BARTON NUCLEAR MODEL 288A DIFFERENTIAL PRESSURE INDICATING SWITCH

User Manual

Part No. 9A-C10301, Rev. 08
AUGUST 2021

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Safety

WARNING: This symbol identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.

CAUTION: **Indicates actions or procedures which if not performed correctly may lead to personal injury or incorrect function of the instrument or connected equipment.**

IMPORTANT: Indicates actions or procedures which may affect instrument operation or may lead to an instrument response that is not planned.

Product Brand

* Mark of Schlumberger.

Other company, product, and service names are the properties of their respective owners.

Section 1—Introduction

General

The Barton* weatherproof Model 288A is a differential pressure indicating switch. The Model 288A has a NEMA-4 watertight die-cast aluminum case (finished with a weather-resistant black epoxy resin paint). The cover lens is secured in the bezel with an elastomer ring to reduce the possibility of accidental breakage. This ring also acts as a seal between the bezel and the case to ensure a moisture, fume and dust-free atmosphere for the indicator and switch mechanism. The large cover lens allows maximum readability of the indicating pointer.

Switches and all adjustments are readily accessible when the cover is removed.

The built-in switches energize either single or dual alarm circuits when the measured differential pressures exceed predetermined limits. These limits may be either maximum, minimum, or both.

Main Components

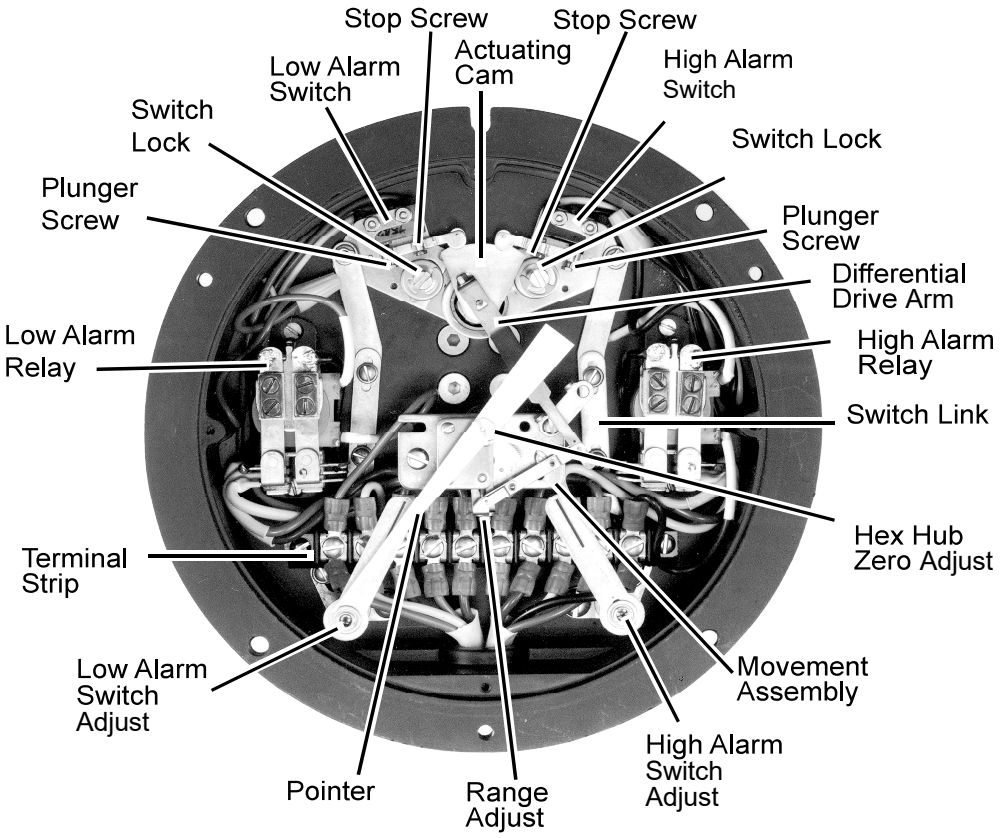
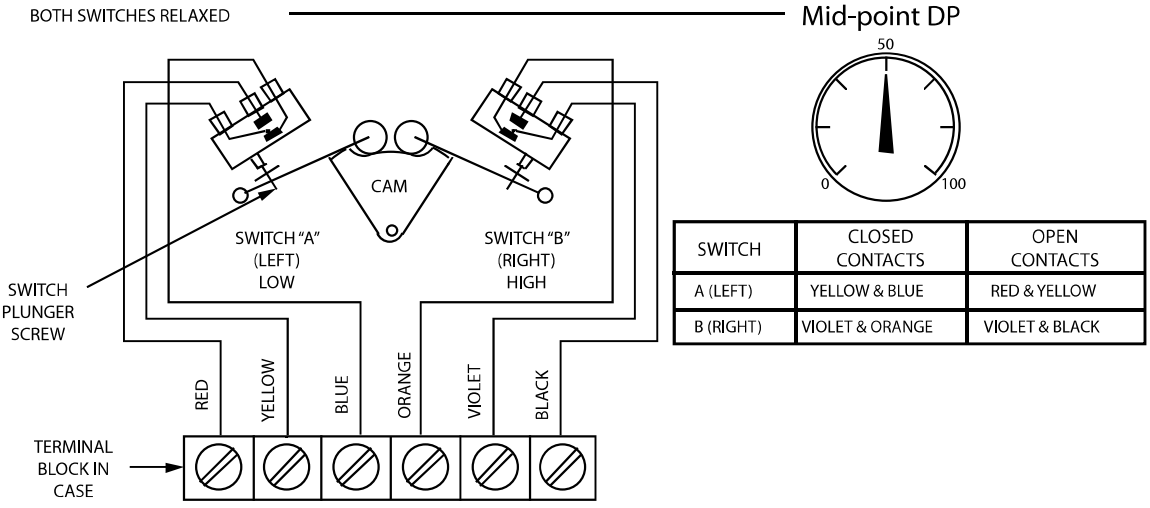


Figure 1.1—Switch components

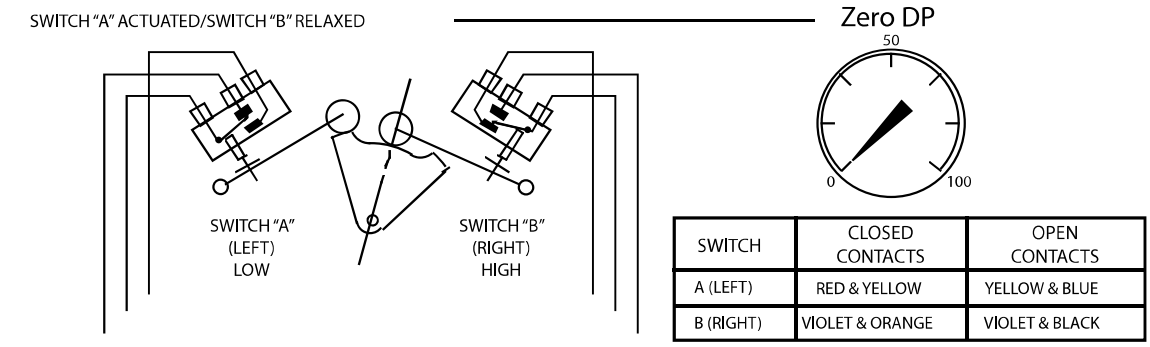
Indicating Switch

(refer to Figure 1.2, Figures 2.1 to 2.6, and Table 2.1)

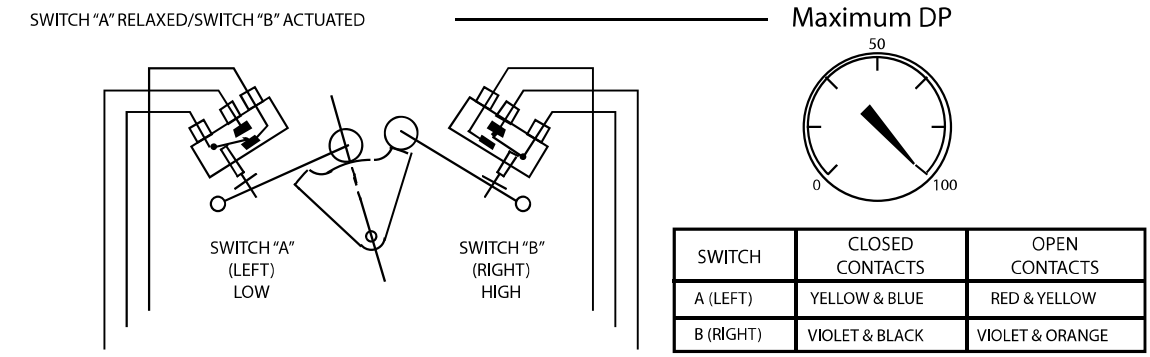
Rotation of the DPU torque tube shaft is coupled through connecting linkage within the switch case to move the pointer across the scale plate. An actuating cam, directly connected to the torque tube shaft, rotates with the motion of the shaft. Two cam follower roller/actuator arm assemblies, one for each switch, respond to torque tube rotation by opening and closing the switches as they ride on and off the cam. The levels of differential pressure at which the switches actuate are adjustable with high and low alarm switch adjustments on the scale plate.



SWITCH	CLOSED CONTACTS	OPEN CONTACTS
A (LEFT)	YELLOW & BLUE	RED & YELLOW
B (RIGHT)	VIOLET & ORANGE	VIOLET & BLACK



SWITCH	CLOSED CONTACTS	OPEN CONTACTS
A (LEFT)	RED & YELLOW	YELLOW & BLUE
B (RIGHT)	VIOLET & ORANGE	VIOLET & BLACK



SWITCH	CLOSED CONTACTS	OPEN CONTACTS
A (LEFT)	YELLOW & BLUE	RED & YELLOW
B (RIGHT)	VIOLET & BLACK	VIOLET & ORANGE

Figure 1.2—Switch actuation example

Standard models can have one or two alarm switches. Each switch can be connected to operate normally-opened or normally-closed. The direct-set switch contacts are adjustable over a scale range of 5-95% nominal.

The cam rotates counterclockwise with increased pressure. In Figure 1.2, page 4, the low switch is set at 25% differential pressure, and the high switch is set at 75% differential pressure.

Switches are available in several variations.

- SPDT: This is the standard model (low, high, or both)
- DPDT: Two switches are stacked and actuated by a single lever (low, high, or both)
- Three or four SPDT: Switches have independent switch points. Switches 1 and 3 are usually low switches set for decreasing pressures; switches 2 and 4 are usually high switches set for increasing pressures.

Relays

Relays are actuated by internal switches and are available in several variations:

- SPDT
- DPDT
- Two SPDT
- Two DPDT

Wiring

No. 22 AWG is used for internal wiring and No. 18 AWG is used for external wiring.

Differential Pressure Unit (DPU)

For detailed information on the Model 224 DPU, see Appendix A.

Specifications

General:

Actuating Unit (DPU)	Model 224 DPU
Dial Size	6 inches (150 mm)
Temperature Limits (Ambient)	-40°F (-40°C) to +180°F (+82°C)
Switch Repeatability	±0.25% of full scale
Switch Deadband	±5% (SPDT); ±6% (DPDT)
Switch Type	Mechanical, Snap-Acting; all switches are SPDT (DPDT switches are stacked SPDT switches with a common actuator)
Relay Contact Type	Single Pole, Double Throw (SPDT) Double Pole, Double Throw (DPDT)
Adjustability	5% to 95% of factory calibrated scale
Activation	Increasing or decreasing scale

Switch Contact Rating:
5.0 Amps @ 250 VAC, 50/60 Hz[1]
3.0 Amps @ 30 VDC (Resistive)[1,2]
1.0 Amp @ 30 VDC (Inductive)[1,2,3]

1. CSA Approved
2. CE Approved (Voltage limited to less than 50 VDC or 35 VAC for CE applications)
3. Arc suppression recommended for inductive loadings.

Relay Contact Ratings:
10 Amps @ 150/250 VAC
10 Amps @ 14/28 VDC
1.0 HP @ 208/240 VAC

Relay Coil Voltages:
120 VAC @ 5VA Max.
110 VDC @ 2W Max.

Coil Power Requirement:
DC Relay ..... 1.5 Watts
AC Relay ..... 2.75 Volt Amps

Accuracy of Indications (1 or 2 SPDT Switches):

0 to 30" WC to 0 to 50" WC	±1-1/4% of full scale DP
0 to 51" WC to 0 to 60 PSI	±1% of full scale DP
0 to 61 PSI to 0 to 150 PSI	±1-1/4% of full scale DP
0 to 151 PSI to 0 to 400 PSI	±1-1/2% of full scale DP
0 to 401 PSI to 0 to 600 PSI	±2% of full scale DP
0 to 601 PSI to 0 to 1000 PSI	±4-1/2% of full scale DP

1 or 2 DPDT Switches (S401)	Add ±1/2% to above values
Near switch setpoint (±10% full scale)	Add ±1/2% to above values
For suppressed ranges	Add ±1/4% to above values

Switch Deadband:
SPDT ..... ±5% of full scale DP (max)
DPDT ..... ±6% of full scale DP (max)

Accuracy of Repeatability ..... ±0.25% of full scale DP

Nuclear Qualifications

The following nuclear qualification applications are based on Cameron Engineering Report 9A-CR3-288A-13 and 50277306-C-0000193 with switch chatter sensitivity addressed in Cameron Engineering Report 9A-CR3-288A-19:

- One or two SPDT switches: Radiation Augmented (3 MRads), Full Functional, 12G, Mild Environment Applications
- One or two DPDT switches: Structural and Pressure Boundary Integrity Applications
- One or two relays: Structural and Pressure Boundary Integrity Applications
- Three or four independently adjustable SPDT switches: Structural and Pressure Boundary Integrity Applications

Section 2—Installation

General

The instrument should be inspected at time of unpacking to detect any damage that may have occurred during shipment.

IMPORTANT: The DPU was checked for accuracy at the factory. Do not change any of the settings during examination or accuracy could be affected.

For applications requiring special cleaning/precautions, a polyethylene bag is used to protect the instrument from contamination. This bag should be removed only under conditions of extreme cleanliness.

Mounting/Piping/DPU Installation

Dimensional drawings are provided in Section 5, page 34. See Appendix A for Model 224 DPU installation and maintenance information.

Electrical Connection (Switches/Relays)

Units are supplied with either single or dual alarm switches and/or relays (depending on customer order). The direct-set switch contacts are adjustable over 5% to 95% of the scale range.

Table 2.1, page 8, shows switch and relay wiring color coding for legacy and current configurations. Figures 2.1 through 2.6 show switch and relay wiring.

The high switch and low switch set point adjustment procedures are covered in Changing Switch Set Point, page 22.

For physical location of switches, see Figure 1.1, page 3.

Switch Use

Switch contact life and setpoint repeatability are influenced by various application conditions such as temperature, humidity, airborne contamination, vibration, amount of plunger travel, cycling rate, and rate of plunger travel (and others), as well as by the electrical (circuit) characteristics.

IMPORTANT: Field calibrations and switch setpoint testing should be performed at the same application conditions as expected when the instruments are required to perform their safety functions. Performance testing at one application condition may not necessarily ensure appropriate performance at another condition.

IMPORTANT: Arc suppression for inductive loads will prolong the life of the switch contacts.

IMPORTANT: Due to their size, subminiature switches have small mechanical clearances; therefore, no rating above 250 VAC has been established.

Table 2.1—Switch/Relay Wire Color Coding (4/06c)

	288A LEGACY CONFIGURATIONS (prior to Apr. 2006)			288A CURRENT CONFIGURATIONS		
	NO	**C**	**NC**	**NO**	**C**	**NC**
SPDT SWITCHES						
Low	Red	Yellow	Blue	Red	Yellow	Blue
High	Black	Green	White	Black	Violet	Orange
DPDT SWITCHES						
Low #1	Red	Yellow	Blue	Red	Yellow	Blue
Low #2	White/Red	White/Yellow	White/Blue	White/Red	White/Yellow	White/Blue
High #1	Black	Green	White	Black	Violet	Orange
High #2	White/Black	White/Green	White/Violet	White/Black	White/Violet	White/Orange
4-INDEPENDENTLY ADJUSTABLE SWITCHES						
Low #1	Red	Yellow	Blue	Red	Yellow	Blue
Low #2	White/Red	White/Yellow	White/Blue	White/Red	White/Yellow	White/Blue
High #1	Black	Green	White	Black	Violet	Orange
High #2	White/Black	White/Green	White/Violet	White/Black	White/Violet	White/Orange
SWITCHES FOR RELAYS						
Low	Red	Yellow	Blue (Note 1)	White/Brown	Brown	White (Note 1)
High	Black	Green	White (Note 1)	White/Gray	Gray	White (Note 1)
RELAYS						
Low #1	Gray	Blue	Brown	Red	Yellow	Blue
Low #2	White/Gray	White/Blue	White/Brown	White/Red	White/Yellow	White/Blue
High #1	Violet	White	Orange	Black	Violet	Orange
High #2	White/Violet	White/Black	White/Orange	White/Black	White/Violet	White/Orange
Coil Wiring:	Legacy Ver.: Low = Red and High = Black			Current Ver.: Low = White/Brown and High = White/Gray		

Note 1: Wire is NOT connected.

Startup

For startup procedures, warnings, and other information, refer to Appendix A.

IMPORTANT: To ensure the unit calibration is within factory-set calibration tolerances, perform the Calibration Check procedure on page 15.

Switch and Relay Wiring Diagrams

IMPORTANT: Figures 2.1 through 2.6 show: switch & relay contacts in the relaxed (shelf) condition, the low switch set to trip at a position below the pointer scale position, and the high switch set to trip at a position above the pointer scale position. NO = Normally Open in (shelf) condition. NC = Normally Closed in (shelf) condition. C= Common.

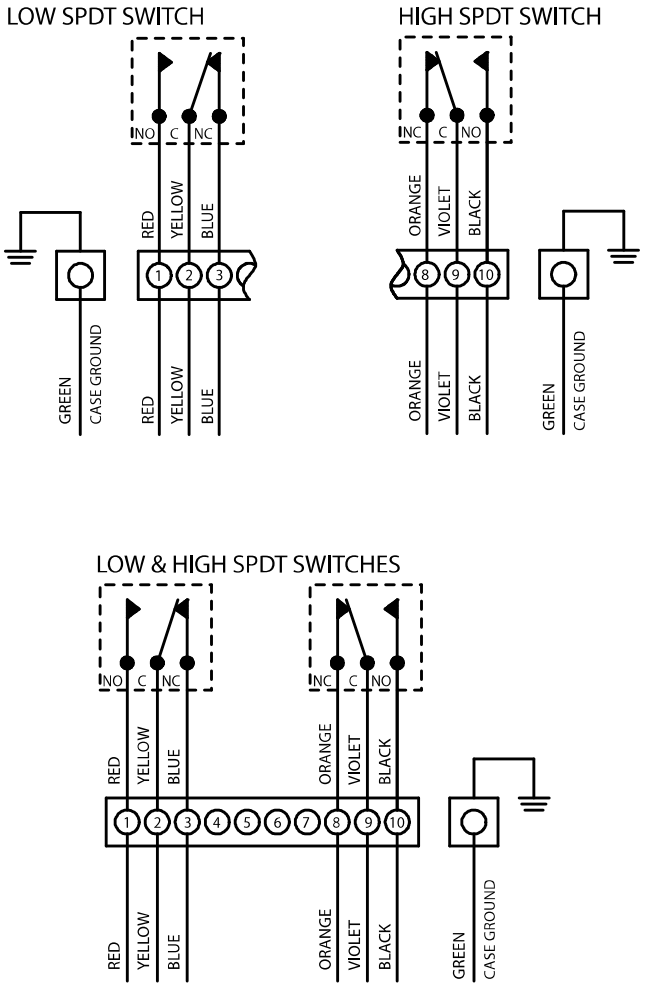


Figure 2.1—Low/high SPDT switch diagrams
(current configuration color codes - see Table 2.1, page 8)

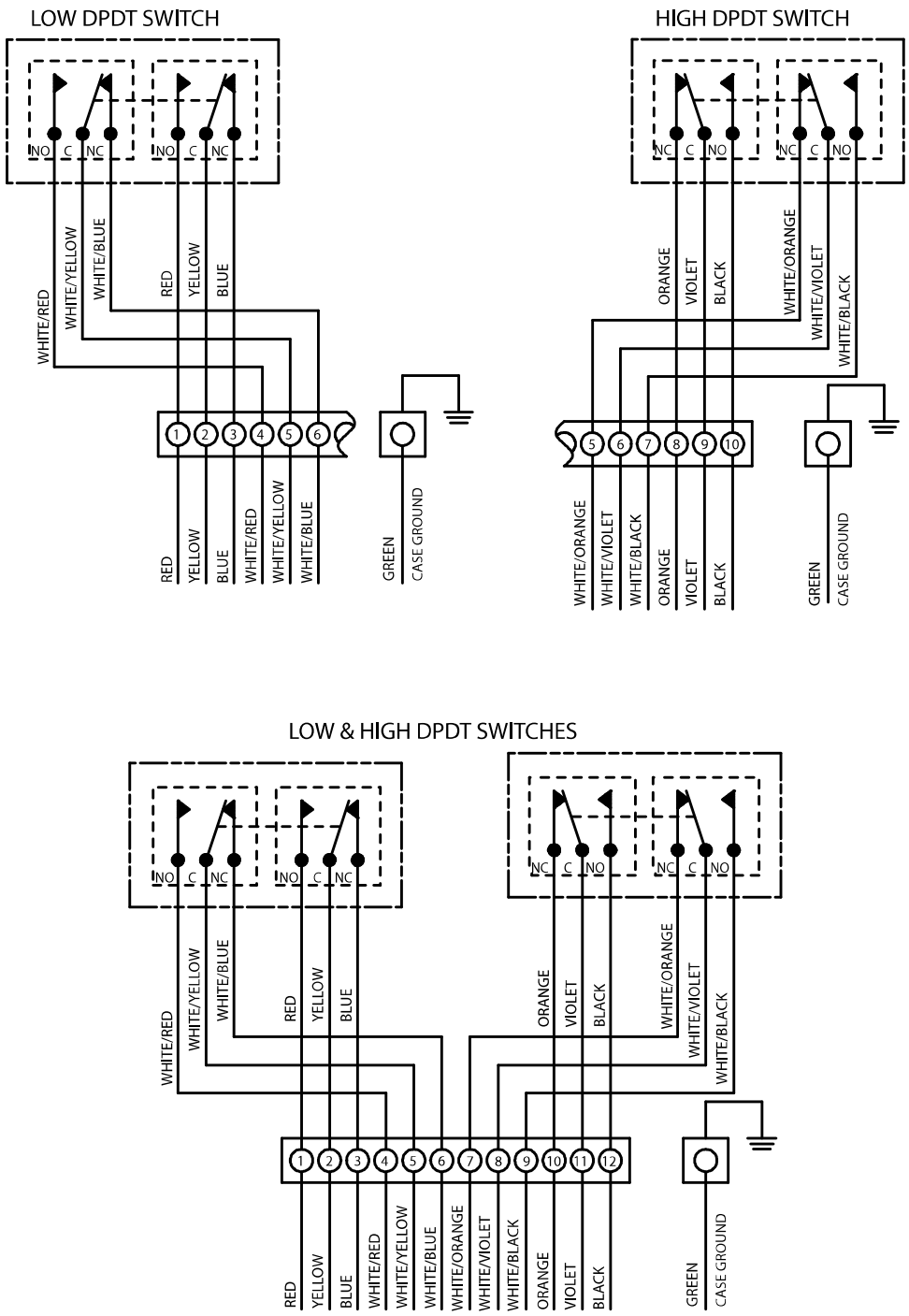


Figure 2.2—Low/high DPDT switch diagrams
(current configuration color codes - see Table 2.1, page 8)

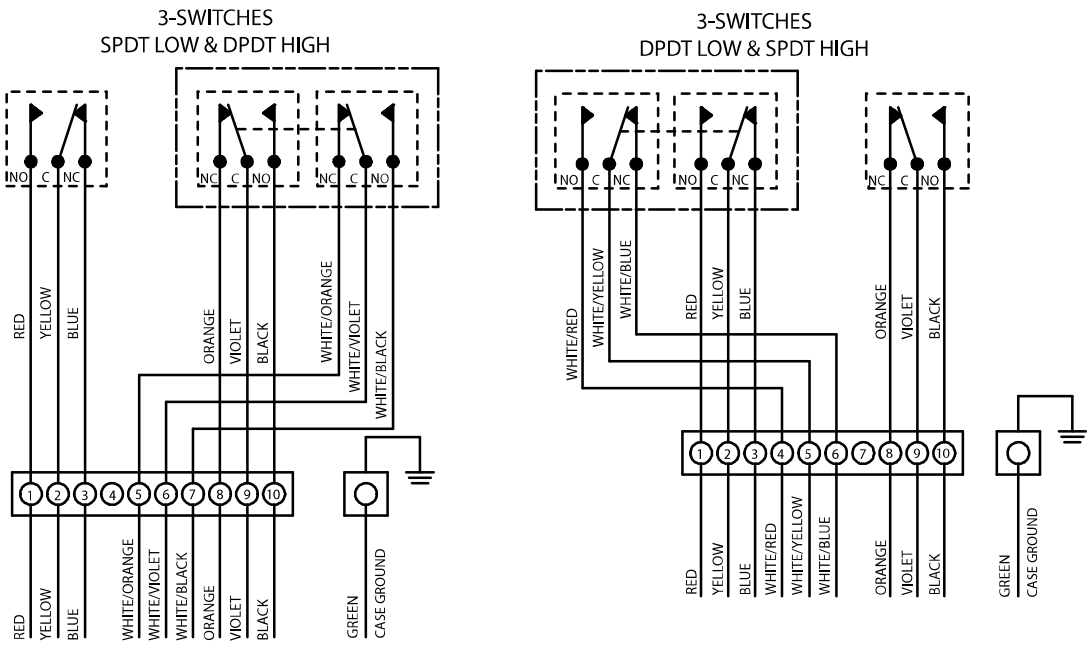


Figure 2.3—3-switch diagram
(current configuration color codes - see Table 2.1, page 8)

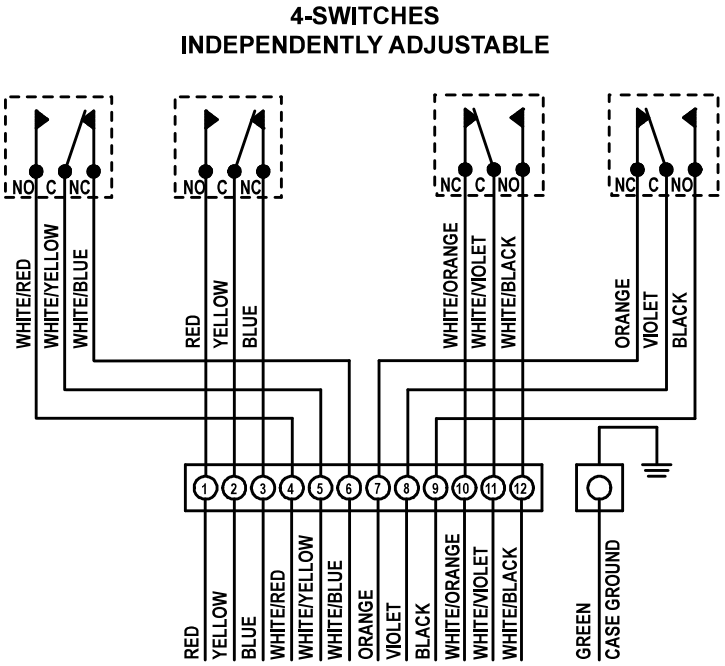


Figure 2.4—4-switch diagram (3 or 4 independently adjustable switches)
(current configuration color codes - see Table 2.1, page 8)

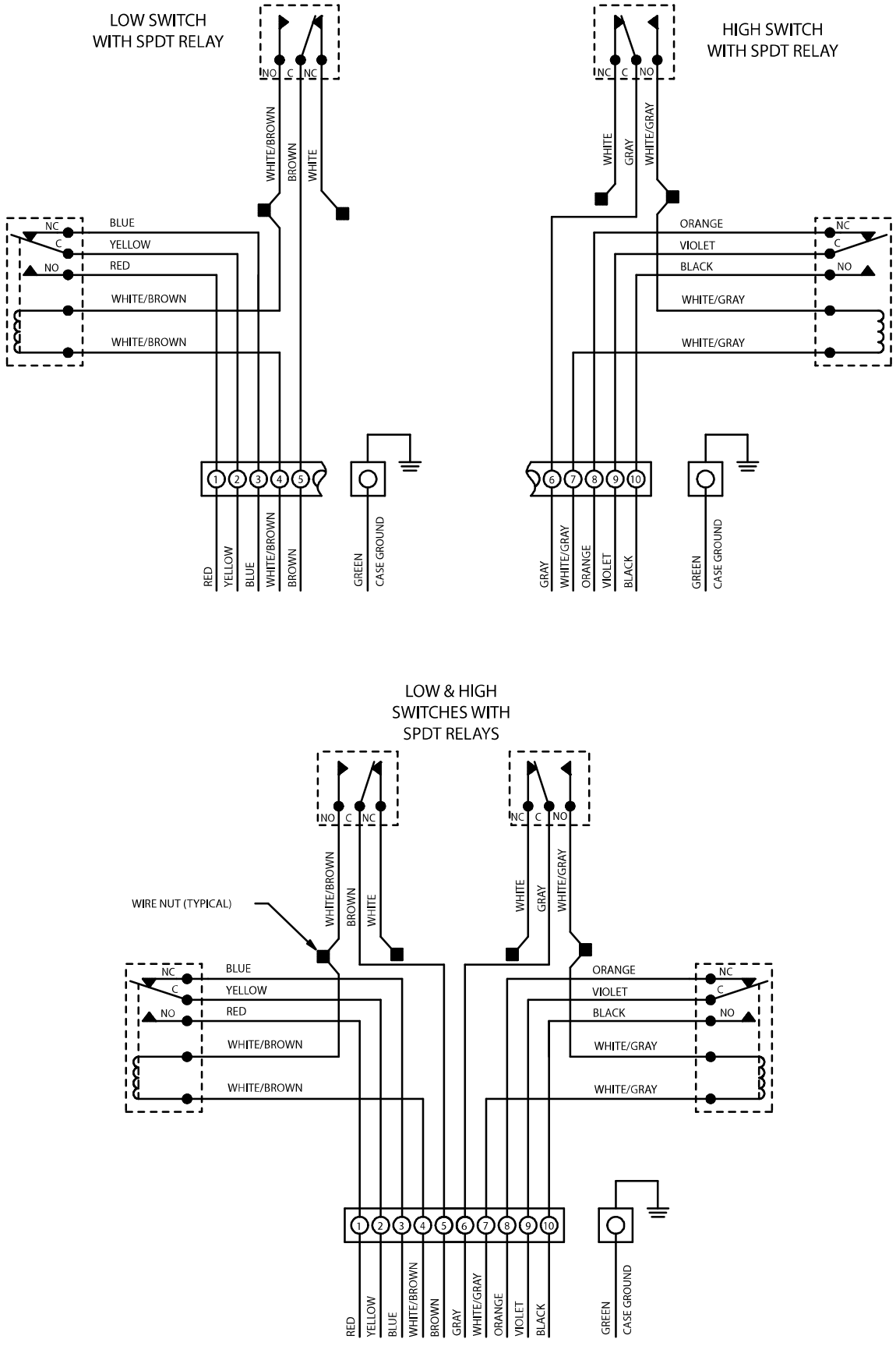


Figure 2.5—Low/high switch(es) w/SPDT relay(s) diagrams
(current configuration color codes - see Table 2.1, page 8)

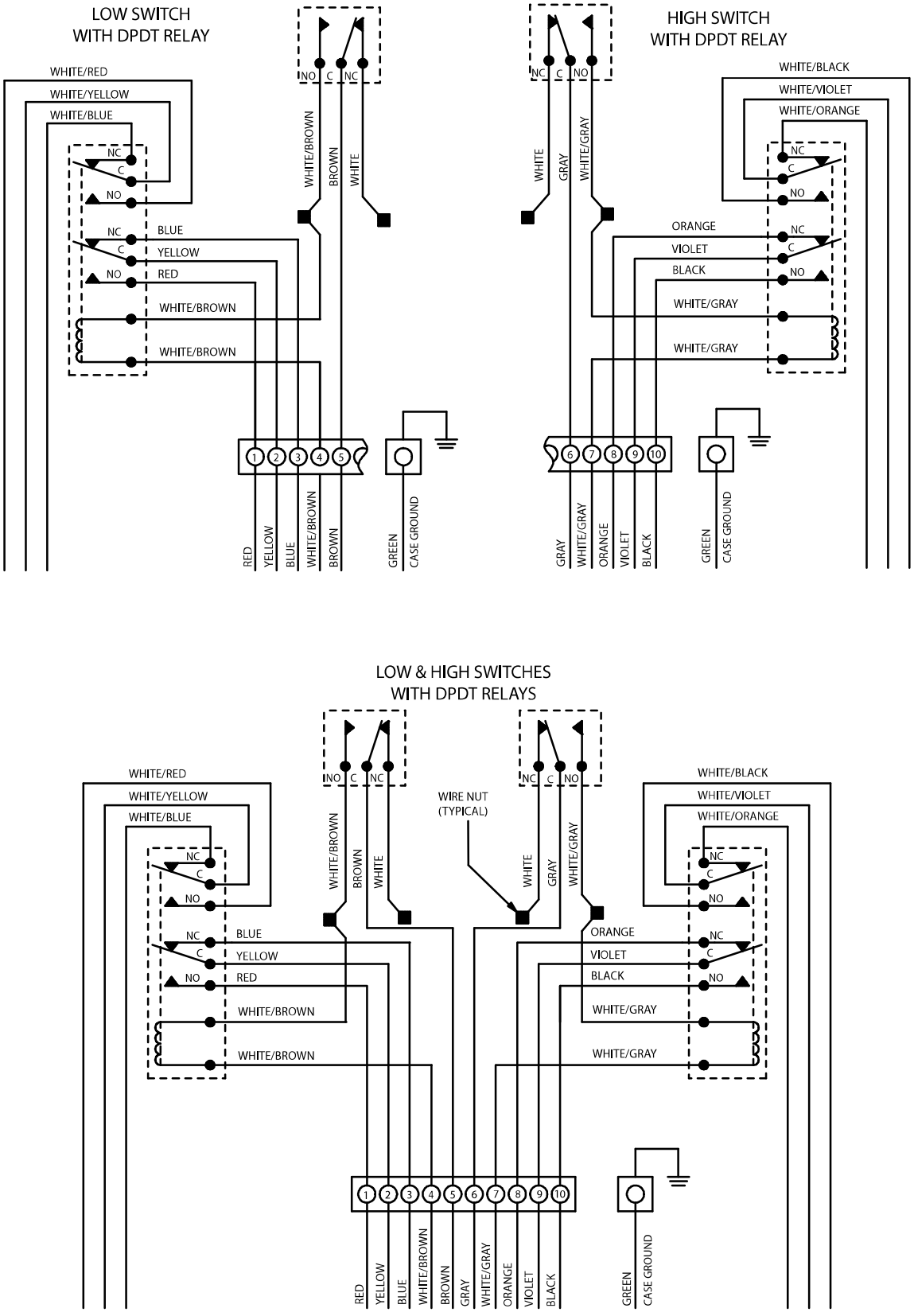


Figure 2.6—Low/high switch(es) w/DPDT relay(s) diagrams
(current configuration color codes - see Table 2.1, page 8)

Section 3—Maintenance and Calibration

The following checks are recommended for preventive maintenance:

- Periodically inspect alarm switch mechanism to verify that all mounting screws are seated properly.
- Inspect linkage for wear.
- Inspect integrity of electrical circuits. Tighten as necessary.

When repairs are necesssary, review this section for maintenance procedures such as bezel/lens installation and removal, pointer installation and removal, indicator calibration, switch calibration, and switch set point changes.

IMPORTANT See Appendix A for related warning/caution notices and instructions on DPU inspection, cleaning, service, repair, range change, and BUA replacement. **Never perform maintenance/repair on the instrument or DPU without first reviewing all procedures and warning/caution notices in Appendix A.**

Tools

The following tools are recommended for general maintenance of the Model 288A DP indicating switch.

Table 3.1—Tools

Equipment	Purpose
Pointer Puller	Pointer removal
Small Screwdriver	Calibration adjustment
Medium Screwdriver	Bezel removal and replacement
1/4" and 1/8" Open-end Wrenches	Zero (1/4") and Range (1/8") adjustments
1/8 Hex Allen Wrench	Switch set point adjustment
3/32" Hex Allen Wrench	Drive Arm Tightness Test

Bezel/Lens (or Cover) Installation and Removal

To remove the bezel and lens (or cover), perform the following steps, using Figure 3.1 for reference.

1. Loosen the three screws on the front of bezel.
2. Tilt the bottom of the bezel and slide the bezel upward.

To reinstall the bezel and lens, assemble the components per Figure 3.1, page 15. The two snubbers (Part No. 9A-C0266-0028C) on the scale plate should not be compressed against the lens cover and the pointer should not touch the lens.

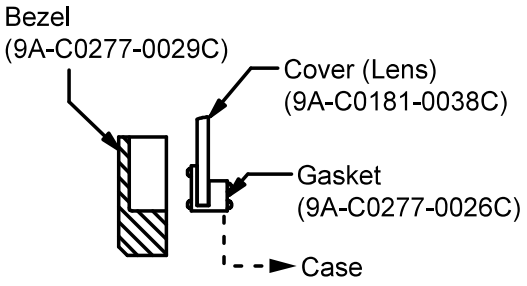


Figure 3.1—Bezel and lens cover

IMPORTANT: Ensure the bezel gasket is properly oriented before placing the instrument back in service. Incorrect gasket orientation will cause the instrument indicator to jam, resulting in inaccurate readings.

Calibration Check

To ensure the unit calibration is within factory-set calibration tolerances, perform the following procedure.

IMPORTANT: Review all procedures, WARNINGS/NOTICES in Appendix A BEFORE performing this procedure.

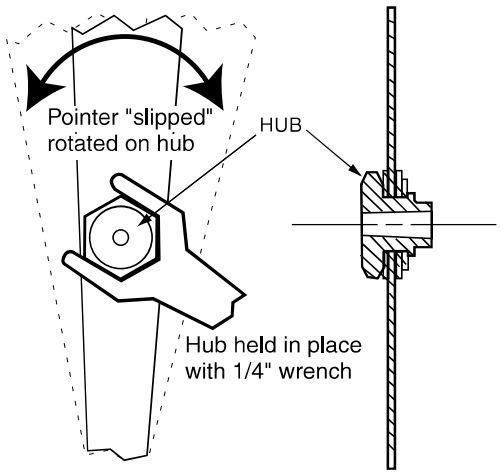


Figure 3.2—"Slipping" pointer

1. Mount the instrument in an approximately level position and connect to a standard pressure source (see Mounting, page A-5).
2. If the zero indication is incorrect, adjust it as follows:
   a. Remove the bezel/lens assembly.
   b. Using a 1/4" open-end wrench (included in calibration toolkit, Part No. 9A-0288-1032B), hold the hexagon pointer hub fixed and rotate the pointer with fingers until the pointer indicates zero on the scale. See Figure 3.2.
   c. Replace the bezel/lens assembly.

3. To test for reverse travel, connect the pressure source to the LP housing and vent the HP housing. Apply pressures approximately 150% of the DP range. The pointer should move approximately 5% to 10% below zero.
4. To test for overtravel, connect the pressure source to the HP housing and vent the LP housing. Apply pressures approximately 150% of DP range. The pointer should move approximately 5% to 10% above full scale.
5. Apply 0, 50, and 100% of full scale pressure. If indication is within specified limits, no adjustments are necessary. If indication is not within specified limits, perform a complete calibration (see Indicator Calibration, page 17).
6. Make sure the instrument zero indication is correct; otherwise, repeat step 2.
7. Verify the switch set points (refer to Changing Switch Set Point, page 22).

Pointer Installation and Removal

During adjustment and calibration of the unit, it may be necessary to remove and reinstall the pointer according to the following procedures.

Pointer Installation

1. Position the pointer on the movement shaft with the pointer set at zero scale. Obtain 75% to 90% pointer hub engagement on the movement pinion shaft. The pinion shaft must not extend through the pointer hub. It may be necessary to enlarge the hub hole, using a tapered broach (included in the calibration toolkit, Part No. 9A-0288-1032B).
2. Lightly tap the pointer hub with a hand-set or other flat-end tool. Use perpendicular blows to avoid bending the shaft.
3. Check the calibration of the indicating switch over its entire range (refer to Indicator Calibration, page 17). If the indicating switch is correctly calibrated, secure the pointer to the movement shaft by tapping the hub with a hand-set or other flat-end tool.
4. Test the pointer for tightness by moving the pointer from the zero to the 50% position manually, and then letting the pointer return freely to zero. If the pointer indicates a shift, tap the pointer hub to tighten it to the shaft.

Pointer Removal

The pointer is removed with a pointer puller shown in Figure 3.3, page 17. This tool is included in the calibration toolkit, Part No. 9A-0288-1032B.

To remove the pointer, perform the following steps:

1. Slide the pointer puller along the pointer until the pin protruding from the tip of the screw in the pointer puller is directly over the movement shaft and the arms of the pointer puller are directly under the pointer.

2. Gently turn the knurled head of the screw clockwise, pushing the pin against the movement shaft and lifting the pointer with the arms. Finger pressure should be sufficient to pull the pointer free. If more pressure is required, an Allen wrench (inserted into head of the screw) can be used. However, care should be exercised to avoid breaking the pin.

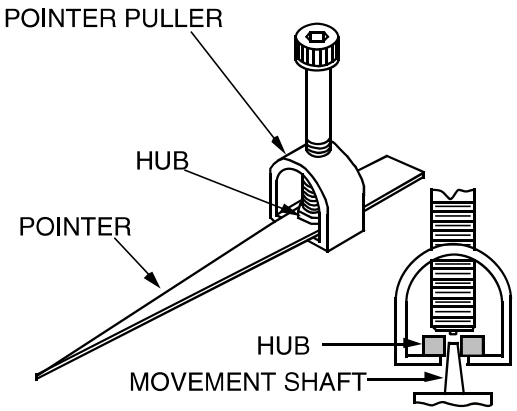


Figure 3.3—Pointer puller (Part No. 9A-0163-0005B)

Indicator Calibration

A complete calibration of the instrument is required whenever the DPU assembly is replaced.

IMPORTANT: Review all procedures, WARNINGS/NOTICES in Appendix A BEFORE performing this procedure.

1. Securely mount the instrument in an approximately level position and connect the DPU, as described in Mounting, page A-5.
2. Remove the bezel/lens assembly.
3. Align the linkage between the drive arm and the movement at 50% differential pressure (DP) as shown in Figure 3.4. Inspect parts for straightness and pivot-fit without binding.

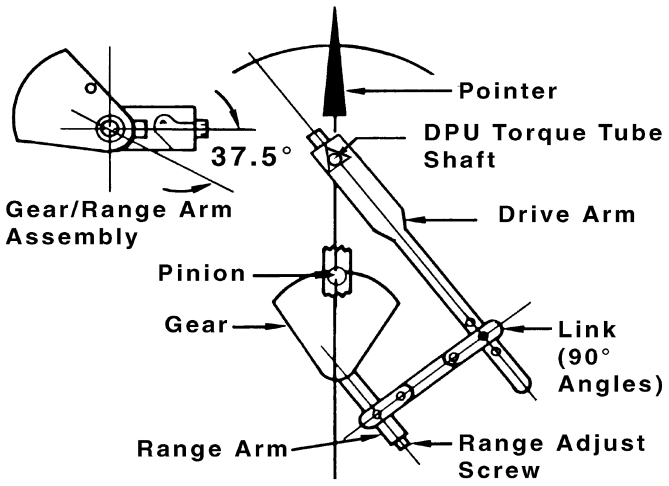


Figure 3.4—Range/linearity adjustment (50% DP)

4. Check the pointer for zero indication. If necessary, set the pointer to zero by slipping the pointer on the hub, per Calibration Check, step 2, page 15.
5. Apply 100% pressure. If the pointer exceeds full-scale, lengthen the movement range arm by adjusting the range adjust screw with a 1/8-in. open-end wrench.
6. Release pressure. Set the pointer to zero, by slipping the pointer on the hub, per Calibration Check, step 2, page 15.
7. Repeat steps 4 and 5, as necessary, to obtain the correct zero/full-scale.
8. Apply 50% DP. If the pointer indicates 50%, proceed to step 9. If the pointer does not indicate 50% scale, adjust linearity as follows.
   a. Loosen the drive arm screw (Figure 3.5) and move the arm to shift the pointer in the direction of the error a distance of about 10 times the linearity error.
   b. Check to see that the drive arm clears the end of torque-tube housing by approximately 0.030 in. before retightening the drive arm screw to prevent interference.
   c. While supporting the block/shaft, tighten clamp screw until snug to shaft.
   d. Still supporting block/shaft, tighten clamp screw an additional 1/3 to 1/2 turn. (This screw can normally turn one full revolution before breaking.)
   e. Perform the Drive Arm Tightness Test described on page 19.

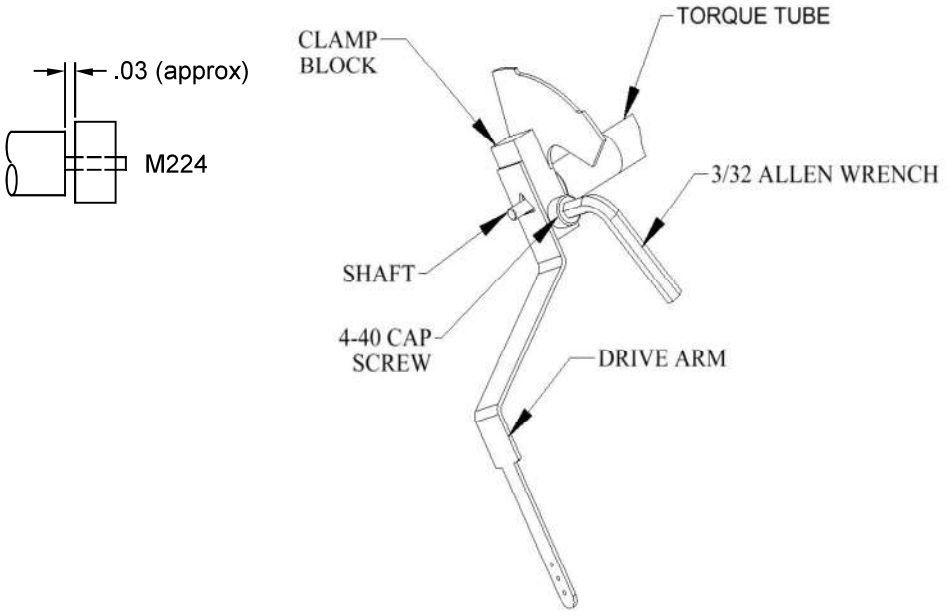


Figure 3.5—Drive arm to torque tube connection

9. Release pressure and reset the pointer at zero. Check the span. If the gear in the movement reaches a limit of travel as a result of linearity adjustment (step 7), slip the range arm along the gear approximately 5 degrees from the normal 37.5 degree angle to approximately 43 degrees (see step

2). The range arm is slipped by applying pressure to the range arm with thumb, while holding the gear firmly in place. Retest the pointer response at 50%, 0%, and 100% of full-scale differential pressure, and adjust the linkage until the readings are acceptable.

10. Apply 0%, 25%, 50%, 75%, 100%, 75%, 50%, 25%, and 0% of full-scale differential pressure consecutively to the instrument without overshoot. Lightly tap the indicator to overcome friction. The pointer should accurately indicate each applied pressure.
11. Test the instrument repeatability by applying 0%, 50%, 0%, 50% of full-scale differential pressure. The indicator should accurately indicate each applied pressure.
12. Set the drive arm stop to prevent the pointer from striking the snubbers on the scale. (See Drive Arm Stop Adjustment, page 20.)
13. Test the pointer for tightness per the pointer installation instructions on page 16.
14. If the drive arm screw has been loosened, verify that it is adequately tight by performing the Drive Arm Tightness Test described below.
15. Reassemble the unit per the cover installation instructions on page 14.

Drive Arm Tightness Test

This procedure tests the tightness of the drive arm's connection to the torque tube by applying torque developed by the DPU onto a fixed drive arm. Care should be taken to apply pressure slowly, as torque is being applied to the connection through the torque tube drive shaft.

1. With the pointer at normal 0% torque tube rotation position (0% on a normal 0 to 100% scale unit), adjust the drive arm stop bracket (or use alternate means) to prevent the pointer from moving (stop bracket interferes with drive arm movement).

IMPORTANT: On reverse acting/split range units, it will be necessary to pressurize the DPU to move the pointer to maximum minimum scale position, and on suppressed units, it will be necessary to apply pressure to establish a reference point to check for "zero" shift.

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2. Pressurize the DPU to full calibrated scale DP (100% of full scale range) to achieve 8 degrees of torque tube equivalent torque onto the connection.
3. Observe the shift in the unit "zero" following DPU depressurization (as required) and drive arm stop bracket readjusting (to allow free movement of drive arm and pointer). A downscale (counter-clockwise) shift in "zero" of greater than 1/2% is indicative of drive arm slippage, necessitating further clamp block tightening.

Drive Arm Stop Adjustment

1. Apply sufficient pressure to the high-pressure housing to deflect the pointer against the full range stop snubber on the scale plate.
2. Slide the upper drive arm stop bracket against the drive arm and tighten the drive arm stop bracket screw.
3. Apply sufficient pressure to the low pressure housing to deflect the pointer against the zero stop snubber on the scale plate.
4. Bend the zero drive arm stop against the drive arm.
5. Verify calibration as applicable.

Switch Calibration

Before performing a complete calibration procedure, verify that the instrument is out of calibration, by performing a calibration check procedure (page 15). If the instrument is out of calibration, before performing a complete calibration procedure, remove the bezel/lens and scale plate and inspect the switch mechanism (Figure 3.6) to verify the following:

- The roller rotates without wobble or binding.
- The cam is relatively centered under the roller.
- The actuator arm moves freely on its pivot.
- All switch mounting screws are tight.
- Linkages are straight and do not bind at the pivots.

Correct any problems that are observed.

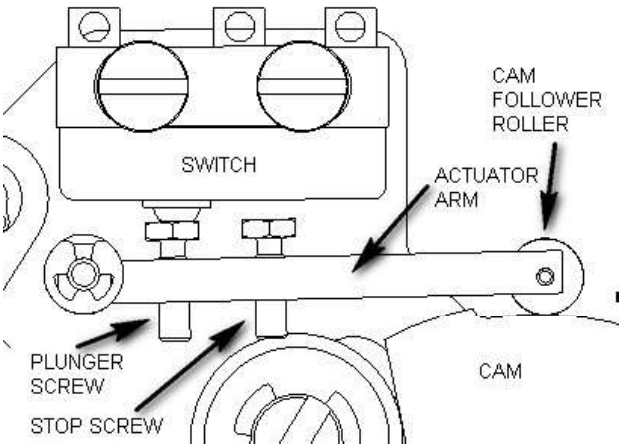

Figure 3.6—Switch mechanism

Calibration Setup

1. Connect the lamp or buzzer to the switch output leads.
2. Connect a test voltage to the switch input terminals on the terminal strip. (A low voltage is recommended for safety.) If a relay is installed in the instrument, coil voltage must be applied to the switch.

3. Unlock the switch plate and move the plate until the roller is positioned at the top of the cam.
4. Advance the plunger screw until the switch activates, then advance the plunger screw an additional 60° (one flat).
5. Exercise the switch roller up and down the cam to verify consistent on/off operation. Advance the stop screw to touch the switch, then back out the screw 1.5 turns (9 flats).

Calibration Procedure

To calibrate the switch linkage (required when the unit is rebuilt), perform the following steps. Refer to Figure 3.7 as needed.

1. Loosen the three linkage screws and turn the crank to the 12 o'clock position.
2. Use a 1/8-inch Allen wrench to hold the index shaft and slip the index pointer to 0 on the switch index. Tighten the screw on the crank to the mid-slot position.
3. Turn the switch index pointer to "1" (index numbers refer to numbers on outer edge of scale plate).
4. Apply 10% differential pressure and adjust the switch plate until the switch actuates. Lock the two linkage screws.
5. Rotate the index pointer to "9." Apply 90% differential pressure and adjust the crank radius until the switch actuates.
6. Recheck 10% and 90% set points. Adjust the crank radius and the index pointer until both set points are 2% accurate (nominal).

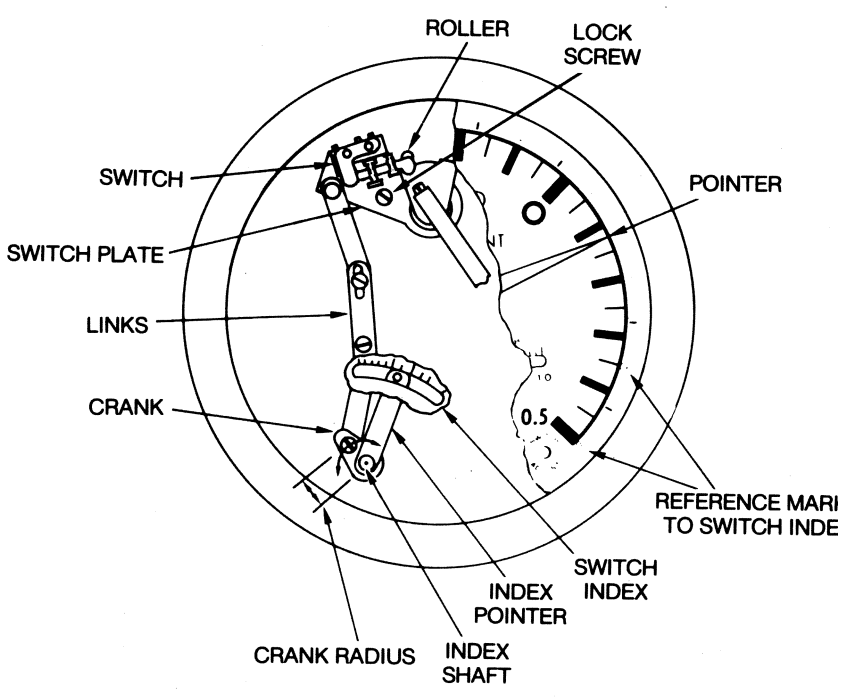

Figure 3.7—Linkage arrangement

7. If the switch is to be field-set at low differential pressure values (1% or 2% of pressure range), check the crank to prevent a top-dead-center position. Otherwise, the minimum set point position will be restricted and the set point may become reversed.
8. Adjust the switch to actuate at the desired pressure by applying test pressures in a decreasing direction, in discrete steps. Allow the unit and the pressure system to stabilize. Then change the pressure by a small amount. The magnitude of the pressure change is determined by the desired accuracy of the test. Tighten the lock screw before testing the switch performance.

IMPORTANT: The high switch is usually set to actuate at increasing pressure — when calibrating the high switch, apply test pressure in an increasing direction. This amount of loading will prevent cam-runout of a similar condition.

IMPORTANT: Excessive plunger loading (more than 3 flats) may cause the roller to drag on the cam. Cam friction will be apparent by excessive hysteresis, erratic pointer readings and inconsistent switch operation.

9. Check the switch deadband, (actuate to reset) by applying differential pressure, first in a decreasing direction, then in an increasing direction (opposite for high switch direction). Observe pressures. To reduce deadband, advance the plunger screw (two flats maximum).
10. Adjust the high switch to actuate at the desired pressure. The procedure is the same as for the low switch.

Changing Switch Set Point

(Tools: Screwdriver, 1/8-in. hex Allen wrench)

Definitions of Terms

Set Point. The measured pressure at which the snap-switch actuates and thereby changes the states of the N.O. and N.C. contacts. For example, the set point of the low switch is 24 psid with decreasing pressure.

Deadband. The difference in measured pressures between switch-actuation and switch-reset. Deadband is usually expressed as percent of full scale (% of F.S.). Deadband is not adjustable. For example, the switch in the set point example above was found to reset at 26.4 psid with increasing pressure. The deadband was 2.4 psi, or 4% of the full scale for a unit calibrated 0 to 60 psid.

Best Practices for Set Points

1. Always check the set point after tightening switch lock screws.
2. Switch setpoints may be set at any point of the scale range, except in a location that will prevent the deadband from enabling the switch to reset

itself. For example, the high switch (right side of scale) may be set at full scale, but should not be set near zero. The low switch may be set at zero, but should not be set near full scale. (Observe deadband values for specific models).

3. If switch performance is unsatisfactory (set point does not repeat, deadband is excessive, pointer exhibits hysteresis, contacts are unstable, etc.), remove the scale and inspect the switch and the switch mechanism. The scale is split to allow for removal without pulling the pointer.

Changing Set Point of an In-Service Instrument

(Not Recommended for Nuclear Qualified Units)

Use the following procedure to set a set point for an instrument that is in service, when calibration pressures cannot be applied. See Figure 3.8 for specific locations denoted by items A, B, C and D.

1. Remove the bezel/cover. Do not remove the pointer or scale.
2. Insert hex wrench in the switch adjust post.
3. Loosen the switch lock-screw, (item B), 1/2 to 1 turn.
4. With a hex wrench, move the index pointer (item C) to the new set point as indicated on the switch index (item D).
5. If possible, check the set point by varying the process pressures and observing the pointer readings when the switch actuates. (Open the manifold bypass valve slowly and watch for "pointer-jump" at the set point or by electrical signal.) Adjust the setting, if necessary, and repeat the test several times to verify stability.

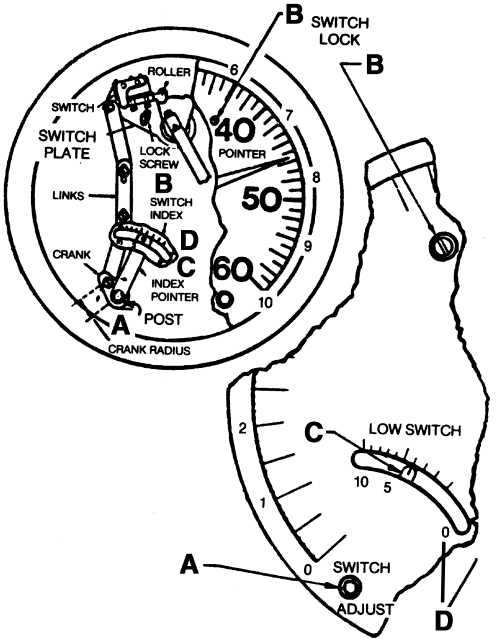

Figure 3.8—Set point adjustment

IMPORTANT: The switch index has 10 divisions, marked 0, 5, and 10. These match the markings on the outer edge of the scale.

Example: Scale has range of 0-60 psid. Set point is 24 psid, with decreasing pressure, (24/60 x 10 = 4).

1. Move the index pointer (item C) for the low switch from division 0 to division 4.
2. Tighten switch lock (Item B) snug plus 1/4 turn to place the set point within ±2% of full scale. Do not overtighten.
3. Repeat step 1 for the high switch, moving the index pointer from division 10 to division 4, and tighten the switch lock as described in step 2.

Changing Set Point of an Out-of-Service Instrument

Use the following procedure to set a set point for an instrument that is out of service—typically, an instrument that is disconnected from process lines or mounted on a bench.

1. Drain and vent housings.
2. Attach the calibration pressure source (air or N_2) to the DPU HP housing.
3. Apply varying pressures and observe pointer readings for accuracy. Use a pressure standard (Heise gage or equiv.) for reference. Change pressures slowly in discrete steps. A “bleed-pressure” method may cause errors.
4. Change switch set point as described in Changing Set Point of an In-Service Instrument, page 23.
5. Check the set point by changing measured pressure to actuate the switch. For example: To verify a low-switch set point of 24 psid, apply approximately 30 psi. Reduce pressure to approximately 25 psid, hold for a few seconds, then continue in 1/4 psid steps until the switch actuates. If the set point is incorrect, continue instructions in Changing Set Point of an In-Service Instrument, page 23.
6. To measure the switch deadband, reduce the pressure to zero, then increase pressure until the switch resets.
7. To verify repeatability of a set point, repeat step 5 several times. For improved accuracy, use smaller increments of pressure. Allow extra time for slow response gages and for test systems that have long runs of small-bore tubing.

High alarm switches (right side of the scale) are adjusted in a similar manner. Apply increasing pressure to establish the switch set point, and apply decreasing pressure to measure the deadband.

Range Changes

Changing the range of a Model 288 differential pressure indicating switch typically requires replacment of the DPU.

Parts Replacement

Due to the new snap-acting microswitch being used in Model 288A differential pressure indicating switch, the Drive Arm and Switch & Plate Assemblies have been redesigned. These assemblies are not backwards compatible and have to be installed at the same time for proper operation of the Model 288A.

Drive Arm and Switch & Plate Assemblies

1. Remove the bezel/cover per Bezel/Lens (or Cover) Installation and Removal, page 15.
2. Remove pointer (see Pointer Installation and Removal, page 17)
3. Remove scale plate by removing (4) Mounting Screws (see Figure 4.1).
4. Disconnect the Link from the original Drive Arm Assembly (see Figure 3.4).*
5. Loosen the Clamp Screw using 1/8” Open-end Wrench (for old style Drive Arm) or 3/32” Hex Allen Wrench (for new style Drive Arm).*
6. Carefully move the Actuator Arms away from the Cam and slide the Drive Arm Assembly off the Torque Tube.*
7. Disconnect the switch leads from the Terminal Block.
8. Carefully remove the Grip Ring and Washer securing the Drive/Link Plate assembly from the Switch and Plate Assembly and save for the installation process.
9. Remove the Lock Screw securing the high side Switch and Plate Assembly first and uninstall the Switch and Plate Assembly. Repeat for the low side assembly.
10. Install and secure the replacement Switch and Plate Assemblies in the reverse order above.
11. Install the replacement Drive Arm Assembly and ensure that the cam is relatively centered under the cam rollers. Tighten the Clamp Screw using 3/32” Hex Allen Wrench.*
12. Reconnect the switch leads to the Terminal Block.
13. Calibrate the switches per Calibration Procedure, page 21.

*Note: These steps may be omitted if the Model 288A is already equipped with the new Drive Arm and Switch & Plate Assemblies.

Troubleshooting

For indicating switch troubleshooting tips, see Table 3.2 below. For information related to the Model 224 DPU, see Table A.3, page A-15.

Table 3.2—Troubleshooting Tips

Problem	Possible Source	Probable Cause	Corrective Action
Low or No Indication	Indicator, Alarm Switch Mechanism	Loose linkage or movement	Tighten or replace
		Out of calibration	Calibrate
		Pointer loose	Tighten pointer
		Dirty or corroded mechanism	Clean or replace
		Wiring interfering with movement	Re-route wiring
		Dirty mechanism	Clean mechanism
High Indication	Indicator, Alarm Switch Mechanism	Loose linkage or movement	Tighten or replace
		Out of calibration	Calibrate
		Linkage dragging or dirty	Adjust or clean
		Pointer dragging on scale plate	Adjust pointer position
Inaccurate or No Electrical Alarm	Power Supply	Blown fuse	Replace fuse
		Broken or loose wire	Repair
	Alarm Switch	Switch not properly adjusted	Adjust switch
		Dirty or burned	Replace switch contacts
Switch Drifts (set point not repeatable)	Process Changes	Transients or surges cause switches to actuate prematurely	Add time delay gages or add time circuit
		Set point and/or deadband are too wide in pressure valves	Specify DP range as low as practical; set point repeatability and deadband are percentage of full range
		Electrical overloads affect the spring properties of the leaf actuator in the switch	Examine circuits for voltage, amperes
		DC inductive loads cause arcing and burning of contacts	Consider arc-suppression devices or relays
		Accumulation of fluids in piping generate artificial signal	Vent gas or drain liquids from signal lines

Table 3.2—Troubleshooting Tips

Problem	Possible Source	Probable Cause	Corrective Action
Switch Drifts (set point not repeat-able)	Calibration Techniques	Failure to check set point after locking	Verify set point repeatability after locking switch plate
Switch Drifts (set point not repeat-able)	Calibration Techniques	Rapid pressure change or venting system	During calibration, make pressure changes in slow, discrete steps
		Pressure application in reverse	Test low-alarm with decreasing pressure and high-alarm with increasing pressure
		Reference gage inaccuracy	Suitable pressure standard such as manometer, dead-weight tester, or Heise-type gage may be required
		Damage to switch contacts	Adjust plunger screws carefully to avoid damage to internal parts of switch

Section 4—Assembly Drawing and Parts Lists

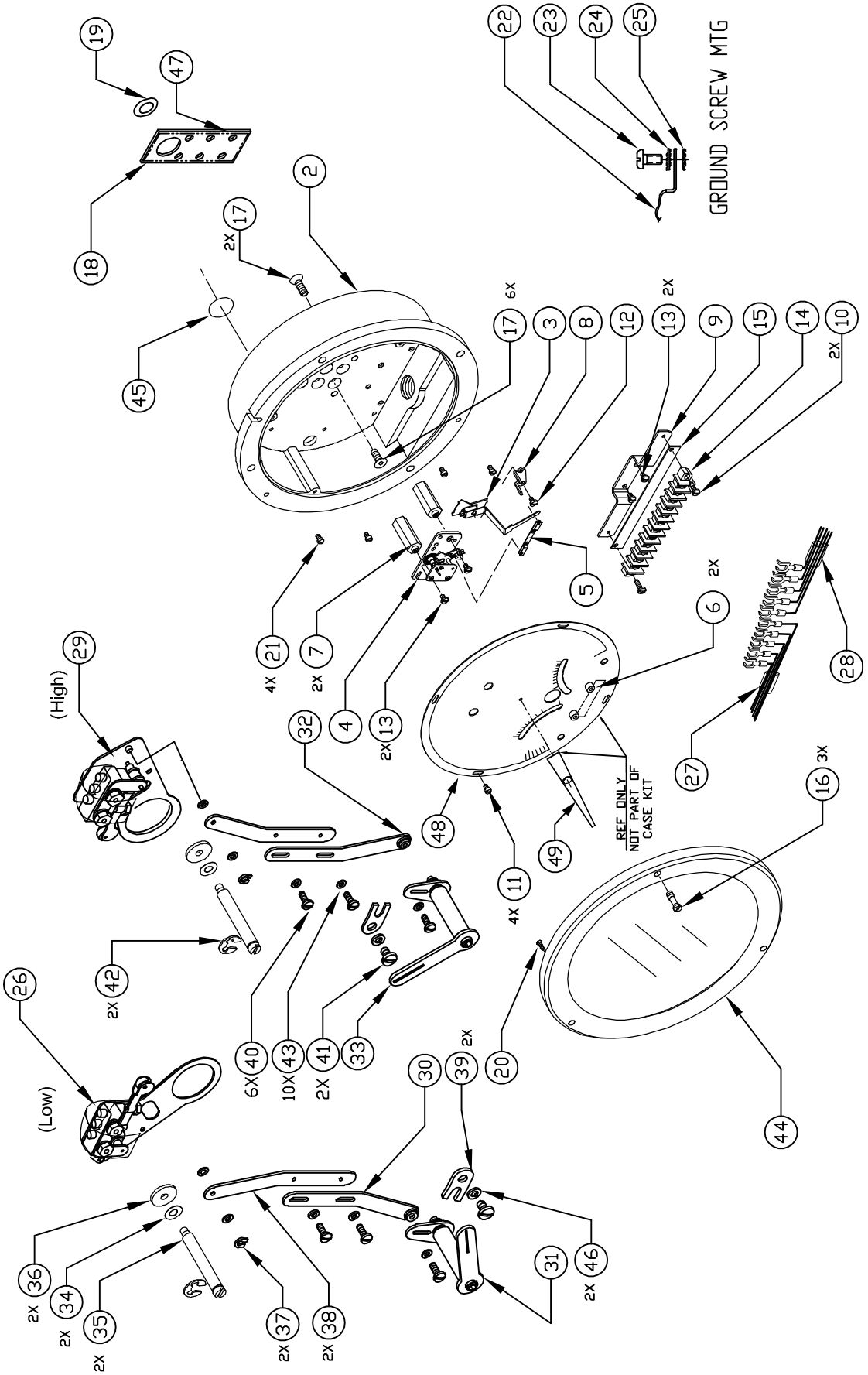

Figure 4.1—Model 288A

Table 4.1—Parts List, Model 288A Indicating Switch

Item	Description	Part No.	Per Unit
1	Differential Pressure Unit (not shown)	See Appendix A	1
2	Case Assembly		1
	1/2 NPT Conduit	9A-C0288-0038B	
	3/4 NPT Conduit	9A-CS666-0050Z	
3	Drive Arm Assembly, SW #1/2	9A-C0288-1190B-N	1
	Drive Arm Assembly, SW #3/4	9A-CS469-1006B-N	
4	Movement Assembly	9A-C0288-0035B	1
5	Link Assembly	9A-C0288-0036B	1
6	Snubber	9A-C0226-0028C	2
7	Movement Riser	9A-C0277-0035C	2
8	Stop Bracket	9A-C0288-0028C	1
9	Bracket, Terminal Block		1
	10-Position (Standard)	9A-C0288-0029C	
	10-Position (For 14 AWG Terminal Blocks)	9A-C0288-1161C	
	12-Position	9A-CS469-0060Z	
10	Screw, Rd Hd, 6-32 x 3/8, BRS, NP	9A-C0111-0015J	2
11	Screw, Sl Fil., Hd., 4-40 X 3/16, SST	9A-C0114-0023J	4
12	Screw, Bd Hd, 4-40 x 3/16, SST	9A-C0117-0012J	1
13	Screw, Bd Hd, 6-32 x 3/16, SST	9A-C0117-0013J	4
14	Terminal Block:		1
	10-Position (Standard)	9A-C0038-0033T	
	10-Position, 14 AWG	9A-C0288-1160C	
	12-Position	9A-CS469-0061Z	
15	Strip, Insulator		1
	10-Position (Standard)	9A-C0038-1345T	
	10-Position (For 14 AWG Terminal Blocks)	9A-C0038-1379T	
	12-Position	9A-C0038-1351T	

* Recommended spare part

** If the scale plate is not identified with an SCR number, provide the following information:

Square root or linear graduations,
Scale (e.g., 0-100, 25-0-100, etc.)
Number of graduations (linear scales only)
Data (e.g., PSI, bar, inches of water column, meter, etc.)

Additional Notes:

1. A/R indicates as required.
2. When ordering parts, specify serial number of instrument.
3. For 224 DPU parts, refer to Table A.4, page A-18.

Table 4.1—Parts List, Model 288A Indicating Switch

Item	Description	Part No.	Per Unit
16	Screw, Bezel	9A-C0181-0007C	3
17	Screw, Flat, Skt Cap, 10-32 x 1/2, SST (Riser/ DPU)	9A-C0240-0019J	8
18	Spacer, DPU to case	9A-C0224-1547C	1
19	O-Ring, 2-111, Viton	9A-C0001-0157R	1
20	Stud, Drive-Lok, Retaining, Bezel	9A-C0004-0005K	1
21	Screw, Relay Mtg. Hole Filler (if relay is not installed, 2 per relay, not shown)	9A-C0111-0007J	A/R
22	Ground Wire Assembly, External Wire	See Table 4.2, page 33	A/R
23	Ground Screw, Hex HD, 8-32 x 5/16, Grn	9A-C0117-1012J	1
24	Washer, Lock, Internal Tooth, #8, SST	9A-C0003-0066K	1
25	Washer, Lock, ET, #8, SST	9A-C0003-0050K	1
26	Switch and Plate Assembly: (Tefzel Insulation-Radiation Resistant) *see also item 29*		A/R
	Low, SPDT	9A-CS666-1200B-N	
	Low, DPDT	9A-CS401-0184B-N	
	Low Relay	9A-CS666-0290B-N	
	Low #1, Independently Adjustable*	9A-CS666-0286B-N	
	Low #2, Independently Adjustable*	9A-CS666-0287B-N	
	*Note: If 3 or 4 independently adjustable switches are used, Low #1 is installed in the upper left position, and Low #2 is installed in the lower right position.		
27	External Wire Assembly, Low	See Table 4.2, page 33	A/R
28	External Wire Assembly, High	See Table 4.2, page 33	A/R

* Recommended spare part

** If the scale plate is not identified with an SCR number, provide the following information:

Square root or linear graduations,
Scale (e.g., 0-100, 25-0-100, etc.)
Number of graduations (linear scales only)
Data (e.g., PSI, bar, inches of water column, meter, etc.)

Additional Notes:

1. A/R indicates as required.
2. When ordering parts, specify serial number of instrument.
3. For 224 DPU parts, refer to Table A.4, page A-18.

Table 4.1—Parts List, Model 288A Indicating Switch

Item	Description	Part No.	Per Unit
29	Switch and Plate Assembly: (Tefzel Insulation-Radiation Resistant) *see also item 26*		A/R
	High, SPDT	9A-CS666-1201B-N	
	High DPDT	9A-CS401-0185B-N	
	High Relay	9A-CS666-0291B-N	
	High #1, Independently Adjustable*	9A-CS666-0288B-N	
	High #2, Independently Adjustable*	9A-CS666-0289B-N	
	*Note: If 3 or 4 independently adjustable switches are used, High #1 is installed in the upper right position, and High #2 is installed in the lower left position.		
30	Low Alarm, Drive Plate Assembly	9A-C0288-0026B	A/R
31	Low Switch, Switch Adjustment Index Assy	9A-C0288-0028B	A/R
32	High Alarm, Drive Plate Assembly	9A-C0288-0027B	A/R
33	High Switch, Switch Adjustment Index Assy	9A-C0288-0029B	A/R
34	Washer, Spring (1 per switch)	9A-C0257-0019C	A/R
35	Screw, Lock (1 per switch)		A/R
	Switch #1 and #2	9A-C0317-0012C	
	Switch #3 and #4 (not shown)	9A-CS469-0045Z	
36	Washer, 1/2 OD x 0.14 ID, SST (1 per switch)	9A-C0317-0019C	A/R
37	Grip Ring (1 per switch)	9A-C0087-0011T	A/R
38	Link Plate (2 required when both low and high switches are used)	9A-C0288-1205C	A/R
39	Strap	9A-C0288-0017C	1
40	Screw, 3-48 x 3/16, SST, Binding Hd. (3 per switch)	9A-C0117-0007J	A/R
41	Screw, 8-32 x 1/4, SST, Binding Hd. (1 per switch)	9A-C0117-0016J	1
42	Retaining Ring (1 per switch)	9A-C0087-0015T	A/R

* Recommended spare part

** If the scale plate is not identified with an SCR number, provide the following information:

Square root or linear graduations,
Scale (e.g., 0-100, 25-0-100, etc.)
Number of graduations (linear scales only)
Data (e.g., PSI, bar, inches of water column, meter, etc.)

Additional Notes:

1. A/R indicates as required.
2. When ordering parts, specify serial number of instrument.
3. For 224 DPU parts, refer to Table A.4, page A-18.

Table 4.1—Parts List, Model 288A Indicating Switch

Item	Description	Part No.	Per Unit
43	Washer, Flat, #3, SST (5 per switch)	9A-C0003-0045K	A/R
44	Bezel Assembly (Bezel, Lens Cover, and Gasket)	9A-C0277-0018B	1
	Bezel (part of 9A-C0277-0018B)	9A-C0277-0029C	
	Lens Cover (part of 9A-C0277-0018B)	9A-C0181-0038C	
	Gasket (part of 9A-C0277-0018B)*	9A-C0277-0026C	
45	Disc, Sealer, 1/2" (w/3M 468 Adhesive)	9A-C0192-1035T	1
46	Washer, Split Lock, #8, SST (1 per switch)	9A-C0003-0036K	A/R
47	Sealing Compound, RTV 103	9A-C0006-1001V	A/R
48**	Scale Plate		1
	White	9A-C0288-1014C	
	Black	9A-C0288-0031C	
49*	Pointer Assembly		1
	White	9A-C0288-0030B	
	Black	9A-C0288-0031B	
	Low Relay Assy (with Tefzel insulated wires) ***Coil Voltage*** ***Wired SPDT*** ***Wired DPDT*** 115 VAC 9A-CS666-0238Z 9A-CS666-0245B 110 VDC 9A-CS666-0231Z 9A-CS666-0256B		1
	High Relay Assy (with Tefzel insulated wires) ***Coil Voltage*** ***Wired SPDT*** ***Wired DPDT*** 115 VAC 9A-CS666-0237Z 9A-CS666-0246B 110 VDC 9A-CS666-0230Z 9A-CS666-0279B		1
	Spacer, Switch Plate (1 per switch, used w/ single high switch or 3 independently adjustable switches when #3 position is not used, not shown)	9A-C0258-0007C	1
	Screw, Switch Lock Hole Filler (if switch is not installed, 1 per switch, not shown)	9A-C0111-0028J	A/R

* Recommended spare part

** If the scale plate is not identified with an SCR number, provide the following information:

Square root or linear graduations,
Scale (e.g., 0-100, 25-0-100, etc.)
Number of graduations (linear scales only)
Data (e.g., PSI, bar, inches of water column, meter, etc.)

Additional Notes:

1. A/R indicates as required.
2. When ordering parts, specify serial number of instrument.
3. For 224 DPU parts, refer to Table A.4, page A-18.

Table 4.1—Parts List, Model 288A Indicating Switch

Item	Description	Part No.	Per Unit
	Screw, Strap Hole Filler (if switch is not installed, 1 per switch, not shown)	9A-C0119-0042J	A/R
*	Calibration Kit (not shown)	9A-0288-1032B	A/R

* Recommended spare part
** If the scale plate is not identified with an SCR number, provide the following information:
Square root or linear graduations,
Scale (e.g., 0-100, 25-0-100, etc.)
Number of graduations (linear scales only)
Data (e.g., PSI, bar, inches of water column, meter, etc.)

Additional Notes:
1. A/R indicates as required.
2. When ordering parts, specify serial number of instrument.
3. For 224 DPU parts, refer to Table A.4, page A-18.

Table 4.2—Tefzel Insulation (Radiation Resistant) External Wire Leads (Table 4.1, Items 27 and 28)

Wire Type	2.5 ft	10 ft	15 ft	20 ft
Low #1	9A-CS666-0213Z	9A-CS666-0190Z	9A-CS666-0194Z	9A-CS666-0201Z
High #1	9A-CS666-0140Z	9A-CS666-0191Z	9A-CS666-0195Z	9A-CS666-0202Z
Low #2	9A-CS666-0166Z	9A-CS666-0241Z	9A-CS666-0268B	9A-CS666-0203Z
High #2	9A-CS666-0167Z	9A-CS666-0242Z	9A-CS666-0269B	9A-CS666-0204Z
Low Relay	9A-CS594-0137Z	—	—	—
High Relay	9A-CS594-0138Z	—	—	—
Ground	9A-CS666-0270B	9A-CS666-0271B	9A-CS666-0272B	9A-CS666-0273B

Section 5—Dimensional Drawings

IMPORTANT: For DPU dimensional information, refer to DPU Dimensional Drawings, page A-19.

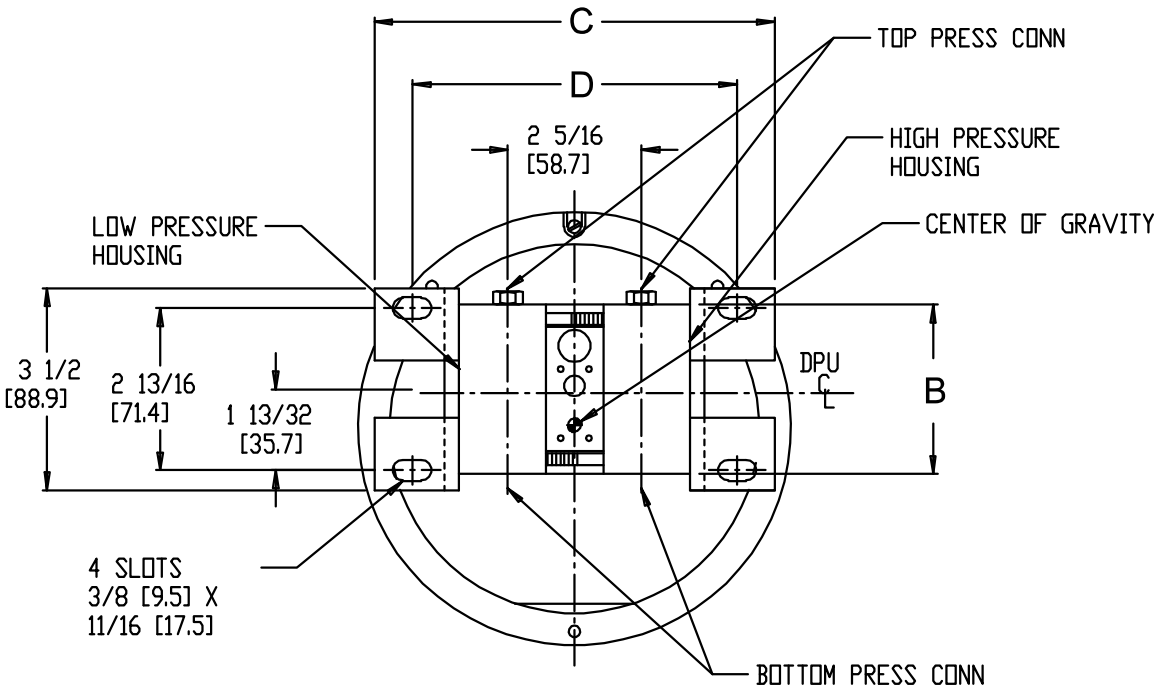

Figure 5.1—Model 288A, rear view

Pressure Rating PSI (MPa)	Housing Material	Dim. A inches (mm)	Dim. B inches (mm)	Dim. C inches (mm)	Dim. D inches (mm)	Pressure Connection (Note 1)	
						Top	Bottom
500 to 1500 (3.4 to 10.3)	ALL	6 1/4 (158.8)	2 15/16 (74.6)	6 15/16 (176.2)	5 5/8 (142.9)	1/2" NPT 1/2" NPT 1/4" NPT 1/4" NPT	1/4" NPT 1/2" NPT 1/4" NPT 1/2" NPT
3000 to 6000 (20.7 to 68.9)	ALL	6 3/8 (161.9)	3 1/4 (82.5)	7 5/16 (185.7)	6 (152.4)	1/2" NPT 1/2" NPT 1/4" NPT 1/4" NPT	1/4" NPT 1/2" NPT 1/4" NPT 1/2" NPT

1. Can be rotated 180° in the field.
2. All Standard pipe fittings furnished by customer.
3. Metric conversions are approximate.

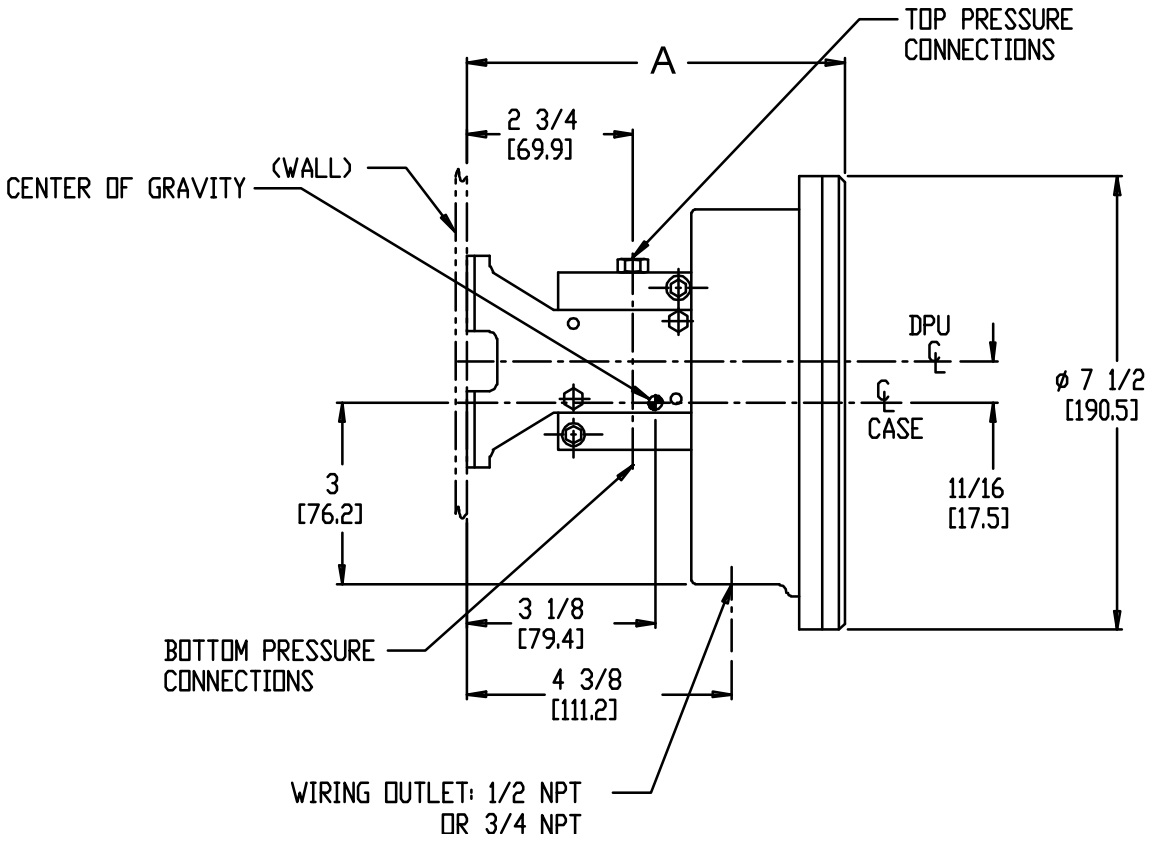

Figure 5.2—Model 288A, side view
(see table in Figure 5.1, page 34, for Dim. A measurements)

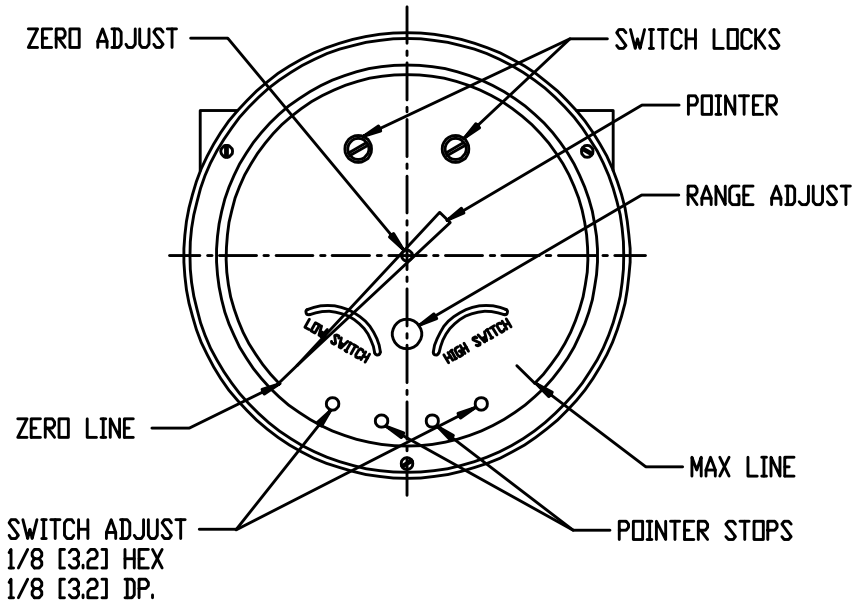

Figure 5.3—Model 288A, front view

Appendix A—Model 224 DPU

DPU Description

The Barton Model 224 Differential Pressure Unit (DPU) is a mechanical device that measures differential pressure relative to a gas or liquid flowing through a process system, or to the level of a liquid contained in a process vessel.

For process flow measurements, the DPU is connected across a primary measuring device (e.g., venturi, orifice plate, or flow tube) located in the process system.

For liquid level measurements, the DPU may be connected in a variety of ways.

The Model 224 DPU is a dual bellows assembly enclosed within pressure housings. The dual bellows assembly consists of two opposing internally connected liquid-filled bellows, a center block, range springs, overrange valves, and a torque tube assembly.

The pressure housings are connected by pipe or tubing to the primary measuring device located in the system piping. Variations in differential pressure within the pressure housings cause the bellows to expand or contract laterally. The linear movement of the bellows causes the torque tube to rotate, which actuates the process monitoring instrument.

The process monitoring instrument may be an indicator, a switch, a transmitter, a recorder, or other process control device.

Specifications

The Model 224 DPU is available in various pressure ratings to measure to specific ranges between 0-30 inches of water column and 0-1000 psi, with safe working pressure (SWP) ratings of 500, 1000, 1500, 3000 and 6,000 psi. See Table A.1, page A-3.

The Model 224 Bellows Unit Assembly (BUA) is available in three bellows diameters: 1 5/8 inch, 3/4 inch and 5/8 inch (shown in Figure A.1, page A-2).

The BUA with 1 5/8-inch bellows accommodates differential pressures to 60 psi. The range springs are contained within the bellows and do not come in contact with the measured liquid.

The BUA with 3/4-inch bellows accommodates differential pressures up to 400 psi. The range springs are grouped around the outside of the bellows and must be of a material that is compatible with the liquid being measured.

The BUA with 5/8-inch bellows accommodates differential pressure ranges up to 1000 psi. Like the BUA with 3/4-inch bellows, the range springs are grouped outside the bellows.

The Model 224 DPU general specifications are presented in Table A.1, page A-3.

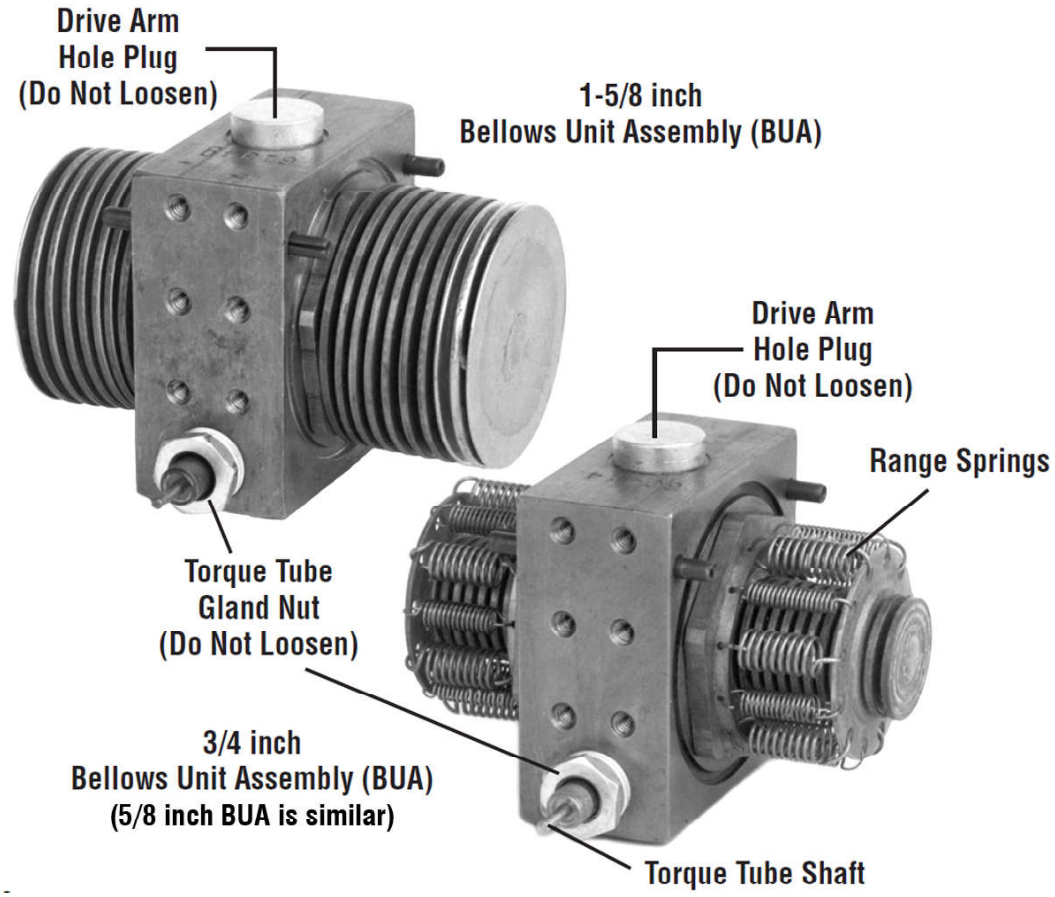

Figure A.1—Bellows Unit Assembly (BUA)

Table A.1—Model 224 DPU Specifications				
SWP psi (bar)	BODY	AVAILABLE DIFFERENTIAL PRESSURE RANGES		
	Housing Material	Stainless Steel/Inconel Bellows		Inconel Bellows
		1-5/8" (41.3 mm) O.D.	3/4" (19.1 mm) O.D.	5/8" (15.9 mm) O.D.
500 (34.5)	Stainless Steel (316) Copper Nickel (70-30)	0-30" (0-762 mm) w.c. to 0-60 psi (0-3.8 bar)	0-61 psi (0-3.9 bar) to 0-400 psi (0-27.6 bar)	0-400 psi (0-27.6 bar) to 0-500 psi (0-34.5 bar)
1,000 (68.9)	Copper Nickel (70-30) (MIL-C-15726)	0-60" (0-1524 mm) w.c. to 0-60 psi (0-3.8 bar)	0-61 psi (0-3.9 bar) to 0-400 psi (0-27.6 bar)	0-400 psi (0-27.6 bar) to 0-1000 psi (0-68.9 bar)
1,500 (103.4)	Stainless Steel (316)	0-60" (0-1524 mm) w.c. to 0-60 psi (0-3.8 bar)	0-61 psi (0-3.9 bar) to 0-400 psi (0-27.6 bar)	0-400 psi (0-27.6 bar) to 0-1000 psi (0-68.9 bar)
3,000 (206.9)	Stainless Steel (316)	0-60" (0-1524 mm) w.c. to 0-60 psi (0-3.8 bar)	0-61 psi (0-3.9 bar) to 0-400 psi (0-27.6 bar)	0-400 psi (0-27.6 bar) to 0-1000 psi (0-68.9 bar)
6,000 (413.8)	Stainless Steel (316)	0-60" (0-1524 mm) w.c. to 0-60 psi (0-3.8 bar)	0-61 psi (0-3.9 bar) to 0-400 psi (0-27.6 bar)	0-400 psi (0-27.6 bar) to 0-1000 psi (0-68.9 bar)
Net Volume (cu. in.)	L.P. Head	1.66" (42.2 mm)	2.51" (63.8 mm)	2.61" (66.3 mm)
	H.P. Head	1.55" (39.4 mm)	2.42" (61.5 mm)	2.50" (63.5 mm)
Displacement in cu. in. for full-scale travel		0.14" (3.6 mm)	0.03" (0.8 mm)	0.025" (0.6 mm)
Pressure Ranges	Zero center or split ranges available on special order (e.g. a 0-60" w.c. (0-1524 mm) range may be ordered 30-0-30" w.c. (762-0-762 mm) or 15-0-45" w.c. (381-0-1143 mm); Absolute pressure ranges available from 30" w.c. (762 mm) to 400 psi (41.4 bar).			
Pressure Connections	1/4 NPT top x 1/4 NPT bottom 1/4 NPT top x 1/2 NPT bottom 1/2 NPT top x 1/4 NPT bottom 1/2 NPT top x 1/2 NPT bottom			
Performance	Torque Tube Rotations (full- scale DP)	8° ± 10%		
	Temperature Limits	-40°F (-40°C) to 180°F (+82°C)		
	Maximum Non-linearity:			
	0-30" wc to 0-150 psi	± 1-1/2%		
	0-150 psi to 0-400 psi	± 2%		
	0-400 psi to 0-1000 psi	± 4%		
	Repeatability	± 0.2% of full scale		
Dimensions	Outline dimension drawings available upon request.			

Theory of Operation

The Barton Model 224 DPU shown in Figure A.2, page A-4, measures the differential pressure in a process system relative to process functions and produces a mechanical output that actuates process monitoring instruments and process control devices.

The high-pressure (HP) housing is connected by pipe or tubing to the high-pressure side of the primary measuring device. The low-pressure (LP) housing is connected to the low-pressure side of the primary device.

As pressure changes within the housings, the bellows move laterally. The connecting drive arm follows the motion of the bellows, and twists the torque tube. The rotation of the torque tube shaft provides the mechanical motion

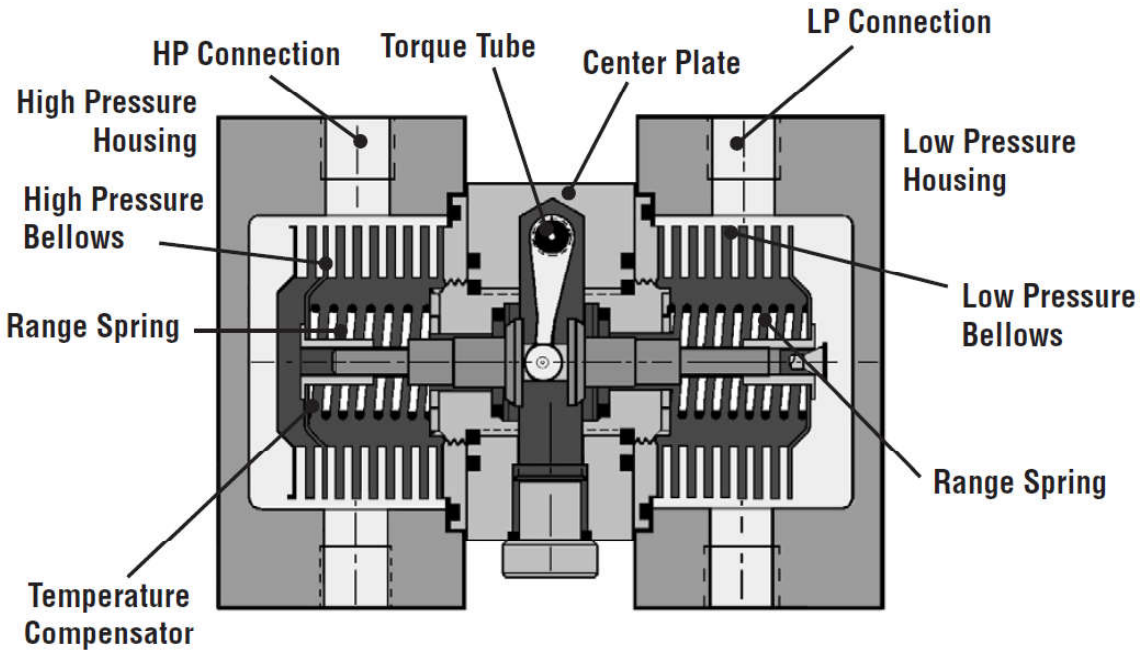

Figure A.2—Model 224 DPU components

required to actuate process instruments, such as recorders, indicators, transmitters, controllers, and switches.

If the bellows are subjected to a pressure greater than the range of the DPU, they move their normal travel range and a small amount of overtravel until the overrange valve seals against the valve seat. As the valve closes, the fill liquid is trapped in the bellows. Since the fill fluid is essentially noncompressible, the bellows are fully supported and will not be damaged regardless of the overpressure (up to the full rated pressure of the instrument) applied to them. Also, since dual overrange valves are used, full protection against overrange is provided in either direction.

An additional convolution in the high-pressure bellows provides for expansion or contraction of the fill fluid relative to ambient temperature changes. This extra convolution acts as an accumulator, permitting the fill fluid to change volume without materially affecting the pressure within the bellows or changing the physical relationship of the two bellows.

DPU Installation

General

Inspect the instrument after unpacking it to detect any damage that may have occurred during shipment.

IMPORTANT: The DPU was checked for accuracy at the factory. Do not change any of the settings during examination or accuracy could be affected.

For applications requiring special cleaning/precautions, a polyethylene bag is used to protect the instrument from contamination. Remove this bag only under conditions of extreme cleanliness.

Mounting

Mount the instrument to a solid support with four 5/16-inch (8 mm) grade 5 or better bolts, and apply 17 ft-lb of torque. To minimize relative motion of the DPU connections, use a mounting structure that will also support the interfacing process tubing.

Mounting structures shall be designed to avoid resonance and/or minimize resulting amplification below 33 Hz. Response spectra at the mounting surface of the instrument shall not exceed those in the applicable nuclear qualification report.

Piping

WARNING: High pressure hazard. To prevent personal injury or damage to equipment, direct all piping away from the operator while connecting the DPU to system piping.

IMPORTANT: Do not share filling or vapor return lines with DPU piping lines.

Observe the following standard practices when installing piping:

- Shorten the distance between the primary measuring device and the DPU as much as possible. Distances exceeding 100 ft are not recommended. For distances up to 50 ft, use 1/4-in. pipe or tubing. For runs of 50 to 100 ft, use 1/2-in. pipe or tubing. The recommended limitation does not apply if an air purge or blow-back system is used.
- Slope all piping at least 1 inch per linear foot to avoid liquid or gas entrapment.
- If process media exceeding +200ºF (+93.3ºC) must be measured, install 2 ft of uninsulated piping between the DPU and the primary measuring device for each 100ºF (37.8ºC) in excess of +180ºF (+82.2ºC).
- Assure that the temperature of the DPU never exceeds 180°F (+82.2°C). When steam tracing is necessary, the steam pressure should not exceed 5 pounds per square inch and insulation should not be used. If pressure must exceed 5 pounds per square inch, limit the length of tubing around the DPU to two turns and do not insulate.
- When severe pulsation is present, install a suitable pulsation dampening device upstream of the DPU.

- Mount the DPU on a solid support to minimize vibration. Tighten all points, using a suitable sealant compound; leaks in piping can cause measurement errors.
- Rotate the housing as necessary to place the pressure connection in the proper position. The DPU has connections in the pressure housings to accommodate various pipe sizes (refer to DPU Assembly Drawing and Parts List, page A-17).
- Install a valve manifold between the DPU and the source of differential pressure to facilitate operation and checking of the DPU.
- Install all shutoff and bypass valves so they are easily accessible from the front of the instrument. Locate block valves at the source of differential pressure.

Piping Diagrams

Diagrams for typical and special flow applications are presented on the following pages. Use the diagram best suited for the application as a guide for piping configuration.

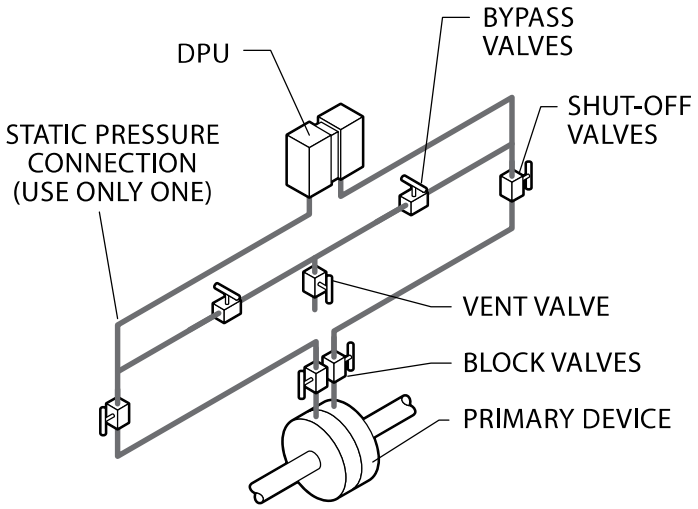

Figure A.3—Gas Flow, DPU Above Run

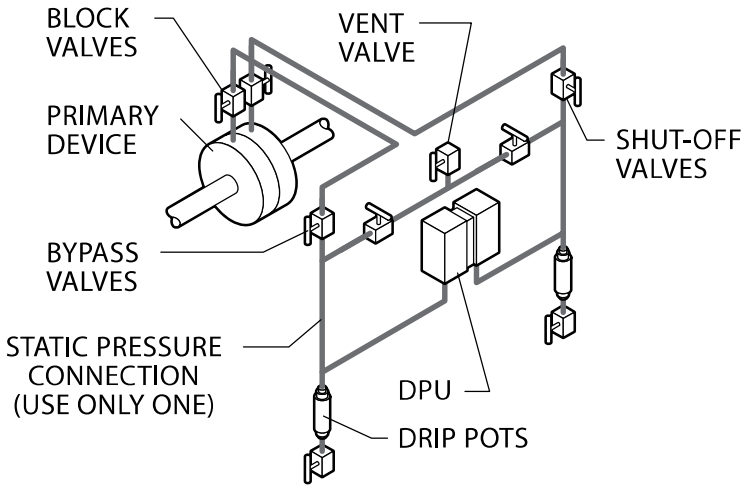

Figure A.4—Gas Flow, DPU Below Run

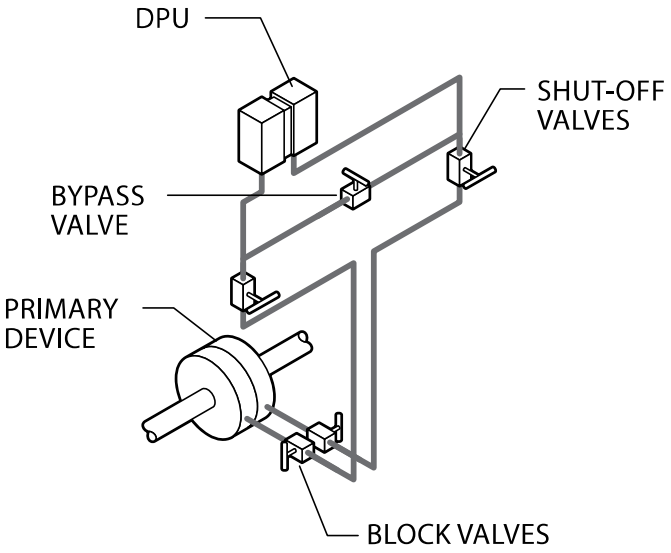

Figure A.5—Gas Flow, Hydrates Present

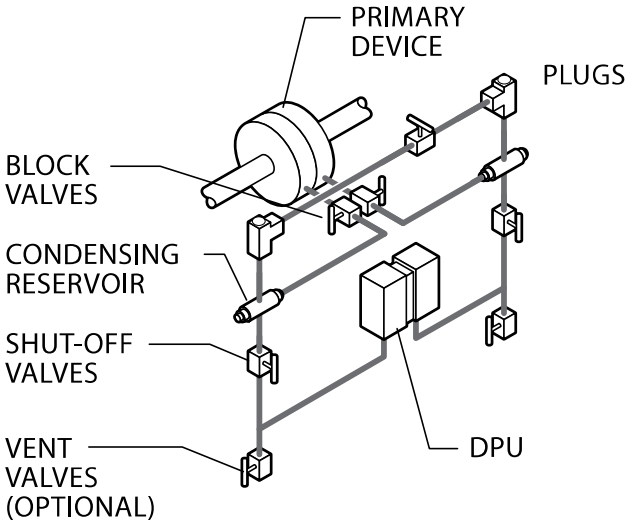

Figure A.6—Steam Flow, DPU Below Run

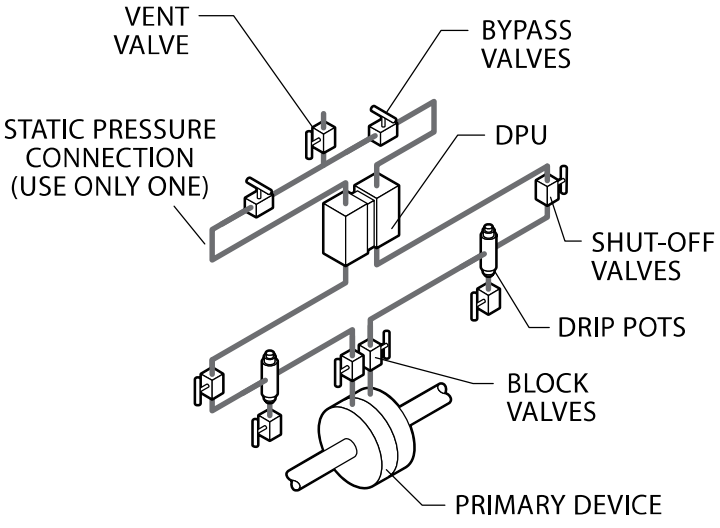

Figure A.7— Liquid Flow, DPU Above Run

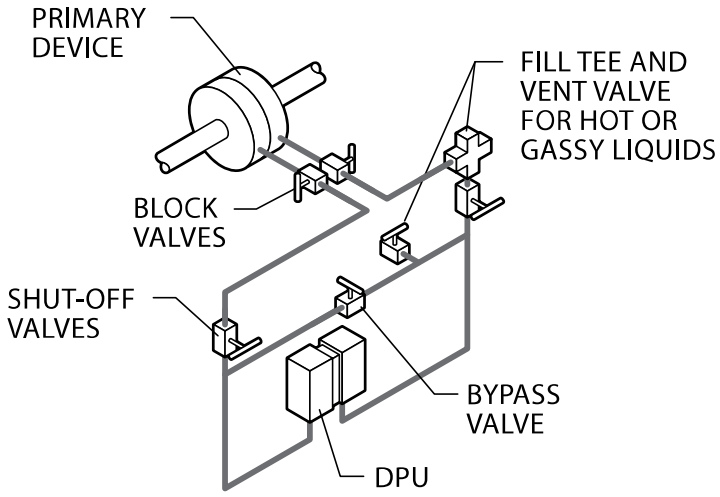

Figure A.8—Liquid Flow, DPU Below Run

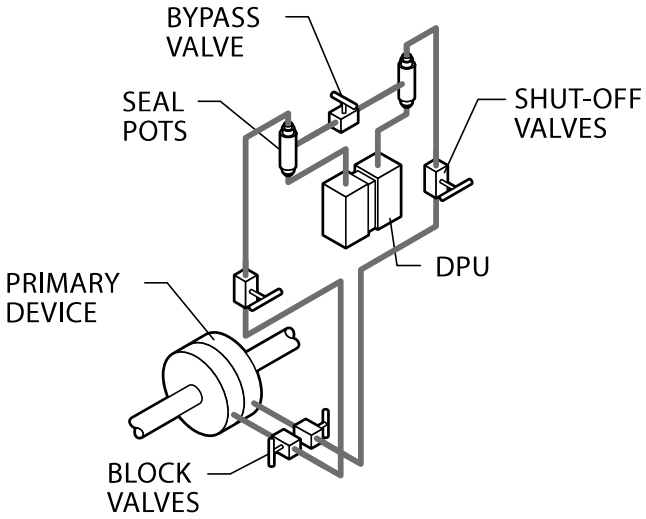

Figure A.9—Corrosive Liquid Flow

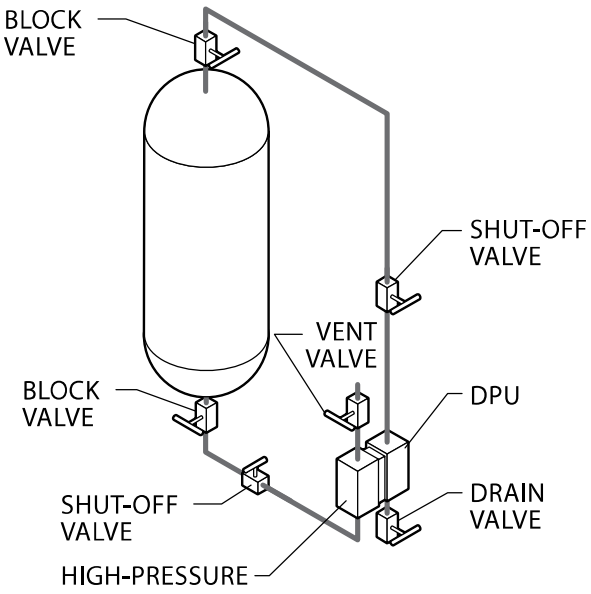

Figure A.10—Cool Non-Condensing Liquid, DPU Level with Tank Bottom

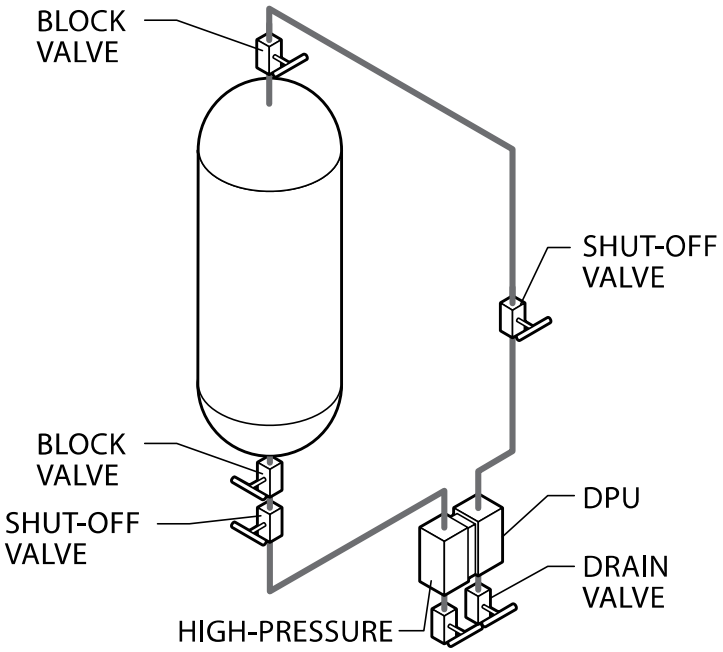

Figure A.11—Cool Non-Condensing Liquid, DPU Below Tank

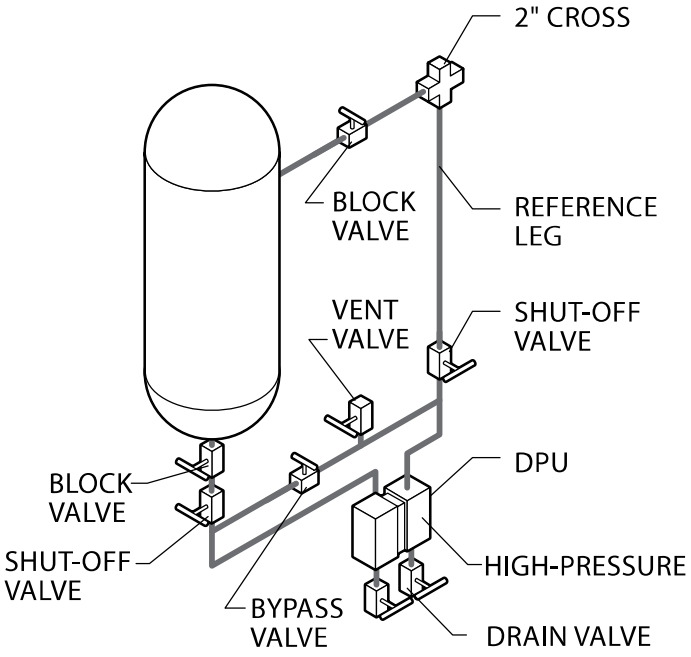

Figure A.12—DPU Bottom Tank with Reference Leg

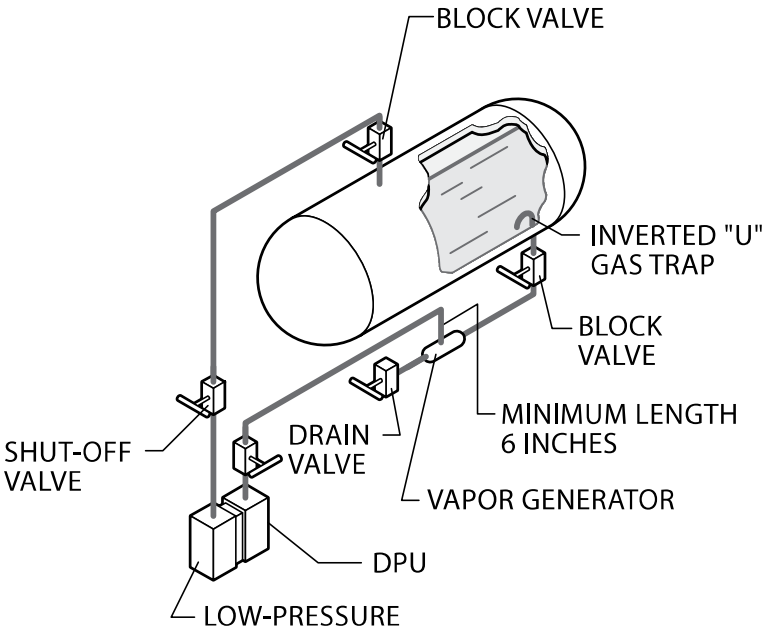

Figure A.13—Liquid CO2

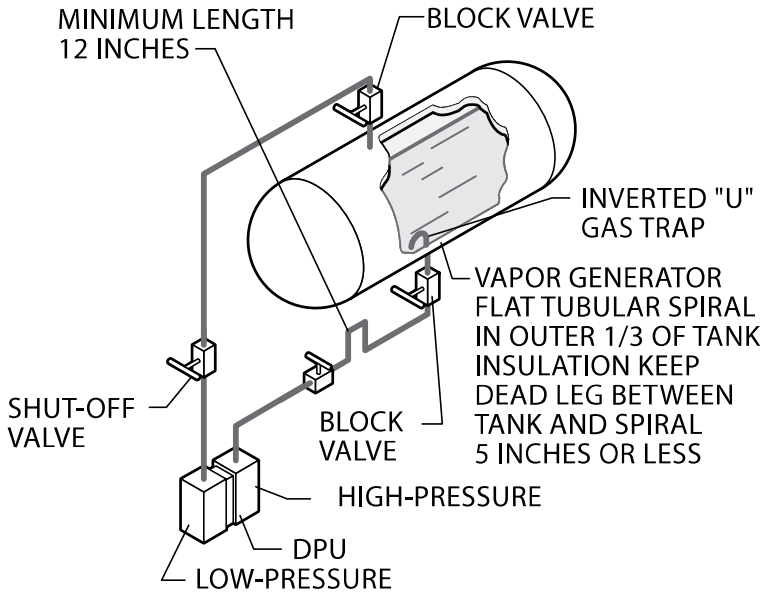

Figure A.14—Cryogenic Liquids

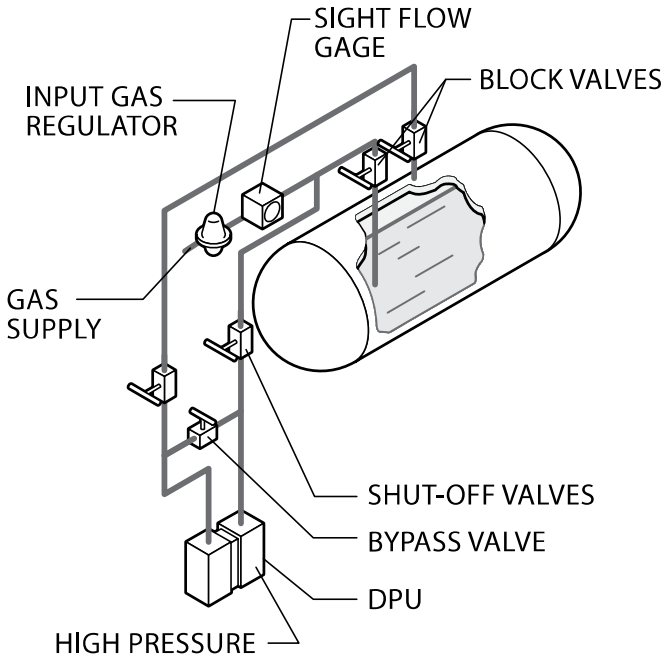

Figure A.15—Bubbler System

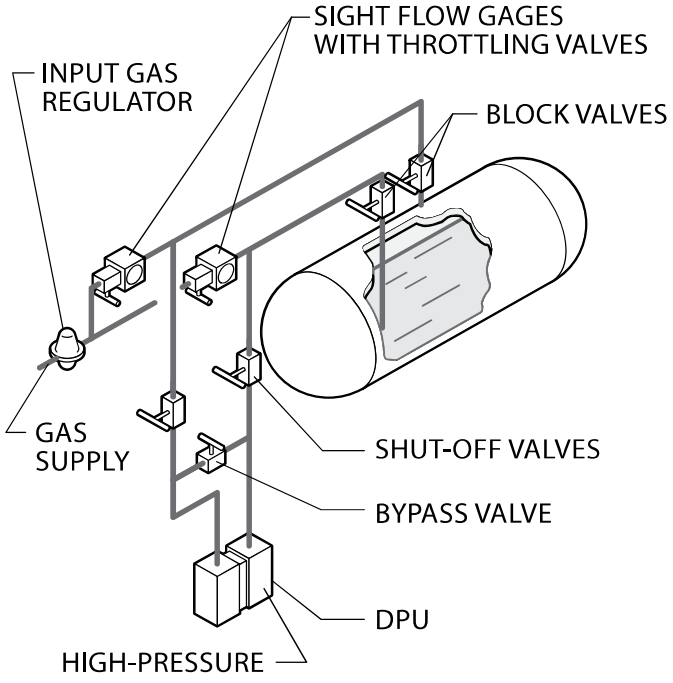

Figure A.16—Liquid Specific Gravity

Startup

Observe the following practices when starting up a process monitoring instrument:

1. Close the block valves.
2. Perform a zero check on the instrument as follows.
   a. Open the bypass valve(s), then open one shutoff valve. This procedure equalizes the pressure between both sides of the instrument. The instrument should indicate zero.
   b. If the instrument does not indicate zero, check for gas or liquid entrapment in the DPU piping or in the DPU (depending on the orientation of the piping layout and service).
   c. If necessary, adjust the pen or pointer by turning the zero adjust knob on the instrument until the pointer indicates zero.

IMPORTANT: For gas service, perform a zero check with both block valves closed. If the gas flow is pulsating, a standing wave effect may occur in the process line which can displace the indicator and appear as a zero error.

3. Check the manifold and piping for leaks as follows.
   a. Open the bypass valve(s), then open one shutoff valve to pressurize the instrument.
   b. Close the shutoff valve and the bypass valve.
   c. Observe the instrument for pen or pointer movement, up or down the scale, which could indicate leakage.

IMPORTANT: Do not subject the DPU to unnecessary shock or overrange pressure during operations.

DPU Maintenance

Periodically inspect the integrity of the DPU piping. Tighten all pipe joints as necessary.

If the instrument is used in services where solids or semi-solids may accumulate inside the pressure housings, periodically inspect and clean the DPU. See DPU Cleaning and Inspection below.

For calibration procedures for the Model 288A Differential Pressure Indicating Switch, see Section 3.

Required Tools

A screwdriver is needed for adjusting screws in the mounting bracket, and a 50-lb torque wrench is recommended for adjusting pressure housing bolts.

WARNING: The unexpected release of internal pressure from a DPU can result in severe personal injury, death or property damage. Before removing DPU housing bolts, perform a pressure check. This is especially important if the DPU is installed in a gas application with working pressures exceeding 200 psig.

DPU Cleaning/Inspection Procedure

1. Remove the DPU from service.
2. Check for internal DPU pressure as follows:
   a. Back off all housing bolts 4 turns.
   b. Attempt to move the housing in and out along the bolts
      If the housing moves freely, no pressure is present. Servicing or repair may continue.
      If the housing does not move freely, the bellows may be pressurized. Immediately stop all disassembly, tighten the housing bolts, and return the unit to the factory or authorized service center for repair. Tag the unit and specify "Gas in the Bellows."
3. Carefully remove the pressure housing bolts and pressure housings.

IMPORTANT: If a heavy buildup of solids or semi-solids has accumulated inside the housing, rapid removal of the housing may damage the bellows convolutions.

4. Remove the accumulation from between the bellows convolutions and from the inside of the housings. Use a solvent if possible. Do not use a hard or sharp instrument to clean between convolutions.
5. Check for broken range springs and replace as necessary.
6. Replace the housings and the O-rings.

IMPORTANT: It is recommended that new O-rings be used whenever pressure housings are replaced.

7. Reinstall housing bolts and apply torque as required. See Table A.2 for appropriate torque values.

Table A.2—Bolt Torque Ratings

HOUSING		BOLT		LUBE (Note 1)	TORQUE LB-FT (Note 2)	ROTATION (Degrees) (Note 3)
SWP	MATL.	MATL.	SIZE			
500	SST	SST	1/4-28 x 2.5	YES	12-14	180
500	CuNi	Monel	1/4-28 x 2.5	YES	9-11	180
1,000	Cu-Ni	Monel	1/4-28 x 2.5	YES	9-11	180
1,500	SST	SST	1/4-28 x 2.5	YES	12-14	180
3,000	SST	SST	3/8-24 x 2.5	YES	35	90
6,000	SST	SST	3/8-24 x 2.5	YES	40	135

Notes: (1) Lubricant: Molykote G paste, graphite-base grease, or similar lubricants. Lube first thread only. **(2)** Torque on bolts is accomplished in 3 or 4 steps. Tighten uniformly. **(3) Cameron recommends using a torque wrench whenever installing housing bolts.** Rotation of bolt head is measured after bolt is "snug" (approx. 1/16 turn past head contact) with approximately 2 ft-lb torque. Do not exceed this rotation. To tighten bolts without torque wrench, use the following values: 1/4 turn = 90º, 1/2 turn = 180º

Changing the DPU Range

To change the range of the DPU, replace the BUA with a unit of the desired range.

Replacing the Bellows Unit Assembly (BUA)

WARNING: Review the warning under DPU Maintenance, page A-12, before performing this procedure.

IMPORTANT: Do not loosen the drive arm hole plug located on the top of the BUA center block when removing the mounting bracket. If the plug is loosened, the fill fluid in the bellows will be lost and the unit will be inoperable.

1. Disconnect the DPU piping, remove the process monitoring instrument from service, and remove the mounting bracket from the DPU.

IMPORTANT: See the manual for the process monitoring instrument for particular components that must be removed to gain access to the DPU mounting fasteners.

2. Loosen the drive arm from the process monitoring instrument and separate it from the torque tube shaft. Do not disconnect the instrument linkage.
3. Perform a pressure check of the DPU as follows:
   a. Back off all housing bolts 4 turns.
   b. Attempt to move the housing in and out along the bolts
      If the housing moves freely, no pressure is present. Servicing or repair may continue.
      If the housing does not move freely, the bellows may be pressurized.

Immediately stop all disassembly, tighten the housing bolts, and return the unit to the factory or authorized service center for repair. Tag the unit and specify "Gas in the Bellows."

4. Carefully remove the pressure housing bolts and pressure housings.

IMPORTANT: It is recommended that new O-rings be used whenever pressure housings are replaced.

5. Install the pressure housings onto the new BUA and attach with appropriate housing bolts (see Table A.2, page A-14 for torque requirements).
6. Reattach the mounting bracket to the DPU.
7. Re-attach the DPU to the process monitoring instrument and install the instrument into service in reverse order of removal. For instructions on attaching the Model 288A Differential Pressure Indicating Switch drive arm to the torque tube, see Section 3.
8. Calibrate the instrument per the instructions in Section 3.

DPU Troubleshooting

Table A.3 provides a description of commonly reported problems, probable causes, and corrective actions for use in troubleshooting issues involving the Model 224 DPU.

See Table 3.2, page 27, for Model 288A Differential Indicating Switch troubleshooting information.

Table A.3—Troubleshooting Tips

Problem	Possible Source	Probable Cause	Corrective Action
Low or No Indication	Primary Element or DPU	Orifice installed backwards or oversized	Replace orifice
		Flow blocked upstream from run	Clean out run or open valve
		Loss of liquid in reference leg (liquid level)	Refill reference leg
		Density changes in process media or reference leg	Refill reference leg with same density liquid as process media
	Piping from Primary Element to DPU	Pressure tap holes plugged and/or piping plugged	Clean out piping
		Bypass valve open or leaking	Close bypass valve(s) or repair leaks
		Liquids or gases trapped in piping	Vent piping
		Block or shutoff valves closed	Open block or shutoff valves
		Piping leaks on high pressure side	Repair leaks

Table A.3—Troubleshooting Tips

Problem	Possible Source	Probable Cause	Corrective Action
Low or No Indication	Bellows Unit	Housing filled with solids restricting bellows movement	Clean out housing
		Gas (liquid service) or liquid (gas service) trapped in housing	Vent housing
		High pressure housing gasket leaks	Replace gasket
		DPU tampered with	Return BUA for repair
High Indication	Primary Source	Orifice partially restricted or too small	Clean out or replace
	Primary Element to DPU piping	Piping leaks on low pressure side	Repair leaks
	Bellows Unit	Gas (liquid service) or liquid (gas service) trapped in housing	Vent housing
		Low pressure housing gasket leaks	Replace gasket
		Range spring broken or DPU tampered with	Return BUA for repair
Erratic Indication	Primary Element	Flow pulsating	Install dampening device upstream of DPU run
Erratic Indication	Primary Element to DPU piping	Liquid (gas service) or gas bubble (liquid service) trapped in piping	Remove
		Vapor generator incorrectly installed	Re-pipe
		Reference leg gassy or liquid vaporizing	See piping instructions
	Bellows Unit	Obstructed bellows travel	Clean bellows
		Gas trapped in DPU high pressure or low pressure housing	Remove (see startup procedure)

DPU Assembly Drawing and Parts List

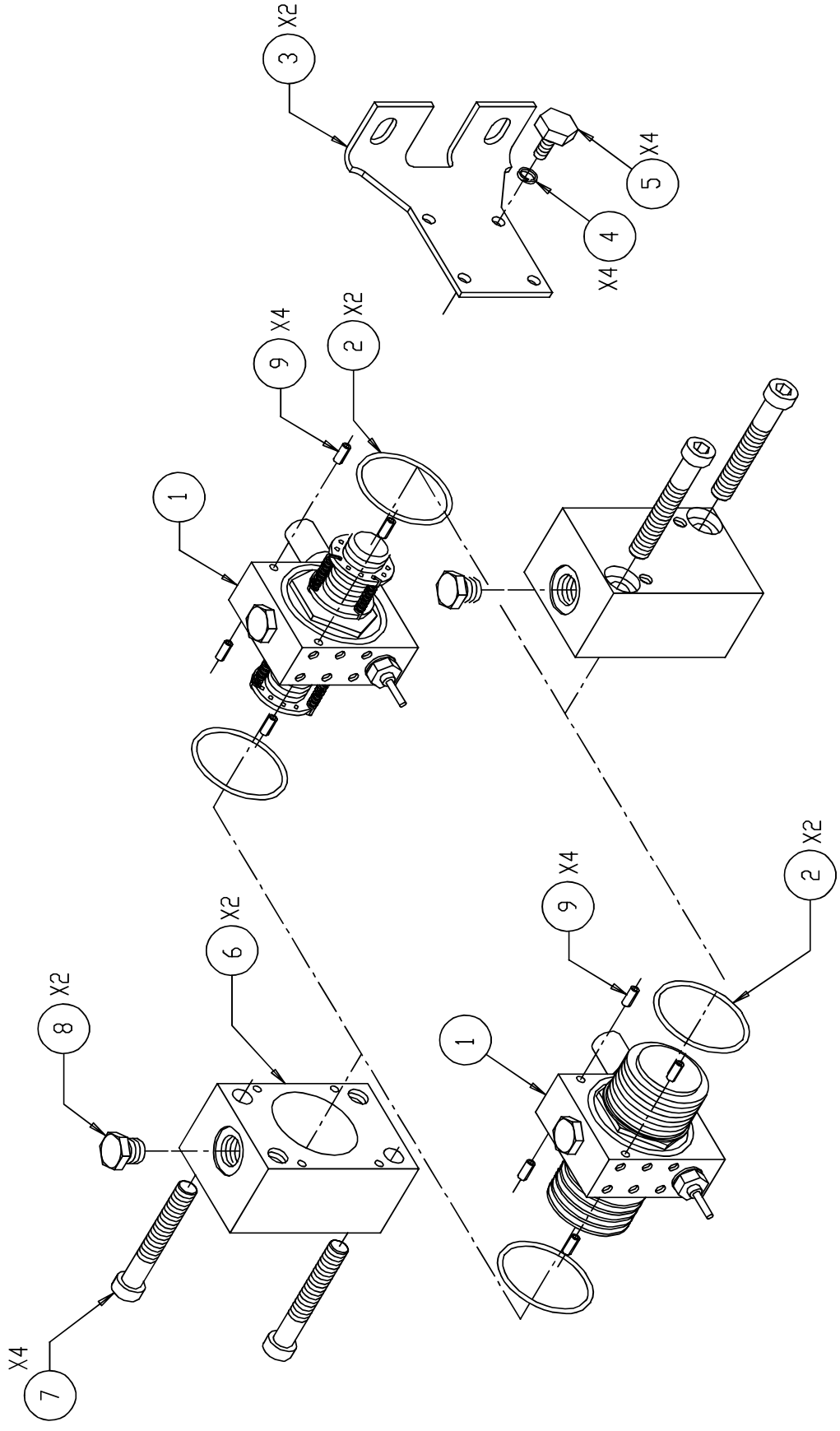

Figure A.17—Model 224 DPU assembly drawing

Table A.4—Model 224 DPU Parts List

Item	Description	Part No.	Qty
1	Bellows Unit Assembly, 3/4" or 5/8"		1
	Bellows Unit Assembly, 1-5/8"		
*2	O-Ring, Housing Gasket		2
	Viton	9A-C0001-0039R	
	EPT	9A-C0001-1054R	
3	Bracket, Mounting	9A-C0273-0001C	2
4	Washer, ET Lock, 1/4" SST	9A-C0003-0068K	4
5	Screw, Hex Hd. SST, 1/4-28 x 1/2"	9A-C0116-1011J	4
6	Housing, Pressure		2
	Housing, SST, .5/1.5K SWP, 1/4 x 1/4 NPT	9A-C0224-1543C	
	Housing, SST, .5/1.5K SWP, 1/4 x 1/2 NPT	9A-C0224-1610C	
	Housing, SST, .5/1.5K SWP, 1/2 x 1/2 NPT	9A-C0224-1579C	
	Housing, SST, .5/1.5K SWP, Absolute	9A-C0224-1618C	
	Housing, SST, 3/6K SWP, 1/4 x 1/4 NPT	9A-C0224-1556C	
	Housing, SST, 3/6K SWP, 1/4 x 1/2 NPT	9A-C0224-1608C	
	Housing, SST, 3/6K SWP, 1/2 x 1/2 NPT	9A-C0224-1580C	
	Housing, CuNi, .5/1K SWP, 1/4 x 1/4 NPT	9A-C0224-1581C	
	Housing, CuNi, .5/1K SWP, 1/4 x 1/2 NPT	9A-C0224-1616C	
	Housing, CuNi, .5/1K SWP, 1/2 x 1/2 NPT	9A-C0224-1655C	
	Housing, CuNi, .5/1K SWP, Absolute	9A-C0224-1651C	
7	Screw, Housing		4
	Soc Head Screw, 1/4-28 x 2-1/2, SST (17-4) (for .5/1.5K SST units)	9A-C0220-1017J	
	Soc Head Screw, 3/8-24 x 2-1/2, SST (17-4) (for 3/6K SST units)	9A-C0220-1014J	
	Soc Head Screw, 1/4-28 x 2-1/2, Monel (for .5/1K CuNi units)	9A-C0220-0045J	
8	Plug, Pipe		2
	Pipe Plug, SST, 1/4 NPT	9A-C0199-0214C	
	Pipe Plug, SST, 1/2 NPT	9A-C0199-0215C	
	Pipe Plug, Monel, 1/4 NPT	9A-C0199-0235C	
	Pipe Plug, Monel, 1/2 NPT	9A-C0199-0234C	
9	Spring Pin	9A-C0003-0002T	4

* Indicates recommended spare parts.

DPU Dimensional Drawings

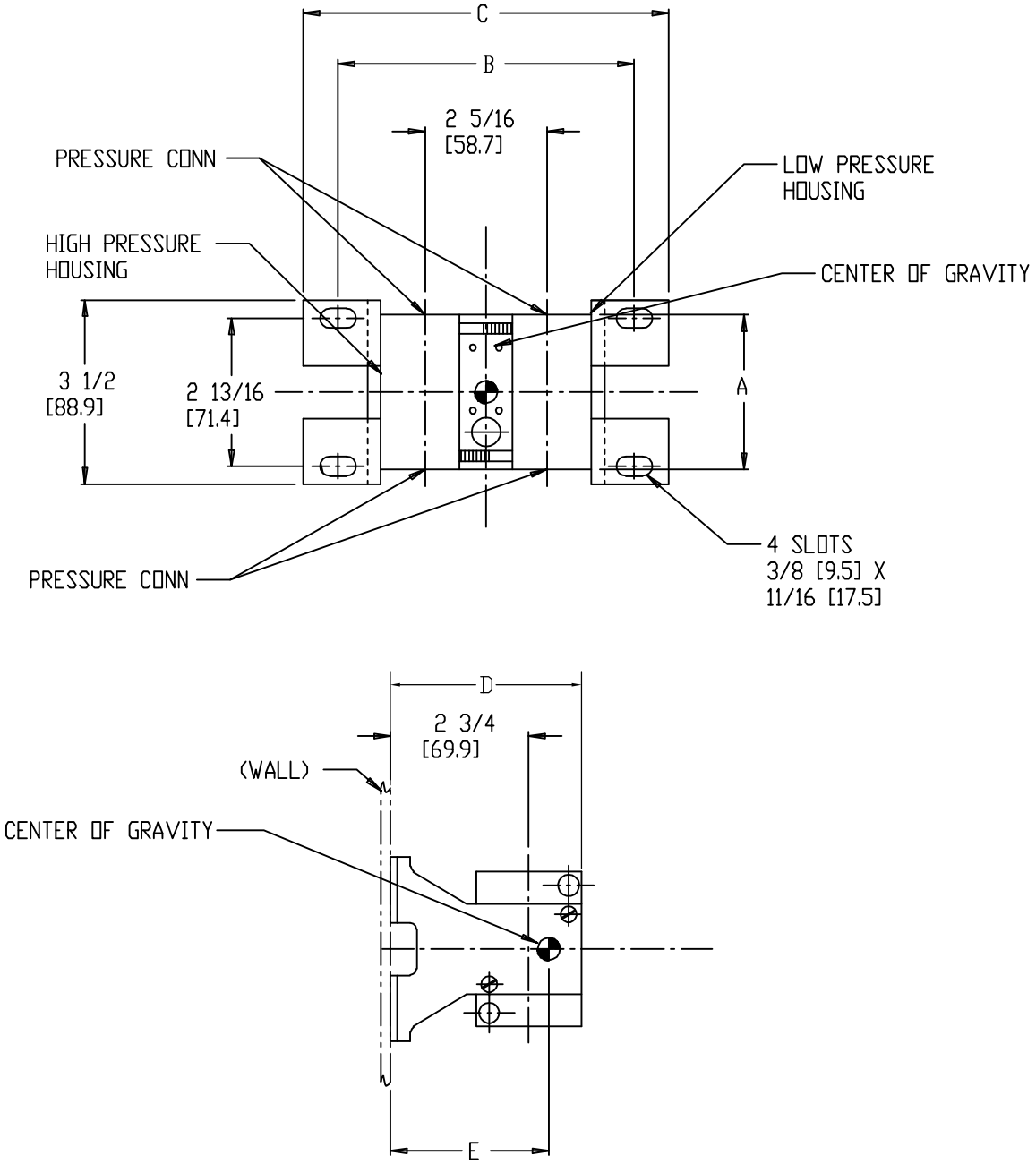

Figure A.18—Model 224 DPU dimensional drawing

Table A.5—Model 224 DPU Dimensions

SWP (psi)	Dim "A" in. (mm)	Dim "B" in. (mm)	DIM "C" in. (mm)	DIM "D" in. (mm)	DIM "E" in. (mm)
500 or 1500	2-15/16 (74.6)	5-5/8 (142.9)	6-15/16 (176.2)	4-3/4 (120.6)	3-1/8 (79.4)
6000	3-1/4 (82.6)	6 (152.4)	7-5/16 (185.7)	4-55/64 (123.4)	3 (76.2)

Product Warranty

A. Warranty

Cameron International Corporation ("Cameron") warrants that at the time of shipment, the products manufactured by Cameron and sold hereunder will be free from defects in material and workmanship, and will conform to the specifications furnished by or approved by Cameron.

B. Warranty Adjustment

(1) If any defect within this warranty appears, Buyer shall notify Cameron immediately.

(2) Cameron agrees to repair or furnish a replacement for, but not install, any product which within one (1) year from the date of shipment by Cameron shall, upon test and examination by Cameron, prove defective within the above warranty.

(3) No product will be accepted for return or replacement without the written authorization of Cameron. Upon such authorization, and in accordance with instructions by Cameron, the product will be returned shipping charges prepaid by Buyer. Replacements made under this warranty will be shipped prepaid.

C. Exclusions from Warranty

(1) THE FOREGOING WARRANTY IS IN LIEU OF AND EXCLUDES ALL OTHER EXPRESSED OR IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE, OR OTHERWISE.

(2) Components manufactured by any supplier other than Cameron shall bear only the warranty made by the manufacturer of that product, and Cameron assumes no responsibility for the performance or reliability of the unit as a whole.

(3) "In no event shall Cameron be liable for indirect, incidental, or consequential damages nor shall the liability of Cameron arising in connection with any products sold hereunder (whether such liability arises from a claim based on contract, warranty, tort, or otherwise) exceed the actual amount paid by Buyer to Cameron for the products delivered hereunder."

(4) The warranty does not extend to any product manufactured by Cameron which has been subjected to misuse, neglect, accident, improper installation or to use in violation of instructions furnished by Cameron.

(5) The warranty does not extend to or apply to any unit which has been repaired or altered at any place other than at Cameron's factory or service locations by persons not expressly approved by Cameron.

Product Brand

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