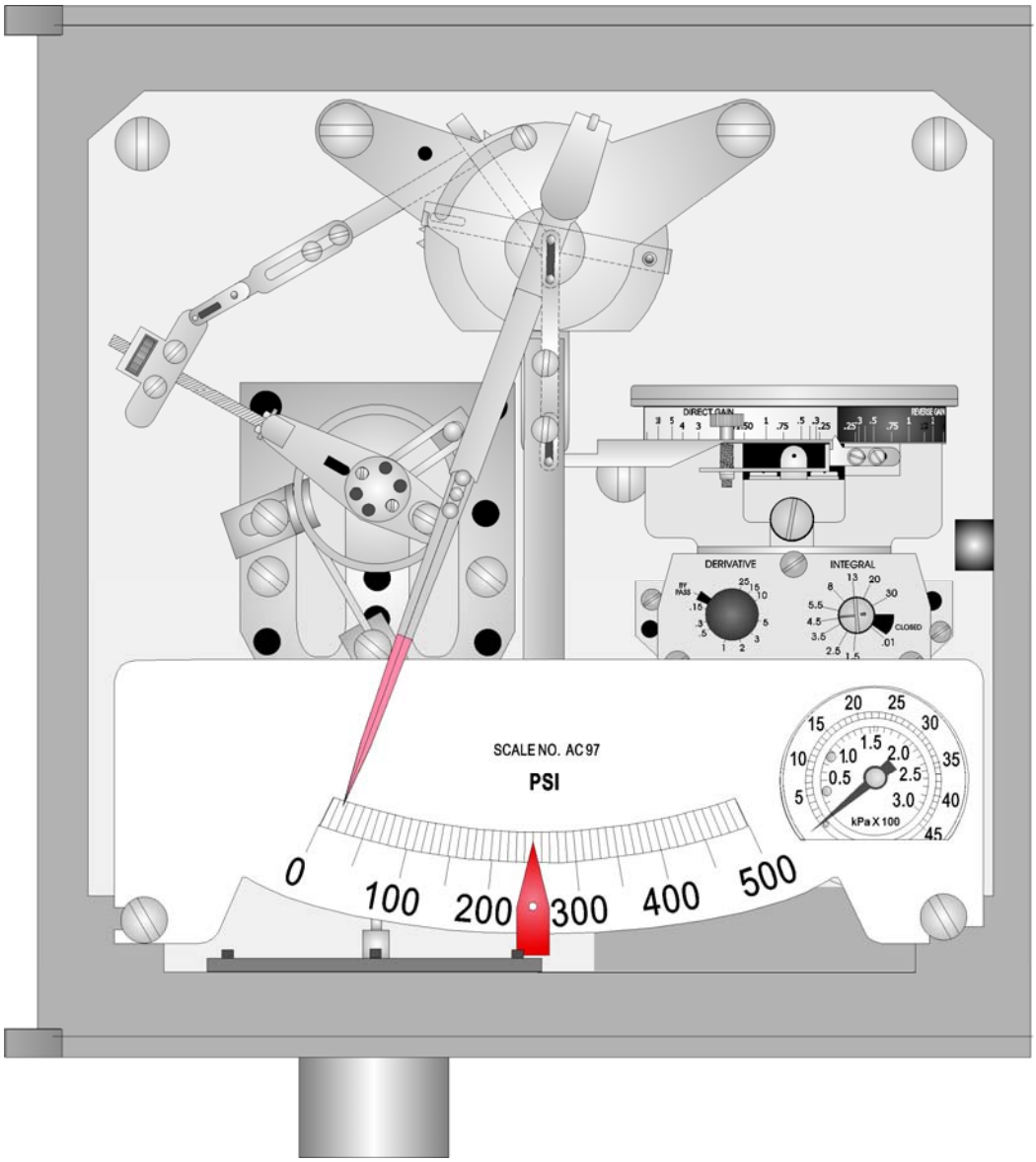
624-II Pneumatic Indicating Instruments Series 5450



IMPORTANT! READ INSTRUCTIONS BEFORE STARTING!

Be sure that these instructions are carefully read and understood before any operation is attempted. Improper use of this device in some applications may result in damage or injury. The user is urged to keep this book filed in a convenient location for future reference.

These instructions may not cover all details or variations in equipment or cover every possible situation to be met in connection with installation, operation or maintenance. Should problems arise that are not covered sufficiently in the text, the purchaser is advised to contact Bristol for further information.

EQUIPMENT APPLICATION WARNING

The customer should note that a failure of this instrument or system, for whatever reason, may leave an operating process without protection. Depending upon the application, this could result in possible damage to property or injury to persons. It is suggested that the purchaser review the need for additional backup equipment or provide alternate means of protection such as alarm devices, output limiting, fail-safe valves, relief valves, emergency shutoffs, emergency switches, etc. If additional in-formation is required, the purchaser is advised to contact Bristol .

RETURNED EQUIPMENT WARNING

When returning any equipment to Bristol for repairs or evaluation, please note the following: The party sending such materials is responsible to ensure that the materials returned to Bristol are clean to safe levels, as such levels are defined and/or determined by applicable federal, state and/or local law regulations or codes. Such party agrees to indemnify Bristol and save Bristol harmless from any liability or damage which Bristol may incur or suffer due to such party's failure to so act.

ELECTRICAL GROUNDING

Metal enclosures and exposed metal parts of electrical instruments must be grounded in accordance with OSHA rules and regulations pertaining to "Design Safety Standards for Electrical Systems," 29 CFR, Part 1910, Subpart S, dated: April 16, 1981 (OSHA rulings are in agreement with the National Electrical Code).

The grounding requirement is also applicable to mechanical or pneumatic instruments that include electrically-operated devices such as lights, switches, relays, alarms, or chart drives.

EQUIPMENT DAMAGE FROM ELECTROSTATIC DISCHARGE VOLTAGE

This product contains sensitive electronic components that can be damaged by exposure to an electrostatic discharge (ESD) voltage. Depending on the magnitude and duration of the ESD, this can result in erratic operation or complete failure of the equipment. Read supplemental document S14006 at the back of this manual for proper care and handling of ESD-sensitive components.

Bristol Inc. 1100 Buckingham Street, Watertown, CT 06795
Telephone (860) 945-2200

WARRANTY

A. Bristol warrants that goods described herein and manufactured by Bristol are free from defects in material and workmanship for one year from the date of shipment unless otherwise agreed to by Bristol in writing.

B. Bristol warrants that goods repaired by it pursuant to the warranty are free from defects in material and workmanship for a period to the end of the original warranty or ninety (90) days from the date of delivery of repaired goods, whichever is longer.

C. Warranties on goods sold by, but not manufactured by Bristol, are expressly limited to the terms of the warranties given by the manufacturer of such goods.

D. All warranties are terminated in the event that the goods or systems or any part thereof are (i) misused, abused or otherwise damaged, (ii) repaired, altered or modified without Bristol's consent, (iii) not installed, maintained and operated in strict compliance with instructions furnished by Bristol, or (iv) worn, injured or damaged from abnormal or abusive use in service time.

E. THESE WARRANTIES ARE EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED (INCLUDING WITHOUT LIMITATION WARRANTIES AS TO MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE), AND NO WARRANTIES, EXPRESS OR IMPLIED, NOR ANY REPRESENTATIONS, PROMISES, OR STATEMENTS HAVE BEEN MADE BY BRISTOL UNLESS ENDORSED HEREIN IN WRITING. FURTHER, THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION OF THE FACE HEREOF.

F. No agent of Bristol is authorized to assume any liability for it or to make any written or oral warranties beyond those set forth herein.

REMEDIES

A. Buyer's sole remedy for breach of any warranty is limited exclusively to repair or replacement without cost to Buyer of any goods or parts found by Seller to be defective if Buyer notifies Bristol in writing of the alleged defect within ten (10) days of discovery of the alleged defect and within the warranty period stated above, and if the Buyer returns such goods to Bristol's Watertown office, unless Bristol's Watertown office designates a different location, transportation prepaid, within thirty (30) days of the sending of such notification and which upon examination by Bristol proves to be defective in material and workmanship. Bristol is not responsible for any costs of removal, dismantling or reinstallation of allegedly defective or defective goods. If a Buyer does not wish to ship the product back to Bristol, the Buyer can arrange to have a Bristol service person come to the site. The Service person's transportation time and expenses will be for the account of the Buyer. However, labor for warranty work during normal working hours is not chargeable.

B. Under no circumstances will Bristol be liable for incidental or consequential damages resulting from breach of any agreement relating to items included in this quotation, from use of the information herein or from the purchase or use by Buyer, its employees or other parties of goods sold under said agreement.

How to return material for Repair or Exchange

Before a product can be returned to Bristol for repair, upgrade, exchange, or to verify proper operation, form (GBU 13.01) must be completed in order to obtain a RA (Return Authorization) number and thus ensure an optimal lead time. Completing the form is very important since the information permits the Bristol Repair Dept. to effectively and efficiently process the repair order.

You can easily obtain a RA number by:

A. FAX
Completing the form (GBU 13.01) and faxing it to (860) 945-3875. A Bristol Repair Dept. representative will return call (or other requested method) with a RA number.

B. E-MAIL
Accessing the form (GBU 13.01) via the Bristol Web site (www.bristolbabcock.com) and sending it via E-Mail to brepair@bristolbabcock.com. A Bristol Repair Dept. representative will return E-Mail (or other requested method) with a RA number.

C. Mail
Mail the form (GBU 13.01) to

Bristol Inc.
Repair Dept.
1100 Buckingham Street
Watertown, CT 06795

A Bristol Repair Dept. representative will return call (or other requested method) with a RA number.

D. Phone
Calling the Bristol Repair Department at (860) 945-2442. A Bristol Repair Department representative will record a RA number on the form and complete Part I, then send the form to the Customer via fax (or other requested method) for Customer completion of Parts II & III.

A copy of the completed Repair Authorization Form with issued RA number should be included with the product being returned. This will allow us to quickly track, repair, and return your product to you.

Bristol Inc. Repair Authorization Form (off-line completion)

(Providing this information will permit Bristol Inc. to effectively and efficiently process your return. Completion is required to receive optimal lead time. Lack of information may result in increased lead times.)

Date_____ **RA #**_____**SH**_ **Line No.**_____

Standard Repair Practice is as follows: Variations to this is practice may be requested in the "Special Requests" section.

- Evaluate / Test / Verify Discrepancy
- Repair / Replace / etc. in accordance with this form
- Return to Customer

Please be aware of the Non warranty standard charge:

- There is a $100 minimum evaluation charge, which is applied to the repair if applicable (√ in "returned" B,C, or D of part III below)

Part I Please complete the following information for single unit or multiple unit returns

Address No. _____ **(office use only)** **Address No.** _____ **(office use only)**

Bill to :_____ **Ship to:**_____

_____ _____

_____ _____

Purchase Order:_____ **Contact Name:**_____

Phone:_____ **Fax:**_____**E-Mail:** _____

Part II Please complete Parts II & III for each unit returned

Model No./Part No._____ **Description** _____

Range/Calibration _____ **S/N** _____

Reason for return : ☐ Failure ☐ Upgrade ☐ Verify Operation ☐ Other _____

1. Describe the conditions of the failure (Frequency/Intermittent, Physical Damage, Environmental Conditions, Communication, CPU watchdog, etc.)

_____

_____

_____

_____(Attach a separate sheet if necessary)

2. Comm. interface used: ☐ Standalone ☐ RS-485 ☐ Ethernet ☐ Modem (PLM (2W or 4W) or SNW) ☐Other:_____

3. What is the **Firmware** revision? _____ What is the **Software** &version? _____

Part III If checking "replaced" for any question below, check an alternate option if replacement is not available

A. If product is within the warranty time period but is excluded due to Bristol's warranty clause, would you like the product: ☐ repaired ☐ returned ☐ replaced ☐ scrapped?

B. If product were found to exceed the warranty period, would you like the product: ☐repaired ☐ returned ☐ replaced ☐ scrapped?

C. If product is deemed not repairable would you like your product: ☐ returned ☐ replaced ☐ scrapped?

D. If Bristol is unable to verify the discrepancy, would you like the product: ☐ returned ☐ replaced ☐ *see below?

* Continue investigating by contacting the customer to learn more about the problem experienced? The person to contact that has the most knowledge of the problem is: _____ phone_____

If we are unable to contact this person the backup person is: _____ phone_____

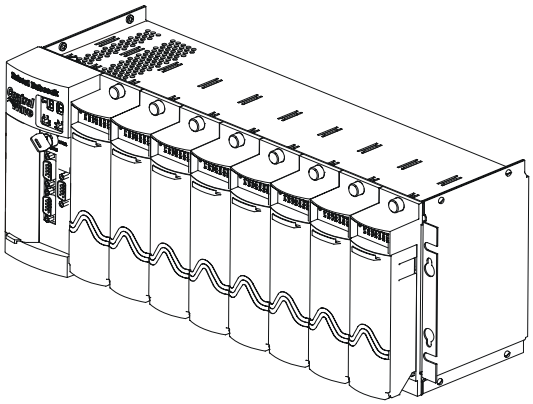
Special Requests: _____

_____

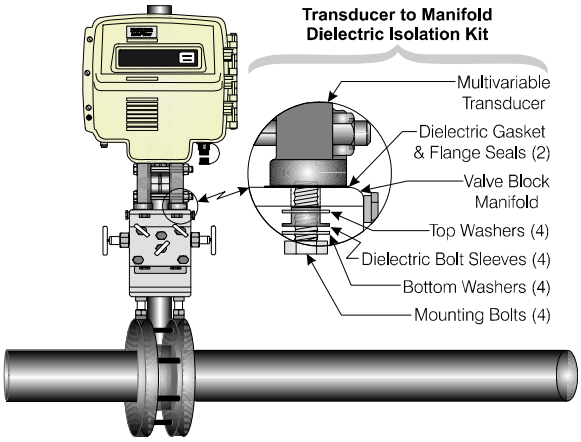
Ship prepaid to: **Bristol Inc., Repair Dept., 1100 Buckingham Street, Watertown, CT 06795**
Phone: 860-945-2442 Fax: 860-945-2220 Form GBU 13.01 Rev. C 04/27/06

Bristol
Training

GET THE MOST FROM YOUR BRISTOL BABCOCK INSTRUMENT OR SYSTEM



- Avoid Delays and problems in getting your system on-line
- Minimize installation, start-up and maintenance costs.
- Make the most effective use of our hardware and software.
- Know your system.



As you know, a well-trained staff is essential to your operation. Bristol Inc. offers a full schedule of classes conducted by full-time, professional instructors. Classes are offered throughout the year at three locations: Houston, Orlando and our Watertown, CT headquarters. By participating in our training, your personnel can learn how to install, calibrate, configure, program and maintain any and all Bristol products and realize the full potential of your system.

For information or to enroll in any class, contact our training department in Watertown at (860) 945-2343. For Houston classes, you can also contact our Houston office, at (713) 685-6200.

A Few Words About Bristol Inc.

For over 100 years, Bristol® has been providing innovative solutions for the measurement and control industry. Our product lines range from simple analog chart recorders, to sophisticated digital remote process controllers and flow computers, all the way to turnkey SCADA systems. Over the years, we have become a leading supplier to the electronic gas measurement, water purification, and wastewater treatment industries.

On off-shore oil platforms, on natural gas pipelines, and maybe even at your local water company, there are Bristol Inc. instruments, controllers, and systems running year-in and year-out to provide accurate and timely data to our customers.

Getting Additional Information

In addition to the information contained in this manual, you may receive additional assistance in using this product from the following sources:

Help Files / Release Notes

Many Bristol software products incorporate help screens. In addition, the software typically includes a 'read me' release notes file detailing new features in the product, as well as other information which was available too late for inclusion in the manual.

Contacting Bristol Inc. Directly

Bristol's world headquarters is located at 1100 Buckingham Street, Watertown, Connecticut 06795, U.S.A.

Our main phone numbers are:

(860) 945-2200
(860) 945-2213 (FAX)

Regular office hours are Monday through Friday, 8:00AM to 4:30PM Eastern Time, excluding holidays and scheduled factory shutdowns. During other hours, callers may leave messages using Bristol's voice mail system.

Telephone Support - Technical Questions

During regular business hours, Bristol's Application Support Group can provide telephone support for your technical questions.

For technical questions about TeleFlow products call (860) 945-8604.

For technical questions about **Control**Wave call (860) 945-2394 or (860) 945-2286.

For technical questions regarding Bristol's **OpenEnterprise** product, call (860) 945-3865 or e-mail: **scada@bristolbabcock.com**

For technical questions regarding **ACCOL** products, **OpenBSI Utilities**, **UOI** and all other software except for **Control**Wave and **OpenEnterprise** products, call (860) 945-2286.

For technical questions about **Network 3000** hardware, call (860) 945-2502.

You can e-mail the Application Support Group at: **bsupport@bristolbabcock.com**

The Application Support Group maintains an area on our web site for software updates and technical information. Go to: **www.bristolbabcock.com/services/techsupport/**

For assistance in interfacing Bristol hardware to radios, contact Bristol's **Communication Technology Group** in Orlando, FL at **(407) 629-9463 or (407) 629-9464**.

You can e-mail the Communication Technology Group at:
orlandoRFgroup@bristolbabcock.com

Telephone Support - Non-Technical Questions, Product Orders, etc.

Questions of a non-technical nature (product orders, literature requests, price and delivery information, etc.) should be directed to the nearest sales office (listed on the rear cover of this manual) or to your Bristol-authorized sales representative.

Please call the main Bristol Inc. number (860-945-2200) if you are unsure which office covers your particular area.

Visit our Site on the World Wide Web

For general information about Bristol Inc. and its products, please visit our site on the World Wide Web at: **www.bristolbabcock.com**

Training Courses

Bristol's Training Department offers a wide variety of courses in Bristol hardware and software at our Watertown, Connecticut headquarters, and at selected Bristol regional offices, throughout the year. Contact our Training Department at **(860) 945-2343** for course information, enrollment, pricing, and scheduling.

PNEUMATIC INDICATING INSTRUMENTS
TABLE OF CONTENTS

Page

CHAPTER 3A - G-I-D CONTROLLER (Continued)

CHAPTER 3B - DIFFERENTIAL GAP CONTROLLER

CHAPTER 3C - REMOTE SETPOINT ACTUATOR

Page

CHAPTER 3C - REMOTE SETPOINT ACTUATOR (Continued)

CHAPTER 3D - INDICATING PNEUMATIC TRANSMITTER

CHAPTER 4 - SPECIFICATIONS

Page

CHAPTER 5 - PARTS LIST

APPENDICES:

SUPPLEMENTS:

Chapter 1
INTRODUCTION

1.1 PRODUCT DESCRIPTION

Series 5450 Indicating Controllers are pneumatically powered instruments used for process measurement and control. They are housed in a compact aluminum case (7-15/16" height x 7-23/32" width x 4" depth) with a durable gray epoxy finish. A typical model is shown in Figure 1-1.

1.2 BASIC TYPES

Series 5450 controllers can be used in many control applications. The following four basic types are offered:

- G-I-D Controllers, Series 5453-10G-ABC-D-E-(F1-F6), 5453-31G-AB-C-D-(E1-E6) & 5453-40G-A-B-C-(D1-D6) (see Chapter 3A)

  These analog controller models may be specified with 3 modes of control algorithms: Gain, Integral and Derivative (G-I-D). Gain mode is standard for all models, while Integral and Derivative are optional. Supply pressures of 20, 30 and 35 psi are offered. The controlled variable (output) can be either a 3-15 or 3-27 psi signal. A Manual/Automatic Station may also be specified.

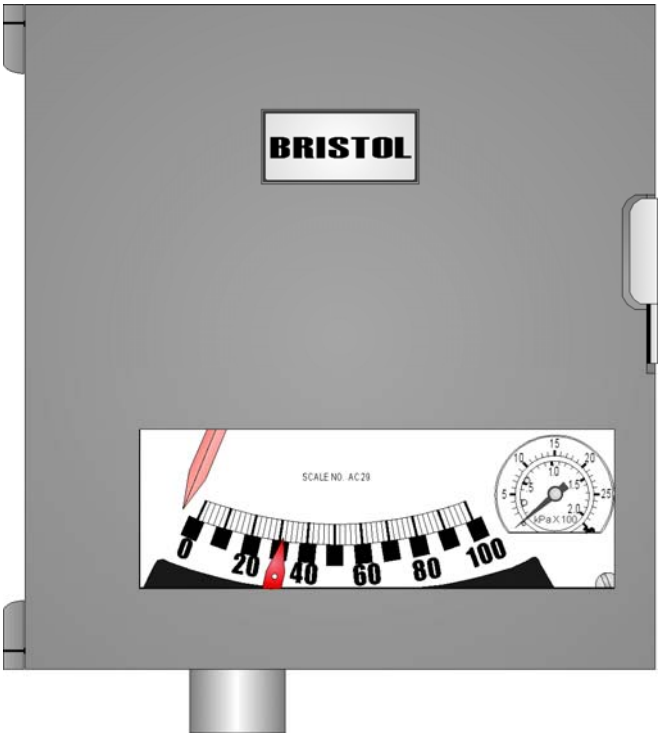


Figure 1-1 - Series 5450 Instrument

- Differentail Gap Controllers, Series 5453-10G-ABC-D-E-(F7), 5453-31G-AB-C-D-(E7) & 5453-40G-A-B-C-(D7) (see Chapter 3B)

  These dual-setpoint controllers provide on-off control action over a desired gap or zone. The width of the gap is adjustable from 5 to 95% of the instrument range. The controller output is switched from 0% to 100% (or vice-verse) of the supply pressure (20 psi) to maintain process control.

- Remote Setpoint Controllers, Series 5457-10G-ABC-D-E-(F1-F6), 5457-31G-AB-C-D-(E1-E6), 5457-40G-A-B-C-(D1-D6) & 5457-70G (see Chapter 3C)

  These instruments are essentially G-I-D Controllers that include an electronic Remote Setpoint Actuator assembly. This assembly mounts at the rear of the instrument housing. Actuators may be specified for use with an analog or raise/lower type input signal. Analog versions accept a 1-5 V or 4-20 mA input, while raise/lower versions accept a continuous on/off or incremental pulse input.

- Pneumatic Transmitter, Series 5453-10G-ABC-D-E-(F8-F9), 5453-31G-AB-C-D-(E8-E9) & 5453-40G-A-B-C-(D8-D9) (see Chapter 3D)

  Transmitter models perform an input measurement and provide an equivalent 3-15 or 3-27 psi output. Their outputs may be connected to the input of a pneumatic receiver, recorder, or a controller such as the G-I-D model listed above.

1.3 MEASUREMENT SYSTEMS

Controller models may be furnished with a variety of measuring systems. The first model number suffix identifies the type of measuring system as follows:

- Series 5450-10

  - Pressure or vacuum system that is furnished with a helical or capsular measuring element.

  - Pneumatic receiver that accepts a 3-15 psi input signal.

- Series 5450-31

  - Equipped with a Model 199 Differential Pressure Unit. Used for DP flow or Liquid Level measurement applications.

- Series 5450-40

  - Performs temperature measurement using a pressurized, gas-filled bulb. Can be specified with Class 1A, 1B or 3B type bulbs.

- Series 5450-70

  - Remote Pneumatic Motor Driven Transmitter with 20, 30 or 35 psi supply (Gain Only).

1.4 SPECIFICATIONS DATA PLATE

A specifications data plate is attached to the inside door of each instrument. The plate gives the model and serial number, operating range and other pertinent data. Always refer to the plate when installing the instrument or requesting information.

Chapter 2
INSTALLATION

2.1 UNPACKING

Unpack instrument slowly. Be careful not to damage any associated thermal capillary systems or external differential pressure units, if so equipped. Remove any packing, cushioning, elastics or cardboard guards used in packing. Sort out all hardware before proceeding.

Some instruments are shipped with pointers secured in a fixed position. If so, remove any tape, elastics or packing materials required. Do not apply excessive force to linkages or mechanisms while unpacking as they can be thrown out of calibration or permanently damaged.

2.2 LOCATION

The instrument location will vary with the process application. In general, select a site convenient to both the process and operator. Avoid areas where dirt, dust, and corrosive fumes are excessive and also areas where vibration is encountered. The location must be such that the instrument operates within its specified ambient temperature (see Chapter 4 - Specifications). If ambient conditions exceed or fall below the specified range, excessive errors and poor performance may result; prolonged exposure to extreme environmental conditions can also cause instrument failure.

2.3 MOUNTING ARRANGEMENTS

Since some models are position sensitive, the instrument must be installed so that it is reasonably level on both its horizontal and depth axis (x and z). This will insure the instrument operates in its factory-calibrated position.

For panel-mounted instruments, provide a proper size cutout as required. Install the instrument in the opening using reversible mounting brackets and tension bolts as shown in Figure 2-1. Tighten each tension bolt until the instrument is rigid and self-supporting, and then secure the bolt locking nuts.

For wall-mounted instruments, attach the reversible mounting brackets to each side and top of the case so that the bracket tangs extend toward the rear (Figure 2-2). Drill starting holes for each bracket at the required distances. Insert lag bolts or screws through the bracket holes and tighten until the case is secure.

For pipe-mounted instruments, assemble the three universal mounting brackets to the instrument case and attach the pipe mounting bracket to the rear of the instrument as shown in Figure 2-3. Position the U-bolts from the hardware kit around the pipe and insert threaded ends into the desired holes of the mounting bracket; select the proper set of holes for vertical or horizontal running pipes as required. Install nuts on U-bolts and tighten until the instrument is self supporting.

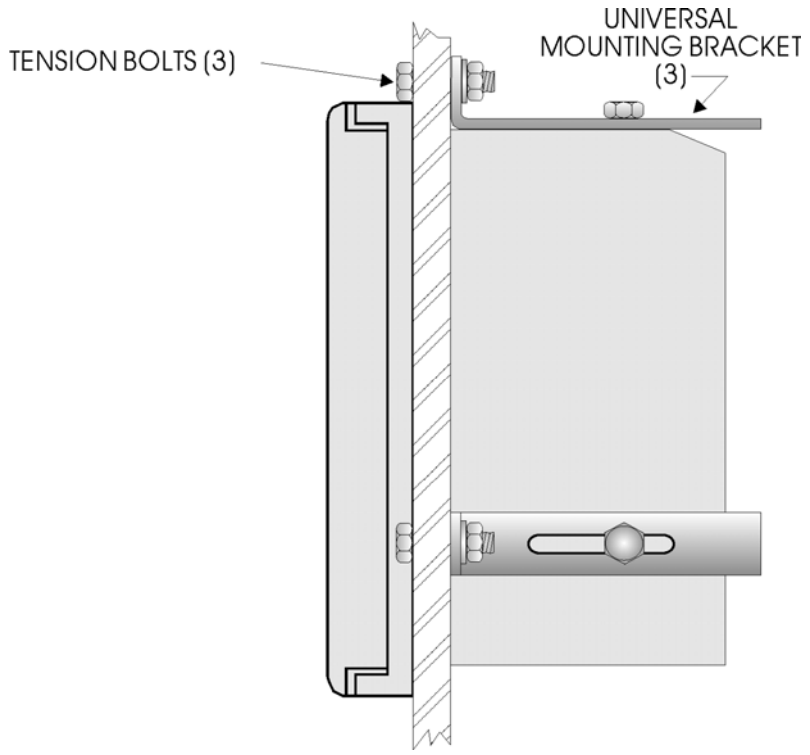


Figure 2-1 - Panel Mounted Instrument

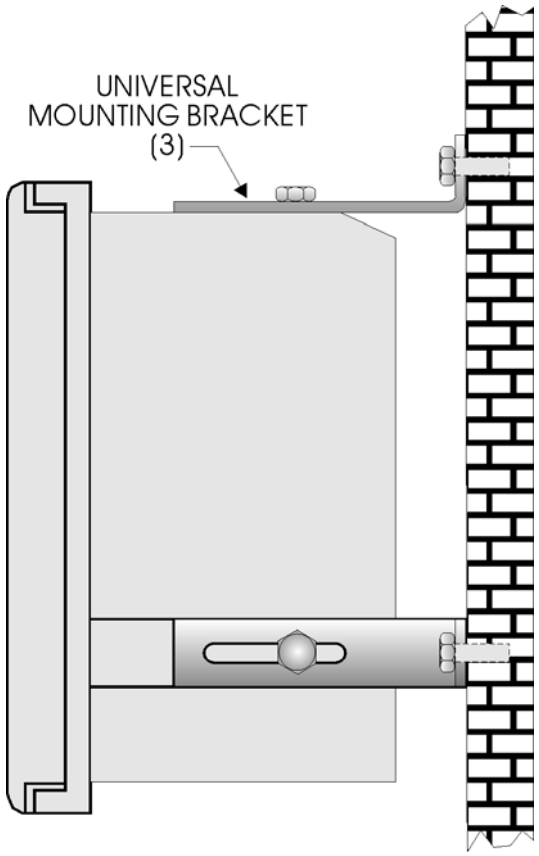


Figure 2-2 - Wall Mounted Instrument

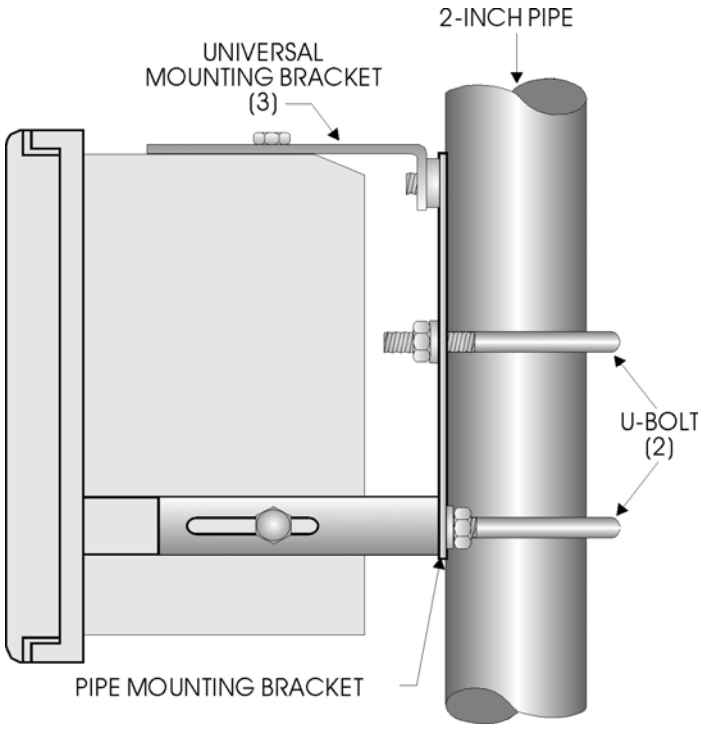


Figure 2-3 - Pipe Mounted Instrument

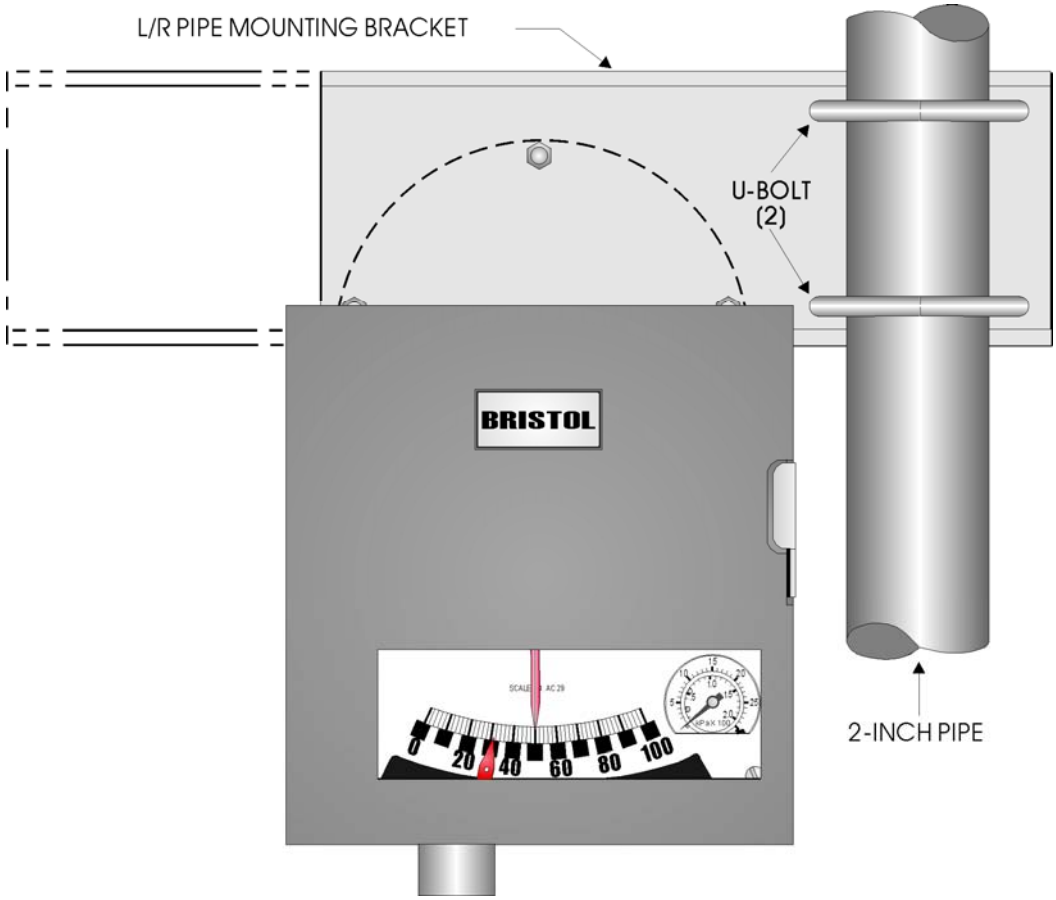


Figure 2-4 - Instrument (with Remote Setpoint Actuator) Pipe-Mounted

For instruments with Differential Pressure measuring assemblies, refer to separate instruction manual furnished with the assembly.

Instruments with Remote Setpoint Actuator assemblies have the actuator factory-assembled to the rear of the case. These models are only intended for flush panel (Figure 2-1) or pipe mounting (Figure 2-4) applications.

2.4 SUPPLY PIPING

Instruments require a clean, dry and steady pressure source. The use of supplemental items such as filters, gauges and pressure regulators will provide proper equipment protection and assure reliable operation.

CAUTION

The supply pressure of the instrument must be kept within specified limits at all times. If the supply pressure is incorrect, the control unit may provide an erroneous output signal to the final control element. The supply line MUST be regulated to guard against accidental overpressure or erroneous outputs.

NOTE

An instrument subject to supply overpressure may not necessarily be damaged but its calibration could be affected. A calibration check will verify its accuracy.

A basic piping diagram is shown in Figure 2-5. The optional gauge in the supply line monitors the supply pressure, while the regulator maintains an accurate supply level. The filter assembly, which is recommended for all installations, provides added assurance against dirt and oil entering the instrument.

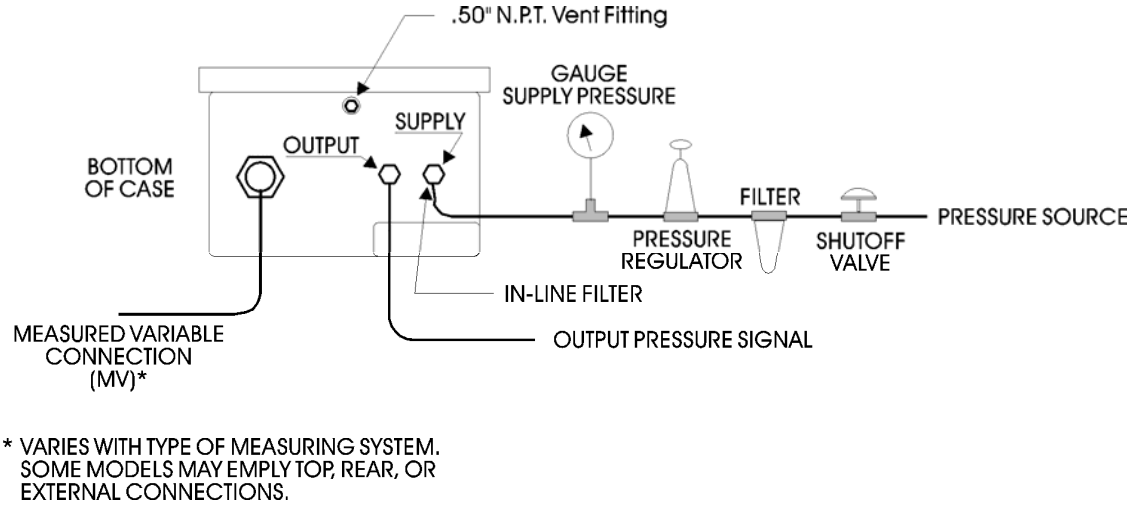


Figure 2-5 - Basic Piping Diagram

The shutoff valve in the supply side permits the operator to isolate or disconnect the instrument from the supply line for without disrupting the supply pressure source.

The instrument should be installed so that the supply and output lines slope downward to allow any condensate trapped in the lines to drain.

For most installations, l/4 inch tubing is satisfactory. However, if the input or output lines run a great distance, the response lag time may become objectionable. In these instances, the use of 3/8 inch tubing is recommended.

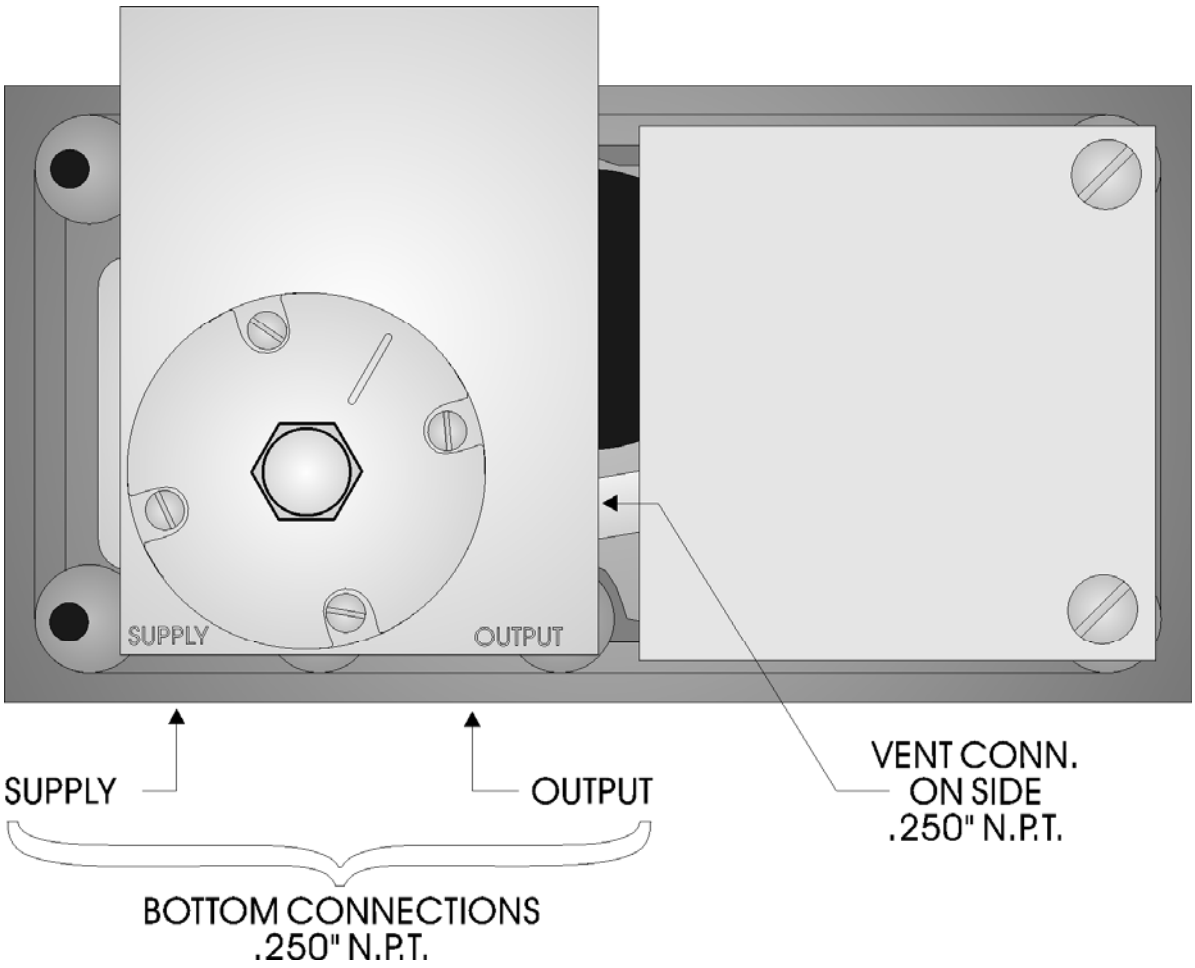


Figure 2-6 - Piping Ports for Manual-Automatic Stations

2.5 CASE VENTING

Because these instruments bleed pressure inside the case, it is essential that the case be properly vented. A vent connection is provided on the bottom of the case. This connection, which consists of a 1/2 inch NPT fitting, must be connected to a pipe that is vented outdoors. This will assure that harmful or flammable gases do not build up in the operating area. The instrument door must always be kept shut and secured to insure proper venting.

NOTE

If it becomes necessary to open the door to make operating or service adjustments, all ignition sources must be well removed from the area.

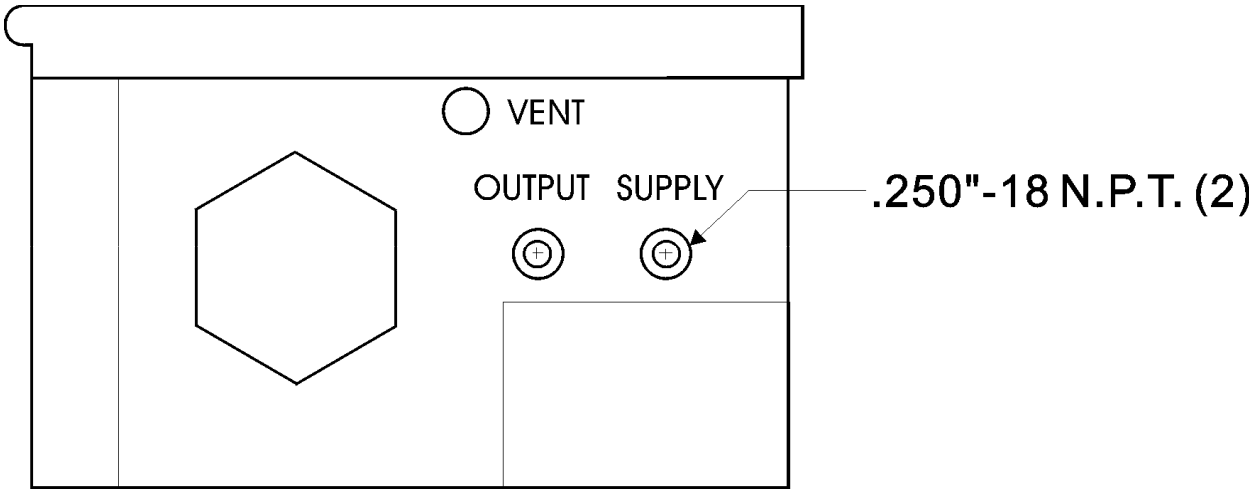


Figure 2-7 - Bottom of Series 5450 Indicating Controller

2.6 MEASURED VARIABLE (MV) CONNECTIONS

Series 5450 instruments utilize a variety of measuring systems that affect the method of connection. Details on these systems are covered in separate instruction units at the end of this manual. General connection information follows:

Pressure Models

The MV connection on models with a pressure input is made at the bottom of the case as shown in Figure 2-5. See Appendix GA for installation of pressure measuring systems, or Appendix AA for installation of pneumatic receivers.

Filled System Thermometers

These models are equipped with a pressurized bulb that senses temperature changes. The bulb is permanently attached by capillary tubing to a pressure element in the instrument. This tubing should not be folded, disconnected or cut as the pressure system will be damaged. See Appendix TA for installation of temperature measuring systems.

Differential Pressure Units

Models with external case-mounted differential pressure units have the MV connections made directly to the unit's body. These units may be used in differential pressure, absolute pressure or liquid-level measurement applications. See manufacturer's instruction manual for installation and application information.

2.7 INSTALLING MODELS WITH MAN-AUTO STATIONS

When a Manual-Automatic Station is furnished with a controller, the supply and output pressure connections are made through two 1/4 inch NPT pipe openings at the bottom of the station. The connection locations are shown in Figure 2-6.

A pressure vent hole is located at the side of the station block. This hole is threaded and usable as an external vent connection (1/4 in. NPT). For normal air pressure supplies, the vent is left unplugged. For gas pressure supplies, the vent is connected by piping to a safe area. Under no circumstances should the vent hole be plugged as the equipment will not operate properly.

2.8 SPECIAL PRECAUTIONS FOR AIR & GAS SUPPLY OPERATION

In some instances it may be possible to operate pneumatic instruments specified for use with air supplies on natural gas (flammable) supplies. This may be done providing the user takes certain precautions.

Exhaust Considerations

All Bristol, Inc. pneumatic instruments will bleed exhaust pressure (air or gas) into the instrument case during normal operation while a separate vent connection on gas-type instruments is used to pipe the bleeding gas away from the operating area. Note that on gas-type instruments, the gas will only bleed away from the operating area as long as the instrument is operated with the door tightly shut.

NEC Classifications

The NEC (National Electrical Code) defines a Division 1 hazardous area as one that is always hazardous or periodically hazardous. A Division 2 area is one that may become hazardous under abnormal conditions such as the rupture of a pipe or the failure of a ventilating system.

Recognizing Explosive Conditions

Natural gas forms an explosive mixture with air in concentrations from 3% to 15%. Therefore, the atmosphere within a case containing a pneumatic device operated by gas must pass through the explosive range during startup or maintenance operations. If the case is properly vented to a remote spot, it would eventually become nonhazardous inside as the concentrations exceed the upper explosive limit. However, when the door is open for operating or service checks, the area would pass through the hazardous concentration range again. At that time, the area in and around the case would probably become Division 1.

Electrical Attachments

The NEC prohibits the use of electrical devices of any kind (alarm contacts, power switches, chart drives, etc.) in a Division 1 area unless they are approved for intrinsically-safe or explosion-proof operation. Since none of the electrical devices that Bristol, Inc. might normally install in a case intended for air operation will meet Division 1 requirements, they should never be used with flammable gas supplies. The only present exceptions to this rule would be instruments employing battery-operated, intrinsically-safe chart drives or motor-operated setpoints with explosion-proof housing offered with some Bristol Babcock products.

Bristol, Inc. pneumatic instruments are furnished for three different user applications as follows:

A. Instruments with Air Supply & Electrical Components

   This type must never be operated with gas supplies (flammable) or operated in or near flammable gas environments since the electrical components may spark and cause fire or explosion.

B. Instruments with Air Supply and No Electrical Components

   Instruments of this type must only be operated from air pressure supplies. Should any user elect to use a flammable gas supply, it is at their risk.

C. Instruments with Gas Vent Attachment and No Electrical Devices

Any instrument in this category may be used with natural gas supplies. Instruments in this category may also be installed indoors in non-hazardous areas providing the vent connection is piped to a safe area (typically outdoors) and that it is operated with door or cover tightly shut.

WARNING

Bristol, Inc. is not responsible for determining which installations, if any, may be operated safely with natural gas. The final decision must be made by the user, based on a careful analysis of local situations and also in consultation with local safety authorities.

Review of Older Installations

It is recommended that all users having older Bristol, Inc. pneumatic instruments operating in "gas" installations check the following:

A. Make sure the instrument does not contain electrical attachments or devices. If such items are present, convert the instrument to air operation or completely disconnect them from the electrical supply.

B. Make sure all instruments using gas supplies have a suitable warning displayed in a prominent position on the front of the door.

Chapter 2A
OVERALL DIMENSION DRAWINGS

This chapter provides overall mounting dimensions to be used in association with product installation. Table 2A-1 below identifies the appropriate drawing for each model of the Series 5450 instrument line.

Table 2A-1 - Series 5450 Dimension Drawing

Model	Description	Figure
5453-10G	Pressure Controller	2A-1
	Pressure Controller with M/A Station	2A-2
	Pressure Receiver Controller	2A-1
	Pressure Receiver Controller with M/A Station	2A-2
	Pressure Transmitter	2A-1
5453-31G	DP Controller (Model 199)	2A-3
	DP Controller (Model 199) with M/A Station	2A-4
	DP Transmitter (Model 199)	2A-3
5453-40G	Temperature Controller	2A-1
	Temperature Controller with M/A Station	2A-2
	Temperature Transmitter	2A-1
5457-10G	Pressure RSP Controller	2A-5
	Pressure RSP Controller with M/A Station	2A-6
	Pressure Receiver RSP Controller	2A-5
	Pressure Receiver RSP Controller with M/A Station	2A-6
5457-31G	DP RSP Controller (Model 199)	2A-7
	DP RSP Controller (Model 199) with M/A Station	2A-8
5457-40G	Temperature RSP Controller	2A-5
	Temperature RSP Controller with M/A Station	2A-6
5457-70G	Pressure RSP Transmitter	2A-5

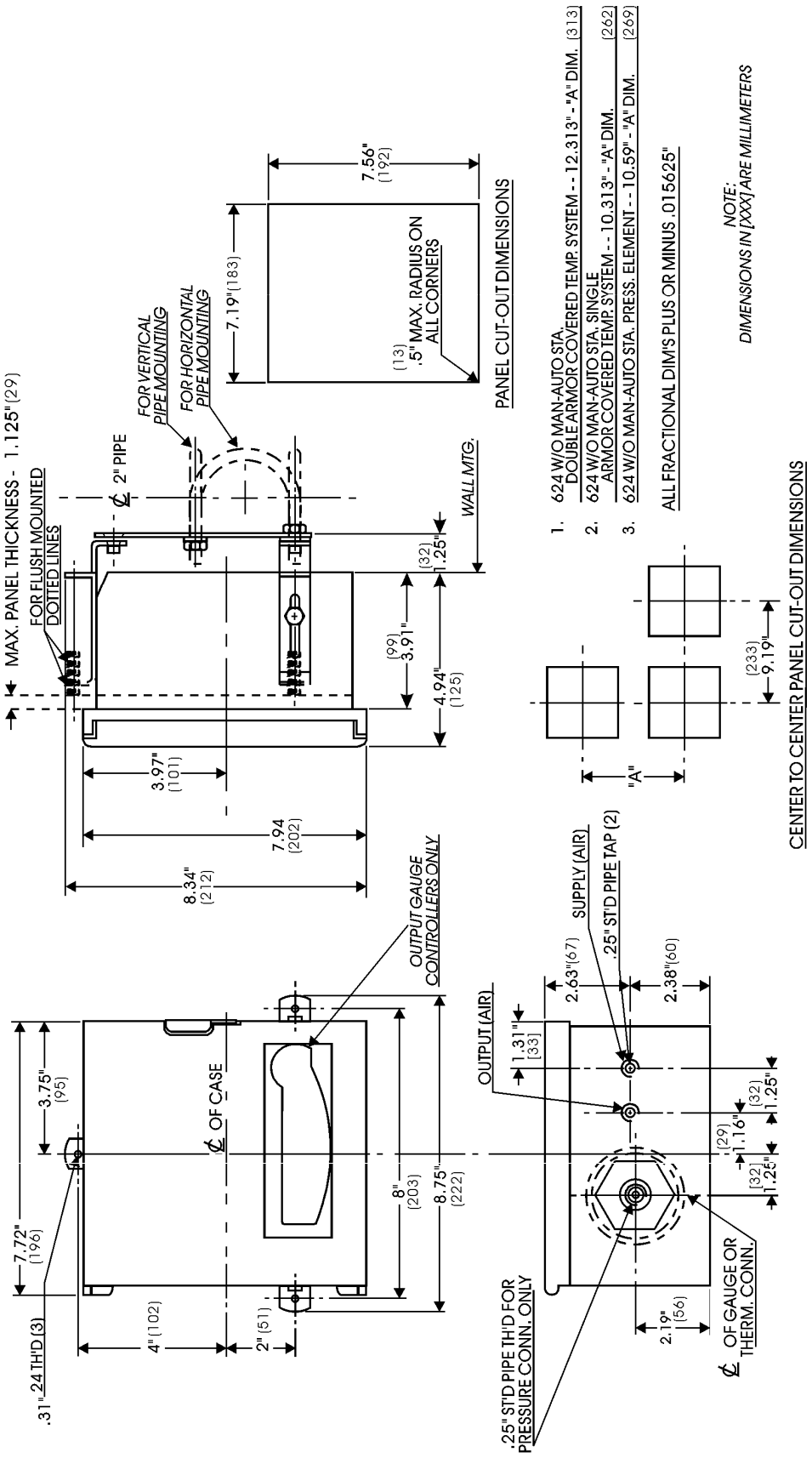


Figure 2A-1 - Models 5453-10G & -40G

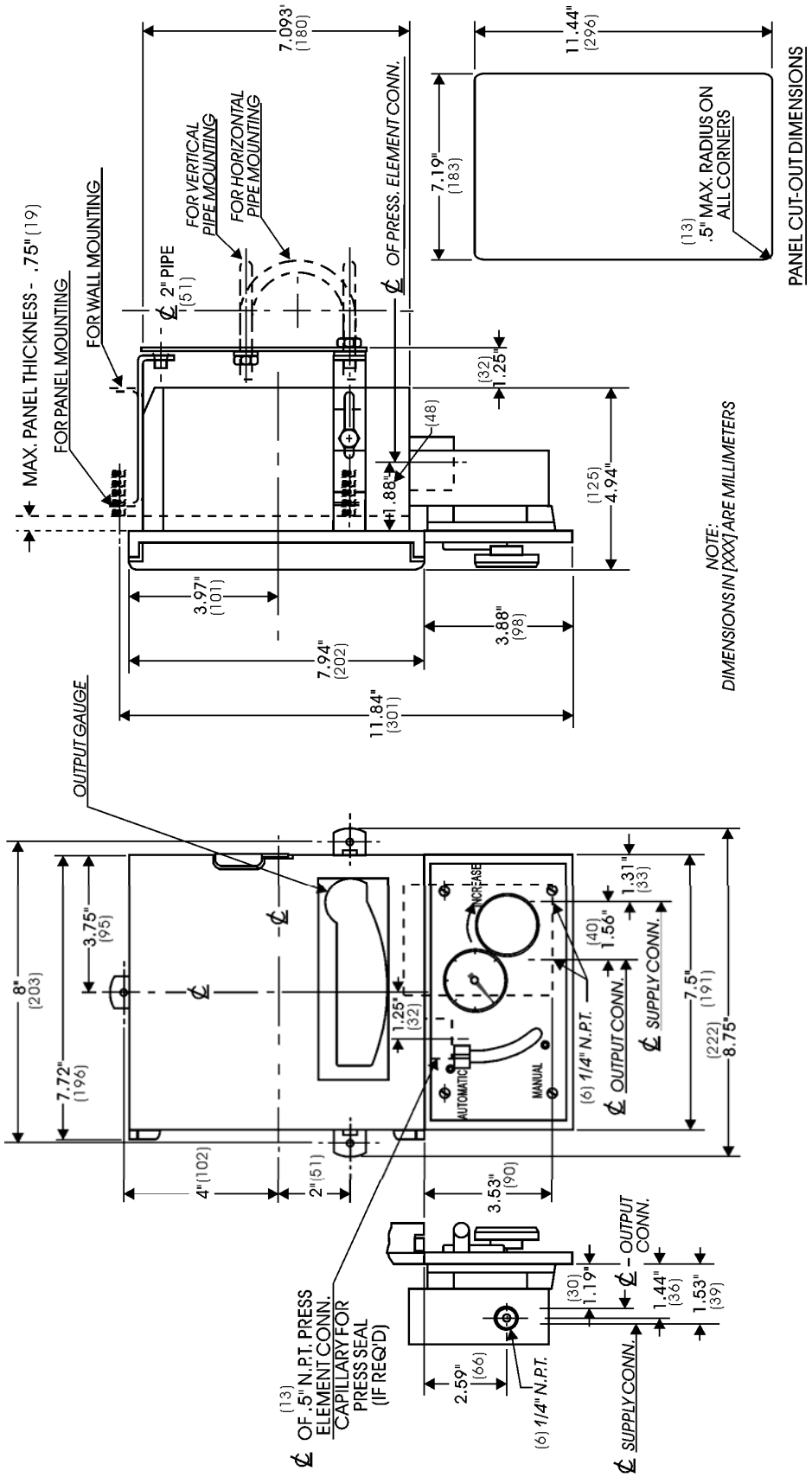


Figure 2A-2 - Models 5453-10G & -40G w/ M-A Station

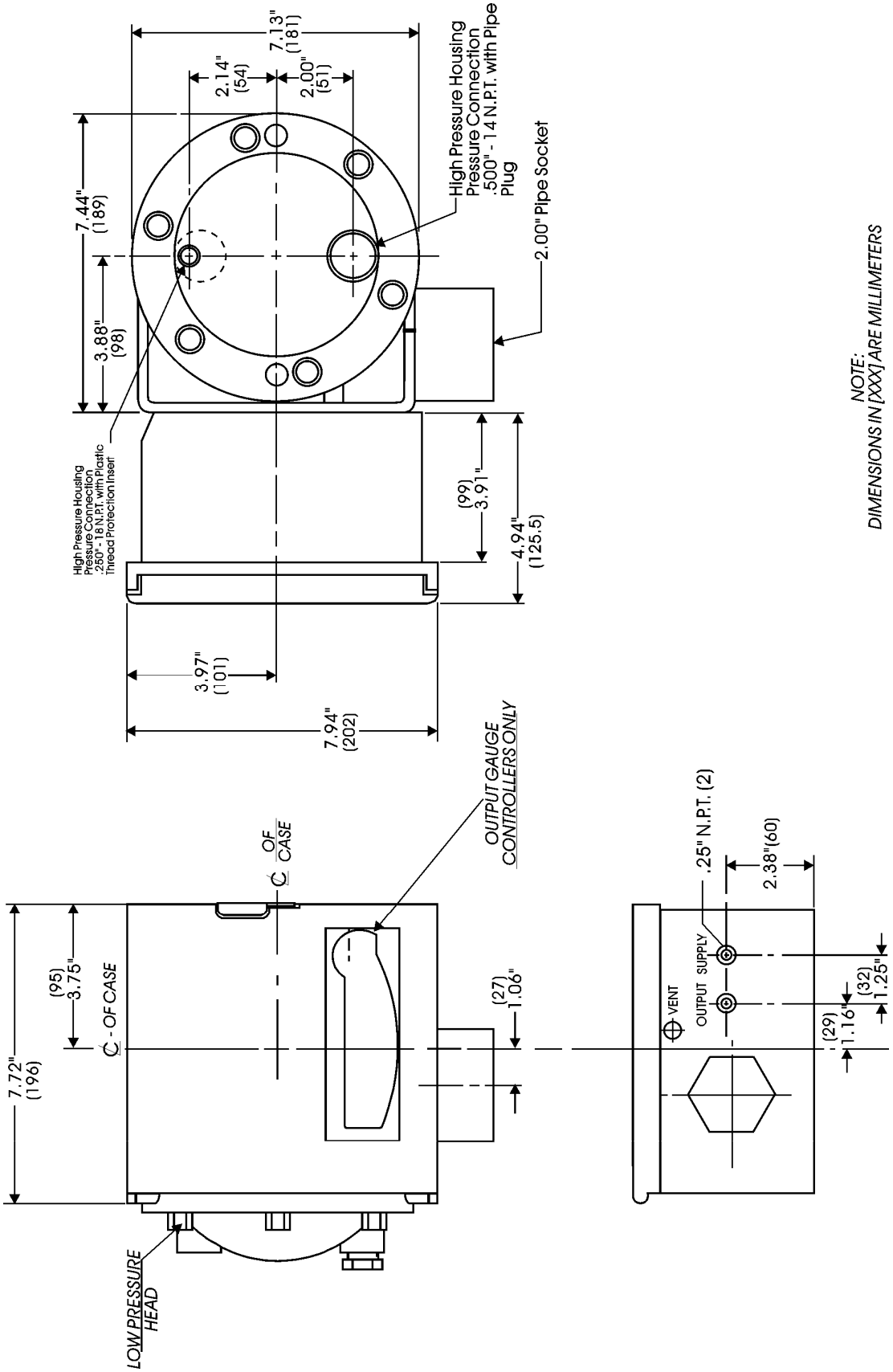


Figure 2A-3 - Model 5453-31G

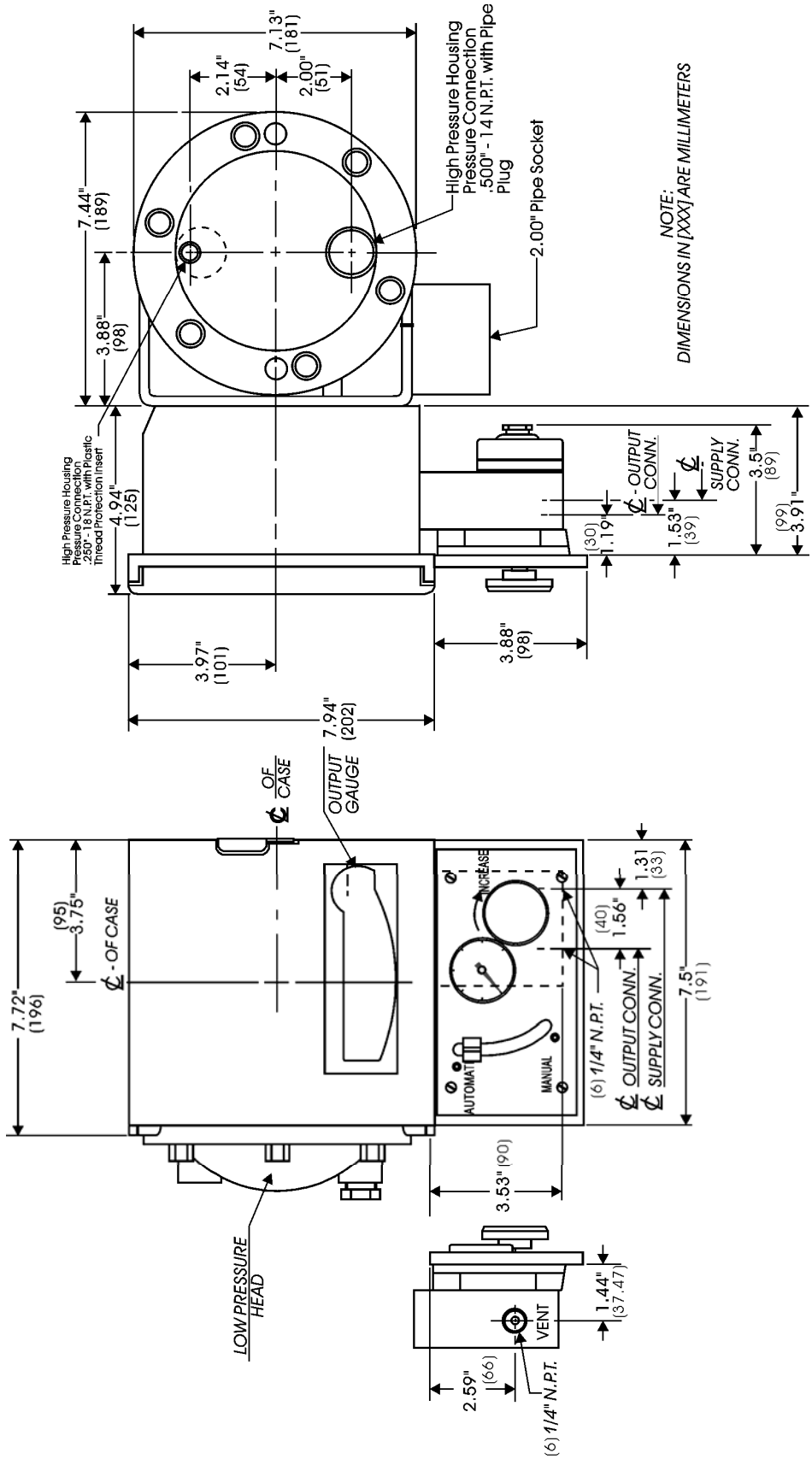


Figure 2A-4 - Model 5453-31G w/ M-A Station

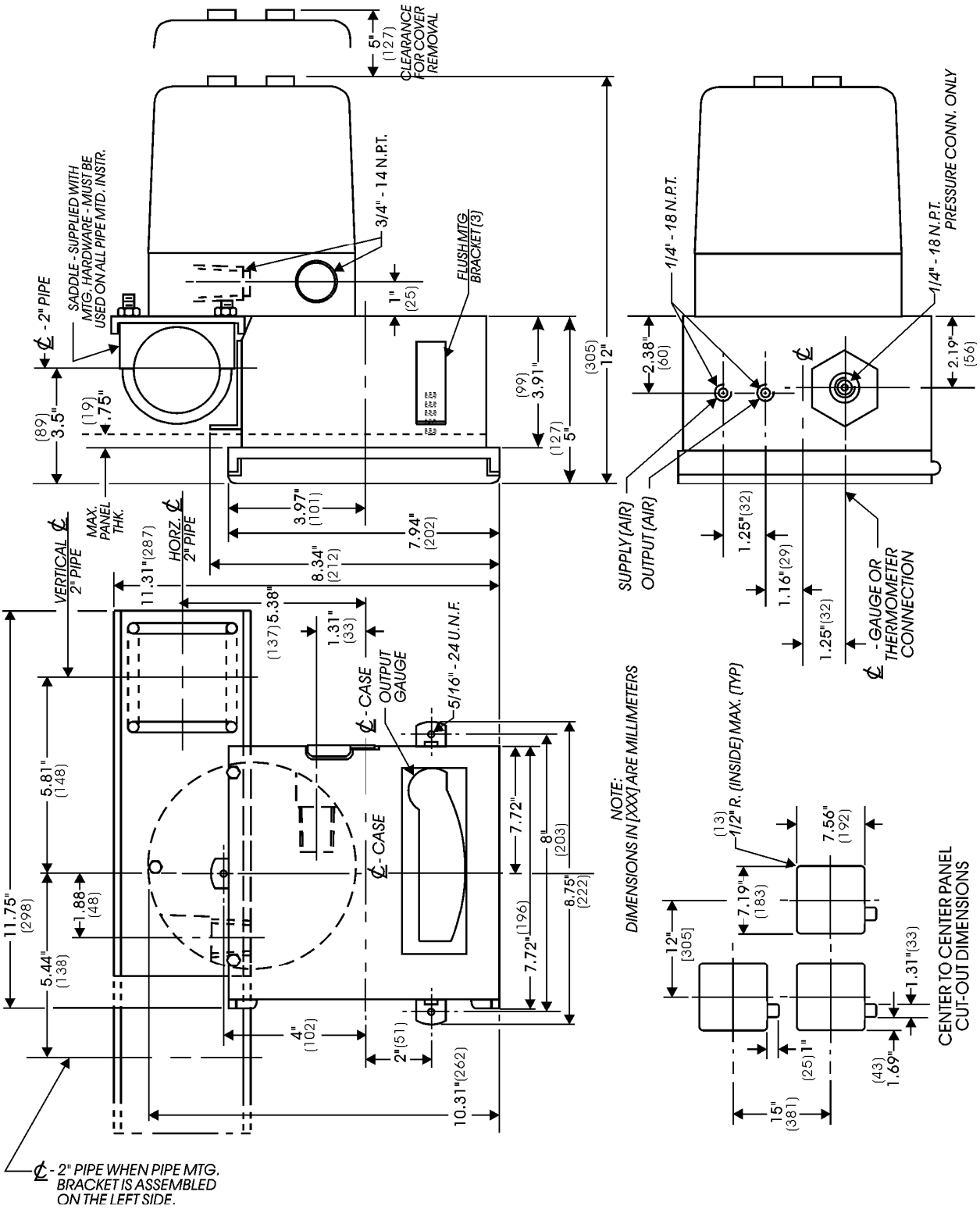


Figure 2A-5 - Models 5457-10G, -40G & -70G

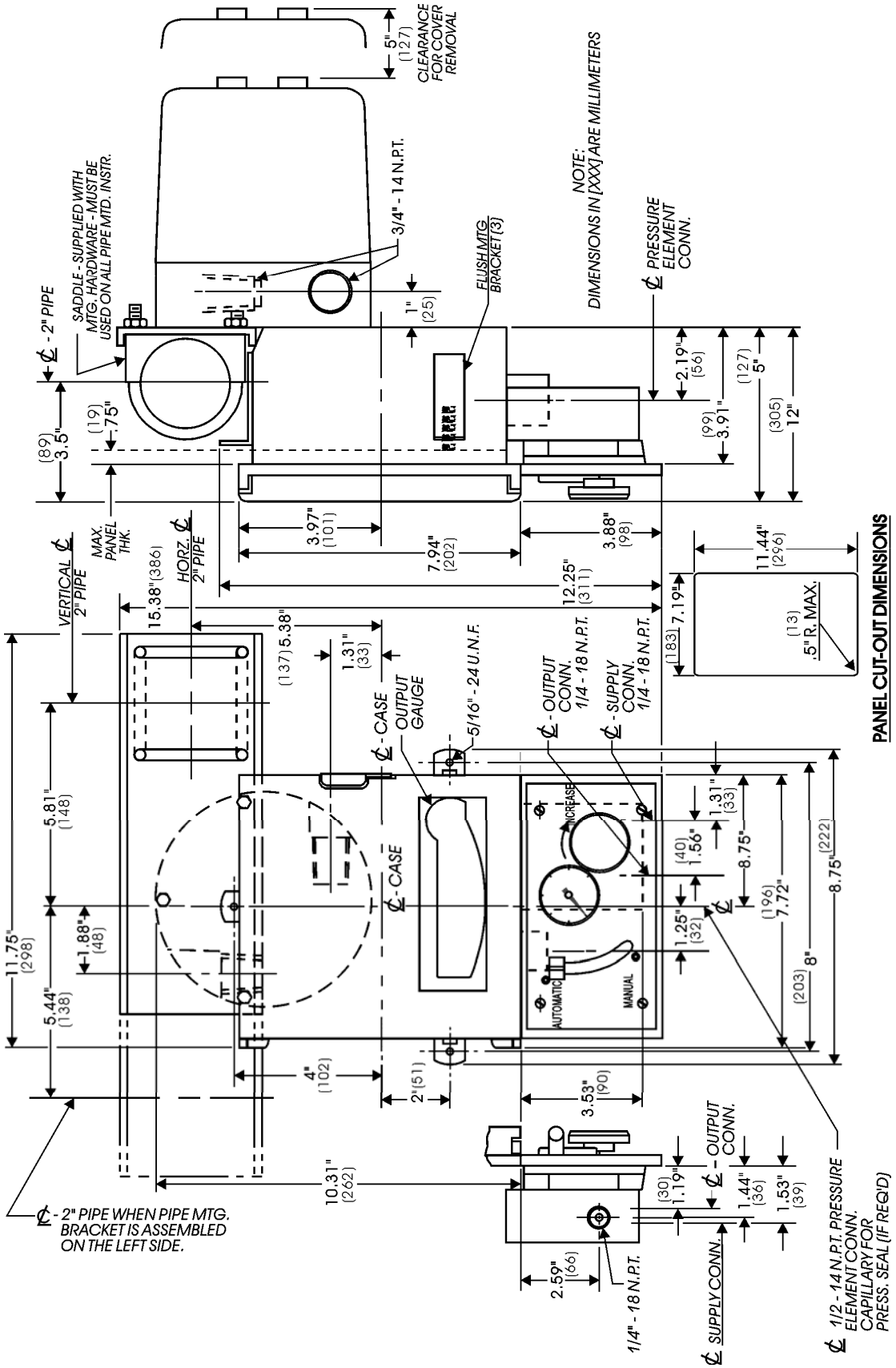


Figure 2A-6 - Models 5457-10G & -40G w/ M-A Station

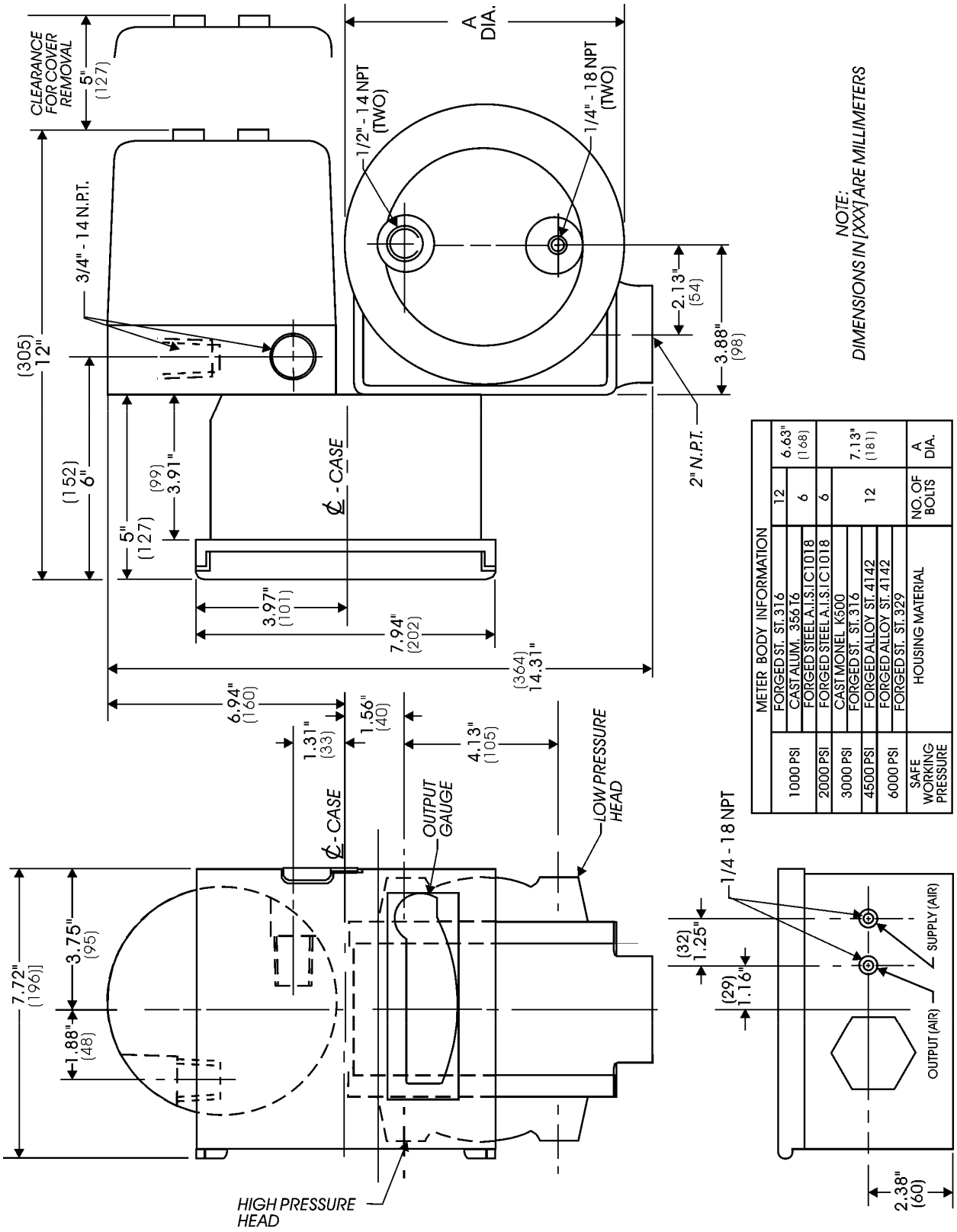
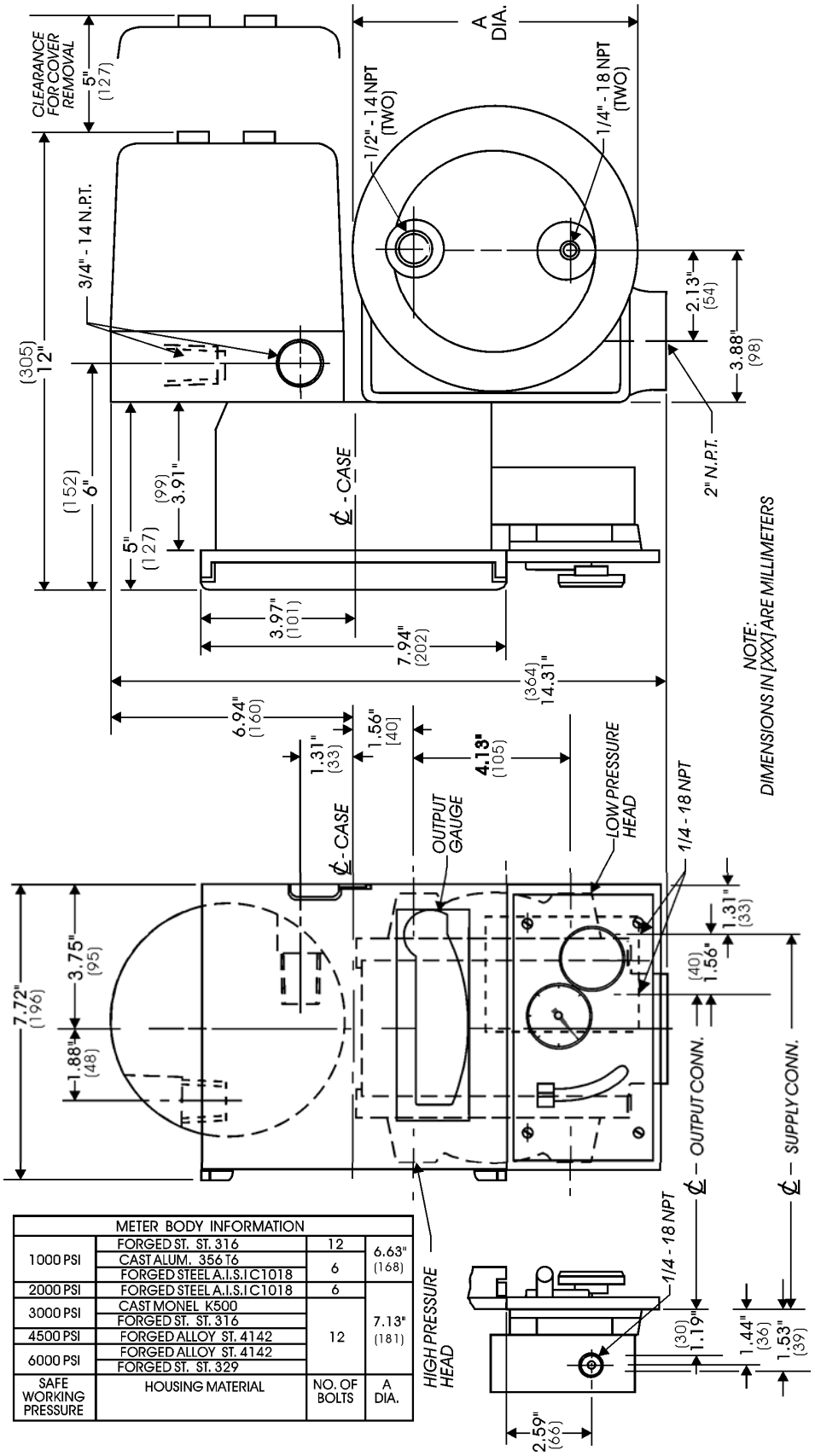


Figure 2A-7 - Model 5457-31G



METER BODY INFORMATION			
1000 PSI	FORGED ST. ST. 316	12	6.63" (168)
	CAST ALUM. 356 T6	6	
	FORGED STEEL A.I.S.I C1018		
2000 PSI	FORGED STEEL A.I.S.I C1018	6	
3000 PSI	CAST MONEL K500	12	7.13" (181)
	FORGED ST. ST. 316		
4500 PSI	FORGED ALLOY ST. 4142		
6000 PSI	FORGED ALLOY ST. 4142		
	FORGED ST. ST. 329		
SAFE WORKING PRESSURE	HOUSING MATERIAL	NO. OF BOLTS	A DIA.

Figure 2A-8 - Model 5457-31G w/ M-A Station

Chapter 3
OPERATION & SERVICE

3.1 GENERAL

This chapter contains operating, servicing, and safety information that is applicable to all instrument models except where noted. Once this information has been covered, you may proceed to one of the chapters listed below for specific information relevant to your model.

Chapter 3A - G-I-D Controller	5453-XXG where (XX = 10, 31 or 40)
Chapter 3B - Differential Gap Controller	5453-XXG where (XX = 10, 31 or 40)
Chapter 3C - Remote Setpoint Actuator	5457-XXG where (XX = 10, 31, 40 or 70)

3.2 STARTING PRECAUTIONS

Before operating the instrument, make sure that it has been properly installed as described in Chapter 2 and that the following warnings are understood:

WARNING

Do not operate instruments with electrical attachments (i.e. alarms, lights, etc.) in hazardous areas where ignitable or explosive atmospheres are present. Doing so may result in fire or explosion. The only exception is the Series 5457-00D Control-ers with Remote Setpoint Actuators; these electrical models have certain lab safety approvals defined in Chapter 3E.

WARNING

If flammable gas is used as the supply pressure source for an instrument installed in a non-hazardous area, make sure the instrument door is tightly shut before applying pressure. Also, check that the instrument's vent connection is piped outdoors away from any potential spark or flame sources.

Pneumatic instruments begin operating the moment supply pressure is applied. Note that controller models may be driven to the extremes of their operating during startup as the control loop begins cycling. For some applications, this could result in damage to the process, equipment, property, and possible injury to persons. You should take precautions to ensure that the process is under some type of guarded control during these critical startup excursions. Optional devices such as the Man-Auto Station may be used with either G-I-D Controllers or Remote Setpoint Actuators to manually control the process during startups and shutdowns.

3.3 GENERAL MAINTENANCE

This section describes instrument care and general maintenance checks. Prior to performing any checks the user should observe these safety precautions:

WARNING

No attempt should be made to service a Series 5450 instrument while it is operating in a hazardous area. Either the area must be made safe, or the instrument must be removed and taken to a safe area.

WARNING

The use flammable gas as a pressure test source is not recommended. Use an air pressure source to guard against accidental ignition.

Instrument Care

The instrument should be inspected and cleaned at regular intervals based on location and usage. Before you start, it is imperative that any electrical options be unplugged or disconnected from the power source to prevent accidental electrical shock.

Internal components of the instrument may be brushed or vacuumed to remove loose dust. Proceed cautiously as some components can easily be thrown out of calibration or damaged by mishandling.

The exterior of the case can be cleaned using a solution of warm water and household detergent. Apply solution sparingly with a moistened cloth. Never spray liquids inside the case as they may react with critical mechanisms and give rise to future problems.

Instrument Cleaning Fluid

Mechanical linkages, valves and restrictions must be kept clean to maintain efficient operation. This can best be accomplished by using isopropyl or denatured alcohol as the cleaning fluid; or, use a fluid that will not attack metallic and plastic parts and will not leave a film that attracts dirt.

Routine Checks

- Optional Air Filter

  Moisture, oil and dirt can collect at the bottom of any external filter in the supply line. To flush out impurities, open the drain valve of the filter (if so equipped) for a few seconds with the supply pressure turned on. This procedure should be performed on a routine basis to prevent build-up of matter. All filters eventually wear out and a scheduled replacement should be performed based on local usage and manufacturers recommendations.

- Supply Port Screen

  A filter screen is located inside the supply port fitting at the bottom of the case (see Figure 2-4). This screen should be checked and cleaned on a regular basis.

- Measuring System

  Each system is different and requires specialized attention. Refer to separate instruction unit furnished for measuring systems. See table of contents.

- Linkages

  Linkages must be kept free of dirt, grease and film. The cleaner recommended for this application is described under the previous topic titled, Instrument Cleaning Fluid. Apply the fluid with a soft brush and allow it to dry. Proceed cautiously as some components can be thrown out of calibration or damaged through mishandling.

- Vent Hole Screen

  The standard vent hole screen at the bottom of the case (Figure 2-4) should be inspected regularly to make sure it is clear. Note that a clogged screen will prevent the controller from operating properly.

3.4 MV LINKAGE CALIBRATION

The section describes the test setup and measurements required to calibrate the MV (Measured Variable) linkage. Typically, most calibration only requires minor touchup of zero and span screw adjustments located on the linkage. Before attempting any checks, observe the following warnings:

WARNING

The tests described here require that the instrument operate at the extremes of its range (0 to 100%). Calibration should never be attempted while an instrument operates in a measurement or control environment as dangerous output conditions may arise. For some applications, this could result in property damage and injury to persons.

WARNING

Calibration should not be performed on instruments operating in hazardous areas or on instruments operating from flammable gas supplies. An accidental spark during testing could result in fire or explosion. Move the instrument to a safe area and use an air pressure source for testing.

Test Conditions

In order to check the calibration, it will be necessary to supply precise levels of 0%, 50% and 100% (±0.1%) to the measuring system (MV input). The type of input signal required will be

a function of the measuring system furnished with the instrument (i.e. pressure, temperature, differential pressure, etc.). The manner, in which this signal is generated, must be determined by the user. If you require further information for supplying test signals, contact Bristol, Inc.

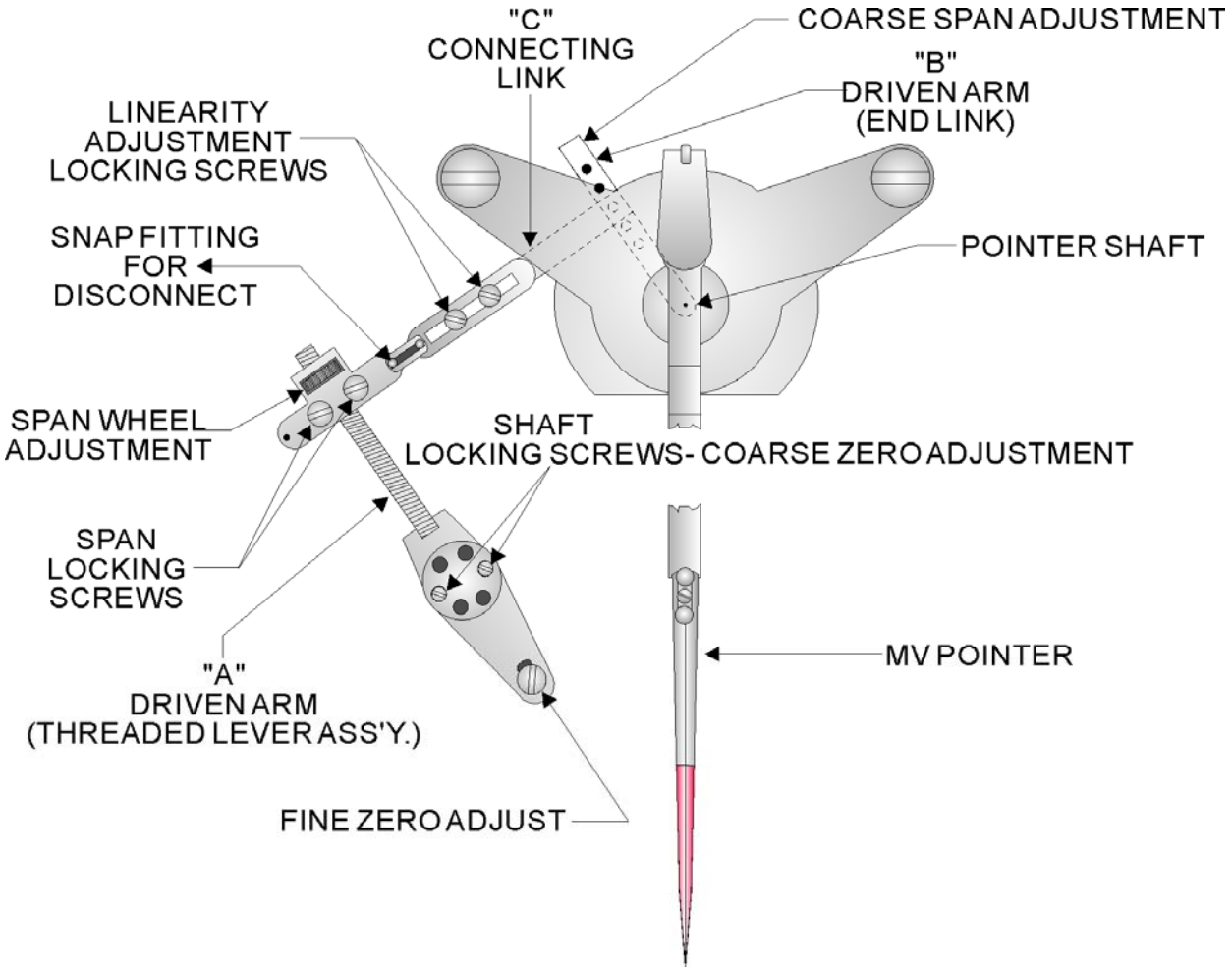


Figure 3-1 - MV Linkage Adjustments

MV Linkage Calibration Procedure

The MV linkage transmits the motion input signal from the measuring system to the MV pointer. This mechanical arrangement, shown in Figure 3-1, contains zero, span and linearity adjustments. The procedure is as follows:

1. Provide input test levels of 0%, 50% and 100% of the measurement span. The MV pointer should track each test level within of ±0.5%. No calibration adjustments will be required if the readings are within tolerance.

2. If the MV pointer readings are displaced by a fixed percentage over the entire scale, a correction can be made by turning the Fine Zero Adjust Screw shown in Figure 3-1. Before using this adjustment, slightly loosen the two Shaft Locking Screws and

turn the Fine Zero Adjust Screw slightly in either direction to correct the error. Secure the locking screws when adjustments are complete.

3. Apply a 100% test input to the instrument. If the MV indication is out of tolerance, a span adjustment will be required. This is accomplished by loosening the two span locking screws on driving arm "A" and turning the Span Adjustment Wheel in small increments to correct the Span Arm Tab setting. This adjustment interacts with the zero adjustment and a recheck of both will be required.

4. If all three check points are within tolerance after zero and span adjustments are completed, no further calibration is required. Otherwise, proceed to step 5.

5. If, after making span and zero adjustments, you find that the readings are within tolerance at the 0% and 100% check points but are off at the 50% point, a linearity adjustment may be required. The Linearity Adjustment is made by first slightly loosening the linearity adjustment locking screws on the connecting linkage and making a slight adjustment in linkage length. An error that is high is corrected by shortening the linkage, while one that is low is corrected by lengthening the linkage. Each time a linearity adjustment is made a recheck of the zero and span adjustments at 0% and 100% points must follow. If the Zero and Span are readjusted, it follows that another linearity check will be required. It may be necessary to repeat these procedures several times until any errors at the three check points are balanced out.

Examples Of Calibration Problems

Apply appropriate 0%, 50% and 100% signals to the input of the instrument and, if it is in calibration the output should read 0%, 50% and 100% of scale. If the instrument is very far out of calibration, you may want to start with 10%, 50% and 90% input signals until the instrument is close to being calibrated and then switch to the 0%, 50% and 100% inputs for the final calibration steps. This procedure will let you observe dial, scale or chart values which will be on the calibration portion.

To check ZERO: See whether 0% input value causes the output motion to coincide with the 0% mark on the chart, scale or dial. If not, adjust as required (see MV Linkage Calibration Procedure step 2, in Section 3.4). See Figure 3-2 (Example 1).

To check SPAN: Subtract the bottom from the top output value. If the resultant is 100%, the span is correct. If not the Span Arm Tab must be adjusted. Perform step 3 of the MV Linkage Calibration Procedure in Section 3.4. See Figure 3-3 (Example 2).

To check LINEARITY: Subtract the middle from the top output value; and the bottom from the middle output value. Compare these two values for equality. If they are equal, there is no linearity problem; but if they are different, the Connecting Link must be adjusted (see step 5 of the MV Linkage Calibration Procedure in this section.

For combinations of two or three problems simultaneously, proceed from the most difficult one present to the least difficult one as shown in Figure 3-4 (Example 3).

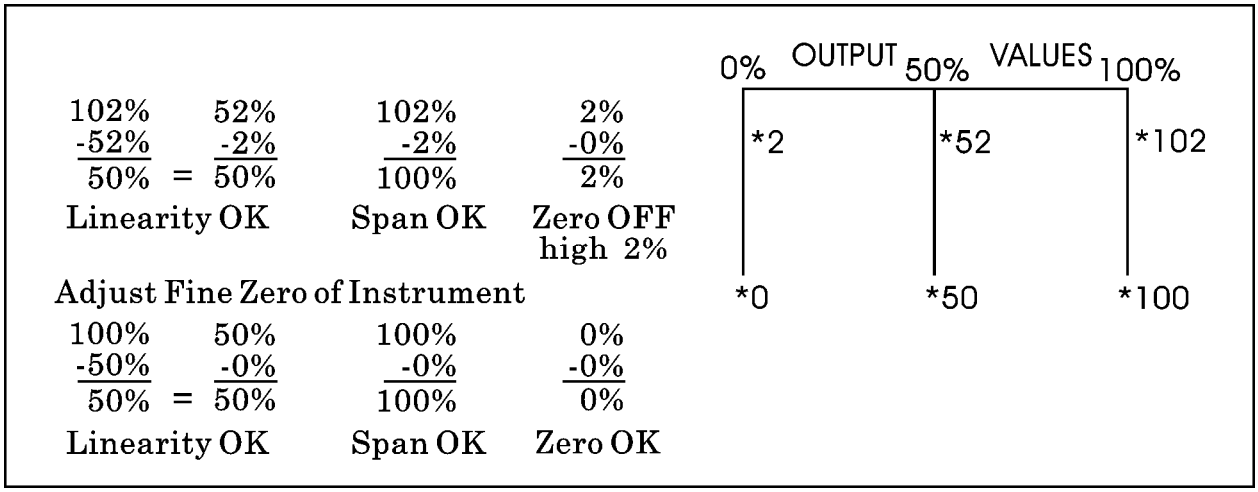


Figure 3-2 - Example 1 - Just a ZERO Problem

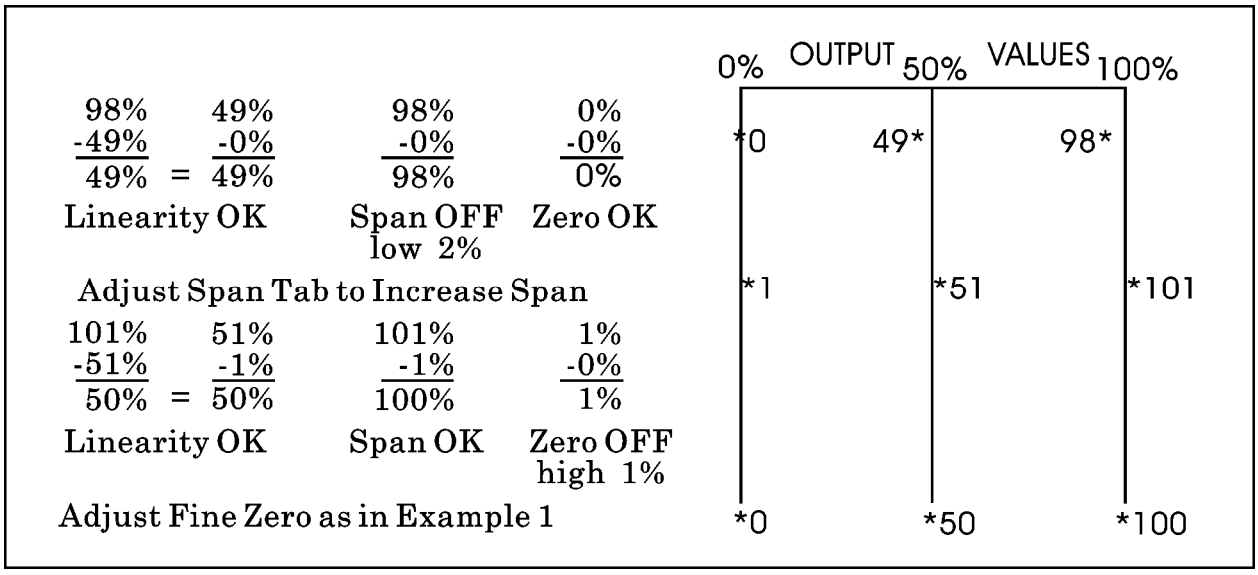


Figure 3-3 - Example 2 - Just a SPAN Problem

Referring to Table 3-1, Figure 3-5 and Table 3-2:

1. Determine calibration difficulty by checking calibration at 0%, 50% and 100% of input values.

2. Make adjustments starting with the most difficult problem present. Proceed to the left of Table 3-2, performing the Zero adjustment last.

   Example: If you determine there is a span problem but no linearity problem, begin by adjusting the span. When it is correct, proceed to adjust zero. See Figure 3-3 (Example 2).

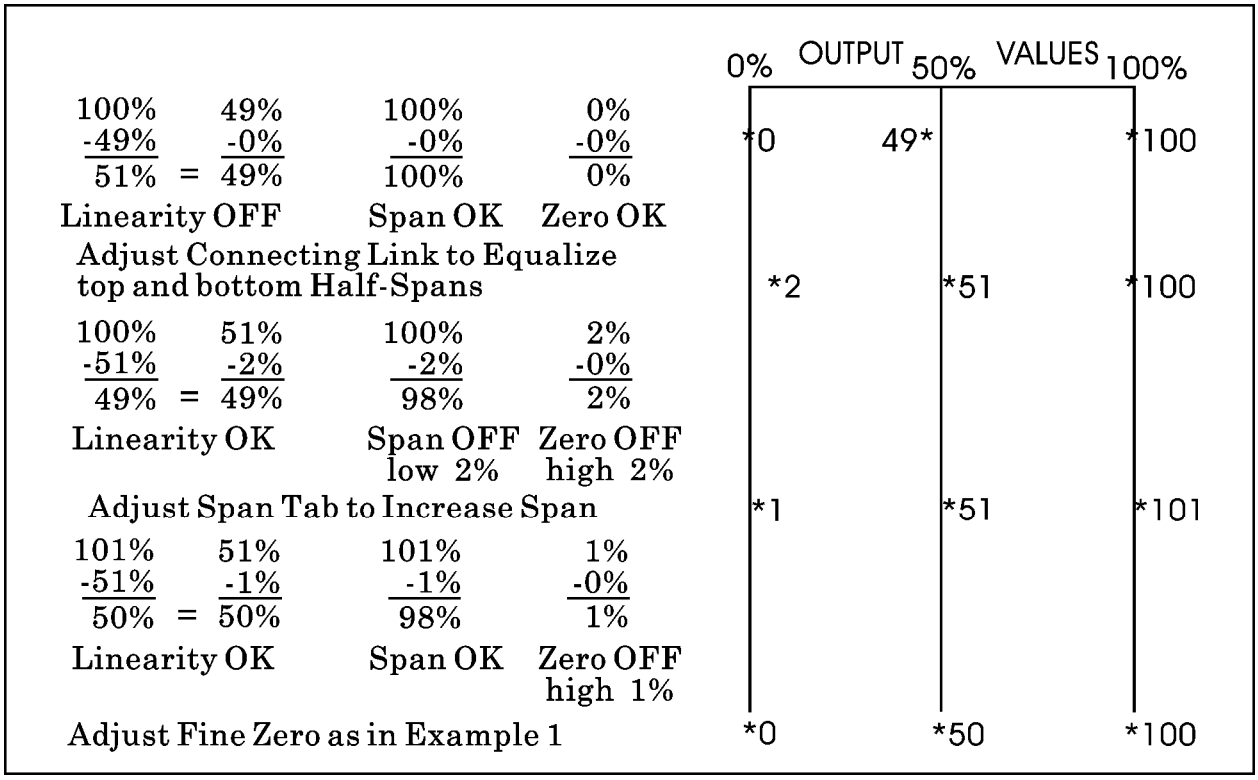


Figure 3-4 - Example 3 - Initially Just a LINEARITY Problem

Table 3-1 - Linearity Adjustment Table - For H & Z Style Links

Percent of Full Scale → 0%	When motion in: Lower part of scale is	50%	When motion in: Upper part of scale is	100%	For increasing values of the measured variable, when Arm A: Pulls on Link C	For increasing values of the measured variable, when Arm A: Pushes on Link C
Pen or Indicator Motion	Too Great		Too Small		Shorten Link C (H) Lengthen Link C (Z)	Lengthen Link C (H) Shorten Link C (Z)
Pen or Indicator Motion	Too Small		Too Great		Lengthen Link C (H) Shorten Link C (Z)	Shorten Link C (H) Lengthen Link C (Z)
Pen or Indicator Motion	Equal or Just Right		Equal or Just Right		Do Not Change C	Do Not Change C

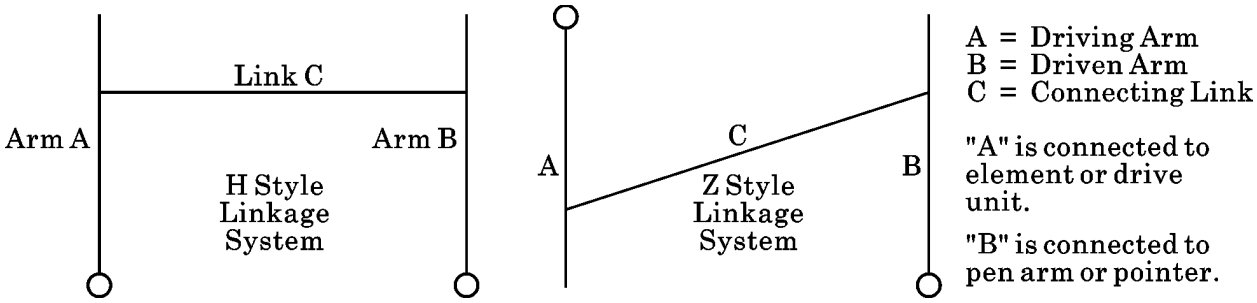


Figure 3-5 - H & Z Style Linkage Systems

Table 3-2 - Zero/Span/Linearity Calibration Table

CHANGING Vs. AFFECTS	ZERO	SPAN	LINEARITY
ZERO	YES	YES	YES
SPAN	NO	YES	YES
LINEARITY	NO	NO	YES
SEE EXAMPLES	Fig. 3-11 EXAMPLE 1	Fig. 3-12 EXAMPLE 2	Fig. 3-13 EXAMPLE 3
CALIBRATION DIFFICULTY	LEAST	MODERATE	MOST

3.5 624-II CONTROL SECTION CALIBRATION

It is important that all calibration procedures outlined here be followed in the proper sequence. Do not attempt any detailed calibration procedures without first performing the "On-Line" test procedures of either the section called "On-Line" Check Of Control Section For Gain Only Type (1-Mode) Units or "On-Line" Check Of Control Section For 2-3 Mode Type (G.I.D.) Units (select as required). In the majority of cases, the results of the "On-Line" tests will provide positive results and eliminate the time and avoid the necessity of detailed bench checks.

Control units that are specified with different output ranges (3-15 psi, 3-27 psi and 6-30 psi) will produce different readings during calibration. In the procedures that follow, only the readings for 3-15 psi type Controllers will be listed. These readings will be followed by a single asterisk (*) which refers the reader to Table 3-3 or Table 3-4. These Tables contain corresponding readings for the other output ranges.

Similarly, Control Units may be specified with a gain range of 0.25 to 10 or 2.5 to 100. Only the readings for the 0.25 to 10 range will be given. These will be followed by a double asterisk (**) that refers the reader to Table 3-5 for the equivalent readings on the 2.5 to 100 gain types.

The MV Linkage calibration checks of Section 3.4 can be performed "on-line" at the process location. The process loop must initially be placed in manual operation by a Man-Auto Station or other means, and a responsible operator must maintain steady safe manual control during these tests. Under no circumstance should the instrument be in control of

the process while calibration is performed. It is also important that notations of the previous setpoint, along with gain, integral and derivative settings, be recorded so that a safe return can be made to automatic operation once calibration was been completed.

"On-Line" Check Of Control Section for Gain Only Type (1-Mode) Units

(see Figures 3-1 & 3-9)

1. Read the previous paragraphs of Section 3.5 before starting.

2. Place the process loop in question under manual control as instructed in the opening paragraphs of this section.

3. Adjust the supply pressure for 20* psi.

4. The MV signal will be at some arbitrary value based on the process measurement. Align the Setpointer with the MV Pointer.

5. Set the Gain Adjust to 2.0** on the DIRECT Scale. The Controller Output Gauge should read 9* psi (±0.2 psi).

6. Rotate the Gain Adjust to 2.0** on the REVERSE Scale. A jump in output pressure should be noted as the Gain Knob is rotated through the DIRECT-REVERSE crossover point. The output pressure should stabilize quickly on the REVERSE Scale and remain at 9* psi.

7. If the output pressure reading obtained on the REVERSE Scale differs from that on the DIRECT Scale, shift the Setpointer slightly to the right or left of the MV Pointer and repeat steps 4 and 5. If pressure readings are still unequal on both scales, continue to experiment with the Setpointer settings until the output readings balance out.

8. If the Setpointer Balance Point is offset from the MV Pointer by a small amount, correct it by turning the Setpoint Adjustment Screw on the Setpointer. For larger errors, turn the Setpoint Adjustment Screw to the middle of its range and turn the Input Beam Adjust Screw on the Controller (Figure 3-9) to correct. Readjust the Setpoint Adjust Screw if required.

9. When balance is achieved, repeat steps 6 and 7 using gain settings of 10** on the DIRECT and REVERSE Scales.

10. Disconnect the MV Pointer Linkage at the output of the measuring device by inserting a screwdriver into the snap fitting on the Threaded Lever Arm (Figure 3-1) and apply a half turn to release.

11. Move the Setpointer to any value on the scale.

12. Position the MV Pointer until it is aligned with the Setpointer. The output should return to 9* psi. If the results of step 9 to 12 are normal, then the Input Beam is properly aligned for all positions of coincidence of the MV Pointer and Setpointer.

13. Reconnect the linkage to the measuring element. Calibration is complete. Restore the process to normal AUTO control.

14. If the Controller does not respond to calibration, proceed to the section titled Test Stand Calibration Procedure.

"On-Line" Check Of Control Section For 2 & 3-Mode Type (G.I.D.) Units

(see Figure 3-9)

1. Read the first four paragraphs of Section 3.5 before starting.

2. Place the process loop in question under manual control as instructed in the opening paragraphs of this section.

3. Adjust the supply pressure for 20* psi.

4. The MV signal will be at some arbitrary value based on the process measurement. Align the Setpointer with the MV Pointer.

5. Set the Gain Adjust to 2.0** on the DIRECT Scale. The Controller Output Gauge should read 9* psi (±0.2 psi).

6. If the unit has the Derivative Adjustment Screw, set to the BYPASS position to eliminate derivative action.

7. Set the Integral Adjustment Screw to 20 repeats/minute. Move the Setpointer slowly in either direction along its scale until 9* psi is observed on the Controller Output Gauge. Continue to experiment until a setting is found that maintains the steady 9* psi value.

8. Lock the 9* psi signal of the previous step by placing Integral Adjust into the CLOSED position.

9. Rotate the Gain Adjust to 0.3** on the DIRECT Scale and then to 0.3** on the REVERSE Scale. Note that as gain is turned from DIRECT to REVERSE or vice-versa, a jitter or oscillation may occur. If so, continue to move Gain Adjust to a high scale value for a moment until the reading stabilizes. Then set gain to the desired value. The Controller output gauge should hold steady at some value, but not necessarily 9* psi for both gain settings.

10. Repeat step 8 using a gain setting of 1.0**. The output should remain steady at some value. If the output pressure creeps up or down, move the Setpointer along its scale until stability is achieved.

11. Repeat step 8 using a gain setting of 10.0**. If necessary, move the Setpointer up or downscale slowly to stabilize the output pressure.

12. If the Setpointer indication is now displaced from the MV Pointer by a small amount, correct it by turning the Setpoint Adjustment Screw to the middle of its range and turn the Input Beam Adjustment Screw on the Control Unit (see Figure 3-9) to correct. Readjust the Setpoint Screw if required.

13. Calibration is now complete. If satisfactory calibration has been achieved, restore Controller settings for normal operating and transfer back to AUTO control. If errors are still present, proceed to the section titled Test Stand Calibration Procedure.

Test Stand Calibration Procedure

Certain adjustments at the top of the Controller are not accessible inside the case and require the use of a special Test Calibration Fixture for bench calibration (see Figure 3-9).

Detailed bench calibration requires a regulated supply pressure, a large paper clip and an accurate pressure gauge (readable to 0.1 psi and used to monitor the Controller's output pressure).

CAUTION

This procedure is intended for control units having severe misalignment problems. It should not be performed until all "on-line" procedures have been tried.

Removal of Controller from Case

Removal of the Controller may vary slightly for different models.

1. Remove the supply pressure connection from the Controller.

2. Remove any indicating scales or other components to access the Controller. Be careful not to force or bend any linkages or arms.

3. Disconnect the Input Beam "A" (see Figure 3-6) of the Controller from the vertical Input Link "J." The snap fitting on the linkage opens with a half turn of a screwdriver. ***Do not loosen any linearity adjustment screws on the linkage during disassembly, as complete recalibration will be required.***

4. Loosen the two captive mounting screws that secure the Controller to the enclosure.

5. Remove the Controller from the instrument.

CAUTION

DO NOT remove the Controller by grabbing the Gain Cap. This could bend the Rock Arm Assembly causing unnecessary repairs and alignment problems.

Gain Pointer Adjustment

6. Rotate the Gain Cap "G" until the tip of the forward Rocker Arm is on the top of the Input Beam Pivot Shaft "E" (see Figure 3-7). This is where the Gain = 0.0 (on the line between the Direct and Reverse modes) (see Figure 3-6).

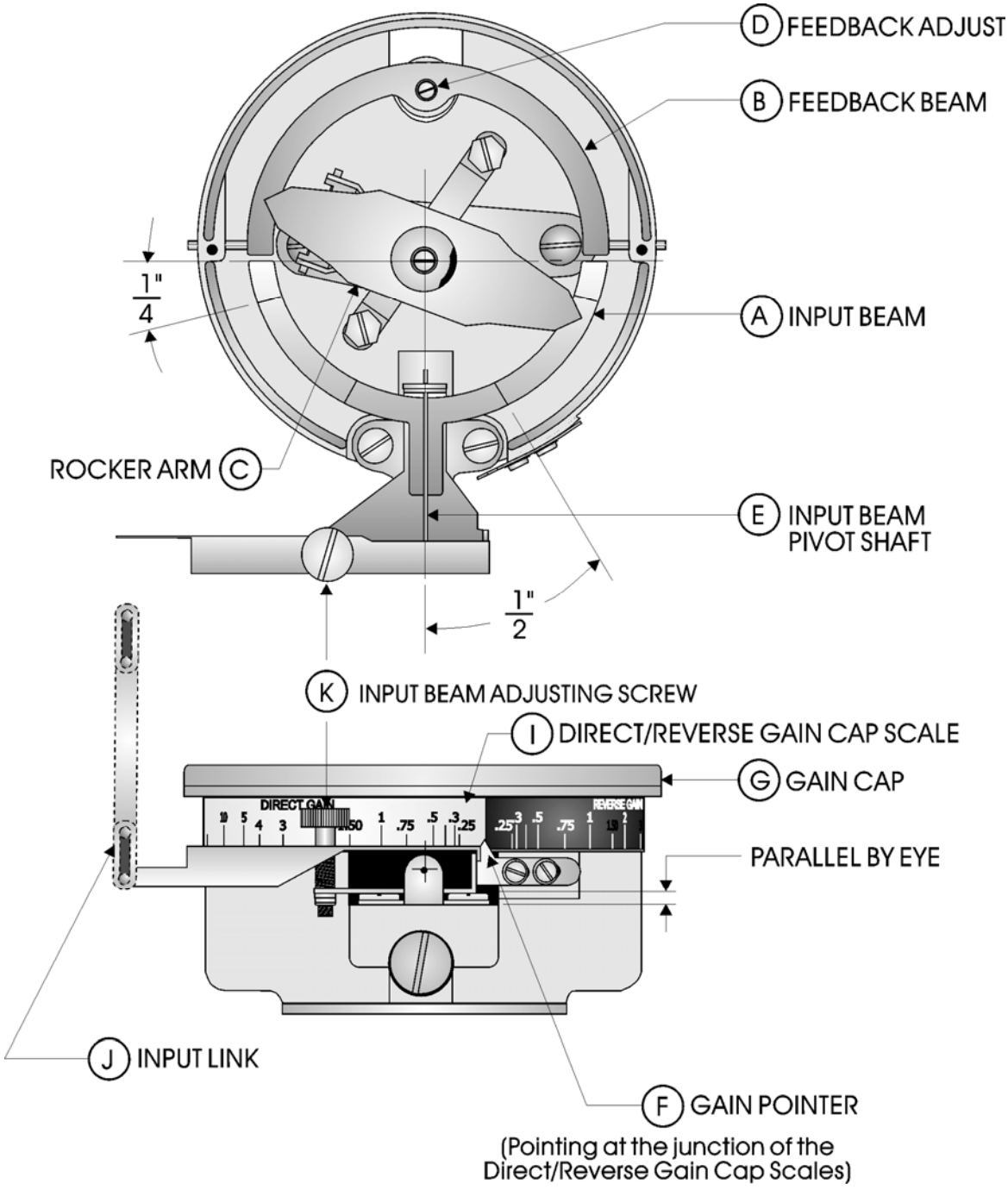


Figure 3-6 - Transmitter Calibration Sketch #1

7. Adjust the Gain Pointer "F" so that it points at the junction of the Direct/Reverse Gain Cap Scale "I" (see Figure 3-6).

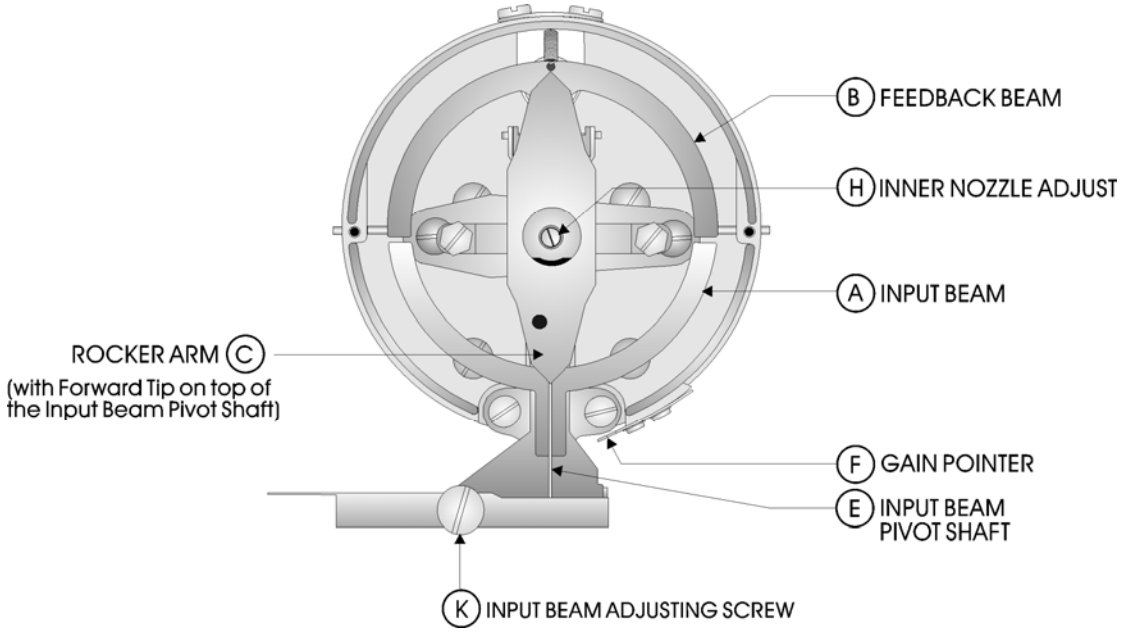


Figure 3-7 - Transmitter Calibration Sketch #2

Marking the Input Beam

To perform the Feedback and Inner Nozzle adjustments (steps 34 through 43), the Gain Cap "G" will have to be removed from the Controller. "Marking the Input Beam" will make it easier to set the proper gain without having to replace the Gain Cap each time.

8. With a pencil or permanent marker, place marks on the Input Beam "A" (see Figure 3-8 at 0.3**, 1.0**, 2.0** and 10** Gain Settings for both the Reverse and Direct sides.

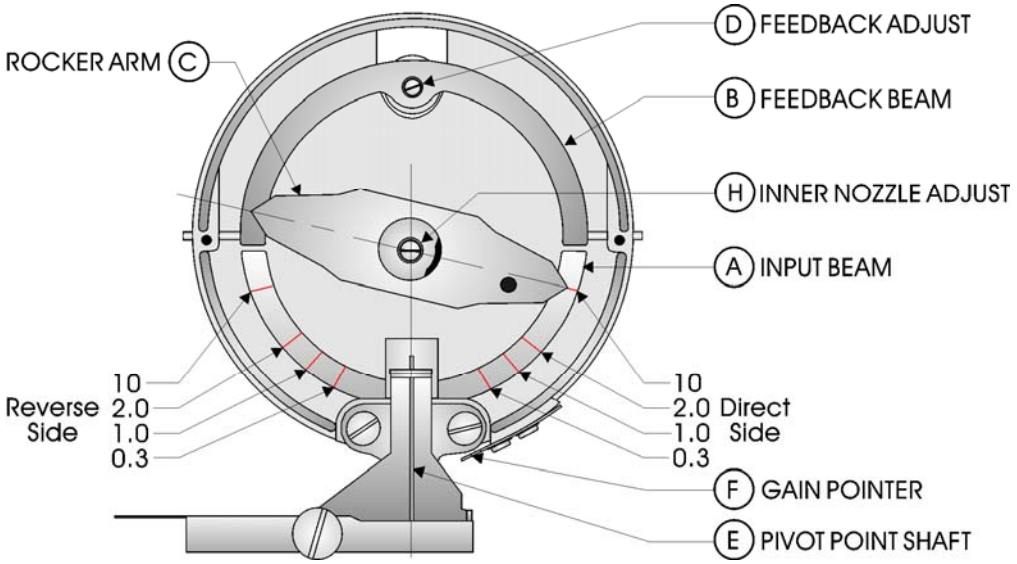


Figure 3-8 - Transmitter Calibration Sketch #3 (Gain = 10/Reverse)

9. Replace the Gain Cap.

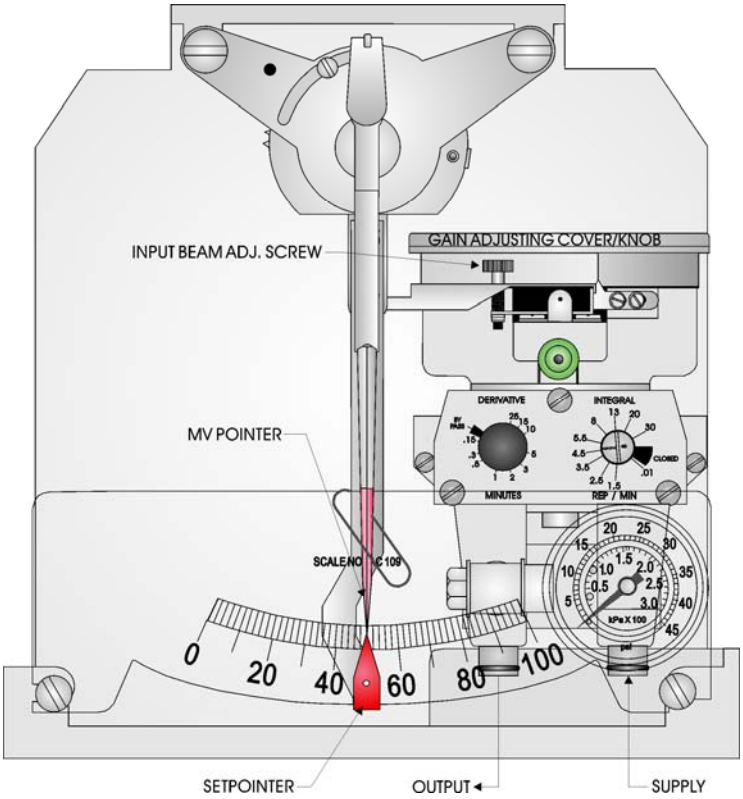


Figure 3-9 - Transmitter In Calibration Test Fixture

Mounting Controller In The Test Stand

10. Mount the Controller in the Test Fixture (see Figure 3-9) using two captive screws.

11. Connect the Test Stand's Connecting Link to the Input Beam on the Controller.

12. Connect Controller as shown in Figure 3-10 and adjust the regulated supply source to 20 psi* (see Table 3-3).

Table 3-3 - Supply Pressure Values (1 psi = 6.894757 kPa)

Controller Output Range	Supply Pressure Range
3-15 psi* (20.7-103.4 kPa)*	18-20 psi* (-137.9 kPa)*
3-27 psi (20.7-186.2 kPa)	30-32 psi (206.8- 220.6 kPa)
6-30 psi (41.4-206.8 kPa)	33-35 psi (227.5-241.3 kPa)

Table 3-4 - Output Pressure Values (1 psi = 6.894757 kPa)

Controller Output %	3-15 psi Range % Values**	3-27 psi Range % Values	6-30 psi Range % Values
0%	3.0 psi (20.7 kPa)	3.0 psi (20.7 kPa)	6.0 psi (41.4 kPa)
25%	6.0 psi (41.4 kPa)	9.0 psi (62.0 kPa)	12.0 psi (82.8 kPa)
50%	9.0 psi (62.0 kPa)	15.0 psi (103.4 kPa)	18.0 psi (124.0 kPa)
75%	12.0 psi (82.8 kPa)	21.0 psi (144.8 kPa)	24.0 psi (165.5 kPa)
100%	15.0 psi (103.4 kPa)	27.0 psi (186.2 kPa)	30.0 psi (206.8 kPa)

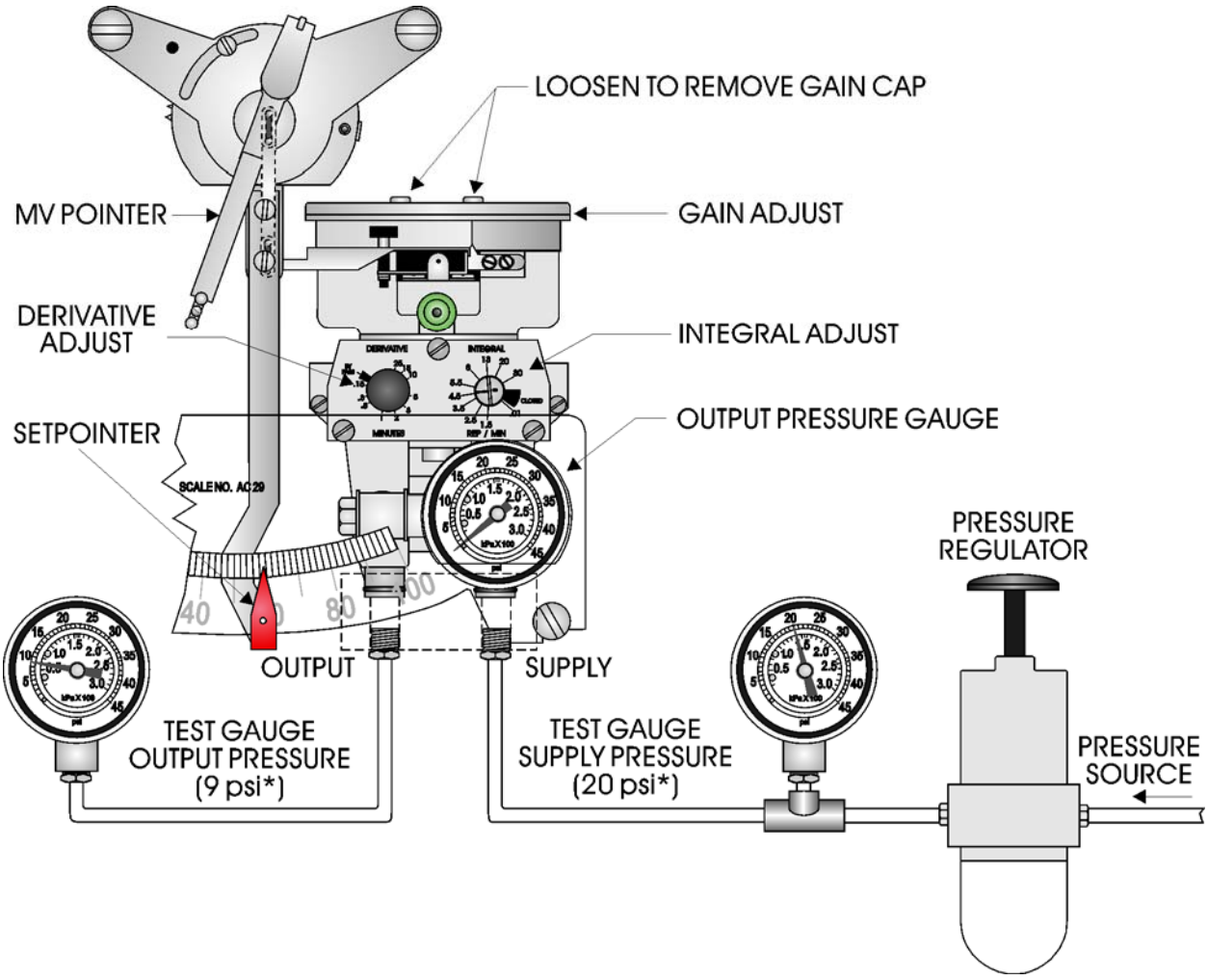


Figure 3-10 - Controller Calibration Setup

Integral Valve Checks

13. Set the DERIVATIVE Adjustment Screw to the BYPASS position if used (see Figure 3-11).

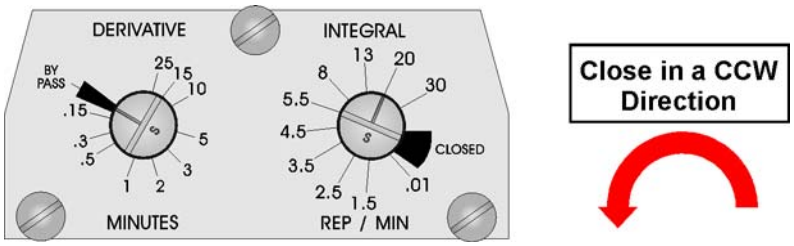


Figure 3-11 - Controller's Derivative & Gain Adjustments

14. Set the GAIN adjustment to 2** (see Table 3-5) on the REVERSE scale.

15. Set the INTEGRAL adjustment to 20 Repeats per Minute (REP/MIN) (see Figure 3-11).

16. Load the Feedback Capsule with a 50% (9.0 psi*) output pressure signal (see Table 3-4). This is accomplished by using the Setpointer, Measured Variable Pointer, and the Gain adjustment to get a 50% output signal on the Output Pressure Test Gauge. The pressure should remain steady for at least 15 seconds.

17. Close the Integral Valve using a counter clockwise rotation (CCW) (turn toward the lower reset values).

Integral Leaks

18. Set the Setpoint for an output pressure reading of about 75% (12 psi*) of the Controller's Output Range on the Test Gauge (see Table 3-4).

Integral Operation

19. The pressure of the previous step should remain constant for at least a minute. If the pressure drifts more than 0.1 psi, the Integral valve might be leaky and need repair prior to proceeding.

20. Open the Integral Valve to a value of 1.5 Repeats per Minute (REP/MIN). The output pressure should start to increase.

21. Increase the Integral Valve to 8 REP/MIN. The output should increase faster. As you further increase the Integral Valve setting to 30 REP/MIN, the output pressure should increase faster until it reaches the saturation point, which is approximately the supply pressure. This shows the Integral Valve is functioning properly.

NOTE: If the output pressure does not change, the integral section is plugged and needs to be repaired before proceeding.

Set the Feedback Beam Height

22. Set the Gain adjustment to 2** (see Table 3-5) on the Reverse side.

23. Set the Integral adjustment to 20 REP/MIN (see Figure 3-11).

24. Load the Feedback Capsule with a 50% (9.0 psi*) output pressure signal. This is accomplished by using the Setpointer, Measured Variable Pointer, and the Gain adjustment to get a 50% output signal on the Output Pressure Test Gauge (see Table 3-4). The pressure should remain steady for at least 15 seconds.

25. Close the Integral Valve using a counter clockwise rotation (CCW) (turn toward the lower reset values).

Pointer Alignment

26. Move the Setpointer to the 50% mark.

27. Anchor the Measured Variable (MV) Pointer to the scale at the 50% mark with a paper clip (see Figure 3-9).

Note: The MV Pointer and the Set Pointer must be pointing at each other.

Table 3-5 - Gain Range & Gain Test Values

Gain Range	Gain Test Setting
.25 - 10**	.3** 1** 2** 10**
2.5 - 100	3 10 20 100

28. Set the GAIN adjustment to 0.3** (see Table 3-5) on the REVERSE Scale.

29. Check that the Output Pressure Test Gauge reading (it can be any value applicable to the unit in question (see Table 3-4), i.e., from 3-15 psi, 3-27 psi or 6-30 psi.

30. Set the GAIN adjustment to 0.3** (see Table 3-5) on the DIRECT Scale.

31. Note the Output Pressure Test Gauge reading (it can be any positive reading).

32. Split the difference in output pressure between the readings in step 29 and step 31 and balance the Input Beam "A" by adjusting the Input Beam Adjusting Screw "K."

33. Repeat steps 28 through 32 until the output reading is exactly the same on both sides of the Input Beam. This is the most important step in the 624-II calibration.

34. Repeat steps 28 through 33 using a Gain Setting of 1 or 10 (depending on the unit's Gain Range) (see table 3-5) in steps 28 and 30. Go to step 35 after step 33.

35. Repeat steps 28 through 33 using a Gain Setting of 2 or 20 (depending on the unit's Gain Range) (see table 3-5) in steps 28 and 30. Go to step 36 after step 33.

36. Repeat steps 28 through 33 using a Gain Setting of 10 or 100 (depending on the unit's Gain Range) (see table 3-5) in steps 28 and 30. Go to step 37 after step 33.

Zero And Feedback Adjustments

37. Remove the Gain Cap (Cover).

38. Set the Rocker Arm "C" to the Gain setting of .3** (see table 3-5) for your use (DIRECT or REVERSE).

39. Adjust the Feedback Adjustment "D" for a 9.0 psi* reading (see Table 3-4) on the Output Pressure Test Gauge.

40. Move the Rocker Arm "C" to the Gain Setting of 10** (see table 3-5) on the same side (DIRECT or REVERSE).

41. Adjust the Inner Nozzle "H" for a 9 psi* reading (see Table 3-4) on the Output Pressure Test Gauge.

42. Repeat steps 38 through 41 until the Test Gauge remains at 9.0 psi* ±0.1 psi (see Table 3-4).

43. Repeat steps 22 through 41 to verify proper calibration.

44. Verify proper operation by checking the calibration on the opposite side of the Controller (DIRECT or REVERSE). If calibration is off it is possible that the Input Beam or Feedback Beam is bent.

45. Set the GAIN adjustment to 2** (see Table 3-5) on the REVERSE Scale and the Setpointer to 50%. The Output Pressure Test Gauge should equal 50% of the Controller's Output Range, i.e., 9.0 psi* (see Table 3-4) when the Measured Variable Pointer is in alignment with the Setpointer.

46. Set the Measured Variable Pointer to 75%. The Output Pressure Test Gauge should read 3.0 psi* (see Table 3-4).

47. Set the Measured Variable Pointer to 25%. The Output Pressure Test Gauge should read 15 psi* (see Table 3-4).

48. Keep the Measured Variable Pointer at 25% for a minute. The Test Gauge pressure should remain constant. If it drifts, it is a sign of a leaky Integral Valve.

Final Check

49. Align the MV Pointer and the Setpointer. The Output Pressure Test Gauge should read 50% (9.0 psi*) of the Controller's output range (see Table 3-4).

50. Adjust the Integral Valve Clockwise (CW) to 20 REP/MIN. If 50% (9.0 psi*) of the Controller's output range was locked in the Integral Chamber at the initial set-up, the output pressure will not move.

51. If the output pressure increases or decreases, move the Setpointer until the Output Pressure Test Gauge reading remains steady within the Controller's Output Range, i.e., between 3.0 psi* and 15.0 psi* (see Table 3-4). If the MV Pointer and the Setpointer are not in alignment and this amount of error is acceptable, you should either quit or start over at step 22.

52. Remove the supply pressure.

53. Remove the Controller from the Test Stand.

54. Install the Gain Cap (Cover).

55. Re-install the Controller in the Instrument case.

56. Apply the correct supply pressure.

REMEMBER when replacing a calibrated Control Unit, the only adjustment necessary might be the Input Beam balance using steps 22 through 36. *DO NOT MAKE ANY OTHER ADJUSTMENTS*. After the controller has been checked out, install it into the Series 5450 Controller and follow the MV Linkage Calibration Procedure in Section 3.4.

- To adjust the Input Beam balance inside the Instrument Case, the Controller should be Off-Line.
- To make it easier to align the Measured Variable Pointer with the Setpointer, disconnect the Measured Variable Connecting Link from the Measured Variable (see Figure 3-9).

Mounting Calibrated 624-II Control Unit into the Series 5450 Controller

Take the Control unit, which has previously been calibrated on the Test Stand, and install it into the Series 5450 Controller. Connect Input Linkage "J" (see Figure 3-12) and follow "on-line" checking procedures. Disconnect the instrument from its process.

1. Connect and apply 20* psi to the instrument.

2. Lock 9* psi into the Feedback Chamber.

3. Move the Setpointer opposite the MV Pointer.

4. Adjust the Gain Cap from 10 DIRECT to 10 REVERSE. The output should read 9* psi.

5. If the output does not read 9* psi, then the Input Beam is not balanced (see Figure 3-6.

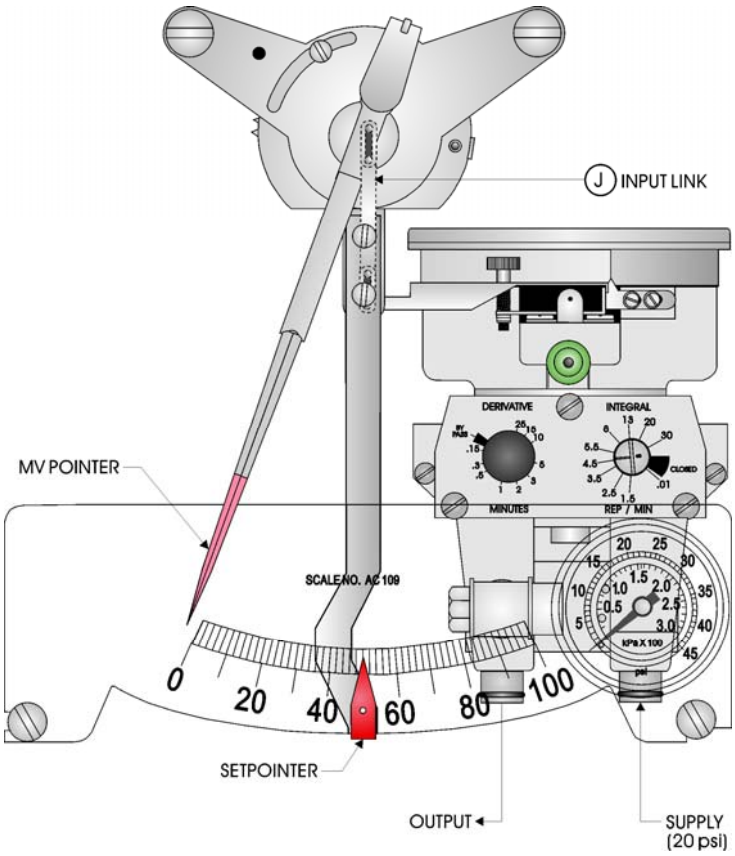


Figure 3-12 - Transmitter In 545X Controller

Chapter 3A
G-I-D CONTROLLER

3A.1 GENERAL DESCRIPTION

Series 5453-XXG Indicating Controllers (Figure 3A-1) are used for process measurement and control. These instruments utilize a pneumatic control unit to maintain a measured variable (MV) at a controlled setpoint.

The MV input to the controller is obtained by one of several types of measuring systems. The base model number identifies the type of system furnished with a controller. Refer to Chapter 1 - Introduction, for a listing of measurement systems.

Series 5453-XXG Controllers are offered with various combinations of control modes (Gain-Integral-Derivative). A Gain range of .25 to 10 is standard for all models, while a range of 2.5 to 100 is optional. The optional Integral mode has a range of .01 to 30 repeats, while the optional Derivative mode has a range of 0 to 30 minutes.

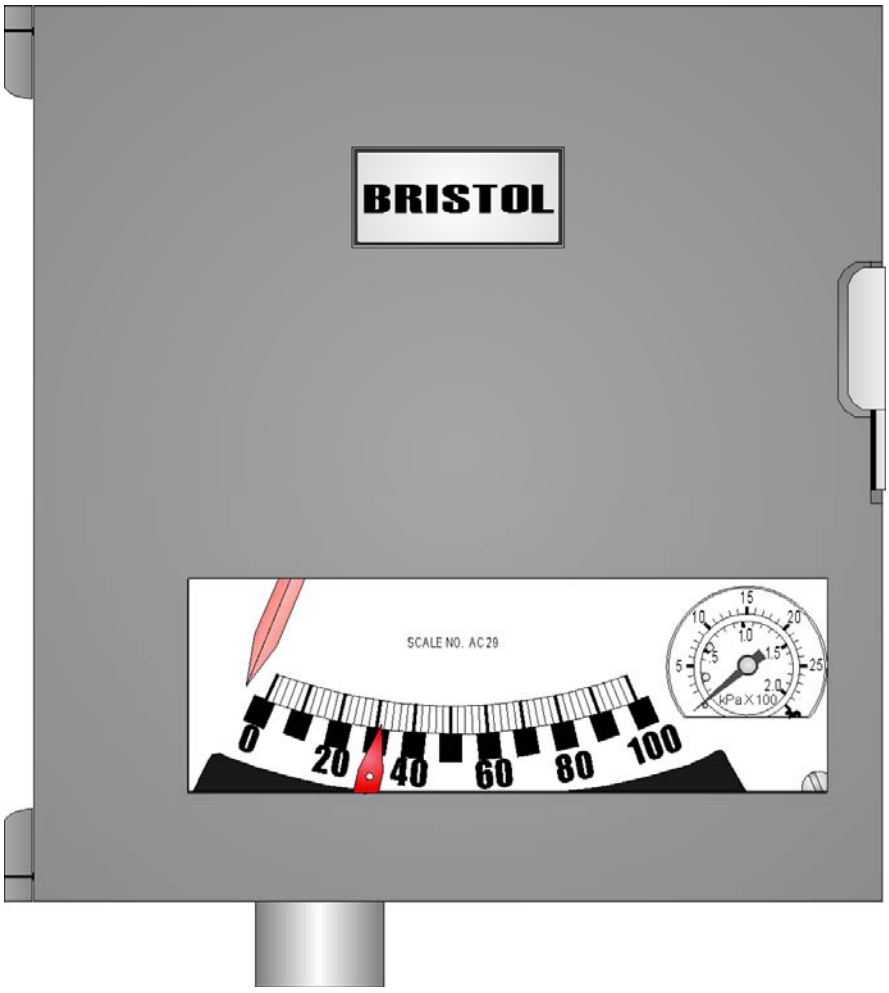


Fig. 3A-1 - Series 5453-XXG

Controllers may be specified with a 3-15 psi, 3-27 psi, or 6-30 psi output range. Each of these outputs operates from different supply pressures.

Some models may be equipped with an optional Manual-Automatic Station to provide selection of either manual or automatic control. These stations are offered with 3-15 psi or 3-27 psi outputs.

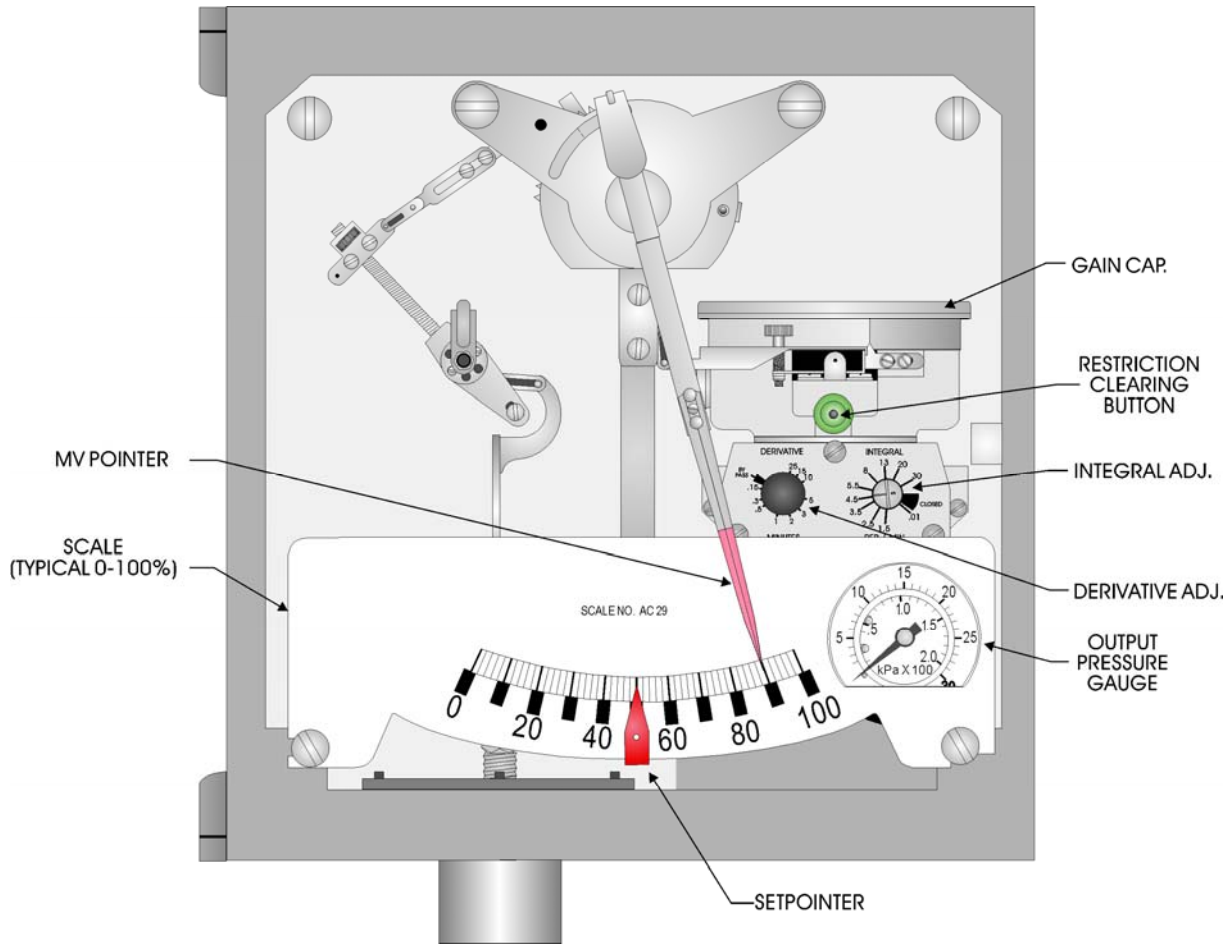


Figure 3A-2 - Operating Adjustments

3A.2 OPERATION

This section describes the operating controls, startup procedures, mode tuning and use of the Man-Auto Station.

Operating Controls and Adjustments

The user should become familiar with the controls and adjustments of the controller before attempting operation. The function of each is as follows:

- MV Pointer:

  Tracks the value of measured variable (MV) over the range of the scale. Once the process has stabilized, this pointer operates in close proximity to the Setpointer.

- Setpointer:

  Determines the value at which the process will be controlled. It is adjustable over the full range of the scale.

- Output Pressure Gauge:

  Monitors the output pressure and may have a 0-30 psi or 0-45 psi scale depending upon the instrument range. See instrument data plate for output range.

- Gain Adjust (Proportional Band):

  Regulates the amount of change that a change of MV has on the controller output. Gain mode may be specified with a standard .25 to 10 range or an optional 2.5 to 100 range. This adjustment also selects Direct or Reverse control action. Direct action is achieved by using the light part of the scale, while Reverse action is obtained by using the dark part. Both scales provide the full range of Gain.

- Integral Adjust:

  Used to counteract offset effects of gain mode caused by variations in the process load. The Integral screw adjustment covers a range from .01 to 30 repeats-per-minute. When this setting is optimized for a process, integral corrective action will correct the controller output to remove offset error. If the adjustment screw is turned to the CLOSE position, integral pressure will be locked in for tuning or calibrating purposes. A setting of .01 repeats may be used during tuning to eliminate integral action.

- Derivative Adjust:

  Used to speed up corrective action and minimize control lag. The Derivative screw adjustment range is from 0 to 30 minutes. If the adjustment screw is turned to the BYPASS position, derivative mode will be shut off.

- Restriction Clearing Button (Optional):

  Provided as a convenient method to remove debris from the restriction of the control unit. This button should be pressed several times to dislodge any matter that may be introduced through the external supply source.

Initial Startup and Process Tuning

The following general procedure is intended for use with processes that are safe to cycle at startup. If the process is critical and cannot tolerate wide cyclic excursions, some other techniques should be used. Contact Bristol Babcock if further information is required.

1. If a Manual-Automatic Station is included set its Selector Switch to AUTO.

2. Set Gain Adjust to 2 on either DIRECT or REVERSE acting portion of scale as required.

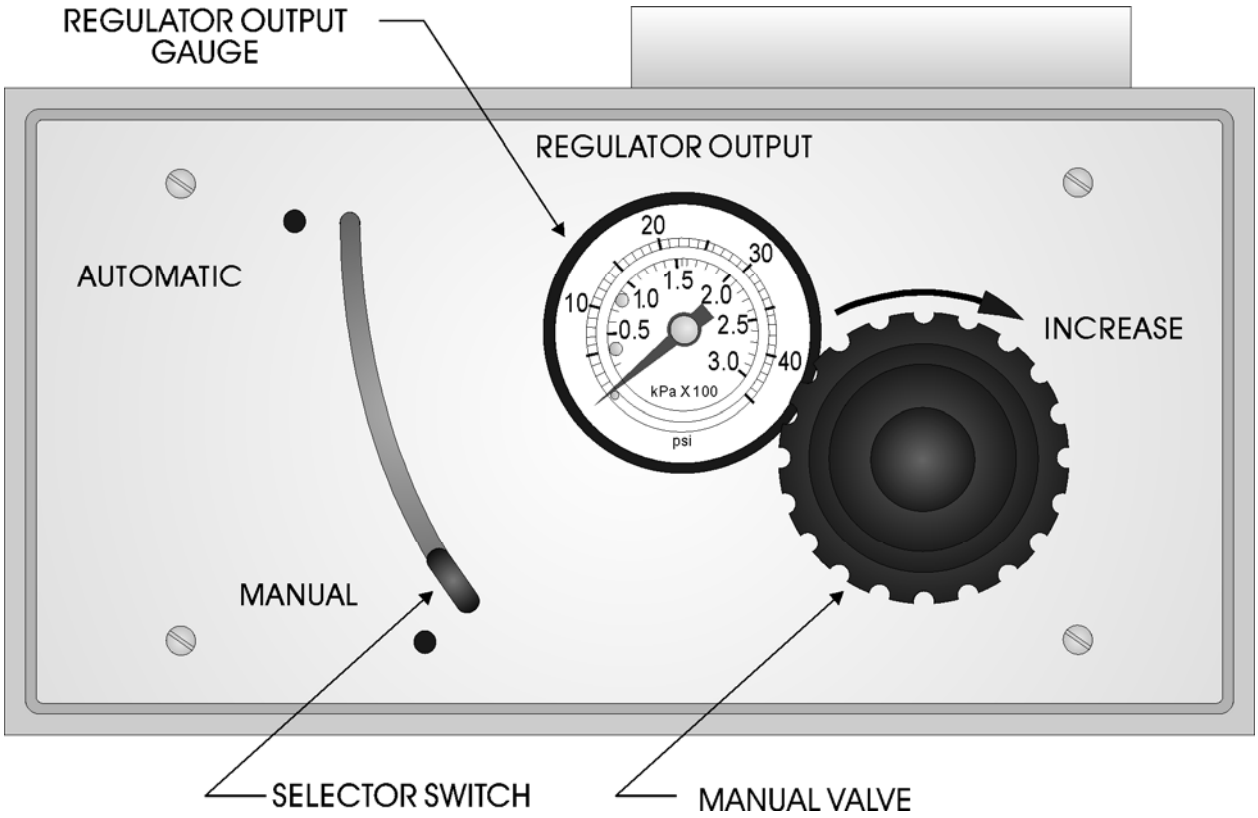


Figure 3A-3 - Manual-Automatic Station

3. For 2 and 3-mode controller models, set Integral Adjust to .01 REPEATS and Derivative Adjust to BYPASS.

4. Adjust Setpointer to desired value on indicating scale.

5. Turn on supply pressure valve and/or external pressure regulator valve. Adjust valve for proper supply pressure.

6. Turn on external process valves (pressure, steam, water, chemicals, and so forth).

7. Process is now under automatic control. Allow process to stabilize.

8. Manually shift the Setpointer up or downscale a slight amount and observe the action of the MV pointer.

9. At this stage, the pointer may begin cycling at a steady rate. Slowly increase or decrease the Gain Adjust Knob to a point where uniform constant amplitude oscillation of the MV pointer occurs. The gain setting that produces this oscillation is defined as ultimate gain (G_u).

10. The initial gain setting is calculated as follows:

    Maximum setting of gain adjust = 0.5 G_u

11. When gain mode is used by itself (1-mode), some amount of natural offset will occur depending upon whether the process load is light or heavy. This condition is normal for 1-mode operation (gain only) and offset will become greater as Gain Adjust is decreased from 0.5 G_u value.

12. The final gain setting must be determined by experimentation. In most cases, the Gain Adjust should not be increased above 0.5 G_u as higher sensitivity may produce oscillation or "jitters." Procedure is now complete. Continue on to step 13 for 2-mode controllers, or step 15 for 3- mode controllers.

13. For 2-mode controllers, manually shift the Setpointer up or downscale a slight amount and measure the time required for the MV pointer to pass through one complete cycle (use an accurate timepiece). Initial settings for ultimate gain (G_u) and the ultimate period (P_u expressed in minutes) are determined as follows:

    Maximum setting of gain adjust = 0.45 G_u (per steps 9 & 10)
    Maximum setting of integral adjust = 1.2/P_u

14. Experiment with settings slightly below the calculated values to achieve best process stability.

15. For 3-mode controllers, manually shift the Setpointer up or downscale a slight amount and measure the time required for the MV pointer to pass through one com-plete cycle (use an accurate timepiece). Initial settings are computed via the ultimate gain (G_u) and the ultimate period (P_u expressed in minutes). Initial settings are com-puted as follows:

    New gain adjust setting = 0.6 G_u
    Integral adjust setting = 2/P_u
    Derivative adjust setting = P_u/8

16. Experiment with settings slightly below the calculated values to achieve best process stability. Startup procedure is complete for 3-mode controllers.

Routine Shutdowns and Startups

Once a controller has been properly set and tuned, it can be closed down by shutting OFF the supply pressure. Subsequent startups can be performed by turning ON the supply. It is normally not necessary to retune the control mode adjustments (gain, integral and derivative) unless different process substances are employed. In these instances, a record of the mode settings for each process should be kept to avoid the need for retuning.

Using Manual-Automatic Stations

Controllers with Manual-Automatic Stations (Figure 3A-3) are typically started in Manual mode and transferred over to Automatic mode for normal controller operation. Conversely, a controller operating in Automatic mode will be closed down in Manual mode.

A transfer from manual to automatic mode is made as follows:

1. Adjust Setpointer until the reading on the Output Gauge of the controller is the same as the reading on the Output Gauge of the station (Figure 3A-2). This procedure balances automatic control level to manual control level.

2. Throw the Selector Switch to the AUTO position. The controlling instrument now operates automatically.

A transfer from automatic to manual mode is made as follows:

1. Adjust the Manual Regulator Valve so that the reading on the station's output gauge (Figure 3A-2) equals the reading on the output gauge of the controller. Manual and automatic output control levels are now balanced.

2. Throw the Selector Switch to MANUAL.

3. Readjust the Manual Valve to the required safe shutdown level of the process, if necessary.

4. Turn off external process devices as required.

3A.3 THEORY OF OPERATION

This section explains the internal mechanism of 1, 2, and 3-mode controllers and includes a description of the Manual-Automatic Station. Technicians qualified to perform service and calibration procedures may find this tutorial helpful before proceeding with sections 3A.4 and 3A.5.

One Mode Controllers (Gain Only)

Figure 3A-4 shows a simplified schematic of a 1-mode control unit interconnected by linkage to the MV pointer, Setpointer and the measuring element (capsular pressure element shown). The measuring element, in operation, moves the pointer and indicates the value of the measured variable (i.e., pressure, temperature or flow). Any movement of the pointer is transferred via linkage to one end of a Differential Beam. The setpoint adjustment moves the opposing end of the beam.

When the measured variable goes above or below the selected setpoint, the Differential Beam rotates around the setpoint pivot. This causes the Error Signal Linkage attached to the beam to move up or down in proportion to the error difference. This relationship is expressed as follows:

$$\text{Error} = (\text{MV} - \text{SP})$$

where: MV = Measured variable signal
SP = Setpoint signal

The Error Signal Linkage transfers its motion to the Input Beam of the control unit. As such, the "C-shaped" Beam is pivoted along the B-B axis. Simultaneously, the Feedback Beam is pivoted along the A-A axis due to an inverse motion generated in the Feedback Capsule.

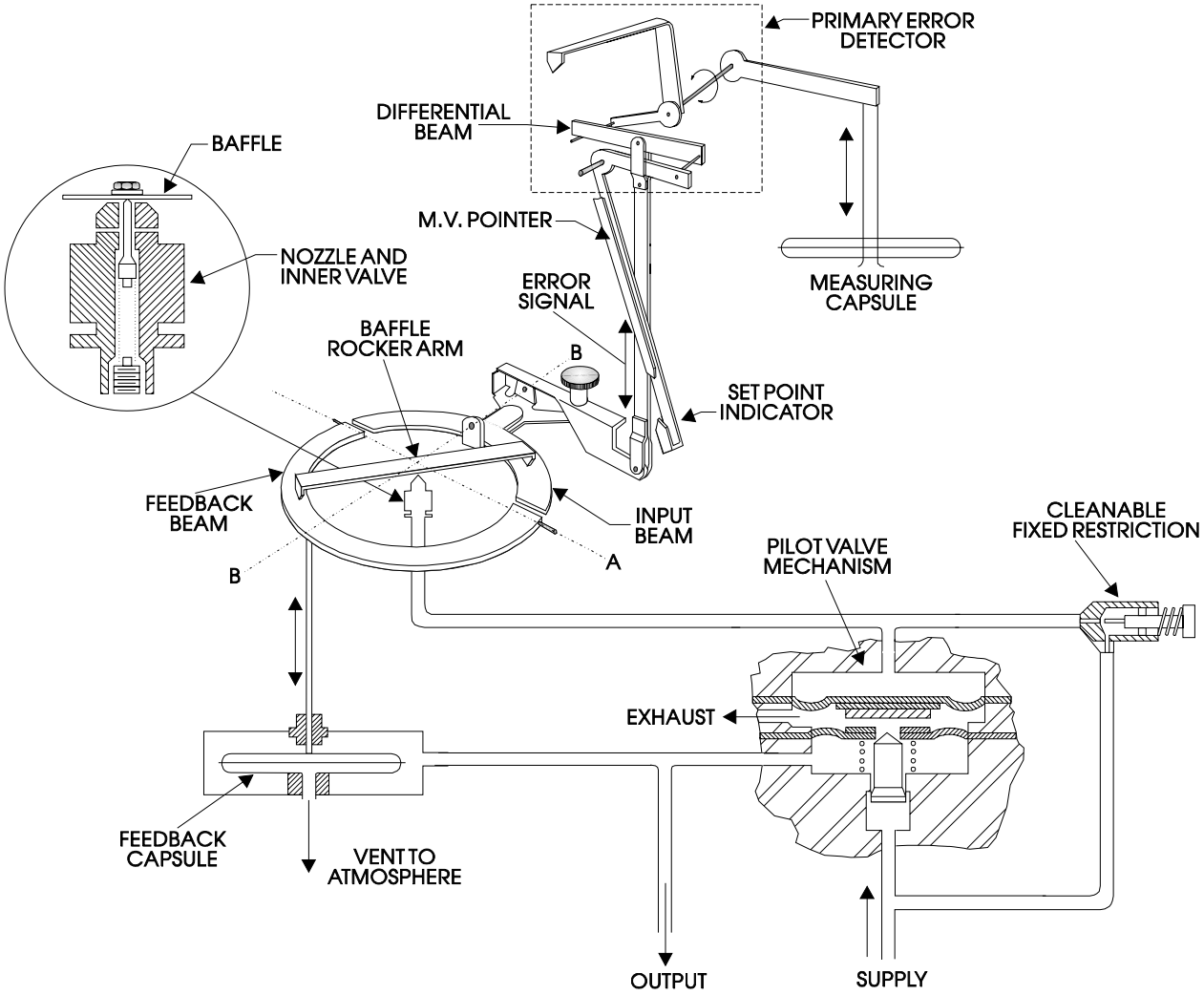


Figure 3A-4 - Schematic of 1-Mode Controller

The Baffle Rocker Arm, shown resting atop the two beams, is mechanically coupled to the Gain Adjust Knob (not shown). Turning the knob will cause the Rocker Arm to rotate anywhere between the two beams. When the arm is set along the B-B axis, the input motion is at a minimum and the opposing feedback motion to the Inner Valve is at a maximum, thus providing low gain or a wide proportional band. Conversely, when the Rocker Arm is set along the A-A axis, the input motion is at a maximum and the feedback motion to the Inner Valve is at a minimum, thus providing high gain or a narrow proportional band. Moving the arm across the B-B axis changes the unit from a "direct" to "reverse" acting control output. Gain settings along this axis are identical to those along the A-A axis except that the output action is reversed.

Movement of the Rocker Arm against the Inner Valve produces changes in the back-pressure that is sensed by the pilot valve. The Pilot Valve amplifies the low-level back-pressure signal and converts it to the required output range (3-15 psi or 3-27 psi). These signals, in turn, operate a process control valve or similar device and provide correction necessary to return the measured variable back to the setpoint. The system is balanced out when the measured variable signal is at the setpoint.

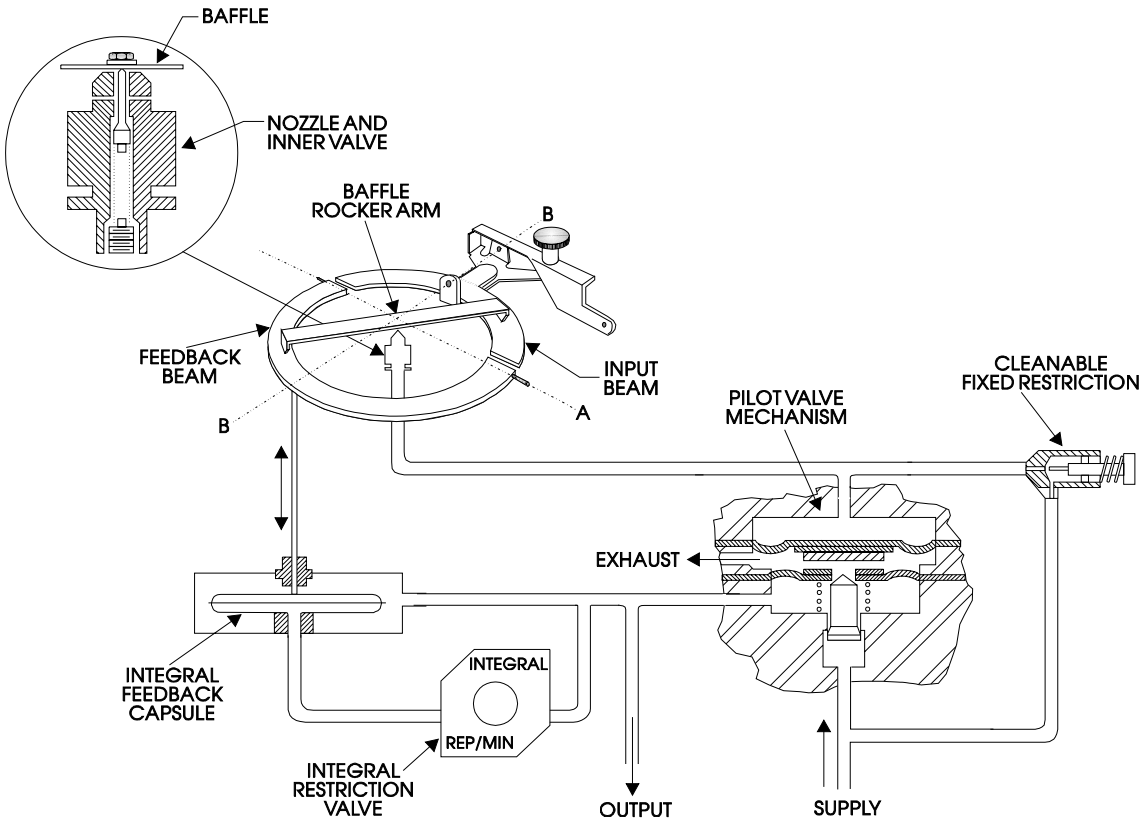


Figure 3A-5 - Schematic of 2-Mode Controller

Two Mode Controllers (Gain + Integral)

This type (Figure 3A-5) is similar in appearance to the gain unit except that the design of the feedback element has been altered to include an Adjustable Integral Scratch Valve Assembly. Normal gain mode feedback pressure is applied to the exterior of the Feedback Cap-sule, while a delayed feedback pressure is introduced to the interior of the Feedback Cap-sule through the Integral Restriction Valve. Therefore, capsular movement is influenced by both gain and integral feedback pressures. This combined motion is transmitted to the Feedback Beam of the Secondary Error Detector to provide two-mode control action.

Three Mode Controllers (Gain + Integral + Derivative)

For these models, two feedback systems consisting of an Integral Capsule and a Derivative Bellows are yoked together so that they generate opposing forces against each other (see Figure 3A-6). Feedback pressure to the two elements is received through separate Integral and Derivative Valves. Both forces influence movement of the Feedback Beam.

The Derivative Bellows initially reduces negative feedback response since its action on the Feedback Pin aids the initial signal change. The Derivative Valve setting temporarily controls the delay of negative feedback, thereby producing a derivative response.

The action of the Integral Capsule opposes the Derivative Bellow's motion and initially gives negative feedback. The Integral Valve, by restricting the flow of pressure into the Integral Capsule, delays positive feedback and integral action takes place.

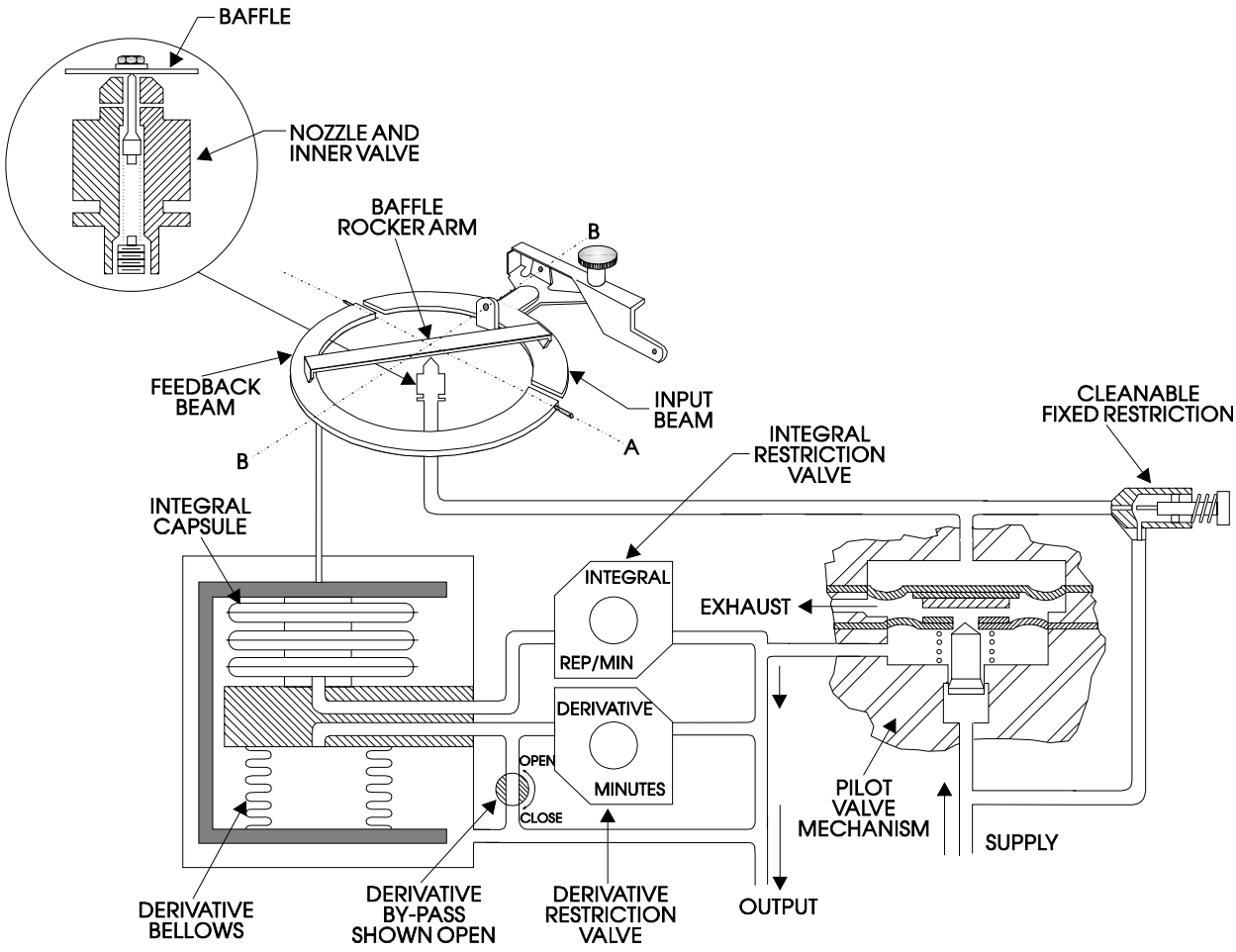


Figure 3A-6 - Schematic of 3-Mode Controller

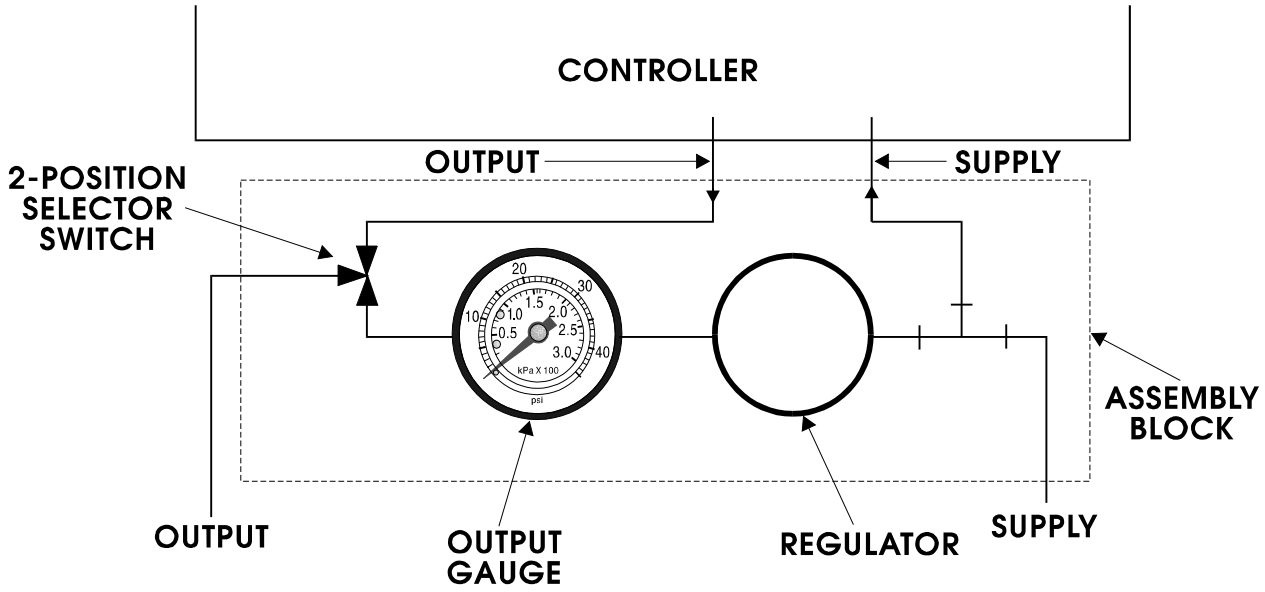


Figure 3A-7 - Schematic of Manual-Automatic Station

Manual-Automatic Station

A schematic for the optional Manual-Automatic Station is shown in Figure 3A-7. It consists essentially of a Regulator, Output Gauge, and a Two-position Switch. When the Selector Switch is in MAN position, the AUTO output is blocked and the output pressure of the regulator passes through the valve to the external control element. When the Selector Switch is set to AUTO, the regulator pressure is blocked and the output of the controller is transferred to the external control element.

3A.4 SERVICE

Before performing any service procedures described here, refer to Chapter 3, section 3.3 for general maintenance and safety warnings.

Troubleshooting

Some typical problems that may be encountered in the field are as follows:

- Output Pressure High or Always On:

  If the reading on the Output Gauge remains high regardless of the Setpointer setting or MV indication, check the Knurled Nut that holds the Restriction Clearing Button in place. Make sure the nut is fully seated. If it is loose, tighten only with fingers. The nut location is shown in Figure 3A-9.

  If the Restriction Clearing Button is jammed due to presence of dirt or foreign substances, shut off the supply pressure. Loosen the Knurled Nut and remove the button assembly. Inject a small amount of Instrument Cleaning Fluid (referenced in section 3.3) into the opening. Replace the assembly and nut. Adjust the supply pressure to its proper level. It may be necessary to repeat this operation several times before the material is dislodged.

- Output Pressure Always Low:

  Check the diaphragm of the external control valve for punctures or leaks in the output pressure line. The Pilot Valve Plunger of the control unit may also be jammed in a manner that restricts the output pressure. Check restriction in the same manner described above for high pressure.

- Slow Integral Rate Not Obtainable:

  The Integral Scratch Valve may leak and require replacement. Remove the three Plate Screws shown in Figure 3A-9 and inspect for dirt or scratches.

- Fast Integral Rate Not Obtainable:

  Check the control unit for leakage of the Integral Feedback Capsule. If the Scratch Valve is plugged, remove and clean it with instrument cleaning fluid. The three Plate Screws of Figure 3A-9 are removed to access the Integral Valve.

- Output Pressure Saturates - No Control:

  If the output saturates and remains hung up regardless of MV change, the Gain Adj. may be set to DIRECT for a direct-acting process or to REVERSE for a reverse-acting process. Turn Gain to opposite segment.:

- Erratic Control Action:

  Check the filter/screen assembled into the supply port for clogging. Also check vent screen at the bottom of the case (or external vent) for clogging.

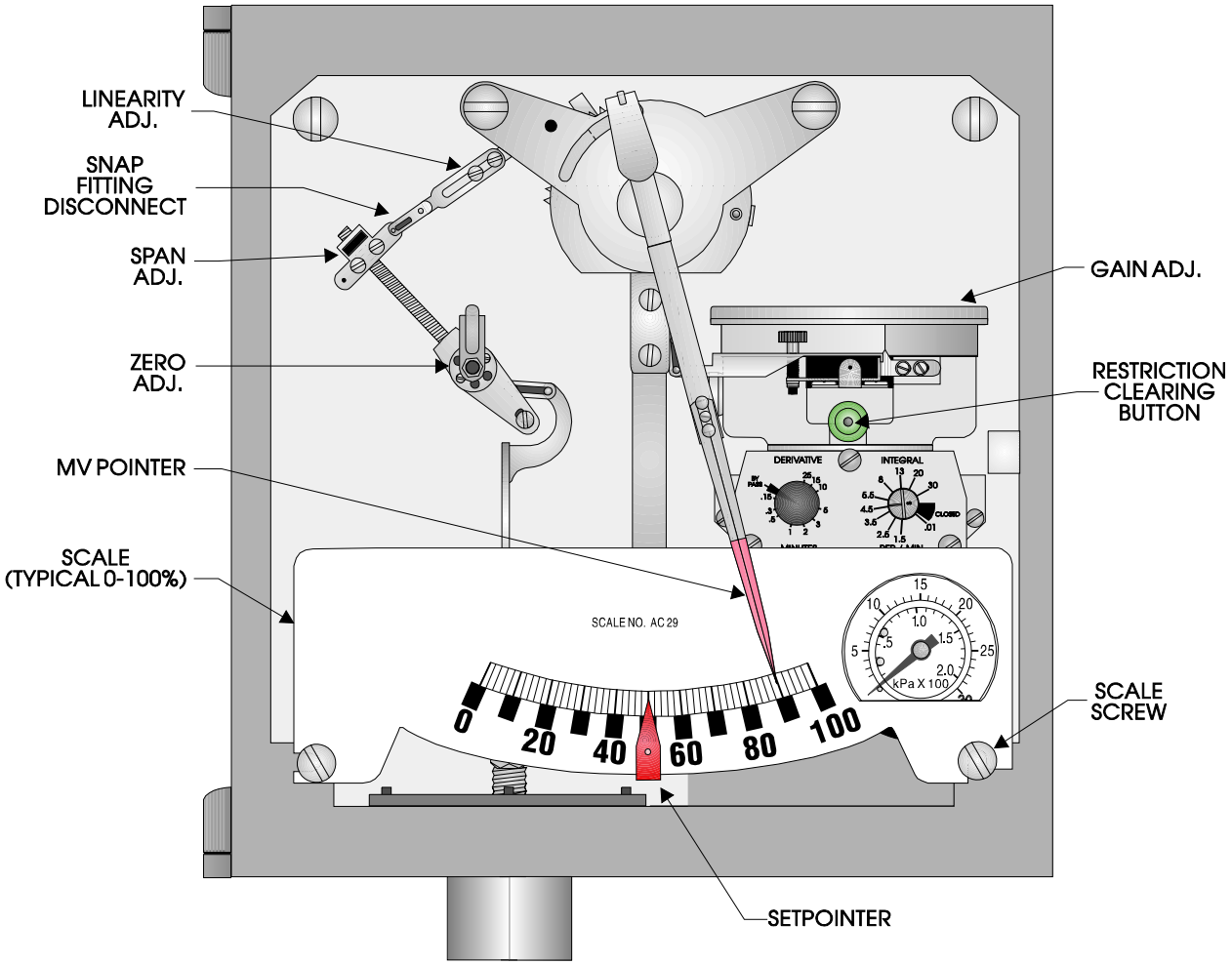


Figure 3A-8 - Interior Of Controller

- False Cycling:

  May be caused by excessive mechanical hysteresis or backlash in the final control element. A sticking control valve will usually cause small amplitude cycling of the MV Pointer with a distinct time interval between each cycle. Also, any pneumatic valves must be checked and lubricated on a regular basis to eliminate friction and lost motion.

- Insufficient Control:

  Control Valve may not be of proper size. A valve that is almost always closed is too large, while one that is almost always open is too small. As a general rule, the Control Valve should be one size smaller than the Control Agent Pipe.

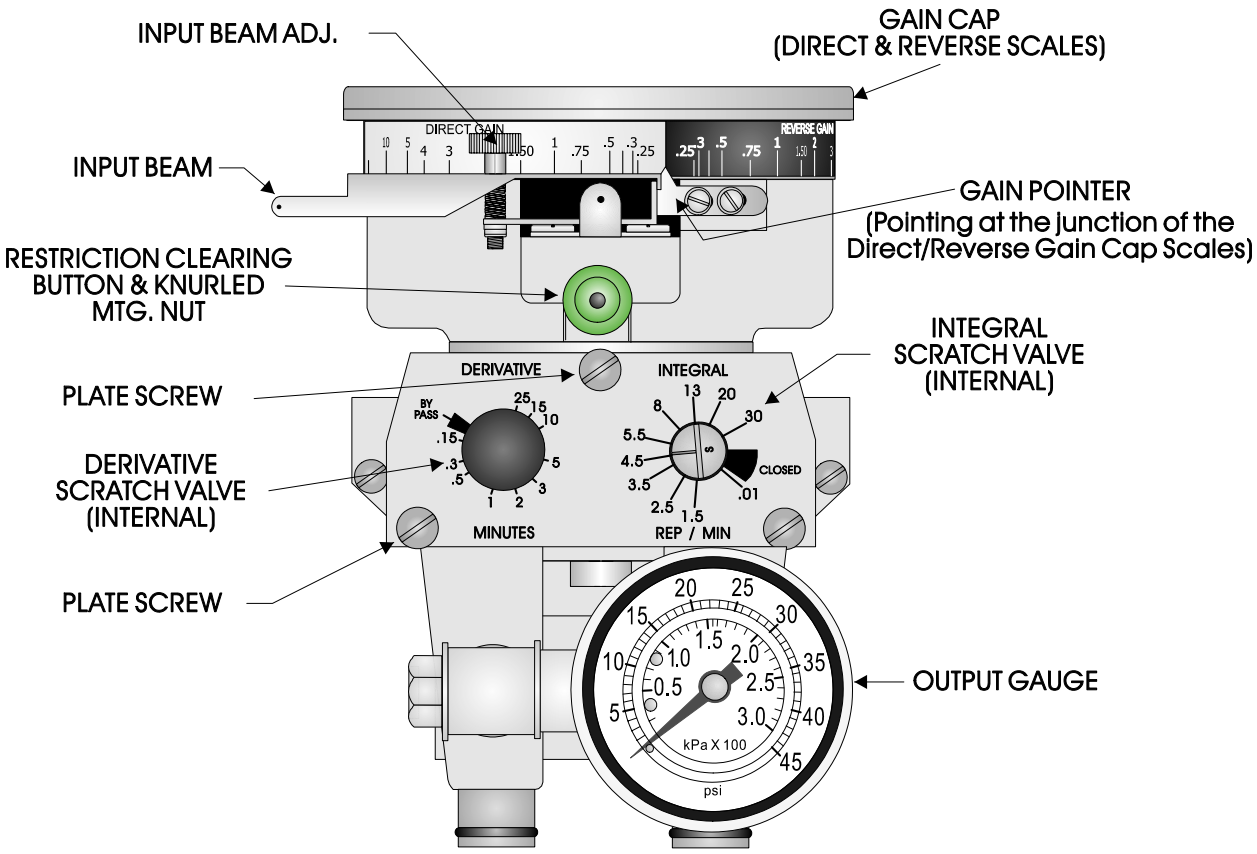


Figure 3A-9 - Pneumatic Control Unit

Removal of Control Unit

This procedure is typical for most instruments. Different models may require slight variations.

1. Remove any indicating scales or other components to access the control unit. Be careful not to force or bend any linkages or arms.

2. Disconnect the Input Beam (Figure 3A-9) of the control unit from the Vertical Linkage connected to the Differential Beam. Do this by turning the Snap Fitting on the linkage one half turn with a screwdriver. Be sure not loosen the Linearity Locking Screws on this linkage during disassembly, as MV calibration will be lost.

3. Loosen the two mounting screws on the control unit and maneuver unit out of enclosure.

4. When replacing the control unit, follow the procedure above in reverse.

3A.5 CALIBRATION

The section describes the test conditions, measurement procedures, and the calibration of the control unit. The calibration of the MV Linkage is described in section 3.4. Typically, most calibration only requires a minor touchup of Zero and Span Screw adjustments associated with the linkage. Detailed calibration of the control unit should only be performed as a last resort.

WARNING

The tests described here require that the controller operate at the extremes of its range (0 to 100%). Calibration should never be performed while the controller is in control of a process as dangerous output conditions may arise. For some applications, this could result in property damage and personal injury.

WARNING

Calibration must not be performed in hazardous areas. Either the area must be made safe or the controller must be removed and taken to a nonhazardous area.

Test Conditions

It will be necessary to supply precise levels of 0%, 50% and 100% (±0.1%) to the measuring system (MV input). The type of input signal required will be a function of the measuring system, (i.e. pressure, temperature, differential pressure, etc.). The manner in which this signal is generated must be determined by the user. If more information is needed, the user is advised to contact Bristol Babcock.

Calibration of MV Linkage

The calibration setup and adjustment procedures for the MV linkage are described in Section 3.4.

General Checks for Control Section

This subsection provides two versions of check procedures. The first covers one-mode controllers (Gain only), while the second covers two or three-mode controllers (Gain + Integral + Derivative). Select the appropriate procedure as required. In the majority of cases, these tests will determine if there is a need for performing detailed calibration of the control unit.

Control units may be furnished with 3-15 psi or 3-27 psi outputs. In the procedures that follow, only the reading for the 3-15 psi types will be listed. These readings will be followed by a single asterisk (*) which refers the reader to Table 3A-A. This table contains corresponding readings for the other output ranges.

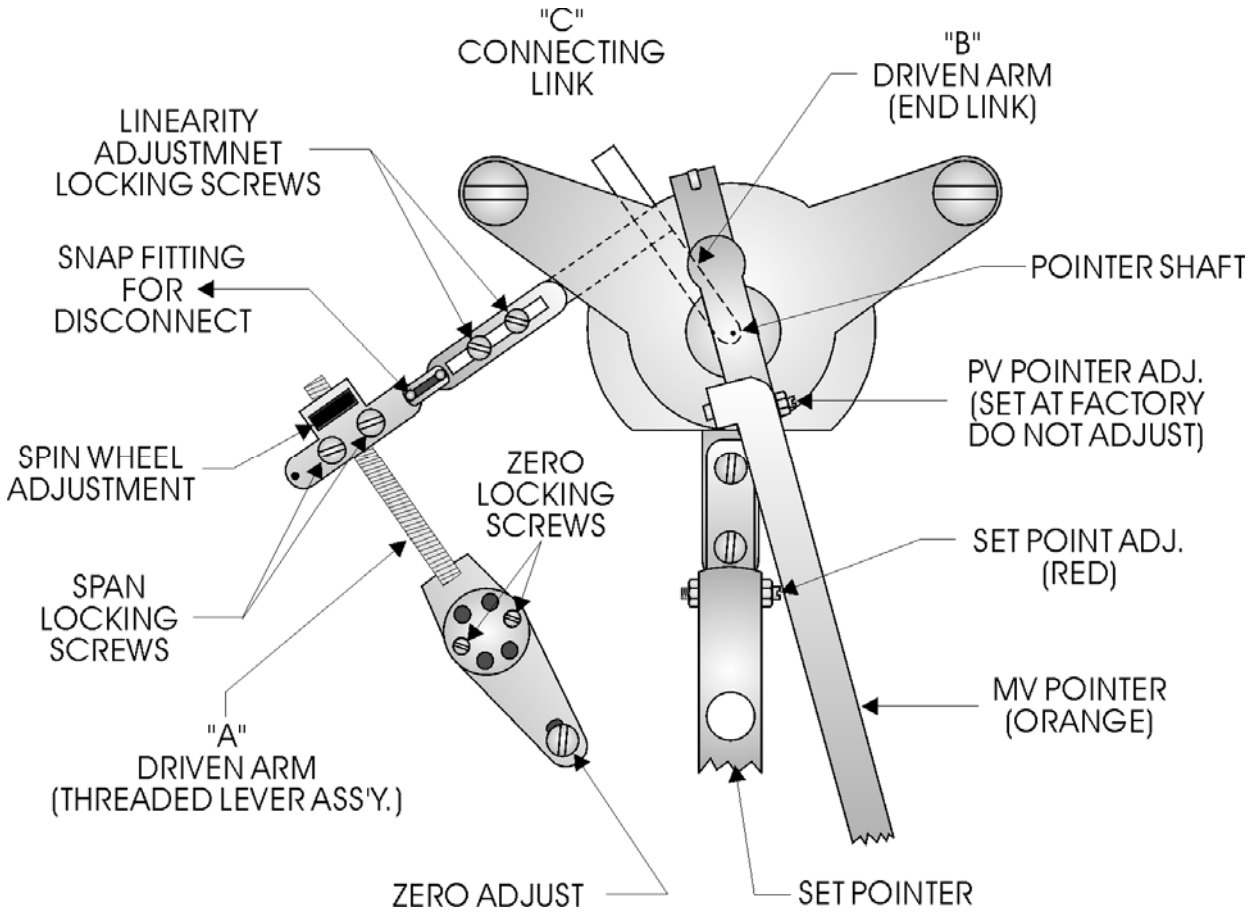


Figure 3A-10 - MV & Setpoint Linkages

Similarly, control units may also be specified with a gain range of 0.25 to 50 or 2.5 to 100. Only the readings for the 0.25 to 10 range will be given. These will be followed by a double asterisk (**) that refers the reader to Table 3A-B for the equivalent readings on the 2.5 to 100 gain types.

Table 3A-A - Pressure Test Values

TYPE OUTPUT RANGE		SUPPLY PRESSURE		OUTPUT TEST VALUE	
psi	kPa	psi	kPa	psi	kPa
3-15	20.7-103.4	20	137.9	9, □0.2	62
3-27	20.7-186.2	30	206.8	15, □0.2	103.4
6-30	41.4-206.8	35	241.3	18, □0.2	124

Table 3A-B - Gain Test Values

TYPE	GAIN TEST SETTINGS			
.25 - 10	3	1	2	10
2.5 - 100	3.0	10	20	100

General Check For 1-Mode Type (Gain Only)

1. Adjust supply pressure for 20* psi.

2. MV signal will be at some arbitrary value based on process measurement. Align the Setpointer with the MV Pointer.

3. Set Gain Adjust to 2.0** on DIRECT Scale. Controller output gauge should read 9* psi (±0.2 psi).

4. Rotate Gain Adjust to 2.0** on REVERSE Scale. A jump in output pressure will be noted as adjustment is rotated through the DIRECT-REVERSE crossover point. Output pressure should stabilize quickly on REVERSE Scale and remain at 9* psi.

5. If output pressure reading obtained on the REVERSE Scale differs from that on DIRECT Scale, shift the Setpointer slightly to the right or left of the MV Pointer and repeat steps 3 and 4. If pressure readings are still unequal on both scales, repeat procedure again and note if results are still the same.

6. If Setpointer balance point is offset from MV Pointer by a small amount, correct it by turning the Setpoint Adjustment Screw (Figure 3A-10). For large offsets, turn the Setpoint Adjust Screw to the middle of its range and turn the Input Beam Adjustment on the control unit (Figure 3A-2) to bring it into coarse range. Turn the Setpoint Adjustment Screw to obtain fine adjustment.

7. When balance is achieved, repeat procedures of steps 4 and 5 using Gain settings of 10** on DIRECT and REVERSE Scales. If necessary, experiment with Setpointer adjustment until balance is achieved.

8. Disconnect the Pointer Linkage at the output of the measuring device by inserting a screwdriver into the Snap Fitting on the Threaded Lever Arm (Figure 3A-2) and giving it a half turn.

9. Move Setpointer to any value on scale.

10. Position MV Pointer until it is aligned with Setpointer. Output should return to 9* psi. If the results of steps 7 to 9 are normal, then the Input Beam is properly aligned for all positions of coincidence of the MV Pointer and Setpointer.

11. Reconnect linkage to measuring element. Calibration is complete. If controller fails these checks, proceed to Calibration of Control Unit in this section.

General Check For 2 & 3-Mode Types

1. Adjust supply pressure for 20* psi.

2. MV signal will be at some arbitrary value based on process measurement. Align Setpointer with MV pointer.

3. Set gain adjust to 2.0** on DIRECT scale. Controller output gauge should read 9* psi (±0.2 psi).

4. If unit has a Derivative Adjust Screw, set it to the BYPASS position to eliminate derivative action.

5. Set Integral Adjust Screw to 20 repeats/minute. Move Setpointer slowly in either direction along its scale until 9* psi is observed on the Controller Output Gauge. Continue to experiment with adjustments until a setting is found that maintains the steady 9* psi value.

6. Lock in the 9* psi signal of the previous step by placing Integral Adjust in CLOSED position.

7. Rotate Gain Adj. to 0.3** on DIRECT scale and then to 0.3** on REVERSE scale. Note that as gain is turned from DIRECT to REVERSE or vice-versa, a jitter or oscillation may occur. If so, continue to move Gain Adj. to a high scale value for a moment until reading stabilizes. Then set gain to desired value. Controller Output Gauge should hold steady at some value, but not necessarily 9* psi for both gain settings.

8. Repeat procedure of step 7 using a gain setting of 1.0**. Output should hold steady at some value. If output pressure creeps up or down, move the Setpointer along its scale until stability is achieved.

9. Repeat procedure of step 7 using a gain setting of 10.0**. If necessary move the Setpointer up or downscale slowly to stabilize output pressure.

10. If Setpointer indication is offset from MV Pointer by a small amount, correct it by turning Setpoint Adjust Screw on Setpointer (Figure 3A-10). For larger errors, turn Setpoint Adjust Screw to the middle of its range and turn Input Beam Adjustment (Figure 3A-8) to correct. Readjust Setpoint Screw if required.

11. Controller calibration is now complete. If errors are still present, proceed to Calibration of Control Unit.

Calibration of Control Unit

The calibration procedure is covered in Chapter 3 under the topic Test Stand Calibration Procedure. The procedure requires a special test fixture (Part Number: 383258-01-4) shown in Figure 3-9. This fixture is available from Bristol Babcock.

Chapter 3B
DIFFERENTIAL GAP CONTROLLER

3B.1 GENERAL DESCRIPTION

Series 5453-00E, Dual-Setpoint, Differential Gap, No-Bleed Controllers are pneumatic instruments that control a measured variable (MV) within a given control gap. The size of the gap is adjustable from 5-95% of the instrument range using separate low and high setpointers.

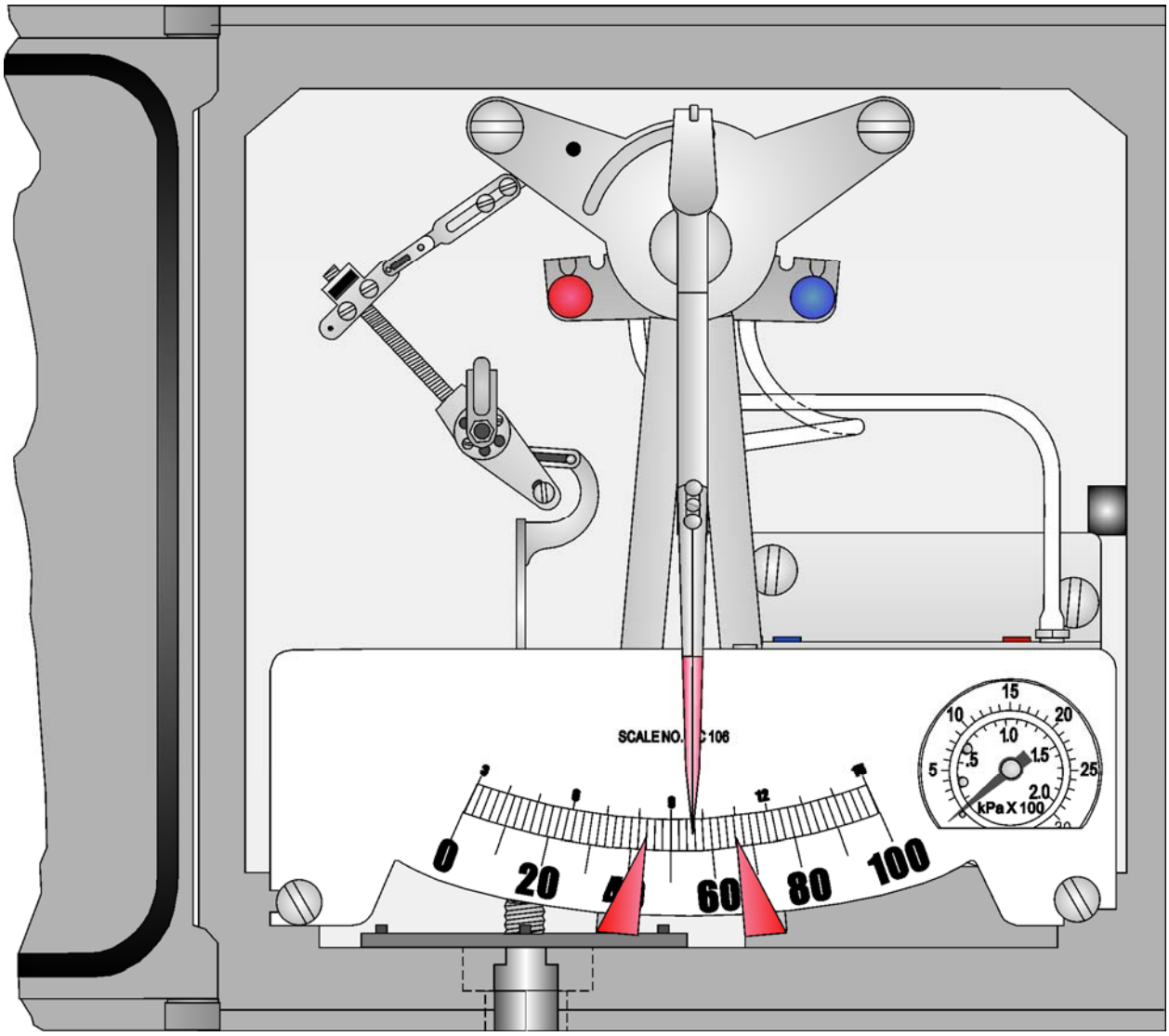


Figure 3B-1 - Series 5453-OOE (D8)

The controller provides an on-off control output that switches between 0 psi and the supply pressure (typically 20 psi). This signal is applied to a pneumatic valve operator that is turned ON or OFF to maintain control of the process.

The controller provides a switching action whereby the MV must cross both setpoints in order to switch the output once. Choices of either a Low-On/High-Off or a High-On/Low-Off output are offered via internal configuration. These choices allow the user to select the proper output switching requirements for the valve operator.

3B.2 OPERATION

This section describes the operating controls, initial startups and the shutdown procedures. General starting precautions will be found in Chapter 3, section 3.2.

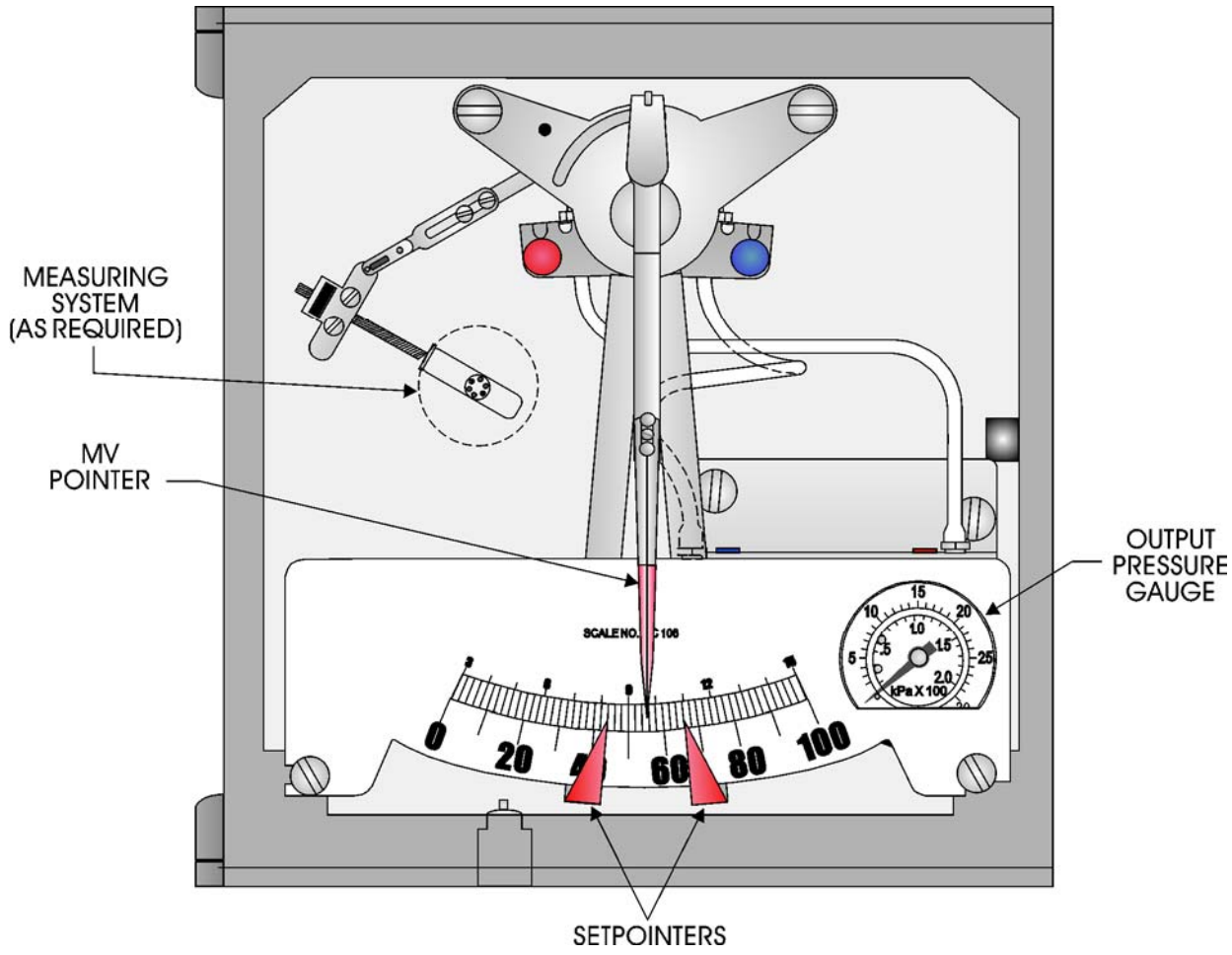


Figure 3B-2 - Operating Components

Operating Controls and Adjustments

The operating controls and adjustments described below are referenced in Figure 3B-2.

- MV Pointer

  This pointer indicates the value of the measured variable (MV), which is the signal coming from the measuring element.

- Hi & Lo Setpointers

  The setpointers determine the width of the control gap. Although each can be adjusted over the full range of the scale, they cannot be crossed due to the mechanical arrangement. When the Hi and Lo setpointers are placed adjacent to each other, a minimum control gap of 5% of span is achieved.

- Output Pressure Gauge

  This gauge has a 0-30 psi scale (0-207 kPa) (standard) and monitors the output pressure. During operation, the output pressure will be either OFF (0 psi) or ON (supply pressure). **Note: Some specially ordered controllers may have higher rated gauges.**

- Output Logic

  The controller provides reversible output logic. If the plastic hoses connecting the setpoint assembly to the control unit are connected as shown in Figure 3B-2, the controller will provide a LO-ON/HI-OFF type output. As such the output will be turned ON when the MV crosses the low setpoint going down, and turned OFF when the MV crosses the high setpoint going up.

  If the hose connections are reversed, the controller will provide a HI-ON/LO-OFF type output. In this mode the output will be turned ON when the MV crosses the high setpoint going up, and turned OFF when the MV crosses the LO setpoint going down.

  When the MV is between both setpoints, the controller will maintain the output status of the previous switchover.

Initial Startup

The startup procedure described below is presented as a general guide. The actual startup procedure will be dependent on the type of type of equipment and the associated process.

1. Check that supply pressure is initially turned OFF.

2. Adjust each setpointer for desired gap on MV scale.

3. Turn ON supply pressure and set to proper value. Output pressure will be ON or OFF depending upon the selected output logic and process condition.

4. If necessary, turn ON external process valves (pressure, steam, water & chemicals).

5. Process is now under automatic control. Pressure indicated on Output Pressure Gauge will be OFF (0 psi) or ON (supply psi) depending upon selected output logic and process condition.

6. If it is desired to experiment with gap adjustment while unit is operating, make all adjustments in small increments and observe results. Allow sufficient time for the controller to stabilize after each adjustment.

Routine Shutdowns and Startups

Once the controller is operating, it can be closed down by turning OFF the supply pressure. Subsequent startups can be performed by turning ON the supply. It is not necessary to reset the gap adjustments unless the controller is used with several different types of processes. In these instances, a record of the settings of each process should be kept to simplify setup time.

3B.3 CONTROLLER THEORY

The Differential Gap Controller is composed of a pointer assembly and a control unit as shown in Figure 3B-3. The pointer assembly includes both setpointers (HI and LO), the MV pointer, and two valve/flapper assemblies that actuate the control unit.

Setpoint Assembly

The size of the differential gap (control zone) is determined by the settings of the two setpointers. The setpointers, in association with the control unit, provide switching whereby the MV pointer must cross both setpoints in order to change the output state once.

Each setpointer includes a one-way valve assembly, while the MV pointer includes a flapper assembly. When the MV crosses a setpoint it causes one of the flappers to make contact with its valve, thereby actuating the control unit for the proper corrective action. The physical separation of the valves relative to each other establishes the control zone or differential gap.

The setpoint assembly sends pressure signals to the control unit through two plastic hoses. The connection of these hoses determines whether the controller provides a LO-ON/HI-OFF or HI-ON/LO-OFF output.

When the hoses are connected as shown in Figure 3B-4, the controller will provide a LO-ON/HI-OFF output. To describe this mode, it must be assumed that the controller is initially in a state where the output is OFF (0 psi), and the MV is at any location between the two setpoints. When the MV drops sufficiently to cross the LO setpoint (going down), the output state will switch from OFF to ON. This causes a corrective action to take place in the process and drive the MV upward on the scale. When the MV crosses the LO setpoint (going up) the output still remains in the OFF state. This condition prevails until the MV crosses the HI setpoint (going up), at which time the output will switch from ON to OFF. This action essentially restores the controller to its original state where no corrective action is required.

When the plastic hose connections are reversed, the controller will provide a HI-ON/LO-OFF output. This mode reverses the direction of switching from that previously described. When the MV crosses the HI setpoint (going up), the controller output will switch from OFF to ON. This state remains in effect until the MV crosses the LO setpoint (going down), thereby switching the output from ON to OFF.

Because the control unit always maintains its output status until the MV crosses the opposite setpoint, it prevents the output signal from chattering when the MV signal is operating at or near the threshold of either setpoint.

Control Unit

The control unit is shown in the cross sectional drawing of Figure 3B-4. The unit contains a spool valve assembly having pistons at each end. The spool valve, and hence the pistons, move laterally between a left and right chamber. A flexible diaphragm on each piston seals the pressure in each chamber and also isolates the chamber pressure from the spool valve pressure.

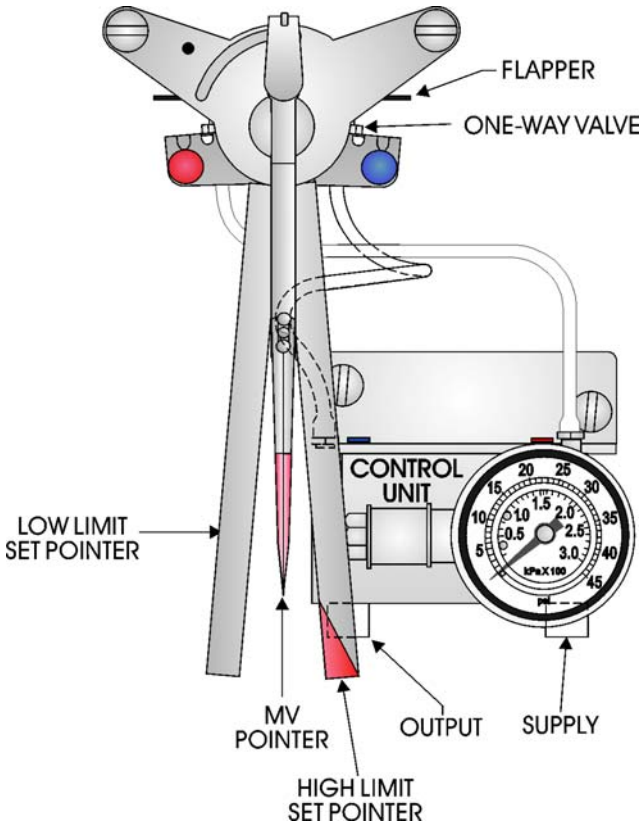


Figure 3B-3 - Pointer Assembly

The supply pressure is fed through the supply passage of the control unit and the outer compartments of the spool valve assembly. The pressure is sealed in the various outer compartments of the spool valve through a system of four "O" Rings.

Pressure in the supply passage of the control unit is blocked from the output passage whenever the spool valve is at the right as shown. An opening in the spool valve lets the pressure enter a hollow opening in the valve that is vented to both ends of the valve shaft.

Supply pressure applied to the hollow spool valve shaft is vented into the left and right cylinder chambers. The one-way valves contained on each setpointer assembly lock that pressure into either chamber. The one-way valves are spring-loaded devices that are normally in a closed position.

Should the MV pointer move in a direction that opens the valve of the left chamber, the pressure in that chamber will be dumped to the atmosphere. Because there is now more pressure stored in the right chamber than the left chamber, the spool valve will snap to the

left. As this happens, pressure stored in the supply passage is released to the output passage (this output is now ON). The piston remains in this position even when the MV returns between the two setpoints because a check valve closes and causes the pressure in both chambers to equalize.

Once the MV cross the right setpoint, the flapper opens the one-way valve for the right chamber and bleeds its pressure to the atmosphere. As a result, the spool valve snaps to the right and shuts OFF the supply pressure to the output passage. This state is main-tained even when the MV re-crosses the right setpoint going in the opposite direction. Once the right one-way valve closes, pressure in the right chamber returns to the supply pressure level and that pressure is locked in until the MV crosses the left setpoint. At that time the control cycle is repeated.

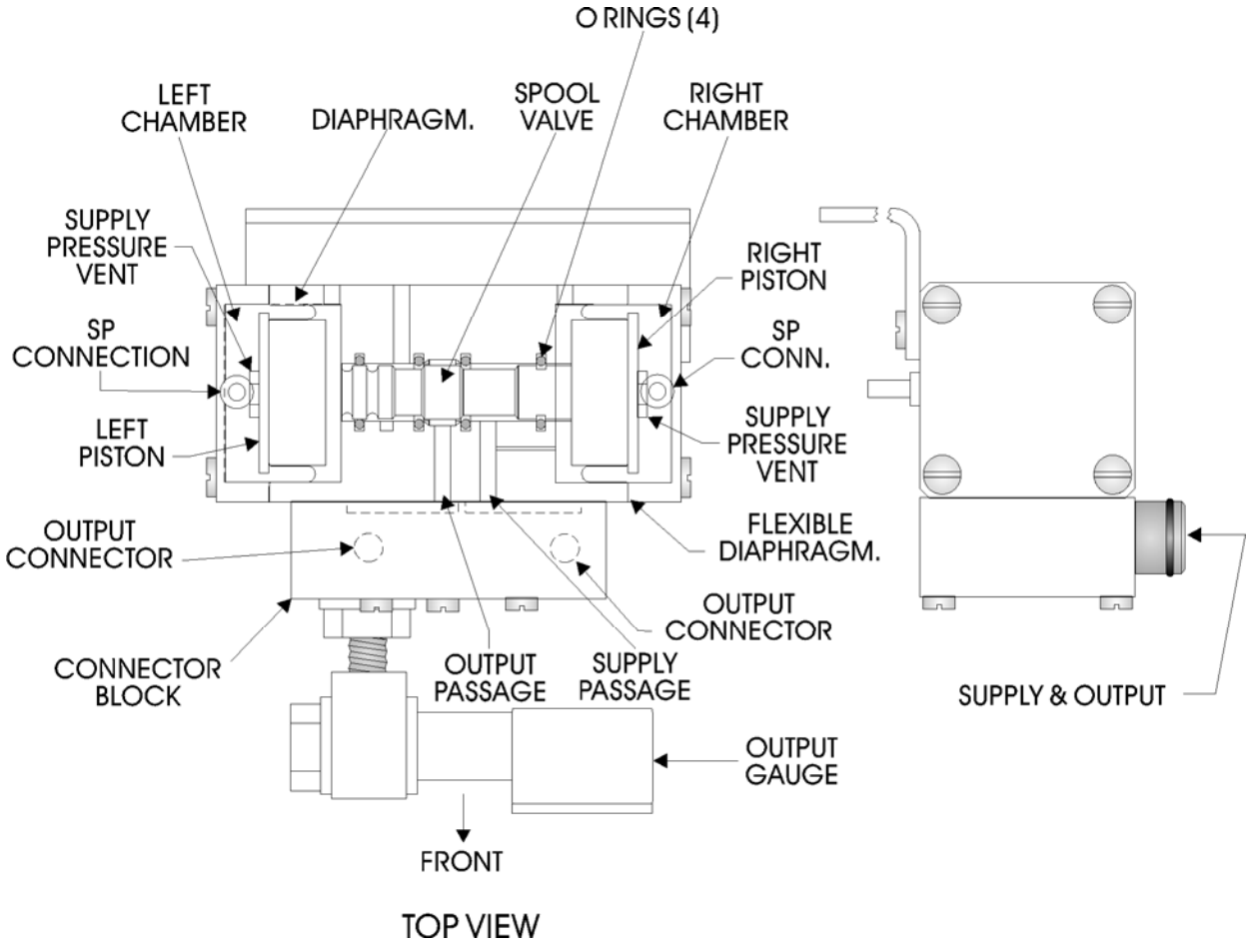


Figure 3B-4 - Cross Section of Control Unit

3B.4 SERVICE

Before performing any service procedures described here, refer to Chapter 3, section 3.3 for general maintenance and safety warnings.

Troubleshooting

Some typical problems that may be encountered in the field are as follows:

- Output Pressure Always or OFF or ON

  If reading on Output Pressure Gauge does not change with control conditions, spool valve of control unit may be jammed. Disassemble control unit and remove spool valve. Check for dirt or oil; clean as required. Inspect O-Rings for wear or deformity; if defective, replace rings with exact type.

- Erratic Control Action

  Check screen assembled into the supply port (Chapter 2, Figure 2-4) for clogging. Also check screen in case vent hole. Clean screens as required. Any associated control valves or operators should also be checked for free movement. Refer to manufacturer's manual for recommended maintenance.

Removal of Control Unit

The disassembly procedure described below is general and may vary somewhat with different models.

1. Remove power from any electrical options present on instrument if so equipped.

2. Disconnect tubing from each nozzle on setpoint assembly.

3. Remove two mounting screws holding bracket of control unit to inside of case.

4. Apply moderate upward pressure to control unit and carefully maneuver unit out of enclosure.

5. Control unit may now be serviced or replaced.

Calibration of MV Linkage

The calibration setup and adjustment procedures for the MV linkage are described in Chapter 3, section 3.4.

Chapter 3C
REMOTE SETPOINT ACTUATOR

3C.1 GENERAL DESCRIPTION

Series 5457 Motor Actuated Instruments utilize an electronic signal (command input) to adjust the mechanical setpoint of a G-I-D controller or the output level (pressure signal) of an indicating transmitter. The actuator assembly, which attaches to the controller or transmitter case as shown in Figure 3C-1, contains circuitry to process data and drive a stepper motor. The stepper motor, in turn, mechanically adjusts the controller setpoint or transmitter output in accordance with the level of the command input signal.

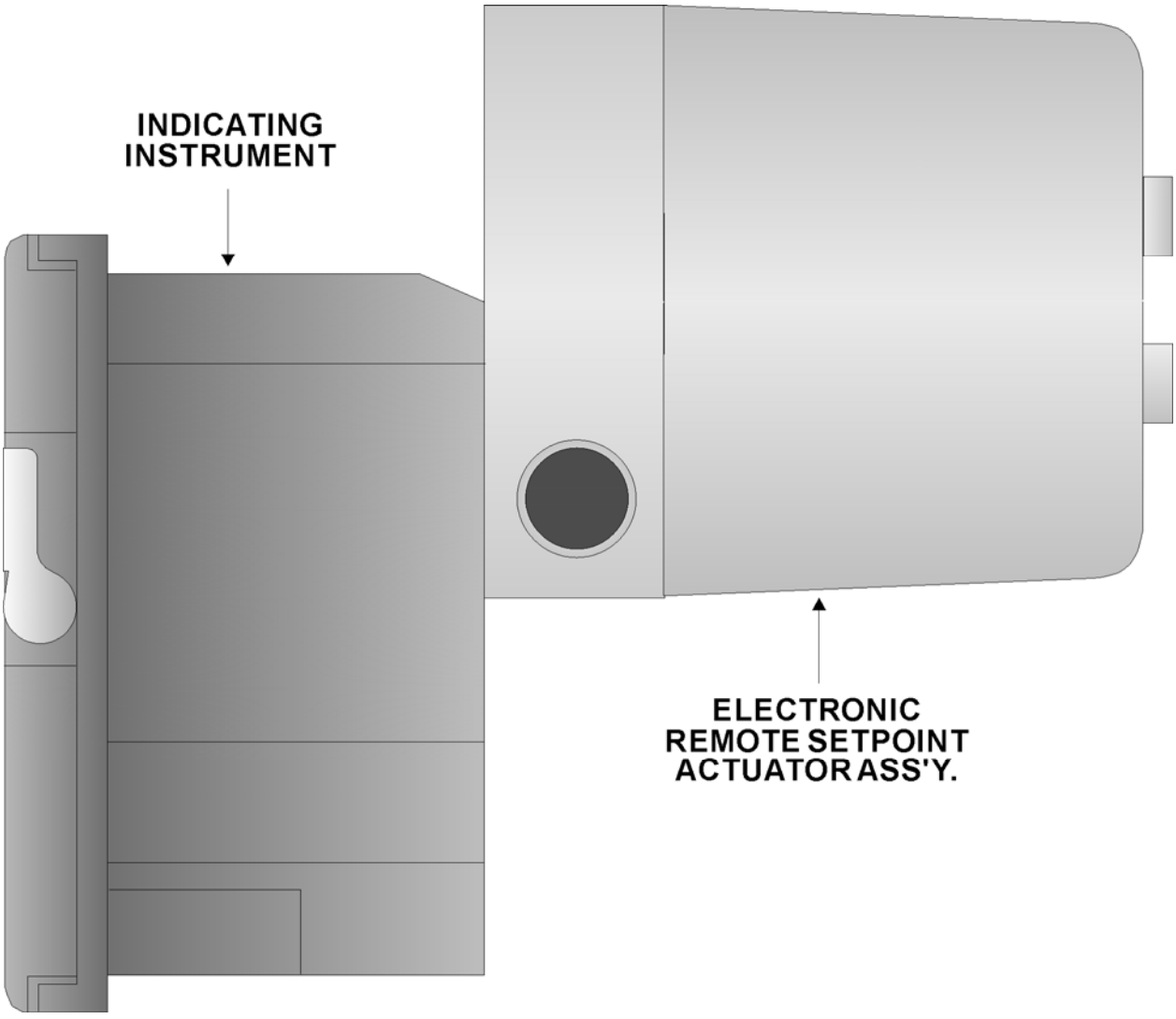


Figure 3C-1 - Series 5457 Remote Setpoint Controller

The Motor Actuated Controller (MAC) models are as follows:

5457-10G MAC w/ pressure or vacuum input
5457-10G MAC w/ 3-15 psi receiver input
5457-31G MAC w/ DP input (Barton 199 unit)
5457-40G MAC w/ temperature input (Class 1A, 1B or 3B bulbs)

The Motor Actuated Transmitter (MAT) model is:

5457-70G MAT w/ 3-5 psi or 3-27 psi output

The MATs and MACs are provided with the following features and options:

- Actuator Types

Instruments may be furnished with analog or raise/lower type actuators. Analog actuators accept either a 1-5 V or 4-20 mA dc signal for the command input. Raise/lower actuators accept a continuous or incremental dc signal for the command input.

The actuator output is mechanical and consists of a stepper motor that positions a pointer on the indicating scale of the instrument. The motor also adjusts the setpoint of a controller model or the output level of a transmitter model (3-15 psi or 3-27 psi) to correspond with scale reading.

- Guard Input

This input can be used to 'enable' or 'inhibit' the command input for telemetry and security applications. When the guard signal is enabled, it allows the actuator output to respond to a change of the command input signal; when inhibited, the actuator output remains at its previous value even though the command input is changing value.

- Optional Pulse Duration Modulation (PDM) Output

The optional PDM output signal tracks the actuator output. The user may select 5 or 15 second transmission rates which are compatible with Bristol Babcock's METAMETER (R) system and other PDM systems.

- Optional Current Output

This optional 4-20 mA output tracks the actuator output. This signal can be applied to the input of analog devices such as recorders, indicators, computers and telemetry transmitters.

- Local-Remote Operation

A two-position switch on the indicating instrument (controller or transmitter) selects local or remote operation. Local mode allows manual adjustment of the driven pointer, while remote mode uses the actuator input signal (command input) to set it.

- Optional High-Low Limits

Adjustable mechanical tabs attached to the scale of the indicating instrument limit the travel range of the driven pointer.

- Power Supply

Actuators are factory-furnished for 12 or 24 V dc supply operation. The supply output rating is fixed and cannot be changed in the field.

- Enclosure Rating

The indicating instrument housing and actuator enclosure are rated for NEMA 3R (FM) installations.

3C.2 INSTALLATION NOTES

In general, the installation of the indicating instrument (controller or transmitter) is performed as described in Chapter 2. The subject matter that follows provides additional information relevant to the actuator assembly.

Actuator Enclosure and Cover

The actuator assembly is contained in a metal enclosure with a gasketed screw-on cover shown in the side view of Figure 3C-2. Four raised lugs on the cover allow the user to loosen the cover with a flat metal bar or similar tool. The cover should be securely tightened by hand when it is replaced.

Once the cover is removed, the Termination Board and CPU Board are accessible as shown by the inside view of Figure 3C-2. The Termination Board contains the field wiring terminals, while the CPU Board contains processing and amplifier circuitry, along with switches for selecting options. The stepper motor gear assembly that mechanically sets the indicating instrument is also accessible when the cover is off.

Electrical Conduit Port

Two electrical ports are provided on the Actuator housing. Either or both ports may be used to bring in signal and supply wiring.

These ports accommodate a standard ¾-inch NPT pipe thread connection. If a port is not used, it must contain a conduit plug as noted in Figure 3C-2.

Installation in Hazardous Areas

The installation of equipment in hazardous areas shall be in compliance with the National Electrical Code ANSI/NPFA-70 and ANSI/ISA S82.01, S82.02 and S82.03 standards.

Instruments approved for operation in hazardous areas will have the mark (identification) of the certifying agency inscribed on the instrument data plate. Motor Actuated Controllers or Transmitters in this category are Fm approved as follows:

CLASS I, Division 1, Groups C and D (Explosion Proof)
CLASS I, Division 2, Groups A, B, C and D (Nonincendive)

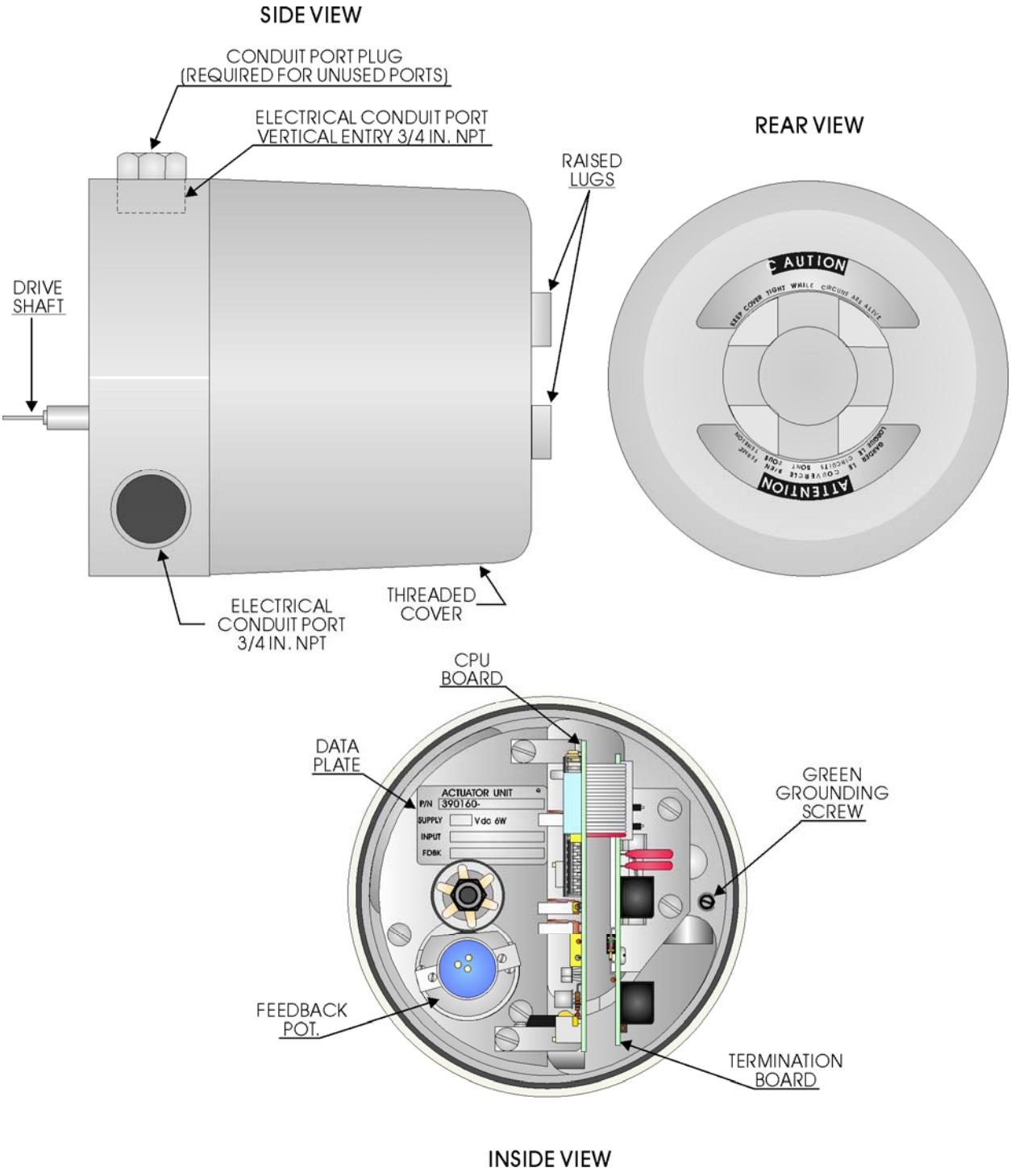


Figure 3C-2 - Actuator Assembly

Instrument cases are rated for NEMA 3R (FM).

In order to maintain the integrity of the Division 1, explosion-proof certification of the installed unit, the following conditions must be met:

A. All wiring that runs through a hazardous area and connects to the actuator must be enclosed in metal conduit. The point where the conduit connection meets the Actuator housing should be properly tightened to prevent entry of gas or other ignitable substances. Explosion-proof wiring practices must be followed to prevent flash-back through the conduit.

B. The cover of the actuator assembly must be screwed in hand tight and fully seated. The cover must not be damaged and no threads should be stripped.

C. The cover of the actuator must never be removed during operation unless the atmosphere is made safe or all electrical power is removed from the instrument.

WARNING

If it becomes necessary to remove the cover of an actuator that is operating in a hazardous area (presence of combustible particles or explosive gases), either the area must first be made non-hazardous or the dc power to the actuator must be turned off. A failure to heed these could result in fire or explosion, i.e., possible injury to persons and damage to property.

3C.3 BOARD CONFIGURATION

This section describes the functions of various board switches and the manner in which they are configured for the user's application. These switches must be set before power is applied to the actuator.

Using Option Switches

Two switch assemblies (SW1 and SW2) are used to set options and select ranges. These switches are located on the CPU Board as shown in Figure 3C-3.

Two types of switch assemblies are used with actuators. One type uses cradle switches, while the other uses slide-type switches. The operation of each type differs as follows:

Cradle Switches with OPEN Designation:

OPEN side pressed down = OFF (open circuit)
Opposite side pressed down = ON (closed circuit)

Slide Switches with ON Designation:

Set in direction of ON arrow = ON (closed circuit)
Set in opposite direction of arrow = OFF (open circuit)

The switch assemblies are fragile and require careful handling. Use a small, blunt object such as a miniature screwdriver to set the switch positions. Do not use pencils, ballpoint pens, or extremely sharp objects for this purpose.

WARNING

All switch options must be set before any power is applied. Incorrect settings can cause improper operation or dangerous control situations that could damage process equipment and property, or cause injury to persons.

NOTE

Attempting to change settings of any switch (excluding SW2-6 and SW2-8) while the unit is powered will not produce a corresponding change of configuration. In order to obtain a valid configuration, it is necessary to turn the transmitter power OFF, set the switches as required, and reapply the power.

If switch settings are changed without turning the power OFF, the present configuration will remain in effect until the unit is turned OFF and powered up again.

Switch Functions

The actuator assembly is configured by two, eight-switch packages which perform the functions listed in Table 3C-1.

Table 3C-1 - Actuator Assembly Switch SW1 & SW2 Functions & Settings

Switch Label	Switch Function	Page Ref.	* Your Setting	** Your Notes
SW1-1	R/L % per pulse increment	3C-7		
SW1-2	R/L % per pulse increment	3C-7		
SW1-3	R/L % per pulse increment	3C-7		
SW1-4	R/L % per pulse increment	3C-7		
SW1-5	R/L % per pulse increment	3C-7		
SW1-6	PDM Output	3C-13		
SW1-7	PDM Output	3C-13		
SW1-8	Input Filter	3C-8		
SW2-1	Guard (Dynamic/Static)	3C-8		
SW2-2	Actuator Output Rate of Change	3C-9		
SW2-3	Actuator Output Rate of Change	3C-9		
SW2-4	Actuator Output Rate of Change	3C-9		
SW2-5	Actuator Output Rate of Change	3C-9		
SW2-6	Guard (Active/Inactive)	3C-8		
SW2-7	Not Used	None		
SW2-8	Analog Input (V or I)	3C-7		

* Record your switch settings (ON or OFF) here for future reference.
** List your corresponding switch functions or values here.

Analog Actuator Input

It is necessary to check the position of switches SW1-1 through SW1-5. These switches must be set to their OPEN positions to properly disable the functions associated with Raise/Lower models.

Analog actuator models can be set to accept a 4-20 mA or 1-5 V dc input. Switch SW2-8 sets this option as follows:

SW2-8	Analog Range
Close	4-20 mA dc
Open	1-5 V dc

Raise/Lower Actuator Input

Raise/Lower Actuator models can be set for continuous or incremental-type input signals via switches SW1-1 through SW1-5. The switch positions are shown in Table 3C-2. The switch selections are described as follows:

- Continuous Signal

  All five switches should be set to the OPEN position (bottom condition of Table 3C-2). This will configure the raise/lower inputs so that the actuator output will only change as long as the signal is in a TRUE state.

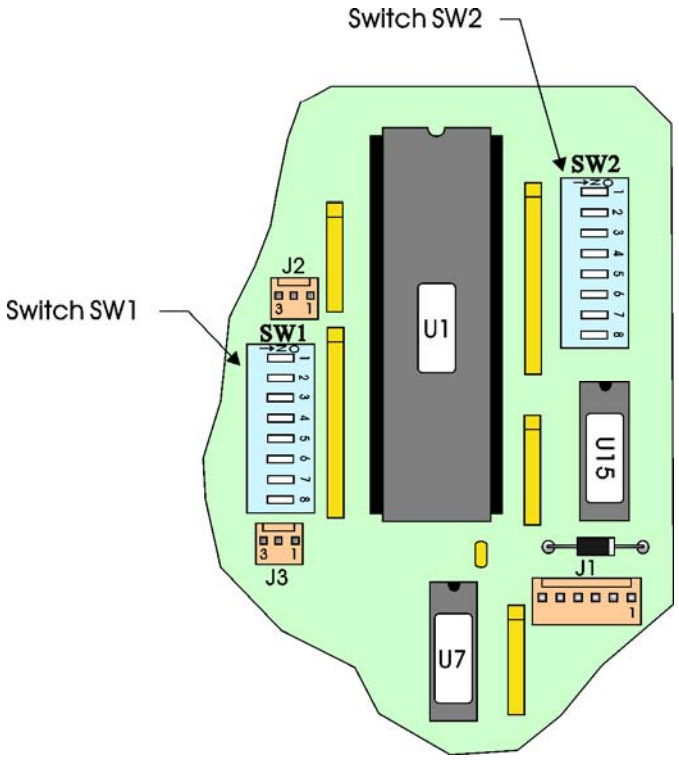


Figure 3C-3 - Option Switches on CPU Board

- Incremental Signal

The five switches can be set for any increment from 0.1% per pulse to 10% per pulse. The pulses that raise or lower the actuator output perform in real time and are not stored. As a requirement, each pulse must remain in a TRUE state for a period of time necessary for the actuator to reach the new output level. Should the input change abruptly from a raise to a lower operation (or vice-versa) before the completion of an incremental step, the unfinished increment will be cut off and the next pulse will be freshly processed.

An Actuator that is set up with a slower rate of change value or a greater percent of full-scale change per input pulse will require a longer input pulse. Therefore, the minimum time period required for an ON and OFF pulse to produce a change of actuator output is dependent upon the settings of switches SW1 (1-5). There are no maximum limits for either the ON or OFF pulse periods (time between pulses).

The relationship between an ON and OFF pulse time periods are shown by the following two equations:

1) T on Minimum (sec.) = (.01 S R) + K
2) T off Minimum (sec.) = K

Where:

T on Minimum = Raise, Lower or Guard pulse
T off Minimum = Time between pulses.
S = Incremental step value (Table 3C-2)
R = Rate of actuator output change (Table 3C-3)
K = .04 sec. with R/L filter active or 0.01 sec. with R/L filter turned off. See topic "Actuator Output Rate of Change" in this section.

Table 3C-2 - Switch SW1 (1-5), Pulse Increments

SW1-5	SW1-4	SW1-3	SW1-2	SW1-1	Pulse Rate
Close	Close	Close	Close	Close	Disabled
Close	Close	Close	Close	Open	0.1% / Pulse
Close	Close	Close	Open	Close	0.2% / Pulse
Close	Close	Close	Open	Open	0.3% / Pulse
Close	Close	Open	Close	Close	0.4% / Pulse
Close	Close	Open	Close	Open	0.5% / Pulse
Close	Close	Open	Open	Close	0.6% / Pulse
Close	Close	Open	Open	open	0.7% / Pulse
Close	Open	Close	Close	Close	0.8% / Pulse
Close	Open	Close	Close	Open	0.9% / Pulse
Open	Close	Close	Close	Open	1.0% / Pulse
Open	Close	Close	Open	Close	2.0% / Pulse
Open	Close	Close	Open	Open	3.0% / Pulse
Open	Close	Open	Close	Close	4.0% / Pulse

Open	Close	Open	Close	Open	5.0% / Pulse
Open	Close	Open	Open	Close	6.0% / Pulse
Open	Close	Open	Open	Open	7.0% / Pulse
Open	Open	Close	Close	Close	8.0% / Pulse
Open	Open	Close	Close	Open	9.0% / Pulse
Open	Open	Close	Open	Close	10.0% / Pulse
Open	Open	Open	Open	Open	Continuous *

* *This selection used only for Analog Actuators and Raise/Lower Actuators set for continuous signal.*

- Input Filter

  A raise or lower input signal can contain noise pulses of amplitude sufficient to change the setpoint. In these situations, switch SW1-8 can be set to activate the filter. The switch positions are given below. For Analog Actuators this switch must always be set to OPEN.

SW1-8	Filter Status
Close	Active
Open	Inactive

Guard Input

The guard input is a dc status signal that is used to Enable or Inhibit the command input. This feature provides assurance that the command input will read its signal only during a security period selected by the user. The guard input can be used with either Analog or Raise/Lower (R/L) Actuators.

- Guard Logic

  The guard logic can be set so that the command input is only activated when the signal at the GUARD terminals is in a TRUE state. The guard logic can also be set so that it is always ON; in this mode the command input will accept signals at all times. Switch SW2-6 is used to set the guard mode as follows:

SW2-6	Guard Mode
Open	Active (Guard signal must be in TRUE state to accept input)
Close	Inactive (All inputs accepted)

- Static or Dynamic Guard Input

  The guard input may be set to operate in a static or dynamic mode. The static mode, which can be used with either analog or raise/lower command signals, allows the setpoint to respond to a command signal only when the guard terminal is in a TRUE state.

The dynamic mode, which is only available with Raise/Lower Actuators, requires the simultaneous transition of two pulse-type signals. Consequently, the actuator output will only change when a guard pulse and a command pulse (either a raise or lower) occur at the same moment. Furthermore, both pulses must remain TRUE until the actuator output change is complete. If either a guard or command pulse is not completed before the specified time, the actuator output will be held at its last value until a new change occurs. This arrangement provides greater system security from minimal interference from extraneous signals. This feature should not be used with Analog Actuators.

The selection of static or dynamic mode is obtained via switch SW2-1 as follows:

SW2-1	Guard Status
Close	Dynamic (R/L type only)
Open	Static (AI or R/L types) *

* The "Open" position must always be used when "Fail Zero" mode is selected. See Analog Failure Modes.

Table 3C-3 - Switch SW2 (2-5), Actuator Output Rate Of Change

SW2-5	SW2-4	SW2-3	SW2-2	Rate Of Change Full-scale Travel
Close	Close	Close	Close	20 Secs.
Close	Close	Close	Open	1 Min.
Close	Close	Open	Close	2 Min.
Close	Close	Open	Open	3 Min.
Close	Open	Close	Close	4 Min.
Close	Open	Close	Open	5 Min.
Close	Open	Open	Close	6 Min.
Close	Open	Open	Open	7 Min.
Open	Close	Close	Close	8 Min.
Open	Close	Close	Open	9 Min.
Open	Close	Open	Close	10 Min.
Open	Close	Open	Open	11 Min.
Open	Open	Close	Close	12 min.
Open	Open	Close	Open	13 Min.
Open	Open	Open	Close	14 Min.
Open	Open	Open	Open	15 Min.

Actuator Output Rate of Change

The amount of time required for the actuator to sweep the driven pointer over the entire scale of the indicating instrument (controller or transmitter) is adjustable from 20 seconds o 15 minutes. The desired rate is selectable by setting switches SW2-2 through SW2-5 as noted in Table 3C-3.

In order to enter a change of switch status, it is first necessary to turn OFF power to the actuator. Once the configuration switches are set, the power is reapplied and the change is initiated.

Analog Failure Mode (Fail Hold & Fail Zero)

The Analog Actuator model has an "Analog Fault Detector" feature which, when selected by jumpers on the Input Termination Assembly, disengages the normal guard function. In the "Fail Hold" mode, the guard terminals are not available for external usage. The Analog Fault Detector will then stop the stepper motor at the last position prior to the loss of the analog input signal. The Fault Detector trip point is factory set at 0.8 volts which corresponds to minus (-) 5% of full-scale.

In the alternate "Fail Zero" mode, the Guard terminals are available for use with an external guard signal. The analog input is sampled when it is enabled by a signal at the Guard terminal. If the input drops to zero while the Guard signal remains TRUE, the actuator output will also follow to zero.

NOTE

If any SW2 switch settings are changed while the unit is operating, no configuration changes will occur. The previous settings will be retained. Reconfiguration can only be accomplished when the power is OFF.

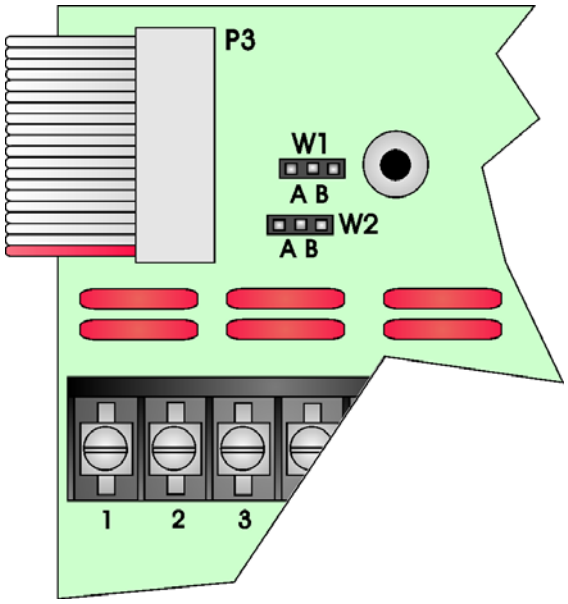
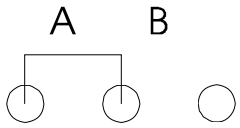


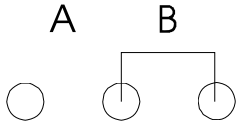
Figure 3C-4 - Jumper Location on Analog Termination Board

The selection of two failure modes is accomplished by setting jumpers W1 and W2. Located on the Termination Board as shown in Figure 3C-4 these jumpers may be plugged in position A or B, however, both jumpers must always be in the same position. The configurations are selected as follows:



FAIL-HOLD MODE
(Both Jumpers in A position)

In the "A" position, a failure at the Command Input (AI value fails below 0%) causes the actuator to hold its output at the value of the last valid sampling period. This condition is maintained until a normal AI is received.



FAIL-ZERO MODE
(Both Jumpers in B position)

In the "B" position, a failure of the AI Command Input signal (AI value fails below 0%) causes the output of the actuator to decay to 0% of scale and remain there until a normal AI is received; this condition will result as long as the signal at the Guard Input remains TRUE. Should the Guard Input go FALSE prior to the AI command failure, the actuator will hold its output at the last value.

PDM Output

Actuators having the optional PDM output will transmit a signal with a value that is equivalent to the setpoint of a controller model or the output level of a transmitter model. If this option is present switches SW1-6 and SW1-7 must be set to select a 3-12, 1-4 or 0-13.3 second output range. The required switch positions listed in Table 3C-4.

Table 3C-4 - PDM Output Switch Settings

SW1-7	SW1-6	Pulse Range	Pulse Cycle
Close	Close	3-12 Secs.	15 Sec.
Close	Open	0-13.33 Secs.	15 Sec.
Open	Open	1-4 Secs.	5 Sec.

3C.4 FIELD WIRING

This section describes the Terminal Block designations and illustrates general wiring connections.

Terminal Block Identification

The Termination Board contains the field wiring terminals. Access to this board is obtained by removing the cover as described on page 3C-3.

Two terminal blocks on the board are identified as TB1 and TB2. The block locations are shown in Figure 3C-5.

The function of each terminal depends on whether the instrument is furnished with an Analog or Raise/Lower Actuator. The terminal designations for the Analog type are given in Table 3C-5, while designations for the R/L types are given in Table 3C-6.

Table 3C-5 - Terminal Identification For Analog Input Actuator

TERMINAL LEGEND	WITH CURRENT FEEDBACK	WITH PDM FEEDBACK
TB1-1	Unused	Unused
TB1-2	Unused	Unused
TB1-3	Analog In+	Analog In+
TB1-4	Analog In-	Analog In-
TB1-5	Guard	Guard
TB1-6	Guard Com	Guard Com
TB2-1	Remote/Local Status	Remote/Local Status
TB2-2	Current Out +	PDM Out +
TB2-3	Current Out -	PDM Out -
TB2-4	Supply +	Supply +
TB2-5	Supply -	Supply -
TB2-6	Unused	Unused
Green Screw	Chassis	Chassis

Table 3C-6 - Terminal Identification For Discrete Input Actuator

TERMINAL LEGEND	WITH CURRENT FEEDBACK	WITH PDM FEEDBACK
TB1-1	Raise	Raise
TB1-2	Raise Com	Raise Com
TB1-3	Lower	Lower
TB1-4	Lower Com	lower Com
TB1-5	Guard	Guard
TB1-6	Guard Com	Guard Com
TB2-1	Remote/Local Status	Remote/Local Status
TB2-2	Current Out +	PDM Out +
TB2-3	Current Out -	PDM Out -
TB2-4	Supply +	Supply +
TB2-5	Supply -	Supply -
TB2-6	Unused	Unused
Green Screw	Chassis	Chassis

Note: Raise, Lower & Guard Terminals are nonpolarized and are opto-isolated.

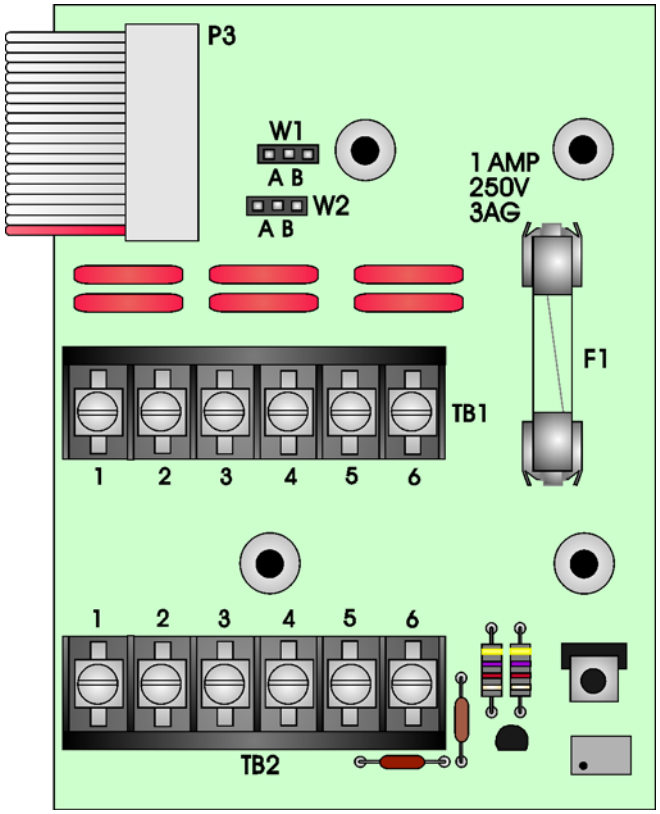


Figure 3C-5 - Field Wiring Terminals

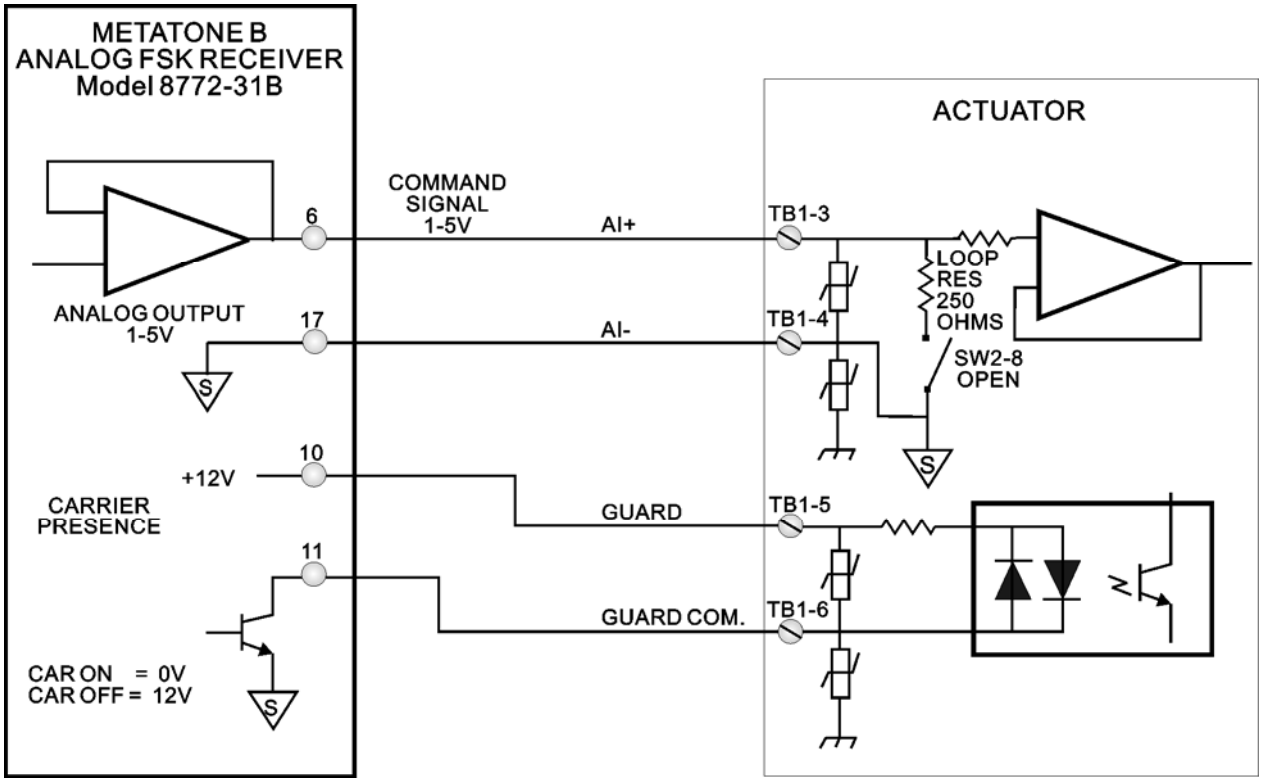


Figure 3C-6 - Analog Voltage Input with Guard

Analog Voltage Input (1-5 V) with Guard

A voltage signal can be used as the command input as shown in Figure 3C-6. In this example, a Bristol Babcock, METATONE B, Analog FSK Tone Receiver (Model 8772-31B) provides the input to the Actuator. Switch SW2-8 of the Actuator must be set to the OPEN position to accommodate a 1-5 V input.

For this application, the carrier presence output signal of the receiver may be connected to the Guard Input of the Actuator as shown. Should the tone carrier fail, the Actuator will hold the last valid output value and not respond to any extraneous signals at the Command Input.

Analog Current Input (4-20 mA) with Guard

In Figure 3C-7, a 4-20 mA signal is obtained from the collector of an output transistor and wired to the input of the Actuator. Switch SW2-8 is set to the CLOSE position to bring the loop resistor into the circuit. The equivalent 1-5 volt drop across the 250-ohm loop resistor is applied to the input of the Actuator circuitry.

A relay contact may be wired to the Guard Terminal as shown in Figure 3C-7. This contact is typically part of a detection circuit that senses bad data or a failure condition. When the contact is closed, source data at the Command Input is accepted; when open, any new data is ignored. The Guard signal may also emanate from an open collector circuit such as shown or the Command Input above.

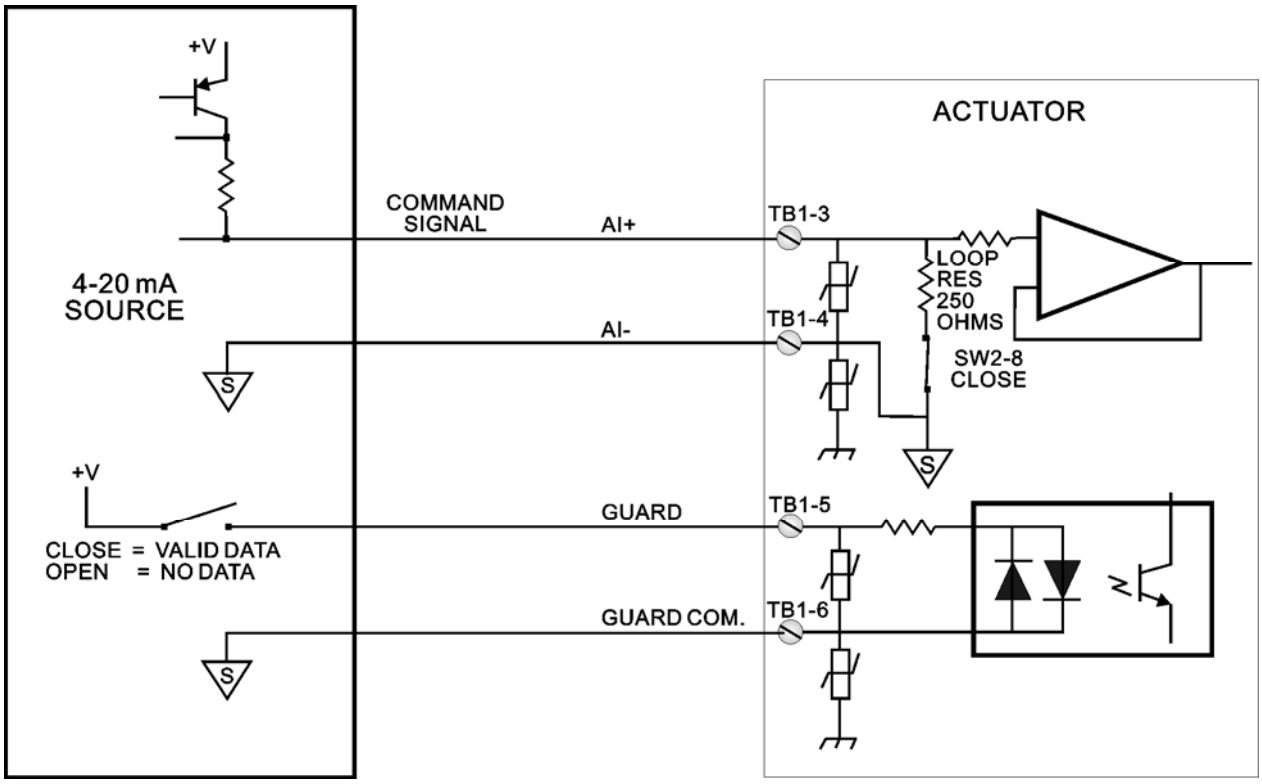


Figure 3C-7 - Analog Current Input with Guard

Raise & Lower Inputs with Guard

The Raise and Lower inputs will accept either a continuous or incremental signal. A continuous signal is one that is maintained in a TRUE state to affect a change of Actuator output. An incremental signal is one that produces a step change of the Actuator output for each TRUE input pulse that is received. Both types of inputs will maintain the last Actuator output value during the FALSE or failed states of the signal. The wiring connections of Figures 3C-8 and 3C-9 can be used with either continuous or incremental signals.

The Guard input performs the same function as previously described for analog inputs. It is electrically identical to the Raise and Lower inputs and is wired in the same manner. Figure 3C-8 shows each input wired to separate relay contact or switched circuits. These circuits connect to a positive voltage source that must have the same value as the supply voltage required to power the Actuator (12 or 24 V type). When a contact is closed, the input is set ON (TRUE). When a contact is open, it is set OFF (FALSE).

The arrangement of Figure 3C-9 receives all three inputs from a METATONE B FSK Tri-State Receiver. This receiver provides a MARK and SPACE output which connect to the respective Raise and Lower input terminals, and a CARRIER output that connects to the Guard Input. The Receiver's tri-state outputs are provided as open collectors to drive the opto-isolated inputs of the Actuator. When any of the receiver's driver transistors conduct, the corresponding Actuator Input will be set TRUE. When any driver transistor is cut off, the corresponding Actuator Input will be set FALSE.

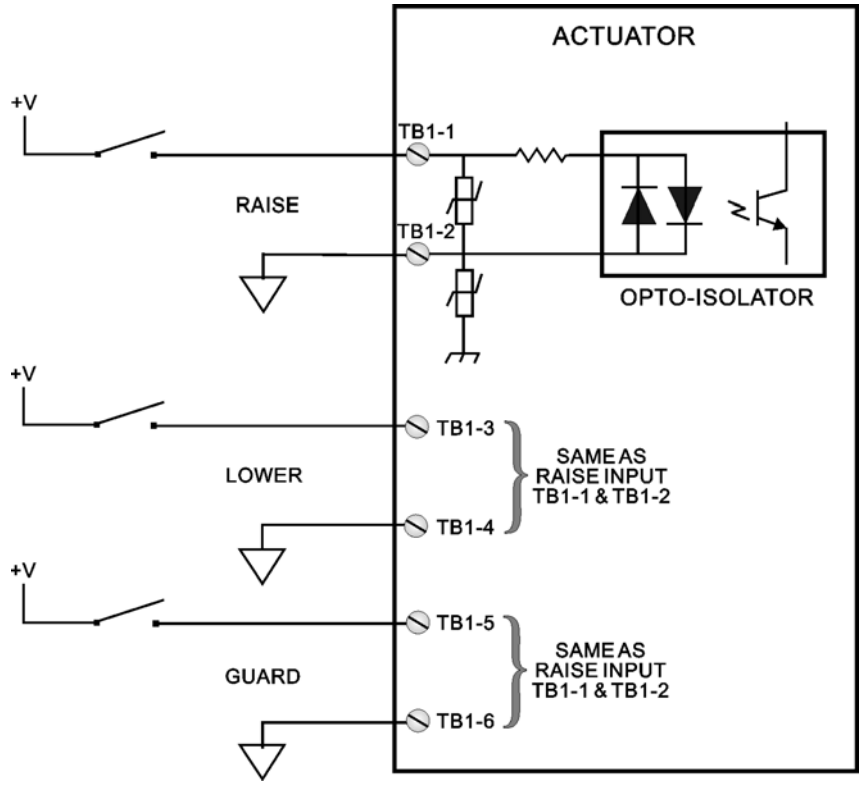


Figure 3C-8 - Raise/Lower & Guard Inputs from Relay Contacts

CAUTION

When using the Actuator with a device that provides latching type outputs (output stays ON until turned OFF), the Raise/Lower inputs must be set for an incremental signal. This will prevent the Actuator from driving full scale should the telemetry line open while in the middle of a Raise or Lower command. By using the incremental configuration, the Raise or Lower value will only change once until the next valid incremental data is received.

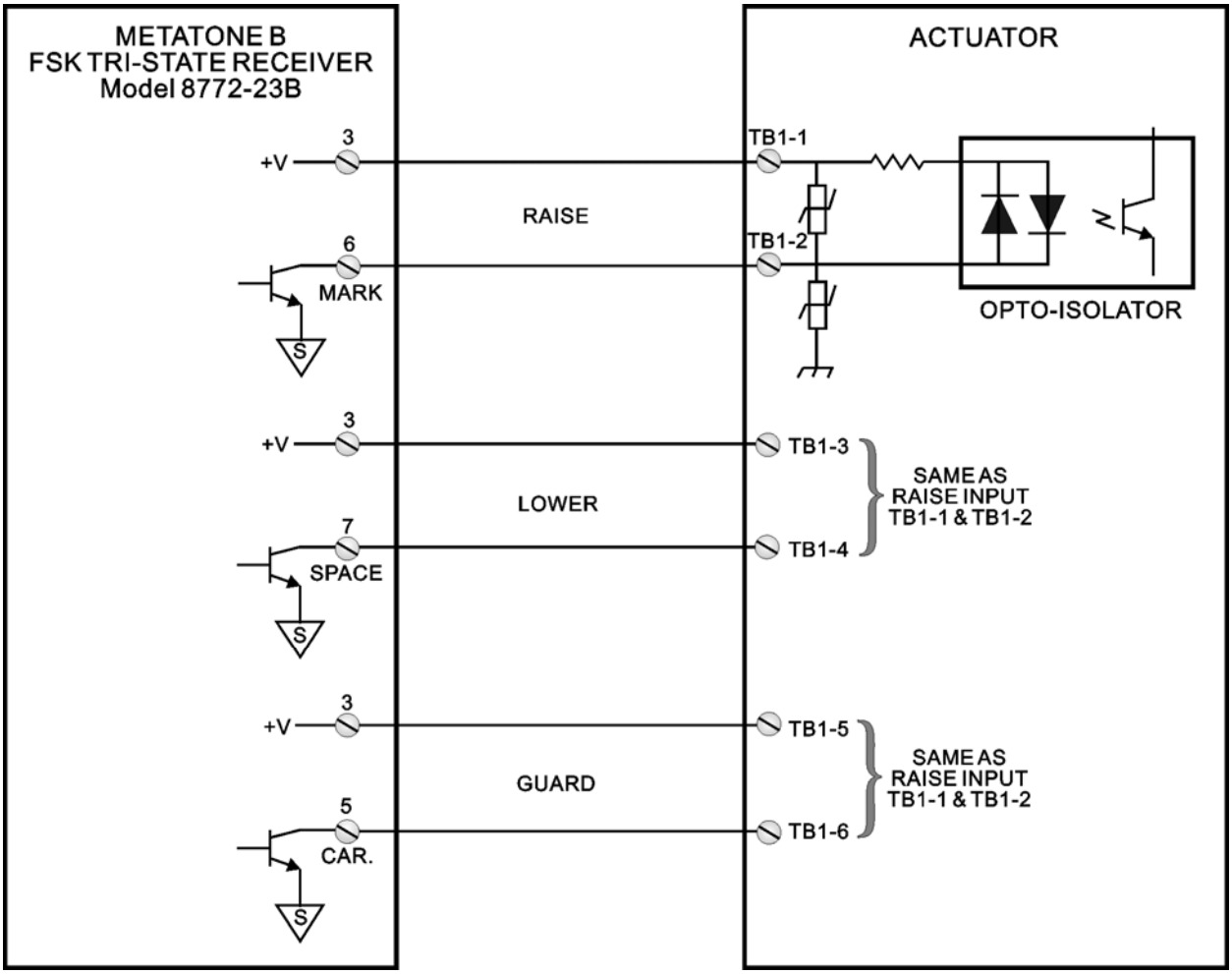


Figure 3C-9 - Raise/Lower & Guard Inputs from Open Collectors

Optional PDM Output (5 or 15 Sec.)

An Actuator equipped with a PDM output can be wired to transmit output data to a METAMETER PDM Receiver at a remote location as shown in Figure 3C-10. Lightning arrestors are placed at both ends of the system to protect the equipment. The enclosure of each device is also grounded in accordance with safety requirements. The correct loop polarity must be observed, as reversed polarity will cause the loop current to be continuously ON.

The alternate arrangement of Figure 3C-11 uses the PDM output to drive a METATONE B, FSK Bi-State Transmitter. The PDM signal modulates an audio tone carrier that is sent via phone lines to a remote location. Lightning arrestors are required at the output of the Bi-State Transmitter and at the input of the corresponding Bi-State Receiver (not shown).

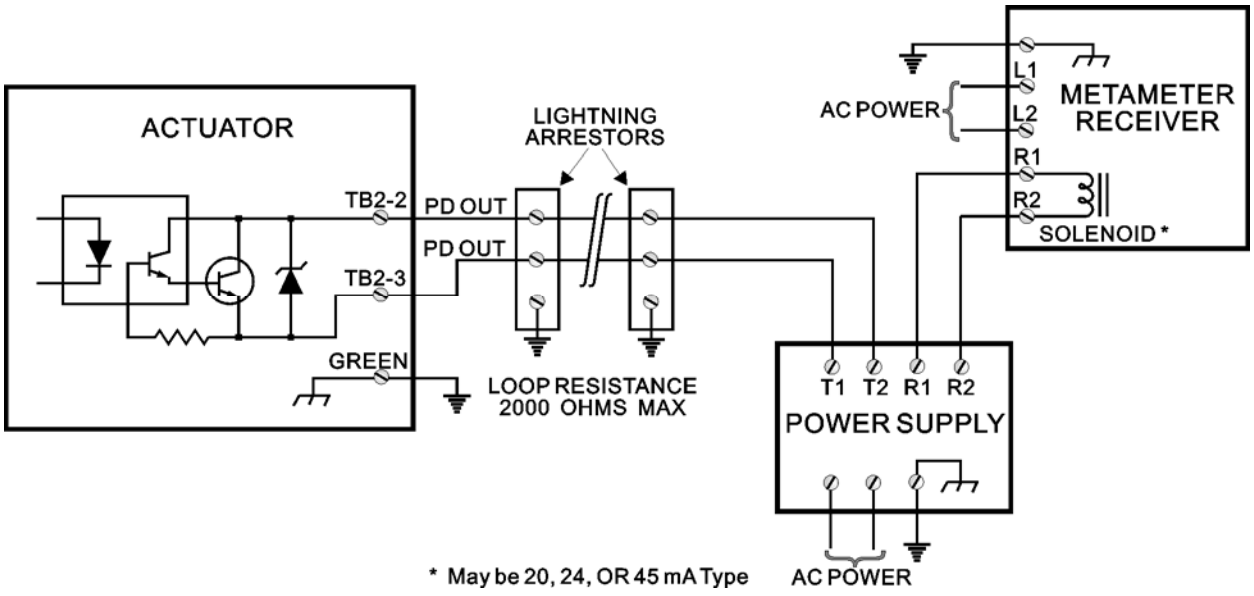


Figure 3C-10 - PDM Output to METAMETER Receiver

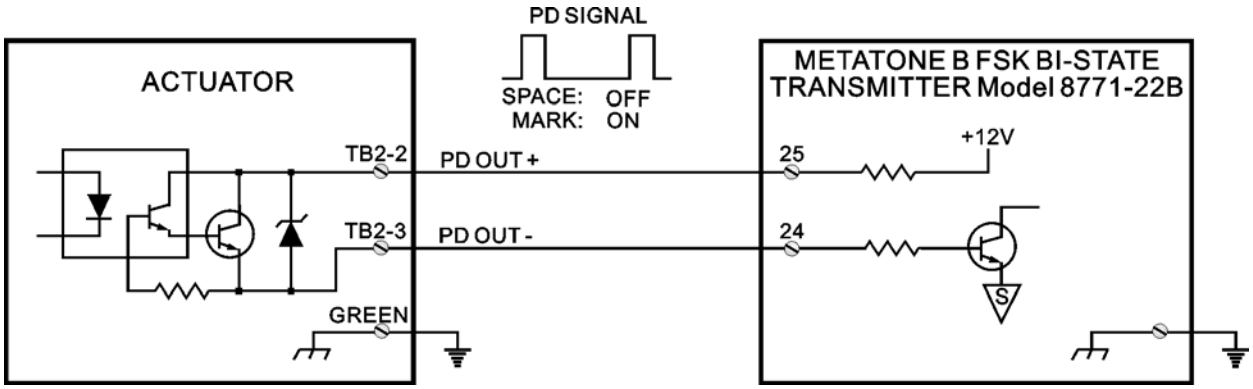


Figure 3C-11 - PDM Output to FSK Bi-State Transmitter

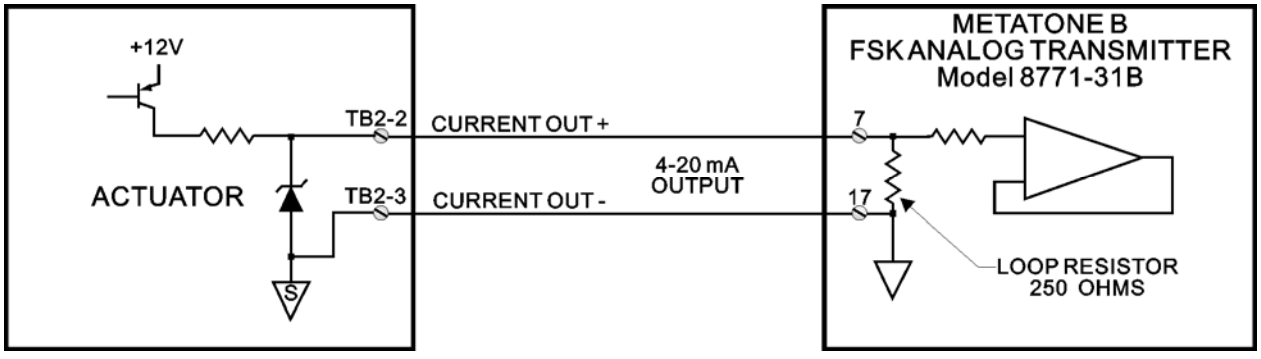


Figure 3C-12 - Current Output to FSK Bi-State Transmitter

Optional Current Output (4-20 mA)

The optional current output can be used to drive a METATONE B, FSK Analog Transmitter as shown in Figure 3C-12. The 4-20 mA current signal is referenced to signal common and flows through the loop resistor present at the input of the Analog Transmitter. The current signal modulates a tone carrier that is sent to an analog tone receiver at the command site (not shown).

Local-Remote Status Indication

A two-position switch selects LOCAL or REMOTE modes to operate the indicating instrument. The position of this switch can be transmitted back to the command site using the wiring arrangement of Figure 3C-13. The switch positions are essentially status signals applied to the input of a METATONE B FSK Bi-State Transmitter. The FSK transmitter sends the status information over a tone carrier to a receiver at the command location (not shown).

Figure 3C-13 - Local-Remote Status to FSK Bi-State Transmitter

DC Power

The Actuator is furnished for 12 or 24 Vdc supply operation. Make sure that the Actuator matches the dc supply source before power is applied.

The dc supply source is wired to the Actuator as shown in Figure 3C-14. A proper ground must be provided for both the Actuator assembly and the supply. The ground connection for the Actuator is made to the green grounding screw located inside the housing.

WARNING

Metal enclosures and exposed metal parts of all electrical instruments and devices must be grounded to prevent accidental electrical shock. Grounding must be in accordance with latest OSHA rules and regulations pertaining to "Design Safety Standards For Electrical Systems" and local authority.

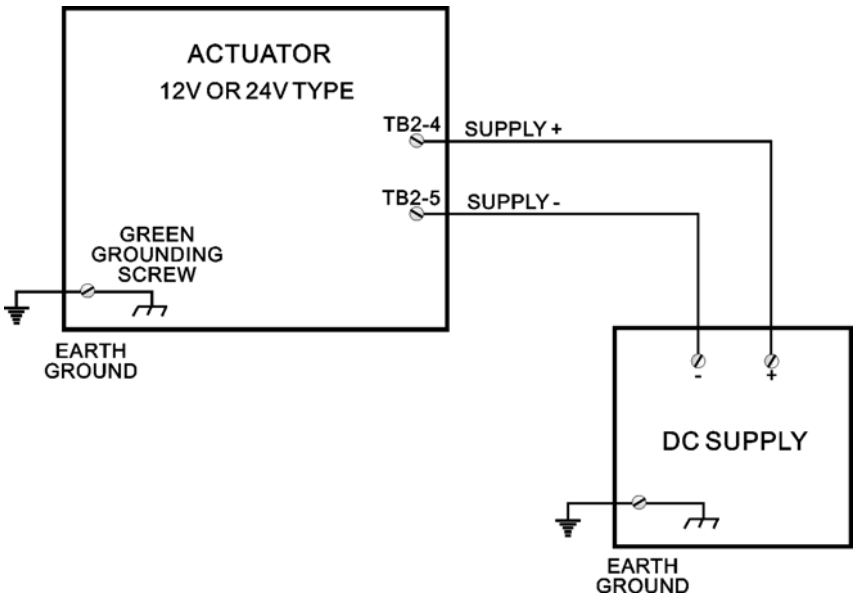


Figure 3C-14 - DC Supply Connections

3C.5 STARTUP

This section describes the startup procedures relative to the Actuator Assembly. The unit must be properly wired and grounded as described in section 3C.4.

Optional Hi-Lo Limits

Some models will be furnished with mechanical high and low limits for the indicating scale of the instrument (see Figure 3C-15). These limits are held in place by a thumbscrew. Once the thumbscrews are loosened, they can be repositioned to any part of the indicating scale.

Should the Command input signal be at a level that forces the driven pointer against a limit for a few seconds, the stepper motor will turned off. If the Command signal returns to its safe operating zone, the stepper motor will restart and reposition the driven pointer accordingly. However, if the Local-Remote switch is transferred to the LOCAL position while the driven pointer is in the active region of the scale, the system may time out. Consequently, when the switch is set back to the REMOTE position, the actuator may not respond and appear to be dead. In this situation, normal operation can be obtained by either repositioning the driven pointer or by changing the level of the Command signal so that the driven pointer moves in the opposite direction.

Local-Remote Switching & Manual Adjustment

The indicating instrument a Local-Remote transfer switch as shown in Figure 3C-15. When this switch is in the LOCAL position, the actuator output is switched OFF and the driven pointer can be set manually using the Manual Adj. Knob. In the REMOTE position, the actuator output is turned ON and the position of the driven pointer is set by the command signal. When starting an instrument, it is recommended that this switch be kept in the LOCAL position until the process parameters have been checked for proper operation.

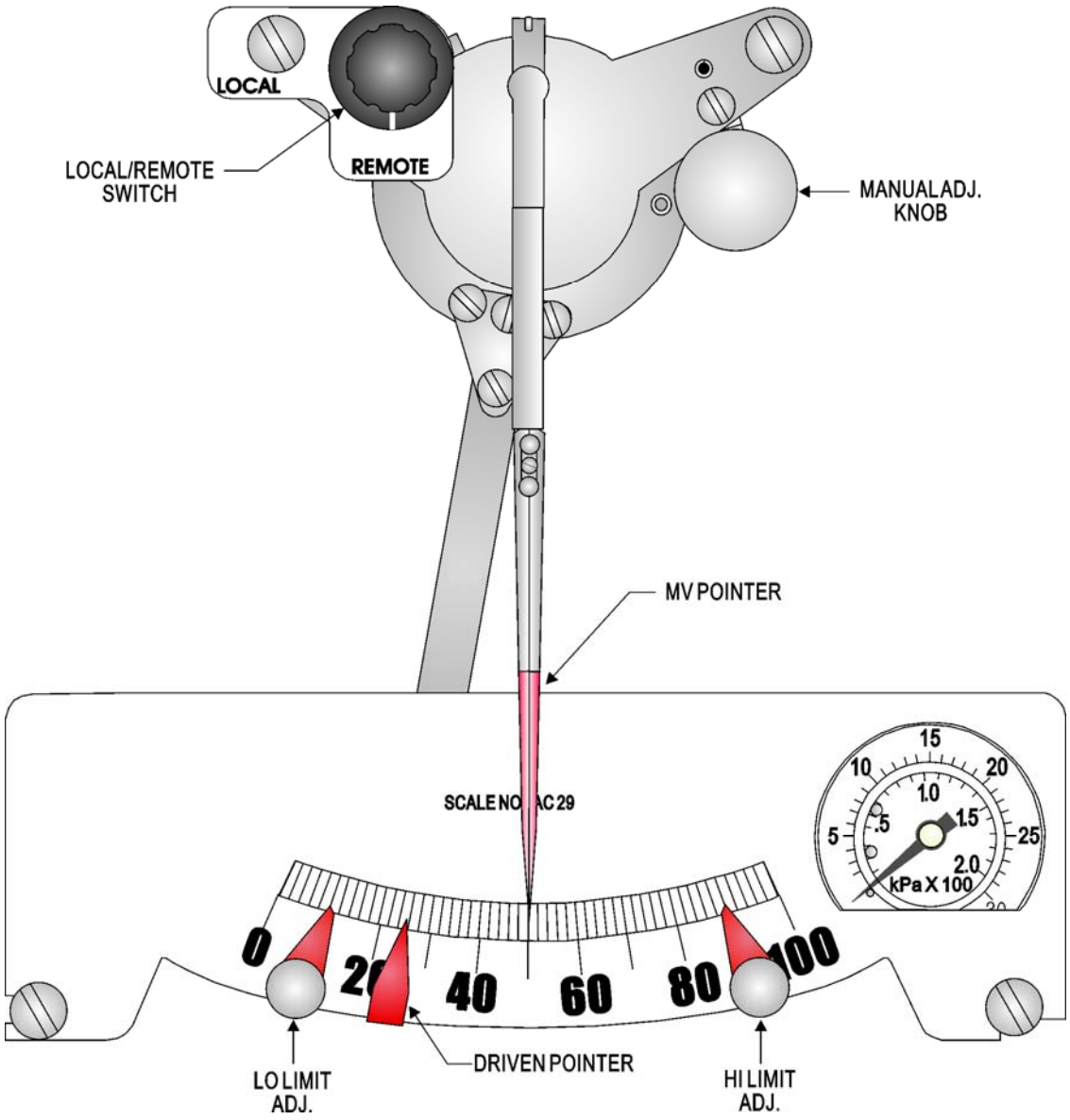


Figure 3C-15 - Operating Controls

Remote Setpoint Actuator Power Up

The Remote Setpoint Actuator (RSA) does not contain a power switch. It begins operating the moment power is applied. If the Local-Remote switch is in the LOCAL position at startup, the driven pointer will not move; the pointer will either indicate the setpoint value on a controller model or the output value on a transmitter model. If it is set to the REMOTE position, the driven pointer will move to a value determined by the command signal (if there is a difference between the local and remote values). If the driven pointer fails to move, even with a change of Command input, the fuse inside the Actuator housing may be blown. Check and replace it as required. If replacement fuses continue to blow, wiring errors may be present at the field wiring terminals or the Actuator may have a defective board. Do not attempt further operation until the source of the problem has been corrected.

3C.6 THEORY OF RSA ACTUATOR OPERATION

The main circuitry of the Remote Setpoint Actuator (RSA) is contained on the CPU Board, while the field terminals and the input protection circuitry are contained on the Termination Board. The CPU Boards used in analog Raise/Lower type Actuators are similar except for differences in the input circuitry as noted in Figures 3C-16A and 3C-16B.

Remote Setpoint (Analog) Actuator

The Analog Actuator is shown in the block diagram of Figure 3C-16A. In this circuit, the Command signal (1-5 V or 4-20 mA) is applied to a buffer amplifier which drives the plus (+) input of the lower comparator and the minus (-) input of the raise comparator. Also note that the opposing inputs of both comparators are referenced to the contact arm of the slide-wire.

The CPU, clock and reset circuitry provides timing, measurement and decision making functions of the Actuator. This circuit analyzes the comparator outputs and sends data to the stepper driver, which in turn, pulses the stepper motor in either direction. Since the drive shaft of the stepper motor is mechanically coupled to the driven pointer and the contact arm of the slide-wire, both will be positioned in accordance with data received from the CPU.

If an increase in signal level occurs at the command input, the raise comparator will become unbalanced since this signal will exceed the voltage present at the contact arm of the slidewire. The lower comparator will be unaffected since the input signal will be of opposite polarity compared to the slide-wire voltage. The CPU senses the increased output at the raise comparator and outputs a signal that drives the stepper motor in an upward direction. The upward driving action will continue until the voltage at the slide-wire contact arm becomes equal to the new signal level. Once the comparator is balanced, the CPU will turn off the stepper motor and the driven pointer will indicate the new value. Input changes that reduce the actuator output will have the opposite effect.

The comparators are biased so that they include a certain amount of hysteresis. This bias keeps the stepper motor in a stable, deenergized zone that is less affected by noise bursts that may appear on the command input line.

The stepper motor is actuated in incremental steps. The pulse signals received from the stepper driver will increment the motor one step at a time. The motor requires 4000 steps for full rotation.

Signal Failure Circuitry

The fault detector, opto-isolated input, and logic circuits shown in Figures 3C-16A and 3C-16B provide two types of signal failure protection modes via a jumper circuit. Position "A" of the jumper circuit provides Fail-Hold mode, while position "B" provides Fail-Zero mode. (The actual circuit uses two jumpers, W1 and W2.)

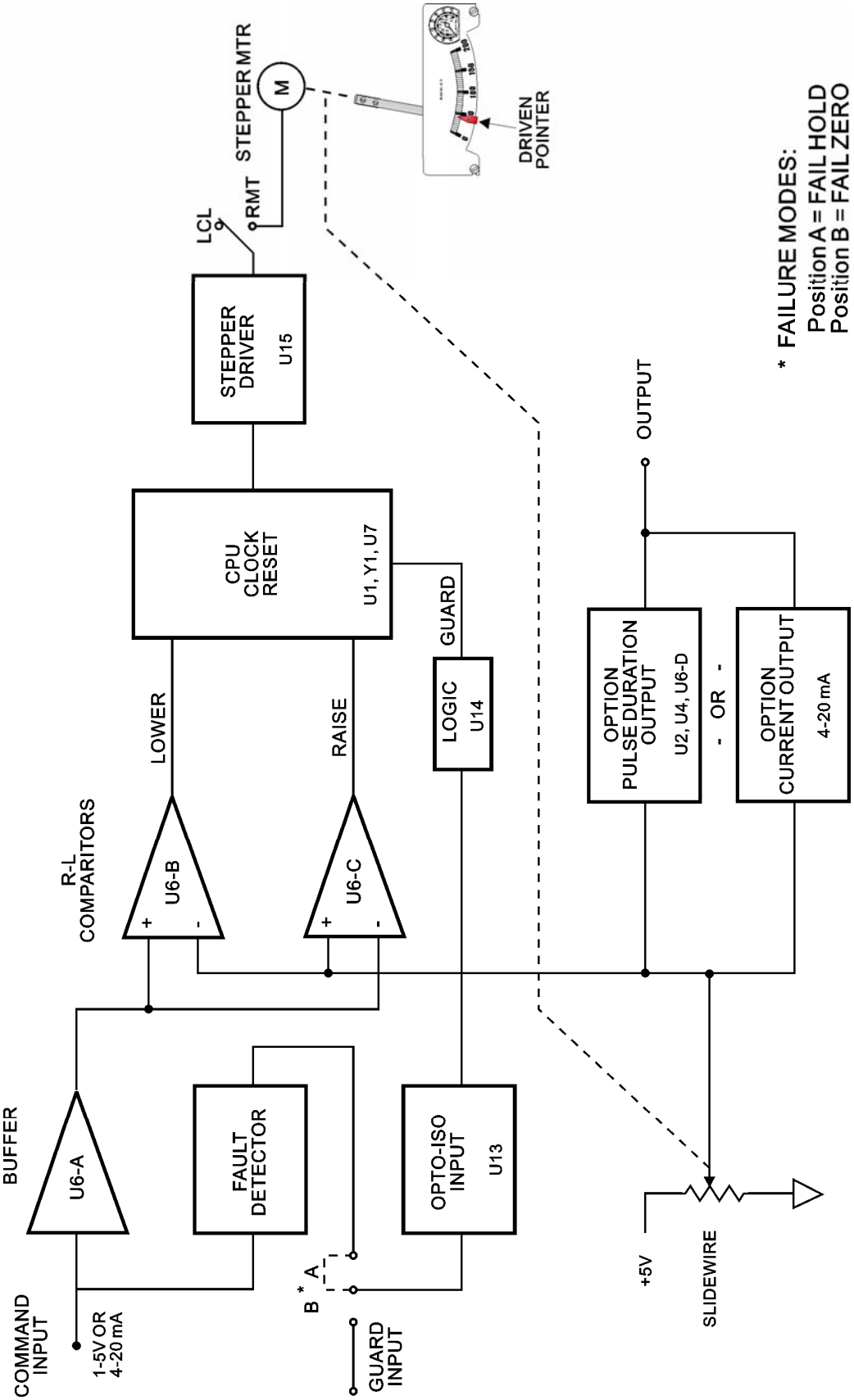


Figure 3C-16A - Block Diagram of Analog Actuator

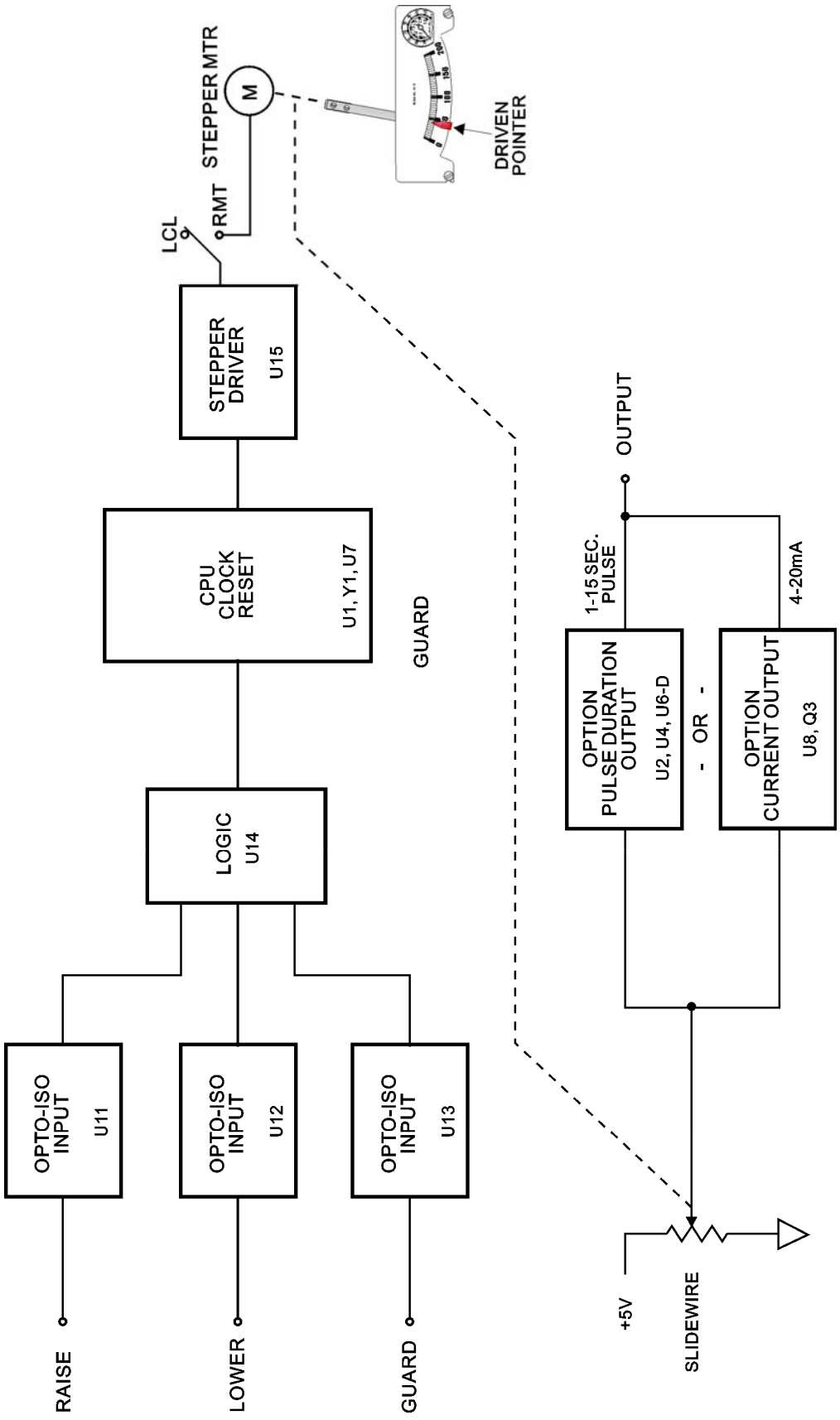


Figure 3C-16B - Block Diagram of Raise/Lower Actuator

When the jumper is set to position "A" as shown, a failure at the Command Input is indicated when the input signal drops below 0% of scale. This failure will be sensed by the fault detector, which in turn, will set the logic and CPU circuits to hold the stepper driver output at the last output value that existed prior to the failure.

When the jumper is set to position "B," the fault detector will be disabled and a user-supplied status signal connected to the guard input will control the opto-isolated input circuit. As long as the guard input is "enabled," the logic and CPU circuits will allow the stepper driver to track the input; should the command input signal fail while in this mode, the stepper output will decay to zero. If a normal signal is present at the command input when the Guard Input is "inhibited," the logic circuit will set the CPU to maintain the stepper driver at the value it held prior to the "inhibit."

PDM Output

Some models may be specified with the optional PDM output (5 or 15 sec.). For these models, additional pulse duration circuitry will be included on the board. This circuitry measures the voltage present at the slide-wire contact arm and provides an analog-equivalent PDM output that can be sent to the command site.

Current Output

Models specified with the optional 4-20 mA current output will track the slide-wire voltage and provide data for the user's application. Inclusion of this option precludes the use of the PDM output option.

Local-Remote Switch

A local-remote switch is used to turn off the stepper motor so that the driven pointer can be operated manually. In LOCAL mode, this switch essentially removes power from the stepper motor. Any manual adjustments made to the driven pointer will be reported to the command site via the PDM or current output signal (if so equipped).

Remote Setpoint (Raise/Lower) Actuator

A block diagram for the Raise/Lower Actuator is shown in Figure 3C-16B. It will be noted that this model is similar to the AI type previously discussed except that they provides separate Raise, Lower and Guard input circuit. These three opto-isolated inputs are applied to a logic circuit that checks the status of the each signal and determines whether the output will be in a raise, lower or guard mode.

Each raise and lower input may be configured for continuous or incremental type signals. The former are steady-state dc signals that are either continuously ON or OFF, while the latter are pulse signals that increment the output.

3C.7 REFERENCE DRAWINGS

This section provides assembly drawings and schematics for user reference. These drawings are listed as follows:

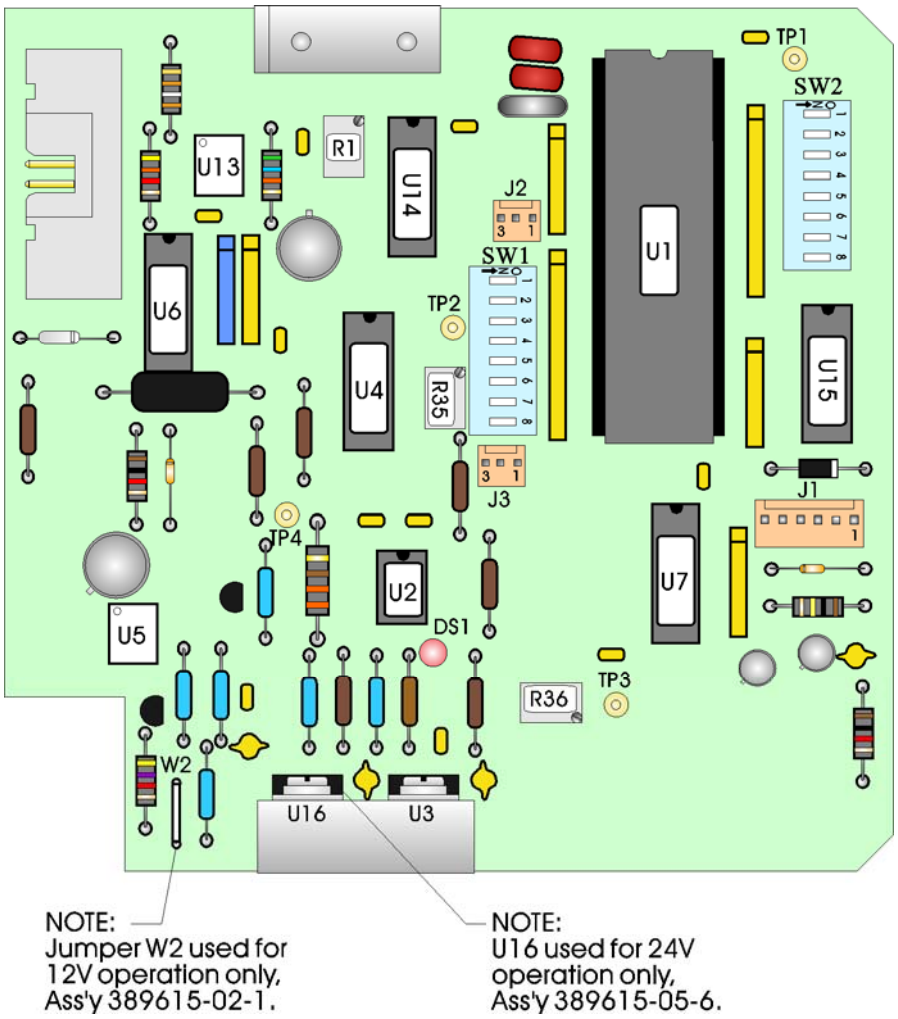


Figure 3C-17 - Assembly, Analog Type CPU Board with PDM Output

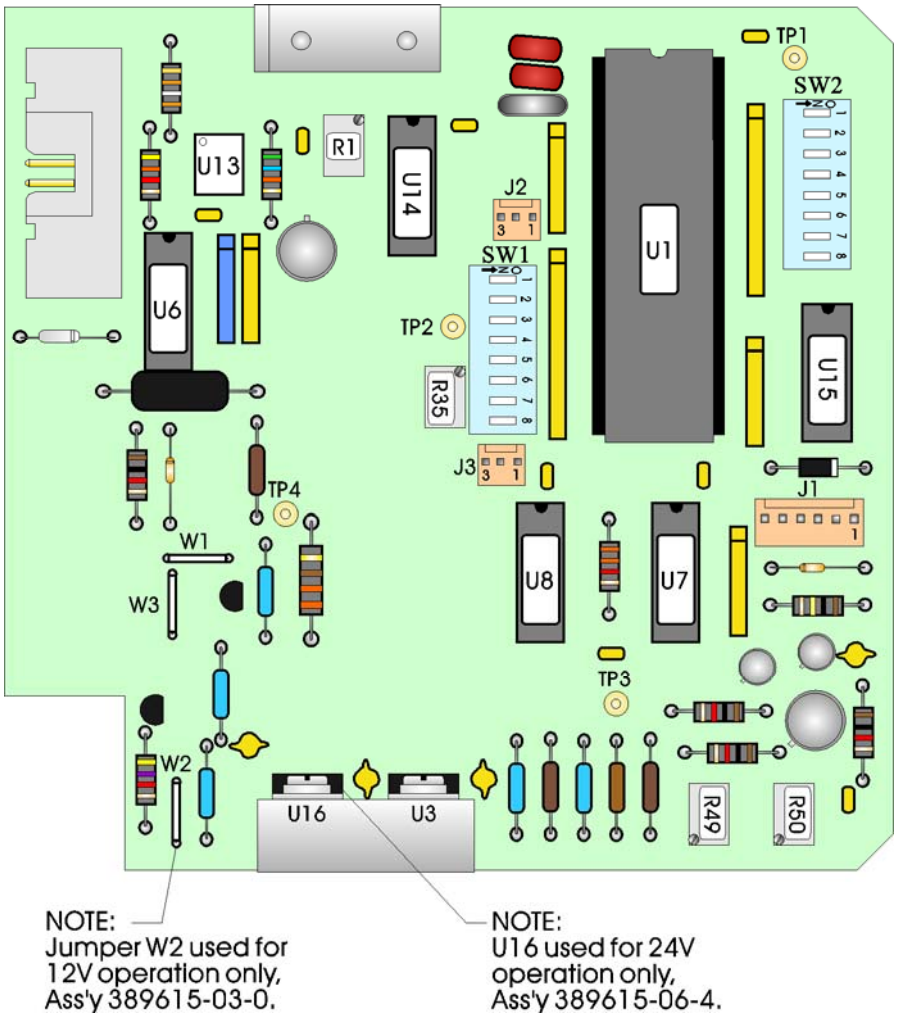


Figure 3C-18 - Assembly, Analog Type CPU Board with Current Output

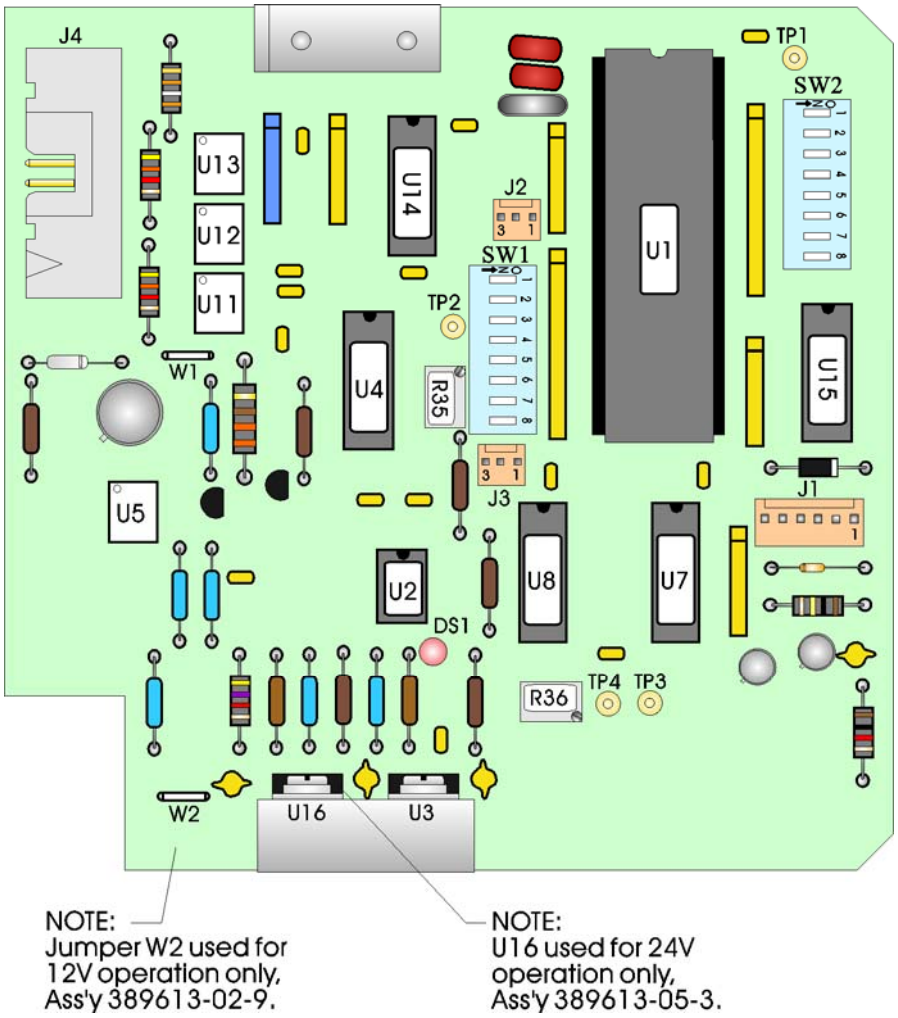


Figure 3C-19 - Assembly, Raise/Lower Type CPU Board with PDM Output

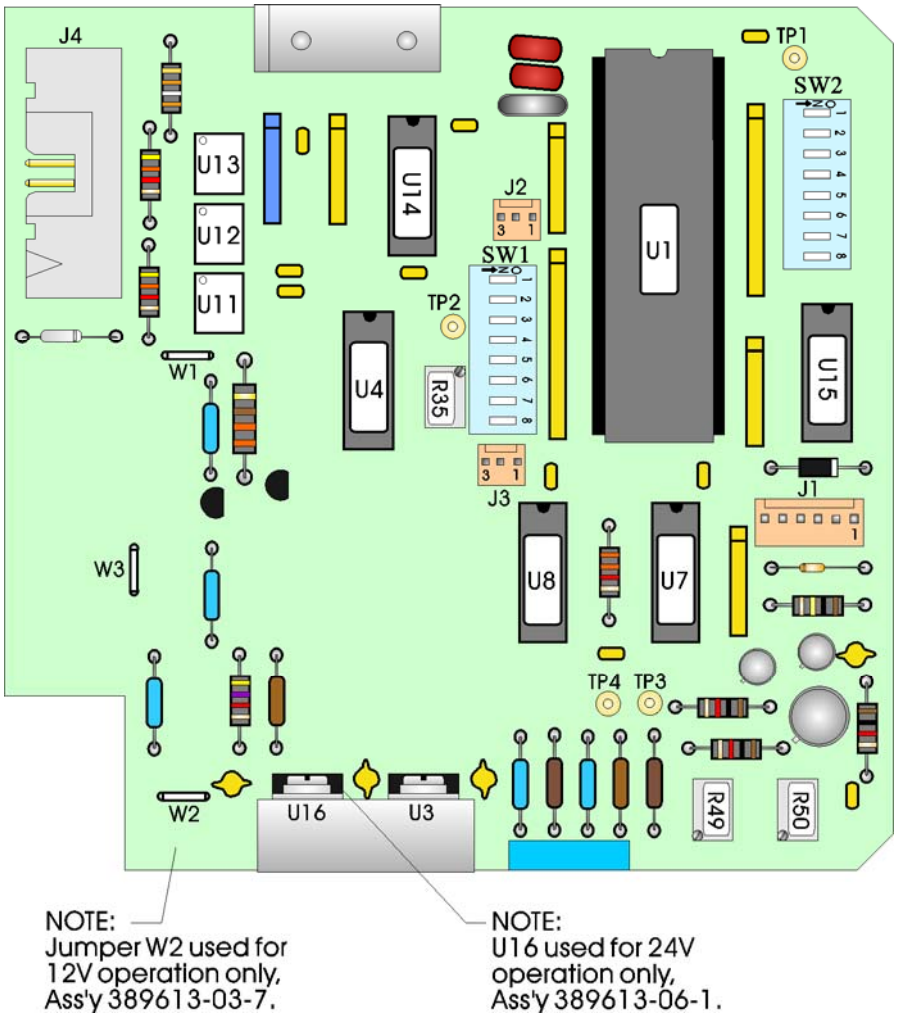


Figure 3C-20 - Assembly, Raise/Lower Type CPU Board with Current Output

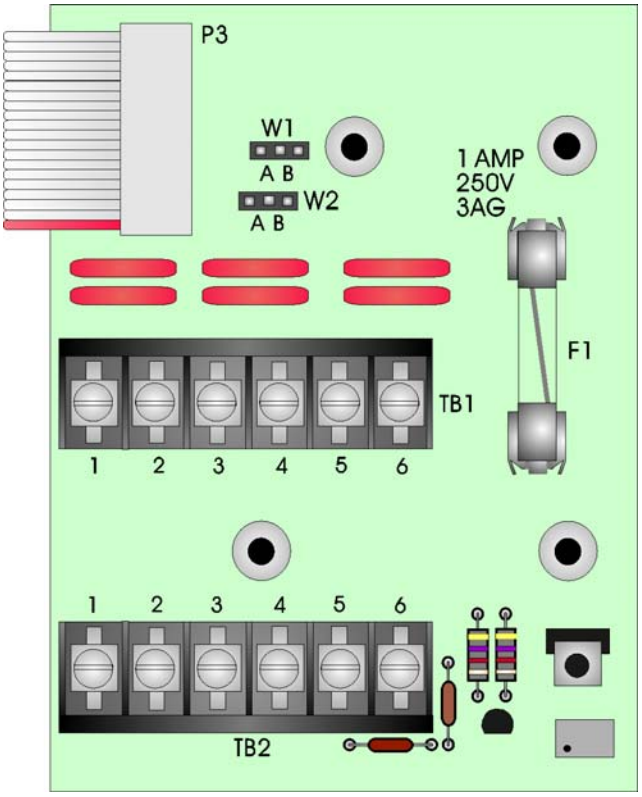


Figure 3C-21 - Assembly, Analog Termination Board

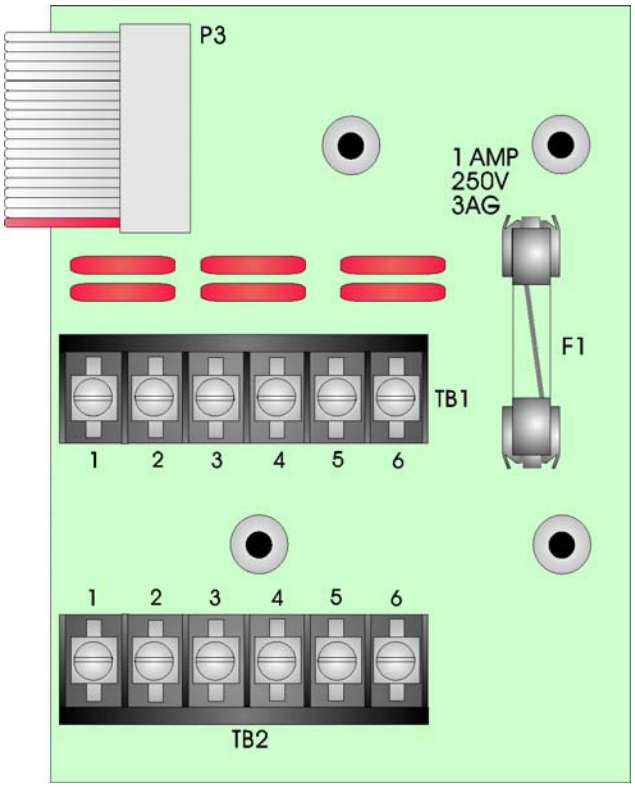


Figure 3C-22 - Assembly, Raise/Lower Termination Board

3C.8 SERVICE

The servicing and calibration procedures described in this section should only be performed by qualified technical personnel.

These procedures should not be performed while the Remote Setpoint Actuator is connected to an on-line process. A laboratory setup is recommended for calibration and servicing. If this is not possible, steps should be taken to close down the process or to isolate the Regulator in such a manner that it has no control over the process.

**** Warning ****

Models intended for operation in hazardous areas require additional precautions. Under no circumstances should the cover be removed while the instrument is powered and operating. If access is required, either the dc power must be turned off, or the environment must be made safe, i.e., non-hazardous. An electrical spark in a hazardous environment could cause fire or an explosion and result in property damage and injury to persons.

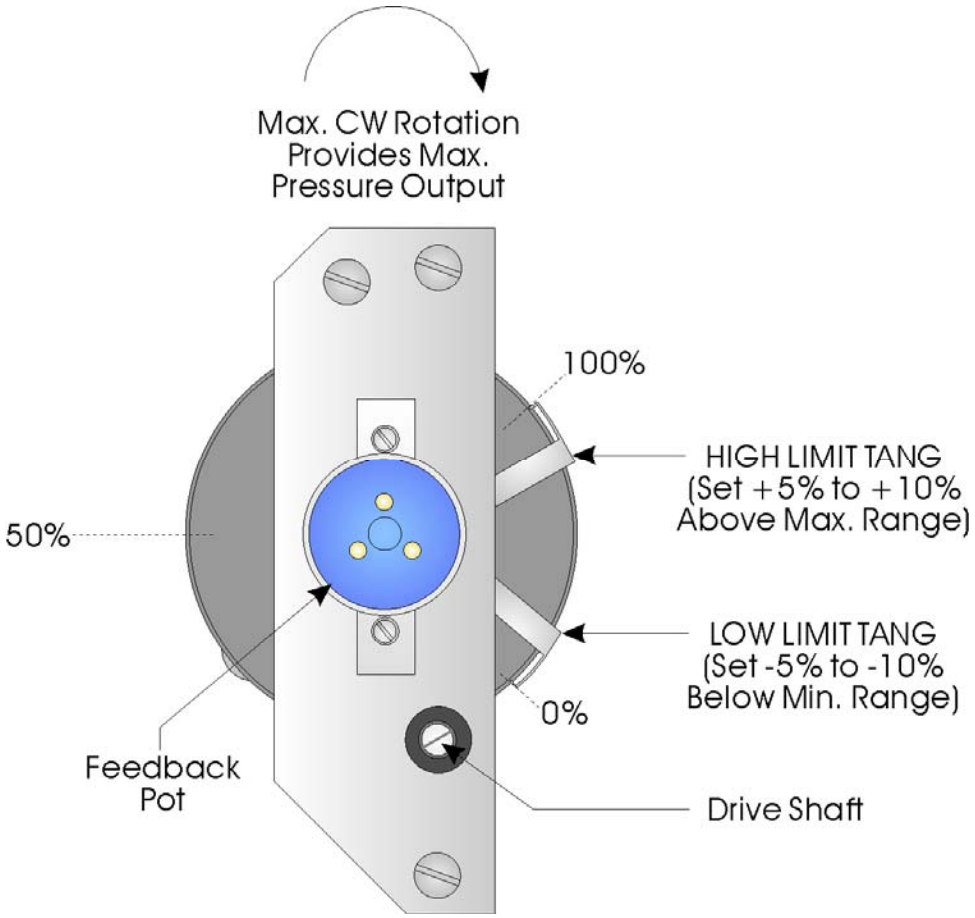


Figure 3C-23 - Rear View of Gear Drive Assembly

Troubleshooting Hints

Some basic types of problems that can occur in the field are listed as follows:

- **Unit dead, no motor movement**

Measure across power terminals TB2-4 & -5 with a DVM. The reading should be 12 or 24 V dc depending upon model. Incorrect or no voltage indicates an external supply problem. If proper voltage is present, check Fuse F1 on the Termination Board. Fuse F1 should be a 1A, 250 V, 3AG type. If replacement fuses continue to blow, a short may be present at the field wiring terminals or in the PC boards.

- **Output drift on Analog model**

Check for open signal lead at input terminals TB1-2 & -3. Measure across terminals with a DVM and check for proper voltage range.

- **Output stays constant with input change**

If Guard mode is used, check for proper signal at Guard terminals TB1-5 & -5. If Guard is not used, make sure SW2-6 is in the CLOSE position.

- **Severe output tracking errors on Analog model**

Check setting of switches SW1 (1-5). If any are set to Pulse Increment mode, the output will not balance properly. These switches must be set OPEN for Analog models.

- **Noisy or Erratic Output on Raise Lower Model**

Try SW1-8 in both positions and choose the one with the lowest noise level. For Analog models, this switch must be set OPEN.

- **Raise or Lower function does not work on Raise/Lower model**

Check voltage at Raise or Lower terminals TB1 (1-4) with voltmeter during activation. Also check across Guard terminals TB1-5 & -6, if used. If no voltage change occurs at any given input, check for broken signal leads or a defect in the external device.

- **Output pressure does not rise above certain point**

A high limit may be set too low or the pressure regulator vent may be restricted. Also check for water or oil in pressure lines.

- **Output pressure drops off with constant level input**

Check for leaks in pressure lines or loose fittings.

Setting Output Limits

General Principles

The Actuator provides mechanical output limits that prevent the output from underranging or overranging the process. When the Command Input is of a value that causes the stepper motor to drive against a limit, the clutch will allow the driveshaft to slip. After the motor has completed several revolutions, the software will turn it OFF to prevent clutch wear. The motor will remain OFF until the Command Input signal returns to a value that is within the set limits.

Test Setup

When a Remote Setpoint Actuator leaves the factory, the low limit is set to about -10% below the minimum range value, and +10% above the high range value. These limits may be changed in the field if the user has the capability to adjust the dc input signal over the full range of the Actuator and to monitor the pressure output. Bench calibration setups similar to those shown in Figures 3C-24 or 3C-25 may be used to set the mechanical limits on Analog or Raise/Lower models. The DMMs (digital multimeters) shown in both illustrations are not required for setting limits.

Procedure

The method of setting the mechanical Hi and Lo Limit adjustments are described as follows:

1. Check that pressure supply to Remote Setpoint Actuator is at proper value. Turn off dc power source (12 or 24 V dc) to Remote Setpoint Actuator and remove Actuator Cover.

2. For all models, set switch SW2-6 to CLOSE to disable the Guard input.

3. For Analog models, set jumpers W1 and W2 for Fail/Hold mode. See topic Analog Failure Mode (Fail Hold & Fail Zero). Turn ON dc power source.

4. Locate two limit adjustment tangs on main gear assembly. Refer to Figure 3C-23.

5. Adjust dc test input level to approximately -20% below minimum range value. Pressure output will fall to a minimum value and remain there.

6. If limit tangs were previously set at factory their positions on main gear will appear about as shown in Figure 3C-23. If tangs are at different positions, other limit values may have been field-selected.

7. Turn off dc power. Limits are set by estimating positions on the main gear assembly. To set a limit, slightly lift edge of tang from teeth of main gear and carefully move tang to approximate desired position. Release tang to lock its position. If access to a tang is blocked, re-apply dc power and adjust dc input level to a value that will rotate main gear in a direction to make tang accessible. Turn off dc power and set limits as required.

8. Once limits have been set, re-apply dc power and adjust input test circuit (analog or raise/lower) for range value above upper limit. When upper limit is reached, main gear will stop rotating and output pressure will hold constant at value of desired limit.

**** Caution ****

Do not attempt to turn main gear or driveshaft by hand to reach a limit. The force generated in this manner can easily damage the gear teeth and limit tangs. Always use a dc test input signal to drive the main gear through its range.

9. If limit values are not at desired points, continue to experiment with tangs until correct positions can be found.

10. When adjustments are complete, disconnect test setup and recheck board configuration as required. Replace cover and restore unit to normal operating status.

3C.9 CALIBRATION

The calibration of the Remote Setpoint Actuator will require a laboratory bench setup. The setup of Figure 3C-24 is used for Analog models, while that of Figure 3C-25 is used for Raise/Lower models.

In Figure 3C-24, the Analog model uses a precision 1 - 5 volt test source to provide an adjustable input signal. In Figure 3C-25, the Raise/Lower model uses a switch test circuit consisting of two pushbutton switches that apply dc power to either the Raise or Lower inputs. As long as a switch is pressed, the output will be raised or lowered assuming continuous dc input configuration.

From this point on, the test setups of Figures 3C-24 and 3C-25 are identical. A digital multimeter (DMM #1) is connected across test points TP3 and TP4 to monitor the voltage at the center arm of the feedback potentiometer. The 250-ohm resistor and switch circuit is used to load the current output circuit, while DMM #2, functioning as a milliammeter, measures the load current.

Calibration Precaution

During calibration, the stepper motor will be driven to both ends of it operating range. Since this movement is extremely slow, do not be tempted to run the unit up or down range by manually forcing the main gear or driveshaft. Doing so can cause damage to the gear teeth and the mechanical limit tangs. Always use a dc test input signal to reposition the main gear and allow the Remote Setpoint Actuator to balance itself out.

Preliminary Calibration Check

Once the test setup of Figure 3C-24 or 3C-25 has been completed, the following conditions must be established.

1. For all models, set switches SW1 (1-5) to OPEN for continuous operation, and SW2-6 to OPEN to disable Guard circuit. For Analog models only, set SW2-8 to OPEN for 1 - 5 V input.

2. See if it is possible to scan the complete range of the Remote Setpoint Actuator by adjusting the input test circuit and observing the Setpointer. If range of travel is not complete, mechanical limits are less than output span or:

   0% < Limits < 100%

   At this time, position limits to following settings (see topic Setting Output Limits):

   Lo Limit = -10% (approx.)
   Hi Limit = +110% (approx.)

   If full range cannot be obtained even with above limits, other problems may be indicated. Refer to the topic Troubleshooting Hints (within this chapter) before proceeding.

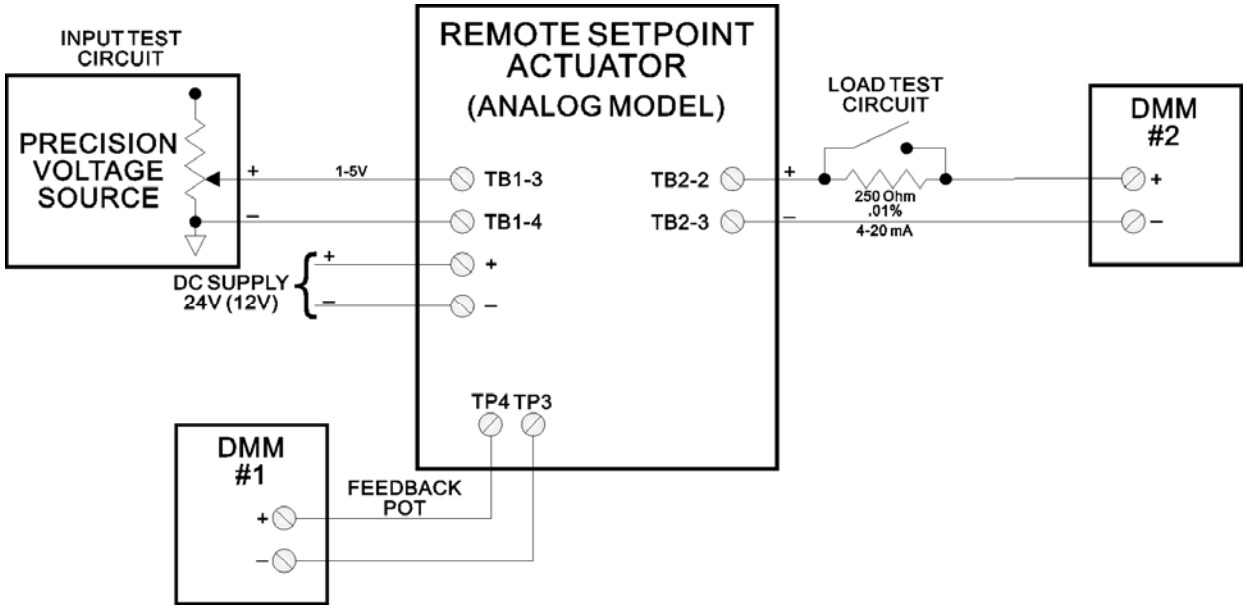


Figure 3C-24 - Analog Test Setup

3. Set input test circuit for 0.995 V reading on DMM #1. DMM #2 should read 4 mA, ±.02 mA Test gauge should read minimum range value (3 or 6 psi), ±5.0%.

4. Press input test circuit push-buttons for 4.995 V, ±0.004 V reading on DMM #1. Reading on DMM #2 should be 20 mA, ±.02 mA.

5. If above readings are within stated specifications, stop! No calibration is required. Restore instrument to normal operation. Otherwise, proceed to topic Detailed Calibration For Analog Model or Detailed Calibration For Raise/Lower Model as required.

Detailed Calibration For Analog Model

If calibration errors were found during the preliminary calibration check, the procedures described herein for Analog models should be performed.

Feedback Zero & Span

The precision voltage of an input test circuit is used to calibrate the zero and span as follows:

1. Adjust input test circuit for 1.000 V output.

2. DMM #1 should read 0.995 V, ±.004 V.

3. If reading of step 2 is out of tolerance, slightly loosen two screws on body of feedback pot (Figure 3C-23) and rotate body until DMM #1 reads as specified in step 2. Secure pot screws to lock in setting.

4. Adjust the input test circuit for 5.000 V.

5. DMM #1 should read 4.995 V, ±.004 V.

6. If the reading of step 5 is out of tolerance, adjust potentiometer R35 on CPU Board to correct.

7. Recheck both points and readjust zero and span if required.

Current Output Span & Load

The current output circuitry is provided with two calibration adjustments. Potentiometer R50 is used for span adjustment, and R49 for load compensation. For these tests, DMM #2 (used as a milliammeter) is connected in series with a 250-ohm load resistor as shown in Figure 3C-24. The pushbutton switch is used for load testing.

1. Adjust input test circuit for 5.000 V.

2. DMM #2 should read 20 mA, ±.02 mA. If necessary, adjust pot R50 to correct.

3. Press load pushbutton while observing DMM #2. If current reading increases, adjust R49 CCW. If reading decreases, turn it CW. Repeat procedure until change is less than ±.02 mA.

4. Final reading should be 20 mA, ±.02 mA. If necessary, reset pot R50 and repeat the procedure.

Detailed Calibration For Raise/Lower Model

If calibration errors were found during the preliminary calibration checks, the procedures described herein for Raise/Lower models are performed.

Feedback Zero & Span

The tracking voltage provided by the motor-driven feedback potentiometer is calibrated against the pressure output as follows:

1. Adjust the Setpointer for a 0% indication on the 5457's Scale.

2. DMM #1 should read 0.995 V, ±.004 V.

3. If reading of step 2 is out of tolerance, slightly loosen two screws on body of feedback pot (Figure 3C-23) and rotate body until DMM #1 reads as specified in step 2. Secure pot screws to lock in setting.

4. Adjust the Setpointer for a 100% indication on the 5457's Scale.

5. DMM #1 should read 4.995 V, ±.004 V

6. If the reading of step 5 is out of tolerance, adjust potentiometer R35 on CPU Board to correct.

7. Recheck both points and readjust if required.

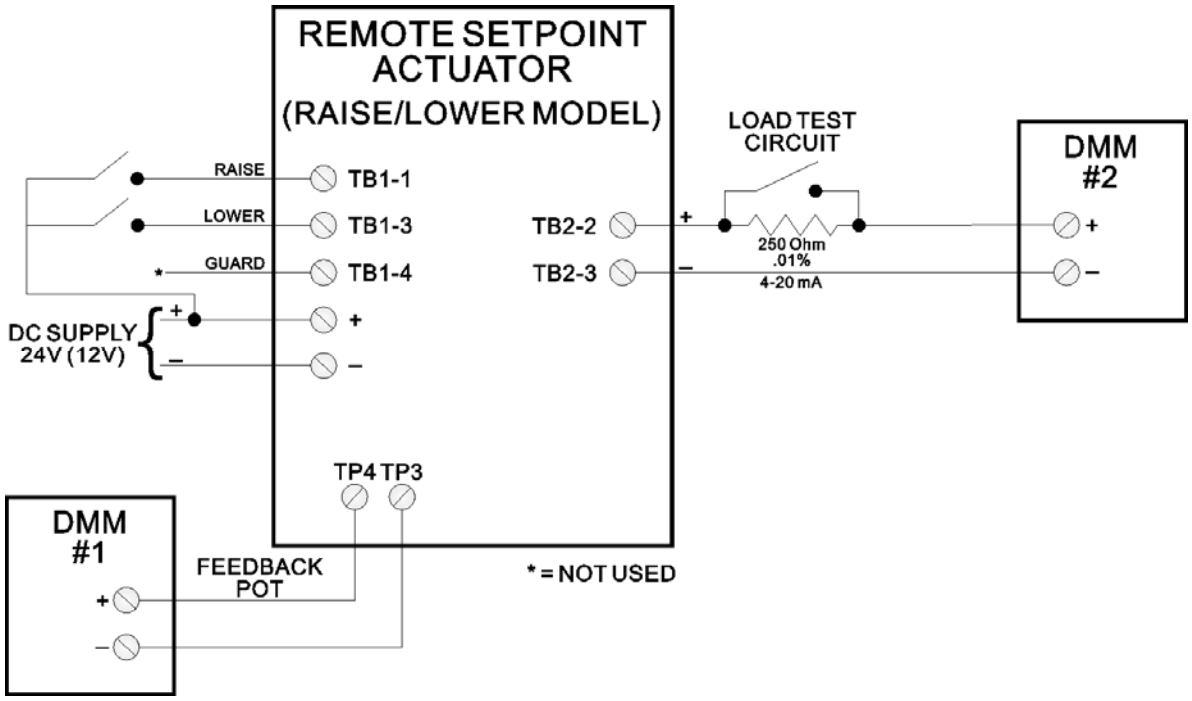


Figure 3C-25 - Raise/Lower Test Setup

Current Output Span & Load

The current output circuitry is provided with two calibration adjustments. Potentiometer R50 is used for span adjustment and R49 for load compensation. For these tests DMM #2

using the current measurement function is connected in series with a 250-ohm resistor load as shown in Figure 3C-25. The pushbutton switch is used to jump the load.

1. Adjust input test circuit for 4.995 V indication on DMM #1.

2. DMM #2 should read 20 mA. If necessary, adjust pot R50 to correct.

3. Press load pushbutton while observing DMM #2. If current reading increases, adjust R49 CCW. If reading decreases, turn it CW. Repeat procedure until change is less than ±.02 mA.

4. Final reading should be 20 mA, ±.02 mA. If necessary, reset pot R50 and repeat procedure.

5. Calibration is complete. Restore unit to normal operating status.

Chapter 3D
INDICATING TRANSMITTER

3D.1 GENERAL DESCRIPTION

Series 5458 Indicating Pneumatic Transmitters provide simultaneous indication and transmission of a measured variable. Output signals are typically transmitted to pneumatic receiving devices such as recorders, controllers and indicators. An internal view of a typical model is shown in Figure 3D-1.

The transmitter output may be a specified as a 3-15 psi or 3-27 psi signal. The former requires a 20 psi supply, and the latter a 30 psi supply.

Transmitters are offered with a variety of measuring systems such as pressure, vacuum, differential pressure, etc. The model number identifies the type of system furnished with a transmitter. A listing of measurement systems was given in Section 1 - Introduction.

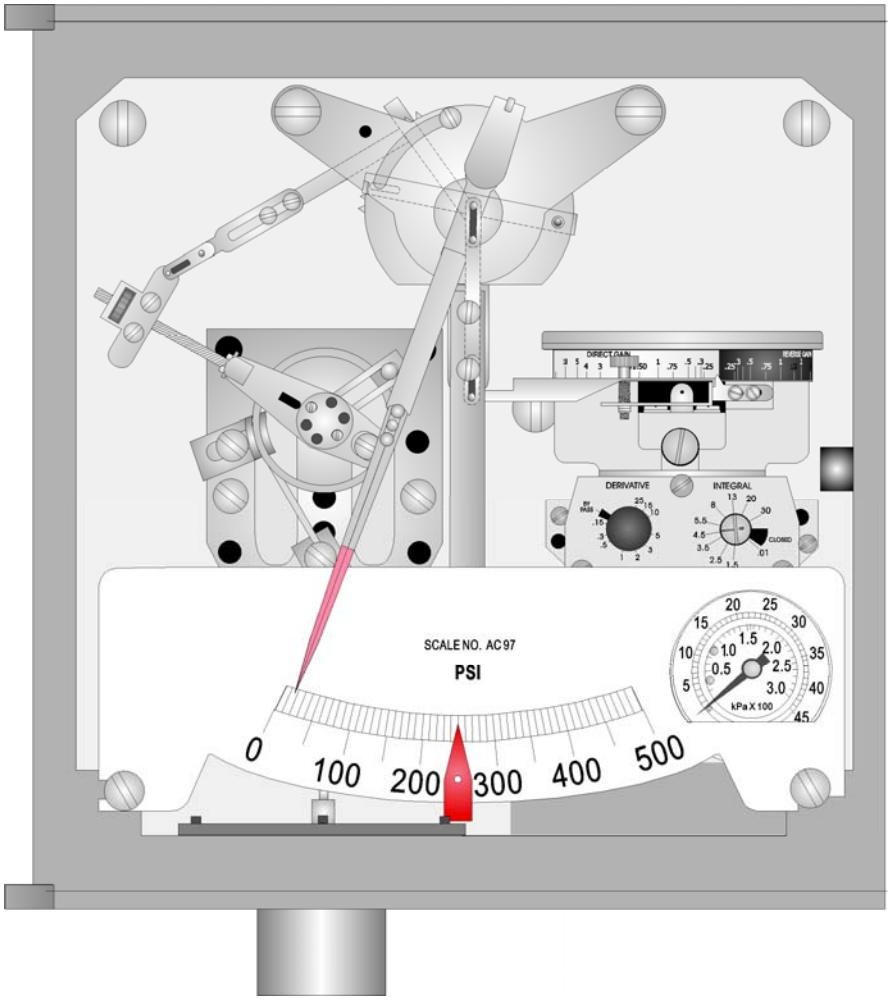


Figure 3D-1 Series 5458 Transmitter

3D.2 THEORY OF OPERATION

The Indicating Transmitter contains a compact transmitter unit that converts the MV (measured variable) input to a pneumatic signal. A schematic of this unit, along with measuring element (pressure type) and linkage arrangement is shown in Figure 3D-2.

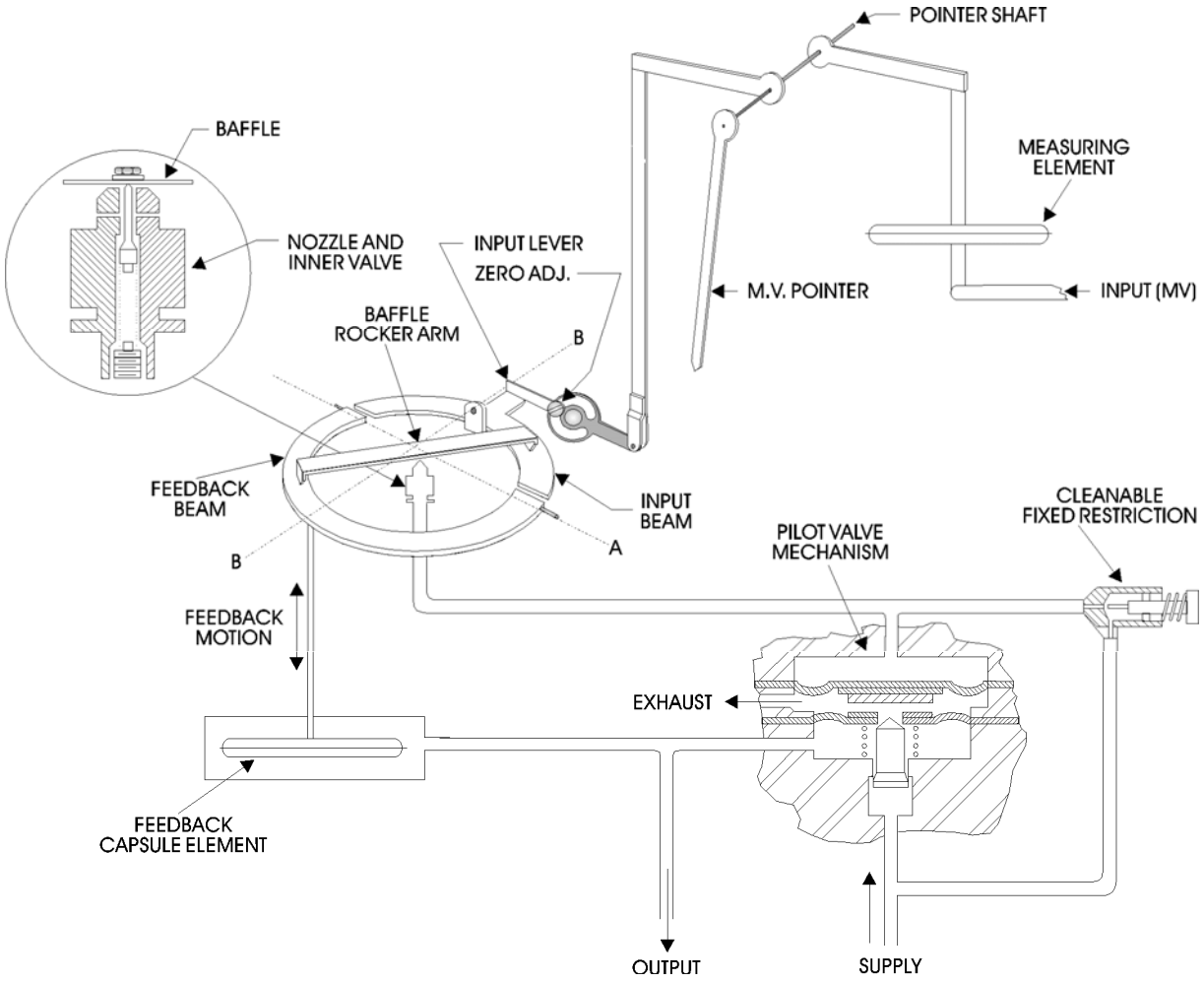


Figure 3D-2 Schematic of Transmitter

The measuring element, in response to changes of the MV, applies a motion to the pointer shaft via the connecting linkage. This same motion is applied to the input beam of the transmitter unit by another linkage. This motion also causes the c-shaped beam to pivot vertically along its B-B axis, while a feedback beam at the opposite end is pivoted along its A-A axis due to feedback motion from the feedback capsular element. The mechanical equivalent of this arrangement is shown in Figure 3D-5.

A baffle rocker arm, seated at the top of the beams, is coupled to the Coarse Span adjustment at the top of the unit (Figure 3D-4). Turning the Coarse Span causes the baffle rocker arm to rotate anywhere between the two beams. When this arm is set along its B-B axis, the input motion is at a minimum and the opposing feedback motion to the baffle rocker arm is at a maximum. Conversely, when the baffle rocker arm is set along the A-A axis, the input motion is at a maximum and the feedback at a minimum. Movement of the

baffle rocker arm against the nozzle causes changes in back pressure that are sensed by the pilot valve. The pilot valve uses the low-level backpressure signals to control the transmitter output (3-15 or 3-27 psi).

The feedback capsular element receives output pressure from the output port of the pilot valve. This element converts output pressure variations to a motion that is applied to the feedback beam. Feedback is used to maintain stability and accuracy of the control unit.

3D.3 SERVICE

Before performing any service procedures described here, refer to Chapter 3, section 3.3 for general maintenance and safety warnings.

Troubleshooting

Some typical problems that may be encountered in the field are as follows:

- Output Pressure Not Steady

  If the Output Pressure Gauge reading is drifting or erratic, depress the Restriction Clearing Button several times to work out debris. If this does not work, check the knurled nut on the button and make sure the nut is secure. If it is loose, tighten only with fingers.

  If the Restriction Clearing Button is jammed, shut off the supply pressure, loosen the knurled nut, and remove the button assembly. Inject a small amount of Instrument Cleaning Fluid (referenced in section 3.3.) into the opening. Replace the assembly and nut and set the supply pressure to its proper level. It may be necessary to repeat this operation until the substance is dislodged.

- Output Pressure Always High or On

  Check output piping and external receiving device for leaks. Also check Restriction Clearing button as described above.

  The pilot valve plunger may also be jammed open due to dirt or corrosion. To clean it, shut of the pressure supply and remove the pilot valve restriction screw (Figure 3D-4). Inject a small amount of Instrument Cleaning Fluid into the restriction. Replace the screw and reapply pressure. Repeat procedure if necessary.

- Output Pressure Always Low

  Check supply and output pressure piping for low pressure or leaks. Look for lines with sharp bends or restrictions.

- Slow Response at Receiving Device

  If the receiver response to a change of transmitted output is extremely slow, check the transmission line. The diameter of the pipe may be too small for the distance covered (see section 2.4).

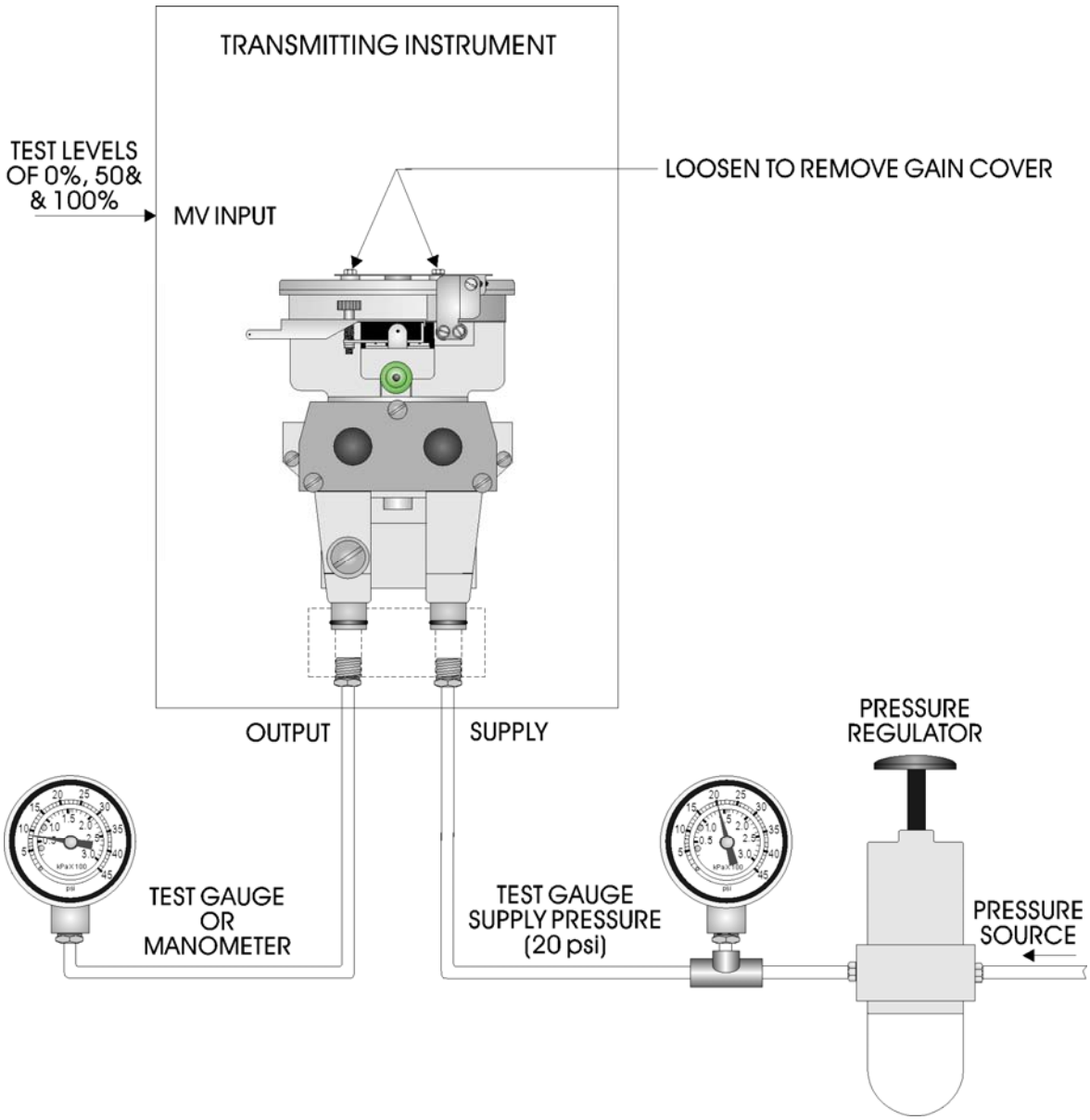


Figure 3D-3 Calibration Test Setup

3D.4 CALIBRATION

This section describes the calibration procedures of the Transmitter Unit. Before attempting any calibration, observe the following warnings.

WARNING

The tests described here require that the transmitter operate at the extremes of its range (0 to 100%). Calibration should never be attempted if the transmitter output is connected to the input of a controller operating in a critical control loop. The test conditions could cause the process to run out of control and result in property damage and injury to persons.

WARNING

Calibration should not be performed in hazardous areas (flammable or explosive environments) because of the potential for danger Either the area must be made safe or the transmitter must be removed and taken to a nonhazardous area.

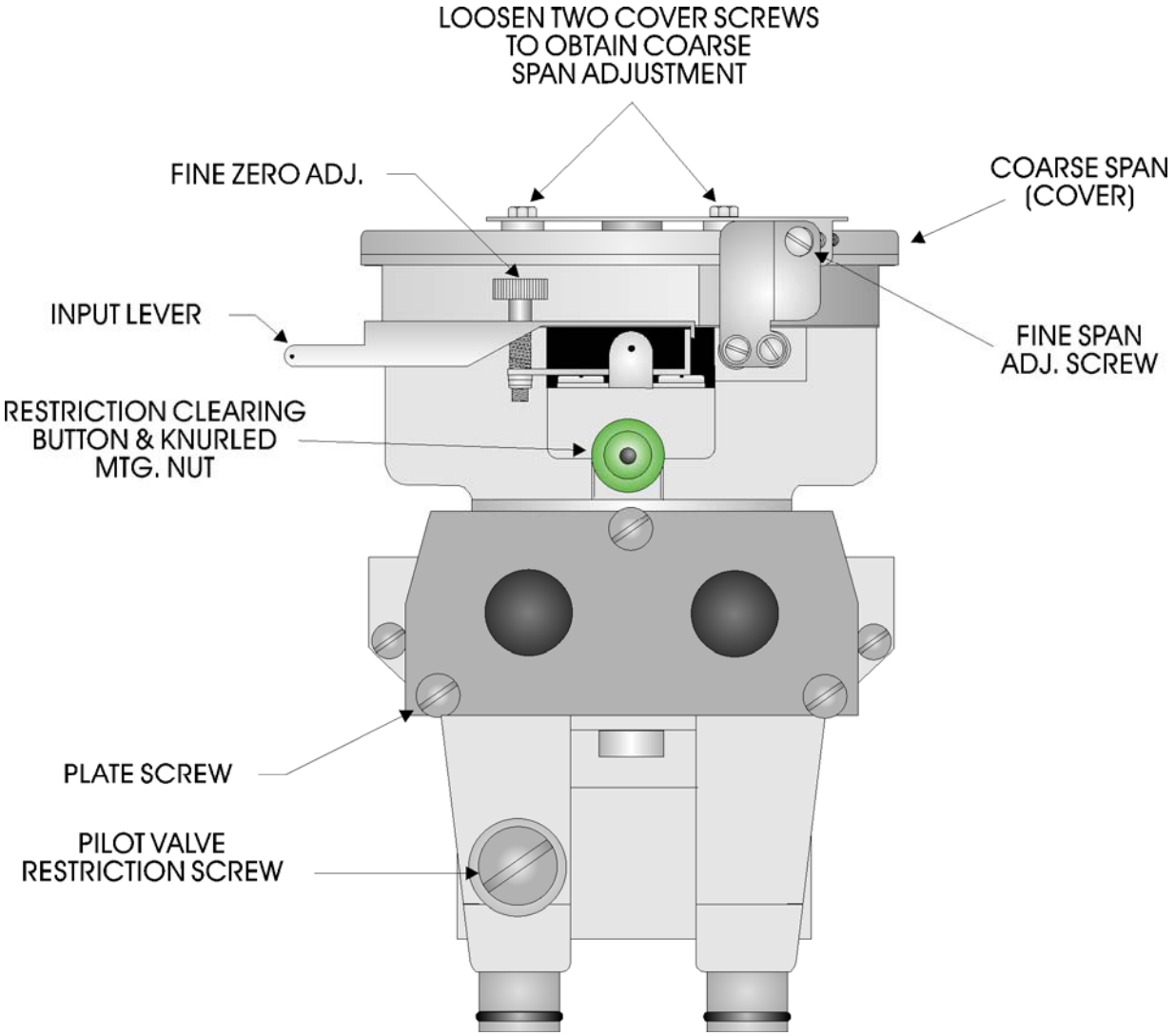


Figure 3D-4 Transmitter Calibration & Service Adjustments

Test Conditions

It will be necessary to supply precise levels of 0%, 50% and 100% (±0.1%) to the measuring system (MV input). The type of input signal required will be a function of the measuring system (i.e. pressure, temperature, differential pressure, etc.). The manner in which this signal is generated must be determined by the user. If more information is needed, the user is advised to contact Bristol, Inc.

Calibration of MV Linkage

The calibration setup and adjustment procedures for the MV pointer were described in section 3.4.

Transmitter Check Procedure

This procedure requires that input test levels of 0, 50 and 100% (accuracy of ±0.1%) be applied to the input of the transmitter (measuring system). The manner in which these signals are generated is dependent upon the type of measuring system furnished with the instrument. If information is needed on this matter, the user is advised to contact Bristol, Inc.

It will also be necessary to monitor the transmitter output with a precision test gauge or manometer as shown in Figure 3D-3. This device should have an accuracy of ±0.1% or better.

Transmitter units may be specified with either a 3-15 or 3-27 psi output. The first reading given in the procedure below applies to the 3-15 psi type, while the reading in parenthesis applies to the 3-27 psi type.

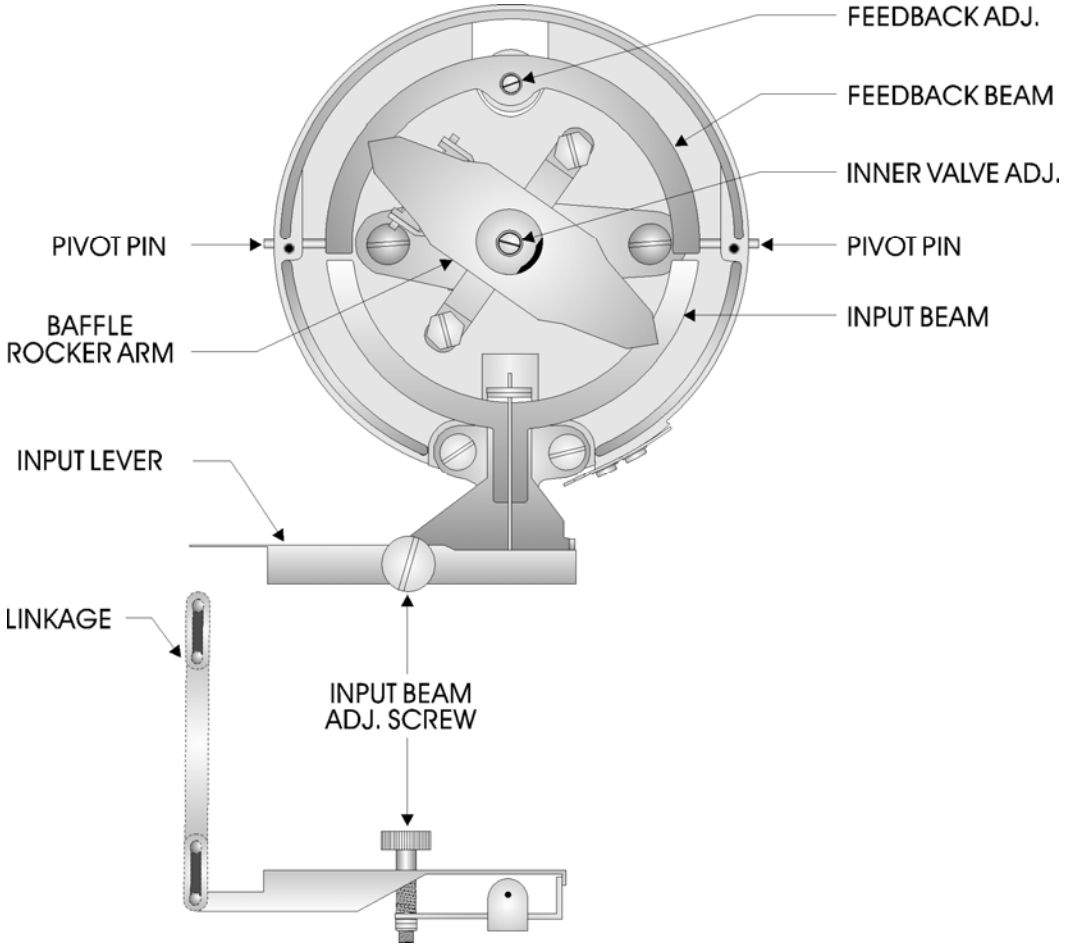


Figure 3D-5 Top Interior of Transmitter Unit

1. Adjust transmitter supply pressure for 20 psi (30 psi).

2. Apply a 0% test signal to the measuring system and observe the test gauge. The output should be 3 psi (3 psi). Accuracy of this reading and those that follow should be within ±0.5%.

3. Repeat above procedure using 50% and 100% test levels. Corresponding output levels should be 9 and 15 psi (15 and 27 psi).

4. If all three readings are within tolerance, no calibration is required. If errors are present, proceed to next topic, Calibration Adjustments.

Calibration of Transmitter Unit

The following adjustments should be made if calibration errors were noted during the "Transmitter Check Procedure" above. The output readings given below should be within ±0.5%. The calibration adjustments of the unit are shown in Figure 3D-4.

1. Readjust test signal to 0% level. If the test gauge reading is not 3 psi (3 psi), turn the Fine Zero Adj. on the transmitter unit to correct.

2. Set test signal to 100% level. If the test gauge does not read 15 psi (27 psi), bring it in with the Fine Span Adj. Should this adjustment lack sufficient range, turn the Fine Span Adj. to midrange and used the Coarse Span adjustment for an approximate reading. To make this adjustment, partially loosen the two locking screws atop the unit and move the Coarse Span slightly in either direction as required. Secure the Coarse Span screws and reset the Fine Span Adj. as required.

3. Since zero and span adjustments interact, repeat steps 1 and 2 as required. Restore unit to normal operation when calibration is complete.

Chapter 4
SPECIFICATIONS

4.1 GENERAL SPECIFICATIONS

The specifications provided in this are common to all Series 5450 Instruments. Spec. for the G-I-D Controller, Differential Gap Controller, Remote Setpoint Actuator Controller, and the Transmitter will be found in respective sections 4.2, 4.3, 4.4 and 4.5.

MV Input	Motion signal from sensor. Sensor may be specified for pressure, pressure receiver, differential pressure, or temperature measurements.
Mounting Options	Panel, wall or two-inch pipe (available for most models)
Supply & Output Connections	1/4 inch NPT, female
Case	Weatherproof, die cast aluminum enclosure
General Case Dimensions	7-15/16" Height, 7-23/32" Width, 4-5/16" Depth. (180.18 cm Height, 179.2 cm Width, 103.9 cm Depth)

4.2 G-I-D CONTROLLER MODELS

General instrument specifications for this model are given in section 4.1.

Function	Compares an MV (measured variable) to a LSP (local setpoint), detects an error difference signal, and provides a corrective analog output to an external process using specified control algorithms (Gain, Integral and Derivative modes).
Control Mode Options	Gain: .25 to 10 std., 2.5 to 100 optional. Integral (optional): .01 to 30 repeats. Derivative (optional): 0 to 30 minutes.
Output Control Action	Direct or reverse control action selectable for all G-I-D models.
Calibrated Accuracy at Gain of 1	For Pressure & Pressure Receiver Models: ±0.5% of span for Ni-Span-C, 316 stainless steel and phosphor bronze elements. For Differential Pressure Models: ±0.5% of span (20-100% of range) For Temperature Models: ±0.5% of span.

Output Signal Range Options	3-15 psi (20.7 - 103.4 kPa) or 3-27 psi (20.7 - 186 kPa) or 6-30 psi (41.4 - 206.8 kPa)
Supply Pressure Limits	For 3-15 psi output models: 18-20 psi (124.1 - 137.9 kPa). For 3-27 psi output models: 30-35 psi (206.8 - 241.1 kPa). For 6-30 psi output models: 31-35 psi (220.4 - 241.1 kPa).
Supply Effect	±5 psi (0.5%)
Ambient Temperature Effects	1%/100oF max.
Repeatability	0.3% max.
Pilot Capacity	3 scfm, exhaust or delivery, for 1 psi change of output pressure.
Supply Pressure Consumption	0.1 scfm at balance with 20 psig air supply.
Temperature Stability	1% of span change in output pressure per 100 °F
Supply Pressure Error	Less than 0.1% of span change of output per 1 psi change in supply pressure.

4.3 DIFFERENTIAL GAP CONTROLLER MODELS

General instrument specifications for this model are given in section 4.1.

Function	Maintains an MV (measured variable) within a desired control zone established by setting of two setpointers (Lo and Hi). Provides a logi cal On-Off output signal to final control element.
Calibrated Accuracy	±0.5% of span with both setpointers set off scale.
Indicated Pneumatic Switching Points to Indicated Setpoints	Within 2.5% of span with MV pointer traveling at a rate of 15 seconds minimum to 1.5 minutes maximum for 0-80% of full scale.
Repeatability	Within .25% of span
Detent Between Setpoints	Within ±5.0% of span
Supply Pressure Limits	20 psi min.; 60 psi max.

Supply Pressure Effect	Changing from 18 to 20 psi will change pneumatic switching points less than ±0.5% of span.
Pneumatic Consumption	Less than 0.1 scfm at 20 psi supply pressure.
Pneumatic Capacity	2-3 scfm with supply set to 20 psi and output open to atmosphere.
Ambient Effects	Pneumatic switching points change less than 1% for ambient temperature change from 0 to 120° F

4.4 REMOTE SETPOINT ACTUATOR MODELS

General instrument specifications for this model are given in section 4.1. Specifications for the pneumatic control system are identical to those given (where applicable) for the G-I-D Controller in section 4.2.

Function	Uses a remote setpoint signal (Analog or Raise/Lower type) to operate a stepper motor that mechanically positions the Setpointer to a desired value.
Types of Actuators	Analog and Raise/Lower types are offered.

Analog Type

Function:	Uses analog input as command signal.
Ranges:	4-20 mA dc or 1-5 Vdc
Input Impedance:	>1 megohm for 1-5 V input. 250 ohms, ±0.1% for 4-20 mA input.

Raise/Lower Type

Function:	Uses separate raise and lower signals as command signal. A continuous or incremental dc signal may be employed.
Input Characteristics:	Opto-isolated and bi-polar. Limited to 47 V by metal oxidevaristor.
Input Pulse Level:	Maximum pulse input level is sized to Actuator supply voltage.
Supply Range:	12 Vdc Supply Type: 11-14Vdc 24 Vdc Supply Type: 22-28Vdc
Input Impedance:	1800 ohms for 12 V type 4300 ohms for 24 V type

Incremental Signal:	Pulse rates adjustable from 0.1%/pulse to 10%/pulse. Pulse must be in TRUE state for period of time neces-sary for Actuator to reach new setpoint. An input that changes state before completion of an operation will have its remaining increment dis-carded. Any new pulse will be processed from its start.
Guard Input	Enables or inhibits command signal input for both Analog and Raise/ Lower type Actuators.

Local/Remote Status Output

Function:	Indicates whether controller is in local or remote operating mode. This status signal is typically sent to a command site.
12-Volt Supply Types:	11-14 volts (supply) through 4.7 K ohms. Local mode 9.4 K ohms to power common.
24-Volt Supply Types:	22-28 volts (supply) through 4.7 K ohms. Local mode 9.4 K ohms to power common.

PDM Option

Function:	PDM feedback signal tracks setpoint position. Signal is typically used to telemeter setpoint value back to command site.
Selectable Ranges:	15 sec. period; 3-12 sec. range. 15 sec. period; 0-13.33 sec. range. 5 sec. period; 1-4 sec. range.
Pulse Characteristics:	45 mA dc nominal. 100 MA dc maximum. 1 V max. during ON period. Unipolar transistor switch.

Analog Output Option

Function:	Current feedback signal tracks setpoint position. Signal is typically used to telemeter setpoint value back to command site.
Range:	4-20 mA common ground type output.
Max. Load Resistance:	380 ohms max.
Setpoint Accuracy	Setpoint position, ±0.5% of span. Setpoint feedback: ±0.5% of span.

Actuator Enclosure

Type of Case:	Weatherproof and explosion proof. Cast aluminum with gasketed screw-on cover. Gray epoxy finish. Certification, where applicable, is as noted on instrument decal or tag.
General Dimensions:	6 in. (152.4 mm) diameter 7 in. (176.8 mm) length

Drive Mechanism

Stepper Motor:	Gearing from motor shaft to setpointer results in 4000 incremental steps for 100%setpoint sweep.
SP Rate of Change:	Full scale sweep adjustable from 20 seconds to15 minutes.
Environmental Effects:	±1.0% max. full scale per 50°F (28°C)
Supply Volt. Effects:	±0.15% max. full scale per 1 volt change

DC Power

12 Volt Actuators:	11-14 Vdc @ 0.35 A max.
24 Volt Actuators:	22-28 Vdc @ 0.25 A max.
Fuse:	1 A, 250 Vdc, 3AG
Pwr. Fail Setpoint Protection:	Mechanical setpoint retains last setpoint setting prior to loss or drop of supply voltage.

Environmental

Temperature Limits:	-20 to 150°F (-29 to 65°C) operating. -40 to 185°F (-40 to 85°C) storage.
Humidity:	10 to 95% to 130°F (55°C). 10 to 50% over 130 to 150°F range (55 to 65°C).
Vibration Limits:	0.1 g max. over 10 to 500 Hz
RFI Rejection:	Per SAMA standard PMC 33.1, Class 1 and 2, 20 MHz to 500 MHz. Rejection is greater than 0.5% full scale error.

4.5 TRANSMITTER MODELS

General instrument specifications for this model are given in section 4.1.

Function	Converts output motion of MV sensor to a pneumatic signal for transmission to an external device (pneumatic indicator or recorder).
Calibrated Accuracy	For Pressure & Pressure Receiver Models: ±0.5% of span for Ni-Span-C, 316 stainless steel and phosphor bronze elements. For Differential Pressure Models: ±0.5% of span (20-100% of range) For Temperature Models: ±0.5% of span.
Output Signal Range Options	3-15 psi (20.7 - 103.4 kPa) or 3-27 psi (20.7 - 186 kPa) or
Supply Pressure Limits	For 3-15 psi output models: 18-20 psi (124.1 - 137.9 kPa). For 3-27 psi output models: 30-35 psi (206.8 - 241.1 kPa).
Supply Pressure Error	Less than 0.1% of span change of output per 1 psi change in supply pressure.
Pilot Capacity	3 scfm, exhaust or delivery, for 1 psi change of output pressure.
Supply Pressure Consumption	0.1 scfm at balance with 20 psig air supply.
Temperature Stability	1% of span change in output pressure per 100° F.

Chapter 5
PARTS LIST

5.1 DOOR ASSEMBLY - ALL MODELS (see Figure 5-1)

Item	Description	Part Number
1	Hook	387456-01-5
2	Door Assy. Complete:	
	For Series 5453 Instruments	374529-02-7
	For Series 5457 Instruments	390261-01-7
3	Gasket	314194-00-2
4	Handle	386887-01-2
5	Flat Spring	387675-01-9
6	Gasket	309339-00-6
7	Nut	374612-06-4
8	Washer Internal Lock (not shown)	243040-00-8
9	Washer #6 Flat (not shown)	374615-06-3
10	Window 2-1/4 x 5-29/64 (Acrylic)	379886-01-4
11	Emblem (logoplate)	315310-00-6

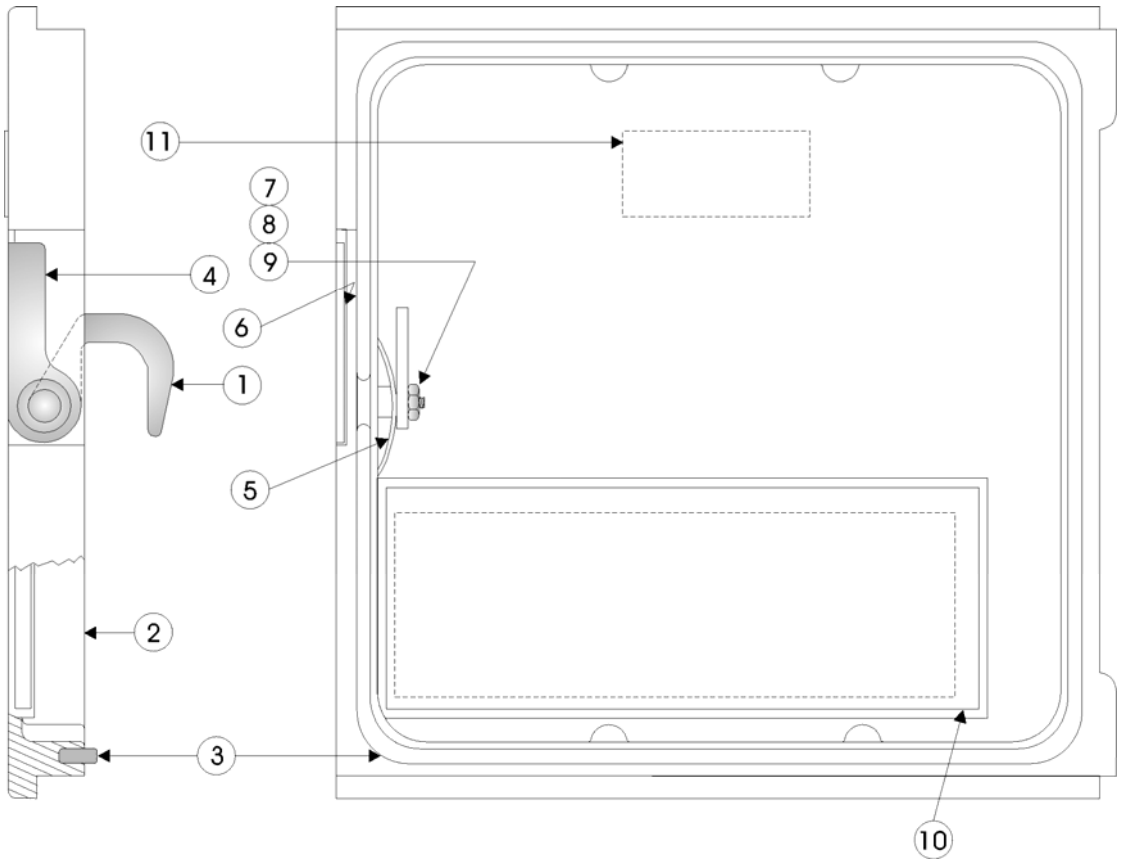


Figure 5-1 - Door Assembly

5.2 SERIES 5453 - G-I-D CONTROLLERS & TRANSMITTERS

(see Figures 5-2A & 5-2B)

Item	Description	Part Number
1	Case Assembly	See Note l
2	Door Assembly	See 5.1
3	Hinge Pin	303233-00-1
4	Roller	296126-00-4
5	Shoulder Screw	296127-00-0
6	Mounting Bracket	379497-01-8

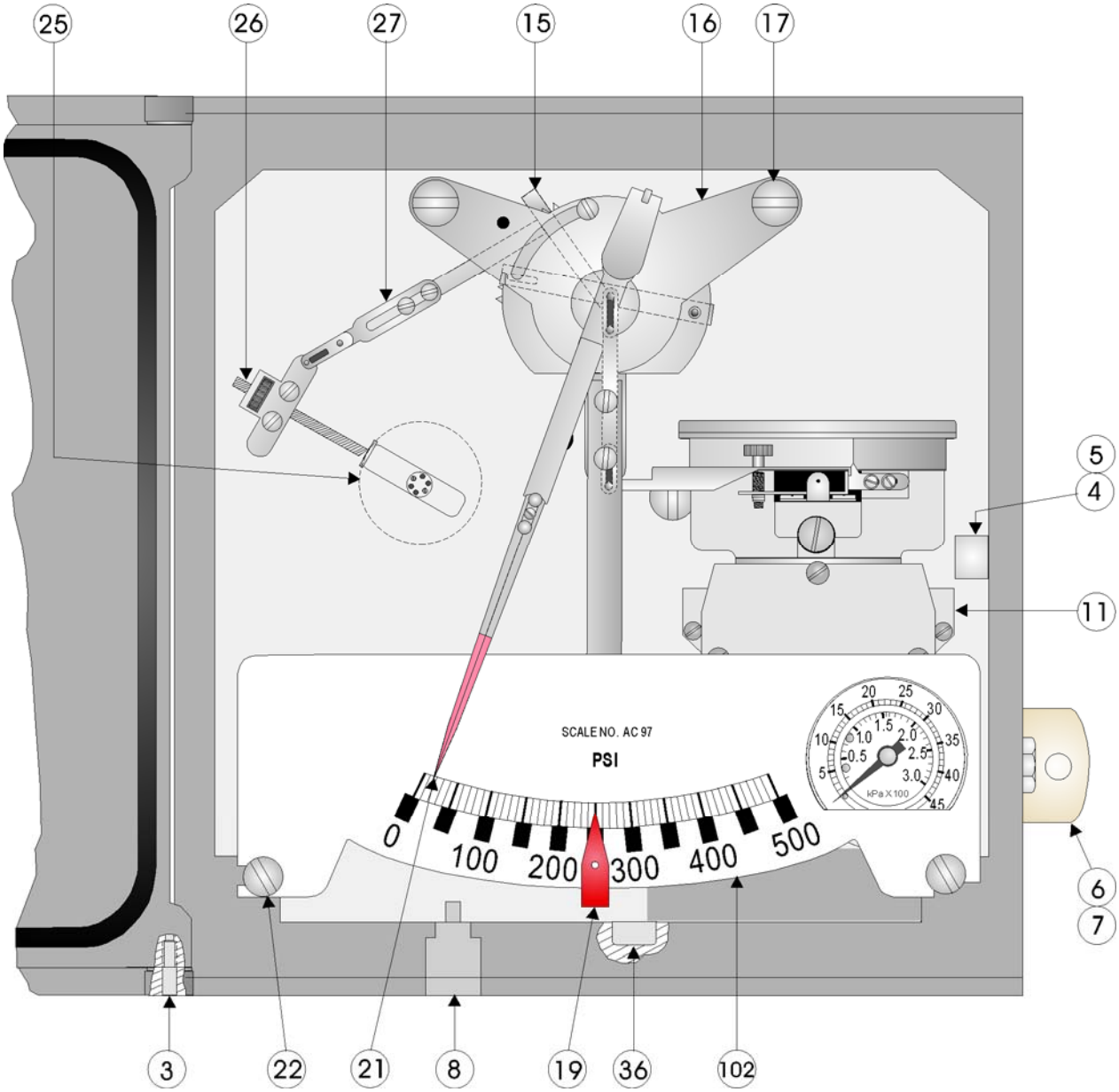


Figure 5-2A - Basic Instrument Assembly (Measuring System Omitted

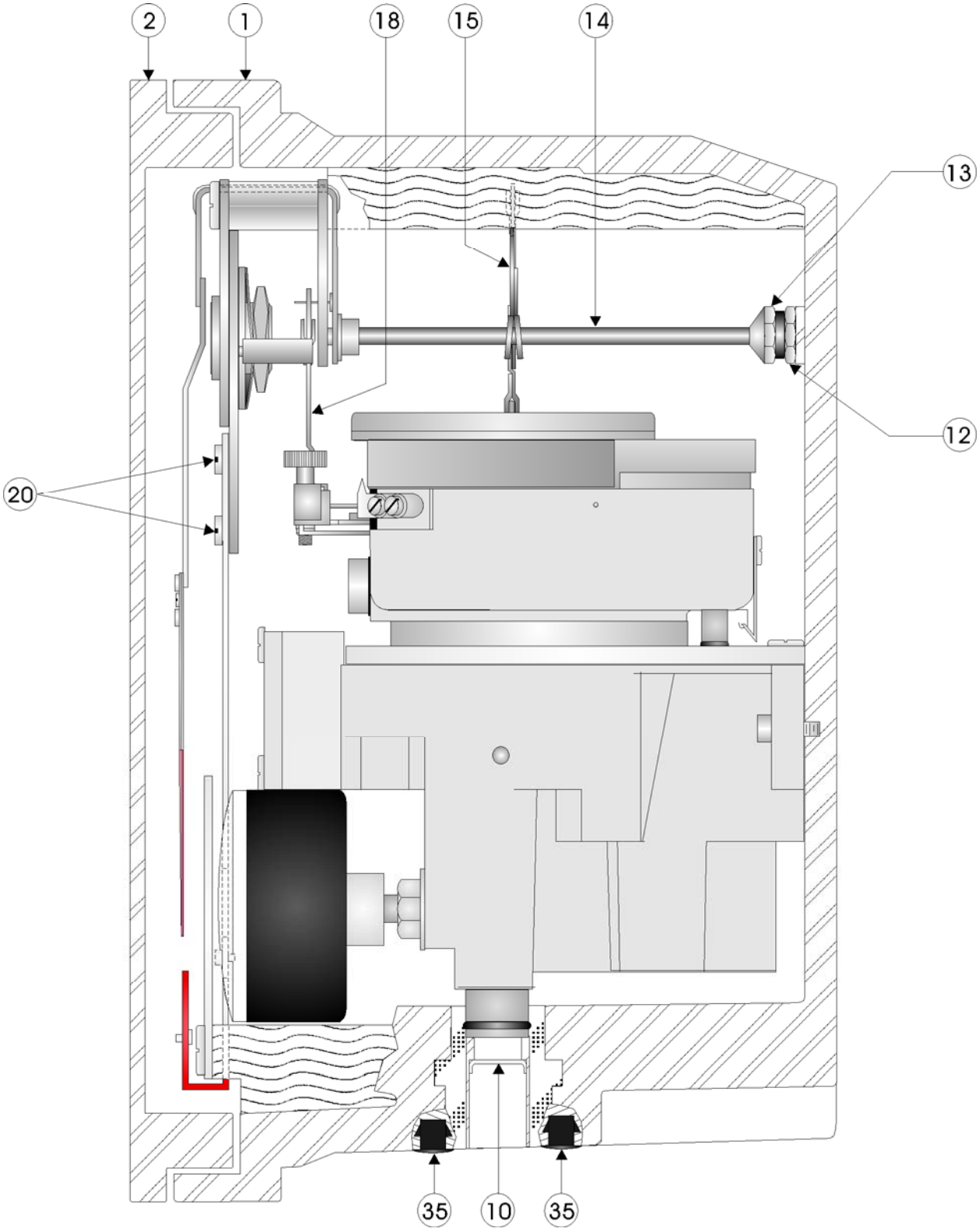


Figure 5-2B - Basic Instrument Assembly (Measuring System Omitted)

Item	Description	Part Number
7	Screw, #1/4-20 x 1/2inch	379496-02-0
8	Bottom Filler Assembly	374638-02-0
10	Screen	3l6602-00-0
11	G-I-D Control Unit	See 5.5
	Transmitter Unit	See 5.8
12	Hex Nut, #10-32	374612-10-2
13	Shaft Adjust Stud	306666-00-6
14	Pointer Shaft Assembly	306659-00-0
15	Lever Arm (.875)	307804-00-3
16	Pointer Mounting Assembly	332316-00-9
17	Screw, #10-32 x 1 inch	374602-16-6
18	Flat Connecting Link	305901-00-1
19	Control Pointer	379459-01-9
20	Screw, #6-40 x 1/8 inch	286804-00-0
21	Indicator Pointer	306677-00-8
22	Screw, #10-32 x 1/4 inch	374602-04-2
25	Measuring Element (Not shown - type varies with model)	Note 1
26	Offset Zero Set, Micro Arm Assembly for 5453-10G, 5453-40G & 5457-40G	307557-00-6
	Zero Set, Micro Arm Assembly for 5453-31G	309303-01-0
27	Connecting Link	Note 1 (see Sect. 5-10)
35	Plug	375558-02-0
36	Standard Vent Screen: Aluminum Cases	375872-01-9
102	Scale	Note 1

5.3 SERIES 5453 DIFFERENTIAL GAP CONTROLLERS

(see Figures 5-3A & 5-3B)

Item	Description	Part Number
1	Case Assembly	Note 1
2	Door Assembly	See 5.1
3	Measuring Element (Not Shown)	Note 1
8	Bottom Filler Assembly	347638-02-1
35	Plug	375558-02-0
40	Hinge Pin	303233-00-1
41	Roller	296126-00-4
42	Shoulder Screw	296127-00-0
43	Hex Nut	374612-10-2
44	Shaft Adjust Stud	306666-00-6
45	Screen	316602-00-0
46	Pointer Assembly	389220-01-9
47	Screw, #10-32 x 1 in.	374602-16-6
48	Pointer Shaft Complete	309034-00-0
49	Left Flapper	389216-01-1

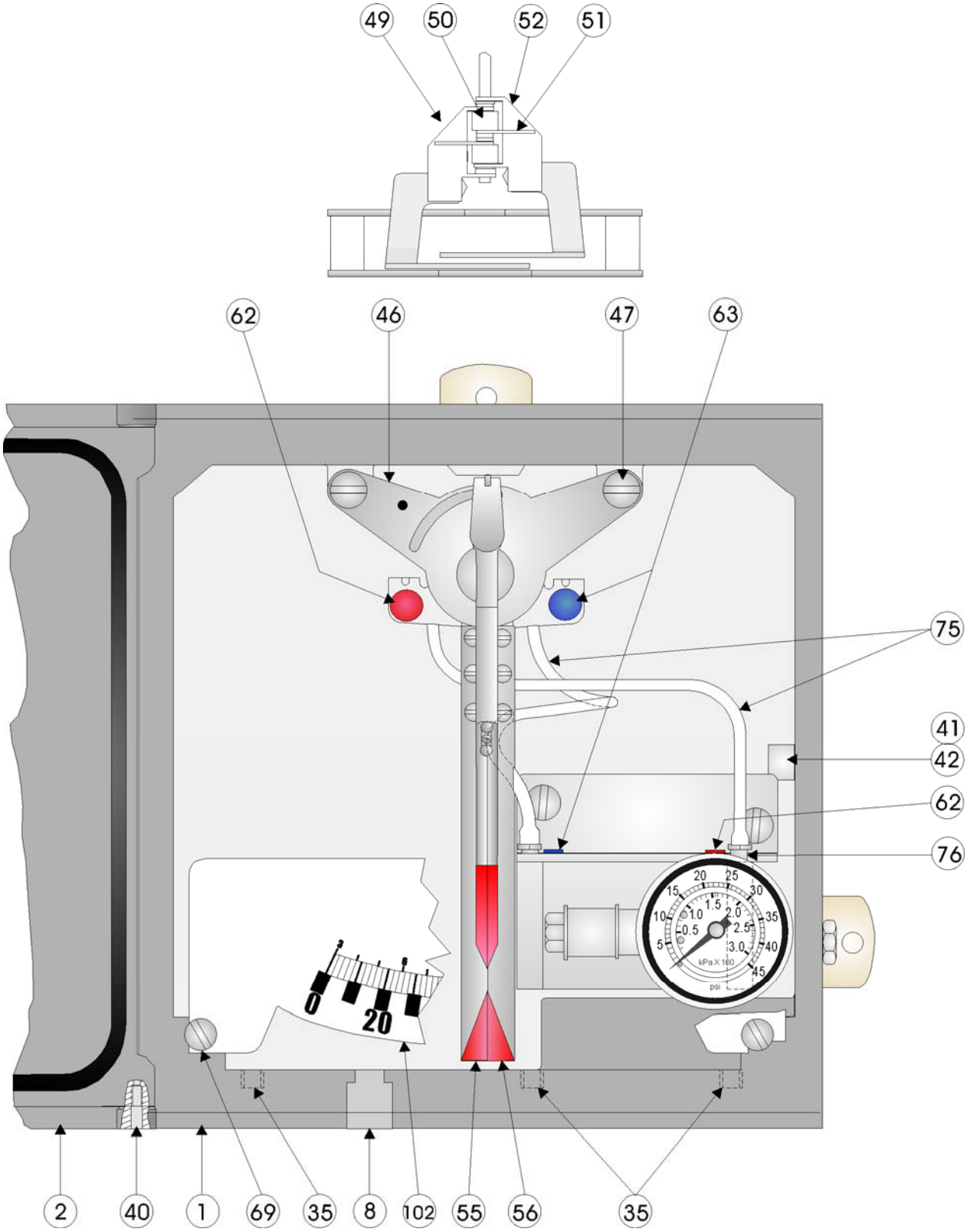


Figure 5-3A - Diff. Gap Controller Instrument Assembly (Less Measuring System)

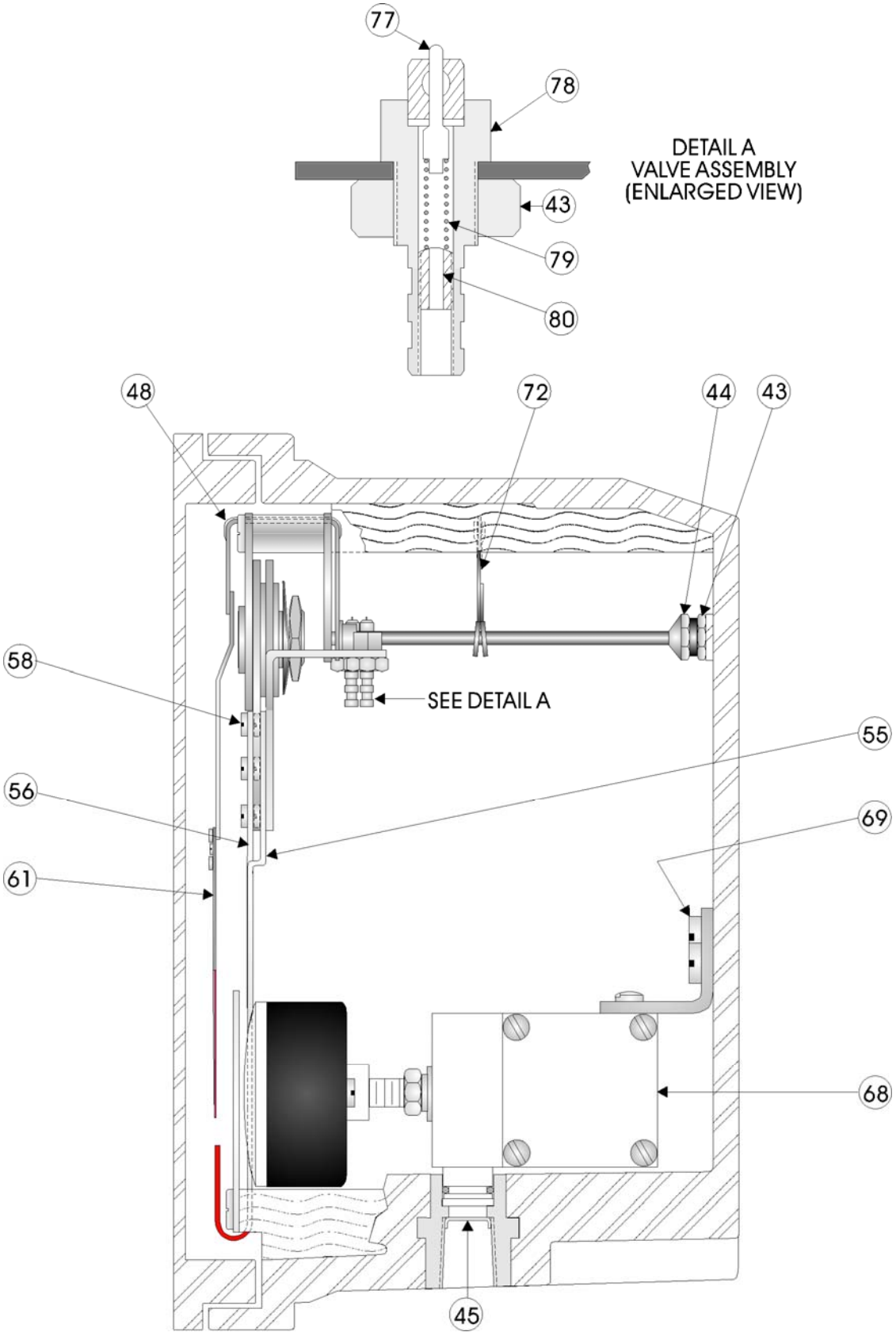


Figure 5-3B - Diff. Gap Controller Instrument Assembly (Less Measuring System)

Item	Description	Part Number
50	Arm Complete	390053-01-5
51	Spring	389100-01-3
52	Right Flapper	389217-01-8
55	Low End Setpointer	390059-01-3
56	High End Setpointer	390058-01-7
58	Screw, 6-40 x 1/4, FH	239770-00-5
61	Indicating MV Pointer	306667-00-8
62	Red Marker	308198-00-0
63	Blue Marker	309044-00-6
68	Differential Gap Control Unit	389297-01-1
69	Screw, 10-32 x 1/4, PH	374602-04-2
72	Lever Arm	249266-00-8
75	Tygon Tubing (specify 12 in. length)	307264-00-9
76	Clip	314196-00-5
77	Valve	383318-01-7
78	Valve Seat Assy.	388555-01-7
79	Spring	309080-00-2
80	Screw, 2-64 x 3/32, SS	309079-00-4
102	Scale	Note 1

5.4 SERIES 5457 CONTROLLERS W/ REMOTE SETPOINT ACTUATOR (See Figures 5-4A, 5-4B & 5-4C) *Note: See Section 5.2 for the following items: 1, 2, 8, 11, 35 and 102.*

Item	Description	Part Number
3	Hinge Pin	303233-00-1
4	Roller	296126-00-4
5	Screw, Shoulder	296127-00-0
10	Screen	316602-00-0
12	Nut, 10-32	374612-10-2
13	Stud, Shaft Adj.	306666-00-6
14	Shaft Assembly, Pointer	389883-01-8
15	Arm, Lever	307804-00-3
16	Mounting Assembly, Pointer	**see Fig. 5-4C**
17	Screw, 10-32 x 1 in.	374602-16-6
18	Link	305901-00-1
19	Pointer, Control	389882-01-1
20	Screw, 6-40 x 1/8	240747-00-3
21	Pointer, Indicating	306667-00-8
22	Screw, 10-32 x 1/4 in.	374602-04-2
24	Decal, LOC-RMT	390195-01-4
26	Knob	390232-01-7
27	Coupling	390099-01-5

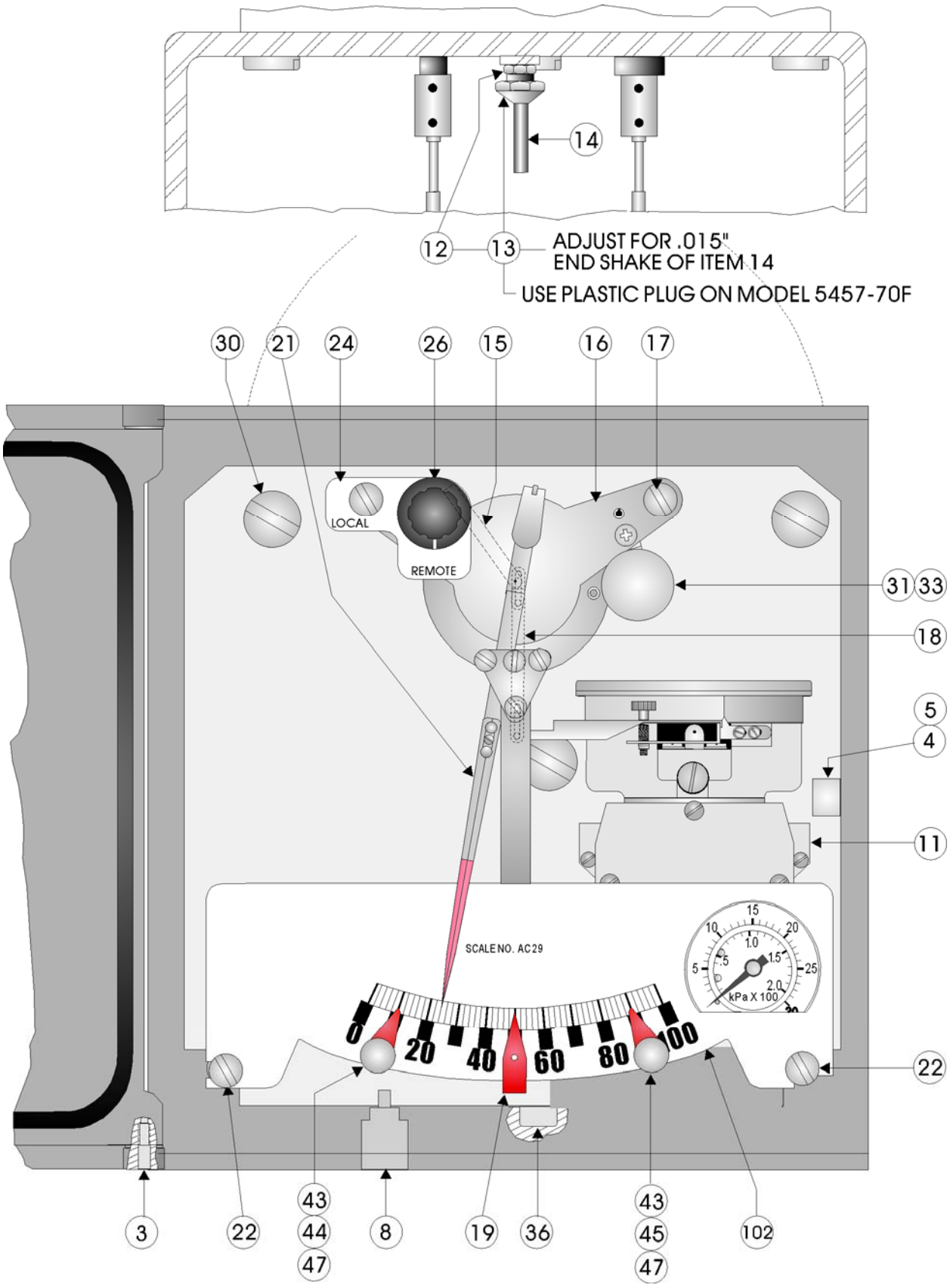


Figure 5-4A - Basic Series 5457 Controller/Transmitter with RSP Actuator

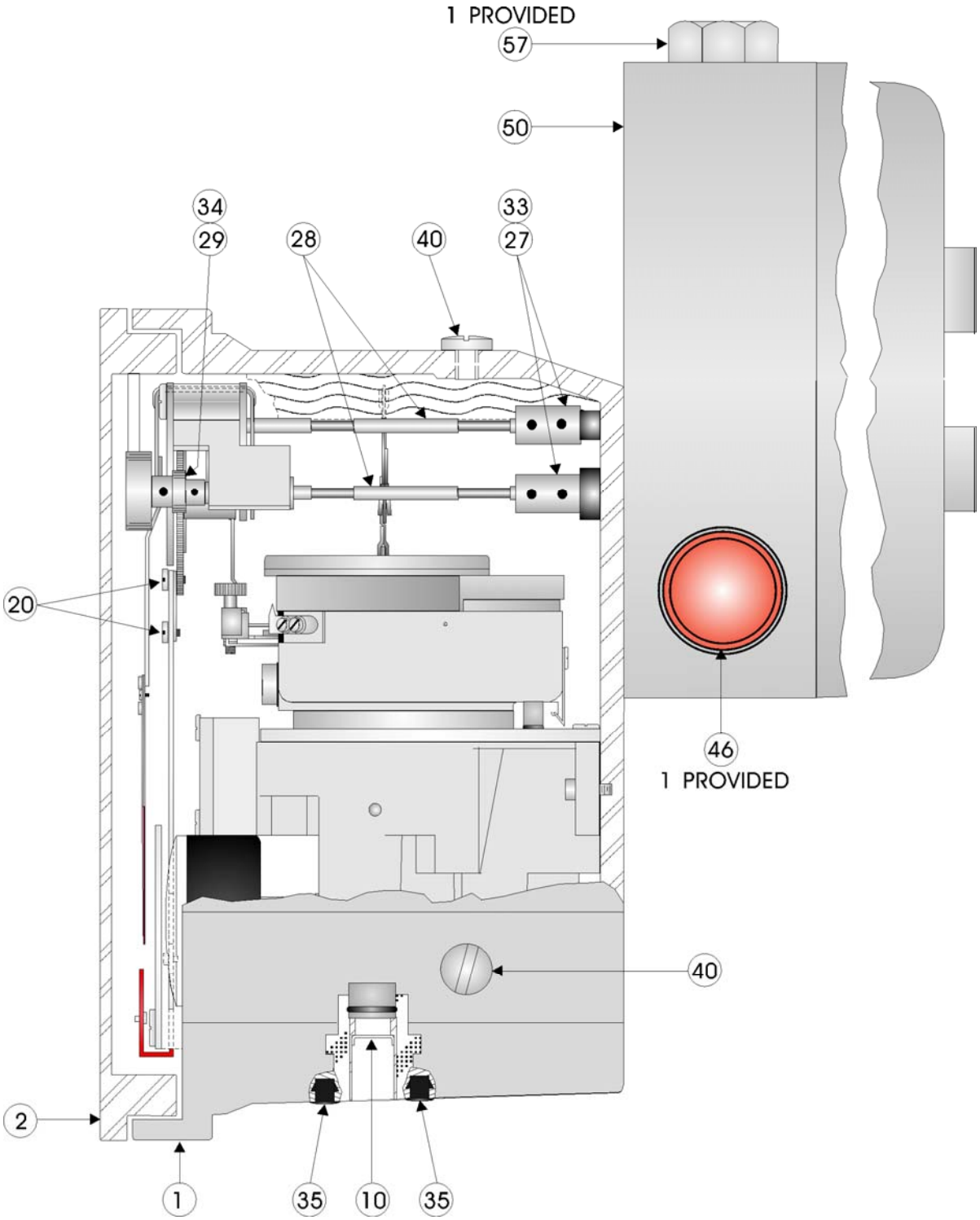
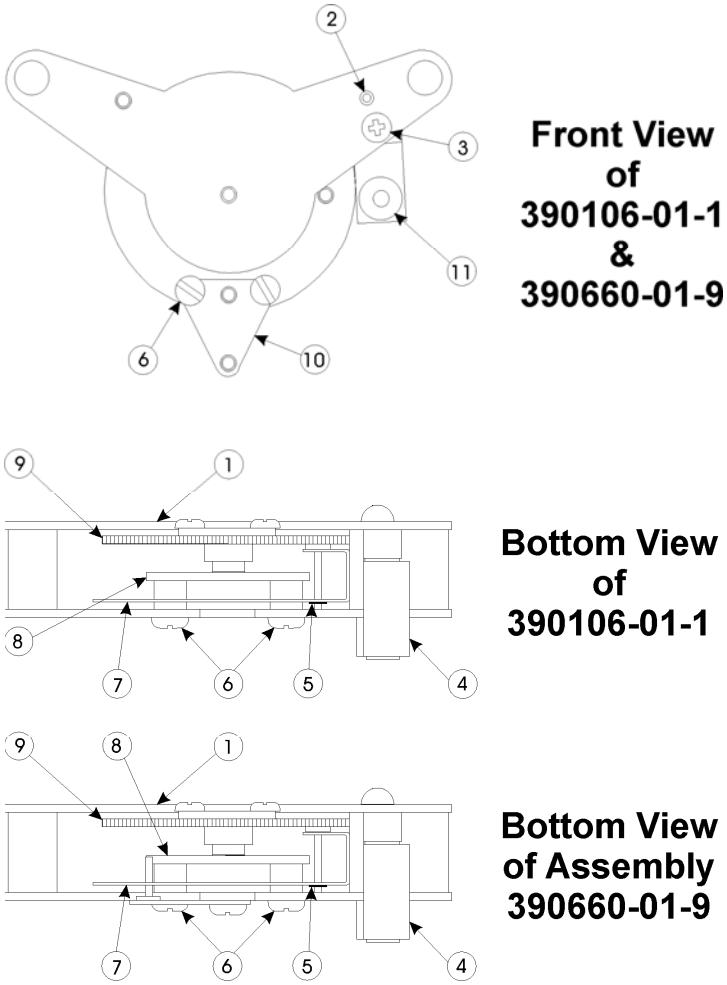


Figure 5-4B - Basic Series 5457 Controller with RSP Actuator

Item	Description	Part Number
28	Shaft	390101-01-0
29	Pinion	390094-01-3
30	Screw, Seal 1/4-20	379425-04-1

Item	Description	Part Number
31	Knob	283851-00-7
33	Setscrew, 6-40 x 1/8 in.	282403-00-0
34	Setscrew, 4-48 x 1/8 in.	294041-00-1
36	Screen	375872-01-9
40	Screw, Seal 1/4-20 PH	379425-06-8
43	Screw, 2-64	308469-00-3
44	Stop, Left	332761-00-2
45	Stop, Right	332762-00-9
46	Protector	370667-03-4
47	Block	308481-00-3
50	Remote Setpoint Actuator Assembly	See 5.7
57	Steel Plug, 3/4" NPT Hex Socket	379891-05-0

5.4.1 SERIES 5457 POINTER MOUNTING ASSEMBLIES (See Figure 5-4C)



Note: Series 5457-10G, -31G & -40G use 390106-01-1
Series 5457-70G use 390660-01-9

Figure 5-4C - Series 5457 Pointer Mounting Assemblies

Item	Description	Part Number
1	Plate Assembly, Remote Set Point	
	For 5457-70G	391335-01-4
	For 5457-10G, 5457-31G & 5457-40G	391325-01-9
2	Roll Pin, .125" OD	308016-00-9
3	Screw, #6-32 x 5/16 inch -Phillips Head	374287-01-5
4	Strut, Pinion Bearing	390096-01-6
5	Retaining Ring, .062" ID - "E" Type	294687-00-9
6	Screw, #6-40 x .1871g Special Head	268345-00-7
7	Arm, Signal Error	310204-00-3
8	Plate, Pneumatic Setpoint	308473-00-0
9	Gear Assembly, Remote Set	390105-01-5
10	Adapter Plate	390078-01-8
11	Ball Bearing, 1/4" - Single Row	307479-00-5

5.5 G-I-D CONTROL UNITS (see Figures 5-5A, 5-5B, 5-5C & 5-5D)

A. Parts Common to All Types

Item	Description	Part Number
1	Screw, #10-32 x 7/16 inch (Pan Head)	375914-01-3
2	Screw, #6-32 x 3/4 inch (Soc. Flat Head)	396349-02-1
3	Screw, #6-32 x 3/16 inch (Pan Head)	374601-03-8
4	Strap, Retaining Nozzle	396373-01-1
5	Screw, #4-40 x 3/16 inch (Pan Head)	374600-03-1
6*	Differential Screw, #2-56 x 5/8 inch (Shoulder)	388851-01-5
7*	Spring, Compression	373962-15-0
8*	Input Beam (Front Rocker Arm Assembly)	388946-01-6
9	Feedback Beam Pivot (Rocker Arm Pivot)	306647-00-1
10	Screw, #2-64 x 1/4 inch (Set)	312470-00-2
11	Feedback Beam (Rear Rocker Arm Assembly)	374480-01-0
13	Screw, #6-32 x 5/16 inch (Pan Head)	374601-05-4
15	Base Assembly (Varies with G-I-D type)	(see 5.5 (B-H)
16	O-Ring, 5/64" ID x 13/64 OD	304073-00-8
18	Pin (for 624 Control Unit)	374476-01-2
19	Seal Plate	387614-01-0
20	O-Ring, Size 2-008	311877-01-0
21	Bracket, Spring (for 624 Control Unit)	301247-00-4
22	Bearing, Follow Up Pin	306803-00-3
23	Rocker Arm Housing (624 Control Unit)	396263-01-1
24	Spring (for 624-II Control Unit)	310248-00-0
25	O-Ring, 2.864" ID x 3.004" OD	375411-15-1
26	O-Ring, Size -006	316135-01-1
27*	Pivot Shaft	388945-01-0
28*	Input Beam Bracket (Rocker Arm for 624 Control Unit)	388944-01-3
29	O-Ring, Size -010	316135-02-0
30	Restriction Assembly, Cleanable	381286-01-0

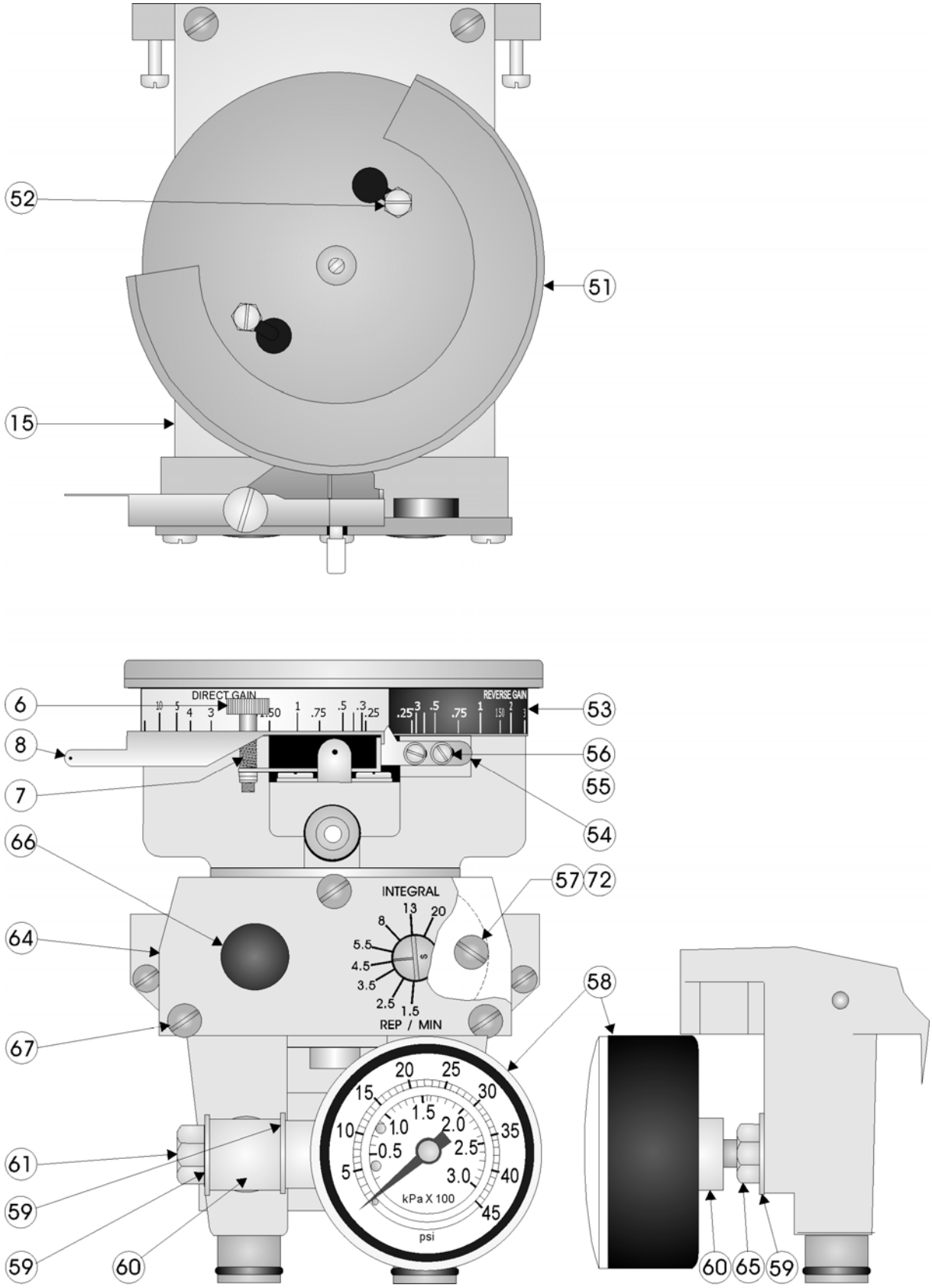


Figure 5-5A - Assembly of G-I-D Control Unit

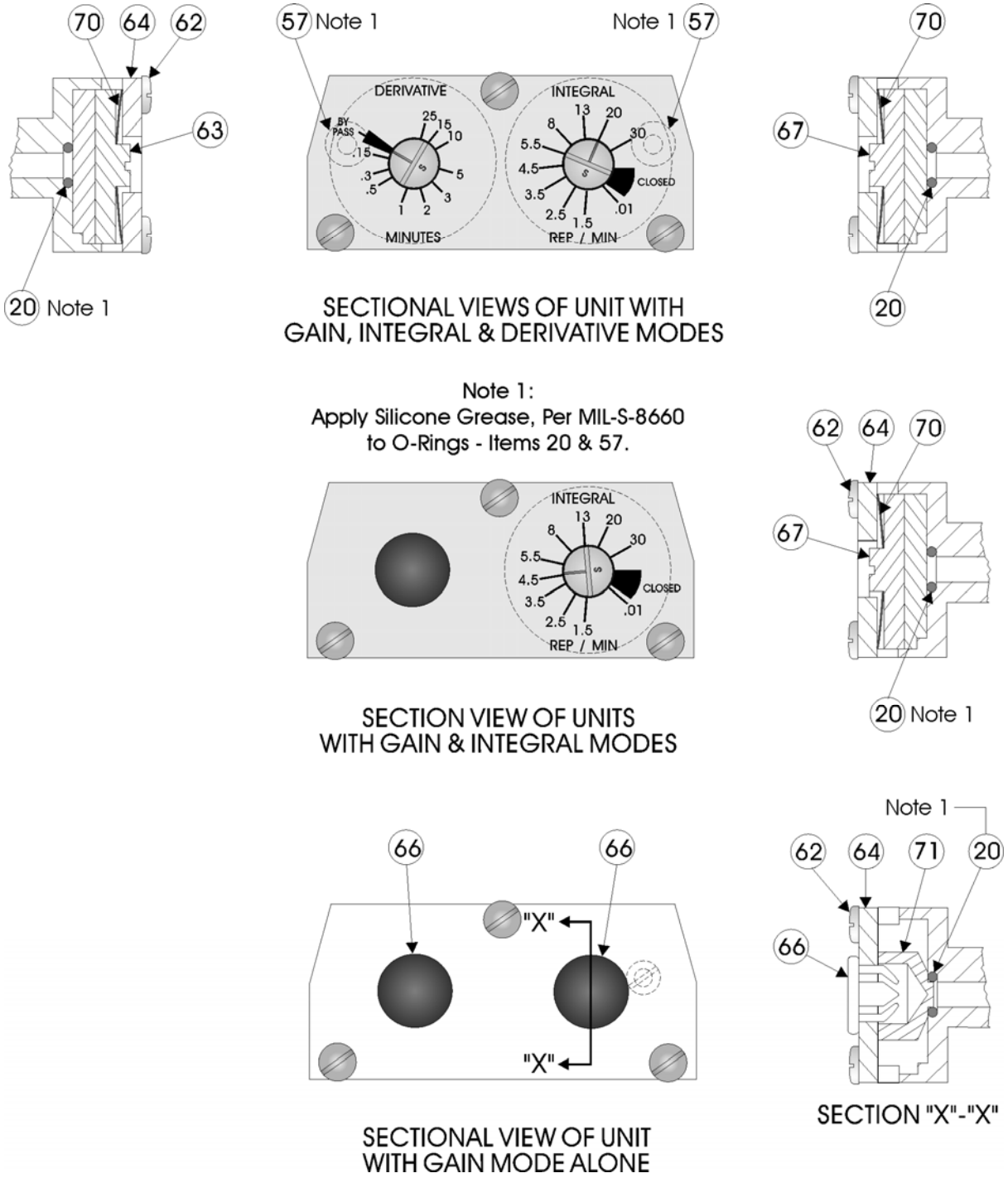


Figure 5-5B - Assembly of G-I-D Control Unit

Item	Description	Part Number
31	Plate Exhaust Assembly	374652-02-3
32	Upper Diaphragm (for A/D Control Unit)	306629-00-3
33	Valve Seat & Diaphragm Assembly	374650-01-2
34	Spring, Diaphragm Valve Seat Assembly	306648-00-8
35	Plunger, Ball Stem	388864-01-0

Item	Description	Part Number
36	Screw, 5/16-32 x 13/32 inch	306655-00-4
37	O-Ring	375411-01-1
51	Cover	332319-01-6
52	Cover Screw	306654-00-8
53	Gain Scale (10/.25)	379446-01-4
54	Pointer	306683-00-8
55	Screw, #2-64 x 3/16 inch	237603-00-4
56	Flat Washer, 3/8 x 3/32 inch	233132-00-7
57	O-Ring, Size 2-006	311877-00-1
59	Thread Seal, 1/4 inch	317443-03-8
60	Gauge Connector	374545-01-4
61	Special Screw, 1/4-20 x 13/16	374544-01-8
62	Screw, #6-32 x 3/8 inch	374601-06-2
65	Hex Nut, 1/4-20	374612-11-0
*	Available as Rocker Arm Assembly Complete	388954-01-9

B. Control Units with Gain and 20 psi Supply

Item	Description	Part Number
-	Unit Complete	374501-01-7
12	Rocker Arm Assembly	396265-01-4
15	Base Assembly	374475-01-6
17	Capsule Assembly	374454-01-9
58	Output Gauge, 0-30 psi	374546-01-0
64	Plate, Cover 624-II Ctrl & Tmr	374429-01-4
66	Hole Plug, 3/8 inch x 13/32	290301-00-9
71	Plug, Seal (Gain Only) 624-II	374667-01-2
72	Screw, 6-32 x 1/4 (Pan Head)	374601-04-6

C. Control Units with Gain + Integral and 20 psi Supply

Item	Description	Part Number
-	Unit Complete	374502-01-3
12	Rocker Arm Assembly	396265-01-4
15	Base Assembly	374475-01-6
17	Capsule Assembly	374454-01-9
58	Output Gauge, 0-30 psi	374546-01-0
64	Scale Plate, Variable Resistor	385213-01-8
66	Plug, 3/8 inch	290301-00-9
67	Integral (Scratch) Valve Assembly	396522-01-7
70	Curved Spring Washer	374486-01-8

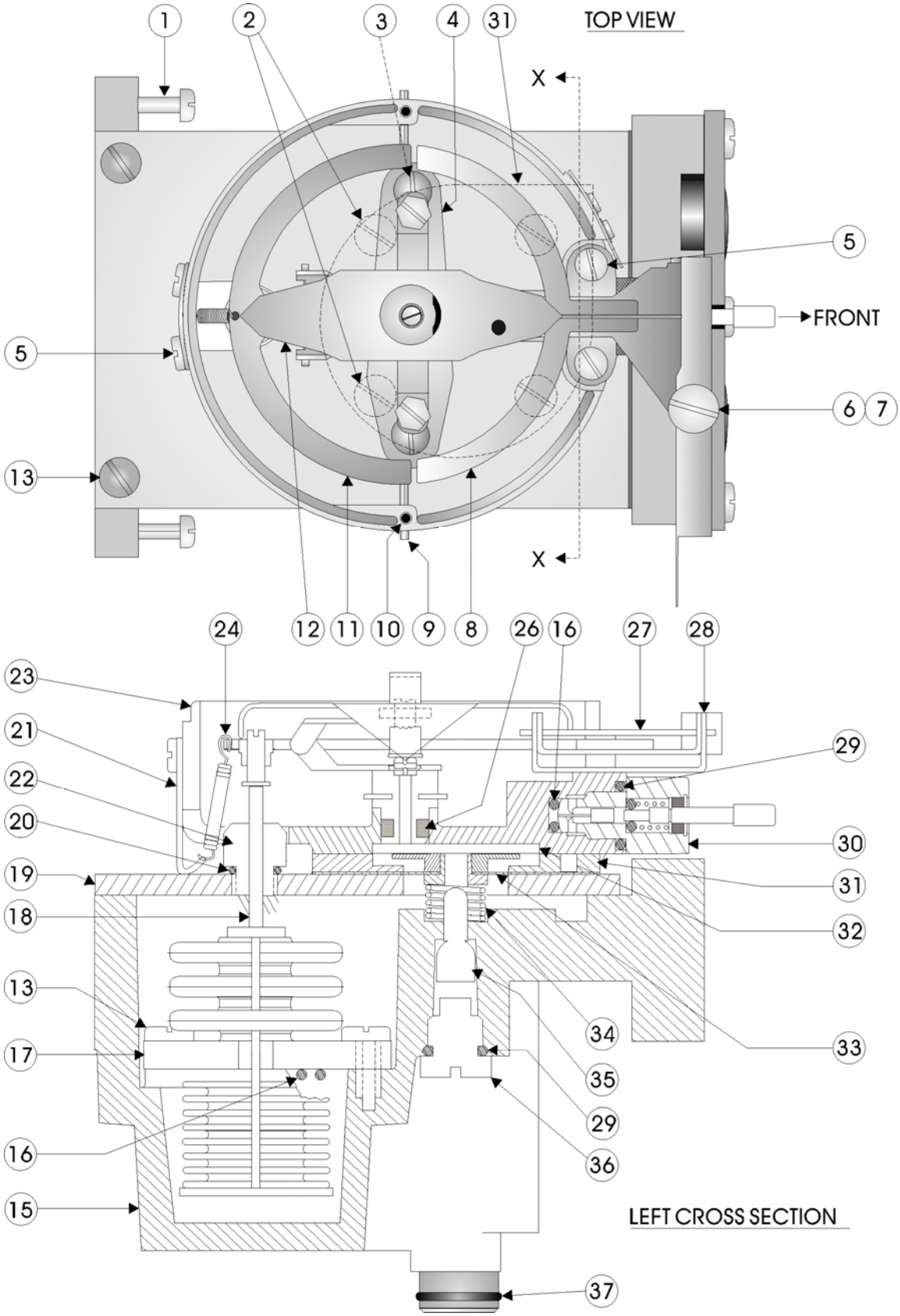


Figure 5-5C - Internal Assembly of G-I-D Unit

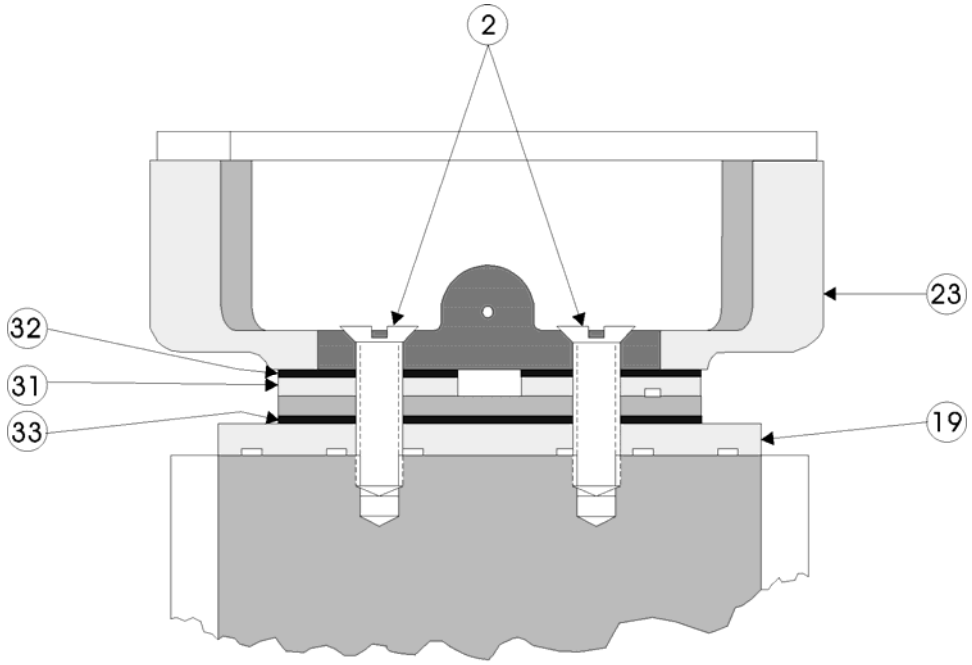


Figure 5-5D - Internal Assembly of G-I-D Unit

D. Control Units with Gain + Integral + Derivative and 20 psi Supply

Item	Description	Part Number
-	Unit Complete	374503-01-0
12	Rocker Arm Assembly	396265-01-4
15	Base Assembly	374493-01-4
17	Capsule and Bellows Assembly	374458-01-4
58	Output Gauge, 0-30 psi	374546-01-0
63	Derivative (Scratch) Valve Assembly	396522-02-5
64	Scale Plate	385213-01-8
67	Integral (Scratch) Valve Assembly	396522-01-7
70	Curved Spring Washer	374486-01-8

E. Control Units with Gain and 30 psi Supply

Item	Description	Part Number
-	Unit Complete	374505-01-2
12	Rocker Arm Assembly	396265-02-2
15	Base Assembly	374475-01-6
17	Capsule Assembly	374455-01-5
58	Output Gauge, 0-45 psi	374546-02-9
64	Scale Plate	374429-01-4
66	Plug, 3/8 inch x 13/32	290301-00-9
71	Seal Plug	374667-01-2

F. Control Units with Gain + Integral and 30 psi Supply

Item	Description	Part Number
-	Unit Complete	374506-01-9
12	Rocker Arm Assembly	396265-02-2
15	Base Assembly	374475-01-6
17	Capsule Assembly	374455-01-5
58	Output Gauge, 0-45 psi	374546-02-9
64	Scale Plate	385213-01-8
66	Plug, 3/8 inch	290301-00-9
67	Integral (Scratch) Valve Assembly	396522-01-7
70	Curved Spring Washer	374486-01-8

G. Control Units with Gain and 35 psi Supply

Item	Description	Part Number
-	Unit Complete	375495-01-0
12	Rocker Arm Assembly	396265-03-0
15	Base Assembly	374475-01-6
17	Capsule Assembly	374455-01-5
58	Output Gauge, 0-45 psi	374546-02-9
64	Cover Plate	374429-01-4
66	Plug, 3/8 inch x 13/32	390301-00-9
71	Seal Plug	374667-01-2
72	Screw, 6-32 x 1/4 Pan Head	374601-04-6

H. Control Units with Gain + Integral and 35 psi Supply

Item	Description	Part Number
-	Unit Complete	375496-01-7
12	Rocker Arm Assembly	396265-03-0
15	Base Assembly	374475-01-6
17	Capsule Assembly	374455-01-5
58	Output Gauge, 0-45 psi	374546-02-9
64	Scale Plate	385213-01-8
66	Plug, 3/8 inch	290301-00-9
67	Integral (Scratch) Valve Assembly	396522-01-7
70	Curved Spring Washer	374486-01-8

5.6 DIFFERENTIAL GAP CONTROL UNIT (see Figure 5-6)

Item	Description	Part Number
-	Diff. Gap Control Unit - Complete	389297-01-1
1	Piston	389289-01-9
2	O-Ring (.070 W x .364 I.D.)	387670-02-5
3	Spool Valve	389271-01-2

Item	Description	Part Number
4	Block	389265-01-2
5	Mounting Bracket	389296-01-5
6	Screw, 10-32 x 5/16, FH	267029-00-4
7	Screw, 6-32 x 5/8, PH	374601-10-0
8	Screw, 6-32 x 1, PH	374601-16-0
9	Connection Block	389295-02-7
10	O-Ring, 3/4 O.D. x .614 I.D.	375411-08-9
11	Diaphragm	389300-01-2
12	Restriction	390519-01-4
13	Retainer	389291-01-3
14	End Cap	389290-01-7
15	O-Ring	375411-01-1
16	Thread Seal, 1/4 in	317443-03-8
17	Nut, 1/4-20	374612-11-0
18	Screw, 1/4-20, SH	374544-01-8
19	Connector	374545-01-4
20	Gauge, 0-45 psi	374546-02-9
	Gauge, 0-30 psi	374546-01-0

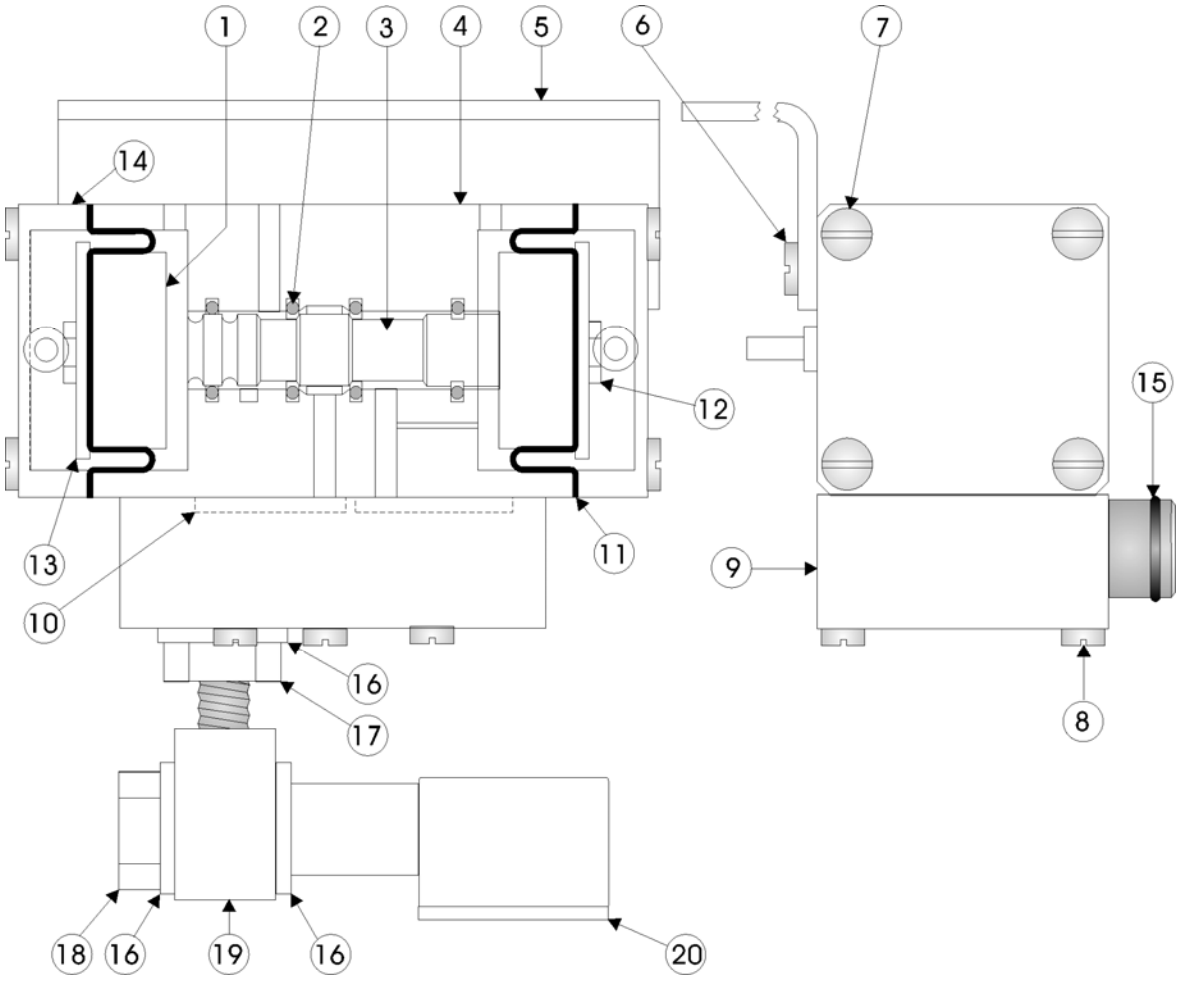


Figure 5-6 - Differential Gap Control Unit

5.7 RSP ACTUATOR ASSEMBIES (see Figure 5-7)

Item	Description	Part Number
1	Housing	390042-02-1
2	O-Ring 5-31/64 x 5-11/16	316135-12-7
3	Screw-On Housing Cover	389385-02-6
4	Plate, Motor Assembly	390077-01-1
5	Clutch Assembly	390087-01-7
6	Pot	390231-01-0
7	Washer	390089-01-0
8	Bushing	390103-01-2
9	Gear Assembly	390097-01-2
10	Ring, Retaining 1/4	310895-00-6
11	Bearing, Ball	288085-00-0
12	Bearing, Ball	307479-00-5
13	Ring, Retaining, 1/8	291665-00-4
14	Shaft	390098-01-9
15	Sleeve, Bearing	390093-01-7
16	Motor, Stepper:	
	12 V dc type	390257-01-0
	24 V dc type	390257-02-8
17	Bracket, PC Assembly	390080-01-2
18	Clamp, Pot	390090-01-8
19	Analog Termination Board *	389644-01-3
	Raise/Lower Termination Board *	389616-01-0
21	O-Ring, 1/2 x 11/16	310792-00-2
22	O-Ring, 1/4 x 7/16	316135-13-5
23	Nut, 1/4-56	252996-00-3
24	Bushing	390111-01-5
25	Plate, Switch	390113-01-8
26	Spring Cam	390112-01-1
27	Cam Assembly	390110-01-9
28	Switch	388666-01-3
29	Bushing	390104-01-9
30	Cable, Pot	390404-01-2
31	Insulator	309163-01-3
32	Screw, 2-56 x 1/4 PH	374287-03-1
33	Screw, 10-32 x 3/8 PH	374602-06-9
34	Screw, 10-32 x 1/2 PH	374602-08-5
35	Screw, 10-32 x 3/4 PH	374602-12-3
36	Screw, 10-32 x 1-1/2 PH	374602-24-7
37	Screw, 2-64 x 3/8 FH	303263-00-8
38	Screw, 6-32 x 3/16 PH	374601-03-8
39	Screw, 6-32 x 5/16 PH	374287-01-5
40	Cable, Switch	390403-01-6
41	Lockwasher, #2	268791-00-7
42	Lockwasher, #10	235638-00-5
43	Screw, 8-32 x 5/16	374616-01-9
44	Cup Washer, #8	387445-01-3

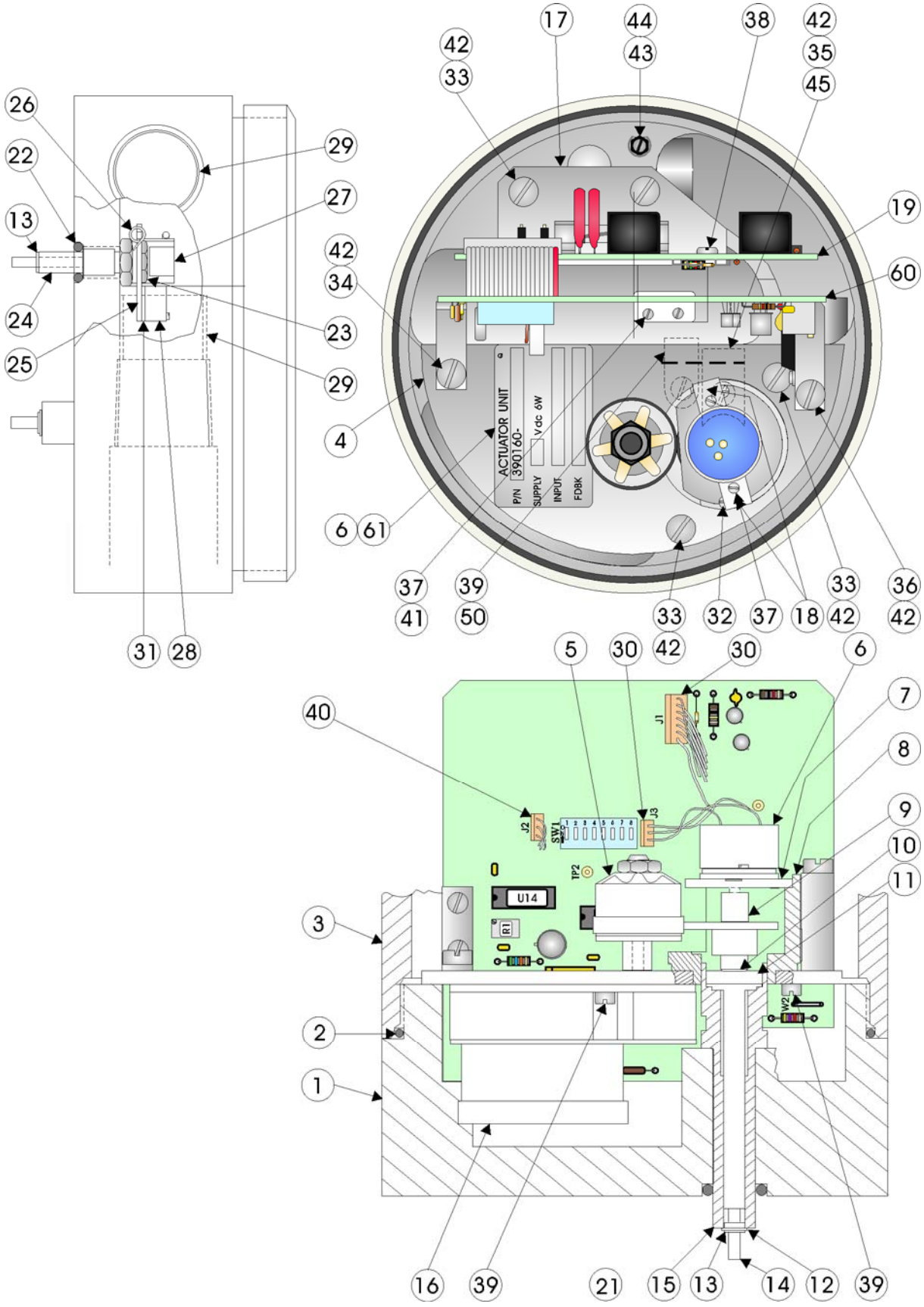


Figure 5-7 - Actuator Assembly

Item	Description	Part Number
45	Clamp, Sleeve	390102-01-6
50	Clamp, Cable	295379-00-6
60	CPU Board Type	(Note 3):

Type	Supply	Output	Part Number
Analog	12 V	PD	389615-02-1
Analog	24 V	PD	389615-05-6
Analog	12 V	Current	398615-03-0
Analog	24 V	Current	389615-06-4
Raise/Lower	12 V	PD	389613-02-9
Raise/Lower	24 V	PD	389613-05-3
Raise/Lower	12 V	Current	389613-03-7
Raise/Lower	24 V	Current	389613-06-1

5.8 TRANSMITTER UNITS (see Figures 5-5C, 5-8A & 5-8B)

Item	Description	Part Number
1	Screw, #10-32 x 7/16 inch (Pan Head)	375914-01-3
2	Screw, #6-32 x 3/4 in. (Soc. Flat Head)	396349-02-1
3	Screw, #6-32 x 3/16 in. (Pan Head)	374601-03-8
4	Strap, Retaining Nozzle	396373-01-1
5	Pan Head Screw, #4-40 x 3/16 in.	374600-03-1
6*	Differential Screw, #2-56 x 5/8 inch (Shoulder)	388851-01-5
7*	Spring, Compression	373962-15-0
8*	Input Beam (Front Rocker Arm Assembly)	388946-01-6
9	Feedback Beam Pivot (Rocker Arm Pivot)	306647-00-1
10	Screw, #2-64 x 1/4 inch (Set)	312470-00-2
11	Feedback Beam (Rear Rocker Arm Assembly)	374480-01-0
12	Front Rocker Arm Assembly - 20 psi	396265-01-4
	Front Rocker Arm Assembly - 30 psi	396265-02-2
	Front Rocker Arm Assembly - 35 psi	396265-03-0
13	Screw, #6-32 x 5/16 inch (Pan Head)	374601-05-4
15	Base Assembly	374475-01-6
16	O-Ring, 5/64" ID x 13/64 OD	304073-00-8
17	Capsule Assembly - for 0-20 psi	374454-01-9
	Capsule Assembly - for 0-30 psi (for 30/35 psi units)	374454-01-5
18	Pin (for 624 Control Unit)	374476-01-2
19	Seal Plate	387614-01-0
20	O-Ring, Size 2-008	311877-01-0
21	Bracket, Spring (for Mod 624)	301247-00-4
22	Bearing, Follow Up Pin	306803-00-3
23	Rocker Arm Housing (624 Control Unit)	396263-01-1
24	Spring (for 624-II Control Unit)	310248-00-0
26	O-Ring, Size -006	316135-01-1
27*	Pivot Shaft	388945-01-0
28*	Input Beam Bracket (Rocker Arm for 624 Control Unit)	388944-01-3

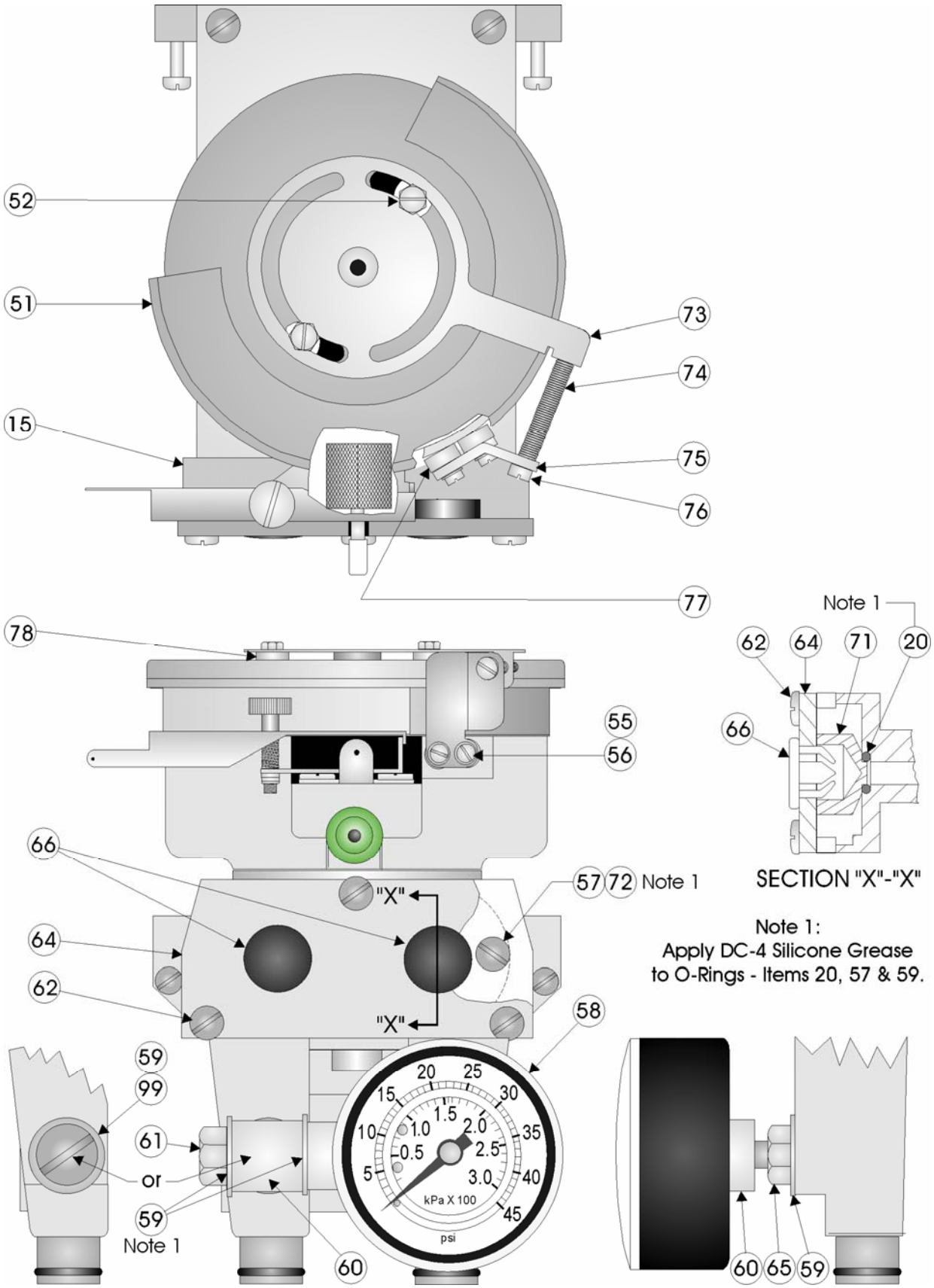
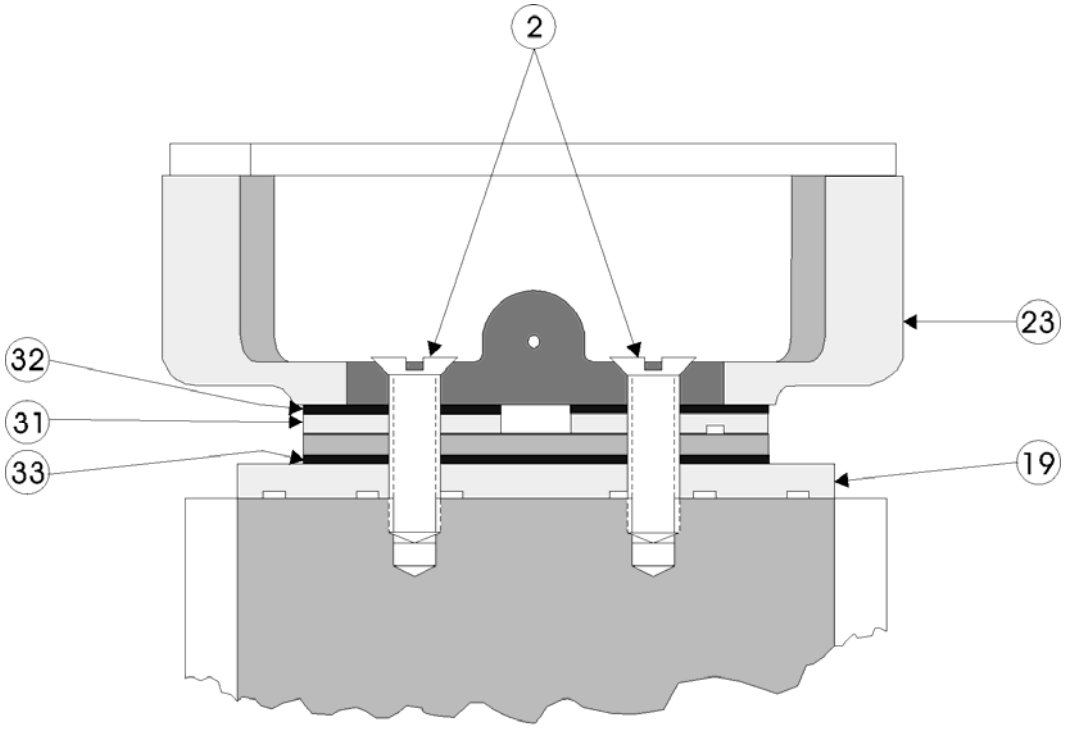


Figure 5-8A - Transmitter Unit



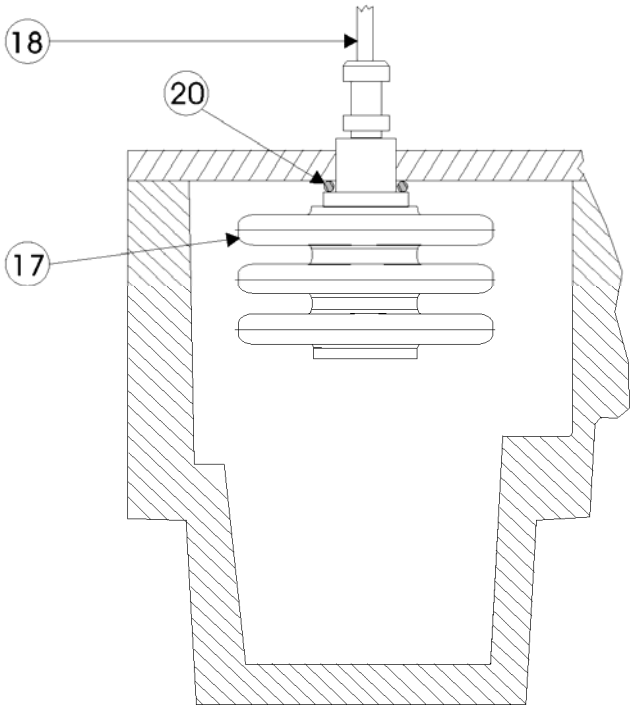


Figure 5-8B - Internal Transmitter Assembly

Item	Description	Part Number
29	O-Ring, Size -010	316135-02-0
30	Restriction Assembly, Cleanable	381286-01-0
31	Plate Exhaust Assembly	374652-02-3
32	Upper Diaphragm (for A/D Control Unit)	306629-00-3
33	Valve Seat & Diaphragm Assembly	374650-01-2
34	Spring, Diaphragm Valve Seat Assembly	306648-00-8
35	Plunger, Ball Stem	388864-01-0
36	Screw, 5/16-32 x 13/32 inch	306655-00-4
37	O-Ring, .351 ID x .495 OD	375411-01-1
51	Cover	332319-01-6
52	Cover Screw, 3-56 x 1/2 (Hex Head)	309011-00-0
55	Screw, 2-64 x 5/16 (Fil Head)	236881-00-0
56	Washer, 3/32" (Flat)	233132-00-7
57	O-Ring, Size 2-006	311877-00-1
58	Gauge, 0-30 psi (for 0-20 & 0-30 psi Transmitters)	374546-01-0
	Gauge, 0-45 psi (for 0-35 psi Transmitter)	374546-02-9
59	Thread Seal, 1/4 in.	317443-03-8
60	Connector, 624-II Gauge	374545-01-4
61	Screw, 1/4-20x 13/16 Special	374544-01-8
62	Screw, #6-32 x 3/8 (Pan Head)	374601-06-2
64	Cover Plate (624-II Ctrl & Tmr)	374429-01-4
65	Nut, 1/4-20 (Hex)	374612-11-0
66	Hole Plug, 3/8 x 13/32	290301-00-9
71	Seal Plug	374667-01-2
72	Screw, #6-32 x 1/4 in.	374601-04-6
73	Adjustment Clamp	309004-00-4
74	Spring, .100 ID x 11/16	286371-00-6
75	Bracket	309003-00-8
76	Screw, 2-64 x 25/32 (Fil Head)	309005-00-0
77	Collar, 1/4 OD x 3/32 LG	303345-00-4
78	Collar, .312 OD x 1/4 LG	295869-00-3
99	Screw, 1/4-20 x 3/8 in.	374603-06-5

5.9 MAN.-AUTOMATIC STATION FOR G-I-D CONTROLLERS

(see Figure 5-9)

Item	Description	Part Number
1	45 psi Gauge	375224-01-7
2	Panel	385191-02-2
3	M/A Station Nameplate	385169-01-9
4	Screw, #4-40 x 3/16 inch	374600-03-1
5	Screw, #1/4-20 x 3/8 inch	374603-06-5
6	Round End Flat Cap	381168-01-8
7	Regulator Knob	385189-01-0
8	Adjusting screw	385168-01-2
9	M/A Station Guard	385341-01-6
10	Shoulder Screw, 10-32 x 1-17/64 inch	385195-01-0

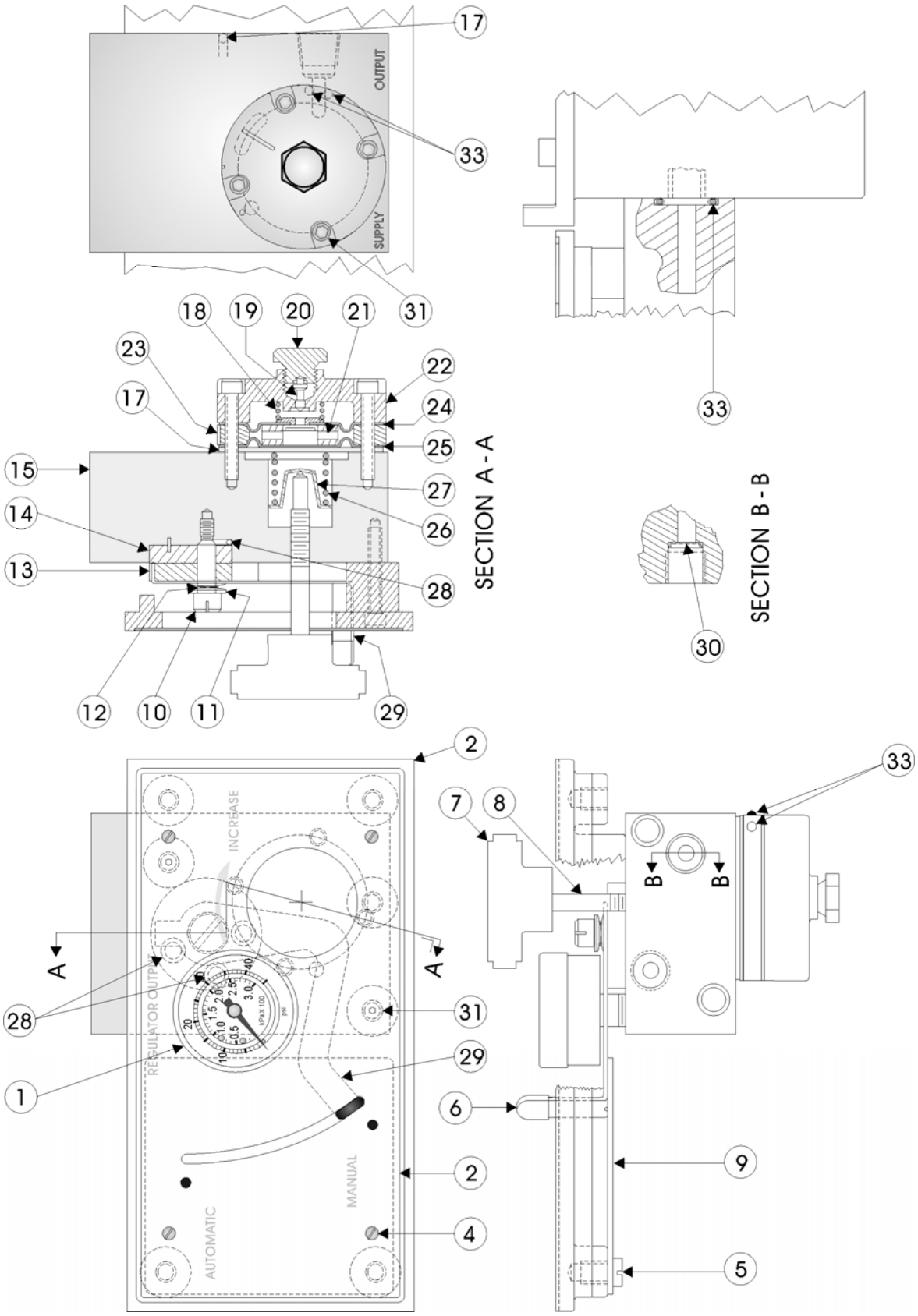
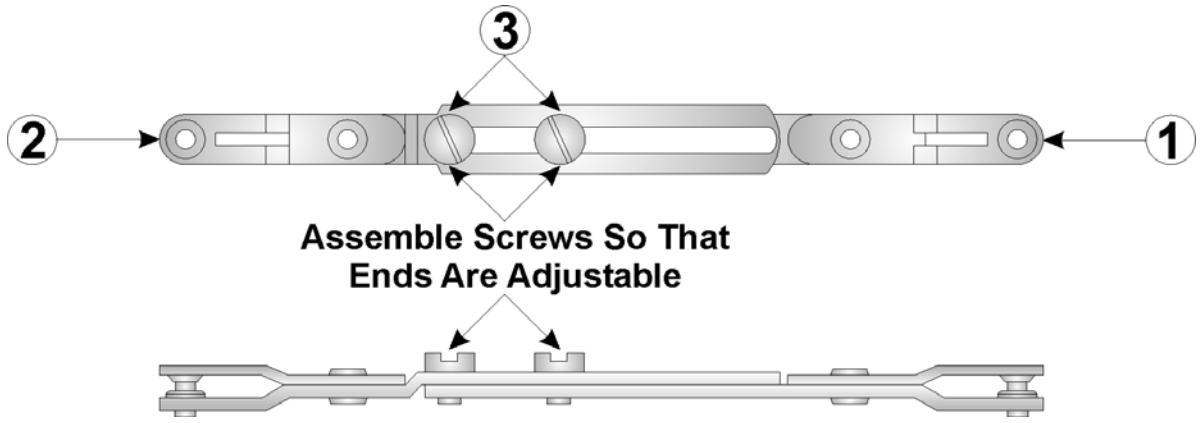


Figure 5-9 - Man-Auto Station

Item	Description	Part Number
11	Flat Washer	264248-00-7
12	Spring Washer	310760-00-3
13	Top Switching Disc	385186-01-0
14	Bottom Switching Disc	385166-01-0
15	M/A Station Block Assembly	385165-01-3
17	Regulator Diaphragm	385628-01-7
18	Helical Compression Spring	307905-00-4
19	Regulator Plunger	307908-00-3
20	Pilot Retaining Screw, 7/16 x 20	297261-00-2
21	Spacer	297248-00-6
22	Pressure Regulator Assembly Base	342172-00-0
23	Regulator Exhaust Ring	385389-01-9
24	Exhaust Diaphragm Assembly	396394-01-9
25	Diaphragm	383825-01-6
26	Helical Compression Spring	297234-00-5
27	Upper Spring Seat	307909-00-0
28	O-Ring 3/16 x 5/16 inch	297010-00-0
29	Switch Arm	385167-01-6
30	Filter Screen	316602-00-0
31	SHCS Screw, #10-32 x 1 inch	396400-01-9
33	O-Ring 11/16 x 7/8 inch	317303-09-0

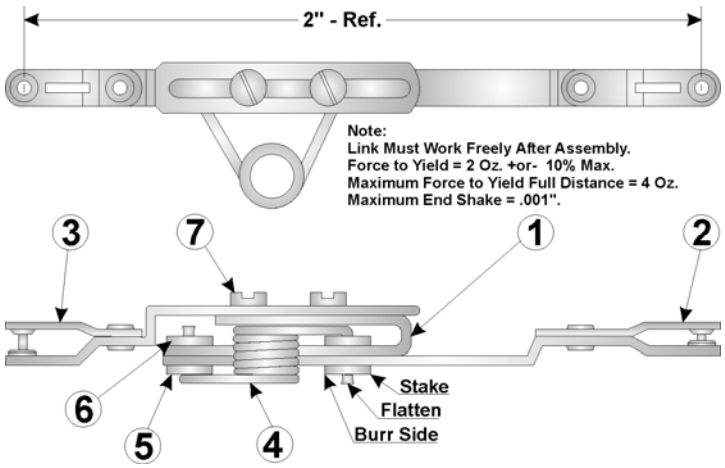
5.10 SERIES 5450 LINK ASSEMBLIES (see Figures 5-2A - item 27, 5-10A, 5-10B, 5-10C & 5-10D)



5450s that use 286120-00-3: 5453-10G (without Range Protection)
5453-40G (without Range Protection)
5457-10G (without Range Protection)
5457-40G (without Range Protection)

Adjustment Length: - 1-15/16" to 2-17/16"
Item 1 - 288454-00-6 - Tapped End Complete
Item 2 - 288453-00-0 - Slotted End Complete
Item 3 - 271465-00-0 - Screw (#0-80 x .078 FIL. HD. SCR.)

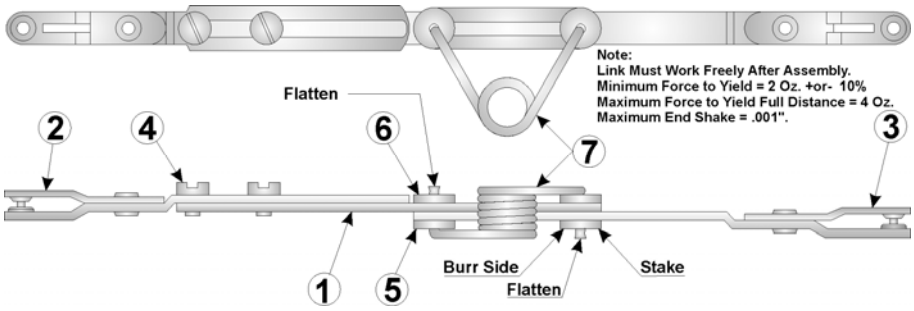
Figure 5-10A - Flat Connecting Link Item 286120-00-3



5450s that use 309355-00-1: 5453-10G (with Over/Under Range Protection)
5453-40G (with Over/Under Range Protection)
5457-10G (with Over/Under Range Protection)
5457-40G (with Over/Under Range Protection)

Adjustment Length: - 2” to 2-1/2”
Item 1 - 310924-00-6 - Tapped End Complete
Item 2 - 302807-00-4 - Slotted End Complete
Item 3 - 302805-00-1 - Adj. End Complete
Item 4 - 286516-00-4 - Spring
Item 5 - 286681-00-5 - Stud
Item 6 - 286680-00-9 - Washer
Item 7 - 271465-00-0 - Screw (#0-80 x .078 FIL. HD. SCR.):

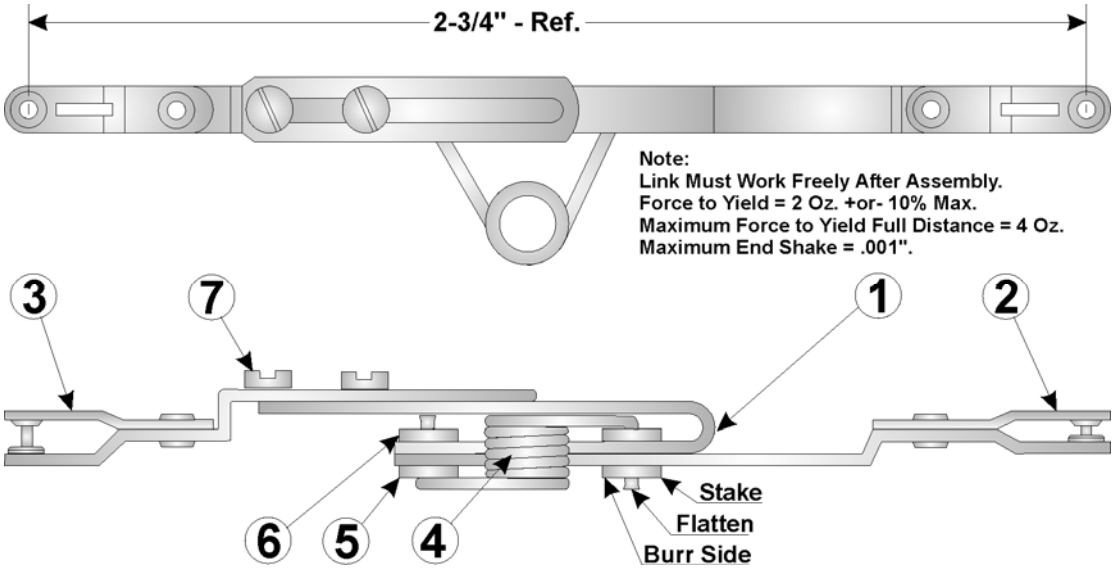
Figure 5-10B - Yielding Flat Connecting Link Item 309355-00-1



5450s that use 287824-00-4: 5457-31G

Adjustment Length: - 3-1/4” to 3-3/4”
Item 1 - 296333-00-0 - Tapped End Complete
Item 2 - 288453-00-0 - Adj. End Complete
Item 3 - 289279-00-3 - Slotted End Complete
Item 4 - 271465-00-0 - Screw (#0-80 x .078 FIL. HD. SCR.)
Item 5 - 286680-00-9 - Washer
Item 6 - 286681-00-5 - Stud
Item 7 - 286516-00-4 - Spring

Figure 5-10C - Yielding Flat Connecting Link Item 287824-00-4



5450s that use 302809-00-7: 5453-31G
Adjustment Length: - 2-3/4" to 3-1/4"
Item 1 - 302808-00-0 - Tapped End Complete
Item 2 - 302807-00-4 - Slotted End Complete
Item 3 - 302805-00-1 - Adj. End Complete.
Item 4 - 286516-00-4 - Spring
Item 5 - 286681-00-5 - Stud
Item 6 - 286680-00-9 - Washer
Item 7 - 271465-00-0 - Screw (#0-80 x .078 FIL. HD. SCR.)

Figure 5-10D - Yielding Flat Connecting Link Item 302809-00-7

5.11 MAINTENANCE & REBUILD KITS

A. 624-II Control Unit Rebuild Kit - (2 Mode with 20 psi Supply) - 600835-01-4

Item	Description	Part Number	Figures
16	O-Ring, 5/64 ID x 13/64 OD	304073-00-8	5-5C
17	Capsule Assembly, Feedback, 624-II	374454-01-9	5-5C
20	Gasket, O-Ring	311877-01-0	5-5B, 5-5C & 5-8A
25	O-Ring, 2.864 ID x 3.004 OD	375411-15-1	None
26	O-Ring, Size -006	316135-01-1	5-5C
29	O-Ring, Size -010	316135-02-0	5-5C
32	Upper Diaphragm for A/D Control Unit	306629-00-3	5-5C
33	Valve Seat & Diaphragm Assembly	374650-01-2	5-5C
34	Spring, Diaphragm Valve Seat Assembly	306648-00-8	5-5C
37	O-Ring, ,351 ID x .495 OD	375411-01-1	5-5C
57	O-Ring, 1/4 OD x 1/8 ID	311877-00-1	5-5B
58	Gauge, 0-30 psi	374546-01-0	5-5A
67	Valve, Scratch (Integral)	396522-01-7	5-5B
-	Gasket, .370 x .145 thk	314194-00-2	None

B. 624-II Control Unit Maintenance Kit - (2 Mode) - 600836-01-0

Item	Description	Part Number	Figure
16	O-Ring, 5/64 ID x 13/64 OD	304073-00-8	5-5C
20	Gasket, O-Ring	311877-01-0	5-5B, 5-5C & 5-8A
25	O-Ring, 2.864 ID x 3.004 OD	375411-15-1	None
26	O-Ring, Size -006	316135-01-1	5-5C
29	O-Ring, Size -010	316135-02-0	5-5C
37	O-Ring, ,351 ID x .495 OD	375411-01-1	5-5C
57	O-Ring, 1/4 OD x 1/8 ID	311877-00-1	5-5B

C. 624-II Control Unit Rebuild Kit - (2 Mode with 30 or 35 psi Supply) - 600842-01-0

Item	Description	Part Number	Figure
16	O-Ring, 5/64 ID x 13/64 OD	304073-00-8	5-5C
17	Capsule Assembly, Feedback, 624-II	374455-01-5	5-5C
20	Gasket, O-Ring	311877-01-0	5-5B, 5-5C & 5-8A
25	O-Ring, 2.864 ID x 3.004 OD	375411-15-1	None
26	O-Ring, Size -006	316135-01-1	5-5C
29	O-Ring, Size -010	316135-02-0	5-5C
32	Upper Diaphragm for A/D Control Unit	306629-00-3	5-5C
33	Valve Seat & Diaphragm Assembly	374650-01-2	5-5C
34	Spring, Diaphragm Valve Seat Assembly	306648-00-8	5-5C
37	O-Ring, ,351 ID x .495 OD	375411-01-1	5-5C
57	O-Ring, 1/4 OD x 1/8 ID	311877-00-1	5-5B
58	Gauge, 0-45 psi	374546-02-9	5-5A
67	Valve, Scratch (Integral)	396522-01-7	5-5B
-	Gasket, .370 x .145 thk	314194-00-2	None

D. Differential GAP Control Unit Rebuild Kit - 600838-01-3

Item	Description	Part Number	Figure
2	O-Ring, .364 ID x .070 W	387670-00-5	5-6
3	Spool, 624 Diff. Gap, 85 Version	389271-01-2	5-6
10	O-Ring, .614 ID x .754 OD	375411-08-9	5-6
11	Diaphragm, 624-II Diff. Gap 85	389300-01-2	5-6
12	Restriction Assembly	390519-01-4	5-6
15	O-Ring, .351 ID x .495 OD	375411-01-1	5-6
75	Tubing, 7/32 OD, Flexible	307264-00-9	5-3A

E. Differential GAP Control Unit Maintenance Kit - 600837-01-7

Item	Description	Part Number	Figure
2	O-Ring, .364 ID x .070 W	387670-00-5	5-6
10	O-Ring, .614 ID x .754 OD	375411-08-9	5-6
11	Diaphragm, 624-II Diff. Gap 85	389300-01-2	5-6
15	O-Ring, .351 ID x .495 OD	375411-01-1	5-6

F. 5457 Remote Set Point, 12Vdc Rebuild Kit - 600844-01-3

Item	Description	Part Number	Figure
2	O-Ring, size -161	316135-12-7	5-7
5	Clutch Assembly	390087-01-7	5-7
9	Drive Gear, Pot, Assembly	390097-01-2	5-7
10	Retaining Ring, .250", External	310895-00-6	4-7
11	Ball Bearing, .650 OD x .250 ID	288085-00-0	5-7
12	Ball Bearing, 1/4" Single Row	307479-00-5	5-7
13	Retaining Ring, 1/8", External	291665-00-4	5-7
14	Shaft, 624-II Remote Set	390098-01-9	5-7
15	Bearing Sleeve	390093-01-7	5-7
16	Motor Assembly	390257-01-0	5-7
21	O-Ring, .500 ID x .094 W	310792-00-2	5-7
22	O-Ring, size -108	316135-13-5	5-7

G. 5457 Remote Set Point, 24Vdc Rebuild Kit - 600844-02-1

Item	Description	Part Number	Figure
2	O-Ring, size -161	316135-12-7	5-7
5	Clutch Assembly	390087-01-7	5-7
9	Drive Gear, Pot, Assembly	390097-01-2	5-7
10	Retaining Ring, .250", External	310895-00-6	4-7
11	Ball Bearing, .650 OD x .250 ID	288085-00-0	5-7
12	Ball Bearing, 1/4" Single Row	307479-00-5	5-7
13	Retaining Ring, 1/8", External	291665-00-4	5-7
14	Shaft, 624-II Remote Set	390098-01-9	5-7
15	Bearing Sleeve	390093-01-7	5-7
16	Motor Assembly	390257-02-8	5-7
21	O-Ring, .500 ID x .094 W	310792-00-2	5-7
22	O-Ring, size -108	316135-13-5	5-7

NOTES:

1. Order by model and serial number. Give complete model number with all suffixes.

2. Specify type and measuring range.

3. Field servicing of PC boards is not recommended. Defective boards in warranty may be returned to the factory for repairs or replacement.

- Appendix AA -
PNEUMATIC RECEIVERS

- Contents -

DESCRIPTION

Pneumatic Receivers consist of a capsular measuring element designed to receive a 3-15 psi (20.7 to 103.3 kPa) signal from a pneumatic transmitter. The expansion or contraction of the element produces a motion that is transmitted via a four-bar linkage to a pen or indicator mechanism. The linkage is calibrated to sweep the full signal range (0-100%).

RECEIVER CONNECTIONS

The procedures described here cover the connections for the pneumatic receiver. For details on mounting the instrument, refer to the installation section of the manual.

Connection Port

The 3-15 psi connection port may be located at the rear or bottom of the case. Refer to the main manual or overall dimension sheet for actual location on instrument.

Instruments are generally shipped with a protective plastic cap inserted in the receiver port. This cap should be left intact until the instrument is mounted.

Tubing

The type and size of the tubing used for pneumatic lines is determined by the measurement application. Steel or copper pipe can be used but their cost may be prohibitive for long runs. Plastic tubing, which is more economical, can be used for many applications not requiring metals.

The response of a pneumatic receiver to a change of signal pressure is affected by the diameter and length of the interconnecting tubing. This relationship is shown by the table below that compares tubing size, line runs and equivalent response time.

Tubing Size	Time Lag in Seconds For:			
(Inches)	200 Ft.	500 Ft.	1000 Ft.	2000 Ft.
3/16 OD x 1/8 ID	0.8	4.4	17.0	68.0
1/4 OD x 3/16 ID	0.3	1.7	7.7	30.8
3/8 OD x 5/16 ID	0.1	0.6	2.9	11.6

Table AA-1 - Piping Characteristics vs. Response Time

TYPICAL RECEIVER APPLICATION

The arrangement in the illustration shows a pneumatic transmitter sending a 3-15 psi signal to an instrument with a pneumatic receiver. Although a recording instrument is shown, it could also be an indicating receiver, controlling receiver, etc. Regardless of the actual function, the piping connections shown in the illustration still apply.

Optional items such as shutoff valves, tees, unions and gauges may also be installed in the system for test or maintenance procedures. A filter and regulator (or a combination unit) is also recommended to provide a clean air supply and a steady pressure.

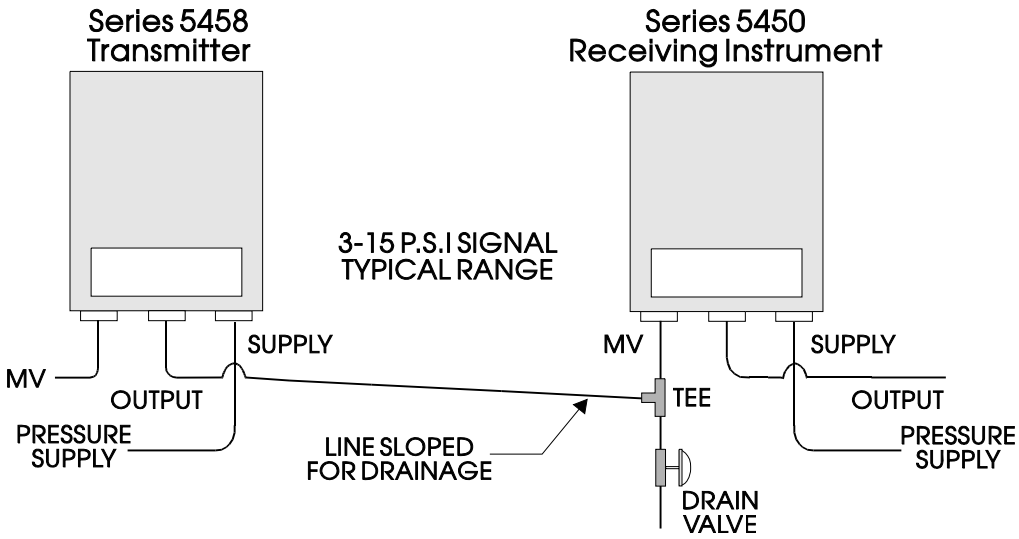


Figure AA-1 - Typical Piping Diagram

MOISTURE BUILDUP

All pneumatic instruments are subject to moisture buildup in the supply or signal lines. This moisture that results from condensation must be drained on occasion so that it does not impair receiver operation. The optional drain valve shown in the illustration may be installed for this purpose.

The drain valve must always be at the lowest point of the system. When the instrument is mounted lower than the transmitter, the valve can be installed at the receiver as shown; when the instrument is higher than the transmitter, the valve can be installed at the output of the transmitter.

To flush the system of moisture, open the drain valve momentarily with pressure applied to the system. Once the moisture has blown out, close the valve. If the drain valve is omitted from the installation, it will be necessary to manually drain the system by loosening the pressure connection at the lowest point of the system.

OPERATION UNDER EXTREME CONDITIONS

Pressure receiver lines must be protected from freezing temperatures. If the line is exposed to temperatures below freezing for short periods, sufficient protection can often be achieved by wrapping the lines with insulation. Line runs subject to prolonged freezing may require thermostatically-controlled, electric, wrap-around heater tape for additional protection.

NOTE

The instrument must not operate in temperatures that exceed or fall below its operating temperature range. Refer to main manual for environment specifications.

- Appendix GA -

PRESSURE MEASURING SYSTEM

- Contents -

A. DESCRIPTION

The pressure measuring system of an instrument will consist of a helical or capsular measuring element that either positions a pointer on a scale, or a pen on a chart. The helical type is essentially a hollow metal coil that winds or unwinds with changes in pressure, while the capsular type consists of a bellows assembly that expands or contracts with pres-sure changes.

Helical elements are used to measure pressures ranges from 0-30 to 0-10000 psi. Capsular elements are used to measure more sensitive pressure ranges from 0-1 in./water to 0-200 psi. The actual range furnished will be found on the instrument data plate.

Pressure elements may be constructed of 316 stainless steel, Ni-Span C or phosphor bronze materials to match the needs of the process application. The type of material furnished for elements will be as specified in the sales order.

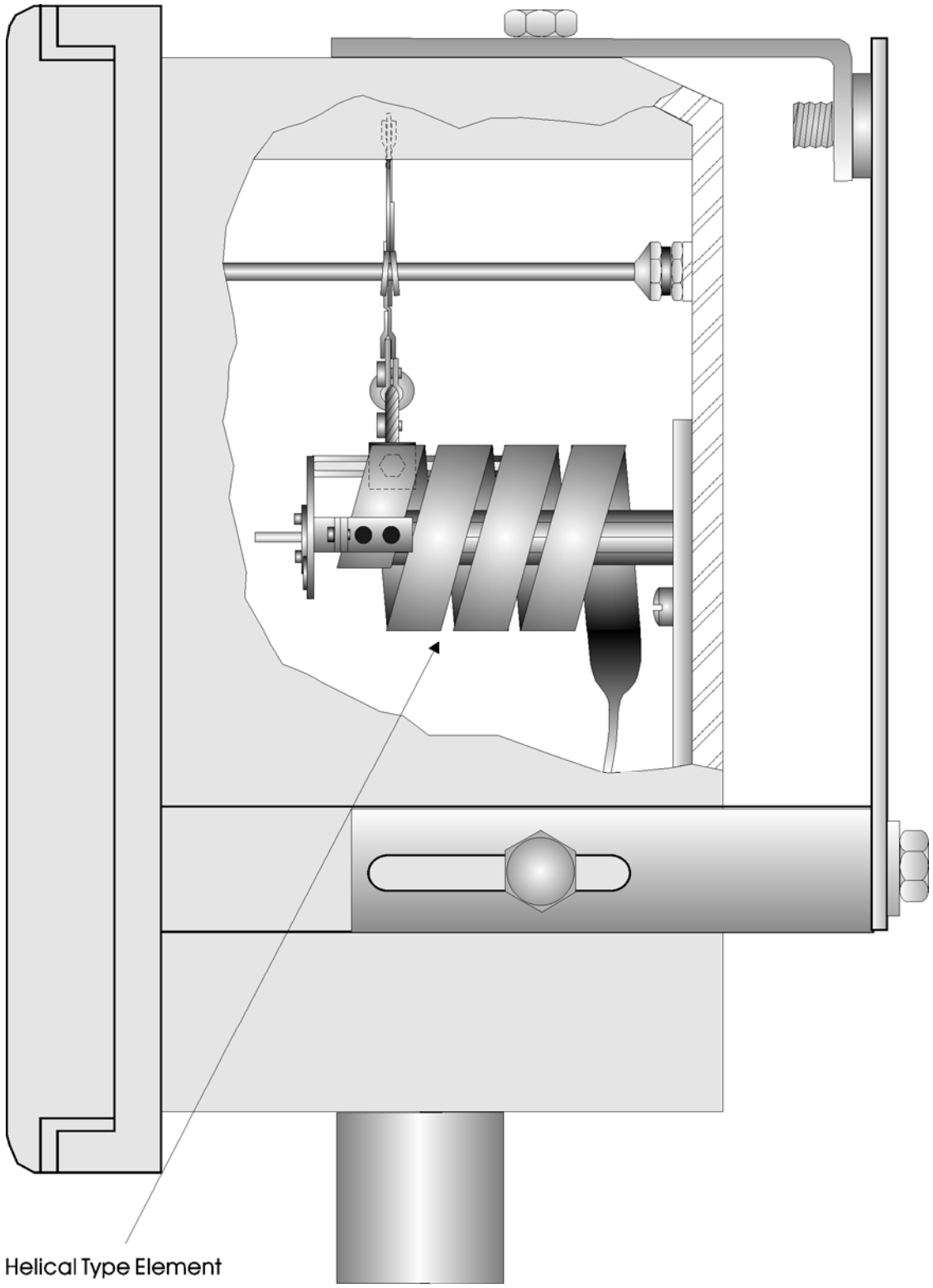


Figure 1 - Series 5450 with Helical Type Pressure Element

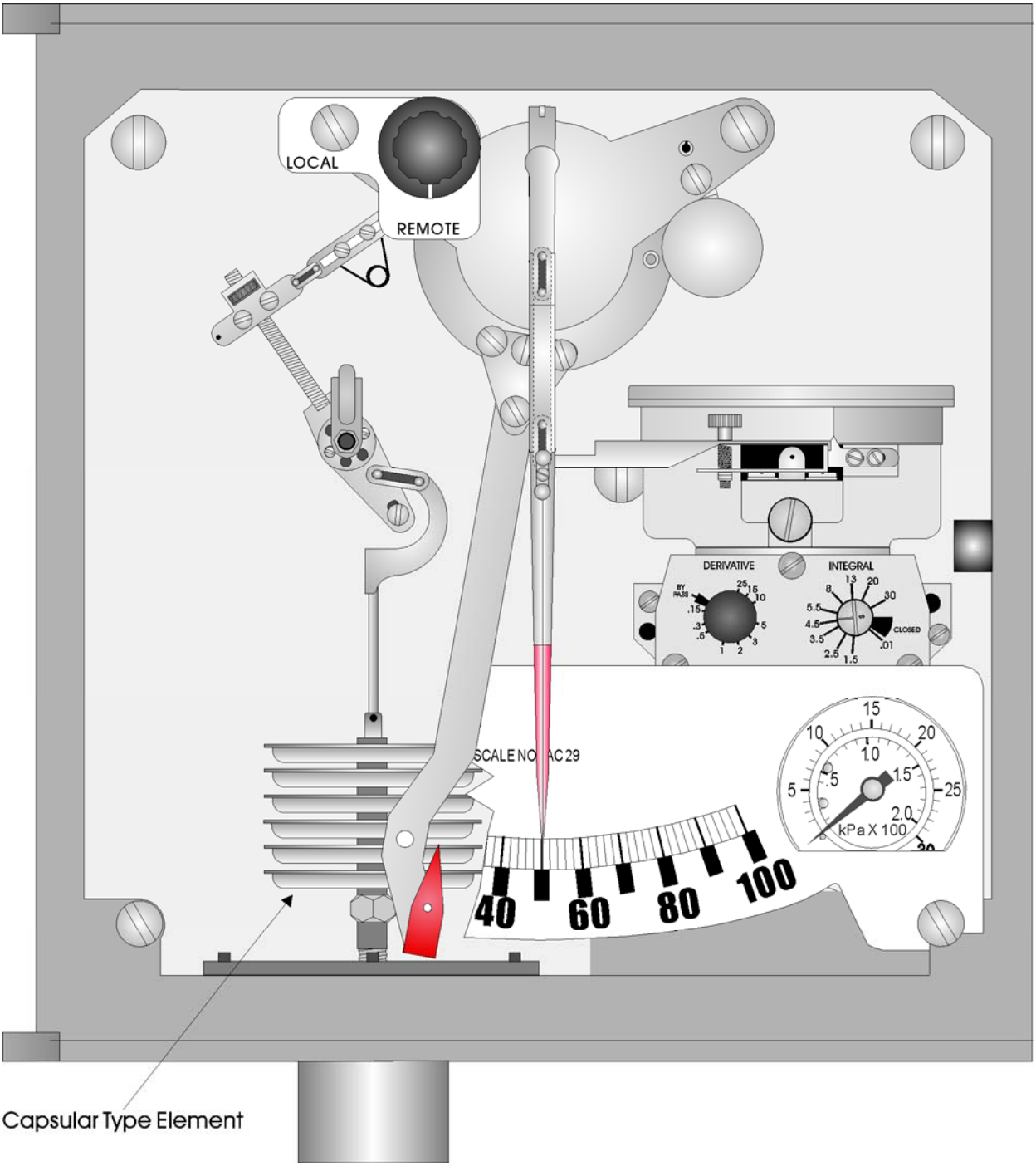


Figure 2 - Series 5450 with Capsular Type Pressure Element

B. PRESSURE CONNECTIONS

The pressure connection consists of 1/2" NPT threaded opening in the case. The location of this connection is identified in the installation section of the manual. Note that instruments are shipped from the factory with a protective cap over the port. This cap should be removed once the instrument case is mounted.

Piping Material and Size

Plastic or copper tubing can be used for most general purpose applications. However, some installations may require tubing or pipe made of steel or special alloys. It is suggested that you review the application before making a choice.

The response time of a pressure instrument to an actual change of pressure is a function of the diameter and length of the connecting line. For some applications involving very long runs, these delays may be sufficient to slow down measurements. In general, fast response will be obtained for distances up to 300 feet using 1/4 inch tubing (inside diameter). For distances up to 500 feet, the use of 3/8 inch is recommended.

Unions & Shutoffs

A union connection and shutoff valve may be installed at the pressure port of the instrument. These items will provide a convenient means to disconnect the instrument from the line for maintenance procedures without disrupting the pressure source. Examples of the use of these items are shown in Figures 4 through 9.

Service Tees with Plug

A tee connected in the pressure line allows the pressure source to be accessed for service or calibration checks. The tee includes a removable plug for bleeding the pressure line of air pockets and moisture.

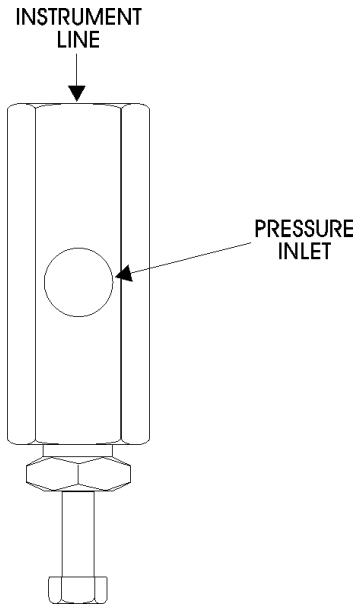


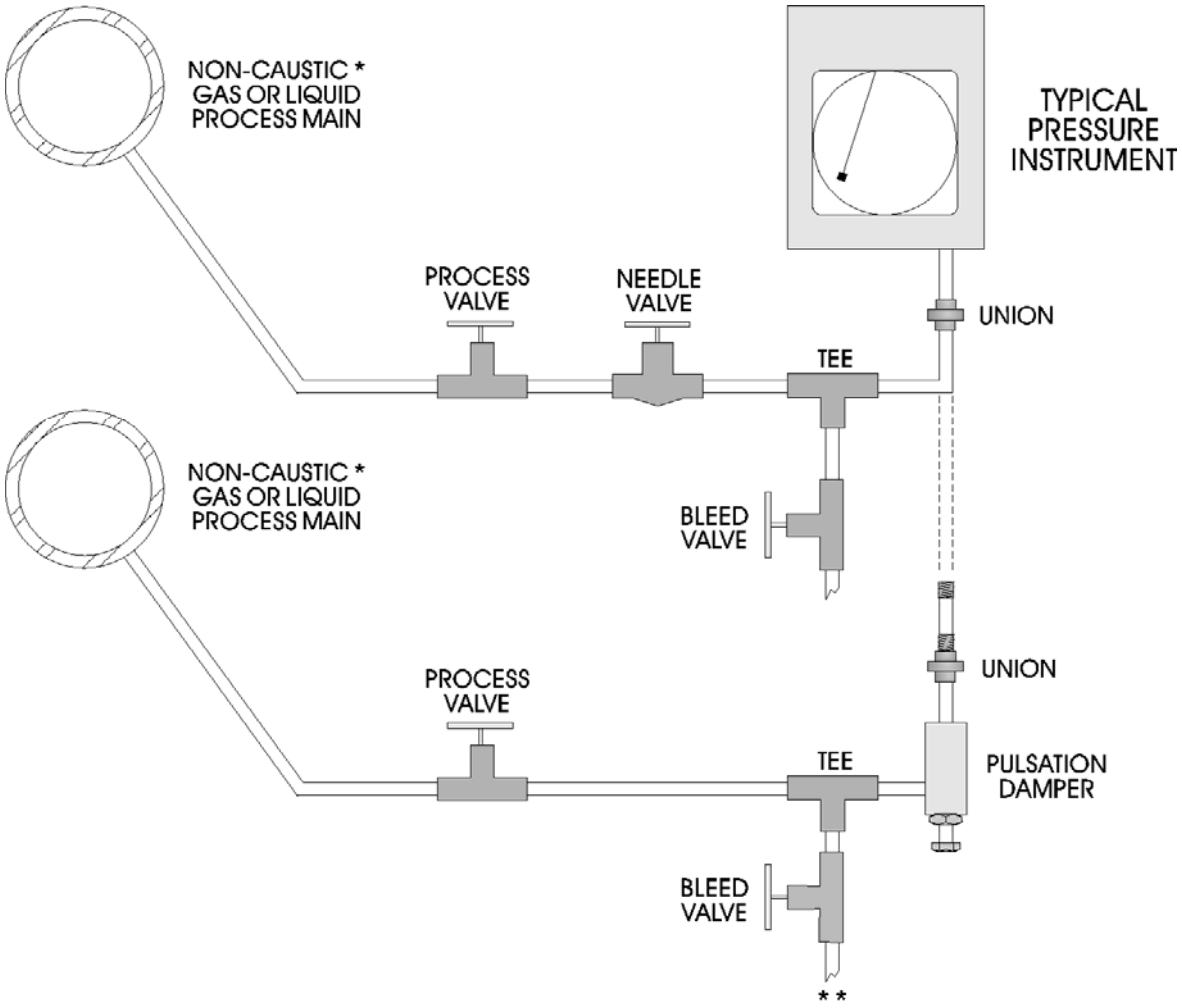
Figure 3 - Typical Pulsation Damper

Needle Valves & Pulsation Dampers

Some unregulated pressure sources may produce rapid fluctuations or oscillations on the line which result in erratic readings at the instrument. These fluctuations, if continued over a long period, accelerate mechanical wear of the measuring system and pivot points.

For minor cases, installing a needle valve in the line close to the instrument will minimize the problem. In operation, the valve smooths out pulsations by restricting them through an adjustable orifice. A proper setting is determined by experimenting with different valve openings until steady readings are obtained.

In cases where severe oscillation or transients are present on the line a needle valve may not prove adequate and a pulsation damper is recommended. This device contains an adjustable needle valve and piston arrangement to regulate the pressure. The piston, whose lateral movement is controlled by changes of input pressure, closes the valve on pressure peaks and opens it on pressure drops. As such, the output pressure remains relatively constant. The valve is adjusted in small increments until steady pressure readings are achieved.



* THIS ARRANGEMENT MAY ALSO BE USED WITH A CAUSTIC PROCESS PROVIDING THE INSTRUMENT AND ASSOCIATED PIPING DRIVERS ARE SPECIFIED WITH CAUSTIC - RESISTANT MATERIAL.

** GAS OR LIQUIDS OF A HAZARDOUS NATURE MUST BE BLED INTO A PROTECTIVE CONTAINER OR AREA AWAY FROM OPERATING PERSONNEL.

Figure 4 - Basic Pressure Measurement Application

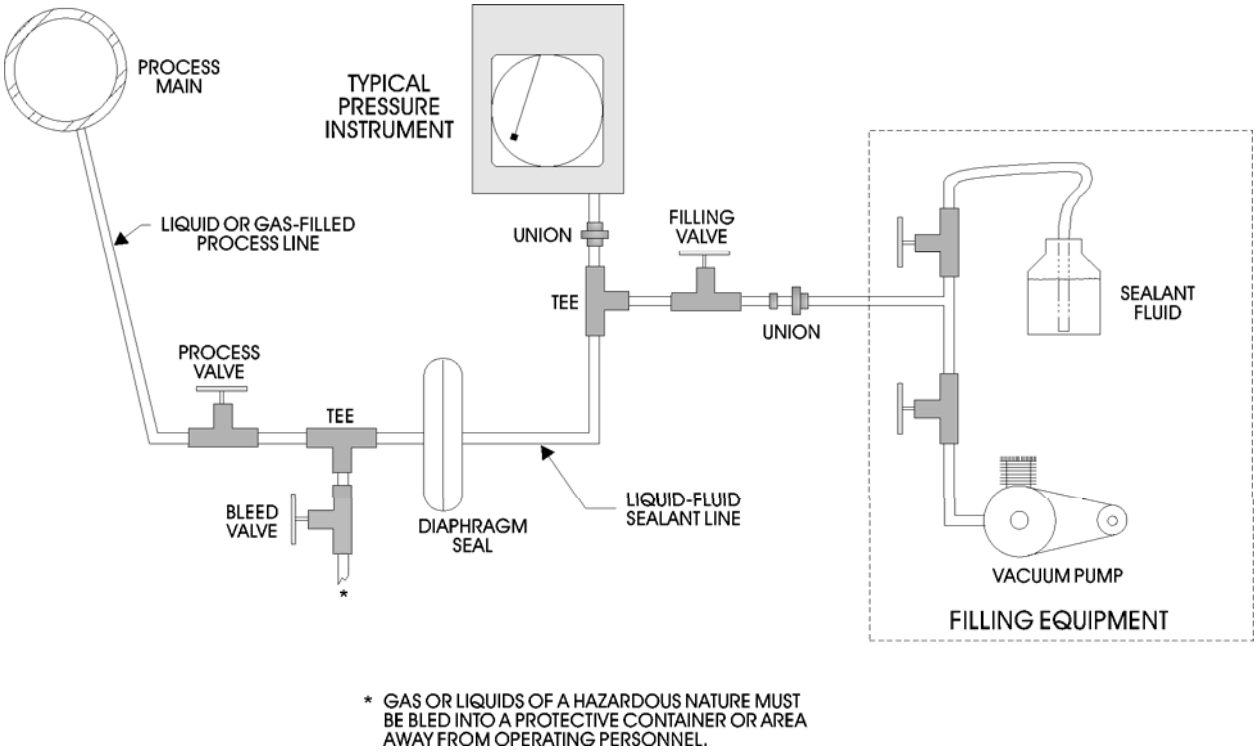


Figure 5 - Caustic Process Using Diaphragm Seal

C. BASIC MEASUREMENT OF AIR, GAS OR LIQUID

A basic installation that connects the instrument to a pressurized air, gas or liquid main is shown in Figure 4. The upper arrangement of this illustration employs a process valve, needle valve, bleed valve and a union connection. The lower arrangement deletes the needle valve and substitutes a pulsation damper. The use of these options was described in topic B.

The application of Figure 4 is chiefly intended for measurement of non-caustic process substances that will not react with materials specified for the measuring element, fittings, and accessory devices. However, these installations can also be used with caustic substances providing that the measuring element and accessories are classified for such service. Since such materials can add significant cost to the installation, the more economic arrangements of topic D should be considered.

NOTE

All warranties for the instrument and accessories provided by Bristol Babcock are void if the configurations of Figure 4 are used to measure caustic substances with under-classified instrument materials.

Air/Gas Installations

This type of system should be bled at the time of installation and periodically during normal usage. Prior to bleeding, the process valve and needle valve (or pulsation damper) must be opened and the bleed valve closed. The bleed valve is then opened until moisture

stops spitting out of the valve's discharge. Once pressure flow is uniform, the bleed valve is closed and the needle valve (or pulsation damper) is adjusted for normal operation.

Liquid Installations

A requirement of these installations is that the pressurized liquid come in direct contact with the instrument measuring element. In order for the instrument to provide accurate and stable readings, the liquid must be free of air bubbles or pockets. Therefore, the lines must be bled at the time of installation. Bleeding is performed in the same manner as described for air/gas systems except that the bleed valve is kept open until the valve's discharge stops spitting and the liquid flow is uniform.

D. MEASUREMENT OF CAUSTIC SUBSTANCES

If the materials used for the instrument measuring system and external accessories are under-classified for measurement of caustic substances, some form of physical isolation between the instrument and the process must be provided. This is achieved by using an isolation device whose material is rated for the measured medium.

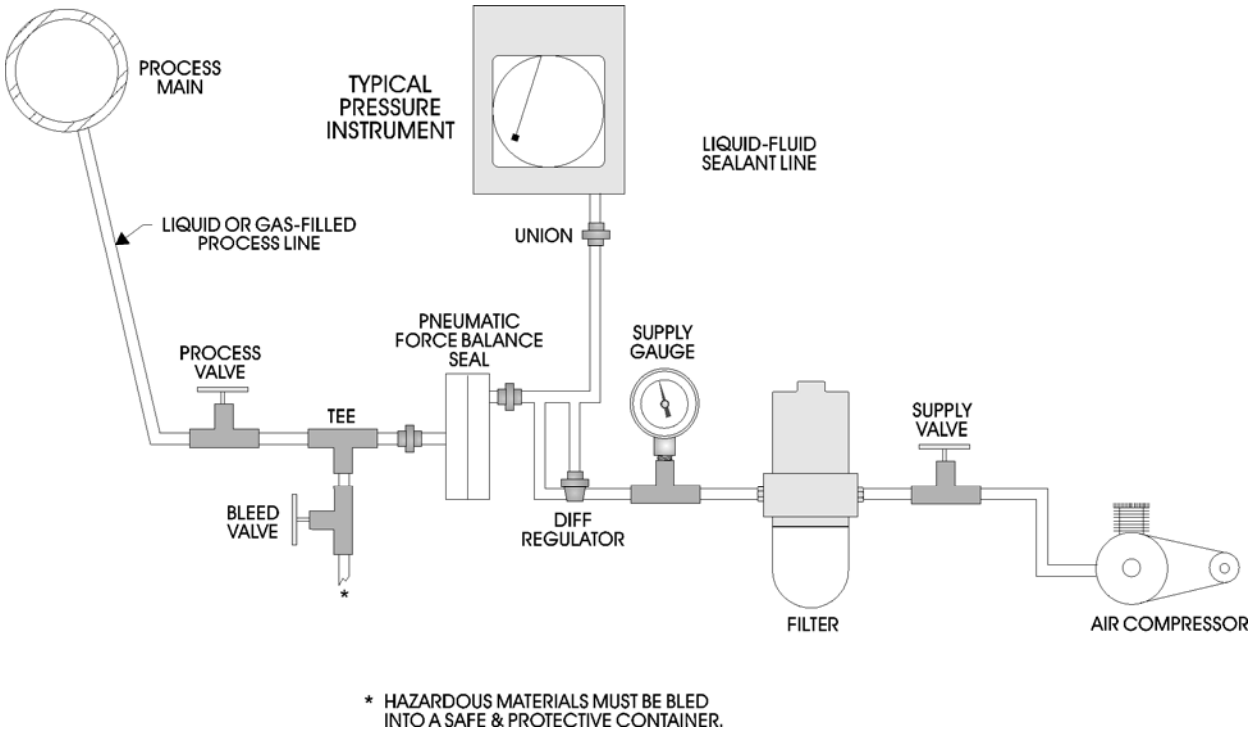


Figure 6 - Caustic Process using Force Balance Seal

Diaphragm Seal

This type of seal consists of a diaphragm that divides two chambers. In Figure 5, the left side is in contact with the process media, while the right side is in contact with a liquid sealant. Pressure variations occurring on the process side are transmitted by the flexible diaphragm to the sealant. The compression and release of the fluid produces a corresponding change of pressure is sensed by the measuring element of the instrument.

Force Balance Seal

An arrangement using a Force Balance Seal is shown in Figure 6. This system, generally used for pressure ranges from 0-12 in/H_2O to 0-100 psi, requires an external air supply to operate the seal mechanism.

Essentially, the Force Balance Seal obtains isolation through the use of a metallic diaphragm coupled to an air valve arrangement. Compressed air applied to the input of the instrument must pass through the air valve. Changes of process pressure cause the diaphragm to move left or right and transmit a lateral motion to the air valve. For an increase of process pressure the diaphragm causes the air valve to close so that less air is bled to the atmosphere and more is supplied to the instrument. For a decrease of process pressure, the air valve bleeds more air into the atmosphere so that less is available for the instrument. In this manner, the instrument's measuring element tracks pressure variations of the process.

Also recommended for use with a Force Balance Seal is a differential pressure regulator. This device regulates pressure variations across the seal for improved stability and measurement accuracy.

E. MEASUREMENT OF VISCOUS OR SOLIDIFYING FLUIDS

Liquids that tend to thicken or solidify at ambient temperatures must be kept out of the measuring element to prevent damage. In the application of Figure 7, a purge system connected to the instrument input line is used to isolate the process media. A typical purge system employs a medium such as water or air that is forced into the input line under heavy pressure. The pressure applied to the medium is generally 2 to 3 times greater than the process pressure.

In operation, the purging medium is forced into the junction of a process tee shown at the left of the bubbler valve. The resultant pressure cushion against the process medium offers resistance to the purge liquid and prevents mixing of fluids. However, if the process pressure falls near or below the purge pressure, the purge liquid will flow into the process line. Therefore, the bubbler valve must be adjusted so that little or no leakage occurs at the lowest pressure to be measured.

Two precautions must be observed when using a bubbler-type purge system. First, the purging fluid must not produce any dangerous reaction when it combines with the process medium. Second, the process material and purging liquid must have a compatible chemical base so that there is no separation of the process medium. And finally, the purging medium flowing into the process must be kept adjusted to a minimum amount to prevent over-dilution of the final product.

F. MEASUREMENT OF STEAM OR HOT VAPORS

When the process medium is steam or condensing vapors, certain precautions must be observed. In order to protect the instrument measuring system, the temperature of the medium at the input of the instrument must not exceed 150 ºF (65 ºC). This protection can be achieved as follows:

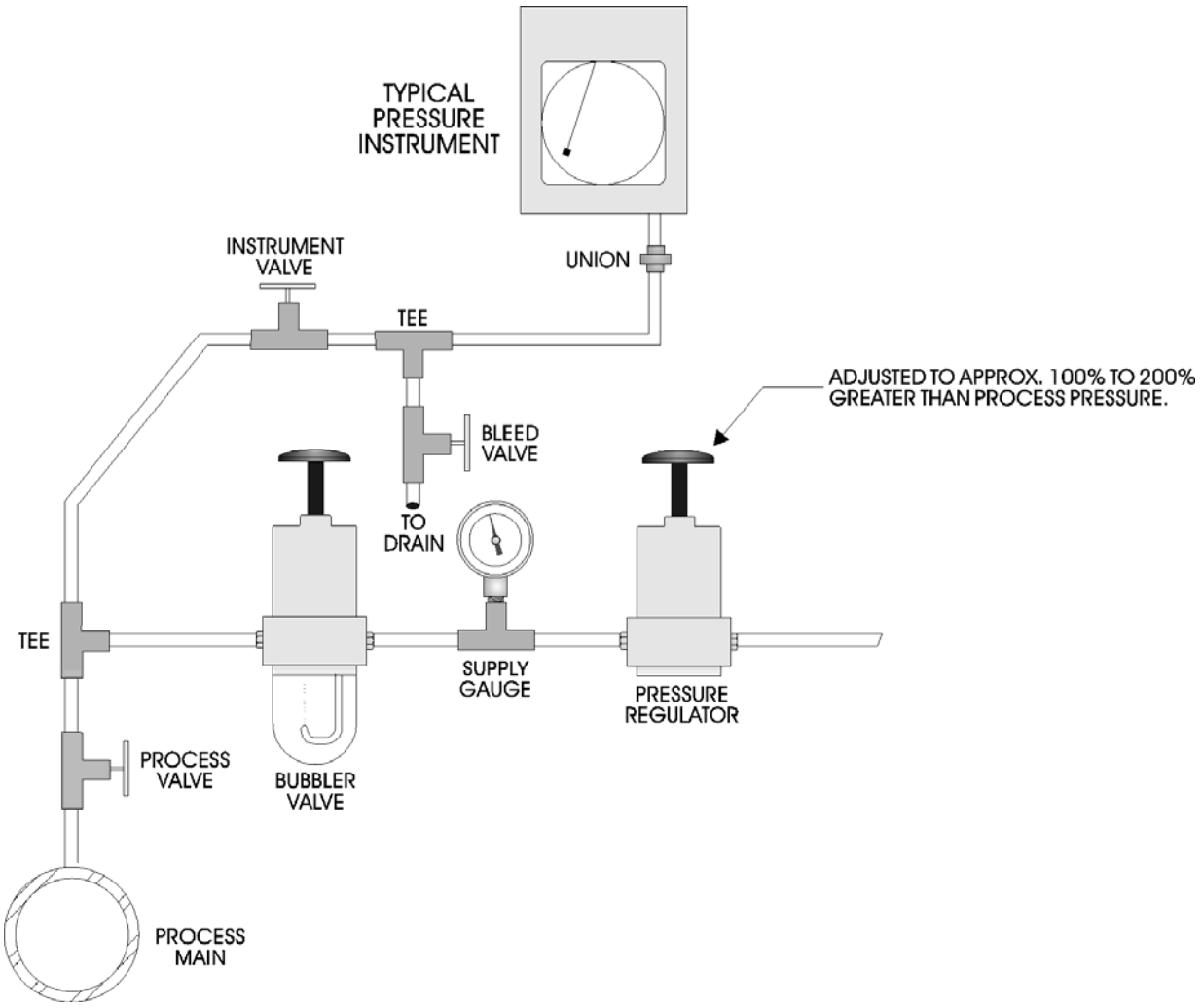


Figure 7 - Viscous Process using Purge System

Instrument Mounted Below Connection

This configuration, shown at the top of Figure 8, is an arrangement whereby the instrument is automatically protected from high temperatures due to the formation of condensate in the pressure line. As long as the line is sloped downward as shown, the steam or vapors will condense to liquid and act as a sealant. The sealant functions as a temperature barrier and prevent steam from getting into the instrument.

Instrument Mounted Above Connection

When the instrument is above the level of the steam main, any accumulated condensate will flow back into the main by gravity. To prevent this, a coil-type trap is installed near the instrument as shown in the lower drawing of Figure 8. The trap maintains a limited amount of liquid in the coil to act as a barrier. For this type of system, the pressure line must initially be primed with water to protect the measuring element from overheating before condensate can form.

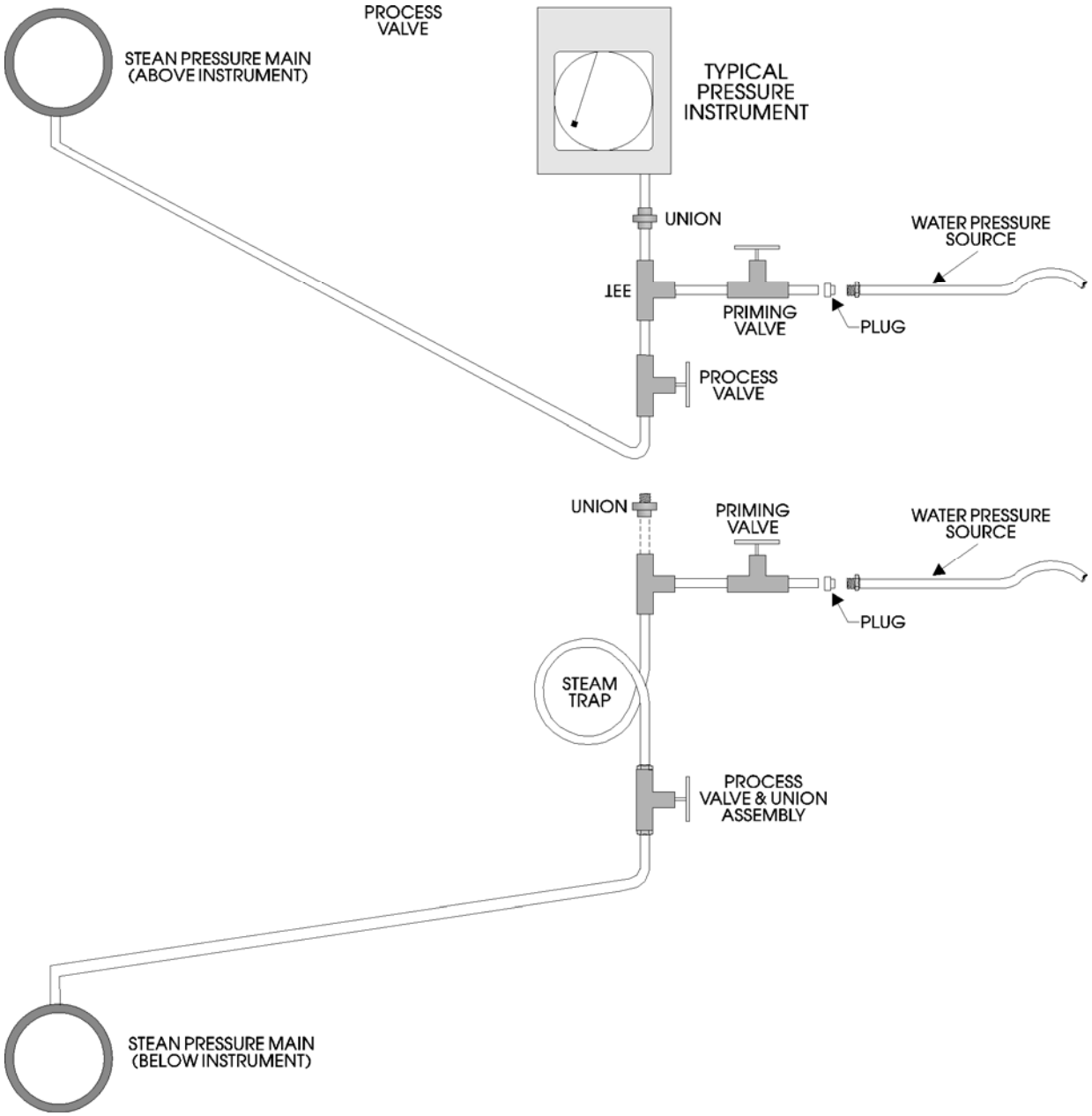


Figure 8 - Steam Pressure Installation

G. VACUUM MEASUREMENTS

Pressure instruments with appropriate ranges (-30 to 0 in./Hg) can also be used for vacuum measurements. Figure 9 illustrates the techniques for above and below-main type installations.

Although air is pulled out of the element and connection line during measurements, it might be assumed that the problem of isolation can be ignored. However, a major problem with vacuum instruments occurs when the vacuum is suddenly released. At that moment oil, grease, dirt or other undesirable substances in the line may be sucked into the measuring system. If allowed to build up, this matter can influence the accuracy and

performance of instrument measurements. The use of seals and filters should be considered when dirty vacuum lines are encountered.

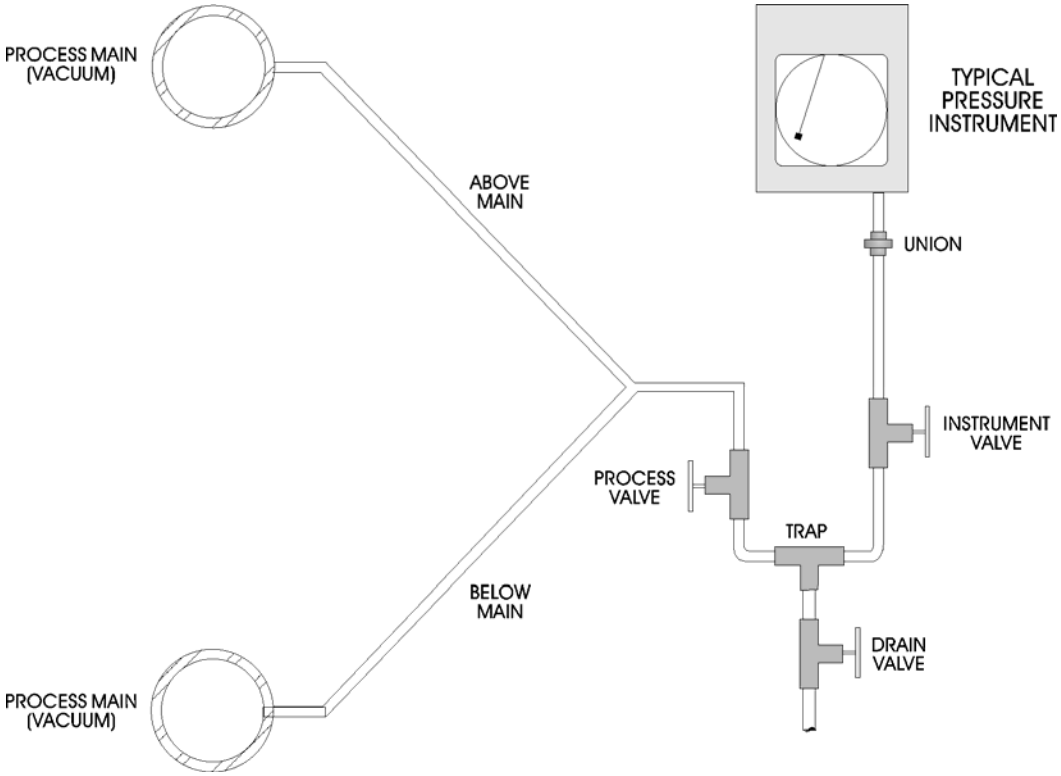


Figure 9 - Vacuum Measurement Application

H. LIQUID LEVEL MEASUREMENTS

Pressure instruments may also be specified for liquid level measurement applications. For these situations, the measuring element measures the pressure head of a column of liquid contained in an open tank or vat. The pressure measurements are read on an instrument scale calibrated in units that correspond to the height of the tank.

Instrument at Zero Line of Tank

Figure 10-A shows an application where the tank has a 0-30 foot measuring range. If the instrument is installed so that the pressure element is at the 0% reference level of the tank, the instrument readings should correlate with the level of the liquid even though the connecting pipe is lower than the zero reference line. In theory, the connecting pipe could be any desired length and distance below the tank, however, this approach has some limitations. If a minor zero offset error is observed at the instrument, a correction can be made by using the Zero Adj. on the MV linkage. For more details, refer to the calibration section of this manual.

Instrument Below Zero Line of Tank

Figure 10-B shows the instrument installed 3 feet below the 0% reference line of the tank. Because of the additional 3-foot head present in the connecting line, the instrument will

show a +3 foot error for all readings. Although this error can be mentally calculated, it is more convenient to recalibrate the instrument for direct scale readings. Refer to the calibration section of this manual for details.

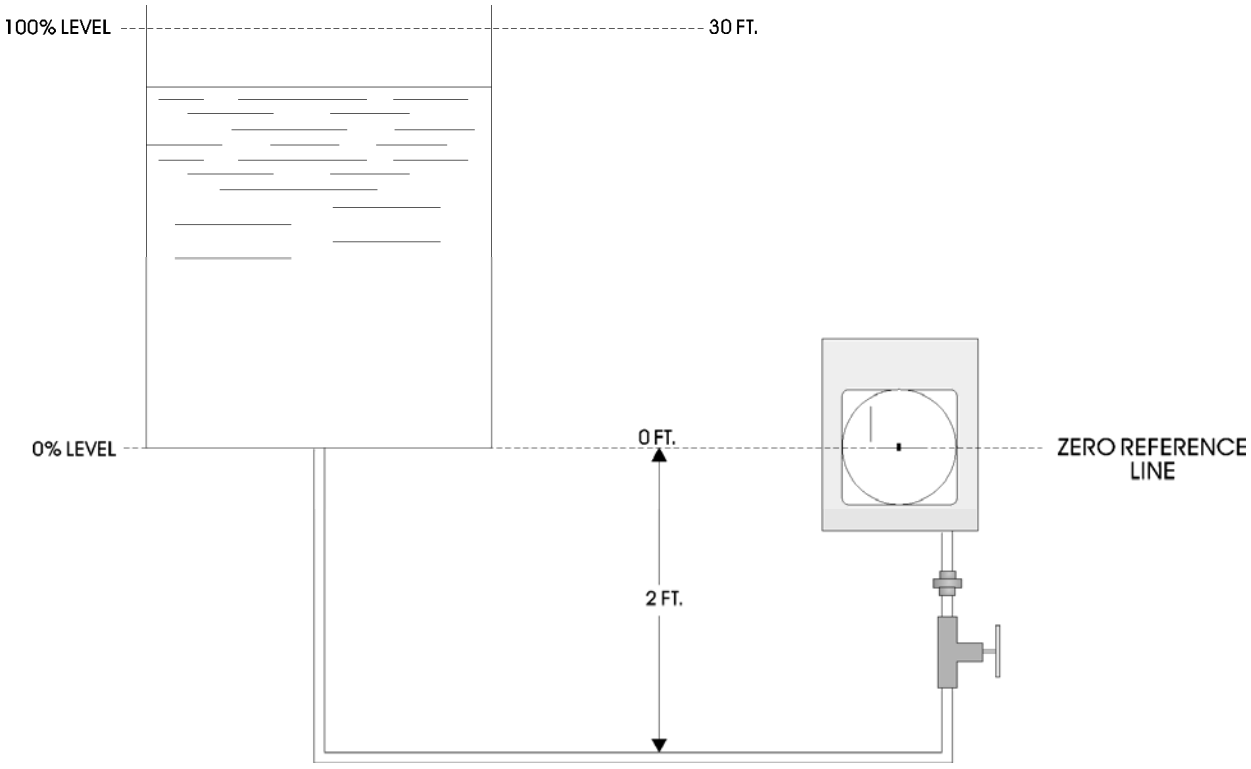


Figure 10-A - Instrument at Zero Reference Level

Instrument Above Zero Line of Tank

Figure 10-C shows the instrument installed 3 feet above the 0% reference line. This results in a -3 foot error for all readings. This error can be corrected by calibration adjustments. Refer to the calibration section of this manual for details.

Specific Gravity Correction

When an instrument intended for liquid level measurement applications leaves our factory, it will be calibrated for the value of SG (Specific Gravity) specified by the purchaser. However, if the type of liquid is changed, an SG error will be introduced into the readings. The amount of error can be calculated by the following formula:

$$\pm PSI = h\,(SG)/2.3097$$

Where:	h =	Measurement span (difference between max. and min. height)
	SG =	Specific Gravity of liquid in tank corrected for temperature, if necessary.
	±PSI =	Change in pressure caused by change in SG error in height units.

An SG error can be corrected by performing zero and span calibration of MV linkage as described in this manual.

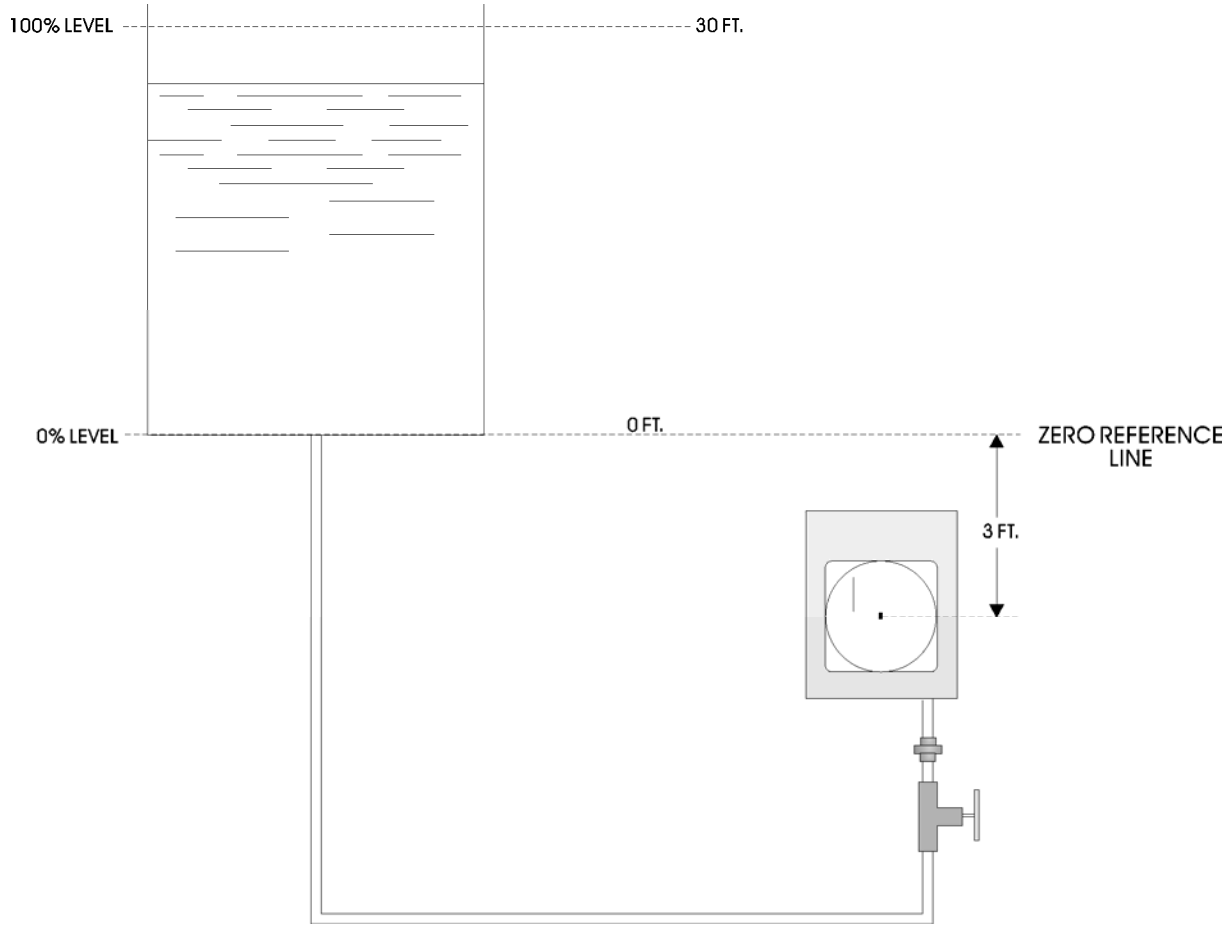


Figure 10-B - Instrument Below Zero Reference Line

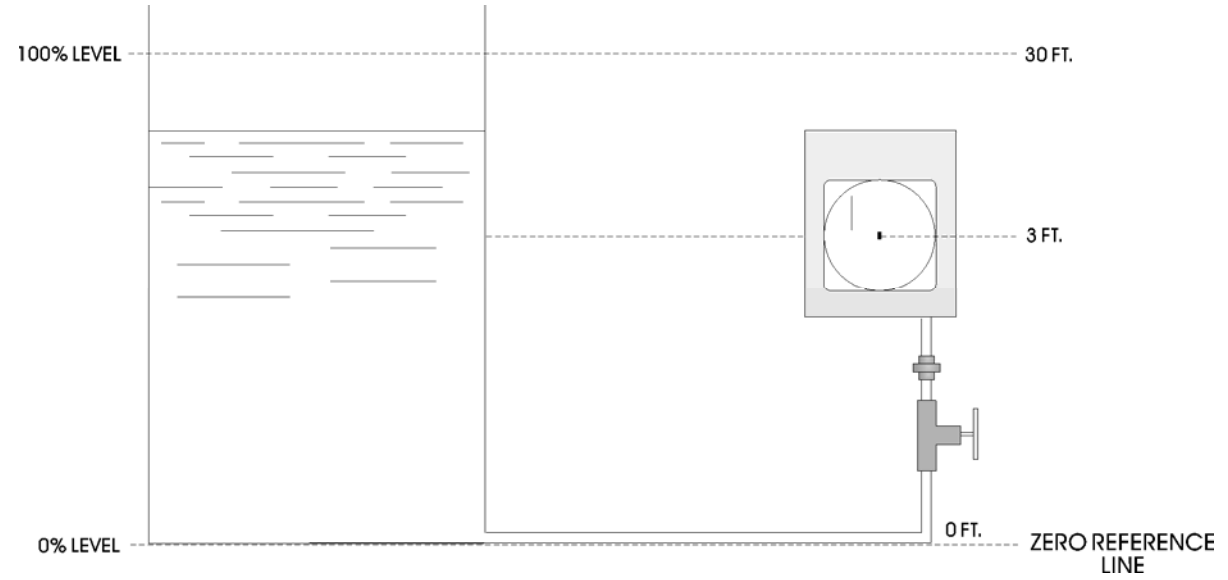


Figure 10-C - Instrument Above Zero Reference Line

I. LOW-RANGE PRESSURE MEASUREMENTS

Instruments with sensitive low-range pressure elements can be affected by changes in barometric pressure and room pressure. In general, these instruments should not be installed in rooms having exhaust or intake fans. Installations near air conditioners, forced air heater ducts, oscillating fans and breezy windows should also be avoided. Opening and closing the door of a tight room can also cause a momentary variation in the reading.

J. MEASUREMENT AT TEMPERATURE EXTREMES

When the temperature of the measured medium is above or below instrument specifications, modifications of the system will be required. A failure to do so may result in inaccurate readings or, in extreme cases, damage to the measuring system and the instrument. Observe the following suggestions before installing instruments in these environments.

High Temperature Extremes

The high temperature limits of an instrument are usually exceeded when the measured medium is steam or hot vapors. The techniques for correcting this situation involve the use of a liquid vapor barrier or a steam seal that isolates the medium from the instrument. More information on this application is given under topic F.

Low Temperature Extremes

Instruments mounted outdoors or in unheated areas may be subject to freezing conditions. To maintain proper operation, both the instrument and the pressure line must be protected from freezing. In moderately cold climates where evening temperatures fall below freezing for short periods, the case can be protected by installing it in an insulated enclosure. Sufficient protection can be achieved for the line by wrapping it with insulation. This method will provide reasonable protection from night time freezing provided that daytime temperatures average 45 °F or higher.

Areas subject to prolonged freezing will require a weatherproof enclosure having an electrical heater-thermostat arrangement. This heater will maintain the interior of the housing within the specified operating range of the instrument. The use of electrical wrap-around heater tape for the pressure line will also be required to keep the line from freezing. The heater tape should also be equipped with a thermostatic control to regulate the temperature.

K. OVERRANGE & UNDERRANGE PROTECTION

The pressure measuring systems used in our instruments are designed to handle a certain amount of pressure overload without damage. However, extreme overpressure or underpressure can permanently warp or damage this system. If you anticipate that over or under-ranging will occur, the use of relief valves are recommended to limit pressure excursions in one or both directions. These valves, which are adjustable, are installed in the pressure line at the input of the instrument.

L. ELEMENT CONSTRUCTION & ACCURACY

The accuracy of our pressure instruments is related to the construction material of the pressure element. Instruments with pressure elements made of Ni-Span C and 316 Stainless Steel are factory-calibrated to an accuracy of ±0.5% of span. Those instruments with pressure elements made of Monel-C tube (per NACE specification MR-01-75) are factory-calibrated to an accuracy of ±1.0% of span. The range and material of the element furnished for your application will be as specified in the sales order.

WARNING

The user should be certain that the pressure element range and material are suitable for the intended measurement application before placing the instrument in operation. A failure to check the element application could result in damage to equipment and property, and possible injury to persons. If the application is in question, the user is urged to contact Bristol, Inc. for additional information.

Appendix TA
TEMPERATURE MEASURING SYSTEM

- Contents -

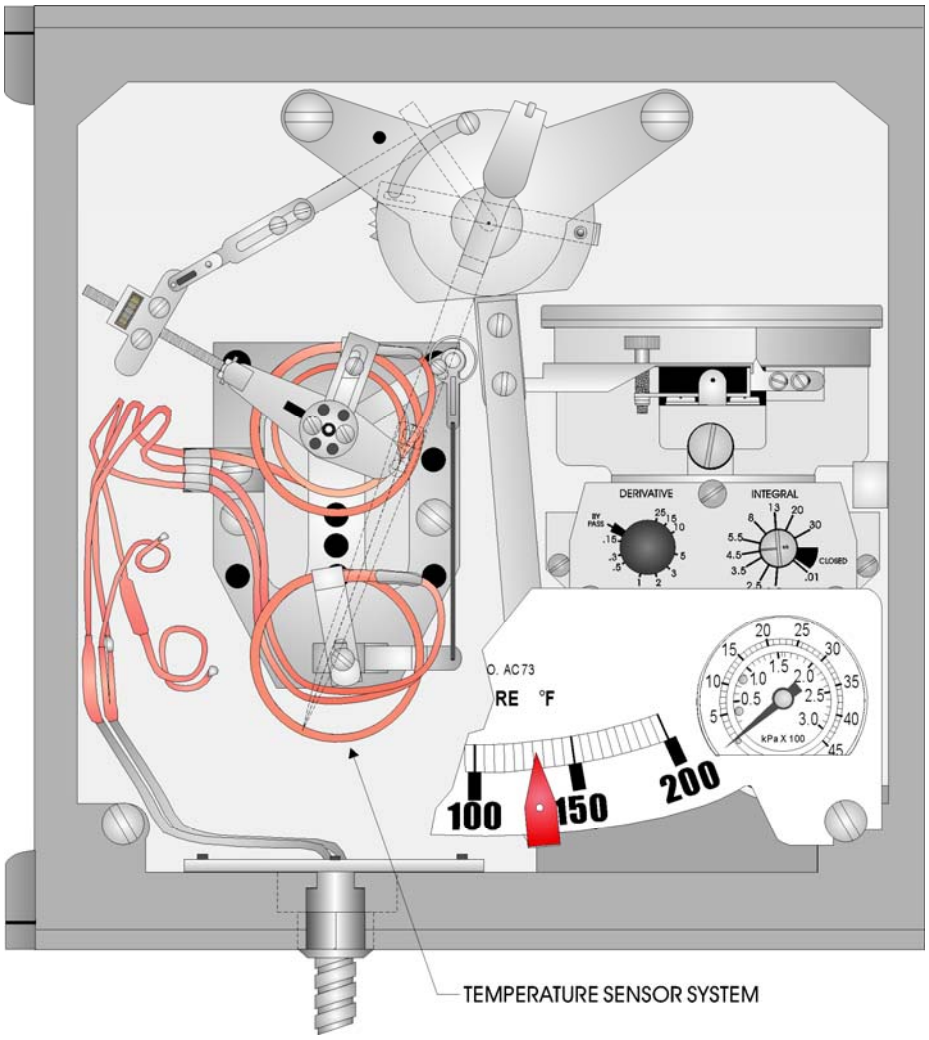


Figure TA-1 - Temperature Controller (Model 545340F-A11-601-G10)

A. DESCRIPTION

The temperature measuring systems consists of a bulb sensor connected by flexible capillary tubing to a helical pressure element in the instrument. The system is factory-filled and charged under pressure with a medium that reacts to temperature changes. Temperature variations sensed at the bulb cause the medium to expand or contract which, in turn, causes the pressure element to wind up or uncoil. The rotary motion of the pressure element is transmitted through a four-bar linkage arrangement to a pointer or pen mechanism that provides the instrument readout.

We provide four classes of filled temperature systems which are identified by the following codes:

Class 1	Liquid Filled System, Case-Mounted Bulb
Class 1A	Liquid Filled System, Fully Compensated
Class 1B	Liquid Filled System, Case Compensated
Class 3B	Gas Filled System, Case Compensated

The class code for your instrument appears on the data plate and the sales order.

B. INSTALLING CAPILLARY TUBING

Carefully straighten out the tubing so that it is free of twists or kinks. Determine the best possible run between the instrument and the bulb. Avoid all sharp bends as the tubing may become sufficiently restricted to interfere with the internal bulb pressure and cause erroneous readings.

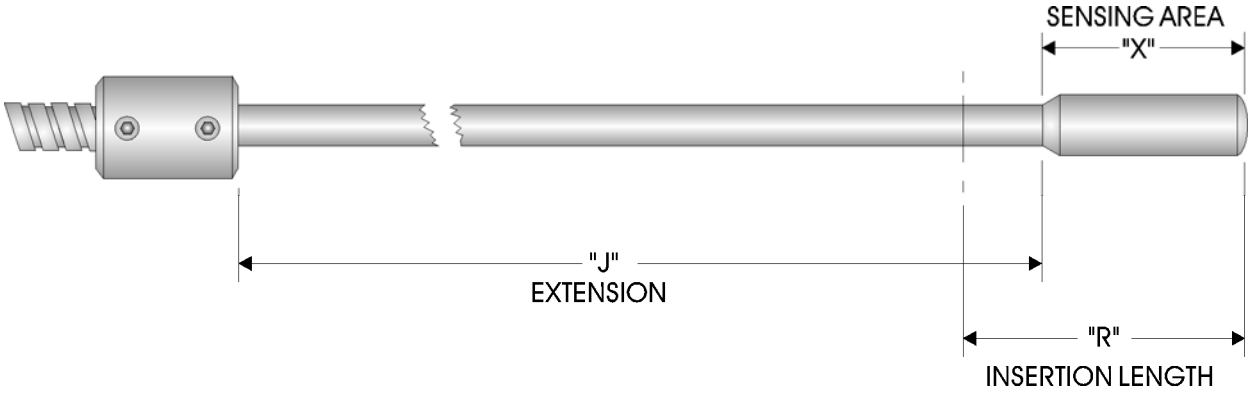


Figure TA-2 - Plain Bulb Mounting

The tubing must be protected from the effects of crushing, abrasions, mechanical strain, or excessive vibration. It is recommended that the tubing be secured along its run using tape, standoffs or staples. Do not secure tubing to hot or cold water pipes, or run it through or along heating or air conditioning ducts or near drafty windows. Strong sunlight beating on the tubing can also influence the accuracy of instrument readings.

The tubing is supplied in standard lengths. Do not attempt to cut off any excess as the fill system will be destroyed. Any excess tubing should be coiled in 12-inch loops near the instrument and secured with tape.

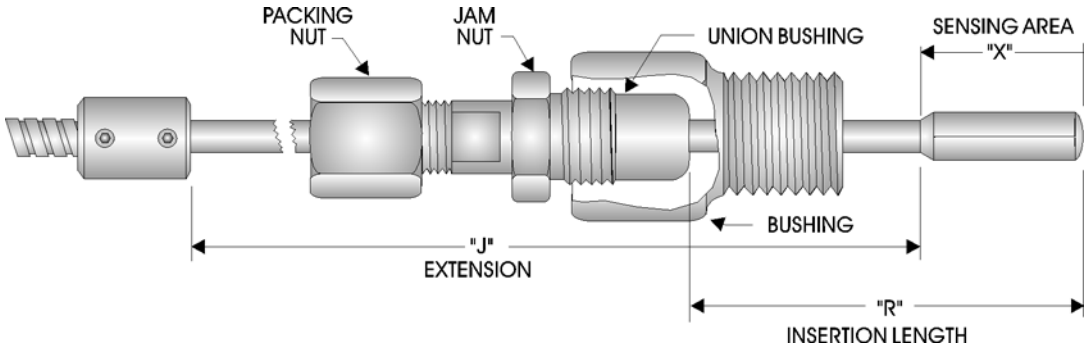


Figure TA-3 - Union Bulb Mounting

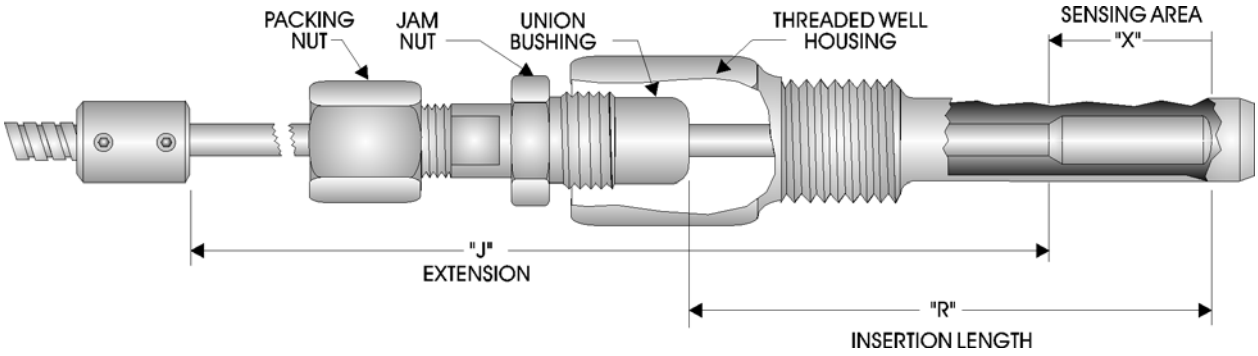


Figure TA-4 - Well Bulb Mounting

Tubing with plastic covering should not be exposed to temperatures above 160 □F (71 □C) as the material will melt.

Armored tubing should not come in contact with caustic or hazardous substances that can react with or corrode metals. Continued contact with such substances could result in permanent damage to the measuring system and disrupt or damage an associated controlled process. Plan runs with armored tubing away from potential sites of splashing, flooding or leaking, of either water or chemicals.

C. BULB MOUNTINGS

Three basic mounting arrangements are furnished for sensing bulbs: plain, union, and well. Combinations of plain/well and union/well are also obtainable.

Before installing any type, you should check the process medium to make sure it is not a type that will attack the bulb material. A failure to do this can result in permanent damage to the bulb and measuring system.

WARNING

All warranties for the instrument and accessories furnished by Bristol Babcock are void if the measured substance reacts with or attacks bulb materials. Check your materials and applications before installing the bulb.

The basic bulb mountings are illustrated in Figures TA-2, 3 and 4. Each of these illustrations identifies a sensing area (bulb), extension area, and a recommended insertion length. The standard calibration for bulbs shipped from the factory is such that the sensitive portion (X) plus three inches equals the total insertion length (R). If the insertion length (R) is too long or short, slight error readings may be experienced. Be sure that the bulb is secured at the correct insertion length to prevent movement.

For those installations where it is not possible to achieve the ideal factory immersion length it is recommended that the required offset be calibrated into the instrument. Refer to the section of this manual that describes zero and span calibration of the four bar linkage associated with the measured variable (MV). In situations where the level of a liquid-type process frequently moves up and down along the insertion length, calibration should be adjusted for the average immersion level. If the liquid falls below the insertion level, the bulb should be moved to a better location or the application should be reconsidered.

Plain Bulb Mounting

The plain bulb mounting of Figure TA-2 is intended for applications where the bulb is in direct contact with the process medium. This type may be installed using a pipe flange and set-screw arrangement, or by using a suitable clamping device. The bulb may also be suspended above the process using a wire or chain but this approach is not recommended for turbulent processes since bulb movement can influence accuracy of temperature readings. Plain bulb applications are shown in Figures TA-5, 6 and 7.

Union Bulb Mounting

Union type bulbs, Figure TA-3, are intended for process fixtures having a threaded mounting hole. This arrangement provides firm support of the bulb at a designated measurement location and places it in direct contact with process medium.

Union bulb assemblies contain a union bushing, jam nut and packing nut for mounting. The union is assembled during factory-construction of the thermal system and cannot be removed after assembly.

To install this type, the jam and packing nuts must first be loosened. The bulb is then inserted into the threaded opening of the process fixture and the union bushing is tightened to provide a good seal. (Note that overtightening can damage the bushing.) The packing nut may now be tightened moderately to prevent any leaks. The packing nut position is secured by tightening the jam nut. Union bulb applications are shown in Figures TA-8, 9, 10 and 11.

Well Bulb Mounting

The well bulb mounting assembly is used to isolate the sensor from the process. This assembly, which is essentially a union bulb with a well, includes a threaded housing, jam nut, packing nut and sensing bulb as shown in Figure TA-4. The bulb assembly may be conveniently detached from the well for maintenance operations without disrupting the process. Well assemblies are also usable with plain bulbs.

Installation is started by loosening the packing nut and jam nut and unscrewing the housing from the bulb. The threaded housing is then screwed into the opening of the process fixture and tightened sufficiently to prevent leaks (overtightening can damage the housing). The bulb is now inserted into the housing and the union bushing is tightened to provide a good seal (overtightening can damage the bushing and/or housing). The packing nut is tightened moderately to obtain a good air seal. The position of the packing nut is maintained by moderately tightening the jam nut. Well bulb applications are shown in Figures TA-12 and 13.

The dead air space inside a well bulb acts as a thermal barrier. As such, it can cause a loss in response time as high as 30:1. To minimize this effect, the bulb should be seated firmly in the well housing and the packing nut should be secured to minimize air leakage. In some instances, a significant increase in response time can be achieved by filling the well with a liquid such as water, oil, glycerin, or other types of liquid approved for this application. The type required will vary with the bulb material and the measurement application. Consult us if you need help in this area.

Bendable Extensions

The extension area (J) identified in Figures TA-2, 3 and 4 is furnished in standard 10 or 30 inch lengths. This extension can be bent to clear pulleys, levers, stirring paddles, etc. to suit the installation. Minimum radius of the bend must not exceed 1 inch. It is recommended that the bend can be carefully around a pipe of proper radius to avoid flattening the extension. Do not repeatedly bend or overbend any part of the extension as it may break. Keep bending at a minimum.

D. MEASUREMENT APPLICATIONS

Various ranges and types of temperature bulbs may be specified for the instrument. This topic describes a few of the applications in which bulbs may be used. You may find this material helpful when setting up the instrument for your application.

Air Temperature Chambers

Prior to mounting a bulb in a heating or refrigerating chamber, consideration must be given to the interior shape of the enclosure. This is a necessary step because the temperature distribution may vary widely from point to point. To achieve best overall temperature measurements, it is recommended that the bulb be tried in several areas of the chamber before a permanent mounting is decided upon. As a general rule, the bulb should not come in direct contact with any heating or cooling elements, nor should it be mounted at the uppermost or lowermost portions of the chamber where thermal stratification can occur.

Pressurized Liquids or Gas

The turbulence of liquids or gas around the bulb should be as high as possible to obtain the best average temperature measurement. Locations near pipe elbows or dead ended tees, or similar locations that interfere with free flow, or those locations where stagnation occurs should be avoided. Typically, the best measurements will be obtained when the bulb is mounted perpendicular to the flow.

Liquid Vats

The bulb should never be located at the bottom of a liquid vat-type process, especially where sludge is a problem. Sludge, when present, impedes the transfer of thermal changes to the bulb and results in slow response of measurements. Choose a location where best circulation of the medium is achieved (i.e. near a mixing device such as a paddle) so that the average temperature is more evenly represented.

Electroplating Tanks

A bulb used to measure the temperature of an electroplating tank requires special consideration. It is imperative that no part of the instrument or the bulb come in contact with the process tank or the process electrodes since electrolysis can occur and result in damage to the measuring system and instrument. The sensing bulb must not be installed between anode and cathode conductors as this location interferes with the process plating. As a general rule, the bulb should be mounted on a nonconducting support between the anode element and the tank wall.

Ambient Outdoor Temperatures

Bulbs used to measure outdoor temperatures should be installed in the shade, at least 10 feet above ground where good air circulation is achieved. If a bulb is installed near a wall, a minimum separation distance of at least three feet should be observed. For roof-top instal-lations, the bulb should be mounted on an 8-foot pole (minimum), away from exhaust vents, chimneys, skylights, arc lamps, and heat generating machinery or surfaces.

E. OVERRANGE AND UNDERRANGE PROTECTION

As the measured temperature varies, its value will be indicated by a pointer or pen. A considerable amount of force can be generated by the measuring system if the sensor is allowed to measure a temperature that goes above the maximum range or below minimum range of the instrument. These conditions, referred to as overranging or underranging, will cause the pointer or pen to be driven off scale. Although the instrument can handle minor overranging or underranging, excessive amounts can affect calibration or damage the internal linkage and indicating mechanism. You are advised to check your application and make sure that the measured temperatures are within safe bounds of the temperature range of the in-strument. The temperature range is listed on the data plate affixed to the instrument.

You should be aware that the temperature range specified for some models can easily be exceeded when the instrument is shipped or stored under ambient conditions where the temperature goes below or above the range of the instrument. As an example, an in-

strument with a range of +40 to +90 °F can be damaged if exposed to temperatures below 40 °F or above 90 °F. Take care to always ship or store such instruments in protective environ-ments.

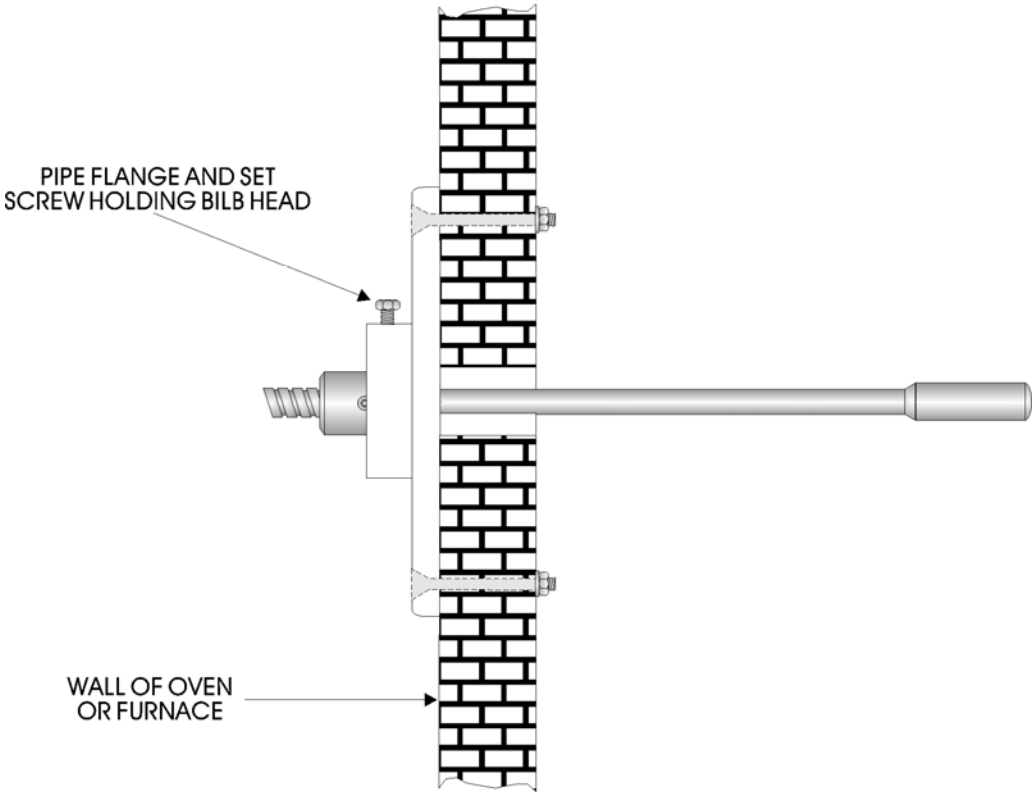


Figure TA-5 - Plain Bulb Perpendicular to Chamber Wall

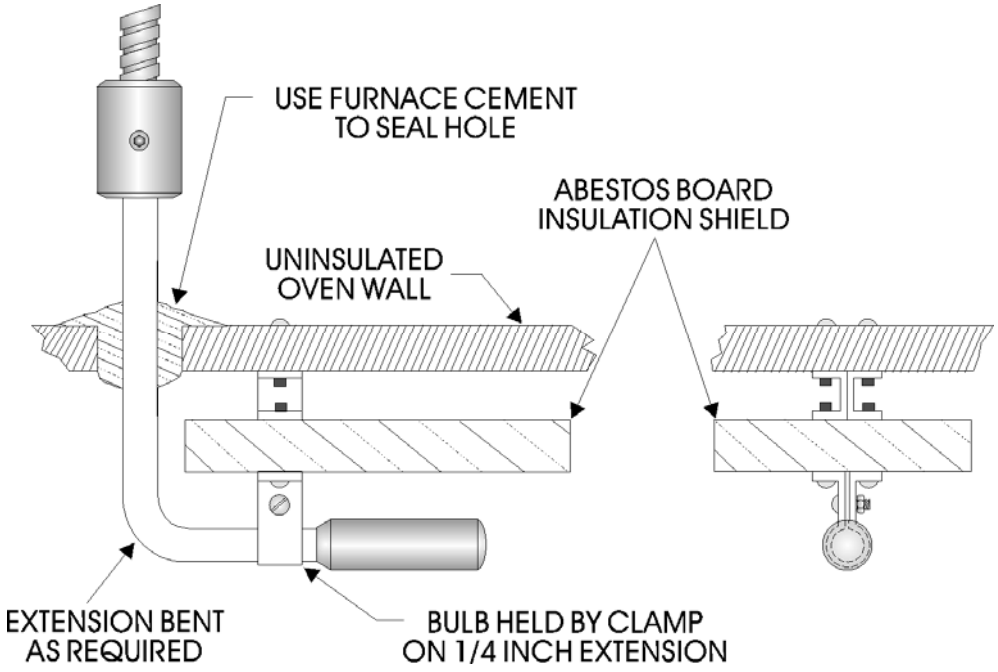


Figure TA-6 - Plain Bulb Parallel to Chamber Wall

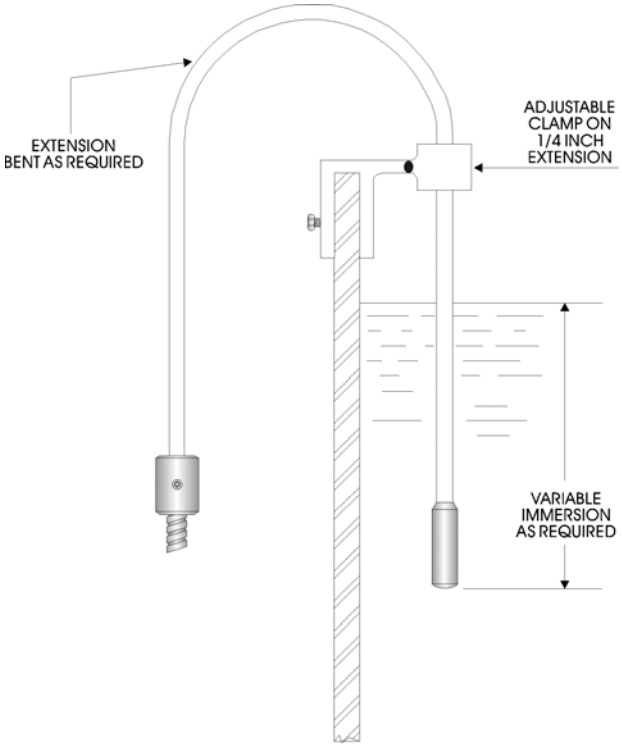


Figure TA-7 - Plain Bulb Above Liquid Tank

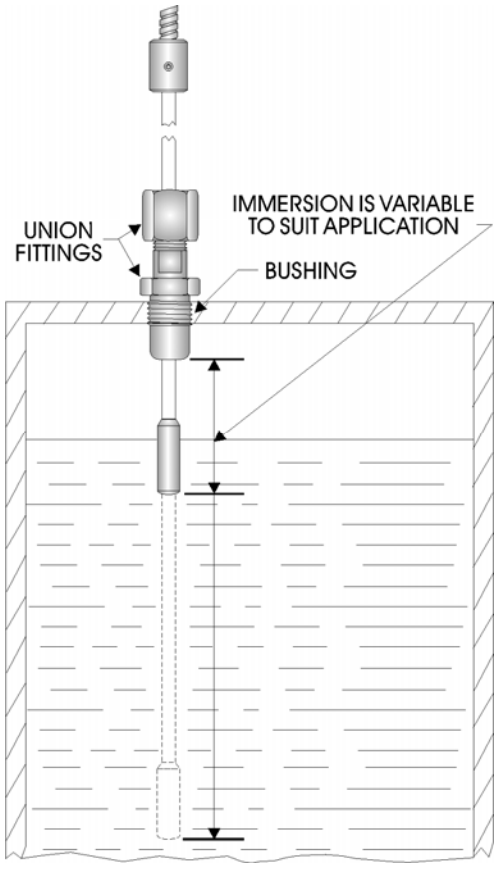


Figure TA-8 - Union Bulb above Liquid Tank

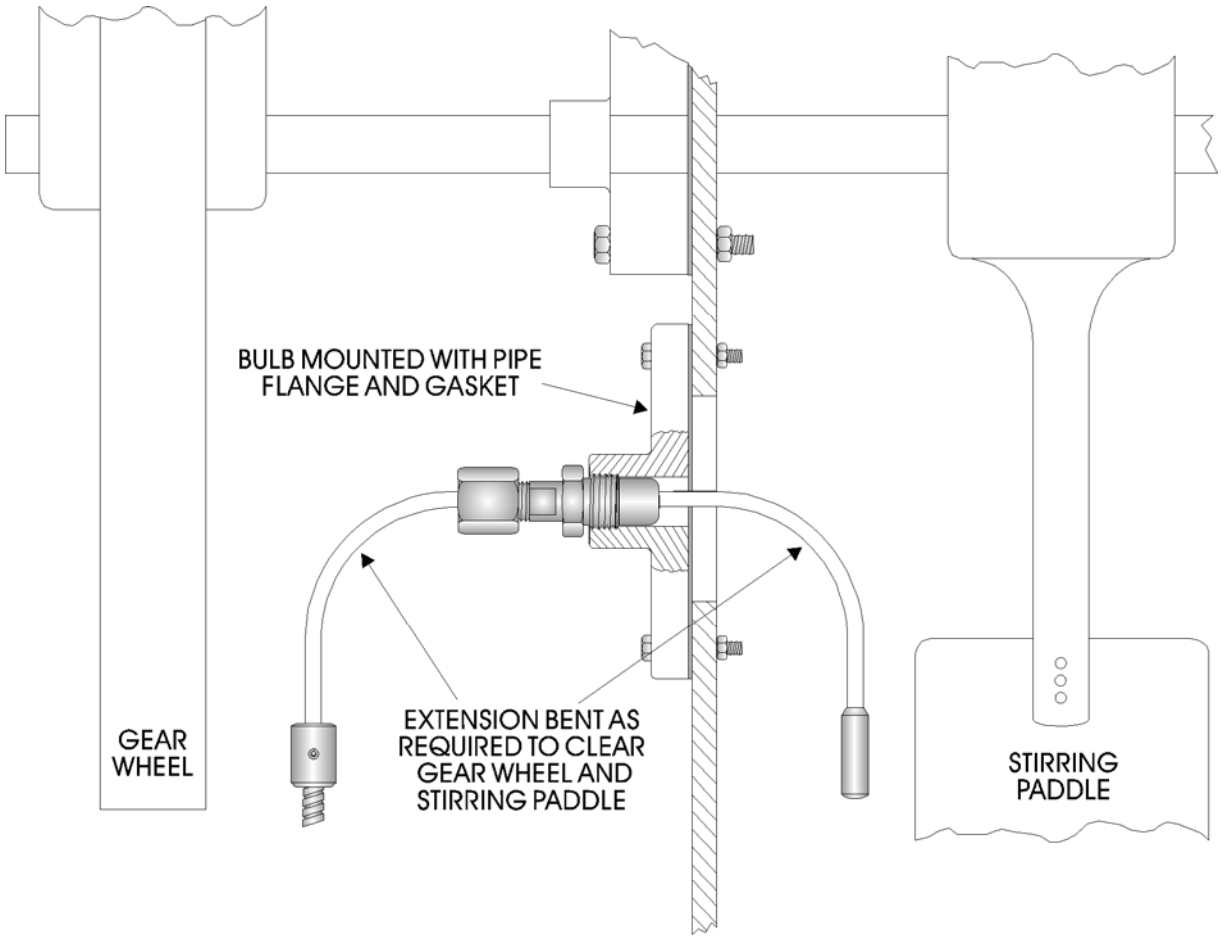


Figure TA-9 - Union Bulb Parallel to Tank Wall

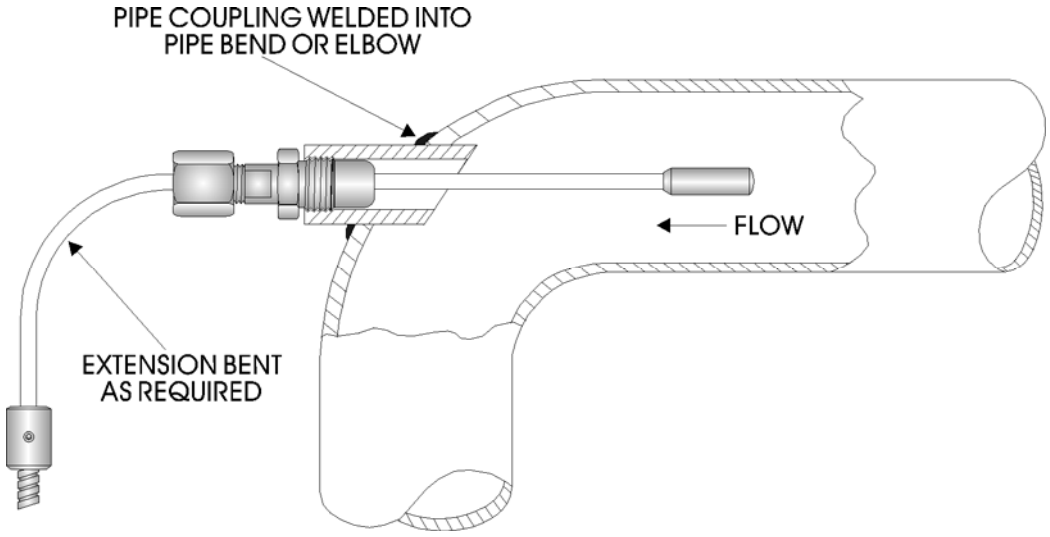


Figure TA-10 - Union Bulb in Pipe Bend (Flow Application)

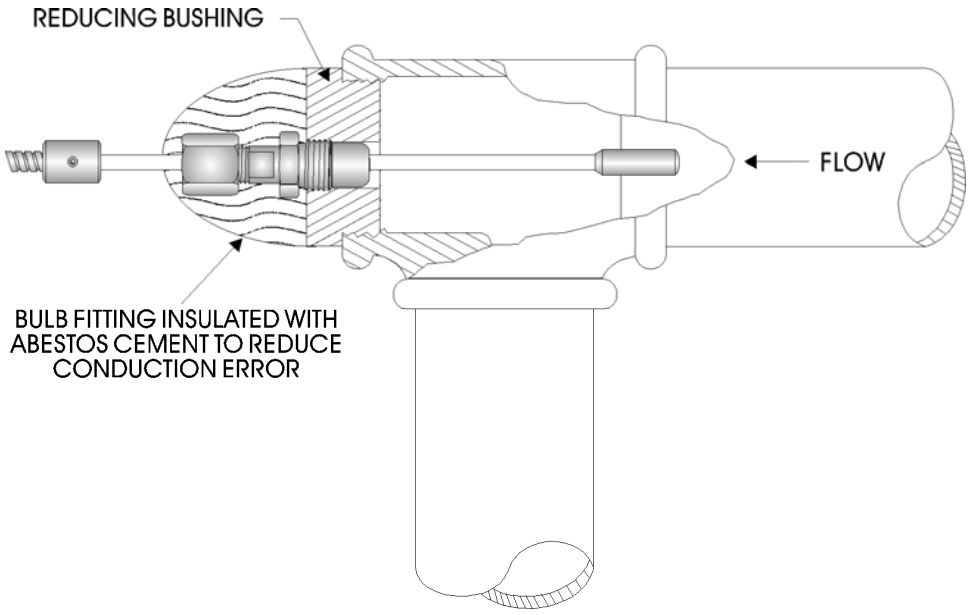


Figure TA-11 - Union Bulb In Pipe Tee (Flow Application)

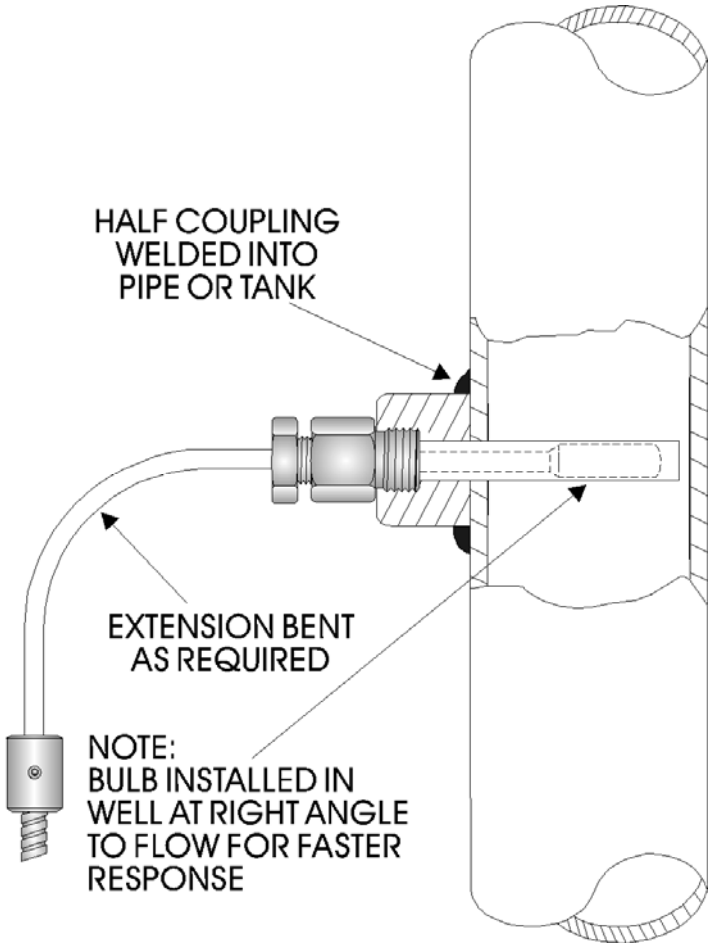


Figure TA-12 - Well Bulb In Pipe (Flow Application)

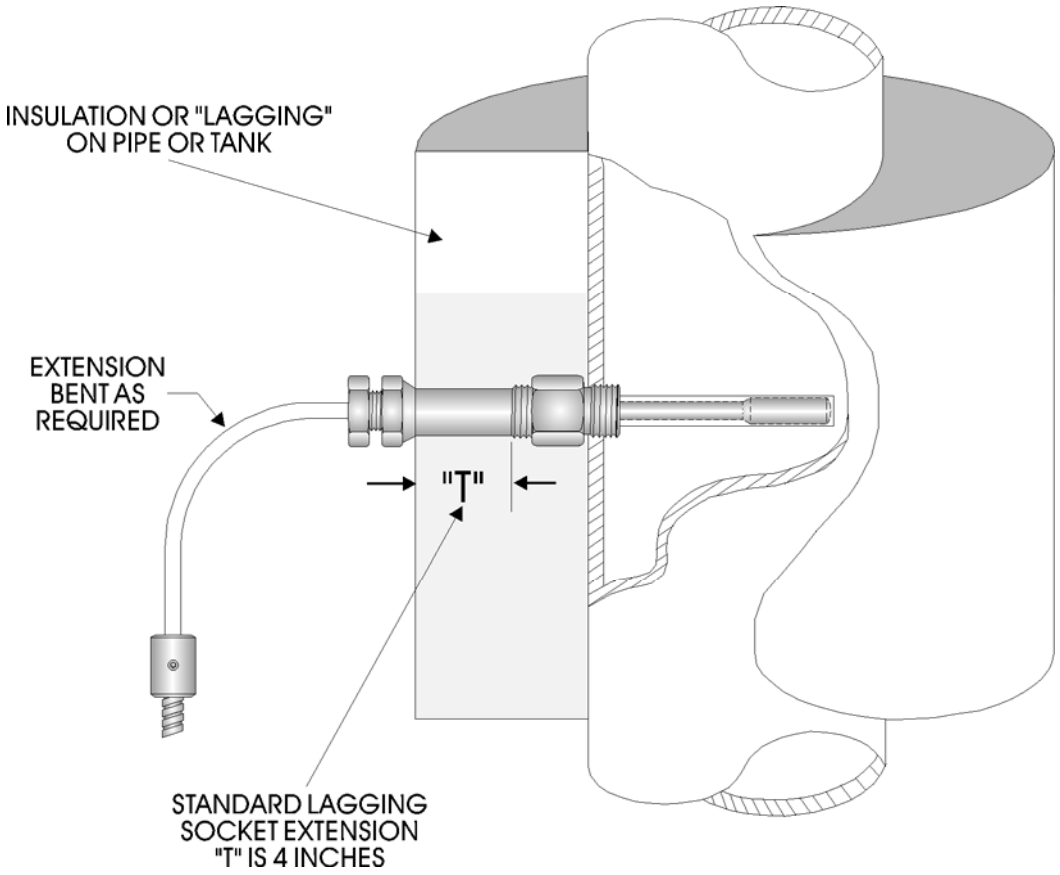


Figure TA-13 - Well Bulb with Standard Lagging Extensions Through Insulation

Material Safety Data Sheets

Material Safety Data Sheets are provided herein to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. This standard must be consulted for specific requirements.

Material Safety Data Sheets are provided in the order listed in Table Z-1 below.

TABLE Z-1 – MSDS

For

Series 5450 Pneumatic Indicating Instruments - CI-5450

Manufacturer	General Description	Bristol Part Number or Media Notes
Acros Organics BVBA	Ethylbenzene, 99%	See Table Z-2
AIRGAS, Inc.	Nitrogen	See Table Z-2
Mallinckrodt Baker, Inc.	Tetrahyronaphthalene AKA: Tetralin	See Table Z-2

TABLE Z-2 – Filled Thermal Systems

Fill Code	MSDS Required	Misc. Notes
B	Ethylbenzene (C_8H_{10})	Class 1A Filled Systems: See Eng. Instruction 900017-39-2 Class 1B Filled Systems: See Eng. Instruction 900017-38-4
N	Nitrogen (N) , or (N_2)	Class 3B Filled Systems: See Eng. Instruction 900017-41-4
O	1,2,3,4-Tetrahyronaphthalene Common Synonyms: Naphthalene, 1,2,3,4-Tetrahydride, & Tetralin ($C_{10}H_{12}$)	Class 1A Filled Systems: See Eng. Instruction 900017-39-2 Class 1B Filled Systems: See Eng. Instruction 900017-38-4

Note: The Fill Code (thermal system code) for a Filled System Thermometer is stamped on the system mounting base using a metal stamp with 1/16" characters.

Material Safety Data Sheet

Ethylbenzene
MSDS# 00596

Section 1 - Chemical Product and Company Identification

MSDS Name:
Ethylbenzene
Catalog Numbers:
11808-0000, 11808-0010, 11808-0025, 11808-0250, 11808-0251, 11808-5000, E/1060/08, E/1060/17
Synonyms:
Ethylbenzol; Phenylethane.
Company Identification: Fisher Scientific UK
Bishop Meadow Road, Loughborough
Leics. LE11 5RG
For information in Europe, call:(01509) 231166
Emergency Number, Europe:01509 231166

Section 2 - Composition, Information on Ingredients

CAS#: 100-41-4
Chemical Name: Ethylbenzene
%: >99
EINECS#: 202-849-4

Hazard Symbols:
XN F
Risk Phrases:
11 20

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Highly flammable. Harmful by inhalation.
Potential Health Effects
Eye:
Causes eye irritation. Vapors may cause eye irritation.
Skin:
Causes skin irritation. Prolonged and/or repeated contact may cause irritation and/or dermatitis. May be absorbed through the skin.
Ingestion:
May cause irritation of the digestive tract. May cause gastrointestinal irritation with nausea, vomiting and diarrhea. May cause central nervous system depression, characterized by excitement, followed by headache, dizziness, drowsiness, and nausea. Advanced stages may cause collapse, unconsciousness, coma and possible death due to respiratory failure. Aspiration of material into the lungs may cause chemical pneumonitis, which may be fatal.
Inhalation:
Inhalation of high concentrations may cause central nervous system effects characterized by nausea, headache, dizziness, unconsciousness and coma. Causes respiratory tract irritation. Vapors may cause dizziness or suffocation.
Chronic:
Chronic inhalation may cause effects similar to those of acute inhalation.

Section 4 - First Aid Measures

Eyes:
Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid immediately.
Skin:
Get medical aid. Flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse.
Ingestion:
Do not induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Never give anything by mouth to an unconscious person. Get medical aid immediately.
Inhalation:
Remove from exposure and move to fresh air immediately. If not

breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

Notes to Physician:

Section 5 - Fire Fighting Measures

General Information:

As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Use water spray to keep fire-exposed containers cool. Flammable liquid and vapor. Vapors are heavier than air and may travel to a source of ignition and flash back. Vapors can spread along the ground and collect in low or confined areas. This liquid floats on water and may travel to a source of ignition and spread fire. May accumulate static electricity.

Extinguishing Media:

Use water spray, dry chemical, carbon dioxide, or appropriate foam.

Section 6 - Accidental Release Measures

General Information:

Use proper personal protective equipment as indicated in Section 8.

Spills/Leaks:

Absorb spill with inert material (e.g. vermiculite, sand or earth), then place in suitable container. Remove all sources of ignition. Provide ventilation. Control runoff and isolate discharged material for proper disposal. Use water spray to cool and disperse vapors and protect personnel.

Section 7 - Handling and Storage

Handling:

Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Use with adequate ventilation. Ground and bond containers when transferring material. Avoid contact with eyes, skin, and clothing. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Keep container tightly closed. Keep away from heat, sparks and flame. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose empty containers to heat, sparks or open flames. Avoid breathing vapor or mist.

Storage:

Keep away from sources of ignition. Store in a tightly closed container. Keep from contact with oxidizing materials. Store in a cool, dry, well-ventilated area away from incompatible substances.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls:

Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits.

Exposure Limits
CAS# 100-41-4:
United Kingdom, WEL - TWA: 100 ppm TWA; 441 mg/m3 TWA
United Kingdom, WEL - STEL: 125 ppm STEL; 552 mg/m3 STEL
United States OSHA: 100 ppm TWA; 435 mg/m3 TWA
Belgium - TWA: 100 ppm VLE; 442 mg/m3 VLE
Belgium - STEL: 125 ppm VLE; 551 mg/m3 VLE
France - VME: 100 ppm VME; 442 mg/m3 VME
France - VLE: 200 ppm VLE; 884 mg/m3 VLE
Germany: 100 ppm TWA (exposure category 1); 440 mg/m3 TWA (exposure category 1)
Germany: skin notation
Japan: 50 ppm OEL; 217 mg/m3 OEL
Malaysia: 100 ppm TWA; 434 mg/m3 TWA
Netherlands: 50 ppm MAC; 215 mg/m3 MAC
Russia: 50 mg/m3 TWA (vapor)
Spain: 100 ppm VLA-ED; 441 mg/m3 VLA-ED
Spain: 200 ppm VLA-EC; 884 mg/m3 VLA-EC

Personal Protective Equipment

Eyes:

Wear chemical splash goggles.

Skin:

Wear appropriate protective gloves to prevent skin exposure.

Clothing:

Wear appropriate protective clothing to prevent skin exposure.

Respirators:

Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Section 9 - Physical and Chemical Properties

Physical State:	Liquid
Color:	clear, colorless
Odor:	aromatic odor
pH:	Not available
Vapor Pressure:	9.6 mm Hg @ 25 deg C
Viscosity:	0.63 mPa s 20 C
Boiling Point:	136 deg C (276.80_F)
Freezing/Melting Point:	-95 deg C (-139.00_F)
Autoignition Temperature: 4	32 deg C (809.60 deg F)
Flash Point:	15 deg C (59.00 deg F)
Explosion Limits:	Lower:1.2%
Explosion Limits:	Upper:6.8%
Decomposition Temperature:	Not available
Solubility in water:	Insoluble
Specific Gravity/Density:	0.86
Molecular Formula:	C8H10
Molecular Weight:	106.17

Section 10 - Stability and Reactivity

Chemical Stability:
Stable under normal temperatures and pressures.
Conditions to Avoid:
Ignition sources, excess heat.
Incompatibilities with Other Materials
Strong oxidizing agents.
Hazardous Decomposition Products
Carbon monoxide, carbon dioxide.
Hazardous Polymerization
Has not been reported.

Section 11 - Toxicological Information

RTECS#:
CAS# 100-41-4: DA0700000
LD50/LC50:
RTECS: CAS# 100-41-4: Draize test, rabbit, eye: 500 mg Severe; Inhalation, mouse: LC50 = 35500 mg/m3/2H; Inhalation, rat: LC50 = 55000 mg/m3/2H; Oral, rat: LD50 = 3500 mg/kg; Oral, rat: LD50 = 3500 mg/kg; Skin, rabbit: LD50 = 17800 uL/kg;.
Other: Inhalation rat LC50: 17.2 mg/l/4H from BASF.
Carcinogenicity:
Ethylbenzene -
ACGIH: A3 - Confirmed animal carcinogen with unknown relevance to humans
California: carcinogen, initial date 6/11/04
IARC: Group 2B carcinogen
Other:
See actual entry in RTECS for complete information.

Section 12 - Ecological Information

Ecotoxicity:
Fish: Rainbow trout: LC50 = 14.0 mg/L; 96 Hr.; Static BioassayFish: Fathead Minnow: LC50 = 12.1 mg/L; 96 Hr.; Flow-through BioassayFish: Bluegill/Sunfish: LC50 = 150.0 mg/L; 96 Hr.; Static Bioassay, pH 6.5-7.9, 21-23 degrees CWater flea EC50 = 2.1 mg/L; 48 Hr.; Static BioassayWater flea EC50 = 75.0 mg/L; 48 Hr.; Static Bioassay

Section 13 - Disposal Considerations

Dispose of in a manner consistent with federal, state, and local regulations.

Section 14 - Transport Information

IATA

Shipping Name:	ETHYLBENZENE
Hazard Class:	3
UN Number:	1175
Packing Group:	II

IMO

Shipping Name:	ETHYLBENZENE
Hazard Class:	3.2
UN Number:	1175
Packing Group:	II

RID/ADR

Shipping Name:	ETHYLBENZENE

Hazard Class: 3
UN Number: 1175
Packing Group: II
USA RQ: CAS# 100-41-4: 1000 lb final RQ; 454 kg final RQ

Section 15 - Regulatory Information

European/International Regulations
European Labeling in Accordance with EC Directives
Hazard Symbols: XN F
Risk Phrases:
R 11 Highly flammable.
R 20 Harmful by inhalation.
Safety Phrases:
S 16 Keep away from sources of ignition - No smoking.
S 24/25 Avoid contact with skin and eyes.
S 29 Do not empty into drains.
WGK (Water Danger/Protection)
CAS# 100-41-4: 1
Canada
CAS# 100-41-4 is listed on Canada's DSL List
US Federal
TSCA
CAS# 100-41-4 is listed on the TSCA Inventory.

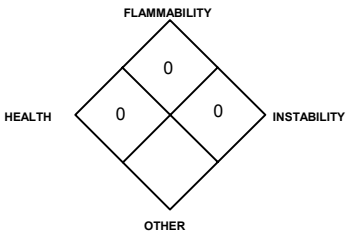
Section 16 - Other Information

MSDS Creation Date:
4/28/1999
Revision #5 Date
2/13/2006
Revisions were made in Sections:
3, 5, 6, 7, 8, 9, 10, 11, 14,
The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantibility or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall the company be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential, or exemplary damages howsoever arising, even if the company has been advised of the possibility of such damages.

Airgas

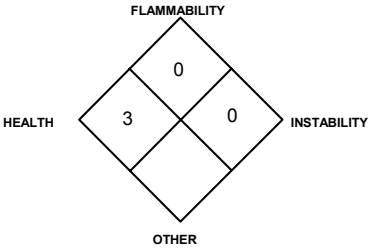
NITROGEN GAS

NFPA RATING



LIQUID NITROGEN

NFPA RATING



MATERIAL SAFETY DATA SHEET

Prepared to U.S. OSHA, CMA, ANSI and Canadian WHMIS Standards

PART I *What is the material and what do I need to know in an emergency?*

1. PRODUCT IDENTIFICATION

CHEMICAL NAME; CLASS:	**NITROGEN - N_2** **LIQUEFIED NITROGEN N_2, (Cryogenic)** Document Number: 001040
PRODUCT USE:	For General Analytical/Synthetic Chemical Uses
SUPPLIER/MANUFACTURER'S NAME:	AIRGAS INC.
ADDRESS:	259 North Radnor-Chester Road Suite 100 Radnor, PA 19087-5283
BUSINESS PHONE:	1-610-687-5253
EMERGENCY PHONE:	1-800-949-7937 International: 423-479-0293
DATE OF PREPARATION:	May 12, 1996
REVISION DATE :	December 8, 2003

2. COMPOSITION and INFORMATION ON INGREDIENTS

CHEMICAL NAME	CAS #	mole %	EXPOSURE LIMITS IN AIR					
			ACGIH-TLV		OSHA-PEL		NIOSH	OTHER
			TWA ppm	STEL ppm	TWA ppm	STEL ppm	IDLH ppm	ppm
Nitrogen	7727-37-9	>99 %	There are no specific exposure limits for Nitrogen. Nitrogen is a simple asphyxiant (SA). Oxygen levels should be maintained above 19.5%.					
Maximum Impurities		<1%	None of the trace impurities in this mixture contribute significantly to the hazards associated with the product. All hazard information pertinent to this product has been provided in this Material Safety Data Sheet, per the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200) and State equivalents standards.					

NE = Not Established. See Section 16 for Definitions of Terms Used.

NOTE (1): ALL WHMIS required information is included in appropriate sections based on the ANSI Z400.1-1998 format. This gas has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.

3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW: Nitrogen is a colorless, odorless, non-flammable gas, or a colorless, odorless, cryogenic liquid. The main health hazard associated with releases of this gas is asphyxiation, by displacement of oxygen. The cryogenic liquid will rapidly boil to the gas at standard temperatures and pressures. The liquefied gas can cause frostbite to any contaminated tissue.

NITROGEN GAS

HAZARDOUS MATERIAL IDENTIFICATION SYSTEM

HEALTH HAZARD	(BLUE)	0
FLAMMABILITY HAZARD	(RED)	0
PHYSICAL HAZARD	(YELLOW)	0

PROTECTIVE EQUIPMENT

EYES	RESPIRATORY	HANDS	BODY
	See Section 8		See Section 8

For Routine Industrial Use and Handling Applications

LIQUID NITROGEN

HAZARDOUS MATERIAL IDENTIFICATION SYSTEM

HEALTH HAZARD	(BLUE)	3
FLAMMABILITY HAZARD	(RED)	0
PHYSICAL HAZARD	(YELLOW)	0

PROTECTIVE EQUIPMENT

EYES	RESPIRATORY	HANDS	BODY
	See Section 8		See Section 8

For Routine Industrial Use and Handling Applications

See Section 16 for Definition of Ratings

SYMPTOMS OF OVEREXPOSURE BY ROUTE OF EXPOSURE: The most significant route of overexposure for this gas is by inhalation. The following paragraphs describe symptoms of exposure by route of exposure.

INHALATION: High concentrations of this gas can cause an oxygen-deficient environment. Individuals breathing such an atmosphere may experience symptoms which include headaches, ringing in ears, dizziness, drowsiness, unconsciousness, nausea, vomiting, and depression of all the senses. The skin of a victim may have a blue color. Under some circumstances, death may occur. The effects associated with various levels of oxygen are as follows:

CONCENTRATION	**SYMPTOMS OF EXPOSURE**
12-16% Oxygen:	Breathing and pulse rate increased, muscular coordination slightly disturbed.
10-14% Oxygen:	Emotional upset, abnormal fatigue, disturbed respiration.
6-10% Oxygen:	Nausea and vomiting, collapse or loss of consciousness.
Below 6%:	Convulsive movements, possible respiratory collapse, and death.

OTHER POTENTIAL HEALTH EFFECTS: Contact with cryogenic liquid or rapidly expanding gases (which are released under high pressure) may cause frostbite. Symptoms of frostbite include change in skin color to white or grayish-yellow. The pain after contact with liquid can quickly subside.

HEALTH EFFECTS OR RISKS FROM EXPOSURE: An Explanation in **Lay Terms**. Overexposure to Nitrogen may cause the following health effects:

ACUTE: The most significant hazard associated with this gas is inhalation of oxygen-deficient atmospheres. Symptoms of oxygen deficiency include respiratory difficulty, headache, dizziness and nausea. At high concentrations, unconsciousness or death may occur. Contact with cryogenic liquid or rapidly expanding gases may cause frostbite.

CHRONIC: Chronic exposure to oxygen-deficient atmospheres (below 18% oxygen in air) may affect the heart and nervous system.

TARGET ORGANS: ACUTE: Respiratory system. CHRONIC: Cardiac system, central nervous system.

PART II *What should I do if a hazardous situation occurs?*

4. FIRST-AID MEASURES

RESCUERS SHOULD NOT ATTEMPT TO RETRIEVE VICTIMS OF EXPOSURE TO NITROGEN WITHOUT ADEQUATE PERSONAL PROTECTIVE EQUIPMENT. At a minimum, Self-Contained Breathing Apparatus and protective clothing should be worn. Remove victim(s) to fresh air, as quickly as possible. Trained personnel should administer supplemental oxygen and/or cardio-pulmonary resuscitation, if necessary. Only trained personnel should administer supplemental oxygen. Victim(s) must be taken for medical attention. Rescuers should be taken for medical attention, if necessary. Take copy of label and MSDS to physician or other health professional with victim(s).

In case of frostbite, place the frostbitten part in warm water. DO NOT USE HOT WATER. If warm water is not available, or is impractical to use, wrap the affected parts gently in blankets. Alternatively, if the fingers or hands are frostbitten, place the affected area of the body in the armpit. Encourage victim to gently exercise the affected part while being warmed. Seek immediate medical attention.

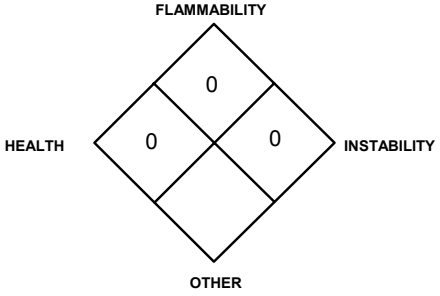
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-existing respiratory conditions may be aggravated by overexposure to Nitrogen.

RECOMMENDATIONS TO PHYSICIANS: Administer oxygen, if necessary. Treat symptoms and reduce overexposure.

5. FIRE-FIGHTING MEASURES

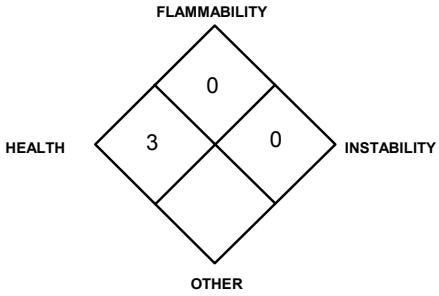
NITROGEN GAS

NFPA RATING



LIQUID NITROGEN

NFPA RATING



See Section 16 for Definition of Ratings

FLASH POINT: Not applicable.

AUTOIGNITION TEMPERATURE: Not applicable.

FLAMMABLE LIMITS (in air by volume, %):

Lower (LEL): Not applicable.

Upper (UEL): Not applicable.

FIRE EXTINGUISHING MATERIALS: Non-flammable, inert gas. Use extinguishing media appropriate for surrounding fire.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Nitrogen does not burn; however, containers, when involved in fire, may rupture or burst in the heat of the fire.

RESPONSE TO FIRE INVOLVING CRYOGEN: Cryogenic liquids can be particularly dangerous during fires because of their potential to rapidly freeze water. Careless use of water may cause heavy icing. Furthermore, the relatively warm water greatly increases the evaporation rate of Nitrogen. If large concentrations of Nitrogen gas are present, the water vapor in the surrounding air will condense, creating a dense fog that may make it difficult to find fire exits or equipment. Liquid Nitrogen, when exposed to the atmosphere, will produce a cloud of ice/fog in the air upon its release.

Explosion Sensitivity to Mechanical Impact: Not Sensitive.

Explosion Sensitivity to Static Discharge: Not Sensitive.

SPECIAL FIRE-FIGHTING PROCEDURES: Structural fire-fighters must wear Self-Contained Breathing Apparatus and full protective equipment. Move fire-exposed cylinders if it can be done without risk to firefighters. Otherwise, cool containers with hose stream and protect personnel. Withdraw immediately in case of rising sounds from venting safety device or any discoloration of tanks due to the fire.

6. ACCIDENTAL RELEASE MEASURES

SPILL AND LEAK RESPONSE: Uncontrolled releases should be responded to by trained personnel using pre-planned procedures. Proper protective equipment should be used. In case of a ***release,*** clear the affected area and protect people. Minimum Personal Protective Equipment should be **Level B: protective clothing, mechanically-resistant gloves and Self-Contained Breathing Apparatus**. Locate and seal the source of the leaking gas. Allow the gas to dissipate. Monitor the surrounding area for oxygen levels. The atmosphere must have at least 19.5 percent oxygen before personnel can be allowed in the area without Self-Contained Breathing Apparatus. Attempt to close the main source valve prior to entering the area. If this does not stop the release (or if it is not possible to reach the valve), allow the gas to release in-place or remove it to a safe area and allow the gas to be released there.

RESPONSE TO CRYOGENIC RELEASE: Clear the affected area and allow the liquid to evaporate and the gas to dissipate. After the gas is formed, follow the instructions provided in the previous paragraph. If the area must be entered by emergency personnel, SCBA, Kevlar gloves, and appropriate foot and leg protection must be worn.

PART III *How can I prevent hazardous situations from occurring?*

7. HANDLING and STORAGE

WORK PRACTICES AND HYGIENE PRACTICES: As with all chemicals, avoid getting Nitrogen IN YOU. Do not eat or drink while handling chemicals. Be aware of any signs of dizziness or fatigue; exposures to fatal concentrations of Nitrogen could occur without any significant warning symptoms, due to oxygen deficiency.

STORAGE AND HANDLING PRACTICES: Cylinders should be stored in dry, well-ventilated areas away from sources of heat. Compressed gases can present significant safety hazards. Store containers away from heavily trafficked areas and emergency exits. Post “No Smoking or Open Flames” signs in storage or use areas.

SPECIAL PRECAUTIONS FOR HANDLING GAS CYLINDERS: Protect cylinders against physical damage. Store in cool, dry, well-ventilated, fireproof area, away from flammable materials and corrosive atmospheres. Store away from heat and ignition sources and out of direct sunlight. Do not store near elevators, corridors or loading docks. Do not allow area where cylinders are stored to exceed 52°C (125°F). Isolate from incompatible materials such as magnesium (see Section 10, Stability and Reactivity for more information), which can react violently. Use only storage containers and equipment (pipes, valves, fittings to relieve pressure, etc.) designed for the storage of Liquid Nitrogen. Cylinders should be stored upright and be firmly secured to prevent falling or being knocked over. Cylinders can be stored in the open, but in such cases, should be protected against extremes of weather and from the dampness of the ground to prevent rusting. Keep Dewar flasks covered with loose fitting cap. This prevents air or moisture from entering the container, yet allows pressure to escape. Use only the stopper or plug supplied with the container. Ensure that ice does not form in the neck of flasks. If the neck of Dewar flask is blocked by ice, follow manufacturer’s instruction for removing it. Ice can also cause pressure release valves to fail. Never tamper with pressure relief devices. The following rules are applicable to situations in which cylinders are being used:

Before Use: Move cylinders with a suitable hand-truck. Do not drag, slide or roll cylinders. Do not drop cylinders or permit them to strike each other. Secure cylinders firmly. Leave the valve protection cap in-place (if provided), until cylinder is ready for use.

During Use: Use designated CGA fittings and other support equipment. Do not use adapters. Do not heat cylinder by any means to increase the discharge rate of the product from the cylinder. Use check valve or trap in discharge line to prevent hazardous backflow into the cylinder. Do not use oils or grease on gas-handling fittings or equipment.

After Use: Close main cylinder valve. Replace valve protection cap (if provided). Mark empty cylinders “EMPTY”.

NOTE: Use only DOT or ASME code containers. Close valve after each use and when empty. Cylinders must not be recharged except by or with the consent of owner. For additional information refer to the Compressed Gas Association Pamphlet P-1, *Safe Handling of Compressed Gases in Containers*. For cryogenic liquids, refer to CGA P-12, *Safe Handling of Cryogenic Liquids*. Also see CGA P-9, the Inert Gases, Argon, Nitrogen, and Helium; CGA Safety Bulletin SB-2, Oxygen Deficient Atmospheres.

PROTECTIVE PRACTICES DURING MAINTENANCE OF CONTAMINATED EQUIPMENT: Follow practices indicated in Section 6 (Accidental Release Measures). Make certain application equipment is locked and tagged-out safely. Purge gas handling equipment with inert gas (e.g., nitrogen) before attempting repairs.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION

VENTILATION AND ENGINEERING CONTROLS: Local exhaust ventilation is preferred, because it prevents Nitrogen dispersion into the work place by eliminating it at its source. If appropriate, install automatic monitoring equipment to detect the level of oxygen.

RESPIRATORY PROTECTION: Maintain concentration of component levels below those listed in Section 2 (Composition and Information on Ingredients) in the workplace. Use supplied air respiratory protection if oxygen levels are below 19.5% or during emergency response to a release of this product.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION (Continued)

RESPIRATORY PROTECTION (continued): If respiratory protection is needed, use only protection authorized in the U.S. Federal OSHA Standard (29 CFR 1910.134), applicable U.S. State regulations, or the Canadian CSA Standard Z94.4-93 and applicable standards of Canadian Provinces. Oxygen levels below 19.5% are considered IDLH by OSHA. In such atmospheres, use of a full-facepiece pressure/demand SCBA or a full facepiece, supplied air respirator with auxiliary self-contained air supply is required under OSHA's Respiratory Protection Standard (1910.134-1998).

EYE PROTECTION: Splash goggles, face-shields or safety glasses. Face-shields must be worn when handling cryogenic Nitrogen. If necessary, refer to U.S. OSHA 29 CFR 1910.133, or Canadian Standards.

HAND PROTECTION: Wear mechanically resistant-gloves when handling cylinders of Nitrogen. Use low-temperature protective gloves (e.g., Kevlar) when working with containers of Liquid Nitrogen. If necessary, refer to U.S. OSHA 29 CFR 1910.138 or appropriate Standards of Canada.

BODY PROTECTION: Use body protection appropriate for task. Transfer of large quantities under pressure may require protective equipment appropriate to protect employees from splashes of liquefied product, as well provide sufficient insulation from extreme cold. If a hazard of injury to the feet exists due to falling objects, rolling objects, where objects may pierce the soles of the feet or where employee's feet may be exposed to electrical hazards, use foot protection, as described in U.S. OSHA 29 CFR.

9. PHYSICAL and CHEMICAL PROPERTIES

VAPOR DENSITY: 1.153 kg/m^3 (0.072 lb/ft^3)

EVAPORATION RATE (nBuAc = 1): Not applicable.

SPECIFIC GRAVITY (air = 1): 0.967

FREEZING POINT: -210°C (-345.8°F)

SOLUBILITY IN WATER (v/v): 1.49%

BOILING POINT @1 atm: -320.4°F (-195.8°C)

EXPANSION RATIO: 696.5 (cryogenic liquid)

pH: Not applicable.

ODOR THRESHOLD: Not applicable. Odorless.

VAPOR PRESSURE (psia): Not applicable.

COEFFICIENT WATER/OIL DISTRIBUTION: Log K_{ow} = 0.92

SPECIFIC VOLUME (ft^3/lb): 13.8

APPEARANCE AND COLOR: Nitrogen is a colorless, odorless gas or a colorless and odorless, cryogenic liquid.

HOW TO DETECT THIS SUBSTANCE (warning properties): There are no unusual warning properties associated with a release of Nitrogen. In terms of leak detection, fittings and joints can be painted with a soap solution to detect leaks, which will be indicated by a bubble formation.

10. STABILITY and REACTIVITY

STABILITY: Normally stable in gaseous state. With cryogenic liquid, when exposed to air, oxygen in the air may condense into the Liquid Nitrogen. Liquid Nitrogen contaminated with oxygen may present the same hazards as Liquid Oxygen and could react violently with organic materials, such as oil and grease.

DECOMPOSITION PRODUCTS: None

MATERIALS WITH WHICH SUBSTANCE IS INCOMPATIBLE: Neodymium, lithium, zirconium and ozone can react with Nitrogen. Calcium, strontium, barium and titanium will react at red heat to form nitrides. Hydrogen reacts on sparking to form ammonia. Liquid Nitrogen in cryogenic grinding of fatty materials can lead to an explosion. A mixture of magnesium powder and Liquid Nitrogen reacts very violently when lit with a fuse, forming magnesium nitride. Liquid Nitrogen is not corrosive to metals.

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: Contact with incompatible materials. Cylinders exposed to high temperatures or direct flame can rupture or burst.

PART IV *Is there any other useful information about this material?*

11. TOXICOLOGICAL INFORMATION

TOXICITY DATA: The following toxicology data for pure Nitrogen are given below.

Eye Irritation (rabbit): Liquid Nitrogen poured into the eye for one or two seconds with the lids held apart, produced no discernible injury. When the exposure was extended to five seconds, slight lesions of the cornea were observed. By the next day, all eyes were entirely normal.

SUSPECTED CANCER AGENT: Nitrogen is not found on the following lists: FEDERAL OSHA Z LIST, NTP, CAL/OSHA, IARC; therefore it is not considered to be, nor suspected to be a cancer-causing agent by these agencies.

IRRITANCY OF PRODUCT: Contact with rapidly expanding gases or liquid can cause frostbite and damage to exposed skin and eyes.

SENSITIZATION OF PRODUCT: Nitrogen is not a human skin or respiratory sensitizer.

REPRODUCTIVE TOXICITY INFORMATION: Listed below is information concerning the effects of Nitrogen on the human reproductive system.

Mutagenicity: Nitrogen is not expected to cause mutagenic effects in humans.

Embryotoxicity: Nitrogen is not expected to cause embryotoxic effects in humans.

Teratogenicity: Nitrogen is not expected to cause teratogenic effects in humans.

Reproductive Toxicity: Nitrogen is not expected to cause adverse reproductive effects in humans.

11. TOXICOLOGICAL INFORMATION (Continued)

REPRODUCTIVE TOXICITY INFORMATION (continued): *A mutagen is a chemical which causes permanent changes to genetic material (DNA) such that the changes will propagate through generation lines. An embryotoxin is a chemical which causes damage to a developing embryo (e.g., within the first eight weeks of pregnancy in humans), but the damage does not propagate across generational lines. A teratogen is a chemical which causes damage to a developing fetus, but the damage does not propagate across generational lines. A reproductive toxin is any substance which interferes in any way with the reproductive process.*

BIOLOGICAL EXPOSURE INDICES (BEIs): Currently, Biological Exposure Indices (BEIs) are not applicable to Nitrogen.

12. ECOLOGICAL INFORMATION

ENVIRONMENTAL STABILITY: Nitrogen occurs naturally in the atmosphere. The gas will be dissipated rapidly in well-ventilated areas.

NITROGEN: Log K_{ow} = 0.92; Water solubility = 1.49% v/v (25°C, 1 atm.).

EFFECT OF MATERIAL ON PLANTS or ANIMALS: Any adverse effect on animals would be related to oxygen deficient environments. No adverse effect is anticipated to occur to plant-life, except for frost produced in the presence of rapidly expanding gases.

EFFECT OF CHEMICAL ON AQUATIC LIFE: No evidence is currently available on the effects of Nitrogen on aquatic life.

13. DISPOSAL CONSIDERATIONS

PREPARING WASTES FOR DISPOSAL: Product removed from the cylinder must be disposed of in accordance with appropriate U.S. Federal, State, and local regulations or with regulations of Canada and its Provinces. Return cylinders with residual product to Airgas, Inc. Do not dispose of locally.

14. TRANSPORTATION INFORMATION

THIS GAS IS HAZARDOUS AS DEFINED BY 49 CFR 172.101 BY THE U.S. DEPARTMENT OF TRANSPORTATION.

	Nitrogen Gas:	**Nitrogen Liquid:**
PROPER SHIPPING NAME:	Nitrogen, compressed	Nitrogen, refrigerated liquid
HAZARD CLASS NUMBER and DESCRIPTION:	2.2 (Non-Flammable Gas)	2.2 (Non-Flammable Gas)
UN IDENTIFICATION NUMBER:	UN 1066	UN 1977
PACKING GROUP:	Not Applicable	Not Applicable
DOT LABEL(S) REQUIRED:	Class 2.2 (Non-Flammable Gas)	Non-Flammable Gas

NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (2000): 121 (Gas); 120 (Liquid)

MARINE POLLUTANT: Nitrogen is not classified by the DOT as a Marine Pollutant (as defined by 49 CFR 172.101, Appendix B).

TRANSPORT CANADA TRANSPORTATION OF DANGEROUS GOODS REGULATIONS: Nitrogen is considered as Dangerous Goods, per regulations of Transport Canada. The use of the above U.S. DOT information from the U.S. 49 CFR regulations is allowed for shipments that originate in the U.S. For shipments via ground vehicle or rail that originate in Canada, the following information is applicable.

	Nitrogen Gas:	**Nitrogen Liquid:**
PROPER SHIPPING NAME:	Nitrogen, compressed	Nitrogen, refrigerated liquid
HAZARD CLASS NUMBER and DESCRIPTION:	2.2 (Non-Flammable Gas)	2.2 (Non-Flammable Gas)
UN IDENTIFICATION NUMBER:	UN 1066	UN 1977
PACKING GROUP:	Not Applicable	Not Applicable
HAZARD LABEL(S) REQUIRED:	Class 2.2 (Non-Flammable Gas)	Non-Flammable Gas
SPECIAL PROVISIONS:	None	None
EXPLOSIVE LIMIT & LIMITED QUANTITY INDEX:	0.12	0.12
ERAP INDEX:	None	None
PASSENGER CARRYING SHIP INDEX:	None	Forbidden
PASSENGER CARRYING ROAD OR RAIL VEHICLE INDEX:	75	50

MARINE POLLUTANT: Nitrogen is not a Marine Pollutant.

15. REGULATORY INFORMATION

ADDITIONAL U.S. REGULATIONS:

U.S. SARA REPORTING REQUIREMENTS: Nitrogen is not subject to the reporting requirements of Sections 302, 304, and 313 of Title III of the Superfund Amendments and Reauthorization Act.

U.S. SARA THRESHOLD PLANNING QUANTITY: There are no specific Threshold Planning Quantities for Nitrogen. The default Federal MSDS submission and inventory requirement filing threshold of 10,000 lb (4,540 kg) may apply, per 40 CFR 370.20.

U.S. CERCLA REPORTABLE QUANTITY (RQ): Not applicable.

15. REGULATORY INFORMATION (Continued)

ADDITIONAL U.S. REGULATIONS (continued):

U.S. TSCA INVENTORY STATUS: Nitrogen is on the TSCA Inventory.

OTHER U.S. FEDERAL REGULATIONS: Not applicable.

U.S. STATE REGULATORY INFORMATION: Nitrogen is covered under the following specific State regulations:

Alaska - Designated Toxic and Hazardous Substances: No.
California - Permissible Exposure Limits for Chemical Contaminants: Nitrogen.
Florida - Substance List: No.
Illinois - Toxic Substance List: No.
Kansas - Section 302/313 List: No.
Massachusetts - Substance List: No.
Michigan - Critical Materials Register: No.
Minnesota - List of Hazardous Substances: No.
Missouri - Employer Information/Toxic Substance List: No.
New Jersey - Right to Know Hazardous Substance List: Nitrogen.
North Dakota - List of Hazardous Chemicals, Reportable Quantities: No.
Pennsylvania - Hazardous Substance List: Nitrogen.
Rhode Island - Hazardous Substance List: Nitrogen.
Texas - Hazardous Substance List: No.
West Virginia - Hazardous Substance List: No.
Wisconsin - Toxic and Hazardous Substances: No.

CGA LABELING (For Compressed Gas):

CAUTION: HIGH PRESSURE GAS.
CAN CAUSE RAPID SUFFOCATION.
Store and use with adequate ventilation.
Use equipment rated for cylinder pressure.
Close valve after each use and when empty.
Use in accordance with the Material Safety Data Sheet.

FIRST AID: **IF INHALED**, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
DO NOT REMOVE THIS PRODUCT LABEL.

CGA LABELING (for Liquid):

ALWAYS KEEP CONTAINER IN UPRIGHT POSITION.

WARNING: EXTREMELY COLD LIQUID AND GAS UNDER PRESSURE.
CAN CAUSE RAPID SUFFOCATION.
CAN CAUSE SEVERE FROSTBITE.
Store and use with adequate ventilation.
Do not get liquid in eyes, on skin or clothing.
For liquid withdrawal, wear face shield and gloves.
Do not drop. Use hand truck for container movement.
Close valve after each use and when empty.
Use in accordance with the Material Safety Data Sheet.

FIRST-AID: **IF INHALED**, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
IN CASE OF FROSTBITE, obtain immediate medial attention.
DO NOT REMOVE THIS PRODUCT LABEL.

ADDITIONAL CANADIAN REGULATIONS:

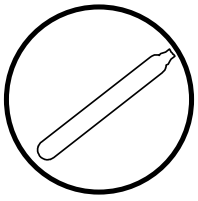
CANADIAN DSL INVENTORY STATUS: Nitrogen is listed on the DSL Inventory.

OTHER CANADIAN REGULATIONS: Not applicable.

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) PRIORITIES SUBSTANCES LISTS: Nitrogen is not on the CEPA Priorities Substances Lists.

CANADIAN WHMIS CLASSIFICATION and SYMBOLS:

Class A: Compressed Gases



16. OTHER INFORMATION

PREPARED BY: CHEMICAL SAFETY ASSOCIATES, Inc.
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DEFINITIONS OF TERMS

A large number of abbreviations and acronyms appear on a MSDS. Some of these which are commonly used include the following:

CAS #: This is the Chemical Abstract Service Number that uniquely identifies each constituent.

EXPOSURE LIMITS IN AIR:

CEILING LEVEL: The concentration that shall not be exceeded during any part of the working exposure.

LOQ: Limit of Quantitation.

MAK: Federal Republic of Germany Maximum Concentration Values in the workplace.

NE: Not Established. When no exposure guidelines are established, an entry of NE is made for reference.

NIC: Notice of Intended Change.

NIOSH CEILING: The exposure that shall not be exceeded during any part of the workday. If instantaneous monitoring is not feasible, the ceiling shall be assumed as a 15-minute TWA exposure (unless otherwise specified) that shall not be exceeded at any time during a workday.

NIOSH RELs: NIOSH's Recommended Exposure Limits.

PEL-Permissible Exposure Limit: OSHA's Permissible Exposure Limits. This exposure value means exactly the same as a TLV, except that it is enforceable by OSHA. The OSHA Permissible Exposure Limits are based in the 1989 PELs and the June, 1993 Air Contaminants Rule (Federal Register: 58: 35338-35351 and 58: 40191). Both the current PELs and the vacated PELs are indicated. The phrase, "Vacated 1989 PEL," is placed next to the PEL that was vacated by Court Order.

SKIN: Used when a there is a danger of cutaneous absorption.

STEL-Short Term Exposure Limit: Short Term Exposure Limit, usually a 15-minute time-weighted average (TWA) exposure that should not be exceeded at any time during a workday, even if the 8-hr TWA is within the TLV-TWA, PEL-TWA or REL-TWA.

TLV-Threshold Limit Value: An airborne concentration of a substance that represents conditions under which it is generally believed that nearly all workers may be repeatedly exposed without adverse effect. The duration must be considered, including the 8-hour.

TWA-Time Weighted Average: **T**ime Weighted Average exposure concentration for a conventional 8-hr (TLV, PEL) or up to a 10-hr (REL) workday and a 40-hr workweek.

IDLH-Immediately Dangerous to Life and Health: This level represents a concentration from which one can escape within 30-minutes without suffering escape-preventing or permanent injury.

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM HAZARD RATINGS:

This rating system was developed by the National Paint and Coating Association and has been adopted by industry to identify the degree of chemical hazards.

HEALTH HAZARD:

0 (Minimal Hazard: No significant health risk, irritation of skin or eyes not anticipated. *Skin Irritation*: Essentially non-irritating. PII or Draize = "0". *Eye Irritation*: Essentially non-irritating, or minimal effects which clear in < 24 hours [e.g. mechanical irritation]. Draize = "0". *Oral Toxicity LD_{50} Rat*: < 5000 mg/kg. *Dermal Toxicity LD_{50}Rat or Rabbit*: < 2000 mg/kg. *Inhalation Toxicity 4-hrs LC_{50} Rat*: < 20 mg/L.); **1** (Slight Hazard: Minor reversible Injury may occur; slightly or mildly irritating. *Skin Irritation*: Slightly or mildly irritating. *Eye Irritation*: Slightly or mildly irritating. *Oral Toxicity LD_{50} Rat*: > 500-5000 mg/kg. *Dermal Toxicity LD_{50}Rat or Rabbit*: > 1000-2000 mg/kg. *Inhalation Toxicity LC_{50}* 4-hrs *Rat*: > 2-20 mg/L); **2** (Moderate Hazard: Temporary or transitory injury may occur. *Skin Irritation*: Moderately irritating; primary irritant; sensitizer. PII or Draize > 0, < 5. *Eye Irritation*: Moderately to severely irritating and/or corrosive; reversible corneal opacity; corneal involvement or irritation clearing in 8-21 days. Draize > 0, ≤ 25. *Oral Toxicity LD_{50} Rat*: > 50-500 mg/kg. *Dermal Toxicity LD_{50}Rat or Rabbit*: > 200-1000 mg/kg. *Inhalation Toxicity LC_{50} 4-hrs Rat*: > 0.5-2 mg/L.); **3** (Serious Hazard: Major injury likely unless prompt action is taken and medical treatment is given; high level of toxicity; corrosive. *Skin Irritation*: Severely irritating and/or corrosive; may destroy dermal tissue, cause skin burns, dermal necrosis. PII or Draize > 5-8 with destruction of tissue. *Eye Irritation*: Corrosive, irreversible destruction of ocular tissue; corneal involvement or irritation persisting for more than 21 days. Draize > 80 with effects irreversible in 21 days. *Oral Toxicity LD_{50} Rat*: > 1-50 mg/kg. *Dermal Toxicity LD_{50}Rat or Rabbit*: > 20-200 mg/kg. *Inhalation Toxicity LC_{50} 4-hrs Rat*: > 0.05-0.5 mg/L.);

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM HAZARD RATINGS (continued):

HEALTH HAZARD (continued):

4 (Severe Hazard: Life-threatening; major or permanent damage may result from single or repeated exposure. *Skin Irritation*: Not appropriate. Do not rate as a "4", based on skin irritation alone. *Eye Irritation*: Not appropriate. Do not rate as a "4", based on eye irritation alone. *Oral Toxicity LD_{50} Rat*: ≤ 1 mg/kg. *Dermal Toxicity LD_{50}Rat or Rabbit*: ≤ 20 mg/kg. *Inhalation Toxicity LC_{50} 4-hrs Rat*: ≤ 0.05 mg/L).

FLAMMABILITY HAZARD:

0 (Minimal Hazard-Materials that will not burn in air when exposure to a temperature of 815.5°C [1500°F] for a period of 5 minutes.); **1** (Slight Hazard-Materials that must be pre-heated before ignition can occur. Material require considerable pre-heating, under all ambient temperature conditions before ignition and combustion can occur, Including: Materials that will burn in air when exposed to a temperature of 815.5°C (1500°F) for a period of 5 minutes or less; Liquids, solids and semisolids having a flash point at or above 93.3°C [200°F] (e.g. OSHA Class IIIB, or; Most ordinary combustible materials [e.g. wood, paper, etc.]; **2** (Moderate Hazard-Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Materials in this degree would not, under normal conditions, form hazardous atmospheres in air, but under high ambient temperatures or moderate heating may release vapor in sufficient quantities to produce hazardous atmospheres in air, Including: Liquids having a flash-point at or above 37.8°C [100°F]; Solid materials in the form of course dusts that may burn rapidly but that generally do not form explosive atmospheres; Solid materials in a fibrous or shredded form that may burn rapidly and create flash fire hazards (e.g. cotton, sisal, hemp; Solids and semisolids that readily give off flammable vapors.); **3** (Serious Hazard- Liquids and solids that can be ignited under almost all ambient temperature conditions. Materials in this degree produce hazardous atmospheres with air under almost all ambient temperatures, or, unaffected by ambient temperature, are readily ignited under almost all conditions, including: Liquids having a flash point below 22.8°C [73°F] and having a boiling point at or above 38°C [100°F] and below 37.8°C [100°F] [e.g. OSHA Class IB and IC]; Materials that on account of their physical form or environmental conditions can form explosive mixtures with air and are readily dispersed in air [e.g., dusts of combustible solids, mists or droplets of flammable liquids]; Materials that burn extremely rapidly, usually by reason of self-contained oxygen [e.g. dry nitrocellulose and many organic peroxides]); **4** (Severe Hazard-Materials that will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or that are readily dispersed in air, and which will burn readily, including: Flammable gases; Flammable cryogenic materials; Any liquid or gaseous material that is liquid while under pressure and has a flash point below 22.8°C [73°F] and a boiling point below 37.8°C [100°F] [e.g. OSHA Class IA; Material that ignite spontaneously when exposed to air at a temperature of 54.4°C [130°F] or below [e.g. pyrophoric]).

PHYSICAL HAZARD:

0 (*Water Reactivity*: Materials that do not react with water. *Organic Peroxides*: Materials that are normally stable, even under fire conditions and will not react with water. *Explosives*: Substances that are Non-Explosive. Unstable *Compressed Gases*: No Rating. *Pyrophorics*: No Rating. *Oxidizers*: No "0" rating allowed. *Unstable Reactives*: Substances that will not polymerize, decompose, condense or self-react.); **1** (*Water Reactivity*: Materials that change or decompose upon exposure to moisture. *Organic Peroxides*: Materials that are normally stable, but can become unstable at high temperatures and pressures. These materials may react with water, but will not release energy. *Explosives*: Division 1.5 & 1.6 substances that are very insensitive explosives or that do not have a mass explosion hazard. *Compressed Gases*: Pressure below OSHA definition. *Pyrophorics*: No Rating. *Oxidizers*: Packaging Group III; Solids: any material that in either concentration tested, exhibits a mean burning time less than or equal to the mean burning time of a 3:7 potassium bromate/cellulose mixture and the criteria for Packing Group I and II are not met. Liquids: any material that exhibits a mean pressure rise time less than or equal to the pressure rise time of a 1:1 nitric acid (65%)/cellulose mixture and the criteria for Packing Group I and II are not met.

DEFINITIONS OF TERMS (Continued)

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM HAZARD RATINGS (continued):

PHYSICAL HAZARD (continued):

1 (continued): *Unstable Reactives*: Substances that may decompose, condense or self-react, but only under conditions of high temperature and/or pressure and have little or no potential to cause significant heat generation or explosive hazard. Substances that readily undergo hazardous polymerization in the absence of inhibitors.); **2** (*Water Reactivity*: Materials that may react violently with water. *Organic Peroxides*: Materials that, in themselves, are normally unstable and will readily undergo violent chemical change, but will not detonate. These materials may also react violently with water. *Explosives*: Division 1.4 – Explosive substances where the explosive effect are largely confined to the package and no projection of fragments of appreciable size or range are expected. An external fire must not cause virtually instantaneous explosion of almost the entire contents of the package. *Compressed Gases*: Pressurized and meet OSHA definition but < 514.7 psi absolute at 21.1°C (70°F) [500 psig]. *Pyrophorics*: No Rating. *Oxidizers*: Packing Group II Solids: any material that, either in concentration tested, exhibits a mean burning time of less than or equal to the mean burning time of a 2:3 potassium bromate/cellulose mixture and the criteria for Packing Group I are not met. Liquids: any material that exhibits a mean pressure rise time less than or equal to the pressure rise of a 1:1 aqueous sodium chlorate solution (40%)/cellulose mixture and the criteria for Packing Group I are not met. *Unstable Reactives*: Substances that may polymerize, decompose, condense, or self-react at ambient temperature and/or pressure, but have a low potential for significant heat generation or explosion. Substances that readily form peroxides upon exposure to air or oxygen at room temperature); **3** (*Water Reactivity*: Materials that may form explosive reactions with water. *Organic Peroxides*: Materials that are capable of detonation or explosive reaction, but require a strong initiating source, or must be heated under confinement before initiation; or materials that react explosively with water. *Explosives*: Division 1.2 – Explosive substances that have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but do not have a mass explosion hazard. *Compressed Gases*: Pressure ≥ 514.7 psi absolute at 21.1°C (70°F) [500 psig]. *Pyrophorics*: No Rating. *Oxidizers*: Packing Group I Solids: any material that, in either concentration tested, exhibits a mean burning time less than the mean burning time of a 3.:2 potassium bromate/cellulose mixture. Liquids: Any material that spontaneously ignites when mixed with cellulose in a 1:1 ratio, or which exhibits a mean pressure rise time less than the pressure rise time of a 1:1 perchloric acid (50%)/cellulose mixture. *Unstable Reactives*: Substances that may polymerize, decompose, condense or self-react at ambient temperature and/or pressure and have a moderate potential to cause significant heat generation or explosion.);

4 (*Water Reactivity*: Materials that react explosively with water without requiring heat or confinement. *Organic Peroxides*: Materials that are readily capable of detonation or explosive decomposition at normal temperature and pressures. *Explosives*: Division 1.1 & 1.2-explosive substances that have a mass explosion hazard or have a projection hazard. A mass explosion is one that affects almost the entire load instantaneously. *Compressed Gases*: No Rating. *Pyrophorics*: Add to the definition of Flammability "4". *Oxidizers*: No "4" rating. *Unstable Reactives*: Substances that may polymerize, decompose, condense or self-react at ambient temperature and/or pressure and have a high potential to cause significant heat generation or explosion.). PPE Rating B: Hand and eye protection is required for routine chemical use. PPE Rating C: Hand, eye, and body protection may be required for routine chemical use.

NATIONAL FIRE PROTECTION ASSOCIATION HAZARD RATINGS:

HEALTH HAZARD: **0** (material that on exposure under fire conditions would offer no hazard beyond that of ordinary combustible materials); **1** (materials that on exposure under fire conditions could cause irritation or minor residual injury); **2** (materials that on intense or continued exposure under fire conditions could cause temporary incapacitation or possible residual injury); **3** (materials that can on short exposure could cause serious temporary or residual injury); **4** (materials that under very short exposure could cause death or major residual injury).

NATIONAL FIRE PROTECTION ASSOCIATION HAZARD RATINGS (continued):

FLAMMABILITY HAZARD: **0** Materials that will not burn under typical fire conditions, including intrinsically noncombustible materials such as concrete, stone, and sand. **1** Materials that must be preheated before ignition can occur. Materials in this degree require considerable preheating, under all ambient temperature conditions, before ignition and combustion can occur **2** Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Materials in this degree would not under normal conditions form hazardous atmospheres with air, but under high ambient temperatures or under moderate heating could release vapor in sufficient quantities to produce hazardous atmospheres with air. **3** Liquids and solids that can be ignited under almost all ambient temperature conditions. Materials in this degree produce hazardous atmospheres with air under almost all ambient temperatures or, though unaffected by ambient temperatures, are readily ignited under almost all conditions. **4** Materials that will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or that are readily dispersed in air and will burn readily.

INSTABILITY HAZARD: **0** Materials that in themselves are normally stable, even under fire conditions. **1** Materials that in themselves are normally stable, but that can become unstable at elevated temperatures and pressures. **2** Materials that readily undergo violent chemical change at elevated temperatures and pressures. **3** Materials that in themselves are capable of detonation or explosive decomposition or explosive reaction, but that require a strong initiating source or that must be heated under confinement before initiation. **4** Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures.

FLAMMABILITY LIMITS IN AIR: Much of the information related to fire and explosion is derived from the **N**ational **F**ire **P**rotection **A**ssociation (**NFPA**). Flash Point - Minimum temperature at which a liquid gives off sufficient vapors to form an ignitable mixture with air. Autoignition Temperature: The minimum temperature required to initiate combustion in air with no other source of ignition. LEL - the lowest percent of vapor in air, by volume, that will explode or ignite in the presence of an ignition source. UEL - the highest percent of vapor in air, by volume, that will explode or ignite in the presence of an ignition source. **TOXICOLOGICAL INFORMATION:**

Human and Animal Toxicology: Possible health hazards as derived from human data, animal studies, or from the results of studies with similar compounds are presented. Definitions of some terms used in this section are: **LD_{50}** - Lethal Dose (solids & liquids) which kills 50% of the exposed animals; **LC_{50}** - Lethal Concentration (gases) which kills 50% of the exposed animals; **ppm** concentration expressed in parts of material per million parts of air or water; **mg/m^3** concentration expressed in weight of substance per volume of air; **mg/kg** quantity of material, by weight, administered to a test subject, based on their body weight in kg. Other measures of toxicity include **TDLo**, the lowest dose to cause a symptom and **TCLo** the lowest concentration to cause a symptom; **TDo**, **LDLo**, and **LDo**, or **TC**, **TCo**, **LCLo**, and **LCo**, the lowest dose (or concentration) to cause lethal or toxic effects. **Cancer Information:** The sources are: **IARC** - the International Agency for Research on Cancer; **NTP** - the National Toxicology Program, **RTECS** - the Registry of Toxic Effects of Chemical Substances, **OSHA** and **CAL/OSHA**. IARC and NTP rate chemicals on a scale of decreasing potential to cause human cancer with rankings from 1 to 4. Subrankings (2A, 2B, etc.) are also used. **Other Information: BEI** - ACGIH Biological Exposure Indices, represent the levels of determinants which are most likely to be observed in specimens collected from a healthy worker who has been exposed to chemicals to the same extent as a worker with inhalation exposure to the TLV.

DEFINITIONS OF TERMS (Continued)

ECOLOGICAL INFORMATION:

EC is the effect concentration in water. **BCF =** Bioconcentration Factor, which is used to determine if a substance will concentrate in lifeforms which consume contaminated plant or animal matter. **TL_m =** median threshold limit; Coefficient of Oil/Water Distribution is represented by **log K_{ow}** or **log K_{oc}** and is used to assess a substance's behavior in the environment.

REGULATORY INFORMATION:

U.S. and CANADA:

This section explains the impact of various laws and regulations on the material. **ACGIH:** American Conference of Governmental Industrial Hygienists, a professional association which establishes exposure limits. **EPA** is the U.S. Environmental Protection Agency. **NIOSH** is the National Institute of Occupational Safety and Health, which is the research arm of the U.S. **O**ccupational **S**afety and **H**ealth **A**dministration (**OSHA**). **WHMIS** is the Canadian Workplace Hazardous Materials Information System. **DOT** and **TC** are the U.S. Department of Transportation and the Transport Canada, respectively. Superfund Amendments and Reauthorization Act **(SARA)**; the Canadian Domestic/Non-Domestic Substances List **(DSL/NDSL)**; the U.S. Toxic Substance Control Act **(TSCA)**; Marine Pollutant status according to the **DOT**; the Comprehensive Environmental Response, Compensation, and Liability Act **(CERCLA or Superfund)**; and various state regulations. This section also includes information on the precautionary warnings which appear on the material's package label. **OSHA** - U.S. Occupational Safety and Health Administration.

MSDS Number: **T1313** * * * * * *Effective Date:* ***08/10/04*** * * * * * *Supercedes:* ***11/02/01***

MSDS Material Safety Data Sheet

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

J.T.Baker ®

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. And Canada
Chemtrec: 703-527-3887

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

1,2,3,4-TETRAHYDRONAPHTHALENE

1. Product Identification

Synonyms: Naphthalene, 1,2,3,4-tetrahydro-; TETRALIN
CAS No.: 119-64-2
Molecular Weight: 132.21
Chemical Formula: C10H12
Product Codes: V577

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Naphthalene, 1,2,3,4-tetrahydro-	119-64-2	97%	Yes
Decahydronaphthalene	91-17-8	2%	Yes
Naphthalene	91-20-3	1%	Yes

3. Hazards Identification

Emergency Overview

WARNING! HARMFUL IF SWALLOWED OR INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. COMBUSTIBLE LIQUID AND VAPOR. CONTAINS NAPHTHALENE WHICH MAY CAUSE ALLERGIC SKIN REACTION AND MAY AFFECT LIVER, KIDNEY, BLOOD AND CENTRAL NERVOUS SYSTEM..

J.T. Baker SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate
Flammability Rating: 2 - Moderate
Reactivity Rating: 0 - None
Contact Rating: 2 - Moderate
Lab Protective Equip: GOGGLES; LAB COAT; VENT HOOD; PROPER GLOVES; CLASS B EXTINGUISHER
Storage Color Code: Red (Flammable)

Potential Health Effects

Inhalation:
Inhalation of vapor or mist is irritating to the respiratory tract. May produce headache, nausea, vomiting. High concentrations can produce central nervous system depression. The predominant reaction of overexposure from the naphthalene component is delayed intravascular hemolysis with symptoms of anemia, fever, jaundice and kidney or liver damage.
Ingestion:
May cause nausea, headache, vomiting and intragastric discomfort. Major hazard (from the decahydronaphthalene component) is aspiration into lungs, which may result in pulmonary edema or chemical pneumonia.
Skin Contact:
Causes skin irritation with discomfort, rash. Sensitized individuals (from naphthalene exposure) may suffer a severe dermatitis.
Eye Contact:
Vapor causes irritation, redness and pain. The naphthalene component, at very high concentrations, can damage the nerves of the eye.
Chronic Exposure:
May cause cataract and kidney and liver damage. Chronic naphthalene exposure has led to cataract formation and may cause skin allergy.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin, eye, kidney or liver, blood or vascular disorders or impaired respiratory function may be more susceptible to the effects of the substance. Particularly susceptible individuals (for naphthalene exposure) are found in the general population, most commonly in dark skinned races.

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4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Ingestion:
Do NOT induce vomiting. Give large amounts of water. Never give anything by mouth to an unconscious person. Get medical attention.
Skin Contact:
Immediately flush skin with plenty of soap and water. Remove contaminated clothing and shoes. Get medical attention. Wash clothing before reuse. Thoroughly clean shoes before reuse.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

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5. Fire Fighting Measures

Fire:
Flash point: 71C (160F) CC
Autoignition temperature: 385C (725F)
Flammable limits in air % by volume:
lel: 0.8; uel: 5.0
Combustible Liquid and Vapor!
Explosion:
Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Vapors can flow along surfaces to distant ignition source and flash back. Can form explosive peroxides which may be concentrated by evaporation or distillation.
Fire Extinguishing Media:
Water spray, dry chemical, alcohol foam, or carbon dioxide. Water may be ineffective. Water spray may be used to keep fire exposed containers cool.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

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6. Accidental Release Measures

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! For the naphthalene component: US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker SOLUSORB® solvent adsorbent is recommended for spills of this product.

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7. Handling and Storage

Protect against physical damage. Outside or detached storage is preferred. Inside storage should be in a standard flammable liquids storage room or cabinet. Separate from oxidizing materials. Storage and use areas should be No Smoking areas. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
For Naphthalene:
-OSHA Permissible Exposure Limit (PEL):
TWA = 10 ppm, 50 mg/m3

-ACGIH Threshold Limit Value (TLV):
TWA = 10 ppm, 52 mg/m3;
STEL = 15 ppm, 79 mg/m3

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, a half-face respirator with an organic vapor cartridge and particulate filter (NIOSH type P95 or R95 filter) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-face piece respirator with an organic vapor cartridge and particulate filter (NIOSH P100 or R100 filter) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. Please note that N series filters are not recommended for this material. For emergencies or instances where the exposure levels are not known, use a full-face piece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.
Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

---

9. Physical and Chemical Properties

Appearance:
Clear, colorless liquid.
Odor:
Like a mixture of benzene and menthol; a moldy turpentine odor.
Solubility:
Insoluble in water.
Specific Gravity:
0.970 @20C/4C
pH:
No information found.
% Volatiles by volume @ 21C (70F):
100
Boiling Point:
207C (405F)
Melting Point:
-35.8C (-33F)
Vapor Density (Air=1):
4.55
Vapor Pressure (mm Hg):
1 @ 38C; 0.368 @ 25C
Evaporation Rate (BuAc=1):
< 1

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10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage. Contact with air may cause formation of tetralin peroxide. Potentially explosive peroxides can form on long-term storage in contact with air. Light and heat accelerate peroxide formation.
Hazardous Decomposition Products:
Carbon dioxide and carbon monoxide may form when heated to decomposition. Under pyrolysis at 700C yields tars that contain 3,4-benzopyrene.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Strong oxidizers.
Conditions to Avoid:
Heat, flame, ignition sources, air, light and incompatibles.

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11. Toxicological Information

For Tetrahydronaphthalene:
Oral Rat LD50: 1620 ul/kg; Skin Rabbit LD50: 17 gm/kg. Irritation Data (skin, rabbit): std Draize= 100 mg/24H, moderate; open Draize= 500 mg, severe. Investigated as a tumorigen.
For Decahydronaphthalene:

Oral Rat LD50: 4170 mg/kg; Skin Rabbit LD50: 5900 mg/kg; Inhalation Rat LC50: 710 ppm/4H; Investigated as a tumorigen.
For Naphthalene:
Oral Rat LD50: 490 mg/kg; Skin Rabbit LD50: > 20 g/kg; Inhalataion rat LC50: 340 mg/m3/1H. Investigated as a tumorigen, mutagen & reproductive effector.

--------\Cancer Lists\----------

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Naphthalene, 1,2,3,4-tetrahydro- (119-64-2)	No	No	None
Decahydronaphthalene (91-17-8)	No	No	None
Naphthalene (91-20-3)	No	No	None

12. Ecological Information

Environmental Fate:
When released into water, this material is expected to readily biodegrade. When released to water, this material is expected to quickly evaporate. When released into the water, this material is expected to have a half-life of less than 1 day. This material is expected to significantly bioaccumulate. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to have a half-life of less than 1 day.
Environmental Toxicity:
No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

Ingredient	TSCA	EC	Japan	Australia
Naphthalene, 1,2,3,4-tetrahydro- (119-64-2)	Yes	Yes	Yes	Yes
Decahydronaphthalene (91-17-8)	Yes	Yes	Yes	Yes
Naphthalene (91-20-3)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\--------

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.
Naphthalene, 1,2,3,4-tetrahydro- (119-64-2)	Yes	Yes	No	Yes
Decahydronaphthalene (91-17-8)	Yes	Yes	No	Yes
Naphthalene (91-20-3)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------

Ingredient	-SARA 302- RQ	TPQ	------SARA 313------ List	Chemical Catg.
Naphthalene, 1,2,3,4-tetrahydro- (119-64-2)	No	No	No	No
Decahydronaphthalene (91-17-8)	No	No	No	No
Naphthalene (91-20-3)	No	No	Yes	No

--------\Federal, State & International Regulations - Part 2\----------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Naphthalene, 1,2,3,4-tetrahydro- (119-64-2)	No	No	No
Decahydronaphthalene (91-17-8)	No	No	No
Naphthalene (91-20-3)	100	U165	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: No Fire: Yes Pressure: No
Reactivity: No (Mixture / Liquid)

Australian Hazchem Code: None allocated.
Poison Schedule: S6
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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16. Other Information

NFPA Ratings: Health: **1** Flammability: **2** Reactivity: **0**
Label Hazard Warning:
WARNING! HARMFUL IF SWALLOWED OR INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. COMBUSTIBLE LIQUID AND VAPOR. CONTAINS NAPHTHALENE WHICH MAY CAUSE ALLERGIC SKIN REACTION AND MAY AFFECT LIVER, KIDNEY, BLOOD AND CENTRAL NERVOUS SYSTEM..
Label Precautions:

Avoid contact with eyes, skin and clothing.
Avoid prolonged or repeated contact with skin.
Avoid breathing vapor or mist.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
Keep away from heat, sparks and flame.

Label First Aid:

In case of skin contact, immediately flush skin with plenty of soap and water. Remove contaminated clothing and shoes. Wash clothing before reuse. In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. In all cases, get medical attention.

Product Use:

Laboratory Reagent.

Revision Information:

No Changes.

Disclaimer:

****

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Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

Appendix YA
SERIES 5450
INSTRUMENT ATTACHMENTS

- Contents -

GENERAL

Series 5450 instruments are offered with a variety of attachments for specialized applications. This appendix identifies these attachments and provides a brief overview of their functions.

A100: PNEUMATICALLY-OPERATED SETPOINTER (5453)

A capsular element mounted inside the housing drives the setpoint mechanism through a four-bar linkage arrangement to position the setpointer. A 3-15 psi signal from an external source drives the capsular element, which in turn adjusts the setpoint value as required. The setpoint pressure connection is located at the bottom of the case.

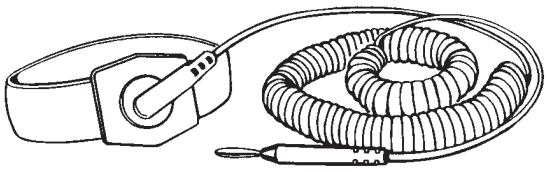
A110: EXTERNAL INTEGRAL FEEDBACK (5453)

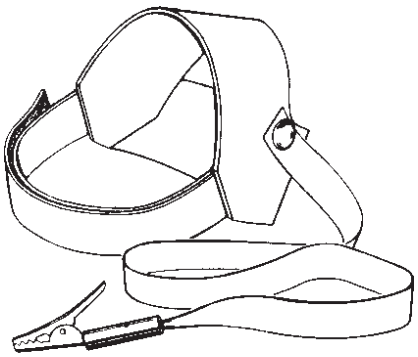
This attachment, which is furnished with 2 or 3-mode Controllers, removes internal integral mode feedback and uses an external feedback signal provided by the user. The feedback connection is provided at the bottom of the housing.

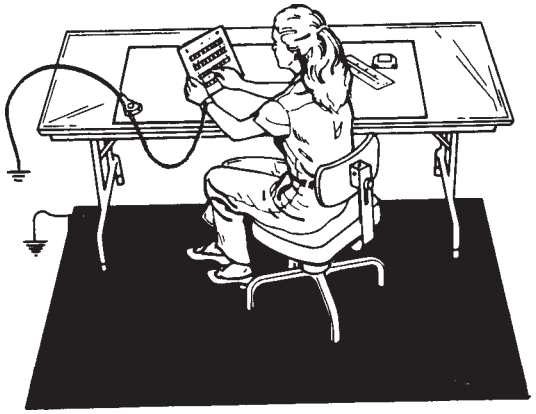
Bristol, Inc. 1100 Buckingham St. Watertown, CT 06795

ESDS Manual
S14006
4/15/92

CARE AND HANDLING OF PC BOARDS AND ESD-SENSITIVE COMPONENTS







BRISTOL BABCOCK

TABLE OF CONTENTS

TOOLS AND MATERIALS REQUIRED

1. Tools

Anti-Static Field kit. It is recommended that an anti-static field kit be kept on any site where solid-state printed circuit boards and other ESD-sensitive components are handled. These kits are designed to remove any existing static charge and to prevent the build-up of a static charge that could damage a PC board or ESD-sensitive components. The typical anti-static field kit consists of the following components:

1. A work surface (10mm conductive plastic sheet with a female snap fastener in one corner for ground cord attachment).

2. A 15-foot long ground cord for grounding the work surface.

3. Wrist strap (available in two sizes, large and small, for proper fit and comfort) with a female snap fastener for ground cord attachment.

4. A coiled ground cord with a practical extension length of 10 feet for attachment to the wrist strap.

Toothbrush (any standard one will do)

2. Materials

- Inhibitor (Texwipe Gold Mist ; Chemtronics Gold Guard, or equivalent)
- Cleaner (Chemtronics Electro-Wash; Freon TF, or equivalent)
- Wiping cloth (Kimberly-Clark Kim Wipes, or equivalent)

ESD-SENSITIVE COMPONENT HANDLING PROCEDURE

1. Introduction

Microelectronic devices such as PC boards, chips and other components are electro-static-sensitive. Electrostatic discharge (ESD) of as few as 110 volts can damage or disrupt the functioning of such devices. Imagine the damage possible from the 35,000 volts (or more) that you can generate on a dry winter day by simply walking across a carpet. In fact, you can generate as much as 6,000 volts just working at a bench.

There are two kinds of damage that can be caused by the static charge. The more severe kind results in complete failure of the PC board or component. This kind of damage is relatively simple, although often expensive, to remedy by replacing the affected item(s). The second kind of damage results in a degradation or weakening which does not result in an outright failure of the component. This kind of damage is difficult to detect and often results in faulty performance, intermittent failures, and service calls.

Minimize the risk of ESD-sensitive component damage by preventing static build-up and by promptly removing any existing charge. Grounding is effective, if the carrier of the static charge is **conductive** such as a human body. To protect components from **nonconductive** carriers of static charges such as plastic boxes, place the component in static-shielding bags.

This manual contains general rules to be followed while handling ESD-sensitive components. Use of the anti-static field kit to properly ground the human body as well as the work surface is also discussed.

Table 1

Typical Electrostatic Voltages

	Electrostatic Voltages	
Means of Static Generation	10-20 Percent Relative Humidity	65-90 Percent Relative Humidity
Walking across carpet	35,000	1,500
Walking over vinyl floor	12,000	250
Worker at bench	6,000	100
Vinyl envelopes for work instructions	7,000	600
Poly bag picked up from bench	20,000	1,200
Work chair padded with poly foam	18,000	1,500

2. General Rules

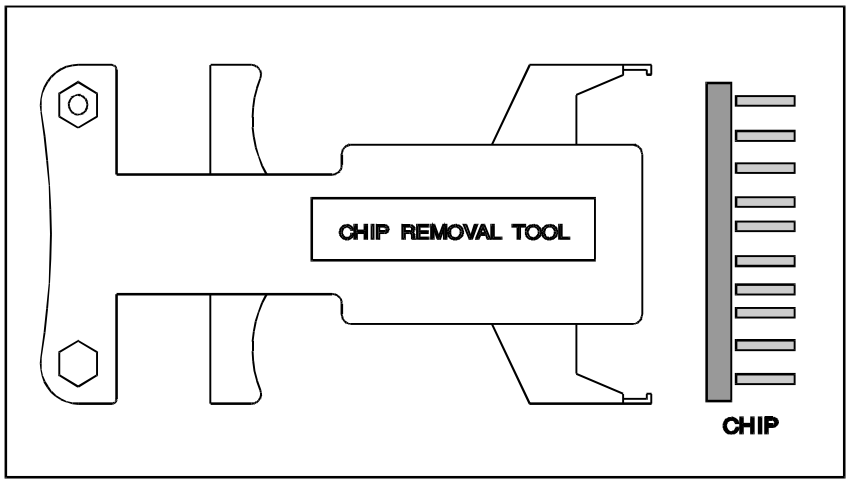
(1) ESD-sensitive components shall **only** be removed from their static-shielding bags by a person who is properly grounded.

(2) When taken out of their static-shielding bags, ESD-sensitive components shall **never** be placed over, or on, a surface which has not been properly grounded.

(3) ESD-sensitive components shall be handled in such a way that the body does not come in contact with the conductor paths and board components. Handle ESD-sensitive components in such a way that they will not suffer damage from physical abuse or from electric shock.

(4) EPROMS/PROMS shall be kept in anti-static tubes until they are ready to use and shall be removed **only** by a person who is properly grounded.

(5) When inserting and removing EPROMS/PROMS from PC boards, use a chip removal tool similar to the one shown in the figure following. Remember, all work should be performed on a properly grounded surface by a properly-grounded person.



Typical Chip Removal Tool

(6) It is important to note when inserting EPROMS/PROMS, that the index notch on the PROM must be matched with the index notch on the socket. Before pushing the chip into the socket, make sure all the pins are aligned with the respective socket-holes. Take special care not to crush any of the pins as this could destroy the chip.

(7) Power the system down before removing or inserting comb connectors/plugs or removing and reinstalling PC boards or ESD-sensitive components from card files or mounting hardware. Follow the power-down procedure applicable to the system being serviced.

(8) Handle all defective boards or components with the same care as new components. This helps eliminate damage caused by mishandling. Do not strip used PC boards for parts. Ship defective boards promptly to Bristol Babcock in a static-shielding bag placed *inside* static-shielding foam and a box to avoid damage during shipment.

CAUTION

Don't place ESD-sensitive components and paperwork in the same bag.

The static caused by sliding the paper into the bag could develop a charge and damage the component(s).

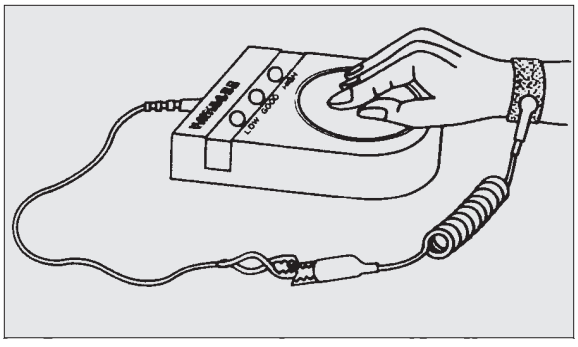
(9) Include a note, which describes the malfunction, in a *separate* bag along with each component being shipped. The repair facility will service the component and promptly return it to the field.

3. Protecting ESD-Sensitive Components

(1) As stated previously, it is recommended that an electrically-conductive anti-static field kit be kept on any site where ESD-sensitive components are handled. A recommended ESD-protective workplace arrangement is shown on page 7. The anti-static safety kit serves to protect the equipment as well as the worker. As a safety feature, a resistor (usually of the one-megohm, 1/2-watt, current-limiting type) has been installed in the molded caps of the wrist strap cord and the ground cord. This resistor limits current should a worker accidently come in contact with a power source. Do not remove the molded caps from grounded cords. If a cord is damaged, replace it immediately.

(2) Be sure to position the work surface so that it does **not** touch grounded conductive objects. The protective resistor is there to limit the current which can flow through the strap. When the work surface touches a grounded conductive object, a short is created which draws the current flow and defeats the purpose of the current-limiting resistor.

(3) Check resistivity of wrist strap periodically using a commercially-available system tester similar to the one shown in the figure below:



Note: If a system checker is not available, use an ohmmeter connected to the cable ends to measure its resistance. The ohmmeter reading should be **1 megohm +/- 15%**. Be sure that the calibration date of the ohmmeter has not expired. If the ohmmeter reading exceeds **1 megohm by +/- 15%**, replace the ground cord with a new one.

4. Static-safe Field Procedure

(1) On reaching the work location, unfold and lay out the work surface on a convenient surface (table or floor). Omit this step if the table or floor has a built-in ESD-safe work surface.

(2) Attach the ground cord to the work surface via the snap fasteners and attach the other end of the ground cord to a reliable ground using an alligator clip.

(3) Note which boards or components are to be inserted or replaced.

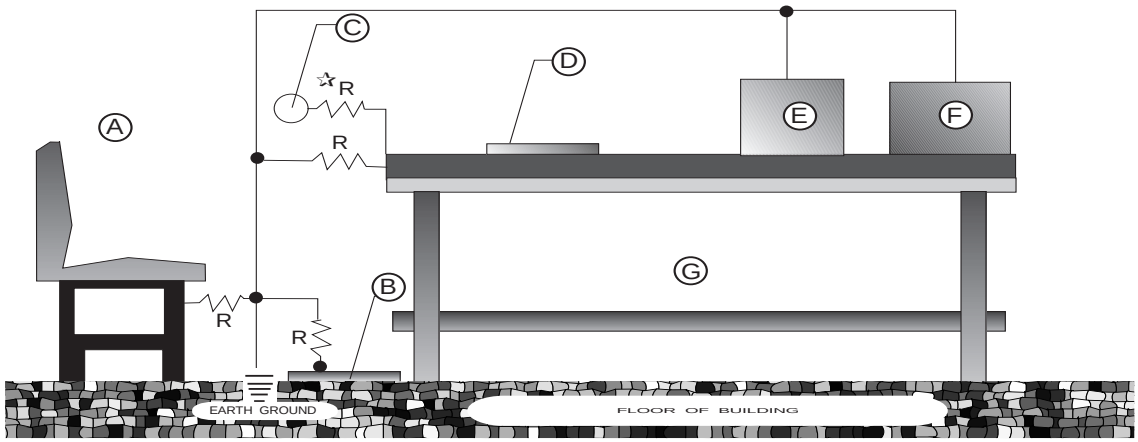
(4) Power-down the system following the recommended power-down procedure.

(5) Slip on a known-good wristband, which should fit snugly; an extremely loose fit is not desirable.

(6) Snap the ground cord to the wristband. Attach the other end of the ground cord to a reliable ground using the alligator clip.

(7) The components can now be handled following the general rules as described in the instruction manual for the component.

(8) Place the component in a static-shielding bag before the ground cord is disconnected. This assures protection from electrostatic charge in case the work surface is located beyond the reach of the extended ground cord.



LEGEND

A - Chair with ground (optional)

B - ESD protective floor mat (optional)

C - Wrist strap

D - ESD protective trays, etc.

E - Ionizer

F - Other electrical equipment

G - Workbench with ESD protective table top

☆ NOTE: ALL RESISTORS 1M Ω +/-10% 1/2W

(9) If a component is to undergo on-site testing, it may be safely placed on the grounded work surface for that purpose.

(10) After all component work is accomplished, remove the wrist straps and ground wire and place in the pouch of the work surface for future use.

5. Cleaning And Lubricating

The following procedure should be performed periodically for all PC boards and when a PC board is being replaced.

CAUTION

Many PC board connectors are covered with a very fine gold-plate.

Do not use any abrasive cleaning substance or object such as a pencil eraser to clean connectors.

Use only the approved cleaner/lubricants specified in the procedure following.

WARNING

Aerosol cans and products are extremely combustible.

Contact with a live circuit, or extreme heat can cause an explosion.

Turn OFF all power and find an isolated, and ventilated area to use any aerosol products specified in this procedure.

(1) Turn the main line power **OFF**. Blow or vacuum out the component. This should remove potential sources of dust or dirt contamination during the remainder of this procedure.

(2) Clean PC board connectors as follows:

a. Review the static-safe field procedure detailed earlier.

b. Following the ESD-sensitive component handling procedures, remove the connectors from the boards and remove the PC boards from their holders.

c. Use cleaner to remove excessive dust build-up from comb connectors and other connectors. This cleaner is especially useful for removing dust.

d. Liberally spray all PC board contacts with Inhibitor. The inhibitor:

- Provides a long lasting lubricant and leaves a protective film to guard against corrosion
- Improves performance and reliability
- Extends the life of the contacts
- Is nonconductive, and is safe for use on most plastics

e. Clean the comb contacts using a **lint-free** wiping cloth.

f. Lightly mist all comb contacts again with Inhibitor.

NOTE: Do not use so much Inhibitor that it drips.

g. Repeat the above procedure for the other PC boards from the device.

(3) Cleaning PC edge connectors

a. Use cleaner to remove excessive dust build-up from connectors. This cleaner is especially useful for removing dust.

b. Liberally spray the outboard connector with Inhibitor.

c. Lightly brush the outboard connector with a soft, non-metallic, bristle brush such as a toothbrush.

d. Spray the connector liberally to flush out any contaminants.

e. Remove any excess spray by shaking the connector or wiping with either a toothbrush, or a **lint-free** wiping cloth.

6. Completion

(1) Replace any parts that were removed.

(2) Make sure that the component cover is secure.

(3) Return the system to **normal** operation.

(4) Check that the component operates normally.

624-II Pneumatic Indicating Instruments Series 5450

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NOTICE

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