INSTRUCTION MANUAL
210
DETECTOR CONTROL UNIT

Serial No. ______________________________

Purchaser ______________________________

Date Issued ______________________________

ORTEC
INCORPORATED
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AN EG&G COMPANY

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A NEW STANDARD TWO-YEAR WARRANTY FOR ORTEC ELECTRONIC INSTRUMENTS

ORTEC warrants its nuclear instrument products to be free from defects in workmanship and materials, other than vacuum tubes and semiconductors, for a period of twenty-four months from date of shipment, provided that the equipment has been used in a proper manner and not subjected to abuse. Repairs or replacement, at ORTEC option, will be made without charge at the ORTEC factory. Shipping expense will be to the account of the customer except in cases of defects discovered upon initial operation. Warranties of vacuum tubes and semiconductors, as made by their manufacturers, will be extended to our customers only to the extent of the manufacturers' liability to ORTEC. Specially selected vacuum tubes or semiconductors cannot be warranted. ORTEC reserves the right to modify the design of its products without incurring responsibility for modification of previously manufactured units. Since installation conditions are beyond our control, ORTEC does not assume any risks or liabilities associated with methods of installation other than specified in the instructions, or installation results.

QUALITY CONTROL

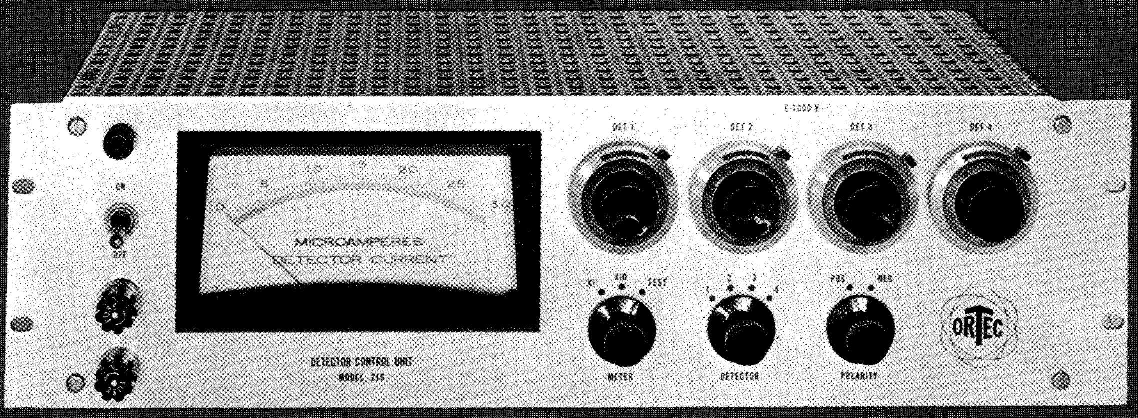
Before being approved for shipment, each ORTEC instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

REPAIR SERVICE

ORTEC instruments not in warranty may be returned to the factory for repairs or checkout at modest expense to the customer. Standard procedure requires that returned instruments pass the same quality control tests as those used for new production instruments. Please contact the factory for instructions before shipping equipment.

DAMAGE IN TRANSIT

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify ORTEC of the circumstances so that we may assist in damage claims and in providing replacement equipment if necessary.



0-1000 V
DET 1
DET 2
DET 3
DET 4
ON
OFF
MICROAMPERES
DETECTOR CURRENT
0
5
10
15
20
25
30
X1
X10
TEST
METER
1
2
3
4
DETECTOR
POS
NEG
POLARITY
ORTEC
DETECTOR CONTROL UNIT
MODEL 210

INSTRUCTION MANUAL ORTEC 210

1. DESCRIPTION

The 210 Detector Control Unit is intended to provide bias voltage of either polarity for semiconductor radiation detectors, and to measure the leakage current of these detectors. The 210 provides for simultaneous operation of four detectors, with switch selection of which detector's current is to be indicated on the leakage current meter.

2. SPECIFICATIONS

2.1 Electrical Specifications

Bias Voltage Range	0-1000 volts
Bias Selectors	10-turn, direct-readout, precision potentiometers
Bias Polarity	Positive or negative, switch selectable
Hum and Noise	Less than 0.0005% peak to peak
Line Voltage Variation	Less than ±0.005% for 105-125 volts AC input
Stability	±0.01% drift in several hours, for average laboratory environment
Bias Selector Linearity	0.25%
Detector Current Meter Ranges	3μA or 30μA, switch selectable
Meter Type	Taut-band suspension, 3μA basic movement
Meter Protection	Short-circuit-proof protector circuit
Checking Provisions	TEST position on meter indicates functioning regulator
Tube and Semiconductor Complement	3 -- OG3 (85A2) 1 -- 6GT5 2 -- 5751 7 -- 1N3195 8 -- 1N457A
Input Power	105-125 or 210-250 volts, 50 or 60 cycles, 35 watts

2.2 Mechanical Specifications

Output Connectors	SHV
Power Connector	NEMA Standard, 3-wire grounding type
Dimensions	Panel -- 5-¼ x 19 inches, standard Depth -- 7½ inches
Net Weight	15 pounds
Shipping Weight	21 pounds

3. INSTALLATION

The unit is designed for mounting in a standard 19-inch relay rack. All operating controls are on the front panel. Bias output connectors are located on the rear chassis apron. Perforated shields completely enclose the unit so that high voltage points are not exposed behind the panel.

WARNING: Do not operate the unit without the protective perforated covers, since lethal high voltages are exposed inside the instrument.

Connectors suitable for mating with the output jacks are series SHV. These are not compatible with ordinary BNC series connectors. Type RG-59/U cable is recommended. For your convenience, ORTEC makes adapter cables in standard 12 foot lengths. The C-34-12 includes an SHV connector on one end and an MHV on the other. The C-35-12 is for SHV to Kings. The C-36-12 includes two SHV connectors.

No provision is made in the unit for the necessary detector load resistor, since this resistor should be physically located in the preamplifier or at the detector itself. The internal resistance of each bias circuit is approximately 0.35 megohm, which may generally be neglected in comparison to the load resistor when computing bias drop due to detector current.

4. OPERATION

4.1 Polarity Selection

The polarity of all four bias outputs on the 210 is the same, and is chosen by turning the front panel POLARITY switch to POS or NEG.

4.2 Bias Voltage Selectors

The desired bias voltage is selected by the 10-turn precision potentiometers. The DET 1, DET 2, DET 3, and DET 4 nomenclature corresponds with the numbering on the output jacks. The dials read directly in volts, with the digit showing in the dial window prefixing the remaining two digits as read from the dial face. Note the transition region indicated by the red line in which the window digit is in process of changing to the next digit. The small black lever may be moved clockwise to lock the bias selector dial against inadvertent movement.

4.3 Meter Function Switch

The meter function switch, labeled METER, has two positions (X1 and X10) which select the 3μA or 30μA full-scale current ranges. The third position, labeled TEST, connects the meter in a simple voltmeter circuit so that the basic 1000-volt regulated power supply causes the meter to indicate at the red line at midscale. If tube or component failure has caused the supply to become unregulated, it will be so indicated. This TEST circuit is not a precision indicator, and deviations of a pointer-width or so are of no concern. An internal adjustment sets the pointer position mechanically.

Both the X10 and TEST positions of the METER switch cause the meter movement to be heavily damped, and at least 10 to 15 seconds should be allowed before noting the final pointer position. This damping, especially that of the TEST position, can be used to good purpose to protect the meter movement against physical shock when the unit is transported.

4.4 Detector Selector Switch

This control, labeled DETECTOR, serves to select the detector whose leakage current is indicated by the meter. The circuit of the other detectors is undisturbed by the selection of any one for current monitoring. Note that the METER switch must be set to either X1 or X10 before the selected detector current will be indicated.

4.5 Input Power Selector

Choice of nominal 115- or 230-volt input power is accomplished by a switch on the rear chassis apron. The escutcheon plate indicating the voltage range to which the switch is set is so arranged to allow the switch to exist only in the indicated position. To change the range, it is necessary to remove the escutcheon plate, move the switch, and replace the plate in the reversed position. The unit is normally supplied with this selector in the 115-volt position, and with the matching 1-ampere fuses. When changing to 230-volt operation, replace the fuses with 0.5-ampere fuses.

5. APPLICATION SUGGESTIONS

5.1 Transient Detector Currents

The 210, as well as the external detector bias circuit with which it is used, has filter circuits on the detector side of the detector current meter which will have normal charging and discharging transient currents. These will be evidenced by a pronounced upswing in indicated detector current when the bias voltage is increased, with a corresponding downswing when voltage is decreased. These transient currents are inherent, and it must be kept in mind that true detector current will be indicated only when the bias voltage selector is not being moved.

5.2 Undesired Leakage Currents

The detector current metering circuit will, of course, indicate currents due to any and all leakage paths beyond the meter in the circuit. Included will be any abnormal leakage in the filter components or wiring of the Detector Control Unit itself, as well as the leakage due to normal or abnormal insulation resistance paths of all cables, connectors, and components that connect the unit to the detector. Obviously, these currents must either be made vanishingly small or accounted for in the determination of actual detector current. Since the meter can easily indicate down to as low as 0.02μA, and since the voltage can be as high as 1000 volts, insulation resistances of the order of 5×10^{10} ohms are significant.

Components and other leakage paths within the unit are checked at the factory to ensure that their effect is insignificant. Should leakage currents within the unit develop with age, the most likely sources are surface leakage from the meter terminals over the meter case to the panel, and surface leakage of the output jacks. Cleaning with pure alcohol should remedy the problem.

It may not always be practical to reduce the leakage in external cables and connections to an insignificant magnitude. In such cases it may suffice to note the residual leakage current with all wiring in place except the detector itself, and to subtract this residual from the indicated current to obtain the actual detector current. If the detector phenomenon is essentially a resistance, then its value may be computed from Ohm's law for use in determining the residual current at various voltages, without the necessity of actual measurement.

5.3 Determination of Actual Detector Bias

In addition to its use as an indicator of physical condition of the detector, the detector current metering function of the Detector Control Unit serves to allow accurate determination of the actual bias voltage across the detector. This actual voltage differs from that indicated by the bias selector dials by the amount of drop in voltage across the detector load and filter resistors due to the detector current. Accurate determination of actual detector voltage is an important parameter in both the depleted (sensitive) depth of the detector and the collecting field strength.

To obtain the actual detector voltage, one must know the sum of all series resistances in the circuit between voltage source and detector. The resistance of the internal circuit of the 210 may be approximated by 350,000 ohms (0.35 megohm), a value which may be neglected in comparison to the usual values of external resistances. Detector load resistors may vary from 10 megohms to 100 megohms in ordinary applications, and may be several thousand megohms in special applications involving cooled detectors. In addition, there is usually a filter resistor of one or more megohms near and in series with the load resistor. The values of these resistors may usually be ascertained from the schematic diagram of the preamplifier used.

Once having determined the total series resistance, the loss of bias in that resistance can be calculated by Ohm's law. It is convenient to remember that each megohm drops a volt per microampere.

5.4 Guard-Ring Voltage Supply

When using detectors that require a separate bias connection to a guard ring, the 210 will prove convenient in that signal electrode bias can be taken from one bias output and guard-ring potential from another. In this way the two potentials can be varied independent of each other to determine the optimum biasing condition. The usual optimum is obtained when both are nearly the same, but a small difference is sometimes beneficial. In general, that setting which minimizes the signal electrode current will be near optimum.

5.5 Detector Considerations at High Bias Voltages

Semiconductor radiation detectors that utilize more than a few hundred volts bias generally require some care in the application of that bias to reduce the risk of damaging the detector. It is helpful to observe the noise output of the main amplifier with an oscilloscope while the bias voltage is advanced.

Small breakdown phenomena which die out within a part of a minute can be observed after a bias increase. For greatest safety, it is advisable to approach the final operating bias in small increments, with brief aging periods between increments.

6. CIRCUIT DESCRIPTION

6.1 Basic Circuit Arrangement

Figure 1 shows the basic circuit arrangement of the Detector Control Unit. The 100-volt regulated power supply is isolated from chassis ground, and the polarity switch connects the chosen polarity output with respect to chassis ground. Selection of the bias voltage is made by a simple voltage divider in which the shunt current through the divider (3.3 milliamperes) is far greater than the maximum expected load current; therefore, the actual output voltage will be accurately indicated by the 1000-division dial of the divider potentiometer. The detector current meter is connected directly in series with the output circuit to indicate the current drawn by the detector. A final filter circuit physically near the output connector minimizes possible noise induced in internal wiring.

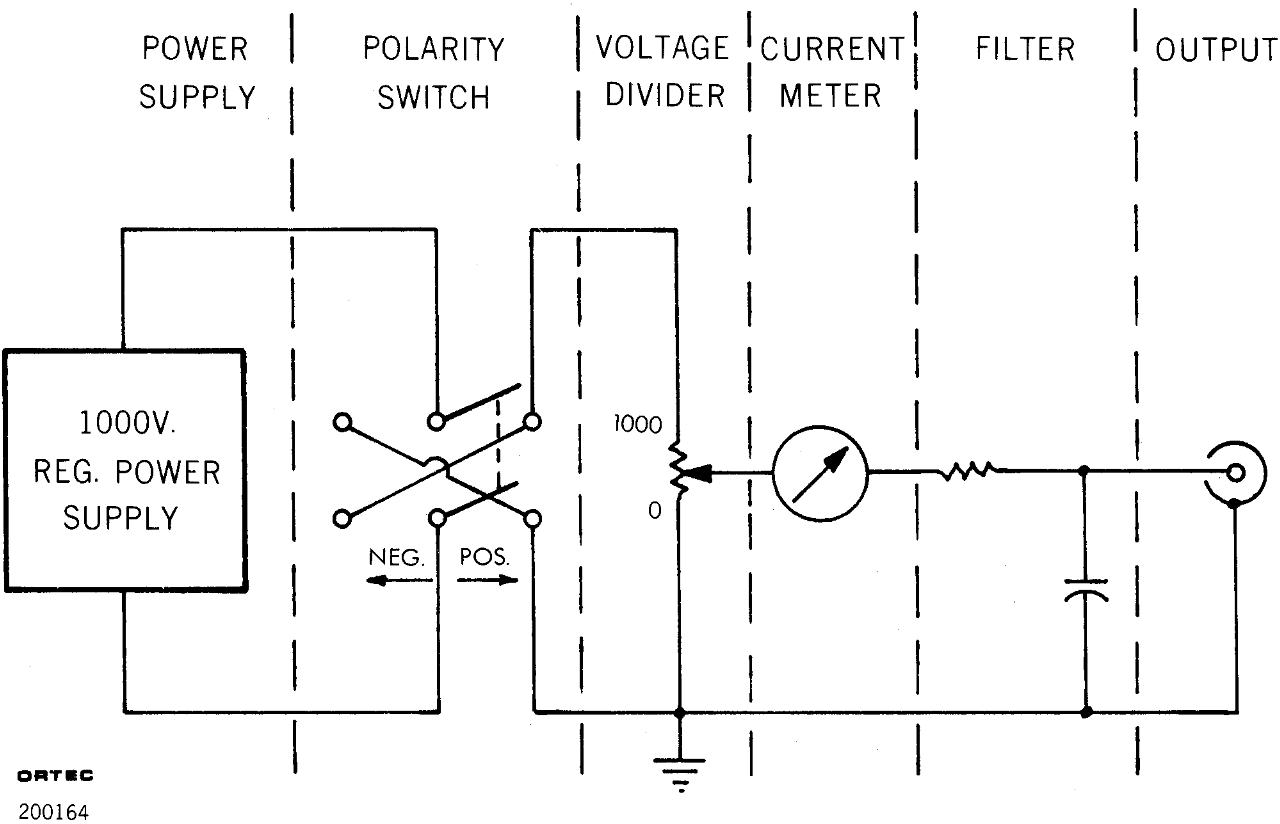


Figure 1 Basic Circuit 210

6.2 1000-Volt Regulated Power Supply

(See Schematic Diagram, Drawing 210-S1.) The regulated 1000-volt supply of the 210 is physically located in the chassis part of the instrument.

The primary windings of the power transformer are arranged for parallel connection for 115-volt nominal input, and series connection for 230-volt input.

The unregulated high voltage supply is a full-wave doubler using silicon rectifiers. The total unregulated voltage, nominally about 1300 volts, appears across filter capacitors C1 and C2. Regulator tube V1,type 6GT5, is a series pass element which is controlled to produce the required 1000-volt output.

The screen supply of the pass tube, V1, and the plate supply of amplifier tube V2 are taken from a separate power supply producing a nominal 120 volts with respect to the cathode of V1. This supply is comprised of the 90-volt transformer winding, half-wave rectifier D7, and filters R16, R17, and C3.

The reference voltage for the regulated supply is supplied by three type 85A2 gas diodes in series, V4, V5, and V6. These are operated through current setting resistors R22, R23, and R24 across the 1000-volt output. The actual reference is a nominal 255 volts negative with respect to the positive output terminal, and appears at Pin 2 of V6. This reference voltage is filtered by R14 and C11, and applied to one grid of the comparator tube, V3, type 5751, a high-mu twin triode. The other grid is supplied a sample of the 1000-volt output determined by voltage divider string R25 through R29. At proper regulation this sample is also 255 volts negative with respect to the positive output terminal. Network R15 and C4 works in conjunction with C11 to make the sensitivity of comparator tube V3 greater for hum and noise than would be provided simply by the voltage divider.

DC deviations and hum and noise of the sample with respect to the reference are amplified by V3 and appear as a differential signal between the two plates. These plates are directly connected to the grids of amplifier tube V2, also a 5751 twin triode. V2 is a cathode-coupled amplifier in which the amplified differential input signal appears at the single plate at Pin 6. This plate is directly connected to the control grid of pass tube V1. The phase of the entire reference-comparator-amplifier chain is such that the feedback to the V1 control grid degenerates all deviations from the desired reference. In this manner, the output voltage is maintained at a constant 1000 volts, in spite of line voltage variations, and hum and noise are reduced to the desired degree.

Network R13 and C12 reduces the gain of the comparator at high frequencies, and precludes oscillation within the degenerative feedback loop.

Final output filters R30-C5 and similar are for the purpose of removing extraneous noise and short rectifier transients that are induced in the internal wiring of the unit.

The regulated 1000 volts is isolated, and is connected to the panel assembly where the POLARITY switch grounds the appropriate side of the supply and delivers the voltage to the voltage dividers and other circuits.

6.3 Panel Assembly Circuit

(See Schematic Diagram, Drawing 210-S2.) Regulated 1000 volts from the chassis unit connects directly to a voltage divider metering circuit, R34, R35, and R36. The output from this divider connects to the TEST position of the METER switch. The TEST indication is made to read at the red line on the meter by adjustment of R36.

The 1000 volts then connects to the lower pair of contacts of the POLARITY switch, S2. These contacts connect the proper polarity supply terminals to ground and to the output circuits. The upper pair of contacts on the POLARITY switch serve to suitably reverse the detector current meter terminals so that the indication is always upscale, regardless of the selected output polarity.

The selected-polarity 1000 volts DC is applied to the 10-turn precision potentiometer, R41. The selected output voltage on the slider of the potentiometer passes through a pair of back-to-back silicon diodes, and then to the chassis unit to pass through the output filter to the output connector.

The detector current meter connects across the back-to-back diodes, with either R37 (100K) or R38 (10K) in series for the respective X1 and X10 current ranges. These resistances are small, compared to other series resistance in the detector circuit, and do not affect the output voltage or current. However, their values are chosen such that when the meter current approaches twice the full-scale value, the voltage drop across the resistors and meter approaches 0.6 volt. At this voltage, the silicon diodes begin to show appreciable forward conduction, and the excess current is shunted through the diodes instead of the meter. In the ranges of current that are on scale, the leakage current of the diodes is not significant, and an accurate current indication is obtained. In this manner, the meter is protected against overloads, including the possibility of short-circuit of the output. The circuit will even protect the meter against direct shorts or arcs inside the instrument where the limiting effect of the output filter resistors is not operative, but the silicon diodes may become damaged. This is satisfactory, since they are very inexpensive units.

The X10 shunt of the meter is obtained by resistors R39 and R40 which are switched across the meter when the METER switch is in X10 position. Calibration of the required shunting resistance to the individual meter movement is possible by adjustment of R39.

Four voltage divider potentiometers are provided in the 210, along with four sets of back-to-back diodes. An additional switch, labeled DETECTOR, switches the detector current metering previously described to the desired pair of diodes, so that the desired detector current is read without interruption of the other three output circuits. This is possible because the diodes will conduct in their forward mode without additional shunting circuitry at the expense of about 0.6 volt drop. This drop is negligible for the purposes of this unit.

7. ADJUSTMENTS AND CALIBRATIONS

7.1 1000-Volt Supply Voltage Adjustment

In drawing 210-S1, it is seen that there is an adjustable resistor, R29, in the voltage divider string that derives the sample of the output voltage that is to be compared to the reference. This adjustment determines the output voltage of the supply, and should be set to produce exactly 1000 volts. The R29 is a multiturn trimming potentiometer physically located by the side of the terminal strip that traverses the length of the chassis underside.

WARNING: Voltages on many circuit points inside the 210 can be lethal. Work carefully, using fully insulated tools and meter leads or clips.

A convenient point to measure the power supply output without series resistance is across the terminals of the bathtub 1μf, 1000-volt oil capacitor. Of course, a meter of trustworthy calibration should be used in setting this voltage. Using an insulated screwdriver, the trimmer potentiometer should be varied until a precise 1000-volt output is obtained. This adjustment should not be necessary unless reference tubes V4, V5, or V6 have been replaced.

7.2 X10 Shunt Adjustment

The X10 shunt for the meter circuit is adjustable by another trimming potentiometer, R39, which is physically located on the terminals of the METER switch. If readjustment is needed, the following procedure applies. Start with the METER switch in the X1 position.

The meter should be adjusted for proper mechanical zero with the power turned off and the instrument in a horizontal position. Then, an external resistance of approximately 50 megohms should be connected to one of the output connectors. With the meter indicating the chosen output position, advance the corresponding bias selector to approximately 50 volts, and set it to whatever value is required to produce exactly 1 microampere of current on the meter. Record the exact value of voltage indicated by the bias selector dial. Now, leaving the same load resistor in place, switch to the X10 position and advance the bias selector to exactly 10 times the recorded value. In this way, exactly 10 times the previous current, or exactly 10 microamperes, is flowing through the meter circuit. Now, adjust the shunt adjustment, R39, until the meter pointer indicates exactly 1 microampere on the meter face.

7.3 TEST Indicator Adjustment

The TEST position of the METER switch is intended as a rough check to see if the power supply is functioning properly. It is a simple voltmeter circuit in which meter indication at the midscale red line corresponds to 1000-volt supply output. Since most failures of the electronic regulator circuit produce drastically higher or lower output, the TEST circuit is a valuable indicator of proper regulation.

Adjustable resistor R36 controls the TEST position meter reading. This resistor is a multiturn trimming potentiometer located on the terminals of the POLARITY switch. When the power supply has been reliably set to 1000-volts output, as described in Section 7.1, R36 should be adjusted to produce indication at the red line when the instrument is in the usual horizontal position.

8. MAINTENANCE

8.1 Troubleshooting Suggestions

In the event of circuit malfunction, the following sequence is suggested:

8.1.1 Using an isolated test meter, verify that the usual unregulated high voltage of about 1300 volts is present across capacitors C1 and C2 in series.

8.1.2 Verify that the separate screen and V2 plate supply of about 120 volts positive with respect to the cathode of V1 is present.

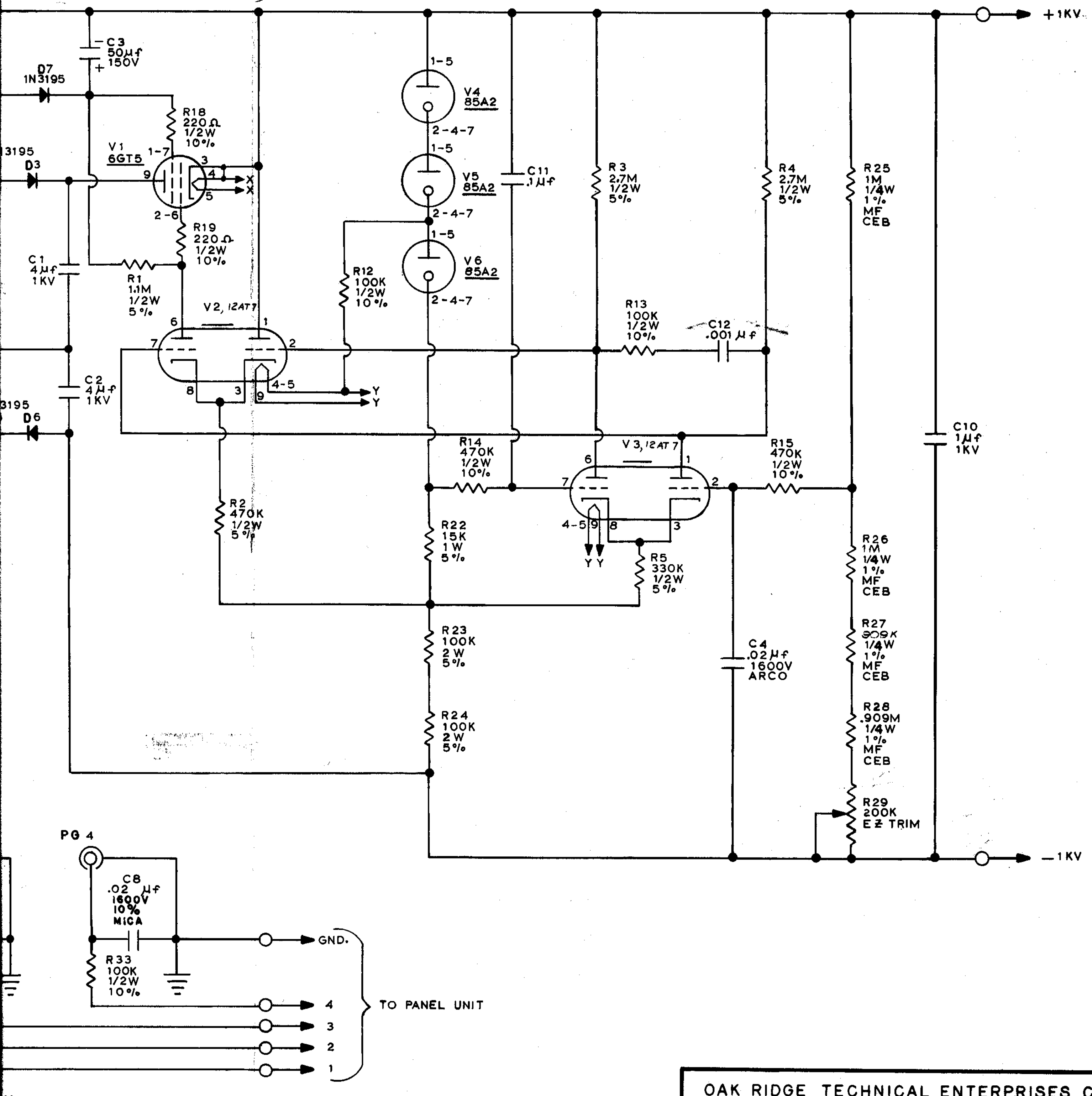
8.1.3 Check the reference tubes visually, to see that all three are burning. Check the reference voltage from the positive output terminal to Pin 2 of V6 for nominal 255 volts.

8.1.4 Using a very high resistance meter, check the sampled voltage at Pin 2 of V3. Deviation from about 255 volts with respect to positive terminal indicates the direction of error. The comparator and amplifier may then be checked in sequence, to determine at what point the degenerative feedback loop is open.

BIN/MODULE CONNECTOR PIN ASSIGNMENTS
FOR AEC STANDARD NUCLEAR INSTRUMENT MODULES
PER TID-20893

Pin	Function	Pin	Function
1	+3 volts	23	Reserved
2	- 3 volts	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 volts
7	Coaxial	*29	- 24 volts
8	200 volts dc	30	Spare Bus
9	Spare	31	Carry No. 2
*10	+6 volts	32	Spare
*11	- 6 volts	*33	115 volts ac (Hot)
12	Reserved Bus	*34	Power Return Ground
13	Carry No. 1	35	Reset
14	Spare	36	Gate
15	Reserved	37	Spare
*16	+12 volts	38	Coaxial
*17	- 12 volts	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	115 volts ac (Neut.)
20	Spare	*42	High Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

**These pins are installed and wired in parallel in the ORTEC 401A Modular System Bin.*



DATE	NO	REVISION	BY
9-12-69	E	ECN 210-11	PR
9-7-66	D	ECN 210-6	
5-23-66	C	ECN 210-5	
3-11-66	B	ECN 210-2	JDW
9-15-65	A	R29 changed from 100K to 200K	JKM

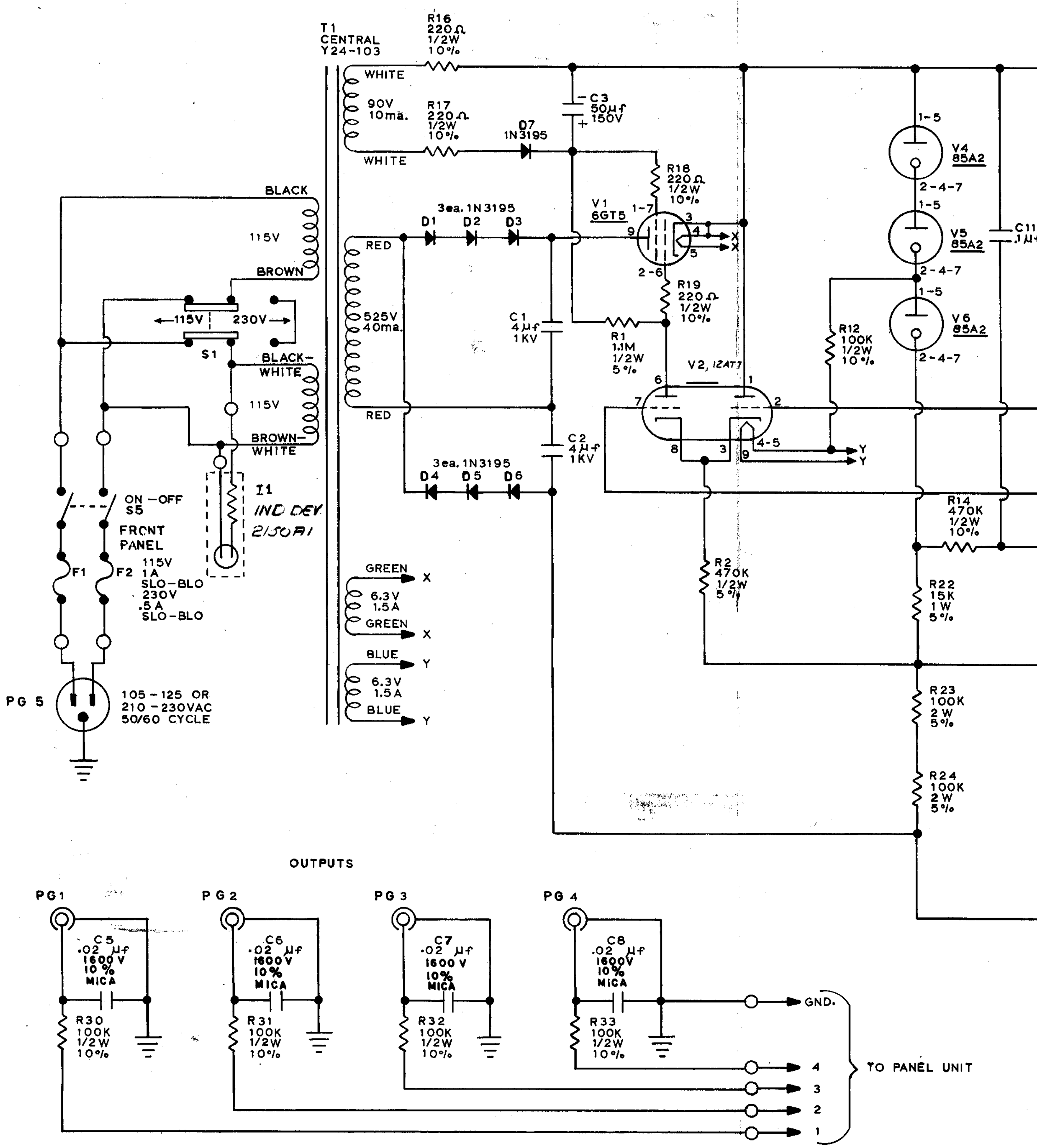
OAK RIDGE TECHNICAL ENTERPRISES CORP
OAK RIDGE, TENN.

SCALE:	DESIGNED BY: R.H. DILWORTH	DRAWN BY: A.A.S.
DATE 2-5-64	RESP. ENGR: R.H. DILWORTH	

SCHEMATIC – CHASSIS UNIT

JOB: MODEL 210 OR 211 DETECTOR CONTROL UNIT

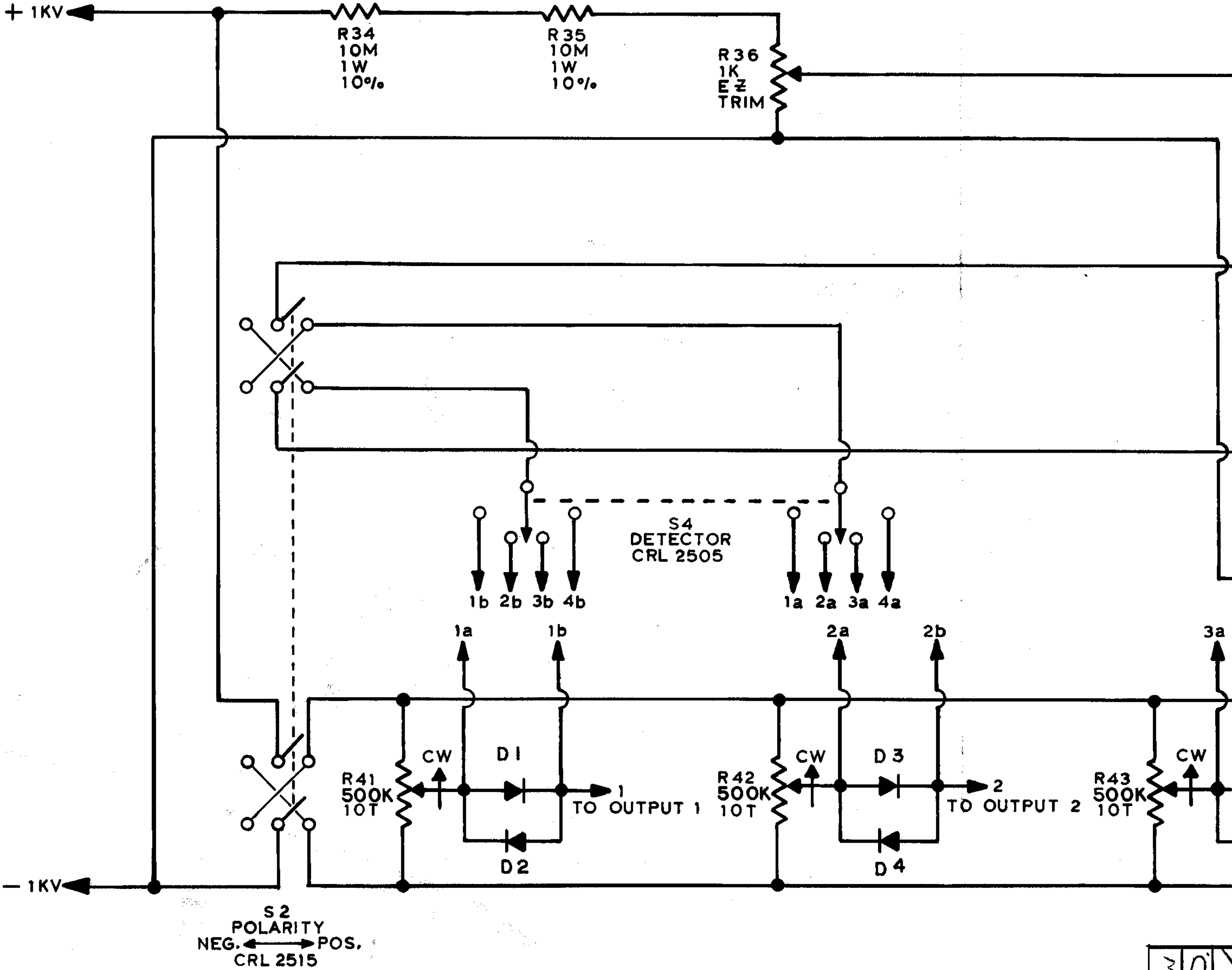
DRAWING NUMBER: 210-S1



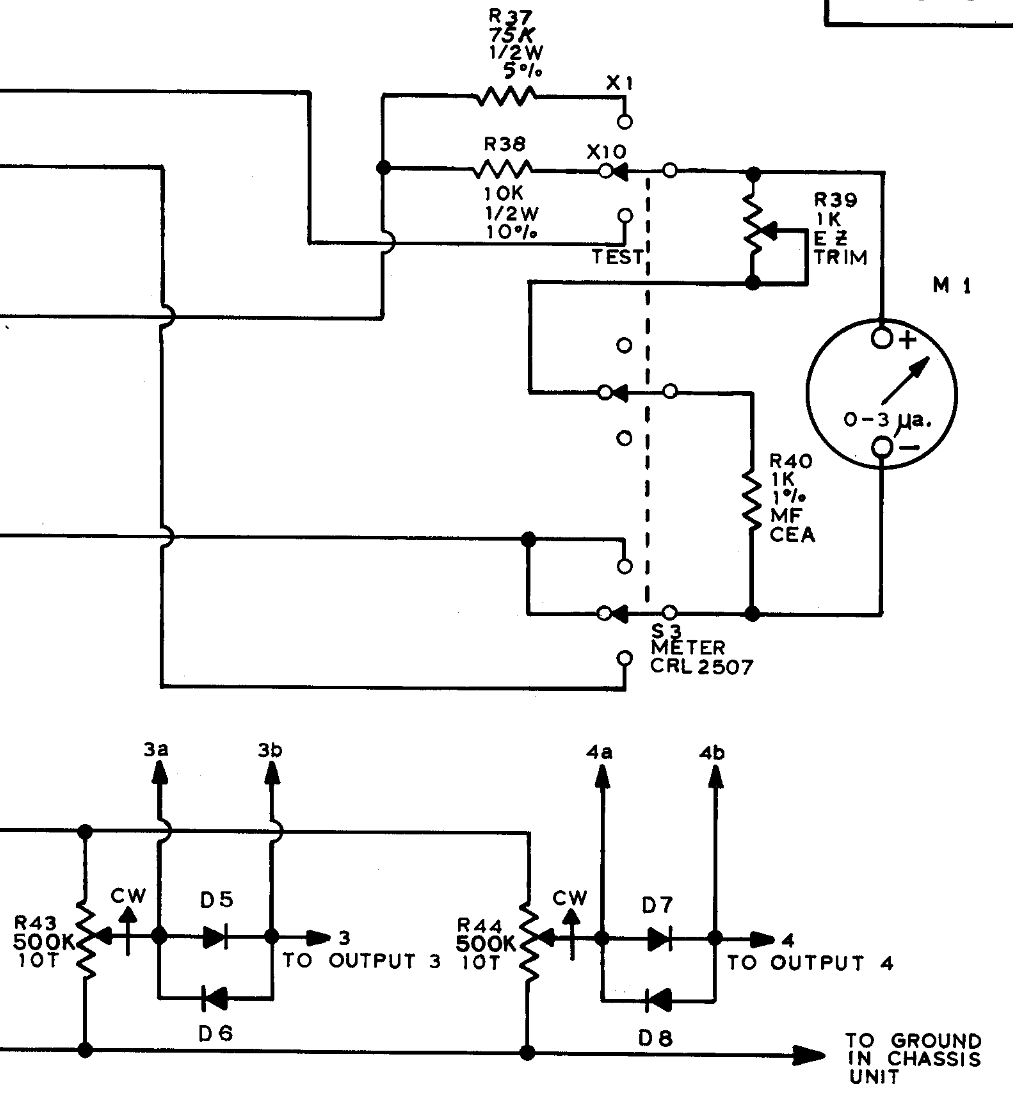
OUTPUTS 2,3 & 4 OMITTED ON MODEL 211

NOTES: 1. ○ = WIRING TO FRONT PANEL

9-12-69	E	ECN 210-11
9-7-66	D	ECN 210-6
5-23-66	C	ECN 210-5
3-11-66	B	ECN 210-2
9-15-65	A	R29 Changed from 100K
DATE	NO	REVISION



NOTE: ALL DIODES ARE 1N457A INSIDE SHRINKABLE BLACK TUBING.



D.N.	D.		BY
210-S2	210-9	ECN 210-3	REV
12-31-69	12 7-66	3-66	DATE

OAK RIDGE TECHNICAL ENTERPRISES CORP.
OAK RIDGE, TENN.

SCALE:	DESIGNED BY: R. H. DILWORTH	DRAWN BY:
DATE: 2-8-64	RESP. ENGR: R. H. DILWORTH	A. A. S.

SCHEMATIC - PANEL UNIT

JOB	DRAWING NUMBER
MODEL 210 DETECTOR CONTROL UNIT	210-S2