730

4500 SERIES

DIGITAL MULTIMETER

350 ACCESSORY MODULE

DANA™

Dana Laboratories Incorporated

Irvine, California 92664

Telephone (714) 833-1234

Teletype 910-595-1136

980415

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Warranty

Within one year of purchase, Dana Laboratories will repair or replace, at our option, your instrument if in any way it is defective in material or workmanship. All parts and labor charges will be paid by Dana Laboratories. Just return the instrument to your nearest authorized Dana Service Center freight prepaid. We will return it to you freight prepaid.

DANA

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SECTION 1

INTRODUCTION

1.1 INTRODUCTION

1.2 This manual describes the Dana Series 4500 Digital Multimeters (DMM). The basic models are the 4530 and the 4570 which differ only in their mechanical packaging. Model 4530 (see figure 1.1) is a thin-line instrument (3 ½ inches high) designed for standard rack mounting while Model 4570 is primarily a bench type instrument. Descriptions in this manual apply to all models unless otherwise indicated.

1.3 MECHANICAL DESCRIPTION

1.4 Each instrument consists of three modules. The Digitizing and Display Module, comprising the left-hand portion of Model 4530 and the upper half of Model 4570 contains the actual measurement circuits and is the same in all instruments in the series. The Signal Conditioning Module, comprising the right-hand side of Model 4530 and the lower half of Model 4570 contains circuits that provide a ten-volt full-scale (plus overrange) analog voltage for measurement by the Digitizing and Display Module. The Power Supply Module, located at the rear of the instrument, provides all the DC voltages needed by the machine and serves as an interconnection board for all other modules. The BCD Output Module (optional) plugs into the rear of the instrument and provides 1-2-4-8 coded BCD for use in data systems.

1.5 This Manual covers Accessory Module 350 which provides measurement of DC voltages on full scale ranges of .1 volt to 1000 volts. AC voltage on full scale ranges of 1 volt to 1000 volts, and ohms on full scale range of 1 Kilohm to 10 Megohm are available as options. The combination of modules produce two DMM models designated as 4530-350 and 4570-350.

1.6 The Digitizing and Display circuits are on a single printed circuit board. The signal conditioning unit consists of an isolator board and an optional ohms-AC Converter board. Circuits consist of integrated circuits except for critical analog circuitry where discrete components are used.

1.7 The output is displayed on a four-digit visual display with a fifth overrange digit that extends full-scale of each range by 20% (9999 to 12000). Automatic ranging is performed by

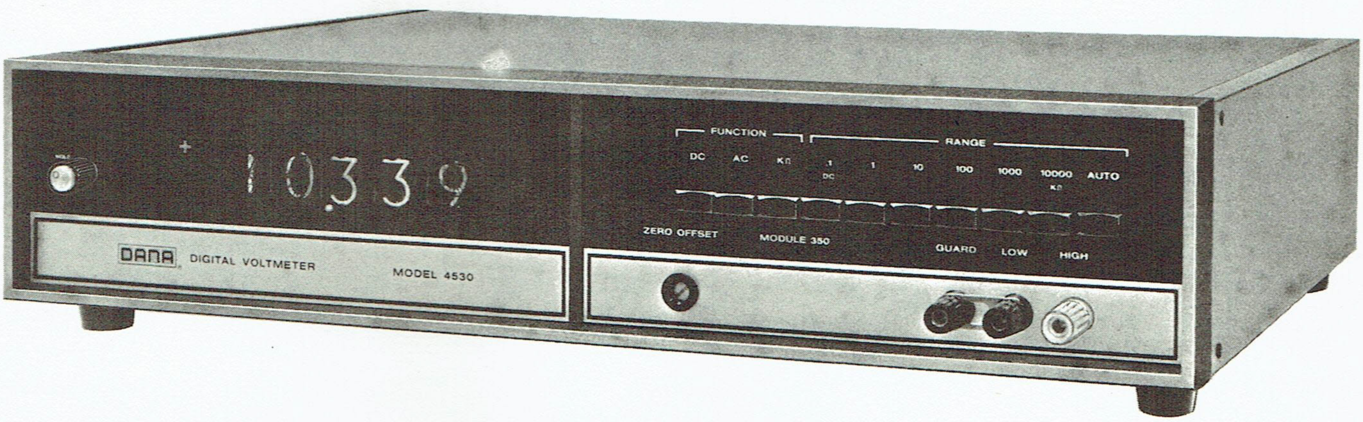


Figure 1.1 - Series 4500 Digital Multimeter

internal circuits that determine that optimum range and switch to that range automatically.

1.8 ELECTRICAL DESCRIPTION

1.9 A block diagram of the DMM is shown in figure 1.2. For DC measurements, the input is applied to a voltage divider at the input that divides the input voltage by 1 or by 100 depending on the range selected. The scaled input is filtered and applied to the Isolator amplifier which delivers 10 volts full scale (12 volts, with overrange) to the Digitizing and Display module. The gain of the amplifier is either 1, 10, or 100 depending on the range.

1.10 For AC measurements, the AC Converter scales the input and rectifies it. The converter output is applied to the voltage divider (set to divide by one), filtered, then applied to the isolator amplifier, set to a gain of 10.

1.11 For Ohms measurement, the Ohms Converter monitors the output of the isolator to provide a constant current to the input terminals. The amount of current is dependent on the range selected. The DMM measures the voltage drop across the unknown resistance connected between the input terminals. The input voltage is applied to the voltage divider (set to divide by one) and then applied to the isolator amplifier, set to a gain of 10. (A detailed analysis of the Signal Conditioning Module is given in Section 4A).

1.12 The Digitizing and Display module measures the analog voltage from the Accessory Module by the high-accuracy dual-slope integration technique. The amplitude of the signal is measured by comparing it to a highly stable internal reference voltage. The DMM readout displays the position of a counter that measures the time required for the ramp voltage to ramp from the level of the input signal to zero. The value displayed is equal to the voltage level of the input. A new reading is taken every 150 milliseconds with the OFF-ON-HOLD switch in the ON position. The HOLD position permits the instrument to remain at the last reading indefinitely. Reading accuracy of the DMM is maintained through the use of a highly stable, zener-regulated, internal reference voltage. (A detailed analysis of the operation of the Digitizing and Display Module is given in section 4B.)

1.13 SPECIFICATIONS

1.14 Specifications are listed in table 1.1.

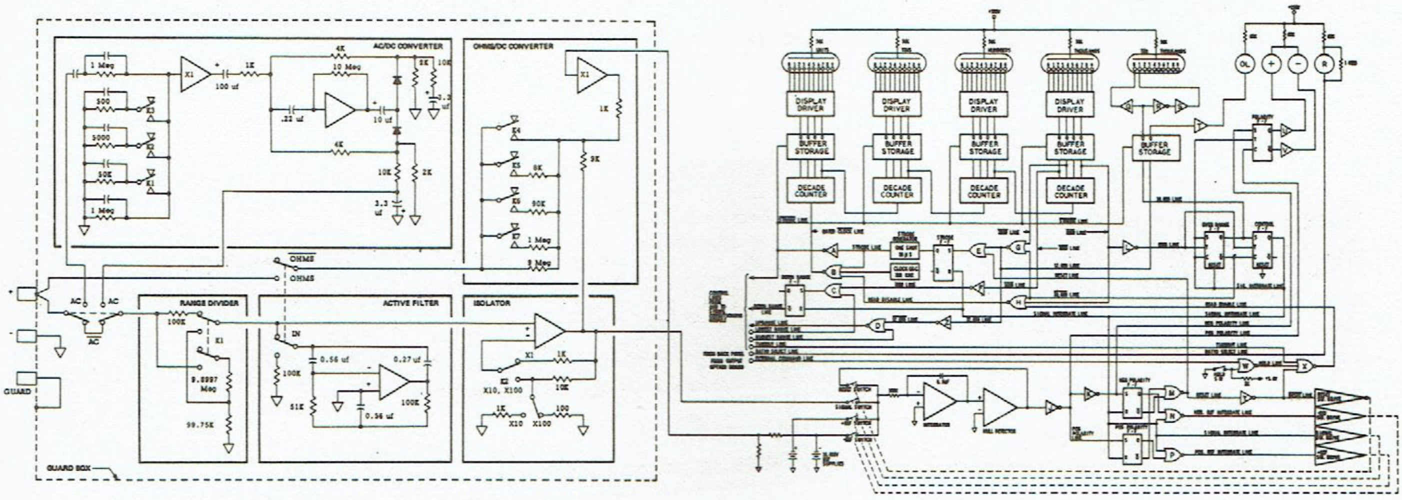


Figure 1.2 - 4500 DMM Simplified Schematic

Table 1.1 - Specifications

All specifications are for 90 days following calibration referred to calibration standard.

DC (4500/350)

Full Scale Ranges: ± .11999, ± 1.1999, ± 11.999, ± 119.99, and 1199.9V
Resolution: 10 μV
Ranging: Automatic or Manual
Accuracy: 90 days, ± 1°C ± 0.01% of reading ± 0.01% of full scale
Temperature Coefficient: 0° to 50°C ± 0.001% of reading ± 0.001% of full scale per °C
Input Impedance:

.1 and 1V Ranges	1000 Megohm minimum
10 V Range	10,000 Megohm minimum
100 and 1000V Ranges	10 Megohm

Normal Mode Noise Rejection: at 60 Hz—100 dB
60 Hz to 100 kHz—60 dB at 59 Hz increasing at 18 dB per octave plus an additional 40 dB at each multiple of 20 Hz
Common Mode Noise Rejection: Up to 1000 ohms in either lead DC to 61 Hz
Settling Time to 0.01% of final value: 650 ms
Maximum Voltage Rating: (Any Range) 1000 volts

DC/DC RATIO (With Option 04)

Full Scale Ranges: + .01199:1, + .11999:1, + 1.1999:1, +11.999:1, and + 119.99:1
Ranging: Automatic or Manual
Accuracy: 90 days, ± 1°C ± 0.03% of reading ± 0.01% (10V/reference) of full scale

		Input Signal (Numerator)	Reference Signal (Denominator)
Voltage Range:		0 to +1000V	0 to +12V
Input Resistance:	.01:1 and .1:1 Ranges	1000 Megohm	10 Kilohm
	1:1 Range	10,000 Megohm	10 Kilohm
	10:1 and 100:1 Ranges	10 Megohm	10 Kilohm

Normal Mode Noise Rejection, Common Mode Noise Rejection, and Settling Time: Same as DC specifications

AC (With Option 01 or Option 03)

Full Scale Ranges: 1.1999, 11.999, 119.99, and 1199.9V rms
Resolution: 100 μV
Ranging: Automatic or Manual
Accuracy: 90 days, ± 1°C
50 Hz to 100 Hz ± 0.25% of reading ± 0.10% of full scale
100 Hz to 5 kHz ± 0.10% of reading ± 0.02% of full scale
5 kHz to 20 kHz ± 0.50% of reading ± 0.05% of full scale
20 kHz to 100 kHz ± 2.00% of reading ± 0.10% of full scale

Table 1.1 - Specifications (Continued)

AC (With Option 01 or Option 03) Continued	*Temperature Coefficient:* 0° to 50°C 50 Hz to 5 kHz ± 0.003% of reading ± 0.002% of full scale per °C 5 kHz to 20 kHz ± 0.005% of reading ± 0.002% of full scale per °C 20 kHz to 100 kHz ± 0.02% of reading ± 0.005% of full scale per °C *Input Resistance:* 1 Megohm *Common Mode Noise Rejection:* Up to 1000 ohms in either lead DC to 61 Hz *Settling Time to 0.1% of final value:* 2 seconds *Shunt Capacitance:* With front input only 150 pF maximum With parallel rear input, 300 pF maximum *Maximum Voltage Rating:* 500 volts rms, 50 Hz to 10 kHz, decreasing linearly to 100 V rms at 100 kHz
KILOHMS (With Option 02 or Option 03)	*Full Scale Ranges:* 1.1999, 11.999, 119.99, 1199.9 and 11999 Kilohms *Resolution:* 100 Milliohms *Ranging:* Automatic or Manual *Accuracy:* 90 days, ± 1°C 1, 10, 100 Kilohm Ranges ± 0.02% of reading ± 0.01% of full scale 1000 Kilohm Range ± 0.04% of reading ± 0.01% of full scale 10,000 Kilohm Range ± 0.14% of reading ± 0.01% of full scale *Temperature Coefficient:* 0° to 50°C 1, 10, 100 Kilohm Ranges ± 0.002% of reading ± 0.001% of full scale per °C 1000 Kilohm Ranges ± 0.005% of reading ± 0.001% of full scale per °C 10,000 Kilohm Range ± 0.02% of reading ± 0.001% of full scale per °C *Normal Mode Noise Rejection:* At 60 Hz — 40 dB minimum *Settling Time to 0.01% of final value:* 1, 10 and 100 Kilohm Ranges — .5 Sec. 1000 Kilohm Ranges — 1.5 Sec. 10,000 Kilohm Range — 3.0 Sec. *Current Through Unknown:* 1 Kilohm Range — 1 milliampere 10 Kilohm Range — 100 microamperes 100 Kilohm Range — 10 microamperes 1000 Kilohm Range — 1 microamperes 10,000 Kilohm Range — .1 microampere *Fault Voltage:* 1 Kilohm Range — 30 Volts peak 10 Kilohm Range — 100 Volts peak 100, 1000, and 10,000 Kilohm Range — 300 Volts peak

Table 1.1 - Specifications
(Continued)

GENERAL	*Digitizing Time:* 150 ms *Maximum Common Voltage:* 250 V *Maximum Power Requirement:* 25 watts *Operating Temperature:* 0^{o} to $50^{o}C$ *Warm Up:* ½ Hour *Dimensions:* Model 4530, 17 x 3½ x 14 inches Model 4570, 8½ x 7 x 14 inches *Weight:* 15 pounds (approx.) net, 20 pounds (approx.) shipping *Guarantee:* 12 months, faulty workmanship or component failure

SECTION 2

INSTALLATION

2.1 UNPACKING AND INSPECTION

2.2 The 4500 series DMM is sandwiched between two forms of plastic foam and packed in a double-walled cardboard carton for shipment. The plastic forms hold the DMM securely in the carton and absorb any reasonable external shock normally encountered in transit. Prior to unpacking, examine the exterior of the shipping carton for any signs of damage. Carefully remove the DMM from the carton and inspect the exterior of the instrument for any signs of damage. If damage is found, notify the carrier immediately.

2.3 The 4500 series DMM, as shipped, is designed for bench-top operation. A standup bracket is provided under the case to aid in reading the visual display. The Model 4530 instrument can be adapted for rack installation with two flange mounting holes located in each of the two side panels. The rack-mounting kit (Dana 402588) is attached to the instrument by removing and discarding the four set screws occupying the mounting screw holes and securing the two rack mounting flanges to the side panels of the instrument with the four screws contained in the rack mounting kit.

2.4 The Model 4570 can be ordered from the factory as a half-rack instrument or the standard instrument can be returned to the factory for modification to accommodate the half-rack mounting hardware.

2.5 POWER CONNECTIONS

2.6 A standard eight-foot, three-wire, power cable is supplied with the instrument. This cord connects to a three-pin power connector at the rear of the unit.

2.7 INPUT CONNECTIONS

2.8 Signal input binding posts are located on the front of the accessory module. Connections to these terminals are made with standard "banana" plugs. Instruments designated by a "dash 1" (-1) following the model number are equipped with a duplicate set of input binding posts on the rear panel of the instrument.

2.9 INITIAL CHECKOUT PROCEDURES

2.10 The following procedure is performed to verify that no damage has occurred during shipment and that the instrument is operative. Slight deviations in readings during the following tests may be corrected by making simple adjustments. For instructions refer to Section 5, "Calibration". Any major discrepancies should be reported to the carrier and to Dana Laboratories immediately.

2.11 Prior to performing the checkout procedure, it is advisable to refer to the operating instructions beginning with paragraph 3.2. Allow one-half hour for instrument to warm up before proceeding.

2.12 ZERO CHECK

(a) Select DC and auto range.

(b) Short input leads. Visual readout should display .00000.

(c) If necessary, adjust ZERO OFFSET control on front panel to obtain this reading.

2.13 POLARITY GAIN CHECK

(a) Select DC and 10 range.

(b) Apply a known voltage of approximately -10 volts to the input. Visual readout should display value of input voltage (within specified tolerance) and proper polarity.

2.14 RANGE CHECK

(a) Select DC and 100 range.

(b) Connect input to a source of +100 volts.

(c) Visual readout should display input value (within specified tolerance) and proper polarity.

(d) Vary input voltage and polarity; check for proper readout.

(e) Repeat the above four steps on 1000-volt range.

(f) Select Auto range and repeat the above checks.

2.15 AC CHECK (optional)

(a) Select AC and connect signal generator to input. Set generator to 50 Hz.

(b) Check for proper readout (within specified tolerance) with each of the following input voltages applied: 9 volts, 90 volts and 125 volts.

2.16 KILOHMS CHECK (optional)

(a) Select Kilohms.

(b) Check for proper readout (within specified tolerance) with each of the following resistances connected across the DMM input: 1K, 10K, 100K, 1 Meg, and 10 Megohm.

NOTES

1) If the DMM has been stored for a prolonged period (5 or 6 months), without use, it is recommended that it be operated with a variable transformer, such as a Variac, at one-half line voltage for about two hours before gradually applying full power. This is done to "reform" the electrolytic capacitors in the amplifier and reduce the chance of capacitor failure.

2) To clean the glass on the readout panel, use a commercial glass cleaner such as Windex. Do not use alcohol or other cleaners containing ketones.

SECTION 3
OPERATION

3.1 CONTROLS

3.2 OFF-ON-HOLD SWITCH. This dual-purpose switch applies power to the instrument and allows the selection of HOLD.

(a) OFF - all power is removed from the instrument.

(b) ON - the instrument is operating and taking readings at 6.6 per second.

(c) HOLD - "freezes" the last reading of the instrument until it is switched back to the ON position.

3.3 All controls on the Model 350 Module, with the exception of the screwdriver-adjusted ZERO control, are pushbutton switches, located on the front panel. If the instrument is not equipped for optional functions (AC or Kilohms), the switches corresponding are disabled.

3.4 AC SELECT. This switch selects the measurement of AC voltages from 50 to 100 kHz on the 1, 10, 100 and 1000 volt range.

3.5 KILOHMS SELECT. This switch selects the measurement of resistance with full scale ranges of 1K, 10K, 100K, 1 Meg and 10 Megohms.

3.6 DC SELECT. This switch selects DC measurements with full scale ranges from .1 volt to 1000 volts. The three function select switches are interlocked to allow the selection of only one function at a time.

3.7 RANGE CONTROL. The range control consists of six interlocking pushbutton switches: .1, 1, 10, 100, 1000 and AUTO.

(a) Manual ranges. Ranges are selected by depressing the appropriate switch. The switches are interlocked so that as one range switch is depressed, the previously selected range switch is returned to the open position.

(b) Auto range. This mode allows the DMM to select the range that provides the highest accuracy for the signal being measured. This switch is interlocked with the five range switches.

3.8 ZERO ADJUST. To zero the DMM, short the two input leads together, select DC and auto-range. Adjust the ZERO OFFSET potentiometer for a DMM readout display of .00000.

3.9 OPERATION

3.10 GENERAL. The instrument has been designed for the simplest possible level of operation. Once the instrument has been connected to the power line and to the signal source in accordance with the instructions, the operator can make all the required measurements by setting the front panel controls to the indicated positions.

CAUTION: Voltage applied between guard and the low-input terminal must not exceed 250 volts. Voltage applied between guard and the instrument case (Power line ground) must not exceed 500V. Voltage applied between the low-input terminal and the instrument case must not exceed 500V.

3.11 DC MEASUREMENTS. Attach the high side of the signal source to the white signal input terminal, the low side to the black signal input terminal. Normally the guard terminal is jumpered to the black signal input terminal.

3.12 AC MEASUREMENTS. (optional). Attach the high side of the signal source to the white signal input terminal, the low side to the black input terminal. Normally, the guard terminal is jumpered to the black signal input terminal.

3.13 OHMS MEASUREMENT (optional). Connect the resistance to be measured between the white and black signal input terminals. Normally the guard terminal is jumpered to the black signal input terminal.

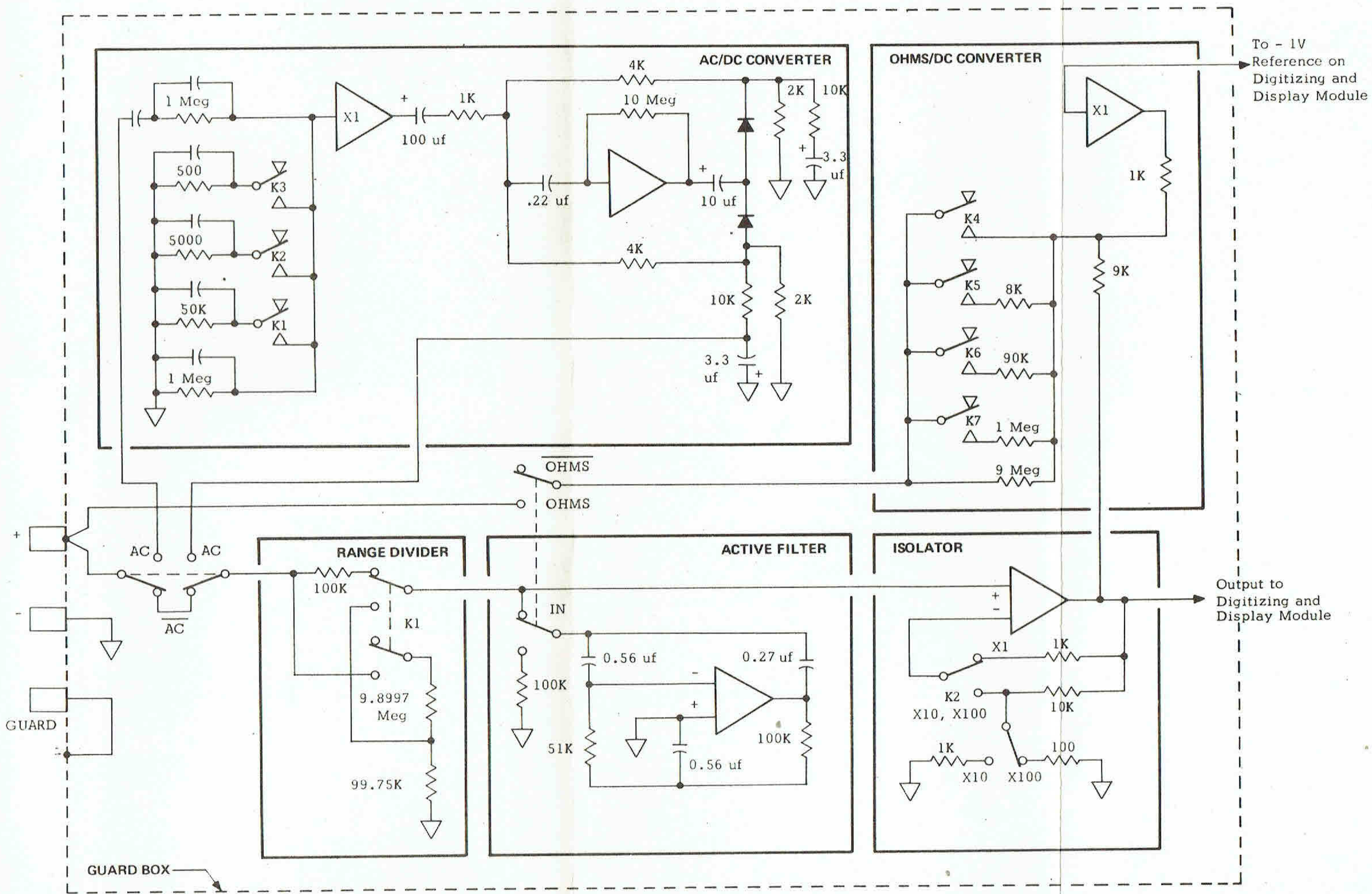


Figure 4A.1 **Signal Conditioning Module, Simplified Schematic.**

SECTION 4A

THEORY OF OPERATION OF THE SIGNAL CONDITIONING MODULE

4A.1 INTRODUCTION

4A.2 The Signal Conditioning Module provides a 10-volt full-scale (12 volts with overrange) analog signal for measurement by the Digitizing and Display Module. The Isolator, range logic circuits and active filter are located on the main board. The AC and Ohms Converters are located on an optional second board which is mounted directly above the isolator board in the module. The output signal from the module may be either a positive or negative voltage when the unit is operating in the DC volts function. Polarity sensing is done in the Digitizing and Display Module. Section 4A assumes the unit to be fully equipped with both AC and Ohms options. For instruments not fully equipped, disregard the appropriate section(s).

4A.3 INPUT CIRCUITRY

4A.4 As an input signal enters the DMM it first encounters the pushbutton switches which select the function. If the DMM is set to the AC VOLTS function, (AC Pushbutton depressed) the input signal is routed directly to the AC/DC converter. If the DMM is not in the AC VOLTS function,

> NOTE
>
> The partial schematics used in Section 4 are intended to describe operating principles only. Reference designators in these schematics may differ from the complete schematics included in Section 6.

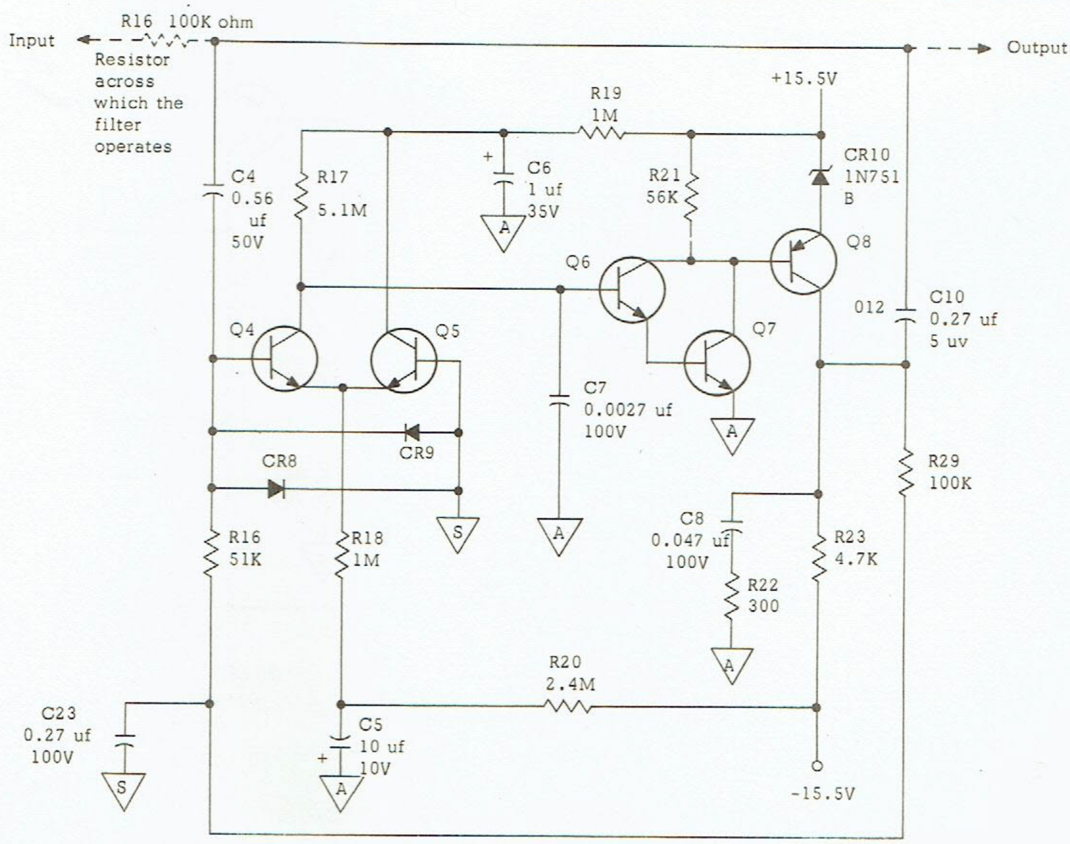


Figure 4A.1 - Active Filter

(AC Pushbutton not depressed) the signal is routed to the RANGE DIVIDER. The Range Divider is a single 100:1 voltage divider consisting of a 9.8997 megohm and a 99.75K ohm precision resistor. It is switched into the circuit only in the DC VOLTS function and then only on the 100 and 1000 volts ranges. A full scale output of 10 volts from the Isolator is achieved for all ranges by changing the gain of the Isolator amplifier and/or switching in the Range Divider. The input circuitry and Range Divider are shown in figure 4A.1.

4A.5 ACTIVE FILTER

4A.6 The filter (figure 4A.2) is a three-pole RC active filter used in both AC and DC measurements. The circuit, a modified gaussian filter, provides a normal mode noise rejection of 60 dB at 60 Hz increasing 18 dB per octave to 80 dB.

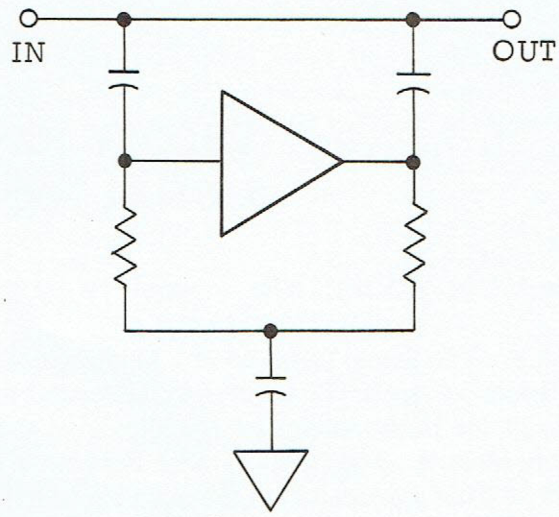


Figure 4A.2 - Active Filter Block Diagram

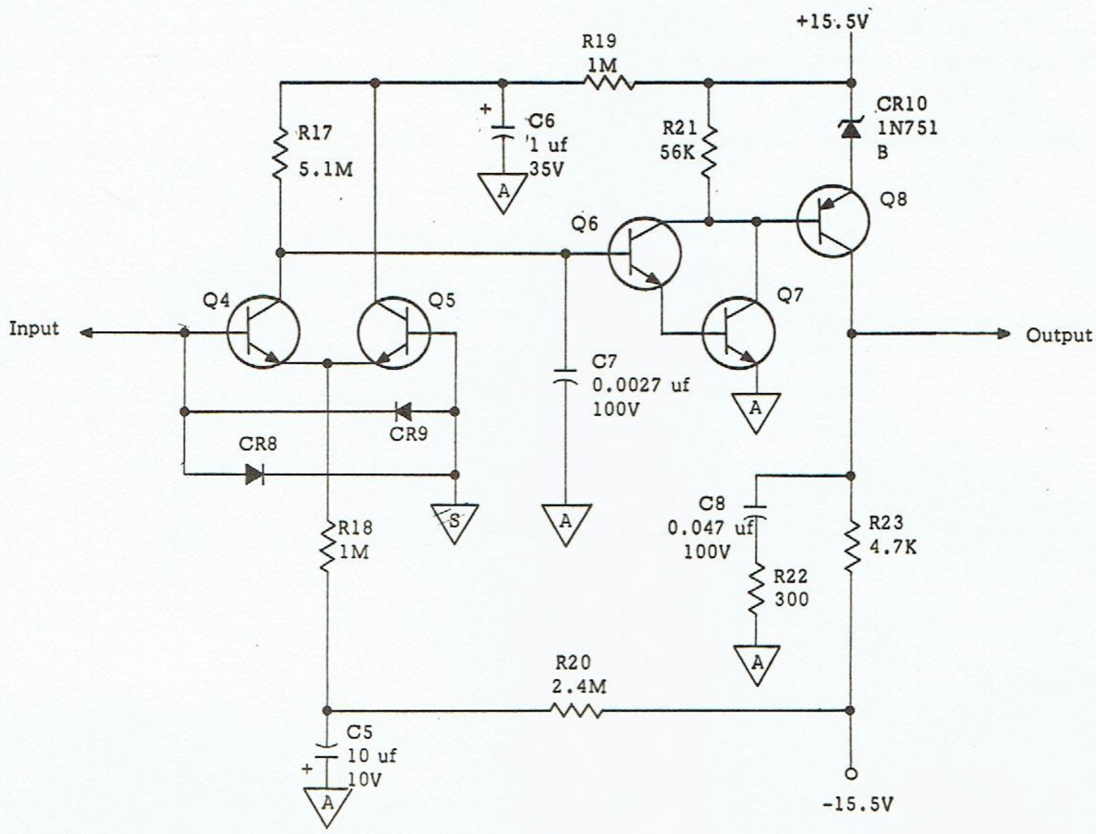


Figure 4A.3 - Active Filter DC Amplifier

4A.7 FILTER OPERATIONAL AMPLIFIER

4A.8 The active element at the heart of the active filter is a DC amplifier. The feedback network around this DC amplifier is so connected that the circuit forms an operational amplifier with resistors R16 and R29 and capacitor C23 forming the feedback path. Capacitor C4 acts as the summing resistor (reactance).

4A.9 The DC amplifier (figure 4A.3) is a differential input amplifier having a single-ended output. The amplifier is connected between positive and negative voltage supplies, enabling its output to swing both positive and negative from zero. The first stage of the amplifier is a long-tailed pair composed of transistors Q4 and Q5. Only a single-ended output is taken from the input pair. This is taken from the collector of transistor Q4 which is the only one of the two input transistors provided with a collector load resistor. The second stage of the amplifier consists of the Darlington—connected pair of transistors Q6 and Q7. Resistor R21 provides the collector load for this stage. The output stage of the amplifier is composed of transistor Q8 with resistor R23 as its collector load. Zener diode CR10 in the emitter circuit of Q8 biases the emitter of Q8 5 volts away from the positive power supply yet provides a low dynamic impedance to AC signals. Diodes CR8 and CR9 across the bases of the input stage clamp the input voltage and never allow it to exceed $\pm$ 0.6V.

4A.10 ISOLATOR

4A.11 The Isolator is a floating input potentiometric amplifier capable of operating at very low signal levels. Its output is a 10-volt full scale analog voltage (12 volts in overrange) that is applied to the Digitizing and Display module for measurement. The amplifier operates at a gain of one, ten, or a gain of one hundred, depending on the range and function to which the DMM is set (see table 4.1). The gain is switched by relays K2 and K3 that control a resistive divider into the feedback circuit when energized.

4A.12 A close examination of the isolator circuitry (figure 4A.4) reveals that it actually consists of two completely separate amplifiers, one that actually processes the signal and one that serves only to bootstrap the power supply feeding the front stages of the main amplifier. This is shown more clearly in figure 4A.5. The output stage, shown in its entirety in figure 4A.5, is a conventional complementary - symmetry type circuit which operates between the regular positive and negative supplies. The output stage is driven by transistor Q23, which also operates off the main plus and minus voltage sources.

4A.13 Refer to figure 4A.4. Transistors Q15 and Q16 form positive and negative current generators which operate off the main positive and negative supply lines. Such current generators exhibit a

Range	Logic	F/S Isolator Input	Isolator Gain	Relay Position		
				K1	K2	K3
0.1	$\overline{R1}$ $\overline{R2}$ $\overline{R3}$	.1V	100	Open	Open	Open
1	R1 $\overline{R2}$ $\overline{R3}$	1V	10	Open	Open	Closed
10	$\overline{R1}$ R2 $\overline{R3}$	10V	1	Open	Closed	Closed
100	R1 R2 $\overline{R3}$	1V	10	Closed	Open	Closed
1000	$\overline{R1}$ $\overline{R2}$ R3	10V	1	Closed	Closed	Closed
10000	R1 $\overline{R2}$ R3	1V	10	Closed	Open	Closed

Table 4A.1 - Range Logic

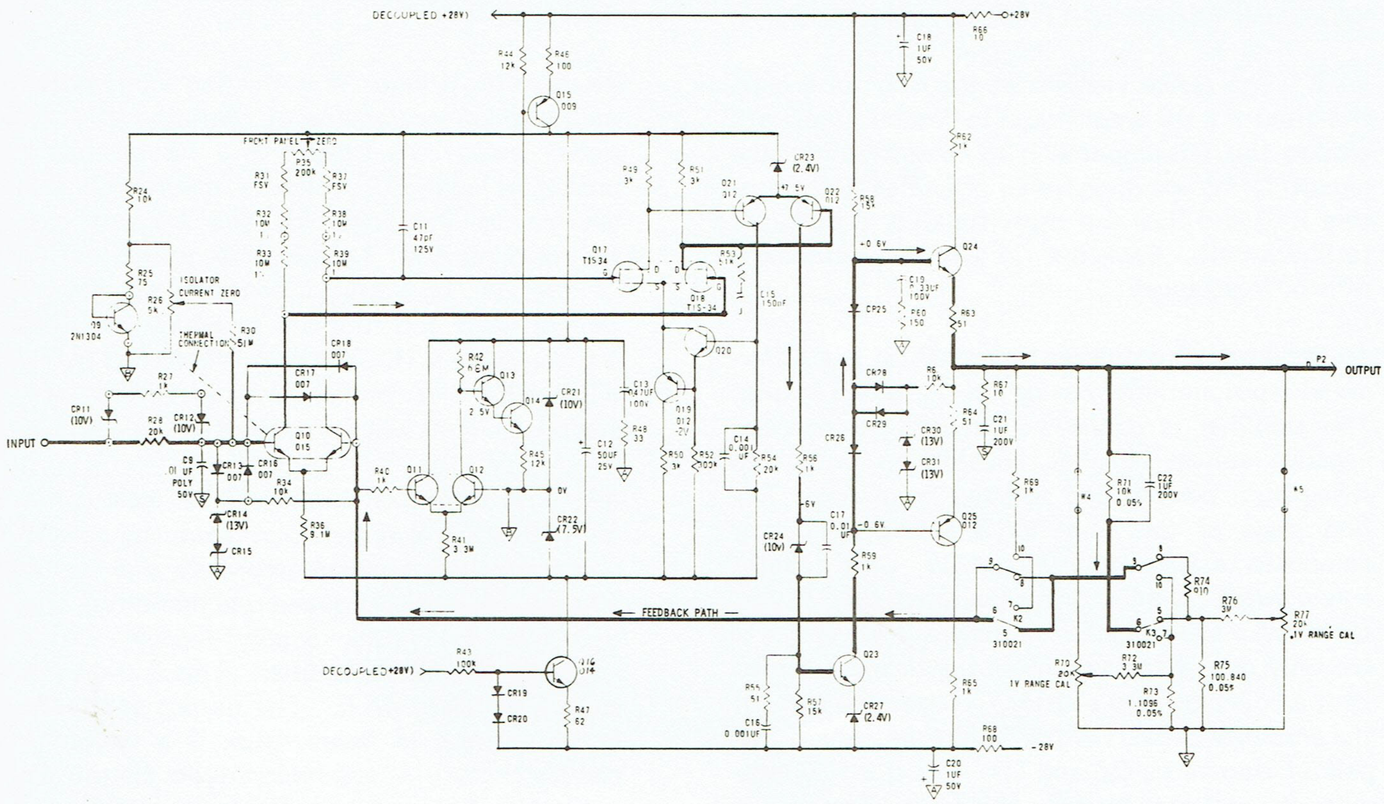


Figure 4A.4 - Isolator

characteristically high output impedance while providing a known and controlled flow of current through Zener diodes CR21 and CR22. This is shown clearly in figure 4A.5. If the node where zener diodes CR21 and CR22 join together were grounded, as is the case in most conventional zener type supplies, the zeners would always deliver positive 10V and negative 7.5V to the forward stages of the amplifier. This node, however, is not grounded and is connected to the output of the bootstrap amplifier. The bootstrap amplifier is a unity gain amplifier whose input is connected to the inverting input of the first stage of the isolator amplifier. The neutral point of the zener supplies is thus driven by the bootstrap amplifier and is always at a voltage potential equal to that at the input of the bootstrap amplifier.

4A.14 Inherent in the operation of high-gain closed loop feedback amplifiers such as the Isolator amplifier is the principle that the error signal (potential difference) across its inputs (inverting and non-inverting input bases) is always very small and can in most practical cases be ignored. This being the case, it can be seen that the voltage at the inverting input to the Isolator (and hence at the input to the bootstrap amplifier) is always equal to the input voltage to the Isolator. The bootstrap amplifier, therefore, always drives the neutral node of the zener supplies to the same voltage as is the input voltage to the isolator. The net effect is that the entire zener supply rides up and down on the two high impedance current generators. The voltages supplied to the first three stages of the Isolator are always 10 volts above and 7.5 volts below the input signal voltage, regardless of what the input signal voltage may be. As a result of this cheme, the input impedance of the Isolator amplifier (as well as the common mode rejection already inherent in such a design) is greatly increased.

4A.15 The input circuitry of the Isolator amplifier centers around transistor Q10 which is a dual NPN silicon transistor consisting of two separate transistors on a common substrate. This type of tran-

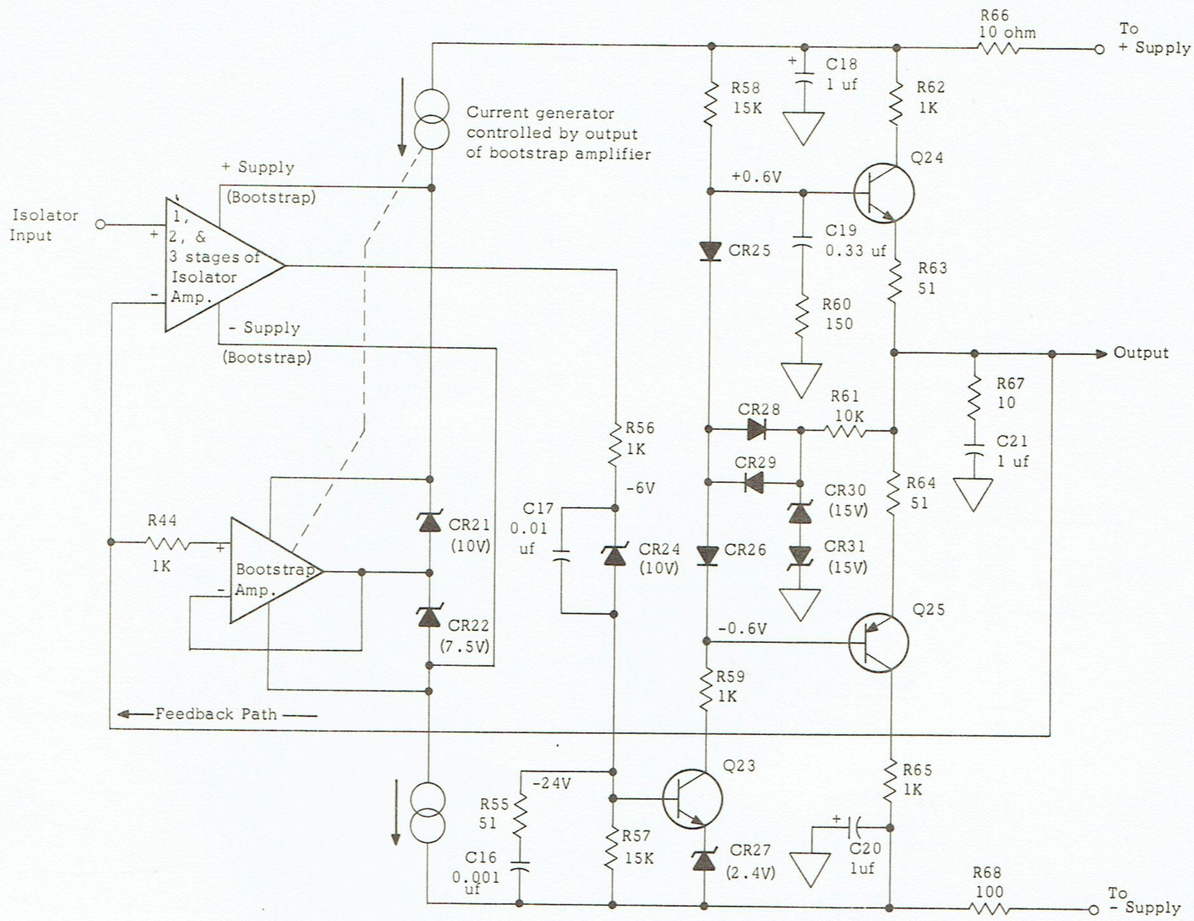


Figure 4A.5 - Isolator, showing function of bootstrap amplifier

sistor exhibits very low thermal drift characteristics. This circuit is shown in detail in figure 4A.6. Potentiometer R35, which is connected between the collector load resistors of the first stage is the front panel zero adjustment potentiometer. Resistors R31 and R37 are factory selected to electrically center potentiometer R35. The error signal (voltage potential appearing between the bases of Q10) is clamped by back-to-back diodes CR17 and Cr18 so that it can not exceed 0.6 volts. The input voltage is clamped by back-to-back zener diodes CR14 and CR15 so that it will not exceed approximately ± 13 volts. Diodes CR13 and CR16 compensate for slight leakage in the back-to-back zeners. When the input voltage is excessive, input current is limited by the 100K ohm resistor R16 (see figure 4A.2-1). Zener diodes CR11 and CR12 and resistor R27 prevent excessive voltage at the active filter node which would otherwise damage the filter capacitors. The input circuit of the Isolator can withstand an input overvoltage condition of up to 100 volts for any length of time, without damage.

4A.16 In any circuit utilizing feedback to obtain high input impedance, some provision must be made to provide adequate base bias to the first stage. This biasing circuit must not introduce a low impedance in itself or the effect gained by the use of feedback will be lost. In the Isolator amplifier, the network consisting of resistors R24, R25, R26, and R30 and transistor Q9 provides a temperature compensated, adjustable current source to bias the input base of the first stage. Potentiometer R26 is factory adjusted to schedule the optimum input current into the input base so that no current is taken from the circuit to which the DMM is connected. The biasing network is connected to the bootstrapped supply which is always referenced to the input signal thus achieving a high input impedance.

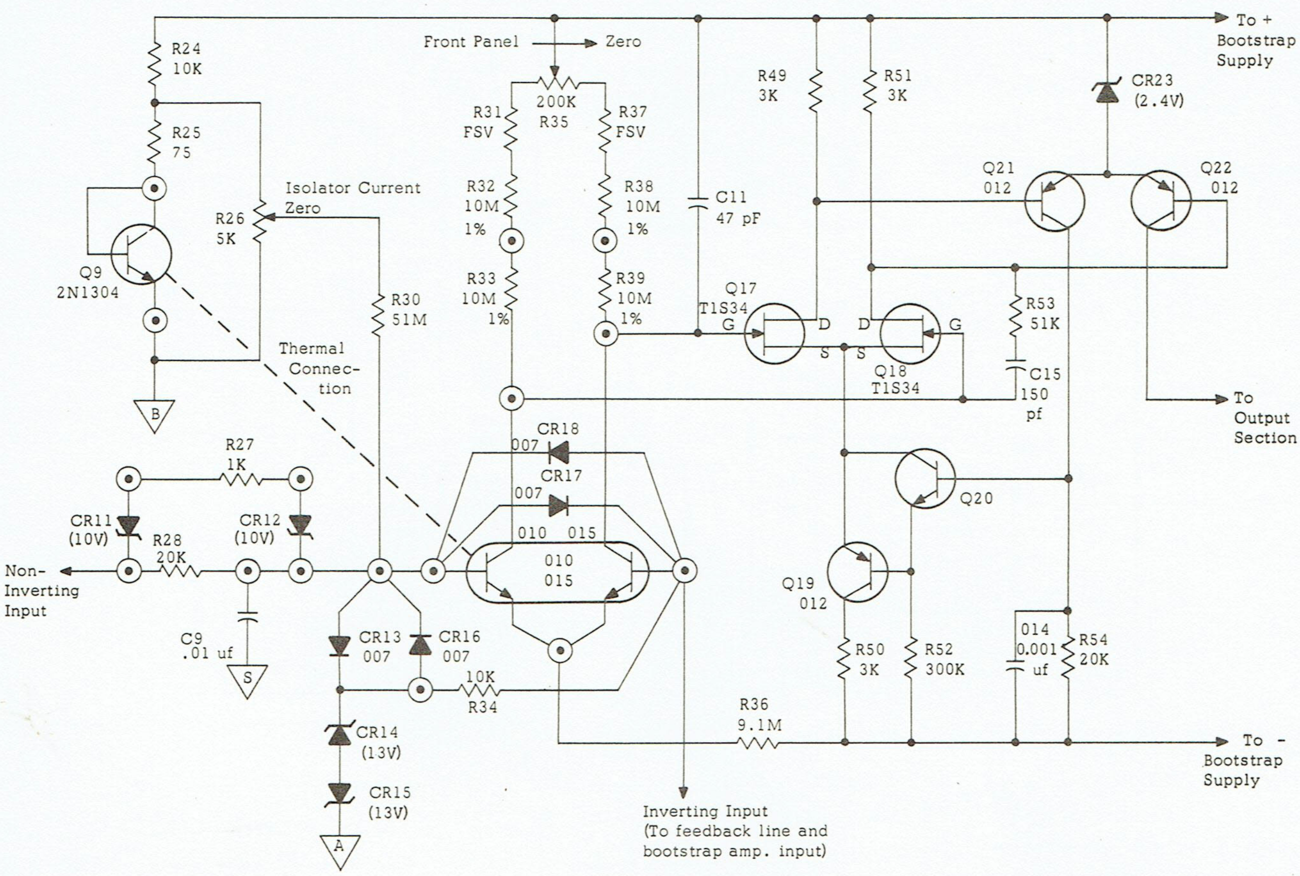


Figure 4A.6 - Isolator Amplifier Input Circuitry

4A.17 AC CONVERTER

4A.18 With AC selected, the input is routed through the AC converter (figure 4A.7) before entering the Isolator. A simplified schematic of the AC converter is shown in figure 4A.8. All AC ranging is accomplished by the voltage divider network at the input of the AC converter. This is shown in simplified form in figure 4A.8 and in detail in figure 4A.7. In the 1V range, relays K1, K2 and K3 are all open. The input signal is divided by the two 1 meg resistors R1 and R9. In the 10V range, relay K1 closes dividing the input signal by 20. In the 100V range relay K2 closes dividing the input signal by 200. In the 1000V range, relay K3 closes dividing the input signal by 2000. Thus the maximum voltage at the output of the input divider is always 0.6V (allowing for the 20% overrange feature) for any range. In cases where the DMM is manually locked in a low range and the full scale input voltage is exceeded, zener diodes CR3 and CR4 clamp the voltage at the output of the divider at ± 3V to prevent damage to the input transistor Q1 and allow fast overload recovery. Diodes CR1 and CR2 compensate for slight leakages that exist in these zeners. Input capacitor C1 blocks any DC from entering the input divider.

4A.19 The AC Converter is composed of two separate amplifiers. This is shown clearly in figure 4A.8. The input amplifier (A-1 on figure 4A.8) consists of transistors Q1, Q2 and Q3 and is a unity gain buffer amplifier having high input impedance and low output impedance. High input impedance is achieved through the use of a single N-channel field effect transistor (Q1) at the input.

4A.20 The output amplifier consists of transistors

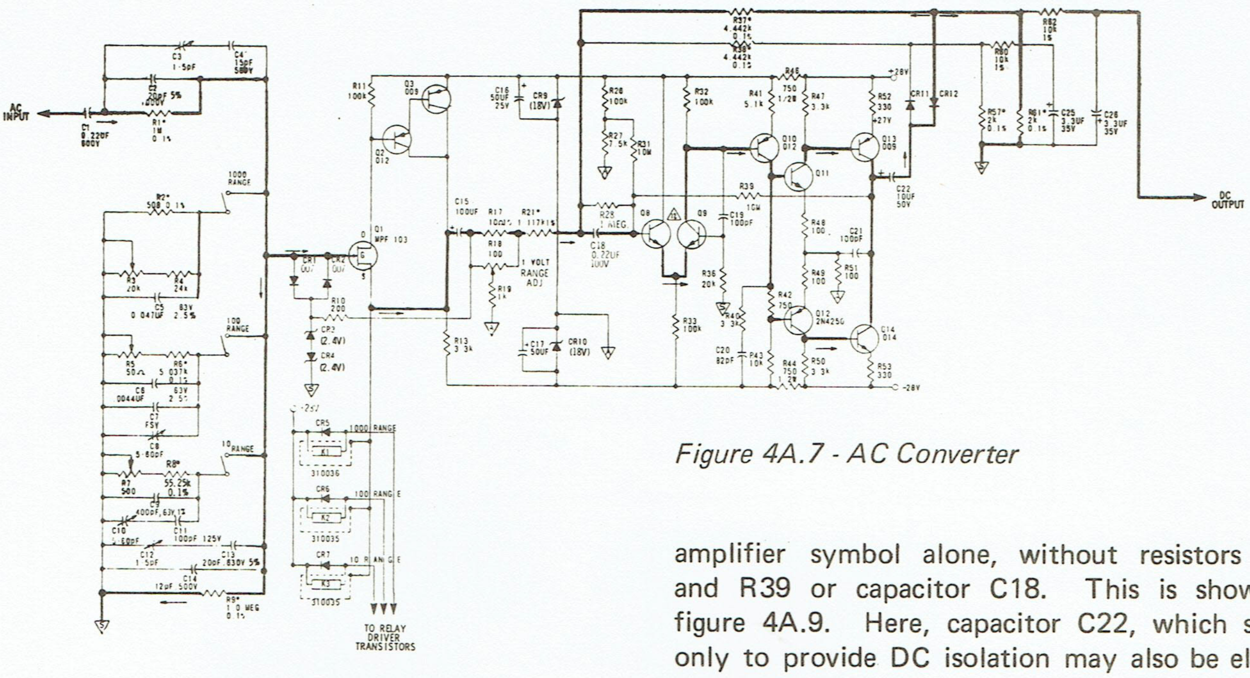


Figure 4A.7 - AC Converter

Q8, Q9, Q10, Q11, Q12, Q13 and Q14. Resistors R28 and R39 establish the DC gain of this amplifier at 10, thus providing DC stability. At all frequencies of interest, however, capacitor C18 presents an extremely low impedance in shunt with resistor R28. This means that the AC gain of the amplifier is essentially equal to its open loop gain and for analysis purposes can be redrawn as an amplifier symbol alone, without resistors R28 and R39 or capacitor C18. This is shown in figure 4A.9. Here, capacitor C22, which serves only to provide DC isolation may also be eliminated. This amplifier is actually connected as an operational amplifier with resistor R38 or resistor R37 acting as the feedback resistor on alternate half cycles. The gain of this section is equal to the value of R21 divided into R38 (or R37) as is illustrated in figure 4A.10. Only the negative half-

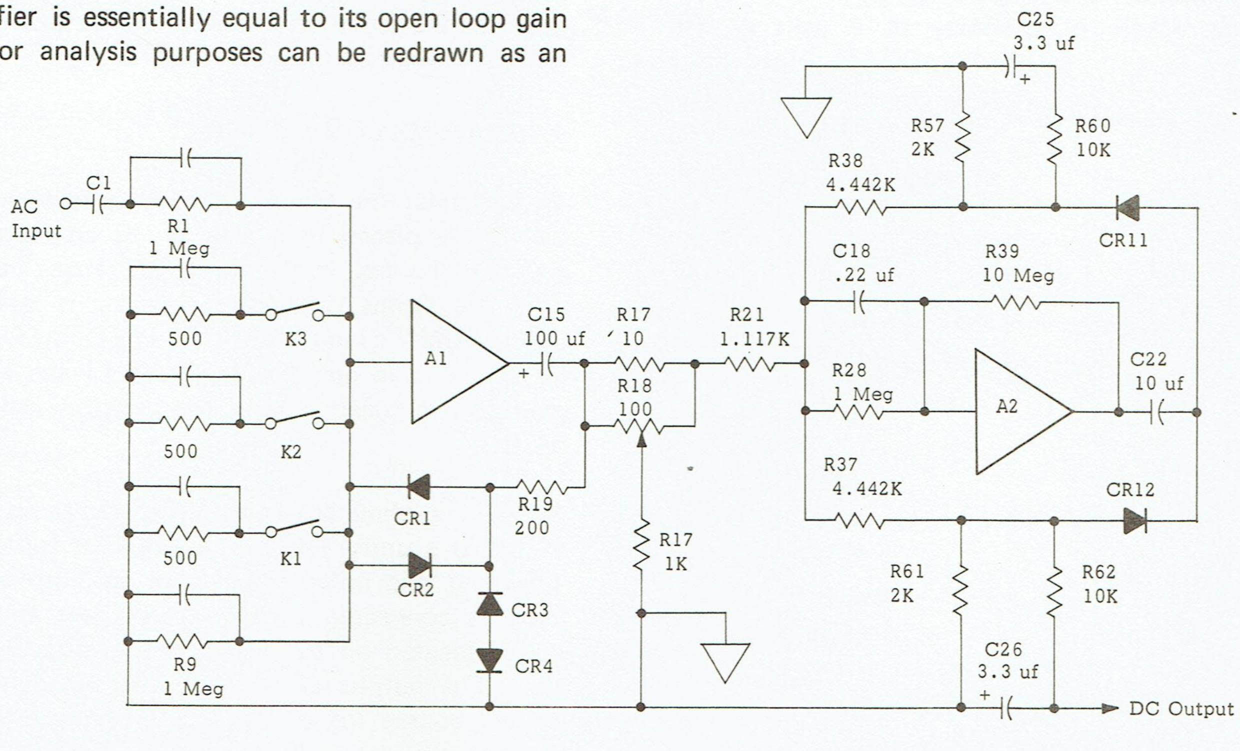


Figure 4A.8 - AC Converter - Simplified Schematic

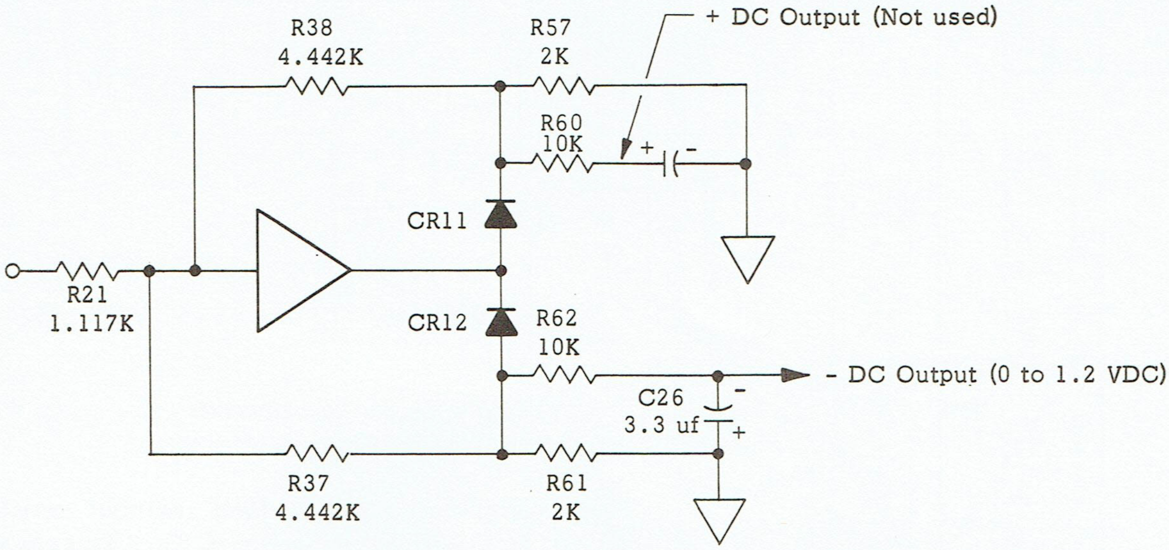
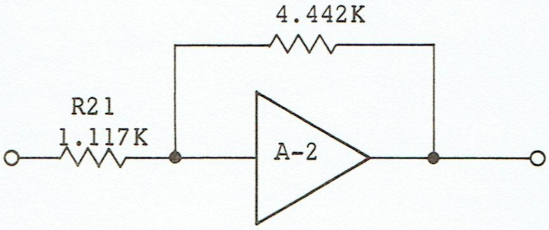


Figure 4A.9 - AC Converter Output Section - Simplified Schematic

cycle, of the rectified output is used. This is taken from the anode of diode CR12. Resistor R61 provides a proper load for diode CR12 and also provides a discharge path for capacitor C26. The rectified output is filtered by capacitor C26 across resistor R62 and is fed directly into the Isolator which is operating at a gain of 10.



$$K = \frac{R38}{R21} = \frac{4.442}{1.117}$$

$$K = 3.977$$

$$K \approx 4$$

Figure 4A.10
AC Converter Output Section,
Gain determining network

4A.21 Resistors R17 and R19 and potentiometer R18 form a simple adjustable voltage divider between amplifiers A-1 and A-2 (figure 4A.8) to set the gain of the entire system. The 1V range is calibrated by adjusting R18 and must be calibrated first, before the other ranges. Capacitor C15 provides DC isolation between the output of A-1 and the voltage divider.

4A.22 OHMS CONVERTER

4A.23 When the Ohms function is selected, the Isolator is placed in a gain of 10 configuration just as is the case in the 1 volt DC range. In addition, the Ohms Converter circuitry is switched into the DMM's input circuitry. The Ohms Converter is shown in detail in figure 4A.11 and in simplified form together with the Isolator, in figure 4A.12.

4A.24 The ohms buffer amplifier, shown in figure 4A.12, is a unity gain buffer amplifier capable of delivering one milliampere from its output. Its input is connected to the -1.0000 volt reference source located on the digitizing and display module. The output of this amplifier appears as a current source (of up to 1 ma) having a precise output terminal voltage of 1.0000 volts at all times. All output current from the ohms buffer

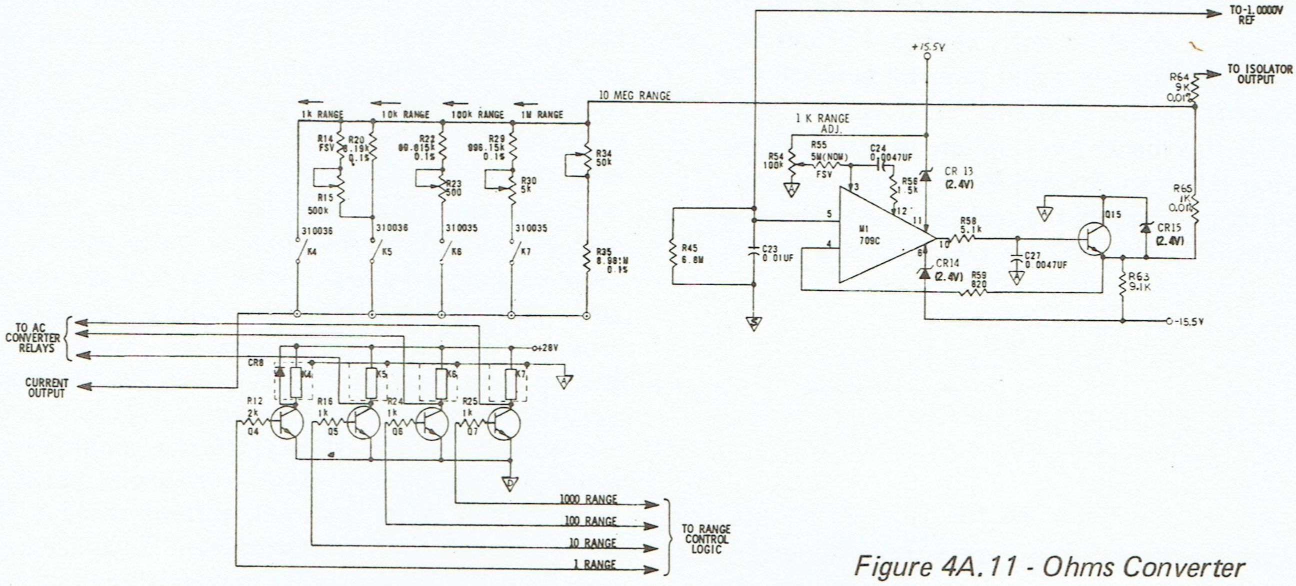


Figure 4A.11 - Ohms Converter

amplifier flows through R65, a 1 Kohm 0.01% precision resistor which is connected in series with it. This resistor serves to limit the output current from the ohms buffer amplifier to 1 ma.

4A.25 An analysis of circuit action in the ohms measurement configuration is best begun by considering the case where the DMM is in the 1000 ohm range. Here relay K4 (figure 4A.12) is closed so none of the current limiting resistors need be considered. To begin the analysis we shall disconnect the 1 volt ohms current source and consider the feedback configuration around the Isolator amplifier. This is shown in simplified form in figure 4A.13. Here resistors Rb and Rc represent the negative feedback network which gives the Isolator a stable forward DC gain of 10. (Here Rb and Rc are shown as 1K and 9K, in reality they are

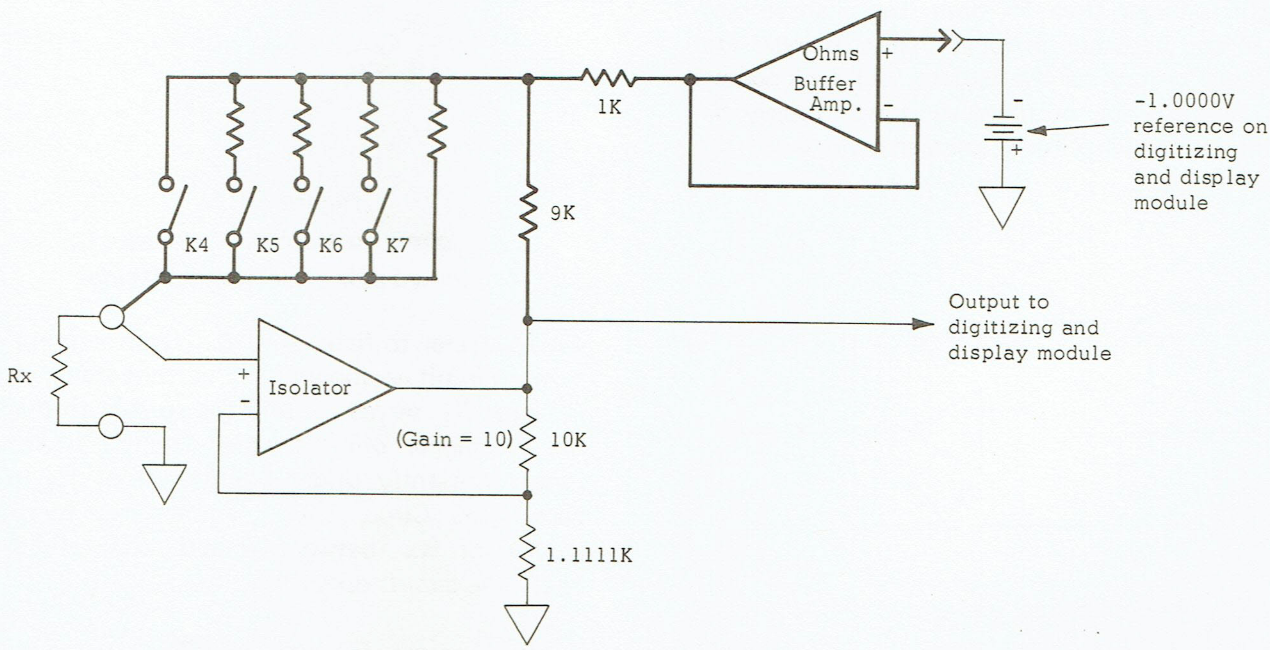


Figure 4A.12 - Ohms Converter, Simplified

1.1111K and 10K. The ratio, which is the important thing, is equal in both cases. 1K and 9K make analysis easier and still give the same gain to the Isolator) Resistors Ra and Rx, however, form a positive feedback loop which will offset the stablizing effect of Rb and Rc if Rx is very large. Resistor Rx represents the resistor being measured when the DMM is in the Ohms configuration.

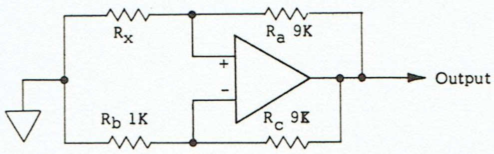


Figure 4A.13

Isolator feedback configuration in ohms mode

4A.26 Consider the case when Rx equals zero ohms. Here Ra acts only as an additional 9K ohm load on the Isolator and has no feedback effect. Since the input node to the Isolator is grounded, its output will be at zero volts. Now we shall increase the value of Rx to 1K ohm. Here the negative feedback stablizing effect of Rb and Rc is exactly offset by the positive feedback effect of Rx and Ra. The output voltage of the Isolator may go anywhere and will probably do so in whatever direction circuit imbalances may "nudge" it. Whenever Rx is larger than 1K ohm, the positive feedback effect becomes proportionally stronger and the output voltage of the Isolator will lock against either the positive or negative power supply depending on which circuit imbalances provide the biggest "nudge".

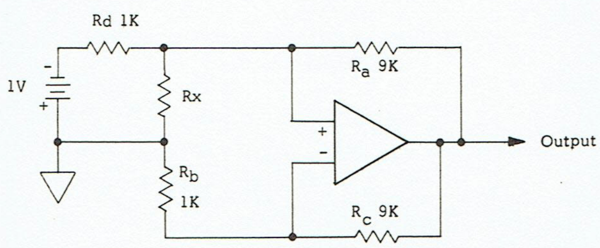


Figure 4A.14

Isolator Feedback with 1V reference supply added

4A.27 Let us now consider the effect of connecting the 1 volt ohms current source into the circuit. This is shown in figure 4A.14. Here, when Rx is infinitely large as is the case for an open circuit, the positive feedback effect of Ra predominates. The -1 volt source connected to the Isolator's input terminal provides a very powerful "nudge" and the output of the Isolator locks against its negative supply voltage. Here again, if Rx equals zero ohms, the input to the Isolator amplifier is grounded and its output is zero volts. For values of Rx between zero and 1200 ohms, the feedback circuit consisting of Ra, Rb, Rc and Rx will allow the output voltage of the Isolator amplifier to reach an equilibrium state somewhere between zero and -12 volts with the current through Rx always equal to 1 milliampere. This concept may be better illustrated by representing the entire ohms measurement circuit as a current-stable bridge. This is shown in figure 4A.15.

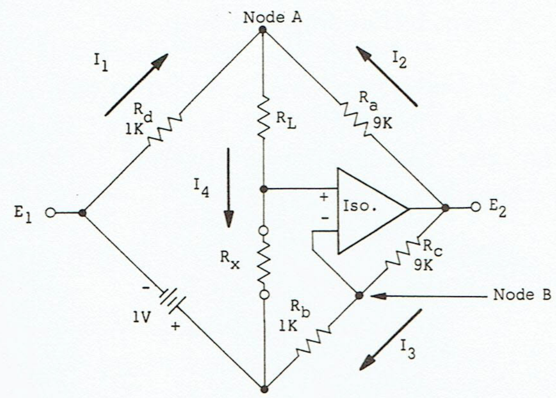


Figure 4A.15

ohms measurement circuit

shown as a current-stable bridge

4A.28 Refer to figure 4A.15. Here the ohms measuring circuit is shown as a current-stable bridge. Resistor R_L serves to limit the current through Rx on the higher ohms ranges. On the 1000 ohms range (presently under consideration) R_L equals zero ohms. Circuit action can be shown by picking values for Rx (between 0 and 1200 ohms) and analyzing circuit operation:

(a) Assume Rx equals 100 ohms. Current

flows out of the 1 volt source through Rd and Rx into circuit common. The 1100 ohm series combination of Rd and Rx limits the current through Rx to 909 microamperes. The 909 microamperes flowing through Rx causes a voltage drop of -90.9 millivolts across it. The -90.9 millivolts across Rx produces an output of -.909 volts at the output of the Isolator amplifier due to the gain of 10 produced by resistors Rb and Rc. Here the output voltage and current through Rx would remain were it not for the positive feed-back effect afforded by resistors Ra and Rx. This causes the output voltage from the Isolator to continue to rise until the voltage at Node A (figure 4A.15) exactly equals the voltage at node B. (The output of an amplifier is stable only when its input error signal equals zero.) The rising output voltage from the Isolator pumps current into node A through Ra causing the voltage at node A to rise. This current is I_2 on figure 4A.15. As the voltage at node A rises, current I_1 decreases slightly. The equillibrium point is reached when the voltage at node A exactly equals the voltage at node B. This occurs when I_1 equals 900 microamperes, I_2 equals 100 microamperes, I_3 equals 100 microamperes and I_4 equals 1000 microamperes (1 milliampere). Voltage E_2, the Isolator output voltage, is equal to I_3 times Rb + Rc. This is equal to -1.0000 volts which is displayed as 0.1000 kilohms on the DMM. 0.1 kilohms equals 100 ohms, the value of Rx.

(b) If Rx is assumed to equal 500 ohms, a very similar effect takes place. Here the 1500 ohms in series with the 1 volt limits the initial current from the 1 volt source to 666 microamperes through Rx. This produces an initial terminal voltage across Rx of 333 millivolts which is boot-strapped up by the positive feedback action of Ra and Rx to 500 millivolts. Here I_1 equals 500 microamperes, I_2 equals 500 microamperes, I_3 equals 500 microamperes and I_4 again equals 1 milliampere. The voltage at the output of the Isolator now equals I_3 x (Rb + Rc) which is -5.000 volts. The DMM displays 0.5000 kilohms. 0.5000 kilohms equals 500 ohms, the value of Rx.

4A.29 On the higher ohms ranges, current limiting resistor R_L (figure 4A.15) is inserted in series with Rx to limit the equillibrium current through it to a value that will result in a full scale IR drop across Rx of one volt on each range. The full scale current through Rx is given in table 4A.2 below for each range.

RANGE	CURRENT THROUGH UNKNOWN
1 Kilohm	1000 Microamps
10 Kilohm	100 Microamps
100 Kilohm	10 Microamps
1000 Kilohm	1 Microamp
10,000 Kilohm	100 Nanoamps

Table 4A.2 - Current thru Unknown resistor for each ohmmeter range

4A.30 RANGE CONTROL (Figure 4A.16)

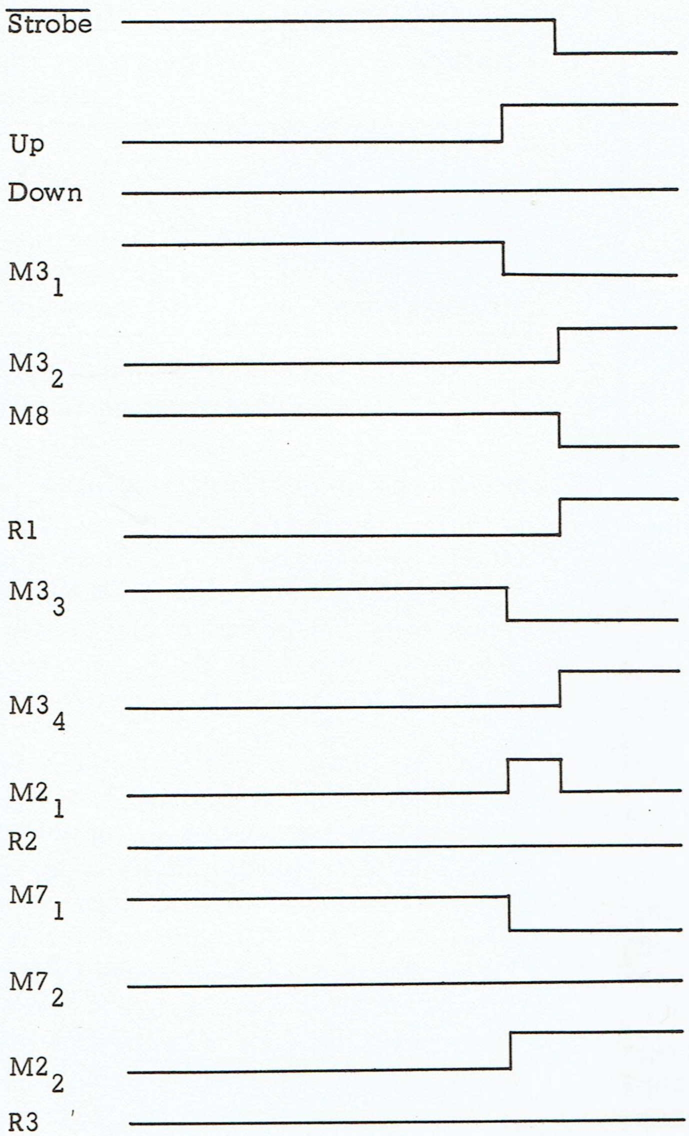
4A.31 Ranging of the instrument is controlled by a three-stage flip-flop counter driven by control signals from the Digitizing and Display Module. The control signals are Up Range, Down Range, and $\overline{\text{Strobe}}$.

4A.32 Up Range is true when the instrument is not on the highest range (1000 in volts or 10,000 in ohms) and the counter in the Digitizing and Display Module registers 12000 or higher. Down Range is true when the instrument is not in the lowest range (1 in AC ohms and 0.1 in DC) and the counter in the Digitizing and Display Module registers 00999 or less. Strobe is true during the measurement period. The negative-going edge of this signal indicates the end of the measurement.

4A.33 The range counter counts up or down in response to the Up Range and Down Range control signals. The state of the flip-flops corresponds to the codes and ranges listed in table 4A.1 A manually selected range "forces" the flip-flops to the proper state by clamping the appropriate counter outputs to common.

4A.34 A one-shot circuit provides a timeout (delay) of about 0.5 seconds at the end of a measurement period to allow time for ranging and for settling time of analog circuits. During this period, the HOLD line goes positive. This line is tied to the input of the control logic circuits in the Digitizing and Display Module where the positive level prevents a new reading from being taken.

4A.35 When operating in a selected range, rather than autorange, the HOLD line is permanently strapped to common by the range switch and new readings are allowed during a range changing attempt.



Example shows range counter initially in $\overline{R1}\ \overline{R2}\ \overline{R3}$ state representing range of 1. "Up" changes counter state to R1 $\overline{R2}\ \overline{R3}$ representing range of 10.

Figure 4A.16 - Range Control

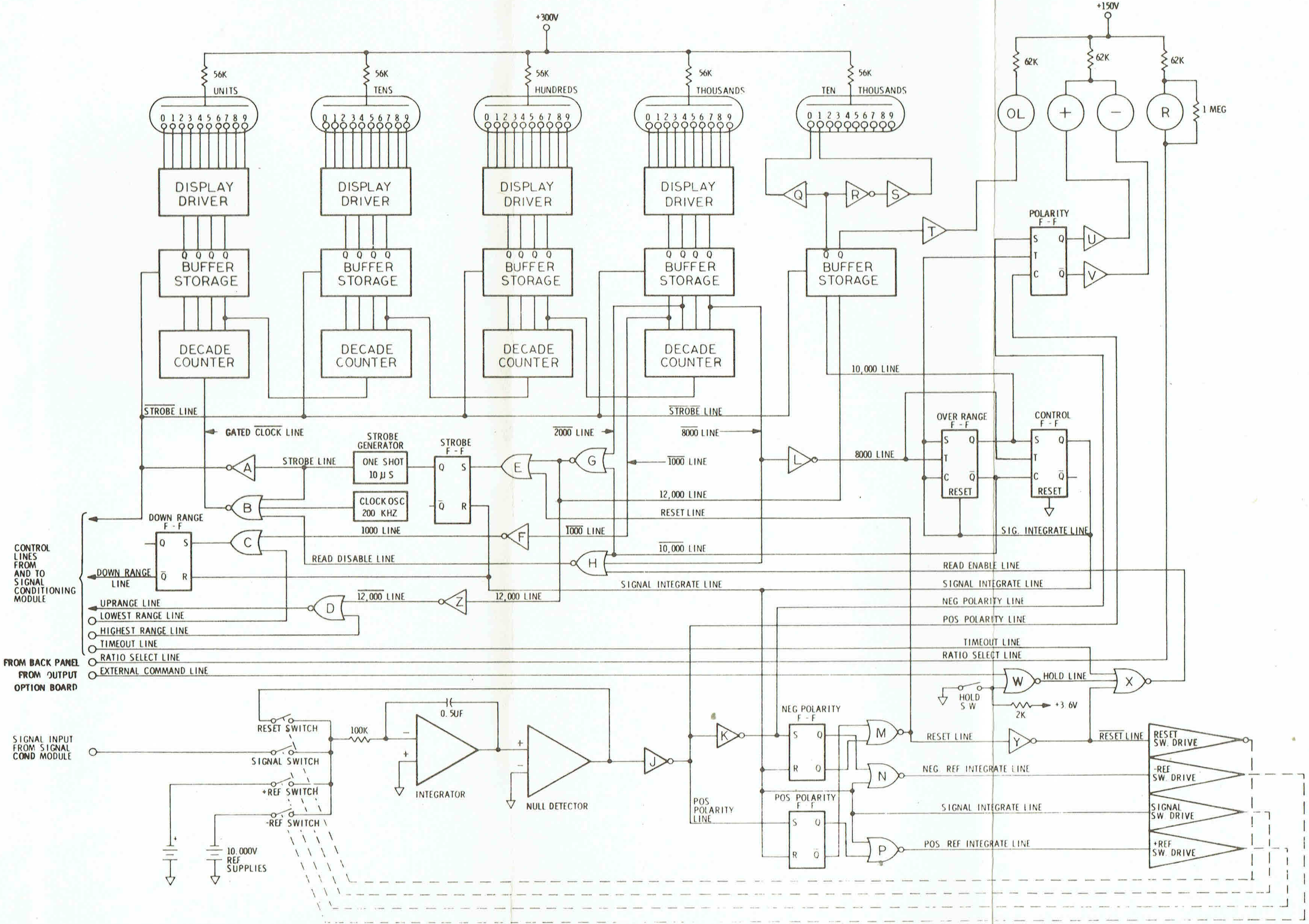


Figure 4B.1 Digitizing and Display Module, Simplified Schematic.

SECTION 4B

THEORY OF OPERATION OF THE DIGITIZING AND DISPLAY MODULE

4B.1 INTRODUCTION

4B.2 The Digitizing and Display Module, shown in simplified form in figure 4B.1 and in detail in the schematic diagram section at the back of this manual is, in itself, a complete DC digital voltmeter. The module will display the voltage and polarity of any DC input signal between zero and 10V full scale (12V with overrange). A 10V input signal gives a displayed reading of 10,000. The Digitizing and Display Module is divided into two main categories, the analog circuitry and the digital circuitry. In addition are the solid state switches at the input to the Integrator which are switched by the digital circuitry but perform an analog function. The digital circuitry is entirely constructed with integrated circuits with the exception of the transistors which drive the decimal points and polarity and overload indicators. Decimal points are placed by the ranging logic which is located on the Signal Conditioning Module. The driver transistors which actually switch the decimal points are located on the Digitizing and Display Module, their driving signal, however, comes from the ranging logic on the Signal Conditioning Module. The analog circuitry is entirely constructed around monolithic, linear, differential amplifier, integrated-circuits, which are connected either as inverting operational, or non-inverting potentiometric amplifiers. The solid-state switching circuitry, at the input to the integrator, consists of four N-channel field effect junction transistors. They and their associated driving circuitry comprise the only other section of the Digitizing and Display Module constructed from discrete components. The Digitizing and Display Module may be broken up into the following sub-sections:

I. ANALOG
- (a) Reference supplies
- (b) Integrator
- (c) Null Detector

II. DIGITAL
- (a) Clock oscillator
- (b) counter-readout
- (c) ranging logic
- (d) polarity sensing logic.

III. FET SWITCHING CIRCUITRY

4B.3 REFERENCE SUPPLIES

4B.4 BASIC OPERATION OF THE REFERENCE SUPPLIES

4B.5 The heart of the accuracy and stability of the digital voltmeter lies in the accuracy and stability of the +10V and -10V reference supplies. These supplies, shown in detail in figure 4B.2 and in simplified form in figure 4B.3, are built around two monolithic, integrated-circuit, differential amplifiers, each of which is housed in a separate 14-pin dual in-line package. The primary reference supply is the +10V supply. The negative supply simply inverts the +10V to -10V using an operational amplifier.

4B.6 The stability of the +10V reference supply is dependent upon the inherent stability of the reference zener. These zeners are individually graded by Dana to obtain the maximum long term stability and minimum temperature coefficient (TC). The zener and the series resistor through which it is biased are connected across a precision 10V source. The series resistor is then factory selected (FSV) to obtain the biasing current which will provide optimum temperature stability (TC). The selected resistor and zener are then installed

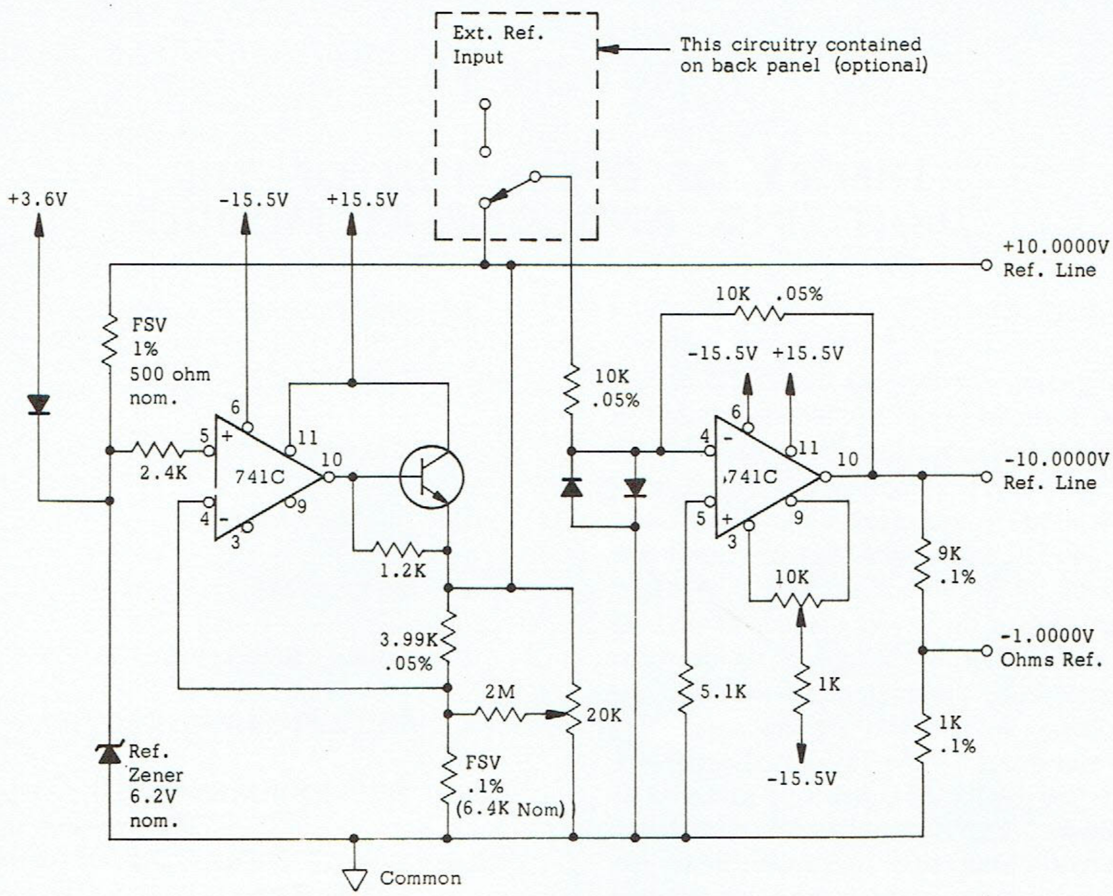


Figure 4B.2 - Reference Supplies

in each unit as a "kit", matched to each other.

4B.7 The amplifier around which the +10V reference supply is constructed consists of an integrated-circuit differential amplifier connected as a non-inverting, potentiometric feedback amplifier. The feedback network sets the forward closed-loop gain of the amplifier at approximately 1.6. A potentiometer in the feedback circuit provides a "fine" adjustment of the gain for calibration purposes. The reference zener and its biasing resistor are connected between the output of the +10V reference supply and circuit common. The cathode voltage of the reference zener provides the input signal to the amplifier in the +10V reference supply. This circuit is shown in figure 4B.2.

4B.8 The -10V reference supply consists of an integrated-circuit differential amplifier which is operated as an operational amplifier with a closed loop gain of one. Since an operational amplifier is an inverting amplifier it simply inverts the +10V reference to -10V. The input impedance of an operational amplifier is equal to the value of the input summing resistor, which in this case is 10K. Thus, the -10V supply draws only one milliampere from the +10V supply.

4B.9 ANALYSIS OF REFERENCE SUPPLY CIRCUIT OPERATION

4B.10 The feedback network of the +10V reference supply, together with the reference zener and its biasing resistor may be looked upon as forming a simple bridge. This is shown in figure 4B.3 which is a simplified schematic of the positive and negative reference supplies. The feedback network sets the forward closed loop gain of the amplifier at approximately 1.6.

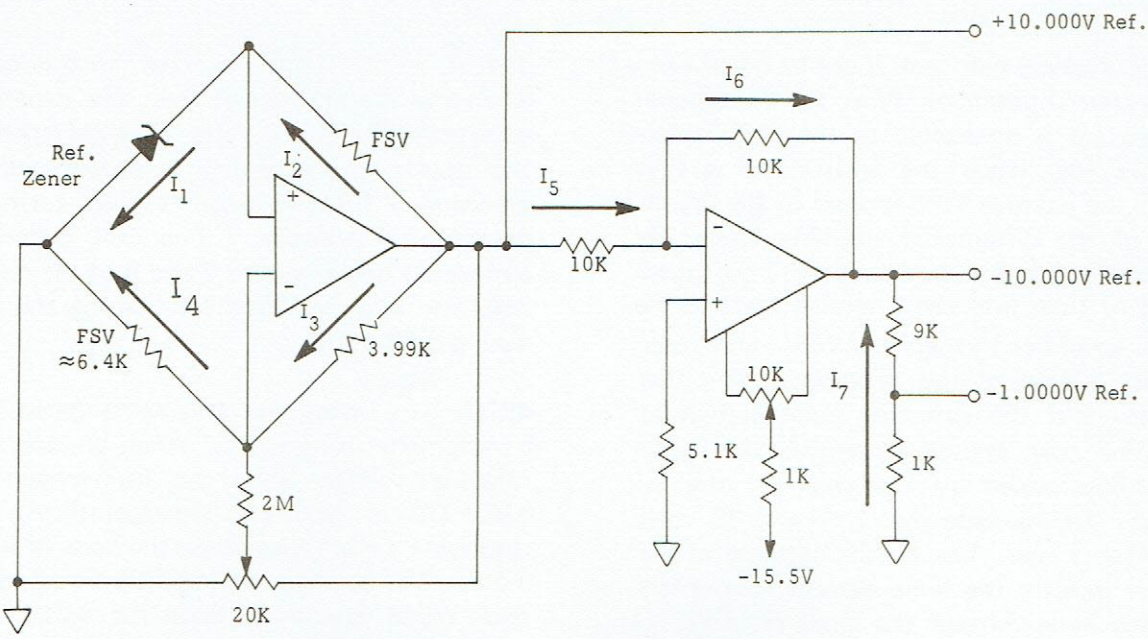


Figure 4B.3 - Simplified Schematic - Reference Supplies

4B.11 In operation, when power is first applied the voltage from the +3.6V power supply forward biases the diode connected between the +3.6V supply and the cathode of the reference zener causing the voltage at the cathode of the zener to rise to approximately +3 volts. As this voltage is below the breakover point of the zener, no current flows through it. Since the input to the reference amplifier is connected to the cathode of the zener, the output voltage from the reference amplifier also rises. As the output voltage from the reference amplifier rises it is fed back in a positive feedback loop to the input of the reference amplifier by the zener biasing resistor which is connected between the output of the reference amplifier and the cathode of the zener (i.e. the input to the reference amplifier). This positive feedback action causes the output voltage from the reference amplifier to continue to rise until the breakover point of the zener is reached. This occurs at a zener cathode voltage of approximately 6.2 volts. The DC open loop gain of the reference amplifier is approximately 100,000. This means that the error signal required to sustain an output level of 10V is approximately 100 microvolts. Thus the bridge circuit will balance when the voltage at the inverting amplifier input (which is connected to the feedback network) is approximately 100 microvolts lower than the voltage at its non-inverting input (which is the zener breakover voltage). When the circuit is balanced, the reference amplifier is delivering currents I_2 and I_3 into the bridge. Current I_2 equals I_1 and is the optimized zener bias current previously discussed. Current I_3 equals I_4 and is approximately equal to 10 volts across 10K or 1 ma. The 20K potentiometer connected between the +10V reference output and circuit common provides a "fine" adjustment of the gain of the reference amplifier over a limited range. This allows the reference supply to be calibrated to precisely +10.000 volts.

4B.12 The negative 10V reference supply is designed around the same type of integrated circuit differential amplifier as is the +10V supply. The difference is that, whereas the +10V supply uses the amplifier connected in a non-inverting potentiometric configuration, in the -10V supply the amplifier is connected as an inverting operational amplifier. This amplifier is operated with a closed loop gain of -1. As is the case with the positive reference amplifier, the negative reference amplifier has an open loop gain of approximately 100,000. Thus the maximum error signal across its input terminals needed to sustain an output of 10V is 100 microvolts. This keeps the voltage at the amplifier's inverting input terminal (summing node) from exceeding 100 microvolts which means that, for all practical purposes, it can be considered as equal to ground potential. When the operational amplifier circuit is connected to the +10V reference supply (or, when the instrument is first turned on) the positive 10V applied to the inverting input of the differential amplifier causes its output to move in a negative direction. This causes current I_5 to flow into the summing node of the operational amplifier through the 10K input resistor. As the action of the operational amplifier attempts to hold the summing node voltage at a point very near ground potential, the input current is determined by the value of the input resistor. In this case the current is 10 volts across 10K or 1 ma. The circuit balances at the point where exactly the same current that enters the summing node through the input resistor (I_5) leaves the summing node through the feedback resistor (I_6). This is the basic principle of operation behind the operational amplifier. (The input impedance of the differential amplifier itself is very high and thus consumes virtually no current.) The gain of the operational amplifier is determined by the relationship of the input resistor to the feedback resistor. If they are equal, as is the case here, exactly the same current will flow through each when each has exactly the same voltage dropped across it. This can occur, in this case, only when the output voltage from the negative reference amplifier is -10 volts. The gain precision of the operational amplifier is determined by the precision of the two resistors which form the gain determining network. The 10K potentiometer connected between pins 3 and 9 of the operational amplifier is a provision for zeroing the amplifier during calibration.

4B.13 The instrument may be equipped for use as a ratiometer (optional). When so operated, the reference voltage, which may be between zero and +10V DC, is applied to the operational amplifier through a switch located on the back of the instrument. The operational amplifier inverts the reference signal just as it does the +10V reference supply.

4B.14 INTEGATOR

4B.15 The integrator, shown in detail in figure 4B.4 and in simplified form in figure 4B.1, is the heart of the analog to digital conversion circuitry. It is designed around a high-gain, monolithic, integrated-circuit differential amplifier. The circuit is connected as an operational amplifier, having a

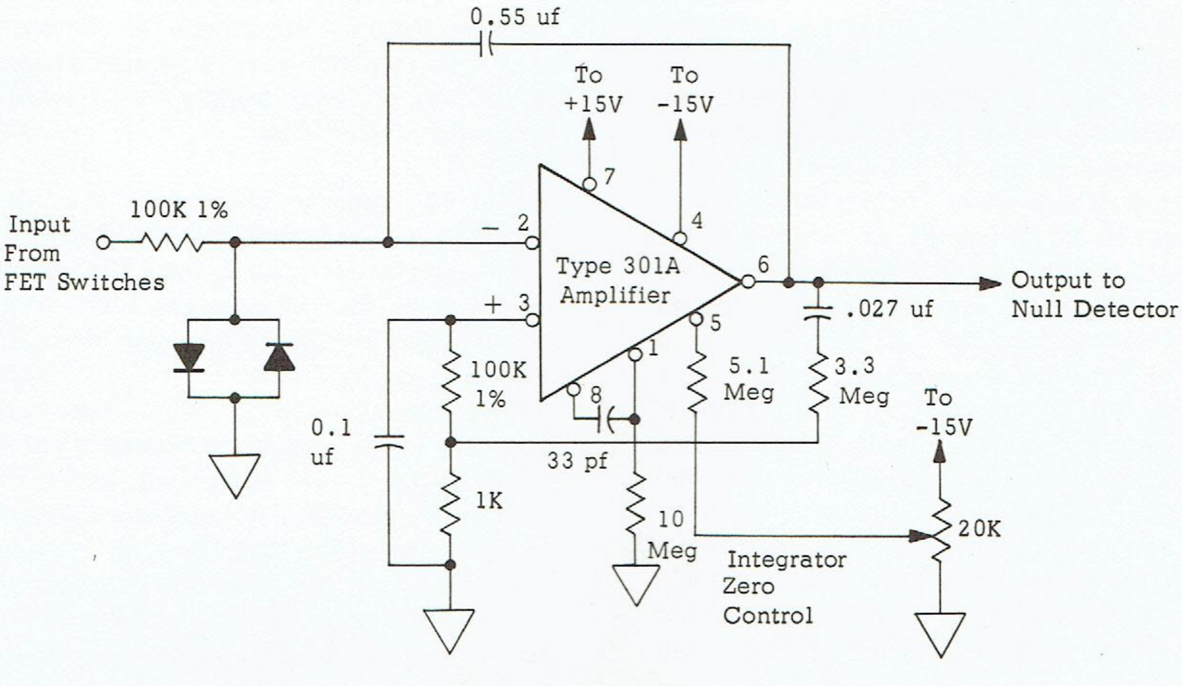


Figure 4B.4 - Schematic, Integrator

summing resistor of 100K ohms, wherein the feedback element is a 0.5 microfarad capacitor. In operation, the circuit functions as outlined below.

4B.16 BASIC OPERATION OF THE INTEGRATOR

4B.17 Immediately prior to the beginning of a new reading the integrator is in a "reset" state. Its input and output are both at zero volts. When the instrument begins a new reading a solid-state switch closes, connecting the input of the Integrator to the output from the Signal Conditioning Module. At this point the output voltage from the integrator begins to move in a polarity opposite to the polarity of the voltage at its input. The Integrator's output voltage moves at a rate which is equal to the charging rate of the 0.5 microfarad feedback capacitor charged at a constant current which is equal to the $\frac{E}{R}$ relationship of the input voltage to the 100K ohm summing resistor. The amplifier acts as a constant current source which charges the capacitor. This charging of the feedback capacitor by a constant current source produces a linear ramp at the output of the Integrator, the change in whose voltage is given by the formula:

(1) $$\Delta V = \frac{-Ein\ Ts}{RC}$$

Where: ΔV = The change in voltage from the integrator

Ein = The input signal voltage

Ts = The fixed time that the switch connecting the Integrator's input to the input signal remains closed.

R = The Integrator's summing resistor

C = The value of the Integrators feedback capacitor.

The solid-state switch connecting the input of the Integrator to the signal voltage remains closed for a fixed period of time. This is referred to as the signal integration time (Ts). At the time that Ts begins, an oscillator of frequency f begins advancing the digital counter. The counter counts until a fixed number of counts (Cf) is reached.

4B.18 When fixed count (Cf) is reached, the signal integration time (Ts) is terminated and the counter is reset to zero. At this point the solid-state switch which connected the signal voltage to the Integrator's input opens and another switch closes connecting the Integrator's input to a precision 10V reference supply. This begins the reference integration period (Tr). The reference supply is opposite in polarity to the polarity of the input signal voltage. This causes the output voltage from the Integrator to ramp back toward zero until zero is reached, at which time the null detector senses the null state and causes the reference integrator time to be terminated. The counter accumulates oscillator counts from the beginning of Tr until Tr is terminated. At this time the counter contains a number of counts (Cx), which is the number displayed in the DVM readout. Since Tr ends with the output voltage from the Integrator at the same level as when Ts started, the changes in voltage at the output of the Integrator must be equal and opposite, thus:

(2) $$\Delta V = \frac{-Eref\ Tr}{RC}$$

Where: ΔV = The change in output voltage from the Integrator

Eref = The voltage of the reference supply

Tr = The reference integration time

R = The value of the Integrator's summing resistor

C = The value of the Integrator's feedback capacitor

Operating on equations (1) and (2), we may equate quantities equal to ΔV:

(3) $$\frac{-Ein\ Ts}{RC} = \frac{-Eref\ Tr}{RC}$$

And by multiplying both sides of equation (3) by RC we have:

(4) $$- Ein\ Ts = - Eref\ Tr$$

Dividing both sides of eq. (4) by - Eref:

(5) $$\frac{-Ein\ Ts}{-Eref} = Tr$$

Eq. (5) is equal to:

(6) $$Tr = \frac{Ein\ Ts}{Eref}$$

Ts is determined by a fixed number of counts (Cf), therefore:

(7) $$Ts = \frac{Cf}{f}$$

Where f is the oscillator frequency

Similarly:

(8) $$Tr = \frac{Cx}{f}$$

By substituting the equivalent values of Ts and Tr in equation (6) we obtain:

(9) $$\frac{Cx}{f} = \frac{Ein\ Cf}{Eref\ f}$$

And by multiplying both sides of eq. (9) by f:

(10) $$Cx = \frac{Ein\ Cf}{Eref}$$

Equation (10) is very important because it shows that the number displayed by the DVM (Cx) is affected only by Cf, which is an invariant digital number, Eref, which is a precision reference voltage, and Ein, which is the voltage to be measured.

The measurement accuracy is entirely based upon the ratio of the signal integration time, a fixed number of counts (Cf), to the reference integration time, a variable number of counts (Cx). It is completely unaffected by oscillator frequency (f), or the RC components in the Integrator, provided only that these quantities remain stable during the time period required to take a measurment.

4B.19 ILLUSTRATION OF INTEGRATOR OPERATION BY EXAMPLE

4B.20 Each time the instrument begins a new reading a solid-state switch closes, connecting the input of the Integrator to the signal output from the Signal Conditioning Module. Since the integrator is connected as an operational amplifier, feedback action keeps the voltage at the summing node (i.e. the inverting amplifier input) at very nearly zero volts. (For this reason, many engineers refer to the summing node as a "virtual ground".) As the summing node is at ground potential, the input current flowing through the summing resistor is equal to the value of the input voltage divided by 100K ohms. The inverting action of the amplifier causes the voltage at its output to move in a polarity opposite the polarity at the input to the summing resistor. The rate is equal to the charging rate of the 0.5 microfarad capacitor charged at a constant current which is equal to the $\frac{E}{R}$ relationship of the input voltage to the 100K ohm summing resistor. The amplifier acts as a constant current source which charges the capacitor. This action produces a linear ramp at the output of the integrator amplifier whose slope is given by the formula:

$$S_1 = -\left(\frac{Ein}{RC}\right)$$

Where: S_1 = The charging slope in volts per second

Ein = The input voltage to the integrator

R = The value of the integrator summing resistor

C = The value of the integrator feedback capacitor.

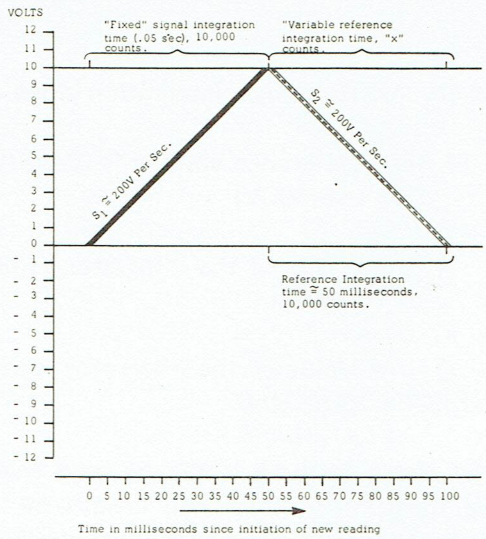


Figure 4B.5 - Integrator ramp with a -10V input signal

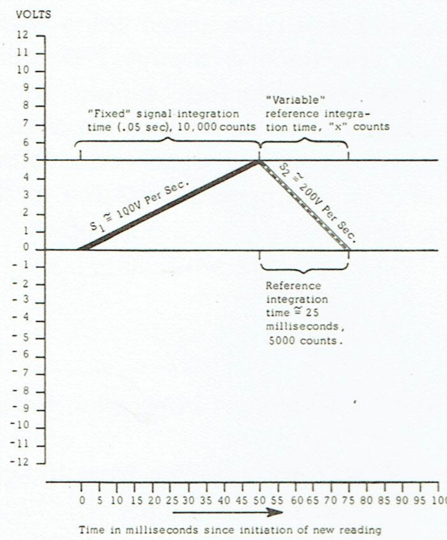


Figure 4B.6 - Integrator ramp with a -5V input signal

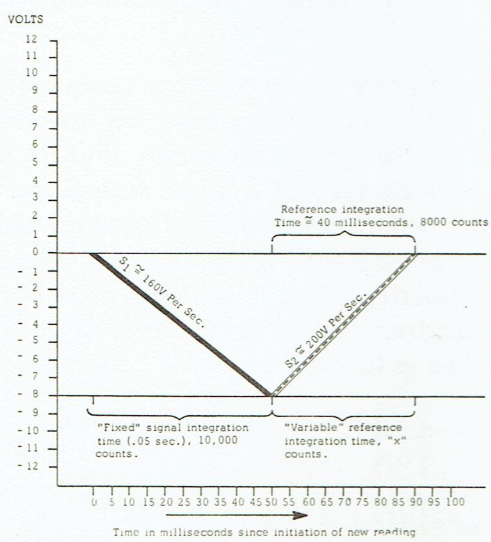


Figure 4B.7 - Integrator ramp with a +8V input signal

If we assume an input to the integrator of -10V, the slope of the ramp is:

$$S_1 = -\left(\frac{Ein}{RC}\right) = -\left(\frac{-10}{(10^5)(5 \times 10^{-7})}\right) = -\left(\frac{-10}{5 \times 10^{-2}}\right)$$

$$S_1 = -(-2 \times 10^2) = -(-200)$$

$$S_1 = +200 \text{ volts per second}$$

The digital circuitry keeps the FET switch connecting the signal to the integrator closed for a period of exactly 0.05 second (50 milliseconds). If the input signal is -10V, the inverting action of the integrator causes its output voltage to ramp in a positive direction at a 200 volt per second rate. The voltage at the output of the integrator at the end of the alloted 50 millisecond signal integration time is given by the formula:

$$V = S_1 t$$

Where: V = The integrator's output voltage at the end on the integration time

S_1 = The charging slope in volts per second during signal integration

t = The total integration time

In this case t is fixed at .05 second and the charging slope is 200 volts per second. Thus:

$$V = S_1 t$$
$$V = 200 \times .05$$
$$V = 10$$

A slope of 200 volts per second, ramping for a period of 50 milliseconds, will allow the voltage at the output of the integrator to reach a level of exactly +10 volts. This is shown as slope S_1 in figure 4B.5. If the input signal to the integrator were -5V, rather than -10V, the slope during the signal integration time would be 100 volts per second (which follows from the above formula). This would allow the output voltage from the integrator to reach a level of +5V during the alloted 50 millisecond integration time. This is shown as slope S_1 in figure 4B.6. If we assume an input signal to the integrator of +8V, the slope during the signal integration time is:

$$S_1 = -\frac{Ein}{RC}$$

$$S_1 = -\frac{8}{5 \times 10^{-2}}$$

$$S_1 = -(1.6 \times 10^2)$$

$$S_1 = -(160)$$

$$S_1 = -160 \text{ volts per second}$$

A slope of -160 volts per second, charging for a period of .05 second gives an integrator output voltage of:

$$V = S_1 t$$

$$V = (-160) \times .05$$

$$V = -8$$

This is shown as slope S_1 of figure 4B.7. From this it can be seen that, *in any case, the output voltage from the integrator at the end of the signal integration period will always be of equal voltage, but of opposite polarity, to the voltage at the integrator input.*

4B.21 At the end of the signal integration period the FET switch connecting the integrator's input to the output signal from the signal conditioning module opens. Simultaneously, another FET switch closes which connects the integrator's input to either the +10.000V or the -10.000V reference supply. The reference supply chosen is whichever one is opposite in polarity to the polarity of the input signal. At this point the output voltage from the integrator begins to ramp back toward zero volts. This is known as the reference integration period. The reference integration slope is calculated by the formula:

$$S_2 = -\frac{E\ ref}{RC}$$

Where: S_2 = Reference integration slope

E ref = Reference voltage (+10.000V or -10.000V)

R = Value of the integrator summing resistor

C = Value of the integrator feedback capacitor

From the above formula it can be seen that the reference integration slope will always be +200 volts per second when the signal being measured is positive (because the -10.000 volt reference supply is switched into the integrator's input) and -200 volts per second when the signal being measured is negative. The slope is always 200 volts per second because the reference supply voltage is always 10 volts. The time it takes the output voltage from the integrator to reach zero volts after the start of the reference integration period is given by the formula:

$$Tr = \frac{V}{S_2}$$

Where: Tr = Reference integration time

V = Output voltage from integrator at the end of the signal integration time.

S_2 = slope of reference integration

Thus, for the case where the signal being measured is -10V, the output voltage from the integrator at the end of the signal integration time is +10V. The slope is always 200 volts per second and since the signal being measured is of negative polarity the slope of reference integration will also be of negative polarity. The time required for the output voltage from the integrator to reach zero volts is calculated as follows:

$$Tr = \left|\frac{V}{S_2}\right|$$

$$Tr = \left|\frac{10V}{-200}\right|$$

$$Tr = \left| -.05 \right|$$

Tr = .05 second

This is shown by slope S_2 of figure 4B.5. Similarly, the reference integration time is 25 milliseconds when the input signal is 5 volts and 40 milliseconds when the input signal is 8 volts. These are shown as slope S_2 in figures 4B.6 and 4B.7.

4B.22 It is the reference integration time, outlined above, which is measured and converted to digital form for display in the DVM readout.

The reading displayed is calculated by the formula;

D = Tr f

Where: D = The displayed reading

Tr = The reference integration time

f = The clock frequency of the instrument (200 kHz)

Thus, in the case where the input voltage being measured is -10V, the reference integration time is .05 second (as shown above) so the displayed reading is:

D = Tr f

D = .05 x 2,000,000

D = 10,000

And when the input signal is 8V, the displayed reading is:

D = Tr f

D = .040 x 2,000,000

D = 8000

Further manipulation of the D=Tr f equation reveals that the reading displayed by the instrument is a function of the ratio of the reference integration time to the signal integration time.

$$D = Tr\ f$$

$$\left(\frac{Ts}{Ts}\right) D = (Tr\ f)\left(\frac{Ts}{Ts}\right)$$

$$D = \frac{Tr\ f\ Ts}{Ts}$$

$$D = \frac{Tr}{Ts}\ (Ts\ f)$$

The case when the input signal is 8V may again be used to illustrate. The clock frequency (f) is 200 kHz and the signal integration time Ts is .05 second. When the input signal is 8V, the reference integration time Tr is .04 second.

$$D = \frac{Tr}{Ts}\ (Ts\ f)$$

$$D = \frac{Tr}{Ts} \times (.05 \times 2{,}000{,}000)$$

$$D = \frac{Tr}{Ts} \times 10{,}000$$

$$D = \frac{.04}{.05} \times 10{,}000$$

D = .8 x 10,000

D = 8000

4B.23 NULL DETECTOR

4B.24 The Null Detector, shown in detail in figure 4B.8 and in simplified form as a part of figure 4B.1 is simply a high gain noninverting amplifier. It also is designed around a high-gain, monolithic, integrated-circuit differential amplifier. The circuit is of the potentiometric feedback type and has a closed-loop gain of 740. The 20K resistor in series with the input and the two back to back diodes serve to limit the input voltage to the null detector to 0.6 volts maximum. The Null Detector has two outputs. One goes directly to the digital circuits, the other is the output of an emitter follower transistor (see figure 4B.8) which feeds back to the 'reset' switch. The 'reset' switch is one of the four FET switches at the input to the integrator.

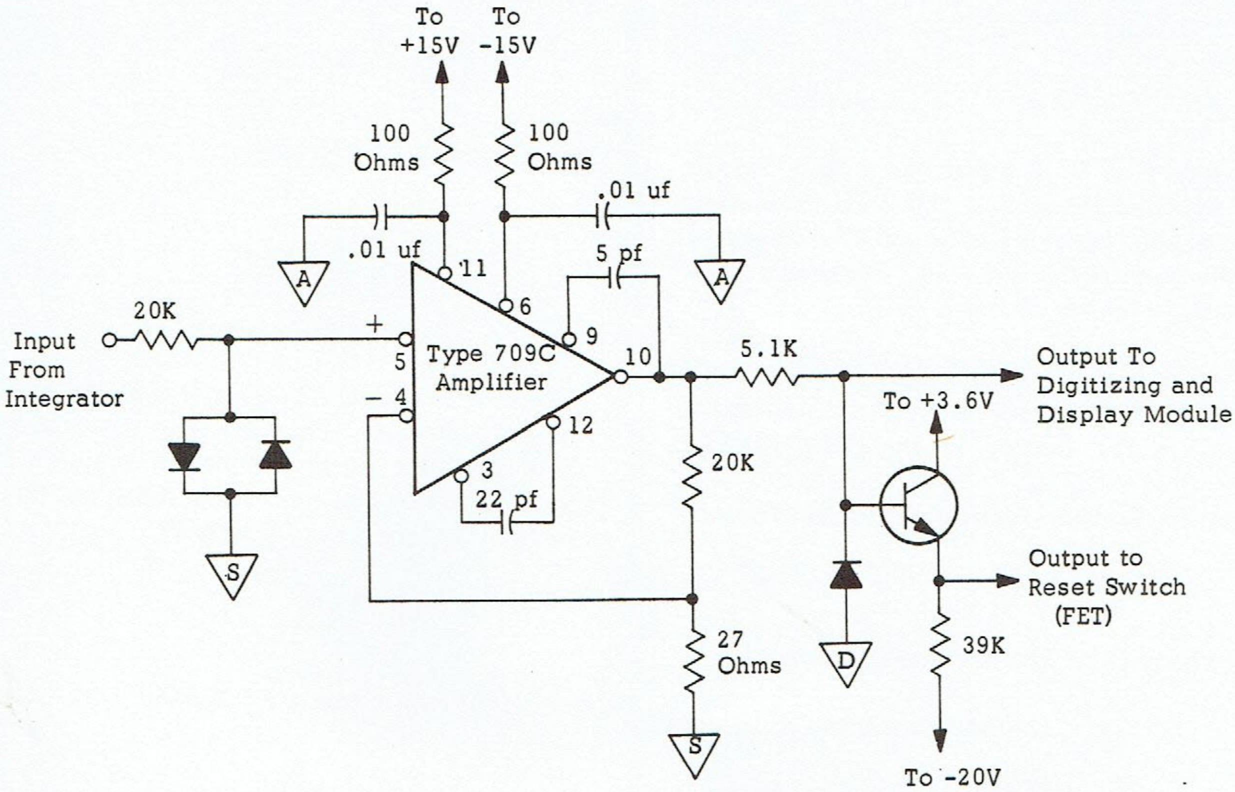


Figure 4B.8 - Null Detector

4B.25 OPERATION OF THE DIGITIZING AND DISPLAY MODULE

4B.26 Refer to figure 4B.1. Figure 4B.1 is a simplified version of the actual schematic which appears in the schematic section at the rear of this manual. As shown, all lines and logic levels are as they actually appear in the instrument. Nor gates which are used as inverters are shown as inverters in figure 4B.1. Similarly, nor gates which are interconnected to form RS flip flops are shown as RS flip flops. Of special interest in this capacity are the Downrange flip flop and the strobe flip flop which use one two-input and one three-input nor gate each connected to form RS flip flops with an or gate at the input. They are so shown on figure 4B.1. The output of the Control flip flop is actually taken from the $\overline{Q}$ side and inverted through a power inverter in order to drive a large number of other circuits which the flip flop alone could not do. This is omitted in figure 4B.1.

4B.27 In operation, the counter, which consists of four individual integrated-circuit decades, is continuously running and is never reset. Nor gate B prevents clock signals from entering the counter (and thus stops it) whenever the instrument is in "hold" and during "strobe" time. A four decade counter can count only to 9999 whereupon it resets itself to 0000. A new reading is initiated every third time the counter reaches 0000.

4B.28 At the beginning of each new reading the signal integrate line goes true. This enables the signal switch driver which closes the FET signal switch at the input to the integrator. The integrator begins to ramp up or down, depending on the polarity of the input signal. (See the preceding section on the operation of the Integrator.) The signal integration ramp of the integrator continues until the counter reaches 9999 and resets to 0000. At the moment the counter resets to 0000, the 8000 line (which went true when the counter reached 8000) goes false. This toggles the control flip flop and the signal integrate line goes false. The signal integrate line going false disables the signal switch driver and the FET signal switch opens.

4B.29 The polarity decision is made at the moment the counter resets from 9999 to 0000. If the input signal to the integrator is positive, the output voltage from the Integrator at the end of the signal integration time is negative. This causes the output voltage from the Null Detector to also be negative. This level is inverted by inverter J, setting the positive polarity line true (positive). The true level of the positive polarity line is inverted by inverter K, setting the negative polarity line false. If the polarity of the input signal were negative, the converse would be true. In short, if the polarity of the input signal is positive, the positive polarity line will be true and the negative polarity line false at the end of the signal integration period. If the polarity of the input signal is negative, the positive polarity line will be false and the negative polarity line true at the end of the signal integration period. When the signal integrate line goes false at the time the counter overflows to 0000, the polarity flip flop toggles. The position taken by the polarity flip flop is determined by the state of the positive polarity line and the negative polarity line at the end of the signal integration period. If the input signal is of positive polarity, the positive polarity line is true and the negative polarity line false. This causes the Q side of the polarity flip flop to be set which enables driver U. Driver U lights the + polarity light. If the input signal is of negative polarity the positive polarity line is false and the negative polarity line is true. This causes the $\overline{Q}$ side of the polarity flip flop to be set which enables driver V. Driver V lights the - polarity light.

4B.30 During the signal integration period the signal integrate line is true. This holds the negative polarity flip flop and the positive polarity flip flop in a reset state. At the time the counter goes from 9999 to 0000 at the end of the signal integration period, one or the other of these flip flops will toggle, depending on whether the positive polarity line or the negative polarity line is true. If the positive polarity line is true, the positive polarity flip flop toggles, its Q output going true. This disables nor gate P, keeping the pos. ref. integrate line from going true when the signal integrate line goes false. Since the negative polarity flip flop did not toggle, its Q output is false. This enables nor gate N as soon as the signal integrate line goes false. When nor gate N is enabled, the neg. ref. integrate line goes true, enabling the neg. ref. switch driver. The neg. ref. switch driver closes the FET neg. ref. switch. At this point the reference integration period begins and the output voltage from the integrator begins to ramp back toward zero volts. Had the input signal being measured been of negative polarity, the positive polarity line would have been false and the negative polarity line true at the end of the signal integration period. This would have caused the negative polarity flip flop to toggle when the signal integrate line went false, leaving the positive polarity flip flop in a reset state. This would have enabled nor gate P, setting the pos. ref. integrate line true (rather than the neg. ref. integrate line) and closed the neg. ref. switch.

4B.31 At the moment the output voltage from the Integrator crosses zero (on the reference integration slope) the positive polarity line and negative polarity line change state. That is, whichever one was true goes false and whichever one was false goes true. This causes the remaining polarity flip flop (positive polarity flip flop or negative polarity flip flop) to toggle. Whichever one did not toggle at the beginning of the reference integration period will do so at the end. This causes both nor gates N and P to be disabled so both the neg. ref. integrate line and the pos. ref. integrate line go (or remain) false. This opens both FET reference switches. When both the positive polarity flip flop and the negative polarity flip flop are in the set state, which occurs at the end of the reference integration period, nor gate M is enabled and the reset line goes true. This level is inverted by inverter Y and the $\overline{\text{reset}}$ line goes false. This holds the output of the integrator at a level of zero volts.

4B.32 When the reset line goes true at the end of the reference integration period, the strobe flip flop is actuated through or gate E. This causes the Q output of the strobe flip flop to go true which actuates the strobe generator which is a 10 microsecond one shot. The strobe generator causes the strobe line to go true for a 10 microsecond period. This is inverted by inverter A and causes the $\overline{\text{strobe}}$ line to go false for a 10 microsecond period. Then the strobe line goes true, nor gate B is disabled, stopping the clock signals from reaching the counter for the duration of the strobe time. The negative level of the $\overline{\text{strobe}}$ line gates the buffer storage units which translate whatever levels exist at their inputs at that moment to their outputs. This information is stored at the outputs of the buffer storage units until the next negative transition of the $\overline{\text{strobe}}$ line at the end of the next reading. The levels at the inputs of the buffer storage units are the output of the counter. Since the transition of the $\overline{\text{strobe}}$ line which actuates the buffer storage units comes exactly at the end of the signal integration period, and at that time the state of the counter represents the value of the voltage being measured, the reading displayed by the instrument equals the value of the signal voltage.

4B.33 At the end of the 10 microsecond strobe time, the strobe line again goes false and the $\overline{\text{strobe}}$ line again goes true. When the strobe line goes false, nor gate B is again enabled and allows clock signals to reach the counter. The counter continues counting until it reaches 9999 whereupon it again resets itself to 0000. On this, the second transition of the counter from 9999 to 0000, the 8000 line going false toggles the overrange flip flop but does not again toggle the control flip flop. (The overrange flip flop did not toggle on the first transition of the 8000 line, at the end of the signal integration period, because both its S and C inputs were held true by the signal integrate line which was true at that time. The control flip flop does not re-toggle on the second transition of the 8000 line because: a) the overrange flip flop, at that time has not yet toggled at all so its Q output is still false and its $\overline{Q}$ output is still true. b) the S and C inputs of the control flip flop are so connected that it cannot re-toggle until after the overrange flip flop does.) The counter continues to count until it again reaches a count of 9999 and resets itself to 0000. At this point the 8000 line again makes a transition from true to false. This time both the overrange flip flop and the control flip flop toggle. The overrange flip flop is reset and the control flip flop is set, causing the signal integrate line to go true, which initiates a new reading.

4B.34 If the input signal voltage is greater than 9999, the overrange flip flop is set before the output voltage from the integrator reaches zero volts. As long as the input signal voltage is less than 12.000V, which is the absolute maximum that the instrument will display, the instrument functions in exactly the same manner as outlined in the preceding paragraphs. The counter overflows to 0000 and begins counting up (to a maximum of 2000). When the zero crossing is detected the reset line goes true and toggles the strobe flip flop which triggers the strobe generator and the state of the counter at the moment of zero-crossing is read into the display. Since the overrange flip flop has been set, the 10,000 line is true at the time strobe is initiated. When the $\overline{\text{strobe}}$ line goes false the $\overline{Q}$ side of the overrange buffer storage unit goes false and the "1" digit is illuminated in the overrange (10,000's) window.

4B.35 Should the counter reach a count of 12,000 prior to the time the output voltage from the integrator reaches zero volts (input signal greater than 12,000V), both the $\overline{2000}$ line and the $\overline{10,000}$ line go false. This enables nor gate G whose output goes true setting the 12,000 line true. When the 12,000 line goes true it toggles the strobe flip flop through or gate E initiating the strobe pulse which causes the $\overline{\text{strobe}}$ line to go false, reading the momentary state of the counter (12,000) into the readout where it is stored by the buffer storage units until the next strobe occurance. Since the 12,000 line is true when the $\overline{\text{strobe}}$ line goes false, the overrange buffer storage unit lights the overrange light through driver T. Upon the completion of the 10 microsecond strobe, the counter continues to count until it again overflows back to 0000. At this point a new reading is initiated with the resetting of the control flip flop at the negative going transition of the 8000 line when the counter overflows. The output voltage from the null detector will reach zero sometime before the counter overflows as the signal input to integrator is limited to about $\pm$ 14 volts. If, for any reason, the counter reaches a count of 18,000 prior to zero detection, it stops and waits for zero detection at 18,000.

4B.36 TIMEOUT AND HOLD OPERATION

4B.37 During range-changing operations, the Digitizing and Display circuitry is inhibited from taking any new readings. This gives the analog circuits in the Signal Conditioning Module enough time to settle following range changes and prevents the display of erronious readings. To accomplish this, the ranging circuitry (located in the Signal Conditioning Module) generates a 500 millisecond timeout pulse. During the timeout period, the timeout line into the Digitizing and Display Module goes true. If the instrument is not in hold (off-on-hold switch in the Hold Position) or operating in an external command mode (from the optional BCD output module), the hold line will be false. Normally, when the instrument is not going through a timeout period, the timeout line is also false. When the output voltage from the Integrator reaches zero volts, during the reference integration period, the reset line goes true setting the $\overline{\text{reset}}$ line false. This is inverted by nor gate X, setting the read enable line true. When the read enable line is true, nor gate H is inhibited and the counter is allowed to count to 19999 (the overrange flip flop has been set) and reset to 00000, thus beginning a new read cycle. When timeout occurs, however, the timeout line goes true, inhibiting nor gate X so the read enable line stays false. When the counter reaches a count of 18000, the $\overline{\text{10,000}}$ line and the $\overline{\text{8000}}$ line both go false. At this point, all inputs to nor gate H are false and the gate is enabled, setting the read disable line true. When the read disable line goes true it disables nor gate B, preventing any further clock signals from reaching the counter, so the counter stops at 18000. At the conclusion of the timeout period, the timeout line goes false enabling nor gate X. This sets the read enable line true disabling nor gate H. At this point the read disable line goes false enabling nor gate B to pass clock signals to the counter. The counter continues counting until it reaches 19999, whereupon it overflows and a new reading begins.

4B.38 When the off-on-hold switch is placed in the hold position, the hold line goes true. This stops the counter at 18,000, in exactly the same manner as when the timeout line goes true. The difference is that the instrument remains that way until the switch is returned to the on position. At that time the instrument resumes normal operation just as it does when the timeout pulse ends.

4B.39 Instruments equipped with the BCD output module (optional) may be operated in an external command mode. In this way they can be programmed to take a reading only upon receiving a signal to do so from an external device, such as a computer. When an instrument is in this mode of operation the external command line into the Digitizing and Display Module is normally held in a false state. The instrument is placed in hold either by the front panel hold switch or by the external hold line (not shown on figure 4B.1). When an external "read command" is initiated, the external command line goes true setting the hold line false. The instrument takes a reading just as it does upon the completion of a timeout pulse.

4B.40 RANGING

4B.41 In order to facilitate automatic ranging operation, uprange and downrange signals are generated by the Digitizing and Display Module. These signals command the range counter in the Signal Conditioning Module to count up or down. If the instrument is in too low a range for the signal voltage being measured the counter will reach a full scale count of 12000 prior to the zero-crossing of the output voltage of the integrator on the reference integration period. When this occurs, the 12,000 line goes true initiating strobe action. When this happens, the $\overline{\text{12,000}}$ line (which is normally always in a true state) goes false. If the instrument is not already in the highest range, the highest range line into the Digitizing and Display Module will be false. This enables nor gate D setting the uprange line true. If the instrument is in too high a range for the signal being measured, null detection (and subsequently strobe) will occur before the counter reaches a count of 1000. This means that at the time strobe occurs the 1000 line is still false. If the instrument is not already in the lowest range the downrange flip flop remains in a reset state. Its $\overline{Q}$ side is true setting the downrange line true. If the instrument is already in the lowest range the lowest range line is true. This causes the downrange flip flop to be "set" as soon as the

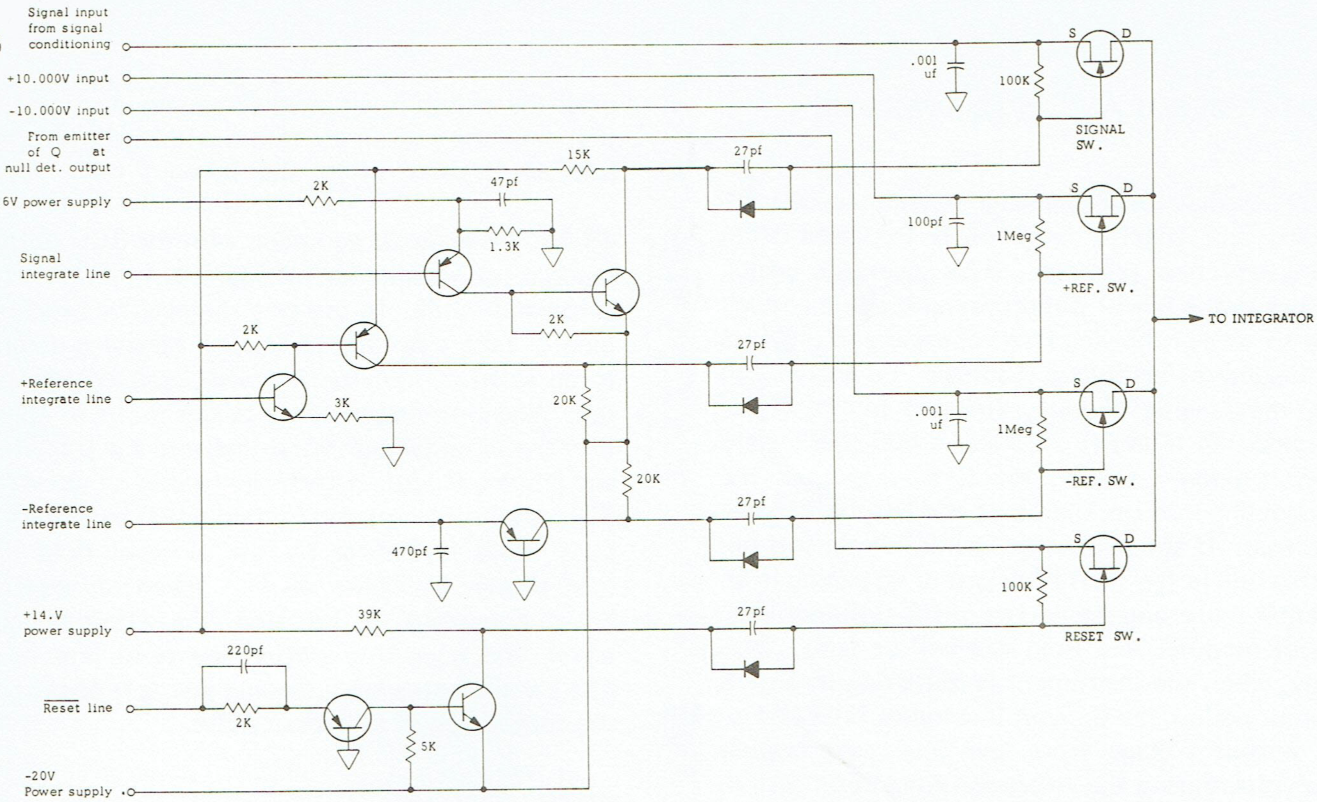


Figure 4B.9 - Schematic, FET switches and switch drivers

signal integrate line goes false at the end of the signal integrate period. When the downrange flip flop is "set" its $\overline{Q}$ side is false causing the downrange line to be false. Whenever the count of the counter is between 1000 and 12,000 at the time the Integrator zero-crossing occurs the 1000 line is true so the downrange flip flop is "set", resulting in no downrange signal and the $\overline{12,000}$ line is true, resulting in no uprange signal.

4B.42 FET SWITCHING CIRCUITRY

4B.43 The four switches at the input to the Integrator are N-channel, field-effect, junction transistors. They are driven by circuitry composed of discrete components. The FET switches and their driving circuitry are shown in figure 4B.9. The source and gate of each FET are connected to each other through fairly high value resistors (100K or 1 Meg). The gate of each FET connects to the driving circuitry through a series diode whose cathode connects to the collector of the driving transistor.

4B.44 In operation, the field-effect transistors are fully cut off (switch open) when the voltage at the gate, with respect to the source, is approximately -6V or more (-6V negative bias). When a FET is turned off, its driving transistor is either fully saturated (as is the case with the signal integrate switch and the reset switch) or fully turned off (as is the case with the + Ref Sw. and the - Ref Sw.). In either case the net effect places its collector voltage at -20V. Since the cathode of the diode which connects to the gate of the FET is connected to the driver transistor's collector it too is at a -20V potential. Under this condition, the diode is forward biased. Current flows through the resistor which is connected between the source and gate of the FET. This produces a voltage drop across the resistor which places the FET's gate voltage at nearly -20V. Since no input signal to any of the FET switches is more negative than about -14V (under overload conditions) this assures that the FET is completely cut off.

4B.45 When a FET is turned on (switch closed) its driver transistor's collector goes positive (relative to the most positive voltage that appears at the source of that particular FET). This causes the diode to be back biased so no current flows through it. Under this condition no current flows through the resistor connected between the source and gate of the FET so the source and gate are at the same potential (zero volts bias).

SECTION 4C

THEORY OF OPERATION OF THE POWER SUPPLY MODULE

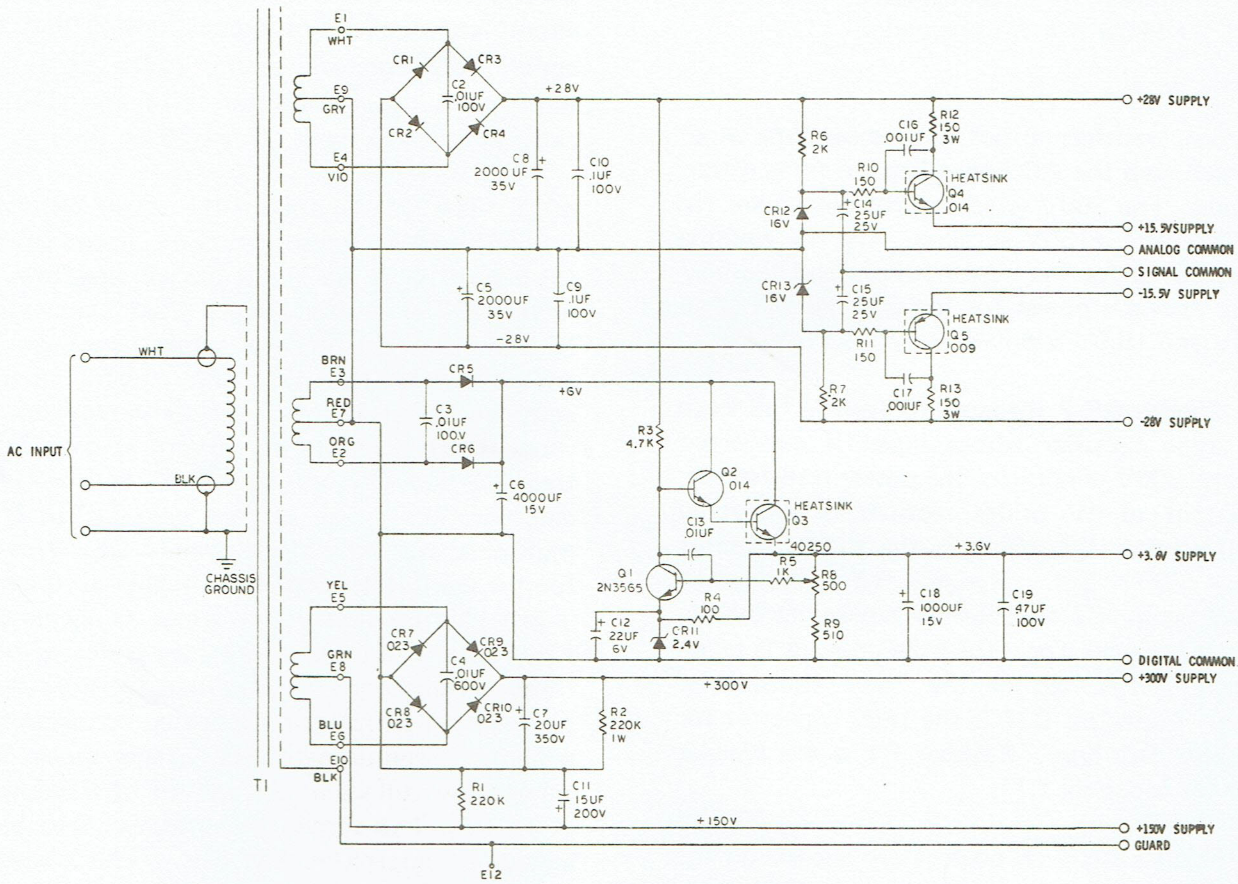


Figure 4C.1 - Power Supply

4C.1 INTRODUCTION

4C.2 The Power Supply Module, shown in detail in the schematic diagram section at the back of this manual, performs two distinct functions. It provides all DC operating power to the instrument and it serves to interconnect the Digitizing and Display Module and the Signal Conditioning Module. It is constructed on a single printed circuit board. Both the Digitizing and Display Module and Signal Conditioning Module plug into sockets on the Power Supply Module.

4C.3 POWER SUPPLY

4C.4 The Power Supply, shown in figure 4C.1, provides DC power to both the analog and digital portions of the instrument. Seven different voltage levels are provided. These are:

+ 28V	unregulated
- 28V	unregulated
+ 15.5V	regulated
- 15.5V	regulated
+ 3.6	regulated
+ 300V	unregulated
+ 150V	unregulated

The power transformer has three secondary windings which step the AC line voltage to three different levels. The 300V winding provides power for the +300V and +150V supplies. The 6V winding supplies power for the +3.6V supply and the 56V winding provides power for the positive and negative 28V and 15.5V supplies.

4C.5 Diodes CR-7 through 10 form a full wave bridge type rectifier whose input is connected across the 300V winding of the power transformer. The output of the bridge rectifier is connected across capacitor C7 which is the filter capacitor for the +300V line. Resistor R2 is connected across capacitor C7 as a bleeder resistor to eliminate shock hazard. The +150V DC output is taken from the center tap of the 300V transformer winding. Capacitor C11 is the filter capacitor for the +150V DC line. Resistor R1 is the bleeder resistor for capacitor C11.

4C.6 Diodes CR-1 through 4 are shown on the schematic diagram connected across the 56V transformer winding as a bridge. In operation, however, they do not function in exactly the same manner as a conventional full wave bridge rectifier. The winding is center tapped and this point is connected to digital common (ground). Diodes CR-3 and CR-4 form a full wave rectifier which charge capacitor C8 to +28V DC. C8 is connected between the +28V line and digital common and is the +28V filter capacitor. Similarly, diodes CR-1 and CR-2 form a full wave rectifier which charges capacitor C5 to -28V DC. C8 is connected between the -28V line and digital common and is the filter capacitor.

4C.7 Transistors Q4 and Q5 are series regulators which reduce the +28V to +15.5V and -28V to -15.5V respectively. Zener diodes CR-12 and CR-13 clamp the bases of these transistors at a 16V level. The voltages at the emitters of these transistors are always about 0.6V less than that at the bases and since the voltage at the bases is clamped by the zeners the 15.5V lines are regulated. Resistors R12 and R13, in series with the collectors of the regulator transistors, provide protection for the transistors in the event of an accidental short circuit between either 15.5V supply line and circuit common. The digital, analog and signal commons all connect together in the Signal Conditioning Module. Capacitors C14 and C15 filter zener noise and keep it off the 15.5V lines.

4C.8 The 6V winding of the power transformer is connected to circuit common. Diodes CR-5 and CR-6 and the center tap of the winding form a full wave rectifier which charges filter capacitor C6. In operation the voltage across capacitor C6 is approximately +6V DC with respect to circuit common. Transistor Q3 is a series regulator transistor which converts the +6V to +3.6V. Transistors Q2 and Q3 are connected in a Darlington configuration. The current gain of Q3 is thus multiplied by the current gain of Q2. Base drive for the Darlington connected regulator transistors is provided by resistor R3 which connects to the +28V line. It is controlled by the collector current through transistor Q1. Base bias for transistor Q1 comes through resistor R5 which connects to the wiper of potentiometer R8. Zener diode CR-11 clamps the voltage at the emitter of transistor Q1 at +2.4V. This forces the voltage at Q1's base to always be approximately +3V. This causes any voltage change at the wiper of potentiometer R8 to result in a directly proportional change in the current through resistor R5. Since this is the current controlling transistor Q2, the zener acts as a reference element which stabilizes the output voltage of the supply. Potentiometer R8 is adjusted to set the collector current through transistor Q1. The potentiometer is adjusted to a point to give enough base drive to the Darlington circuit to keep the emitter voltage of transistor Q3 at exactly +3.6V. If the voltage at the emitter of Q3 should drop (due to a change in either the line voltage or level current) the available base drive to transistor Q1 will also decrease. This will cause less collector current to flow through transistor Q1. More current is available as base drive for the regulator transistors. This current turns transistor Q3 on harder and raises the emitter voltage back to +3.6V.

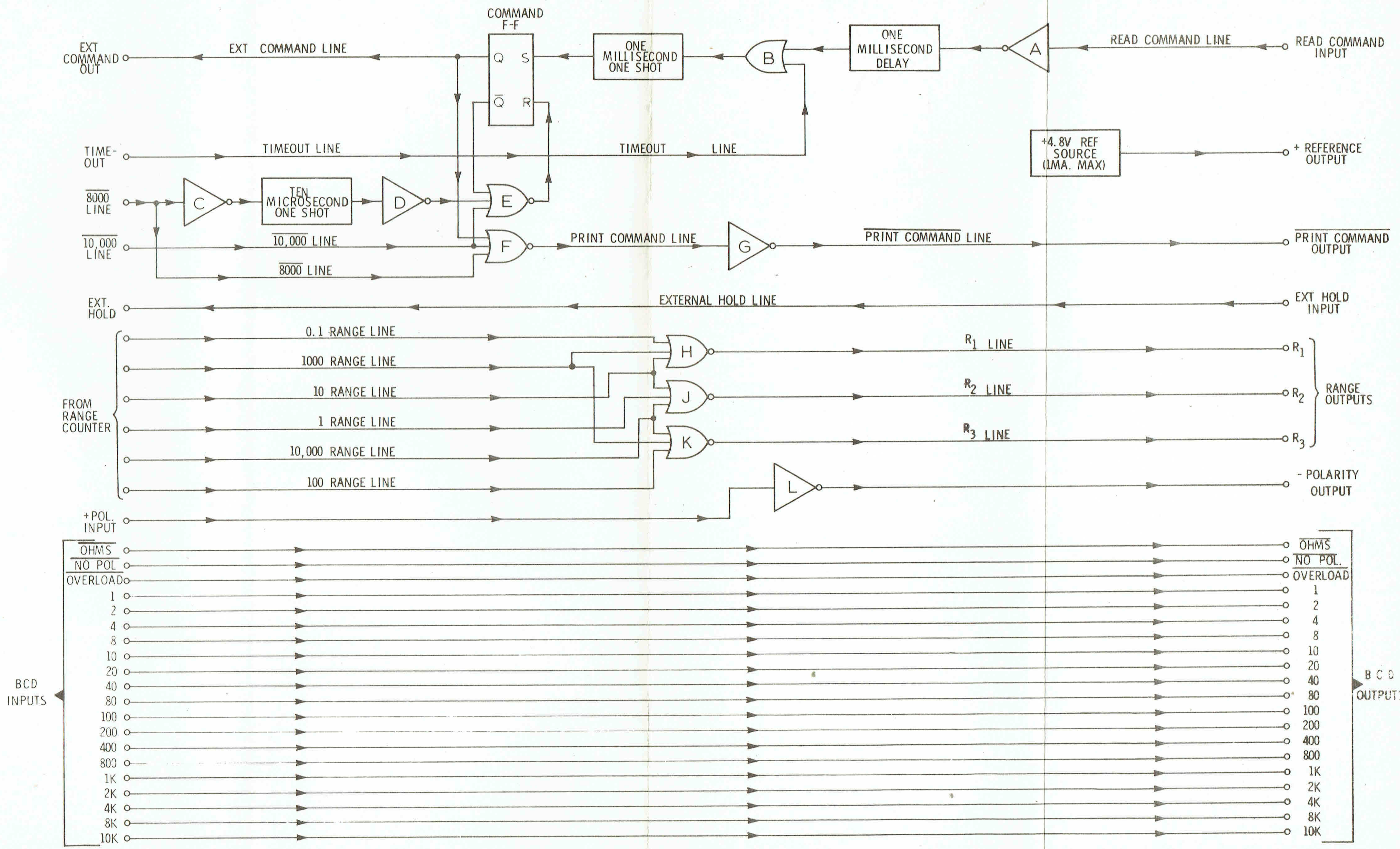


Figure 4D.1 BCD Output Module, Simplified Schematic.

SECTION 4D

THEORY OF OPERATION OF BCD OUTPUT MODULE (OPTIONAL)

4D.1 INTRODUCTION

4D.2 The BCD Output Module, shown in detail in the schematic diagram section at the back of this manual and in simplified form in figure 4D.1, is an optional feature which plugs into the rear of the instrument. It allows the instrument to be used as part of a larger digital system. Through the BCD Output Module, the instrument may be commanded to take a reading or to go into the "hold" mode. The module provides BCD outputs of function, range, and the state of the readout. In addition, a print command output is provided for use with digital printers.

4D.3 LOGIC LEVEL OF BCD OUTPUT

4D.4 The logic levels used by the RTL circuitry inside the instrument are +3.6V for a "true" state and 0V for a "false" state. This is converted by the BCD Output Module to approximately +5V for a "true" state and 0V for a "false" state to permit the instrument to be used with external T^2 (transistor-transistor) integrated-circuit logic. The logic level of the print command line (see figure 4D.1) is +12V for a "true" state and 0V for a "false" state. This permits it to be used with certain printers which require a higher level voltage. This voltage may be reduced to any desired level by connecting an external resistor between pins 43 and 48 of the output connector on the module (J-15).

4D.5 Transistor Q2 (shown as inverter G on figure 4D.1) is the print command output transistor. The "true" logic level of the print command line is determined by the voltage division ratio of resistors R8 and R9. When the print command line is in a "true" state transistor Q2 is fully turned off. When the line is in a "false" state Q2 is fully saturated.

4D.6 All other logic level conversions are done by dividing between the +28V line and the +3.6V line. Resistors R3 and R4 are a typical case in point. When transistor Q1 is turned off the -polarity line is in a "true" state. Resistors R3 and R4 form a voltage divider between the +28 and +3.6V lines such that the voltage at the -polarity line is approximately +5V. Resistors R5 through R7 and R15 through R34 perform the same function for their respective lines as does R4 for the -polarity line. Here the lower value resistor is inside the respective integrated circuit.

4D.7 RANGE CODING

4D.8 The instrument is equipped with six operating ranges, 0.1 through 10,000 (although not all ranges are used for all functions). Coding for which range is in use at any given time is brought out on three lines. These are designated the R_1, R_2, and R_3 lines. The state of these lines for each range is given in table 4D.1.

Table 4D.1

Range	R_1	R_2	R_3	BCD Value
0.1	False	True	True	6
1	True	False	True	5
10	False	False	True	4
100	True	True	False	3
1000	False	True	False	2
10,000	True	False	False	1

True = +5V (approx.)
False = 0V

4D.9 POLARITY

4D.10 A single line is brought out of the BCD Output Module carrying polarity information. This is designated the - POLARITY OUTPUT line. The + POLARITY INPUT line to the BCD Output Module (see figure 4D.1) connects to the Q side of the polarity flip flop (see figure 4B.1). When the instrument is in + polarity this line is true. The true level is inverted to false by inverter L (see figure 4D.1) and the - POLARITY OUTPUT line is false. When the instrument is in - polarity the input to inverter L is false so the - POLARITY OUTPUT line is true.

4D.11 + 4.8V REFERENCE SOURCE

4D.12 Diodes CR3 and CR4 are forward biased through resistor R14 between the + 28V and +3.5V lines. The voltage at the anode of CR4 is held at approximately +4.8V. Resistor R14 limits the maximum output current from this supply to approximately one milliampere.

4D.14 When the instrument is operated in the "external read command" mode, either the external hold line must be grounded or the off-on-hold switch on the front of the instrument must be in the "hold" position. If this is not done the instrument will continue taking readings automatically every 150 milliseconds.

4D.15 Resistors R12 and R13 bias the read command line at +5V. Thus the line (and the input to inverter A on figure 4D.1) is normally always in a "true" state. This holds the output of inverter A in a "false" state. The one millisecond delay shown at the output of inverter A on figure 4D.1 is caused by the charging time required for capacitor C4. Or gate B and the one millisecond one shot shown on figure 4D.1 are composed of resistor R10, capacitor C3, diode CR1, and ½ of M3. The command flip flop is composed of the other half of M3. Nor gates E and F and inverter A on figure 4D.1 are made from M2. Nor gates H, J, and K are M1. Resistor R2 and capacitor C1 comprise the ten microsecond one shot. Inverters C and D of figure 4D.1 are shown only because positive triggered one shots are assumed on the simplified schematic. Resistor R11 and zener diode CR1 protect the input of inverter A from overload damage if an excessive voltage is applied to the READ COMMAND INPUT. Diode CR5 prevents the external hold line from going negative.

4D.16 When an externally commanded reading is initiated, the READ COMMAND INPUT is grounded, setting the read command line false. This causes the output of inverter A to go true which appears as a true input to or gate B after a one millisecond delay (to prevent false triggering due to noise or "bouncing" switch contacts). The output of or gate B goes true enabling the one millisecond one shot which generates a one millisecond pulse. This pulse sets the command flip flop causing its Q output to go true. This sets the external command line true, which causes the instrument to take a reading.

4D.17 In the process of taking each new reading, the digital counter in the Digitizing and Display Module of the instrument counts from 00000 to 09999. It then resets to 00000 and counts to 18000 where it stops to await a new read command. (See section 4B.) When the counter reaches a count of 18000, the 8000 line goes false. This enables the ten microsecond one shot. Since the 10000 line is already false (having gong false when the counter reaches 10000) the output of the ten microsecond one shot enables nor gate E if the timeout line is not true. The output of nor gate E goes true for a ten microsecond period, resetting the command flip flop. When the command flip flop is reset, its Q output goes false. This enables nor gate F (since the 10000 and 8000 lines are already false). When nor gate F is enabled, the print command line goes true. This is inverted by inverter G, setting the print command line false. When the print command line goes false it triggers the external digital printer (or other circuitry).

4D.18 If, during the process of taking a reading a range change is involved, the timeout line will be set true before the counter reaches 18000. In this event the command flip flop is not reset and the instrument continues taking readings until the correct range is found. In this event the print command line remains true until the instrument has settled on the correct range.

05 OPTION
PIN CONNECTIONS

IDENTIFICATION		PINS J20			IDENTIFICATION
RANGE	R1	1	26	R3	RANGE
RANGE	R2	2	27	R4	RANGE
FUNCTION	F2	3	28	F4	FUNCTION
FUNCTION	F1	4	29	F3	FUNCTION
UNITS	X1	5	30	X3	UNITS
UNITS	X2	6	31	X4	UNITS
10'S	X1	7	32	X3	10'S
10'S	X2	8	33	X4	10'S
100'S	X1	9	34	X3	100'S
100'S	X2	10	35	X4	100'S
1000'S	X1	11	36	X3	1000'S
1000'S	X2	12	37	X4	1000'S
10,000'S	X1	13	38	X3	10,000'S
10,000'S	X2	14	39	X4	10,000'S
		15	40		
		16	41		
OVERLOAD	X1	17	42	X3	OVERLOAD
OVERLOAD	X2	18	43	X4	OVERLOAD
		19	44		
		20	45		
		21	46	READ COMMAND INPUT	
		22	47	$\overline{\text{EXTERNAL HOLD}}$	
		23	48	$\overline{\text{PRINT COMMAND}}$	
LOGIC COMMON	24	24	49		
+ LOGIC REFERENCE		25	50	LOGIC COMMON	

MODEL 05 OUTPUT OPTION													Binary Weight
J20 Pin No's	1	2	26	27	4	3	29	28	17	18	42	43	
RANGE 0.1	0	1	1	0									6
RANGE 1	1	0	1	0									5
RANGE 10	0	0	1	0									4
RANGE 100	1	1	0	0									3
RANGE 1000	0	1	0	0									2
RANGE 10,000	1	0	0	0									1
FUNCTION OHMS					0	1	0	0					2
FUNCTION AC					1	1	0	0					3
FUNCTION –					1	1	1	0					7
FUNCTION +					1	0	1	0					5
OVERLOAD									0	0	0	0	0
NO OVERLOAD									1	0	0	0	1
CODE	1	2	4	8	1	2	4	8	1	2	4	8	

SAMPLE DATA VALUES

	10,000				1000				100				10				UNITS			
J20 Pin No's	13	14	38	39	11	12	36	37	9	10	34	35	7	8	32	33	5	6	30	31
00001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
00007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
00014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
00101	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
01246	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0
12000	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Code	1	2	4	8	1	2	4	8	1	2	4	8	1	2	4	8	1	2	4	8

0 = FALSE

1 = TRUE

SECTION 4E

INTEGRATED CIRCUITS USED IN THE 4500

4E.1 DIGITAL INTEGRATED CIRCUITS

4E.2 The following basic digital integrated circuit elements are used in the type 4500 DMM:

MC817P	Quad Two-input NOR Gate
MC824P	Quad Two-input NOR Gate
MC879P	Multifunction
MC889P	Hex Inverter
MC890P	Dual J-K Flip-flop
MC892P	Triple-3-Input Gate
CuL9958	Decade Counter
CuL9959	Buffer Storage Unit
CuL9960	Decoder Display Driver

4E.3 The physical and electrical characteristics of each of these basic elements are tabulated in figures 4E.6 through 4E.14 of this section.

4E.4 ANALOG INTEGRATED CIRCUITS

4E.5 The following basic analog integrated circuits are used in the type 4500 DMM:

Type 301A	Differential Amplifier
Type 709C	Differential Amplifier
Type 741C	Differential Amplifier

4E.6 The physical and electrical characteristics of each of these basic elements are tabulated in figures 4E.15 through 4E.17 of this section.

4E.7 FLIP-FLOP OPERATING MODES

4E.8 The J-K flip-flop is used in both the Signal Conditioning and Digitizing and Display Modules of the DMM. Figure 4E.5 shows the five common modes of operating the J-K flip-flop. Output Q, prior to the receipt of the Cd pulse, is determined by the previous state of the flip-flop. Output Q is the inverse of Q.

4E.9 The R-S flip-flop is used in the Digitizing and Display Module and in the optional BCD Output Module. Figure 4E.1 shows how two NOR gates are interconnected so as to obtain an R-S flip-flop. In the "reset" state, the Q output of the R-S flip-flop is low (false) and the Q output is high (true). The flip-flop will "set" when the S input goes high (true), provided the R input is not also high (true). The flip-flop will be "reset" when the R input goes high (true), provided the S input is not still high.

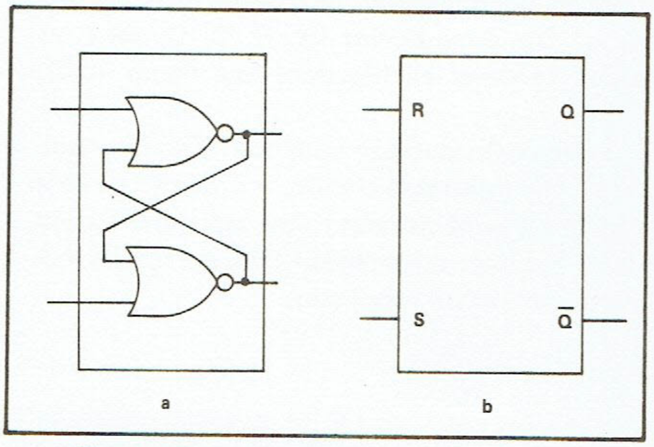


Figure 4E.1 - Interconnected Nor Gates

4E.10 SCHEMATIC IDENTIFICATION OF LOGIC DEVICES

4E.11 Reference designators for all devices regardless of type have the letter "M" as a designating letter. This is followed by a number to identify the component uniquely (see figure 4E.2).

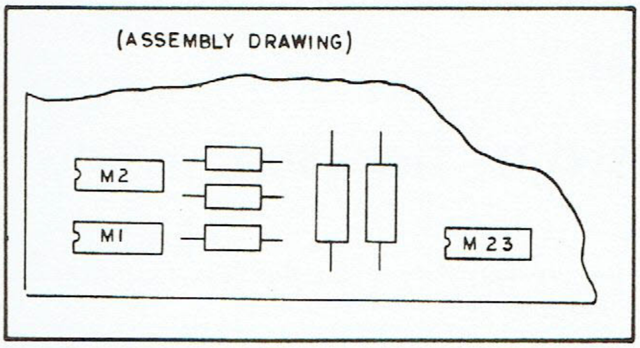


Figure 4E.2 - Component Identification

4E.12 Identification of logic function symbols. Individual logic functions are identified on the schematic by the designator of the logic device in which they appear (except on the simplified schematics in the "Theory of Operation" sections). In most cases, circuitry for more than one function is encased within the same module. To distinguish between them, an additional letter designator is affixed on the schematic, to indicate different sections of the same device (A, B, C, D, etc.), as required to cover all functions (see figure 4E.3).

4E.13 Input-Output pin numbers. The pin numbers of the integrated-circuits are placed outside the function symbols next to the input and output leads on the main schematics. They are not included on the simplified schematics.

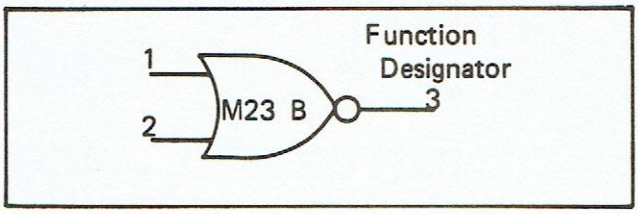


Figure 4E.3 - Function Designator

4E.14 Circuit diagrams of integrated-circuit devices. Circuit diagrams of the individual integrated-circuit devices, both analog and digital, do not appear on each schematic; rather, schematics in figures 4E.7 through 4E.18 describe all elements used.

4E.15 Restriction on logic symbols usage. On schematics appearing in the schematic diagram section at the back of this manual that contain both integrated circuits and discrete components, the logic symbols describe only that circuitry which is contained within the devices. In other words, no logic symbols are used to represent a function that is made up of discrete components. On the simplified schematics appearing in the "Theory of Operation" sections this rule is not adhered to.

4E.16 Standard Symbols. Figure 4E.4 shows the standard integrated-circuit logic symbols used on Dana drawings.

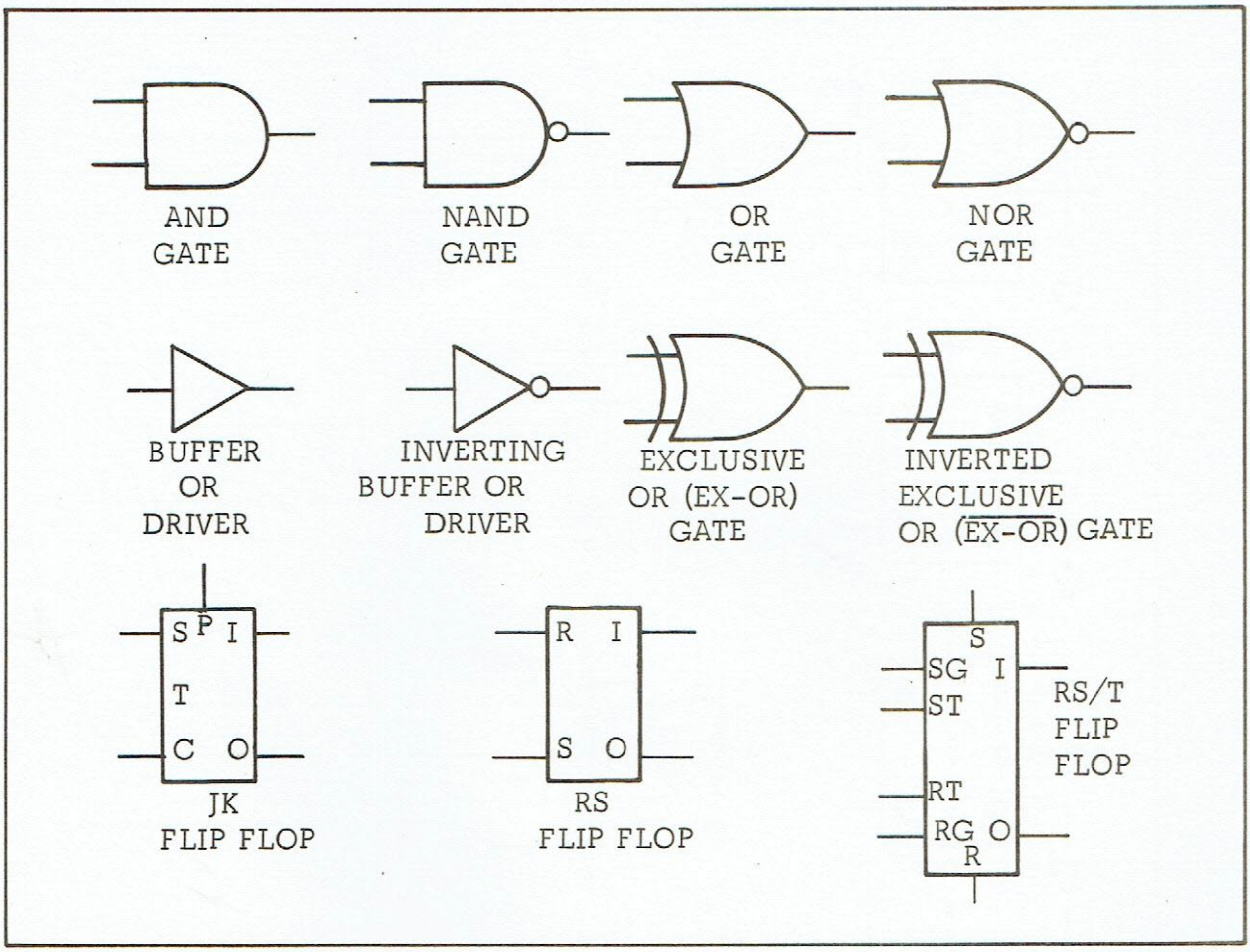


Figure 4E.4 - Logic Symbols

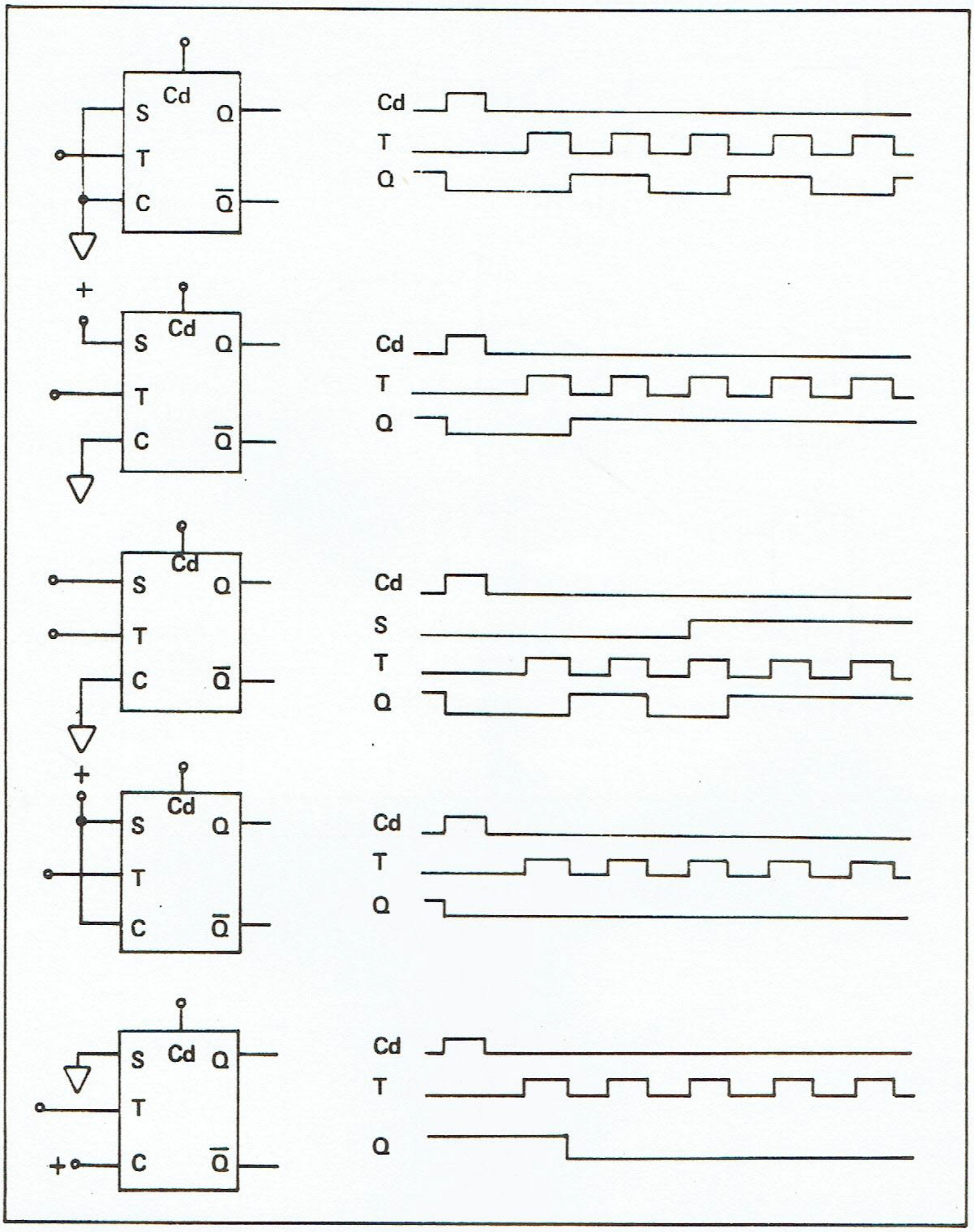


Figure 4E.5 - Flip-Flop Operating Modes

Type 741C

Amplifier / Linear Integrated Circuit

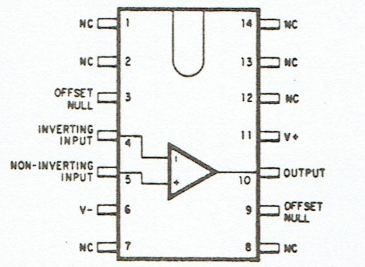
ABSOLUTE MAXIMUM RATINGS

Supply Voltage	± 18V
Internal Power Dissipation	500 mW
Differential Input Voltage	± 30V
Input Voltage (Note 1)	± 15V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	0°C to +70°C
Lead Temperature (Soldering, 60 sec)	300°C
Output Short-Circuit Duration (Note 2)	Indefinite

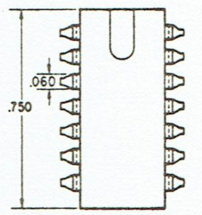
NOTE 1: For Supply Voltages less than ± 15V, the absolute maximum input voltage is equal to the Supply Voltage.

NOTE 2: Short circuit may be to ground or either supply.

GENERAL DESCRIPTION — The type 741C is a high performance monolithic differential amplifier constructed on a single silicon chip. It is intended for a wide range of analog applications. The high gain and wide range of operating voltages provide excellent performance in integrator, summing amplifier, and general feedback applications. The 741C is short-circuit protected and requires no external components for frequency compensation. The internal 6 dB/octave roll-off insures stability in closed loop applications.

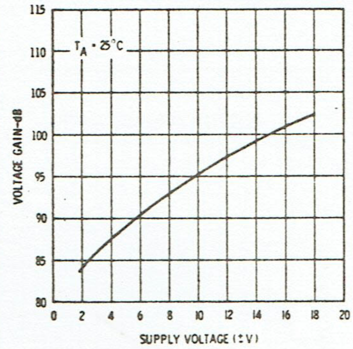


CONNECTION DIAGRAM

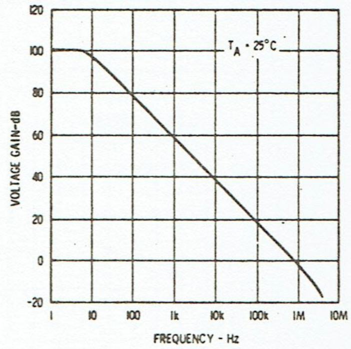


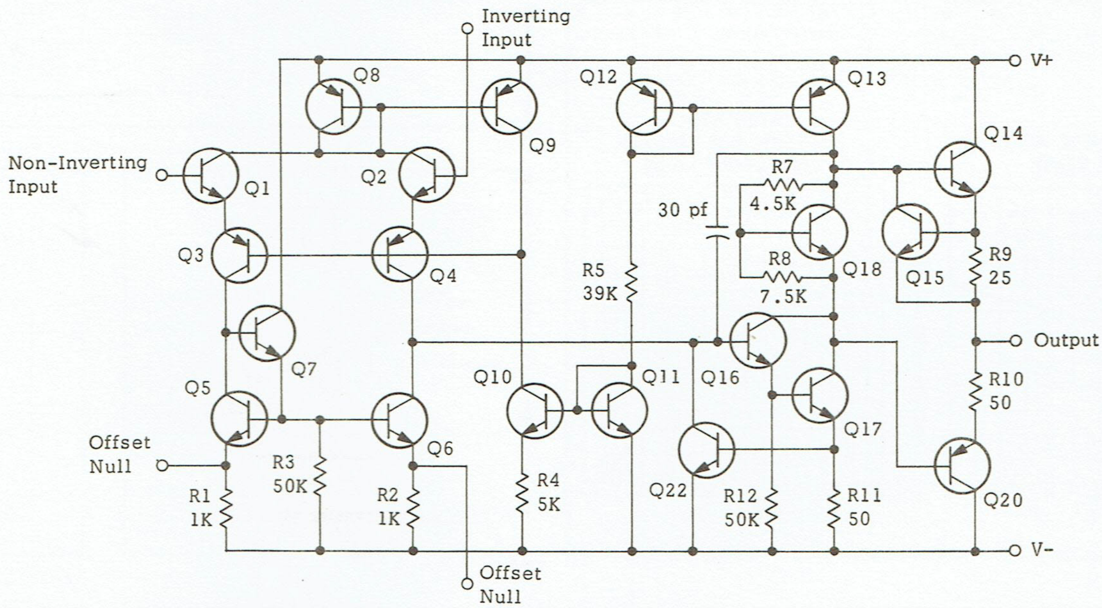
CONNECTOR

OPEN LOOP VOLTAGE GAIN



OPEN LOOP FREQUENCY RESPONSE





ELECTRICAL CHARACTERISTICS (V_s = ± 15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$R_s \leq$ 10k		2.0	6.0	mV
Input Offset Current			30	200	nA
Input Bias Current			200	500	nA
Input Resistance		0.3	1.0		MΩ
Large-Signal Voltage Gain	$R_L \geq$ 2k, V_{out} = ± 10V	20,000	100,000		
Output Voltage Swing	$R_L \geq$ 10k	± 12	± 14		V
	$R_L \geq$ 2k	± 10	± 13		V
Input Voltage Range		± 12	± 13		V
Common Mode Rejection Ratio	$R_s \leq$ 10k	70	90		dB
Supply Voltage Rejection Ratio	$R_s \leq$ 10k		30	150	µV/V
Power Consumption			50	85	mW

980415

Type 709C

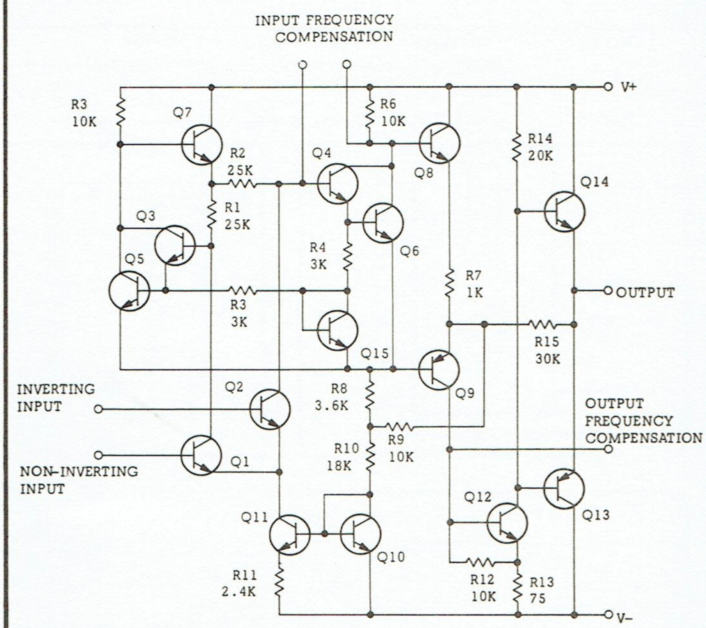
Amplifier / Linear Integrated Circuit

ABSOLUTE MAXIMUM RATINGS

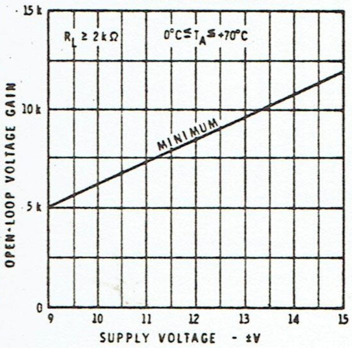
Supply Voltage	± 18V
Internal Power Dissipation (Note 1)	250 mW
Differential Input Voltage	± 5.0 V
Input Voltage	± 10 V
Output Short-Circuit Duration (T_A = 25°C)	5 sec
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	0°C to +70°C
Lead Temperature (Soldering, 60 sec)	300°C

NOTE 1: Rating applies for ambient temperatures to +70°C.

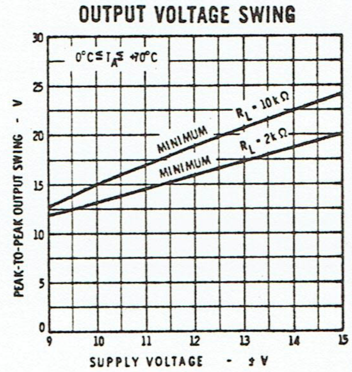
GENERAL DESCRIPTION — The type 709C is a high-gain differential amplifier constructed on a single silicon chip. It features low offset, high input impedance, large input common mode range, high output swing under load and low power consumption. The device displays excellent temperature stability and will operate over a wide range of supply voltages with little degradation of performance.



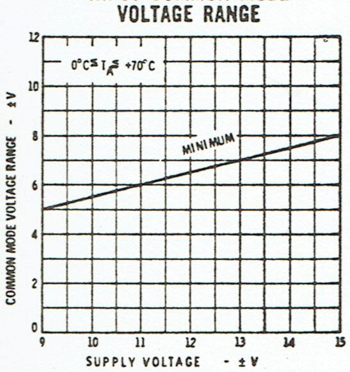
VOLTAGE GAIN



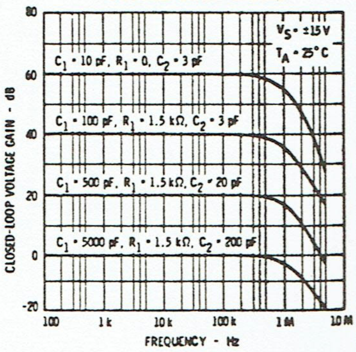
OUTPUT VOLTAGE SWING

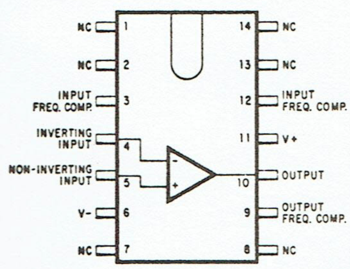


INPUT COMMON MODE VOLTAGE RANGE

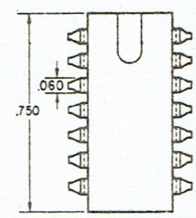


FREQUENCY RESPONSE FOR VARIOUS CLOSED-LOOP GAINS





CONNECTION DIAGRAM



CONNECTOR

ELECTRICAL CHARACTERISTICS (V_s = ± 15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$R_s \leq$ 10k, ± 9V $\leq V_s \leq$ ± 15V		2.0	7.5	mV
Input Offset Current			100	500	nA
Input Bias Current			0.3	1.5	μA
Input Resistance		50	250		k
Output Resistance			150		
Large-Signal Voltage Gain	$R_L \geq$ 2k, V_{out} = ± 10V	15,000	45,000		
Output Voltage Swing	$R_L \geq$ 10k	± 12	± 14		V
	$R_L \geq$ 2k	± 10	± 13		V
Input Voltage Range		± 8.0	± 10		V
Common Mode Rejection Ratio	$R_s \leq$ 10k	65	90		dB
Supply Voltage Rejection Ratio	$R_s \leq$ 10k		25	200	μV/V
Power Consumption			80	200	mW

Type 301A

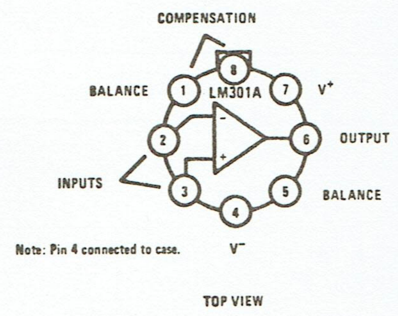
Amplifier/Linear Integrated Circuit

The type 301A is a general purpose differential, integrated-circuit amplifier which features low input currents and low temperature drift of the input current. The amplifier is provided with overload protection on the input and output and will not latch-up when the common mode range is exceeded. The open loop response is rolled off externally with the use of a 30 pf capacitor. This allows the compensation to be tailored to a particular application. The unit provides excellent accuracy and low noise in high impedance circuitry. The low input currents make it particularly well suited for long interval integrators or timers.

absolute maximum ratings

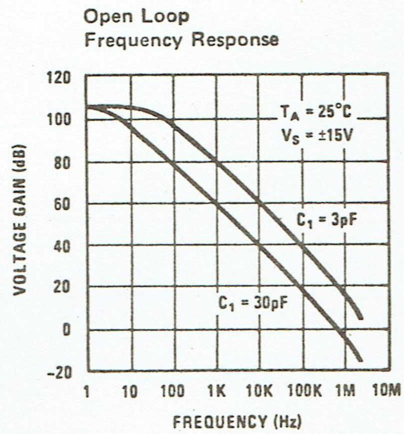
Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to 70°C

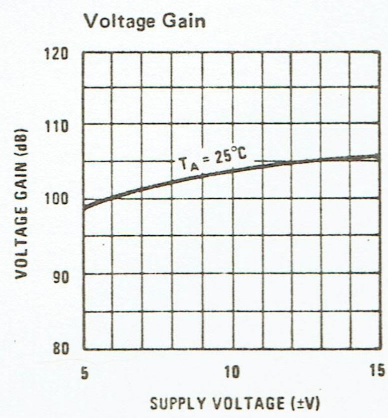
connection diagram



electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Resistance	$T_A = 25°C$	0.5	2		MΩ
Supply Current	$T_A = 25°C$, $V_S = \pm15V$		1.8	3.0	mA
Input Offset Voltage	$R_S \leq 50\ k\Omega$			10	mV
Input Offset Current				70	nA
Input Bias Current				300	nA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 2\ k\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$ $R_L = 2\ k\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm15V$	±12			V
Common Mode Rejection Ratio	$R_S \leq 50\ k\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 50\ k\Omega$	70	96		dB





Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C.

Note 4: These specifications apply for $0°C \leq T_A < 70°C$, $\pm5V \leq V_S \leq \pm15V$ and C1 = 30 pF unless otherwise specified.

980415

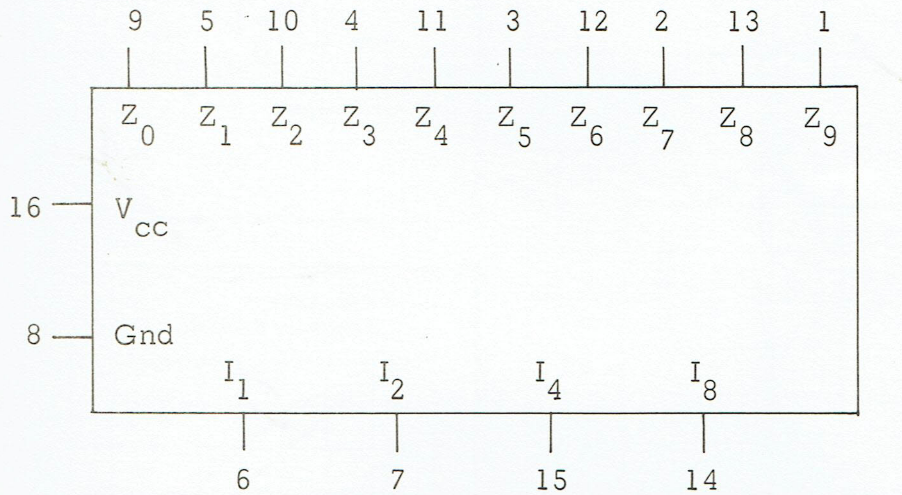
CµL 9960

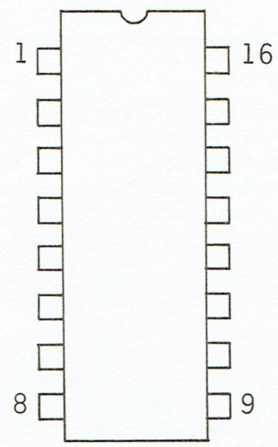
Decoder Display Driver

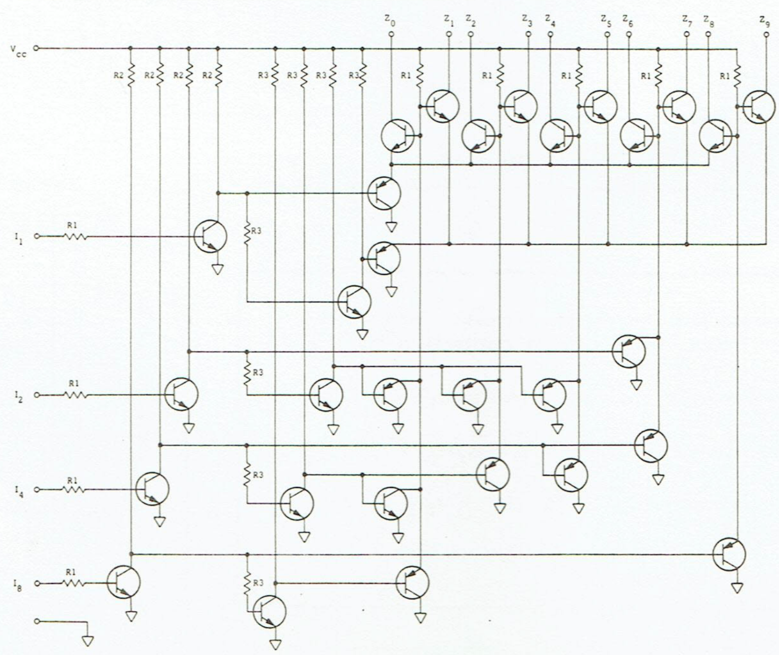
Input \ Digit	0	1	2	3	4	5	6	7	8	9
1	1	0	1	0	1	0	1	0	1	0
2	1	1	0	0	1	1	0	0	1	1
4	1	1	1	1	0	0	0	0	1	1
8	1	1	1	1	1	1	1	1	0	0

1 = Vcc 0 = Gnd

R_1	2K
R_2	4K
R_3	5K
V_{off}	+0.4V Max.
V_{on}	+1.0V Min.
I_{out}	10.0 Ma Max.
V_{cc}	+4.4V ± 25%





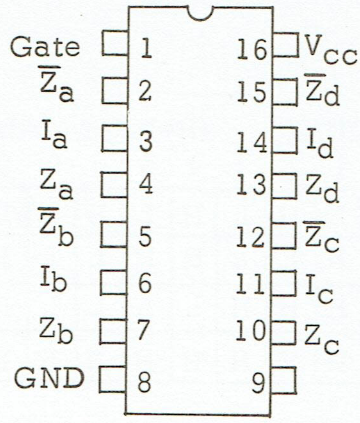


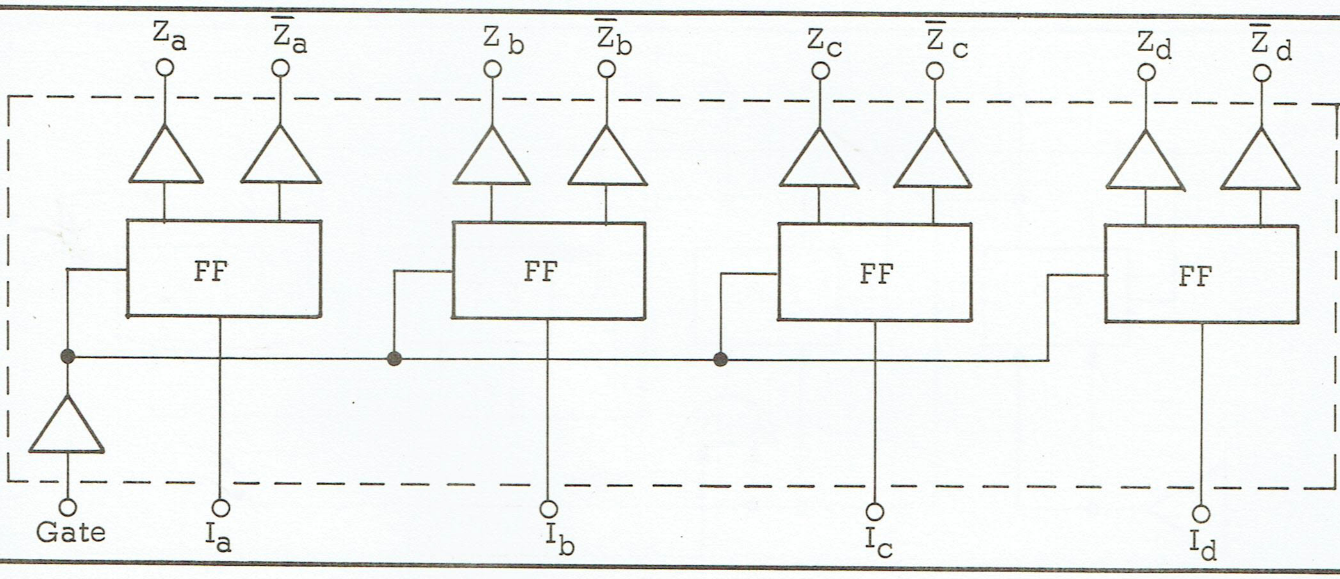
CμL 9959

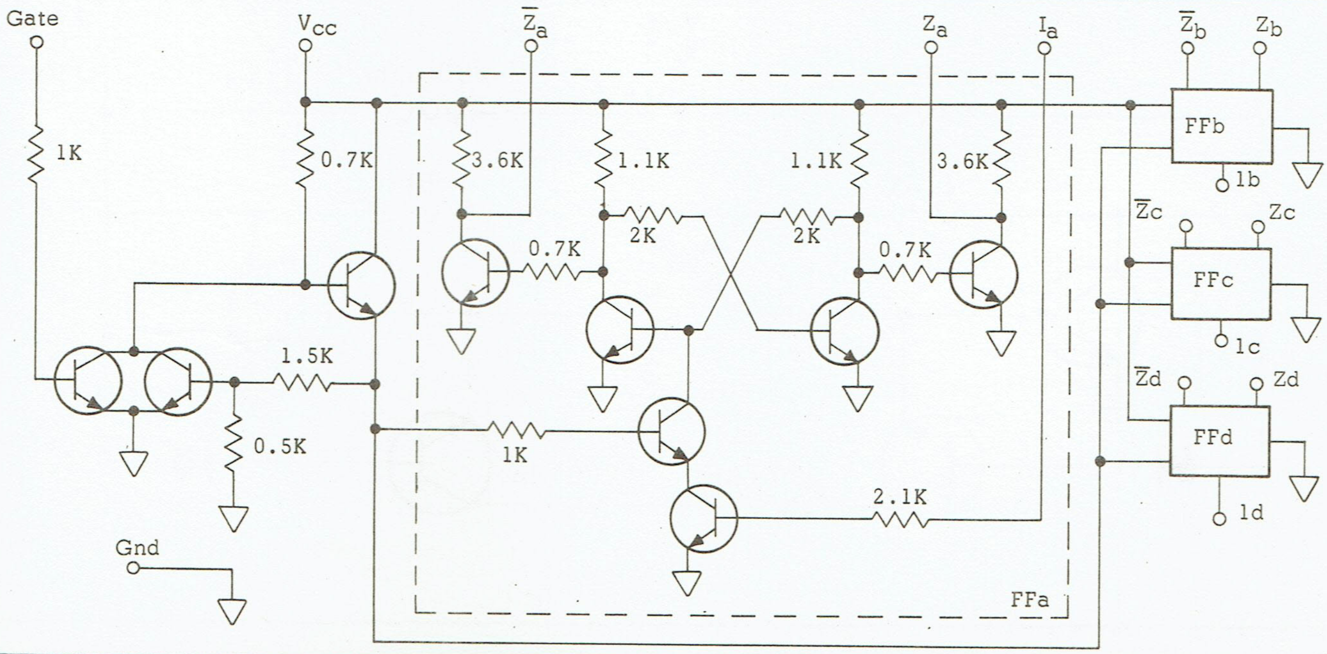
Buffer Storage Unit

Gate	I	Z	$\overline{Z}$
L	L	L	H
L	H	H	L
H	ANY	Q	$\overline{Q}$

H = HIGH
L = LOW
Q = THE STATE ASSUMED PRIOR TO "GATE HIGH" IS MAINTAINED





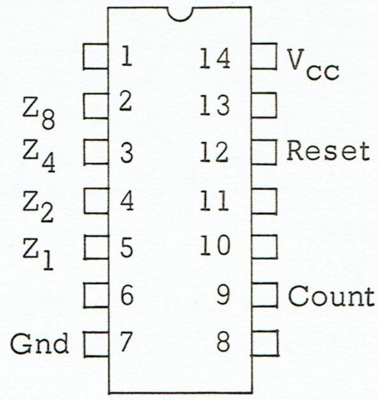


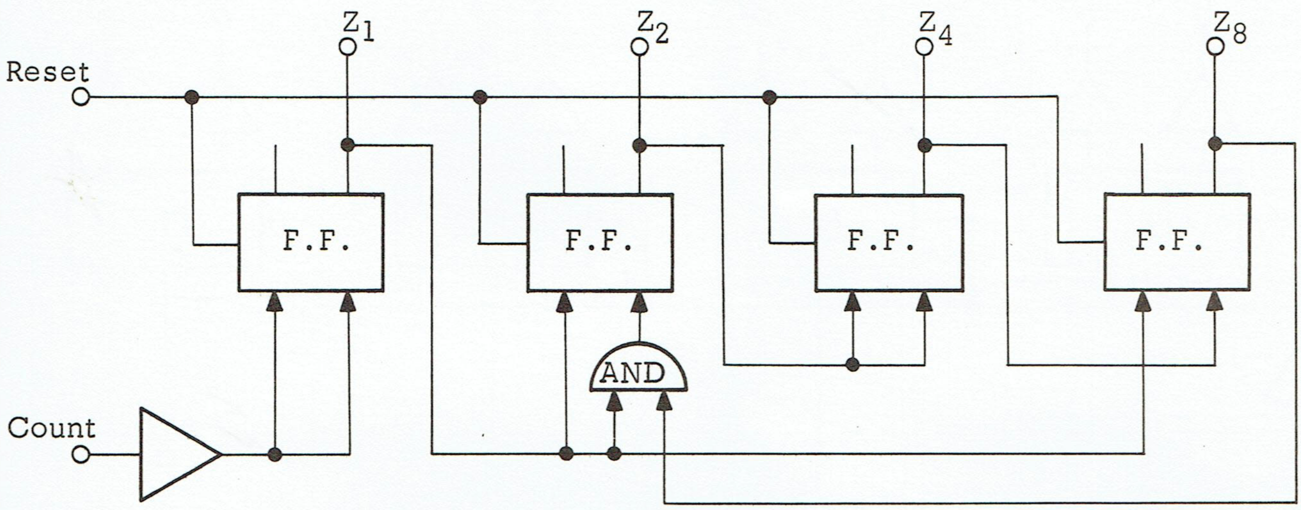
CμL 9958

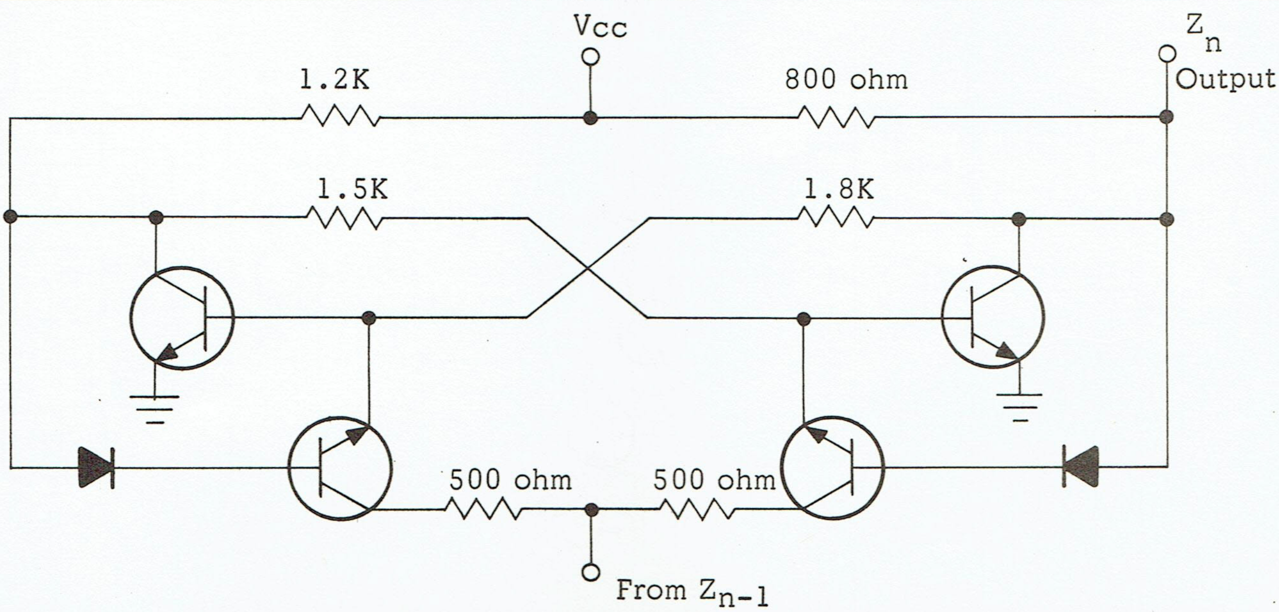
Decade Counter

COUNT (H=High, L=Low)

	0	1	2	3	4	5	6	7	8	9
Z_1	H	L	H	L	H	L	H	L	H	L
Z_2	H	H	L	L	H	H	L	L	H	H
Z_4	H	H	H	H	L	L	L	L	H	H
Z_8	H	H	H	H	H	H	H	H	L	L



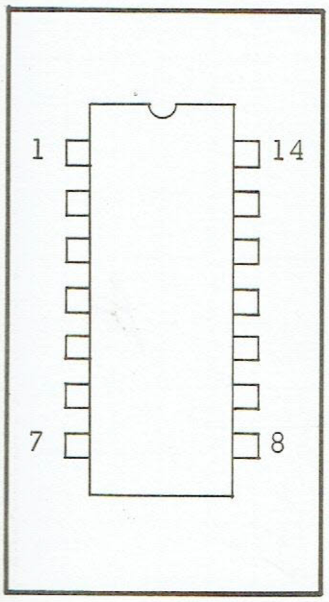


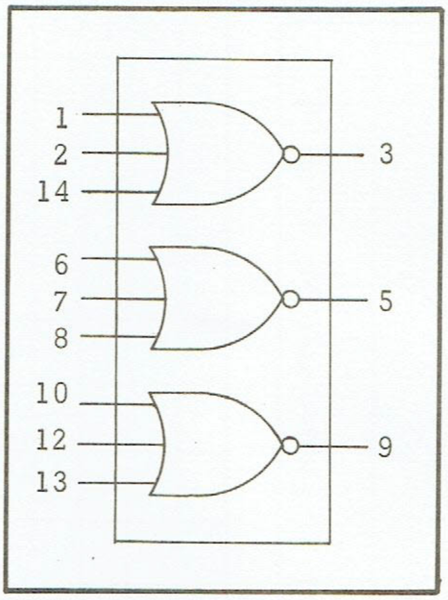


MC 892 P

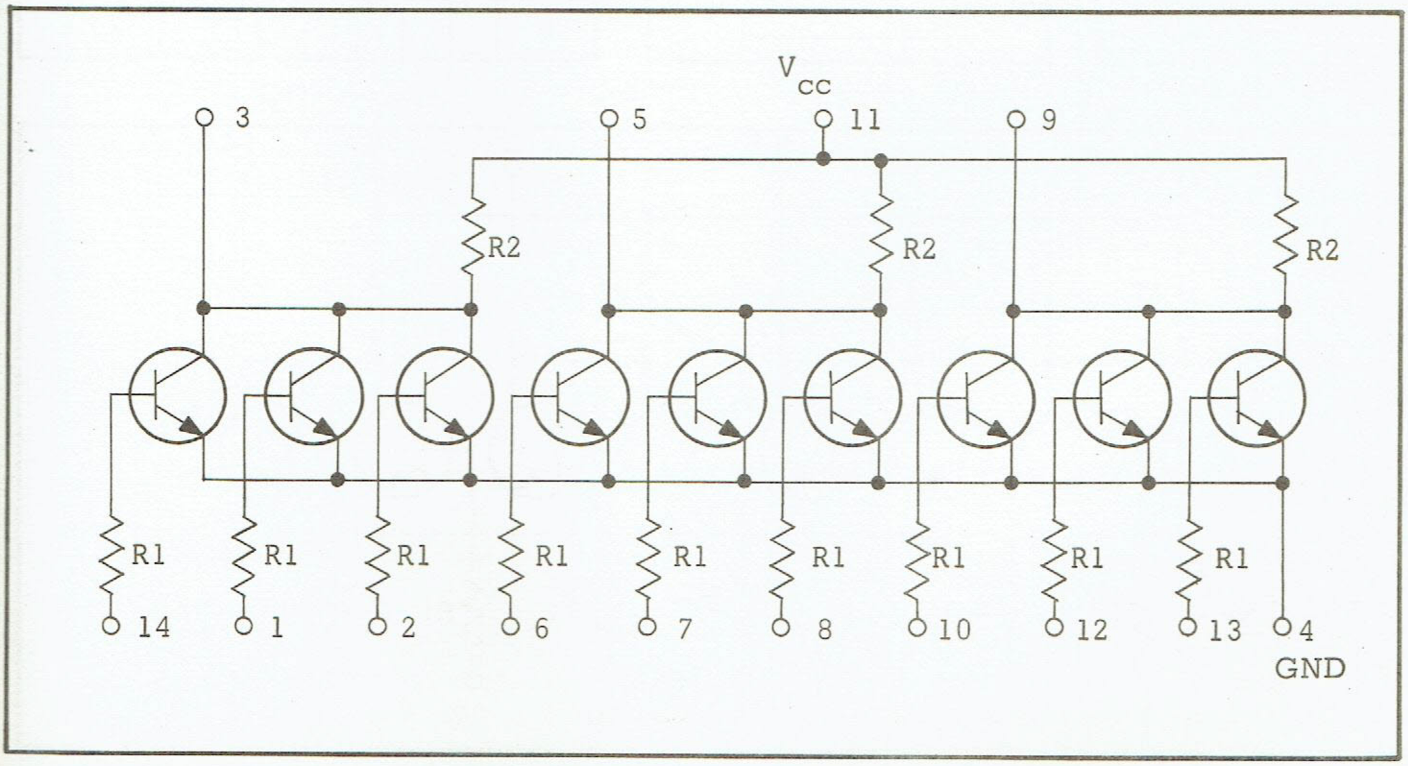
Triple 3 - Input Gate

R_1	450 ohms
R_2	640 ohms





Inputs									Outputs		
1	2	14	6	7	8	10	12	13	3	5	9
0	0	0							1		
0	0	1							0		
0	1	0							0		
0	1	1							0		
1	0	0							0		
1	0	1							0		
1	1	0							0		
1	1	1							0		
			0	0	0					1	
			0	0	1					0	
			1	0	1					0	
			0	1	1					0	
			1	0	0					0	
			1	0	1					0	
			1	1	0					0	
			1	1	1					0	
						0	0	0			1
						0	0	1			0
						0	1	0			0
						0	1	1			0
						1	0	0			0
						1	0	1			0
						1	1	0			0
						1	1	1			0

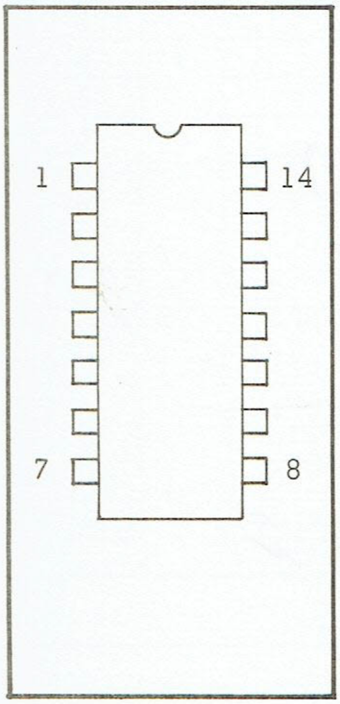


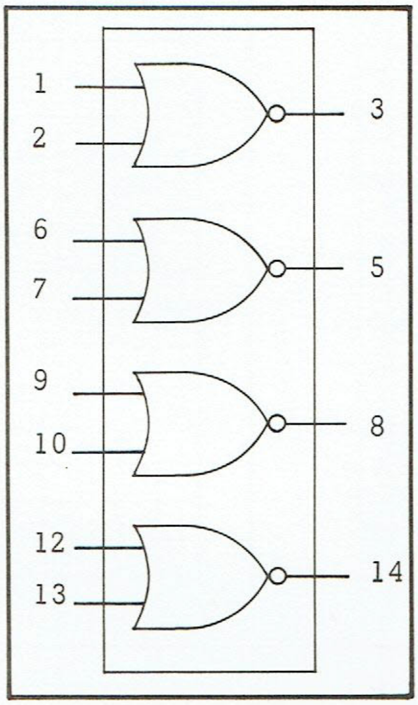
MC 817P / MC 824P

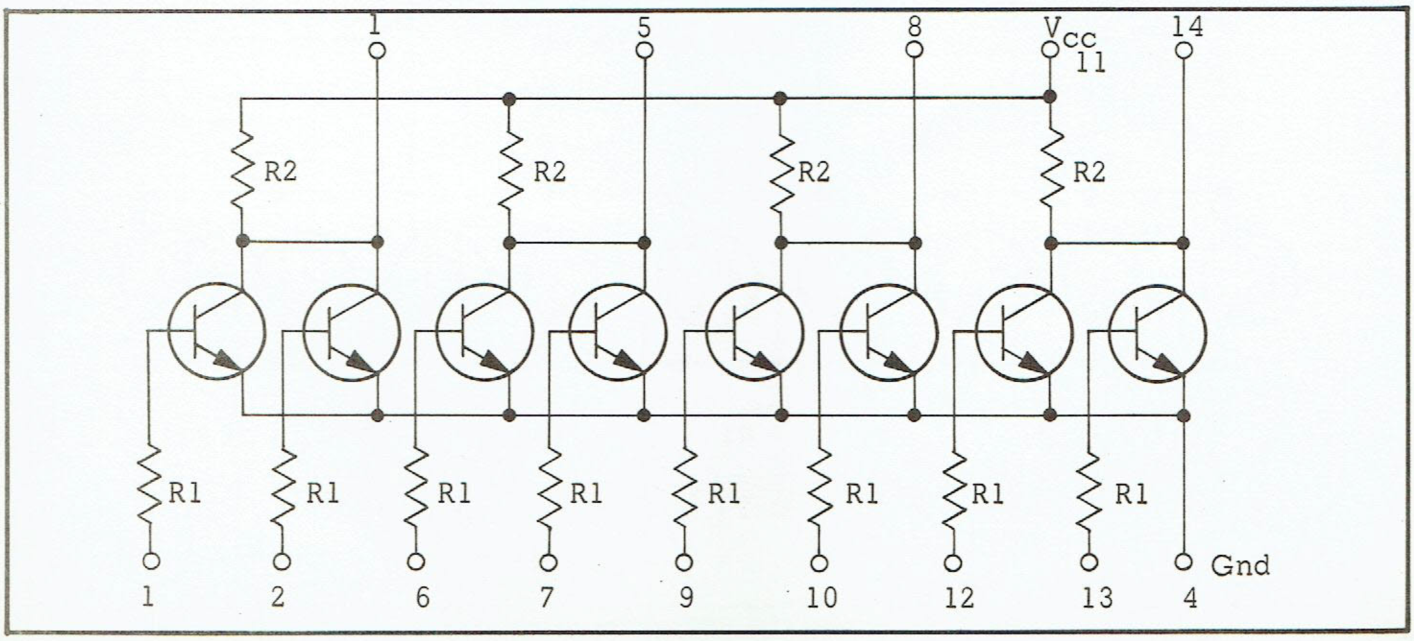
Quad 2 - Input Nor Gate

	MC817P	MC824P
R_1	1.5K	450 Ohms
R_2	3.6K	640 Ohms
V_{off}	0.46 Max	
V_{on}	0.85 Min	
V_{out}	0.3 Max	
V_{cc}	3.6 ± 10%	

Inputs								Output			
1	2	6	7	9	10	12	13	3	5	8	14
0	0							1			
1	0							0			
0	1							0			
1	1							0			
		0	0						1		
		1	0						0		
		0	1						0		
		1	1						0		
				0	0					1	
				1	0					0	
				0	1					0	
				1	1					0	
						0	0				1
						1	0				0
						0	1				0
						1	1				0



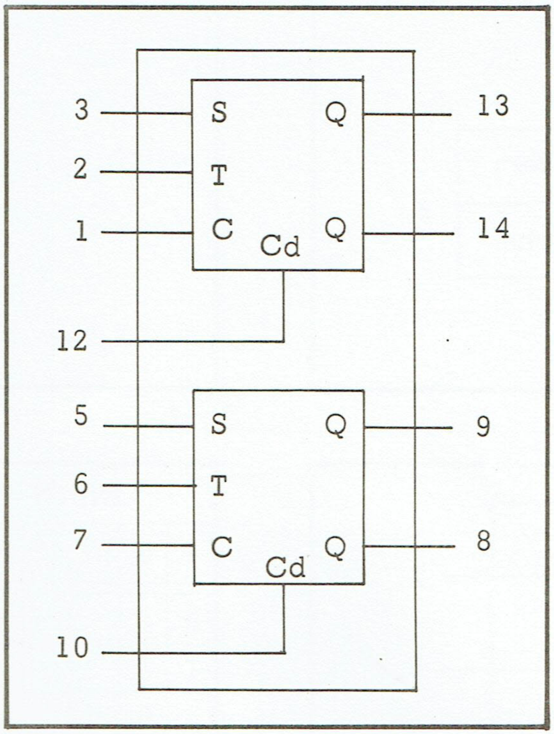


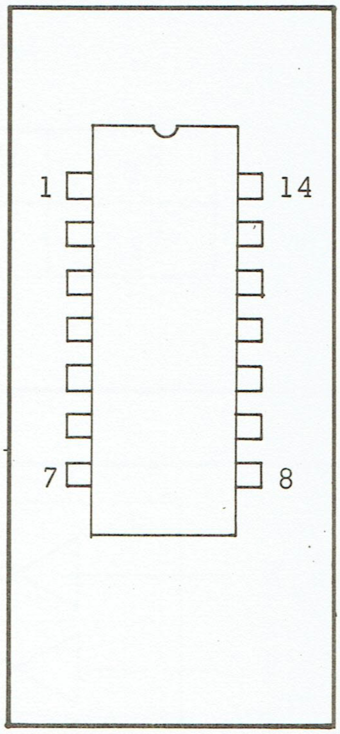


MC 890 P

Dual 3-K Flip-Flop

R_1	450 Ohms
R_2	640 Ohms
R_3	510 Ohms
R_4	225 Ohms
R_5	300 Ohms
V_{off}	+0.46V Max
V_{on}	+0.85V Min
V_{out}	+0.3V Max
V_{cc}	+3.6V ± 10%
f_{tog}	4 mHz



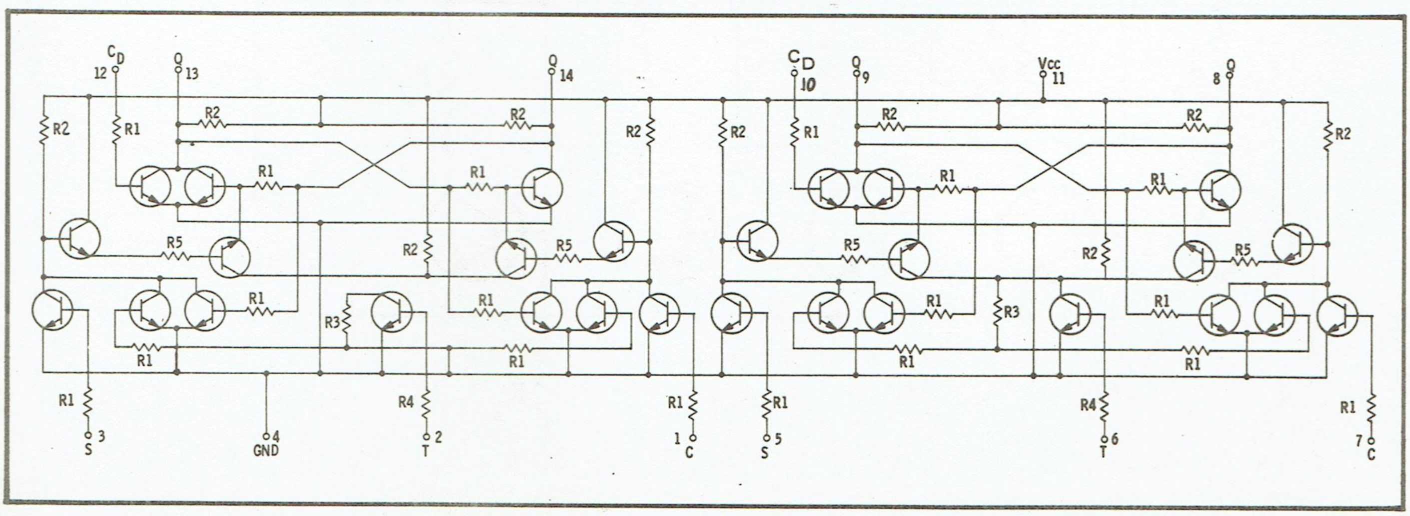


TN (Note 2)		TN + 1 (Note 2)	
S	C	Q	$\overline{Q}$
1	1	QN[3]	$\overline{Q}$N
1	0	1	0
0	1	0	1
0	0	$\overline{Q}$N	QN[3]

(Note 3)

NOTES:

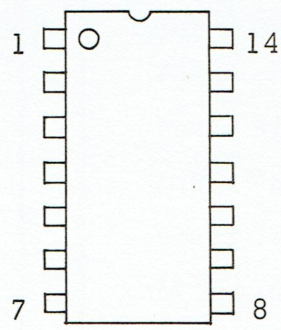
1. Direct input Cd must be low.
2. The time period prior to the negative transition of the clock pulse is denoted Tn and the time period subsequent to this transition is denoted Tn+1.
3. Qn is the state of the Q output in the time period Tn.
4. Clock Pulse (T) inputs must have a fall time within the range of 10ns to 100ns. Fall time is a straightline function from 1V to ground.

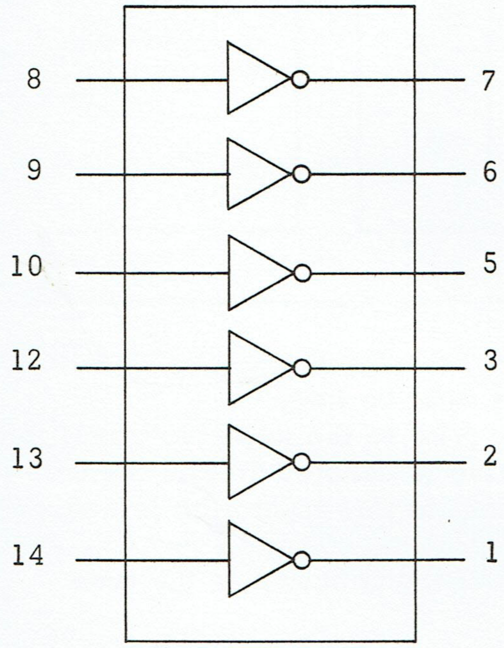


MC 889 P

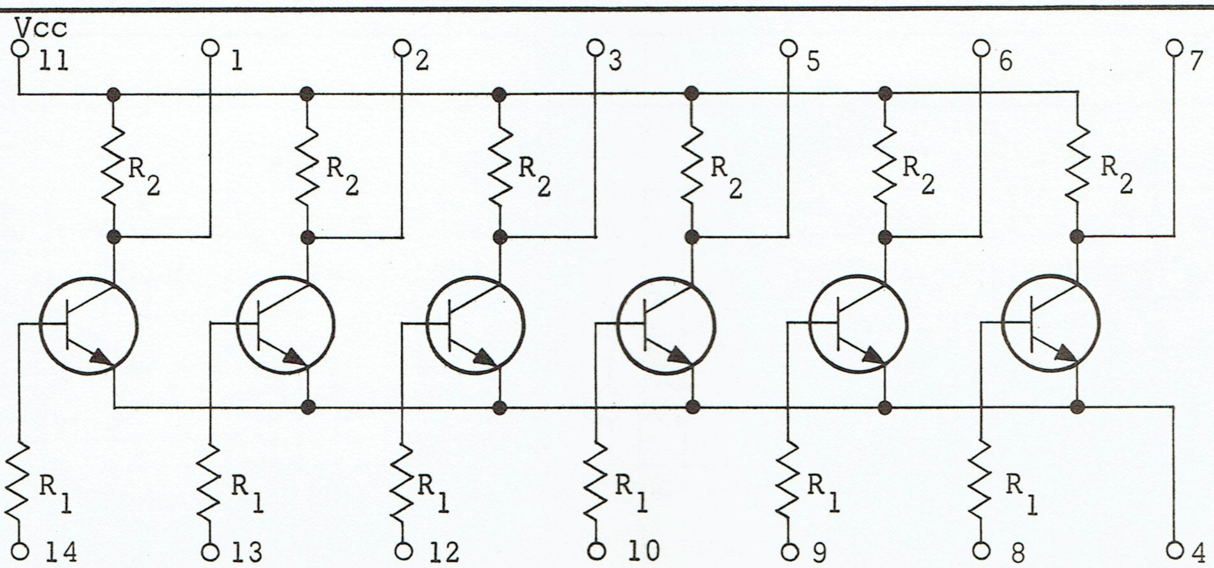
Hex Inverter

R_1	450 ohm
R_2	640 ohm





INPUT						OUTPUT					
8	9	10	12	13	14	7	6	5	3	2	1
0						1					
1						0					
	0						1				
	1						0				
		0						1			
		1						0			
			0						1		
			1						0		
				0						1	
				1						0	
					0						1
					1						0



MC 879 P
Multifunction

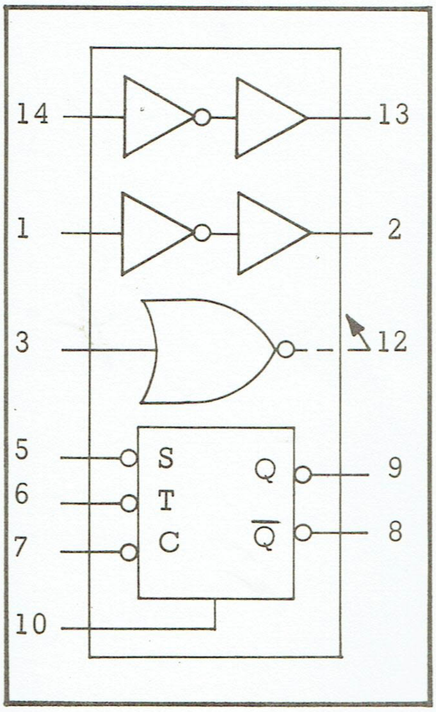
(J-K flip-flop, 1 expander 2 buffers)

R_1	450 Ohms
R_2	640 Ohms
R_3	510 Ohms
R_4	225 Ohms
R_5	100 Ohms

TN (Note 2)		TN + 1 (Note 2)	
S	C	Q	$\overline{Q}$
1	1	QN[3] (Note 3)	$\overline{Q}$N
1	0	1	0
0	1	0	1
0	0	$\overline{Q}$N	QN[3]

Buffer Section

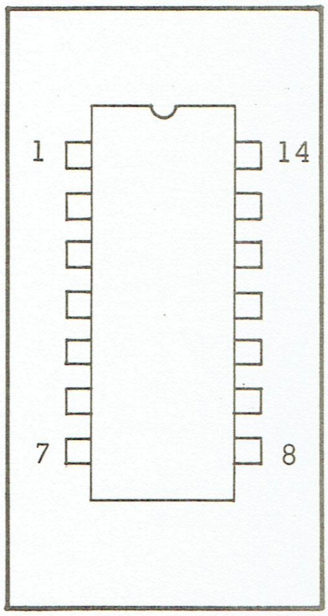
Input		Output	
1	14	2	13
0		1	
1		0	
	0		1
	1		0

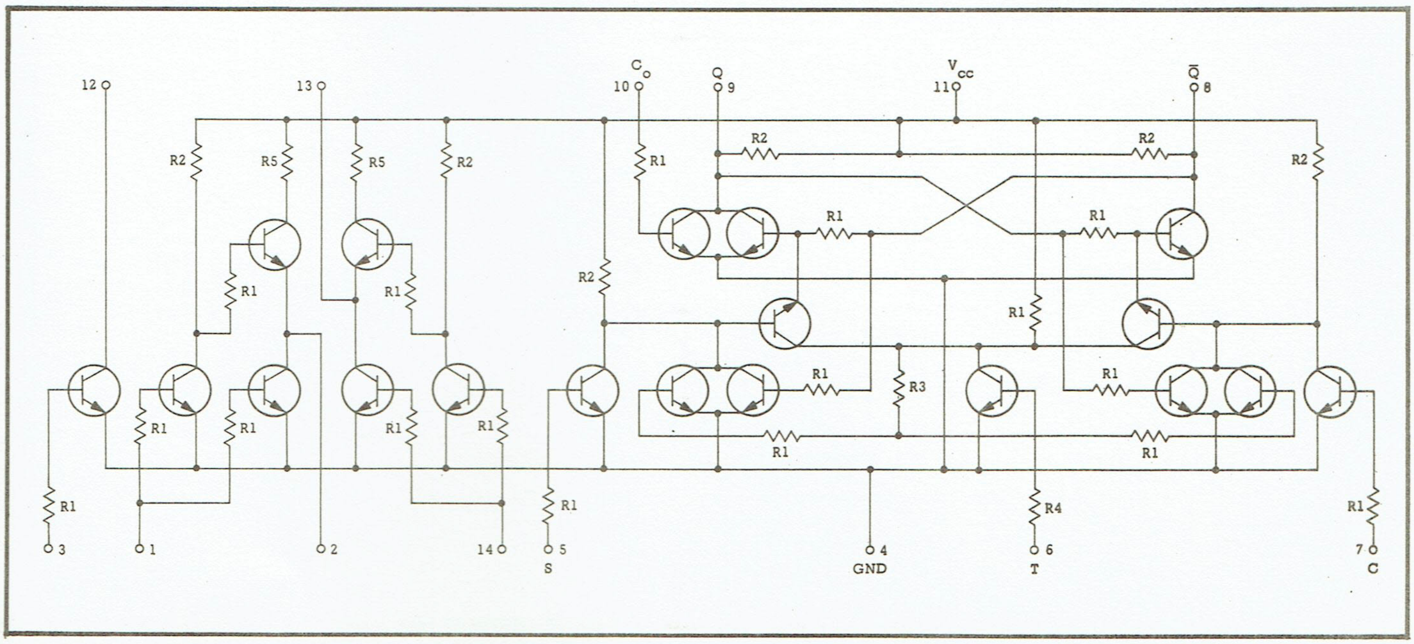


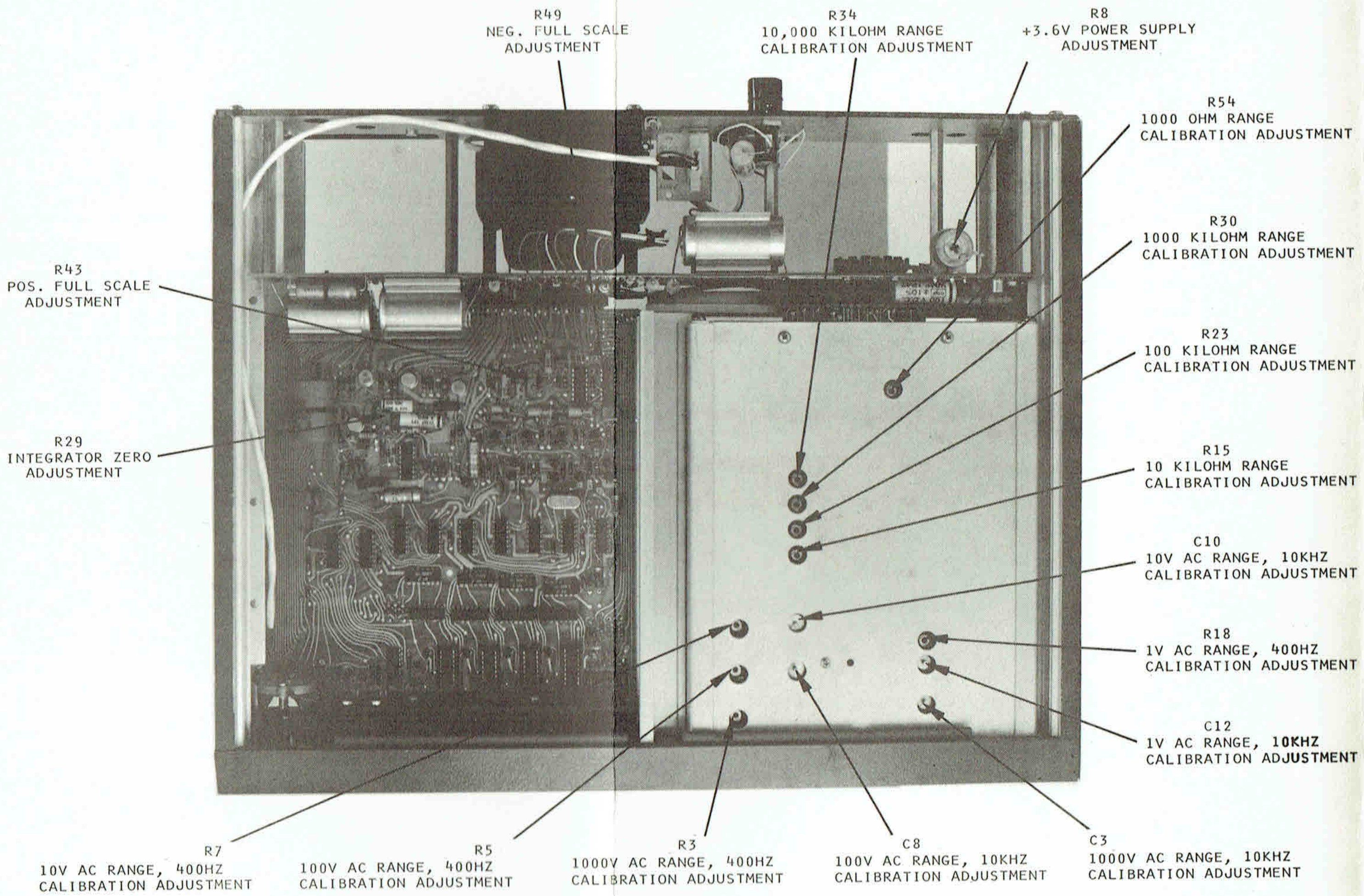
NOTES:

1. Direct input Cd must be low
2. The time period prior to the negative transition of the clock pulse is denoted Tn and the time period subsequent to this transition is denoted Tn +1.
3. Qn is the state of the Q output in the time period Tn.
4. Clock Pulse (T) inputs must have a fall time within the range of 10 ns to 100 ns. Fall time is a straightline function from 1V to ground.

NOTE: Collector load on expander output (pin 12) must not be lower than 640 ohms.







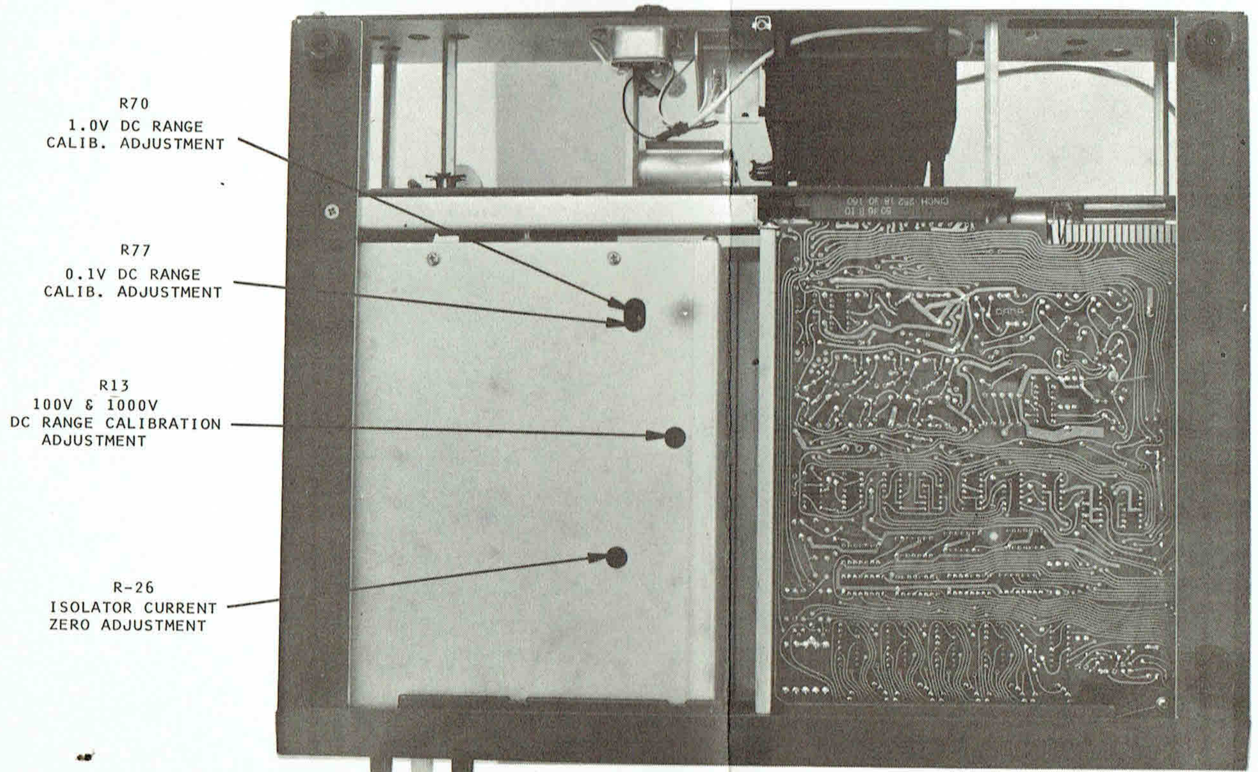


Figure 5.1 Calibration Adjustments

SECTION 5

CALIBRATION

5.1 INTRODUCTION

5.2 This calibration procedure is designed to keep the model 4500-350 DMM operating within its specifications. Any necessary maintenance should be done prior to calibration. The calibration steps in this procedure rely on the adjusted accuracy of the preceding step, therefore care must be taken to make each adjustment in the order that it appears in this procedure.

5.3 EQUIPMENT REQUIRED

5.4 The following equipment, or an acceptable equivalent, is required for DMM calibration and is listed in the order of use. The test equipment specifications listed are recommended by Dana as necessary to give satisfactory calibration.

I. Basic DC Calibration of the Instrument

(a) A precision DC voltage standard (calibrator) variable from 0 to 1000 volts having a resolution of 100 microvolts or better at 10 volts (10 PPM), and an accuracy of .003% with a stability of .001%. For example, the Fluke model 332A or the Cohu model 351.

(b) A guarded absolute ratio voltbox capable of precision voltage division of 100:1, 10:1 and 1:1 with a resolution of ½ part per million. The input resistance should be 50 kilohms, minimum, at a ratio of 10:1 and 500 kilohms, minimum, at a ratio of 100:1. An ESI model 1040 A is recommended. (This instrument, when used in conjunction with the DC standard and a standard cell traceable to N.B.S., can normalize the DC standard to the traceable source).

(c) A precision decade voltage divider capable of 10:1 and 100:1 division, having an input resistance of 10,000 ohms minimum, an output resistance of 5000 ohms maximum, and an accuracy of .005% or better. For example, the ESI model RV-622A.

(d) A one megohm 5% carbon resistor.

II. AC Calibration (required only if the instrument has the AC option)

(a) An AC laboratory power source, variable from 0 to 500 volts and 50 Hz to 10 kHz, having a resolution better than 100 PPM, harmonic distortion of 0.1% or less and a stability of .01%. For example, the Optimation type AC 104, (oscillator, matching transformer, and power amplifier).

(b) An AC/DC laboratory transfer standard (for calibration of the AC source) having an accuracy of .05% or better. For example, the Holt Model 6 Thermal Transfer Voltmeter.

III. Ohms Calibration (required only if the instrument has the OHMS option.)

(a) Standard resistors: 1K, 10K, 100K, and 1 Megohm with value known to within .005%; and a 10 Megohm with value known to within .01%. For example, the ESI SR 1 series standard resistors.

5.5 TOOLS

(a) An insulated blade-type calibration tool.

(b) A No. 1 Phillips screwdriver.

5.6 PREPARATION

(a) Remove the two screws which secure the top and bottom covers of the instrument. Slide (only) the top cover back and remove it.

(b) Set the DMM controls as follows:

Function: DC volts
Range: Auto
Ext Ref Switch (on rear panel): Out (if applicable)

(c) Set the OFF-ON-HOLD switch on the front of the instrument to the ON position.

(d) Connect the GUARD terminal on the front of the instrument to the LO input terminal. Connect a test lead to the HI (only) input terminal of the instrument.

5.7 POWER SUPPLY CHECK (Refer to Figure 5.2)

(a) Using the test lead installed in the preceding step (5.6-d), the instrument can measure its own operating voltages at the four test points listed below. If any of the voltages do not measure within the tolerances indicated the defective power supply must be repaired before any further calibration is attempted. (NOTE: The uncalibrated accuracy of the instrument is normally adequate for measuring these voltages within the specified limits unless the unit in need of repair.)

Test Point	Voltage
D	+15 volts ± 10%
H	-20 volts ± 10%
N	-15 volts ± 10%
X	+3.6 volts ±0.1 volt (If not within tolerance, adjust potentiometer R-8 on the Power Supply Module to set the voltage to +3.6 volts)

(b) Remove the test lead from the "HI" input terminal.

(c) Short the "HI" and the "LO" input terminals of the instrument together. (NOTE: This clip lead must use plain, unplated copper clips. Cadmium plated clips act like thermocouples, generating enough voltage to cause several digits of zeroing error in some cases.)

(d) Replace the top cover on the unit and allow at least 30 minutes for the instrument to reach a stable internal ambient operating temperature.

5.8 ANALOG ZERO ADJUSTMENT

(a) With the two input terminals jumpered together, place the instrument (manually) in the 10 volt DC range. Carefully note the reading indicated on the instrument's readout.

(b) Now place the instrument in the 0.1 volt DC range and adjust the ZERO OFFSET potentiometer on the front of the Signal Conditioning Module to obtain a reading within ± 1 digit of the reading noted in step "a" above.

5.9 INTEGRATOR ZERO ADJUSTMENT (Refer to Figure 5.1)

(a) With the input terminals on the front of the instrument jumpered together, manually place the instrument in the 10 volt DC range.

(b) Slide the top cover of the instrument back just enough to expose potentiometer R-29 (integrator zero adjustment potentiometer).

(c) Adjust R-29 so that the readout indicates 00.000 with the polarity indicators "bouncing" between + and -, then slightly clockwise for a steady "+" polarity indication and all zeros in the readout.

(d) Slide the top cover forward over the instrument and allow a minimum of five minutes for the internal temperature to re-stabilize.

(e) After five minutes, verify that the readout still indicates a good steady reading of "plus" and all zeros (+00.000).

(f) Remove the short from the input terminals.

(g) Connect the test equipment and the instrument under calibration as shown in figure 5.2. Connect the test leads from the decade voltage divider to the DMM such that the input voltage to the DMM will be of negative polarity.

(h) Set the absolute ratio voltbox to 0.01 (100:1). Set the decade voltage divider to .002000. This applies an input signal of -0.00020 volt to the DMM. If the adjustment of R-29 is correct the polarity indicator should switch from + to - with an input of 0.0002 volt. If the polarity indication does not change, R-29 is set too far clockwise and steps 5.7-a through 5.9-f must be repeated before proceeding to the next step.

5.10 VOLTAGE CALIBRATION OF THE DIGITIZING AND DISPLAY MODULE (Refer to Figure 5.1.)

(a) Set the absolute ratio voltbox to 1.0 (1:1). Set the decade voltage divider to .999950. This applies an input signal of -9.99950 volts to the DMM.

(b) Slide the top cover of the instrument back just enough to expose potentiometer R-43 (negative full scale adjustment potentiometer).

(c) Adjust R-43 so that the indication on the readout is "bouncing" between -09.999 and -10.000.

(d) Slide the top cover forward over the instrument.

(e) Reverse the polarity of the input signal so that it is now +9.9995 volts.

(f) Slide the top cover of the instrument back just enough to expose potentiometer R-49 (positive full scale adjustment potentiometer).

(g) Adjust R-49 so that the readout is "bouncing" between +09.999 and +10.000.

(h) Slide the top cover forward over the instrument and wait a minimum of five minutes to allow the internal temperature to restabilize.

(i) Verify that the indication on the instrument's readout will still "bounce" between +09.999 and +10.000 with an input signal of from +9.9994 to +9.9996 volts. Similarly verify that the reading will "bounce" between -09.999 and -10.000 with an input signal of from -9.9994 to -9.9996 volts. If necessary, repeat the adjustments of R-43 and R-50 outlined in steps 5.10-a through 5.10-h to obtain the specified readings.

5.11 LINEARITY TEST (NOTE: There are no adjustments to be made in section 5.11. These tests are included to verify the overall accuracy of the instrument up to this point.)

(a) Set the DMM controls as follows:

Function: DC
Range: 10
Ratio X10 Switch (on rear panel): Out (if applicable)

(b) Verify the DMM readout for the following input voltages:

Voltage Input	DMM Readout
-11.9950	-11.995 ± 1 digit
-10.0000	-10.000 ± 1 digit
- 9.0000	-09.000 ± 1 digit
- 8.0000	-08.000 ± 1 digit
- 7.0000	-07.000 ± 1 digit
- 6.0000	-06.000 ± 1 digit
- 5.0000	-05.000 ± 1 digit
- 4.0000	-04.000 ± 1 digit
- 3.0000	-03.000 ± 1 digit
- 2.0000	-02.000 ± 1 digit
- 1.0000	-01.000 ± 1 digit
0.0000	+00.000 ± 1 digit

(c) Reverse the polarity of the input to the DMM and verify the readout for the following input voltages:

Voltage Standard Input	DMM Readout
+1.00000	+01.000 ± 1 digit
+2.00000	+02.000 ± 1 digit
+3.00000	+03.000 ± 1 digit
+4.00000	+04.000 ± 1 digit
+5.00000	+05.000 ± 1 digit
+6.00000	+06.000 ± 1 digit
+7.00000	+07.000 ± 1 digit
+8.00000	+08.000 ± 1 digit
+9.00000	+09.000 ± 1 digit
+10.0000	+10.000 ± 1 digit
+11.9950	+11.995 ± 1 digit
0.0000	+00.000 ± 1 digit

NOTE: If the instrument is not within the tolerance indicated in the above tests, the adjustments in sections 5.8 through 5.10 must be rechecked for error. If this does not correct the problem, the instrument is in need of repair.

(d) Disconnect the DMM from the voltage standard.

5.12 TEST OF THE "RATIO" MEASUREMENT ACCURACY (NOTE: **If the instrument is not equipped with the optional RATIO feature, disregard this section and proceed to Section 5.13**).

(a) Connect the instrument to a stable source of approximately 10 volts as shown in figure 5.3. (10V ± 10%).

(b) Place the instrument in the "ratio" function by pressing the RATIO X10 pushbutton located on the rear panel.

(c) Place the instrument in the 10 volt DC range.

(d) Verify that the readout indicates 10.000 ± 3 digits.

(e) Adjust the voltage of the stable voltage source to approximately one volt. (1V ± 10%)

(f) Verify that the readout indicates 10.000 ± 30 digits.

NOTE: If the instrument is not within the tolerances indicated in the above tests, recheck the adjustments outlined in sections 5.8 through 5.10 for error. If this does not correct the problem the instrument is in need of repair.

(g) Switch the RATIO X10 pushbutton to "out" and disconnect the reference and signal input leads from the instrument.

5.13 ADJUSTMENT OF ANALOG CURRENT ZERO (Refer to Figure 5.1.)

(a) Place the instrument on its side in a manner such that the adjustment potentiometers located on the bottom side of the Signal Conditioning Module can be adjusted when the bottom cover has been slid back far enough to expose them. Leave the bottom cover in place at this time.

(b) Place the instrument in the DC VOLTS function and manually select the lowest range.

(c) Connect a 1 Megohm 5% carbon resistor across the input terminals of the instrument by loosening the binding posts, placing the resistor leads through the binding post holes and tightening the binding posts on the resistor leads.

(d) Connect a short clip lead across the input terminals of the instrument. (NOTE: This clip lead must use plain, unplated copper clips. Cadmium plated clips act like thermocouples, generating enough voltage to cause several digits of zeroing error in some cases.)

(e) Adjust the front panel ZERO OFFSET potentiometer for a reading of +.00000.

(f) Remove the clip lead.

(g) Slide the bottom cover of the instrument back just enough to expose potentiometer

R-26 (the Isolator Current Zero potentiometer).

(h) Adjust R-26 to obtain a reading of .00000 ± 2 digits

(i) Re-check steps d through h above to eliminate any interaction.

(j) Remove the 1 Megohm resistor from the DMM input terminals.

5.14 DC VOLTAGE CALIBRATION OF THE SIGNAL CONDITIONING MODULE (Refer to Figure 5.1.)

(a) Connect the test equipment and the instrument under calibration as shown in figure 5.2. Set all dials on the voltage standard and decade voltage divider to zero.

(b) Set the DMM controls as follows:

Function: DC Volts
Range: Auto
Ratio X10 Switch (rear panel): Out (if applicable)

(c) Verify that the DMM readout indicates all zeros and "bounces" between + and - polarity indicators. If necessary adjust the ZERO OFFSET potentiometer on the front of the instrument.

(d) Set the DC voltage standard to -10.0000 volts.

(e) Set the absolute ratio voltbox to X.01 (100:1).

(f) Set the decade voltage divider to .999950.

(g) Slide the bottom cover of the instrument back just enough to expose the calibration potentiometers on the bottom of the signal conditioning module.

(h) Adjust potentiometer R-77 (the 0.1 volt adjustment potentiometer) so that the indication on the readout is "bouncing" between -.09999 and -.10000.

(i) Set the absolute ratio voltbox to X.1 (10:1).

(j) Adjust potentiometer R-70 (the 1V DC range calibration potentiometer) so that the indication on the readout is "bouncing" between -0.9999 and -1.0000.

(k) Set the absolute ratio voltbox to X.01 (100:1) or disconnect it from the DC voltage standard.

(l) Connect the DMM input directly to the DC voltage standard as shown in figure 5.4.

(m) Adjust the output of the DC voltage standard to -99.995 volts.

(n) Adjust potentiometer R-13 (the 100 and 1000 volt adjustment potentiometer) so that the indication on the readout is "bouncing" between -099.99 and -100.00.

(o) Adjust the output of the DC voltage standard to zero volts.

(p) Slide the bottom cover of the instrument forward into place and set the instrument in an upright position. Allow five minutes for the operating temperature of the instrument to re-stabilize.

(q) Verify the accuracy of each range by following the tests in table 5.1.

Table 5.1

Set DC Voltage Standard To	Instrument Readout Should Indicate
+1000.00 volts	+1000.0 ± 1 digit[1]
+100.000 volts	+100.00 ± 1 digit[1]
+10.0000 volts	+10.000 ± 0 digits[2]
+1.00000 volt	+1.0000 ± 1 digit[1]
+.100000 volt[3]	+.10000 ± 1 digit[1]
- .100000 volt[3]	- .10000 ± 1 digit[1]
- 1.00000 volt	- 1.0000 ± 1 digit[1]
- 10.0000 volts	- 10.000 ± 0 digits[2]
- 100.000 volts	- 100.00 ± 1 digit[1]
- 1000.00 volts	- 1000.0 ± 1 digit[1]

NOTES:

1) If the DMM readout is not within the specified accuracy, re-check the adjustments outlined in Section 5.14.

2) If the DMM readout is not within the specified accuracy, re-check the adjustments outlined in Section 5.10.

3) It is necessary to use a 10:1 voltage divider out of the DC voltage standard to reduce noise and increase accuracy.

(r) Remove the DMM input leads from the DC voltage standard

(s) Reduce the output voltage of the DC voltage standard to zero volts.

5.15 AC VOLTAGE CALIBRATION OF THE SIGNAL CONDITIONING MODULE (Refer to Figure 5.1)

(NOTE: If the instrument is not equipped with the optional AC feature, disregard this section and proceed to section 5.16.)

(a) Set the DMM controls as follows:

Function: AC volts
Range: Auto
Ratio X10 Switch (on rear panel): Out (If applicable)

(b) Connect the DC voltage standard, thermal transfer voltmeter, AC laboratory source, and the DMM under calibration, as illustrated in figure 5.5.

NOTE: There are eight distinct steps in the calibration of the AC Converter. They must be performed in sequence. All eight steps are shown in table 5.2. Sections 5.15-c through 5.15-h, which follow, give detailed instructions on how to perform step one. The remaining steps (2 through 8) are simply repeats of the same process at different voltages and frequencies and adjusting different controls. These differences are listed in table 5.2.

(c) Switch the thermal transfer voltmeter to DC input.

(d) Adjust the DC voltage standard for an output of +1 volt.

(e) Null the thermal transfer voltmeter. Allow sufficient time for the thermocouple in the voltmeter to stabilize.

(f) Switch the thermal transfer voltmeter to AC input and apply a 1 volt RMS, 400 Hz sine wave signal from the AC laboratory source. Adjust the amplitude controls on the AC source to produce the same null on the thermal transfer voltmeter as with 1 volt DC.

(g) Slide the top cover of the instrument back far enough to expose the calibration controls on the top of the Signal Conditioning Module. (NOTE: If the instrument under calibration is a model 4570 it will be necessary to extend the Signal Conditioning Module forward, using extender kit no. 403017.)

(h) Adjust potentiometer R-118 on the top of the Signal Conditioning Module to obtain a reading of 1.0000 _ 1 digit on the instruments readout.

(i) You have now completed step one of the eight steps required for calibration of the AC converter. Repeat the same general procedure outlined in steps c through h above for each of the remaining calibration steps listed in table 5.2. Change the voltage and frequency, as indicated, for each range.

(NOTE: Other techniques using an AC calibrator or a standardized digital voltmeter will perform this calibration procedure equally as well. Figure 5.6 illustrates the use of a Dana model 5700 DVM as the standardized digital voltmeter in such an application. This arrangement provides a direct reading capability.)

Table 5.2

Step	AC Input Voltage	Signal Frequency	Adjust	Readout Should Indicate	Remarks
1	1.00000V	400 Hz	R118	0.999 to 1.0001	1V Low Frequency
2	500.00V	400 Hz	R103	0499.9 to 0500.1	1000V Low Freq.
3	500.00V	10 kHz	C103	0499.9 to 0500.1	1000V High Freq.
4	1.00000V	10 kHz	C112	0.9999 to 1.0001	1V High Freq.
5	10.0000V	400 Hz	R107	09.999 to 10.001	10V Low Freq.
6	10.0000V	10 kHz	C110	09.999 to 10.001	10V High Freq.
7	100.000V	400 Hz	R105	099.99 to 100.01	100V Low Freq.
8	100.000V	10 kHz	C108	099.99 to 100.01	100V High Freq.

Table 5.3

If the Input Signal, on any given range, is:	The maximum number of digits error from 50 Hz to 100 Hz is:	The maximum number of digits error from 100 Hz to 5 kHz is:	The maximum number of digits error from 5 kHz to 20 kHz is:	The maximum number of digits error from 20 kHz to 100 kHz is:
0% of full scale (Input shorted)	± 5 digits	± 2 digits	± 5 digits	± 10 digits
10% of full scale	± 8 digits	± 3 digits	± 10 digits	± 30 digits*
20% of full scale	± 10 digits	± 4 digits	± 15 digits	± 50 digits
30% of full scale	± 13 digits	± 5 digits	± 20 digits	± 70 digits
40% of full scale	± 15 digits	± 6 digits	± 25 digits*	± 90 digits
50% of full scale	± 18 digits*	± 7 digits*	± 30 digits	± 110 digits
60% of full scale	± 20 digits	± 8 digits	± 35 digits	± 130 digits
70% of full scale	± 23 digits	± 9 digits	± 40 digits	± 150 digits
80% of full scale	± 25 digits	± 10 digits	± 45 digits	± 170 digits
90% of full scale	± 28 digits	± 11 digits	± 50 digits	± 190 digits
100% of full scale	± 30 digits	± 12 digits	± 55 digits	± 210 digits
110% of full scale	± 33 digits	± 13 digits	± 60 digits	± 230 digits
120% of full scale	± 35 digits	± 14 digits	± 65 digits	± 250 digits

Table 5.4

Maximum percentage of full scale AC RMS input on the 1000 V AC range is 500 V RMS from 50 Hz to 10 kHz decreasing to 100 V RMS at 100 kHz.

Frequency	Maximum AC Input Voltage
50 Hz to 10 kHz	500 V RMS
20 kHz	455 V RMS
30 kHz	415 V RMS
40 kHz	370 V RMS
50 kHz	325 V RMS
60 kHz	275 V RMS
70 kHz	230 V RMS
80 kHz	190 V RMS
90 kHz	145 V RMS
100 kHz	100 V RMS

(j) The calibration of the AC converter is now complete. A check of the accuracy of the instrument at other frequencies and voltages than those listed in table 5.2 may be referring to table 5.3. This step is not necessary to the calibration of the AC converter, however certain user applications may require a more exact knowledge of the instruments accuracy at specific voltages and frequencies

5.16 OHMS CALIBRATION OF THE SIGNAL CONDITIONING MODULE (Refer to Figure 5.1)

(NOTE: If the instrument is not equipped with the optional OHMS feature, the calibration is now concluded).

(a) Clip the input leads on the end of the instrument's input cable together.

(b) Set the DMM controls as follows:

Function: DC
Range: Auto
Ratio X10 Switch (on rear panel): Out (If applicable)

(c) The instrument should auto-range to the lowest range and read .00000.

(d) Adjust the ZERO OFFSET potentiometer on the front of the instrument so that the polarity indicators are "bouncing" between + and -.

(e) Select the OHMS function. The instrument should now indicate 0.0000 plus the resistance of the input cable. This resistance may give an offset of one or two digits from zero. Carefully note the exact amount of this offset (if any).

(f) Connect the test leads to the 1000 ohm standard resistor.

(g) Adjust the 1 Kilohm range calibration control (R-54) so that the instrument indicates the exact value of the standard resistor plus the number of digits offset noted in step c above (the resistance of the input cable).

(h) Connect the test leads to the 10 Megohm standard resistor.

(i) Adjust the 10,000 Kilohm range calibration control (R-34) so that the instrument indicates the exact value of the standard resistor.

(k) Adjust the 10 Kilohm range calibration control (R-15) so that the instrument indicates the exact value of the standard resistor.

(l) Connect the test leads to the 100 Kilohm standard resistor.

(m) Adjust the 100 Kilohm calibration control (R-23) so that the instrument indicates the exact value of the standard resistor.

(n) Connect the test leads to the 1 Megohm standard resistor.

(o) Adjust the 1000 Kilohm calibration control (R-30) so that the instrument indicates the exact value of the standard resistor.

(p) Re-check steps e through o above and repeat any adjustments necessary until the instrument indicates correctly on each range without further adjustment.

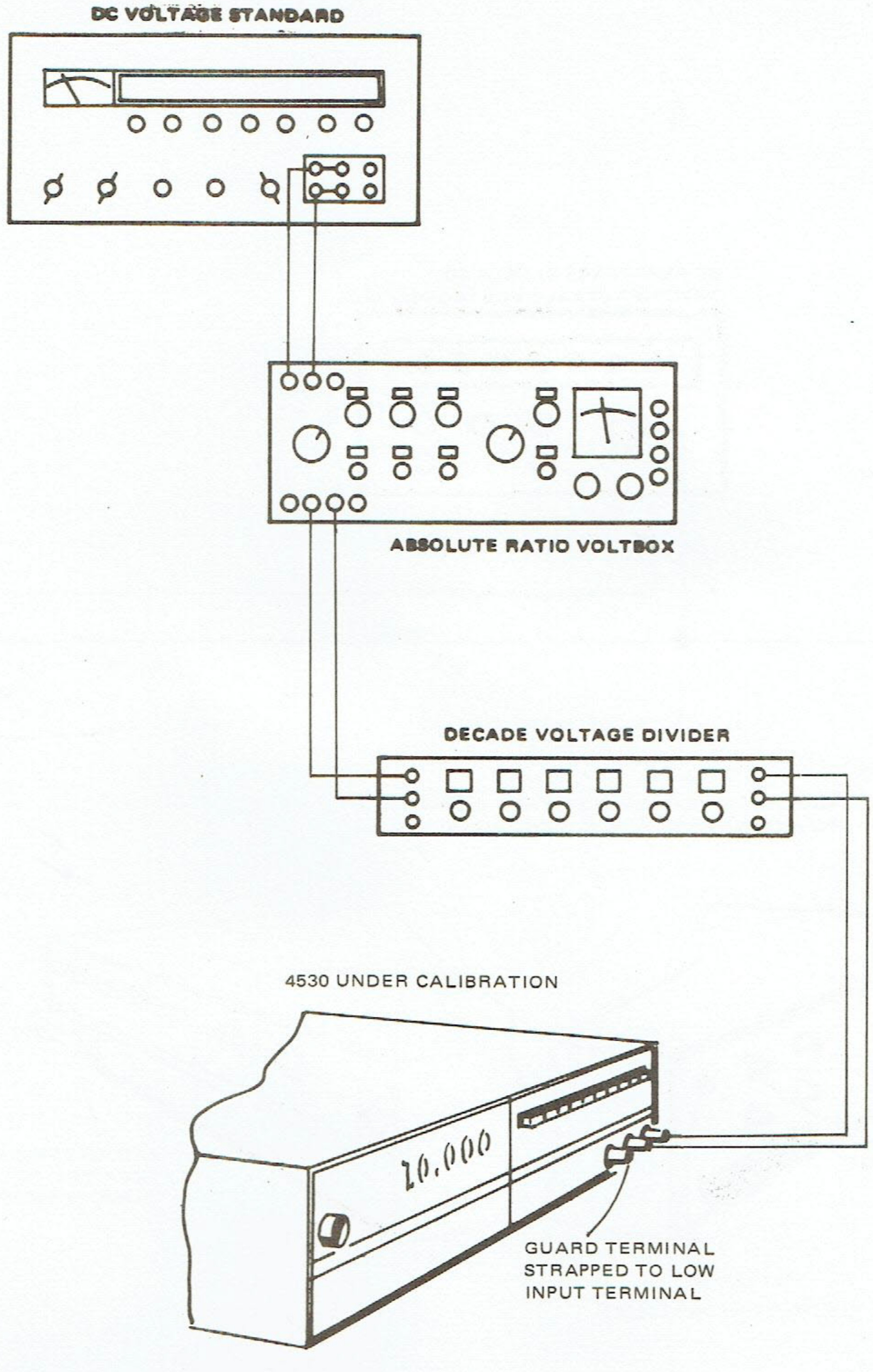


Figure 5.2 - Setup for calibration of lower DC voltage ranges

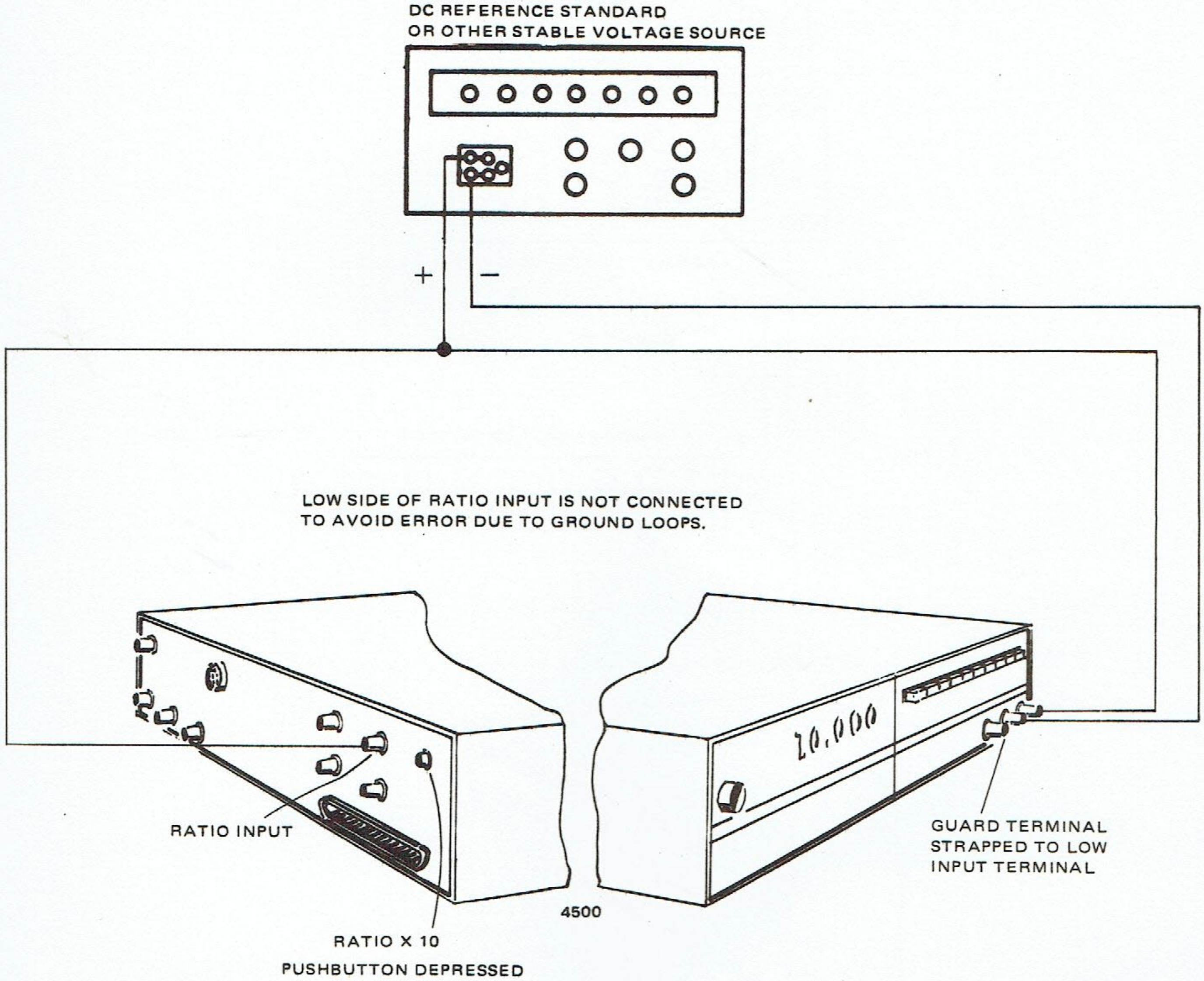


Figure 5.3 - Ratio measurement accuracy test setup

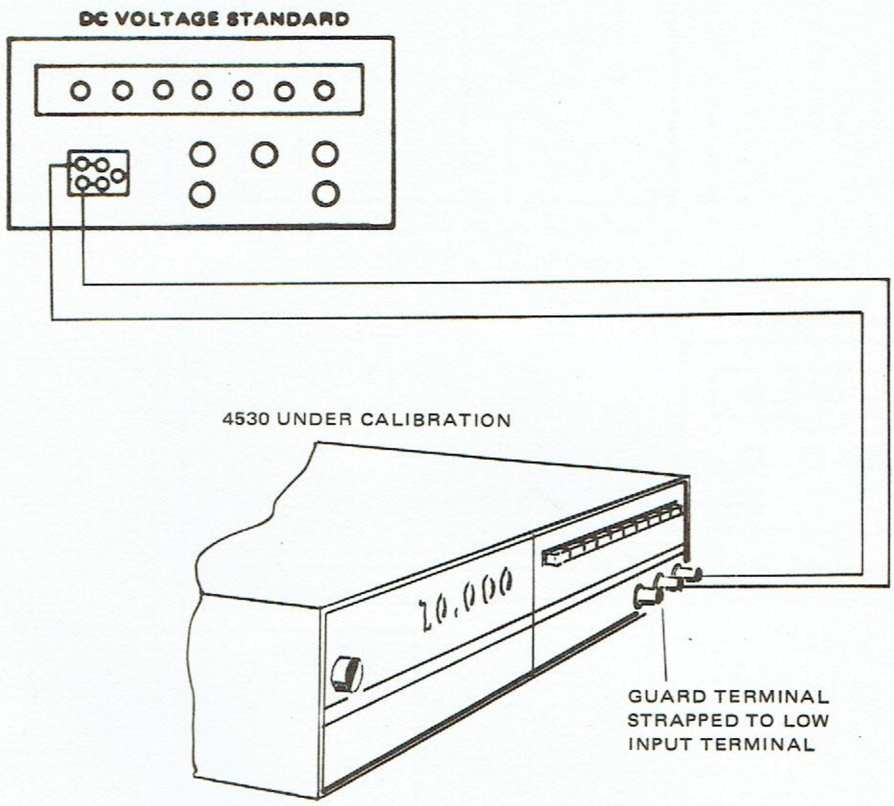


Figure 5.4 - Setup for 100V and 1000V DC range calibration

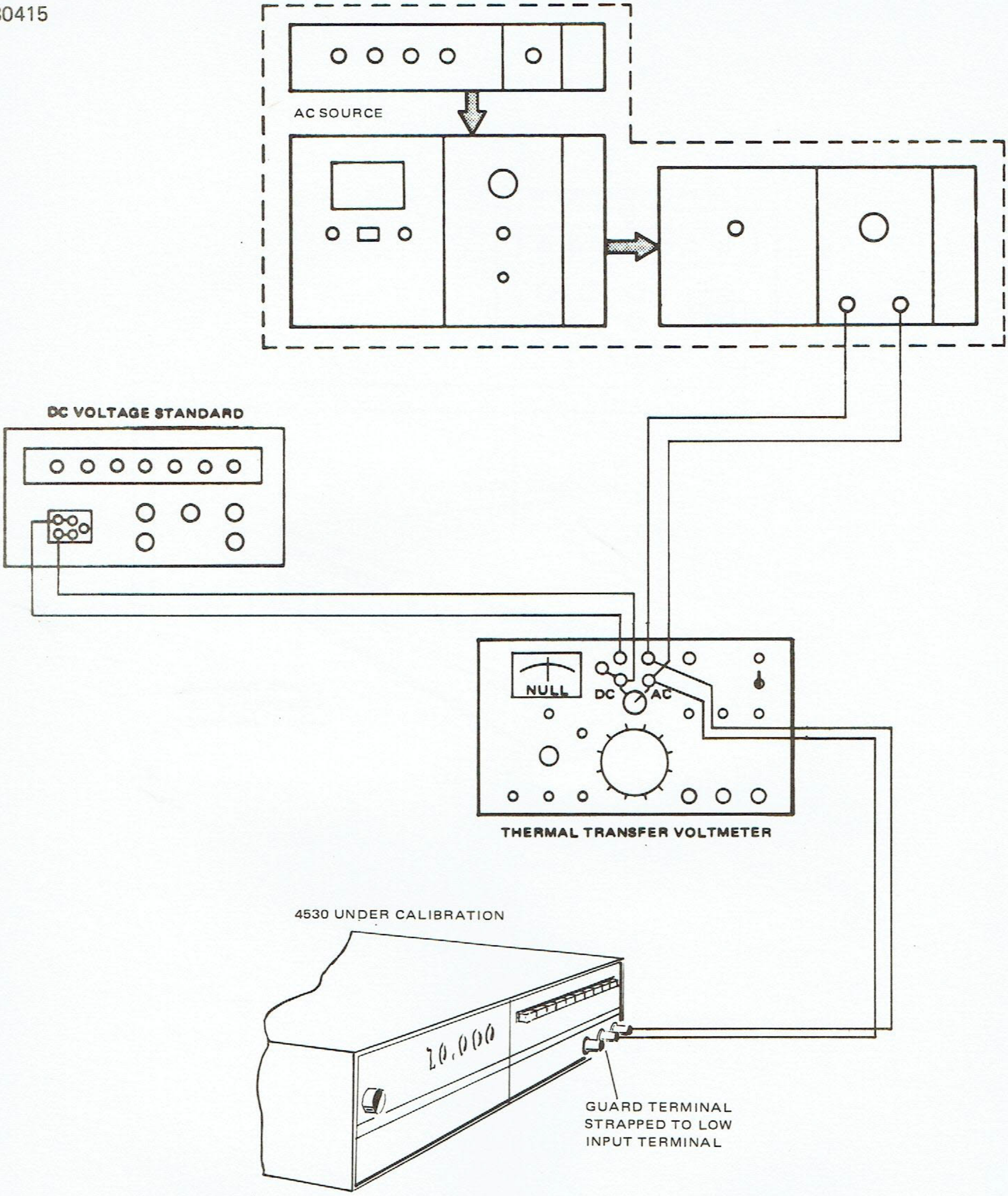


Figure 5.5 - Setup for AC calibration

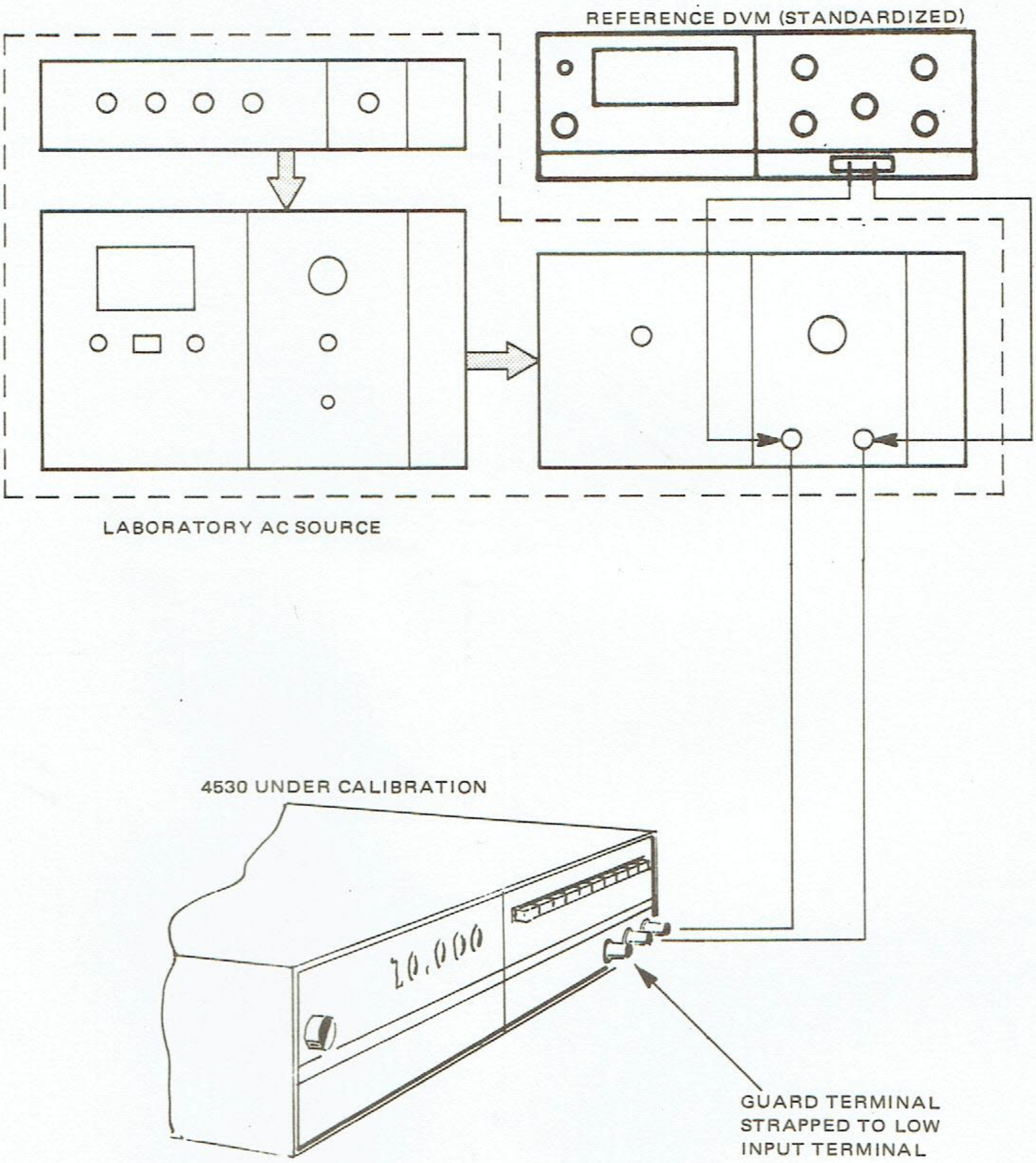


Figure 5.6 - Attenuate setup for AC calibration

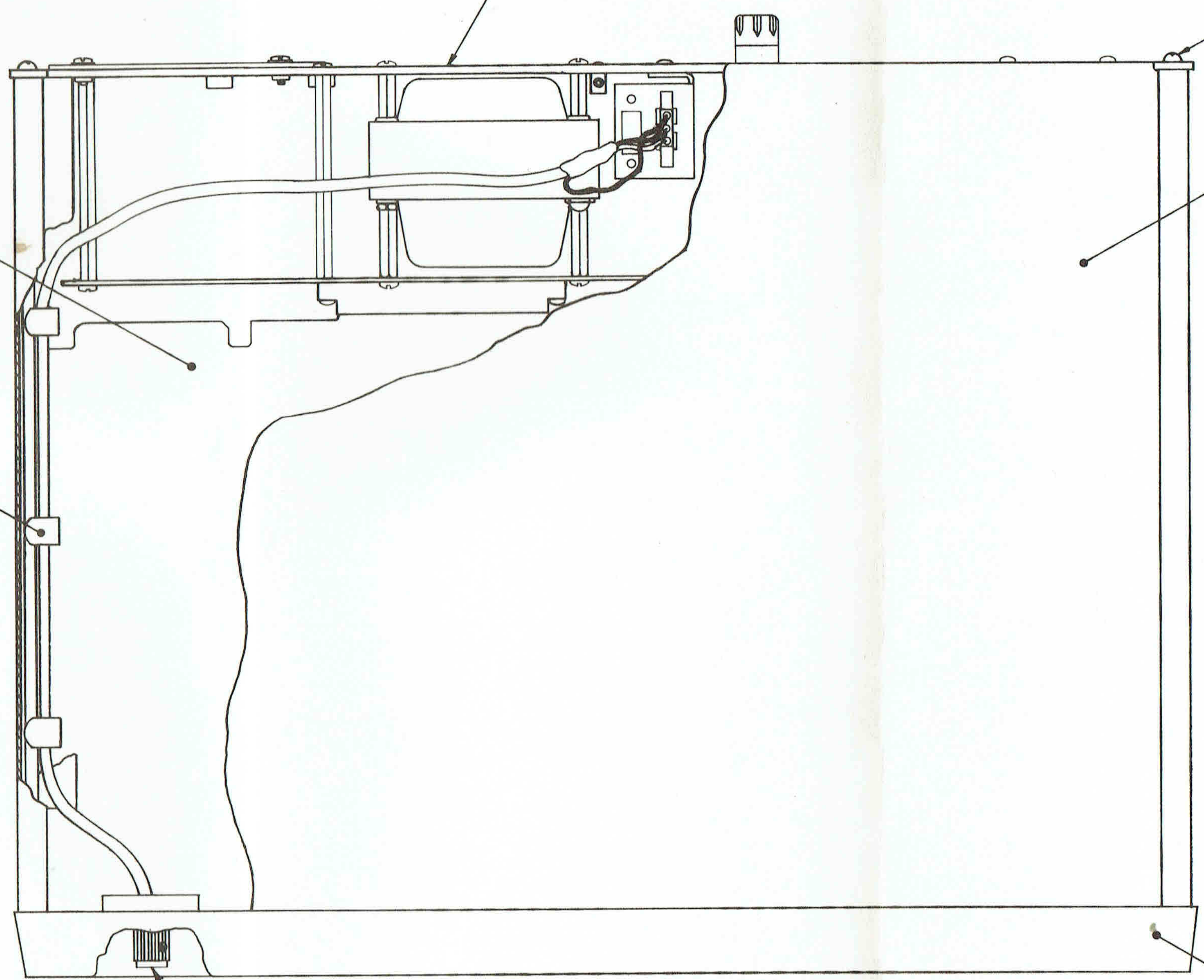
SECTION 6

DRAWINGS

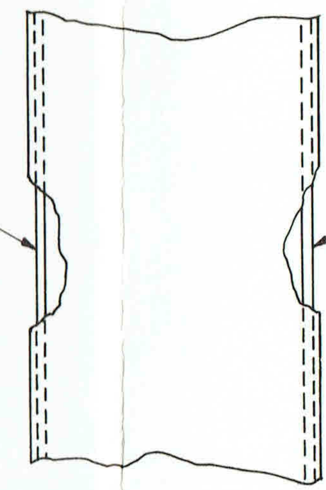
6.1 DRAWINGS

DVM 4530 Full Rack Assembly	403206
DVM 4570 Half Rack Assembly	403232
Readout Assembly	403082
Readout Schematic	430843
Power Supply, Assembly 4530	403208
Power Supply, Assembly 4570	403233
PCB Assembly, Power Supply 4530	403081
PCB Assembly, Power Supply 4570	403225
Power Supply, Schematic	430842
PCB Assembly, Isolator	403198
Isolator, Schematic	430867
Ohms Converter Assembly	403228
PCB Assembly, Ohms Converter	403169
Ohms Converter, Schematic	430871
AC Converter Assembly	403203
PCB Assembly, AC Converter	403214
AC Converter, Schematic	430870
AC & Ohms Converter Assembly	403229
PCB Assembly, AC & Ohms Converter	402581
AC & Ohms Converter, Schematic	430868
PCB Assembly, Printer Output	403212
Printer Output, Schematic	430854
Ratio Option 04	403263
Analog Signal Output Option 06	403262
Rear Input Assembly 350-1	403199
Rear Input Assembly 4500	403230
Power Supply Assembly 220/240V	403269

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 873		6-25-?	
B	CHANGE KNOB TO P/N 920381 PER EO 4949	8-8-69 R.CARROLL		
C	920326 WAS 920381 EO. 5547	CARROLL 2-23-70		



TOP VIEW



SIDE VIEW
DETAIL

⚠2 ALL INDICATED HARWARE IS INCLUDED IN FINISHING KIT, (REF 403209).
1. ASSEMBLY PROCEDURE AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.
NOTE: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	NA	FA
—	4530	—	—
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS .X .030 .XX .020 .XXX .010 | ANGLES 0° 30′ | FORMED ANGLES 1.0
MATERIAL
FINISH

CONTRACT NO.

DRAWN	JOHN GIBB	5-1-69
CHECK		5-27-69
DESIGN	R Prchal	5/22/69
PROJ ENGR		

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

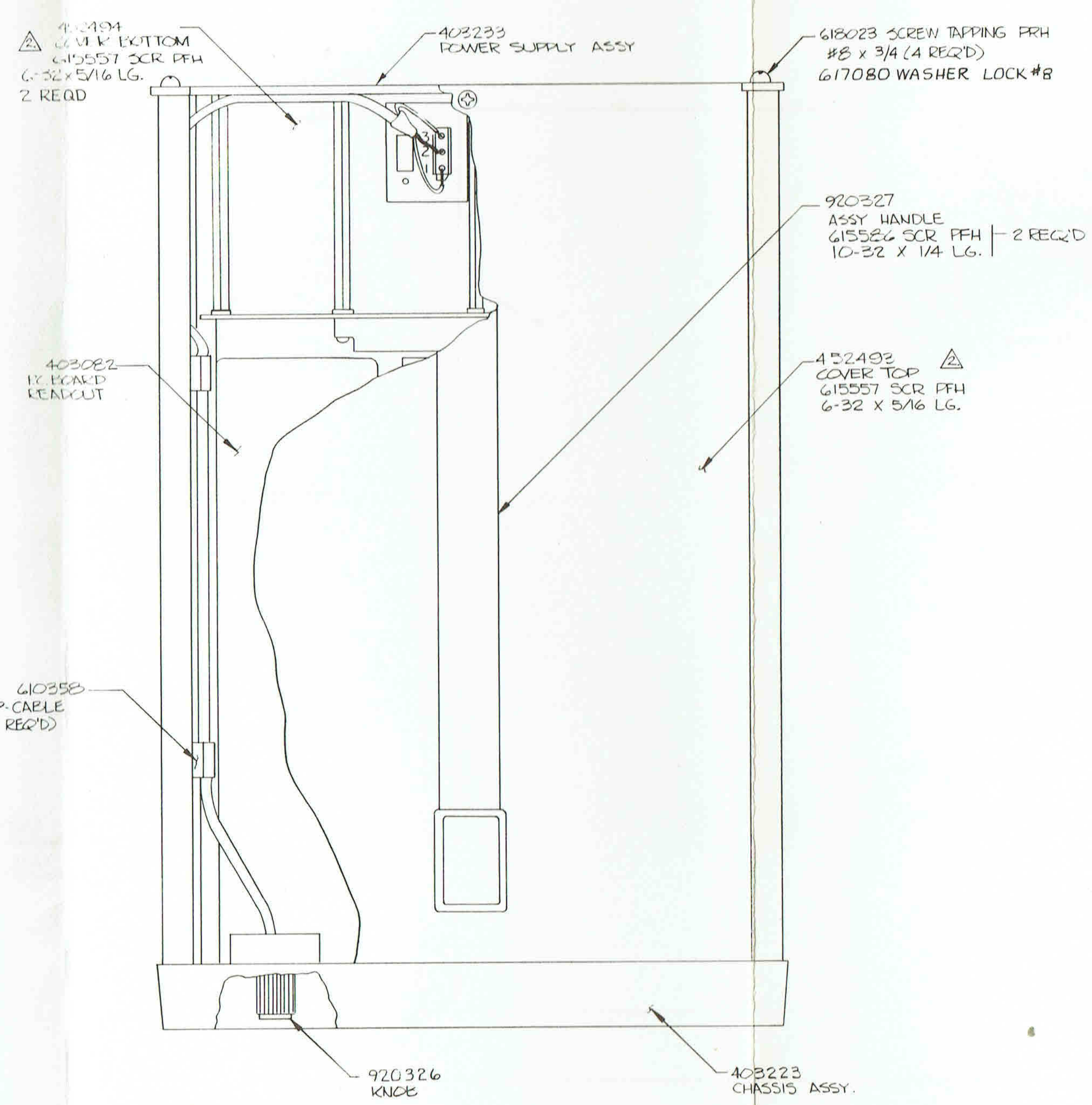
ASSY – DVM 4530
FULL RACK

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403206	C

SCALE 1/1 WT SHEET 1 OF 2

SHT 2 IS AN "A" SIZE

LTR	REVISIONS DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 902 7-31-9			
B	920326 WAS 920381 EO 5547			



TOP VIEW

2. FINISHING KIT REFERENCE #403224.
1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
	4570		
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES: DECIMALS X.030 XX.020 XXX.010; ANGLES 0° 30' FORMED 1° 0'; HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN 7-2-69 · CHECK 7/4/69 · DESIGN 7/10/69 · MECH ENGR · PROJ ENGR 7/11/69 · PROD ENGR 7/24/69

DANA LABORATORIES INC. IRVINE, CALIFORNIA

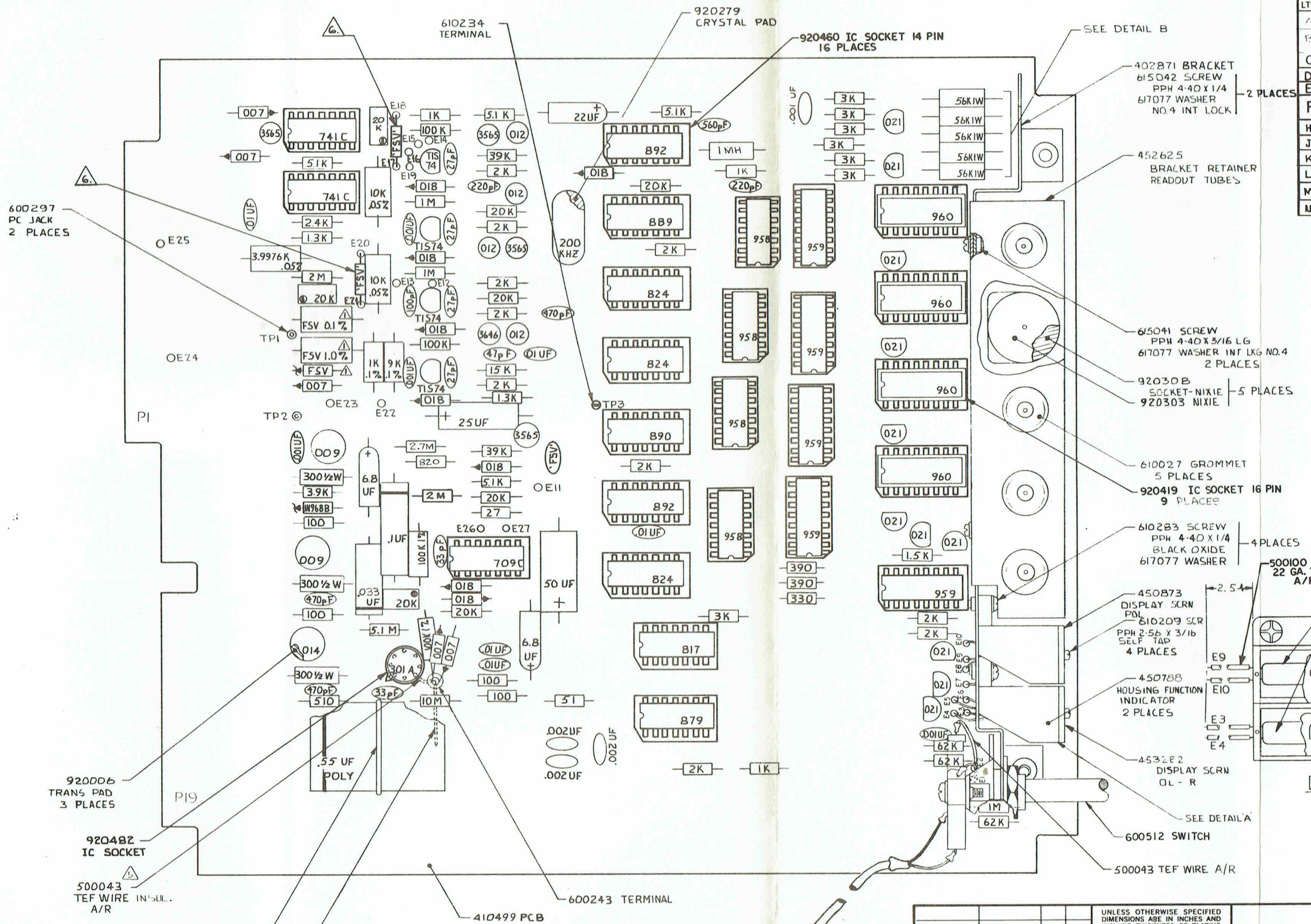
ASSY – DVM 4570 HALF RACK

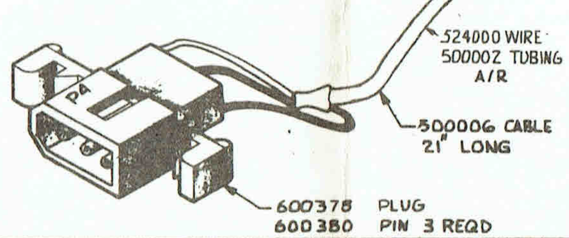
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403232	B

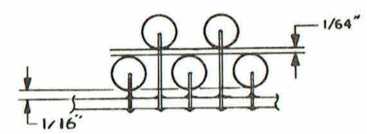
SCALE NONE · SHEET 2 IS "A" SIZE · SHEET 1 OF 2

DANA 980346 DIETERICH-POST CLEARPRINT 1020

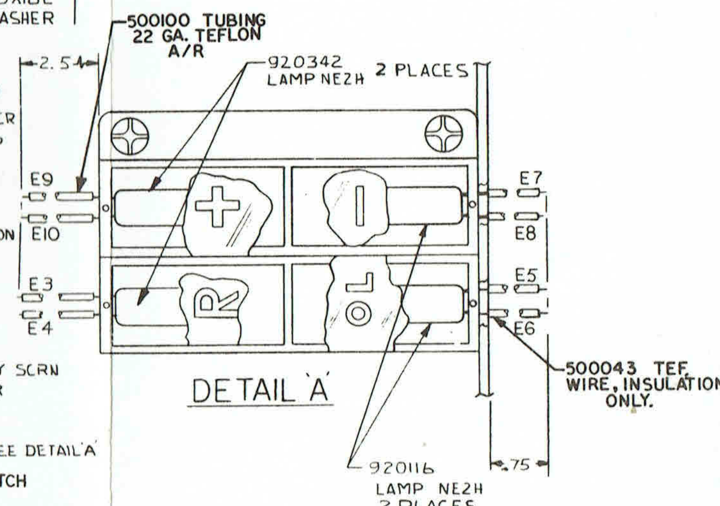
REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 883 5-26-9			
B	[illegible]	K.C. 7-69		
C	CHANGE SWITCH TO P/N 600512 E.O.4949	8-8-69 CARROLL		
D	ADD IC SOCKETS PER E.O. 5091	9-2-69 CARROLL	9-4-69	
E	ADD 500100, REVISE DETAIL "B". E.O 5145	9-15-69 CARROLL		
F	REPLACE 220036 WITH 403294, REVISE NOTE 1. PER E.O. 5177	9-18-69 CARROLL		
H	REVISED PER E.O. 5455	12-17-9 CARROLL	12-19-69	
J	040092 WAS 040026 PER E.O.5649	CARROLL 3/13/70		
K	ADD C37 PER E.O. 5652	3/13/70		
L	ADD NOTE 6. PER E.O. 5728	CARROLL 5-4-70		
M	ADD 920482 PER E.O. 5768	CARROLL 6-8-70	6-8-70	
N	C37 WAS 100 PF, PER E.O 5818	CARROLL 7-13-70		







DETAIL 'B'



DETAIL 'A'

6. R44 & R45 ARE "FSV" WHEN REQUIRED.
5. SLEEVING TO RUN [illegible] TO COMPONENT
4. ALL RESISTORS ARE OHMS ±5%, 1/4W CARBON.
3. SCHEMATIC REF 430843
2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
1. PART OF ZENER KIT 403294

NOTES: UNLESS OTHERWISE SPECIFIED

403206	4530	1	1
403232	4570	1	1
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS X.030 XX.020 XXX.010	ANGLES 0° 30' FORMED 1° 0'	HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	Ron Wellman	4-28-69
CHECK	[illegible]	5/7/69
DESIGN	P. Dunmore	5/19/69
MECH ENGR		
PROJ ENGR	[illegible]	
PROD ENGR	[illegible]	

DANA® DANA LABORATORIES INC. IRVINE, CALIFORNIA

P.C.BOARD - ASSY READOUT

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403082	N

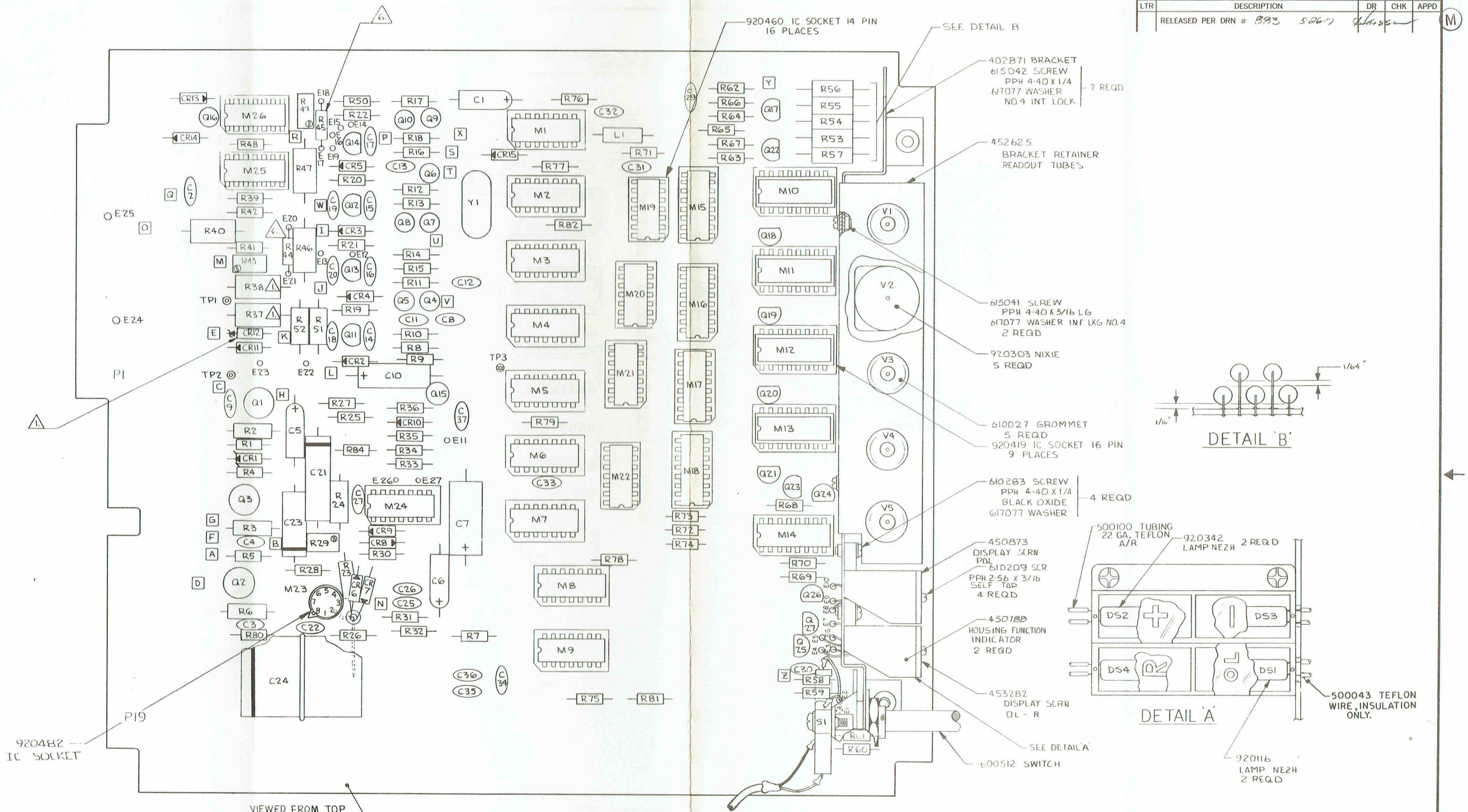
SCALE 1/1 | SHEET 1 OF 7

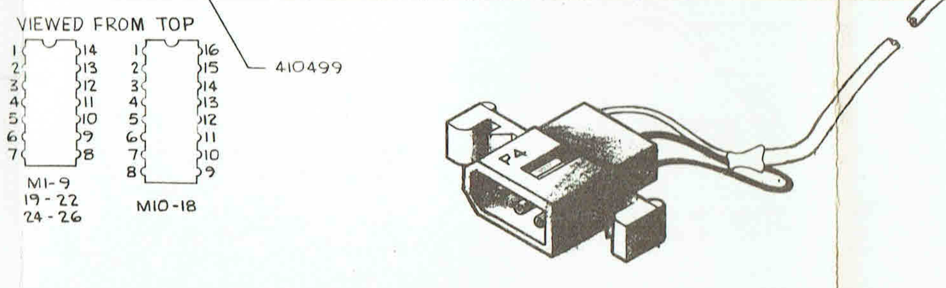
SHEETS 3 THRU 7 ARE 'A' SIZE

DANA 980346 DIETERICH-POST CLEARPRINT 1020-10

LTR	DESCRIPTION	DR	CHK	APPD
	RELEASED PER DRN # 883 5-26-?			

REVISIONS (M)





6. R44 & R45 ARE "FSV" WHEN REQUIRED.
5. SLEEVING TO RUN UP TO COMPONENT.
4. ALL RESISTORS ARE OHMS ± 5%, 1/4 W CARBON.
3. SCHEMATIC REF. 430843.
2. ASSY. PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
1. PART OF ZENER KIT 403294.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403206	4530	1	1
403232	4570	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 -.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL — FINISH

DRAWN	Ron Wellman	4-28-69
CHECK		
DESIGN		5/22/69
MECH ENGR		
PROJ ENGR		
PROD ENGR		

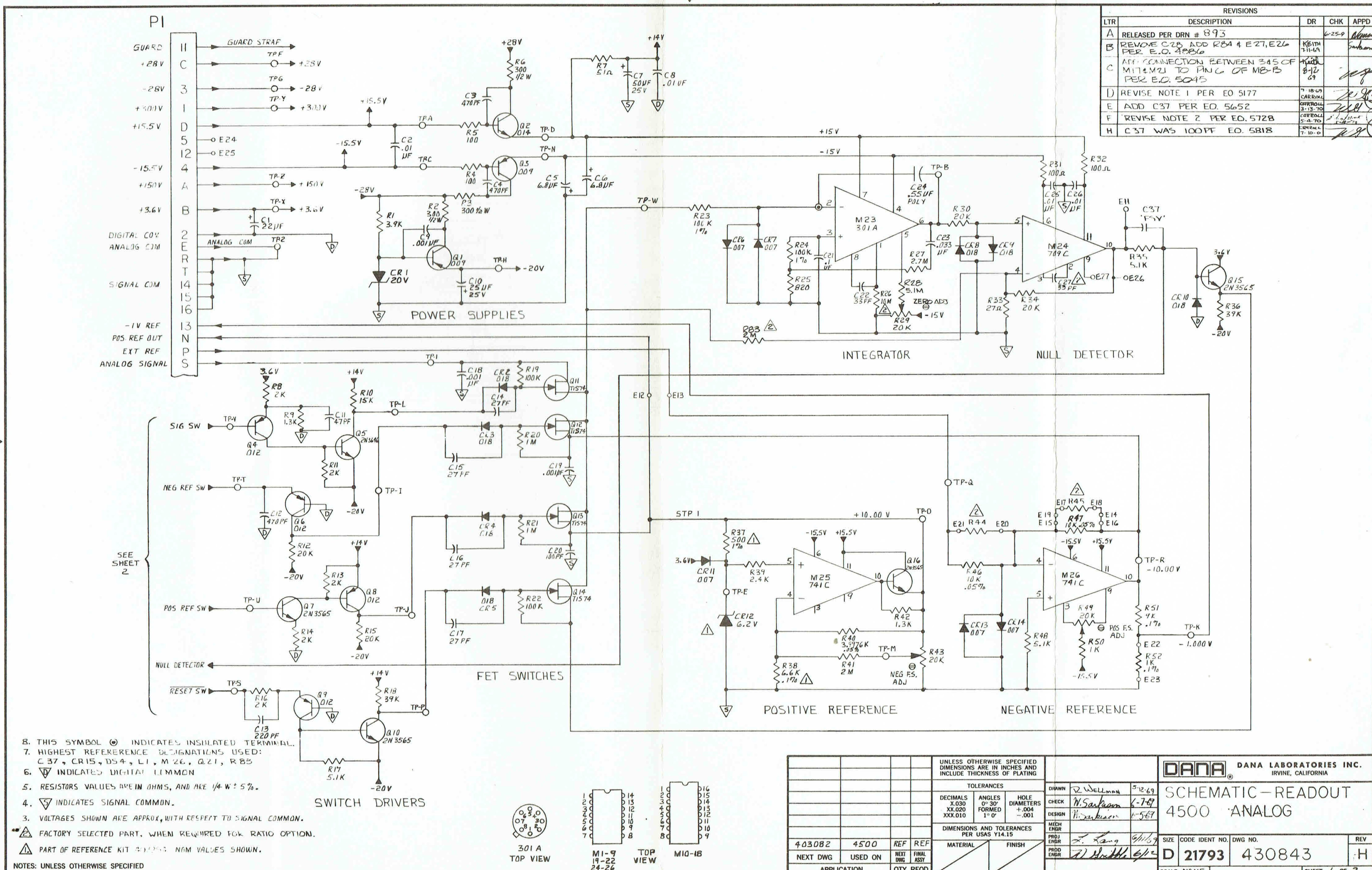
DANA LABORATORIES INC. IRVINE, CALIFORNIA

ASSY - READOUT 4500

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403082	N

SCALE 1/1 — SHEET 2 OF 7

DANA 980345 DIETERICH-POST CLEARPRINT 1020-10



REVISIONS

LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 893		6-25-9	
B	REMOVE C28 ADD R84 & E27, E26 PER E.O. 4886	KEITH 7-11-69		Sarkisian
C	ADD CONNECTION BETWEEN 3&5 OF M17&M21 TO PIN 6 OF M8-B PER E.O. 5045	Keith 8-12-69		
D	REVISE NOTE 1 PER EO 5177	9-18-69 CARROLL		
E	ADD C37 PER EO. 5652	CARROLL 3-13-70		
F	REVISE NOTE 2 PER EO. 5728	CARROLL 5-4-70		
H	C37 WAS 100PF EO. 5818	CARROLL 7-10-0		

8. THIS SYMBOL ⊙ INDICATES INSULATED TERMINAL.
7. HIGHEST REFERENCE DESIGNATIONS USED: C37, CR15, DS4, L1, M26, Q21, R83
6. Ⓓ INDICATES DIGITAL COMMON
5. RESISTORS VALUES ARE IN OHMS, AND ARE 1/4 W ± 5%.
4. Ⓢ INDICATES SIGNAL COMMON.
3. VOLTAGES SHOWN ARE APPROX, WITH RESPECT TO SIGNAL COMMON.

⚠2 FACTORY SELECTED PART, WHEN REQUIRED FOR RATIO OPTION.

⚠1 PART OF REFERENCE KIT [illegible] NOM VALUES SHOWN.

NOTES: UNLESS OTHERWISE SPECIFIED

403082	4500	REF	REF
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30′ FORMED 1° 0′	+.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL / FINISH

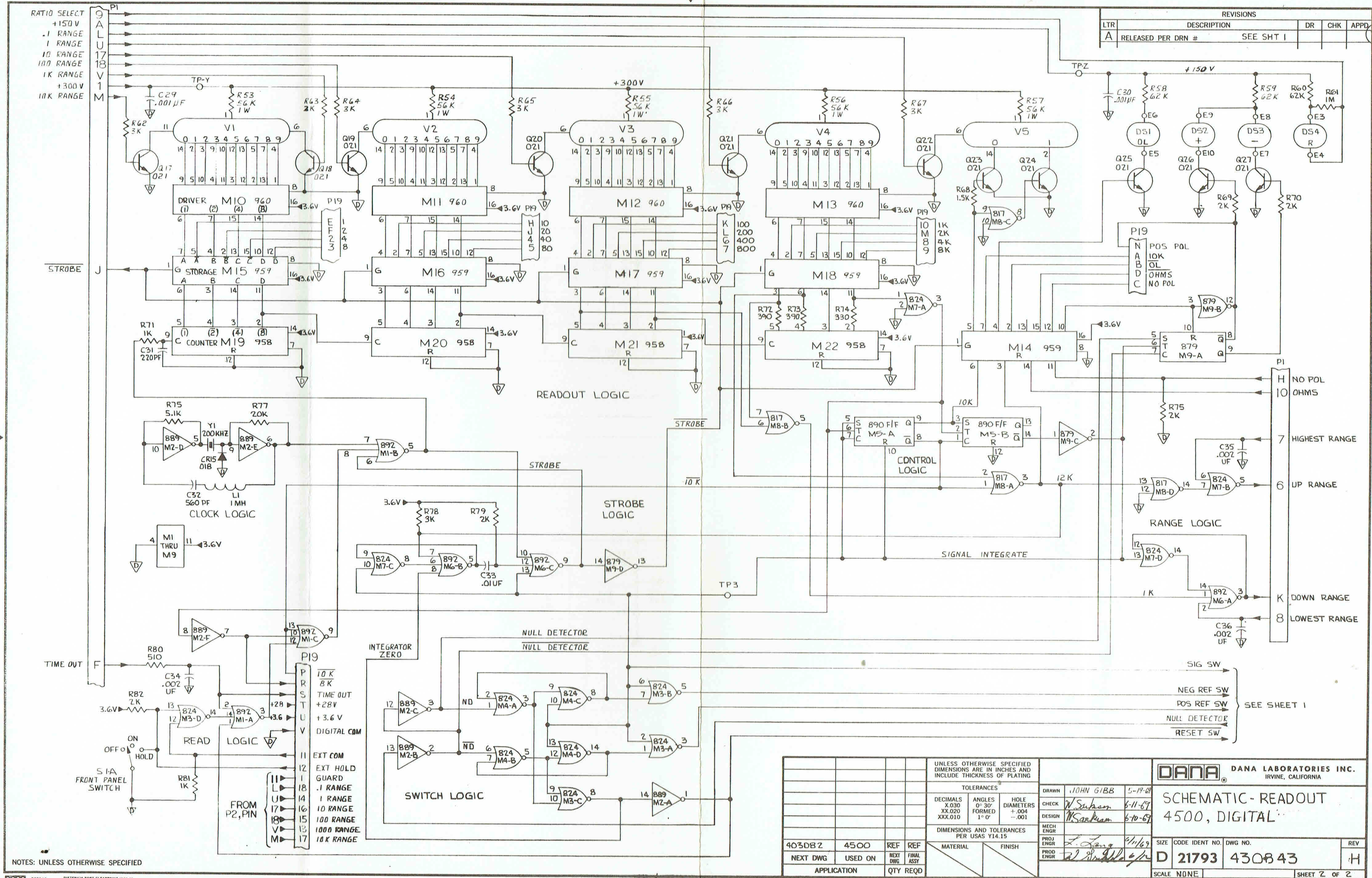
DRAWN	R. Wellman	5-12-69
CHECK	W. Sarkisian	6-7-69
DESIGN	W. Sarkisian	6-5-69
MECH ENGR		
PROJ ENGR	L. Lang	6/11/69
PROD ENGR	[illegible]	6/12

DANA® DANA LABORATORIES INC. IRVINE, CALIFORNIA

SCHEMATIC—READOUT 4500 ANALOG

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430843	H

SCALE NONE SHEET 1 OF 2



NOTES: UNLESS OTHERWISE SPECIFIED

LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # SEE SHT 1			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES: DECIMALS X.030 XX.020 XXX.010 — ANGLES 0° 30' FORMED 1° 0' — HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL — FINISH

DRAWN	JOHN GIBB	5-19-69
CHECK	W. Sakan	6-11-69
DESIGN	W. Sakan	6-10-69
MECH ENGR		
PROJ ENGR	L. Lang	6/11/69
PROD ENGR		

NEXT DWG	USED ON	REF	REF
403082	4500	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

DANA LABORATORIES INC. IRVINE, CALIFORNIA

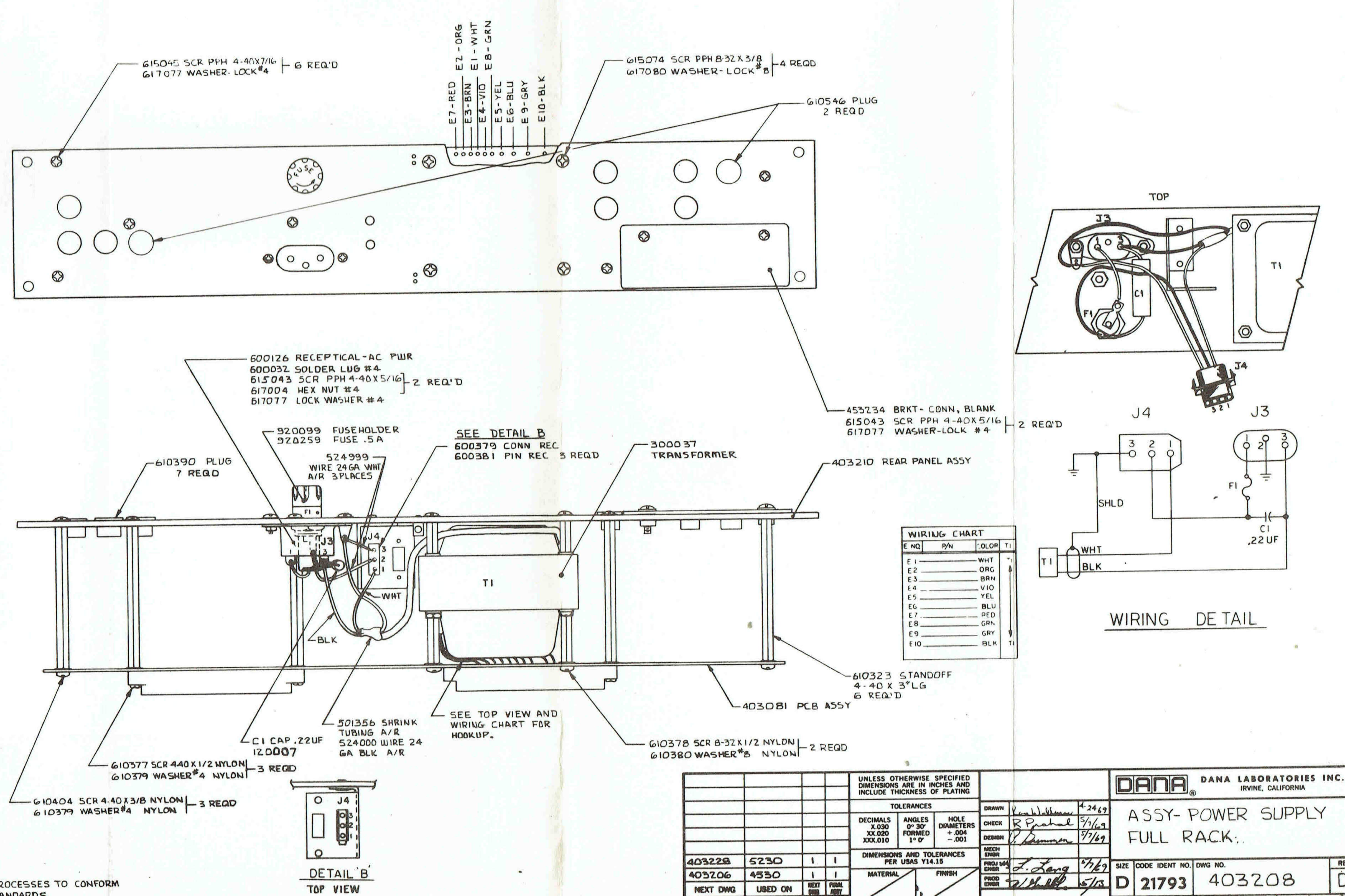
SCHEMATIC - READOUT 4500, DIGITAL

SIZE D — CODE IDENT NO. 21793 — DWG NO. 430843 — REV H

SCALE NONE — SHEET 2 OF 2

DANA 980346 DIETRICH-POST CLEARPRINT 1020-10

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN #879		5-20-69	J.S.L.
B	REVISED PER EO 4944			
C	REVISED PER EO 5071			
D	ADD WIRING DETAIL EO 5557			



2. SCHEMATIC REF NO. 430842.
1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT ASSY	FINAL ASSY
403228	5230	1	1
403206	4530	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES: DECIMALS X.030 XX.020 XXX.010 — ANGLES 0° 30' FORMED 1° 0' — HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL — FINISH

DRAWN 4-24-69 · CHECK R. Prahal 5/1/69 · DESIGN 5/7/69 · PROJ ENGR L. Lang 5/7/69 · PROD ENGR 5/13

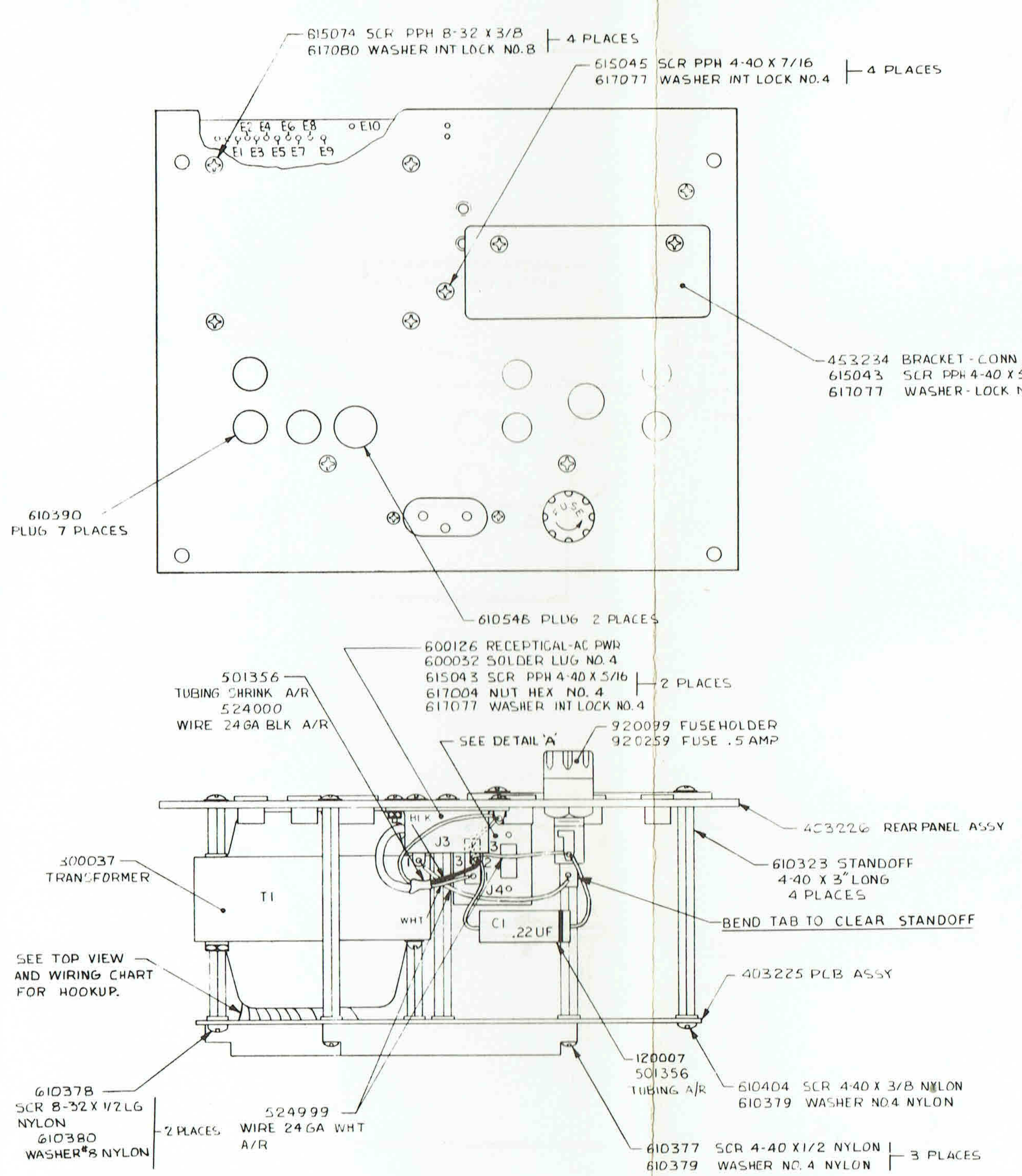
DANA LABORATORIES INC. IRVINE, CALIFORNIA

ASSY- POWER SUPPLY FULL RACK

SIZE D · CODE IDENT NO. 21793 · DWG NO. 403208 · REV D

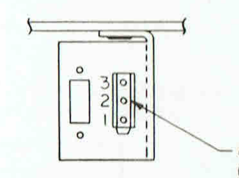
SCALE 1/1 · SHEET 1 OF 3

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 902 7-31-9	[illegible]		
B	REVISED PER EO 5071	[illegible]	9-4-69	
C	CHANGE 401376 TO 501356, ADD MTG. INSTRUCTIONS TO FUSE, EO. 5145	[illegible]		
D	[illegible] L1, PER EO 5468	[illegible]	12-17-69	
E	ADD WIRING DETAIL EO.5558	CORROLL 2-6-70		

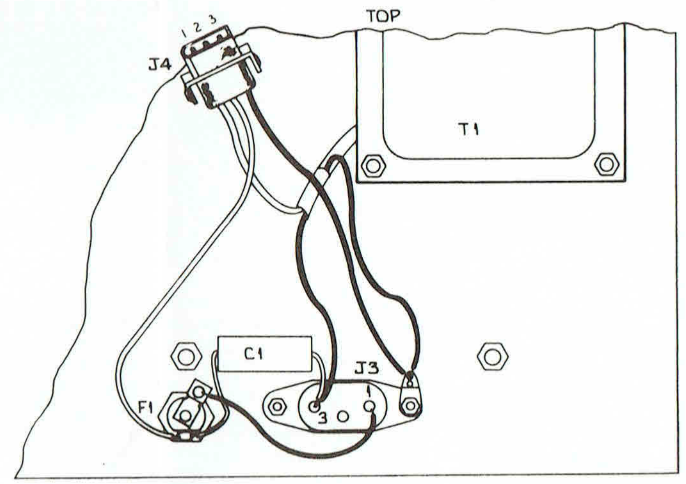


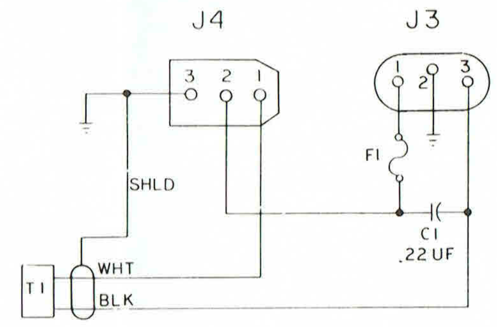
WIRING CHART

E NO	P N	COLOR	T1
E1		WHT	T1
E2		ORG	
E3		BRN	
E4		VIO	
E5		YEL	
E6		BLU	
E7		RED	
E8		GRN	
E9		GRY	
E10		BLK	T1



DETAIL 'A'
TOP VIEW





WIRING DETAIL

2 SCHEMATIC REF 430E42
1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.
NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403284	5270	1	1
403232	4570	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 -.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	Ron Wellman	6-1-69
CHECK	[illegible]	[illegible]
DESIGN	[illegible]	7/10/69
MECH ENGR		
PROJ ENGR	[illegible]	[illegible]
PROD ENGR	[illegible]	7/24/69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

POWER SUPPLY ASSY
HALF RACK

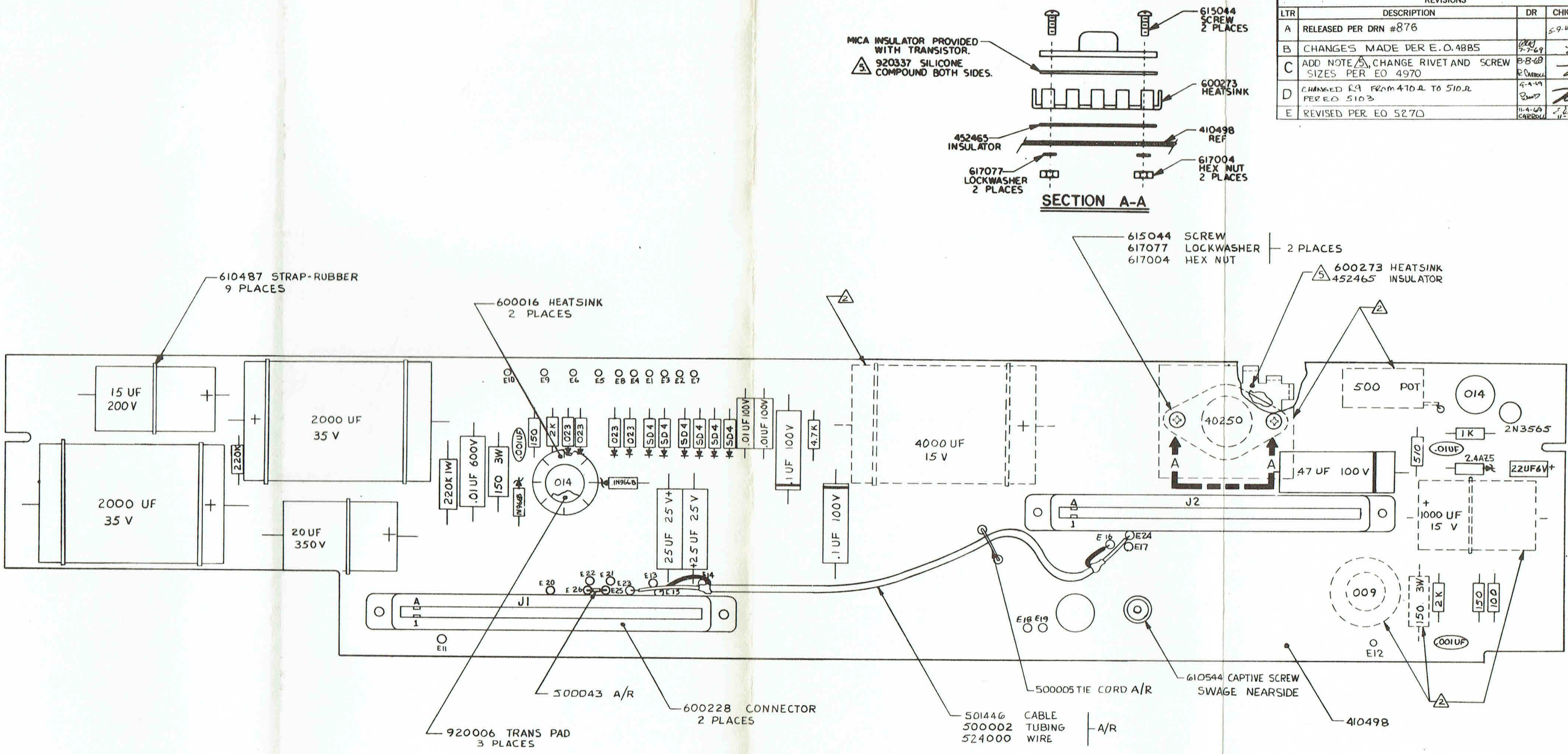
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403233	E

SCALE 1/1 SHEET 1 OF 3

SHT 2 AND 3 IS A SIZE

DANA 980346 DIETERICH-POST CLEARPRINT 1020

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN #876		5-9-69	J.L.
B	CHANGES MADE PER E.O. 4885	7-7-69		
C	ADD NOTE 5, CHANGE RIVET AND SCREW SIZES PER EO 4970	8-8-69 R CARROLL		
D	CHANGED R9 FROM 470Ω TO 510Ω PER EO 5103	9-4-69		
E	REVISED PER EO 5270	11-4-69 CARROLL	11-7-69	



5. PUT SILICONE COMPOUND 920337 ON BOTH SIDES OF THE MICA INSULATOR PROVIDED WITH THE 40250 PWR TRANSISTOR.
4. ALL RESISTORS ARE IN OHMS 1/4W, ± 5% CARBON
3. REF SCHEMATIC NO. 430842.
2. COMPONENTS LOCATED FARSIDE.
1. ASSEMBLY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403208	4530	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	E.T. Wellman	4-9-69
CHECK		4-30-69
DESIGN		4/30/69
MECH ENGR		
PROJ ENGR		5/1/69
PROD ENGR		5/6

DANA LABORATORIES INC. IRVINE, CALIFORNIA

PC BOARD ASSY POWER SUPPLY FULL RACK

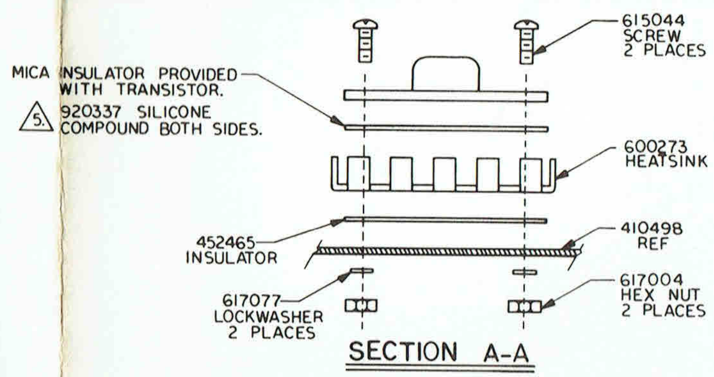
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403081	E

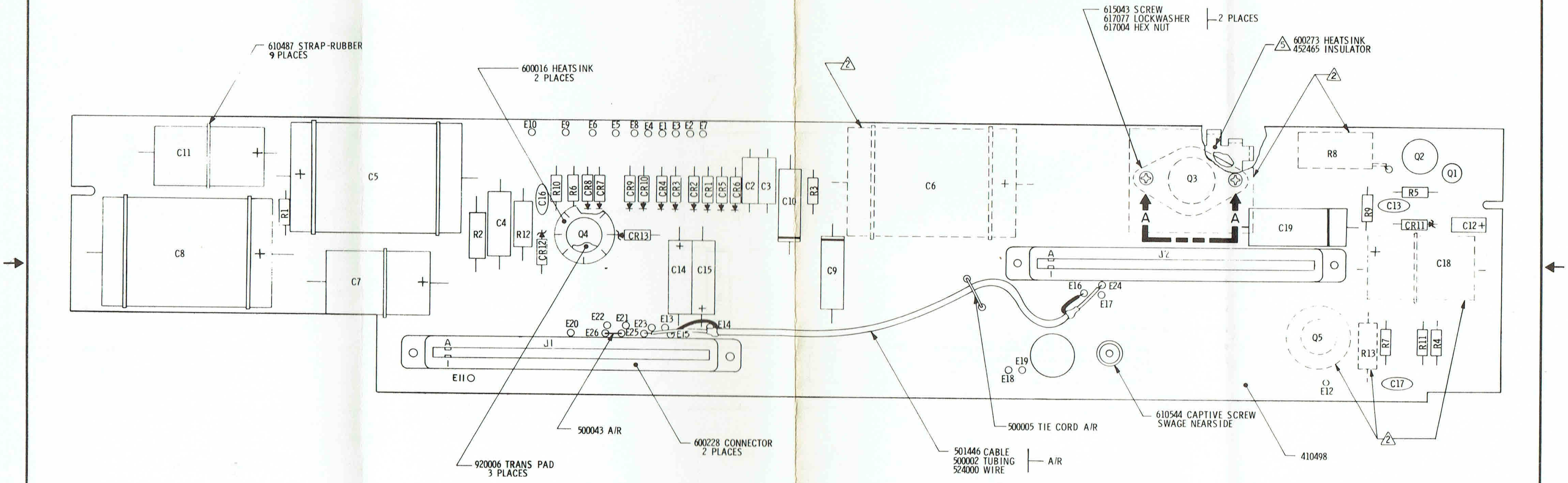
SCALE 2/1 SHEET 2 OF

SHTS 3, 4, 5 ARE 'A' SIZE

960246 DIETERICH-POST CLEARPRINT 1000

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN #876		5-9-69	J.L.
B	CHANGED PER E.O. 4885			
C	ADD NOTE 5, CHANGE RIVET AND SCREW SIZES PER EO 4970	8-8-69 Carroll		





5\. PUT SILICONE COMPOUND 920337 ON BOTH SIDES OF THE MICA INSULATOR PROVIDED WITH THE 40250 PWR TRANSISTOR.

4\. ALL RESISTORS ARE IN OHMS 1/4W, ±5% CARBON.

3\. REF SCHEMATIC NO. 430842.

2\. COMPONENTS LOCATED FARSIDE.

1\. ASSEMBLY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403208	4530	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0 30' FORMED 1 0'	+.004 -.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL — FINISH

DRAWN	R.T. Wellman	4-9-69
CHECK		
DESIGN		
MECH ENGR		
PROJ ENGR		
PROD ENGR		

DANA LABORATORIES INC. IRVINE, CALIFORNIA

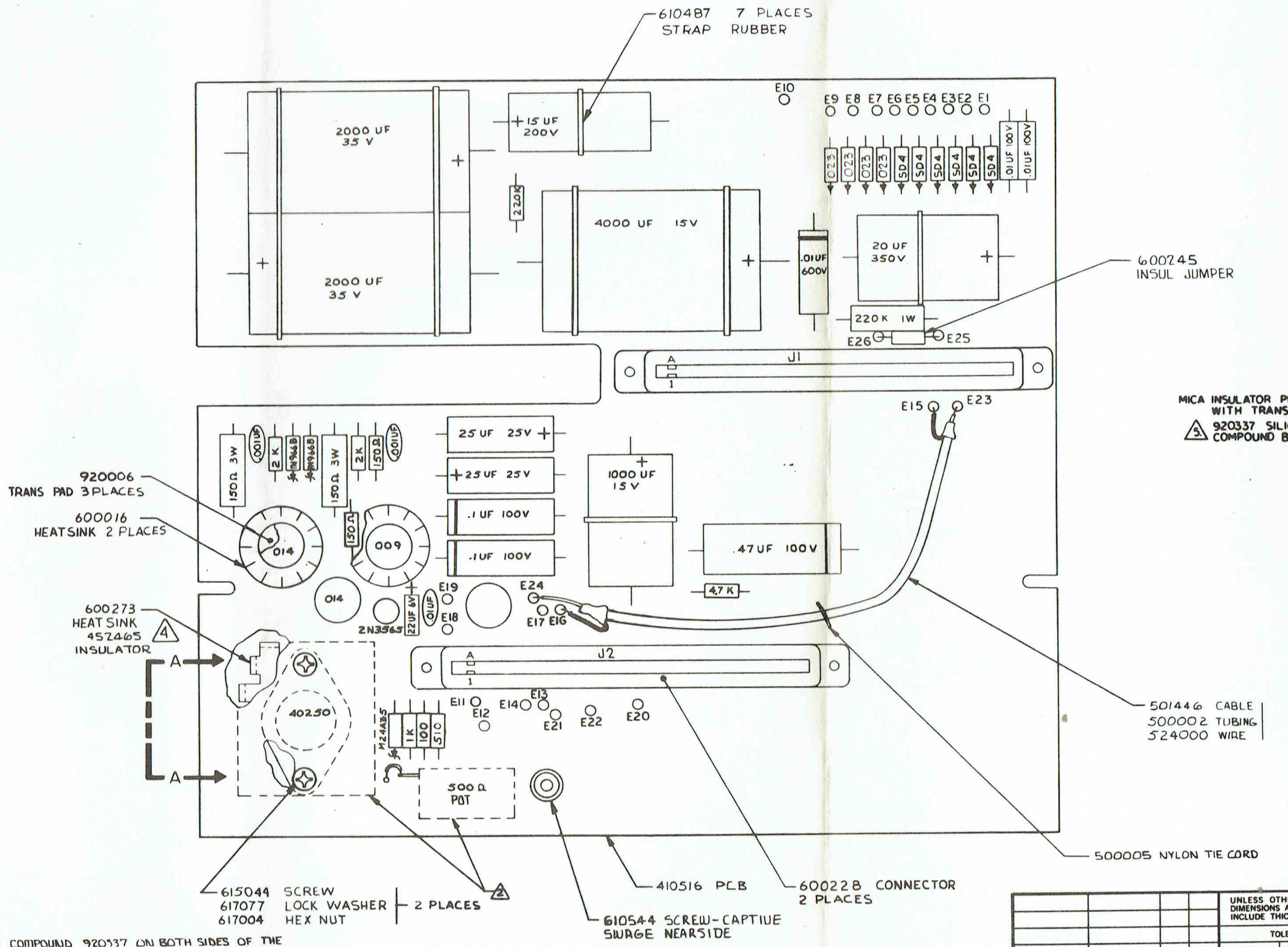
PC BOARD ASSY POWER SUPPLY FULL RACK

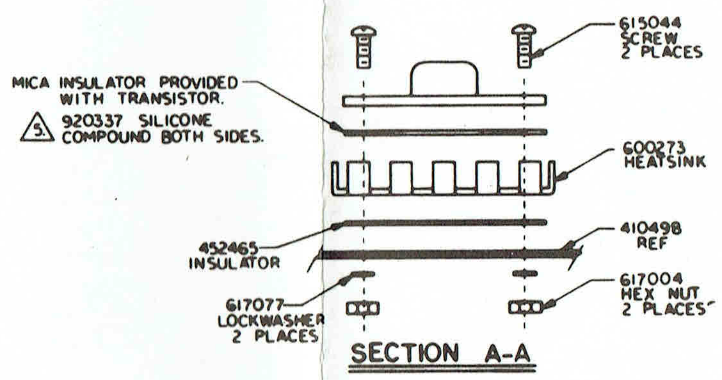
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403081	E

SCALE 1/1 — SHEET 2 OF 5

DANA 980346 DIETERICH-POST CLEARPRINT 1020

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 902 7-31-9			
B	CORRECTED 610544 MTG. INSTRUCTION TO SWAGE NEARSIDE PER EO. 5018	8-21-69		
C	REVISED PER EO 5270	11-6-69		
D	REVISED PER EO 5324	12-1-69		





SECTION A-A

4. PUT SILICONE COMPOUND 920337 ON BOTH SIDES OF THE MICA INSULATOR PROVIDED WITH THE 40250 PWR TRANSISTOR.

3. REF SCHEMATIC NO 430842.

2. COMPONENTS LOCATED FARSIDE.

1. ASSEMBLY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT ASSY	FINAL ASSY
403233	4570	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES: DECIMALS X.030 XX.020 XXX.010; ANGLES 0° 30′ FORMED 1° 0′; HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	R.T. Wellman	4-7-69
CHECK	W. Saxton	7/8/69
DESIGN	P. Hummel	7/8/69
MECH ENGR		
PROJ ENGR		
PROD ENGR		7-24/69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

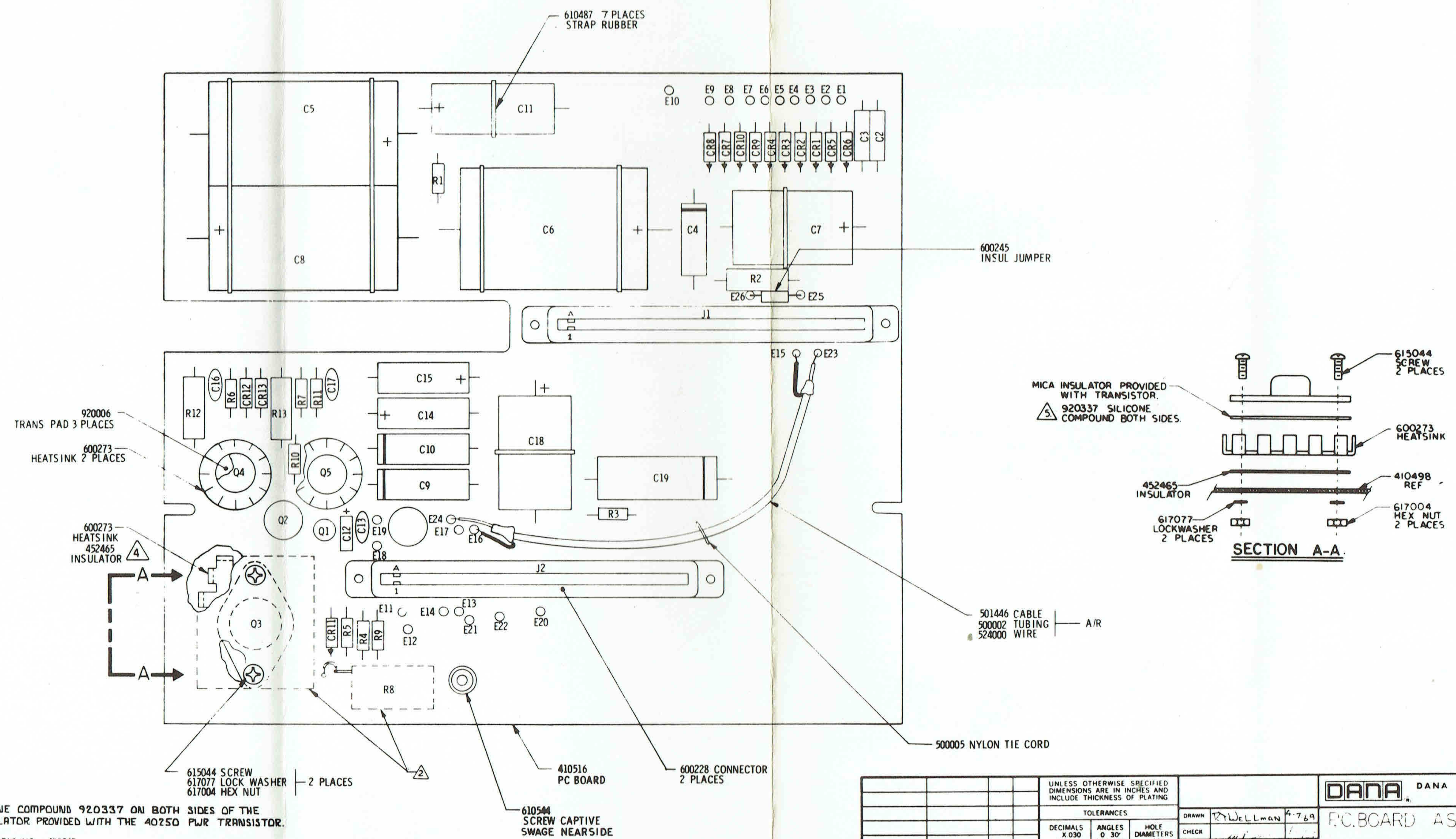
P.C. BOARD ASSY - POWER SUPPLY, HALF RACK

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403225	D

SCALE 2/1 SHEET 1 OF 5

SHTS 2,4,4 5 1& "A"

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # [illegible]	[illegible]		



4. PUT SILICONE COMPOUND 920337 ON BOTH SIDES OF THE MICA INSULATOR PROVIDED WITH THE 40250 PWR TRANSISTOR.

REF SCHEMATIC NO. 430842.

2. COMPONENTS LOCATED FARSIDE.

1. ASSEMBLY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES. UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403233	4570	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS	ANGLES	HOLE DIAMETERS
X .030 XX .020 XXX .010	0 30' FORMED 1° 0'	+ .004 − .001

DIMENSIONS AND TOLERANCES PER USAS Y14 15

MATERIAL | FINISH

DRAWN	R Wellman	4-7-69
CHECK	[illegible]	
DESIGN	P. Gummeson	7/8/69
MECH ENGR		
PROJ ENGR		
PROD ENGR		

DANA LABORATORIES INC. IRVINE CALIFORNIA

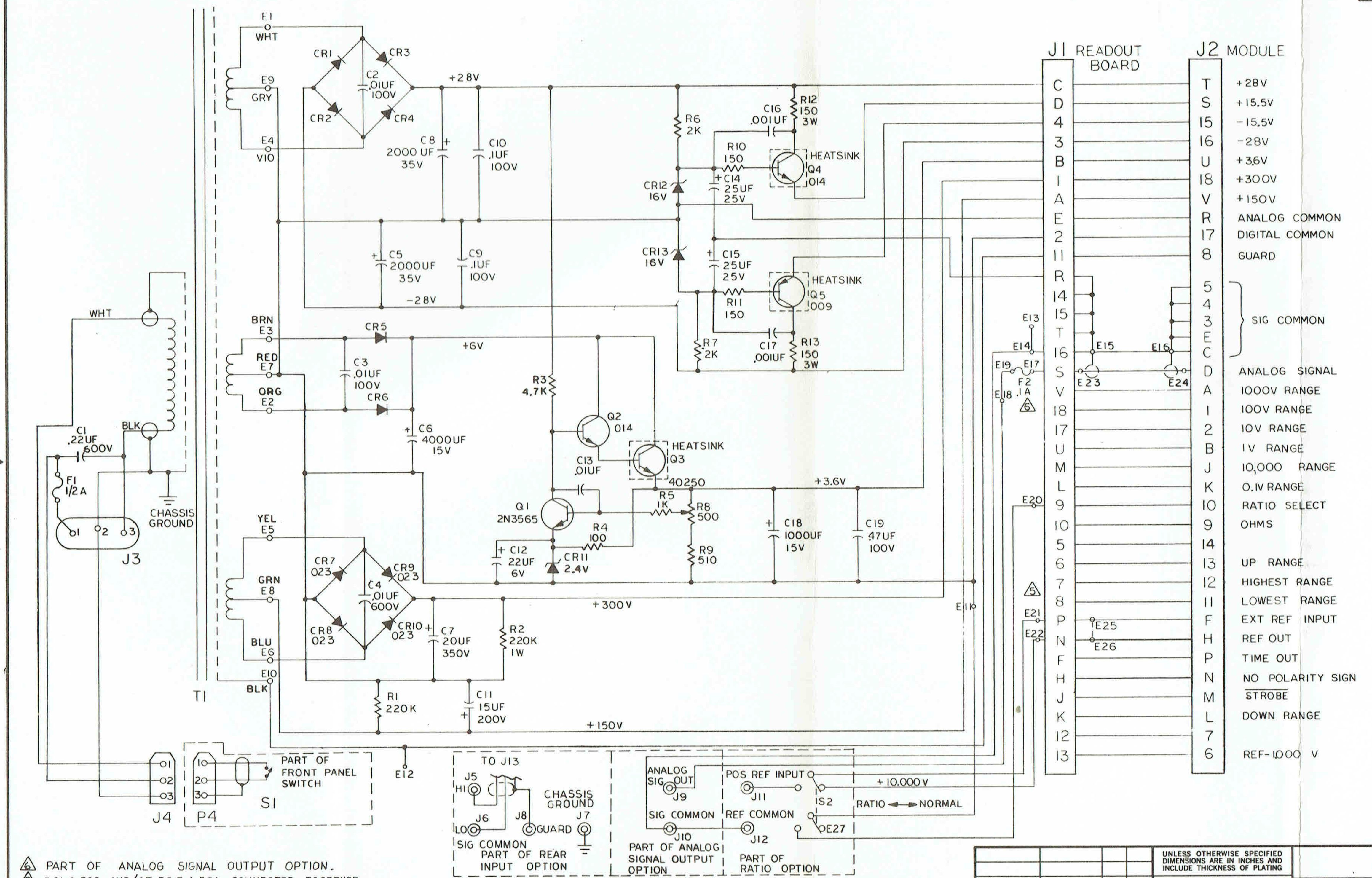
P.C. BOARD ASSY – POWER SUPPLY, HALF RACK

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	403225	D

SCALE 2/1 SHEET 2 OF 5

DANA 980346

LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN #876		5-9-69	J.L.
B	REVISED PER EO 5071		9-4-69	
C	REVISE CONNECTION OF C16 & C17 PER EO 5270	11-4-69	11-7-69	



⚠6 PART OF ANALOG SIGNAL OUTPUT OPTION.
⚠5 E21 & E22 AND/OR E25 & E26 CONNECTED TOGETHER WITHOUT RATIO OPTION.
4. HIGHEST REF DES USED: C19; CR13; E27; Q5; R13; J12; S2; T1; F2
3. ALL VOLTAGES ARE APPROX VALUES MEASURED WITH RESPECT TO ANALOG COMMON.
2. ALL RESISTOR VALUES ARE IN OHMS 1/4W ±5% CARBON.
1. ALL DIODES ARE SD4

NOTES: UNLESS OTHERWISE SPECIFIED

403081	4530	REF	REF
403185	4570	REF	REF
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 -.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN 3-27-69 · CHECK 4-30-69 · DESIGN 4-30-69 · MECH ENGR · PROJ ENGR 5/1/69 · PROD ENGR 5/5

DANA LABORATORIES INC. IRVINE, CALIFORNIA

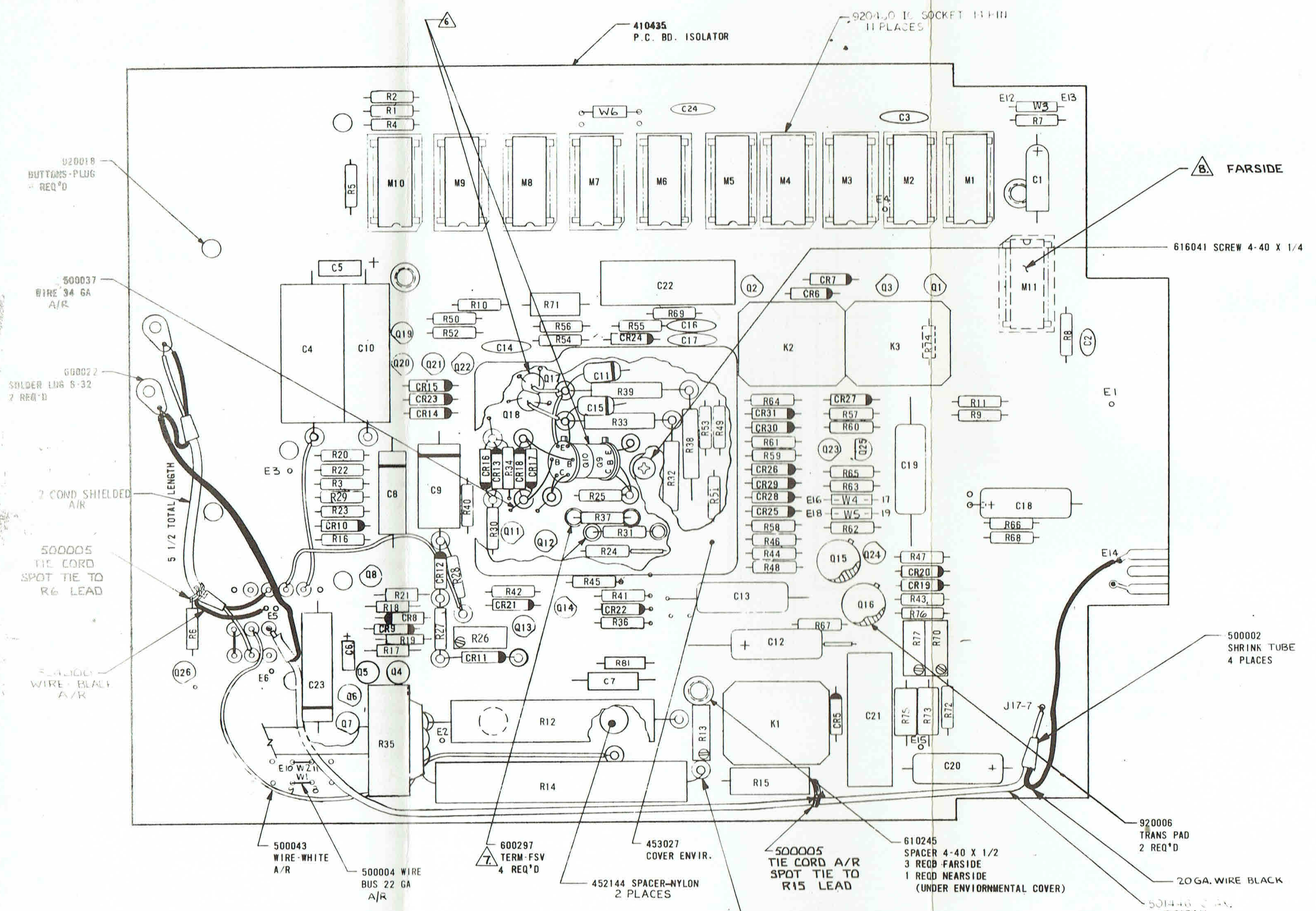
POWER SUPPLY 4500

SIZE D · CODE IDENT NO. 21793 · DWG NO. .430842 · REV C

SCALE · SHEET 1 OF 1

REVISIONS

LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN 893		2-25-69	
B	ADD IC SOCKETS P/N 920430 EO.5012			
C	REPLACE 500006 WITH 501446 EO. 5164	9-18-69 CARROLL		
D	ADD R81, CHANGE VALUES OF C5, R21, & R22 PER EO. 5277	11-14-69 CARROLL		
E	MOUNT ONE END OF R34 TO PCB EO. 5327	11-14-69 CARROLL		
F	CHANGE Q4 & 5 TO 2N3565 PER EO. 5393	11-17-69 CARROLL		
H	REVISED PER EO. 5494	1-5-69 CARROLL		
J	REVISED PER EO. 5507	CARROLL 1-20-70		1-20-70
K	ADD DETAIL 'A' TO CLARIFY Q9-10 GLUING INSTR. PER EO. 5575	CARROLL 2-18-70		
L	DELETE 920035 PER EO. 5835	CARROLL 7-15-70		



8. MII SOCKET AND COMPONENT MOUNTED ON FARSIDE.
7. DO NOT SOLDER JUMPERS IN FSV TERMINALS.
6. TO BE CEMENTED TOGETHER WITH EASTMAN #910 (P/N 920008)
5. RELAYS K1, K2, K3, RESISTOR R35 AND ALL PUSH BUTTON SWITCHES ARE TO BE FREE OF CONTAMINANTS
4. SCHEMATIC REFERENCE. 430867
3. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS
2. ALL DIODES TO BE 018
1. ALL RESISTORS ARE IN OHMS 1/4 W, ±5% CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

9. CONN. END OF 403243 CABLE IS TO BE COVERED WITH A 1 1/4" LG. PIECE OF 500063 SHRINK TUBING TO INSULATE CONNECTIONS AND EXPOSED PINS. WHEN NONE OF THE CONVERTER ACCESSORIES ARE INSTALLED, SHRINK THE TUBING IN PLACE, LOOP THE CONN. END BACK AND SPOT TIE IT TO THE CABLE NEAR 33 TO SECURE IT.

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403201	350	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON:

DECIMALS	ANGLES	HOLE DIAMETERS
.X .030	0 30'	.004
.XX .020	FORMED	.001
.XXX .010	1 0'	

MATERIAL

FINISH

DRAWN	John Gibb	2-25-69
CHECK	W Sarkisian	6-5-69
DESIGN	P. Dunnam	6/6/69
MECH ENGR		
PROJ ENGR		6/6/69
		6/9/69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

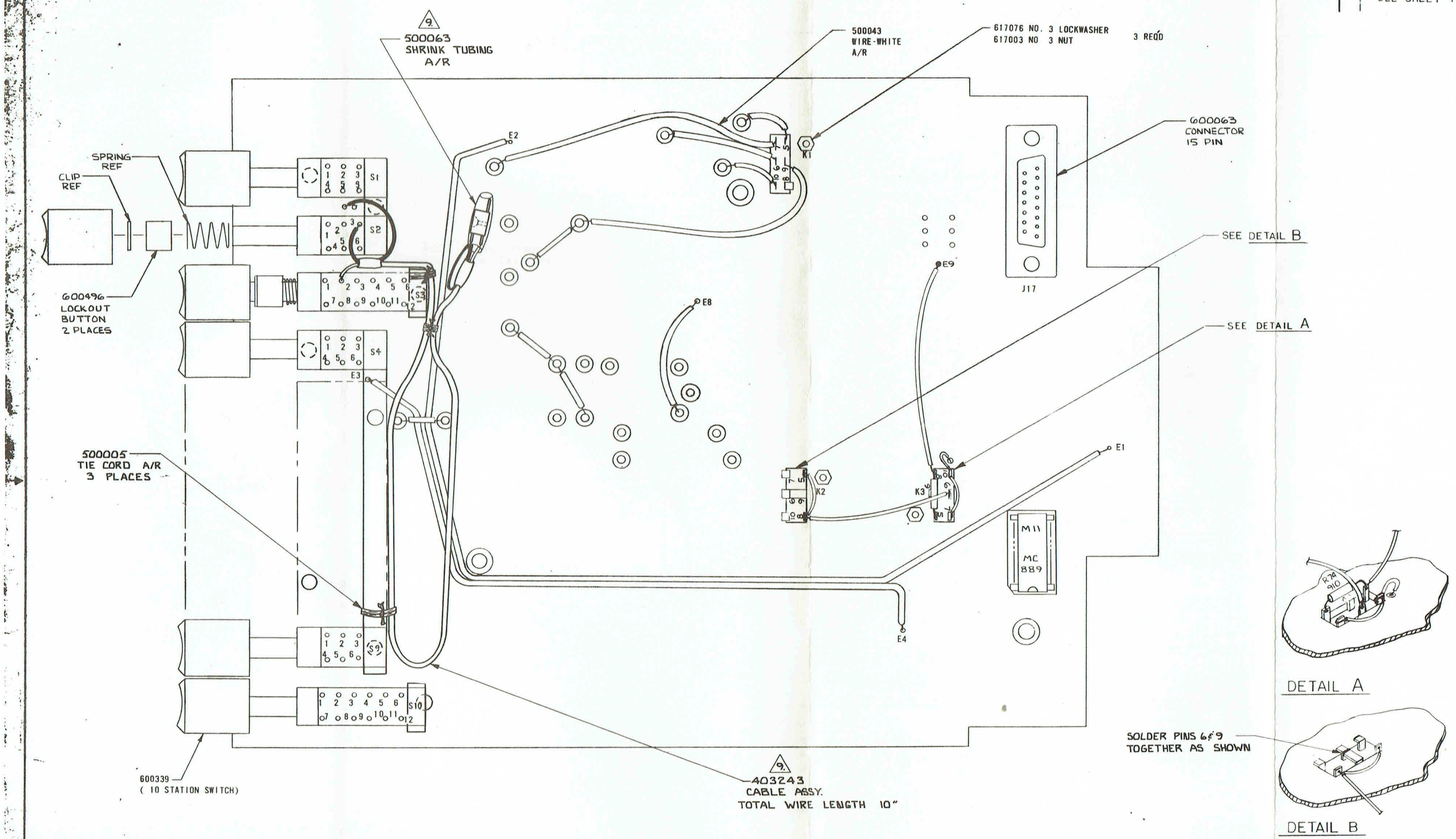
P.C. BD. ASSY
ISOLATOR MODEL 350

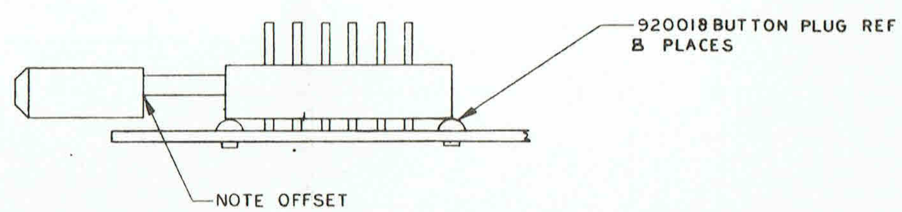
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403198	L

SCALE 2:1 SHEET 1

SHTS 4 THRU 9 ARE "A" SIZE

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
	SEE SHEET 1			





NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	QTY REQD NEXT DWG	QTY REQD FINAL ASSY
403201	350	1	1

APPLICATION

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON:

DECIMALS	ANGLES	HOLE DIAMETERS
.X .030	0° 30′	+.004
.XX .020	FORMED	−.001
.XXX .010	1° 0′	

MATERIAL

FINISH

DRAWN	John R. Gibb	2-25-64
CHECK	W. Sarkison	6-5-67
DESIGN	J. Dummeson	6/6/64
MECH ENGR		
PROJ ENGR	L. Lang	6/6/64

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

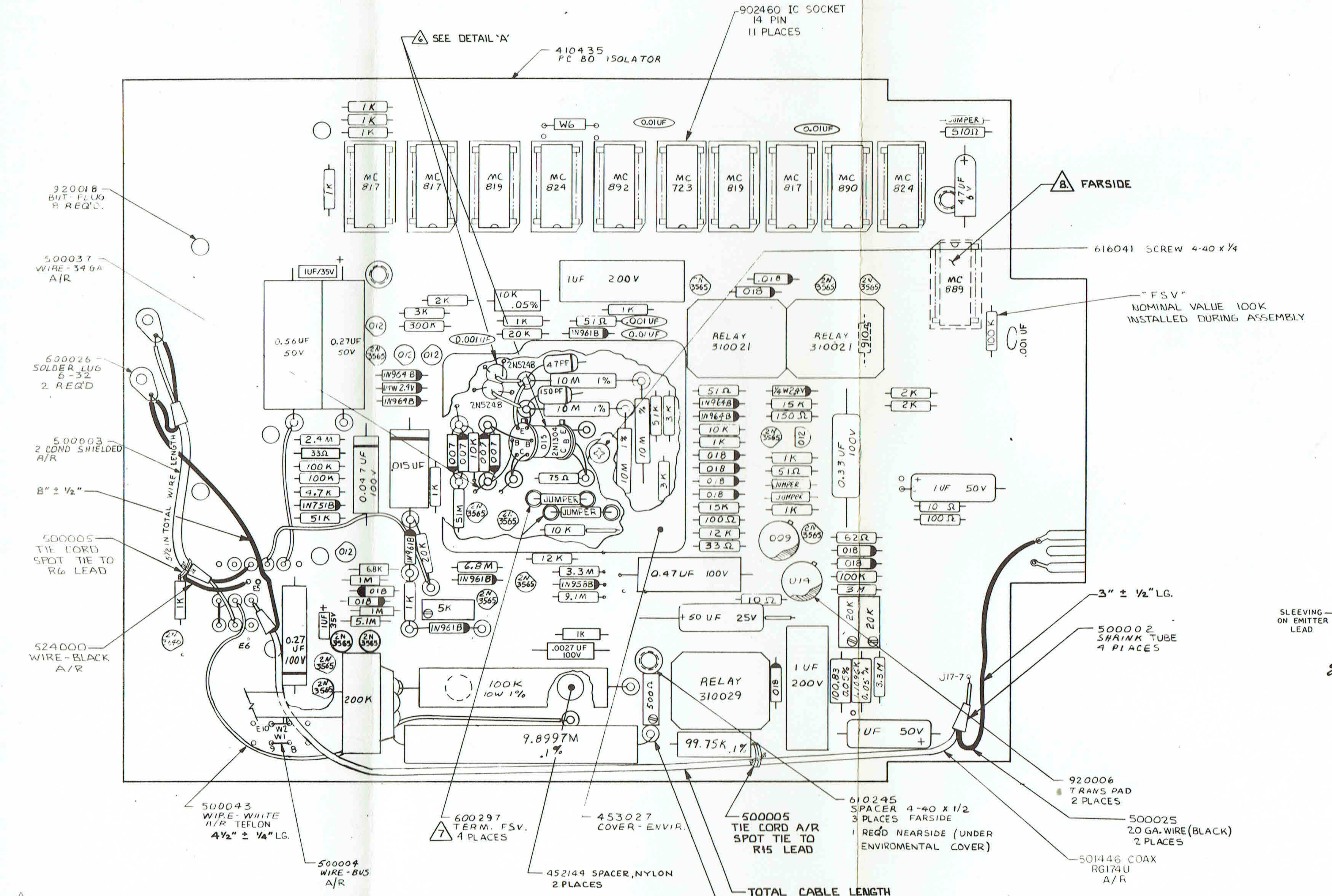
P.C. BD. ASSY–
ISOLATOR—MODEL 350

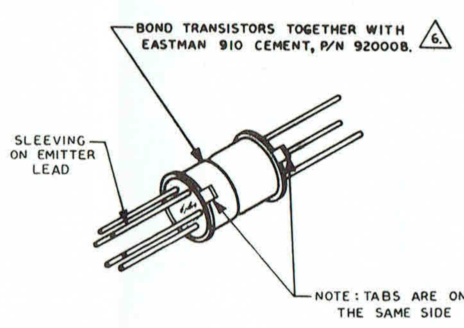
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403198	L

SCALE 2:1 SHEET 2 OF 9

LTR	DESCRIPTION	DR	CHK	APPD
	SEE SHEET 1			

REVISIONS





DETAIL A

8. MII SOCKET AND COMPONENT MOUNTED ON FARSIDE.
7. DO NOT SOLDER JUMPERS IN FSV TERMINALS.
6. TO BE CEMENTED TOGETHER WITH EASTMAN #910 (P/N 920008)
5. RELAYS K1, K2, K3, RESISTOR R35 (200K ZERO POT) AND ALL PUSH BUTTON SWITCHES ARE TO BE FREE OF CONTAMINANTS
4. SCHEMATIC REFERENCE : 430867
3. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS
2. REF. SCHEMATIC NO. 430867.
1. ALL RESISTORS ARE IN OHMS 1/4W, ± 5% CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

9. CONN. END OF 403243 CABLE IS TO BE COVERED WITH A 1 1/4" LG. PIECE OF 500063 SHRINK TUBING TO INSULATE CONNECTIONS AND EXPOSED PINS WHEN NONE OF THE CONVERTER ACCESSORIES ARE INSTALLED. SHRINK THE TUBING IN PLACE, LOOP THE CONN. END BACK AND SPOT TIE IT TO THE CABLE NEAR S3 TO SECURE IT.

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403201	350	1	1

APPLICATION — QTY REQD

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON:

DECIMALS	ANGLES	HOLE DIAMETERS
.X .030	0 30'	+.004
.XX .020	FORMED	.001
.XXX .010	1 0'	

MATERIAL

FINISH

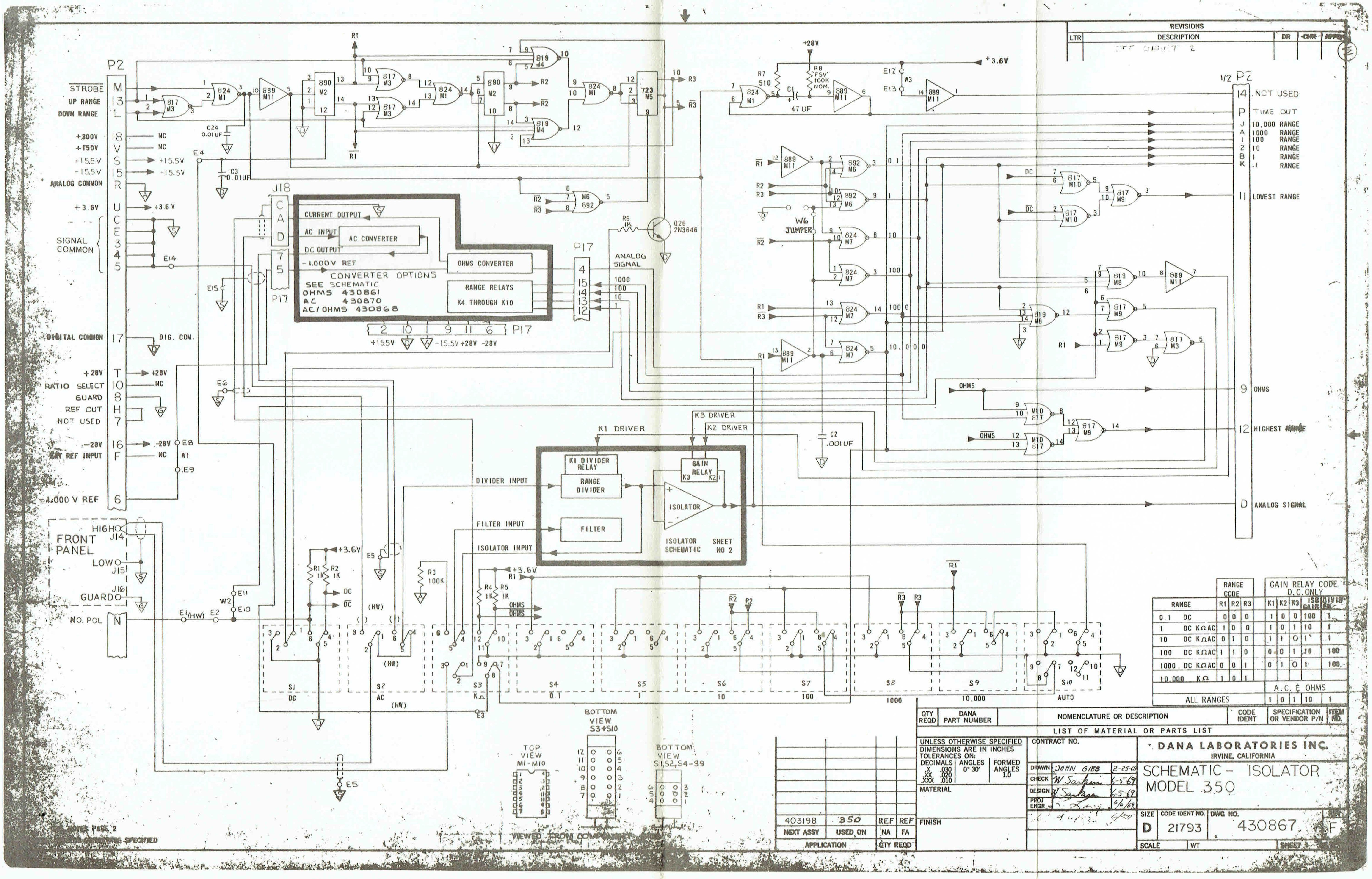
DRAWN	[signature]	2-25-69
CHECK	[signature]	6-5-69
DESIGN	[signature]	6/6/69
MECH ENGR		
PROJ ENGR	[signature]	6/6/69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P.C. BD. ASSY
ISOLATOR MODEL 350

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403198	L

SCALE 2:1 — SHEET 3 OF 9



RANGE		RANGE CODE R1	R2	R3	GAIN RELAY CODE D.C. ONLY K1	K2	K3	ISO GAIN	DIVIDER
0.1	DC	0	0	0	1	0	0	100	1
1	DC KΩ AC	1	0	0	1	0	1	10	1
10	DC KΩ AC	0	1	0	1	1	0	1	1
100	DC KΩ AC	1	1	0	0	0	1	10	100
1000	DC KΩ AC	0	0	1	0	1	0	1	100
10,000	KΩ	1	0	1					
ALL RANGES	A.C. & OHMS				1	0	1	10	1

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS .X .030 .XX .020 .XXX .010 ANGLES 0° 30' FORMED ANGLES 1.0

MATERIAL

FINISH

NEXT ASSY	USED ON	QTY REQD	
403198	350	REF NA	REF FA

APPLICATION

CONTRACT NO.

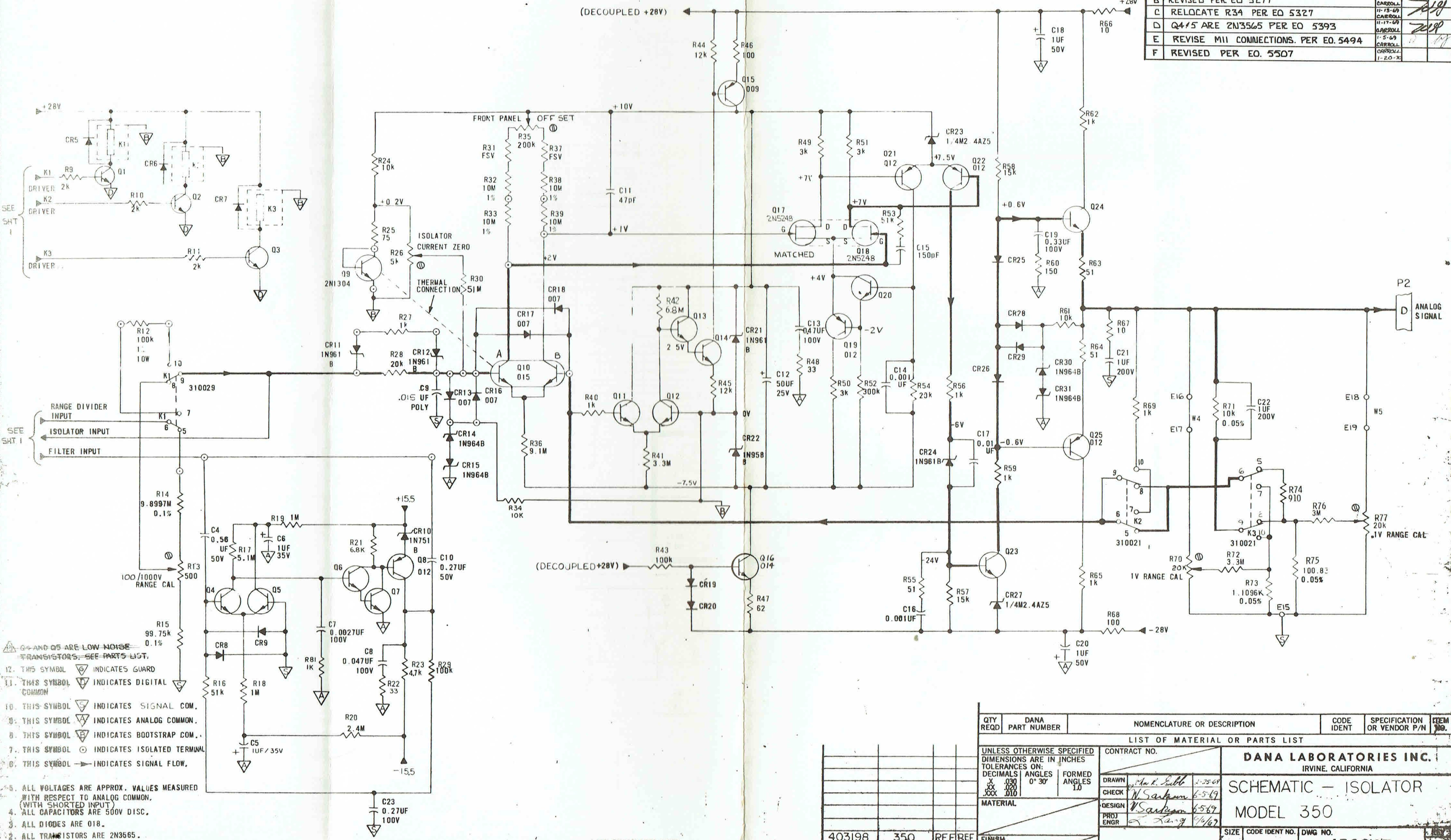
DRAWN JOHN GIBB 2-25-69
CHECK W. Sarkan 6-5-69
DESIGN W. Sarkan 6-5-69
PROJ ENGR 6/6/69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC - ISOLATOR MODEL 350

SIZE D | CODE IDENT NO. 21793 | DWG NO. 430867 | F

SCALE | WT | SHEET 1



REVISIONS

LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN NO		6-25-9	
B	REVISED PER EO 5277	11-13-69 CARROLL		
C	RELOCATE R34 PER EO 5327	11-13-69 CARROLL		
D	Q4&5 ARE 2N3565 PER EO 5393	11-17-69 CARROLL		
E	REVISE M11 CONNECTIONS. PER EO. 5494	1-5-69 CARROLL		
F	REVISED PER EO. 5507	CARROLL 1-20-70		

~~13. Q4 AND Q5 ARE LOW NOISE TRANSISTORS. SEE PARTS LIST.~~

12. THIS SYMBOL (G) INDICATES GUARD
11. THIS SYMBOL (D) INDICATES DIGITAL COMMON
10. THIS SYMBOL (S) INDICATES SIGNAL COM.
9. THIS SYMBOL (A) INDICATES ANALOG COMMON.
8. THIS SYMBOL (B) INDICATES BOOTSTRAP COM.
7. THIS SYMBOL ⊙ INDICATES ISOLATED TERMINAL
6. THIS SYMBOL —▶— INDICATES SIGNAL FLOW.
5. ALL VOLTAGES ARE APPROX. VALUES MEASURED WITH RESPECT TO ANALOG COMMON. (WITH SHORTED INPUT)
4. ALL CAPACITORS ARE 500V DISC.
3. ALL DIODES ARE 018.
2. ALL TRANSISTORS ARE 2N3565.
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 5% CARBON.

NOTE: UNLESS OTHERWISE SPECIFIED

LAST DESIGNATOR USED

R81	C24	Q26	CR31	K3	E19

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

403198	350	REF	REF
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON:

DECIMALS	ANGLES	FORMED ANGLES
.X .030 .XX .020 .XXX .010	0° 30'	1.0

MATERIAL

FINISH

CONTRACT NO.

DRAWN		2-25-69
CHECK	W. Sarkisian	6-5-69
DESIGN	W. Sarkisian	6-5-69
PROJ ENGR	L. Lang	6/6/69

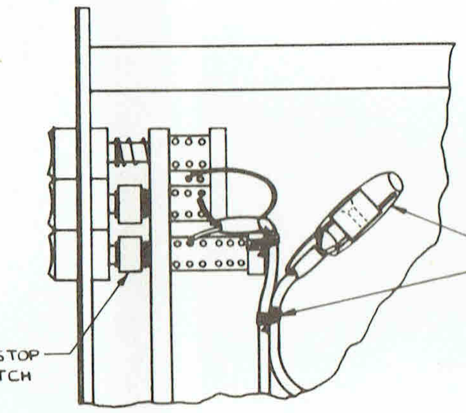
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

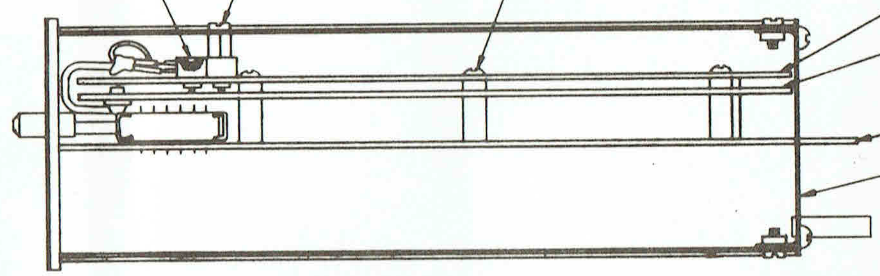
SCHEMATIC — ISOLATOR MODEL 350

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430867	F

SCALE | WT | SHEET 2

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
	RELEASED PER DRN # [illegible] 5309	[illegible]		
B	SPOT TIE COAX TO SWITCH E.O. 5145	9-8-69 CARROLL	[illegible]	
C	DELETE P/N FOR ISOLATOR AND ASSY MODULE PER E.O. 5386	12-16-69		[illegible]
D	REVISE CABLE VIEW PER E.O. 5498	CARROLL 1-12-70	[illegible] 1-20-70	





SIDE EXTRUSION REMOVED FOR CLARITY

⚠2 ALL INDICATED HARDWARE IS INCLUDED IN FINISHING KIT (403227)

1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	SUB ASSY	FINAL ASSY
403293	5200	1	1
403201	4300	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS X.030 XX.020 XXX.010	ANGLES 0° 30′ FORMED 1° 0′	HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	[signature]	6/13/69
CHECK	W. Sarkisian	6/24/69
DESIGN	[signature]	6/13/69
MECH ENGR		
PROJ ENGR	L. Lang	6/26/69
PROD ENGR	[signature]	6/30

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

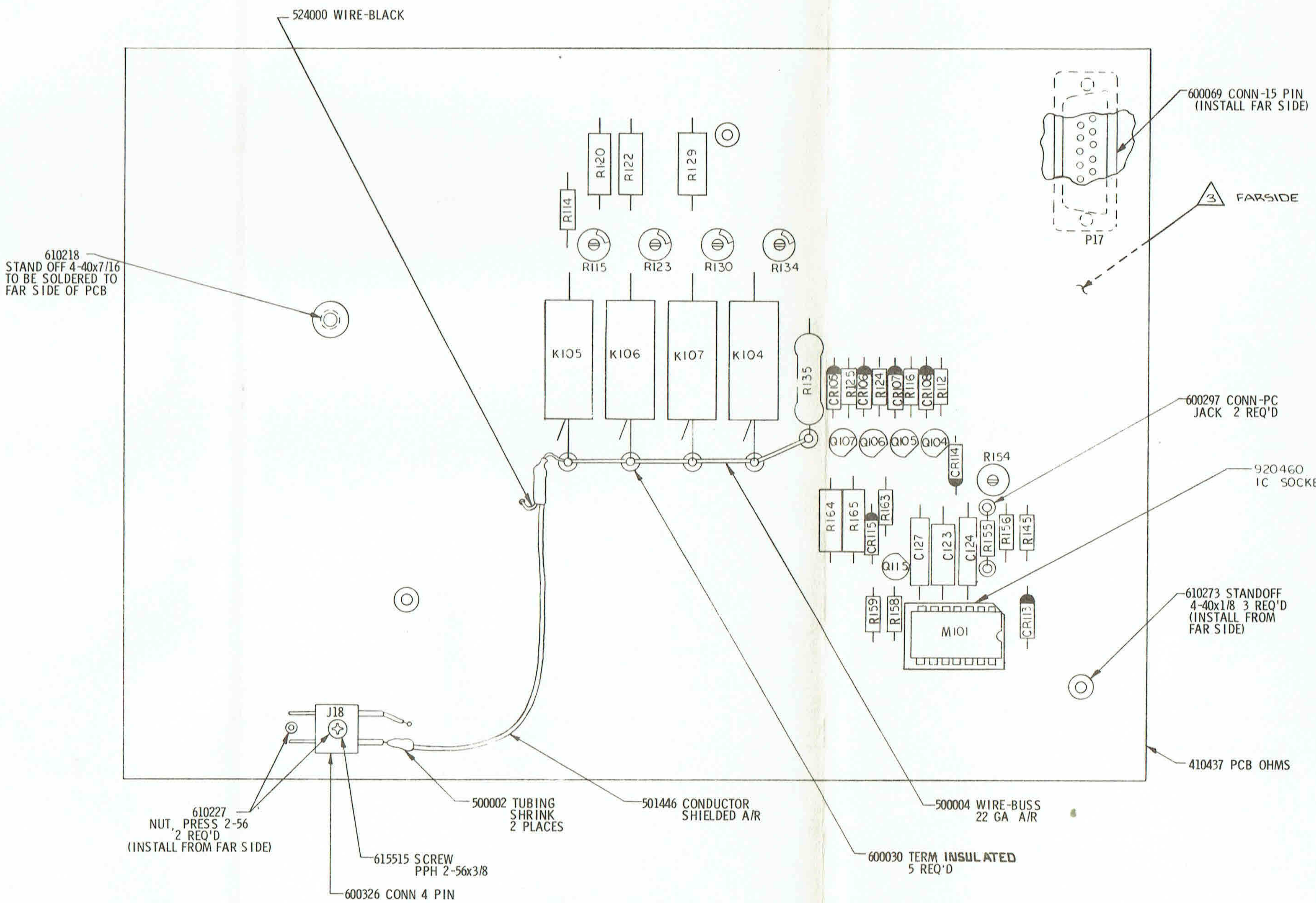
ASSY- OHMS ACCESSORY

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403228	D

SCALE 1/1 SHEET 1 OF 2

SHT 2 IS AN 'A' SIZE

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 870	CRANE	4-1-9	y.c.
B	ADVANCE ALL REF. DESIGNATORS TO MATCH THOSE ON 430868 PER EO. 5022	8-27-69 CARROLL		
C	ADD 920460 PER EO. 5092	9-26-69 CARROLL		
D	ADD NOTE 3 PER EO. 5487	CARROLL 1-12-70		1-12-70



REF DES OR ITEM	P/N	DESCRIPTION	QTY
C123	121088	CAP 0.01 UF/100V	1
C124	121146	CAP 0.0047 UF/100V	2
C127	121146	CAP 0.0047 UF/100V	REF
CR108	211083	DIODE 018	4
CR107	211083	DIODE 018	REF
CR106	211083	DIODE 018	REF
CR105	211083	DIODE 018	REF
CR113	221177	1/4 M 2.4 AZ5	3
CR114	221177	1/4 M 2.4 AZ5	REF
CR115	221177	1/4 M 2.4 AZ5	REF
K104	310036	RELAY	2
K105	310036	RELAY	REF
K106	310035	RELAY	2
K107	310035	RELAY	REF
M101	230026	IC MC709C	1
Q115	200043	TSTR 2N3565	5
Q104	200043	TSTR 2N3565	REF
↕	↕	↕	↕
Q107	200043	TSTR 2N3565	REF
R112	000202	RES 2K	4
R114	001737	RES FSV (680K NOM)	2
R115	040159	POT 500K	1
R116	000202	RES 2K	REF
R120	020494	RES 8.19K 0.1%	1
R122	020495	RES 89.815K 0.1%	1
R123	040115	POT 500 OHM	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R124	000202	RES 2K	REF
R129	020496	RES 996.15K 0.1%	1
R130	040097	POT 5K	1
R125	000202	RES 2K	REF
R134	040104	POT 50K	1
R135	010357	RES 8.981M 0.1%	1
R145	000685	RES 6.8M	1
R154	040088	POT 100K 10%	1
R155	001737	RES FSV (5.1M NOM)	REF
R156	000152	RES 1.5K	1
R159	000821	RES 820 OHM	1
R158	000512	RES 5.1K	1
R163	000912	RES 9.1K	1
R164	020050	RES 9K 0.01%	1
R165	021395	RES 1K 0.01%	1
	920460	I.C. SOCKET	1
	410437	PCB AC & OHMS	1
	430871	SCHEMATIC	REF
	500002	TUBING SHRINK	A/R
	500004	WIRE-BUSS 22 GA	A/R
	501446	CONDUCTOR SHIELDED	A/R
	524000	WIRE-BLACK	A/R
	600030	TERM, ISOLATED	5
	600069	CONN-15 PIN	1
	600297	CONN-PC JACK	2
	600326	CONN 4 PIN	1
	610218	STANDOFF, 4-40x7/16	1
	610227	NUT-PRESS 2-56	2
	610273	STANDOFF, 4-40x1/8	3
	615515	SCREW, PFH 2-56x3/8	1
	920026	SOLDER WIRE	A/R

3. LEADS TO BE CUT SO THAT NONE EXTEND BEYOND .062, (1/16") FROM THE CIRCUIT SIDE OF THE BOARD (FARSIDE)

2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

1. SCHEMATIC REFERENCE 430871

NOTES: UNLESS OTHERWISE SPECIFIED

	550		
	350		
403174	285	1	1
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL — FINISH

DRAWN	John R Bibb	3-10-69
CHECK	W. Sarkesen	3-17-69
DESIGN		
MECH ENGR		
PROJ ENGR		3/28/69
PROD ENGR	W Bibb	3/31

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

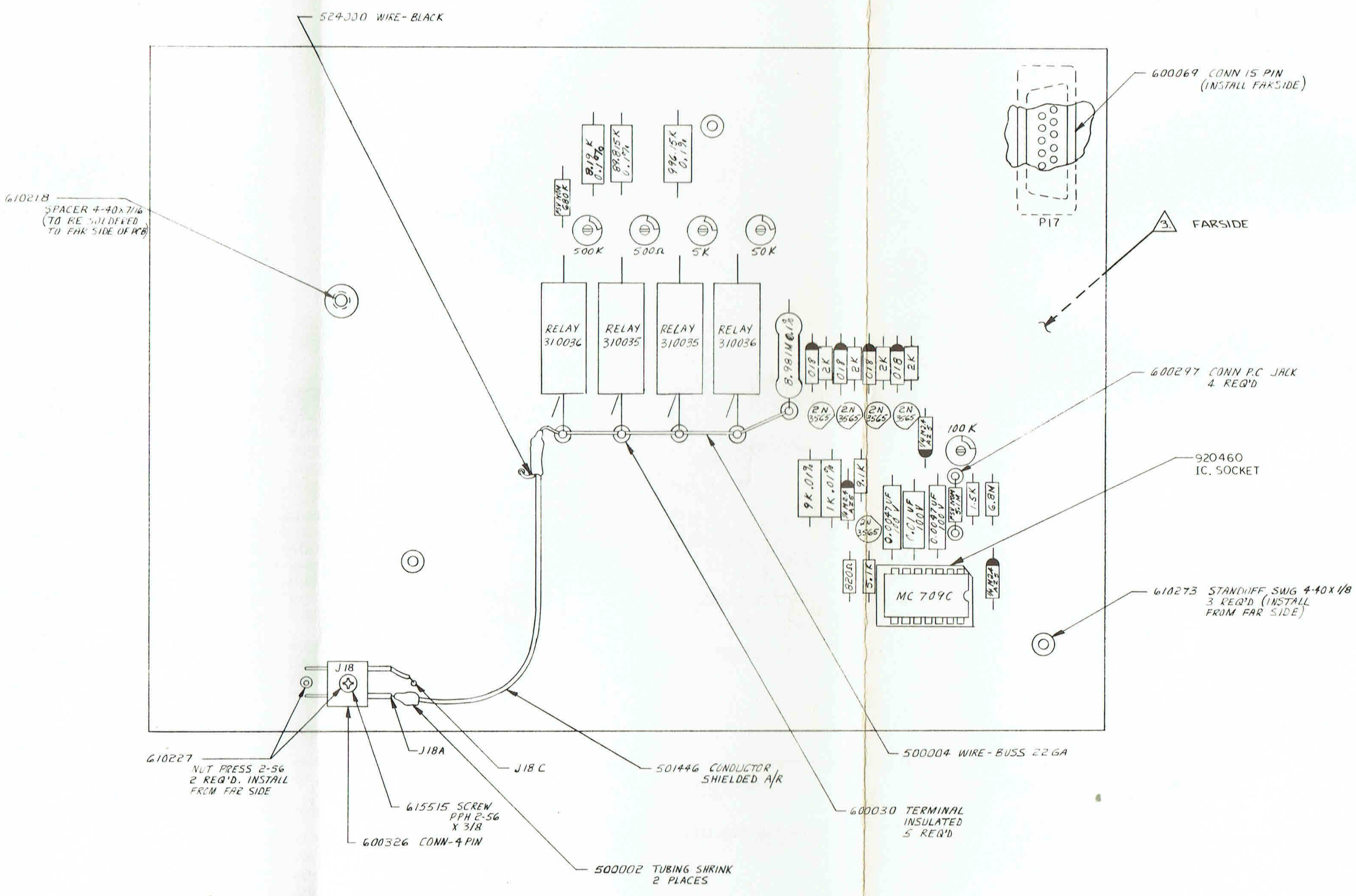
ASSEMBLY
OHMS CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403169	D

SCALE 2-1 — SHEET 1 OF 2

DANA 980346 DIETERICH-POST CLEARPRINT

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 870	CRANE	4-1-9	J.C.



3. LEADS TO BE CUT SO THAT NONE EXTEND BEYOND .062, (1/16") FROM THE CIRCUIT SIDE OF THE BOARD (FARSIDE)

2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.

1. SCHEMATIC REFERENCE 430871.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
	550		
	350		
403174	225	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES: DECIMALS X.030 XX.020 XXX.010 — ANGLES 0° 30' FORMED 1° 0' — HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL — FINISH

DRAWN	John Gibb	3-11-69
CHECK	L. Sorenson	3-27-69
DESIGN		
MECH ENGR		
PROJ ENGR	L. Lang	3/28/69
PROD ENGR	[illegible]	3/31

DANA LABORATORIES INC. IRVINE, CALIFORNIA

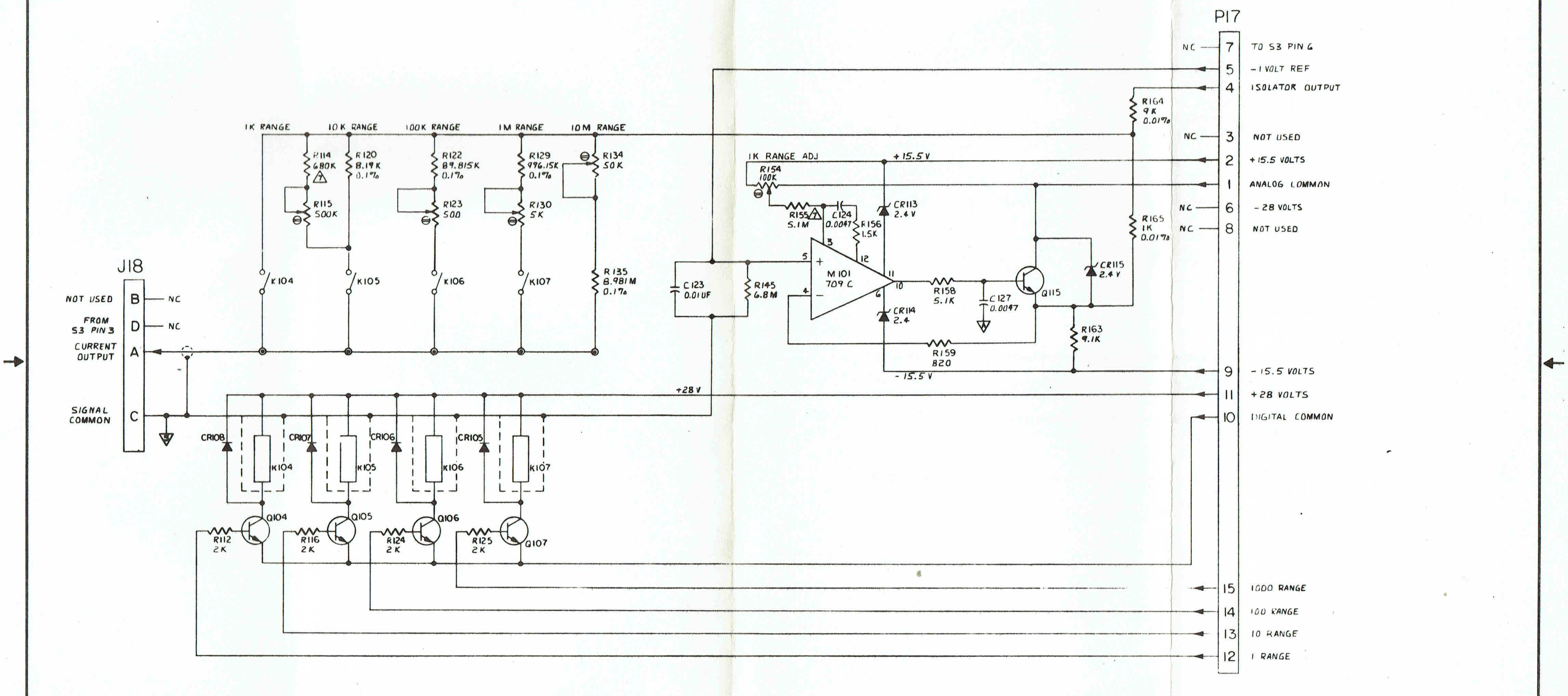
ASSEMBLY OHMS CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403169	D

SCALE 2-1 — SHEET 2 OF 2

DANA 980346 DIETERICH POST CLEARPRINT 1020-10

LTR	DESCRIPTION	DR	CHK	APPD
REVISIONS				
A	RELEASED PER DRN #893		6-25-9	
B	REVISE REF. DESIGNATORS TO MATCH THOSE ON 430868 PER EO. 5022		CARROLL	



8. REF DESIGNATORS MATCH SIMILAR COMPONENT ON DWG. 430868.

~~8. HIGHEST REF DESIGNATORS USED: C3, CR7, K4, M1, Q5, R22.~~

7. FACTORY SELECT, NOMINAL VALUES SHOWN.

6. THIS SYMBOL ⊖ INDICATES INSULATED TERMINAL.

5. ALL VOLTAGES ARE APPROXIMATE VALUES MEASURED WITH RESPECT TO ANALOG COMMON.

4. THIS SYMBOL ▽ INDICATES SIGNAL COMMON.

3. ALL DIODES TO BE: D18.

2. ALL TRANSISTORS TO BE: 2N3565.

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 5% CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

403169	350	REF	REF
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES: DECIMALS X .030, XX .020, XXX .010; ANGLES 0° 30', FORMED 1° 0'; HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	John Sibt	6-5-69
CHECK	W Sankam	6-12-69
DESIGN	W. Sankam	6-6-69
MECH ENGR		
PROJ ENGR	L. Lam	6/1/69
PROD ENGR	W. Snubbs	6/12

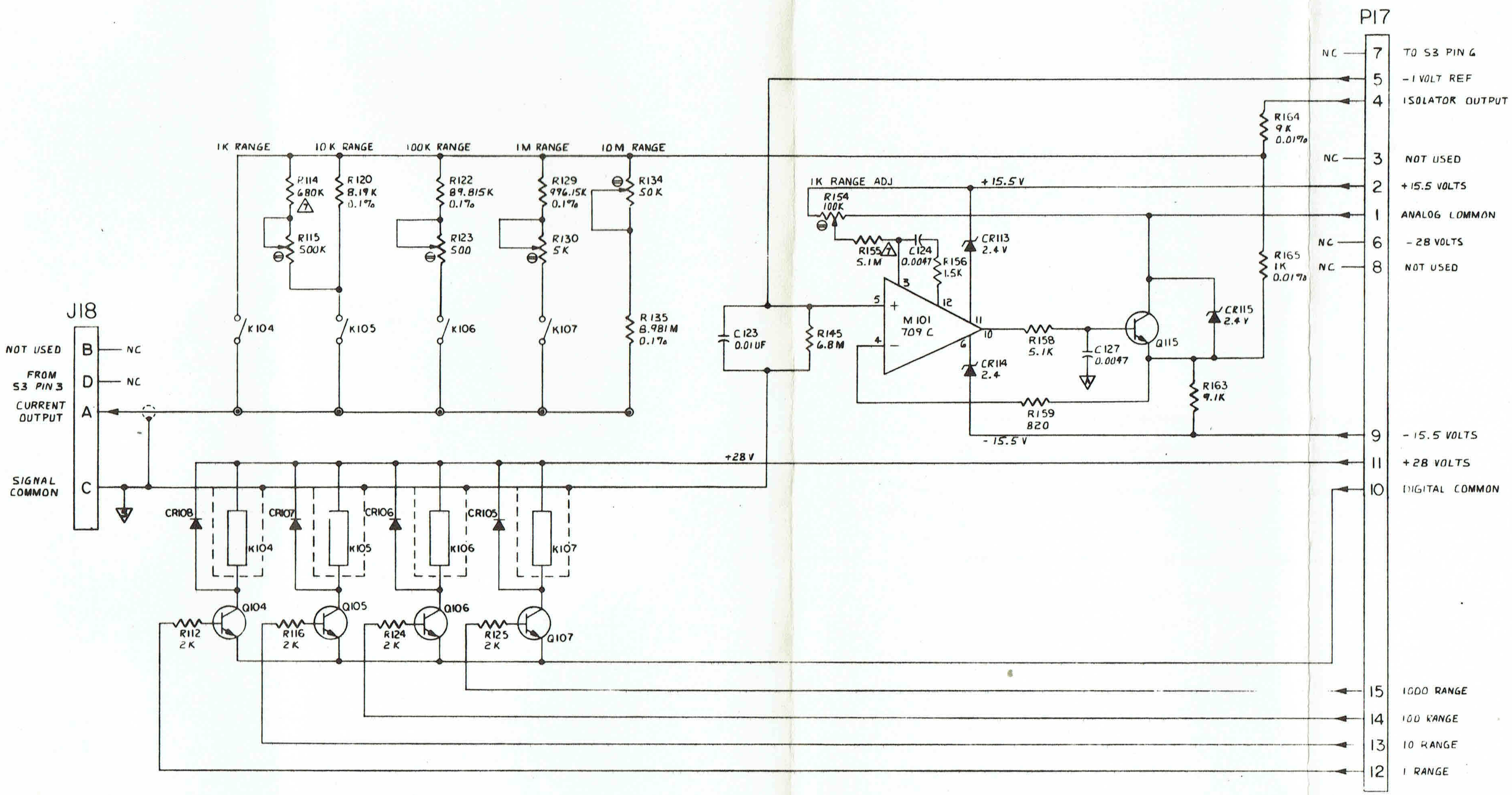
DANA LABORATORIES INC. IRVINE, CALIFORNIA

SCHEMATIC - OHMS CONVERTER MODEL 350

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430871	B

SCALE — SHEET 1 OF 1

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN #893		6-25-9	
B	REVISE REF DESIGNATORS TO MATCH THOSE ON 430868 PER EO.5022			



8. REF DESIGNATORS MATCH SIMILAR COMPONENT ON DWG. 430868.

~~8. HIGHEST REF DESIGNATORS USED: C3, CR7, K4, M1, Q5, R22.~~

7. ⚠ FACTORY SELECT, NOMINAL VALUES SHOWN.

6. THIS SYMBOL ⊖ INDICATES INSULATED TERMINAL.

5. ALL VOLTAGES ARE APPROXIMATE VALUES MEASURED WITH RESPECT TO ANALOG COMMON.

4. THIS SYMBOL ▽ INDICATES SIGNAL COMMON.

3. ALL DIODES TO BE: D18.

2. ALL TRANSISTORS TO BE: 2N3565.

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 5% CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

403169	350	REF	REF
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 -.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	John Sitt	6-5-69
CHECK	W Sanborn	6-15-69
DESIGN	W. Sanborn	6-6-69
MECH ENGR		
PROJ ENGR	L. Lam	6/11/69
PROD ENGR	W. Strubble	6/12

DANA LABORATORIES INC. IRVINE, CALIFORNIA

SCHEMATIC - OHMS CONVERTER MODEL 350

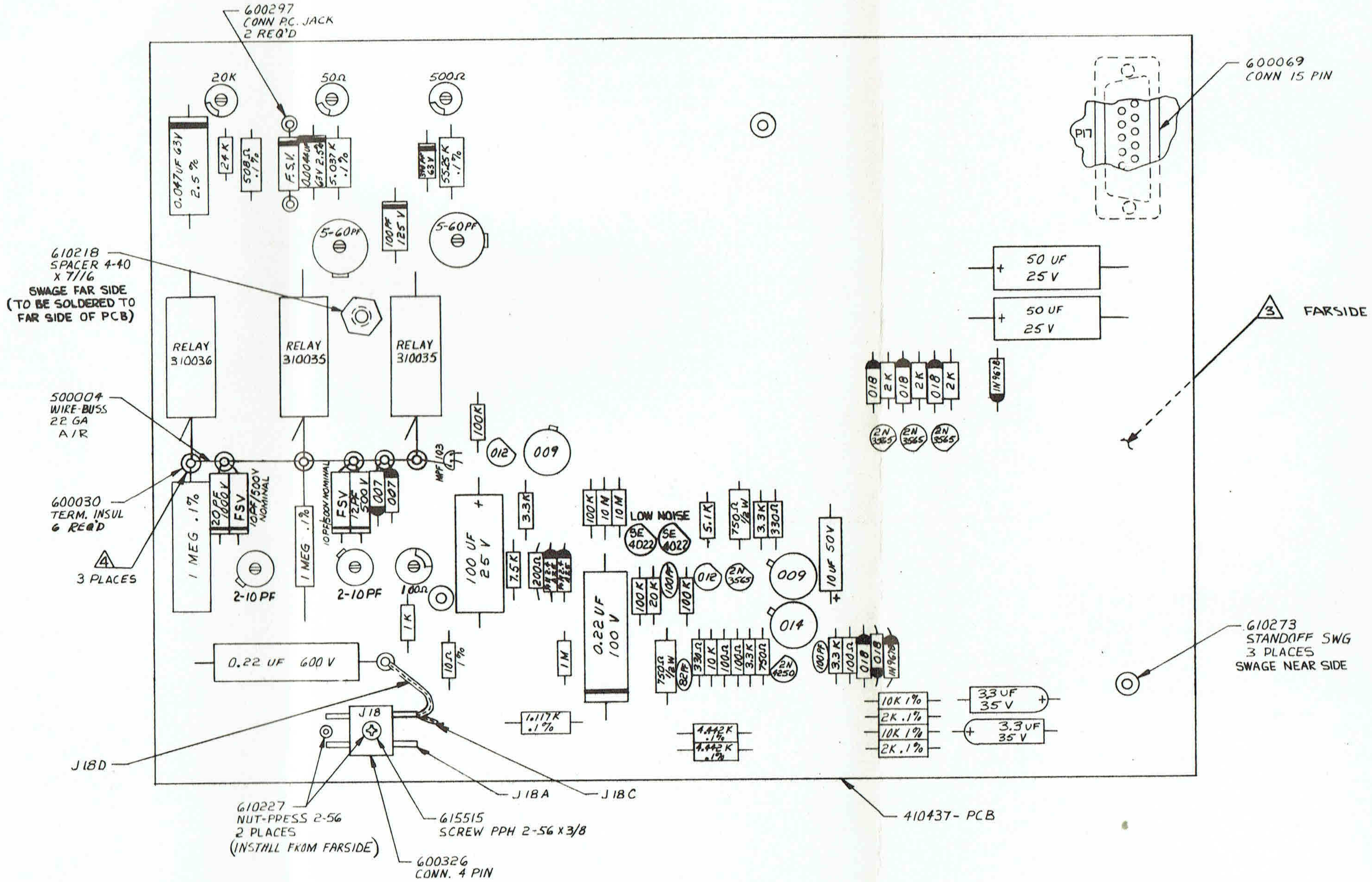
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430871	B

SCALE — SHEET 1 OF 1

DANA 980346 DIETZGEN POST CLEARPRINT 1000-10

REVISIONS

LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 893		6-25-9	
B	ADVANCE ALL REF. DESIGNATORS TO MATCH THOSE ON 430868 E.O. 5022	8-27-69 CARROLL		W.G.
C	REVISED PER EO 5486	CARROLL 1-13-70		1-13-70
D	EO 5817 - CHANGE Q108 & 109 FROM SELECT 2N3565 TO SE4022, REVERSED POLARITY C122, ADDED NOTE 4, CHANGED C104 & C113 TO FSV, CHANGED C103 & C112 TO 2-10 PF	C W 7-20-70		7/21/70



4. DO NOT WRAP RELAY LEADS AROUND TERMINALS

3. ALL COMPONENT LEADS MUST BE CUT SO THAT NONE EXTEND BEYOND .062, (1/16") FROM THE CIRCUIT SIDE OF THE BOARD (FARSIDE)

2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

1. SCHEMATIC REFERENCE 430870.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403203	350	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	John Lobb	4-17-69
CHECK	W. Sarkan	6-10-69
DESIGN	P. Summerson	6/10/69
MECH ENGR		
PROJ ENGR	L. Long	6/11/69
PROD ENGR		

DANA LABORATORIES INC. IRVINE, CALIFORNIA

P.C.B. ASSEMBLY A.C. CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403214	D

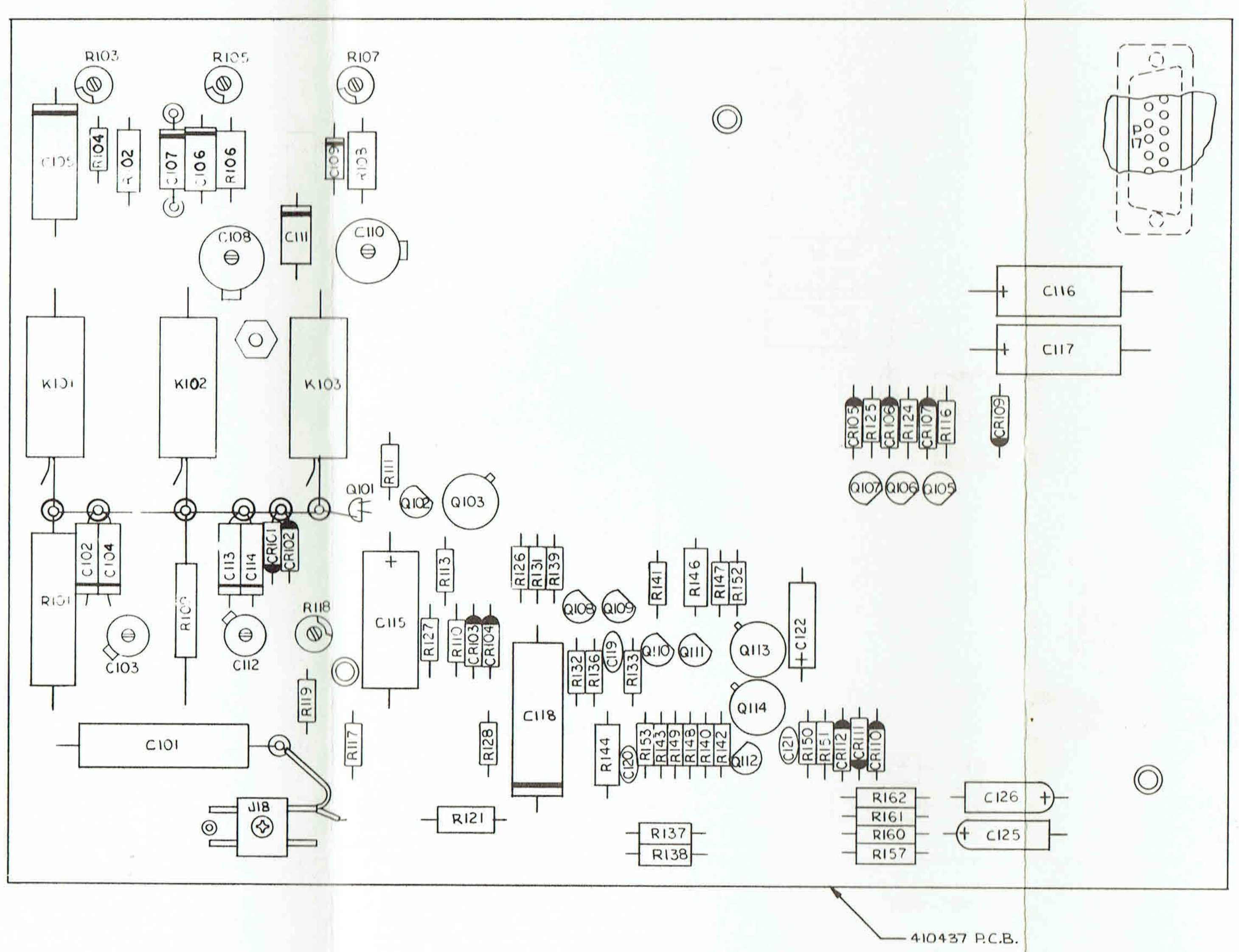
SCALE 1/1 | SHEET 1 OF 6

SHTS 3 THRU 6 ARE A SIZE

DANA 990346 DIETERICH-POST CLEARPRINT 1000

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
	RELEASED PER DRN # 693		6-25-9	

SEE SHEET 1.



2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

1. REF SCHEMATIC NO. 430870.

NOTES: UNLESS OTHERWISE SPECIFIED

403203	350	1	1
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL / FINISH

DRAWN	P. Dunmmon	6/6/69
CHECK	W. Sarkisian	6-10-69
DESIGN	P. Dunmmon	6/6/69
MECH ENGR		
PROJ ENGR		6/11/69
PROD ENGR		

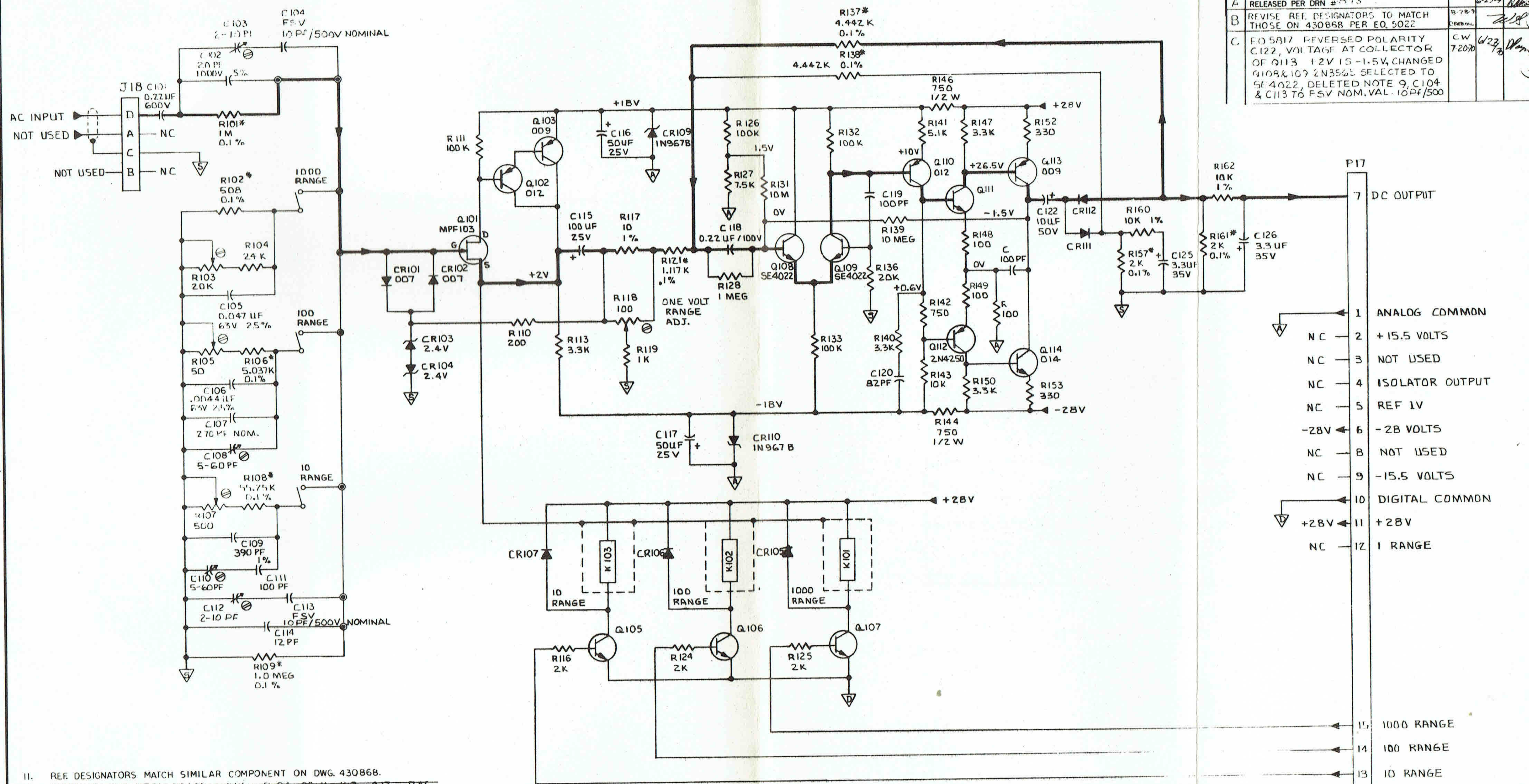
DANA® DANA LABORATORIES INC. IRVINE, CALIFORNIA

P.C.B. ASSEMBLY
A.C. CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403214	D

SCALE SHEET 2 OF 6

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 893		6-25-9	
B	REVISE REF. DESIGNATORS TO MATCH THOSE ON 430868 PER EO. 5022	8-7-8-9		
C	EO 5817 REVERSED POLARITY C122, VOLTAGE AT COLLECTOR OF Q113 +2V IS -1.5V, CHANGED Q108 & 109 2N3565 SELECTED TO SE 4022, DELETED NOTE 9, C104 & C113 TO FSV NOM. VAL. 10 PF/500	C.W. 7-20-70	6/23/70	



11. REF. DESIGNATORS MATCH SIMILAR COMPONENT ON DWG. 430868.
~~11. HIGHEST REF. DESIGNATORS ARE C 24, CR 11, K 3, Q13, R46.~~
10. THIS SYMBOL ◉ INDICATES INSULATED TERMINALS.
9. (deleted)
8. THIS SYMBOL (D) INDICATES DIGITAL COMMON.
7. THIS SYMBOL (A) INDICATES ANALOG COMMON.
6. THIS SYMBOL * INDICATES PART OF RESISTOR SET.
5. THIS SYMBOL (S) INDICATES SIGNAL COMMON.
4. ALL CAPACITORS TO BE 500V DISC.
3. ALL DIODES TO BE 618.
2. ALL TRANSISTORS TO BE 2N3565.
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 5% CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

403214	4500	REF	REF
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 -.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	John Gibb	6-5-69
CHECK	W. Sarkisian	6-7-69
DESIGN	W. Sarkisian	6-6-69
MECH ENGR		
PROJ ENGR	L. Lang	6/11/69
PROD ENGR		6/12

DANA DANA LABORATORIES INC. IRVINE, CALIFORNIA

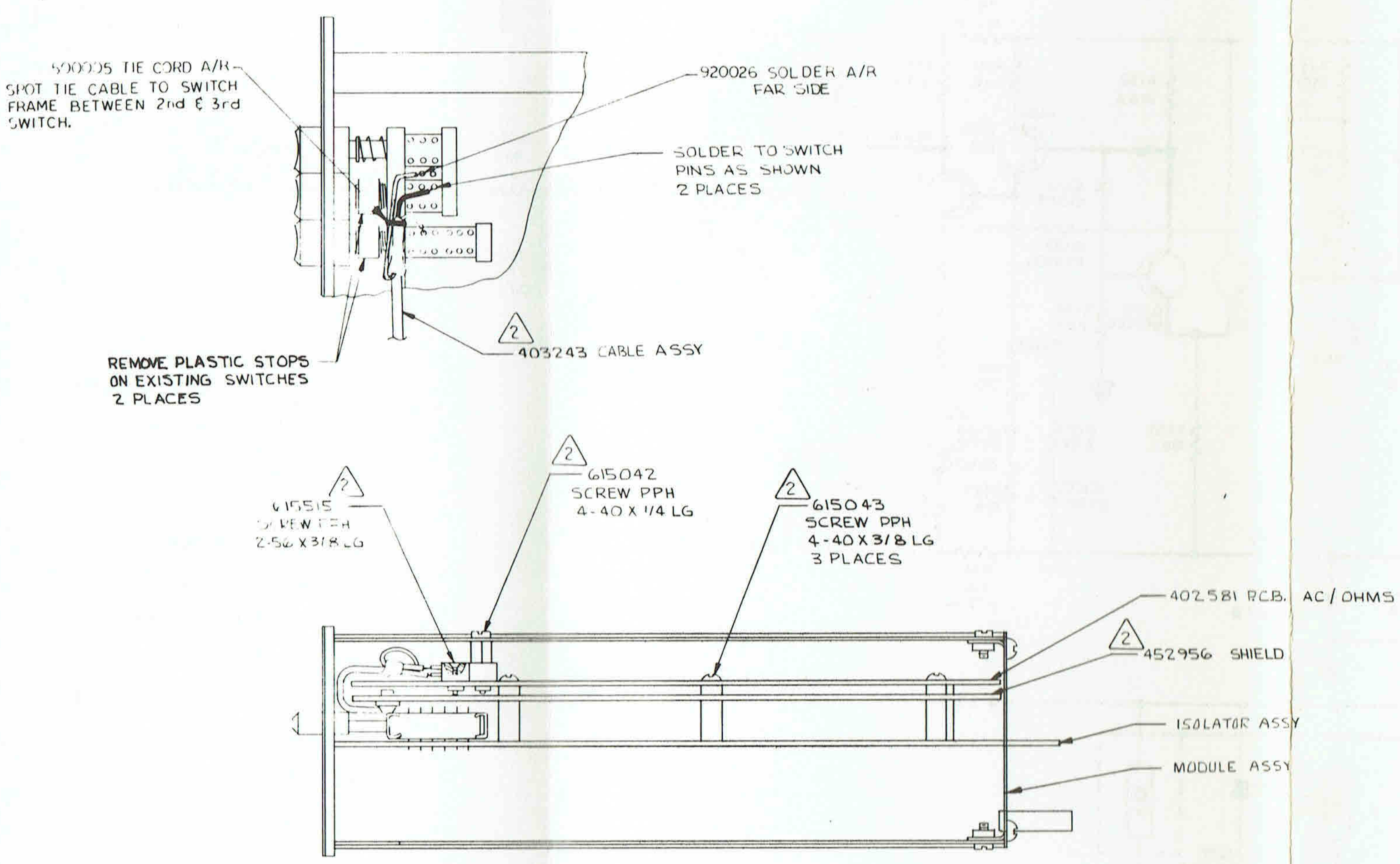
SCHEMATIC – A C CONVERTER MODEL 4500

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430870	C

SCALE NONE | SHEET 1 OF 1

DANA 980346 DIETERICH-POST CLEARPRINT 1020-10

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN #895 6-30-9	[illegible]		
B	SPOT TIE CABLE TO SWITCH PER E.O. 5145	9-8-69		
C	REMOVE P/N FOR ISOLATOR AND ASSY MODULE PER E.O. 5386	12-16-69		



SIDE EXTRUSION REMOVED FOR CLARITY

NOTES: UNLESS OTHERWISE SPECIFIED
1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
2. ALL INDICATED HARDWARE IS INCLUDED IN FINISHING KIT (403227)

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
	5200	1	1
	4500	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS X.030 XX.020 XXX.010	ANGLES 0° 30' FORMED 1° 0'	HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL / FINISH

DRAWN	P. Dummon	6/13/69
CHECK	[illegible]	[illegible]
DESIGN	P. Dummon	6/13/69
MECH ENGR		
PROJ ENGR	L. Lang	6/26/69
PROD ENGR	[illegible]	6/30

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY AC/OHMS ACCESSORY

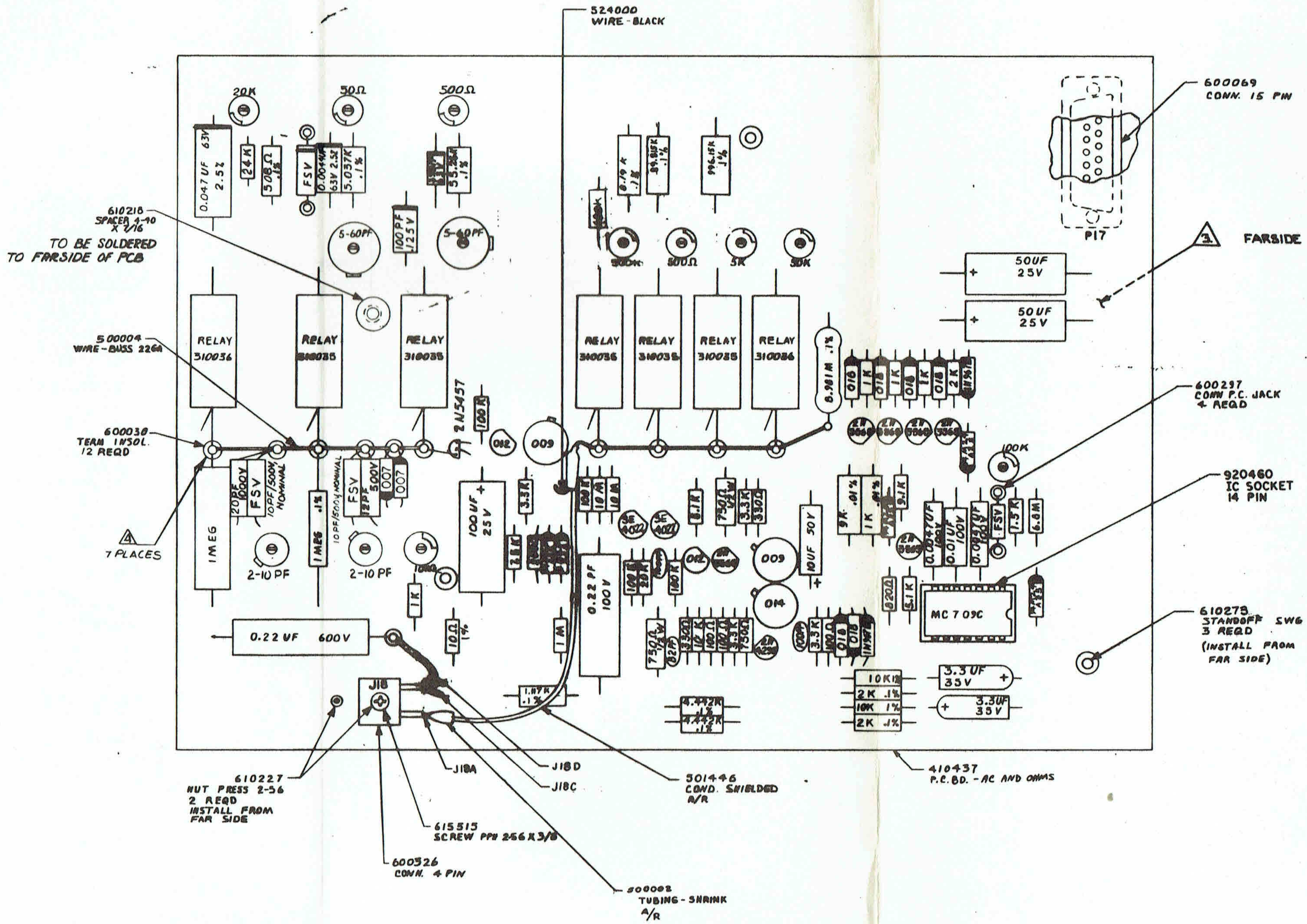
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403229	C

SCALE 1/1 SHEET 1 OF 2

SHT 2 IS AN "A" SIZE

DANA 980346 DIETERICH-POST CLEARPRINT 1020

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
	SEE SHEET ONE			



3. DO NOT WRAP RELAY LEADS AROUND TERMINALS
3. ALL COMPONENT LEADS MUST BE CUT SO THAT NONE EXTEND BEYOND .062, (1/16") FROM THE CIRCUIT SIDE OF THE BOARD (FARSIDE.)
2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.
1 SCHEMATIC REFERENCE 430579

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON		
403229	550	1	1
403229	350	1	1
402592	230	1	1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON:

DECIMALS	ANGLES	HOLE DIAMETERS
.X .030	0° 30'	+.004
.XX .020	FORMED	-.001
.XXX .010	1° 0'	

MATERIAL

FINISH

DRAWN	P. HASLAM	8-5-68
CHECK		10-3-68
DESIGN		10/4/68
MECH ENGR		10/4
PROJ ENGR	D Payne	10/4

D Payne 10/4
G Meyer 10/4

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY
A.C. & OHMS CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402581	T

SCALE 2:1 SHEET 2 OF 3

101				
102	120197	1000V	1	
103	130054	2-10 PF		
104	120218	CAP FSV 10PF/500V	1	
105				
106				
107				
108				
109				
110				
111				
112		2-10 PF		
113	120218	FSV 10PF/500V	1	
114	98	2	1	
115				
116				
117				
118		CAP 0.22UF/100V		
119				
120	100008			
121				

122			
123			
124			
125			
126			
127			
101	211236	007	2
102	211236	007	
103	221177		
104	221177		
105			6
106			
107			
108			
109	220015		
110	220015		
111			
112			
113	221177		
114	221177		
115	221177		
P17			
18			

101		
102		
103		
104		
105		
106		
107		
101		MC 709C
101		2N5457
102		
103		
104		
105		
106		
107		
Q108	200136	SE4022
109	200136	SE4022
110		
111		
112		
113		
114		

115				
101*				
102*				
103				
104	249	24		
105				
106*				
107	040115	500 OHM POT		2
108*				
109*				
110				
111				4
112				
113				
114	001737	FSV	1/4W 5%	2
115	040159	500K	OHM	1
116				
117				
118				
119				
120				
121*				
122				

123	1	POT	REF	
124				
125				
126				
127				
128				
129				
130	040097	POT		
131				
132				
133				
134				
135				
136		1/4W 5%		
* 137				
* 138				
139				
140				
141				
142				
143	000103			1
144				
145				
146				

147				
148				
149				
150				
151				
152				
153				
154		POT 10%		
155	001737	FSV 1/4W 5%		REF
156				
157*				
158				
159				
160				
161*				
162				
163				
164				
165				
	430829			

Y

600207	FSV TERM 4-40	4
		12
610273	SWAGED SPACER 1/4 D. X .125 LG .06 MTG	3
920460	IC SOCKET 14 PIN,	1

1. THIS SYMBOL * INDICATES RESISTOR SET.

NOTES: UNLESS OTHERWISE SPECIFIED

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403229	550	1	1
403229	350	1	1
402582	230	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON:

DECIMALS	ANGLES	HOLE DIAMETERS
.X .030	0° 30'	+.004
.XX .020	FORMED	-.001
.XXX .010	1° 0'	

MATERIAL

FINISH

DRAWN	V.T. Williams	6-6-68
CHECK	[illegible]	10-3-68
DESIGN	[illegible]	10/4/68
MECH ENGR	L. Wall	10/4/68
PROJ ENGR	D. Payne	10/4
	D. Payne 10/4	
	R. Mayer 10/4	

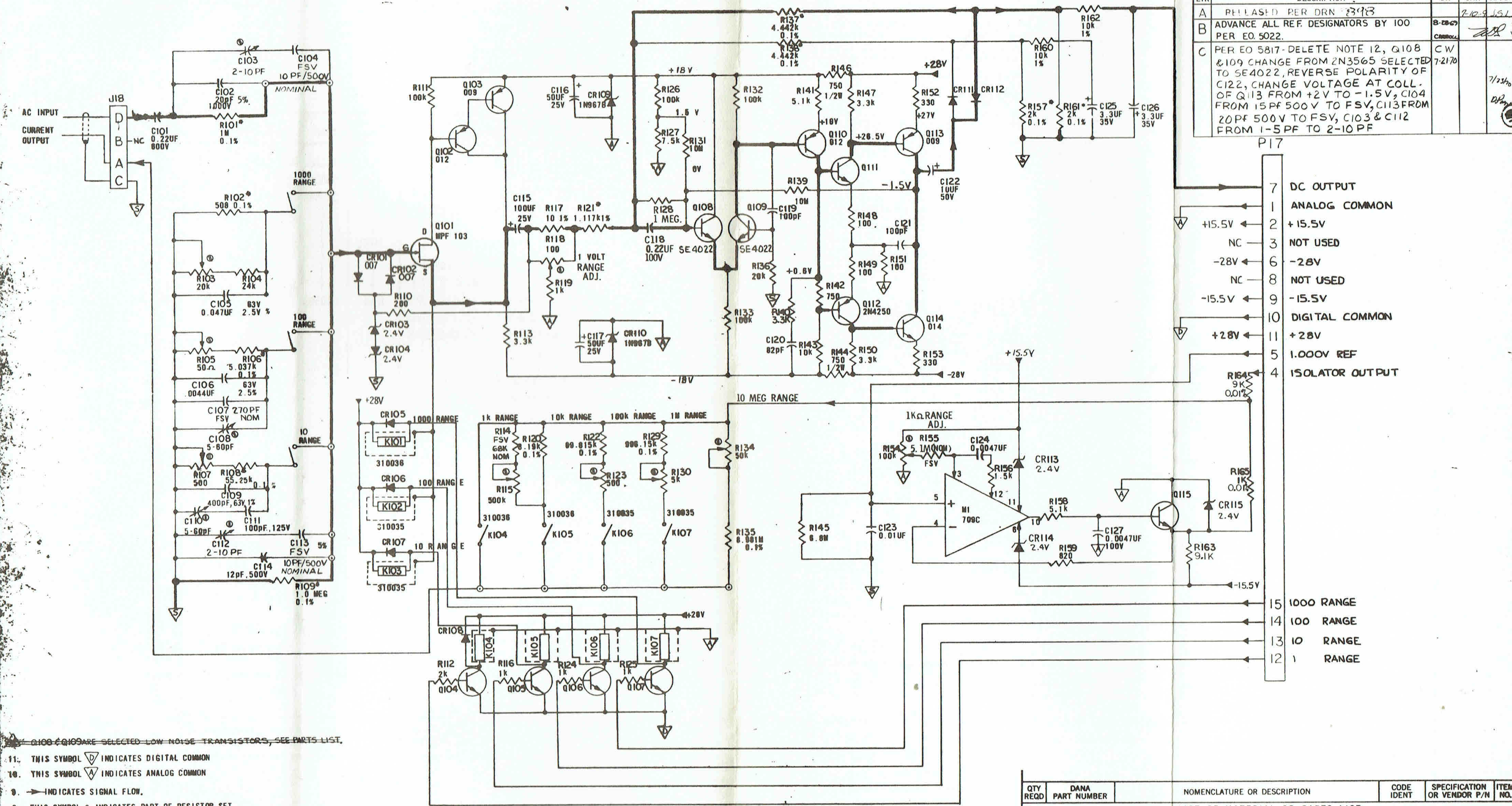
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY
A.C. & OHMS CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402581	T

SCALE SHEET 3 OF 3

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN 3398		2-10-9	LSL
B	ADVANCE ALL REF. DESIGNATORS BY 100 PER EO. 5022.	8-28-69 CARROLL		
C	PER EO 5817 - DELETE NOTE 12, Q108 & 109 CHANGE FROM 2N3565 SELECTED TO SE4022, REVERSE POLARITY OF C122, CHANGE VOLTAGE AT COLL. OF Q113 FROM +2V TO -1.5V, C104 FROM 15 PF 500V TO FSV, C113 FROM 20 PF 500V TO FSV, C103 & C112 FROM 1-5 PF TO 2-10 PF	CW 7-21-70		7/23/70



~~Q108 & Q109 ARE SELECTED LOW NOISE TRANSISTORS, SEE PARTS LIST.~~

11. THIS SYMBOL (D) INDICATES DIGITAL COMMON
10. THIS SYMBOL (A) INDICATES ANALOG COMMON
9. ➝ INDICATES SIGNAL FLOW.
8. THIS SYMBOL * INDICATES PART OF RESISTOR SET.
7. THIS SYMBOL ⊙ INDICATES INSULATED TERMINAL
6. ALL VOLTAGES ARE APPROXIMATE VALUES MEASURED WITH RESPECT TO ANALOG COMMON.
5. ALL CAPACITORS TO BE 500V DISC.
4. THIS SYMBOL (S) INDICATES SIGNAL COMMON.
3. ALL DIODES TO BE: 018
2. ALL TRANSISTORS TO BE 2N3565
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W. 5%. CARBON

NOTE: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	QTY REQD NA	QTY REQD FA
402581	350	REF	REF

APPLICATION

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS .X .030, .XX .020, .XXX .010; ANGLES 0° 30'; FORMED ANGLES 1.0
MATERIAL
FINISH
CONTRACT NO.

DRAWN	JOHN R. GIBB	2-25-69
CHECK	W. Sankasen	7-7-69
DESIGN	P. Bummeson	7/7/69
PROJ ENGR	L. Lang	7/7/69

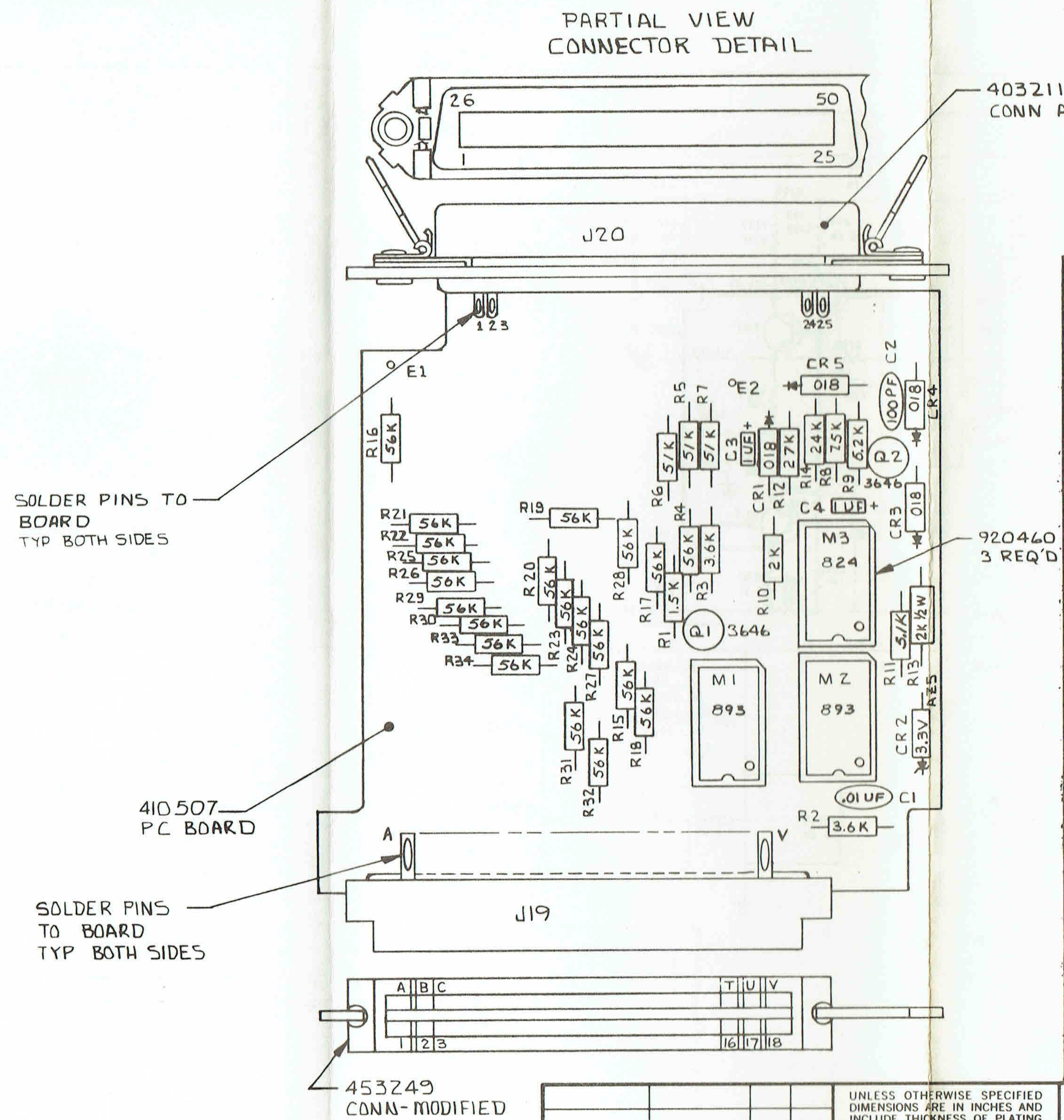
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC AC AND OHMS CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430868	C

SCALE | WT | SHEET

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN #879		5-20-69	
B	CHANGED PER E.O. 4946	7-21-69		
C	ADD 3 920460 PER ED 5414	12-5-69 CARROLL		12-5-69



REF DES OR ITEM	P/N	DESCRIPTION		QTY
C1	100017	.01UF	CAP	1
C2	101145	100PF	↕	1
C3	110071	1UF/35V		2
C4	110071	1UF/35V	CAP	REF
CR1	211083	018	DIODE	4
CR2	220031	1/4M 3.3V AZ5	↕	1
CR3	211083	018		REF
CR4	211083	018		REF
CR5	211083	018	DIODE	REF
M1	230024	MC893P	I.C.	2
M2	230024	MC893P	↕	REF
M3	230019	MC824P	I.C.	1
Q1	200037	2N3646	TRANS	2
Q2	200037	2N3646	TRANS	REF
R1	000152	1.5K	RES	1
R2	000362	3.6K	↕	2
R3	000362	3.6K		REF
R4	000563	56K		21
R5	000513	51K		3
R6	000513	51K		REF
R7	000513	51K		REF
R8	000752	7.5K		1
R9	000622	6.2K		1
R10	000202	2K		1
R11	000512	5.1K		1
R12	000273	27K	RES	1

REF DES OR ITEM	P/N	DESCRIPTION		QTY
R13	001261	2K 1/2W	RES	1
R14	000243	24K	↕	1
R15	000563	56K		REF
↕ THRU	↕	↕		↕
R34	000563	56K	RES	REF
	403211	CONN ASSY-PRINTER OUTPUT		1
	410507	P.C.B. PRINTER OUTPUT		1
	430854	SCHEMATIC		REF
	453249	CONN MODIFIED		1
	600497	CONN VIKING 18 PIN		REF
	920460	IC SOCKET 14 PIN		3

2. SCHEMATIC REF 430854

1. ASSEMBLY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
—	4500	—	—
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

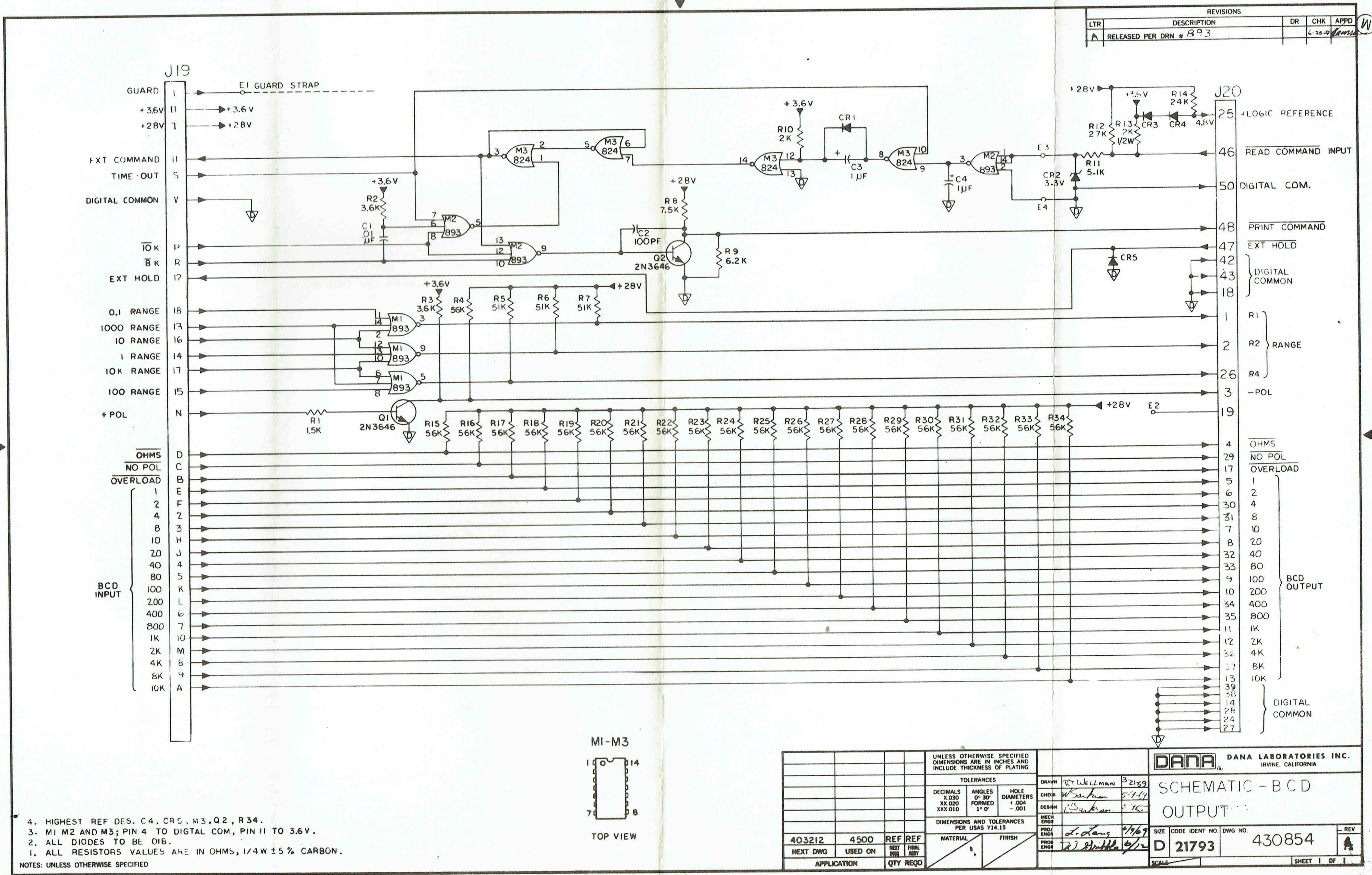
DRAWN	R T WELLMAN	4-14-69
CHECK	P. Summers	5/12/69
DESIGN	R Prchal	5/5/69
MECH ENGR		
PROJ ENGR		5/12/69
PROD ENGR		5/12

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

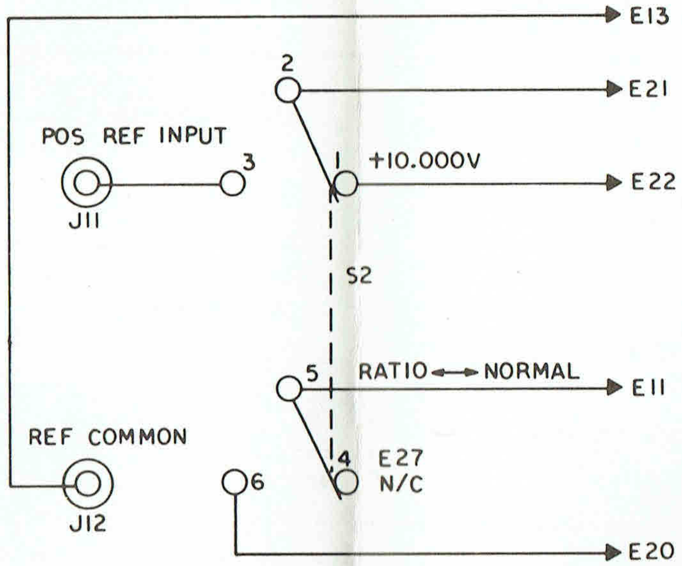
PC BOARD ASSY BCD OUTPUT

SIZE	CODE IDENT NO.	DWG NO.	REV
C	21793	403212	C
SCALE 2/1		SHEET 1 OF 1	

DANA 980337 DIETERICH-POST CLEARPRINT 1000

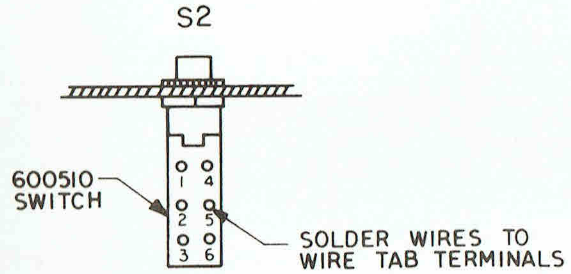

REVISIONS
LTR | DESCRIPTION | DR | CHK | APPD
A | RELEASED PER DRN # 893 | | 6-26-69 |
J19
GUARD 1
+3.6V 11
+28V 7
EXT COMMAND 11
TIME-OUT S
DIGITAL COMMON V
10K P
8K R
EXT HOLD 12
0.1 RANGE 18
1000 RANGE 13
10 RANGE 16
1 RANGE 14
10K RANGE 17
100 RANGE 15
+POL N
OHMS D
NO POL C
OVERLOAD B
BCD INPUT
1 E
2 F
4 Z
8 3
10 H
20 J
40 4
80 5
100 K
200 L
400 6
800 7
1K 10
2K M
4K 8
8K 9
10K A
E1 GUARD STRAP
R1 1.5K
Q1 2N3646
Q2 2N3646
R2 3.6K
C1 .01 µF
C2 100PF
R8 7.5K
R9 6.2K
R10 2K
CR1
C3 1µF
C4 1µF
R3 3.6K
R4 56K
R5 51K
R6 51K
R7 51K
R11 5.1K
R12 27K
R13 2K 1/2W
R14 24K
CR2 3.3V
CR3
CR4
CR5
E2
E3
E4
4.8V
M1 893
M2 893
M3 824
R15 56K
R16 56K
R17 56K
R18 56K
R19 56K
R20 56K
R21 56K
R22 56K
R23 56K
R24 56K
R25 56K
R26 56K
R27 56K
R28 56K
R29 56K
R30 56K
R31 56K
R32 56K
R33 56K
R34 56K
J20
25 +LOGIC REFERENCE
46 READ COMMAND INPUT
50 DIGITAL COM.
48 PRINT COMMAND
47 EXT HOLD
42, 43, 18 DIGITAL COMMON
1 R1
2 R2 RANGE
26 R4
3 -POL
19
4 OHMS
29 NO POL
17 OVERLOAD
BCD OUTPUT
5 1
6 2
30 4
31 8
7 10
8 20
32 40
33 80
9 100
10 200
34 400
35 800
11 1K
12 2K
36 4K
37 8K
13 10K
39, 38, 14, 28, 24, 27 DIGITAL COMMON
M1-M3
TOP VIEW
4. HIGHEST REF DES. C4, CR5, M3, Q2, R34.
3. M1 M2 AND M3; PIN 4 TO DIGTAL COM, PIN 11 TO 3.6V.
2. ALL DIODES TO BE 018.
1. ALL RESISTORS VALUES ARE IN OHMS, 1/4W ±5% CARBON.
NOTES: UNLESS OTHERWISE SPECIFIED
403212 | 4500
NEXT DWG | USED ON
APPLICATION
REF | REF
QTY REQD
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING
TOLERANCES
DECIMALS X.030 XX.020 XXX.010
ANGLES 0° 30' FORMED 1° 0'
HOLE DIAMETERS +.004 -.001
DIMENSIONS AND TOLERANCES PER USAS Y14.15
MATERIAL
FINISH
DRAWN R.T. WELLMAN 3/21/69
DANA LABORATORIES INC.
IRVINE, CALIFORNIA
SCHEMATIC - BCD OUTPUT
SIZE D
CODE IDENT NO. 21793
DWG NO. 430854
REV A
SCALE
SHEET 1 OF 1

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 905 8-7-9	HANSSEN		
B	CORRECT 500025 WIRE CALLOUT TO 20 GA. PER EO 5145.	9-8-69 CARROLL	GRIBBLE	
C	CHANGE WIRE LIST TO: J12 TO J2-3 & REDRAW PER EO. 5164.	9-22-69 CARROLL		
D	RELABEL J1 & J2, CORRECT WIRE LIST PER EO 5415	12-8-9 CARROLL		

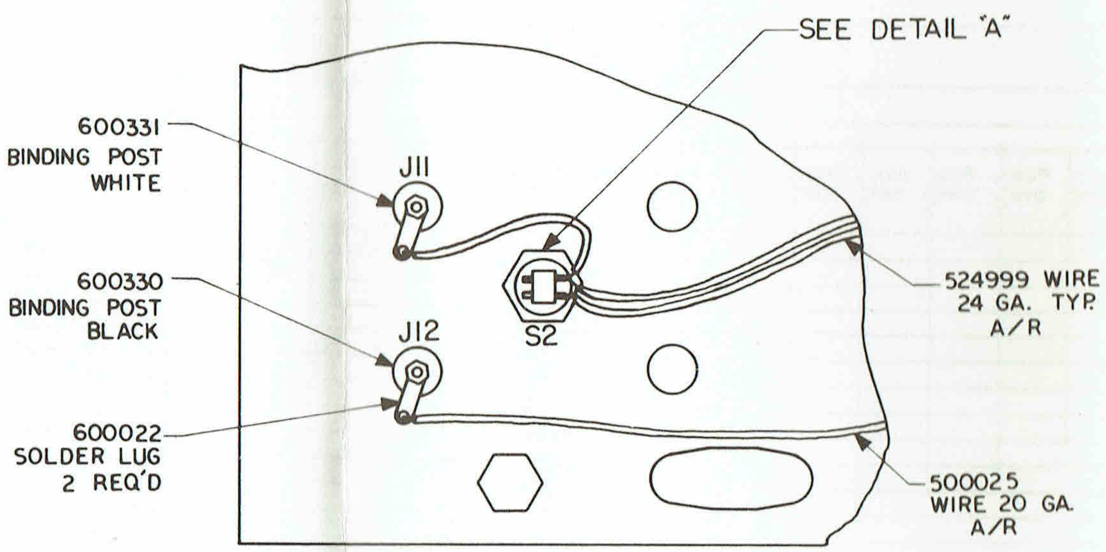


SCHEMATIC

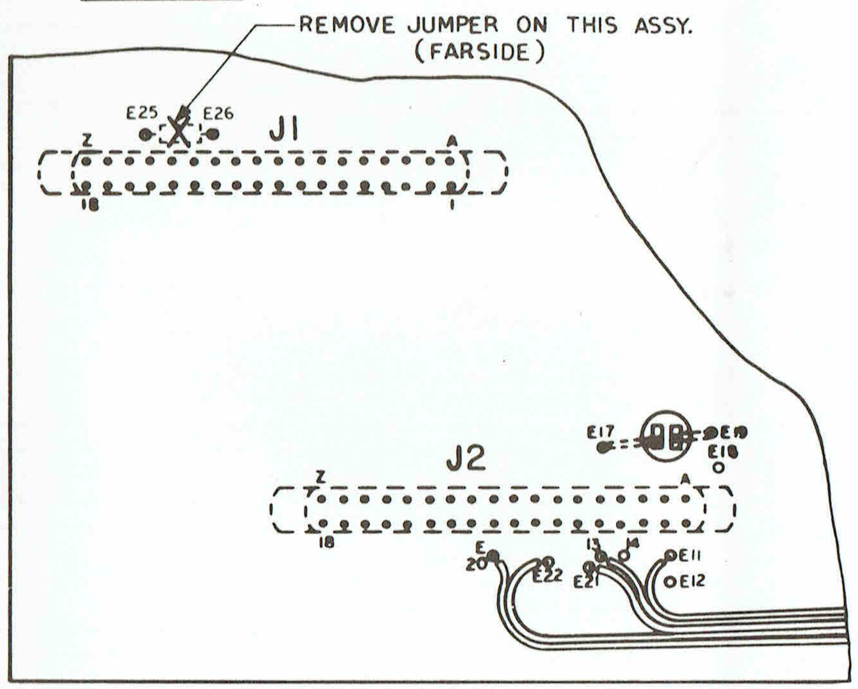
WIRING LIST		
SWITCH	TO	E NO.
S2-1	—	E22
S2-2	—	E21
S2-6	—	E20
S2-5	—	E11
S2-3	—	J11
BINDING POST		
J12	—	E13
J11	—	S2-3
CUT JUMPER FROM		
E25	—	E26



DETAIL A



REAR PANEL



POWER SUPPLY BOARD

REAR VIEW

HALF RACK

	4570		
	4530		
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS X .030 XX .020 XXX .010	ANGLES 0° 30' FORMED 1° 0'	HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	R. CARROLL	9-19-69
CHECK	W. SARKISON	7-29-69
DESIGN	P. GUMMESON	7-29-69
MECH ENGR		
PROJ ENGR	W. SARKISON	7-30-69
PROD ENGR	P. SALERNO	7-31-69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY RATIO

SIZE	CODE IDENT NO.	DWG NO.	REV
C	21793	403263	D

SCALE — SHEET 1 OF 3

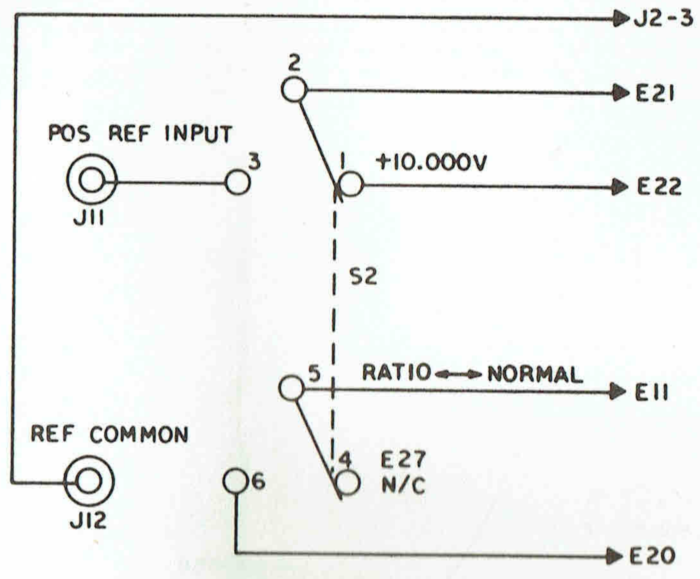
NOTES: UNLESS OTHERWISE SPECIFIED

DANA 980337 DIETERICH-POST CLEARPRINT 1020

SHT 3 IS A size

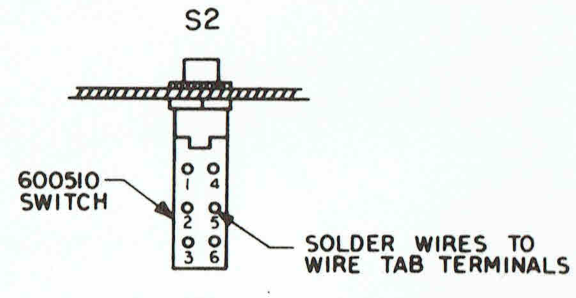
REVISIONS					
LTR	DESCRIPTION		DR	CHK	APPD
A	RELEASED PER DRN # 905	8-7-9	HANSSEN		

SEE SHEET 1

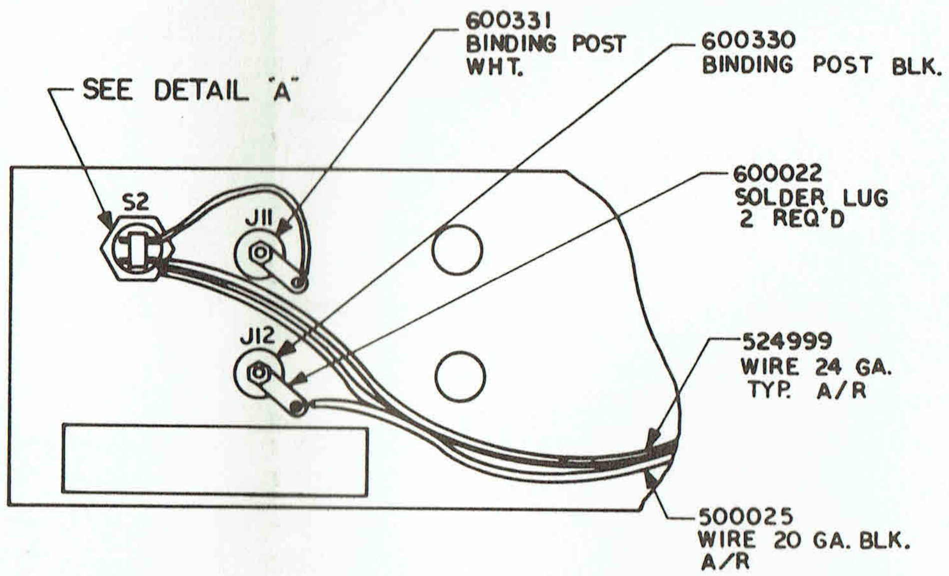


SCHEMATIC

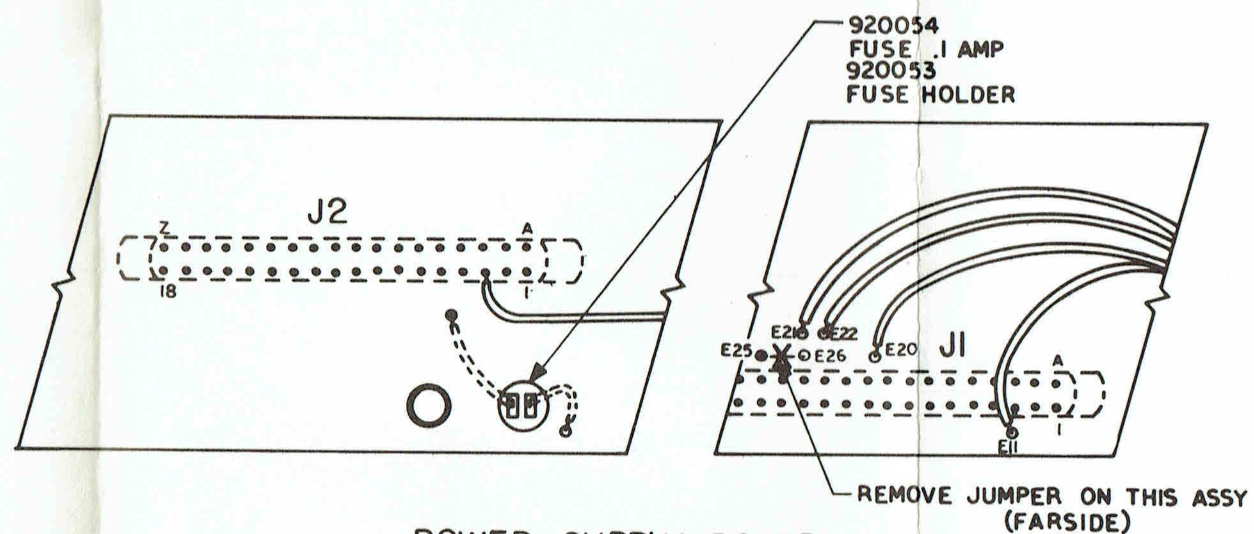
WIRING LIST		
SWITCH	TO	E NO.
S2-1	——	E22
S2-2	——	E21
S2-6	——	E20
S2-5	——	E11
S2-3	——	J11
BINDING POST		
J12	——	J2-3
J11	——	S2-3
CUT JUMPER FROM		
E25	——	E26



DETAIL A



REAR PANEL



POWER SUPPLY BOARD

REAR VIEW

FULL RACK

	4570		
	4530		
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS X.030 XX.020 XXX.010	ANGLES 0 30' FORMED 1 0'	HOLE DIAMETERS +.004 -.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL	FINISH

DRAWN	R. CARROLL	9-19-69
CHECK	W. SARKISON	7-29-69
DESIGN	P. GUMMESON	7-29-69
MECH ENGR		
PROJ ENGR	W. SARKISON	7-30-69
PROD ENGR	P. SALERNO	7-31-69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY RATIO

SIZE	CODE IDENT NO.	DWG NO	REV
C	21793	403263	D

SCALE ——— SHEET 2 OF 3

NOTES: UNLESS OTHERWISE SPECIFIED

DANA 980337 DIETERICH-POST CLEARPRINT 1020

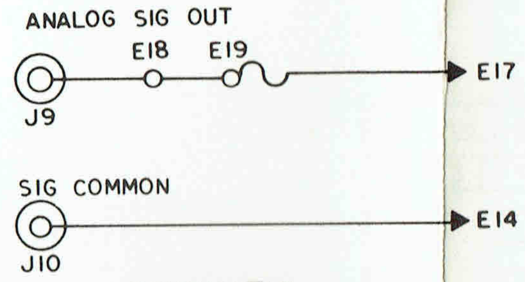
REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 905 8-7-9	HANSSEN		
B	CHANGE WIRE LIST TO:J10 TO J2-3 & REDRAW PER EO. 5164	9-23-69 CARROLL		
C	CORRECT WIRING DIAGRAM RE-LABEL J1-J2 PER EO 5415	12-6-69 CARROLL		

WIRING LIST

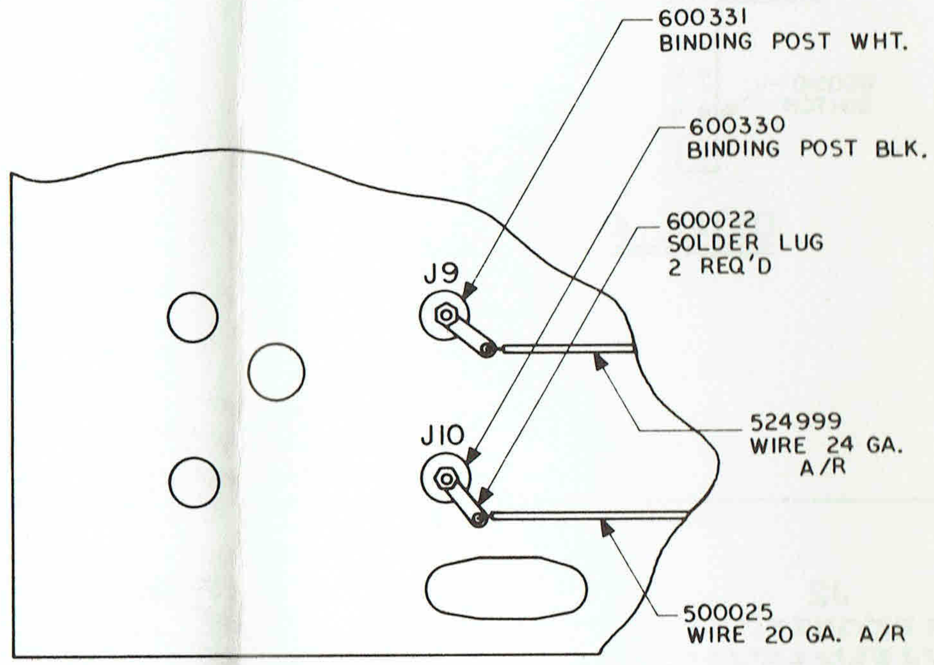
FUSE	TO	E NO.
TERM 1		E17
TERM 2		E19

BINDING POST

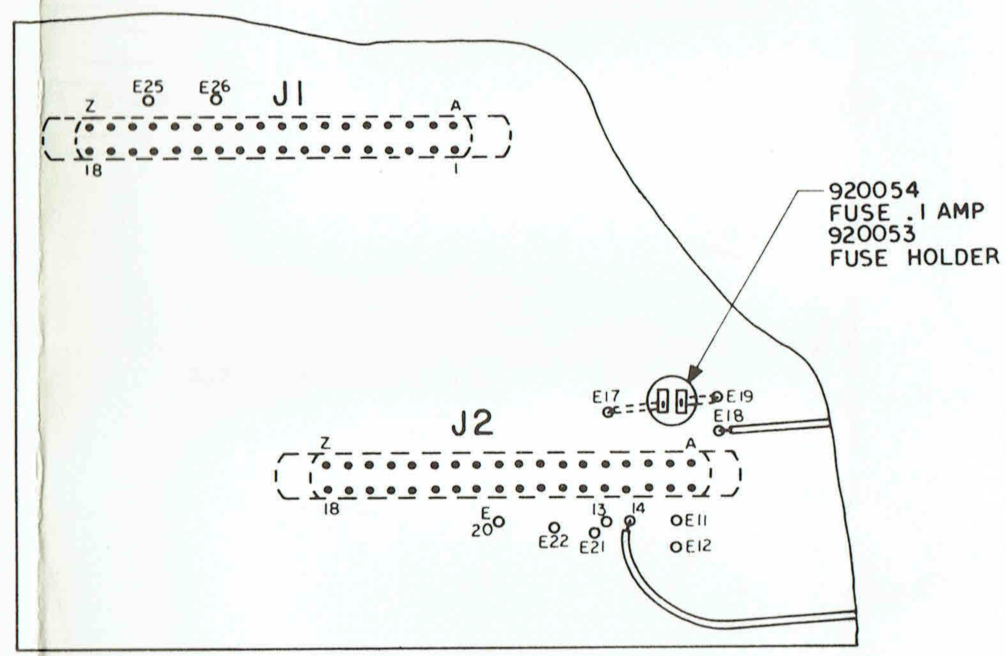
JACK	TO	E NO.
J9		E18
J10		E14



SCHEMATIC



REAR PANEL



POWER SUPPLY BOARD

REAR VIEW

HALF RACK

NOTES: UNLESS OTHERWISE SPECIFIED

	4530		
	4570		
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X .030 XX .020 XXX .010	0° 30' FORMED 1° 0'	+.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	R. CARROLL	9-19-69
CHECK	W. SARKISON	7-29-69
DESIGN	P. GUMMESON	7-29-69
MECH ENGR		
PROJ ENGR	W. SARKISON	7-30-69
PROD ENGR	P. SALERNO	7-31-69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY ANALOG SIGNAL OUTPUT

SIZE	CODE IDENT NO	DWG NO.	REV
C	21793	403262	C

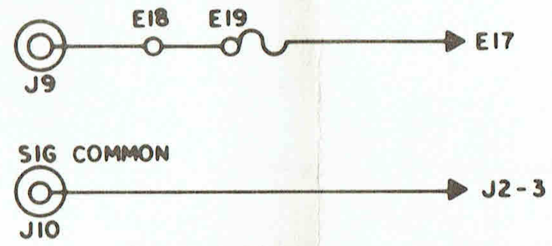
SCALE — SHEET 1 OF 3

DANA 980337 DIETERICH-POST CLEARPRINT 1020

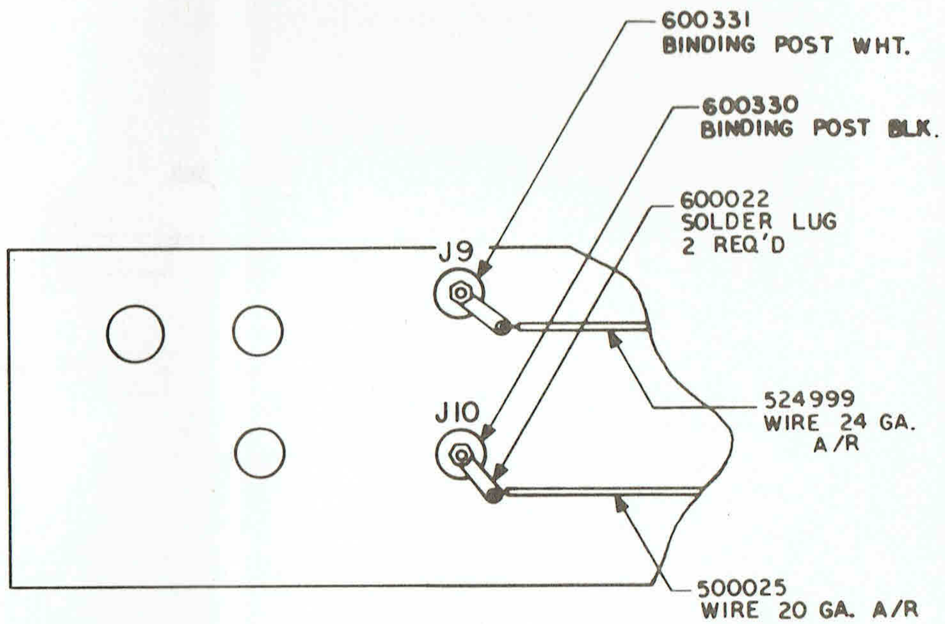
REVISIONS						
LTR	DESCRIPTION		DR	CHK	APPD
A	RELEASED PER DRN # 905	8-7-9	HANSSEN		

SEE SHEET 1

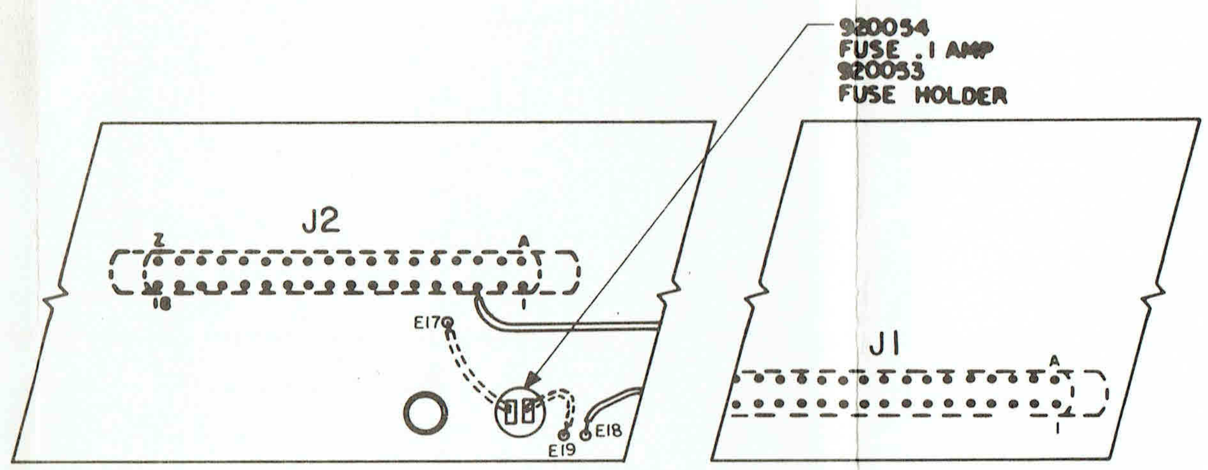
WIRING LIST		
FUSE	TO	E NO.
TERM 1		E17
TERM 2		E19
BINDING POST		
JACK	TO	E NO.
J9		E18
J10		J2-3



SCHEMATIC



REAR PANEL



POWER SUPPLY BOARD

REAR VIEW

FULL RACK

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
	4530		
	4570		
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS X.030 XX.020 XXX.010	ANGLES 0° 30' FORMED 1° 0'	HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL	FINISH

DRAWN	R. CARROLL	9-19-69
CHECK	W. SARKISON	7-29-69
DESIGN	P. GUMMESON	7-29-69
MECH ENGR		
PROJ ENGR	W. SARKISON	7-30-69
PROD ENGR	P. SALERNO	7-31-69

DANA® DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY ANALOG SIGNAL OUTPUT

SIZE	CODE IDENT NO.	DWG NO.	REV
C	21793	403262	C

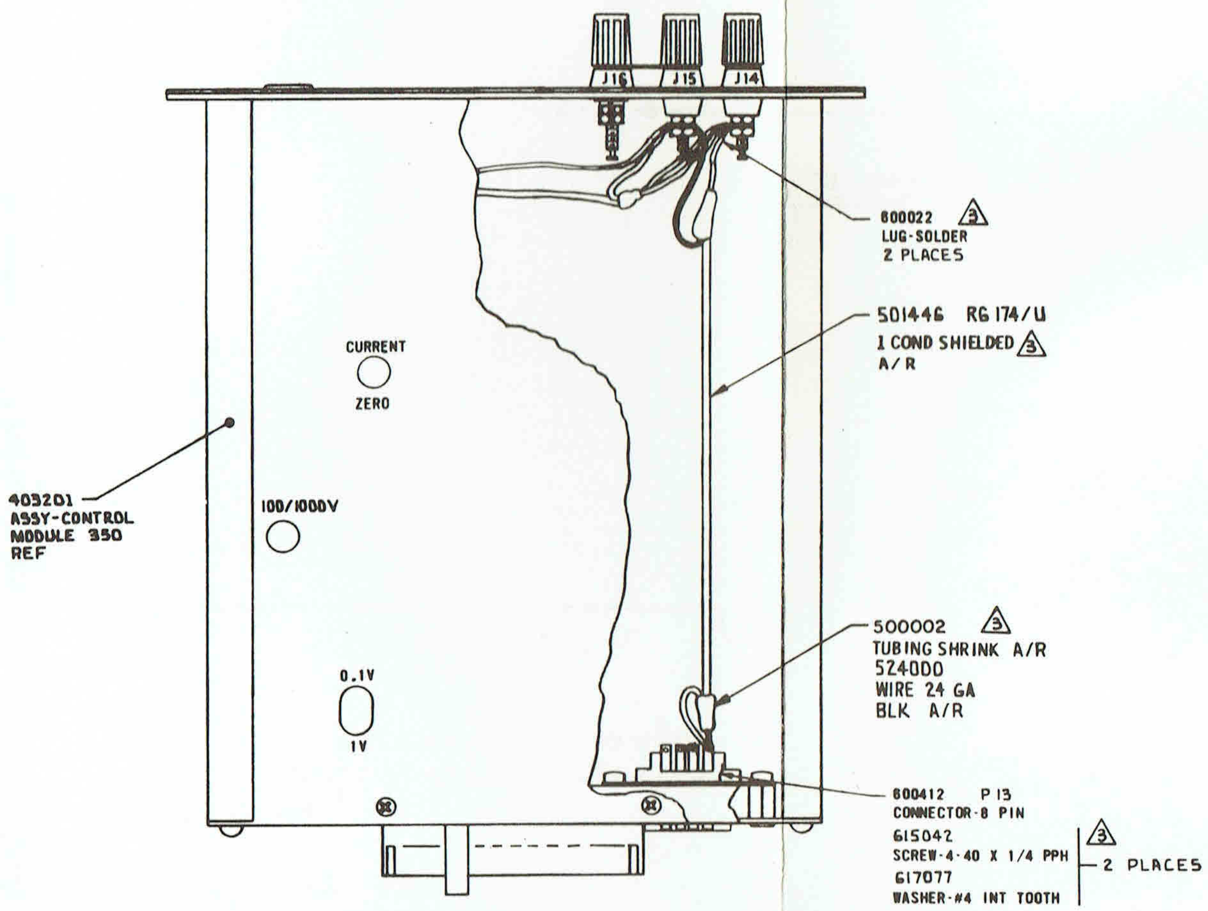
SCALE — SHEET 2 OF 3

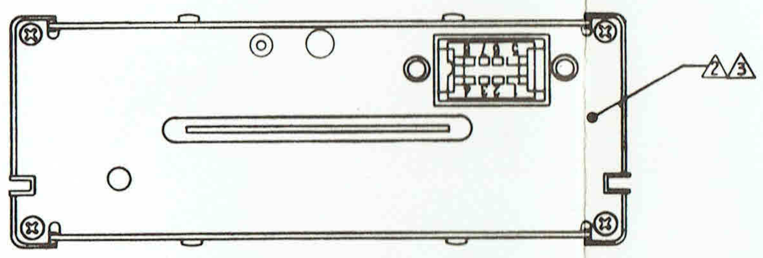
SHT 3 is A SIZE

DANA 980337 DIETERICH-POST CLEARPRINT 1020

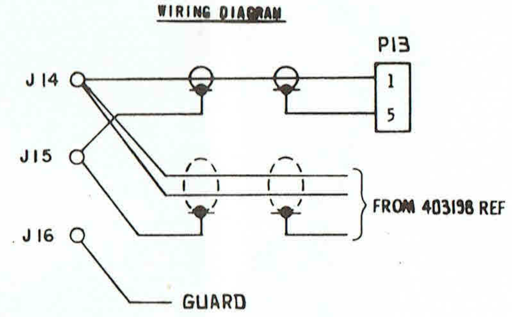
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN # 393		6-25-9	

REVISIONS





WIRING DIAGRAM



3 ALL HARDWARE IS INCLUDED IN REAR INPUT KIT (403205).
2 REPLACE PANEL 453212, WITH 453211, (PART OF REAR INPUT KIT).
1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
—	4500	—	—
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030	0° 30'	+.004
XX.020	FORMED	-.001
.XXX.010	1° 0'	

DIMENSIONS AND TOLERANCES PER USAS Y14.15-66

MATERIAL | FINISH

DRAWN		
CHECK		
DESIGN	R Prchal	6/2/69
MECH ENGR		
PROJ ENGR	L Lang	6/11/69
PROD ENGR		

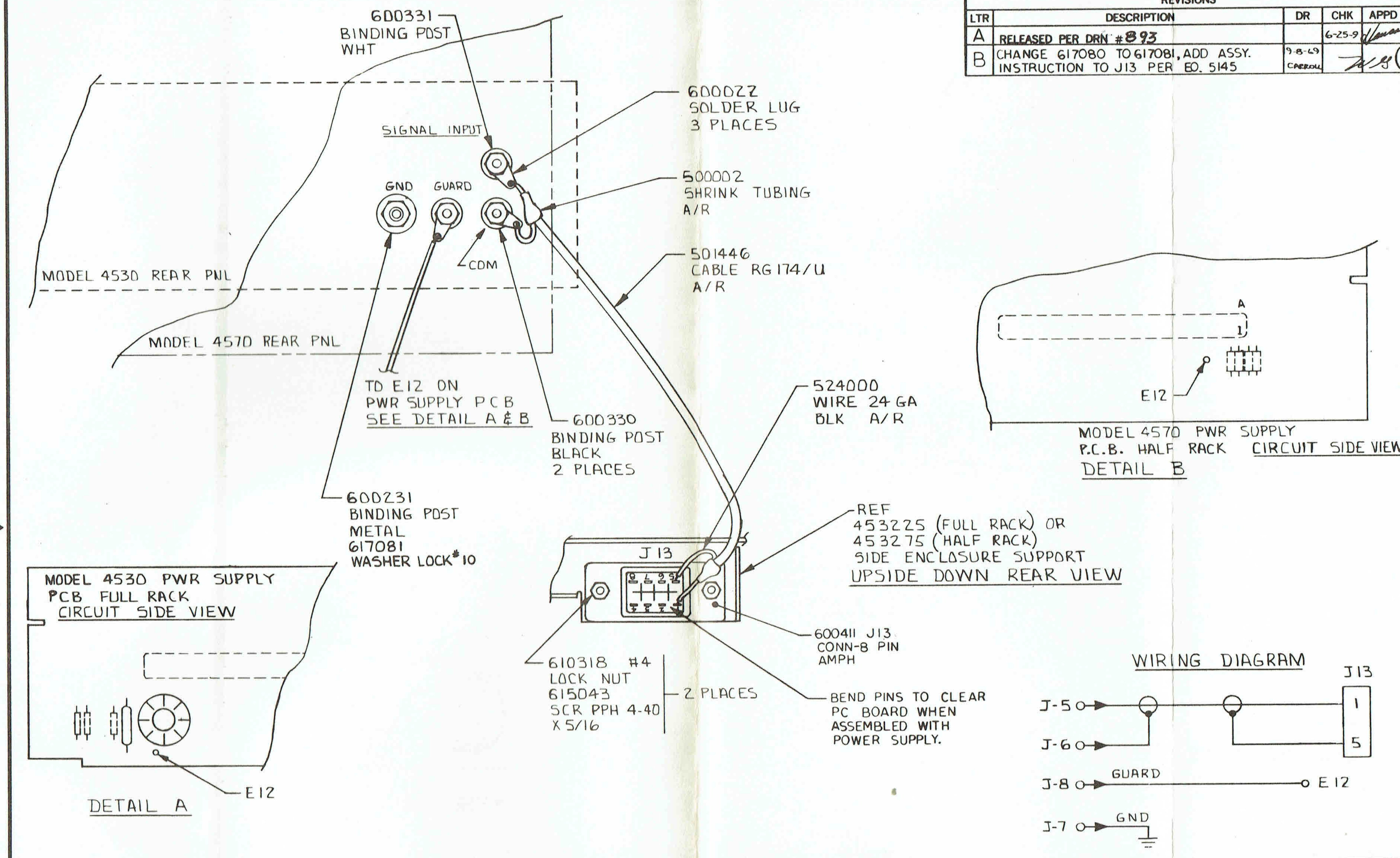
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ACCESSORY ASSY
REAR INPUT MODEL
350

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403199	A

SCALE 1/1 SHEET 1 OF 2

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
A	RELEASED PER DRN #893		6-25-9	
B	CHANGE 617080 TO 617081, ADD ASSY. INSTRUCTION TO J13 PER EO. 5145	9-8-69 CARROLL		



403232	4570	REF	REF
403206	4530	REF	REF
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES		
DECIMALS X.030 XX.020 XXX.010	ANGLES 0° 30′ FORMED 1° 0′	HOLE DIAMETERS +.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	R Prchal	6/3/69
CHECK	W. Sanderson	6-5-69
DESIGN	R Prchal	6/3/69
MECH ENGR		
PROJ ENGR	L. Lang	6/11/69
PROD ENGR		

DANA LABORATORIES INC. IRVINE, CALIFORNIA

ASSEMBLY — REAR INPUT

SIZE	CODE IDENT NO.	DWG NO.	REV
C	21793	403230	B

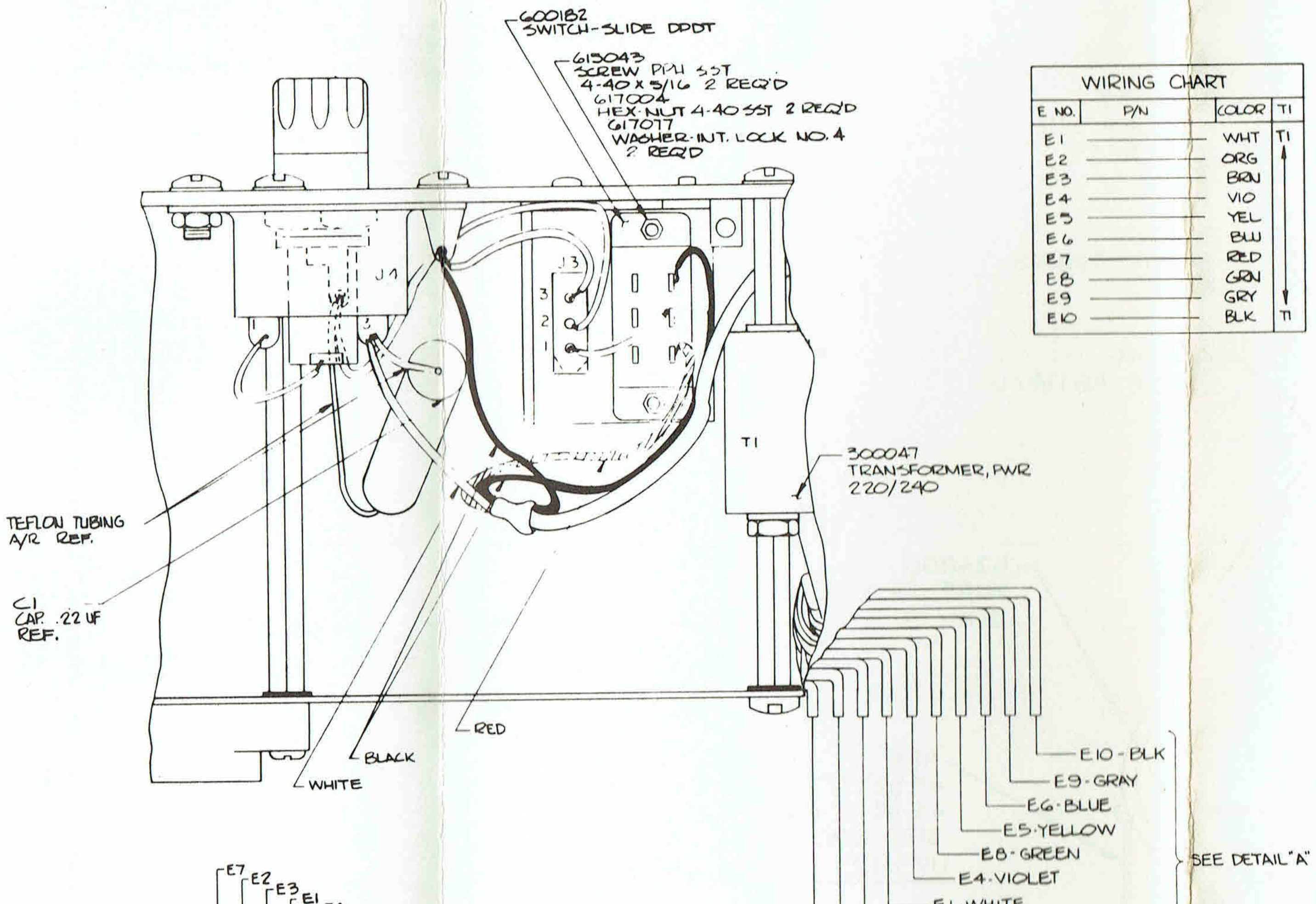
SCALE 1/1 | SHEET 1 OF 2

NOTES: UNLESS OTHERWISE SPECIFIED

DANA 900337 DIETERICH-POST CLEARPRINT 1000

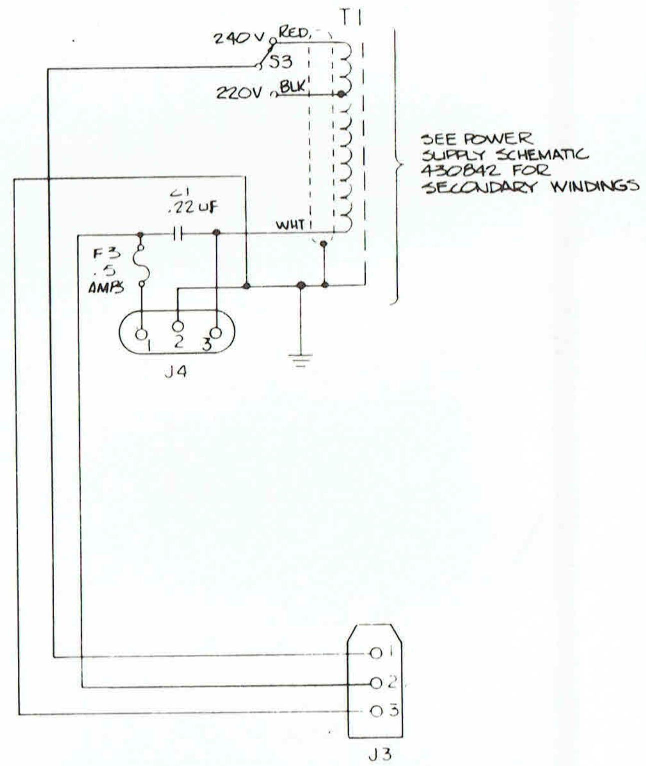
SHT 2 IS AN "A" SIZE

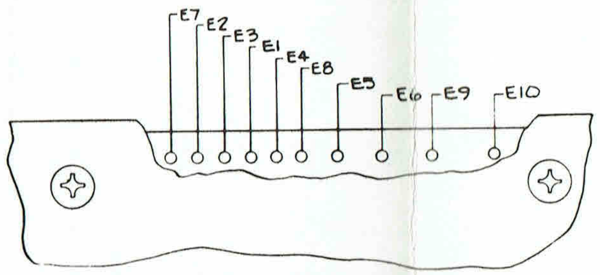
REVISIONS					
LTR	DESCRIPTION		DR	CHK	APPD
A	RELEASED PER DRN # 905	8-7-9			
B	ADD WIRING DETAIL ED 5577		2-20-70	2-20-70	



WIRING CHART

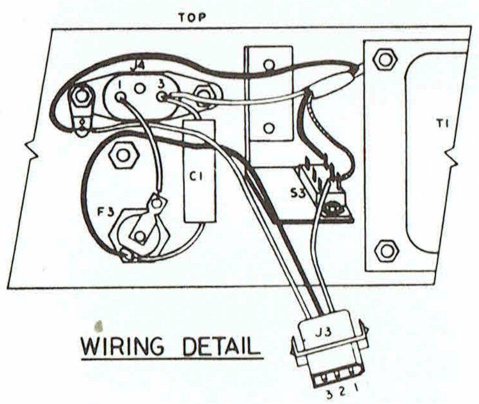
E NO.	P/N	COLOR	T1
E1		WHT	T1
E2		ORG	
E3		BRN	
E4		VIO	
E5		YEL	
E6		BLU	
E7		RED	
E8		GRN	
E9		GRY	
E10		BLK	T1





FULL RACK
POWER SUPPLY VIEWED FROM REAR

DETAIL "A"



WIRING DETAIL

FULL RACK MODIFICATION

1. ASSY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
403284	5270	1	1
403288	5230	1	1
403233	4570	1	1
403206	4530	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X .030 XX .020 XXX .010	0° 30' FORMED 1° 0'	+.004 -.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	K.A. Cunningham	7-24-69
CHECK	W. Sarkan	7-29-69
DESIGN	P. Grunmeson	7/29/69
MECH ENGR		
PROJ ENGR	W. Sarkan	7-31-69
PROD ENGR	G. Sakima	7-31-69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

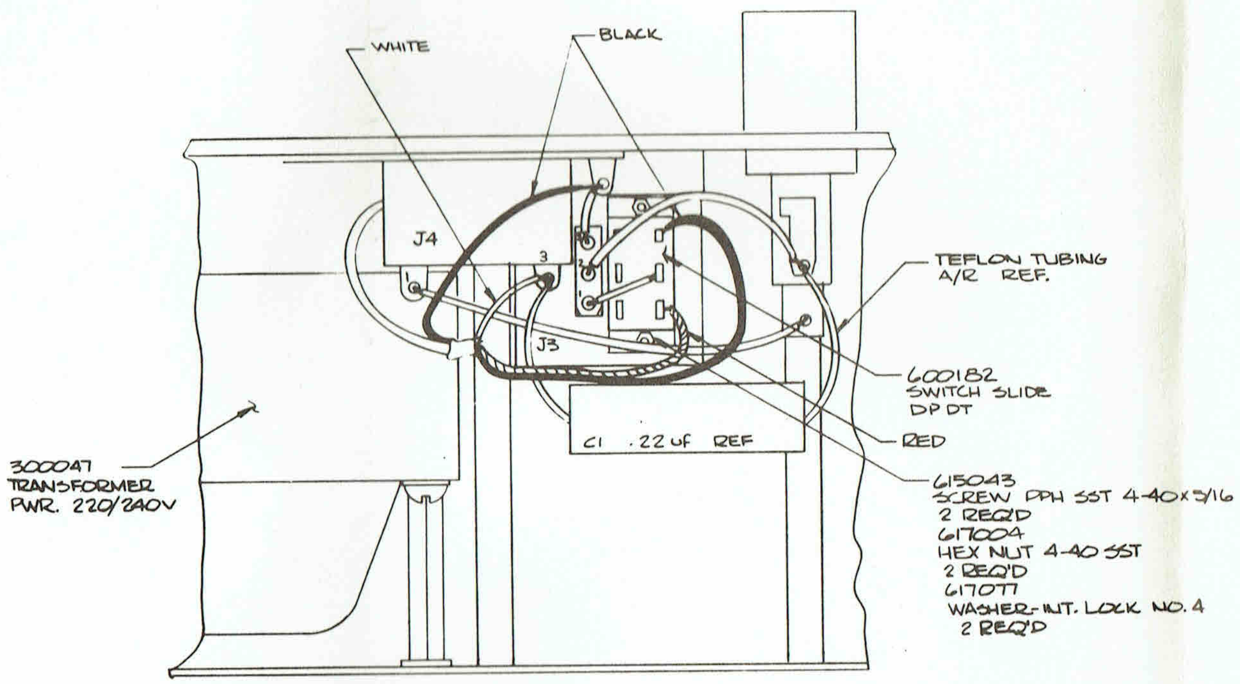
ASSY POWER SUPPLY
MODI. 220/240V

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403269	B

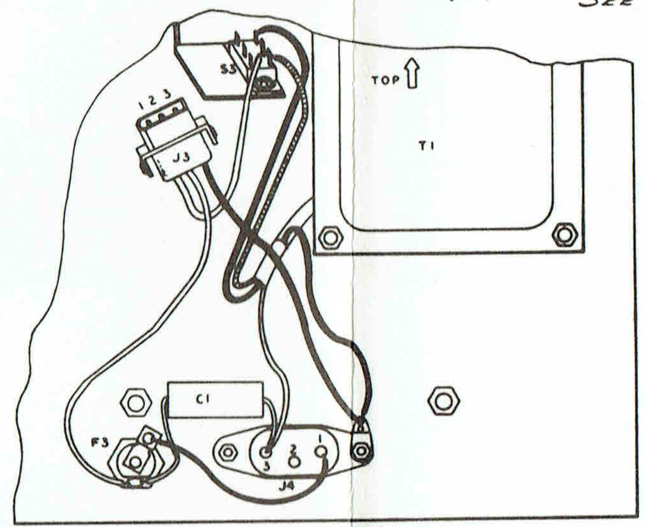
SCALE | SHEET 1 OF 3

SHT 3 IS A SIZE

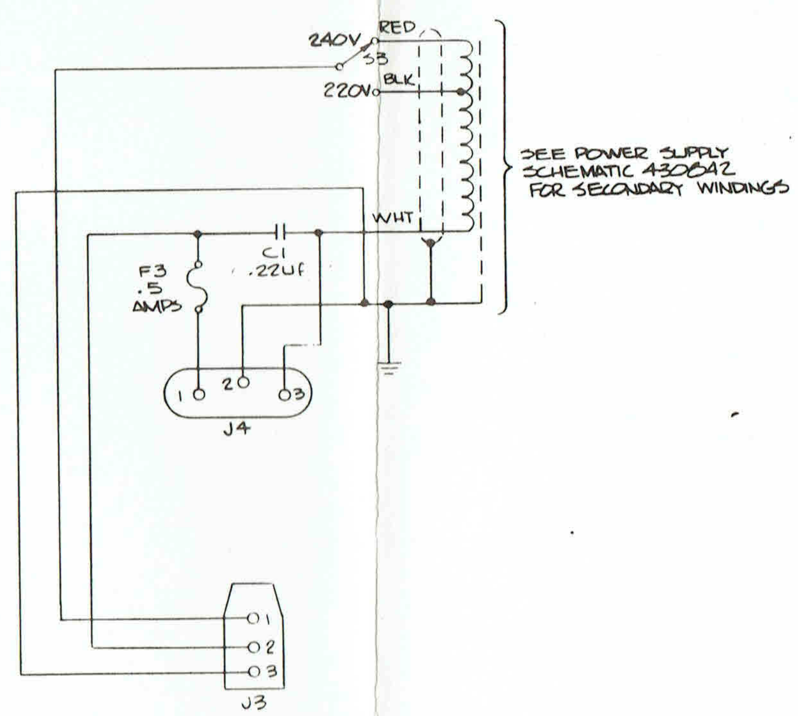
REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
	RELEASED PER DRN # SEE SHEET 1			

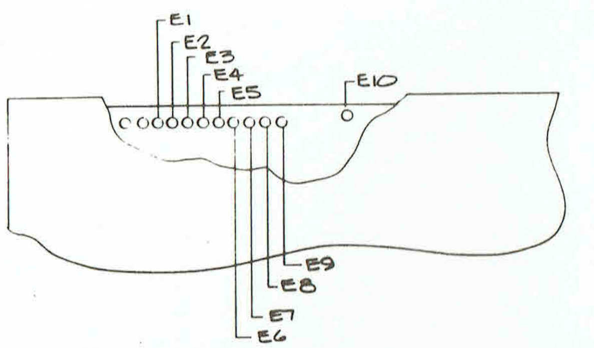


WIRING CHART			
E NO.	P/N	COLOR	T1
E1		WHT	↑
E2		ORG	
E3		BRN	
E4		VIO	
E5		YEL	
E6		BLU	
E7		RED	
E8		GRN	
E9		GRY	↓
E10		BLK	T1



WIRING DETAIL





HALF RACK POWER SUPPLY VIEWED FROM REAR

HALF RACK MODIFICATION

NOTES: UNLESS OTHERWISE SPECIFIED

See SHT 1			
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.030 XX.020 XXX.010	0° 30' FORMED 1° 0'	+.004 −.001

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

DRAWN	Kinningham	7-24-69
CHECK	W. Sackman	7-28-69
DESIGN	P. Hemmerson	7/29/69
MECH ENGR		
PROJ ENGR	W. Sackman	7-30-69
PROD ENGR	B. Jackson	7-31-69

DANA LABORATORIES INC. IRVINE, CALIFORNIA

ASSY POWER SUPPLY MODI: 220/240V

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	403269	B

SCALE | SHEET 2 OF 2

PARTS LIST

ASSEMBLY 403082 Readout Assembly · A

REF. DESIG.	PART NO.	DESCRIPTION				
CR01	220011	DIODE SILICO ZENER 1N968A		1	MOTOROLA	1N968A
CR02	211083	DIODE SILICO	018	1	DANA	211083
CR03	211083	DIODE SILICO	018	1	DANA	211083
CR04	211083	DIODE SILICO	018	1	DANA	211083
CR05	211083	DIODE SILICO	018	1	DANA	211083
CR06	211236	DIODE SILICO	007		DANA	211236
CR07	211236	DIODE SILICO	007		DANA	211236
CR08	211083	DIODE SILICO	018	1	DANA	211083
CR09	211083	DIODE SILICO	018	1	DANA	211083
CR10	211083	DIODE SILICO	018	1	DANA	211083
CR11	211236	DIODE SILICO	007		DANA	211236
CR12	220036	DIODE	KIT		DANA	220036
CR13	211236	DIODE SILICO	007		DANA	211236
CR14	211236	DIODE SILICO	007		DANA	211236
CR15	211083	DIODE SILICO	018	1	DANA	211083
C01	110032	CAP TANTA	22 MFD 15 V	10%1	KEMET	K22C15K
C02	100017	CAP CERAM	.01 MFD 200 V	10%	SPRAGUE	TH-S10
C03	101641	CAP CERAM	470 PFD 500 V	10%1	AEROVOX	SCD1X5F
C04	101641	CAP CERAM	470 PFD 500 V	10%1	AEROVOX	SCD1X5F
C05	110001	CAP TANTA	6.8 MFD 35 V	10%1	KEMET	K6R8C35K
C06	110001	CAP TANTA	6.8 MFD 35 V	10%1	KEMET	K6R8C35K
C07	110047	CAP ELECT	50 MFD 50 V	20%	DUCATI	50-50
C08	100017	CAP CERAM	.01 MFD 200 V	10%	SPRAGUE	TH-S10
C09	101174	CAP CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C10	110045	CAP TANTA	12 MFD 20 V	10%1	KEMET	K12C20K
C11	101182	CAP CERAM	47 PFD 500 V	10%1	AEROVOX	TCD-N750
C12	101641	CAP CERAM	470 PFD 500 V	10%1	AEROVOX	SCD1X5F
C13	101175	CAP CERAM	220 PFD 500 V	10%1	AEROVOX	SCD1X5F
C14	100016	CAP CERAM	27 PFD		AEROVOX	N750
C15	100016	CAP CERAM	27 PFD		AEROVOX	N750
C16	100016	CAP CERAM	27 PFD		AEROVOX	N750
C17	100016	CAP CERAM	27 PFD		AEROVOX	N750
C18	101174	CAP CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C19	101174	CAP CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C20	101145	CAP CERAM	100 PFD 500 V	10%1	AEROVOX	SCD1X5F
C21	120003	CAP MYLAR	.1 MFD 100 V	10%1	CDE	WMF1P1
C22	100012	CAP CERAM	33 PFD 500 V	10%	AEROVOX	TCD-N750
C23	121091	CAP MYLAR	.033 MFD 100 V	10%1	CDE	WMF1533
C24	120208	CAP POLYS	55 MFD 63 V	5%	MIAL	602

PARTS LIST

ASSEMBLY 403082 Readout Assembly A

REF. DESIG.	PART NO.	DESCRIPTION					
C25	100017	CAP	CERAM	.01 MFD 200 V	10%	SPRAGUE	TH-S10
C26	100017	CAP	CERAM	.01 MFD 200 V	10%	SPRAGUE	TH-S10
C27	100012	CAP	CERAM	33 PFD 500 V	10%	AEROVOX	TCD-N750
C29	101174	CAP	CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C30	101174	CAP	CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C31	101175	CAP	CERAM	220 PFD 500 V	10%1	AEROVOX	SCD1X5F
C32	100038	CAP	CERAM	560 PFD 500 V	5%	AEROVOX	TCD-N 750
C33	100017	CAP	CERAM	.01 MFD 200 V	10%	SPRAGUE	TH-S10
C34	100019	CAB	CERAM	.002 MFD 10000V		SPRAGUE	5GA-D20
C35	100019	CAB	CERAM	.002 MFD 10000V		SPRAGUE	5GA-D20
C36	100019	CAB	CERAM	.002 MFD 10000V		SPRAGUE	5GA-D20
L01	310054	CHOKE		1 MH		JEFFERS	1331-35J
M01	230053	INTEGRATED CIRCUIT		MC892P		MOTOROLA	MC892P
M02	230022	INTEGRATED CIRCUIT		MC889P		MOTOROLA	MC889P
M03	230019	INTEGRATED CIRCUIT		MC824P		MOTOROLA	MC824P
M04	230019	INTEGRATED CIRCUIT		MC824P		MOTOROLA	MC824P
M05	230023	INTEGRATED CIRCUIT		MC890P		MOTOROLA	MC890P
M06	230053	INTEGRATED CIRCUIT		MC892P		MOTOROLA	MC892P
M07	230019	INTEGRATED CIRCUIT		MC824P		MOTOROLA	MC824P
M08	230018	INTEGRATED CIRCUIT		MC817P		MOTOROLA	MC817P
M09	230052	INTEGRATED CIRCUIT		MC879P		MOTOROLA	MC879P
M10	230014	INTEGRATED CIRCUIT		UL9960		FAIRCHILD	UL9960
M11	230014	INTEGRATED CIRCUIT		UL9960		FAIRCHILD	UL9960
M12	230014	INTEGRATED CIRCUIT		UL9960		FAIRCHILD	UL9960
M13	230014	INTEGRATED CIRCUIT		UL9960		FAIRCHILD	UL9960
M14	230050	INTEGRATED CIRCUIT		CUL9959		FAIRCHILD	CUL9959
M15	230050	INTEGRATED CIRCUIT		CUL9959		FAIRCHILD	CUL9959
M16	230050	INTEGRATED CIRCUIT		CUL9959		FAIRCHILD	CUL9959
M17	230050	INTEGRATED CIRCUIT		CUL9959		FAIRCHILD	CUL9959
M18	230050	INTEGRATED CIRCUIT		CUL9959		FAIRCHILD	CUL9959
M19	230049	INTEGRATED CIRCUIT		CUL9958		FAIRCHILD	CUL9958
M20	230049	INTEGRATED CIRCUIT		CUL9958		FAIRCHILD	CUL9958
M21	230049	INTEGRATED CIRCUIT		CUL9958		FAIRCHILD	CUL9958
M22	230049	INTEGRATED CIRCUIT		CUL9958		FAIRCHILD	CUL9958
M23	230054	INTEGRATED CIRCUIT		LM301A		NAT SEMI	LM301A
M24	230026	INTEGRATED CIRCUIT		MC709C		MOTOROLA	MC709C
M25	230045	INTEGRATED CIRCUIT		UA741C		FAIRCHILD	UA741C
M26	230045	INTEGRATED CIRCUIT		UA741C		FAIRCHILD	UA741C

PARTS LIST

ASSEMBLY 403082 Readout Assembly A

REF. DESIG.	PART NO.	DESCRIPTION							
Q01	200052	TRANS	SILICO PNP	009			DANA	200052
Q02	200035	TRANS	SILICO NPN	014			DANA	200035
Q03	200052	TRANS	SILICO PNP	009			DANA	200052
Q04	200022	TRANS	SILICO PNP	012			DANA	200022
Q05	200037	TRANS	SILICO NPN	2N3646			FAIRCHILD	2N3646
Q06	200022	TRANS	SILICO PNP	012			DANA	200022
Q07	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q08	200022	TRANS	SILICO PNP	012			DANA	200022
Q09	200022	TRANS	SILICO PNP	012			DANA	200022
Q10	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q11	200103	TRANS		TIS 74			TI	TIS 74
Q12	200103	TRANS		TIS 74			TI	TIS 74
Q13	200103	TRANS		TIS 74			TI	TIS 74
Q14	200103	TRANS		TIS 74			TI	TIS 74
Q15	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q16	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q17	200079	TRANS		021			DANA	200079
Q18	200079	TRANS		021			DANA	200079
Q19	200079	TRANS		021			DANA	200079
Q20	200079	TRANS		021			DANA	200079
Q21	200079	TRANS		021			DANA	200079
Q22	200079	TRANS		021			DANA	200079
Q23	200079	TRANS		021			DANA	200079
Q24	200079	TRANS		021			DANA	200079
Q25	200079	TRANS		021			DANA	200079
Q26	200079	TRANS		021			DANA	200079
Q27	200079	TRANS		021			DANA	200079
R01	000392	RES	CARBON	0003.9 K	5%	1/4 W1	OHMITE	RC07GF392J
R02	001742	RES	CARBON	300 OHM	5%	1/2 W	OHMITE	RC20GF301J
R03	001742	RES	CARBON	300 OHM	5%	1/2 W	OHMITE	RC20GF301J
R04	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R05	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R06	001742	RES	CARBON	300 OHM	5%	1/2 W	OHMITE	RC20GF301J
R07	000510	RES	CARBON	51 OHM	5%	1/4 W1	OHMITE	RC07GF510J
R08	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R09	000132	RES	CARBON	1.3 K	5%	1/4 W	OHMITE	RC07GF132J
R10	000153	RES	CARBON	15 K	5%	1/4 W1	OHMITE	RC07GF153J
R11	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J

PARTS LIST

ASSEMBLY 403082 Readout Assembly A

REF. DESIG.	PART NO.	DESCRIPTION							
R12	CC0203	RES	CARBON	20 K	5%	1/4 W1	OHMITE	RC07GF203J
R13	CC0202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R14	CC0202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R15	CC0203	RES	CARBON	20 K	5%	1/4 W1	OHMITE	RC07GF203J
R16	CC0202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R17	CC0512	RES	CARBON	5.1 K	5%	1/4 W1	OHMITE	RC07GF512J
R18	CC0393	RES	CARBON	39 K	5%	1/4 W	OHMITE	RC07GF393J
R19	CC0104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R20	CC0105	RES	CARBON	1 M	5%	1/4 W1	OHMITE	RC07GF105J
R21	CC0105	RES	CARBON	1 M	5%	1/4 W1	OHMITE	RC07GF105J
R22	CC0104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R23	C10169	RES	METAL	100 K	1%	1/4 W	ELECTRA	RN60D1003F
R24	C10169	RES	METAL	100 K	1%	1/4 W	ELECTRA	RN60D1003F
R25	CC0821	RES	CARBON	820 OHM	5%	1/4 W	OHMITE	RC07GF821J
R26	CC0106	RES	CARBON	10 M	5%	1/4 W1	OHMITE	RC07GF106J
R27	CC0275	RES	CARBON	2.7 M	5%	1/4 W	OHMITE	RC07GF275J
R28	CC0515	RES	CARBON	5.1 M	5%	1/4 W	OHMITE	RC07GF515J
R29	C40026	RES	VARI	20 K	10%	1 W	TECHNO	35
R30	CC0203	RES	CARBON	20 K	5%	1/4 W1	OHMITE	RC07GF203J
R31	CC0101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R32	CC0101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R33	CC0270	RES	CARBON	27 OHM	5%	1/4 W	OHMITE	RC07GF270J
R34	CC0203	RES	CARBON	20 K	5%	1/4 W1	OHMITE	RC07GF203J
R35	CC0512	RES	CARBON	5.1 K	5%	1/4 W1	OHMITE	RC07GF512J
R36	CC0393	RES	CARBON	39 K	5%	1/4 W	OHMITE	RC07GF393J
R39	CC0242	RES	CARBON	2.4 K	5%	1/4 W1	OHMITE	RC07GF242J
R40	C20552	RES	WW	3.9976 K	.05%	1/4 W	JORDAN	J12
R41	CC0205	RES	CARBON	2 M	5%	1/4 W1	OHMITE	RC07GF205J
R42	CC0132	RES	CARBON	1.3 K	5%	1/4 W	OHMITE	RC07GF132J
R43	C40026	RES	VARI	20 K	10%	1 W	TECHNO	35
R46	C20553	RES	WW	10 K	.05%	1/4 W	JORDAN	J12
R47	C20553	RES	WW	10 K	.05%	1/4 W	JORDAN	J12
R48	CC0512	RES	CARBON	5.1 K	5%	1/4 W1	OHMITE	RC07GF512J
R49	C40026	RES	VARI	20 K	10%	1 W	TECHNO	35
R50	CC0102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R51	C20533	RES	WW	9 K	.1%		JORDAN	J11
R52	C20139	RES	WW	1 K	.1%	1/8 W	KELVIN	J-11

PARTS LIST

ASSEMBLY 403082 Readout Assembly

REF. DESIG.	PART NO.	DESCRIPTION						
R53	030020	RES	CARBON	56 K	5%	1 W	OHMITE	RC32GF563J
R54	030020	RES	CARBON	56 K	5%	1 W	OHMITE	RC32GF563J
R55	030020	RES	CARBON	56 K	5%	1 W	OHMITE	RC32GF563J
R56	030020	RES	CARBON	56 K	5%	1 W	OHMITE	RC32GF563J
R57	030020	RES	CARBON	56 K	5%	1 W	OHMITE	RC32GF563J
R58	000623	RES	CARBON	62 K	5%	1/4 W1	OHMITE	RC07GF623J
R59	000623	RES	CARBON	62 K	5%	1/4 W1	OHMITE	RC07GF623J
R60	000623	RES	CARBON	62 K	5%	1/4 W1	OHMITE	RC07GF623J
R61	C00105	RES	CARBON	1 M	5%	1/4 W1	OHMITE	RC07GF105J
R62	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J
R63	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J
R64	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J
R65	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J
R66	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J
R67	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J
R68	000152	RES	CARBON	1.5 K	5%	1/4 W1	OHMITE	RC07GF152J
R69	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R70	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R71	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R72	000391	RES	CARBON	390 OHM	5%	1/4 W	OHMITE	RC07GF391J
R73	000391	RES	CARBON	390 OHM	5%	1/4 W	OHMITE	RC07GF391J
R74	000331	RES	CARBON	330 OHM	5%	1/4 W1	OHMITE	RC07GF331J
R75	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R76	000512	RES	CARBON	5.1 K	5%	1/4 W1	OHMITE	RC07GF512J
R77	000203	RES	CARBON	20 K	5%	1/4 W1	OHMITE	RC07GF203J
R78	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J
R79	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R80	000511	RES	CARBON	510 OHM	5%	1/4 W1	OHMITE	RC07GF511J
R81	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R82	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R83	000205	RES	CARBON	2 M	5%	1/4 W1	OHMITE	RC07GF205J
Y01	920440	CRYSTAL		200 KHZ			DANA	920440

FORM NO. 10110-P

PARTS LIST

ASSEMBLY 403081 and 403225 PCB ASSEMBLY, Power Supply

REF. DESIG.	PART NO.	DESCRIPTION				
CR01	210004	DIODE SILICO	SD4		DIODES IN	SD4
CR02	210004	DIODE SILICO	SD4		DIODES IN	SD4
CR03	210004	DIODE SILICO	SD4		DIODES IN	SD4
CR04	210004	DIODE SILICO	SD4		DIODES IN	SD4
CR05	210004	DIODE SILICO	SD4		DIODES IN	SD4
CR06	210004	DIODE SILICO	SD4		DIODES IN	SD4
CR07	210014	DIODE SILICO	023		DANA	210014
CR08	210014	DIODE SILICO	023		DANA	210014
CR09	210014	DIODE SILICO	023		DANA	210014
CR10	210014	DIODE SILICO	023		DANA	210014
CR11	221177	DIODE SILICO ZENER		1/4 W1	MOTOROLA	M.2.4A25
CR12	220035	DIODE ZENER	IN966B		MOTOROLA	IN966B
CR13	220035	DIODE ZENER	IN966B		MOTOROLA	IN966B
C02	121088	CAP MYLAR	.01 MFD 100 V	10%	CDE	WMF1S1
C03	121088	CAP MYLAR	.01 MFD 100 V	10%	CDE	WMF1S1
C04	120072	CAP MYLAR	.01 MFD 600 V	10%	CDE	WMF651
C05	110067	CAP ELECT	2000 MFD 35 V	20%	DUCATI	2000-35
C06	110107	CAP ELECT	4000 MFD 15 V		DUCATI	4000DX1512-10
C07	110065	CAP ELECT	20 MFD 350 V	20%	DUCATI	20-350
C08	110067	CAP ELECT	2000 MFD 35 V	20%	DUCATI	2000-35
C09	120003	CAP MYLAR	.1 MFD 100 V	10%1	CDE	WMF1P1
C10	120003	CAP MYLAR	.1 MFD 100 V	10%1	CDE	WMF1P1
C11	110066	CAP ELECT	15 MFD 200 V	20%	DUCATI	15-200
C12	110070	CAP ELECT	22 MFD 6 V	10%	KEMET	K22W6K
C13	100017	CAP CERAM	.01 MFD 200 V	10%	SPRAGUE	TH-S10
C14	110043	CAP ELECT	25 MFD 25 V	20%	DUCATI	25-25
C15	110043	CAP ELECT	25 MFD 25 V	20%	DUCATI	25-25
C16	101174	CAP CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C17	101174	CAP CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C18	110077	CAP ELECT	1000 MFD 15 V		AMPEREX	C437PR/E1000
C19	120019	CAP MYLAR	.47 MFD 100 V	10%	CDE	WMF1P47
Q01	200043	TRANS SILICO NPN	2N3565		FAIRCHILD	2N3565
Q02	200035	TRANS SILICO NPN	014		DANA	200035
Q03	200030	TRANS SILICO NPN	40250		RCA	40250
Q04	200035	TRANS SILICO NPN	014		DANA	200035
Q05	200052	TRANS SILICO PNP	009		DANA	200052
R01	000224	RES CARBON	220 K	5% 1/4 W1	OHMITE	RC07GF224J
R02	030014	RES CARBON	220 K	5% 1 W	OHMITE	RC32GF224J

ASSEMBLY 403081 and 403225 PCB ASSEMBLY, Power Supply A

REF. DESIG.	PART NO.	DESCRIPTION							
R03	000472	RES	CARBON	4.7 K	5%	1/4 W1	OHMITE	RC07GF472J
R04	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R05	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R06	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R07	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R08	040063	RES	VARI	500 OHM	10%	1.5 W	CTS	110
R09	000511	RES	CARBON	510 OHM	5%	1/4 W1	OHMITE	RC07GF511J
R10	000151	RES	CARBON	150 OHM	5%	1/4 W1	OHMITE	RC07GF151J
R11	000151	RES	CARBON	150 OHM	5%	1/4 W1	OHMITE	RC07GF151J
R12	030007	RES	CARBON	150 OHM	5%	3 W	OHMITE	4396
R13	030007	RES	CARBON	150 OHM	5%	3 W	OHMITE	4396

PARTS LIST

ASSEMBLY 403198 PCB Isolator, Assembly A

REF. DESIG.	PART NO.	DESCRIPTION				
CR01	211083	DIODE SILICO	018	1	DANA	211083
CR02	211083	DIODE SILICO	018	1	DANA	211083
CR03	211083	DIODE SILICO	018	1	DANA	211083
CR04	211083	DIODE SILICO	018	1	DANA	211083
CR05	211083	DIODE SILICO	018	1	DANA	211083
CR06	211083	DIODE SILICO	018	1	DANA	211083
CR07	211083	DIODE SILICO	018	1	DANA	211083
CR08	211083	DIODE SILICO	018	1	DANA	211083
CR09	211083	DIODE SILICO	018	1	DANA	211083
CR10	220007	DIODE SILICO ZENER	1N751	1	MOTOROLA	1N751
CR11	220004	DIODE SILICO ZENER	1N961B	1	MOTOROLA	1N961B
CR12	220004	DIODE SILICO ZENER	1N961B	1	MOTOROLA	1N961B
CR13	211236	DIODE SILICO	007		DANA	211236
CR14	220016	DIODE SILICO ZENER	1N964B		MOTOROLA	1N964B
CR15	220016	DIODE SILICO ZENER	1N964B		MOTOROLA	1N964B
CR16	211236	DIODE SILICO	007		DANA	211236
CR17	211236	DIODE SILICO	007		DANA	211236
CR18	211236	DIODE SILICO	007		DANA	211236
CR19	211083	DIODE SILICO	018	1	DANA	211083
CR20	211083	DIODE SILICO	018	1	DANA	211083
CR21	220004	DIODE SILICO ZENER	1N961B	1	MOTOROLA	1N961B
CR22	220012	DIODE SILICO ZENER	1N958B	1	MOTOROLA	1N958B
CR23	221177	DIODE SILICO ZENER		1/4 W1	MOTOROLA	M.2.4A25
CR24	220004	DIODE SILICO ZENER	1N961B	1	MOTOROLA	1N961B
CR25	211083	DIODE SILICO	018	1	DANA	211083
CR26	211083	DIODE SILICO	018	1	DANA	211083
CR27	221177	DIODE SILICO ZENER		1/4 W1	MOTOROLA	M.2.4A25
CR28	211083	DIODE SILICO	018	1	DANA	211083
CR29	211083	DIODE SILICO	018	1	DANA	211083
CR30	220016	DIODE SILICO ZENER	1N964B		MOTOROLA	1N964B
CR31	220016	DIODE SILICO ZENER	1N964B		MOTOROLA	1N964B
C01	110086	CAP TANTA	47 MFD 10 V	10%	KEMET	K47C6K
C02	101174	CAP CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C03	100017	CAP CERAM	.01 MFD 200 V	10%	SPRAGUE	TH-S10
C04	120177	CAP MYLAR	.56 MFD 50 V	5%	IMB	PV2A564J
C05	110071	CAP ELECT	.1 MFD 35 V	10%	KEMET	K1W35K
C06	110071	CAP ELECT	.1 MFD 35 V	10%	KEMET	K1W35K
C07	120175	CAP MYLAR	.0027 MFD 100 V	10%	IMB	ZA1296K

PARTS LIST

ASSEMBLY 403198 PCB Isolator, Assembly A

REF. DESIG.	PART NO.	DESCRIPTION					
C08	121093	CAP	MYLAR	.047 MFD 100 V	10%1	CDE	WMF1S47
C09	120135	CAP	POLYS	.015 MFD 33 V	10%	MIAL	611.3S
C10	120178	CAP	MYLAR	.27 MFD 50 V	5%	IMB	PV2A274J
C11	120153	CAP	POLYS	47 PFD 125 V	10%	MIAL	611
C12	110047	CAP	ELECT	50 MFD 50 V	20%	DUCATI	50-50
C13	120026	CAP	MYLAR	.47 MFD 100 V	10%1	IMB	AS2B474K
C14	101174	CAP	CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C15	120176	CAP	POLY	150 PFD 63 V	20%	MIAL	611.1
C16	101174	CAP	CERAM	.001 MFD 500 V	10%1	AEROVOX	SCD3X5F
C17	100017	CAP	CERAM	.01 MFD 200 V	10%	SPRAGUE	TH-S10
C18	110040	CAP	ELECT	1 MFD 50 V	20%	DUCATI	1-50
C19	120185	CAP	MYLAR	.33 MFD 100 V	10%	CD	WMF1P33
C20	110040	CAP	ELECT	1 MFD 50 V	20%	DUCATI	1-50
C21	120134	CAP	MYLAR	1 MFD 200 V	10%	PAKTRON	MF1200LL
C22	120134	CAP	MYLAR	1 MFD 200 V	10%	PAKTRON	MF1200LL
C23	120110	CAP	MYLAR	.27 MFD 100 V	10%	CD	WMF1P27
K01	310029	RELAY				AM ZETTLR	AZ420-56
K02	310021	RELAY DC		2 PDT 24V	1	ALLIED	AZ42056105
K03	310021	RELAY DC		2 PDT 24V	1	ALLIED	AZ42056105
M01	230019	INTEGRATED CIRCUIT	MC824P			MOTOROLA	MC824P
M02	230023	INTEGRATED CIRCUIT	MC890P			MOTOROLA	MC890P
M03	230018	INTEGRATED CIRCUIT	MC817P			MOTOROLA	MC817P
M04	230055	INTEGRATED CIRCUIT	MC819P			MOTOROLA	MC819P
M05	230015	INTEGRATED CIRCUIT	MC723P			MOTOROLA	MC723P
M06	230053	INTEGRATED CIRCUIT	MC892P			MOTOROLA	MC892P
M07	230019	INTEGRATED CIRCUIT	MC824P			MOTOROLA	MC824P
M08	230055	INTEGRATED CIRCUIT	MC819P			MOTOROLA	MC819P
M09	230018	INTEGRATED CIRCUIT	MC817P			MOTOROLA	MC817P
M10	230018	INTEGRATED CIRCUIT	MC817P			MOTOROLA	MC817P
M11	230022	INTEGRATED CIRCUIT	MC889P			MOTOROLA	MC889P
Q01	200043	TRANS SILICO NPN		2N3565		FAIRCHILD	2N3565
Q02	200043	TRANS SILICO NPN		2N3565		FAIRCHILD	2N3565
Q03	200043	TRANS SILICO NPN		2N3565		FAIRCHILD	2N3565
Q04	200043	TRANS SILICO NPN		2N3565		FAIRCHILD	2N3565
Q05	200043	TRANS SILICO NPN		2N3565		FAIRCHILD	2N3565
Q06	200043	TRANS SILICO NPN		2N3565		FAIRCHILD	2N3565
Q07	200043	TRANS SILICO NPN		2N3565		FAIRCHILD	2N3565
Q08	200022	TRANS SILICO PNP		012		DANA	200022

PARTS LIST

ASSEMBLY 403198 PCB Isolator, Assembly A

REF. DESIG.	PART NO.	DESCRIPTION						
Q09	201084	TRANS	GERMAN PNP	2N1304		1	TI	2N1304
Q10	200027	TRANS	SILICO	FSV			DANA	200027
Q11	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q12	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q13	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q14	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q15	200052	TRANS	SILICO PNP	009			DANA	200052
Q16	200035	TRANS	SILICO NPN	014			DANA	200035
Q17	200083	TRANS	DUAL	TIS34			DANA	200083
Q18	200083	TRANS	DUAL	TIS34			DANA	200083
Q19	200022	TRANS	SILICO PNP	012			DANA	200022
Q20	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q21	200022	TRANS	SILICO PNP	012			DANA	200022
Q22	200022	TRANS	SILICO PNP	012			DANA	200022
Q23	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q24	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q25	200022	TRANS	SILICO PNP	012			DANA	200022
Q26	200037	TRANS	SILICO NPN	2N3646			FAIRCHILD	2N3646
R01	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R02	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R03	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R04	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R05	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R06	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R07	000511	RES	CARBON	510 OHM	5%	1/4 W1	OHMITE	RC07GF511J
R08	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R09	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R10	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R11	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R12	030015	RES	WW	100 K	1%	10 W	C-F	M-100
R13	040093	RES	VARI	500 OHM			SPECTRO	50-3-1-501
R14	010334	RES		SET			DANA	010334
R15	010334	RES		SET			DANA	010334
R16	000513	RES	CARBON	51 K	5%	1/4 W1	OHMITE	RC07GF513J
R17	000515	RES	CARBON	5.1 M	5%	1/4 W	OHMITE	RC07GF515J
R18	000105	RES	CARBON	1 M	5%	1/4 W1	OHMITE	RC07GF105J
R19	000105	RES	CARBON	1 M	5%	1/4 W1	OHMITE	RC07GF105J
R20	000245	RES	CARBON	2.4 M	5%	1/4 W	OHMITE	RC07GF245J

PARTS LIST

ASSEMBLY 403198 PCB Isolator, Assembly 'A

REF. DESIG.	PART NO.	DESCRIPTION							
R21	000682	RES	CARBON	6.8 K	5%	1/4 W	OHMITE	RC07GF682J	
R22	000330	RES	CARBON	33 K	5%	1/4 W	OHMITE	RC07GF330J	
R23	000472	RES	CARBON	4.7 K	5%	1/4 W1	OHMITE	RC07GF472J	
R24	000103	RES	CARBON	10 K	5%	1/4 W1	OHMITE	RC07GF103J	
R25	000750	RES	CARBON	75 OHM	5%	1/4 W1	OHMITE	RC07GF750J	
R26	040109	RES	VARI	5 K			SPECTROL	50-3	
R27	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J	
R28	000203	RES	CARBON	20 K	5%	1/4 W1	OHMITE	RC07GF203J	
R29	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J	
R30	000516	RES	CARBON	51 M	5%	1/4 W	OHMITE	RC07GF516J	
R32	010337	RES	METAL	10 MEG	1%		DALE	DCS1/2	
R33	010337	RES	METAL	10 MEG	1%		DALE	DCS1/2	
R34	000103	RES	CARBON	10 K	5%	1/4 W1	OHMITE	RC07GF103J	
R35	040134	RES	VARI	200 K			CTS	134	
R36	000915	RES	CARBON	910 K	5%	1/4 W	OHMITE	RC07GF915J	
R38	010337	RES	METAL	10 MEG	1%		DALE	DCS1/2	
R39	010337	RES	METAL	10 MEG	1%		DALE	DCS1/2	
R40	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J	
R41	000335	RES	CARBON	3.3 M	5%	1/4 W1	OHMITE	RC07GF335J	
R42	000685	RES	CARBON	6.8 MEG	5%	1/4 W	OHMITE	RC07GF685J	
R43	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J	
R44	000123	RES	CARBON	12 K	5%	1/4 W1	OHMITE	RC07GF123J	
R45	000123	RES	CARBON	12 K	5%	1/4 W1	OHMITE	RC07GF123J	
R46	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J	
R47	000620	RES	CARBON	62 OHM	5%	1/4 W1	OHMITE	RC07GF620J	
R48	000330	RES	CARBON	33 K	5%	1/4 W	OHMITE	RC07GF330J	
R49	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J	
R50	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J	
R51	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J	
R52	000304	RES	CARBON	300 K	5%	1/4 W	OHMITE	RC07GF304J	
R53	000513	RES	CARBON	51 K	5%	1/4 W1	OHMITE	RC07GF513J	
R54	000203	RES	CARBON	20 K	5%	1/4 W1	OHMITE	RC07GF203J	
R55	000510	RES	CARBON	51 OHM	5%	1/4 W1	OHMITE	RC07GF510J	
R56	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J	
R57	000153	RES	CARBON	15 K	5%	1/4 W1	OHMITE	RC07GF153J	
R58	000153	RES	CARBON	15 K	5%	1/4 W1	OHMITE	RC07GF153J	
R59	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J	

PARTS LIST

ASSEMBLY 403198 PCB Isolator, Assembly A

REF. DESIG.	PART NO.	DESCRIPTION							
R60	000151	RES	CARBON	150 OHM	5%	1/4 W1	OHMITE	RC07GF151J
R61	000103	RES	CARBON	10 K	5%	1/4 W1	OHMITE	RC07GF103J
R62	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R63	000510	RES	CARBON	51 OHM	5%	1/4 W1	OHMITE	RC07GF510J
R64	C00510	RES	CARBON	51 OHM	5%	1/4 W1	OHMITE	RC07GF510J
R65	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R66	000100	RES	CARBON	10 OHM	5%	1/4 W1	OHMITE	RC07GF100J
R67	000100	RES	CARBON	10 OHM	5%	1/4 W1	OHMITE	RC07GF100J
R68	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R69	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R70	040026	RES	VARI	20 K	10%	1 W	TECHNO	35
R71	020241	RES	WW	10 K	.05%	1/8 W	JORDAN	J-11
R72	C00335	RES	CARBON	3.3 M	5%	1/4 W1	OHMITE	RC07GF335J
R73	020554	RES	WW	1.1096 K	.05%		JORDAN	J11
R74	000911	RES	CARBON	910 OHM	5%	1/4 W1	OHMITE	RC07GF911J
R75	020170	RES	WW	100.83 OHM	.05%	1/8 W	KELVIN	EP-20
R76	000305	RES	CARBON	3 M	5%	1/4 W	OHMITE	RC07GF305J
R77	040026	RES	VARI	20 K	10%	1 W	TECHNO	35
R81	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J

PARTS LIST

ASSEMBLY 403169 Assembly Ohms Converter

REF. DESIG.	PART NO.	DESCRIPTION						
CR108	211083	DIODE	SILICO	018		1	DANA	211083
CR107	211083	DIODE	SILICO	018		1	DANA	211083
CR106	211083	DIODE	SILICO	018		1	DANA	211083
CR105	211083	DIODE	SILICO	018		1	DANA	211083
CR113	221177	DIODE	SILICO ZENER			1/4 W1	MOTOROLA	M.2.4A25
CR114	221177	DIODE	SILICO ZENER			1/4 W1	MOTOROLA	M.2.4A25
CR115	221177	DIODE	SILICO ZENER			1/4 W1	MOTOROLA	M.2.4A25
C123	121088	CAP	MYLAR	.01 MFD 100 V	10%		CDE	WMF1S1
C124	121146	CAP	MYLAR	.0047 MFD 100 V	10%1		CDE	WMF1D47
C127	121146	CAP	MYLAR	.0047 MFD 100 V	10%1		CDE	WMF1D47
K104	310036	RELAY	REED				ELEC-TROL	R2096-3
K105	310036	RELAY	REED				ELEC-TROL	R2096-3
K106	310035	RELAY	REED	SPST 24V			AZTEC	LIA24-S1
K107	310035	RELAY	REED	SPST 24V			AZTEC	LIA24-S1
M101	230026	INTEGRATED CIRCUIT MC709C					MOTOROLA	MC709C
Q115	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q104	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q105	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q106	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
Q107	200043	TRANS	SILICO NPN	2N3565			FAIRCHILD	2N3565
R112	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R114	001737	RES	FSV		5%	1/4 W	DANA	001737
R115	040159	RES	VARI	500 K		1/2 W	BECKMAN	62PR500K
R116	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R120	020494	RES	WW	8.19 K	.1%		JORDAN	J11
R122	020495	RES	WW	89.815 K	.1%		JORDAN	J11
R123	040115	RES	VARI	500 K	10%		BECKMAN	62PR500
R124	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R129	020496	RES	WW	996.15 K	.1%		JORDAN	J11
R130	040097	RES	VARI	5 K	10%		BECKMAN	62PR5K
R125	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R134	040104	RES	VARI	50 K			BECKMAN	62P
R135	010357	RES	METAL	8.981 MEG	.1%		PYROFILM	PME 70 T2
R145	000685	RES	CARBON	6.8 MEG	5%	1/4 W	OHMITE	RC07GF685J
R154	040088	RES	VARI	100 K	10%		BECKMAN	62PR100K
R155	001737	RES	FSV		5%	1/4 W	DANA	001737
R156	000152	RES	CARBON	1.5 K	5%	1/4 W1	OHMITE	RC07GF152J
R159	000821	RES	CARBON	820 OHM	5%	1/4 W	OHMITE	RC07GF821J

FORM NO. 10110-P

PARTS LIST

ASSEMBLY 403169 Assembly Ohms Converter A

REF. DESIG.	PART NO.	DESCRIPTION							
R158	000512	RES	CARBON	5.1 K	5%	1/4 W1	OHMITE	RC07GF512J
R163	000912	RES	CARBON	9.1 K	5%	1/4 W1	OHMITE	RC07GF912J
R164	020050	RES	WW	9.0 K	.01%	1/4 W1	KELVIN	EP-21
R165	021395	RES	WW	1 K	.01%	1/4 W	JORDAN	J-12

PARTS LIST

ASSEMBLY 403214 PCB Assembly, AC Converter

REF. DESIG.	PART NO.	DESCRIPTION							
CR101	211236	DIODE	SILICO	007				DANA	211236
CR102	211236	DIODE	SILICO	007				DANA	211236
CR103	221177	DIODE	SILICO ZENER			1/4 W	1	MOTOROLA	M.2.4A25
CR104	221177	DIODE	SILICO ZENER			1/4 W	1	MOTOROLA	M.2.4A25
CR105	211083	DIODE	SILICO	018			1	DANA	211083
CR106	211083	DIODE	SILICO	018			1	DANA	211083
CR107	211083	DIODE	SILICO	018			1	DANA	211083
CR109	220015	DIODE	SILICO ZENER	1N967B				MOTOROLA	1N967B
CR110	220015	DIODE	SILICO ZENER	1N967B				MOTOROLA	1N967B
CR111	211083	DIODE	SILICO	018			1	DANA	211083
CR112	211083	DIODE	SILICO	018			1	DANA	211083
C101	120007	CAP	MYLAR	.22	MFD	600 V	20%	ELEC CUBE	210B1F224
C102	120197	CAP	POLYS	20	PFD	1000 V		DUCATI	20-1000
C103	130054	CAP	CERAM	1-5	PFD		10%	AMPREX	C010KA/5E
C104	120218	CAP	POLYS	FSV				DANA	120218
C105	120161	CAP	POLYS	.047	MFD	63 V	2.5%	DIEL	N100
C106	120162	CAP	POLYS	.0044	MFD	63 V	2.5%	MIAL	611.2D
C107	120142	CAP	POLYS	FSV				DANA	120142
C108	130055	CAP	CERAM	5-60	PFD		10%	AMPREX	C010MA/60E
C109	120158	CAP	POLYS	390	PFD	63 V	5%	MIAL	611
C110	130055	CAP	CERAM	5-60	PFD		10%	AMPREX	C010MA/60E
C111	120034	CAP	POLYS	100	PFD	500 V	5%	CRL	CPR-100J
C112	130054	CAP	CERAM	1-5	PFD		10%	AMPREX	C010KA/5E
C113	120218	CAP	POLYS	FSV				DANA	120218
C114	120198	CAP	POLYS	12	PFD	500 V	20%	MALLORY	SX412

PARTS LIST

ASSEMBLY 403214 PCB Assembly, AC Converter

REF. DESIG.	PART NO.	DESCRIPTION							
C115	111148	CAP	ELECT	100 MFD	25 V	20%1		SPRAGUE	TE1211
C116	110047	CAP	ELECT	50 MFD	50 V	20%		DUCATI	50-50
C117	110047	CAP	ELECT	50 MFD	50 V	20%		DUCATI	50-50
C118	121393	CAP	MYLAR	.22 MFD	100 V	10%		CDE	WMF1P22
C119	101145	CAP	CERAM	100 PFD	500 V	10%1		AEROVOX	SCD1X5F
C120	100008	CAP	CERAM	82 PFD	500 V	10%		AEROVOX	TCD-N750
C121	101145	CAP	CERAM	100 PFD	500 V	10%1		AEROVOX	SCD1X5F
C122	110005	CAP	TANTA	10 MFD	50 V	10%1		SEMCOR	TSW1K-50-10
C125	110022	CAP	TANTA	3.3 MFD	35 V	10%1		KEMET	K33C35K
C126	110022	CAP	TANTA	3.3 MFD	35 V	10%1		KEMET	K33C35K
K101	310035	RELAY	REED	SPST	24V			AZTEC	LIA24-S1
K102	310035	RELAY	REED	SPST	24V			AZTEC	LIA24-S1
K103	310036	RELAY	REED					ELEC-TROL	R2096-3
Q101	200085	TRANS		MPF103				MOTOROLA	MPF103
Q102	200022	TRANS	SILICO PNP	012				DANA	200022
Q103	200052	TRANS	SILICO PNP	009				DANA	200052
Q105	200043	TRANS	SILICO NPN	2N3565				FAIRCHILD	2N3565
Q106	200043	TRANS	SILICO NPN	2N3565				FAIRCHILD	2N3565
Q107	200043	TRANS	SILICO NPN	2N3565				FAIRCHILD	2N3565
Q108	200136	TRANS	SILICO NPN	SELECTED				DANA	200136
Q109	200136	TRANS	SILICO NPN	SELECTED				DANA	200136
Q110	200022	TRANS	SILICO PNP	012				DANA	200022
Q111	200043	TRANS	SILICO NPN	2N3565				FAIRCHILD	2N3565
Q112	200076	TRANS		2N4250				FAIRCHILD	2N4250
Q113	200052	TRANS	SILICO PNP	009				DANA	200052
R101	010356	RES	METAL	MATCH SET				DANA	010356
R102	010356	RES	METAL	MATCH SET				DANA	010356
R103	040046	RES	VARI	20 K		10%	1/4 W	BECKMAN	62PR20K
R104	000243	RES	CARBON	24 K		5%	1/4W1	OHMITE	RC07GF243J

PARTS LIST

ASSEMBLY 403214 PCB Assembly, AC Converter

REF. DESIG.	PART NO.	DESCRIPTION							
R105	040114	RES	VARI	50 K	10%		BECKMAN	62PR50
R106	010356	RES	METAL	MATCH SET			DANA	010356
R107	040115	RES	VARI	500 K	10%		BECKMAN	62PR500
R108	010356	RES	METAL	MATCH SET			DANA	010356
R109	010356	RES	METAL	MATCH SET			DANA	010356
R110	000201	RES	CARBON	200 OHM	5%	1/4 W1	OHMITE	RC07GF201J
R111	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R113	000332	RES	CARBON	3.3 K	5%	1/4 W1	OHMITE	RC07GF332J
R116	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R117	010321	RES	METAL	10 OHM	1%		ELECTRA	RN60D10R0F
R118	040110	RES	VARI	100 OHM			BBECKMAN	62PR100
R119	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R121	010356	RES	METAL	MATCH SET			DANA	010356
R124	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R125	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R126	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R127	000752	RES	CARBON	7.5 K	5%	1/4 W1	OHMITE	RC07GF752J
R128	000105	RES	CARBON	1 M	5%	1/4 W1	OHMITE	RC07GF105J
R131	000106	RES	CARBON	10 M	5%	1/4 W1	OHMITE	RC07GF106J
R132	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R133	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R136	000203	RES	CARBON	20 K	5%	1/4 W1	OHMITE	RC07GF203J
R137	010356	RES	METAL	MATCH SET			DANA	010356
R138	010356	RES	METAL	MATCH SET			DANA	010356
R139	000106	RES	CARBON	10 M	5%	1/4 W1	OHMITE	RC07GF106J
R140	000332	RES	CARBON	3.3 K	5%	1/4 W1	OHMITE	RC07GF332J
R141	000512	RES	CARBON	5.1 K	5%	1/4 W1	OHMITE	RC07GF512J
R142	000751	RES	CARBON	750 OHM	5%	1/4 W1	OHMITE	RC07GF751J
R143	000103	RES	CARBON	10 K	5%	1/4 W1	OHMITE	RC07GF103J
R144	001712	RES	CARBON	750 OHM	5%	1/2 W	OHMITE	RC20GF751J

PARTS LIST

ASSEMBLY 403214 PCB Assembly, AC Converter

REF. DESIG.	PART NO.	DESCRIPTION						
R146	001712	RES	CARBON	750 OHM	5%	1/2 W	OHMITE	RC20GF751J
R147	000332	RES	CARBON	3.3 K	5%	1/4 W1	OHMITE	RC07FG332J
R148	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R149	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R150	000332	RES	CARBON	3.3 K	5%	1/4 W1	OHMITE	RC07FG332J
R151	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R152	000331	RES	CARBON	330 OHM	5%	1/4 W1	OHMITE	RC07GF331J
R153	000331	RES	CARBON	330 OHM	5%	1/4 W1	OHMITE	RC07GF331J
R157	010356	RES	METAL	MATCH SET			DANA	010356
R160	010060	RES	METAL	10 K	1%	1/4 W	ELECTRA	RN60D1002F
R161	010356	RES	METAL	MATCH SET			DANA	010356
R162	010060	RES	METAL	10 K	1%	1/4 W	ELECTRA	RN60D1002F

PARTS LIST

ASSEMBLY 402581 AC & OHMS CONVERTER A

REF. DESIG.	PART NO.	DESCRIPTION					
CR101	211236	DIODE SILICO		007		DANA	211236
CR102	211236	DIODE SILICO		007		DANA	211236
CR103	221177	DIODE SILICO	ZENER		1/4 W1	MOTOROLA	M.2.4A25
CR104	221177	DIODE SILICO	ZENER		1/4 W1	MOTOROLA	M.2.4A25
CR105	211083	DIODE SILICO		018	1	DANA	211083
CR106	211083	DIODE SILICO		018	1	DANA	211083
CR107	211083	DIODE SILICO		018	1	DANA	211083
CR108	211083	DIODE SILICO		018	1	DANA	211083
CR109	220015	DIODE SILICO	ZENER	1N967B		MOTOROLA	1N967B
CR110	220015	DIODE SILICO	ZENER	1N967B		MOTOROLA	1N967B
CR111	211083	DIODE SILICO		018	1	DANA	211083
CR112	211083	DIODE SILICO		018	1	DANA	211083
CR113	221177	DIODE SILICO	ZENER		1/4 W1	MOTOROLA	M.2.4A25
CR114	221177	DIODE SILICO	ZENER		1/4 W1	MOTOROLA	M.2.4A25
CR115	221177	DIODE SILICO	ZENER		1/4 W1	MOTOROLA	M.2.4A25
C 101	120007	CAP	MYLAR	.22 MFD 600 V	20%	ELEC CUBE	210B1F224
C 102	120197	CAP	POLYS	20 PFD1000 V		DUCATI	20-1000
C 103	130054	CAP	CERAM	1-5 PFD	10%	AMPREX	C010KA/5E
C 104	120218	CAP	POLYS	FSV		DANA	120218
C 105	120161	CAP	POLYS	.047 MFD 63 V	2.5%	DIEL	N100
C106	120162	CAP	POLYS	.0044 MFD 63 V	2.5%	MIAL	611.2D
C107	120142	CAP	POLYS	FSV		DANA	120142
C108	130055	CAP	CERAM	5-60 PFD	10%	AMPREX	C010MA/60E
C109	120158	CAP	POLYS	390 PFD 63 V	5%	MIAL	611
C110	130055	CAP	CERAM	5-60 PFD	10%	AMPREX	C010MA/60E
C111	120034	CAP	POLYS	100 PFD 500 V	5%	CRL	CPR-100J
C112	130054	CAP	CERAM	1-5 PFD	10%	AMPREX	C010KA/5E
C113	120218	CAP	POLYS	FSV		DANA	120218
C114	120198	CAP	POLYS	12 PFD 500 V	20%	MALLORY	SX412
C115	111148	CAP	ELECT	100 MFD 25 V	20%1	SPRAGUE	TE1211
C116	110047	CAP	ELECT	50 MFD 50 V	20%	DUCATI	50-50
C117	110047	CAP	ELECT	50 MFD 50 V	20%	DUCATI	50-50
C118	121393	CAP	MYLAR	.22 MFD 100 V	10%	CDE	WMF1P22
C119	101145	CAP	CERAM	100 PFD 500 V	10%1	AEROVOX	SCD1X5F
C120	100008	CAP	CERAM	82 PFD 500 V	10%	AEROVOX	TCD-N750
C121	101145	CAP	CERAM	100 PFD 500 V	10%1	AEROVOX	SCD1X5F
C122	110005	CAP	TANTA	10 MFD 50 V	10%1	SEMCOR	TSW1K-50-10
C123	121088	CAP	MYLAR	.01 MFD 100 V	10%	CDE	WMF1S1

PARTS LIST

ASSEMBLY 402581 AC & OHMS CONVERTER A

REF. DESIG.	PART NO.	DESCRIPTION							
C124	121146	CAP	MYLAR	.0047 MFD 100 V	10%1			CDE	WMF1D47
C125	110022	CAP	TANTA	3.3 MFD 35 V	10%1			KEMET	K33C35K
C126	110022	CAP	TANTA	3.3 MFD 35 V	10%1			KEMET	K33C35K
C127	121146	CAP	MYLAR	.0047 MFD 100 V	10%1			CDE	WMF1D47
K101	310036	RELAY REED						ELEC-TROL	R2096-3
K102	310035	RELAY REED		SPST 24V				AZTEC	LIA24-S1
K103	310035	RELAY REED		SPST 24V				AZTEC	LIA24-S1
K104	310036	RELAY REED						ELEC-TROL	R2096-3
K105	310036	RELAY REED						ELEC-TROL	R2096-3
K106	310035	RELAY REED		SPST 24V				AZTEC	LIA24-S1
K107	310035	RELAY REED		SPST 24V				AZTEC	LIA24-S1
M101	230026	INTEGRATED CIRCUIT MC709C						MOTOROLA	MC709C
Q101	200085	TRANS		MPF103				MOTOROLA	MPF103
Q102	200022	TRANS SILICO PNP		012				DANA	200022
Q103	200011	TRANS SILICO PNP		009				DANA	200011
Q104	200043	TRANS SILICO NPN		2N3565				FAIRCHILD	2N3565
Q105	200043	TRANS SILICO NPN		2N3565				FAIRCHILD	2N3565
Q106	200043	TRANS SILICO NPN		2N3565				FAIRCHILD	2N3565
Q107	200043	TRANS SILICO NPN		2N3565				FAIRCHILD	2N3565
Q108	200136	TRANS SILICO NPN		SELECTED				DANA	200136
Q109	200136	TRANS SILICO NPN		SELECTED				DANA	200136
Q110	200022	TRANS SILICO PNP		012				DANA	200022
Q111	200043	TRANS SILICO NPN		2N3565				FAIRCHILD	2N3565
Q112	200076	TRANS		2N4250				FAIRCHILD	2N4250
Q113	200011	TRANS SILICO PNP		009				DANA	200011
Q114	200035	TRANS SILICO NPN		014				DANA	200035
Q115	200043	TRANS SILICO NPN		2N3565				FAIRCHILD	2N3565
R101	010356	RES	METAL	MATCH SET				DANA	010356
R102	010356	RES	METAL	MATCH SET				DANA	010356
R103	040046	RES	VARI	20 K	10%	1/4 W		BECKMAN	62PR20K
R104	000243	RES	CARBON	24 K	5%	1/4 W		OHMITE	RC07GF243J
R105	040114	RES	VARI	50 K	10%			BECKMAN	62PR50
R106	010356	RES	METAL	MATCH SET				DANA	010356
R107	040115	RES	VARI	500 K	10%			BECKMAN	62PR500
R108	010356	RES	METAL	MATCH SET				DANA	010356
R109	010356	RES	METAL	MATCH SET				DANA	010356
R110	000201	RES	CARBON	200 OHM	5%	1/4 W1		OHMITE	RC07GF201J
R111	000104	RES	CARBON	100 K	5%	1/4 W1		OHMITE	RC07GF104J

PARTS LIST

ASSEMBLY 402581 AC & OHMS CONVERTER

REF. DESIG.	PART NO.	DESCRIPTION						
R 112	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R 113	000332	RES	CARBON	3.3 K	5%	1/4 W1	OHMITE	RC07GF332J
R 114	001737	RES	FSV		5%	1/4 W	DANA	001737
R 115	040159	RES	VARI	500 K		1/2 W	BECKMAN	62PR500K
R 116	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R 117	010321	RES	METAL	10 OHM	1%		ELECTRA	RN60D10R0F
R 118	040110	RES	VARI	100 OHM			BBECKMAN	62PR100
R 119	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R 120	020494	RES	WW	8.19 K	.1%		JORDAN	J11
R 121	010356	RES	METAL	MATCH SET			DANA	010356
R 122	020495	RES	WW	89.815 K	.1%		JORDAN	J11
R 123	040115	RES	VARI	500 K	10%		BECKMAN	62PR500
R 124	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R 125	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R 126	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R 127	000752	RES	CARBON	7.5 K	5%	1/4 W1	OHMITE	RC07GF752J
R 128	000105	RES	CARBON	1 M	5%	1/4 W1	OHMITE	RC07GF105J
R 129	020496	RES	WW	996.15 K	.1%		JORDAN	J11
R 130	040097	RES	VARI	5 K	10%		BECKMAN	62PR5K
R 131	000106	RES	CARBON	10 M	5%	1/4 W1	OHMITE	RC07GF106J
R 132	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R 133	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R 134	040104	RES	VARI	50 K			BECKMAN	62P
R 135	010357	RES	METAL	8.981 MEG	.1%		PYROFILM	PME 70 T2
R 136	000203	RES	CARBON	20 K	5%	1/4 W1	OHMITE	RC07GF203J
R 137	010356	RES	METAL	MATCH SET			DANA	010356
R 138	010356	RES	METAL	MATCH SET			DANA	010356
R 139	000106	RES	CARBON	10 M	5%	1/4 W1	OHMITE	RC07GF106J
R 140	000332	RES	CARBON	3.3 K	5%	1/4 W1	OHMITE	RC07GF332J
R 141	000512	RES	CARBON	5.1 K	5%	1/4 W1	OHMITE	RC07GF512J
R 142	000751	RES	CARBON	750 OHM	5%	1/4 W1	OHMITE	RC07GF751J
R 143	000103	RES	CARBON	10 K	5%	1/4 W1	OHMITE	RC07GF103J
R 144	001712	RES	CARBON	750 OHM	5%	1/2 W	OHMITE	RC20GF751J
R 145	000685	RES	CARBON	6.8 MEG	5%	1/4 W	OHMITE	RC07GF685J
R 146	001712	RES	CARBON	750 OHM	5%	1/2 W	OHMITE	RC20GF751J
R 147	000332	RES	CARBON	3.3 K	5%	1/4 W1	OHMITE	RC07GF332J
R 148	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R 149	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J

PARTS LIST

A

ASSEMBLY 402581 AC & OHMS CONVERTER

REF. DESIG.	PART NO.	DESCRIPTION							
R150	000332	RES	CARBON	3.3 K	5%	1/4 W1	OHMITE	RC07GF332J
R151	000101	RES	CARBON	100 OHM	5%	1/4 W1	OHMITE	RC07GF101J
R152	000331	RES	CARBON	330 OHM	5%	1/4 W1	OHMITE	RC07GF331J
R153	000331	RES	CARBON	330 OHM	5%	1/4 W1	OHMITE	RC07GF331J
R154	040088	RES	VARI	100 K	10%		BECKMAN	62PR100K
R155	001737	RES	FSV		5%	1/4 W	DANA	001737
R156	000152	RES	CARBON	1.5 K	5%	1/4 W1	OHMITE	RC07GF152J
R157	010356	RES	METAL	MATCH SET			DANA	010356
R158	000512	RES	CARBON	5.1 K	5%	1/4 W1	OHMITE	RC07GF512J
R159	000821	RES	CARBON	820 OHM	5%	1/4 W	OHMITE	RC07GF821J
R160	010141	RES	METAL	10 K	.25%	1/4 W	PYROFILM	PME6010
R161	010356	RES	METAL	MATCH SET			DANA	010356
R162	010141	RES	METAL	10 K	.25%	1/4 W	PYROFILM	PME6010
R163	000912	RES	CARBON	9.1 K	5%	1/4 W1	OHMITE	RC07GF912J
R164	020050	RES	WW	9.0 K	.01%	1/4 W1	KELVIN	EP-21
R165	021395	RES	WW	1 K	.01%	1/4 W	JORDAN	J-12

PARTS LIST

ASSEMBLY 403212 PCB Assembly, Printer Output A

REF. DESIG.	PART NO.	DESCRIPTION							
CR01	211083	DIODE SILICO		018		1		DANA	211083
CR02	220031	DIODE SILICO ZENER		1/4M3.3AZ5				MOTOROLA	1/4M3.3AZ5
CR03	211083	DIODE SILICO		018		1		DANA	211083
CR04	211083	DIODE SILICO		018		1		DANA	211083
CR05	211083	DIODE SILICO		018		1		DANA	211083
C01	100017	CAP	CERAM	.01 MFD	200 V	10%		SPRAGUE	TH-S10
C02	101145	CAP	CERAM	100 PFD	500 V	10%1		AEROVOX	SCD1X5F
C03	110071	CAP	ELECT	.1 MFD	35 V	10%		KEMET	K1W35K
C04	110071	CAP	ELECT	.1 MFD	35 V	10%		KEMET	K1W35K
M01	230024	INTEGRATED CIRCUIT		MC893P				MOTOROLA	MC893P
M02	230024	INTEGRATED CIRCUIT		MC893P				MOTOROLA	MC893P
M03	230019	INTEGRATED CIRCUIT		MC824P				MOTOROLA	MC824P
Q01	200037	TRANS SILICO NPN		2N3646				FAIRCHILD	2N3646
Q02	200037	TRANS SILICO NPN		2N3646				FAIRCHILD	2N3646
R01	000152	RES	CARBON	1.5 K		5%	1/4 W1	OHMITE	RC07GF152J
R02	000362	RES	CARBON	3.6 K		5%	1/4 W1	OHMITE	RC07GF362J
R03	000362	RES	CARBON	3.6 K		5%	1/4 W1	OHMITE	RC07GF362J
R04	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R05	000513	RES	CARBON	51 K		5%	1/4 W1	OHMITE	RC07GF513J
R06	000513	RES	CARBON	51 K		5%	1/4 W1	OHMITE	RC07GF513J
R07	000513	RES	CARBON	51 K		5%	1/4 W1	OHMITE	RC07GF513J
R08	000752	RES	CARBON	7.5 K		5%	1/4 W1	OHMITE	RC07GF752J
R09	000622	RES	CARBON	6.2 K		5%	1/4 W1	OHMITE	RC07GF622J
R10	000202	RES	CARBON	2 K		5%	1/4 W1	OHMITE	RC07GF202J
R11	000512	RES	CARBON	5.1 K		5%	1/4 W1	OHMITE	RC07GF512J
R12	000273	RES	CARBON	27 K		5%	1/4 W1	OHMITE	RC07GF273J
R13	001261	RES	CARBON	2 K		5%	1/2 W1	OHMITE	RC20GF202J
R14	000243	RES	CARBON	24 K		5%	1/4 W1	OHMITE	RC07GF243J
R15	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R16	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R17	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R18	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R19	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R20	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R21	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R22	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R23	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J
R24	000563	RES	CARBON	56 K		5%	1/4 W	OHMITE	RC07GF563J

ASSEMBLY 403212 PCB Assembly, Printer Output A

REF. DESIG.	PART NO.	DESCRIPTION						
R25	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J
R26	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J
R27	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J
R28	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J
R29	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J
R30	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J
R31	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J
R32	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J
R33	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J
R34	000563	RES	CARBON	56 K	5%	1/4 W	OHMITE	RC07GF563J