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Title →

THE PULSETRONIC
ELECTRODELESS CONDUCTIVITY INSTRUMENT
REFERENCE MANUAL

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January 1974

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ABSTRACT

The instrument described in the following is a result of development work performed by the Pacific Northwest Laboratories of Battelle Memorial Institute under the sponsorship of Atlantic Richfield Hanford Company, Separations Process Engineering (OSE), G. A. Nicholson, Manager, and H. M. Jones, principal contact.

A few words of history are perhaps appropriate to place the development work in its proper perspective. Over the past ten years electrolytic conductivity work in support of plant application has been pursued with the evaluation and testing of several commercially available conductivity systems. The systems were generally workable, but involved risks with respect to long-term integrity of various components of the system such as seals, temperature compensation components and materials of construction.

The development work was therefore directed toward the design of an electrodeless conductivity system with specifications to include: a life of ten years, a radiation exposure to 10^{10} R gamma, pressures to 100 psi, temperatures to 50°C and exposure to 3M nitric acid.

A novel electronic system was developed to provide instrumentation responsive to the requirements for high sensitivity and electronic stability, low maintenance despite changes in the exposed magnetic components with time, service at high temperature, and radiation exposure.

Conventionally, stabilization of the magnetic components is accomplished at the expense of sensitivity and noise. A conventional oscillator with stable amplitude and frequency that drives the toroid

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which induces the current in the solution loop requires adjustment to compensate for anticipated changes in magnetic properties. This design concept also requires that if the resistive loop is to be interrogated by measuring current flow, then a constant voltage must drive the loop. Therefore, the rate of change of flux must be constant during the measuring period.

The instrument designed in this program satisfies this criterion by open-loop operation through use of the (pulsetronic) system developed. It can be shown that the peak voltage induced in the solution loop is constant over a large range of solution loop resistances despite changes in temperature and magnetic properties. This is true for a switch time, t , of essentially zero. However, the peak at $t=\pi/W$ has an attenuation factor of $\exp(-\frac{1}{2} \pi R/WL)$ and therefore is affected by circuit values.

INTRODUCTION

The term "electrodeless conductivity" generally refers to an in-line instrument to measure electrolyte conductivity which operates without the use of electrodes in their common form. The distinguishing features of the electrodeless system are:

- (1) The fluid being monitored forms part of the one-turn coupling circuit between a driven toroidal transformer and a pick-up or receiver toroidal transformer.
- (2) The cell consists of an electrically nonconductive pipe over which the toroids are slipped, making the monitored fluid a section of the electrical loop coupling the toroids.
- (3) An external electrical shunt joining the cell end connection or an equivalent solution path completes the in-line portion of the conductive loop.
- (4) The windings of the driven toroid are connected to a power source which induces a current in the secondary or solution loop. This current varies with the solution electrolytic conductivity and induces a voltage in the receiver toroid windings. The receiver toroid output, after suitable amplification, provides an electrical analog of the conductivity of the solution. See Figure 1 for a simplified schematic.

A calibration loop is incorporated into the instrument which allows the measurement of the solution loop resistance.

DEVELOPMENT ACTIVITIES

Design of electrodeless conductivity systems has evolved with time (references 1 through 6). The design of the Hanford system was greatly influenced by the prior design of a capacitance system.⁽⁷⁾ The Hanford system, when used with an appropriate capacitor, can be used to measure conductivities in nitric acid solutions with molarities on the order

of 0.01. (8) To adapt the instrument for use in acid concentrations of the order of 4 molar, the pulse transformer was divided into a toroidal pair. Coupling is still provided by the conductivity of the solution.

The pilot systems operated at a nominal 2 MHz and utilized micro circuit devices for the comparator and preamplifiers. However, a study of plant cabling problems disclosed that a more practical frequency for operation was a nominal 10 kHz.

The circuitry required for the 10 kHz frequency region is well within the capabilities of state-of-the-art operational amplifiers. The low cost and high reliability coupled with ease of maintenance provided by these operational amplifiers has been established by extended plant and laboratory experience.

The Circuit

The electronic circuitry is assembled on two circuit boards. Three boards are used if active thermal compensation is incorporated into the instrument. These boards are referred to as (a) the driver board; (b) the converter board; and (c) an optional, thermal compensation board which is used in conjunction with a resistance thermometer for high radiation service. Figure 2 shows the general instrument schematic.

The function of these boards is as follows:

- (a) Driver - This board contains the circuitry necessary to form a damped oscillatory circuit when connected to the driver toroid. See Figure 3.

The driver capacitor (C-1) is charged to a highly regulated

voltage through resistor R-1 and the driven toroid. Periodically the capacitor is switched to circuit ground through the action of transistor switch Q-1 which is operated by the relaxation oscillator formed by transistor Q-2, capacitor C-3, and resistors R-3, R-4, and R-5. Typical wave forms at salient points are indicated on Figure 3.

- (b) Converter Board - This board (Figure 4) contains three operational amplifiers which function as follows: Amplifier (A-1) is used as a non-inverting preamplifier whose input is connected to the pickup toroid which senses the current driven through the solution loop.

Amplifiers (A-2) and (A-3) form a peak height converter. The preamplifier (A-1) signal is introduced to amplifier (A-2) whose negative signal portion is fed to (A-3) through diode (D-2). Amplifier (A-3) integrates the current through (D-2) and applies the voltage to the positive input of (A-2) in order to diminish the negative output.

In summary, a positive input voltage to (A-1) results in a positive output introduced to inverting amplifier (A-2) whose negative output is proportional to the difference between the input and the feedback signal from the output of integrating amplifier (A-3). This feedback causes the output of (A-3) to reach the peak height of the positive input to (A-2).

- (c) Thermal Compensation Board - The thermal compensation board (Figure 5) operates upon the analog of the conductivity and computes its value at a chosen reference temperature, usually 25°C.

Since the conductivity of a solution at temperature (T) referred to 25°C is of the form $C_T = C_{25} [1 + \alpha(T-25) + \beta(T-25)^2]$, and C_T and T are measured inputs, computation of C_{25} can be obtained by dividing C_T , the analog of the conductivity, by the factor $[1 + f(\Delta T)]$. Amplifier (A-4), in conjunction with the thermometer bridge, forms a value $K(\Delta T)$, which is scaled and summed along with a passive analog of $(\Delta T)^2$, derived from the function generator, by amplifier (A-5) to form a scaled value of the factor $[1 + f(\Delta T)]$. The analog divider performs the division of C_T by $[1 + f(\Delta T)]$. In practice, to simplify calibration, only $K(\Delta T)$ is used in the formation of $f(\Delta T)$.

INSTRUCTIONS FOR THE INSTALLATION AND OPERATION OF THE PULSETRONIC
ELECTRODELESS CONDUCTIVITY SYSTEM

Historical Data

The following instructions apply to the electrodeless conductivity system constructed for use in monitoring HAW, HAS, and various condensates. The materials and design used vary with the application. They are reported in the attached sketches and drawings, and Table I below. The following table and notes are introduced as an aid to long-term maintenance and replacement.

Work Sponsor: G. A. Nicholson, Manager, Separations Process
Engineering, OSE, ARHCO

Instrument Construction: J. L. Duce, Sr. Engineering Technician,
Chemical Technology Department, BNW

Design: BNW pulsetronic developed under the sponsorship of H. M.
Jones, Sr. Engineer, ARHCO

Developed by: O. H. Koski, Sr. Engineer, Chemical Technology
Department, BNW

Machinist: Glenn E. Brown, BNW

TABLE I. TABLE OF NOTES AND SPECIFICATIONS

<u>Application System</u>	<u>Revisions to Std.</u>	<u>Installation</u>	<u>Probe Drawings</u>	<u>Cell Constants and Ident.</u>
HAS	bias added w/ range 100/300/1000	Figure 7	Figure 6 A&B	HAS-001 7.407 HAS-002 7.407
HAW	bias added w/range 100/300/1000 driver supply separate AC coupled pre-amp	Figure 8	SK-2-3745	HAW-001 9.74 HAW-002 11.4
Condensate monitors	None	cells coded to match electronics see Fig. 7 typ.	H-3-32570	11.4
In tank general			H-3-32559	9.4

Instrument Function

Switches selectable on rear panel of instrument

- (a) Uncompensated conductivity
- (b) Compensated conductivity
- (c) Temperature

Instrument Range

Switches selected at front panel

- (a) Sensitivity low - 0 to 1000 millimhos
- (b) Sensitivity high - 0 to 100 millimhos
- (c) Range pot - 0-1000 millimhos (available on request)
- (d) Range selector switch - 0, 100, 300, 1000 millimhos F.S.
Provided as a revision by customer request.

Bias Selection and Adjustment

A modification was requested by plant personnel to allow the selection of ranges with a suppressed zero on the HAS and HAW conductivity monitors. This is accomplished with static components by injecting a current of direction opposite to the normal output in the meter record output circuit. Since the normal uncompensated output is positive and the temperature compensated output is negative, bias current is also switched when the function switch is changed. Bias is not normally desired with temperature readout and therefore the bias must be switched off to read temperature in the normal manner.

Nominally, the instruments are operated with a span of 300 millimhos and a zero suppression of 350 millimhos. The suppression or bias adjustments are available on the rear of the units supplied for HAW and HAS monitoring. (See Figures 9 and 9 Rev. for the normal and

revised circuits. Note that a revised range selection is also provided.)

Instrument Readout

Meter: 0 to 1 corresponds to Δ temperature of 100°C, and conductivities of 0 to 100, or 0 to 1000, as determined by the function switch and range selection.

Recorder output: 0 to 10 MV corresponds to ΔT of 0 to 100°C and conductivities of 0 to 100, or 0 to 1000, as determined by function and range switch selection. Outputs are 0 to 50 MV on instruments supplied to PRF. Other outputs are available on request.

Installation

The HAW probes are intended for installation in the canyon of 202-A Bldg. and have 50 feet of four coaxial cables attached. The identification of the cables is on glass tape tabs attached to each individual cable. Cell identification is inscribed on the cells.

Wiring of the HAW probes and instrumentation external to the cell are shown in Figure 8. Details of the wiring internal to the converter are shown in Figures 2, 3, 4, 5 and 9. Details of the construction of this immersion-type probe are shown in Sketch SK-2-3745, attached. A resistive temperature device, Rosemount Part No. 104U100A, is inserted in internal holes of Part 4 of this sketch with wiring as shown in Figure 8.

The HAS monitor probes sketched in Figure 6A and the cell-to-converter wiring hookup are depicted in Figure 7. Note that for the HAS cell a by-pass strap joining the conductive pipe sections is required.

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Three cells of the type shown on the attached drawing H-3-32570 and intended for use as condensate monitors were supplied to the plant.

The converter is designed to be flange-mounted on a panel. Cutout and mounting instructions are shown in Figure 10.

Operating Instructions

After cabling has been accomplished as per instructions, an operational check of the instrument may be made as follows:

- a. Turn power switch ON. The pilot light will indicate if power is being supplied.
- b. Set function switch on rear panel to uncompensated mode. Select low sensitivity on front panel.
- c. Dial one turn on the CALIBRATE potentiometer on the front panel.
- d. Depress PUSH TO CALIBRATE button on instrument front panel.

A reading of about 30% of F.S. should result for HAW cells and about 20% for HAS cells. If the cells contain a conductive fluid during calibration, the above test should be modified as follows: Depress the PUSH TO TEST button and adjust the potentiometer to achieve a minimum output. The resistance of the fluid in ohms is calculated from the potentiometer reading as follows:

$$R_{\text{fluid}} = 300 \times N/10 + K$$

where:

K = the resistance of the calibration loop wiring, nominally 5 to 10 ohms.

N = number of turns on potentiometer.

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For normal operation:

- a. Select function desired on rear panel (uncompensated or compensated, conductivity, or temperature).
- b. Select high or low range as desired on front panel.
- c. Select readout to be used. Recorder and meter output are proportioned to each other, regardless of range chosen.
- d. Consult plots of conductivity versus meter or recorder display for fluid being monitored. Figures 11, 12 and 13 are for HNO_3 , and Figure 14 is for sodium nitrate with nitric acid concentration as the parameter.
- e. The calibration loop may be used to determine the resistance of the solution and specific conductivity of possible changes in gain or calibration which might occur. By finding the real value of the resistance and computing from the formula below, concentration can be determined.

calibration resistance = fluid resistance

Quantitatively,

$$300 \times \frac{N}{10} + K = \frac{\text{cell constant}}{\text{specific cond. of fluid}}$$

or

$$\text{specific conductivity} = \text{cell constant} / (300 \times \frac{N}{10} + K)$$

where N is the number of turns used on the 10-turn potentiometer and K is the resistance of the calibration loop wiring which, for high accuracy, is measured after installation is complete. The cell constants for the various cells provided are given in Table I on page 7.

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The uncompensated conductivity is available as an electronic analog on β in (S) of the converter board. The voltage-to-conductivity relationship is as follows:

$$E_{\text{uncomp}} = 5 \times 10^{-3} [C_T] [\text{cond}(\text{mmhos})] \text{ volts}$$

where

$$C_T = \text{cond. in mmhos at temp } T^{\circ}\text{C.}$$

The conductivity of nitric acid solutions is related to concentration and temperature by the formula

$$C_T \text{ cond}(\text{mmhos}) = [338M - 34.54M^2][1 + 0.0139(t - 25) - 1.27 \times 10^{-5}(T - 25)^2].$$

Then

$$E_{\text{comp}} = -5.0 \times 10^{-3}(338M - 34.5M^2).$$

This quantity is measured at pin (S) of the compensation board.

General Maintenance

Periodic maintenance and adjustment of the instrument are not anticipated to be required for continued use. Values for each amplifier and the multiplier, temperature coefficient, and reference temperature selection were preset during instrument checkout and except for the reference temperature adjustment are not expected to require change. The reference temperature adjustment may differ from the lab setting due to slight imbalance in the resistance of the lead wiring used but should be accurate to 1°C for 0.369 ohms of imbalance.

A check of the system can be performed with a DC voltmeter with a capability of measuring to 1 MV. As a preliminary step, remove the instrument cover and remove the pickup cable (code red) from the back panel of the instrument.

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The chassis contains three boards which can be identified by reference to photos P-1, P-2 and P-3, and to Figures 3, 4 and 5. The left-hand board when facing the instrument is the converter board, Figure 4; the center one is the temperature compensation board, Figure 5; and the right-hand board is the driver (Figure 3). Reference to photographs P-1, P-2 and P-3 will help identification.

The offset potentiometers are located on the top edge of each board in close proximity to the amplifier being adjusted. The amplifiers are located on their respective boards in roughly the same layout as shown in the schematics (Figures 4 and 5), i.e., with the first amplifier closest to the connector end of the board. (Also see photos P-1, P-2 and P-3). A scaling potentiometer is associated with the input to amplifier 1 of the converter board. It is adjusted to provide a full-scale output (5 volts) on pin (S) of the converter board for the full-scale value of conductivity (1000 mmhos).

The scaling potentiometer makes it possible to use any cell with the electronic unit. To dry-lab the calibration, a loop of wire through the cell with a resistance decade box joining the loop ends can be used. Since the loop resistance for 1000 millimhos will be equal to the cell constant for the cell in question, this value is used to achieve 5 volts output on pin (S) of the converter board, which in turn produces full-scale meter readout with the function switch in the uncompensated mode, and a full-scale output on the recorder. Note that the meter readout has an accuracy of only 2%. Also note that the calibration loop, if used as a calibration tool, gives a peak at a switch time of $t = \pi / W$. This peak is not an accurate analog of conductivity used in the null mode.

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Pin voltages of importance are listed below (referred to voltage common).

<u>Board</u>	<u>Pin</u>	<u>Component</u>	<u>Nominal Value</u>
Conv.	R	A-1 out	± 0.002 volts
Comp.	S	A-3 out	$+ 0.020$ volts ± 10 MV
TC	R	A-4 out	$+ 50$ MV/ $^{\circ}$ C ΔT above ref. 0 with pins J and K shorted
TC	A	A-5 out	$5.0 +$ twice E at pin B at 5.00 V with pins J and K shorted
TC	S	M/O out	0.00 equal to nominal value of pin(S) converter board

Troubleshooting (See Guide, Figure 15)

Step 1. The power supply used in this instrument was chosen from Stores stock (16-1890-100) or (16-1890-200) and is mounted beneath the chassis. If power is being supplied to the instrument, check pins P(+15 V), E(Common) on any board, and pins M(-15 V) on converter board. If voltage is low, check fuses on inside chassis surface (left side behind front panel for stock No. 16-1890-100, or power supply for stock No. 16-1890-200).

Step 2. Check wave form at TP-3 as shown in Figure 3 to test if driver system is working. If TP-3 is not proper but is of the form of TP-1 then an open toroid or cable is indicated.

Step 3. If output is low, the preamplifier output can be checked with a scope on pin (R) of the converter board. Assuming Steps 1 and 2 produced proper results, a zero output indicates an open circuit in the receiver toroid or cable.

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Notes: The circuit for use with HAW has an isolated power supply and a capacitor input to the pre-amp. (See notes, Figure 4.) This is necessary due to the limitation on the number of conductors available at the cell wall (see Figure 8) where the temperature element conductor is common with the pickup return conductor. Thus, the DC potential of the temperature element is blocked from the pre-amp.

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The performance of the work was particularly aided through the efforts of J. L. Duce, Sr. Engineering Technician, and Glenn Brown, Machinist, of the Battelle-Northwest Staff.

OPERATING PRINCIPLE

STEP 1

THE CAPACITOR IS CHARGED TO VOLTAGE E_{supply}

STEP 2

THE SWITCH MOVES TO POSITION 2 FORMING AN L-C CIRCUIT WITH A DAMPED OSCILLATORY WAVE.

NOTES:

THE SOLUTION LOOP IMPEDANCE IS EXPECTED TO BE PURE RESISTANCE AND THEREFORE e_0 WILL BE A MEASURE OF z_L . e_0 IS MEASURED AND CONVERTED TO DC AT ITS MAXIMUM VALUE. THAT IS $e_{0 \text{ max}} = (K)$ CONVERTER DC OUTPUT WHERE K IS RECIPROCAL OF THE PREAMP GAIN. THE $\omega t = 0$ PEAK AT SWITCHING TIME t HAS SOME JITTER BUT ZERO TEMPERATURE COEFFICIENT. THE $\omega t = \pi$ PEAK IS SMOOTH BUT CAREFUL SELECTION OF TOROIDS IS REQUIRED.

NOTE THAT CALIBRATION LOOP RESISTANCE IF ADJUSTED TO EQUAL z_L WILL RESULT IN $e_0 = 0(+)$ WITH CALIBRATION SWITCH IN CLOSED POSITION. THE MINIMUM OUTPUT IS DEPENDENT IN PRACTICE ON SOLUTION RESISTANCE.

FIGURE 1. SIMPLIFIED SCHEMATIC PULSETRONIC ELECTRODELESS CONDUCTIVITY

FIGURE 2. ELECTRODELESS CONDUCTIVITY GENERAL INSTRUMENT SCHEMATIC

FIGURE 3. ELECTRODELESS CONDUCTIVITY DRIVER BOARD SCHEMATIC

OP AMP	MOD	MANUFACTURER
A-1	DDC D-8	DATA DEVICE CORP
A-2	B/B 3118/12C	BURR-BROWN
A-3	ADO-45	FAIRCHILD
D-1,2	IN648 OR EQUIV	(IN484A IS USED WITH DASHED LINE CIRCUIT TO FEEDBACK ON A-2)

NOTE:

1. CAPACITOR REPLACES SHUNT IN HAW MONITOR
2. CALIBRATING RESISTANCE CHOSEN FOR PARTICULAR CELL
NOMINAL 1K, 1K POT USED IN LATER MODELS
3. ON WN-1 AND 32A SYSTEMS (P_U RECLAMATION)
1K POT AND IN484's ARE USED
4. SHUNTED WITH IN648 ALTERNATE TO DASHED

FIGURE 4. ELECTRODELESS CONDUCTIVITY CONVERTER BOARD CIRCUIT PULSE HEIGHT TO DC CONVERSION

MAJOR COMPONENT	MODEL	MANUFACTURER	REMARKS
A-4 OP AMP	D-8 DATA DEVICES	DATA DEVICES CORP	
A-5	SEE ABOVE	AS ABOVE	
MULT-DIVIDER	107-C	HYBRID SYSTEMS CORP	TRANSCONDUCTANCE TYPE

FIGURE 5. ELECTRODELESS CONDUCTIVITY TEMPERATURE COMPENSATION BOARD CIRCUIT

NOTES:

MATERIAL ALL UPVC NOMINAL 1" PIPE FITTINGS EXCEPT WHERE NOTED BY (N)

1. COAX CONNECTOR BNC (STORES 16-0999-150) CODE BLACK DRIVER CODE RED PICKUP
2. 3 PIN CONNECTOR BENDIX PC00A-8-3P STORES 16-0990-010 CODE BLACK CALIB CODE RED TEMP
3. TEMPERATURE ELEMENT RTD ROSEMOUNT 104U100A OR EQUIVALENT
4. ALUMINUM CAN 10 GA. ENDS EPOXY JOINED
5. TOROID FERROXCUBE SERIES 846T250 TYPE 3E2A 76 TURNS #20 GE FORMEX MAGNET WIRE
6. ALUMINUM CLAMP WITH 1/4" TUBE AS RTD HOUSING AND TAB LEAD SUPPORT
7. TOROID AS IN 5 ABOVE 110 TURNS NOMINAL INDUCTANCE 20 MH

* CELL HAS-001, ALL CONNECTORS ONE END; HAS-002, TWO EACH END

FIGURE 6A. ELECTRODELESS CONDUCTIVITY CELL H A S

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1. COAX CONNECTOR BNC STORES STK # 16-0999-150
2. 3 PIN CONNECTOR BENDIX PC 00A-8-3P STORE STK # 16-0990-010
3. TOROID FERROXCUBE SERIES 846T250 TYPE 3E2A WITH 76 TURNS # 20 GE FORMEX MAGNET WIRE (DRIVER)
4. SAME AS 3 ABOVE WITH 110 TURNS NOMINAL INDUCTANCE 20 MH-PICKUP
5. KYNAR 1" PIPE FLANGE STORES STK # 45-2456-210
6. KYNAR 1" PIPE STORES STK # 45-6865-200

FIGURE 6B. TYPICAL INLINE CELL

CONNECTORS

CELL	CHASSIS	MATE	STORES #
R AMP 31-003 BNC BENDIX	4890-1 BNC AMP	31-212	16-0770-060
B AMP 31-003 BNC	AS ABOVE	AS ABOVE	AS ABOVE
B/3P BENDIX		PC-06A-8-3S	16-0990-070
PC00A-8-3P		CLAMP 10-101980-81	16-0990-500
R/3P BENDIX		AS ABOVE	AS ABOVE
PC00A-8-3P			
	C-3		
	MS-3102A-145-6S		16-0700-251
	C-3 MATE		
	MS-3106A-148-6P		16-0690-560
	RECORD MATE		
	PC 06A-8-3S		16-0990-070

FIGURE 7. H A S WIRING INSTRUCTIONS

FIGURE 8. H A W IMMERSION PROBE WIRING SCHEMATIC

TEMPERATURE RESISTANCE BRIDGE
UNDERSIDE OF CHASSIS
(ERIE STRIP)

LOCATION
CIRCUIT BOARD CONNECTOR
BULK HEAD
TEMPERATURE COMPENSATION COEFF
ADJUSTMENT

MULTIPLIER INPUT
SCALING ON
ERIE STRIP
UNDER CHASSIS

UNCOMPENSATED
CONDUCTIVITY
CONVERTER BOARD

*NOTE 1000 OHM ON WM-1 AND 32-A
SYSTEM AND OTHERS

WIRING OF FUNCTION SWITCH, SENSITIVITY, OUTPUT & METER

LOCATIONS
S1 FUNCTION SWITCH
REAR PANEL
SENSITIVITY SWITCH
FRONT PANEL
METER - FRONT PANEL
OUTPUT - REAR PANEL

FIGURE 9. MISCELLANEOUS CIRCUITS H A W, H A S ELECTRODELESS CONDUCTIVITY CHASSIS

FIGURE 9R. ELECTRODELESS CONDUCTIVITY REVISION SHOWING BIAS AND SPAN ADDITIONS

FIGURE 10. DETAILS FOR MOUNTING

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FIGURE 11. SPECIFIC CONDUCTIVITY FOR HNO₃ (25°C)

FIGURE 12. CONVERTER AND RECORDER OUTPUT VS CONDUCTIVITY

FIGURE 13. CONVERTER AND RECORDER OUTPUT VS CONDUCTIVITY

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FIGURE 14. CONDUCTIVITY OF NaNO_3 VS CONCENTRATION WITH HNO_3 PARAMETERS (NOMINAL 25°C)

FIGURE 15. PULSETRONIC ELECTRODELESS CONDUCTIVITY TROUBLESHOOTING GUIDE

DRIVER
BOARD

TEMPERATURE
COMPENSATION
BOARD

M/D ↑

A5 ↑

A4 ↑

ADJUST AMP OFFSETS
(TYPICAL)

A3 ↑

A2 ↑

A1 ↑

ADJUST FOR FULL SCALE OUTPUT
WITH CELL TO BE USED

CONVERTER
BOARD

CONVERTER BOARD

TEMPERATURE COMPENSATION BOARD

DRIVER BOARD

ELECTRODELESS CONDUCTIVITY PROBE NO. 1

ASSEMBLY

U.S. ATOMIC ENERGY COMMISSION	
RICHLAND OPERATIONS OFFICE	
PACIFIC NORTHWEST LABORATORY	
OPERATED BY BATTELLE MEMORIAL INSTITUTE	
ELECTRODELESS CONDUCTIVITY PROBE NO. 1	
DATE	3/28
BY	H-3-32559
REVISIONS	NONE

① ASSEMBLY

② SST

③ SST

④ TEFLON

⑤ TEFLON

⑥ SST

⑦ SST

⑧ ALUMINUM

GENERAL NOTES:

1. TOLERANCES: DEC. 0.001, FINE 0.0005, AND 0.0001
2. BREAK ALL SHARP CORNERS AND REMOVE ALL BURRS
3. ALL MACHINED SURFACES TO SURFACE TEXTURE 10
4. ACCORDANCE WITH AMS1 846 (LATEST REVISION)
5. GEOMETRIC TOLERANCING AND DIMENSIONING
6. 1/16" ACCORDANCE WITH AMS1 846 (LATEST REVISION)
7. ALL MATERIAL SHALL BE AS SPECIFIED OR APPROVED QUALITY
8. FOR FAST TEMP RESPONSE DO NOT LOCATE PTFE OVER PORTION OF TUBE WITH TEFLON LINER
9. ALL SST PARTS 304L OR EQUIVALENT

REV	DATE	DESCRIPTION	MATERIAL
1		ASSEMBLY	
2		MALE UNION	
3		FEMALE UNION	
4		SEALING	TEFLON
5		GASKET	TEFLON
6		TUBE	SST
7		END PLATE	SST
8		SPACER RING	ALUMINUM
9		SET SCREW-ALLEN CONE POINT 1/4" DIA. 5-32	SST
10		GRAPHITE INSERT 1/4" DIA. 5-32, 1.455" LG.	
11		MUT-UNION 1/4"	SST
12		TORRIDA, MAGNETIC INC. TYPE 3, NO. 433-1-10	
13		ALLEN LOCKWASHER CAP SCREW 5-32, 1/4" LG.	SST
14		CONNECTOR BENCH, NO. PC004 5-32, 1/4" DIA	
15		BULKHEAD RECEPTACLE 1/4" DIA. 5-32	
16		BULKHEAD RECEPTACLE 1/4" DIA. 5-32	
17		NO. 100000 HIRSH, HEAVY DUTY, 1/4" DIA.	
18		4-90 RH MACH. SCR.	SST
19		TERMINAL, LERCO # 6-4069-10	
20		RESISTIVE THERMAL 25-28 250V/0.15A 300A PLATINUM 1000 1/4" DIA. 1.455" LG.	
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U.S. ATOMIC ENERGY COMMISSION
 RICHLAND OPERATIONS OFFICE
 PACIFIC NORTHWEST LABORATORY
 OPERATED BY BATTELLE MEMORIAL INSTITUTION

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 CONDUCTIVITY SENSOR
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