the frequency-output transmitter, the frequency signal is transmitted to a SPEC 200 input component, where the frequency signal is converted to a 0 to 10 V dc signal.

SUPPLEMENTAL INSTRUCTIONS

This instruction covers the milliampere-output transmitter, and unless otherwise noted, also covers the frequency-output transmitter. Some topics contain material that only applies to the milliampere-output transmitter. Information in these topics for the frequency-output transmitter is covered in Instruction MI 020-340.

For a detailed principle of operation of the transmitter, see Technical Information TI 37-76a (milliampere output), or TI 37-75c (frequency output).

For detailed information on international codes and safety standards, see Technical Information TI 005-100, obtainable from Foxboro.

CONTENTS...

FOXBORO®

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STANDARD SPECIFICATIONS

Measurement Limits:

SENSOR RANGE	MPa		psi	
	RANGE*	SPAN**	RANGE*	SPAN**
LOW	-0.1 and +0.35	0.07 and 0.35	-15 and +50	10 and 50
MED	-0.1 and +1.0	0.2 and 1.0	-15 and +150	30 and 150
HIGH	-0.1 and +4.2	0.8 and 4.2	-15 and +600	120 and 600

*Upper limits are different for frequency-output; see Instruction MI 020-340.
**Limits listed are overall limits for each sensor. Actual values depend on position of span jumper; see Page 8.

Maximum Overrange: 150% of upper range limit
Output Signal:
4 to 20 mA
10 to 50 mA
Frequency
} as specified on data plate
Process Connection: Tapped for 1/4 NPT, 1/2 NPT, R 1/4, or R 1/2; as specified.
Temperature Limits
Process: Silicone Oil Fill, -40 and +120°C (-40 and +250°F); or Fluorinert Oil Fill, -18 and +80°C (0 and 180°F); as specified
Ambient: -40 and +80°C (-40 and +180°F)
Power Supply: See Page 5
Output Load: See Figure 9

Power Consumption: 4 to 20 mA output, 1.25 W max; 10 to 50 mA output, 3.5 W max; frequency output, 2.5 W max
Accuracy: ±0.2% of span
Housing: Weatherproof, dusttight, and watertight, as defined in IEC IP65 and NEMA Type 4.
Zero Suppression: Up to 300% of minimum span limit. Sum of span plus suppression cannot exceed upper range limit of sensor.
Zero Elevation: Zero can be elevated up to a full vacuum.
Mass (approximate): 5 kg (11 lb)
Electrical Classification: See Figure 2

TRANSMITTER IDENTIFICATION

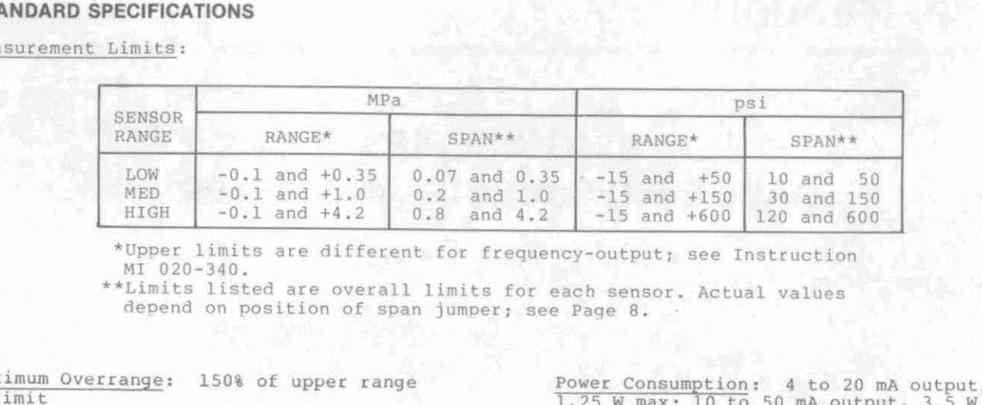


Figure 2

TO REPLACE SENSOR

1. Disconnect external wiring and process piping.
2. Disconnect violet and gray wires from terminals on electronics module. Loosen captive screws on module (Figure 27).
3. Lift out module (with remaining wires attached) to expose stop screw. Loosen screw.
4. Loosen locknut so that locking plate falls from recess in topworks.
5. Unscrew sensor (about six turns) from topworks. While unscrewing sensor, rotate violet and gray pair of wires so that they do not twist. When sensor is separated from topworks, ease wires out of topworks.
6. Lift off locking plate and locknut from old sensor and position them onto new sensor. Sides of plate must be parallel to sides of sensor.
7. Remove the four bolts that hold sensor and cover together. Remove cover.
8. Lubricate threads and O-ring on neck of new sensor with silicone grease.
9. Install cover with new gasket on sensor. Lightly lubricate bolts. Tighten bolts gradually and uniformly to a torque of 27 N·m (20 lb·ft).
10. Thread sensor wires up into topworks. Screw sensor and topworks together as far as they will go. Rotate violet and gray pair of wires so that they do not twist.
11. Tighten stop screw and then back off 1/4 turn (head of screw should be below surface of casting). Unscrew topworks until stop screw hits stop.
12. If in Step 11, topworks was rotated at least 3/4 of a turn, proceed to Step 13.

    If topworks could not be rotated 3/4 of a turn, loosen stop screw and unscrew topworks an additional 1/4 turn. Tighten stop screw and back off screw about 1/4 turn.
13. Orient topworks (with respect to sensor assembly) in desired position. Insert locking plate up into recess in topworks and tighten locknut.
14. Position tie-wrap that is attached to violet and gray wires behind plate on rear of module. Connect wires to terminals.

    Position both pairs of wires in groove of module.
15. Position module in housing. Tighten captive screws, making sure that no wire will be crimped.
16. Complete A ADJ potentiometer adjustment (Figure 26) as follows:
    a. Connect voltmeter to BAL TEST terminals. Set up bench calibration equipment (Figure 16).
    b. With no calibrating pressure on transmitter, adjust ZERO screw so that voltmeter at BAL TEST terminals reads 0.000 ±0.002 V.
    c. Adjust A ADJ potentiometer so that voltmeter in output loop reads 2.000 ±0.002 V.
17. Calibrate transmitter.

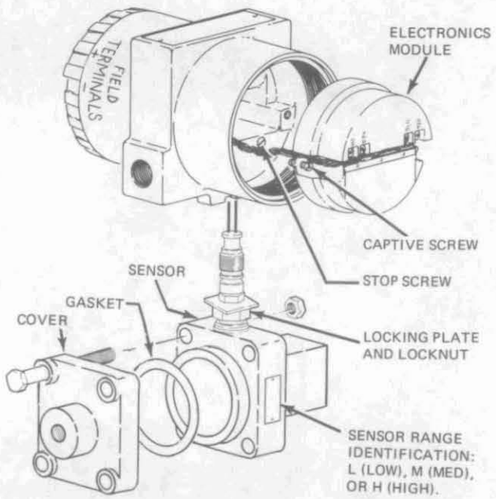


Figure 27

SPEC 200 is a trademark of The Foxboro Company.

TO REPLACE ELECTRONICS MODULE

1. Turn off power. Remove topworks cover from operating-adjustment compartment.

2. Disconnect the two pairs of wires (Figure 25) from terminals. Note how pairs are positioned in grooves in electronics module.

3. Loosen the two captive screws that hold module to housing. Lift out module. Cut tie-wrap that holds red and blue pair to rear of module.

4. Connect blue and red wires to new module; note color identifications at terminals.

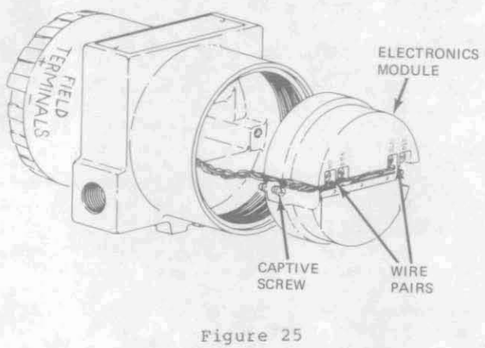


Figure 25

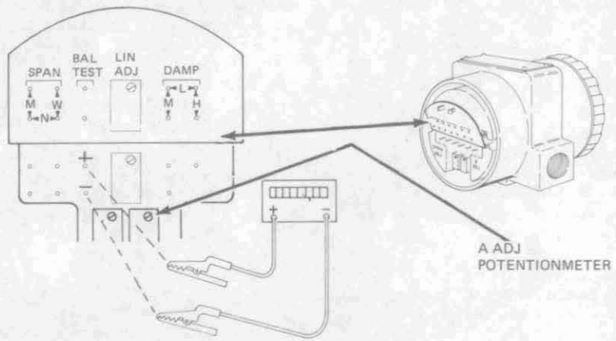


Figure 26

5. Position these wires in side groove of module, and fasten pair with a tie-wrap to rear of module.

6. Position tie-wrap that is attached to violet and gray wires behind plate on rear of module, and position these wires in groove of module. Connect wires to terminals.

7. Position module in housing. Tighten captive screws, making sure that no wires will be crimped.

8. Complete A ADJ potentiometer adjustment (Figure 26) as follows:

   a. Connect voltmeter to BAL TEST terminals. Set up bench calibration equipment (Figure 16).

   b. With no calibrating pressure on transmitter, adjust ZERO screw so that voltmeter at BAL TEST terminals reads 0.000 ±0.002 V.

   c. Adjust A ADJ potentiometer so that voltmeter in output loop reads 2.000 ±0.002 V.

9. Calibrate transmitter.

INSTALLATION

TRANSMITTER DIMENSIONS

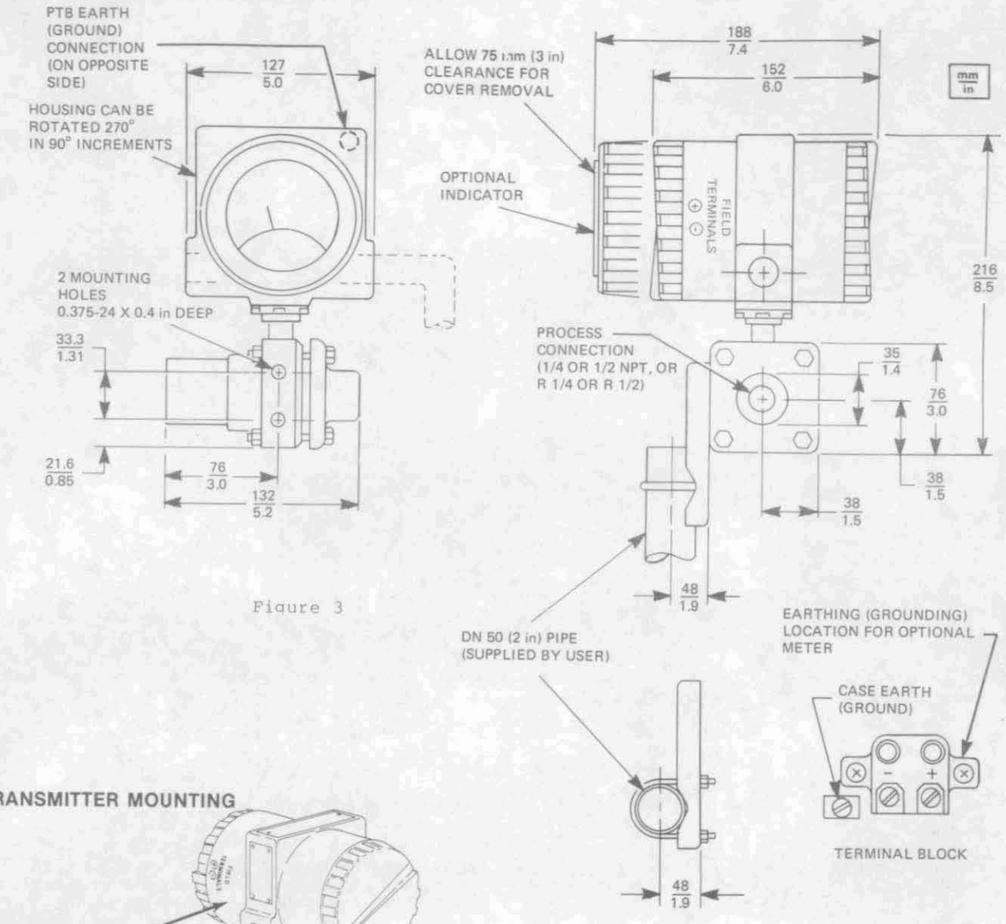


Figure 3

TRANSMITTER MOUNTING

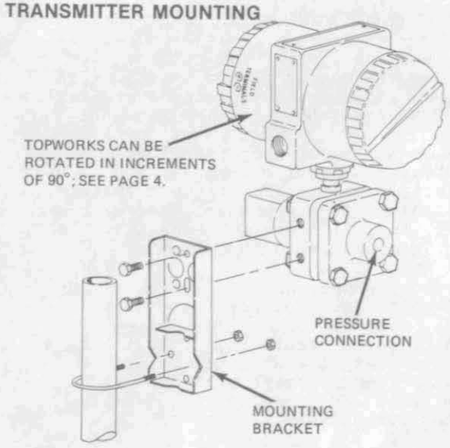


Figure 4

The transmitter can be mounted in any position.

The U-bolt (supplied with the mounting bracket) clamps the bracket to a DN 50 or 2 in pipe. See Figure 4.

The pipe can be clamped to another pipe, or flanged and bolted to the floor or wall. The pipe can be horizontal or vertical (as shown). The U-bolt can be rotated 90° for use with a horizontal pipe.

TYPICAL TRANSMITTER PIPING

Transmitter At or Above Level of Process Connection

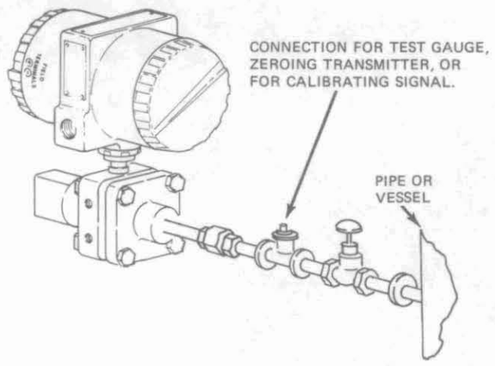


Figure 5

Transmitter Below Level of Process Connection

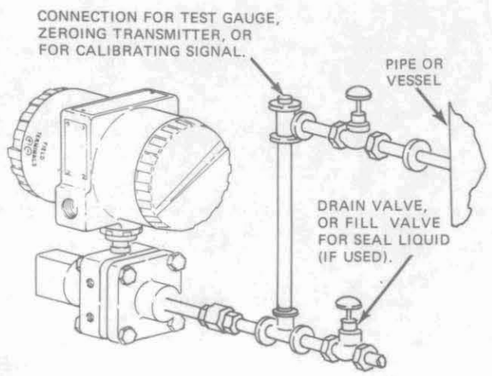


Figure 6

If the material whose pressure is being measured must not come in contact with the transmitter, the line between the tank and the transmitter can be filled with a suitable seal liquid. This liquid must be heavier than the pressure material, must be immiscible with it, and must not react chemically to it.

TO ROTATE TOPWORKS

The topworks can be rotated to any one of four positions in 90° increments. Choose the position which permits access to field terminals, room for removal of topworks covers, and convenient conduit installation.

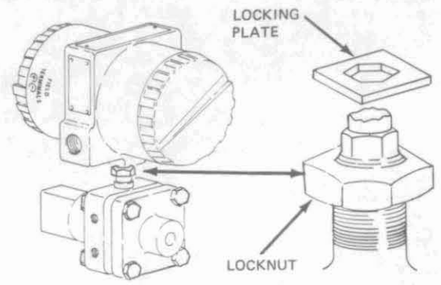


Figure 7

1. Lower the locknut (Figure 7) that holds topworks in place (turn clockwise as viewed from above) until locking plate falls from recess in top works.
   (If locking plate does not fall after locknut is loosened, pry out plate with pointed tool.)
2. Rotate topworks to desired position. Tighten locknut, making sure that locking plate is seated in square recess in topworks.

INSTALLATION WIRING

This section applies only to the milliampere-output transmitter; for the frequency-output transmitter installation details, see Instruction MI 020-340.

Connect the supply-receiver loop wiring to the transmitter terminals (Figure 8). Polarities are marked at the terminals. If the loop is to contain other instruments, install them in the negative lead, observing polarities as shown.

The jack connections (above the wiring terminals) are used for output test leads, for the optional output meter (±2% of scale accuracy), or, with the 4 to 20 mA output transmitter, for the optional jumper (Part D0151CC) which permits an additional 25 Ω resistance in the output loop.

The output at these connections is 100 to 500 mV dc, corresponding to 0 to 100% output.

TO CHECK FOR DEFECTIVE COMPONENT IN TOPWORKS

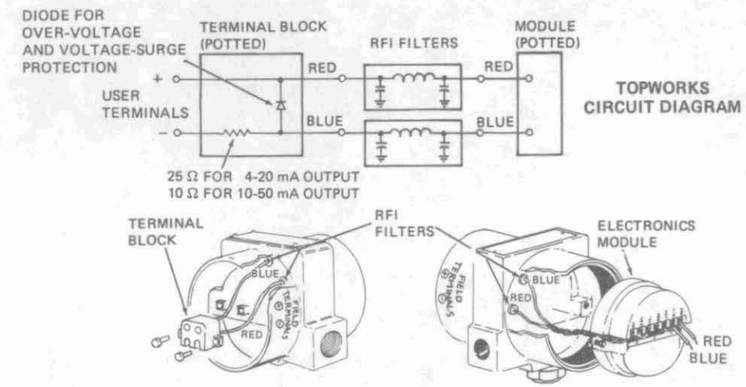


Figure 22

To Check for Defective Diode

(In Step 2, two values of voltage and current are listed. The first value is for transmitters with 4 to 20 mA output, and the second value [in parentheses] is for transmitters with 10 to 50 mA output.)

1. Disconnect blue and red leads at module. Connect test equipment as shown in Figure 23.
2. Slowly increase supply voltage. Milliammeter should read 0 mA until voltage is between 65 and 72 V (95 and 105 V). Current should then increase as voltage increases. At 75 V (115 V), current should be between 3 and 11 mA (10 and 30 mA).
3. Reduce voltage to 0 V. Reverse the polarity of leads at terminal block (positive [+] lead goes to negative [-] terminal, etc.).
4. Very slowly increase voltage. Current should begin to rise at less than 1 V. At 10 V, current should be between 9 and 10 mA.
5. If all these conditions are not met, replace terminal block.

   NOTE: Use care when soldering terminal block leads; RFI filters can be damaged with excessive heat.

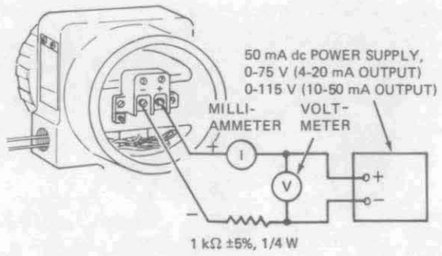


Figure 23

To Check for Defective RFI Filter

1. Disconnect blue and red leads at module. Use ohmmeter to check continuity between input terminals and ground, as shown in Figure 24.
2. If there is continuity between either the positive (+) terminal and ground, or the negative (-) terminal and ground, replace both RFI filters, (Part H0183CZ).
   (Remove filters from field-terminal compartment side using a 3/16 socket wrench. When inserting filters, tighten to a torque of 0.6 to 0.8 N•m [5 to 7 lb•in]. NOTE: These filters can be damaged with excessive heat; use care when soldering leads.)
3. Check continuity between user terminals and associated leads disconnected from module in Step 1.

   If there is not continuity between either the positive (+) terminal and red lead at module, or the negative (-) terminal and blue lead at module, replace both RFI filters.

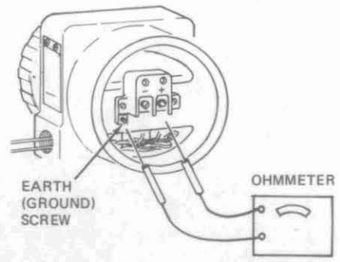


Figure 24

TO IDENTIFY DEFECTIVE COMPONENT

This procedure (Figure 20) is applicable only to milliampere-output transmitters. For frequency-output transmitters, see Instruction MI 020-340.

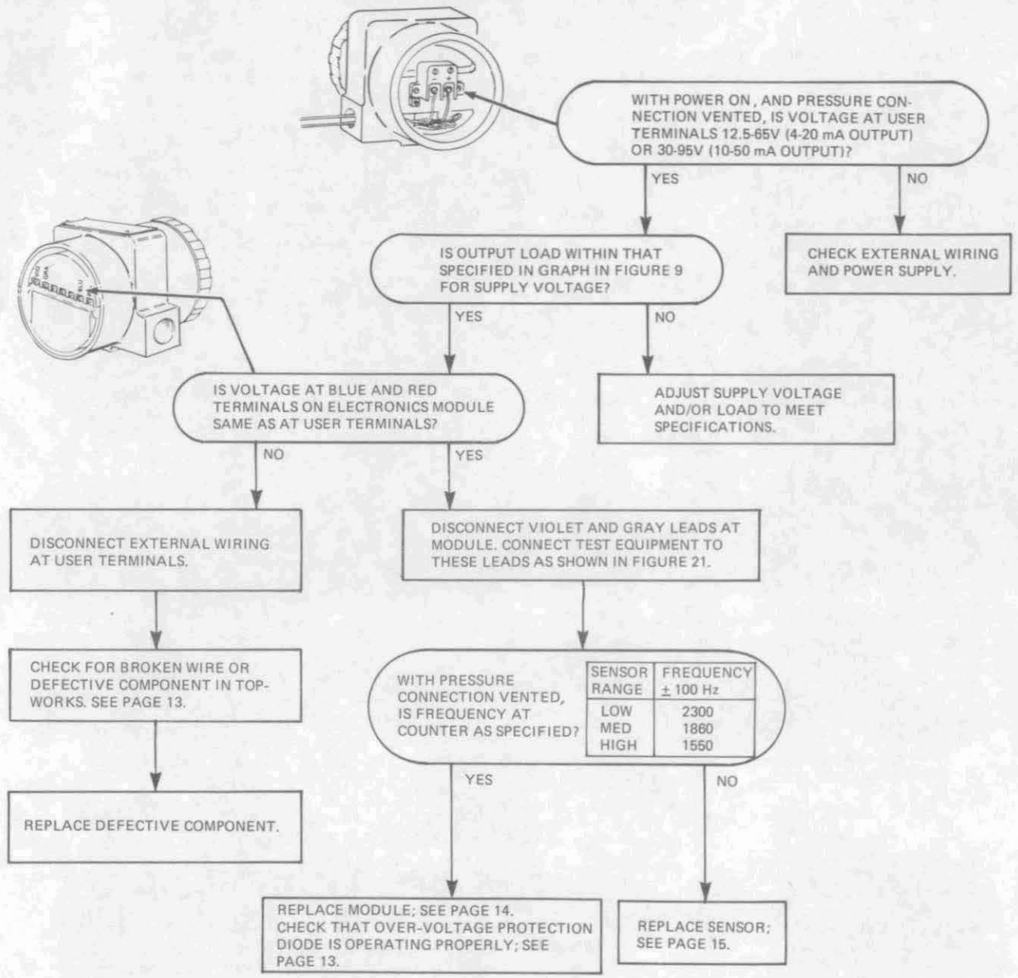


Figure 20

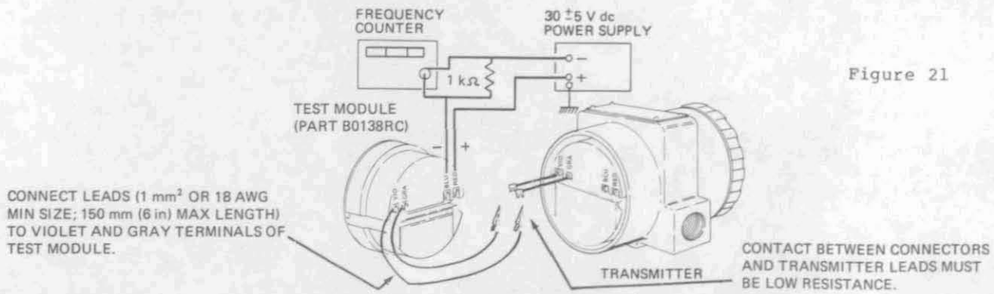


Figure 21

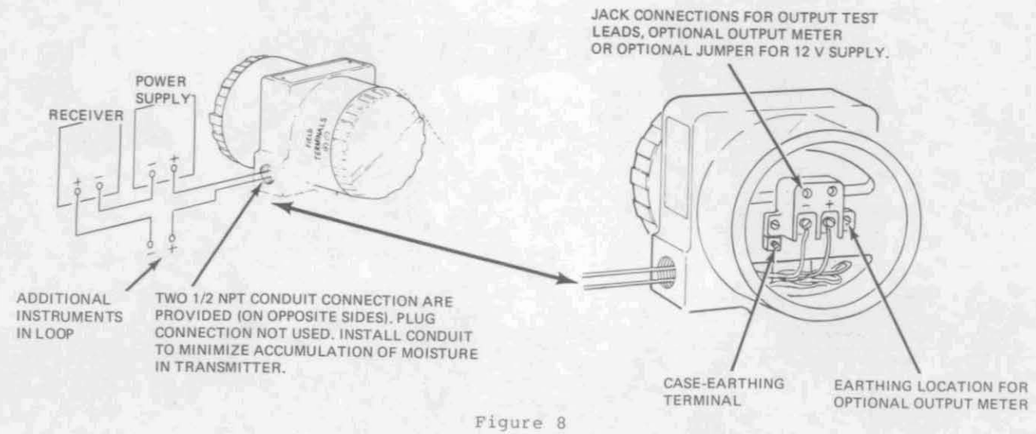


Figure 8

POWER SUPPLY

This section covers only the milliampere-output transmitter; the power supply for the frequency-output transmitter is part of the SPEC 200 nest (see Instruction MI 020-340).

The supply voltage limits at the transmitter terminals are indicated in the applicable graph in Figure 9. However, for a given supply voltage, the limits of the transmitter output loop resistance are set. (For example, with a 4 to 20 mA output transmitter, if supply voltage is 60 V dc, allowable loop resistance is 150 to 2400 Ω.) To determine the output loop resistance, add the series resistance of each component in the loop.

The power supply must be capable of supplying 22 mA (4 to 20 mA output) or 55 mA (10 to 50 mA output). For additional power supply details, see Table 1, Page 7.

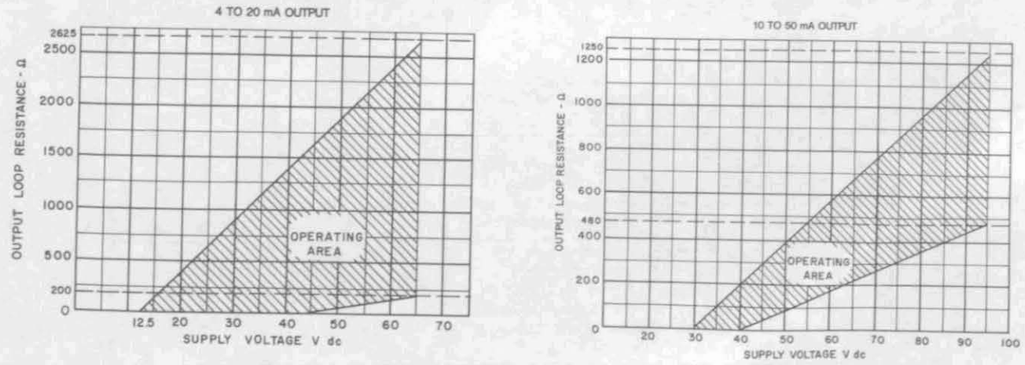


Figure 9

TRANSMITTER EARTHING (GROUNDING)

The transmitter case is normally earthed. Refer to the applicable electric code for earthing requirements.

A case-earthing terminal (Figure 8) is provided in the field-terminal compartment in the topworks. CSA installations require earthing with this terminal. With PTB installations, an external earthing terminal (see Figure 3) is provided.

If the signal circuit must be earthed, it is preferable to earth the negative terminal of the dc power supply. CAUTION: To avoid circulating currents in earth loops, or the possibility of short-circuiting groups of instruments in a loop, there should be only one earth in a loop.

CERTIFICATION DETAILS

⚠ WARNING

1. To maintain explosion-proof, dust-ignition-proof, and NEMA 4 protection, unused conduit opening (two 1/2 NPT connections are provided) must be plugged with metallic pipe plug which engages a minimum of five full threads.
2. This milliampere-output transmitter may have agency certification for installation in hazardous locations or for intrinsic safety. Refer to label affixed to transmitter for type of certification, and observe applicable wiring practices. Conditions of certification are listed below. Similar details for frequency-output transmitters are covered in Instruction MI 020-340.

Output (mA)	Testing Laboratory	Types of Protection and Area Classification	Conditions of Certification
4 to 20	CSA	Explosion-proof for Class I, Groups B, C, and D, Division 1. Dust-ignition-proof for Class II, Groups E, F, and G, Division 1; and Class III, Division 1. Suitable for use in Class I, Groups A, B, C, and D, Division 2.	—
	FM	Explosion-proof for Class I, Groups B, C, and D, Division 1. Dust-ignition-proof for Class II, Groups E, F, and G, Division 1. Nonincendive resistive for Class I, Groups A, B, C, and D, Division 2; and Class II, Groups F and G, Division 2.	—
	CSA	Intrinsically safe for Class I, Groups B, C, and D, Division 1.	When connected according to SI 8-00478.
		Intrinsically safe for Class I, Groups A, B, C, and D, Division 1.	When connected to CSA-certified Zener barriers rated: 33 V, 415 Ω; 30 V, 300 Ω; 28 V, 240 Ω; 26.7 V, 200 Ω; or 20 V, 70 Ω.
		Intrinsically safe for Class I, Groups C and D, Division 1	When connected to CSA-certified Zener barriers rated: 33 V, 185 Ω; 30 V, 130 Ω; 28 V, 115 Ω; or 20 V, 30 Ω.
	FM	Intrinsically safe for Class I, Groups A, B, C, and D, Division 1; and Class II, Groups E, F, and G, Division 1.	1. When connected according to TI 005-101. 2. Associated control room equipment shall not use or generate more than 250 V rms.
	PTB	Intrinsically safe (Ex) ib IIC.	When connected to PTB-certified SPEC 200, UIO, and UCM input components.
	BASEEFA	Intrinsically safe for Groups IIC, IIB, IIA, Zone 1 or Zone 0.	1. When used in BASEEFA-certified systems in conjunction with SPEC 200, UIO, and UCM components. 2. For Zone 0 applications use isolated input cards only.
	LCIE	Flameproof combined with intrinsic safety, EExd (ia) IIC 45°C.	—
10 to 50	CSA	Explosion-proof for Class I, Groups B, C, and D, Division 1. Dust-ignition-proof for Class II, Groups E, F, and G, Division 1; and Class III, Division 1. Suitable for use in Class I, Groups A, B, C, and D, Division 2.	—
	FM	Explosion-proof for Class I, Groups B, C, and D, Division 1. Dust-ignition-proof for Class II, Groups E, F, and G, Division 1. Nonincendive resistive for Class I, Groups A, B, C, and D, Division 2; and Class II, Groups F and G, Division 2.	—
	LCIE	Flameproof combined with intrinsic safety, EExd (ia) IIC 45°C.	—

LIN ADJ (LINEARITY ADJUSTMENT) POTENTIOMETER ADJUSTMENT

If the output corresponding to a mid-range input is not satisfactory, complete this adjustment and then the calibration procedure.

1. Turn LIN ADJ screw (Figure 17) clockwise until there is no further change in output reading on voltmeter.
2. Apply calibrating pressure equal to upper range value to transmitter. Adjust SPAN screw so that output on voltmeter is 10.000 V.
3. With calibrating pressure at mid-range value, note output on voltmeter ("R" in formula in Step 5).
4. In Figure 18, locate span in applicable abscissa. Project up to curve, and note corresponding multiplication factor ("MF" in formula in Step 5).
5. Use following formula to calculate LIN ADJ voltage

   $$\text{voltage} = (R) - \left[(R - 6.000)(MF)\right]$$

   See example below.
6. Turn LIN ADJ screw counterclockwise until voltmeter reads calculated value.
7. Apply calibrating pressure equal to upper range value. Adjust span screw so that output is 10.000 V.
8. Apply calibrating pressure equal to lower range value. If output is not 2.000 V, adjust ZERO screw to get correct value.

   If ZERO screw required adjustment, repeat Step 7.
9. Adjust calibrating pressure to mid-range value. Output should be 6.000 V. If output is not satisfactory, repeat this entire procedure.
10. Repeat calibration procedure.

EXAMPLE: Transmitter sensor, medium range
Range 25 to 100 psi (span = 75 psi)
MF value from graph, 8.5
Output at mid-scale input, 6.011 V

$$\text{LIN ADJ voltage} = (6.011) - \left[(6.011 - 6.000)(8.5)\right]$$
$$= 5.918 \text{ V}$$

MAINTENANCE

The transmitter normally requires servicing only if it cannot be calibrated, or if the range is to be changed (see section below).

If the transmitter cannot be calibrated, check for a defective component (Page 12).

TRANSMITTER DISASSEMBLY

The disassembly of the transmitter is usually limited to that shown below. The electronics module and the sensor assembly are the only parts that may require replacement in normal operation.

The process gasket should be replaced each time the transmitter body is opened.

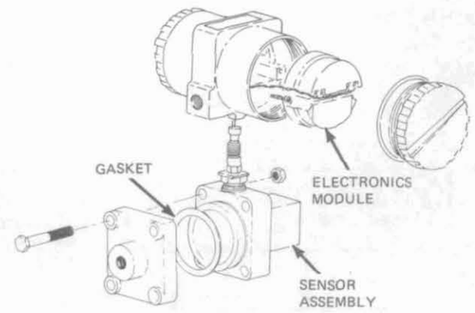


Figure 19

TO CHANGE RANGE

The transmitter can be calibrated to any range within the limits of the particular sensor installed in the transmitter [see sensor measurement limits and sensor identification (Page 2)].

If the desired range is outside the sensor limits, but within the limits of one of the other available sensors, install this new sensor (Page 14). Recalibrate the transmitter to the new range (Page 8 for milliampere-output transmitter, or Instruction MI 020-340 for frequency-output transmitter).

Alter the data plate to indicate the new conditions.

CALIBRATION PROCEDURE

The outputs specified in this procedure (and in the "LIN ADJ Potentiometer Adjustment" procedure on Page 11) assume that the bench calibration is used. These outputs are 2.000, 6.000, and 10.000 V, corresponding to inputs of 0, 50, and 100% of scale.

If the field calibration is used, substitute outputs of 100.0, 300.0, and 500.0 mV respectively.

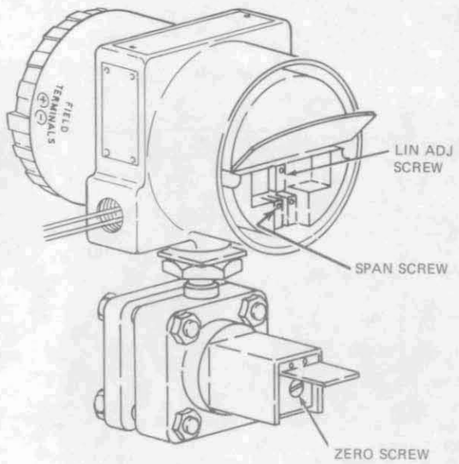


Figure 17

1. Set up applicable calibrating equipment as shown in Figures 13 through 16.

2. Set calibrating pressure equal to lower range value. Output should be 2.000 V.

   If necessary, adjust ZERO screw (Figure 17) to get correct output.

3. Set calibrating pressure equal to upper range value. Output should be 10.000 V.

   If necessary, adjust SPAN screw to get correct output.

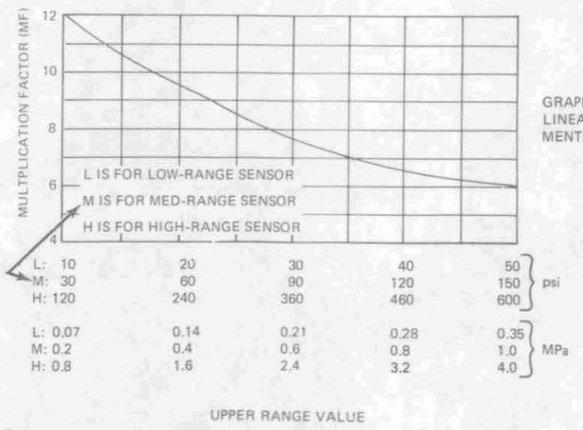
4. Repeat Steps 2 and 3 until both outputs are correct without adjustment.

5. Set calibrating pressure equal to midrange value. Output should be 6.000 V.

   If output is satisfactory (see table below), calibration is complete. If output is not satisfactory, complete "LIN ADJ Potentiometer Adjustment" procedure on Page 11.

OUTPUT DEVIATION FROM 6.000 V	ERROR (% OF SPAN)
±0.008 V	±0.1
±0.016 V	±0.2*
±0.040 V	±0.5

*Maximum factory-calibrated error.



GRAPH USED WITH LINEARITY ADJUSTMENTS ON PAGE 11.

Figure 18

Table 1. Additional Power Supply Details

RECEIVER LOOP	4 to 20 mA OUTPUT TRANSMITTER	10 to 50 mA OUTPUT TRANSMITTER
4 to 20 mA	Use built-in power supply in SPEC 200 nest or in E20S-1 Series Recorder.*	--
10 to 50 mA	Use Current Converter (Part B0129XS) and nominal 80 V dc power supply.	Use SPEC 200 field bus with nominal 75 V dc power supply and appropriate input module.*

*If individual power supply is not used.

OPERATION

The three operation adjustments below apply only to the milliampere-output transmitter. These procedures for the frequency-output transmitter are covered in Instruction MI 020-340.

DAMPING ADJUSTMENT

If the measurement signal varies rapidly enough to cause a pulsating output, the response of the transmitter can be altered to damp out these pulsations. The transmitter has jumper positions for three levels of damping (low, medium, and high; labeled L, M, and H). See Figure 12.

The low position is used for normal applications, and the medium and high positions are used to screen out undesirable process noise. Note that if the jumper is withdrawn, the damping automatically goes to the low level.

SUPPRESSED AND ELEVATED ZERO APPLICATIONS

The ZERO screw has enough adjustment so that the lower range value (which produces a 0% output) can be either above or below 0 input gauge pressure. For example, the transmitter zero can be suppressed so that the lower range value is +10 psi; or elevated so that the lower range value is -10 psi (the lower range limit is a full vacuum).

See the specifications on Page 2 for limitations of zero suppression.

ZERO ADJUSTMENT

Complete this adjustment with the transmitter in its operating position before putting it into operation. This is an operating adjustment only; for calibration, see Page 8.

If the transmitter is not calibrated to the desired range, complete the calibration before starting the zero adjustment.

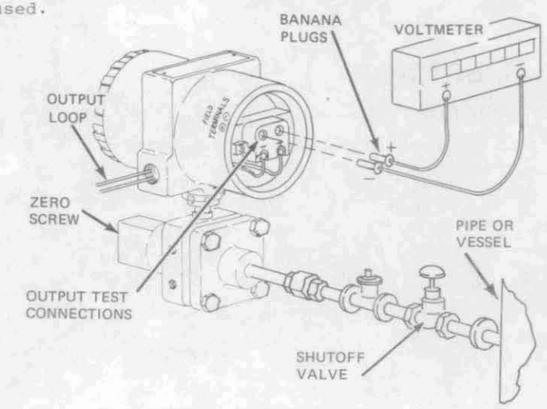


Figure 10

1. Connect voltmeter (Figure 10) to output test connections in field-terminal compartment in topworks. Close shutoff valve.

2. If transmitter is connected below level of process connections and if process fluid is a liquid, fill tee connection vertical line with process liquid (or seal liquid, if used) to level of process connection.

3. TRANSMITTER WITHOUT ZERO ELEVATION OR SUPPRESSION:

   Vent tee connection.

   TRANSMITTER WITH ZERO ELEVATION OR SUPPRESSION:

   Connect test gauge to tee connection. Open shutoff valve. Adjust pressure to some value on scale. Use formula in Figure 11 to calculate output corresponding to this pressure.

4. Turn ZERO adjustment screw so that voltmeter reading is 100 mV or calculated value.

   If necessary, change zero adjustment on receiver so that its reading is correct.

Formula To Calculate mV Output For Any Input

$$\text{mV Output} = (400)\left(\frac{\text{Test gauge reading - Lower range value}}{\text{Upper range value - Lower range value}}\right) + 100$$

EXAMPLE: Transmitter range, 400 to 600 psi
Test gauge reading, 425 psi

$$\text{Output} = (400)\left(\frac{425 - 400}{600 - 400}\right) + 100 = 150 \text{ mV}$$

Figure 11

CALIBRATION

CALIBRATION NOTES

1. This section covers milliampere-output transmitters only. For calibration of frequency-output transmitters, see Instruction MI 020-340.

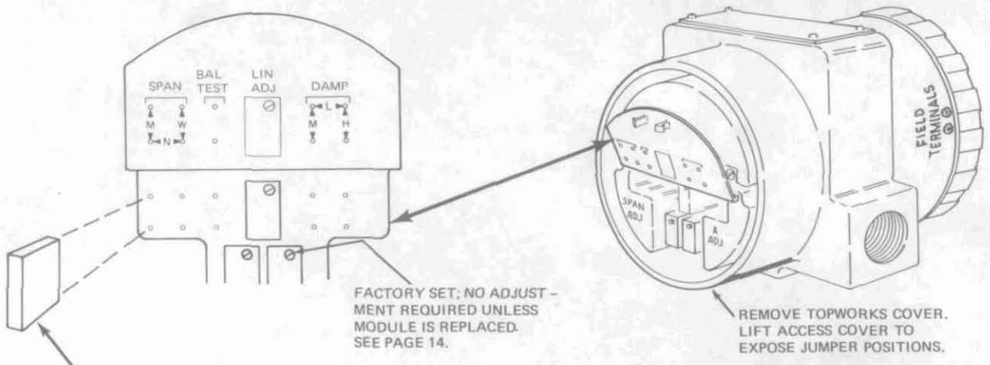
2. If range is to be changed, span jumpers may require repositioning prior to recalibration (Figure 12).

3. Accuracy of calibration equipment should be a minimum of three times desired accuracy of transmitter. If necessary, apply correction factors for such external influences as temperature, barometric pressure, and local acceleration of gravity.

SPAN JUMPER POSITIONS (COARSE SPAN ADJUSTMENT)

In the operating-adjustment compartment of the topworks, set the coarse span by inserting the span jumper into the applicable position as specified in Figure 12. Then calibrate the transmitter to the desired range.

The spans corresponding to jumper positions are approximate. If necessary, use another jumper position if the transmitter cannot be calibrated to the desired span.



JUMPER POSITION		SPANS					
		MPa	psi	MPa	psi	MPa	psi
N	(NARROW)	0.07 to 0.09	10 to 13.5	0.20 to 0.28	30 to 40	0.8 to 1.1	120 to 160
M	(MEDIUM)	0.09 to 0.18	13.5 to 26	0.28 to 0.55	40 to 80	1.1 to 2.55	160 to 370
W	(WIDE)	0.18 to 0.35	26 to 50	0.55 to 1.0	80 to 150	2.55 to 4.2	370 to 600
		LOW RANGE SENSOR		MEDIUM RANGE SENSOR		HIGH RANGE SENSOR	

SPAN = UPPER RANGE VALUE – LOWER RANGE VALUE

Figure 12

CALIBRATION PIPING

Air Pressure Calibration Signal

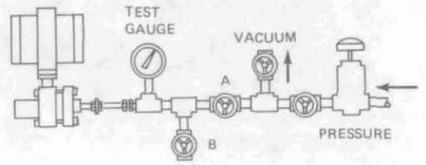


Figure 13

Lock in desired pressure or vacuum with valve (A). Reduce by bleeding at (B).

Hydraulic Pressure Calibrating Signal

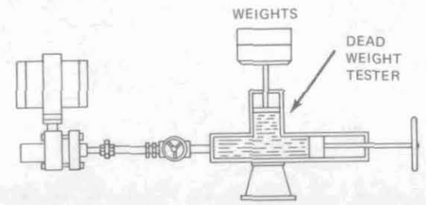


Figure 14

Increase pressure with crank until pressure supports an accurately-known weight. Accurate test gauge may be used with hydraulic pump in a similar set up.

CALIBRATION WIRING

Field Calibration

The field calibration does not require removal of the external wiring. Calibrating signals of 0 to 100% of range produce proportional 100.0 to 500.0 mV output readings on the voltmeter.

The maximum inherent error due to the built-in resistor across the output test terminals is ±0.1% of span.

Connect voltmeter to output test connections in field-terminal compartment in topworks. (See Figure 15).

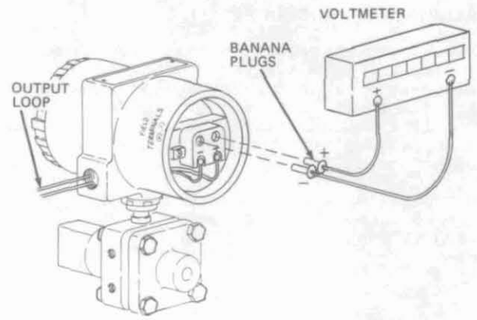


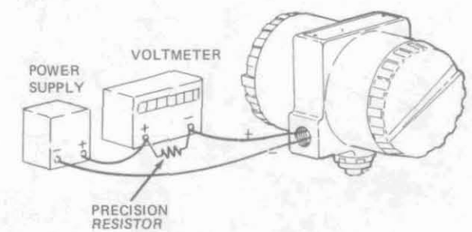
Figure 15

Bench Calibration

The bench calibration requires a power supply and a precision resistor, as specified in Figure 16. Calibrating signals of 0 to 100% of range produce proportional 2.000 to 10.000 V output readings on the voltmeter.

Connect the power supply, voltmeter, and precision resistor to the transmitter input terminals in the field-terminal compartment of the topworks. Observe polarity.

Check that the loop resistance is within the operating area for the power supply voltage; see applicable graph in Figure 9.



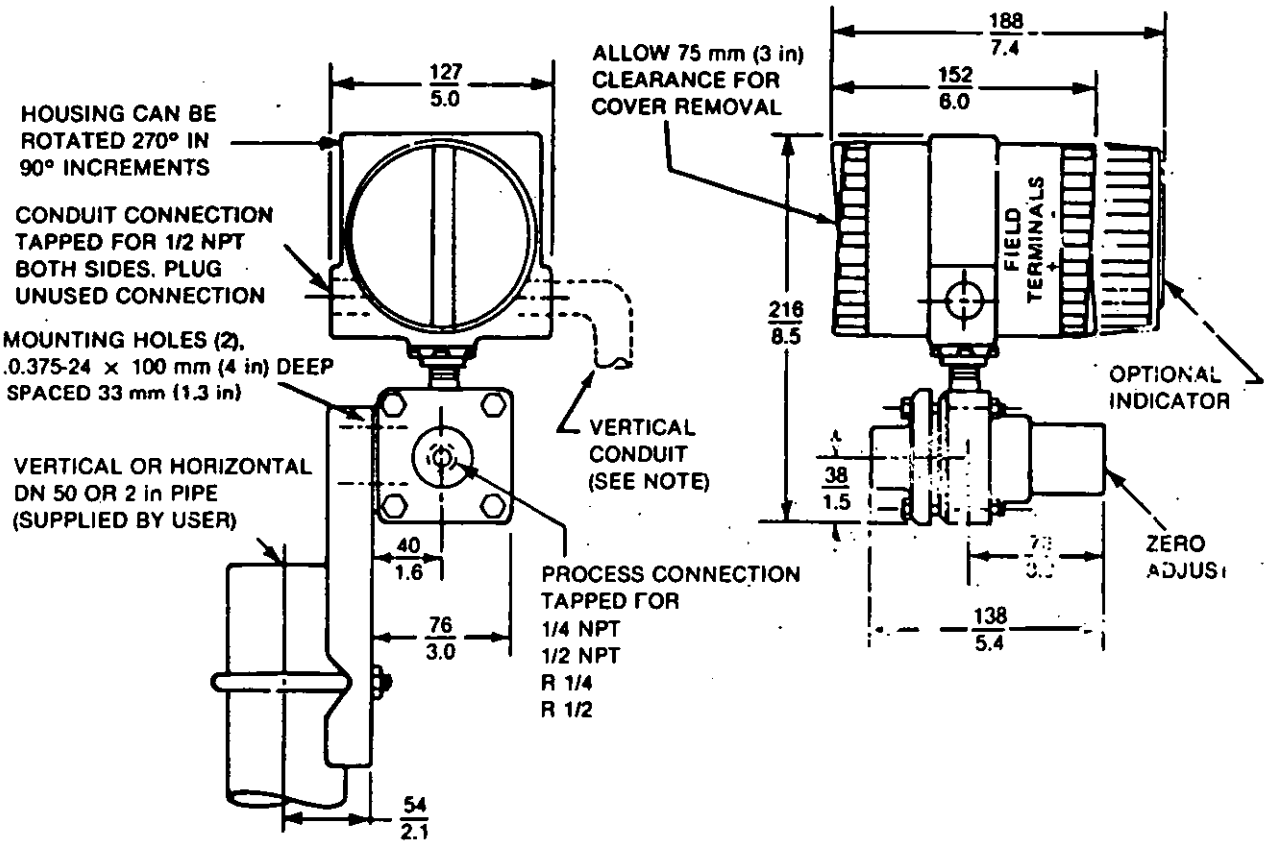
OUTPUT SIGNAL	RESISTOR	PART NUMBER
4 to 20 mA	500 Ω ±0.01% W, 5 ppm/°C	E0286ZM
10 to 50 mA	200 Ω ±0.01% W, 5 ppm/°C	E0286ZL

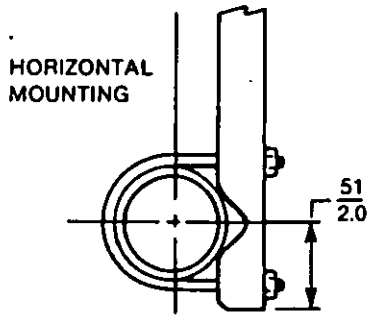
Figure 16

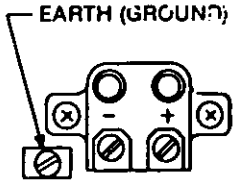
Dimensional Print

CDP
020-336
AUGUST 19[illegible]

821GM ELECTRONIC GA 'GE PRESSURE TRANSMITTER







NOTE:

VERTICAL CONDUIT (SUPPLIED BY USER). USED TO AVOID ACCUMULATION OF MOISTURE IN TERMINAL BLOCK ENCLOSURE.

CUSTOMER _____ I.R. _____

CUSTOMER ORDER _____ FOXBORO ORDER _____

ITEM–TAG _____

_____

_____

_____

CERTIFIED BY _____ DATE _____

AMERICAN PROJECTION

FOXBORO®

Parts List

PL
009-115
March 1984

821GM
GAUGE PRESSURE TRANSMITTER
Style A

Model Code

821GM = Gauge Pressure Transmitter

Output Signal
-I = 4 to 20 mA dc
-H = 10 to 50 mA dc
-F = Frequency with SPEC 200 Input Component

Body (Flange) Material
K = Cadmium-plated carbon steel
S = 316 ss
C = Hastelloy C
M = Monel

Sensor Wetted Parts Material
1N = Cobalt-nickel-chrome alloy (standard)
1S = 316 ss
1C = Hastelloy C
1M = Monel

Span Limits
L = 0.07 and 0.35 MPa, 10 and 50 psi, or 0.7 and 3.5 bar or kg/cm²
M = 0.21 and 1.05 MPa, 30 and 150 psi, or 2.1 and 10.5 bar or kg/cm²
H = 0.84 and 4.2 MPa, 120 and 600 psi, or 8.4 and 42 bar or kg/cm²

Process Connection
1 = Tapped for 1/4 NPT
2 = Tapped for 1/2 NPT
3 = Tapped for R 1/4
4 = Tapped for R 1/2
5 = Machined for 9/16-18 Aminco fitting

Optional Features
-A = Indicator with a 0 to 100% uniform scale
-C = Indicator with scale per sales order
-Y = Delete mounting bracket

FOXBORO®

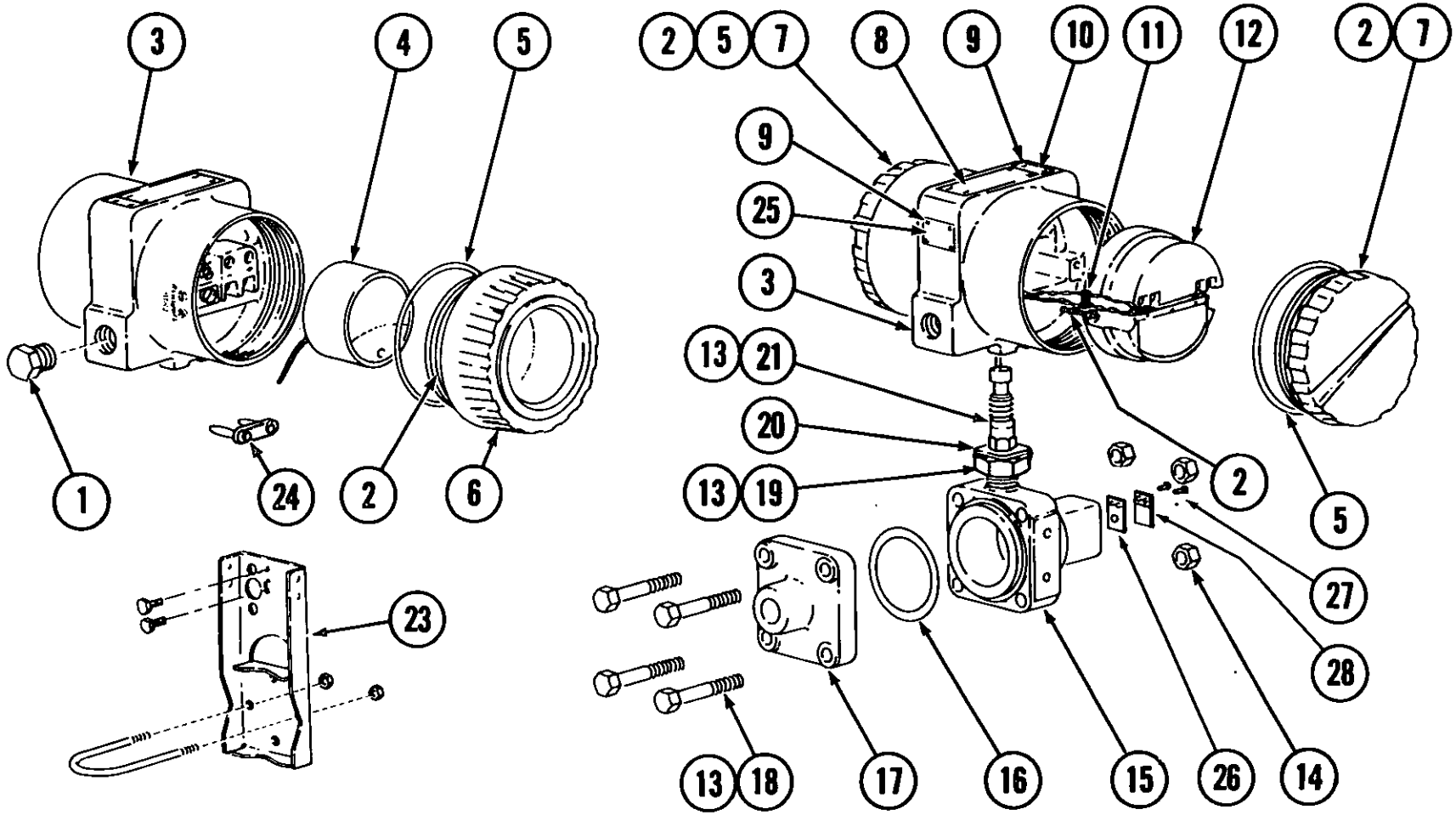

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Fig. E1944C

Parts are illustrated on Page 2

Item	Part No.	Qty.	Part Name
1	—	1	1/2 NPT Plug (customer supplied), see note 1
2	X0114AT	1	Lubriplate Lubricant, 0.45 kg (1 lb)
3	—	1	Housing Assembly (see p 4)
4	B0138YM	1	Indicator Assembly (optional) 0 to 100 percent, uniform (Code -A)
5	B0138QU	2	*Gasket
6	Below	1	Cover Assy. (used with optional indicator)
	B0138QZ		Standard
	B0140LN		LCIE
7	B0138QV	2	Cover (standard)
8	M0125WP	1	Nameplate (blank)
9	X0161CT	8	Screw, Tapping
10	B0125WQ	1	Address Plate (U.S. Issue)
11	N0139FR	1	Tie Wrap
12	—	1	*Module Assembly (see p 5)
13	0048130	1	Lubricant, Silicone, 150 kg (5.3 oz)
14	Below	4	Nut, 0.375-16 (see notes 2, 3, and 4)
	X0170ZM		Cadmium plated carbon steel (standard)
	X0171AX		17-4 PH stainless steel
	X0171WQ		Cadmium plated carbon steel ASTM A-194 grade 2M
15	—	1	Sensor Assembly (see p 5)
16	Below	1	*Gasket, glass-filled ptfe
	B0139RB		standard
	B0139YX		cleaned for oxygen and chlorine service
17	—	1	Flange Connector (see below)
18	Below	4	Screw, Hex H., 0.375-16 x 2.500 (see notes 2, 3 and 4)
	X0170ZL		Cadmium plated carbon steel (standard)
	X0171AY		17-4 PH stainless steel
	X0171WP		Cadmium plated carbon steel ASTM A-193 grade B7M
19	B0138QT	1	Nut, M22X1.5
20	B0139DP	1	Restraining Pad
21	E0121AE	1	O-Ring (included in Item 15)
23	P0120NP	1	Mounting Set
—	0011962	2	Nut, 0.312-18
—	N0141ZW	1	Bracket
—	D0114SM	1	U-Bolt
—	Below	2	Screw, Hex H., 0.437-20 x 0.625
	X0116FB		Plated steel (standard)
	P0120RN		Stainless steel
24	P0151CC	1	Plug-in Shorting Bar, to permit an additional 25 ohm in output load capability, 4 to 20 mA (optional)
25	—	1	Certification Plate
26	Below	1	Cover
	D0135SC		Frequency Outputs
	D0135FC		mA Outputs
27	Below	2	Screw, Pan H., 0.112-40
	A2003ZW		0.250 in long (Frequency Outputs)
	A2003ZY		0.375 in long (mA Outputs)
28	D0135HT	1	Zero Cover (mA Outputs only)

Note 1: To maintain explosion-proof and dust ignition-proof protection you must plug unused conduit opening with a metallic pipe plug which engages a minimum of five full threads.

Note 2: For replacement of Flange Connector nuts and screws use only those Foxboro part numbers listed.

Note 3: "Standard" plated steel screws and nuts and optional 17-4 PH stainless steel screws and nuts are non-process wetted and are only suitable for Class III bolting requirements of NACE Standard MR-01-75.

Note 4: Optional B7M screws and 2M nuts are non-process wetted and are suitable for Class II bolting requirements of NACE Standard MR-01-75.

Flange Connector (Item 17, Above)

Part No.	Flange Material	(Code)	Process Connection	(Code)
D0143CS☆	cadmium plated steel	(K)	1/4 NPT	(1)
D0143CN☆	cadmium plated steel	(K)	1/2 NPT	(2)
D0143CU☆	cadmium plated steel	(K)	R 1/4	(3)
D0143CQ☆	cadmium plated steel	(K)	R 1/2	(4)
D0143CJ☆	316 stainless steel	(S)	1/4 NPT	(1)
D0143CE☆	316 stainless steel	(S)	1/2 NPT	(2)
D0143CL☆	316 stainless steel	(S)	R 1/4	(3)
D0143CG☆	316 stainless steel	(S)	R 1/2	(4)
D0135GF	Hastelloy C	(C)	1/4 NPT	(1)
D0135GB	Hastelloy C	(C)	1/2 NPT	(2)
D0135GH	Hastelloy C	(C)	R 1/4	(3)
D0135GD	Hastelloy C	(C)	R 1/2	(4)
D0135FP	Monel	(M)	1/4 NPT	(1)
D0135FN	Monel	(M)	1/2 NPT	(2)
D0135FM	Monel	(M)	R 1/4	(3)
D0135FL	Monel	(M)	R 1/2	(4)

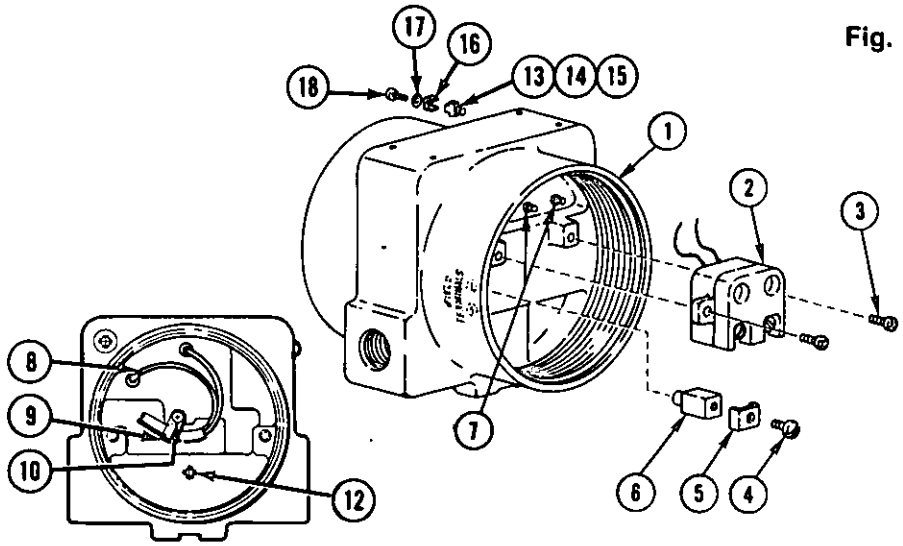
17-4 PH is a trademark of Armco Steel Corporation.
Hastelloy C is a trademark of the Stellite Division of the Cabot Corporation.
Lubriplate is a trademark of Lubriplate Division of Fiske Brothers Refining Company.
Monel is a trademark of Huntington Alloys Incorporated.

☆Star indicates metallic process wetted material conforming to NACE Standard MR-01-75.

***Parts preceded by asterisks are those most commonly replaced**
GIVE INSTRUMENT MODEL NUMBER AND REFERENCE NUMBER WHEN ORDERING PARTS

Housing Assembly

Fig. E1945B



Item	Part No.	Qty.	Part Name
—	Below	1	Housing Assembly
	D0135KZ		10 to 50 mA (-H)
	B0138UA		4 to 20 mA (-I) and Frequency (-F)
	B0138VW		4 to 20 mA (-I, PTB) and Frequency (-F, PTB)
	B0140LR		4 to 20 (-I, LCIE)
	B0140LS		10 to 50 (-H, LCIE)
1	Below	1	Housing
	B0138UB		Standard (used in D0135KZ, B0138UA)
	B0138VV		PTB (used in B0138VW)
	B0140LQ		LCIE (used in B0140LR, B0140LS)
2	Below	1	Terminal Block Assembly
	B0138WH		10 to 50 mA (used in D0135KZ, B0140LS)
	B0138QH		4 to 20 mA, Frequency (used in B0138UA, B0140LR, B0138VW)
3	X0170PZ	2	Screw, Tapping
4	X0169FE	1	Screw, Pan H., 0.164-32 x 0.500 with Lockwasher
5	B0138YS	1	Clamp
6	B0138YR	1	Stud, Earth (Ground)
7	H0183CZ	2	Filter, RFI

Item	Part No.	Qty.	Part Name	
—	X0170BS	—	Sealant	For Sealing Item 7
—	X0170BT	—	Primer	
8	B0138UW	1	Wiring Harness	
9	0049805	1	Clamp	
10	X0170FR	1	Screw, Tapping	
12	X0171TS	1	Set Screw	
13	B0138XW	1	Bushing	PTB Only
14	B0138VQ	1	Stud	
15	B0138UV	1	Tag	
16	B0138VR	1	Clamp	
17	X0143NB	1	Lockwasher	
18	X0142KB	1	Screw	

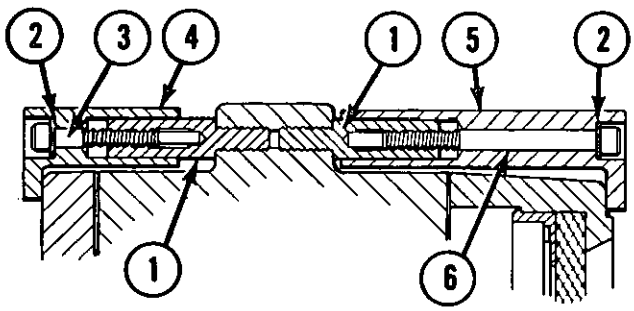


Fig E2429

LCIE Cover Lock

Item	Part No.	Qty.	Part Name	
1	B0139CR	2	Standoff	
2	X0170WF	2	Lockwasher	
3	X0170YM	2	Screw	W/O Indicator
4	B0139CY	2	Cover Lock	
3	X0170YM	1	Screw	With Indicator
4	B0139CY	1	Cover Lock	
5	B0139EG	1	Cover Lock	
6	X0170YN	1	Screw	

Module Assembly

Output Signal					
Code -H 10 to 50 mA	Code -H (LCIE) 10 to 50 mA	Code -I 4 to 20 mA	Code -I (LCIE) 4 to 20 mA	Code -I (PTB) 4 to 20 mA	Code -F Frequency
D0135PZ	D0135XB	D0135PY	D0135XA	D0135PW	B0140EX

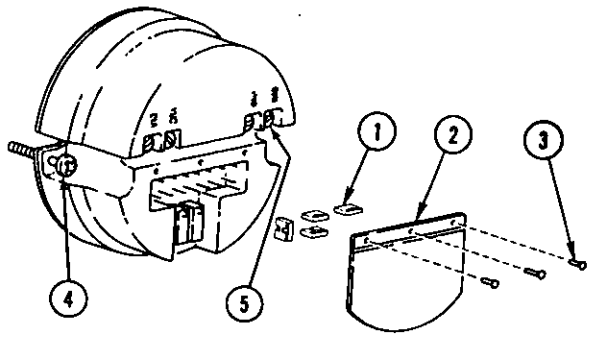


Fig. E2330A

Item	Part No.	Qty.	Part Name	
1	B0138LY	2,4	*Jumper	
2	Below	1	Cover	See Note
	D0135MS		Hinged (used in D0135PY, D0135PZ)	
	B0138VN		Rigid (used in D0135PW)	
3	Below	—	Screw	
	X0166BZ	3	used in D0135PY, D0135PZ	
	X0170QV	2	used in D0135PW	
4	B0138ZY	2	Captive Screw	
5	B0138RT	4	Screw	

NOTE: Module Part B0140EX for frequency output does not have front cover, Item 2, or Screws, Item 3.

Sensor Assembly (Item 15, Page 3)

Code		Span Limits			Wetted Materials	Sensor Fill Fluid
		Low (L) 0.07 and 0.35 MPa 10 and 50 psi 0.7 and 3.5 bar or kg/cm²	Medium (M) 0.21 and 1.05 MPa 30 and 150 psi 2.1 and 10.5 bar or kg/cm²	High (H) 0.84 and 4.2 MPa 120 and 600 psi 8.4 and 42 bar or kg/cm²		
-H or -I	1N	D0135GW☆	D0135ND☆	D0135NH☆	cobalt-nickel	silicone
	1S	D0135NA	D0135NE	D0135NJ	316 ss	silicone
	1C	D0135NC	D0135NG	D0135NL	Hastelloy C	silicone
	1M	D0135NB	D0135NF	D0135NK	Monel	silicone
-F	1N	D0135PA☆	D0135PB☆	D0135PC☆	cobalt-nickel	silicone
	1S	D0135PD	D0135PE	D0135PF	316 ss	silicone
	1C	D0135PG	D0135PH	D0135PJ	Hastelloy C	silicone
	1M	D0135PK	D0135PL	D0135PM	Monel	silicone
-H or -I	2N	D0139LA☆	D0139LB☆	D0139LC☆	cobalt-nickel	Fluorinert
	2S	D0139LD	D0139LE	D0139LF	316 ss	Fluorinert
	2C	D0139LG	D0139LH	D0139LZ	Hastelloy C	Fluorinert
	2M	D0139LJ	D0139LK	D0139LL	Monel	Fluorinert
-F	2N	D0135XN☆	D0135XP☆	D0135XQ☆	cobalt-nickel	Fluorinert
	2S	D0135XR	D0135XS	D0135XT	316 ss	Fluorinert
	2C	D0135XU	D0135XV	D0135XW	Hastelloy C	Fluorinert
	2M	D0135XX	D0135XY	D0135XZ	Monel	Fluorinert

Note: Fluorinert-filled sensors listed above are not precleaned for oxygen or chlorine service. When ordering these sensors, clearly state on the purchase order whether cleaning is required and indicate the type of service (oxygen or chlorine).

☆Star indicates metallic process materials conforming to NACE Standard MR-01-75.

Options

Ermeto Connectors		PG-11 Trumpet Connections
1/4 NPT X 6 mm Tubing		N7000AA - Trumpet Case Connection N7141KR - Connector
U7002AS	316 ss	Both Required
U7002AT	Cad. Pl. cs	
1/2 NPT X 12 mm Tubing		**PG-13.5 Trumpet Connection**
		N7141DW - Connector
U7002AP	316 ss	N7141KC - Connector
U7002AR	Cad. Pl. cs	Both Required

Steam Tracing Kit	Maintains Process Temperature to 120°C (250°F)
2-Stud	D0135MV

Metric Conduit Connector

Part N7141DX - Connector (M20 x 1.5-7H)

Hawke Cable Gland

Part N7141HX - Gland

Printed in England

Instruments and Systems for
Indicating, Recording, Controlling . . .

Air Weight
Btu
Capacitance
Composition
Compression
Concentration, Solution
Conductivity, Solution
Consistency
Current — a-c, d-c
Density
Dew Point
Displacement
Drag
Flow
Force
Gas Analysis
Humidity
Interface
Ion Selection
Liquid Analysis
Liquid Level
Load
Moisture Content
Motion
Motor Load
Operation, Schedule
Operation, Time
Oxidation-Reduction Potential
pH
Position
Power, Electric
Pressure
Resistance, Electric
Sheet Moisture
Sheet Weight
Specific Gravity
Speed
Strain
Stress
Temperature
Tension
Thrust
Torque
Vacuum
Viscosity
Voltage
Weight

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

FOXBORO®

MS 0283

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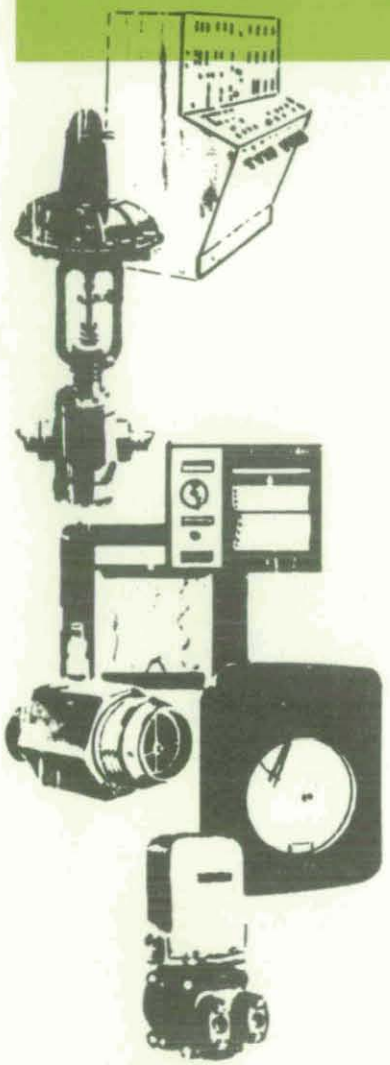
INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct installation of your Foxboro Instruments, and in their proper operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number.*

Book No. 0 2439

FOXBORO

Foxboro Yoxall
A Division of Foxboro Great Britain Limited

Redhill Surrey England
RH1 2HL
Tel: Redhill (0737) 65000
Telex: 892852
Telegram: Yoxbri Redhill

Guarantee

The Company undertakes to replace free of charge any component of its own manufacture (which excludes electronic tubes) which, in the opinion of the Company, is not within the specified limit of calibration or is defective in material or workmanship under normal or proper use, provided that the same is returned at the customer's risk and expense to the Company's works within twelve months from the date of the despatch by the Company of the equipment to the customer.
All representations, conditions, guarantees and warranties by law or otherwise howsoever expressed or implied are hereby excluded to the intent, except as above provided, after delivery to and acceptance by the customer of any equipment or apparatus, the Company shall not be liable for any loss, damage, injury, delay or expense or consequential loss or damage howsoever arising from or in respect of the equipment or apparatus or the use thereof.

Pyrometer Thermocouples, Resistance Thermometer Bulbs, and Protection Tubes, on account of the severity of their usage, are not subject to replacement unless returned unused.

The Company shall not be liable for loss, damage, detention or delay caused by fire, strike, civil, or military authority, insurrection or riot, or for other cause beyond its reasonable control. Acceptance of apparatus by the Purchaser shall constitute a waiver of all claims for delay.

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The Company is anxious to be of every possible assistance to you, to ensure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service in the British Isles should be made with the Company at Redhill. In other parts of the World arrangements should be made through the nearest Representative and/or Factory listed at the end of this book.
A unique feature of Foxboro service — of particular interest to Companies which do not have Instrument Departments or enough qualified Staff to carry out regular inspection and maintenance — is the Service Contract. Under this arrangement, a Foxboro Service Engineer will call at stated intervals to check the condition and operation of all Foxboro Instruments in your Plant. The Service Contract is also used by Companies for the routine inspection and maintenance of highly technical instrumentation which requires specialised knowledge and experience.
The Company provides an expertly staffed and fully equipped Training Centre at Redhill devoted to the instruction of customers' Instrumentation Engineers and Service Men. The courses cover: theory of operation maintenance and application of the principal types of instruments. Applications from Companies in the British Isles should be made to Redhill, Surrey; from those in other parts of the world, to our nearest Representative as listed at the end of this book.

Parts

Parts Lists for Foxboro Instruments may be obtained by writing to the above address. It is strongly urged that only genuine Foxboro parts be used. Always give the serial number from the instrument data plate when requesting parts lists or ordering parts. (Those unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment, should not be permitted to undertake any major service work.)

Replacement

The Company has considerable knowledge and experience in regard to the economic life of Foxboro instrument equipment and will give advice on the desirability or otherwise, of fitting new parts into the older models. Improvements in design, materials, or methods sometimes make it more economic to replace rather than repair an instrument which has been in service for a long period of time.

Charts

To obtain the most accurate and consistent recording performance from our instruments, we strongly recommend the use of genuine Foxboro strip and circular charts.

FOXBORO

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

FOXBORO®

TO REPLACE ELECTRONICS MODULE

1. Turn off power. Remove topworks cover from operating-adjustment compartment.

   Disconnect the seven wires from terminals. Note how pairs are positioned in groove on side of module.

2. Loosen the two captive screws (Figure 27) that hold module to housing. Lift out module. Cut tie-wrap that holds five wires to rear of electronics module.

3. Connect all but gray and violet wires to new module. Note color identifications at terminals.

4. Position the five-wire assembly securely in left groove of module, and fasten these wires to rear of module with a new tie-wrap.

5. Position tie-wrap that is attached to violet and gray wires behind plate on rear of module, and position these wires in groove of module. Connect wires to terminals.

6. Position module in housing. Tighten captive screws, making sure that no wires will be crimped.

7. Calibrate transmitter.

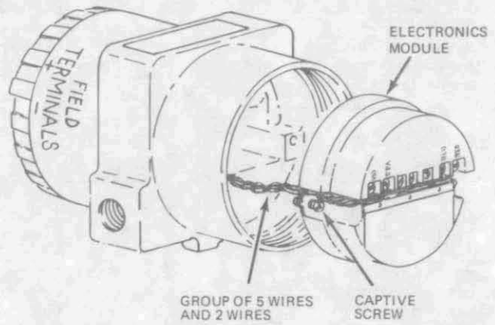

Figure 27

SPEC 200 is a trademark of The Foxboro Company.

MB 100

Printed in England

0283

Instruction

MI
020-339
February 1983

821AL SERIES
ABSOLUTE PRESSURE TRANSMITTER

INTRODUCTION

Figure 1

The 821AL Series Absolute Pressure Transmitter uses the resonant wire principle to measure absolute pressure. The transmitter transforms this measurement to a proportional electric signal.

The output of the pressure sensor is a frequency signal. In the milliampere-output transmitter, the frequency signal is converted, within the transmitter, to a milliampere signal. In the frequency-output transmitter, the frequency signal is transmitted to a SPEC 200 input component, where the frequency signal is converted to a 0 to 10 V dc signal.

SUPPLEMENTAL INSTRUCTIONS

This instruction covers the milliampere-output transmitter, and unless otherwise noted, also covers the frequency-output transmitter. Some topics contain material that only apply to the milliampere-output transmitter. Information in these topics for the frequency-output transmitter is covered in Instruction MI 020-340.

For a detailed principle of operation of the transmitter, see Technical Information TI 37-76b (milliampere output), or TI 37-75c (frequency output).

For detailed information on international codes and safety standards, see Technical Information TI 005-100, obtainable from Foxboro.

CONTENTS . . .

FOXBORO®

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STANDARD SPECIFICATIONS

Measurement Limits:

SENSOR RANGE	kPa ABSOLUTE		mm Hg ABSOLUTE	
	RANGE	SPAN*	RANGE	SPAN*
LOW	0 and 7.2	1.2 and 7.2	0 and 55	9.5 and 55
MED	0 and 36	6 and 36	0 and 280	50 and 280
HIGH	0 and 180	30 and 180	0 and 1400	235 and 1400

*Limits listed are overall limits for each sensor. Actual values depend on position of span jumper; see Page 8.

Maximum Overrange: 1 MPa (8000 mmHg, 150 psia)
Output Signal:
4 to 20 mA
10 to 50 mA } as specified on data plate
Frequency
Temperature Limits:
Minimum: -40°C (-40°F)
Maximum:

SENSOR	MINIMUM PRESSURE (abs)		MAXIMUM TEMP.	
	kPa	mmHg	°C	°F
L	0	0	+40	+100
	1	7	+50	+120
	2.3	17	+60	+140
M & H	-		+60	+140

Process Connection: Tapped for 1/4 NPT, 1/2 NPT, R 1/4 or R 1/2; as specified.
Power Supply: See Page 5
Output Load: See Figure 9
Power Consumption: 4 to 20 mA output, 1.25 W maximum; 10 to 50 mA output, 3.5 W maximum; frequency output, 2.5 W maximum.
Accuracy: ±0.2% of span
Housing: Weatherproof, dusttight, and watertight, as defined in IEC IP65 and NEMA Type 4.
Zero Suppression: Up to 150% of calibrated span limit. Sum of span plus suppression cannot exceed upper range limit of sensor.
Mass (approximate): 5.2 kg (11.5 lb)
Electrical Classification: See Figure 2

TRANSMITTER IDENTIFICATION

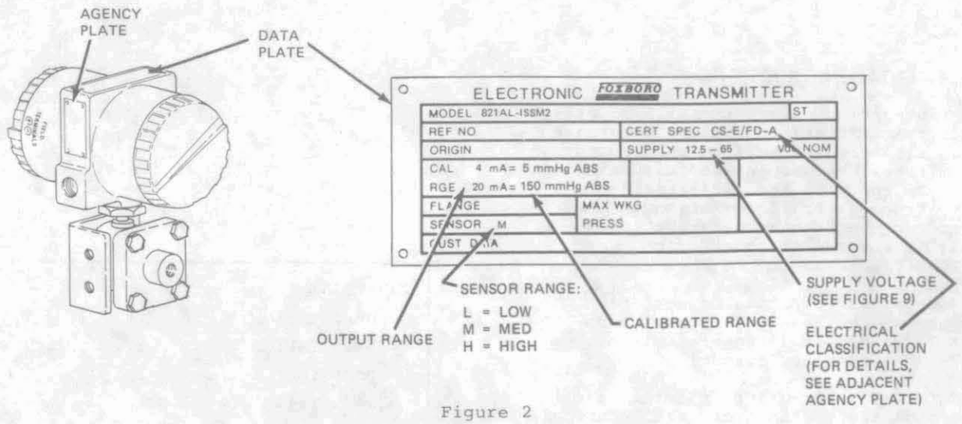


Figure 2

TO REPLACE SENSOR

1. Disconnect external wiring and process piping.
2. Disconnect violet and gray wires from terminals on electronics module. Loosen captive screws (Figure 26) on module.
3. Lift out module (with remaining wires attached) to expose stop screw. Loosen screw.
4. Loosen locknut so that locking plate falls from recess in topworks.
5. Unscrew sensor (about six turns) from topworks. While unscrewing sensor, rotate violet and gray pair of wires so that they do not twist. When sensor is separated from topworks, ease wires out of topworks.
6. Lift off locking plate and locknut from old sensor and position them onto new sensor. Sides of plate must be parallel to sides of sensor.
7. Remove the four bolts that hold sensor covers. Remove covers.
8. Lubricate threads and O-ring on neck of new sensor with silicone grease.
9. Install cover with new gasket on sensor. Lightly lubricate bolts. Tighten bolts gradually and uniformly to a torque of 20 N•m (14 lb•ft).
10. Thread sensor wires up into topworks. Screw sensor and topworks together as far as they will go. Rotate violet and gray pair of wires so that they do not twist.
11. Tighten stop screw and then back off 1/4 turn (head of screw should be below surface of casting). Unscrew topworks until stop screw hits stop.
12. If in Step 11, topworks was rotated at least 3/4 of a turn, proceed to Step 13.

    If topworks could not be rotated 3/4 of a turn, loosen stop screw and unscrew topworks an additional 1/4 turn. Tighten stop screw and back off screw about 1/4 turn.
13. Orient topworks (with respect to sensor assembly) in desired position. Insert locking plate up into recess in topworks and tighten locknut.
14. Position tie-wrap that is attached to violet and gray wires behind plate on rear of module. Connect wires to terminals.

    Position both groups of wires in groove of module.
15. Position module in housing. Tighten captive screws, making sure that no wire will be crimped.
16. Calibrate transmitter.

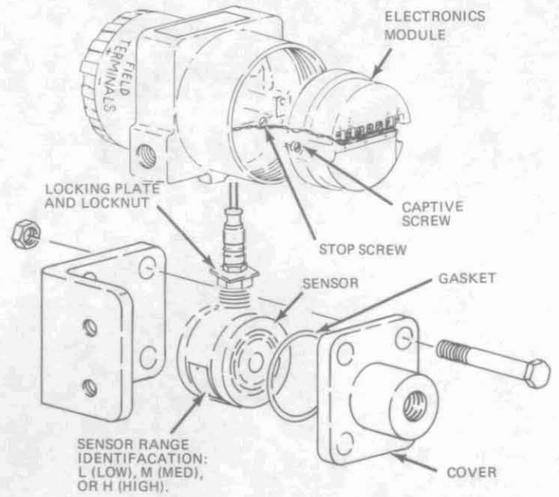


Figure 26

To Replace Zero Potentiometer
(Milliampere-output transmitter only.)

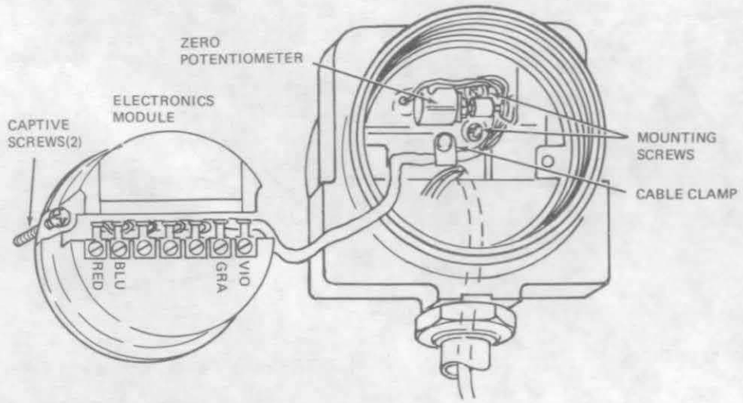


Figure 24

1. In operating-adjustment compartment of topwords, unscrew the two captive screws on electronics module, and lift out module.

2. Remove the two mounting screws holding potentiometer bracket to casting.

3. Carefully raise left side of potentiometer-bracket assembly, so that potentiometer shaft slips out of rubber coupling.

4. Cut the three leads off the potentiometer terminals. Strip insulation off ends of wires.

   If more slack in 5-wire cable is required, loosen cable clamp.

5. Note orientation of potentiometer on bracket for correct installation of new potentiometer. Remove old potentiometer.

6. Mount new potentiometer onto bracket, maintaining original orientation.

7. Carefully solder the three leads onto terminals of new potentiometer, observing color-coding in Figure 25. Use suitable sealant on soldered joints.

8. Reinstall potentiometer in reverse order of removal. Use care to avoid crimping wires or damaging terminals of RFI filters. Reinstall module.

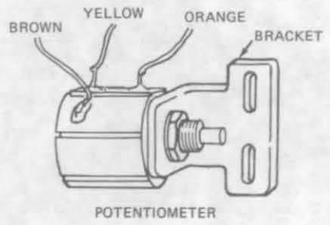


Figure 25

INSTALLATION

TRANSMITTER DIMENSIONS

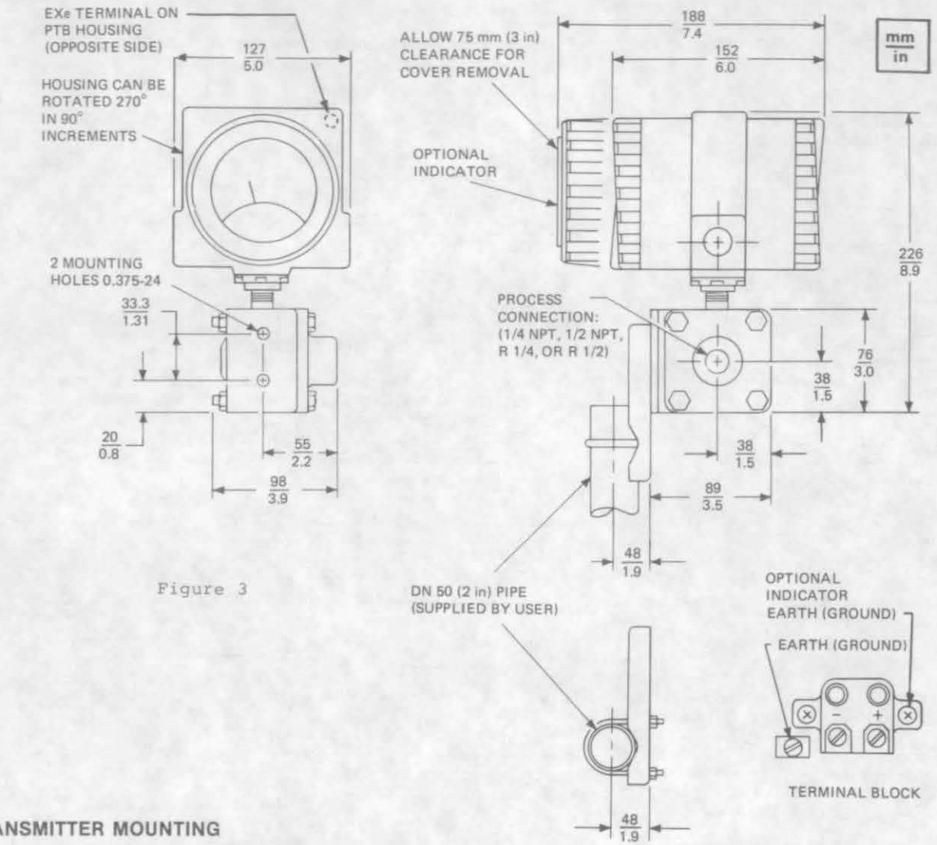


Figure 3

TRANSMITTER MOUNTING

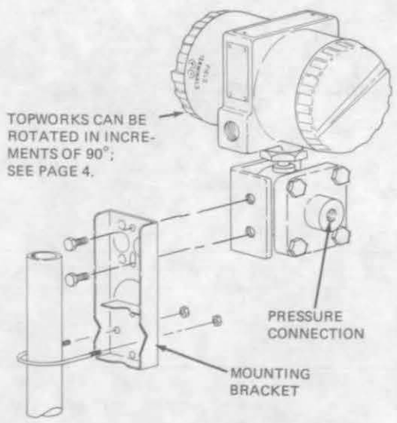


Figure 4

The transmitter can be mounted in any position.

The U-bolt (supplied with the mounting bracket) clamps the bracket to a DN 50 or 2 in pipe. See Page 4.

The pipe can be clamped to another pipe, or flanged and bolted to the floor or wall. The pipe can be horizontal or vertical (as shown). The U-bolt can be rotated 90° for use with a horizontal pipe.

TYPICAL TRANSMITTER PIPING

The recommended minimum size line is DN 15 or 1/2 in pipe, or 12 x 8 mm or 0.500 in tubing. Arrange piping to minimize accumulation of condensate in lines and transmitter.

With Transmitter Mounted Below Level of Connection to Process

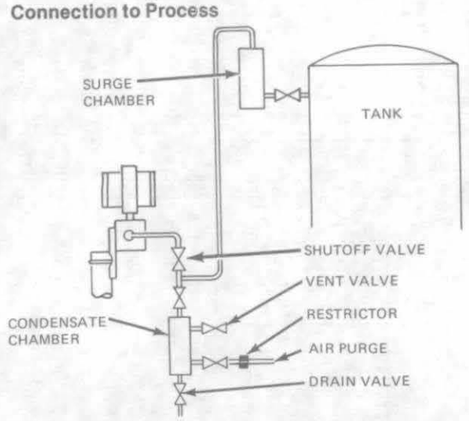


Figure 5

With Transmitter Mounted Below Level of Connection to Process

An air purge (atmospheric or pressurized) will keep tank vapors out of measurement line. Use Foxboro restrictor, Part 0032060. This restrictor contains a 0.13 mm (0.005 in) diameter pinhole, passing about 0.05 m^3/h (2 ft^3/h) of air. The surge and condensate chambers can be made from a 200 mm (8 in) long piece of DN 100 or 4 in pipe.

If the purge air flows through a considerable length of measurement line, the pressure drop may cause a measurement error.

To determine the error due to the purge air, note the absolute pressure with the air on; then note the pressure with the air off. The difference in pressures is the error. If the error is objectionable, increase the size of the line and/or decrease the flow of purge air.

Drain the condensate as often as required. To drain, close the shutoff valve and then open the vent and drain valves.

With Transmitter Mounted At or Above Level of Connection to Process

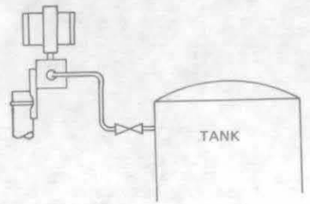


Figure 6

TO ROTATE TOPWORKS

The topworks can be rotated to any one of four positions in 90° increments. Choose the position which permits access to field terminals, room for removal of topworks covers, and convenient conduit installation.

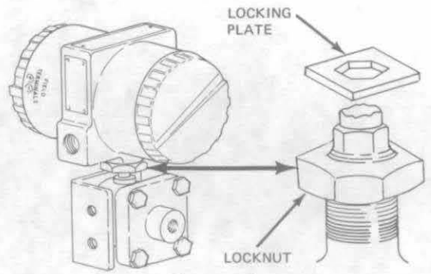


Figure 7

1. Lower the locknut (Figure 7) that holds topworks in place (turn clockwise as viewed from above) until locking plate falls from recess in top works.

   (If locking plate does not fall after locknut is loosened, pry out plate with pointed tool.)

2. Rotate topworks to desired position. Tighten locknut, making sure that locking plate is seated in square recess in topworks.

Table 1. Additional Power Supply Details

RECEIVER LOOP	4 to 20 mA OUTPUT TRANSMITTER	10 to 50 mA OUTPUT TRANSMITTER
4 to 20 mA	Use built-in power supply in SPEC 200 nest or in E20S-1 Series Recorder.*	--
10 to 50 mA	Use Current Converter (Part B0129XS) and nominal 80 V dc power suply.	Use SPEC 200 field bus with nominal 75 V dc power supply and appropriate input module.*

*If individual power supply is not used.

TO CHECK FOR DEFECTIVE COMPONENT IN TOPWORKS

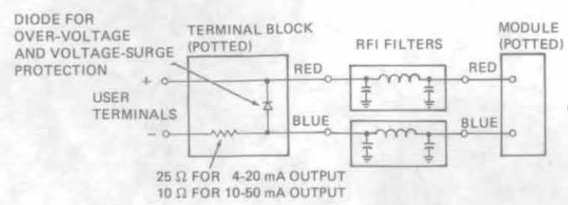
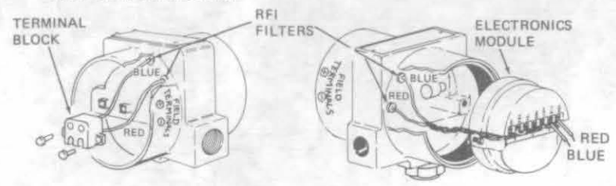


Figure 21



To Check For Defective Diode

(In Step 2, two values of voltage and current are listed. The first value is for transmitters with 4 to 20 mA output, and the second value [in parentheses] is for transmitters with 10 to 50 mA output.)

1. Disconnect blue and red leads at module. Connect test equipment as shown in Figure 22.

2. Slowly increase supply voltage.

   Milliammeter should read 0 mA until voltage is between 65 and 72 V (95 and 105 V). Current should then increase as voltage increases. At 75 V (115 V), current should be between 3 and 11 mA (10 and 30 mA).

3. Reduce voltage to 0 V. Reverse the polarity of leads at terminal block (positive [+] lead goes to negative [-] terminal, etc.).

4. Very slowly increase voltage. Current should begin to rise at less than 1 V. At 10 V, current should be between 9 and 10 mA.

5. If all these conditions are not met, replace terminal block.

NOTE: Use care when soldering terminal block leads; RFI filters can be damaged with excessive heat.

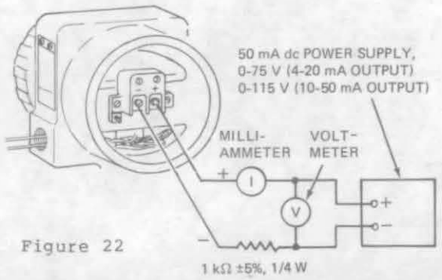


Figure 22

To Check For Defective RFI Filter

1. Disconnect blue and red leads at module. Use ohmmeter to check continuity between input terminals and ground, as shown in Figure 23.

2. If there is continuity between either the positive (+) terminal and ground, or the negative (-) terminal and ground, replace both RFI filters, (Part HO183CZ).

   (Remove filters from field-terminal compartment side using a 3/16 socket wrench. When inserting filters, tighten to a torque of 0.6 to 0.8 N·m (5 to 7 lb·in). NOTE: These filters can be damaged with excessive heat; use care when soldering leads.)

3. Check continuity between user terminals and associated leads disconnected from module in Step 1.

   If there is not continuity between either the positive (+) terminal and red lead at module, or the negative (-) terminal and blue lead at module, replace both RFI filters.

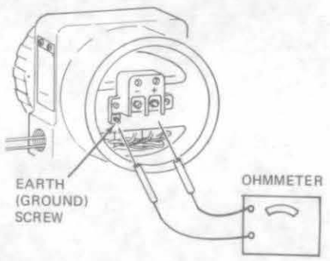


Figure 23

TO IDENTIFY DEFECTIVE COMPONENT

This procedure is applicable only to milliampere-output transmitters. For frequency-output transmitters, see Instruction MI 020-340.

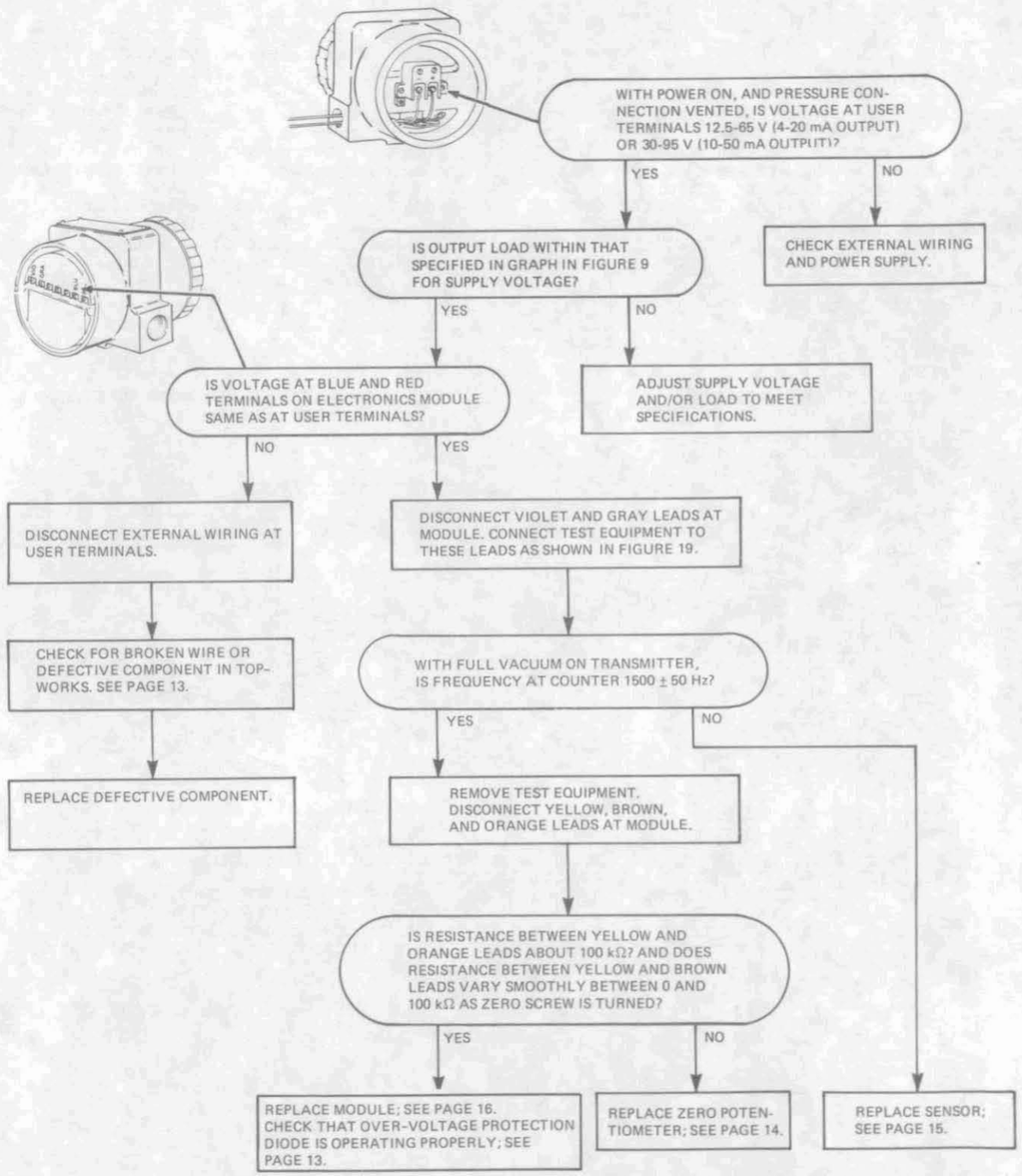


Figure 20

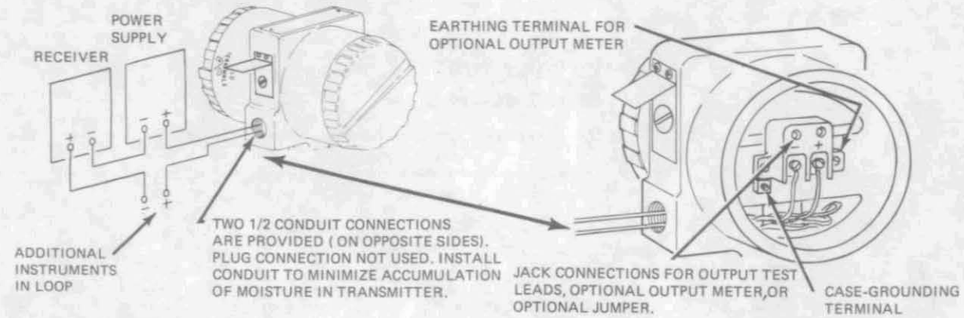


Figure 8

INSTALLATION WIRING

This section applies only to the milliampere-output transmitter; for the frequency-output transmitter installation details, see Instruction MI 020-340.

Connect the supply-receiver loop wiring to the transmitter terminals (Figure 8). Polarities are marked at the terminals. If the loop is to contain other instruments, install them in the negative lead, observing polarities as shown.

The jack connections, above the wiring terminals, are used for output test leads, for the optional output meter (±2% of scale accuracy), or, with the 4 to 20 mA output transmitter, for the optional jumper (Part D0151CC) which permits an additional 25 Ω resistance in the output loop. The output at these jack connections is 100 to 500 mV dc, corresponding to 0 to 100% output.

For details on transmitter earthing (grounding), see Page 7.

POWER SUPPLY

This section covers only the milliampere-output transmitter; the power supply for the frequency-output transmitter is part of the SPEC 200 nest (see Instruction MI 020-340).

The supply voltage limits at the transmitter terminals are indicated in the applicable graph in Figure 9. However, for a given supply voltage, the limits of the transmitter output loop resistance are set. (For example, with a 4 to 20 mA output transmitter, if supply voltage is 60 V dc, allowable loop resistance is 150 to 2400 Ω.) To determine the output loop resistance, add the series resistance of each component in the loop.

The power supply must be capable of supplying 22 mA (4 to 20 mA output) or 55 mA (10 to 50 mA output). For additional power supply details, see Table 1, Page 4.

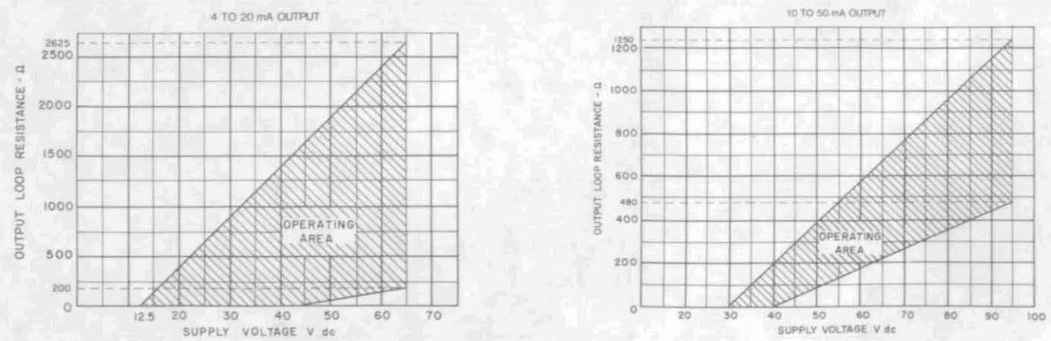


Figure 9

CERTIFICATION DETAILS

⚠ WARNING

1. To maintain explosion-proof, dust-ignition-proof, and NEMA 4 protection, unused conduit opening (two 1/2 NPT connections are provided) must be plugged with metallic pipe plug which engages a minimum of five full threads.

2. The milliampere-output transmitter may have agency certification for installation in hazardous locations or for intrinsic safety. Refer to label affixed to transmitter for type of certification, and observe applicable wiring practices. Conditions of certification are listed below. Similar details for frequency-output transmitters are in Instruction MI 020-340.

Output (mA)	Testing Laboratory	Types of Protection and Area Classification	Conditions of Certification
4 to 20	CSA	Explosion-proof for Class I, Groups B, C, and D, Division 1. Dust-ignition-proof for Class II, Groups E, F, and G, Division 1; and Class III, Division 1. Suitable for use in Class I, Groups A, B, C, and D, Division 2.	—
	FM	Nonincendive resistive for Class I, Groups A, B, C, and D, Division 2; and Class II, Groups F and G, Division 2.	—
	CSA	Intrinsically safe for Class I, Groups B, C, and D, Division 1.	When connected according to SI 8-00478.
		Intrinsically safe for Class I, Groups A, B, C, and D, Division 1.	When connected to CSA-certified Zener barriers rated: 33 V, 415 Ω; 30 V, 300 Ω; 28 V, 240 Ω; 26.7 V, 200 Ω; or 20 V, 70 Ω.
		Intrinsically safe for Class I, Groups C and D, Division 1	When connected to CSA-certified Zener barriers rated: 33 V, 185 Ω; 30 V, 130 Ω; 28 V, 115 Ω; or 20 V, 30 Ω.
	FM	Intrinsically safe for Class I, Groups A, B, C, and D, Division 1; Class II, Groups E, F, and G, Division 1.	1. When connected according to TI 005-101. 2. Associated control room equipment shall not use or generate more than 250 V rms.
	PTB	Intrinsically safe (Ex) ib IIC.	When connected to PTB-certified SPEC 200, UIO, and UCM input components.
	BASEEFA	Intrinsically safe for Groups IIC, IIB, IIA, Zone 1 or Zone 0.	1. When used in BASEEFA-certified systems in conjunction with SPEC 200, UIO, and UCM components. 2. For Zone 0 applications use isolated input cards only.
	LCIE	Flameproof combined with intrinsic safety, EExd (ia) IIC 45°C.	—
10 to 50	CSA	Explosion-proof for Class I, Groups B, C, and D, Division 1. Dust-ignition-proof for Class II, Groups E, F, and G, Division 1; and Class III, Division 1. Suitable for use in Class I, Groups A, B, C, and D, Division 2.	—
	FM	Nonincendive resistive for Class I, Groups A, B, C, and D, Division 2; and Class II, Groups F and G, Division 2.	—
	LCIE	Flameproof combined with intrinsic safety, EExd (ia) IIC 45°C.	—

MAINTENANCE

The transmitter normally requires servicing only if it cannot be calibrated or if the range is to be changed.

If the transmitter cannot be calibrated, check for a defective component (Page 12).

TRANSMITTER DISASSEMBLY

The disassembly of the transmitter is usually limited to that shown in Figure 18. The electronics module, the sensor assembly, and the zero potentiometer (milliampere-output transmitter only) are the only parts that may require replacement in normal operation.

The process gasket should be replaced each time the transmitter body is opened.

TRANSMITTER DISASSEMBLY

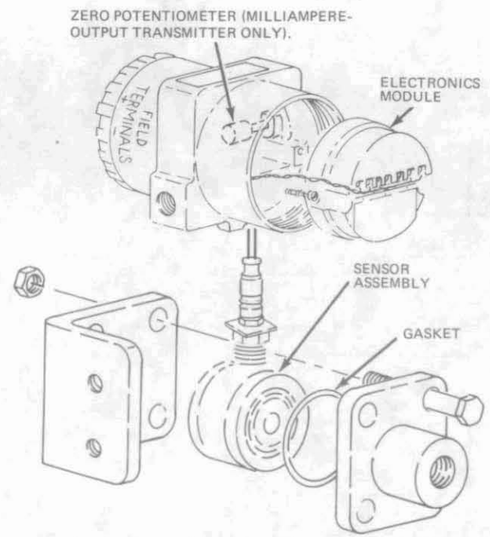


Figure 18

TO CHANGE RANGE

The transmitter can be calibrated to any range within the limits of the particular sensor installed in the transmitter [see sensor measurement limits and sensor identification (Page 2)].

If the desired range is outside the sensor limits, but within the limits of one of the other available sensors, this new sensor and its corresponding electronics module (see Parts List PL 009-102) must be ordered. However, with a frequency-output transmitter, the same module can be used with all sensors.

After the new parts are installed, recalibrate the transmitter to the desired range, and alter the data plate to indicated the new conditions.

HOOKUP TO CHECK FOR DEFECTIVE MODULE
(SEE PAGE 12 FOR PROCEDURE.)

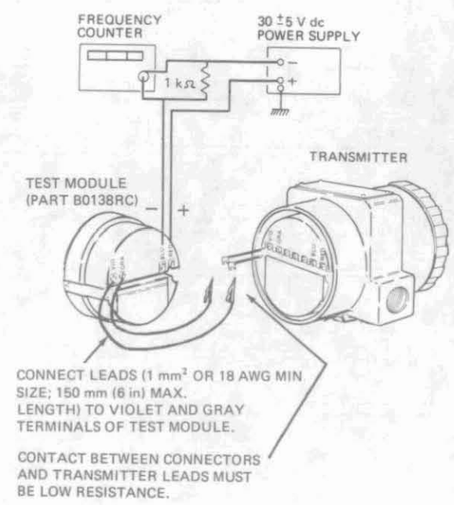


Figure 19

PRELIMINARY CALIBRATION ADJUSTMENT

This additional procedure is required:

- If either the sensor or electronics module has been replaced, and/or
- If either the range or span is being changed:

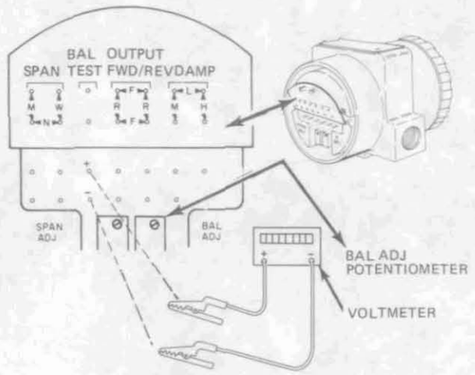


Figure 17

1. Connect voltmeter to BAL TEST terminals. Set up bench calibrating equipment (Figure 15).
2. Apply a pressure of 0.01% of span or lower to transmitter. Adjust BAL ADJ potentiometer so that voltmeter at BAL TEST terminals reads 0.000 ±0.002 V.
3. Repeat calibration procedure.

BAL ADJ (BALANCE ADJUSTMENT) POTENTIOMETER ADJUSTMENT

This adjustment is required if the output corresponding to a mid-scale input is not satisfactory. Complete this adjustment, then continue with the calibration procedure on Page 9.

1. Connect voltmeter to BAL TEST terminals (Figure 17).
2. Use formula in Figure 18 to calculate BAL TEST voltage.
3. Adjust BAL ADJ potentiometer so that voltmeter reads calculated value.
4. With power on, apply a pressure of 0.01% of span or lower to transmitter, adjust BAL ADJ potentiometer so that voltmeter across BAL ADJ terminals reads calculated value.
5. Continue with Step 2 of calibration procedure on Page 9.

Formula to Calculate BAL TEST Voltage

$$\text{BAL TEST voltage} = (-1)(\text{mid-range error})\left(\frac{0.8}{\frac{\text{span}}{C} - 0.2}\right)\left(\frac{\text{upper range value}}{\text{span}}\right)$$

VALUE OF C IN FORMULA		
SENSOR	kPa	mmHg
Low	5	30
Medium	25	180
High	125	900

Where: $\text{mid-range error in \% of span} = (100)\left(\frac{M - \frac{U + L}{2}}{U - L}\right)$

U = Output voltage at upper-range value
L = Output voltage at lower-range value
M = Output voltage at mid-range value
C = Constant; see table below

EXAMPLE: Transmitter with range of 20 to 140 mmHg (medium sensor)

U = 10.040 V
L = 2.020 V
M = 6.050 V

NOTE
With reverse output, reverse sign of calculated value.

$$\text{Mid-range error} = (-1)(100)\left(\frac{6.050 - \frac{10.040 + 2.020}{2}}{10.040 - 2.020}\right) = \frac{1}{4.01}$$

$$\text{BAL TEST voltage} = (-1)\left(\frac{1}{4.01}\right)\left(\frac{0.8}{\frac{120}{180} - 0.2}\right)\left(\frac{140}{140 - 20}\right) = -0.4988 \text{ V}$$

TRANSMITTER EARTHING (GROUNDING)

The transmitter case is normally earthed. Refer to the applicable electric code for earthing requirements.

A case-earthing terminal (Figure 8) is provided in the field-terminal compartment in the topworks. [CSA installations require earthing with this terminal. With PTB installations, an external earthing terminal (see Figure 3) is provided.]

If the signal circuit must be earthed, it is preferable to earth the negative terminal of the dc power supply. CAUTION: To avoid circulating currents in earth loops, or the possibility of short-circuiting groups of instruments in a loop, there should be only one earth in a loop.

OPERATION

The three operation adjustments below apply only to the milliampere-output transmitter. These procedures for the frequency-output transmitter are covered in Instruction MI 020-340.

TO CHANGE OUTPUT ACTION

Depending on the positions of two jumpers, the transmitter will have either an increasing or a decreasing output, with an increasing input pressure. For an increasing output, position the jumper in F (forward) positions; for a decreasing output, position the jumpers in R (reverse) positions. See Figure 12.

DAMPING ADJUSTMENT

If the measurement signal varies rapidly enough to cause a pulsating output, the response of the transmitter can be altered to damp out these pulsations. The transmitter has jumper positions for three levels of damping (low, medium, and high; labeled L, M, and H). See Figure 12.

The low position is used for normal applications, and the medium and high positions are used to screen out undesirable process noise. Note that, if the jumper is withdrawn, the damping automatically goes to the low level.

ZERO ADJUSTMENT

Complete this adjustment with the transmitter in its operating position before putting it into operation. This is an operating adjustment only.

If the transmitter is not calibrated to the desired range, complete the calibration before starting the zero adjustment. For calibration, see Page 8.

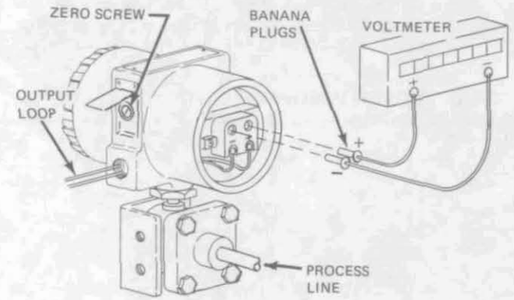


Figure 10

1. Connect voltmeter (Figure 10) to output test connections in field-terminal compartment in topworks. Close shutoff valve at transmitter.
2. Apply best vacuum attainable within range to transmitter. For details on measuring input pressures, see "Calibration Piping," Page 8.
3. Use formula in Figure 11 to calculate output reading on voltmeter corresponding to input pressure.
4. Turn ZERO adjustment screw so that reading on voltmeter is calculated value.

   If necessary, change zero adjustment on receiver so that reading is correct.

Formula to Calculate mV Output for Any Input

$$\text{mV Output} = (400)\left(\frac{\text{Test gauge reading - Lower range value}}{\text{Upper range value - Lower range value}}\right) + 100$$

EXAMPLE: Transmitter range, 100 to 200 mmHg abs
Test gauge reading, 125 mmHg abs

$$\text{Output} = (400)\left(\frac{125 - 100}{200 - 100}\right) + 100 = 200 \text{ mV}$$

Figure 11

CALIBRATION

CALIBRATION NOTES

1. This section covers milliampere-output transmitters only. For calibration of frequency-output transmitters, see Instruction MI 020-340.

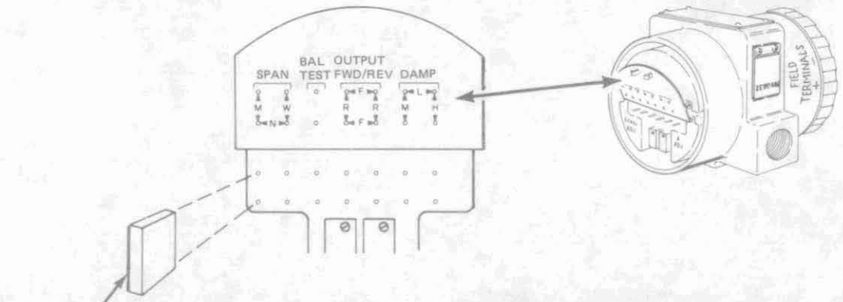
2. If range is to be changed, span jumpers may require repositioning prior to recalibration (Figure 12).

3. Accuracy of calibration equipment should be a minimum of three times desired accuracy of transmitter. If necessary, apply correction factors for such external influences as temperature, barometric pressure, and local acceleration of gravity.

SPAN JUMPER POSITIONS (COARSE SPAN ADJUSTMENT)

In the operating-adjustments compartment of the topworks, set the coarse span by inserting the span jumper into the applicable position as specified in Figure 12. Then calibrate the transmitter to the desired range.

The spans corresponding to jumper positions are approximate. If necessary, use another jumper position if the transmitter cannot be calibrated to the desired range.



JUMPER POSITION	SPANS					
	mm Hg	kPa	mm Hg	kPa	mm Hg	kPa
N (NARROW)	9.5 to 14	1.2 to 1.8	50 to 70	6 to 9	235 to 350	30 to 45
M (MEDIUM)	14 to 28	1.8 to 3.6	70 to 140	9 to 18	350 to 700	45 to 90
W (WIDE)	28 to 55	3.6 to 7.2	140 to 280	18 to 36	700 to 1400	90 to 180
	LOW RANGE SENSOR		MEDIUM RANGE SENSOR		HIGH RANGE SENSOR	

SPAN = UPPER RANGE VALUE – LOWER RANGE VALUE

Figure 12

CALIBRATION PIPING

Disconnect the process piping to the transmitter and connect the calibrating piping.

Use a special manometer reading in absolute pressure units. Or, use an ordinary manometer connected to read vacuum and/or pressure, in conjunction with a mercury barometer, reading atmospheric pressure in absolute units.

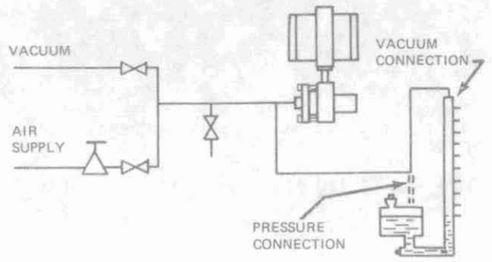


Figure 13

CALIBRATION WIRING

Field Calibration

The field calibration does not require removal of the external wiring. Calibrating signals of 0 to 100% of range produce proportional 100.0 to 500.0 mV output readings on the voltmeter.

The maximum inherent error due to the built-in resistor across the output test terminals is ±0.1% of span.

Connect voltmeter to output test connections in field-terminal compartment in topworks. See Figure 14.

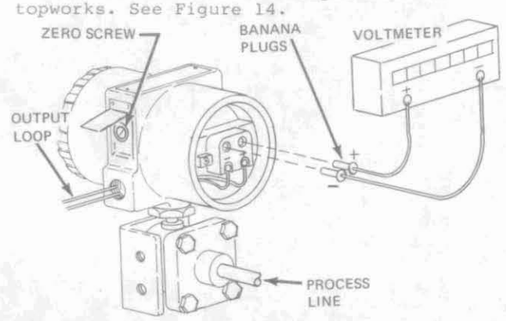


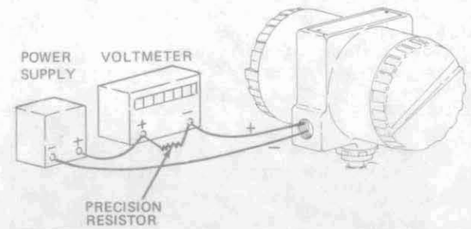
Figure 14

Bench Calibration

The bench calibration requires a power supply and a precision resistor, as specified in Figure 15. Calibrating signals of 0 to 100% of range produce proportional 2.000 to 10.000 V output readings on the voltmeter.

Connect the power supply, voltmeter, and precision resistor to the transmitter input terminals in the field-terminal compartment of the topworks. Observe polarity.

Check that the loop resistance is within the operating area for the power supply voltage; see applicable graph in Figure 9.



OUTPUT SIGNAL	RESISTOR	PART NUMBER
4 to 20 mA	500 Ω ±0.01%, 1 W, 5 ppm/°C	E0286ZM
10 to 50 mA	200 Ω ±0.01%, 1 W, 5 ppm/°C	E0286ZL

Figure 15

CALIBRATION PROCEDURE

If either the sensor or electronics module has been replaced, and/or if either the range or span is being changed, complete the preliminary calibration adjustment on Page 10 before proceeding with the calibration procedure.

The outputs specified in this procedure assume that the bench calibration is used. These outputs are 2.000, 6.000, and 10.000 V, corresponding to inputs of 0, 50, and 100% of range.

If the field calibration is used, substitute outputs of 100.0, 300.0, and 500.0 mV respectively.

If the output-action jumpers are in the R (reverse) position, interchange the output values corresponding to calibrating signals of 0 and 100%.

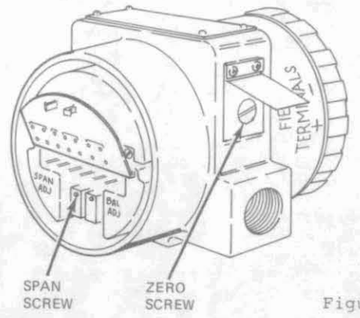


Figure 16

1. Set up calibrating equipment shown in Figure 13 and either Figure 14 or 15.

2. Set calibrating pressure at lowest value attainable. Calculate corresponding output; use formula in Figure 11. If necessary, adjust ZERO screw (Figure 16) to get correct output

3. Set pressure equal to upper range value. Output should be 10.000 V. If necessary, adjust SPAN screw to get correct output.

4. Repeat Steps 2 and 3 until both outputs are correct without adjustment.

5. Set calibrating pressure equal to midrange value. Output should be 6.000 V.

   If output is satisfactory (see table), calibration is complete. If output is not satisfactory, complete "BAL ADJ Potentiometer Adjustment" on Page 10.

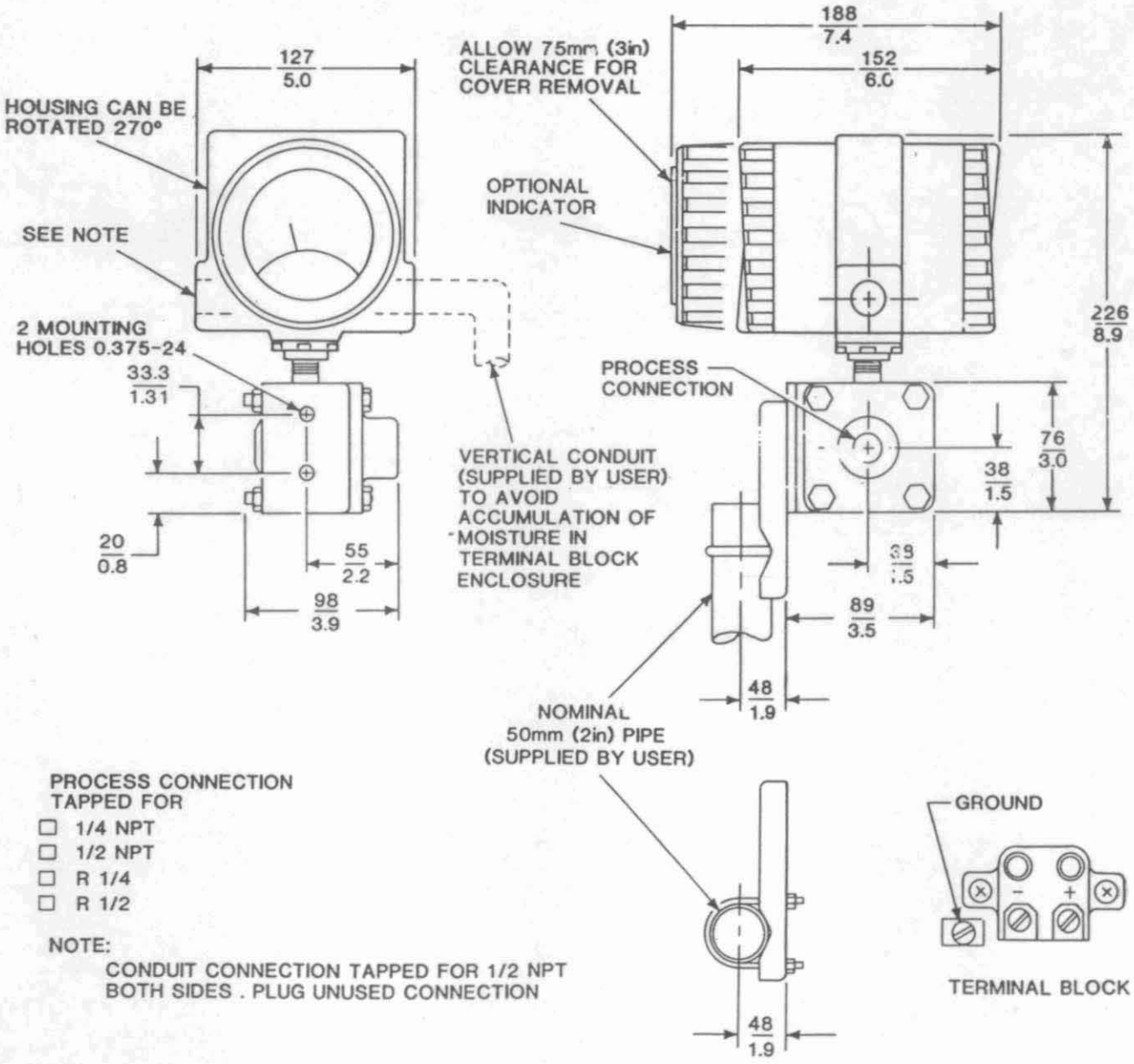
OUTPUT DEVIATION FROM 6.000 V	ERROR % OF SPAN
±0.008 V	±0.1
±0.016 V	±0.2*
±0.040 V	±0.5

*Maximum factory-calibrated error

Dimensional Print

CDP
020-339
MARCH 1982

MODEL 821AL ABSOLUTE PRESSURE TRANSMITTER



PROCESS CONNECTION TAPPED FOR

- ☐ 1/4 NPT
- ☐ 1/2 NPT
- ☐ R 1/4
- ☐ R 1/2

NOTE:

CONDUIT CONNECTION TAPPED FOR 1/2 NPT BOTH SIDES . PLUG UNUSED CONNECTION

CUSTOMER _____ I.R. _____

CUSTOMER ORDER _____ FOXBORO ORDER _____

ITEM–TAG _____

AMERICAN PROJECTION

mm
inch

CERTIFIED BY _____ DATE _____

FOXBORO®

Parts List

PL
009-102
March 1984

821AL ELECTRONIC ABSOLUTE PRESSURE TRANSMITTER Style A

Model Code

821AL = Absolute Pressure Transmitter

Output Signal
-I = 4 to 20 mA dc
-H = 10 to 50 mA dc
-F = Frequency with SPEC 200 Input Component

Flange Material
K = Carbon Steel
S = 316 ss
C = Hastelloy C
M = Monel

Sensor Wetted Parts Material
1N = Cobalt-nickel-chrome alloy (standard)
1S = 316 ss
1C = Hastelloy C
1M = Monel

Span Limits
L = 1.2 and 7.2 kPa, 9.5 and 55 mmHg, or 0.012 and 0.07 bar or kg/cm²
M = 6.0 and 36 kPa, 50 and 280 mmHg, or 0.06 and 0.36 bar or kg/cm²
H = 30 and 180 kPa, 235 and 1400 mmHg, or 0.30 and 1.80 bar or kg/cm²

Process Connection
1 = Tapped for 1/4 NPT
2 = Tapped for 1/2 NPT
3 = Tapped for R 1/4
4 = Tapped for R 1/2

Optional Features
-A = Indicator with 0 to 100% uniform scale
-C = Indicator with scale per Sales Order
-Y = Delete bracket for pipe mounting

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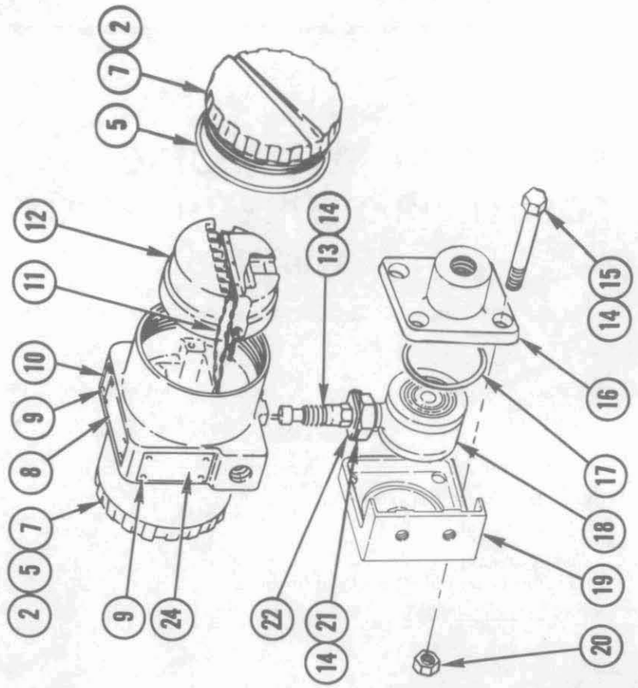


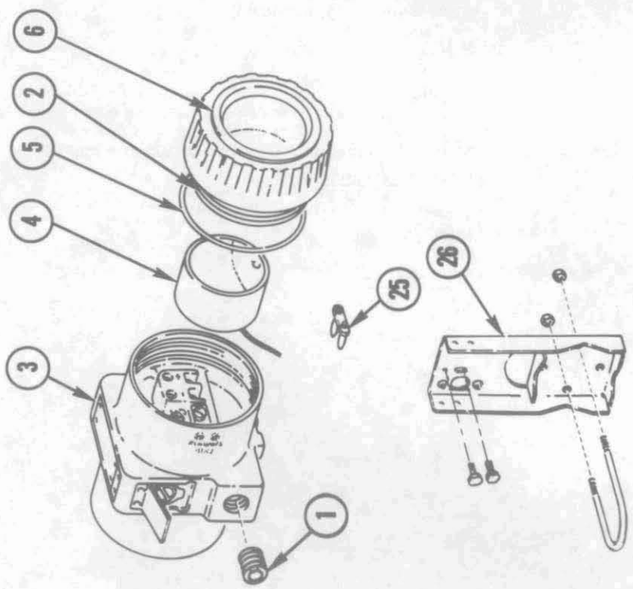


Fig. E2032C

Module Assembly

Span Limits	Output Signal					
	Code -H 10 to 50 mA	Code -H (LCIE) 10 to 50 mA	Code -I 4 to 20 mA	Code -I (LCIE) 4 to 20 mA	Code -I (PTB) 4 to 20 mA	Code -F Frequency
Low	B0139FZ	B0140ME	B0139FY	B0140EF	B0139FS	B0140EX
Med	B0138RB	B0140MF	B0138RA	B0139YD	B0138VK	B0140EX
High	B0139EZ	B0140MG	B0139EY	B0140EH	B0139FR	B0140EX

Item	Part No.	Qty.	Part Name	
1	B0138LY	4	*Jumper	
2	Below	1	Cover	See Note
	D0135MS		Hinged standard	
	B0138VM		Rigid (PTB, LCIE)	
3	Below	—	Screw	
	X0166BZ	3	Standard	
	X0170QV	2	PTB, LCIE	
4	B0138ZY	2	Captive Screw	
5	B0138RT	7	Screw	

NOTE: Module Part B0140EX for Frequency Output does not have Front Cover, Item 2, or Screws, Item 3.

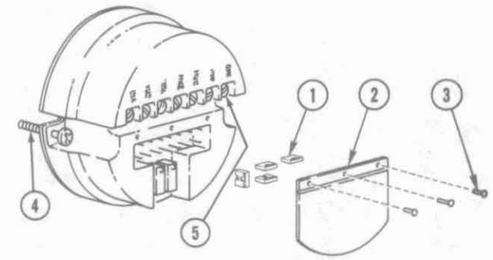


Fig. E1827A

Sensor Assembly
(Item 18, Page 3)

Code	Span Limits			Wetted Materials	Sensor Fill Fluid
	Low (L) 9.5 and 55 mm Hg	Medium (M) 50 and 280 mm Hg	High (H) 235 and 1400 mm Hg		
1N	D0135WG☆	D0135WL☆	D0135WQ☆	cobalt-nickel	silicone
1S	D0135WF	D0135WK	D0135WP	316 ss	silicone
1C	D0135WD	D0135WH	D0135WM	Hastelloy C	silicone
1M	L0112WN	L0112WP	L0112WQ	Monel	silicone

☆Star indicates metallic process wetted materials conforming to NACE standard MR-01-75.

Options

Ermeto Connectors		PG-11 Trumpet Connection
1/4 NPT X 6 mm Tubing		N7000AA - Trumpet Case Connection N7141KR - Connector Both Required
U7002AS	316 ss	
U7002AT	Cad. Pl. cs	
1/2 NPT X 12 mm Tubing		PG-13.5 Trumpet Connection
		N7141DW - Trumpet Case Connection N7141KC - Connector Both Required
U7002AP	316 ss	
U7002AR	Cad. Pl. cs	

Metric Conduit Connector
Part N7141DX - Connector (M20 x 1.5-7H)

Hawke Cable Gland
Part N7141HX - Gland

Parts are illustrated on page 2.

Item	Part No.	Qty.	Part Name
1	—	1	1/2 NPT Plug (customer supplied), see note 1
2	X0114AT	1	Lubriplate Lubricant, 0.45 kg (1 lb)
3	—	1	Housing Assembly (see p 4)
4	B0138YM	1	Indicator Assembly (optional) 0 to 100 Uniform Scale (Code -A)
5	B0138QU	2	O-Ring
6	Below	1	Cover Assy. (for optional indicator)
	B0138QZ		Standard
	B0140LN		LCIE
7	B0138QV	2	Cover
8	Below	1	Nameplate
	B0125WP		4 to 20 mA (Code -I)
	B0125WP		10 to 50 mA (Code -H)
	B0126LG		Frequency (Code -F)
9	X0161CT	8	Screw, Tapping
10	B0125WQ	1	Address Plate (U.S. Issue)
11	N0139FR	1	Tie Wrap
12	—	1	Module Assembly (see p 5)
13	E0121AE	1	O-Ring (Included in Item 18)
14	0048130	1	Grease, Silicone, 150 g (5.3 oz)
15	Below	4	Screw, Hex H., 0.375-16 x 3.000 (see notes 2, 3, and 4)
	X0171GY		Cadmium plated steel (standard)
	X0171GZ		17-4 stainless steel
	X0171XM		Cadmium plated steel ASTM A-193 Grade B7M
16	—	1	Flange Connector (see table)
17	B0139RB	1	Gasket, glass filled ptfe
18	—	1	Sensor Assembly (see p 5)
19	D0135WA	1	Bracket
20	Below	4	Nut, 0.375-16 (see notes 2, 3, and 4)
	X0170ZM		Cadmium plated steel (standard)
	X0171AX		17-4 PH stainless steel
	X0170WQ		Cadmium plated steel ASTM A-194 Grade 2M
21	B0138QT	1	Nut, M22X1.5
22	B0139DP	1	Restraining Pad
24	—	†	Certification Plate (give instrument reference number)
25	P0151CC	1	Plug-in Shorting Bar, to permit additional 25 ohm output load capability (optional)
26	P0120NP	1	Mounting Set
	0011962	2	Nut, 0.312-18
	N0141ZW	1	Bracket
	D0114SM	1	U-Bolt
	Below	2	Screw, Hex H., 0.375-24 x 0.625
	X0116FB		Plated Steel
	P0120RM		Stainless Steel (optional)

Note 1: To maintain explosion-proof and dust ignition-proof protection you must plug the unused conduit opening with a metallic pipe plug which engages a minimum of five full threads.

Note 2: For replacement of Flange Connector nuts and screws, use only the Foxboro part numbers listed.

Note 3: "Standard" plated steel screws and nuts and optional 17-4 PH stainless steel screws and nuts are non-process wetted and are only suitable for Class III bolting requirements of NACE Standard MR-01-75.

Note 4: Optional B7M screws and 2M nuts are non-process wetted and are suitable for Class II bolting requirements of NACE Standard MR-01-75.

Flange Connector (Item 16, Above)

Part No.	Flange Material	(Code)	Process Connection	(Code)
D0143CS☆	cadmium plated steel	(K)	1/4 NPT	(1)
D0143CN☆	cadmium plated steel	(K)	1/2 NPT	(2)
D0143CU☆	cadmium plated steel	(K)	R 1/4	(3)
D0143CQ☆	cadmium plated steel	(K)	R 1/2	(4)
D0143CJ☆	316 stainless steel	(S)	1/4 NPT	(1)
D0143CE☆	316 stainless steel	(S)	1/2 NPT	(2)
D0143CL☆	316 stainless steel	(S)	R 1/4	(3)
D0143CG☆	316 stainless steel	(S)	R 1/2	(4)
D0135GF	Hastelloy C	(C)	1/4 NPT	(1)
D0135GB	Hastelloy C	(C)	1/2 NPT	(2)
D0135GH	Hastelloy C	(C)	R 1/4	(3)
D0135GD	Hastelloy C	(C)	R 1/2	(4)
D0135FP	Monel	(M)	1/4 NPT	(1)
D0135FN	Monel	(M)	1/2 NPT	(2)
D0135FM	Monel	(M)	R 1/4	(3)
D0135FL	Monel	(M)	R 1/2	(4)

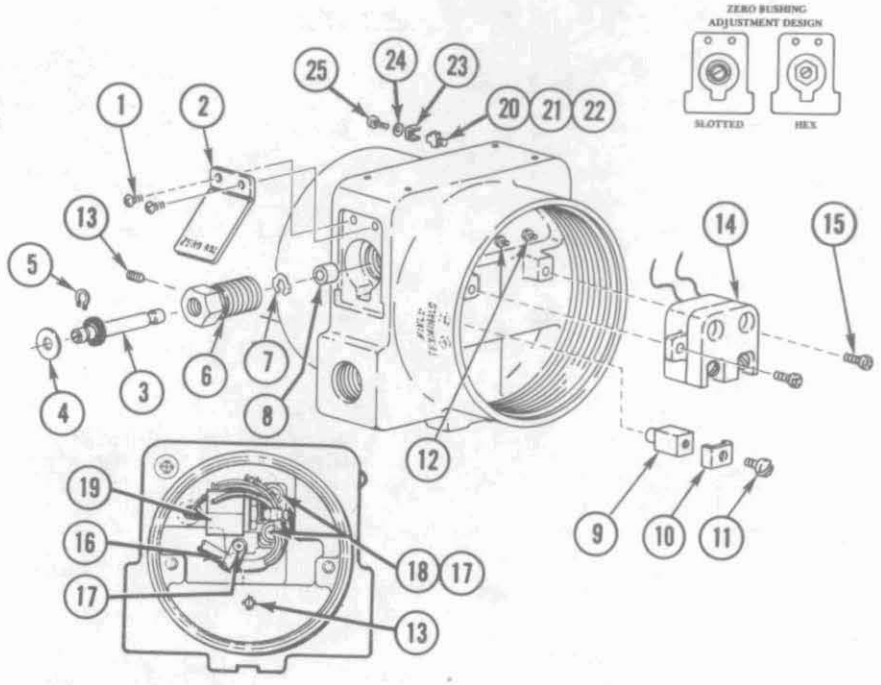
Monel is a trademark of Huntington Alloys Incorporated.
Hastelloy C is a trademark of the Stellite Division of the Cabot Corporation.
17-4 PH is a trademark of the Armco Steel Corporation.
Lubriplate is a trademark of Lubriplate Division of Fiske Brothers Refining Company.

☆Star indicates metallic process wetted materials conforming to NACE Standard MR-01-75.

***Parts preceded by asterisks are those most commonly replaced**
GIVE INSTRUMENT MODEL NUMBER AND REFERENCE NUMBER WHEN ORDERING PARTS

Housing Assembly

Fig. E2009B



Item	Part No.	Qty.	Part Name
—	Below	—	Housing Assembly
	B0138WA		10 to 50 mA, -H
	B0138QA		4 to 20 mA, -I
	B0138VT		4 to 20 mA, -I (PTB)
	B0139DJ		10 to 50 mA, -H (LCIE)
	B0139CT		4 to 20 mA, -I (LCIE)
	B0138UA		Frequency, -F — See Note 1
	B0138VW		Frequency, -F (PTB) — See Note 1
1	X0170DQ	2	Screw, Pan H., 0.112-40 x 0.312
2	B0138QD	1	Zero Cover
3	B0135HH	1	Zero Screw Assy. — See Note 2
—	X0114AT	1	Lubriplate, Lubricant, 0.45 kg (1 lb) — See Note 2
4	B0140FD	1	Disc — See Note 2
5	X0171TA	1	Retaining Ring — See Note 2
6	B0140FE	1	Zero Bushing — See Note 2
—	S0106CX	1	Thread, Sealant, 0.9 kg (2 lb) — See Note 2
7	X0170GU	1	Retaining Ring — See Note 2
8	B0138PP	1	Clutch — See Note 2
9	B0138YR	1	Earth (ground) Stud
10	B0138YS	1	Clamp
11	X0169FE	1	Screw, Pan H., 0.164-32 x 0.375
12	H0183CZ	2	Filter, RFI
—	X0170BS	—	Sealant, for Item 12
—	X0170BT	—	Primer, for Sealant

Item	Part No.	Qty.	Part Name
13	X0171TS	1	Set Screw, 0.250-20 x 0.375
14	Below	1	Terminal Block Assembly
	B0138WH		10 to 50 mA (B0138WA, B0139DJ)
	B0138QH		4 to 20 mA (B0138QA, B0138VT, B0139CT)
	B0138QH		Frequency (B0138UA, B0138VW)
15	X0170PZ	2	Screw, Pan H., 0.164-32 x 0.500
16	0049805	1	Cable Clamp
17	X0170FR	3	Screw, Pan H., 0.164-32 x 0.375
18	X0143FA	2	Washer
19	Below	1	Zero Pot and Harness Assembly
	B0138QL		B0138QA, B0138WA, B0138VT
	B0138UW		B0138UA, B0138VW
	B0138QL		B0139CT, B0139DJ
—	E0285VD	1	Potentiometer
20	B0138XW	1	Bushing — PTB only
21	B0138VQ	1	Stud — PTB only
22	B0138UV	1	Tag — PTB only
23	B0138VR	1	Clamp — PTB only
24	X0143NB	1	Lockwasher — PTB only
25	X0124KB	1	Screw — PTB only

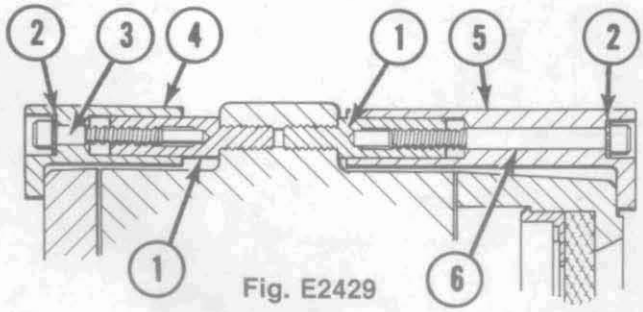


Fig. E2429

LCIE Cover Lock

Item	Part No.	Qty.	Part Name
1	B0139CR	2	Standoff
2	X0170WF	2	Lockwasher
3	X0170YM	2	Screw — W/O Indicator
4	B0139CY	2	Cover Lock — W/O Indicator
4	B0139CY	1	Cover Lock — With Indicator
5	B0139EG	1	Cover Lock — With Indicator
3	X0170YM	1	Screw — With Indicator
6	X0170YN	1	Screw — With Indicator

Note 1: Frequency housings do not have Zero Adjustment components.
Note 2: Replace Zero Adjustment components of the Slotted Bushing design with Kit-G-B0138QF.

Instruments and Systems for Indicating, Recording, Controlling . . .

Air Weight
Btu
Capacitance
Composition
Compression
Concentration, Solution
Conductivity, Solution
Consistency
Current — a-c, d-c
Density
Dew Point
Displacement
Drag
Flow
Force
Gas Analysis
Humidity
Interface
Ion Selection
Liquid Analysis
Liquid Level
Load
Moisture Content
Motion
Motor Load
Operation, Schedule
Operation, Time
Oxidation-Reduction Potential
pH
Position
Power, Electric
Pressure
Resistance, Electric
Sheet Moisture
Sheet Weight
Specific Gravity
Speed
Strain
Stress
Temperature
Tension
Thrust
Torque
Vacuum
Viscosity
Voltage
Weight

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

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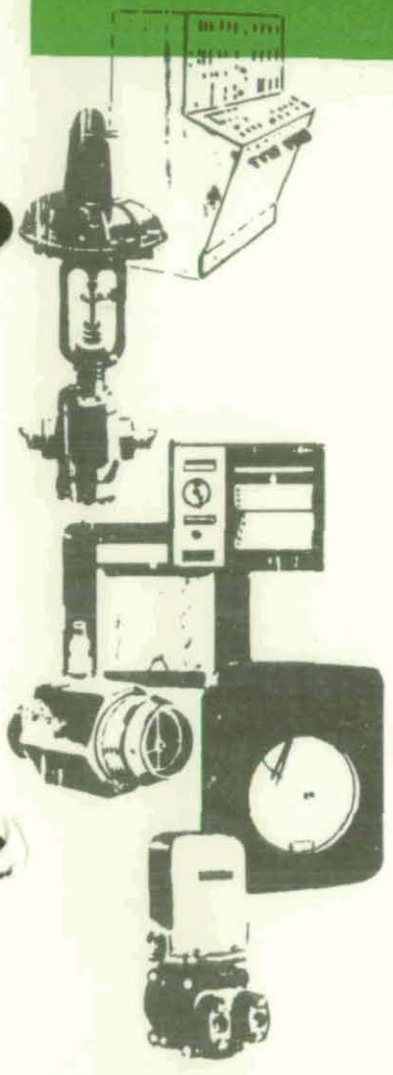
INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct installation of your Foxboro Instruments, and in their proper operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number.*

Book No. 2142

FOXBORO

IMPORTANT

Style Indication

Some of the following sheets may refer to a different style of instrument from that indicated on the cover of this instruction book.
The reason for this is that some sheets are valid for more than one style.
You may be assured that this book, in it's totality, will provide all the necessary information on installation, operation and maintenance of the instrument and style indicated on the cover.

S.I. Unit System

Foxboro, as a world-wide Organization, is an ardent supporter of world-wide standardization. Because of this general policy and the legal requirements in Europe, Foxboro has decided to adhere to the S.I. unit system (système internationale d'unités).
A beginning has been made with revising the extensive documentation accordingly so that you may find that this book contains one or more sheets with the units already expressed in the S.I. unit system.

Document Number Prefix

The document number of certain sheets out of this book may be preceded by the letter "V". This denotes that these "Printed in the Netherlands" sheets deviate to some extent from the original issue; for example, by adhering to the specifications of local requirements or to indicate that measurement units are expressed in the S.I. unit system.

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

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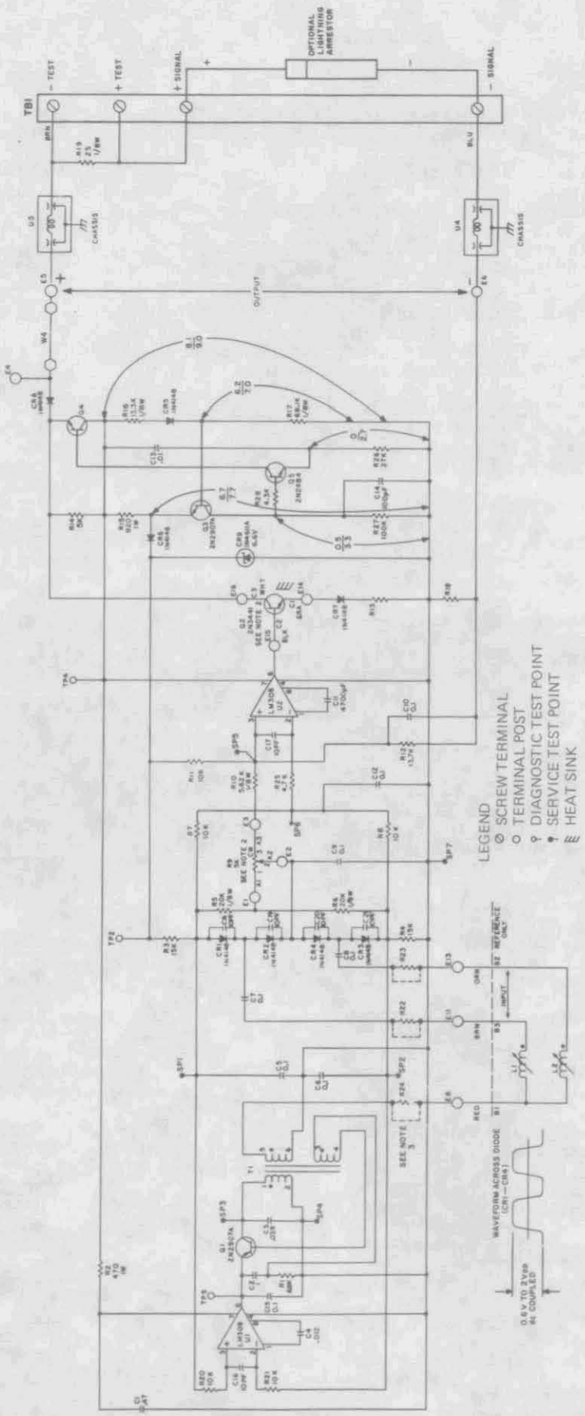


NOTES:
1. Unless otherwise specified, resistors are in ohms, ¼ W and capacitors are in microfarads.
2. Resistor R9 and R10 and transistor Q2 are not part of printed wiring board assembly.
3. Resistors R22, R23, and R24 are used in converters with 4 to 20 mA output. Wire jumpers replace these resistors in converters with 10 to 50 mA output.
4. Where two voltages are shown, voltages represent range in which voltage is correct.

Schematic Diagram
10102UV

10/78

Printed in England

Instruction

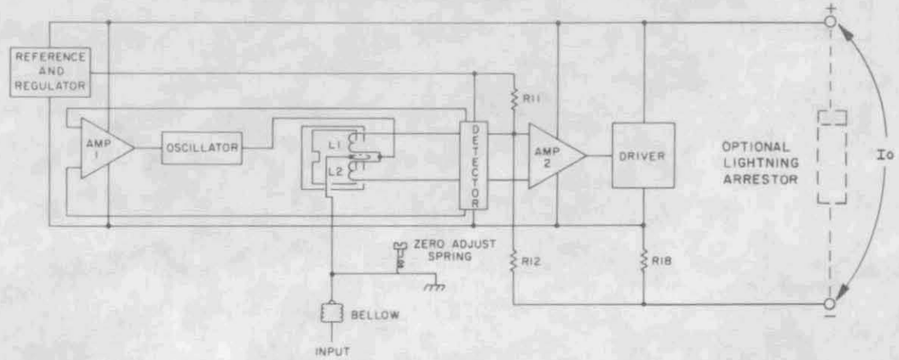
MI
20-411
June 1979

E92-R SERIES
PNEUMATIC-TO-CURRENT CONVERTER
(Rack-Mounted) Style B

The E92-R Series Converter receives a pneumatic pressure signal and transmits it as a proportional electrical 4 to 20 mA or 10 to 50 mA output signal.

When two values of current are given in this instruction, the first value is for converters with a 4 to 20 mA output, and the second value, which is in parentheses, is for converters with a 10 to 50 mA output.

Principle of Operation



The input signal is applied to a bellows which moves a lever fastened to a closed loop. The movement of the loop changes the inductance in coils L1 and L2, also changing the amplitude of the LC oscillator. The change in oscillator amplitude is sensed by a detector, which develops a voltage drop across resistor R12. The voltage drop is then fed to amplifier 2 which is used to drive the output transistor producing output current I_o. The output current is sensed by resistor R18 and fed back to the other input of amplifier 2. Resistor R11 is used to bias amplifier 2.

When the input signal is at 60 kPa or 9 psi and the converter output at 12 mA (30 mA), the loop is at the mechanical center position. Amplifier 1 causes the sum of the currents through L1 and L2 to be equal to a reference current by regulating the oscillator amplitude. The reference current is established by the regulator. At this stage, the oscillator output is at maximum amplitude.

A change in input signal from 60 kPa or 9 psi, moves the loop from the mechanical center position. This causes a difference current to flow through inductors L1 and L2 producing a decrease in oscillator amplitude. Depending on whether the difference current is positive or negative, the output current will either increase or decrease from the 12 mA (30 mA) center position.

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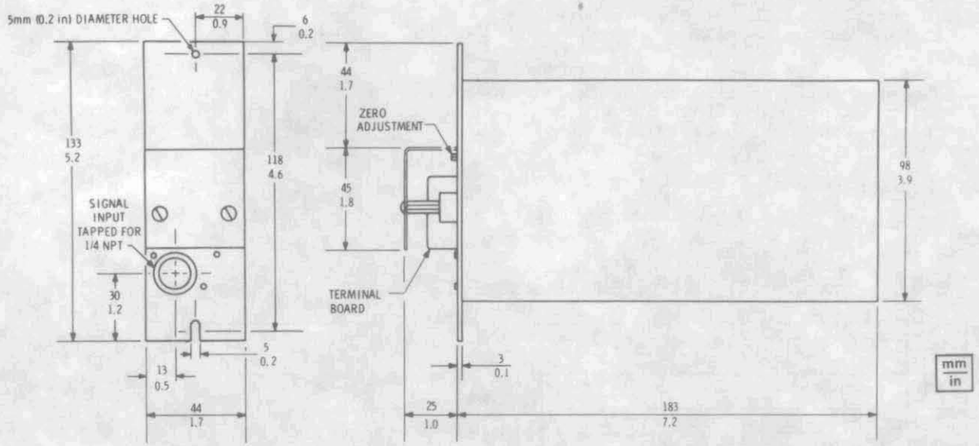
Specifications

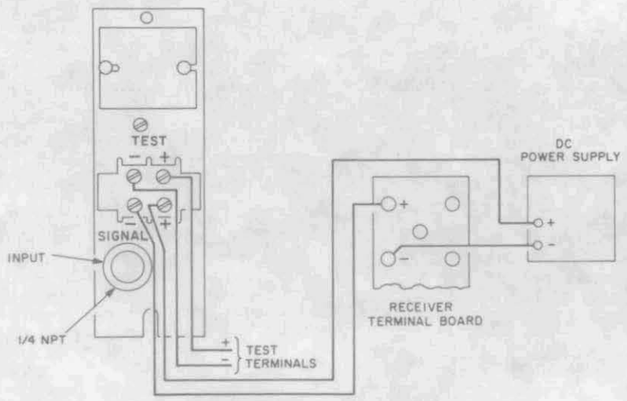
Input Signal:	20 to 100 kPa or 3 to 15 psi
Output Signal:	4 to 20 mA (see Page 3)
	10 to 50 mA into a 480 to 660 Ω load
Accuracy:	±0.25% of span
Ambient Temperature Limits:	5 and 50°C (40 and 120°F)
Power Supply:	4 to 20 mA output; 24 to 50 V dc, or +15 and -15 V dc from SPEC 200 source
	10 to 50 mA output; 63 to 100 V dc
Electrical Classification:	As listed on data plate

Converter Dimensions



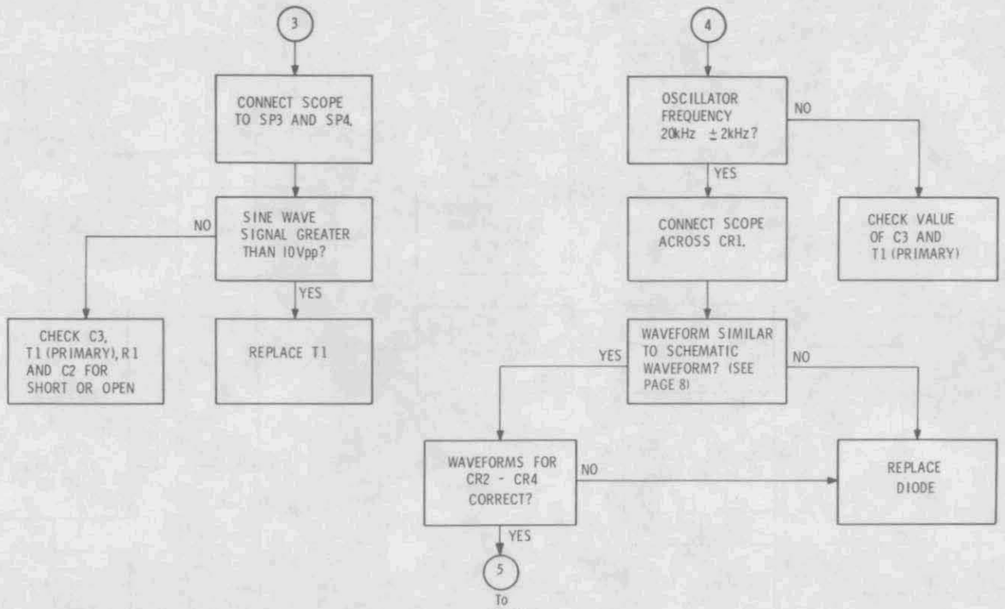
Installation Piping and Wiring

Make pneumatic and electrical connections as shown. Test terminals provide a 100 to 500 mV test signal which is directly proportional to the current output signal.

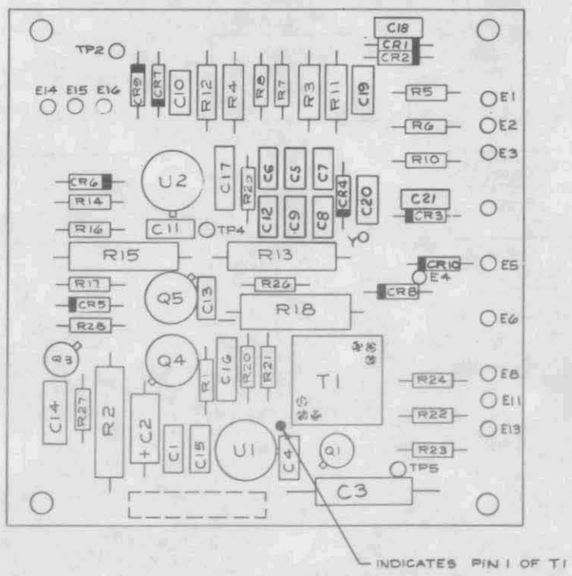


Parts List

Item	Description	Part No.
---	Printed Wiring Assembly (4-20 mA)	N0138NC
--	Printed Wiring Assembly (10-50 mA)	N0138ND
R1	Resistor, 68 kΩ ±2%, 1/4 W	E0156LY
R2	Resistor, 470 Ω ±2%, 1 W	E0158EX
R3, R4	Resistor, 15 kΩ ±0.1%, matched pair	E0286HC
R5, R6	Resistor, 20 kΩ ±1%, 1/8 W	E0133BW
R7, R8	Resistor, 10 kΩ ±2%, 1/4 W	E0156KT
R9	Potentiometer, 5 kΩ (Not part of Printed Board Assembly)	E0285TN
R10	Resistor, 5.62 kΩ ±1%, 1/8 W	E0132YR
R11, R12	Resistor, 10 kΩ, 13.7 kΩ, matched pair	E0286HE
R13	Resistor, 270 Ω ±2%, 1 W (4-20 mA)	E0158EN
	Resistor, 120 Ω ±2%, 1 W (10-50 mA)	E0158EA
R14	Resistor, 15 kΩ ±2%, 1/4 W	E0156KZ
R15	Resistor, 820 Ω ±2%, 1/4 W	E0158FE
R16	Resistor, 13.3 kΩ ±1%, 1/8 W	E0143AW
R17	Resistor, 68.1 kΩ ±1%, 1/8 W	E0143FW
R18	Resistor, 100 Ω ±0.1%, 1/4 W (4-20 mA)	E0288TK
	Resistor, 40.2 Ω ±0.1%, 1/4 W (10-50 mA)	E0288LX
R19	Resistor, 25 Ω (4-20 mA) } (Not on Printed	E0286GH
	Resistor, 10 Ω (10-50 mA) } Board Assembly)	N0143TX
R20, R21	Resistor, 10 kΩ ±2%, 1/4 W	E0156KT
R22, R23	Resistor, 43 Ω ±2%, 1/4 W (on FM Intrinsically Safe)	E0286QG
	Resistor, 750 Ω ±2%, 1/4 W (on all other 4-20 mA)	E0156FC
R24	Resistor, 560 Ω ±2%, 1 W (on FM Intrinsically Safe)	E0286QE
	Resistor, 820 Ω ±2%, 1/4 W (on all other 4-20 mA)	E0156FE
R25	Resistor, 4.7 kΩ ±2%, 1/4 W	E0156KF
R26	Resistor, 27 kΩ ±2%, 1/4 W	E0156LK
R27	Resistor, 100 kΩ ±2%, 1/4 W	E0156MC
R28	Resistor, 4.3 kΩ ±2%, 1/4 W	E0156KE
C1	Capacitor, 0.47 µF, 50 V, ceramic	H0140BK
C2	Capacitor, 1 µF, 50 V, ceramic	H0140BM
C3	Capacitor, 0.039 µF, 50 V, polycarbonate	H0176BC
C4	Capacitor, 0.012 pF, 100 V	H0110BM
C5-C10	Capacitor, 0.1 µF, 100 V	H0111CB
C11	Capacitor, 4700 pF, 100 V	H0111BC
C12	Capacitor, 0.1 µF, 100 V	H0111CB
C13	Capacitor, 0.01 µF	H0111BL
C14	Capacitor, 100 pF, mica	H0104BA
C15	Capacitor, 0.1 µF, 100 V	H0111CB
C16-C17	Capacitor, 10 pF, mica	H0104GE
C18-C21	Capacitor, 10 pF, ceramic	H0113AX
CR1-CR8	Diode, Type 1N4148	N0258DC
CR9	Diode, Type 1N4611A	N0257TZ
Q1, Q3	Transistor, Type 2N2907A	N0282AL
Q2	Transistor, Type 2N3441 (Not part of Printed Board Assembly)	K0120RZ
Q4	Transistor, Type 2N2905A (4-20 mA)	N0282EN
	Transistor, Type 2N5680 (10-50 mA)	N0282BM
Q5	Transistor, Type 2N2484 (4-20 mA)	K0120RY
	Transistor, Type 2N3440 (10-50 mA)	N0282BB
U1, U2	Operational Amplifier, Type LM308	N0284SP
T1	Transformer	N0233CF
RF1, RF2	Filter, radio frequency interference (Not on Printed Board Assembly)	H0183CA
--	Converter Assembly (Not part of Printed Board Assembly)	N0138PA



Component Location Diagram



NOTE

Resistors R22, R23, and R24 are used in converters with 4 to 20 mA output. Wire jumpers replace these resistors in converters with 10 to 50 mA output.

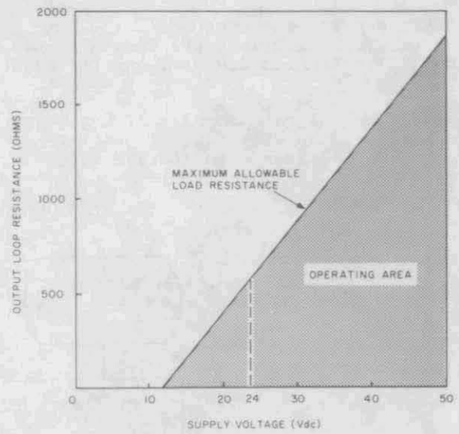
WARNING

Components R2, R22, R23, R24, R28, and CR8 are relied upon for intrinsic safety. Substitution of any of these components may invalidate applicable certification.

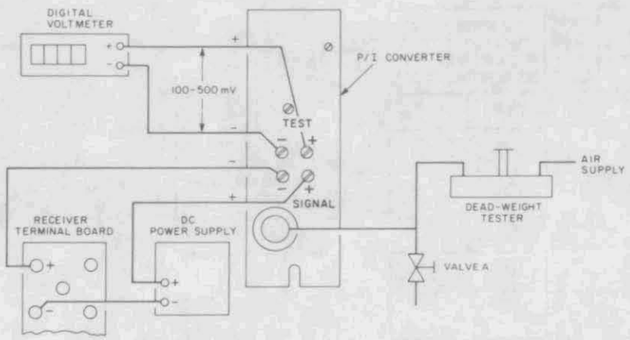
Converter Output Load Resistance
(4 to 20 mA Output only)

For a given supply voltage between 24 and 50 V dc, the converter must operate within the shaded area in graph at right. For example, with a 24 V dc power supply, the converter output loop load resistance must be between 0 and 575 ohms.

To determine the converter output load resistance, add the input resistance of each component in a series loop connected to the converter output.

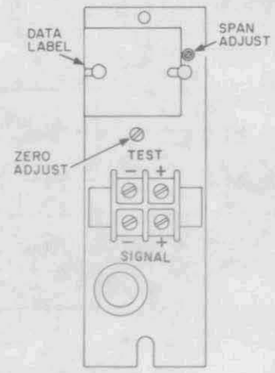


Calibration



1. Connect equipment as shown above.
2. Close Valve A.
3. Adjust dead-weight tester for 60 kPa or 9 psi output.
4. Turn zero adjustment screw until digital voltmeter measures 300 mV.
5. Adjust dead-weight tester for 100 kPa or 15 psi output.
6. Turn span adjustment screw until digital voltmeter measures 500 mV. Slide data label to the left to get access to the span adjustment screw.

   To reduce input pressure signal, open Valve A.
7. Adjust dead-weight tester for 20 kPa or 3 psi output. Digital voltmeter should measure 100 mV.
8. Repeat Steps 3 through 7 until outputs are correct without adjustment.

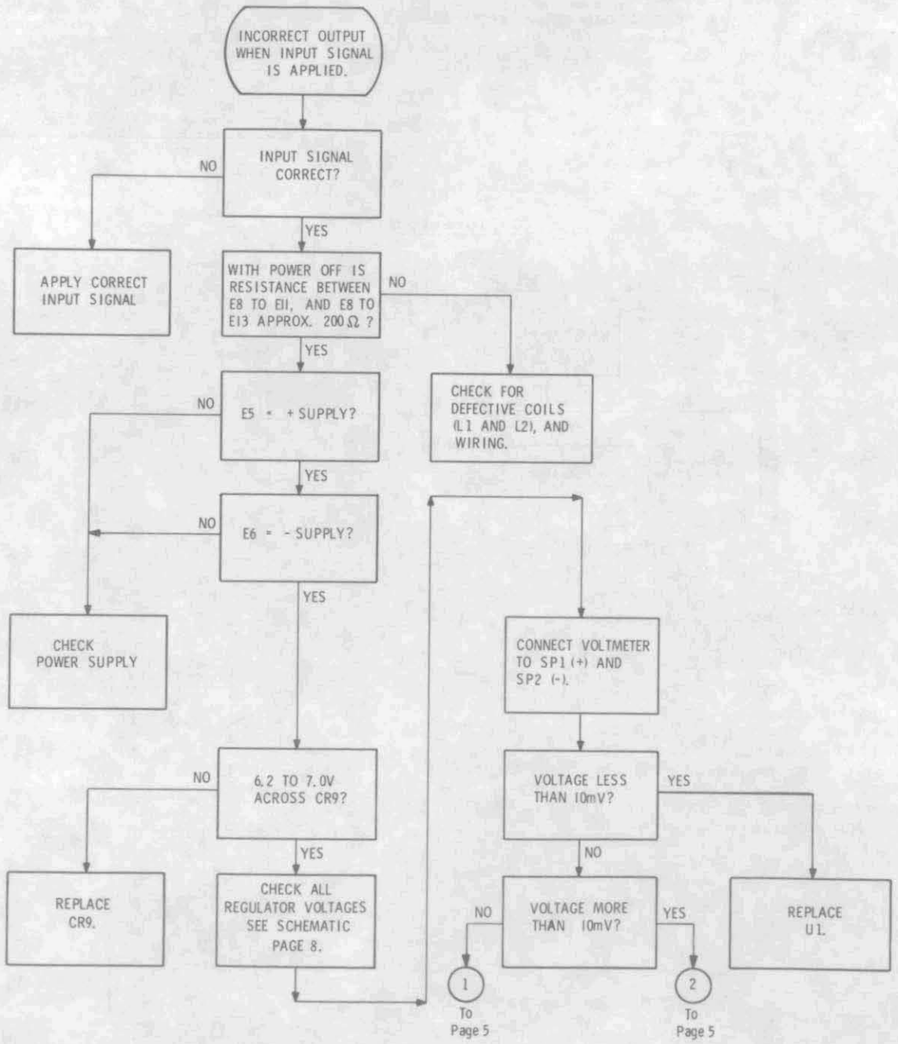


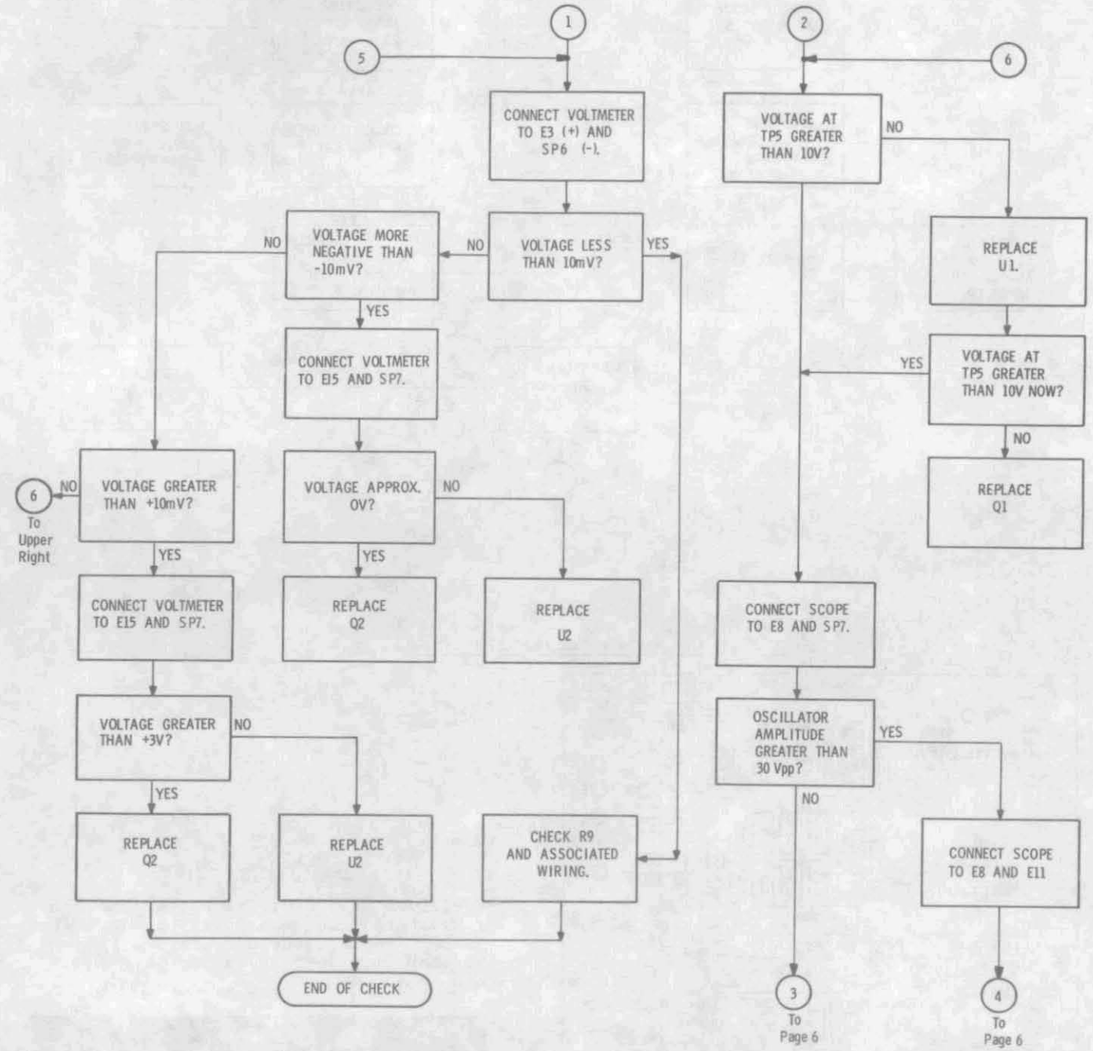
Fault Location (Troubleshooting)

This section includes the following aids: (1) flow diagrams, (2) component diagrams, (3) schematic diagram, and (4) parts list.

The flow diagrams consist of servicing checks to be made with fault isolating branches to be taken when a malfunction is encountered.

Service points referred to on the flow diagrams (such as SP3) are shown on the schematic diagram. All voltages are referenced to E6 on schematic diagram unless otherwise specified.





Parts List

PL
008-430
October 1983

E92-R
P/I AND P/V CONVERTERS

Styles A and B

Model Code

E92-R = P/I and P/V Converter, Rack Mounted

Testing Laboratory
B = BASEEFA
C = CSA
F = FM

Design Requirements—Equipment Location
A = Intrinsically Safe, (Ex)ia, Zone 0 (When used with Certified SPEC 200 I/O Module)
B = Intrinsically Safe, (Ex)ib, Zone 1, Div. 1 (see note)
N = "Nonsparking" and other Type N, (Ex)n, Div. 2, Zone 2
G = Ordinary Locations

Input Signal
2 = 3 to 15 psi
3 = 3 to 27 psi (20.7 to 186.2 kPa)
4 = 0.2 to 1.0 kg/cm²
5 = 20 to 100 kPa
6 = 0.2 to 1.0 bar

Output Signal
H = 10 to 50 mA dc
I = 4 to 20 mA dc
V = 0 to 10 V dc

Optional Suffix (P/I ONLY)
-A = Lightning Arrestor

Note: Intrinsically Safe (Div. 1) available with 4 to 20 mA dc output signal ONLY.

MB 150
1083
Printed in England

FOXBORO®

E92-R CONVERTERS
Styles A and B

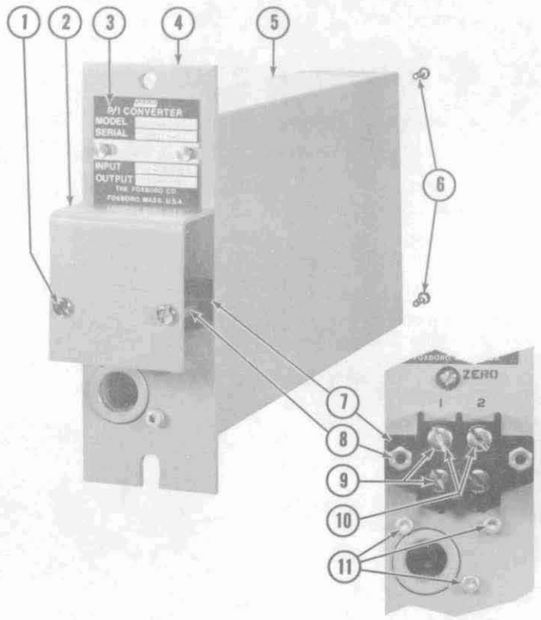


Figure E839

Item	Part No.	Qty.	Part Name
1	X0122UH	2	Screw, Pan H., 0.138-32 x 0.250
2	N0138NK	1	Terminal Board Cover
3	Below	1	Data Plate
	N0138NX		Output Code V
	N0138NM		Output Code H or I
4	Below	1	Frame Assembly
	N0138NJ		Output Code H or I
	N0138RN		Output Code V
5	N0138PJ	1	Cover
6	N0138QB	2	Screw (special)
7	N0138PR	1	Terminal Board
8	N0138NL	2	Column
9	X0116CR	4	Screw, Pan H., 0.164-32 x 0.250
10	N0138NW	2	Column, (Output Code V only)
11	X0116MZ	3	Screw, Socket H., 0.125-40 x 0.312

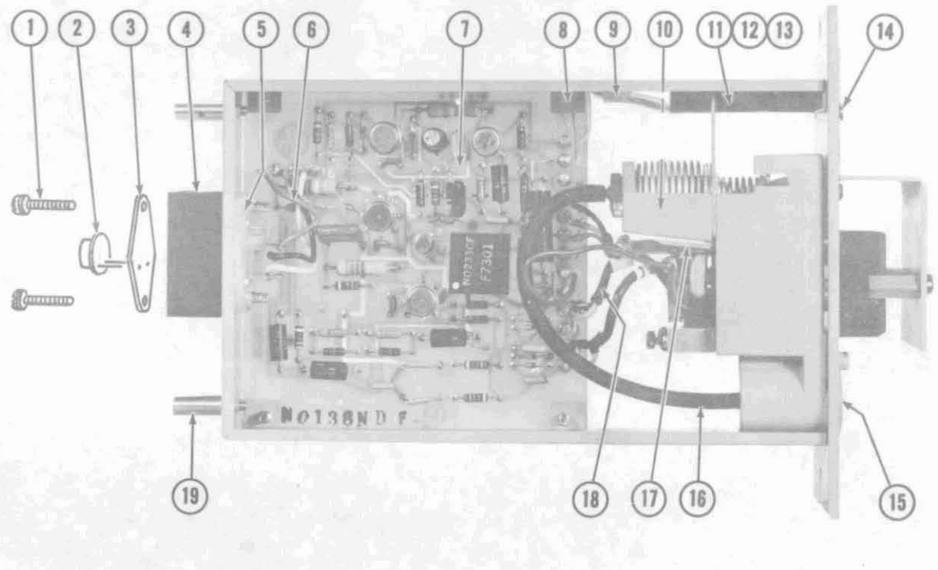


Figure E840

Item	Part No.	Qty.	Part Name
1	K0121XS	2	Screw, Tapping
2	N0282AN	1	Transistor, 2N3441
3	K0121XW	1	Spacer
4	N0264AP	1	Heat Sink (Style A)
5	K0120SX	1	Socket
6	—	3	Copper Wire, 50 mm (2 in) lengths, 0.2 mm² (24 AWG)

Items 1-6 on mA output models (H and I) only.

Item	Part No.	Qty.	Part Name
7	Below	1	Printed Circuit Board
	N0138NC		Output Code I
	N0138ND		Output Code H
	N0138NE		Output Code V
—	N0262AB	2	1/4 A Fuse
	N0138QG		Output Code I, FM version only
8	X0169RJ	4	Screw, B.H., 0.112-40 x 0.312
9	X0167KK	3	Clip
10	Below	1	Converter Assembly
	N0138PA		3 to 15 psi Input (Code 2) 0.2 to 1.0 kg/cm² (Code 4) 20 to 100 kPa (Code 5) 0.2 to 1.0 bar (Code 6)
	N0138KR		3 to 27 psi (Code 3)
11	E0285UW	1	Potentiometer
12	X0169RC	2	Screw, Pan H., 0.086-56 x 0.375
13	N0138QC	2	Washer
14	N0138NV	2	Stud
15	C0128FK	1	Insert
16	R0128AA	—	Tubing, order 0.3 m (1 ft.) per instrument
17	—	3	Copper Wire, 100 mm (4 in) lengths, 0.3 mm² (22 AWG)
18	—	3	Copper Wire, 100 mm (4 in) lengths, 0.3 mm² (22 AWG)
19	C0151AG	2	Column
—	H0183CV	2	Filter (on back panel)
—	—	4	Copper Wire, 200 mm (8 in) lengths, 0.2 mm² (24 AWG), used with filters
—	T0103RA	1	Grommet (in back panel)
—	Below	1	Resistor (on back of front panel)
	E0286GH		25 Ohm (Output Code I)
	N0143TX		10 Ohm (Output Code H)
—	Below	1	Lightning Arrestor
	B0158EZ		10 to 50 mA (Output Code H)
	B0158EY		4 to 20 mA (Output Code I)

***Parts preceded by asterisks are those more commonly replaced**
GIVE INSTRUMENT SERIAL NUMBER WHEN ORDERING

***Parts preceded by asterisks are those more commonly replaced**
GIVE INSTRUMENT SERIAL NUMBER WHEN ORDERING

WARRANTY

Except as hereinafter provided, the Company (hereinafter called "Foxboro") warrants that all parts manufactured by it (but not by others) shall be within specified limits of calibration, if any, and free from defects in material or workmanship, under proper and normal use. Foxboro, at its option, shall replace or repair, free of charge, any part covered by this warranty which shall be returned, transportation charges prepaid, within one year from shipment by Foxboro and which examination proves not to be within the specified limit of calibration or not to be free from such defects in material or workmanship. Foxboro shall not be liable for any repairs or replacements of parts by others and covered by this warranty except those made with Foxboro's written consent. Foxboro shall be liable for breach of this warranty only if it receives written notice of such breach within one year from the date of shipment of the product to which the breach relates. The foregoing shall constitute the sole remedy of the purchaser for any breach by Foxboro of its warranty.

FOXBORO MAKES NO WARRANTIES REGARDING PARTS MANUFACTURED BY IT OR OTHERS (INCLUDING WITHOUT LIMITATION WARRANTIES AS TO MERCHANTABILITY), EITHER EXPRESSED OR IMPLIED, EXCEPT AS PROVIDED HEREIN.

SERVICE

The Company is anxious to be of every possible assistance to you, to insure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service may be made through your nearby Foxboro Sales Representative. When factory repairs are required, the instrument may be sent to any Foxboro plant. Check with your International Sales Representative who will advise you as to which plant should be utilized.

The Foxboro Company, Foxboro Mass. U.S.A.; Foxboro-Yoxall Ltd., Redhill, Surrey, England; and Foxboro (Nederland) N.V., Soest, Netherlands provide expertly staffed and fully equipped Training Schools devoted to the instruction of customer's Instrumentation Engineers and Service Men. The courses cover theory of operation, maintenance and application of the principial types of instruments. Applications from Companies in the British Isles should be made to Foxboro-Yoxall Ltd.; from those in the other parts of the world, to the nearest International Sales Representative as listed on the last sheet of this book.

PARTS

When repairs are to be made by the customer, it is strongly urged that only genuine Foxboro parts be used. Parts lists for Foxboro Instruments may be obtained by writing to your Foxboro Representative. Always give the serial number from the instrument data plate when requesting parts lists or ordening parts. (Men unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment should not be permitted to undertake any major service work).

REPLACEMENT

Improvements in design, materials, or methods sometimes make it worth while to replace rather than repair an instrument which has been in service for a long period of time. We can help you in every way possible in discussing such problems with you.

In this way you will be made aware of the latest available equipment.

CHARTS

Since the accuracy of any recording instrument depends, finally, on the accuracy of the cart, the use of Foxboro Humitex Carts with Foxboro Instruments is essential if full performance of the instrument is to be realized.

FOXBORO

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

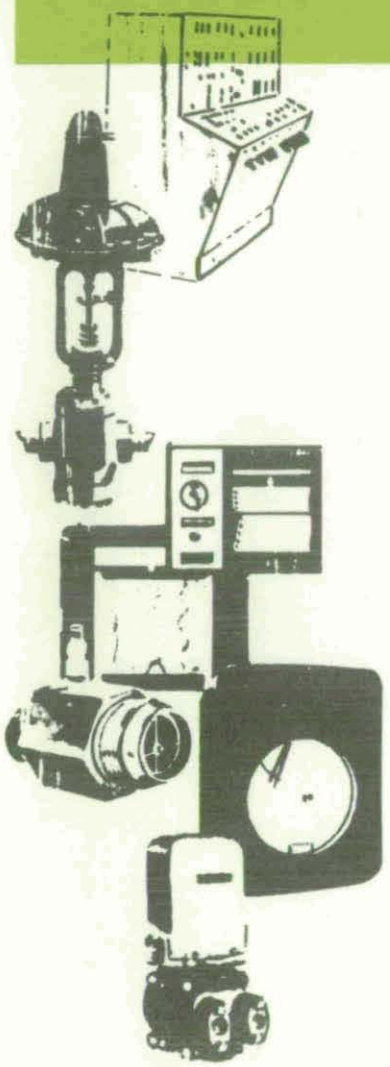
Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

FOXBORO®

MS 0283

Printed in the Netherlands

INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct installation of your Foxboro Instruments, and in their proper operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number.*

Book No. 6 1015

FOXBORO

Foxboro Yoxall
A Division of Foxboro Great Britain Limited

Redhill Surrey England
RH1 2HL
Tel: Redhill (0737) 65000
Telex: 892852
Telegram: Yoxbri Redhill

Guarantee

The Company undertakes to replace free of charge any component of its own manufacture (which excludes electronic tubes) which, in the opinion of the Company, is not within the specified limit of calibration or is defective in material or workmanship under normal or proper use, provided that the same is returned at the customer's risk and expense to the Company's works within twelve months from the date of the despatch by the Company of the equipment to the customer.
All representations, conditions, guarantees and warranties by law or otherwise howsoever expressed or implied are hereby excluded to the intent, except as above provided, after delivery to and acceptance by the customer of any equipment or apparatus, the Company shall not be liable for any loss, damage, injury, delay or expense or consequential loss or damage howsoever arising from or in respect of the equipment or apparatus or the use thereof.

Pyrometer Thermocouples, Resistance Thermometer Bulbs, and Protection Tubes, on account of the severity of their usage, are not subject to replacement unless returned unused.

The Company shall not be liable for loss, damage, detention or delay caused by fire, strike, civil, or military authority, insurrection or riot, or for other cause beyond its reasonable control. Acceptance of apparatus by the Purchaser shall constitute a waiver of all claims for delay.

Service

The Company is anxious to be of every possible assistance to you, to ensure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service in the British Isles should be made with the Company at Redhill. In other parts of the World arrangements should be made through the nearest Representative and/or Factory listed at the end of this book.
A unique feature of Foxboro service — of particular interest to Companies which do not have Instrument Departments or enough qualified Staff to carry out regular inspection and maintenance — is the Service Contract. Under this arrangement, a Foxboro Service Engineer will call at stated intervals to check the condition and operation of all Foxboro Instruments in your Plant. The Service Contract is also used by Companies for the routine inspection and maintenance of highly technical instrumentation which requires specialised knowledge and experience.
The Company provides an expertly staffed and fully equipped Training Centre at Redhill devoted to the instruction of customers' Instrumentation Engineers and Service Men. The courses cover: theory of operation maintenance and application of the principal types of instruments. Applications from Companies in the British Isles should be made to Redhill, Surrey; from those in other parts of the world, to our nearest Representative as listed at the end of this book.

Parts

Parts Lists for Foxboro Instruments may be obtained by writing to the above address. It is strongly urged that only genuine Foxboro parts be used. Always give the serial number from the instrument data plate when requesting parts lists or ordering parts. (Those unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment, should not be permitted to undertake any major service work.)

Replacement

The Company has considerable knowledge and experience in regard to the economic life of Foxboro instrument equipment and will give advice on the desirability or otherwise, of fitting new parts into the older models. Improvements in design, materials, or methods sometimes make it more economic to replace rather than repair an instrument which has been in service for a long period of time.

Charts

To obtain the most accurate and consistent recording performance from our instruments, we strongly recommend the use of genuine Foxboro strip and circular charts.

FOXBORO

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

FOXBORO®

Instruction

MI
016-126
April 1981

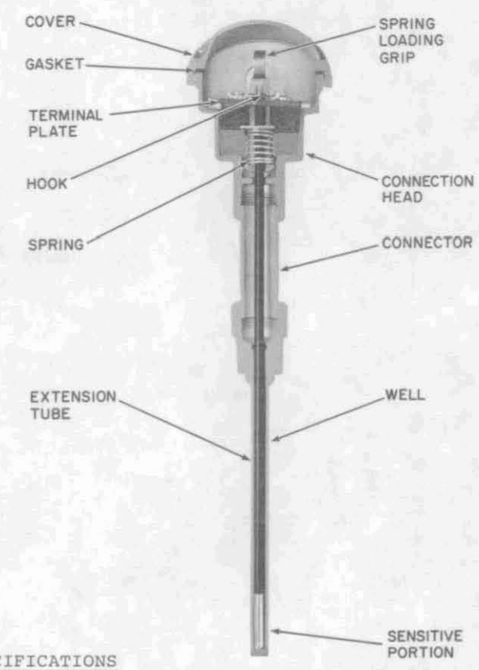
PR SERIES
PLATINUM RESISTANCE TEMPERATURE DETECTORS
With Aluminum Cap-Type Head

Foxboro Platinum Resistance Temperature Detectors (RTD's) consist of a sensitive element containing a platinum resistance winding, an extension tube, a terminal block, and leads connecting the resistance winding to the terminal plate.

The PR Series can accommodate either a single or dual RTD element. They are available as either bare or well-type assemblies.

When the sensitive element is in contact with the process, heat is transferred to the resistance winding. Alloy leads from the resistance winding pass out of the sensitive portion into the extension tube. This tube protects the leads between the sensitive element and the terminal plate in the connection head.

The PR1B, PR2B, PR1X, and PR2X are designed for bare mounting and have a 1/2 NPT process bushing welded to the neck. This bushing provides for direct mounting to the process vessel. The PR1N, PR2N, PR1U, and PR2U are designed for mounting in a well. A spring-loading device keeps the tip pressed against the bottom of the well for close metal-to-metal contact. This improves thermal response and minimizes shock and vibration effects.



STANDARD SPECIFICATIONS

Calibration Curve: SAMA Standard RC 21-4-1966
PR 278 and PR 279 (Foxboro TI 5-27a)
98.129 Ω at 0°C (32°F)

DIN Standard 43760, Sept 1968
PR 238 and PR 239 (Foxboro TI 5-26a)
100 Ω at 0°(32°F)

Temperature Limits
Connection Head: 105°C (225°F) maximum
Tube and Element: -200 and +480°C (-320 and +900°F), 316 ss
-40 and +650°C (-40 and +1200°F), Inconel

Accuracy:

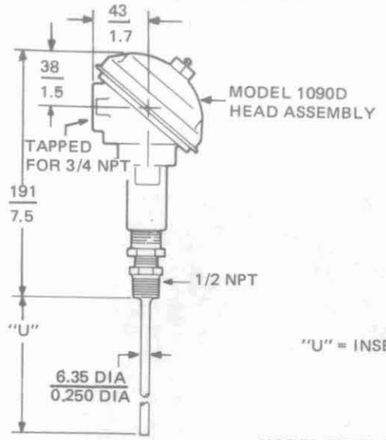
SAMA CALIBRATION		DIN CALIBRATION
480°C (900°F) and under	Over 480°C (900°F)	Up to 650°C (1200°F)
±0.26°C (±0.50°F) or ±0.25% of reading, whichever is larger	±0.5% of reading	±0.26°C (0.50°F) or ±0.5% of reading, whichever is larger

FOXBORO®
® Registered Trademark

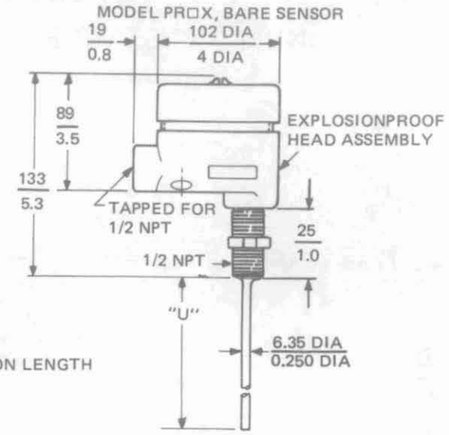
MOUNTING DIMENSIONS

mm / in

MODEL PR□B, BARE SENSOR



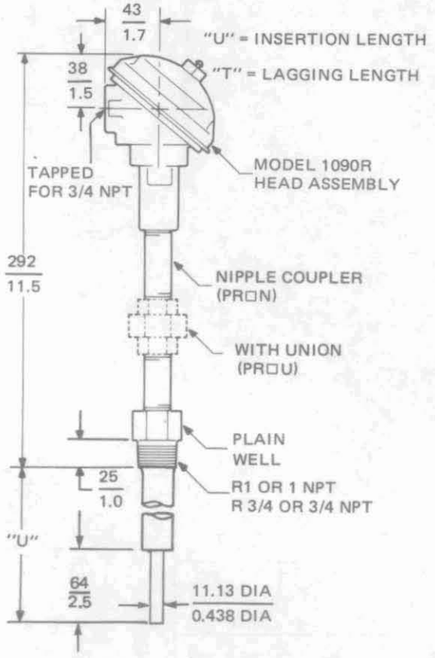
MODEL PR□X, BARE SENSOR



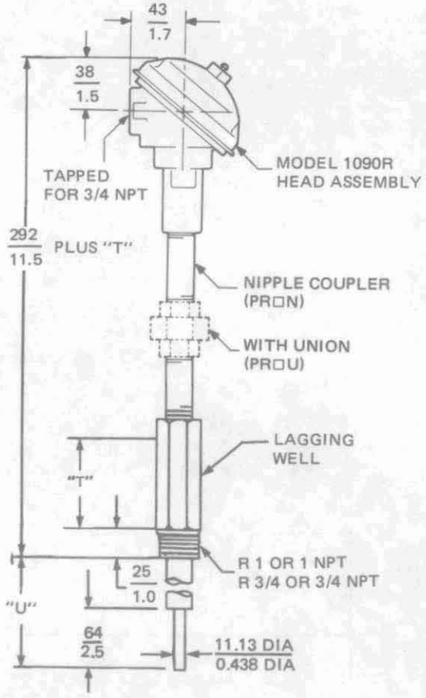
"U" = INSERTION LENGTH

MODEL PR□N OR PR□U WITH WELL

WITH PLAIN WELL



WITH LAGGING WELL

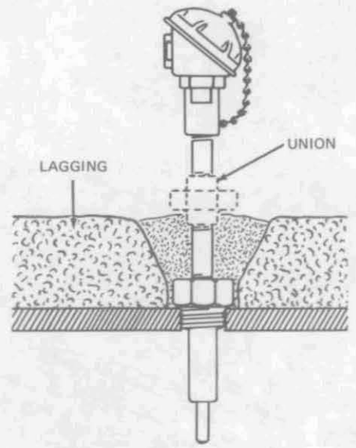


INSTALLATION

Installation With 1090R Connection Head

When the RTD is to be used with an existing well, it is necessary to connect a 1090R Connection Head to the well using the appropriate pipe fittings or adapters, install the RTD, and make the electrical connections. The internal threads of the connection head are 3/4 NPT.

Referring to Figure below, connection head is connected to well having internal pipe thread. Union is optional for convenience when head is to be frequently removed.

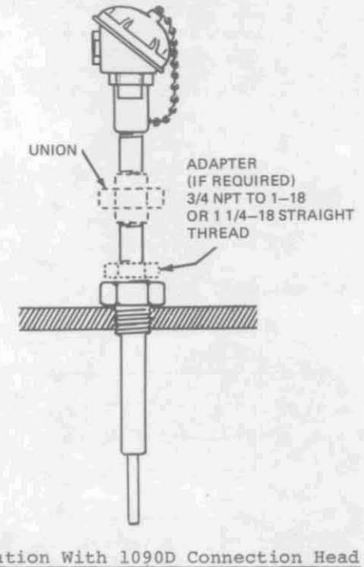


NOTE

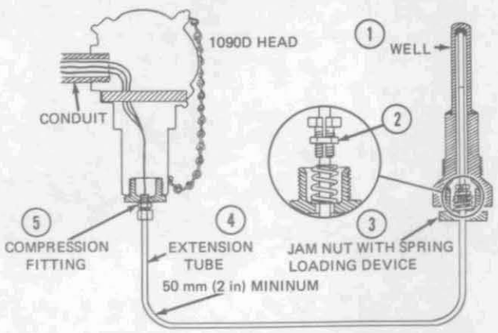
Lagging is cut away in preference to furnishing a lagging extension on well.

Insulation filler should be added after installation of RTD to avoid error due to heat radiation.

The Figure below is similar to adjacent configuration, except that well has an internal machine thread requiring an adapter. Union is also optional in this configuration.



Installation With 1090D Connection Head

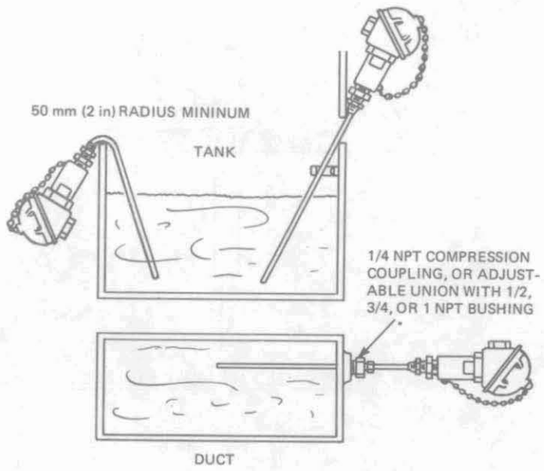


Refer to illustration above. This type of installation is used where it is undesirable to attach the connection head directly to the well by using pipe fittings. The extension tube (4) serves as a bendable protective conduit for the sensor connecting wires, and is connected to the head by a compression fitting (5). The extension tube should not be bent with a radius of less than 50 mm (2 in). The spring loading device is not supplied in the head, but is contained in a jam nut (3) which screws directly into the well (1). A split nut (2) is clamped to the extension tube at the correct location so that tightening of

the jam nut will compress the spring and push the sensor against the bottom of the well. The jam nut may have a 1-18 machine thread, or a 3/4 or 1/2 NPT thread. Adapters are available for use where jam nut and well have different threads.

Bare RTD Installation

The illustrations below show three typical bare sensor installations with 1090R Connection Heads (without spring loading device). These installations are in a tank and a duct and do not use a well.



Immerse the sensor at least 75 mm (3 in). It can be bent with a radius of not less than 50 mm (2 in) at any point more than 75 mm (3 in) from the tip. It should not be installed in any location where it can become coated with a substance that will tend to insulate it from the process temperature, thus causing its output to be in error.

⚠ WARNING

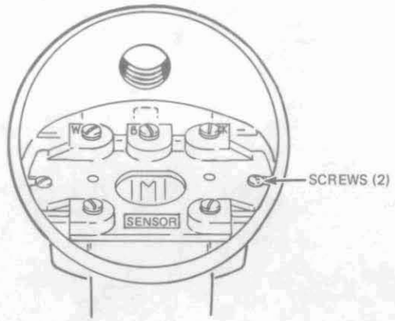
Temperature sensor must not be removed from operating process when it is installed by means of a bushing. If removal of sensor is required during process operation, a well should be used in place of bushing.

To Install RTD and Well As A Unit

When an RTD and its well are purchased together, they are shipped as a unit. It is necessary only to install the well and to connect the black, white, and green extension wires to the receiver as shown on Page 5.

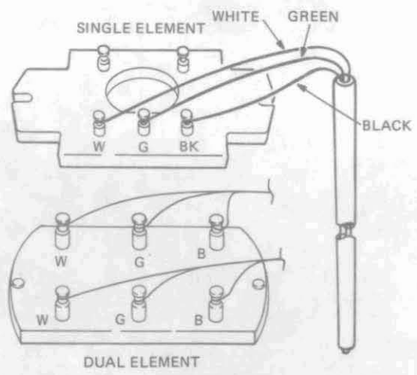
To Install RTD In An Existing Well

1. Screw necessary pipe fittings or adapters to the well to accommodate 1090R Connection Head.
2. Screw on connection head.
3. Loosen two screws and remove terminal plate.

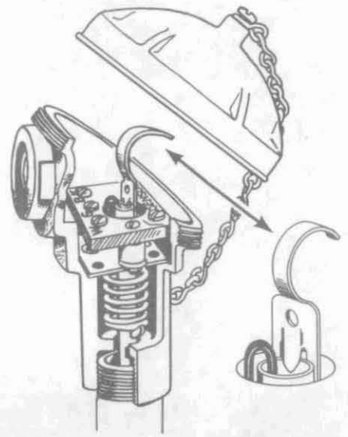


NOTE
Terminals labeled SENSOR are not used with platinum resistance sensor.

4. Solder white, green, and black connecting wires to turrets on BACK of terminals marked W, G, and BK (or B) on single element or dual element terminal plate.



5. Insert sensor into connection head and press down firmly at bottom of well.
6. Replace terminal plate in head. Coil excess connecting wire neatly under terminal plate.
7. Pull up spring loading assembly and engage hook over top edge of sensor.

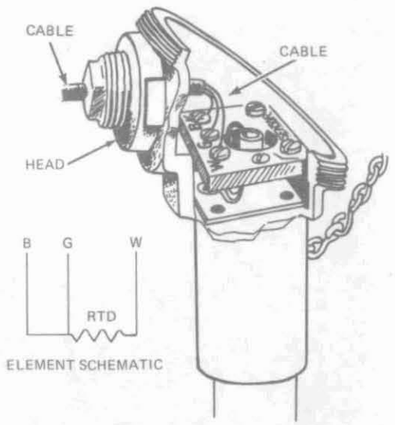


Installation Wiring

To prevent errors due to change of lead resistance with either change in ambient temperature or change of lead length within prescribed limits, the recommended wiring is a 3-conductor cable, Part R0101LY, available from Foxboro (or equivalent). If any other type of wiring is used, all three wires must be the same size and length, and should run parallel and as close together as possible throughout the entire distance between the RTD and receiver. If connections along the leads are necessary, they must be carefully soldered and then taped to make a waterproof joint.

Do not use patent quick-connectors because their contact resistance will often cause calibration errors.

The optimum wiring installation is to run the 3-wire cable in a separate conduit above ground, arranged so that water and steam cannot enter the system and cause leakage, short circuits, or earths (grounds). Do not run power leads in the same conduit with RTD extension wires. For wiring details, see illustration below.



To protect RTD assembly from vibration and strain, do not connect rigid conduit directly to head; use flexible conduit or no conduit at this point.

The three conductors of cable R0101LY are color-coded white, green, and black. Connect white to W, green to G, and black to BK (or B) terminals as shown.

FUNCTIONAL TESTING

After the RTD has been installed and wired, the installation should be checked for short circuits, leakage, or earths (grounds) by simple resistance measurements with an ohmmeter, as follows:

1. Disconnect extension wires from terminal panel at receiver.
2. Measure resistance between black (or green) and white leads. Resistance values should be approximately 102 Ω at 10°C (50°F), 106 Ω at 21°C (70°F), and 110 Ω at 32°C (90°F). Resistance values at other temperatures for SAMA curve RC 21-4-1966 can be obtained from Tables TI 5-27a. For DIN curve 43760, refer to TI 5-26a.
3. Measure resistance between green and black wires. This resistance should be 0 Ω.
4. Measure resistance from each wire to earth using a megohm range. Resistance to earth should be over 50 MΩ and preferably around 200 MΩ. If this resistance is less than 10 MΩ, the sensor should not be used.

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Instruction

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020-455
June 1981

E94-A SERIES TEMPERATURE TRANSMITTER

INTRODUCTION

The E94 Series Temperature Transmitter provides a 4 to 20 milliampere dc output which is proportional to the temperature of a resistance temperature element. The transmitter is available in three types: wide-span temperature measurement, narrow-span temperature measurement, and narrow-span temperature difference measurement.

The range of the transmitter can be trimmed in the field. Two screwdriver adjustments are externally available for calibration of zero and span.

Figure 1

STANDARD SPECIFICATIONS

TYPE RTD*	UNITS	RANGE LIMITS	SPAN	
			TEMPERATURE	TEMPERATURE DIFFERENCE
Nickel Curves NR-226, -227	°C °F	-200 and +320 -320 and +600	12 to 340° 20 to 600°	12 to 56° 20 to 100°
Platinum DIN Curves PR-238, -239 SAMA Curves PR-278, -279	°C °F	-200 and +650 -320 and +1200	6 to 610° 10 to 1100°	6 to 28° 10 to 50°

*Resistance Temperature Detector

Output Load: See Figure 2
Output Signal: 4 to 20 mA

dc Supply Voltage: See Figure 2
Ambient Temperature Limits: -40 and +80°C (-40 and +180°F)

The maximum load resistance depends on the supply voltage shown in Figure 2. This relationship results because the transmitter itself requires a minimum of 12.5 volts to operate.

$$\text{Maximum Resistance (in ohms)} = \left(\frac{\text{Supply Voltage} - 12.5\ \text{V}}{20\ \text{mA}}\right)(1000)$$

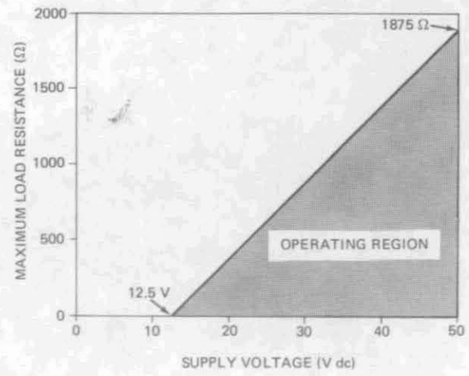


Figure 2

FOXBORO®

INSTALLATION

Dimensions and Mounting

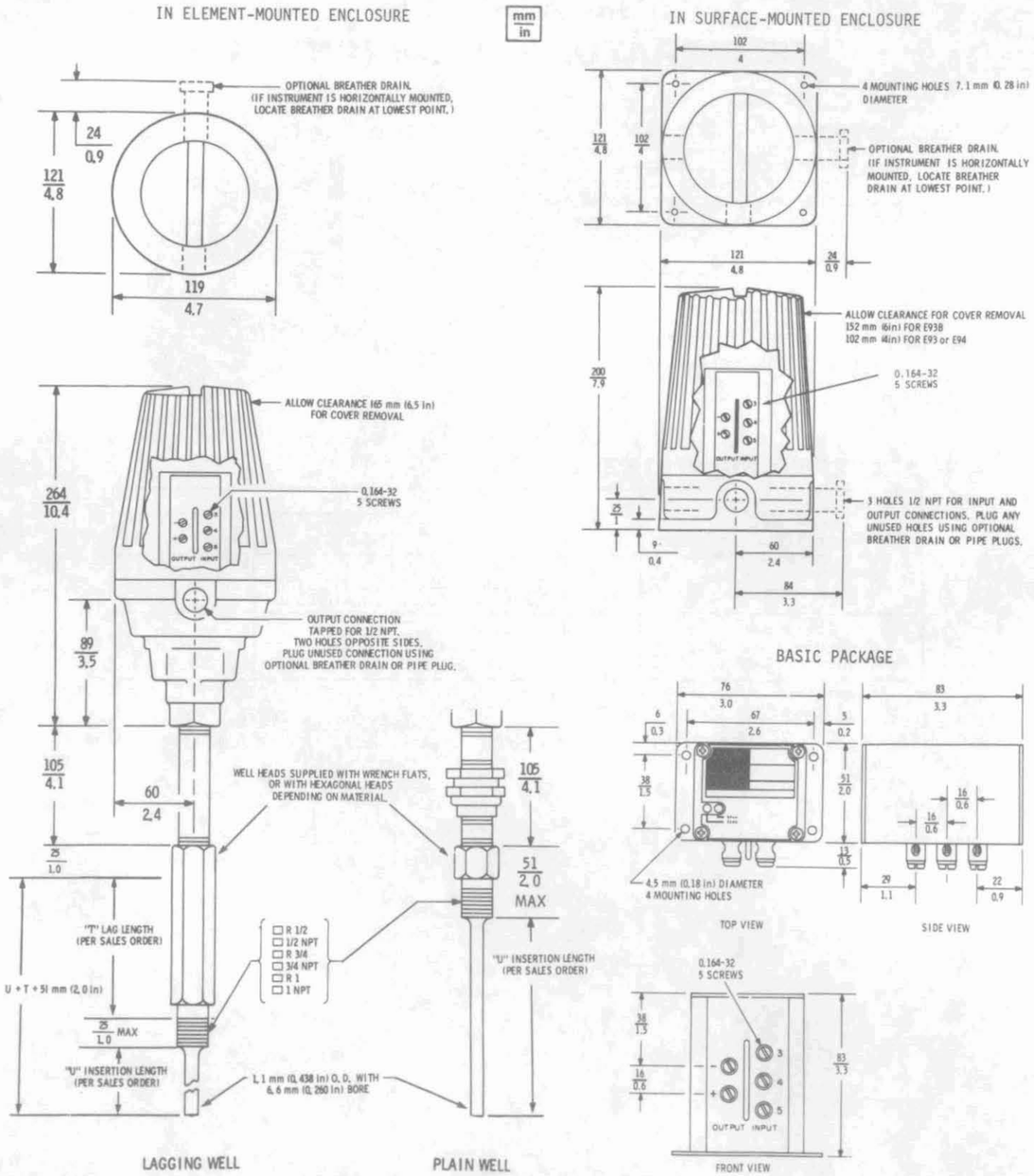


Figure 3

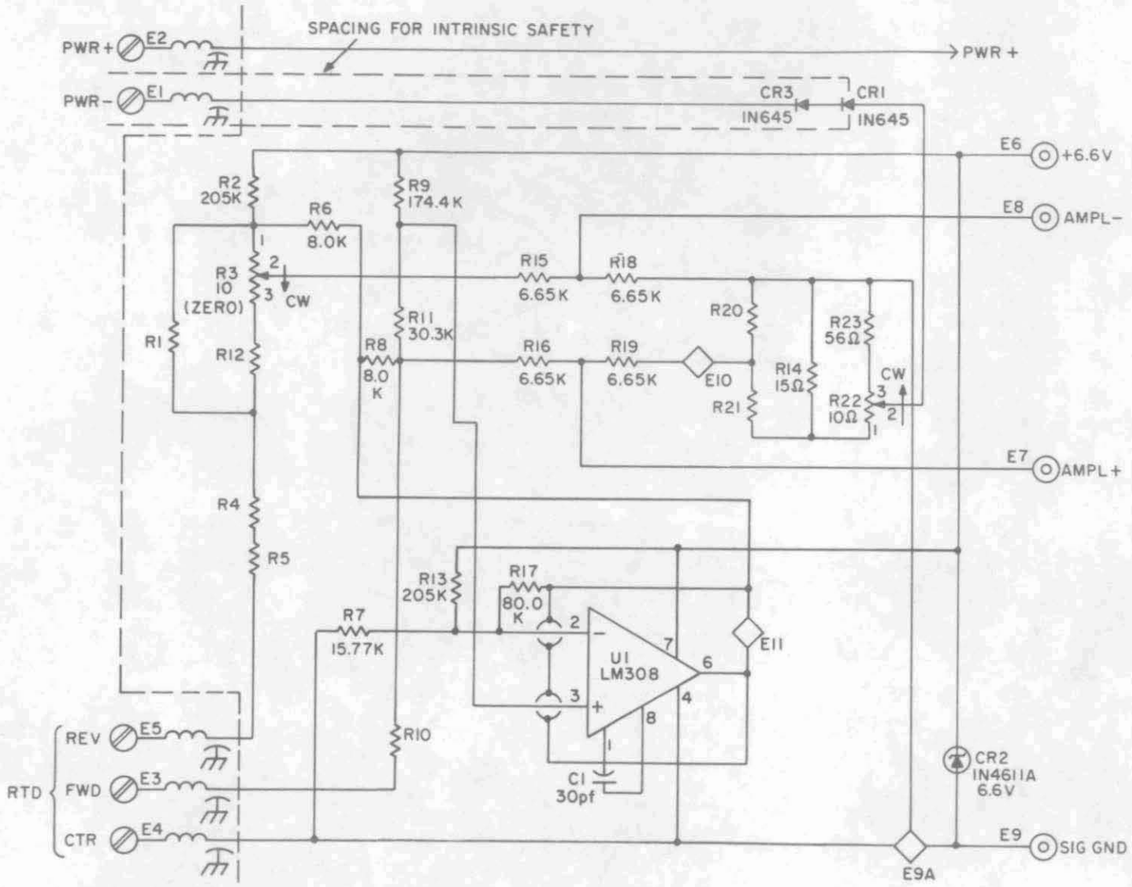
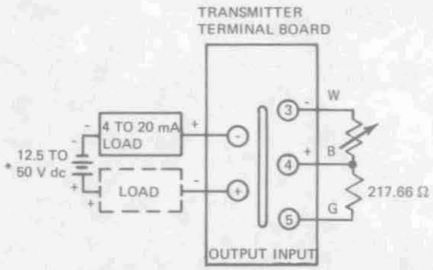
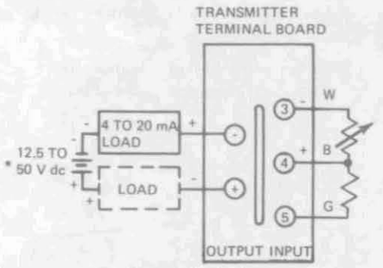


Figure 21.
Circuit Diagram Platinum Resistance,
Wide Span Range PWA

Wiring

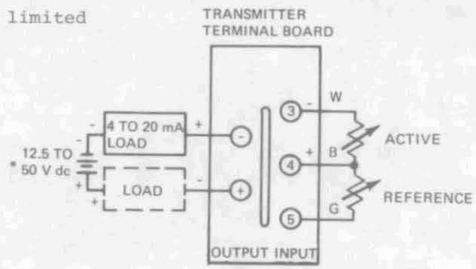


NICKEL RESISTANCE TEMPERATURE INPUT



PLATINUM RESISTANCE TEMPERATURE INPUT

*Unless otherwise limited by safety codes.



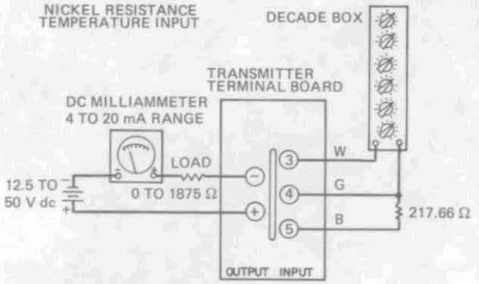
NICKEL AND PLATINUM RESISTANCE
TEMPERATURE DIFFERENCE INPUT

NOTE: If 3-wire cable is used for each RTD, green wires are not used and should be taped back.

Figure 4

Electrical pickup through the signal leads of the measuring element may be minimized by either locating the element and leads in areas relatively field-free, or shielding the leads in separate earthed (grounded) conduits.

The transmitter provides a 2-wire output (the same two terminals are used for power and for output). The load may be inserted in series with either the plus (+) or minus (-) power supply lead. See Figure 4.



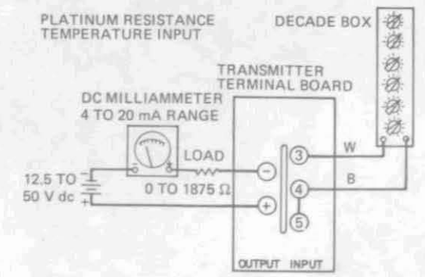


Figure 5

Calibration Procedure—Temperature Transmitter

1. Make connections as shown in Figure 5. Determine resistance range of transmitter from temperature resistance curve supplied with transmitter.

2. Set required minimum input resistance on decade box. If output is not 4 ±0.16 mA, adjust ZERO screw (Figure 6).

3. Set required maximum input resistance on decade box. If output is not 20 ±0.016 mA, adjust SPAN screw (Figure 6).

4. Repeat Steps 2 and 3 until both readings are correct.

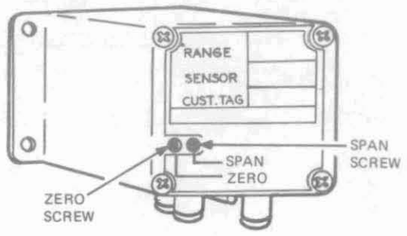


Figure 6

Calibration Procedure—Temperature Difference Transmitter

The values listed in this procedure are for a transmitter with a nickel RTD and a temperature difference range of 0 to 50°F ΔT, at a reference temperature of 100°F. In this example, the zero, midscale, and full-scale temperatures of the active RTD are 100, 125, and 150°F respectively.

1. Set up equipment as in Figure 7.

2. Determine resistances corresponding to zero, midscale, and full-scale temperatures. Use Curve NR-226 [°F] for this example.

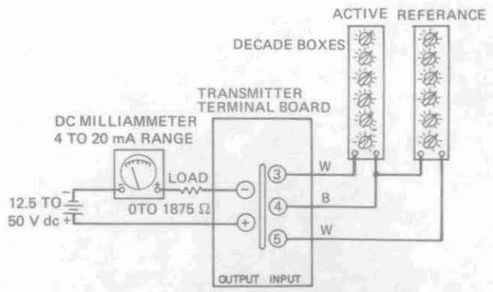


Figure 7

3. Set reference decaded box to reference (zero scale) value (252.89 Ω for 125°F).

   Set active decade box to middle of difference (midscale) value (259.76 Ω for 100°F or 25°F ΔT).

4. Adjust ZERO screw (see Figure 6) so that output reading is 12 ±0.016 mA.

5. Set active decade box (Figure 7) to maximum difference (full scale) value (266.81 Ω for 150°F or 50°F ΔT).

6. Adjust SPAN screw (see Figure 6) so that output reading is 20 ±0.016 mA.

7. Repeat Steps 3 through 6 until no further adjustment is necessary.

8. Set active decade box (see Figure 7) to reference (zero scale) value (252.89 Ω or 100°F).

9. Output should read 4 ±0.016 mA. If incorrect, repeat Steps 3 through 6.

SERVICING

In normal usage, the transmitter should not require servicing. However, if required, it is recommended that the transmitter be sent back to The Foxboro Company, Valencia, CA.

If the user services the transmitter, servicing should be limited to the replacement of the range and/or amplifier printed wiring assemblies (PWA's). When ordering these parts, all information on the data plate should be included.

The design of the circuitry is such, that it is highly unlikely that the range PWA will fail. If there is a transmitter malfunction, replacing the amplifier PWA should correct the condition. If the malfunction continues, the range PWA should be replaced.

If the transmitter range is to be changed, a new range PWA is required. Many standard range PWA's are available from Foxboro. If the range is changed, alter the data plate on top of the transmitter.

Platinum Resistance Range PWA, Wide Span

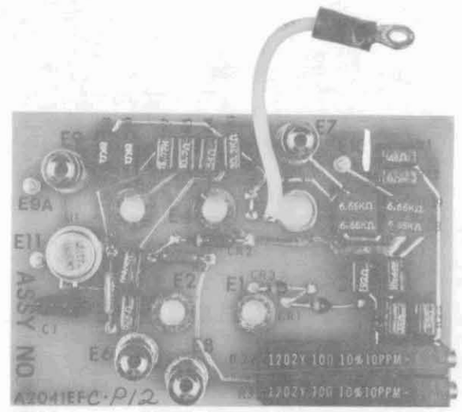


Figure 20

Parts List

Item	Description	Part No.
R2	Resistor, 205 kΩ ±[1]%, 1/8 W 25 ppm/°C	E0133MN
R3	Potentiometer, 10 Ω ±5%, 1/2 W, 10 ppm/°C	E0285KC
R6, R8 Pair	Resistors, 8.0 kΩ ±0.1%, 1/8 W, 5 ppm/°C each, 2 ppm/°C match and track	A2039VU
R7	Resistor, 15.77 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039VQ
R9	Resistor, 174.4 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039VS
R11	Resistor, 30.3 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039VR
R13	Resistor, 205 kΩ ±1%, 1/8 W, 25 ppm/°C	E0133MN
R14	Resistor, 15 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LN
R15, R16 Pair R18, R19 Pair	Resistors, 6.65 kΩ %0.1%, 1/8 W, 5 ppm/°C each, 2 ppm/°C match and track	A2039LD
R17	Resistor, 80 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039VT
R22	Potentiometer, 10 Ω ±5%, 1/2 W, 10 ppm/°C	E0285KC
R23	Resistor, 56 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LU
	NOTE: Resistors R1, R3, R4, R5, R10, R12, R20, and R21 are selected for input range	
C1	Capacitor, 30 pF ±5%, 500 V	H0104AF
CR1	Diode, Rectifier, Type 1N645	N0258AF
CR2, CR3	Diodes, Zener, Type 1N4611A, 6. V	N0257TZ
U1	Integrated Circuit, Type LM308	N0284PB

Platinum Resistance Range PWA, Narrow Span

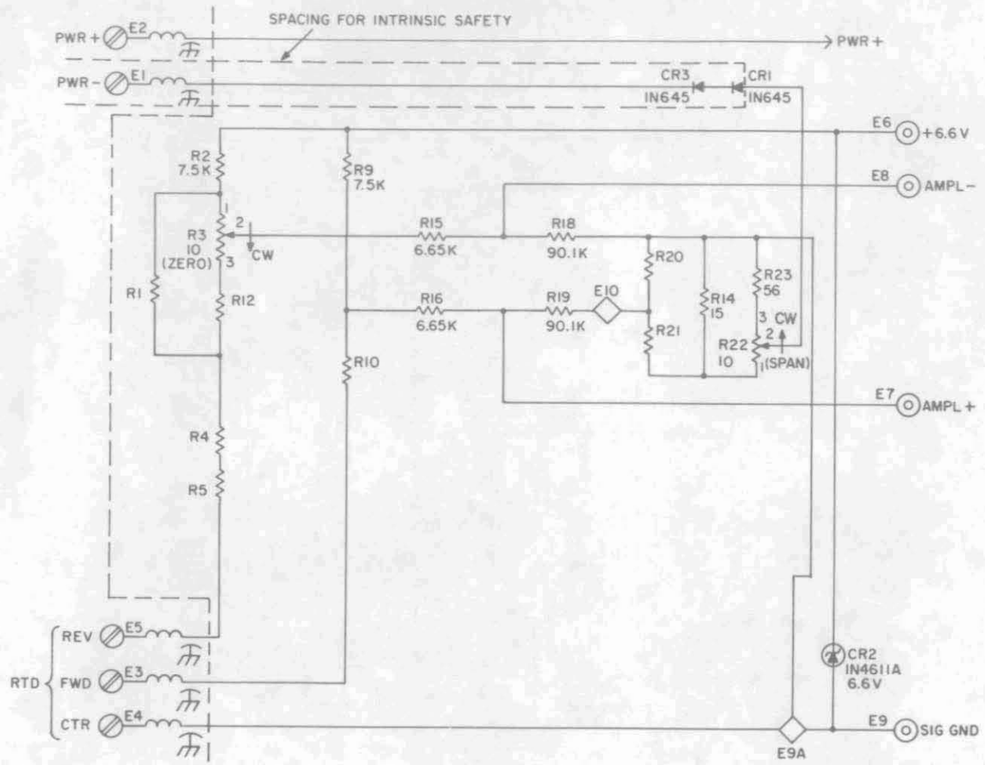


Figure 18

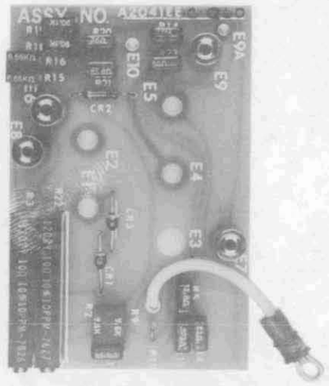


Figure 19

Parts List

Item	Description	Part No.
R3	Potentiometer, 10 Ω ±5%, 1/2 W, 10 ppm/°C	E0285KC
R2, R9 Pair	Resistors, 7.5 kΩ ±0.1%, 1/8 W 5 ppm/°C. 2 ppm/°C match and track	A2039LE
R14	Resistor, 15 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LN
R15, R16 Pair	Resistors, 6.65 kΩ ±0.1%, 1/8 W, 5 ppm/°C, 2 ppm/°C match and track	A2039LD
R18, R19 Pair	Resistors, 90.1 kΩ ±0.1%, 1/8 W 5 ppm/°C, 2 ppm/°C match and track	A2039LC
R22	Potentiometer, 10 Ω ±5%, 1/2 W 10 ppm/° C	E0285KC
R23	Resistor, 56 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LU
	NOTE: Resistors R1, R4, R5, R10, R12, R20, and R21 are selected for input span.	
CR1, CR3	Diodes, Rectifier, Type 1N645	N0258AF
CR2	Diode, Zener, Type 1N4611A, 6.6 V	N0257TZ

Remove Electronic Assembly

1. Remove the four screws holding cover to housing (Figure 8). Remove small screw from upper side.

2. Slide assembly out of housing by pushing against lower terminal posts with thumbs while bracing other fingers against base.

   NOTE
   When sliding assembly out of housing, note how flange of terminal board and flange of metal shielding fit in groove of housing. When reinstalling assembly in housing (Page 6), these parts must be positioned in the same arrangement.

3. To reinstall assembly, see Page 6.

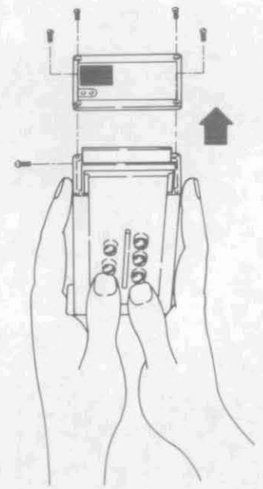


Figure 8

Remove PWA'S

The entire electronics assembly (with the exception of the external terminal board) is coated as a unit with a transparent humidity-resistant compound. Before the individual PWA's can be removed, this coating must be removed from the slots of the screws holding down each PWA.

1. Remove the five screws (at E2, E6, E7, E8, and E9) connecting amplifier PWA to range PWA. (Figure 9).

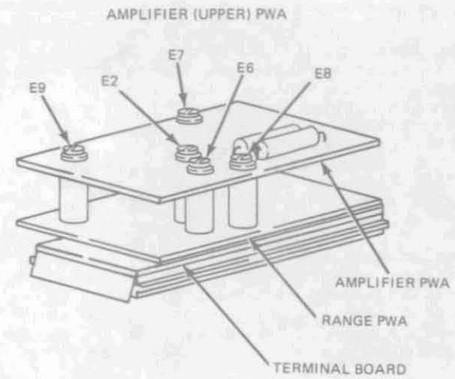


Figure 9

2. Separate and remove amplifier PWA from rest of assembly.

   NOTE
   The coating tends to hold the PWA's together. Force may be required to separate them. Do not damage components on the PWA which is not being replaced.

3. Remove the four screws at E1, E3, E4, E5 (Figure 10) and hex standoff E2, connecting range PWA to terminal board.

4. Separate range PWA from terminal board.

   NOTE
   When lifting off range PWA, female extension of standoff at E3 (at underside of PWA) must be lifted off male extension of terminal 3 (located on blue terminal board).

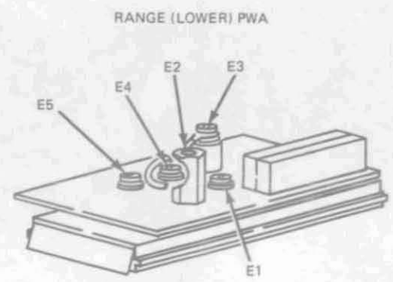


Figure 10

Install PWA'S

Replacement PWA's are factory-coated on both sides with a humidity-resistant compound; areas that will be in contact with mounting screws and standoffs have been protected with a peel-off covering. This covering must be removed before installation to ensure electrical contact. After installation, exposed portions of these areas must be coated with humidity-resistant compound.

Replacement PWA's are shipped with a stripper-coating kit to remove old coating and to coat exposed areas. Required mounting screws and washers to replace the old hardware are also included.

Interconnections between the PWA's and the terminal board are made through mounting screws and their mating standoffs. All screws must be securely tightened.

1. If range PWA is being replaced, the existing coating at the five mounting pads on both sides of the amplifier PWA (which must be removed first) must be removed to ensure good electrical contact.

   Apply stripping compound supplied with PWA to these areas. After about one minute, clean these areas throughly with a cotton swab soaked in isopropyl alcohol.

2. Install parts in reverse order of disassembly.

   All mounting screws are #4-40. Amplifier PWA uses five 3/8 in long screws. Range PWA uses four screws and a hex standoff. The shorter screw is used at the wire tang.

3. Use a cotton swab to paint all uncoated areas with coating compound supplied with PWA. Allow to dry in air for one hour.

4. Reinstall assembly into housing. See adjacent section.

Reinstall Electronics Assembly

If the electro-magnetic interference protection of the transmitter is to be maintained, the flange of the metal shielding and the flange of the terminal board must fit in the groove of the housing as shown in Figure 11.

NOTE

The clearance between the assembly and the housing is very small, and the procedure must be followed exactly.

1. While compressing flange of shielding, as shown in Figure 11:

   a. Position assembly in line with housing.

   b. Position flange of compressed shielding so that it is in line with bottom of groove in housing.

   c. Ease assembly into housing.

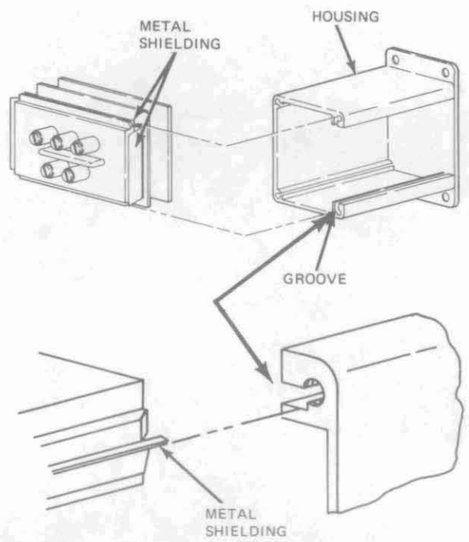


Figure 11

Nickel Resistance Range PWA, Narrow and Medium Spans

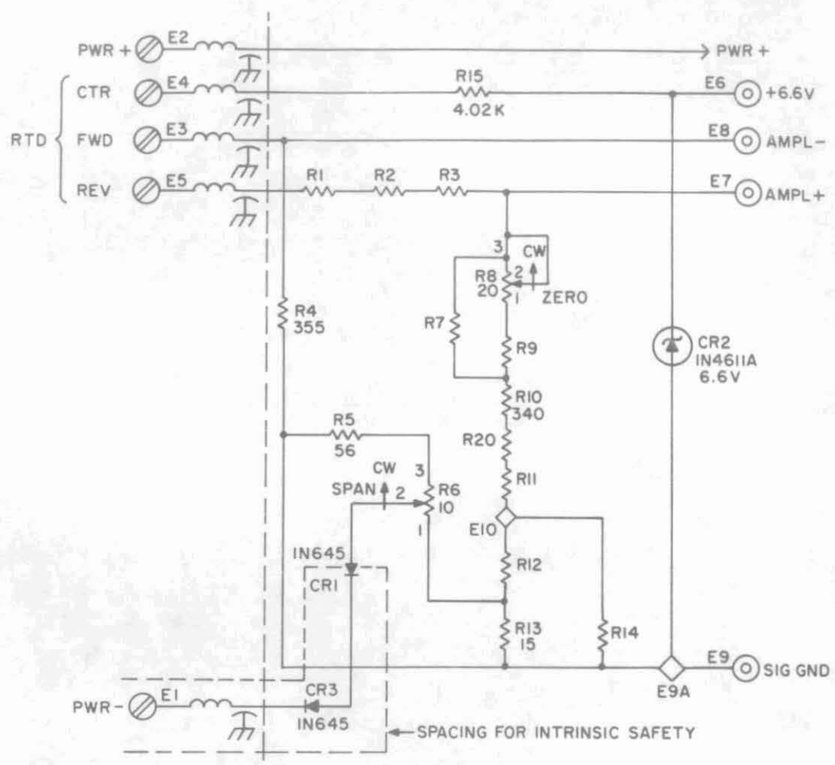


Figure 16

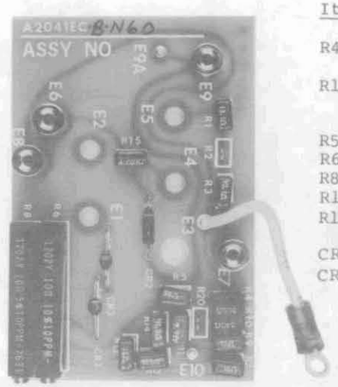


Figure 17

Parts List

Item	Description	Part No.
R4, R10 (Pair)	Resistor, 340 Ω ±0.1%, 1/8 W, 5 ppm/°C each, 2 ppm/°C match and track	A2039VP
	Resistor, 355 Ω ±0.1%, 1/8 W, 5 ppm/°C each, 2 ppm/°C match and track	
R5	Resistor, 56 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LU
R6	Potentiometer, 10 Ω ±5%, 1/2 W 10 ppm/°C	E0285KC
R8	Potentiometer, 20 Ω ±5%, 1/2 W, 10 ppm/°C	E0285TK
R13	Resistor, 15 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LN
R15	Resistor, 4.02 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039MF
CR1, CR3	Diodes, Rectifier, Type 1N645	N0258NF
CR2	Diode, Zener, Type 1N4611A, 6.6 V	N0257TX

NOTE: Resistors R1, R2, R3, R7, R9, R11, R12, and R14 are selected for input range.

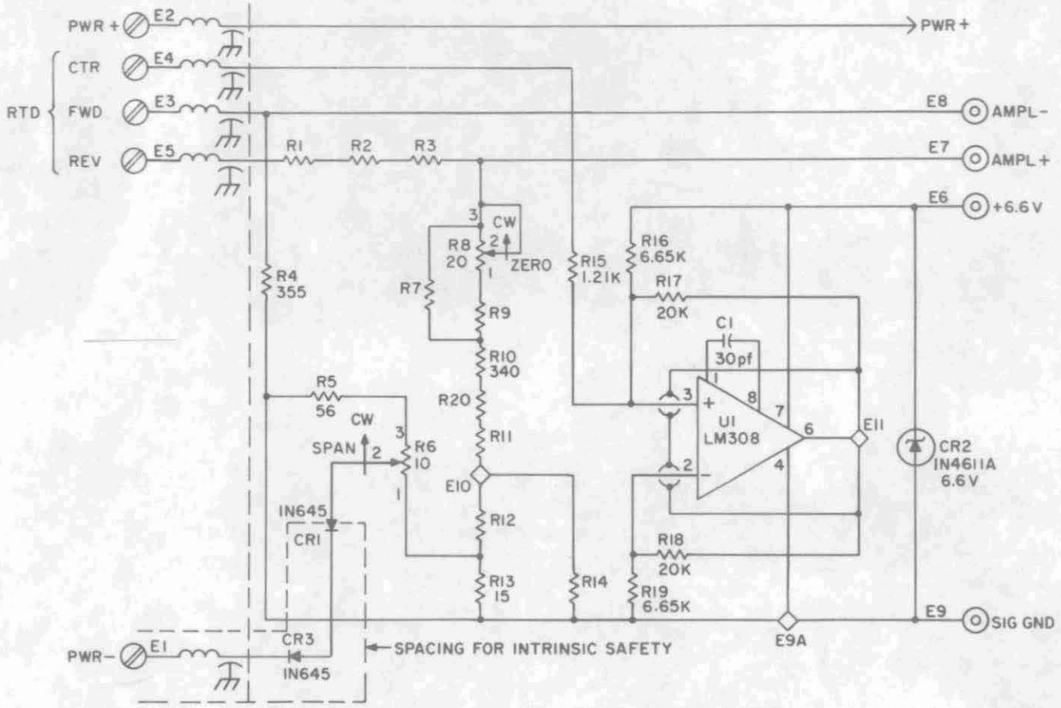


Figure 15.
Circuit Diagram Nickel Resistance Range,
Wide Span PWA

CIRCUIT DIAGRAMS AND PARTS LIST

Standard Version, Part A2041EA

PTB Version, Part A2043FY
(Right hand portion shown)

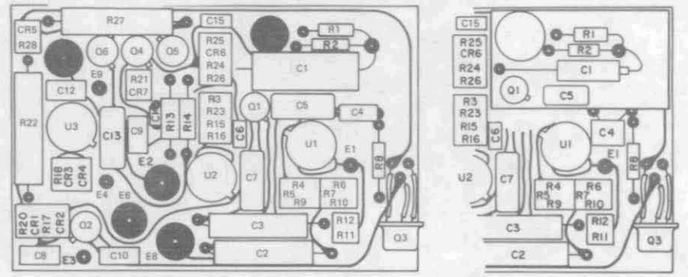


Figure 12. Amplifier PWA

⚠ CAUTION

The parts lists and circuit diagrams provided in this Instruction are solely for informational purposes. The use of this information for repair of the instrument is not recommended and the user shall be responsible for any damage to the instrument, or possible violation of warranty, resulting from such repair.

Parts List

Item	Description	Part No.
R1	Resistor, film, 180 Ω ±2%, 1/4 W, 200 ppm/°C	E0156EF
R2, R3	Resistors, metal film, 2 kΩ ±1%, 1/8 W, 50 ppm/°C	E0142WB
R4, R5	Resistors, metal film, 200 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143MM
R6, R7	Resistors, metal film, 10 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143AB
R8	Resistor, film, 2 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156FT
R9, R10	Resistors, metal film, 68.1 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143FW
R11	Resistor, metal film, 100 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143KT
R12	Resistor, film, 10 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156KT
R13, R14	Resistors, film, 200 kΩ ±1%, 1/8 W, 100 ppm/°C	E0301MM
R15	Resistor, 1 MΩ ±1%, 1/8 W, 50 ppm/°C	E0143SL
R16	Resistor, film, 274 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143NE
R17, R18	Resistors, film, 332 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143NS
R20, R23	Resistors, film, 100 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156MC
R21	Resistor, carbon composition, 18 MΩ ±5%, 1/4 W	E0152RK
R22	Resistor, film, 300 Ω ±2%, 1 W, 200 ppm/°C	E0158EP
R24	Resistor, film, 27 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156LK
R25	Resistor, metal film, 30.1 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143CW
R26	Resistor, metal film, 68.1 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143FW
R27	Resistor, film, 1.2 kΩ ±2%, 1 W, 200 ppm/°C	E0158FM
R28	Resistor, film, 24 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156LF
C1 (standard)	Capacitor, 15 µF ±10%, 35 V dc, tantalum	H0160CN
C1 (PTB)	Capacitor, 15 µF ±10%, 20 V dc	H0159PX
C2, C3	Capacitors, 0.1 µF ±5%, 50 V dc, polycarbonate	A2038YL
C4	Capacitor, 1.0 µF ±20%, 50 V dc, ceramic	H0140BM
C5, C7	Capacitors, 3.0 pF ±5%, 500 V dc, mica	H0104GC
C6	Capacitor, 0.01 µF ±10%, 50 V dc, polycarbonate	A2043ET
C8, C9, C10, C12	Capacitors, 0.1 µF ±10%, 100 V dc, ceramic	H0111CB
C13	Capacitor, 100 pF ±5%, 500 V dc, mica	H0104BA
C14	Capacitor, 1000 pF ±20%, 100 V dc, ceramic	A2041VE
C15	Capacitor, 0.01 µF ±10%, 100 V dc, ceramic	H0111BL
CR1-CR4 CR6, CR7	Diodes, Switching, Type 1N4531	N0258DB
CR5	Diode, Rectifier, Type 1N645	N0258AF
Q1, Q2	Transistors, N-JFET, Type 2N4393	N0282AT
Q3	Transistor, NPN, Type 2N3440	A2029TN
Q4	Transistor, NPN, Type 2N2484	K0120RY
Q5, Q6	Transistors, PNP, Type 2N2907A	N0282AL
--	Transistor Pad (used with Q1, Q2, Q4, Q5, and Q6)	A2040YP
U1	IC, Operational Amplifier, Type LM308 (Select)	A2042DX
U2, U3	IC, Operational Amplifier, Type LM308	N0284PB

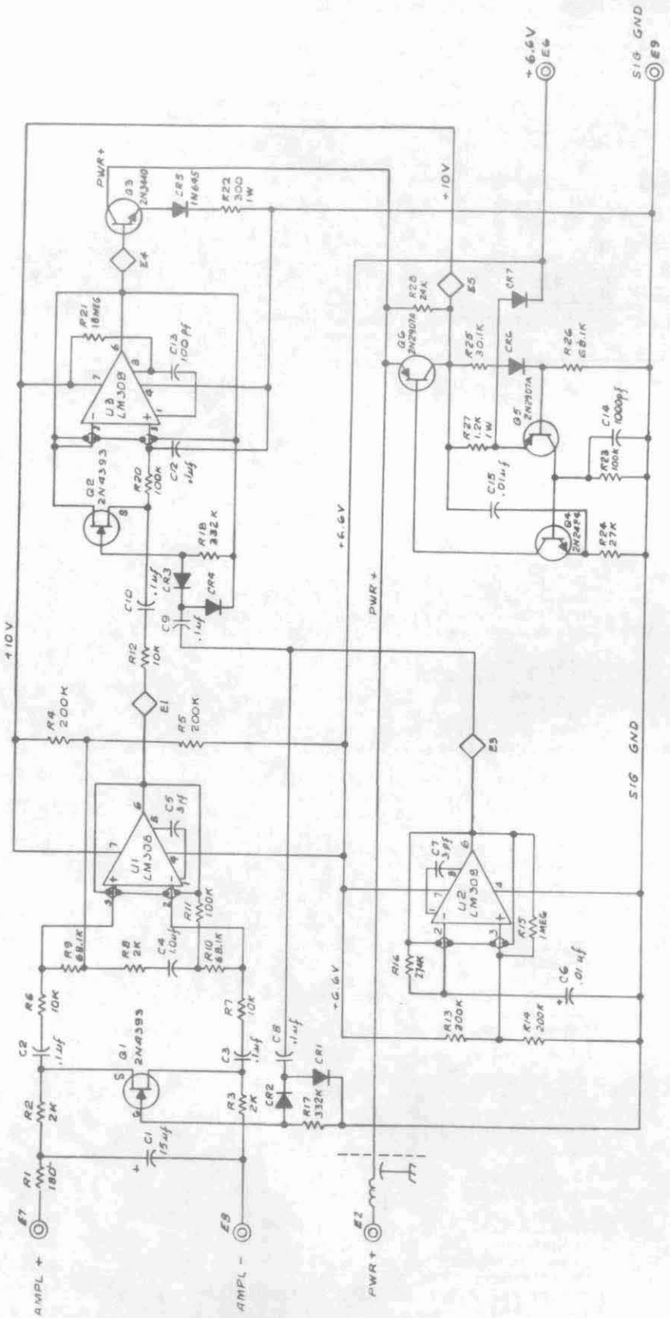


Figure 13.
Circuit Diagram Amplifier PWA

Nickel Resistance Range PWA, Wide Span

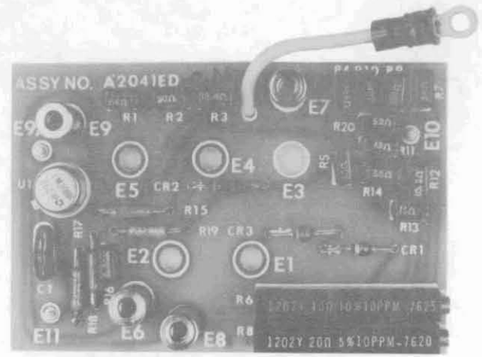


Figure 14

Parts List

Item	Description	Part No.
R4, R10 (Pair)	Resistor, 355 Ω ±0.1%, 1/8 W, 5 ppm/°C, 2 ppm/°C match and track	A2039VP
	Resistor, 340 Ω ±0.1%, 1/8 W, 5 ppm/°C, 2 ppm/°C match and track	
R5	Resistor, 56 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LU
R6	Potentiometer, 10 Ω ±5%, 1/2 W, 10 ppm/°C	E0285KC
R8	Potentiometer, 20 Ω ±5%, 1/2 W, 10 ppm/°C	E0285TK
R13	Resistor, 15 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LN
R15	Resistor, 1.21 kΩ ±1%, 1/8 W, 25 ppm/°C	E0132SX
R16	Resistor, 6.65 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2040MD
R17, R18	Resistors, 20 kΩ ±1%, 1/8 W, 25 ppm/°C	E0133BW
R19	Resistor, 6.65 kΩ ±1%, 1/8 W, 25 ppm/°C	E013122A
	NOTE: Resistors R1, R2, R3, R7, R9, R11, R12, R14, and R20 are selected for input range.	
C1	Capacitor, 30 pF ±5%, 500 V	H0104AF
CR1, CR3	Diodes, Rectifier, Type 1N645	N0258AF
CR2	Diode, Zener, Type 1N4611A, 6.6 V	N0257T4
U1	Integrated Circuit, Operation Amplifier, Type LM308	N0284PB
	Integrated Circuit Pad	A2040YQ

SAMA TYPE II NICKEL RTD TEMPERATURE-RESISTANCE TABLES
Curve NR-227 (°C vs Absolute Ω) and Curve NR-226 (°F vs Absolute Ω)

The values listed in these tables were calculated using the equations found in Foxboro Drawing 10104MU, Temperature Calibration Sources.

Curve NR-227, °C vs Absolute Ω

°C	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
-130	182.967									
-120	186.531	186.171	185.812	185.454	185.097	184.740	184.384	184.029	183.674	183.320
-110	190.164	189.797	189.432	189.066	188.702	188.338	187.976	187.613	187.252	186.891
-100	193.868	193.494	193.121	192.749	192.378	192.007	191.637	191.268	190.899	190.531
-90	197.644	197.263	196.883	196.503	196.125	195.747	195.369	194.993	194.617	194.242
-80	201.493	201.105	200.718	200.331	199.945	199.559	199.175	198.791	198.408	198.025
-70	205.418	205.022	204.627	204.233	203.839	203.446	203.054	202.663	202.272	201.883
-60	209.419	209.016	208.613	208.211	207.809	207.409	207.009	206.610	206.212	205.815
-50	213.498	213.057	212.676	212.266	211.857	211.449	211.041	210.635	210.229	209.824
-40	217.657	217.237	216.818	216.401	215.984	215.567	215.152	214.737	214.323	213.910
-30	221.896	221.468	221.042	220.616	220.192	219.766	219.343	218.920	218.498	218.077
-20	226.218	225.782	225.347	224.913	224.479	224.047	223.615	223.184	222.754	222.324
-10	230.624	230.180	229.736	229.293	228.852	228.410	227.970	227.531	227.092	226.655
0	235.116	234.663	234.211	233.760	233.309	232.859	232.411	231.963	231.516	231.070
0	235.116	235.570	236.025	236.481	236.937	237.395	237.853	238.313	238.773	239.234
10	239.696	240.159	240.622	241.087	241.552	242.019	242.486	242.954	243.423	243.894
20	244.364	244.836	245.309	245.783	246.257	246.733	247.209	247.687	248.165	248.644
30	249.124	249.605	250.087	250.570	251.054	251.539	252.024	252.511	252.998	253.487
40	253.976	254.467	254.958	255.451	255.944	256.438	256.933	257.429	257.926	258.424
50	258.923	259.423	259.924	260.426	260.929	261.433	261.938	262.443	262.950	263.458
60	263.966	264.476	264.987	265.499	266.011	266.525	267.039	267.555	268.072	268.589
70	269.108	269.628	270.148	270.671	271.192	271.716	272.241	272.766	273.293	273.821
80	274.350	274.879	275.410	275.942	276.475	277.008	277.543	278.079	278.616	279.154
90	279.693	280.233	280.774	281.317	281.860	282.404	282.949	283.496	284.043	284.591
100	285.141	285.692	286.243	286.796	287.350	287.904	288.460	289.017	289.575	290.135
110	290.695	291.256	291.819	292.382	292.947	293.512	294.079	294.647	295.216	295.786
120	296.357	296.929	297.502	298.077	298.652	299.229	299.807	300.386	300.966	301.547
130	302.129	302.713	303.297	303.883	304.469	305.057	305.646	306.237	306.828	307.420
140	308.014	308.609	309.205	309.802	310.400	310.999	311.600	312.201	312.804	313.408
150	314.013	314.620	315.227	315.836	316.446	317.057	317.669	318.282	318.897	319.513
160	320.130	320.748	321.367	321.988	322.609	323.232	323.856	324.482	325.108	325.736
170	326.365	326.995	327.627	328.259	328.893	329.528	330.164	330.802	331.441	332.081
180	332.722	333.364	334.008	334.653	335.299	335.946	336.595	337.245	337.896	338.549
190	339.202	339.857	340.514	341.171	341.830	342.490	343.151	343.814	344.478	345.143
200	345.809	346.477	347.146	347.816	348.488	349.161	349.835	350.510	351.187	351.865
210	352.545	353.226	353.908	354.591	355.276	355.962	356.649	357.338	358.028	358.719
220	359.411	360.106	360.801	361.497	362.196	362.895	363.596	364.298	365.001	365.706
230	366.412	367.120	367.828	368.539	369.250	369.963	370.678	371.393	372.110	372.829
240	373.549	374.270	374.993	375.717	376.442	377.169	377.898	378.627	379.358	380.091
250	380.825	381.560	382.297	383.035	383.775	384.516	385.258	386.002	386.747	387.494
260	388.242	388.992	389.743	390.496	391.250	392.005	392.762	393.520	394.280	395.042
270	395.804	396.569	397.334	398.102	398.870	399.640	400.412	401.185	401.960	402.736
280	403.514	404.293	405.073	405.856	406.639	407.424	408.211	408.999	409.789	410.580
290	411.373	412.167	412.963	413.761	414.560	415.360	416.162	416.966	417.771	418.577
300	419.386	420.195	421.007	421.820	422.634	423.450	424.268	425.087	425.908	426.730
310	427.554	428.380	429.207	430.036	430.866	431.698				
°C	0	1	2	3	4	5	6	7	8	9

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Curve NR-226, °F vs Absolute Ω

°F	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
-200	183.359									
-190	185.335	185.137	184.938	184.740	184.542	184.345	184.147	183.950	183.753	183.556
-180	187.332	187.131	186.931	186.731	186.531	186.331	186.131	185.932	185.733	185.534
-170	189.350	189.148	188.945	188.743	188.540	188.338	188.137	187.935	187.734	187.533
-160	191.391	191.186	190.981	190.776	190.572	190.368	190.164	189.960	189.757	189.553
-150	193.453	193.245	193.038	192.832	192.625	192.419	192.213	192.007	191.801	191.596
-140	195.537	195.328	195.118	194.909	194.701	194.492	194.284	194.076	193.868	193.660
-130	197.644	197.432	197.221	197.009	196.798	196.588	196.377	196.167	195.957	195.747
-120	199.773	199.559	199.346	199.132	198.919	198.706	198.493	198.280	198.068	197.856
-110	201.926	201.710	201.493	201.278	201.062	200.847	200.632	200.417	200.202	199.988
-100	204.101	203.883	203.664	203.446	203.228	203.011	202.793	202.576	202.359	202.142
-90	206.301	206.080	205.859	205.638	205.418	205.198	204.978	204.759	204.539	204.320
-80	208.523	208.300	208.077	207.854	207.631	207.409	207.187	206.965	206.743	206.522
-70	210.770	210.544	210.319	210.094	209.868	209.644	209.419	209.195	208.971	208.747
-60	213.041	212.813	212.585	212.357	212.130	211.903	211.676	211.449	211.222	210.996
-50	215.336	215.106	214.875	214.645	214.415	214.186	213.956	213.727	213.498	213.269
-40	217.657	217.423	217.191	216.958	216.726	216.493	216.262	216.030	215.798	215.567
-30	220.002	219.766	219.531	219.296	219.061	218.826	218.592	218.357	218.124	217.890
-20	222.372	222.134	221.896	221.658	221.421	221.184	220.947	220.710	220.474	220.238
-10	224.768	224.527	224.287	224.047	223.807	223.567	223.327	223.088	222.849	222.611
0	227.190	226.947	226.703	226.461	226.218	225.976	225.734	225.492	225.250	225.009
0	227.190	227.433	227.677	227.921	228.166	228.410	228.655	228.901	229.146	229.392
10	229.638	229.884	230.130	230.377	230.624	230.872	231.119	231.367	231.615	231.863
20	232.112	232.361	232.610	232.859	233.109	233.359	233.609	233.860	234.111	234.362
30	234.613	234.864	235.116	235.368	235.621	235.873	236.126	236.379	236.633	236.887
40	237.141	237.395	237.650	237.904	238.159	238.415	238.670	238.926	239.183	239.439
50	239.696	239.953	240.210	240.468	240.725	240.984	241.242	241.501	241.760	242.019
60	242.278	242.538	242.798	243.059	243.319	243.580	243.841	244.103	244.364	244.626
70	244.889	245.151	245.414	245.677	245.941	246.205	246.469	246.733	246.997	247.262
80	247.527	247.793	248.058	248.324	248.591	248.857	249.124	249.391	249.659	249.926
90	250.194	250.463	250.731	251.000	251.269	251.539	251.808	252.078	252.349	252.619
100	252.890	253.161	253.433	253.704	253.976	254.249	254.521	254.794	255.068	255.341
110	255.615	255.889	256.163	256.438	256.713	256.988	257.264	257.540	257.816	258.092
120	258.369	258.646	258.923	259.201	259.479	259.757	260.036	260.314	260.594	260.873
130	261.153	261.433	261.713	261.994	262.275	262.556	262.837	263.119	263.401	263.684
140	263.966	264.250	264.533	264.817	265.100	265.385	265.669	265.954	266.239	266.525
150	266.811	267.097	267.383	267.670	267.957	268.244	268.532	268.820	269.108	269.396
160	269.685	269.975	270.264	270.554	270.844	271.134	271.425	271.716	272.007	272.299
170	272.591	272.883	273.176	273.469	273.762	274.056	274.350	274.644	274.938	275.233
180	275.528	275.824	276.119	276.415	276.712	277.008	277.305	277.603	277.901	278.198
190	278.497	278.795	279.094	279.394	279.693	279.993	280.293	280.594	280.895	281.196
200	281.497	281.799	282.101	282.404	282.707	283.010	283.313	283.617	283.921	284.226
210	284.530	284.836	285.141	285.447	285.753	286.059	286.366	286.673	286.980	287.288
220	287.596	287.904	288.213	288.522	288.832	289.141	289.451	289.762	290.072	290.383
230	290.695	291.007	291.319	291.631	291.944	292.257	292.570	292.884	293.198	293.512
240	293.827	294.142	294.457	294.773	295.089	295.406	295.722	296.039	296.357	296.675
250	296.993	297.311	297.630	297.949	298.269	298.588	298.909	299.229	299.550	299.871
260	300.193	300.515	300.837	301.159	301.482	301.806	302.129	302.453	302.777	303.102
270	303.427	303.753	304.078	304.404	304.731	305.057	305.384	305.712	306.040	306.368
280	306.696	307.025	307.354	307.684	308.014	308.344	308.675	309.006	309.337	309.669
290	310.001	310.333	310.666	310.999	311.333	311.666	312.001	312.335	312.670	313.005
300	313.341	313.677	314.013	314.350	314.687	315.025	315.362	315.700	316.039	316.378
310	316.717	317.057	317.397	317.737	318.078	318.419	318.760	319.102	319.444	319.787
320	320.130	320.473	320.816	321.160	321.505	321.850	322.195	322.540	322.886	323.232
330	323.579	323.926	324.273	324.621	324.969	325.317	325.666	326.015	326.365	326.715
340	327.065	327.416	327.767	328.118	328.470	328.822	329.175	329.528	329.881	330.235
350	330.589	330.944	331.298	331.654	332.009	332.365	332.722	333.078	333.436	333.793
360	334.151	334.509	334.868	335.227	335.587	335.946	336.307	336.667	337.028	337.390
370	337.751	338.114	338.476	338.839	339.202	339.566	339.930	340.295	340.660	341.025
380	341.390	341.757	342.123	342.490	342.857	343.225	343.593	343.961	344.330	344.699
390	345.069	345.439	345.809	346.180	346.551	346.923	347.295	347.667	348.040	348.413
°F	0	1	2	3	4	5	6	7	8	9

Curve NR-226, °F vs Absolute Ω (Cont.)

°F	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
400	348.787	349.161	349.535	349.910	350.285	350.661	351.037	351.413	351.790	352.167
410	352.545	352.923	353.301	353.680	354.059	354.439	354.819	355.199	355.580	355.962
420	356.343	356.725	357.108	357.491	357.874	358.258	358.642	359.027	359.411	359.797
430	360.183	360.569	360.956	361.343	361.730	362.118	362.506	362.895	363.284	363.674
440	364.063	364.454	364.845	365.236	365.627	366.020	366.412	366.805	367.198	367.592
450	367.986	368.381	368.776	369.171	369.567	369.963	370.360	370.757	371.155	371.553
460	371.951	372.350	372.749	373.149	373.549	373.949	374.350	374.752	375.154	375.556
470	375.959	376.362	376.765	377.169	377.574	377.978	378.384	378.789	379.196	379.602
480	380.009	380.417	380.825	381.233	381.642	382.051	382.461	382.871	383.281	383.692
490	384.104	384.516	384.928	385.341	385.754	386.167	386.581	386.996	387.411	387.826
500	388.242	388.659	389.075	389.492	389.910	390.328	390.747	391.166	391.585	392.005
510	392.425	392.846	393.267	393.689	394.111	394.534	394.957	395.380	395.804	396.229
520	396.654	397.079	397.505	397.931	398.358	398.785	399.212	399.640	400.069	400.498
530	400.927	401.357	401.788	402.218	402.650	403.081	403.514	403.946	404.379	404.813
540	405.247	405.682	406.117	406.552	406.988	407.424	407.861	408.299	408.736	409.175
550	409.613	410.053	410.492	410.932	411.373	411.814	412.256	412.698	413.140	413.583
560	414.027	414.471	414.915	415.360	415.805	416.251	416.698	417.144	417.592	418.039
570	418.488	418.936	419.386	419.835	420.285	420.736	421.187	421.639	422.091	422.544
580	422.997	423.450	423.904	424.359	424.814	425.269	425.725	426.182	426.639	427.096
590	427.554	428.013	428.472	428.931	429.391	429.851	430.312	430.774	431.236	431.698
600	432.161									
°F	0	1	2	3	4	5	6	7	8	9

DIN PLATINUM RTD TEMPERATURE-RESISTANCE TABLES
Curve PR-238 (°C vs Absolute Ω) and Curve PR-239 (°F vs Absolute Ω)

The values listed in these tables were calculated using the equations found in Foxboro Drawing 10104MU, Temperature Calibration Sources.

Curve PR-238, °C vs Absolute Ω

°C	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
-220	10.408									
-210	14.360	13.951	13.546	13.145	12.746	12.350	11.955	11.565	11.177	10.793
-200	18.530	18.119	17.689	17.268	16.849	16.429	16.012	15.595	15.182	14.769
-190	22.782	22.354	21.928	21.501	21.073	20.646	20.221	19.796	19.373	18.950
-180	27.049	26.623	26.197	25.771	25.345	24.918	24.492	24.064	23.637	23.209
-170	31.280	30.859	30.437	30.015	29.592	29.169	28.746	28.322	27.898	27.473
-160	35.478	35.060	34.641	34.222	33.803	33.383	32.963	32.543	32.122	31.701
-150	39.651	39.234	38.818	38.401	37.984	37.567	37.150	36.732	36.315	35.897
-140	43.802	43.387	42.973	42.559	42.144	41.729	41.314	40.898	40.483	40.067
-130	47.932	47.520	47.107	46.695	46.282	45.869	45.456	45.043	44.629	44.215
-120	52.041	51.631	51.221	50.811	50.400	49.989	49.578	49.167	48.755	48.344
-110	56.131	55.722	55.314	54.906	54.497	54.088	53.679	53.270	52.861	52.451
-100	60.201	59.794	59.388	58.982	58.575	58.168	57.761	57.354	56.946	56.538
-90	64.252	63.847	63.443	63.038	62.634	62.229	61.823	61.418	61.012	60.607
-80	68.282	67.880	67.478	67.075	66.673	66.270	65.866	65.463	65.059	64.656
-70	72.291	71.892	71.491	71.091	70.690	70.290	69.889	69.487	69.086	68.684
-60	76.279	75.882	75.483	75.085	74.687	74.288	73.889	73.490	73.091	72.691
-50	80.250	79.854	79.457	79.061	78.664	78.267	77.870	77.472	77.075	76.677
-40	84.212	83.816	83.420	83.024	82.628	82.232	81.836	81.439	81.043	80.647
-30	88.170	87.774	87.378	86.983	86.587	86.191	85.795	85.399	85.003	84.607
-20	92.127	91.731	91.336	90.940	90.545	90.149	89.753	89.357	88.962	88.566
-10	96.072	95.679	95.285	94.891	94.496	94.102	93.707	93.312	92.917	92.522
0	100.000	99.608	99.216	98.823	98.431	98.038	97.645	97.253	96.859	96.466
0	100.000	100.391	100.781	101.172	101.562	101.952	102.343	102.733	103.123	103.512
10	103.902	104.292	104.681	105.070	105.460	105.849	106.238	106.627	107.015	107.404
20	107.793	108.181	108.569	108.957	109.345	109.733	110.121	110.509	110.897	111.284
30	111.671	112.059	112.446	112.833	113.220	113.607	113.993	114.380	114.766	115.153
40	115.539	115.925	116.311	116.697	117.083	117.468	117.854	118.239	118.624	119.010
50	119.395	119.780	120.164	120.549	120.934	121.318	121.702	122.087	122.471	122.855
60	123.239	123.623	124.006	124.390	124.773	125.157	125.540	125.923	126.306	126.689
70	127.071	127.454	127.837	128.219	128.601	128.983	129.365	129.747	130.129	130.511
80	130.893	131.274	131.655	132.037	132.418	132.799	133.180	133.560	133.941	134.322
90	134.702	135.082	135.463	135.843	136.223	136.602	136.982	137.362	137.741	138.121
100	138.500	138.879	139.258	139.637	140.016	140.395	140.773	141.152	141.530	141.908
110	142.286	142.664	143.042	143.420	143.798	144.175	144.553	144.930	145.307	145.684
120	146.061	146.438	146.815	147.191	147.568	147.944	148.320	148.697	149.073	149.449
130	149.824	150.200	150.576	150.951	151.326	151.702	152.077	152.452	152.827	153.201
140	153.576	153.951	154.325	154.699	155.073	155.448	155.822	156.195	156.569	156.943
150	157.316	157.690	158.063	158.436	158.809	159.182	159.555	159.927	160.300	160.672
160	161.045	161.417	161.789	162.161	162.533	162.905	163.276	163.648	164.019	164.391
170	164.762	165.133	165.504	165.875	166.245	166.616	166.986	167.357	167.727	168.097
180	168.467	168.837	169.207	169.576	169.946	170.315	170.685	171.054	171.423	171.792
190	172.161	172.530	172.898	173.267	173.635	174.003	174.372	174.740	175.108	175.475
200	175.843	176.211	176.578	176.946	177.313	177.680	178.047	178.414	178.781	179.147
210	179.514	179.880	180.247	180.613	180.979	181.345	181.711	182.076	182.442	182.808
220	183.173	183.538	183.903	184.268	184.633	184.998	185.363	185.727	186.092	186.456
230	186.821	187.185	187.549	187.913	188.276	188.640	189.004	189.367	189.730	190.093
240	190.457	190.819	191.182	191.545	191.908	192.270	192.633	192.995	193.357	193.719
250	194.081	194.443	194.804	195.166	195.527	195.889	196.250	196.611	196.972	197.333
260	197.694	198.054	198.415	198.775	199.136	199.496	199.856	200.216	200.576	200.935
270	201.295	201.655	202.014	202.373	202.732	203.091	203.450	203.809	204.168	204.526
280	204.885	205.243	205.601	205.959	206.317	206.675	207.033	207.391	207.748	208.106
290	208.463	208.820	209.177	209.534	209.891	210.248	210.604	210.961	211.317	211.673
°C	0	1	2	3	4	5	6	7	8	9

DIN = Deutsches Institut fur Normung

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Curve PR-238, °C vs Absolute Ω (Cont.)

°C	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
300	212.030	212.386	212.741	213.097	213.453	213.808	214.164	214.519	214.874	215.230
310	215.585	215.939	216.294	216.649	217.003	217.358	217.712	218.066	218.420	218.774
320	219.128	219.482	219.835	220.189	220.542	220.895	221.248	221.602	221.95A	222.307
330	222.660	223.012	223.365	223.717	224.069	224.421	224.773	225.125	225.477	225.829
340	226.180	226.532	226.883	227.234	227.585	227.936	228.287	228.638	228.988	229.339
350	229.689	230.039	230.389	230.739	231.089	231.439	231.789	232.138	232.488	232.837
360	233.186	233.535	233.884	234.233	234.582	234.930	235.279	235.627	235.975	236.324
370	236.672	237.020	237.367	237.715	238.063	238.410	238.757	239.105	239.452	239.799
380	240.146	240.492	240.839	241.186	241.532	241.878	242.225	242.571	242.917	243.262
390	243.608	243.954	244.299	244.645	244.990	245.335	245.680	246.025	246.370	246.715
400	247.059	247.404	247.748	248.092	248.436	248.780	249.124	249.468	249.811	250.155
410	250.498	250.842	251.185	251.528	251.871	252.214	252.556	252.899	253.242	253.584
420	253.926	254.268	254.610	254.952	255.294	255.636	255.977	256.319	256.660	257.001
430	257.342	257.683	258.024	258.365	258.706	259.046	259.387	259.727	260.067	260.407
440	260.747	261.087	261.427	261.766	262.106	262.445	262.784	263.123	263.462	263.801
450	264.140	264.479	264.817	265.156	265.494	265.832	266.170	266.508	266.846	267.184
460	267.522	267.859	268.196	268.534	268.871	269.208	269.545	269.882	270.218	270.555
470	270.891	271.228	271.564	271.900	272.236	272.572	272.908	273.244	273.579	273.914
480	274.250	274.585	274.920	275.255	275.590	275.925	276.259	276.594	276.928	277.262
490	277.597	277.931	278.265	278.598	278.932	279.266	279.599	279.932	280.266	280.599
500	280.932	281.265	281.597	281.930	282.263	282.595	282.927	283.260	283.592	283.924
510	284.255	284.587	284.919	285.250	285.582	285.913	286.244	286.575	286.906	287.237
520	287.568	287.898	288.229	288.559	288.889	289.219	289.549	289.879	290.209	290.539
530	290.868	291.198	291.527	291.856	292.185	292.514	292.843	293.172	293.500	293.829
540	294.157	294.485	294.813	295.141	295.469	295.797	296.125	296.452	296.780	297.107
550	297.434	297.761	298.089	298.415	298.742	299.069	299.395	299.722	300.048	300.374
560	300.700	301.026	301.352	301.678	302.003	302.329	302.654	302.979	303.304	303.630
570	303.954	304.279	304.604	304.928	305.253	305.577	305.901	306.226	306.549	306.873
580	307.197	307.521	307.844	308.168	308.491	308.814	309.137	309.460	309.783	310.106
590	310.428	310.751	311.073	311.395	311.717	312.039	312.361	312.683	313.005	313.326
600	313.648	313.969	314.290	314.611	314.932	315.253	315.574	315.895	316.215	316.535
610	316.856	317.176	317.496	317.816	318.136	318.455	318.775	319.094	319.414	319.733
620	320.052	320.371	320.690	321.009	321.327	321.646	321.964	322.283	322.601	322.919
630	323.237	323.555	323.873	324.190	324.508	324.825	325.142	325.459	325.776	326.093
640	326.410	326.727	327.043	327.360	327.676	327.992	328.309	328.625	328.940	329.256
650	329.572	329.887	330.203	330.518	330.833	331.148	331.463	331.778	332.093	332.408
660	332.722	333.036	333.351	333.665	333.979	334.293	334.607	334.920	335.234	335.547
670	335.861	336.174	336.487	336.800	337.113	337.426	337.738	338.051	338.363	338.675
680	338.988	339.300	339.612	339.923	340.235	340.547	340.858	341.170	341.481	341.792
690	342.103	342.414	342.725	343.035	343.346	343.656	343.967	344.277	344.587	344.897
700	345.207	345.517	345.826	346.136	346.445	346.754	347.064	347.373	347.682	347.990
710	348.299	348.608	348.916	349.225	349.533	349.841	350.149	350.457	350.765	351.072
720	351.380	351.687	351.995	352.302	352.609	352.916	353.223	353.529	353.836	354.143
730	354.449	354.755	355.061	355.367	355.673	355.979	356.285	356.591	356.896	357.201
740	357.507	357.812	358.117	358.422	358.726	359.031	359.336	359.640	359.944	360.249
750	360.553	360.857	361.160	361.464	361.768	362.071	362.375	362.678	362.981	363.284
760	363.587	363.890	364.193	364.495	364.798	365.100	365.402	365.704	366.006	366.308
770	366.610	366.912	367.213	367.515	367.816	368.117	368.418	368.719	369.020	369.321
780	369.621	369.922	370.222	370.522	370.823	371.123	371.422	371.722	372.022	372.322
790	372.621	372.920	373.220	373.519	373.818	374.116	374.415	374.714	375.013	375.311
800	375.609	375.907	376.205	376.503	376.801	377.099	377.396	377.694	377.991	378.289
810	378.586	378.883	379.180	379.477	379.773	380.070	380.366	380.662	380.959	381.255
820	381.551	381.847	382.143	382.438	382.734	383.029	383.324	383.620	383.915	384.209
830	384.504	384.799	385.094	385.388	385.682	385.977	386.271	386.565	386.859	387.153
840	387.446	387.740	388.033	388.327	388.620	388.913	389.206	389.499	389.791	390.084
850	390.377									
°C	0	1	2	3	4	5	6	7	8	9

Curve PR-239, °F vs Absolute Ω (Cont.)

°F	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
900	274.995	275.181	275.367	275.553	275.739	275.925	276.111	276.296	276.482	276.668
910	276.854	277.040	277.225	277.411	277.597	277.782	277.968	278.153	278.339	278.524
920	278.710	278.895	279.080	279.266	279.451	279.636	279.821	280.007	280.192	280.377
930	280.562	280.747	280.932	281.117	281.302	281.487	281.671	281.856	282.041	282.226
940	282.410	282.595	282.780	282.964	283.149	283.333	283.518	283.702	283.887	284.071
950	284.255	284.440	284.624	284.808	284.992	285.177	285.361	285.545	285.729	285.913
960	286.097	286.281	286.465	286.649	286.832	287.016	287.200	287.384	287.568	287.751
970	287.935	288.118	288.302	288.485	288.669	288.852	289.036	289.219	289.403	289.586
980	289.769	289.952	290.136	290.319	290.502	290.685	290.868	291.051	291.234	291.417
990	291.600	291.783	291.966	292.148	292.331	292.514	292.697	292.879	293.062	293.245
1000	293.427	293.610	293.792	293.975	294.157	294.339	294.522	294.704	294.886	295.069
1010	295.251	295.433	295.615	295.797	295.979	296.161	296.343	296.525	296.707	296.889
1020	297.071	297.253	297.434	297.616	297.798	297.979	298.161	298.343	298.524	298.706
1030	298.887	299.069	299.250	299.431	299.613	299.794	299.975	300.157	300.338	300.519
1040	300.700	300.881	301.062	301.243	301.424	301.605	301.786	301.967	302.148	302.329
1050	302.509	302.690	302.871	303.052	303.232	303.413	303.593	303.774	303.954	304.135
1060	304.315	304.496	304.676	304.856	305.037	305.217	305.397	305.577	305.757	305.937
1070	306.117	306.297	306.477	306.657	306.837	307.017	307.197	307.377	307.557	307.736
1080	307.916	308.096	308.275	308.455	308.635	308.814	308.994	309.173	309.352	309.532
1090	309.711	309.890	310.070	310.249	310.428	310.607	310.786	310.966	311.145	311.324
1100	311.503	311.682	311.861	312.039	312.218	312.397	312.576	312.755	312.933	313.112
1110	313.291	313.469	313.648	313.826	314.005	314.183	314.362	314.540	314.718	314.897
1120	315.075	315.253	315.431	315.609	315.788	315.966	316.144	316.322	316.500	316.678
1130	316.856	317.034	317.211	317.389	317.567	317.745	317.922	318.100	318.278	318.455
1140	318.633	318.810	318.988	319.165	319.343	319.520	319.697	319.875	320.052	320.229
1150	320.407	320.584	320.761	320.938	321.115	321.292	321.469	321.646	321.823	322.000
1160	322.177	322.353	322.530	322.707	322.884	323.060	323.237	323.413	323.590	323.767
1170	323.943	324.120	324.296	324.472	324.649	324.825	325.001	325.177	325.354	325.530
1180	325.706	325.882	326.058	326.234	326.410	326.586	326.762	326.938	327.114	327.290
1190	327.465	327.641	327.817	327.992	328.168	328.344	328.519	328.695	328.870	329.046
1200	329.221	329.397	329.572	329.747	329.922	330.098	330.273	330.448	330.623	330.798
1210	330.973	331.148	331.323	331.498	331.673	331.848	332.023	332.198	332.373	332.547
1220	332.722	332.897	333.071	333.246	333.420	333.595	333.769	333.944	334.118	334.293
1230	334.467	334.641	334.816	334.990	335.164	335.338	335.512	335.687	335.861	336.035
1240	336.209	336.383	336.556	336.730	336.904	337.078	337.252	337.425	337.599	337.773
1250	337.947	338.120	338.294	338.467	338.641	338.814	338.988	339.161	339.334	339.508
1260	339.681	339.854	340.027	340.200	340.374	340.547	340.720	340.893	341.066	341.239
1270	341.412	341.585	341.757	341.930	342.103	342.276	342.448	342.621	342.794	342.966
1280	343.139	343.311	343.484	343.656	343.829	344.001	344.173	344.346	344.518	344.690
1290	344.863	345.035	345.207	345.379	345.551	345.723	345.895	346.067	346.239	346.411
1300	346.583	346.754	346.926	347.098	347.270	347.441	347.613	347.785	347.956	348.128
1310	348.299	348.471	348.642	348.813	348.985	349.156	349.327	349.498	349.670	349.841
1320	350.012	350.183	350.354	350.525	350.696	350.867	351.038	351.209	351.380	351.551
1330	351.721	351.892	352.063	352.234	352.404	352.575	352.745	352.916	353.086	353.257
1340	353.427	353.598	353.768	353.938	354.109	354.279	354.449	354.619	354.789	354.959
1350	355.129	355.299	355.469	355.639	355.809	355.979	356.149	356.319	356.489	356.658
1360	356.828	356.998	357.167	357.337	357.507	357.676	357.846	358.015	358.184	358.354
1370	358.523	358.692	358.862	359.031	359.200	359.369	359.539	359.708	359.877	360.046
1380	360.215	360.384	360.553	360.721	360.890	361.059	361.228	361.397	361.565	361.734
1390	361.903	362.071	362.240	362.408	362.577	362.745	362.914	363.082	363.250	363.419
1400	363.587	363.755	363.923	364.092	364.260	364.428	364.596	364.764	364.932	365.100
1410	365.268	365.436	365.604	365.771	365.939	366.107	366.275	366.442	366.610	366.778
1420	366.945	367.113	367.280	367.447	367.615	367.782	367.950	368.117	368.284	368.452
1430	368.619	368.786	368.953	369.120	369.287	369.454	369.621	369.788	369.955	370.122
1440	370.289	370.456	370.622	370.789	370.956	371.122	371.289	371.456	371.622	371.789
1450	371.955	372.122	372.288	372.455	372.621	372.787	372.953	373.120	373.286	373.452
1460	373.618	373.784	373.951	374.116	374.282	374.448	374.614	374.780	374.946	375.112
1470	375.278	375.443	375.609	375.775	375.940	376.106	376.272	376.437	376.603	376.768
1480	376.933	377.099	377.264	377.430	377.595	377.760	377.925	378.090	378.256	378.421
1490	378.586	378.751	378.916	379.081	379.246	379.411	379.575	379.740	379.905	380.070
1500	380.234	380.399	380.564	380.728	380.893	381.057	381.222	381.386	381.551	381.715
1510	381.880	382.044	382.208	382.372	382.537	382.701	382.865	383.029	383.193	383.357
1520	383.521	383.685	383.849	384.013	384.177	384.340	384.504	384.668	384.832	384.995
1530	385.159	385.323	385.486	385.650	385.813	385.977	386.140	386.303	386.467	386.630
1540	386.793	386.957	387.120	387.283	387.446	387.609	387.772	387.935	388.098	388.261
1550	388.424	388.587	388.750	388.913	389.076	389.238	389.401	389.564	389.726	389.889
1560	390.051									
°F	0	1	2	3	4	5	6	7	8	9

Curve PR-239, °F vs Absolute Ω

°F	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
-360	11.263									
-350	13.457	13.234	13.011	12.791	12.570	12.350	12.131	11.912	11.695	11.479
-340	15.735	15.513	15.273	15.045	14.816	14.587	14.359	14.133	13.907	13.681
-330	18.062	17.829	17.596	17.362	17.129	16.895	16.662	16.430	16.198	15.966
-320	20.408	20.172	19.936	19.700	19.462	19.229	18.992	18.761	18.527	18.296
-310	22.780	22.543	22.305	22.067	21.830	21.592	21.354	21.119	20.882	20.644
-300	25.153	24.916	24.678	24.439	24.204	23.968	23.729	23.491	23.254	23.017
-290	27.519	27.284	27.049	26.811	26.573	26.338	26.099	25.864	25.627	25.390
-280	29.873	29.638	29.403	29.169	28.932	28.697	28.462	28.227	27.990	27.755
-270	32.214	31.981	31.747	31.512	31.280	31.045	30.811	30.576	30.341	30.107
-260	34.547	34.315	34.082	33.848	33.615	33.383	33.149	32.915	32.682	32.448
-250	36.871	36.639	36.407	36.175	35.942	35.710	35.478	35.246	35.012	34.780
-240	39.188	38.957	38.725	38.493	38.262	38.030	37.798	37.567	37.335	37.103
-230	41.498	41.267	41.036	40.805	40.575	40.343	40.113	39.882	39.651	39.419
-220	43.802	43.571	43.341	43.111	42.881	42.650	42.420	42.189	41.959	41.729
-210	46.098	45.869	45.640	45.410	45.180	44.951	44.721	44.491	44.261	44.031
-200	48.389	48.160	47.932	47.702	47.474	47.245	47.015	46.786	46.557	46.328
-190	50.674	50.445	50.217	49.989	49.761	49.532	49.304	49.075	48.847	48.618
-180	52.952	52.724	52.496	52.269	52.041	51.813	51.585	51.358	51.130	50.902
-170	55.223	54.996	54.769	54.543	54.315	54.088	53.861	53.634	53.406	53.179
-160	57.489	57.263	57.037	56.810	56.584	56.357	56.130	55.904	55.677	55.450
-150	59.749	59.524	59.298	59.072	58.846	58.620	58.394	58.168	57.942	57.716
-140	62.003	61.778	61.553	61.328	61.103	60.877	60.652	60.426	60.201	59.975
-130	64.252	64.027	63.802	63.578	63.353	63.128	62.903	62.679	62.454	62.229
-120	66.493	66.270	66.046	65.822	65.598	65.373	65.149	64.925	64.700	64.476
-110	68.729	68.506	68.282	68.059	67.836	67.612	67.388	67.165	66.941	66.717
-100	70.958	70.735	70.512	70.290	70.067	69.844	69.621	69.398	69.175	68.952
-90	73.179	72.958	72.736	72.514	72.291	72.069	71.847	71.625	71.402	71.180
-80	75.395	75.174	74.952	74.731	74.509	74.288	74.066	73.845	73.623	73.401
-70	77.605	77.384	77.163	76.942	76.721	76.500	76.279	76.058	75.837	75.616
-60	79.810	79.589	79.369	79.149	78.928	78.708	78.487	78.267	78.046	77.825
-50	82.012	81.792	81.572	81.351	81.131	80.911	80.691	80.471	80.250	80.030
-40	84.212	83.992	83.772	83.552	83.332	83.112	82.892	82.672	82.452	82.232
-30	86.411	86.191	85.971	85.751	85.531	85.311	85.091	84.871	84.651	84.432
-20	88.610	88.390	88.170	87.950	87.730	87.510	87.290	87.071	86.851	86.631
-10	90.808	90.588	90.369	90.149	89.929	89.709	89.489	89.269	89.050	88.830
0	93.005	92.785	92.566	92.346	92.127	91.907	91.687	91.467	91.248	91.028
0	93.005	93.224	93.444	93.663	93.882	94.102	94.321	94.540	94.759	94.978
10	95.197	95.416	95.635	95.854	96.072	96.291	96.510	96.728	96.947	97.165
20	97.383	97.602	97.820	98.038	98.256	98.474	98.692	98.910	99.128	99.346
30	99.564	99.782	100.000	100.217	100.434	100.651	100.868	101.085	101.302	101.519
40	101.736	101.952	102.169	102.386	102.603	102.819	103.036	103.253	103.469	103.686
50	103.902	104.118	104.335	104.551	104.768	104.984	105.200	105.416	105.633	105.849
60	106.065	106.281	106.497	106.713	106.929	107.145	107.361	107.577	107.793	108.008
70	108.224	108.440	108.656	108.871	109.087	109.302	109.518	109.733	109.949	110.164
80	110.380	110.595	110.810	111.026	111.241	111.456	111.671	111.887	112.102	112.317
90	112.532	112.747	112.962	113.177	113.392	113.607	113.821	114.036	114.251	114.466
100	114.680	114.895	115.110	115.324	115.539	115.753	115.968	116.182	116.397	116.611
110	116.825	117.040	117.254	117.468	117.682	117.896	118.111	118.325	118.539	118.753
120	118.967	119.181	119.395	119.608	119.822	120.036	120.250	120.464	120.677	120.891
130	121.105	121.318	121.532	121.745	121.959	122.172	122.386	122.599	122.812	123.026
140	123.239	123.452	123.665	123.878	124.091	124.305	124.518	124.731	124.944	125.157
150	125.369	125.582	125.795	126.008	126.221	126.433	126.646	126.859	127.071	127.284
160	127.497	127.709	127.922	128.134	128.346	128.559	128.771	128.983	129.196	129.408
170	129.620	129.832	130.044	130.256	130.469	130.681	130.893	131.104	131.316	131.528
180	131.740	131.952	132.164	132.375	132.587	132.799	133.010	133.222	133.433	133.645
190	133.856	134.068	134.279	134.491	134.702	134.913	135.125	135.336	135.547	135.758
200	135.969	136.180	136.391	136.602	136.813	137.024	137.235	137.446	137.657	137.868
210	138.079	138.289	138.500	138.711	138.921	139.132	139.342	139.553	139.763	139.974
220	140.184	140.395	140.605	140.815	141.026	141.236	141.446	141.656	141.866	142.076
230	142.286	142.496	142.706	142.916	143.126	143.336	143.546	143.756	143.965	144.175
240	144.385	144.595	144.804	145.014	145.223	145.433	145.642	145.852	146.061	146.271
°F	0	1	2	3	4	5	6	7	8	9

Curve PR-239, °F vs Absolute Ω (Cont.)

°F	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
250	146.480	146.689	146.898	147.108	147.317	147.526	147.735	147.944	148.153	148.362
260	148.571	148.780	148.989	149.198	149.407	149.616	149.824	150.033	150.242	150.450
270	150.659	150.868	151.076	151.285	151.493	151.702	151.910	152.118	152.327	152.535
280	152.743	152.952	153.160	153.368	153.576	153.784	153.992	154.200	154.408	154.616
290	154.824	155.032	155.240	155.448	155.655	155.863	156.071	156.278	156.486	156.694
300	156.901	157.109	157.316	157.524	157.731	157.938	158.146	158.353	158.560	158.768
310	158.975	159.182	159.389	159.596	159.803	160.010	160.217	160.424	160.631	160.838
320	161.045	161.251	161.458	161.665	161.872	162.078	162.285	162.492	162.698	162.905
330	163.111	163.318	163.524	163.730	163.937	164.143	164.349	164.555	164.762	164.968
340	165.174	165.380	165.586	165.792	165.998	166.204	166.410	166.616	166.822	167.027
350	167.233	167.439	167.645	167.850	168.056	168.262	168.467	168.673	168.878	169.083
360	169.289	169.494	169.700	169.905	170.110	170.315	170.521	170.726	170.931	171.136
370	171.341	171.546	171.751	171.956	172.161	172.366	172.571	172.775	172.980	173.185
380	173.390	173.594	173.799	174.003	174.208	174.413	174.617	174.821	175.026	175.230
390	175.435	175.639	175.843	176.047	176.252	176.456	176.660	176.864	177.068	177.272
400	177.476	177.680	177.884	178.088	178.292	178.495	178.699	178.903	179.107	179.310
410	179.514	179.717	179.921	180.124	180.328	180.531	180.735	180.938	181.142	181.345
420	181.548	181.751	181.955	182.158	182.361	182.564	182.767	182.970	183.173	183.376
430	183.579	183.782	183.985	184.187	184.390	184.593	184.796	184.998	185.201	185.403
440	185.606	185.808	186.011	186.213	186.416	186.618	186.821	187.023	187.225	187.427
450	187.630	187.832	188.034	188.236	188.438	188.640	188.842	189.044	189.246	189.448
460	189.650	189.851	190.053	190.255	190.457	190.658	190.860	191.061	191.263	191.464
470	191.666	191.867	192.069	192.270	192.471	192.673	192.874	193.075	193.276	193.478
480	193.679	193.880	194.081	194.282	194.483	194.684	194.885	195.086	195.286	195.487
490	195.688	195.889	196.089	196.290	196.491	196.691	196.892	197.092	197.293	197.493
500	197.694	197.894	198.094	198.295	198.495	198.695	198.895	199.096	199.296	199.496
510	199.696	199.896	200.096	200.296	200.496	200.696	200.895	201.095	201.295	201.495
520	201.694	201.894	202.094	202.293	202.493	202.692	202.892	203.091	203.291	203.490
530	203.689	203.889	204.088	204.287	204.486	204.686	204.885	205.084	205.283	205.482
540	205.681	205.880	206.079	206.278	206.477	206.675	206.874	207.073	207.271	207.470
550	207.669	207.867	208.066	208.264	208.463	208.661	208.860	209.058	209.257	209.455
560	209.653	209.851	210.049	210.248	210.446	210.644	210.842	211.040	211.238	211.436
570	211.634	211.832	212.030	212.227	212.425	212.623	212.821	213.018	213.216	213.413
580	213.611	213.808	214.006	214.203	214.401	214.598	214.796	214.993	215.190	215.387
590	215.585	215.782	215.979	216.176	216.373	216.570	216.767	216.964	217.161	217.358
600	217.555	217.751	217.948	218.145	218.342	218.538	218.735	218.931	219.128	219.324
610	219.521	219.717	219.914	220.110	220.307	220.503	220.699	220.895	221.092	221.288
620	221.484	221.680	221.876	222.072	222.268	222.464	222.660	222.856	223.052	223.247
630	223.443	223.639	223.835	224.030	224.226	224.421	224.617	224.813	225.008	225.203
640	225.399	225.594	225.790	225.985	226.180	226.375	226.571	226.766	226.961	227.156
650	227.351	227.546	227.741	227.936	228.131	228.326	228.521	228.715	228.910	229.105
660	229.300	229.494	229.689	229.883	230.078	230.273	230.467	230.661	230.856	231.050
670	231.245	231.439	231.633	231.827	232.022	232.216	232.410	232.604	232.798	232.992
680	233.186	233.380	233.574	233.768	233.962	234.155	234.349	234.543	234.737	234.930
690	235.124	235.318	235.511	235.705	235.898	236.092	236.285	236.478	236.672	236.865
700	237.058	237.251	237.445	237.638	237.831	238.024	238.217	238.410	238.603	238.796
710	238.989	239.182	239.375	239.567	239.760	239.953	240.146	240.338	240.531	240.724
720	240.916	241.109	241.301	241.494	241.686	241.878	242.071	242.263	242.455	242.647
730	242.840	243.032	243.224	243.416	243.608	243.800	243.992	244.184	244.376	244.568
740	244.760	244.952	245.143	245.335	245.527	245.718	245.910	246.102	246.293	246.485
750	246.676	246.868	247.059	247.250	247.442	247.633	247.824	248.016	248.207	248.398
760	248.589	248.780	248.971	249.162	249.353	249.544	249.735	249.926	250.117	250.308
770	250.498	250.689	250.880	251.070	251.261	251.452	251.642	251.833	252.023	252.214
780	252.404	252.595	252.785	252.975	253.165	253.356	253.546	253.736	253.926	254.116
790	254.306	254.496	254.686	254.876	255.066	255.256	255.446	255.636	255.825	256.015
800	256.205	256.395	256.584	256.774	256.963	257.153	257.342	257.532	257.721	257.911
810	258.100	258.289	258.479	258.668	258.857	259.046	259.235	259.424	259.613	259.802
820	259.991	260.180	260.369	260.558	260.747	260.936	261.125	261.313	261.502	261.691
830	261.879	262.068	262.256	262.445	262.633	262.822	263.010	263.199	263.387	263.575
840	263.764	263.952	264.140	264.328	264.516	264.704	264.892	265.080	265.268	265.456
850	265.644	265.832	266.020	266.208	266.396	266.583	266.771	266.959	267.146	267.334
860	267.521	267.709	267.897	268.084	268.271	268.459	268.646	268.833	269.021	269.208
870	269.395	269.582	269.769	269.956	270.144	270.331	270.518	270.705	270.891	271.078
880	271.265	271.452	271.639	271.826	272.012	272.199	272.385	272.572	272.759	272.945
890	273.132	273.318	273.504	273.691	273.877	274.064	274.250	274.436	274.622	274.808
°F	0	1	2	3	4	5	6	7	8	9

SAMA 100 OHM (NOMINAL) PLATINUM RTD TEMPERATURE-RESISTANCE TABLES
Curve PR-279 (°C vs Absolute Ω) and Curve PR-278 (°F vs Absolute Ω)

The values listed in these tables were calculated using the equations found in Foxboro Drawing 10104MU, Temperature Calibration Sources.

Curve PR-279, °C vs Absolute Ω

°C	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
-250	16.665									
-190	20.972	20.543	20.113	19.684	19.254	18.823	18.392	17.961	17.530	17.098
-180	25.244	24.818	24.392	23.966	23.539	23.112	22.685	22.257	21.829	21.401
-170	29.483	29.060	28.637	28.214	27.791	27.367	26.943	26.519	26.094	25.669
-160	33.691	33.271	32.852	32.432	32.011	31.591	31.170	30.748	30.327	29.905
-150	37.871	37.454	37.037	36.620	36.202	35.784	35.366	34.948	34.529	34.110
-140	42.023	41.609	41.195	40.780	40.365	39.950	39.535	39.119	38.703	38.287
-130	46.151	45.739	45.327	44.915	44.503	44.090	43.677	43.264	42.851	42.437
-120	50.255	49.846	49.436	49.026	48.616	48.206	47.795	47.385	46.974	46.562
-110	54.337	53.930	53.522	53.115	52.707	52.299	51.890	51.482	51.073	50.664
-100	58.399	57.994	57.588	57.182	56.777	56.370	55.964	55.558	55.151	54.744
-90	62.441	62.038	61.634	61.230	60.826	60.422	60.018	59.613	59.209	58.804
-80	66.466	66.064	65.662	65.260	64.858	64.456	64.053	63.650	63.248	62.844
-70	70.473	70.073	69.673	69.273	68.872	68.472	68.071	67.670	67.269	66.867
-60	74.465	74.067	73.668	73.269	72.870	72.471	72.072	71.673	71.273	70.873
-50	78.442	78.045	77.648	77.251	76.853	76.456	76.058	75.660	75.262	74.864
-40	82.405	82.009	81.614	81.218	80.822	80.425	80.029	79.633	79.236	78.839
-30	86.355	85.960	85.566	85.171	84.776	84.382	83.986	83.591	83.196	82.801
-20	90.292	89.898	89.505	89.112	88.718	88.325	87.931	87.537	87.143	86.749
-10	94.216	93.824	93.432	93.040	92.648	92.255	91.863	91.470	91.077	90.685
0	98.129	97.738	97.347	96.956	96.565	96.174	95.783	95.391	95.000	94.608
0	98.129	98.520	98.910	99.301	99.691	100.081	100.471	100.861	101.251	101.641
10	102.030	102.420	102.809	103.198	103.588	103.977	104.366	104.754	105.143	105.532
20	105.920	106.308	106.697	107.085	107.473	107.861	108.248	108.636	109.024	109.411
30	109.798	110.186	110.573	110.960	111.347	111.733	112.120	112.506	112.893	113.279
40	113.665	114.051	114.437	114.823	115.209	115.594	115.980	116.365	116.750	117.136
50	117.521	117.905	118.290	118.675	119.059	119.444	119.828	120.212	120.597	120.981
60	121.364	121.748	122.132	122.515	122.899	123.282	123.665	124.048	124.431	124.814
70	125.197	125.579	125.962	126.344	126.727	127.109	127.491	127.873	128.254	128.636
80	129.018	129.399	129.780	130.162	130.543	130.924	131.305	131.685	132.066	132.447
90	132.827	133.207	133.588	133.968	134.348	134.727	135.107	135.487	135.866	136.246
100	136.625	137.004	137.383	137.762	138.141	138.520	138.898	139.277	139.655	140.033
110	140.411	140.789	141.167	141.545	141.923	142.300	142.678	143.055	143.432	143.809
120	144.186	144.563	144.940	145.317	145.693	146.069	146.446	146.822	147.198	147.574
130	147.950	148.325	148.701	149.077	149.452	149.827	150.202	150.577	150.952	151.327
140	151.702	152.076	152.451	152.825	153.199	153.573	153.947	154.321	154.695	155.069
150	155.442	155.816	156.189	156.562	156.935	157.308	157.681	158.054	158.426	158.799
160	159.171	159.543	159.916	160.288	160.660	161.031	161.403	161.775	162.146	162.517
170	162.889	163.260	163.631	164.002	164.372	164.743	165.114	165.484	165.854	166.225
180	166.595	166.965	167.335	167.704	168.074	168.443	168.813	169.182	169.551	169.920
190	170.289	170.658	171.027	171.395	171.764	172.132	172.500	172.869	173.237	173.604
200	173.972	174.340	174.707	175.075	175.442	175.809	176.177	176.544	176.910	177.277
210	177.644	178.010	178.377	178.743	179.109	179.475	179.841	180.207	180.573	180.938
220	181.304	181.669	182.034	182.400	182.765	183.130	183.494	183.859	184.224	184.588
230	184.952	185.317	185.681	186.045	186.409	186.772	187.136	187.500	187.863	188.226
240	188.589	188.953	189.316	189.678	190.041	190.404	190.766	191.129	191.491	191.853
250	192.215	192.577	192.939	193.301	193.662	194.024	194.385	194.746	195.107	195.468
260	195.829	196.190	196.551	196.911	197.272	197.632	197.992	198.352	198.712	199.072
270	199.432	199.791	200.151	200.510	200.870	201.229	201.588	201.947	202.306	202.664
280	203.023	203.381	203.740	204.098	204.456	204.814	205.172	205.530	205.888	206.245
290	206.603	206.960	207.317	207.674	208.031	208.388	208.745	209.102	209.458	209.814
°C	0	1	2	3	4	5	6	7	8	9

FOXBORO®

Curve PR-279, °C vs Absolute Ω (Cont.)

°C	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
300	210.171	210.527	210.883	211.239	211.595	211.951	212.306	212.662	213.017	213.372
310	213.727	214.083	214.437	214.792	215.147	215.501	215.856	216.210	216.565	216.919
320	217.273	217.627	217.980	218.334	218.688	219.041	219.394	219.747	220.101	220.453
330	220.806	221.159	221.512	221.864	222.217	222.569	222.921	223.273	223.625	223.977
340	224.329	224.680	225.032	225.383	225.734	226.085	226.436	226.787	227.138	227.489
350	227.839	228.190	228.540	228.890	229.240	229.590	229.940	230.290	230.640	230.989
360	231.339	231.688	232.037	232.386	232.735	233.084	233.433	233.781	234.130	234.478
370	234.826	235.174	235.522	235.870	236.218	236.566	236.913	237.261	237.608	237.955
380	238.303	238.650	238.996	239.343	239.690	240.036	240.383	240.729	241.075	241.421
390	241.767	242.113	242.459	242.805	243.150	243.495	243.841	244.186	244.531	244.876
400	245.221	245.565	245.910	246.254	246.599	246.943	247.287	247.631	247.975	248.319
410	248.662	249.006	249.349	249.693	250.036	250.379	250.722	251.065	251.408	251.750
420	252.093	252.435	252.777	253.120	253.462	253.804	254.145	254.487	254.829	255.170
430	255.512	255.853	256.194	256.535	256.876	257.217	257.557	257.898	258.238	258.579
440	258.919	259.259	259.599	259.939	260.279	260.618	260.958	261.297	261.636	261.976
450	262.315	262.654	262.993	263.331	263.670	264.008	264.347	264.685	265.023	265.361
460	265.699	266.037	266.375	266.712	267.050	267.387	267.724	268.061	268.398	268.735
470	269.072	269.409	269.745	270.082	270.418	270.754	271.090	271.426	271.762	272.098
480	272.433	272.769	273.104	273.440	273.775	274.110	274.445	274.780	275.114	275.449
490	275.783	276.118	276.452	276.786	277.120	277.454	277.788	278.121	278.455	278.788
500	279.122	279.455	279.788	280.121	280.454	280.787	281.119	281.452	281.784	282.117
510	282.449	282.781	283.113	283.444	283.776	284.108	284.439	284.771	285.102	285.433
520	285.764	286.095	286.426	286.756	287.087	287.417	287.748	288.078	288.408	288.738
530	289.368	289.398	289.727	290.057	290.386	290.716	291.045	291.374	291.703	292.032
540	292.360	292.689	293.018	293.346	293.674	294.002	294.331	294.658	294.986	295.314
550	295.641	295.969	296.296	296.624	296.951	297.278	297.605	297.931	298.258	298.585
560	298.911	299.237	299.563	299.890	300.216	300.541	300.867	301.193	301.518	301.844
570	302.169	302.494	302.819	303.144	303.469	303.794	304.118	304.443	304.767	305.091
580	305.415	305.740	306.063	306.387	306.711	307.034	307.358	307.681	308.004	308.328
590	308.651	308.973	309.296	309.619	309.941	310.264	310.586	310.908	311.230	311.552
600	311.874	312.196	312.517	312.839	313.160	313.482	313.803	314.124	314.445	314.766
610	315.086	315.407	315.727	316.048	316.368	316.688	317.008	317.328	317.648	317.967
620	318.287	318.606	318.925	319.245	319.564	319.883	320.202	320.520	320.839	321.157
630	321.476	321.794	322.112	322.430	322.748	323.066	323.384	323.701	324.019	324.336
640	324.653	324.971	325.288	325.604	325.921	326.238	326.555	326.871	327.187	327.503
650	327.820									
°C	0	1	2	3	4	5	6	7	8	9

Curve PR-278, °F vs Absolute Ω

°F	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
-320	18.584									
-310	20.972	20.734	20.495	20.257	20.018	19.779	19.540	19.301	19.062	18.823
-300	23.349	23.112	22.875	22.637	22.400	22.162	21.924	21.686	21.448	21.210
-290	25.716	25.480	25.244	25.007	24.771	24.534	24.297	24.060	23.823	23.586
-280	28.073	27.838	27.603	27.367	27.132	26.896	26.663	26.424	26.188	25.952
-270	30.420	30.186	29.952	29.717	29.483	29.248	29.013	28.778	28.543	28.308
-260	32.758	32.525	32.291	32.058	31.824	31.591	31.357	31.123	30.889	30.655
-250	35.087	34.855	34.622	34.390	34.157	33.924	33.691	33.458	33.225	32.992
-240	37.408	37.176	36.944	36.712	36.480	36.248	36.016	35.784	35.552	35.320
-230	39.719	39.489	39.258	39.027	38.796	38.565	38.333	38.102	37.871	37.639
-220	42.023	41.793	41.563	41.333	41.103	40.872	40.642	40.411	40.181	39.950
-210	44.319	44.090	43.861	43.631	43.402	43.172	42.943	42.713	42.483	42.253
-200	46.608	46.380	46.151	45.922	45.693	45.465	45.236	45.007	44.778	44.549
°F	0	1	2	3	4	5	6	7	8	9

Curve PR-278, °F vs Absolute Ω (Cont.)

°F	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
1000	291.639	291.817	291.995	292.178	292.360	292.543	292.726	292.908	293.091	293.273
1010	293.455	293.638	293.820	294.002	294.185	294.367	294.549	294.731	294.913	295.095
1020	295.278	295.460	295.641	295.823	296.005	296.187	296.369	296.551	296.733	296.914
1030	297.096	297.278	297.459	297.641	297.822	298.004	298.185	298.367	298.548	298.730
1040	298.911	299.092	299.273	299.455	299.636	299.817	299.998	300.179	300.360	300.541
1050	300.722	300.903	301.084	301.265	301.446	301.627	301.807	301.988	302.169	302.350
1060	302.530	302.711	302.891	303.072	303.252	303.433	303.613	303.794	303.974	304.154
1070	304.335	304.515	304.695	304.875	305.055	305.235	305.415	305.595	305.775	305.955
1080	306.135	306.315	306.495	306.675	306.855	307.034	307.214	307.394	307.573	307.753
1090	307.933	308.112	308.292	308.471	308.650	308.830	309.009	309.189	309.368	309.547
1100	309.726	309.905	310.085	310.264	310.443	310.622	310.801	310.980	311.159	311.338
1110	311.516	311.695	311.874	312.053	312.232	312.410	312.589	312.767	312.946	313.125
1120	313.303	313.482	313.660	313.838	314.017	314.195	314.373	314.552	314.730	314.908
1130	315.086	315.264	315.442	315.620	315.798	315.976	316.154	316.332	316.510	316.688
1140	316.866	317.043	317.221	317.399	317.576	317.754	317.932	318.109	318.287	318.464
1150	318.642	318.819	318.996	319.174	319.351	319.528	319.706	319.883	320.060	320.237
1160	320.414	320.591	320.768	320.945	321.122	321.299	321.476	321.653	321.829	322.006
1170	322.183	322.360	322.536	322.713	322.889	323.066	323.243	323.419	323.595	323.772
1180	323.948	324.125	324.301	324.477	324.653	324.830	325.006	325.182	325.358	325.534
1190	325.710	325.886	326.062	326.238	326.414	326.590	326.765	326.941	327.117	327.293
1200	327.468									
°F	0	1	2	3	4	5	6	7	8	9

Curve PR-278, °F vs Absolute Ω (Cont.)

°F	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
-190	48.890	48.662	48.434	48.206	47.978	47.750	47.521	47.293	47.065	46.837
-180	51.164	50.937	50.710	50.482	50.255	50.028	49.800	49.573	49.345	49.117
-170	53.432	53.205	52.979	52.752	52.526	52.299	52.072	51.845	51.618	51.391
-160	55.693	55.467	55.241	55.015	54.789	54.563	54.337	54.111	53.885	53.658
-150	57.948	57.723	57.498	57.273	57.047	56.822	56.596	56.370	56.145	55.919
-140	60.198	59.973	59.748	59.524	59.299	59.074	58.849	58.624	58.399	58.174
-130	62.441	62.217	61.993	61.769	61.545	61.320	61.096	60.871	60.647	60.422
-120	64.679	64.456	64.232	64.008	63.785	63.561	63.337	63.113	62.889	62.665
-110	66.912	66.689	66.466	66.243	66.019	65.796	65.573	65.350	65.126	64.903
-100	69.139	68.917	68.694	68.472	68.249	68.026	67.803	67.581	67.358	67.135
-90	71.362	71.140	70.918	70.696	70.473	70.251	70.029	69.807	69.584	69.362
-80	73.579	73.358	73.136	72.915	72.693	72.471	72.249	72.028	71.806	71.584
-70	75.792	75.571	75.350	75.129	74.908	74.687	74.465	74.244	74.022	73.801
-60	78.001	77.780	77.560	77.339	77.118	76.897	76.676	76.456	76.235	76.014
-50	80.205	79.985	79.765	79.544	79.324	79.104	78.883	78.663	78.442	78.222
-40	82.405	82.185	81.965	81.746	81.526	81.306	81.086	80.866	80.645	80.425
-30	84.601	84.382	84.162	83.943	83.723	83.504	83.284	83.064	82.845	82.625
-20	86.793	86.574	86.355	86.136	85.916	85.697	85.478	85.259	85.040	84.820
-10	88.981	88.762	88.543	88.325	88.106	87.887	87.668	87.449	87.231	87.012
0	91.165	90.946	90.728	90.510	90.292	90.073	89.855	89.636	89.418	89.199
0	91.165	91.383	91.601	91.819	92.037	92.255	92.473	92.691	92.909	93.127
10	93.345	93.563	93.781	93.998	94.216	94.434	94.651	94.869	95.087	95.304
20	95.522	95.739	95.957	96.174	96.391	96.609	96.826	97.043	97.260	97.478
30	97.695	97.912	98.129	98.346	98.563	98.780	98.997	99.214	99.431	99.648
40	99.864	100.081	100.298	100.514	100.731	100.948	101.164	101.381	101.597	101.814
50	102.030	102.247	102.463	102.679	102.896	103.112	103.328	103.544	103.760	103.977
60	104.193	104.409	104.625	104.841	105.057	105.273	105.488	105.704	105.920	106.136
70	106.352	106.567	106.783	106.999	107.214	107.430	107.645	107.861	108.076	108.292
80	108.507	108.722	108.938	109.153	109.368	109.583	109.798	110.014	110.229	110.444
90	110.659	110.874	111.089	111.304	111.518	111.733	111.948	112.163	112.378	112.592
100	112.807	113.022	113.236	113.451	113.665	113.880	114.094	114.309	114.523	114.737
110	114.952	115.166	115.380	115.594	115.808	116.023	116.237	116.451	116.665	116.879
120	117.093	117.307	117.521	117.734	117.948	118.162	118.376	118.589	118.803	119.017
130	119.230	119.444	119.657	119.871	120.084	120.298	120.511	120.725	120.938	121.151
140	121.364	121.578	121.791	122.004	122.217	122.430	122.643	122.856	123.069	123.282
150	123.495	123.708	123.921	124.133	124.346	124.559	124.771	124.984	125.197	125.409
160	125.622	125.834	126.047	126.259	126.472	126.684	126.896	127.109	127.321	127.533
170	127.745	127.957	128.170	128.382	128.594	128.806	129.018	129.230	129.441	129.653
180	129.865	130.077	130.289	130.500	130.712	130.924	131.135	131.347	131.559	131.770
190	131.982	132.193	132.404	132.616	132.827	133.038	133.250	133.461	133.672	133.883
200	134.094	134.305	134.516	134.727	134.938	135.149	135.360	135.571	135.782	135.993
210	136.204	136.414	136.625	136.836	137.046	137.257	137.467	137.678	137.888	138.099
220	138.309	138.520	138.730	138.940	139.150	139.361	139.571	139.781	139.991	140.201
230	140.411	140.621	140.831	141.041	141.251	141.461	141.671	141.881	142.091	142.300
240	142.510	142.720	142.929	143.139	143.348	143.558	143.767	143.977	144.186	144.396
250	144.605	144.814	145.024	145.233	145.442	145.651	145.860	146.069	146.279	146.488
260	146.697	146.905	147.114	147.323	147.532	147.741	147.950	148.158	148.367	148.576
270	148.785	148.993	149.202	149.410	149.619	149.827	150.036	150.244	150.452	150.661
280	150.869	151.077	151.285	151.494	151.702	151.910	152.118	152.326	152.534	152.742
290	152.950	153.158	153.366	153.573	153.781	153.989	154.197	154.404	154.612	154.820
300	155.027	155.235	155.442	155.650	155.857	156.064	156.272	156.479	156.686	156.894
310	157.101	157.308	157.515	157.722	157.929	158.136	158.343	158.550	158.757	158.964
320	159.171	159.378	159.585	159.792	159.998	160.205	160.412	160.618	160.825	161.031
330	161.238	161.444	161.651	161.857	162.064	162.270	162.476	162.682	162.889	163.095
340	163.301	163.507	163.713	163.919	164.125	164.331	164.537	164.743	164.949	165.155
350	165.361	165.566	165.772	165.978	166.183	166.389	166.595	166.800	167.006	167.211
360	167.417	167.622	167.827	168.033	168.238	168.443	168.649	168.854	169.059	169.264
370	169.469	169.674	169.879	170.084	170.289	170.494	170.699	170.904	171.109	171.313
380	171.518	171.723	171.927	172.132	172.337	172.541	172.746	172.950	173.155	173.359
390	173.564	173.768	173.972	174.176	174.381	174.585	174.789	174.993	175.197	175.401
°F	0	1	2	3	4	5	6	7	8	9

Curve PR-278, °F vs Absolute Ω (Cont.)

°F	0	1	2	3	4	5	6	7	8	9
	RESISTANCE IN ABSOLUTE OHMS									
400	175.605	175.809	176.013	176.217	176.421	176.625	176.829	177.033	177.236	177.440
410	177.644	177.847	178.051	178.255	178.458	178.662	178.865	179.068	179.272	179.475
420	179.679	179.882	180.085	180.288	180.491	180.695	180.898	181.101	181.304	181.507
430	181.710	181.913	182.116	182.318	182.521	182.724	182.927	183.130	183.332	183.535
440	183.737	183.940	184.143	184.345	184.548	184.750	184.952	185.155	185.357	185.559
450	185.762	185.964	186.166	186.368	186.570	186.772	186.974	187.176	187.378	187.580
460	187.782	187.984	188.186	188.388	188.589	188.791	188.993	189.195	189.396	189.598
470	189.799	190.001	190.202	190.404	190.605	190.806	191.008	191.209	191.410	191.612
480	191.813	192.014	192.215	192.416	192.617	192.818	193.019	193.220	193.421	193.622
490	193.823	194.024	194.224	194.425	194.626	194.826	195.027	195.228	195.428	195.629
500	195.829	196.030	196.230	196.430	196.631	196.831	197.031	197.232	197.432	197.632
510	197.832	198.032	198.232	198.432	198.632	198.832	199.032	199.232	199.432	199.632
520	199.831	200.031	200.231	200.430	200.630	200.830	201.029	201.229	201.428	201.628
530	201.827	202.027	202.226	202.425	202.624	202.824	203.023	203.222	203.421	203.620
540	203.819	204.018	204.217	204.416	204.615	204.814	205.013	205.212	205.411	205.609
550	205.808	206.007	206.205	206.404	206.603	206.801	207.000	207.198	207.397	207.595
560	207.793	207.992	208.190	208.388	208.586	208.784	208.983	209.181	209.379	209.577
570	209.775	209.973	210.171	210.369	210.566	210.764	210.962	211.160	211.358	211.555
580	211.753	211.951	212.148	212.346	212.543	212.741	212.938	213.135	213.333	213.530
590	213.727	213.925	214.122	214.319	214.516	214.713	214.910	215.107	215.304	215.501
600	215.698	215.895	216.092	216.289	216.486	216.683	216.879	217.076	217.273	217.469
610	217.666	217.862	218.059	218.255	218.452	218.648	218.845	219.041	219.237	219.433
620	219.630	219.826	220.022	220.218	220.414	220.610	220.806	221.002	221.198	221.394
630	221.590	221.786	221.982	222.177	222.373	222.569	222.765	222.960	223.156	223.351
640	223.547	223.742	223.938	224.133	224.329	224.524	224.719	224.914	225.110	225.305
650	225.500	225.695	225.890	226.085	226.280	226.475	226.670	226.865	227.060	227.255
660	227.450	227.645	227.839	228.034	228.229	228.423	228.618	228.812	229.007	229.201
670	229.396	229.590	229.785	229.979	230.173	230.368	230.562	230.756	230.950	231.144
680	231.339	231.533	231.727	231.921	232.115	232.308	232.502	232.696	232.890	233.084
690	233.278	233.471	233.665	233.859	234.052	234.246	234.439	234.633	234.826	235.020
700	235.213	235.406	235.600	235.793	235.986	236.180	236.373	236.566	236.759	236.952
710	237.145	237.338	237.531	237.724	237.917	238.110	238.303	238.495	238.688	238.881
720	239.073	239.266	239.459	239.651	239.844	240.036	240.229	240.421	240.614	240.806
730	240.998	241.191	241.383	241.575	241.767	241.959	242.152	242.344	242.536	242.728
740	242.920	243.112	243.303	243.495	243.687	243.879	244.071	244.262	244.454	244.646
750	244.837	245.029	245.221	245.412	245.604	245.795	245.986	246.178	246.369	246.560
760	246.752	246.943	247.134	247.325	247.516	247.707	247.898	248.090	248.281	248.471
770	248.662	248.853	249.044	249.235	249.426	249.616	249.807	249.998	250.188	250.379
780	250.570	250.760	250.951	251.141	251.331	251.522	251.712	251.902	252.093	252.283
790	252.473	252.663	252.853	253.043	253.234	253.424	253.614	253.804	253.993	254.183
800	254.373	254.563	254.753	254.943	255.132	255.322	255.511	255.701	255.891	256.080
810	256.270	256.459	256.649	256.838	257.027	257.217	257.406	257.595	257.784	257.974
820	258.163	258.352	258.541	258.730	258.919	259.108	259.297	259.486	259.674	259.863
830	260.052	260.241	260.430	260.618	260.807	260.995	261.184	261.373	261.561	261.750
840	261.938	262.126	262.315	262.503	262.691	262.880	263.068	263.256	263.444	263.632
850	263.820	264.008	264.196	264.384	264.572	264.760	264.948	265.136	265.324	265.511
860	265.699	265.887	266.074	266.262	266.450	266.637	266.825	267.012	267.200	267.387
870	267.574	267.762	267.949	268.136	268.323	268.511	268.698	268.885	269.072	269.259
880	269.446	269.633	269.820	270.007	270.194	270.381	270.567	270.754	270.941	271.128
890	271.314	271.501	271.687	271.874	272.060	272.247	272.433	272.620	272.806	272.992
900	273.179	273.365	273.551	273.737	273.924	274.110	274.296	274.482	274.668	274.854
910	275.040	275.226	275.412	275.597	275.783	275.969	276.155	276.341	276.526	276.712
920	276.897	277.083	277.268	277.454	277.639	277.825	278.010	278.195	278.381	278.566
930	278.751	278.936	279.122	279.307	279.492	279.677	279.862	280.047	280.232	280.417
940	280.602	280.787	280.971	281.156	281.341	281.526	281.710	281.895	282.080	282.264
950	282.449	282.633	282.818	283.002	283.186	283.371	283.555	283.739	283.924	284.108
960	284.292	284.476	284.660	284.844	285.028	285.212	285.396	285.580	285.764	285.948
970	286.132	286.315	286.499	286.683	286.867	287.050	287.234	287.417	287.601	287.784
980	287.968	288.151	288.335	288.518	288.701	288.885	289.068	289.251	289.434	289.618
990	289.801	289.984	290.167	290.350	290.533	290.716	290.899	291.081	291.264	291.447
°F	0	1	2	3	4	5	6	7	8	9

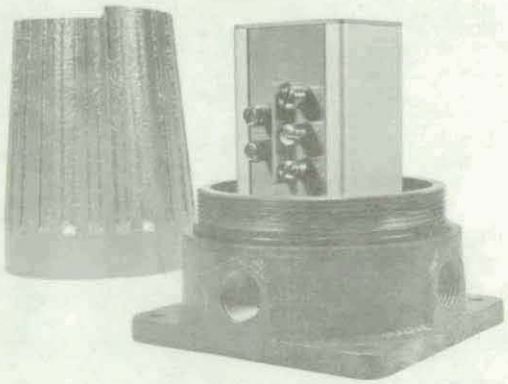
Technical Information

39-94a
August 1973

E94 SERIES TEMPERATURE TRANSMITTER

(a) Basic Transmitter Package.

(b) Surface Mounted Housing.



(c) Element Mounted Housing, with Optional Platinum RTD.

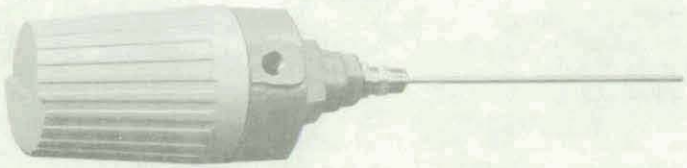


Figure 1. E94 Series Temperature Transmitter.

Printed in England

GENERAL

The E94 Series Temperature Transmitter receives an input signal from RTD (Resistance Temperature Detector or Bulb) temperature sensors and transmits a 4-20 mA dc signal proportional to the measured temperature. Illustrated in Figure 1, it is a field mounted, two wire instrument.

Two wire, field mounted transmitters can lower installation costs by virtually eliminating the need for special element extension cables. They transmit a high level, 4-20 mA dc signal over conventional, unshielded copper wires. Also, to further minimize the cost of installation, several loops can frequently be powered from a single power supply with multiconductor cable. The transmitter is designed to be intrinsically safe when used in specified SPEC 200 measurement and control loops.

Interchangeable range units can be selected from a wide variety of standard ranges. Both nickel and platinum RTD range units are available for either temperature or temperature difference measurements.

PRINCIPLE OF OPERATION

The E94 Series Transmitter provides a two wire output similar to the field proven concept used in other Foxboro transmitters. As shown in Figure 2, the same wiring is used for power and output. The load resistance is connected in series with a dc power supply, and the current drawn from the supply is the 4-20 mA output signal.

Field mounting the transmitter at or near the actual measurement point eliminates the installation of special resistance bulb extension wires to the receiver. In some applications there are long distances between the point of measurement and the ultimate receiver instrument. Here, loop performance is often improved because there is virtually no lead wire error.

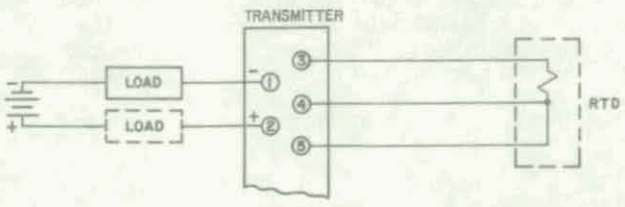


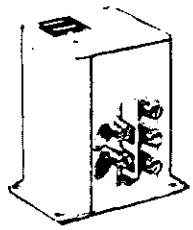
Figure 2. Connection of the E94 Series Transmitter.

FOXBORO

Technical Information

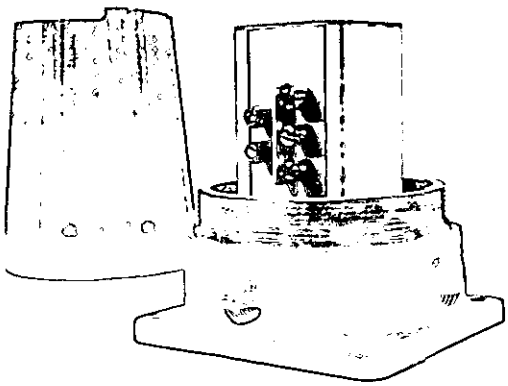
39-94a
August 1973

E94 SERIES TEMPERATURE TRANSMITTER



(a) Basic Transmitter Package.

(b) Surface Mounted Housing.



(c) Element Mounted Housing, with Optional Platinum RTD.

Figure 1. E94 Series Temperature Transmitter.

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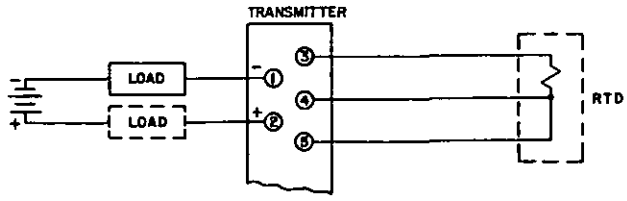

Figure 2. Connection of the E94 Series Transmitter.

FOXBORO

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

FOXBORO®

MS 0283 Printed in England

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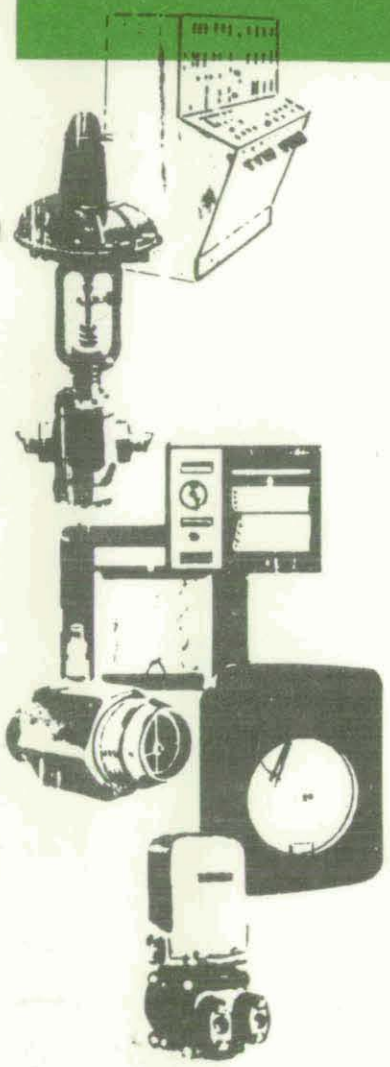
INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct installation of your Foxboro Instruments, and in their proper operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number*.

Book No. 2572

FOXBORO

IMPORTANT

Style Indication

Some of the following sheets may refer to a different style of instrument from that indicated on the cover of this instruction book.
The reason for this is that some sheets are valid for more than one style.
You may be assured that this book, in it's totality, will provide all the necessary information on installation, operation and maintenance of the instrument and style indicated on the cover.

S.I. Unit System

Foxboro, as a world-wide Organization, is an ardent supporter of world-wide standardization. Because of this general policy and the legal requirements in Europe, Foxboro has decided to adhere to the S.I. unit system (système internationale d'unités).
A beginning has been made with revising the extensive documentation accordingly so that you may find that this book contains one or more sheets with the units already expressed in the S.I. unit system.

Document Number Prefix

The document number of certain sheets out of this book may be preceded by the letter "V". This denotes that these "Printed in the Netherlands" sheets deviate to some extent from the original issue; for example, by adhering to the specifications of local requirements or to indicate that measurement units are expressed in the S.I. unit system.

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

FOXBORO®

Instruction

MI
611-012
October 1983

870CC TRANSMITTERS, 871CC SENSORS, AND ACCESSORIES CONTACTING CONDUCTIVITY

INTRODUCTION

The two-wire Foxboro 870CC Contacting Conductivity Transmitter, in conjunction with an 871CC Sensor, measures relatively low levels of conductivity in liquids. The measurement is transformed within the transmitter to a proportional 4 to 20 mA dc signal. This signal is transmitted to a receiver to control, record, and/or indicate the conductivity.

A temperature compensation circuit in the transmitter adjusts the output signal to indicate equivalent conductivity at 25°C (77°F), rather than at the actual solution temperature.

Figure 1 illustrates an 870CC Transmitter with an 871CC Sensor. For a detailed explanation of conductivity measurement, see Technical Information TI 612-112.

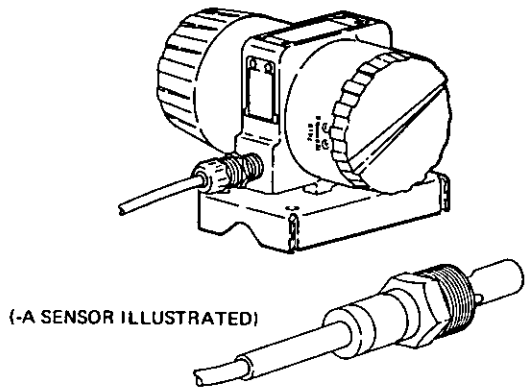


Figure 1.
870CC Transmitter With An 871CC Sensor

STANDARD SPECIFICATIONS

Transmitter Specifications

Output Signal: 4 to 20 mA dc
Signal Connections: Two conduit connections tapped for 1/2 NPT
Accuracy

% OF SPAN	SENSOR CABLE LENGTH
±0.5	6 m (20 ft)
±1.0	30 m (100 ft) or less

Power Supply: 20 to 40 V dc, depending on output-loop resistance (see Figure 8)
Power Consumption: 0.8 W maximum (except under fault conditions)
Mass (approximate): 5 kg (11 lb)
Add 0.5 kg (1 lb) for optional indicator
Installation Dimensions: See Dimensional Print DP 611-010
Ambient Temperature Limits: -30 and +70°C (-22 and +158°F)
Zero Suppression: Up to 100% of calibrated span. (Must be specified in sales order if suppressed range is desired.)
Measurement Ranges: See Table 1

CONTENTS . . .

FOXBORO®

Transmitter Certification Specifications

TESTING LABORATORY	TYPES OF PROTECTION AND AREA CLASSIFICATION	CONDITIONS OF CERTIFICATION	TEMP CLASS	CS REFERENCE
CSA	General purpose (ordinary locations)	--	--	CS-E/CG-A
FM*	Nonincendive for Class I, Groups A, B, C, and D, Division 2 and Class II, Groups F and G, Division 2 hazardous locations.	--	T6	CS-E/FN-A
FM*	Intrinsically safe for Class I, Groups A, B, C, and D, Division 1 and Class II, Groups E, F, and G, Division 1.	When connected: • to 871CC Sensors • according to TI 005-101	T6	CS-E/FB-A
Foxboro	Nonincendive, Class I, Groups A, B, C, and D, Division 2 and Class II, Groups F and G, Division 2 hazardous locations.	--	T6	CS-E/XN-F
Foxboro*	Intrinsically safe for Class I, Groups A, B, C, and D, Division 1 and Class II, Groups E, F, and G, Division 1 hazardous locations.	When connected to Foxboro intrinsically safe associated apparatus and 871CC Sensors.	T6	CS-E/XB-F

*Not available for optional suffix -A (Pure Water Automatic Temperature Compensation).

Table 1. Measurement Ranges
(See Parts List PL 611-012 for range resistor module part numbers.)

MEASUREMENT RANGE[a]		SENSOR CELL FACTOR[c]
MODULE SUFFIX[b]	VALUE IN µS/cm	
-01	0 to 1	0.1 cm^{-1}
-02	0 to 2	
-03	0 to 3	
-05	0 to 5	
-06	0 to 10	
-07	0 to 20	
-08	0 to 30	
-09	0 to 50	
-10	0 to 100	
-11	0 to 200	10 cm^{-1}
-12	0 to 300	
-13	0 to 500	
-14	0 to 1000	
-15	0 to 2000	
-16	0 to 3000	
-17	0 to 5000	
-18	0 to 10 000	
-19	0 to 20 000	
-20	Suppressed Zero[d]	

(a) For intermediate range, use next larger listing.
(b) Identified on transmitter data plate (see "Transmitter Identification" section).
(c) Identified on sensor (see "Sensor Identification" section).
(d) Specified in sales order.

Transmitter Identification

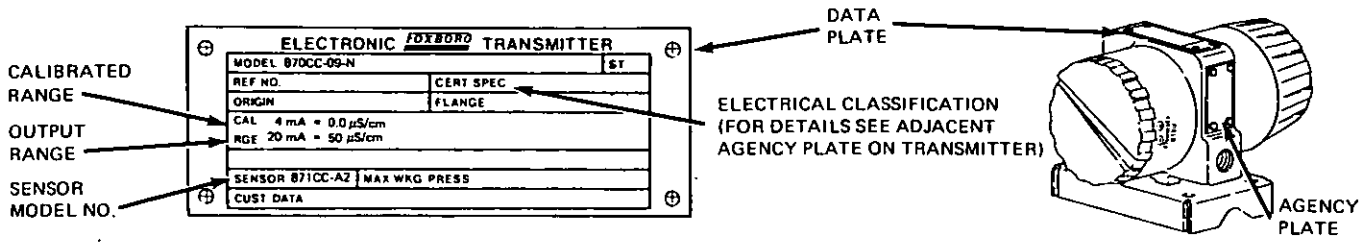


Figure 2. 870CC Transmitter Identification

Sensor Specifications

Temperature and Pressure Limits

STANDARD TEMPERATURE SENSORS[a] (MOUNTING DESIGN -A, -B, -E, AND -F)		HIGH TEMPERATURE SENSORS[b] (MOUNTING DESIGN -C, -D, -H, AND -J)
TEMPERATURE LIMITS	PRESSURE LIMITS	TEMPERATURE LIMIT AT MAXIMUM PRESSURE
0 and 120°C (32 and 250°F)	-0.1 and +1.4 MPa (-15 and +200 psi)	120°C (250°F) at 3.4 MPa (500 psi) 150°C (300°F) at 2.5 MPa (375 psi) 175°C (350°F) at 1.7 MPa (250 psi)[c]

Note: Sensor types -B, -E, and - J may have additional limititions depending on bushing used. See sensor installation details.

(a) See "Sensor Identification" and "Sensor Applications" sections for STANDARD or HIGH temperature identification.
(b) Low range limits same as for STANDARD sensors.
(c) For sensors with 0.1 cm^{-1} cell factor only.

Cell Factor: 0.1 or 10 cm^{-1}, as specified
Measurement Range:
  0.1 Cell Factor: 0-1 to 0-100 µS/cm
  10 Cell Factor: 0-200 to 0-20 000 µS/cm
Cable Length: 6 m (20 ft) standard, other lengths [up to 30 m (100 ft)] optional

Sensor Identification

The identification of the operating details are contained within the suffix of the sensor model number. The first character in the suffix (a letter) refers to the type of mounting of the sensor (see "Sensor Applications" section). The second character (either "2" or "4") refers to the cell factor; 2 = a cell factor of 0.1 cm^{-1}, and 4 = a cell factor of 10 cm^{-1}.

The complete sensor model number is either marked on a label attached to the sensor cable end or stamped on the maximum diameter on the sensor immersion end (see Figure 3).

PRINTED LABEL
MOUNTING TYPES -A, -E, -F, AND -H;
(TYPE -A IS ILLUSTRATED)

STAMPED MODEL NUMBER
MOUNTING TYPES -B, -C, -D, and -J;
(TYPE -B IS ILLUSTRATED)

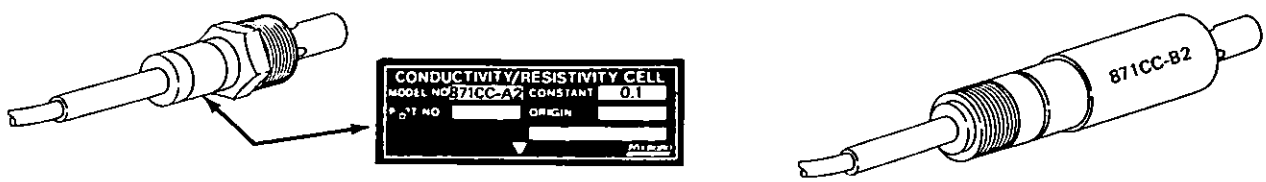
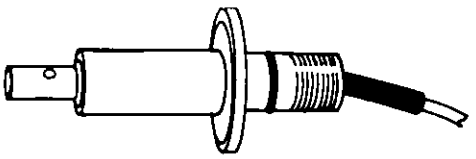
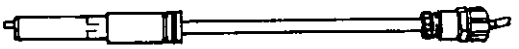
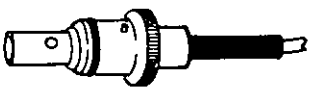
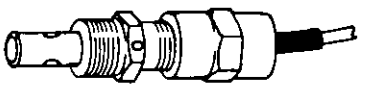
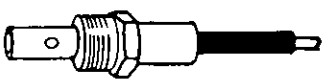


Figure 3. Sensor Identification

Sensor Applications

(Note: See Product Specifications [PSS] 6-3C2 A for additional sensor and accessory specifications.)

SENSOR MOUNTING DESIGN	APPLICATION	SENSOR
-A	A standard sensor incorporating a 3/4 NPT process connection that offers a wide variety of installation configurations. Mating cell holders are available.	
-B	Universal-mount sensors designed to utilize Foxboro flanges and hex-head bushings. Used in larger diameter piping and in the sides of tanks.	
-C*	Sensors with sanitary fittings mate with 50 mm (2 in) Tri-Clamp fittings.	
-D*	Insertion sensors are used with gate-valve insertion systems which allow the sensor to be removed from the system while it is operating without shutting down the process.	
-E	Twist-Lock sensors are used with mating cell holders. A 1/4 turn by hand permits removal of the sensor for inspection and cleaning.	
-F	Threaded bushings, 3/4 NPT with 1/2 NPT conduit connector.	
-H*	Threaded bushing, 3/4 NPT high temperature.	
-J*	Universal high temperature.	

*High temperature sensors. See Temperature and Pressure Limits (Page 3) for additional details.

TRANSMITTER INSTALLATION

The mounting bracket, restraining pad, two U-bolts and nuts, and a hex-head bolt are included (in package) with the transmitter.

The transmitter can be pipe or surface (wall or panel) mounted. For convenience, the transmitter can be rotated in the mounting bracket to any one of four positions in 90° increments (see "To Rotate Transmitter" section). Attach the transmitter to the bracket before mounting the bracket. For input and output transmitter wiring, see "Installation Wiring" section.

Dimensions

Refer to Dimension Print DP 611-010 for transmitter dimensions, and to DP 611-131 to DP 611-136 for sensor and accessories dimensions.

Pipe Mounting

The transmitter can be mounted on either a vertical or horizontal (illustrated in Figure 4) DN 50 or 2 in pipe. If the pipe is horizontal, the transmitter can be positioned at any angle.

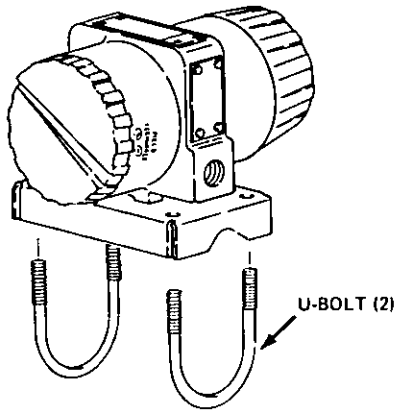


Figure 4. Transmitter Pipe Mounting

Surface Mounting

The transmitter can be mounted on a wall or panel. The mounting bracket must be attached to the surface with four 5/16 in bolts supplied by the user (see Figure 5).

For panel-mounting without the mounting bracket, the hex-head bolt (M16 x 1.5 x 35) can be used to mount the transmitter on the panel. The maximum panel thickness is 13 mm (1/2 in).

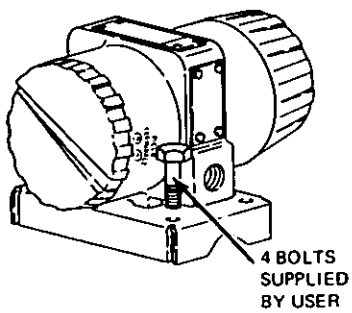


Figure 5. Transmitter Surface Mounting

To Rotate Transmitter

In choosing a mounting position, consideration should be given to access to operating adjustments, field terminals, optional indicator, and the removal of the transmitter covers.

For the desired position, insert the square projection on the base of the transmitter into the square recess on the mounting bracket (see Figure 6). Securely attach the transmitter to the base using the hex-head bolt and the mounting bracket.

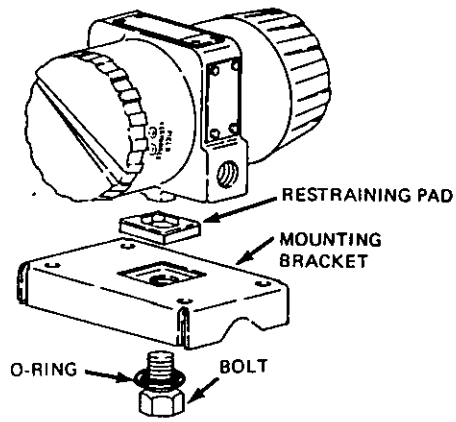


Figure 6.
Positioning Transmitter Mounting Bracket

Transmitter Earthing (Grounding)

The transmitter case is normally earthed (grounded). Refer to the applicable electric code for earthing (grounding) requirements.

An earthing terminal is provided in the field-terminal compartment of the transmitter housing, as well as an earthing terminal for the optional output indicator (see Figure 10).

If the signal circuit must be earthed, it is preferable to do so at the dc power supply. To avoid circulating currents in earth (ground) loops, or the possibility of short-circuiting groups of instruments in a loop, there should be only one earth in a loop.

Installation Wiring

All the installation wiring is made to the terminals in the field-terminal compartment of the transmitter. This wiring consists of the sensor wiring (input) and the supply-receiver loop wiring (output) (see Figure 7).

Both cables should be installed in metal conduit wherever possible for mechanical and radio-frequency interference (RFI) protection. Install the conduit to minimize the accumulation of condensate in the transmitter.

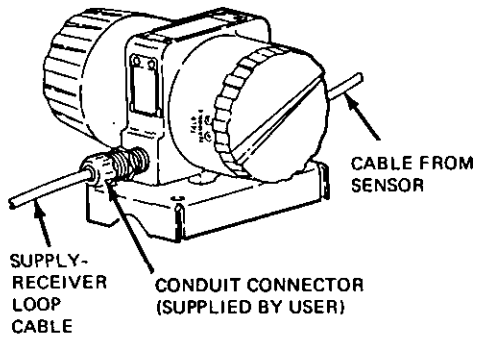


Figure 7. Transmitter Installation Wiring

Supply-Receiver Loop Wiring

Run the supply-receiver loop cable into the transmitter through the left conduit connection (facing the field-terminal compartment, connect the two leads as shown in Figure 10). The polarities are marked at the terminals. If the loop is to contain other instruments, install them in the negative lead, observing polarities as shown.

The jack connections (below the input terminals) can be used for the optional output indicator (±2% of scale accuracy). The voltage at the jack connections is 100 to 500 mV dc, corresponding to 0 and 100% output.

Power Supply

The supply voltage limits are 20 and 40 V dc as indicated in Figure 8. However, for a given supply voltage, there is a maximum output-loop resistance. (For example, if the supply voltage is 30 V dc, the maximum allowable loop resistance is 800 Ω.) To determine the actual output loop resistance, add the series resistance of each component in the loop.

The power supply must be capable of supplying 22 mA dc. If the transmitter is used with a SPEC 200 receiver, the built-in 30 V dc (+15, -15 V dc) power supply can be used (provided the output loop resistance is not over 800 Ω).

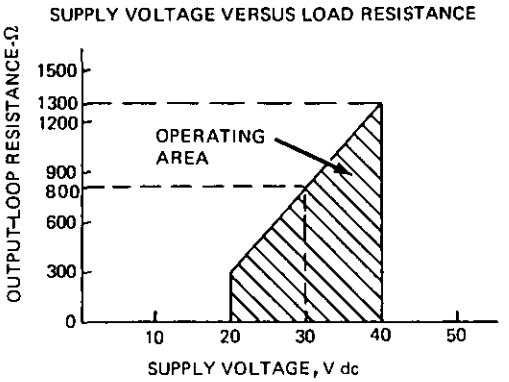


Figure 8.
Transmitter Supply Voltage and Output-Loop Resistance

Sensor Cable Wiring Details

Run the sensor cable through the right 1/2 NPT connection (facing the field-terminal compartment). Connect the four leads as shown in Figure 9.

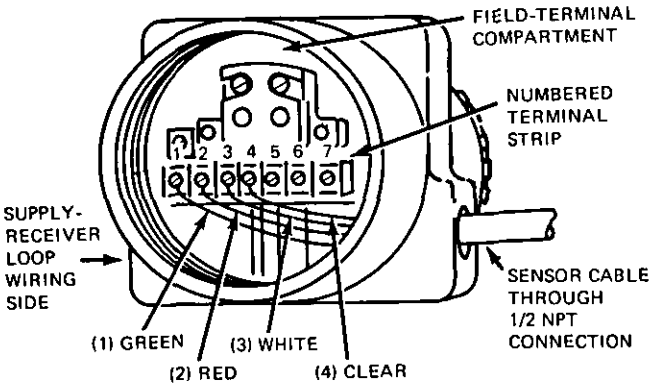


Figure 9. Sensor Cable Wiring

Output Wiring

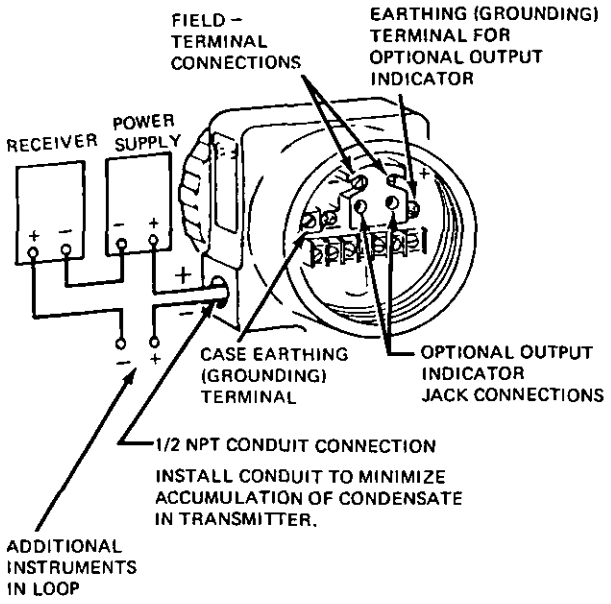


Figure 10. Transmitter Output Wiring

SENSOR INSTALLATION

Proper installation of the sensor is important for efficient and accurate operation.

For all applications and sensor configurations, mounting arrangements must be located so that:

1. Sample at the sensing area is representative of solution.
2. Solution circulates actively and continuously pass the sensing area.
3. Flow velocity at sensing area does not cause cavitation or cell damage.
4. Position and orientation of the sensor does not trap air bubbles within the sensing area.
5. Deposits of sediment or other foreign material do not accumulate within the sensing area.
6. If cable is installed in metal conduit (recommended), either flexible conduit should be used or some other provision made for the removal of the sensor from the process.
7. Lubricate all O-rings with a thin film of suitable grease.

Installation of Sensor Types -A, -F, and -H

These sensors have a 3/4 NPT male process connection. Illustrated in Figure 11 is a typical installation. These sensors can also be installed in a flow chamber available from Foxboro (installation is similar to that in Figure 14).

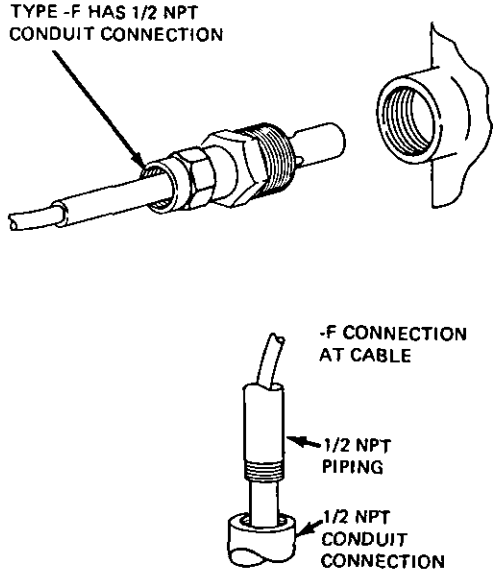


Figure 11.
Installation of
Sensor Types -A, -F, and -H

Installation of Sensor Types -B and -J

These sensors can be connected to either a 2 through 4 in ANSI Class 150 flange or 1 1/4 through 2 NPT female process connection (see Figure 12). Sensor mounting parts are available for each type of installation (these mounting parts are specified and ordered separately by part number). Other mating parts are supplied by the user. The temperature-pressure limitations of the bushings are 200°C (390°F) at 1.7 MPa (250 psi).

Installation of Sensor Type -C

This sensor mates with a 2 NPT Tri-Clamp flange (see Figure 13). The flange on the process tank, the gasket, and the clamp are supplied by the user.

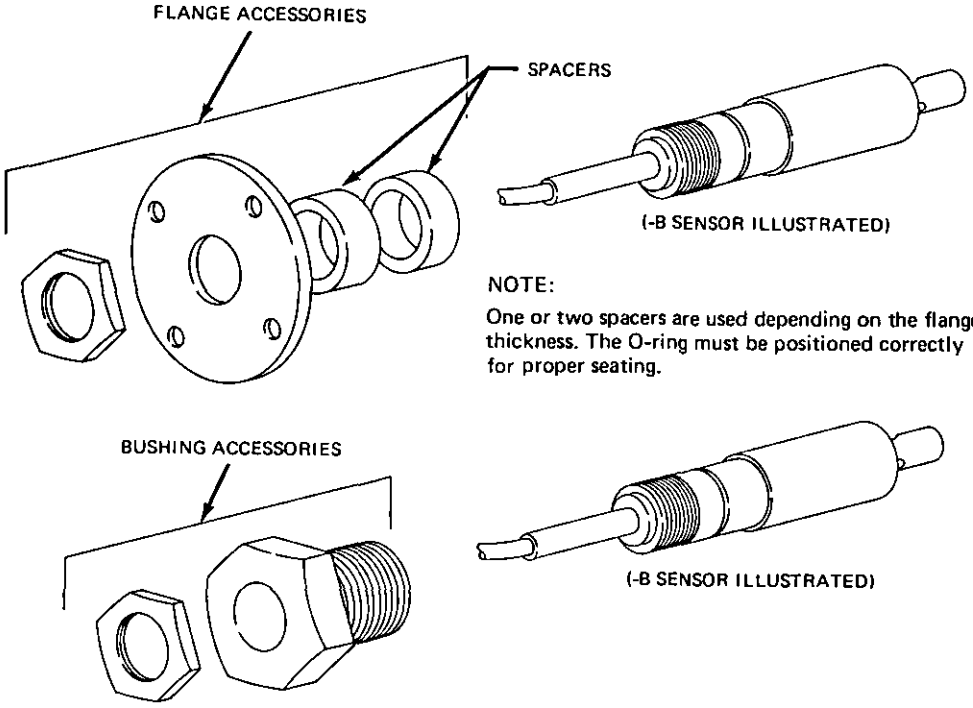


Figure 12.
Installation of Sensor Types -B and -J

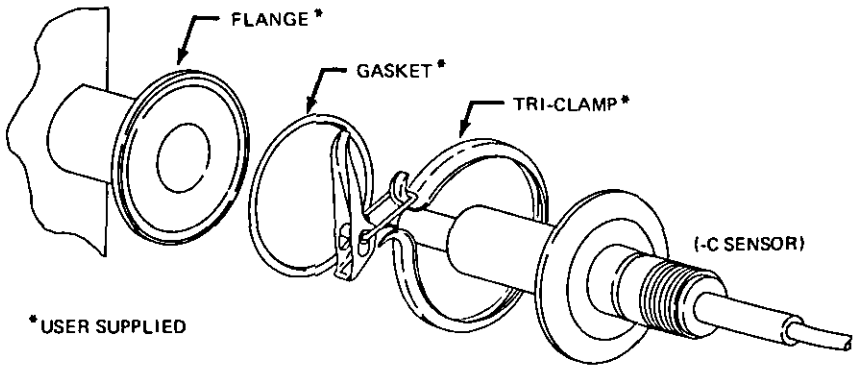


Figure 13.
Installation of Sensor Type -C

Installation of Sensor Type -E

This sensor connects to either a Twist-Lock flow chamber (see Figure 14 and Table 2), or a 1 1/4 or 1 1/2 NPT Twist-Lock bushing available from Foxboro. With the Twist-Lock bushing, the sensor can be connected to the user's 1 1/4 or 1 1/2 NPT male process connection.

NOTE

Sensor Types -A, -F, and -H can be installed in flow chambers having a 3/4 NPT sensor connection (in place of the Twist-Lock connection illustrated). All other flow chamber installation details are the same.

Table 2.
Flow Chamber Specifications

THREAD SIZE (in)	RATED PRESSURE AT RATED TEMPERATURE				
	MATERIAL	MPa	psi	°C	°F
1 1/4 NPT	PVC	0.4	60	50	120
		0.2	30	80	175
1 1/4 NPT	316 ss	1.4	200	125	260

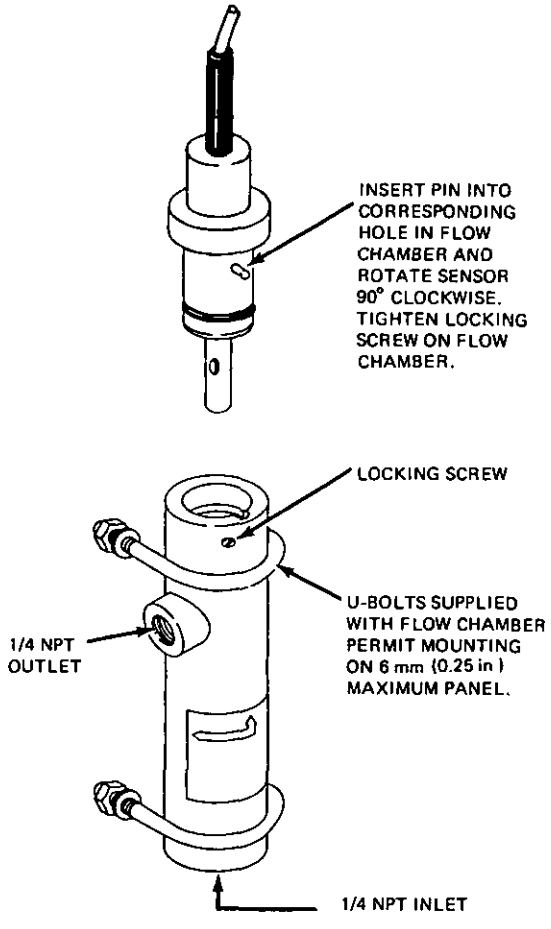


Figure 14. Installation of Sensor Type -E

Installation of Sensor Type -D

Table 3. Gate-Valve Specifications

PROCESS LINE CONNECTION (in)	RATED PRESSURE AT RATED TEMPERATURE				MATERIAL OF PROCESS WETTED PARTS		
	MPa	psi	°C	°F	GATE VALVE	SHOCK ABSORBER	O-RING
1 NPT	1.4	200	120	250	316 ss	ptfe	Viton
	3.4	500	175	350			

This sensor joins with a 1 NPT gate-valve assembly, which is available from Foxboro. When the gate valve is installed, the sensor can be inserted or removed without disturbing the process. For gate-valve assembly specifications, refer to Table 3 and Dimensional Print DP 611-120.

A gate-valve assembly installation must meet mounting arrangements specified in "Sensor Installation" section as well as the following requirements:

1. Install the gate-valve assembly in a tee, boss, or flange that will accept a 1 NPT connection.
2. Direct the flow of the solution (as much as possible) toward the sensing area.
3. Provide a minimum of 610 mm (24 in) space for removal of the sensor in the gate-valve assembly.

Assembly of Gate-Valve Insertion Sensor

NOTE
This procedure is for a new installation. The process stream is unfilled and unpressurized.

1. Disassemble the locknut and the housing nut from the installed gate-valve assembly housing (see Figure 15).

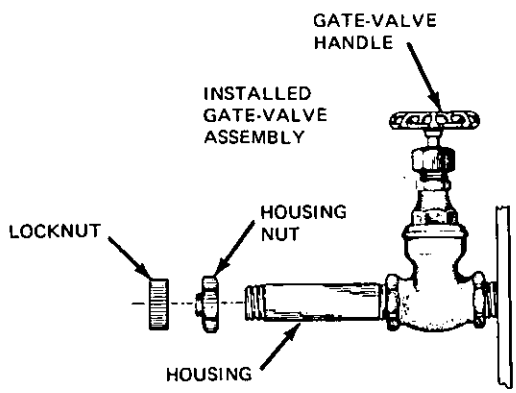


Figure 15.
Disassembly of Locknut and Housing Nut

2. Select the appropriate Mounting Design (-D) gate-valve insertion sensor for the application.
3. Assemble parts onto the gate-valve insertion sensor cable as shown in Figure 16.

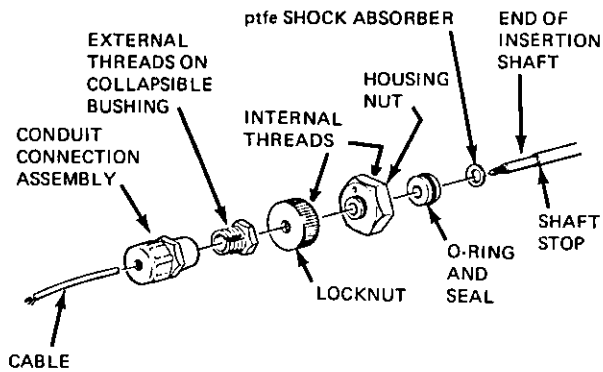


Figure 16.
Assembly of Parts
Onto Gate-Valve Insertion Sensor Cable

4. Lightly lubricate insertion shaft with silicone grease (or equivalent).
5. Slide the ptfe shock absorber and the O-ring and seal onto the insertion shaft until the shock absorber is against the sensor assembly (see Figure 17).

⚠ CAUTION

Do not nick the O-rings.

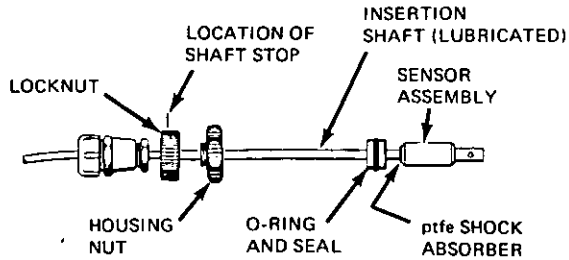


Figure 17.
Assembly of Gate-Valve Insertion Sensor

6. Slide housing nut onto the shaft to a position just beyond the shaft stop.

7. Slide the locknut against the shaft stop.

8. Slide the collapsible bushing and conduit connection onto the end of the shaft. (Do not tighten.)

Installation of Gate-Valve Insertion Sensor

1. Turn the gate-valve handle clockwise (see Figure 18) until the valve is completely seated (closed).

2. Fill and pressurize the process line or tank as required. Check for and eliminate leaks.

⚠ CAUTION

Do not exceed the sensor temperature and pressure limits.

3. Insert the gate-valve insertion sensor into the housing isolation chamber until the O-ring and seal are seated into the end of the housing (see Figure 18).

⚠ CAUTION

Do not nick the O-rings.

4. Tighten the housing nut onto the end of the housing.

NOTE
The housing nut is supplied lubricated and should be relubricated periodically to prevent galling.

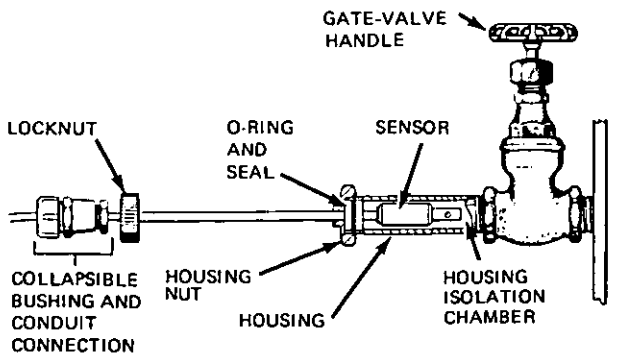


Figure 18.
Installation of Insertion Sensor Into Gate Valve

5. Slowly turn the gate-valve handle counterclockwise to fully open the valve.

⚠ CAUTION

Gate-valve insertion sensor may retract while opening the valve.

6. Check for and eliminate leaks.

7. Insert the sensor into the process and tighten the locknut onto the housing nut.

8. Slide the collapsible bushing against the locknut.

9. Assemble the conduit connection assembly onto the collapsible bushing and secure the bushing onto the shaft of the gate-valve insertion sensor.

Removal of Gate-Valve Insertion Sensor

⚠ WARNING

Do not loosen the housing nut (Figure 19) when the gate-valve unit is in the open position and the process line or tank is filled and pressurized.

1. Carefully loosen and detach the locknut only.

⚠ CAUTION

Gate-valve insertion sensor may retract rapidly.

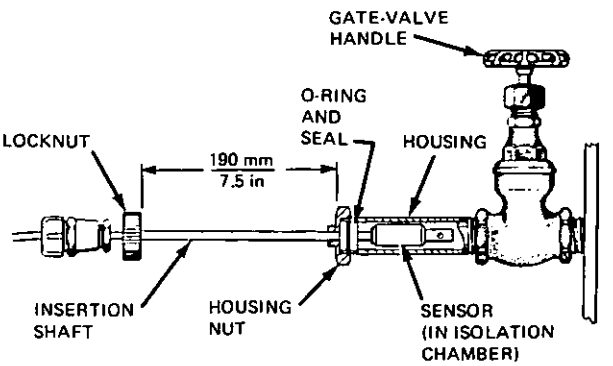


Figure 19.
Removal of Gate-Valve Insertion Sensor

2. Allow the sensor to enter into the gate-valve housing isolation chamber (see Figure 19).

NOTE
Expose the insertion shaft 190 mm (7.5 in) minimum before attempting to close the valve.

3. Turn the gate-valve handle clockwise until valve is completely seated (closed).

⚠ CAUTION

Do not loosen the housing nut if there is a continuous leakage through the port on the housing nut.

Check to be sure the valve is completely closed. If the leakage continues, the gate valve is not seating. The process line or tank may have to be emptied and depressurized.

4. Loosen the housing nut and withdraw the insertion sensor shaft assembly from the housing isolation chamber.

JUNCTION BOX INSTALLATION

Junction Box Mounting

The junction box is used when the transmitter is more than the maximum length of the sensor cable away.

⚠ CAUTION

Cable length must be considered so that connections can be made without exposing the cable to damage.

1. Select a rigid surface and a position protected from damage or exposure to excessive moisture or corrosive fumes.
2. Position the junction box against the mounting surface and mark the location of the mounting holes.
3. Drill the mounting holes on the marked centers.
4. Mount the junction box with appropriate hardware (user supplied).

Junction Box Wiring

1. Remove the junction box cover and loosen the cable connectors (see Figure 20).
2. Insert the sensor cable through the appropriate connector and connect the numbered terminals of the sensor cable to the corresponding numbered terminals on the terminal strip.
3. Insert extension cable assembly through appropriate connector and connect the numbered terminals of extension cable assembly opposite the corresponding numbered terminals of the sensor cable.

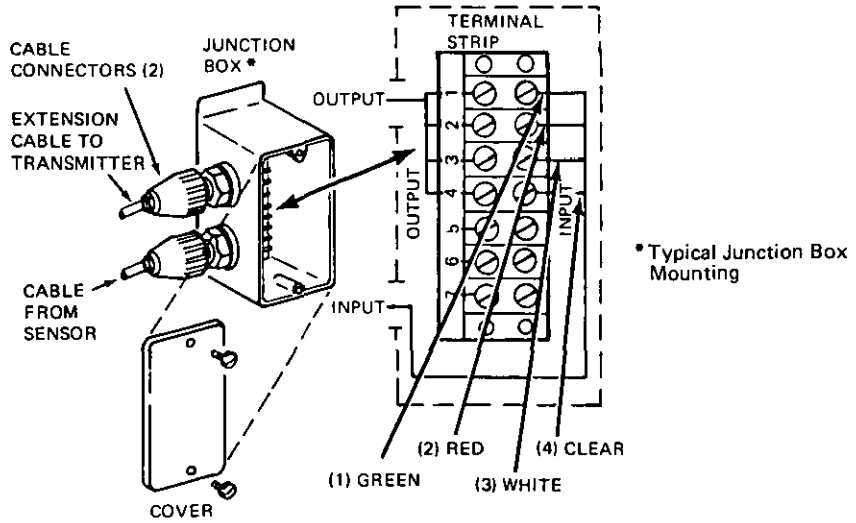


Figure 20. Junction Box Wiring

OPERATION

Periodic Cleaning of Sensor

The accuracy of the sensor may be affected by deposits from the process liquid. Therefore, the sensor may require cleaning on a scheduled basis (see "To Clean Electrode" section).

Zero Adjustment

Complete this procedure after the system is installed, but before putting the system in operation. This is an operating adjustment only. For a calibration check, see "Calibration Check" section. For a complete calibration, see "Calibration Procedure" section.

If the transmitter is equipped with an optional output indicator, the indicator should not be used for this procedure as its accuracy is ±2%.

1. Insert a 4-digit ±0.1% milliammeter into the supply-receiver loop (see Figure 21).
2. By independent means, accurately (±0.5% or better) determine the conductivity of the process solution.

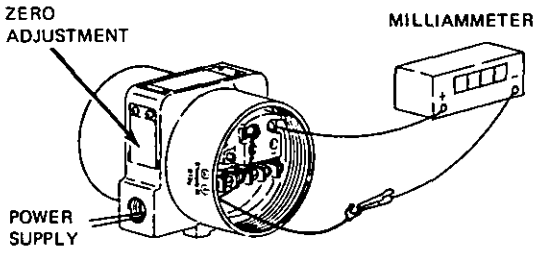


Figure 21.
Milliammeter in Supply-Receiver Loop

3. Calculate (use the formula in Table 4) the transmitter output corresponding to the independently determined conductivity.
4. Turn the ZERO adjustment so that output on the milliammeter reads the calculated value.

The system is now ready for operation.

Table 4.
Output Calculations

EXAMPLE 1: Formula To Calculate Output for any Conductivity Input is as follows:

$$\text{Output mA} = \left(\frac{\text{Measured conductivity}}{\text{Upper-range value}}\right)(16) + 4$$

If, System measurement range = 0 to 10 000 µS/cm

and, Measured conductivity = 5000 µS/cm

$$\text{then, Output} = \left(\frac{5000}{10\ 000}\right)(16) + 4 = 12.00 \text{ mA}$$

EXAMPLE 2: With a suppressed-zero range, the formula is:

$$\text{mA} = \frac{\text{Measured value - Lower-range value}}{\text{Upper-range value - Lower-range value}}\ (16) + 4$$

If, System measurement range = 10 000 to 20 000 µS/cm

and, Measured conductivity = 15 000 µS/cm

$$\text{then, Output} = \left(\frac{15\ 000 - 10\ 000}{20\ 000 - 10\ 000}\right)(16) + 4 = 12 \text{ mA dc}$$

CALIBRATION

Calibration Check*

This procedure requires an accurately prepared solution of NaCl. This solution is used for the upper-range value (or near upper-range value) conductivity test input.

Table 5 lists the conductivity corresponding to various concentrations of an NaCl solution. If the calibrated upper-range value conductivity is not listed, use the solution concentration of the next-lower value. The milliampere output corresponding to this value can be calculated using the formula in Table 6.

Table 5. Conductivity Versus NaCl Concentrations

SOLUTION CONDUCTIVITY [µS/cm at 25°C (77°F)]	CONCENTRATION NaCl SOLUTION (ppm or mg/L)	SOLUTION CONDUCTIVITY [µS/cm at 25°C (77°F)]	CONCENTRATION NaCl SOLUTION (ppm or mg/L)
1	0.44	160	75
2	0.90	180	85
4	1.8	200	91
6	2.7	250	117
8	3.7	300	140
10	4.6	400	190
12	5.5	500	237
14	6.4	600	288
16	7.4	700	341
18	8.3	800	391
20	9.2	900	445
22	10.1	1000	495
24	11	1500	747
26	12	2000	1000
28	13	3000	1520
30	14	4000	2065
40	19	5000	2650
50	23	6000	3150
60	28	7000	3756
70	32	8000	4270
80	37	9000	4950
100	47	10 000	5400
120	57	20 000	11 300
140	66		

Table 6. Formula To Calculate Output For Any Conductivity Input

$$\text{Output mA} = \left(\frac{\text{Solution conductivity}}{\text{Upper-range value}}\right)(16) + 4$$

EXAMPLE: System measurement range = 0 to 1600 µS/cm
(Since the solution with this conductivity is not listed in Table 5, use the solution with the next lower value, 1500 µS/cm.)

Concentration of 1500 µS/cm solution = 747 ppm (from Table 5).

$$\text{Output} = \left(\frac{1500}{1600}\right)(16) + 4 = 19.00 \text{ mA dc}$$

With a suppressed-zero range, the formula is:

$$\text{Output mA} = \left(\frac{\text{Solution condutivity - Lower-range value}}{\text{Upper-range value - Lower-range value}}\right)(16) + 4$$

*For low conductivity ranges (i.e., -01 and -02), use calibration procedures on Pages 13 through 15 without the solution tests due to the fact it is difficult to accurately prepare a stable solution of such low conductivity.

1. Insert a 4-digit ±0.1% milliammeter into supply-receiver loop (see Figure 22).

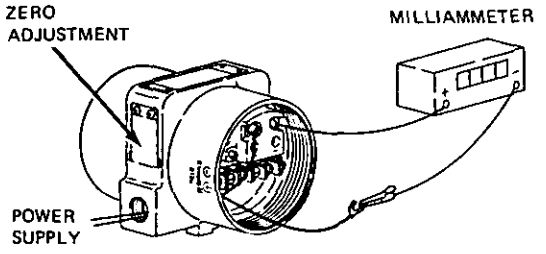


Figure 22.
Milliammeter in Supply-Receiver Loop

2. Remove the sensor from the process. Wash the immersion end in distilled water.

3. Immerse the sensor in distilled water.

4. Adjust the ZERO adjustment to 4 mA dc on the milliammeter.

5. Dry the immersion end of the sensor and put this end into an NaCl solution of proper concentration (see Table 5).

NOTE

Not applicable to ranges -01 and -02.

6. If output is not 20 mA dc (or calculated value), the transmitter requires calibration (see "Calibration Procedure" section).

NOTE

Not applicable to ranges -01 and -02.

Calibration Procedure

1. Remove the field-compartment housing cover to disconnect the external wiring (power supply loop and sensor leads) in the field-terminal compartment of the transmitter [field-terminal leads from terminals 1, 2, 3, 4, (+), and (-)].

2. Remove the transmitter housing cover from the electronic module compartment. Remove the two captive mounting screws and lift out the electronic module (see Figure 23).

   Use a small screwdriver to remove the right screw from the range resistor module cover. Loosen the left screw. Swing the cover down to expose the SPAN screw (see Figure 23).

NOTE

The electronic module should be supported to prevent strain on the cable connecting the electronic module to transmitter.

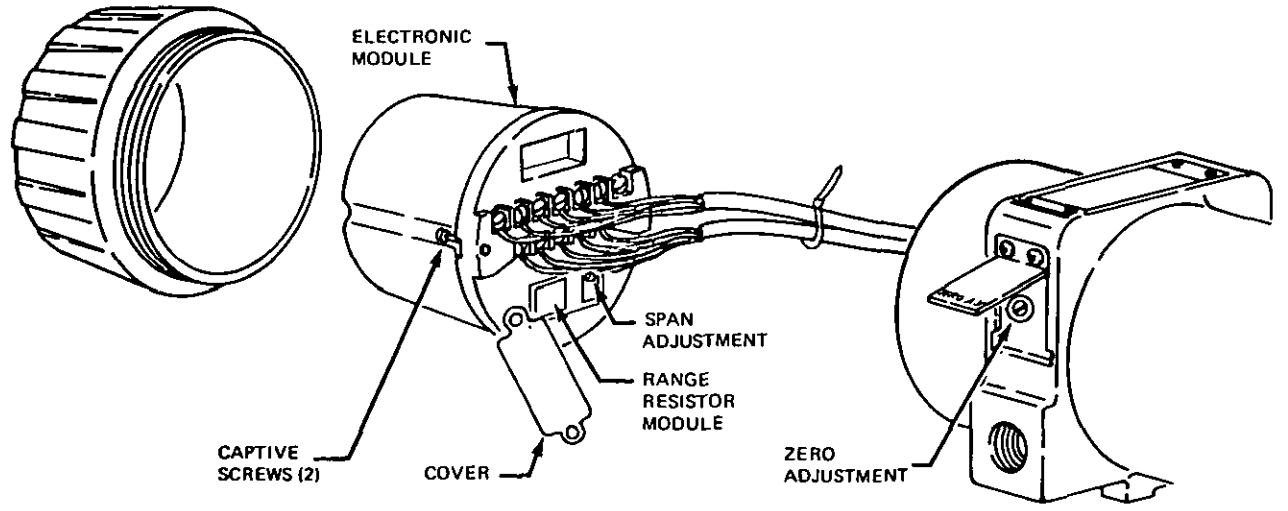


Figure 23. Access to Electronic Module

3. Connect the calibrating equipment as shown in Figure 24.

   Check that all terminal screws on the electronic module and in the field-terminal compartment are secure.

4. Disconnect one decade box lead (infinite resistance). Adjust the ZERO adjustment to 4 mA dc output on the milliammeter.

5. Calculate the resistance corresponding to the upper-range value (use the formula in Table 7).

6. Reconnect the decade box lead and set the decade box at the calculated value. Adjust the SPAN adjustment to 20 mA dc output on the milliammeter.

7. Repeat Steps 5 and 6. Reconnect the original wiring.

NOTE

Not applicable to ranges -01 and -02.

Suppressed Zero

NOTE

Not applicable for optional Suffix -A (Pure Water Automatic Temperature Compensation).

1. Use the formula in Table 7 to calculate the resistance corresponding to the upper-range value.

2. Calculate the resistance corresponding to the lower-range value (use the formula in Table 8).

3. Set the decade box to the value calculated in Step 2 (for the lower-range value resistance). Adjust the ZERO adjustment to 4 mA dc output on the milliammeter.

4. Set the decade box to the value calculated in Step 1 (for the upper-range value resistance). Adjust the SPAN adjustment to 20 mA dc output on the milliammeter.

5. Repeat Steps 3 and 4 until further adjustments are not required.

6. Reconnect the original wiring.

Table 7.
Formula To Calculate Resistance
Corresponding To Upper-Range Value

$$\text{Resistance} = \left(\frac{\text{Cell Factor}}{\text{Upper-Range Value Conductivity in } \mu S/cm}\right)(10^6)$$

EXAMPLE: Range = 0 to 2000 µS/cm

Cell Factor = 10 cm^{-1}

$$\text{Resistance} = \left(\frac{10}{2000}\right)(10^6) = 5000\ \Omega$$

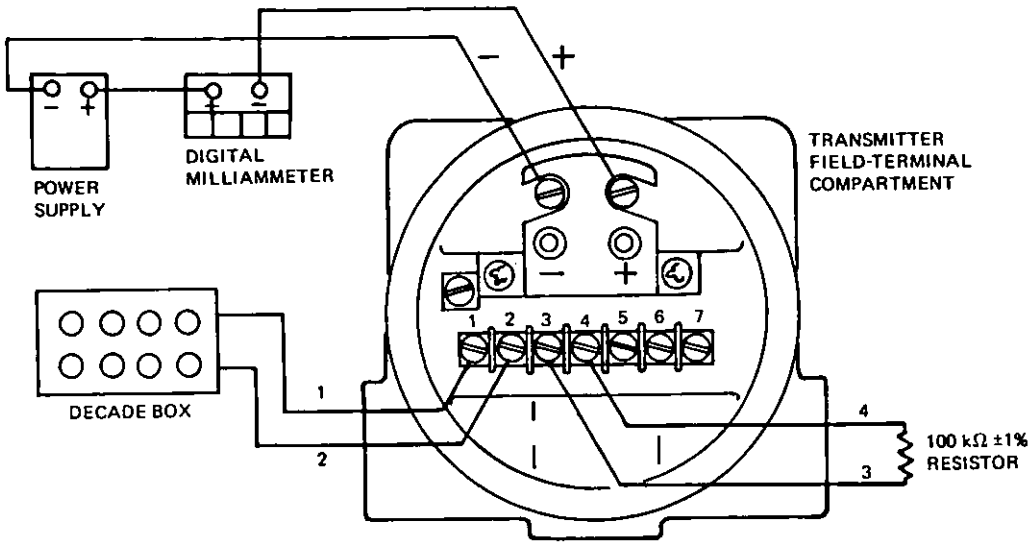
Table 8.
Formula To Calculate Resistance
Corresponding To Lower-Range Value

$$\text{Resistance} = \left(\frac{\text{Cell Factor}}{\text{Lower-Range Value Conductivity in } \mu S/cm}\right)(10^6)$$

EXAMPLE: Range = 1000 to 2000 µS/cm

Cell Factor = 10 cm^{-1}

$$\text{Resistance} = \left(\frac{10}{1000}\right)(10^6) = 10\ 000\ \Omega$$



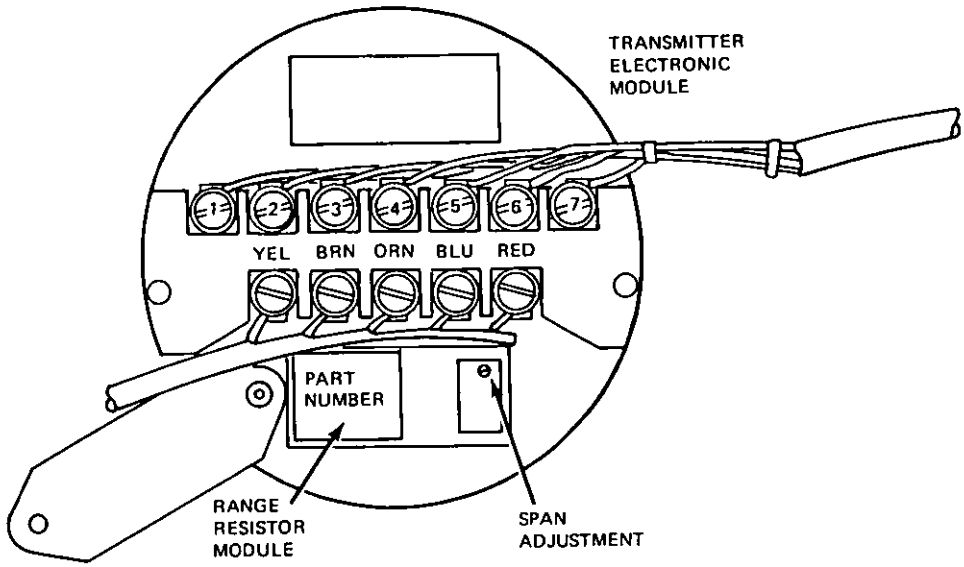


Figure 24. Calibration Equipment Connections and Adjustments

PREVENTIVE MAINTENANCE

Electrode Inspection

Inspect the electrodes as needed. The electrode should be cleaned periodically. See "To Clean Electrode" section for details.

The transmitter normally requires servicing only if the transmitter cannot be calibrated, if the system is malfunctioning, or if the range is to be changed.

If the transmitter cannot be calibrated, or if the system is malfunctioning, check for a defective component and replace this component.

To Clean Electrode

Deposits on the electrode (immersion portion of the sensor, [see Figure 25]) can seriously affect the sensor's accuracy.

A tentative schedule for cleaning the electrode should be established. The time interval between cleanings can be increased or decreased (depending on the nature of the process liquid or the difference between the conductivity readings before and after cleaning).

1. Remove the sensor from the process.
2. Gently move the immersion portion of sensor in a dilute solution of a suitable acid or base (to agitate solution) until the deposits are loosened.

   Choice of the cleaning solution depends on the nature of the process liquid and deposits.
3. Use a soft brush (e.g., toothbrush) to wipe away deposits. Remove deposits from inaccessible areas with a cotton swab.
4. Repeat Steps 2 and 3 until sensor is clean.
5. With a sensor having a cell factor of 10 cm^{-1}, slide the plastic sleeve over retaining pin and remove sleeve (see Figure 25). Clean both sides of the plastic sleeve.
6. Rinse sensor thoroughly in distilled water, reinstall plastic sleeve (if removed), and return the sensor to the process.

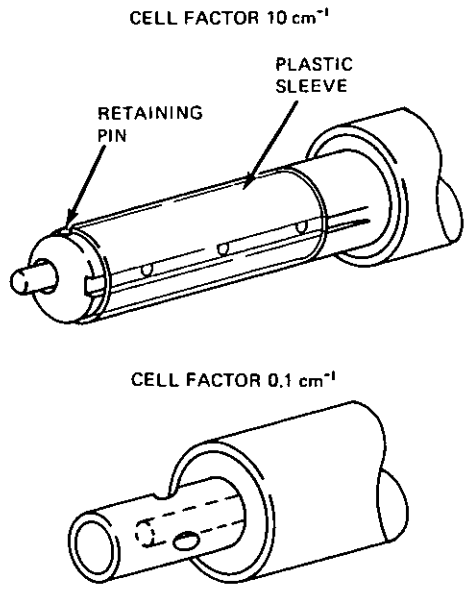
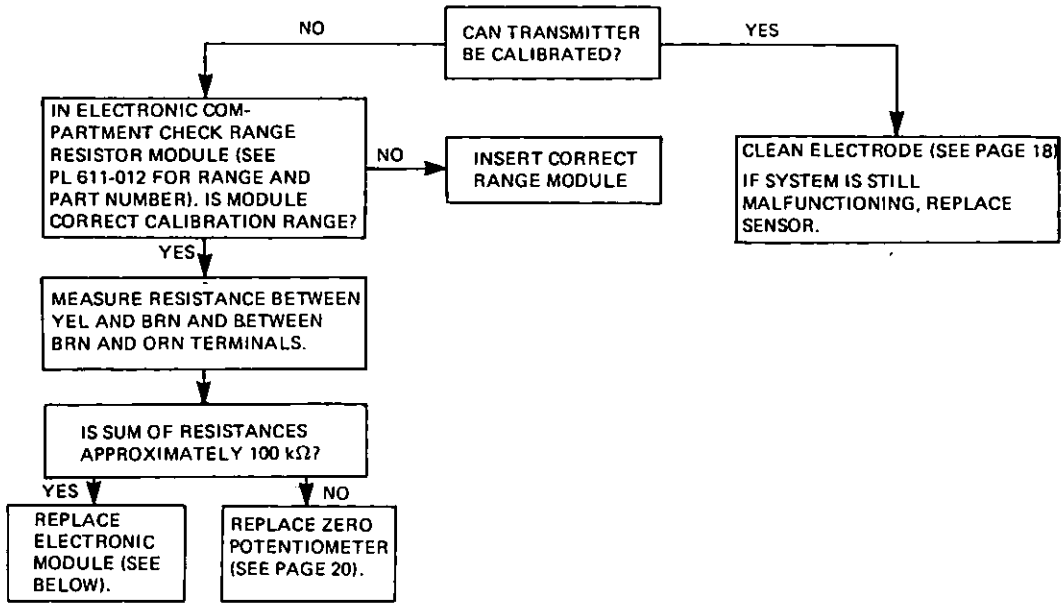


Figure 25. Immersion Portion of Sensors

CORRECTIVE MAINTENANCE

To Identify Defective Component



To Replace Electronic Module

(See "Transmitter Disassembly" section for electronic module replacement details.)

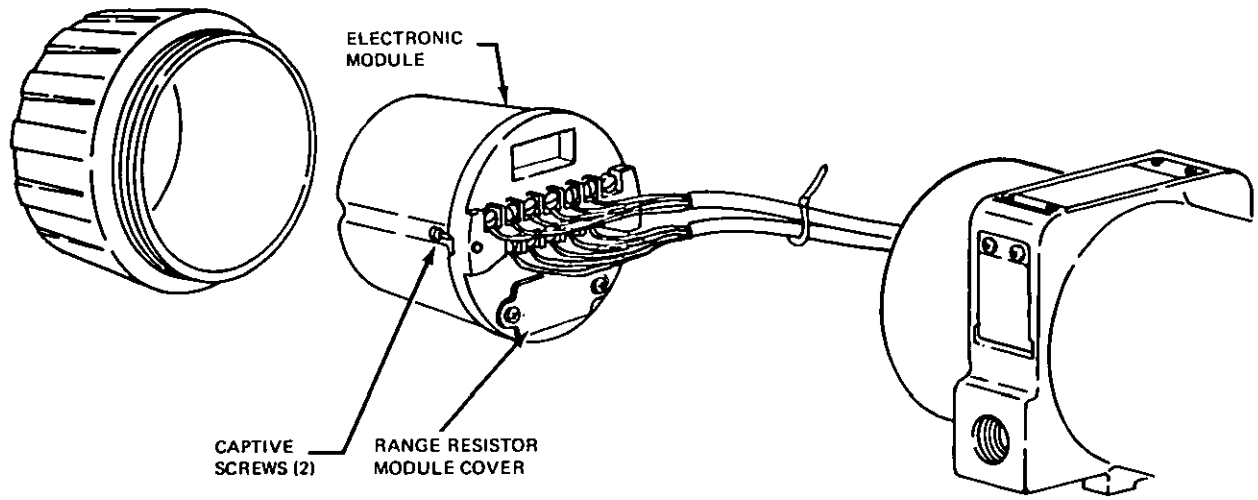


Figure 26. Electronic Module Replacement

Transmitter Disassembly

The disassembly of the transmitter is usually limited to that shown in Figures 23 and 26. Normally, the electronic module and ZERO potentiometer are the only parts that will require replacement.

NOTE
The range resistor module may require replacement if the range is to be changed (see "To Replace Range Resistor Module" section).

1. Disconnect the external wiring (supply-receiver loop and sensor leads) from field terminals of transmitter.
2. Remove the cover from the electronic module compartment. Loosen the two captive mounting screws and lift out the electronic module from the transmitter housing (see Figure 26).
3. Disconnect the seven leads from the upper terminals, and the five leads from the lower terminals.
4. Connect these leads to the corresponding terminals on the new electronic module.
5. Calibrate the transmitter.

To Change Range

The system can be calibrated to any range within the limits specified for the particular combination of the sensor cell factor (either 0.1 or 10 cm^{-1}) and the range resistor module installed in the electronic module. Table 1 lists the range limits for each combination of cell factor.

If the desired range is outside the limits of either the range resistor module or the combination of the range resistor module and sensor, install the appropriate new components.

NOTE
For transmitter with optional Suffix -A (Pure Water Automatic Temperature Compensation) range resistor must also be replaced (see Figure 27). See Parts Lists PL 611-012 for applicable numbers for range resistor and range resistor module.

Recalibrate the transmitter to the new range and change the data plate to indicate the new conditions.

To Replace Range Resistor Module

1. Lift out the electronic module from the transmitter housing (see Steps 1 and 2 in "Transmitter Disassembly" section).
2. Remove the right screw from the range resistor module cover (use a small screwdriver). Loosen the left screw. Move the cover down to expose the range resistor module (see Figure 27).

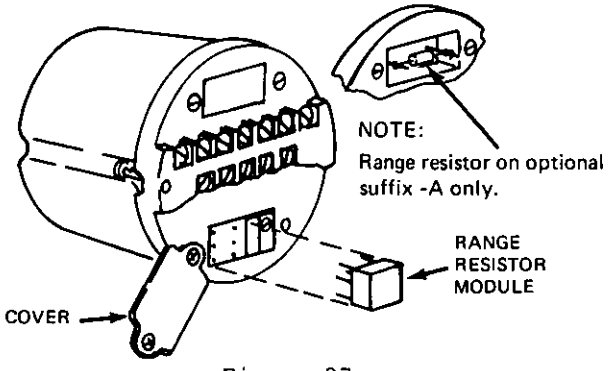


Figure 27.
Range Resistor and Range Resistor Module Replacement

3. Use two small thin-blade screwdrivers to pry up range resistor module.
4. Insert the new range resistor module.
5. Calibrate the transmitter.

To Replace ZERO Potentiometer

1. Remove, but do not disconnect, the electronic module from the transmitter (Steps 1 and 2 in "Transmitter Disassembly" section).
2. Remove the two mounting screws holding the ZERO potentiometer bracket to the casting (see Figure 28).

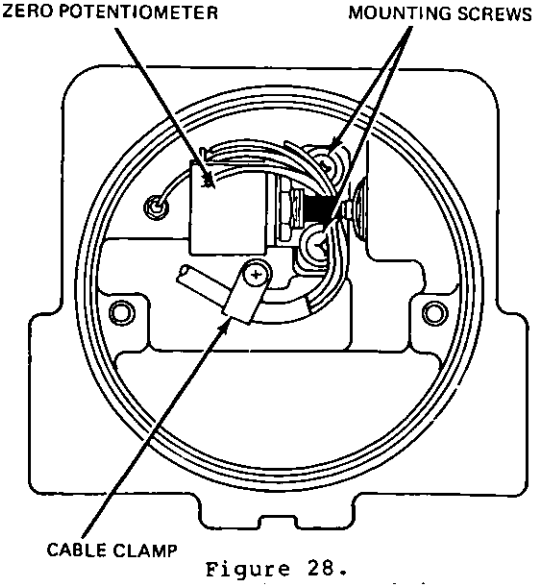


Figure 28.

3. Raise (carefully) the left side of the ZERO potentiometer bracket assembly, so that the ZERO potentiometer shaft slips out of the rubber coupling.

4. Cut the three leads off the ZERO potentiometer terminals (see Figure 29). Strip insulation off the ends of the wires.

   Loosen the cable clamp (if more slack in the 5-wire cable is required).

5. Remove the ZERO potentiometer from bracket. (Note the orientation of the ZERO potentiometer on the bracket for correct reinstallation.)

6. Mount the potentiometer onto the bracket, maintaining original orientation.

7. Solder (carefully) the three leads onto the terminals of the new ZERO potentiometer. Use a suitable sealant on the soldered joints.

8. Reinstall the new ZERO potentiometer in reverse order of removal. Use care not to damage the RFI terminals or wires.

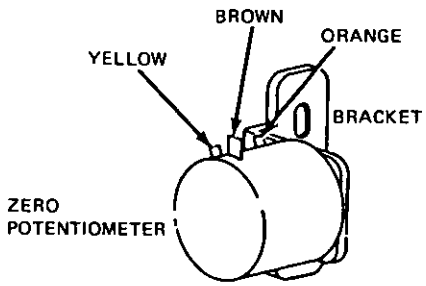


Figure 29.
ZERO Potentiometer Wiring

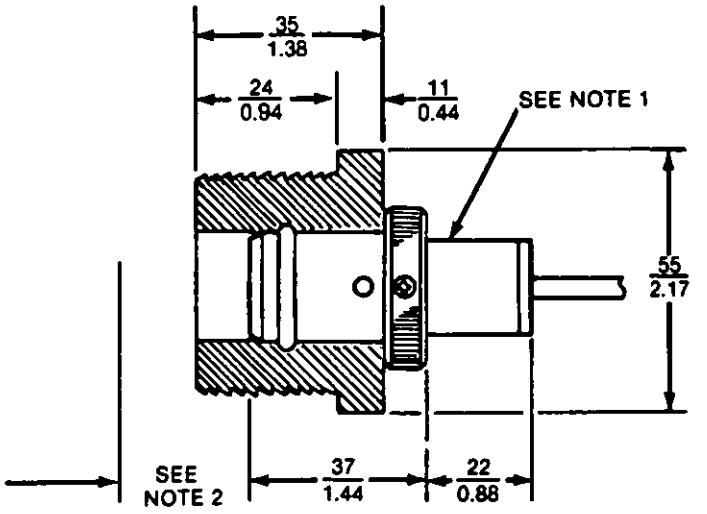
SPEC 200 is a trademark of The Foxboro Company.
Tri-Clamp is a trademark of Ladish Company.
Viton is a trademark of E.I. duPont de Nemours and Company.

1083
Printed in U.S.A.

Dimensional Print

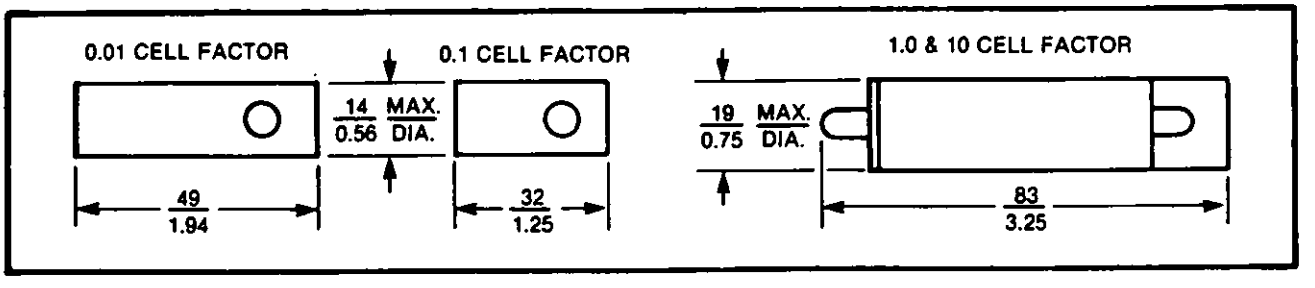
DP
611-094
JUNE 1983

TWIST-LOCK BUSHING (PVC) USED WITH 871CC, 910, 920, AND 921 CONDUCTIVITY SENSORS



NOTES:

1. A 910, 920 SERIES SENSOR IS ILLUSTRATED.
2. FOR TOTAL SENSOR LENGTH (WHERE APPLICABLE), ADD CELL FACTOR LENGTH (SHOWN BELOW) TO THE LEFT OF THE SENSOR.



(Not for construction unless certified.)

AMERICAN PROJECTION

FOXBORO®

MB 123

Printed in U.S.A.

WARRANTY

Except as hereinafter provided, the Company (hereinafter called "Foxboro") warrants that all parts manufactured by it (but not by others) shall be within specified limits of calibration, if any, and free from defects in material or workmanship, under proper and normal use. Foxboro, at its option, shall replace or repair, free of charge, any part covered by this warranty which shall be returned, transportation charges prepaid, within one year from shipment by Foxboro and which examination proves not to be within the specified limit of calibration or not to be free from such defects in material or workmanship. Foxboro shall not be liable for any repairs or replacements of parts by others and covered by this warranty except those made with Foxboro's written consent. Foxboro shall be liable for breach of this warranty only if it receives written notice of such breach within one year from the date of shipment of the product to which the breach relates. The foregoing shall constitute the sole remedy of the purchaser for any breach by Foxboro of its warranty.

FOXBORO MAKES NO WARRANTIES REGARDING PARTS MANUFACTURED BY IT OR OTHERS (INCLUDING WITHOUT LIMITATION WARRANTIES AS TO MERCHANTABILITY), EITHER EXPRESSED OR IMPLIED, EXCEPT AS PROVIDED HEREIN.

SERVICE

The Company is anxious to be of every possible assistance to you, to insure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service may be made through your nearby Foxboro Sales Representative. When factory repairs are required, the instrument may be sent to any Foxboro plant. Check with your International Sales Representative who will advise you as to which plant should be utilized.

The Foxboro Company, Foxboro Mass. U.S.A.; Foxboro-Yoxall Ltd., Redhill, Surrey, England; and Foxboro (Nederland) N.V., Soest, Netherlands provide expertly staffed and fully equipped Training Schools devoted to the instruction of customer's Instrumentation Engineers and Service Men. The courses cover theory of operation, maintenance and application of the principial types of instruments. Applications from Companies in the British Isles should be made to Foxboro-Yoxall Ltd.; from those in the other parts of the world, to the nearest International Sales Representative as listed on the last sheet of this book.

PARTS

When repairs are to be made by the customer, it is strongly urged that only genuine Foxboro parts be used. Parts lists for Foxboro Instruments may be obtained by writing to your Foxboro Representative. Always give the serial number from the instrument data plate when requesting parts lists or ordening parts. (Men unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment should not be permitted to unoertake any major service work).

REPLACEMENT

Improvements in design, materials, or methods sometimes make it worth while to replace rather than repair an instrument which has been in service for a long period of time. We can help you in every way possible in discussing such problems with you.

In this way you will be made aware of the latest available equipment.

CHARTS

Since the accuracy of any recording instrument depends, finally, on the accuracy of the cart, the use of Foxboro Humitex Carts with Foxboro Instruments is essential if full performance of the instrument is to be realized.

FOXBORO

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

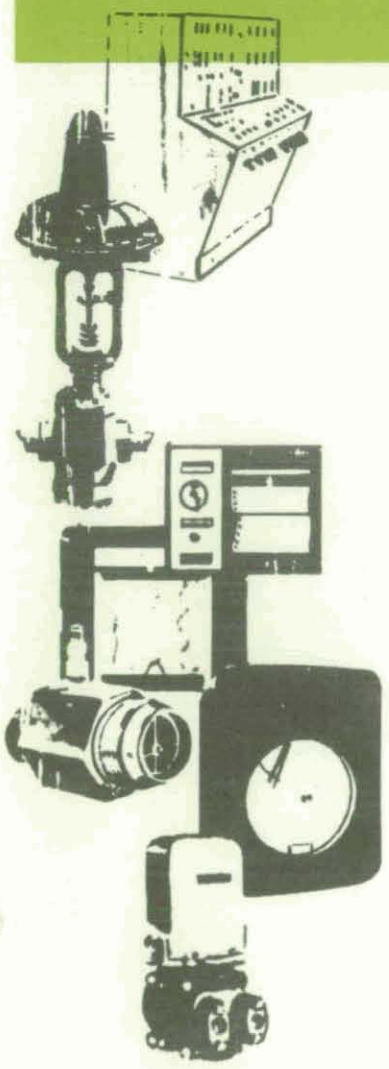
Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

FOXBORO®

MS 0283

Printed in the Netherlands

INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct installation of your Foxboro Instruments, and in their proper operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number.*

Book No. 6 1017

FOXBORO

Foxboro Yoxall
A Division of Foxboro Great Britain Limited

Redhill Surrey England
RH1 2HL
Tel: Redhill (0737) 65000
Telex: 892852
Telegram: Yoxbri Redhill

Guarantee

The Company undertakes to replace free of charge any component of its own manufacture (which excludes electronic tubes) which, in the opinion of the Company, is not within the specified limit of calibration or is defective in material or workmanship under normal or proper use, provided that the same is returned at the customer's risk and expense to the Company's works within twelve months from the date of the despatch by the Company of the equipment to the customer.
All representations, conditions, guarantees and warranties by law or otherwise howsoever expressed or implied are hereby excluded to the intent, except as above provided, after delivery to and acceptance by the customer of any equipment or apparatus, the Company shall not be liable for any loss, damage, injury, delay or expense or consequential loss or damage howsoever arising from or in respect of the equipment or apparatus or the use thereof.

Pyrometer Thermocouples, Resistance Thermometer Bulbs, and Protection Tubes, on account of the severity of their usage, are not subject to replacement unless returned unused.

The Company shall not be liable for loss, damage, detention or delay caused by fire, strike, civil, or military authority, insurrection or riot, or for other cause beyond its reasonable control. Acceptance of apparatus by the Purchaser shall constitute a waiver of all claims for delay.

Service

The Company is anxious to be of every possible assistance to you, to ensure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service in the British Isles should be made with the Company at Redhill. In other parts of the World arrangements should be made through the nearest Representative and/or Factory listed at the end of this book.
A unique feature of Foxboro service — of particular interest to Companies which do not have Instrument Departments or enough qualified Staff to carry out regular inspection and maintenance — is the Service Contract. Under this arrangement, a Foxboro Service Engineer will call at stated intervals to check the condition and operation of all Foxboro Instruments in your Plant. The Service Contract is also used by Companies for the routine inspection and maintenance of highly technical instrumentation which requires specialised knowledge and experience.
The Company provides an expertly staffed and fully equipped Training Centre at Redhill devoted to the instruction of customers' Instrumentation Engineers and Service Men. The courses cover: theory of operation maintenance and application of the principal types of instruments. Applications from Companies in the British Isles should be made to Redhill, Surrey; from those in other parts of the world, to our nearest Representative as listed at the end of this book.

Parts

Parts Lists for Foxboro Instruments may be obtained by writing to the above address. It is strongly urged that only genuine Foxboro parts be used. Always give the serial number from the instrument data plate when requesting parts lists or ordering parts. (Those unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment, should not be permitted to undertake any major service work.)

Replacement

The Company has considerable knowledge and experience in regard to the economic life of Foxboro instrument equipment and will give advice on the desirability or otherwise, of fitting new parts into the older models. Improvements in design, materials, or methods sometimes make it more economic to replace rather than repair an instrument which has been in service for a long period of time.

Charts

To obtain the most accurate and consistent recording performance from our instruments, we strongly recommend the use of genuine Foxboro strip and circular charts.

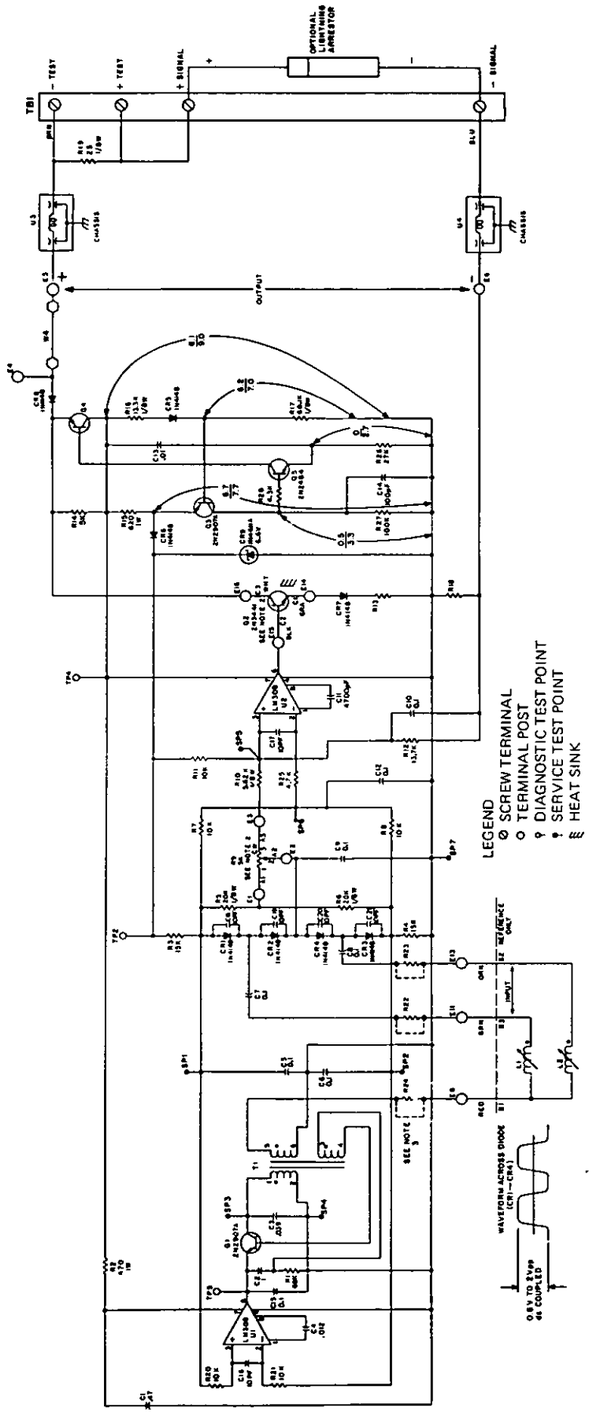
FOXBORO

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

FOXBORO®



NOTES:
1. Unless otherwise specified, resistors are in ohms, ¼ W and capacitors are in microfarads.
2. Resistor R9 and R10 and transistor Q2 are not part of printed wiring board assembly.
3. Resistors R22, R23, and R24 are used in converters with 4 to 20 mA output. Wire jumpers replace these resistors in converters with 10 to 50 mA output.
4. Where two voltages are shown, voltages represent range in which voltage is correct.

Schematic Diagram
10102UV

10/78

Printed in England

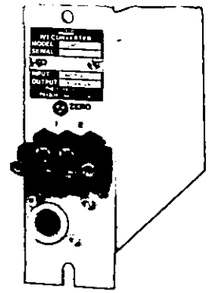
Instruction

MI
20-411
June 1979

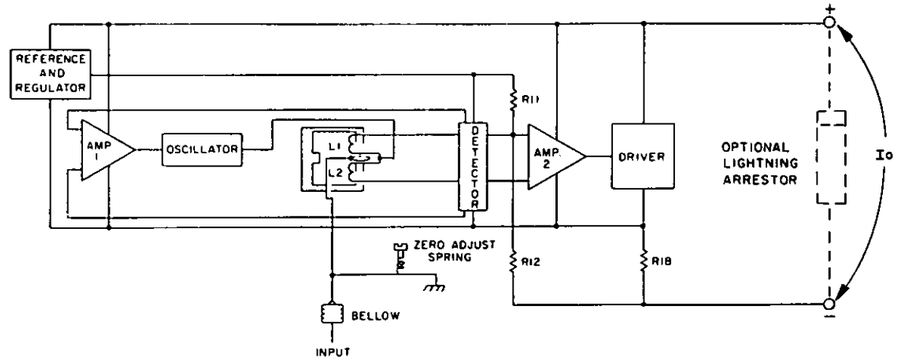
E92-R SERIES
PNEUMATIC-TO-CURRENT CONVERTER
(Rack-Mounted) Style B

The E92-R Series Converter receives a pneumatic pressure signal and transmits it as a proportional electrical 4 to 20 mA or 10 to 50 mA output signal.

When two values of current are given in this instruction, the first value is for converters with a 4 to 20 mA output, and the second value, which is in parentheses, is for converters with a 10 to 50 mA output.



Principle of Operation



The input signal is applied to a bellows which moves a lever fastened to a closed loop. The movement of the loop changes the inductance in coils L1 and L2, also changing the amplitude of the LC oscillator. The change in oscillator amplitude is sensed by a detector, which develops a voltage drop across resistor R12. The voltage drop is then fed to amplifier 2 which is used to drive the output transistor producing output current I_o. The output current is sensed by resistor R18 and fed back to the other input of amplifier 2. Resistor R11 is used to bias amplifier 2.

When the input signal is at 60 kPa or 9 psi and the converter output at 12 mA (30 mA), the loop is at the mechanical center position. Amplifier 1 causes the sum of the currents through L1 and L2 to be equal to a reference current by regulating the oscillator amplitude. The reference current is established by the regulator. At this stage, the oscillator output is at maximum amplitude.

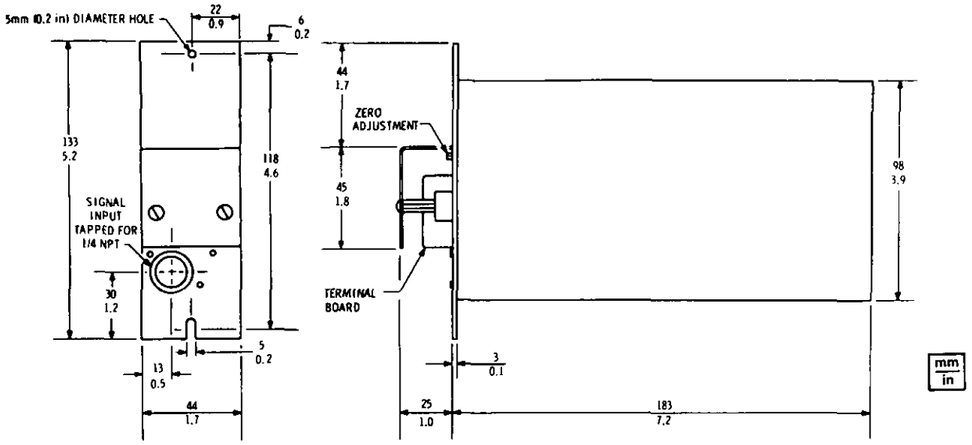
A change in input signal from 60 kPa or 9 psi, moves the loop from the mechanical center position. This causes a difference current to flow through inductors L1 and L2 producing a decrease in oscillator amplitude. Depending on whether the difference current is positive or negative, the output current will either increase or decrease from the 12 mA (30 mA) center position.

FOXBORO®

Specifications

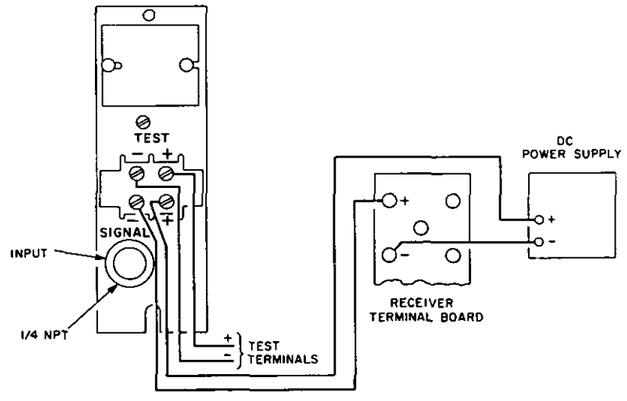
Input Signal:	20 to 100 kPa or 3 to 15 psi
Output Signal:	4 to 20 mA (see Page 3)
	10 to 50 mA into a 480 to 660 Ω load
Accuracy:	±0.25% of span
Ambient Temperature Limits:	5 and 50°C (40 and 120°F)
Power Supply:	4 to 20 mA output; 24 to 50 V dc, or +15 and -15 V dc from SPEC 200 source
	10 to 50 mA output; 63 to 100 V dc
Electrical Classification:	As listed on data plate

Converter Dimensions



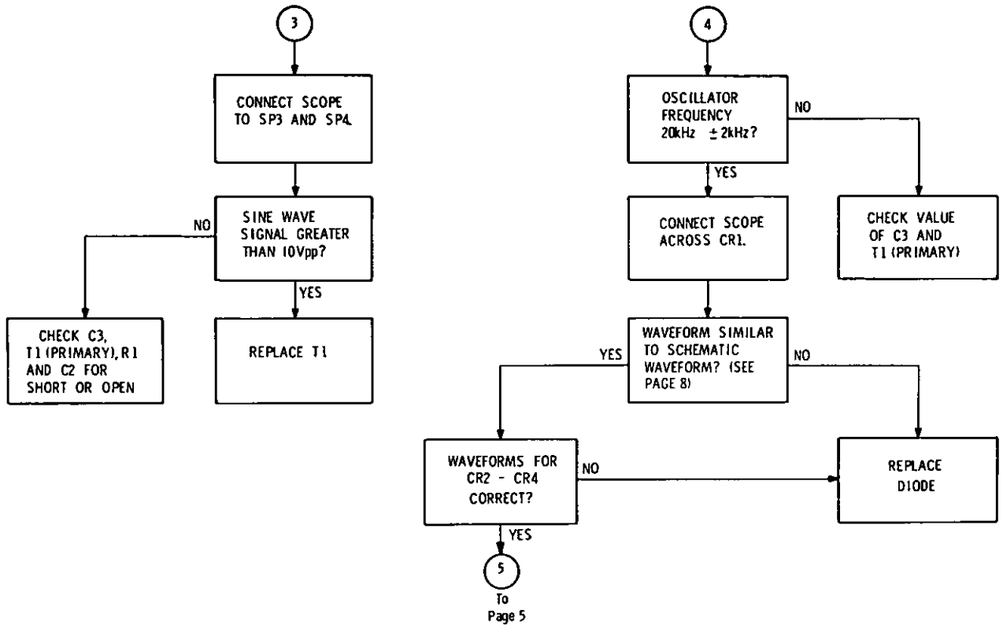
Installation Piping and Wiring

Make pneumatic and electrical connections as shown. Test terminals provide a 100 to 500 mV test signal which is directly proportional to the current output signal.

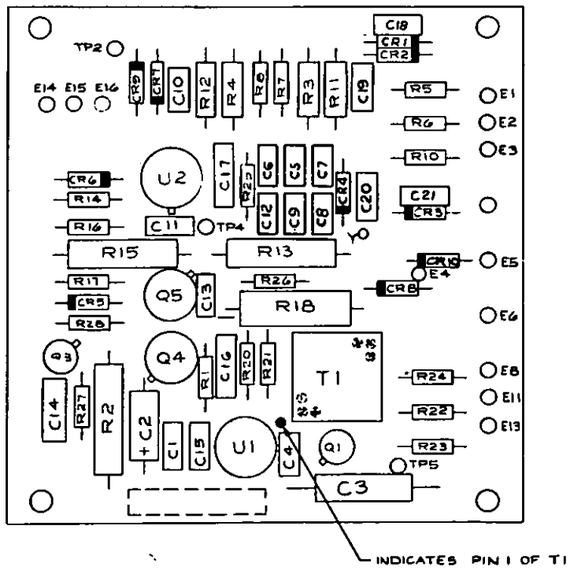


Parts List

Item	Description	Part No.
---	Printed Wiring Assembly (4-20 mA)	N0138NC
--	Printed Wiring Assembly (10-50 mA)	N0138ND
R1	Resistor, 68 kΩ ±2%, 1/4 W	E0156LY
R2	Resistor, 470 Ω ±2%, 1 W	E0158EX
R3, R4	Resistor, 15 kΩ ±0.1%, matched pair	E0286HC
R5, R6	Resistor, 20 kΩ ±1%, 1/8 W	E0133BW
R7, R8	Resistor, 10 kΩ ±2%, 1/4 W	E0156KT
R9	Potentiometer, 5 kΩ (Not part of Printed Board Assembly)	E0285TN
R10	Resistor, 5.62 kΩ ±1%, 1/8 W	E0132YR
R11, R12	Resistor, 10 kΩ, 13.7 kΩ, matched pair	E0286HE
R13	Resistor, 270 Ω ±2%, 1 W (4-20 mA)	E0158EN
	Resistor, 120 Ω ±2%, 1 W (10-50 mA)	E0158EA
R14	Resistor, 15 kΩ ±2%, 1/4 W	E0156KZ
R15	Resistor, 820 Ω ±2%, 1/4 W	E0158FE
R16	Resistor, 13.3 kΩ ±1%, 1/8 W	E0143AW
R17	Resistor, 68.1 kΩ ±1%, 1/8 W	E0143FW
R18	Resistor, 100 Ω ±0.1%, 1/4 W (4-20 mA)	E0288TK
	Resistor, 40.2 Ω ±0.1%, 1/4 W (10-50 mA)	E0288LX
R19	Resistor, 25 Ω (4-20 mA) } (Not on Printed	E0286GH
	Resistor, 10 Ω (10-50 mA) } Board Assembly)	N0143TX
R20, R21	Resistor, 10 kΩ ±2%, 1/4 W	E0156KT
R22, R23	Resistor, 43 Ω ±2%, 1/4 W (on FM Intrinsically Safe)	E0286QG
	Resistor, 750 Ω ±2%, 1/4 W (on all other 4-20 mA)	E0156FC
R24	Resistor, 560 Ω ±2%, 1 W (on FM Intrinsically Safe)	E0286QE
	Resistor, 820 Ω ±2%, 1/4 W (on all other 4-20 mA)	E0156FE
R25	Resistor, 4.7 kΩ ±2%, 1/4 W	E0156KF
R26	Resistor, 27 kΩ ±2%, 1/4 W	E0156LK
R27	Resistor, 100 kΩ ±2%, 1/4 W	E0156MC
R28	Resistor, 4.3 kΩ ±2%, 1/4 W	E0156KE
C1	Capacitor, 0.47 µF, 50 V, ceramic	H0140BK
C2	Capacitor, 1 µF, 50 V, ceramic	H0140BM
C3	Capacitor, 0.039 µF, 50 V, polycarbonate	H0176BC
C4	Capacitor, 0.012 pF, 100 V	H0110BM
C5-C10	Capacitor, 0.1 µF, 100 V	H0111CB
C11	Capacitor, 4700 pF, 100 V	H0111BC
C12	Capacitor, 0.1 µF, 100 V	H0111CB
C13	Capacitor, 0.01 µF	H0111BL
C14	Capacitor, 100 pF, mica	H0104BA
C15	Capacitor, 0.1 µF, 100 V	H0111CB
C16-C17	Capacitor, 10 pF, mica	H0104GE
C18-C21	Capacitor, 10 pF, ceramic	H0113AX
CR1-CR8	Diode, Type 1N4148	N0258DC
CR9	Diode, Type 1N4611A	N0257TZ
Q1, Q3	Transistor, Type 2N2907A	N0282AL
Q2	Transistor, Type 2N3441 (Not part of Printed Board Assembly)	K0120RZ
Q4	Transistor, Type 2N2905A (4-20 mA)	N0282EN
	Transistor, Type 2N5680 (10-50 mA)	N0282BM
Q5	Transistor, Type 2N2484 (4-20 mA)	K0120RY
	Transistor, Type 2N3440 (10-50 mA)	N0282BB
U1, U2	Operational Amplifier, Type LM308	N0284SP
T1	Transformer	N0233CF
RF1, RF2	Filter, radio frequency interference (Not on Printed Board Assembly)	H0183CA
--	Converter Assembly (Not part of Printed Board Assembly)	N0138PA



Component Location Diagram



NOTE

Resistors R22, R23, and R24 are used in converters with 4 to 20 mA output. Wire jumpers replace these resistors in converters with 10 to 50 mA output.

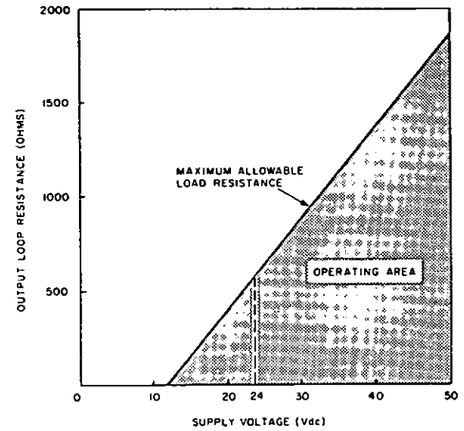
WARNING

Components R2, R22, R23, R24, R28, and CR8 are relied upon for intrinsic safety. Substitution of any of these components may invalidate applicable certification.

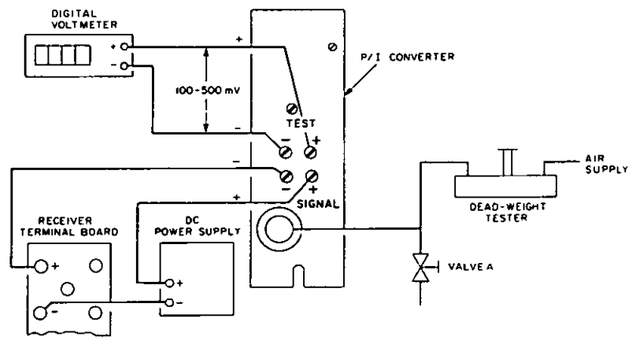
Converter Output Load Resistance (4 to 20 mA Output only)

For a given supply voltage between 24 and 50 V dc, the converter must operate within the shaded area in graph at right. For example, with a 24 V dc power supply, the converter output loop load resistance must be between 0 and 575 ohms.

To determine the converter output load resistance, add the input resistance of each component in a series loop connected to the converter output.

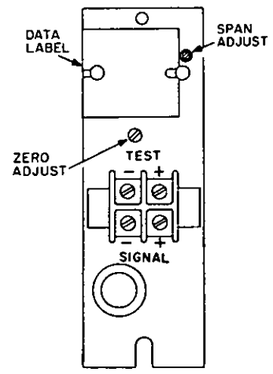


Calibration



1. Connect equipment as shown above.
2. Close Valve A.
3. Adjust dead-weight tester for 60 kPa or 9 psi output.
4. Turn zero adjustment screw until digital voltmeter measures 300 mV.
5. Adjust dead-weight tester for 100 kPa or 15 psi output.
6. Turn span adjustment screw until digital voltmeter measures 500 mV. Slide data label to the left to get access to the span adjustment screw.

   To reduce input pressure signal, open Valve A.
7. Adjust dead-weight tester for 20 kPa or 3 psi output. Digital voltmeter should measure 100 mV.
8. Repeat Steps 3 through 7 until outputs are correct without adjustment.

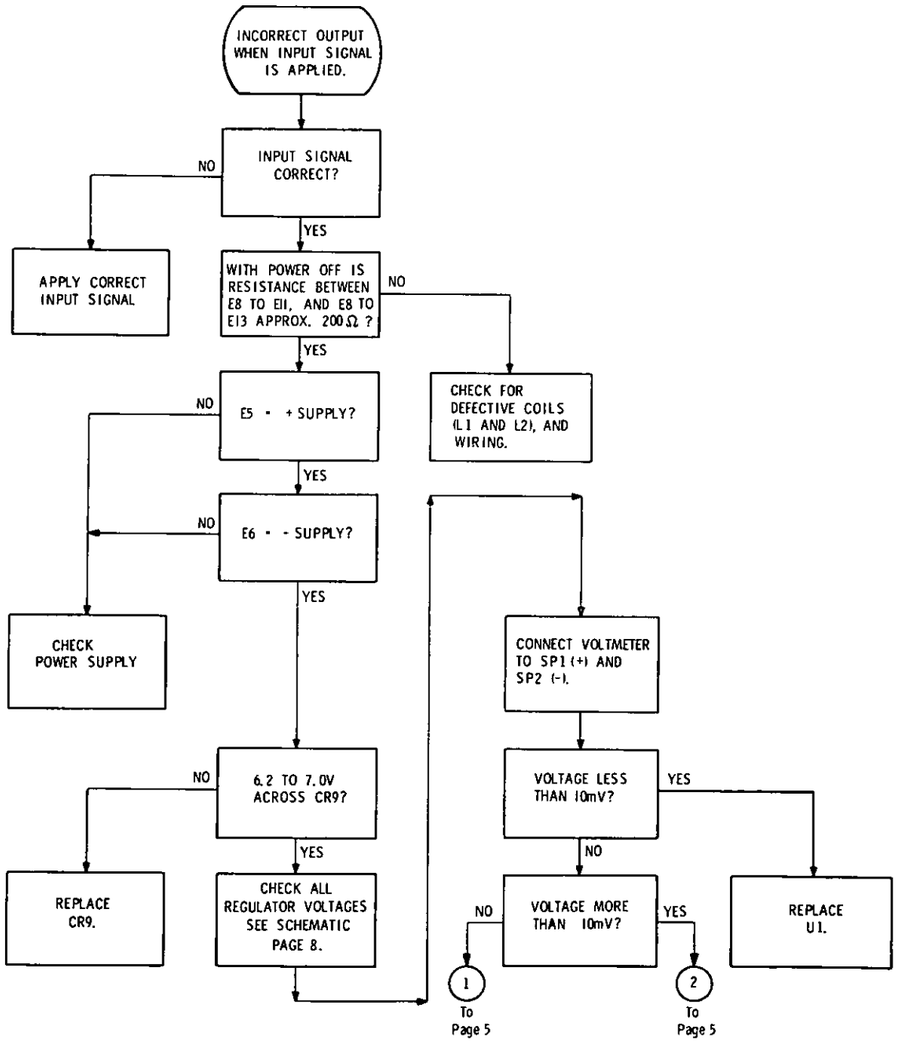


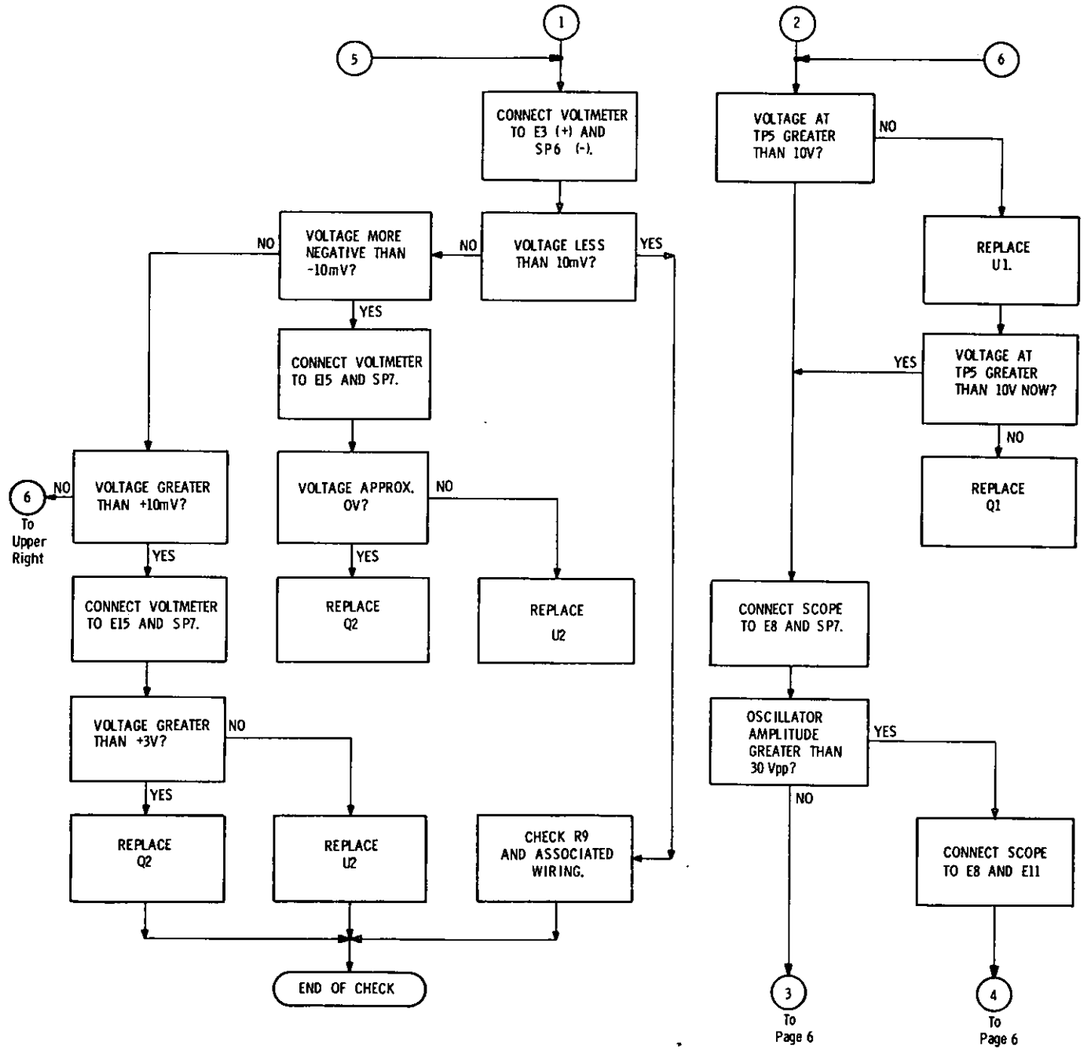
Fault Location (Troubleshooting)

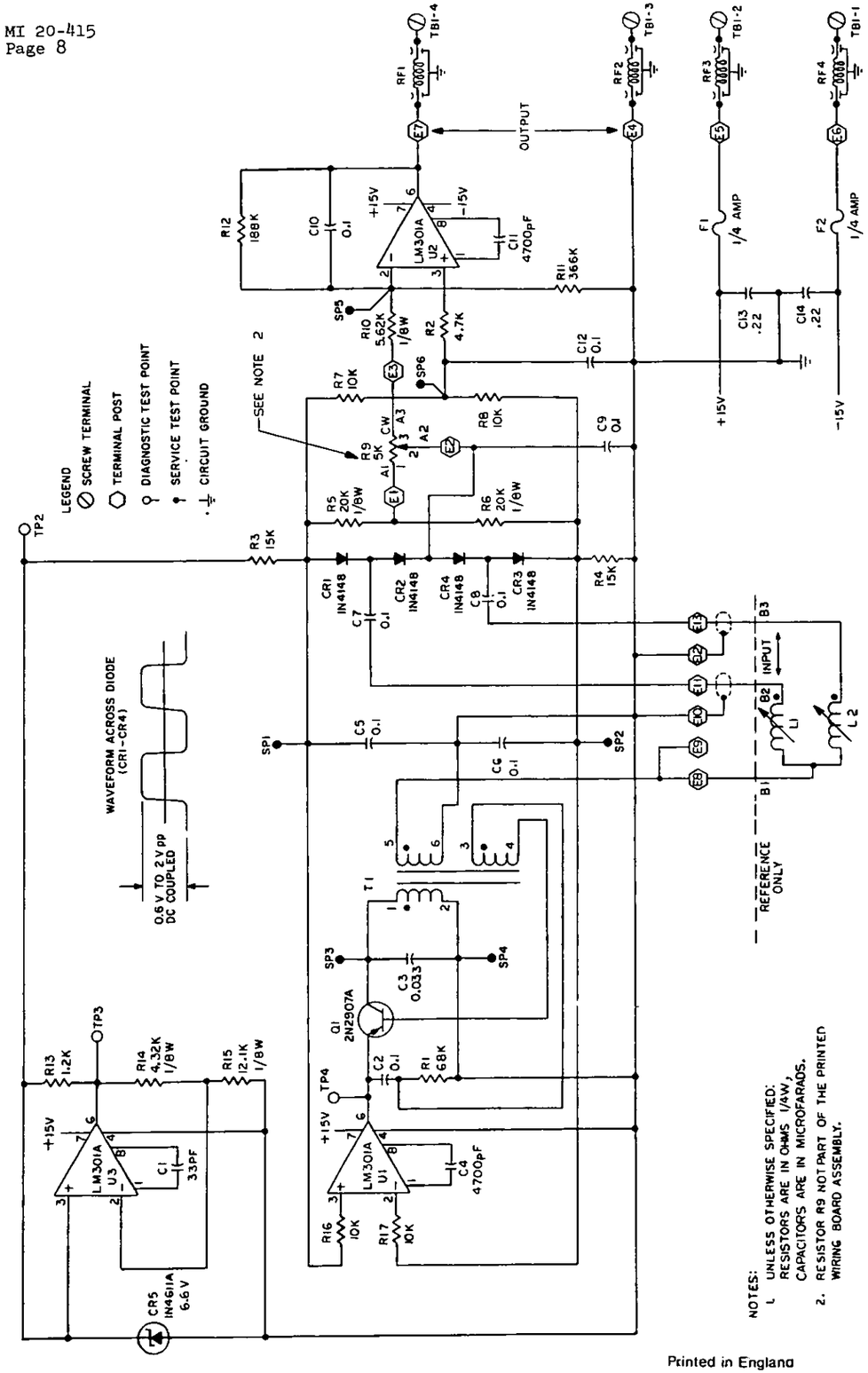
This section includes the following aids: (1) flow diagrams, (2) component diagrams, (3) schematic diagram, and (4) parts list.

The flow diagrams consist of servicing checks to be made with fault isolating branches to be taken when a malfunction is encountered.

Service points referred to on the flow diagrams (such as SP3) are shown on the schematic diagram. All voltages are referenced to E6 on schematic diagram unless otherwise specified.







Schematic
(For Parts List, see Page 7)

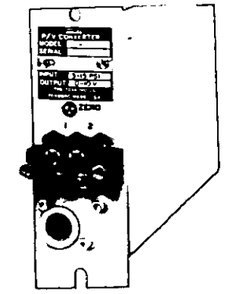
NOTES:
1. UNLESS OTHERWISE SPECIFIED: RESISTORS ARE IN OHMS 1/4W, CAPACITORS ARE IN MICROFARADS.
2. RESISTOR R9 NOT PART OF THE PRINTED WIRING BOARD ASSEMBLY.

Printed in England 7/78

Instruction

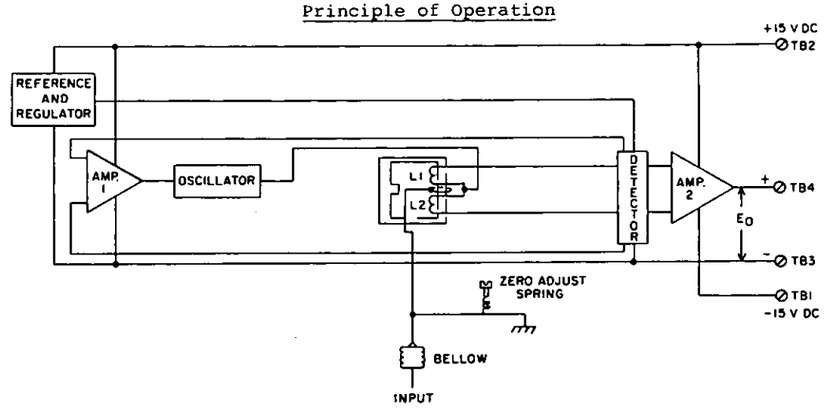
MI
20-415
June 1979

E92-R SERIES PNEUMATIC-TO-VOLTAGE CONVERTER
(Rack-Mounted) Styles A and B



The E92-R Series Converter receives a pneumatic 20 to 100 kPa or 3 to 15 psi pressure signal and transmits it as a proportional 0 to 10 V dc output signal.

Principle of Operation



The input signal is applied to a bellows which moves a lever fastened to a closed loop. The movement of the loop changes the inductance in coils L1 and L2, also changing the amplitude of the LC oscillator. The change in oscillator amplitude is sensed by a detector, which develops a voltage drop across a resistor. The voltage drop is then fed to amplifier 2 which produces output voltage E_o.

When the input signal is at 60 kPa or 9 psi and the converter output at 5 V, the loop is at the mechanical center position. Amplifier 1 causes the sum of the currents through L1 and L2 to be equal to a reference current by regulating the oscillator amplitude. The reference current is established by the regulator. At this stage, the oscillator output is at maximum amplitude.

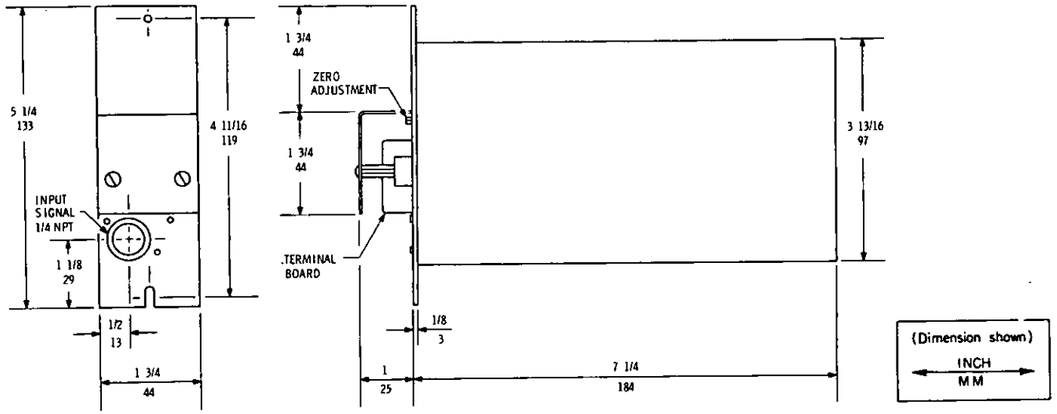
A change in input signal from 60 kPa or 9 psi, moves the loop from the mechanical center position. This causes a difference current to flow through inductors L1 and L2 producing a decrease in oscillator amplitude. Depending on whether the difference current is positive or negative, the output current will either increase or decrease from the 5 V center position.

FOXBORO®

Specifications

Input Signal:	3 to 15 psi or 20 to 100 kPa
Output Signal:	0 to 10 V dc
Accuracy:	±0.25% of span
Ambient Temperature:	40 to 120 °F (5 to 50 °C)
Output Load:	2 kΩ to infinity
Power Supply:	+15 V dc ±5%, 8 mA -15 V dc ±5%, 2 mA
Mounting:	Rack

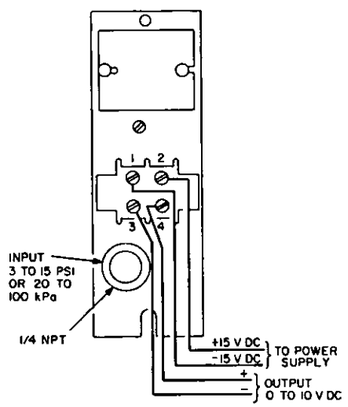
Converter Dimensions



Installation Piping and Wiring

Make pneumatic and electrical connections as shown.

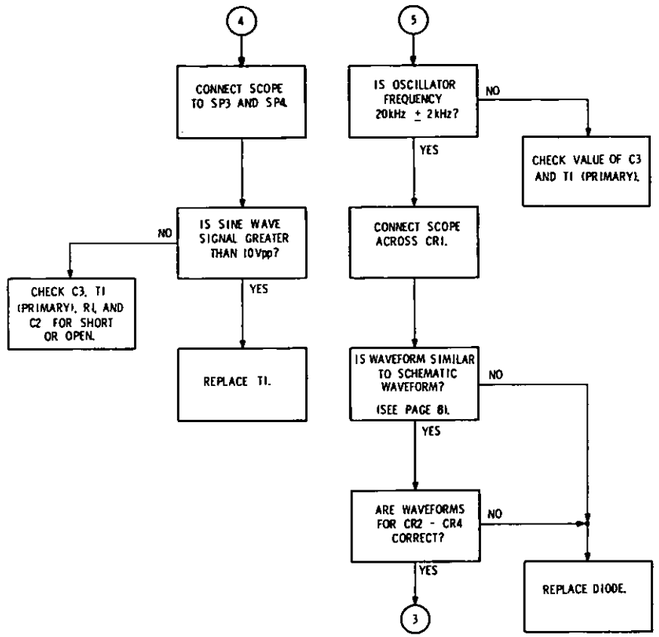
NOTE: Connect output (-) to system common, or power supply common to system common.



Parts List

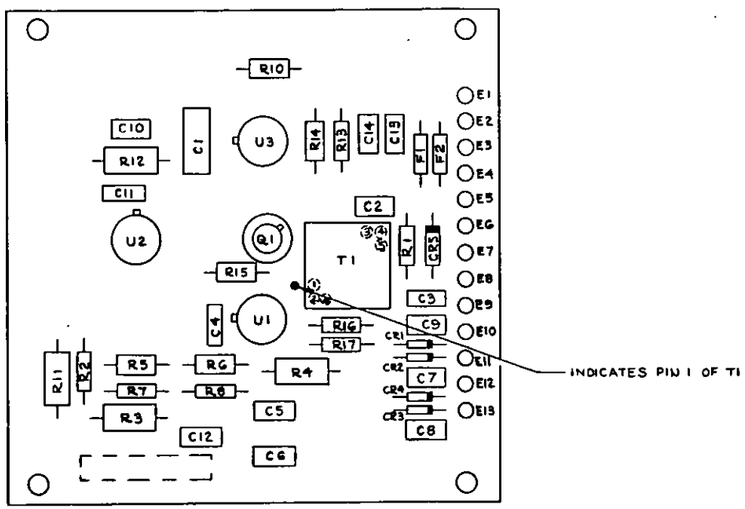
Item	Description	Part No.
-	Printed Wiring Board	N0138NE
R1	Resistor, 68 kΩ ±2%, 1/4 W	E0156LY
R2	Resistor, 4.7 kΩ ±2%, 1/4 W	E0156KF
R3, R4	Resistors, 15 kΩ ±0.1%, matched pair	E0286HC
R5, R6	Resistors, 20 kΩ ±1%, 1/8 W	E0133BW
R7, R8	Resistors, 10 kΩ ±2%, 1/4 W	E0156KT
R9	Potentiometer, 5 kΩ (not on printed wiring board)	E0285TN
R10	Resistor, 5.62 kΩ ±1%, 1/8 W	E0132YR
R11, R12	Resistors, 366 kΩ, 188 kΩ, matched set	E0286HD
R13	Resistor, 1.2 kΩ ±2%, 1/4 W	E0156FM
R14	Resistor, 4.32 kΩ ±1%, 1/8 W	E0142XZ
R15	Resistor, 12.1 kΩ ±1%, 1/8 W	E0143AP
R16, R17	Resistors, 10 kΩ ±2%, 1/4 W	E0156KT
C1	Capacitor, 33 pF, 500 V	H0104AK
C2	Capacitor, 0.1 µF, 100 V	H0111CB
C3	Capacitor, 0.033 µF, 50 V	H0110BT
C4	Capacitor, 4700 pF, 100 V	H0111BC
C5-C10	Capacitors, 0.1 µF, 100 V	H0111CB
C11	Capacitor, 4700 pF, 100 V	H0111BC
C12	Capacitor, 0.1 µF, 100 V	H0111CB
C13, C14	Capacitors, 0.22 µF, 50 V	H0140BC
CR1-CR4	Diodes, Type 1N4148	N0258DC
CR5	Diode, Zener, Type 1N4611A	N0257TZ
RF1-RF4	Filters, radio frequency interference (not on printed board)	H0183CA
Q1	Transistor, Type 2N2907A	N0282AL
U1-U3	Integrated Circuits, Type LM301A	N0284LW
T1	Transformer	N0233CF
F1, F2	Fuses, 1/4 A	N0262AB
-	Transistor Pad	N0264BL
-	Converter Assembly (not on printed board)	N0138PA

Troubleshooting (continued)

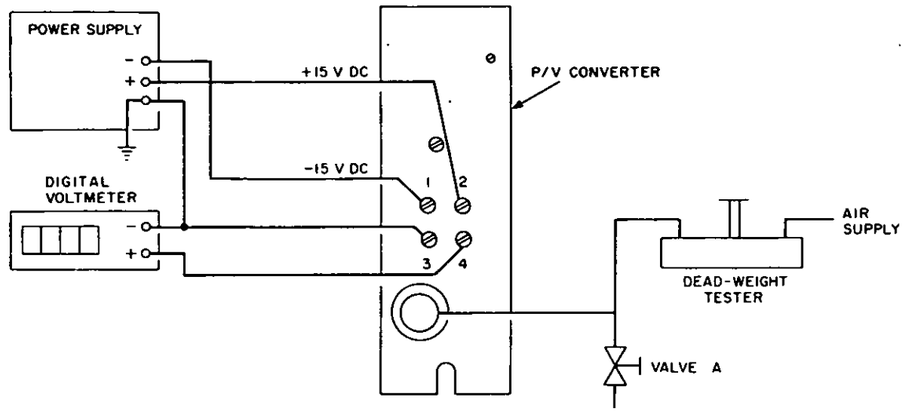


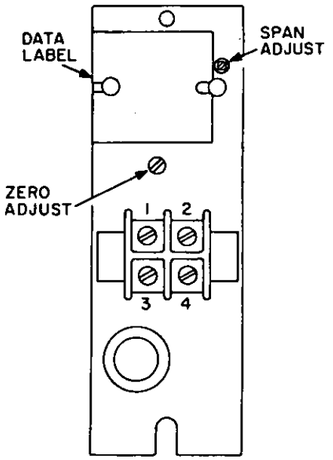
CONTINUED ON PAGE 5

Component Location Diagram



Calibration





1. Connect equipment as shown above.
2. Close Valve A.
3. Adjust dead-weight tester for 60 kPa or 9 psi output.
4. Turn zero adjustment screw until digital voltmeter measures 5 V.
5. Adjust dead-weight tester for 100 kPa or 15 psi output.
6. Turn span adjustment screw until digital voltmeter measures 10 V. Slide data label to the left to get access to the span adjustment screw.

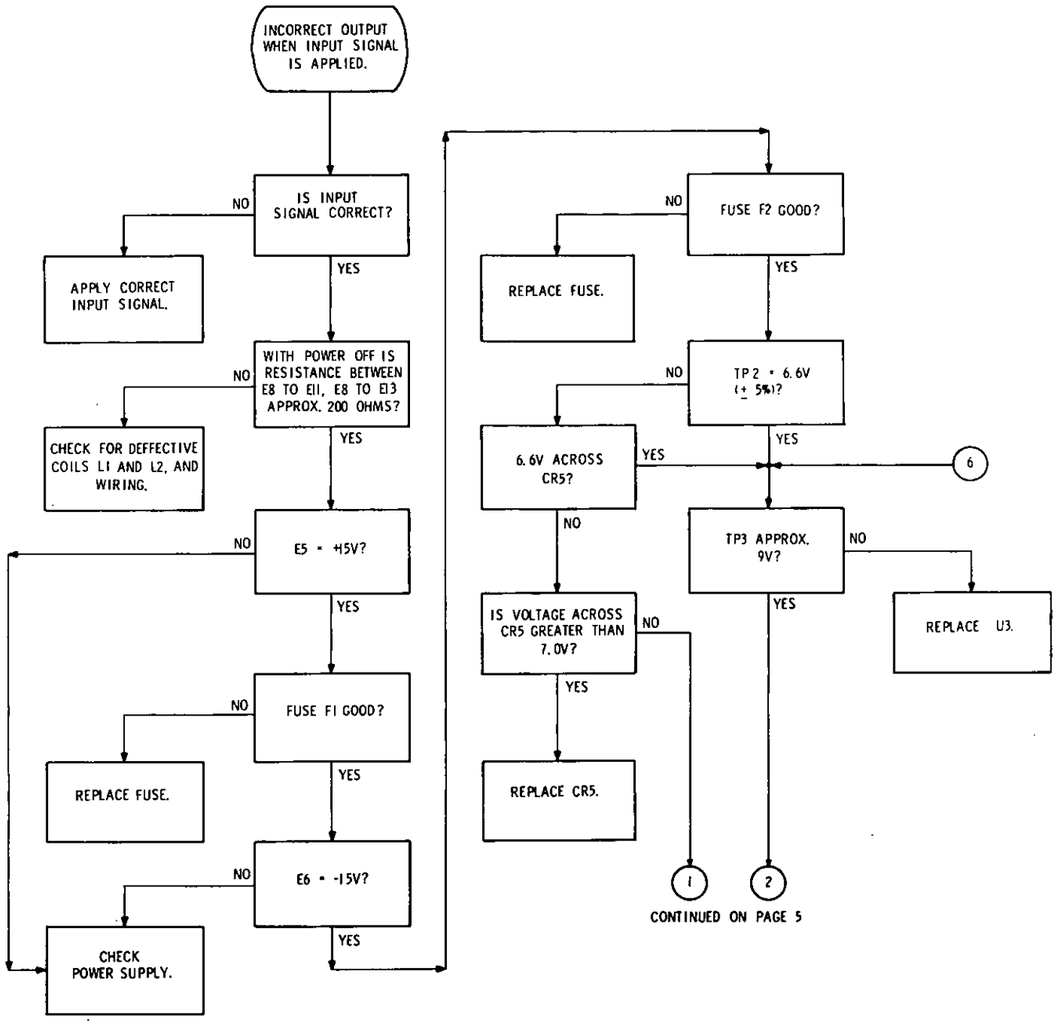
   To reduce input pressure signal, open Valve A.
7. Adjust dead-weight tester for 20 kPa or 3 psi output. Digital voltmeter should measure 0 V.
8. Repeat Steps 3 through 7 until outputs are satisfactory without adjustments.

Troubleshooting

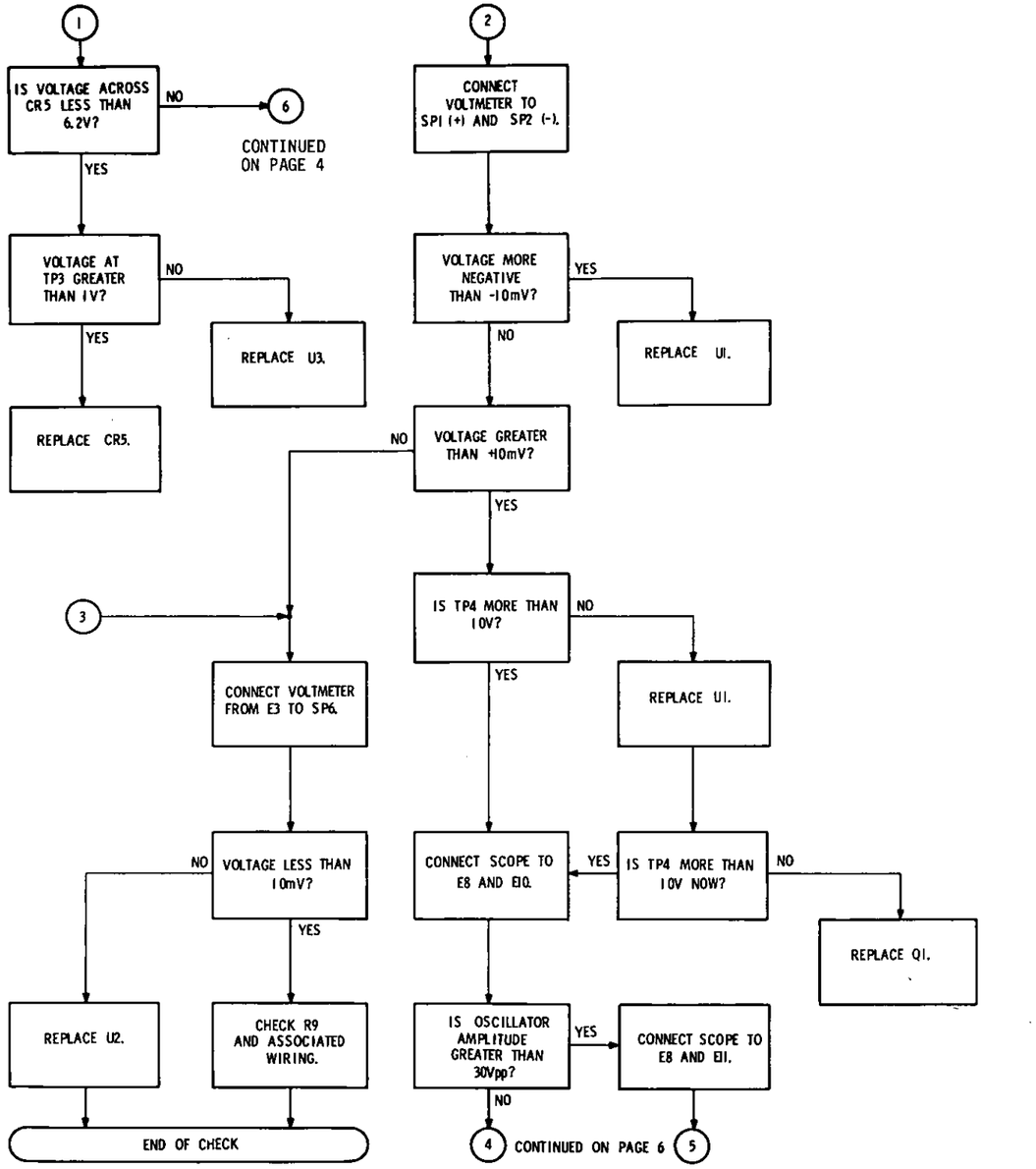
This section includes the following troubleshooting aids: (1) troubleshooting flow diagrams, (2) component diagram, (3) schematic diagram, and (4) parts list.

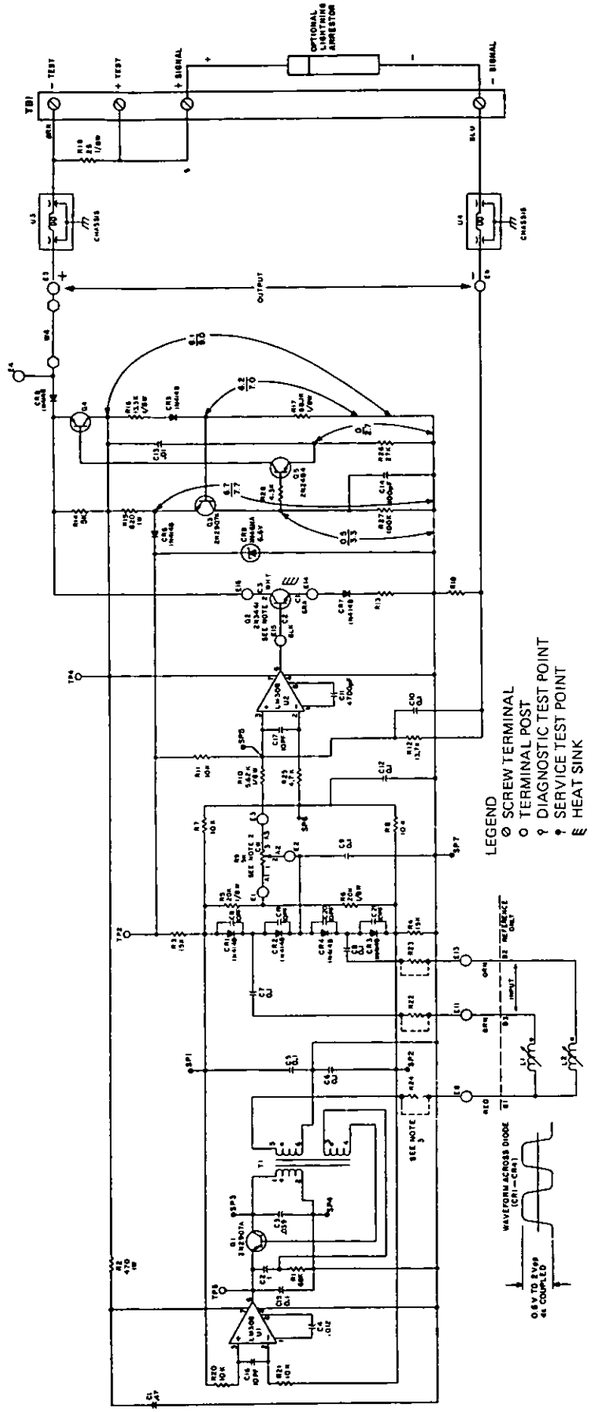
The troubleshooting flow diagrams consist of servicing checks to be made with fault isolating branches to be taken when a malfunction is encountered.

Service points referred to on the flow diagrams (such as SP3) are shown on the schematic diagram. All voltages are referenced to E4 on schematic diagram unless otherwise specified.



Troubleshooting (continued)





Schematic Diagram
10102UV

NOTES:
1. Unless otherwise specified, resistors are in ohms, ¼ W and capacitors are in microfarads.
2. Resistor R9 and R10 and transistor Q2 are not part of printed wiring board assembly.
3. Resistors R22, R23, and R24 are used in converters with 4 to 20 mA output. Wire jumpers replace these resistors in converters with 10 to 50 mA output.
4. Where two voltages are shown, voltages represent range in which voltage is correct.

10/78

Printed in England

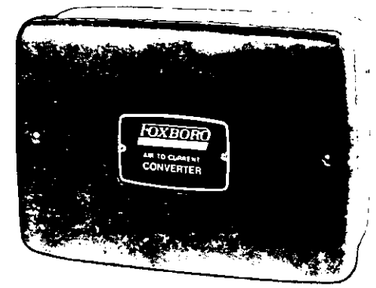
Instruction

MI
20-420
June 1979

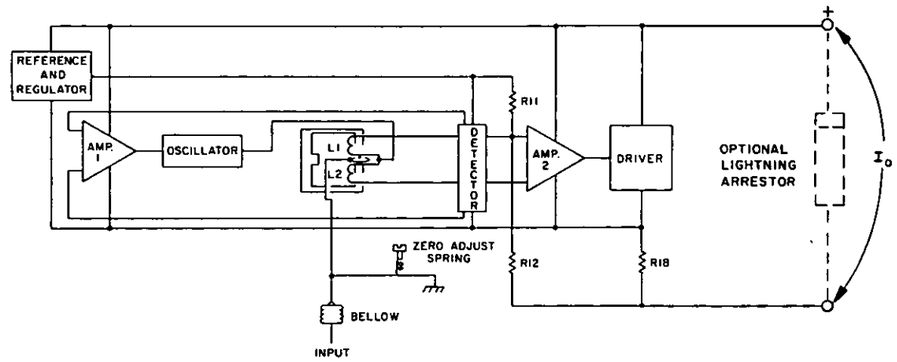
E92-F SERIES
PNEUMATIC-TO-CURRENT CONVERTER
(Field-Mounted)

The E92-F Series Converter receives a pneumatic pressure signal and transmits it as a proportional electrical 4 to 20 mA output signal.

When two values of current are given in this instruction, the first value is for converters with a 4 to 20 mA output, and the second value, which is in parentheses, is for converters with a 10 to 50 mA output.



Principle of Operation



The input signal is applied to a bellows which moves a lever fastened to a closed loop. The movement of the loop changes the inductance in coils L1 and L2, also changing the amplitude of the LC oscillator. The change in oscillator amplitude is sensed by a detector, which develops a voltage drop across resistor R12. The voltage drop is then fed to amplifier 2 which is used to drive the output transistor producing output current I_o. The output current is sensed by resistor R18 and fed back to the other input of amplifier 2. Resistor R11 is used to bias amplifier 2.

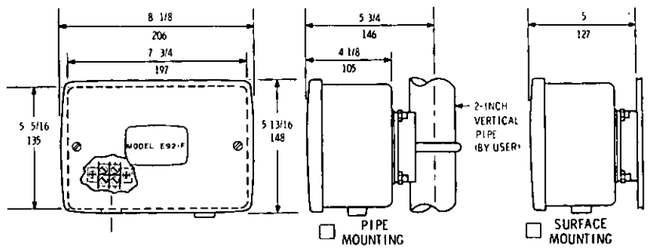
When the input signal is at 60 kPa or 9 psi and the converter output at 12 mA (30 mA), the loop is at the mechanical center position. Amplifier 1 causes the sum of the currents through L1 and L2 to be equal to a reference current by regulating the oscillator amplitude. The reference current is established by the regulator. At this stage, the oscillator output is at maximum amplitude.

A change in input signal from 60 kPa or 9 psi, moves the loop from the mechanical center position. This causes a difference current to flow through inductors L1 and L2 producing a decrease in oscillator amplitude. Depending on whether the difference current is positive or negative, the output current will either increase or decrease from the 12 mA (30 mA) center position.

Specifications

Input Signal:	20 to 100 kPa or 3 to 15 psi
Output Signal:	4 to 20 mA (see Page 3)
	10 to 50 mA into a 480 to 660 Ω load
Accuracy:	±0.25% of span
Ambient Temperature Limits:	-40 and +80°C (-40 and +180°F)
Power Supply:	4 to 20 mA output; 24 to 50 V dc, or +15 and -15 V dc from SPEC 200 source
	10 to 50 mA output; 63 to 100 V dc
Electrical Classification:	As listed on data plate

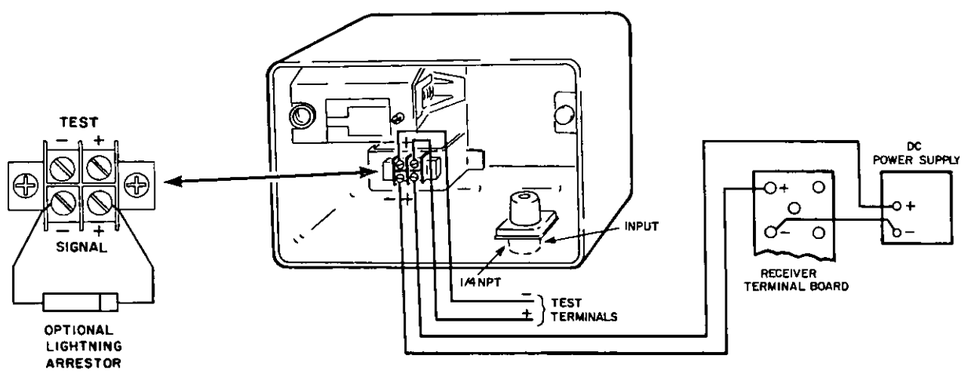
Converter Dimensions



(Dimension shown)
INCH
MM

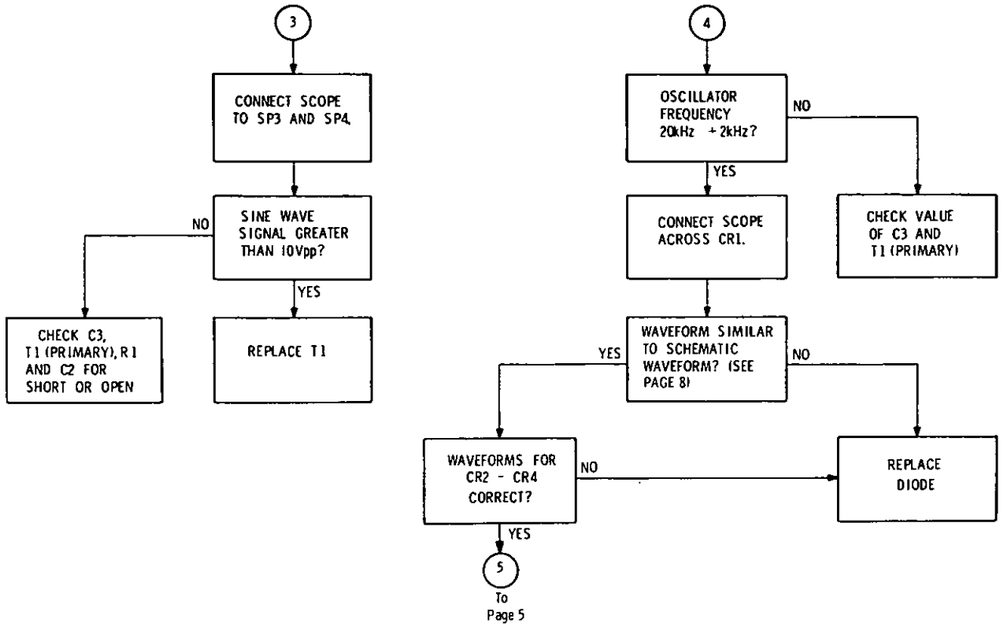
Installation Piping and Wiring

Make pneumatic and electrical connections as shown. Test terminals provide a 100 to 500 mV test signal which is directly proportional to the current output signal.

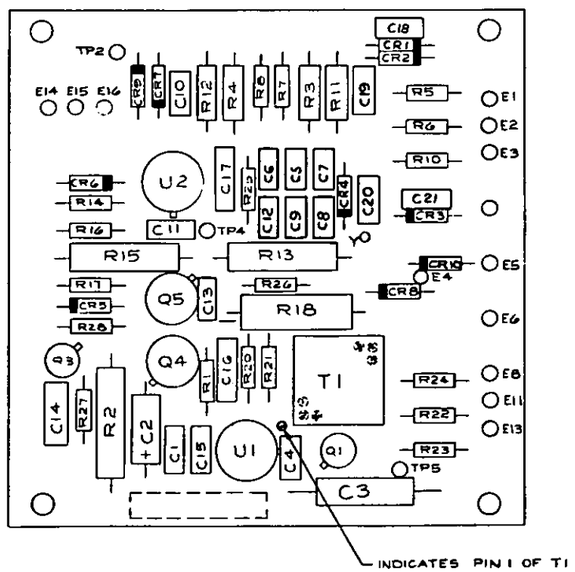


Parts List

Item	Description	Part No.
---	Printed Wiring Assembly (4-20 mA)	N0138NC
--	Printed Wiring Assembly (10-50 mA)	N0138ND
R1	Resistor, 68 kΩ ±2%, 1/4 W	E0156LY
R2	Resistor, 470 Ω ±2%, 1 W	E0158EX
R3, R4	Resistor, 15 kΩ ±0.1%, matched pair	E0286HC
R5, R6	Resistor, 20 kΩ ±1%, 1/8 W	E0133BW
R7, R8	Resistor, 10 kΩ ±2%, 1/4 W	E0156KT
R9	Potentiometer, 5 kΩ (Not part of Printed Board Assembly)	E0285TN
R10	Resistor, 5.62 kΩ ±1%, 1/8 W	E0132YR
R11, R12	Resistor, 10 kΩ, 13.7 kΩ, matched pair	E0286HE
R13	Resistor, 270 Ω ±2%, 1 W (4-20 mA)	E0158EN
	Resistor, 120 Ω ±2%, 1 W (10-50 mA)	E0158EA
R14	Resistor, 15 kΩ ±2%, 1/4 W	E0156KZ
R15	Resistor, 820 Ω ±2%, 1/4 W	E0158FE
R16	Resistor, 13.3 kΩ ±1%, 1/8 W	E0143AW
R17	Resistor, 68.1 kΩ ±1%, 1/8 W	E0143FW
R18	Resistor, 100 Ω ±0.1%, 1/4 W (4-20 mA)	E0288TK
	Resistor, 40.2 Ω ±0.1%, 1/4 W (10-50 mA)	E0288LX
R19	Resistor, 25 Ω (4-20 mA) } (Not on Printed	E0286GH
	Resistor, 10 Ω (10-50 mA) } Board Assembly)	N0143TX
R20, R21	Resistor, 10 kΩ ±2%, 1/4 W	E0156KT
R22, R23	Resistor, 43 Ω ±2%, 1/4 W (on FM Intrinsically Safe)	E0286QG
R24	Resistor, 750 Ω ±2%, 1/4 W (on all other 4-20 mA)	E0156FC
	Resistor, 560 Ω ±2%, 1 W (on FM Intrinsically Safe)	E0286QE
	Resistor, 820 Ω ±2%, 1/4 W (on all other 4-20 mA)	E0156FE
R25	Resistor, 4.7 kΩ ±2%, 1/4 W	E0156KF
R26	Resistor, 27 kΩ ±2%, 1/4 W	E0156LK
R27	Resistor, 100 kΩ ±2%, 1/4 W	E0156MC
R28	Resistor, 4.3 kΩ ±2%, 1/4 W	E0156KE
C1	Capacitor, 0.47 µF, 50 V, ceramic	H0140BK
C2	Capacitor, 1 µF, 50 V, ceramic	H0140BM
C3	Capacitor, 0.039 µF, 50 V, polycarbonate	H0176BC
C4	Capacitor, 0.012 pF, 100 V	H0110BM
C5-C10	Capacitor, 0.1 µF, 100 V	H0111CB
C11	Capacitor, 4700 pF, 100 V	H0111BC
C12	Capacitor, 0.1 µF, 100 V	H0111CB
C13	Capacitor, 0.01 µF	H0111BL
C14	Capacitor, 100 pF, mica	H0104BA
C15	Capacitor, 0.1 µF, 100 V	H0111CB
C16-C17	Capacitor, 10 pF, mica	H0104GE
C18-C21	Capacitor, 10 pF, ceramic	H0113AX
CR1-CR8	Diode, Type 1N4148	N0258DC
CR9	Diode, Type 1N4611A	N0257TZ
Q1, Q3	Transistor, Type 2N2907A	N0282AL
Q2	Transistor, Type 2N3441 (Not part of Printed Board Assembly)	K0120RZ
Q4	Transistor, Type 2N2905A (4-20 mA)	N0282EN
	Transistor, Type 2N5680 (10-50 mA)	N0282BM
Q5	Transistor, Type 2N2484 (4-20 mA)	K0120RY
	Transistor, Type 2N3440 (10-50 mA)	N0282BB
U1, U2	Operational Amplifier, Type LM308	N0284SP
T1	Transformer	N0233CF
RF1, RF2	Filter, radio frequency interference (Not on Printed Board Assembly)	H0183CA
--	Converter Assembly (Not part of Printed Board Assembly)	N0138PA



Component Location Diagram



NOTE

Resistors R22, R23, and R24 are used in converters with 4 to 20 mA output. Wire jumpers replace these resistors in converters with 10 to 50 mA output.

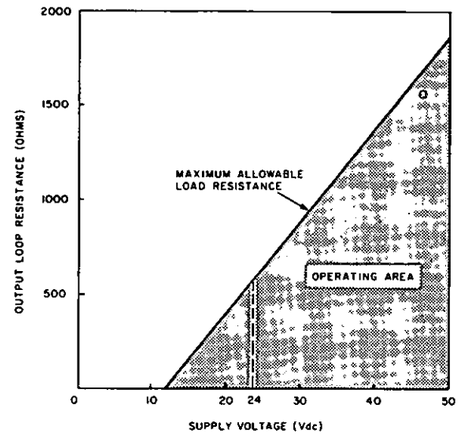
WARNING

Components R2, R22, R23, R24, R28, and CR8 are relied upon for intrinsic safety. Substitution of any of these components may invalidate applicable certification.

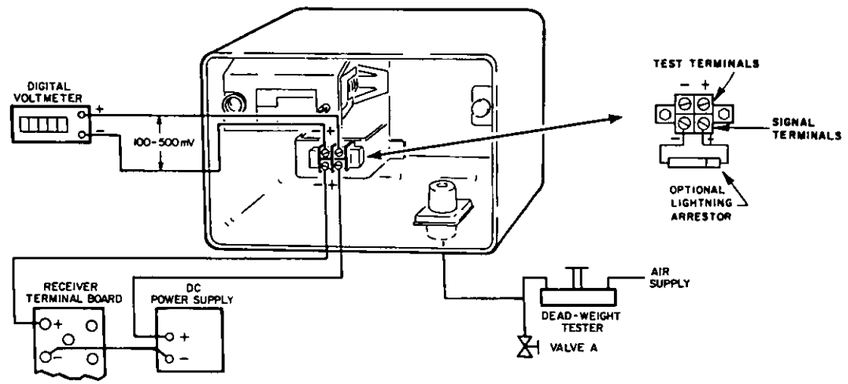
Converter Output Load Resistance
(4 to 20 mA Output only)

For a given supply voltage between 24 and 50 V dc, the converter must operate within the shaded area in graph at right. For example, with a 24 V dc power supply, the converter output loop load resistance must be between 0 and 575 ohms.

To determine the converter output load resistance, add the input resistance of each component in a series loop connected to the converter output.

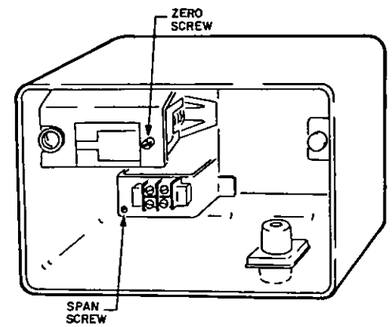


Calibration



1. Connect equipment as shown above.
2. Close Valve A.
3. Adjust dead-weight tester for 60 kPa or 9 psi output.
4. Turn zero adjustment screw until digital voltmeter measures 300 mV.
5. Adjust dead-weight tester for 100 kPa or 15 psi output.
6. Turn span adjustment screw until digital voltmeter measures 500 mV.

   To reduce input pressure signal, open Valve A.
7. Adjust dead-weight tester for 20 kPa or 3 psi output. Digital voltmeter should measure 100 mV.
8. Repeat Steps 3 through 7 until outputs are correct without adjustment.

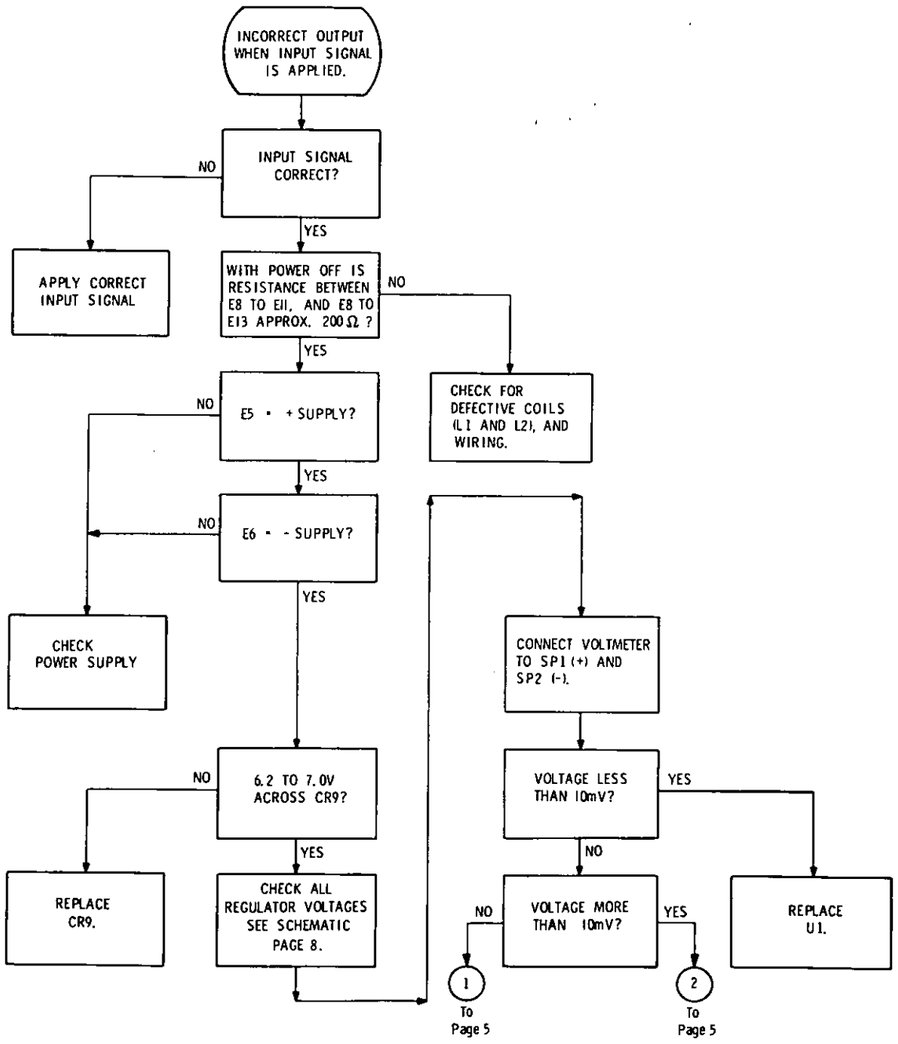


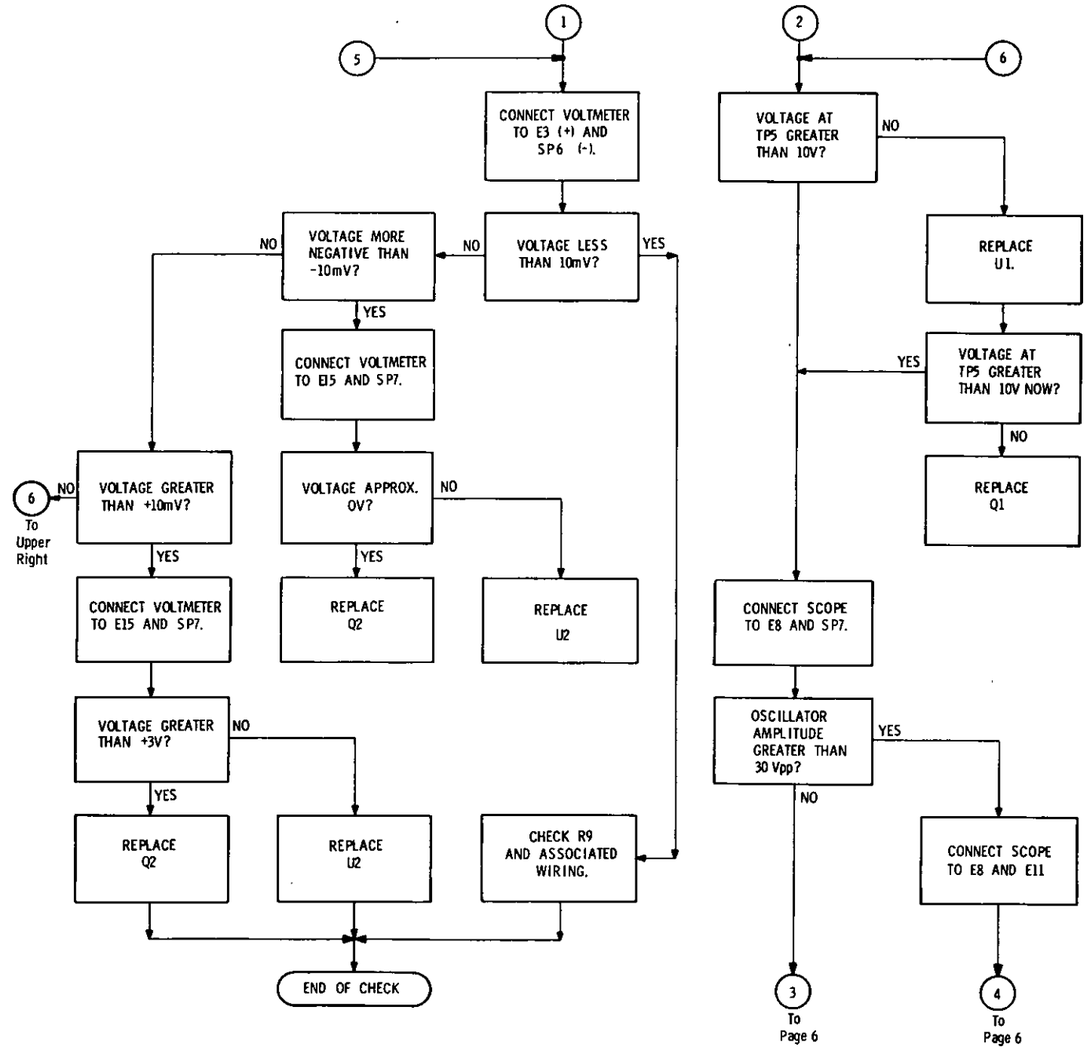
Fault Location (Troubleshooting)

This section includes the following aids: (1) flow diagrams, (2) component diagrams, (3) schematic diagram, and (4) parts list.

The flow diagrams consist of servicing checks to be made with fault isolating branches to be taken when a malfunction is encountered.

Service points referred to on the flow diagrams (such as SP3) are shown on the schematic diagram. All voltages are referenced to E6 on schematic diagram unless otherwise specified.





Parts List

PL
008-430
October 1983

E92-R
P/I AND P/V CONVERTERS

Styles A and B

Model Code

E92-R = P/I and P/V Converter, Rack Mounted

Testing Laboratory
B = BASEEFA
C = CSA
F = FM

Design Requirements—Equipment Location
A = Intrinsically Safe, (Ex)ia, Zone 0 (When used with Certified SPEC 200 I/O Module)
B = Intrinsically Safe, (Ex)ib, Zone 1, Div. 1 (see note)
N = "Nonsparking" and other Type N, (Ex)n, Div. 2, Zone 2
G = Ordinary Locations

Input Signal
2 = 3 to 15 psi
3 = 3 to 27 psi (20.7 to 186.2 kPa)
4 = 0.2 to 1.0 kg/cm²
5 = 20 to 100 kPa
6 = 0.2 to 1.0 bar

Output Signal
H = 10 to 50 mA dc
I = 4 to 20 mA dc
V = 0 to 10 V dc

Optional Suffix (P/I ONLY)
-A = Lightning Arrestor

Note: Intrinsically Safe (Div. 1) available with 4 to 20 mA dc output signal ONLY.

MB 150

Printed in England

1083

FOXBORO®

E92-R CONVERTERS
Styles A and B

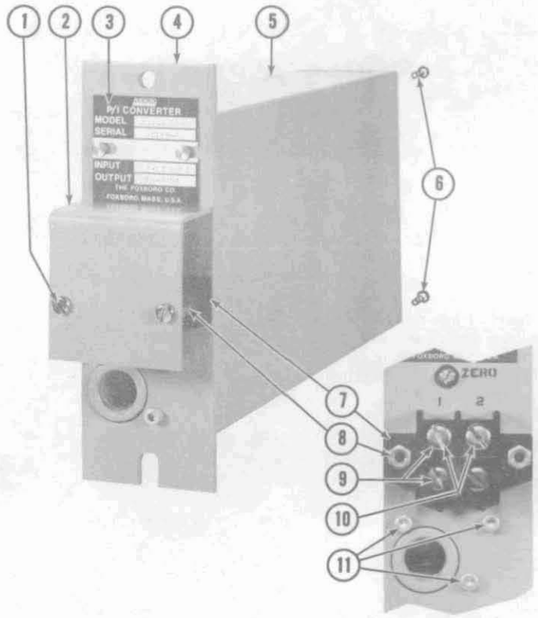


Figure E839

Item	Part No.	Qty.	Part Name
1	X0122UH	2	Screw, Pan H., 0.138-32 x 0.250
2	N0138NK	1	Terminal Board Cover
3	Below	1	Data Plate
	N0138NX		Output Code V
	N0138NM		Output Code H or I
4	Below	1	Frame Assembly
	N0138NJ		Output Code H or I
	N0138RN		Output Code V
5	N0138PJ	1	Cover
6	N0138QB	2	Screw (special)
7	N0138PR	1	Terminal Board
8	N0138NL	2	Column
9	X0116CR	4	Screw, Pan H., 0.164-32 x 0.250
10	N0138NW	2	Column, (Output Code V only)
11	X0116MZ	3	Screw, Socket H., 0.125-40 x 0.312

***Parts preceded by asterisks are those more commonly replaced**
GIVE INSTRUMENT SERIAL NUMBER WHEN ORDERING

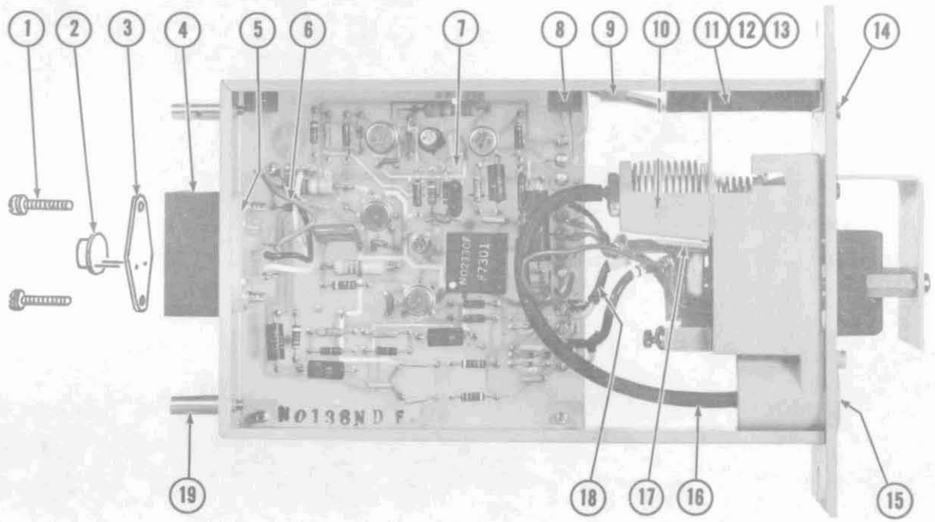


Figure E840

Item	Part No.	Qty.	Part Name
1	K0121XS	2	Screw, Tapping
2	N0282AN	1	Transistor, 2N3441
3	K0121XW	1	Spacer
4	N0264AP	1	Heat Sink (Style A)
5	K0120SX	1	Socket
6	—	3	Copper Wire, 50 mm (2 in) lengths, 0.2 mm² (24 AWG)

Items 1-6 on mA output models (H and I) only.

7	Below	1	Printed Circuit Board
	N0138NC		Output Code I
	N0138ND		Output Code H
	N0138NE		Output Code V
—	N0262AB	2	1/4 A Fuse
	N0138QG		Output Code I, FM version only
8	X0169RJ	4	Screw, B.H., 0.112-40 x 0.312
9	X0167KK	3	Clip
10	Below	1	Converter Assembly
	N0138PA		3 to 15 psi Input (Code 2) 0.2 to 1.0 kg/cm² (Code 4) 20 to 100 kPa (Code 5) 0.2 to 1.0 bar (Code 6)
	N0138KR		3 to 27 psi (Code 3)
11	E0285UW	1	Potentiometer
12	X0169RC	2	Screw, Pan H., 0.086-56 x 0.375
13	N0138QC	2	Washer
14	N0138NV	2	Stud
15	C0128FK	1	Insert
16	R0128AA	—	Tubing, order 0.3 m (1 ft.) per instrument
17	—	3	Copper Wire, 100 mm (4 in) lengths, 0.3 mm² (22 AWG)
18	—	3	Copper Wire, 100 mm (4 in) lengths, 0.3 mm² (22 AWG)
19	C0151AG	2	Column
—	H0183CV	2	Filter (on back panel)
—	—	4	Copper Wire, 200 mm (8 in) lengths, 0.2 mm² (24 AWG), used with filters
—	T0103RA	1	Grommet (in back panel)
—	Below	1	Resistor (on back of front panel)
	E0286GH		25 Ohm (Output Code I)
	N0143TX		10 Ohm (Output Code H)
—	Below	1	Lightning Arrestor
	B0158EZ		10 to 50 mA (Output Code H)
	B0158EY		4 to 20 mA (Output Code I)

***Parts preceded by asterisks are those more commonly replaced**
GIVE INSTRUMENT SERIAL NUMBER WHEN ORDERING

Parts List

PL
008-432
April 1981

MODEL E92-F PNEUMATIC-TO-CURRENT CONVERTER

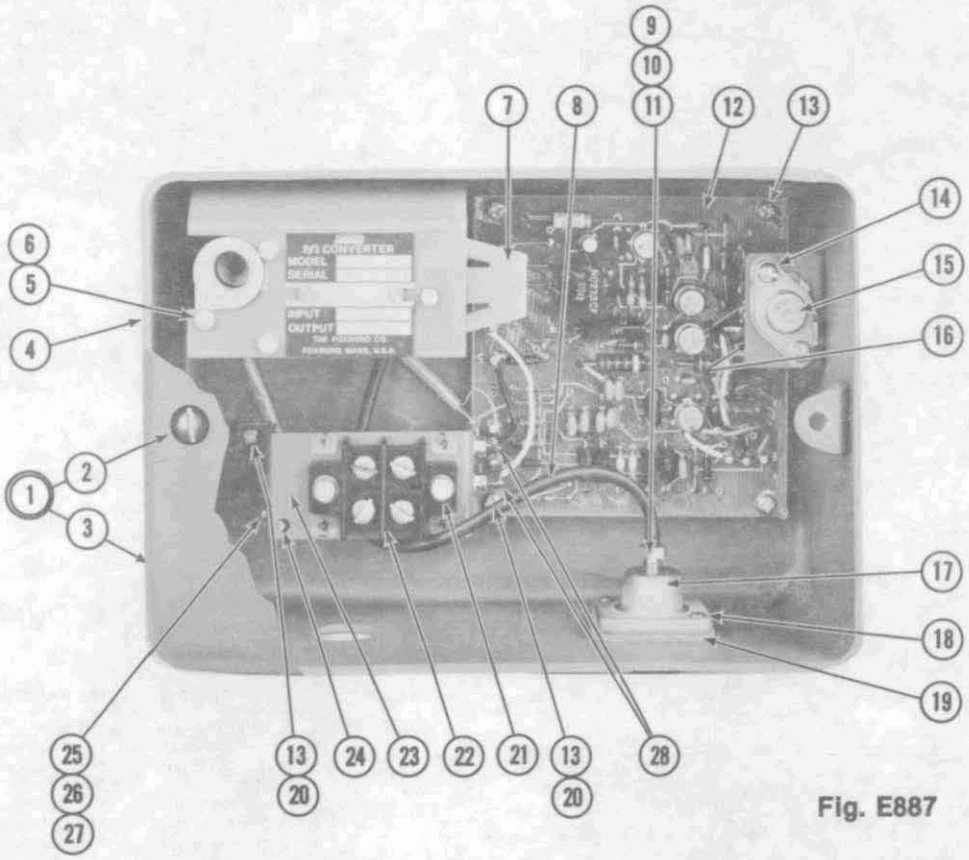


Fig. E887

m	Part No.	Qty.	Part Name
1	M0149AA	1	Cover Assembly
2	X0129RX	2	Screws, Fil.H., 0.250-28 x 0.625
—	M0148AW	2	Washers
—	B0105LA	2	Retaining Washers
3	M0117NR	1	*Gasket
—	N0138NY	1	Nameplate (not shown)
—	0025522	2	Screws, Tapping, Pan H., 0.086-32 x 0.125
4	N0138NN	1	Case Assembly
5	X0116MZ	3	Screws, Socket H., 0.125-40 x 0.312
6	0048245	3	Lockwashers
7	Below	1	Converter Assembly
	N0138KS		3 to 15 psi, 20 to 100 kPa or 0.2 to 1.0 bar or kg/cm²
	N0138KV		3 to 27 psi
8	R0128AA	—	Tubing, order 0.3 m (1 ft) per instrument
9	U0100CB	1	Compression Screw
10	X0107AA	1	Sleeve
11	C0125PA	1	Connector
12	Below	1	Circuit Board Assembly
			Output Range Classification Code
	N0138ND		10 to 50 mA FCN, FFN (H)
	N0138NC		4 to 20 mA FCA, FCN, FFN (I)
	N0138QG		4 to 20 mA FFA (I)

Item	Part No.	Qty.	Part Name
13	0044851	5	Screws, Pan H., 0.138-32 x 0.187
14	K0121XS	2	Screws, R.H., Tapping, 0.138-32 x 0.625
15	N0282AN	1	Transistor 2N3441
—	X0114BY	A/R	Heat Sink Compound
16	K0120SX	1	Socket
17	P0102AA	1	Connector
18	X0116EL	2	Screws, R.H., 0.190-32 x 0.375
19	B0101LK	1	Gasket
20	X0102AX	2	Lockwashers
21	X0122UH	2	Screws, R.H., 0.138-32 x 0.250 with Lockwashers
22	N0138PR	1	Terminal Block
—	X0100PZ	4	Screws, Pan H., 0.164-32 x 0.187
23	N0138KU	1	Bracket
24	E0285UW	1	Potentiometer
25	X0100AY	2	Screws, R.H., 0.086-56 x 0.437 with Lockwashers
26	0021536	2	Nuts, 0.086-56
27	0038100	2	Spacers
28	H0183CV	2	Filters
—	Below	1	Lightning Arrestor
	B0158EZ		10 to 50 mA (H)
	B0158EY		4 to 20 mA (I)

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MOUNTING PARTS

Item	Part No.	Qty.	Part Name
1	M0149AN	1	U-Bolt and Nuts
2	M0149AL	1	Bracket
3	X0142KX	4	Nuts, 0.250-20
—	X0143QY	4	Lockwashers (not shown)

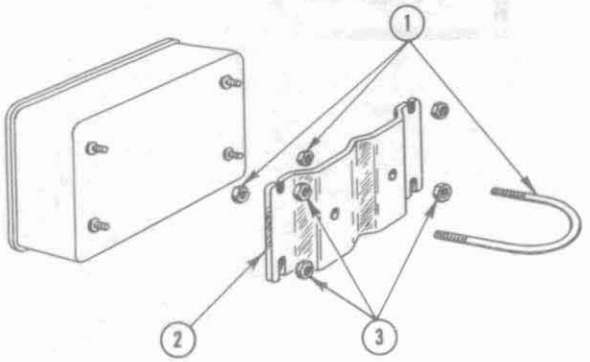

Fig. B6118

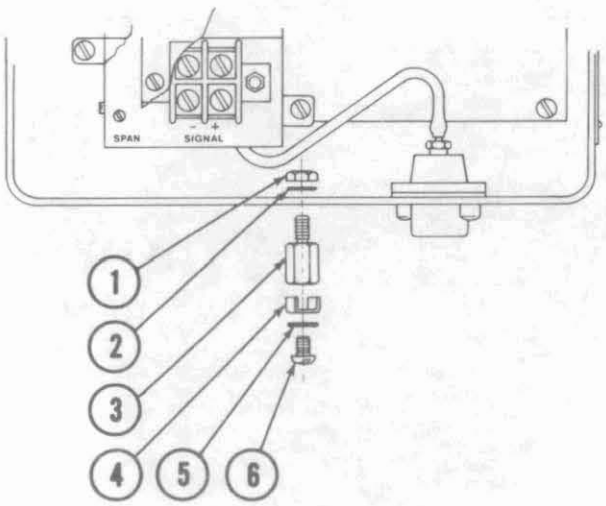

Fig. E1854

EARTH CONNECTION (Ground)

Item	Part No.	Qty.	Part Name
1	X0166JH	1	Nut, 0.190-32
2	X0143SC	1	Lockwasher
3	N0311AR	1	Column
4	N0305RN	1	Clamp
5	X0143SB	1	Lockwasher
6	X0124FY	1	Screw, Pan H., 0.164-32 x 0.312

***Parts preceded by asterisks are those more commonly replaced**
GIVE INSTRUMENT SERIAL NUMBER WHEN ORDERING

Printed in England

Instruments and Systems for
Indicating, Recording, Controlling . . .

Air Weight
Btu
Capacitance
Composition
Compression
Concentration, Solution
Conductivity, Solution
Consistency
Current — a-c, d-c
Density
Dew Point
Displacement
Drag
Flow
Force
Gas Analysis
Humidity
Interface
Ion Selection
Liquid Analysis
Liquid Level
Load
Moisture Content
Motion
Motor Load
Operation, Schedule
Operation, Time
Oxidation-Reduction Potential
pH
Position
Power, Electric
Pressure
Resistance, Electric
Sheet Moisture
Sheet Weight
Specific Gravity
Speed
Strain
Stress
Temperature
Tension
Thrust
Torque
Vacuum
Viscosity
Voltage
Weight

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

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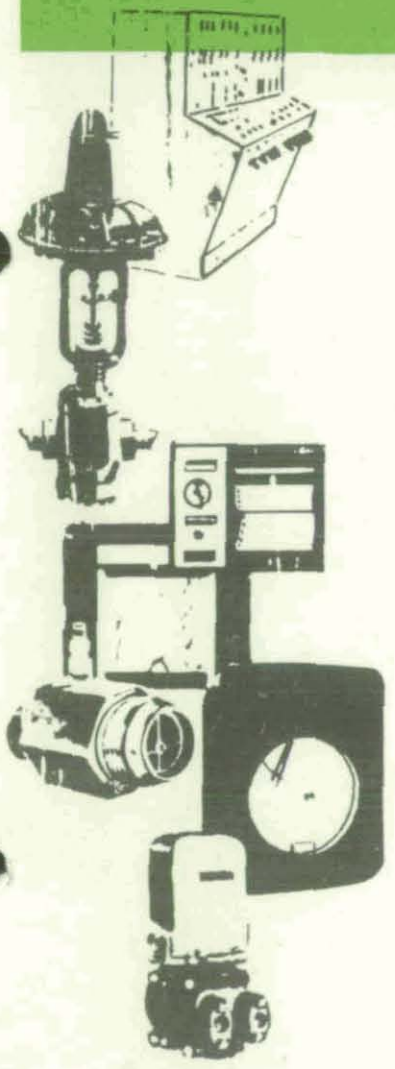
INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct *installation of your Foxboro Instruments, and in their proper* operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number.*

Book No. 2289

FOXBORO

IMPORTANT

Style Indication

Some of the following sheets may refer to a different style of instrument from that indicated on the cover of this instruction book.
The reason for this is that some sheets are valid for more than one style.
You may be assured that this book, in it's totality, will provide all the necessary information on installation, operation and maintenance of the instrument and style indicated on the cover.

S.I. Unit System

Foxboro, as a world-wide Organization, is an ardent supporter of world-wide standardization. Because of this general policy and the legal requirements in Europe, Foxboro has decided to adhere to the S.I. unit system (système internationale d'unités).
A beginning has been made with revising the extensive documentation accordingly so that you may find that this book contains one or more sheets with the units already expressed in the S.I. unit system.

Document Number Prefix

The document number of certain sheets out of this book may be preceded by the letter "V". This denotes that these "Printed in the Netherlands" sheets deviate to some extent from the original issue; for example, by adhering to the specifications of local requirements or to indicate that measurement units are expressed in the S.I. unit system.

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

FOXBORO®

Instruction

MI
018-435
December 1981

E69R CURRENT-TO-PNEUMATIC SIGNAL CONVERTER

The E69R Current-to-Pneumatic Signal Converter is a rack-mounted instrument that transforms a dc milliampere input signal to a proportional pneumatic output signal.

This output signal can be used either to operate such pneumatic devices as dampers and valve actuators, or as the input to various pneumatic instruments.

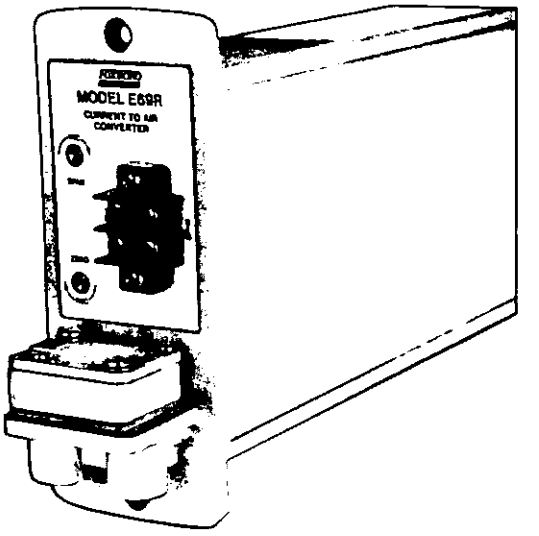


Figure 1

PRINCIPLE OF OPERATION

A dc milliampere input signal is converted to a proportional pneumatic output signal in the following manner. See Figure 2. A coil positioned in the field of a permanent magnet reacts to the current by producing a tangential thrust proportional to the input signal flowing through it. This thrust, acting through coil flexures, varies the gap between a flapper and nozzle. This causes a change in the output pressure of the relay, which is also the converter output pressure. This pressure is fed to a feedback bellows which exerts a force on a feedback flexure to move the nozzle and establish a throttling relationship between the flapper and nozzle.

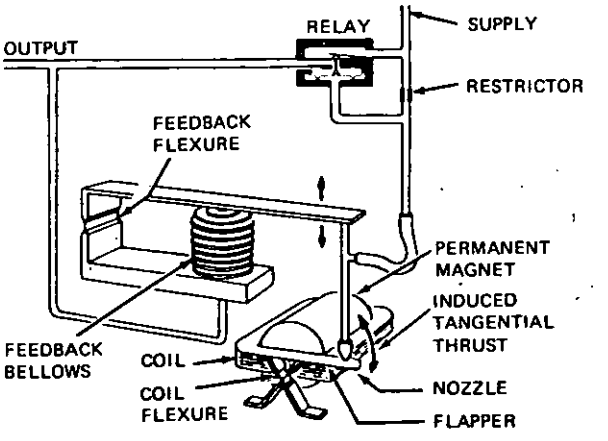


Figure 2

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STANDARD SPECIFICATIONS

Input and Output Ranges

INPUT (mA)	OUTPUT[3]	
	kPa	psi
4 to 20[1]	20 to 100	3 to 15
	----	3 to 27
or	40 to 200	6 to 30
	7 to 125	1 to 18
10 to 50[2]	7 to 220	1 to 32

[1] 4 to 12 or 12 to 20 mA } with addition of optional
[2] 10 to 30 or 30 to 50 mA } feedback spring
[3] Direct or reverse action, as specified

NOTE
Ranges are listed in kPa and psi. For alternative ranges in kg/cm^2 or bar, divide applicable kPa values by 100.

Input Impedance

4 to 20 mA Input: 170 Ω
10 to 50 mA Input: 27 Ω

Air Consumption
20 to 100 kPa or 3 to 15 psi output: 40G Relay; 0.5 m^3/h (0.30 cfm) at standard conditions.
All other outputs: 40D Relay; 1.3 m^3/h (0.75 cfm) at standard conditions with 140 kPa or 20 psi supply.
1.7 m^3/h (1.0 cfm) at standard conditions with 240 kPa or 35 psi supply.

Ambient Temperature Limits
Normal Operating Conditions: 5 and 50°C (40 and 120°F)
Operative Limits: -40 and +80°C (-40 and +180°F).

Electrical Classification Refer to data plate.

Calibrated Accuracy ±0.5% of span; but ±2% of span with inputs of 7 to 125 and 7 to 220 kPa or 1 to 18 and 1 to 32 psi.

Mass Approximately 2.3 kg (5 lb).

Supply Pressure

NOMINAL	LIMITS
140 kPa or 20 psi	130 and 160 kPa or 19 and 23 psi
240 kPa or 35 psi	225 and 260 kPa or 33 and 38 psi

Supply pressure must not be less than 20 kPa or 3 psi above the maximum signal.

INSTALLATION

Wiring and Piping

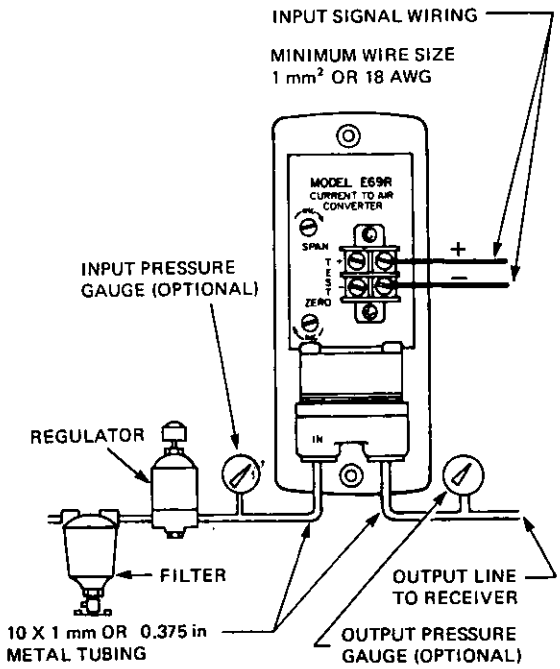


Figure 3

ELECTRICAL CERTIFICATION

⚠ WARNING

This converter may have agency certification for installation in hazardous locations or for intrinsic safety. Refer to label affixed to the converter for type of certification and observe applicable wiring practices. Conditions of certification are in the following table:

AGENCY AND CS CODE	TYPE OF PROTECTION AND AREA CLASSIFICATION	CONDITIONS OF CERTIFICATION
BASEEFA CS-E/BN-A	Type N (nonsparking) for use in IEC Zone 2.	Connect to power source of 75 V dc and 35 mA maximum and house in IEC IP54 enclosure or install in pressurized room.
FM CS-E/FB-A	Intrinsically safe for use in Class I, Groups A, B, C, and D, Division 1 and Class II, Groups E, F, and G, Division 1 hazardous locations.	Connect to FM approved SPEC 200 modules per TI 005-101. 4 to 20 mA input only.
CSA CS-E/CB-A	Intrinsically safe for use in Class I, Groups B, C, and D, Division 1 hazardous locations.	Connect to CSA approved SPEC 200 modules. 4 to 20 mA input only.
PTB CS-E/PB-A	Intrinsically safe (Ex)i.	Connect to PTB approved source whose short circuit current does not exceed 90 mA. 4 to 20 mA input only.
BASEEFA CS-E/BA-A	Intrinsically safe (Ex)ia IIC.	For use in Zone 0, connect to 2AO-V2I-BGA or 2AO-VAI-BGA SPEC 200 converters or to approved shunt diode safety barriers. For use in Zone 1, connect to 2AO-V3I-BGB or 2AS-I3I-BGB SPEC 200 converters. 4 to 20 mA input only. Power source must not exceed 35 V dc and 0.66 W.
S-COMM	Intrinsically safe (Sib) IIC for use in Zone 1, Group IIA, B, C.	Connect to S-COMMISSION certified equipment with a maximum short circuit current of 90 mA. 4 to 20 mA input only.

CALIBRATION

For simplicity, the procedure below assumes a converter with a 4 to 20 mA input and a 20 to 100 kPa or 3 to 15 psi output. For other ranges, substitute the applicable values. The specific input and output are listed on the converter data plate.

In-Line Zero Adjustment

1. Connect voltmeter to TEST terminals on front of converter. See Figure 4. (100 and 500 mV correspond to 0 and 100% of calibrated input.)
2. Calculate output corresponding to actual mV reading using formula below:

$$\text{Output} = \left(\frac{\text{mV} - 100}{400}\right) (\text{Span}) + 0\% \text{ Output}$$

where: mV = Voltmeter reading
Span = Output span

EXAMPLE: Output range = 20 to 100 kPa
Voltmeter reading = 200 mV

$$\text{Output} = \left(\frac{200 - 100}{400}\right) (80) + 20 = 40 \text{ kPa}$$

3. Adjust zero screw so that reading on output test gauge is correct.

Equipment Setup

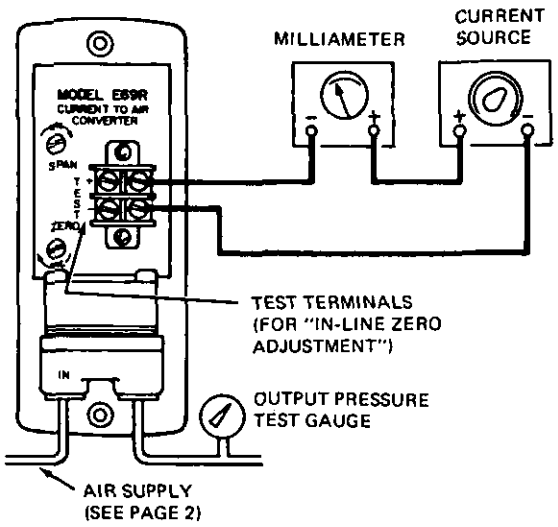


Figure 4

Procedure

NOTE
Any adjustment to the span will interact with the zero adjustment and will change the initial zero setting. Therefore, any adjustment made to the span must be followed by readjustment of zero.

1. Set up equipment as shown in Figure 4.

2. Apply 12 mA (50%) input to converter and adjust output (zero adjustment screw) to 60 kPa or 9 psi (50%). See Figure 5.

3. Apply 20 mA (100%) input to converter and note the amount of error above or below 100 kPa or 15 psi (100%) output. If error is greater than ±2% (1.6 kPa or 0.025 psi), perform Step 4. If error is less than ±2%, proceed to Step 5.

4a. Loosen 5/16 in bellows locknut. Note reference line on bellows. Rotate bellows* so that reference line moves toward motor to decrease span or away from motor to increase span until the error is within ±2%. Tighten bellows locknut. (To facilitate adjustment, the top and side rails may be removed to allow easier access to bellows.)

4b. Repeat Steps 2 and 3.

5. Turn span screw a proportional amount (noted in Step 3) based on the following: one revolution of the span adjustment screw will correct the error by approximately 3%.

   Disregard output changes which occur when span adjustments are made.

6. Apply 12 mA (50%) input to converter and adjust output (zero screw) to 60 kPa or 9 psi (50%).

7. Apply 20 mA (100%) input and check output for 100 kPa or 15 psi (100%). If output is not acceptable, repeat Steps 5 through 7.

8. Apply 4 mA (0%) and check output for 20 kPa or 3 psi (0%).

9. Adjust zero and span until optimum output is achieved.

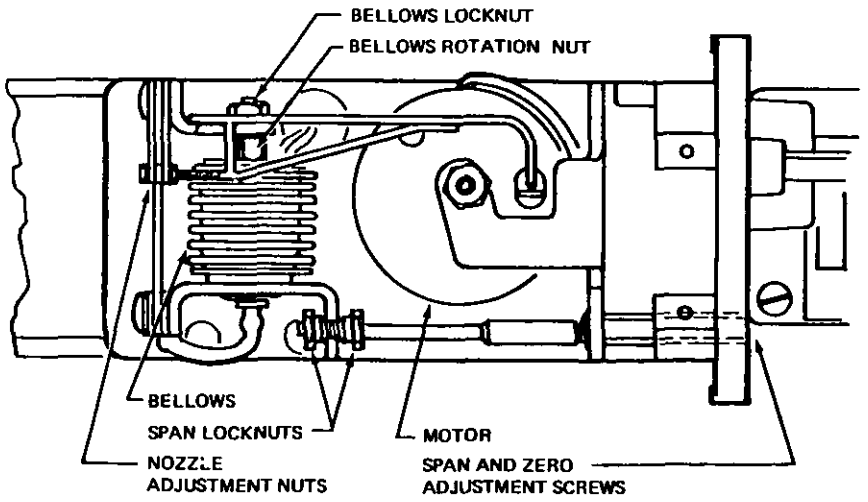


Figure 5

*Bellows assembly is on an eccentric.

SERVICING AND MAINTENANCE

To Remove Relay

Remove the two large screws and pry off relay. A gasket is supplied with each replacement relay.

For servicing details, see Instruction MI 011-493 (Model 40G) or MI 011-491 (Model 40D).

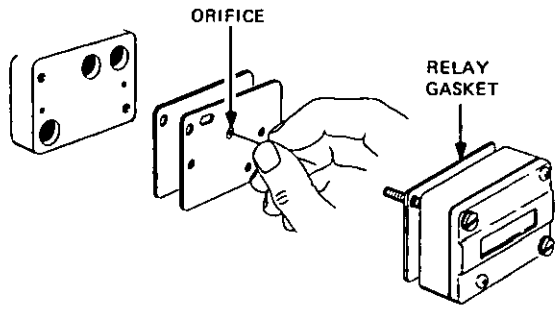


Figure 6

To Clean Restrictor

Remove relay (see illustration above).

Clean by inserting a 0.005 in diameter wire (or Foxboro cleaning wire, Part 0042527) through orifice.

MODIFICATIONS

NOTE:
Foxboro does not consider the following modifications a field conversion. They are considered factory modifications due to the complexity of the procedures and the large amount of time required to perform them. If the modifications must be made in the field, use the following procedures and contact Foxboro for additional assistance.

TO REVERSE CONVERTER ACTION

The existing action of the converter is indicated by the marking on the exposed top of the motor cover: INC-INC (increasing input produces an increasing output), or INC-DEC (increasing input produces a decreasing output). When reinstalling the motor (Step 11), the exposed marking on the motor cover must indicate the desired action.

1. Disconnect instrument from installation (input wiring, air lines and mounting screws) and remove converter from rack.

2. Remove side covers and top rail.

3. Loosen span locknuts. Remove two screws holding feedback assembly (with bellows). Note routing of tubing for later reinstallation.

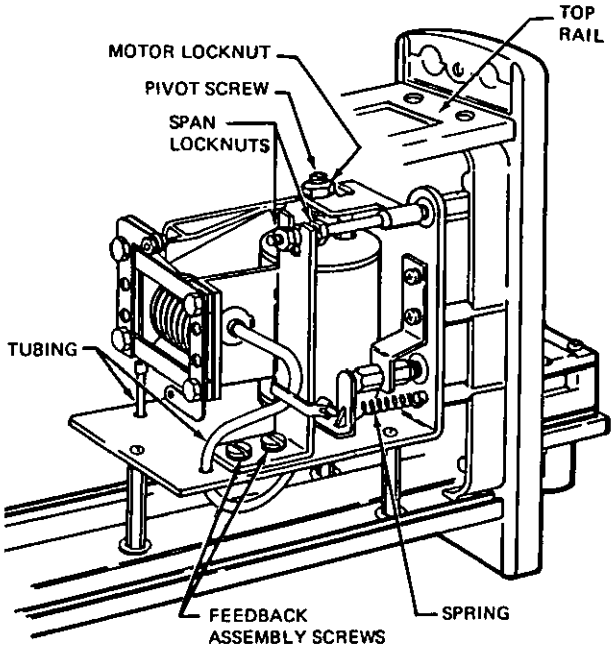


Figure 7

4. Lift aside feedback assembly (do not damage nozzle). Unhook spring from motor bracket.

   (For convenience, feedback assembly can be removed entirely by removing two screws and disconnecting tubing. See Figure 7. Note identification of tubing for later reconnection.)

5. On feedback assembly, remove two hex head (formerly button head) screws. See Figure 8.

6. Interchange location of angle bracket and spacer. See Figure 8.

7. Reinstall hex head screws and tighten to a torque of 0.21 to 0.25 N•m (30 to 35 oz•in).

NOTE:
Switching locations of angle bracket and spacer, allows the Ni-Span angle bracket to correct for temperature induced errors in the INC-DEC mode.

Figure 8 shows parts in INC-INC arrangement.

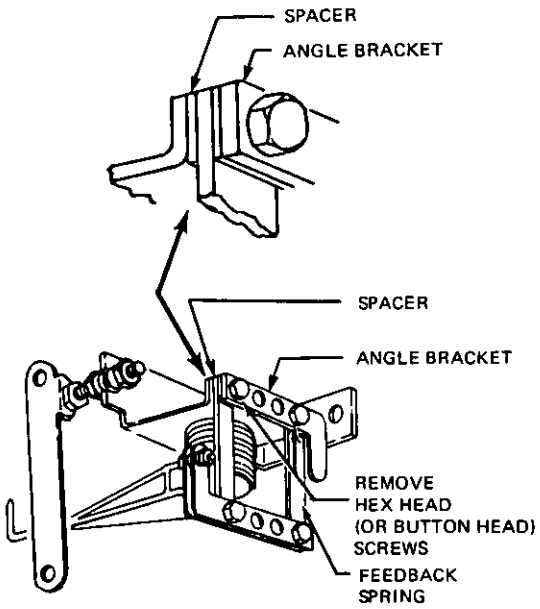


Figure 8

8. Loosen motor locknut and remove motor pivot screw. See Figure 7.

9. Remove motor with gradual rotating, tilting and lifting action.

10. Remove two screws holding motor bracket to bottom of motor. See Figure 9.

    Invert motor and reinstall motor bracket (to side of motor that was formerly on top).

11. Wind excess wire clockwise around motor and carefully place motor into position in case assuring that bottom arm is in hole provided. Make sure that wires will not interfere with moving parts and pivot is in hole at bottom of motor.

    NOTE
    Marking on top of motor must indicate desired action.

12. Replace and adjust motor pivot screw to remove all end play (approximately 1/8 to 1/4 turn interference). Tighten locknut. Reconnect spring to motor bracket.

13. Reinstall feedback assembly and other remaining parts. Make sure that tubing is not kinked and is connected properly. Tighten screws removed in Steps 2 and 3 gradually and uniformly.

14. Perform "Full Realignment" (Page 7).

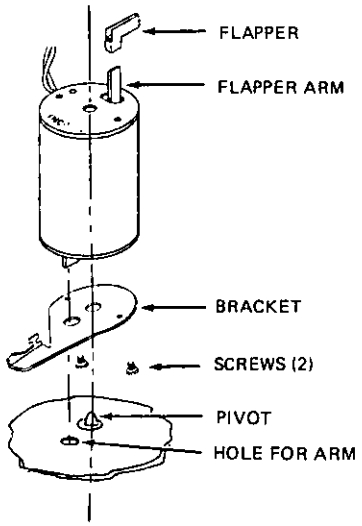


Figure 9

TO SPLIT-RANGE CONVERTER

The converter input signal may be split-ranged with the addition of a flat spring (available from Foxboro). Refer to Page 2 for available ranges.

1. Perform Steps 1 thru 4 in "To Reverse Converter Action" section.

2. Loosen the four hex head screws (formerly button head screws) but do not remove. See Figure 10.

3. Insert flat spring into space between the feedback springs.

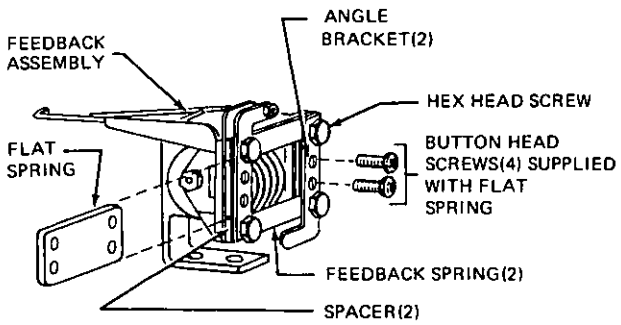


Figure 10

4. Line up edges of flat spring, angle bracket, feedback spring and spacer to be flush with feedback assembly bracket.

5. Insert four button head screws supplied with flat spring and tighten assembly securely.

6. Tighten four hex head screws to a torque of 0.21 to 0.25 N·m (30 to 35 oz·in).

7. Perform Steps 13 and 14 in "To Remove Converter Action" section.

Full Realignment

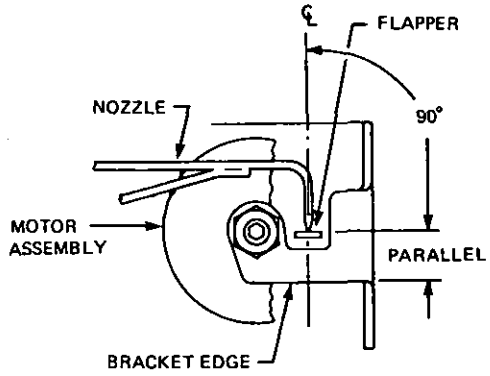
1. Set up equipment as shown in Figure 4, with side covers and top rail removed. Turn on air supply and current source.

2. Apply 12 mA (50%) input signal and adjust zero screw to position flapper parallel to bracket edge as shown in Figure 11.

3. Turn span screw clockwise to stop, and back off approximately 3 turns (midadjustment position). Use 5/16 in span locknuts to position nozzle to center of flapper width as shown. Lock nuts securely.

   NOTE
   When moving span locknuts, one nut must be loosened prior to any adjustment. Do not try to force one nut against the other even for small adjustments.

4. Move 5/32 in nozzle adjustment nuts to obtain 60 kPa or 9 psi output within 2% (1.6 kPa or 0.25 psi). See Figure 5.



FLAPPER/NOZZLE DETAIL AT 50% INPUT

Figure 11

5. Nozzle should now be at 90° to flapper. If not, trim slightly with zero screw and repeat Step 4.

6. Set input signal to 4 mA (0%) and adjust zero screw for 20 kPa or 3 psi (0%) output.

7. Momentarily turn off power. When power is returned, output should respond crisply. If not, recheck Step 5 at 12 mA (50%) input and repeat Steps 6 and 7.

8. Calibrate converter.

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— AIR SUPPLY SYSTEM —

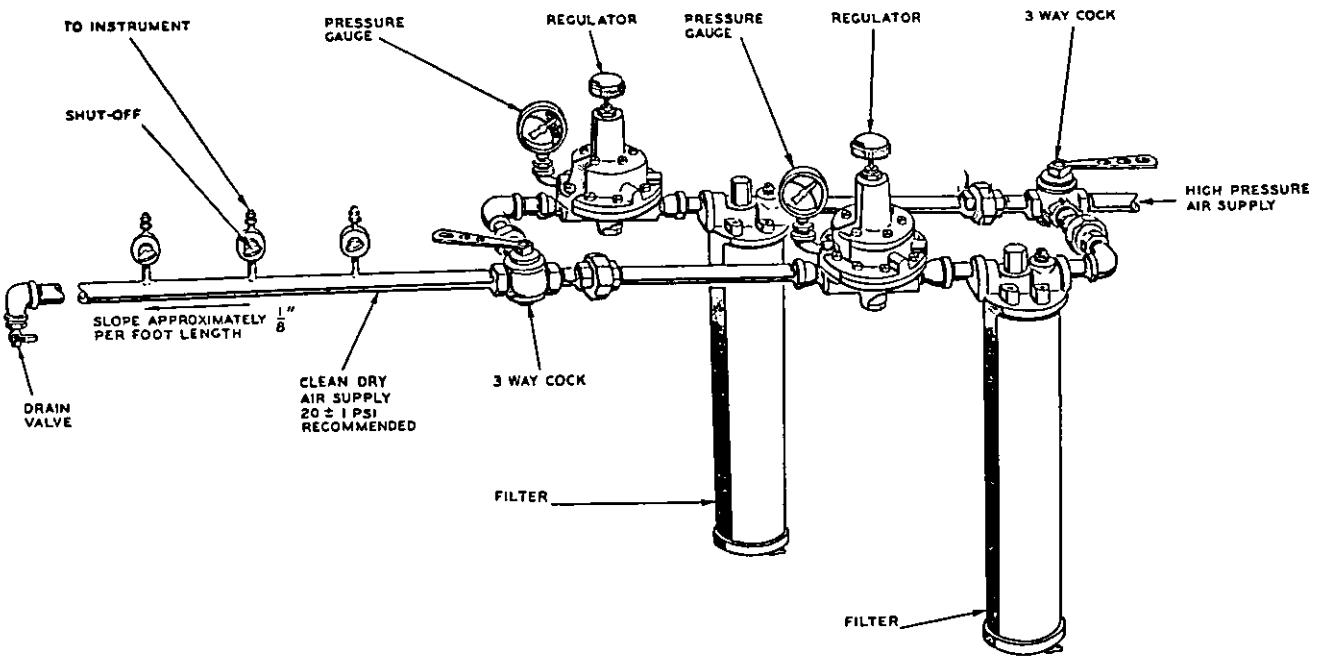


Fig. A1875

Air Supply System for Panel Mounted Instruments

General

In order to operate successfully and with low maintenance, a pneumatic instrument must be adequately supplied with clean dry air. The installation must be planned to prevent water, oil, or dirt being carried through the piping into the instrument.

All tubing, pipe, and fittings must be clean inside, and free from burrs. Shellac or joint compound may be applied sparingly, but only to the male threads. Check all joints while under pressure with soap and water solution.

Air Supply

Be sure to have an adequate supply of air. Air requirements may be estimated by allowing 0.50 cfm of free air for each control relay. The Model 59 Controller, which does not use a control relay, requires approximately 0.9 cfm of free air. The control mechanism operates on a supply pressure of 20 psi or 1.5 kg per sq cm. This regulated pressure may be maintained in the header as shown in Fig. A1875. A high pressure in the header may be reduced by a regulator at the instrument as in Fig. A1876 (on reverse side of this sheet).

When air lines are exposed to freezing temperatures, an adequate air dryer should be installed at the takeoff from the main plant air system.

Supply Header

A supply header furnishing air to a series of instruments should be sloped at least ⅛" per foot to facilitate drainage of entrained moisture or oil. Clean, new, brass or iron pipe and fittings, ½" or larger, should be used for the header.

Supply Piping

As a precaution against moisture, the supply piping from header to instruments should be taken off preferably at the top of the header. The connections may be made at the side of the header when necessary, but never at the bottom. Piping should be ⅜" O.D. (not less than .300" I.D.) copper tubing.

Printed in England

Master Regulator

With several instruments grouped together, it is generally more economical to provide one or two common regulators to provide an air supply of 20 psi or 1.5 kg per sq cm. Particularly where the number of instruments is large, it is recommended that two regulators be used in parallel. With this arrangement a temporary stoppage in one of the regulators will not disrupt all the instruments on the panel. See Fig. A1875. The 3-way cocks shown permit isolation of either supply system for servicing, or parallel operation of both systems.

The following table may be used in selecting the correct supply regulator and filter dripwell where a number of instruments are to be supplied from one source.

Supply Regulators

(for a controlled pressure of 20 psi)

1-4 pilots (relays)	Type 67
1-20 " "	Type 20
1-75 " "	Moore M/42-H-30

Filter Dripwell

1-4 pilots (relays)	Part B-102-ZT
1-20 " "	Part B-102-WC
1-75 " "	Part B-110-XF

The air supply to all instruments must be clean and dry and where group installations are considered, it is sometimes desirable to use a common dripwell and air filter rather than an individual one at each instrument. (See Fig. A1875.) There are many types of such devices and the choice depends to a large extent on individual preference.

NOTE: The recommendations contained in this sheet are not intended to exclude other arrangements which are perfectly satisfactory and may be quite common. It is intended that this sheet be used as a guide for those customers who are not familiar with the installation of instruments and will require a recommendation from The Foxboro Company.

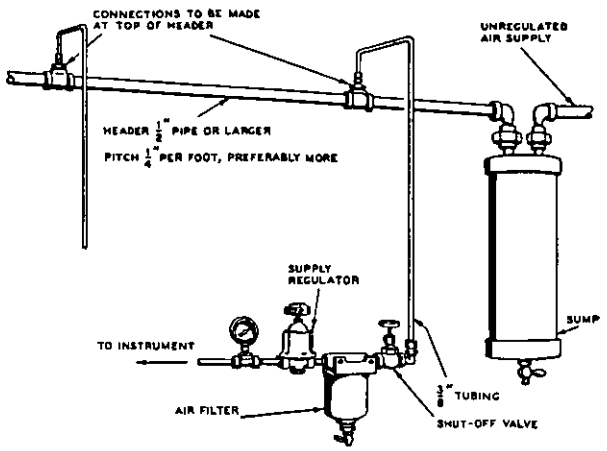


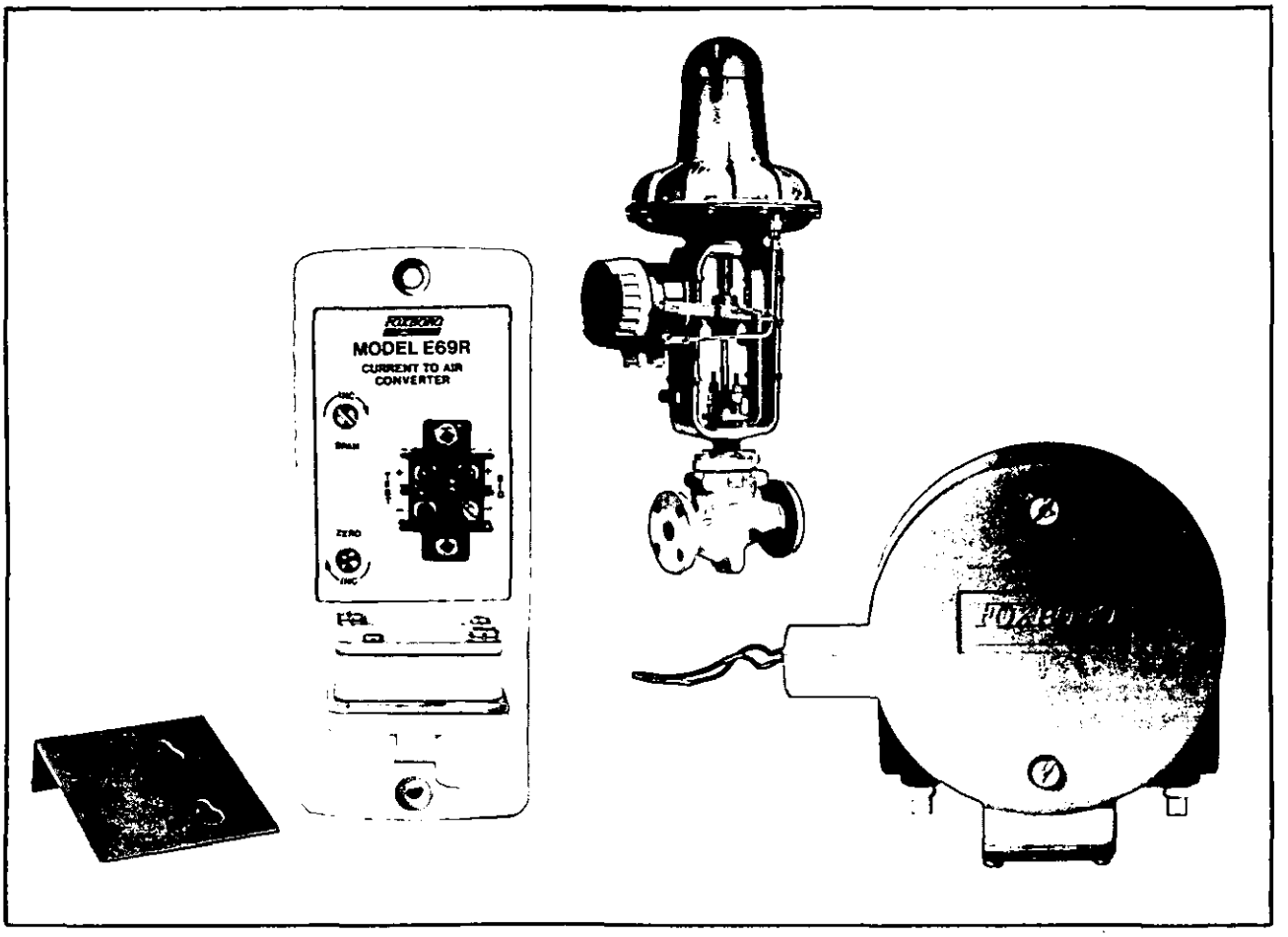
Fig. A1876

Air Supply System for Field Mounted Instruments

Dripwell and Supply Regulator

Fig. A1876 shows the air supply system for field mounted instruments, or individually mounted instruments. The filter dripwell and supply pressure regulator, where necessary, are installed in the supply piping immediately adjacent to the instrument, and should be firmly supported. Note the arrow for flow direction on the supply regulator. It is advisable to install a shut-off valve in the supply piping to enable removal of the instrument without shutting off the entire air supply system.

The dripwell serves to catch any moisture, oil or dirt remaining in the air despite previous safeguards. A petcock on the bottom provides a means for periodically blowing out the sump. Normally this should be done daily, but under severe conditions of liquid-laden air it should be done more frequently. Proper attention to this detail will eliminate the greatest source of controller trouble.



E69 SERIES CURRENT-TO-PNEUMATIC CONVERTERS AND POSITIONER

The E69 Series instruments, shown above, include the E69R Rack Mounted and E69F Field Mounted converters, and the E69P Valve Positioner. All of these instruments accept a standard direct current signal, 4 to 20 or 10 to 50 mA.

The E69R and E69F convert the input signal to a pneumatic signal which may be 20 to 100 or 40 to 200 kPa (0.2 to 1.0 or 0.4 to 2.0 kg/cm^2 or bar), 3 to 15, 6 to 30, 1 to 18 or 1 to 32 psi. This output signal can be used as the input to various pneumatic instruments or to power valve actuators directly.

The E69P Positioner, mounted on a valve yoke, is an instrument that converts a current input signal to a proportional valve stem position. The pneumatic output of the positioner supplies air pressure to a pneumatic valve actuator. The valve stem is mechanically linked to a shaft on the positioner.

CONTENTS . . .

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Split input ranges are available where a less than full scale input current will provide a full scale pneumatic output or full scale valve movement, as for example, a 4 to 12 mA input produces a 3 to 15 psi output. Reverse action, where an increasing current input causes a decreasing output, is also available.

As shown above, there are two types of covers available for either of the field mounted instruments. Depending upon the electrical classification, either the cover attached with screws or the cover threaded into the case will be provided.

PRINCIPLE OF OPERATION

These instruments are examples of position balanced systems. The small changes in position generated by a galvanometric motor when a change in the current input signal occurs is balanced by a pneumatically actuated follower system.

The unique galvanometric motor, shown in Figure 1, consists of a wound rectangular coil of fine copper wire surrounding but not contacting a cylindrical permanent magnet. The coil is suspended and restricted in movement by flexures which permit it a small amount of rotation about the magnet axis. Input current flowing through the coil interacts with the magnetic field causing the coil to rotate a maximum of 7^{o} about the axis against the spring rate of the flexure. A shorted turn on the coil provides back-emf damping, which, along with the carefully balanced assembly, the stiff flexures in the feedback mechanism, and the low mass of the moving components, contribute greatly to the vibration and position insensitivity of the instruments. This is a very important feature, particularly for the field mounted instruments, where, as the next to the last element in a control loop, they may be subject to vibration from mixers, pumps or other types of equipment.

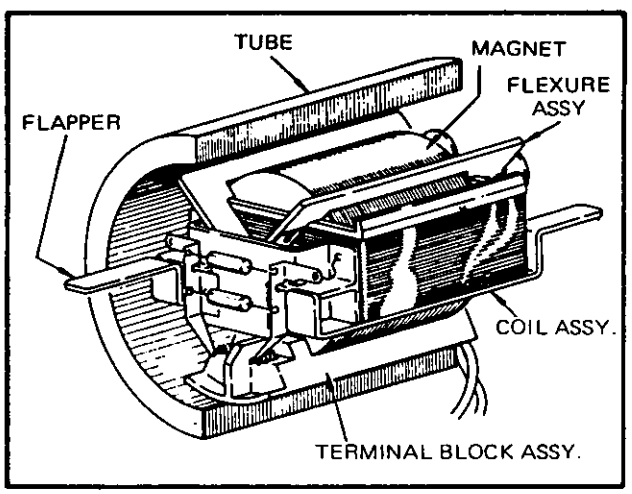

FIGURE 1

As shown in Figures 2 and 3, a flapper is an integral part of the coil structure. As the coil is rotated by an increasing input signal, the flapper moves to cover a pneumatic nozzle. This increases the nozzle back pressure. The nozzle is connected to a pneumatic relay. As the back pressure from the nozzle increases, the output pressure from the relay is increased.

It is at this point that the converters differ from the positioner in the feedback method employed.

As shown in Figure 2 for the converters, the output from the relay flows to external devices, such as valves, and also provides pressure to a feedback bellows within the converter. Increasing pressure in this bellows, acting against a spring, moves the nozzle assembly in the same direction as the flapper-coil assembly moves when the input current signal changes. A new equilibrium position is achieved where the output pressure is proportional to the input current signal. Thus it can be seen that the converters are current-to-position-to-pneumatic devices with pneumatic feedback.

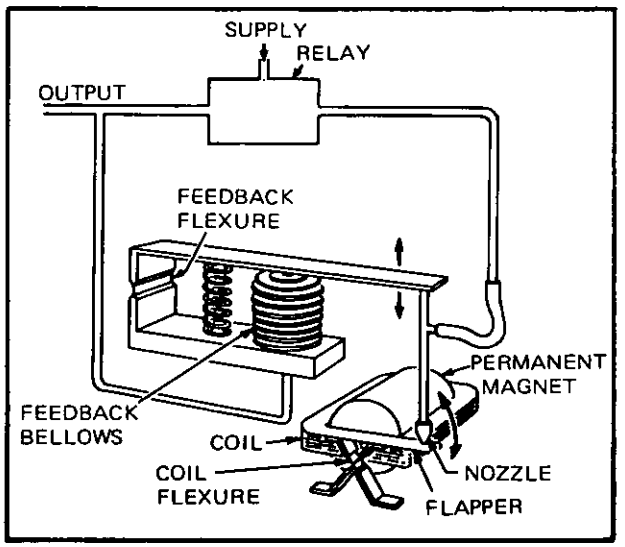

FIGURE 2

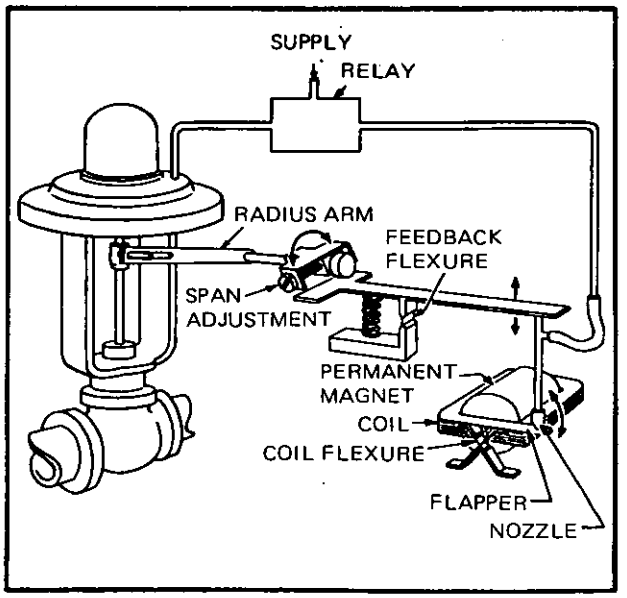

FIGURE 3

The E69P positioner, on the other hand, is a current-to-position-to-pneumatic device with mechanical feedback. As can be seen in Figure 3, the relay output is connected to the valve actuator. As the valve stem moves to open or close the valve, a radius arm connected to the feedback shaft of the positioner and to the valve stem acts to move the nozzle assembly in the same direction as the flapper-coil assembly. In this device equilibrium position is achieved where the valve position is proportional to the input current signal. Full supply pressure may be applied, if necessary, by the relay to the valve actuator to move the valve to achieve this balance.

CONSTRUCTION DETAILS AND ADJUSTMENTS

In position balanced systems, which the converters and positioner represent, small movements have large effects on accuracy and linearity. Great care has been taken in selection of materials, in matching materials with similar coefficients of expansion and in designing the assemblies to minimize or eliminate the effects of differential expansion caused by ambient temperature changes.

Adjustments on the instruments are simple and few.

Zero adjustment is accomplished in all models by mounting the galvanometric motor on spring loaded pivots and using a zero screw to rotate the motor on these pivots, thus moving the flapper relative to the nozzle. This adjustment is sensitive enough to permit accurate setting of zero and yet allow the zero to be shifted enough to accommodate, for example, an input range of 12 to 20 mA. For split ranges an additional feedback flexure must be added to the mechanism.

Span adjustment for the converters is provided in two ways. Coarse span adjustment is accomplished by varying the fulcrum point of the eccentric mounting of the feedback bellows. Fine adjustment is provided by moving the nozzle, thus varying the effective length of the flapper.

Range selection in the converters is accomplished by a choice of feedback bellows and/or feedback flexures.

In the positioner, movement of the valve stem is transferred to the positioner input shaft by a choice of several different lever arms available to accommodate a variety of valve and yoke sizes. The span screw in the positioner provides a wide range of adjustment for valve stroke.

For all models, reverse output (increasing current input causes decreasing pressure from the relay) is accomplished by inverting the motor position in the frame, thus changing the direction of the flapper rotation. The unit is then recalibrated.

CONCLUSION

Conversion of electronic signals to pneumatic signals or to valve position is an important part of the control loop. The E69 Series of instruments offered by Foxboro can be depended upon to perform this important function with lasting accuracy under widely diverse process situations. These instruments are the result of considered design, rigorous testing and careful selection of materials of construction.

Printed in England 0977

Parts List

PL
008-646
September 1981

MODEL E69R
CURRENT TO PNEUMATIC
CONVERTER

E69R Series Data Coding

Model

E96R = Rack Mounted Current-to-Pneumatic Converter.

Input Signal

-H = 10 to 50 mA, 10 to 30 mA, 30 to 50 mA (May be reversed)
-I = 4 to 20 mA, 4 to 12 mA, 12 to 20 mA (May be reversed)

Output Signal

2 = 3 to 15 psi, 20 to 100 kPa, 0.2 to 1.0 kg/cm², 0.2 to 1.0 bar
3 = 6 to 30 psi, 3 to 27 psi, 40 to 200 kPa, 0.4 to 2.0 kg/cm², 0.4 to 2.0 bar
7 = 1 to 18 psi, 7 to 125 kPa, 0.07 to 1.3 kg/cm², 0.07 to 1.3 bar
8 = 1 to 32 psi, 7 to 220 kPa, 0.07 to 2.2 kg/cm², 0.07 to 2.2 kg/cm²
X = Other - Specify

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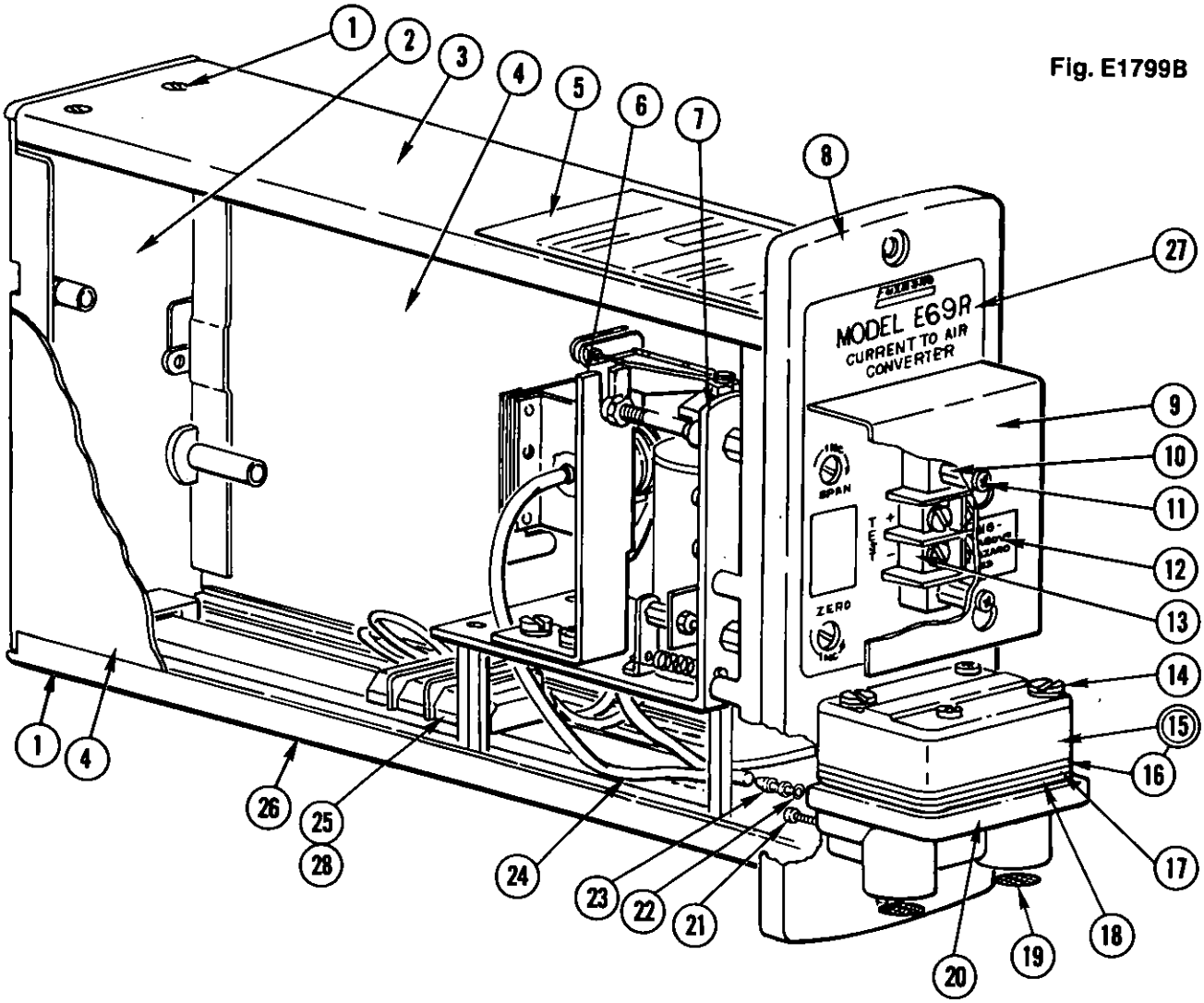
Fig. E1799B



Item	Part No.	Qty.	Part Name
1	N0196ZK	8	Screw, F.H., 0.164-32 x 0.312
2	N0149MA	1	Back Panel
3	N0986AE	1	Top Rail
4	B0130YP	2	Side Cover
—	X0106AX	2	Retaining Ring
—	0031203	2	Washer
—	N0149NP	2	Screw
5	B0125QN	1	Data Label
6	—	1	Feedback Assembly (see Page 4)
7	D0127XY	1	Bracket Assembly (see Page 3)
8	B0130ZC		Front Plate
9	B0136FT	1	Cover
10	N0138RM	2	Standoff
11	X0166HV	2	Screw, Pan H., 0.138-32 x 0.250
12	B0125JR	1	Warning Label
13	Below	1	Terminal Block Assembly
	B0130ZF		(Code -H) 10 to 50 mA, input
	N0143TX	1	Resistor, 10 ohm
	B0130WZ		(Code -I) 4 to 20 mA, input
	E0286GH	1	Resistor, 25 ohm
	N0138PR	1	Terminal Board
	X0116CR	4	Screw, Pan H., 0.164-32 x 0.250
14	X0126YL	2	Screw, Pan H., 0.190-32 x 1.125 with Lockwasher

Item	Part No.	Qty.	Part Name
15	Below	1	*Relay (output Code 2)
	C0136HZ		M40G, U.S. Issue
	C0136HK		M40G, European Issue
15	C0136XR	1	*Relay, M40D (all other outputs)
16	C0100EM	1	*Gasket
17	B0130VL	1	Plate
18	B0130VM	1	*Gasket
19	U0103FP	2	*Screen
20	B0130ZD	1	Relay Manifold
21	X0126HV	2	Screw, Pan H., 0.190-32 x 0.437 with Lockwasher
22	N0124MS	2	Washer
23	B0136EQ	2	Connector
24	R0128AA	—	Tubing, order 0.3 m (1 ft) per unit
25	0041055	1	Terminal Block
—	X0143EX	2	Washer
—	X0122TW	2	Screw, Pan H., 0.138-32 x 0.500
—	N0138EK	1	Mounting Pad
—	N0139FR	1	Cable Tie
26	B0130ZL	1	Bottom Rail
27	B0125NB	1	Information Label
28	0045087	2	Terminal
—	N6007DC	1	Zener Diode (BASEEFA only)

***Parts preceded by asterisks are those more commonly replaced**

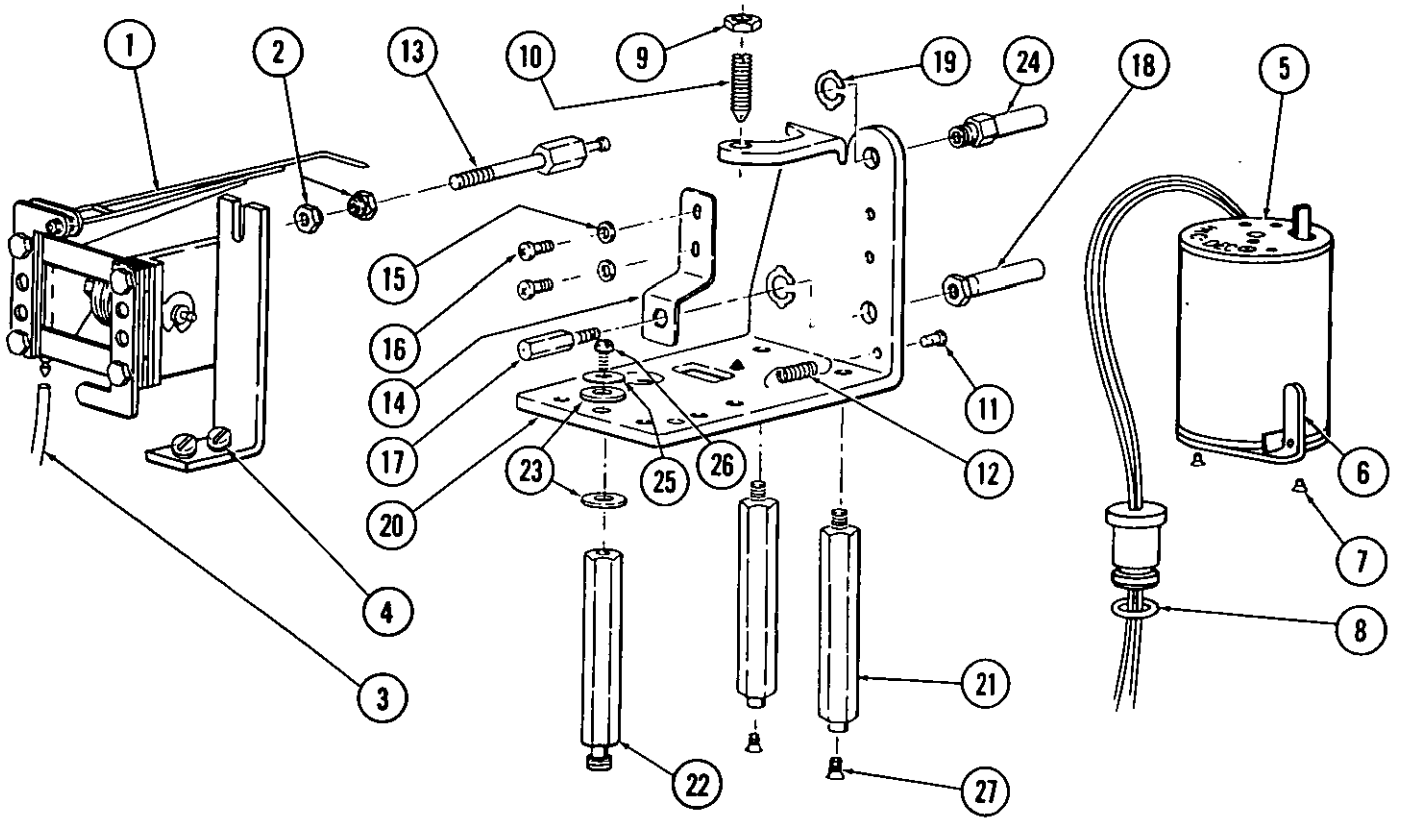


Fig. E1800B

Item	Part No.	Qty.	Part Name
1	See P. 4	1	Pneumatic Feedback Assembly
2	B0130XC	2	Nut, Special
3	C0138NZ	—	Tubing, order 0.3 m (1 ft) per unit
4	X0127KX	2	Screw, Pan H., 0.190-32 x 0.250
5	Below	1	Galvo Motor Assembly
	D0124ZY		10 to 50 mA input (Code -H)
	D0124ZX		4 to 20 mA input (Code -I)
	D0124ZZ		4 to 20 mA input (Code -I, PTB, BASEEFA, S-Comm.)
6	D0127XT	1	Zero Lever Assembly
7	X0167LQ	2	Screw, F.H., 0.112-40 x 0.125
8	C0123AX	1	O-Ring, 9.3 mm (0.36 in) ID
—	D0127XY	1	Bracket Assembly, consisting of:
9	X0168WL	1	Nut, 0.250-40
10	B0158WC	1	Pivot Screw
11	B0130ZM	1	Pin
12	B0135HG	1	Zero Spring
13	D0135RX	1	Stem

Item	Part No.	Qty.	Part Name
14	B0130ZP	1	Plate
15	X0143EX	2	Washer
16	X0169CM	2	Screw, Fil. H., 0.138-32 x 0.250
17	D0135RZ	1	Screw, Zero Adjustment
18	D0135RY	1	Nut, Zero Adjustment
19	X0166KR	2	Retaining Ring
20	D0127UW	1	Mounting Bracket
—	D0127XW	1	Pivot
21	B0130ZJ	2	Column
22	B0158WB	1	Column
23	C0123AS	2	O-Ring, 4.5 mm (0.18 in) ID
24	D0135RW	1	Nut, Span Adjustment
25	X0143AD	1	Washer
26	A2003ZN	1	Screw, Pan H., 0.112-40 x 0.187
27	X0166HY	2	Screw, F.H., 0.138-32 x 0.375

***Parts preceded by asterisks are those more commonly replaced**

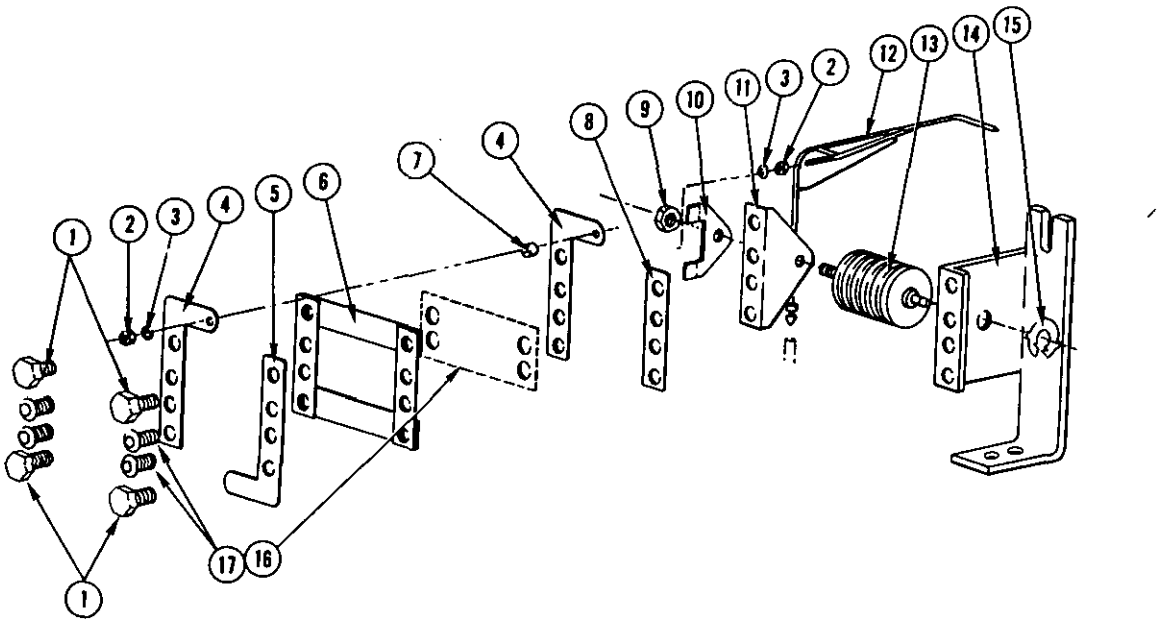


Fig. E1801A

Item	Part No.	Qty.	Part Name
	Below	1	Feedback Assembly, by output code:
	B0130UP		Code 2 = 20 to 100 kPa, 3 to 15 psi, 3 to 27 psi, 0.2 to 1 bar or kg/cm²
	B0130UQ		Code 3 = 40 to 200 kPa, 6 to 30 psi, 0.4 to 2 bar or kg/cm²
	B0130UB		Code 7 = 7 to 125 kPa, 1 to 18 psi, 0.07 to 1.3 bar or kg/cm²
	B0130UC		Code 8 = 7 to 220 kPa, 1 to 32 psi, 0.07 to 2.2 bar or kg/cm²
1	D0127XX	4	Screw, Hex H., 0.164-32 x 0.250
2	X0142KP	2	Nut, 0.073-72
3	X0143EJ	2	Washer
4	B0130WQ	2	Spacer
5	B0130ZS	1	Spacer
6	B0130UT	1	Range Assembly for Codes 2 and 3
6	B0130XZ	1	Range Assembly for Codes 7 and 8
7	B0136FN	1	Spacer Washer
8	B0136EP	1	Spacer
9	X0104CY	1	Nut, 0.164-32
10	B0130XG	1	Clamp
11	B0130WS	1	Bracket
12	B0130UG	1	*Nozzle Assembly
13	B0130UR	1	Bellows Assembly for Codes 2 and 7
13	B0130US	1	Bellows Assembly for Codes 3 and 8
14	B0130XA	1	Bracket
15	X0166KR	1	Retaining Ring

Optional Feature—Split Input Range

16	Below	1	Split Range Spring (see note)
	B0130WU		Codes 2 and 3
	B0130XQ		Codes 7 and 8
17	X0168TF	4	Screw, for springs above

Note: Split Range Spring is required if input is other than standard 4 to 20 mA or 10 to 50 mA or their equivalents.

***Parts preceded by asterisks are those more commonly replaced**

Printed in England

WARRANTY

Except as hereinafter provided, the Company (hereinafter called "Foxboro") warrants that all parts manufactured by it (but not by others) shall be within specified limits of calibration, if any, and free from defects in material or workmanship, under proper and normal use. Foxboro, at its option, shall replace or repair, free of charge, any part covered by this warranty which shall be returned, transportation charges prepaid, within one year from shipment by Foxboro and which examination proves not to be within the specified limit of calibration or not to be free from such defects in material or workmanship. Foxboro shall not be liable for any repairs or replacements of parts by others and covered by this warranty except those made with Foxboro's written consent. Foxboro shall be liable for breach of this warranty only if it receives written notice of such breach within one year from the date of shipment of the product to which the breach relates. The foregoing shall constitute the sole remedy of the purchaser for any breach by Foxboro of its warranty.

FOXBORO MAKES NO WARRANTIES REGARDING PARTS MANUFACTURED BY IT OR OTHERS (INCLUDING WITHOUT LIMITATION WARRANTIES AS TO MERCHANTABILITY), EITHER EXPRESSED OR IMPLIED, EXCEPT AS PROVIDED HEREIN.

SERVICE

The Company is anxious to be of every possible assistance to you, to insure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service may be made through your nearby Foxboro Sales Representative. When factory repairs are required, the instrument may be sent to any Foxboro plant. Check with your International Sales Representative who will advise you as to which plant should be utilized.

The Foxboro Company, Foxboro Mass. U.S.A.; Foxboro-Yoxall Ltd., Redhill, Surrey, England; and Foxboro (Nederland) N.V., Soest, Netherlands provide expertly staffed and fully equipped Training Schools devoted to the instruction of customer's Instrumentation Engineers and Service Men. The courses cover theory of operation, maintenance and application of the principial types of instruments. Applications from Companies in the British Isles should be made to Foxboro-Yoxall Ltd.; from those in the other parts of the world, to the nearest International Sales Representative as listed on the last sheet of this book.

PARTS

When repairs are to be made by the customer, it is strongly urged that only genuine Foxboro parts be used. Parts lists for Foxboro Instruments may be obtained by writing to your Foxboro Representative. Always give the serial number from the instrument data plate when requesting parts lists or ordening parts. (Men unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment should not be permitted to undertake any major service work).

REPLACEMENT

Improvements in design, materials, or methods sometimes make it worth while to replace rather than repair an instrument which has been in service for a long period of time.

We can help you in every way possible in discussing such problems with you.

In this way you will be made aware of the latest available equipment.

CHARTS

Since the accuracy of any recording instrument depends, finally, on the accuracy of the cart, the use of Foxboro Humitex Carts with Foxboro Instruments is essential if full performance of the instrument is to be realized.

FOXBORO

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

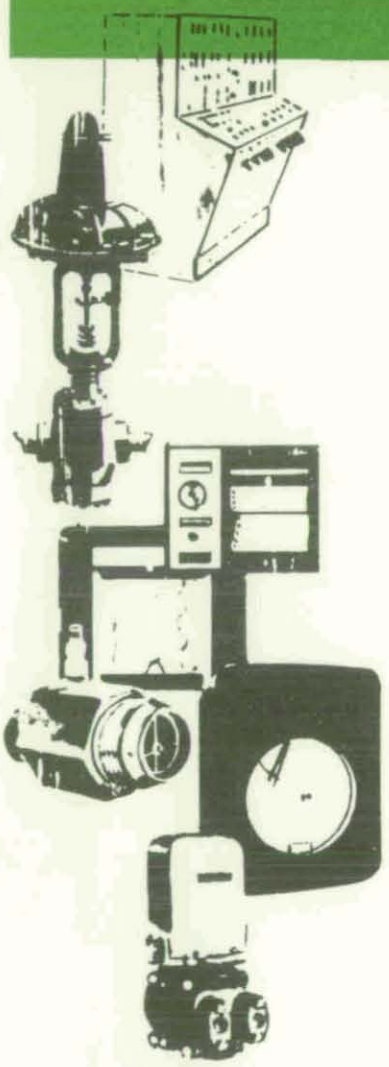
Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

FOXBORO®

MS 0283

Printed in the Netherlands

INSTRUCTIONS



INSTALLATION
OPERATION
MAINTENANCE

Even the best equipment will fail to give complete satisfaction unless it is correctly installed and cared for. These instructions have been prepared to assist in the correct installation of your Foxboro Instruments, and in their proper operation and maintenance. Please file this book where it will be accessible to instrument men servicing the equipment.

If any further information is needed, the nearest Foxboro Branch Office will be glad to help you. When writing about an instrument or ordering spare parts, please be sure to mention the *Instrument Serial Number.*

Book No. 2127

FOXBORO

IMPORTANT

Style Indication

Some of the following sheets may refer to a different style of instrument from that indicated on the cover of this instruction book.
The reason for this is that some sheets are valid for more than one style.
You may be assured that this book, in it's totality, will provide all the necessary information on installation, operation and maintenance of the instrument and style indicated on the cover.

S.I. Unit System

Foxboro, as a world-wide Organization, is an ardent supporter of world-wide standardization. Because of this general policy and the legal requirements in Europe, Foxboro has decided to adhere to the S.I. unit system (système internationale d'unités).
A beginning has been made with revising the extensive documentation accordingly so that you may find that this book contains one or more sheets with the units already expressed in the S.I. unit system.

Document Number Prefix

The document number of certain sheets out of this book may be preceded by the letter "V". This denotes that these "Printed in the Netherlands" sheets deviate to some extent from the original issue; for example, by adhering to the specifications of local requirements or to indicate that measurement units are expressed in the S.I. unit system.

GENERAL INSTRUCTIONS

Foxboro designs, manufactures, and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use, and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using, and maintaining Foxboro products.

- Read and save all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Foxboro representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in Foxboro site planning/installation instructions and per applicable local/national codes. Connect all products to the proper electrical and/or pressure sources.
- Handle, move, and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Foxboro. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified personnel, to prevent electrical shock and personal injury.

FOXBORO®

Instruction

MI
020-455
June 1981

E94-A SERIES TEMPERATURE TRANSMITTER

INTRODUCTION

The E94 Series Temperature Transmitter provides a 4 to 20 milliampere dc output which is proportional to the temperature of a resistance temperature element. The transmitter is available in three types: wide-span temperature measurement, narrow-span temperature measurement, and narrow-span temperature difference measurement.

The range of the transmitter can be trimmed in the field. Two screwdriver adjustments are externally available for calibration of zero and span.

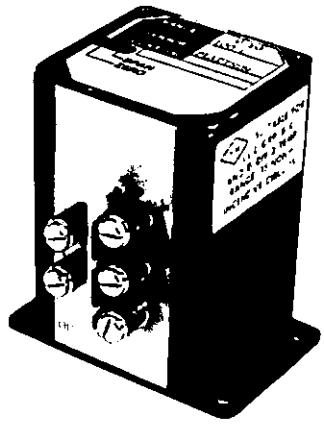


Figure 1

STANDARD SPECIFICATIONS

TYPE RTD*	UNITS	RANGE LIMITS	SPAN	
			TEMPERATURE	TEMPERATURE DIFFERENCE
Nickel Curves NR-226, -227	°C °F	-200 and +320 -320 and +600	12 to 340° 20 to 600°	12 to 56° 20 to 100°
Platinum DIN Curves PR-238, -239 SAMA Curves PR-278, -279	°C °F	-200 and +650 -320 and +1200	6 to 610° 10 to 1100°	6 to 28° 10 to 50°

*Resistance Temperature Detector

Output Load: See Figure 2
Output Signal: 4 to 20 mA

dc Supply Voltage: See Figure 2
Ambient Temperature Limits: -40 and +80°C (-40 and +180°F)

The maximum load resistance depends on the supply voltage shown in Figure 2. This relationship results because the transmitter itself requires a minimum of 12.5 volts to operate.

$$\text{Maximum Resistance (in ohms)} = \left(\frac{\text{Supply Voltage} - 12.5\ \text{V}}{20\ \text{mA}}\right)(1000)$$

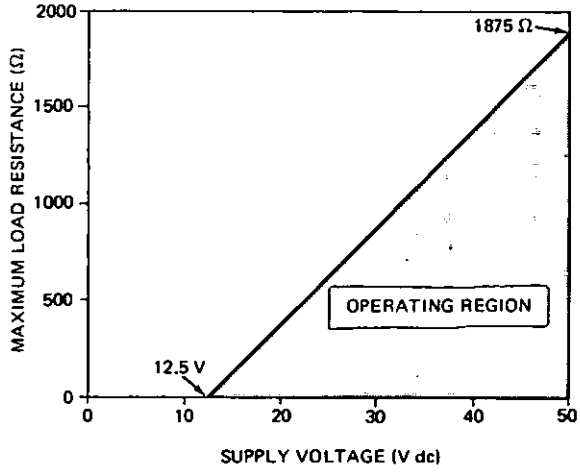


Figure 2

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INSTALLATION

Dimensions and Mounting

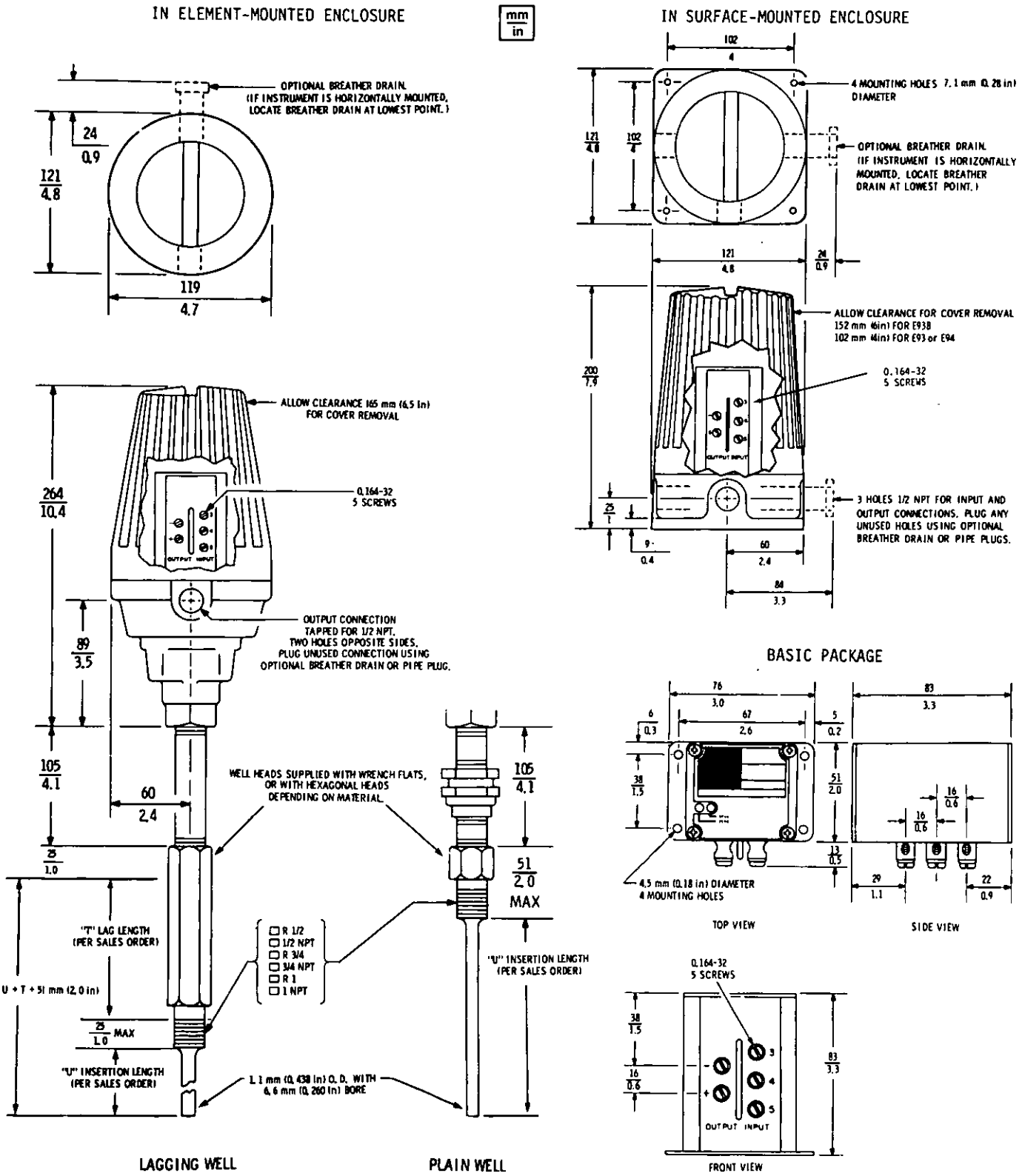
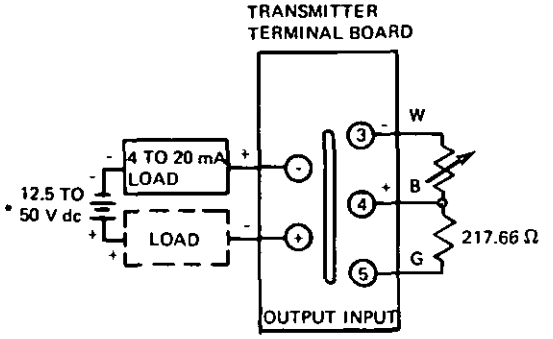
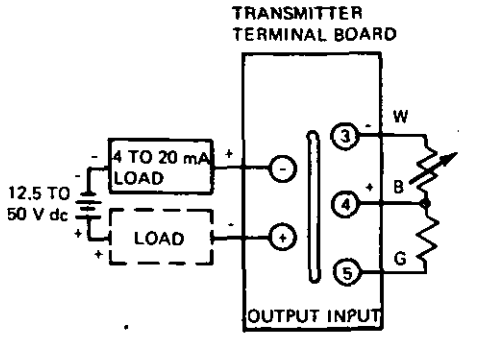


Figure 3

Wiring

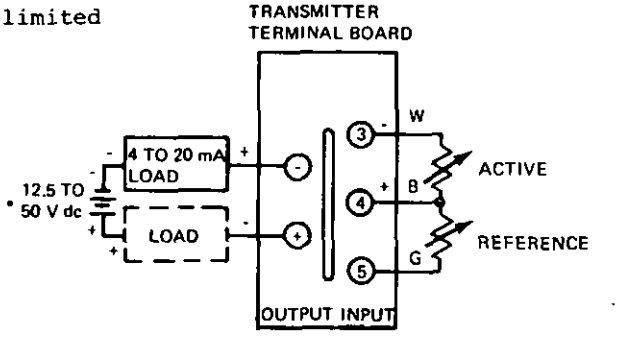


NICKEL RESISTANCE TEMPERATURE INPUT



PLATINUM RESISTANCE TEMPERATURE INPUT

*Unless otherwise limited by safety codes.



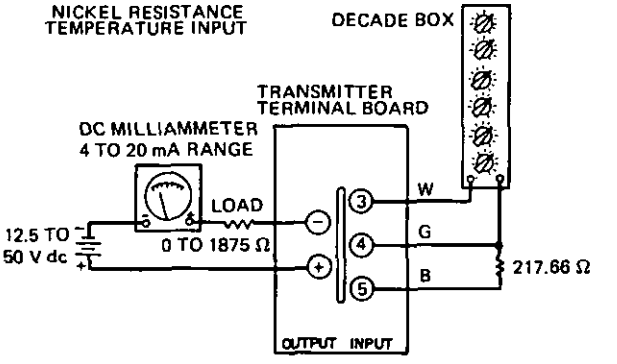
NICKEL AND PLATINUM RESISTANCE TEMPERATURE DIFFERENCE INPUT

NOTE: If 3-wire cable is used for each RTD, green wires are not used and should be taped back.

Figure 4

Electrical pickup through the signal leads of the measuring element may be minimized by either locating the element and leads in areas relatively field-free, or shielding the leads in separate earthed (grounded) conduits.

The transmitter provides a 2-wire output (the same two terminals are used for power and for output). The load may be inserted in series with either the plus (+) or minus (-) power supply lead. See Figure 4.



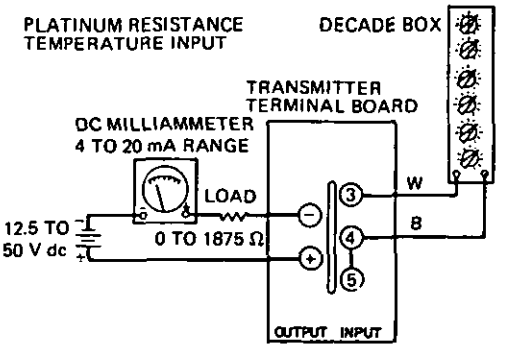


Figure 5

Calibration Procedure— Temperature Transmitter

1. Make connections as shown in Figure 5. Determine resistance range of transmitter from temperature resistance curve supplied with transmitter.

2. Set required minimum input resistance on decade box. If output is not 4 ±0.16 mA, adjust ZERO screw (Figure 6).

3. Set required maximum input resistance on decade box. If output is not 20 ±0.016 mA, adjust SPAN screw (Figure 6).

4. Repeat Steps 2 and 3 until both readings are correct.

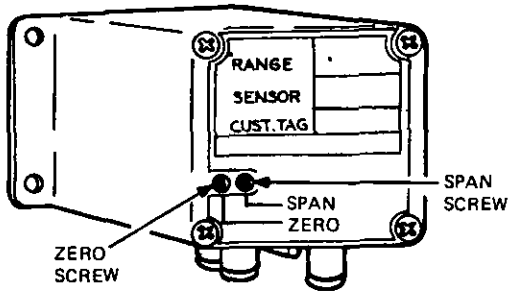


Figure 6

3. Set reference decaded box to reference (zero scale) value (252.89 Ω for 125°F).

   Set active decade box to middle of difference (midscale) value (259.76 Ω for 100°F or 25°F ΔT).

4. Adjust ZERO screw (see Figure 6) so that output reading is 12 ±0.016 mA.

5. Set active decade box (Figure 7) to maximum difference (full scale) value (266.81 Ω for 150°F or 50°F ΔT).

6. Adjust SPAN screw (see Figure 6) so that output reading is 20 ±0.016 mA.

7. Repeat Steps 3 through 6 until no further adjustment is necessary.

8. Set active decade box (see Figure 7) to reference (zero scale) value (252.89 Ω or 100°F).

9. Output should read 4 ±0.016 mA. If incorrect, repeat Steps 3 through 6.

Calibration Procedure— Temperature Difference Transmitter

The values listed in this procedure are for a transmitter with a nickel RTD and a temperature difference range of 0 to 50°F ΔT, at a reference temperature of 100°F. In this example, the zero, midscale, and full-scale temperatures of the active RTD are 100, 125, and 150°F respectively.

1. Set up equipment as in Figure 7.

2. Determine resistances corresponding to zero, midscale, and full-scale temperatures. Use Curve NR-226 [°F] for this example.

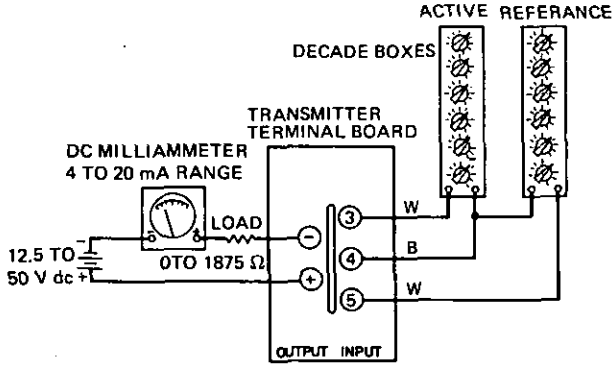


Figure 7

SERVICING

In normal usage, the transmitter should not require servicing. However, if required, it is recommended that the transmitter be sent back to The Foxboro Company, Valencia, CA.

If the user services the transmitter, servicing should be limited to the replacement of the range and/or amplifier printed wiring assemblies (PWA's). When ordering these parts, all information on the data plate should be included.

The design of the circuitry is such, that it is highly unlikely that the range PWA will fail. If there is a transmitter malfunction, replacing the amplifier PWA should correct the condition. If the malfunction continues, the range PWA should be replaced.

If the transmitter range is to be changed, a new range PWA is required. Many standard range PWA's are available from Foxboro. If the range is changed, alter the data plate on top of the transmitter.

Remove Electronic Assembly

1. Remove the four screws holding cover to housing (Figure 8). Remove small screw from upper side.

2. Slide assembly out of housing by pushing against lower terminal posts with thumbs while bracing other fingers against base.

   NOTE
   When sliding assembly out of housing, note how flange of terminal board and flange of metal shielding fit in groove of housing. When reinstalling assembly in housing (Page 6), these parts must be positioned in the same arrangement.

3. To reinstall assembly, see Page 6.

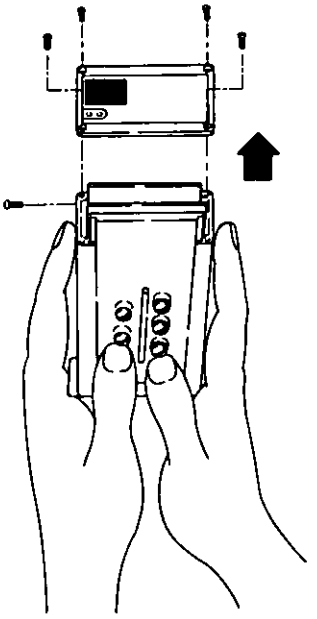


Figure 8

Remove PWA'S

The entire electronics assembly (with the exception of the external terminal board) is coated as a unit with a transparent humidity-resistant compound. Before the individual PWA's can be removed, this coating must be removed from the slots of the screws holding down each PWA.

1. Remove the five screws (at E2, E6, E7, E8, and E9) connecting amplifier PWA to range PWA. (Figure 9).

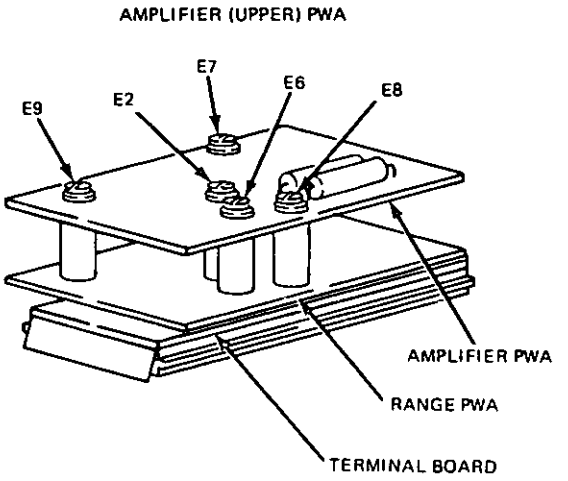


Figure 9

2. Separate and remove amplifier PWA from rest of assembly.

   NOTE
   The coating tends to hold the PWA's together. Force may be required to separate them. Do not damage components on the PWA which is not being replaced.

3. Remove the four screws at E1, E3, E4, E5 (Figure 10) and hex standoff E2, connecting range PWA to terminal board.

4. Separate range PWA from terminal board.

   NOTE
   When lifting off range PWA, female extension of standoff at E3 (at underside of PWA) must be lifted off male extension of terminal 3 (located on blue terminal board).

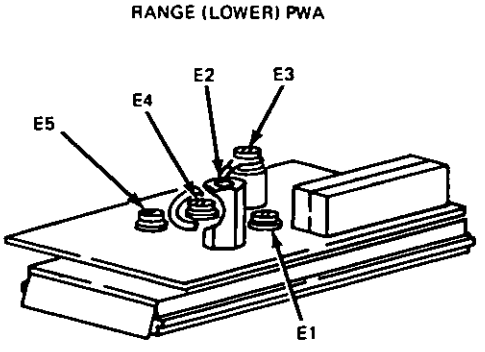


Figure 10

Install PWA'S

Replacement PWA's are factory-coated on both sides with a humidity-resistant compound; areas that will be in contact with mounting screws and standoffs have been protected with a peel-off covering. This covering must be removed before installation to ensure electrical contact. After installation, exposed portions of these areas must be coated with humidity-resistant compound.

Replacement PWA's are shipped with a stripper-coating kit to remove old coating and to coat exposed areas. Required mounting screws and washers to replace the old hardware are also included.

Interconnections between the PWA's and the terminal board are made through mounting screws and their mating standoffs. All screws must be securely tightened.

1. If range PWA is being replaced, the existing coating at the five mounting pads on both sides of the amplifier PWA (which must be removed first) must be removed to ensure good electrical contact.

   Apply stripping compound supplied with PWA to these areas. After about one minute, clean these areas throughly with a cotton swab soaked in isopropyl alcohol.

2. Install parts in reverse order of disassembly.

   All mounting screws are #4-40. Amplifier PWA uses five 3/8 in long screws. Range PWA uses four screws and a hex standoff. The shorter screw is used at the wire tang.

3. Use a cotton swab to paint all uncoated areas with coating compound supplied with PWA. Allow to dry in air for one hour.

4. Reinstall assembly into housing. See adjacent section.

Reinstall Electronics Assembly

If the electro-magnetic interference protection of the transmitter is to be maintained, the flange of the metal shielding and the flange of the terminal board must fit in the groove of the housing as shown in Figure 11.

NOTE

The clearance between the assembly and the housing is very small, and the procedure must be followed exactly.

1. While compressing flange of shielding, as shown in Figure 11:

   a. Position assembly in line with housing.

   b. Position flange of compressed shielding so that it is in line with bottom of groove in housing.

   c. Ease assembly into housing.

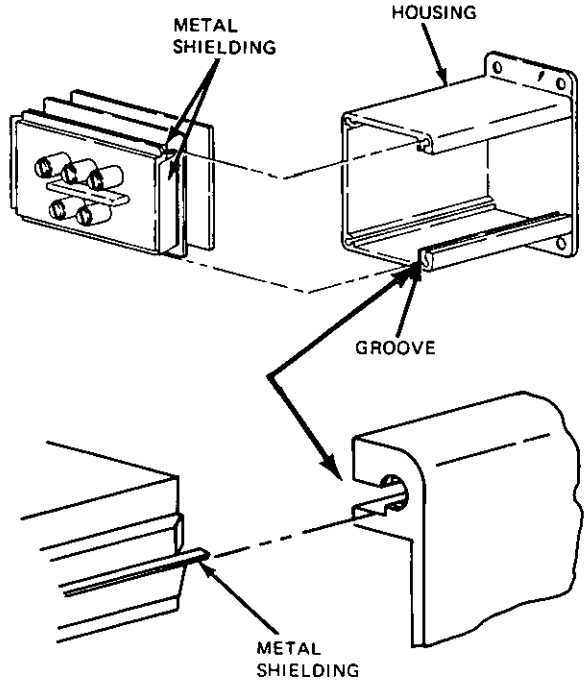


Figure 11

CIRCUIT DIAGRAMS AND PARTS LIST

Standard Version, Part A2041EA

PTB Version, Part A2043FY
(Right hand portion shown)

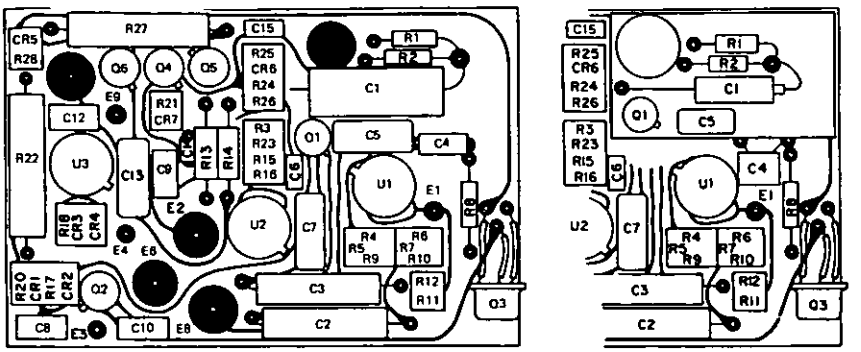


Figure 12. Amplifier PWA

⚠ CAUTION

The parts lists and circuit diagrams provided in this Instruction are solely for informational purposes. The use of this information for repair of the instrument is not recommended and the user shall be responsible for any damage to the instrument, or possible violation of warranty, resulting from such repair.

Parts List

Item	Description	Part No.
R1	Resistor, film, 180 Ω ±2%, 1/4 W, 200 ppm/°C	E0156EF
R2, R3	Resistors, metal film, 2 kΩ ±1%, 1/8 W, 50 ppm/°C	E0142WB
R4, R5	Resistors, metal film, 200 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143MM
R6, R7	Resistors, metal film, 10 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143AB
R8	Resistor, film, 2 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156FT
R9, R10	Resistors, metal film, 68.1 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143FW
R11	Resistor, metal film, 100 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143KT
R12	Resistor, film, 10 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156KT
R13, R14	Resistors, film, 200 kΩ ±1%, 1/8 W, 100 ppm/°C	E0301MM
R15	Resistor, 1 MΩ ±1%, 1/8 W, 50 ppm/°C	E0143SL
R16	Resistor, film, 274 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143NE
R17, R18	Resistors, film, 332 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143NS
R20, R23	Resistors, film, 100 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156MC
R21	Resistor, carbon composition, 18 MΩ ±5%, 1/4 W	E0152RK
R22	Resistor, film, 300 Ω ±2%, 1 W, 200 ppm/°C	E0158EP
R24	Resistor, film, 27 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156LK
R25	Resistor, metal film, 30.1 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143CW
R26	Resistor, metal film, 68.1 kΩ ±1%, 1/8 W, 50 ppm/°C	E0143FW
R27	Resistor, film, 1.2 kΩ ±2%, 1 W, 200 ppm/°C	E0158FM
R28	Resistor, film, 24 kΩ ±2%, 1/4 W, 200 ppm/°C	E0156LF
C1 (standard)	Capacitor, 15 µF ±10%, 35 V dc, tantalum	H0160CN
C1 (PTB)	Capacitor, 15 µF ±10%, 20 V dc	H0159PX
C2, C3	Capacitors, 0.1 µF ±5%, 50 V dc, polycarbonate	A2038YL
C4	Capacitor, 1.0 µF ±20%, 50 V dc, ceramic	H0140BM
C5, C7	Capacitors, 3.0 pF ±5%, 500 V dc, mica	H0104GC
C6	Capacitor, 0.01 µF ±10%, 50 V dc, polycarbonate	A2043ET
C8, C9, C10, C12	Capacitors, 0.1 µF ±10%, 100 V dc, ceramic	H0111CB
C13	Capacitor, 100 pF ±5%, 500 V dc, mica	H0104BA
C14	Capacitor, 1000 pF ±20%, 100 V dc, ceramic	A2041VE
C15	Capacitor, 0.01 µF ±10%, 100 V dc, ceramic	H0111BL
CR1-CR4 CR6, CR7	Diodes, Switching, Type 1N4531	N0258DB
CR5	Diode, Rectifier, Type 1N645	N0258AF
Q1, Q2	Transistors, N-JFET, Type 2N4393	N0282AT
Q3	Transistor, NPN, Type 2N3440	A2029TN
Q4	Transistor, NPN, Type 2N2484	K0120RY
Q5, Q6	Transistors, PNP, Type 2N2907A	N0282AL
--	Transistor Pad (used with Q1, Q2, Q4, Q5, and Q6)	A2040YP
U1	IC, Operational Amplifier, Type LM308 (Select)	A2042DX
U2, U3	IC, Operational Amplifier, Type LM308	N0284PB

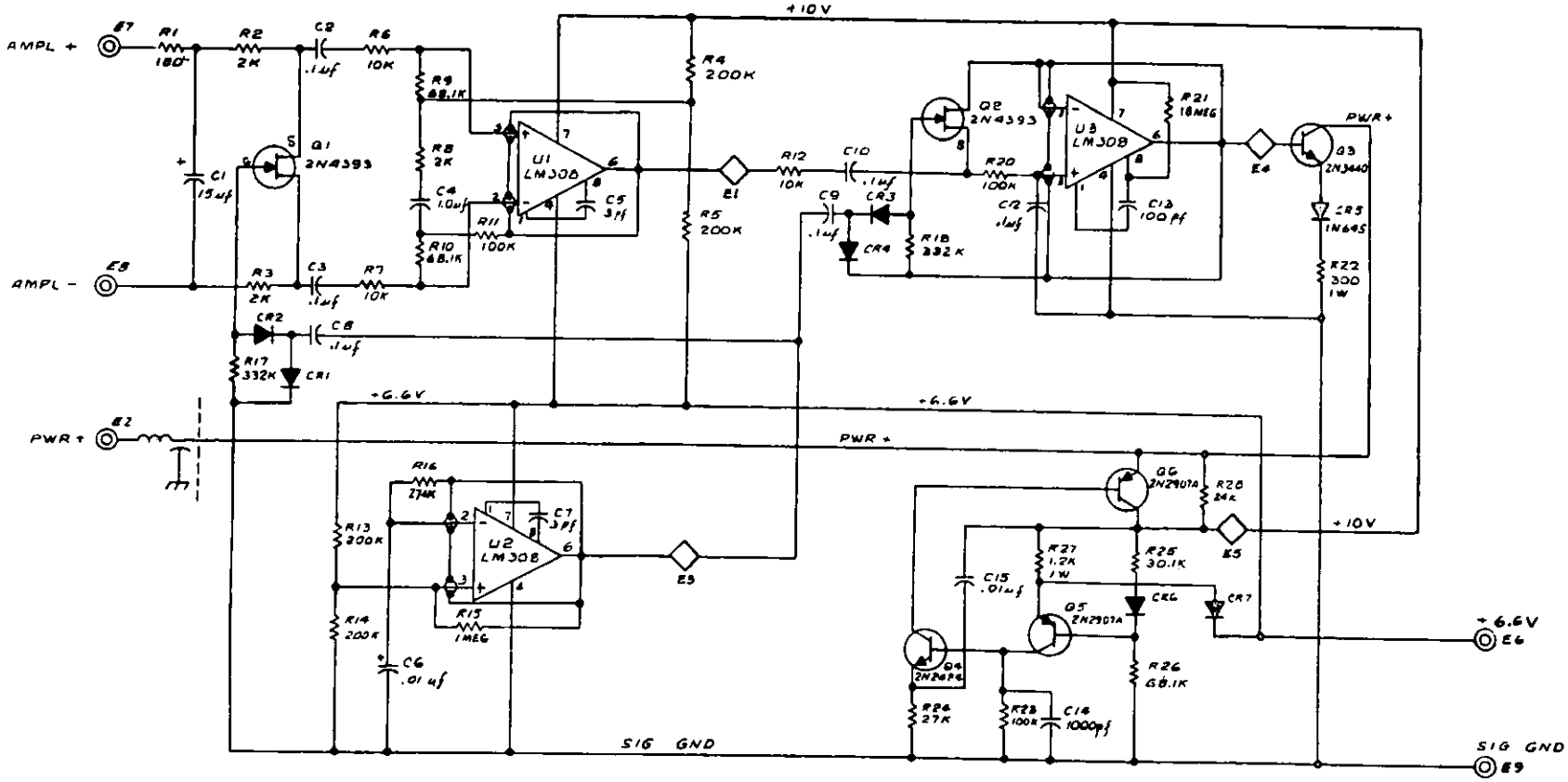


Figure 13.
Circuit Diagram Amplifier PWA

Nickel Resistance Range PWA, Wide Span

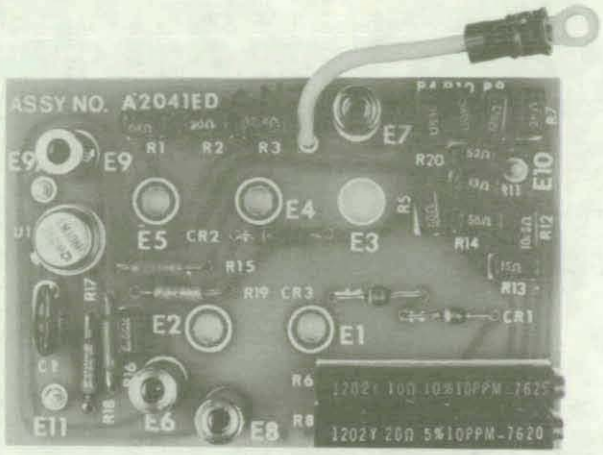


Figure 14

Parts List

Item	Description	Part No.
R4, R10 (Pair)	Resistor, 355 Ω ±0.1%, 1/8 W, 5 ppm/°C, 2 ppm/°C match and track	A2039VP
	Resistor, 340 Ω ±0.1%, 1/8 W, 5 ppm/°C, 2 ppm/°C match and track	
R5	Resistor, 56 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LU
R6	Potentiometer, 10 Ω ±5%, 1/2 W, 10 ppm/°C	E0285KC
R8	Potentiometer, 20 Ω ±5%, 1/2 W, 10 ppm/°C	E0285TK
R13	Resistor, 15 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LN
R15	Resistor, 1.21 kΩ ±1%, 1/8 W, 25 ppm/°C	E0132SX
R16	Resistor, 6.65 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2040MD
R17, R18	Resistors, 20 kΩ ±1%, 1/8 W, 25 ppm/°C	E0133BW
R19	Resistor, 6.65 kΩ ±1%, 1/8 W, 25 ppm/°C	E01312ZA
	NOTE: Resistors R1, R2, R3, R7, R9, R11, R12, R14, and R20 are selected for input range.	
C1	Capacitor, 30 pF ±5%, 500 V	H0104AF
CR1, CR3	Diodes, Rectifier, Type 1N645	N0258AF
CR2	Diode, Zener, Type 1N4611A, 6.6 V	N0257TZ
U1	Integrated Circuit, Operation Amplifier, Type LM308	N0284PB
	Integrated Circuit Pad	A2040YQ

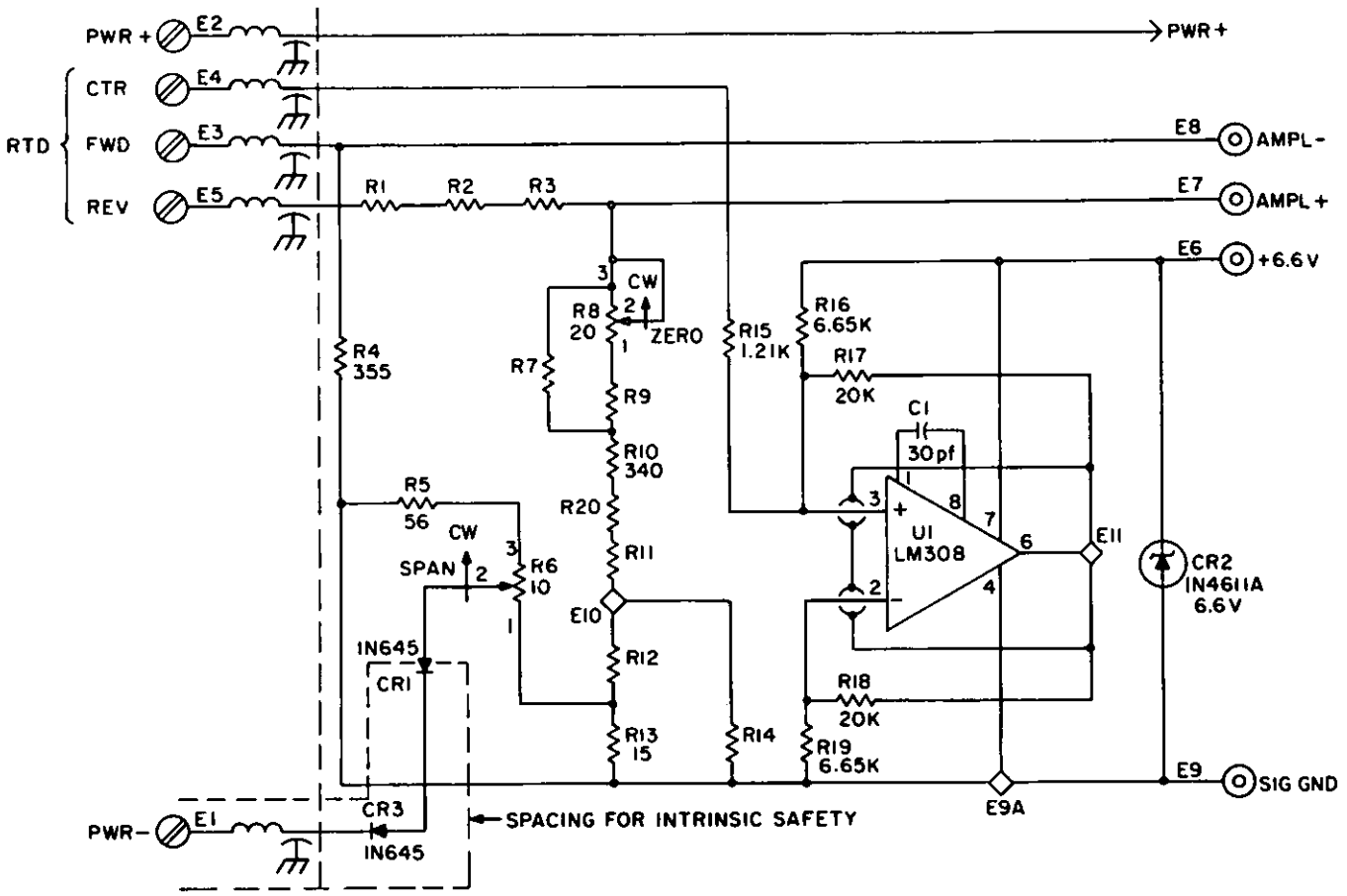


Figure 15.
Circuit Diagram Nickel Resistance Range,
Wide Span PWA

Nickel Resistance Range PWA, Narrow and Medium Spans

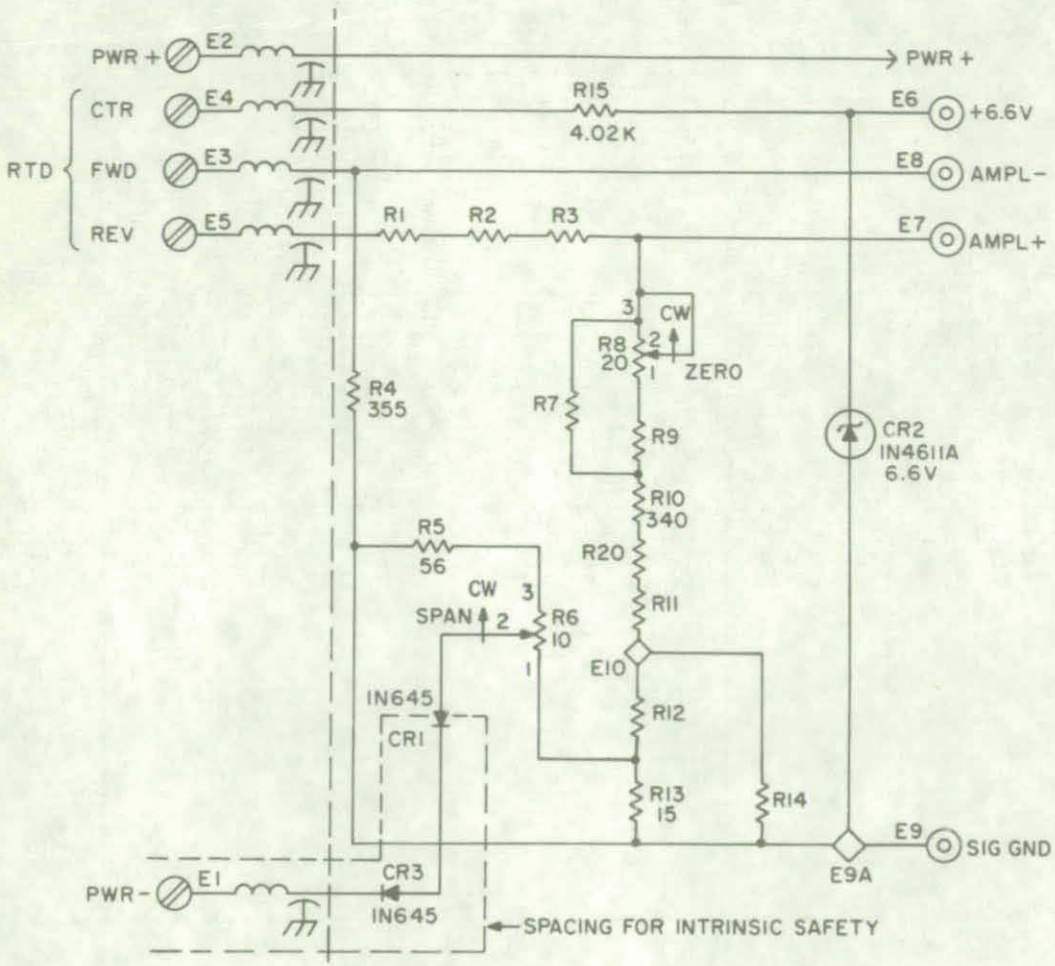


Figure 16

Parts List

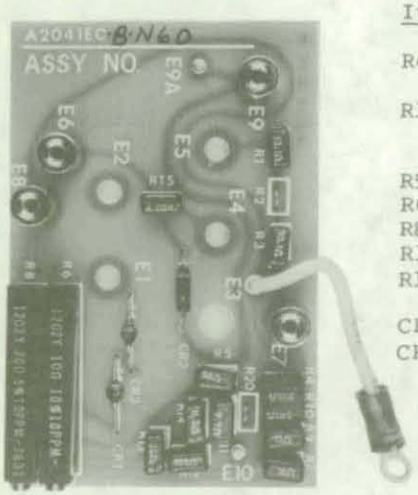


Figure 17

Item	Description	Part No.
R4, R10 (Pair)	Resistor, 340 Ω ±0.1%, 1/8 W, 5 ppm/°C each, 2 ppm/°C match and track	A2039VP
	Resistor, 355 Ω ±0.1%, 1/8 W, 5 ppm/°C each, 2 ppm/°C match and track	
R5	Resistor, 56 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LU
R6	Potentiometer, 10 Ω ±5%, 1/2 W 10 ppm/°C	E0285KC
R8	Potentiometer, 20 Ω ±5%, 1/2 W, 10 ppm/°C	E0285TK
R13	Resistor, 15 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LN
R15	Resistor, 4.02 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039MF
CR1, CR3	Diodes, Rectifier, Type 1N645	N0258NF
CR2	Diode, Zener, Type 1N4611A, 6.6 V	N0257TZ
	NOTE: Resistors R1, R2, R3, R7, R9, R11, R12, and R14 are selected for input range.	

Platinum Resistance Range PWA, Narrow Span

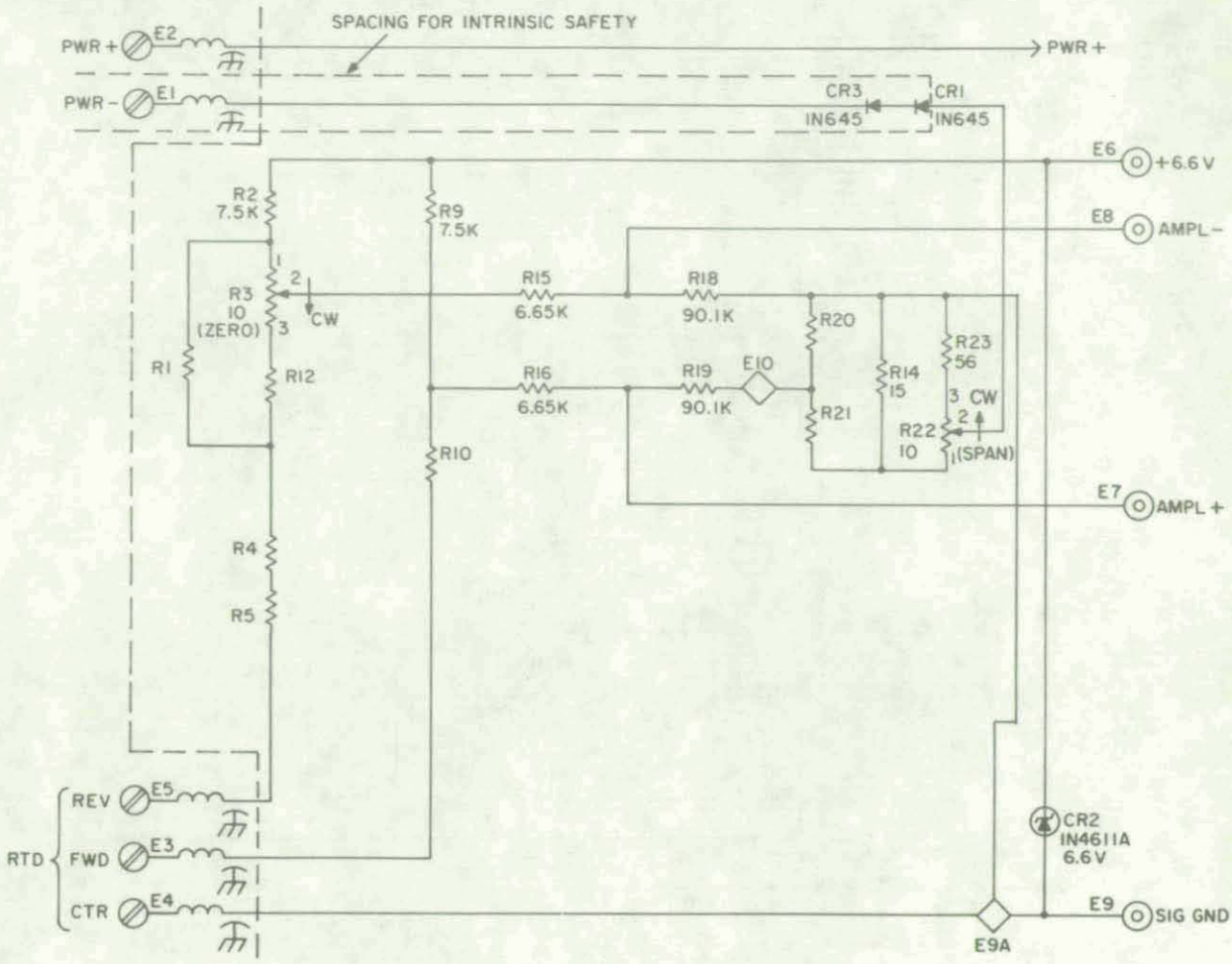


Figure 18

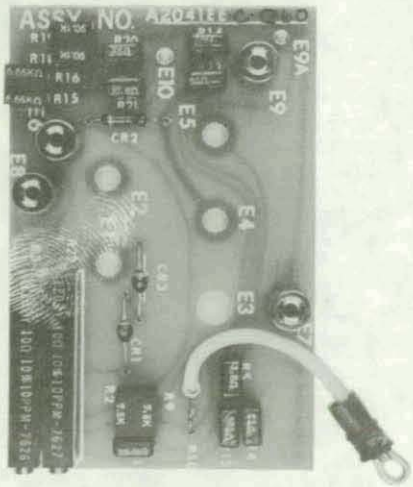


Figure 19

Parts List

Item	Description	Part No.
R3	Potentiometer, 10 Ω ±5%, 1/2 W, 10 ppm/°C	E0285KC
R2, R9 Pair	Resistors, 7.5 kΩ ±0.1%, 1/8 W 5 ppm/°C. 2 ppm/°C match and track	A2039LE
R14	Resistor, 15 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LN
R15, R16 Pair	Resistors, 6.65 kΩ ±0.1%, 1/8 W, 5 ppm/°C, 2 ppm/°C match and track	A2039LD
R18, R19 Pair	Resistors, 90.1 kΩ ±0.1%, 1/8 W 5 ppm/°C, 2 ppm/°C match and track	A2039LC
R22	Potentiometer, 10 Ω ±5%, 1/2 W 10 ppm/° C	E0285KC
R23	Resistor, 56 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LU
	NOTE: Resistors R1, R4, R5, R10, R12, R20, and R21 are selected for input span.	
CR1, CR3	Diodes, Rectifier, Type 1N645	N0258AF
CR2	Diode, Zener, Type 1N4611A, 6.6 V	N0257TZ

Platinum Resistance Range PWA, Wide Span

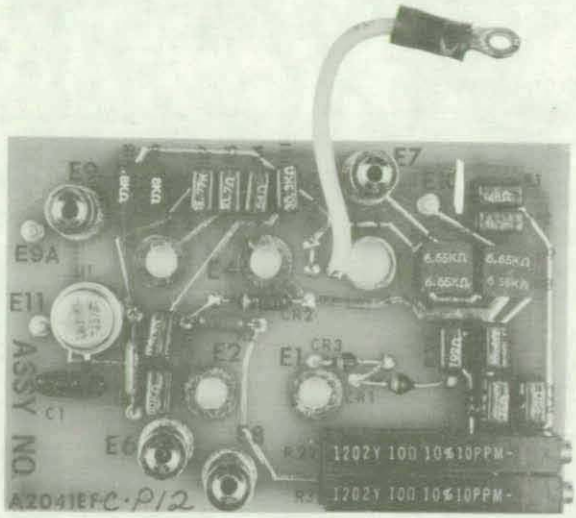


Figure 20

Parts List

Item	Description	Part No.
R2	Resistor, 205 kΩ ±1%, 1/8 W 25 ppm/°C	E0133MN
R3	Potentiometer, 10 Ω ±5%, 1/2 W, 10 ppm/°C	E0285KC
R6, R8 Pair	Resistors, 8.0 kΩ ±0.1%, 1/8 W, 5 ppm/°C each, 2 ppm/°C match and track	A2039VU
R7	Resistor, 15.77 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039VQ
R9	Resistor, 174.4 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039VS
R11	Resistor, 30.3 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039VR
R13	Resistor, 205 kΩ ±1%, 1/8 W, 25 ppm/°C	E0133MN
R14	Resistor, 15 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LN
R15, R16 Pair R18, R19 Pair	Resistors, 6.65 kΩ %0.1%, 1/8 W, 5 ppm/°C each, 2 ppm/°C match and track	A2039LD
R17	Resistor, 80 kΩ ±0.1%, 1/8 W, 5 ppm/°C	A2039VT
R22	Potentiometer, 10 Ω ±5%, 1/2 W, 10 ppm/°C	E0285KC
R23	Resistor, 56 Ω ±0.1%, 1/8 W, 5 ppm/°C	A2039LU
	NOTE: Resistors R1, R3, R4, R5, R10, R12, R20, and R21 are selected for input range	
C1	Capacitor, 30 pF ±5%, 500 V	H0104AF
CR1	Diode, Rectifier, Type 1N645	N0258AF
CR2, CR3	Diodes, Zener, Type 1N4611A, 6. V	N0257TZ
U1	Integrated Circuit, Type LM308	N0284PB

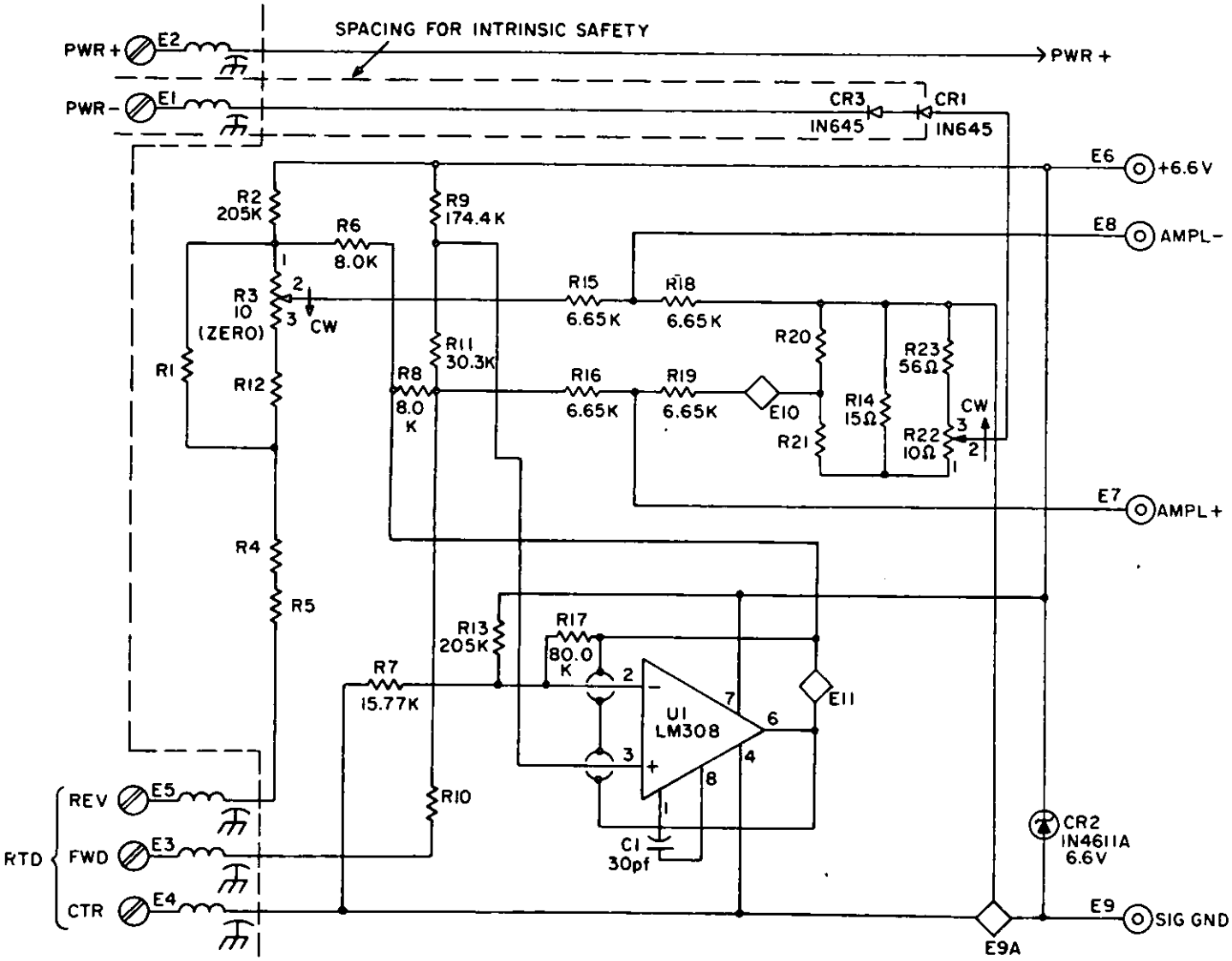


Figure 21.
Circuit Diagram Platinum Resistance,
Wide Span Range PWA

Printed in England

Instruction

MI
020-452
January 1983

E93 AND E94 SERIES TEMPERATURE TRANSMITTERS OPTIONAL JUNCTION BOX

INTRODUCTION

The E93 and E94 Series with surface mounting temperature transmitters can be equipped with an optional junction box. The junction box contains jack connections for a local readout or for mounting an optional output meter. The output meter dial has uniform (0 to 100%) graduations corresponding to a 4 to 20 mA output.

The junction box can be rotated to any position and the terminal block within the junction box can be rotated in 90° increments.

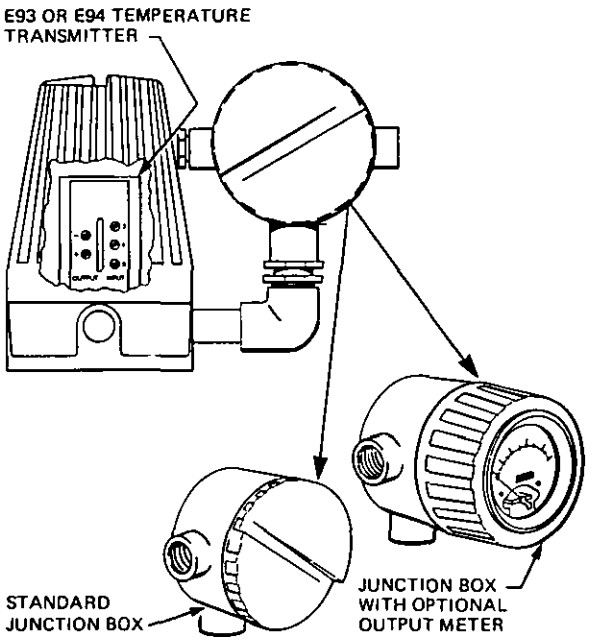


Figure 1

INSTALLATION

Piping

To prevent condensation build up, the junction box should be mounted in the upright position. (See Figure 1)

Wiring

Optional Junction Box Wiring

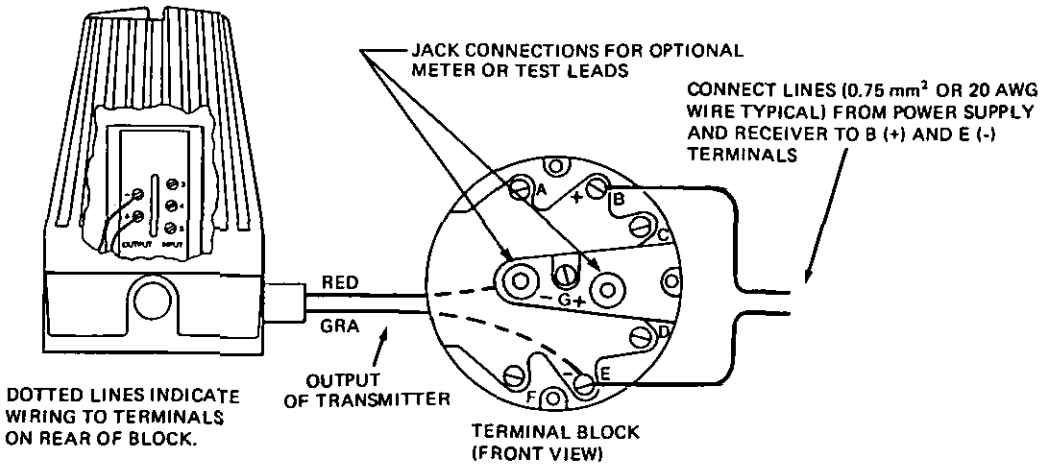


Figure 2

FOXBORO®

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Internal Wiring

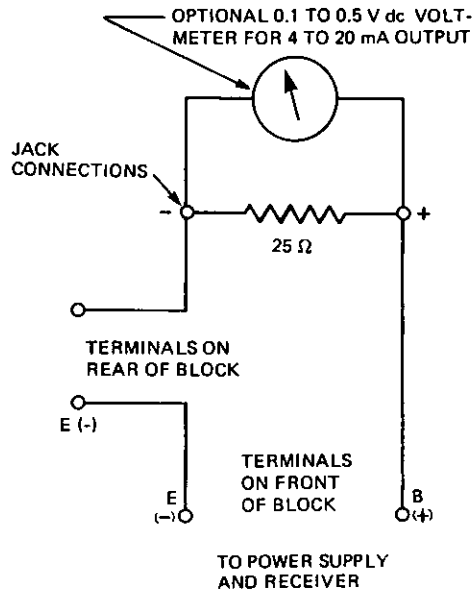


Figure 3

Rotating Junction Box

1. Loosen hex locknut. (See Figure 4)
2. Rotate box to desired position. Retighten locknut, holding box stationary.

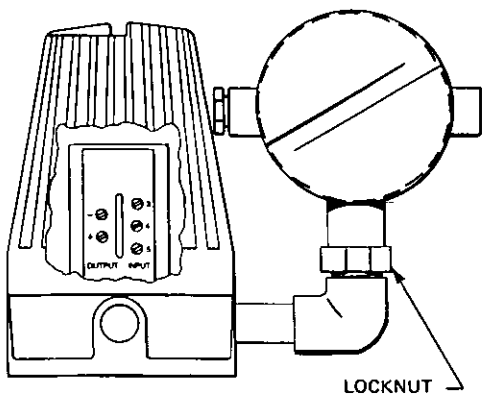


Figure 4

Rotating Terminal Block

1. Unscrew cover and lift out meter (Figure 5).
2. Remove the two screws holding terminal block and lift out block. Rotate block to desired position, and reconnect to junction box.
3. Reinsert meter into block and screw on cover hand tight.

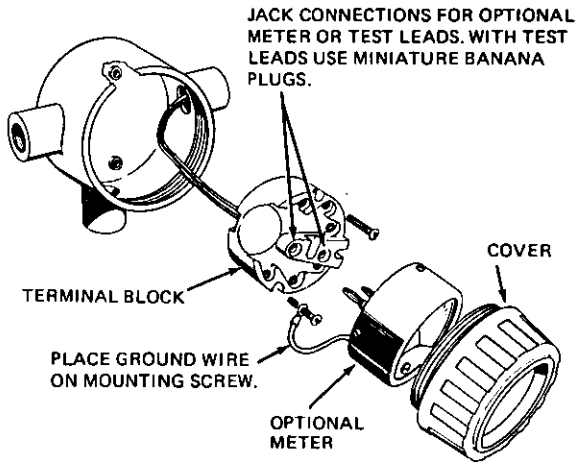


Figure 5

Reference Documents

For standard instructions of transmitter see:

MI 020-450	E93-A (Non-Isolated)
MI 020-451	E93-B (Isolated)
MI 020-455	E94

0183

Printed in England

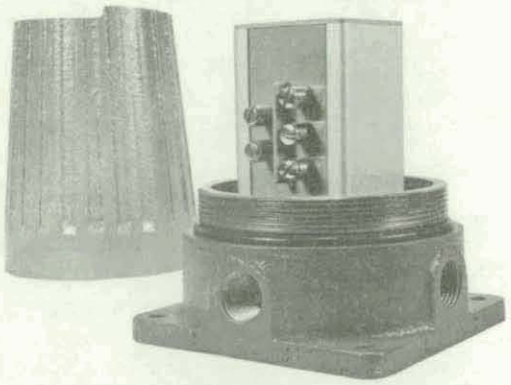
Technical Information

TI
39-94a
August 1973

E94 SERIES TEMPERATURE TRANSMITTER

(a) Basic Transmitter Package.

(b) Surface Mounted Housing.



(c) Element Mounted Housing, with Optional Platinum RTD.

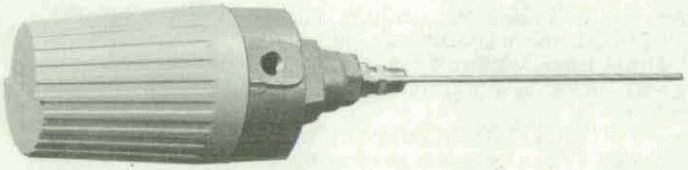


Figure 1. E94 Series Temperature Transmitter.

GENERAL

The E94 Series Temperature Transmitter receives an input signal from RTD (Resistance Temperature Detector or Bulb) temperature sensors and transmits a 4-20 mA dc signal proportional to the measured temperature. Illustrated in Figure 1, it is a field mounted, two wire instrument.

Two wire, field mounted transmitters can lower installation costs by virtually eliminating the need for special element extension cables. They transmit a high level, 4-20 mA dc signal over conventional, unshielded copper wires. Also, to further minimize the cost of installation, several loops can frequently be powered from a single power supply with multiconductor cable. The transmitter is designed to be intrinsically safe when used in specified SPEC 200 measurement and control loops.

Interchangeable range units can be selected from a wide variety of standard ranges. Both nickel and platinum RTD range units are available for either temperature or temperature difference measurements.

PRINCIPLE OF OPERATION

The E94 Series Transmitter provides a two wire output similar to the field proven concept used in other Foxboro transmitters. As shown in Figure 2, the same wiring is used for power and output. The load resistance is connected in series with a dc power supply, and the current drawn from the supply is the 4-20 mA output signal.

Field mounting the transmitter at or near the actual measurement point eliminates the installation of special resistance bulb extension wires to the receiver. In some applications there are long distances between the point of measurement and the ultimate receiver instrument. Here, loop performance is often improved because there is virtually no lead wire error.

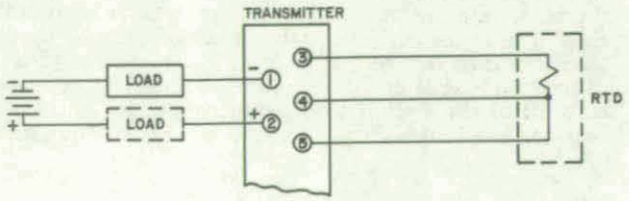


Figure 2. Connection of the E94 Series Transmitter.

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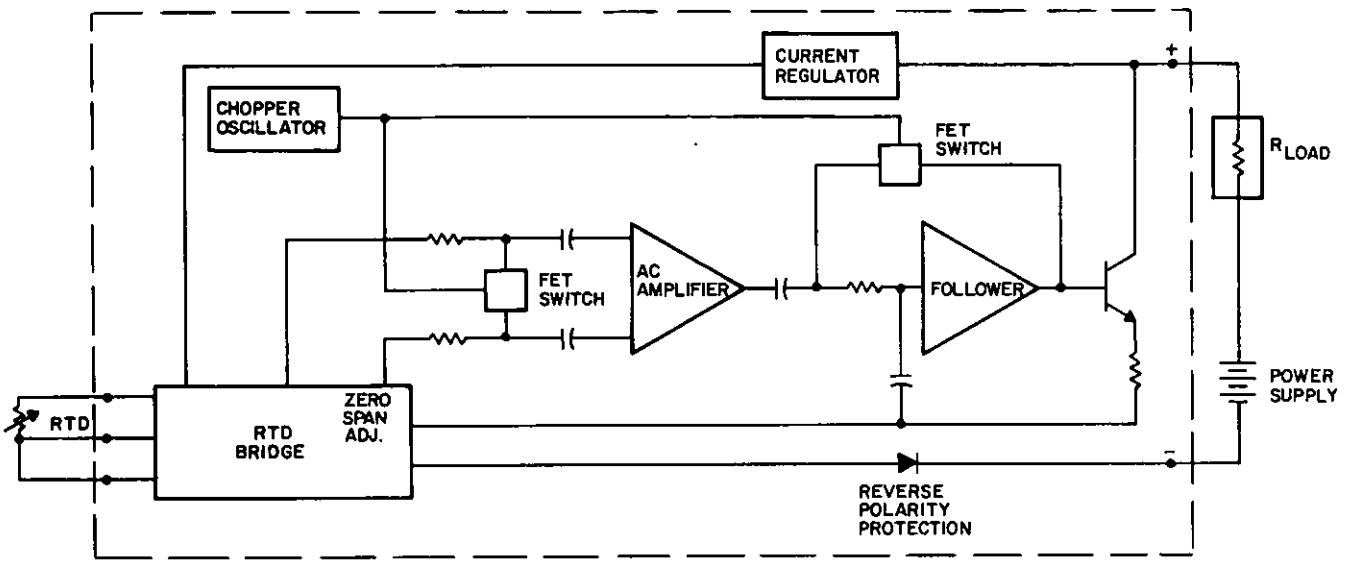


Figure 3. Simplified Circuit Diagram of the E94 Series Transmitter.

The bridge circuits vary depending on the type of RTD, nickel or platinum, and the span of measurement. Either wide or narrow range bridge circuits may be used with nickel and platinum RTD measurements.

A nickel RTD, following the NR226 or NR227 curve, has a uniform percentage increase of resistance with temperature. The narrow span nickel RTD circuit used in the E94 Series Transmitter has a current division bridge. The wide span nickel RTD circuit also has an operational amplifier to provide a constant current excitation.

A platinum RTD has a nearly linear resistance vs temperature curve. The narrow span platinum RTD circuit is similar to the narrow span nickel RTD circuit. However, the wide span platinum RTD circuit requires another type of bridge. In order to obtain a linear voltage vs temperature output from the bridge, slight variations of the current through the bulb are necessary. In this way, the current source is programmed to increase or decrease in the desired manner.

Figure 3 is a simplified circuit diagram of the E94 Series Transmitter. To provide compensation for the effect of lead resistance on zero, a three wire connection is used with all types of RTD. One lead is in series with the bulb, one in series with the zeroing resistors and the third is in series with the high impedance current source. The amplifier is a very high gain, chopper stabilized difference amplifier. It functions as a null detector by controlling the 4-20 mA output current to maintain a null between the bridge output and the feedback voltages.

The transmitter is protected from reverse polarity connection of the power supply by means of a diode in the negative lead of the output circuit.

CONSTRUCTION

The transmitter contains two circuit board assemblies: a range board, fastened to the user connection terminal block, and an amplifier, fastened to the range board. All electrical interconnections are made through spacer posts; no internal wiring changes are needed for disassembly or range changes. The basic transmitter consists of the circuit board assemblies mounted in an extruded aluminum housing. This basic unit can be mounted in nonhazardous Ordinary Locations. The E94 Series Transmitter is also available in a surface or element mounted housing designed for use in Class I, Group C or D, Division 1 Hazardous Locations.

SUMMARY OF FEATURES

1. The two wire transmitter concept decreases total installed costs in many applications.

2. Interchangeable range units allow flexibility in original or subsequent applications.

3. The completely solid-state construction of the E94 Series Transmitter - featuring integrated circuits and industrial grade components - provides high accuracy and dependable service.

Parts List

PL
008-582
February 1983

E94
TEMPERATURE TRANSMITTER

Style C

Model Code

E94 = Temperature Transmitter

Measuring Element Type
-Q = Temperature, Platinum RTD, 100 Ω DIN
-P = Temperature, Platinum RTD, 100 Ω SAMA
-N = Temperature, Nickel RTD, NR-226 or NR-227
-C = Temperature Difference, Platinum RTD
-B = Temperature Difference, Nickel RTD
-X = Nonstandard

Measurement Range
See Instrument Data Label

Transmitter Package Code
B = Basic Amplifier Package
(Amplifier in control room environment or for replacement)
S = Surface-Mounted Transmitter Package
(RTD remote and transmitter in field environment)
W = Integrally-Mounted Element Package
(RTD mounted to transmitter, bare element)
L = Integrally-Mounted Element Package
(RTD mounted to transmitter, element spring-loaded into well)

FOXBORO®

Basic Package
(Code B)

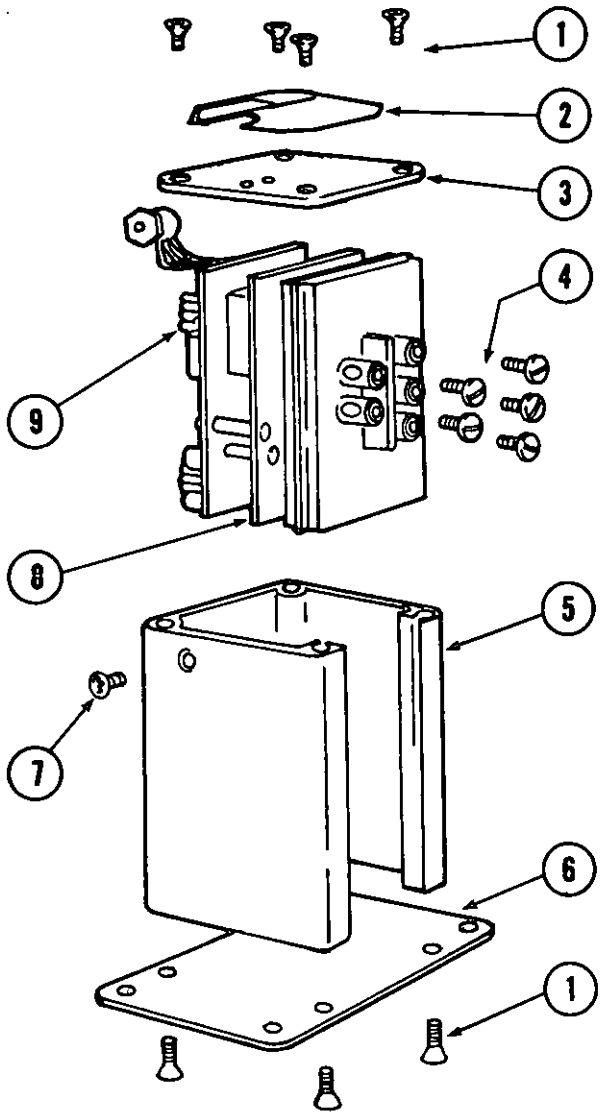
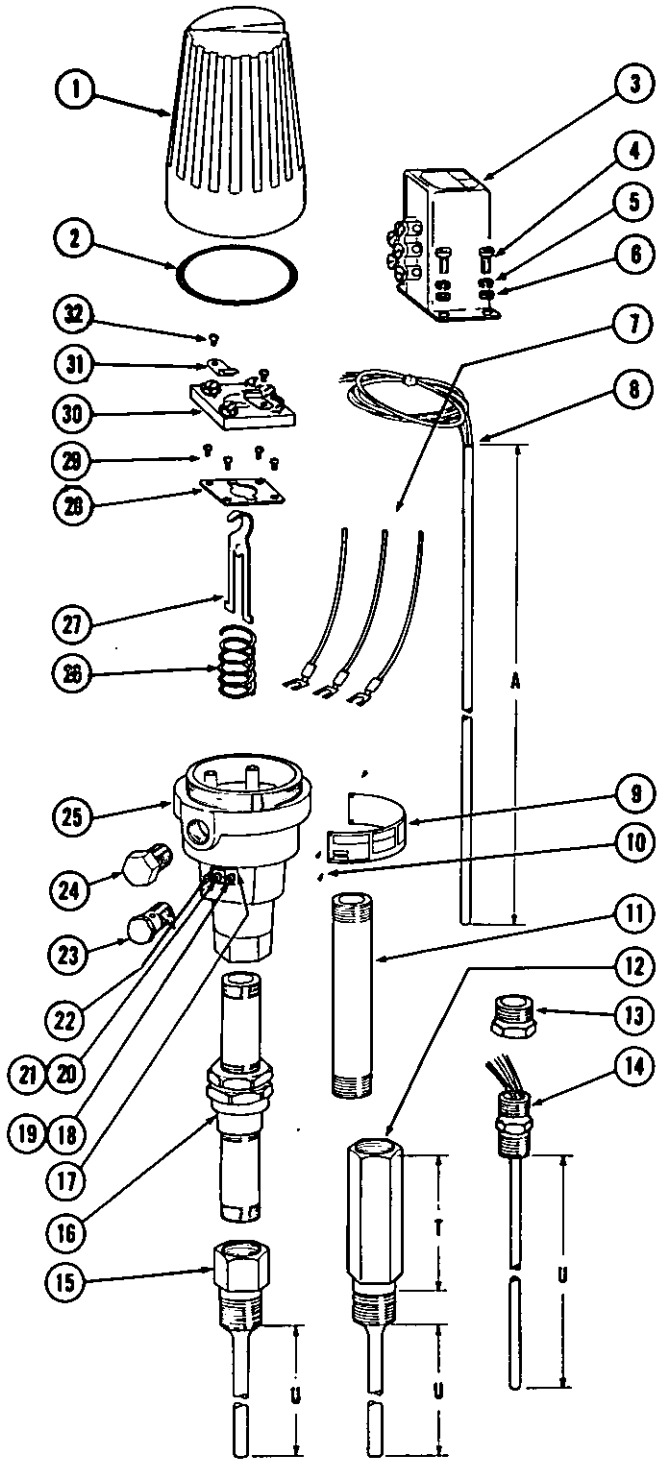


Figure E1574A

Item	Part No.	Qty.	Part Name
1	A2041EQ	8	Screw, F.H., 0.138-32 x 0.500
2	—	1	Label (give origin, range, and sensor information)
3	A2041DQ	1	Top Plate
4	X0100RL	5	Screw, Pan H., 0.164-32 x 0.375
5	A2041EM	1	Housing
6	A2041EL	1	Bottom Plate
7	A2041ET	1	Screw, F.H., 0.112-40 x 0.187
8	—	1	PWA, Range (give origin, range, and sensor information)
9	—	1	PWA, Amplifier (give origin, range, and sensor information)
—	A2045EV	1	Mounting Kit (for installing basic package on 2-in pipe)

Element Mounted Assembly (Codes L or W)
Surface Mounted Assembly (Code S)



Item	Part No.	Qty.	Part Name
1	A2043LK	1	Cover
2	A2040AH	1	Gasket
3	—	1	E94 Temperature Transmitter (see page 2)
4	X0156VD	4	Screw, Pan H., 0.164-18 x 0.500
5	0026003	4	Lockwasher
6	N0119RL	4	Washer
7	Below	—	Wire Lead, 150 mm (6 in)
	N0249LE		Green
	N0249LK		Black
	N0249LJ		White
—	A2014ZM	3	Terminal
—	A2038TG	3	Terminal Lug
8	—	1	Resistance Temperature Detector (RTD), (For well type installations, give "A" length of bulb plus "U" and "T" lengths of well.) Includes Padder Board, item 30
9	Below	1	Data Plate
	A2041WR		Standard
	B0125GN		PTB Application
10	N0143WX	4	Screw, Pan H., 0.086 x 0.187
11	Below	1	Nipple
	A2041UN		140 mm (5.5 in), see note
	E0119FC		125 mm (5 in)
12	—	1	Well, 3/4 NPT Lagging, (give material and "U" and "T" lengths)
13	0029775	1	Reducing Bushing (used with bare bulb)
14	—	1	Resistance Temperature Detector (RTD), (For bare bulb installations 1/2 NPT, give "U" length.) Includes Padder Board, Item 30
15	—	1	Well, 3/4 NPT Plain, (give material and "U" length)
16	Below	1	Coupling Assembly
	A2041YZ		140 mm (5.5 in), see note
	A2041YY		125 mm (5 in)
17	A2043EM	1	Grounding Strap
18	X0122UH	1	Screw — For PTB Only
19	A2014ZY	1	Lockwasher — For PTB Only
20	X0124FZ	1	Screw — For PTB Only
21	A2014ZZ	1	Lockwasher
22	A2043EN	1	Grounding Strap
23	A2040CJ	1	Drain – Breather
24	D0116KR	1	Plug, 1/2 NPT
25	Below	1	Base, Element Mounted (Codes L, W)
	A2043LL		Standard
	A2043NK		PTB Application
25	Below	1	Base, Surface Mounted (Code S)
	A2043LM		Standard
	A2043NH		PTB Application
26	B0129KA	1	Spring — Well Models Only
27	A2042RL	1	Hook — Well Models Only
28	N0207AB	1	Pressure Plate — Well Models Only
29	X0156NK	4	Screw — Well Models Only
30	—	—	RTD Padder Board (included in items 8 and 14)
31	E0119FM	2	Clip
32	X0156NK	2	Screw, Pan H., 0.138-20 x 0.375

Note: Order Spacer A2041UR (not shown) when using 140 mm (5.5 in) coupling or nipple.

Figure E1593

MB 150

0283

Printed in England

WARRANTY

Except as hereinafter provided, the Company (hereinafter called "Foxboro") warrants that all parts manufactured by it (but not by others) shall be within specified limits of calibration, if any, and free from defects in material or workmanship, under proper and normal use. Foxboro, at its option, shall replace or repair, free of charge, any part covered by this warranty which shall be returned, transportation charges prepaid, within one year from shipment by Foxboro and which examination proves not to be within the specified limit of calibration or not to be free from such defects in material or workmanship. Foxboro shall not be liable for any repairs or replacements of parts by others and covered by this warranty except those made with Foxboro's written consent. Foxboro shall be liable for breach of this warranty only if it receives written notice of such breach within one year from the date of shipment of the product to which the breach relates. The foregoing shall constitute the sole remedy of the purchaser for any breach by Foxboro of its warranty.

FOXBORO MAKES NO WARRANTIES REGARDING PARTS MANUFACTURED BY IT OR OTHERS (INCLUDING WITHOUT LIMITATION WARRANTIES AS TO MERCHANTABILITY), EITHER EXPRESSED OR IMPLIED, EXCEPT AS PROVIDED HEREIN.

SERVICE

The Company is anxious to be of every possible assistance to you, to insure your continued satisfaction. A fully qualified Service Engineer will call promptly if the need arises. Arrangements for this service may be made through your nearby Foxboro Sales Representative. When factory repairs are required, the instrument may be sent to any Foxboro plant. Check with your International Sales Representative who will advise you as to which plant should be utilized.

The Foxboro Company, Foxboro Mass. U.S.A.; Foxboro-Yoxall Ltd., Redhill, Surrey, England; and Foxboro (Nederland) N.V., Soest, Netherlands provide expertly staffed and fully equipped Training Schools devoted to the instruction of customer's Instrumentation Engineers and Service Men. The courses cover theory of operation, maintenance and application of the principial types of instruments. Applications from Companies in the British Isles should be made to Foxboro-Yoxall Ltd.; from those in the other parts of the world, to the nearest International Sales Representative as listed on the last sheet of this book.

PARTS

When repairs are to be made by the customer, it is strongly urged that only genuine Foxboro parts be used. Parts lists for Foxboro Instruments may be obtained by writing to your Foxboro Representative. Always give the serial number from the instrument data plate when requesting parts lists or ordening parts. (Men unfamiliar with Foxboro Instruments, or lacking the proper tools and equipment should not be permitted to uncertake any major service work).

REPLACEMENT

Improvements in design, materials, or methods sometimes make it worth while to replace rather than repair an instrument which has been in service for a long period of time.

We can help you in every way possible in discussing such problems with you.

In this way you will be made aware of the latest available equipment.

CHARTS

Since the accuracy of any recording instrument depends, finally, on the accuracy of the cart, the use of Foxboro Humitex Carts with Foxboro Instruments is essential if full performance of the instrument is to be realized.

FOXBORO

The Foxboro Company sells and services more than 1,000 products used to measure, analyze, indicate, record, and control such process variables as flow, temperature, pressure, level, and composition. Products range from instruments that sense and transmit these variables to computer-based systems that control entire plants. Industries served are chemical, oil and gas, power, pulp and paper, food, metals, minerals, marine, and textile.

Manufactured in 9 countries, Foxboro products are identical in design and performance around the world, where they are sold and serviced in 160 major industrial areas. Services include engineering, project management, commissioning and start-up, maintenance and repair, and training. European Manufacturing Resources based in Redhill, Surrey, England, Phone: 0737-65000, and Soest, The Netherlands, Phone: 021 55-90911. Corporate offices are located at 38 Neponset Avenue, Foxboro, Massachusetts, U.S.A. 02035, Phone: 617 543-8750.

FOXBORO®

MS 0283

Printed in the Netherlands

Instruction

MI
22-472
January 1983

13F AND 15F SERIES LIQUID-LEVEL TRANSMITTERS CALIBRATION AND SERVICING

CALIBRATION

Calibration Notes

1. Calibration is required if transmitter has been taken apart for cleaning or parts replacement, if range is to be changed, or if amount of elevation or suppression is to be changed substantially.

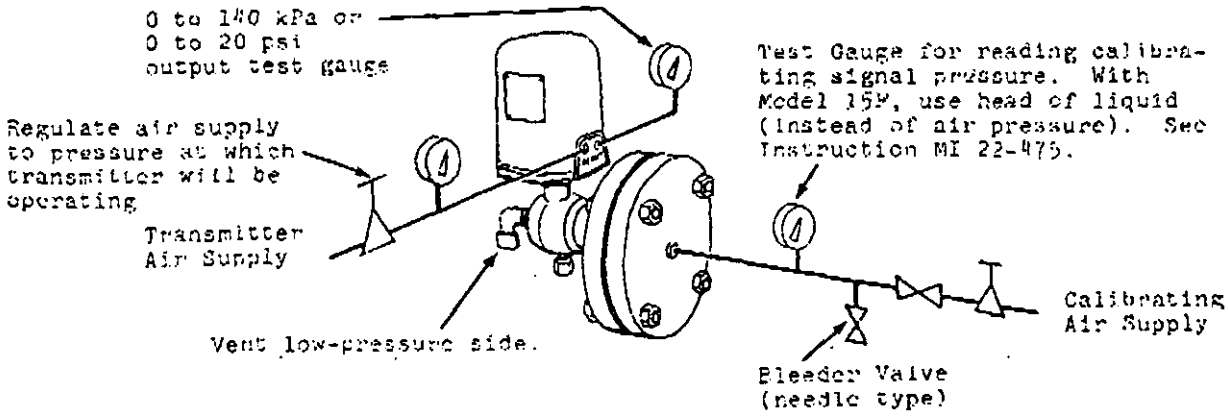
2. Transmitter can be calibrated in several different units such as SI (20 to 100 kPa) or various customary units (e.g. 3 to 15 psi). These ranges are not exactly equivalent; therefore transmitter must be calibrated to same signal pressure range as receiver with which it is used.

3. Transmitter is calibrated either by applying a known input and adjusting output to corresponding value (bench calibration, Page 3), or by positioning range wheel to a specific location on range bar corresponding to a predetermined span (in-place calibration, Page 2).

4. If range is to be changed, see Page 2.

Piping for Bench Calibration

Calibrating signals are generated by applying an air pressure (Models 13F and 13FE) or a head of liquid (Model 15F) to the diaphragm. A suggested calibration fixture is a mating blind flange with a tapped hole as the pressure connection (illustrated below). (With Model 13FE, use a ring flange with a capped 4 in. pipe welded to it.) Note that a calibration fixture is not required for a transmitter with an elevated-zero range.



With elevated zero range, apply calibrating pressures to low-pressure side. Apply a pressure numerically equal to the lower range value for 20 kPa or 3 psi output; apply this value minus span for 100 kPa or 15 psi output.

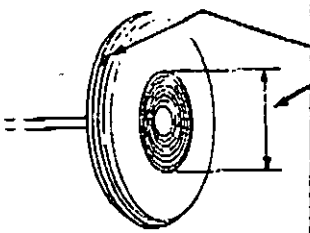
FOXBORO®

To Change Range of Transmitter

The range of the transmitter, as calibrated at the factory, is stamped on the data plate. By recalibration, the range can be changed to any value within the limits of the diaphragm capsule assembly.

With Models 13F and 13FE, if the desired range is outside the limits of the particular capsule installed in the transmitter, but within the limits of the other available capsule, install this other capsule.

Listed below are the range limits and identifications of the various capsules. The data plate should be altered to indicate the new range.



CAPSULE IDENTIFICATION	TRANSMITTER MODEL	SPAN ΔP BETWEEN HEAD OF WATER	
		METRES	INCHES
LO 122 mm (4.8 in)	15F	0.13 and 0.6	5 and 25
MED 81 mm (3.2 in)	13F, 13FE	0.5 and 6	20 and 250
HI 44 mm (1.7 in)	13F, 13FE	5 and 21	200 and 850

In-Place Calibration

Since 1974, all transmitters have been equipped with a vernier-type range adjustment which permits the user to read with high accuracy (4 figures) the position of the range wheel on the range bar.

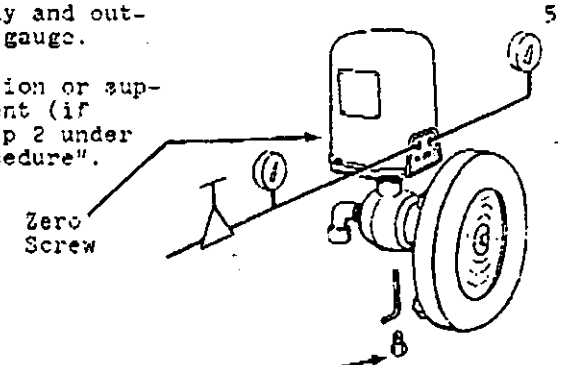
If the transmitter is calibrated (see Page 3) to several desired ranges (without change in zero elevation or suppression) and the position of the range wheel is noted for each calibration, the transmitter can be recalibrated to any of these ranges, with 0.5% of span accuracy, by merely repositioning the range wheel to its associated position. Tighten the range wheel securely before putting the transmitter back into operation.

Flexure Locknut Adjustment

Make this adjustment if diaphragm assembly was removed or if flexure locknut was loosened. This procedure is not applicable to Model 13FE.

1. Connect air supply and output-reading test gauge.

2. Disconnect elevation or suppression attachment (if present); see Step 2 under "Calibration Procedure".



3. Remove bottom drain plug, and loosen flexure locknut with a 1/4 in hex-key wrench.

4. With no pressure on diaphragm capsule, adjust zero screw so that output is 20 kPa or 3 psi.

5. Carefully tighten flexure locknut so that output pressure does not change by more than ±2.7 kPa or ±0.4 psi.

   If output pressure is not within these limits, loosen locknut and carefully retighten.

   If output pressure is still not within limits, it indicates that index marks on capsule and body are not aligned. Correct by repositioning capsule (see Step 6 on Page 5).

6. When output pressure is within limits after tightening locknut, replace bottom plug and calibrate transmitter (see Page 3).

Calibration Procedure

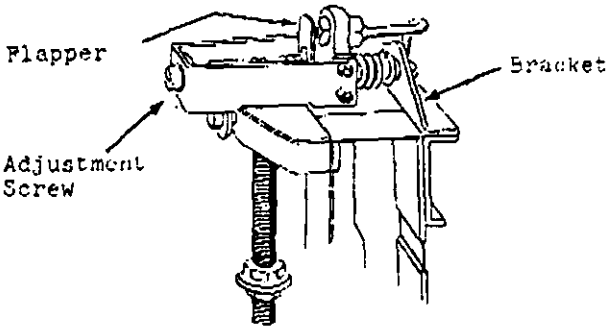
Steps 2, 4, and 5 in procedure below pertain only to transmitters with elevated-zero or suppressed-zero ranges. Illustrations for these steps show suppressed-zero range attachment. If transmitter has elevated-zero range attachment, location of the two screws mentioned is reversed. If transmitter has neither elevated nor suppressed-zero range, skip these steps.

1. Set up calibration equipment as shown on Page 1.

2. If transmitter has elevated or suppressed zero range, disconnect spring from force bar as follows:

   a. Remove screw from end of spring.

   b. Turn adjustment screw clockwise until spring is clear of bracket. Spring must not bind against flapper or casting.



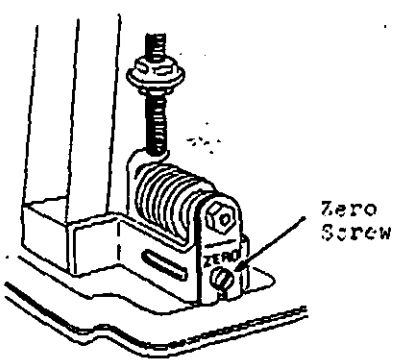
3. With no pressure on transmitter, adjust zero screw so that output on test gauge reads 20 kPa or 3 psi.

NOTES

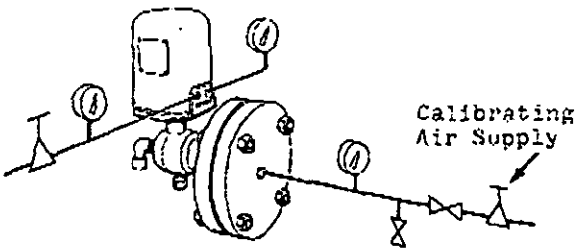
1. To convert liquid level expressed in inches of water to psi, multiply by 0.0361.

2. To convert liquid level expressed in metres of water to kPa, multiply by 9.79.

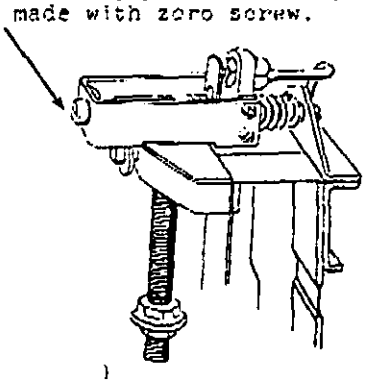
If screw was removed in Step 2-a, replace it.



4. With elevated or suppressed zero range, set calibrating pressure equal to lower range value. (With elevated-zero range, apply calibrating pressure to low-pressure side of transmitter; calibration flange is not required.)

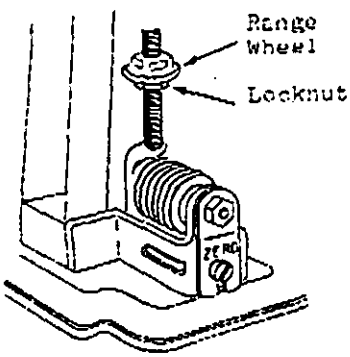


5. Turn adjustment screw so that output is 20 kPa or 3 psi. Fine adjustment can be made with zero screw.



6. Set calibrating pressure equal to upper range value. The output should be 100 kPa or 15 psi.

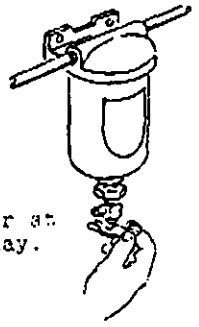
7. If output is incorrect, loosen locknut and adjust range wheel for correct output. Turning range wheel down increases output. Retighten locknut after each adjustment.



8. Repeat Steps 3 through 7 until the desired accuracy is obtained. Tighten range wheel locknut securely.

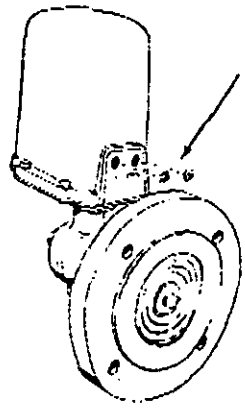
SERVICING

To Service Supply Air Filter



Blow out filter at least once a day.

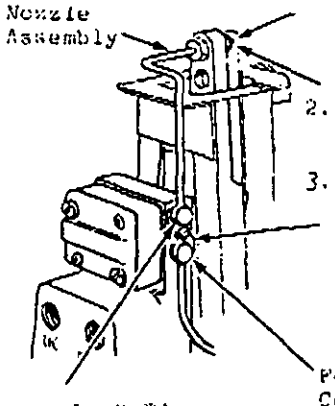
To Clean or Replace Screen Filters



If fine screen air filters become clogged remove with a pointed tool for cleaning or replacement.

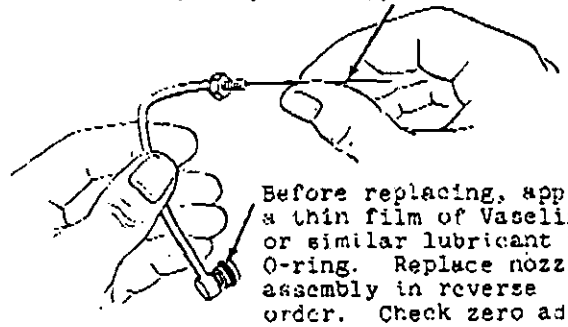
To Clean Nozzle Assembly

NOTE: An accumulation of dirt at the flapper nozzle may cause a zero shift.



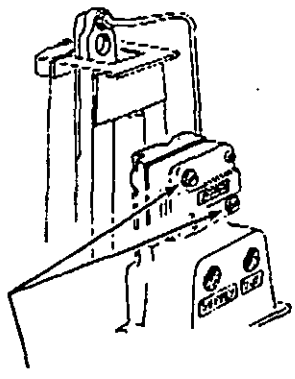
1. Unscrew nozzle nut. Do not let soldered nut on opposite side of casting turn.
2. Ease nozzle out of casting.
3. Loosen clamp screw and rotate S-clamp. Withdraw nozzle O-ring connection with twisting motion. Do not bend tubing.

Clean nozzle with 0.76 mm (0.030 in) diameter wire, compressed air, or suitable solvent. Wipe top of flapper clean.



Before replacing, apply a thin film of Vaseline or similar lubricant to O-ring. Replace nozzle assembly in reverse order. Check zero adjustment; see Instruction MI 22-470.

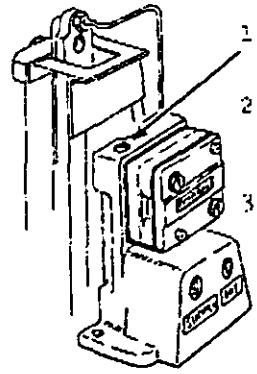
To Replace Relay



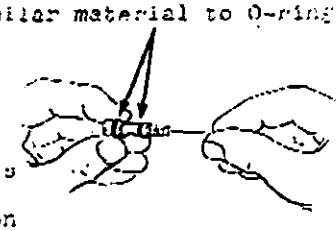
Remove the two large screws and pry off relay. A gasket is supplied with each replacement relay. For servicing details, see Instruction MI 11-493.

To Clean Restrictor

NOTE: A plugged restrictor will cause low output pressure.

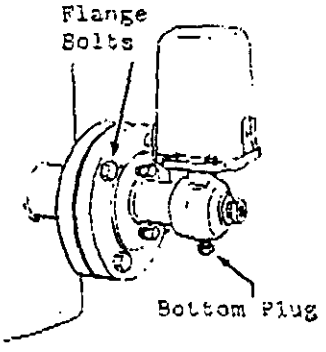


1. Unscrew restrictor from top of relay base.
2. Clean with 0.005 in diameter wire (Part 0042527).
3. Before reinstalling, apply a thin film of Vaseline or similar material to O-ring.



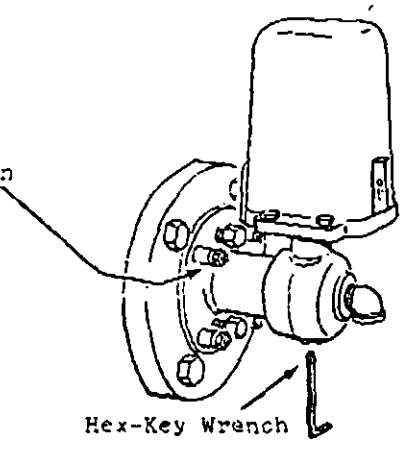
NOTE: On earlier models restrictor was located either under relay or on side of relay base.

To Remove Diaphragm Capsule Assembly



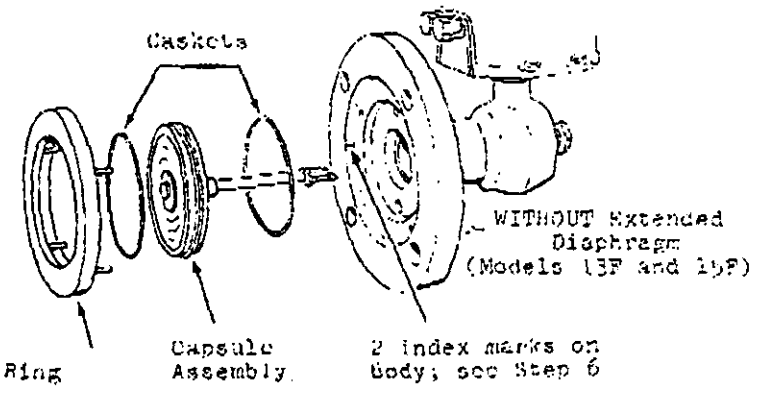
1. Disconnect transmitter piping. Remove flange bolts and lift transmitter off tank.
2. Remove bottom plug.
3. Remove nuts and washers holding outer ring to flange. Do not lose spacers in bolt holes.

   NOTE: With Model 13FE (transmitter with extended diaphragm), ring is part of capsule assembly; see right illustration below.
4. Insert 1/4 in hex-key wrench into bottom opening and loosen flexure locknut (see bottom illustration).



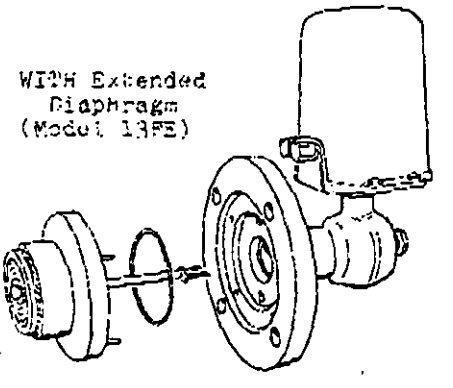
5. Carefully ease capsule assembly out of transmitter body without twisting assembly.

   Inspect gaskets. If surface is not perfectly smooth, replace gasket.



NOTE

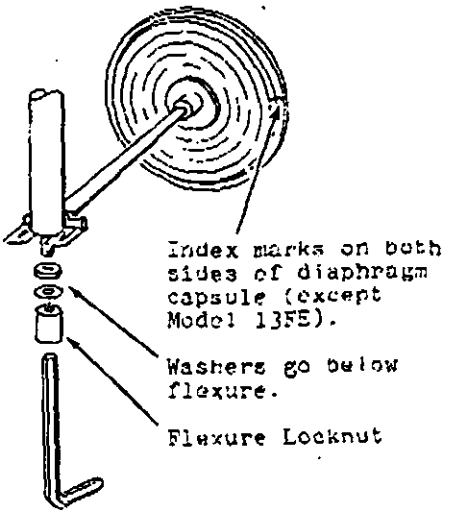
On tantalum and Hastelloy C-276 construction, ptfe gasket should seat on 45° bevel on edge of capsule. Do not stretch ptfe gasket over side of capsule. To install, insert one gasket into body and one into ring. (With extended diaphragm models, ring and extension are part of diaphragm assembly. Seal is maintained by O-ring on mating surface of ring.)



6. Reinstall parts in reverse order of disassembly.

   Use care when inserting flexure onto force bar to avoid damaging flexure. Position diaphragm capsule so that index marks on body and on capsule are in line.

   (With Model 13FE, after flexure is positioned on force bar, loosely tighten nuts removed in Step 3, tighten flexure locknut, and then finish tightening nuts.)
7. Make flexure locknut adjustment (Page 2)(except Model 13FE), check static alignment (Page 7), and then calibrate transmitter (Page 3).



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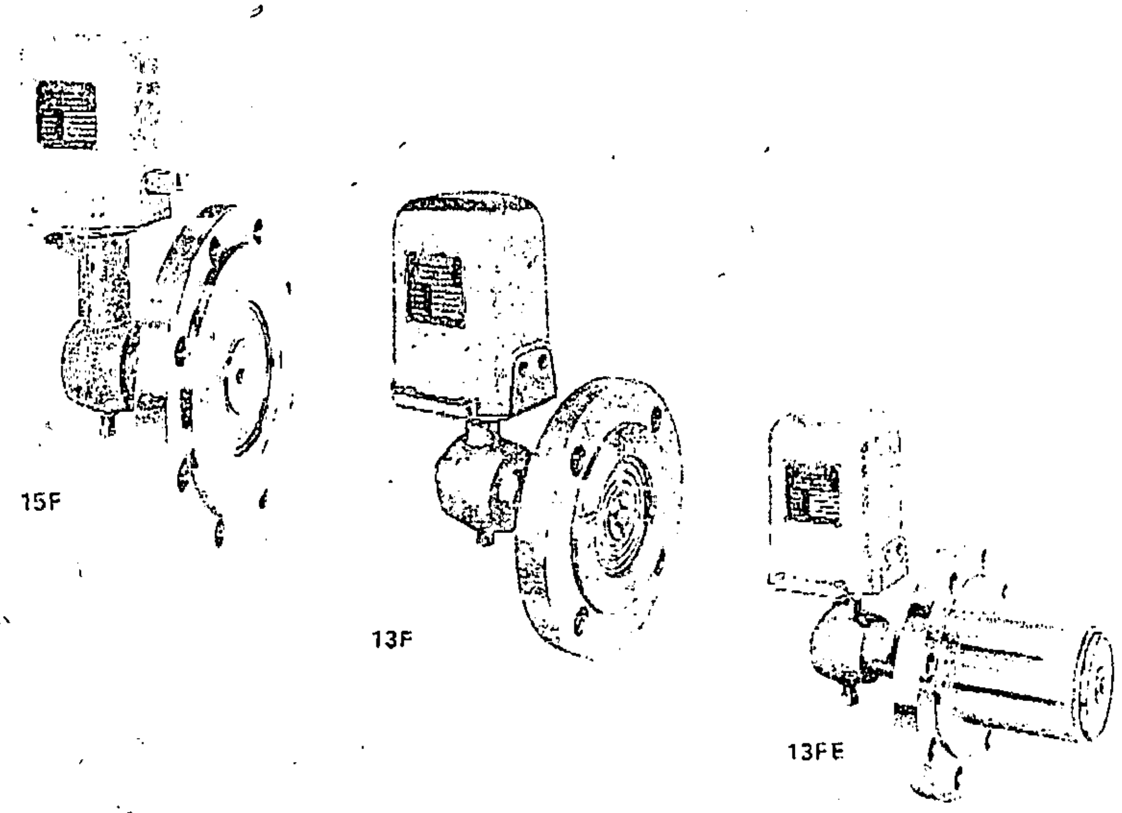


15F, 13F, AND 13FE PNEUMATIC LIQUID LEVEL OR DENSITY FLANGED d/p Cell TRANSMITTERS

These tranmitters provide precise ... of the level or density of virtually any liquid in open or closed tanks ... standard pneumatic signal to receivers that may be up to several hundred ... away.

PROVEN DEPENDA...

Foxboro pneumatic ... the same topworks ... Transmitters ... of the process indust... ment ever since Fox... ago. Many thousand... have demonstrated ... outstanding trans...

...pped with a vernier range ad... operator to select one of sev...

Position
15F Transmitter Must be mounted with the capsule in the vertical plane.
13F and 13FE Transmitters May be mounted in any orientation.

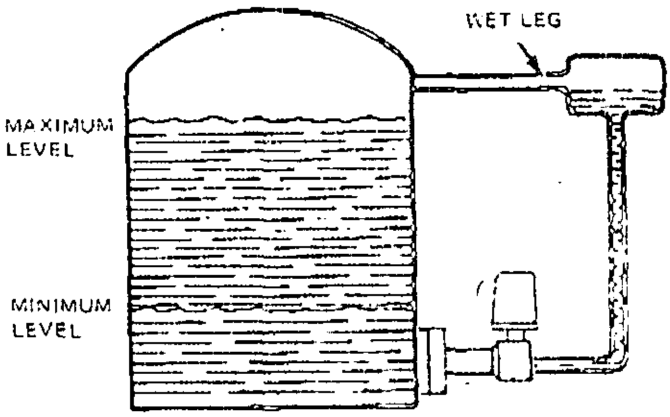
Air Connections The supply and output connections are tapped for 1/4 NPT.

Output Signal 20 to 100 kPa, 3 to 15 psi, or 0.2 to 1.0 bar or kg/cm², as specified.

Air Consumption under Normal Operation 0.42 m³/h (0.25 cfm) at standard conditions.

Process Connections The body, or low-pressure side, is tapped for 1/2 NPT. A 1/4 NPT reducer is included with carbon steel bodies. Refer to "MODEL CODES" for flange selection for high-pressure side.

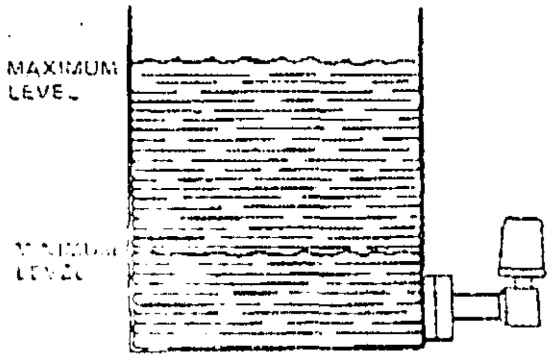
Examples of Zero Elevation and Zero Suppression



TYPICAL RANGE FOR 13F OR 13FE TRANSMITTER:

-0.5 TO +2.5 METRES HEAD OF WATER
-30 TO +100 INCHES HEAD OF WATER

ZERO ELEVATION



TYPICAL RANGE FOR 13F OR 13FE TRANSMITTER:

0.51 TO 5.1 METRES HEAD OF WATER
20 TO 200 INCHES HEAD OF WATER

ZERO SUPPRESSION

PERFORMANCE SPECIFICATIONS

(Under Reference Operating Conditions Unless Otherwise Specified)

Accuracy (Includes linearity, hysteresis, [illegible] ability)
15F Transmitter ±0.5% [illegible]
13F and 13FE Transmitters
Spans between 0.51 and 10 [illegible] 25 [illegible]
Head of Water ±0.5 [illegible]
Spans between [illegible]
Head of Water [illegible]

Repeatability 0.1% [illegible]

Hysteresis
15F Transmitter [illegible]
head of water [illegible]
13F and 13FE Transmitters [illegible]
0.1% of span or [illegible]
whichever is [illegible]
6.3 m (20 and [illegible]
0.1% of spa[illegible]
and 850 in) h[illegible]

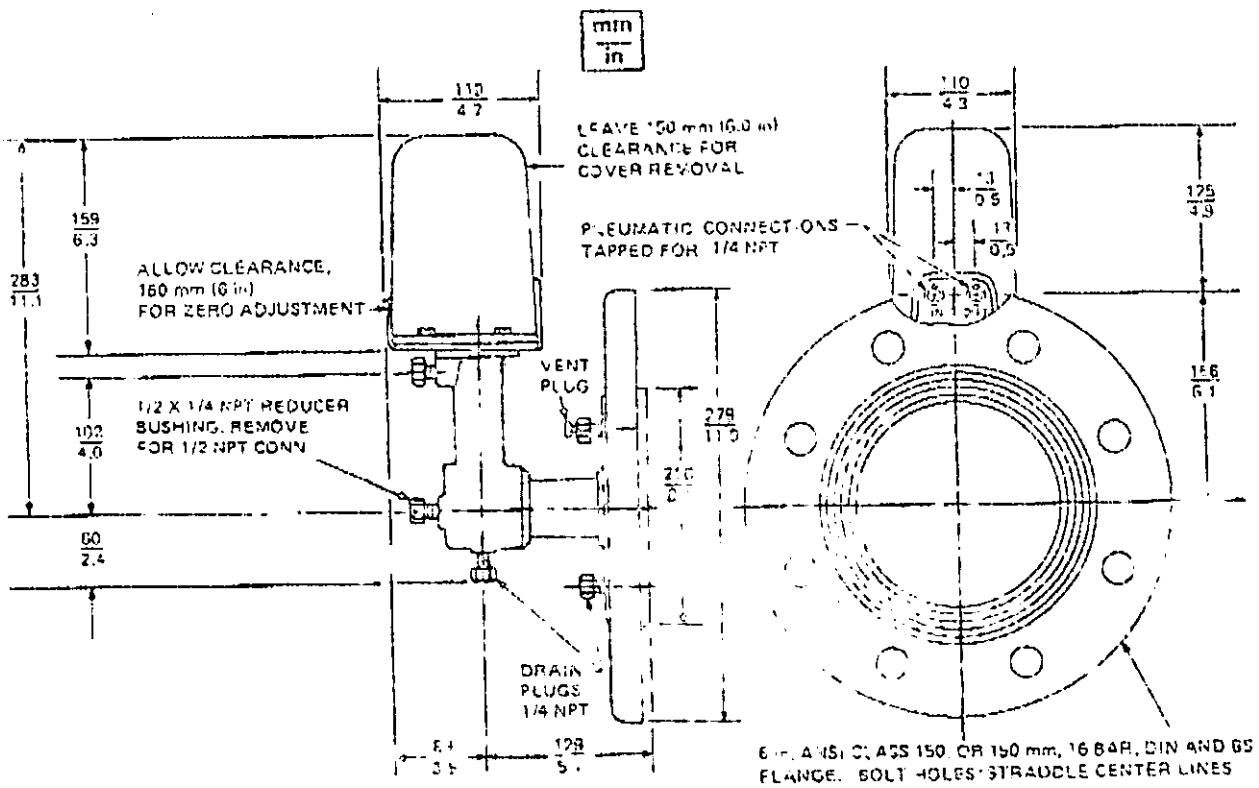
Dead Band [illegible]

Reproducibility (Includes effects of hysteresis, repeatability, dead band, and drift over a one hour period) 0.15% of span

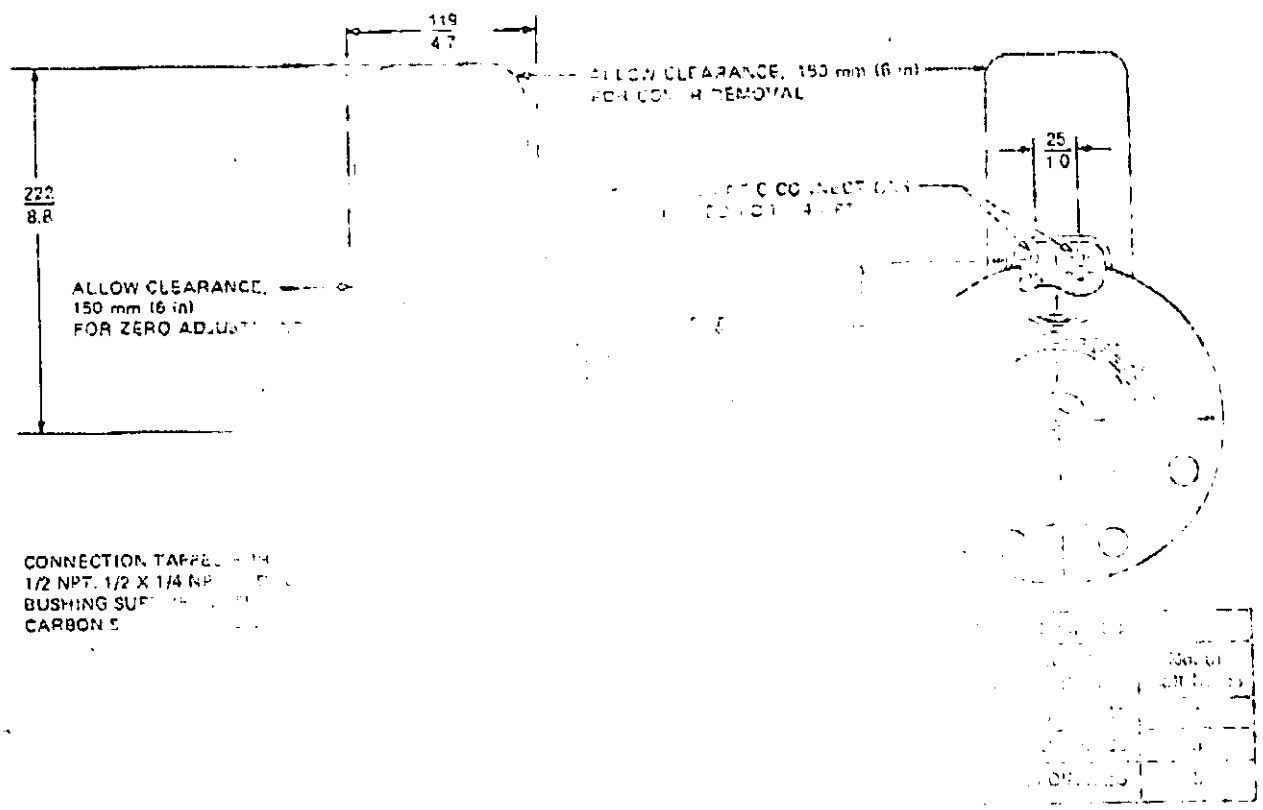
Position Effect Zero shifts caused by mounting position may be [illegible] adjusting the zero adjustment screw.

Supply Pressure Effect The maximum zero shift is [illegible] change in [illegible] results

DIMENSIONS—NOMINAL



15F TRANSMITTER



CONNECTION TAPPED FOR
1/2 NPT, 1/2 X 1/4 NPT
BUSHING SUPPLIED
CARBON S

MODEL CODES (Continued)

13F = Pneumatic d/p Cell Transmitter with Flange—[illegible] and High Range

Body and Flange Material
A = 316 ss
A1 = cs

Capsule Code and Span Limits
-M = 0.51 and 6.3 m (20 and 250 in) head of water
-H = 5.1 and 21.6 m (200 and 850 in) head of water

Body and Flange Material and Connection
K33D = cs; 80 mm, 40 Bar, DIN and BS
S33D = 316 ss; 80 mm, 40 Bar, DIN and BS
K31A = cs, 3 in ANSI Class 150
K33A = cs; 3 in ANSI Class 300
S31A = 316 ss; 3 in ANSI Class 150
S33A = 316 ss, 3 in ANSI Class 300

Flange Extension Length
5 = 125 mm (5 in)
8 = 200 mm (8 in)

Option Suffix
-L = Zero-Elevation Kit
-R = Zero-Suppression Kit

13FE = Pneumatic d/p Cell Transmitter with Flange and Capsule Extension—Medium and High Range

Body and Flange Material
A = 316 ss
A1 = cs

Capsule Code and Span Limits
-M = 0.51 and 6.3 m (20 and 250 in) head of water
-H = 5.1 and 21.6 m (200 and 850 in) head of water

Body and Flange Material and Connection
K41D = cs; 100 mm, 16 Bar, DIN and BS
K43D = cs; 100 mm, 40 Bar, DIN and BS
S41D = 316 ss; 100 mm, 16 Bar, DIN and BS
S43D = 316 ss; 100 mm, 40 Bar, DIN and BS
K41A = cs, 4 in ANSI Class 150
K43A = cs, 4 in ANSI Class 300
S41A = 316 ss, 4 in ANSI Class 150
S43A = 316 ss, 4 in ANSI Class 300

Example

PHYSICAL SPECIFICATIONS

Process-Wetted Parts Materials

High-Pressure Side

Capsule Diaphragm AISI Type [illegible] steel (316L ss)

Other Capsule Parts AISI Type [illegible] (316 ss)

Capsule Gasket 316 ss (non[illegible]

Retaining Ring (Raised Face [illegible] 316 ss

Low-Pressure Side

Body Cadmium-plated [illegible] 316 ss, as specified by [illegible]

Capsule Diaphragm 316 [illegible]

Capsule Gasket 15F a[illegible]

Force Bar 316 ss

Force Bar Diaphragm [illegible] loy. Refer to TI 037-078 and TI 037-[illegible] tion regarding the universal corrosion [illegible] perties of the standard [illegible] sensor diaphragm materia[illegible]

Force Bar Gasket Silicone elastomer

Capsule Extension (13FE on [illegible]

[illegible] Parts Materials [illegible] number. [illegible]

Approximate [illegible] [illegible] ANSI Class [illegible] [illegible] ANSI/CES [illegible]

[illegible] as a optional Custom [illegible]

MODEL CODES

15F = Pneumatic d/p Cell Transmitter with Flange—Low Range

Body and Flange Material

A [illegible] 316 ss

A[illegible] ss

[illegible]

EASY TO INSTALL

The transmitters are easy to handle and to install. They are mounted directly to a mating flange on the vessel and require no other support.

WIDE CHOICE OF MATERIALS

Only the capsule diaphragm, ... portion of the flange, and capsule gasket are wetted by the process on the high-pressure side. A wide variety ... available to meet the needs of almost ...

STURDY CONSTRUCTION

The forged, uniformly stress-relieved ... sures freedom from metallurgical ... ternal stresses.

FLUSH AND EXTENDED DIAPHRAGMS

Because the transmitters are close coupled to the process, there are no sensing lines to become clogged or fouled. This enables these transmitters to be used effectively in wet chemicals, slurries, asphalt and other sticky, viscous, or otherwise difficult-to-measure processes.

EASE OF MAINTENANCE AND COMMONALITY OF PARTS

The ... design of the topworks and the field-replaceable capsule make servicing these transmitters ... easy and economical. In addition, the ... pneumatic/liquid level differential pressure, accuracy, and target transmitters ... minimizing spare parts inventories ... maintenance routines.

Influence	Storage and Shipping Limits
Ambient Temperature	-40°C
Process Temperature • With DIN Flange	• Not Applicable
• with ANSI Flange	• Not Applicable
Relative Humidity	
Supply Pressure	

Span and Range Limits

Transmitter	Capsule C...
15F	
13F and 13FE	

(a)Non-zero b... and lower...
(b)Negative v...

Static Pressure ... of flange.

Overrange ...

Elevation ... be adjusted ... screw. Use ...