

INSTRUCTION MANUAL

Capacitance Transmitter

Model 167

Robertshaw

Industrial Products Division

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Instruction Manual Number

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SECTION I – DESCRIPTION

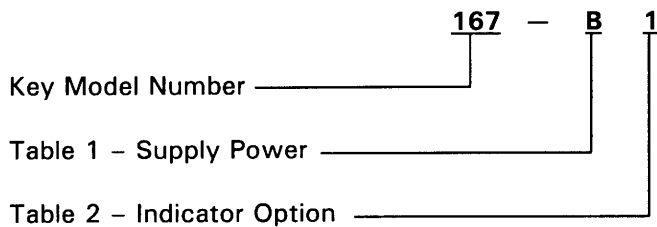
1.1 GENERAL

The Model 167 is a Capacitance Transmitter which converts capacitance signals input to a standard 4-20 milliampere current output. Together with a capacitance probe, the transmitter is used to measure a continuous level or interface of liquids, slurries, or granulars.

The Model 167 applies the latest CMOS solid state technology and advance techniques developed by Robertshaw. Advantages to the customer are a capacitance transmitter with lower cost of installation, increased safety, and Improved performance over the conventional capacitance transmitter. Supply voltage ranges from 17 VDC up to 35 VDC with either floating, positive or negative ground, or 120 or 240 VAC. The advanced techniques provide an accurate level measurement independent of sticky or crystalline coating or regardless of moisture content of the granulars (providing moisture content does not vary).

1.2 MODEL IDENTIFICATION

Identify instrument models in accordance with the description and variations listed in each table. Dashes are used in the model number only in those spaces as indicated in the example below.



Key Model Number

Key Model No.	Description
167	The Model 167 is a Capacitance Transmitter which converts the capacitance signal input to a standard 4-20 ma current output. The enclosure is suitable for explosion-proof, Class I, Division 1 and 2, Groups C and D; Class II, Division 1 and 2, Groups E, F, and G; and Water-Tight NEMA-4 specifications.

Table 1 – Supply Power

Designation	Description
A	17-35 VDC, 2-Wire System
B	120 VAC, 50/60 Hz, 4-Wire System
C	240 VAC, 50/60 Hz, 4-Wire System

Table 2 – Indicator Option

Designation	Description
1	None
2	Explosion-proof Indicator.

SECTION II – SPECIFICATIONS

2.1 ENVIRONMENTAL

Enclosure	Suitable for Explosion-proof, Class I, Division 1 and 2, Groups C and D; Class II, Division 1 and 2, Groups E, F, and G; and Water-Tight NEMA-4 Specifications.
167-A(1,2)	Intrinsically Safe for Class I, Division 1, Groups C & D; Class II, Division 1, Groups E, F, & G, when used with appropriate barriers per Robertshaw drawing 907GA681 and probes 702, 728, 729, 736, 738, 739, 740, or 741. Refer to Figure 3 for drawing 907GA681.
Temperature Range:	
Storage	-55°F to +225°F (-48°C to +107°C)
Operating	-40°F to 180°F (-40°C to +82°C)
Vibration	± 2G's 10 to 200 Hz
Shock	75G's for 11 Milliseconds
Humidity	95% RH @ 100°F (38°C)

2.2 ELECTRICAL

Supply:

AC Version	3 VA, 1.75 Watts @ 120 VAC, 50/60 Hz.
	3 VA, 1.75 Watts @ 240 VAC, 50/60 Hz.
DC Version	28 Ma. Max. @ 17 VDC Min. to 35 VDC
	Max. across Input. (Ref. to paragraph 3.3.2).
Output Load	(Ref. to paragraph 3.3.1).
Control Range	30 to 2000 pf
Terminal Capacitance Range	30 to 1000 pf
Span Capacitance Range	10 to 1700 pf

Interconnect Wires:

For 4-20 ma Circuit:

Preferred: Two wire (color coded) twisted pair shielded.
Belden #8762 or equal, #22 awg minimum, #12 awg maximum, rated 80°C minimum. Shield to be terminated at one end only, preferably at the model 167.

Alternate..... Two wire (color coded) twisted pair in conduit with no power lines present. Belden #8205 or equal, #22 awg minimum, #12 awg maximum, rated 80°C minimum.

Length:..... For DC powered instruments the maximum length is limited by total load resistance (load plus wire resistance) as shown in Section 3.3.1.1.
For AC powered instruments the maximum length is limited by a total load resistance (load plus wire resistance) of 1150 ohms.

For supply power (AC models only): Wires to be per the local code.

2.3 PERFORMANCE

Linearity	± 0.25%, less than 500 pf Span	
	± 0.5%, 500 to 1700 pf Span	
Temperature Effect:		
Span	0.01%/°F (0.018%/°C) or	whichever is greater
	0.01 pf/°F (0.018 pf/°C)	
Zero.....	0.01%/°F (0.018%/°C) or	whichever is greater
	0.01 pf/°F (0.018 pf/°C)	
Maximum Recommended		
Terminal/Span Ratio	5:1	
Supply/Load Effect	0.1% within Supply/Load Limits	
Output Ripple.....	0.23% Peak-to-Peak	
Response Time.....	100 Milliseconds	
Stability	1% max./30 days, noncumulative	
Repeatability	± 0.1%	
Sensitivity	0.01% Minimum	

SECTION III — INSTALLATION

3.1 GENERAL

Examine the instrument for possible shipping damages. **IMPORTANT:** If for any reason it is determined that equipment should be returned to the factory, please notify the nearest Robertshaw Industrial Products sales representative prior to shipment. Each unit must be properly packaged to prevent damage. Robertshaw assumes no responsibility for equipment damaged in shipment.

Choose the location in accordance with good instrument practice, avoiding extremes of temperature, humidity, and vibration. (See SPECIFICATIONS, Section II.)

3.2 PROBE MOUNTING

Robertshaw probes are purchased separately in a variety of sizes and types for specific applications involving liquids or granular materials. Insulated probes are used for liquid solutions or liquid interface detection where the product is electrically conductive. Bare probes can be used on non-conductive materials only.

When installing the probe in a nozzle, recess, or open-end well, careful consideration must be given to the possibility of material collecting in the nozzle, recess, or well and causing false or erratic operation.

CAUTION

When installing an insulated probe, care should be taken to prevent accidental puncture of the probe insulation.

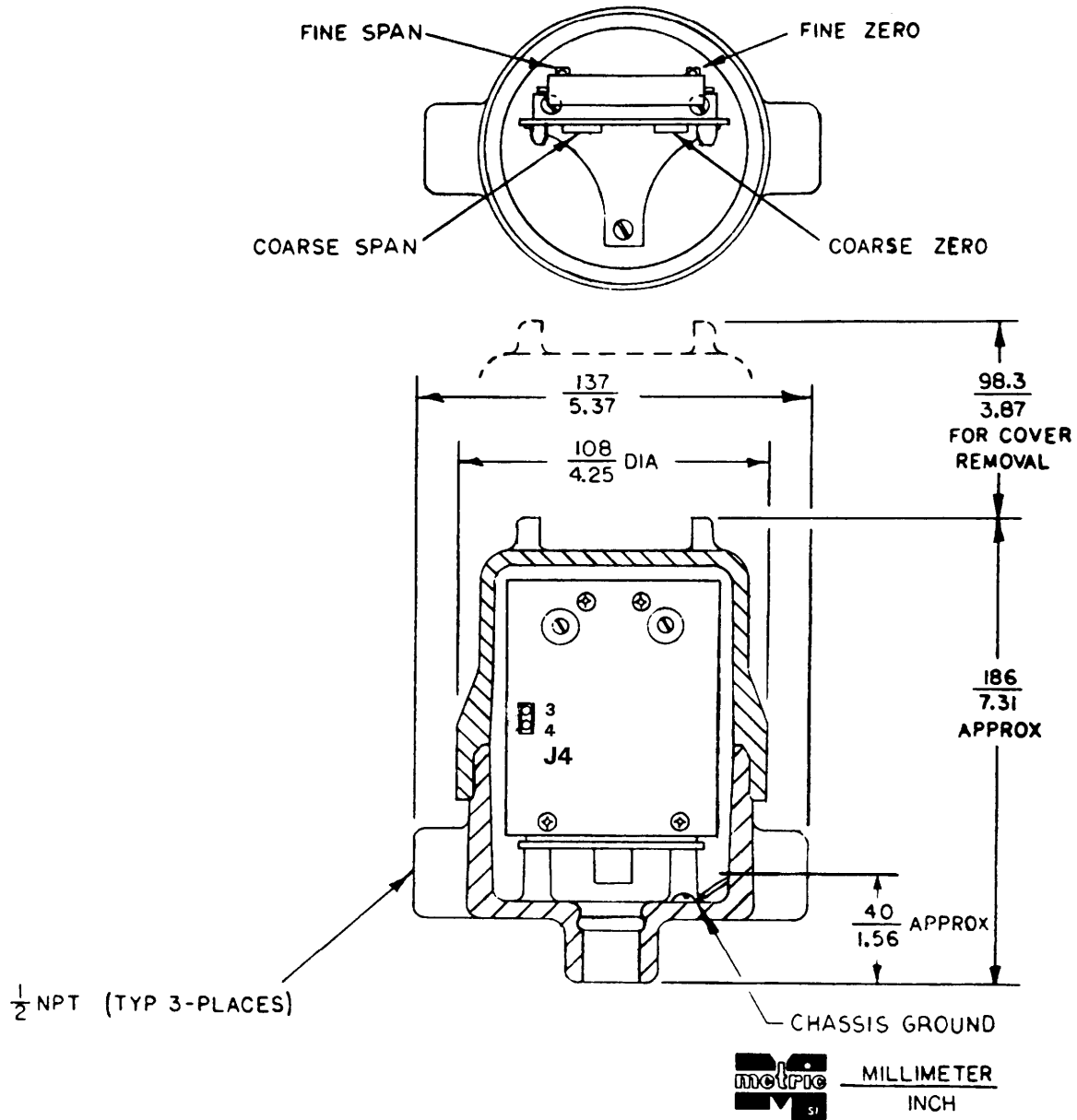
Probes used with the Model 167 for continuous level measurement are mounted vertically and can be mounted in either the top or bottom of the vessel. When the probe is mounted in a metal vessel, the probe senses the change in product or material level as a function of the capacitance between the probe and the vessel wall. When the probe is mounted in a vessel that is made of a material other than metal, a ground plane (for nonconductive material in vessel) or a ground wire (for conductive material in vessel) must be installed in the vessel to generate the proper capacitance signal.

3.3 TRANSMITTER UNIT MOUNTING

The Model 167 Capacitance Transmitter is designed to be mounted directly on the probe external pipe thread. See Figure 1 and 2 for mounting dimensions and electrical connections of the transmitter. When intrinsic safety is required for a 2-Wire transmitter also refer to Figure 3.

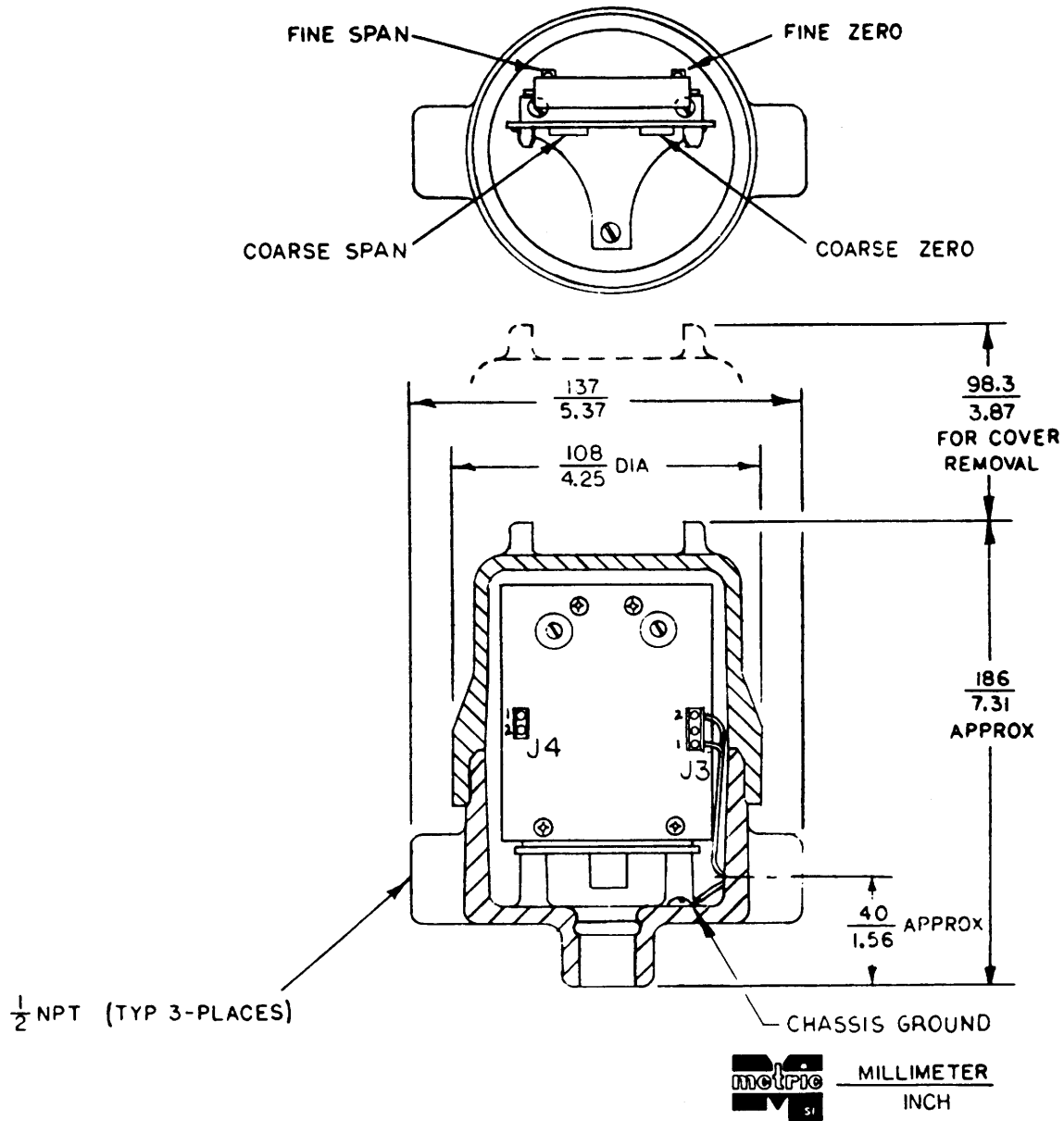
NOTE

Before assembling the transmitter to the probe, the probe electrical connection pin (packed with the transmitter) shall be installed in the end of the probe to provide electrical connections between the probe and transmitter when installed.



MODEL NO.	J4 TERMINAL	DESCRIPTION
167-A1	(+) 4	Supply
167-A2	(-) 3	17-35 VDC

Figure 1. (Sheet 1 of 3) Mounting Dimensions and Electrical Connections for Model 167-(A) () Capacitance Transmitter.



MODEL NO.	J3 TERMINAL	DESCRIPTION	J4 TERMINAL	DESCRIPTION
167-B1	2 (H)	120 VAC	2 (+)	Output
167-B2	1 (N)	Supply	1 (-)	4-20 MADC
167-C1	2 (H)	240 VAC	2 (+)	Output
167-C2	1 (N)	Supply	1 (-)	4-20 MADC

Figure 1. (Sheet 2 of 3) Mounting Dimensions and Electrical Connections for Model 167-(B, C) () Capacitance Transmitter.

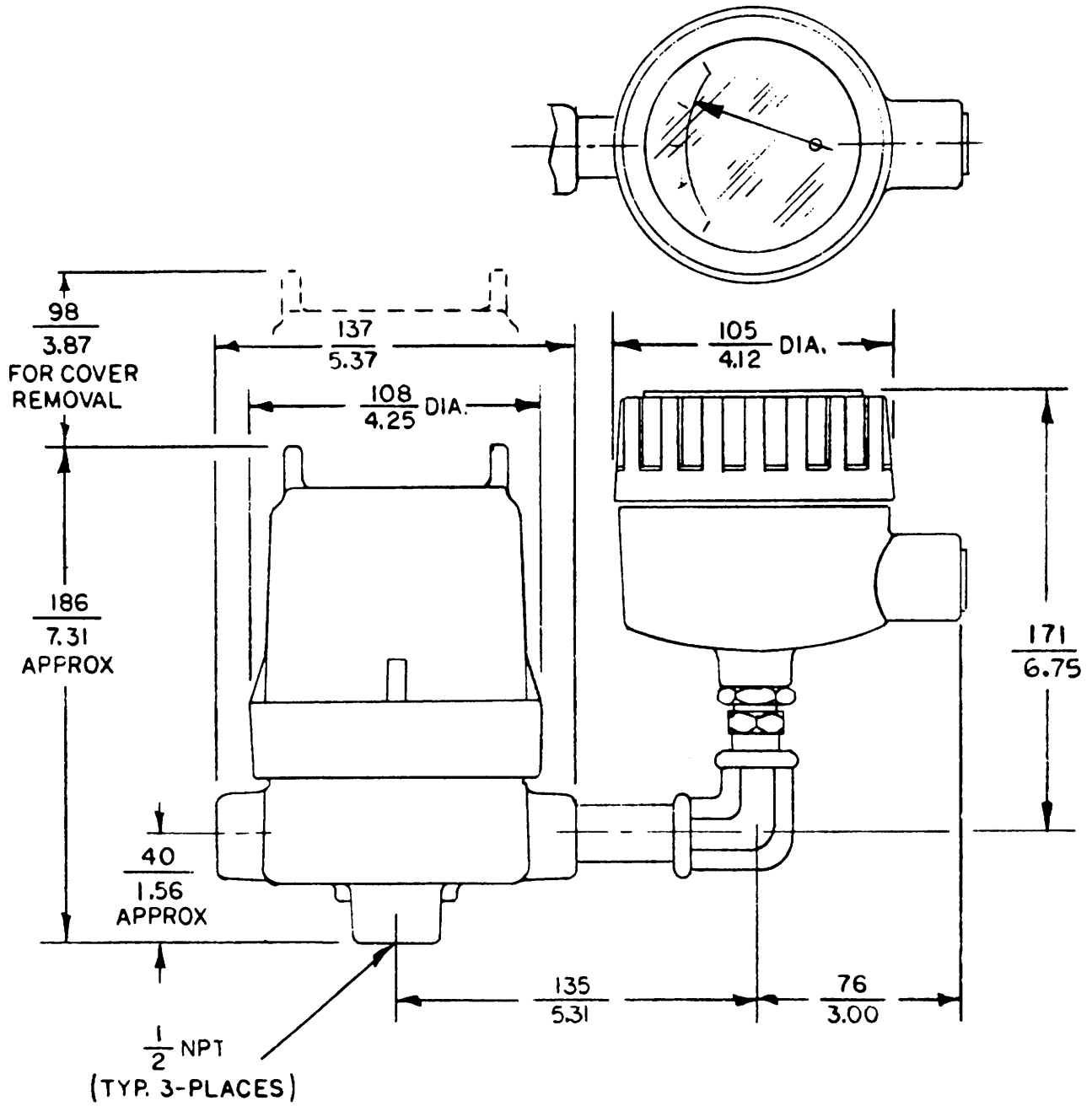


Figure 1. (Sheet 3 of 3) Mounting Dimensions for Model 167-() (2) Capacitance Transmitter.

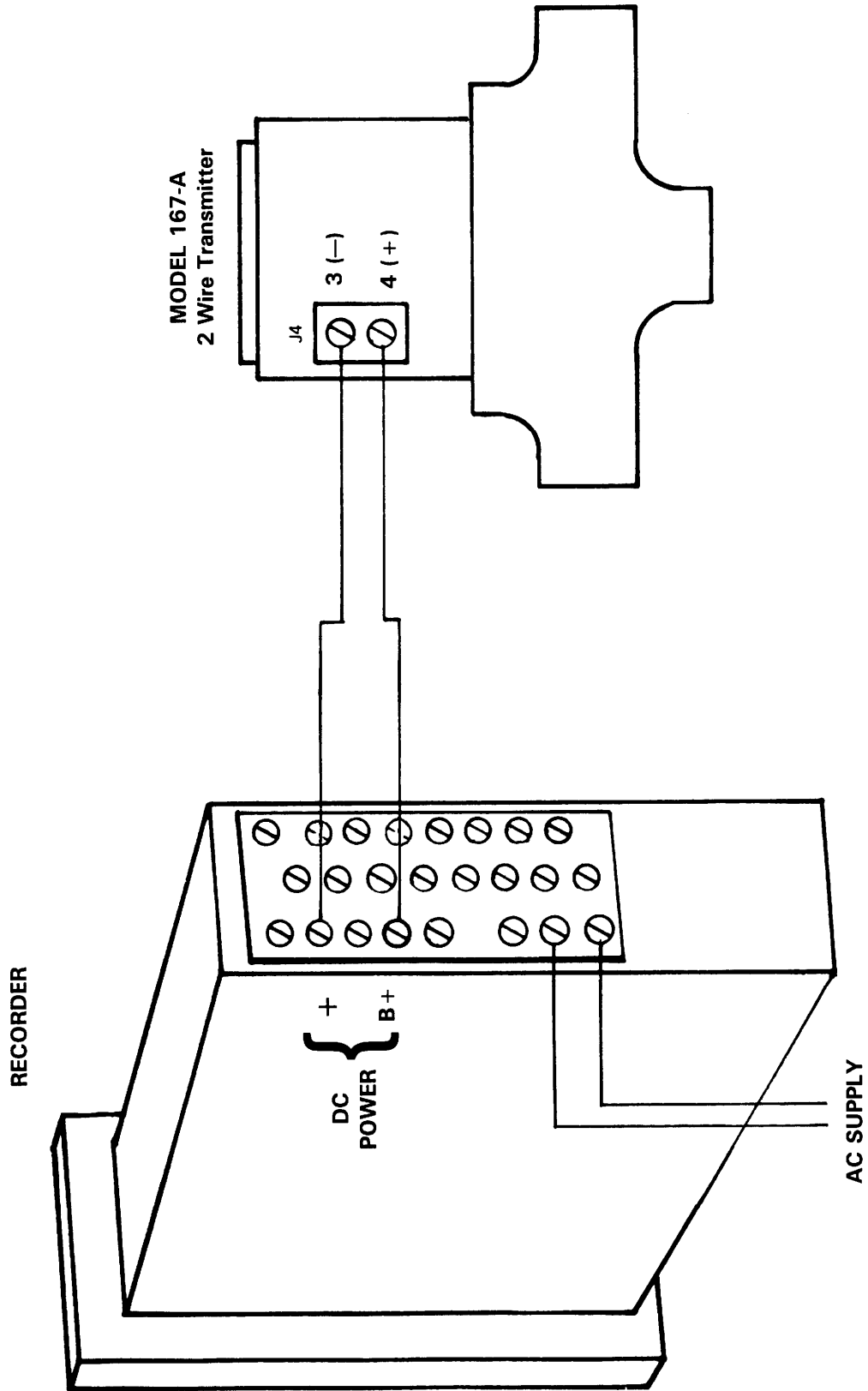


Figure 2. (Sheet 1 of 3) Typical Connections for Model 167-(A) () to devices with built-in power supplies.

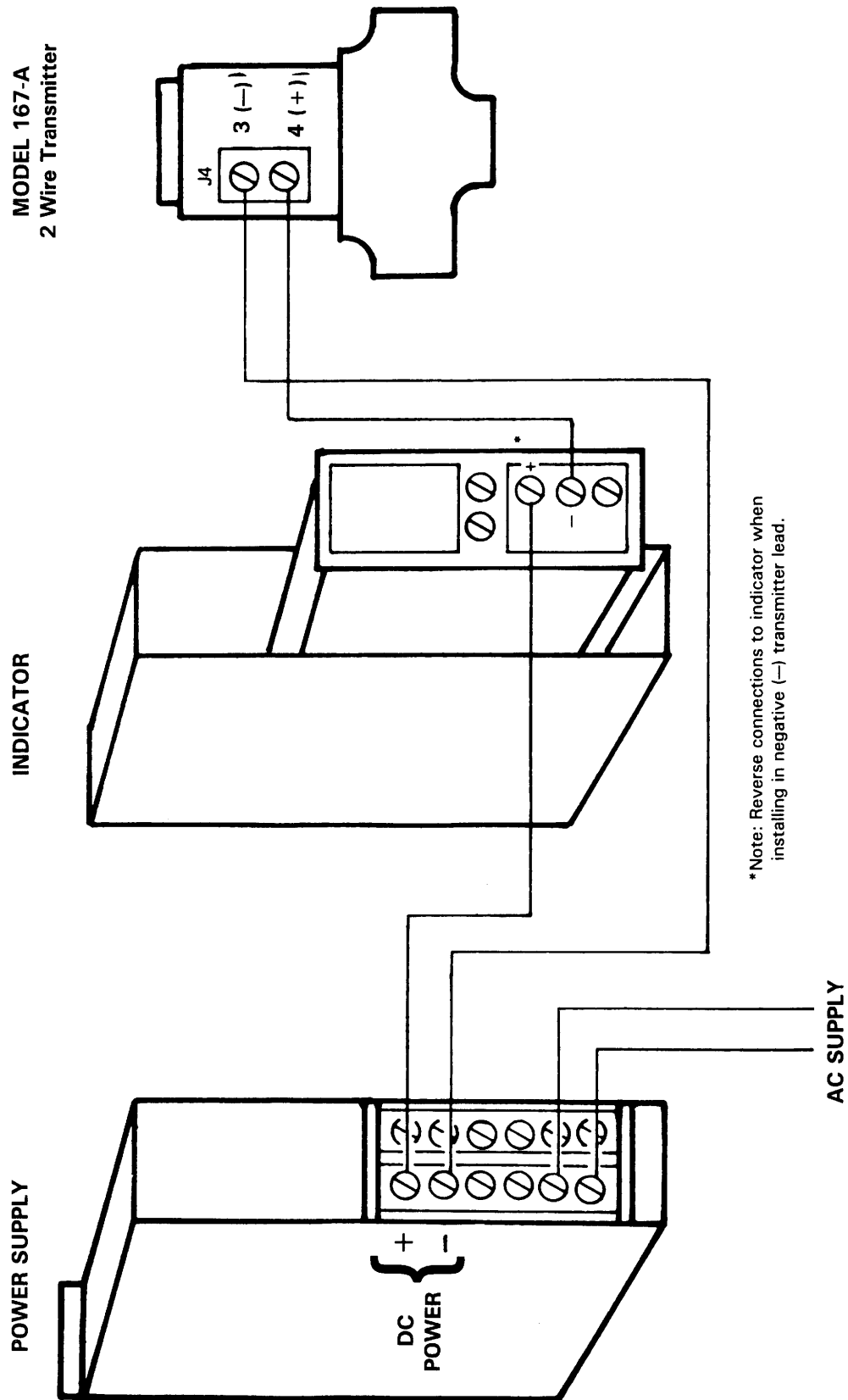


Figure 2. (Sheet 2 of 3) Typical Connections for Model 167-(A) () to devices lacking built-in power supplies.

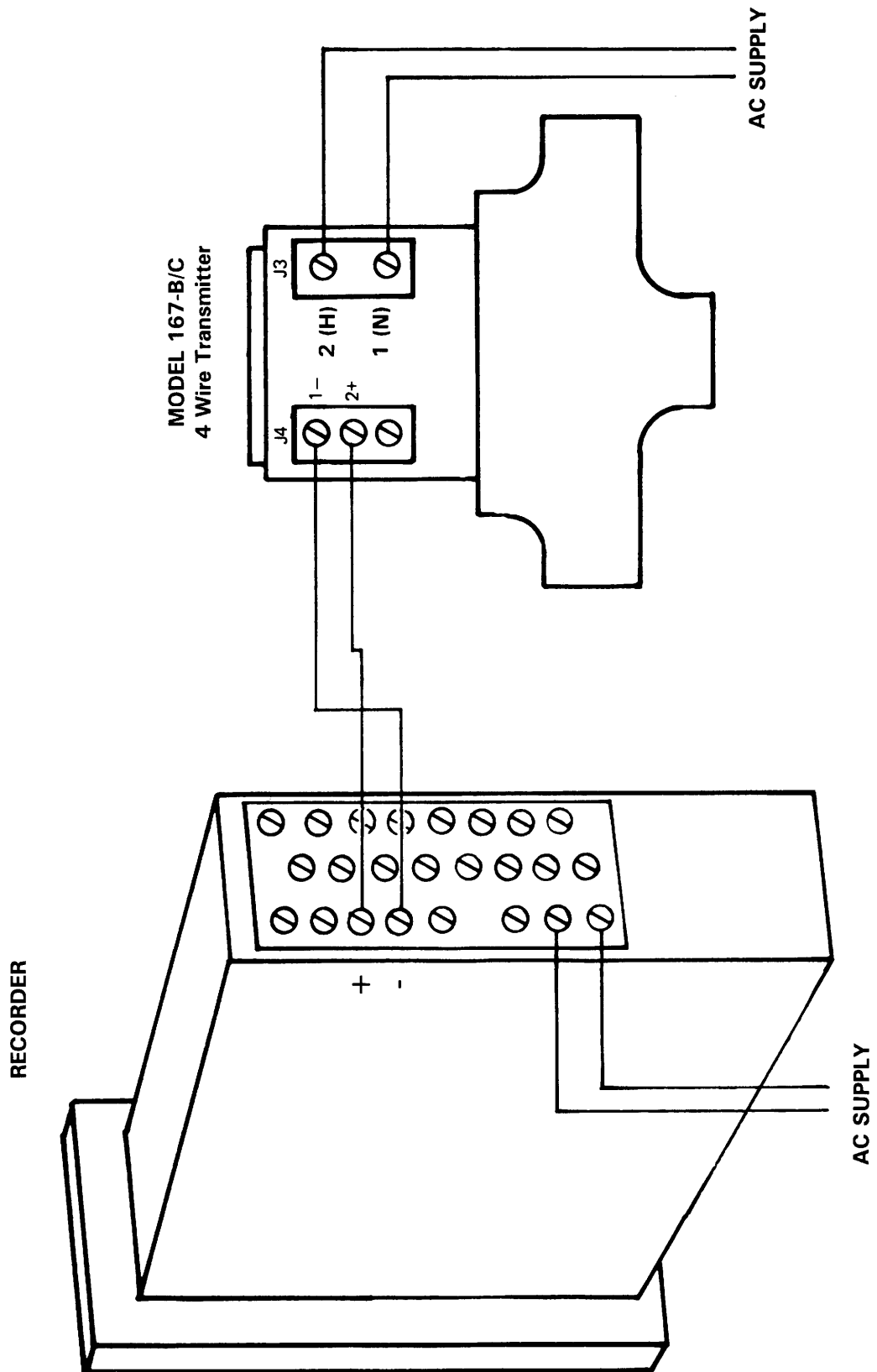
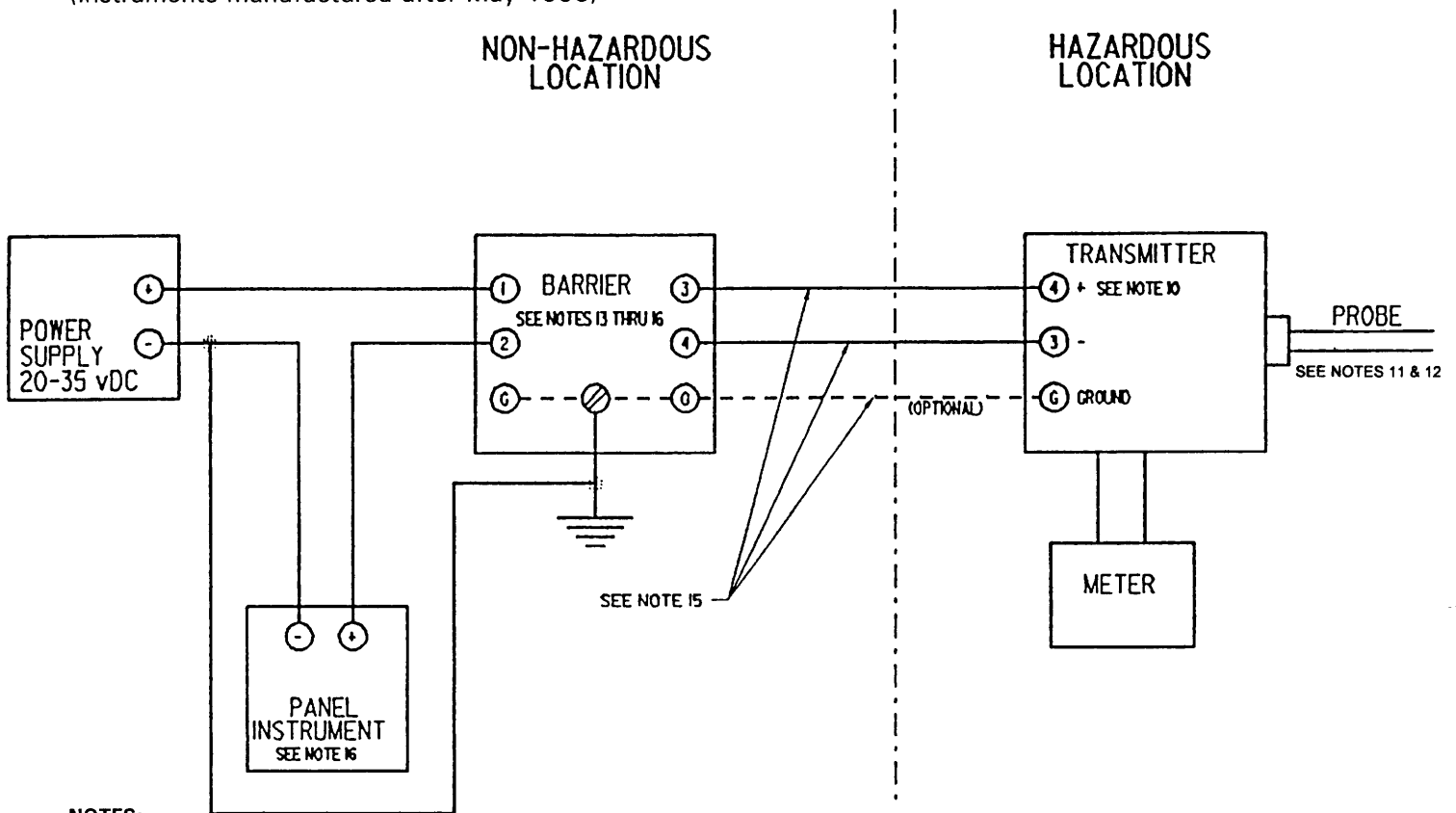


Figure 2. (Sheet 3 of 3) Typical Connections for Model 167-(B, C) ().

DRAWING 907GA681

For Model 167-A (1,2)

This drawing applicable to instruments employing printed circuit assembly 044KB896-01 Rev S and subsequent. (Instruments manufactured after May 1998)



NOTES:

1. Through 8. (Not applicable)
9. When connected as shown the transmitter and probe are CSA Certified as intrinsically safe for hazardous locations:
Class I, Division 1, Groups C and D
Class II, Division 1, Groups E, F, and G
10. Transmitter is Robertshaw Model 167-A1 (W/O Meter) or Model 167-A2 (W/Meter).
11. Probe is Robertshaw Model 702, 728, 729, 736, 738, 739, 740, or 741.
12. Insulated Probes only may be used in Class II, Groups E or F areas.
13. CSA Certified intrinsic safety (Isolating Type) with output parameters of:
28V maximum and 267 ohms minimum
- or -
25V maximum and 200 ohms minimum
14. The barrier must be mounted and grounded outside of the hazardous area in accordance with the instructions packed with the barrier.
15. Safety barrier and its intrinsically safe wiring must be installed in accordance with Article 504 of the NEC ANSI/NFPA 70 or, if applicable, the Canadian Electrical Code.
16. Recommended safety barriers:

Manufactures	Part Number	Max Loop Resistance
R. Stahl Inc.	9001/51-280-110-14	750Ω
MTL	4041-B	650Ω
MTL	702 +	850Ω
Pepperl + Fuchs Inc.	KFD2-CR-EX 130 200	1KΩ

17. The example wiring diagram shown is for Stahl 9001/51-280-110-14, for other barriers consult the diagram supplied with the barrier.

Figure 3. For Intrinsic Safe Connections (When Required)

NOTE:

The instrument housing must be sealed at the conduit outlets with a suitable compound or "trap" to prevent infiltration of moisture-laden air or corrosive gases into the housing. All instrument installation wiring must be done in accordance with local codes and commonly accepted practices.

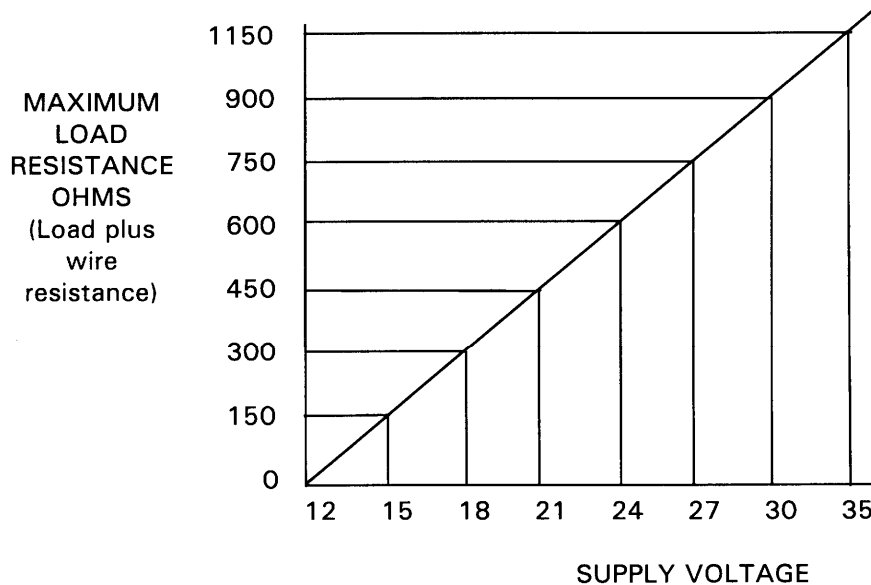
3.3.1 Determining Maximum Output Load

3.3.1.1 Model 167-A ()

The maximum output load (i.e. meter resistance) which may be used with a specific, fixed-voltage power supply may be determined from the formula given below. The chart, also given below, may be used to determine the approximate maximum load where exact calculations are not required.

$$R_{\max} = \frac{\text{Supply Voltage minus 12 Volts} \times 1000 \text{ Ohms}}{20}$$

(Example: $R_{\max} = 600 \text{ Ohms}$ for 24 VDC supply)



3.3.1.2 Model 167-(B,C) ()

The built-in power supply has an output of approximately 35 volts dependent upon line voltage. This output allows use with the maximum variety of load resistances, up to a maximum of 1150 ohms (load plus wire resistance).

3.3.2 Determining Minimum Power Supply Requirements

Use of the Model 167-A() with a specific, fixed output load (i.e. meter resistance) requires use of a power supply capable of maintaining the required 4-20 ma current in the circuit. The minimum supply voltage required may be determined from the formula given below. Note however, that the supply voltage must be in the specified 17-35 VDC range. The chart above (Ref. to para. 3.3.2) may also be used to determine the approximate required supply voltage.

$$\text{Supply Voltage minus 12 volts} = \text{specific load resistance} \times \frac{20}{1000 \text{ Ohms}}$$

Example: Supply Voltage = 24 volts for 600 Ω total load (load plus wire resistance)

3.3.3 Ground Terminal

When the Model 167 is used for continuous level measurement, the unit is designed to be mounted directly on the top of a standard Robertshaw capacitance probe. The enclosure can be grounded through the probe gland to the metal vessel or to the ground wire of the capacitance level system. For those installations where the vessel is nonconductive, the "GND" terminal may be used to connect the ground wire of the capacitance level system.

3.3.4 DC Ground Within the Control Loop

Figure 2 shows the wiring diagram for a Typical Control Loop. If DC ground is required within the control loop, the DC ground shall be located between B+ of the Power Supply and terminal (+) on the Model 167. If a DC ground is connected to the negative side of the Model 167, a regulated Power Supply should be used. The Model 167 is AC grounded to the positive terminal. If the DC ground is connected to the negative terminal, the power supply ripple will bypass the Model 167 and affect the meter or other accessory equipment.

SECTION IV — OPERATION

4.1 CALIBRATION ADJUSTMENTS

The adjustments for calibrating the Model 167 consist of the following:

4.1.1 Zero Adjustment (0% Process Level Point)

The zero adjustment can be obtained by the use of the Fine and Coarse Zero adjustments. The Fine Zero adjustment is a multi-turn potentiometer (approximately 20 turns). The Coarse Zero adjustment is a 10-position switch. Clockwise rotation of the zero adjustments will increase the output signal. When used in combination, the zero adjustments are capable of varying the 0% Process Level Point through an approximate range between 30 and 1000 pf of terminal capacitance.

4.1.2 Span Adjustment

The span adjustment can be obtained by the use of the Fine and Coarse Span adjustments. The Fine Span adjustment is a multi-turn potentiometer (approximately 20 turns). The Coarse Span adjustment is a 10-position switch. Clockwise rotation of the Span adjustments will increase the output signal.

When used in combination the span adjustments are capable of varying the span capacitance range between 10 and 1700 pf.

4.2 CALIBRATION PROCEDURE

With the Model 167 mounted and electrical connections made, the following procedures should be followed in calibrating the instruments.

4.2.1 First Method

- a. Adjust the COARSE SPAN switch to position No. 8.
- b. With the process level in the vessel or tank at the desired 0% (low) level, adjust the COARSE and FINE ZERO until the output current indicates approximately 5 ma. Slowly turn the FINE ZERO adjustment counterclockwise until the output indicates exactly 4 ma. DO NOT OVERADJUST otherwise nonlinearity or interaction between Span and Zero will occur.
- c. Change the process level in the tank to the desired 100% (high) level and adjust the COARSE and FINE SPAN until the output or meter indicates 100% (20 ma). Clockwise rotation of the SPAN adjustments will increase the output current. The instrument is now calibrated and ready for operation.

4.2.2 Second Method

The second method should be used where the desired 0% level cannot be obtained, e.g. if emptying the vessel is not practical. Calibration values can be determined by measuring the capacitance change resulting from a known product level change. To minimize any calibration error, the level change should be the maximum possible.

This method of calibration is accomplished using a Robershaw Model 905 Capacitance Test Instrument.

NOTE

In all tests and calibrations that follow, remove your hands from the vicinity of the cables after making connections. Your body has a dielectric value which will affect the results.

- a. Disconnect the probe by removing the printed circuit assembly from the enclosure.

- b. Connect the BNC test lead to the "C IN/OUT" receptacle on the test instrument.
- c. Select 30 pF range. Depress the "BATT" switch to make sure the battery is okay, then depress the "ON" switch. Making sure the pointer of the meter is above zero, adjust the "ZERO" control until the meter pointer is on zero.
- d. Connect the test cable alligator clips to the sensing probe. The black lead should be connected to the probe ground.
- e. Depress the "ON" button and select a "RANGE" pushbutton to give the highest on-scale reading.
- f. Read and record the capacitance in pF on the meter scale corresponding to the selected "RANGE" button.
- g. Vary the product level on the probe by several inches if possible, and record this distance. Varying the product level as much as possible will result in more accurate readings.

NOTE

Product level variations can be made by actually removing or adding product to the vessel, or by unscrewing the probe from the vessel and raising or lowering the probe in the product. If the probe is raised or lowered in the product, insure that the ground connection between the probe gland and the vessel is maintained by using a jumper cable.

- h. After varying the product level, read and record the probe capacitance for the new product level.
- i. By comparing the capacitance values obtained in steps f and h and noting the distance the product level was varied on the sensing probe, the capacitance change per foot of product level (pF/ft) can be easily determined.
- j. Reinstall the probe in the vessel if it was removed, and read and record the capacitance value on the meter of the test instrument.
- k. By using the pF/ft value determined in step i and adding or subtracting from the capacitance value obtained in step j, the "Zero" and "Span" values required can be determined.
- l. Disconnect the test cable from the sensing probe.
- m. Make sure all "OUTPUT CAPCITANCE" pushbuttons are out and adjust the "OUTPUT VERNIER" control to minimum.

- n. Select the 30 pF range and depress the "ON" switch. Make sure the pointer is above zero on the meter dial and then adjust the "ZERO" control clockwise until the meter pointer is on zero.
- o. Connect the test cable to the input jack on the printed circuit assembly. Be sure the black lead is connected to ground.
- p. If the Model 167 being calibrated is not equipped with an output indicator, install a cable from jack J2 on the power board to the meter phone jack on the test instrument to monitor the output current of the transmitter.
- q. Apply power to the circuit board.
- r. Push the "SEND" button in and depress the proper "OUTPUT CAPACITANCE" buttons in combination with the "OUTPUT VERNIER" control to transmit the "ZERO" capacitance value determined in step k.
- s. Adjust the "COARSE and FINE ZERO" adjustments on the circuit board until the output current of the Model 167 is approximately 5 mA. Slowly turn the "FINE ZERO" adjustment counterclockwise until the output is exactly 4 mA. DO NOT OVERADJUST, otherwise non-linearity or interaction between span and zero will occur.
- t. Depress the proper "OUTPUT CAPACITANCE" buttons in combination with the "OUTPUT VERNIER" control to transmit the "SPAN" capacitance value determined in step k.
- u. Adjust the "COARSE and FINE SPAN" adjustments on the circuit board until the output current is 20 mA.
- v. Disconnect the test cable(s) and reinstall the printed circuit assembly in the enclosure. Calibration is complete and the unit is ready for operation.

4.2.3 Null Adjustment Calibration

THIS ADJUSTMENT IS FACTORY SET AND ADJUSTMENT SHOULD NOT BE REQUIRED. However should calibration of the NULL adjustment be required, perform the following procedure.

- a. Disconnect the probe by removing the Printed Circuit Assembly from the enclosure.
- b. Adjust the COARSE ZERO switch to position No. 1 and the COARSE SPAN switch to position No. 8.
- c. Adjust the NULL adjustment (R39) until the output indicates 3.98 milliamperes.
- d. Reinstall the Printed Circuit Assembly in the enclosure.
- e. Recalibrate the instrument.

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