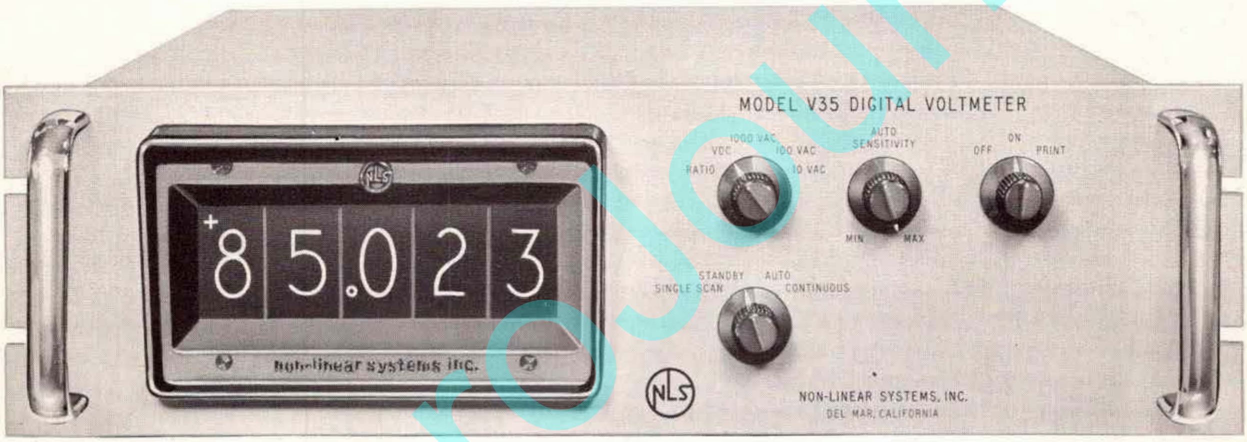
DIGITAL VOLTMETER
MODELS V34 AND V35



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Section 1
INTRODUCTION

The NLS V34 and V35 Digital Voltmeters are designed for users who demand a highly accurate, easily maintained instrument possessing a high order of reliability.

Although discussed in detail elsewhere in this handbook, the leading particulars of the V34 and V35 are summarized here, both to show how NLS has met user demand and to familiarize the reader with the instruments.

• **RELIABLE ACCURACY** Regardless of all the features that an instrument may possess, the most important single quality sought by our users is high reliability. In the V34 and V35 accuracy is achieved by a reliance upon the minimum of critical components. The accuracy of the instrument is *not* due to the careful maintenance of balance among selected parts, the failure of one of which could throw off the whole instrument. Instead, through careful design it has been possible to control only two factors to assure top accuracy – the zener reference supply, and the decade and range resistors (manufactured by NLS). Thus other components can operate across a fairly broad band of tolerance without upsetting the accuracy of the instrument. The area of critical components is reduced to a minimum; this is the basis for our claim of "reliable accuracy".

• **MODULAR CONSTRUCTION** Except for the power supply, all of the circuit components are on plug-in boards; thus it is possible to keep the V34 and V35 operative with a minimum of down time. What would otherwise be written off as hours spent in troubleshooting activity can now be listed as minutes spent in module replacement. This type of maintenance has had wide appeal among instrument users who demand that both trained and untrained personnel be able to service the instruments properly. We recognize that the digital voltmeter is often a small part of a large system in which the failure of any part can cause the failure of the whole system. It is for this reason, largely, that we have designed the V34 and V35 around a plug-in maintenance concept.

• **INDIVIDUAL PLUG-IN OIL BATH STEPPING SWITCHES** To further simplify maintenance and repair, the stepping switches are hermetically sealed and oil bathed so that the need for periodic lubrication is eliminated. Not only are all of the decade stepping switches interchangeable with each other, but their mechanical wear is held to a minimum because the logic system in the V34 and V35 eliminates considerable needless operation. Also, electrical wear is minimized because separate drive circuits are used, thus avoiding the necessity of passing high current through switch contacts. For these reasons the spares requirement is minimal; under typical conditions of use it will be found that only one decade switch spare and one transfer switch spare need be kept per instrument.

• **RAPID-ACTION LOGIC** The V34 and V35 employ the fastest possible logic which can be used with stepping switches. With the NLS system it has been possible to achieve a significant reduction in the number of steps required to complete a reading. This contributes not only to rapid readout but also to long life and reduced maintenance costs.

• **SNAP-IN READOUT ASSEMBLY** The plug-in concept applies also to the whole readout assembly. Lamps, Lucite panes, and contacts may be removed from the front of the instrument. There is no need to disturb wiring or other assemblies even if the DVM is mounted into a rack with other equipment. A burnt-out lamp may be replaced in a few moments without the use of any tools.

• **FULL ONE DIGIT RESOLUTION** The V34 (four digit) and V35 (five digit) have full resolution of the least significant digit. The V35, incidentally, is the first DVM developed with a factual fifth digit having full sensitivity.

• **AUTOMATIC RANGE AND POLARITY SELECTION** Operation of the V34 and V35 instruments is simplified by automatic range and polarity selection. The decimal point and polarity signs will properly adjust themselves regardless of input voltage. Beside this, the possibility of damage from having selected too low a range for measurement is eliminated. The user may indiscriminately apply an input of a very few millivolts, obtain his reading, and then apply up to 1000 volts and again obtain a reading without having to manipulate any controls on the DVM.

• **INSTANT VOLT-TO-RATIO CHANGE-OVER** The simple manipulation of a front-panel control permits rapid change from one mode of operation to another. No connections or disconnections need be made each time the instrument is to be shifted from one function to the other.

• **COMPACT, TRANSISTORIZED DESIGN** Since no vacuum tubes are used in the V34 and V35, a remarkably compact design has been achieved. By the use of solid-state devices throughout, it has been possible to build an instrument which takes only 5¼ inches of standard rack space.

• **STANDARD INSTRUMENT FULLY EQUIPPED** The V34 and V35 are supplied complete; there is no need for accessory equipment to allow the instruments to work with printers. Self-contained contact closures are provided to actuate external indicating or printing devices.

Our Engineering Department will be pleased to help you with specific application problems and, of course, we will gladly welcome your comments and suggestions.

SPECIFICATIONS

	MODEL V35 5 digits	MODEL V34 4 digits
ABSOLUTE DC MEASUREMENTS		
RANGES	±0.0001 to ±999.99 volts in steps of ±9.9999/99.999/999.99 volts	±.0001 to ±999.9 volts in steps of ±.9999/9.999/99.99/999.9 volts
ACCURACY	±0.01% of reading or ±1 digit	±1 digit
RESOLUTION	±1 digit	±1 digit
INPUT IMPEDANCE	10 megohms	10 megohms
DC VOLTAGE RATIO MEASUREMENTS		
RANGE	±00.001% to ±99.999%	±00.01% to ±99.99%
OVER-ALL ACCURACY	±0.005% or ±1 digit full scale	±0.01% full scale
INPUT IMPEDANCE (for signal)	10 megs or 1000 megs*	10 megs or 1000 megs*
INPUT IMPEDANCE (for reference)	50,000 ohms	50,000 ohms
EXTERNAL REFERENCE VOLTAGE	±10 volts	±1 volt
BALANCING TIME	2.3 seconds, maximum	1.9 seconds, maximum
RANGE CHANGING AND POLARITY INDICATION	Automatic	Automatic
POWER REQUIREMENTS	115 volts ± 10%, 60 CPS. 20 watts standby, 50 watts balancing.	
AC MEASUREMENTS	Use NLS 125C AC/DC Converter	
LOW LEVEL DC MEASUREMENTS	Use NLS 141 DC Preamplifier	
WEIGHT Net	45 pounds	45 pounds
Shipping	65 pounds	65 pounds
PAINT	Front Panel: light gray per MIL-E-15090B, Type 3, Class 1	
SIGNAL GROUND CONNECTION	On Series 30 instruments, the signal ground is not connected to the frame of the instrument.	

* 1000 megohms is obtained by disconnecting one internal wire.

Specifications are subject to change without notice

Section 2
INSTALLATION AND OPERATION

2-1 Connections

2-1.1 Primary Power Supplies: The V34 and V35 Digital Voltmeters operate on 105-125 volts, AC, 50-60 cps. If the DVM is to be used with a 230-volt alternating current source, the primary windings of the power transformer may be wired in series. See the main schematic for jumper connection coding when making this change.

NOTE

The AC power cord is polarized. Correct connection *must* be made with the power source. Despite the presence of a third grounding pin, there is no real assurance that the instrument will be correctly connected. It has been found that the power outlets in many installations are erroneously wired. To be certain that the power source is in agreement with the power and grounding requirements of the instrument, check Figure 2-1 against the power outlet.

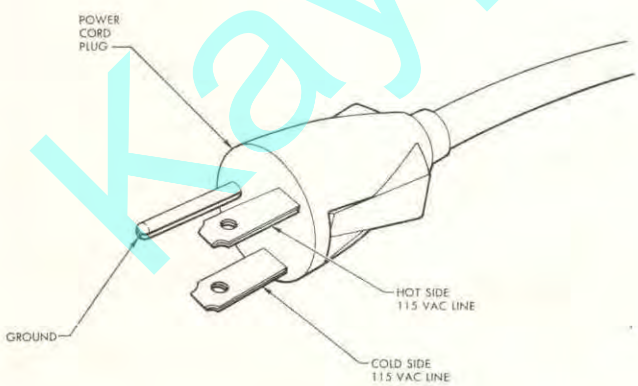


Figure 2-1. Power Plug Pin Coding.

Before connecting the instrument, see that it is protected with the correct fuse, as shown on the main board assembly schematic. The fuse is readily accessible at the rear panel and may be extracted for inspection.

While the instrument will give readings as soon as it is turned on, a 15-minute warm-up period is required for very accurate readings. To calibrate the DVM, a 30-minute warm-up is recommended. Once the DVM has been turned on, it may be left in STANDBY position for an indefinite period. This position keeps the instrument in readiness without imposing any wear upon relays or stepping switches.

2-1.2 Signal Input Connections: The signal input cable has three clips — red, black, and uninsulated. The red clip is always connected to the signal. The black clip is connected to the signal ground. The uninsulated clip, coming from the chassis of the DVM, is used *only* to tie the chassis of the DVM with the chassis of the device from which the input signal is derived. If the two chassis are already tied to the same ground, the uninsulated connector should not be used. A ground-loop effect may result if the two devices are grounded in separate places. Always observe proper grounding precautions to avoid ground loops and the resultant bias and ripple effects. When trouble develops, a measure of the potential difference between various signal and power grounds is often very revealing. In all cases, the impedance between signal and power grounds must be kept low.

For stable operation the input leads must be shielded to minimize electrical pickup. This is particularly important when the impedance of the source to be measured is high. Excessive electrical noise pickup can cause unstable readout and/or a bias (i.e., offset) effect in readings. If excessive electrical noise is present at the input terminals, external filtering may be beneficial although the series resistance of the filter can cause errors because of its voltage drop.

2-1.3 **External Reference Supply:** An external reference supply connector is provided on the back of the DVM when it is to be used as a ratiometer. Connect the red clip to the positive reference supply, the combination red and black clip to the negative reference supply, and the black clip to the reference common.

To measure positive and negative input voltages, the ratio-measuring circuits are connected as shown in Figure 2-3A & B. However, if your application requires measuring inputs of a single polarity, external reference A or external reference B can be eliminated. This is shown in Figure 2-3B. Note that when the input voltage is zero, or close to zero, the instrument may, if the signal is "noisy", display a polarity sign opposite to that of the reference voltage and read all nines. Use a "dummy" reference voltage in place of the eliminated reference voltage to permit a smooth transition in readings (rather than a jump to a reading of all nines) when close to zero. This connection provides much greater convenience when using the instrument to adjust the unknown voltage to zero. The dummy reference stability and value are unimportant if only the elimination of the sudden jump to a reading of all nines is desired. For this reason a single carbon-zinc or mercury cell may be used. If approximately correct readings are required of voltages whose polarity is opposite to that of the main reference supply, the dummy reference voltage should approximate the main reference voltage.

While the DVM is designed to use a ± 10 volt (V35) or ± 1 volt (V34) external DC reference supply, reference voltages up to ± 100 volts may be used by simply removing the jumper wire connected to the junction terminals of CR-610 and CR-611 on the amplifier board as shown on Figure 2-2 and the amplifier schematic. When used with voltages higher than ± 10 volts (V35) or higher than ± 1 volt (V34), the DVM may continuously recycle when in the AUTO mode until the AUTO SENSITIVITY CONTROL is moved toward its "minimum" setting. If the reference voltage is so high that the recycling does not stop, then the DVM should be operated in the SINGLE SCAN mode.

CAUTION

When the CR-610 to CR-611 jumper is removed, the chopper protection circuit is eliminated. The input and reference signals should never be allowed to exceed 100 volts without this jumper installed or the chopper may be damaged.

NOTE

The input attenuator is connected to provide a 10 megohm input impedance. However, when it is desired to make ratio measurements, or absolute measurements on the instrument's lowest voltage range (±9.999 volts for the V35, or ±.9999 volt for the V34), an input impedance of 1000 megohms is available by removing a jumper in the amplifier. This jumper is shown in the amplifier schematic and referenced in the schematic notes. The V34 or V35, however, will be disabled in two ways by this change:

1. The range multiplier becomes disabled and the DVM cannot read above its lowest range.
2. The NLS Model 125C AC to DC Converter cannot be used with this modification.

2-1.4 **AC-DC Converter Connection:** The Model 125C AC to DC Converter may be

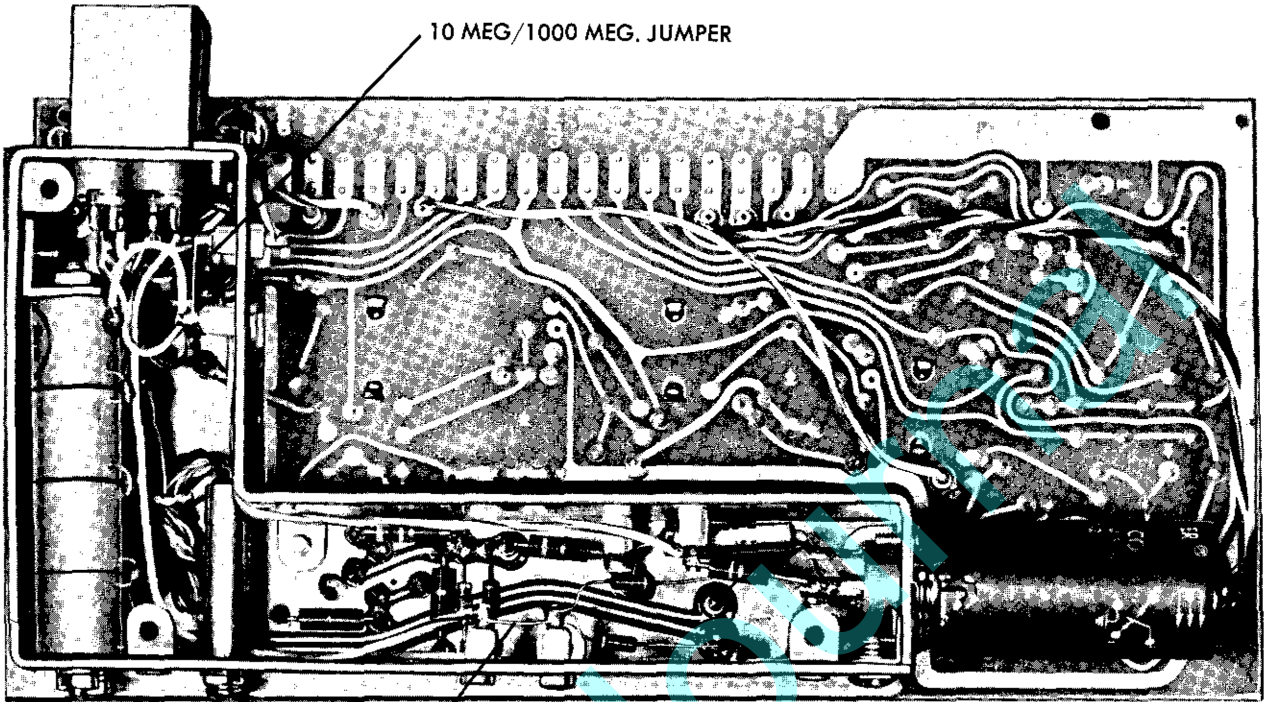


Figure 2-2. Amplifier Board Jumper Locations.

connected directly through a 34-pin plug at the rear of the DVM. This plug connection supplies switched AC power to the converter and connections to the AC range relays in the converter. Connect the signal input cable to the converter. The 3-wire interconnecting cable ties the output of the converter to the DVM. When the DVM is switched to volts DC or to RATIO, relays in the converter connect the signal input directly through to the DVM.

NOTE

If the converter is *not* used with the DVM, no special shorting plug will be needed in its place.

2-1.5 **Printer Connection:** A 75-pin plug at the rear of the DVM provides connection for use with a Clary printer, IBM typewriter, Flexo-writer, and other printing devices. All commons as well as all numbers, etc., are brought out to the 75-pin connector, so that either Clary or IBM printing may be used without internal print harness modification. The print command is normally wired for IBM. However, several jumper wires will have to be moved to provide the correct print command for Clary printer. Instructions for this modification are included on the main board schematic.

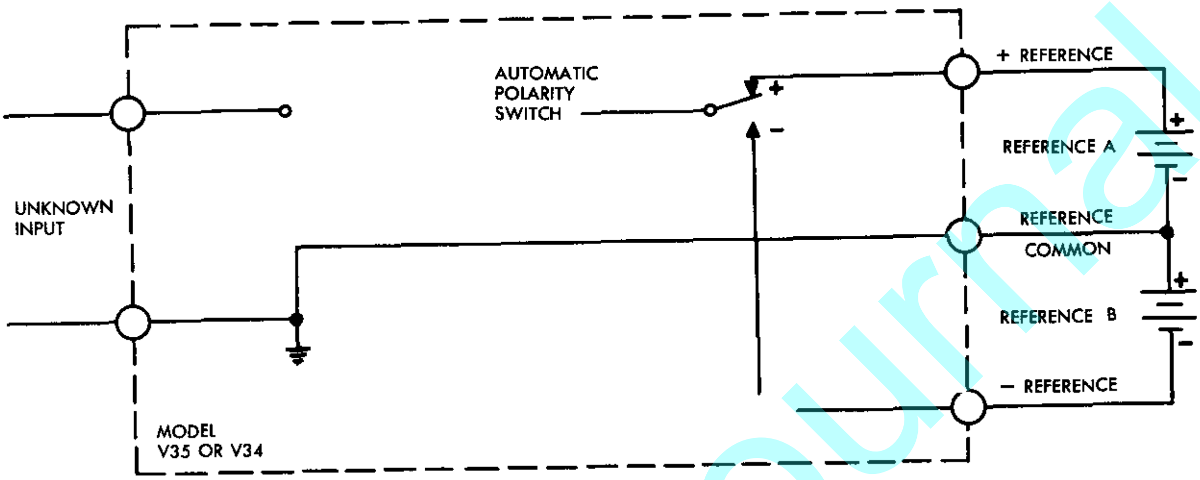


Figure 2-3A. External Reference Supply Connection . . . To Measure Positive and Negative Input Voltages.

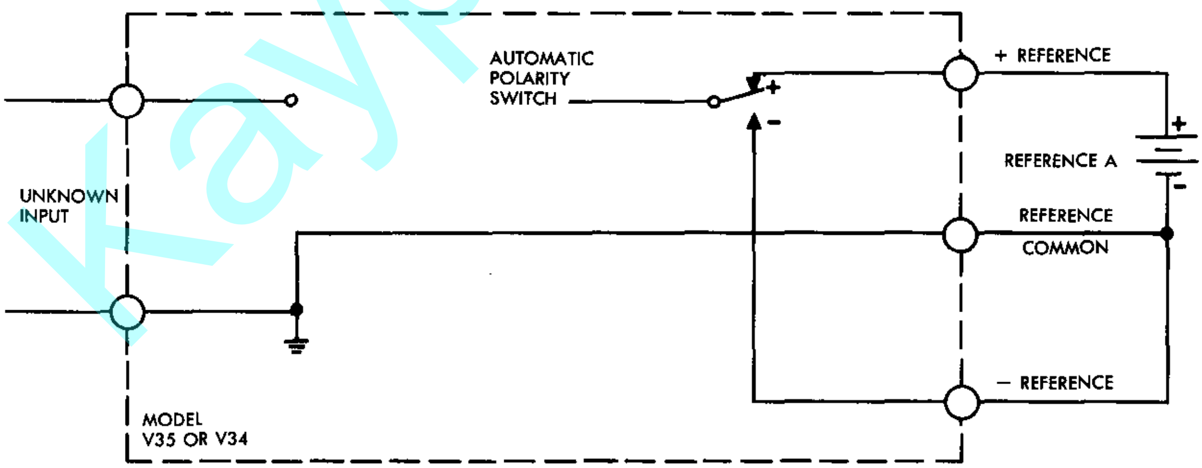


Figure 2-3B. External Reference Supply Connection . . . To Measure Input Voltages of a Single Polarity.

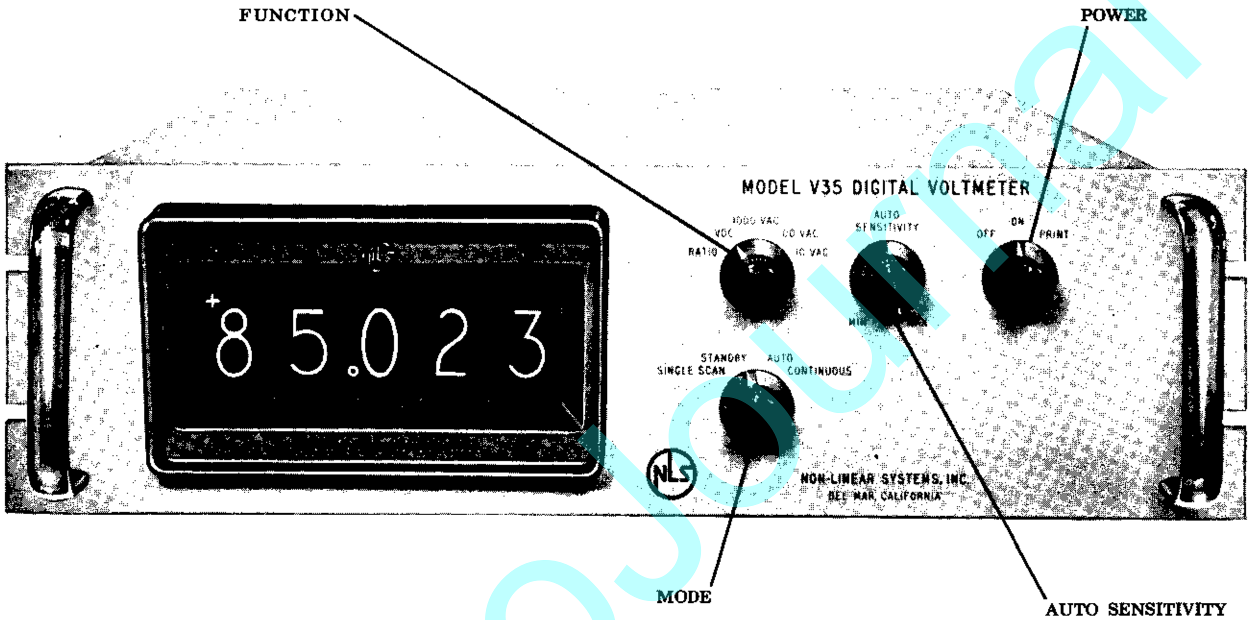


Figure 2-4. Front Panel Controls.

2-2 Controls:
The V34 and V35 Digital Voltmeters are controlled from the front panel. Figure 2-4 shows the position of each of the four controls. The following four subsections describe fully the function of each control.

Power Switch: The POWER switch has three positions:

1. OFF — At OFF the instrument is completely deenergized.

2. ON — At ON the instrument operates, but the print command is inhibited.

3. PRINT — The PRINT command is issued automatically at the end of each reading. This position is used when operating a Clary printer, IBM typewriter, Flexowriter, etc.

NOTE

If the instrument is turned on while the input leads are shorted, the readings may oscillate between positive and negative. This is normal. Opening the input leads will permit the instrument to complete its first scan and be ready for operation.

Function Switch: This control has the following positions:

1. RATIO — For use with an external reference supply.

2. VDC — For measuring DC voltage. Automatic range and polarity selection are built into the DVM.

3. AC — There are three AC positions: 1000, 100, and 10 volt ranges. These settings are used with the Model 125C AC to DC Converter.

Mode Switch: This control offers an unusual flexibility of action. It has the following positions:

1. SINGLE SCAN — In this position the DVM makes a single voltage measurement and locks the readout.

2. STANDBY — This position keeps the instrument warm while avoiding needless wear of stepping switches and relays. It also permits the readout to be locked in order to preserve a particular reading.

3. AUTO — This is the most commonly used position. In the AUTO position the DVM scans whenever there is a variation in the signal input amplitude, but the DVM does not scan when the input is stable. The change necessary to initiate a new scan is controlled by the AUTO SENSITIVITY control.

4. CONTINUOUS — In this position the instrument continually scans whether or not the signal input amplitude shows any variation. This position is normally used when the DVM is being used with a printer-scanner system.

Auto Sensitivity Control: This control changes the amount of voltage needed to cause the instrument to scan automatically in the AUTO mode; it can be adjusted from plus or minus one digit to plus or minus ten digits. Note that this control just sets the voltage difference level at which recycling will occur in the AUTO mode; it does not affect the stability of readings of varying voltages in the SINGLE SCAN mode and it does not reduce the resolution during any measurement. Thus, despite minor variations in signal amplitude, the DVM will maintain a stable readout but give a quick and accurate reading if the signal varies by a predetermined amount.

When the AUTO SENSITIVITY control is set at MAXIMUM with the MODE switch at AUTO, the instrument may change readings in two-digit rather than one-digit steps. This characteristic has been built into the instrument so as to avoid continuous recycling of the reading when the input voltage is "between digits" (e.g., an input of 9.86725, and a reading of 9.8672 or 9.8673) in the AUTO mode. Full one-digit resolution always occurs when the instrument actually makes a measurement in the AUTO mode because the AUTO SENSITIVITY control only affects the level at which the instrument *recycles;* it does not affect the sensitivity during the *measuring* process. Full one-digit resolution is also obtained when the MODE switch is in the SINGLE SCAN or CONTINUOUS position.

2-3 Operation with Data Recorders

When the POWER switch is set to PRINT, the instrument's recycling is as described under MODE switch (Section 2-2) with the following exceptions:

1. A PRINT command pulse is issued to command data printing at the end of each reading.

2. The instrument's reading remains locked (regardless of MODE switch position) until the data printer issues a momentary Form "C" contact transfer ("Print Complete" signal) to the DVM. Upon completion of the contact transfer, the instrument reads and prints again when in CONTINUOUS mode; when in AUTO mode, it reads and prints again when the input changes from the previous value.

2-4 External Control of Scan

A remote Form "C" contact may be used for controlled manual scanning by means of a push button, foot pedal, or the like. Connection is made to pins 76, 79, and 80 of J-117, as shown on the main board assembly schematic. When used in this way, the POWER switch is set at PRINT and the "Print Complete" lines are removed from the data recorder for which the manual control connections are made, as described in the preceding sentence. Essentially, operation will be the same as with a data recorder except that a relay or switch controls the DVM recycling. Contact transfer should be made only upon completion of a reading.

Section 3
CALIBRATION

While the V34 and the V35 are, on the whole, similar instruments, the calibration procedure for each is slightly different. To calibrate either instrument the following items, or their equivalents, will be required:

1. Two voltage dividers; one with 10:1 ratio, the other with 100:1 ratio; each divider calibrated for a 10 megohm load; each divider at least .005% accurate.
2. Stable, but not necessarily accurate, DC sources of 9 to 9.999, 90 to 99.99, and 900 to 999.9 volts.
3. Stable and accurate to .005% (or better) DC source of between 9 and 9.9999 volts. Ordinarily, 9 standard cells in series will meet this requirement. With this arrangement, 9.1656 volts is typical.

To prepare the instrument for calibration, allow it to warm up for 30 minutes and remove the top cover. The V34 and V35 tables which follow, along with their notes, give all of the necessary information. It is important to follow the steps in the sequence listed. The physical location of each adjustment potentiometer is shown in Figure 3-1.

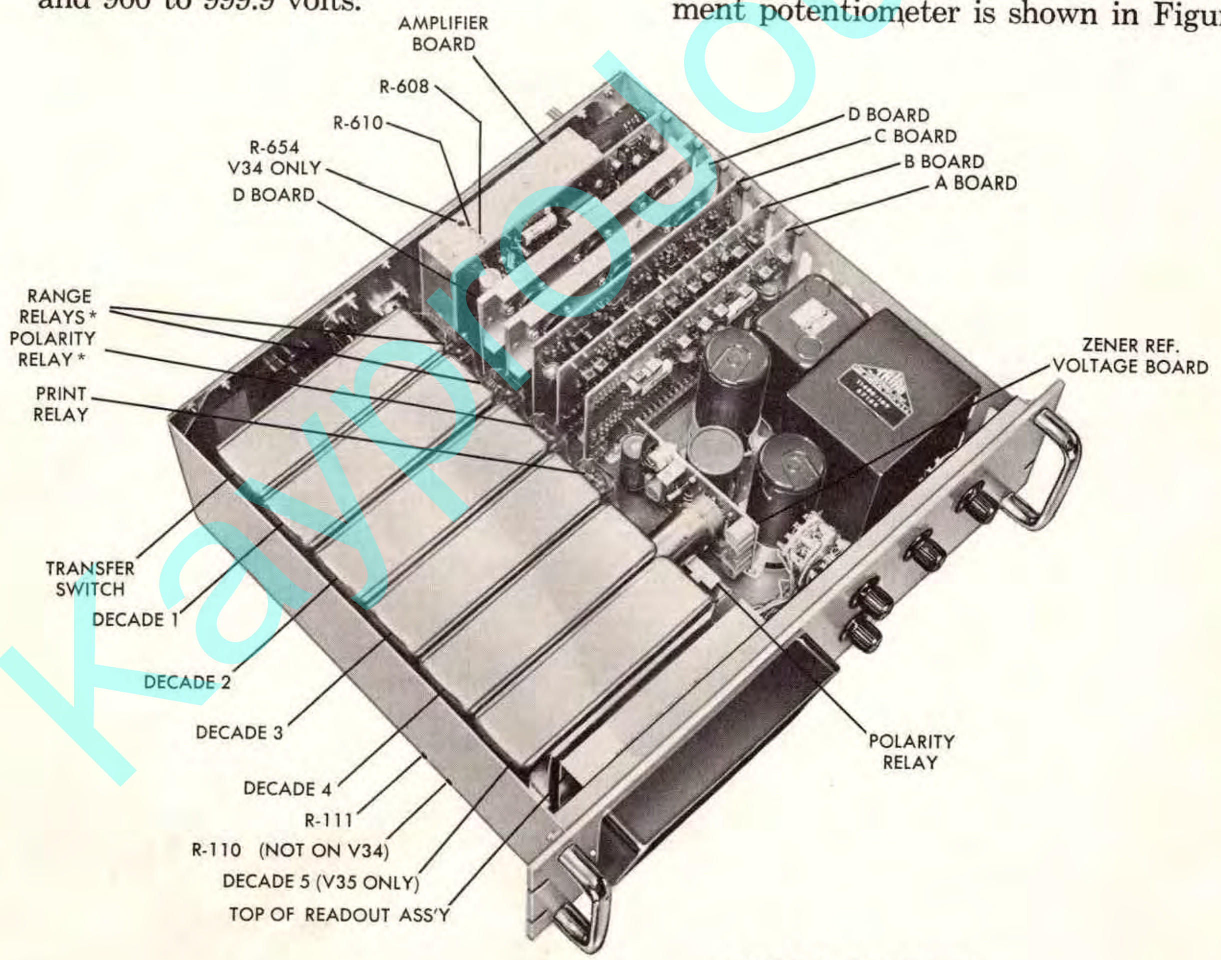


Figure 3-1. Calibration Adjustment Points and Plug-In Component Identification.

V34 Calibration Steps

Step No.	Source[1]	Ratio[2]	Readout Display[3]	Adjustment	Purpose
1R	+9 V	10 : 1	.9 V		
2	+9 V	1 : 1	9 V	R-608	
3	−9 V	10 : 1	.9 V		
4	−9 V	1 : 1	9 V	R-608	
5R	+90 V	10 : 1	9 V		
6	+90 V	1 : 1	90 V	R-610	
7	−90 V	10 : 1	9 V		Ranging
8	−90 V	1 : 1	90 V	R-610	
9R	+900 V	100 : 1	9 V		
10	+900 V	1 : 1	900 V	R-654	
11	−900 V	100 : 1	9 V		
12	−900 V	1 : 1	900 V	R-654	
13	+9 V		9 V	R-111	Absolute
14	−9 V		9 V	R-111	Accuracy

V35 Calibration Steps

Step No.	Source[1]	Ratio[2]	Readout Display[3]	Adjustment	Purpose
1R	+90 V	10 : 1	9 V		
2	+90 V	1 : 1	90 V	R-608	
3	−90 V	10 : 1	9 V		
4	−90 V	1 : 1	90 V	R-608	
5R	+900 V	100 : 1	9 V		Ranging
6	+900 V	1 : 1	900 V	R-610	
7	−900 V	100 : 1	9 V		
8	−900 V	1 : 1	900 V	R-610	
9	+9 V		9 V	R-111 (coarse)	Absolute
10	−9 V		9 V	R-110 (fine)	Accuracy

Notes to Calibration Tables:

1. The voltage source indicated is not exactly at the voltage listed but is within the range shown under Item 2 in the first paragraph of this Section. Item 3 covers the Absolute Accuracy source requirement.
2. The 1:1 ratios indicated are to be obtained with the voltage divider connected so that the 10 megohm load is constant for all adjustments.
3. The readout in Steps 1 through 4 must have digital correspondence (without regard for decimal point position) within specifications. The same requirement also applies to Steps 5 through 8, and in the V34 to Steps 9 through 12 as well. "R" in the Step No. column means Record the reading at that point. In each case the 3 following steps must show correspondence.

Section 4
THEORY OF OPERATION

4-1 Basic Theory

The NLS Series 30 Digital Voltmeters (Models V34 and V35) are basically closed looped servos in which a feedback voltage is driven to equal an unknown input voltage. The value of this feedback voltage is then displayed on the digital readout.

The Models V34 and V35 are essentially of the same design with only minor differences. This section describes the Model V35. Where differences exist, they are described.

Figure 4-1 is a block diagram of the DVM. The unknown input voltage is fed through the input attenuator to one side of a non-shorting chopper. The feedback voltage is fed to the other side of the chopper. The output of the chopper is fed to the error amplifier which compares the input with the feedback and produces one of three outputs: U, an up pulse (signal more positive than the feedback), D, a down pulse (signal more negative than the feedback), or $\overline{UD}$, no U or D pulse (signal equal to the feedback). These three pulse lines are fed to the digital logic circuits. The timing generator drives the chopper and controls the timing of the digital logic circuits.

The transfer switch is the heart of the scan logic used in the DVM. It routes the output pulses from the digital logic circuits to the proper stepping switch in the Kelvin-Varley bridge (or to the range attenuator relays) and selects the proper output from the Kelvin-Varley bridge to be used as the feedback voltage. The novel scan logic used in this DVM utilizes the normal output of the Kelvin-Varley bridge, as well as other outputs from various points in the bridge.

The Kelvin-Varley bridge is fed by a precision reference voltage supply. The output voltage of this supply is very closely controlled by a stable, low-temperature-coefficient zener diode mounted in a crystal oven.

The input attenuator divides the signal by 1:1, 10:1, 100:1, and in the V34, 1000:1. The input attenuator also controls the position of the decimal point in the digital readout.

4-2 The Kelvin-Varley Bridge and Scan Logic. Figure 4-2 is a simplified schematic of the stepping-switch-controlled Kelvin-Varley bridge and the transfer switch circuitry.

The Kelvin-Varley bridge is a decade voltage divider, each decade having two outputs and two inputs. Each decade is identical and is composed of one 12.5kΩ and eleven 5kΩ precision resistors and a stepping switch, all contained in a plug-in oil bath can. The switch is so wired that two adjacent 5kΩ resistors are always paralleled by 10kΩ of resistance (12.5kΩ in parallel with the 50kΩ input resistance of the following decade). Thus the resulting input resistance is 50kΩ and the output voltage across the two resistors is one-tenth of the input voltage. In addition, this voltage may be positioned at any 10% increment of the input voltage. Each decade therefore, has a low and a high input and a low and a high output. Shown below in tabular form are the various output voltages for a low input of 0 volts and a high input of 10 volts. Two additional levels on the stepping switch provide data to the readout and to the external printer connector.

Digit Displayed In Readout	Low Output Voltage	High-Output Voltage
0	0	1
1	1	2
2	2	3
3	3	4

Digit Displayed In Readout	Low Output Voltage	High-Output Voltage
4	4	5
5	5	6
6	6	7
7	7	8
8	8	9
9	9	10

As shown in Figure 4-2, the decades are so connected that each decade floats on the output of the preceding decade, dividing in turn the input voltage by ten. If each decade is adjusted in sequence to bracket the signal, starting with Decade 5 and proceeding through to Decade 1, each approximation will be more accurate, resulting in a final accuracy of five decimal digits in the V35 or

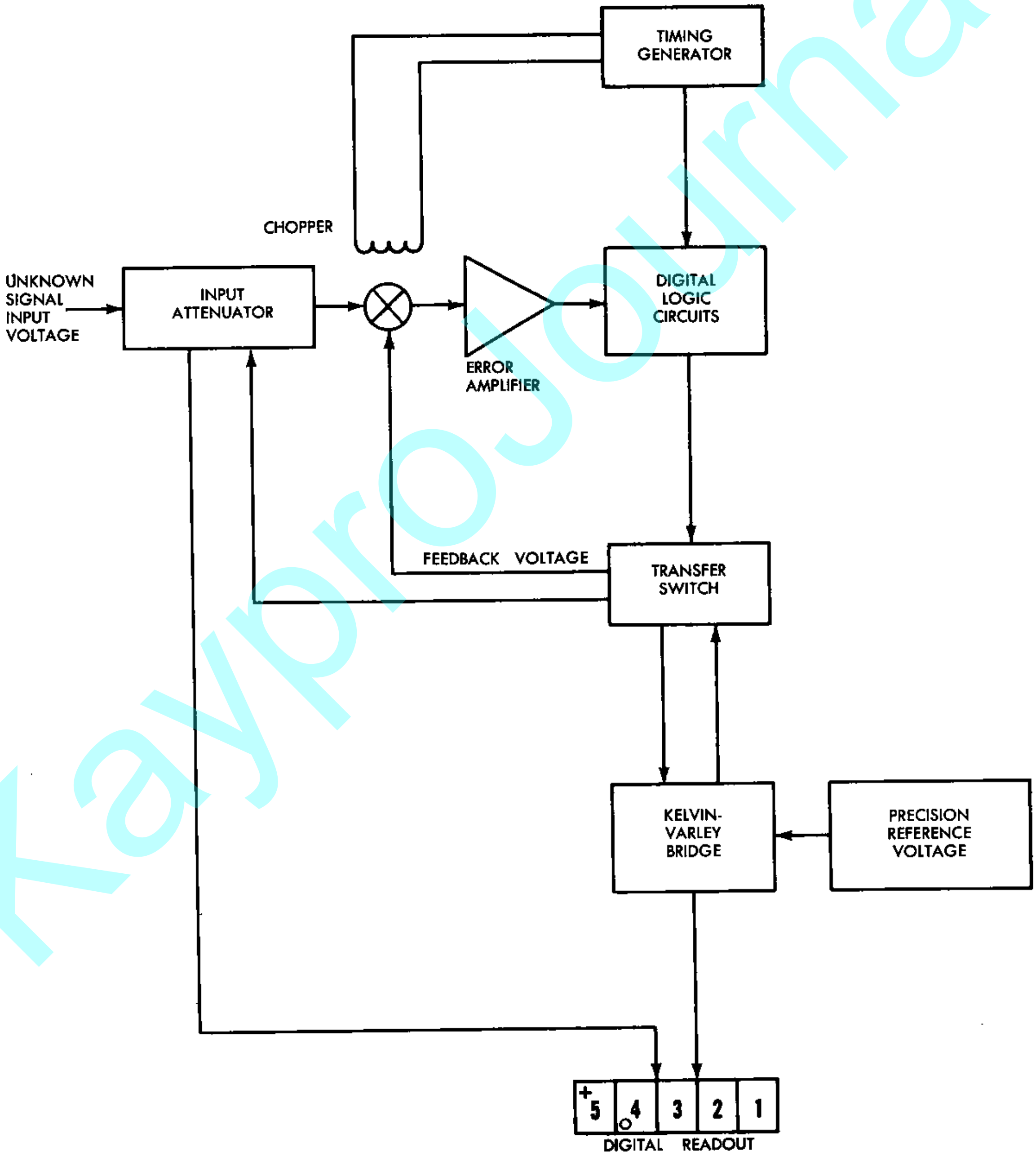


Figure 4-1. Block Diagram of V34 and V35.

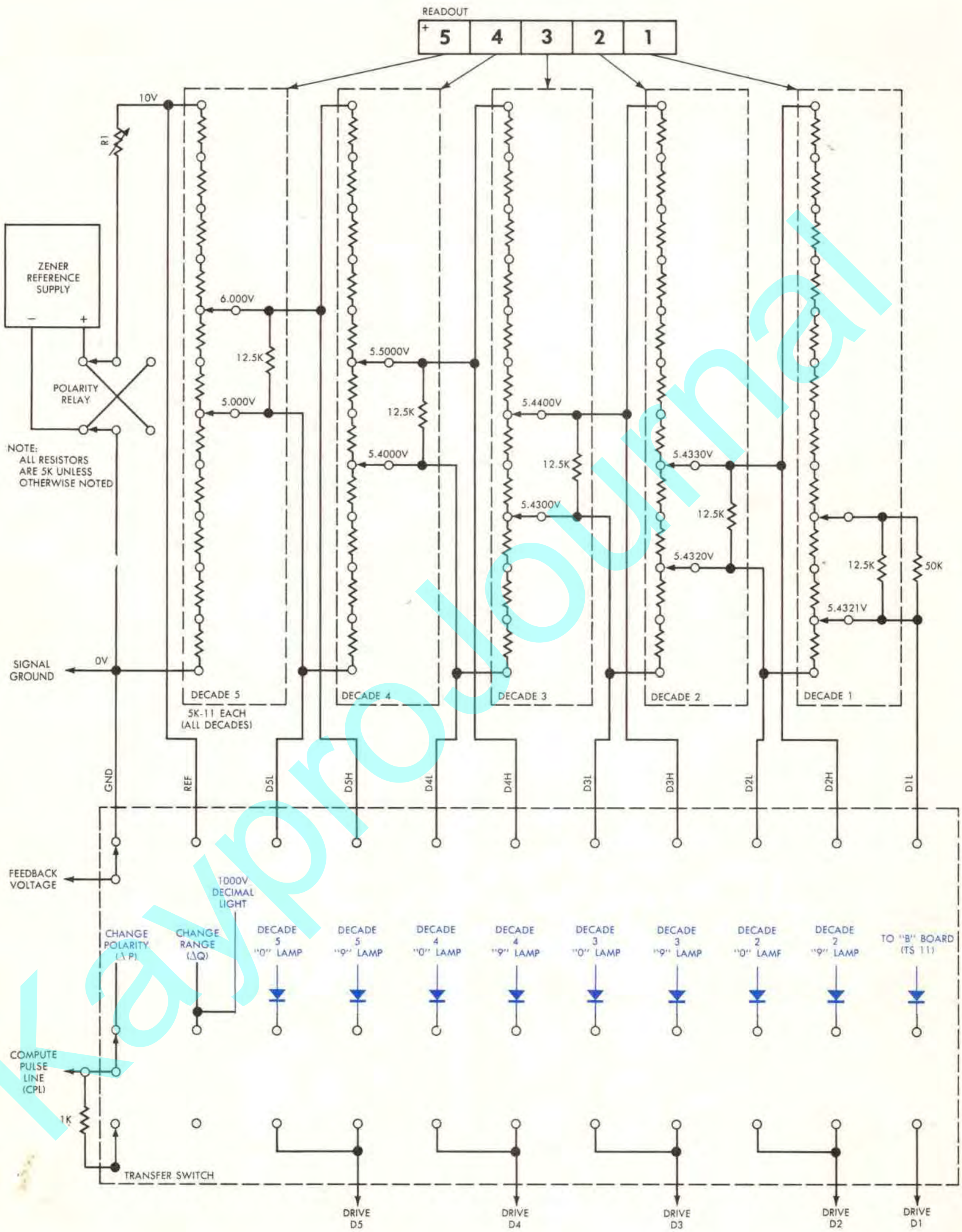


Figure 4-2. Stepping Switch, Kelvin-Varley Bridge, and Transfer Switch Circuitry.

four digits in a V34. In these two instruments the transfer switch scans the outputs of each decade in proper sequence. One level of the switch selects the feedback and the other two levels route the drive pulse to the correct stepping switch coil. The outputs of the error amplifier, in conjunction with the logic circuits, drive each decade so that the two outputs bracket the signal. Note that the error amplifier must not load the bridge or errors will result.

Figure 4-2 shows the zener reference supply feeding through the polarity relay and the calibrating resistor R_1 to the bridge. R_1 is adjusted so that the input voltage to the bridge (REF) is exactly 10 volts. The $50k^{\Omega}$ resistor on the output of the bridge is added to properly load Decade 1. Note that only the low output of Decade 1 is used since it is the final output of the bridge, and bracketing is not necessary.

To determine whether a particular decade is positioned correctly or must be changed, the logic circuits require three sources of information: amplifier output, polarity, and transfer switch position. Polarity information is necessary since the amplifier output determines only whether the signal is more positive or negative than the feedback, not whether it is greater or smaller. Exact transfer switch position data is not utilized since the logic is the same for every other position of the transfer switch. The odd-even flip-flop is used to supply this information to the logic circuits. This flip-flop changes state each time the transfer switch moves.

The timing generator controls both the chopper drive and the stepping switch drive. Each sample of the chopper will generate a pulse out of the amplifier, U, D, or $\overline{UD}$ on one of three pulse lines. For each amplifier pulse, one stepping switch drive pulse is generated.

Stepping switches operate in the following manner: A pulse energizes the switch coil which, in turn, cocks a spring, without moving the switch. At the end of the pulse, the spring moves the switch. Thus the switch moves only one step for each pulse. Because of this, a pulse may be routed to the coil of a stepping switch through its own contacts since the switch does not move during the pulse. This characteristic is utilized without the need for passing high-current pulses through the contacts since each stepping switch has its own power amplifier.

The output of the logic circuits is the Compute Pulse Line (CPL). If conditions call for changing a particular decade, a pulse will occur on this line. This is called CP and is "read": Compute Pulse. This pulse is routed through the transfer switch to the power amplifier associated with the proper decade switch, and the decade switch will move one step. If a pulse does not occur on CPL, the transfer switch will move one step. This is called $\overline{CP}$ and is "read": No Compute Pulse.

In order for a particular decade to be properly positioned, two conditions must exist: the low output must be equal to or less than the signal, and the high output must be greater than the signal. When scanning, the transfer switch first connects the low output of a decade to the feedback. If the low output is not equal to or less than the signal, CP's will occur and the decade switch will be driven one step at a time until the required condition is met. Since the switch moves in one direction "0" to "9," the switch will move up to "9" and on the next step will go to "0." At this point, the feedback should be equal to or less than the signal. As a result, CP's will stop, producing $\overline{CP}$, and the transfer switch moves to the high output position. If the feedback is not equal to or less than the signal when the decade has reached "0" (due to the signal changing or some previous error), the logic circuits will generate a CP. This could cause the decade to step continuously if it were not for the transfer switch connecting a diode from the "0" readout light to CPL. When the decade switch gets to the

"0" position, the diode conducts, shorting any CP's to ground, resulting in $\overline{CP}$, and the transfer switch moves on to the next position; the scan is completed, and the error is corrected on the next scan.

When the transfer switch connects the high output of a decade to the feedback, CP's are generated unless the feedback is greater than the signal. If the feedback should equal the signal at this point, a CP must be generated since an exact null cannot be reached unless the decade switch is advanced one more step. (Example: a 6.0000 volt signal cannot be nulled with Decade 5 in the "5" position.) If CP's still exist when the decade reaches the "9" position, they are shorted to ground by a diode connected to the "9" light through the transfer switch resulting in $\overline{CP}$. As before, this prevents the decade from continually stepping, never reaching a null.

Automatic polarity and ranging are accomplished by relays. Two relays are used for polarity, one to switch the zener reference supply, and one to provide the readout and print data. Four relays are used for ranging, two to switch the input attenuator, and two to provide readout and print data. All of the relays are connected as flip-flop loads. The range relays are driven by two commutatively coupled flip-flops, which can provide four ranges. (Four ranges are used in the V34, but only three ranges are used in the V35.) At the start of each scan, the range flip-flops are set, putting the DVM into the lowest range. If a higher range is necessary to null the signal, CP's will step the range attenuator one range at a time, until the proper range is reached.

Figure 4-3 presents in tabular form the logic of the V34 and V35 instruments. In conjunction with Figure 4-2, several of the symbols used on the schematics are explained. The "A" flip-flop referred to is zero for all positions of the transfer switch except position 11 (D1L) and is set when the transfer switch moves into position 11. The flip-flop is zeroed at the beginning of each scan when the transfer switch moves from position 11 to position 1 (GND). Since the high output of Decade 1 is not used as a feedback, the logic for Decade 1 is slightly different from that of the other decades. The "A" flip-flop "informs" the logic circuits that the transfer switch is in position 11.

At the start of a scan, the range flip-flops are set to the lowest range condition, and the transfer switch is moved from position 11 to position 1. The first test is for polarity. The feedback is ground (GND), the odd-even flip-flop is odd (OE), CPL is connected to ΔP, and the "A" flip-flop is zero. If the signal is positive, the amplifier output will be a U pulse, and if negative, the output will be a D pulse. If the polarity relay is in the positive position and a D pulse occurs, the polarity is incorrect and must be changed. In this event, the logic causes a CP pulse to occur, and the polarity is changed. At the next sampling time, the polarity will be correct; $\overline{CP}$ will occur, and the transfer switch will move to position 2 (REF). Conversely, a CP will be generated for the polarity relay in the negative position, and a positive signal (U pulse).

The second test is for range. The feedback is REF (input to the bridge), the odd-even flip-flop is even ($\overline{OE}$), and CPL is connected to ΔQ. If the polarity is now positive and the signal is over 10 volts, a U pulse will occur, causing a CP which will change the range to the next higher range. CP's will continue, until the correct range is reached, at which point $\overline{CP}$ will occur and the transfer switch will move to position 3. Should the polarity relay be in the negative position, CP would be generated by D pulses. If, through some previous error, CP's should continue after the 1000-volt range is reached, they would be shorted to ground by the diode connected to the 1000-volt decimal light. Should the signal be exactly ± 10 (or ± 100) volts, (± 1, ± 10 or ± 100 volts for the V34) no U or D

LOGIC STEP	TRANSFER SWITCH POSITION	FEEDBACK	ODD-EVEN FLIP-FLOP	POLARITY	AMPLIFIER OUTPUT NECESSARY FOR A COMPUTE PULSE (CP)	COMPUTE PULSE WHEN NO UP OR DOWN PULSE? ($\overline{UD}$)	"A" FLIP-FLOP	COMPUTE PULSE LINE (CPL) CONNECTED TO:
1	1	Ground (GND)	Odd (OE)	Pos (P_A) Neg (P_B)	Down (D) Up (U)	No	Zero ($\overline{A}$)	Change Polarity (△ P)
2	2	Reference (REF)	Even ($\overline{OE}$)	Pos (P_A) Neg (P_B)	Up (U) Down (D)	Yes	Zero ($\overline{A}$)	Change Range (△ Q)
3	3	Decade 5 Low (D5L)	Odd (OE)	Pos (P_A) Neg (P_B)	Down (D) Up (U)	No	Zero ($\overline{A}$)	Decade 5 (D5)
4	4	Decade 5 High (D5H)	Even ($\overline{OE}$)	Pos (P_A) Neg (P_B)	Up (U) Down (D)	Yes	Zero ($\overline{A}$)	
5	5	Decade 4 Low (D4L)	Odd (OE)	Pos (P_A) Neg (P_B)	Down (D) Up (U)	No	Zero ($\overline{A}$)	Decade 4 (D4)
6	6	Decade 4 High (D4H)	Even ($\overline{OE}$)	Pos (P_A) Neg (P_B)	Up (U) Down (D)	Yes	Zero ($\overline{A}$)	
7	7	Decade 3 Low (D3L)	Odd (OE)	Pos (P_A) Neg (P_B)	Down (D) Up (U)	No	Zero ($\overline{A}$)	Decade 3 (D3)
8	8	Decade 3 High (D3H)	Even ($\overline{OE}$)	Pos (P_A) Neg (P_B)	Up (U) Down (D)	Yes	Zero ($\overline{A}$)	
9	9	Decade 2 Low (D2L)	Odd (OE)	Pos (P_A) Neg (P_B)	Down (D) Up (U)	No	Zero ($\overline{A}$)	Decade 2 (D2)
10	10	Decade 2 High (D2H)	Even ($\overline{OE}$)	Pos (P_A) Neg (P_B)	Up (U) Down (D)	Yes	Zero ($\overline{A}$)	
11	11	Decade 1 Low (D1L)	Odd (OE)	Pos (P_A) Neg (P_B)	Down (D) Up (U)	No	Set (A)	Decade 1 (D1)
12	11	Decade 1 Low (D1L)	Even ($\overline{OE}$)	Pos (P_A) Neg (P_B)	Up (U) Down (D)	No	Set (A)	

Figure 4-3. Tabular Presentation of V34 and V35 Logic.

pulse would occur, but $\overline{UD}$ causes CP to be generated, stepping the range attenuator to the next higher range.

Figure 4-3 shows that the logic is the same for all even steps of the transfer switch. Likewise, the logic is the same for all odd steps. $\overline{UD}$ causes a CP for all even steps except step 12. When in step 12,"A"being set eliminates the generation of CP's by $\overline{UD}$.

The logic equation which sums up all of the information contained in Figure 4-3 may be stated:

$$CP = OE \cdot P_A \cdot D + OE \cdot P_B \cdot U + \overline{OE} \cdot P_A \cdot U + \overline{OE} \cdot P_B \cdot D + \overline{OE} \cdot \overline{UD} \cdot \overline{A}$$

This may be put into words as follows:
A compute pulse (CP) exists (=) if
the odd-even flip-flop is odd (OE)
and (·) the polarity relay is positive (P_A)
and (·) a D pulse occurs (D)
or (+) odd (OE)
and (·) negative (P_B) and (·) U pulse (U)
or (+) even ($\overline{OE}$) and (·) positive (P_A)
and (·) U pulse (U)
or (+) even ($\overline{OE}$) and (·) negative (P_B)
and (·) D pulse (D)
or (+) even ($\overline{OE}$) and (·) no U or D pulse ($\overline{UD}$)
and (·) not in position 11 ($\overline{A}$).

Following ranging, the transfer switch scans through Decades 5, 4, 3, 2, and finally Decade 1. At this point, the scan is complete and the readout will display the unknown signal input voltage to five places in the V35 and to four places in the V34. Note that the logic employed in these instruments avoids the necessity of "homing" each decade switch to "O" at the beginning of every scan, thus increasing speed and extending switch life. If the signal should change from −5.5555 volts to −5.5655 volts, only Decade 3 moves, or if the signal changes from −5.5555 volts to +5.5555 volts, only the polarity relay changes.

The "fail-safe" diodes for Decade 1 are located on the "B" board, and are routed to transfer switch position 11 (TS11).

To make a V34 out of a V35, the Decade 5 switch assembly is replaced by an adapter. This adapter is wired to simulate the Decade 5 swich in the "O" position, thus attenuating the reference voltage by ten. The wire from position 2 of the transfer switch is moved from REF to Decade 5 High, and the wires from positions 3 and 4 are moved to GND. Shorting wires in the adapter simulate both a "9" and a "O" in order to short out any CP's which would attempt to change the adapter.

4-3 **End-of-scan Logic** Three flip-flops (termed FF) are associated with the end-of-scan logic: "A," "B," and "ES." The sequence of operation for these FF's is tabulated in Figure 4-4. As the transfer switch moves into position 11, "A" is set. Once "A" is set, the transfer switch is locked in position and kept from moving back to position 1 to start another scan. As with the other decades, both low-output and high-output logic are performed on Decade 1, even though only the low output is used as feedback. The exception to this is that "A" being set prevents $\overline{UD}$ from producing a CP. In Step 1, low-output logic is performed, and Decade 1 is driven until the feedback is equal to or less than the signal. Once this condition is reached, $\overline{CP}$ occurs, and "B" is set. In Step 2, high-output logic is performed, and Decade 1 is driven until the feedback is equal to or greater than the signal. At this point, $\overline{CP}$ occurs, and "ES" (End of Scan) is set. The scan is now complete since the feedback has been driven to equal exactly the signal within one digit. "ES" being set, shorts out any CP's, preventing Decade 1 from moving. Should the POWER switch be in the PRINT position, the setting of "ES" gives the Print Command by operating the Print Command Relay for 50 to 100 milli-

STEP	STATE OF FLIP-FLOPS			TRANSFER SWITCH	COMPUTE PULSE LINE (CPL)	CONDITION FOR CHANGE OF STATE
	A	B	ES			
0	ZERO	ZERO	ZERO	Unlocked	Unshorted	
						Transfer Switch Moves to Position 11
1	SET	ZERO	ZERO	Locked	Unshorted	
						No Compute Pulse ($\overline{CP}$)
2	SET	SET	ZERO	Locked	Unshorted	
						No Compute Pulse ($\overline{CP}$)
3	SET	SET	SET	Locked	Shorted	
						Automatically (ON) or Print Feedback (PRINT)
4	SET	ZERO	SET	Locked	Shorted	
						Controlled by Mode Switch
5	ZERO	ZERO	SET	Unlocked	Shorted	
						Automatically
0	ZERO	ZERO	ZERO	Unlocked	Unshorted	

Figure 4-4. End-of-Scan Logic Table.

seconds. The DVM remains locked in Step 3 until the Print Feedback Command is received from the printer, or from some external switch. The Print Feedback Command zeros "B." If the POWER switch is in the ON position, the setting of "ES" does not cause the Print Command, but it does zero "B." The instrument is now in Step 4, and further stepping is controlled by the MODE switch. In STANDBY, the instrument remains locked in Step 4. In AUTO, U or D pulse from the amplifier zeros "A." In CONTINUOUS, "A" is zeroed by the timing generator. In SINGLE SCAN, an uncharged capacitor allows the timing generator to zero "A." Once "A" is zeroed, the transfer switch coil is energized to move into position 1, since "ES" is still shorting out CPL. "ES" is zeroed at the end of the transfer switch coil drive and the next scan is initiated.

Fail-safe "O" and "9" light lockout of CPL is required in Decade 1 as it is in the other decades. This is accomplished on the B Board by a diode matrix and an emitter follower. "B" controls whether the "0" or "9" light locks out CPL.

During the end-of-scan logic period, the odd-even flip-flop (OE) continues to function as described previously until "ES" is set at which point "OE" is locked. At the beginning of each scan, the zeroing of "A" sets "OE."

4-4 Logic Circuitry Figure 4-5 is an example of AND-OR gates. If X_1 or X_2 (or both) are at ground potential, e_1 will be at ground. If both X_1 and X_2 go negative, e_1 will be pulled negative by R_1. Thus if both X_1 and X_2 are negative, e_1 will be negative. The same applies to e_2 with respect to X_3 and X_4. The ohmic value of R_2 is always several times that of R_1. If both e_1 and e_2 are at ground, e_3 will also be at ground, but if either e_1 or e_2 goes negative, e_3 will also go negative. The output of the circuit in Figure 4-5 may be expressed: $X_1 \cdot X_2 + X_3 \cdot X_4$. This means that the output is negative if X_1 AND X_2 are negative OR X_3 AND X_4 are negative.

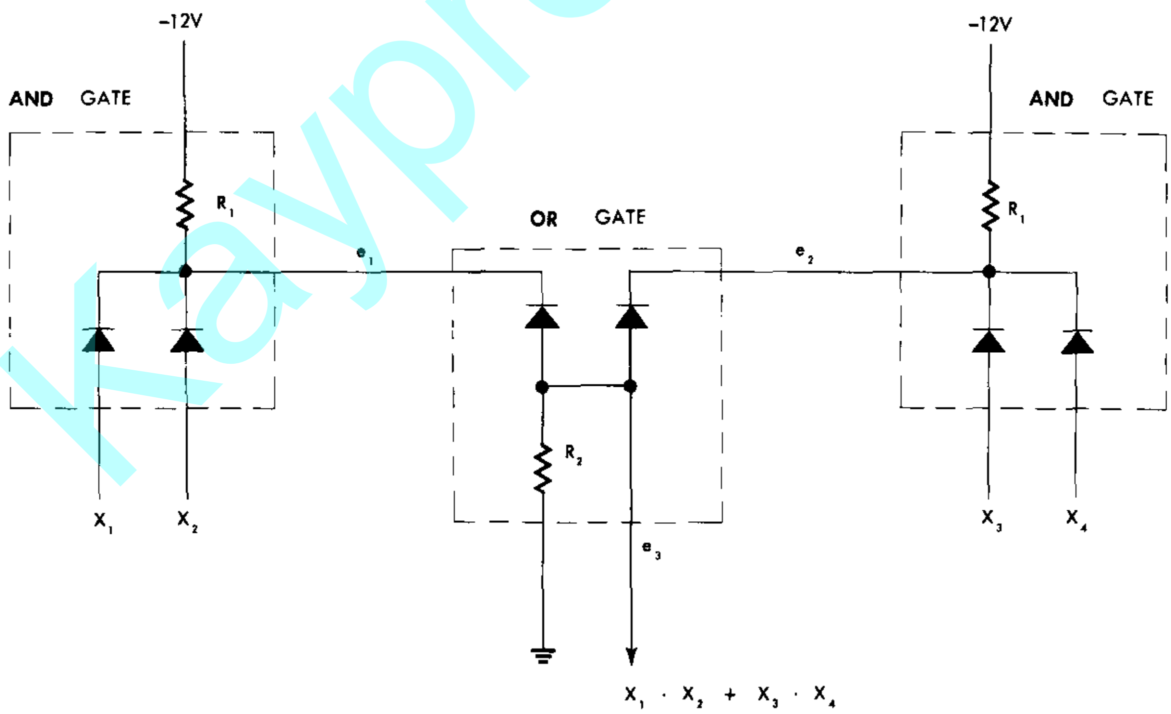


Figure 4-5. And-Or Gates.

Figure 4-6 is a sample flip-flop trigger circuit used in the V34 and V35. X_1, X_2, and X_3 are fed into an AND gate. When they all go negative, e_1 will be pulled negative by R_1. Since R_1 is very large compared to R_3 and R_4 in parallel, the current through C_1 will be small, and the voltage at e_2 will remain near 0 volts. When X_1, X_2, or X_3 goes to ground, a surge of current limited by R_2 (R_2 is small compared to R_3 and R_4) will flow through C_1, causing e_2 to go positive. The PNP transistor is turned off when e_2 goes positive with respect to ground.

Figure 4-7A is a schematic of a typical logic FF used in the V34 and V35. The FF has two outputs, X and $\overline{X}$. If X is negative, $\overline{X}$ is 0, and if X is 0, $\overline{X}$ is negative. Figure 4-7B illustrates the flip-flop with its trigger circuits. The 27kΩ resistors connected to the collectors serve the same function as R_1 in Figure 4-6. The dotted circuit at the bottom of the diagram illustrates an additional set trigger. Parallel triggers such as this accomplish OR logic without the necessity for AND-OR gates.

4-5 **A Board** Located on the A Board are the timing generator and the compute pulse generator. Figure 4-8 is a block diagram of the plug-in assembly and Figure 4-9 illustrates the timing of the pulses generated. The 60 cps oscillator is a free-running multivibrator synchronized to the power line frequency. (This multivibrator will also synchronize with 50 cps power.) The timing FF divides the frequency by two, producing 30 cps square waves, the bit rate of the DVM. The timing FF sets the chopper drive FF at the beginning of each bit and zeroes the compute pulse (CP) FF at the middle of each bit. The chopper drive FF is a one-millisecond monostable FF. CD and $\overline{CD}$ drive the center-tapped chopper coil, thus

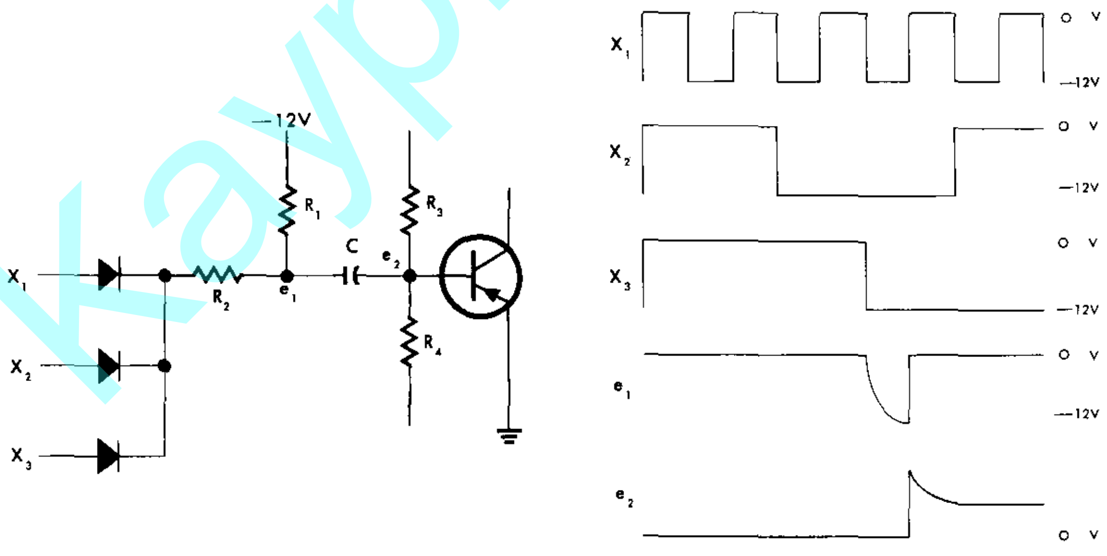


Figure 4-6. Flip-Flop Trigger Circuit.

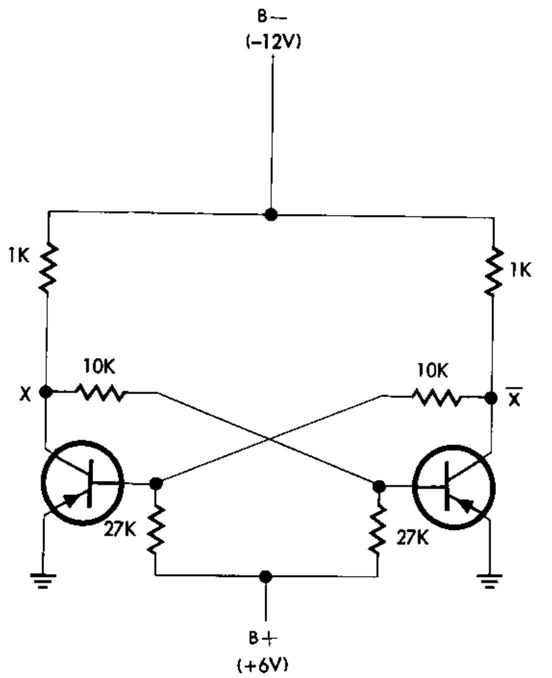


Figure 4-7A. Flip-Flop Only.

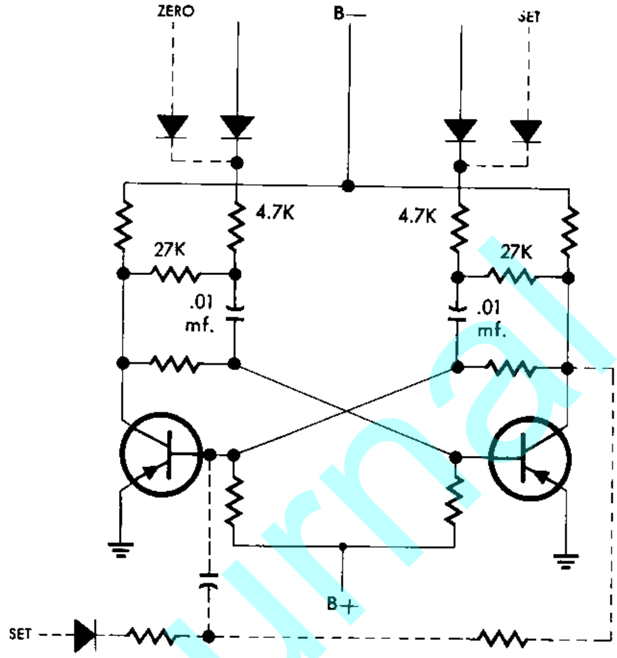


Figure 4-7B. Flip-Flop With Trigger.

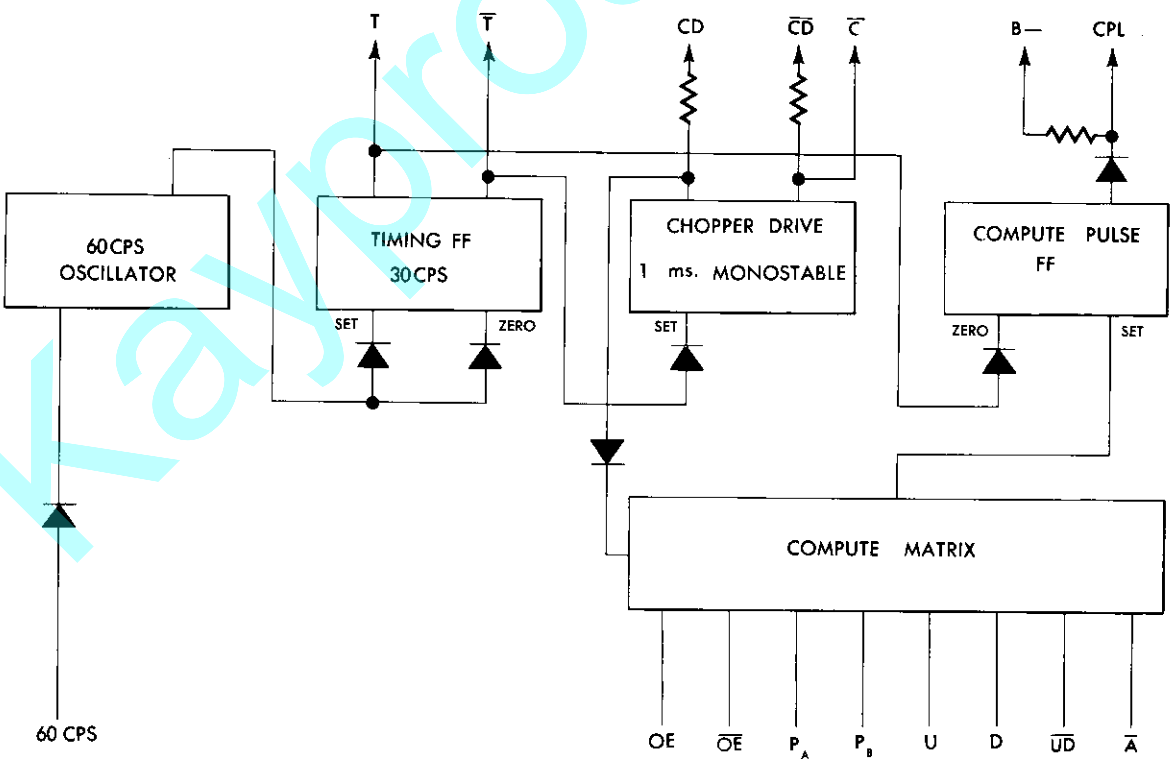


Figure 4-8. "A" Board Block Diagram.

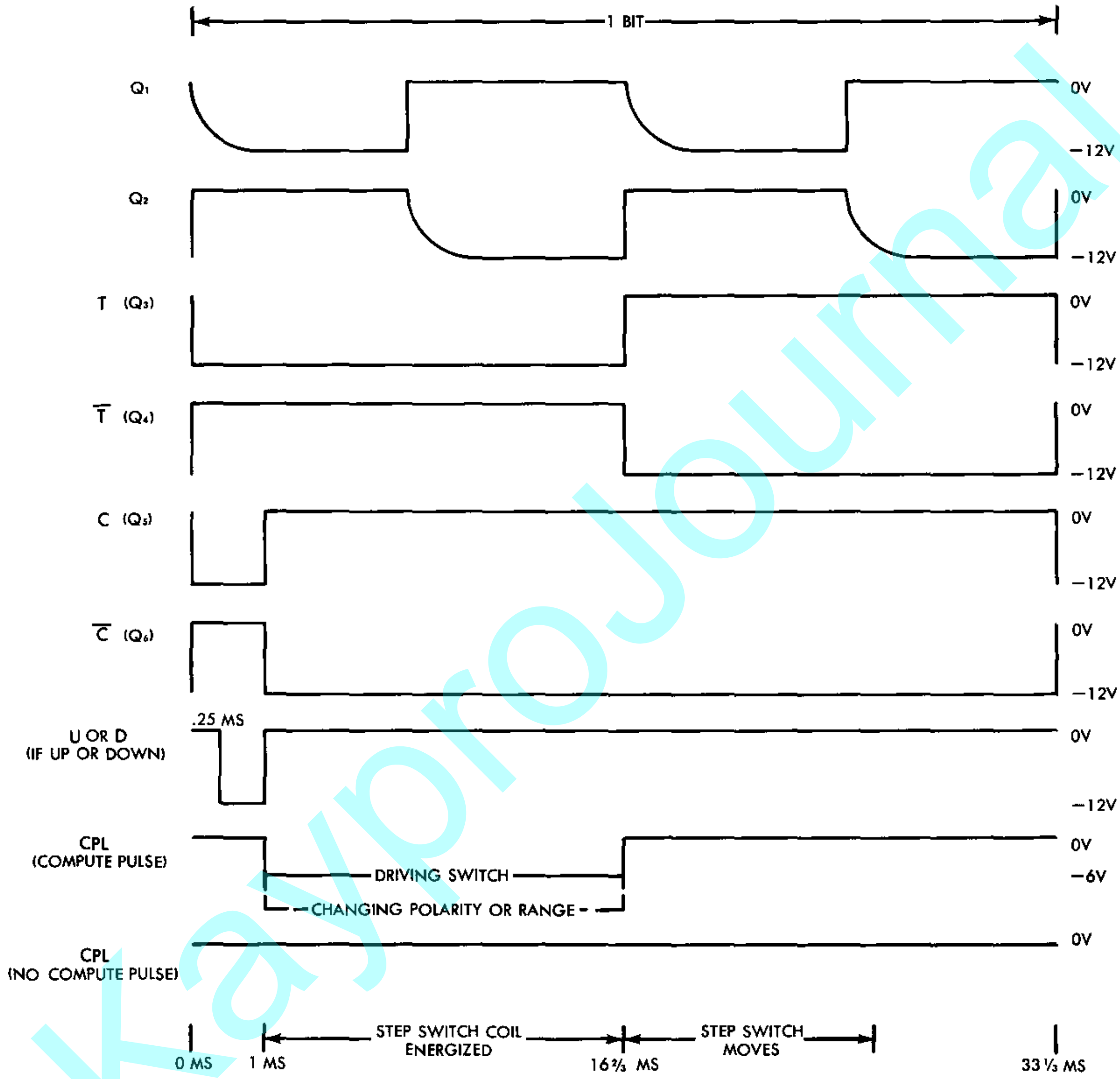


Figure 4-9. Timing Chart.

the chopper is asymmetrically driven, 32⅓ ms in one direction and 1 ms in the other. The diode matrix acts as a gate for the end-of-chopper-drive pulse, (a pulse generated at the end of the 1 ms drive). If the logic equation derived in Section 4-2 is satisfied, the end-of-chopper-drive pulse causes the compute pulse FF to be set, and a CP is generated on CPL. As described previously, this CP may be shorted to ground by the "O" or "9" lights (Section 4-2) or by the "ES" FF (Section 4-3).

4-6 **B Board** Located on the B board, as shown in Figure 4-10, are the A, B, and ES flip-flops associated with the end-of-scan logic, the OE FF associated with the compute logic, an inverter, and an emitter follower. The emitter follower is driven by the diode matrix, and provides the "O" and "9" CPL lockout for Decade 1 by shorting transfer switch position 11 (TS_{11}) to ground. The B FF determines whether "O" (D_1-O) or "9" (D_1-9) light controls the lockout. The inverter, in conjunction with the timing signals T and $\overline{C}$, provides the drive pulses for the transfer switch on D_T. If a CP exists, D_T will be positive with respect to ground. If a CP does not exist ($\overline{CP}$), D_T will be about 0.2 volts negative during the same timing interval for a CP. The diode connected to $\overline{A}$ prevents the transfer switch from moving during the end-of-scan logic. The inverter, T, and $\overline{C}$ also provide the $\overline{CP}$ signals to ES, OE, and B.

All FF's in the V34 and V35 are triggered by positive pulses as described in Section 4-4 except the A FF. Figure 4-10 shows the A FF trigger diodes reversed. The triggers for the A FF operate in the same manner as in the other FF's except that the trigger turns the transistor on rather than off. The MODE switch (MS) controls the zero trigger to A when B is zero and ES is set. A is zeroed at the middle of the bit by $\overline{T}$.

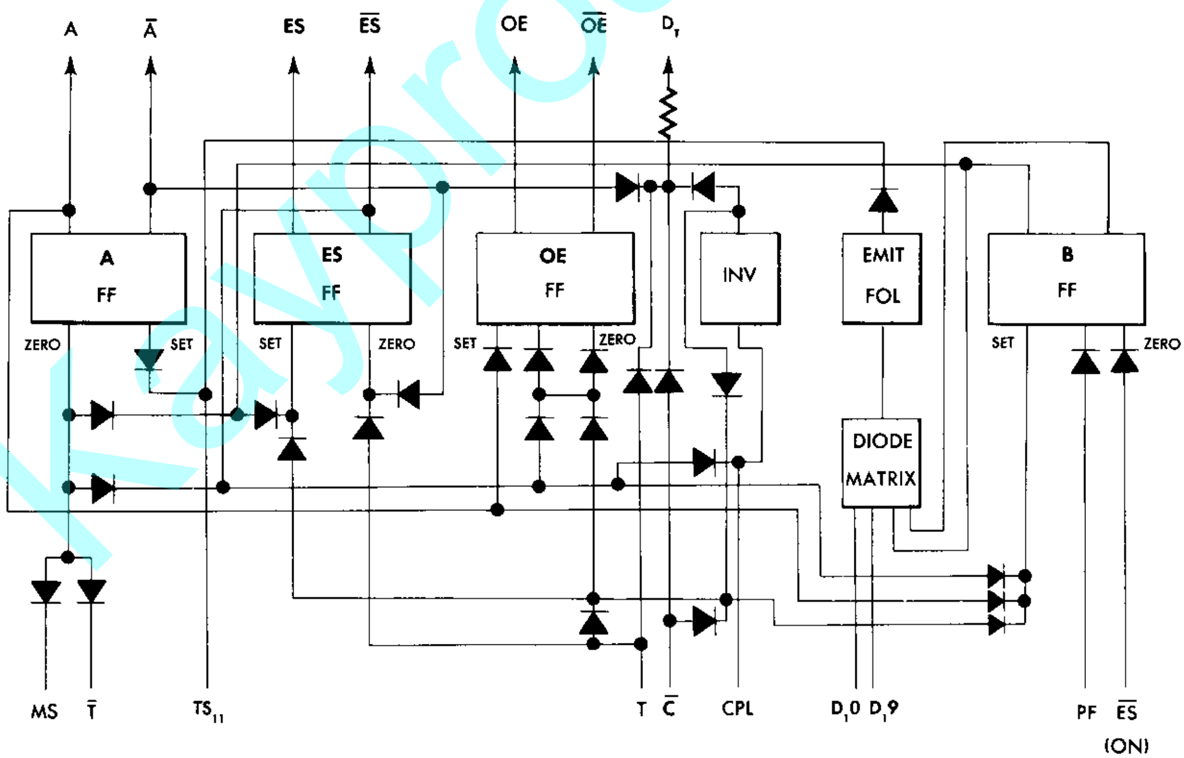


Figure 4-10. "B" Board Block Diagram.

A is set by TS_{11}. ES is set by $\overline{CP}$ after B is set. ES is zeroed at the middle of the next bit after A is zeroed. OE is changed by $\overline{CP}$ if ES is zero. OE is set at the beginning of each scan by the zeroing of A. B is set by $\overline{CP}$ when A is set and ES is zero. B is zeroed by the setting of ES when the POWER switch is ON. B is zeroed by the print feedback (PF) when in PRINT.

4-7 C Board The C board contains the FF's which drive all of the relays in the DVM. A block diagram is shown in Figure 4-11. The print command (PC) FF is a 50 to 100 millisecond monostable flip-flop. It drives the print command relay, and is triggered by the setting of ES when the POWER switch is in the PRINT position. ΔQ (transfer switch position 2) drives the Q FF through an inverter. Q in turn drives the R FF. Q_A and R_A are connected to the coils of the two relays which operate the range attenuator. Q_B and R_B are connected to the coils of the two relays which provide range data to the readout and the external printer. The Q and R FF's are set to the lowest range at the beginning of each scan by the zeroing of ES. ΔP (transfer switch position 1) drives the P FF through an inverter. P_A is connected to the coil of the relay which switches the zener reference supply. P_B is connected to the coil of the relay which provides the polarity data. CP's on ΔQ or ΔP changes the range or polarity FF's.

DCL, RL, and ACL provide the range and/or the polarity lockouts. DCL is connected to the 1000-volt decimal light. RL is grounded when the FUNCTION switch is in the RATIO position, thus locking the DVM in the lowest range. (The readout is in percentage, not volts.) ACL is grounded when the FUNCTION switch is in any of the VAC positions. This locks the DVM in positive

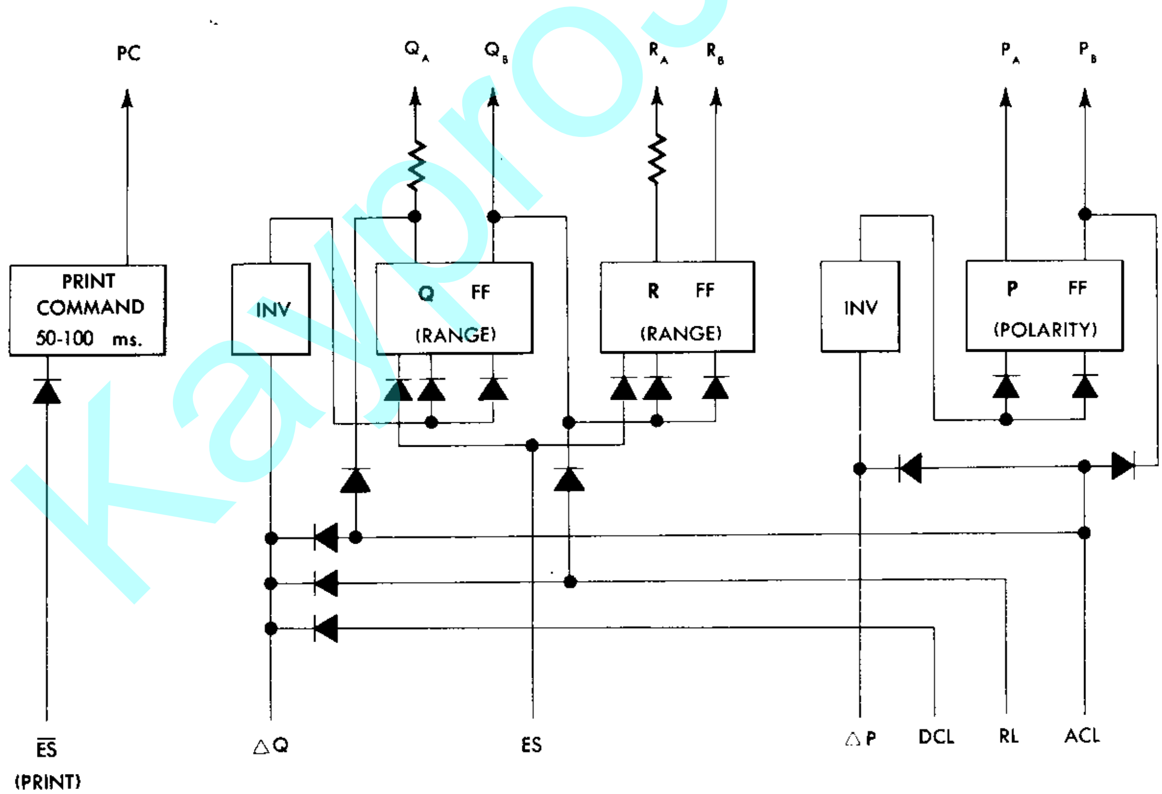


Figure 4-11. "C" Board Block Diagram.

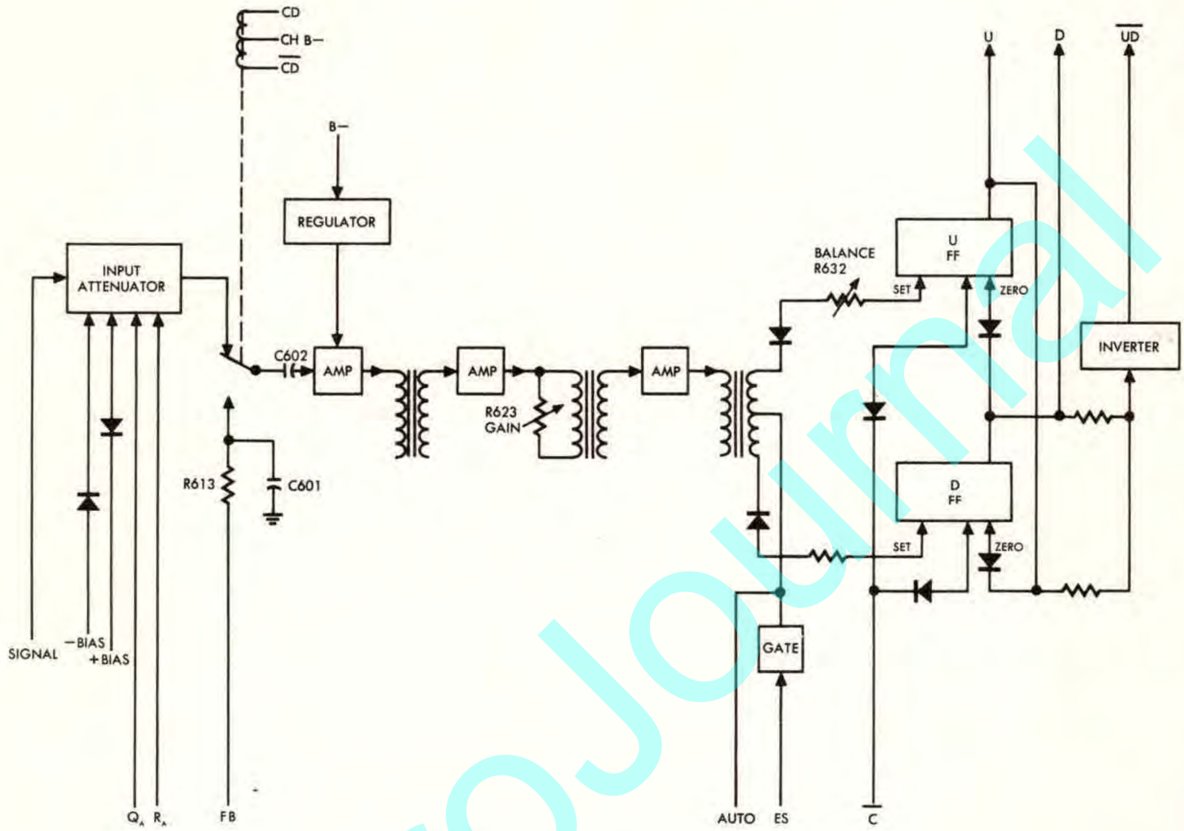


Figure 4-12. Error Amplifier Block Diagram.

polarity and the second range.

4-8 **D Board** The instrument contains two identical D boards. Each contains three identical stepping-switch power amplifiers. See Schematic 11400-500, Sheet 2. The power amplifier consists of a driver (2N185) and power transistor (2N456). The diode, capacitor, and 4.7KΩ resistor enable the power transistor to absorb the energy stored in the magnetic field of the stepping switch coil. The C's are connected to stepping switch coils. The D's are connected to the transfer switch, or to the B board (D_T). The −15 V supply voltage is slightly higher than the B− voltage used throughout the DVM. The other ends of the coils are connected to this −15 V supply.

4-9 **Amplifier** Figure 4-12 is a block diagram of the error amplifier. The unknown input signal is fed through the input attenuator to one side of the chopper. The input attenuator is controlled by the Q_A and R_A relays. The voltage across the chopper is limited by the two diodes connected to the *+BIAS* and *−BIAS*. These diodes are in the circuit on the 10-volt range only in the V35 amplifier and on the 1-volt and 100-volt ranges in the V34 amplifier. The V35 amplifier has three ranges and the V34 amplifier has four ranges. Other than this, the two amplifiers are identical. The V35 bias voltages are approximately 15 volts; the V34 bias voltages are approximately 1.5 volts.

C602 is connected to the signal for the most of a bit ($32\frac{1}{3}$ milliseconds), and thus charges to the exact signal voltage. The input attenuator has a maximum output resistance of 1 megohm. C601 charges to the exact feedback voltage (FB) through R613. Just after the beginning of a bit, C602 is switched to C601. If the feedback voltage does not exactly equal the signal voltage, a surge of current is passed through C602 to the input transistor of the amplifier. The direction of current flow depends upon the polarity of the error. The time constant of this current surge is approximately 2 microseconds. The error pulse is amplified by a transformer-coupled pulse amplifier. The gain of the amplifier is controlled by R623. Depending upon the polarity of the pulse, the Up (U) or Down (D) FF will be set. The two FF's are cross coupled so that if one of them is set, the other is held zeroed. If either is set, $\overline{UD}$ will be held at ground. R632 is adjusted so that the sensitivity of the U and D FF's are equal. At the end of the chopper drive, $\overline{C}$ locks both U and D FF's in the zero state. This lockout holds until the beginning of the next bit.

During the scan, the gate controlled by ES shorts the center tap of the transformer to ground. At the end of scan, the gate opens, and the voltage at the center tap goes positive. AUTO is connected to the arm of the AUTO SENSITIVITY control, which regulates the amplitude of this positive voltage. Positive voltage on the center tap reduces the sensitivity of the U and D FF's and hence the over-all gain of the amplifier. This gain cutback controls the error amplitude necessary to initiate a scan when the MODE switch is in the AUTO position.

4-10 **Zener Reference Supply** The zener reference supply, shown schematically on 11400-050 Sheet 2, consists of a rectifier and a current regulator driving a zener diode bridge circuit. The current regulator greatly reduces the effects of varying power line voltage and the bridge circuit compensates for the dynamic impedance of the zener diodes.

Two models of the supply are in use: 11400-050 ⓪ and 11400-050 ③. The two are very similar, the principal difference being the number of components located within the oven. R801, and R811 of board ⓪, and R808 of board ③, are adjustments for the dynamic characteristics of the particular matched pair of zener diodes CR811. These adjustments are set at the factory and normally should not require adjustment unless the diodes are changed. They are NOT calibrating adjustments.

4-11 **Power Supply** The power transformer, as shown on all main board schematics, has two secondary windings. One winding supplies voltage to the zener reference supply and the other provides voltage for the five remaining supplies: +bias, −bias, −15 v, B−, and B+. CR125 and CR126 are in the +bias supply and CR123 and CR124 are in the −bias supply. CR113 and CR114 are in the B+ supply (approximately 6 volts). CR111 and CR112 rectify for −15 v and B− (approximately −13 volts). L101 and C105 provide additional filtering for B−. The supplies are all conventional.

Section 5
MAINTENANCE

This Section presents maintenance information from two points of view—the plug-in substitution method, Section 5.1, and the trouble-shooting approach, Sections 5.3 and 5.4.

5.1 **Plug-In Substitution** Except for the power supply, all of the circuit components are assembled on plug-in boards. Thus the maintenance problems on this complex instrument are simplified to the point where the DVM can be kept operating without the need for highly trained personnel. Certain other maintenance advantages accrue because of the plug-in design:

- Down time is held to a minimum; the DVM can be kept operating under conditions where it would be impractical or inconvenient to return the instrument to a repair facility or to the manufacturer.
- The complexity of the DVM poses no problem, either to the semi-skilled worker or to the trained engineer, since there is no need to troubleshoot, as such, beyond the simple search for a defective plug-in unit.
- The defective plug-in unit can be easily located without a detailed study of symptoms. Only a very few minutes are needed to replace all of the plug-in components. Thus by using the trial-and-error method the DVM can be made to function properly.
- The need for testing equipment is eliminated if a small, space-saving kit (see Section 6) of spares is kept at hand.

Rather than to rely solely upon the trial-and-error method of plug-in replacement, the user can speedily detect the defective plug-in component by following the symptomatic approach:

PLUG-IN COMPONENT FAILURE	SYMPTOMS
"A" BOARD	Meter fails to scan—No timing pulses. Meter scans but digits will not change.
"B" BOARD	Meter fails to scan—End-of-scan flip-flop not working properly. Meter fails to scan—Transfer switch drive circuitry bad. Meter will not stop scanning in STANDBY. Decade 1 "rolls." Some or all of the Decades go to 9's.
"C" BOARD	Meter will work on one polarity only. Meter ranges improperly. No print command.
"D" BOARDS (2 used)	Meter fails to scan—one of the power amplifiers inoperative.

PLUG-IN COMPONENT FAILURE	SYMPTOMS
AMPLIFIER BOARD	Readings erratic. Meter o.k. in one range but not in another (range relays). Offset in low range but not in second range. Malfunction at very high voltages (range relays). Meter drifts on ranges other than lowest range.
ZENER REFERENCE SUPPLY	Meter drifts out of specification. +, —, offset. Meter goes to all 9's, both polarities.
POLARITY RELAY	Meter o.k. on one polarity, but goes to all 9's on other polarity. +, —, offset (contact resistance).
DECADE SWITCH ASSEMBLIES (5 used)	Meter fails to scan – open coil. Meter o.k. some readings – N.G. others.
TRANSFER SWITCH	Readings erratic. Meter fails to scan – open coil. Malfunction every 3rd, 6th, 9th, etc., scan or 2 out of 3 scans.

5.2 Main Power Supply The V34 and V35 power supplies are the only main portions of the instrument which are not of plug-in design. The relatively large physical size of the power supply components, coupled with the virtually trouble-free design, make plug-in replacement unnecessary. In general, the power supply is of conventional design. It should be noted, however, that the DC output is not at all pure; do not expect the power supply to provide a battery-like absence of peaks when measured upon an oscilloscope. The V34 and V35 are designed to work without the need for pure, or even nearly pure, DC.

If the power supply is to be checked for output, the following voltage chart will serve as a guide:

NOTE

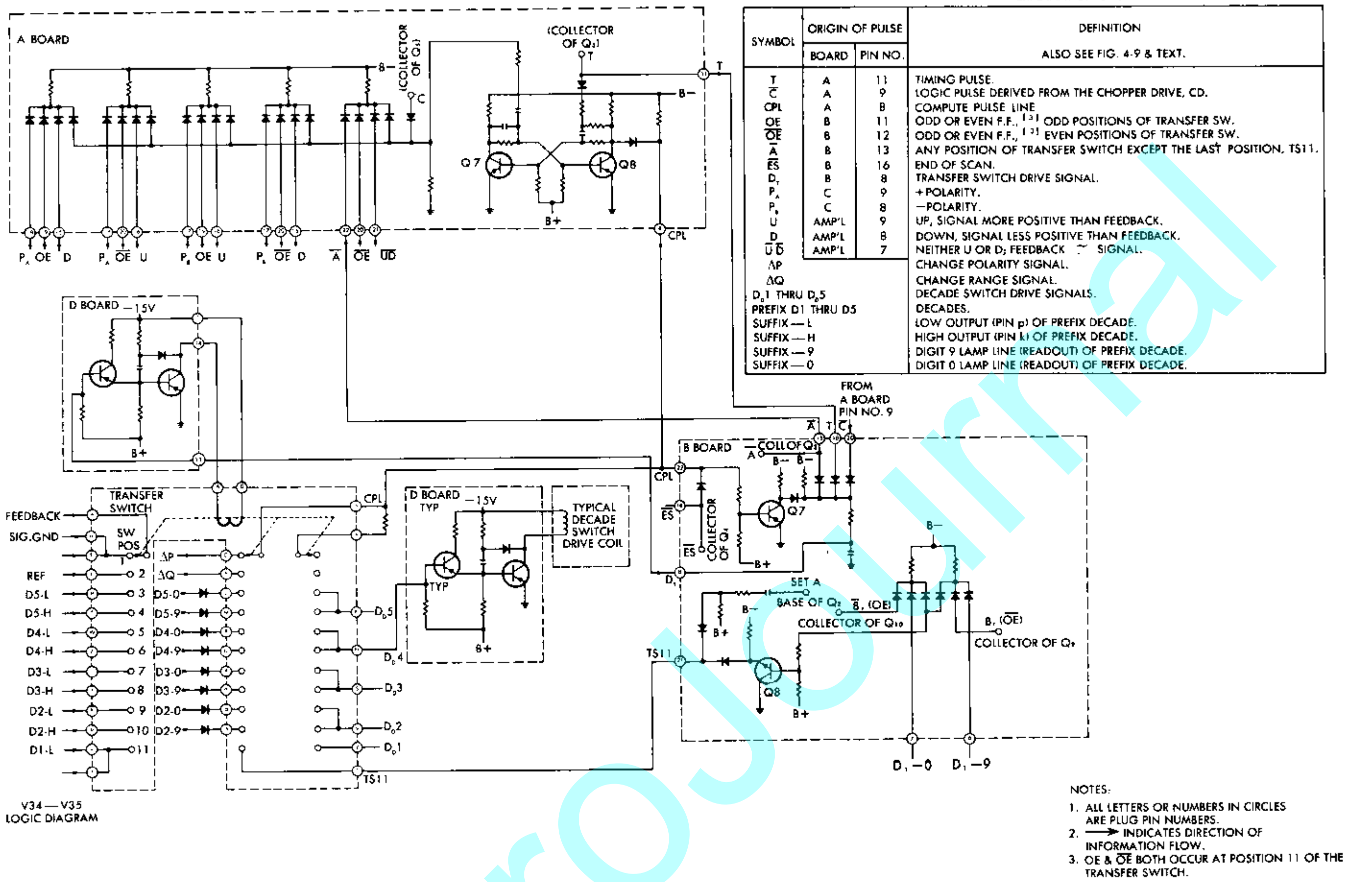
All measurements are made with the power source at 115 VAC. Any good 20,000 ohm-per-volt meter may be used. Readings taken with this chart as a guide should be accurate ± 10%.

DC measurements:

B— SUPPLY	B+ SUPPLY	—15V SUPPLY	MODE Switch Setting
—13	+6.1	—15.3	STANDBY
—12.3	+5.3	—14.7	CONTINUOUS (input leads shorted)

AC measurements: Set oscilloscope for peak-to-peak volts

B— SUPPLY	B+ SUPPLY	—15V SUPPLY	MODE Switch Setting
.01	.14	.8	STANDBY
.7	.4	2.5	CONTINUOUS (input leads shorted)



EXPLANATION OF SYMBOLS USED.

SYMBOL	ORIGIN OF PULSE		DEFINITION
	BOARD	PIN NO.	ALSO SEE FIG. 4-9 & TEXT.
T	A	11	TIMING PULSE.
$\overline{C}$	A	9	LOGIC PULSE DERIVED FROM THE CHOPPER DRIVE, CD.
CPL	A	8	COMPUTE PULSE LINE
OE	B	11	ODD OR EVEN F.F., (3) ODD POSITIONS OF TRANSFER SW.
$\overline{OE}$	B	12	ODD OR EVEN F.F., (3) EVEN POSITIONS OF TRANSFER SW.
$\overline{A}$	B	13	ANY POSITION OF TRANSFER SWITCH EXCEPT THE LAST POSITION, TS11.
$\overline{ES}$	B	16	END OF SCAN.
D_T	B	8	TRANSFER SWITCH DRIVE SIGNAL.
P_A	C	9	+ POLARITY.
P_B	C	8	−POLARITY.
U	AMP'L	9	UP, SIGNAL MORE POSITIVE THAN FEEDBACK.
D	AMP'L	8	DOWN, SIGNAL LESS POSITIVE THAN FEEDBACK.
$\overline{U}\,\overline{D}$	AMP'L	7	NEITHER U OR D; FEEDBACK ≃ SIGNAL.
ΔP			CHANGE POLARITY SIGNAL.
ΔQ			CHANGE RANGE SIGNAL.
D_D1 THRU D_D5			DECADE SWITCH DRIVE SIGNALS.
PREFIX D1 THRU D5			DECADES.
SUFFIX — L			LOW OUTPUT (PIN p) OF PREFIX DECADE.
SUFFIX — H			HIGH OUTPUT (PIN k) OF PREFIX DECADE.
SUFFIX — 9			DIGIT 9 LAMP LINE (READOUT) OF PREFIX DECADE.
SUFFIX — 0			DIGIT 0 LAMP LINE (READOUT) OF PREFIX DECADE.

Figure 5-1. Simplified Schematic Logic Circuits.

5.3 Logic Checkout Using Dummy Amplifier. The Dummy Amplifier (Part No. 3017-016) provides a simple means of checking out all of the logic circuits in either the V34 or V35. The dummy amplifier simulates the amplifier plug-in assembly. It provides proper loading resistors and output pulses. Either an UP (U), DOWN (D), or NO UP OR DOWN ($\overline{U}\overline{D}$) pulse may be selected by a switch. The test procedure which follows provides a quick method to assure that all of the logic circuits are functioning properly as well as providing a simple means for locating any malfunctioning assembly.

The Dummy Amplifier, along with its extension board, is substituted for the actual amplifier board when the tests described in this section are made.

For the following tests the FUNCTION switch should be in the VDC position. The MODE switch should normally be in the STANDBY position. Scans should be initiated by moving it to SINGLE SCAN. The POWER switch is in the ON position.

The front panel controls should be checked out first:

Mode Switch — In STANDBY, the meter should not scan in any dummy amplifier switch position. Moving to SINGLE SCAN should cause one scan only. Another scan may be initiated by moving to STANDBY and returning to SINGLE SCAN.
In AUTO the meter should scan continuously when the dummy amplifier is in either U or D, but should not scan when the dummy amplifier is in $\overline{UD}$. In CONTINUOUS the meter should scan continuously for all three positions of the dummy amplifier.

Power Switch — Turn the POWER switch to PRINT and the MODE switch to CONTINUOUS. The meter should scan once, and lock up. You should be able to hear the print command relay operate momentarily at the end of scan. Momentarily returning the POWER switch to ON should initiate another scan.

Once it is ascertained that the front panel controls are working properly, the scan logic circuits may be checked out. Operate the DVM in VDC and SINGLE SCAN mode.

DUMMY AMPLIFIER	READING	
	V35	V34
U	+999.99	+999.9
D	—999.99	—999.9

Repeat several times. All of the lower range decimal lights should flicker at the beginning of each scan: With the reading at +999.99, short △P on C board to power ground.

DUMMY AMPLIFIER	READING	
	V35	V34
D	+0.0000	+.0000
$\overline{UD}$	+999.90	+999.0
U	+999.99	+999.9

Repeat the sequence several times. The lower range lights should flicker for U and $\overline{UD}$. Remove the △P to ground short. Set the dummy amplifier to D and scan once, producing a reading of —999.99. Short △P to ground.

DUMMY AMPLIFIER	READING	
	V35	V34
U	—0.0000	—.0000
$\overline{UD}$	—999.90	—999.0
D	—999.99	—999.9

Repeat the sequence several times. Remove the △P to ground short. The logic checkout is complete.

If scan errors occur 1 out of 3, 2 out of 3, 1 out of 6, etc., the trouble is a stepping switch. If errors occur in one polarity but not in the other, the A Board is bad. If polarity doesn't change properly or if the meter doesn't range properly, the C Board is faulty. If the meter "rolls" continuously in any decade but Decade 1, one of the "0" or "9" light diodes located on the main board under the transfer switch is bad. If Decade 1 rolls continuously, the B Board is bad. If the decimal lights oscillate, interchange K-103 and K-104, the rear two plastic cased relays. If the malfunction still occurs, replace them both. If the malfunction persists, replace the C Board. If 0's appear instead of 9's, or 9's instead of 0's, the fault is most likely the B Board.

A survey of the plug-in symptom chart in Section 5-1 will reveal that many plug-in units can cause scan failure. Failure to scan will always show up in the logic checkout. Figure 5-1 is a simplified schematic of the Compute Pulse Line (CPL) and its associated circuitry. This diagram can be of considerable assistance in tracing the faulty plug-in assembly.

Connect an oscilloscope from CPL (Pin 22 on the B Board) to power ground (Pin 3 on the B Board). If a pulse similar to that pictured in Figure 4-9 exists, then a Compute Pulse (CP) exists. Using Figure 5-1 as a guide, trace CPL through the transfer switch to $\triangle P$, $\triangle Q$, or one of the decade drives. If CP exists on $\triangle P$ or $\triangle Q$, the C Board is at fault. If CP exists on one of the decade drives, the trouble is either the appropriate D Board or Decade switch. A CP on one of the decade drives will fall to about —0.3 volts, instead of —6 volts as on CPL. If a CP does not exist ($\overline{CP}$), the transfer switch should be stepping. Connect the oscilloscope to D_T (pin on the B Board). This point should show a pulse from approximately +6 volts to —0.3 volts. If the pulse exists, the fault is either the appropriate D Board or the transfer switch. If the pulse does not exist, the fault is most likely the B Board.

Satisfactory completion of the logic test assures that the following assemblies are functioning properly:

A Board
B Board
C Board
D Boards
Transfer Switch (logic levels only)

5.4 Non-Logic Malfunctions Non-logic malfunctions are limited to zener reference supply, Kelvin-Varley bridge circuits (including one level of the transfer switch), the polarity relay, and the amplifier assembly. Malfunctions of this type are most easily corrected by plug-in assembly substitutions. The plug-in symptom chart of Section 5-1 may be used as a guide. The following list is arranged in order of failure probability, commencing with the most probable component.

Range Relays
Amplifier Assembly, proper
Transfer Switch
Chopper
Decade Switch
Zener Reference Supply

NOTE

+, —, offset is most often caused by power plug reversal (see Section 2.1). It is seldom that the cause is actually a faulty component. Improper connection to a remote printer may be the cause of offset.

5.5 Amplifier Tests and Adjustments This Section describes the procedure for making gain and balance adjustments and signal-to-noise ratio measurements.

NOTE

No amplifier adjustments should be made unless it has been determined that all other portions of the DVM are functioning properly.

To test and adjust the amplifier, the following items, or their equivalents, will be required:

1. Oscilloscope, Tektronix 502 or 533.
2. Dekavider, Model DV-411.
3. Voltage source, as shown in Figure 5-2.

Procedure:

1. Connect oscilloscope to amplifier as follows: (see Fig. 5-3).
   A. Gnd to Pin 1.
   B. Input to A.

2. On the amplifier board clip B to Pin 1. Set voltage source to +.00050 volts, and flip the MODE switch to SINGLE SCAN position one time. The readout should display +0.0005, ± one digit in the V35, or +.0005, ± one digit in the V34.

3. Set the oscilloscope controls as follows:
   A. Sensitivity (10:1 probe), .05 V/CM.
   B. Sweep Rate, 2 Millisecond C/M.
   C. Line trigger.

4. Set voltage source at +0.0015 with the DVM in STANDBY position and observe large pulse appear on oscilloscope face. If no pulse is visible, flip the oscilloscope's SYNC POLARITY switch back and forth until the error pulse is visible.

NOTE

At this sweep rate the pulse is very narrow; careful observation will be needed to see it.

When the pulse has been located, center it upon the oscilloscope face and expand the sweep by 20 or more.

5. Return the voltage source to +.00050 and slowly vary the Dekavider 1/10,000 dial to obtain an absolute minimum pulse. Record this reading. The difference between the new Dekavider setting and :00050 is the offset of the DVM. If the offset is greater than .00005, there is excessive leakage or AC pickup in the signal or feedback. Correct this trouble, if it occurs, before going ahead with amplifier adjustments.

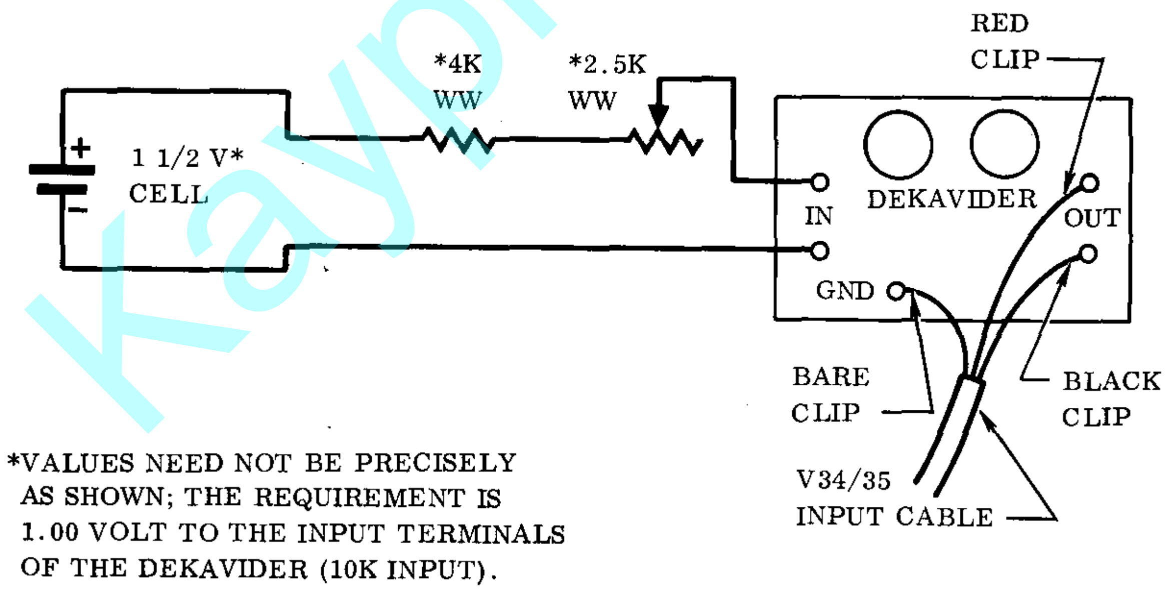


Figure 5-2. Voltage Source and Amplifier Input.

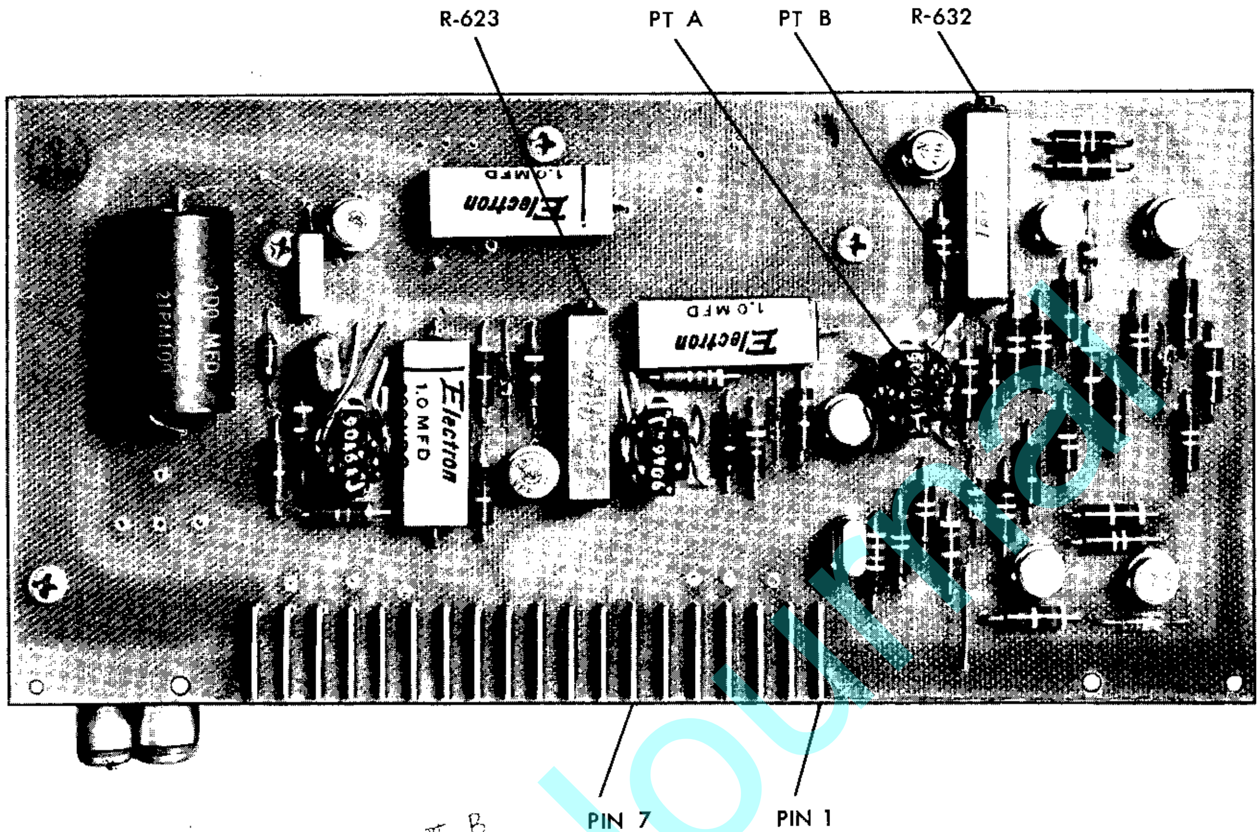


Figure 5-3. Amplifier, Component Side.

6. Connect the oscilloscope input to Pin 7 of the amplifier board and proceed as follows:

A. Set the Dekavider to a reading which is .00008 *less* than the null reading recorded in Step 5. Example: If null reading is .00047, the Dekavider setting will be .00039.

B. If a steady square wave (leading edge at the same point as the error pulse) now appears, rotate R-623 ccw (counterclockwise) until the square wave starts to "blip"; if the square wave is blipping initially, or if no square wave exists, proceed immediately to Step C.

C. *Slowly* turn R-623 cw (clockwise) until the square wave *just* becomes steady.

D. Set the Dekavider to a reading .00004 *less* than the null reading. The square wave should be completely gone (no blips). If Step C has been done correctly and the square wave still appears, it can be assumed that the amplifier is excessively noisy and requires repair.

E. Set the Dekavider to a reading .00008 *more* than the null reading. Example: If null reading is .00047, the Dekavider setting will be .00055.

F. If a steady square wave appears, turn R-632 cw until the square wave *just* starts to blip; if the square wave is blipping initially, proceed immediately to Step G.

G. *Slowly* turn R-632 ccw until the square wave *just* becomes steady.

H. Repeat the instructions in Paragraph 5. If the new null differs from the previously recorded null by more than ±.0001, repeat all of the steps listed in Paragraph 6.

7. Set Dekavider to a reading .0001 *greater* than the recorded null reading and observe the ratio of the error pulse to the noise. This ratio should never be less than 3:1; a typical amplifier is 4:1. See Figure 5-4 for typical output wave form.

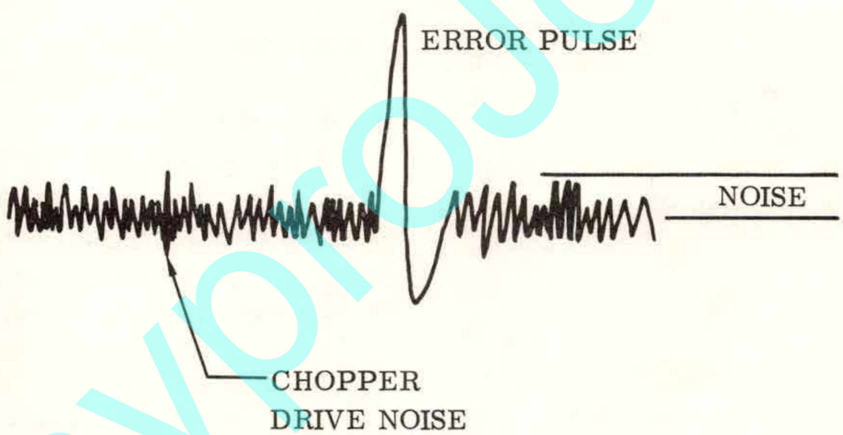


Figure 5-4. Amplifier Output Wave Form.

5.6 Zener Reference Voltage Supply The V34 and V35 zener reference supply plug-in units have been correctly matched to the instrument by means of a string of four series-connected calibrate resistors in the 10-volt bridge circuit. At the time that the instrument was factory equipped with a zener reference supply, jumpers were installed across certain of these resistors so that the absolute voltage adjustment potentiometers would be capable of being set according to the directions given in the calibration discussion, Section 3.

If a new zener reference supply board is obtained for the instrument, it will be necessary to inspect the jumper connections and probably change them. The new zener supply unit is shipped to the user with a note attached to the oven case, showing the volts range of the particular unit. The resistors associated with these jumpers are all grouped on the underside of the main board adjacent to calibration potentiometers R-110 (V35 only), and R-111. These potentiometers may be located on Figure 3-1 which shows all calibration points. While the jumper points themselves are not numbered, the resistor values are clearly marked. By consulting Figure 5-5 it will be possible to determine the jumper points and to see just which connections are to be made.

5.7 Digital Readout Maintenance The digital readout does not ordinarily require maintenance other than the replacement of lamp bulbs or an occasional cleaning. To remove the readout, proceed as follows:

1. Gently lift the black readout visor and then pull outward. The readout assembly is now exposed and the retaining side brackets may be observed.

2. Spread the two retaining side brackets and gently tilt the readout forward from the top, allowing the bottom to pivot.

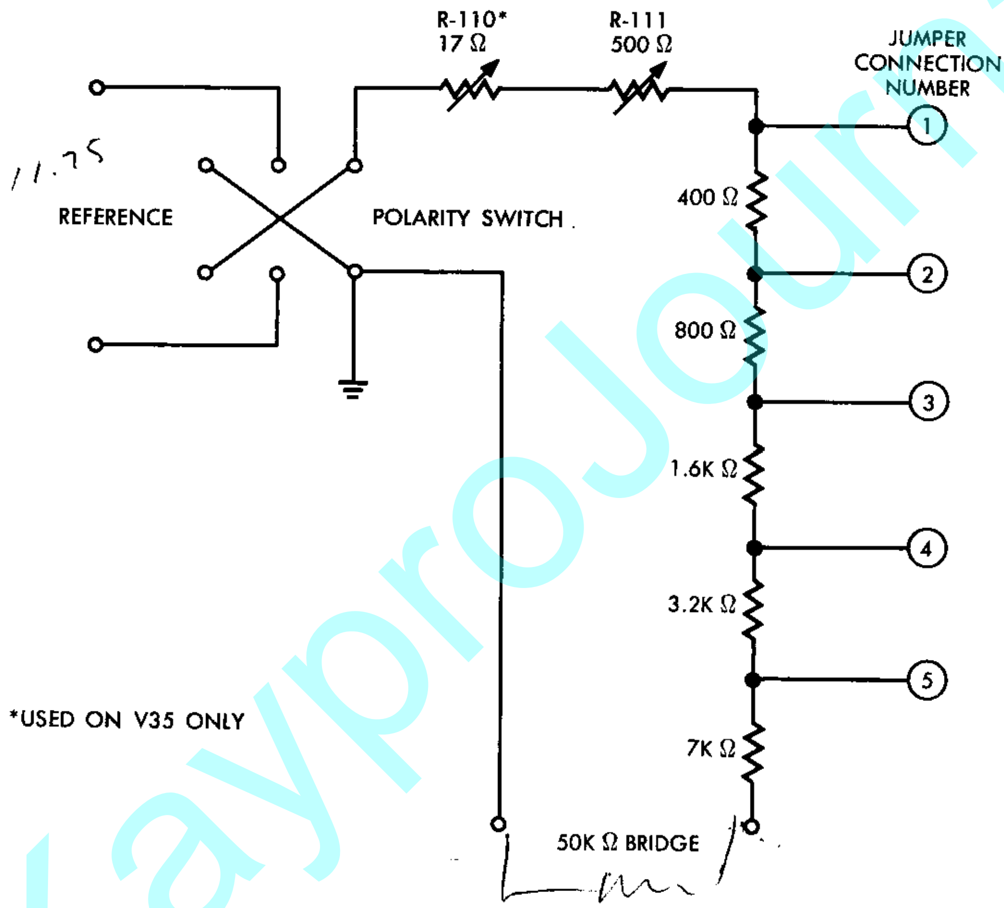
3. The readout is now free to continue its travel outward. Be certain to avoid exerting a direct pull; instead, allow the readout to come forward while keeping the pivot points seated in the pivot slots. At the end of travel the readout can be readily removed without danger of bending the lamp contact springs.

4. To replace the readout, first engage it at the pivot points. Failure to do so may cause the lamp springs to become bent. It will be necessary to spread aside the retaining end brackets to allow the body of the readout to return to its correct position. When the readout is in place, the retaining end brackets will normally fall into position, locking the readout.

Once the readout has been removed, the lamps may be extracted. Prior to replacing any lamps, the contact springs for the bulbs (in the readout receptacle) should be examined. If any are bent down, they should be gently lifted to the level of the others. To locate the proper bulb position, a drawing is provided on the main schematic at the end of this handbook. Note that this is a diagram of the readout contact board, *not* the readout.

Under extremely adverse dust or humidity conditions, the individual readout plates may require cleaning. If accumulated dust particles are likely to be unusually abrasive, a camel's hair brush or artist's sable brush should first be used to remove loose dust particles. The plates may then be cleaned with commercial isopropyl alcohol and lint-free paper such as Kimwipes 900-L manufactured by Kimberly Clark, Neenah, Wisconsin. The individual plates are readily slid out of their grooves by removing either structural end plate from the readout. It is well to be systematic about this operation so as to avoid replacing the plates in improper order. Care should be taken to avoid replacing the plates backwards; this sort of error is most likely to occur with plates marked 1, 0, 6, 8, or 9. Note that the engraved side always faces to the rear of the readout.

The Polaroid filter at the front of the display may be removed and cleaned in the same manner as the readout plates. Care should be taken to reinstall the filter so that the polarizing action is correct. Look through the filter at a piece of shiny metal, like the chrome rim of a wristwatch. If the metal shows a markedly violet cast, then the filter front is the surface closest to the eye.



VOLTS RANGE OF REF. FOR 10 VOLT BRIDGE	JUMPER CONNECTION NUMBERS	
12.700-12.600	———	———
12.620-12.520	1 & 2	———
12.540-12.440	2 & 3	———
12.460-12.360	1 & 3	———
12.380-12.280	3 & 4	———
12.300-12.200	3 & 4	1 & 2
12.220-12.120	2 & 4	———
12.140-12.040	1 & 4	———
12.060-11.960	4 & 5	———
11.980-11.880	4 & 5	1 & 2
11.900-11.800	4 & 5	2 & 3
11.820-11.720	4 & 5	1 & 3
11.740-11.640	3 & 5	———
11.660-11.560	3 & 5	1 & 2
11.580-11.480	2 & 5	———
11.500-11.400	1 & 5	———

Figure 5-5. Jumper Connections for 10 Volt Calibrate Resistors.

Section 6

RECOMMENDED SPARE PARTS LIST MODELS V34 & V35 DIGITAL VOLTMETERS

While any of the components shown may be purchased separately, a spares and service kit is designed to meet the spares requirements for 15 Series 30 instruments. In addition to spares, the kit contains extension boards which raise the plug-in circuits boards to a position which makes access convenient. Also in the kit is a dummy amplifier board to be used as explained in the Maintenance Section, 5.3.

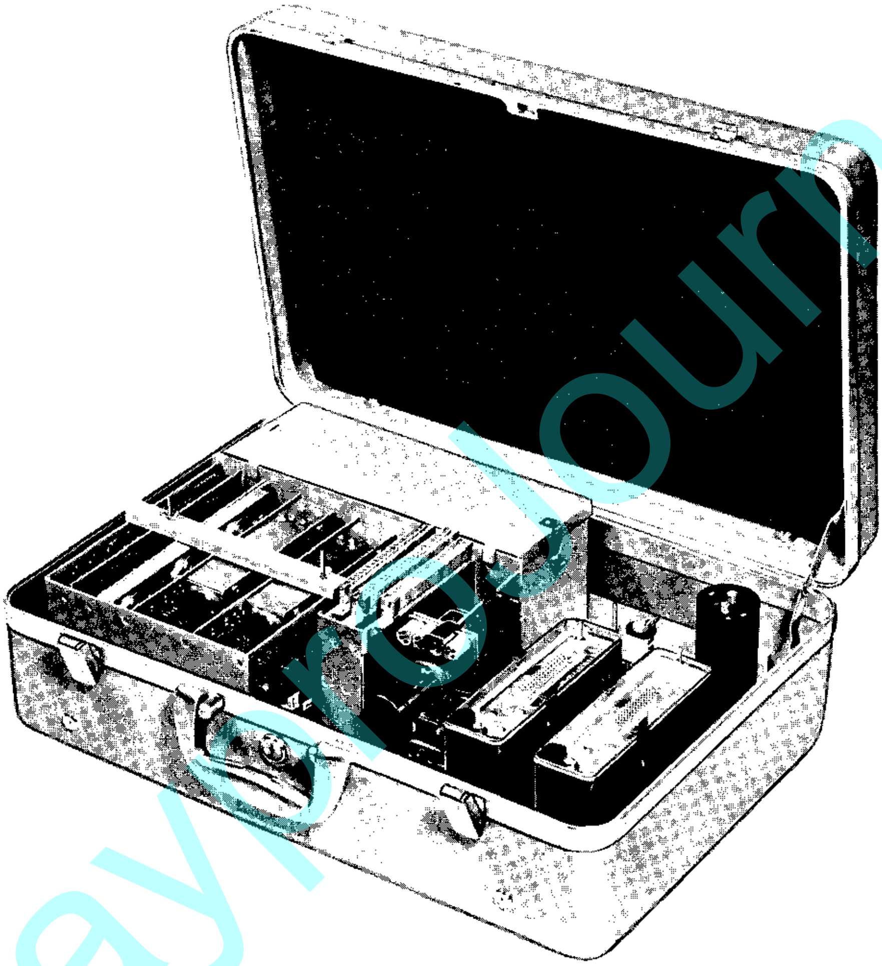


Figure 6-1. Spares and Service Kit.

Dummy Amplifier 3017-016

Extension Board (D Board) 3017-018

Extension Board (A, B, C Boards) 3017-022

Extension Board (Amplifier Board) 3017-019

NOMENCLATURE	PART NO.	SPARES REQ'D PER YEAR FOR TEN UNITS
Board "A"	11400-200	2
Board "B"	11400-300	2
Board "C" (V34 & V35 S/N 11.3069 & below)	11400-400	2
Board "C" (V34 & V35, S/N 11.3070 & higher)	11400-402	2
Board "D"	11400-500	2
Board Amplifier (V34 only)	11400-600	2
Board Amplifier (V35 only)	11500-600	2
Zener Assembly	11400-050	2
Capacitor	52RRB4M	2
Capacitor	05RTK500	2
Capacitor	52RM25	2
Capacitor	M2-30	2
Capacitor	05RM100	2
Capacitor	D2-473E	2
Capacitor (V34 only)	TE1211	2
Chopper	C1417-2	2
Diode	1N1124R	4
Diode	LD125	10
Diode	1N2071	4
Fuse, 3AG, 1 amp, Slo-Blo	313001	20
Lamp, 14 V	330	100
Potentiometer (V35 only)	025-R-17	2
Potentiometer	025-OL-1-500	2
Relay	11400-123	10
Relay	KRP11D	2
Relay	KRP14D	2
Resistor	PRC-5A-.6 ohm	4
Spring	12110-004	10
Switch, Decade	11400-700	2
Switch, Transfer	11400-730	2
Adapter, Decade 5 (V34 only)	11400-750	1

NOTE: Unless otherwise indicated, all parts are common to both the Model V34 and Model V35 digital voltmeter.

Section 7

PARTS LIST

This section lists the parts used with the Models V34 and V35 DVM's. Since these instruments rely upon plug-in components, the parts listing is broken down to a plug-in level. Circuit references to individual parts are coded according to the dash number of the schematic drawing associated with the particular board. For example, "D" board resistors are all numbered in the 500 series. R-1, in this example, is called out as R-501, both on the parts list and on the "D" board schematic. In each case the part number given is that of the manufacturer.

Circuit Reference	Part No.	Description	Manufacturer	Quan.	Not Used in V34	Not Used in V35
	11400-050	–ZENER SUPPLY ASSEMBLY–		1		
R-804	PW1719	Resistor, 25 K ohms, 1% WW	NLS	1		
R-807		Resistor, 5.6 ohms, 1W, 5%		1		
R-801	PW1719	Resistor, 300 ohms, .25% WW	NLS	1		
R-803, 806	PW1719	Resistor, 3.2 K ohms, .25% WW	NLS	2		
R-805	PW1719	Resistor, 1 K ohms, .25% WW	NLS	1		
Q-801	2N526	Transistor	GE	1		
CR-801, 802, 804	1N2071	Diode	TI	3		
CR-803	1N429	Diode	Hoffman	1		
R-808		Potentiometer, 17 ohms	Conelco	1		
R-802		Potentiometer, 200 ohms	Atohm	1		
C-801	05RM100	Capacitor, 100 mfd. 50VDC	Industrial Cond	1		
C-802	CM-20B-501	Capacitor, 500 mmfd, 600V, mica	Arco	1		
		Oven, 110VAC, 1$\frac{3}{16}$" ins. ht. 70°C	Bulova	1		
CR-811	020359A	Diode (in oven)	Hoffman	1		
R-811	PW1719	Resistor (in oven) 100 ohms, .5%	NLS	1		
		–MAIN BOARD ASSEMBLY–				
	70-3-2G	Knob, dial, Skirted Rd. Black	Raytheon	4		
	10019-005	Visor		1		
K-101, 102	KRP11D	Relay, DPDT, 12VDC, 120 ohm coil	Potter Brum.	2		
K-103, 104	KRP14D	Relay, 3PDT, 12VDC, 120 ohm coil	Potter Brum.	2		
	15004-075	Cable, Input		1		
	15004-077	Cable, External Reference		1		
K-105	11400-123	Relay		1		
K-105	11400-124	Shield, Relay, Magnetic		1		
F-101	313001	Fuse, 1 Amp. Slow Blow, 3AG	Littelfuse			
R-105	11400-111	Potentiometer, 1000 ohm, linear	Ohmite	1		
S-103	11400-120	Switch, Power, 3 Pole, 3 pos. shtg	Centralab (NLS)	1		
S-102	11400-121	Switch, Mode, 1 Pole, 4 pos. nsht	Centralab (NLS)	1		
S-101	11400-122	Switch, Function, 9 Pole, 5 pos. nsht	Centralab (NLS)	1		
L-101	11400-108	Choke		1		
T-101	11400-109	Transformer, power		1		
C-110, 111	05RM100	Capacitor, 100 mfd. 50 VDCW	Industrial Cond	2		
C-104, 105	52RRB4M	Capacitor, 4000 mfd. 25 VDCW	Industrial Cond	2		
C-106	05RTK500	Capacitor, 500 mfd. 50 VDCW	Industrial Cond	1		
C-102	52RM25	Capacitor, 25 mfd. 25 VDCW	Industrial Cond	1		
C-108, 109	52RM25	Capacitor, 25 mfd. 25 VDCW	Industrial Cond	2	X	
C-108, 109	52RM25	Capacitor, 100 mfd. 25 VDCW	Industrial Cond	2		X
C-101, 103	M2-30	Capacitor, paper, 1. mfd, 200VDC	Electron	2		
C-107	D2-473E	Capacitor, Mylar, .047 mfd. 300VDC	Electron	1		
R-110	025-R-17	Potentiometer, 17 ohm	Conelco	1	X	
R-111	025-OL-1-500	Potentiomter, 500 ohm	Conelco	1		
R-117	KC 60	Resistor, Carb. film, 50K, ¼W 1%	Key	1		
R-112	AW816	Resistor, 400 ohm, 0.1W 1%	NLS	1		
R-113	AW816	Resistor, 800 ohm, 0.1W 1%	NLS	1		
R-114	AW816	Resistor, 1.6K, 0.1W 1%	NLS	1		
R-115	AW816	Resistor, 3.2K, 0.1W 1%	NLS	1		
R-116	AW1720	Resistor, 7 K, 0.1W, .05%	NLS	1		
R-127		Resistor, 39 ohms, ½W 10%		1		
R-108, 108		Resistor, 0.5 ohm, 5W, 1%	PRL	2		
R-104		Resistor, 27K ohms, ½W 10%		1		
R-109		Resistor, 180 ohms, 1W, 10%		1		
R-101		Resistor, 5.1 K ohms, ½W, 5%		1		
R-103		Resistor, 270 ohms, ½W, 10%		1		
R-118		Resistor, 1 K ohms, ½W, 10%		1		
R-102		Resistor, 4.7 K ohms, ½W, 10%		1		
R-106		Resistor, 1 Meg. ½W, 10%		1		
R-119		Resistor, 47 ohms, ½W, 10%		1		
R-120		Resistor, 100 ohms, ½W, 10%		1		
R-121, 122		Resistor, 10 K ohms, ½W, 10%		2	X	
R-121, 122		Resistor, 1.3 K ohms, ½W, 10%		2		X
R-123, 124		Resistor, 47 K ohms, ½W, 10%		2	X	
R-123, 124		Resistor, 130 ohms, ½W, 10%		2		X
CR-111, 112	1N1124R	Rectifier	TI	2		
CR-115-122	1N34A	Diode	CBS	8		
CR-102, 109, 110, 113, 114, 123-126	1N2071	Diode	TI	9		

Circuit Reference	Part No.	Description	Manufacturer	Quan.	Not Used in V34	Not Used in V35
		–"A" BOARD ASSEMBLY–		1		
Q201-208	2N185	Transistor	TI	8		
CR201-230	1N34A	Diode	CBS	30		
C-201, 202, 206	M2-30	Capacitor, paper, 1 mfd, 200VDC	Electron	3		
C-203, 204, 205, 208, 210, 207	S36AGD103PYV	Capacitor, Ceramic, .01, 500 VDCW	AB	6		
C-209	D2473E	Capacitor, Mylar, .047, 200 VDCW	Electron	1		
R-214, 218		Resistor, 100 ohms, ½W, 10%		2		
R-201, 204, 206, 210, 215, 221, 222, 227, 228, 232		Resistor, 1 K ohms, ½W, 10%		10		
R-216, 220		Resistor, 2.2 K ohms, ½W, 10%		2		
R-205, 223, 226		Resistor, 4.7 K ohms, ½W, 10%		3		
R-208, 212, 217, 224, 230, 233, 235-239		Resistor, 10 K ohms, ½W, 10%		11		
R-207, 209, 211, 213, 219, 225, 229, 231, 234		Resistor, 27 K ohms, ½W, 10%		9		
R-202, 203		Resistor, 13 K ohms, ½W, 5%		2		
		–"B" BOARD ASSEMBLY–				
Q-308	2N444A	Transistor	GI	1		
Q-301-307, 309, 310	2N185	Transistor	TI	9		
CR301-328, 331-334, 336	1N34A	Diode		33		
CR329, 330	1N461					
CR-335	1N753	Diode	TI	2		
C-305	D2-473E	Capacitor, Mylar, .047, 200 WVDC	Electron	1		
C-301-307, 309-311	S36AGD103PYV	Capacitor, Ceramic, .01, 500 WVDC	AB	10		
R-302, 307, 323, 327, 334, 335, 344, 348, 354		Resistor, 1 K ohms, ½W, 10%		9		
R-303, 311, 337, 352, 341, 342		Resistor, 2.2 K ohms, ½W, 10%		6		
R-305, 314, 316, 322, 326, 333, 343, 344, 346, 353, 355		Resistor, 4.7 K ohms, ½W, 10%		11		
R-304, 308, 315, 319, 325, 329, 336, 338, 349, 356,		Resistor, 10 K ohms, ½W, 10%		10		
R-301, 306, 309, 310, 313, 317, 320, 321, 325, 329, 332, 340, 350, 351, 347		Resistor, 27 K ohms, ½W, 10%		15		
R-312, 318		Resistor, 620 ohms, ½W, 5%		2		
R-324, 328		Resistor, 220 K ohms, ½W, 10%		2		
		–"C" BOARD ASSEMBLY–		1		
Q-401-410	2N185	Transistor	TI	10		
CR-401-403, 407-410, 412-426	1N34A	Diode	CBS	22		
CR-404, 405	1N461	Diode	TI	2		
CR-406, 411	1N774A	Diode	Gt	2		
C-402	52RM25	Capacitor, 25 mfd, 25 WVDC	Industrial Cond	1		
C-401, 405, 406	D2-473E	Capacitor, Mylar, .047, 200 WVDC	Electron	3		
C-403, 404, 407, 408, 409, 410	S36AGD103PYV	Capacitor, Ceramic, .01, 500 WVDC	AB	6		
R-401, 409, 415, 427, 438, 440		Resistor, 1 K ohms, ½W, 10%		7		
R-402, 412, 420, 429, 434		Resistor, 2.2 K ohms, ½W, 10%		5		
R-405, 408, 425, 403		Resistor, 4.7 K ohms, ½W 10%		4		
R-404, 406, 410, 416, 417, 423, 424, 426, 432, 433		Resistor, 10 K ohms, ½W, 10%		10		
R-407, 418, 419, 421, 428, 230		Resistor, 27 K ohms, ½W, 10%		6		
R-411, 413		Resistor, 220 K ohms, ½W, 10%		2		
R-435, 436		Resistor, 39 ohms, ½W, 10%		2		
R-414, 422, 431		Resistor, 3 K ohms, ½W, 5%		3		
		–"D" BOARD ASSEMBLY–		2		
	NOTE: The 30-series instruments each use two "D" boards. Quantities listed in this parts list are for one board only.					
Q-501, 503, 505	2N185	Transistor	TI	3		
Q-502, 504, 506	2N456	Transistor	TI	3		
CR-501-503	LD125	Diode	CBS	3		
C-501-503	M2-30	Capacitor, 1 mfd, 200 WVDC	Electron	3		
R-501-505, 509		Resistor, 100 ohms, 1W, 10%		3		
R-504, 508, 512		Resistor, 1 K ohms, ½W, 10%		3		
R-503, 502, 506, 507, 510, 511		Resistor, 4.7 K ohms, ½W, 10%		6		

PARTS LIST

Circuit Reference	Part No.	Description	Manufacturer	Quan.	Not Used in V34	Not Used in V35
		–AMPLIFIER ASSEMBLY–		1		
K-603	C1417-2	Chopper, 188 ohm CT coil	Bristol	1		
K-601, 602	11400-123	Relay		2		
T-601, 602	90464-J	Transformer	Harder	2		
T-603	90464-H	Transformer	Harder	1		
Q-601, 603, 604	2N582	Transistor	RCA	3		
Q-606-609	2N581	Transistor	RCA	4		
Q-602, 610	2N185	Transistor	TT	2		
Q-605	2N44A	Transistor	GT	1		
CR-601	1N456	Diode	Hughes	1		
CR-605, 606	1N192	Diode	Hughes	2		
CR-602, 603, 604, 607, 608	1N34A	Diode	CBS	5		
CR-609	1N753	Diode	TI	1		
CR-610, 611	1N458	Diode	Hughes	2		
C-606	21RM100	Capacitor, 100 mfd, 12 VDCW	Industrial Cond	1		
C-603, 605, 607	M2-30	Capacitor, 1 mfd, 200 VDCW	Electron	3		
C-604	D2-473E	Capacitor, Mylar, .047, 200 VDCW	Electron	1		
C-601	XK2-682	Capacitor, Polyst., .0068, 200V	Electron	1		
C-602	XL2-222	Capacitor, Polyst., .0022, 200V	Electron	1		
C-608	DD102	Capacitor, Ceramic, .001, 1000V	Centralab	1		
R-623	275-1-103	Potentiometer, 10 K ohms	Bourns	1		
R-632	275-1-102	Potentiometer, 1 K ohms	Bourns	1		
R-608	025-OL-1-2K	Potentiometer, 2 K ohms	Conelco	1		
R-610	025-OL-1-200	Potentiometer, 200 ohms	Conelco	1		
R-654	025-OL-1-20	Potentiometer, 20 ohms	Conelco	1		X
R-611	RW1818SP	Resistor, 89.9 K ohms, ½W, .05%	NLS	1		X
R-655	RW1818SP	Resistor, 9.991 K ohms, ½W, .05%	NLS	1		X
R-602-607	RW1818SP	Resistor, 1.5 Meg., ½W, .05%	NLS	6		
R-609	RW1818SP	Resistor, 899 K ohms, ½W, .05%	NLS	1		
R-611	RW1818SP	Resistor, 99.911 K ohms, ½W, .05%	NLS	1	X	
R-640		Resistor, 470 ohms, ½W, 10%		1		
R-630, 638, 645		Resistor, 1K ohms, ½W, 10%		3		
R-634, 639, 641, 642, 644, 649, 653		Resistor, 4.7K ohms, ½W, 10%		7		
R-613, 628, 629, 636, 637, 646, 648, 651, 650		Resistor, 10K ohms, ½W, 10%		9		
R-652		Resistor, 27 K ohms, ½W, 10%		1		
R-601		Resistor, 100 K ohms, ½W, 10%		1		
R-635, 647		Resistor, 15 K ohms, ½W, 10%		2		
R-619, 617		Resistor, 75 ohms, ½W, 5%		2		
R-621		Resistor, 620 ohms, ½W, 5%		1		
R-616, 618, 620, 625, 633, 643		Resistor, 2 K ohms, ½W, 5%		6		
R-615, R-622		Resistor, 30 K ohms, ½W, 5%		2		
R-627, 624		Resistor, 51 ohms, ½W, 5%		2		
R-614, 626		Resistor, 130 ohms, ½W, 5%		2		
R-631		Resistor, 360 ohms, ½W, 5%		1		
	12184	–READOUT ASSEMBLY, 3W5, Invert.	NLS	1		
	330	Bulb, 14 V, for readout	GE	56		
	11400-700	–DECADE SWITCH ASS'Y, sealed–	NLS	5	X	
	11400-700	–DECADE SWITCH ASS'Y, sealed–	NLS	4		X
	11400-730	–TRANSFER SWITCH ASS'Y, sealed–	NLS	1		
	11400-750	–DECADE #5 ADAPTER–	NLS			X

Non-Linear Systems, Inc. warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any instrument returned, prepaid, to the factory for that purpose.

This warranty does not cover tubes, transistors, choppers, fuses, or batteries. However, non-oil-bathed stepping switches are guaranteed for 90 days provided they have been lubricated in accordance with manufacturer's instructions.

Instruments returned to the factory are accepted only when prior authorization has been given by an authorized representative of Non-Linear Systems, Inc.

Non-Linear Systems, Inc. reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of Non-Linear Systems, Inc., and Non-Linear Systems, Inc., neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of Non-Linear Systems, Inc. instruments.

SHIPPING INSTRUCTIONS

Depending upon location, the choice of carrier will vary. Never ship an instrument to us without having received shipping instructions. If requested, an estimate of charges can be made before work begins.

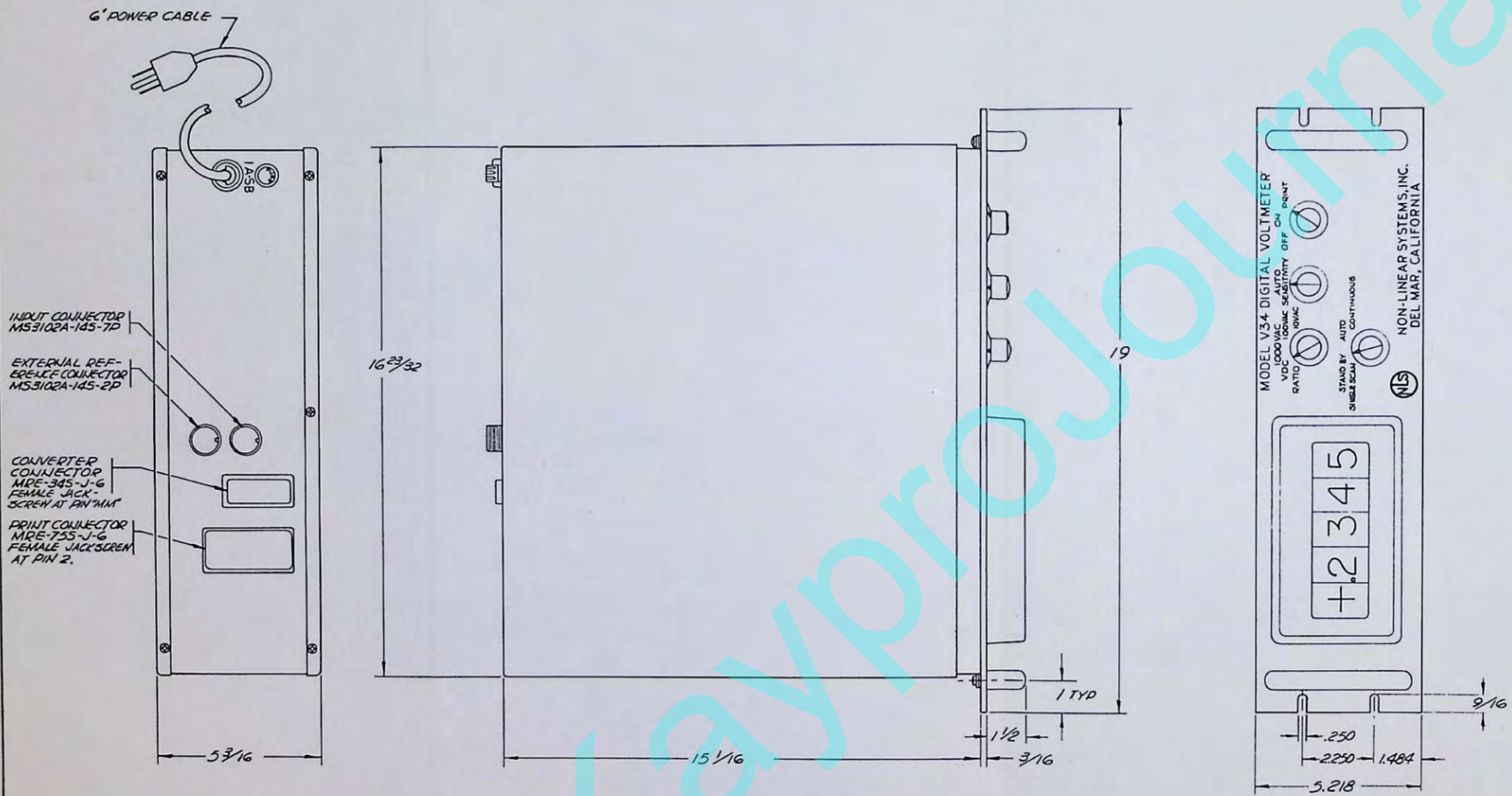
Be certain to pack the instrument carefully; while an outer and inner box, separated by two or three inches of excelsior is desirable, the instrument can be placed into a single container provided it is so packed that it will not shift about. As with the double box method, use two or three inches of shock-absorbent packing materials. The instrument itself should be first wrapped in heavy paper so as to keep excelsior or other particles from entering the instrument's louvres.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it does not operate or is damaged, a claim should be made with the carrier. The claim agent should receive a full report of damage, and this report sent to Non-Linear Systems, Inc. After receiving such a report we will advise you of the disposition of the instrument and arrange for its repair or replacement. Be certain to include model and serial number when corresponding.

REVISIONS

SYM	EFFECT.	DESCRIPTION	DATE	APPROVAL
1		REVISED ACCURACY SPEC & EXTERNAL REF VOLTAGE	10-16-59 KLOB	10-16-59



INSTRUMENT CHARACTERISTICS

GENERAL

STRUCTURE FABRICATED FROM ALUMINUM ALLOY.
PRINTED CIRCUIT BOARDS MADE FROM COPPER CLAD EPOXY.
READOUT WINDOWS MADE FROM PLEXIGLASS.
VISOR MADE FROM HIGH IMPACT STYRENE PLASTIC.
FRONT PANEL PAINTED LIGHT GRAY PER MIL-E-15090B, TYPE 3, CLASS 1.
CABINET PAINTED LIGHT GRAY PER MIL-E-15090B, TYPE 3, CLASS 2.

ELECTRICAL

DIGITS DISPLAYED - 4.
VOLTAGE RANGE, DC VOLTS: ±.9999/9.999/99.99/999.9
RANGE CHANGING: AUTOMATIC
POLARITY CHANGING: AUTOMATIC
INPUT IMPEDANCE: 10 MEGOHMS
INTERNAL REFERENCE VOLTAGE: TEMPERATURE COMPENSATED, ZENER DIODE TYPE DC POWER SUPPLY.

ACCURACY: ± 1 DIGIT

RESOLUTION: 1 DIGIT
EXTERNAL REFERENCE VOLTAGE ±1 VDC.
EXTERNAL REFERENCE LOAD 50,000 OHMS.
PRIMARY POWER: 115/230 VOLTS ±10%, 50-60 CPS APPROXIMATELY 50 VOLT-AMPS.

FEATURES

INDIVIDUAL PLUG-IN OIL BATH STEPPING SWITCHES.
COMPLETELY TRANSISTORIZED.
BALANCING TIME MAXIMUM: 1.9 SECONDS
AVERAGE: .75 SECOND
SNAP IN READOUT

CONNECTIONS

SIGNAL INPUT CONNECTOR:
- A - INPUT
- B - INPUT COMMON
- C - CHASSIS GROUND

EXTERNAL REFERENCE CONNECTOR:
- A - + REFERENCE
- B - - REFERENCE
- C - REFERENCE COMMON
- D - CHASSIS GROUND

11400 SHT 3

1

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

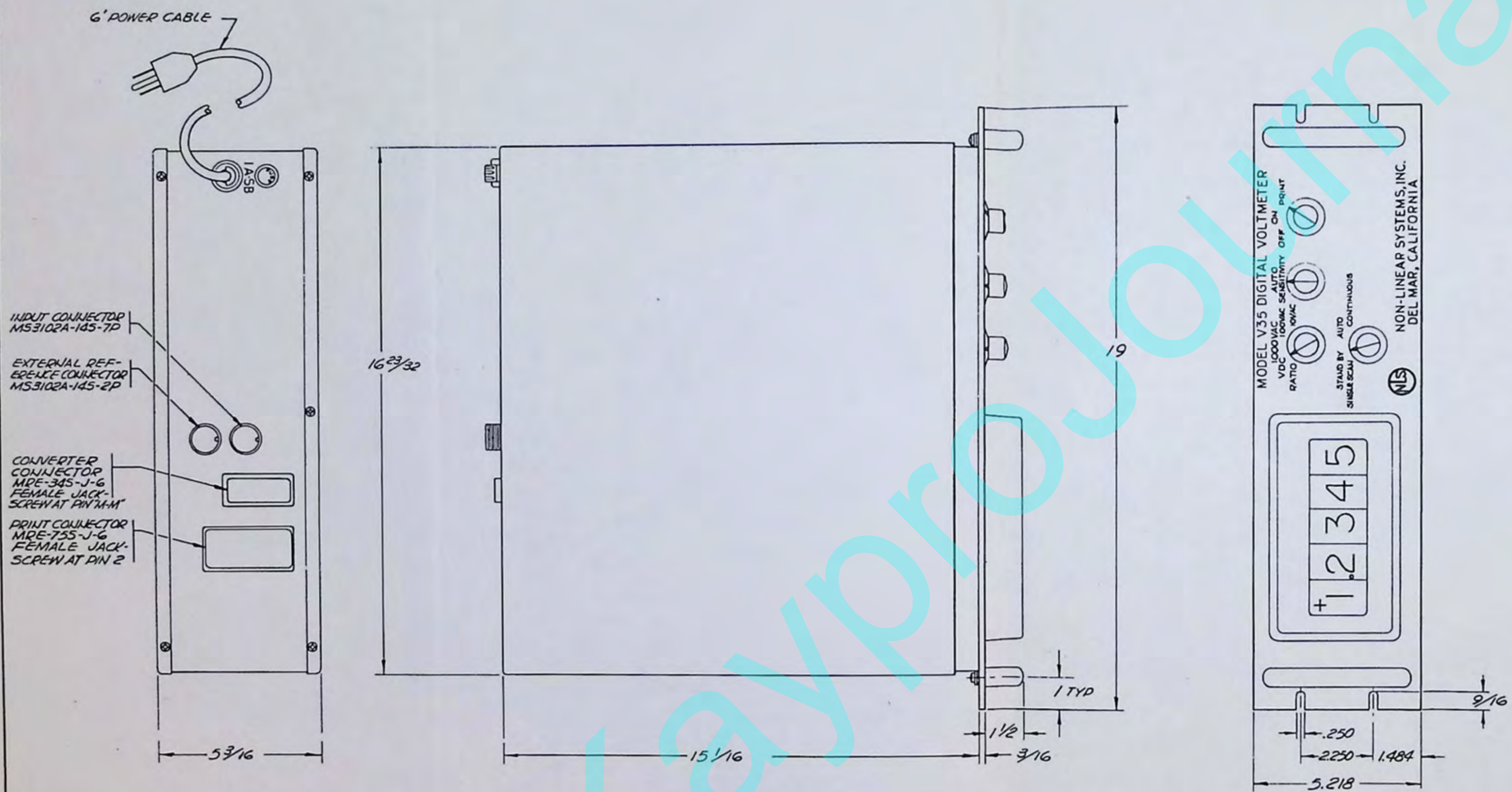
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTION ± 1/32 DECIMAL ±.010 ANGLES ±
MATERIAL —
DRAWN BY H. BRINLEY DATE 5-11-59
CHECKED BY [illegible] DATE 5-14-59
APPROVED BY [illegible] DATE 5/19/59
FINISH —

TITLE: DIGITAL VOLTMETER MODEL V34 OUTLINE DRAWING

NLS NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400
SCALE 1/2 WT.
SHEET 3 OF

:REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL
1		REVISED ACCURACY SPEC & EXTERNAL REF VOLTAGE.	10-16-59 [illegible]	[illegible] 10-16-59



INSTRUMENT CHARACTERISTICS

GENERAL

STRUCTURE FABRICATED FROM ALUMINUM ALLOY.
PRINTED CIRCUIT BOARDS MADE FROM COPPER CLAD EPOXY.
READOUT WINDOWS MADE FROM PLEXIGLASS.
VISOR MADE FROM HIGH IMPACT STYRENE PLASTIC.
FRONT PANEL PAINTED LIGHT GRAY PER MIL-E-15090B, TYPE 3, CLASS 1.
CABINET PAINTED LIGHT GRAY PER MIL-E-15090B, TYPE 3, CLASS 2.

ELECTRICAL

DIGITS DISPLAYED - 5.
VOLTAGE RANGE, DC VOLTS: ± 9.9999/ 99.999/999.99
RANGE CHANGING: AUTOMATIC
POLARITY CHANGING: AUTOMATIC
INPUT IMPEDANCE: 10 MEGOHMS
INTERNAL REFERENCE VOLTAGE: TEMPERATURE COMPENSATED, ZENER DIODE TYPE DC POWER SUPPLY.
ACCURACY: ±.01% OF READING OR ±1 DIGIT.

RESOLUTION: 1 DIGIT
EXTERNAL REFERENCE VOLTAGE ±10 VDC.
EXTERNAL REFERENCE LOAD 50,000 OHMS.
PRIMARY POWER: 115/230 VOLTS ±10%, 50-60 CPS APPROXIMATELY 50 VOLT-AMPS.

FEATURES

INDIVIDUAL PLUG-IN OIL BATH STEPPING SWITCHES.
COMPLETELY TRANSISTORIZED.
BALANCING TIME MAXIMUM: 2.3 SECONDS
AVERAGE: 1 SECOND
SNAP IN READOUT

CONNECTIONS

SIGNAL INPUT CONNECTOR:
- A - INPUT
- B - INPUT COMMON
- C - CHASSIS GROUND

EXTERNAL REFERENCE CONNECTOR:
- A - + REFERENCE
- B - - REFERENCE
- C - REFERENCE COMMON
- D - CHASSIS GROUND

11500 SHT 3

1

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTION ± 1/32 DECIMAL ±.010 ANGLES ±
MATERIAL —

DRAWN BY H. BRINLEY DATE 5-11-59
CHECKED BY [illegible] DATE 5-19-59
APPROVED BY [illegible] DATE 5/19/59
FINISH —

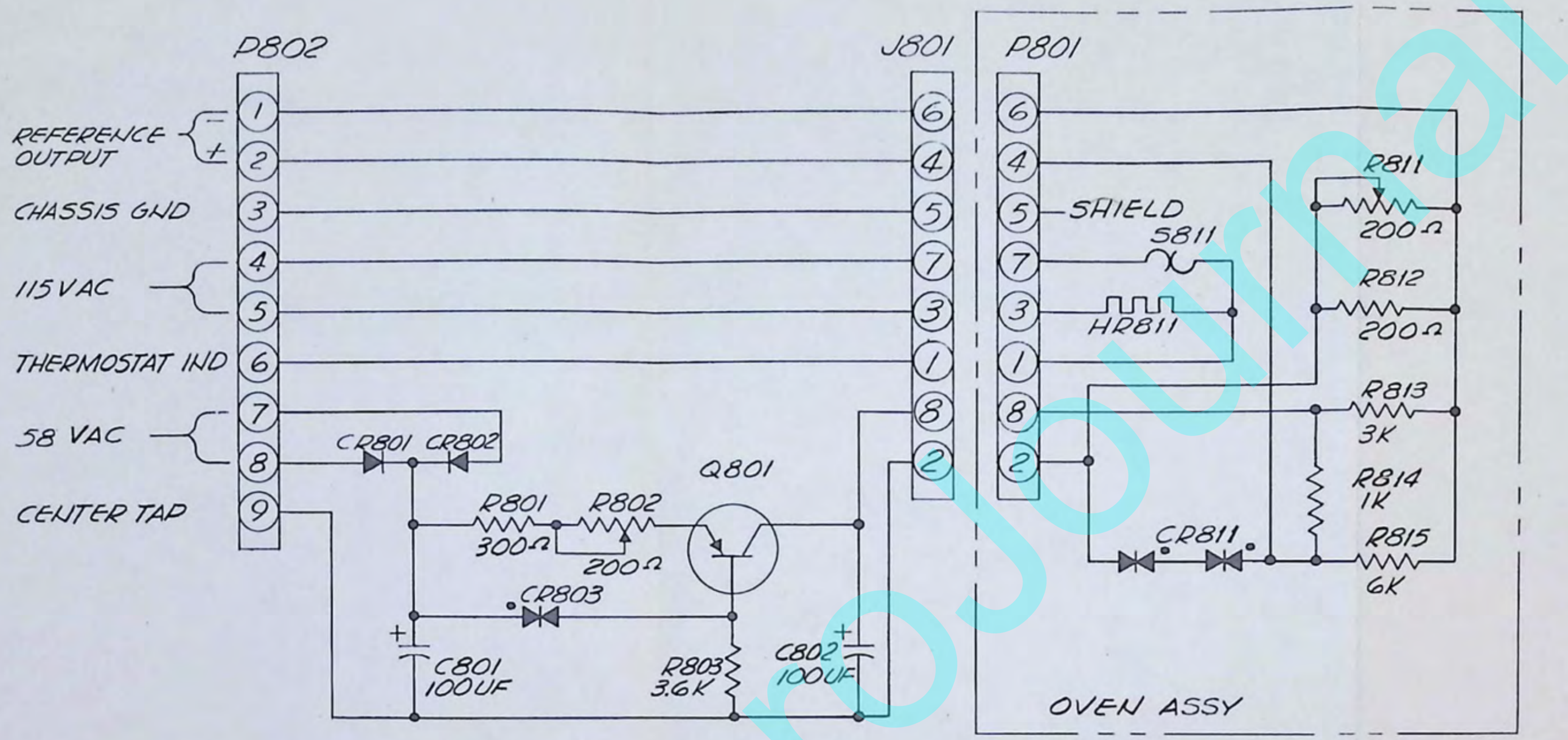
TITLE DIGITAL VOLTMETER MODEL V35 OUTLINE DRAWING

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11500
SCALE 1/2 WT.
SHEET 3 OF

REVISIONS

SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL



11400-050 SHT 2

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±
MATERIAL
FINISH

DRAWN BY H. BRINLEY DATE 5-6-59
CHECKED BY DATE
APPROVED BY [illegible] DATE 5-6-59

TITLE ZENER SUPPLY SCHEMATIC

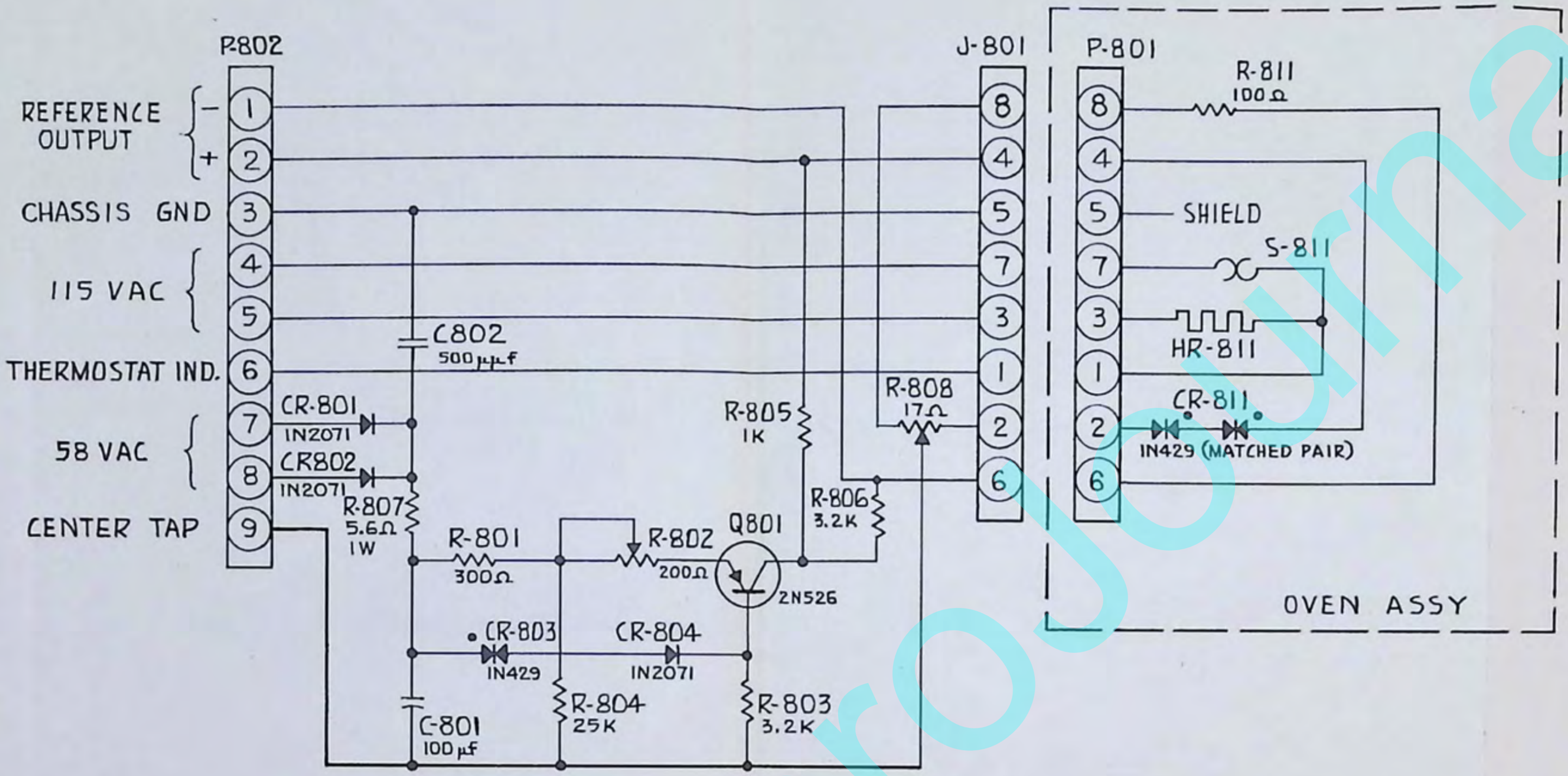
MODEL V34 & 35

SCALE NONE WT.

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-050
SHEET 2 OF

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL
1	1	REVISED & REDRAWN	11-20-59 ARW	H Clement
2		P-802-1 WAS TO R-808 & J801-6 J-801-8 WAS TO R-806	12-21-59 ARW	H Clement
3	AL	ADDED IDENTIFICATION OF DIODES TRANSISTOR & VALUE OF R802	3-23-60 ARW	Soulé



11400-050
SHEET 2

3

⚠1 REVISION 1 EFFECTIVE AS FOLLOWS: MODELS V34 & V35 (11400 & 11500): N372 & ON; MODEL 50 (9000): N363 & ON (S/N 11.3190 & ON)

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
	9000		
	11500		
	11400		
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±
MATERIAL

DRAWN BY H. BRINLEY — DATE 5-6-59
CHECKED BY — DATE
APPROVED BY J.N.N. — DATE 11-20-59
FINISH

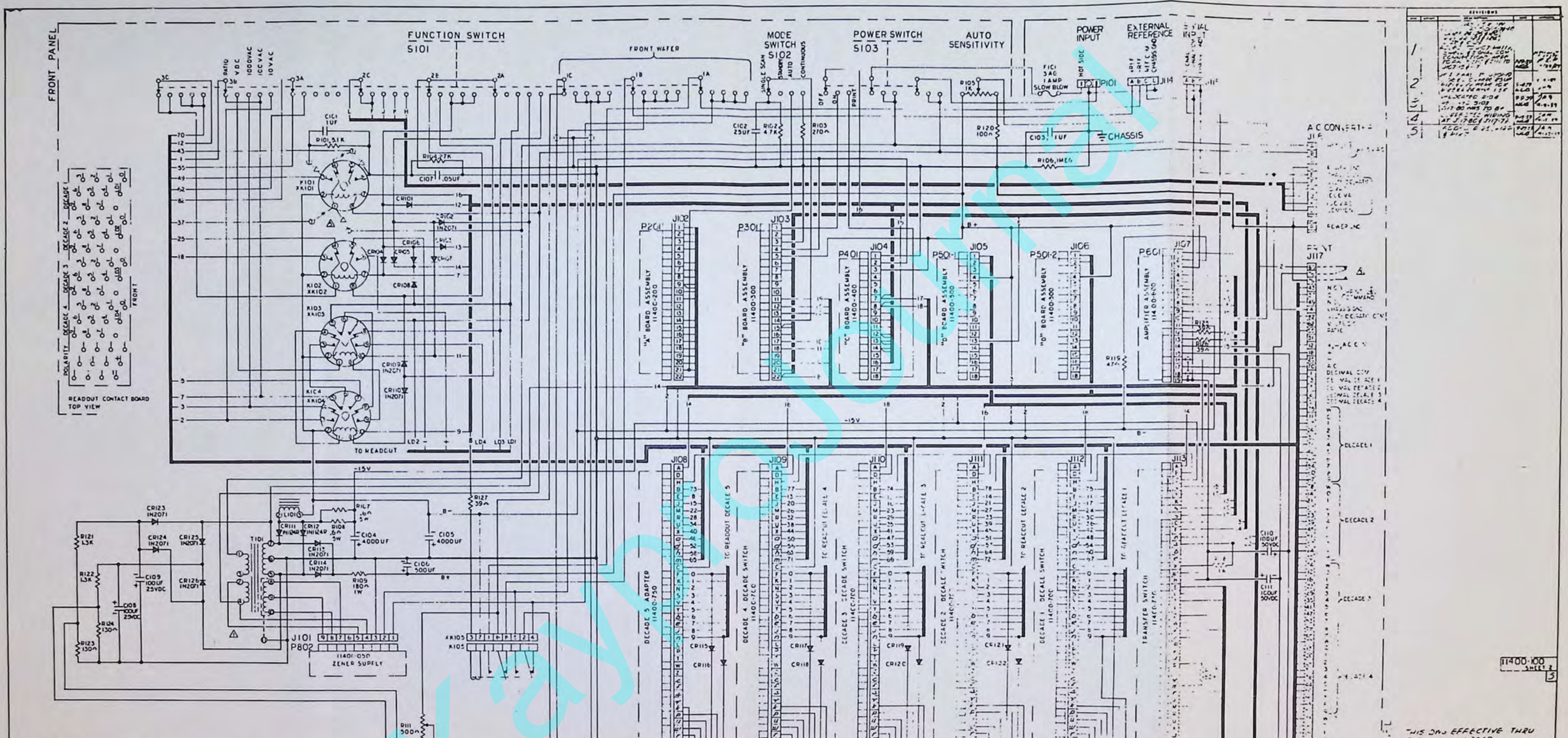
TITLE
SCHEMATIC-
ZENER SUPPLY

MODEL-V34

SCALE — WT.

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-050
SHEET 2 OF



6. DIODES ARE TYPE 1N34A.

5. ✱ CONNECTIONS FOR IBM ETC (FORM C) (NORMAL CONNECTIONS)
△ CONNECTIONS FOR CLARY PRINTER (115VAC PULSE)

4. MOMENTARY TRANSFER OF FORM C CONTACTS OR MOMENTARY PULSE OF 115VAC AT END OF SCAN WHEN IN "PRINT" (SEE △)

3. MOMENTARY TRANSFER OF PRINTER CONTACTS CAUSES VOLTMETER TO START SCAN AT COMPLETION OF TRANSFER.

2. CERTAIN COMBINATIONS ARE SHORTED TO COMPENSATE FOR ZENER DIODE VOLTAGE (SEE MANUAL)

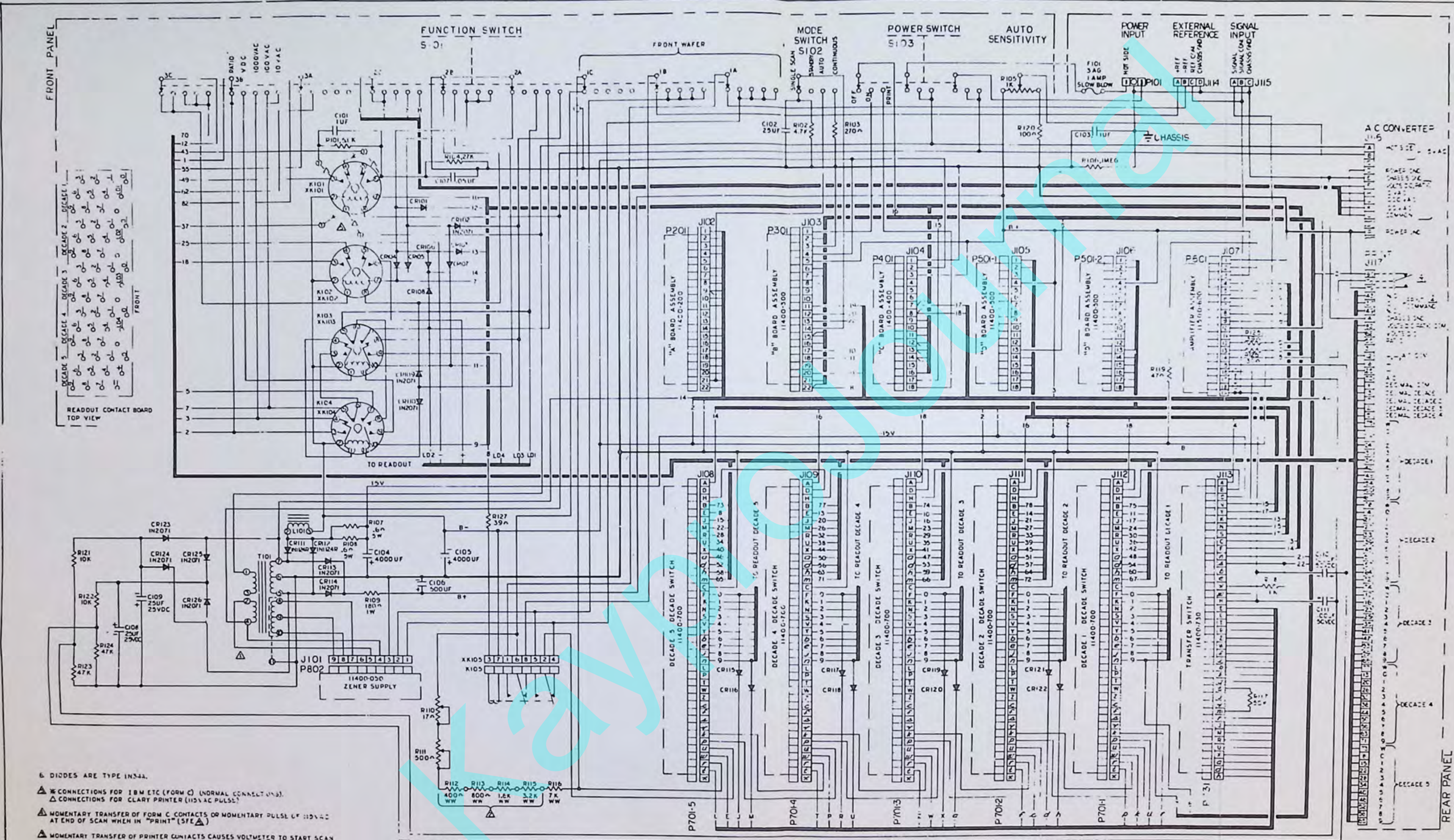
1. FOR 115VAC POWER: JUMPER TERMINALS 1 TO 2 AND 3 TO 4 ON POWER TRANFORMER
FOR 230VAC POWER: JUMPER TERMINALS 2 TO 3 ON POWER TRANSFORMER

NOTES: UNLESS OTHERWISE SPECIFIED

MAIN BOARD ASSEMBLY, SCHEMATIC MODEL V34

NON-LINEAR SYSTEMS INC

11400-100



THIS DWG EFFECTIVE THRU SERIAL NO. 11.3069

6. DIODES ARE TYPE 1N34A.

△ ✱ CONNECTIONS FOR IBM ETC (FORM C) (NORMAL CONNECTIONS).
△ CONNECTIONS FOR CLARY PRINTER (115VAC PULSE)

△ MOMENTARY TRANSFER OF FORM C CONTACTS OR MOMENTARY PULSE OF 115VAC AT END OF SCAN WHEN IN "PRINT" (SEE △)

△ MOMENTARY TRANSFER OF PRINTER CONTACTS CAUSES VOLTMETER TO START SCAN AT COMPLETION OF TRANSFER.

△ CERTAIN COMBINATIONS ARE SHORTED TO COMPENSATE FOR ZENER DIODE VOLTAGE. (SEE MANUAL)

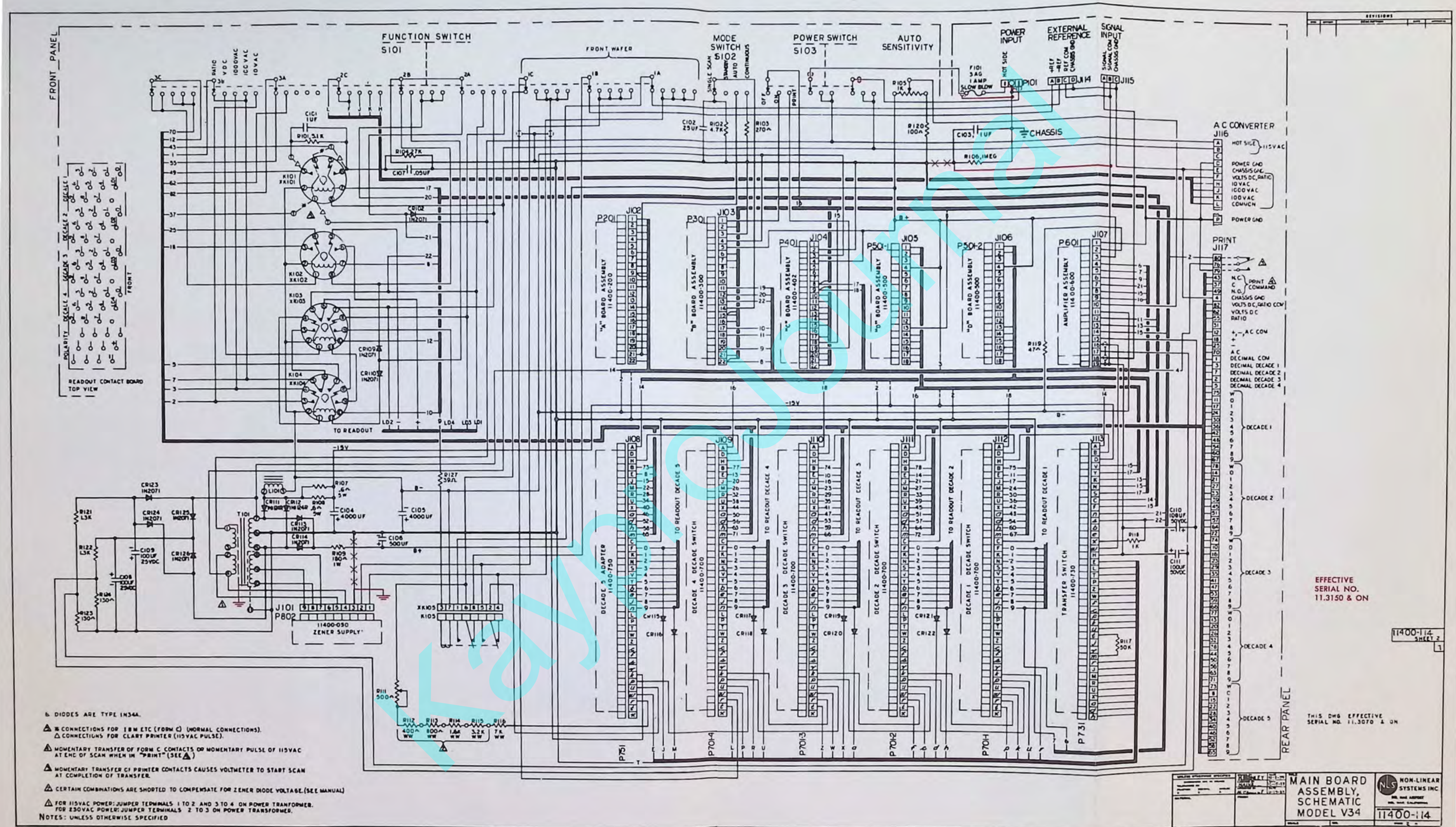
△ FOR 115VAC POWER: JUMPER TERMINALS 1 TO 2 AND 3 TO 4 ON POWER TRANSFORMER
FOR 230VAC POWER: JUMPER TERMINALS 2 TO 3 ON POWER TRANSFORMER

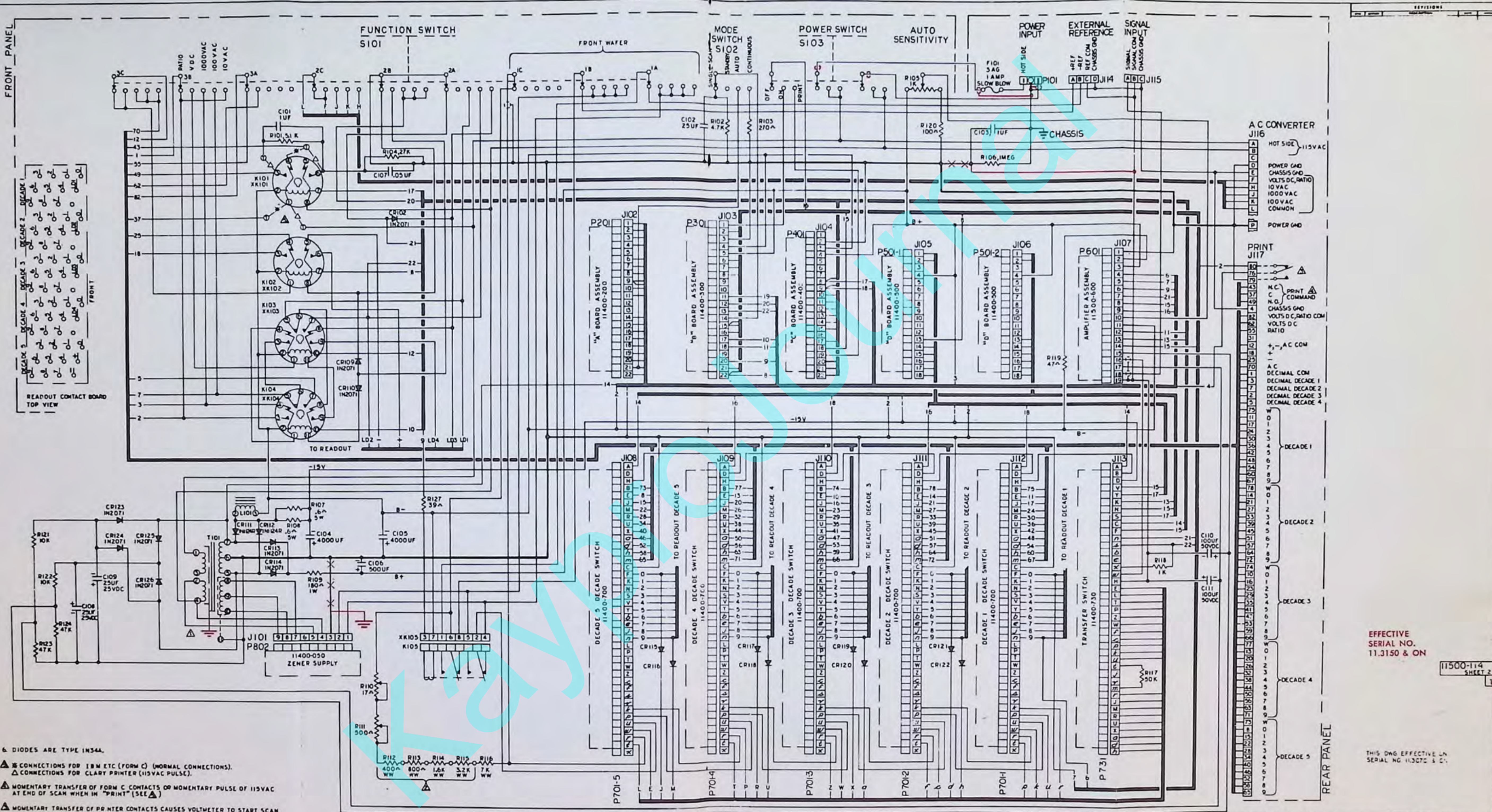
NOTES: UNLESS OTHERWISE SPECIFIED

MAIN BOARD ASSEMELY, SCHEMATIC MODEL V35

NON LINEAR SYSTEMS INC.

11500-100


FRONT PANEL
FUNCTION SWITCH S101
FRONT WAFER
MODE SWITCH S102
POWER SWITCH S103
AUTO SENSITIVITY
POWER INPUT
EXTERNAL REFERENCE
SIGNAL INPUT
F101 3AG 1 AMP SLOW BLOW
P101
J114
J115
CHASSIS
A C CONVERTER J116
PRINT J117
READOUT CONTACT BOARD TOP VIEW
"A" BOARD ASSEMBLY 11400-200
"B" BOARD ASSEMBLY 11400-300
"C" BOARD ASSEMBLY 11400-402
"D" BOARD ASSEMBLY 11400-500
AMPLIFIER ASSEMBLY 11400-600
DECADE 5 ADAPTER 11400-750
DECADE 4 DECADE SWITCH 11400-700
DECADE 3 DECADE SWITCH 11400-700
DECADE 2 DECADE SWITCH 11400-700
DECADE 1 DECADE SWITCH 11400-700
TRANSFER SWITCH 11400-730
TO READOUT
11400-050 ZENER SUPPLY
REAR PANEL
EFFECTIVE SERIAL NO. 11.3150 & ON
THIS DWG EFFECTIVE SERIAL NO. 11.3070 & ON
11400-114 SHEET 2
6. DIODES ARE TYPE 1N34A.
CONNECTIONS FOR IBM ETC (FORM C) (NORMAL CONNECTIONS).
CONNECTIONS FOR CLARY PRINTER (115VAC PULSE).
MOMENTARY TRANSFER OF FORM C CONTACTS OR MOMENTARY PULSE OF 115VAC AT END OF SCAN WHEN IN "PRINT" (SEE)
MOMENTARY TRANSFER OF PRINTER CONTACTS CAUSES VOLTMETER TO START SCAN AT COMPLETION OF TRANSFER.
CERTAIN COMBINATIONS ARE SHORTED TO COMPENSATE FOR ZENER DIODE VOLTAGE.(SEE MANUAL)
FOR 115VAC POWER: JUMPER TERMINALS 1 TO 2 AND 3 TO 4 ON POWER TRANFORMER.
FOR 230VAC POWER: JUMPER TERMINALS 2 TO 3 ON POWER TRANSFORMER.
NOTES: UNLESS OTHERWISE SPECIFIED
MAIN BOARD ASSEMBLY, SCHEMATIC MODEL V34
NON-LINEAR SYSTEMS INC
11400-114



EFFECTIVE SERIAL NO. 11.3150 & ON

11500-114 SHEET 2

THIS DWG EFFECTIVE ON SERIAL NO 11.3070 & ON

6. DIODES ARE TYPE IN34A.

△ CONNECTIONS FOR IBM ETC (FORM C) (NORMAL CONNECTIONS).
△ CONNECTIONS FOR CLARY PRINTER (115VAC PULSE).

△ MOMENTARY TRANSFER OF FORM C CONTACTS OR MOMENTARY PULSE OF 115VAC AT END OF SCAN WHEN IN "PRINT" (SEE △)

△ MOMENTARY TRANSFER OF PRINTER CONTACTS CAUSES VOLTMETER TO START SCAN AT COMPLETION OF TRANSFER.

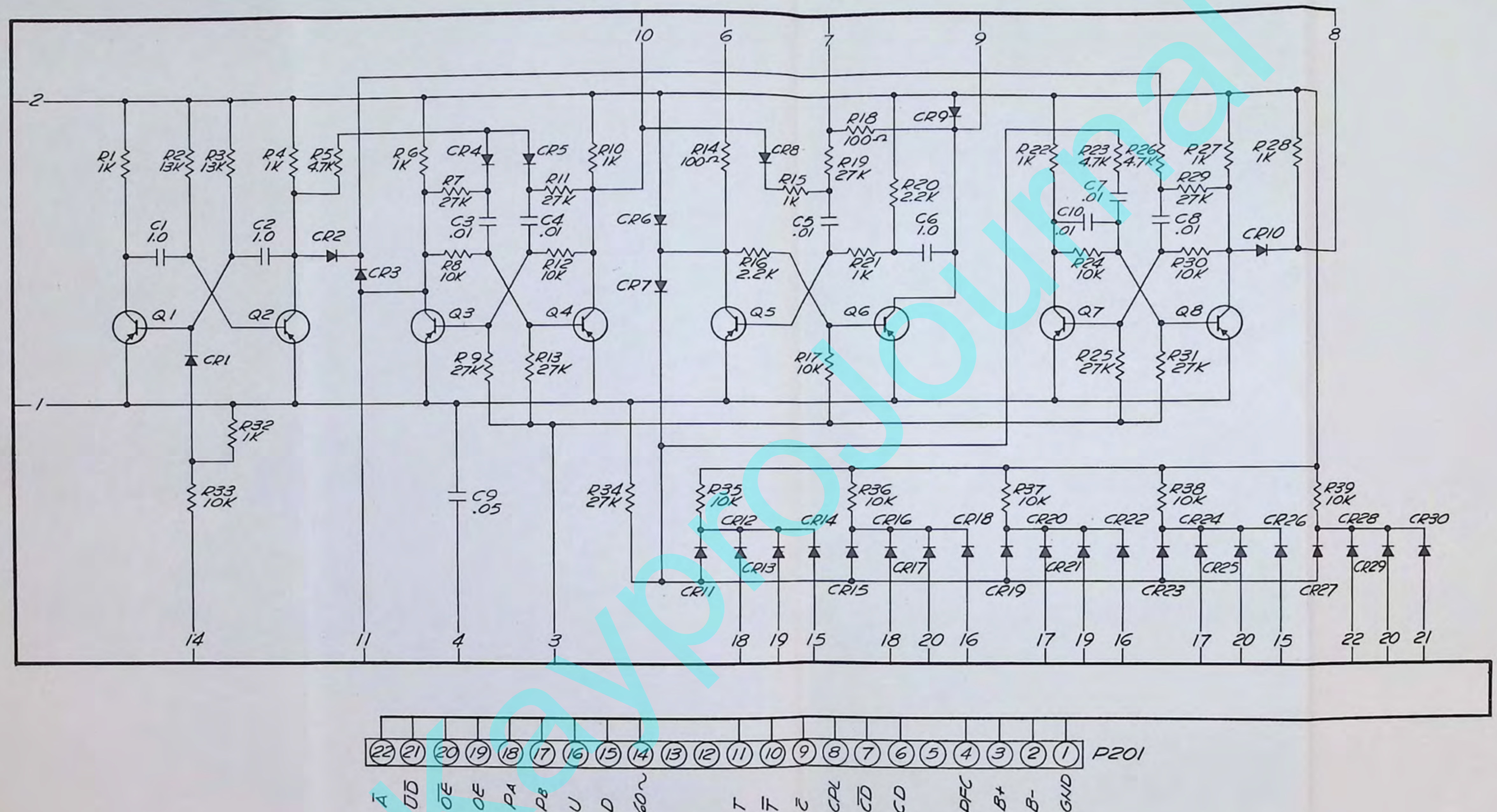
△ CERTAIN COMBINATIONS ARE SHORTED TO COMPENSATE FOR ZENER DIODE VOLTAGE. (SEE MANUAL)

△ FOR 115VAC POWER: JUMPER TERMINALS 1 TO 2 AND 3 TO 4 ON POWER TRANFORMER.
FOR 230VAC POWER: JUMPER TERMINALS 2 TO 3 ON POWER TRANSFORMER.

NOTES: UNLESS OTHERWISE SPECIFIED

MAIN BOARD ASSEMBLY, SCHEMATIC	NON-LINEAR SYSTEMS INC
MODEL V35	11500-114

SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL
1		ADDED C10	7-14-59	7-14-59
2		C9 WAS .01	7-22-59	7-22-59



4. ALL COMPONENT REFERENCE NUMBERS ARE IN THE 200 SERIES, i.e. R32 = R232.
3. ALL DIODES ARE TYPE IN34A.
2. ALL TRANSISTORS ARE TYPE 2N185.
1. ALL CAPACITANCE IS IN MICROFARADS.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTION ± DECIMAL ± ANGLES ±

MATERIAL

FINISH

DRAWN BY H. BRINKLEY 6-3-59
CHECKED BY NAIVE 6-8-59
APPROVED BY H. Clement 6-8-59

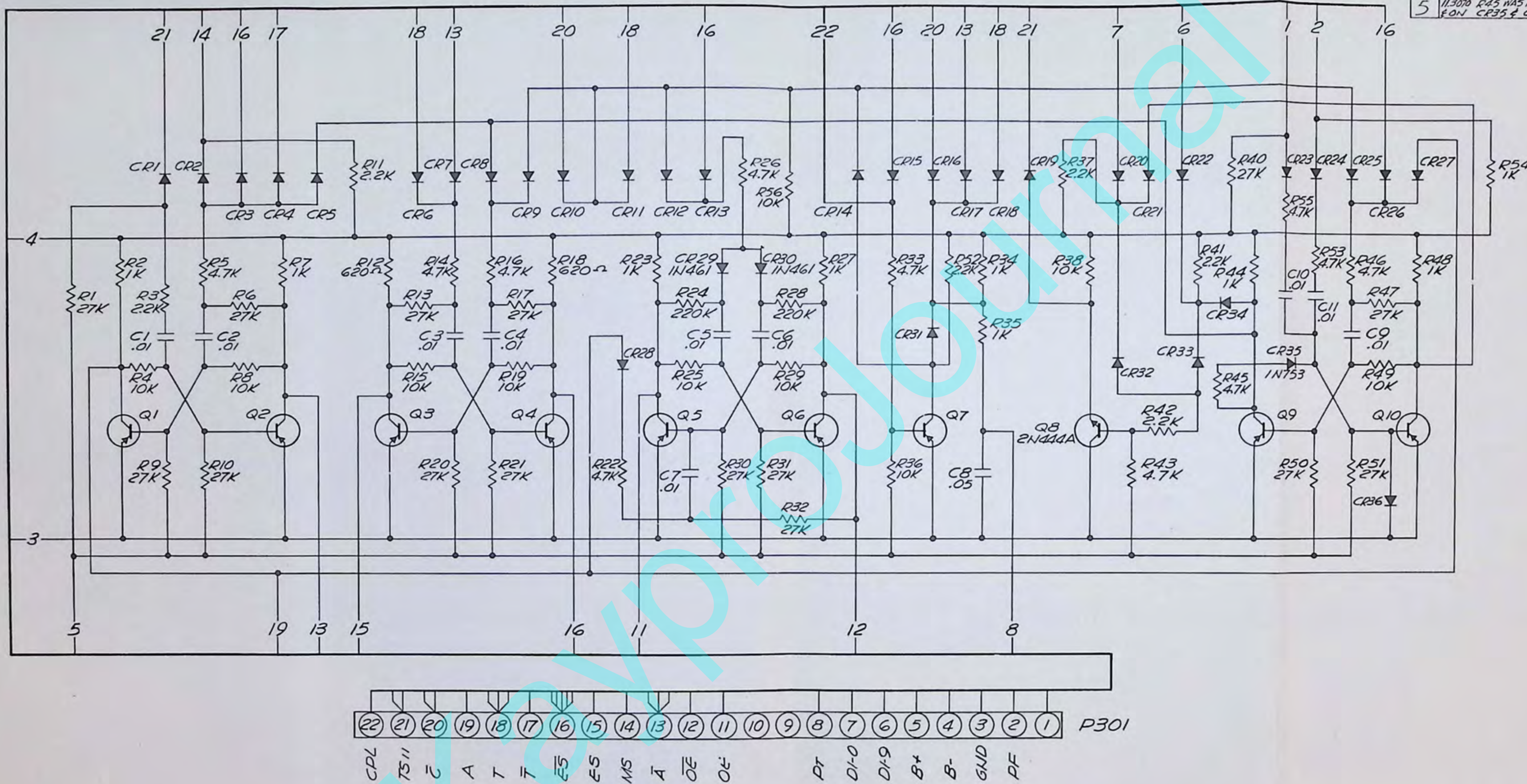
TITLE "A" BOARD ASSEMBLY, SCHEMATIC MODEL V34 & V35

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-200

SCALE NONE WT. SHEET 2 OF

SYM.	EFFECT.	REVISIONS DESCRIPTION	DATE	APPROVAL
1		CR29 & CR30 WERE IN34A. R24 & R28 WERE 27K. ADDED R52	6-26-59 HGB	J.u.m.
2		ADDED CONNECTION TO P301-19 "A".	7-15-59 HGB	J.u.m. 7-13-59
3		ADDED R53 & R54	7-22-59 HGB	J.u.m. 7-23-59
4		ADDED R55,56 & C10,11. R53 WAS 2.2K. REMOVED R39-3.9K. RE-LOCATED R54.	9-9-59 HGB	J.u.m. 9-9-59
5	11,3070 & ON	R45 WAS 10K. ADDED CR35 & CR36.	10-16-59 HGB	J.u.m. 10-16-59



11400-300 SHT2
5

4. ALL COMPONENT REFERENCE NUMBERS ARE IN THE 300 SERIES, i.e. R9 = R309.
3. ALL DIODES ARE TYPE IN34A
2. ALL TRANSISTORS ARE TYPE 2N185.
1. ALL CAPACITANCE IS IN MICROFARADS
NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±
MATERIAL
FINISH

		DATE
DRAWN BY	H. BRAWLEY	6-2-59
CHECKED BY	NAIVE	6-8-59
APPROVED BY	H. Clemens	6-9-59

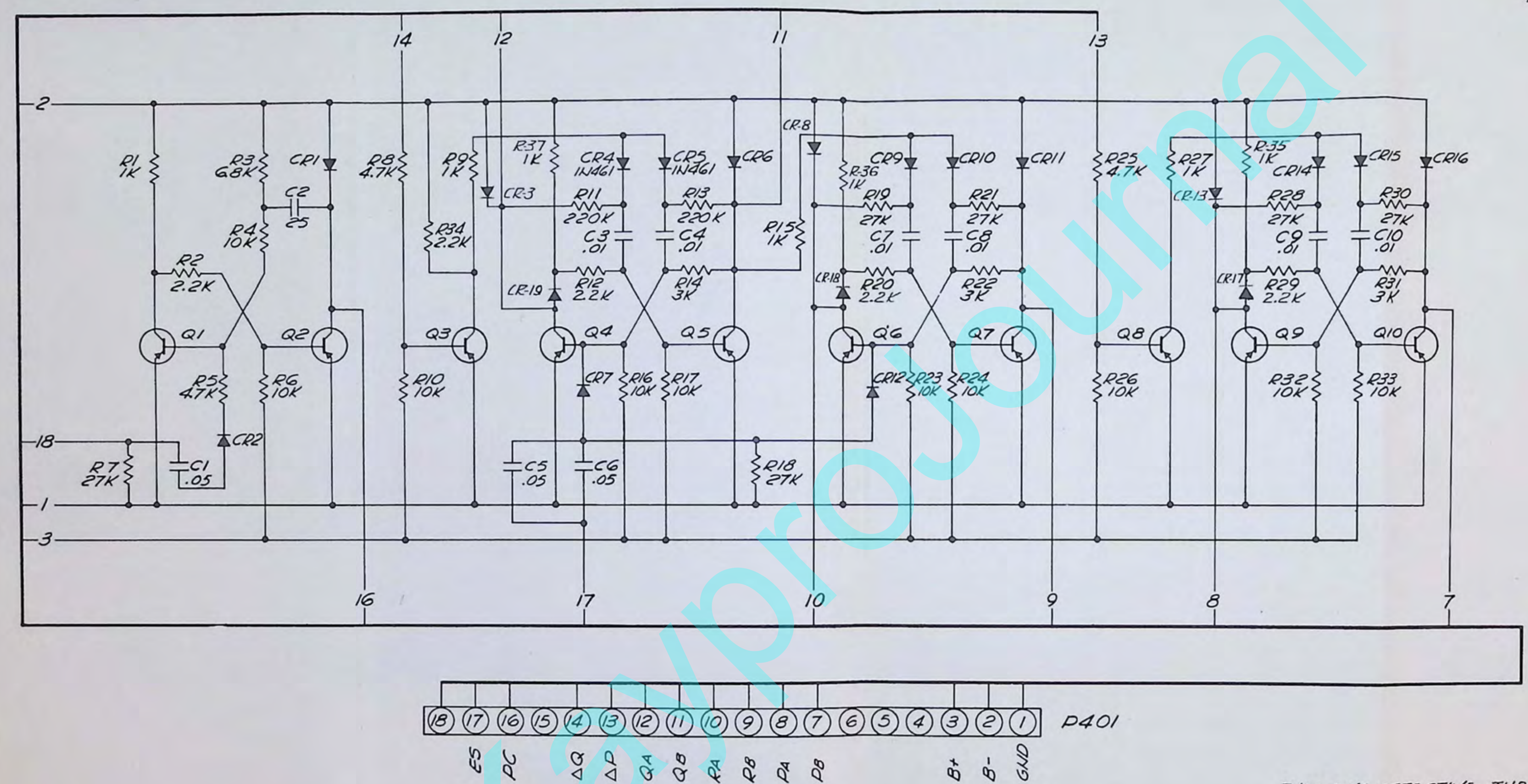
TITLE "B" BOARD ASSEMBLY, SCHEMATIC
MODEL V34 & V35

NLS NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-300
SCALE WT. SHEET 2 OF

REVISIONS

SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL
1		CR4 & CR5 WERE 1N34A RII & RI3 WAS 27K. ADDED R34.	6-26-59 HDB	JUM 6-27-59
2		RELOCATED C1. REMOVED P401-15 CON.	9-9-59 HDB	JAM 9-9-59
3		R-12, R-14, R20, R22, R29, R31, WERE 2.2K EACH	9-23-49 ARW	JAM 9-23-59
4		R-12 R-20 & R-29 WERE 3K EACH ADDED R-35, R36, R-37, CR-17 CR-18 & CR-19	10-1-59 ARW	JAM 10-1-59



11400-400 SHT 2

4

THIS DWG EFFECTIVE THRU SERIAL No. 11.3069

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL CAPACITANCE IS IN MICROFARADS.
2. ALL TRANSISTORS ARE TYPE 2N185.
3. ALL DIODES ARE TYPE 1N34A.
4. ALL COMPONENT REFERENCE NUMBERS ARE IN THE 400 SERIES, i.e. R7=R407.

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±
MATERIAL

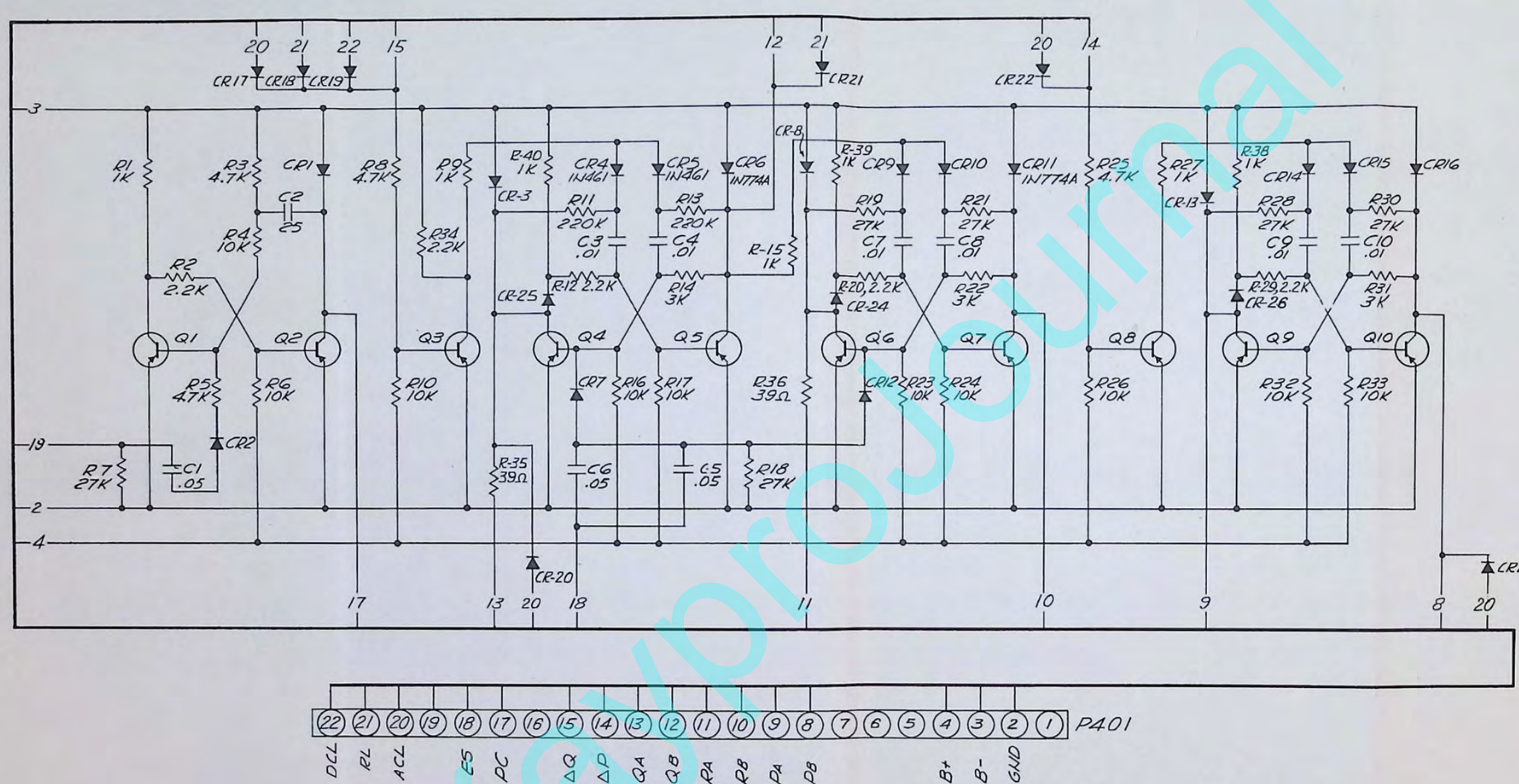
DRAWN BY H. BRINKLEY DATE 6-3-59
CHECKED BY NAIVE DATE 6-8-59
APPROVED BY H Clement DATE 6-9-59
FINISH

TITLE "C" BOARD ASSEMBLY, SCHEMATIC
MODEL V34 & V35

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-400
SCALE NONE WT.
SHEET 2 OF

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL



11400-402 SHT 2

1

EFFECTIVE - S/N 11.3070 & ON

4. ALL COMPONENT REFERENCE NUMBERS ARE IN THE 400 SERIES, i.e. R7=R407.
3. ALL DIODES ARE TYPE IN34A.
2. ALL TRANSISTORS ARE TYPE 2N185.
1. ALL CAPACITANCE IS IN MICROFARADS.
NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±
MATERIAL
FINISH

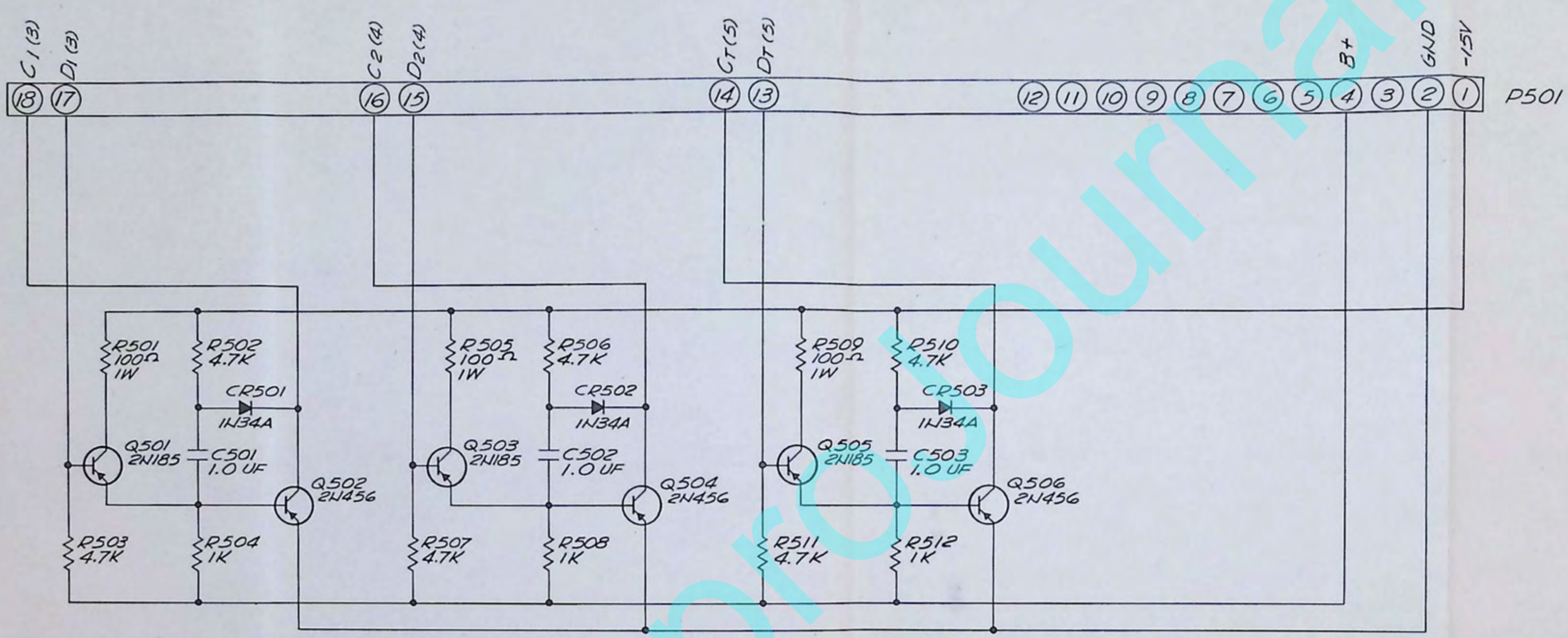
DRAWN BY A.R. WALLIN — DATE 9-29-59
CHECKED BY NAIVI — DATE 9-23-59
APPROVED BY [signature] — DATE 9-25-59

TITLE "C" BOARD ASSEMBLY, SCHEMATIC MODEL V34 & V35

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-402

SCALE NONE WT. SHEET 2 OF



11400-500 SHT 2

REVISIONS				
SYM	EFFECT.	DESCRIPTION	DATE	APPROVAL

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±
MATERIAL

DRAWN BY H. BRINLEY DATE 6-2-59
CHECKED BY NAIVE DATE 6-8-59
APPROVED BY H Clement DATE 6-9-59
FINISH

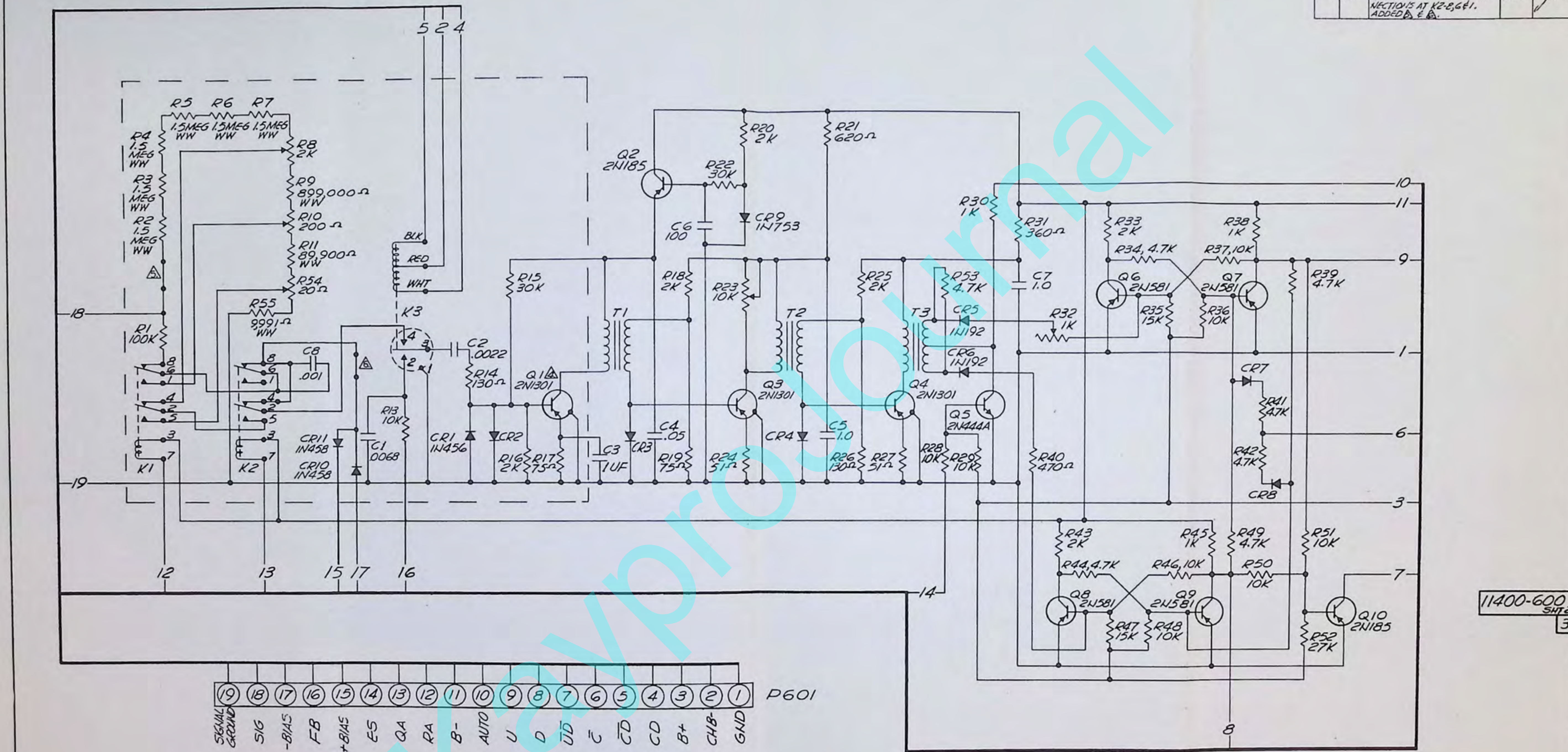
TITLE
"D" BOARD ASSEMBLY, SCHEMATIC
MODEL V34 & V35

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-500
SCALE
WT.
SHEET 2 OF

REVISIONS

SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL
3	113070 & ON	REVISED & [illegible] Q1 WAS 2N384, Q2 & Q4 WERE 2N274. RELOC CONNECTIONS AT K2-8,6&1. ADDED 4 & 5.	10-12-59 HDB	10-15-59



11400-600 SHT 2

3

4 REMOVE JUMPER TO USE AS RATIOMETER WITH EXTERNAL REFERENCE VOLTAGE GREATER THAN ±1.0VDC

5 REMOVE JUMPER FOR 1000 MEGOHM INPUT IMPEDANCE.

6 SELECTED FOR LOW NOISE.

3. ALL COMPONENT REFERENCE NUMBERS ARE IN THE 600 SERIES, i.e. R4=R604.

2. ALL DIODES ARE TYPE 1N34A.

1. ALL CAPACITANCE IS IN MICROFARADS.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTION ± DECIMAL ± ANGLES ±

MATERIAL

FINISH

DRAWN BY H.BINKLEY 6-5-59
CHECKED BY NAIVE 6-9-59
APPROVED BY H.Clement 6-9-59

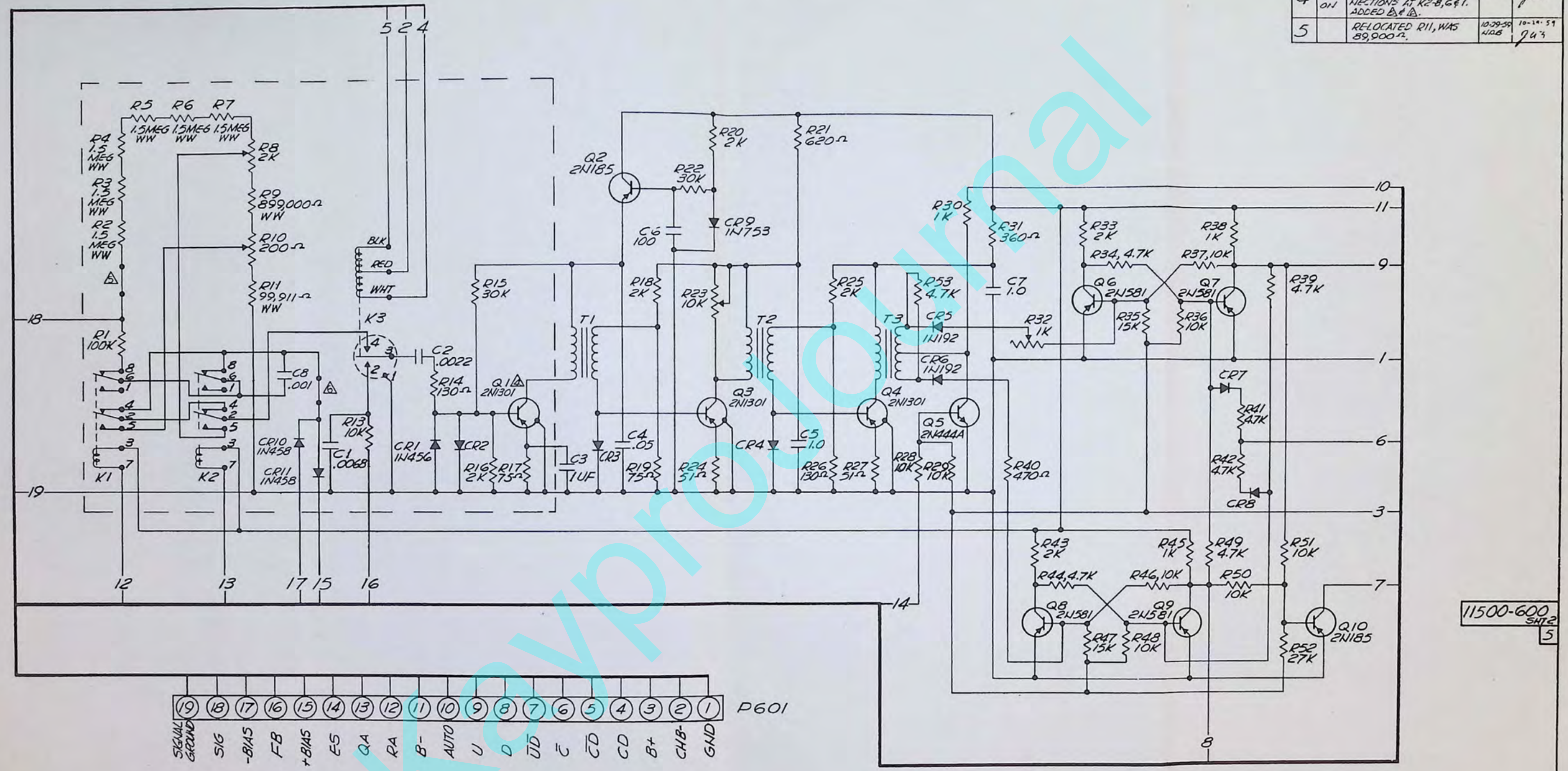
TITLE
AMPLIFIER ASSEMBLY, SCHEMATIC MODEL V34

NLS NON-LINEAR SYSTEMS INC. DEL MAR AIRPORT DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-600

SCALE WT. SHEET 2 OF

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL
4	11.3070 & ON	REVISED & REDRAWN Q1 WAS 2N584, Q3 & Q4 WERE 2N274 RELOC CONNECTIONS AT K2-8, 6 & 1. ADDED △ & △.	10-12-59	10-15-59
5		RELOCATED R11, WAS 89,900Ω.	10-29-59 NAB	10-29-59



11500-600 SHT 2
5

△ REMOVE JUMPER TO USE AS RATIOMETER WITH EXTERNAL REFERENCE VOLTAGE GREATER THAN ± 10 VDC.
△ REMOVE JUMPER FOR 1000 MEGOHM INPUT IMPEDANCE.
△ SELECTED FOR LOW NOISE.
3. ALL COMPONENT REFERENCE NUMBERS ARE IN THE 600 SERIES, i.e. R4 = R604.
2. ALL DIODES ARE TYPE 1N34A.
1. ALL CAPACITANCE IS IN MICROFARADS.
NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTION ± DECIMAL ± ANGLES ±
MATERIAL

DRAWN BY H. BRINKLEY DATE 6-5-59
CHECKED BY NAIVE DATE 6-9-59
APPROVED BY H Clement DATE 6-9-59
FINISH

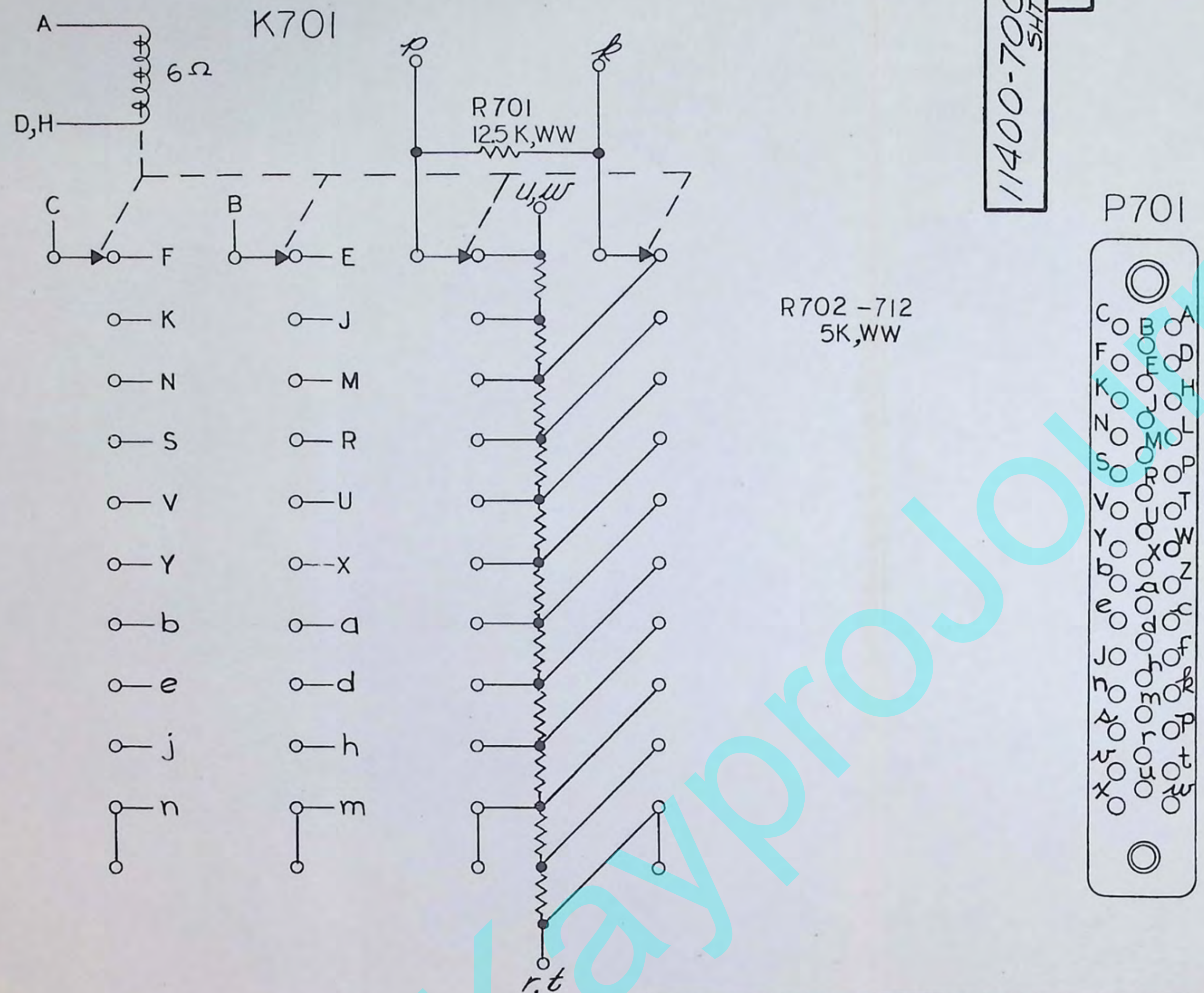
TITLE AMPLIFIER ASSEMBLY, SCHEMATIC MODEL V35

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11500-600
SCALE WT. SHEET 2 OF

11400-700 SHT 2

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL



NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED		
DIMENSIONS ARE IN INCHES TOLERANCES ON		
FRACTION ±	DECIMAL ±	ANGLES ±
MATERIAL		

DRAWN BY	H. BRINLEY	DATE 6-10-59
CHECKED BY	NAIVE	DATE 6-11-59
APPROVED BY	H Clement	DATE 6-12-59
FINISH		

TITLE

DECADE SWITCH ASSEMBLY, SCHEMATIC

MODEL V34 & V35

NON-LINEAR SYSTEMS INC.

DEL MAR AIRPORT

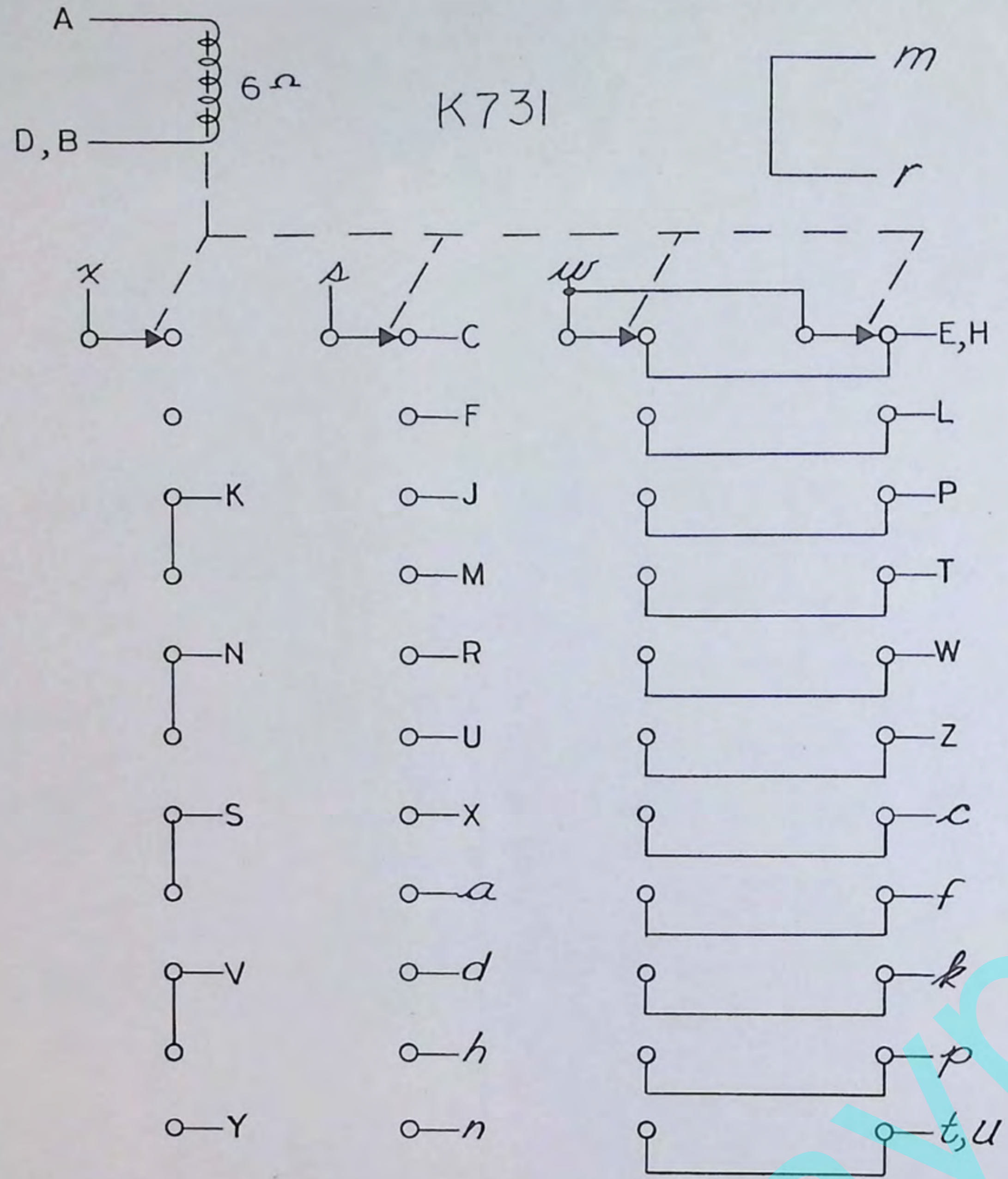
DEL MAR, CALIFORNIA

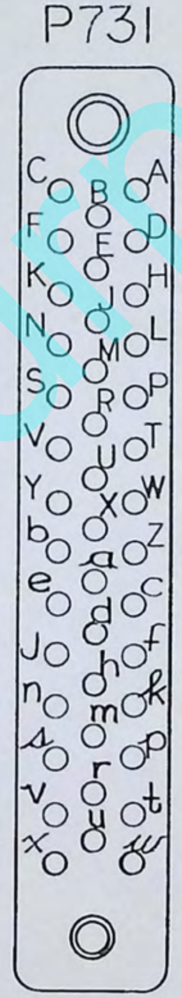
DRAWING NUMBER 11400-700

SCALE | WT. | SHEET 2 OF

11400-730 SHT 2

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL





NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

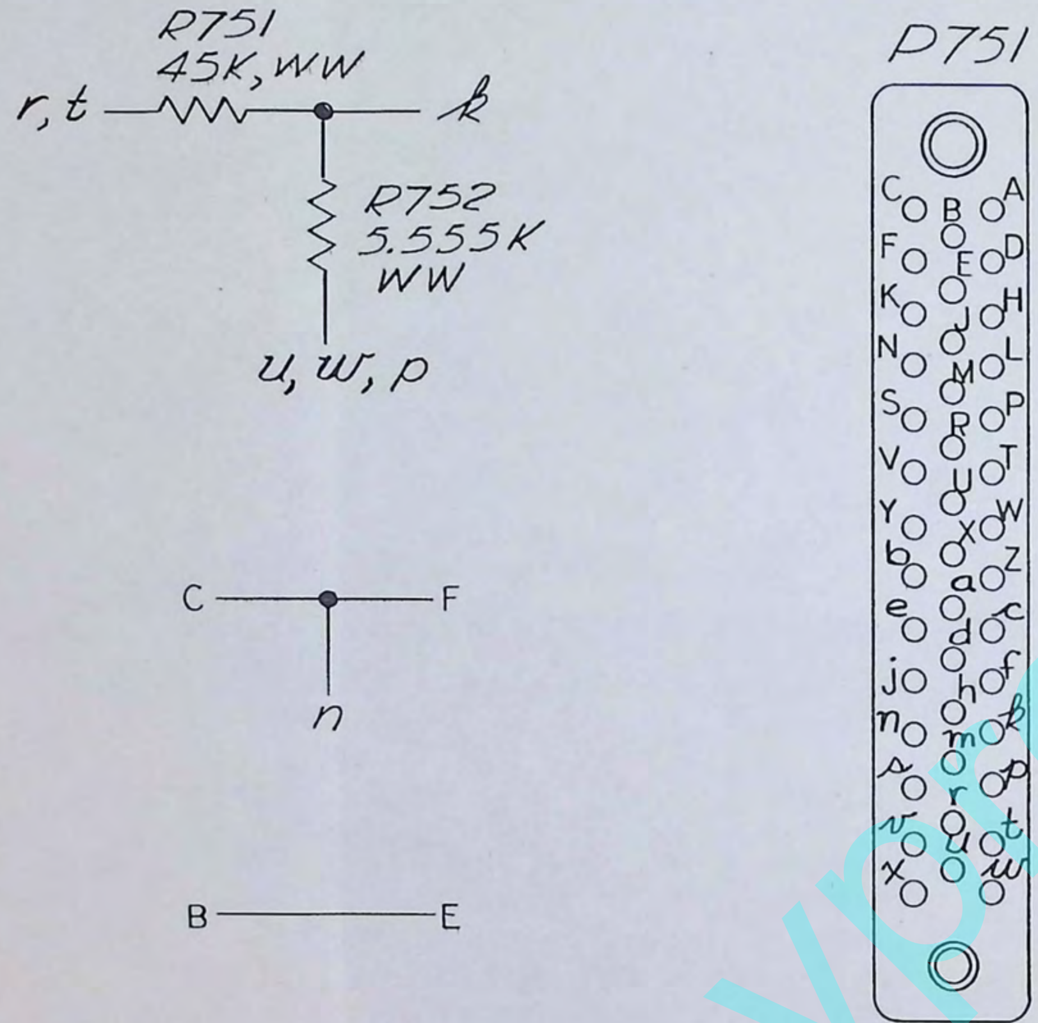
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTION ± DECIMAL ± ANGLES ±	DRAWN BY H. BRINLEY CHECKED BY NAIVE APPROVED BY [illegible]	DATE 6-10-59 DATE 6-11-59 DATE [illegible]	TITLE TRANSFER SWITCH ASSEMBLY, SCHEMATIC MODEL V34 & V35
MATERIAL	FINISH		SCALE / WT.

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-730
SHEET 2 OF

11400-750 SHEET 2

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL



NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±

MATERIAL

FINISH

DRAWN BY H. BRINLEY	DATE 7-9-59
CHECKED BY NAIVE	DATE 7-13-59
APPROVED BY SOULE	DATE 7-13-59

TITLE DECADE 5 ADAPTER SCHEMATIC

MODEL V34

SCALE WT.

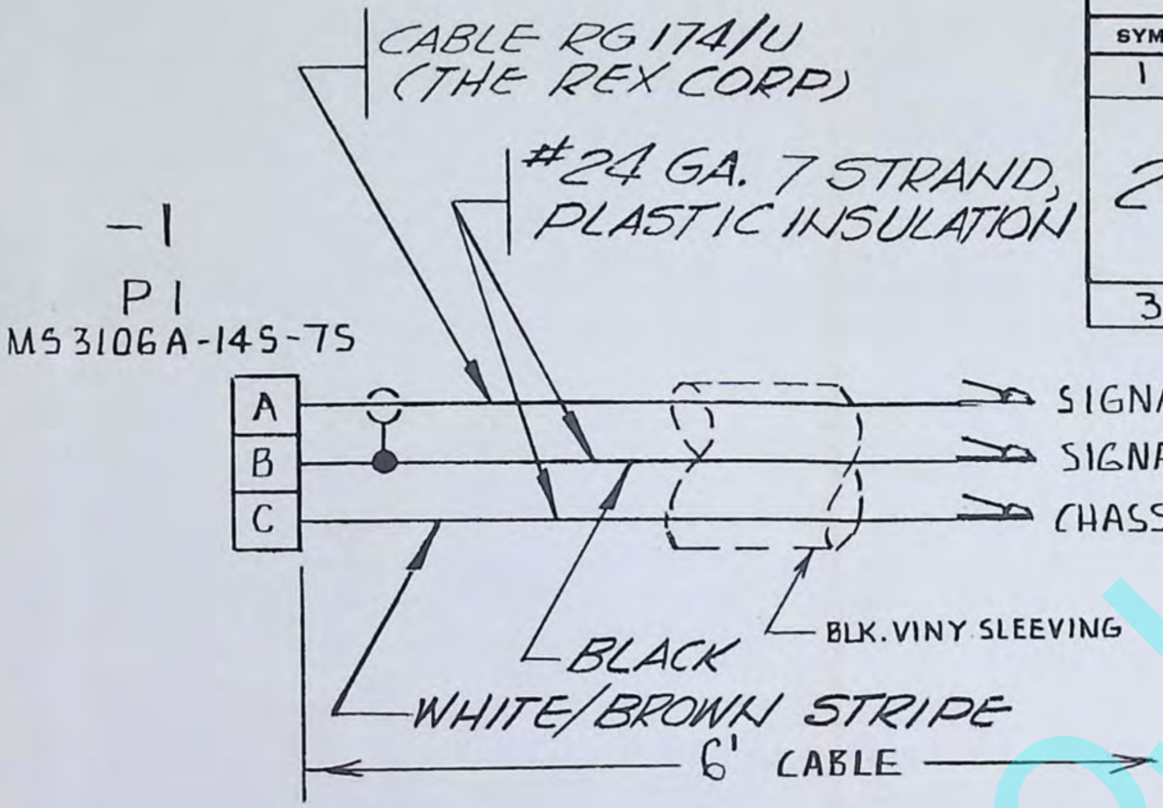
NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 11400-750

SHEET 2 OF

DRAWING NUMBER 15004-075 | 3

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL
1		ADDED P1 DESIGNATION	6-10-59	H.L.C.
2		RG174/U REX CABLE WAS #18 AWG WITH VINYL COVERED SPIRAL WRAPPED SHIELD. PIN "B" LEAD WAS SHIELDED. ADDED SMITH NOS.	7-14-59 6109B	MTS 7-14-59 JC
3		ADDED -2	8-12-59	H Clement



3 -2: SAME AS -1 EXCEPT USE SPADE LUGS - NO. 2600 (VACO) -3 REQ IN PLACE OF CLIPS (SMITH 300, 337B & 337R)

2. MARK OR STAMP PART NO. & "CABLE-INPUT" ON ALUM. TAG #9-1639 NATIONAL TAG CO. OR EQUIV & ATTACH TO CABLE.

1. CONNECTORS TO HAVE GOLD CONTACTS & DAP INSULATION

NOTE: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
11400	11400	1	1
10050	10050	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTION ± DECIMAL ± ANGLES ±	DRAWN BY A. R. WALLIN — DATE 26 MAR '59 CHECKED BY JIM CLEMENT — DATE 27 MAR '59 APPROVED BY H Clement — DATE 21-Mar 59	TITLE CABLE, INPUT MODEL 24 & 34
MATERIAL	FINISH	SCALE WT.

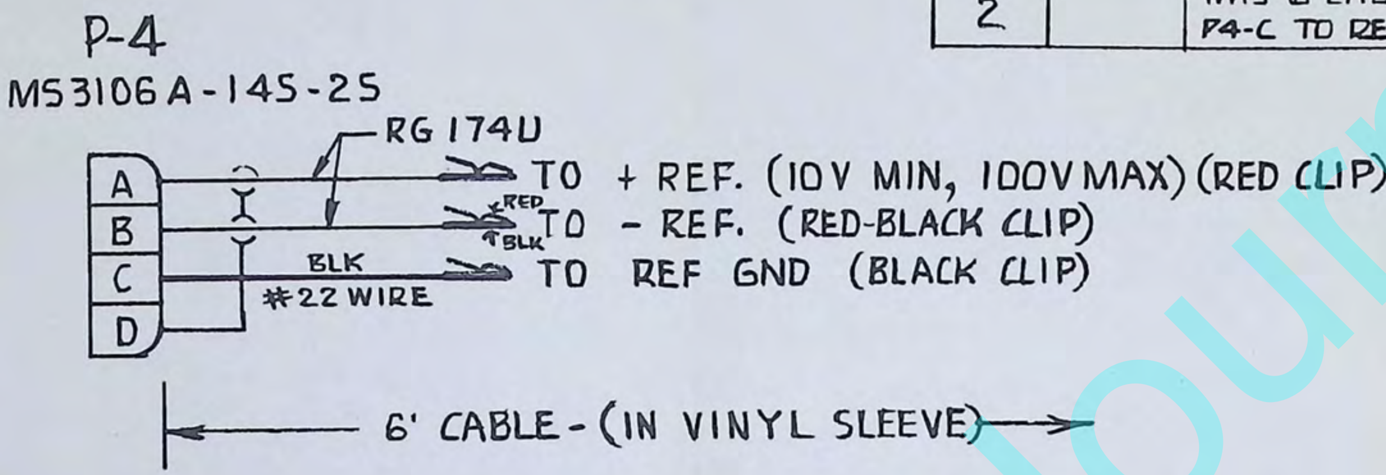
NLS NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 15004-075

SHEET OF

DRAWING NUMBER 15004-077 | 2

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL
1		ADDED P4 DESIGNATION	6-10-59 DAS	H. L. C.
2		WAS 6' CABLE-MOHAWK #5254 P4-C TO REF GND WAS SHIELDED	11-10-59 ARW	11-12-59 H Clement



1. MARK OR STAMP PART NO. & "EXTERNAL REF. TO B UNIT" ON ALUM. TAG - #9-1639 NATIONAL TAG COMPANY OR EQUIV & ATTACH TO CABLE.

NOTES: UNLESS OTHERWISE SPECIFIED —

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTION ± DECIMAL ± ANGLES ±	DRAWN BY A. R. WALLIN — DATE 26 MAR '59 CHECKED BY JIM CLEMENT — DATE 27 MAR '59 APPROVED BY H Clement — DATE 27 Mar 59	TITLE CABLE, TEST — EXTERNAL REF. TO "B" UNIT
MATERIAL	FINISH	SCALE — WT.

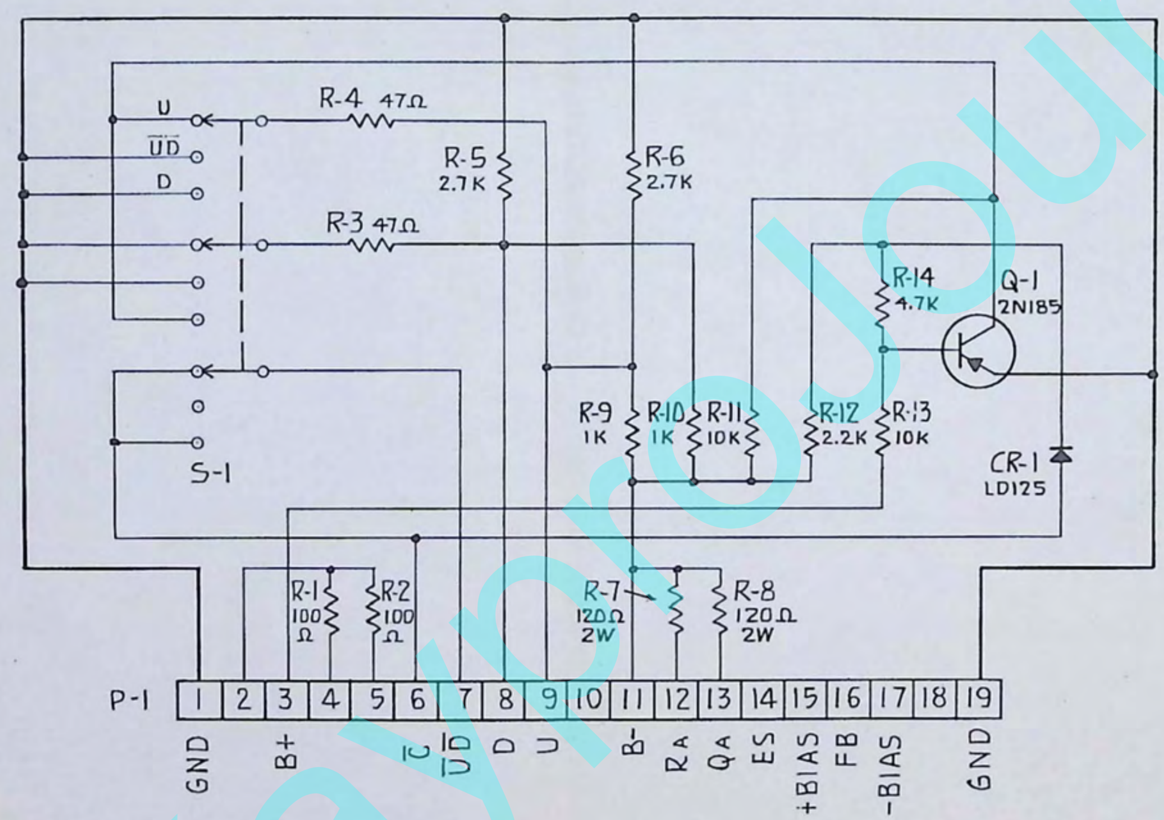
NLS NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 15004-077

SHEET OF

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL

3017-016
SHEET 2



NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±
MATERIAL

DRAWN BY ARWALLIN DATE 11-18-59
CHECKED BY [signature] DATE 11-20-59
APPROVED BY [signature] DATE 11-20-59
FINISH

TITLE
SCHEMATIC, AMPLIFIER ASSY – TEST

MODEL V35 DIGITAL VOLTMETER

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 3017-016
SCALE WT. SHEET 2 OF