Hallmark Refining Corporation
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HRC REFINING

OPERATION AND INSTRUCTION MANUAL

FX 6000
SILVER RECOVERY SYSTEM

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HRC Hallmark Refining Corporation®

STATEMENT OF WARRANTY AND LIABILITY

All equipment manufactured by Hallmark Refining Corporation is guaranteed against defects in material and workmanship for a period of six months from the date of shipment from the factory. Any claimed defects must be reported, and the materials and/or equipment must be returned, freight prepaid, to HRC within the guarantee period. HRC's liability for defects in material and workmanship shall be limited to replacing or repairing (at its option) such defective materials or equipment at no cost to the original purchaser. Any damage or loss occurring during shipment is not covered by the terms of this warranty. Any shipping damage is the responsibility of the carrier(s) and should be reported to the carrier(s) immediately.

All material and/or equipment furnished by other suppliers are not warranted by HRC and are covered by the suppliers warranty only for defects in material and workmanship. Transportation, handling damage, normal wear and tear and other damage outside the control of HRC are not covered by this warranty. Under no circumstances will HRC be responsible for any of the following: damage, loss or liability of any nature arising out of the installation and/or use of the materials equipment and furnished.

There are no other warranties expressed or implied, except at stated above. This warranty becomes null and void if any devices or accessories other than those distributed or officially recommended by HRC are installed, attached or used in conjunction with this equipment.

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ILLUSTRATIONS

1. THE ELECTROLYTIC SILVER PLATING PROCESS

1.1 The Electrolytic Silver Plating Process

This silver recovery method applies a direct current across two electrodes in a silver bearing solution. Metallic silver deposits on the cathode. Sulfite and thiosulfate are oxidized on the anode.

Care must be taken to control the current density in the cell because high density can cause “sulfiding.” Sulfiding is the decomposition of thiosulfate into sulfite at the cathode, which contaminates the deposited silver and reduces recovery efficiency. The higher the silver concentration, the higher the current density can be without sulfiding.

The HRC ELECTRO Series of silver recovery systems are designed to utilize the maximum amount plating surface in the cell. The cathode is a stainless steel cylinder in continuous motion, during the plating process. This creates a high level of agitation and maximizes the silver yield.

2. SPECIFICATIONS

Average Recovery Capacity	20 Troy Ounces Per Hour/Per Cell
Plating Range	250 Amps
Footprint (200 gal. Holding Tank)	47”L x 37”W
Dimensions (Incl. Power Supply Cabinet)	80”L x 72”W x 72”H
Tank Capacity	Lower Tank: 165 gal. Upper Tank: 65 gal. Ea.
Materials of Construction	Tanks: Stress Relieved Polypropylene Metal Fittings: 316 S/S inside plating cells 18-8 S/S outside plating cell Piping: PVC wrapped with Teflon Tape
Electrical Requirements	240/208V, 30 Amps, 60 Hz/50Hz
Net Weight	900 lbs.
Shipping Weight	1300 lbs.

3. INSTALLATION

The unit is shipped pre-plumbed, complete with all fittings and required tubing. The electrical outlets and sockets are pre-wired at the factory, ready for fast and easy installation.

3.1 Unpacking

Remove the unit from the shipping container. Remove all packing and protective materials. Examine all the components for any obvious shipping damage and report it immediately to the carrier.

3.2 Site Planning and Preparation

Before you install the FX 6000 silver recovery equipment consider the location carefully. The recovery equipment should be located so that the discharge lines from the process equipment can be easily connected to the lower tank of the recovery unit. Consider using PVC pipe instead of tubing if the run is long. You must also consider the Mark 26 tailing system and transfer pump station and the proximity to a drain for discharge to the sewer after the recovery process is completed. Setting the equipment on the floor to see how it will layout before final installation is a good starting place.

3.3 System Placement

After you have determined the desired location, check the floor for level and adjust the FX 6000 unit as necessary to a level operating position.

3.4 Assembly

Remove the top cell splash covers and check the cathode coupling bolts for secure operation. The cathode drive shafts must be installed in the drive couplings so the cathodes do not rub on the anodes or tank bottom.

3.4.1 Installation of Discharge Lines

Install the discharge tubing on the silver probe mounting assembly located at the rear of the lower tank. The fitting is marked “out” and returns the desilvered solution to the processor. This return line must pass through a flow meter and valve prior to entry back into the processor. This flow meter and valve is not supplied with the unit. Install and secure hose clamps on these fittings.

3.4.2 Installation of Inlet Lines

Connect overflow lines from the processor(s) to the inlet of the FX 6000 lower tank. Connect the overflow lines from the lower tank of the FX 6000 to a transfer station. This station is required, and is available as an added option to the system. The lines going to the FX 6000 must be ***silver bearing waste only***. (Fixers, Bleach/Fix and Stabilizers) It is the responsibility of the installer to provide any flow control or anti-siphoning devices required for the operation of the unit.

3.4.3 Connection to the Power Supply

Position the power supply in front of the FX 6000. Check the control panel to insure that all switches are in the “off” position. Connect the power cord to the outlet box at the rear of the power supply with a 208/240VAC 50/60 Hz power source capable of delivering a minimum of 30 amperes. Improper supply source voltages or grounds will void all warranties. Connect cathode and anode cable to the back of the power supply with the supplied bolts. Connect flexible conduit from the power supply to the FX 6000 top cell and match the numbered wires to the same numbers on the terminal switch. **NOTE Make "minus" cables and "plus" cables go to the corresponding location on the power supply.**

3.4.4 Connection to the Silver Controller

Mount the Silver Controller on a wall that is in close proximity to the FX 6000 unit. Check the Controller to insure that the power switch is in the "off" position. Connect to a 115VAC 50/60 Hz power source. Connect the color coded multi pin plug from the power supply into the connector from the silver controller. Connect the color coded multi pin connector from the silver controller to the silver probe pre-amp (white box mounted at the rear of the FX 6000) Control wires need to be run in a separate shielded conduit.

3.4.5 Wiring Connection of Pumps, Top Cells, "Pump Saver"

Connect flexible conduit between the top cells. Match the numbered wires to the numbered terminal strip. Connect flexible conduit to the lower pump outlet boxes. Connect the power cords from the pumps through the cord grips at the outlet boxes. Match the numbers using the wire nuts provided. Install end covers on the sides of the top cells and covers over the outlet boxes.

3.4.6 Position of Pumps and Plumbing

Install Pump 1 and Pump 2 by matching color coded valves. **NOTE Make sure valve "O" rings are in place**. Connect tubing provided from pumps 1 and 2 to top cell valves. Connect tubing from Pump 3 to silver probe plumbing at the rear of the unit. Make sure all clamps are secure.

3.4.7 Pump Saver

Hang the pump saver float switch assembly in the clamp provided between the top cells at the front of the unit. Plug the connector into the receptacle which is mounted on the side of the right top cell support. **NOTE Unit will not operate with float switch in the open or off position. Check level of fix in the lower tank.**

3.4.8 Drain Plugs and Anti-Aeration Plumbing (Tee Assembly)

Install plugs provided on drain fittings positioned over lower tank. Install 3" anti aeration tee assembly to 3" fitting located at the bottom of each top cell.

4. OPERATION - 250 AMP POWER SUPPLY

4.1 Configuration and Computer Control

The 250 Amp power supply is normally connected to the distribution box. The two units work together as an integrated system. Most of the sophisticated computer control and intelligence of the system is found in the distribution box module. If the distribution box is disconnected, or if the installation does not have a distribution box, the 250 Amp power supply can function as a stand alone unit with its own basic computer control. The stand-alone unit **cannot** be used as a retrofit for existing Hallmark installations that have older power supply units with external relay control and/or external timers.

The input buttons and display screen are physically located on the main power supply itself, but when it is connected to the distribution box, most of the computer control occurs in the distributions box's computer.

This documentation is for the functions of the power supply when it is connected to the distribution box and silver probe. It does not cover the operation of the unit when it is disconnected from the distribution box and functioning as a stand-alone unit (with less computer intelligence).

The Probe Continuous Recovery Diagram on the following page shows the layout of the Batch Tank and the Silver Probe Control Box in the Hallmark processing unit.

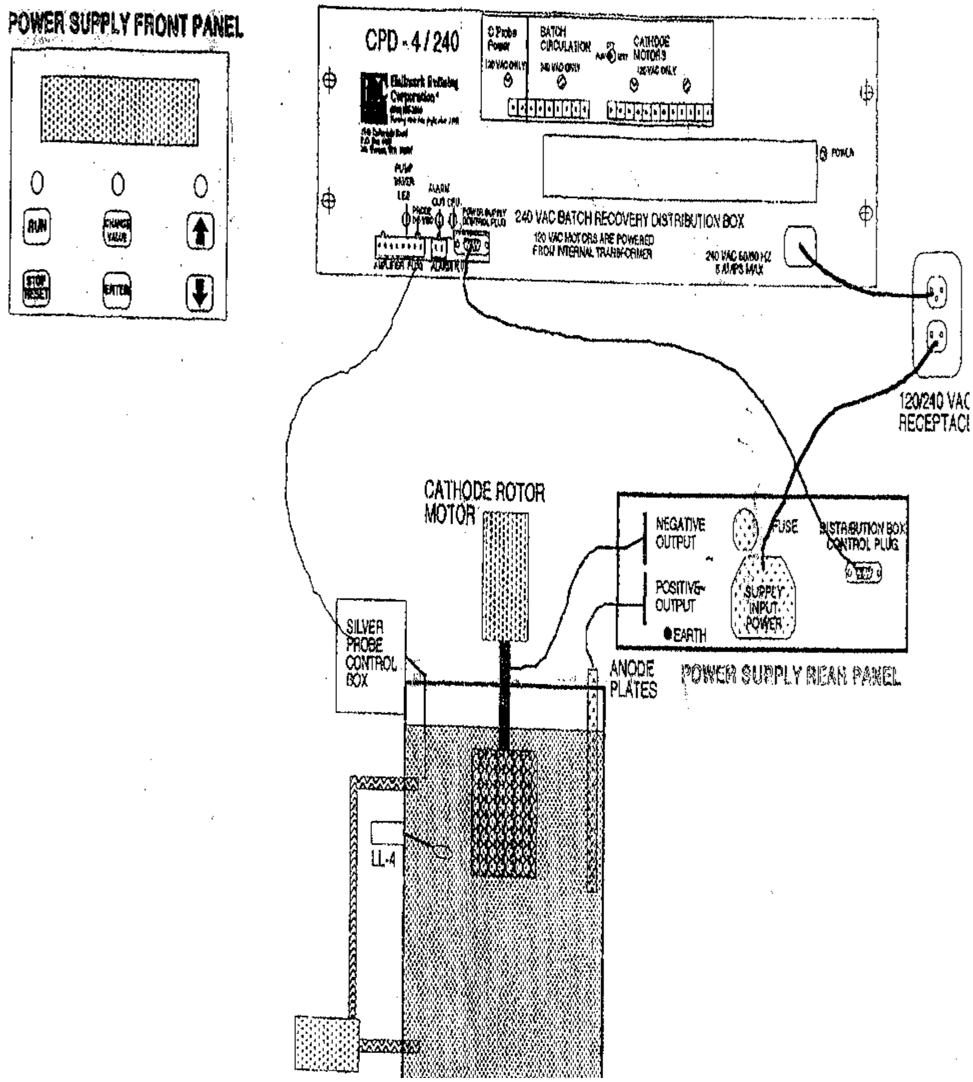

Figure 4.1 **Batch Circulating Pump** **BATCH TANK**

Probe Continuos Recovery Diagram

4.2 Startup Conditions

A proper earth ground must be provided to assure the safety of people who work near machinery. For the unit to operate with the distribution box (smart mode), power must be applied to the IEC plug and the DB9 communication cable connecting the power supply to the distribution box must be connected. External power must be supplied to the distribution box through its external 120 VAC or 240 VAC (depending on the model of the distribution box). If any of these conditions are not met, the unit reverts to a stand-alone operation mode (dumb mode). See the documentation for dumb stand-alone mode if it is necessary to run without the distribution box. The program and display buttons operate differently in the stand-alone (dumb mode), and all message displays start with the letters “SA”. SA denotes Stand Alone mode.

4.3 Fault Conditions

Fault conditions that can cause the power supply to shut down or not start up.

1. The overtemperature sensor has shut down the PWM switching control chip. The unit is too hot. The fan must not be blocked. It must have an adequate source of fresh, unheated air.
2. The undervoltage lockout signal has sensed a low AC voltage input. The AC power available has a voltage that is too low. The installer must check to make sure the AC input voltage levels match the specifications shown on the back panel of the power supply.
3. The unit also must be properly grounded to ensure the reliability of the output diodes.

4.4 General Operation

The unit is designed to be **ON** full time so that the CPU in the main power supply stays alive. The front panel switches that turn the unit OFF only disable the unit from outputting power. The unit is actually still ON, but in an idle state. The unit is designed to be connected to the AC power from the power line 100% of the time during normal operation.

The distribution box computer is equipped with EEPROM to store all of the user’s inputs. All settings that have been stored in the computer, and are not lost if the distribution box loses it source of AC power or if it is disconnected to the main power supply. When the distribution box is reconnected to the power supply and all startup conditions are met, it will resume operating with the stored values previously input by the user.

4.5 Silver Probe Operation

The silver probe detects the conductivity of the liquid in the batch tank. When the conductivity increases due to a higher silver content in the liquid, the silver probe control box increases its voltage signal to the power supply. The power supply responds by increasing the amps it outputs. The power supply has settings to adjust the number of amps it will output per millivolt of increased voltage output from the silver probe control box. The settings range from 1 millivolt per amp to 108 millivolts per amp. This adjusment is set through the Change Values routine (CV1).

4.5.1 Linear Response vs. Log Response *Set Through Change Values Routine – CV8*

The higher the silver concentration in the batch tank, the larger the current should be (more amps). The power supply responds in a linear (straight line) relationship if it is set in the linear response mode. It increases the amps when the silver probe control box detects more conductivity and outputs more control volts. The corresponding increase in amps is linear. Chart X.X through X.X show the linear response under several conditions.

The unit can be set for a log (logarithmic) response instead of a linear response. When the logarithmic response is set, the unit increases the amps more rapidly during conditions of high concentration of silver in the tank liquid.

4.5.2 Offset *Set Through Change Values Routine - CV2*

Offset changes the effective range of the silver probe's output. The silver probe voltage offset can be changed from 0 to 2.55 Volts in 10 millivolt increments. With a zero offset, the probe's voltage is referenced to zero volts. If the offset is increased, the minimum voltage that the power supply looks at and acts upon is increased. If there is an offset voltage set, the power supply ignores voltages below that amount. Example: A typical silver probe output runs .3 volts to 1.2 volts. If the offset is set to 0.3 volts, the operating range of the unit is set to ignore readings below .3 volts.

4.6 Keypad Controls and Message Display

The power supply has a 6 button keypad and 2 line message display. The top line of the display always shows the operating state (mode) of the unit, or the significant action that is occurring in the processing system.

The power supply has two modes of operation when it is connected to the distribution box and the silver probe: **Always Run Mode** and **Timed Run Mode.**

Always Run Mode
The Display Shows:

First Line of Display	Running P-N.NN A-NNN	The unit is running. P- numbers show the Probe Voltage. NNN denotes the numerals showing on the display. A- numbers show the Amps the unit is outputting.
Second Line of Display (rolling)	Amps NNN NNN	
Second Line	Volts NNN	
Second line	CV8 Linear Or CV8 Log	The unit is operating in Linear calibration mode, rather than log (logarithmic) mode.

4.7 Change Values

The power supply has many setpoints that can be changed through the Change Values Routine.

The values can be changed while the system is running, or while it is in standby mode. Pressing the Change Value key brings up the first of the settable values that can be altered through operator input from the keypad. Repeated presses of the Change Values key brings up the next settable item that can be changed.

Change Values Screen Display (In order of appearance when Change Value Key Pressed)

CV1	MV per Amp	Adjustment of millivolts per amp. The range can be set from 1 mV to 108 Mv per amp.	Pressing UP and DOWN arrows on the keypad change the miilivolts setting. Pressing the ENTER key sets the value.
CV2	Offset	Volts of offset can be set from 0.0 V to 2.55 V, in 10 millivolt increments.	Pressing the UP and Down arrows on the keypad change the number of volts. Pressing the ENTER key sets the value.
CV3	Always Run or Timed Run	Toggle between Always Run Mode and Timed Run Mode.	Pressing the UP and Down arrows on the keypad change the mode. Pressing the ENTER key sets the value.
CV4	End Hours	Hours for Timed Run Mode.	Pressing the UP and Down arrows on the keypad change the number of hours. Pressing the ENTER key sets the value.
CV5	End Min	Minutes for Timed Run Mode.	Pressing the UP and Down arrows on the keypad change the number of minutes. Pressing the ENTER key sets the value.
CV6	Display Average or Display Peak	Toggle between Average or Display Peak	Pressing the UP and Down arrows on the keypad change the setting from Average or Peak. Pressing the ENTER key sets the value.
CV7	Restart Timer	Reset timer for timed runs.	Pressing the ENTER key resets the timer. The timer countdown starts over, using the hours and minutes set in the End Hours and End Minutes settings (CV4 and CV5)
CV8	Linear or Log	Toggle between linear mode and log mode. Log mode will give a logarithmic response in output amps when the silver probe control box outputs different voltages.	Pressing the UP and down arrows change the setting from Linear to Log response. Pressing the ENTER key sets the value.
CV9	LL4 Disable or Enable	Disable or enable reading of Liquid Level 4 switch. If the Liquid Level 4 switch indicates the batch tank is not adequately full and this setting is enabled, the unit will not run.	Pressing the UP arrow changes the mode setting. Pressing the ENTER key sets the new mode.
CV10	Trip on PF or Restart on PF	If Trip on Power Failure is enabled, the unit will not run after an external power failure	Pressing the UP arrow changes the mode setting. Pressing the ENTER key sets the new mode.

		(AC power source interruption). If restart on PF is enabled, it will restart after AC power is restored.	
CV11	Rstart Amps	Restart Amps setting. The number of Amps the unit must output before it restarts after a shutdown caused by the depletion of the amount of silver in the batch tank.	Pressing the UP arrow changes the mode setting. Pressing the ENTER key sets the new mode.
CV12	Exit Change Values	Leave the change values routine and resume normal operation and display.	Pressing the ENTER key immediately enters any changes to the variables and exits the change values routine. It is not necessary to use this routine to leave the change values routine, as the unit will do it automatically 6 seconds after the last key is pressed on the keypad.

5. TESTING

5.1 Silver Concentration Test Procedure

Required Material: Silver Test Paper (“Ag-Fix” Gallard-Schlesinger, #MD-9000)

Procedure:
1) Immerse a strip of the Ag-Fix paper for (5) five seconds in a sample of the solution to be tested.
2) Immerse the strip in a beaker of fresh water for one minute without agitation.
3) Allow the strip to dry for two to three minutes.
4) Compare the strip of paper with the dispenser (estimating in-between colors) and read the concentration in gram/liter from the color that matches the best.

A goal of 200-500 PPM in silver concentration should be achieved in a ELECTRO-plating process. The final treatment is then completed in the Mark 15 Silver Recovery Tailing System.

5.2 pH Test Procedure

Required Material: Fil-Chem pH paper #6074 is recommended; #6680 is an alternative. Both products are available from Fil-Chem, Inc., Paul Frank Division, 29 east 22nd Street New York, N. Y. 10010

Procedure:
1) Immerse the a pH test strip into a sample for (5) five seconds.
2) Remove and shake off the excess liquid and read immediately (holding the strip up to the light or placing it on a white background is sometimes helpful)
3) Using the indicator bar (the largest bar located in the middle of the scale) determine which smaller pH bar matches it in color. Estimate in-between values, if the colors are not perfectly matched.
4) Read the pH value of the bar from the scale provided on the box.

The ideal pH operating range for plating silver in the BFX 500 is 7.8 to 8.4.

*The alternative use of a pH meter is preferable, if one is available.

6. MAINTENANCE

Do a routine daily visual inspection of the system and observe the following guidelines:

- Periodically inspect tubing and tighten clamp connections to avoid leaks. Check threaded PVC pipe connections and rewrap with teflon tape if necessary.
- Inspect drive assembly brushes and rubber couplers for wear. Replace if necessary.
- Inspect filters and pumps for proper flow. The flow meter should not fall below 8 Gals./Min. If this happens, replace the filter and/or inspect the pumps for proper operation.
- Check calibration of silver controller and silver probe periodically. See Calibration, Section 16.
- Check silver sensor electrodes for wear of fouling.
- Inspect the drum (cathode) for proper plating and take corrective action if necessary.
- Inspect electrical connections at anode bar, drive assembly , power supply. Pay special attention to large cable connections.
- Grease the bearings after harvesting the silver and cleaning the cathode.
- Keep extra parts on hand to avoid costly down time. It is recommended that you keep a complete liquid end for each model of pump in service as well as rubber couplings, a drive motor, drive motor bearings, brushes and drive shaft with slip ring.
- Keep your equipment clean and the work area around it free of clutter to avoid accidents when working on or around the recovery unit.

6.1 Harvesting the Silver

1) After 25 to 30 lbs. of silver has been processed, the cathode drum should be removed from the recovery unit by loosening the bolt securing it to the drive head. Rinse excess chemical with fresh water.
2) The silver can than be removed from the drum using a putty knife or other scraping tool that will minimize the scratching of the drum.
3) The plated silver should be scraped from the drum and allowed to dry.
4) Wash the drum with plain soap and water before returning the it to the recovery unit.
5) Place the drum back in the drive and tighten bolt securing it to the drive head.
6) The dry silver can than be packaged and shipped to Hallmark for refining.

<u>Note: Silver can be shipped as a non-hazardous material in all states except California. Silver is a hazardous material in California and it must be labeled and manifested for shipment.</u>

7. TROUBLESHOOTING

PROBLEM	PROBABLE SOLUTION
Cathode will not plate.	• Cathode coupling may be loose or dirty connection. • Brush may be sticking in holder, clean and lubricate • Power supply malfunction, check circuit breaker. Replace power supply if necessary.
Plating on cathode is soft.	• Too much power is being applied. Reduce the amperage, fixer low on sulfite.
Plating on cathode not smooth (nodules on plating surface).	• Not enough power is being applied. Increase amperage.
Solution empties from the tank during the plating time.	• On lower tank, check for leaks or breaks in the plumbing. Check filter and lines back to processor. • On Upper tank, check for leaks or breaks. Make sure check valves are working. • Solution may be siphoning out through the pump out tube. The tube should be raised to level higher than the plating tank.
Drive motor not turning.	• A voltage spike may have blown the fuse. Check fuse in drive head.
Pump not transferring solution.	• Check switch and circuit breaker. Liquid end may be clogged. • Check pump motor for operation. • Lower tank switch may have shut down unit due to no solution returning from the film processors
System cycles on and off past the silver sensor set points for on and off	• Re-calibrate probe and solution • Signal wires to probe need to be shielded and properly grounded
Cathode not turning	• Rubber coupling defective • Circuit breaker open • Check manual auto switch.

8. REPLACEMENT PARTS LIST

Ref No	Part Number	Part Description	Quantity
Fig. 1		Power Supply	1
1		Dual 125 Controller	1
2		Drive Assembly Mounting Bolts	32
3		Dual 125 Amp Power Supply	1
4		Cathode Coupler Set Screw 316 S/S	8
5		Cathode Coupler Bolt 3/8"x1/2" 316 SS	8
6	107-010	Tubing Reinforced 1"	12
7	18645A23	Lid Handles 316 SS	6
8	250-001	Power Supply Door Hinge SS	2
9	250-006	Drive Assembly Hinge 6"x3" SS	4
10	251-002	Drive Assembly Rubber Feet	8
11	253-010	Plastic Pipe Bracket 1" Clic	5
12	4276	Transformer	1
13	504-010	Valve Globe Asahi 1"	2
14	506-010	Valve Duo Bloc Asahi 1"	8
15	507-010	Valve Plastomatic	3
16	522-010	Hose Clamps #10 SS	6
17	524-001	Liquid Level Switch/Compac (Inside tank)	1
18	540-006	Filter Chamber Bracket 1"	2
19	540-210	Filter Chamber	3
20	540-213	Filter	3
21	541-011	Flowmeter (0-40 GPM)	2
22	543-043	Flexible Reducer 4"x3" (Inside tank)	2
23	600-001	Outlet Box	2
24	601-005	Cord Grip ½"	6
25	710-016	Power Cord 16x3 Chemically Resistant	6
26	710-020	2/0 Cable	32
27	710-250	Cable 250MCM	12
28	711-020	2/0 Lug	8
29	711-300	300 Lug	4
30	713B4A1001	Silver Sensor Probe (Detail Fig. 27.3)	1
31	726-001	Switch On-Off	1
32	726-002	Switch On-Off-On	17
33	741-003	Circuit Breaker 3 Amp	6
34	741-007	Circuit Breaker 7 Amp	1
35	742-001	Polytuff Flexible Conduit ¾"	16
36	742-002	Straight Liquid Tite Connector	11
37	742-003	Elbow Liquid Tite	3
38	744-003	Terminal Strip	44
39	744-117	Panel Mount 16 Pin Socket Connector	2
40	77005	Anode Mounting Bolts 316SS	76
41	78013	Anode Mounting Washers 316SS	76
42	900-002	Anode Clip	2
43	900-004	Anode Ring	2
44	900-007	Anode Support	32
45	900-008	Electro Lock/Drive Support	4
46	903-115	Drive Motor 1/15 HP 85 RPM	4
47	903-312	Flange Bearing ¾"	4

Ref No	Part Number	Part Description	Quantity
48	903-315	Capacitor	4
49	903-402	Drive Housing	4
50	903-404	Rear Drive Cover	4
51	903-407	Plexiglass Mounting Block	4
52	903-408	Drive Housing Shim (8”x8”)	4
53	903-411	Plexiglas Drive Cover	4
54	903-414	Brush	4
55	903-416	Drive Motor Shaft w/Commutator ¾”	4
56	903-427	Drive Mounting Plate	8
57	903-428	End Piece ¾”	4
58	903-430	End Piece 5/8"	4
59	903-440	Silver Sensor Assembly	1
60	903-441	Silver Sensor Pre Amp.	1
61	903-442	Silver Analyzer (Detail Fig. 15.1)	1
62	903-446	Cathode 14”x20”	4
63	903-516	Rubber Motor Coupling	4
64	903-517	Brush Holder	4
65	903-600	Plating Tank FX-6000	2
66	903-601	Power Supply Cabinet FX-6000	1
67	903-605	Lid Assembly (3 pieces)	2
68	903-608	Pump Saver Assembly	1
69	903-609	Top Cell End Covers (10”x19 ½”)	2
70	903-610	Pump Mounting Pad (7”x11”)	3
71	903-611	Silver Assembly Mounting Pad (19”x36”)	1
72	903-618	Cathode Coupling ¾”	4
73	903-660	Desilvering Tank FX-6000	1
74	903-806	Carbon Anode ½”x5.5”x24” Coarse	32
75	912-010	Salt Bridge	2
76	99X5H1001	Silver Sensor Mounting Tee O- Ring	1
77	AG1101-60	Silver Controller Electrode	2
78	MD-100TC	MD-100RT 220V Mag. Drive Pump	1
79	MD-70TC	MD-70RT 220V Mag. Drive Pump	2
80	MH536N6AZ	Silver Sensor Mounting Tee	1

9. ASSEMBLY DRAWINGS

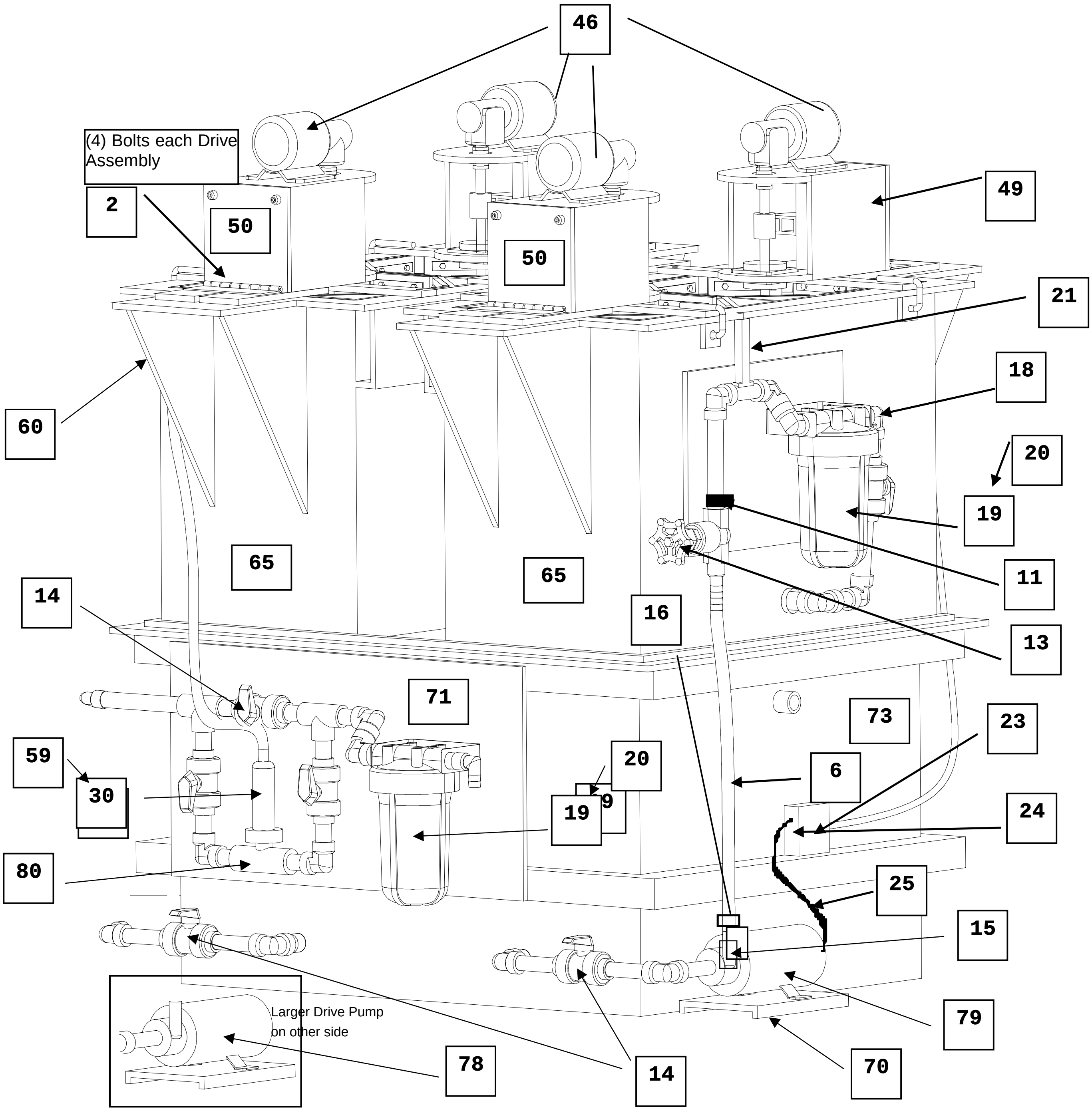

FIGURE 9-1: Complete Assembly

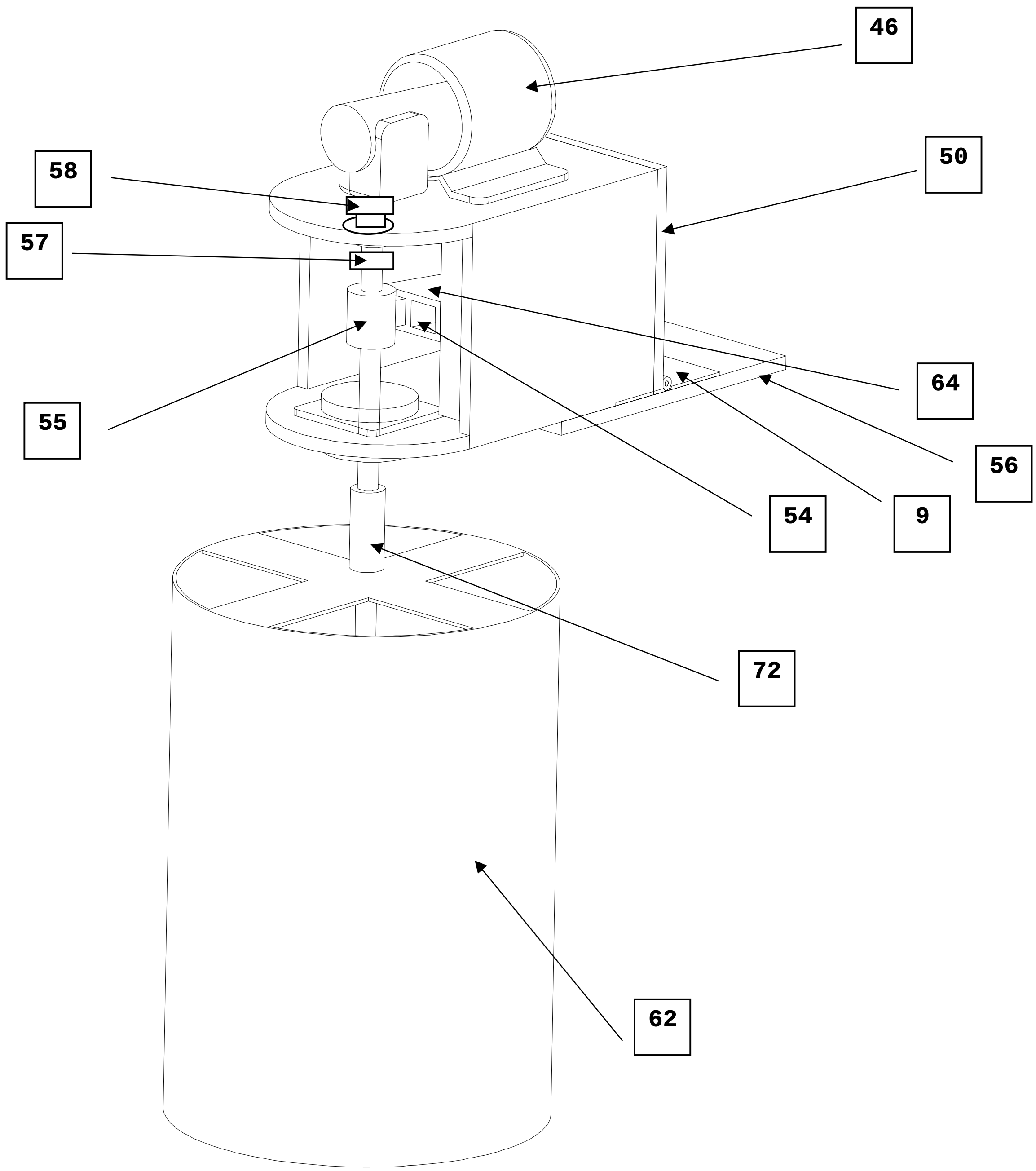

FIGURE 9-2: Drive Assembly

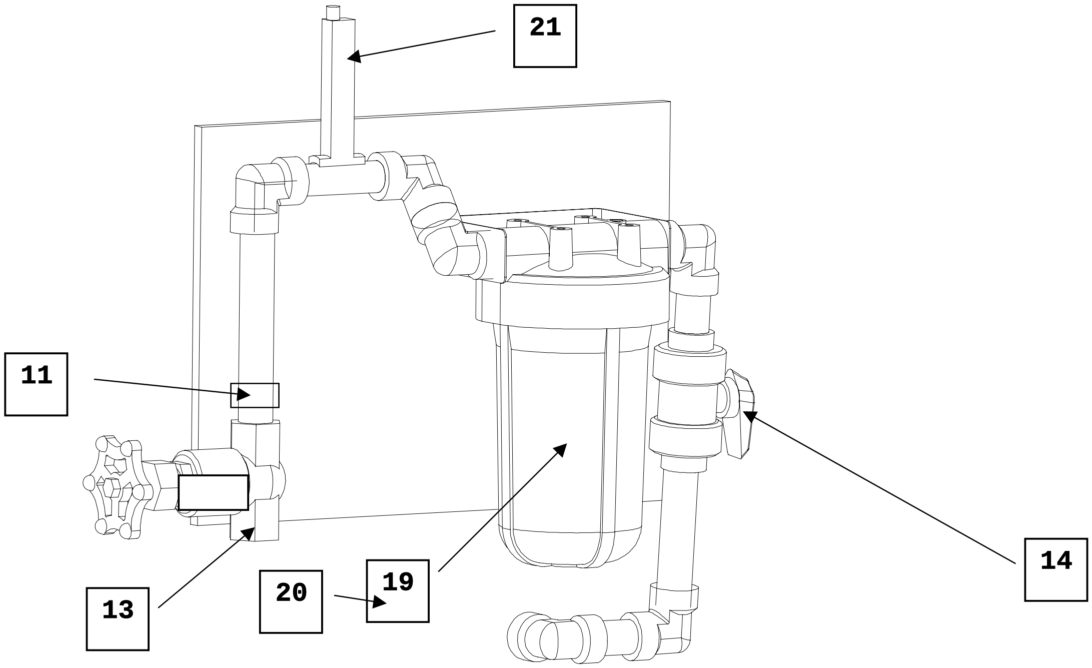

FIGURE 9-3: Flowmeter with Filter Chamber

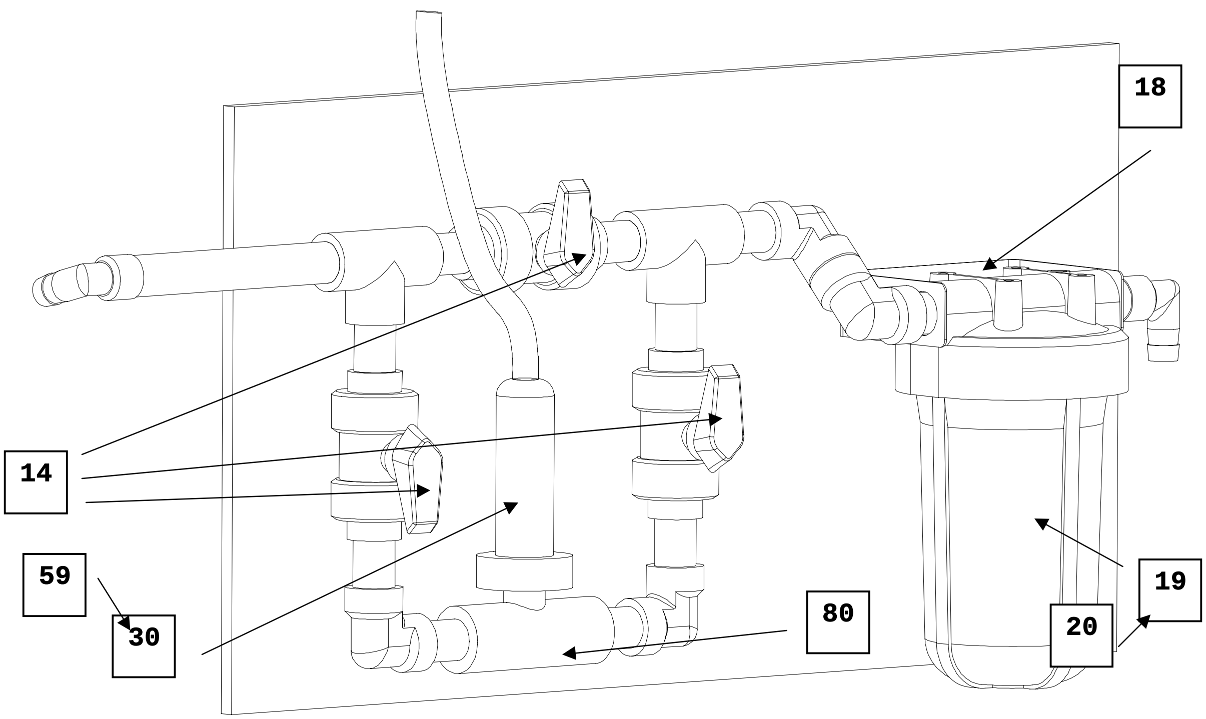

FIGURE 9-4: Silver Probe with Filter Chamber

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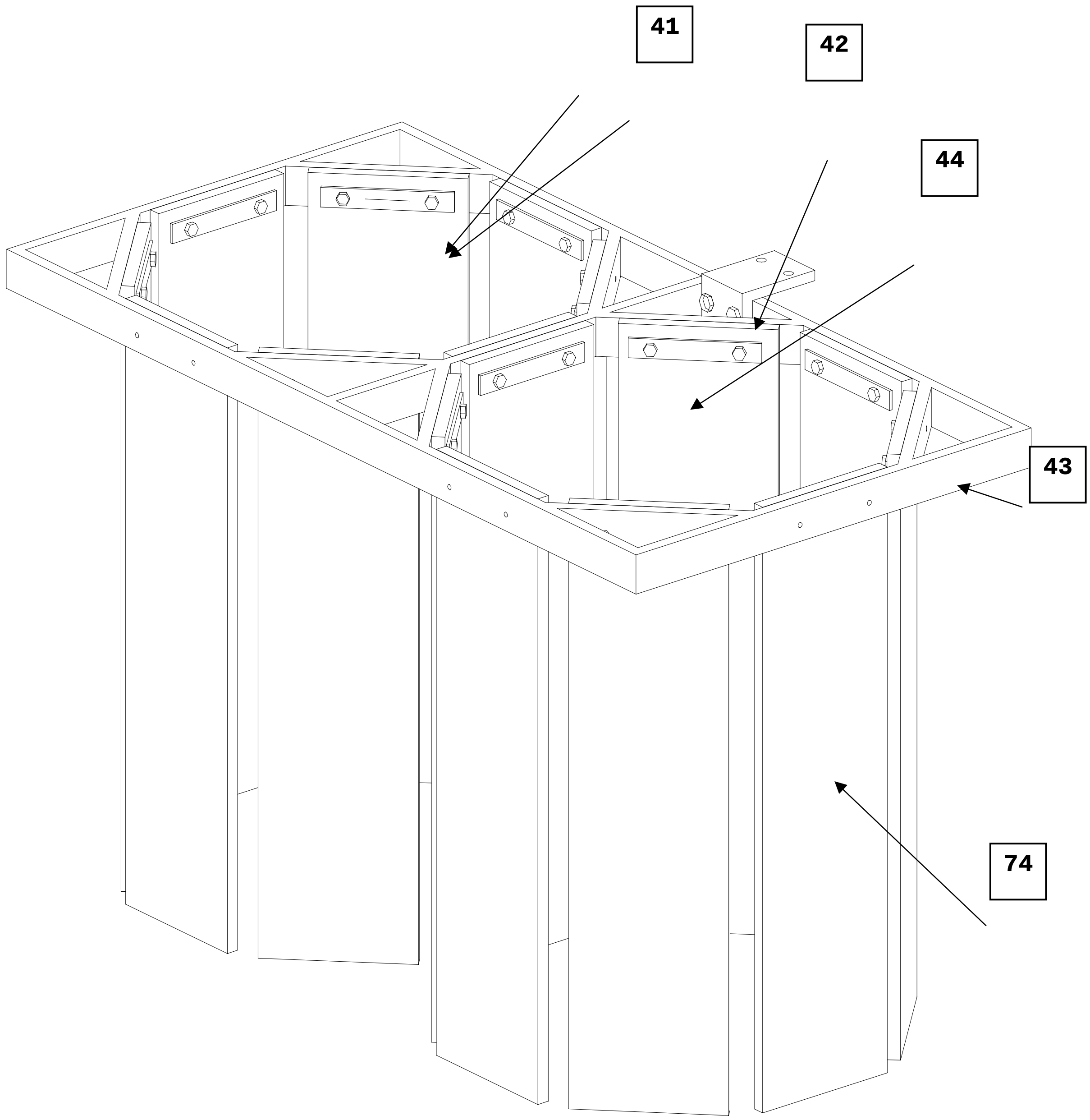


FIGURE 9-5: Anode Ring Assembly

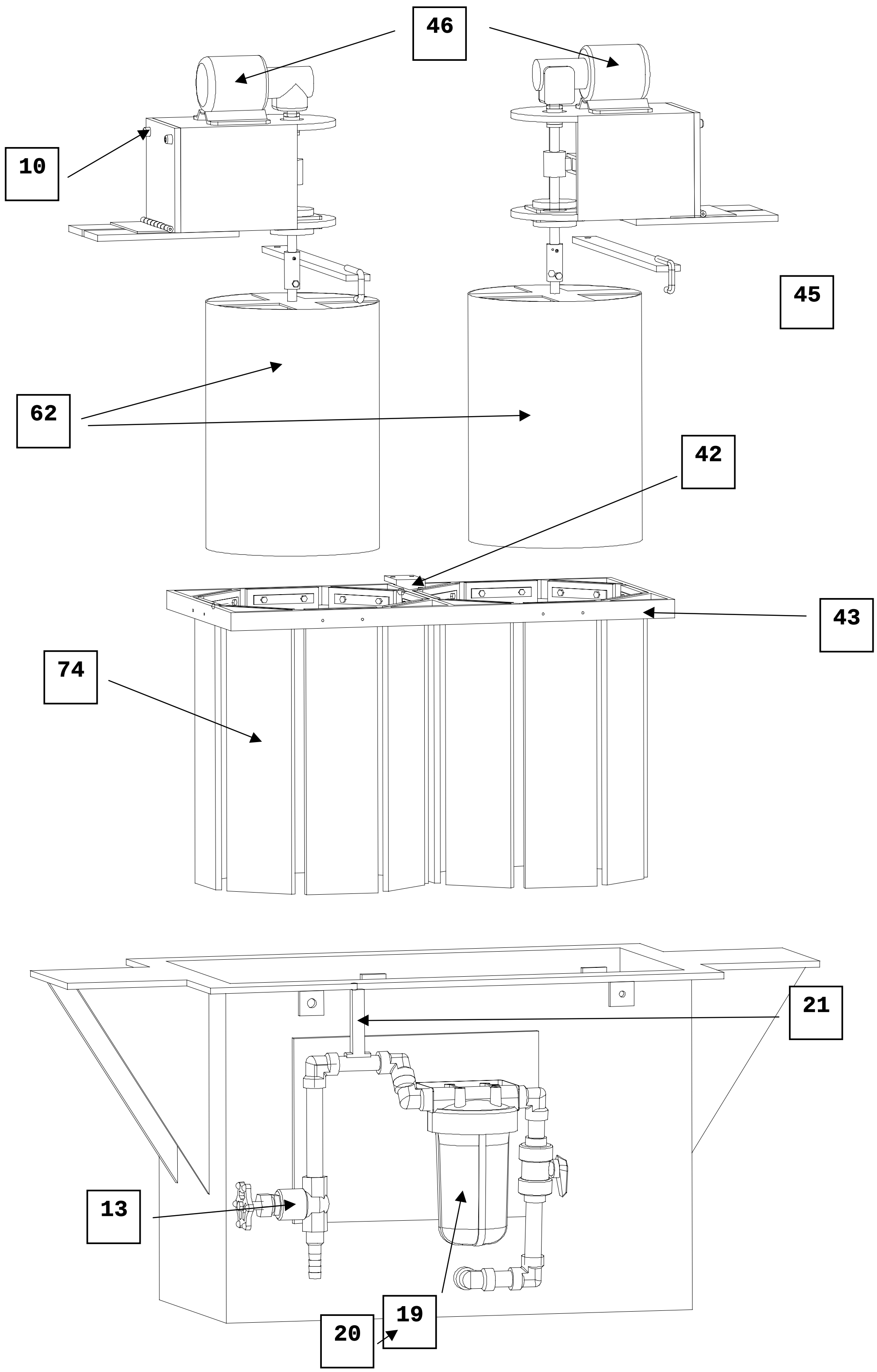


FIGURE 9-6: Top Cell Exploded View

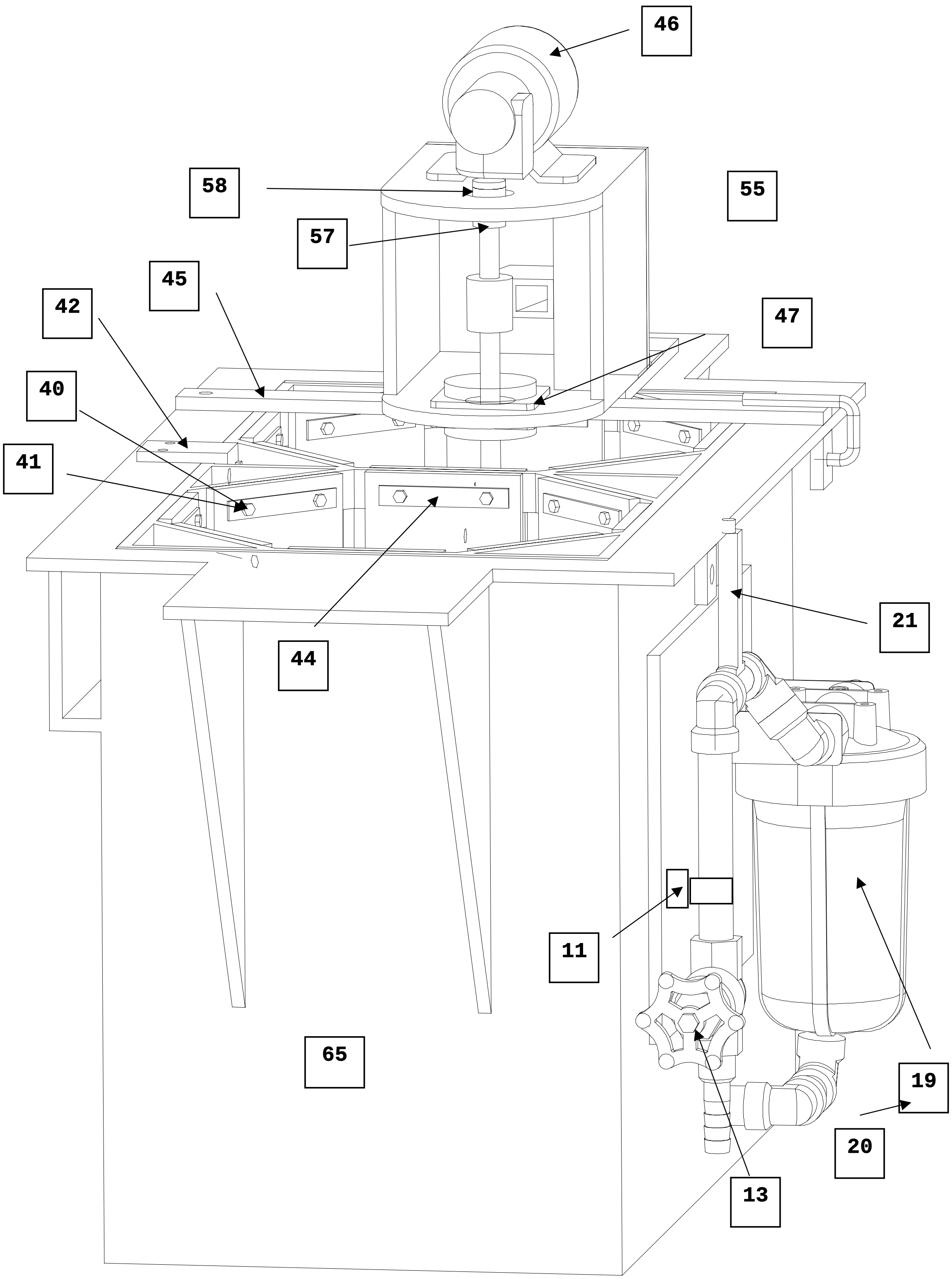


FIGURE 9-7: Top Cell Complete

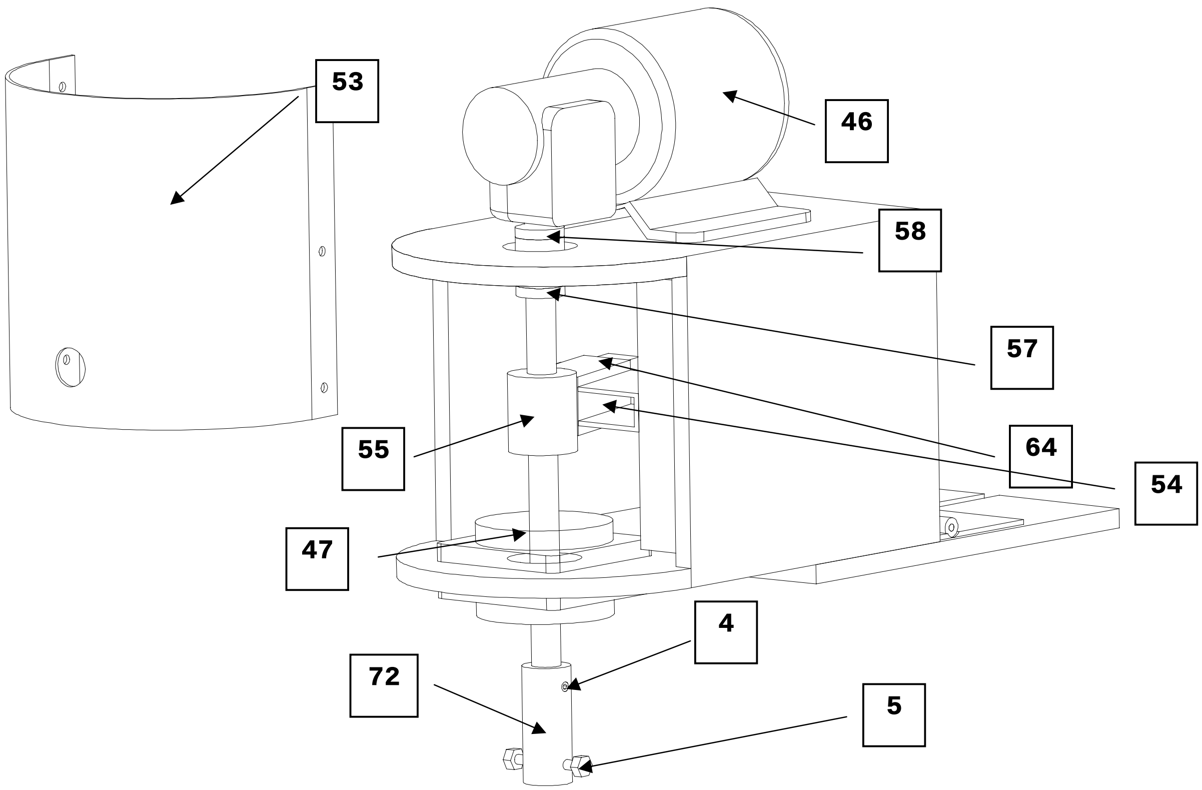


FIGURE 9-8: Drive Assembly Detail #1

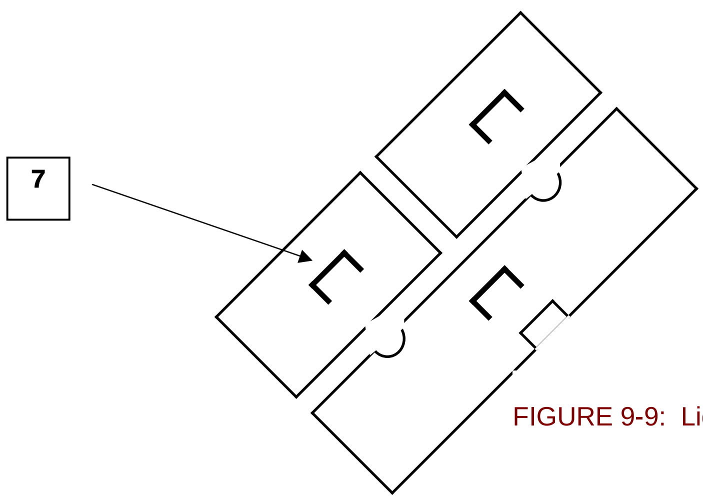


FIGURE 9-9: Lid Assembly

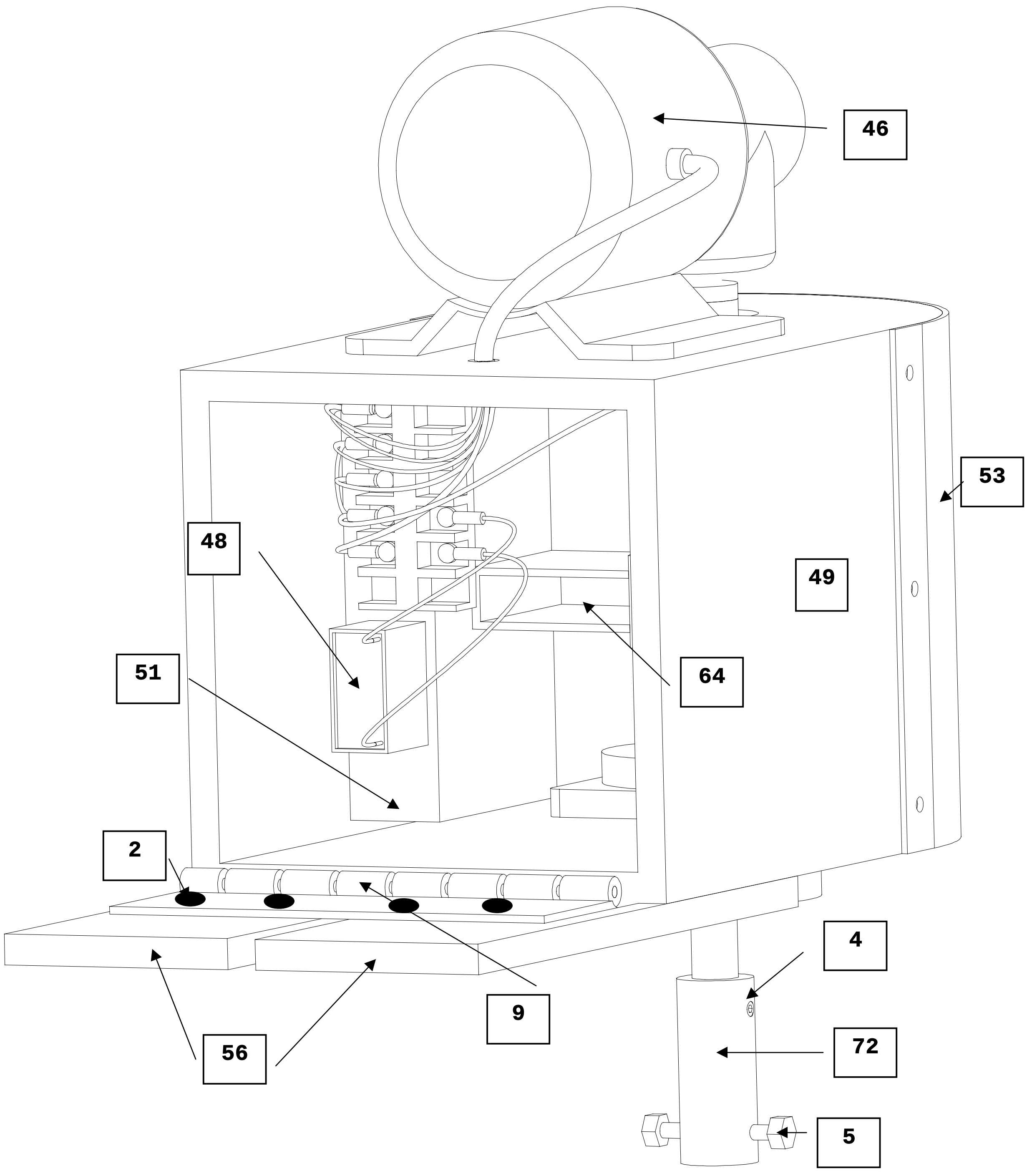


FIGURE 9-11: Drive Assembly Detail #2

10. ELECTRO SILVER SENSOR (ANALYZER)

10.1 GENERAL INFORMATION

- This manual includes information on installing, operating, maintaining and troubleshooting the Model 90H Specific Ion Analyzer. Identification of controls, switches and indicators is bold-faced for easy reference.
- The Model 90H is a compact electronic instrument which provides power for the associated sensor, receives signals from sensor and processes those signals which may be used for indication, transmission and control functions.
- The Model 90H can be equipped with a variety of options. This manual describes all analog output and relay options. Only options supplied with this instrument will apply.
- The instrument requires line power as specified on the label affixed to the enclosure. Whenever line power is discussed in this manual, assume it to be that which is specified.

11. SPECIFICATIONS

11.1 OPERATIONAL

Sensitivity………………………………….	0.1% of span
Stability…………………………………….	0.2% span per 24 hrs., non-cumulative
Non-Linearity……………………………..	0.1% of span
Display…………………………………….	4 ½" mirrored scale
Response Time…………………………..	0.1 and 1.0 seconds, selectable
Ambient Conditions……………………..	-30º to 50ºC (-22º to 122ºF), 0-100% R.H.
Control/Alarm Setpoints………………..	0-100% of full scale, adjustable with press-to-display setpoint feature
Control Deadband……………………….	0-50% of full scale, adjustable
Indicators………………………………….	LED lights when relay turns on
*Contact Rating (U.L.)…………………..	SPDT, 5A 115/230 VAC, 30A @ 30 VDC resistive
Temperature Compensation……………	Automatic, 0-95ºC (32º-203ºF)
Sensor-to-Analyzer Distance…………..	3000 feet maximum

***NOTE:**

Control or alarm relays operate on increasing or decreasing reading, switch selectable.

11.2 ELECTRICAL

Power……………………………………..	98-132 VAC, 50 or 60 Hz.
Analog Outputs…………………………..	One voltage and one current signal (non-isolated): 0-1 mA, 100 ohms maximum load 0-5 VDC, 50K ohms minimum load

11.3 ENCLOSURE…………………………

NEMA 4X, styrene structural foam (with flame retardant additive), panel/surface/pipe mount

11.4 NET WEIGHT

12 lbs. (5.5 kg) maximum

12. PRINCIPAL OF OPERATION

12.1 The analyzer is a special type of differential voltmeter with analog output. The instrument uses solid-state integrated circuits which operate on low voltages. The gains and offsets of most circuits are set by 1% precision resistors. This and the use of high gain integrated circuits provide stability and eliminate changes due to component aging.

12.2 The power supply uses a transformer to step down the line voltage. The stepped-down voltage is full-wave rectified by a diode bridge. Ripple voltages are removed in a capacitor input filter which provides a DC voltage for integrated circuit regulators. Four voltages are produced: (+) and (-) 15 VDC and (+) and (-) 18 VDC.

12.3 The scaling section of the analyzer consists of three stages. The first stage subtracts the two signals from the sensor, yielding a differential measurement. The second stage feeds this differential signal through a resistor network which includes a temperature sensitive resistor in the sensor to accomplish the required temperature compensation. The third stage amplifies this signal to scale it to 0-5 VCK over the range of interest. This 0-5 VDC signal is used for the analog output(s), display indication and as an input to analyzer options.

12.4 The current output/range expand section amplifies the 0-5 VDC signal and shifts it to expand the range. This signal is fed to a current output stage which changes the signal voltage to a current output. The output stage is a true current injector (load resistor is not required in current output circuit).

12.5 The isolated current output section, if provided, uses the 0-5 VDC signal produced by the scaling section. The input side of the isolator compares the 0-5 VDC signal to a triangle wave and generates a pulse train of variable duty cycle applied to a light emitting diode (LED) in an optical isolator. The optical isolator has a photo transistor which intercepts the LED’s optical output and generates a pulsed output of variable duty cycle. This pulse train is filtered and scaled to produce a 0-5 VDC signal over the full range. This signal is used for display and as an input to other options. The input and output are isolated to 1000 VDC.

12.6 The relay control section, if provided, operates by comparing the 0-5 VDC signal to a variable setpoint signal. When the signal is greater than the setpoint signal, the output of a high gain amplifier changes voltage levels to turn on the relay. Part of the amplifier output is fed back to the amplifier input to establish a degree of hysteresis (deadband). The deadband range may be varied from 0-50% of full scale by adjusting the amount of feedback. When a relay turns on, an LED lights next to the relay’s setpoint control. This aids in setting the control.

13. INSTALLATION

13.1 Mount in as clean and dry a location as possible where minimal mechanical vibration exists. Avoid locations where corrosive fluids may fall on the instrument or its ambient temperature limits may be exceeded.

13.2 Refer to Figure 13-1 for enclosure and mounting dimension details. Figure 13-2 illustrates various mounting configurations. Use the two stainless steel brackets provided to panel, surface or pipe-mount the instrument. The bracket attachment configuration determines the mounting method.

13.3 Conduit hubs or cable feed-thru fittings should be used where cables enter the enclosure. Holes not used for cable entry should be sealed with plugs.

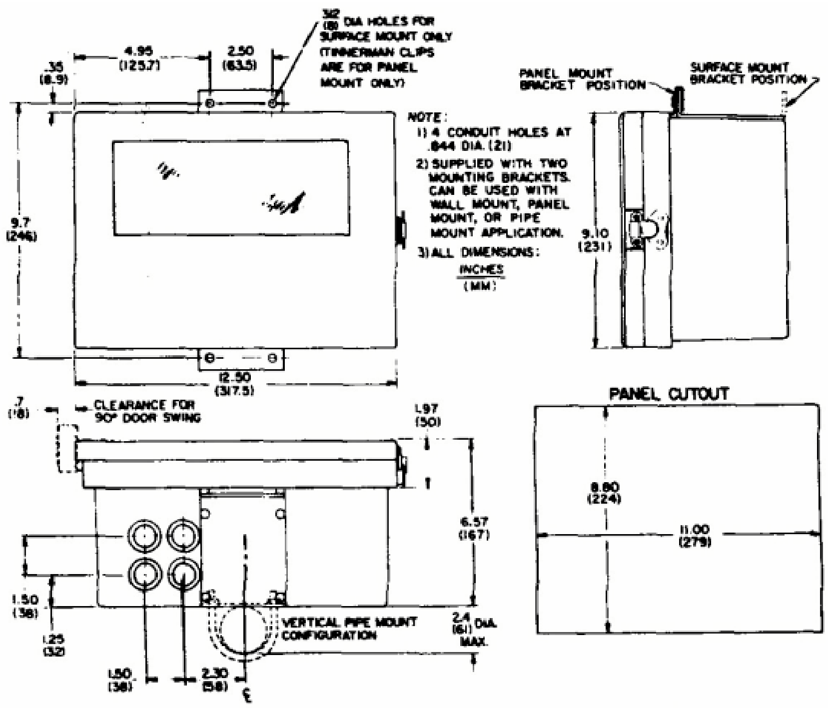


FIGURE 13-1 Enclosure Outline

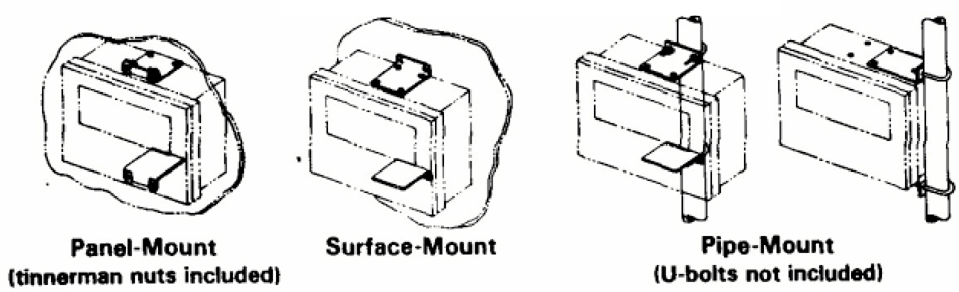


FIGURE 13-2 Mounting Configurations

14. ELECTRICAL CONNECTIONS

Electrical connections are made to terminal strips within the instrument enclosure. They are accessed by loosening two thumbscrews and swinging open the inner control panel. Refer to appropriate electrical hook-up diagram for connection details.

14.1 SENSOR

Connect sensor (or interconnect) cable lead wires to Terminals 15 through 20 on TB2, matching colors as indicated.

It is recommended that sensor and interconnect cable be run in ½" metal conduit for protection against moisture and mechanical damage. Do no run power or control wiring in the same conduit ("electrical noise" may interfere with sensor signal).

14.2 ANALOG OUTPUTS

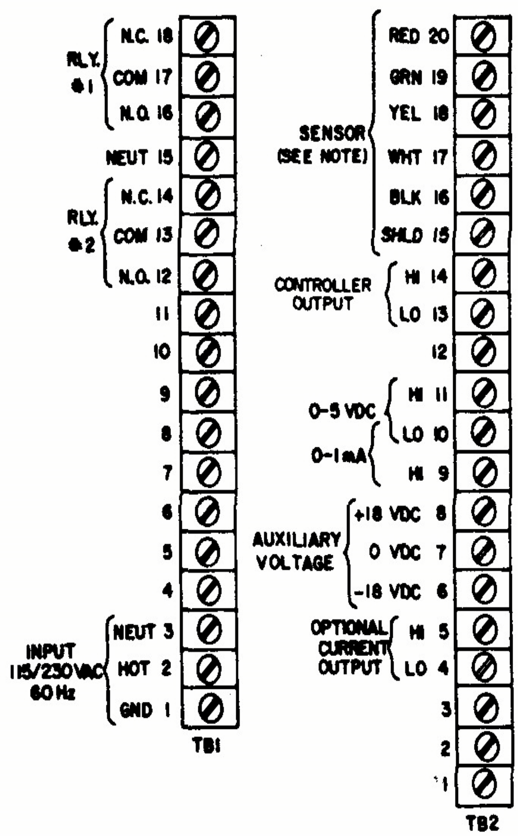


FIGURE 14-1

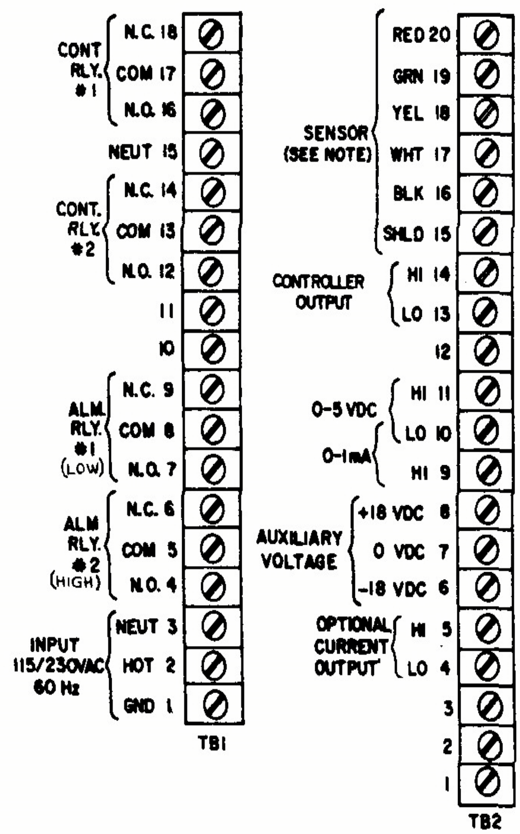


FIGURE 14-2

14.21 Standard 0-1 mA and 0-5 VDC analog outputs are provided at Terminals 9, 10 and 10, 11 respectively on TB2. An optional current output, if provided, is located at Terminals 4 and 5 on TB2.

14.22 When connecting loads (recorder, indicator, etc.), match polarity as indicated. Refer to Section 11.2 for load impedance limitations.

14.3 RELAY OUTPUTS

14.2.1 If the instrument has relays, SPDT relay outputs are provided on TB1. Relay outputs must be powered. The instrument's line power may also be used to power other devices via the relay contacts. Always check control wiring to insure that line power will not be shorted by the switching action of the relay contacts.

14.2.2 Do not exceed each relay's contact rating of 5A 115/230 VAC. If larger currents are to be switched, use of an auxiliary relay will extend relay life. When relay outputs are used, the instrument's line power wiring must be adequate to conduct the anticipated load.

14.4 LINE POWER

14.3.1 Connect line power to Terminals 1, 2 and 3 on TB!. Use only the standard three-wire connection. The green ground lead grounds the instrument which is mandatory for safe instrument operation.

CAUTION: Any other wiring scheme may be unsafe or cause improper instrument operation.

Do not run line power in same conduit with sensor or interconnect cables ("electrical noise") may interfere with sensor signal).

15. OPERATION

15.1 CONTROLS AND INDICATORS

The frequently used controls are located on the control panel and are accessed by opening the enclosure door. The seldom used controls are located on the main circuit board or on specific plug-in circuit cards as noted in the following descriptions.

The following items are provided on all instruments.

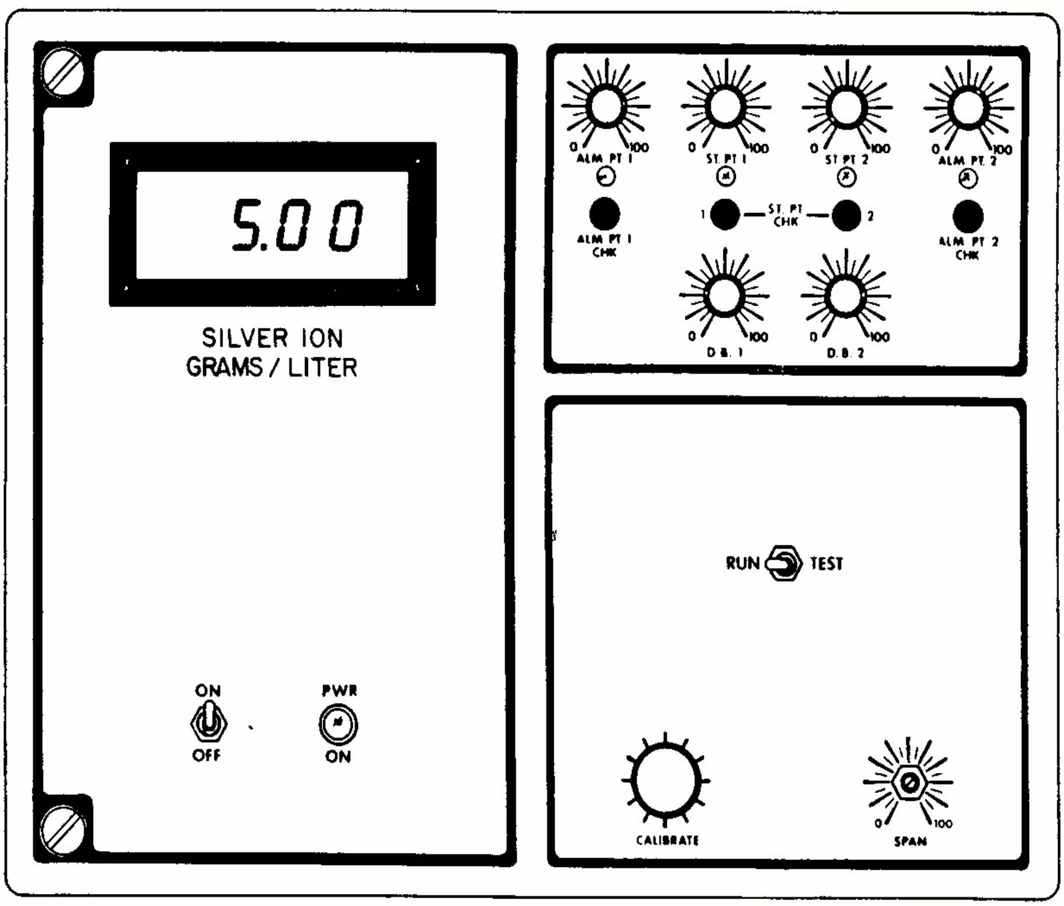


FIGURE 15-1
Control Panel Layout, Instruments With Four Relays (Two Control, Two Alarm)

15.1.1 ON/OFF power switch (on front panel see Figure 15-1)

ON - Connects line power to instrument circuits through ½ amp. in-line fuse.
OFF - Removes line power from instrument circuits.

15.1.2 PWR ON indicator (green, on front panel, see Figure 15-1)

Lights whenever instrument is powered and in-line fuse is intact.

15.1.3 RUN/TEST switch (on front panel, see Figure 15-1)

RUN - Connects sensor signal to analyzer circuits to measure value.
TEST - Connects simulated sensor signal to analyzer circuits for test or diagnostic purposes. In this position, specific ion values can be simulated with CALIBRATE control to manually set display reading and analog outputs to desired value without disrupting instrument calibration. Control setpoints, alarm points and range expand are established using this switch position.

15.1.4 CALIBRATE control (on front panel, see Figure 15-1)

Continuously variable control has two functions depending on position of RUN/TEST switch:

A. In RUN, it shifts display reading to proper value for calibration with sensor in solution of known value.
B. In TEST, it shifts display reading and analog outputs for test or diagnostic purposes. This includes setting control setpoints, alarm points and range expand.

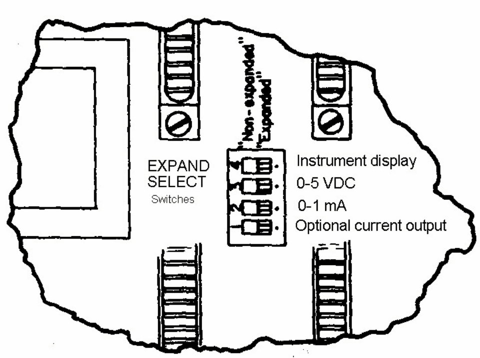
Control's 0-100 adjustment range represents 0-100% of full scale.

15.1.5 SPAN control (on front panel, factory-set and locked, see Figure 15-1)

Continuously variable control adjusts span (gain) of instrument during factory calibration with RUN/TEST switch in RUN position only. This control shifts display reading slightly and its adjustment range is arbitrary.

15.1.6 EXPAND SELECT switches (on main circuit board, see Figure 15-2)

This block of four individual slide switches select specific analog outputs to represent the full measuring scale ("non-expanded" position) or a selected segment of the measuring



scale span ("expanded" position). Each switch represents a specific analog output:

Switch 1…Optional current output at Terminals 4 and 5, TB2.
Switch 2…0-1 mA at Terminals 9 and 10, TB2.
Switch 3…0-5 VDC at Terminals 10 and 11, TB2.
Switch 4…Instrument display (allows full scale indication to represent smaller segment of the measuring scale not less than 10% of the measuring scale span.

> **NOTE:** When Switch 4 is in “expanded” position, instrument display scale no longer applies. In its place, display scale values represent the segment determined by the range expand procedure.

Any combination of these switches may be in the “expanded” position, but each related output will represent the same selected segment of the measuring scale established with the range expand procedure (refer to Section 15.4).

NOTE: Instruments not supplied with the optional current output must have all four switches placed in the “non-expanded” position or instrument will not operate properly.

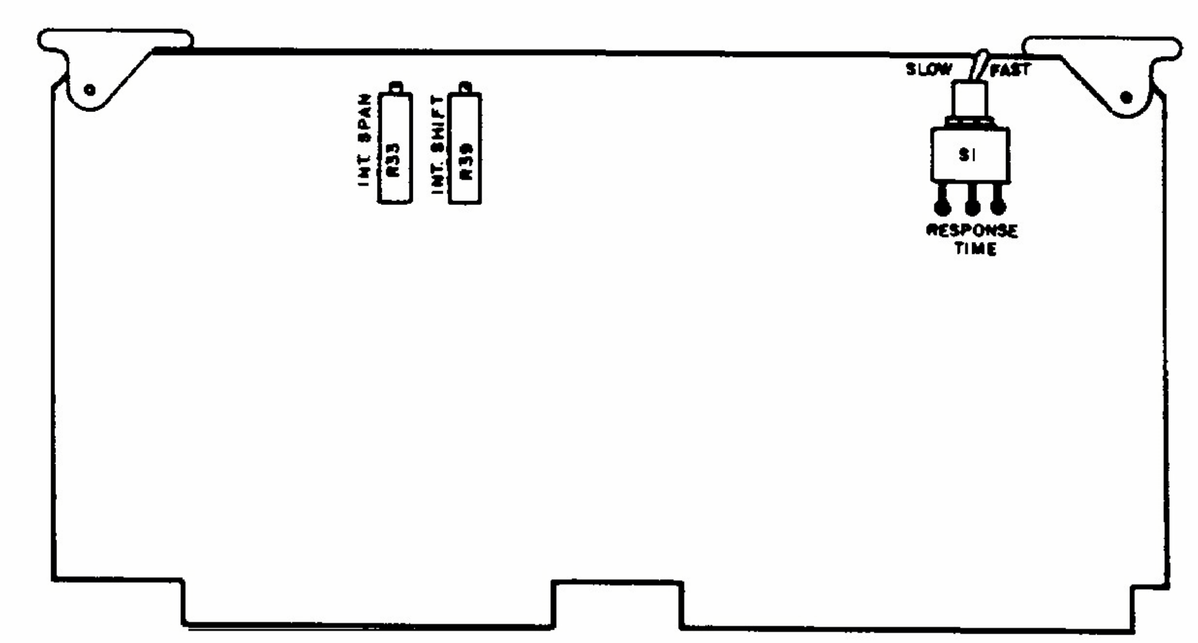


Figure 15-2 Main Circuit Board
Location of EXPAND SELECT Switches

15.1.7 SLOW/FAST switch (on green-handled card, see Figure 15-3)

Two-position switch selects instrument’s response time:

SLOW - Provides 1.0 second response.
FAST - Provides 0.1 second response.

The following items are only provided on instruments supplied with an optional current output.

15.1.8 INT. SHIFT control (R39 on green-handled card, see Figure 15-3)

Continuously variable control adjusts display reading to its minimum-scale value during range expand procedure to establish the low limit of a selected segment of the measuring scale (see Section 15.4). The minimum value of each analog output selected with EXPAND SELECT switches (item 6) is provided when the specific ion value is at or below segment's low limit. Control's adjustment range is 0 to 100% of full scale.

15.1.9 INT. SPAN control (R33 on green-handled card, see Figure 15-3)

Continuously variable control adjusts display reading to its maximum-scale value during range expand procedure to establish the high limit of a selected segment of the measuring scale (see Section 6.4). The maximum value of each analog output selected with EXPAND SELECT switches (item 6) is provided when the specific ion value is at or above segment's high limit. Control's adjustment range is 0 to 10% of full scale.

The following items are only provided on instruments supplied with a relay option.

15.1.10 RELAY 1 (2) MODE switches (on red-handled card, see Figure 15-4)

HI - Selects "high phase" operation for respective relay; turns on in response to increasing specific ion value.
LO - Selects "low phase" operation for respective relay; turns on in response to decreasing specific ion value.

NOTE: If instrument is supplied with four relays, these switches apply to control relays only.

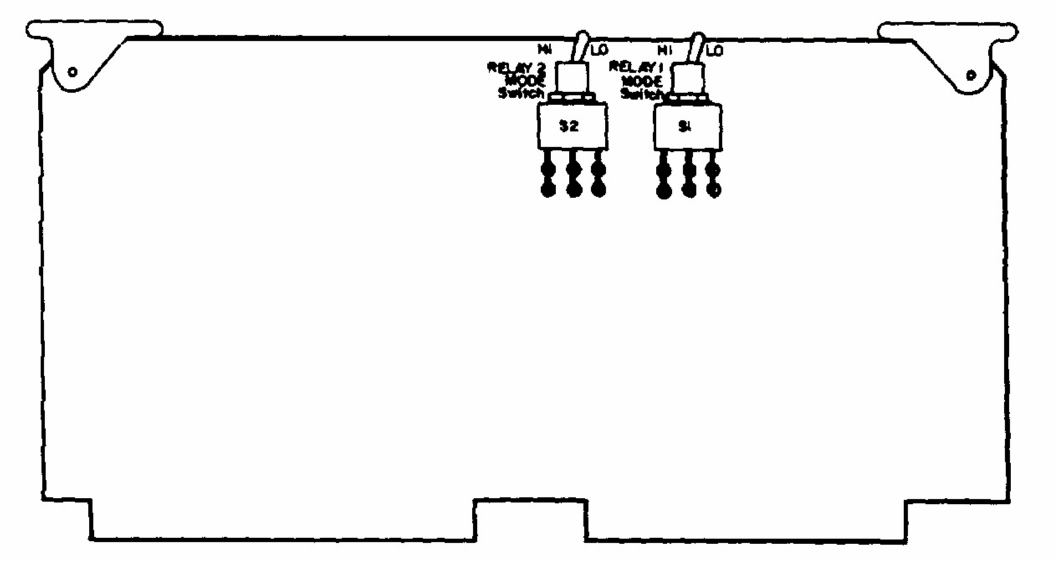


FIGURE 15-4 Red Handled Card
Location of RELAY 1 MODE and RELAY 2 MODE Switches

15.1.11 ST.PT

Each continuously variable control sets the point at which its respective control relay (1, 2) turns on in response to increasing specific ion value. Relay remains on whenever specific ion value is above this selected setpoint value. Control's 0-100 adjustment range represents 0 to 100% fo the full scale.

NOTE: Underlines indicate "high phase" relay operation. Opposite relay operation occurs when a "low phase" is selected with RELAY MODE switch (see item 19).

15.1.12 ST.PT.1 (2) indicator (yellow, on front panel, see Figure 15-1)

Each indicator lights whenever their respective controls relay (1, 2) turns on.

15.1.13 ST.PT.1 (2) CHK push-button switches (on front panel, see Figure 15-1)

Each switch, when pressed, displays its respective control relay's setpoint value set by the ST.PT.1 and ST.PT.2 controls. When released, momentary action type switch returns to its "off" position and display resumes its "regular" indication mode.

15.1.14 D.B.1 (2) controls (on front panel, see Figure 15-1)

Each continuously variable control sets the point at which its respective control relay (1, 2) turns off when the specific ion value decreases below the preselected setpoint value set by the ST.PT.1 and ST.PT.2 controls. This establishes a range or "deadband" in which the control relay remains on. Control's 0-100 adjustment range represents approximately 0 to 50% of full scale.

NOTE: Underlines indicate "high phase" relay operation. Opposite relay operation occurs when a "low phase" is selected with RELAY MODE switch (see item 10).

15.1.15 ALM.PT.1 (2) controls (on front panel, see Figure 15-1)

Each continuously variable control sets the point at which its respective alarm relay turns on (in response to decreasing specific ion value for alarm relay #1 and increasing specific ion value for alarm relay #2). Whenever specific ion value is below ALM.PT.1 or above ALM.PT.2, the respective relay remains on. Control's 0-100 adjustment range represents 0 to 100% of full scale.

15.1.16 ALM.PT.1 (2) indicators (red, on front panel, see Figure 15-1)

Each indicator lights whenever its respective alarm relay (1, 2) turns on.

15.1.17 ALM.PT.1 (2) CHK push-button switches (on front panel, see Figure 15-1)

Each switch, when pressed, displays its respective alarm relay's alarm point value set by the ALM.PT.1 and ALM.PT.2 controls. When released, momentary action type switch returns to its "off" position and display resumes its "regular" indication mode.

The following control is only provided on instruments with a meter display.

15.1.18 METER ZERO control (located on meter face)

Adjusts meter movement mechanically to align meter pointer to minimum-scale value with line power removed from the instrument.

15.2 PRELIMINARY SET-UP

15.2.1 Before operating instrument for the first time, place power ON/OFF switch to OFF and the following controls and switches to these settings:

NOTE: Depending on options supplied with his instrument, specific controls may not apply.

Control	Setting
CALIBRATE control…………………	Mid-range
SPAN control………………………..	Mid-range
RUN/TEST switch…………………..	TEST
INT. SHIFT control………………….	Fully counterclockwise (left)
INT. SPAN control…………………..	Fully counterclockwise (left)
EXPAND SELECT switches……….	“Non-expanded” (see Figure 6-2)
- Instrument with Relay Option -	
RELAY 1 (2) MODE switches……..	HI or LO (see Table A, item 10)
ST.PT.1 (2) controls………………..	Fully counterclockwise (left)
D.B.1 (2) controls…………………….	Fully counterclockwise (left)
ALM.PT.1 control…………………….	Fully counterclockwise (left)
ALM.PT.2 control…………………….	Fully clockwise (right)

15.2.2 For instruments with meter displays, adjust METER ZERO control to make meter exactly indicate its minimum-scale value.

15.2.3 Apply line power and allow instrument to stabilize for at least 10 minutes before calibrating. While waiting, control setpoints, deadbands and alarm points may be set.

15.3 SETTING RELAY FUNCTIONS

With RUN/TEST switch in TEST, use CALIBRATE control to make display indicate desired specific ion value when establishing relay operation.

NOTE: If instrument is calibrated, note value on display when placing RUN/TEST switch to TEST. After establishing relay functions, use CALIBRATE control to restore noted reading so calibration will be maintained when RUN/TEST. Switch is returned to RUN.

15.3.1 Place RUN/TEST switch to TEST.

15.3.2 To set control relay 1's setpoint, adjust CALIBRATE control until display indicates 0.70 g/l. Turn ST.PT.1 control slowly until ST.PT.1 indicator lights (relay turns on).

15.3.3 To set control relay 1's deadband, turn D.B.1 control fully clockwise (right). Adjust CALIBRATE control until display indicates 0.50 g/l. Turn D.B.1 control slowly counterclockwise (left) until ST.PT.1 indicator turns off (relay turns off).

15.3.4 To set control relay 2's set point, adjust CALIBRATE control until display indicates 1.00 g/l. Turn ALM.PT.1 control slowly until ST.PT.2 indicator lights (relay turns on).

15.3.5 To set CONTROL Relay 2's deadband, turn D.B.2 control fully clockwise. Adjust CALIBRATE control until display indicates 0.70 G/L. Turn D.B.W control slowly counterclockwise until ST.PT.2 indicator turns off (Relay turns off).

15.3.7 Use CALIBRATE control to shift display reading back and forth, through the established setpoint and deadband, to verify that relays turn on and off at these points. If further adjustment is required, repeat the steps previously described.

After relay functions are set, relay setpoint and alarm point values may be displayed and verified any time by pressing the appropriate ST.PT.CHK push-buttons.

15.3.6 Changing Relay Setpoint

A. Press relay's ST.PT.CHK push-button and simultaneously adjust its ST.PT. control to make display indicate new setpoint value. The new setpoint is now set and displayed for verification.

NOTE: a 0.5% of full scale difference can exist between the press-to-display value and the actual setpoint value the relay turns on at. If this is critical, always use the procedure described in steps 15.3.1 through 15.3.7 for setting the setpoint.

B. Release ST.PT.CHK push-button.

The alternate method for changing a relay setpoint is to use steps 15.3.1 through 15.3.7.

NOTE: Changing the setpoint does not affect the deadband setting. The deadband range will remain as a percent of full scale units from the setpoint.

15.4 SETTING THE RANGE EXPAND

INT. SHIFT and INT. SPAN controls are used to establish a segment of the measuring scale that will represent the analog outputs selected with the EXPAND SELECT switches (see Table A, item 6).

NOTE: Selected segment cannot be smaller that 10% of the measuring scale span, but may be positioned anywhere within that span.

The procedure to apply the range expand feature is described using the following example. Suppose measuring scale is 0.10-5.00 g/l (4.90 g/l span). The smallest segment that may be expanded is 0.49 g/l (10% of measuring scale span). The 4-20 mA analog output is desired within a selected segment between 0.20 and 2.50 g/l.

15.4.1 Place RUN/TEST switch to TEST. Note display reading.

15.4.2 Adjust CALIBRATE control until display indicates the value at which 4 mA is to be provided (0.20 g/l for this example).

15.4.3 Place EXPAND SELECT switch 4 to “expanded”. Adjust INT. SHIFT control until display indicates its minimum-scale value (0.10 g/l for this example).

15.4.4 Place EXPAND SELECT Switch 4 to “non-expanded”. Adjust CALIBRATE control until display indicates the value at which 20 mA is to be provided (2.50 g/l for this example).

15.4.5 Place EXPAND SELECT Switch 4 to “expanded”. Adjust INT.SPAN control until display indicates its full-scale value (5.00 g/l for this example).

15.4.6 To obtain greater accuracy, repeat steps 15.4.2 through 15.4.5 until the segment’s limits correspond with minimum-scale and full-scale values.

15.4.7 Place EXPAND SELECT Switch 1 to “expanded”. The 4-20 mA analog output is now provided within the desired segment (0.20 to 2.50 g/l for this example).

NOTE: Each analog output selected with EXPAND SELECT switches represents the same segment established using this procedure. When EXPAND SELECT Switch 4 is in “expanded” position, instrument’s measuring scale represents values established with range expand procedure.

15.4.8 Adjust CALIBRATE control until display indicates the value noted in step 15.4.1 Place RUN/TEST switch to RUN. This maintains calibration if instrument was calibrated prior to setting the range expand.

16. CALIBRATION

16.1 This instrument's measuring accuracy is a function of the calibration procedure. This procedure requires a clean sensor and a sample of solution whick has the same specific ion value as the sensor Is standard cell solution.

16.2 Place RUN/TEST switch to RUN.

Place clean sensor, with protective cap removed, in the sample of solution. Allow sensor to attain temperature equilibrium with the solution (display reading stabilizes). Adjust CALIBRATE control until display indicates the known value of the solution

The instrument is now calibrated. The SPAN control has been preset and locked at the factory. No adjustment of this control is required.

The RUN/TEST switch allows the CALIBRATE control to be changed without disrupting system calibration. Anytime the CALIBRATE control is used for relay function or range expand set-up, place RUN/TEST switch to TEST, note display reading and set these functions as required. Then, using the CALIBRATE control, return display reading back to noted value and place RUN/TEST switch back to RUN.

17. SYSTEM OPERATION AIDS

17.1 The sensor is shipped and should be stored with its protective plastic cap over the electrode end. Remove cap just before use. Store this cap for future use. If sensor is to be out of solution for more than a day or two, put a few drops of water into protective cap and replace it oil sensor. This keeps the salt bridge from drying out which avoids slow response when sensor is put back into service.

NOTE: Protective cap must be removed when sensor is put into service or it will not operate.

The sensor's electrodes must be clean for accurate readings.

17.2 This instrument may be affected by electrical disturbances referred to as It ground 'loops". around loops may occur when an analog signal) is connected to an external device with a grounded input. Relay control normally will not cause ground loops. To check, for a ground loop which may cause erroneous readings, disconnect analog signal leads and observe if display changes to a different reading. A new reading indicates a ground loop and the need for an isolation amplifier.

17.3 The sensor-to-analyzer interconnect cable should not be run in same conduit with line power. Excess cable should not be recoiled near motors. Cable should be cut to proper length during installation to avoid unnecessary inductive 11 electrical noise" pickup which may interfere with sensor signal.

If current output load resistance specification is exceeded, output will track measuring Scale up to some point and then remain constant. Refer to Section 11.2 for output load specifications.

18. MAINTENANCE

18.1 SENSOR CABLE

If sensor-to-analyzer interconnect cable has not been put in conduit or other protective means, it should be inspected every few months for physical damage. At the same time, disconnect cable at the sensor and instrument, and check leads for internal shorts with an ohmmeter.

18.2 PERIODIC SYSTEM CHECK

Depending on the application, system calibration should be performed periodically to maintain measurement accuracy. Frequent checks are suggested until operational history indicates the optimum time between checks that will suffice.

18.3 RELAY REPLACEMENT

If a defective relay needs to be replaced, remove its wire keeper, unplug relay from its socket and replace it with an equivalent relay (GLI part number 99X2TO323).

19. TROUBLESHOOTING

A few simple checks can determine if the measuring system (sensor and instrument) is functioning properly.

19.1 ELECTRICAL CONNECTION CHECK

19.11 Verify line power is reaching appropriate instrument terminals.

19.12 Push all wire harness connector halves together as tightly as possible. Tighten lead wire connections to meter display.

19.2 INSTRUMENT OPERATION CHECK

19.21 Disconnect sensor, place RUN/TEST switch to TEST and apply line power to instrument.

19.22 Turn CALIBRATE control through its full adjustment range to make display indicate its entire scale. If this is accomplished, instrument operates properly but sensor or interconnect cable (if used) may be defective. Proceed with step 19.2.3. If indication cannot be attained, instrument is defective.

19.2.3 Reconnect sensor directly to instrument (purposely excluding interconnect cable, if used). Calibrate the system using calibration procedure described in Section 16. If calibration is accomplished, the instrument and sensor are operating properly. If system cannot be properly calibrated, sensor is defective.

19.2.4 If interconnect cable is used and step 19.2.3 determines that instrument and sensor operate properly, the interconnect cable is defective.

19.3 Because high quality components are used, it is unlikely that the instrument will require servicing if it is wired properly and its maximum ratings are not exceeded. If an electronic component does fail, the easiest method of repair is to replace the entire circuit card containing the defective component. When removing a plug-in card, simultaneously lift both handles for "leverage" to extract it from its edge connector and pull card outward from its guides. To replace card, align or "key" it correctly into its edge connector (board components face away from terminal strips) and simultaneously push both handles firmly until card is fully inserted. The red-handled plug-in card is located closest to terminal strips, middle card is green-handled and furthest card is white-handled.

If it becomes necessary to disconnect any circuit card interconnect cables, always detach cable end connected to control panel board(s). Each cable connector is "keyed" to avoid an incorrect connection. To disconnect interconnect cable, gently pull connector from circuit card pins. When reconnecting, make sure connector is properly "keyed" and gently push it onto mating pins until fully engaged.

19.4 If a component can be verified to be defective, it may be replaced. All components used can be obtained from Hallmark Refining Corporation.

19.5 Should service, parts or assistance in troubleshooting or repair be required, please contact HRC technical support.

When ordering spare or replacement printed circuit cards, use the complete circuit card assembly part number printed in black ink on the foil side of the circuit card.

A description of the malfunction as well as the proper return address should accompany all instruments or circuit cards returned for repair, freight prepaid. All instruments or circuit cards out of warranty should be accompanied by a purchase order to cover costs of repair.

20. SILVER SENSOR (ORP) ASSEMBLY

The Silver Controller is a true differential sensor system which uses a digital controller to provide a constant readout of silver level. Capable of interfacing with all manufacturer's cells, this controller features two silver sensors which compare the silver level in the processors' fixing bath to the silver level in a known sample.

The unit is designed to provide either a two or three level control depending on the capability of the electrolytic cell to accept the three-level control. In the three-level mode, the unit will provide a switch closure and power a 10A relay to turn on the "LO" setting on the power supply at a present level (e.g. 0.5 g/l). When the silver exceeds a second level (e.g. 1.0 g/l), the "HI" setting on the power supply is activated. The "HI" setting will remain until the adjustable deadband setting is reached (e.g. 0.7 g/l) is achieved where the unit turns off. This provides a lower current density (and ability to plate to a lower level without sulfiding). Receptacles are provided to power a metering pump for replenishment on a demand basis. If the electrolytic cell is designed for an on/off operation and the power requirement is less than 10 amps, the unit is plugged directly to the controller for automatic operation. Receptacles are provided to operate replenisher pumps and remote signaling devices when the Silver Controller calls for plating.

21. GENERAL INFORMATION

21.1 INTRODUCTION

This manual provides information on field serviceable flow-thru ORP sensors. Sections 1 through 6 apply to both mounting types. Different installation procedures for flow-thru and submersion sensors are described in Sections 7 and 8 respectively. Instructions for replacing electrodes are detailed in Section 9.

21.2 CAUTIONS TO BE OBSERVED

21.2.1 Consult the factory before using the sensor in extremely strong solvents such as ethylene dichloride.

21.2.2 Before placing the sensor into service, remove each protective plastic cap from the process electrode and salt bridge. Store these caps for future use.

NOTE:

If the sensor is to be out of solution for more than a day or two, put a few drops of water in the salt bridge cap and replace it on the sensor. This keeps the salt bridge from drying out, thus avoiding slow response when the sensor is put back into service.

22. SPECIFICATIONS

Wetted Materials	CPVC, Kynar or ceramic, glass, vinyl ester, titanium palladium alloy, viton O-rings
Temperature Range	-5º to 8ºC (23º to 176ºF)
Maximum Pressure	100 psig
Maximum Flow Rate	10 feet per second
Measuring Range	(-)2000 to (+) 2000 millivolts
Stability	0.5 millivolts per day, non-cumulative
Sensitivity	0.1 millivolts
Output Impedance	580 ohms
Sensor Cable: Flow-Thru Submersion	 5 conductor (plus shield, 10 ft. (3m) 5 conductor (plus shield, 4.5 ft. (1.3m)
Mounting Connections: Flow-Thru Submersion	 Special lock ring with O-ring seal 1” NPT (female) to mate with 1” pipe
Transmission Distance	3000 feet maximum

23. PRINCIPLE OF OPERATION

23.1 The sensor contains two “batteries” whose voltages are measured and transmitted by electronic amplifiers. One battery is formed by the titanium palladium electrode and the platinum (or gold) process electrode. The voltage of this battery is a function of the solution ORP. The other battery is formed by the same titanium palladium electrode and the standard electrode which contains a pH electrode in a chemical standard of fixed pH (pH 6.5). The voltage of the second battery is subtracted from the voltage of the first battery, in the analyzer. The result is a differential measurement, the final signal being that of an ORP electrode in the process being compared to a pH electrode **in a pH 6.5 solution.**

23.2 A temperature sensitive resistor is included in the sensor to compensate for process temperature variations. This is very useful when using ORP to maintain a concentration. If temperature compensation is not required or desired, refer to the note in Section 27.1 or Section 27.2.

24. MAINTENANCE

24.1 CLEANING THE SENSOR

24.1.1 Check the platinum (or gold) process electrode regularly for fouling. Carefully wipe the electrode with a soft cloth and rinse with clean water. Place in an ORP reference solution to check for quick response and approximately correct span.

WARNING: DO NOT ACID CLEAN SENSORS USED IN PROCESSES CONTAINING CYANIDE SOLUTIONS.

If careful wiping and rising doesn't restore sensor performance, place sensor electrode in 10% HCl (hydrochloric acid) for 1 to 5 minutes to remove contaminants that are acid soluble. In some cases, use of other dilute or concentrated acids such as nitric (HNO_3) or sulfuric (H_2SO_4) may be required to clean the electrodes. Tars or greases can usually be removed using acetone or alcohol. Oils are best removed with dishwashing detergent. The best cleaning method must be determined by trying different techniques.

NOTE:

Whenever strong acids, bases or solvents are used for cleaning, the sensor's response may slow and its span accuracy may be temporarily incorrect. Placing the sensor in an ORP reference solution for 30-60 minutes usually restores the sensor to its proper operation.

24.1.2 The sensor's ground electrode need not be as clean as the glass process electrode, but should not be grossly fouled.

24.1.3 Never use abrasive cleaners on the sensor or its electrodes.

24.2 RENEWING THE SALT BRIDGE

The outer removable portion of the standard cell is referred to as the salt bridge. When the salt bridge is removed, the standard electrode and its solution-filled chamber are exposed. The salt bridge and pH solution (standard cell buffer) in the standard cell may need periodic replacement. To do so;

24.2.1 Hold sensor in upright position and remove salt bridge by turning it counterclockwise. It may be necessary to use pliers to initially loosen it. If so, take care not to damage the protruding glass electrode. Grip only the end of the salt bridge to avoid breakage.

24.2.2 After removing salt bridge, pour out and discard contaminated standard cell buffer.

24.2.3 Flush standard electrode chamber with distilled water and refill with distilled water.

Replace the salt bridge. Inspect ring for imperfections and replace if necessary. Turn salt bridge clockwise until fingertight. Then tighten ¼ turn more with pliers. A new salt bridge may be obtained from HRC.

25. TROUBLESHOOTING

A few simple measurements can determine if the sensor is operating properly. A multimeter and a 200 millivolt ORP reference solution are required for the following test:

25.1 Clean sensor and check salt bridge in accordance with Section 24.

25.2 Remove power from the instrument. Disconnect sensor's red, green, yellow and black lead wires from the system.

25.3 Place sensor in 200 millivolt reference solution. Before performing steps 5.4 through 5.6, wait for the temperature of the sensor and reference solution to come to 25º C (room temperature).

25.4 The sensor's temperature compensator changes resistance with solution temperature variations. To verify its operation, measure the resistance between the yellow and black lead wires. The reading should be between 250 and 350 ohms at 25º C.

25.5 Reconnect yellow and black lead wires and apply power to instrument.

25.6 Measure the voltage between red and green lead wires with the sensor in 200 millivolt reference solution. The reading should be 200 mV, (+) or (-) 25 mV. If not, the sensor is defective.

25.7 Should service, parts or assistance in troubleshooting or repair be required, please contact Hallmark Refining Corporation .

A description of the malfunction as well as the proper return address should accompany all sensors returned for repair, freight prepaid. All sensors out of warranty should be accompanied by a purchase order to cover costs of repair.

NOTE: If the sensor is damaged during return shipment as a result of inadequate pack- aging , the customer assumes responsibility for repair costs. It is recommended to use the original HRC carton or an equivalent. Also, HRC will not accept sensors returned for repair or replacement unless they are thoroughly cleaned and all process chemicals are removed.

26. REPAIR AND SPARE PARTS

Description	Part Number
Salt Bridge	912-010
Platinum Electrode	99X3E1069
Viton O-ring for mounting tee	99X5H1001

27. ELECTRICAL CONNECTIONS

The sensor is electrically connected directly to the instrument or indirectly with a junction box and interconnect cable.

27.1 Direct Hook-up

27.1.1 Route sensor cable to instrument. Use watertight connector, such as cable feed-thru fitting, in instrument's cable entry hole.

27.1.2 Connect sensor cable lead wires in accordance with instrument hook-up diagram.

NOTE:

If automatic temperature compensation is not desired, disconnect the yellow lead wire and tape its end. Connect a 1% 300 ohm , ¼ watt resistor between the designated yellow and black terminals in the instrument to simulate a fixed 25º temperature.

27.2 Indirect Hook-up with Junction Box

27.2.1 Mount junction box (with terminal strip) on flat surface such that its cover is removable when installed.

27.2.2 Route sensor cable to junction box through watertight connector such as cable feed-thru fitting.

NOTE:

Keep terminal strip dry to prevent problems caused by wet and/or corroded terminals.

27.2.3 Route interconnect cable to junction box and instrument. It is recommended that this cable be run in ½" metal conduit for protection against moisture and mechanical damage. Use conduit hubs where cable enters junction box and instrument enclosure.

NOTE:

Do not run line power in same conduit with interconnect cable ("electrical noise" may interfere with sensor signal).

27.2.4 Connect sensor and interconnect cable lead wires, by matching colors, to junction box terminal strip. Fasten cover onto junction box.

27.2.5 Connect interconnect cable lead wires to instrument in accordance with instrument hook-up diagram.

NOTE:

If automatic temperature compensation is not desired, disconnect the yellow interconnect cable lead wire and tape its end. Connect a 1%, 300 ohm, ¼ watt resistor between the designated yellow and black terminals in the instrument to simulate a fixed 25ºC temperature.

27.3 MOUNTING

The sensor and special mounting tee are factory-assembled. Unfasten the lock ring and remove the sensor from the mounting tee. Mount sensor vertically, electrodes down. If sensor must be installed on an angle, it should be at least 15º above horizontal. Other mounting angles may cause erratic readings.

27.3.1 Install special 1-1/2" NPT mounting tee into a horizontal run of the sample or process line. Use thread sealant on mounting hardware threads to avoid leaks. Teflon tape or pipe sealant with Teflon (Loctite No. 59231 or equivalent) is recommended. Experience indicates that Teflon tape may not provide an adequate seal, especially at higher solution temperatures.

27.3.2 Electrically connect sensor to instrument as described in the first paragraph, Section 27.

27.3.3 Remove protective plastic cap from sensor and calibrate the system with ORP reference solution before mounting sensor into process line.

27.3.4 Insert sensor into mounting tee. Make sure O-ring is properly seated in its groove and tighten lock ring. This completes the installation.

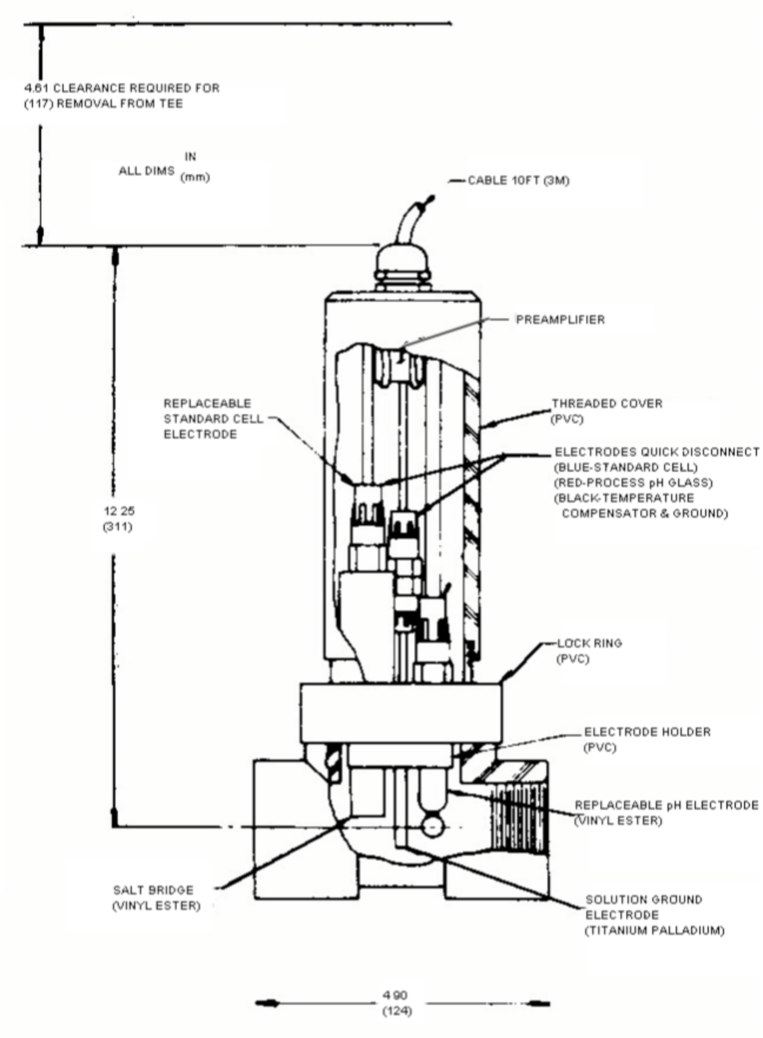


FIGURE 27-1: Flow-Thru Sensor Assembly Details

28. REPLACING ELECTRODES

To replace the process (or standard) electrode, it's not necessary to disconnect the sensor cable at the instrument A color coded quick-disconnect fitting is provided on each electrode head (red for process electrode, blue for standard electrode).

28.1 Loosen lock ring and remove sensor from process.

28.2 Loosen cable feed-thru nut at top of sensor cover and push cable feed-thru grommet back 6 inches on sensor cable.

28.3 Unscrew and remove sensor cover.

28.4 Disconnect electrode cable from electrode head by twisting quick-disconnect fitting counterclockwise and pulling apart all in one motion. Unscrew and remove the electrode.

28.5 Remove washer and small O-ring from electrode holder. Inspect O-ring for cuts, cracks and compressive deformation. Replace it if necessary (p/n 99X5H1004).

28.6 Apply silicone grease on small O-ring and place in its seat on electrode holder. Place washer (p/n 99X5H1005) on O-ring.

28.7 Insert new electrode (process or standard) into electrode holder. Turn electrode clockwise until fingertight. Then tighten ¼ turn more with pliers. Do not overtighten!

NOTE: New electrodes have an electrical connector protector in the head. This protector must be removed before quick-disconnect fitting can be attached.

28.1 Sealant is not required on electrode threads. If sample or process line pressure will approach 100 psig, it may be desirable at this time to check the electrode assembly for leaks. To do this, it is necessary to assemble electrode holder to flow-thru mounting tee and pressurize the system without the sensor cover in place. After the union and electrode O-ring seals have been checked for leaks, the sensor cover and cable feed-thru fitting can be assembled.

28.2 Reconnect quick-disconnect fitting to electrode head by pushing and turning in one motion.

NOTE: New electrodes have an electrical connector protector in the head. This protector must be removed before quick-disconnect fitting can be attached

28.3 Replace sensor cover and cable feed-thru fitting. Recalibrate the system before reinstalling sensor in the process.