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440R™ Series Model C
Pneumatic Indicating Controller

Instructions



ABB Instrumentation

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ABB INSTRUMENTATION

The Company

ABB Instrumentation is an established world force in the design and manufacture of instrumentation for industrial process control, flow measurement, gas and liquid analysis and environmental applications.

As a part of ABB, a world leader in process automation technology, we offer customers application expertise, service and support worldwide.

We are committed to teamwork, high quality manufacturing, advanced technology and unrivaled service and support.

The quality, accuracy and performance of the Company's products result from over 100 years experience, combined with a continuous program of innovative design and development to incorporate the latest technology.

The NAMAS Calibration Laboratory No. 0255(B) is just one of the ten flow calibration plants operated by the Company, and is indicative of ABB Instrumentation's dedication to quality and accuracy.

BS EN ISO 9001

St Neots -
Certificate No. Q5907
Stonehouse -
Certificate No. FM 21106

ISO 9001

Rochester, USA -
Certificate No. AQ-8618
Flow, Transmitter and Multiloop Contol product

EN 29001 (ISO 9001)

Lenno, Italy -
Certificate No. 90/90A

Stonehouse -
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Use of Instructions

Warning. An instruction that draws attention to the risk of injury or death.

Caution. An instruction that draws attention to the risk of the product, process or surroundings.

Note. Clarification of an instruction or additional information.

Information. Further reference for more detailed information or technical details.

Although Warning hazards are related to personal injury, and **Caution** hazards are associated with equipment or property damage, it must be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process system performance leading to personal injury or death. Therefore, comply fully with all **Warning** and **Caution** notices.

Information in this manual is intended only to assist our customers in the efficient operation of our equipment. Use of this manual for any other purpose is specifically prohibited and its contents are not to be reproduced in full or part without prior approval of ABB Instrumentation.

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Health and Safety

To ensure that our products are safe and without risk to health, the following points must be noted:

1. The relevant sections of these instructions must be read carefully before proceeding.
2. Warning Labels on containers and packages must be observed.
3. Installation, operation, maintenance and servicing must only be carried out by suitably trained personnel and in accordance with the information given or injury or death could result.
4. Normal safety procedures must be taken to avoid the possibility of an accident occurring when operating in conditions of high pressure and/or temperature.
5. Chemicals must be stored away from heat, protected from temperature extremes and powders kept dry. Normal safe handling procedures must be used.
6. When disposing of chemicals, ensure that no two chemicals are mixed.

Safety advice concerning the use of the equipment described in this manual may be obtained from the Company address on the back cover, together with servicing and spares information.

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1
INTRODUCTION

1.1 DESCRIPTION

The FULSCOPE® 440R Series Pneumatic Indicating Controller is a single-duty, universal instrument that can be used to measure, indicate, and/or control temperature, pressure (differential, gauge or absolute), vacuum, volumetric pressure (remote seals), liquid level, or flow. The 400R Series Controller may include On-Off, Proportional Only (includes a Differential Gap option), Proportional with Automatic Reset (Integral), Proportional with PRE-ACT™ (Derivative), or Proportional with Auto Reset and PRE-ACT control responses. Pneumatic remote set-point, auto-manual, electric alarms and external feedback are additional options. Measurement systems are listed under **Section 1.3 Product Identification** information character 5.

This book describes the following variations on the 440 series.

440K Indicator
The 440K Pneumatic Indicator has no control functions, no output and may be configured with electric alarms.

440R With Fixed High (on-off)
The 440R Pneumatic Indicating Controller is a basic on-off controller. The instrument can operate in direct or reverse action, has a fixed proportional response, and has a gain of 125 minimum.

441R With Proportional Response and Differential Gap
The 441R maintains a minimum or maximum output pressure while the process remains within the differential gap band width set by the operator. There are two trip-points set by the operator on either side of the differential gap bandwidth. Once the process indicator moves beyond the trip-point, the instrument output automatically switches from maximum to minimum or vice versa. The instrument can operate in either direct or reverse action.

441T Indicating Transmitter
The 441T Pneumatic Indicating Transmitter includes an output without any control functions. Electric alarms may be added to the configuration.

442R With Proportional and Reset
The 442R has an adjustable proportional response (gain is adjustable from 0.2 to 35% output per % input) and reset (integral – 0.05 to 200 repeats per minute). The proportional response adjusts the controller to provide an output that is proportional to any change of the process measurement. The reset rate is used to eliminate the offset between the set-point and the process. The instrument can operate in either direct or reverse action.

443R With Proportional and PRE-ACT™
The 443R has an adjustable proportional response (gain is adjustable from 0.2 to 35% output per % input) and an adjustable PRE-ACT (derivative – 0.1 to 20 minutes). The proportional response adjusts the controller to provide an output that is proportional to any change of the process measurement. The PRE-ACT reduces recovery time of the instrument when the process measurement moves away from the set-point, thus speeding up any corrective action taken by the instrument. The instrument can operate in either direct or reverse action.

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444R With Proportional, Reset, and PRE-ACT
The 444R includes all three PID adjustable control responses: proportional (gain is adjustable from 0.2 to 35), reset (integral – 0.05 to 200 repeats per minute), and PRE-ACT (derivative – 0.1 to 20 minutes). All responses are adjustable. The instrument can operate in either direct or reverse action.

1.2 TECHNICAL CHARACTERISTICS

CONTROL RESPONSES & ADJUSTABILITY

On-Off	Fixed high output (gain is fixed at 125 minimum)
Proportional	Gain is adjustable from 0.2 to 35
Reset (Integral)	0.05 to 200 repeats per minute
PRE-ACT (Derivative)	0.1 to 20 minutes
Differential Gap	1 to 100%
Action	Direct or reverse (field changeable)
Output Signal	3 to 15 psi 20 to 100 kPa 0.2 to 1.0 kg/cm^2

AIR SUPPLY

Nominal	20 psi (140 kPa)
Minimum	18 psi (125 kPa)
Maximum	30 psi (200 kPa)

WARNING
Use of a supply gas other than air can create a hazardous environment because a small amount of gas continuously vents to the atmosphere.

Air Consumption	0.2 scfm maximum at steady state

CONNECTIONS

Pneumatic	Supply and output: 1/4 in. Int. NPT; bottom connections only
Electrical	1/2 in. Int. NPT alarm connection
Process	Dependent upon measuring element: 1/4 in. Int. NPT; 1/2 in. Ext. NPT

ALARMS (High, Low)

Electric, High and Low Adjustability	
High Alarm	5 to 100%
Low Alarm	0 to 95%
Double Alarm Proximity	3% of range
Contract Arrangement	SPDT
Contract Rating	5A, 125/250V dc 4A, 30V dc resistive 3A, 30V dc inductive

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ELECTRIC CONTACT	
Control Switch Adjustability	0 to 100% (Controller set-point adjustment)
Rating	10A, 125V ac; 5A, 250V ac; 0.5A, 125V dc; 0.25A, 250V dc
Output Gauge	
Standard	0 to 30 psi, 0 to 200 kPa
Optional	0 to 2.0 kg/cm^2
Repeatability	Better than 0.3%
Calibrated Accuracy	Dependent on measuring element specified. Typically < ±1.0%, ±2.0% maximum. Process indicating pointer to ±2% across range for most measuring elements. Process control better than ±2% across range for most measuring elements. The following measuring elements produce deadband and repeatability within twice the stated values: Barton D/P Model 199, Barton Model 224 (Absolute Pressure or D/P), Type 42 Low Pressure Capsule units below 30 in. H_20 span, and Type 36 Low Pressure Bellows units below 3 psi span.
Positional Limit	To be mounted with sides and back of case vertical within 5°
Ambient Temperature	-20 to 180°F (-29 to 82°C). Temperature limits may vary depending upon individual measuring element. Available to -40°F (-40°C) in some forms. When supplied with an EME (electrical-to-motion element): -20 to 167°F (-29 to 75°C).
Flammability Rating	UL94V–O
PHYSICAL	
Case and Door	Glass fiber filled reinforced polyester compounded for superior corrosion resistance
Finish	Glass Fiber Housing Door is molded, beige; case is light brown
Housing	Designed to meet IEC IP54 and provides environmental protection of NEMA Type 3
Window	Glass (Standard) Acrylic (Optional)
Mounting	Surface or panel (Standard) Vertical pipe mounting bracket (Optional)
Size (approximate)	
Height	11-7/8 in. (302 mm)
Width	10 in. (254 mm)
Depth	4- 3/4 in. (121 mm)
Scale Length	6-3/8 in. (162 mm)
Weight (approximate)	11.9 lb (5.4 kg)

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1.3 PRODUCT IDENTIFICATION

The serial number stamped on the data plate consists of the catalog number and a sequential identification number. The catalog number contains a series of single and multiple character codes which provide specific information concerning the various size and structural options of the instrument. Inquiries regarding product installed in the field should reference the stamped serial number.

Code No.	Description
	BASE NUMBER - 1st through 4th. characters
440K	Pneumatic Indicator only, no control functions
440R	Pneumatic Indicating Controller with Fixed, high gain, (on-off) Response
441T	Pneumatic Indicating Transmitter, no control functions
441R	Pneumatic Indicating Controller with Proportional Response
442R	Pneumatic Indicating Controller with Proportional plus Integral Response
443R	Pneumatic Indicating Controller with Proportional and Derivative Response
444R	Pneumatic Indicating Controller with Proportional, Integral and Derivative Response
	MEASURING ELEMENT ACTUATION - 5th character
G	Temperature - Gas System; refer to SS-4-1
M	Temperature - Mercury System; refer to SS-4-1
R	Temperature - MONOLEX_ System; refer to SS-4-1
S	Temperature - DUCALEX_ System; refer to SS-4-1
V	Temperature - Vapor System; ; refer to SS-4-1
A	Absolute Pressure; refer to SS-4-2 and SS-4-5A
D	Differential Pressure Capsule; refer to SS-4-2
C	Differential Pressure Meter Body; termination 183 -186 refer to SS-4-5A
Z	Differential Pressure Meter Body; termination 191 -197 refer to SS-4-5A
F	Gauge Pressure refer to SS-4-2 and 4-2A
N	Gauge Pressure, Remote-Seals; refer to SS-4-3, 4-3B, and 4-3C
T	Electrical- EME (Electrical-to-Motion Element); refer to SS-4-10A
J	Less Differential Pressure Meter Body; termination 183 -186
P	Less Differential Pressure Meter Body; termination 191 -197
L	Less any measuring element . except C and Z. then use code J or P
	SET-POINT ADJUSTMENT - 6th character
1	Internal Set-Point Adjustment Knob.
5	External Set-Point Adjustment Knob.
6	Pneumatic Remote set-point input.
7	Pneumatic Remote set-point input with alarm option
8	Transmitter option. Required for 441T not valid with 441R
	AUTOMATIC TO MANUAL UNIT - 7th character
5	None. Required code for 441T
6	No Auto to Manual unit required.
7	with internal 2-position Auto/manual unit
8	without internal 2-position Auto/manual unit, Alarm option is required
9	with internal 2-position Auto/manual unit, when alarm option is required
	EXTERNAL FEEDBACK - 8th character
0	None
1	External feedback connection to the Reset bellows (reset windup limiting)
2	External feedback connection to the Reset bellows (reset windup Loading or venting

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ALARMS - 9th character

0	None.
1	Electric Alarm High
2	Electric Alarm Low
3	Electric Alarm High and Low
4	Electric Alarm Low and Lower

OUTPUT CALIBRATION AND CONTROL ACTION - 10th character

A	3 to 15 psi, control action is DIRECT
B	0.2 to 1.0 Bar, control action is DIRECT
C	0.2 to 1.0 Kg/cm^2 , control action is DIRECT
D	20 to 100 kPa, control action is DIRECT
G	3 to 15 psi, control action is REVERSE
H	0.2 to 1.0 Bar, control action is REVERSE
J	0.2 to 1.0 Kg/cm^2, control action is REVERSE
K	20 to 100 kPa, control action is REVERSE
N	None (440K only)

DOOR OPTIONS - 11th character

0	Glass windows
1	Glass windows and door lock
2	Glass windows, and external set-point adjustment.
3	Glass windows, door lock, and external set-point adjustment.
4	Acrylic windows
5	Acrylic windows and door lock
6	Acrylic windows, and external set-point adjustment.
7	Acrylic windows, door lock, and external set-point adjustment.
8	Glass window for 440K
9	Acrylic window for 440K

AIR REGULATOR AND AIR SUPPLY GAUGE (PIPED AND MOUNTED) - 12th character

0	None
1	Dual scale gauge, psi and Kg/cm^2 , refer to SS 7-1B for details
2	Dual scale gauge, Bar and kPa, refer to SS 7-1B for details

MOUNTING BRACKETS - 13th character

1	For 1 1/4 to 2 inch (32 to 50 mm) pipe mounting
0	For panel or surface mounting

TAGGING AND CERTIFICATIONS - 14th character

0	No tags or certifications required
1	Custom Information on the instrument data plate
2	Custom Information stamped on a 316 Stainless Steel tag and wired to the instrument
3	Customer Information stamped on a 316 Stainless Steel tag and permanently attached to the instrument
4	3- point Certificate of Calibration
5	Combination of codes 1 and 4
6	Combination of codes 2 and 4
7	Combination of codes 3 and 4

C **DESIGN REVISION LEVEL** - 15th character

440RG1000A000C Sample Model Number

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* NOTE The air set filter regulator feature of the FULSCOPE 440R Series Controller (Character 12) is also identified in the general catalog as the 1004F Air Supply Filter Regulator (with or without gauge). The purpose of the air set filter regulator is to clean the air in the instrument and regulate the air pressure going into the instrument supply.

1.4 RELATED DUCUMENTATION

Additional documentation related to the use of the 440R can be found in the following documents.

- **IB-04F108** 1400L Model D Electrical-to-Motion Element (EME) for 440K, 440R - 444R. The 1400L Series EME units, are solid-state electro-mechanical units that convert electrical input signals to a mechanical movement compatible with the instrument linkage systems. An optional fitting allows an instrument having any type of actuation (filled systems) to be converted to accommodate an EME.

- Measuring Elements Section of Specification Book

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2
INSTALLATION

2.1 MOUNTING LOCATION

Select a vertical mounting location which is free from vibration and corrosive atmospheric conditions. The ambient temperature on the case should not be less than -20°F (-29°C) or more than 180°F (82°C). When supplied with an electrical-to-motion element the ambient temperature should not be less than -20°F (-29°C) or more than 167°F (75°C).

The controller can be either panel or surface mounted by reversing the mounting brackets, Figure 1. The pipe mounting bracket permits mounting on 1¼", 1½", or 2" diameter vertical pipe. The standard mounting bracket kit is 14S511K and the pipe mounting bracket kit is 14S510K.

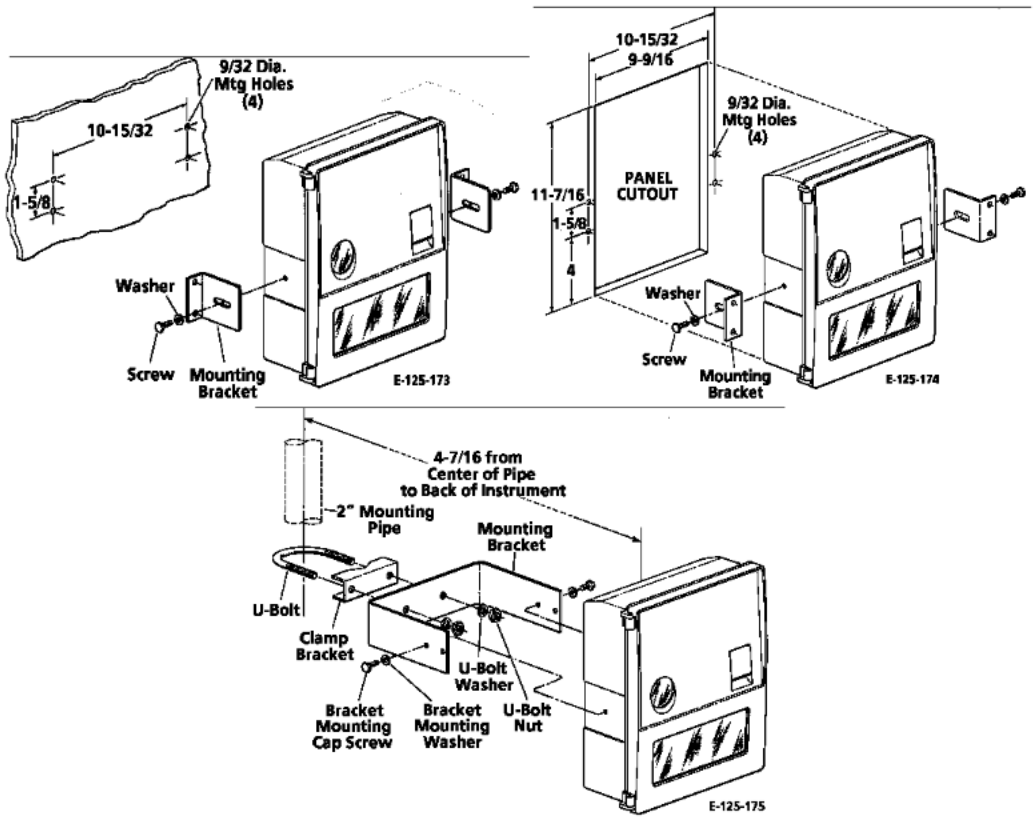
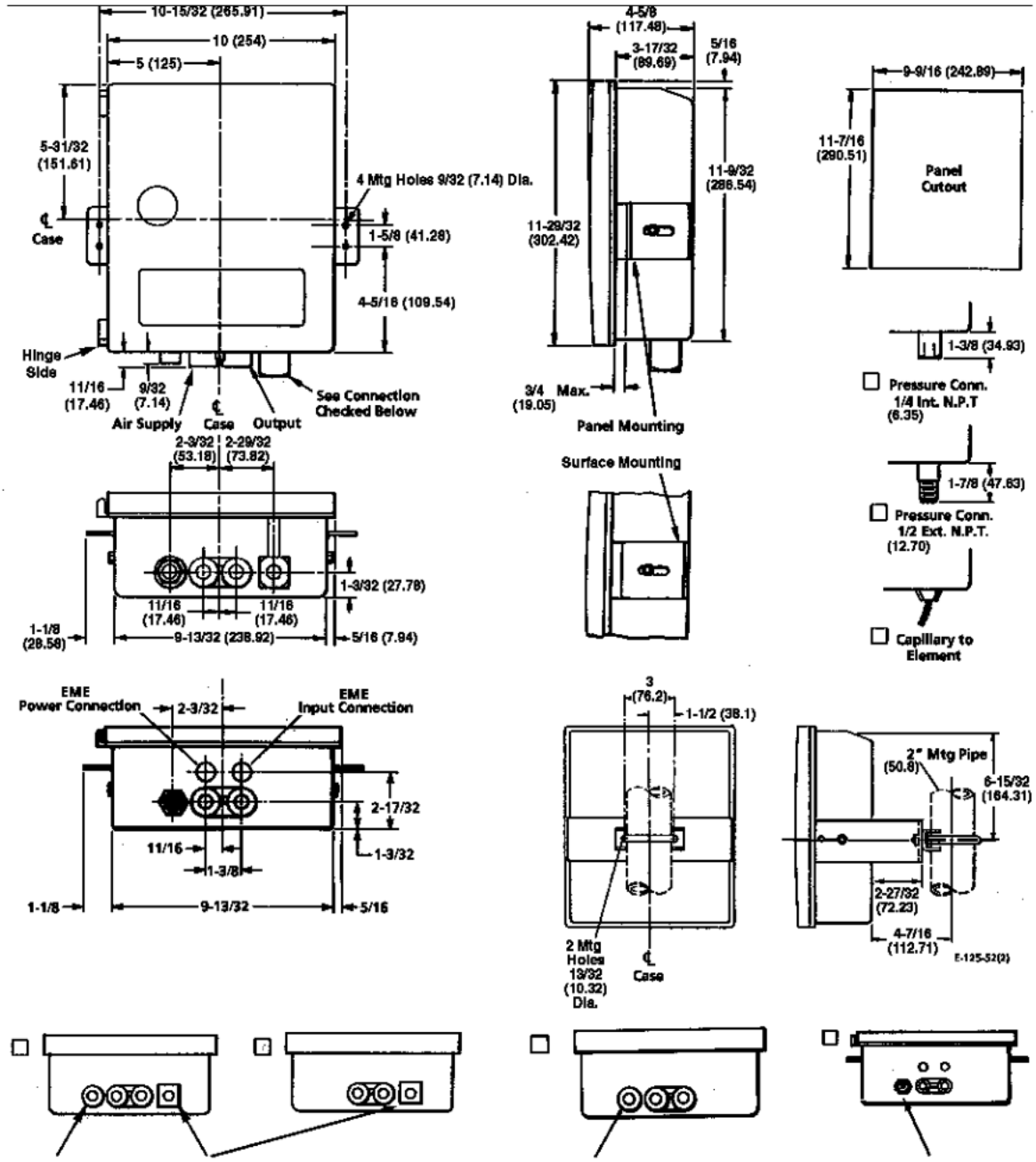


Figure 1. Panel and Surface Mounting Brackets

2.2 MOUNTING DIMENSIONS

Refer to the following mounting dimension drawings for installation requirements.

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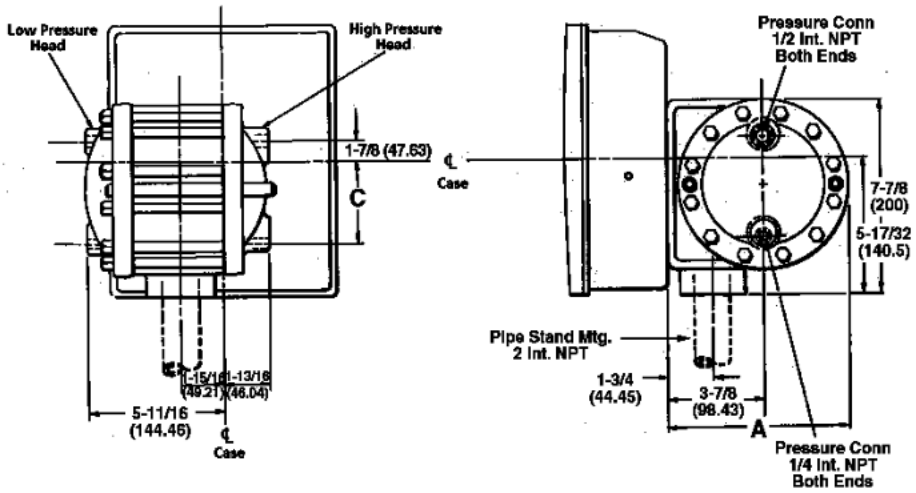
Pneumatic Set	Thermal System	Pneumatic Set	Pneumatic Set
High Pressure	Absolute, Gauge Pressure	External Feedback w/reset windup limiting (1)	External Feedback (1)
Low Pressure	Volumetric Pressure	External Feedback w/reset loading & venting (2)	External Feedback (2)
External Feedback	Receiver Pressure		
Alarm	Absolute Pressure		
	High Pressure		

Dimensions shown in inches (mm).
All air connections ¼ Int. NPT unless otherwise marked.

Figure 2. 440 Series for Panel, Surface or Pipe Mounting

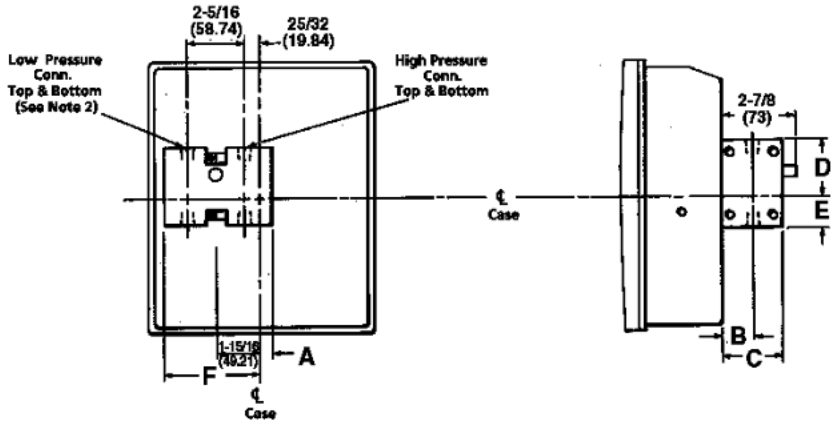
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☐ **Catalog Termination Nos 181, 183-186**



TERM. NO.	WORKING PRESSURE	PRESSURE CONN See Note 3		A	C
		TOP	BOTTOM		
183	2500 psi	1/2" NPT	1/4" NPT	7-7/16 (189)	2-1/4 (57)
184	3000 psi	1/2" NPT	1/4" NPT	7-7/16 (189)	2-1/4 (57)
185	4500 psi	1/2" NPT	1/4" NPT	7-7/16 (189)	2-1/4 (57)
186	6000 psi	1/2" NPT	1/4" NPT	7-7/16 (189)	2-1/8 (54)

☐ **Catalog Termination Nos 191, 192, 194, 196 and 197**



TERM. NO.	WORKING PRESSURE	PRESSURE CONN		A	B	C	D	E	F
		TOP	BOTTOM						
**191	1000 psi	1/8" NPT	1/8" NPT	1/16 (1.59)	1 (25.4)	2 (50.8)	2-1/32 (51.6)	29/32 (23)	3-15/16 (100)
**192	1500 psi	1/4" NPT	1/4" NPT	1/16 (1.59)	1 (25.4)	2 (50.8)	2-1/32 (51.6)	29/32 (23)	3-15/16 (100)
*194	3000 psi	1/4" NPT	1/2" NPT	1/8 (3.18)	1-1/8 (28.6)	2-1/4 (57.15)	2-3/16 (55.56)	1-1/16 (27)	4 (101.6)
*196	6000 psi	1/4" NPT	1/2" NPT	1/4 (6.35)	1-1/8 (28.6)	2-1/4 (57.15)	2-3/16 (55.56)	1-1/16 (27)	4-1/8 (104.8)
197	10000 psi	1/4" NPT	1/4" NPT	1/4 (6.35)	1-1/8 (28.6)	2-1/4 (57.15)	2-3/16 (55.56)	1-1/16 (27)	4-1/8 (104.8)

Notes:

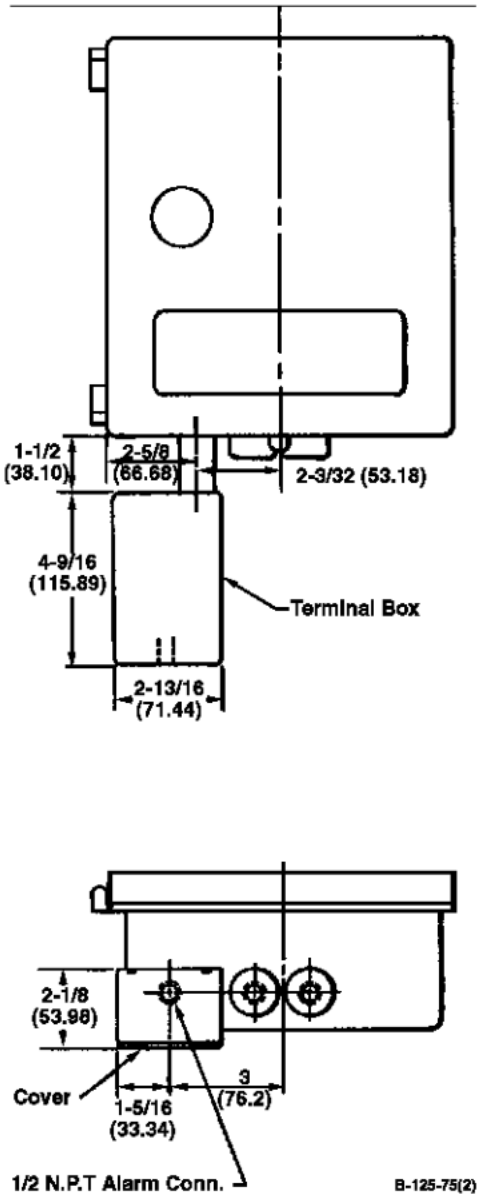
****1. Absolute Pressure Meter Body available in Cat. Term. Nos 191 and 192 only.**

2. These connections not supplied on Absolute Pressure Meter Bodies.

***3. 1/2" and 1/4" Pressure Connections can be reversed by rotating heads 180°.**

Figure 3. 440 Series with Absolute or Differential Pressure Meter Body (Manometer)

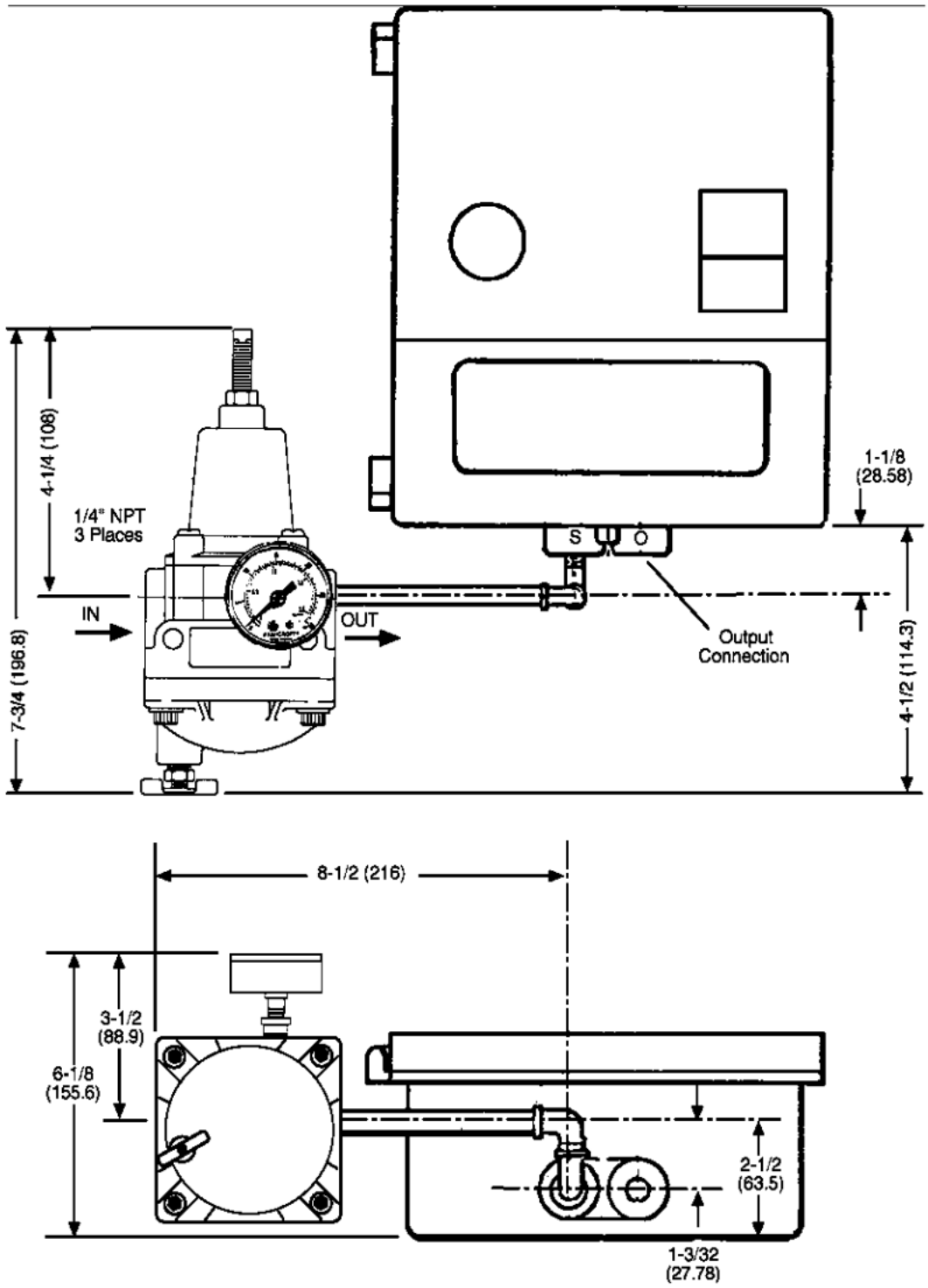
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Dimensions shown in inches (mm).
All air connections ¼ Int. NPT unless otherwise marked.

Figure 4. 440 Series with Electric Primary Driven Alarms

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Dimensions shown in inches (mm).
All air connections ¼ Int. NPT unless otherwise marked.

Dimensions apply only to pressure regulator and filter set as shown with filter regulator connected to instrument air supply connection.

Figure 5. 440 Series with Pressure Filter Regulator and Gauge Set for Indicating Controller

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2.3 PNEUMATIC CONNECTIONS

WARNING
Use of a supply gas other than air can create a hazardous environment because a small amount of gas continuously vents to the atmosphere.

The air supply and output ports are located at the bottom center of the instrument as shown in Figure 6. Both ports are ¼" Int. NPT and are equipped with screen inserts.

Connect a clean, dry air supply of 20 psi (140 kPa) to the port marked "S". Before making the final instrument connection, blow out the line thoroughly.

Connect the control element to the output port marked "O". IT IS IMPORTANT THAT THE OUTPUT AIR LINE BE FREE OF LEAKS TO ENSURE FULL OUTPUT TO THE FINAL ELEMENT. Check for leaks at all fittings with a soap solution.

2.3.1 Process Connections

Refer to the specific section of this manual for information on instrument-specific process connections for each type of measuring element.

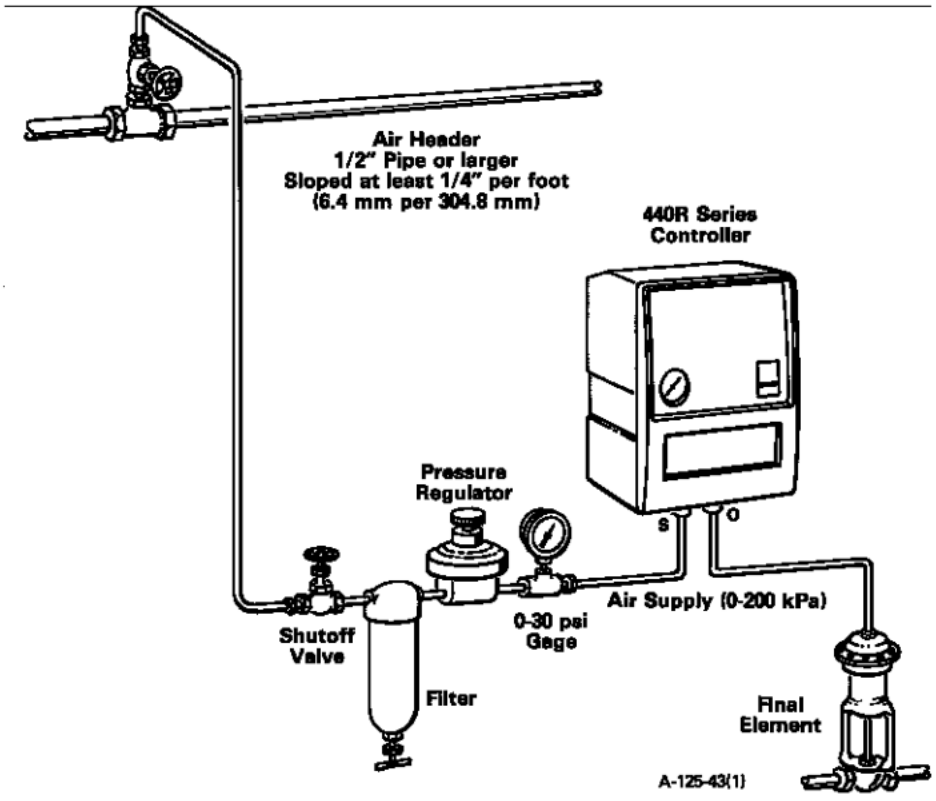


Figure 6. Pneumatic Connections

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2.4 PRE-STARTUP CHECK

Before putting the instrument into operation, make certain it is correctly installed and operational by checking the following:

1. Air lines are connected to the correct ports and there are no leaks.
2. Air supply is turned off.
3. Sensing element is correctly installed.
4. Block valves around the process control valve are closed so that the control valve can be opened and closed safely.
5. Process indicator is zero-set. Apply an input equal to the control point and adjust process indicator fine zero if necessary. Refer to Figure 7.
6. Valve operation tab, located near the output gauge, reads correctly for valve action. Refer to Figure 8. If it does not, reverse the tab.
7. Gain dial is set for the required action. See Figures 9 and 10. If it is not, lower gain dial lock and rotate dial.

- Direct Action; output pressure increases as process indicator moves to the right.
- Reverse Action; output pressure decreases as process indicator moves to the right.
- Raise gain dial lock.

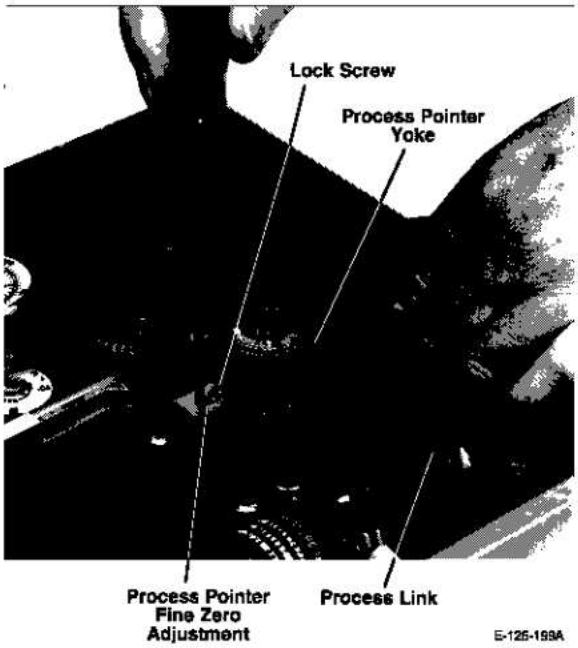


Figure 7. Process Pointer Fine Zero Adjustment

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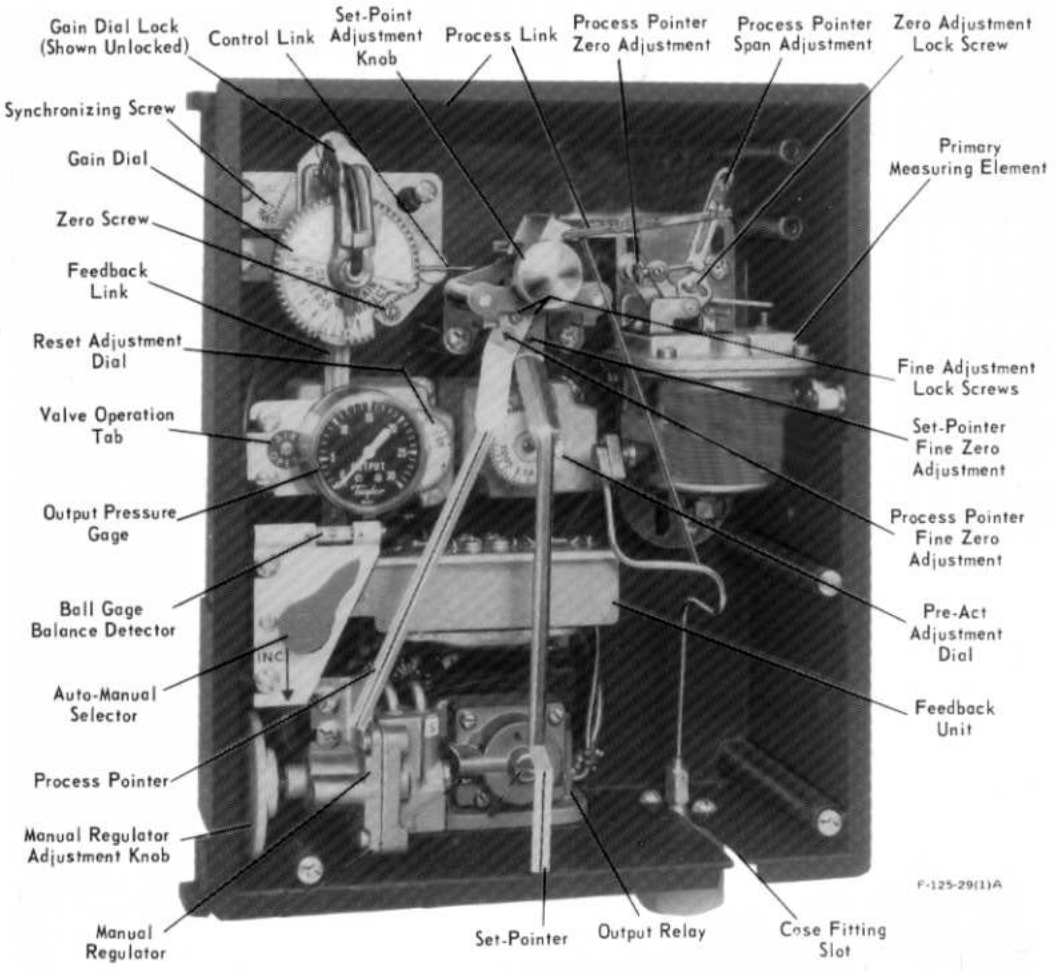


Figure 8. Location of Components

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Fixed High Controller Gain Dial

Proportional Controller Gain Dial Shown Set at 25% Differential Gap

Figure 9. Gain Dials Shown Set in Reverse Action

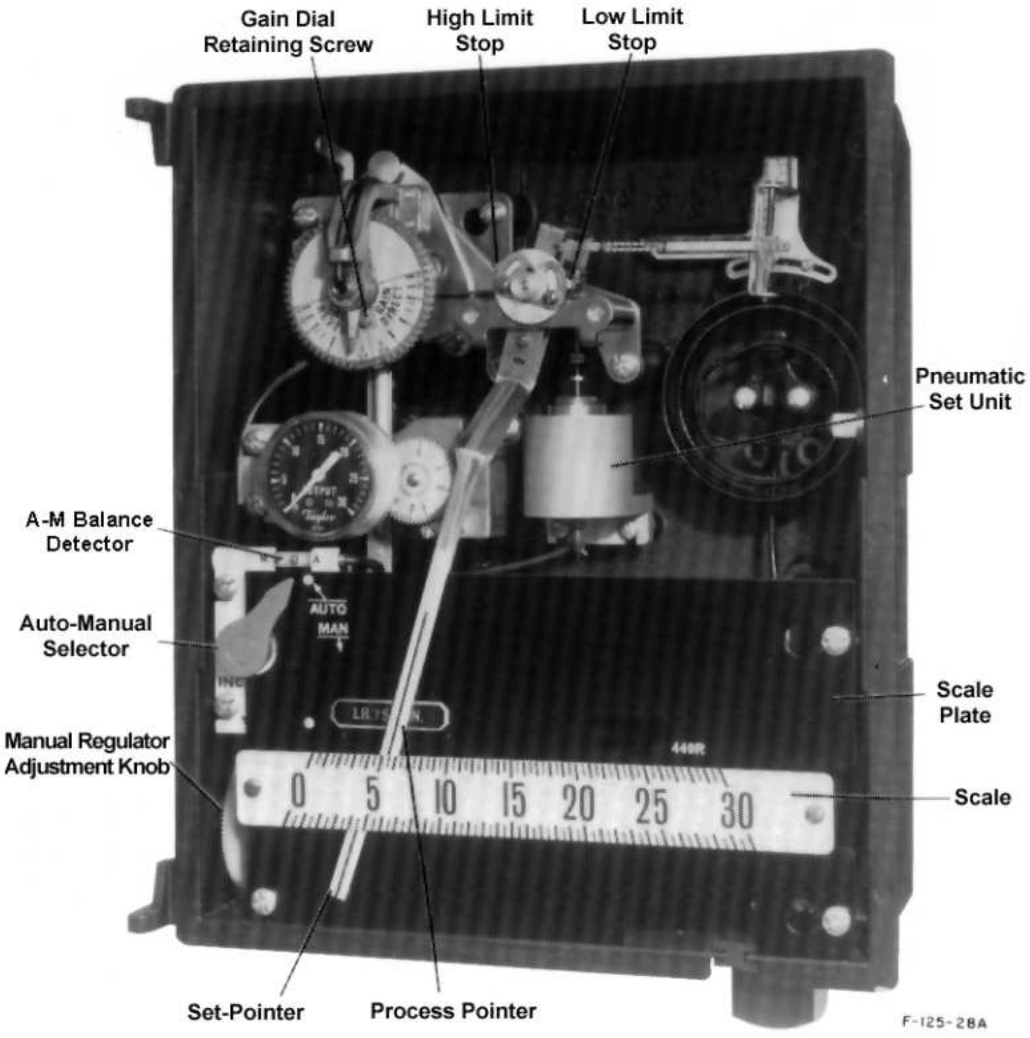


Figure 10. 442R Controller with Pneumatic Set

WARNING

Use of a supply gas other than air can create a hazardous environment because a small amount of gas continuously vents to the atmosphere.

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3
OPERATION

3.1 DESCRIPTION OF OPERATION

Schematic diagrams of the 440R Series Controllers are shown in Figures 11 through 15. These controllers operate on the motion balance principle; motion from a pneumatic feedback unit balances the motion from a process measuring element.

When the temperature at the sensing element increases, the Bourdon spring uncoils and moves the process pointer to the right and the baffle actuating pin to the left. The movement of the pin lowers the baffle to decrease the nozzle-baffle gap and thus increases the nozzle-back pressure. This pressure is then fed to chamber A of the output relay.

As the pressure in chamber A increases, the diaphragm assembly moves the relay stem downward closing the vent port and opening the air supply port to increase the output. The output increases until it balances the downward force on the diaphragm assembly.

On controllers having proportional response, Figures 12 through 15, the output pressure is fed to the follow-up bellows and raises the baffle actuating pin and the baffle itself. Ultimately the original nozzle-baffle gap is restored and equilibrium is established.

Reset response, Figures 13 and 15, automatically returns the process variable to the set-point after a sustained load change. This is accomplished by opposing the action of the follow-up bellows with a reset bellows. The output pressure is fed to the reset bellows through a needle valve.

PRE-ACT response, Figures 14 and 15, reduces the offset caused by a process disturbance as well as reducing the recovery time following the disturbance. This is accomplished by feeding the output pressure to the follow-up bellows through a needle valve.

The controller can be set for either direct or reverse action by positioning the gain dial.

Direct Action: As process pointer moves to the right, output increases.

Reverse Action: As process pointer moves to the right, output decreases.

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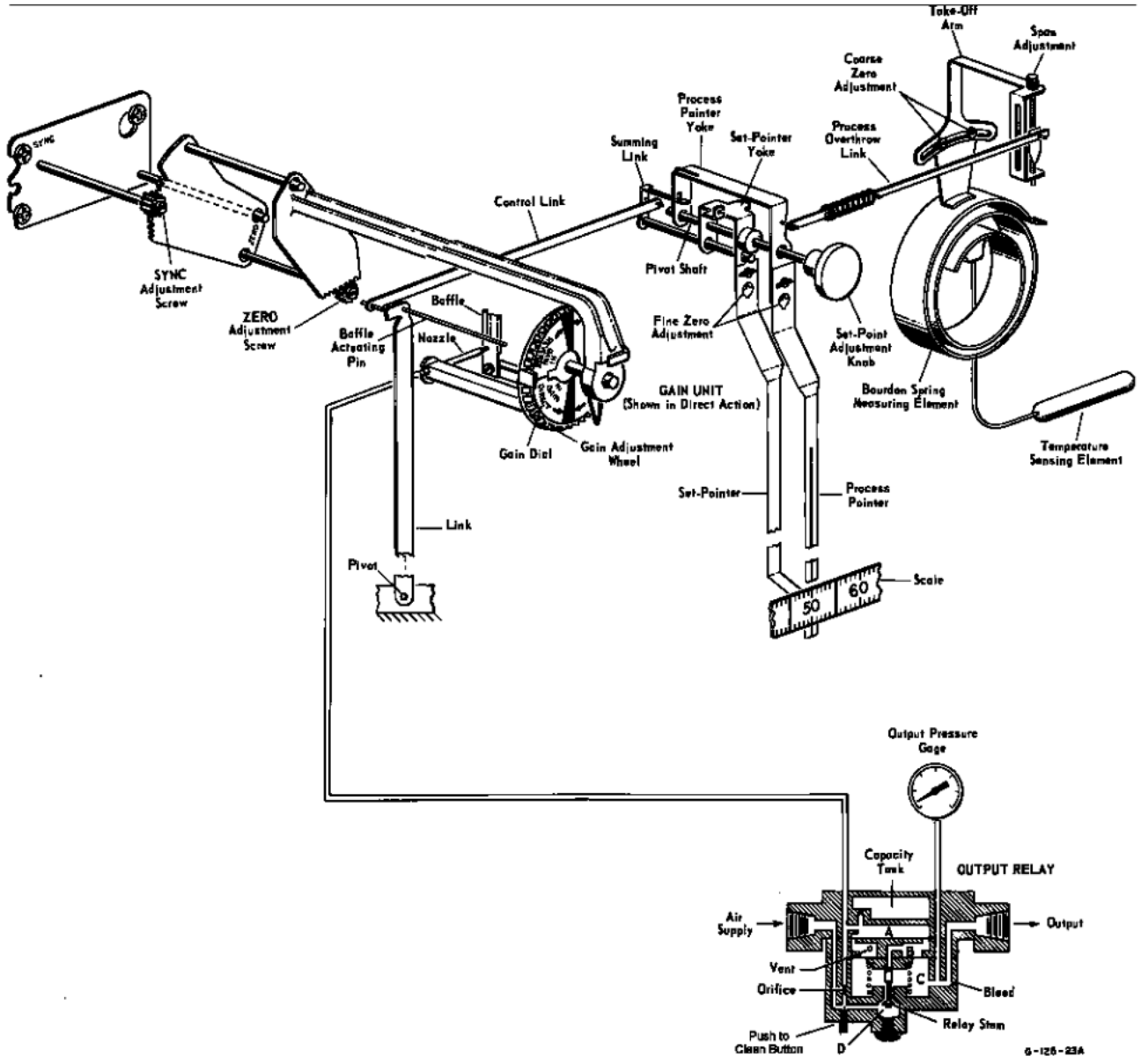


Figure 11. Schematic Diagram of 440R Fixed High Response

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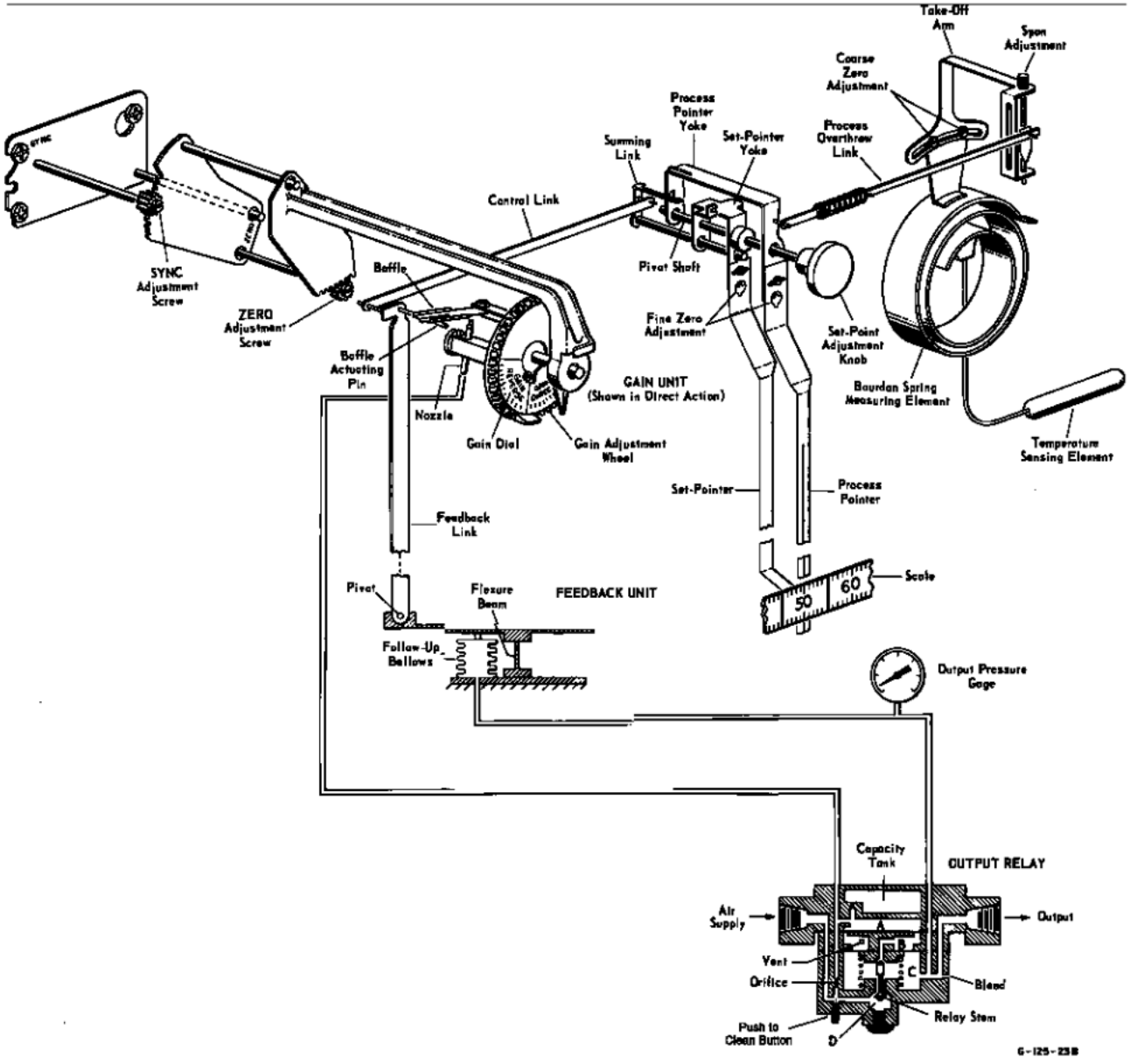


Figure 12. Schematic Diagram of 441R Proportional Response

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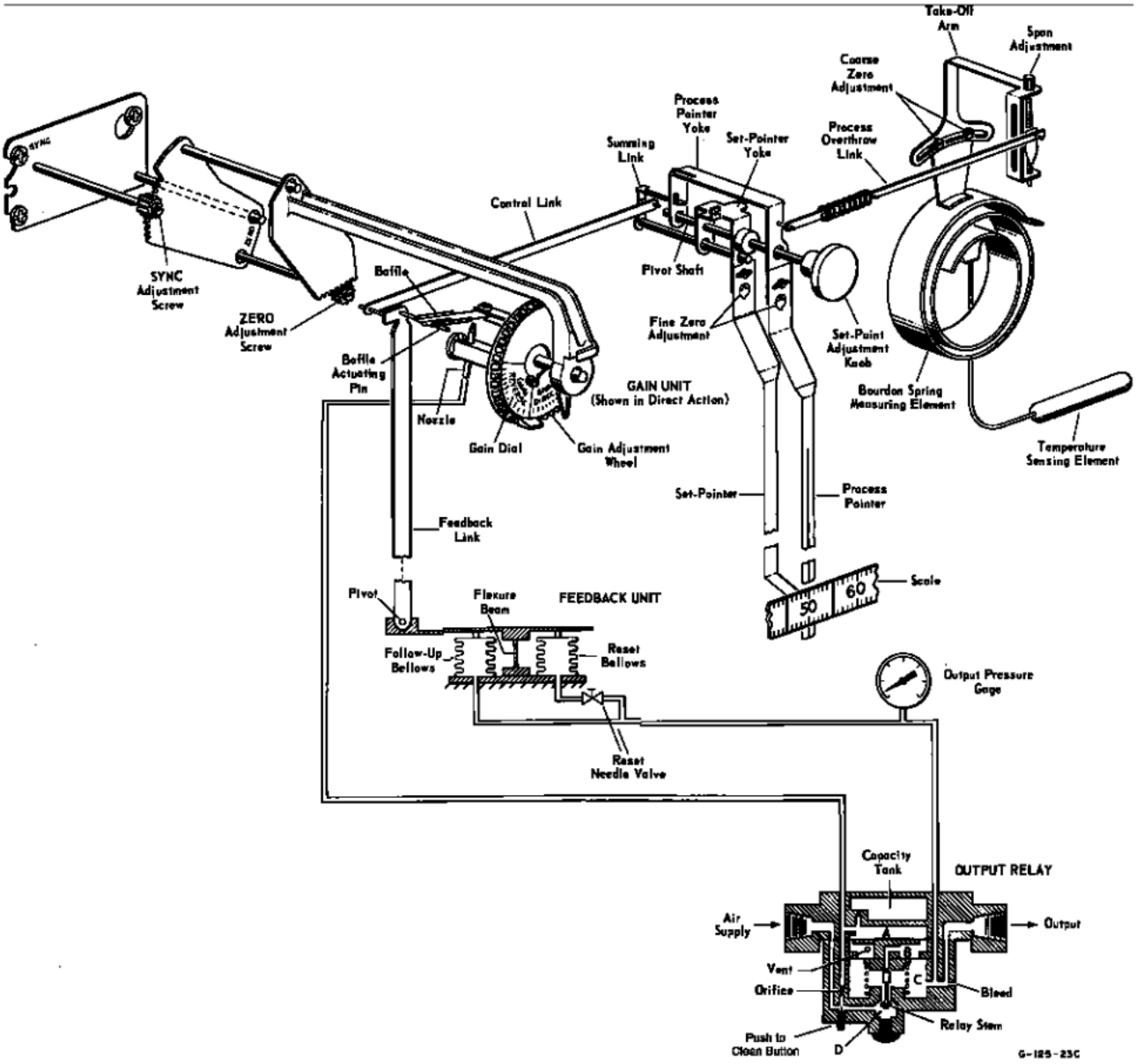


Figure 13. Schematic Diagram of 442R Proportional and Reset Responses

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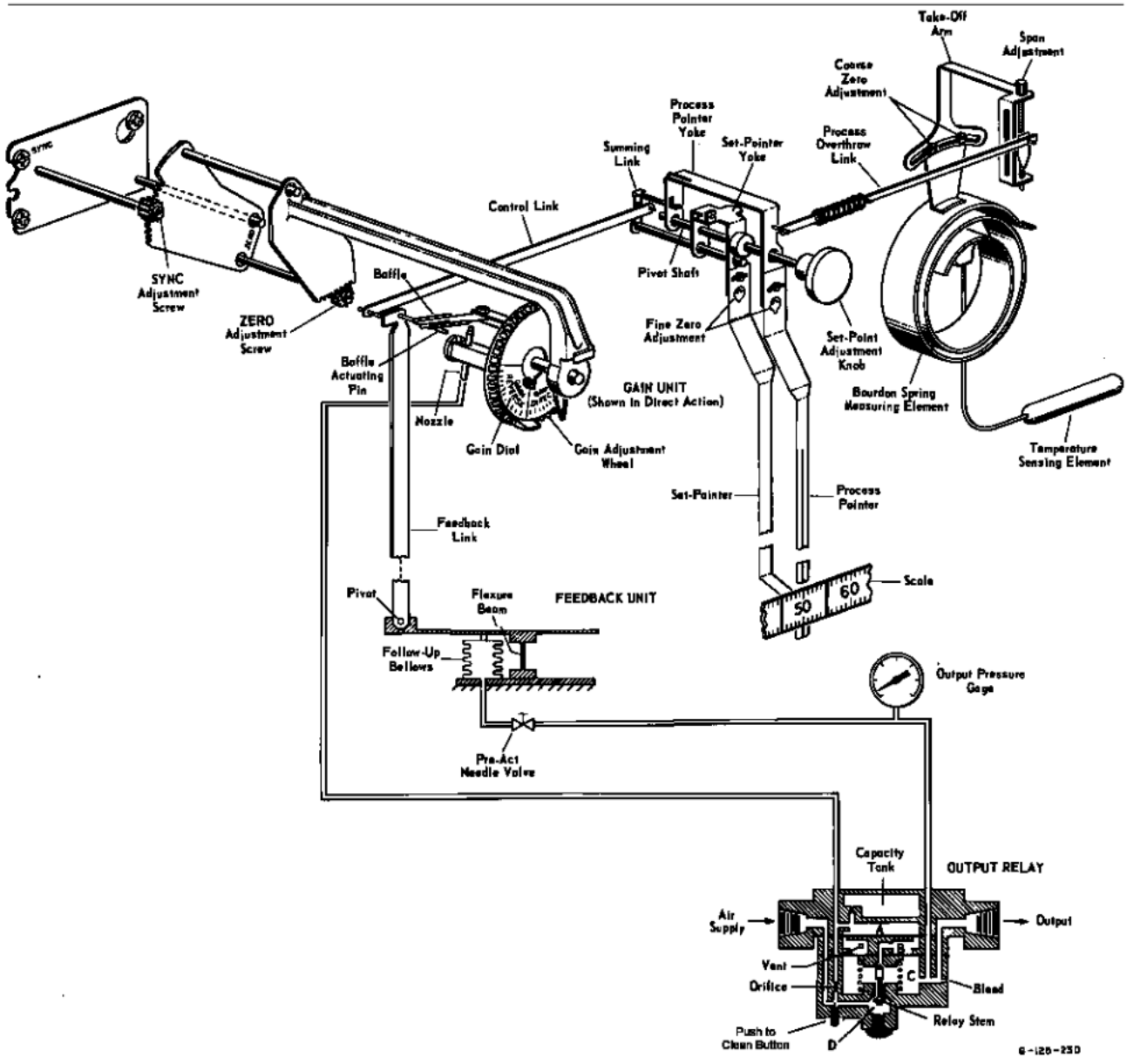


Figure 14. Schematic Diagram of 443R Proportional and PRE-ACT Responses

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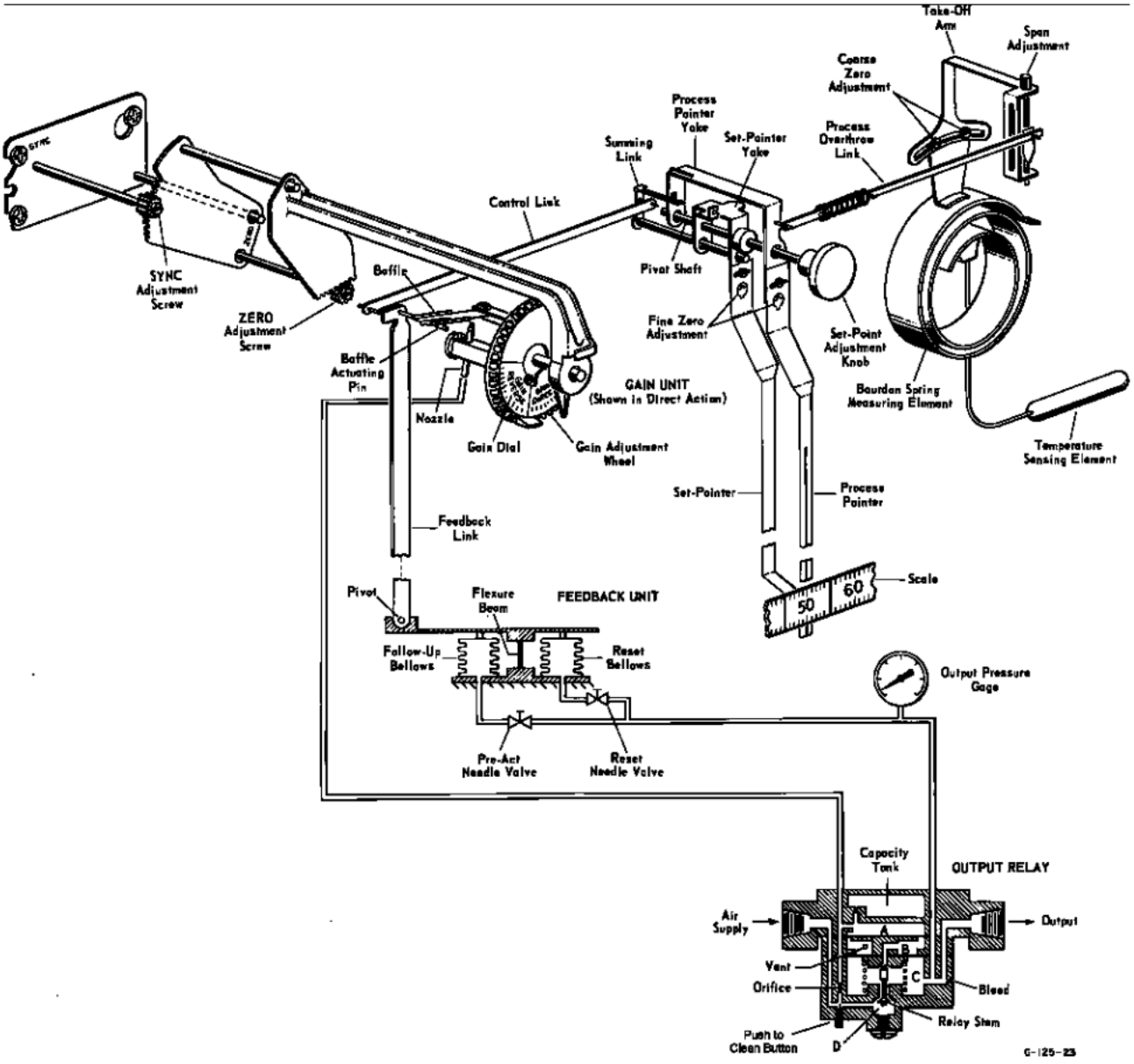


Figure 15. Schematic Diagram of 444R Proportional, Reset and PRE-ACT Responses

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Differential-Gap response (441R only) maintains a minimum or maximum output pressure until the process pointer crosses a reverse trip-point. There are two trip-points located equal distant from the set-pointer, Figure 16. The differential gap between the trip-points can be set between 4% and 100% of input span. When the process pointer reaches either trip-point, the output pressure will reverse (maximum to minimum, or minimum to maximum). The trip-points are set by rotating the gain dial to the required percent of gap setting. The controller can be set for either direct or reverse action by positioning the gain dial.

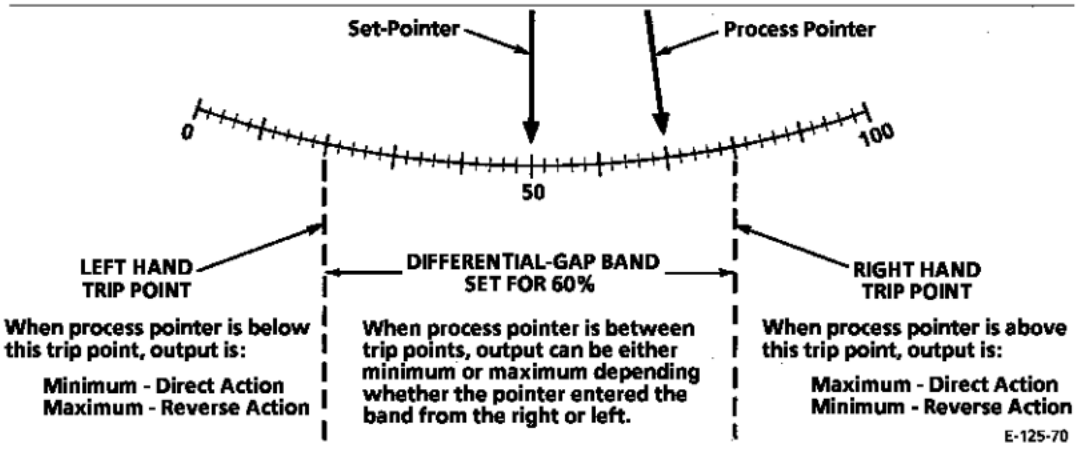


Figure 16. Differential Gap Operation

When a 441R Controller is set for differential-gap operation, the baffle is located on the opposite side of the baffle actuating pin. Refer to Figure 17. As the process pointer moves the pin to decrease or increase the nozzle-baffle gap, the follow-up bellows moves the baffle in the same direction to either cap or uncap the nozzle. The output pressure will go to minimum or maximum, and remain at this pressure until the process pointer reaches the other trip-point.

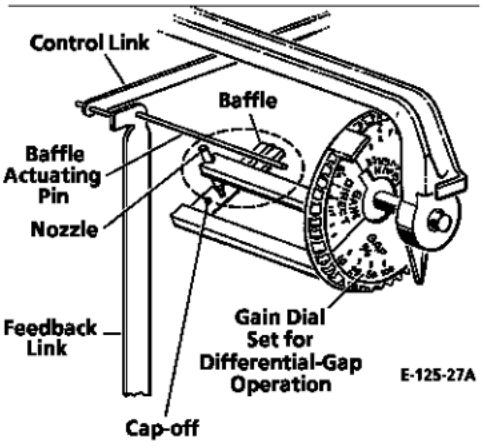


Figure 17. Schematic Diagram of Gain Unit Set for Differential Gap Operation

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3.1.1 Pneumatic-Set Operation

The pneumatic-set option, Figure 18, consists of a pneumatic-set unit having 3 to 15 psig (20 to 100 kPa) bellows mechanically connected with an overthrow link to the set-pointer yoke. The input to the bellows is an external signal from a manual regulator for remote-set, or from another controller for cascade operation.

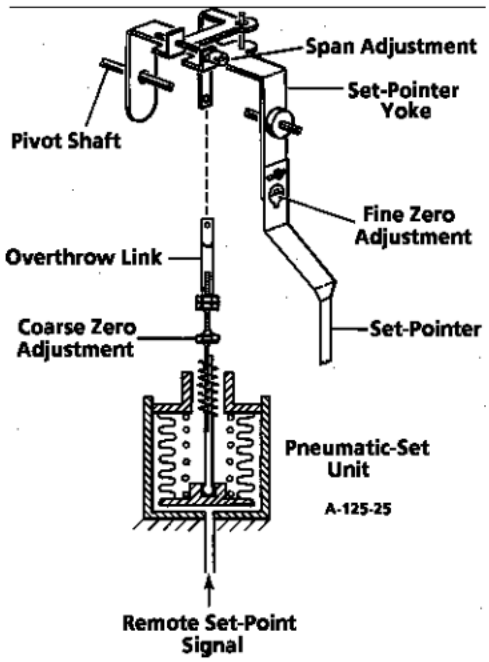


Figure 18. Schematic Diagram, Pneumatic-Set Option

With an increase in input signal, the bellows compresses. The link moves upward and the set-pointer moves to the right.

With a decrease in input signal, the bellows will extend by force of its internal spring. The link will move downward and the set-pointer will move to the left.

All units are provided with high and low limit stops which can be set to limit travel of set-pointer to any position of the scale.

3.1.2 AUTO/MAN Option

The manual regulator provides a pneumatic output signal through the AUTO/MAN selector when the switch is in the manual position. Refer to Figure 19.

When the manual adjustment knob is rotated downward, the diaphragm and the relay stem move to the right. An air supply from chamber C enters chamber B through a more open valve for an increased regulator output. Equilibrium is established when the output pressure against the diaphragm in chamber B equals the force exerted by the loading spring in chamber A.

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As the manual adjustment knob is rotated upward, the diaphragm and relay stem move to the left. The air supply from chamber C is throttled and pressure in chamber B is relieved to chamber A through inner valve and to atmosphere for a decreased output. Equilibrium will occur when the decreased output pressure in chamber B balances the decreased spring force.

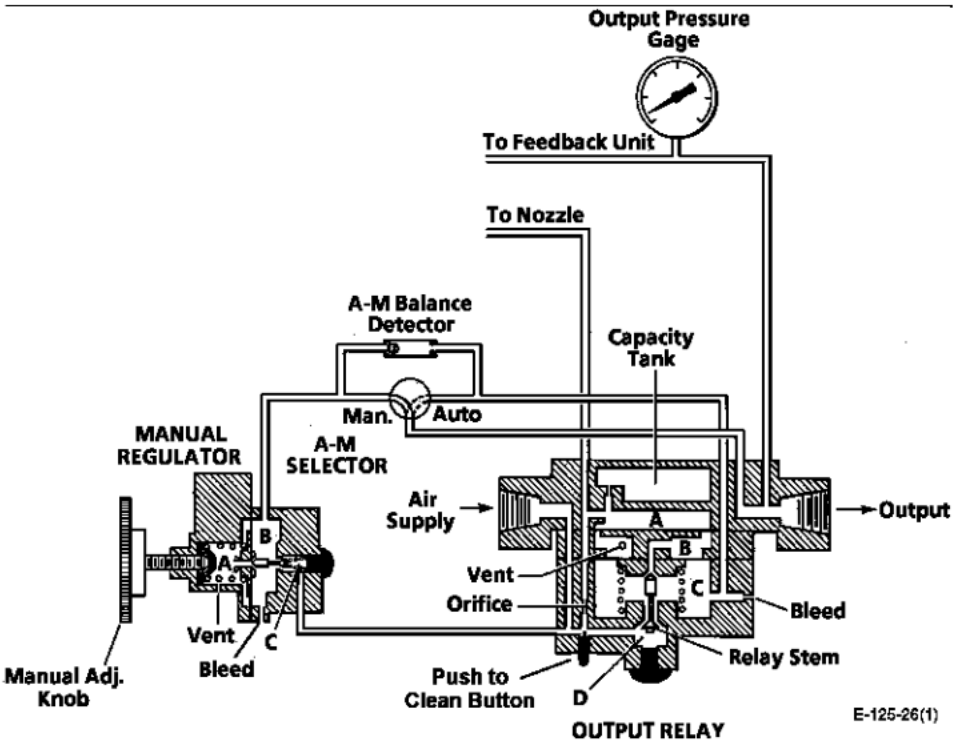


Figure 19. Schematic Diagram, AUTO/MAN Option

The AUTO/MAN balance detector is a ball gauge with O-rings at extreme travel. The ball seals at the left end as shown in Figure 19, when the controller output exceeds manual regulator output at the right end when manual output exceeds controller output.

When the controller and manual output pressures are equal within 0.1 psig (0.7 kPa), the ball will be centered. The AUTO/MAN selector may then be rotated for a bumpless transfer. Refer to AUTO/MAN Switching for procedure.

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3.1.3 External Feedback with Reset Windup Limiting

The purpose of external feedback is to prevent “reset windup” when the process goes outside the proportional band. When “reset windup” occurs, the output pressure goes to 0 or 20 psig (140 kPa) and does not return to a throttling position until after the process measurement returns to and crosses over the set-point. The resulting overpeak may adversely affect the process.

External feedback eliminates “reset windup” by providing connections for an external reset limiter or other device to control the pressure to the reset bellows.

External feedback is accomplished by connecting a reset limiter to the external feedback and output line, Figure 20. The reset limiter, Figure 21, causes the reset bellows to fill or vent through the reset needle valve as limited by the output pressure.

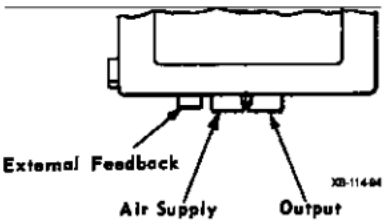


Figure 20. Air Connections for 442R, 444R with Reset Windup Limiting

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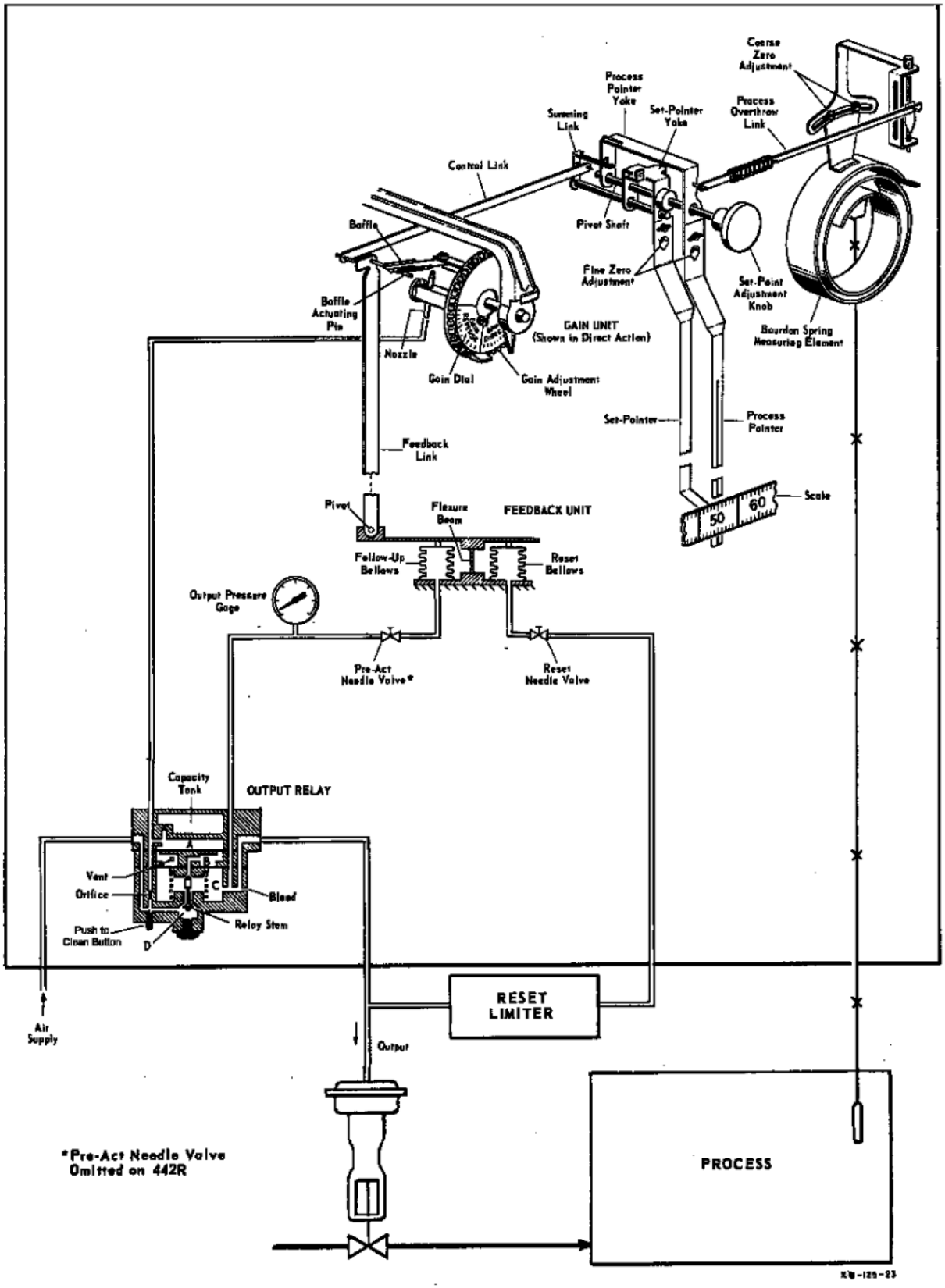


Figure 21. Schematic Diagram of 444R Controller with Reset Windup Limiting

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3.1.4 External Feedback with Reset Windup Loading or Venting

This controller, 442R or 444R, is used on batch processes where it is necessary to change from reset to proportional response during startup to eliminate reset windup.

Reset loading or venting is accomplished by connecting a regulated air supply or vent to the reset loading or venting connection, Figure 22, through the solenoid. When the solenoid, Figure 23, is opened to pass air through the reset loading or venting connection, the reset bellows fills or vents to the required air pressure. When the solenoid shuts off, the reset bellows fills or vents through the reset needle valve.

** NOTE:* Make certain that the solenoid sealed properly or the controller will not function correctly.

Due to the additional capacity of the reset loading tubing, the reset rate must be set at a higher value than a controller without reset loading.

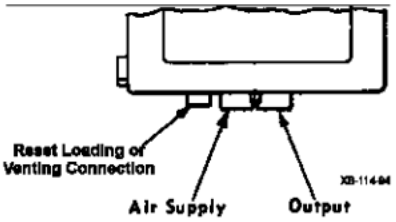


Figure 22. Air Connections for 442R, 444R with Reset Windup Loading or Venting

CAUTION When reassembling the feedback link, do not overstress the baffle leaf springs by bending the baffle too far away from the nozzle.

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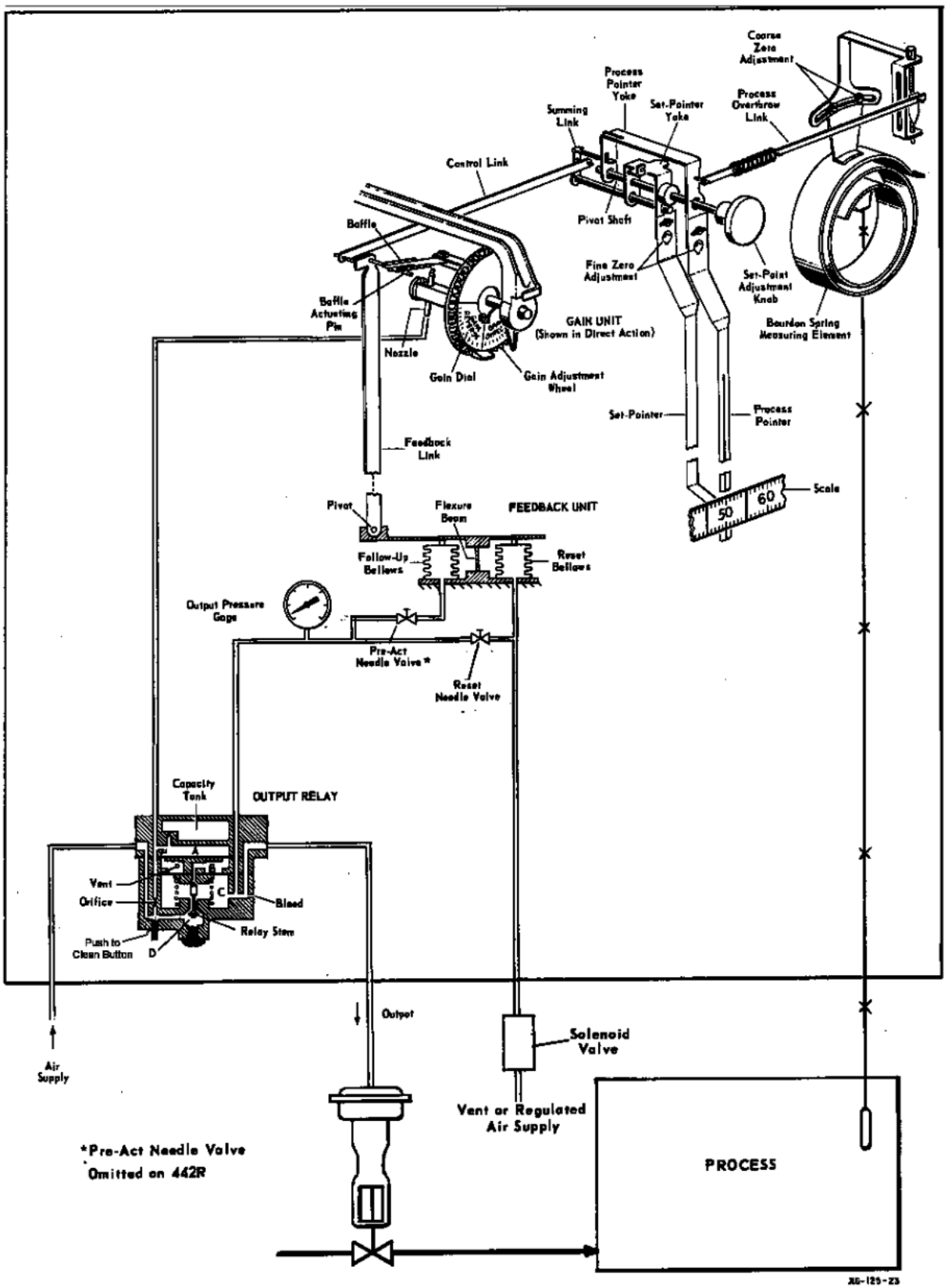


Figure 23. Schematic Diagram of 444R Controller with Reset Windup Loading or Venting

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3.2 INITIATING OPERATION

Be sure that all steps in **Section 2.4 PRE-STARTUP CHECK** have been completed. If response settings have been established, proceed to make these adjustments. If response settings are not known, make additional adjustments that apply as follows:

Gain	1
Reset	1
PRE-ACT	minimum

3.2.1 Without AUTO/MAN Operation

1. Turn on 20 psig (140 kPa) air supply.
2. If possible, adjust set-pointer until output pressure positions control valve for startup; otherwise adjust set-point at required value.
3. Open block valves around control valve. If control valve cannot be properly positioned for startup by adjusting the set-pointer, open block valves slowly to start up process at required rate.
4. Adjust set-pointer adjustment knob gradually until process pointer is at required value.
5. Refer to **Section 3.3 OPTIMUM CONTROLLER SETTINGS** to make proper adjustments.

THE PROCESS IS NOW ON AUTOMATIC CONTROL.

3.2.2 With AUTO/MAN Option

1. Set AUTO/MAN selector to MAN, clockwise to the stop.
2. Turn on 20 psig (140 kPa) air supply.
3. Rotate manual regulator adjustment knob until output pressure positions control valve for startup.
4. Open block valves around control valve.
5. Rotate manual regulator adjustment knob gradually, until process pointer is at required value.
6. Rotate set-point adjustment knob until ball in balance detector is centered or until very slight set-point adjustments cause the ball to move back and forth.
7. Set AUTO/MAN selector to AUTO position, counterclockwise to the stop.
8. Refer to **Section 3.3 OPTIMUM CONTROLLER SETTINGS** to make proper adjustments.

THE PROCESS IS NOW ON AUTOMATIC CONTROL.

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3.2.3 AUTO/MAN Switching

Use this procedure only if controller has been in operation. Otherwise, refer to **Section 3.2 INITIATING OPERATION**.

AUTOMATIC TO MANUAL:

1. Rotate manual regulator adjustment knob until ball in balance detector is centered.
2. Set AUTO/MAN selector to MAN, clockwise to the stop.

THE PROCESS IS NOW ON MANUAL CONTROL.

MANUAL TO AUTOMATIC:

1. Rotate set-point adjustment knob until ball in balance detector is centered or until very slight set-point adjustments cause the ball to move back and forth.
2. Set AUTO/MAN selector to AUTO, counterclockwise to the stop.

THE PROCESS IS NOW ON AUTOMATIC CONTROL.

3.3 OPTIMUM CONTROLLER SETTINGS

Optimum controller settings enable the controller to do the best possible job of controlling its process variable. It is easy to check for optimum control settings because the process pointer, after any upset will swing so that each successive swing from right to left is 1/4 as long as the previous swing from right to left.

To obtain optimum settings, follow the procedure given in the specific controller as follows:

3.3.1 441R – Proportional Controller

1. Put process on automatic control with a gain setting of 1.
2. Move set-pointer up or down scale enough to observe behavior of process pointer as controller seeks the new control point.
3. Compare length of swing of process pointer on successive swings from right to left:
   a) At optimum gain setting, each swing will be 1/4 the length of the previous swing from right to left.
   b) If the second swing is shorter than 1/4 the length of the first, gain is too low. Increase it and move set-pointer back to its original position.
   c) If the second swing is longer than 1/4 of the length of the first, gain is too high. Reduce it and move set-pointer back to its original position.
   d) Continue adjusting gain and moving set-pointer back and forth until the optimum setting is obtained.
4. If pointers are not together under stable conditions, refer to Figure 9, and synchronize the 441R proportional Controller as follows:
   a) At a gain setting to 10 or lower, turn the SYNC adjustment to align the pointers.
   b) At a gain setting above 10, turn the zero adjustment to align the pointers.

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3.3.2 442R – Proportional Plus Automatic Reset Controller

1. Set gain at 1, reset rate at 1, and put process on automatic control at required control point, adjusting set-pointer as required.

2. Open reset needle valve by turning reset adjustment dial clockwise to the stop. Keep process at control point 30 seconds by adjusting set-pointer as required.

3. Close reset needle valve by tuning reset adjustment dial counterclockwise to the stop.

4. Adjust gain as proportional controller to obtain optimum gain setting without automatic reset. Refer to **Section 3.3.1 441R – Proportional Controller**, Steps 2 and 3.

5. After gain has been adjusted, determine time in minutes required for process pointer to swing from right to left and back to right after a process upset. (Such as changing the set-point.)

6. Set reset at 1 divided by the time determined in Step 5 above.

7. Repeat Step 4 to obtain optimum gain with automatic reset. It will normally be necessary to reduce gain setting about 10%.

8. After optimum gain and reset values have been adjusted and process is stable, the process and set-pointers should be lined up. If they do not, turn the SYNC adjustment, Figure 24, to bring them together.

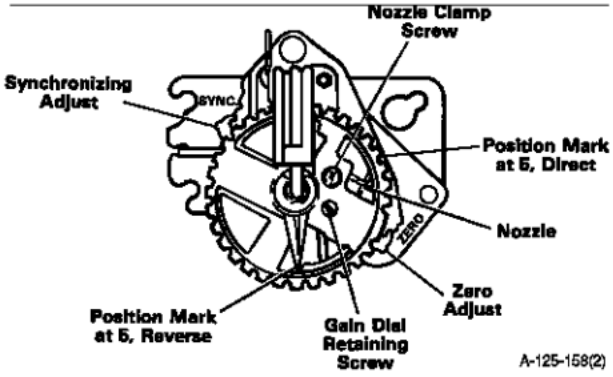


Figure 24. Gain Unit, Dial Removed

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3.3.3 443R – Proportional Plus PRE-ACT Controller

1. Set PRE-ACT adjustment dial to lowest value, clockwise to the stop.
2. Set gain at 1 and put controller on automatic control at required set-point.
3. Determine optimum gain setting as a proportional controller.

   Refer to **Section 3.3.1 441R – Proportional Controller**, Steps 2 and 3.
4. After optimum gain setting has been determined, move set-pointer up or down enough to create an upset and measure the time required in minutes for the process pointer to make a swing from right to left and back to the right.
5. Set the PRE-ACT dial to 1/6 of the time measured in Step 4.
6. Repeat Step 3.
7. After optimum gain and reset values have been adjusted and the process is stable, the process and set-pointers should be lined up. If they are not, refer to **Section 3.3.1 441R – Proportional Controller**, Step 4, and synchronize the controller.

3.3.4 444R – Proportional Plus Reset and PRE-ACT Controller

1. Set PRE-ACT adjustment dial to lowest value, clockwise against the stop.
2. Set gain at 1, and put process on automatic control at required set-point, adjusting set-pointer as required.
3. Open reset needle valve by turning reset adjustment dial clockwise to the stop. Keep the process at set-point 30 seconds by adjusting set-pointer as required.
4. Close reset needle valve by turning reset adjustment dial clockwise to the stop.
5. Determine optimum gain as proportional controller. Refer **Section 3.3.1 441R – Proportional Controller**, Steps 2 and 3.
6. Time a complete swing of the pointer, from right to left and back to the right side after a process upset (such as changing the set-point).
7. Set PRE-ACT dial to 1/6 of the time (in minutes) measured in Step 6.
8. Set reset at a value equal to 1.5 divided by the time in minutes for one complete swing.
9. Repeat Step 5 to determine optimum gain with PRE-ACT reset.
10. After this optimum gain setting has been determined and the process is stable, the process and set-pointer should line up. If they do not, turn SYNC adjustment, Figure 24, to bring them together.

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4
MAINTENANCE

4.1 PROCESS POINTER CALIBRATION

The following procedure is based on supplying 0%, 50%, and 100% input to the controller. If the instrument uses a temperature measuring element, substitute 20% for 0% and 80% for 100%.

Make sure the process link that is calibrated with the measuring element is in place, and the proper ball pivots on the process pointer yoke and the process link are used. Ball pivots selected during factory calibration are identified with a circle scribed at he base of the pivot ball.

Table 1. Ball Pivot Selection Table

MEASURING ELEMENT	NORMAL PIVOT (FIGURE 25)
Open Pressure Spiral Bourdon	B
Low-Pressure Bellows	B
Low-Pressure Capsule	B
Receiver Bellows	A
Helical Bourdon	C
Differential Pressure Meter Body	D
Temperature Systems	C
Remote Seal Pressure:	
Spiral Bourdon	B
Helical Bourdon	C

* *NOTE*: The ball pivot recommendations shown in Table 1 are nominal. Due to manufacturing tolerances, factory and field calibration may require the selection of an adjacent ball pivot for more or less pointer movement (span).

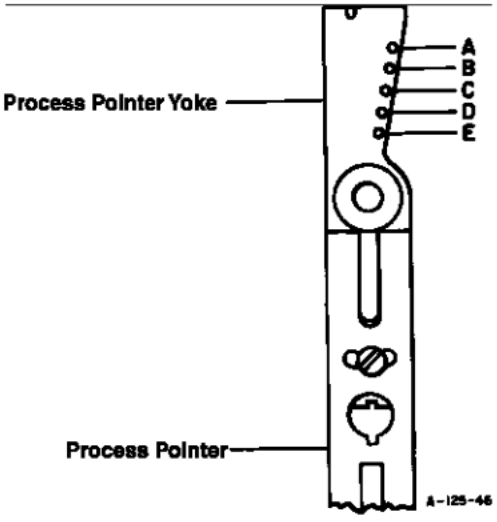


Figure 25. Ball Pivot Designations

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4.1.1 Zero Adjustment

1. Apply 0% input. Process pointer should indicate 0% ±2 of full scale.
2. If it does not, adjust pointer fine zero (screws located at the top of the process and set-pointer, Figure 26), until 0% ±2 of full scale is obtained.

   For adjustments exceeding 5%, use coarse zero adjustment on take-off arm, Figure 27.

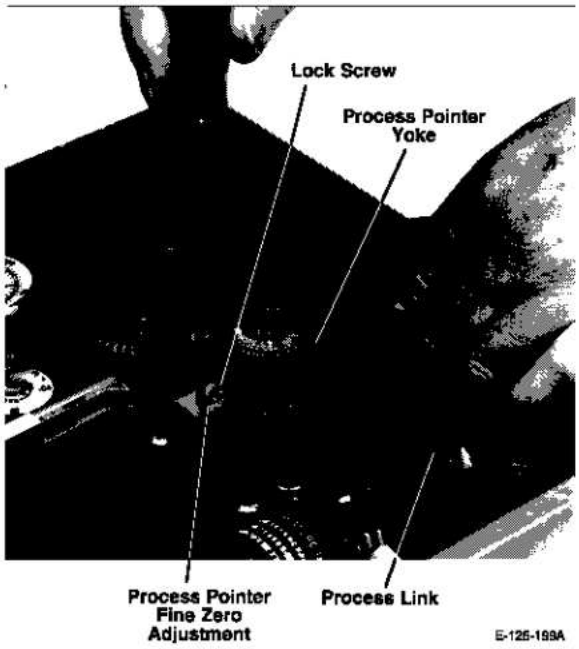


Figure 26. Process Pointer Fine Zero Adjustment

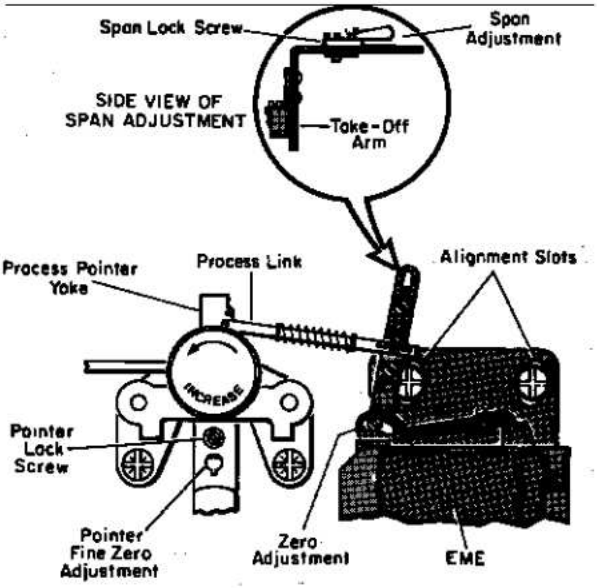


Figure 27. Coarse Zero and Span Adjustment on Take-off Arm

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4.1.2 Span Adjustment

1. Apply 100% input. Process pointer should indicate 100% ±2 of full scale.

   If it does not, turn span adjustment. Moving process link away from the center of rotation of measuring element increases pointer travel.

2. Repeat **Zero Adjustment**.
3. Repeat Steps 1 and 2 until required pointer readings are obtained.

4.1.3 Linearity Adjustment

1. Apply 50% input. If process pointer indicates 50% ±2 of full scale, calibration is complete.
2. To change linearity adjustment, select another ball pivot on right end of process link, Figure 25.
   - If indication is low, shorten the link.
   - If indication is high, lengthen the link.
3. Repeat **Zero**, **Span**, and **Linearity** adjustments.

4.2 PNEUMATIC-SET POINTER CALIBRATION

Make test hook-up as shown in Figure 28. Set high and low limit stops to upper extreme for unrestricted travel of set-pointer as shown in Figure 29.

Calibration will be checked at 0%, 50%, and 100% of scale.

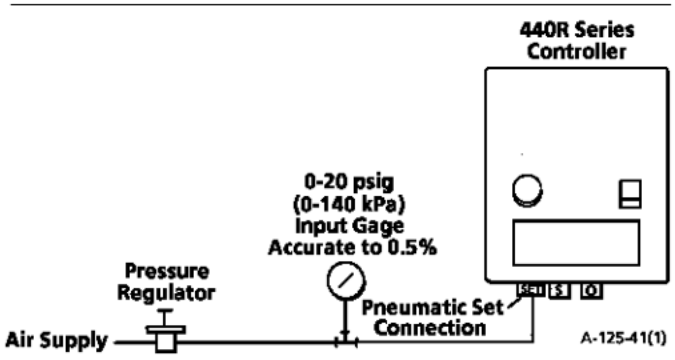


Figure 28. Test Hook-up for Pneumatic-Set Calibration

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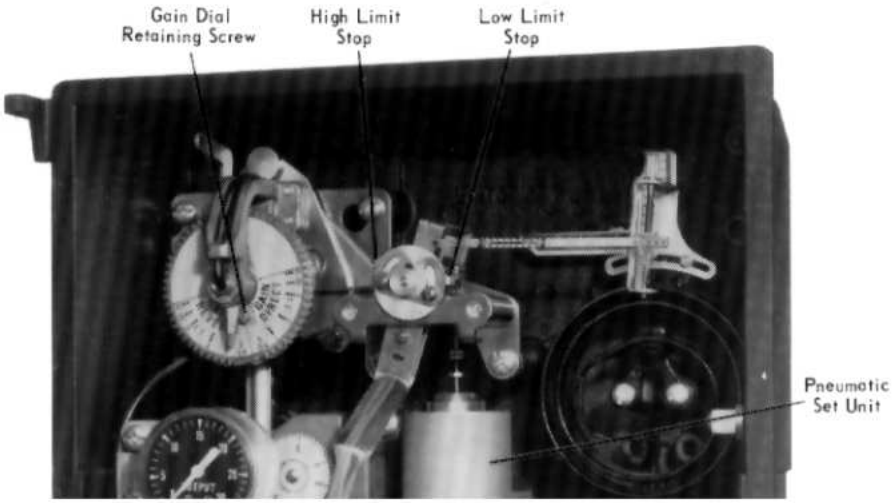


Figure 29. High and Low Stop Limits

4.2.1 Zero Adjustment

1. Apply 3.0 psig (20 kPa) input. Set-pointer should read 0% ±2 of full scale.
2. If it does not, adjust the set-pointer fine zero adjustment (screws located at the top of the process and set-pointer, Figure 30), until 0% ±2 of scale is obtained.

   For adjustments exceeding 5%, use coarse zero adjustment on pneumatic-set link, Figure 31.

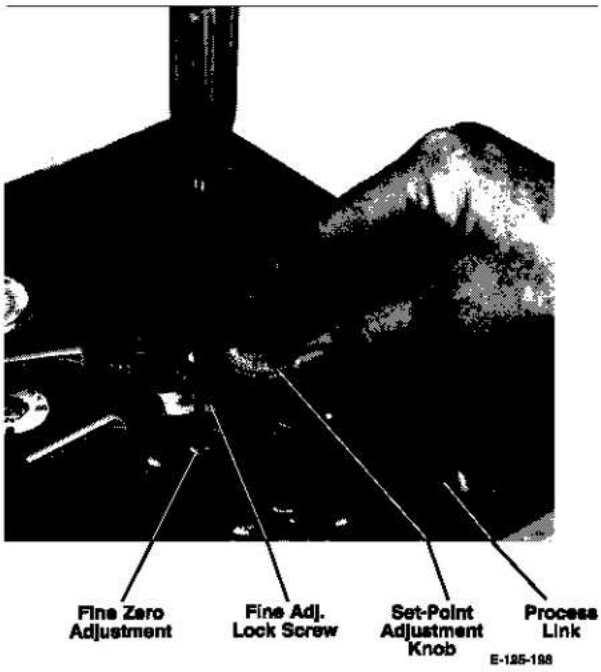


Figure 30. Set-Pointer Fine Zero Adjustment

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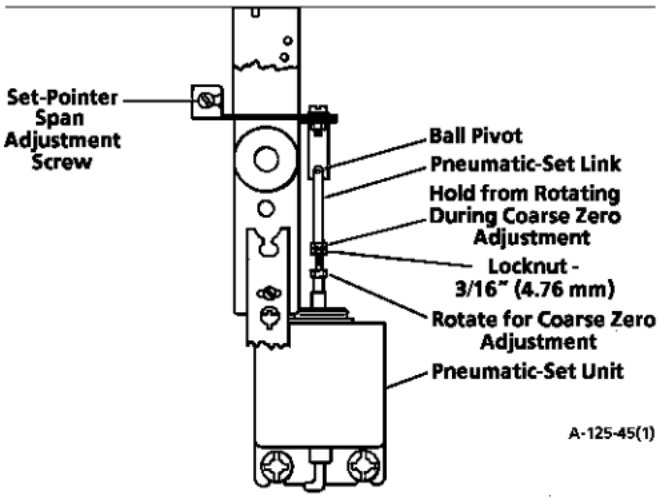


Figure 31. Span and Zero Adjustments for Pneumatic-Set Pointer

4.2.2 Span Adjustment

1. Apply 15.0 psig (100 kPa). Set-pointer should read 100% ±2 of full scale.

   If indication in step 1 is low, rotate span adjustment, Figure 31, clockwise.

   If indication in step 1 is high, rotate span adjustment, Figure 31, screw counterclockwise.

2. Repeat **Zero** and **Span** adjustments.
3. Apply 9.0 psig (60 kPa). Set-pointer should indicate 50% ±2 of full scale. If it does not, check for damaged pneumatic-set bellows.

   Set high and low limit stops to required values and calibration is complete.

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4.3 CONTROLLER ALIGNMENT

The purpose of controller alignment is to position the baffle actuating pin directly behind the center of the gain dial when the process pointer and set-pointer are together anywhere along the scale. This is particularly important during startup, for it allows the gain dial setting to be changed without changing the operating point of the controller.

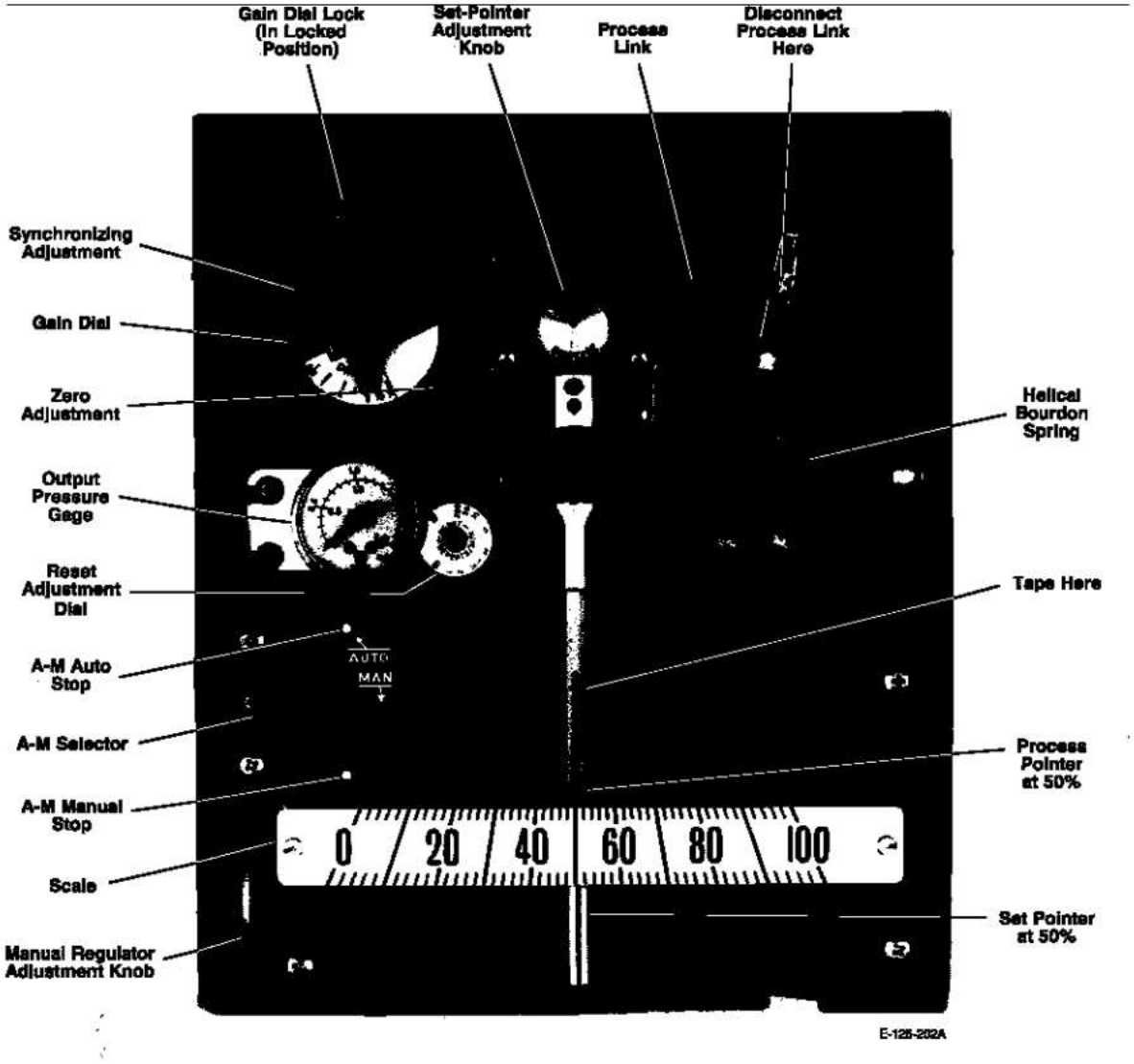


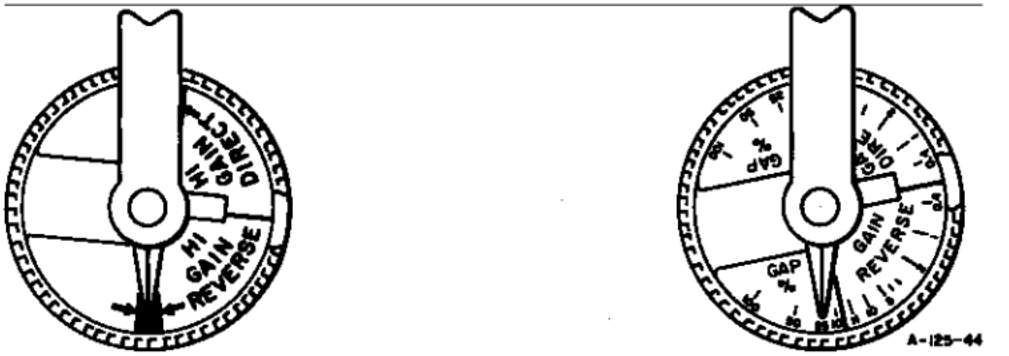
Figure 32. Initial Calibration and Setup

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4.3.1 440R – Fixed High Controller

Connect a 20 psig (140 kPa) air supply to port S and a 0 to 30 psig (0 to 200 kPa) gauge, accurate to 1%, to port O. An input is not required for alignment.

1. Disconnect left hand end of the process link from the process pointer, being sure to note which pivot is used. Refer to label on right side of case for ball pivot operator instructions.
2. If controller has an auto/manual option, turn selector to AUTO.
3. Adjust set-pointer to 50% of full scale. Tape process pointer to scale plate at 50% of full scale. See Figure 32.
4. Lock gain dial in action to be used; either DIRECT or REVERSE, Figure 33.
5. Set gain dial at stop midway between HI-DIRECT and HI-REVERSE (0 gain position). Turn SYNC adjustment, Figure 34, to obtain 9 psig (60 kPa) output.
6. Turn gain dial to HI gain position. Turn ZERO adjustment, Figure 34, to obtain 9 psig (60 kPa) output.
7. Remove tape and connect process link to proper pivot on pointer yoke.



Fixed High Controller Gain Dial

Proportional Controller Gain Dial Shown Set at 25% Differential Gap

Figure 33. Gain Dials Shown Set in Reverse Action

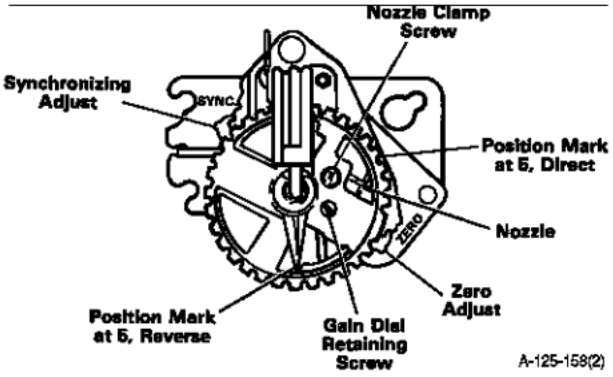


Figure 34. Gain Unit, Dial Removed

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4.3.2 441R – Differential-Gap Controller

1. First, align as a proportional controller in the same action required by the process for differential-gap operation. Refer to **441R – Proportional Controller**, **Section 4.3.3** Steps 1 through 9.
2. Set gain dial, Figure 33, at required percent of gap in the required action. Refer to Figure 16. Raise lock lever.
3. Remove tape and move pointer alternately across the scale. Observe readings as controller output trips.
4. Adjust gap percent dial setting to increase or decrease differential-gap between trip-points as required. Right and left trip-points will be approximately equal distant above and below the set-pointer.

   To move differential-gap to the right, with respect to the set-point, rotate ZERO adjustment, Figure 34, counterclockwise.
5. Attach process link to proper ball pivot on the pointer yoke.

4.3.3 441R – Proportional Controller

Connect to 20 psig (140 kPa) air supply to port S and 0 to 30 psig (0 to 200 kPa) gauge, accurate to ±1 %, to port O. An input is not required for alignment.

1. Disconnect left hand end of process link from process pointer, being sure to note which pivot is used.
2. If controller has an auto/manual option, turn selector to AUTO.
3. Adjust set-pointer to 50% of full scale. Tape process pointer to scale plate at 50% of full scale.
4. Lock gain dial in the action to be used; either DIRECT or REVERSE.
5. Set gain dial to stop between 0.4 DIRECT and 0.4 REVERSE (0 gain position). Turn SYNC adjustment, Figure 34, to obtain 9 psig (60 kPa).
6. Set gain at 5. Turn ZERO adjustment to obtain 9 psig (60 kPa).
7. Repeat steps 5 and 6 until output change is within ±0.24 psi (1.6 kPa) when gain dial is rotated between 0 and 5.

   If output change cannot be reduced to ±0.24 psi (1.6 kPa) perform **4.4 Nozzle Height Adjustment**, then repeat steps 4 through 7.
8. If required, alignment pressure is other than 9 psig (60 kPa), set gain at 0 and turn SYNC adjustment to obtain required output.
9. Remove tape from process pointer and connect process link at proper pivot on pointer yoke.

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4.3.4 442R – Proportional plus Reset Controller

Connect to 20 psig (140 kPa) air supply to port S and 0 to 30 psig (0 to 200 kPa) gauge, accurate to ±1 %, to port O. An input is not required for alignment.

1. Disconnect left hand end of process link from process pointer, being sure to note which pivot is used.
2. Adjust set-pointer to 50% of full scale. Tape process pointer to scale plate at 50% of full scale.
3. Lock gain dial in the action to be used; either DIRECT or REVERSE.
4. Set gain dial to stop between 0.4 DIRECT and 0.4 REVERSE (0 gain position). Set the reset at 10 repeats/minute.
5. Lock 9 psig (60 kPa) in reset bellows as follows:
   a) CONTROLLER WITHOUT AUTO/MANUAL OPTION: Turn SYNC adjustment until output remains steady at 9 psig (60 kPa). Keep adjusting screw until steady at 9 psig (60 kPa) is sustained for approximately 15 seconds to ensure equalization of pressures in the reset and follow-up bellows, then turn reset knob counterclockwise to its stop to lock 9 psig (60 kPa) in reset bellows.
   b) CONTROLLER WITH AUTO/MANUAL OPTION: Turn AUTO/MAN selector to MAN. Turn manual regulator knob to obtain 9 psig (60 kPa) output and allow approximately 15 seconds for pressure to stabilize in reset bellows, then turn reset knob counterclockwise to its stop to lock 9 psig (60 kPa) in reset bellows. Turn AUTO/MAN selector to AUTO.
6. Set gain at 5. Turn ZERO adjustment to obtain 9 psig (60 kPa).
7. Set gain at 0. Turn SYNC adjustment to obtain 9 psig (60 kPa).
8. Repeat steps 6 and 7 until output change is within ±0.24 psi (1.6 kPa) when gain dial is rotated between 0 and 5.

   If output change cannot be reduced to ±0.24 psi (1.6 kPa) perform **Nozzle Height Adjustment**, **Section 4.4**, then repeat steps 3 through 8.
9. Remove tape from process pointer and connect process link at proper pivot on pointer yoke.

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4.3.5 443R – Proportional plus PRE-ACT Controller

Connect to 20 psig (140 kPa) air supply to port S and 0 to 30 psig (0 to 200 kPa) gauge, accurate to ±1 %, to port O. An input is not required for alignment.

** NOTE:* When making an adjustment on a controller with PRE-ACT, wait several seconds to allow the controller to stabilize before reading the output.

1. Turn PRE-ACT adjustment clockwise to its stop to fully open the PRE-ACT needle valve, Figure 35.
2. Follow procedure for **441R – Proportional Controller, Section 4.3.3**.

4.3.6 444R – Proportional plus Reset and PRE-ACT Controller

Connect to 20 psig (140 kPa) air supply to port S and 0 to 30 psig (0 to 200 kPa) gauge, accurate to ±1 %, to port O. An input is not required for alignment.

** NOTE:* When making an adjustment on a controller with PRE-ACT, wait several seconds to allow the controller to stabilize before reading the output.

1. Turn PRE-ACT adjustment clockwise to its stop to fully open the PRE-ACT needle valve, Figure 35.
2. Follow procedure for **442R – Proportional plus Reset Controller, Section 4.3.4**.

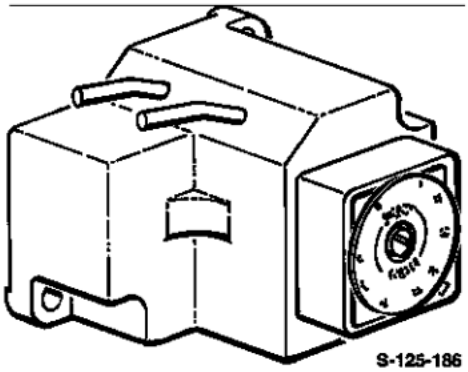


Figure 35. Reset or PRE-ACT Unit

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4.4 NOZZLE HEIGHT ADJUSTMENT

Use this procedure only if the controller cannot be aligned within the tolerance specified in the controller alignment procedure.

** NOTE:* Nozzle height on replacement gain units is preset at the factory. Adjustment is not required after installation.

The air supply and output connections are the same as those used for alignment. The set-pointer and the process pointer should be at 50% of full scale while adjusting the nozzle.

1. Preliminary adjustments:
   a) Mark gain position for 5 DIRECT and 5 REVERSE on gain wheel as shown in Figure 34. Mark 0 gain position approximately mid-way between 0.4 DIRECT and 0.4 REVERSE.
   b) Remove gain dial from gain unit.
   c) Push gain dial lock fully downward.

** NOTE:* If controller has a reset response, be sure 9 psig (60 kPa) is locked in reset bellows. Refer to steps 4 and 5 under **442R – Proportional plus Reset Controller, Section 4.3.4**.

If controller has PRE-ACT response, be sure PRE-ACT adjustment is turned clockwise to its stop.

2. Set gain wheel at 0 gain. Turn SYNC adjustment to obtain 9 psig (60 kPa) output.
3. Set gain at 5 REVERSE. Turn ZERO adjustment to obtain 9 (60 kPa) psig.
4. Set gain at 5 DIRECT. Output should be 9 psig (60 kPa) ±4 (±26.7 kPa).

   If it is, note pressure and proceed to step 6.

   If it is not, a preliminary nozzle adjustment is required. Proceed to step 5.
5. Make preliminary nozzle adjustments as follows:
   a) With gain at 5 DIRECT, turn ZERO adjustment to obtain 9 psig (60 kPa).
   b) Set gain at 5 REVERSE. Loosen nozzle clamp screw just enough to allow nozzle to be moved. Adjust nozzle height until output is between 8.5 and 9.5 psig (56.6 and 63.3 kPa), then trim to 9 psig (60 kPa) with ZERO adjustment.

   Avoid overtightening nozzle clamp screw. This may dent the nozzle tube and make subsequent adjustment difficult.

   c) Repeat steps 2, 3, and 4.
6. Turn ZERO adjustment to bring output halfway between 9 psig (60 kPa) an pressure noted in step 4.
7. Set gain at 5 REVERSE. Pressure should be the same as that obtained in step 6 within ±0.10 psi (0.66 kPa).

   If it is not, make further zero adjustments as follows:

   First at 5 REVERSE, then at 5 DIRECT, keep turning ZERO adjustment to bring output pressure halfway back to previous reading. Repeat until output is the same within ±0.1 psi (0.66 kPa) at both 5 DIRECT and 5 REVERSE.
8. Set gain at 0. Turn SYNC adjustment to obtain 9 psig (60 kPa)

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9. Set gain at 5 REVERSE. Using the method in step 5b, adjust nozzle until output is between 8.5 and 9.5 psig (56.6 and 63.3 kPa), then repeat step 8.
10. Turn gain wheel from 5 REVERSE to 5 DIRECT. Output should remain between 8 and 10 psig (53.3 and 70 kPa).

If it does not, repeat steps 2, 3, and 4.

Proceed to **Section 4.3 CONTROLLER ALIGNMENT.**

4.5 PERIODIC SERVICING

If the air supply is clean and dry, the instrument should be serviced once a year. If the air supply is dirty or oily, more frequent servicing may be required.

4.5.1 Nozzle Baffle

Clean nozzle tip and baffle surface with a pipe cleaner or small brush dipped in a solvent such as alcohol.

4.5.2 Output Relay

The nozzle line orifice is behind the push-to-clean button, Figure 36. With the air supply on, clean the orifice by depressing the button three times. Air supply pressure will return the button to position.

The output bleed orifice is located in the cap. The orifice is 0.015 inch (0.38 mm) in diameter. Clean this orifice with a wire from the Orifice Cleaner Kit, part number 153S20.

The new relay normally requires no servicing other than that listed. Do not take the unit apart, as disassembly will damage critical components. The output relay unit can be replaced if necessary.

** NOTE:* The relay mounting screws are the thread-forming type. When installing a new output relay unit, start the screws by hand to prevent cross-threading.

To install a new relay, insert the four screws and lockwashers through the new relay unit and nozzle chamber gasket. Hand-start the screws; then tighten them uniformly.

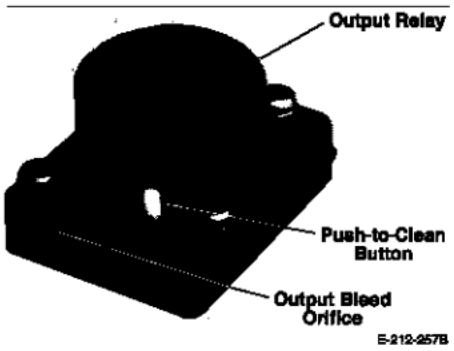


Figure 36. Output Relay

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4.6 RESET AND PRE-ACT RESTRICTORS

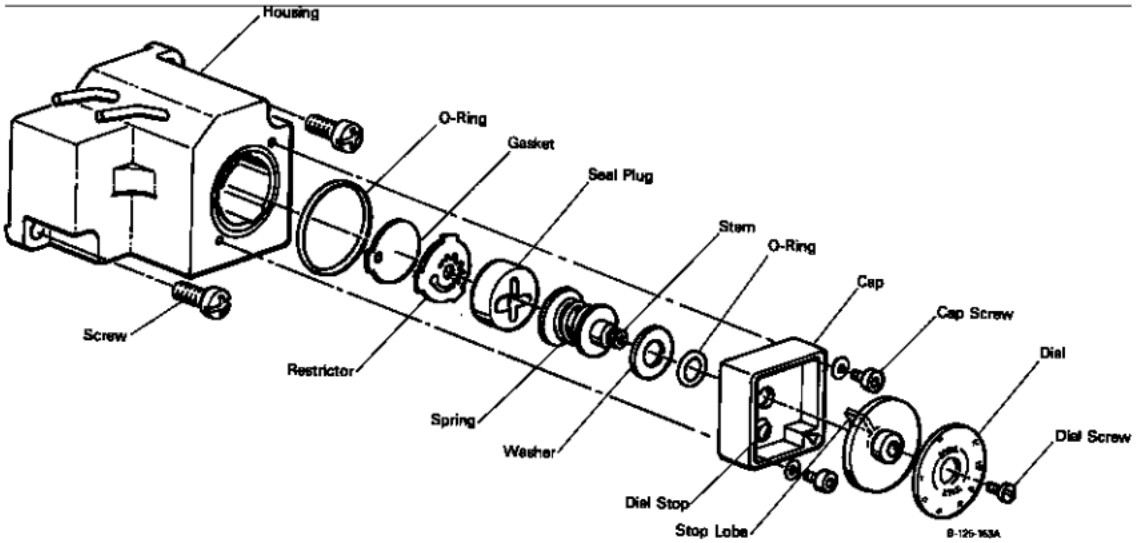


Figure 37. Exploded View of Reset and PRE-ACT Unit

The restrictors can be cleaned without the calibration of their dials. Proceed as follows:

1. Remove dial, Figure 37, then remove cap. Loosen cap screws uniformly until spring load against cap is relieved.
2. Remove parts from cavity. Tip housing upside-down to get the seal plug and restrictor out of the cavity. If restrictor sticks to gasket at bottom of cavity, use a screwdriver to press down firmly on one of the tabs at the edge of restrictor to break it loose. Be very careful not scratch the surface of the restrictor.
3. Wash parts with solvent. Use a toothbrush to clean etched surface of restrictor. Examine seal plug surface which contacts restrictor. If surface is scratched or scored, replace plug.
4. Insert gasket and cleaned restrictor into cavity. Etched side of restrictor must face upward. Use finger tip or clean eraser-end of a pencil to push restrictor into place.
5. Insert seal plug and spring into cavity. Be sure roll pin on spring seats in seal plug slot.
6. Place washer and cap on spring. Be sure O-ring is in place and cap is oriented as shown in Figure 37. Before tightening cap screws, turn spring stem so that smooth section on stem faces away from dial stop; exact location is not important. Tighten cap screws uniformly to compress spring.
7. Fit dial onto stem. Smooth section of dial recess (near stop lobe) must mate with smooth section on stem. When correctly positioned, dial fits freely on stem. If dial jams or feels tight, it is in the wrong position. After positioning dial, insert and tighten dial screw.
8. Check assembly by turning dial clockwise to its stop. A reset dial should read above 200 repeats per minute. A PRE-ACT dial should read below 0.01 minutes.

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4.7 AUTO/MANUAL SWITCH

If the AUTO/MAN switch is difficult to turn or there is evidence it is leaking, the internal O-ring seal may be damaged or may require lubrication. Replace O-ring or lubricate with silicone grease, DC 55, or equivalent if required.

Table 2. Troubleshooting

Problem	Possible Cause	Action
Process indicator does not accurately indicate condition of process variable (including no indication)	a. Process sensing line or capillary plugged or broken.	a. Check sensing lines or capillaries and repair or replace as required.
	b. Process link connected to wrong pivot balls, or not connected at one end.	b. Connect process link to correct pivot ball at each end. Refer to Figures 25.
	c. Indicator out of calibration. Measuring element not damaged.	c. Check reading at 10%, 50%, and 90% of full scale. Calibrate if required. (section **4.1**)
	d. Measuring element damaged.	d. Recalibrate if possible, replace if required.
	e. Process no longer operates on scale.	e. Replace scale and replace or calibrate measuring element.
Output air pressure low, or leaking	a. Output air line leaking or not connected.	a. Locate and repair leaks. Connect if required.
	b. Control element air motor leaking.	b. Locate and replace leaking O-rings and diaphragms.
	c. Low air supply pressure.	c. Check air supply and bring it back to proper pressure. Check for valves closed, filters clogged, regulator not working, compressor failure.
	d. Nozzle line orifice in output relay clogged.	d. With air supply on, depress Push-to-Clean button on relay three times, Figure 36.
	e. Baffle does not cap nozzle.	e. • Realign controller. • Clean baffle. • Replace baffle if bent or sprung.
	g. Leak in nozzle air line.	g. Check nozzle air line, replace tubing and clips if required.

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Table 2. Troubleshooting (Cont'd)

Problem	Possible Cause	Action
Output air pressure low, or leaking (continued)	h. Leak in nozzle pressure chamber in output air relay.	h. Disassemble output relay and replace diaphragm.
	i. Major air leak in other pneumatic tubing, or around reset or PRE-ACT needle valve stems.	i. Repair tubing leak or place needle valve assembly.
	j. Process conditions call for low output air pressure.	j. Check to see if position of control element corresponds to process requirements.
	k. Controller in wrong action.	k. Check action of control element. Reverse action of control element or controller as required.
	l. AUTO/MAN switch in manual position.	l. Switch to AUTO position.
	m. AUTO/MAN switch O-ring leaking excessively.	m. Replace O-ring. Lubricate with silicone grease, DC 55 or equivalent.
Output air pressure too high	a. Process is calling for full controller output.	a. Check to see if position of final control element corresponds to process requirements.
	b. Controller in wrong action.	b. Check action of control element. Reverse action of control element or controller as required.
	c. Nozzle air tube pinched or kinked.	c. Trace air tube and eliminate trouble.
	d. Output air screen plugged. Output shows on output gauge but none reaches the control element.	d. Remove fitting from output connection of instrument. Remove screen and screen retainer. Clean screen and screen retainer, and filling.
	e. Large leak in feedback air line or bellows.	e. Replace air line or bellows.
	f. AUTO/MAN switch in manual position.	f. Switch to AUTO.
	g. AUTO/MAN switch O-ring leaking excessively.	g. Replace O-ring. Lubricate with silicone grease, DC55 or equivalent.

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Table 2. Troubleshooting (Cont'd)

Problem	Possible Cause	Action
Poor control – point wanders	a. Low gain.	a. Refer to **Optimum Controller Settings**.
	b. Low reset.	b. Refer to **Optimum Controller Settings**.
	c. Low PRE-ACT.	c. Refer to **Optimum Controller Settings**.
	d. Output relay bleed orifice plugged.	d. Clean orifice with 0.010" (0.25 mm) diameter wire.
	e. Changes in process load causes process to be offset from set-point.	e. Provide automatic reset response.
	f. Control element not responding to controller output.	f. Check action of control element. Should be operating smoothly without excessive friction.
	g. Control element wide open or completely shut part of the time.	g. Check adequacy of final control element. Is it adequately sized, or does it leak excessively in the closed position? Replace if inadequate. Check adequacy of process equipment.
	h. Lack of sufficient controlling medium – steam, air, cooling water, etc.	h. Provide adequate supply of controlling medium.
	i. Controller continuously recovering from upsets.	i. Eliminate or reduce magnitude of upsets. Change process or control system for better controllability. Replace if found inadequate.

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Table 2. Troubleshooting (Cont'd)

Problem	Possible Cause	Action
Poor control – pointer cycles about set-point	a. High gain.	a. Refer to **Optimum Controller Settings**.
	b. High reset.	b. Refer to **Optimum Controller Settings**.
	c. Too much PRE-ACT.	c. Refer to **Optimum Controller Settings**.
	d. Control element sticking and jumping.	d. Correct action of control element.
	e. Friction in measuring system.	e. Correct action of measuring system.
	f. Control element closing or opening during some part off the control cycle.	f. Resize control element or change condition of controlling medium to avoid operating at extreme ends of control element action.
	g. Disturbances from other processes affecting controlling medium.	g. Provide controls to eliminate or minimize disturbances.

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5
ELECTRIC ALARMS

5.1 ELECTRIC ALARMS

The electric alarms for the 440R Series Indicating Controllers consist of a high and / or low primary actuated alarm Figure 38. All alarm switches are wired for both NC and NO operation.

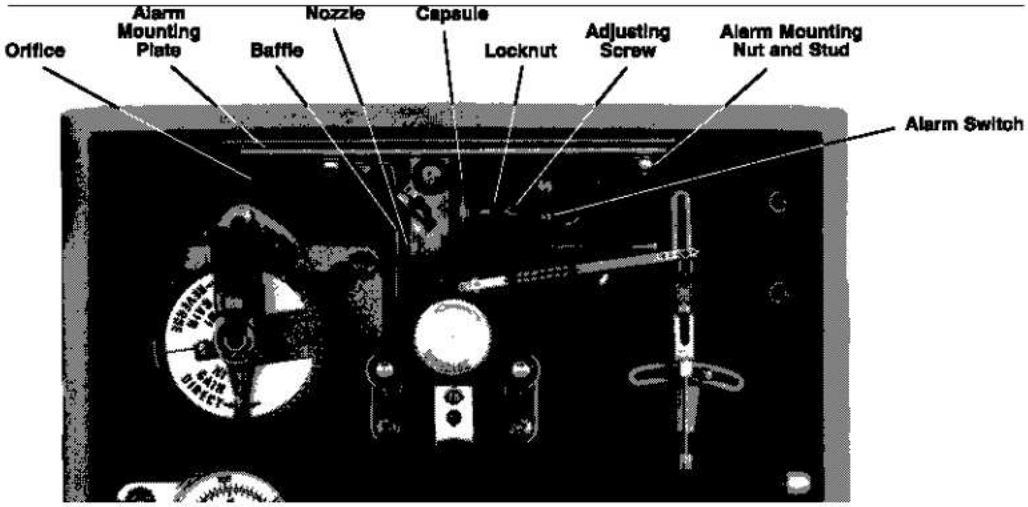


Figure 38. Primary Actuated Electric Alarms

5.1.1 Electric Alarm Installation

Before making any electrical connections, check the alarm rating stamp on the data plate. Also refer to the alarm specification in **Section 1.2, Technical Characteristics**.

The electrical connections are made to the terminals in the external connection box on the bottom of the controller, Figure 39, as indicated in the connection diagram, Figure 40.

Conduit may be connected to any of the 1/2" NPT holes in the terminal box.

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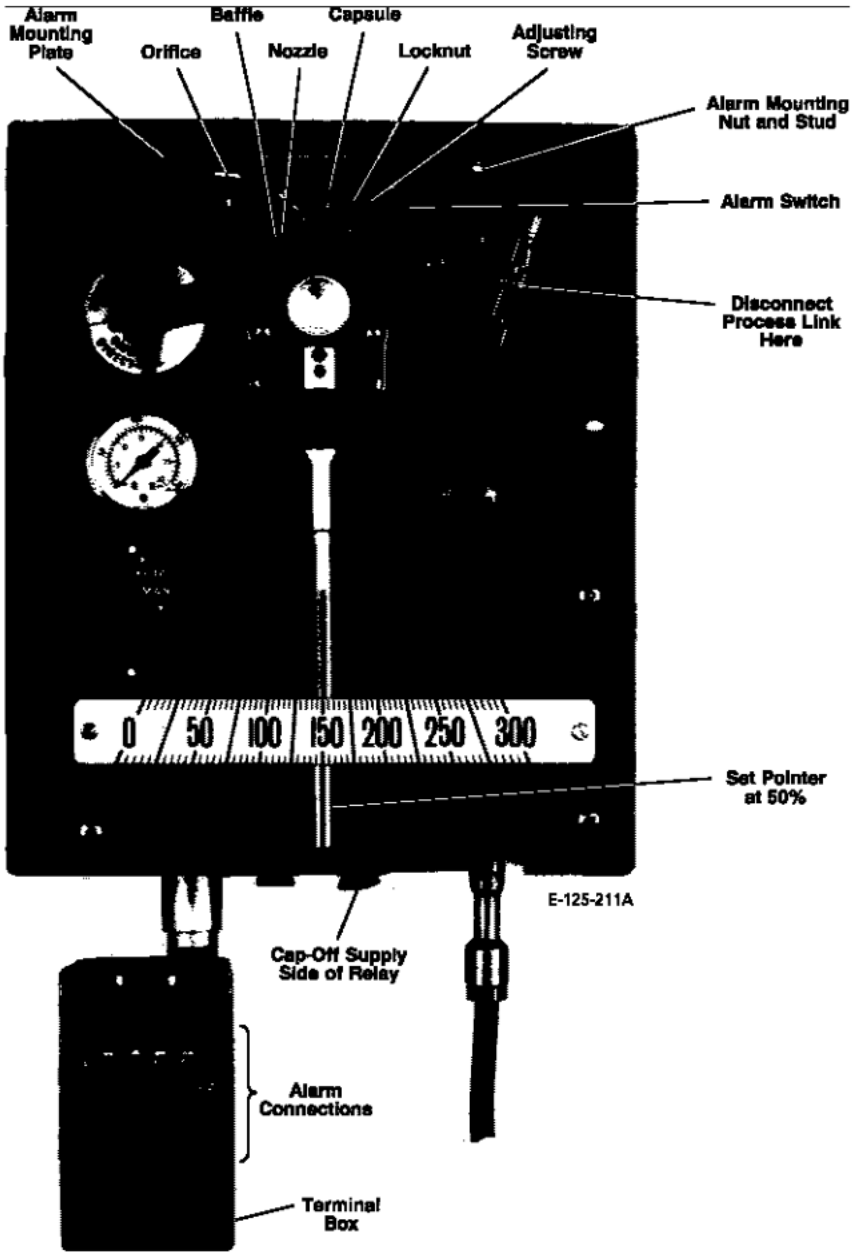


Figure 39. Primary Actuated Electric Alarms Connections

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5.1.2 Electric Alarm Operation (Primary Actuated Alarm)

The primary alarm operates when the process variable moves above or below a preset value. Each alarm contains a nozzle baffle unit with an alarm switch, Figure 40. When the process pointer is above the preset value for low alarm or below the reset value for a high alarm, the alarm nozzle is capped by the baffle. The resulting back pressure inflates the capsule which keeps the alarm switch in the NO (normally open) position. When the process variable changes and the process pointer moves to the preset value, the yoke of the process pointer will uncap the baffle. The capsule will deflate as the nozzle back pressure drops and the alarm switch will transfer to the NC (normally closed) position. The alarm switch will remain in the NC position until the process pointer moves to a point which allows the baffle to cap the nozzle. At this point, the back pressure again inflates the capsule which actuates the alarm switch to the NO position.

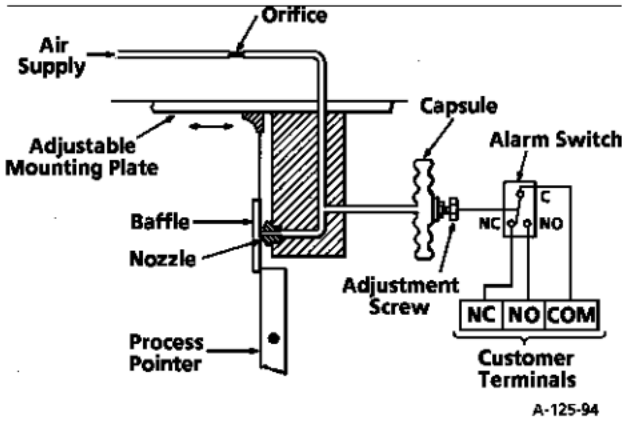


Figure 40. Schematic of operation, Primary Actuated Alarm

5.1.3 Adjusting Alarm Switch

** NOTE:* Alarm switch adjustment is required only after disassembly of the unit or for major maintenance.

1. Loosen two screws retaining alarm assembly to top of controller case.
2. Move alarm assembly to tright or left so alarm baffle will not contact pointer yoke.
3. Disconnect air supply tube at nozzle block and connect test gauge as shown in Figure 41.

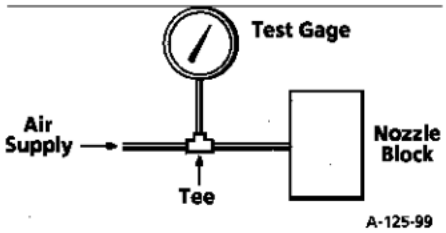


Figure 41. Test Gauge Hookup.

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4. Adjust air supply to nozzle block until test gauge indicates between 9 and 10psig.
5. Loosen locknut on capsule adjustment screw.
6. Cap nozzle and turn adjustment screw on capsule until alarm switch actuates. Vary air supply pressure to check point at which alarm switch actuates. This should be between 9 and 10 psig. Tighten locknut on capsule adjustment screw.
7. Adjust alarm point as indicated below.

5.1.4 Calibrating Alarm

** NOTE:* After disassembly or major maintenance, first adjust the alarm switch as described above.

1. Adjust air supply pressure to 20 psig.
2. Adjust process input until process pointer is at the required alarm point scale.
3. Loosen the two screws retaining the alarm assembly to the top of the controller case. Use a 1/4" wrench. Adjust the position of the alarm assembly until the baffle on the alarm assembly uncaps the nozzle and the alarm switch actuates. Tighten the two retaining screws.
4. Adjust the process input above and below the required alarm point to check the accuracy of the alarm setting.
5. Repeat steps 2 through 4 for required accuracy.

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5.2 ELECTRIC ALARMS PARTS LIST

The 440 Series primary actuated electric alarms, Figure 42, parts are identified in Figure 43 and listed in Table 3. The alarm switch sub-assembly parts, Figure 44, are listed in Table 4. The Output Relay Sub-Assembly parts, Figure 45 are listed in Table 5. Air tube configurations are shown in Figure 46 and listed in Table 6.

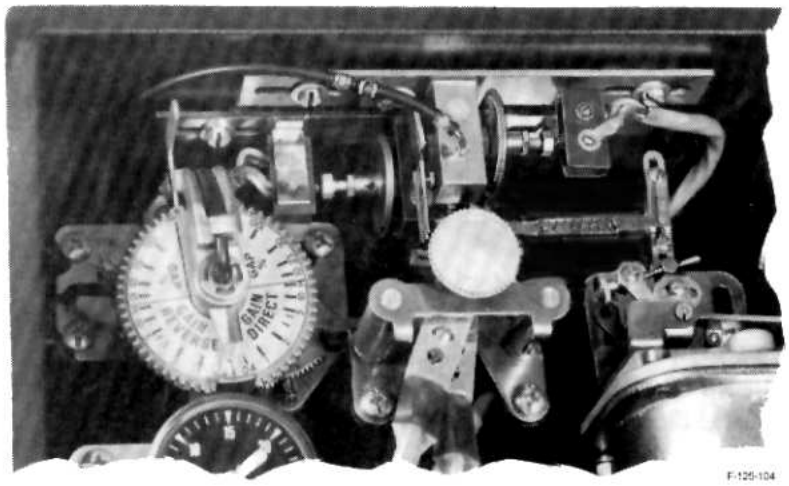


Figure 42. Primary Actuated Alarms, Location

Table 3. Primary Actuated Alarms Parts List

Item	Part No.	Description	No. Req'd
1	 2P995 2P998 2P1001	Case for Spiral Bourdon Spring, Helical Bourdon Spring, Receiver Bellows Element, Gauge Low-Pressure Bellows Element, Absolute Low-Pressure Bellows Element, Gauge Low-Pressure Capsule Element for Differential Pressure Meter Body Model 199 for Differential Pressure Meter Body Model 244	1
2	10P726	Alarm Switch Mounting Spacers (2 for High or Low, 4 for High/Low)	2 or 4
3	10P759	Terminal Block Mounting Spacers	2
4	29P269	Alarm Switch Insulators (2 for High or Low, 4 for High/Low)	2 or 4
5	29P588	Terminal Block Insulators (1 for High or Low, 2 for High/Low)	1 or 2
6	43P434	Cover Screw Retaining Rings	2
7	43P918	Cover Gasket	1
8	45P693A	Color Code Label, Red	1
9	45P693B	Color Code Label, Green	1
10	48P335	Terminal Box Mounting Bushing	1
11	59P475	Terminal Block Mounting Pillars	2
12	61S762	Output Relay SA - See Table 5	1
12	61S770	Output Relay SA, with Auto-Manual Unit - See Table 5	1
13	74S651	Alarm Switch SA (1 for High or Low, 2 for High/Low) - See Table 4	1 or 2
14	109S535	Switch and Cable (High and High/Low)	1
15	109S536	Switch and Cable (Low and High/Low)	1
16	113P14	Terminal Block Jumper(s) (1 for High or Low, 2 for High/Low)	1 or 2
17	113P340	Terminal Box Cover	1
18	507M11	Cover Mounting Screws, #8-32 x ½" Oval Hd	2
19	113S633	Terminal Box (High, or Low)	1
19	113S634	Terminal Box (High/Low)	1
20	113S635	Terminal Box SA, 4 Place	1

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Table 3. Primary Actuated Alarms Parts List (Cont'd)

Item	Part No.	Description	No. Req'd
21	-	Screws, #8-32 x 3/16" Binding Hd	8
22	504M63	Alarm Switch Mtg Screws, #8-32 x 5/16" Hex Hd	
23	543M7	Terminal Block Mtg Nuts, #6S	
24	546M7	Terminal Block Mtg Washers, #65	
25	546M22	Alarm Switch Insulator Mtg Washers, #2	
26	546M35	Alarm Switch Mtg Washers, #8	
27	548M68	Terminal Block Mtg Lockwashers, #6	
28	561M4	Terminal Block Mtg Screws, #6-32 x 5/8" Pan Hd	
29	561M13	Terminal Block Mtg Screws, #6-32 x 7/8" Pan Hd	
30	562M6	Terminal Block Pillar Mtg Screws, – #6-32 x 5/16" Pan Hd	
31	562M13	Alarm Switch Mtg Screws, #2-56 x 3/8" Pan Hd	
32	562M19	Case Plug Screws, #8-32 x 1/8" Pan Hd	
33	1373M21	Terminal Box Mounting Nipple	1
34	1414M55	Terminal Box Mounting Coupling	1

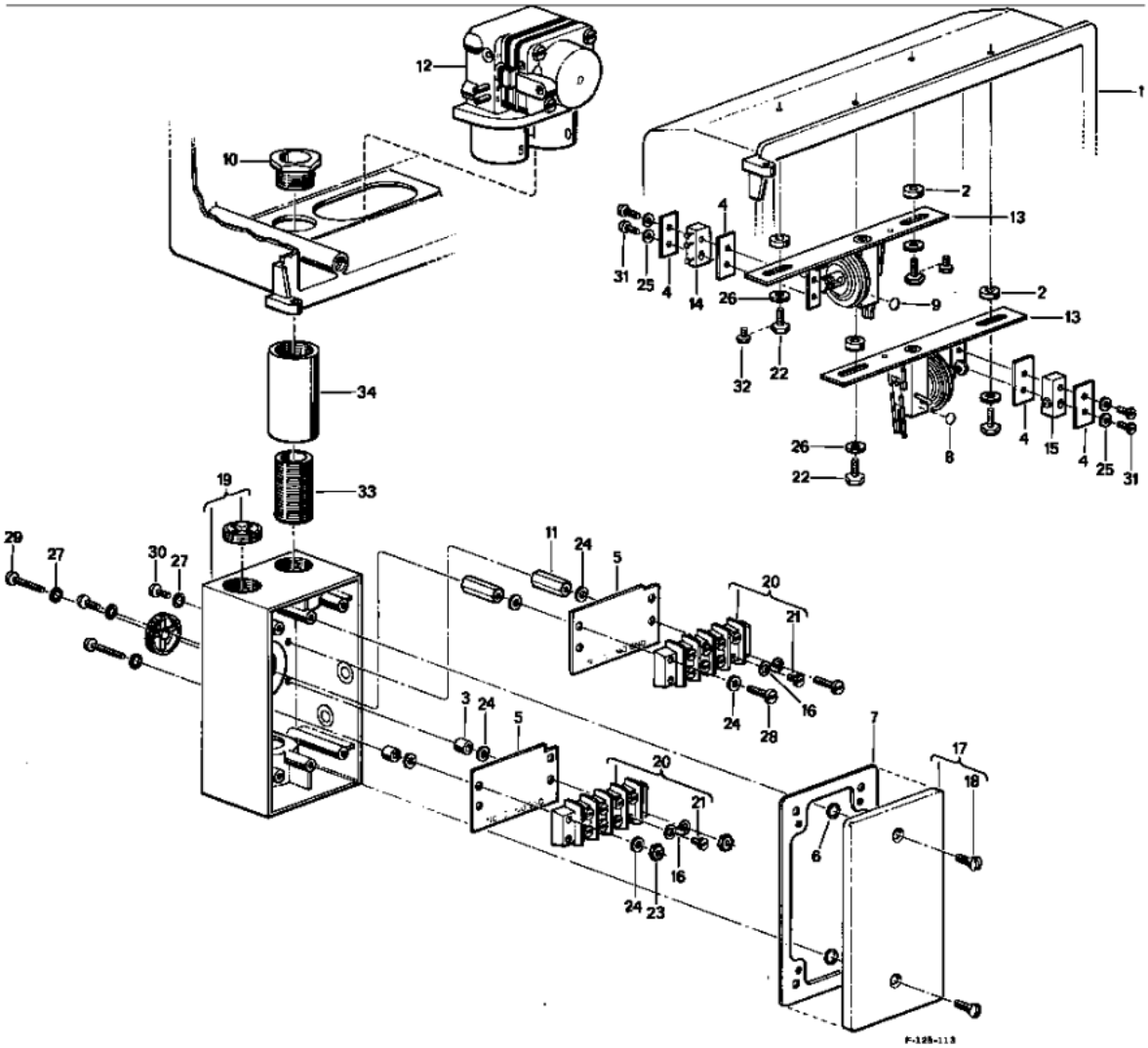


Figure 43. Primary Actuated Alarms Parts View

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Table 4. Alarm Switch Sub-Assembly Parts List

Item	Part No.	Description	No. Req'd
1	6S1012	Switch Mounting Bracket	1
1	6S1012	Switch Mtg Bracket	1
2	9P1108	Adjustment Screw	1
3	32P448	Adjustment Screw Locknut	1
4	3 75498	Baffle	1
5	43P380	Capsule Mtg O- Ring	1
6	43P412	Nozzle Mtg 0-Ring	1
7	61561	Capsule	1
8	88P37	Nozzle	1
9	546M4	Baffle Mtg Washer, #4	1
10	548M89	Baffle Mtg Lockwasher, #4	1
11	504M58	Baffle Mtg Screw, #4-40 x 1 /4" Hex Slotted Hd	1

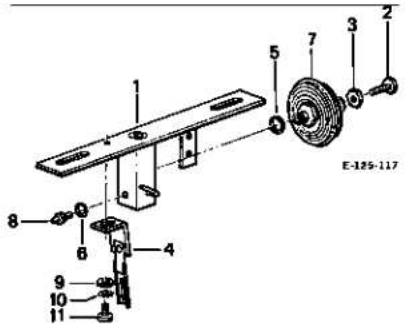


Figure 44. Alarm Switch Sub-Assembly Parts View

Table 5. Output Relay Sub-Assembly Parts List for 61S1066, 61S1067

Item	Part No.	Description	No. Req'd
1	4S368	Manifold for 61S1067	1
1	4S374	Manifold with Auto-Manual Unit for 61S1066	1
2	155S349	Relay Cap SA	1
3	89S34	Filter Screens	

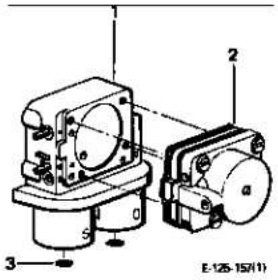


Figure 45. Output Relay Sub-Assembly Parts View

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Table 6. Primary Actuated Alarms Air Tubes Parts List

Item	Part No.	Description	No. Req'd
–	47P1169	Air Tubing	
1	–	(specify 1-1/4" length) – High and High/Low Alarm	1
2	–	(specify 2-1/4" length) – High/Low Alarm	1
3	–	(specify 5" length) – Low and High/Low Alarm	1
4	–	(specify 7-1/2" length) – High/Low Alarm	1
5	–	(specify 9-3/4" length) – High/Low Alarm	1
6	–	(specify 10-3/4" length) – High/Low Alarm with Auto-Manual	1
7	–	(specify 13" length) – Low Alarm	1
8	–	(specify 14" length) – Low Alarm with Auto-Manual	1
9	–	(specify 16-1/2" length) – High Alarm	1
10	–	(specify 17-1/2" length) – High Alarm with Auto-Manual	1
11	48P217Y	Air Tube Tee	1
12	51P341	Air Tube Clamps	2 per tube
13	88P208	Air Tube Orifice – High or Low Alarm	1
13	88P208	Air Tube Orifice – High/Low Alarm	2

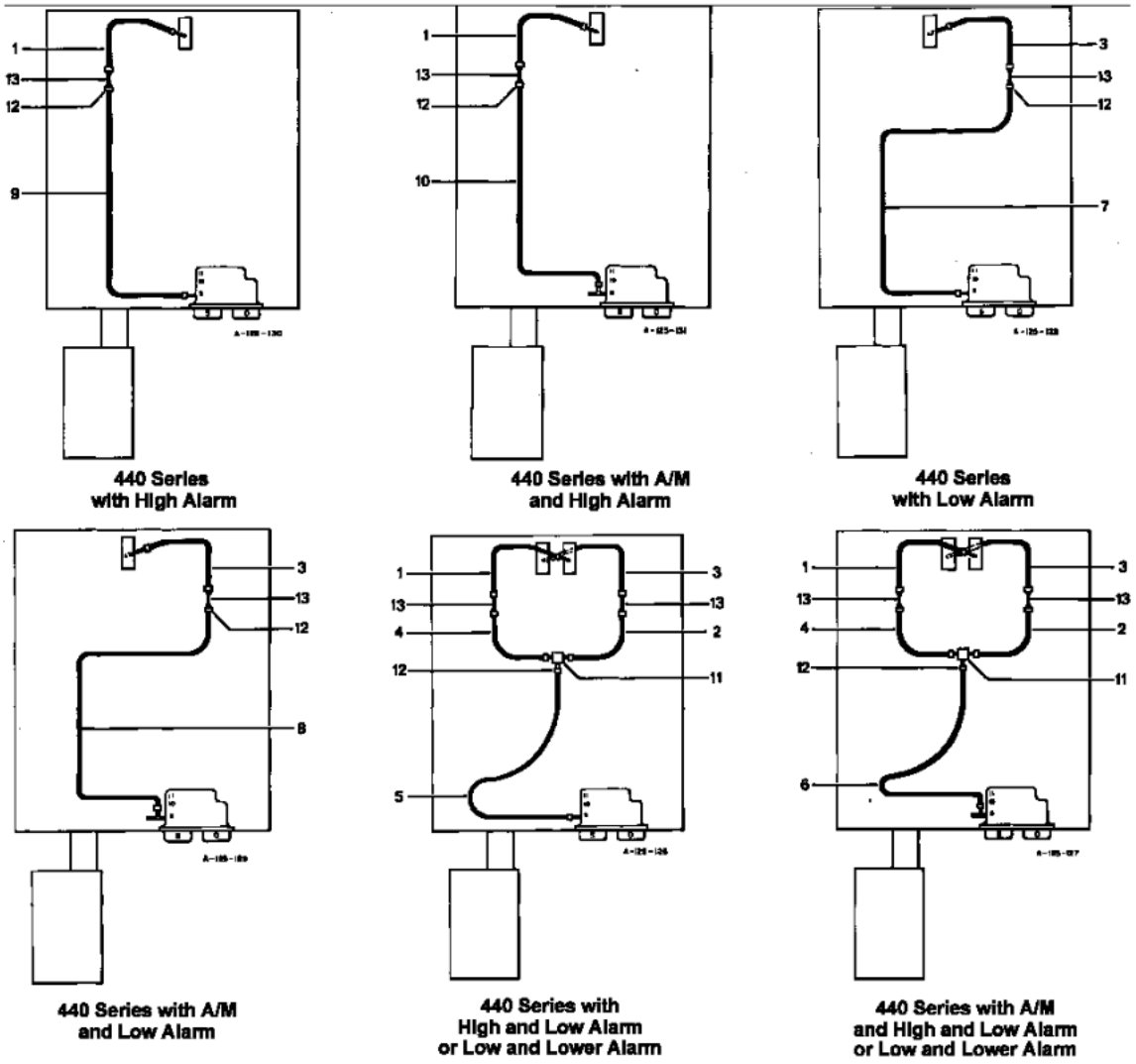


Figure 46. Primary Actuated Alarms Air Tubes Parts View

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6
PARTS LIST

6.1 ORDERING INFORMATION

When ordering parts always specify the complete serial number of the instrument.

6.2 RECOMMENDED SPARE PARTS

A plus (+) sign before the item number indicates that the item is a recommended spare part.

6.3 PARTS AVAILABILITY

The parts list may contain parts that are not salable. These parts are identified with an asterisk (*) in the part number column. They are listed and shown as required o provide a comprehensive breakdown of assembly.

6.4 PARTS AND COMPONENTS IDENTIFICATION

An assembly or subassembly (SA) in the parts description may be followed by part descriptions which have bullets preceding them. These bullets indicate the parts are components of that assembly or SA.

6.5 UNIDENTIFIED ITEMS AND PARTS

A dash (–) in the item number column indicates that the part is not illustrated in the referenced figure. A dash (–) in the part number column indicates there is no part identification available (not for sale; go to the next level). A bullet (•) in the part number column indicates the part is locally available.

6.6 UNDERSCORE IDENTIFICATION

Underscores in place of characters in a catalog number (e.g. 440R _ _ _ _ _ _ _ _ _ _ C) indicate any character may apply. Refer to **Section 1.3 Product Identification**.

6.7 PARTS LISTS

Figure 47 shows component arrangements for the different combinations of 440 series controllers. Parts listings for the final assembly and subassemblies follow.

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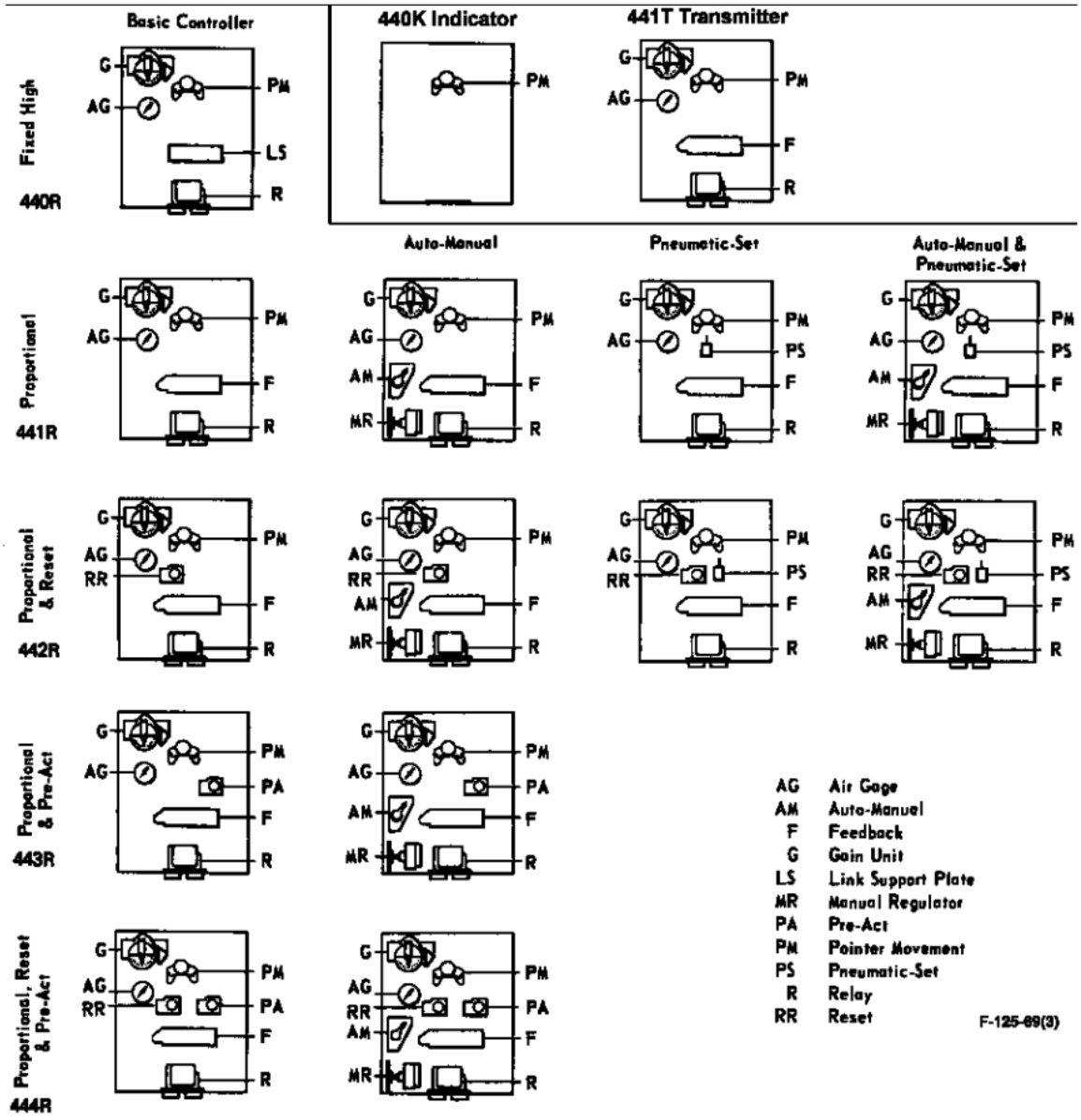


Figure 47. Component Arrangement

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6.7.1 Final Assembly

Refer to Figure 48 for the final assembly parts listed in Table 7.

Table 7. Final Assembly Parts List

Item	Part No.	Description	No. Req'd
1	3S1273†	Polyester Door SA	1
1	3S1274†	Polyester Door SA	1
1	3S1275†	Polyester Door SA	1
1	3S1276†	Polyester Door SA	1
2	155S951	• Latch Plate Kit	1
3	7S20K - -	• Hinge Pin Kit •• Hinge Pin •• Hinge Pin Retaining Ring	1 1 1
7	155S948	• Scale Window Kit, Glass (Std)	1
7	155S950	• Scale Window Kit, Plexiglas (Opt)	1
	-	•• Speed Nut	10
13	-	•• Push Nut	10
8	-	•• Scale Window, Glass (Std)	1
8	-	•• Scale Window, Plexiglas (Opt)	1
9	-	•• Scale Window Gasket	1
+10	155S948	• Gauge Window Kit, Glass (Std)	1
+10	155S950	• Gauge Window Kit, Plexiglas (Opt)	1
11	34P134	•• Gauge Window, Glass (Std) •• Gauge Window, Plexiglas (Opt)	1 1
12	-	•• Gauge Window Gasket	1
13	-	•• Gauge Window Speed Nut	4
13	-	•• Gauge Window Push Nut	4
+14	43P876	• Door Gasket (42" Length)	1
15	53S34K	• Door Lock SA	1
16	*	•• Lock Stirke Plate	1
17	*	•• Lock Cam	1
18	*	•• Lock	1
19	*	••• Lock Retaining Nut, 3/4" -24	1
20	*	•• Cam Mtg Screw, #10-24 x 1/4" Binding Hd	1
21	*	•• Washer, 7/16"	1
22	*	•• Lockwasher, 3/4" Shakeproof	1
23	*	•• Strike Plate Mtg Screw, #10-32 x 1/2" Pan Hd	2
24	57P439	• Latch	1
25	70S83K	• External Set-Point Adj Knob (Orange)	1
26	-	•• Mounting Nut	1
27	*	•• Collar	1
28	*	• Latch Plate Mtg Screw, #8-32 x 5/16" Flat Hd	2
29	6P2619	Scale Plate	1

* Refer to Parts Availability

† Add suffix letter to identify window material: A-Glass, B-Safety Glass, C-Acrilic

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Table 7. Final Assembly Parts List (Cont'd)

Item	Part No.	Description	No. Req'd
30	–	Unit Label	1
	45P402	LB LOAD X 1000	
	45P403	CELCIUS	
	45P404	LB/SQ IN	
	45P405	KG/SQ CM	
	45P406	FAHRENHEIT	
	45P407	IN. OF WATER	
	45P408	LB/SQ IN. – ABS	
	45P409	LEVEL	
	45P410	ATMOSPHERES	
	45P411	REAUMUR	
	45P412	FLOW	
	45P413	IN. HG VAC	
	45P414	IN. WATER VAC	
	45P415	IN. HG ABS	
	45P417	IN. HG PRESS	
	45P419	MM HG ABS	
	45P420	DIFF PRESS	
	45P421	INDICATOR	
	45P537	VAC – PRESS	
	45P538	LBS LOAD	
	45P550	FT OF WATER	
	45P581	IN. HG VAC – PSI	
	45P663	BARRELS	
	45P664	X 1000 LBS	
	45P672	X 100	
	45P685	BARRELS OF H_2O	
	45P834	CAPACITY	
	45P871	PERCENT POSITION	
	45P1176	FLOW RATE BRIT. IMP. GPM	
	45P2222	KILOPASCAL	
	45P2223	KILOGRAM	
32	†	Scale	1
36	*	Scale Mtg Screw, #6-32 x 3/16" Pan Hd	2
37	*	Scale Plate Mtg Tap Screw, #10-32 x 1/2" Pan Hd	3

† Specify instrument serial number and scale range required.
* Refer to Parts Availability.

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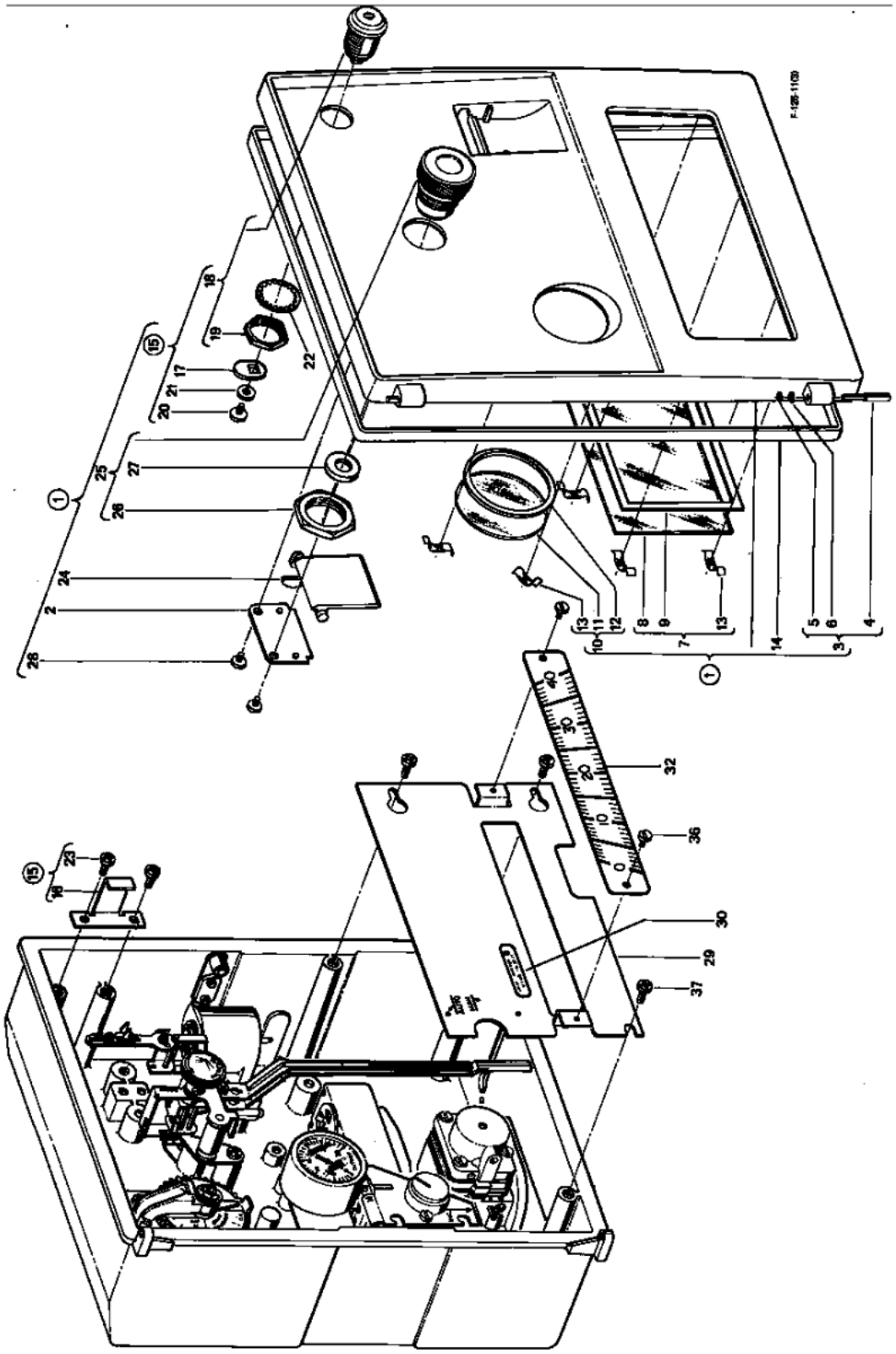


Figure 48. Final Assembly

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6.7.2 Semi-Final Assembly

Refer to Figure 49 for the semi-final assembly parts listed in Table 8.

Table 8. Semi-Final Assembly Parts List

Item	Part No.	Description	No. Req'd
1	2S1729 2S1731 2S1732	Polyester Case SA for 440R -444R for Spiral Bourdon Spring, Helical Bourdon Spring, Receiver Bellows Element, Gauge Low-Pressure Bellows Element, Absolute Low-Pressure Bellows Element, Gauge Low-Pressure Capsule Element for Differential Pressure Meter Body Model 199 for Differential Pressure Meter Body Model 244	1
2	*	• Sub Base Plate	
3	*	• Polyester Case	
4	*	• Plate Mtg Pad	
5	*	• Plate Mtg Lockwasher. #10 external tooth	
6	*	• Plate Mtg Screw, #10-32 x 1/2" Pan Hd	
7A	6S943	Link Support Plate SA – 440R	1
+7B	58S560	Feedback Subassembly – 441R, 443R	1
+7B	58S561	Feedback Subassembly – 442R, 444R	1
8	6P4170	Mounting Plate	1
9	10S214	Latch Strike SA	1
10	-	• Adjustment Plate	
11	-	• Roller	
12	-	• C-Washer	
13	13S236	Feedback Link	1
14	-	• Pivot Operator	
15	13S309	Control Link	1
16	-	• Link	
17	-	• Pivot Operator	
18	22P194	Pointer Adj Washer	2
19	22P425	Pointer Adj Spring Washer	2
20	32P790	Latch Strike Nut Plate	1
+21	41S657	Manual Regulator SA	1
+22	41S1006	Auto-Manual Selector SA	1
+23	41S798	Reset Response SA – 442R, 444R	1
+24A	41S799	Pre-Act Response SA – 443R, 444R	1
+24B	61S1143	Pneumatic -Set SA – 440R-442R	1
+25	*	Output Gauge SA, 0 to 30 psig and 0 to 2 kg/cm^2	1
26	-	• Mounting Bracket	
27	-	• Mounting Nut	
28	-	• Valve Action tab	
29	-	• Screw, #4-40 x 3/16" Binding Hd	
30	52P1089 52P1660 52P1661	Gain Dial, Fixed High – 440R Gain Dial, Proportional only or Differential Gap – 441R Gain Dial, Proportional only – 442R-444R	1 1 1

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Table 8. Semi-Final Assembly Parts List (Cont'd)

31	51P318-1	Cable Binding Clamp	1
+32	58S562	Gain Arm SA, Feedback SA	1
+33	61S1064 61S1065	Output Relay SA Output Relay SA with Auto Manual	1
34	63P331	Set-Pointer, orange	1
35	63P332	Process Pointer, orange	1
+36 +36 +36	93S414 93S415 93S540	Pointer Movement – 440R-444R Pointer Movement – 440R-442R Pointer Movement – 440K	1 1 1
37	501M15	Latch Strike Mtg Screw, #8-32 x 3/8" Flat Hd	2
38	570M3	Pneumatic-Set SA Mtg Tap Screw, #8-32 x 1/2" Pan Hd – 440R-442R	2
39	546M14	Cable Clamp Mtg Washer, #10	1
40	562M1	Pointer Adj Screw, #2-56 x 1/8" Pan Hd	2
41	562M2	Gain Unit Dial Mtg Screw, #4-40 x 3/16" Pan Hd	1
42	570M1	Component Mtg Tap Screw #10-32 x 1/2" Cross Recess Slot Pan Hd	14 to 23
43	570M3	Plate Mtg Screw, #8 x 1/2" Swage Form	2

* Refer to Parts Availability.

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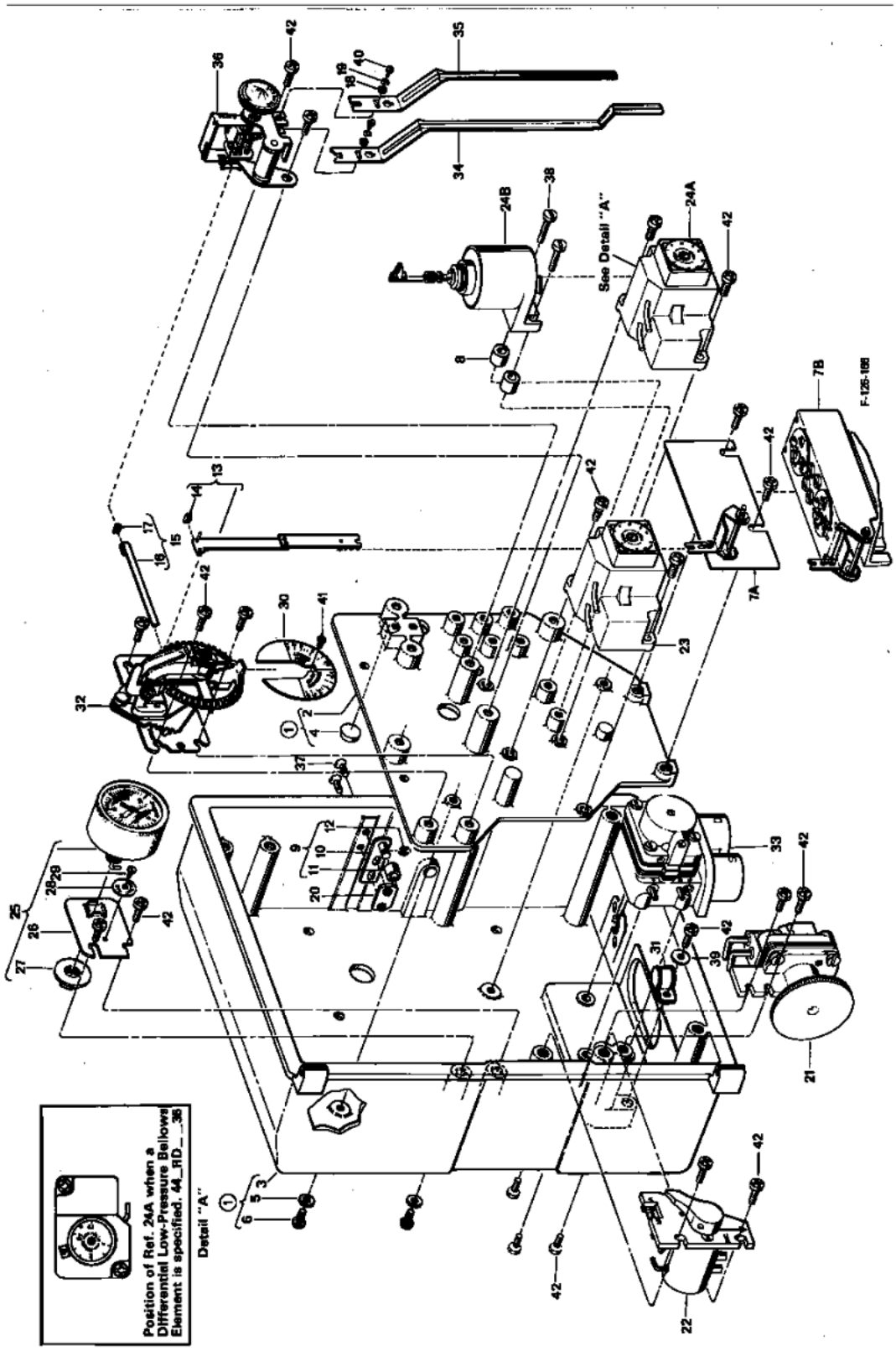


Figure 49. Semi-Final Subassembly

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6.7.3 Gain Unit Subassembly, 58S562 (no dial)

Refer to Figure 50 for the Gain Unit Subassembly parts listed in Table 9.

Table 9. Gain Unit Subassembly Parts List

Item	Part No.	Description	No. Req'd
1	*	Base Plate (marked SYNC)	
2	*	Synchronizing Sector (marked ZERO)	
3	*	Zero Adj Sector (no mark)	
4	*	Stop Stud	
5	*	Pivot Stud	
6	*	Gain Arm	
7	–	Gain Wheel Washer	
8	–	Stud and Pinion Spring Washer	
9	–	Gain Wheel E-Ring	
10	–	Action Lever Spring Washer	
11	–	Self Locking Push Nut	
12	–	Dial Mtg Speed Nut	
13	–	Action Rversing Lever	
	155S952	Nozzle Baffle Kit (items 14, 15 and 16)	1
+14	37S488	• Baffle	1
15	59P1056	• Nozzle Clamp	1
+16	88P557	• Nozzle	1
17	–	Gain Adjustement Wheel	1
18	•	Gain Dial Mtg Screw, #4-40 x 3/16" Pan Hd	1
19	•	Nozzle Clamp Mtg Screw, #4-40 x 3/16" Pan Had	1
20	•	Bafle Mtg Screw, #4-40 x 3/16" Pan Had	1
21	•	Zero Sector Mtg Tap Screw, #8-32 x 5/16" Flat Head	2
–	52P1089	Gain Dial, Fixed High – 440R	1
–	52P1660	Gain Dial, Proportional only or Differential Gap – 441R	1
–	52P1661	Gain Dial, Proportional only – 442R-444R	1

** Refer to Parts Availability.*

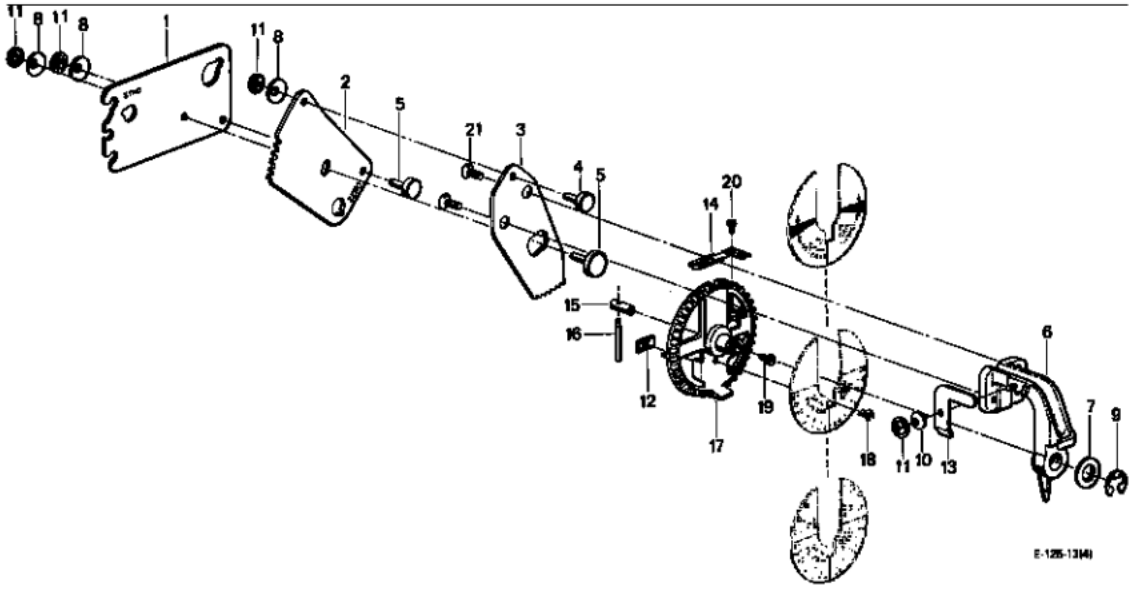


Figure 50. Gain Unit Subassembly

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6.7.4 Manual Regulator Subassembly, 41S657 – 441R-444R

Refer to Figure 51 for the Manual Regulator Subassembly parts listed in Table 10.

Table 10. Manual Regulator Subassembly Parts List

Item	Part No.	Description	No. Req'd
1	9S119	Manual Control Adj Wheel	1
2	11P1219	Adjustment Screw Compression Spring	1
3	–	Adjustment Screw Housing	1
4	–	Manifold	1
+5	61S625	Relay Diaphragm	1
6	78P515	Compression Spring Seat	1
7	-	Port Label, S	1
8	•	Adjustment Housing Mtg Lockwasher, #6	4
9	•	Adjustment Housing Mtg Tap Screw, #6-32 x 3/4" Cross Recess Slot Pan Hd	4

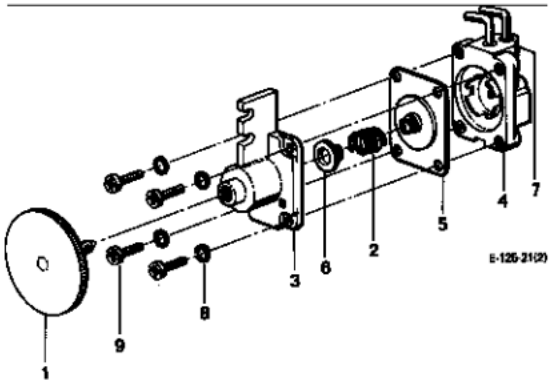


Figure 51. Manual Regulator Subassembly

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6.7.5 Auto-Manual Selector Subassembly, 41S1006

Refer to Figure 52 for the Auto-Manual Selector Subassembly parts listed in Table 11.

Table 11. Auto-Manual Selector Subassembly Parts List

Item	Part No.	Description	No. Req'd
1	*	Switch Body	
2	-	Auto/Manual Balance Detector Bracket	
3	-	Switch Plug	
+4	43P880	Plug O-Ring	1
+5	43P1540	Plug O-Ring	1
6	-	Balance Detector	
7	70S352	Auto/Manual Knob	1
8	-	Knob Set Screw #8-32 x 3/16" Socket Hd Cup Pt	1
9	-	Body Mtg Screw, #6-32 x 3/16" Pan Hd	2
–	155S751	Ball Gauge and Bracket Replacement Kit (items 6 and 2)	1

** Refer to Part Availability.*

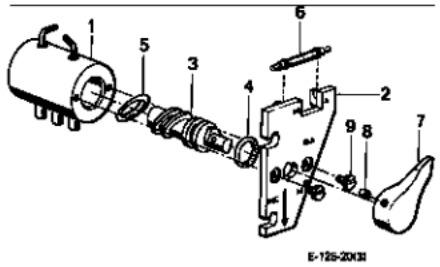


Figure 52. Auto-Manual Selector Subassembly

6.7.6 Output Relay Subassembly, 61S1064, 61S1065 Output Relay SA

Refer to Figure 53 for the Output Relay Subassembly parts listed in Table 12.

Table 12. Output Relay Subassembly Parts List

Item	Part No.	Description	No. Req'd
1	4S277 4S278	Manifold – 440R-444R Manifold – 440R-444R with Auto Manual	1 1
+2	155S349	Relay Cap Kit	1
3	89S34	Filter Screen	2

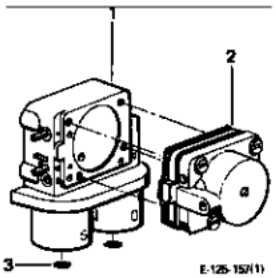


Figure 53. Output Relay Subassembly

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6.7.7 Mounting Bracket Kits

Refer to Figure 54 and Table 13 for the Standard Mounting Bracket Kit, 14S511K. Refer to Figure 55 and Table 14 for the Pipe Mounting Bracket Kit, 14S510K.

Table 13. Standard Mounting Bracket Kit 14S511K Parts List

Item	Part No.	Description	No. Req'd
1	–	Mounitng Bracket	2
2	–	Bracket Mtg Cap Screw, 1/4"-20 x 1/2" Hex Hd	2
3	–	Bracket Mtg Washer, 1/4"	2

Table 14. Pipe Mounting Bracket Kit 14S510K Parts List

Item	Part No.	Description	No. Req'd
1	–	U-Bolt	1
2	–	Mounitng Bracket	1
3	–	Clamp Bracket	1
4	–	Bracket Mtg Cap Screw, 1/4"-20 x 1/2" Hex Hd	2
5	–	U-Bolt Nut, 3/8"-16 Hex	2
6	–	Bracket Mtg Washer, 1/4"	2
7	–	U-Bolt Washer, 3/8"	2

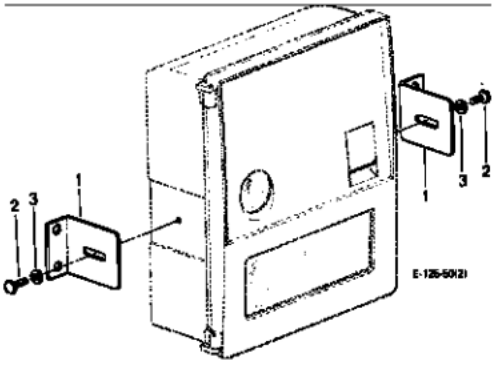


Figure 54. Standard Mounting Bracket Kit, 14S511K

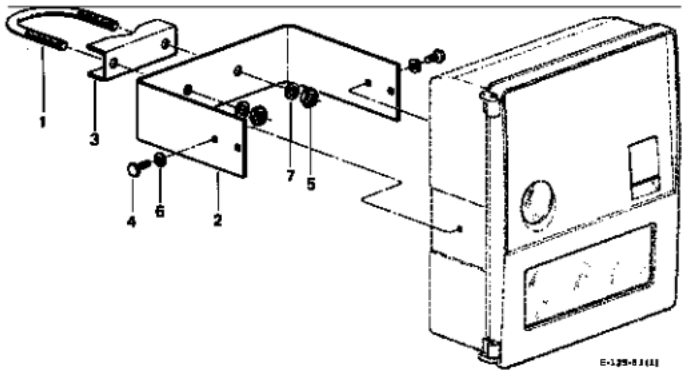


Figure 55. Pipe Mounting Bracket Kit, 14S510K

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6.7.8 Air Tubing And Clamps

Refer to Figures 56 (440R, 441R) and Figure 57 (442R, 443R, 444R) for the Air Tubing And Clamps parts listed in Table 15.

Table 15. Air Tubing And Clamps Parts List

Item	Part No.	Description	No. Req'd
	155S953	**Pneumatic Set Kit**	
1	*4S222*	Air Connection, Pneumatic-Set	1
2	*32P589*	Air Connection Mtg Nut	1
+8	*47P1141*	Air Tubing, Medium Diam (specify 12" length)	1
28	*89S34*	Air Strainer – 440R	1
	155S954	**Air Tubing Kit**	
3	*35S520*	Tubing Plug, Small	1
4	*7P348*	Rivet	1
5	*47P829*	Tubing (specify 11/16" length)	1
6	*51P341*	Tubing Clamp, Small	1
+7	*47P993*	Air Tubing (specify 22" length)	1
–	*47P1142*	Air Tubing, Large Diam	
+9	–	(specify 4" length)	3
+10	–	(specify 4-1/2" length)	1
+11	–	(specify 10-1/2" length)	1
–	*47P1169*	Air Tubing, Small Diam	
+13	–	(specify 1-3/4" length)	1
+14	–	(specify 2-1/2" length)	1
+15	–	(specify 2-3/4" length)	1
+16	–	(specify 2-7/8" length)	1
+17	–	(specify 3" length)	1
+18	–	(specify 5-1/4" length)	1
+19	–	(specify 6-1/2" length)	1
+20	–	(specify 8-1/2" length)	2
21	–	(specify 12" length)	1
22	–	(specify 15-1/2" length)	1
23		Tube Assembly	
+24	*48P217Y*	Tubing Tee	2
25	*51P341*	Air Tubing Clamp, Small	2 per tube
26	*51P347*	Air Tubing Clamp, Medium	2 per tube
27	*51P480-1*	Air Tubing Clamp, Large	2 per tube
28	*89S34*	Air Strainer - 440R	1
29	95963-11	Label	1

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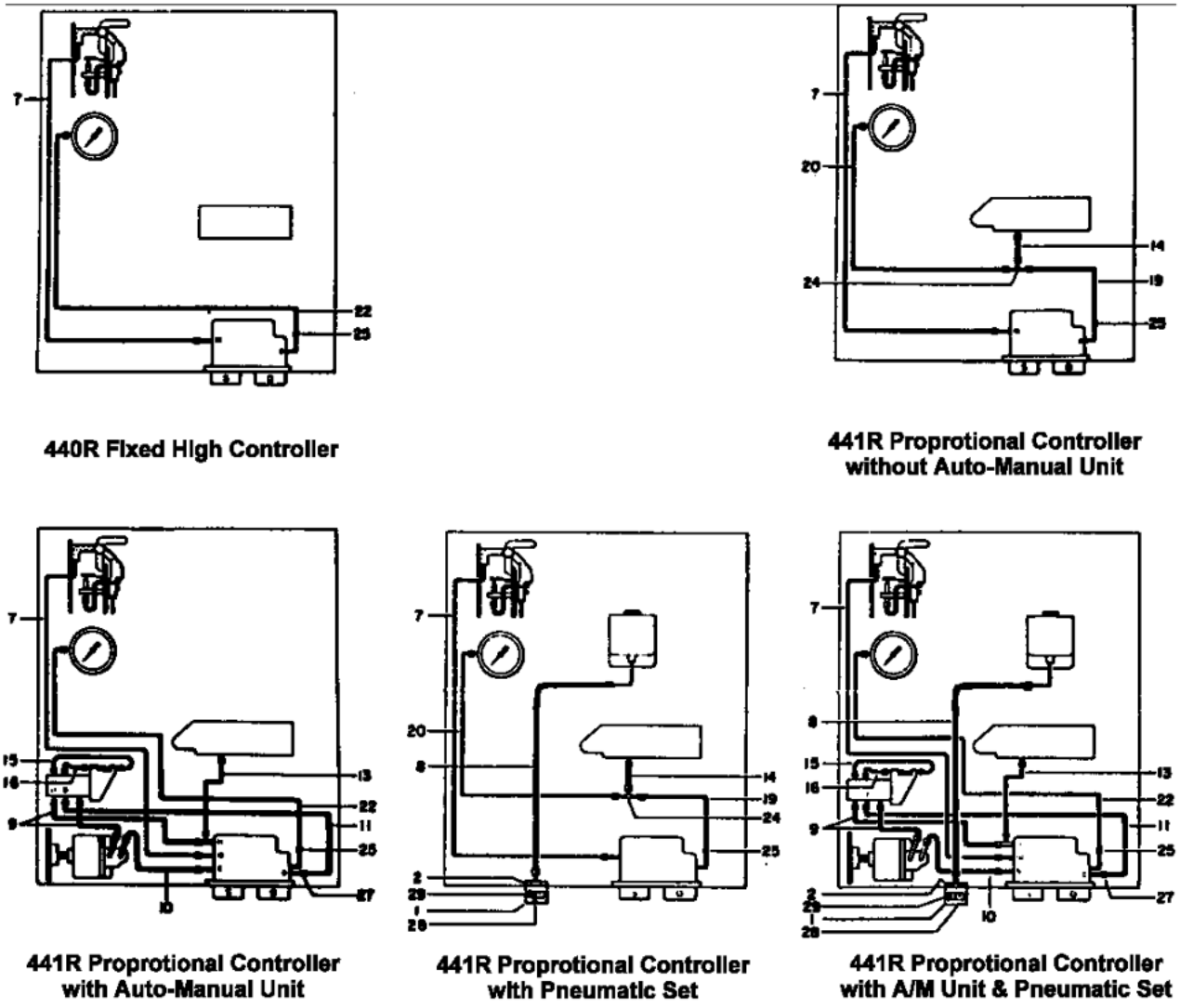


Figure 56. Air Tubing and Clamps – 440R, 441R

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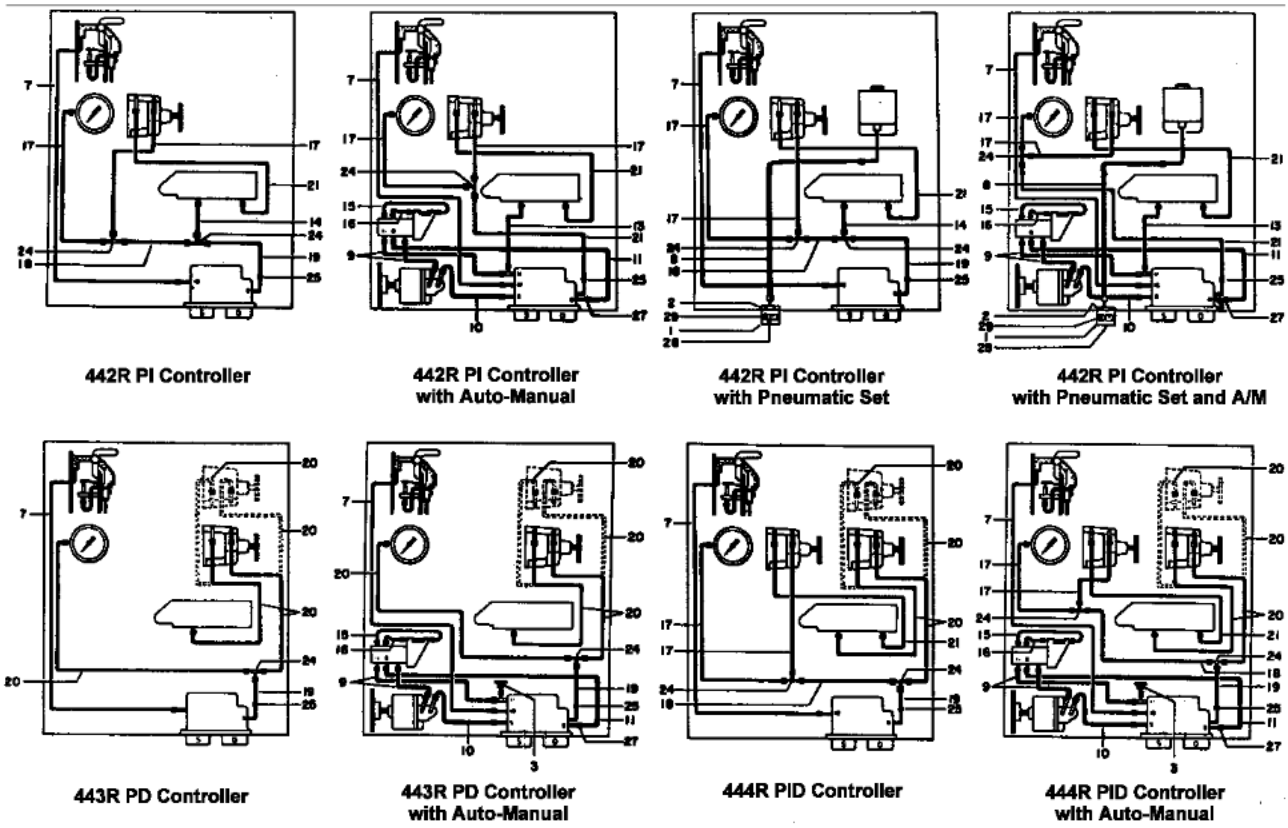


Figure 57. Air Tubing and Clamps – 442R, 443R, 444R

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6.7.9 Kits For Adding Auto-Manual Unit

Refer to Figure 58 and Figure 59 for the Auto-Manual Unit Kits parts listed in Table 16.

41S729A-K Kit for adding Auto-Manual Unit to 441R Controllers with Proportional Response and Controllers with Proportional Response and Pneumatic-Set

41S729B-K Kit for adding Auto-Manual Unit to 443R and 444R Controllers with Proportional and Pre-Act Responses and Controllers with Proportional, Reset and Pre-Act Responses

41S729C-K Kit for adding Auto-Manual Unit to 442R Controllers with Proportional and Reset Responses and Controllers with Proportional and Reset Response and Pneumatic-Set

Table 16. Auto-Manual Unit Kits Parts List

Item	Part No.	Description	No. Req'd
1	35S520	Tubing Plug – 443R, 444R	1
5	41S657	Manual Regulator	1
6	41S1006	Auto-Manual Selector Switch	1
7	47P1142	Air Tubing (specify 4" length)	1
8	47P1142	Air Tubing (specify 4-1/2" length)	1
9	47P1142	Air Tubing (specify 5" length)	1
10	47P1142	Air Tubing (specify 10-1/2" length)	1
11	47P1169	Air Tubing (specify 1-3/4" length) – 441R, 442R	1
12	47P1169	Air Tubing (specify 12" length) – 442R	1
13	47P1169	Air Tubing (specify 15-1/2" length) – 441R	1
14	51P341	Air Tubing Clamp, Small – 441R, 442R	2 per tube
15	51P480-1	Air Tubing Clamp, Large	2 per tube
16	61S1065	Output Relay with Alarm	1
17	•	Manual Regulator and Selector Switch Mtg Screw, #10-32 x 1/2" Pan Hd	4

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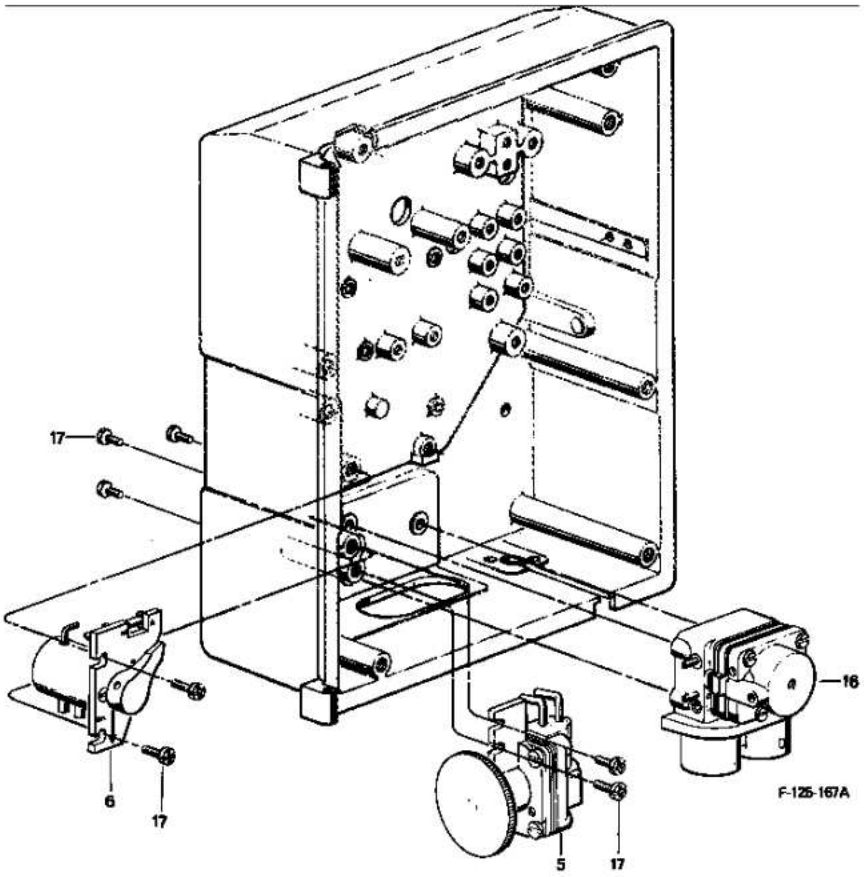


Figure 58. Location of Auto-Manual Unit

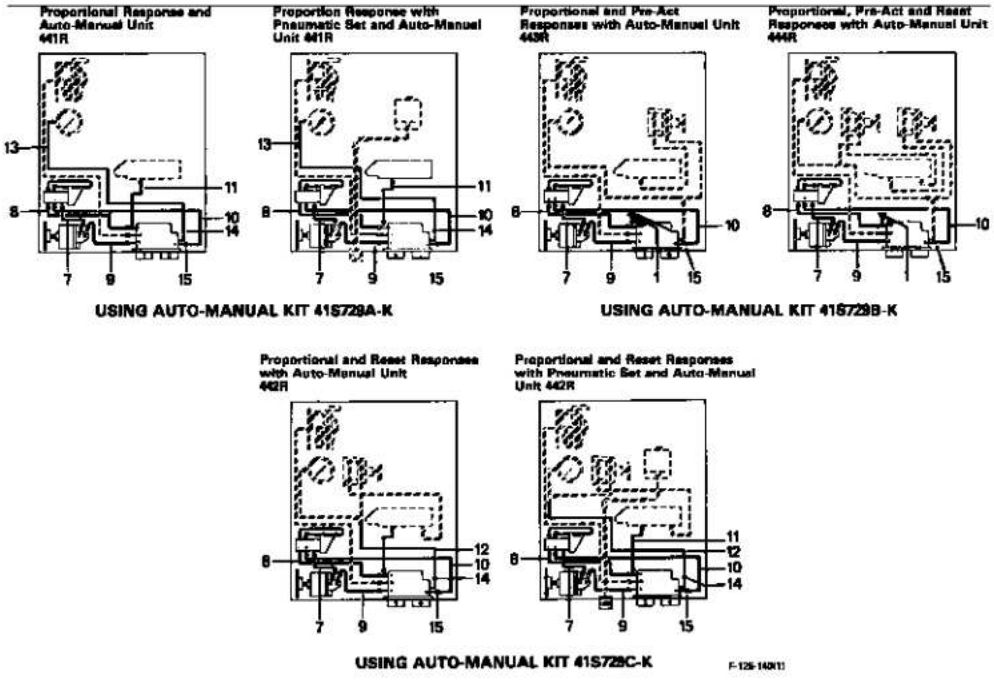


Figure 59. Location of Air Tubes

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6.7.10 Kits For Adding Reset Response

Refer to Figure 60 and Figure 61 for the Reset Response Kits parts listed in Table 17.

41S730A-K Kit for adding Reset Response to 442R Controllers with Proportional Response and Controllers with Proportional Response and Pneumatic-Set

41S730B-K Kit for adding Reset Response to 444R Controllers with Proportional and Pre-Act Responses and Controllers with Proportional and Pre-Act Responses and Auto-Manual Unit

41S730C-K Kit for adding Reset Response to 442R Controllers with Proportional Response and Auto Manual Unit and Controllers with Proportional Response, Auto-Manual Unit, and Pneumatic-Set

Table 17. Reset Response Kits Parts List

Item	Part No.	Description	No. Req'd
1	41S798	Reset Response Unit	1
2	47P1169	Air Tubing (specify 3" length)	2
3	47P1169	Air Tubing (specify 5-1/4" length)	1
4	47P1169	Air Tubing (specify 12" length)	1
5	48P217Y	Tubing Tee	1
6	51P341	Air Tube Clamp	2 per tube
7	52P1661	Gain Dial – 442R	1
8	58S561	Feedback Unit	1
9	570M1	Reset Response Unit Mtg Screw, #10-32 x 1/2" Pan Hd	2

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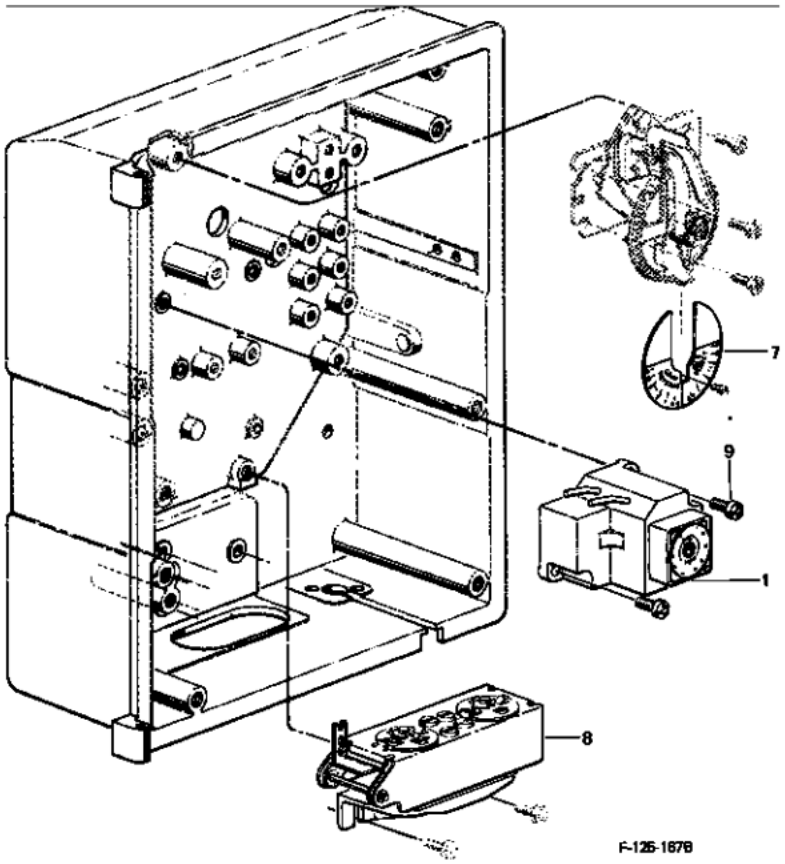


Figure 60. Location of Reset Unit

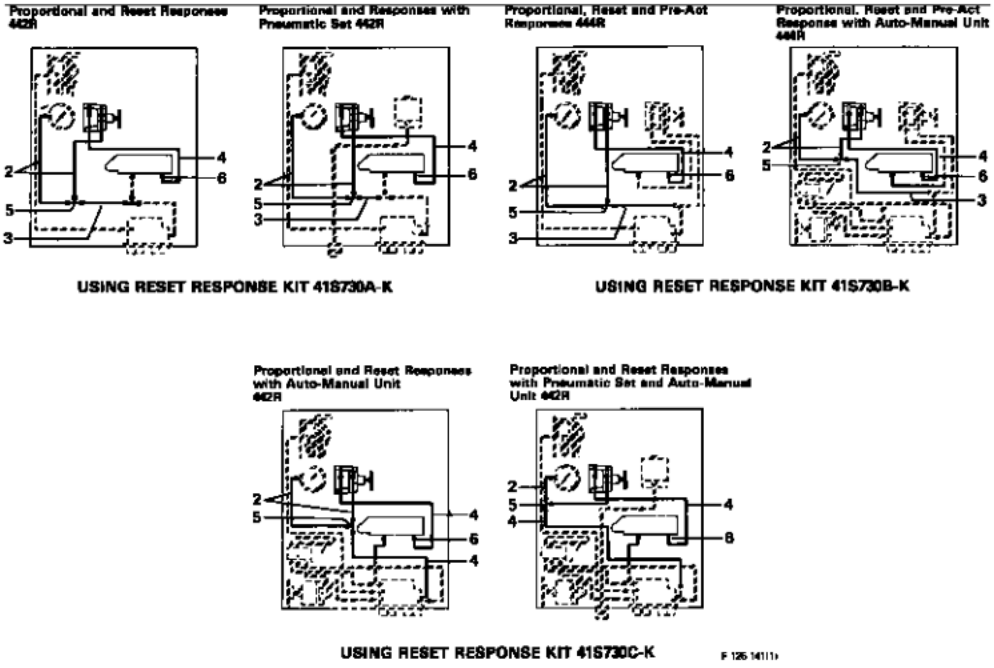


Figure 61. Location of Air Tubes

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6.7.11 Kits For Adding Pre-Act Response

Refer to Figure 62 and Figure 63 for the Pre-Act Response Kits parts listed in Table 18.

41S731A-K Kit for adding Pre-Act Response to 443R Controllers with Proportional Response
41S731B-K Kit for adding Pre-Act Response to 444R Controllers with Proportional and Reset Responses
41S731C-K Kit for adding Pre-Act Response to 444R Controllers with Proportional and Reset Responses and Auto-Manual Unit
41S731D-K Kit for adding Pre-Act Response to 443R Controllers with Proportional Repsonse and Auto-Manual Unit

Table 18. Pre-Act Response Kits Parts List

Item	Part No.	Description	No. Req'd
1	35S520	Tubing Plug	1
2	*	• Rivet	1
3	47P1169	• Air Tubing (specify 11/16" length)	1
4	51P341	• Air Tubing Clamp	1
5	41S799	PRE-ACT Response Unit	1
6	47P1169	Air Tubing (specify 5-1/4" length)	1
7	47P1169	Air Tubing (specify 6-1/2" length)	1
8	47P1169	Air Tubing (specify 8-1/2" length)	2
8	47P1169	Air Tubing (specify 8-1/2" length)	3
9	48P217Y	Tubing Tee	1
10	51P341	Air Tubing Clamp	2 per tube
11	52P1661	Gain Dial	1
12	570M1	Pre-Act Response Unit Mtg Screw, #10-32 x 1/2 Pan Hd	2

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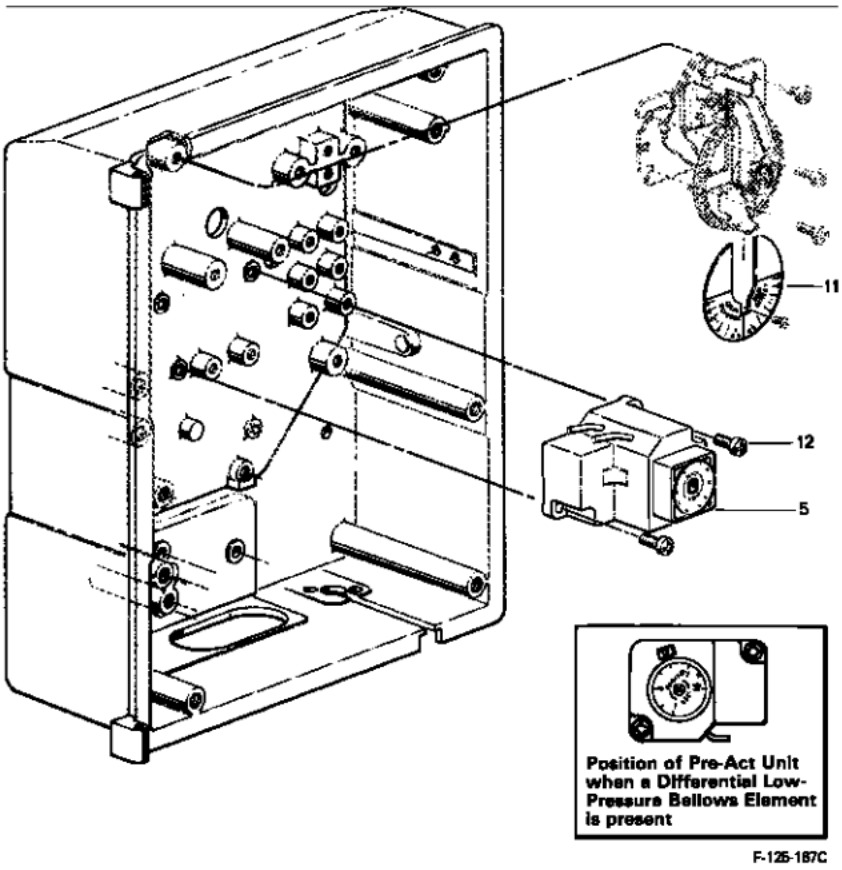


Figure 62. Location of PRE-ACT Unit

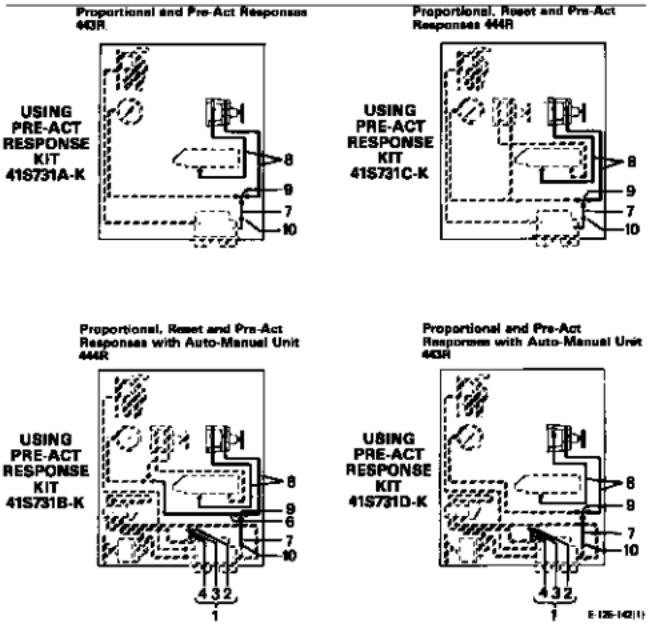


Figure 63. Location of Air Tubes

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