W-15886

OPERATION AND MAINTENANCE MANUAL

FOR THE

DEEP INJECTION AND MONITORING WELLS

AT THE

SYSTEM 9 NORTH WASTEWATER TREATMENT PLANT

Palm Beach County
Water Utilities
Department

Prepared By

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January 1986

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INTRODUCTION

Section 1
INTRODUCTION

PURPOSE AND SCOPE

This manual has been prepared by CH2M HILL as a reference guide for the operation and maintenance of the deep injection well effluent disposal system servicing the Palm Beach County Water Utilities Department System No. 9 North and South Plants, hereafter referred to as WWTP 9N and WWTP 9S. The preparation of this manual follows the guidelines set forth in specific conditions contained in the Florida Department of Environmental Regulation (FDER) Test/Injection Well Permit UC 50-092095.

GENERAL SYSTEM DESCRIPTION

The Palm Beach County Water Utilities Department (PBCWUD) System No. 9 provides wastewater collection and treatment service to the southern unincorporated area of Palm Beach County. The system consists of two treatment facilities, known as the north plant or WWTP 9N, and the south plant, or WWTP 9S. Figure 1 shows the approximate location of the two treatment plants. WWTP 9N is located at 19110 South State Road 7, adjacent to State Road 7 between the American Homes and Moon Lake Subdivisions. WWTP 9S is located at 22438 S.W. 7th Street, within the Sandalfoot Cove Golf Course. WWTP 9N has a treatment capacity of 4.5 million gallons per day (mgd) and WWTP 9S has a capacity of 3.0 mgd.

The primary components of the new effluent disposal system serving System No. 9 are a deep injection well, injection pump station, and monitoring well at WWTP 9N, an effluent transfer pump station at WWTP 9S and an effluent transmission main between the two WWTP's. The transmission main is routed along S.W. 3rd Street and State Road 7 as shown on Figure 1.

WWTP 9N

A flow diagram and site plan for the WWTP 9N is shown on Figure 2. Effluent flow from the secondary treatment units can be split to either the wet well serving the injection pump station or the advanced treatment units consisting of filtration and disinfection facilities. Under normal operating conditions only water serving a useful purpose is directed to the advanced treatment process. Examples of the uses of this water include plant usage such as yard irrigation, wash down, chlorine solution supply, and pump seal water. In the future, advanced treatment will also be provided to enable land application of the effluent on large irrigation sites in the area such as golf courses.

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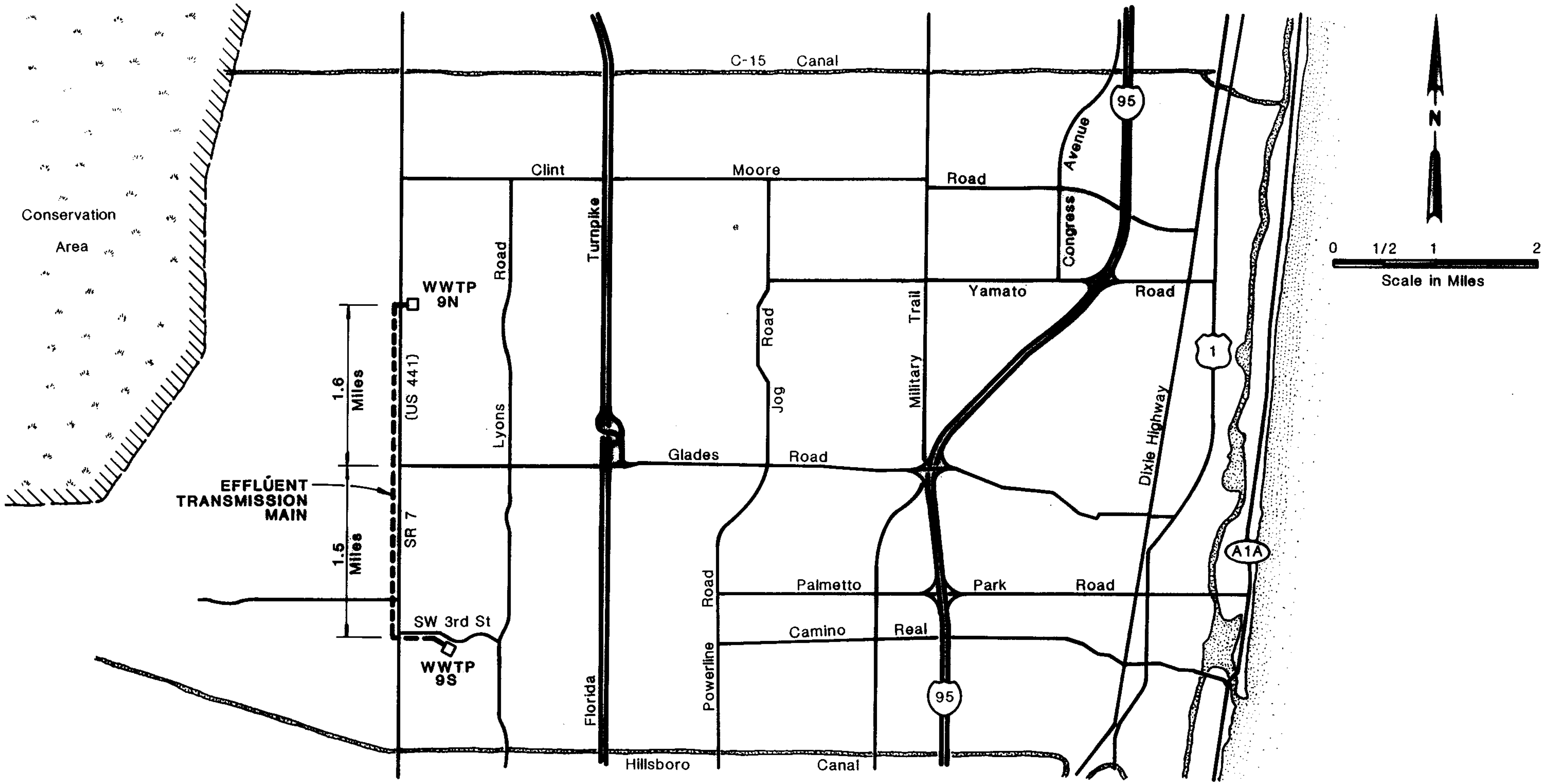

FIGURE 1-1
Facilities Location Map

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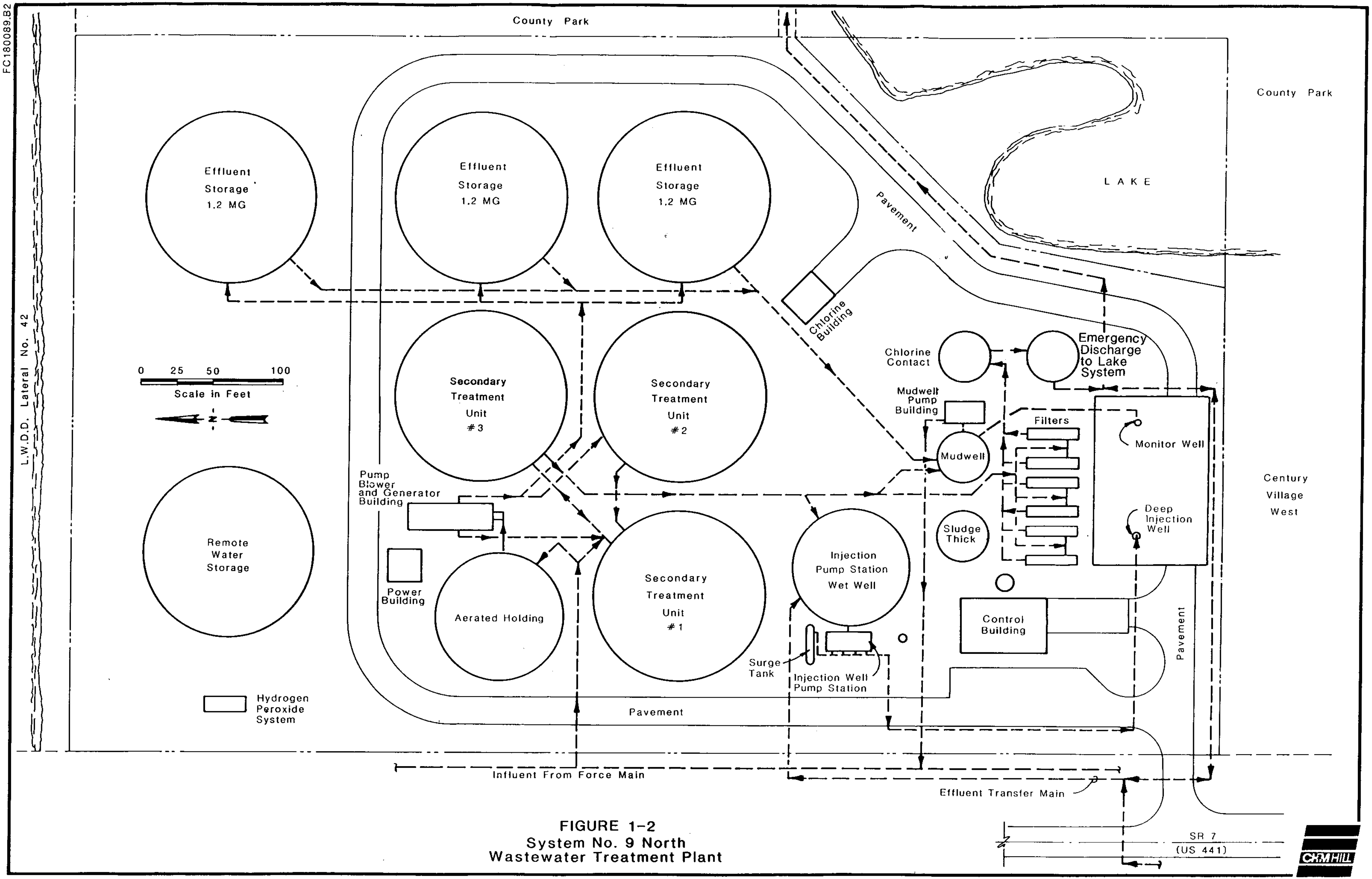

FIGURE 1-2
System No. 9 North
Wastewater Treatment Plant

Effluent not required for usage is directed to the injection pumping system consisting of a wet well, pump station, and surge control system. All effluent delivered to the wet well is pumped to the deep injection well for disposal.

In the event of a failure of the injection system, all effluent from WWTP 9N is to be diverted through the advanced treatment units for disposal in the lake system via the emergency discharge piping. Effluent from WWTP 9S is to be disposed of by discharge to the existing percolation ponds.

WWTP 9S

A process flow diagram for WWTP 9S is shown on Figure 3. Effluent from the secondary treatment units flows to the advanced treatment process of filtration and disinfection. After disinfection, effluent flows to the effluent holding tank (wet well) from which it is pumped, by the effluent transfer pumps, into the effluent transmission main. The effluent transmission main transports WWTP 9S effluent to the WWTP 9N injection wet well where it is discharged. Thus, the injection pumping system and disposal well receive effluent from both WWTP's 9N and 9S.

Although piping is in place at WWTP 9S to enable pumping of secondary effluent directly from the treatment units, the FDER is requiring that only advanced secondary effluent be carried in the transmission main. This requirement is based upon a plan to use the main in the future to carry advanced secondary effluent to land application sites. The FDER will not allow the transmission main to carry undisinfected effluent if it will carry land application quality water in the future.

Further information on WWTP 9S facilities and operating procedures can be found in the Operations Manual for PBCWUD System No. 9 South WWTP, dated January 1986.

OPERATOR RESPONSIBILITY

The interconnector force main, injection well, monitor well, injection well pumping system, and surge control system are integral parts of the wastewater treatment plant and must be operated and maintained by skilled personnel in order to properly dispose of the treated effluent.

Operator qualifications must include a working knowledge of pumps, motors, electrical and electronic equipment, hydraulics, wastewater treatment, and good safety practices. The Operator must maintain the system and correct any deficiencies properly and promptly. The Operator must also be capable of interpreting, recording, filing, and reporting the system operating and monitoring data.

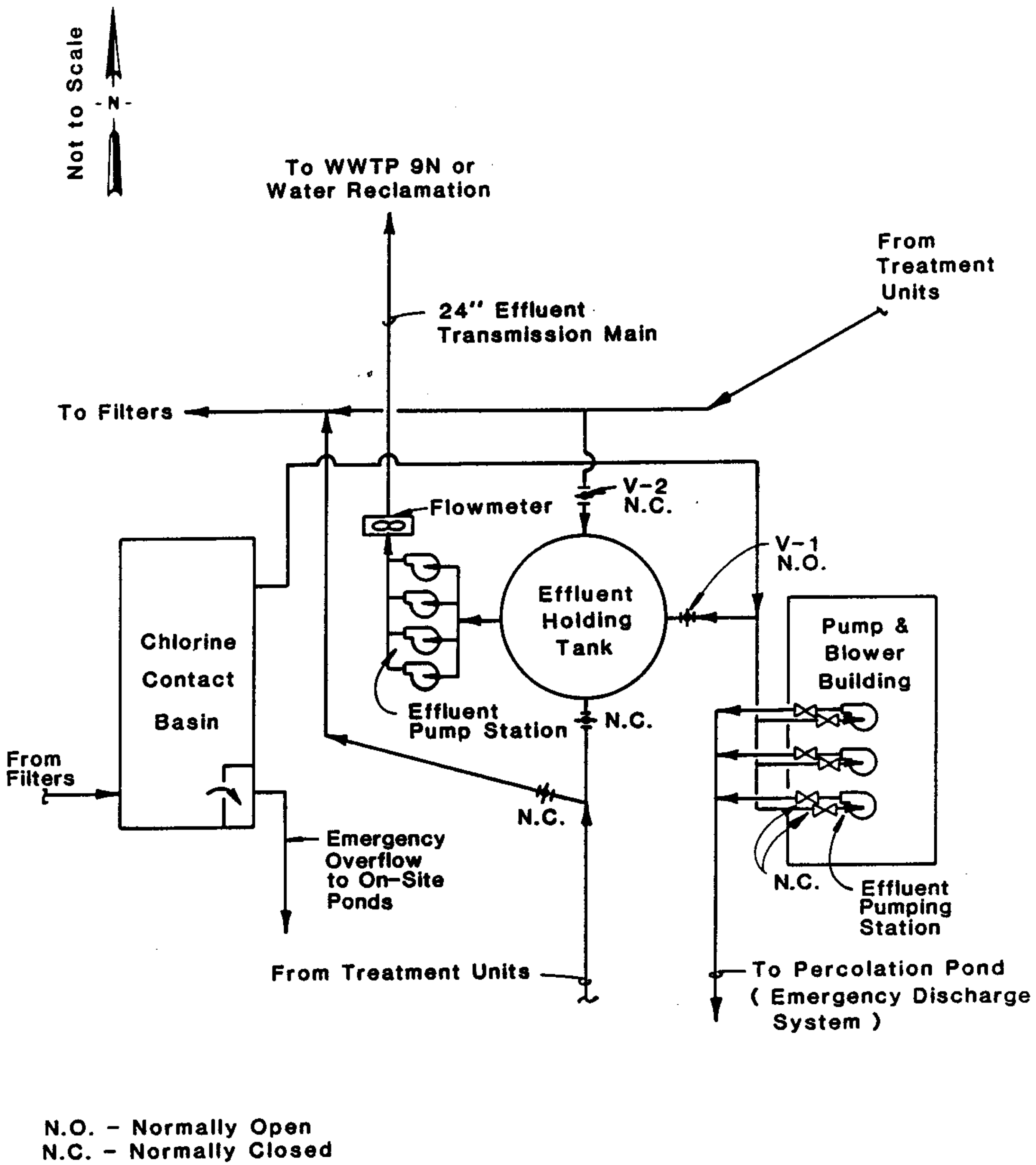

FIGURE 1-3
WWTP 9S
Effluent Pumping
System

The Utility is responsible for the allocation of sufficient funds for maintenance, repairs, parts inventory, tools, and site security. The Operator must keep Management advised of the condition of the wastewater treatment and process systems.

Both the Operator and Management should keep in mind that the goal of the wastewater treatment system is to treat the wastewater to the level required by law and to ensure that the effluent is disposed of in an environmentally sound manner.

SECTION 2

SYSTEM DESCRIPTION

Section 2
SYSTEM DESCRIPTION

FACILITIES DESCRIPTION

A detailed description of the facilities associated with the underground injection system is presented in the following.

DEEP INJECTION WELL

The deep injection well has the capacity to receive up to 15 mgd. The well is constructed to enable disposal of treated effluent into a hydrogeologic unit known as the Boulder Zone. This zone is a highly transmissive dolomitized interval of the Oldsmar Limestone. Native waters in this zone, a portion of the lower Floridan aquifer, exceed 35,000 TDS and are equivalent to sea water in basic chemical composition. This feature underlies most of southeast Florida and is used for effluent disposal by many utilities.

The injection well has four fully-cemented, ½-inch thick steel casings installed as shown on Figure 2-1, Injection Well Construction Details. The casings are designed to enable drilling and isolate and protect the aquifers from contamination by injected fluids.

The surficial aquifer, which provides the major portion of the Palm Beach County water supply, is contained in formations that extend to a depth of approximately 220 feet at the System 9 site. The outer casing, 54 inches in diameter, is set to a depth of 250 feet from land surface.

The 44-inch diameter casing was set to a depth of 1,000 feet to facilitate construction of the well by isolating the Hawthorne Clays and Tampa Limestones occurring between 220 and 950 feet in depth.

The 34-inch diameter intermediate casing was set to a depth of 1,800 feet to isolate the artesian waters of the Upper Floridan Aquifer during construction.

The final casing string, 24 inches in diameter, is set to 2,650 feet, just below the base of the first competent confining interval above the injection zone, a tan biomicritic limestone of the mid-Eocene Series Lake City Limestone.

The injection zone is located in Oldsmar Limestone between the depths of 2,700 and 2,900 feet. It is separated from the potable water of the surficial aquifer by approximately 2,600 feet of limestones and clay which comprise confining units of varying transmissivities. The heavy clays of the

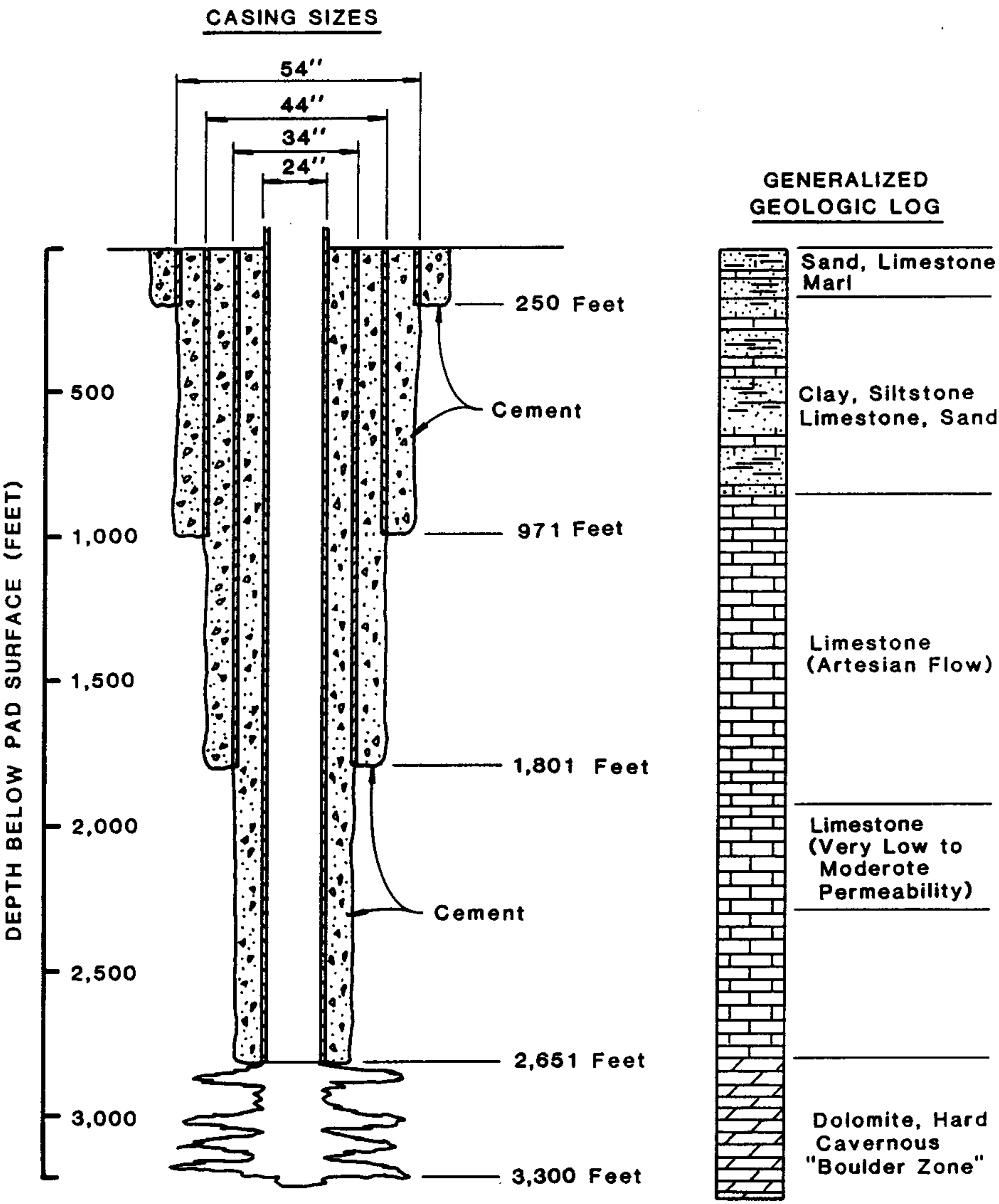

FIGURE 2-1
Injection Well
Construction Details

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Hawthorne unit, approximately 300-feet thick, form an excellent aquiclude and the possibility of contaminating the surficial aquifer with fluid from the injection zone is very slight.

Extensive lithologic and hydrologic data has been collected during construction of the well. This data is presented in the engineering report titled "Drilling and Testing of the Injection and Monitoring Wells for Palm Beach County System No. 9 North". It is recommended that a copy of this report be made available to all plant personnel for reference purposes.

The injection well has been constructed in accordance with the requirements of the Florida Administrative Code (FAC) Chapter 17-28 under the Florida Department of Environmental Regulation (FDER) Construction Permit No. UC 50-092-95.

Instrumentation and Control

The I&C loops for the injection well consist, primarily of flow and pressure measurement and recording equipment.

Flow. The effluent flow rate into the injection well is measured with an insert-type Venturi flow element manufactured by the Badger Meter Company (24-inch PMT-1 Plastic Insert Flow Tube with 304 Stainless Steel Throat rated for a maximum flow rate of 7,200 gpm).

The Venturi element is located in the effluent injection line 10 feet from the center line of the injection well. The unit reads a maximum of 227.04 inches of water at 7,200 gpm. Accuracy of flow measurement is within approximately .25% when the unit has been calibrated. The installation contractor has calibrated the unit. Should it ever become necessary to recalibrate the unit, calibration data is included in Appendix B MANUFACTURERS' LITERATURE.

A Rosemount Alphaline Flow Transmitter Model 1151DP5J22B1 at the well head converts the pressure differential to a 4-20 milliamp signal recorded on a Fisher & Porter Series Circular Chart Recorder (Model Number 51B1102DBBXXXXXX2BB2BBX) located adjacent to the main control panel in the Control Building. The 12-inch circular chart scale reads from zero to 75 and the flow rate is obtained by multiplying the chart reading times 100 gpm. In addition, an eight digit totalizer is included and reads in units of 1,000 gallons.

Pressure. Also at the well head is a Robertshaw 314B pressure gage reading 0-60 psi. A Rosemount 4-20 milliamp pressure transmitter Model 115GP6E22B1 sends a signal that is recorded on a Fisher Porter circular chart recorder Model 51B1102DMXXXDBXXX2BB2BB mounted adjacent to the main control panel (MCP-1) in the Control Building. The recorder reads on a direct linear scale 0 to 60 psi.

Figure 2-2 shows the injection well head configuration.

MULTI-ZONE FLORIDAN AQUIFER MONITOR WELL

In accordance with the requirements of Chapter 17-28.24 of the FAC, a monitor system has been designed and constructed to provide for the early detection of any upward migration of treated effluent.

The Multi-Zone Floridan Aquifer Monitor Well is a dual-zone monitor well located 80 feet east of the injection well. Construction details of the monitor well are shown in Figure 2-3, Floridan Aquifer Monitor Well, and Figure 2-4, Floridan Aquifer Monitor Well, Well-Head Details.

The upper monitor zone (zone 1) lies between the depths of 970 feet and 1,105 feet below land surface in the limestones of the Suwannee Formation of the Oliogocene Series. This is the upper-most zone of the artesian Floridan aquifer. The shut-in artesian pressure of this zone was recorded at completion of construction as 6.2 psi. Any significant deviation from this value will indicate either an instrumentation error, which must be corrected, or an abnormal event that must be reported to the appropriate regulatory agencies as detailed in the Operating Permit.

This portion of the Floridan aquifer is monitored through the annular space between the 16-inch and 6-inch casing. A 2-inch tap and ball valve on the 16-inch casing may be opened to allow the zone to flush before drawing a sample for analysis (see Figure 2-4, Floridan Aquifer Monitor Well - Well Head Details). The naturally-occurring artesian head at this depth is 37.5 feet above mean sea level (MSL) and the zone will flow at a rate of approximately 75 gallons per minute (gpm) through the monitor discharge line on the 16-inch casing. Native formation water at this depth is brackish with chlorides in the range of 1000 to 1500 mg/L and total dissolved solids in the range of 5000 to 6000 mg/L.

The lower monitor zone (zone 2) extends from the base of the 6-inch casing at 1,699 feet to a depth of 1,800 feet below land surface. The lithology of the lower monitor zone is a soft, yellowish gray, biomicritic limestone typical of the Avon Park Limestones of the Upper Eocene Series. The shut-in artesian pressure of this zone was recorded at completion of construction as 8.5 psi. As with the upper monitor zone, significant deviation from this value will indicate either an instrumentation error that must be corrected or an abnormal event that must be reported to the appropriate regulatory agencies. The naturally occurring artesian head

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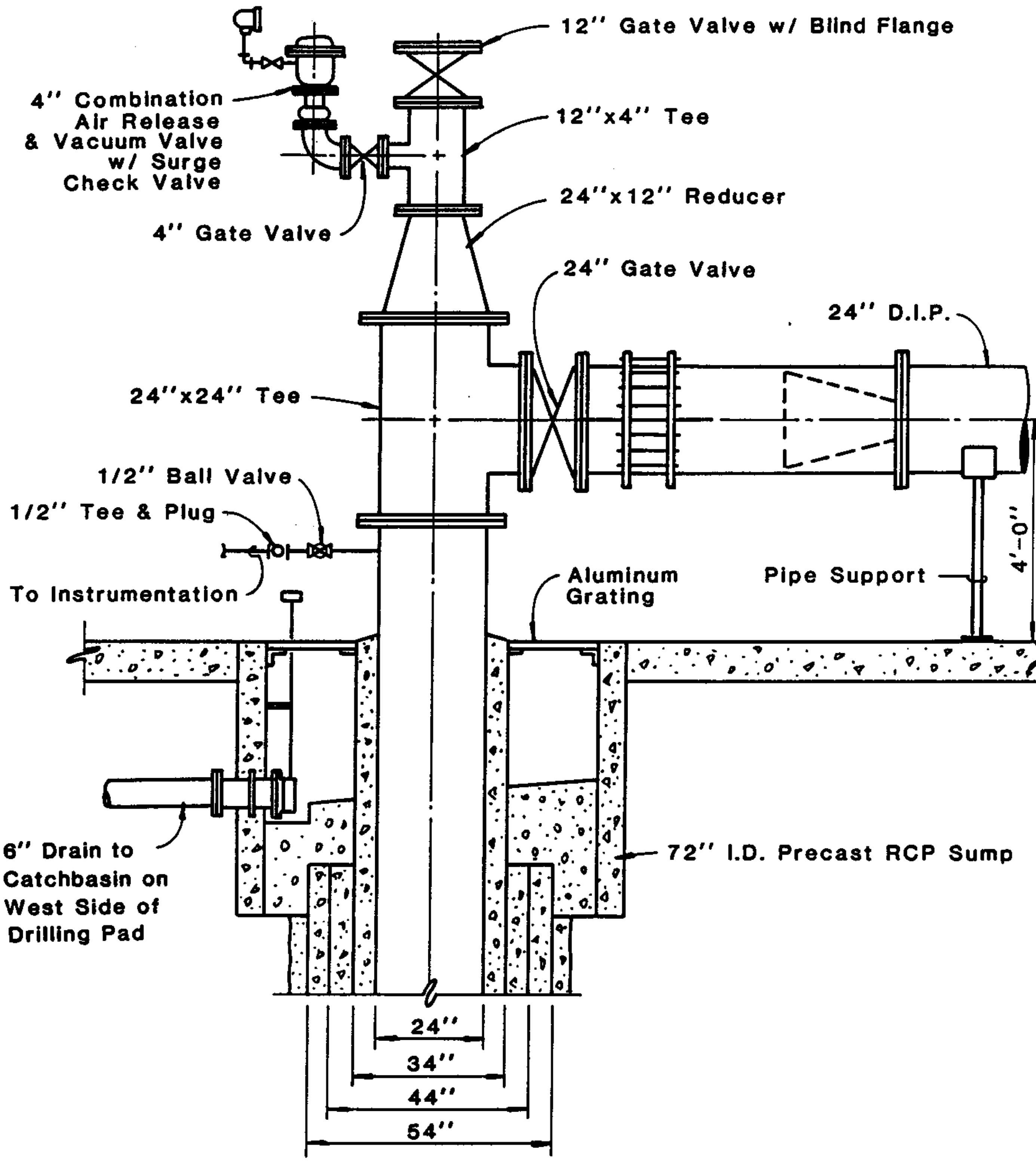

FIGURE 2-2
Injection Well Head

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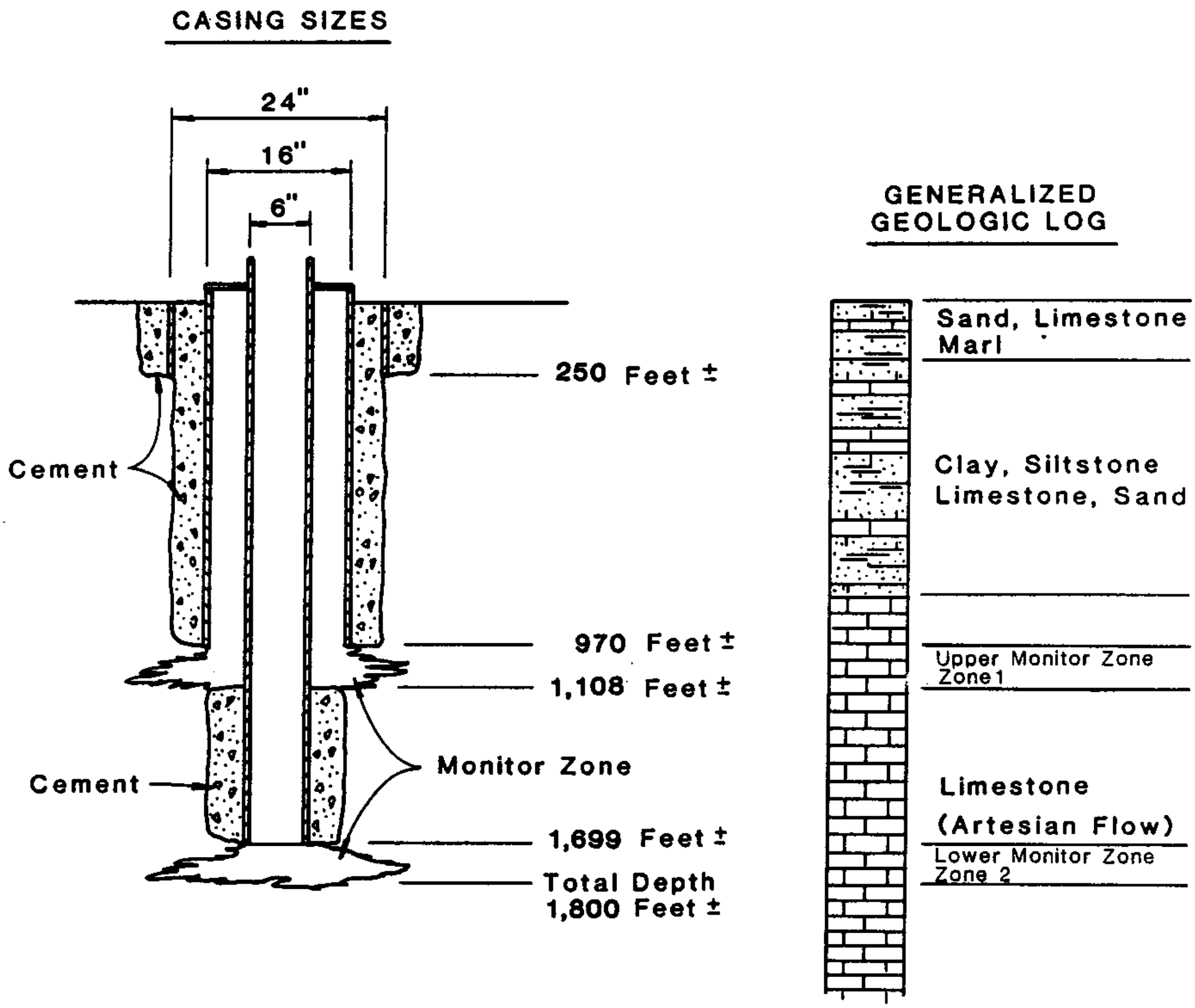

FIGURE 2-3
Monitor Well
Construction Details

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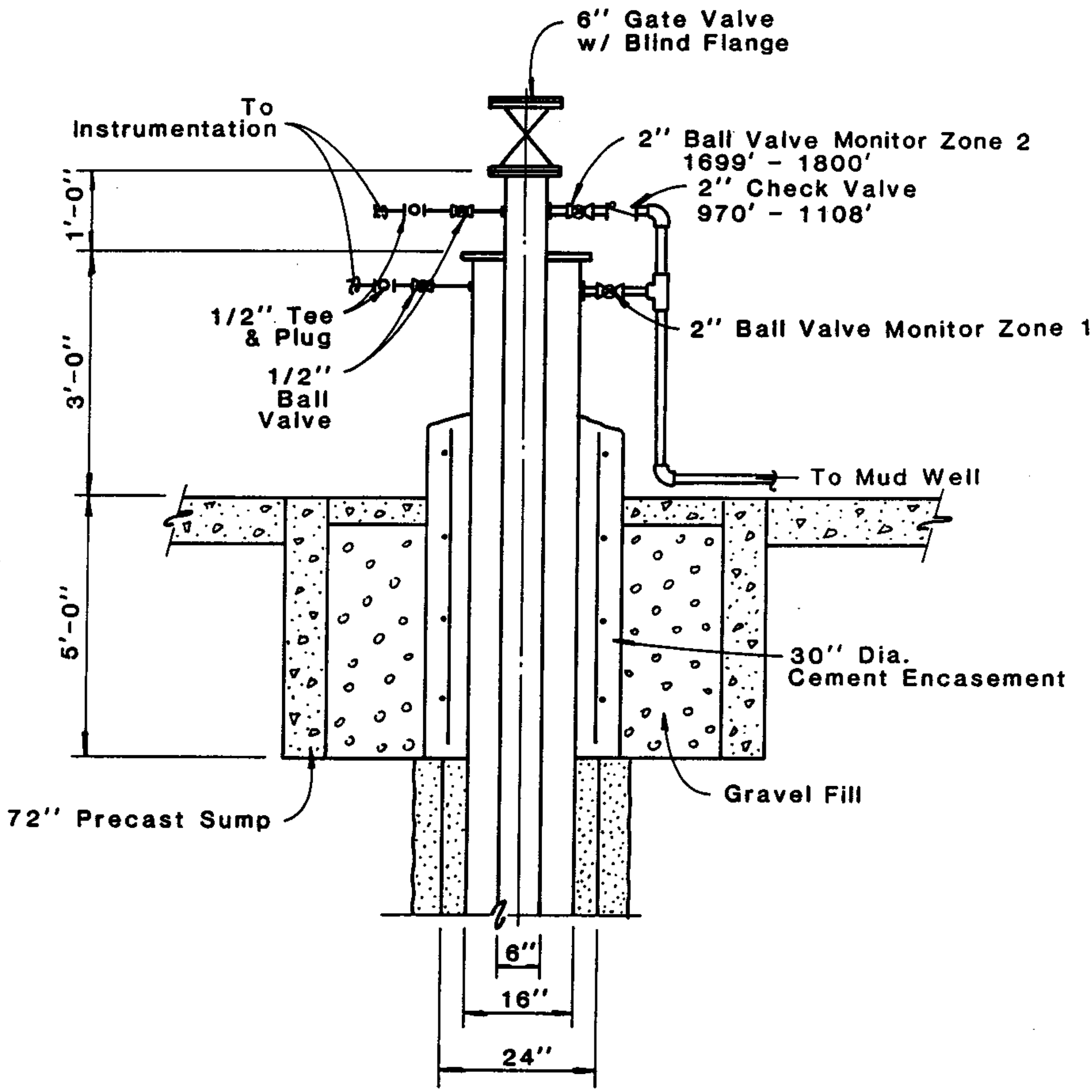

FIGURE 2-4

Dual-Zone Monitor Well Head

in the lower monitor zone is 42.8 feet above MSL and this zone also flows at a rate of approximately 75 gpm. Native formation water at this depth is brackish with chlorides in the range of 2000 to 2500 mg/L and total dissolved solids in the range of 8000 to 9000 mg/L.

The lower monitor zone may be flushed for sampling through the 2-inch tap and ball valve on the 6-inch casing (see Figure 2-4, Floridan Aquifer Monitor Well - Well Head Details).

The upward movement of effluent into a monitor zone would result in a decrease in the density of the monitor zone fluids and an increase in observed pressure. Confirmation of a leak would be provided by a significant reduction in conductivity, a reduction of chloride content, and/or the presence of coliform bacteria in the monitor zone fluids.

Pressure in each monitor zone is continuously recorded and water quality of the monitor zones is to be checked each month. Proper procedures for the collection and analysis of water quality samples and for the reporting of data are addressed in Section 3 - DATA COLLECTION AND REPORTING PROCEDURES.

Plant personnel responsible for gathering water quality samples should familiarize themselves with those procedures.

Monitor Well Instrumentation

Pressure from each monitor zone is measured and recorded. Both monitor zones are provided with Robertshaw 314B pressure gauges and Rosemount Alphaline Gauge Pressure Transmitters (Model 1151GP6E22B1) that send a 4-20 milliamp signal to the Fisher and Porter 12-inch circular chart recorder (Model 51B1102DXXXDBXXX2BB2BB) mounted in MCP-1 in the Control Building.

INJECTION PUMP STATION

The injection pump station consists of 4 horizontal, centrifugal pumps. Specific information on each pump is presented below:

Pump Tag No.	Rated Capacity	Motor hp	Model No.
P-01-2-1	1,400 gpm @ 104' TDH	50	Worthington 6LR13
P-01-1-1	3,000 gpm @ 96' TDH	100	8LR14
P-01-1-2	3,000 gpm @ 96' TDH	100	8LR14
P-01-2-2	1,400 gpm @ 104' TDH	50	6LR13

The design capacity of the four pumps is 8,800 gpm or 12.7 mgd. Provisions were made on the suction and discharge headers to add additional pumps in the future. The units are located outdoors on a concrete slab. The motors are horizontally-mounted, TEFC, squirrel-cage induction type, manufactured by U.S. Motors.

An existing above-grade, steel constructed alum coagulation treatment unit was converted into the pump station wet well. The scraper mechanisms were removed, pipe connections for the WWTP 9N and 9S discharges were made and a connection for the pump station suction header was installed. The pumps are actuated by a bubbler-type, level control system.

The motors are connected to the plant's emergency power system. One set of 50 and 100 hp motors are connected to one of the two generators and the other set of motors is connected to the other generator. Thus, should a situation arise where a power outage occurs and one of the generators is out of service, the injection pump station will remain in operation.

Instrumentation and Control

The instrumentation and control loops associated with the pumping system are pump discharge pressure indication, pump ON-OFF-AUTO control, wet well level, and control of flow split between wet well and filters.

These functions are controlled from Master Control Panel 1 (MCP-1) located in the Control Building.

Figure 2-5 shows the instrumentation layout on the control panel MCP-1.

Pump Discharge Pressure. A pressure gauge is mounted on the discharge pipe of each injection pump. The gauges are Robertshaw Acragage 314 B, 0- to 60-psi scale. The gauges indicate discharge pressures from the pumps.

Pump ON-OFF-AUTO Control. At MCP-1, each injection pump has a hand switch for ON, OFF or AUTO control. Adjacent to each switch are two lights which indicate if the pumping unit is "ON" or "OFF".

When the hand switch is set to the "AUTO" mode, pump operations are controlled by a bubbler-level switch system housed in field panel FP-01-1, located adjacent to the pump station. Air supply for the bubbler system is provided by the air compressor serving the surge control system.

Figure 2-6 presents a graphic representation of the control plan for the injection pumps. High and low water level

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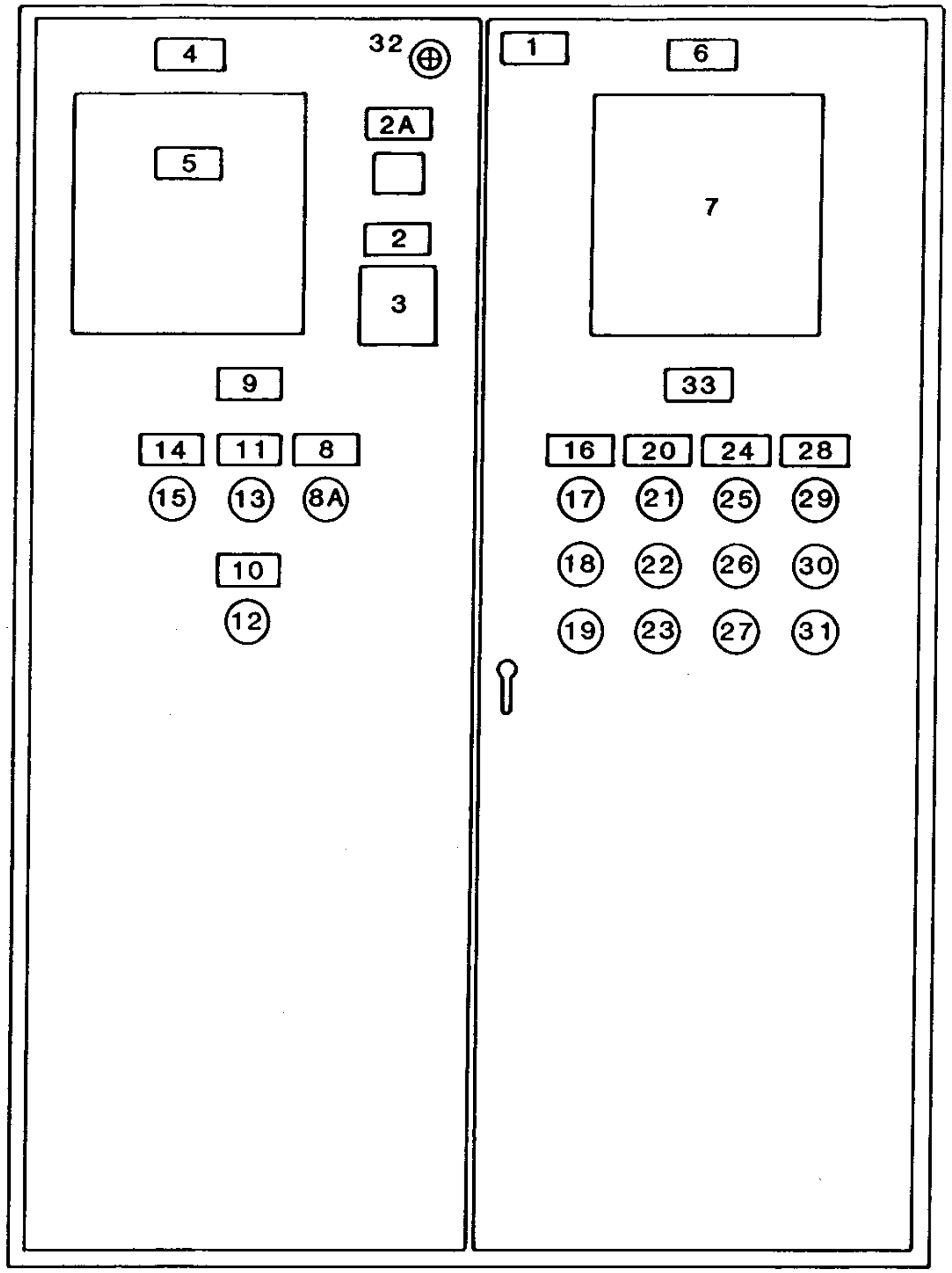

MCP-1

Located in Control Building

LEGEND

FI	Flow Indicator
FR	Flow Recorder
FQI	Flow Totalizer
HS	Hand Switch
LLHH	Alarm-Light High Level
LLLL	Alarm-Light Low Level
P	Pump
PR	Pressure Recorder
QA	Alarm-Horn
QL	Alarm-Light

MCP-1 PANEL SCHEDULE

ITEM NO.	TAG NUMBER	NAMEPLATE INSCRIPTION (SERVICE LEGEND)
1	Nameplate	MCP-1
2	Nameplate	Filter Influent Flow Rate - GPM
2A	Nameplate	Filter Total Flow - Gals.x1,000
3	FI-01-4	————
4	Nameplate	Injection Well Flow Rate - GPM
5	FR/FQI-01-5	(Total Flow to Injection Well 1 Digit 1,000 Gallons)
6	Nameplate	Injection Well Pressure - PSIG
7	PR-01-5	(Red Pen - Inlet Pressure Blue Pen - Zone A Pressure Green Pen - Zone B Pressure)
8	Nameplate	Surge System Trouble
8A	QL-01-7	————
9	Nameplate	New Wet Well
10	Nameplate	Low
11	Nameplate	High
12	LLLL-01-3	————
13	LLHH-01-3	————
14	Nameplate	New Wet Well Inlet Throttling Valve
15	QL-01-4 [Close]	(Close)
16	P-01-2-1	Injection Well Pump No. 1
17	HS-01-2-1[00A]	(On-Off-Auto)
18	QL-01-2-2-1 [00]	(On)
19	QL-01-2-2-1 [00]	(Off)
20	P-01-1-1	Injection Well Pump No. 2
21	HS-01-1-1 [00A]	(On-Off-Auto)
22	QL-01-1-2-1 [00]	(On)
23	QL-01-1-2-1 [00]	(Off)
24	P-01-1-2	Injection Well Pump No. 3
25	HS-01-1-2 [00A]	(On-Off-Auto)
26	QL-01-1-2-2 [00]	(On)
27	QL-01-1-2-2 [00]	(Off)
28	P-01-2-2	Injection Well Pump No. 4
29	HS-01-2-2 [00A]	(On-Off-Auto)
30	QL-01-2-2-2 [00]	(On)
31	QL-01-2-2-2 [00]	(Off)
32	QA-01-7 [Surge System Trouble]	————
33	Nameplate	Injection Well Pumps

FIGURE 2-5
Elevation View of MCP-1

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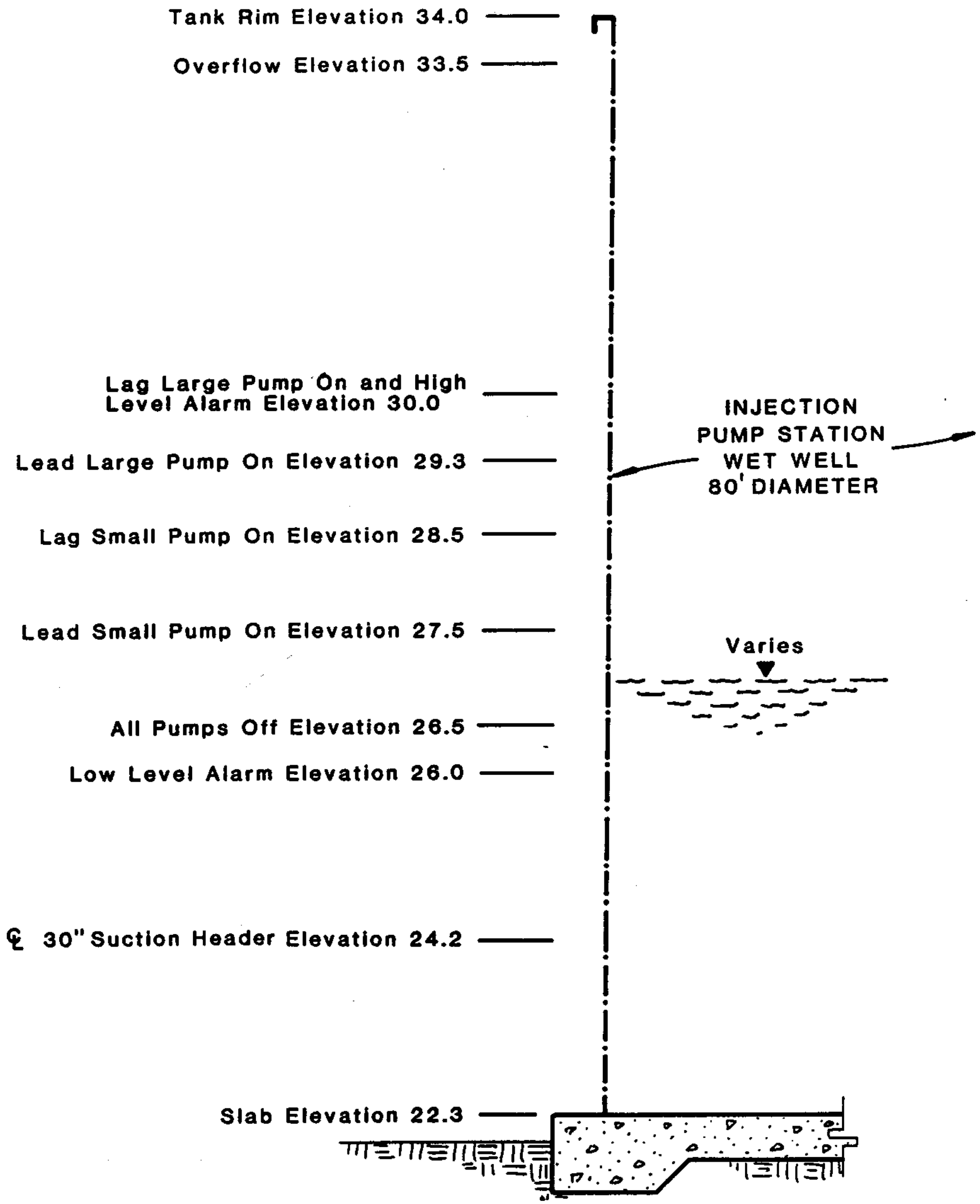

NOTE: The lead and lag sequence of the pumps are automatically alternated.

FIGURE 2-6
Level Control Settings for Injection Pump Station

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conditions activate a wet well trouble light at MCP-1 in the Control Building.

FLOW SPLIT CONTROL

A control valve on the inlet pipe to the wet well enables the operators to perform a flow split between wastewater for disposal and reuse. As shown on Figure 1-2, after secondary treatment the wastewater flow can follow two possible paths. One is to the wet well for deep well injection and the other is to the filtration and disinfection systems to receive the advanced treatment required for reuse or emergency discharge to the lake system.

The primary components of the control loop are a Limitorque motor-actuated butterfly valve on the wet well inlet pipe, a Sparling turbine flow meter on the filter influent pipe, a Fisher and Porter flow controller, and a G.E. vertical scale flow indicator with adjustable set point.

The system is designed to enable the operators to control and limit the wastewater flow going to the filtration and disinfection processes. Operation of the control system is relatively simple, requiring the following steps:

1. Check hand switch on Limitorque actuator on wet well inlet valve. Switch should be set on REMOTE.

2. At MCP-1, turn the plastic adjustment screw on the G.E. vertical dial indicator until the desired flow to the filters is set.

3. Check existing plant flow meter and filters to see if system is operating properly.

A constant flow rate will be delivered to the filters and all excess flow will enter the wet well for deep well disposal. Total volume to the filters is indicated on a mechanical totalizer on the vertical dial indicator.

SURGE CONTROL SYSTEM

The surge control system consists of a 6,000-gallon, 6-foot diameter horizontal steel tank, an air compressor, instrumentation, control, valving and piping. The function of the surge tank is to dampen pressure surges. When pumps are stopped, the water within the system remains in motion, due to momentum of the water column. The continued movement produces a vacuum behind the water column that persists until the flow reverses. This sudden drop in pressure, followed by a rapid increase in pressure as the flow reverses, can produce extreme pressure variations in the injection system, and severe damage to the pipe or well casing could result.

The moment the pumps stop, the surge tank supplies water to the pump station discharge pipe and well. By supplying this water to the system, the pressure wave created when the flow momentum reverses and comes back up and out of the well is greatly dampened.

For proper operation, the surge tank should be about half full of water. The remaining volume is filled with air supplied by the air compressor. The System No. 9 surge control system was designed so that the correct air/water volume ratio would be automatically maintained. This is accomplished by an instrumentation and control loop which, based on water level in the tank sensed by electrodes, allows air to be supplied to the tank when the water level is too high or allows air to vent from the tank when the water level is too low. Alarms notify the operators in the Control Building when extreme high or low water levels occur. A sight glass is provided on the tank to enable visual inspection of the water level.

The air compressor for the system is a duplex, 5 hp Ingersoll Rand T30 Model 242 5C unit located adjacent to the surge tank. The receiver tank has a capacity of 80 gallons. The compressor control system operates independent of the other surge control instrumentation. The pressure switches are set so that the air receiver tank remains pressurized at 100 psi.

Surge System Instrumentation and Control

The instrumentation and control loops associated with the surge control system are graphically shown on Figure 2-7.

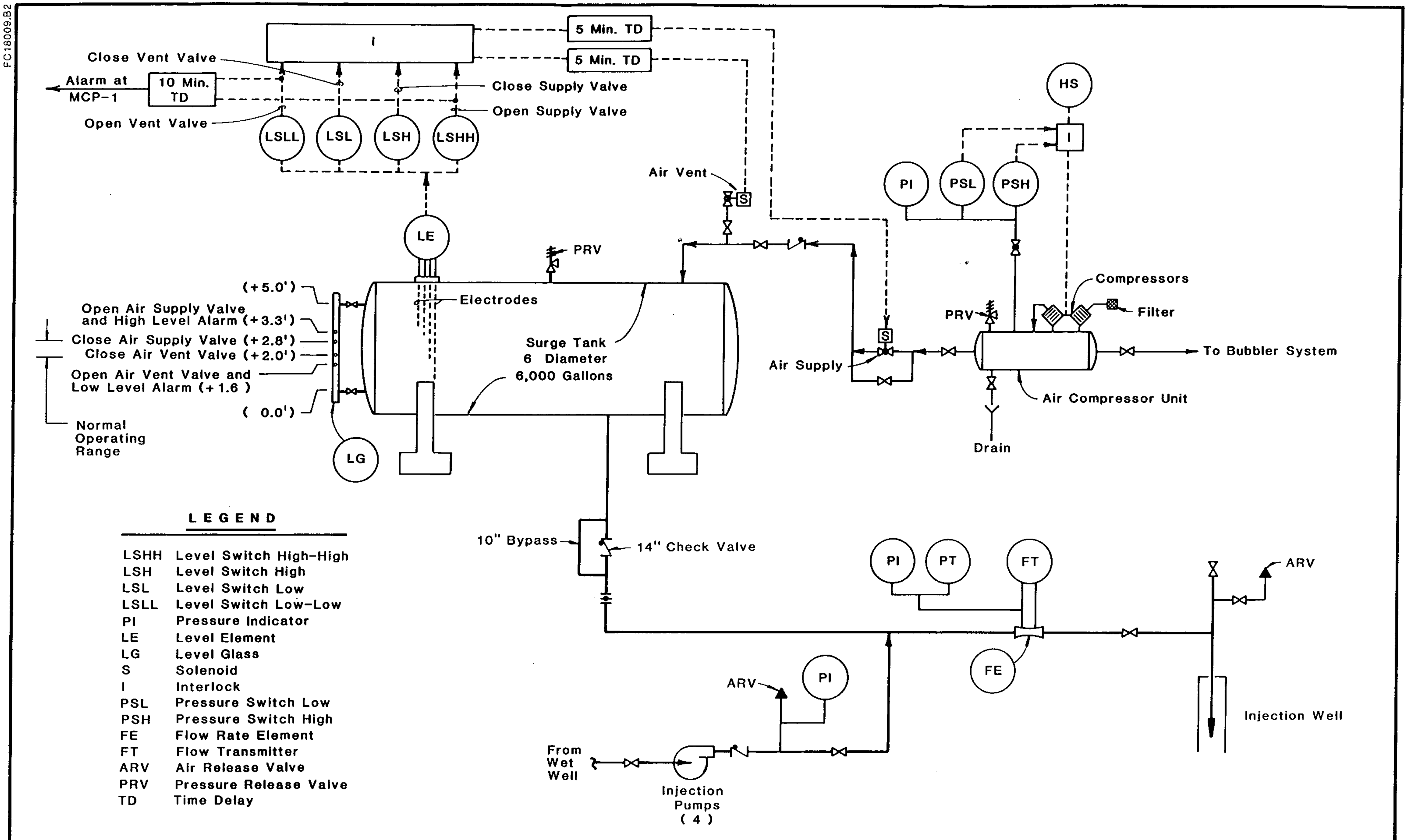

FIGURE 2-7
Surge Control Process and Instrumentation Diagram

SECTION 3

OPERATION AND DATA COLLECTION

Section 3
OPERATION AND DATA COLLECTION

OPERATION OF THE SYSTEM 9 NORTH EFFLUENT DISPOSAL SYSTEM

The following instructions are provided to assist the operator in assuring the safe and efficient performance of the deep injection well effluent disposal system. The instructions presented are general in nature and are for the system as constructed. Before performing the operations listed below the operator must assure himself that the system has not been modified since preparation of this manual.

Before operating any of the equipment associated with effluent disposal system the operator should read the equipment supplier's information provided in the Appendix of this document. If the equipment in place does not match that described in the appendix the operator should contact his supervisor for specific operating instructions.

The surge control system is of paramount importance for the protection of the effluent disposal system and must be in service if the injection well is to be used.

GENERAL PUMPING INSTRUCTIONS

The following are general instructions that apply to the operation of injection well pump station:

1. Insure that the surge control system is functioning properly, with the water level in the tank at the approximate midpoint of the tank. The reading on the sight glass mounted at the front of the tank should be between the marks indicating High Level and Low Level. Check the Main Control Panel (MCP-1) in the Control Building for Surge System trouble. If the surge control system is not functioning properly, do not start injection, contact a supervisor and advise them of the condition. Do not commence injection if the surge control system is not functioning.

2. Check to make sure that all valves in the flow path to the injection well are open. The discharge valve on individual pumps may be chained in a partial closed position in order to bring the pump onto a more efficient point of its performance curve. This determination of efficiency is based on effluent flows at the time of construction and the operator may wish to modify the valve settings as plant flows increase over the operating life of the system.

Care should be taken that the pumps are never operated against fully closed valves. Damage to the pumps may result due to overheating or pressure build-up.

The pumps are operated from the control panel designated MCP-1 located in the operators room. Each injection pump has an individual three position switch, On, Off, or Auto. Under normal operating conditions a pump should be in the Auto position, with control of the pump being provided by the wet well bubbler-type level control system.

3. To prevent personal injury or damage to equipment, de-energize each piece of electrical equipment at its main disconnect (circuit breaker) prior to performing repairs or maintenance. Such work should be undertaken only by properly qualified personnel. In particular, care should be exercised to insure that maintenance involving electrical equipment is carried by properly certified and trained electricians.

4. Before undertaking any action (such as removing a pump from service for maintenance), the operator should be fully aware of its effect on the effluent disposal system. Routine maintenance should be scheduled for periods of low flow and should be discussed with a supervisor before being undertaken.

SURGE PROTECTION SYSTEM OPERATION

Refer to Section 2 Surge Control System for a description of the Surge Control components.

Normal operation of the Surge Control system is fully automatic, being controlled by tank water level sensors in the surge tank.

It is strongly recommended that the operator visually check the sight glass on the front of the tank at least once a day to confirm that the proper water level is being maintained in the tank. The water level should be at the approximate mid-point of the sight glass during normal operation. It may fluctuate during pump startup and shutdown but must return to the midpoint after the fluctuations subside.

If the system cannot maintain the proper water level in the tank, repair efforts must be initiated immediately and the injection system not used until the proper water level in the tank can be maintained.

The air compressor operates independently of the water level control system in that a constant pressure is maintained in the air receiver by independent pressure switches. An ON-OFF-AUTO switch is located in the motor control panel adjacent to the surge tank and should be left in the auto position during normal operation.

The following summarizes the operation of the water level control system.

Air addition proceeds as follows:

1. Activation of the High-High level element occurs when the water level in the tank exceeds the High-High set point of 29.3 feet above msl (3.3 feet above the centerline of the bottom valve on the glass sight tube mounted on the front of the surge tank). This situation causes the air addition valve to open, allowing air into the tank from the compressor storage tank. An adjustable time delay of up to five minutes is provided to allow system vibrations to dampen out.

2. The air addition valve remains open until the water level is forced to below the High-level set point, 28.8 feet above msl (2.8 feet above the centerline of the bottom valve of the glass sight tube).

3. The balance of air/injection fluid pressure maintains the water level between the High and Low set points (28.8 and 28.0 feet msl respectively) within the surge tank.

Air Venting proceeds as follows:

1. If the water level drops to the Low-Low set point, (27.6 feet above msl, or 1.6 feet above the bottom valve on the sight glass) the air vent valve opens, thereby releasing air from the tank to the atmosphere. An adjustable time delay of up to five minutes prevents the air vent valve from opening during surge conditions.

2. The venting of air allows the water level in the tank to rise until the LOW level element closes the air vent valve at 28.0 feet above msl, or 2.0 feet above the bottom valve on the sight glass.

When a Low-Low or High-High level situations exists for a period longer than the time set on the time delay (5 minute maximum), a SURGE SYSTEM TROUBLE alarm light and annunciator is activated in the operator's room. The operator should immediately investigate the cause of the malfunction in the surge control system and, if the water level in the sight glass is not within the normal operating range, the level must be manually controlled and repair procedures initiated immediately.

To manually operate the system, air can be added to the tank by opening the bypass valve beside the air addition solenoid valve near the air compressor. Observe the water level change in the sight glass. Air can be released from the tank by removing the solenoid-operated air vent valve near the top of the tank and manually venting the ½-inch gate valve.

INITIATION OF EMERGENCY DISCHARGE PROCEDURE

In the event that it becomes necessary to initiate operation of the emergency discharge system, the following general steps should be taken.

1. Immediately advise your supervisor of the condition requiring emergency discharge and confirm that emergency discharge is the proper option.

2. Open the valve isolating the emergency discharge system from the chlorine contact basins.

3. Working at MCP-1 in the Control Building, divert flow from the injection pump station wet well to the filters by closing the New Wet Well Inlet Throttling Valve (see Figure 2-5).

4. Contact the WWTP 9S Operator and advise of the emergency discharge condition. The 9S Operator should be instructed to activate the emergency discharge system for that plant and commence effluent disposal to the existing percolation ponds.

5. Contact the Florida Department of Environmental Regulation/Underground Injection Control, West Palm Beach, Florida (305/689-5800) and advise them that emergency discharge has been initiated. A detailed written report will be required at a later date.

6. Contact the Palm Beach County Health Department (305/837-3070) and advise them that the emergency discharge system to the Hamptons Country Club Lakes has been activated. It will be important to ensure that it is understood that the emergency discharge is permitted under the FDER operating

permit and that the effluent being discharged has been filtered and chlorinated.

7. Prepare and submit a written report to FDER of the conditions causing the emergency discharge and the acts undertaken to correct those conditions.

DATA COLLECTION AND REPORTING

Injection system monitoring data are collected to provide a record of system performance and to alert the operator in the event that problems develop with the injection system. The record represents the only direct indication of the injection system performance and serves to substantiate recommendations for future decisions concerning the injection system. Table 3-1, Injection System Monitoring Program, summarizes the parameters and procedures used in monitoring injection well performance.

MONITORING DATA

The monitoring data to be collected and their frequency of collection are:

1. Injection flow in million of gallons per day (mgd) is recorded continuously on a circular chart recorder located in the Main Control panel in the Operators room of the Control Building.

2. Injection pressure in pounds per square inch (psi) is recorded continuously on a similar circular chart recorder (refer to Figure 2-5). Injection pressure will fluctuate with the injection rate.

3. Artesian pressure in psi of the monitoring zones is recorded continuously on the same circular chart recorder used for the injection pressure. The artesian pressure of both monitor zones should remain fairly constant. Significant variation in the recorded pressure in either zone is cause for concern and must be investigated.

4. Effluent suspended solids in milligrams per liter - to be determined daily following the standards of the wastewater treatment plant operating permit.

5. Effluent specific conductance in microhos per centimeter at 25 degrees centigrade - to be determined daily following the standards of the wastewater treatment plant operating permit.

6. Water quality of the monitor zones is to be checked monthly for specific conductance,

Table 3-1
INJECTION SYSTEM MONITORING PROGRAM

Parameter	Equipment or Procedure	Frequency
Injection Flow Rate (gpm)	24-hour circular chart recorder in MCP-1	Continuous
Injection Pressure (psig)	24-hour circular chart recorder in MCP-1 Red Pen	Continuous
Pressure in the Upper Monitoring Zone-- 970-1105 ft (psig)	24-hour circular chart recorder in MCP-1 Blue Pen	Continuous
Pressure in the Lower Monitoring Zone-- 1699-1800 ft (psig)	24-hour circular chart recorder in MCP-1 Green Pen	Continuous
Water Quality of Injected Fluid:		
Specific Conductance	Sample in Plant	Weekly
Suspended Solids	Sample in Plant	Weekly
Temperature	Sample in Plant	Weekly
Water Quality of the Two Monitoring Zones: Specific Conductance Chloride Concentration Temperature Fecal Coliform BOD_5	Sample after flowing zones	Monthly
Specific Injectivity of Injection Well	Inject @ 1800 gpm; measure pressure and calculate specific injectivity	Monthly

temperature, chloride concentration, fecal coliform and biological oxygen demand. See Monitor Zone Sampling, this section.

7. A specific injectivity test is to be performed quarterly to evaluate the injection capacity of the well in order to detect any changes in flow capacity that may occur over time. See specific Injectivity Test, this section.

DATA COLLECTION

Monitoring Zone Sampling

Water quality samples are to be collected from the two monitoring zones on a monthly basis and reported quarterly to FDER. When compared to the pre-injection water quality data collected during the drilling and testing of the monitor well, the data will detect the changes that would be caused by escape of effluent from the injection zone.

If effluent were to migrate through the confining zones, it would result in a freshening of the native waters of the monitor zones. A reduction of conductivity and chloride levels would become apparent as a trend in the reported data.

The process for collecting monthly samples for analysis is as follows:

1. Open both monitoring zone 2-inch ball valves (See Figure 2-3). The pressure in both monitoring pressure recorders will drop significantly. A note should be entered on the circular chart as to the cause of the pressure drop.

2. In order to procure representative samples from the monitor zone it is necessary to flush at least three monitor tube volumes from each monitor. Both zones will flow at an approximate rate of 75 gpm, the upper zone taking 108 minutes to discharge one casing volume, the lower zone taking 33 minutes. As a matter of convenience to the operator, it is recommended that both zones be allowed to flow at the same time, and that the zones be flushed continuously for 7 hours prior to taking the samples. The brackish water produced from the zones is piped to the plant mudwell, processed through the plant and injected to the boulder zone.

3. After the monitor zones have been flushed sterilize the sample tap on the instrumentation line to avoid bacterial contamination of the sample. Flush the

sample tap and take samples for the tests noted in Monitoring Data, Item 6.

4. Close both monitoring zone two-inch ball valves and check the monitoring zone pressures. They should return to approximate pre-flushing values.

5. Run the tests in accordance with the standard laboratory procedures specified in the plant operating permit.

6. Record the data on the appropriate form (See Appendix C, Sample Form for Monitoring Well Water Quality Monthly Report). Note any deviation from normal monitoring sampling procedures or from normal monitoring parameters.

Normal Monitoring Parameters

Table 3-2, Injection System Monitoring Program Normal Values and Trouble Shooting Chart, shows the monitoring parameters and values to be expected when the injection system is functioning properly. If the actual values measured for any of the monitoring parameters vary from the normal range, immediate steps should be taken to report the anomaly and to identify and correct the cause.

Table 3-2 also lists the corrective actions for the most common causes of abnormal values. If the operator cannot identify and correct the cause of the problem a qualified professional must be contacted.

Specific Injectivity Test

A specific injectivity test is to be performed on a quarterly basis to detect any changes in the performance of the injection system over time. The test is performed by injecting at a specific rate (1800 gpm) and recording the injection pressure at that rate. The specific injectivity index is derived from that data and used to compare the relative performance of the well over time.

The test is run as follows:

1. Schedule the test for a period when its performance will not interfere with normal plant operations.

2. Working at MCP-1, take pumps P-01-2-2, P-01-1-1, and P-01-2-2 out of service.

3. Using the discharge valve of pump P-01-2-1, throttle the flow rate to 1800 gpm.

Table 3-2
INJECTION SYSTEM MONITORING PROGRAM
NORMAL VALUES AND TROUBLESHOOTING CHART

Parameter	Normal Range of Values	Suggested Corrective Action if Abnormal Monitoring Values are Encountered[a]
Injection Flowrate (flow recorder)	Average: 6,000 gpm Maximum: 10,500 gpm	1. Check injection pressure for abnormal values. 2. Check water level in pump sump. 3. Check flow path for closed or obstructed valves or fittings. 4. Check and clear clogged pressure line to sender. 5. Check and calibrate flow recorder malfunction. 6. Check for electrical flow transmitter malfunction. 7. Notify plant operations manager. 8. Remove pump from service. 9. Inspect bowls for obstruction or wear. 10. Inspect shaft, bearings, and motor for wear or damage.
Injection Pressure (pressure recorder)	Static: 35 psig Pumping: 35-45 psig	1. Look for leak in injection line or in check valves. 2. Check gauge at wellhead to determine if electrical pressure sender is malfunctioning. 3. Repair and calibrate pressure recorder. 4. Pump station malfunction; see items 1-10 above. 5. Inspect and repair plugged or damaged injection well. 6. Notify plant operations manager.
Zone 1 Upper Monitoring Zone Pressure (pressure recorder - Blue Pen)	6.2 psi 37.5 ft of water msl	1. Check bleed valve; close if necessary. 2. Check and clear clogged pressure line to recorder.
Zone 2 Lower Monitoring Zone Pressure (pressure recorder - Green Pen)	8.5 psi 42.8 ft of water msl	3. Check pressure recorder malfunction; repair and calibrate. 4. Water quality change; see Monitoring Zone Water Quality, Items 1 and 2 below. 5. Notify plant operations manager.
Anticipated Upper Monitoring Zone Water Quality[b] (quarterly water sample)	Chloride mg/L: 1,000-1,500 Specific Conductance µmhos/cm: 9,000-10,000	1. Resample to verify laboratory values. 2. Notify plant operations manager of possible effluent migration into monitoring zones.
Anticipated Lower Monitoring Zone Water Quality[b] (quarterly water sample)	Chloride mg/L: 1,000-1,500 Specific Conductance µmhos/cm: 14,000-16,000	
Injected Fluid Water Quality (weekly water sample)	Specific Conductance µmhos/cm: 500-1,500 Suspended Solids mg/L: 0-20	1. Check process control and correct as necessary.

[a]Corrective actions not necessarily in appropriate sequence for all conditions.

[b]Water quality for monitor zones after extensive well development was:

Upper zone: Cl^- = 1,500 mg/L
Cond = 9,870 µmhos/cm
Lower zone: Cl^- = 2,020 mg/L
Cond = 15,000 µmhos/cm

TMC2/d.4

4. Once the flow rate has stabilized, record the injection pressure with the pressure gauge at the the injection wellhead. Compare the pressure noted at the well head against the pressure recorded on the circular chart in the operator's room. If there is a discrepancy, determine which unit is at fault and correct the problem before continuing.

5. Turn off the pump while carefully watching the injection pressure gauge. After the pressure has stabilized (approximately 5 minutes) record the shut-in pressure.

6. Subtract the shut-in pressure from the injection pressure measured at 1800 gpm and divide the pressure difference into 1800 gpm. The resulting number, reported in gpm/psig, is the specific injectivity index.

7. Report the results of the test on the Specific Injectivity Test - Quarterly Report Form.

REPORTING OF MONITORING DATA

One of the primary responsibilities of the injection well system operator is to insure that the system monitoring data is recorded and reported accurately.

Three sample reporting forms are included in Appendix C.

Monitoring Well Water Quality Report

Specific Injectivity Test Report

Daily Monitoring Data, Monthly Report

These reports are to be sent to the local FDER office and to FDER Tallahassee along with other treatment plant monthly report forms.

It is recommended that the operator compile the daily monitoring data at the same time each day. This will allow a more accurate comparison of system performance over time.

The data for the Monitoring Data Monthly Report are to be compiled using the influent recorder chart, the injection flowmeter recorder chart, and the injection pressure and monitor systems pressure recorder chart. The effluent water quality is to be determined from grab samples as specified in the Wastewater Treatment Plant Operating Permit. Sampling points and procedures are outlined in the treatment plant O&M manual.

Any unusual condition at the time data is collected should be noted on the Monitoring Data Monthly Report.

Table 3-1, Injection System Monitoring, program provides an overview of the data to be reported.

Table 3-2, Injection System Monitoring Program Normal Values and Troubleshooting Chart, gives the expected monitoring parameters for normal function of the injection system.

SECTION 4

MAINTENANCE

Section 4
MAINTENANCE

MAINTENANCE PROGRAM

The effluent disposal system for the PBCWUD System No. 9 represents a sizeable investment and requires a sound maintenance program. This section is intended to help the operator and management implement such a program.

Repairs that have to be made on a breakdown or emergency basis are ultimately more expensive than preventive maintenance and also cause considerable annoyance and disruption. Thus, a good maintenance program contributes to successful operation by minimizing both expensive emergency repairs and unexpected disruption of the operating schedule.

A good maintenance program requires an effective records system which the operator must maintain. This system will show when maintenance is due and will provide a record of equipment performance.

The responsibility for general and preventive maintenance resides with the operator. It is imperative, therefore, that all operations personnel be familiar with the schedule of required maintenance, and that they ensure that preventive maintenance is carried out in a timely manner.

MAINTENANCE AND LUBRICATION RECORDS

All mechanical equipment in the effluent pumping system requires periodic inspection, lubrication, and adjustment. While performing such maintenance, ALWAYS REFER TO THE INDIVIDUAL MANUFACTURER'S OPERATION AND MAINTENANCE MANUALS FOR DETAILED RECOMMENDATIONS, INSTRUCTIONS FOR PERFORMING MAINTENANCE DUTIES, AND SPECIAL STARTUP PROCEDURES.

CARD FILE SYSTEM

Various forms of card file systems, such as single cards, three-card systems, edge-punched cards, and cards with color tabs, are available from office supply houses. The single card system, which uses ordinary ruled 5 x 8-inch or 8-1/2 x 11-inch cards, is appropriate for plants where a single supervisor is solely responsible for maintenance and record-keeping; this system is recommended for the City of Margate facility. A single card should be filed either alphabetically or by equipment number for each item of equipment. The equipment card should contain the following information:

1. Name and location of equipment

2. Name of manufacturer or supplier

3. Cost and installation date

4. Type, style, model

5. Capacity, size, rating

6. Serial and code numbers

7. Nature and frequency of maintenance and calibrations

8. Proper lubricants, coatings

The back of each card is used to record the date the work is performed, the type of work, and the initials of the person performing the tasks. Corrective maintenance tasks may also be noted on the back of the card to provide a complete record of all maintenance work performed on the equipment.

EQUIPMENT SUPPLIERS

A list of the manufacturers and their regional representatives is provided in Table 4-1, Major Injection System Equipment Suppliers, for the surge control components, valves, and injection and monitoring instrumentation used on the second injection system. The manufacturers or their representatives should be contacted to obtain spare or replacement parts and for information about unusual problems. Changes in addresses, phone numbers, and representatives' names should be recorded for future reference. A supply of replacement parts should be purchased ahead of time and kept on hand for emergency use.

The respective manufacturers or their representatives must be contacted for repair service on equipment under warranty. Unauthorized repair by plant personnel or others could void the equipment warranties.

MECHANICAL MAINTENANCE

Mechanical maintenance is of prime importance in keeping the equipment in good operating condition to maintain satisfactory performance. Disabled or improperly working equipment is a threat to the injection well system's capability to provide the required service.

Operating personnel should thoroughly read the equipment manufacturers' information on the mechanical maintenance of equipment and should understand the procedures discussed.

Table 4-1
MAJOR INJECTION SYSTEM EQUIPMENT SUPPLIERS

Equipment Items	Service Representative
Injection Pumps	Worthington Division McGraw Edison Co. 2550 W. Oakland Park Blvd. Ste. 215 Ft. Lauderdale, FL 33311 305/484-1411
Surge Tank and Air Compressor	Hydro Pumps 3441 N.E. 12th Terrace Ft. Lauderdale, FL 33334 305/563-3133
Instrumentation and Control (including flow meters, panels)	C.C. Control Corp. 7321 Southern Blvd. Ste. C1 West Palm Beach, FL 33413 305/684-3547
Electrical Equipment	Edwards Electric Corp. 7321 Southern Blvd. West Palm Beach, FL 33413 305/683-7066
Valves	American-Darling Valve P. O. Box 2727 Birmingham, AL 34202 205/325-7861

The preventive maintenance program is designed to help operating personnel keep all equipment in satisfactory operating condition. Also, it will aid in correcting malfunctions before they develop into major problems.

The following are general checklists of maintenance items required at various operating intervals.

DAILY OPERATION

1. Check pumps, packing, valves, check valves, and motors.

2. Perform necessary running lubrication.

3. Check to see if motors are running unusually hot.

4. Check pumps for noise or vibration.

5. Check the water level in the surge tank.

WEEKLY OPERATION

1. Wipe down all machinery.

2. Perform required lubrication.

3. Tighten packing glands, making sure that there is an adequate amount of water leakage.

MONTHLY OPERATION

1. Operate all valves after pump shutdown. Valves should be fully opened and closed.

2. Review and check alarm system.

3. Perform all scheduled maintenance.

4. Run specific injectivity test as described in Section 3.

QUARTERLY OPERATION

Collect monitoring well water quality samples and analyze.

YEARLY OPERATION

1. Inspect all electrical items for proper operation and condition (a qualified electrician should do this work).

2. Dismantle pumps one at a time. Check impeller, shaft sleeve, shaft, and pump bowl. Replace worn equipment and parts as necessary.

3. Perform all scheduled maintenance.

4. Review monthly and quarterly monitoring reports and look for any change or trend in any of the monitoring parameters.

ELECTRICAL MAINTENANCE

Major electrical equipment should be maintained by qualified, experienced electricians in accordance with the recommendations of the manufacturer, although some inspection, lubrication, and simple routine maintenance may be done by plant maintenance personnel.

These maintenance instructions are general. Maintenance of individual pieces of equipment should be performed specifically in accordance with the recommendations of the manufacturer. Operating procedures and unexpected ambient conditions such as excessive rain, wind, dust, and/or vibration may dictate maintenance schedules different from those recommended herein.

Electrical equipment is dangerous, and especially so for unqualified people. Use the following safety procedures:

1. Have qualified electricians perform all but simple routine maintenance.

2. Do not wear loose clothing, ties, or long hair around rotating machines.

3. When inspecting energized equipment, wear safety glasses to avoid injury to the eyes.

4. BEFORE DISASSEMBLING OR WORKING ON ELECTRICAL EQUIPMENT, MAKE SURE THE EQUIPMENT IS DE-ENERGIZED. Such work should be performed by qualified, licensed electricians only.

5. Tag the open breaker or disconnect, and, if possible, lock it in the OPEN position.

6. Advise the plant operator that the unit is going out of service and that power to the unit is to remain disconnected until further notice.

MAJOR MAINTENANCE

The following work items should be performed in accordance with the manufacturer's instructions, but not less often than once per year, and more often if the equipment is in an environment of excessive dirt or vibration.

ELECTRICAL EQUIPMENT

The following applies to all electrical equipment that contains contact-making devices (circuit breakers, contactors, switches, relays, etc.), electrical coils (transformers, reactors, solenoids, etc.), electrical terminations, insulators, or accessible electrical wiring or busses.

1. Open equipment and wipe insulators and busses with clean, soft, lint-free rags. Clean interior with soft brush or vacuum cleaner.

2. Check all accessible electrical terminations and connections, including terminations of power and control cables, bolted bus connections, and all accessible ground connections. Check visually and with a screwdriver or wrench; tighten loose connections. Taped connections need not be checked.

3. Record the voltage at each power and distribution transformer's secondary, both loaded and unloaded. Compare with previous readings. Change taps or contact the power company if voltage is more than 5 percent high or low.

4. Inspect contacts on switches, contactors, circuit breakers, disconnects, and relays if the contacts are accessible. Dress or replace contacts if they are pitted or burned. Replace contacts in pairs, rather than single contacts.

INSTRUMENTATION AND CONTROL (I&C) MAINTENANCE

These maintenance instructions are general. Maintenance of individual pieces of equipment should be performed specifically in accordance with the recommendations of the manufacturer. Operating procedures and ambient conditions of dirt and vibration may dictate maintenance schedules different from those recommended herein.

Modern I&C equipment requires little maintenance if it is in the proper environment. It must be kept clean, cool, and dry. If the equipment is chosen and designed properly, it will withstand ambient temperature and dampness and needs only to be kept clean by periodic maintenance.

Every 3 months, open the instruments and/or withdraw them from their cases; inspect the instruments, and clean with a soft brush. Those instruments which have moving parts should be lightly lubricated in accordance with the instructions of the manufacturer. Do not over-lubricate. Check for interferences between moving parts. Fill ink reservoirs on recorders. Look for sources of unusual heat, sound, or odors.

Check the calibration annually on instruments, gauges, and pressure switches. If possible, they should be calibrated in-place, using the piping, wiring, and fluids of the processes, calibrating a whole subsystem at once. This method is cheapest and most reliable because it does not require removing the instrument, and it avoids errors such as bad connections and leaks on reinstallation. The disadvantages are that it may disrupt the process, and it may be difficult to obtain sufficient accuracy and range.

Calibrate pressure gauges and pressure switches by connecting to a pressure header with a bleed valve and a pressure valve connected to an air tank. Use a gauge of known accuracy and recent calibration for a reference. Check set points of pressure switches on increasing or decreasing pressure. Gauges and pressure switches should be checked annually.

Table 4-1
MAJOR INJECTION SYSTEM EQUIPMENT SUPPLIERS

Equipment Items	Service Representative
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Electrical Equipment	Edwards Electric Corp. 7321 Southern Blvd. West Palm Beach, FL 33413 305/683-7066
Valves	American-Darling Valve P. O. Box 2727 Birmingham, AL 34202 205/325-7861

SECTION 5

SAFETY

Section 5
SAFETY

Although the establishment of a safety program is primarily management's responsibility, day-to-day participation in the program is the responsibility of all employees. This section presents an overview of the safety program recommended for the City of Margate facility.

GENERAL PRECAUTIONS

Written emergency instructions must be placed in the pump station electrical enclosure and must be accessible to all personnel. Such instructions should include the following:

1. The telephone number and address of the nearest doctor, the company safety office, and emergency numbers for fire department, electric power company, and police station.

2. First aid instructions.

All personnel should be trained in first aid. Instructions in first aid should be given annually. Drills, particularly resuscitation exercises, should be conducted periodically.

The major hazards to which an employee may be exposed at a deep well installation are:

1. Physical injuries
2. Infections
3. Electrical shock
4. Burns
5. Drowning

Physical injuries can be minimized by an established employee training program; adequate lighting; an orderly and scheduled good housekeeping program; proper protective clothing such as safety shoes, harness, and hard hats; proper identification of all equipment; and maintaining the disconnecting equipment in good repair.

A potential for infections exists due to the nature of the effluent and daily employee exposure. Infections can be controlled by personal hygiene, inoculations, especially for typhoid and tetanus, and protective clothing. Rubber clothes and gloves should be available for protection where needed.

Electricity is a hazard that requires careful attention. Ordinary 110-volt electricity can be fatal. Since electricity kills by paralyzing the nervous system and stopping muscular action, it is essential that the victim be freed from the live conductor promptly by use of a dry stick or other non-conductor. Never use bare hands to remove a live wire. A qualified person should start mouth-to-mouth resuscitation immediately and continue until breathing starts, or until instructed by a physician to stop.

It is important that all operating personnel understand the necessity of using available safety equipment at all times. There is no excuse for injury or damage if proper equipment is available but not used.

ACCIDENTS DO NOT HAPPEN; THEY ARE CAUSED.

Recommended general publications on safety and environmental regulation are listed in Table 5-1, Recommended Publications.

SAFETY EQUIPMENT

All safety equipment must be checked, cleaned, and repaired at regular intervals. A list of typical safety equipment includes the following:

1. One complete first aid kit

2. At least one fire extinguisher in each building

3. One portable blower with hose attachments for ventilating tanks and manholes

4. Adequate warning signs

5. One self-contained air supply appliance for use in the chlorine building. This must be available for use anywhere in the plant in the event an emergency occurs either with a noxious gas or where an oxygen-deficient condition occurs.

Refer to Safety in Wastewater Works, WPCF Manual of Practice No. 1, for safety equipment and procedures for operation and maintenance of sewerage systems.

ACCIDENT REPORT

In the event of any injury, the following action should be taken:

1. Notify supervisor as soon as possible within 24 hours. If necessary, seek medical attention.

2. Fill out the Supervisor Investigation Report Form within 24 hours of accident.

3. Fill out the Worker's Compensation form.

Table 5-1
RECOMMENDED PUBLICATIONS

<u>Safety in Wastewater Works</u>

Manual of Practice No. 1
Water Pollution Control Federation
3900 Wisconsin Avenue
Washington, D.C. 20016

<u>U.S. Department of Labor--OSHA</u>

General Industry Safety and Health Regulations
Occupational Safety and Health Administration
Washington, D.C.

<u>National Electric Code Handbook</u>

NFPA No. 70
National Fire Protection Association
470 Atlantic Avenue
Boston, MA 02210

U.S. Department of Labor
Municipal Employees Safety Program
Bureau of Labor Standards
Washington, D.C.

Note that failure to follow proper reporting procedure may result in disqualification for benefits under Worker's Compensation law.

Accident report forms may be obtained from the plant supervisor.

PERSONAL SAFETY PRACTICES

This section gives some general safety practices which should be followed on a daily basis in operating any equipment at the City of Margate. The importance of the proper use of safety procedures and equipment around a sewage treatment plant cannot be overemphasized.

Basic personal safety measures include the following:

1. To avoid back strain, lift equipment straight up, using leg muscles instead of back muscles.
2. Ensure that first aid equipment is readily available for treating minor cuts, burns, and wounds.
3. Place suitable rubber mats in front of all high-voltage equipment switchboards.
4. Pick up all tools and practice good housekeeping.
5. Keep walkways free of grease, oil, and ice.
6. Do not use electrical panels as racks for clothing or tools.
7. Do not use gasoline as a cleaning fluid.
8. Do not inhale solvent fumes.
9. Use portable lighting equipment to provide proper visibility in areas where permanent lighting facilities are not available.
10. Regularly practice putting on and using respiratory-protective equipment to ensure quick, proper use in times of emergency.
11. Promptly replace guards which have been removed for servicing belts, gears, and other exposed moving machine parts.
12. Adequately mark pipelines and faucets that contain non-potable water.

13. The creation of a safe working atmosphere with adequate ventilation is always preferable to wearing any type of respiratory-protective equipment. Portable blowers should be provided for ventilating tanks, pits, and manholes. Under some conditions, an air compressor can be used for induced ventilation.

PREVENTING INFECTION

New employees, at their discretion or as required by city policy, should have a series of three injections of typhoid vaccine followed annually by booster shots and, at 3-year intervals, with another series of shots. All employees should receive yearly booster shots for tetanus. Other measures for preventing infection include the following:

1. Use rubber gloves when in contact with areas subject to sewage contamination.

2. Wash hands frequently.

3. Give prompt medical attention to any injury that breaks the skin.

4. Keep fingers out of the mouth and keep fingernails short. Remove foreign materials from fingernails with a knife, nail file, or stiff soapy brush.

5. Do not smoke when hands are contaminated.

6. Prominently display accident-prevention instructions including the following:

   - Names, telephone numbers, and addresses of the nearest physicians, fire stations, police, and sheriff.

   - The location and directions for use of the nearest respiratory-protective equipment.

   - First aid directions for common physical injuries.

   - Procedure for the mouth to mouth, cardiopulmonary, back-pressure, arm-lift, and prone-pressure methods of resuscitation.

PROTECTIVE CLOTHING

Guidelines for protective clothing use include the following:

1. Wear protective hats in all areas designated as hard hat areas.

2. Use ear protectors in areas of high noise levels.

3. Use hoods and safety glasses where there is danger from splashes of corrosive chemicals.

4. Wear safety glasses when using grinding wheels or other work that might involve objects which could fly into the eyes.

5. Wear welding masks at all times when welding.

6. Use protective creams to protect the skin from contamination by oils, greases, paints, and dust.

7. Wear leggings and knee pads to protect knees against bruises on jobs which require kneeling for long time periods.

8. Wear safety shoes, toe guards, and nonsparking footwear where conditions indicate.

ELECTRICAL SAFETY

Guidelines for electrical safety include the following:

1. Never check or repair any instrument or equipment unless you have made sure that it is disconnected from the source of energy.

2. When working near electricity, do not ground yourself on pipes or drains.

3. Allow only authorized, properly trained people to work on electrical equipment or to make repairs.

4. Keep all electrical controls accessible and well marked. Post warning signs at appropriate places.

5. Place rubber mats on the floor in front of electrical panels.

6. Never use metal ladders around or beneath electrical equipment. Do not raise pipes or other metal into electrical gear above.

7. Treat all wires as though they are "live" wires, including those in circuit breakers.

8. Ground all electrical tools.

9. In case of electric shock, free the victim from the live conductor by use of a dry stick or other non-conductor. Never use bare hands to remove a live wire. Immediately apply artificial respiration until breathing is restored or until instructed by a physician to stop.

10. Carbon-dioxide type fire extinguishers should be used around electrical equipment.

11. Before disassembling or working on electrical equipment, make sure the equipment is de-energized. Tag the open breaker or disconnect, and, if possible, lock it in the OPEN position. In addition, ground all phases rated higher than 600 volts.

LABORATORY SAFETY

The dangers of laboratory work include risks such as exposure from improper storage, faulty techniques, burns, poisons, explosions, improper handling or disposal, electrical shock, toxic fumes, and fires.

Many hazardous chemicals are supplied at the wastewater treatment plant for routine analysis of required biological parameters. Plant personnel should take special care when handling these chemicals in order to avoid injury. The most hazardous chemicals found in the plant laboratory are:

1. Acids--sulfuric acid solution, concentrated sulfuric acid, concentrated phosphoric acid, acetic acid (glacial), and hydrochloric acid.

2. Alkalies--sodium hydroxide (pellets).

3. Miscellaneous--potassium dichromate solution and crystals, arsenic trioxide powder, iodine crystals, standard phenylarsine oxide solution, and mercuric sulfate reagent.

NOTE: Arsenic trioxide, mercuric sulfate, and standard phenylarsine oxide solutions are extremely toxic, and special care should be taken when handling these chemicals. Always wash hands immediately after using these chemicals and never pipette these solutions by mouth; use a pipette bulb.

Other safety considerations include the following:

1. Provide a special container for disposal of all broken glassware.

2. When using volatile solvents, bases, or acids, work under a ventilated hood. Keep your head out of the hood.

3. Add concentrated acid to water and not water to the acid. If a person is splashed with acid, apply large volumes of water immediately to prevent serious burns.

4. Control grease fires by using a carbon-dioxide type extinguisher.

5. USE SUCTION BULBS ON PIPETTES TO AVOID CONTACTING CONTAMINATED PIPETTES WITH YOUR MOUTH AND TO AVOID SUCKING ACID OR BASE INTO THE MOUTH.

6. When handling dangerous chemicals (as listed above), use rubber apron and face shield.

7. When connecting rubber tubing to glass tubing, wear rubber gloves.

8. Use laboratory ventilation equipment to prevent the accumulation of fumes and dust.

9. Do not smoke or eat in the laboratory.

10. Store cylinders of oxygen in a separate well-ventilated section of the laboratory.

11. Provide a carbon-dioxide fire extinguisher in the laboratory in a readily accessible location.

12. Isolate all oil and petroleum products from chlorine gas and HTH (calcium hypochloride) to prevent explosion.

APPENDIX A

INJECTION SYSTEM DESIGN CRITERIA

Appendix A
INJECTION SYSTEM DESIGN CRITERIA

EFFLUENT INJECTION PUMPS

Number	4 horizontal electically driven centrifugal pumps
Capacity (each)	2 @ 1,400 gpm 2 @ 3,000 gpm
Maximum	12.7 mgd

SURGE SYSTEM

Tank	6,000 gal
Air Compressor	
Capacity	20 SCFM
Operating Pressure	100 psig

INJECTION WELL (IW-2)

Injected Flow	
Measured	Venturi Flow Element 10.5 mgd maximum
Recorded	Fisher and Port 0 to 7,500 gpm
Injected Pressure	
Measured	Flow element and differential flow transmitter
Recorded	Fisher and Porter 60 psi
Casings	54 in/250 ft 44 in/971 ft 34 in/1,801 ft 24 in/2,651 ft Open/2,651-3,300 ft

MONITORING WELL (M-2)

Casings, Floridan Well	24 in/250 ft 16 in/970 ft 6 in/1,699 ft Zone 1, Upper Monitor, open/970-1108 ft Zone 2, Lower Monitor, open/1,699-1,800 ft
Pressure Upper & Lower Zones	
Recorder	Fisher and Porter

APPENDIX B

EQUIPMENT MANUFACTURES INFORMATION

VENTURI FLOW TUBE

Model:	Badger Meter 24 inch PMT-1 Plastic Insert Flow Tube With 504 Stainless Steel Throat
Throat:	9.783 Inches Diameter
Max Flow Rate:	7,200 gpm at 227.04 Inches Water

Lo-Loss®
Plastic Insert Series

Technical Brief

Closed Pipe File

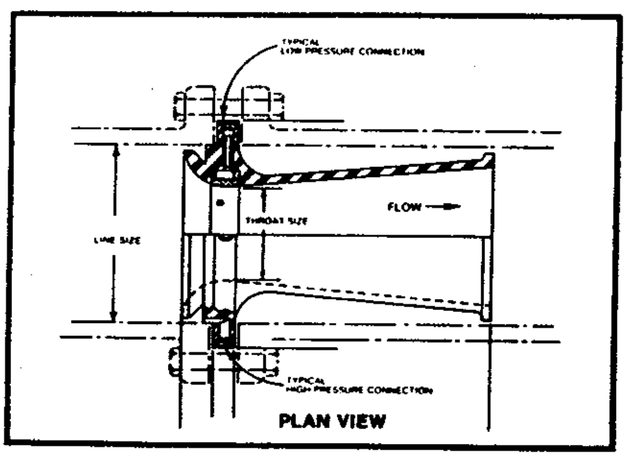
Description

The plastic insert series of the Badger Meter Lo-Loss® is a modified venturi flow element. It has greater rangeability and a lower permanent pressure loss than any other differential-producing primary element. The unique configuration of the Badger Lo-Loss flow element is designed for insertion within a pipe and then secured by the companion flanges. The insert series is constructed of fiberglass reinforced polyester resin with throat materials of PVC in the PMT-IP series and either bronze or stainless steel in the PMT-I series. The PMT-I or PMT-IP utilizes a cast thermo-setting resin with exact diameter dimensions to set in the throat liner.

1. **PMT-IP:** The PMT-IP Lo-Loss is an insert pressure differential device constructed of a fiberglass reinforced polyster resin body and a precision-machined PVC throat section without an annular chamber.
2. **PMT-I:** The PMT-I Lo-Loss is an insert pressure differential device constructed of a fiberglass reinforced polyster resin body with either a bronze or stainless steel precision machined throat section. Two versions exist — the PMT-I which has an annular chamber and the PMT-IL which has none.

Applications

The plastic insert series of the Lo-Loss is designed to measure full-pipe clean fluids or clean gases with 2% or less solids concentration. The inserts can be manufactured in standard sizes from 4" to 24" pipe diameters.



Piping Requirements

The Lo-Loss flowmeters may be either horizontally or vertically mounted. A well-developed symmetrical velocity profile is required. General practice requires the pipe to be maintained full and the upstream piping be sufficient to assure profile conditioning. Refer to ASME Fluid Meters, 6th Edition, Page 180, for general conditions. The Badger Lo-Loss requires one pipe diameter less than the classic venturi.

General Specifications

ACCURACY:
Within the specified flow range and piping configurations the Lo-Loss flowmeters produce accurate measurements of

±.75% uncalibrated
±.25% calibrated

PRESSURE LOSS:
The permanent pressure loss of the Lo-Loss is expressed as a percentage of the differential produced as given in Table 1 and is the lowest of any differential-producing type primary element.

BETA RATIO:
Badger Meter is the only manufacturer of differential pressure producing devices that can furnish beta ratios for the Lo-Loss from .35 to .85. By custom computer designing a Lo-Loss to the exact flow conditions with the proper beta ratio, Badger can guarantee the most accurate and reliable primary element with the lowest permanent pressure loss.

Operating Conditions

The plastic insert series for the Lo-Loss primary device operates within the following temperature and pressure ranges:

1. Temperature	32°F to 80°F
Pressure	Less than 500 psi
2. Temperature	81°F to 200°F
Pressure	Less than 50 psi

Badger Meter, Inc.

P.O. Box 581390
Tulsa, Oklahoma 74158
(918) 836-8411
Telex: RCA 203605

TABLE 1
PLASTIC INSERT SERIES
LO-LOSS® FLOW TUBE CAPACITIES
(Water at 60° F.)

Pipe Size Inches	Throat Diameter	% Head Loss	Approx. Laying Length Inches Insert*	APPROXIMATE CAPACITIES (Maximum Differential in Inches of Water) Million Gallons per Day 42.39"	75.36"	117.75"	301.44"	Gallons per Minute 42.39"	75.36"	117.75"	301.44"
6	2.529	5.3	15 1/4	.300	.400	.500	.800	208.3	277.7	347.2	555.5
	3.114	4.2	13 1/16	.450	.600	.750	1.200	312.5	416.6	520.8	833.3
	4.000	3.3	8 5/8	.750	1.000	1.250	2.000	520.8	694.4	868	1389
	4.428	2.8	8 3/16	.9375	1.250	1.5625	2.500	651	868	1085	1736
8	3.466	5.0	19 15/16	.562	.750	.937	1.500	390.3	520.8	650.7	1041
	4.018	4.3	17 7/16	.750	1.000	1.250	2.000	520.8	694.4	868	1389
	4.919	3.7	14 5/8	1.125	1.500	1.875	3.000	781.3	1041	1302	2083
	5.978	2.8	10 3/8	1.725	2.300	2.875	4.600	1198	1597	1996	3194
10	3.991	5.7	26 1/8	.750	1.000	1.250	2.000	520.8	694.4	868	1389
	4.919	4.4	22 3/4	1.125	1.500	1.875	3.000	781.3	1041	1302	2083
	6.343	3.5	15 7/8	1.875	2.500	3.125	5.000	1302	1736	2170	3472
	6.907	3.1	12 1/2	2.250	3.000	3.750	6.000	1563	2083	2604	4167
	7.710	2.6	13 7/8	2.906	3.875	4.844	7.750	2018	2691	3364	5381
12	4.892	5.7	31	1.125	1.500	1.875	3.000	781.3	1041	1302	2083
	5.675	4.6	28 1/4	1.500	2.000	2.500	4.000	1042	1389	1736	2778
	6.966	4.0	23 3/8	2.250	3.000	3.750	6.000	1563	2083	2604	4167
	8.000	3.4	17 1/16	3.000	4.000	5.000	8.000	2083	2778	3472	5556
14	5.600	5.7	36 1/2	1.500	2.000	2.500	4.000	1042	1389	1736	2778
	6.958	4.4	30 1/4	2.250	3.000	3.750	6.000	1563	2083	2604	4167
	8.044	3.9	23 7/8	3.000	4.000	5.000	8.000	2083	2778	3472	5556
	9.757	3.1	22 3/8	4.500	6.000	7.500	12.000	3125	4167	5208	8333
	10.328	2.8	18 1/2	5.250	7.000	8.750	14.000	3646	4861	6076	9722
16	6.932	5.1	39 7/8	2.250	3.000	3.750	6.000	1563	2083	2604	4167
	8.036	4.3	35	3.000	4.000	5.000	8.000	2083	2778	3472	5556
	9.838	3.6	24 3/8	4.500	6.000	7.500	12.000	3125	4167	5208	8333
18	8.011	4.9	44	3.000	4.000	5.000	8.000	2083	2778	3472	5556
	9.849	3.9	34 5/8	4.500	6.000	7.500	12.000	3125	4167	5208	8333
	12.592	3.0	30 3/4	7.500	10.000	12.500	20.000	5208	6944	8681	13889
20	9.839	4.4	45 1/2	4.500	6.000	7.500	12.000	3125	4167	5208	8333
	13.813	3.1	29 3/4	9.000	12.000	15.500	24.000	6250	8333	10417	16667
	15.602	2.5	23 3/8	12.000	16.000	20.000	32.000	8333	11111	13888	22222
24	9.783	5.7	62	4.500	6.000	7.500	12.000	3125	4167	5208	8333
	13.931	3.9	43 3/4	9.000	12.000	15.000	24.000	6250	8333	10417	16667
	16.000	3.3	31 1/4	12.000	16.000	20.000	32.000	8333	11111	13888	22222
	17.677	2.8	28	15.000	20.000	25.000	40.000	10417	13889	17361	27778

*Flange thickness for model PMT-I: Pipe Sizes 4" and smaller, flange thickness is 1-1/8"; Pipe Sizes 6" and larger, flange thickness is 1-3/8".

Design Notes

Recalibration with New Flow or Differential Pressures

Maximum differential pressures listed under "Approximate Capacities" are for specific throat diameters for each flow tube. To determine different pressures or flow rates the following formulas can be used:

1. Differential Pressure

$$\left(\frac{\text{New Flow}}{\text{Known Flow}}\right)^2 \times \text{Known } \Delta P = \text{New } \Delta P$$

Examples:
ΔP = 42.39 inches
6" Pipe
Existing Q = 1.125 Mgd
Throat Dia. = 4.29 inches
New Q = 3.0 Mgd

$$\Delta P = \left(\frac{3.0}{1.125}\right)^2 \times 42.39 = 301.44 \text{ inches}$$

2. Flow Rate

$$\left(\frac{\text{New } \Delta P}{\text{Known } \Delta P}\right)^{1/2} \times \text{Known Flow} = \text{New Flow}$$

6" Pipe
Existing Q = 1.125 Mgd
Existing ΔP = 42.39 inches
Throat Dia. = 4.29 inches
New ΔP = 50 inches

$$\text{New Q} = \left(\frac{50}{42.39}\right)^{1/2} \times 1.125 = 1.22 \text{ Mgd}$$

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S-353-87 DRAWING NO. | A ISSUE

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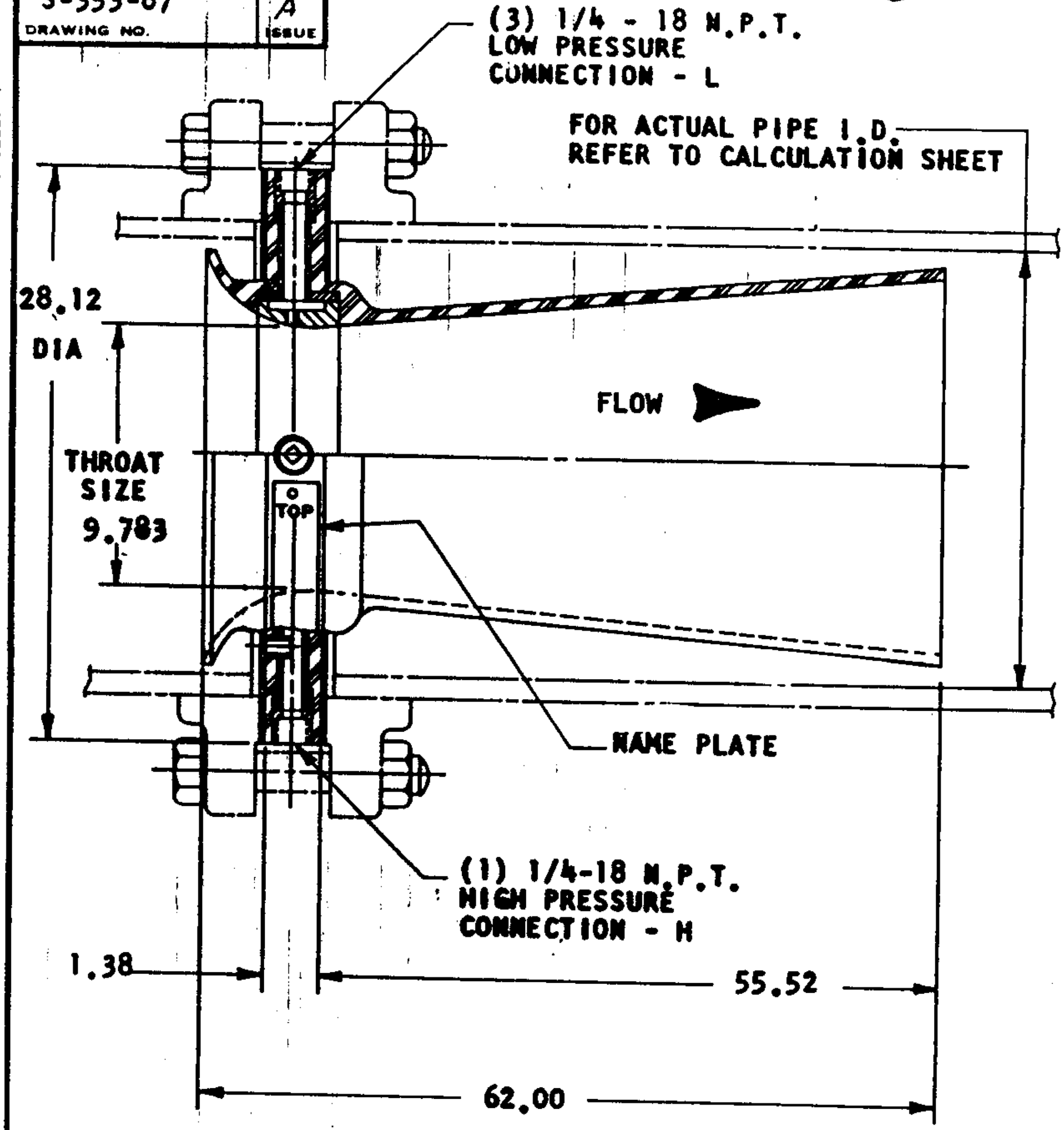

NOTES:

1. FLANGE BOLT HOLES MUST STRADDLE HORIZONTAL & VERTICAL CENTERLINES.
2. IN HORIZONTAL PIPE RUNS, FLOW TUBE MUST BE INSTALLED SO THAT NAMEPLATE IS AT UPPER CENTER AS SHOWN.
3. MATERIAL
   a. THROAT: REFER TO CALCULATION SHEET
   b. BODY: FIBERGLASS REINFORCED THERMOSETTING RESIN
   c. FLANGE: THERMOSETTING RESIN
4. FLANGE RATING: 125/150#
5. FOR TAGGING INFORMATION REFER TO CALCULATION SHEET.

CERTIFIED BY: GP DATE: 5/5/75 CORRECT

ISSUE	CHANGE	BY	DATE
A	5465	DL	10-15-73
1	5368	GR	9-21-72

BADGER METER, INC.

TYPE: PMT-I LO-LOSS FLOW TUBE	DRAWN: G. REHN 9-13-71
MODEL / SIZE: 24 x 9.783	CHECKED: CW WILSON 2-14-72
PART NAME: INSTALLATION DIMENSIONS	S-353-87 A

Badger Meter, Inc.

P.O. BOX 581390
6116 EAST 15th STREET
TULSA, OKLAHOMA 74158-1009
(918) 836-8411 • TELEX: RCA 203605

DIFFERENTIAL ELEMENT
PRIMARY DATA/CALCULATION SHEET
WATER CALCULATION - VOLUMETRIC FLOW

DATE	7MAR85
BADGER S.O.NO.	I-3456
CUSTOMER	C.C. CONTROLS INC.
CUSTOMER P.O.NO.	
USER	CITY OF WEST PALM BEACH, FL
CONSULTING ENGR.	

LO-LOSSDATA:

LO-LOSS STYLE	PMT-I	SERIAL NO.	I-3456
NOMINAL SIZE	24	TAG	SYSTEMS #9
THROAT DIA (IN.)	9.783	BODY MATERIAL	PLASTIC
BETA RATIO	.416	THROAT MATERIAL	S304
TAP SIZE	1/4	FLANGE MATERIAL	PLASTIC
TAP LOCATION	INTEGRAL		

DIFFERENTIAL PRESSURE IS 227.04 INCHES WATER AT 7200 GPM.
PERMANENT PRESSURE LOSS IS 5.35 % OF DIFFERENTIAL.
PERMANENT PRESSURE LOSS IS 12.14 INCHES OF WATER AT 7200 GPM.

FLUID DATA

FLUID	WATER	OPER.SP.GR.	.99775
OPER.PRES.(PSIA)	69.7	BASE SP.GR.	1.00017
OPER.TEMP.(F)	80	OPER.VISC.(CP)	.857
BASE TEMP.(F)	60		

FLOW DATA

MAX.FLOW (GPM)	7200	PIPE REYNOLDS NO.	1128933
NORM.FLOW (GPM)	5040	PIPE REYNOLDS NO.	790253

CUSTOMER PIPELINE & FLANGE DATA

NOM.PIPE SIZE	24	PIPE MATERIAL	METAL
PIPE SCHED/CLASS	10	PIPE I.D.	23.5
FLANGE TYPE	ANSI	FLANGE RATING	125

APPLICABLE DOCUMENTS:

INSTALLATION/APPROVAL	PRODUCTION
....	....
....	....
....	....
....	....

REFERENCE: FLOW METER ENGINEERING HANDBOOK, C.F.CUSICK, 3RD ED., 1961

CERTIFIED CORRECT BY: , DATE:

PREPARED BY :RV

Badger Meter, Inc.

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6116 EAST 15th STREET
TULSA, OKLAHOMA 74158-1009
(918) 836-8411 • TELEX: RCA 203605

DIFFERENTIAL ELEMENT
SUPPLEMENTARY DATA SHEET
WATER CALCULATION - VOLUMETRIC FLOW

DATE	7MAR85
BADGER S.O.NO.	I-3456
CUSTOMER	C.C. CONTROLS INC.
CUSTOMER P.O.NO.	
USER	CITY OF WEST PALM BEACH, FL
CONSULTING ENGR.	

LO-LOSSDATA:

LO-LOSS STYLE	PMT-I	SERIAL NO.	I-3456
NOMINAL SIZE	24	TAG	SYSTEMS #9

WORKING EQUATION FOR LIQUID FLOW
GAL/HR AT BASE TEMPERATURE

QGH=340.11(S)(FA)(D2)(FHM)(FGB)(FGF), (EQ 15, PG 95)

QGH = 432000	FHM = 15.06794
S = .1528	FGB = .99982
FA = 1.00022	FGF = .99887
D2 = 552.25	

REYNOLDS NO. EQUATION FOR LIQUID FLOW
GAL/HR AT BASE TEMPERATURE

RD=52.654(QGHA)(GB)/(D)(U), (EQ 20, PG 97)

QGHA = 302400	D = 23.5
GB = 1.00017	U = .85753

DISCHARGE COEFFICIENT =.86838

Badger Meter, Inc.

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6116 EAST 15th STREET
TULSA, OKLAHOMA 74158-1009
(918) 836-8411 • TELEX: RCA 203605

DIFFERENTIAL METER

FLOW VS DIFFERENTIAL CALCULATIONS

BADGER S.O.	I-3456
DATE	7MAR85
CUSTOMER	C.C. CONTROLS INC.
ELEMENT	23.500 X 9.783 LO-LOSS
SERIAL NO(S)	I-3456
TAG INFO.	SYSTEMS #9

FLUID	WATER	THROAT I.D.(IN)	9.78300
OPER.TEMP.(F)	80.000	PIPE I.D.(IN)	23.50000
OPER.PRES.(PSIA)	69.7000		

RESOLUTION	1.000 PERCENT OF MAXIMUM
DIFF.UNITS	INCHES OF 68F WATER

FLOW (GPM)	DIFF (IN)	FLOW (GPM)	DIFF (IN)	FLOW (GPM)	DIFF (IN)	FLOW (GPM)	DIFF (IN)
7200	227.0	7128	222.5	7056	218.0	6984	213.6
6912	209.2	6840	204.9	6768	200.6	6696	196.3
6624	192.1	6552	188.0	6480	183.9	6408	179.8
6336	175.8	6264	171.8	6192	167.9	6120	164.0
6048	160.2	5976	156.4	5904	152.6	5832	148.9
5760	145.3	5688	141.7	5616	138.1	5544	134.6
5472	131.1	5400	127.7	5328	124.3	5256	120.9
5184	117.7	5112	114.4	5040	111.2	4968	108.0
4896	104.9	4824	101.9	4752	98.89	4680	95.92
4608	92.99	4536	90.10	4464	87.26	4392	84.47
4320	81.72	4248	79.02	4176	76.36	4104	73.75
4032	71.19	3960	68.67	3888	66.19	3816	63.76
3744	61.38	3672	59.04	3600	56.75	3528	54.50
3456	52.29	3384	50.14	3312	48.03	3240	45.96
3168	43.94	3096	41.96	3024	40.03	2952	38.15
2880	36.31	2808	34.52	2736	32.77	2664	31.07
2592	29.41	2520	27.80	2448	26.23	2376	24.71
2304	23.23	2232	21.80	2160	20.42	2088	19.08
2016	17.78	1944	16.54	1872	15.33	1800	14.18
1728	13.06	1656	12.00	1584	10.98	1512	10.00
1440	9.074	1368	8.188	1296	7.349	1224	6.554
1152	5.806	1080	5.102	1008	4.444	936.0	3.832
864.0	3.265	792.0	2.743	720.0	2.266		

THIS CALIBRATION DATA MAY DIFFER FROM THE NORMAL SQUARE ROOT RELATION BETWEEN FLOW AND DIFFERENTIAL PRESSURE DUE TO THE EFFECTS OF DISCHARGE COEFFICIENT VS REYNOLDS NUMBER VARIATION AND/OR (IN COMPRESSIBLE FLOWS) ADIABATIC EXPANSION. EITHER OR BOTH OF THE EFFECTS ARE INCORPORATED INTO THIS DATA AS APPROPRIATE.

INJECTION FLOW TRANSMITTER

Model:	Rosemount 1151DP5J22B1
Housing:	NEMA 4
Flow Range:	0 - 7,500 gpm
Max Flow Rate:	7,500 gpm at 245.2+ Inches Water
Output:	4-20 MA D.C. Linear

FT-01-5-1

INSTRUCTION MANUAL
MODEL 1151DP
ALPHALINE®
√ΔP
FLOW TRANSMITTER
(WITH "J" OUTPUT CODE)

Rosemount

MODEL 1151DP ALPHALINE® $\sqrt{\Delta P}$ FLOW TRANSMITTER (WITH "J" OUTPUT CODE)

CAUTION:
TO AVOID POSSIBLE WARRANTY INVALIDATION READ THIS MANUAL BEFORE ATTEMPTING INSTALLATION OR MAINTENANCE

CONTENTS

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Rosemount Inc. POST OFFICE BOX 35129 MINNEAPOLIS, MINNESOTA 55435
PHONE: (612) 941-5560 TWX: 910-576-3103 TELEX: 29-0183 CABLE: ROSEMOUNT

Revised 8/79

INSTALLATION SECTION

GENERAL

The quality of a flow measurement depends to a great extent on the proper installation of the transmitter and the impulse piping. Proper installation of the primary measuring element is also critical to the accuracy of the measurement.

Because of process and economic considerations, flow transmitters must often be installed in harsh environmental locations. The transmitter should, however, be located to minimize the effects of temperature gradients and temperature fluctuations, and to avoid vibration and shock.

MOUNTING

The 1151DP transmitter may be supported by the piping connections if it is mounted directly at the point of measurement, or may be wall mounted or mounted to a 2-inch pipe by means of the accessory mounting bracket.

Process connections on the transmitter flanges are 1/4-18 NPT. Flange adapter unions are supplied which have 1/2-NPT connections. The flange adapters allow the transmitter to be easily disconnected from the process by removing the flange adapter bolts. The process connections on the flanges are on 2-1/8" centers to allow direct mounting to orifice flanges. By rotating the flange adapters, connection centers of 2", 2-1/8" or 2-1/4" can be obtained.

To insure a tight seal on the adapter flange, the following procedure should be performed: finger tighten both bolts, wrench tighten first bolt, wrench tighten second bolt, then retighten first bolt.

The transmitter body may be rotated in the flanges for mounting convenience. As long as the flanges are vertical, there is no shift in zero caused by rotating the transmitter body. If the flanges are horizontal (for example, to measure flow in a vertical pipe) the transmitter must be rezeroed to cancel the liquid head effect caused by the difference in height of the process connection.

IMPULSE PIPING

Proper location of the transmitter with respect to the process pipe depends on the process material. The following should be considered in determining the best location.

1. Corrosive or hot process material must be kept out of contact with the transmitter.

2. Sediment should be kept from depositing in the impulse piping.

3. The liquid head must be kept balanced on both legs of the impulse piping.

4. Impulse piping should be kept as short as possible.

5. Ambient temperature gradients and fluctuations should be avoided.

For liquid flow measurement, taps should be made to the side of the line to avoid sediment deposits, and the transmitter should be mounted beside or below the taps so that gases will vent into the process line. For gas flow measurement, taps should be made to the top or side of the line and the transmitter should be mounted beside or above the taps so that liquid will drain into the process line. For steam flow measurement, taps should be made to the side of the line, and the transmitter should be mounted below the taps so that the impulse piping will stay filled with condensate.

Taps should be made to the side of the line for transmitters having side vent/drains. For liquid service the side vent/drain should be mounted upward to allow the venting of gases. For gas service it should be mounted down to allow draining of any accumulated liquid. See Figure 1. Side vent/drains may be changed from top to bottom by rotating the process flange 180°.

Care should be exercised so that in steam or other elevated temperature services the transmitter temperature limits are not exceeded.

For steam service, lines should be filled with water to prevent contact of the live steam with the transmitter. Condensate chambers are not necessary since the volumetric displacement of the transmitter is negligible.

The piping between the process and the transmitter must transfer the pressure seen at the process taps to the transmitter. Possible sources of error in this pressure transfer are:

1. Leaks.

2. Friction loss (particularly if purging is used).

3. Trapped gas in a liquid line (head error).

4. Liquid in gas line (head error).

5. Temperature-induced density variation between legs (head error).

The following precautions are suggested to minimize the possibility of errors.

1. Make impulse piping as short as possible.

2. Slope piping at least 1 inch per foot up toward the process connection for liquid and steam.

3. Slope piping at least 1 inch per foot down toward the process connections for gas.

4. Avoid high points in liquid lines and low points in gas lines.

5. Keep both impulse legs at the same temperature.

6. Use impulse piping of sufficient diameter to avoid friction effects.

7. Be sure all gas is vented from liquid piping legs.

8. When sealing fluid is used, fill both piping legs to the same level.

9. When purging is used, make the purge connection close to the process taps and purge through equal lengths of the same size pipe. Avoid purging through the transmitter.

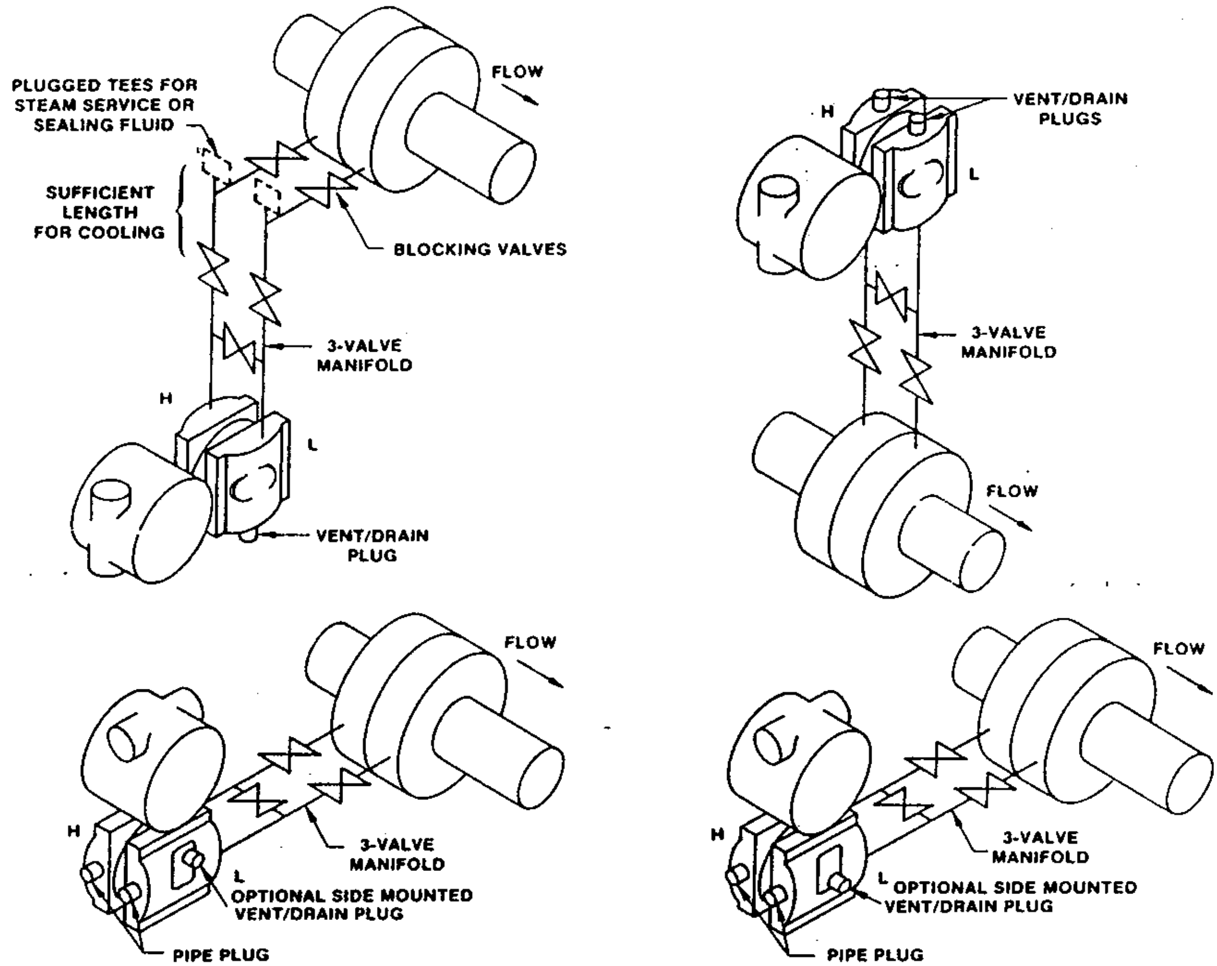
WIRING

Signal terminals are located in the electrical housing in a separate compartment. Connections can be made by removing the cover on the side designated as "terminal side" on the nameplate. The upper terminals are the signal terminals and the lower terminals are test or indicator terminals (Figure 1). The test terminals have the same 4-20 mA current signal as the signal terminals for use with the optional indicating meter or for testing. All power to the transmitter is supplied over the signal wiring. There is no additional wiring required. DO NOT CONNECT POWERED SIGNAL WIRING TO THE TEST TERMINALS. Power will blow out the diode in the test connection. If this should accidentally happen, the test connection can be jumpered for operation of the transmitter.

Signal wiring need not be shielded, but twisted pairs should be used for best results. Signal wiring should not be run in conduit or in open trays with power wiring, and should not be run near heavy electrical equipment.

Conduit connections on the transmitter housing should be sealed or plugged (using a sealing compound) to avoid accumulation of moisture in the housing.

FIGURE 1
INSTALLATION

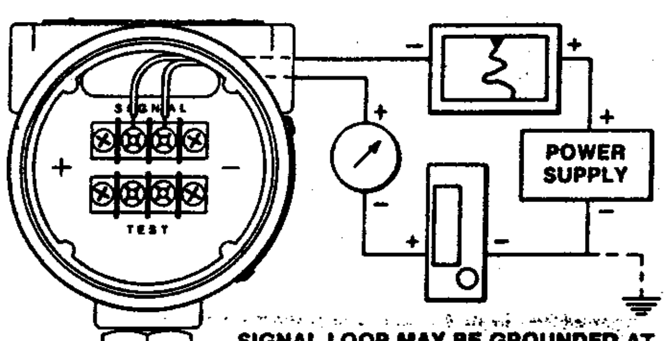


LIQUID SERVICE

GAS SERVICE

NOTE: FOR STEAM SERVICE DO NOT BLOW DOWN IMPULSE PIPING THROUGH TRANSMITTER. FLUSH LINES WITH BLOCKING VALVES CLOSED AND REFILL LINES WITH WATER BEFORE RESUMING MEASUREMENT.

WIRING CONNECTIONS



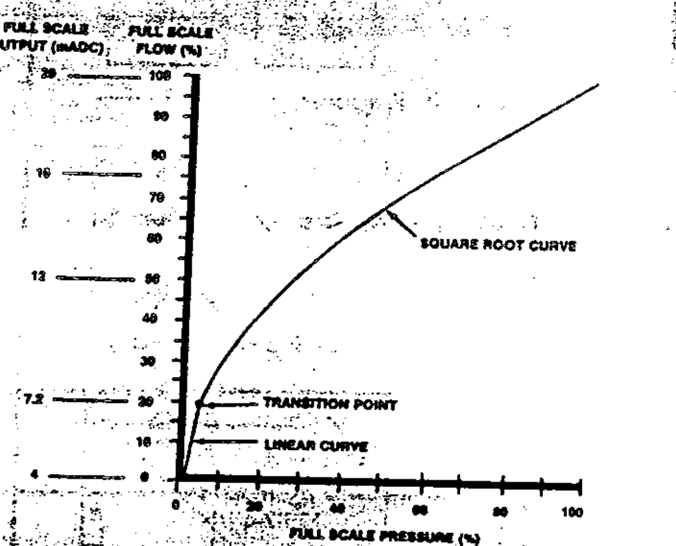
SIGNAL LOOP MAY BE GROUNDED AT ANY POINT OR LEFT UNGROUNDED

If the connections are not sealed, the transmitter should be mounted with the electrical housing downward for draining.

Signal wiring may be ungrounded (floating) or grounded at any place in the signal loop. The transmitter case may be grounded or ungrounded. Power supply regulation is not critical; even with a power supply ripple of 1 volt peak to peak, the ripple in the output signal would be negligible.

Because the transmitter is capacitance coupled to ground, insulation resistance should not be checked with a high voltage megger. No more than 100 volts should be used in circuit checks. Output current is limited to 30 mADC.

FIGURE 2
TRANSITION POINT POSITIONING
(Non-Adjustable)



HAZARDOUS LOCATIONS

In order to maintain the explosion-proof rating for the installed transmitter, the following conditions must be met: (See Functional Specifications for approved locations.)

1. Covers must be on hand tight and the threads must not be damaged.

2. The sensor housing must be screwed into the electrical housing with at least five threads engaged.

3. Conduit must be properly installed with appropriate seals.

4. If one of the conduit connections on the housing is not used, it must be closed with a threaded metal plug with at least five threads engaged.

5. The sealing barrier between the circuit side and the terminal side of the electrical housing must not be damaged and the terminal blocks must be intact.

6. The retaining clips on the span and zero adjustments must be in place.

Calibration

The 1151DP Flow Transmitter is factory calibrated to the range shown on the nameplate. This range may be changed within the limits of the transmitter. Zero may also be adjusted to elevate or suppress zero. The span and zero adjustments are external and located under the nameplate. Span is limited by 6 to 1 ranging; for example, 0-25 to 0-150" H_2O on the mid-range unit. Zero elevation and suppression adjustments are limited to 10% of flow span.

PRESSURE TO FLOW TO OUTPUT CONVERSIONS

To convert from a particular pressure within the calibrated span to a percent of flow, first express the pressure as a percent of calibrated span. Take the square root of this pressure percentage and multiply by 10 to get the percent of flow equivalent.

Example: 1151DP4J calibrated to 0-50" H_2O. The calibrated span is 50" H_2O. The equivalent percent of flow for 32" H_2O is determined as follows:

1) $32''/50'' \times 100 = 64\%$

2) $\sqrt{64\%} \times 10 = 8\% \times 10 = 80\%$ of calibrated flow.

To convert from a percent of the calibrated flow to the equivalent output current, first divide the percent flow by 100. Multiply this by the 16mADC output current and then add the 4mADC minimum output. Referring back to the above example, the output current for 80% of calibrated flow is determined as follows:

$$\frac{80\% \text{ calibrated flow}}{100} \times 16\text{mADC} + 4\text{mADC} = 16.8\text{mADC}.$$

RECOMMENDED PROCEDURE FOR CALIBRATION ADJUSTMENT

The 1151DP Flow Transmitter has a 4-20 mADC output which is proportional to the square root of the pressure being measured. A switching circuit is designed into the electronics such that the squaring circuit is deactivated when the differential pressure being measured approaches zero in order to insure stable zero output. This is necessary due to the difficulties associated with taking the square root of zero. The transition point is fixed at 4% of full scale pressure (equivalent to 20% of flow) and is not adjustable. The circuit makes a smooth transition from the linear to the square root mode at this point, with no step change or discontinuity in output. Because the transition point is fixed and does not need adjustment only zero, span and linearity adjustments are necessary.

Span and Zero Adjustment

The span and zero adjustment screws are accessible externally and are located behind the nameplate on the side of the electronics housing (Figure 3). The output of the transmitter increases with clockwise rotation of the adjustment screws.

The span adjustment screw has little or no effect on zero. The zero adjustment screw has little or no effect on span. As a result, zero can be set very nearly independently of span and vice versa. Large changes in span may cause a slight change in the zero position.

SPAN ADJUSTMENT RANGE

The span on all 1151 transmitters is continuously adjustable to allow calibration anywhere between maximum span and 1/6 of maximum span. For example, the span on a range 4 1151 can be continuously adjusted between 0-150" H_2O and 0-25" H_2O.

ZERO ADJUSTMENT RANGE

The zero adjustment on an 1151 with J output is limited to ± 10% of span. Zero elevation or suppression are not desirable because they would result in an output error due to the square root extraction. Zero based spans eliminate this error.

FIGURE 3
ZERO AND SPAN ADJUSTMENT

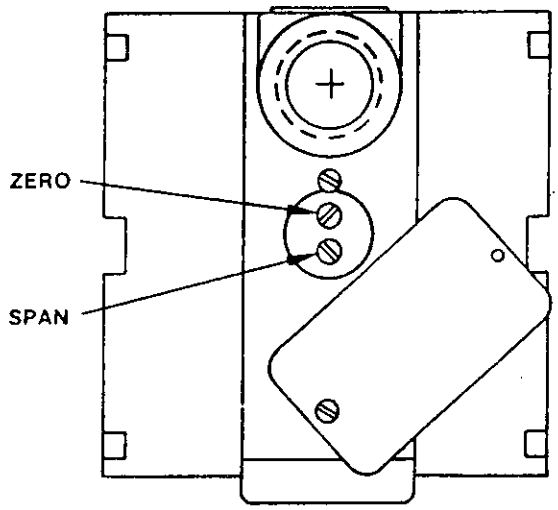
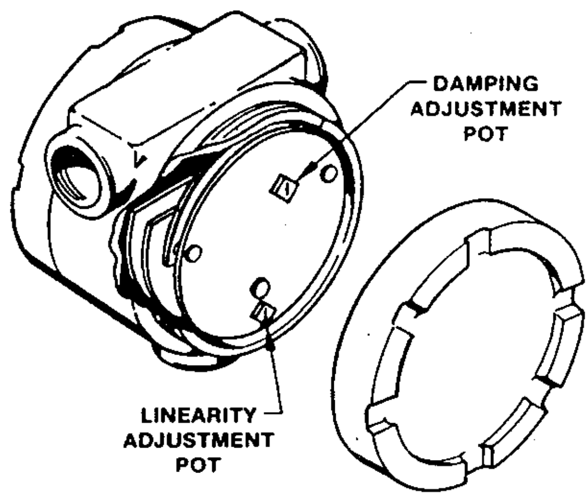


FIGURE 4
LINEARITY ADJUSTMENT
(4-20 mA OUTPUT)



LINEARITY ADJUSTMENT

In addition to the span and zero adjustments, there is a linearity adjustment located inside the transmitter on the calibration board (Figure 4). This is a factory calibration and is **not** normally adjusted in the field. Linearity is factory adjusted for optimum performance over the calibrated range of the instrument. If it is desired to maximize linearity over some particular range, the following procedure should be used:

1. Apply mid-range pressure and note the error between theoretical and actual output signal. Theoretical output signal is 15.314 mADC at midpoint pressure based on endpoints of exactly 4.0 mADC and 20.0 mADC.

2. Apply full scale pressure. Multiply the error noted in step 1 by 4.24 and by the range down factor.

$$\text{Range down factor} = \frac{\text{Maximum Allowable Span}}{\text{Calibrated Span}}$$

Add the result to the full-scale output for negative errors, or subtract the result from the full-scale output for positive errors, by adjusting the trimmer marked "Linearity" (Figure 4). Example: At 4 to 1 range down the midscale point is low by 0.05 mA. Therefore, adjust "Linearity" trimmer until full-scale output increases by (0.05 mA × 4.24 × 4 = .848 mA.

3. Readjust span.

4. Readjust zero.

5. Recheck linearity and repeat steps 1-4 if necessary.

DAMPING ADJUSTMENT

The J output amplifier board is designed to permit damping of rapid pulsations in the pressure source by adjusting the trimmer marked "Damping" located on the solder side of the amplifier board (Figure 4). The settings available provide time constant values between 0.2 seconds (nominal) and 1.0 seconds. The instrument is calibrated and shipped with this adjustment set at the counterclockwise stop (0.2 second time constant). It is recommended that the shortest possible time constant setting be selected. Since the transmitter calibration is not influenced by the time constant setting, the damping adjustment may be set with the transmitter installed on the process. Turn the "Damping" adjustment clockwise until the desired damping is obtained.

Caution: The pot has positive stops at both ends. Forcing the pot beyond the stops may cause permanent damage.

Span Correction for High Line Pressures

High static pressure will cause a small span shift in the transmitter. The span change is −0.75 ± 0.1% of reading/1000 psi for the 0-5/30" H_2O range unit and −0.5 ± 0.1% of reading/1000 psi for the other ranges (0-25/150" H_2O, 0-125/750" H_2O). This shift can be compensated prior to installation by changing the span calibration at zero static pressure.

EXAMPLE

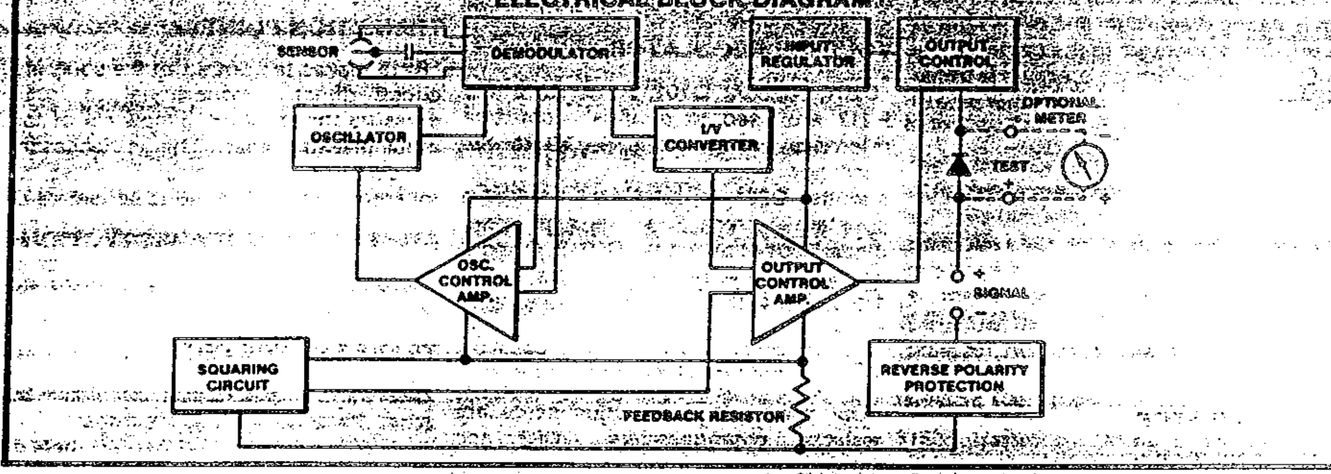
It is desired to operate 0-25/150" H_2O range unit calibrated to 0-100" H_2O at a line pressure of 1200 psi. The line pressure effect will be:

$$\frac{-.5\%}{1000\ \text{psi}} \times 1200\ \text{psi} = -0.6\%$$

Since the full-scale output of the transmitter will be lower by 0.6% when operated at line pressure, the span output should be increased by 0.6% at 0 line pressure (i.e., 0.6% of 16 mA = .096 mA). The transmitter should be calibrated to 4 mA at 0" H_2O and 20.096 mA at 100" H_2O.

OPERATION SECTION

FIGURE 5
ELECTRICAL BLOCK DIAGRAM



GENERAL

The block diagram in Figure 5 illustrates the operation of the system. A schematic diagram is shown in the Parts List Section of this manual.

The Rosemount Model 1151 Series ALPHALINE Pressure Transmitters have a variable capacitance sensing element, the δ-CELL (Figure 6). Differential capacitance between the sensing diaphragm and the capacitor plates is converted electronically to a 2-wire 4-20 mADC signal.

This approach is based on the following concepts:

1. $P = K \dfrac{C_1 + C_2}{C_1 + C_2}$

Where: P is the process pressure.
K is constant.
C_1 is the capacitance between the high pressure side and the sensing diaphragm.
C_2 is the capacitance between the low pressure side and the sensing diaphragm.

2. $I_{diff} = fV_{pp}\,(C_1 - C_2)$

Where: I_{diff} is the difference in current from C_1 and C_2.
V_{pp} is the peak-to-peak oscillation voltage.
f is the oscillation frequency.

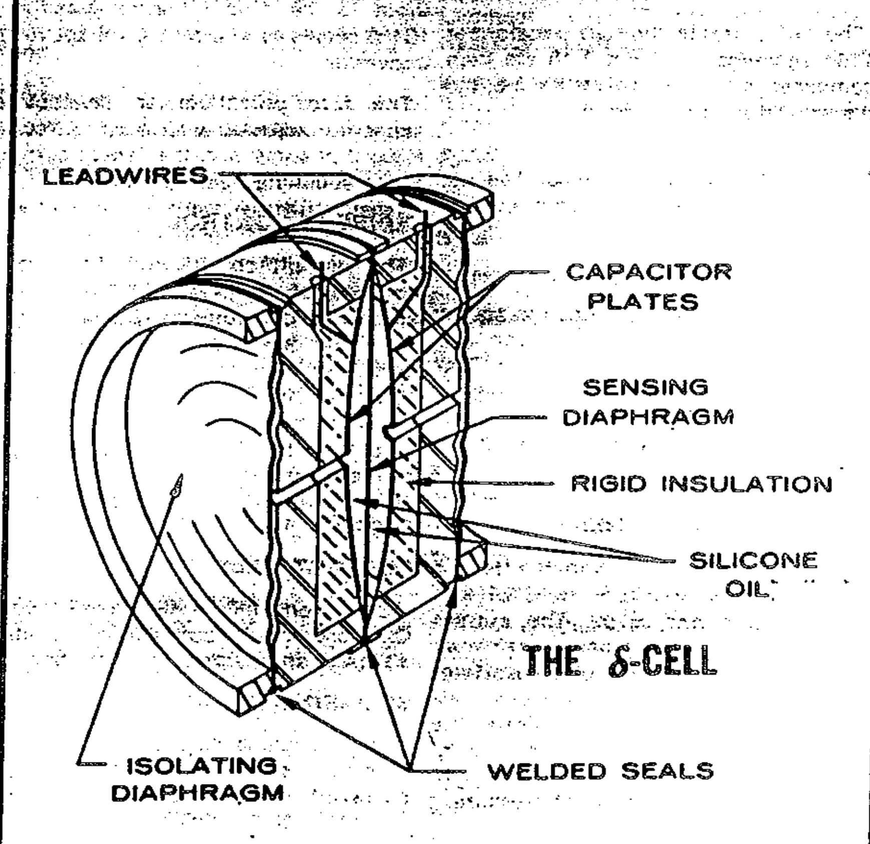
3. $fV_{pp} = \dfrac{I_{ref}}{C_1 + C_2}$

Where: I_{ref} is the constant current source.

Therefore:

$$P = K_2 \times I_{diff} = I_{ref}\,\frac{C_1 - C_2}{C_1 + C_2}$$

FIGURE 6
THE δ-CELL



Theory of Operation

THE δ-CELL SENSOR

Process pressure is transmitted through an isolating diaphragm and oil fill fluid to a sensing diaphragm in the center of the δ-CELL. The reference pressure is transmitted in like manner to the other side of the sensing diaphragm.

The position of the sensing diaphragm is detected by the capacitance plates on both sides of the sensing diaphragm. The capacitance between the sensing diaphragm and either capacitor plate is approximately 150 pF. The sensor is driven by an oscillator at approximately 30 kHz and 30 V_{pp}. It is then rectified through a demodulator.

DEMODULATOR

The demodulator consists of a diode bridge D1 through D8 which rectifies the AC signal. (Refer to Drawing 1151-0371 in Drawings and Schematics Section.)

The DC currents through transformer T101 windings 1-12 and 3-10 are then compared in IC102A. This is the input to the oscillator control circuit.

The DC currents through diodes D2 and D4 are algebraically summed. The net current is directly proportional to pressure, i.e.,

$$I_{diff} = fV_{pp}\,(C_1 - C_2)$$

The diode bridge and a span temperature compensating thermistor are located inside the sensor module. The effect of the thermistor is controlled by resistors R4 and R5 located on the compensation board which is part of the sensor module.

LINEARITY ADJUSTMENT

Linearity is adjusted by variable resistor R101, two 10K resistors in IC101 and diodes D101 and D102. The current generated through this part of the circuit is summed into the input of the oscillator control circuit. This provides a programmed correction which raises the oscillator peak-to-peak voltage to compensate for first order non-linearity of capacitance as a function of pressure.

OSCILLATOR

The oscillator, consisting of components Q101, T101, C105, C106, and R102, has a frequency determined by the capacitance of the sensing element and the inductance of the transformer windings.

The sensing element capacitance is variable. Therefore, the frequency is variable about nominal value 30 kHz.

IC102A is used in a feedback capacitor circuit and control voltage so that:

$$fV_{pp} = \frac{I_{ref}}{C_1 - C_2}$$

VOLTAGE REGULATOR

D201, IC203A, Q201, R215, R216 and R217 are used to provide a constant reference voltage of 6.5 VDC to the oscillator, squaring and current control circuits. Q201 is controlled so that a constant current flows through zener diode D201 at all times. IC101B, C and D provide voltage reference points of 1/4, 1/2 and 3/4 of the primary reference of 6.5 V.

ZERO AND SPAN ADJUSTMENTS

The zero and span adjustments are resistive potentiometers (R302 and R304).

The voltage developed across the span potentiometer and R305 by the sensor current flowing through them (I_{diff}) is an input to the output control amplifier. IC103 serves as a current to voltage (I/V) converter.

The zero potentiometer develops a separate adjustable current through R303 that sums with the sensor current at the summing point (pin 5).

CURRENT CONTROL

The current control amplifier circuit consists of IC104, Q102, Q103 and associated components. The two inputs of IC104 are the voltage developed across the span potentiometer in the I/V converter and the voltage output of the squaring circuit. IC104 compares the input from the I/V converter to the output of the squaring circuit and adjusts the output current by means of Q102 and Q103.

CURRENT LIMIT

The current limit consisting of R115 and Q201 prevents the output from exceeding 30 mA in an overpressure condition.

SQUARING CIRCUIT

The squaring circuit squares the output current as sensed by resistor R306. This squared signal is fed into the current control amplifier.

The output current from the transmitter flows through resistor R306. The voltage developed across this resistor is divided by R203 and R204 such that for an output current equal to 4 mADC, the input to the squaring amplifier (consisting of IC201, VTL202, IC202, IC203B, R209, R210, R213, R220 and others) is equal to the reference voltage at the output of IC102B. For any output current greater than 4 mADC, the input to the squaring circuit is multiplied by itself and stored across C113 as the output of the squaring circuit. IC201 is an oscillator driving switches within IC202.

TRANSITION POINT

R213 makes the output of the squaring circuit directly proportional to input pressure for pressures below 4% of the input pressure span. This is necessary because of the electronic instability inherent with attempting to square zero.

REVERSE POLARITY PROTECTION

Reverse polarity protection is provided by diode D106.

TRANSIENT PROTECTION

Transient protection is provided by zener diode D104.

Specifications - 1151DP $\sqrt{\Delta P}$ Flow Transmitter

Functional Specifications

Service

Liquid, gas or vapor.

Ranges

0-5/30 inches H_2O
0-25/150 inches H_2O
0-125/750 inches H_2O

Outputs

4-20 mADC, square root of differential input pressure between 4% and 100% of input. Linear with differential input pressure between 0% and 4% of input.

Power Supply

External power supply required. Up to 55 VDC. Transmitter operates on 12 VDC with no load.

Load Limitations

See Figure 1.

Indication

Optional meter with 1-3/4" linear scale, 0-100%. Indication accuracy is ±2% of span.

Hazardous Locations

Explosion proof: Approved by Factory Mutual (FM) for Class I, Division 1, Groups B*, C and D; Class II, Division 1, Groups E, F and G; and Class III, Division 1. Certification by Canadian Standards Association (CSA) for Class I, Groups C and D available as an option. **Intrinsically safe:** FM certification optional for Class I, Division 1, Groups A, B, C and D when used with approved barrier systems. CSA certification for Class I, Division 1, Groups A, B, C and D pending.

Span and Zero

Continuously adjustable externally, non-interacting.

Zero Elevation and Suppression

Zero elevation or zero suppression adjustable up to 10% of calibrated flow span.

Temperature Limits

−20 to +150°F Amplifier operating.
−40 to +220°F Sensing element operating.
−60 to +180°F Storage.

Static Pressure and Overpressure Limits

0 psia to 2000 psig on either side without damage to the transmitter. Operates within specifications between static line pressure of 1/2 psia and 2000 psig. 10,000 psig proof pressure on the flanges.

Humidity Limits

0 to 100% RH.

Volumetric Displacement

Less than 0.01 cubic inches.

Optional meter not approved for Group B.

Damping

Time constant continuously adjustable between 0.2 and 1.0 seconds.

Turn-on Time

2 seconds. No warmup required.

Performance Specifications

(ZERO BASED SPANS, REFERENCE CONDITIONS, 316SS ISOLATING DIAPHRAGMS. APPLIES FROM 20% TO 100% FLOW).

Accuracy

±0.25% of calibrated span for range of 20% to 100% of flow (4% to 100% of input pressure). Includes combined effects of hysteresis, repeatability and conformity of the square root function. Output linear with input pressure for the range of 0% to 20% of flow (0% to 4% of input pressure).

Dead Band

None

Stability

±0.25% of upper range limit for six months.

Temperature Effect

The total output effect, whether at zero or full scale, including zero and span errors: ± 1.5% of upper range limit per 100°F. (± 2.5% for range 3).

Overpressure Effect

Zero shift of less than ±0.25% of differential pressure upper range limit for 2000 psi (±1.0% for range 5).

Static Pressure Effect

Zero Error: ±0.25% of differential pressure upper range limit for 2000 psi (±0.5% for range 3).
Span Error: −0.5 ± 0.1% of reading per 1000 psi (−0.75 ± 0.1% for range 3).
This is a systematic error which can be calibrated out for a particular pressure before installation.

Vibration Effect

±0.05% of upper range limit per g to 200 Hz in any axis.

Power Supply Effect

Less than 0.005% of output span per volt.

Load Effect

No load effect other than the change in power supplied to the transmitter.

Mounting Position Effect

Zero shift of up to 1" H_2O which can be calibrated out. Range 3 transmitters should be installed with diaphragm in vertical plane. No span effect. No effect in plane of diaphragm.

Physical Specifications

Material of Construction†

Isolating Diaphragms

316SS, *Hastelloy C, Monel or Tantalum.*

Drain/Vent Valves

316SS, *Hastelloy C, or Monel.*

Process Flanges and Adapters

Cadmium Plated Carbon Steel, 316SS, *Hastelloy C or Monel.*

Wetted O-Rings

Viton.

Fill Fluid

Silicone Oil or *Fluorolube* Oil.

Bolts

Cadmium Plated Carbon Steel.

Electronics Housing

Low-copper aluminum (NEMA4).

Paint

Epoxy-Polyester.

Process Connections:

1/4-NPT on 2-1/8" centers on flanges. 1/2-NPT on 2", 2-1/8 or 2-1/4" centers with adapters.

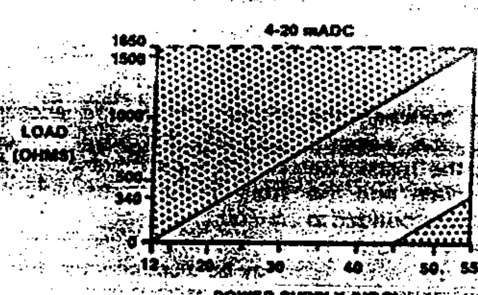
Electrical Connections

1/2-inch conduit with screw terminals and integral test jacks, compatible with miniature banana plugs (*Pomona* 2944, 3690 or equal).

Weight

12 pounds excluding options.

FIGURE 7
LOAD LIMITATIONS



†Monel is a trademark of International Nickel Co.
Hastelloy is a trademark of the Cabot Corp.
Viton is a DuPont trademark.

MAINTENANCE SECTION

GENERAL

The 1151 Series has no moving parts and requires a minimum of scheduled maintenance. Calibration procedures for adjusting or changing ranges are outlined in the calibration section.

Test terminals are available for in-process checks. For bench checks, the transmitter can be divided into three active physical components: the sensing element, the amplifier/squaring assembly, and the calibration board.

This section outlines a technique for checking out the components, the method for disassembly and reassembly, and a trouble shooting guide.

An illustrated drawing, schematic diagram, parts location and parts list are included in this manual.

TEST TERMINALS

The test terminals are connected across a diode through which the loop signal current passes. The indicating meter or test equipment shunts the diode when connected to the test terminals and as long as the voltage across the terminals is kept below the diode's threshold voltage, no current passes through the diode. To assure that there is no leakage current through the diode when a test reading is being made or when an indicating meter is connected, the resistance of the test connection or meter should not exceed 10 ohms. Resistance values of 3 times that above will cause less than a 1% error. The test terminal screws are bored to accept a miniature banana plug (Pomona 2944, 3690 or equal).

SENSING ELEMENT CHECKOUT

The sensing element (24) is not field repairable and must be replaced if found to be defective. If no obvious defect, such as a punctured isolating diaphragm or loss of fill fluid is observed, the sensing element may be checked in the following manner.

1. Disconnect the compensation board (16) as described in the disassembly section of the manual. The sensing element need not be removed from the electrical housing for checkout.

2. Jump connections 1 and 2 on the header assembly.

3. Check the resistance between the combined junction and the sensing element housing. This is the resistance between one capacitor plate and the sensing diaphragm, which is grounded to the housing. This resistance should be greater than 10 megohms.

4. Check the capacitance between these connections and the sensing element housing. This capacitance should be 150 ± 30 picofarads.

5. Jump connections 3 and 4 on the header assembly and repeat steps 3 and 4.

CIRCUIT BOARD CHECKOUT

The printed circuit boards (11 and 13) can most easily be checked for a malfunction by substituting a spare into the circuit.

For isolating a failure on the board, refer to the schematic diagram and parts list. Reference voltages are shown on the schematic. A block diagram and a discussion of each function is included under the theory of operation section.

Disassembly Procedure

PROCESS SENSOR BODY

1. Transmitter should be removed from service before disassembling sensor body.

2. Process flanges (25) can be detached by removing the four large bolts (26). CARE SHOULD BE TAKEN NOT TO SCRATCH OR PUNCTURE THE ISOLATING DIAPHRAGMS.

3. Isolating diaphragms may be cleaned with a soft rag and a mild cleaning solution. DO NOT USE ANY CHLORINE OR ACID SOLUTIONS TO CLEAN THE DIAPHRAGMS. Rinse diaphragms with clear water.

4. Flange adapters (21) and process flanges (25) may be rotated or reversed for mounting convenience.

ELECTRICAL HOUSING

1. Electrical connections are located in a compartment identified as "Terminal Side" on the nameplate. The signal terminals and the test terminals are accessible by unscrewing the cover (1) on the terminal side. The terminals are permanently attached to the housing and must not be removed, or the housing seal between compartments will be broken. THIS WOULD INVALIDATE THE EXPLOSION PROOF CONSTRUCTION OF THE HOUSING.

2. Circuit boards are located in a separate compartment identified as "Circuit Side" on the nameplate. The circuit boards are accessible by unscrewing the cover (1) on the circuit side. It is good practice to remove power from the transmitter before removing the circuit cover.

3. The amplifier/squaring assembly (13) may be disconnected after removing the three holding screws (14). This assembly consists of two boards, the amplifier and squaring boards, which have been mated together and then calibrated for conformity to the square root function. These two boards should never be separated.

4. The compensation board (16) is permanently attached to the sensor module (24) and contains the temperature compensating resistors. There is enough slack wire to pull this board off of the pins and out of the way for access to the calibration board (11).

5. The calibration board (11) may be disconnected by aligning the zero and range adjust screws so that they are perpendicular to the board. The board may be pulled out by inserting a #6-32 screw in the rivnut on the board.

6. The zero and range adjustment screws (4) may be removed by removing the nameplate (8) and detaching the snap rings (6).

REMOVING SENSOR FROM ELECTRICAL HOUSING

1. Remove amplifier/squaring assembly and calibration board as described above.

2. Loosen the lock nut (17).

3. Unscrew the sensor module (24) from the electronics housing, being careful not to damage the sensor leads. Then carefully pull the compensation board through the hole. The threaded connection has a sealing compound on it and must be broken loose. BE CAREFUL NOT TO DAMAGE THE ISOLATING DIAPHRAGMS WHEN UNSCREWING THE SENSOR.

4. The sensor module (24) is a welded assembly and cannot be further disassembled.

Reassembly Procedure

PRELIMINARY

1. Inspect all "O" rings and replace if necessary. Lightly grease with silicone oil to insure a good seal.

2. Inspect threaded connections to make sure five undamaged threads will fully engage for explosion proof requirements.

CONNECTING ELECTRICAL HOUSING TO SENSOR

1. Insert compensation board (16) through electronics housing.

2. Use a sealing compound on the threads of the sensor module (24) to assure a water tight seal on the electronics.

Numbers in parentheses refer to item numbers in drawing 1151-28.

3. Screw sensor module (24) into electrical housing (3) making sure that five full threads are engaged. Be careful not to damage or twist the sensor leads.

4. Align the sensor module with the high and low pressure sides oriented for convenient installation.

5. Tighten the lock nut (17).

ELECTRICAL HOUSING

1. Examine circuit boards to see that they are clean.

2. Check that "O" rings and snap rings are secure on the zero and span adjustment screws (4). The snap rings must be in place for explosion-proof operation.

3. *Align the zero and span adjustment screws with the potentiometers on the calibration board (11)* and push the calibration board onto the bayonet connectors.

4. Slide the compensation board (16) onto the pins with the component side toward the pins. Slide excess wire behind calibration board.

5. Push the amplifier/squaring assembly (13) onto the bayonet connectors. Secure the assembly with the three holding screws (14).

OPTIONAL INDICATING METER

1. Meter may be rotated in its holder bracket for convenient reading.

2. If the glass in the meter cover is disassembled for any reason, be sure that the "O" ring is in place behind the glass before reassembly. For explosion-proof operation the retaining ring must be tightened so that a 1-1/2 mil feeler gage will not fit between the glass and the metal:

PROCESS SENSOR BODY

1. Carefully place the process "O" rings (23) around the isolating diaphragms.

2. Place the flanges (25) in the desired orientation and finger tighten the four bolts (26).

3. Evenly seat the flanges on the sensor housing by the following procedure:

a. Tighten all four bolts finger-tight.
b. Tighten one bolt until the flanges seat.
c. Torque down the bolt diagonally across from this one.
d. Torque down the first bolt.
e. Torque down the two remaining bolts.
f. Inspect the flange to sensor seating to be sure that the flanges are not cocked.
g. Check that all four bolts are securely tightened (roughly between 15 and 45 foot-pounds).

INTERCHANGE OF PARTS

Mechanical hardware, flanges, flange adapters, electronics housing, electronics covers and mounting brackets are interchangeable among units without regard to range, calibration or output signal. Interchange of electronics and sensors is subject to the following conditions:

1. Indicating meters may be added to units or interchanged among units with the same output signal without regard to range.

2. The amplifier/squaring assemblies (01151-0378-0001) are interchangeable among $\sqrt{\Delta P}$ Flow Transmitters with identical output codes, without regard to range.

3. The calibration circuit boards (01151-0377-0001) are interchangeable among $\sqrt{\Delta P}$ Flow Transmitters with identical output codes without regard to range. The unit must, however, be recalibrated, including linearity recalibration, whenever the calibration board is changed.

4. To convert an 1151 $\sqrt{\Delta P}$ Flow Transmitter which has C output electronics to J output electronics, both the amplifier/squaring assembly and calibration board must be replaced.

5. All 1151DP range 3, 4 and 5 sensors may be used with J output electronics. Sensors with zero compensation resistors R26, R27 and R28 installed on the compensation board (16) may not be used with C output electronics.

6. The compensation board (16) is permanently attached to the sensor module and is not interchangeable.

WARRANTY

Rosemount warrants all equipment manufactured by it to be free from defects in workmanship or material under normal use and service. If any part of the equipment proves to be defective in workmanship or material and if such part is, within 12 months of the date of shipment from the Seller's factory, returned to such factory, transportation charges prepaid, and if the same is found by the Seller to be defective in workmanship or material, it will be replaced or repaired, free of charge, f.o.b. the Seller's factory. The Seller assumes no liability for consequential damages of any kind, and the Buyer by acceptance of this equipment will assume all liability for the consequences of its use or misuse by the Buyer, his employees or others. A defect within the meaning of this warranty in any part of any piece of equipment shall not, when such part is capable of being renewed, repaired or replaced, operate to condemn such piece of equipment.

This warranty is in lieu of all other warranties (including without limiting the generality of the foregoing warranties of merchantability and fitness for a particular purpose), guarantees, obligations or liabilities expressed or implied by the Seller or its representatives and by the statute or rule of law.

RETURN OF MATERIAL

Material returned for repair, whether in or out of warranty, should be shipped prepaid to:

Rosemount Inc.
12001 West 78th Street
Eden Prairie, Minnesota 55344
Attention: Service Center

The shipping container should be marked:

Return for Repair
Model__________

The returned material should be accompanied by a letter of transmittal which should include the following:

1.) Location, type of service and length of time in service of the device.

2.) Description of the faulty operation of the device and the circumstances of the failure.

3.) Name and telephone number of the person to contact if there are questions about the returned material.

4.) Statement as to whether warranty or non-warranty service is requested.

5.) Complete shipping instructions for the return of the material.

6.) Original purchase order number and date of purchase.

Adherence to these procedures will expedite handling of the returned material, and will prevent unnecessary additional charges for inspection and testing to determine the problem with the device.

If the material is returned for out-of warranty repairs, a purchase order for repairs should be enclosed.

SYMPTOM: HIGH OUTPUT

POTENTIAL SOURCE AND CORRECTIVE ACTION

Primary Element
Check for restrictions at primary element.

Impulse Piping
Check for leaks or blockage.
Check that blocking valves are fully open.
Check for entrapped gas in liquid lines and for liquid in dry lines.
Check that density of fluid in impulse lines is unchanged.
Check for sediment in transmitter process flanges.

Transmitter Electronics Connections
Make sure bayonet connectors are clean and check the sensor connections.
Check that bayonet pin #8 is properly grounded to the case.

Transmitter Electronics Failure
Determine faulty circuit board by trying spare boards.
Replace faulty board.

Sensing Element
See Sensing Element Checkout Section.

SYMPTOM: ERRATIC OUTPUT

POTENTIAL SOURCE AND CORRECTIVE ACTION

Loop Wiring
Check for adequate voltage to the transmitter.
Check for intermittent shorts, open circuits and multiple grounds.
NOTE: DO NOT USE OVER 100 VOLTS TO CHECK THE LOOP!

Process Fluid Pulsation
Adjust electronic damping pot.

Impulse Piping
Check for entrapped gas in liquid lines and for liquid in dry lines.

Transmitter Electronics Connections
Check for intermittent shorts or open circuits.
Make sure that bayonet connectors are clean and check the sensor connections.
Check that bayonet pin #8 is properly grounded to the case.

SYMPTOM: LOW OUTPUT OR NO OUTPUT

POTENTIAL SOURCE AND CORRECTIVE ACTION

Primary Element
Check installation and condition of element.
Note any changes in process fluid properties which may affect output.

Loop Wiring
Check for adequate voltage to transmitter.
Check for shorts and multiple grounds.
Check polarity of connections.
Check loop impedance.
NOTE: DO NOT USE OVER 100 VOLTS TO CHECK THE LOOP!

Impulse Piping
Check that pressure connection is correct.
Check for leaks or blockage.
Check for entrapped gas in liquid lines.
Check for sediment in transmitter process flange.
Check that blocking valves are fully open and that bypass valves are tightly closed.
Check that density of fluid in impulse piping is unchanged.

Transmitter Electronics Connections
Check to see that calibration adjustments are in control range.
Check for shorts in sensor leads.
Make sure bayonet connectors are clean and check the sensor connections.
Check that bayonet pin #8 is properly grounded to the case.

Test Diode Failure
Replace test diode or jumper test terminals together.

Transmitter Electronics Failure
Determine faulty circuit board by trying spare boards.
Replace faulty circuit board.

Sensing Element
See Sensing Element Checkout Section.

Ordering Information

MODEL	
1151DP	ALPHALINE $\sqrt{\Delta P}$ FLOW TRANSMITTER

CODE	RANGES
3	0-5 to 0-30 inches H_2O (0-127 to 0-762 mm H_2O)
4	0-25 to 0-150 inches H_2O (0-635 to 0-3810 mm H_2O)
5	0-125 to 0-750 inches H_2O (0-3175 to 0-19050 mm H_2O)

CODE	OUTPUT
J	4-20 mADC, square root of input with adjustable damping

CODE	MATERIALS OF CONSTRUCTION: FLANGE ADAPTER	DRAIN/VENT VALVE	ISOLATING DIAPHRAGM	FILL FLUID
12	Cadmium Plated C.S.	316SS	316SS	SILICONE
13	Cadmium Plated C.S.	*Hastelloy C*	*Hastelloy C-276*	SILICONE
14	Cadmium Plated C.S.	*Monel*	*Monel*	SILICONE
15	Cadmium Plated C.S.	316SS	Tantalum	SILICONE
22	316SS	316SS	316SS	SILICONE
23	316SS	316SS	*Hastelloy C-276*	SILICONE
24	316SS	316SS	*Monel*	SILICONE
25	316SS	316SS	Tantalum	SILICONE
33	*Hastelloy C*	*Hastelloy C*	*Hastelloy C-276*	SILICONE
35	*Hastelloy C*	*Hastelloy C*	Tantalum	SILICONE
44	*Monel*	*Monel*	*Monel*	SILICONE
1A	Cadmium Plated C.S.	316SS	316SS	FLUOROLUBE
2A	316SS	316SS	316SS	FLUOROLUBE
1B	Cadmium Plated C.S.	*Hastelloy C*	*Hastelloy C-276*	FLUOROLUBE
2B	316SS	316SS	*Hastelloy C-276*	FLUOROLUBE
3B	*Hastelloy C*	*Hastelloy C*	*Hastelloy C-276*	FLUOROLUBE
1D	Cadmium Plated C.S.	316SS	Tantalum	FLUOROLUBE
2D	316SS	316SS	Tantalum	FLUOROLUBE
3D	*Hastelloy C*	*Hastelloy C*	Tantalum	FLUOROLUBE

CODE	OPTIONS (See Product Data Sheet 2360 for Additional Options)
M1	Linear Meter, 0-100% Scale
B1	Mounting Bracket for Mounting to 2" Pipe
B2	Mounting Bracket for Panel Mounting
B3	Flat Mounting Bracket for Mounting to 2" Pipe
D1	Side Vent/Drain, Top
D2	Side Vent/Drain, Bottom
F1	FM Intrinsic Safety Approval with *Foxboro* 2AI-12V-FGB or 2AI-13V-FGB Barriers for Class I, Division 1, Groups A, B, C and D.
F2	FM Intrinsic Safety Approval with *Taylor* 124S1134 or 124S1144 Barriers for Class I, Division 1, Groups B, C and D. Barriers 124S931, 124S932, 124S1254 and 124S1264 approved for Groups C and D.
—	Other Options. Note: Insert the appropriate Option Codes to specify any of the additional Options described in Product Data Sheet 2360.

1151DP	4	J	12	M1, B1	→ COMPLETED DESIGN SPECIFICATION

ADDITONAL OPTIONS

All Series 1151 Transmitter Options are described in Product Data Sheet 2360. Some not shown in the Ordering Information Table include optional materials, outputs, tests, etc. Other FM or CSA Certifications for use with *Westinghouse, Leeds & Northrup, Fischer & Porter, Fisher Controls* and *Honeywell* barriers are also shown. Any appropriate Option Code can be added to the basic 1151 Transmitter Model Number.

ACCESSORY 3-VALVE MANIFOLD (Packaged separately)

Part No. 1151-150-1:
3-Valve Manifold, Carbon Steel (Anderson, Greenwood & Co., M4AVC).

Part No. 1151-150-2:
3-Valve Manifold, 316SS (Anderson, Greenwood & Co., M4AVS).

Other Series 1151 Pressure Transmitter Product Data Sheets:

PDS2255: 1151GP Remote Seal Gage Pressure
PDS2256: 1151DP Differential Pressure
PDS2257: 1151DP High Differential Pressure
PDS2258: 1151HP High Line Pressure Differential
PDS2260: 1151GP Gage Pressure
PDS2261: 1151AP Absolute Pressure
PDS2262: 1151LL Liquid Level
PDS2294: 1151DR Draft Range Differential Pressure

OPTION ORDERING INFORMATION

CODE	TRANSMITTER MODEL AND PRODUCT DATA SHEET (PDS) NUMBER.	1151DP (PDS 2256)	1151DP High Differential (PDS 2257)	1151HP (PDS 2258)	1151DP Square Root (PDS 2259)	1151GP (PDS 2260)	1151GP/DP Remote Seal (PDS 2255)	1151AP (PDS 2261)	1151LL (PDS 2262)	1151DR (PDS 2294)
CODE	**MOUNTING BRACKETS**									
B1	Bracket for 2" Pipe Mounting	•	•	•	•	•	•	•	NA	•
B2	Bracket for Panel Mounting	•	•	•	•	•	•	•	NA	•
B3	Flat Bracket for 2" Pipe Mounting	•	•	•	•	•	•	•	NA	•
B4	Bracket for 2" Pipe with Series 300 SST Bolts	•	•	•	•	•	•	•	NA	•
B5	Bracket for Panel with Series 300 SST Bolts	•	•	•	•	•	•	•	NA	•
B6	Flat Bracket for 2" Pipe with Series 300 SST Bolts	•	•	•	•	•	•	•	NA	•
CODE	**METERS** (Not available with options V2, V3)									
M1	Integral Linear Meter, 0-100% Scale	•	•	•	•	•	•	•	•	•
M2	Integral Square Root Meter, 0-10 Scale	•	•	•	NA	NA	NA	NA	NA	•
CODE	**CERTIFICATIONS**									
CE	Explosion Proof, CSA	•	•	•	•	•	•	•	•	•
F1	Intrinsic Safety, FM, Foxboro	•	•	•	•	•	•	•	•	•
F2	Intrinsic Safety, FM, Taylor	•	•	•	•	•	•	•	•	•
F3	Intrinsic Safety, FM, Westinghouse	•	•	•	•	•	•	•	•	•
F4	Intrinsic Safety, FM, Leeds & Northrup	•	•	•	•	•	•	•	•	•
F5	Intrinsic Safety, FM, Fischer & Porter	•	•	•	•	•	•	•	•	NA
F6	Intrinsic Safety, FM, Fisher Controls	•	•	•	•	•	•	•	•	•
F7	Intrinsic Safety, FM, Honeywell	•	•	•	•	•	•	•	•	•
C1	Intrinsic Safety, CSA, Zener Barrier	•	•	•	•	•	•	•	•	•
C2	Intrinsic Safety, CSA, Foxboro	•	•	•	•	•	•	•	•	NA
C3	Intrinsic Safety, CSA, Fisher Controls	•	•	•	•	•	•	•	•	•
	(F1–C3) Intrinsic Safety Approval Not Valid With Output Code B (See page 3)									
CODE	**BOLTS FOR FLANGE AND ADAPTERS**									
L1	Austenitic Series 300 SST	•	•	•	•	•	•	•	•	•
L2	17-4 SST	•	•	•	•	•	•	•	•	•
L3	ANSI 193-B7	•	•	•	•	•	•	•	•	•
CODE	**PROCESS CONNECTIONS**									
D1	Side Vent/Drain Top (Material Same as Flange)	•	•	•	•	•	NA	•	NA	•
D2	Side Vent/Drain Bottom (Material Same as Flange)	•	•	•	•	•	NA	•	NA	•
D3	1/4" NPT Process Connection	•	•	•	•	•	NA	•	•	•
CODE	**WETTED O-RINGS**									
W2	Buna - N	•	•	•	•	•	•	•	•	•
W3	Ethylene - Propylene	•	•	•	•	•	•	•	•	•
CODE	**PROCEDURES**									
P1	Hydrostatic Testing	•	•	•	•	•	•	•	•	NA
P2	Cleaning for Special Service	•	•	•	•	•	•	•	•	•
P3	Cleaning for Nuclear Service	•	•	•	•	•	NA	•	•	•
P4	Calibration at Line Pressure	•	•	•	•	NA	NA	NA	NA	NA
P5	Calibration at Temperature	•	•	•	•	•	•	•	•	•
CODE	**OUTPUTS**									
V1	Reverse Output	•	•	•	NA	•	•	NA	NA	•
V2	1Ω Test Resistor (Test Resistors Not Available With Options M1 or M2)	•	•	•	•	•	•	•	•	•
V3	5Ω Test Resistor (Test Resistors Not Available With Options M1 or M2)	•	•	•	•	•	•	•	•	•

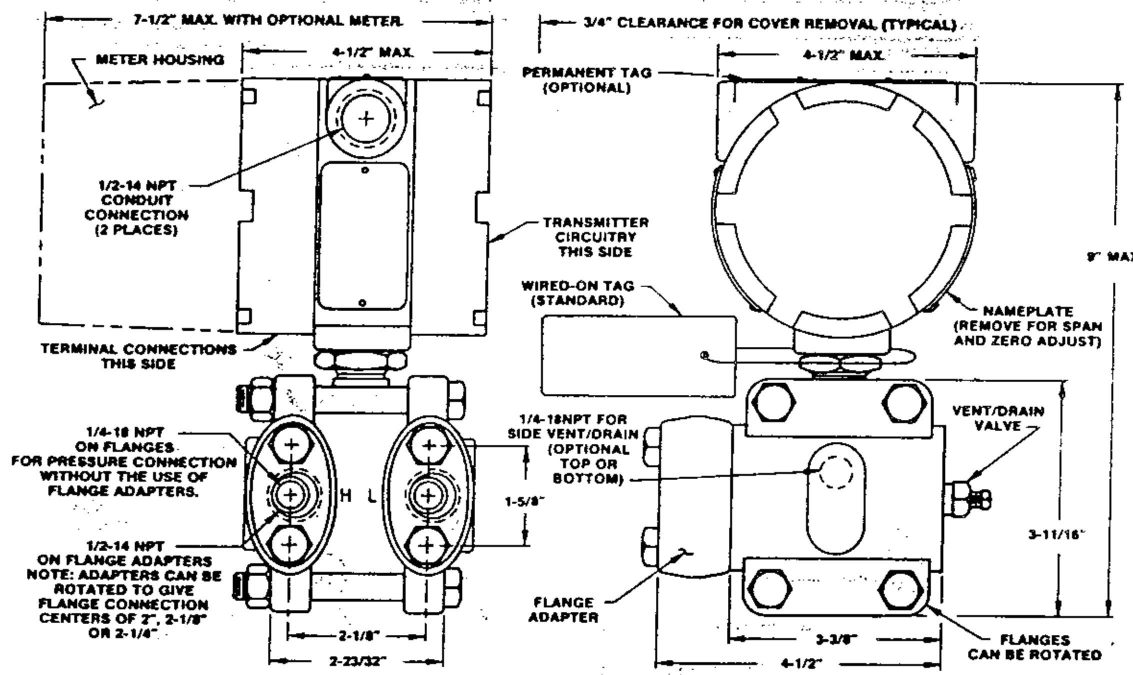
The options listed in this Product Data Sheet may be ordered by placing the appropriate code or codes at the end of the transmitter model number.

Example: 1151DP4E12 B1 M1 D2 P1
Basic Model No. (1151DP4E12)

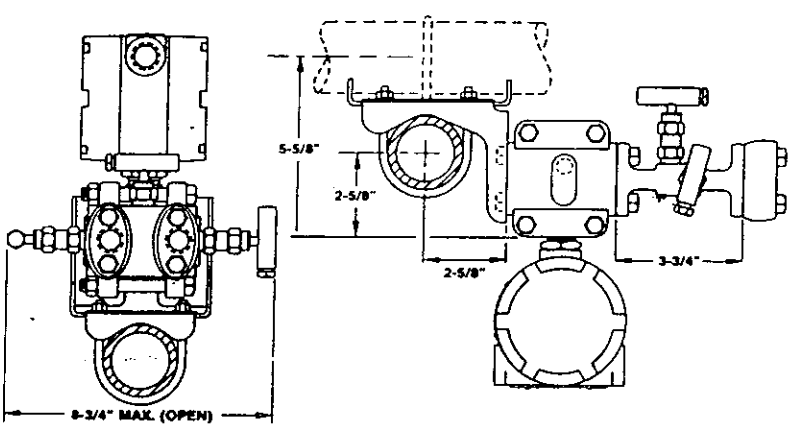
• - Available
NA - Not Available

PARTS LIST/DRAWINGS SECTION

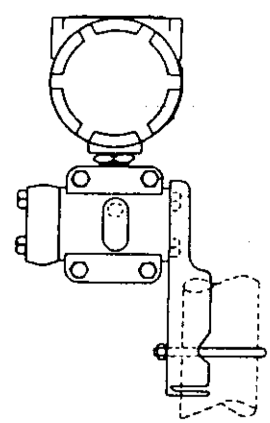
Dimensional Drawings



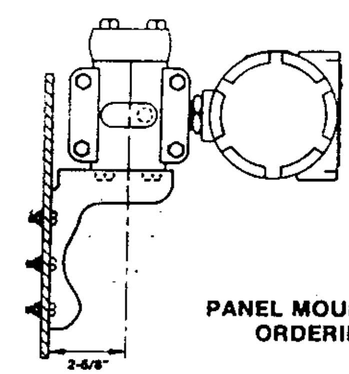
OPTIONAL MOUNTING BRACKETS
SHOWN IN TYPICAL MOUNTING CONFIGURATIONS



MOUNTING BRACKET AND OPTIONAL 3-VALVE
MANIFOLD BRACKET ORDERING CODE B1



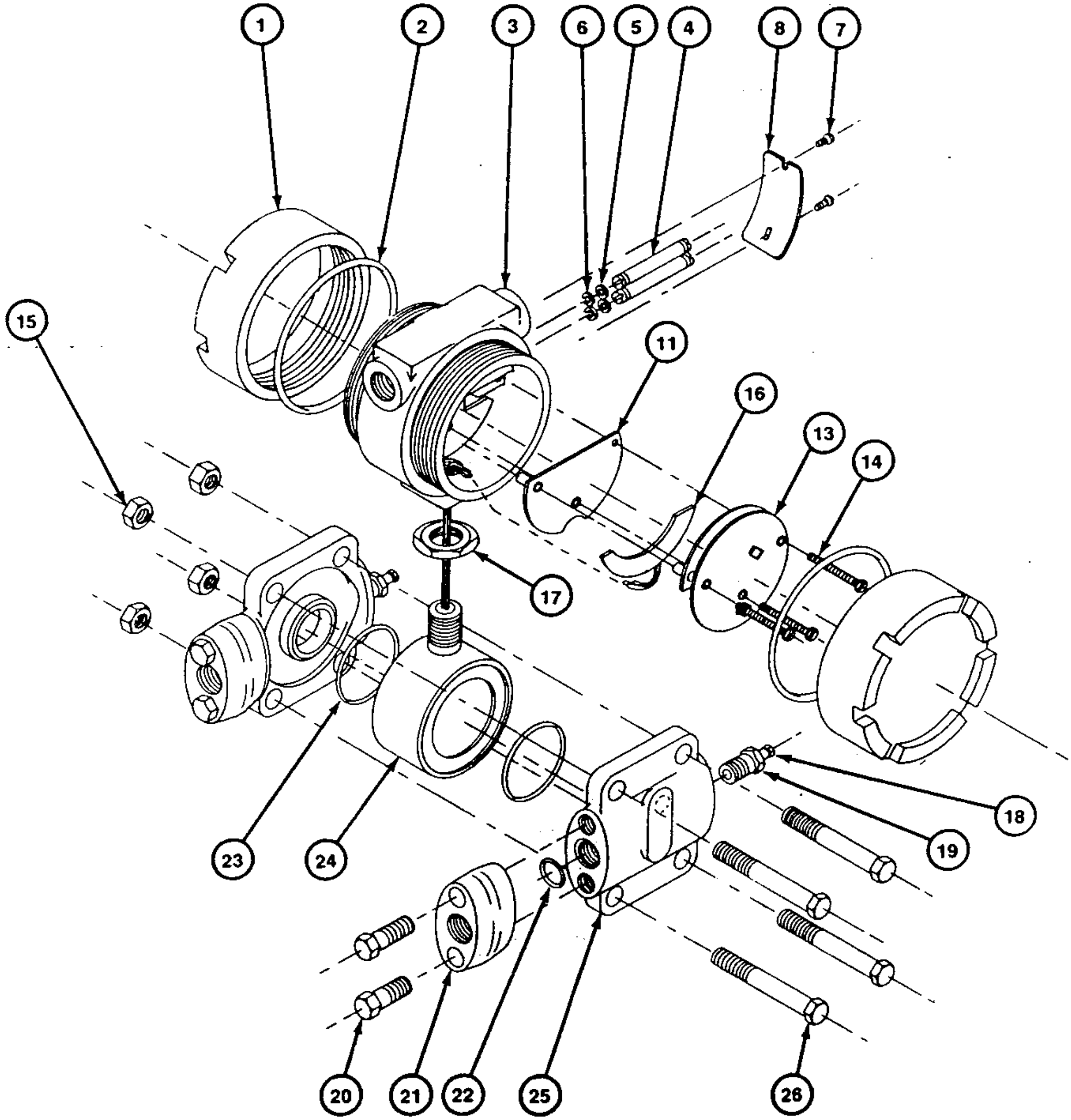
FLAT MOUNTING BRACKET
ORDERING CODE B3



PANEL MOUNTING BRACKET
ORDERING CODE B2

Parts Drawing

(Drawing 1151-28)



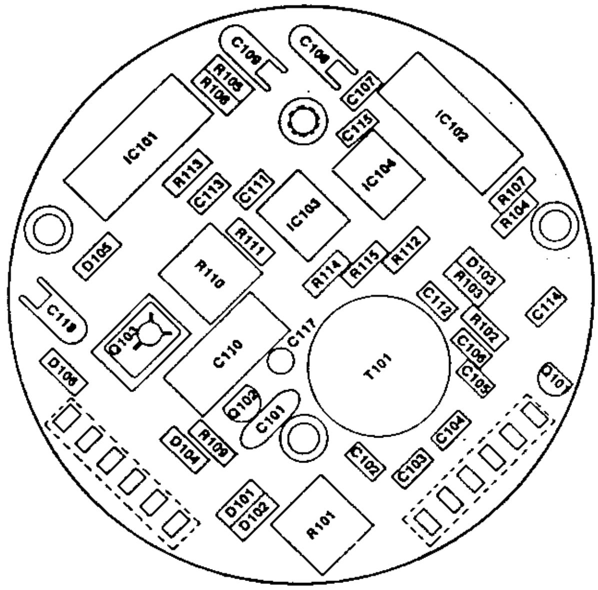
Parts List
(Drawing 1151-28)

PART DESCRIPTION (DRAWING 1151-23-2)	ITEM No.	SILICONE FILL Order No.	FLUOROLUBE FILL Order No.	SPARES CATEGORY°
J OUTPUT CODE 4-20 mADC, Square Root of Input				
Amplifier/Squaring Assembly	13	01151-0378-0001		A
Calibration Circuit Board	11	01151-0377-0001		A
C OUTPUT OPTION, Replaced by J output. If either an amplifier or a calibraton circuit board from a "C" output unit requires replacement, order a "J" amplifier/squaring assembly AND calibration board.				
Sensor Module, 0-5/30" H_2O	24			
316SST		01151-0011-0032	01151-0230-0032	B
HASTELLOY C-276		01151-0011-0033	01151-0230-0033	B
MONEL		01151-0011-0034	NA	B
TANTALUM		01151-0011-0035	01151-0230-0035	B
Sensor Module, 0-25/150" H_2O				
316SST		01151-0011-0042	01151-0230-0042	B
HASTELLOY C-276		01151-0011-0043	01151-0230-0043	B
MONEL		01151-0011-0044	NA	B
TANTALUM		01151-0011-0045	01151-0230-0045	B
Sensor Module, 0-125/750" H_2O				
316SST		01151-0011-0052	01151-0230-0052	B
HASTELLOY C-276		01151-0011-0053	01151-0230-0053	B
MONEL		01151-0011-0054	NA	B
TANTALUM		01151-0011-0055	01151-0230-0055	B
Electronics Housing	3	01151-0060-0007		
Electronics Cover	1	90032-0240-0003		
Process Flange	25			
Cadmium Plated Carbon Steel		01151-0236-0001		
316SST		01151-0213-0002		
HASTELLOY C		01151-0213-0004		
MONEL		01151-0213-0003		
Process Flange for Side Drain/Vent Valve				
Cadmium Plated Carbon Steel		01151-0236-0011		
316SST		01151-0213-0012		
HASTELLOY C		01151-0213-0014		
MONEL		01151-0213-0013		
Flange Adapter Union	21			
Cadmium Plated Carbon Steel		90001-0033-0001		
316SST		01151-0211-0002		
HASTELLOY C		01151-0211-0004		
MONEL		01151-0211-0003		
Valve Stem, 316SST	18	} 01151-0028-0022		A
Valve Seat, 316SST	19			
Plug, 316SS (used with side drain/vent)	18A	C10386-0002		
Valve Stem, HASTELLOY C	18	} 01151-0028-0023		A
Valve Seat, HASTELLOY C	19			
Plug, HASTELLOY C (used with side drain/vent)	18A	C10386-0202		
Valve Stem, MONEL	18	} 01151-0028-0024		A
Valve Seat, MONEL	19			
Plug, MONEL (used with side drain/vent)	18A	C10386-0102		
Adjustment Screw	4	} 01151-0029-0001		
Retaining Ring	6			
O-Ring for Adjustment Screw	5			

MOUNTING BRACKET Part Description Complete with Hardware	Order No.
B1 Style Bracket	01151-0036-0001
B2 Style Bracket	01151-0036-0004
B3 Style Bracket	01151-0036-0005

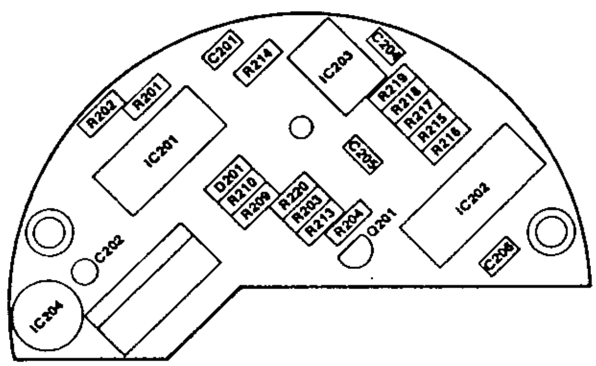
Component Layout, Amplifier PWA

(Drawing 1151-373 Rev. B)



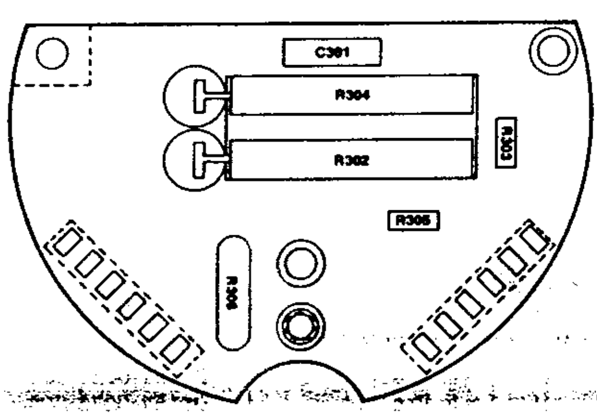
Component Layout, Squaring PWA

(Drawing 1151-375 Rev. A)

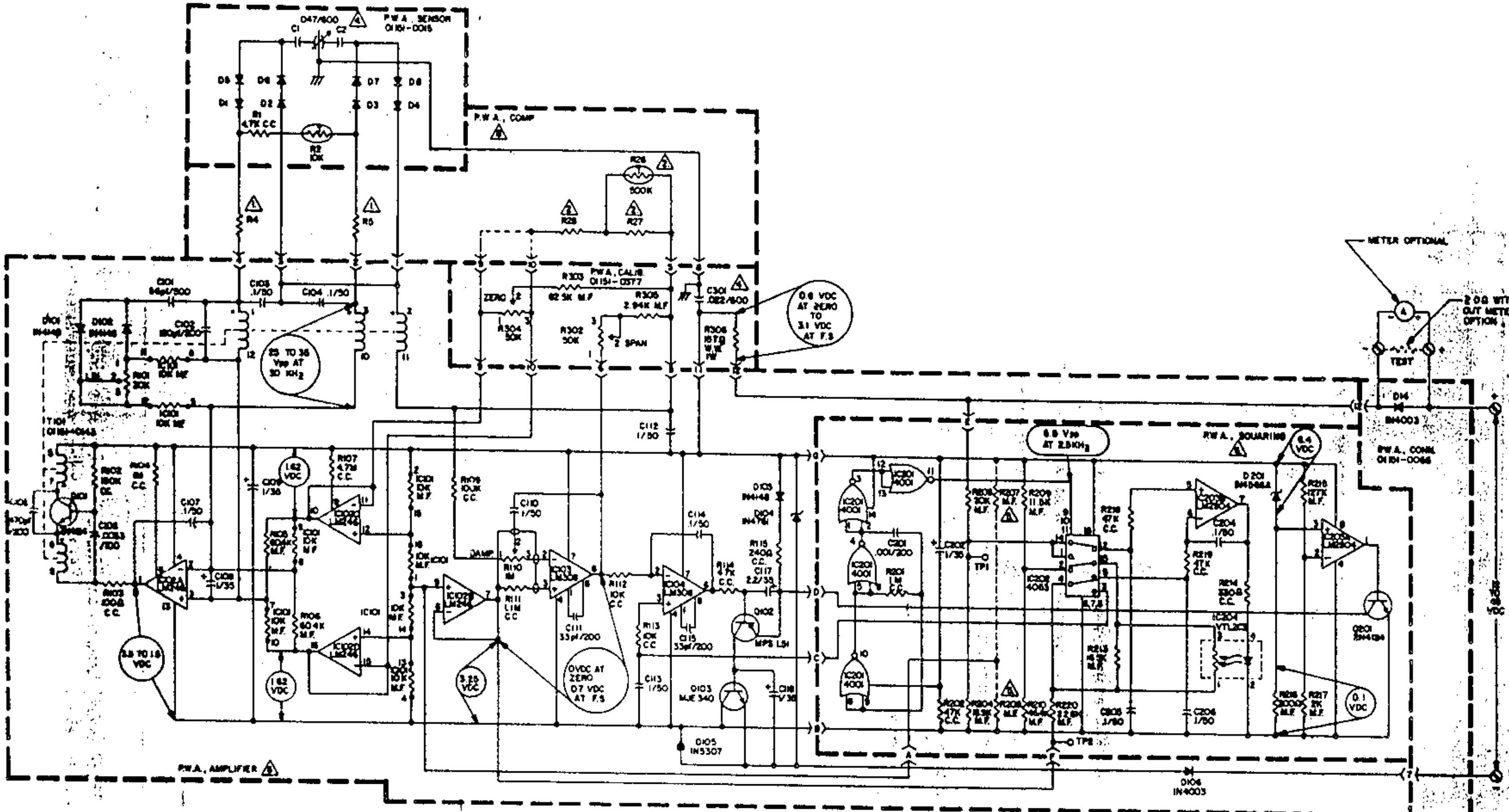


Component Layout, Calibration PWA

(Drawing 1151-377 Rev. A)



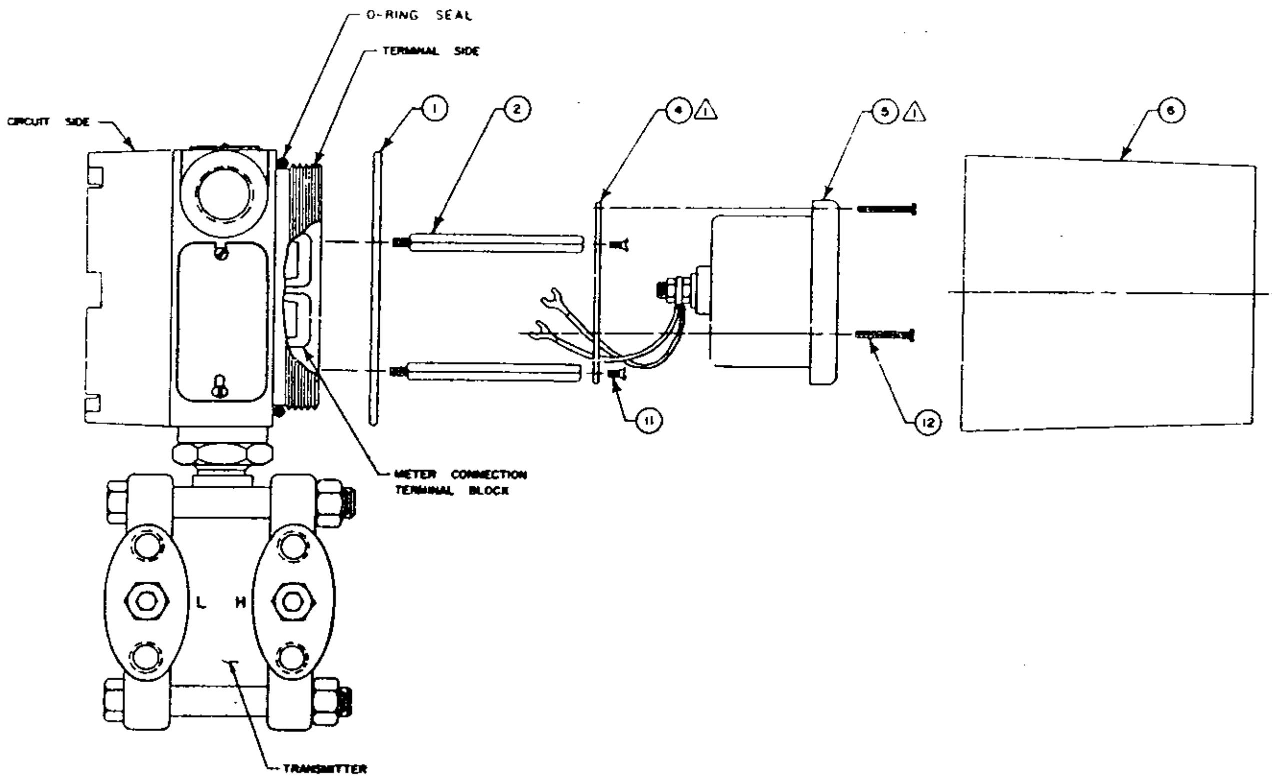
Schematic Diagram, 4-20 mADC Output (Drawing 1151-371 Rev B)



- P.W.A. COMP IS PART OF THE SENSOR MODULE ASSEMBLY
- 7 THE END PRODUCT THIS SCHEMATIC DESCRIBES HAS BEEN SUBMITTED FOR INTRINSIC SAFETY APPROVAL. ANY CHANGES IN DESIGN, COMPONENT TYPE, COMPONENT VALUE, COMPONENT RATING OR BOARD LAYOUT MAY AFFECT APPROVAL AND REQUIRE RESUBMITTAL
- P.W.A., SQUARING AMPLIFIER ASSEMBLY, P/N 01151-0376-0001
- R207 OR R208 IS SELECTED FOR LINEARIZING THE SQUARING STAGE AND ARE 100K MINIMUM. AT 4 MADC THE VOLTAGE FROM TP1 TO TP2 SHOULD BE ± 1.0 mVDC MAX.
- C1, C2 AND C301 HAVE BEEN TESTED TO WITHSTAND 500 VAC FOR 10 MIN WITHOUT FAILURE BY ELECTRICAL RESEARCH ASSOCIATION OF ENGLAND.
- 3 ALL M.F. RESISTORS ARE 1/10 WATT, ALL C.C. RESISTORS ARE 1/4 WATT, ALL POTS ARE 3/4 WATT, ALL CAPACITORS ARE MICROFARAD/VOLTAGE RATING, UNLESS OTHERWISE NOTED
- R26, R27 AND R28 ARE FOR ZERO TEMPERATURE COMPENSATION AND ARE 100K MINIMUM
- R4 AND R5 ARE FOR SPAN TEMPERATURE COMPENSATION AND ARE 0Ω MINIMUM, 300Ω MAXIMUM

Meter Assembly

(Drawing 1151-25, Rev. D)



DESCRIPTION	ITEM	ORDER	QTY. REQ'D
*Kit, 4-20 mADC, Linear Scale		01151-0006-0005	1
Meter, 4-20 mADC, Linear Scale	5	09997-0001	1
Cover/Faceplate Assembly	6	01151-0098-0002	1
Meter Bracket Assembly Mounting Ring Standoff Screw for Mounting Ring Screw for Meter	 4 2 11 12	01151-0037-0001†	1
"O" Ring for Cover	1	01151-0033-0002	**

*Kit includes meter, cover, bracket assembly, "O" ring and wiring.
**Part number is for package of 12 - only one required per transmitter.
†Kit containing enough parts for one transmitter.

LTR	DESCRIPTION	ECA CHG. NO.	APP'D	APP'D	DATE
A	New Release	761372	[illegible]	[illegible]	[illegible]
B	Add Honeywell Inc.	762440			[illegible]
B_1	Correct Honeywell Model Numbers	770831		[illegible]	[illegible]

Rosemount 1151 and 1144 transmitters are FM approved as intrinsically safe when used with the barriers shown below only for the Class I, Division 1 Groups listed.

To assure an intrinsically safe system the 1151 and 1144 must be wired in accordance with the barrier manufacturers field wiring instructions listed below.

Barrier Manufacturer	Barrier Model	Approved Class I Division 1 Areas			Manufacturers Publication #
Fisher Controls	AC 302	-	C	D	A33A5385
Honeywell Inc	38545-XXXX-0110 -113-F5B5	B	C	D	30734039-000
Honeywell Inc	38545-XXXX-0110 -111/112-F5B5	-	C	D	30734577-000

	DATE
DR. BY Edwards	2/25/76
CHK'D BY [illegible]	7/2/76
APP'D [illegible]	[illegible]/12/76
APP'D	

Rosemount Inc. MINNEAPOLIS, MINNESOTA

TITLE: INDEX OF INTRINSICALLY SAFE SYSTEM WIRING DRAWINGS FOR 1151 AND 1144 TRANSMITTERS

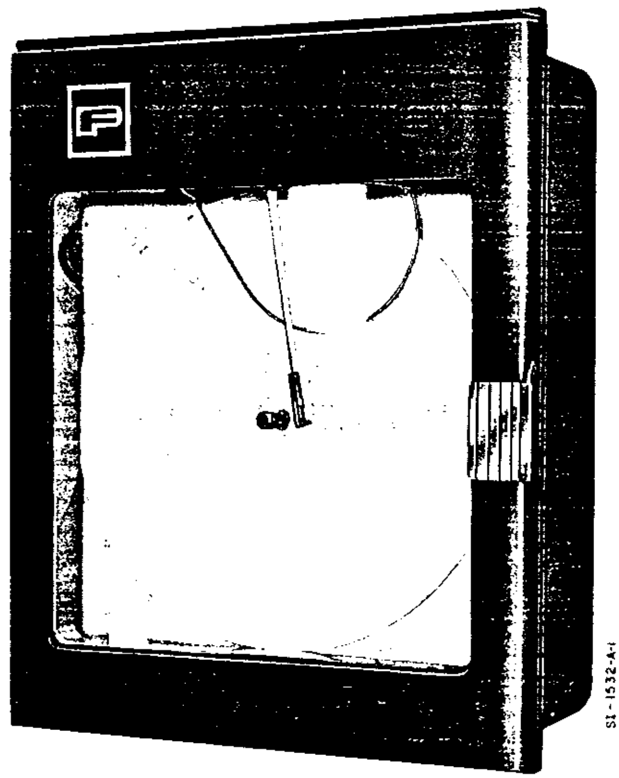
SIZE	CODE IDENT NO	DRAWING NO.
A	04274	1151-0214

SCALE: REV. B_1 SHEET 1 OF 1

INJECTION FLOW RECORDER

Model:	Fischer & Porter 51B1102DBBXXXXXXX2BB2BB
Display:	Circular Chart Recording, 12 Inch
Chart Drive:	120 VAC 60Hz, 24 Hour Rotation
Input:	4-20 MA D.C. Linear
Pen:	Fibre Tip, Disposable Red
Options:	Mechanical Input Integrator W/8 Digit Counter 52TR4011DX11 (Count x 1,000 - Gallons)
Flow Range:	0 to 7,500 gpm
Chart/Scale:	0 to 75 Linear (Chart X100 = Value)

INSTRUCTION BULLETIN
for
SERIES 51B1100DB (DM)
INDICATOR/RECORDER
Design Levels A & B



FISCHER & PORTER

TABLE OF CONTENTS

The instructions given herein cover generally the description, installation, operation and maintenance of subject equipment. F&P reserves the right to make engineering refinements that may not be reflected in this Bulletin. Should any questions arise which may not be answered specifically by these instructions they should be directed to the Fischer & Porter Co. for further detailed information and technical assistance.

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INTRODUCTION

I. Utility

The Fischer & Porter Series 51B1100DB (or DM) Indicator/Recorder, shown on the frontispiece, produces a visual indication and/or permanent chart record of any process variable that is metered by a transducer/converter with a direct current analog output equivalent to 200 millivolt minimum span. Although basically operating from a voltage signal input (e.g., 1-5 V dc), this Indicator/Recorder also accepts current signal inputs (e.g., 4-20 mA dc) which are converted to a proportional voltage by means of a precision input shunt resistor.

The process measurement section of all 51B1100DB (or DM) Indicator/Recorders is a unique signal-to-motion servo-receiver, the F&P Series 50TQ1000 TORQ-ER™ Receiver, that uses a contactless feedback device called a "flux bridge." The Indicator/Recorder may be furnished with one to four such receivers depending upon the display option selected and output functions desired. Each indicating pointer and/or recording pen is color-coded to identify different inputs. Two-wire input transmission loops may be operated from an internal dc power supply furnished with certain models of each TORQ-ER Receiver.

Several optional secondary functions are available with most models of the Series 51B1100DB Indicator/Recorder, such as integration, pulse totalization, pneumatic transmission or control signals, digital or analog electrical retransmission of process values, and high or low limit alarm or control signals. However, these options may be limited by the number of receivers required in a particular Indicator/Recorder.

The TORQ-ER Receiver constitutes the electronic servo-operator portion of the Series 51B1100DB (DM) Indicator/Recorder and, along with basic and accessory instrument case wiring, is described in this Instruction Bulletin. Details concerning mechanical aspects of the instrument case are given within Instruction Bulletin 51-1100, appended. Separate Instruction Bulletins are also appended for each accessory instrument (except resistance transmission given herein), if supplied. See listings given under "II-Model Numbering System," following.

II. Model Numbering System

Refer to the F&P Manufacturing Specification Sheet — or — the instrument data tag for the specific model number of the instrument furnished. Standard instrument options may be identified from the following breakdown.

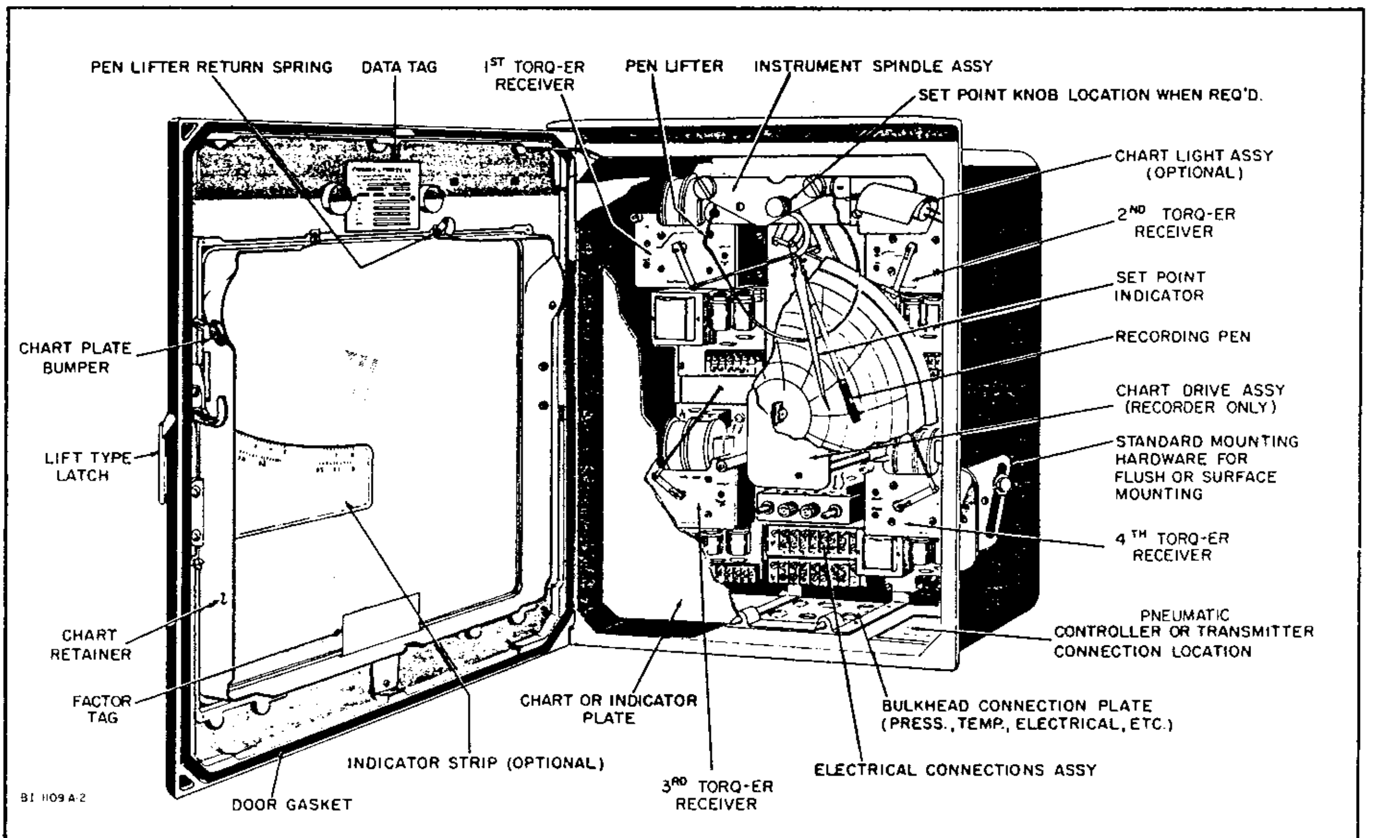


FIGURE 1. SERIES 51B1100DB (DM) INDICATOR/RECORDER

TM — Trade Mark of Fischer & Porter Co.

INTRODUCTION (Continued)

Indicator/Recorder Case:

Basic Model Number 51 B 1100 DB CAT DB CAT

Engineering File Reference
Indicators & Recorders ------------- 51

Design Level - Letter assigned by the factory; letter changes when some part is no longer interchangeable.
- Original Design --------------------- A
- Disposable Inking System ------------ B

Case Style & Design; 14-1/2 w x 18-1/4" h
- Segmental Indicator ------------------- 1101
- Circular Chart Recorder --------------- 1102

Receiver; 4-20 mA Torq-er (See Fig. 1)
1st Receiver ---------------------------------- DB
2nd Receiver -- DB
1st and 3rd Receiver ------------------------- DM
2nd and 4th Receiver -------------------------------- DM

Output Functions CAT CAT
- Position C: Controller/Integrator
  Refer to Table A ----------------------------- C C
- Position A: Alarms
  Refer to Table B ------------------------------ A A
- Position T: Transmitters
  Refer to Table C ------------------------------ T T

Accessory Station 1 2 3 4 5 6

Continued 51 B 1100 DB CAT DB CAT 0 A A 0 A A

Recording Pen Option
Not Required - Indicator ---------------------- X
Disposable Inking System ---------------------- 2

Case & Mounting Options
Surface or Flush Mounting ----------------------- B
Pipe Mounting ----------------------------------- E
Pipe Mounting w/2" Pipe & Flange ---------------- F

Door Options
- Standard (No Accessories) ----------------------- B
- Chart Light - Recorder Only --------------------- E
- Door Lock & Safety Glass ------------------------ H
- Door Lock, Safety Glass and
  Chart Light - Recorder Only --------------------- N

Chart Speed
Not Required - Indicator ---------------------------- X
8 h/rev ---------- 1 7 days/rev ---------- 3
24 h/rev ---------- 2 8 days/rev ---------- 4

Power Requirements

Chart Power Volts	Chart Power Hz	Instrument Power Volts	Instrument Power Hz	Code
120	60	120	50/60	B
120	50	120	50/60	C
230	60	230	50/60	D
230	50	230	50/60	E
24	60	24	dc	F
24	50	24	dc	G
120	60	24	dc	H
120	50	24	dc	J
230	60	24	dc	K
230	50	24	dc	L
Indicator		120	50/60	M
Indicator		230	50/60	N
Indicator		24	dc	P

Enviroment
Non-Hazardous -- B
Class I, Division 2, Group D ---------------------------- C

TABLE A CONTROLLER AND/OR INTEGRATOR OUTPUT FUNCTION

51-1100 X X C A T X X C A T

- Not Required ---------------------------- X ------- X
- Non-Standard ---------------------------- A ------- A
- Integrator, Mechanical ------------------ B ------- B
- Controller, Pneumatic; Knob Adjust Set Point -------------------- C ------- C
- Controller, Pneumatic; Remote Set Point -- D ------- D
- Controller, Ratio, Pneumatic; Knob Adjust Ratio ------------------------ E ------- E
- Controller ("C" above) w/ Integrator ("B" above) ------------------ G ------- G
- Controller ("D" above) w/ Integrator ("B" above) ------------------ H ------- H
- Controller, Ratio ("E" above) w/ Integrator ("B" above) ------------------ J ------- J
- Counter w/Controller ("C" above) --------- M ------- M

TABLE B ALARM OUTPUT FUNCTION

51-1100 X X C A T X X C A T

- Not Required ------------------------------ X ------- X
- Non-Standard ------------------------------ A ------- A
- Mechanical Alarm, Single; w/Screwdriver Set Point ------------------- B ------- B
- Inductalarm, Single; w/Screwdriver Set Point ------------------- L ------- L

TABLE C TRANSMITTER OUTPUT FUNCTION

51-1100 X X C A T X X C A T

Not Required ---------------------------------- X ------- X
Non-Standard ---------------------------------- A ------- A
Transmitter, Pneumatic ------------------------ B ------- B
Transmitter, Time Pulse ----------------------- E ------- E

INTRODUCTION (Continued)

TORQ-ER Receiver:

```
                                                        50TQ 1 0 00 C
Electronic TORQ-ER Receiver ----------------- 50TQ

Design Designation ------------------------------ 1

Power Supply
Non-Standard ---------------------------------------- 0
120 V ac w/ 2-wire Transmitter Supply --------------- 1
24 V dc --------------------------------------------- 3
120 V ac w/o 2-wire Transmitter Supply -------------- 4

Input Signal
Non-Standard ---------------------------------------- 00
1-5 V dc -------------------------------------------- 01
0-4 V dc -------------------------------------------- 02
0-1 V dc -------------------------------------------- 03
0.25-1.25 V dc -------------------------------------- 04

Design Level - Letter assigned by the factory; letter
changes when some part is no longer interchangeable. ----- C
```

TABLE D STANDARD SIGNAL RANGES

Voltage Signals		Current Signals	
Range in V dc	Input Impedance in Ohms†	Range in mA dc	Input Shunt Resistor* in Ohms
1-5	1 MΩ	1-5 4-20 10-50	1000 ± 0.1% 250 ± 0.1% 100 ± 0.1%
0-4	1 MΩ	0-4 0-16 0-40	1000 ± 0.1% 250 ± 0.1% 100 ± 0.1%
0-1	250 kΩ	—	—
0.25-1.25	250 kΩ	—	—

†-Input impedance of special ranges equals 250 kΩ/volt of input span except for 200 mV dc which equals 300 kΩ minimum.

* See manufacturing specification sheet for value used, if applicable.

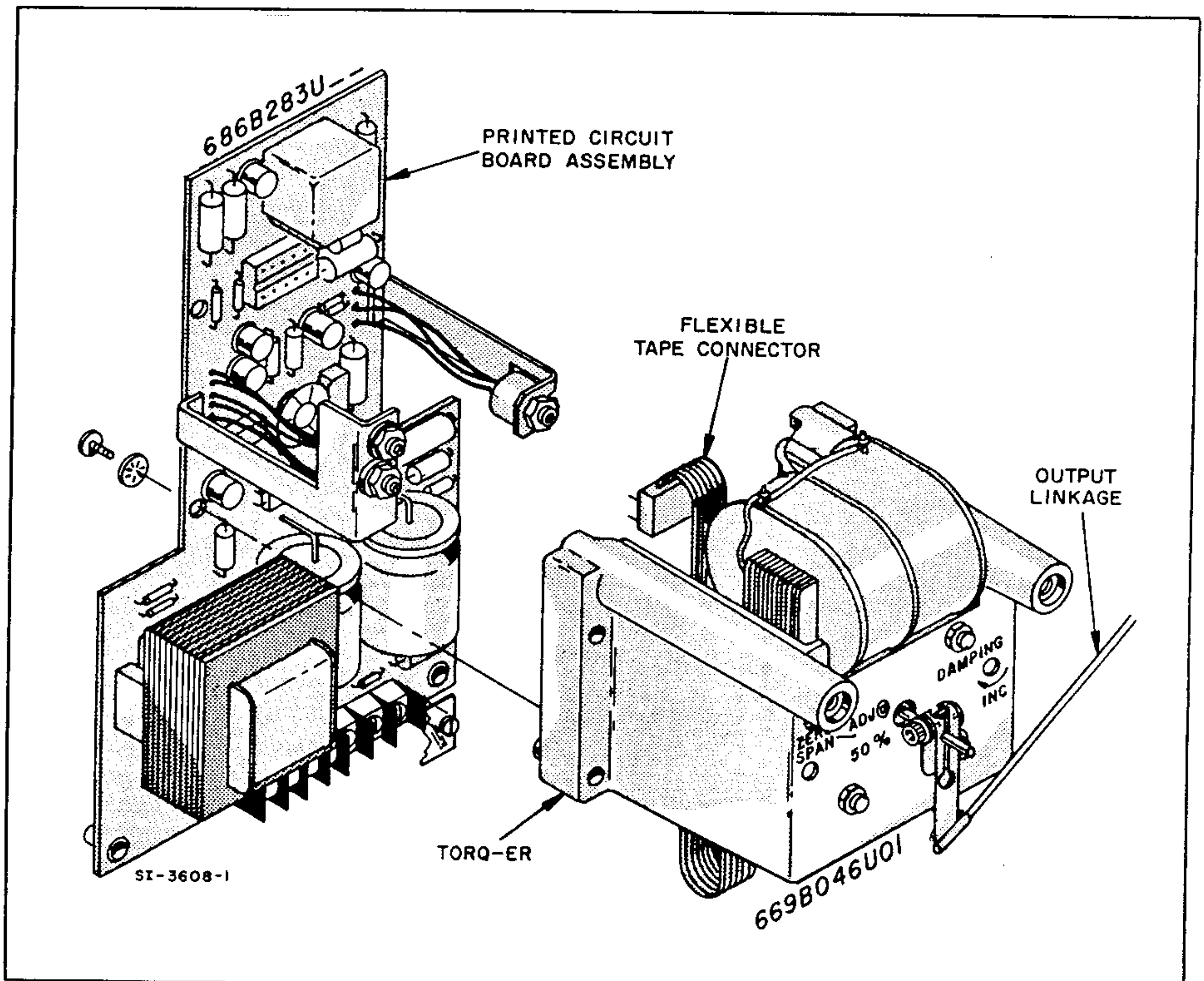


FIGURE 2. TORQ-ER RECEIVER (50TQ1000C)

III. Specifications

Operating Power	
Line Service	120 V ac ± 10%, 50 or 60 Hz ± 5% — or — 24 to 26 V dc, regulated — plus — 120 V ac or 24 V ac for chart drive and/or ac accessory (if required).
Power Consumption	
TORQ-ER Receiver	
AC Supply	4 watts, 4.5 VA, per receiver.
DC Supply	80 mA dc per receiver.
Recorders Only	add 5 watts, 5.6 VA, for chart drive.
Accessories	see applicable Instruction Bulletin.
Environmental Limits	
Ambient Temperature Range	+4° to +52°C (+40° to +125°F).
Humidity	5 to 95% @ +38°C (+100°F).
Input Requirements	
Signal	see Table D for standard input signal ranges.
V_{span}	must be between +4 and +0.2 volts, where $V_{span} = V_{100\%} - V_{0\%}$. Example : $V_{100\%} = +2V$ $V_{0\%} = -1V$ $V_{span} = +2V - (-1V) = 3V$
Suppression ($V_{0\%}$)	+1 to −2 times span, but not lower than −3 volts.
TORQ-ER Receiver Output	
Shaft Rotation	34° (ccw is upscale) transmitted via linkage to appropriate spindle.
Damping (100% input step change)	
Minimum	0.36 seconds for 63% scale — or — 1.7 seconds full scale.
Maximum	15 to 25 seconds for 63% scale.
Torque at Stall	1 inch-pound minimum.
Transmitter Power Supply (Option)	
Output Voltage	24 to 27 V dc @ 20 mA to remote 2-wire transmitter, one supply per receiver (120 V ac models only).
Ripple	50 mV p-p maximum.
Short Circuit Current	current limited to 60 mA.
Accuracy	± 0.5% of span.
Linearity	± 0.25% of span.
Repeatability	0.2% of span.
Deadband	0.2% of span.
Power Supply Effect	± 0.1% of span for ± 10% input voltage change.
Temperature Effect	± 0.5% of span for 28°C (50°F) change.
Electrical Environment	non-hazardous or Class I, Division 2, Group D, (supplied for non-hazardous service unless otherwise specified). Enclosure meets requirements of NEMA 2/IEC IP22.
Optional Features	door lock, chart light, safety glass, air purge.
Physical Characteristics	See Accessory Station [2] of Model No.
Mounting Style	Surface (Wall or Panel) = B 2" Pipe Mounting = E 2" Pipe Mounting with Floor Flange = F
Outline Dimensions	See Figure 5.
Weight	approximately 35 pounds (15.9 kg) with single TORQ-ER Receiver and no accessories. Add 5 pounds (2.27 kg) for each additional TORQ-ER Receiver.

Display	
Segmental Indicator	5-5/8" long scale, percentage or direct reading (two TORQ-ER Receivers maximum per instrument).
Concentric Dial Indicator	11-1/8" diameter scale, percentage or direct reading (one TORQ-ER Receiver maximum per instrument).
Circular Chart Recorder	
Scale	12" diameter, 4-5/8" calibrated scale, percentage or direct reading, 100 charts supplied (four TORQ-ER Receivers maximum per instrument).
Pens	#1-red, #2-blue, #3-green, #4-black (ink cartridges provide 4-6 months supply).
Chart Drive (Electrical)	Speed — See Accessory Station [4] of Model No. 8 hrs/rev = 1 24 hrs/rev = 2 7 days/rev = 3 8 days/rev = 4 Not Required = X* * Used with Series 1101 only.
Connections	
Pneumatic	1/2" NPTI w/filter screen.
Electrical	1/2" and 3/4" conduit knockouts (see Figure 5), signal and power cables terminated at barrier strips (see Figures 6-8).

IV. Functional Description

A. Composition

All instrumentation comprising the Series 51B1100DB (or DM) Indicator/Recorder is housed within a die-cast aluminum case which is accessible by means of a fully-gasketed door complete with display window.

A Recorder case may be fitted with one to four Series 50TQ1000 TORQ-ER Receivers, each operating an associated chart pen as typified in Figure 1. Segmental indicators are limited to two TORQ-ER Receivers with associated indicating pointers. A single Receiver operating a dial pointer is the maximum furnished in a Concentric Indicator. Compare the Receiver model number designations, "DB" & "DM", as given under "II-Model Numbering System" with the physical "in-case" locations, as typified in Figure 1.

The Series 50TQ1000 TORQ-ER Receiver consists of an electronic printed circuit board coupled to a TORQ-ER as shown in Figure 2. The printed circuit board utilizes the latest solid state and integrated circuit design techniques to provide a high level of performance and reliability. The TORQ-ER Receiver is modular in construction and may be readily withdrawn from the instrument case by decoupling the drive linkage and removing a few mounting screws and electrical connections. The printed circuit board then becomes accessible for inspection by removing four additional TORQ-ER housing mounting screws.

Several major accessory instruments are available with a Series 51B1100DB Indicator/Recorder; i.e., 1st TORQ-ER Receiver location (see Figure 1):

1) an electromechanical integrator equipped with an eight-digit counter and, if desired, output pulsing contacts to operate a remote electrical counter; thus providing cumulative totals of any rate function process variable under measurement.

2) a one-, two- or three-mode pneumatic controller to facilitate actuation of any valve-controlled process variable.

3) a pneumatic or vacuum transmitter to facilitate retransmission of the process variable to a remotely-located receiver.

4) time pulse or resistance retransmitters.

5) high and/or low limit contact actuators for purposes of alarm or control.

6) a 6- or 8-digit electromechanical counter for totalization of a pulse type signal from an auxiliary instrument.

A pneumatic receiver is included when pneumatic controllers are furnished with remote set point or ratioing features.

Electrical interconnections are accomplished thru a cable entry plate at the base of the instrument case to an interconnection block and power input bracket located in the lower central section of the case, as shown in Figure 1. An incandescent scale/chart light, door lock and safety glass display window may have been provided as an equipment option.

INTRODUCTION (Continued)

The Indicator/Recorder may be provided, at special option, to meet Class I, Division 2, Group D hazardous area requirements. Such instruments are manufactured in accordance with the specific code but are not submitted to Underwriters Laboratories for approval. The instrument enclosure meets requirements of NEMA 2/IEC 1P22.

B. Principles of Operation

The Series 50TQ1000 TORQ-ER Receiver is essentially an electronic converter-servo receiver, which produces an angular displacement of a torque motor output shaft that is proportional to the input signal. The position of the torque motor is established by simultaneous comparison of the magnitude of the input signal to the feedback voltage. The resulting signal controls the on-off duty cycle of the "up-down" output gates. Refer to the functional block diagram of Figure 3 to supplement this discussion.

The process variable signal is applied to a voltage divider and a passive damping network that provides adjustable servo-response. The damped input signal is then applied to one input of a temperature-stable differential amplifier. The differential amplifier controls the "up" or "down" channel of an output driver which, in turn, fixes the duty cycle of the signal applied to the respective upscale and downscale windings of a torque motor. The torque motor output shaft positions 1) an indicating pointer or recording pen, 2) input linkages of any accessory output instrumentation furnished, and 3) flux gates of a contactless "flux bridge" which serves as a signal feedback device for null-balancing of the servo-loop.

A 10 kHz, controlled-amplitude, symmetrical square-wave reference voltage is developed by an electronic switch that is triggered by a free running multivibrator. The multivibrator output is shaped and limited before application to the primary winding of the flux-bridge (shown in Figure 4). The phase and magnitude of voltage developed in the secondary winding is a function of the flux gate displacement from mid-position. Recall that the flux bridge gates are directly coupled to the torque motor shaft. Secondly, a permanent magnet in the flux bridge as rotated by the torque motor produces a motion developed voltage in a velocity winding to provide a degenerative rate feedback voltage. The resultant of position and velocity feedback voltages is demodulated and applied to the second or reference input (-) of the differential amplifier, U1.

The torque motor, functionally illustrated in Figure 4, consists of a permanent magnet armature that is actuated by application of a direct current thru an upscale or downscale field winding. At null balance

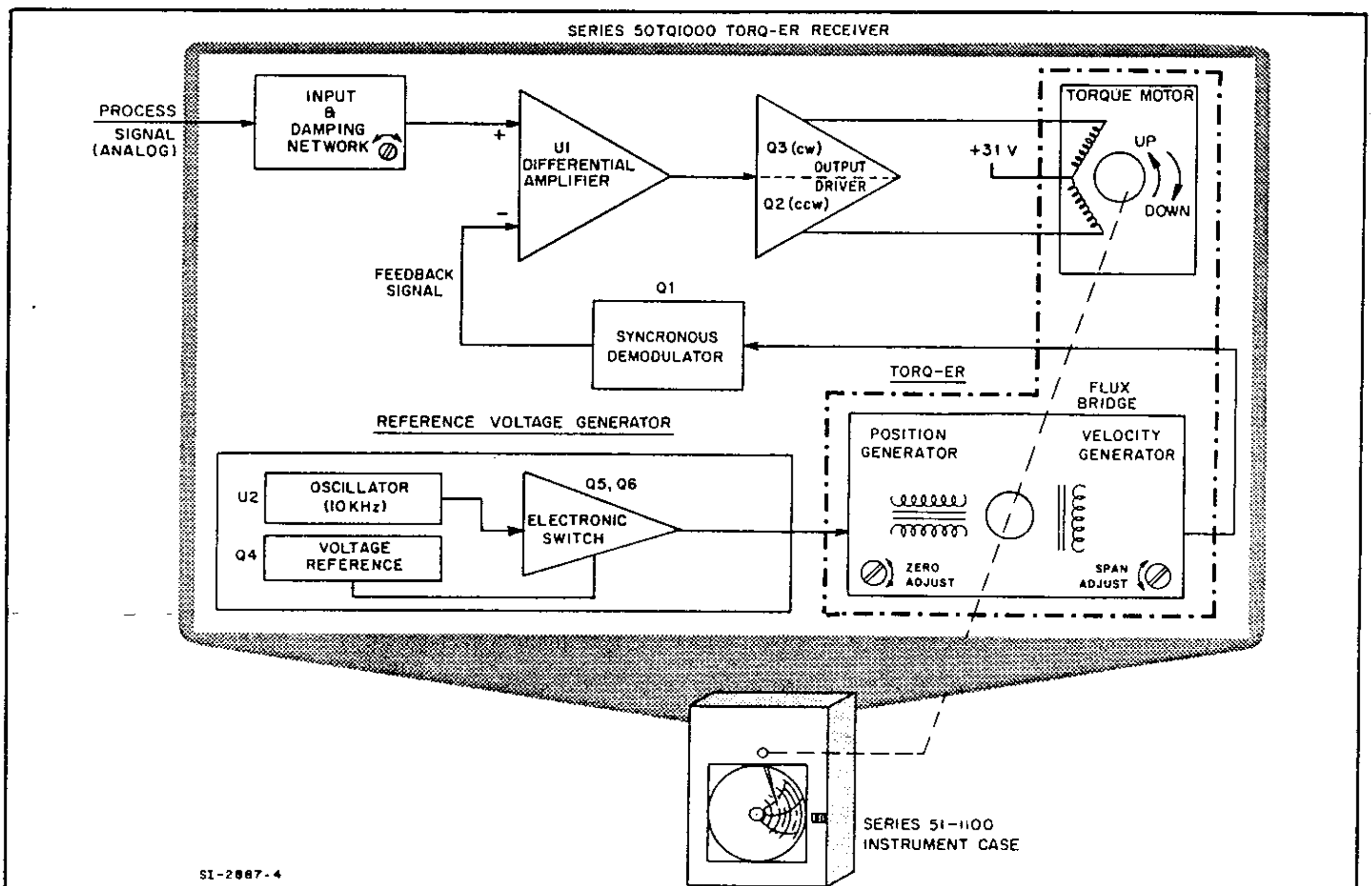


FIGURE 3. BLOCK DIAGRAM

the output stages (Q2 and Q3) will alternately switch on-off at the same duty cycle (nominally 1500 Hz); hence, the torque motor will hold that position. When the process variable input signal either increases or decreases, the unbalance between input and reference signal causes the differential amplifier-output driver to apply additional current in the upscale or downscale torque motor winding. The armature rotates the flux bridge to a new position level where the reference feedback equals the input signal and the servo-system comes to rest at a new pen or pointer balance position. Full scale rotation of the torque motor armature is accomplished within 34 degrees of arc.

INSTALLATION

I. Inspection

The Fischer & Porter Series 51B1100DB (DM) Indicator/Recorder should be inspected immediately upon arrival for indications of damage which may have occurred during shipment. Generally, a careful visual inspection is sufficient to determine whether damage has occurred. All reasonable packing precautions have been taken to prevent such damage. All damage claims should be reported to the shipping agent involved for instruments shipped F.O.B. Warminster or to Fischer & Porter Company for instruments shipped F.O.B. job site before installation is attempted. If damage is such that faulty operation is likely to result, it should be brought to the attention of the Fischer & Porter Company Service Department.

Normal care exercised in the handling and operation of this equipment will contribute substantially toward satisfactory performance. Carefully inspect the packing material before discarding it to prevent loss of mounting hardware, connectors, cables or instructions that may have been included with the shipment. Any instructions given on tags attached to the instrument should be followed carefully.

II. Location

The selected installation site should be well lighted and relatively vibration free. Ambient temperature limits should be maintained between 40° to 125°F (4° to 52°C). Unless furnished for Class I, Division 2, Group D, operation, the Indicator/Recorder should be operated in a non-hazardous atmosphere. The proper line service must be made available at the installation site.

III. Mounting

The outline and mounting dimensions of this instrument are given in Figure 5. Perform the applicable mounting procedure given below. Additional details for mounting accessories, changing the connection plate location, and air purging requirements are discussed in Instruction Bulletin 51-1100.

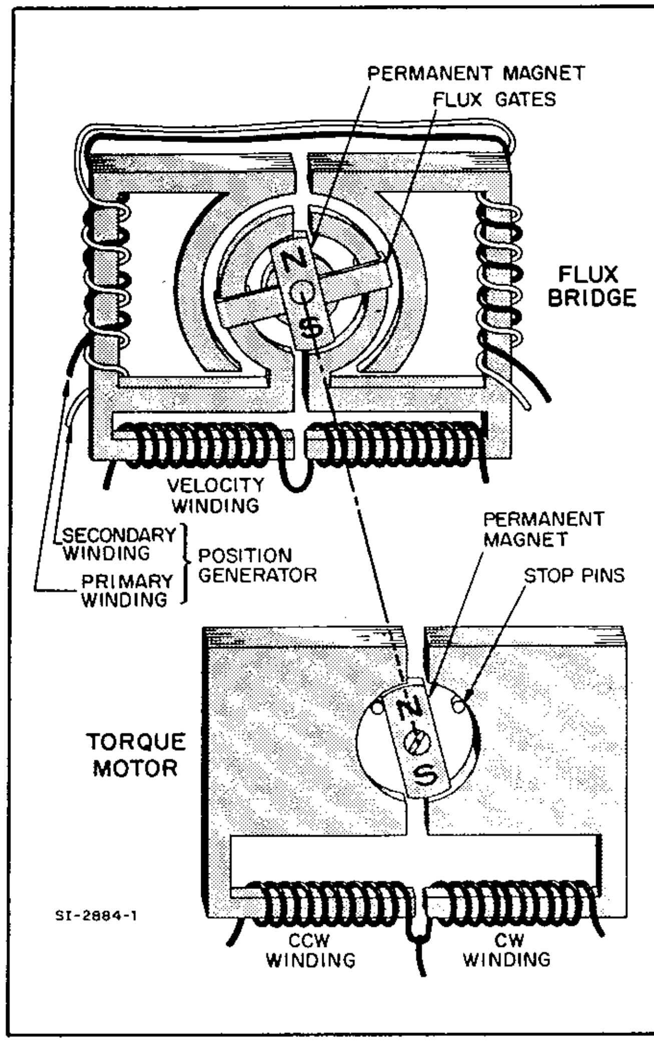


FIGURE 4. FUNCTIONAL DIAGRAM OF TORQ-ER

A. Surface Mounting

1. Flush Panel

If the Indicator/Recorder is to be flush panel mounted, prepare the panel cut-out in accordance with the dimensions specified. Have the instrument inserted thru the cut-out from the front of the panel and attach the three mounting brackets to the sides and top of the case using the 1/4-inch hex head bolts provided. Adjust each bracket on its slide mount until the bracket face bears firmly upon the panel; then tighten each bracket bolt.

2. Vertical Surface

Attach the three mounting brackets to the sides and top of the instrument case using the 1/4-inch hex bolts thru the hole, rather than the slide mount slot, on the bracket. Fix the instrument case to the wall or panel using the three 9/32-inch diameter clearance holes, the centers of which are defined in Figure 5.

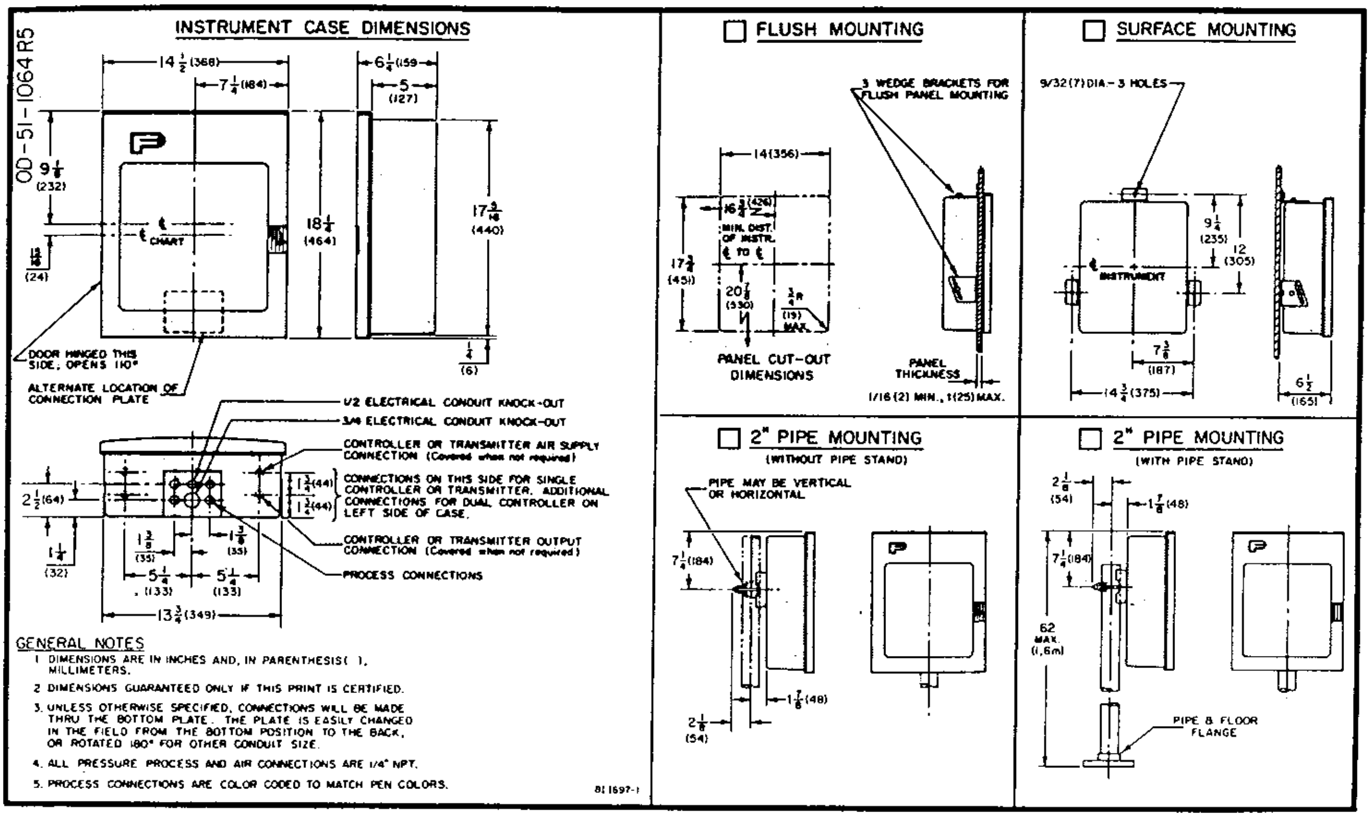


FIGURE 5. OUTLINE & MOUNTING DIMENSIONS

INSTALLATION (Continued)

B. 2" Pipe Mounting

1. Without Pipe Stand

The instrument case may be mounted to an existing 2-inch horizontal or vertical pipe by means of a yoke assembly that is attached to the rear of the case. First, remove the 5/16 diameter hex head nuts, washers and pipe clamping bracket from the yoke assembly. If the two 3-3/4-inch carriage bolts are in the wrong position for the particular installation, remove the four fillister head screws which fasten the yoke bracket to the rear of the case. The bracket can then be oriented for either vertical or horizontal pipe mounting, as required. Remount the yoke bracket to the case by replacing the four 1/4-inch fillister head screws and lockwashers.

While supporting the instrument case, place the yoke bracket against the 2" pipe, with the pipe between the two carriage bolts. Then, install the clamping bracket (opposite the yoke) and replace the two washers and nuts. Position the instrument case to obtain the desired height and orientation. Finally, tighten the hex head nuts alternately to maintain equal pressure on each side of the clamping bracket, until the applied pressure is sufficient to support the instrument case firmly.

TORQ-ER Power Req'd.		Chart Drive And/Or ac Accessory Power Req'd.				See Accessory Station 5 of Instrument Model Number	Inter-Connection Diagram See Fig.
120 V ac 50/60 Hz	24 V dc	120 V ac 60 Hz	120 V ac 50 Hz	24 V ac 60 Hz	24 V ac 50 Hz		
x		x				= B	6
x			x			= C	
	x			x		= F	7
	x				x	= G	
	x	x				= H	
	x		x			= J	
x		None				= M	6
	x	None				= P	7

TABLE E LINE VOLTAGE REQUIREMENTS

2. With Pipe Stand

The mounting procedure is identical to that discussed in 1.—Without Pipe Stand, preceding, except that the 2" pipe section with attached 2" standard pipe flange provided with the instrument must first be secured to the floor (or foundation) before the instrument case is mounted. Mounting the pipe stand consists of inserting four 1/4 diameter bolts (not supplied by F&P) through the 5/16 diameter clearance holes provided in the pipe flange. These mounting bolts must be selected to suit the particular installation. The pipe flange can be used as a template for pilot hole location.

IV. Electrical Connections

A. General

Electrical entrance facilities are provided at the base of the instrument case as convenience knockouts for 1/2-inch and 3/4-inch conduit. See Figure 1. Open the instrument case door, remove the circular chart (if applicable), raise the pen or pointer by means of the pen lifter and remove the scale/chart plate for access to the interconnection barrier strip located in the lower central section of the case.

To determine the power requirements of the particular Indicator/Recorder at hand, refer to the model number given on the instrument nameplate or manufacturing specification sheet. The letter given in the "station 5" location of the model number, as specified under "II-Model Numbering System" of the INTRODUCTION, should be compared to Table E to define the line service needed to place your instrument in operation.

Refer to the appropriate interconnection diagram, Figures 6 or 7, for terminal identification. Note that the instrument is protected by an internal one ampere fuse connected in series with the respective power switch(es).

B. Input Power

1. AC Service

Connect a source of 120 volts, 50-60 Hz, to terminals #4 (phase) and #5 (neutral) on the interconnection barrier strip as shown in Figure 6. When the recording chart drive motor is specified, or if Indicator/Recorder ac accessory instruments are furnished, the applicable line voltage must be either 50 or 60 Hz as indicated by the model number.

2. DC Service

Connect a source of 24 to 26 volts dc to terminals #6 (—) and #7 (+) as shown in Figure 7. An external supply ground is recommended; however, it is not necessary for the operation of the instrument. If the instrument is a Recorder or if ac accessory instrumentation is furnished, a supplementary ac line source of 24 volt or 120 volt at 50 or 60 Hz (See Table 2) must be connected to terminal #4 (phase) and #5 (neutral).

Connect a good external ground to terminal "G" of the interconnection barrier strip to ground the instrument case.

C. Input Signals

1. Voltage Inputs

If the process variable input signal is generated by a voltage transmission device, direct connections to the following input terminal pairs are required, as furnished: terminals #10 (+) and #11 (—) for 1st TORQ-ER (red pen or pointer); terminals #12 (+) and #13 (—) for 2nd TORQ-ER (blue pen or pointer); terminals #14 (+) and #15 (—) for 3rd TORQ-ER (green pen); and terminals #8 (+) and #9 (—) for 4th TORQ-ER (black pen). The signal voltage input range will be specified on the instrument nameplate or manufacturing specification sheet.

2. Current Inputs

If the process variable input signal is generated by a current transmission device, such as an F&P Two-Wire Electronic Transmitter, a precision resistor, Rx, must be connected across the same voltage signal input terminals given above to convert this current to a voltage. See Figures 6 and 7. Note that a TORQ-ER Receiver with a 1-5 (or 0-4) volt dc input range is used when standard current transmission devices are to be monitored. Thus, a ± 0.1%, 3 watt, wirewound resistor is recommended with resistance value as follows: 1000 Ω for input signals of 1-5 or 0-4 mA; 250 Ω for input signals of 4-20 or 0-16 mA; or 100 Ω for input signals of 10-50 or 0-40 mA. For non-standard current transmission ranges the shunt input resistance in ohms is obtained by:

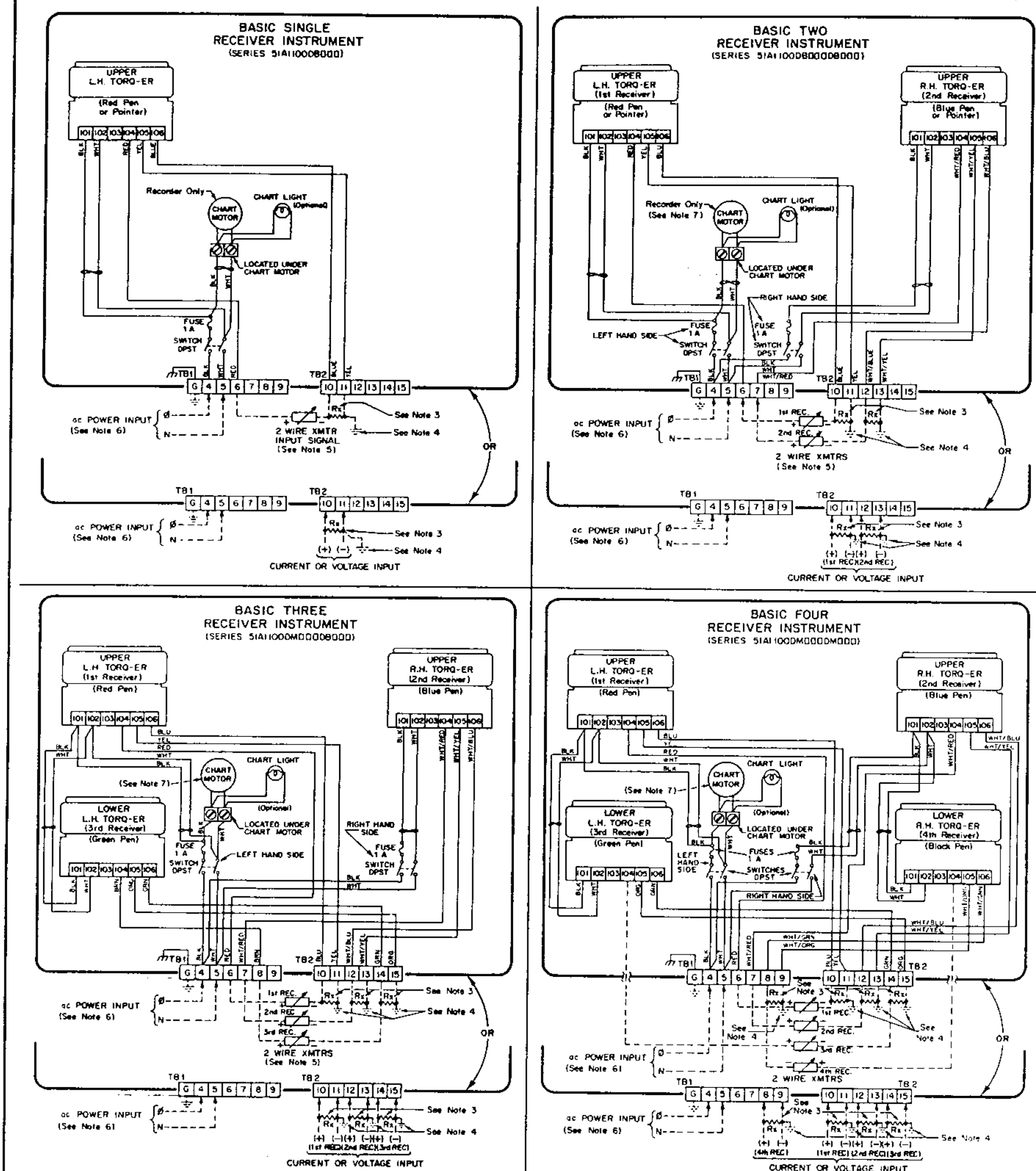
$$Rx = \frac{Es}{Is}$$

Where,

Es = Standard voltage input span in dc volts = 1 to 5 V = 4 V

Is = Current input span in dc amperes

If the Indicator/Recorder TORQ-ER(s) operate from the 120 volt ac service, an isolated 24 volt dc power supply can be furnished within each TORQ-ER Receiver. This option must be specified at time-of-purchase. The positive leg of each internal supply may be used to energize the associated "two-wire" current transmitter. The positive leg of these sources are either wired to Indicator/Recorder interconnection barrier strip, TB 1, or require connection directly to terminal #104 of the individual TORQ-ER barrier strip as shown in Figure 6.



NOTES

1. (————) INDICATES INTERNAL WIRING.
2. (– – – – – –) INDICATES CUSTOMER WIRING.
3. Rx IS USED TO CONVERT A CURRENT SIGNAL TO VOLTAGE. RESISTOR IS ±0.1% WIREWOUND (SUPPLIED BY F&P).
   Example:
   1-5 mA dc —— 1000 OHM (1-5 V dc)
   4-20 mA dc —— 250 OHM (1-5 V dc)
   10-50 mA dc —— 100 OHM (1-5 V dc)
4. RECOMMENDED GROUND - THERE SHOULD BE ONLY ONE GROUND PER CONTROL LOOP OR POWER SUPPLY. GROUND IS NOT NECESSARY FOR THE OPERATION OF THE TORQ-ER
5. A SEPARATE 24 VOLT TRANSMITTER POWER SUPPLY CAN BE PROVIDED AS AN OPTION IN EACH AC POWERED TORQ-ER. THE 1st RECEIVER SUPPLY IS LOCATED BETWEEN TERMINALS #10(-) & #6(+). THE 2nd RECEIVER SUPPLY IS LOCATED BETWEEN TERMINALS #12(-) & #7(+). ON THREE RECEIVER INSTRUMENTS, THE 3rd RECEIVER SUPPLY IS LOCATED BETWEEN TERMINALS #14(-) & #8(+). ON FOUR RECEIVER INSTRUMENTS, THE 3rd RECEIVER SUPPLY IS LOCATED BETWEEN TERMINALS #14(-) & #104(+), OF THE 3rd RECEIVER, & THE 4th RECEIVER SUPPLY IS LOCATED BETWEEN TERMINALS #8(-) & #104(+), OF THE 4th RECEIVER
6. ac POWER INPUT 120 V ac, 50-60 Hz PER CUSTOMER ORDER
7. IT SHOULD BE NOTED THAT ON DUAL RECEIVER INSTRUMENTS, THE CHART DRIVE POWER IS SWITCHED AND FUSED WITH THE 1ST RECEIVER (LEFT HAND SWITCH AND FUSE).

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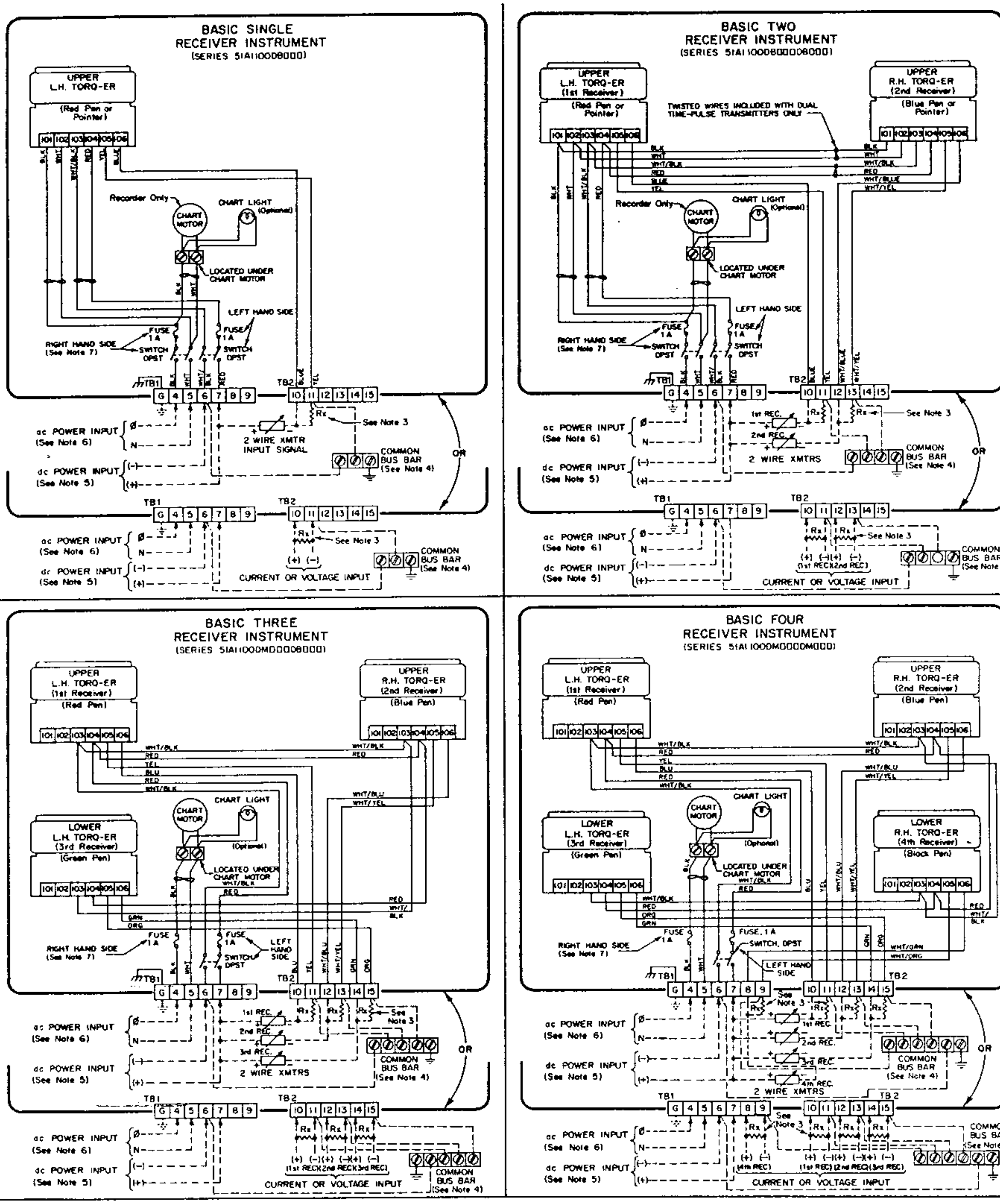
FIGURE 6. INTERCONNECTION DIAGRAM: AC SERVICE



NOTES

1. (———) INDICATES INTERNAL WIRING.
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3. Rx IS USED TO CONVERT A CURRENT SIGNAL TO VOLTAGE. RESISTOR IS ±0.1% WIREWOUND (SUPPLIED BY F & P).
   Example:
   1-5 mA dc —— 1000 OHM (1-5 V dc)
   4-20 mA dc —— 250 OHM (1-5 V dc)
   10-50 mA dc —— 100 OHM (1-5 V dc)
4. RECOMMENDED GROUND-THERE SHOULD BE ONLY ONE GROUND PER CONTROL LOOP OR POWER SUPPLY.
5. THE dc POWER INPUT MUST BE 24 TO 26 V dc AT 80 mA FOR A SINGLE RECEIVER, 160 mA FOR TWO RECEIVERS, 240 mA FOR THREE RECEIVERS, AND 320 mA FOR FOUR RECEIVERS.
6. AC POWER INPUT 120 Vac OR 24 Vac PER CUSTOMER ORDER
   THE ac IS USED TO POWER THE CHART MOTOR AND OR ACCESSORY INSTRUMENTS IF INCLUDED
   THE CHART MOTOR & ACCESSORY INSTRUMENTS SPECIFIED MUST HAVE THE SAME VOLTAGE AND FREQUENCY REQUIREMENTS.
7. THE RIGHT HAND SWITCH AND FUSE CONNECTED TO TERMINALS 4 & 5 ARE NOT ALWAYS INCLUDED. SEE TABLE BELOW FOR COMBINATION USED:

INSTRUMENT TYPE	COMBINATION IN SERIES WITH TERMINALS 4 & 5
RECORDER W/o ACCESSORIES	FUSE ONLY
RECORDER W/ ACCESSORIES	SWITCH & FUSE
INDICATOR W/o ACCESSORIES	NONE (No ac Wiring)
INDICATOR W/ ACCESSORIES	SWITCH & FUSE

FIGURE 7. INTERCONNECTION DIAGRAM: DC SERVICE

If the Indicator/Recorder TORQ-ER Receivers require a 24-26 volt dc power input service, the positive leg of this external source may be used as a common supply source for all "two-wire" current transmitters as shown in Figure 7.

D. Optional Electrical Accessories

Whenever a Series 51B1100DB Indicator/Recorder is equipped with a single TORQ-ER (1st receiver), the case can accommodate additional accessory instrumentation; both pneumatic and electrical. Further, a Series 51B1100DB Indicator/Recorder may be furnished with a pair of Mechanical Alarms or Time Pulse Transmitters, each operated from the associated TORQ-ER (1st & 2nd receivers). Most details covering accessory instruments will be found within applicable Instruction Bulletins, appended. Wiring and interconnection details for electrical accessories within the Indicator/Recorder case are given in Figure 8 and the following discussion.

1. Series 52T-4000 Electromechanical Integrator

Single receiver models of Series 51B1100DB Indicator/Recorders may be equipped with a quantity totalizing Series 52T-4000 Electromechanical Integrator. If this Integrator is not equipped with motion-actuated electrical contacts, no further electrical connections are required. However, if Integrator pulsing contacts have been provided, a remote electrical counter rated at the same line voltage as the service to the Indicator/Recorder may be interconnected to terminals #12 and #13 of barrier strip TB2. Run 2-conductor, #14 AWG cable thru 1/2-inch conduit via the knockout provided in the instrument connection plate and connect cable to electric counter terminals as shown in Figure 8.

Note that if Integrator pulsing contacts are required, the accessory combination of Integrator and Inductalarm is limited by terminal availability such that only a single, not a dual, Inductalarm may be used.

2. Series 50MF2000 Time Pulse Transmitter

Certain models of Series 51B1100DB Indicator/Recorders may be equipped with the Series 50MF2000 Time Pulse Transmitter (see "II-Model Numbering System" of the INTRODUCTION). This device provides remote digital transmission of the metered process variable values. The pulsing contacts of Time Pulse Transmitter in a single TORQ-ER receiver instrument are available on 1) terminals #8 and #9 of TB2 when no Series 55AC1000 Mechanical Alarms are also provided—or 2) terminals #12 and #13 of TB2 when alarms are provided as shown in Figure 8.

It is also possible to have one Time Pulse Transmitter for each of two TORQ-ER Receiver; pulsing contacts for the 1st Receiver available on terminals #8 and #9 and for the 2nd Receiver available on terminals #14 and #15 of barrier terminal strip, TB2.

Route external wiring thru 1/2-inch conduit. Wiring access is provided via a knockout in the Indicator/Recorder connection plate. Complete specifications concerning wire size, interconnection distances, etc., are given within the applicable Instruction Bulletin which is appended when this accessory instrument is supplied.

3. Resistance Transmission

The single TORQ-ER Receiver (Indicator/Recorder) may be equipped with a servo-driven slide-wire potentiometer to facilitate analog electrical transmission of the measured process variable to a remote station.

Standard potentiometer resistance values are 100, 500 or 1000 ohms. Note that when the process display indicates either 0% or 100% of scale or chart, the slider will be positioned at 7.5% from alternate resistance element extremes. The slider arm of the resistance potentiometer is available for direct connection, the resistance extremes are connected at terminals #12 and #13 of barrier strip, TB1. Using a 3-conductor, #14 AWG cable, interconnect as shown on Figure 8 and run the cable thru 1/2-inch conduit to the user-furnished reference supply and receiving instrument.

4. Series 55AC1000 Mechanical Alarm

Single or dual Mechanical Alarms may be furnished with Indicator/Recorders equipped with 1st and/or 2nd TORQ-ER Receivers. Note that a "high" alarm is defined as one producing a switch closure on increasing process; a "low" alarm produces a switch closure on decreasing process. Load interconnection is as shown in Figure 8. Use #14 AWG leads routed thru 1/2-inch conduit to the load(s) whenever practical. Refer to Instruction Bulletin 55AC1000, appended, when this alarm is furnished.

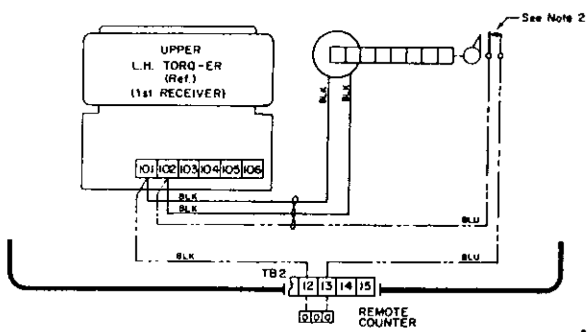
5. Series 55AD2000 Inductalarm

Interconnections for the single and dual Inductalarm are also given in Figure 8. Contact states for various operational modes are also given. Reference to Instruction Bulletin 55AD2000 will provide installation and operating procedures for the Inductalarm, when this option is included.

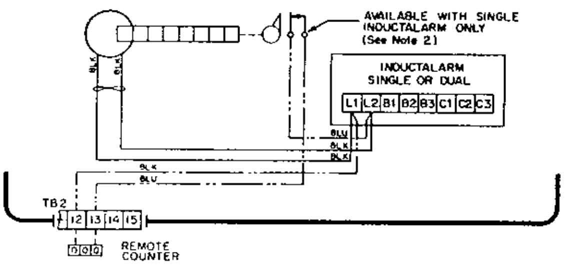
6. Electromechanical Counter

A 6- or 8-digit electromechanical counter can be supplied for integration of some process variable function; such as delivered volume. The counter requires a 24 V dc pulse input signal with a minimum pulse duration of 20 ms. Maximum count rate is 25 Hz with a minimum of 20 ms between pulses. When supplied, the counter is located on the right-hand side of the chart plate. Applicable interconnection wiring is shown in Figure 8.

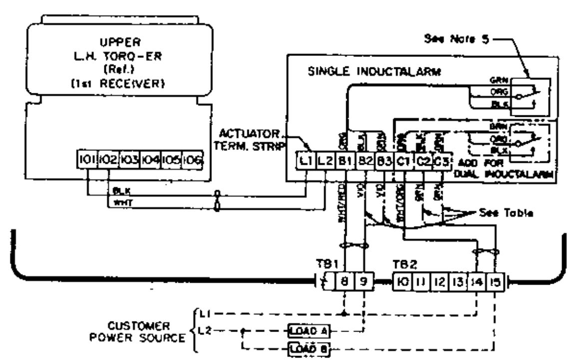
SERIES 52TR4000 INTEGRATOR



SERIES 52TR4000 INTEGRATOR WITH SERIES 55AD2000 INDUCTALARMS



SERIES 55AD2000 INDUCTALARMS



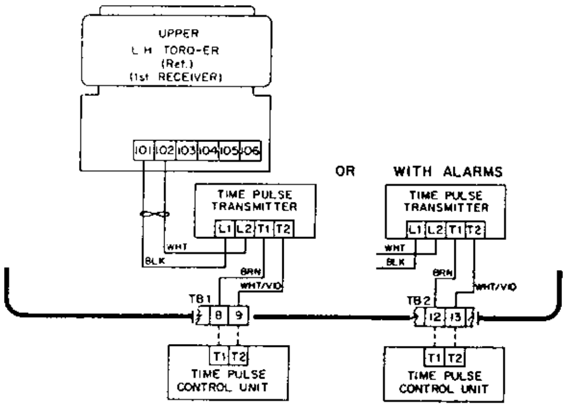
FOR ACCEPTABLE ZONE TYPE INDUCTALARM

LOAD A & B	BELOW ZONE	WITHIN ZONE	ABOVE ZONE
CONNECT VIO & GRN WIRES TO TERM. B2 & C2	LOAD ENERGIZED	LOAD DE-ENERGIZED	LOAD ENERGIZED
CONNECT VIO & GRN WIRES TO TERM. B3 & C3	LOAD DE-ENERGIZED	LOAD ENERGIZED	LOAD DE-ENERGIZED

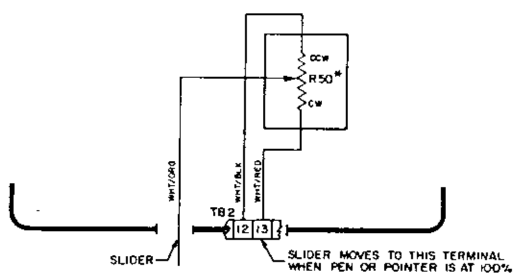
FOR DIFFERENTIAL TYPE INDUCTALARMS

LOAD A & B	BELOW SET POINT	ABOVE SET POINT
CONNECT VIO & GRN WIRES TO TERM. B3 & C3	LOAD ENERGIZED	LOAD DE-ENERGIZED
CONNECT VIO & GRN WIRES TO TERM. B2 & C2	LOAD DE-ENERGIZED	LOAD ENERGIZED

SERIES 50MF2000 SINGLE TIME PULSE TRANSMITTER



RESISTANCE RE-TRANSMISSION

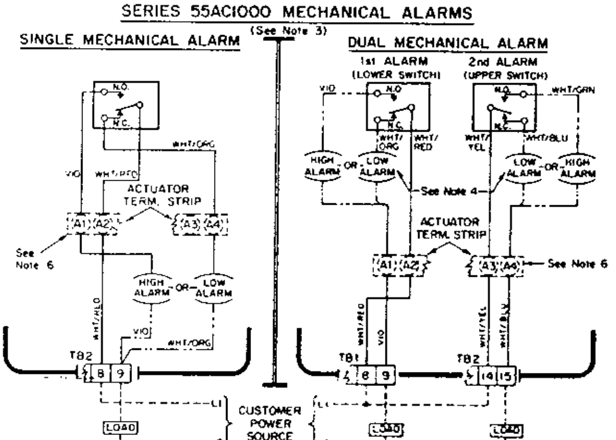


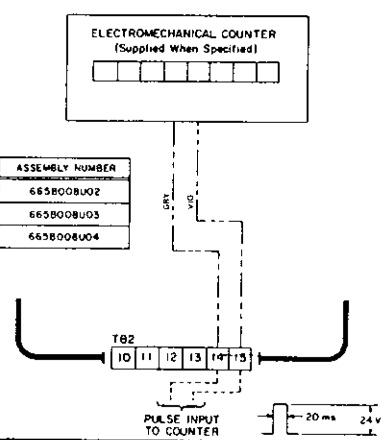
* THE VALUE OF THE POTENTIOMETER IS PER CUSTOMER ORDER (100, 500, & 1000 OHMS ARE STANDARD VALUES). THE TEMPERATURE COEFFICIENT OF THE POTENTIOMETER IS ±200 PPM/°C MAX.

WHEN THE RECORDING PEN OR POINTER IS AT 0%, THE OUTPUT BETWEEN SLIDER AND TERMINAL 12 WILL BE 7.5% OF THE TOTAL RESISTANCE, AND WITH PEN OR POINTER AT 100%, THE OUTPUT WILL BE 92.5% OF THE TOTAL RESISTANCE.

SERIES 55AC1000 MECHANICAL ALARMS

(See Note 3)





COUNTER TYPE	ASSEMBLY NUMBER
6-DIGIT W/O RESET	665B008U02
6-DIGIT W/MAN. RESET	665B008U03
8-DIGIT W/O RESET	665B008U04

1. (———) INDICATES INTERNAL WIRING.
   (- - - - -) INDICATES CUSTOMER WIRING.
   (— - - —) INDICATES OPTIONAL WIRING.
2. FURNISHED WHEN REMOTE COUNTER IS SPECIFIED.
3. SWITCHES SHOWN IN ZERO PROCESS POSITION. CONTACT RATING, 2 AMPS MAX. AT 120 Vac NON-INDUCTIVE. "HIGH" ALARM SWITCH CLOSES ON RISING PROCESS. "LOW" ALARM SWITCH CLOSES ON FALLING PROCESS. THE 1st ALARM IS CONNECTED TO THE 1st RECEIVER ON DUAL RECEIVER INSTRUMENTS, ONE ALARM PER RECEIVER.
4. WHEN ONE HIGH AND ONE LOW DUAL MICRO-SWITCH ALARM IS FURNISHED, THE 1st ALARM IS ALWAYS "HIGH".
5. RELAY CONTACTS SHOWN IN DE-ENERGIZED POSITION. CONTACT RATING, 5A AT 120 Vac OR 24 Vdc NON-INDUCTIVE.
6. ACTUATOR TERMINAL STRIP MAY NOT ALWAYS BE USED MICRO-SWITCH WIRING WILL THEN GO DIRECTLY TO MAIN TERMINAL STRIP. UNUSED WIRE(S) WILL BE INSULATED AND NOT CONNECTED.

FIGURE 8. WIRING DIAGRAM: OPTIONAL ACCESSORIES

OPERATION

I. Pre-Operative Procedures

1) Ascertain that all electrical connections have been completed as given under INSTALLATION, preceding. Any pneumatic interconnections should have been made in accordance with the instructions covering applicable pneumatic accessory instrumentation.

2) If a Recorder was supplied, raise the recording pen(s) by means of the pen lifter, mount a circular chart on the chart drive spindle and orient the chart in the correct time position relative to the lowered pen. Insert the ink cartridge(s) into the hypodermic holder(s) and prime the ink into the pen as given in the instrument case Instruction Bulletin, appended.

3) Inasmuch as the Indicator/Recorder is normally factory-calibrated to the user's pre-specified measurement range, no further zero or span adjustment should be required. However, if verification of range alignment is desired, refer to ALIGNMENT, following.

4) Place the Indicator/Recorder line voltage toggle switch(es) located within the cut-out in the lower central section of the chart plate, in the ON position.

NOTE

For instruments equipped with ac line-powered TORQ-ER Receivers, the left-hand switch and fuse energize the 1st and 3rd Receivers. The right hand switch and fuse control the 2nd and 4th TORQ-ER Receivers. For instruments equipped with dc line-powered TORQ-ER Receivers, the left-hand switch and fuse control all Receivers. The right-hand switch and fuse energize the ac line-powered chart drive motor and/or accessory instrumentation, if furnished.

Energize other metering instrumentation associated with the Indicator/Recorder. Start-up each process being displayed and note upscale deflection of associated pen or pointer. If a pinned downscale display is observed on any process, reverse the signal input leads to the associated TORQ-ER Receiver.

II. Operation

With all elements of the metering system(s) energized and process(es) activated, the Indicator/Recorder is operational. In normal operation the DAMPING (screwdriver) control should be adjusted completely counterclockwise. However, if the pen or pointer should produce an undesired "paint brush" effect due to a fluctuating process, rotate the DAMPING control sufficiently clockwise to smooth the display response. The pen or pointer will drive momentarily to zero and then return to its metering position at the response speed newly set. An increase of 0.1% metering error will be introduced at the maximum damping adjustment.

ALIGNMENT

I. General

The Series 51B1100DB(DM) Indicator/Recorder is aligned at the factory to the user's pre-specified input signal limits. Therefore, this instrument should be in proper operating alignment for utilization with the transducer or signal converter originally specified. These operating limits are given on the manufacturing specification sheet that normally accompanies this Instruction Bulletin — and/or — are engraved on a metal tag that is mounted on the upper inner surface of the instrument case door.

Inasmuch as ranging components used within each Series 50TQ1000 TORQ-ER Receiver as provided within the Indicator/Recorder, were selected for specific measurement limits, the latitude of span and zero adjustment is moderate. In the event that the signal input requirements change significantly, a new TORQ-ER Receiver printed circuit board or modification of the input divider and damping circuit will be required. See "III Changing the Range," following, for range conversion procedures. It should be noted that a precision voltage source and/or digital voltmeter is required for calibration.

To verify range alignment, calibrate, or demonstrate proper performance of the TORQ-ER Receiver, perform the applicable procedure as outlined below.

II. Calibration

This alignment procedure assures that the process transducer or transducer-amplifier being used has a predictable calibrated signal output versus process measurement characteristic that may be simulated accurately by means of a calibrated adjustable dc voltage reference source.

Perform the following procedure:

1) Ascertain that all electrical interconnections have been completed as given under INSTALLATION, preceding.

2) Open the instrument case door —

a) lift the circular chart pen or segmental scale pointer by means of the lifter arm — or — withdraw and remove the concentric dial pointer from its shaft, —

b) remove the circular chart from the chart motor spindle if the instrument is a Recorder and —

c) remove the chart or scale plate.

ALIGNMENT (CONTINUED)

3) Remove the interconnecting process transducer signal input lead(s) from those terminals of Indicator/Recorder barrier strip, TB2 or TB1, associated with the TORQ-ER Receiver to be calibrated. See Figures 6 & 7. Also remove the precision shunt input resistor from these same terminals if the TORQ-ER Receiver accepts a current input signal. Make certain that terminal "G" of barrier strip, TB1, — or — that the instrument case, is connected to a good ground.

4) Determine the signal input voltage limits to which your instrument has been factory aligned as specified on the metal tag mounted on the upper, inner surface of the instrument case door. If more than one TORQ-ER Receiver is furnished, each range specification is identified by pen or pointer color that represents the Receiver mounting location as identified in Figure 6 or 7. Note that if an input signal is specified in dc milliamperes, the TORQ-ER Receiver input range should first be converted to dc volts, as follows:

$$E_{limit} = (I_{limit})(Rx) \times 10^{-3}$$

where,

E_{limit} = input signal at 0% or 100% in volts dc
I_{limit} = input signal at 0% or 100% in milliamperes dc
Rx = resistance of precision input shunt in ohms

5) Obtain a precision voltage source that is capable of producing a calibrated voltage output which is at least equal to the greatest absolute range limit for the TORQ-ER Receiver under alignment (see Figure 9).

6) Interconnect the voltage source e.m.f. output terminals to the appropriate terminal pair (see Figure 6 and 7) of barrier strip, TB1 or TB2.

7) Remount the Indicator/Recorder scale plate — or — chart plate and circular chart. Lower the pen or segmental scale pointer to operating position — or — remount the concentric scale pointer. Place the Indicator/Recorder power switch(es) in the ON position.

8) Adjust the precision voltage source to produce that dc voltage level at its output terminals equal to the mid-value of the signal input range.

9) The pen/pointer should indicate 50% of full scale. If necessary, adjust the TORQ-ER Receiver screwdriver ZERO control such that the pen or pointer aligns with 50% of chart or scale. Note that alignment access slots have been provided in the scale/chart plate for the 3rd and 4th TORQ-ER Receivers, when furnished. For recorders, the chart may be lifted or a portion torn away to uncover these slots.

10) Adjust the precision voltage source to produce

a) a dc voltage equal to the maximum value of the input signal range —or—

b) a dc voltage equal to the minimum value of the input signal range.

11) The pen/pointer should indicate the selected value. If required, adjust the TORQ-ER Receiver screwdriver SPAN control to produce pen or pointer alignment with —

a) 100% of chart or scale if step #10) -a) applies.

b) 0% of chart or scale if step #10) -b) applies.

12) Repeat step #8 thru 11) until the pen or pointer remains exactly on the two calibration points.

13) Adjust the precision voltage source to check alignment accuracy at additional points, such as 25%, 50%, 75% of scale, to verify that the receiver is accurately calibrated and tracking properly.

14) If an input shunt resistor was utilized to convert a dc current input signal to a voltage input, check the resistance of the shunt by means of a laboratory standard bridge. The tolerance of this resistor should not exceed ±0.1% from the value specified on the manufacturing specification sheet. If tolerances are greater than ±0.1%, contact your local Fischer & Porter office, referencing the F&P serial number that appears on the metal plate mounted inside your instrument case door. When the resistance is satisfactory, reconnect it across the proper signal input terminals.

15) Repeat the alignment verification procedures for each of the TORQ-ER Receivers furnished in your Indicator/Recorder.

NOTE

In the event alignment procedures do not produce proper results, refer to the MAINTENANCE section.

16) When proper calibration has been demonstrated satisfactorily, disconnect test equipment and restore interconnection wiring as given in the INSTALLATION section.

III. Changing the Range

A TORQ-ER Receiver input range may be changed by ordering a replacement printed circuit board to new range specifications, by ordering a range conversion to a factory-returned printed circuit board, or may be done at the user's facility by performing the following conversion procedure. As previously discussed, precision test equipment is required for accurate calibration. Further, only skilled maintenance technicians familiar with solid state service technique should be permitted to make circuit modifications.

ALIGNMENT (Continued)

Note that input spans down to 200 millivolts dc may be specified since the TORQ-ER receiver is basically a 200 millivolt measurement device with a resistive voltage divider at its input. Note that the input zero may fall anywhere within +1 to -2 times span. Further, the input impedance of the TORQ-ER Receiver diminishes as the span is reduced; i.e., 250 kilohms per volt of span. However, for the singular case of a 200 millivolt dc span, the input impedance is greater than 300 kilohms. To supplement this discussion refer to Figure 11.

A. Range Modification

To change the range of the TORQ-ER receiver proceed as outlined below.

1) Determine the input span voltage by use of the following equation.

$$V_{span} = V_{100\%} - V_{0\%}$$

For example:

$$V_{100\%} = +2\ V$$
$$V_{0\%} = -1\ V$$

then,

$$V_{span} = +2\ V - (-1\ V) = 3\ V$$

NOTE

The input span must be between + 4.0 and + 0.20 volts. If V_{span} is less than 200 millivolts, full scale deflection cannot be obtained.

2) When V_{span} has been determined, select the appropriate resistance values for use in the input divider and damping circuit.

a) V_{span} is between +0.4 and +4.0 volts; use R3 = 953 kΩ, omit R4, R5 = 49.9 kΩ.

b) V_{span} is between +0.26 and +0.40 volts; change R5 to 100 kΩ, omit R4 and replace R3 with a jumper.

c) V_{span} is between +0.2 volts and +0.26 volts; omit R4 and R5 and replace R3 with a jumper.

d) If V_{span} is more than 4 volts, the user must employ an external resistor divider to effect a 4 volt span at the input to the TORQ-ER.

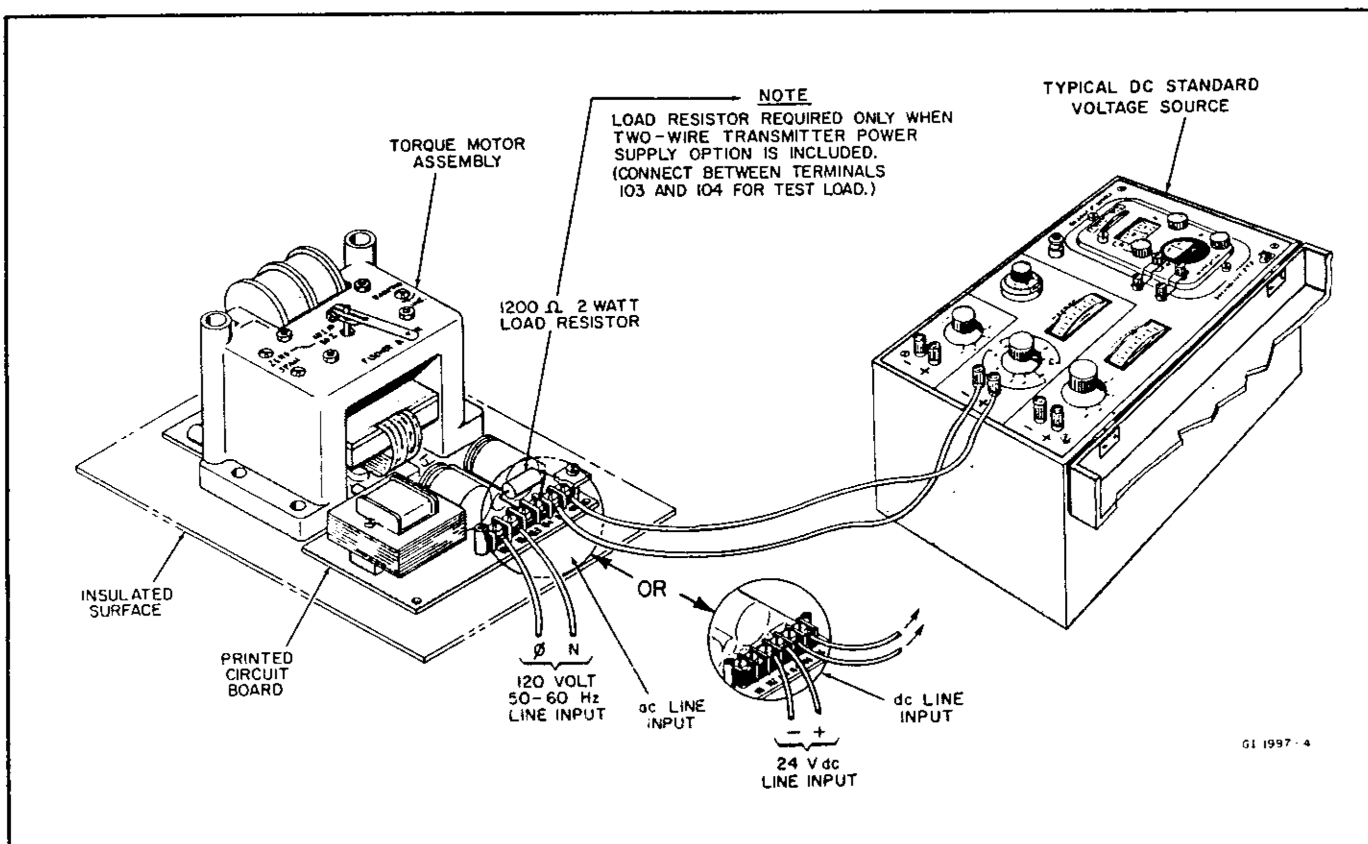


FIGURE 9. INTERCONNECTION FOR DYNAMIC TEST

B. Zero Correction

1) Calculate the ratio of input zero over input span. V_{span} must be between -3.0 and +4.0 volts. For example:

$$\text{Ratio} = \frac{V_{0\%}}{V_{span}}$$

Assuming, $V_{0\%}$ = -1 volt and V_{span} = +3.0 volts, then

$$\text{Ratio} = \frac{-1\ V}{+3\ V} = -.33$$

NOTE

This ratio must be between − 2.0 and + 1.0, otherwise readings will be off scale.

2) Using the value calculated in step 1., preceding, proceed as follows:

a) If ratio is between +0.30 and +1.0, replace R9 with a jumper.

b) If ratio is between −0.40 and +0.35 no change is required.

c) If ratio is between −2.0 and −0.40 replace R11 with a jumper.

When modifications have been completed, reassemble TORQ-ER Receiver and replace it in the instrument case. Align TORQ-ER Receiver using the procedure outlined under "II-Calibration" in this section.

CIRCUIT DESCRIPTION

I. Input & Damping Network

The dc input signal is applied to TORQ-ER Receiver terminals #106 (+) and #105 (-) by way of Indicator/Recorder interconnection barrier strip, TB1 or TB2, as shown in Figure 6 or Figure 7, as applicable. If the process variable information is transmitted as a current signal, either by a two-wire transmitter or the conventional method, a precision wirewound shunt resistor is connected across those input terminals to convert the current to a properly ranged voltage input signal as given in Table I—Standard Signal Ranges under "III-Specifications" of the INTRODUCTION.

The input signal (voltage) is then coupled thru an adjustable damping network to a high impedance voltage divider consisting of resistors R3 (or R4) and R5, as shown on the schematic diagram, Figure 11. Basically the damping network is utilized to filter noisy or erratic signals in order to obtain a clear chart record. The ratio of the output voltage developed across R5 to the input voltage is approximately 20:1; e.g., a 200 mV output for a 4 volt input span. This attenuated signal is in turn introduced to the non-inverting (+) input of an integrated circuit operational amplifier, U1, employed in a differential amplifier configuration.

Zener diode CR1 maintains a fixed negative bias across damping capacitor C1, to assure that the voltage polarity remains in the proper direction even if a negative input signal is required. However, the absolute low limit for input voltage is −3 volts. (Damage to capacitor C1 will occur if this limit is exceeded.) Adjustment of the DAMPING potentiometer, R1, permits varying the overall circuit time constant to obtain the desired degree of damping; i.e., pen or pointer traverse time can be varied between the nominal limits of 0.36 seconds minimum to 25 seconds maximum (for 63% of scale deflection following a 100% step change). Rotation of the DAMPING control in a clockwise direction will increase the RC time constant, thereby increasing the amount of damping.

II. Reference Voltage Generator

The reference voltage generator circuit consists of an oscillator, electronic switch and a temperature stable voltage source. The oscillator stage, U2, is an integrated circuit operational amplifier utilized as a free-running multivibrator. The multivibrator operates at a frequency of 10 kHz and provides a symmetrical square wave output signal with a stability of ± 1% per 25°C ambient temperature change. (Refer to test point "F".)

The output of the oscillator is used to drive an electronic solid state switch, Q5 and Q6. The electronic switch alternately shorts or opens a circuit in parallel with Zener diode CR8. Functionally, when the 10 kHz signal voltage applied to the base of Q6 swings in the positive direction, Q6 and Q5 will conduct. As a result, Q5 now grounds CR8 while Q6 simultaneously cuts off the voltage source, Q4. Alternately, when the oscillator signal switches to ground on the 2nd half of each cycle, Q5 and Q6 will now be cut off. Concurrently, Q4 will switch "on," thereby charging capacitor C9 until Zener CR8 limits the voltage (+9 V).

Thus, a square wave of constant frequency, symmetry and amplitude is developed at the junction of CR8 and C9. This signal is ac coupled to the primary winding of transformer T2 (refer to test point "E"). In addition, this signal is also rectified and filtered by CR7 and C3, respectively, to provide a stable −4 volt dc reference supply.

III. Flux Bridge & Feedback System

Transformer T2 has two secondary windings, one used to provide a reference voltage to the flux bridge and the other used to drive a synchronous demodulator. The center-tapped coil of T2 secondary provides a 1.4 volt peak-to-peak reference signal which is applied simultaneously to the primary winding of the flux bridge feedback system and a parallel resistance network (R9, 10 & 11). Potentiometer R9 is used to set the required ZERO ADJUST voltage.

The signal output from the secondary winding (position generator) of the flux bridge varies from 200 millivolts p-p at minimum scale through zero output at midscale to 200 millivolts p-p of opposite phase at full scale. The output level of this "position" signal is adjustable by means of the SPAN ADJ. potentiometer, R6. This preset position signal is now returned to the center tap of the reference transformer where it is added to the "zero" signal. The resultant voltage appearing at the slider of the ZERO control varies between 100 and 500 millivolts p-p depending upon the servo-controlled pen or pointer position (refer to test point "C").

A synchronous demodulator, Q1, is employed to rectify the position signal. This is accomplished by using the 10 kHz square wave signal developed by the other secondary winding of the reference transformer (T2) to control the demodulator. Functionally, a bias voltage is developed alternately through resistor R8 or through reverse bias diode CR6. The bias voltage is essentially an alternating high to a low impedance gating signal and results in half wave rectification of the 100 to 500 millivolt p-p reference feedback signal. Capacitor C4 filters the dc feedback signal while capacitor C3 bypasses any remaining 10 kHz component to ground. Finally, a filtered dc signal (see test point "B") is coupled to the inverting input (—) of the differential amplifier, U1, for comparison with the process signal. The reference feedback signal is now subjected to an added voltage component developed by the velocity generator winding of the flux bridge. The voltage output from this winding represents a rate function; i.e., voltage magnitude is proportional to pen or pointer speed.

IV. Differential Amplifier

The differential amplifier, U1, simultaneously compares the magnitude of the process and feedback signals applied to its inputs. When these signals are of equal magnitude, the output of U1 will be a relatively symmetrical square wave. Any unbalance between the input voltages will cause the amplifier output wave form to unbalance, i.e., the duty cycle will change in proportion to the magnitude and direction of the error. For example, if the process signal increases, the amount of time that the output of U1 is high will also increase, thereby causing the torque motor to drive "upscale" until the feedback signal equals the applied process input voltage. When a null condition has been re-established, the torque motor will hold its position. Hence, the TORQ-ER receiver is essentially a closed loop system; i.e., any change in the position of the torque motor (whose shaft is common to that of the flux bridge) will cause a proportional change in the magnitude of the feedback voltage until the unbalance is reduced to zero.

Capacitors C6, C7 and resistor R13 form a feedback network which has both low pass and high pass characteristics. The former gives an integral characteristic to the system, while the latter acts to maintain self-oscillation of the system at 1200 to 1500 Hz (see test point "G"). This high frequency is selected to preclude any influence on the pen and inking system of recorders.

V. Output Driver & Torque Motor

The output driver stage consists of two transistors, Q2 and Q3, which are connected in an alternately on-off mutually exclusive arrangement. The output voltage from the differential amplifier, U1, is applied to the base of output transistor Q2, which in turn drives the "ccw" winding of the torque motor. When the instantaneous output voltage from U1 rises above +0.7 volts, Q2 will conduct and cause cutoff of Q3 (de-energizes the "ccw" winding). Then, when the output of U1 drops below +0.7 volts, Q2 will be cut off and Q3 will conduct and energize the "cw" winding of the torque motor. In either conducting condition the feedback system will automatically change its output signal to effect a balance condition at the input of U1. At balance, transistors Q2 and Q3 will repeat on-off states at the same duty cycle (1200 to 1500 Hz).

NOTE

> "CW" and "CCW" refer to clockwise or counterclockwise rotation of the torque motor shaft. "CW" is upscale pointer/pen movement.

The output driver stage is designated to that most of the power is dissipated across the torque motor windings. Further, as Q2 and Q3 operate in the switching mode, power dissipation of these transistors is very small. It should be noted that since an integrating amplifier is used in the TORQ-ER Receiver, the current in one winding will increase over a small period of time if the output shaft is manually held "off null." When the output shaft is released, the pen or pointer will be momentarily deflected until the feedback system regains true balance with the process input voltage.

Under normal operation the torque motor has a torque of 1 inch-pound in either direction. If the motor will drive in only one direction, check the continuity of the windings. The normal dc resistance of each winding is 360 ohms measured between pin 5 and 8 and pin 6 and 8. The torque motor may drive to either 100% or 0% if power is not applied; this is normal and is due to the internal permanent magnet rotor. If the torque motor is defective, the entire motor-feedback assembly (TORQ-ER) must be replaced.

VI. Power Supply (As Specified)

A. 120 Volt, 50-60 Hz, Power Input

The 120 V ac line power applied to terminals 101 (phase) and 102 (neutral) is stepped down via power transformer T1. The voltage developed in the secondary winding of T1 is first rectified by CR3 and, in turn, the rectified dc is then applied to a capacitor input type filter, C12. The output of the filter is +31 V dc used to drive the torque motor. In addition, +15 V dc and +7.5 V dc outputs are derived from a Zener diode series divider network, CR4 and CR5, respectively. The +15 V and +7.5 V dc supplies are used to power the solid state circuitry. Note that test point "A" is power supply common.

A two-wire transmitter power supply can be supplied as an option in the 120 V ac powered TORQ-ER Receiver only. This option must be specified at time-of-purchase. This two-wire supply is also driven by the voltage developed in the secondary winding of transformer T1. A full wave rectifier, CR10 and CR11, converts this ac to a dc voltage which is then filtered and applied to a transistor voltage regulator circuit. The output voltage is fixed at approximately 25.7 V dc by Zener diode CR12. This two-wire supply provides short circuit protection by the use of series limiting resistors. The output voltage for the remote two-wire transmitter is presented at terminals 104 (+) and 103 (−).

B. 24 to 26 V dc Power Input

An external +24 to +26 V dc power supply can be used to power the TORQ-ER Receiver. When this power service is specified, power transformer T1, rectifier CR3 and capacitor C12 are deleted from the printed circuit assembly. The power is introduced to the TORQ-ER Receiver at terminals 104 (+) and 103 (− and common). Diode CR2 is now added across the power input terminals to provide reverse voltage protection. The +24 V dc is coupled to the filter section of the internal power supply through jumper J1. In addition, to minimize noise on the process input, a copper cut removes the "−" side of the process input line (terminal 105) from internal common. An external jumper, Jx, is then connected from terminal 105 to terminal 103 (the "−" line of the external 24 V dc power supply). When power for a remote two-wire transmitter is required, it can be powered directly from the external 24 to 26 V dc power service.

MAINTENANCE

I. General

The F&P Series 50TQ1000 TORQ-ER Receiver consists of two modular units; the TORQ-ER unit and the servo-amplifier printed circuit board. Maintenance beyond the modular level should be attempted only by a trained electronic technician. When qualified electronic maintenance personnel are not available, the complete TORQ-ER Receiver may be returned prepaid to the manufacturer for servicing. If the instrument is beyond the coverage of the warranty, a reasonable service charge may be expected.

If minimizing downtime in the event of instrument malfunction is of major importance, spares should be maintained on a modular basis. Defective modules may then be repaired from component level spares without interruption of the process. Service problems that cannot be solved by normal trouble shooting procedures should be referred to the manufacturer's service department with complete information as to the nature of the difficulty. Instructions covering corrective measures and parts replacement, if component failure is indicated, will be furnished promptly.

II. Routine Maintenance

No routine maintenance procedures are required for the TORQ-ER Receiver within the Series 51B1100DB(DM) Indicator/Recorder. Routine maintenance procedures for any accessory instrumentation furnished within the instrument case are given within the applicable Instruction Bulletin, appended.

III. Disassembly of TORQ-ER Receiver

To remove a TORQ-ER Receiver from the instrument case for inspection, troubleshooting or replacement, perform the following disassembly procedure:

1) Open the instrument case door and raise the pen(s) or pointer(s) by means of the lifter arm. Withdraw a concentric dial indicating pointer from its hub. Remove the circular chart from a Recorder. Remove the scale or chart plate.

2) Disengage the connecting link to the instrument case spindle from the TORQ-ER take-off lever.

3) Place TORQ-ER Receiver power switch in the OFF position.

4) Remove the clear plastic shield that covers the TORQ-ER Receiver interconnection barrier strip. Loosen terminal screws and remove all interconnecting leads from this barrier strip.

5) Remove the four #10 fillister head screws and two #6 binder head screws that mount the TORQ-ER

Receiver to the instrument plate. Two of these screws are at the base corners of the printed circuit board and four of them are located on the torque motor assembly housing flange. Further, if the TORQ-ER Receiver is mounted in the upper section of the instrument case (1st & 2nd Receiver location), remove the single mounting screw that attaches the instrument spindle plate to the torque motor assembly housing.

6) Withdraw the TORQ-ER Receiver from the instrument case.

7) Remove the four #6 pan head screws and lockwashers from the rear of the printed circuit board that mount the TORQ-ER unit.

8) If necessary, disconnect the miniature 14-pin plug which connects flexible interconnection tape cable to the servo-amplifier board from the TORQ-ER.

IV. Troubleshooting

A. Sensory Inspection

In the event of equipment malfunction, perform a visual inspection of components for indications of charred resistors, broken or shorted leads, etc. Overheated transformers or electrolytic capacitors may help to localize touble spots. The acrid or pungent aroma of a charred resistor or punctured electrolytic capacitor also serves as a localizing means. If component failure can be localized by the senses, analyze the schematic diagram of Figure 11 for possible causes of component failure. Replace all suspected subassemblies or components. Refer to the parts list following section VI for subassembly or component replacement specifications.

B. Troubleshooting

Further assistance in the localization of the more probable areas of system malfunction is given in the following troubleshooting table.

TROUBLESHOOTING TABLE

TROUBLE & PROBABLE CAUSE	REMEDY
1. Receiver inoperative with associated power switch "on." Line fuse blown.	1. Isolated internal short circuit to TORQ-ER Receiver or accessories, if ac TORQ-ER is furnished, by removing accessory line leads from TORQ-ER Receiver terminals #101 & 102. Replace fuse and apply line voltage. If fuse blows, short is in TORQ-ER Receiver — if not, check accessories as outlined in associated Instruction Bulletins.
a) Shorted filter capacitors, C12 or C14 (ac Receivers only).	a) Replace defective capacitor and 1 ampere fuse.
b) Shorted power transformer, T1 (ac Receivers only).	b) Replace defective transformer and 1 ampere fuse.
c) Defective full wave rectifier, CR3.	c) Replace rectifier CR3 and 1 ampere fuse.
d) Defective Zener diodes, CR4 & CR5. (Fuse may not blow.)	d) Replace defective diode(s) and 1 ampere fuse, if applicable.
e) Defective filter capacitor, C12, C13 or C14, C15.	e) Replace defective capacitor, as applies, and 1 ampere fuse, if applicable.
f) Shorted transistor in reference or error signal circuitry. (Fuse may not blow.)	f) Replace defective transistor or entire servo-amplifier board and 1 ampere fuse, if applicable.

TROUBLESHOOTING TABLE (Continued)

TROUBLE & PROBABLE CAUSE	REMEDY
2. Pen or pointer pins upscale with proper signal interconnections and with zero or upscale signal input.	2. Attempt to move off upscale pin by adjusting ZERO control. If unable, check —
a) Defective component in reference voltage generator circuitry.	a) Perform dynamic checks in section V, following, to isolate defective component.
b) Defective feedback bridge circuitry.	b) Same as 2 a), above. Replace defective component or servo-amplifier board.
c) Defective flux bridge.	c) Same as 2 a), above. Replace TORQ-ER unit.
d) Shorted or open torque motor windings.	d) Replace TORQ-ER unit.
e) Defective differential amplifier circuitry.	e) Check voltage waveforms at amplifier U1 & Q2. Replace, if defective.
3. Pen or pointer pins downscale with proper signal interconnections and "on scale" signal input.	3. Attempt to move off downscale pin by adjusting SPAN control. If unable, check —
a) Defective signal input or damping circuitry.	a) Check dc voltage level at input circuitry as given on instrument data tag. Remove input signal and line power and check static resistance of input circuitry. Replace defective components.
b) Same as 2 e), above.	b) Check U1, Q2 & Q3. Replace, if defective.
c) Same as 2 d), above.	c) Same as 2 d), above.
4. Pen or pointer motion is erratic or oscillates.	4. Determine that this is not function of input signal that can be overcome by adjusting DAMPING control clockwise.
a) Intermittent defect in reference voltage generator or differential amplifier circuitry.	a) Same as 2 a), above.
b) Intermittent connection in tape cable between servo-amplifier board and torque motor assembly.	b) Check for loose or broken wire. Repair as necessary. Clean contacts of 14-pin connector with suitable solvent.

V. Dynamic Test

A. General

In the event that procedures given in the preceding troubleshooting section do not isolate instrument malfunction it may be necessary to perform dynamic testing. To gain accessibility for dynamic tests, remove the TORQ-ER Receiver from the instrument case and separate the printed circuit board from the TORQ-ER unit as given under "III-Disassembly of TORQ-ER Receiver," preceding. Position the printed circuit board, component side up, on an insulated surface with the TORQ-ER unit, still interconnected, adjacent to the board.

Obtain an adjustable dc standard voltage source that is capable of producing the dc signal voltage limits required of the TORQ-ER Receiver with an accuracy of at least ±0.1%. An accurate voltmeter or calibrated oscilloscope will also be required. If the TORQ-ER Receiver operates from a two-wire or conventional current signal source, calculate and use the equivalent voltage limits produced across the input shunt resistor at the instrument case interconnection barrier strip. Next, obtain a 1200 ohm, 2 watt resistor if the TORQ-ER Receiver is an ac model with two-wire transmitter. Interconnect for dynamic tests as shown in Figure 9. All tests are taken with a simulated signal input voltage level set at 50% of maximum unless otherwise specified.

Note that the test points, as well as circuit designations, are screened on the servo-amplifier board to serve as an aid for dynamic testing (see Figure 10). Typical waveforms associated with these test points are given on the schematic diagram of Figure 11. These should be measured with an oscilloscope with a 1 millisecond sweep.

B. DC Power Supply Check

1) Check the 24 volt dc supply (ac TORQ-ER Receivers only) by measuring from the "+" junction of CR3 and C12 to power supply common (test point "A"). This should measure +31.5 volts dc ± 5% when input is 120 volts ac. The 120 Hz output ripple should be 2.0 volts p-p or less. If measurements do not fall within these limits, examine power transformer, T1; full wave bridge rectifier, CR3; filter capacitors, C12 or C13; dropping resistor, R23; and zener diodes, CR4 & CR5.

2) Check the 15 V dc supply by measuring at the junction of CR5, R23 & C13 to power supply common. This should measure +15 volts dc ± 5%. The 120 Hz output ripple should be 0.15 volts p-p maximum with no more than 50 millivolts p-p high frequency ripple.

3) Check the —4 V dc supply by measuring from the junction of diode CR7 and capacitor C8 to signal common. This should measure —3.8 volts dc ± 10% with a 1.0 mA load. The 10 kHz output ripple should not exceed 30 millivolts p-p. If measurements do not fall within these limits, refer to "C. Reference Voltage Generator," following.

4) Check the two-wire transmitter dc supply (option in 120 V ac TORQ-ER Receivers only) by measuring between terminals #103 (—) and #104 (+) of the board barrier strip. This should measure between 24 and 26 volts dc with a maximum 60 Hz and 120 Hz output ripple of 50 millivolts p-p either with or without the 1200 ohm load resistor attached. If measurements do not fall within these specified limits, perform a static resistance check of all components associated with this power supply.

NOTE

This two-wire power supply is capable of sustaining a short circuit load for one hour without damaging components. Short circuit current = 60 mA dc maximum.

C. Reference Voltage Generator

1) Check the reference voltage generator by observing the waveform measured between —

a) Test Points "A" and "F" of the board. This should be a 10 kHz, 14 volt p-p ± 5% square wave.

b) Test Points "A" and "E" of the board. This should be a 10 kHz, 9 volt p-p square wave.

2) Compare the waveforms observed at test points "F" and "E." Both should be a 10 kHz symmetrical square wave. If the correct voltage exists at test point "F," but not at "E," suspect transistors, Q4-6; transformer, T2; diodes, CR7 or CR8; or capacitors, C8 or C9. If proper voltage exists at test point "E," proceed to step #3.

3) Observe the waveform between test point "D" and power supply common. This should be 0-200 mV p-p square wave with a repetition rate of 10 kHz. If the correct voltage exists at test point "D," but not at "C," all circuitry associated with the flux bridge and demodulator, Q1, becomes suspect. Note that the voltage applied to pins P2-4 and P2-14 of the flux bridge must be 1.4 volts p-p ± 7%.

4) Observe the waveform (velocity feedback signal) between the test point "B" and power supply common. This should be a 50 to 250 mV rectified dc signal with a repetition rate of 10 kHz. Ripple at test point "B" should be less than 15 mV p-p; however, large spikes up to 100 mV p-p may also be present.

D. Flux Bridge & Feedback Circuit

1) Manually adjust the TORQ-ER output shaft from 0% to 100% of operating range while measuring the dc voltage between test point "B" and signal common. This should change from 50 millivolts to 250 millivolts dc. Disregard random spikes of 100 millivolts p-p. If proper measurements are obtained, proceed to "E. Input & Damping Circuit," following. If improper, check field effect transistor, Q1; capacitors, C3 and C4; and diode CR6. Also, disconnect line voltage from the TORQ-ER Receiver, and check the flux bridge velocity generator winding by connecting the negative lead of a multimeter to terminal "P2-13" and the positive lead to termainal "P2-3" of the 14-pin miniature connector. With the multimeter set to its lowest dc voltage measurement range, quickly displace the TORQ-ER output shaft upscale; the meter pointer should deflect slightly positive. The meter pointer should deflect slightly negative if the pen is quickly displaced downscale. If assembly and components are sound, proceed to step #2.

2) With the line voltage reapplied to the TORQ-ER Receiver check the output of the flux bridge position generator by observing the waveform be-

tween terminals, "P2-2" and "P2-12." Vary the TORQ-ER shaft from 0% thru 50% to 100% of range. A 10 kHz, 200 millivolt p-p square wave should be obtained with the shaft at 0%, dropping to zero with the shaft at 50%, and rising again to a 200 millivolt p-p square wave of opposite phase with the shaft at 100% input. If improper voltages are obatined, the flux bridge may be defective. Disconnect line voltage and check for short circuits to ground from terminals 2, 3, 4 and 12, 13, 14 of P2. If the flux bridge is found defective, the entire TORQ-ER unit must be replaced.

CAUTION

Do not attempt to disassemble the flux bridge or torque motor. Return the entire assembly to Fischer & Porter Company, Warminster, Pa. for servicing or substition.

3) With line voltage reconnected and the input signal adjusted to 0% or 100% of its rotation, adjust the screwdriver SPAN control to its extreme limits. The TORQ-ER output shaft should rotate approximately 30% of its full span. With the input signal adjusted to 50%, little or no output shaft motion should occur with the same SPAN control adjustment.

4) With a 50% input signal, a full adjustment of the screwdriver ZERO control is capable of moving the TORQ-ER output shaft 75% of its full sweep; i.e., cw to ccw adjustment limits.

E. Input and Damping Circuit

1) With the DAMPING screwdriver control adjusted completely counterclockwise, manually adjust the simulated dc signal input voltage from 0% to 100% of its operating range while measuring the dc voltage between U1-pin 5 and signal common. This should change from 50 millivolts to 250 millivolts dc. The output shaft should rotate smoothly between its limits without oscillations. If improper measurements are noted, check input dividers, R1, R3 and R5 and capacitors, C1 and C2.

2) Check the damping circuitry by suddenly changing the dc input signal voltage from 0% to 100% of operating range. The output shaft should rotate full scale in approximately 1.5 seconds. With the input signal at 0%, rotate the DAMPING screwdriver control completely clockwise. The output shaft should return to its 0% position and stabilize. Suddenly increase input signal to 100%; the output shaft should reach 62% of maximum position in 15 to 25 seconds. If improper operation occurs, check capacitors, C1 and C2, and resistors, R3 and R4. When testing is complete, adjust the DAMPING control completely counterclockwise.

F. Differential Amplifier

Compare the input and feedback signals by measuring the dc voltage level at the inputs of differential amplifier, U1. Measure the respective voltages applied to pins 4 and 5 to signal common. They should measure 150 millivolts dc ± 10% at 50% of maximum, but more importantly both test points should measure within 10 millivolts of one another in normal operation. When both input voltages are equal, the output of U1 should be a 1200 to 1500 Hz square wave with 50% duty cycle. If the position feedback signal at pin 4 is not equal to the process signal at pin 5, check the reference voltage generator and feedback system for proper operation.

G. Torque Motor

1) Observe the voltage across each torque motor winding; P2 pins 5 and 6 to common. A typical waveform is shown for test point "G" (see Figure 11). The output current through each motor winding should be a sqaure wave of about 1200 to 1500 Hz when the circuit is operating normally and at null.

2) Remove line voltage from the TORQ-ER Receiver. The torque motor output shaft will normally drive to 0% or 100% position because of its permanent magnet rotor. Measure the dc resistance of each motor winding. The respective winding should measure 360 ohms (± 10%) from terminals 5 to 8 and 6 to 8 of P2. If the torque motor is defective, the entire TORQ-ER unit must be replaced.

VI. Parts Replacement

It is recommended that certain complementary spares be maintained in stock so as to facilitate rapid maintenance in the event of instrument breakdown.

Replacement spares for the TORQ-ER Receiver may be maintained on one of two maintenance levels; i.e.: 1) the single printed circuit board and the TORQ-ER, and/or 2) individual electronic component spares for the printed circuit board. Note that the TORQ-ER unit is not considered repairable on a component level basis in the field.

A separate Parts List is available for mechanical components integrally mounted in the Series 1100 Indicator/Recorder instrument case. Refer to Parts List 51-1100.

If minimizing down-time is of paramount importance, it is recommended that spares be maintained on a subassembly basis. A defective printed circuit board may then be repaired from component level spares without prolonged interruption of the process.

REPLACEABLE PARTS LIST
TORQ-ER RECEIVER 50TQ1000C

TABLE A SUB-ASSEMBLY & COMPLETE RECEIVER PART NUMBERS

MODEL NUMBER	PC BOARD PART NUMBER	TORQ-ER PART NUMBER	TORQ-ER RECEIVER PART NUMBER
50TQ1101 & 1102	686B283U05	698B046U01	698B046U02
50TQ1103 & 1104	686B283U04	698B046U01	698B046U03
50TQ1301 & 1302	686B283U03	698B046U01	698B046U04
50TQ1303 & 1304	686B283U02	698B046U01	698B046U05
50TQ1401 & 1402	686B283U07	698B046U01	698B046U06
50TQ1403 & 1404	686B283U06	698B046U01	698B046U07

TABLE B TORQUE MOTOR ASSEMBLY

DESCRIPTION	F&P PART NUMBER
Torque Motor	669B047U02
Bracket, cast aluminum	354B011U02

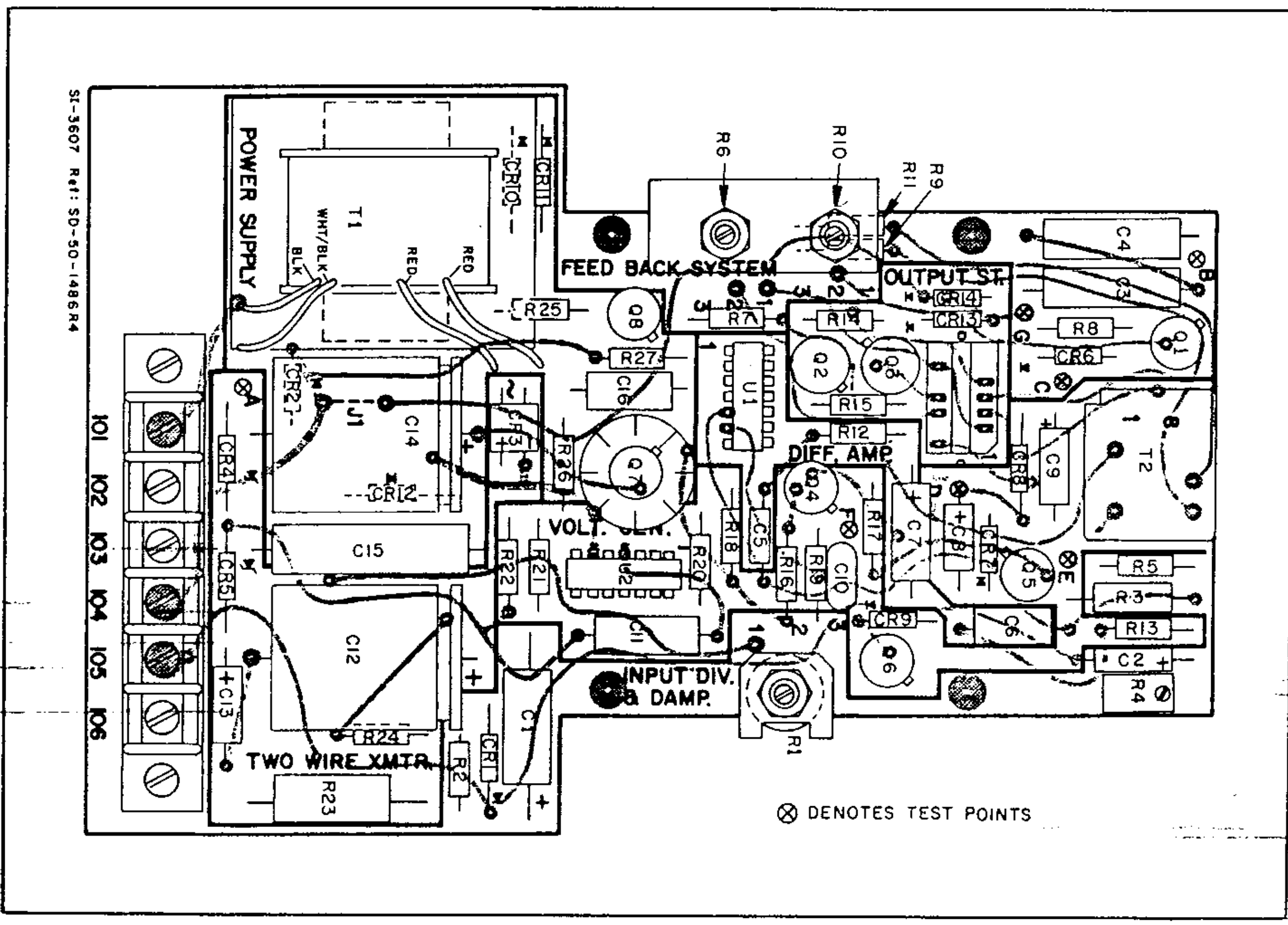
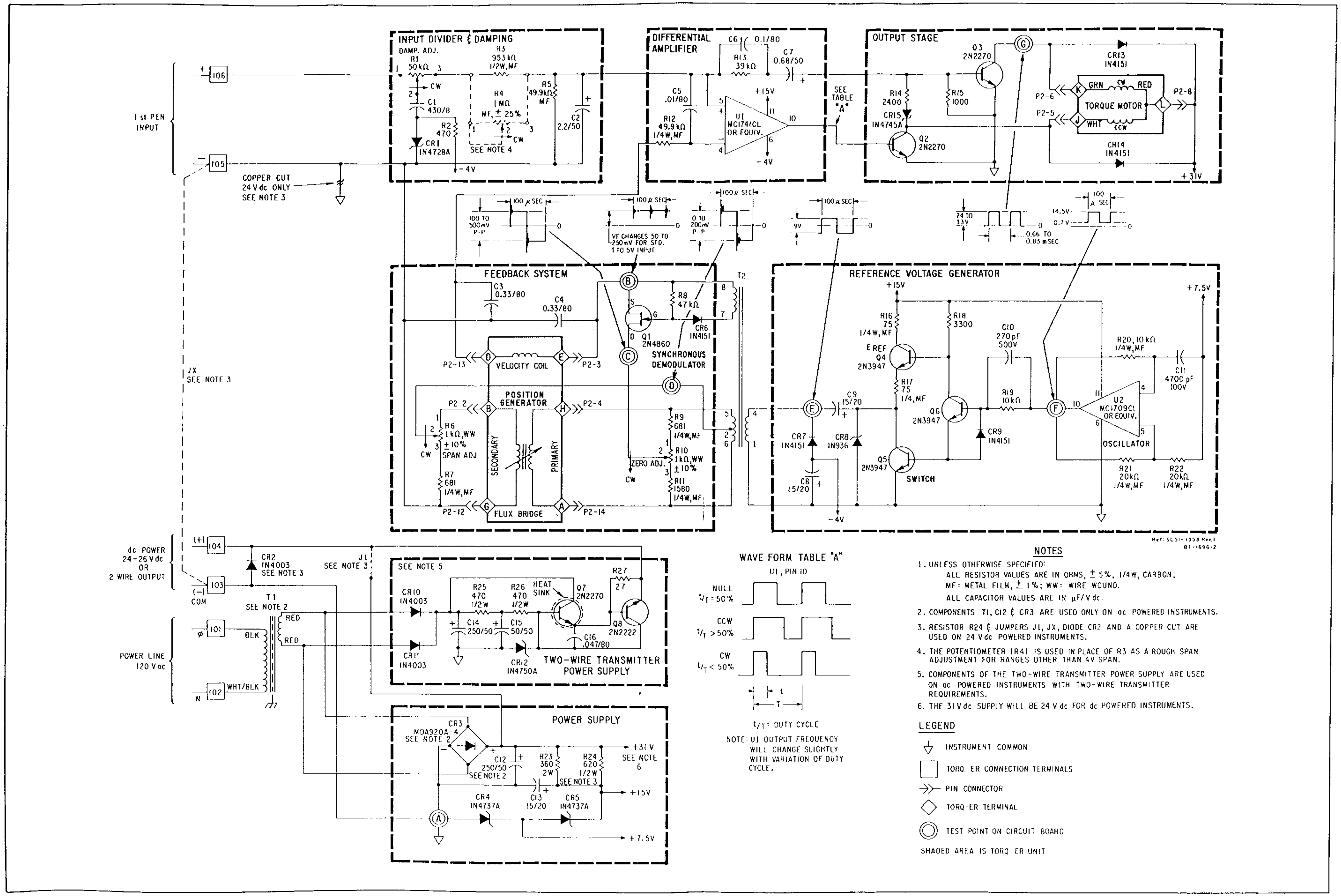


FIGURE 10. COMPONENT LAYOUT: PC BOARD



NOTES

1. UNLESS OTHERWISE SPECIFIED:
   ALL RESISTOR VALUES ARE IN OHMS, ± 5%, 1/4W, CARBON;
   MF = METAL FILM, ± 1%; WW = WIRE WOUND.
   ALL CAPACITOR VALUES ARE IN μF/Vdc.
2. COMPONENTS T1, C12 & CR3 ARE USED ONLY ON ac POWERED INSTRUMENTS.
3. RESISTOR R24 & JUMPERS J1, JX, DIODE CR2 AND A COPPER CUT ARE USED ON 24 Vdc POWERED INSTRUMENTS.
4. THE POTENTIOMETER (R4) IS USED IN PLACE OF R3 AS A ROUGH SPAN ADJUSTMENT FOR RANGES OTHER THAN 4V SPAN.
5. COMPONENTS OF THE TWO-WIRE TRANSMITTER POWER SUPPLY ARE USED ON ac POWERED INSTRUMENTS WITH TWO-WIRE TRANSMITTER REQUIREMENTS.
6. THE 31 Vdc SUPPLY WILL BE 24 V dc FOR dc POWERED INSTRUMENTS.

LEGEND

- INSTRUMENT COMMON
- TORQ-ER CONNECTION TERMINALS
- PIN CONNECTOR
- TORQ-ER TERMINAL
- TEST POINT ON CIRCUIT BOARD

SHADED AREA IS TORQ-ER UNIT

FIGURE 11. SCHEMATIC DIAGRAM

REPLACEABLE PARTS LIST

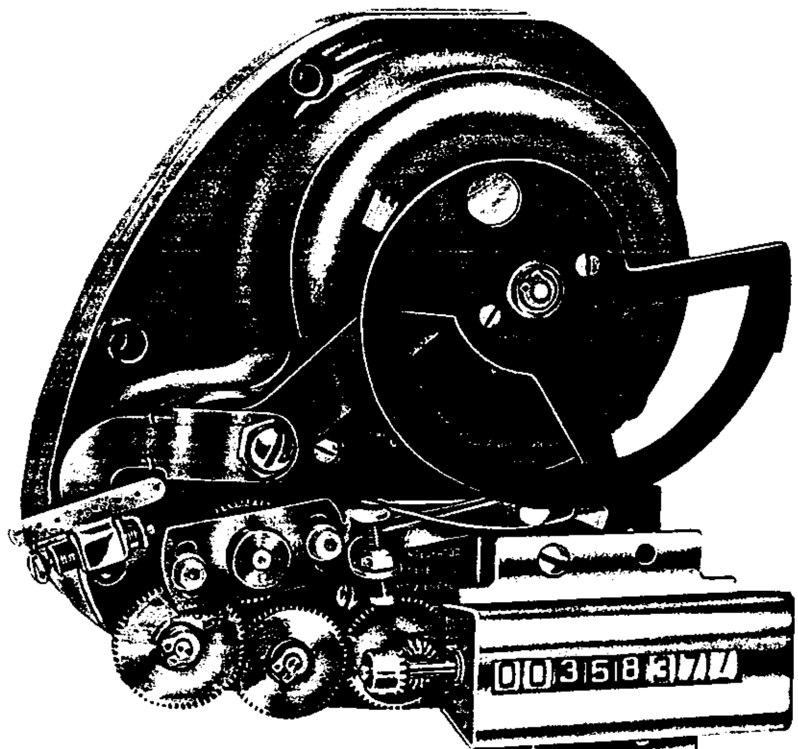
TABLE C. PRINTED CIRCUIT ASSEMBLY

SYMBOL	DESCRIPTION	PART NUMBER
C1	CAPACITOR, Tantalum: 430 µF, 8 V dc	160K022U03
C2	CAPACITOR, Tantalum: 2.2 µF, 50 V dc	160K046U01
C3, 4	CAPACITOR, Polyester Film: 0.33 µF, 80 V dc	160H485U27
C5	CAPACITOR, Polyester Film: 0.01 µF, 80 V dc	160H485U09
C6	CAPACITOR, Polyester Film: 0.1 µF, 80 V dc	160H485U21
C7	CAPACITOR, Mylar: 0.68 µF, 50 V dc	160K038U06
C8, 9, 13	CAPACITOR, Tantalum: 15 µF, 20 V dc	160K036U02
C10	CAPACITOR, Silv'd Mica: 270 pF, 500 V dc	160G061U01
C11	CAPACITOR, Polystyrene: 4700 pF, 100 V dc	160H482U01
C12*, 14*	CAPACITOR, Electrolytic: 250 µF, 50 V dc	160A025U15
C15*	CAPACITOR, Electrolytic: 50 µF, 50 V dc	160A013U01
C16*	CAPACITOR, Polyester Film: 0.047 µF, 80 V dc	160H485U17
CR1	DIODE: Type 1N4728A, Zener	166B113U01
CR2+, 10*, 11*	DIODE: Type 1N4003	166B050U01
CR3*	DIODE: Type MDA920A-4	166E004U01
CR4, 5	DIODE: Type 1N4737A, Zener	166B113U10
CR6, 7, 9, 13, 14	DIODE: Type 1N4151	166B112U15
CR8	DIODE: Type 1N936, Zener	166B053U01
CR12*	DIODE: Type 1N4750A, Zener	166B113U23
CR15	DIODE: Type 1N4745A, Zener	166B113U18
Q1	TRANSISTOR: Type 2N4860, FET	156B125U01
Q2, 3, 7*	TRANSISTOR: Type 2N2270, NPN	156B127U09
Q4, 5, 6	TRANSISTOR: Type 2N3947, NPN	156B127U04
Q8*	TRANSISTOR: Type 2N2222, NPN	156B127U08
R1	POTENTIOMETER, Wirewound: 50 kΩ, 10%, 1/2 W	162A166U01
R2	RESISTOR, Composition: 470 Ω, 5%, 1/4 W	161K228U17
R3‡	RESISTOR, Metal Film: 953 kΩ, 1%, 1/2 W	161T030U95
R4+	POTENTIOMETER, Metal Film: 1 MΩ, 25%, 1 W	162C185U16
R5, 12	RESISTOR, Metal Film: 49.9 kΩ, 1%, 1/4 W	161T022U68
R6, 10	POTENTIOMETER, Wirewound: 1 kΩ, 10%, 1/2 W	162C188U01
R7, 9	RESISTOR, Metal Film: 681 Ω, 1%, 1/4 W	161T020U81
R8	RESISTOR, Composition: 47 kΩ, 5%, 1/4 W	161K230U17
R11	RESISTOR, Metal Film: 1580 Ω, 1%, 1/4 W	161T021U20
R13	RESISTOR, Composition: 39 kΩ, 5%, 1/4 W	161K230U15
R14	RESISTOR, Composition: 2400 Ω, 5%, 1/4 W	161K229U10
R15	RESISTOR, Composition: 1000 Ω, 5%, 1/4 W	161K229U01
R16, 17	RESISTOR, Metal Film: 75 Ω, 1%, 1/4 W	161T019U85
R18	RESISTOR, Composition: 3300 Ω, 5%, 1/4 W	161K229U13
R19	RESISTOR, Composition: 10 kΩ, 5%, 1/4 W	161K230U01
R20	RESISTOR, Metal Film: 10 kΩ, 1%, 1/4 W	161T022U01
R21, 22	RESISTOR, Metal Film: 20 kΩ, 1%, 1/4 W	161T022U30
R23	RESISTOR, Composition: 360 Ω, 5%, 2 W	161G361U01
R24+	RESISTOR, Composition: 620 Ω, 5%, 1/2 W	161A621U01
R25*, 26*	RESISTOR, Composition: 470 Ω, 5%, 1/2 W	161A471U01
R27*	RESISTOR, Composition: 27 Ω, 5%, 1/4 W	161K227U11
T1*	TRANSFORMER, Power: 120 V ac, 50-60 Hz primary	380E112U01
T2	TRANSFORMER, Reference: 155T/320T & 27T ct	380E108U01
U1	INTEGRATED CIRCUIT: Type MC1741CL	177B003U04
U2	INTEGRATED CIRCUIT: Type MC1709CL	177B003U02

* ac Only
\+ dc Only
‡ R3 or R4

INSTRUCTION BULLETIN
for
SERIES 52T□4000
MECHANICAL INTEGRATORS

Design Level "B" & "C"



SI 1285

FIGURE 1 TYPICAL RIGHT HAND MTD. INTEGRATOR
GENERAL PURPOSE MODEL 52TR4011C SHOWN

FISCHER
& PORTER

TABLE OF CONTENTS

The instructions given herein cover generally the description, installation, operation and maintenance of subject equipment. F&P reserves the right to make engineering refinements that may not be reflected in this Bulletin. Should any questions arise which may not be answered specifically by these instructions they should be directed to the Fischer & Porter Co. for further detailed information and technical assistance.

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MODEL NUMBERING

Refer to the F&P data sheet or the instrument name plate for the specific model number of the equipment furnished. The basic details of the model number are explained below. Explanation is not shown beyond the 9th digit due to the technical nature of the information – this information serves only to key the "building" drawings.

52 T☐ 40 00 C

Integrator, Mechanical Input

	Enclosure	Mounting
TL	51-1400 & 51-1100	Left Hand
TM	52-1231	Right Hand
TR	51-1400 & 51-1100	Right Hand

Operation

	Motor	Service
40	Electric	General Purpose
41	Electric	Class 1, Group D, Div. 1
42	Pneumatic	All
45	Electric	Class 1, Group D, Div. 2

Counter, Contact Options

	Counter	Contacts	
11	Mechanical	None	
12	Mechanical	Micro-Switch	
13	Mechanical	*Glaswitch	
14	None	Micro-Switch	Not Available in Design Level C
15	None	*Glaswitch	Not Available in Design Level C

*Contacts of Glaswitch are used to pilot a relay only.

Design Level: Letter assigned by factory; letter changes when some part is no longer interchangeable in both directions.

- A = Original Design; 3-wire capacitor motor (not discussed)
- B = 2-wire motor
- C = 52 TM 4000 input sector gear & pointer separated: Die cut cams for linear & Sq. Rt. inputs

INTRODUCTION

The F&P Series 52T☐4000 Integrator is a component used in a flow rate measuring instrument. It is used to show the total cumulative quantity of the flowing fluid that is being measured by the instrument. The Integrator receives its input signal via a connecting link from the instrument spindle that is indicating the process. The link positions a cam that is cut so that its profile represents the flowmeter curve. A synchronous motor, either electrically or pneumatically operated, provides a timed source of power to operate a contact arm (feeler mechanism) that detects the position of the input cam. A unidirectional clutch drives the output counter when the contact arm is being driven away from the cam.

The Integrator is available for mounting in various instrument enclosures. To accommodate the Integrator in all locations, a left and right hand version are built; in one instance the counter mechanism is turned at right angles to provide display from another side. Optional equipment includes either a Micro-Switch or a Glaswitch operating in synchronism with the counter. These switches are electrically interconnected to remote mounted equipment for counting or control functions.

This Instruction Bulletin fully describes the operation of the electric motor operated Integrator. The pneumatically operated Integrator differs only in the method of operating the contact arm. This difference is discussed in an appropriate section of the instruction. The Master Timing Unit that serves to drive the pneumatic motor is discussed in a separate Instruction Bulletin that is furnished with that equipment.

INSTALLATION - OPERATION

The Integrator is always factory mounted in an instrument enclosure and calibrated prior to shipment. All that is required by the customer is to connect either the electrical or pneumatic power source. *If this is an electrically operated Integrator, a wiring diagram is furnished* with the instructions for the particular instrument supplied. *If this is a pneumatically operated Integrator, it is used in conjunction with a Master Timing Unit.* Instructions are supplied with the Master Timing Unit that shows the arrangement of the piping.

If the Integrator is furnished as a spare part to be added to an existing instrument, a supplementary Instruction Bulletin will be furnished.

To place the Integrator into operation, turn on the supply to the electric or pneumatic motor. The Integrator is now operational and will begin to accumulate counts in accordance with the process level. Normal operation of the Integrator will be noted by the actuation of the contact arm that touches the cam.

The Integrator reading, time and date should be noted at the starting time or at such time that it is desirable to integrate the measured process. Usually Integrator readings are noted on a periodic basis; e.g., 24 hours, week or month. Subtract the present reading from the previous reading, then multiply the difference by the counter factor. The resulting number is the cumulative total quantity of the measured process for that given period of time.

If it is desirable to obtain integration over a very short period of time, the time at which the counter reading is taken becomes very important. The loss of a few seconds time may result in serious errors.

ACCURACY CHECK

To check the accuracy of the Integrator, the process signal (input measurement) must be held steady at a particular value for a reasonable period of time. The Integrator count is, in most instances, far more important than the value displayed by the instrument recording pen or indicator. The ideal method of checking the Integrator count is to adjust the process for a known value and note the increase in the count over an accurately timed period. If the process cannot be held steady, then it will be necessary to simulate the process conditions. For instance, if the instrument is receiving a 3-15 psig pneumatic signal, disconnect the input and apply a manually adjusted air pressure to simulate the process. If the instrument is a variable area flowmeter, the flow thru the meter could be bypassed and the float blocked in position with a dowel stick (by removing the inlet fitting) to simulate the process.

There are many conditions where it may not be practical to adjust the process or disconnect the instrument as in the above paragraph. Under these conditions, the only remaining practical method of checking the accuracy is to position the recording pen or pointer by hand to the desired check point(s). In most instruments the connecting link between the process receiver and instrument spindle will have to be temporarily removed to position the pen/pointer. In the Magnabond™ type flow rate indicator/recorder, the pen or pointer can be positioned to the desired scale point without removing any linkage. Use any appropriate method to hold the pen or pointer at the desired value. The Magnabond beam can be held in place by wedging cardboard between the follower magnets and the extension well.

The accuracy of the Integrator should be checked in at least three points. If the results of the accuracy check are plotted on a graph, similar to that shown in Figure 2, it may easily be determined if the Integrator or the instrument linkage is at fault. In the majority of cases all that will be required is a zero adjustment.

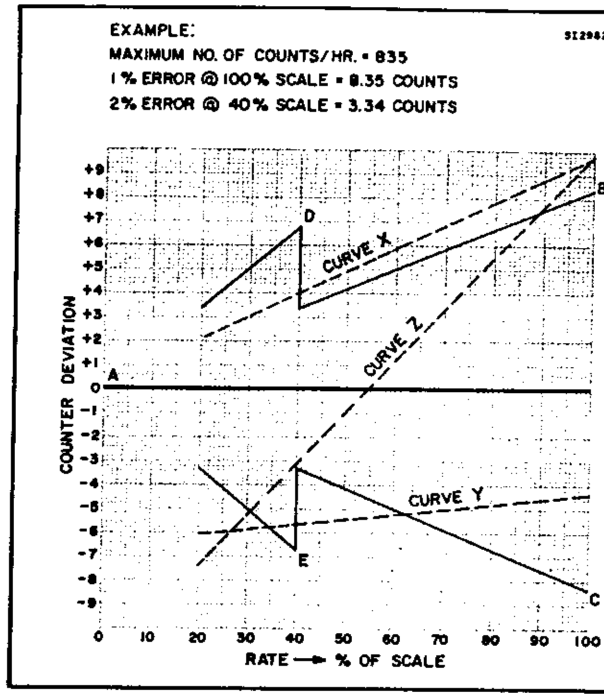

FIGURE 2 ACCURACY CHECK GRAPH

To draw the "error" graph, substitute the actual scale numbers for the "percent of scale" readings. To calculate the maximum allowable error, two calculations are made. The tolerance between 40% and 100% of scale is 1% of rate; between 20% and 40% of scale a 2% of rate tolerance is permitted. If for example, the Integrator was designed for 835 counts per hour at 100% scale, a 1% error would be 8.35 counts at 100%. Plot points B and C and connect through the graph zero; disregard these lines below 40% scale. At 40% scale (334.0 counts/hour) a 2% error would be 6.68 counts. Plot points D and E, then connect through the graph zero; disregard this line below 20% scale.

For an accurately timed interval note the increase in counter reading at three or more widely separated scale points. Compare the desired reading with the actual reading and plot the plus or minus errors on the graph; draw a curve through the plot points.

If the resulting curve is similar to curve X or Y, a zero correction is indicated. A zero correction to the contact arm will move the curve toward the base line by equal amounts along the curve. If a curve similar to curve Z results, it is an indication that the linkage has been altered. To correct this situation a range adjustment in conjunction with a zero adjustment would be required. A bow in the curve (not illustrated) would indicate the need for a linearity correction. Refer to the Alignment and/or Calibration section for the alignment of the linkages and the zero adjustment method.

Selection of the time interval is very important for the accuracy check. The maximum number of counts is usually used as the determining factor. For example, if the Integrator accumulates 136 counts per hour, in 15 minutes only 34 counts would be shown; if on the other hand, the maximum number of counts is 1496 per hour, in 15 minutes 374 counts would be accumulated. Thus, as the number of counts per hour increases, any error would be amplified so that it is more easily seen. Realize that the counter readout is digital, therefore, if the accuracy is to be checked within 1% of rate at least 100 counts should be collected.

An electric clock operating off the same voltage and frequency as the Integrator should be used when making an accuracy check. A few seconds may make considerable difference in the counter reading. An electric clock is preferred to a mechanical stop watch or clock since the Integrator is operated by a synchronous motor that is affected by the frequency of the power supply. The frequency of the power supply should be accurately controlled since records are usually kept by the day, week, month or year.

To sum up, the following is an example of how the accuracy check is made at one point. Assume the process variable has positioned the recording pen or pointer at 50% scale which is the equivalent of 90 gallons per minute. If the time interval selected is 30 minutes, the increase in counter total should be equivalent to 90 x 30 or 2700 gallons. A counter factor is usually involved because of the large numbers. If the counter factor is 10, divide by this factor, 2700 ÷ 10 or 270 counts would have turned up. The allowable tolerance @ 50% scale is 1% or an error of ±2.7 counts. Other points throughout the normal operating range are checked in a similar manner.

If non-repeat is suspected, conduct the test at some given value, then move the process variable either up or down scale and return to the original point. Then, conduct a second test, both readings should agree within ±1 of rate (2% of rate below 40% scale).

FUNCTIONAL DESCRIPTION

Reference to Figure 3, a functional schematic of the Integrator, will aid in the discussion that follows.

A synchronous motor is used to operate the Integrator. A drive wheel with a pin mounted off center is driven by the motor and as the pin moves through its orbit, it drives a spring loaded follower arm. The follower arm thus causes a timed oscillation of the main shaft. Attached to the opposite end of the main shaft is the contact arm. The contact arm detects the position or profile of the cam that represents the process. If the process variable is at 100% scale, the contact arm will oscillate through a 30% arc. At lesser process variable values, the contact arm travel is limited by the higher cam profile. Thus for each position of the cam there is a discrete angle of rotation produced on the main shaft.

Summation of the main shaft rotation is accomplished through the use of a unidirectional clutch that is attached to the main shaft. Actuation of this clutch engages a digital counter on the return stroke of the main shaft (contact arm moving away from the cam).

Figure 4 illustrates the operation of the double faced unidirectional clutch. Illustration A shows

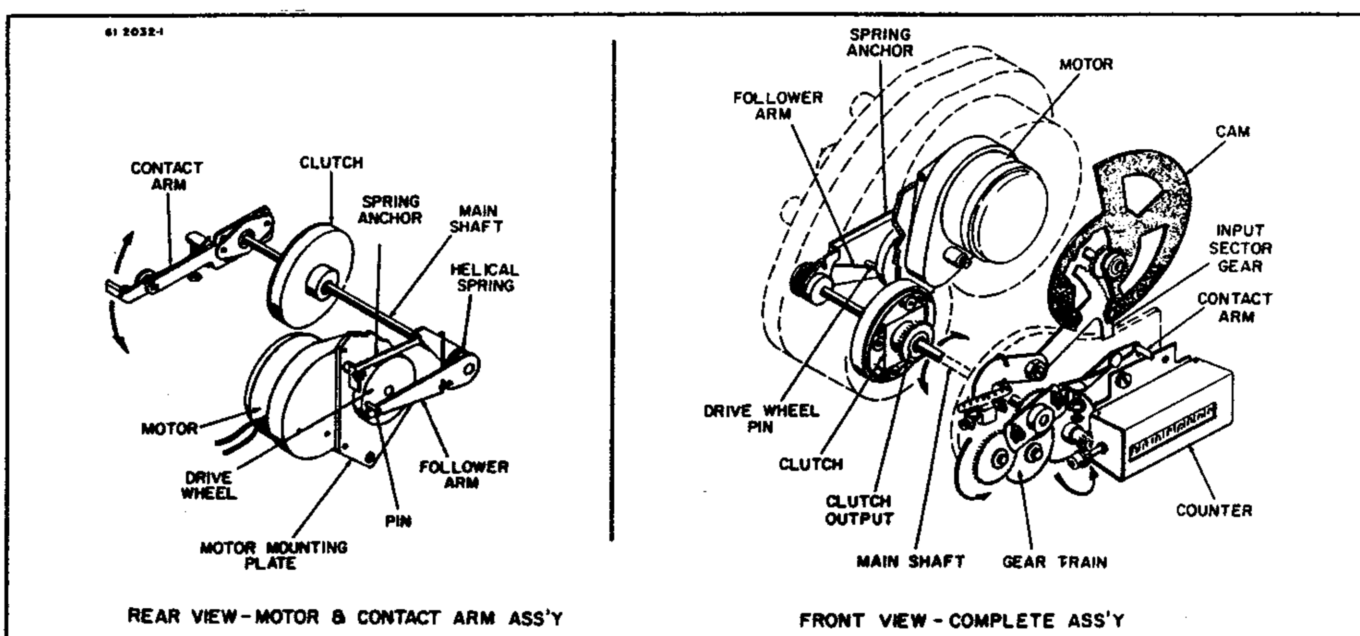

FIGURE 3 FUNCTIONAL SCHEMATIC

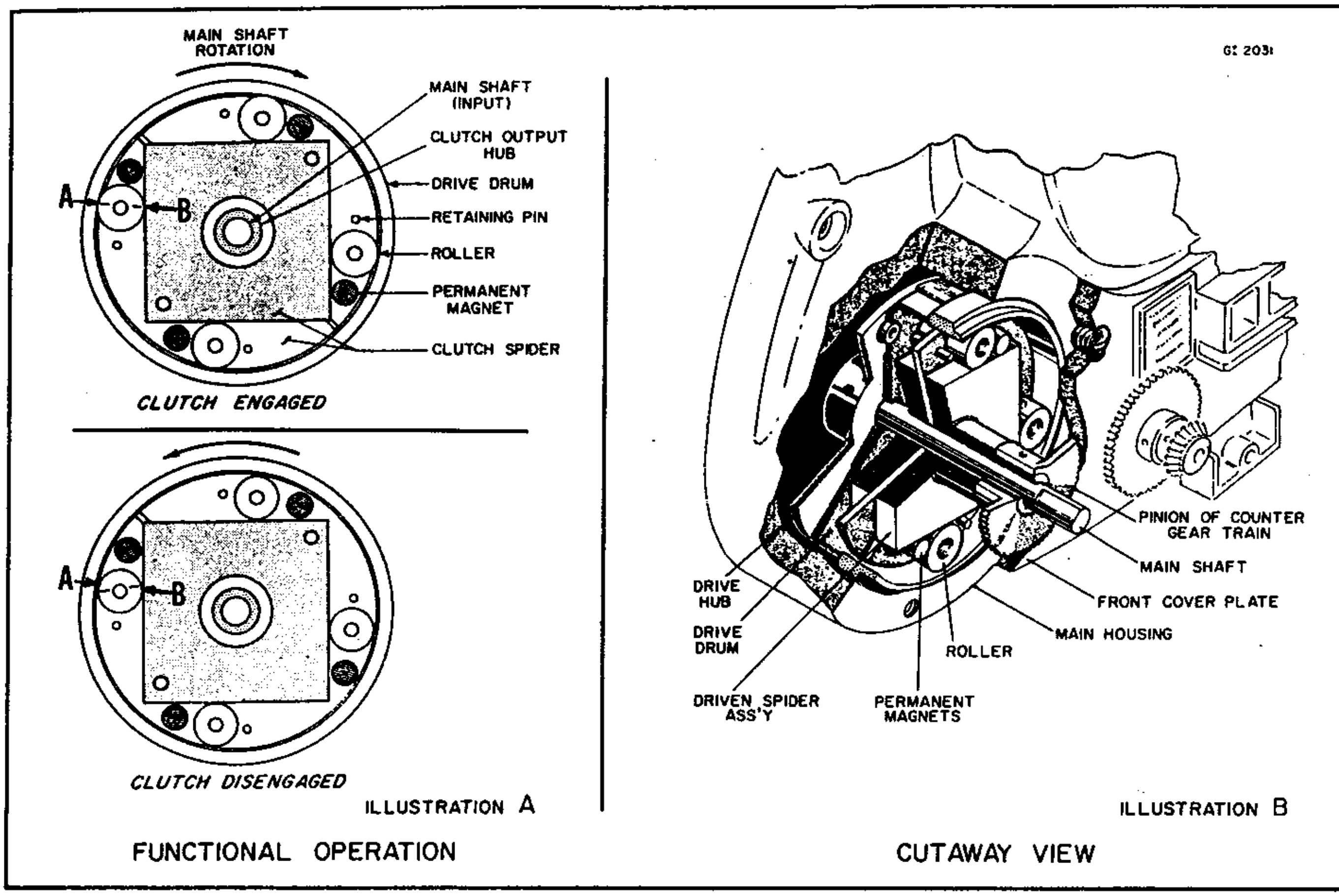

FIGURE 4 UNIDIRECTIONAL CLUTCH – FUNCTIONAL OPERATION AND CUTAWAY VIEW

FUNCTIONAL DESCRIPTION (Continued)

both the engaged and disengaged positions. Small diameter permanent magnets are used to hold the rollers in position. To engage the clutch, the drive drum attached to the main shaft is rotated clockwise. The rolling action of the drive drum and the magnetic attraction of the rollers to the permanent magnets causes the rollers to become wedged at the points indicated as A-B. The wedging action locks the drive drum to the clutch spider and that in turn drives the output hub which operates the counter. The clutch will disengage when the main shaft rotates counterclockwise. The opposite direction of the drum tends to move the rollers away from the points indicated as A-B. Thus, the wedge is removed and the output hub is no longer driven.

Notice in Illustration B, the cutaway drawing of ~~the clutch, that there~~ are actually two clutches back to back. One clutch drives the gear train; whereas, the other clutch prevents the gear train from backdriving. The latter clutch rollers lock against the clutch brake ring secured to the housing.

The frequency of the power supply determines ~~the number of strokes~~ that the contact arm makes. If the Integrator is connected to 60 Hz power, the arm will move 24 strokes/minute; 50 Hz and 25 Hz power will produce 20 and 10 strokes/minute respectively. The pneumatic unit is pulsed at 8 strokes/minute.

In the case of 60 Hz, each stroke at maximum provides 30° rotation; thus, 24 strokes/minute times 30° rotation/stroke equals 720° rotation/minute, or 43,200° rotation per hour. By dividing this figure by 360° it will be found that the main shaft made 120 revolutions at maximum input signal.

By selecting the gear train ratio, between the main shaft and the counter, the proper total count can be selected. If the 30° arc is too large, the cam profile is adjusted to reduce the maximum angle. From cam maximum to minimum the cam is cut to suit the characteristics of the measurement device. The gear train, shown in Figure 5 is a schematic

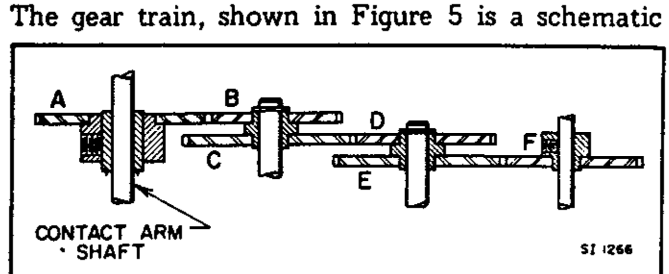

FIGURE 5 FUNCTIONAL SCHEMATIC OF THE COUNTER GEAR TRAIN

Counts Or Impulses Per Hour at 100% (60 Cycle Operation)	Number of Teeth On Gears						Gear Train Ratio
	A	B	C	D	E	F	
136.5	52	56	28	80	28	80	.1137
144.3	44	64	36	72	28	80	.1203
150.0	36	72	36	72	36	72	.1250
158.3	56	52	28	80	28	80	.1319
168.0	48	60	36	72	28	80	.1400
183.7	60	48	28	80	28	80	.1531
195.0	52	56	36	72	28	80	.1625
206.1	36	72	36	72	44	64	.1718
213.8	64	44	28	80	28	80	.1781
226.1	56	52	36	72	28	80	.1884
240.0	36	72	36	72	48	60	.2000
262.5	36	72	28	80	60	48	.2187
278.5	36	72	36	72	52	56	.2321
288.8	44	64	28	80	54	54	.2407
300.0	36	72	36	72	54	54	.2500
310.9	44	64	28	80	56	52	.2591
322.8	36	72	36	72	56	52	.2690
336.0	48	60	28	80	54	54	.2800
362.1	52	56	28	80	52	56	.3017
375.0	36	72	36	72	60	48	.3125
390.0	52	56	28	80	54	54	.3250
420.0	80	28	28	80	28	80	.3500
436.3	36	72	36	72	64	44	.3636
453.7	44	64	44	64	48	60	.3781
488.7	48	60	28	80	64	44	.4073
517.2	52	56	52	56	36	72	.4310
528.0	48	60	48	60	44	64	.4400
566.4	44	64	44	64	54	54	.4720
600.0	36	72	72	36	36	72	.5000
614.5	48	60	48	60	48	60	.5119
656.4	60	48	28	80	60	48	.5470
672.0	48	60	28	80	72	36	.5600
694.8	56	52	56	52	36	72	.5790

Counts Or Impulses Per Hour at 100% (60 Cycle Operation)	Number of Teeth On Gears						Gear Train Ratio
	A	B	C	D	E	F	
712.8	48	60	48	60	52	56	.5940
763.5	60	48	28	80	64	44	.6363
826.8	52	56	52	56	48	60	.6890
856.8	36	72	36	72	80	28	.7140
888.4	64	44	28	80	64	44	.7404
937.4	60	48	60	48	36	72	.7812
960.0	48	60	54	54	54	54	.8000
1034.0	52	56	52	56	54	54	.8621
1114.2	54	54	54	54	52	56	.9285
1200.0	54	54	54	54	54	54	1.0000
1269.3	64	44	64	44	36	72	1.0578
1293.3	52	56	52	56	60	48	1.0778
1391.6	56	52	56	52	54	54	1.1597
1498.7	56	52	56	52	56	52	1.2489
1534.8	48	60	48	60	72	36	1.2790
1620.4	44	64	44	64	80	28	1.3504
1678.8	72	36	72	36	28	80	1.3990
1745.4	54	54	54	54	64	44	1.4545
1875.0	60	48	60	48	54	54	1.5625
2024.4	56	52	56	52	64	44	1.6870
2069.2	52	56	52	56	72	36	1.7244
2193.6	48	60	48	60	80	28	1.8280
2343.6	60	48	60	48	60	48	1.9530
2538.0	64	44	64	44	54	54	2.1150
2733.6	64	44	64	44	56	52	2.2780
2782.8	56	52	56	52	72	36	2.3190
2955.6	52	56	52	56	80	28	2.4630
3172.8	64	44	64	44	60	48	2.6440
3299.8	72	36	72	36	44	64	2.7499
3428.4	80	28	28	80	80	28	2.8570
3692.7	64	44	64	44	64	44	3.0773
3838.8	72	36	72	36	48	60	3.1990
3975.6	56	52	56	52	80	28	3.3130

NOTES

1) To determine counts or impulses per hour for other frequencies or the pneumatic integrator, multiply the above values by the factor shown below
- 25 cycle - multiply by 5/12
- 50 cycle - multiply by 5/6
- pneumatic - multiply by 1/3

2) gear train ratio =

$$\frac{\text{max. variable measurement (in units per hr.)}}{\text{counter factor} \times K}$$

where:
counter factor = units/count or impulse (electric counter).
K = 1200 for 60 cycle, 500 for 25 cycle, 1000 for 50 cycle, 400 for pneumatic

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TABLE A. GEAR TRAINS

representation that shows the four fixed shafts that carry the six spur gears. By interchanging ten different gears in the six positions, the appropriate gear train can be supplied. If the exact gearing factor is not available, the cam is cut to interpolate the desired factor. Table A lists the standard gear trains that are available.

NOTE

Throughout the description, reference is made to a mechanical counter. The description is also valid if the mechanical counter has been replaced by either a Micro-Switch or a Glaswitch. These switches provide electrical contact closures that are used to actuate remote mounted counters or process equipment.

MAINTENANCE

I. General

No routine mechanical maintenance is required for the Integrator. It is suggested that a good grade of machine oil be applied to the various external shafts about once a year. A single drop of oil on each shaft will be sufficient. The internal moving parts have been lubricated for the life of the instrument.

If an accuracy check shows that counter reading is high or low, usually a zero adjustment of the contact arm assembly will correct the error.

Should an Integrator be replaced with a rebuilt unit, transfer the cam from the original Integrator to the rebuilt unit. The plastic cams are not generally interchangeable from one Integrator to another; however, the metal cams are interchangeable. A more detailed explanation of the cam follows in the Alignment and/or Calibration section.

If for any reason the original cam becomes damaged and requires replacement, order a new cam from Fischer & Porter Company. The complete serial number of the instrument must be furnished to obtain an exact duplicate.

II. Zero Alignment

If an accuracy check indicates a need for a zero alignment, it is preferably made at the normal operating level of the instrument. Although the curve should extrapolate through zero, it is possible to have extreme accuracy at the operating point if the curve is allowed to exceed the tolerance at the lower portion of the scale (in most flow measuring primaries the measurement accuracy falls off at the lower end and is not usually operated at low scale points). If the counter readings are on the high side, turn the zero adjustment, located on the contact arm assembly, as shown in Figure 11, in a clockwise direction to reduce the total count. Conversely, if the counter readings are low, turn the zero adjustment counterclockwise to increase the count. The gear train ratio of the Integrator determines the amount of rotation required on this zero adjustment; therefore, the amount of rotation must be determined by empirical means. It is suggested that 1/2 turn increments be tried as a starting point to determine the effectiveness of this adjustment.

If the Integrator has been disassembled, note that the contact arm must have a small motion at zero percent scale. This motion permits the cam to rotate when the process changes from zero. A small (but constant) amount of "lost motion" is built into the clutch so that at zero position the contact arm can move away from the cam about 3/32" without driving the counter. If the contact arm moves appreciably more or less than this amount, make a preliminary adjustment of the contact arm position on the hub by means of the adjusting slots and screws. Make a final adjustment with the zero adjusting screw. Turning this screw clockwise moves the contact arm away from the cam. The final zero adjustment should then be determined by means of an accuracy check discussed in a previous section.

III. Trouble Shooting

Should the Integrator fail to operate, as evidenced by no movement of the contact arm, check to see that the power supply to the motor is turned on; the service switch is "on", and the fuses intact. If the motor starts when the load is removed (by lifting the contact arm from the cam), excessive friction is indicated. Check the external gear train, counter and/or Micro-Switch actuator (if present). If these are all properly aligned and operating freely, the difficulty is probably due to clutch or main shaft friction. Such friction is probably caused by the main shaft being bent from mechanical damage.

If the contact arm fails to return to the cam after being lifted, either by the motor or manually, the difficulty may be: 1) a broken or bent main shaft; 2) loose set screws in the hub of the contact arm or follower arm; or 3) a broken spring on the follower arm.

If non-repeat of the counter reading is noted, check for the following:

1) Lost motion in the input linkage, especially around the over-travel spring of the input sector gear.

2) Friction in the gear train due to an accumulation of dirt on the gears or the bevel gears at the counter being meshed too tight.

3) Binding of the input sector gear due to improper adjustment of the eccentric pivot or dirt accumulation on the sector or in the bearings in the cam hub.

4) Failure of the clutch due to an accumulation of dirt.

Refer to the trouble shooting chart in the rear of Instruction Bulletin for other possible sources of trouble.

IV. Disassembly

The Integrator is available in several different forms. This disassembly procedure applies directly to the basic electric motor operated Integrator. Parts V and VI discuss and illustrate the variations that are encountered with the Glaswitch and the pneumatic operated Integrator, respectively.

A. Integrator Removal

To remove the Integrator from the instrument case proceed as follows:

1) Turn off the electrical service to the instrument.

2) Remove the scale or chart plate from the 51-1100 or 51-1400 instrument; the indicator plate in the 52-1231 instrument does not have to be removed. Then, disconnect the electrical leads to the Integrator. Tag the wires to aid in replacement.

NOTE

The Series 52TM4000 Integrator that is used in the Series 52-1231 instrument has two input levers. One input lever positions the sector gear while the other positions the flow rate pointer. Each lever is mounted on an eccentric bushing for independent setting. Make appropriate text adjustment.

3) Disconnect the link between the instrument spindle and the Integrator.

4) Remove the three mounting screws securing the Integrator and remove it from the instrument enclosure.

B. Removing Front Mounted Parts

Refer to Figure 6, an exploded view of the right hand Integrator, to aid the disassembly procedure. Proceed as follows:

1) Remove the mounting screw and eccentric bushing from the input sector gear and withdraw the sector gear. Inspect the sector gear assembly for lost motion at the point where the overtravel spring contacts both pieces. If lost motion is noted, the parts should be repaired or replaced.

2) Remove the retainer ring (ring is a friction fit-no groove) from the cam spindle. Lift the cam, with the attached hub and bearings, from the spindle. (The spindle is pressed into the housing.) Unless cam replacement is required, do not remove

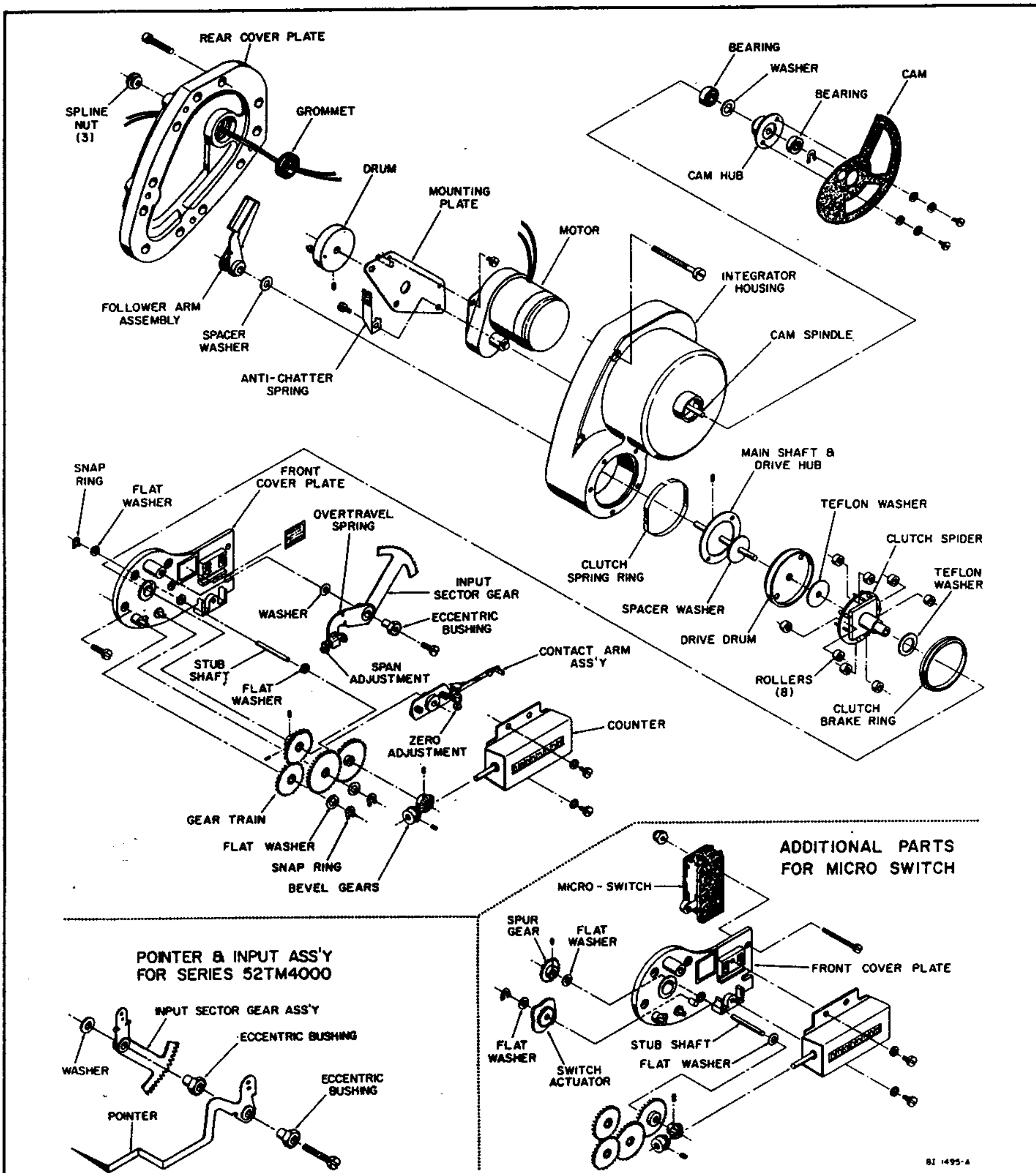

FIGURE 6 EXPLODED VIEW OF STANDARD ELECTRIC MOTOR OPERATED INTEGRATOR

the cam from the hub. Inspect the bearings and the gear attached to the hub for signs of wear or excessive dirt. If there is any sign of rust on the bearings, they should be replaced. When replacing bearings, do not use a screwdriver or pointed tool to press the bearings in place.

3) Loosen the set screw and remove the contact arm assembly from the main shaft. Inspect the contact arm to see that the knife edge is sharp. Further disassembly of this arm is not required unless parts replacement is necessary.

4) If present, remove the Micro-Switch.

5) Remove the counter after checking to see that the bevel gears used to drive the counter are meshing properly. Undue friction at this point can cause Integrator failure.

6) Remove snap rings and/or loosen set screws and remove gears used to drive the counter (and Micro-Switch). For ease in re-assembly, record the placement of the gears.

7) Remove the five screws securing the cover plate to the main housing, then lift the cover from the housing.

8) Inspect the exposed portion of the main shaft for burrs. Remove any burrs with a very fine file or emery cloth before proceeding any further. Then, lift the clutch spider from the shaft and housing. Be careful not to lose the eight (8) rollers and two (2) Teflon spacer washers associated with the clutch spider.

Clean all the clutch parts in a suitable solvent, then carefully inspect the rollers for any signs of wear (flat spots, pit marks, etc.). Replace any defective rollers.

Do not disassemble the clutch spider any further. If any defects are noted, order a complete clutch spider from F&P.

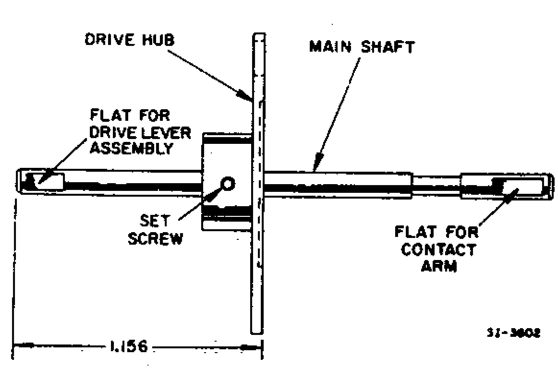

FIGURE 7 ADJUSTMENT OF THE CLUTCH DRIVE HUB

9) Lift the clutch brake ring from the housing and inspect for wear. Replace if scored or pitted.

10) The drive drum may be removed from the main shaft by turning the Integrator face down and tapping the housing. (The drive drum will slide off the shaft.) Inspect this part for signs of wear on the inner periphery. If signs of pitting or score marks are noted, the part should be replaced. When replacing the drive drum, make certain that the clutch spring ring is in place.

C. Removing Rear Mounted Parts

1) Remove the four screws securing the rear cover plate to the main housing, then carefully lift the cover from the housing being careful not to damage the electrical leads.

2) Loosen the set screw securing the follower arm assembly to the main shaft. Carefully pull this assembly from the shaft – do not lose the plastic spacer washer that is below the assembly.

3) From the front, withdraw the main shaft with the attached drive drum hub. If the main shaft is to be replaced, set the hub 1.156" from the inner end of the shaft to the face of the clutch drive hub, as shown in Figure 7.

NOTE

The Integrator with a Glaswitch uses a different motor assembly. The procedures discussed in the following steps do not apply. Refer to Part V and to Figure 8 for the appropriate information.

4) Remove the drive drum from the motor shaft by loosening the set screw. The anti-chatter spring should be removed and inspected for signs of wear.

5) Remove the remaining two screws to take out the motor assembly. This completes the disassembly procedure.

D. Re-assembly

Re-assembly consists mainly of reversing the disassembly procedure. Note the following points.

1) Unless the Integrator is relatively new, the Teflon washers and cam hub bearings should be replaced.

2) A small amount of graphited oil should be applied to the clutch spider where the rollers rest. A good grade of light machine oil should be applied to the internal main shaft bearings and external gear shafts.

3) Make certain that the drive hub is properly located on the main shaft as shown in Figure 7.

4) Leave the front cover plate screw loose. Position the cover for free shaft rotation, then tighten cover screws.

5) When replacing the gear train, be very careful with the gear (A) that attaches to the clutch spider hub. The gear set screws to the hub and the hub is very thin. Excess pressure will distort the hub and cause the shaft to bind.

6) If the contact arm has been separated from its driving hub, re-assemble so that the set screws will be aligned with the flat on the main shaft. The two adjusting screws should be centered in the slots.

7) Make certain that the contact arm and the follower lever assembly are aligned so that the set screws engage the flats on the main shaft.

8) Engage the sector gear with the cam pinion so that cam rotation is from 0 to 100% with respect to the contact arm.

9) Rotate the sector gear eccentric bushing, as necessary, to obtain proper meshing of the sector gear and pinion. Backlash must be prevented without introducing friction.

V. Servicing Glaswitch

Refer to Figure 8 for an exploded view of the Glaswitch and associated operating parts. To remove these parts, the Integrator must be removed from its enclosure. Realize that the Glaswitch may be operated in an explosive atmosphere – therefore, make certain that the power is turned off before removing any parts.

The Glaswitch is a low level reed switch and can be damaged by current overload. Realize that there is no mechanical connection between the parts attached to the rear of the front cover plate and the Glaswitch that is inside of the housing. Check that the gears and magnetic wheel assembly are free to rotate without undue friction or lost motion. The gear support plate has the lower mounting hole slotted to permit adjustment of the gear mesh.

To check the operation of the switch, connect the switch leads to an ohmmeter and rotate the magnet wheel. Observe the point at which the switch closes. Continue to rotate the magnet wheel in the same direction until the switch opens. If the switch opens before the magnet wheel rotates 160°, the bias magnet should be moved toward the center of the housing; if closed more than 200°, move bias magnet away from the center.

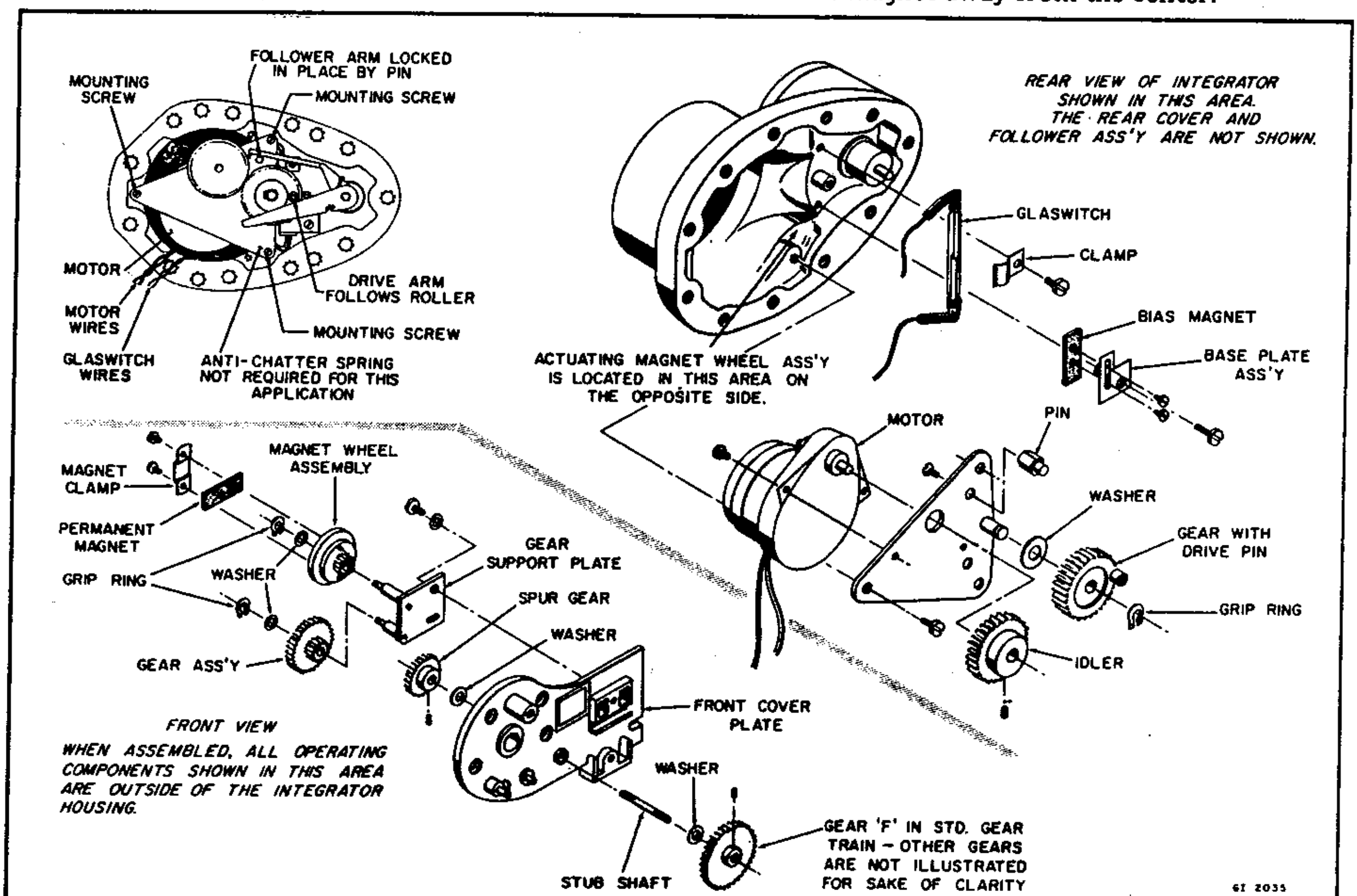

FIGURE 8 EXPLODED VIEW OF GLASWITCH COMPONENTS

MAINTENANCE (Continued)

VI. Servicing the Pneumatically Operated Integrator

A. General

The pneumatically operated Integrator differs from the electric motor operated unit only in the method of actuating the contact arm. In this version, a diaphragm, push rod, bell crank, coil springs and a connecting rod are used to drive the contact arm. Figure 9 is a cutaway view of the pneumatically operated Integrator. A source of power is provided by a Master Timing Unit.

The Master Timing Unit is a separate piece of equipment having its own Instruction Bulletin. Briefly, the Master Timing Unit is a device that transduces clock time to accurately timed pneumatic pulses. The resultant pulses are transmitted via tubing to the Integrator. The Integrator accepts these 8 pulses per minute that increase from zero to 4-1/2 psig (approximately) as a source of operating power.

As the pressure of the pulse increases, the diaphragm moves which thru the linkage causes the main shaft to rotate thru a 30° angle. As the pressure of the pulse falls, the return springs move to return the diaphragm while the main shaft returns to its original position. If the contact arm is halted by the cam profile, a lesser angle of rotation is made by the main shaft. To accommodate the reduced angle, the connecting link is slotted so that when the main shaft stops, the drive arm pin can continue to move clockwise. The drive arm pin is spring loaded against the end of the connecting link slot.

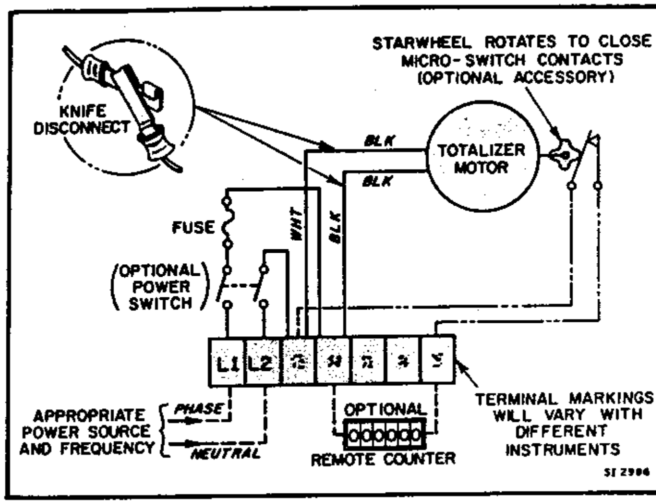

FIGURE 10 WIRING DIAGRAM

B. Disassembly - Re-assembly

The disassembly procedure of the front mounted parts is the same as the electric motor operated Integrator discussed in Part IV. The rear mounted parts are different as indicated in the cutaway drawing shown in Figure 9. The following points should be observed when re-assembling the Integrator.

1) Set the clutch drive hub 0.531" from the inner end of the shaft instead of 1.156" as indicated in Figure 7 for the electric operated Integrator.

2) If the diaphragm is being replaced, assemble the backing plates so that the rounded edge of the plates contact the diaphragm. Also assemble the diaphragm ring to the housing so that the rounded edge is against the diaphragm.

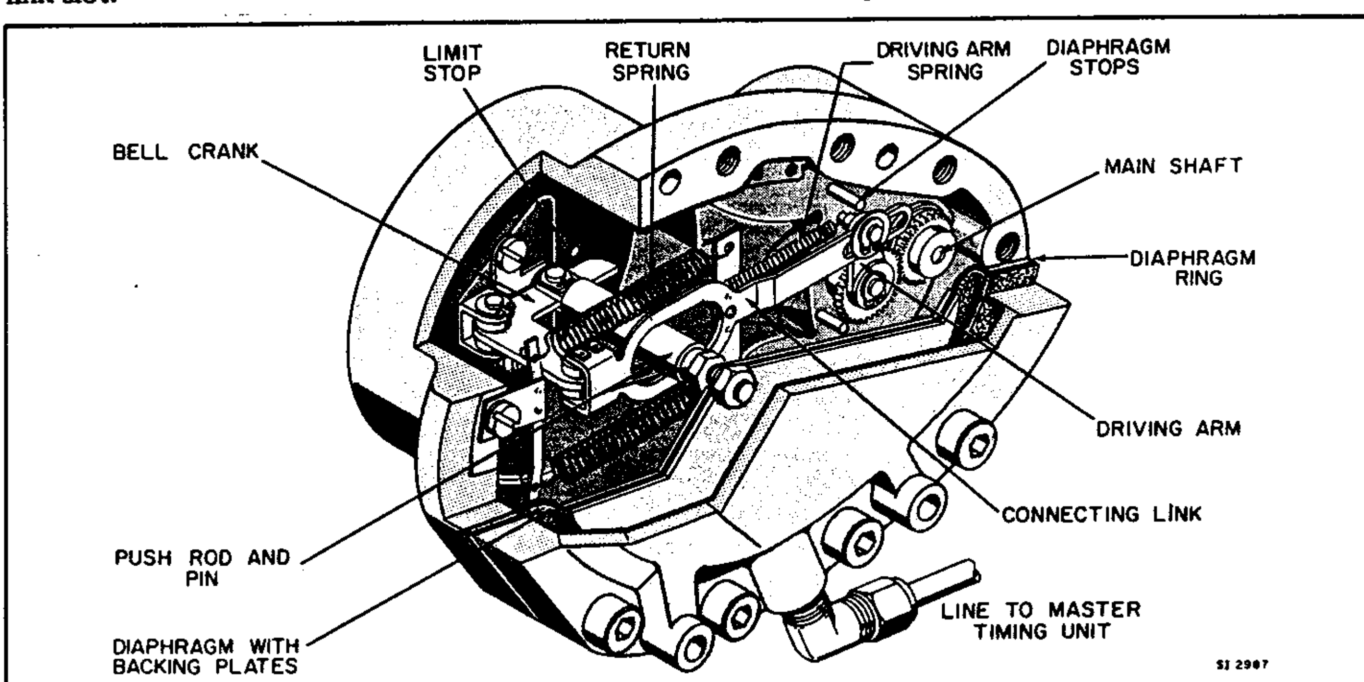

FIGURE 9 CUTAWAY VIEW OF PNEUMATIC MOTOR OPERATED INTEGRATOR

ALIGNMENT and/or CALIBRATION

I. General

The Integrator may have either a custom cut cam or a precision die cut cam. The die cut cam has been in use since approximately mid 1971. This type cam is used on instruments having either a true linear or square root input signal; all others use the custom cut cam.

Before proceeding, determine which type of cam is on the Integrator to be aligned and/or calibrated.

The custom cut cam is made of a black plastic material and is marked on the surface with light scribe lines during the factory calibration. Certain of these scribe lines are marked with the number of degrees that the main shaft rotated at a specific indicated flow rate on the scale. The degree marking is only useful for the cam cutting machine; however, the flow rate value is useful in checking the calibration. For example, if the cam is marked 6°/40.3, the indicated flow rate should be 40.3 actual engineering unit when the contact arm strikes the cam profile at this scribe mark. This type of cam has the instrument serial number marked on the cam. This type of cam has been factory calibrated; no further calibration should be attempted in the field. However, it may be necessary to adjust the alignment of the cam with respect to the process indicator or recording pen after repair.

The precision die cut cam is made of aluminum, having a black anodize finish. The cam has a "0" and 3 lines stamped on the cam surface (some early cams have several lines silk screened on the surface). With this type of cam, it will be necessary to calibrate the cam for various flow rates, then adjust the alignment with respect to the process indicator.

II. Alignment of the Custom Cut Cam

Reference to Figure 11 will aid in locating the adjustments used in the following procedure.

The reference marks can be used to rapidly check the alignment of the linkage to the Integrator. Position the process indicator or recording pen so that the Integrator contact arm is striking the reference marks. Compare the actual indicated or recorded value with respect to the reference marks. If the test shows any deviation, this indicates that the linkage or cam has been moved.

There are three types of adjustments to align the cam position to the process (or indicated value); namely, zero, span and linearity.

If all check points on the cam are offset to the same degree, a zero adjustment is required. The zero adjustment may be made by loosening the two screws securing the cam to the hub and moving the cam in the proper direction. Retighten the screws. A fine zero adjustment can be made by turning the knob in the connecting link.

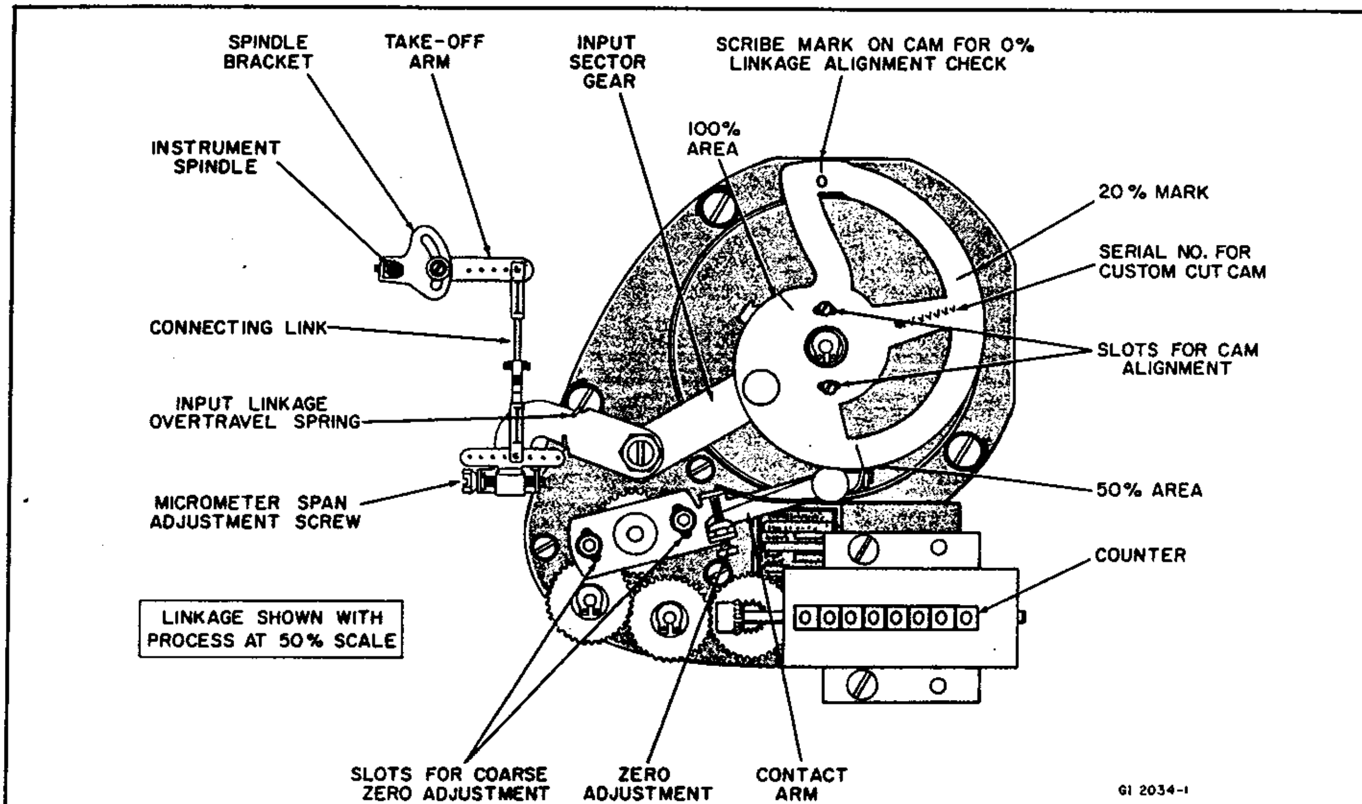

FIGURE 11 LOCATION OF ADJUSTMENT POINTS

If a span adjustment is indicated, a micrometer adjustment screw is provided for this purpose on the input sector gear of the Integrator. To increase the span, turn the micrometer adjustment screw counterclockwise; conversely, to decrease the span, turn the adjustment screw clockwise. After making a span adjustment, it will be necessary to make a slight zero correction. Alternately check zero and span until the desired degree of accuracy is obtained.

If a linearity adjustment is indicated (after making the span adjustment), the adjustment is made by altering the connecting link length and the angle of the take-off arm on the instrument spindle assembly. The take-off arm may be moved by loosening the screw at the kidney shaped slot on the spindle bracket. This take-off arm will be moved the amount necessary to accommodate the new length of the connecting link. When making this adjustment, set the pen or pointer at the mid-scale value. With the pen or pointer thus set, observe the same value on the cam using the contact arm (contact arm resting on the cam) as a reference point. If the reference mark on the cam is to the left, the length of the connecting link should be increased and the take-off arm adjusted accordingly. If the scribe mark is to the right, the length of the connecting link should be decreased and the take-off arm adjusted accordingly. Any correction of linearity will affect the zero and span adjustments. Therefore, these adjustments should be rechecked and adjusted as necessary.

III. Calibration of the Die Cut Cam

Field calibration of the Die Cut Cam is not difficult but it is rather time consuming. Be prepared to spend at least 5 to 6 hours until experience is gained; with experience 4 hours is about normal.

The cam is calibrated completely independent of the input linkage. Only after the cam calibration is completed is the linkage attached and aligned. Proceed as follows:

1) Temporarily disconnect and put aside the connecting link that is used to drive the input sector gear of the Integrator.

2) Check that the input sector gear mesh is proper. To do this, hold the contact arm down with one hand and move the input lever with the other hand. If the gears bind, loosen the sector gear pivot screw and rotate the eccentric bushing in a compensating direction, then retighten the screw.

3) With the Integrator contact arm in operation, rotate the cam so that the arm strikes the 20% mark exactly. With a piece of self-adhesive tape, tape the cam in this position. Extend the tape across the face of the cam and allow the ends to attach to the casting. Use a magnifying glass to make certain that this 20% point is correctly set. (The 20% mark is the first mark above the "0".)

4) Calculate the counts that the Integrator will accumulate at 20% scale and then the approximate time required to turn up 100 counts. Note: at 20% scale the accuracy specification is ±1% of rate; therefore, 100 counts are required to show the addition or subtraction of 1 count.

For Example:

full scale counts = 360 counts/hr

360 counts/hr x .20 = 72 counts/hr @ 20% scale

$$\frac{72 \text{ counts/hr}}{60 \text{ minutes/hr}} = 1.2 \text{ counts/minute @ 20\% scale}$$

$$\frac{100 \text{ counts (desired)}}{1.2 \text{ counts/minute}} = \begin{matrix}\text{83.3 min. to accumulate} \\ \text{100 counts @ 20\% scale}\end{matrix}$$

Since it would be difficult to figure a stop point 83.3 minutes ahead (1 hr., 23 min., 20 sec.), for ease in calculation choose 90 minutes and work backwards; 90 minutes x 1.2 counts/min = 108.0 counts ±1% tolerance = 108.0 counts x .01 or ±1.08 counts.

5) Allow the Integrator to operate at 20% for the above time to accumulate the counts as shown. If this is the initial calibration, the zero adjustment on the contact arm may be considerably out of adjustment. In fact, a coarse zero adjustment (slots in contact arm) may be necessary. It is suggested that the Integrator count be taken every minute, for 5 minutes initially to see if gross errors exist. Using the preceding example, 1.2 counts/min are to be accumulated. Using an accurate stop watch take a counter reading and start timing. Note: Start the stop watch just as the contact arm leaves the cam. If the counter reading at the start is:

```
            12752008
                +1.2 counts/min the counter reading
            ________
should be      009.2 @ end 1st min.
                +1.2
               _____
               010.4 @ end 2nd min.
                +1.2
               _____
               011.6 @ end 3rd min.
                +1.2
               _____
               012.8 @ end 4th min.
                +1.2
               _____
               014.0 @ end 5th min.
```

As the minutes go by, the count may begin to drift high or low. If the counter readings are *high*, turn the zero adjustment, located on the contact arm, in a *clockwise* direction. Conversely, for a *low* counter reading turn zero adjustment *counter-clockwise*. It is suggested that the zero adjustment be turned one full turn as a starting point. The gear train ratio determines the effect that this adjustment has.

If the limit of the zero adjustment is reached, a coarse zero adjustment is required. The slots in the contact arm provide this adjustment. To make this adjustment, stop the Integrator motor when the contact arm is just off the cam (approximately 1/8" by eye). Loosen the screws at the slots and rotate the arm in a corrective direction about 1/8". Moving the arm *towards* the cam will *lower* the count for the same cam position; conversely, *away from* the cam will *raise* the count. Return the fine zero adjustment to its mid-position of travel.

Continue to run 1 thru 5 minute checks, adjusting the fine and coarse zero until the Integrator is accurate for a 5 minute period. Once it is accurate for a 5 minute period, extend the timing period to collect at least 100 counts. In the example given it will take 90 minutes to collect 108 counts ±1.08 counts.

Make as many adjustments as necessary to get the Integrator within tolerance at the 20% scale value before proceeding to the next step. *Once the contact arm zero adjustment is properly set, do not move it for the remainder of the calibration procedure.*

6) Remove the tape and rotate the cam to the position where the contact arm will strike the 50% reference mark. Tape the cam in this position.

7) Calculate the counts that the Integrator will accumulate at 50% scale and the approximate time required to turn up 200 counts. Note: 200 counts chosen because accuracy is ±0.5% of rate above 40% scale.

For Example:

360 counts x .50 = 180 counts/hr @ 50% scale

$$\frac{180 \text{ counts/hr}}{60 \text{ minutes/hr}} = 30 \text{ counts/minute}$$

$$\frac{200 \text{ counts (desired)}}{30 \text{ counts/minute}} = \text{6.6 minutes to accumulate 200 counts}$$

therefore choose 7 minutes x 30 counts/minute

or 210 counts

±0.5% tolerance = 210 x .005

or ±1.05 counts

8) Run a count at 50% against the clock. If the counts are correct (within the calculated tolerance), mark the point of contact on the cam with a sharp pencil.

If the counts are high or low, the cam should be rotated to a new position. If the count is *high*, move the cam slightly in a *clockwise* direction; conversely, for a *low* count move the cam *counter-clockwise*.

NOTE

A shorter time period of one or two minutes can be used to "rough in" the cam position.

Recheck the count at the new cam position; make changes as necessary to the cam until the count is correct. When the count is correct, mark the cam with a sharp pencil at the point of contact.

9) Remove the tape and rotate the cam to the 100% reference mark. Retape the cam in this position. Calculate the counts that the Integrator will accumulate at 100% scale and conduct a check, as previously discussed.

For Example:

$$\frac{360 \text{ counts/hr}}{60 \text{ minutes/hr}} = 60 \text{ counts/minute}$$

$$\frac{200 \text{ counts (desired)}}{60 \text{ counts/minute}} = \text{3.3 minutes to accumulate 200 counts}$$

therefore choose 4 minutes x 60 counts/minute

or 240 counts

±0.5% tolerance = 240 counts x .005

or ±1.2 counts

When the cam is in the correct position, mark the cam with a sharp pencil to indicate the true 100%. *The cam is now calibrated for the Integrator to which it is attached.* The 20% mark and the pencil marks at 50% and 100% *provide three alignment points* for adjusting the input linkage.

10) Remove the tape from the cam and replace the connecting link. Adjust the process so that the recording pen or indicator is at 50% scale. It is assumed that the process receiving element is properly positioning the recording pen or indicator.

If the instrument has the Integrator mounted on the *right side* of the case, the linkage should appear as shown in Figure 11. Notice that the instrument spindle take-off lever is horizontal and that the connecting link is in the last hole. The bottom of the link should be in a hole in the center of the span adjustment carrier.

If the instrument has the Integrator mounted on the *left side* of the case, a similar linkage arrangement should exist. The only exception is that the instrument spindle take-off lever should be approximately 15 to 20° above the horizontal center line.

11) Adjust the process to position the recording pen or indicator at 20% scale. Adjust the length of the connecting link, by turning the roller adjustment, so that the arm strikes the 20% mark exactly; use a magnifying glass to set this point.

It may be necessary to loosen the cam clamp screws and rotate the cam in the appropriate direction. If the end of the adjustment slots are reached, remove the retaining ring from the cam hub shaft. Pull the cam assembly from the shaft and rotate it one gear tooth in a corrective direction. Return the cam assembly and replace the retaining ring. Do not place the retaining ring tight against the bearing hub as it will bind the bearing ring. The cam slots can be used to make the final adjustment.

12) Apply a signal to the receiver that is equal to 100% scale input. The contact arm should touch the actual 100% mark on the cam (the pencil mark that was put on the cam).

If the contact arm touches the cam at the pencil mark, the cam rotation is correct. If the arm touches the cam *beyond* the actual 100% pencil mark, the span is *long*; *below* the pencil mark, the span is *short*.

Correct a long span by turning the micrometer adjustment screw on the Integrator input lever clockwise. This increases the length of the input lever to reduce the cam travel. Conversely, turn the adjustment counterclockwise to correct a short span. It is suggested that the adjustment screw be turned one complete revolution as a starting point to check its effectiveness.

13) Reduce the input signal to its 20% value. The arm should strike the 20% mark; however, if a span adjustment was made in the previous step, it will be necessary to readjust the length of the connecting link. An adjustment at either end (zero or span) will affect the other adjustment.

14) Alternately check and adjust the span at 100% scale and the connecting link length at 20% scale until both points are correct. It is not practical to put a tolerance on the position of the cam with respect to the contact arm. Realize that each serration on the cam profile represents approximately 1/4 of 1% of full scale.

15) Apply an input signal equal to 50% scale and observe the point at which the contact arm strikes the cam. If the contact arm touches the actual 50% line (pencil line), the linkage alignment is completed. If the contact arm touches the cam above or below the actual 50% mark, a linearity correction is required.

If the contact arm touches *below* the 50% pencil line, the angle between the connecting link and the instrument spindle take-off lever must be *reduced*; conversely, *increase* the angle if the contact arm touches *above* the 50% mark. To *reduce* the angle, loosen the screw that locks the instrument spindle take-off lever to the spindle bracket and move the lever up about 1/8" (for a 1% linearity correction); conversely, to *increase* the angle, move the lever down. Then, adjust the length of the connecting link to restore the cam to the 50% mark.

16) After making a linearity correction, return to the 20% mark and readjust the length of the connecting link, if necessary. Recheck and adjust span at 100% as before. When the 20% and 100% points are correct, recheck the linearity. Repeat this process until all three points are correct.

17) Check to see that the contact arm does not fall off the cam when the pointer is at zero on the scale. If it does, the stop on the receiver must be adjusted to prevent this.

TROUBLE SHOOTING CHART

TROUBLE	PROBABLE CAUSE	REMEDY
Counter reading does not change (with primary meter in operation).	1) Faulty process receiver or instrument linkage.	1) Repair faulty receiver. Check for bent or disconnected linkage. Input changes should cause movement of sector gear and cam.
	2) Loose or missing gear in train to counter or electrical switch.	2) Tighten, repair or replace faulty gear(s).
	3) Defective mechanical counter or electrical switch.	3) Isolate trouble. Repair or replace defective element.
	4) Integrator inoperative due to defective motor or electrical service.	4) Check power supply, switches, fuses and wiring.
	5) Excessive friction in gear train or clutch.	5) Inspect gear train, clean or replace gears, check mesh of counter bevel gears. Disassemble, clean and repair clutch and check for bent main shaft. If equipped with Micro-Switch or Glaswitch check associated gears.
	6) Broken spring on follower lever assembly inside Integrator.	6) Install new spring, remove all broken pieces of spring from housing.
Inaccurate counter reading.	1) Primary measuring transmitter out of calibration.	1) Align primary transmitter.
	2) Receiving element in secondary instrument out of calibration.	2) Align secondary instrument receiver and synchronize with primary transmitter.
	3) Inaccurate time comparison standard.	3) Make certain power supply frequency is exactly as specified. Frequency variation will change Integrator speed.
	4) Bent connecting links or loose instrument spindle sectors.	4) Repair and align linkage as discussed under Alignment and/or Calibration.
	5) Improper zero adjustment.	5) Perform accuracy check to determine corrective action.
	6) Worn cam.	6) Replace cam. Order from F&P; identify instrument by giving complete serial number or part number.
	7) Incorrect counter factor used.	7) Check instrument data tag or mfg. specification sheet for correct factor.
	8) Shift in cam position on its hub.	8) Reposition arm. See Alignment and/or Calibration.
	9) Span adjustment of Integrator linkage improperly adjusted.	9) Check linkage alignment. See Alignment and/or Calibration.
Integrator fails to start when power is applied.	1) Defective motor, fuse or wiring.	1) Check power supply, switches and wiring.
	2) Excessive load on the motor for starting.	2) Eliminate source of friction.

PRESSURE TRANSMITTERS

Injection Well Head Pressure
Monitor Zone 1 Pressure
Monitor Zone 2 Pressure

Model:	Rosemount 1151GP6E22B1
Housing:	NEMA 4
Range:	0-17/100 PSIG
Output:	4-20MA D.C. Linear

INSTRUCTION MANUAL 4260/4261
October, 1984

PT-01-5-1
PT-01-6-1
PT-01-6-2

Instruction Manual

Rosemount Alphaline® Model 1151AP Absolute And Model 1151GP Gage Pressure Transmitter

Rosemount

ROSEMOUNT ALPHALINE®
MODEL 1151AP ABSOLUTE
AND MODEL 1151GP GAGE
PRESSURE TRANSMITTERS

CAUTION:

TO AVOID POSSIBLE WARRANTY INVALIDATION, READ BEFORE ATTEMPTING INSTALLATION OR MAINTENANCE

TABLE OF CONTENTS

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May be protected by one or more of the following U.S. Patent Nos. 3,618,390; 3,646,538; 3,793,885; 3,800,413; 3,975,719 and Re. 30,603. CANADA PATENTED (BREVETE) 1968, 1974, 1975, 1976 and 1979. MEXICO PATENTADO NO. 118,892. May Depend on Model. Other Foreign Patents Issued and Pending.

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INSTALLATION SECTION

GENERAL

The quality of the pressure measurement depends to a great extent on the proper installation of the transmitter and the impulse piping.

Because of process and economic considerations, gage and absolute pressure transmitters must often be installed in harsh environmental locations. The transmitter should, however, be located to minimize the effects of temperature fluctuations, and to avoid vibration and shock.

MOUNTING

The 1151GP or 1151AP transmitter may be supported by the piping connection if it is mounted directly at the point of measurement, or may be wall mounted or mounted to a 2-inch pipe by means of the mounting bracket accessory.

The process connection on the transmitter flange is 1/4-18 NPT. A flange adapter union is supplied with a 1/2-14 NPT connection. These process connections require thread sealant. The flange adapter allows the transmitter to be easily disconnected from the process by removing the flange adapter bolts.

To ensure a tight seal on the adapter flange, the following procedure should be performed: finger tighten both bolts, wrench tighten first bolt, wrench tighten second bolt, then retighten first bolt. Torque to approximately 29 ft-lb.

The transmitter body may be rotated in the flanges for mounted convenience. As long as the flanges are vertical, there is no shift in zero caused by rotating the transmitter body.

If the flange is horizontal, a slight zero pressure cahnge (0.03 psi) will occur due to the liquid head of the transmitter. For ranges up to 0-17/100 psi the transmitter should be rezeroed.

Proper location of the transmitter with respect to the process pipe depends on the process material. The following should be considered in determining the best location.

1. Corrosive or hot process material must be kept out of contact with the transmitter.

2. Sediment should be kept form depositing in the impulse piping.

3. Impulse piping should be kept as short as possible.

4. Ambient temperature gradients and fluctuations should be avoided.

For liquid pressure measurement, the tap should be made to the side of the line to avoid sediment deposits, and the transmitter should be mounted beside or below the taps so that gases will vent into the process line. For gas pressure measurement, the tap should be made to the top or side of the line and the transmitter should be mounted beside or above the taps so that liquid will drain into the process line. For steam flow measurement, the tap should be made to the side of the line, and the transmitter should be mounted below the taps so that the impulse piping will stay filled with condensate.

The tap should be made to the side of the line for transmitters having side vent/drains. For liquid service the side vent/drain should be mounted upward to allow the venting of gases. For gas service it should be mounted down to allow draining of any accumulated liquid. See Figure 1. Side vent/drains may be changed from top to bottom by rotating the process flange 180°.

Care should be exercised so that in steam or other elevated temperature services the transmitter temperature limits are not exceeded.

For steam service, lines should be filled with water to prevent contact of the live steam with the transmitter. Condensate chambers are not necessary since the volumetric displacement of the transmitter is negligible.

IMPULSE PIPING

The piping between the process and the transmitter must transfer the pressure seen at the process tap to the transmitter. Possible sources of error in this pressure transfer are:

1. Leaks.

2. Friction loss (particularly if purging is used).

3. Trapped gas in a liquid line (head error).

4. Liquid in gas line (head error).

The following precautions are suggested to minimize the possibility of errors:

1. Make impulse piping as short as possible.

2. Slope piping at least 1 inch per foot up toward the process connection for liquid and steam.

3. Slope piping at least 1 inch per foot down toward the process connections for gas.

4. Avoid high points in liquid lines and low points in gas lines.

5. Use impulse piping of sufficient diameter to avoid friction effects.

6. Be sure all gas is vented from liquid piping legs.

7. Especially for high pressure applications, be sure the impulse piping is of adequate strength to be compatible with anticipated pressures.

WIRING

Signal terminals are located in the electrical housing in a separate compartment. Connections can be made by removing the cover on the side designated as "terminal side" on the nameplate. The upper terminals are the signal terminals and the lower terminals are test or indicator terminals (Figure 1). The test terminals have the same current signal (4-20 mADC or 10-50 mADC) as the signal terminals for use with the optional indicating meter or for testing. All power to the transmitter is supplied over the signal wiring. There is no additional wiring required. DO NOT CONNECT POWERED SIGNAL WIRING TO THE TEST TERMINALS. Power will blow out the diode in the test connection. If this should accidentally happen, the test connection can be jumpered for operation of the transmitter.

Signal wiring need not be shielded, but twisted pairs should be used for best results. Signal wiring should not be run in conduit or in open trays with power wiring, and should not be run near heavy electrical equipment.

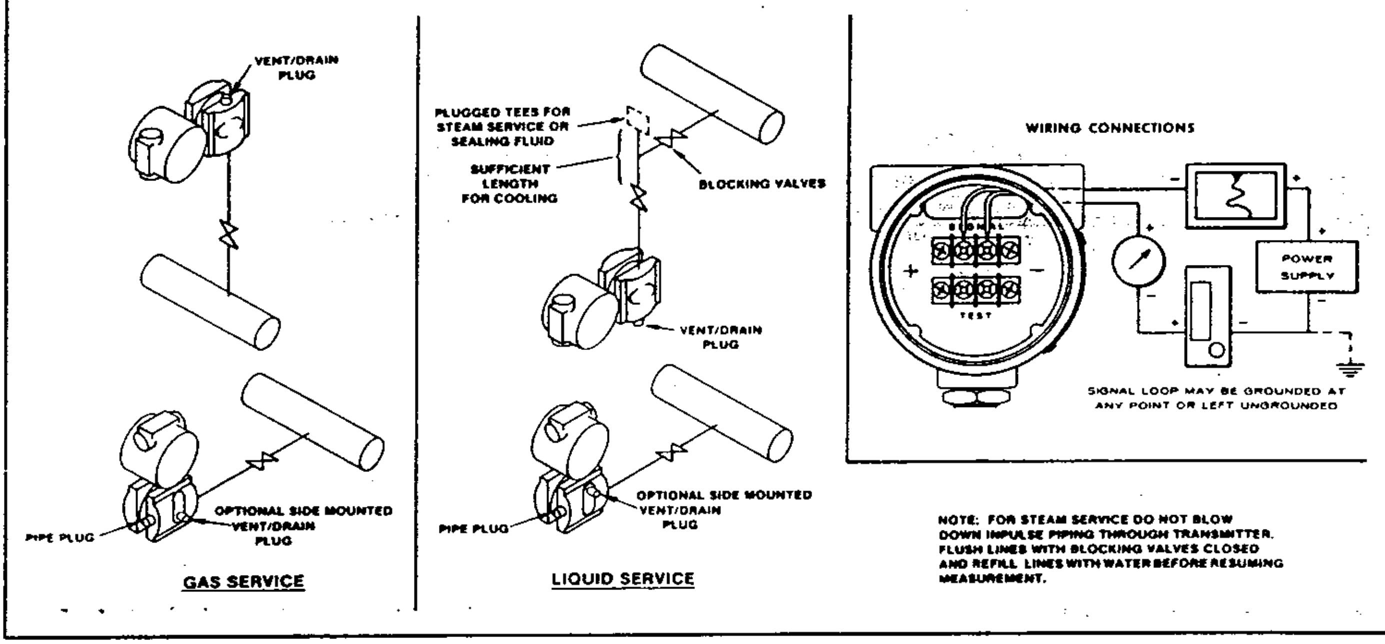
Conduit connections on the transmitter housing should be sealed or plugged (using a sealing compound) to avoid accumulation of moisture in the housing. If the connections are not sealed, the transmitter should be mounted with the electrical housing downward for draining.

Signal wiring may be ungrounded (floating) or grounded at any place in the signal loop. The transmitter case may be grounded or ungrounded. Power supply regulation is not critical, even with a power supply ripple of 1 volt peak to peak, the ripple in the output signal would be negligible.

Because the transmitter is capacitance coupled to ground, insulation resistance should not be checked with a high voltage megger. No more than 100 volts should be used in circuit checks.

Output current is limited to 30 mADC on the 4-20 mADC unit and 150 mADC on the 10-50 mADC unit.

FIGURE 1
INSTALLATION



CALIBRATION – E Output Option (4-20 mA)

SPAN ADJUSTMENT RANGE

The span on all 1151 transmitters is continuously adjustable to allow calibration anywhere between maximum span and 1/6 of maximum span. For example, the span on a range 4 transmitter can be continuously adjusted between 0-150" H_2O to 0-25" H_2O.

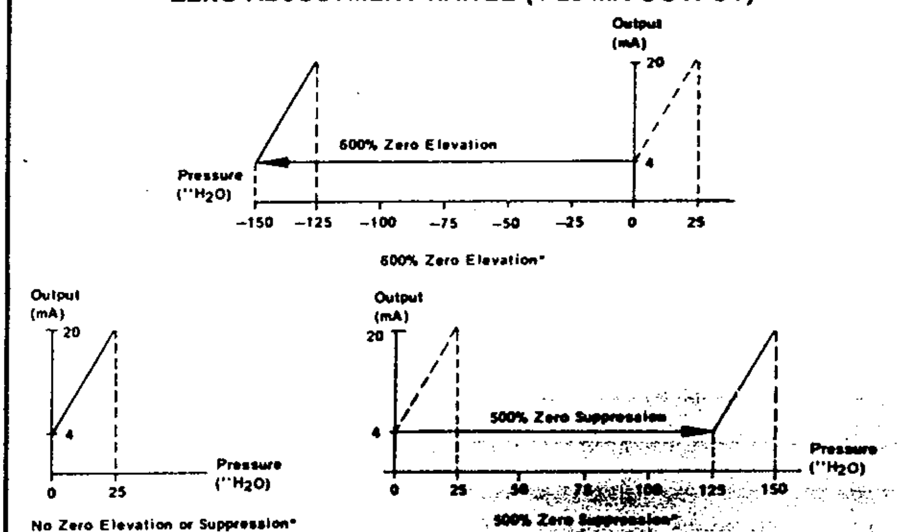
ZERO ADJUSTMENT RANGE

Model 1151GP with E output code can be adjusted for zero suppression up to 500% of span, or 600% zero elevation, down to 28" Hg vacuum (See Figure 2). Model 1151AP can be adjusted for zero suppression up to 500% of span (absolute).

The zero may be elevated or suppressed to the above extremes with the limitation that no applied pressure within the calibrated range exceeds the full-range pressure limit. For example, a range 4 1151 cannot be calibrated for 100" to 200" H_2O (only 100% zero suppression) because the 200" H_2O exceeds the 150" H_2O full-range pressure limit of a range 4.

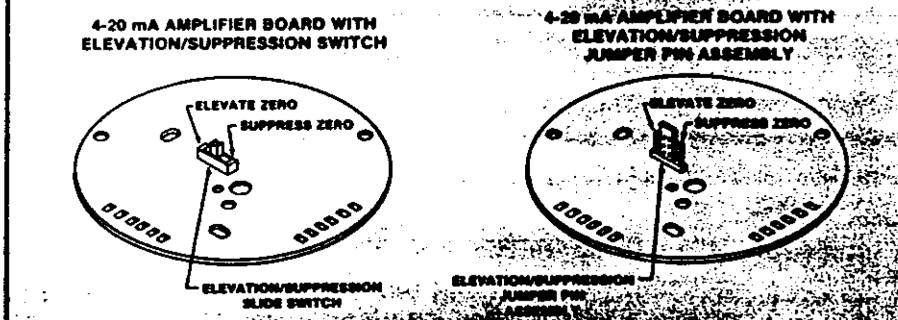
In order to achieve large amounts of elevation or suppression it is necessary to make an adjustment on the component side of the amplifier board. On this board is either an elevation/suppression switch, or a jumper pin assembly (which has replaced the switch, see Figure 3). The slide switch, or jumper pin, has three positions. The middle position will allow normal amounts of elevation or suppression. In order to achieve large amounts of elevation or suppression it is necessary to move the switch, or jumper, to the "elevate zero"

FIGURE 2
ZERO ADJUSTMENT RANGE (4-20 mA OUTPUT)



*Graphs based on a range 4 (0–25" H_2O to 0–150" H_2O) 1151 with a calibrated span of 25" H_2O)

FIGURE 3
ACHIEVING MAXIMUM ELEVATION AND SUPPRESSION



NOTE: THE SWITCH, OR JUMPER PIN, IS LOCATED ON THE COMPONENT SIDE OF THE AMPLIFIER BOARD. BOARD MUST BE UNPLUGGED FROM TRANSMITTER TO GAIN ACCESS TO THIS COMPONET.

or "suppress zero" position. The 1151GP transmitter may be calibrated to cross zero (e.g., −75" H_2O to +75" H_2O) but this may result in a slight reduction in linearity, which can be corrected by linearity adjustment. Note: Always insure that the jumper is fully seated on its pins. In the event that the jumper has not been placed in any of the three positions, the amplifier board will function to provide normal amounts of elevation or suppression.

Recommended Procedure for Zero and Span Adjustment

The zero and span adjustment screws are accessible externally and are located behind the nameplate on the side of the electronics housing (Figure 4). The output of the transmitter increases with clockwise rotation of the adjustment screws.

The zero adjustment screw and the "elevate/suppress zero" switch have very little effect on the span. The span adjustment, however, does affect zero. The effect is minimized with no suppression or elevation, where the span adjustment changes the zero output and the full-scale output by approximately the same percentage. Therefore, it is best to calibrate the transmitter from 0 to the desired span and finish the calibration by adjusting the zero screw (and elevate/suppress zero switch if necessary) to achieve the desired elevation or suppression.

Example (for an 1151GP4)
Initial Transmitter Calibration: 25 to 125" H_2O (100" H_2O span with zero suppressed 25" H_2O)
Desired Transmitter Calibration: 125" to 150" H_2O (25" H_2O span with zero suppressed 125" H_2O).

A. Adjust zero to eliminate any existing zero elevation or suppression. With 0" pressure applied to transmitter, turn zero adjustment clockwise until output reads 4 mA. The unit is now calibrated 0 to 100" H_2O.

B. Adjust the span to the desired new span. To reduce the span, turn the span screw clockwise until the output, with 0" H_2O pressure input, equals

$$4 \text{ mA} \times \left(\frac{\text{Existing Span}}{\text{Desired Span}}\right) = 4 \text{ mA} \left(\frac{100"}{25"}\right) = 16 \text{ mA}$$

(If the span was to be increased from 25 to 100" H_2O the span screw would be turned counterclockwise until the output, with 25" H_2O input, equalled

$$20 \text{ mA} \times \left(\frac{\text{Existing Span}}{\text{Desired Span}}\right) = 20 \text{ mA} \left(\frac{25"}{100"}\right) = 5 \text{ mA}$$

C. Adjust the zero screw counterclockwise to bring the output, with 0" input, back to 4 mA. The transmitter calibration should now be very close to 0 to 25" H_2O.

D. Check full-span output and fine tune the span and zero adjustment if required. Remember zero adjustments do not affect span, but span adjustments do affect zero predictably. Adjusting the span screw will affect the zero 1/5 as much as it affects the span. To compensate for this effect, simply overcompensate by 25%. For example, if, after completing Step C, the transmitter output read 19.900 mA at 25" H_2O the span pot would be turned clockwise until the output (at 25" H_2O) read 20.025 mA.

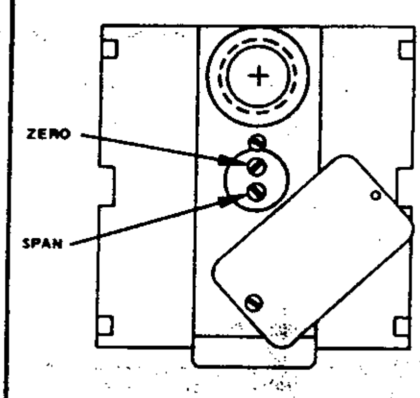
$$19.900 + (20.000 - 19.900) \times 1.25 = 19.900 + .125 = 20.025.$$

Since the span adjustment affects zero 1/5 as much as the span, the .125 mA increase in span causes a .025 mA increase in zero. Therefore, turn the zero adjustment counterclockwise (at 25" H_2O) until the output reads 20.000 mA. The unit should now be calibrated for 0 to 25" H_2O).

E. Suppress Zero. Turn zero screw counterclockwise until the output reads 4 mA with 125" H_2O applied to the high side of the transmitter. The output may stop changing before the desired 4 mA reading is obtained. If this occurs, turn off power to the unit, unplug the amplifier board (refer to exploded view and parts list in the back of this manual to locate the amplifier board), change the switch position (Figure 3) to "suppress zero", plug the amplifier back in and complete the zero adjustment. If the zero was being elevated, the same basic procedure would apply except the switch would be thrown to the elevate zero position.

F. Recheck full scale and zero and fine tune if necessary.

FIGURE 4
ZERO AND SPAN ADJUSTMENT



There is some mechanical backlash in the zero and span adjustments, so there will be a dead band when direction of adjustment is changed. Because of the backlash, the simplest procedure, if the desired setting is overshot, is to purposely overshoot a larger amount before reversing the direction of the adjustment.

Linearity Adjustment

In addition to the span and zero adjustments, there is a linearity adjustment located on the solder side of the amplifier board (Figure 5). This is a factory calibration adjusted for optimum performance over the calibrated range of the instrument and is not normally adjusted in the field. If it is desired to maximize linearity over some particular range, the following procedure should be used:

1. Apply mid-range pressure and note the error between theoretical and actual output signal.

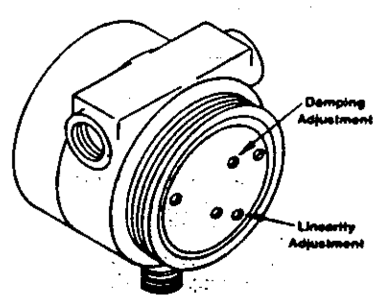
2. Apply full-scale pressure. Multiply the error noted in Step 1 by six and by the range down factor.

$$\text{Range Down Factor} = \frac{\text{Maximum Allowable Span}}{\text{Calibrated Span}}$$

Add the result to the full scale output for negative errors, or subtract the result from the full-scale output for positive errors, by adjusting the trimmer marked "Linearity" (Figure 5). Example: At 4 to 1 range down the midscale point is low by .05 mA. Therefore, adjust "Linearity" trimmer until full-scale output increases by (0.05 mA x 6 x 4) = 1.2 mA.

3. Readjust zero and span.

FIGURE 5
LINEARITY ADJUSTMENT
(4-20 mA OUTPUT)



Access to linearity and damping adjustments is gained by simply removing cover on circuit board side

Damping Adjustment

The E output 4-20 mA amplifier board is designed to permit damping of rapid pulsations in the pressure source by adjusting the trimmer marked "Damping" located on the solder side of the amplifier board (Figure 5). The settings available provide time constant values between 0.2 seconds (nominal) and 1.66 seconds. The instrument is calibrated and shipped with this adjustment set at the counterclockwise stop (0.2 second time constant). It is recommended that the shortest possible time constant setting be selected. Since the transmitter calibration is not influenced by the time constant setting, the damping adjustment may be set with the transmitter installed on the process. Turn the "Damping" adjustment clockwise until the desired damping is obtained. **Caution.** The pot has positive stops at both ends. Forcing the pot beyond the stops may cause permanent damage.

CALIBRATION – B Output Option (10-50 mA)

ZERO AND SPAN ADJUSTMENT

The full region in which span and zero can be adjusted is shown in Figure 6. The shaded area represents the maximum boundaries, but is not the only restriction on settings. Span is limited by 6 to 1 ranging, for example, 25 to 150" H_2O on the 1151GP4. Zero suppression and elevation for the 1151GP is limited to 150% of span (50% for ranges 6, 7, 8, 9 and 0) and can be elevated for compound gage ranges down to 28" HgV. Zero adjustment for the 1151AP is limited to zero suppression of 150% of span (50% for ranges 6, 7 and 8). The range can cross zero (e.g., span of 765 psi from –15 psi to 750 psi) but may result in a slight reduction of linearity. A further limitation on zero adjustment is that the top of the span may not exceed the maximum range.

RECOMMENDED PROCEDURE FOR ZERO AND SPAN ADJUSTMENT (RANGES 3, 4 AND 5)

The zero and span adjustment screws are accessible externally and are located behind the nameplate on the side of the electronics housing (Fig. 6). Adjustment of zero has negligible affect on the span. Span adjustment does effect zero and will have a noticeable effect when zero is elevated or suppressed because the span is rotated about a point close to zero gage pressure. The following example shows the proper sequence for changing a 75 to 150" H_2O range (suppressed zero of 75" H_2O, span of 75" H_2O) to a range of 60" H_2O to 150" H_2O. Please refer to Figure 6.

1. Turn the zero adjustment in the clockwise direction to bring the range from 75-150" down to 0-75" H_2O.

2. Turn the span adjustment in the counterclockwise direction to bring the range from 0-75" H_2O to 0-90" H_2O.

3. Turn the zero adjustment in the counterclockwise direction to bring the range from 0 to 90" H_2O to 60 to 150" H_2O.

4. Recheck full scale and zero adjust as necessary.

There is some mechanical backlash in the zero and span adjustments, so there will be a dead band when direction of adjustment is changed. Because of the backlash, the simplest procedure if the desired setting is slightly overshot is to purposely overshoot a larger amount before reversing the direction of adjustment.

RECOMMENDED PROCEDURE FOR ZERO AND SPAN ADJUSTMENT (RANGES 6, 7, 8, 9 and 0)

Adjustment of zero has negligible effect on the span. Span adjustment has a significant effect on zero. Because of this effect, when adjusting range, an increase in the full scale reading will only account for part of an increase in span. (A drop in the zero reading will account for the remaining portion of the span increase.) This effect becomes increasingly more pronounced as the span is decreased. In fact, the span effect on zero is great enough in some instances to cause a decrease in full scale output with an increase in span.

The recommended procedure is to adjust span first. This requires taking readings at both desired full scale and zero pressures.

As part of the range adjustment, it is necessary to keep zero above 10 mA. (The exact value of zero is unimportant at this stage.)

After adjusting span, adjust zero. The zero adjustment has very little effect on span and should be the last adjustment to be made.

LINEARITY ADJUSTMENT

In addition to the span and zero adjustments, there is a linearity adjustment located inside the transmitter on the calibration board (Figure 7). This is a factory calibration and is not normally adjusted in the field. Linearity is factory adjusted for optimum performance over the calibrated range of the instrument. If it is desired to maximize linearity over some particular range, the following procedure should be used:

1. Apply mid-range pressure and note the error between theoretical and actual output signal.

2. Apply full-scale pressure. Multiply the error noted in Step 1 by six and by the range down factor.

$$\text{Range Down Factor} = \frac{\text{Maximum Allowable Span}}{\text{Calibrated Span}}$$

Add the result to the full-scale output for negative errors, or subtract the result from the full-scale output for positive errors, by adjusting the trimmer marked "Linearity" (Figure 7). Example: At 4 to 1 range down the midscale point is low by 0.05 mA. Therefore, adjust "Linearity" trimmer until full-scale output increases by (.05 mA x 6 x 4) = 1.2 mA.

3. Readjust zero and span.

FIGURE 6
ZERO AND SPAN ADJUSTMENTS FOR 10-50 mA OUTPUT

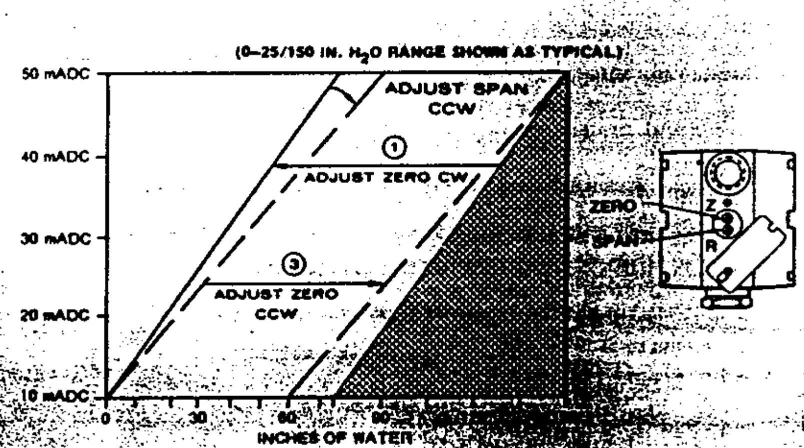


FIGURE 7
LINEARITY ADJUSTMENT (10-50 mA OUTPUT)

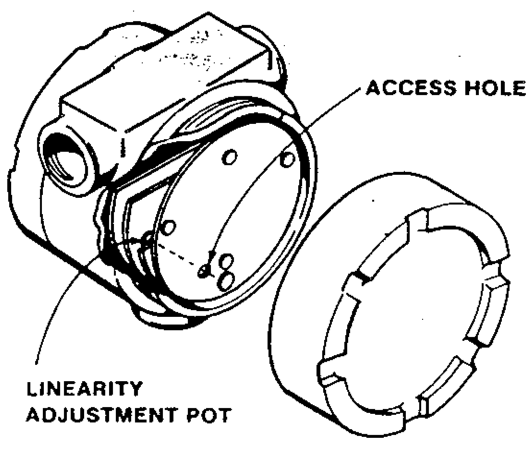
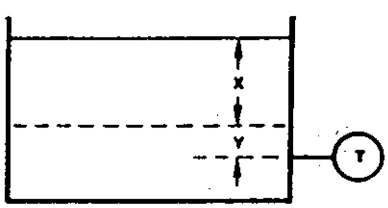


FIGURE 8
LEVEL MEASUREMENT EXAMPLE



Let X equal the vertical distance between the minimum and maximum measurable levels (500 inches.)
Let Y equal the vertical distance between the transmitter datum line and the minimum measurable level (100 inches.)
Let SG equal the specific gravity of the fluid (0.9).
Let **h** equal the maximum head pressure produced by **X**, expressed in inches of water.
Let **e** equal head pressure produced by **Y**, expressed in inches of water.
Range equals **e** to **e + h**.

Then h = **(X) (SG)**
= 500 x 0.9
= 450 inches WC
e = **(Y) (SG)**
= 100 x 0.9
= 90 inches WC
Range = 90 to 540 inches WC

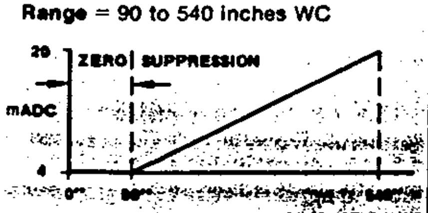
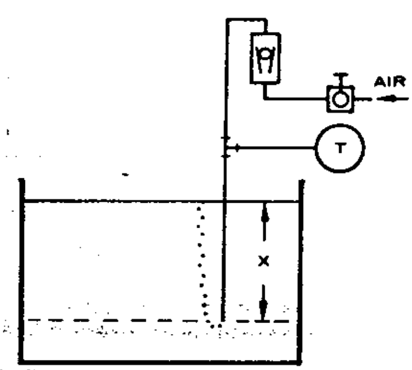
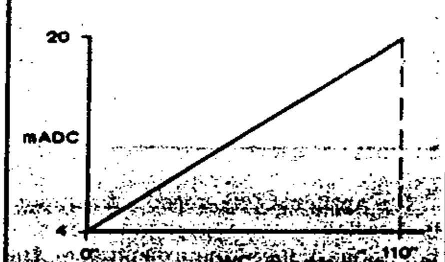


FIGURE 9
"BUBBLER" SYSTEM EXAMPLE



Let X equal the vertical distance between the minimum and maximum measurable levels (100 inches).
Let **SG** equal the specific gravity of the fluid (1.1).
Let **h** equal the maximum head pressure produced by **X**, expressed in inches of water.
Range equals zero to h.

Range equals 0 to 110 inches WC.



HAZARDOUS LOCATIONS

Factory Mutual explosion proof certification is standard for the 1151 series. Other certifications are available as options. In order to maintain these certified ratings for installed transmitters, they must be installed in accordance with all applicable codes and standards.

Liquid Level Measurement

IN OPEN VESSELS

Gage pressure transmitters, used for liquid level, measure hydrostatic pressure head. This pressure is equal to the liquid height above the tap multiplied by the specific gravity of the liquid. It is independent of volume or vessel shape.

In open vessels a pressure transmitter mounted near the bottom of the tank will measure the pressure corresponding to the height of the fluid above it.

The connection is made to the high pressure side of the transmitter. The low pressure side is vented to atmosphere.

If the zero point of the desired level range is above the transmitter, zero suppression of the range must be made.

"BUBBLER" SYSTEM FOR LIQUID LEVEL MEASUREMENT

A "bubbler" system using a top mounted pressure transmitter can be used in open vessels. This system consists of an air supply, a pressure regulator, a constant flow meter, a pressure transmitter, and tube extending down into the vessel.

Air is bubbled through the tube at a constant flow rate. The pressure required to maintain flow is determined by the vertical height of the liquid above the tube opening times the specific gravity.

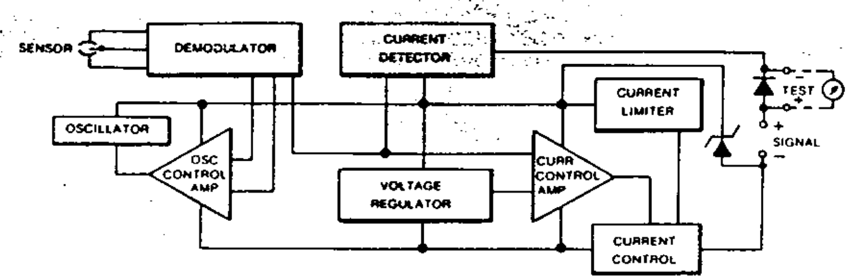
OPERATION SECTION

GENERAL

The block diagram in Figure 10 illustrates the operation of the system. A schematic diagram is shown in the Parts List Section of this manual.

The Rosemount Model 1151 Series ALPHALINE Pressure Transmitters have a variable capacitance sensing element, the δ-CELL (Figure 11). Differential capacitance between the sensing diaphragm and the capacitor plates is converted electronically to a 2-wire 4-20 mADC signal.

FIGURE 10
ELECTRICAL BLOCK DIAGRAM



1. $P = K_1 \dfrac{C_1 - C_2}{C_1 + C_2}$

WHERE:

- P is the process pressure.
- K_1 is a constant.
- C_1 is the capacitance between the high pressure side and the sensing diaphragm.
- C_2 is the capacitance between the low pressure side and the sensing diaphragm.

2. $fV_{pp} = \dfrac{I_{ref}}{C_1 + C_2}$

WHERE:

- I_{ref} is the current source.
- V_{pp} is the peak-to-peak oscillation voltage.
- f is the oscillation frequency.

3. $I_{diff} = fV_{pp}(C_1 - C_2)$

WHERE:

- I_{diff} is the difference in current between C_1 and C_2.

4. $I_{sig} = K_2 \times I_{diff}$

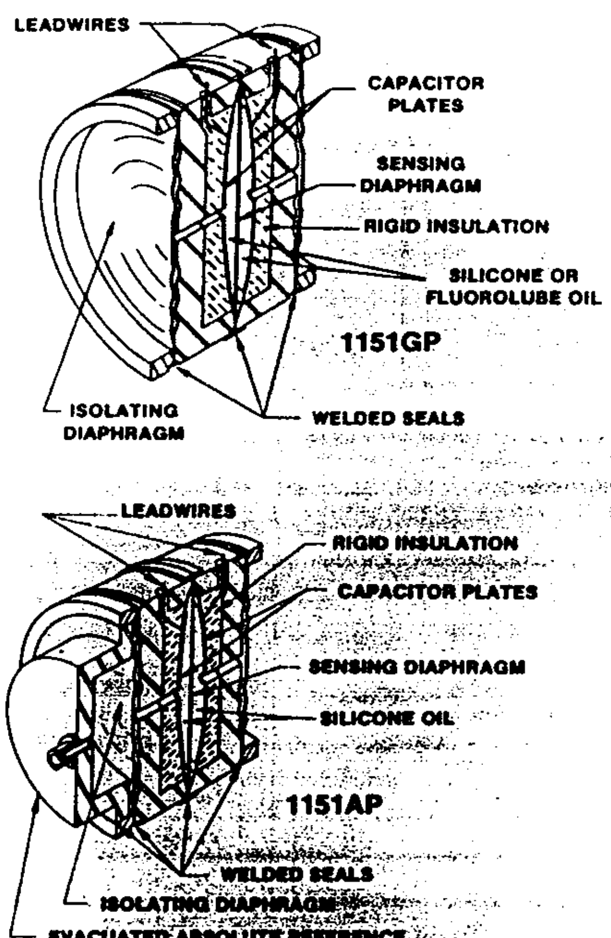
WHERE:

- I_{sig} is the signal current.
- K_2 is a constant.

THEREFORE:

$$I_{sig} = K_2 I_{ref} \frac{C_1 - C_2}{C_1 + C_2} = \text{Constant} \times P.$$

FIGURE 11
THE δ-CELL



THEORY OF OPERATION
E Output Option (4-20 mA)

THE δ-CELL SENSOR

Process pressure is transmitted through an isolating diaphragm and silicone oil fill fluid to a sensing diaphragm in the center of the δ-CELL. The reference pressure is transmitted in like manner to the other side of the sensing diaphragm.

The position of the sensing diaphragm is detected by the capacitance plates on both sides of the sensing diaphragm. The capacitance between the sensing diaphragm and either capacitor plate is approximately 150 pf. The sensor is driven by an oscillator at roughly 32 KHz and 30 V_{p-p}. It is then rectified through a demodulator.

DEMODULATOR

The demodulator consists of a diode bridge D1-D8 which rectifies the AC signal (refer to drawing 1151-0135 in Drawings and Schematics section).

The oscillator driving current I_{ref} is the sum of the DC currents through transformer windings 1-12 and 3-10 are summed and controlled to be a constant by IC1 driving the oscillator.

The DC current through transformer winding 2-11 is a current directly proportional to pressure; i.e.,

$$I_{diff.} = fV_{pp}(C_1 - C_2)$$

The diode bridge and span temperature compensating thermistor are located inside the sensor module. The effect of the thermistor is controlled by resistors R4 and R5 located in the electronics housing.

LINEARITY ADJUSTMENT

Linearity is adjusted by a variable resistance network (R20, R22 and R23), capacitor C3 and diodes D9 and D10. The currents generated through this part of the circuit are summed into the inputs of the oscillator control circuit. This provides a programmed correction which raises the oscillator peak-to-peak voltage to compensate for first order nonlinearity of capacitance as a function of pressure.

OSCILLATOR

The oscillator, consisting of components Q1, T1, C19, C20, R29 and R30 has a frequency determined by the capacitance of the sensing element and the inductance of the transformer windings.

The sensing element capacitance is variable. Therefore, the frequency is variable about a nominal value of 32KHz.

IC1 is used as a feedback control circuit and controls the oscillator drive voltage such that:

$$fV_{pp} = \frac{I_{ref}}{C_1 + C_2}$$

VOLTAGE REGULATOR

The transmitter uses zener diode D11, transistor Q2 and resistors R15 and R16 to provide a constant voltage of 6.4 VDC for the reference and 7 VDC to supply the oscillator, IC1, IC2, and IC3.

ZERO AND SPAN ADJUSTMENTS

Zero adjustment components consist of potentiometer R35 and resistor R36 which develop a separate adjustable current that sums with the sensor current. Resistors R20 or R21 may be switched in by SW1 to add another fixed zero current which shifts the range of zero adjustment to allow larger amounts of suppression or elevation.

Span adjustment is performed with R32 which determines the amount of loop current which is sensed and fed back to the current control amplifier IC3.

CURRENT CONTROL

The current control amplifier consists of IC3, Q3, Q4 and associated components. The IC reference voltage is established at the junction of R10 and R13.

The current control amplifier drives the current control to a level such that the current detector feeds back a signal through R34 equal to the sum of the zero current and the variable sensor current.

CURRENT LIMIT

The current limit consisting of R18 and Q2 prevents the output current from exceeding 30 mA in an overpressure condition.

REVERSE POLARITY PROTECTION "E" OUTPUT

Reverse polarity protection is provided by diode D14 except when an integral meter is connected across the test terminals, in which case, diode D13 provides limited protection.

THEORY OF OPERATION B Output Option (10-50 mA)

THE δ-CELL SENSOR

Process pressure is transmitted through an isolating diaphragm and silicone oil fill fluid to a sensing diaphragm in the center of the δ-CELL. The reference pressure is transmitted in like manner to the other side of the sensing diaphragm.

The position of the sensing diaphragm is detected by the capacitance plates on both sides of the sensing diaphragm. The capacitance between the sensing diaphragm and either capacitor plate is approximately 150 pf. The sensor is driven by an oscillator, at roughly 50 KHz and 50 V_{pp}. It is then rectified through a demodulator.

DEMODULATOR

The demodulator consists of a diode bridge D1 through D8 which rectifies the AC signal. (Refer to Drawing 1151-4 in the Drawings and Schematics section.)

The DC currents through transformer windings T1-12 and T3-10 are summed and controlled to be a constant by IC1 driving the oscillator.

The DC currents through transformer windings T2-11 and T4-9 are algebraically summed. The net current is directly proportional to pressure; i.e.,

$$I_{diff} = fV_{pp}(C_1 - C_2).$$

The diode bridge and a span temperature compensating thermistor are located inside the sensor module. The effect of the thermistor is controlled by resistors R4 and R5 located in the electronics housing.

LINEARITY ADJUSTMENT

Linearity is adjusted by a variable capacitor network (C3 and C4) and diodes D9 and D10. The current generated through this part of the circuit is summed into the input of the oscillator control circuit. This provides a programmed correction which raises the oscillator peak-to-peak voltage to compensate for first order nonlinearity of capacitance as a function of pressure.

OSCILLATOR

The oscillator, consisting of components Q1, T1, C15 and C10, has a frequency determined by the capacitance of the sensing element and the inductance of the transformer windings.

The sensing element capacitance is variable. Therefore, the frequency is variable about a nominal value 50 KHz.

IC1 is used in a feedback control circuit and controls the oscillator drive voltage such that:

$$fV_{pp} = \frac{I_{ref}}{C_1 + C_2}$$

VOLTAGE REGULATOR

The transmitter uses zener diode D12 to provide a constant voltage supply of 6.2 VDC for reference. Q4, D15, and D16 are a constant current source providing power for IC1, IC2, and the oscillator.

ZERO AND SPAN ADJUSTMENTS

The zero and span adjustments are resistive potentiometers (R7 and R8).

The span potentiometer and R15 divide the δ-CELL sensing element current. It takes 0-320 μA sensor current and splits off 0-40 μA to the input of the current amplifier.

The zero potentiometer develops a separate adjustable current that sums with the current of the span potentiometer at Pin 11.

CURRENT CONTROL

The current control amplifier circuit consists of IC2 and Q3. The IC reference voltage is established at the junction of R17 and R21.

The 0-40 μA sensor current flows into the junction R16 and R20. This tries to suppress the voltage across the lower leg of the divider. The IC drives this voltage back to reference, which results in a change in voltage across R14. This change in voltage across R14 is proportional to pressure and to the output current.

REVERSE POLARITY PROTECTION "B" OUTPUT

Reverse polarity protection provided by diode D17.

Specifications - 1151AP Absolute Pressure Transmitter

Functional Specifications

Service
Liquid, gas or vapor.

Ranges
0-2/11 inches HgA (0-6.77 to 0-37.25 kPa)
0-10/55 inches HgA (0-33.86 to 0-186.25 kPa)
0-17/100 psia (0-117.21 to 0-689.48 kPa)
0-50/300 psia (0-0.34 to 0-2.07 MPa)
0-170/1000 psia (0-1.17 to 0-6.89 MPa)

Outputs
4-20 mADC or 10-50 mADC.

Power Supply
External power supply required.
4-20 mADC: Transmitter operates on 12 VDC to 45 VDC with no load.
10-50 mADC: Transmitters operates on 30 VDC to 85 VDC with no load.

Load Limitations See Figure 12.

Indication
Optional meter with 1-3/4" scale. Indication accuracy is ±2%.

Hazardous Locations
Factory Mutual (FM) Approvals:
Explosion Proof: Class I, Divisions 1 and 2, Groups B, C, and D.
Dust-Ignition Proof: Class II, Divisions 1 and 2, Groups E, F, and G.
Suitable For Use In: Class III, Divisions 1 and 2. Indoor and outdoor use. NEMA 4X.

Canadian Standards Association (CSA) Approvals:
Certified for Class I, Division 2, Groups A, B, C, and D; Class I, Division 1, Groups C and D; Class II, Divisions 1 and 2, Groups E, F, and G; Class III hazardous locations; CSA enclosure 4; Factory sealed.

Intrinsic Safety Approvals:
FM and CSA certifications optional for specific Classes, Divisions, and Groups when connected with approved barrier systems. See summary in PDS 2360.

FM Explosion Proof tag standard. Appropriate tag will be substituted if optional certification is selected.

Span and Zero
Continuously adjustable externally.

Zero Suppression
Regardless of output specified, zero suppression must be such that neither the span nor the upper or lower range value exceed 100% of the upper range limit.
4-20 mADC Maximum zero suppression: 500% of calibrated span.
10-50 mADC Maximum zero suppression: 150% of calibrated span for ranges 4 and 5, and 50% of calibrated span for ranges 6, 7 and 8.

Temperature Limits
−20°F to +200°F Amplifier operating.
−40°F to +220°F Sensing element operating.
−60°F to +250°F Storage.

Overpressure Limits
0 psia to 2000 psi without damage to the transmitter. 10,000 psig proof pressure on the flanges.

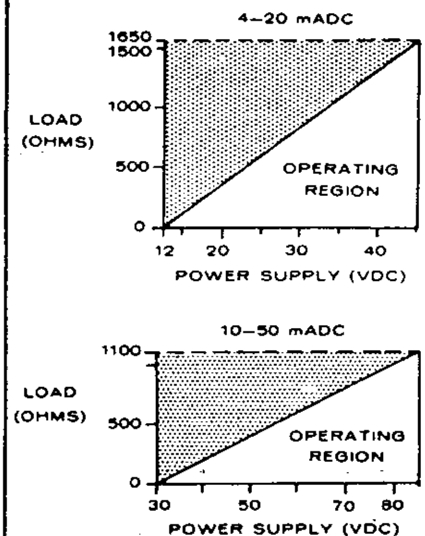
Humidity Limits
0-100% RH.

Volumetric Displacement
Less than 0.01 cubic inches.

Damping
4-20 mADC: Time constant continuously adjustable between 0.2 and 1.67 seconds.
10-50 mADC: Time constant fixed at 0.2 second for ranges 4 and 5, and 0.1 second for ranges 6, 7 and 8.

Turn-on Time
2 seconds. No warmup required.

FIGURE 12
LOAD LIMITATIONS



Performance Specifications

(ZERO BASED SPANS, REFERENCE CONDITIONS, 316SS ISOLATING DIAPHRAGMS)

Accuracy
±0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability.

Stability
±0.25% of upper range limit for 6 months.

Temperature Effect

At Maximum Span (e.g. 0-100 psia for 0-17/100 psia range)
Zero Error: ±0.5% of span per 100°F. Total effect including span and zero errors: ±1.0% of span per 100°F.

At Minimum Span (e.g. 0-17 psia for 0-17/100 psia range)
Zero Error: ±3.0% of span per 100°F. Total effect including span and zero errors: ±3.5% of span per 100°F.

Vibration Effect
±0.05% of upper range limit per g to 200 Hz in any axis.

Power Supply Effect
Less than 0.005% of output span per volt.

Load Effect
No load effect other than the change in power supplied to the transmitter.

Mounting Position Effect
Zero shift of up to 1" H_2O which can be calibrated out. No span effect. No effect in plane of diaphragm.

Physical Specifications

Materials of Construction†

Isolating Diaphragms and Drain/Vent Valves:
316SS, HASTELLOY C or MONEL.

Process Flange and Adapter:
Cadmium or Nickel-plated Carbon Steel, 316SS, HASTELLOY C or MONEL.

Wetted O-Rings:
VITON.

Fill Fluid:
Silicone Oil.

Bolting Flange and Bolts:
Cadmium Plated Carbon Steel.

Electronics Housing:
Low-copper aluminum (NEMA4)

Paint:
Epoxy-polyester.

Process Connections:
1/4-NPT on flange, 1/2-NPT on adapter.

Electrical Connections:
1/2-inch conduit with screw terminals and integral test jacks compatible with miniature banana plugs (Pomona 2944, 3690 or equal).

Weight:
12 pounds excluding options.

†MONEL is a trademark of International Nickel Co.
HASTELLOY is a trademark of the Cabot Corp.
VITON is a trademark of E.I. DuPont De Nemours & Co.
Terminology per SAMA Standard PMC20.1-1973.

Specifications - 1151GP Gage Pressure Transmitter

Functional Specifications

Service Liquid, gas or vapor.

Ranges
0-5/30 in. H_2O (0-1.25 to 0-7.46 kPa)(reverse flanges for vacuum)
0-25/150 in. H_2O (0-6.22 to 0-37.29 kPa)(reverse flanges for vacuum)
0-125/750 in. H_2O (0-31.08 to 0-186.45 kPa)(reverse flanges for vacuum)
0-17/100 psig (0-117.21 to 0-689.48 kPa)
0-50/300 psig (0-0.34 to 0-2.07 MPa)
0-170/1000 psig (0-1.17 to 0-6.89 MPa)
0-500/3000 psig (0-3.45 to 0-20.68 MPa)
0-1000/6000 psig (0-6.89 to 0-41.37 MPa)

Outputs 4-20 mADC or 10-50 mADC.

Power Supply
External power supply required.
4-20 mADC: Transmitter operates on 12 VDC to 45 VDC with no load.
10-50 mADC: Transmitter operates on 30 VDC ot 85 VDC with no load.

Load Limitations See Figure 12.

Indication
Optional meter with 1-3/4", 0-100% scale. Indication accuracy is ±2% of span.

Hazardous Locations
Factory Mutual (FM) Approvals:
Explosion Proof: Class I, Divisions 1 and 2, Groups B, C, and D.
Dust-Ignition Proof: Class II, Divisions 1 and 2, Groups E, F, and G.
Suitable For Use In: Class III, Divisions 1 and 2. Indoor and outdoor use. NEMA 4X.

Canadian Standards Association (CSA) Approvals:
Certified for Class I, Division 2, Groups A, B, C, and D; Class I, Division 1, Groups C and D; Class II, Divisions 1 and 2, Groups E, F, and G; Class III hazardous locations; CSA enclosure 4; Factory sealed.

Intrinsic Safety Approvals:
FM and CSA certifications optional for specific Classes, Divisions, and Groups when connected with approved barrier systems. See summary in PDS 2360.

FM Explosion Proof tag standard. Appropriate tag will be substituted if optional certification is selected.

Span and Zero
Continuously adjustable externally.

Zero Elevation and Suppression
Regardless of output specified, zero elevation and suppression must be such that neither the span nor the upper or lower range value, exceed 100% of the upper range limit.
4-20 mADC Maximum zero elevation: 600% of calibrated span. Maximum zero suppression: 500% of calibrated span.
10-50 mADC Maximum zero elevation or suppression: 150% of calibrated span for ranges 3, 4 and 5; 50% of calibrated span for ranges 6, 7, 8, 9 and 0.

Temperature Limits
−20°F to +200°F Amplifier operating.
−40°F to +220°F Sensing element operating with Silicone fill.
+32°F to +160°F Sensing element operating with Fluorolube fill.
−60°F to +250°F Storage.

Overpressure Limits
0 psia to 2000 psi for ranges to 1000 psig, 4500 psi for the 3000 psig range and 7500 psi for the 6000 psig range without damage to the transmitter. Operates within specifications for pressure above 1/2 psia for silicone oil transmitters and above atmospheric pressure for fluorolube filled transmitters. 10,000 psig proof pressure on flanges.

Humidity Limits 0-100% RH.

Volumetric Displacement
Less than 0.01 cubic inches.

Damping
4-20 mADC: Time constant continuously adjustable between 0.2 (0.4 for range 3) to 1.67 seconds for silicone fill.
10-50 mADC: Time constant fixed at 0.4 second for range 3, 0.2 second for range 4 and 5 and 0.1 second for range 6 and 7, 8, 9 and 0 for silicone fill.
Fluorolube Fill: Higher time constant.

Turn-on Time
2 seconds. No warmup required.

Performance Specifications

(ZERO BASED SPANS, REFERENCE CONDITIONS, SILICONE OIL FILL, 316SS ISOLATING DIAPHRAGMS)

Accuracy
±0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability.

Stability
±0.25% of upper range limit for six months.

Temperature Effect
At Maximum Span (e.g. 0-100 psig for 0-17/100 psig range)
Zero Error: ±0.5% of span per 100°F.
Total effect including span and zero errors: ±1.0% of span per 100°F.

Note: Double the specified effect for range code 3.

At Minimum Span (e.g. 0-17 psig for 0-17/100 psig range)
Zero Error: ±3.0% of span per 100°F.
Total effect including span and zero errors: ±3.5% of span per 100°F.

Note: Double the specified effect for range code 3.

Vibration Effect
±0.05% of upper range limit per g to 200 Hz in any axis.

Power Supply Effect
Less than 0.005% of output span per volt.

Load Effect
No load effect other than the change in power supplied to the transmitter.

Mounting Position Effect
Zero shift of up to 1" H_2O which can be calibrated out. No span effect. No effect in plane of diaphragm.

Physical Specifications

Materials of Construction†

Isolating Diaphragm:
316L SS, HASTELLOY C, MONEL, or Tantalum.

Drain/Vent Valves:
316L SS, HASTELLOY C, or MONEL.

Process Flange and Adapter:
Cadmium or Nickel-plated Carbon Steel, 316SS, HASTELLOY C or MONEL.

Wetted O-Rings:
VITON.

Fill Fluid:
Silicone oil or Fluorolube oil.

Bolting Flange and Bolts:
Cadmium Plated Carbon Steel.

Electronics Housing:
Low-copper aluminum (NEMA 4)

Paint:
Epoxy-Polyester.

Process Connections:
1/4 NPT on flange. 1/2 NPT on adapter.

Electrical Connections:
1/2-inch conduit with screw terminals and integral test jacks compatible with miniature banana plugs (Pomona 2944, 3690 or equal).

Weight:
12 pounds excluding options.

†MONEL is a trademark of International Nickel Co.
HASTELLOY is a trademark of the Cabot Corp.
VITON is a trademark of E.I. DuPont De Nemours & Co.
Fluorolube is a trademark of the Hooker Chemical Co.
Terminology per SAMA Standard PMC20.1-1973.

MAINTENANCE SECTION

GENERAL

The 1151 Series has no moving parts and requires a minimum of scheduled maintenance. Calibration procedures for adjusting or changing ranges are outlined in the calibration section.

Test terminals are available for in-process checks. For bench checks, the transmitter can be divided into three active physical components: the sensing element, the amplifier board, and the calibration board.

This section outlines a technique for checking out the components, the method for disassembly and reassembly, and a trouble shooting guide.

An illustrated drawing, schematic diagram, parts location and parts list are included in this manual.

TEST TERMINALS

The test terminals are connected across a diode through which the loop signal current passes. The indicating meter or test equipment shunts the diode when connected to the test terminals and as long as the voltage across the terminals is kept below the diode's threshold voltage, no current passes through the diode. To assure that there is no leakage current through the diode when a test reading is being made or when an indicating meter is connected, the resistance of the test connection or meter should not exceed 10 ohms for the 4-20 mADC model or 4 ohms for the 10-50 mADC model. Resistance values of 3 times those shown will cause less than a 1% error. The test terminal screws are bored to accept a miniature banana plug (Pomona 2944, 3690 or equal).

SENSING ELEMENT CHECKOUT

The sensing element (24) is not field repairable and must be replaced if found to be defective. If no obvious defect, such as a punctured isolating diaphragm or loss of fill fluid (isolating diaphragm tightly pressed to backup plate) is observed, the sensing element may be checked in the following manner.

1. Disconnect the header assembly board (16) as described in the disassembly section of the manual. The sensing element need not be removed from the electrical housing for checkout.

2. Jump connections 1 and 2 on the header assembly.

3. Check the resistance between the combined junction and the sensing element housing. This is the resistance between one capacitor plate and the sensing diaphragm, which is grounded to the housing. This resistance should be greater than 10 megohms.

4. On gage units, check the capacitance between the combined junction and the sensing element housing. This capacitance should be 150±30 picofarads.

5. Jump connections 3 and 4 and repeat steps 3 and 4.

CIRCUIT BOARD CHECKOUT

The printed circuit boards (11 and 13) can most easily be checked for a malfunction by substituting a spare into the circuit.

For isolating a failure on the board, refer to the schematic diagram and parts list. Reference voltages are shown on the schematic. A block diagram and a discussion of each function is included under the theory of operation section.

Disassembly Procedure

PROCESS SENSOR BODY

1. Transmitter should be removed from service before disassembling sensor body.

2. Process flanges (25, 27) can be detached by removing the four large bolts (26). CARE SHOULD BE TAKEN NOT TO SCRATCH OR PUNCTURE THE ISOLATING DIAPHRAGMS.

3. Isolating diaphragms may be cleaned with a soft rag and a mild cleaning solution. DO NOT USE ANY CHLORINE OR ACID SOLUTIONS TO CLEAN THE DIAPHRAGMS. Rinse diaphragms with clear water.

4. Flange adapters (21) and process flanges (25) may be rotated for mounting convenience.

ELECTRICAL HOUSING

1. Electrical connections are located in a compartment identified as "Terminal Side" on the nameplate. The signal terminals and the test terminals are accessible by unscrewing the cover (1) on the terminal side. The terminals are permanently attached to the housing and must not be removed, or the housing seal between compartments will be broken. THIS WOULD INVALIDATE THE EXPLOSION PROOF CONSTRUCTION OF THE HOUSING.

2. Circuit boards are located in a separate compartment identified as "Circuit Side" on the nameplate. The circuit boards are accessible by unscrewing the cover (1) on the circuit side. It is good practice to remove power from the transmitter before removing the circuit cover.

3. The 4-20 mADC amplifier board (13) may be unplugged after removing 3 holding screws (14). The 10-50 mADC has one additional screw that is captive to the board that is removed last.

4. The header assembly board (16) is permanently attached to the sensor module (24) and contains the temperature compensating resistors. There is enough slack wire to pull this board off of the pins and out of the way for access to the calibration board (11).

5. The calibration board (11) may be disconnected by removing the three stand-offs (12) and aligning the zero and span adjust screws so that they are perpendicular to the board. The board may be removed by pulling up on the interference pin on the 4-20 mADC board or by inserting a #6-32 screw in the rivnut on the 10-50 mADC board.

6. The zero and range adjustment screws (4) may be removed by removing the nameplate (8) and detaching the snap rings (6).

REMOVING SENSOR FROM ELECTRICAL HOUSING

1. Remove amplifier board and calibration board as described above.

2. Loosen the lock nut (17).

3. Unscrew the sensor module (24) from the electronics housing, being careful not to damage the sensor leads. Then carefully pull the header assembly board through the hole. The threaded connection has a sealing compound on it and must be broken loose. BE CAREFUL NOT TO DAMAGE THE ISOLATING DIAPHRAGMS WHEN UNSCREWING THE SENSOR.

4. The sensor module (24) is a welded assembly and cannot be further disassembled.

Reassembly Procedure

PRELIMINARY

1. Inspect all "O" rings and replace if necessary. Lightly grease with silicone oil to insure a good seal.

2. Inspect threaded connections to make sure five undamaged threads will fully engage for explosion proof requirements.

NOTE: Numbers in parentheses refer to item

CONNECTING ELECTRICAL HOUSING TO SENSOR

1. Insert header assembly board (16) through electronics housing.

2. Use a sealing compound (loctite 222 - Small Screw Threadlocker, Rosemount P/N C12728-0202) on the threads of the sensor module (24) to assure a water tight seal on the electronics.

3. Screw sensor module (24) into electrical housing (3) making sure that five full threads are engaged. Be careful not to damage or twist the sensor leads.

4. Align the sensor module with the high and low pressure sides oriented for convenient installation.

5. Tighten lock nut (17) to approximately 35 ft-lb.

ELECTRICAL HOUSING

1. Examine circuit boards to see that they are clean.

2. Check that "O" rings and snap rings are secure on the zero and span adjustment screws (4). The snap rings must be in place for explosion-proof operation.

3. Make sure that the bayonet connectors on the connection board are clean.

4. *Align the zero and span adjustment screws with the potentiometers on the calibration board (11)* and push the calibration board onto the bayonet connectors. Secure the calibration board with the three standoffs (12). The upper-right-hand standoff grounds the electronics to the case and must be firmly in place.

5. Slide the header assembly board (16) onto the pins with the component side toward the pins. Slide excess wire behind calibration board.

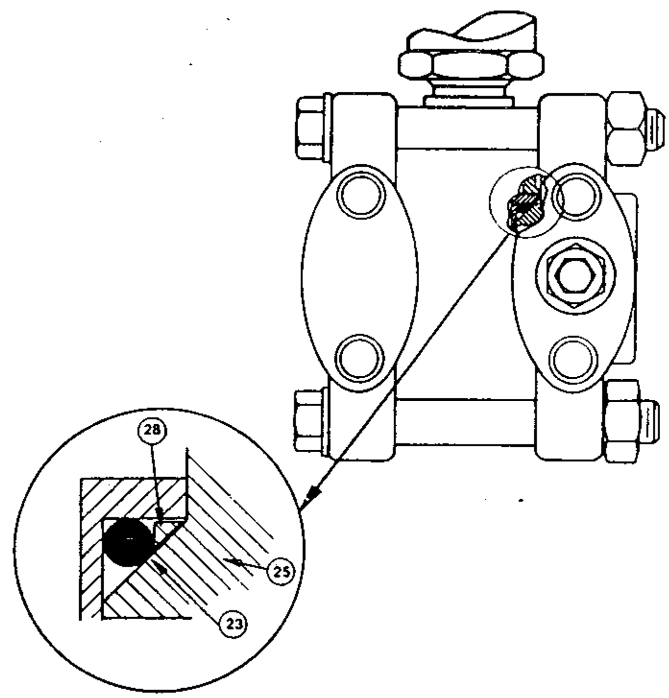
6. Push the amplifier board (13) onto the bayonet connectors and secure with the holding screws (14).

OPTIONAL INDICATING METER

1. Meter may be rotated in its holder bracket for convenient reading.

2. If the meter cover is disassembled for any reason, be sure the "O"-ring (1) is in place between the cover and housing before reassembly. Refer to the Meter Assembly drawing (1151-25) in this manual. Note that the meter needle need not rest on the zero index to meet its 2% accuracy requirement over the full deflected scale. Test the meter with power ON and "tap" for correct reading.

FIGURE 13
DETAIL SHOWING PROCESS O-RING AND BACK-UP RING INSTALLATION MODULE SEAL AREA FOR MODEL 1151GP0 ONLY



PROCESS SENSOR BODY

1. Carefully place the process "O"-ring (23) around the isolating diaphragms.

1a. For 1151GP0 only, a metal back-up ring (28) is required to ensure protection against process flange O-ring extrusion. Refer to Figure 14 and Parts Drawing. Carefully place the rubber process O-rings (23) around the isolating diaphragms, and then install the metal backup rings as shown in Figure 13.

NOTE: It is important to orient the ring chamfer as shown. Handle metal rings with care.

2. Place the flanges (25, 27) in the desired orientation and finger tighten the four bolts (26).

3. Evenly seat the flanges on the sensor housing by the following procedures:

a. Tighten all four bolts finger tight.
b. Tighten 1 bolt until the flanges seat.
c. Torque down the bolt diagonally across from this one.
d. Torque down the first bolt.
e. Torque down the 2 remaining bolts.
f. Inspect the flange to sensor seating to be sure that the flanges are not cocked.
g. Check that all four bolts are torqued to approximately 29 ft-lb.

INTERCHANGE OF PARTS

Mechanical hardware - flanges, flange adapters, electronics housing, electronics covers, and mounting brackets are interchangeable among units without regard to range, calibration, or output signal. Interchange of electronics and sensors is subject to the following conditions:

1. Indicating meters may be added to units or interchanged among units with the same output signal without regard to range, but are not interchangeable between 4-20 mADC output units and 10-50 mADC output units.

2. The amplifier (13) and calibration (11) circuit boards are interchangeable among units with the same output signal without regard to range for models 1151DP, 1151HP, 1151GP, 1151AP, and 1151LLT. The amplifier and calibration boards determine the output signal of the transmitter (4-20 mADC or 10-50 mADC); therefore, the output may be changed by changing board sets. Recalibration will be required after interchanging boards.

3. The header assembly board (16) is permanently attached to the sensor module and is not interchangeable.

NOTE: Numbers in parentheses refer to item numbers on parts drawing 1151-67, 1151-68 and 1151-25 in Parts List Section.

RETURN OF MATERIAL

Material returned for repair, whether in or out of warranty, should be shipped prepaid to the Rosemount factory or to the nearest Rosemount Service Center.

The shipping container should be marked.

Return for Repair
Model________

The factory address is:

Rosemount Inc.
12001 West 78th Street
Eden Prairie, Minnesota 55344
West Bldg., Dock 3
Attn: IIG Systems Service Center

Rosemount Service Centers are located in:

- Baton Rouge, Louisiana
- Charlotte, North Carolina
- Cleveland, Ohio
- Houston, Texas
- Freeport, Texas
- Los Angeles, California
- Calgary, Alberta (Canada)
- Mississauga, Ontario (Canada)

The return material should be accompanied by a letter of transmittal which should include the following:

1. Location, type of service, and length of time in service of the device.

2. Description of the faulty operation of the device and the circumstances of the failure.

3. Name and telephone number of the person to contact if there are questions about the returned material.

4. Statement as to whether warranty or non-warranty service is requested.

5. Complete shipping instructions for the return of the material.

6. Original purchase order number and date of purchase.

Adherence to these procedures will expedite handling of the returned material, and will prevent unnecessary additional charges for inspection and testing to determine the problem with the device.

If the material is returned for out-of-warranty repairs, a purchase order for repairs should be enclosed.

TROUBLESHOOTING

SYMPTOM: High Output

POTENTIAL SOURCE AND CORRECTIVE ACTION

IMPULSE PIPING
Check for leaks or blockage.
Check for liquid in dry lines.
Check for sediment in transmitter process flanges.

TRANSMITTER ELECTRONICS CONNECTIONS
Make sure bayonet connectors are clean and check the sensor connections.
Check that bayonet pin #8 is properly grounded to the case.

TRANSMITTER ELECTRONICS FAILURE
Determine faulty circuit board by trying spare boards. Replace faulty circuit board.

SENSING ELEMENT
See Sensing Element Checkout Section.

POWER SUPPLY
Check output of power supply.

SYMPTOM: Low Output or No Output

POTENTIAL SOURCE AND CORRECTIVE ACTION

LOOP WIRING
Check for shorts and multiple grounds
Check polarity of connections.
Check loop impedance.
NOTE: DO NOT USE OVER 100 VOLTS TO CHECK THE LOOP

IMPULSE PIPING
Check that pressure connection is correct.
Check for leaks or blockage.
Check for entrapped gas in liquid lines.
Check for sediment in transmitter process flanges.

TRANSMITTER ELECTRONICS CONNECTIONS
Check for shorts in sensor leads.
Make sure bayonet connectors are clean and check the sensor connections.
Check that bayonet pin #8 is properly grounded to the case.

TEST DIODE FAILURE
Replace test diode or jumper test terminals.

TRANSMITTER ELECTRONICS FAILURE
Determine faulty circuit board by trying spare boards. Replace faulty circuit board.

SENSING ELEMENT
See Sensing Element Checkout Section.

SYMPTOM: Erratic Output

POTENTIAL SOURCE AND CORRECTIVE ACTION

LOOP WIRING
Check for intermittent shorts, open circuits and multiple grounds.
NOTE: DO NOT USE OVER 100 VOLTS TO CHECK THE LOOP.

PROCESS FLUID PULSATION
Adjust electronic damping pot (4-20 mADC only).

IMPULSE PIPING
Check for entrapped gas in liquid lines and for liquid in dry lines.

TRANSMITTER ELECTRONICS CONNECTIONS
Check for intermittent shorts or open circuits.
Make sure that bayonet connectors are clean and check the sensor connections.
Check that bayonet pin #8 is properly grounded to the case.

TRANSMITTER ELECTRONICS FAILURE
Determine faulty circuit board by trying spare boards. Replace faulty circuit board.

PARTS LIST / DRAWINGS SECTION

Design Specifications

(Ref. to Drawing 1151AP)

MODEL	
1151AP	ABSOLUTE PRESSURE TRANSMITTER

CODE	RANGES
4	0–2 to 0–11 inches HgA (0–6.77 to 0–37.25 kPa)
5	0–10 to 0–55 inches HgA (0–33.86 to 0–186.25 kPa)
6	0–17 to 0–100 psia (0–117.21 to 0–689.48 kPa)
7	0–50 to 0–300 psia (0–0.34 to 0–2.07 MPa)
8	0–170 to 0–1000 psia (0-1.17 to 0-6.89 MPa)

CODE	OUTPUT
E	4–20 mADC with adjustable damping
B	10–50 mADC with fixed damping

CODE	MATERIALS OF CONSTRUCTION: FLANGE AND ADPATER	DRAIN/VENT VALVE	ISOLATING DIAPHRAGM	FILL FLUID
12	Cadmium Plated C.S.	316SST	316LSST	Silicone
22	316SST	316SST	316LSST	Silicone
23	316SST	316SST	*Hastelloy C-276*	Silicone
24	316SST	316SST	*Monel*	Silicone
33	*Hastelloy C*	*Hastelloy C*	*Hastelloy C-276*	Silicone
44	*Monel*	*Monel*	*Monel*	Silicone
53	Nickel Plated C.S.	316SST	*Hastelloy C-276*	Silicone
54	Nickel Plated C.S.	316SST	*Monel*	Silicone
73	316SST	*Hastelloy C*	*Hastelloy C-276*	Silicone

CODE	OPTIONS
M1	Linear Meter, 0–100% Scale
B1	Mounting Bracket for Mounting to 2" Pipe
B2	Mounting Bracket for Panel Mounting
B3	Flat Mounting Bracket for Mounting to 2" Pipe
D1	Side Vent/Drain Valve, Top
D2	Side Vent/Drain Valve, Bottom
E6	Canadian Standards Association (CSA) Approvals. Certified for Class I, Division 2, Groups A, B, C, and D; Class I, Division 1, Groups C and D; Class II, Divisions 1 and 2, Groups E, F, and G; Class III hazardous locations; CSA enclosure 4. Factory sealed.
I5	Factory Mutual (FM) Non-incendive, and Intrinsic Safety Approval. Intrinsic safety approval requires connection with approved barrier systems in accordance with Rosemount drawing 1151-0214. See summary in PDS 2360. (Available with Output Code E only.)
I6	Canadian Standards Association (CSA) Intrinsic Safety Approval when connected with approved barrier systems. See summary in PDS 2360. (Available with Output Code E only.)
--	Other Options. Note: Insert the appropriate Option Code to specify any of the additional options described in PDS 2360.

1151AP 6 E 12 M1 B1 ← TYPICAL MODEL NUMBER

Design Specifications
(Ref. to Drawing 1151GP)

MODEL	
1151GP	GAGE PRESSURE TRANSMITTER

CODE	RANGES	
3	0–5 to 0–30 inches H_2O (0–1.25 to 0–7.46 kPa)	
4	0–25 to 0–150 inches H_2O (0–6.22 to 0–37.29 kPa)	
5	0–125 to 0–750 inches H_2O (0–31.08 to 0–186.45 kPa)	
6	0–17 to 0–100 psig (0–117.21 to 0–689.48 kPa)	
7	0–50 to 0–300 psig (0–0.34 to 0–2.07 MPa)	
8	0–170 to 0–1000 psig (0-1.17 to 0-6.89 MPa)	
9	0–500 to 0–3000 psig (0–3.45 to 0–20.68 MPa)	Codes 9 and 0 not available with *Fluorolube* fill or tantalum isolating diaphragms.
0	0–1000 to 0–6000 psig (0–6.89 to 0–41.37 MPa)	

CODE	OUTPUT
E	4-20 mADC with adjustable damping
B	10–50 mADC with fixed damping

MATERIALS OF CONSTRUCTION

CODE	FLANGE AND ADPATER	DRAIN/VENT VALVE	ISOLATING DIAPHRAGM	FILL FLUID
12	Cadmium Plated C.S.	316SST	316LSST	
15	Cadmium Plated C.S.	316SST	Tantalum	
22	316SST	316SST	316LSST	Silicone
23	316SST	316SST	*Hastelloy C-276*	Silicone
24	316SST	316SST	*Monel*	Silicone
25	316SST	316SST	Tantalum	Silicone
33	*Hastelloy C*	*Hastelloy C*	*Hastelloy C-276*	Silicone
35	*Hastelloy C*	*Hastelloy C*	Tantalum	Silicone
44	*Monel*	*Monel*	*Monel*	Silicone
53	Nickel Plated C.S.	316SST	*Hastelloy C-276*	Silicone
54	Nickel Plated C.S.	316SST	*Monel*	
73	316SST	*Hastelloy C*	*Hastelloy C-276*	
1A	Cadmium Plated C.S.	316SST	316LSST	
2A	316SST	316SST	316LSST	Fluorolube
5B	Nickel Plated C.S.	316SST	*Hastelloy C-276*	Fluorolube
2B	316SST	316SST	*Hastelloy C-276*	Fluorolube
3B	*Hastelloy C*	*Hastelloy C*	*Hastelloy C-276*	Fluorolube
7B	316SST	*Hastelloy C*	*Hastelloy C-276*	Fluorolube
1D	Cadmium Plated C.S.	316SST	Tantalum	Fluorolube
2D	316SST	316SST	Tantalum	Fluorolube
3D	*Hastelloy C*	*Hastelloy C*	Tantalum	Fluorolube

CODE	OPTIONS (See Product Data Sheet 2360 for Additional Options)
M1	Linear Meter, 0–100% Scale
B1	Mounting Bracket for Mounting to 2" Pipe
B2	Mounting Bracket for Panel Mounting
B3	Flat Mounting Bracket for Mounting to 2" Pipe
D1	Side Vent/Drain Valve, Top
D2	Side Vent/Drain Valve, Bottom
E6	Canadian Standards Association (CSA) Approvals. Certified for Class I, Division 2, Groups A, B, C, and D; Class I, Division 1, Groups C and D; Class II, Divisions 1 and 2, Groups E, F, and G; Class III hazardous locations; CSA enclosure 4; Factory sealed.
I5	Factory Mutual (FM) Non-incendive, and Intrinsic Safety Approval. Intrinsic safety approval requires connection with approved barrier systems in accordance with Rosemount drawing 1151-0214. See summary in PDS 2360. (Available with Output Code E only.)
I6	Canadian Standards Association (CSA) Intrinsic Safety Approval when connected with approved barrier systems. See summary in PDS 2360. (Available with Output Code E only.)
–	Other Options. Note: Insert the appropriate Option Code to specify any of the additional options described in PDS 2360.

1151GP 6 E 12 M1 B1 ← TYPICAL MODEL NUMBER

OPTION ORDERING INFORMATION

CODE	TRANSMITTER MODEL AND PRODUCT DATA SHEET (PDS) NUMBER.	1151DP (PDS 2256)	1151DP High Differential (PDS 2257)	1151HP (PDS 2258)	1151DP Square Root (PDS 2259)	1151GP (PDS 2260)	1151GP/DP Remote Seal (PDS 2394)	1151AP (PDS 2261)	1151LLT (PDS 2262)	1151DR (PDS 2294)
CODE	**MOUNTING BRACKETS**									
B1	Bracket for 2" Pipe Mounting	•	•	•	•	•	•	•	NA	•
B2	Bracket for Panel Mounting	•	•	•	•	•	•	•	NA	•
B3	Flat Bracket for 2" Pipe Mounting	•	•	•	•	•	•	•	NA	•
B4	Bracket for 2" Pipe with Series 300 SST Bolts	•	•	•	•	•	•	•	NA	•
B5	Bracket for Panel with Series 300 SST Bolts	•	•	•	•	•	•	•	NA	•
B6	Flat Bracket for 2" Pipe with Series 300 SST Bolts	•	•	•	•	•	•	•	NA	•
CODE	**METERS (Not available with options V2, V3)**									
M1	Integral Linear Meter, 0-100% Scale	•	•	•	•	•	•	•	•	•
M2	Integral Square Root Meter, 0-10 Scale	•	•	•	NA	NA	NA	NA	NA	•
CODE	**CERTIFICATIONS**									
E6	CSA Explosion Proof	•	•	•	•	•	•	•	•	•
I5	FM Intrinsic Safety*	•	•	•	•	•	•	•	•	•
I6	CSA Intrinsic Safety*	•	•	•	•	•	•	•	•	•
	*NOTE: Intrinsic Saftey Option Available only with E Output Code. (See 1151-0214, list of Approved Barrier Systems in this Manual.)									
CODE	**BOLTS FOR FLANGES AND ADAPTERS**									
L3	ANSI 193-B7	•	•	•	•	•	•	•	•	•
L4	Austenitic 316 SST	•	•	•	•	•	•	•	•	•
CODE	**PROCESS CONNECTIONS**									
D1	Side Vent/Drain Top	•	•	•	•	•	NA	•	•	•
D2	Side Vent/Drain Bottom	•	•	•	•	•	NA	•	•	•
D3	1/4" NPT Process Connection	•	•	•	•	•	NA	•	•	•
K1	1/4" NPT Kynar Process Flange Insert*	•	•	NA	•	•	NA	•	•	•
K2	1/2" NPT Kynar Process Flange Insert*	•	•	NA	•	•	NA	•	•	•
S1	Assembly of one remote diaphragm seal	•	•	NA	NA	•	•	•	•	NA
S2	Assembly of two remote diaphragm seals	•	•	NA	NA	NA	•	NA	NA	NA
CODE	**WETTED O-RINGS**									
W2	Buna - N	•	•	•	•	•	•	•	•	•
W3	Ethylene - Propylene	•	•	•	•	•	•	•	•	•
CODE	**PROCEDURES**									
P1	Hyrostatic Testing	•	•	•	•	•	•	•	•	•
P2	Cleaning for Special Service	•	•	•	•	•	•	•	•	•
P4	Calibration at Line Pressure	•	•	•	•	NA	NA	NA	NA	NA
P5	Calibration at Temperature	•	•	•	•	•	•	•	•	•
CODE	**OUTPUTS**									
V1	Reverse Output	†	†	†	†	•	•	NA	NA	†
V2	1Ω Test Resistor } Test Resistors Not Available With Options M1, M2, I5 or I6.	•	•	•	•	•	•	•	•	•
V3	5Ω Test Resistor }	•	•	•	•	•	•	•	•	•

The options listed in this Product Data Sheet may be ordered by placing the appropriate code or codes at the end of the transmitter model number.

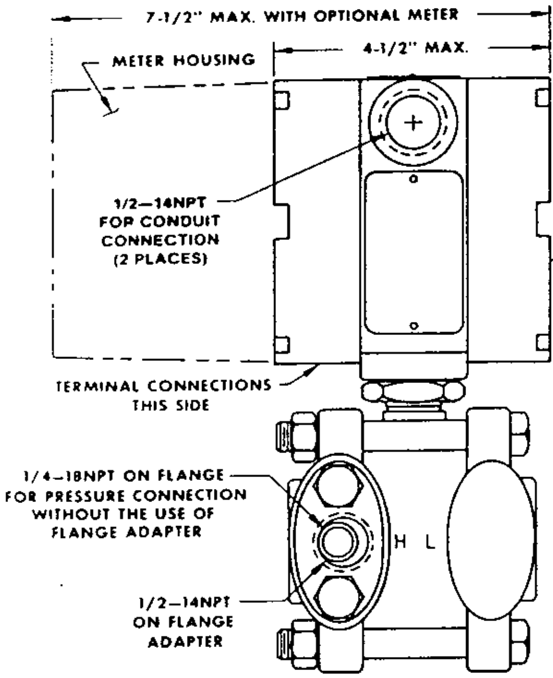
*Kynar Flange Insert (Patent Pending)

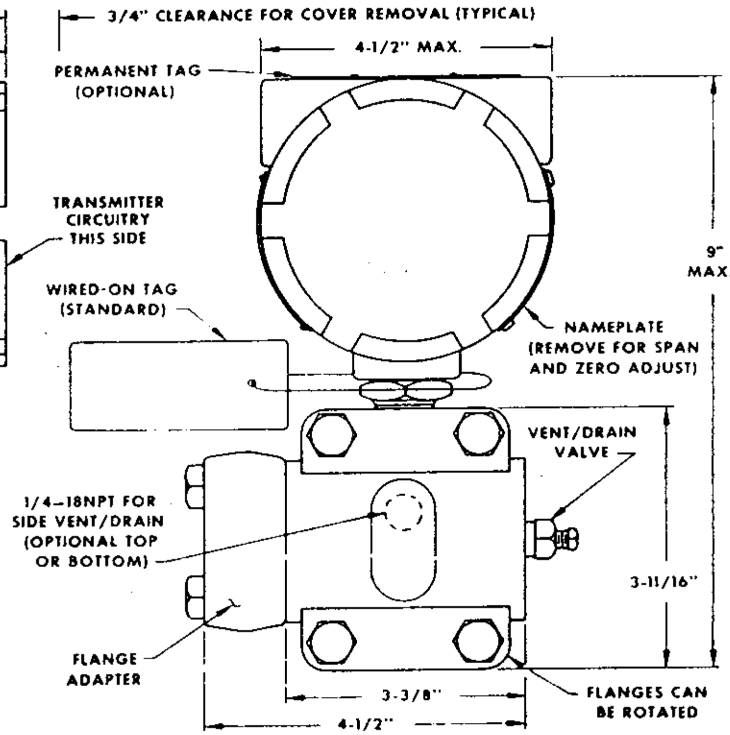
Example: 1151DP4E12 **B1 M1 D2 P1**

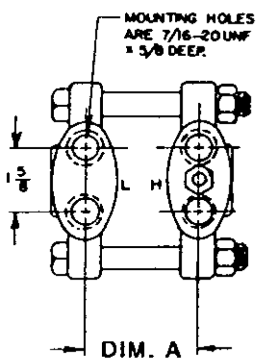
Basic Model No.

• - Available
NA - Not Available
† - Not Applicable

Dimensional Drawings





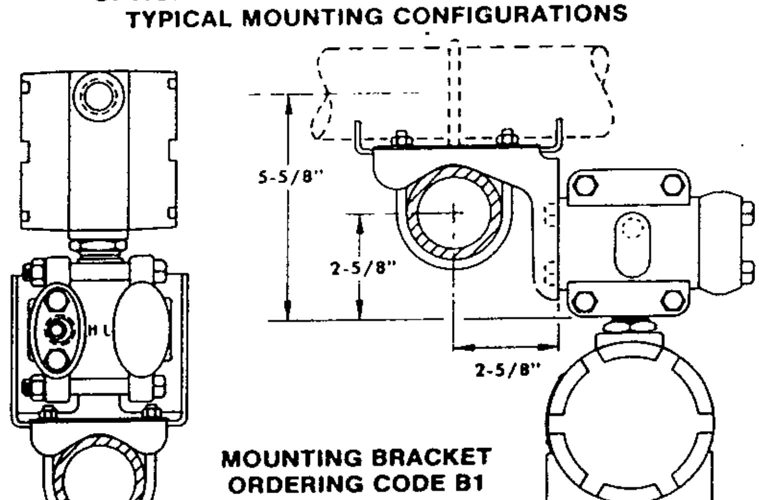


TABULATION

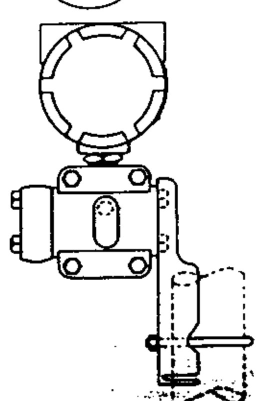
Model No.	DIMENSION A Inches (mm)	
1151GP3, 4, 5	2-1/8	(54.0)
1151GP6, 7	2-3/16	(60.3)
1151GP8	2-1/4	(57.2)
1151GP9	2-9/32	(57.9)
1151GP0	2-21/64	(59.1)
1151AP4, 5	2-1/8	(54.0)
1151AP6, 7	2-3/16	(60.3)
1151AP8	2-1/4	(57.2)

METRIC EQUIVALENTS Inches (mm)	
5/8	(15.9)
3/4	(19.0)
1-5/8	(41.3)
2-5/8	(66.7)
3-3/8	(85.7)
3-11/16	(93.7)
4-1/2	(114.0)
5-5/8	(142.9)
7-1/2	(190.5)
9	(228.6)

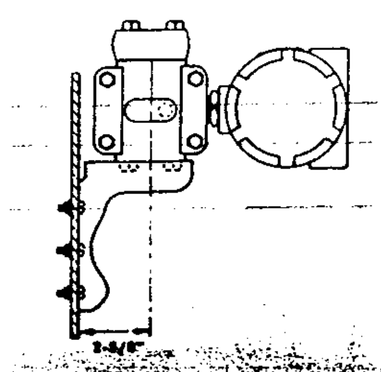
OPTIONAL MOUNTING BRACKETS SHOWN IN TYPICAL MOUNTING CONFIGURATIONS



MOUNTING BRACKET ORDERING CODE B1



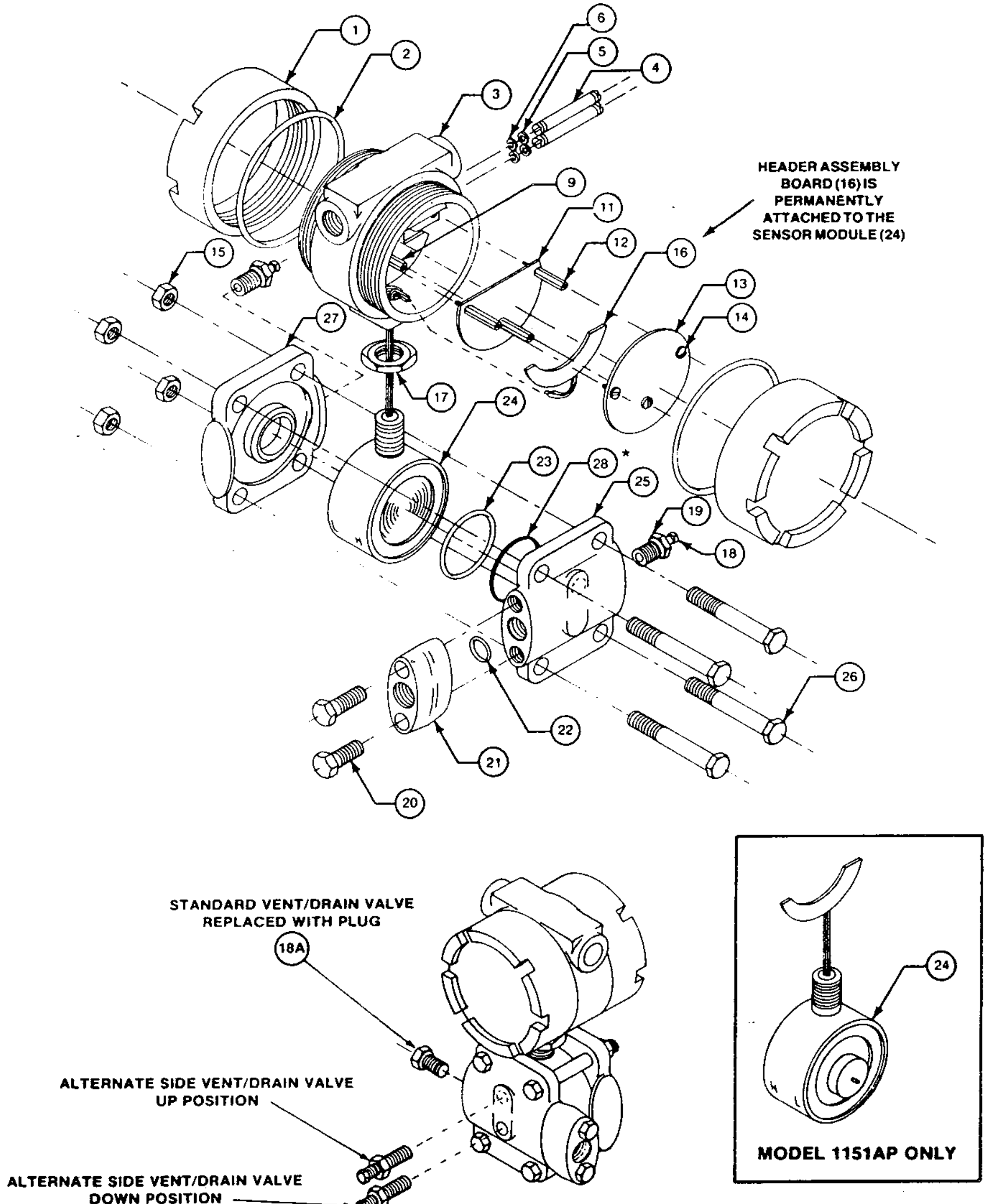
FLAT MOUNTING BRACKET ORDERING CODE B3



PANEL MOUNTING BRACKET ORDERING CODE B2

1151AP, 1151GP ILLUSTRATED PARTS LIST

(Drawing 1151-68, 1151-67)



* Item 28 used on Model 1151GP0 only.

SPARE PARTS LIST
MODEL 1151AP ABSOLUTE AND 1151GP GAGE PRESSURE TRANSMITTERS

PART DESCRIPTION (DRAWING 1151-23)	ITEM NO.	ORDER NUMBER		QTY. REQ. PER TRANS.	SPARES CATEGORY*
● For Model 1151GP Gage Pressure Transmitter					
		SILICONE FILL	FLUOROLUBE FILL		
Sensor Module, 0-5/30" H_2O (Range 3) 316LSST HASTELLOY C-276 MONEL TANTALUM	24	 01151-0011-0032 01151-0011-0033 01151-0011-0034 01151-0011-0035	 01151-0230-0032 01151-0230-0033 NA 01151-0230-0035	1	B
Sensor Module, 0-25/150" H_2O (Range 4) 316LSST HASTELLOY C-276 MONEL TANTALUM	24	 01151-0011-0042 01151-0011-0043 01151-0011-0044 01151-0011-0045	 01151-0230-0042 01151-0230-0043 NA 01151-0230-0045	1	B
Sensor Module, 0-125/750" H_2O (Range 5) 316LSST HASTELLOY C-276 MONEL TANTALUM	24	 01151-0011-0052 01151-0011-0053 01151-0011-0054 01151-0011-0055	 01151-0230-0052 01151-0230-0053 NA 01151-0230-0055	1	B
Sensor Module, 0-17/100 PSIG (Range 6) 316LSST HASTELLOY C-276 MONEL TANTALUM	24	 01151-0041-0162 01151-0041-0163 01151-0041-0164 01151-0041-0165	 01151-0230-0162 01151-0230-0163 NA 01151-0230-0165	1	B
Sensor Module, 0-50/300 PSIG (Range 7) 316LSST HASTELLOY C-276 MONEL TANTALUM	24	 01151-0041-0172 01151-0041-0173 01151-0041-0174 01151-0041-0175	 01151-0230-0172 01151-0230-0173 NA 01151-0230-0175	1	B
Sensor Module, 0-170/1000 PSIG (Range 8) 316LSST HASTELLOY C-276 MONEL TANTALUM	24	 01151-0041-0182 01151-0041-0183 01151-0041-0184 01151-0041-0185	 01151-0230-0182 01151-0230-0183 NA 01151-0230-0185	1	B
Sensor Module, 0-500/3000 PSIG (Range 9) 316LSST HASTELLOY C-276 MONEL	24	 01151-0112-0092 01151-0112-0093 01151-0112-0094	 ——— ——— ———	1	B
Sensor Module, 0-1000/6000 (Range 0) 316LSST HASTELLOY C-276 MONEL	24	 01151-0112-0002 01151-0112-0003 01151-0112-0004	 ——— ——— ———	1	B
"O"-Ring for Adjustment Screw "O"-Ring for Electronics Cover "O"-Ring for Flange Adapter, VITON "O"-Ring for Flange Adapter, BUNA-N "O"-Ring for Flange Adapter, ETHYLENE-PROP.	5 2 22 22 22	01151-0032-0001 01151-0033-0003 01151-0035-0001 01151-0035-0002 01151-0035-0004		1**	B
"O"-Ring for Process Flange, VITON Ranges to 1000 psi Ranges from 1000 psi to 3000 psi Range above 3000 psi	23 23, 28	 01151-0034-0001 01151-0034-0005 01151-0034-0006		 1** 1** 1***	B
"O"-Ring for Process Flange, BUNA-N Ranges to 1000 psi Ranges from 1000 psi to 3000 psi Ranges above 3000 psi	23 23, 28	 01151-0034-0002 01151-0034-0009 01151-0034-0010		 1** 1** 1***	B
"O"-Ring for Process Flange, ETHYLENE-PROP. Ranges to 1000 psi Ranges from 1000 psi to 3000 psi Ranges above 3000 psi	23 23, 28	 01151-0034-0004 01151-0034-0007 01151-0034-0008		 1** 1** 1***	B
Bolt for Flange, Carbon Steel Bolt for Process Flange, Carbon Steel Nut for Process Flange, Carbon Steel	20 26 15	01151-0031-0002 (Ranges 3-8) 01151-0031-0003 (Range 9) 01151-0031-0019 (Range 0)		1	
Bolt for Flange Adapter, 316SST Bolt for Process Flange, 316SST Nut for Process Flange, 316SST	20 26 15	01151-0031-0024 (Ranges 3-8) 01151-0031-0025 (Range 9) 01151-0031-0026 (Range 0)		1	
Bolt for Flange Adapter, ANSI 193-B7 Bolt for Process Flange, ANSI 193-B7 Nut for Process Flange, ANSI 193-B7	20 26 15	01151-0031-0013 (Ranges 3-8) 01151-0031-0014 (Range 9) 01151-0031-0022 (Range 0)		1	

PART DESCRIPTION (DRAWING 1151-23)	ITEM NO.	ORDER NUMBER	QTY. REQ. PER TRANS.	SPARES CATEGORY*
• For Model 1151AP Absolute Pressure Transmitter				
Sensor Module, 0-2/11" HgA (Range 4) 316LSST HASTELLOY C-276 MONEL		01151-0054-0042 01151-0054-0043 01151-0054-0044	1	B
Sensor Module, 0-10/55" HgA (Range 5) 316LSST HASTELLOY C-276 MONEL	24	01151-0054-0052 01151-0054-0053 01151-0054-0054	1	B
Sensor Module, 0-17/100 psia (Range 6) 316LSST HASTELLOY C-276 MONEL		01151-0054-0062 01151-0054-0063 01151-0054-0064	1	B
Sensor Module, 0-50/300 psia (Range 7) 316LSST HASTELLOY C-276 MONEL		01151-0054-0072 01151-0054-0073 01151-0054-0074	1	B
Sensor Module, 0-170/1000 HgA (Range 8) 316LSST HASTELLOY C-276 MONEL		01151-0054-0082 01151-0054-0083 01151-0054-0084	1	B
"O"-Ring for Adjustment Screw "O"-Ring for Electronics Cover (See Note) "O"-Ring for Process Flange, VITON "O"-Ring for Flange Adapter, VITON "O"-Ring for Process Flange, BUNA-N "O"-Ring for Flange Adapter, BUNA-N "O"-Ring for Process Flange, ETHYLENE-PROP. "O"-Ring for Flange Adapter, ETHYLENE-PROP.	5 2 23 22 23 22 23 22	01151-0032-0001 01151-0033-0003 01151-0034-0001 01151-0035-0001 01151-0034-0002 01151-0035-0002 01151-0034-0004 01151-0035-0004	1**	B
Bolt for Flange Adapter, Carbon Steel Bolt for Process Flange, Carbon Steel Nut for Process Flange, Carbon Steel	20 26 15	• 01151-0031-0002	1	
Bolt for Flange Adapter, 316SST Bolt for Process Flange, 316SST Nut for Process Flange, 316SST	20 26 15	• 01151-0031-0024	1	
Bolt for Flange Adapter, ANSI 193-B7 Bolt for Process Flange, ANSI 193-B7 Nut for Process Flange, ANSI 193-B7	20 26 15	• 01151-0031-0013	1	
• For 1151AP or 1151GP Pressure Transmitters				
E OUTPUT CODE 4-20 mADC Amplifier Circuit Board Calibration Circuit Board	 13 11	 01151-0137-0001 01151-0139-0001	 1 1	 A A
B OUTPUT CODE 10-50 mADC Amplifier Circuit Board Calibration Circuit Board	 13 11	 01151-0008-0001 01151-0059-0001	 1 1	 A A
Electronics Housing (See Note) Electronics Cover (See Note)	3 1	01151-0060-0007 90032-0240-0003	1 2	
Process Flange Cadmium Panel Carbon Steel 316SST HASTELLOY C MONEL	25	01151-0236-0001 01151-0213-0002 01151-0213-0004 01151-0213-0003	1	
Process Flange for Side Drain/Vent Valve Cadmium Plated Carbon Steel 316SST HASTELLOY C MONEL		01151-0236-0011 01151-0213-0012 01151-0213-0014 01151-0213-0013	1	
Blank Flange, Cadmium Plated Carbon Steel	27	90043-0046-0001	1	
Flange Adapter Union Cadmium Plated Carbon Steel 316SST HASTELLOY C MONEL	21	90001-0033-0001 01151-0211-0002 01151-0211-0004 01151-0211-0003	1	

TABLE CONTINUED ON NEXT PAGE

*Rosemount recommends one spare part for every 25 transmitters in Category A, and one spare part for every 50 transmitters in Category B.

**Part Number is for package of 12 "O"-Rings — only 1 required per transmitter.

***Part Number is for package of 2 "O"-Rings — only 1 required per transmitter.

• Kit containing enough parts for one transmitter.

PART DESCRIPTION (DRAWING 1151-23)	ITEM NO.	ORDER NUMBER	QTY. REQ. PER TRANS.	SPARES CATEGORY*
Valve Stem, 316SST Valve Seat, 316SST Plug, 316SST, (used with side drain/vent)	18 19 18A	• 01151-0028-0012 C50246-0002	1 1	A
Valve Stem, HASTELLOY C Valve Seat, HASTELLOY C Plug, HASTELLOY C (used with side drain/vent)	18 19 18A	• 01151-0028-0013 C50246-0202	1 1	A
Valve Stem, MONEL Valve Seat, MONEI Plug, MONEL (used with side drain/vent)	18 19 18A	• 01151-0028-0014 C50246-0102	1 1	A
Adjustment Screw Retaining Ring "O"-Ring for Adjustment Screw	4 6 5	• 01151-0029-0001	1	
Electronics Assembly Hardware Standoff Standoff Screw Screw Lock Nut	 9 12 7 14 17	• 01151-0030-0001	1	A

*Rosemount recommends one spare part for every 25 transmitters in Category A, and one spare part for every 50 transmitters in Category B.
**Part Number is for package of 12 "O"-Rings — only 2 required per transmitter.

• Kit containing enough parts for one transmitter.

MOUNTING BRACKETS (Complete with Hardware)

ORDER NUMBER	DESCRIPTION	ORDER NUMBER	DESCRIPTION
01151-0036-0001	Mounting Bracket, Style B1	01151-0036-0003	Mounting Bracket, Style B4
01151-0036-0004	Mounting Bracket, Style B2	01151-0036-0006	Mounting Bracket, Style B5
01151-0036-0005	Mounting Bracket, Style B3	01151-0036-0007	Mounting Bracket, Style B6

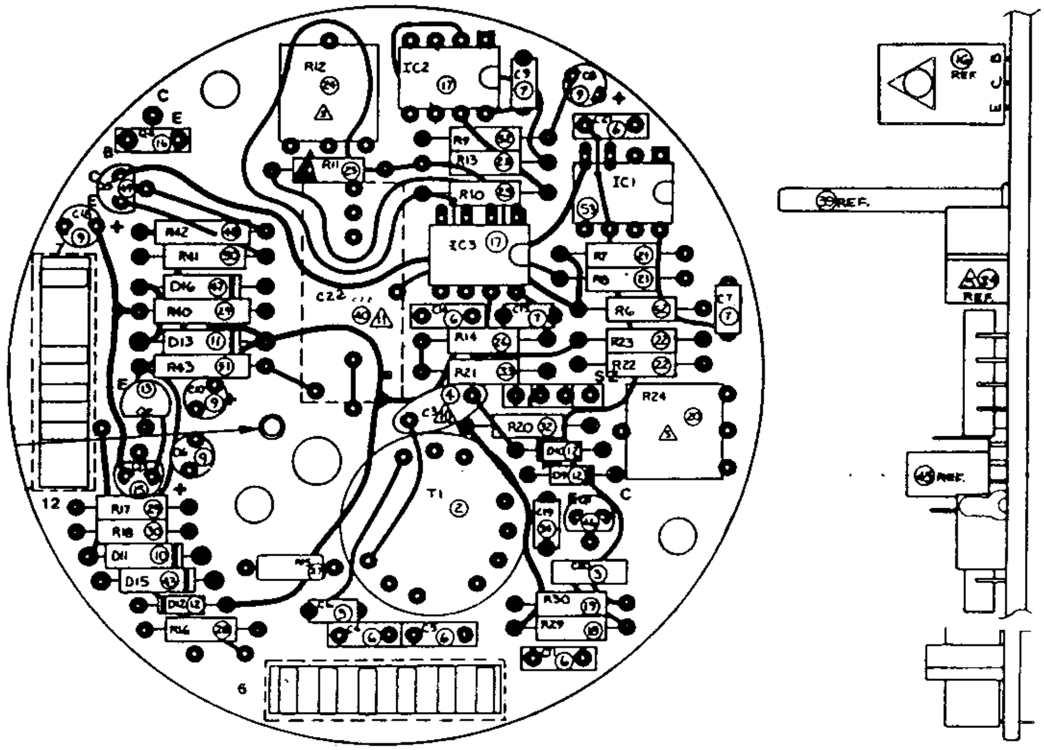
NOTE

For Transmitters with Serial Numbers below 23,000 use these numbers:

ORDER NUMBER	DESCRIPTION
01151-0060-0002	Electronics Housing
90032-0240	Electronics Cover
01151-0033	"O"-Ring for Electronics Cover

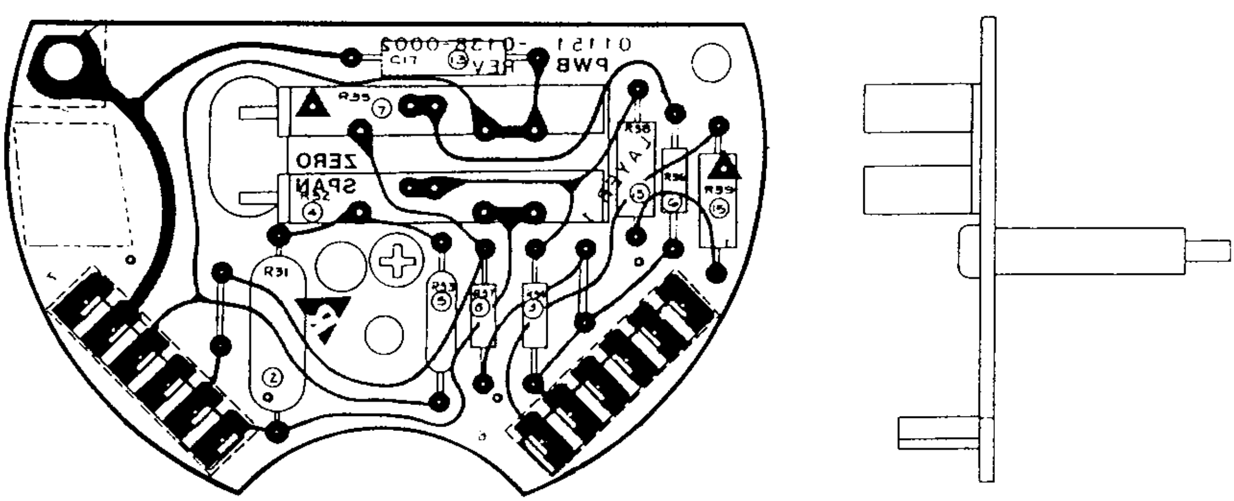
E Output Component Layout, 4-20 mADC Amplifier PWA

(Drawing 1151-137, Rev. AD)



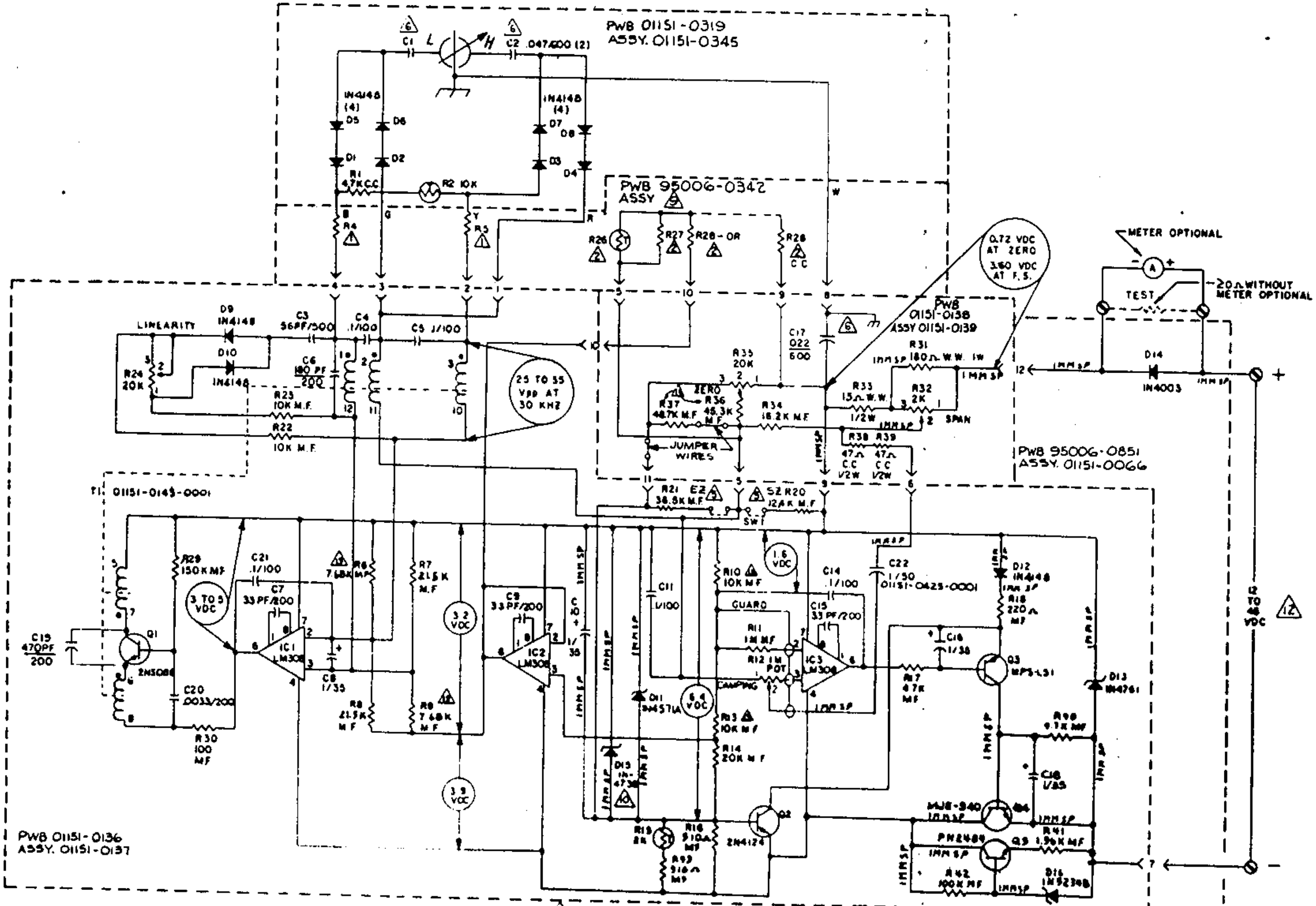
E Output Component Layout, 4-20 mADC Calibration PWA

(Drawing 1151-139, Rev. U)



E Output Schematic Diagram, 4-20 mADC Output

(Drawing 1151-135, Rev. M)



C1, C2, AND C17 HAVE BEEN TESTED TO WITHSTAND 500 VAC FOR 10 MIN WITHOUT FAILURE BY ELECTRICAL RESEARCH ASSOCIATION OF ENGLAND.

R20 OR R21 IS SWITCHED TO PIN 5 FOR SPECIAL CALIBRATIONS

ALL CAPACITORS ARE MICROFARADS/VOLTAGE RATING UNLESS NOTED

ALL M.F. RESISTORS ARE 1/10 WATT, ALL C.C. RESISTORS ARE 1/4 WATT, ALL POTS ARE 3/4 WATT, UNLESS NOTED.

R26, R27, AND R28 ARE FOR ZERO TEMPERATURE COMPENSATION AND ARE 10K MINIMUM

R4 AND R5 ARE FOR SPAN TEMPERATURE COMPENSATION AND ARE 0Ω MINIMUM, 300Ω MAXIMUM

NOTES:

INPUT VOLTAGE OF 28 VDC MAX FOR INTRINSIC SAFETY ANALYSIS

TEMPERATURE COEFFICIENT OF ±25 PPM/°C

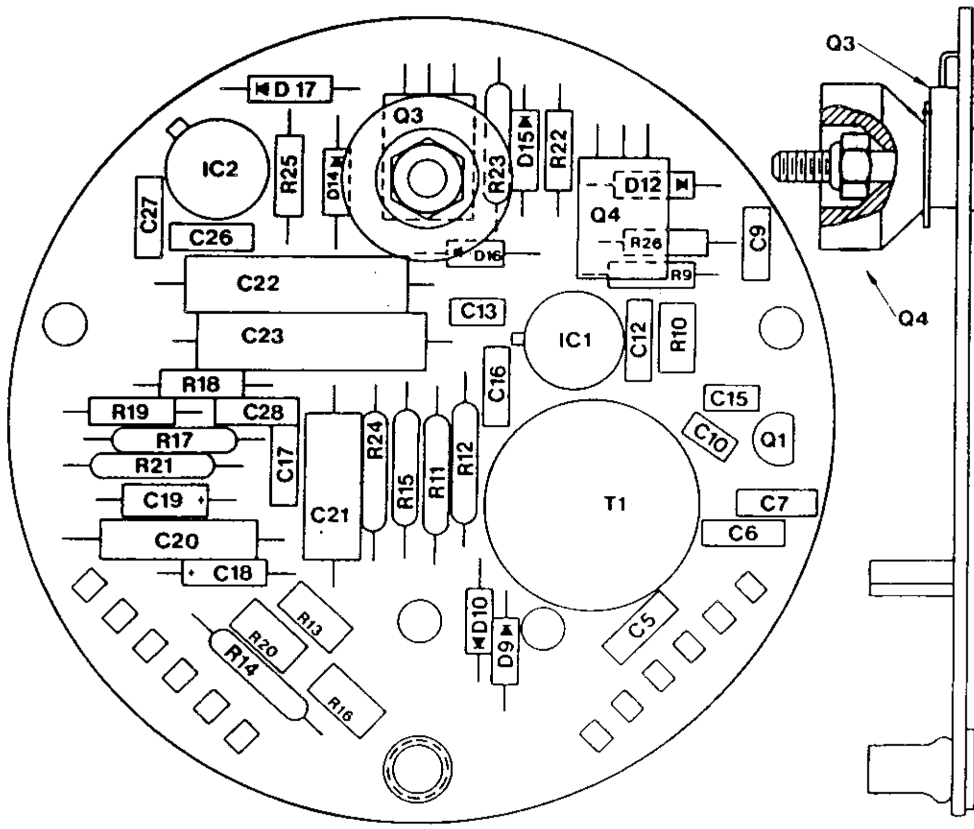
D15 IS USED ON 01151-0137-0005 ASSEMBLY ONLY

COMP. PWA IS PART OF SENSOR MODULE ASSEMBLY

8. THE END PRODUCT THIS SCHEMATIC DESCRIBES HAS BEEN SUBMITTED FOR INTRINSIC SAFETY APPROVAL. ANY CHANGES IN DESIGN, COMPONENT TYPE, COMPONENT VALUE, COMPONENT RATING OR BOARD LAYOUT MAY AFFECT APPROVAL AND REQUIRE RESUBMITTAL

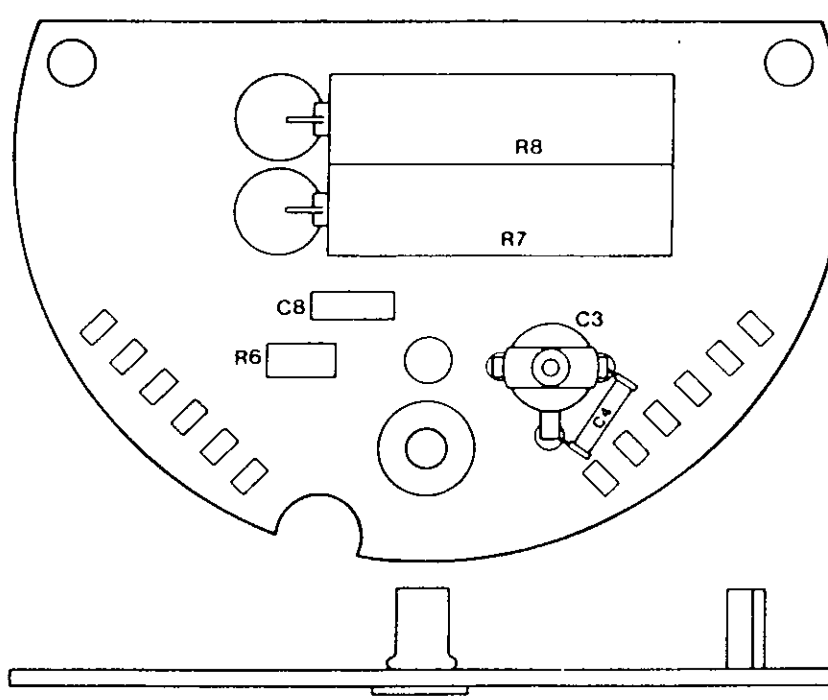
B Output Component Layout, 10-50 mADC Amplifier PWA

(Drawing 1151-8, Rev. M)



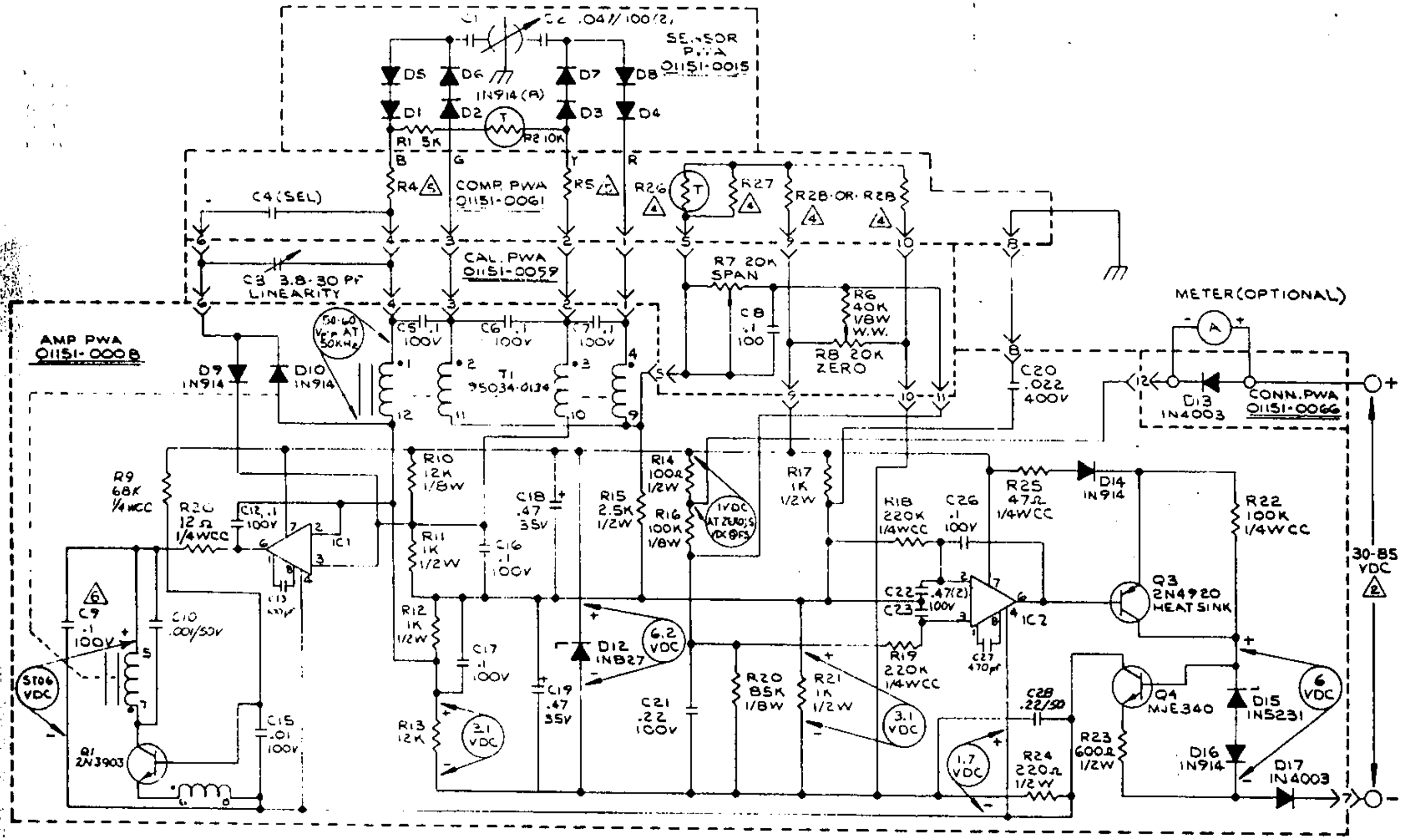
B Output Component Layout, 10-50 mADC Calibration PWA

(Drawing 1151-59, Rev. D1)



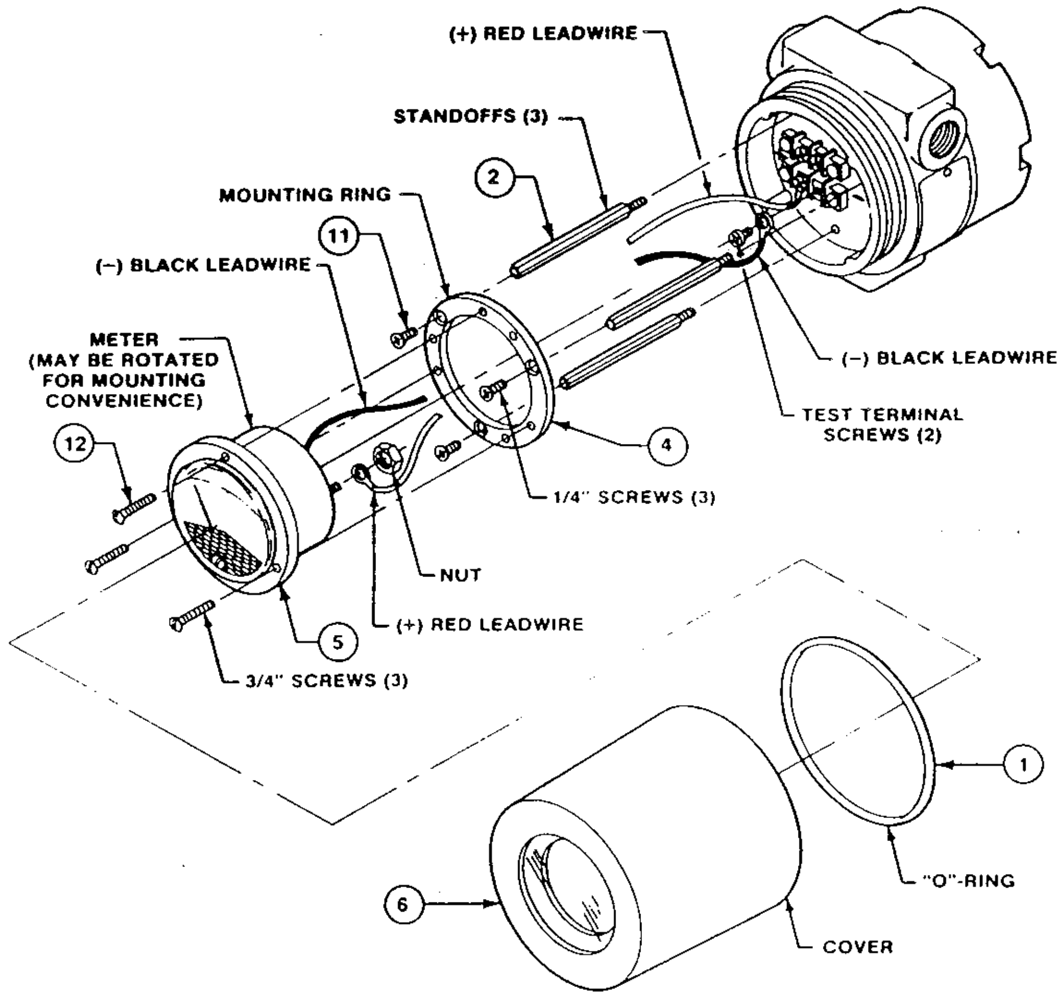
B Output Schematic Diagram, 10-50 mADC Output

(Drawing 1151-4, Rev. G)



6. Optional for oscillator performance.
5. R4 and R5 are selected for span temperature coefficient compensation, and are equal values.
4. R26, R27, R28 and position of R28 optional for zero temperature compensation
3. Reference voltages are nominal values measured across component.
2. Impedance Limitation: Max Load (Ohms) = 20X (Power Supply Voltage-30VDC).
1. All capacitors are microfarads unless noted.

Meter Assembly
(Drawing 1151-25, Rev. D)



DESCRIPTION	ITEM NO.	ORDER NO.	FOR UNITS WITH SERIAL NUMBER BELOW 23,000	QTY. REQ'D PER TRANS.
*Kit, 4-20 mADC, Linear Scale *Kit, 10-50 mADC, Linear Scale *Kit, 4-20 mADC, Square Root *Kit, 10-50 mADC, Square Root		01151-0006-0005 01151-0006-0007 01151-0006-0006 01151-0006-0008	01151-0006-0001 01151-0006-0003 01151-0006-0002 01151-0006-0004	1
Meter, 4-20 mADC, Linear Scale Meter, 10-50 mADC, Linear Scale Meter, 4-20 mADC, Square Root Meter, 10-50 mADC, Square Root	5	C09997-0001 C09997-0003 C09997-0002 C09997-0004		1
Cover/Faceplate Assembly	6	01151-0098-0002	01151-0098-0001	1
Meter Bracket Assembly Mounting Ring Standoff Screw for Mounting Ring Screw for Meter	 4 2 11 12	01151-0037-0001 †		1
"O"-Ring for Cover	1	01151-0033-0003	01151-0033	**

*Kit includes meter, cover, bracket assembly, "O"-ring and wiring.
**Part number is for package of 12 - only one required per transmitter.
†Kit containing enough parts for one transmitter.

PROPRIETARY INFORMATION IS CONTAINED HEREIN AND MUST BE HANDLED ACCORDINGLY.
BY __________ DATE __________

REVISIONS

REV.	DESCRIPTION	CHG. NO.	APP'D	DATE
J	Add Model 2051, Contents Page, Entity Parameter			

CONTENTS	
SYSTEM APPROVALS	SHEETS 2 THRU 6
APPROVED BARRIER LISTINGS	SHEETS 2 THRU 4
CIRCUIT DIAGRAMS	SHEETS 5 AND 6
ENTITY PARAMETERS	SHEET 7

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES. REMOVE ALL BURRS AND SHARP EDGES. MACHINE SURFACE FINISH 125

—TOLERANCES—

DECIMALS .X ± .1 .XX ± .02 .XXX ± .010

FRACTIONS ± 1/32

ANGLES ± 2°

DO NOT SCALE PRINT

CONTRACT NO.

DR.

CHK'D

APP'D.

APP'D. GOVT.

Rosemount Inc. MINNEAPOLIS, MINNESOTA

TITLE INDEX OF INTRINSICALLY SAFE BARRIER SYSTEMS AND ENTITY PARAMETERS FOR 1151, 1144, 1135, 444, AND 2051 TRANSMITTERS AND 751 FIELD INDICATORS

A 04274 1151-0214

SCALE SHEET 1 OF 7

FORM NO. 60651A-1 REV. B

REVISIONS				
REV.	DESCRIPTION	CHG. NO.	APP'D	DATE

Rosemount 1151, 1144, 1135, 444, and 2051 transmitters are FM approved as Intrinsically Safe when used with the barriers shown below for Class I, II, III, Div. 1, Groups listed. The Rosemount 751 Field Signal Indicator is FM approved as Intrinsically Safe when used in circuit with Rosemount Models 1151,1144, and 444 and the barriers shown below for Class I, II, III, Div. 1, Groups listed.

To assure an Intrinsically Safe system, the 1151, 1135, 1144, 444, 2051 must be wired in accordance with the barrier manufacturer's field wiring instructions and the applicable circuit diagram indicated below.

Barrier Manufacturer	Barrier Model	Approved Class I, II, III, Div. 1, Groups	Manufacturer's Publication No.	Circuit Diagram
Fisher Controls	AC302	C, D, E, F, G	4828	1
Foxboro	2A1-I2V-FGB	A, B, C, D, E, F, G	MI-2AI-135	1
	2A1-I3V-FGB	A, B, C, D, E, F, G	MI-2AI-140	1
	2AS-I3I-FGB	A, B, C, D, E, F, G	MI-2AS-100	1
	3A2-I2D-CS-E/FGB-A	A, B, C, D, E, F, G	MI-3A2-103	1
	3A2-I3D-CS-E/FGB-A	A, B, C, D, E, F, G	MI-3A2-104	1
Honeywell	38545-0000-0110-113-F5B5	A, B, C, D, E, F, G	S385-22	1
	38545-0000-0110-111/112-F5B5	C, D, E, F, G	S385-22	1
Leeds & Northrup	316569	A, B, C, D, E, F, G	Directions 177849	1
	316747	A, B, C, D, E, F, G	Directions 177849	1

Rosemount Inc. MINNEAPOLIS, MINN.	SIZE	FSCM NO.	DRAWING NO.
DR.	A	04274	1151-0214
ISSUE	SCALE:	WT.	SHEET 2 OF 7

FORM NO. 60651A-2 REV. A

REVISIONS				
REV.	DESCRIPTION	CHG. NO.	APP'D	DATE

Barrier Manufacturer	Barrier Model	II, III, Div. 1, Groups	Manufacturer's Publication No.	Circuit Diagram
Measurement Technology	115	A, B, C, D, E, F, G	PS 300-10	1
	122	A, B, C, D, E, F, G	PS 300-10	1
	128+	A, B, C, D, E, F, G	PS 300-10	1
	128-	A, B, C, D, E, F, G	PS 300-10	1
	129	A, B, C, D, E, F, G	PS 300-10	1
	188, 188R, 322	A, B, C, D, E, F, G	PS 300-10	1
Stahl	8901/31-199/130/7	A, B, C, D, E, F, G	8901603310	1
	8901/31-199/100/7	A, B, C, D, E, F, G	8901603310	1
	8901/31-280/070/7	A, B, C, D, E, F, G	8901603310	1
	8901/30-199/130/7	A, B, C, D, E, F, G	8901603310	1
	8901/30-199/100/7	A, B, C, D, E, F, G	8901603310	1
	8901/30-280/070/7	A, B, C, D, E, F, G	8901603310	1
	8901/31-280/100/7	A, B, C, D, E, F, G	8901603310	1
	8901/31-280/165/8	C, D, E, F, G	8901603310	1
	8901/30-280/165/8	C, D, E, F, G	8901603310	1
(Supply) (Return)	8903/51-200/050/7 8901/31-086/150/7	A, B, C, D, E, F, G	8901603310	2
(Supply) (Return)	8903/31-315/050/7 8901/31-086/150/7	A, B, C, D, E, F, G	8901603310	2

Rosemount Inc.
MINNEAPOLIS, MINN.

DR.		SIZE	FSCM NO.	DRAWING NO.	
		A	04274	1151-0214	
ISSUE		SCALE:	WT.	SHEET 3	OF 7

FORM NO. 60651A-2 REV. A

REVISIONS				
REV.	DESCRIPTION	CHG. NO.	APP'D	DATE

Barrier Manufacturer	Barrier Model	II, III, Div. 1, Groups	Manufacturer's Publication No.	Circuit Diagram
Stahl (Supply) (Return)	8901/31-280/165/8 8901/31-086/150/7	C, D, E, F, G	8901603310	2
Taylor	5850FL81100	A, B, C, D, E, F, G	IB-21E600	1
	5851FL81100	A, B, C, D, E, F, G	IB-21E600	1
	5850FL81200	C, D, E, F, G	IB-21E600	1
	5851FL81200	C, D, E, F, G	IB-21E600	1
	1130FF21000	C, D, E, F, G	IB17E211	1
	1130FF22000	C, D, E, F, G	IB17E211	1
	1135FF21000	C, D, E, F, G	IB17E212	1
	1135FF22000	C, D, E, F, G	IB17E212	1
Westinghouse	75SB02	A, B, C, D, E, F, G	IB-101-916	1

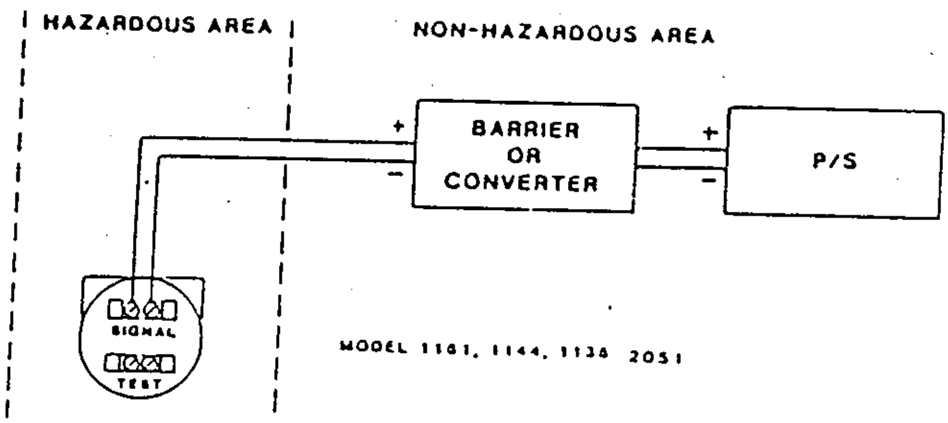
Rosemount Models, Barrier Manufacturers, Barrier Models, Approved Classes, Divisions, Groups, and Manufacturers' Publication Numbers cannot be added or deleted without approval by Factory Mutual.

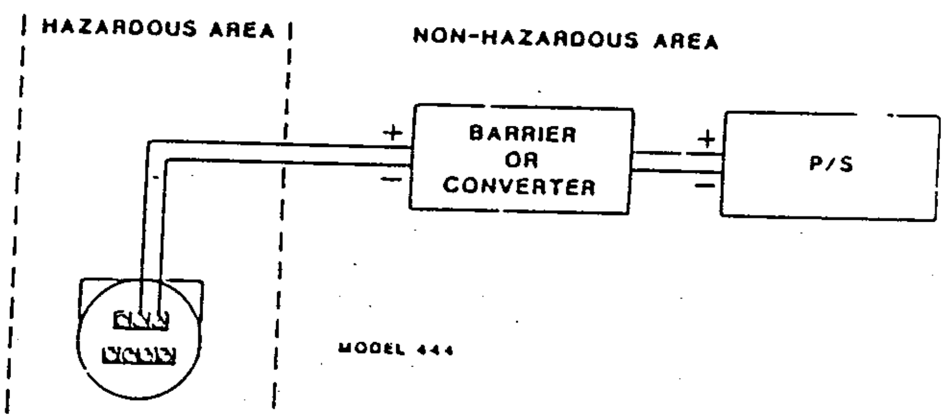
Rosemount Inc. MINNEAPOLIS, MINN.	SIZE	FSCM NO.	DRAWING NO.	
DR.	A	04274	1151-0214	
ISSUE	SCALE:	WT.	SHEET 4	OF 7

FORM NO. 60651A-2 REV. A

REVISIONS				
REV.	DESCRIPTION	CHG. NO.	APP'D	DATE

CIRCUIT DIAGRAM 1
SINGLE BARRIER OR CONVERTER





UP TO FOUR MODEL 751 INDICATORS MAY BE WIRED IN SERIES WITH THE TRANSMITTERS SHOWN ABOVE AND MAY BE LOCATED IN EITHER THE HAZARDOUS OR SAFE AREA

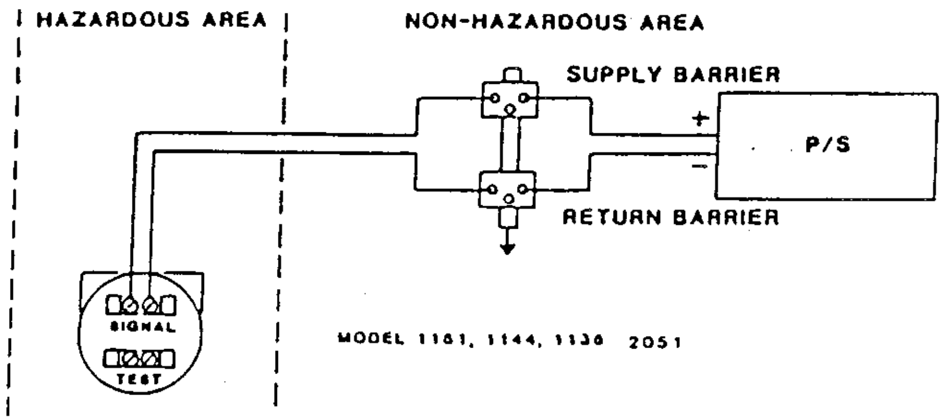
MASTER DRAWING

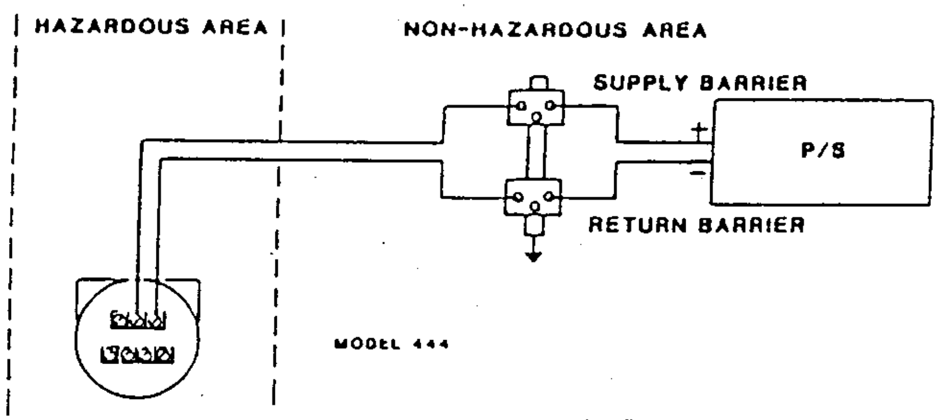
Rosemount Inc. MINNEAPOLIS, MINN.		SIZE	FSCM NO.	DRAWING NO.	
DR. S. BERRY	9/7/5	A	04274	1151-0214	
ISSUE		SCALE: —	WT.	SHEET 5 OF 7	

FORM NO. 60651A-2 REV. A

REVISIONS				
REV.	DESCRIPTION	CHG. NO.	APP'D	DATE

CIRCUIT DIAGRAM 2
SUPPLY AND RETURN BARRIERS





UP TO FOUR MODEL 751 INDICATORS MAY BE WIRED IN SERIES WITH THE TRANSMITTERS SHOWN ABOVE AND MAY BE LOCATED IN EITHER THE HAZARDOUS OR SAFE AREA

MASTER DRAWING

Rosemount Inc. MINNEAPOLIS, MINN.		SIZE	FSCM NO.	DRAWING NO.	
DR. S. BERRY	9/2/85	A	04274	1151-0214	
ISSUE		SCALE: —	WT.	SHEET 6	OF 7

FORM NO. 60661A-2 REV. A

REV.	DESCRIPTION	CHG. NO.	APP'D	DATE

ENTITY CONCEPT APPROVALS

The Entity Concept allows interconnection of Intrinsically Safe apparatus to associated apparatus not specifically examined in combination as a system. The approved values of maximum open circuit voltage (V_{OC}) and maximum short circuit current (I_{SC}) for the associated apparatus must be less than or equal to the maximum safe input voltage (V_{MAX}) and input current (I_{MAX}) of the Intrinsically Safe apparatus. In addition, the approved maximum allowable connected capacitance (C_A) and inductance (L_A) of the associated apparatus must be greater than the maximum unprotected internal capacitance (C_I) and inductance (L_I) of the Intrinsically Safe apparatus. The approved Entity Concept Parameters for Intrinsically Safe Rosemount transmitters and associated apparatus are as follows:

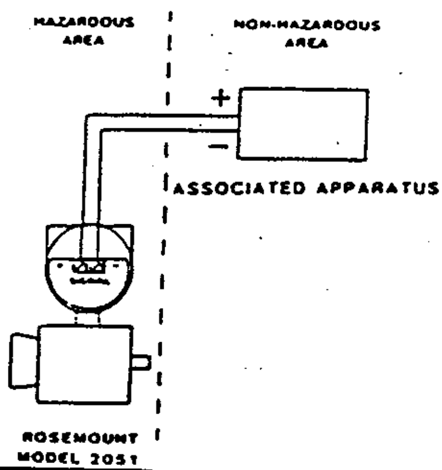
Model 2051

Class I, Div. I, Groups A and B

V_{MAX} = 40V	V_{OC} is less than or equal to 40V
I_{MAX} = 165mA	I_{SC} is less than or equal to 165mA
C_I = 0.012μF	C_A is greater than 0.012μF
L_I = 480μH	L_A is greater than 480μH

Class I, Div. I, Groups C and D

V_{MAX} = 40V	V_{OC} is less than or equal to 40V
I_{MAX} = 225mA	I_{SC} is less than or equal to 225mA
C_I = 0.012μF	C_A is greater than 0.012μF
L_I = 480μH	L_A is greater than 480μH

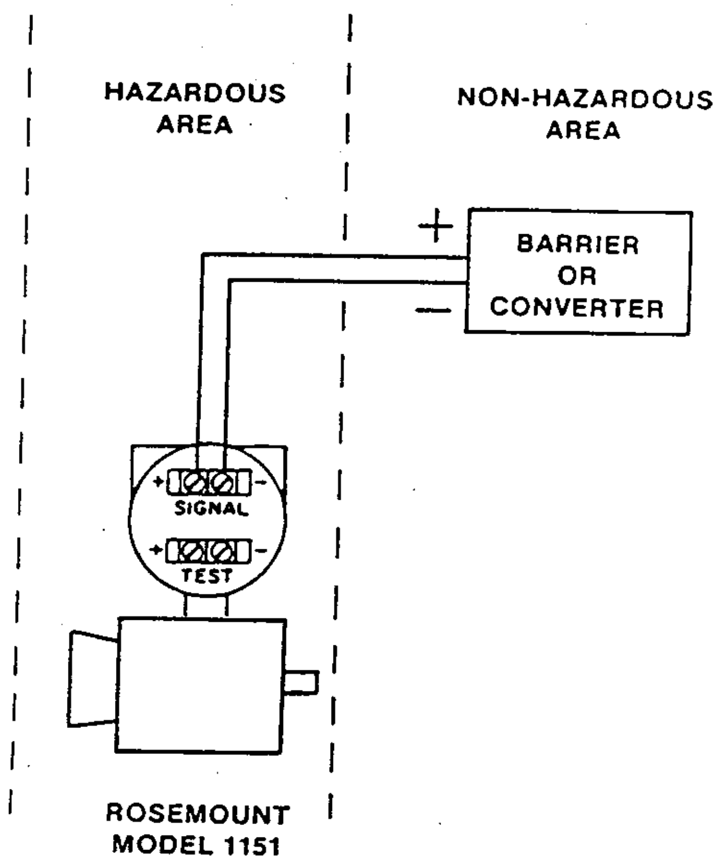


Rosemount Inc. MINNEAPOLIS, MINN.	SIZE	FSCM NO.	DRAWING NO.
DR.	A	04274	1151-0214
ISSUE	SCALE:	WT.	SHEET 7 OF 7

FORM NO. 60651A-2 REV. A

CSA INTRINSIC SAFETY APPROVALS

1151 CIRCUIT CONNECTION WITH BARRIER OR CONVERTER



"Exia"

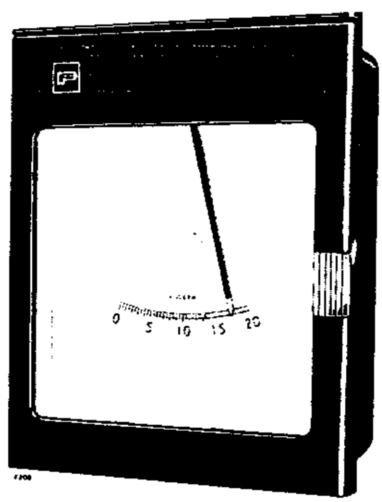
Intrinsically Safe/Securite Intrinseque

DEVICE	PARAMETERS	APPROVED FOR CLASS I, DIV. 1
CSA approved Zener Barrier	30 V or Less 300 Ohms or More	Groups A, B, C, & D
CSA approved Zener Barrier	28 V or Less 240 Ohms or More	Groups A, B, C, & D
Foxboro Converters 2AI-12V-CGB, 2AI-13V-CGB 2AS-13I-CGB, 3A2-12D, 3A2-13D	----	Groups B, C, & D
CSA approved Zener Barrier	30 V or Less 120 Ohms or More	Groups C & D

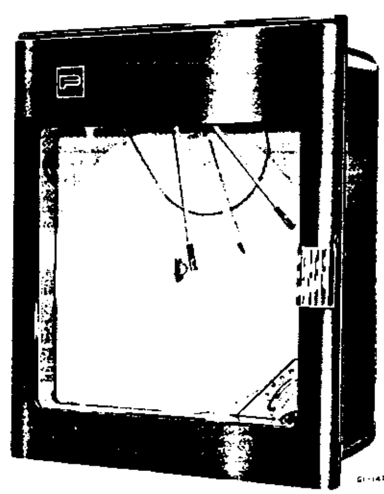
PRESSURE RECORDER

Model:	Fischer & Porter 51B1102DMXXXDBXXX2BB2BB
Display:	Circular Chart Recording, 12 Inch
Chart Drive:	120 VAC 60Hz, 24 Hour Rotation
Input:	(A) Pen No. 1 (Red) 4-20MA Linear Injection Pressure
	(B) Pen No. 2 (Blue) 4-20MA Linear Monitor Zone 1
	(C) Pen No. 3 (Green) 4-20MA Linear Monitor Zone 2
Pen:	Fibre Tip, Disposable
Measuring Range:	0 to 60 PSIG
Chart/Scale:	0 to 60 Linear (Chart Direct Reading)

INSTRUCTION BULLETIN
for
SERIES 1100 INSTRUMENT CASE
(Large Case Indicators and Recorders)



TYPICAL TYPE 1101 INDICATOR


TYPICAL TYPE 1102 RECORDER

FISCHER & PORTER

TABLE OF CONTENTS

The instructions given herein cover generally the description, installation, operation and maintenance of subject equipment. F&P reserves the right to make engineering refinements that may not be reflected in this Bulletin. Should any questions arise which may not be answered specifically by these instructions they should be directed to the Fischer & Porter Co. for further detailed information and technical assistance.

PREFACE

This Instruction Bulletin provides information relative to the F&P Series 1100 Instrument Cases. Individual Instruction Bulletins are supplied with the instrument to cover the various components contained within or related to the specific model instrument supplied. Series 1100 Instrument Cases may be furnished as indicators (Series 1101) or as recorders (Series 1102).

DESCRIPTION

The F&P 1100 Instrument Cases are of die cast aluminum. Two typical instruments are shown on the front cover. These instruments may be mounted in various ways. The case may be flush or surface mounted with the standard mounting brackets. As an option, a 2" (DN 50) pipe mounting bracket may be furnished. With this bracket, the instrument can be attached to either a vertical or horizontal pipe.

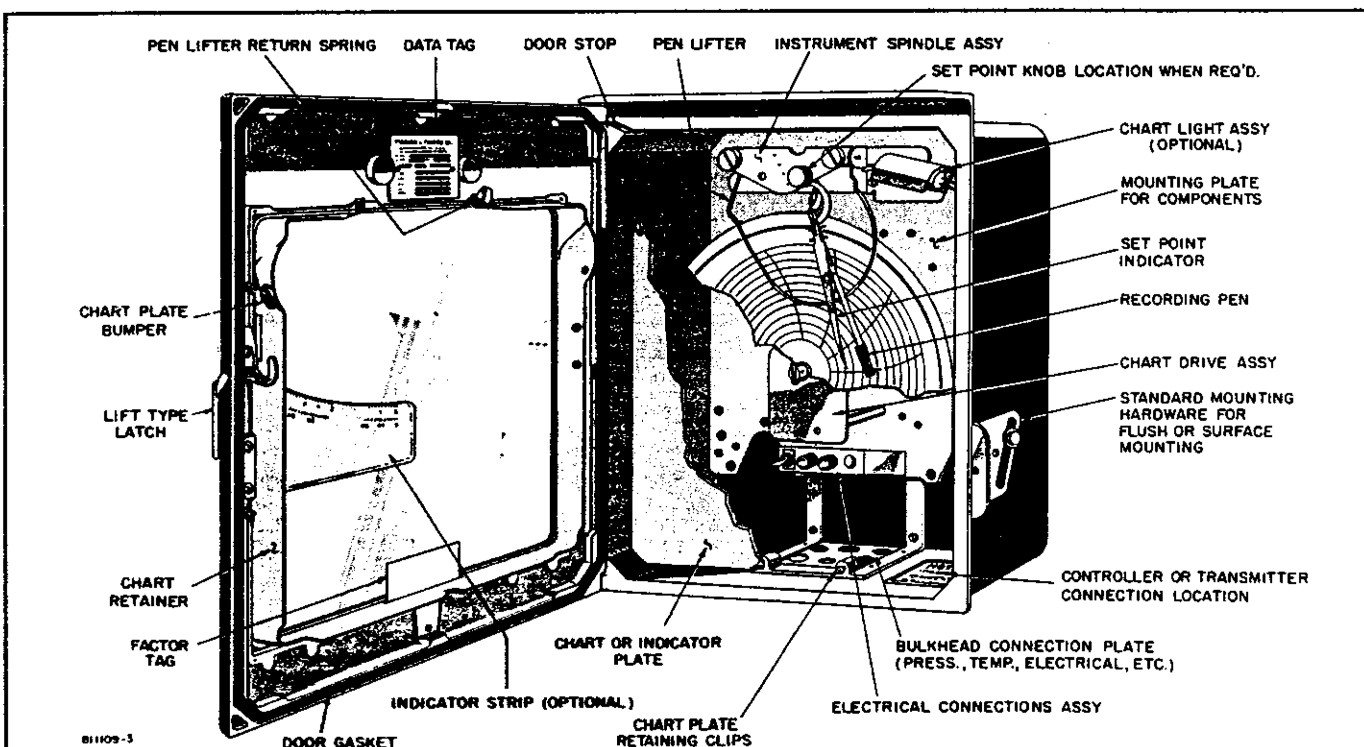


FIGURE 1. COMPONENT IDENTIFICATION

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SERIES 1100 INSTRUMENT CASE

The case door, as shown in Figure 1, is hinged on the left side; a lift type latch is used to secure the door. All components within the case are supported on a mounting plate attached to the rear wall of the case. Attached to the upper portion of the mounting plate is the instrument spindle assembly. The function of this assembly is to convert the linear positions of the receiving element, by way of linkage, to angular shaft positions proportional to the process. The recording pen or indicator attached to the spindle is thus positioned along an arc line of the recording chart or segmental scale, as may be applicable. The instrument spindle assembly is designed to accommodate four spindles. Two of these spindles may be used for set point mechanisms.

The Series 1102 Recorder may have a 5" Indicator Strip for visual display of the recorded value. For increased readability, both the 1101 Indicator and the 1102 Recorder may have a 10" Indicator Scale. Both of these options are discussed in detail in Part VI under Component Information.

Recording instruments may have either an electric or spring operated chart drive. A combination chart hub and holder extends from the chart drive assembly through a slot in the chart plate to hold and drive the chart. A chart retainer on the door (flange around the glass) restrains the outer edge of the chart.

A connection plate is provided in the bottom or the back of the instrument case, as specified. This connection plate is for process or electrical conduit connections as required.

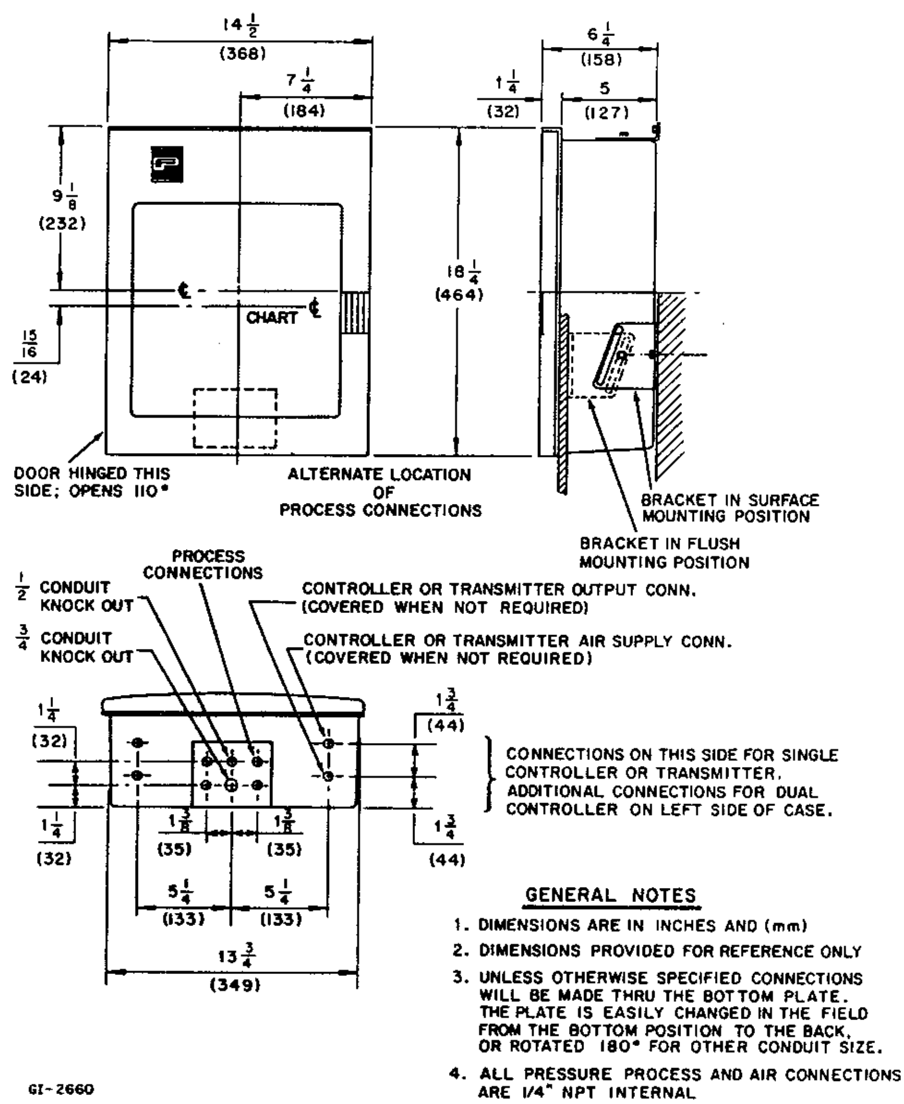

FIGURE 2. OUTLINE DIMENSIONS

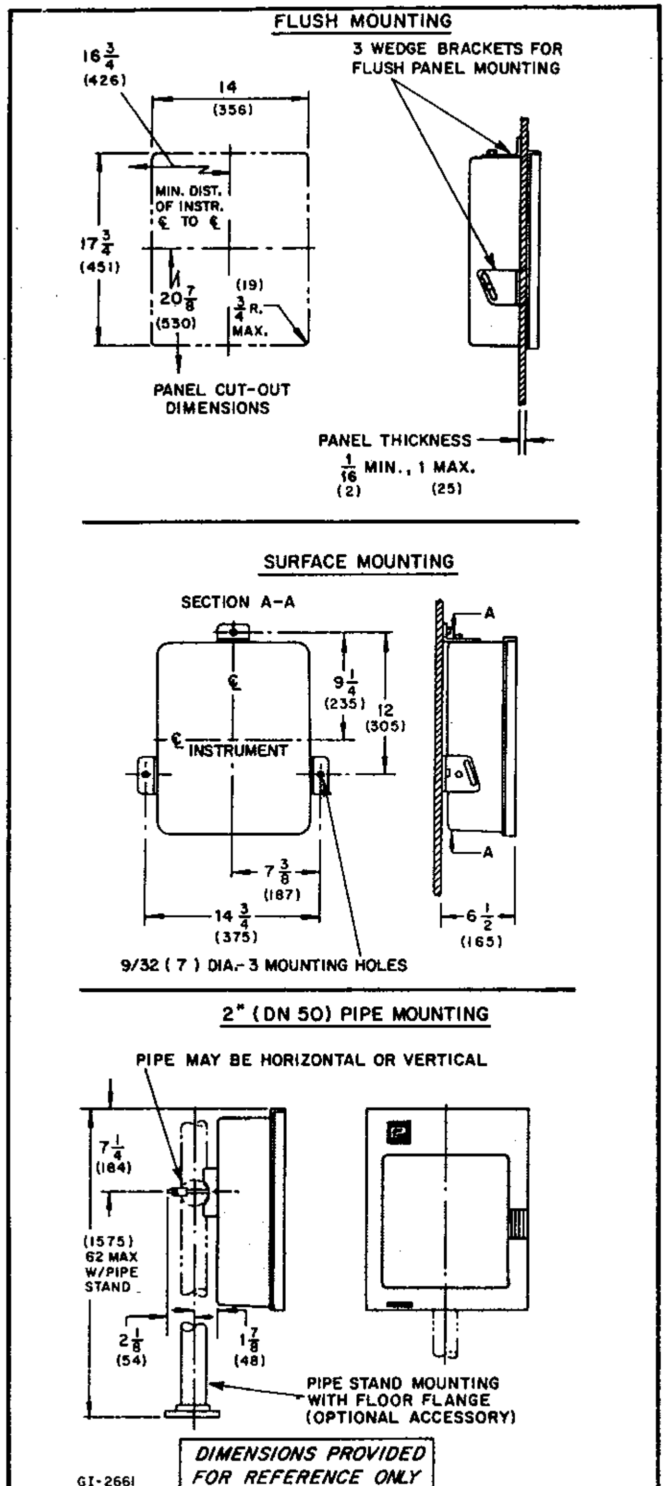

FIGURE 3. MOUNTING OPTIONS

INSPECTION

When the instrument is received, unpack and visually inspect it immediately for damage. Any damage should be reported to the shipping agent involved before attempting to install or operate the instrument.

Check the itemized packing list against the shipment. Mounting accessories are packaged and shipped with each instrument.

INSTALLATION

I. General

The instrument components may determine the mounting location. The standard enclosure meets NEMA 2R and IEC IP22 requirements; the weather-proof option is NEMA 3R and IEC IP24. Although the case is gasketed for dust and dirt and is reasonably weather proofed, the ideal condition for mounting is one free from dust, dirt, corrosive fumes, vibration and temperature extremes. By way of example: electronic instruments should not be subjected to extreme temperature variations; a vacuum transmitter should not be mounted in corrosive atmosphere since atmospheric air is being pulled into the system. It is suggested that the location chosen be well lighted.

Mount the instrument case in a level, vertical position. The use of a plumb bob or level is recommended. Basic case dimensions are shown in Figure 2. Mounting options are shown in Figure 3. Externally mounted components or meters attached to the case, as illustrated in Figure 4, will affect these dimensions. Instruments are normally mounted so that the indicated or recorded value is at eye level.

II. Mounting the Case

The case may be flush or surface mounted with the standard hardware. A pipe clamp is available for attaching the case to a vertical or horizontal pipe. A pipe stand with a floor flange may be supplied when specified — this is used with the pipe clamp.

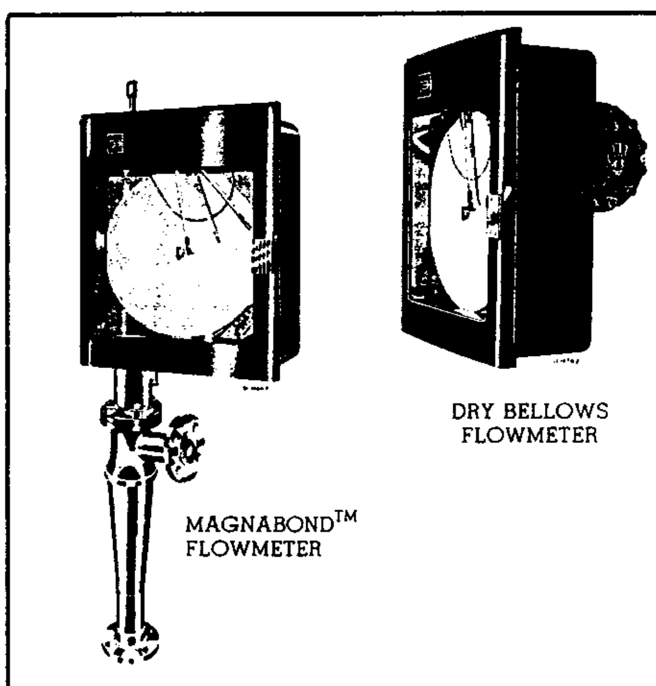

FIGURE 4. RECORDERS WITH EXTERNALLY MOUNTED MEASURING ELEMENTS

CAUTION

When installing an instrument case that houses a temperature or pressure element equipped with capillary tubing, be extremely careful not to bend the tubing sharply. Do not, under any condition, cut the capillary tubing.

When mounting an instrument case with externally mounted measuring elements (i.e., Magnabond flowmeter, dry bellows flowmeter, etc.), allow sufficient room around the instrument case for component removal and service accessibility.

III. Case Connections

A. General

A connection plate for process and/or electrical conduit connections will be located in the bottom of the case unless otherwise specified. A blank plate is located in the back of the case, and the two plates may be interchanged as required to suit the particular application.

Knock-outs for ¾" and ½" electrical conduit are provided. Process pressure connections are ¼" NPT (internal) with an internal screen; ½" NPT optional. Notice in Figure 2 (the outline dimension drawing) that separate ¼" NPTI connections, located on either side of the connection plate, are used for pneumatic Controllers or Transmitters. These connections, when required, are marked "Air Supply" and "Air Output". Other process pressure connections are made to the connection plate, with the exception of connections to externally mounted meters (such as a dry bellows flowmeter).

B. Changing Connection Plate Location

The connection plate can be relocated from the bottom to the back of the case or rotated 180° to reverse the position of the conduit connections. To relocate the connection plate from the bottom to the back proceed as follows:

1) Disconnect all non-flexible customer connections such as pipe, conduit, etc. from the case (sealed system connections must not be disturbed).

2) Remove the four screws securing the blank plate and remove it from the case.

3) Remove the four screws securing the connection plate.

4) Carefully move the connection plate to its new position, with the attached internal pressure and/or sealed system capillary. Secure the connection plate in its new location.

5) Position and secure the blank plate in the opening formerly occupied by the connection plate.

6) Reconnect the customer connections that may have been disconnected while making the change-over.

COMPONENT INFORMATION

I. Inking System

A. General

The F&P inking system is shown in Figure 5 and consists of a pen arm that carries an easily removable Disposable Inking System (DIS). This DIS consists of a plastic container that holds the ink formulation (in a styrofoam fill) and a fiber tip writing nib. Writing takes place due to surface tension effects of the chart paper pulling the ink from the nib as it moves. The DIS, under favorable conditions, will write for a considerable period of time; shorter writing time may be expected if the recorded process is active.

A maximum of four DIS pens can be accommodated. The first and shortest nib length DIS carries red ink. If additional DIS pens are used, blue, green and black are added in that order. The nib on each DIS is longer to avoid interference. When more than one DIS is furnished, the operating components and the case connections are color coded to match the DIS color.

The white pointer stripe on the DIS is useful when reading process values displayed on an indicator strip. Figure 7 shows the recorder with the indicator strip.

B. Placing In Operation

The DIS is shipped in a foil package to increase the shelf life. Do not open a foil package unless the DIS is to be placed into service.

To place a DIS in operation, proceed as follows:

1) Open the instrument case door as illustrated and lift the pen arm(s) by operating the pen lifter.

2) Select the proper color DIS and attach it to the desired pen arm. Three views of the DIS being attached to the pen arm are shown. With the DIS in place, remove the nib cover (its just pressed on lightly).

3) Return the pen(s) to the chart paper by pushing the pen lifter in until it touches the paper. The DIS is now operative — close the door to complete the procedure.

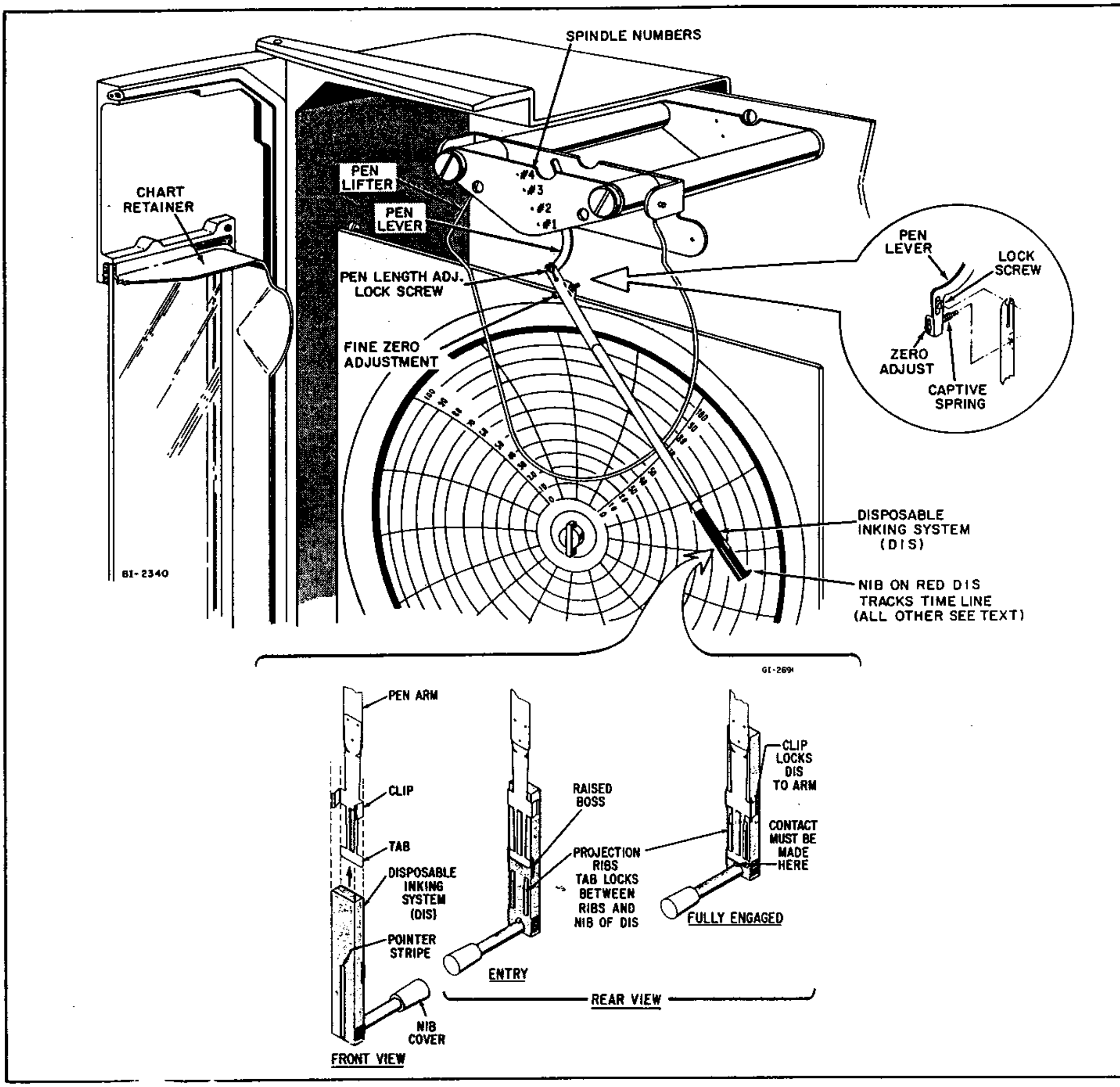

FIGURE 5. INKING SYSTEM

COMPONENT INFORMATION (Continued)

C. Color and Number Designations of Pens

The color designated for a recording pen or indicator is carried throughout the instrument to identify the components and connections when the instrument serves more than one function. For example, an instrument that serves to record two pressures will have a red and blue recording pen. The components associated with the red pen will be color coded red and those with the blue pen are coded blue. The process receiving element will have a color dot on it and the process connection will have a circle of color around the connection on the bottom of the case.

Fischer & Porter instruments may contain from 1 to 4 recording pens or indicators, each being carried on a separate spindle. The instrument spindles are numbered from the bottom up and are designated #1, 2, 3, and 4. The #2 spindle is used for the prime measurement; when additional functions are added, #3, #1 and #4 spindles are used in that order. The recording pen or indicator color is derived from the spindle location. The following designations are F&P standards; variations may be supplied upon request and will be so stated on the F&P Manufacturing Specification Sheet (data sheet).

Colors are as follows:

Spindle #2 .... Red
Spindle #3 .... Blue
Spindle #1 .... Green
Spindle #4 .... Black*

*When a single controller is supplied and all four spindles are used, green is specified for spindle #4.

When a single controller is supplied, the process recording pen or indicator is attached to spindle #2 (red) and its set pointer is attached to spindle #1 and is color coded red.

If a second controller is supplied, the process recording pen or indicator is attached to spindle #3 (blue) and its set pointer is attached to spindle #4 and is color coded blue.

A ratio controller always has the wild line coded red and the controlled line coded blue.

II. Fuses and Switches

Instruments containing only a chart drive motor (recorder) have a fuse in the phase side of the line but no service switch is provided. Usually instruments containing other power consuming devices are provided with both a service switch and fuses. A wiring diagram is furnished with instruments containing electrical components to show the exact details. Voltage and frequency information appears on the instrument data tag and the F&P Manufacturing Specification Sheet.

III. Data Tags

The data tag is affixed to the inside of the instrument case door above the window. This data tag states the instrument Serial and Model numbers as well as other pertinent information relative to the calibration factors. If this is a secondary instrument, the tag also identifies the primary instrument associated with the instrument.

Other data tags may be affixed to the individual components that state information relative to the particular component.

When ordering spare parts, always give the instrument Serial and Model numbers plus any other data tag information relative to the particular component involved.

IV. Installing a Recorder Chart

To install a recorder chart, proceed as follows:

1) Open the recorder door and lift the pen(s) from the chart by using the pen lifter.

2) Push the chart hub wedge lock to one side and turn it out to remove the chart.

3) Install a clean chart that has been properly dated (and integrator reading noted if required). Turn the chart to the proper time grid arc as indicated by a stamped line on the chart plate.

4) Pull the chart hub wedge lock forward slightly and allow it to turn against the paper. Push the wedge to lock the hub to the chart.

5) Close the recorder door. As the door is closed, the pen lifter return spring mounted on the door will return the pen(s) to the chart.

V. Charts

A. General

Recorders may be provided with either standard 24 hour (7 day, 30 day, etc.) charts, as shown in Figure 6, or the universal time gride chart shown in Figure 8.

The universal chart was developed by Fischer & Porter Co. to provide, on one chart, direct reading time graduations for the most commonly used rotations. This chart has 96 time grid arcs and by using a factor, many other rotation requirements can be met.

B. Universal Chart

1. Inner Ring

24 hour chart rotation is most common. The inner ring carries graduations for both the 12 and 24 hour system and for the 24 hour system with night shading between 6:00 P.M. and 6:00 A.M. The inner ring may also be used for 24 minute rotation test work. Where test durations exceed 24 minutes, this speed may be preferred for its flexible time scale, since charts can usually be overrun one revolution without confusing the record.

2. Outer Ring

The outer time ring provides for weekly or 8 day service as desired. Days are named and day-night shading is provided. Notice that with weekly change, the chart can be started on Sunday or Monday and run thru the 8 day period without conflict of day names. This same outer ring contains the numbers 1 to 8 for 8 hour or 8 minute rotations. As before,

COMPONENT INFORMATION (Continued)

overrunning is convenient for slightly longer operating times, particularly the occasional 12 hour requirement.

3. Factor Reading

Many other rotation requirements are met by the 96 arc time grid of the universal chart; hence, special charts are rarely needed for any time period. Obviously, a convenient multiplier can be used for various speeds if corresponding chart drive speeds are available. For example: 24 minutes times 4 equals 96 minutes; thus for 96 minute rotations each quarter hour graduation is exactly one minute. Also 24 minutes times 10 equals 240 minutes or 4 hours rotation.

C. Duplication

Fischer & Porter charts are designed for reproducing without limiting choice of ink color and in addition they reproduce well without undue prominence of the grid lines with reference to the record line. Charts are printed on a stock which can be copied directly by white or blue print process if a slow printing time is accurately selected.

When copying services are available, it may be more practical to make a reduced size copy to such a scale that the desired area from one or more charts is within the standard 8-1/2" x 11" page size instead of the full 11-7/8" diameter.

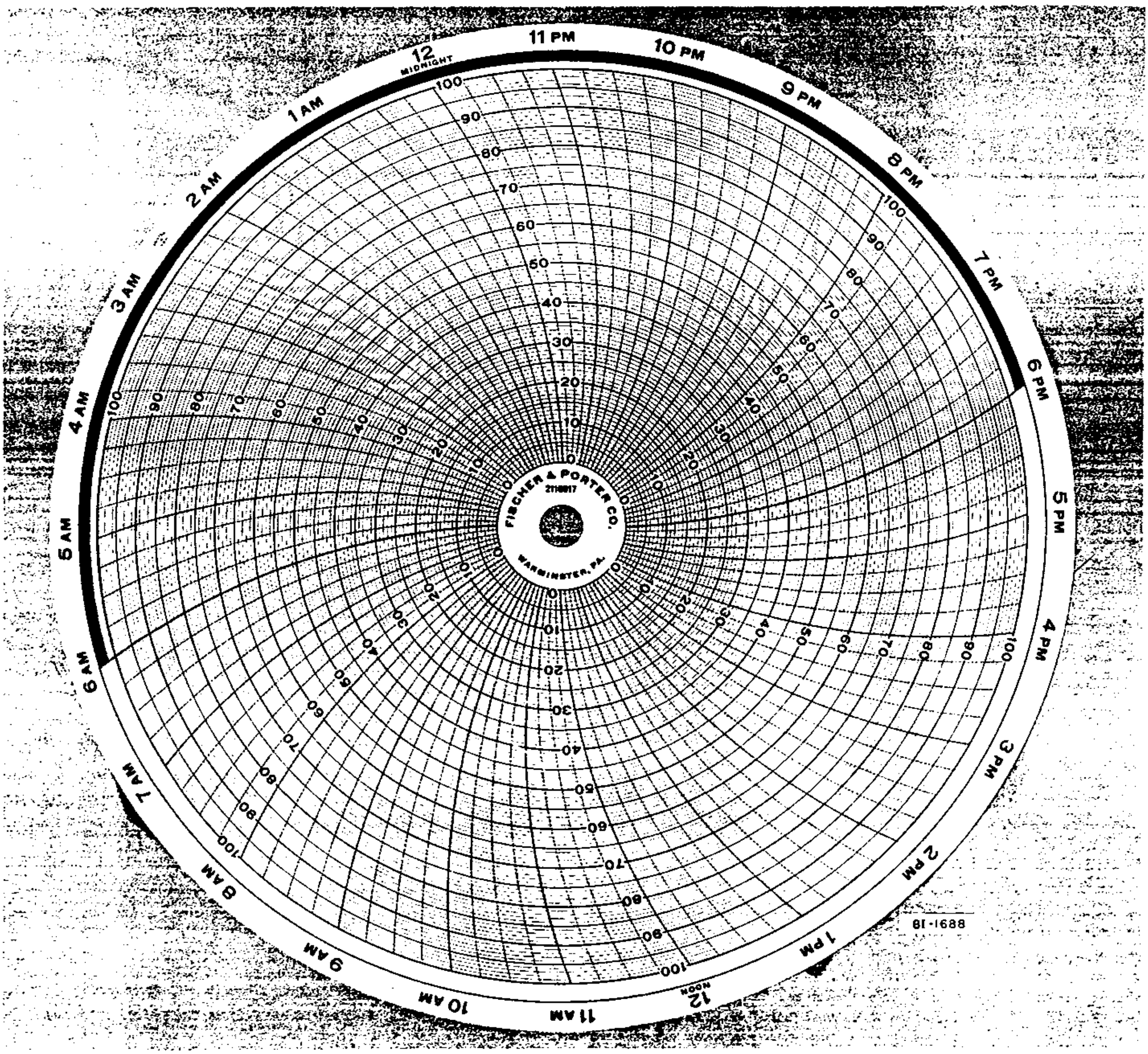

FIGURE 6. TYPICAL STANDARD RECORDING CHART

VI. Indicator Scales

A. Indicator Strip

When visual display of the recorded value is required the Indicator Strip shown in Figure 7 may be specified. The Indicator Strip is a calibrated scale on a plastic segment attached to the inside of the door. For viewing, the color coded recording pen is directly behind the indicator strip. Thus, the recording pen provides a permanent record, while the indicator shows the instantaneous value. The indicator strip may be calibrated in any desired engineering units and is frequently different than the recorded units.

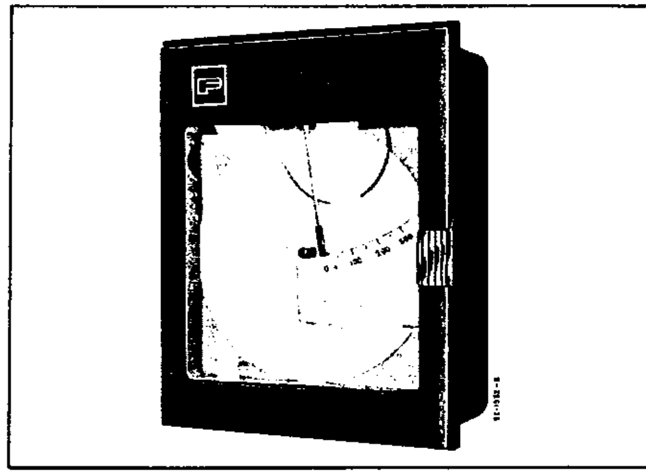

FIGURE 7. RECORDER WITH AN INDICATOR STRIP

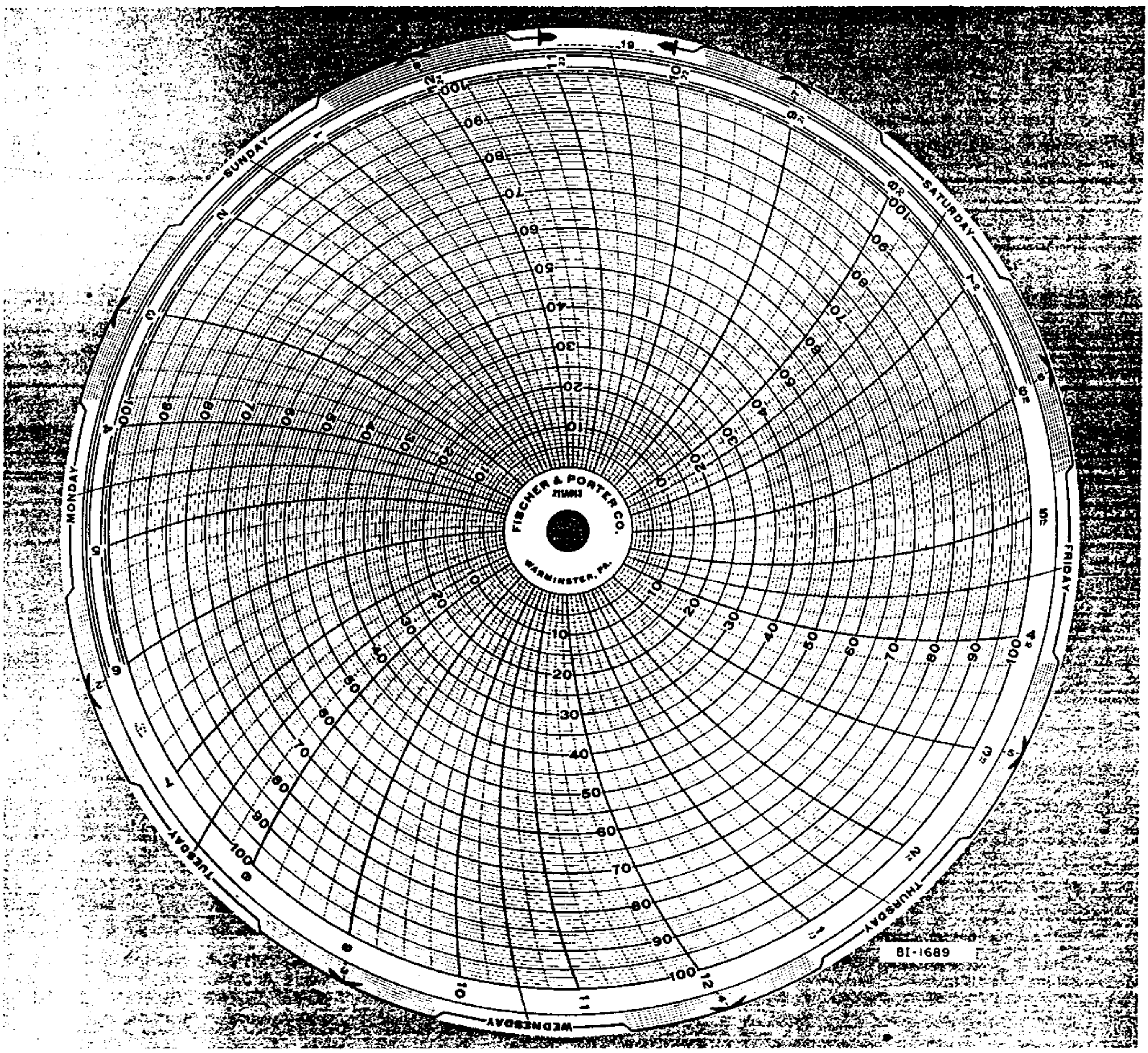

FIGURE 8. TYPICAL UNIVERSAL RECORDING CHART

COMPONENT INFORMATION (Continued)

If the value of two recorded items is to be displayed, a second scale is provided on the door strip. Each scale on the indicator strip is color coded to match the associated recording pen. A maximum of two recording pens may be indicated.

B. 10" Indicator

When visual display of the recorded value with increased readability is required, a 10" Indicator may be specified. The 10" Indicator, shown in Figure 9, is a calibrated scale engraved on a plastic plate attached to the inside of the door. To read the process variable value, an indicator (pointer) is positioned behind the scale. This indicator is operated by a separate instrument spindle.

The process variable recording pen moves approximately 4-5/8" across the recorder chart from minimum to maximum value. The recording pen spindle, thru an intermediate linkage, is used to operate the pointer across the 10" scale; thus slightly better than a 2:1 amplification of the pen motion is required.

The illustration shows the intermediate linkage and related pointer parts. The spindle designated #2 represents the process variable input signal. This spindle positions 1) the red recording pen and 2) a linkage that attaches to a sub-spindle approximately 5" below the main spindle. The lever arm on spindle #2 is approximately twice as long as the lever arm on the sub-spindle. This bottom lever length is adjustable so that an effective multiplication of the 4-5/8" chart travel to the 10" indicator travel is achieved. A 1:1 linkage connects this sub-spindle to instrument spindle #3. Attached to the forward end of this spindle is the pointer that moves behind the 10" indicator scale.

MAINTENANCE

I. Removing Chart or Indicator Plate

If servicing of internal components of the instrument is necessary, the chart or indicator plate is easily removed to expose the components.

Proceed as follows:

1) Open the instrument case door.

2) On recording instruments, remove the chart by pushing the chart hub wedge lock to one side and turning it out to release the chart.

3) Lift the chart or indicator plate slightly to clear the retainer clips (by grasping the plate at the 1" diameter hole near the bottom). Move the plate forward and down to complete the removal. The upper end of the plate is held by two clips, one each side of the plate. A "U" shape slot in each clip engages a trunion screw to maintain alignment.

II. Chart Drives

Chart drives may be either electrically operated or spring wound. The standard electric drive is suited for general purpose electrical requirements. Spring drives are available in various speeds and running times. The 24 hours per revolution drive can be specified for 1 or 7 days per wind. Other speeds are available on special request.

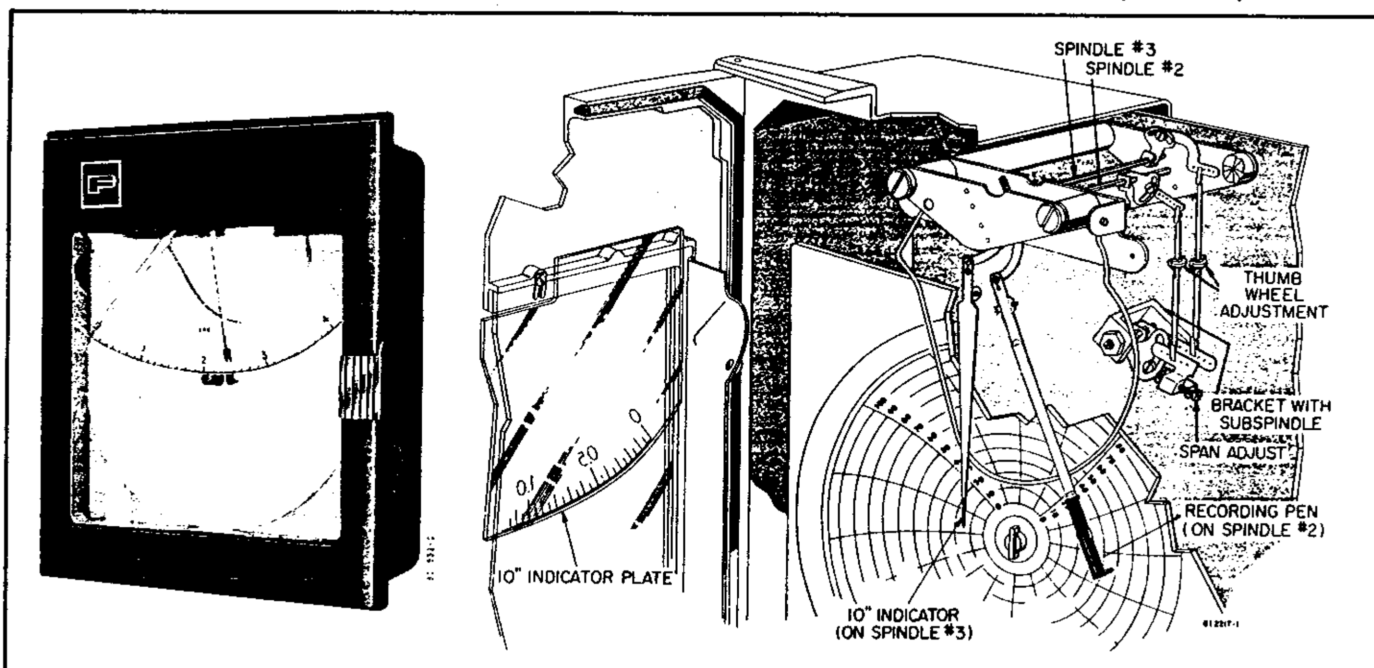

FIGURE 9. RECORDER WITH 10" INDICATOR

Chart drive assemblies are pre-lubricated and sealed; thus, no lubrication is required for the life of the instrument.

Adjustment is provided on the standard chart drives to position the chart drive hub so that the chart lays flat against the chart plate. Loosen the set screw in the hub and rotate the hub on the shaft threads in the direction required to make the chart lay flat. Retighten the set screw.

III. Removal of Connecting Links

If a connecting link is to be removed from an instrument component, carefully note the hole in the take-off lever that is being used. It is strongly recommended that a sketch be made to show the exact location rather than relying on memory. When the instrument is calibrated in the factory, the unused holes were painted with black paint, so that the unpainted hole is normally the proper location. However, component replacement or range changes may have obsoleted the original factory markings. Be careful when handling the connecting link not to change its length, as a turn of the connecting link adjustment may seriously affect the instrument calibration.

IV. Disposable Inking Systems (DIS) (Recording Pens)

A. DIS Pressure

The DIS nib should have 0.5 grams pressure on the chart paper. The use of a gram scale is recommended. However, the pressure may be checked by depressing the chart plate. When the chart is moved in 1/8", the nib should be clear of the chart paper. If an adjustment is indicated, remove both the chart and the chart plate. A properly adjusted DIS will show the nib tip 1/8" below the chart hub gripper surface. A strip of light gauge sheet metal with a 1/2" diameter hole in one end may be installed in place of the chart so that the distance may be observed. Adjust the DIS pressure by bending the pen lever (not the flexible pen arm). Operate the pen lifter a couple of times and recheck the pen pressure. If okay, replace the chart plate and chart.

B. Time Line Tracking

When an additional recording pen is installed in an existing instrument, the length of the new pen must be adjusted so that the writing tip will not interfere with the tips of the existing pens. The original recording pen, in an instrument, is always attached to the number 2 instrument spindle. The length of this pen is factory adjusted to the center-

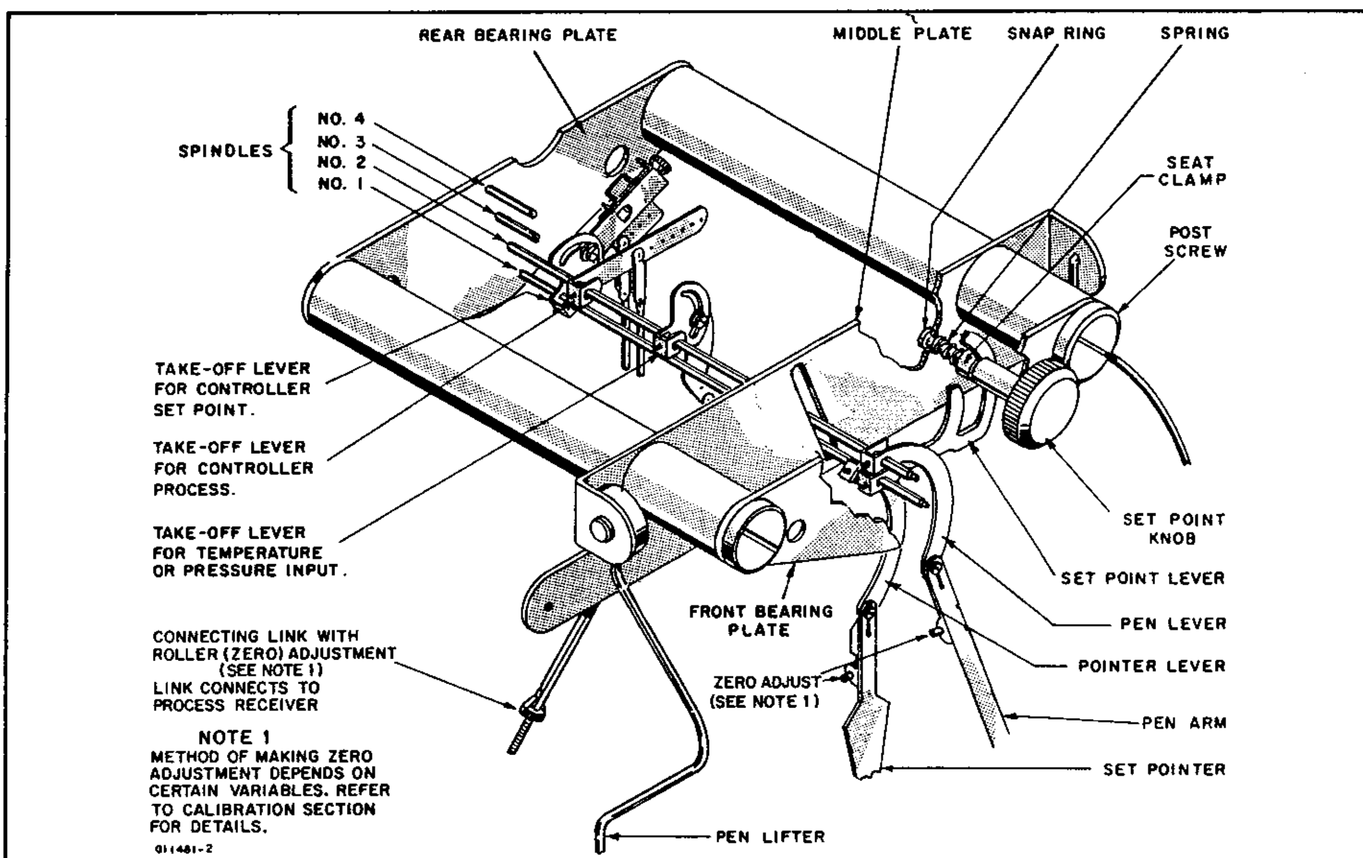

FIGURE 10. INSTRUMENT SPINDLE ASSEMBLY

line of the chart drive (with the chart hub removed) and must follow the time line within 0.015" over the full scale.

The length of the new pen is adjusted by loosening the screw at the top of the recording pen arm where it attaches to the pen lever. Move the pen arm up or down in the slot as necessary and retighten the screw.

If the new pen is attached to the number 3 spindle (second spindle used) the pen arm length should be adjusted to clear the bottom of the pen attached to the number- 2 spindle when it is positioned at 50% chart.

If the new pen is attached to the number 1 spindle (third spindle used) it should be adjusted to clear the top of the pen attached to the number 2 spindle at 50% chart.

If the new pen is attached to the number 4 spindle (fourth spindle used) it should be adjusted to clear the pen attached to spindle number 1 at zero and 100% chart.

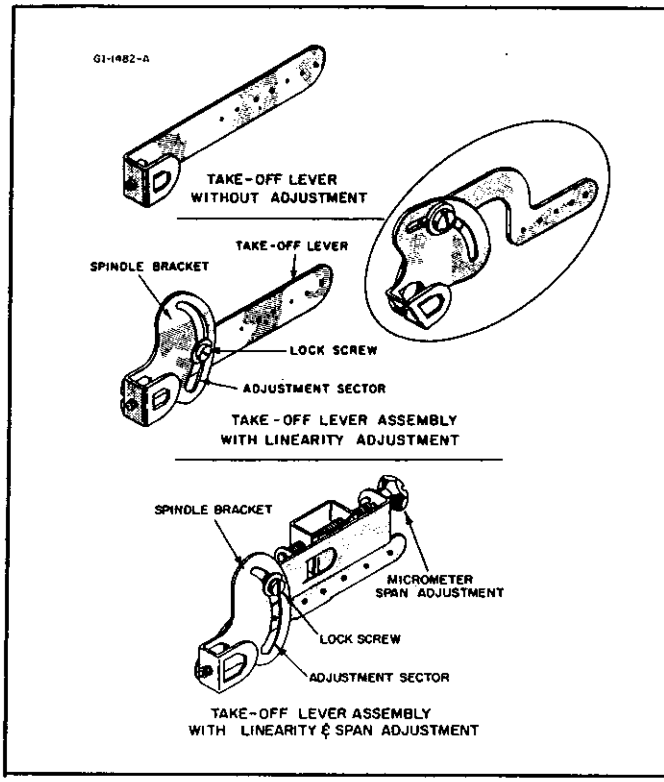

FIGURE 11. TYPICAL TAKE-OFF LEVERS

V. Instrument Spindle Assembly

A. General

The instrument spindle assembly is shown in Figure 10. In this illustration the front and middle bearing plates are cut away to show the components used for the right hand set point mechanism. The spindle assembly, as shown, is typical of the arrangement used to operate a pneumatic controller from a pressure or temperature signal. Notice that two additional spindles (numbers 3 and 4) may be added to accommodate two additional recording pens (indicators) or one additional controller. The set point mechanism for the second controller would be located on the left side of the spindle assembly.

Various types of take-off levers are used to accommodate the needs of the particular instrument. Some of the more common types of take-off levers are illustrated in Figure 11. In actual practice, the levers may be curved or offset to clear the spindles, but the end result is the same.

Figure 12 illustrates the optional double depth instrument case. This design permits additional receiving elements to be attached to a rear mounting plate. The spindle(s) extend thru the case to a rear bearing plate. Also shown in the illustration is the optional external set point adjustment.

To operate the set pointer, the knob on the front of the door is pressed inward and then turned. The knurled disc on the back of the door contacts the "O" ring on the spindle assembly internal set point knob to form a friction drive.

The instrument spindle assembly does not require any lubrication. Experience has shown that lubrication is detrimental since the lubricant collects dust and air, causing friction and wear.

B. Modifying the Spindle Assembly

1. General

When an instrument component is to be added to an existing instrument, the instrument spindle assembly must be modified to accommodate the additional linkage. It is usually easier to modify the instrument in the instrument shop where facilities exist to perform any required calibration. It is suggested that the instrument mounting plate be removed and placed on a bench while the spindle assembly is being modified, especially where more than one spindle is involved.

2. Disassembly

To add a spindle, spindle bracket, set point mechanism, etc., proceed as follows:

1) Shut off the source of air or electrical power to the instrument.

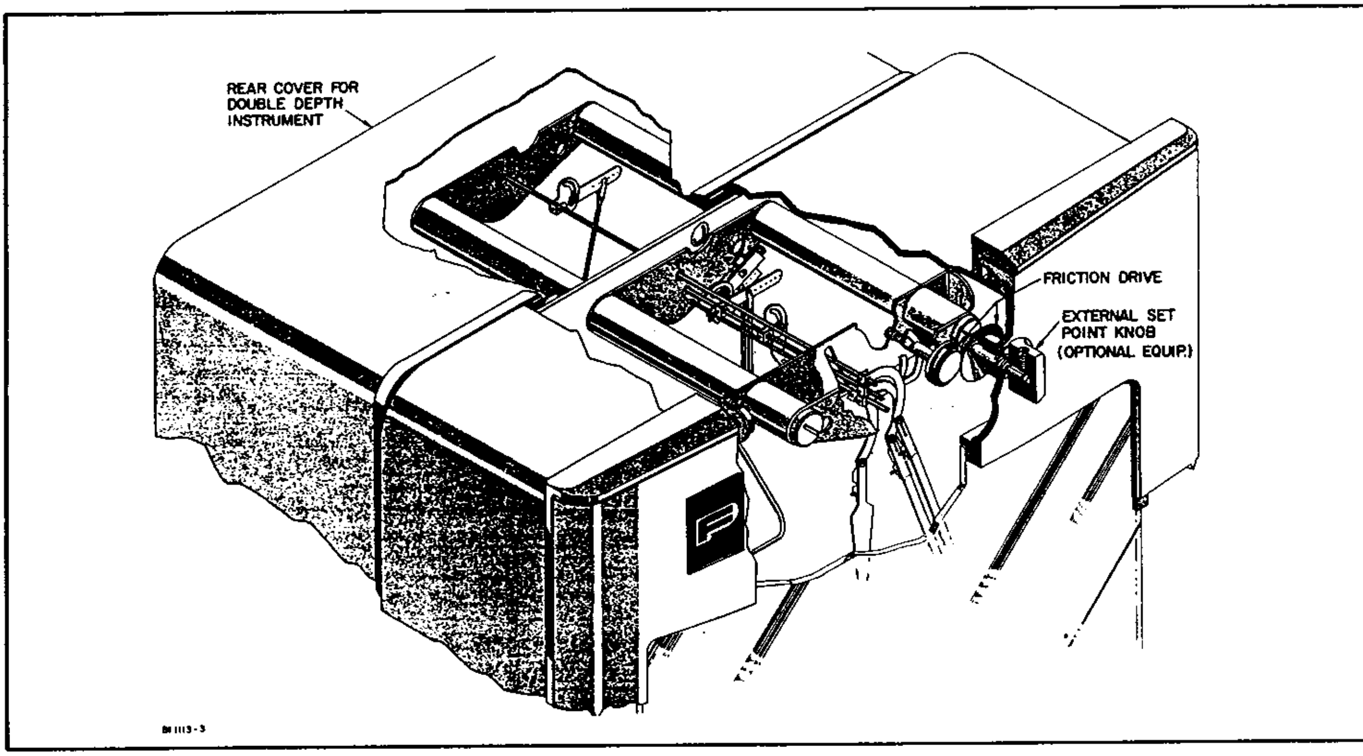

FIGURE 12. DOUBLE DEPTH INSTRUMENT SPINDLE ASSEMBLY

2) Raise the recording pens from the chart and remove the chart; then remove the chart plate.

3) Carefully note the location of the connecting linkage by making a sketch. This sketch should show the hole that is used for each take-off lever in order that the linkage may be replaced properly.

4) If the spindle assembly does not have a set point mechanism, remove the post screws and front bearing plate to release the spindles.

5) If the spindle assembly has a set point mechanism, first remove the snap ring from the set point knob shaft (this snap ring is located behind the middle plate). Then, pull the set point knob from the spindle assembly by pulling it forward. When the knob is pulled forward, a spring and a seat clamp (bushing) will fall from the assembly. Be careful not to lose these parts. Remove the post screws and the front bearing plate to release the spindles.

6) Note the location of the flat on the hexagon spindle that the pen or pointer lever set screw contacts, then loosen the set screw and remove the pen and pointer assemblies. This allows the spindle to be removed from the slot in the middle plate (plate that holds the pen lifter).

3. Re-assembly

To re-assemble the instrument spindle assembly proceed as follows:

1) Add any required take-off levers and orient as required.

2) Slip the spindle thru the slot in the middle plate. Seat the spindle in the proper rear bearing plate hole, then replace the pen or pointer assemblies and the front bearing plate. Make certain that the front of the spindle is in the corresponding bearing hole.

3) Replace the post screws, then tighten the set screws in each pen or pointer lever when it is properly oriented with respect to the take-off levers (set screw on flat of hexagon spindle originally noted).

4) If a set point mechanism is to be installed refer to Figure 10 for the location of the various parts.

NOTE

If the set point mechanism is added to the right side of the spindle assembly, it must operate spindle #1 and the process must be on spindle #2; on the left side the set point mechanism operates spindle #4 and the process must be on spindle #3.

5) Refer to the component Instruction Bulletin for the method of adjusting the connecting links and take-off levers. Perform the required calibration procedures discussed in detail in these Instruction Bulletins.

CALIBRATION

I. General

This instrument was carefully calibrated prior to shipment from the factory for proper and dependable operation. Very little attention is ever required to the various linkages attached. Should any field calibration be required, refer to the Instruction Bulletin on the instrument component involved. It is suggested that a tracking test be made prior to making any adjustments to determine the exact nature of the correction to be made.

If the instrument case houses a Controller or Transmitter, check the tracking of the process receiving element with respect to the recording pen or indicator first as any error in the process measurement will affect the final Controller or Transmitter output signal.

II. Tracking

The tracking test is conducted to determine the movement of the recording pen or indicator with respect to the process. Tracking should be checked in at least three points. Usually for convenience, scale points of 20, 50 or 80% are used. The results of this test may be plotted on a graph as shown in Figure 13.

EXAMPLE:

It is desired to check the tracking of a 0 to 50 psig pressure indicator. Proceed as follows:

1) Install a "test accurate" pressure gauge in the pressure line to the instrument.

2) Adjust the process so that the pressure on the pre-calibrated gauge indicates 50% of the instrument span (in this case 25 psig is required).

3) The process pointer should indicate 50% scale. The offset, if any, should be plotted on the graph.

4) Adjust the process so that the pressure on the pre-calibrated gauge indicates 20% and then 80% of the instrument span (in this case 10 and 40 psig) and note the offset. The offset at either point should be plotted on the graph.

5) Draw a line through the plot points of the graph to show the instrument curve. If the test indicates that the process pointer is within ±1/2 to ±1% (depending upon the accuracy desired) at 20, 50 and 80% scale, the tracking is correct. If this specification is not met, three adjustments are provided to adjust the tracking.

III. Tracking Adjustments

A. Description

The three adjustments provided to alter the tracking of the process recording pen or pointer are zero, span and linearity. Refer to the component Instruction Bulletin for greater detail; controller adjustments are slightly different than those discussed subsequently.

1) The <u>zero</u> adjustment shown in Figure 13, Graph A, shifts the instrument curve up or down scale to the same degree. If all output readings are offset to the same degree, this is the only adjustment required.

2) The <u>span</u> adjustment varies a slope of the curve as shown in Graph B. If the recording pen or pointer position is correct at the 50% scale position and the two extreme measurement points are expanded or suppressed by the same amount, only a span adjustment is required. However, if the plotted crosses the ideal curve at some other point, a zero and a span adjustment are required. This situation is illustrated in Graph C, curves A and B.

3) The <u>linearity</u> adjustment changes the shape of the curve causing it to increase or decrease at mid-scale positions. Graph D illustrates two conditions that indicate the need of linearity correction. If the instrument span is correct, the need for linearity correction would appear as shown in curve A. If the instrument span is short, the need for linearity correction would appear as shown in curve B.

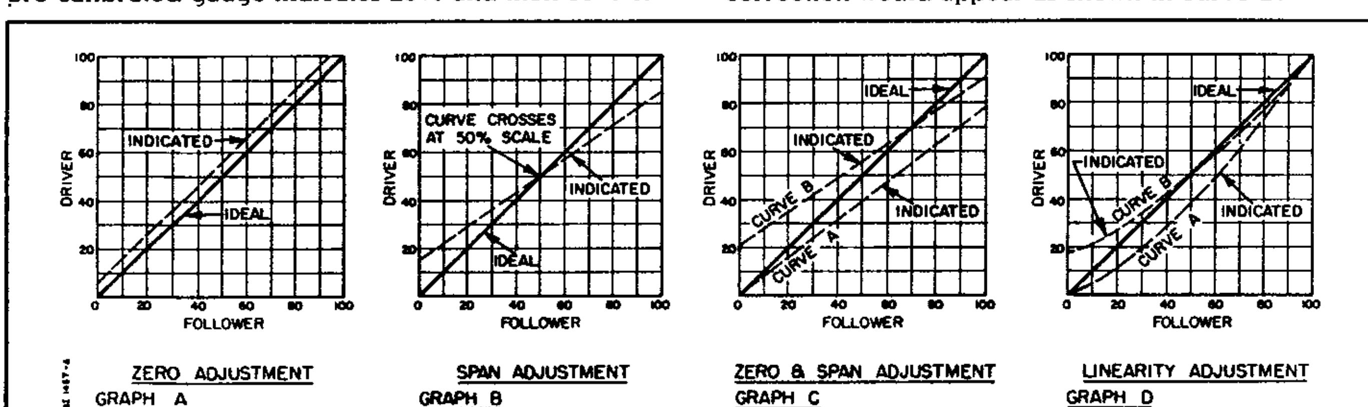

FIGURE 13. TRACKING GRAPHS

B. Procedure

1. Zero Adjustment

The zero adjustment can be made at any point along the scale, but it preferably made at 50% scale (for ease in checking span). If the recording pen or pointer is at other than the desired value, and the instrument is recording or indicating only (no controller, transmitter, or integrator) turn the zero adjustment on the recording pen or pointer. This adjustment is set at the factory in the midpoint and and zero adjustments of ±4% can be made. Turn this adjustment clockwise to decrease the indicated reading.

When the instrument is operating some other component, controller, transmitter or integrator, the adjustment on the pen or pointer should not be used except for extremely fine adjustment (± 1/4%) since it would offset the relationship between the components. In this case the adjustment can be made in either one of two ways as follows: 1) If the pen or pointer is within ±3%, the zero adjustment can be made by increasing or decreasing the length of the connecting link with the roller adjustment. Theoretically, the length of the link should not be changed as this would effect the linearity of the system. However, in actual practice, the link length can be changed a small amount without adverse effects; 2) the zero adjustment may also be made by way of the adjustment sector on a take-off lever with a spindle bracket that has an adjustment sector. This take-off lever may be attached to either the receiving element or the instrument spindle. In either event, loosen the lock screw at the adjustment sector and move the take-off lever in the direction required to bring the recording pen or pointer to the desired value. Retighten the screw when the adjustment is completed.

2. Span Adjustment

The span adjustment (also known as multiplication or range adjustment) is made by turning the micrometer adjustment screw on one of the take-off levers in the linkage system. Turning this adjustment screw increases or decreases the length of the take-off lever. The movement of the follower (process pointer) with respect to the driver (receiving element) is determined by the length of the levers used. Levers of equal length will transmit motion one to one if the levers are parallel in the mid-position. By increasing the length of the driver lever only or by decreasing the length of the follower lever only, the total rotation of the follower (process pointer) is increased, for the same change of the driver (receiving element).

Should the limit of the adjustment screw travel be reached, move the associated connecting link to the next hole, then restore the micrometer adjustment to its useful range. When this type of adjustment is made, recheck that the connecting link forms 90° angles with each take-off lever when the process variable is at 50% of its scale.

If both a span and zero adjustment are required, the span adjustment should be made first and then the zero adjustment.

Example:

Scale range = 0-100%

Input signal = 25 & 75% scale

Indicated value on scale = 22-74% scale

Make the indicated value (22-74% or 52% of scale) equal to the desired span (25-75% or 50% of scale) by turning the adjustment screw. The span is now correct, but readings are low throughout the scale. Bring the indication to its true value by zero adjustment.

3. Linearity Adjustment

Linearity adjustments are rarely required if the linkage is properly squared. Link type instruments are normally designed for linear travel of the follower. The levers of the driver and follower devices should be parallel with the connecting link forming a 90° angle to each of the levers when they are in the mid-position of travel. Note: This 90° angle is measured to an *imaginary* center line that goes through the hole used in the take-off lever and the center line of the spindle to which the lever pivots.

The linearity adjustment is made only after making appropriate tests that indicate the need for such an adjustment. Linearity adjustment is made by changing the length of the connecting link and maintaining a higher or lower angle at the take-off levers. This angle is changed by using the adjustment sector of a spindle bracket.

It is important to realize that the adjustments are not independent. After making a linearity adjustment, span and zero must be rechecked and adjusted. This check and recheck procedure must continue until the desired result is obtained.

As a general rule, if the connecting link is changed in length by approximately 1/8", a 1% linearity correction is achieved. If the calibration test shows that the indicated value bows low at 50% scale (as shown in graph D) the connecting link should be shortened to correct the condition.

The easiest way to make this adjustment is to change the length of the link and reconnect. Then with the driver at 50% scale, make a zero correction to bring the follower to its true value. Recheck and adjust all previous adjustments.

APPENDIX C

REGULATIONS

CHAPTER 17-28

UNDERGROUND INJECTION CONTROL

PART VI
CLASS V WELL PERMITTING

or calculated for new Class III wells:

1. Fluid pressure;

2. Temperature;

3. Fracture pressure;

4. Other physical and chemical characteristics of the injection zone;

5. Physical and chemical characteristics of the formation fluids; and

6. Compatibility of injected fluids with formation fluids.

(c) Where the injection formation is not a water bearing formation, the information in paragraph (b)(3) and (b)(4) of this section must be submitted.

(9) Environmental Concerns During Construction.

(a) For Class I and III wells, the disposal of drilling fluids or cuttings and the disposal of formation water or waste during testing shall be in a sound environmental manner that avoids violation of surface and ground water quality standards. The proposed disposal method must be approved by the Department prior to start of construction.

(b) For Class I wells the use of drilling pads will be required. The pads will be designed to collect spillage of contaminants and to support the heaviest load that will be encountered during drilling. At locations where the unconfined aquifer contains less than 10,000 mg/l total dissolved solids, monitor wells capable of detecting any contamination of the unconfined aquifer from drilling activities shall be required.

(c) For Class I wells, flow control shall be used when drilling into formations in which pressure heads exceed land surface, to prevent uncontrolled release of formation or drilling fluids at land surface.

(d) For Class III wells, the applicant is advised that other permits may be required for surface facilities associated with the mining activity.

Specific Authority: 403.061, 403.087, 403.101, 403.704, 403.721, F.S.
Law Implemented: 403.021, 403.061, 403.062, 403.087, 403.101, 403.161, 403.702, 403.721, F.S.
History: New 4-1-82, Amended 5-8-85.

17-28.23 Operating Requirements for Class I and III Wells.

(1) Class I Well Operating Requirements.

Operating requirements for Class I wells shall, at a minimum, specify that:

(a) To preserve the integrity of the formations, bottom hole (including hydrostatic) pressure shall not exceed a maximum so as to insure that the injection pressure does not initiate new fractures or propagate existing fractures in the injection zone, initiate fractures in the confining zone, significantly alter the fluid movement capabilities of the confining zone, or cause the movement of injection or formation fluids into an underground source of drinking water or into an essential monitoring zone;

(b) To protect the integrity of the well structure, total pressure shall not exceed the maximum allowable stress of the materials used to construct the well;

(c) Injection for disposal purposes is prohibited:

1. Between the outermost casing protecting the underground sources

of drinking water and the well bore;

2. Through annular monitor tubes, and;

3. Through wells designed to monitor the injection zone except when specifically designed as a temporary injection well or approved (in writing) for emergency discharge use.

(d) Unless an alternative to a packer has been approved under Rule 17-28.22(1)(d)1., FAC, the annulus between the tubing, where required, and the final or innermost string of casing shall be filled with a fluid and a pressure shall be maintained on the annulus. Both the type of fluid and the proposed pressure shall be approved by the Department;

(e) The maximum velocity of injected fluid shall not exceed the point where the mechanical limits of the well design or structure of the formation will be adversely affected. The maximum injection velocity of a well that begins operation after June 1, 1985 shall not exceed eight ft/sec (feet per second), unless the applicant can prove to the satisfaction of the Department that higher velocities will not compromise the integrity or operation of the well.

(2) Class III Well Operating Requirements.

Operating requirements prescribed for Class III wells shall, at a minimum, specify that:

(a) Injection pressure at the wellhead shall not exceed a maximum which shall be calculated so as to assure that the pressure in the injection zone during injection does not initiate new fractures in the confining zone or cause the migration of injection or formation fluids into an underground source of drinking water; and

(b) Injection between the outermost casing protecting underground sources of drinking water and the well bore is prohibited;

(c) Where the proposed mining operation includes mining a portion of the confining zone, a sufficient amount of confining zone must remain to provide an effective confinement that protects aquifers above and below the mining area.

(3) Operation and Maintenance Manual.

(a) An operation and maintenance manual(s) for injection well disposal facilities, or portions thereof, shall be prepared for the use of operators, maintenance personnel, technicians, laboratory personnel and others, as appropriate, and shall consist of:

1. Written instructions provided to the injection system operators for the safe reliable operation of the system;

2. Records of the basic engineering design and equipment description;

3. A program to assure proper maintenance of the system.

(b) The operation and maintenance manual(s) is subject to approval by the Department under Section 17-4.22 F.A.C. prior to issuance of a permit and shall be submitted to the Department upon request.

(c) A copy of the approved manual shall be provided to the operators, maintenance personnel, technicians, laboratory personnel and others, as appropriate, by the permittee of the facility. The manual(s) shall be available for reference at the facility or other approved site.

(d) The Department may require revisions to the manual to reflect any facility modifications performed in order to comply with the requirements of this Chapter, or to reflect experience resulting from facility operation.

(4) Abnormal Events.

(a) In the event the permittee is temporarily unable to comply with any of the conditions of a permit, due to breakdown of equipment, power outages, destruction by hazard of fire, wind, or by other cause, the permittee of the facility shall notify the Department. Notification shall be made in person, by telephone, or by telegraph to the nearest office of the Department within 24 hours of breakdown or malfunction.

(b) A report shall be required by the appropriate district office within 72 hours of the notification referenced in (a), above. A final written report shall be submitted within two weeks and shall describe the nature and cause of the breakdown or malfunction, the steps being taken or planned to be taken to correct the problem and prevent its reoccurrence, emergency procedures in use pending correction of the problem, and the time when the facility will again be operating in accordance with permit conditions.

(c) Under emergency conditions in which the permittee is unable to use the permitted primary disposal method, the permittee may use an emergency discharge only if prior Department approval of the emergency method has been obtained. The applicant shall address the emergency disposal methods in the construction permit application and the operating manual.

(d) In the event a well must be redeveloped, the applicant shall address disposal of backwashed fluids. The disposal method shall be approved by the Department.

Specific Authority: 403.061, 403.087, 403.101, 403.704, 403.721, F.S.
Law Implemented: 403.021, 403.061, 403.062, 403.087, 403.101, 403.161, 403.702, 403.721, F.S.
History: New 4-1-82, Amended 5-8-85.

17-28.24 Monitoring Well Construction Standards for Class I and III Wells.

(1) General Design Considerations.

(a) For Class I wells, associated on-site, cluster, multihorizon, or annular monitoring wells shall not penetrate the injection zone or final confining bed.

(b) For satellite and regional monitor wells associated with Class I wells, cluster or multihorizon monitoring wells may penetrate the injection zone or final confining bed only if the applicant can demonstrate that the underground sources of drinking water and confining strata will be protected, the integrity of the monitoring and injection well system will be protected, and the well is designed in such a way that it can be easily repaired.

(c) All monitoring wells constructed for Class III injection operations shall be constructed in accordance with Chapter 17-21, FAC.

(d) Department approval is required prior to any remedial procedures that alter the basic design specifications.

(2) Exploratory Pilot Hole.

For Class I wells, the Department may require an exploratory pilot hole and may require that the hole be drilled in stages. If the applicant does not propose an exploratory pilot hole, he must demonstrate that it is not needed for logging or other purposes.

(3) Drilling.

The Department shall require that a step-by-step drilling plan be submitted with the design specifications.

(4) Casings and Tubing.

(a) The casings or tubing used in the construction of each newly drilled well shall be designed for the life expectancy of the well.

(b) The number, thickness, type of material, and length of casing or tubing shall be sufficient to protect the quality of drinking water resources and the integrity of the well and the confining strata. The type of materials used in the monitoring well shall not bias the sampling parameters used in the monitoring program.

(c) Exact setting depths for all casings or tubing shall be determined in the field, based on all available information, and subject to the Department's prior approval.

(5) Cementing.

(a) The applicant shall submit the proposed cementing program with the design specifications. The cement used in the construction of each newly drilled well shall be designed for the life expectancy of the well. The applicant shall submit a list of proposed additives for Department approval.

(b) Cement must be compatible with the native fluids and the formation, but in no case less than the quality of American Society for Testing and Materials Type 2 or its equivalent (Standard Specification for Portland Cement, American National Standards Institute/American Society for Testing and Materials C 150-78(a), 1978).

(c) Cement placement shall be in such a manner that the purposes and characteristics of the cement are retained, and shall be subject to Department approval and in accordance with "AWWA Standard for Deep Wells", American Water Well Association A100-66, 1966.

(d) The applicant shall submit his cement testing program with the permit application for Department approval.

(e) For Class I monitor wells other than annular monitor wells, a nominal thickness of 2-1/2 inches of cement surrounding the casings with not less than five inches of overdrill is required, except for the annulus being used for monitoring in wells with open annulus monitoring.

(f) All casings and tubing shall be centralized where possible to ensure uniform cementing.

(g) All outer surfaces of casing or tubing which are uncemented shall be protected from corrosion for a minimum of thirty feet above and below the uncemented portion.

(6) Testing of Monitoring Well Construction.

Tests may include but not be limited to:

(a) Cement Bond Survey.

(b) Temperature Survey.

(c) Pressure test to at least 1.5 times the expected ultimate monitoring pressure but not less than 50 pounds per square inch for one hour, with no pressure drop after temperature correction.

(d) A pumping test to determine if the monitor well has sufficient capacity to yield a representative ground water sample.

(e) Chemical analyses of water from strata tapped by well.

17-22.104, FAC, and the minimum criteria provided in Rule 17-3.402, FAC.

b. For the injection zone and monitor zones in G-IV ground water the criteria shall be established on a case by case basis.

(f) The Department shall require monitor wells above the injection zone near the injection well, field or project.

1. The permittee shall be able to monitor the following:

a. The absence of fluid movement adjacent to the well bore as required in Rule 17-28.13(6), FAC, and;

b. The long-term effectiveness of the confining zone.

(g) The Department may require monitor wells above and in the injection zone at a sufficient distance from the well, field or project for regional monitoring.

(h) For Class I wells, a five gallon unacidized representative sample of native water from the injection zone shall where practical be collected and provided to the Florida Department of Environmental Regulation, 2600 Blair Stone Road, Tallahassee, Florida 32301 or a laboratory specified by the Department.

(i) Post-closure monitoring. For Class I wells, the permit applicant may be required to submit a post-closure monitoring plan designed to monitor the attenuation of any pressure effects and water quality changes caused by the underground injection operation both in the injection zone and/or in overlying aquifers. The proposed monitoring plan shall at a minimum utilize the injection wells and associated monitor wells, to the extent that they are capable of yielding representative ground water samples. The proposed monitoring plan may also include other accessible wells.

1. Items to be addressed by the permit applicant in the proposed post-closure monitoring plan shall include, but not be limited to:

a. Designation of the wells to be used for post-closure monitoring;

b. The parameters to be monitored, by well;

c. The sampling frequency;

d. The proposed duration of the post-closure monitoring period; and

e. A documented estimate of the total cost of the post-closure monitoring program.

2. A revision of the post-closure monitoring plan may be required by the Department, when appropriate, in order to reflect changes in the design or scope of the underground injection operation, inflation of costs associated with the plan, or other factors resulting from the construction or operation of the injection well system. The permittee also may initiate modification of the post-closure monitoring plan, subject to Department approval.

(2) Class III Wells.

For Class III wells, monitoring requirements shall, at a minimum, specify:

(a) The analyses of the physical and chemical characteristics of the injected fluid with sufficient frequency to yield representative data on its characteristics;

(b) Installation and use of continuous recording devices to monitor the injection pressure, flow rate and volume;

(c) The demonstration of mechanical integrity pursuant to Section 17-28.13(6) at least once every five years during the life of

(f) Water level measurement referenced to mean sea level.
Specific Authority: 403.061, 403.087, 403.101, 403.704, 403.721, F.S.
Law Implemented: 403.021, 403.061, 403.062, 403.087, 403.101, 403.161, 403.702, 403.721, F.S.
History: New 4-1-82, Amended 5-8-85.

17-28.25 Monitoring Requirements for Class I and III Wells.

(1) Class I Wells.

For Class I wells, monitoring requirements shall, at a minimum, include:

(a) The analysis of the injected fluids at a frequency specified in the operating permit to yield representative data on their characteristics;

(b) The installation and use of continuous indicating, recording, and totalizing devices to monitor flow rate and volume, and installation and use of continuous indicating and recording devices to monitor the injection pressure and the pressure on the annulus between the tubing and the final or innermost string of casing, if there is an annulus;

1. The Department may periodically require a controlled injection test or a bottom hole pressure survey, if a long-term trend of increasing injection pressure is indicated.

(c) A demonstration of mechanical integrity pursuant to Rule 17-28.13(6), FAC, at least once every five years during the life of the well; and

1. As part of the baseline monitoring information, a video television survey from the surface to the bottom of the injection zone shall be run prior to injection but after completion of testing, except for those wells that inject through tubing or where it is physically impossible to do so, and every five years thereafter, or more frequently if deemed necessary by the Department.

2. The television survey may be either black and white or color.

3. Adequate provisions must be made to centralize the camera in the borehole.

4. Before running the survey, adequate provisions shall be made to assure that fluid in both the casing and open borehole is of sufficient clarity to provide a baseline survey of a quality acceptable to the Department.

(d) Within the area of review, the type, number, and location of well(s) to be used to monitor any potential migration of fluids into or in the direction of underground sources of drinking water, and pressure in the underground sources of drinking water; the parameters to be measured and the frequency of monitoring shall be stated in the application for the construction permit.

(e) The background water quality of the injection zone and the monitoring zone(s) shall be determined prior to injection for both domestic wastewater and industrial Class I wells (including reverse osmosis reject water), in accordance with the sampling and testing methods outlined in Rule 17-19.04, FAC.

1. Background levels shall be determined pursuant to the following criteria:

a. For monitor zones in Class G-I, G-II or G-III ground waters the primary and secondary drinking water quality parameters listed in Rule exploratory pilot hole, he must demonstrate that it is not needed for logging or other purposes.

(3) Drilling.

The Department shall require that a step-by-step drilling plan be submitted with the design specifications.

(4) Casings and Tubing.

(a) The casings or tubing used in the construction of each newly drilled well shall be designed for the life expectancy of the well.

(b) The number, thickness, type of material, and length of casing or tubing shall be sufficient to protect the quality of drinking water resources and the integrity of the well and the confining strata. The type of materials used in the monitoring well shall not bias the sampling parameters used in the monitoring program.

(c) Exact setting depths for all casings or tubing shall be determined in the field, based on all available information, and subject to the Department's prior approval.

(5) Cementing.

(a) The applicant shall submit the proposed cementing program with the design specifications. The cement used in the construction of each newly drilled well shall be designed for the life expectancy of the well. The applicant shall submit a list of proposed additives for Department approval.

(b) Cement must be compatible with the native fluids and the formation, but in no case less than the quality of American Society for Testing and Materials Type 2 or its equivalent (Standard Specification for Portland Cement, American National Standards Institute/American Society for Testing and Materials C 150-78(a), 1978).

(c) Cement placement shall be in such a manner that the purposes and characteristics of the cement are retained, and shall be subject to Department approval and in accordance with "AWWA Standard for Deep Wells", American Water Well Association A100-66, 1966.

(d) The applicant shall submit his cement testing program with the permit application for Department approval.

(e) For Class I monitor wells other than annular monitor wells, a nominal thickness of 2-1/2 inches of cement surrounding the casings with not less than five inches of overdrill is required, except for the annulus being used for monitoring in wells with open annulus monitoring.

(f) All casings and tubing shall be centralized where possible to ensure uniform cementing.

(g) All outer surfaces of casing or tubing which are uncemented shall be protected from corrosion for a minimum of thirty feet above and below the uncemented portion.

(6) Testing of Monitoring Well Construction.

Tests may include but not be limited to:

(a) Cement Bond Survey.

(b) Temperature Survey.

(c) Pressure test to at least 1.5 times the expected ultimate monitoring pressure but not less than 50 pounds per square inch for one hour, with no pressure drop after temperature correction.

(d) A pumping test to determine if the monitor well has sufficient capacity to yield a representative ground water sample.

(e) Chemical analyses of water from strata tapped by well.

the well;

(d) Weekly monitoring of fluid level and of the parameters chosen to measure water quality in the injection zone with sufficient frequency to yield representative data on its characteristics;

(e) Quarterly monitoring of wells adacent to the injection site to detect any migration from the injection zone into an underground source of drinking water;

(f) All Class III wells may be monitored on a field or project basis rather than an individual well basis by manifold monitoring. Manifold monitoring may be used in cases of facilities consisting of more than one injection well operating with a common manifold. Separate monitoring systems for each well are not required provided the owner/operator demonstrates that manifold monitoring is comparable to individual well monitoring;

(g) The Department may require that the applicant monitor for a period of time after mining operations cease. If the monitoring reveals violations, the permittee must investigate and take corrective action.

(i) Monitoring Criteria.

1. Where injection is into a formation which contains water with less than 10,000 mg/1 total dissolved solids, monitoring wells shall be completed into the injection zone and into any underground sources of drinking water above, and may be required below, the injection zone which could be affected by the mining operation. These wells shall be located in such a fashion as to detect any excursion of injected fluids, process by-products, or formation fluids outside the mining area or zone. If the operation may be affected by subsidence or catastrophic collapse, the monitoring wells shall be located so that they will not be physically affected.

2. Where injection is into a formation which does not contain water with less than 10,000 mg/1 total dissolved solids, monitoring wells may be required above and in the injection zone.

3. Where the injection wells penetrate an underground source of drinking water in an area subject to subsidence or catastrophic collapse an adequate number of monitoring wells shall be completed into the underground source of drinking water to detect any movement of injected fluids, process by-products or formation fluids into the underground source of drinking water. The monitoring wells shall be located outside the physical influence of the subsidence or catastrophic collapse.

4. The Department may require monitoring for subsidence.

(j) In determining the number, location, construction and frequency of monitoring of the monitoring wells the following criteria shall be considered:

1. The population relying on the underground source of drinking water affected or potentially affected by the injection operation;

2. The proximity of the injection operation to points of withdrawal of drinking water;

3. The local geology and hydrology;

4. The operating pressures and whether a negative pressure gradient is being maintained;

5. The toxicity and volume of the injected fluid, the formation water, and the process by-products; and

17-22.104, FAC, and the minimum criteria provided in Rule 17-3.402, FAC.

b. For the injection zone and monitor zones in G-IV ground water the criteria shall be established on a case by case basis.

(f) The Department shall require monitor wells above the injection zone near the injection well, field or project.

1. The permittee shall be able to monitor the following:

a. The absence of fluid movement adjacent to the well bore as required in Rule 17-28.13(6), FAC, and;

b. The long-term effectiveness of the confining zone.

(g) The Department may require monitor wells above and in the injection zone at a sufficient distance from the well, field or project for regional monitoring.

(h) For Class I wells, a five gallon unacidized representative sample of native water from the injection zone shall where practical be collected and provided to the Florida Department of Environmental Regulation, 2600 Blair Stone Road, Tallahassee, Florida 32301 or a laboratory specified by the Department.

(i) Post-closure monitoring. For Class I wells, the permit applicant may be required to submit a post-closure monitoring plan designed to monitor the attenuation of any pressure effects and water quality changes caused by the underground injection operation both in the injection zone and/or in overlying aquifers. The proposed monitoring plan shall at a minimum utilize the injection wells and associated monitor wells, to the extent that they are capable of yielding representative ground water samples. The proposed monitoring plan may also include other accessible wells.

1. Items to be addressed by the permit applicant in the proposed post-closure monitoring plan shall include, but not be limited to:

a. Designation of the wells to be used for post-closure monitoring;

b. The parameters to be monitored, by well;

c. The sampling frequency;

d. The proposed duration of the post-closure monitoring period; and

e. A documented estimate of the total cost of the post-closure monitoring program.

2. A revision of the post-closure monitoring plan may be required by the Department, when appropriate, in order to reflect changes in the design or scope of the underground injection operation, inflation of costs associated with the plan, or other factors resulting from the construction or operation of the injection well system. The permittee also may initiate modification of the post-closure monitoring plan, subject to Department approval.

(2) Class III Wells.

For Class III wells, monitoring requirements shall, at a minimum, specify:

(a) The analyses of the physical and chemical characteristics of the injected fluid with sufficient frequency to yield representative data on its characteristics;

(b) Installation and use of continuous recording devices to monitor the injection pressure, flow rate and volume;

(c) The demonstration of mechanical integrity pursuant to Section 17-28.13(6) at least once every five years during the life of

6. Number of injection wells per unit area.

Specific Authority: 403.061, 403.087, 403.101, 403.704, 403.721, F.S.
Law Implemented: 403.021, 403.061, 403.062, 403.087, 403.101, 403.161, 403.702, 403.721, F.S.
History: New 4-1-82, Amended 5-8-85.

17-28.26 Reporting Requirements for Class I and III Wells.

(1) Class I Exploratory Well Construction Permit and Class I Test/Injection Well Construction Permit.

(a) The Department may require periodic data reports and progress reports that may include, but not be limited to, the following:

1. Driller's log
2. Geophysical surveys
3. Core analyses
4. Lithologic Logs
5. Drill stem tests
6. Pump tests
7. Daily job (construction) reports
8. Water quality analyses.

(b) The frequency of reporting shall be specified in the individual permit.

(c) Interpretation of data is required in the data reports or progress reports at the completion of each significant phase of construction, such as completion of test well construction and testing, completion of injection well construction, and completion of injection well testing.

(d) The Department may request that the applicant provide direct distribution of the data reports, progress reports, and final reports to members of the Technical Advisory Committee.

(e) The applicant shall submit final reports of all data collected from the exploratory well with interpretations, to the Department with the application for a Class I Test/Injection Well Construction and Testing Permit and a Class I Injection Well Operation Permit. The Final Report submitted with the application for a Class I Injection Well Operation Permit shall include, but not be limited to, all information and data collected under Rules 17-28.33(2) and 17-28.33(3), FAC, with appropriate interpretations.

(2) Class I Injection Well Operating Permit

(a) The applicant must submit, for Department approval, the proposed methodology for collection and reporting of operational data, to ensure that the data is collected, correlated, and reported in a fashion that would enable the agency to evaluate well performance.

(b) Reporting requirements shall be in accord with Chapter 17-19, FAC, where applicable. The frequency of reporting shall be specified in the individual permits, and at a minimum include:

1. Operating reports to the Department on:

a. The physical, chemical and other relevant characteristics of injection fluids;

b. Daily readings of the pressure and flow for each well shall be submitted. For each domestic effluent disposal well, a specific injectivity test shall be performed quarterly while the pumping rate to the well(s) has been set at a predetermined level and reported as the specific injectivity index (gpm/specific pressure (psig)). The applicant shall propose which pumping rate will be used based on the expected flow, the design of the pump station including the volume of the wet well and pump type(s), and the type of pump controls used.

c. Monthly average, maximum and minimum values for injection pressure, flow rate and volume, and annular pressure; and

d. The results of monitoring prescribed under Rule 17-28.25(1)(d), FAC.

2. Reporting the results, within three months after the completion of:

a. Periodic tests of mechanical integrity;

b. Any other test of the injection well conducted by the permittee if required by the Department; and

c. Any well work over.

(c) The Department may require additional data to be submitted with the periodic operations reports, the content and frequency of which are specified in the individual permit.

(d) A Class I well operating permit shall be written to require that if Rule 17-28.13(5)(c)1., FAC, is applicable, progress reports shall be submitted no later than thirty days following each interim date and the final date of compliance.

(3) Class III Well Construction/Operating/Plugging and Abandonment Permit.

(a) The permitting agency may require periodic data reports and progress reports that may include, but not be limited to, the following:

1. Driller's log
2. Geophysical surveys
3. Core analyses
4. Lithologic Logs
5. Drill stem tests
6. Withdrawal or aquifer tests
7. Number of wells constructed, abandoned, in operation, and recorded on property deeds
8. Results of post-closure monitoring
9. Daily construction reports

(b) The frequency of reporting shall be specified in the individual permit. However, the applicant may be required to submit monthly operating reports that shall include but not be limited to, the number of wells constructed, number in operation, number abandoned, and number of wells recorded on property deeds for that month.

(c) Interpretation of data is required in the data reports or progress reports at the completion of each significant phase of construction.

(d) The permitting authority may request that the applicant provide direct distribution of the data reports and progress reports to members of the Technical Advisory Committee.

(e) Reporting Requirements. Reporting requirements shall, at a minimum include:

1. Quarterly reporting to the Department on required monitoring;

2. Results of mechanical integrity and any other periodic test required by the Department reported with the first regular quarterly report after the completion of the test; and

3. The Department may require that monitoring be reported on a project or field basis rather than individual well basis.

(f) At least once every year, but more frequently if specified in the permit, the applicant shall record the plugging method and location of each abandoned well abandoned during that year with the property records of the county courthouse.

(g) The applicant shall submit a Final Report of all data collected with interpretations, to the permitting authority with the application for permit renewal. The Final Report shall include, but not be limited to all information and data collected under Section 17-28.33(2) and (3), with appropriate interpretations.

(4) Abandonment Reports for Class I and III Wells.

(a) Upon completion of plugging and abandonment of a well or well field the permittee shall submit to the Department a Final Report which includes, but is not limited to, the following:

1. Certification of completion in accordance with approved plans and specifications by the engineer of record;

2. Evidence, such as a sealed copy or certification from the county clerk, that a surveyor's plot of the location of the abandoned wells has been recorded in the county courthouse property records.

Specific Authority: 403.061, 403.087, 403.101, 403.704, 403.721, F.S.
Law Implemented: 403.021, 403.061, 403.062, 403.087, 403.101, 403.161, 403.702, 403.721, F.S.
History: New 4-1-82, Amended 8-30-82, 5-8-85.

17-28.27 Plugging and Abandonment Criteria and Procedures for Class I and III Wells.

(1) The Department may order a well plugged when it has been abandoned or when it is determined to be a threat to the waters of the State.

(2) Any Class I or III permit shall include conditions to ensure that plugging and abandonment of the well will not allow the movement of fluids either into an underground source of drinking water or from one underground source of drinking water to another. Any applicant for an Underground Injection Control permit shall be required to submit a plan for plugging and abandonment, which may include post-closure monitoring of the injection operation. The post-closure monitoring plan shall be designed in accordance with the requirements of Rule 17-28.25(1)(i), FAC. Where the plan meets the requirements of this Rule, the Department shall incorporate it into the permit as a condition. Where the Department's review of an application indicates that the permittee's plan is inadequate, the Department shall require the applicant to revise the plan, prescribe conditions meeting the requirements of this Rule, or deny the application. For purposes of this Rule, temporary intermittent cessation of injection operations is not abandonment. Where applicable, the plugging and abandonment plan shall address the proposed post-closure monitoring.

(3) Prior to abandoning Class I or III wells the well shall be plugged with cement in a manner which will not allow the movement of fluids either into or between underground sources of drinking water. The Department may allow Class III wells to use other plugging materials if it is satisfied that such materials will prevent movement of fluids into or between underground sources of drinking water. The proposed plugging method and type of plugging material shall be approved in writing by the Department.

(4) Placement of the plugging material shall be accomplished by

one of the following methods:

(a) The Balance Method;

(b) The Dump Bailer Method;

(c) The Two-Plug Method; or

(d) Any other recognized method as effective or more effective than the above which is approved in writing by the Department on a case by case basis.

(5) The well to be abandoned shall be in a state of static equilibrium with the mud weight equalized from top to bottom, either by circulating the mud in the well at least once or by a comparable method prescribed by the Department, prior to the placement of the cement plug(s).

(6) The permittee shall notify the Department at least 180 days before conversion or abandonment of a Class I well, unless abandonment within a lesser period of time is necessary to protect the waters of the State.

(7) For all Class I wells, the final or innermost string of casing shall be filled with neat cement grout or an approved equivalent from the bottom of the casing to the surface. The Department may require or allow the use of other fillers in the open hole provided that the objectives of confining injected fluids to the injection horizon and prevention of migration of injected and/or native fluids between aquifers are satisfied. Annular monitor tubes in an injection well may be left unplugged temporarily if they are to be used for their intended purpose and do not compromise the objectives listed above. If temporarily left open, the annular monitor tubes shall, after Department approval, be plugged with cement at the end of post-closure monitoring. If the tubes are not used for monitoring, they shall be filled with neat cement from the bottom of the monitor zone to land surface.

(8) The plugging and abandonment plan required in Rules 17-28.27 and 17-28.35, FAC, shall, in the case of a Class III well field which underlies or is in an aquifer which has been exempted under Rule 17-28.13(3), FAC, also demonstrate that no movement of contaminants from the mined zone into an underground source of drinking water will occur. The Department shall prescribe aquifer cleanup and monitoring where deemed necessary and feasible to insure that no migration of contaminants from the mined zone into an underground source of drinking water will occur.

(9) Financial responsibility. The permit shall require the permittee to maintain financial responsibility and resources, in the form of performance bonds or other equivalent form of financial assurance approved by the Department, to close, plug, and abandon the underground injection operation in a manner prescribed by the Department. In lieu of individual performance bonds, the applicant may furnish a bond or other equivalent form of financial guarantee approved by the Department covering all his injection wells in this State. The Department may require a certificate that the applicant has assured, through a performance bond or other appropriate means, the resources necessary to cover post-closure monitoring and any corrective action resulting from this monitoring.

(10) In the event a radioactive source tool has been irretrievably lost down an injection well, the Department shall be immediately notified. The well shall not be

APPENDIX D

SAMPLE FORMS

SAMPLE FORM 1

Sample Equipment Record Card

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

Preventive Maintenance Program	Equipment Record Number ______

EQUIPMENT DESCRIPTION		ELECTRICAL OR MECHANICAL DATA
Name		Size
Serial No.		Model
Vendor		Type
Vendor Address		
Vendor Rep.	Phone	
Initial Cost	Date	

WORK TO BE DONE	FREQUENCY	TIME

DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED

SAMPLE FORM 2

Maintenance File Card

EQUIPMENT ______________________________

SERIAL NO. ______________________ MAKE ______________

TYPE ______________________ STYLE ______________

R.P.M. ______________________ PHASE ______________

SIZE ______________________________

LOCAL REPR. ______________________________

ADDRESS ______________________________

PHONE NO. ______________________________

____

SCHEDULE ______________________________

WORK PERFORMED	DATE	OPT. INT.
PARTS		
COMMENTS		

SAMPLE FORM 3

ACCIDENT REPORT

______________________________ ______________________________
Facility Location

DATE OF REPORT ______________________________

PERSON REPORTING ______________________________

NAME OF INJURED PERSON ______________________________

TYPE OF INJURY ______________________________

OCCUPATION ______________________ AGE ______ SEX ______

DATE OF INJURY ____________ TIME ________ PLACE ____________

____

DESCRIPTION OF ACCIDENT

1. CAUSE OF ACCIDENT ______________________________

____

____

2. REASON FOR ACCIDENT ______________________________

____

____

CORRECTIVE ACTION TAKEN ______________________________

____

____

____

____

____

DATE ____________________ SUPERINTENDENT ____________________

PALM BEACH COUNTY
WATER UTILITIES DEPARTMENT WWTP 9N

Deep Injection and Monitoring Well System

Monitoring Data Report

Month__________ 19 ____

Compiled By __________

	1	2	3	4	5	6	7	8	9	10	11
	Plant Influent		Injection Well				Monitoring Zones		Injected Effluent		
Day of Month	Totalizer Reading (mgd)	Flow (mgd)	Injection Flow Rate at 9:00	Injection Pressure at 9:00 a.m. (psi)	Maximum Flow Rate (mgd)	Maximum Pressure (psi)	Zone 1 970-1108 (psi)	Zone 2 1699-1800 (psi)	Suspended Solids (mg/L)	Specific Conductance (Uhos/cm)	Collected By
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											
31											
Total											
Max											
Min											
Average											

NOTES: 1. To Convert Injection Pressure psi To Feet of Head msl, Multiply psi X 2.31 and Add 23'.

2. To Convert Monitor Zones 1 or 2 psi To Feet of Head msl, Multiply psi X 2.31 and Add 23.14'.

Sample Form 4

CH2M HILL

Palm Beach County Water Department
Deep Injection and Monitoring Well
System.

Monitoring Well Water Quality
Report for ____Quarter, 19____

Parameter	Months of Quarter 1	2	3
Date of Sampling			
Monitoring Well Annulus U-per Zone (970' - 1108')			
Temperature ^{o}F			
Specific Conductance (umhos / cm)			
Chloride (mg / L)			
Fecal Coliform (colonies/100 mL)			
BOD_5 (mg/L)			
Monitoring Well Lower Zone (6-inch casing) - (1699' - 1800')			
Temperature ^{o}F			
Specific Conductance (umhos/cm)			
Chloride (mg/L)			
Fecal Coliform (colonies/100 mL)			
BOD_5 (mg/L)			

Remarks: ____

____

____

____

____

Submitted by ______________________ Date ______________________

Submitted by ______________________ Date ______________________

Submitted by ______________________ Date ______________________

Sample Form 5

CH2M HILL

Sample Form 6
SPECIFIC INJECTIVITY TEST

Date ______________________________, 19___

Injection Rate (gpm)	Total Pressure (psig)	-	Shut-In Pressure (psig)	=	Specific Pressure (psig)	Specific Injectivity (gpm/psig)
______	________		________		________	__________

COMMENTS: ____

____

____

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____

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____

____

APPENDIX E

INJECTION WELL OPERATING PERMIT