

INSTRUCTION MANUAL  
SERIES X-2  
DIGITAL VOLTMETER



Originator of the Digital Voltmeter

**non-linear systems, inc.**

DEL MAR, CALIFORNIA

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**CAUTION**

WHEN THE INSTRUMENT DESCRIBED IN THIS MANUAL IS INSTALLED IN A SERIES X-1-TYPE OUTER CHASSIS (FOR SYSTEM APPLICATION), REMOVE CABLE CONNECTIONS PRIOR TO REMOVING THE INSTRUMENT DRAWER ASSEMBLY FROM THE CHASSIS. FAILURE TO OBSERVE THIS PRECAUTION MAY CAUSE DAMAGE TO CABLE AND INSTRUMENT CONNECTORS.

## TABLE OF CONTENTS

| Chapter | Title                                                 | Page |
|---------|-------------------------------------------------------|------|
| I       | INTRODUCTION AND SPECIFICATIONS .....                 | 1-1  |
|         | Optional Function Accessories .....                   | 1-1  |
|         | General .....                                         | 1-1  |
|         | Operating Principle .....                             | 1-1  |
|         | Digital Output .....                                  | 1-1  |
|         | Floating Input .....                                  | 1-1  |
|         | Common-Mode-Rejection .....                           | 1-1  |
|         | Procedure to Determine CMR .....                      | 1-2  |
|         | Specifications .....                                  | 1-2  |
| II      | INSTALLATION AND OPERATION .....                      | 2-1  |
|         | Unpacking .....                                       | 2-1  |
|         | Mounting .....                                        | 2-1  |
|         | Power Source .....                                    | 2-1  |
|         | Fusing .....                                          | 2-1  |
|         | Power Grounding .....                                 | 2-1  |
|         | Connectors (S/N's X-2. 1 thru X-2. 156) .....         | 2-1  |
|         | Connectors (S/N's X-2. 157 & Subsequent) .....        | 2-2  |
|         | Cable Connections .....                               | 2-2  |
|         | Controls .....                                        | 2-2  |
|         | Power Switch (S/N's X-2. 1 thru X-2. 156) .....       | 2-2  |
|         | Power Switch (S/N's X-2. 157 & Subsequent) .....      | 2-2  |
|         | Remote Triggering (S/N's X-2. 157 & Subsequent) ..... | 2-2  |
|         | Range Switch .....                                    | 2-4  |
|         | Operating Cautions .....                              | 2-5  |
|         | Function Switch .....                                 | 2-7  |
|         | Offset Controls .....                                 | 2-7  |
|         | Digital Readout .....                                 | 2-7  |
| III     | CALIBRATION .....                                     | 3-1  |
|         | Scope .....                                           | 3-1  |
|         | DC Voltage Calibration .....                          | 3-1  |
|         | Equipment Required .....                              | 3-1  |
|         | Initial Preparation .....                             | 3-1  |
|         | Procedure .....                                       | 3-1  |
|         | Reference Adjustment .....                            | 3-1  |
|         | Zero Offset Adjustment .....                          | 3-2  |
|         | 10-Volt Range Calibration for Positive Input .....    | 3-2  |

## TABLE OF CONTENTS (CON'T)

| Chapter | Title                                              | Page |
|---------|----------------------------------------------------|------|
| III     | CALIBRATION (Cont'd)                               |      |
|         | 10-Volt Range Calibration for Negative Input ..... | 3-4  |
|         | 100-Volt Range Calibration .....                   | 3-4  |
|         | 1000-Volt Range Calibration .....                  | 3-5  |
|         | AC Converter Calibration .....                     | 3-5  |
|         | Additional Equipment Required .....                | 3-5  |
|         | Initial Preparation .....                          | 3-5  |
|         | Procedure .....                                    | 3-5  |
|         | Ohms Converter and Pre-Amplifier Calibration ..... | 3-6  |
|         | Additional Equipment Required .....                | 3-6  |
|         | Initial Preparation .....                          | 3-6  |
|         | Procedure .....                                    | 3-6  |
|         | Precision Pre-Amplifier Calibration .....          | 3-7  |
|         | Initial Preparation .....                          | 3-7  |
|         | Procedure .....                                    | 3-7  |
| IV      | MAINTENANCE .....                                  | 4-1  |
|         | Digital Readout Replacement .....                  | 4-1  |
|         | Troubleshooting .....                              | 4-12 |
|         | Fan Lubrication .....                              | 4-1  |
| V       | RECOMMENDED SPARE PARTS LIST .....                 | 5-1  |
|         | APPENDIX .....                                     | A-1  |

### LIST OF TABLES

| Number | Title                          | Page |
|--------|--------------------------------|------|
| I      | Measurement Capabilities ..... | 2-7  |
| II     | Troubleshooting .....          | 4-12 |

### LIST OF ILLUSTRATIONS

| Figure | Title                                | Page |
|--------|--------------------------------------|------|
| 1-1    | Connections to Determine CMR .....   | 1-3  |
| 1-2    | Series X-2 DVM Outline Drawing ..... | 1-3  |
| 2-1    | Power Plug Pin Coding .....          | 2-2  |
| 2-2    | Front Views .....                    | 2-3  |
| 2-3    | Rear Views .....                     | 2-3  |

## LIST OF ILLUSTRATIONS (CONT)

| Figure | Title                                                                                                                       | Page |
|--------|-----------------------------------------------------------------------------------------------------------------------------|------|
| 2-4    | Input Connections.....                                                                                                      | 2-4  |
| 3-1    | Cover Removal.....                                                                                                          | 3-2  |
| 3-2    | Location of Major Subassemblies & Adjustment Points.....                                                                    | 3-3  |
| 3-3    | Reference Adjustment.....                                                                                                   | 3-4  |
| 3-4    | Precision Pre-Amplifier Assembly Adjustment Points.....                                                                     | 3-8  |
| 4-1    | Block Diagram Series X-2 DVM.....                                                                                           | 4-2  |
| 4-2    | Simplified Diagram, Auto-Ranging .....                                                                                      | 4-3  |
| 4-3    | Simplified Diagram, Reference Supply .....                                                                                  | 4-4  |
| 4-4    | Simplified Diagram, Series X-2 Input-Integrator with<br>Resetter Circuitry and Temperature Compensation Potentiometers..... | 4-5  |
| 4-5    | Simplified Diagram, AC Converter .....                                                                                      | 4-6  |
| 4-6    | Simplified Diagram, Pre-Amplifier.....                                                                                      | 4-7  |
| 4-7    | Simplified Diagram, Ohms Converter.....                                                                                     | 4-7  |
| 4-8    | Type SN7490N Decade Counter .....                                                                                           | 4-8  |
| 4-9    | Type SN7473N Dual J-K Master-Slave Flip-Flop .....                                                                          | 4-8  |
| 4-10   | Type SN7474N Dual D-Type Edge-Triggered Flip-Flop.....                                                                      | 4-9  |
| 4-11   | Type SNX7441N BCD-to-Decimal Decoder/Driver .....                                                                           | 4-9  |
| 4-12   | Type SN7472N JK Master-Slave Flip-Flop.....                                                                                 | 4-10 |
| 4-13   | Type SN7400N Quadruple 2-Input Positive Nand Gate .....                                                                     | 4-10 |
| 4-14   | Type SN7430N 8-Input Positive Nand Gate .....                                                                               | 4-10 |
| 4-15   | Type SN7475N Quadruple Bistable Latch.....                                                                                  | 4-11 |

## LIST OF SCHEMATIC DIAGRAMS

| Dwg. No.           | Title                              |
|--------------------|------------------------------------|
| 37-30, "B" Change  | Decade Assembly                    |
| " " "D" Change     | Decade Assembly                    |
| 37-36              | Reference Assembly                 |
| 37-39              | Attenuator Assembly                |
| 37-69              | Start/Stop Assembly                |
| 37-72              | Main Board & Power Supply Assembly |
| 37-105             | Main Board & Power Supply Assembly |
| 37-160             | Decade Assembly                    |
| 37-272             | Reference Assembly                 |
| 37-272, "A" Change | Reference Assembly                 |
| 37-275, "A" Change | Attenuator Assembly                |
| 37-275, "C" Change | Attenuator Assembly                |
| 37-275, "D" Change | Attenuator Assembly                |
| 37-298             | Main Board & Power Supply Assembly |
| 37-360             | Decade Assembly                    |

## LIST OF SCHEMATIC DIAGRAMS (CON'T)

| Dwg. No.          | Title                                             |
|-------------------|---------------------------------------------------|
| 36-658            | MV Converter Assembly                             |
| 37-33             | Start/Stop & Auto Range Assembly                  |
| 37-42             | Pre-Amplifier & K $\Omega$ /DC Converter Assembly |
| 37-45             | AC/DC Converter Assembly (10K Hz)                 |
| 37-77             | AC/DC Converter Assembly (100K Hz)                |
| 37-89             | Print Board Assembly                              |
| 37-278,"A" Change | Pre-Amplifier & K $\Omega$ /DC Converter Assembly |
| 37-278,"E" Change | Pre-Amplifier & K $\Omega$ /DC Converter Assembly |
| 37-281            | AC/DC Converter Assembly (10K Hz)                 |
| 37-315            | AC/DC Converter Assembly (100K Hz)                |
| 37-316            | Print Board Assembly                              |

## CHAPTER I

### INTRODUCTION AND SPECIFICATIONS

The NLS Series X-2 Digital Voltmeter is a three-range, four-digit instrument with automatic polarity and with provisions for 20% over-ranging on the two lowest ranges. An automatic ranging feature is offered as an option. The instrument may be used as a bench model or, with the use of rack-mounting adapters, may be rack-mounted in a standard 19-inch mounting rack.

#### OPTIONAL FUNCTION ACCESSORIES

In addition to measuring DC voltages, the Series X-2 DVM is capable of measuring AC voltages, millivolts and ohms. These extra features may be obtained by utilizing optional plug-in modules. A K Ohms converter/pre-amplifier provides ohms and millivolt measurements or a precision pre-amplifier provides higher accuracy in millivolt measurements, and one of two types of AC converters (50 Hz to 10K Hz or 50K Hz to 100K Hz) provides AC voltage measurement.

#### GENERAL

The Series X-2 Digital Voltmeters are solid state integrating instruments that measure the absolute value of DC voltages or the integral of varying voltages. In these instruments the unknown input voltage is converted to a pulse train whose repetition rate is directly proportional to input voltage magnitude. The total number of pulses generated over a clocked 0.1 second interval is counted electronically and displayed as the voltage value.

#### OPERATING PRINCIPLE

An input of 10 volts to the instrument creates 10,000 pulses in 0.1 second; this is displayed

as 10.000 volts. If the input voltage changes during the measuring interval, the pulse repetition rate changes proportionately, and the total number of pulses that occurs during the 0.1 second sample period is a measure of the number of volt-seconds at the input. Since these instruments mathematically integrate the input voltage, they are useful for obtaining the velocity from a voltage which is proportional to acceleration. In addition, these instruments are inherently able to reject sinusoidal ripple because the integrated value of an integral number of sine waves is zero. Therefore if an integral number of cycles of sine wave noise occurs during the 0.1-second sampling interval, its contribution to the overall reading is "integrated out".

#### DIGITAL OUTPUT

Beginning with serial number X-2.157, the instrument possesses a printout and remote triggering capability for operation with data printers, tape punches, typewriters and other recording devices. For printout, the Print Board Assembly, with pendant cable and connector is offered as an option.

#### FLOATING INPUT

Because input signal leads may be disconnected from the Series X-2's outer chassis (by removing a shorting strap between J5 and J6 on the rear of the instrument), signal-to-chassis potentials up to 500 volts are permissible. Floating input adds to the DVM's versatility by permitting it to measure voltage sources which could not be accurately measured by a non-isolated meter.

#### COMMON-MODE-REJECTION

Rejection of common-mode signals, those

caused by AC or DC currents flowing between signal source ground and instrument chassis ground is a feature of the Series X-2 DVM. (To obtain CMR, the shorting strap described in the above paragraph must be removed.) Common-mode signal rejection is important in a wide range of applications - testing complex electrical and electronic systems, in automatic measuring systems, and measuring outputs from thermocouples, strain gages and other transducers where common-mode signals may be many times greater than the measured DC voltage.

#### PROCEDURE TO DETERMINE CMR

1. Turn the X-2 DVM on and allow 30 minutes for warm-up.
2. Remove shorting strap between J5 and J6.
3. Connect DVM to signal source and common-mode source as shown in Figure 1-1. Signal source is preferably a series string of three or four 1.5V batteries (flashlight cells or 1.3V mercury cells). To obtain an accurate measurement of CMR, the source resistance of the signal source should be less than 10 ohms. The output of a variac, connected as shown in Figure 1-1, will adequately provide the required common-mode source.
4. Set variac to zero volts then advance variac in voltage until a one digit "bobble"

is observed in the least significant decade then, back off variac until "bobble" just stops. Measure the variac output with an AC voltmeter and convert to peak-to-peak voltage.

5. To obtain rejection ratio, divide peak-to-peak common voltage by 1 MV.

$$\text{Common-mode rejection ratio} = \frac{E_{p-p}}{10^{-3}}$$

$$\text{DB} = 20 \log \frac{E_{p-p}}{10^{-3}}$$

$$\text{DB} = 20 \log 1,000 E_{p-p}$$

6. For example, if the common-mode voltage is 3.5V

$$E_{p-p} = 3.5 \times 2.828$$

$$E_{p-p} = 10V \text{ and}$$

$$\text{DB} = 20 \log 1,000 \times 10$$

$$\text{DB} = 20 \log 10^4$$

$$\text{DB} = 20 \times 4 = 80$$

Common-mode rejection = 80 DB

The NLS Sales Representative or Engineering Department will be pleased to assist you with specific application problems and, of course, will gladly welcome your comments and suggestions.

#### SPECIFICATIONS

CIRCUITRY:

All solid state.

ANALOG-TO-DIGITAL  
CONVERSION:

Bi-polar integrator.

FULL SCALE DC RANGES:

$\pm 9.999$ ,  $\pm 99.99$ ,  $\pm 999.9$  with 20% over-range on the two lower ranges.

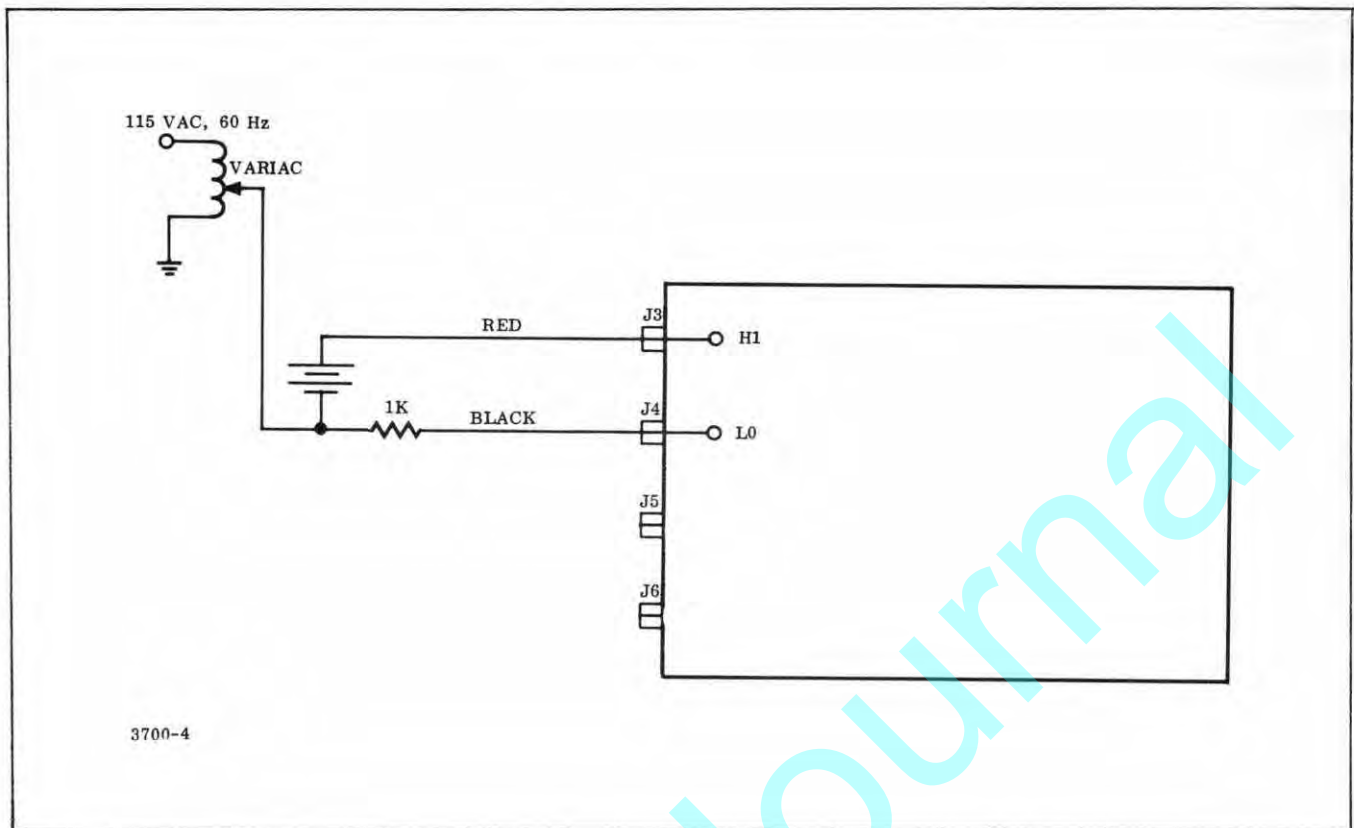


Figure 1-1. Connections to Determine CMR

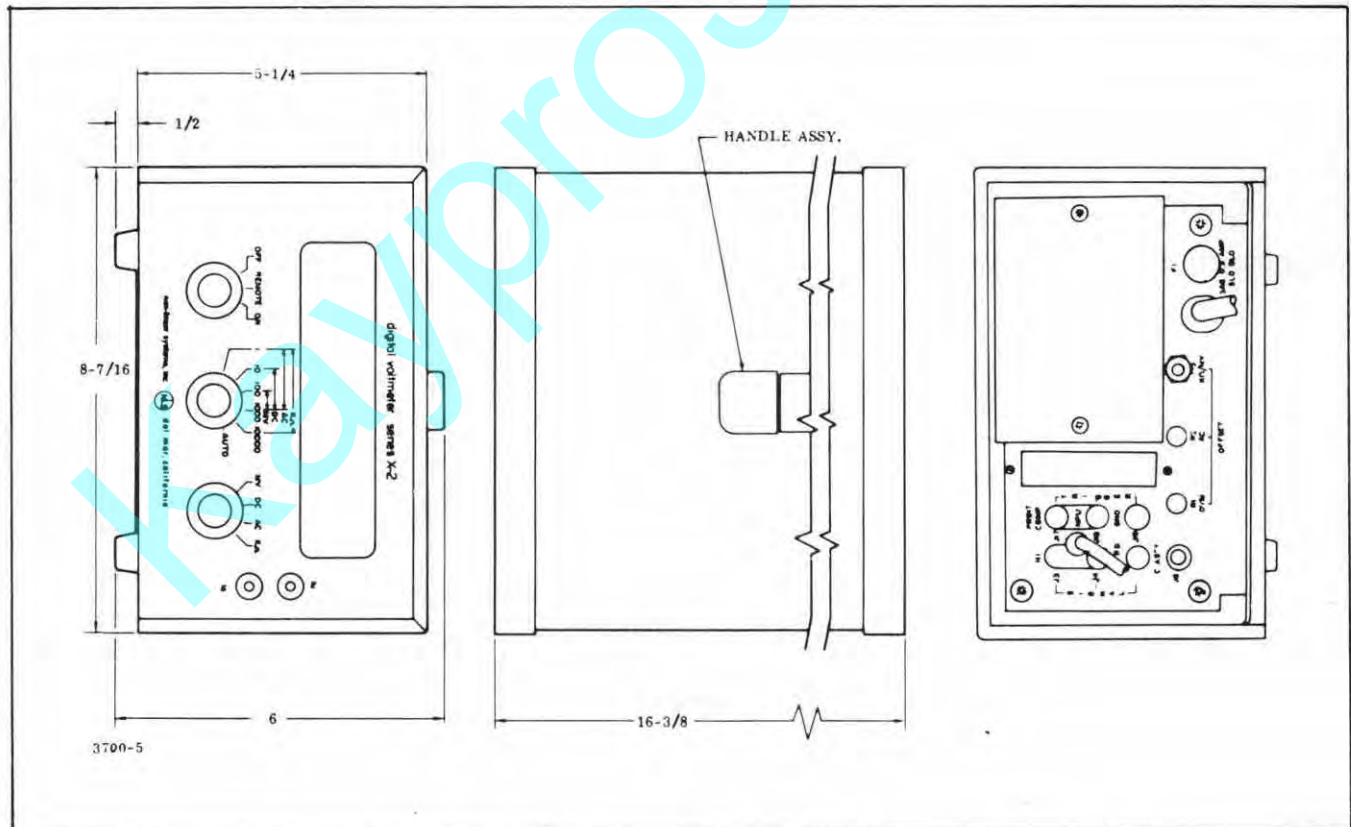


Figure 1-2. Series X-2 DVM Outline Drawing

|                                          |                                                                                                                                                                                                                                 |
|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ACCURACY AT ASA<br>REFERENCE CONDITIONS: | $\pm 0.01\%$ of full scale $\pm 0.02\%$ of reading.                                                                                                                                                                             |
| RESOLUTION:                              | One digit.                                                                                                                                                                                                                      |
| RESPONSE TIMES:                          | Voltage-to-Frequency<br>Converter Settling Time - 100 MS (with filter).<br>Digitizing Time - 100 MS.<br>Range Selection Time - 100 MS.                                                                                          |
| INPUT RESISTANCE:                        | 10 megohms, constant all ranges, except when 20% over-range is exceeded.                                                                                                                                                        |
| COMMON-MODE-REJECTION:                   | 100 DB @ DC; 80 DB @ 60 Hz -- 1K $\Omega$ unbalance                                                                                                                                                                             |
| RANGE SELECTION:                         | Manual or Automatic/Manual (see options).                                                                                                                                                                                       |
| POLARITY SELECTION:                      | Automatic.                                                                                                                                                                                                                      |
| INPUT CONNECTIONS:                       | Front and rear. Input may be floated $\pm 500$ volts above chassis by removing shorting strap from rear input connectors.                                                                                                       |
| AMBIENT TEMPERATURE:                     | Extreme - 12° C to 50° C.                                                                                                                                                                                                       |
| POWER REQUIREMENTS:                      | 105/125 VAC, 50/60 Hz.                                                                                                                                                                                                          |
| MOUNTING POSITION:                       | Any.                                                                                                                                                                                                                            |
| WEIGHT:                                  | 12 pounds                                                                                                                                                                                                                       |
| SIZE:                                    | 5-1/4 inches (excluding feet and handle) x<br>8-7/16 inches x 16-3/8 inches.                                                                                                                                                    |
| OPTIONS AVAILABLE:                       | Automatic ranging.                                                                                                                                                                                                              |
| ACCESSORIES AVAILABLE:                   | AC/DC Converters<br>K Ohms/DC Converter and Pre-Amplifier<br>Precision Pre-Amplifier<br>Print Board Assembly - BCD 8-4-2-1<br>Logic "0" = 0 volt to +0.5 volt,<br>Logic "1" = +3 volts $\pm 0.1$ volt<br>Rack Mounting Adapters |

AC/DC Converter, Types I and II for X-2

|                                     |                                                                                                                                                          |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| RANGES; including<br>20% over-range | 1. 1999/11.999<br>119.99 & 500.00 VAC                                                                                                                    |
| FREQUENCY RESPONSE                  | 10K Hz<br>100K Hz<br>Lower frequency converters are available on special order.<br>The 10K Hz converter is usable to 30 K Hz in the manual ranging mode. |

|                 |         |                                                                                                                                                                   |
|-----------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ACCURACY:       | 10K Hz  | 0.05% reading + 0.02% FS, 200 Hz to 3K Hz, 1000 VAC<br>0.1% reading + 0.05% FS, 50 Hz to 200 Hz and 3K Hz to 10K Hz, 1000 VAC<br>30 Hz accuracy is typically 0.3% |
|                 | 100K Hz | Same as 10K Hz, plus:<br>0.3% reading + 0.1% FS, 10K Hz to 30K Hz, 500 VAC<br>0.5% reading + 0.1% FS, 30K Hz to 100K Hz, 150 VAC                                  |
| RESPONSE TIME   |         | 600 milliseconds to 0.1% of final value                                                                                                                           |
| INPUT IMPEDANCE |         | One megohm, shunted by 100 PF                                                                                                                                     |
| RANGING         |         | Automatic and manual                                                                                                                                              |

#### Ohms/DC Converter

| ACCURACY                                                                                               | Four Digit                                                                                                                    | Maximum Current                            |
|--------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| $\pm 0.01\%$ FS and $\pm 0.02\%$ reading (1K $\Omega$ , 10K $\Omega$ , 100K $\Omega$ and 1000K ranges) | 1.19999K $\Omega$<br>11.999K $\Omega$<br>119.99K $\Omega$<br>1199.9K $\Omega$                                                 | 10 MA<br>1 MA<br>100 $\mu$ A<br>10 $\mu$ A |
| $\pm 0.01\%$ FS $\pm 0.1\%$                                                                            | 11,999.K $\Omega$                                                                                                             | 1 $\mu$ A                                  |
| STABILITY                                                                                              | 0.05% full scale for at least 90 days on all ranges                                                                           |                                            |
| RESPONSE TIME                                                                                          | 100 milliseconds for step response. 200 milliseconds for step response with range change. 700 milliseconds on 10 megohm range |                                            |
| RANGING                                                                                                | Automatic and manual (Manual only 10,000K Range)                                                                              |                                            |

|                     |                                          |
|---------------------|------------------------------------------|
| INPUT CONFIGURATION | Two wire with voltage protection         |
|                     | <u>Automatic Ranging DC Preamplifier</u> |

|                 |      |                                                                                                                                |
|-----------------|------|--------------------------------------------------------------------------------------------------------------------------------|
| RANGES          | X10  | $\pm 000.1$ MV to $\pm 1199.9$ MV                                                                                              |
|                 | X100 | $\pm 00.01$ MV to $\pm 119.99$ MV                                                                                              |
| ACCURACY        | X10  | $\pm 0.02\%$ reading and $\pm 0.01\%$ Full Scale                                                                               |
|                 | X100 | $\pm 0.05\%$ reading and $\pm 0.05\%$ Full Scale                                                                               |
| GAIN STABILITY  |      | 0.01% for at least 30 days                                                                                                     |
| ZERO STABILITY  |      | Drift does not exceed $\pm 50 \mu$ V or $\pm 5$ digits, whichever is greater, for at least seven days at constant temperature. |
| INPUT INPEDANCE |      | Greater than 100 megohms                                                                                                       |
| RESPONSE TIME   |      | 500 MS for step response to 0.01%                                                                                              |

### Precision Pre-Amplifier

RANGES: 119.99/1199.9 MVDC

ACCURACY UNDER ASA

REFERENCE CONDITIONS:  $\pm(0.01\%$  of reading +  $0.01\%$  of full scale)

STABILITY: Short Term:  $\pm(0.01\%$  of full scale)

Long Term: See Rated Accuracy

RESPONSE TIME: Step to  $0.01\%$  of final value: 1 second\*

Each range change to  $0.01\%$  of final value: 1 second\*

INPUT CHARACTERISTICS: Resistance, Steady State: 100 M $\Omega$  minimum

Resistance, Dynamic: 20 K $\Omega$  minimum

\* Response time is considerably increased for signals whose source resistance is higher than 10 K $\Omega$ .

*Specifications are Subject to Change Without Notice*

## CHAPTER II

### INSTALLATION AND OPERATION

#### UNPACKING

The instrument is shipped in a heavy cardboard container. Cut the tape on the top of the container and open. If damage is seen, promptly notify the carrier.

#### MOUNTING

The instrument was primarily designed as a bench instrument, however, three types of mounting adapters for mounting in a standard 19-inch mounting rack are available at customer's option. One type may be obtained with an additional drawer for storage of tools, spare parts, etc; a second type will accommodate two Series X-2 DVM's; and the third type is a 19-inch front panel attached to the instrument.

#### **CAUTION**

Do not operate the instrument before ensuring that each plug-in board is firmly in place. Failure to take this precaution may cause damage to components on the board assemblies.

#### POWER SOURCE

Instruments bearing S/N's X-2.1 thru X-2.462 were usually supplied for operation from 110-120 volt, 50-60 Hz, single phase power sources. Instruments bearing S/N's X-2.463 and subsequent operate from 110-120 volts, 50-420 Hz, single phase power sources. All instruments will operate from 220-230 volt sources if the two primaries of the power transformer are wired in series instead of in parallel. The ventilating fan (S/N's X-2.157

thru X-2.462 and others so modified) must be rated at the correct voltage. The Serial No. tag at the rear of the instrument indicates the correct power source if other than 110-120 volts.

#### FUSING

The instrument is protected by a 3AG one-half ampere fuse which is located in an extractor post on the rear panel. When a 220-230 volt power source is to be used (and the power transformer primary rewired as indicated above), it is recommended that a one-fourth ampere fuse be used to provide maximum protection.

#### POWER GROUNDING

The third pin of the power plug grounds the outer chassis of the instrument (Figure 2-1). Despite the presence of the third grounding pin, there is no real assurance that the instrument will be correctly connected since the power outlets in many installations are erroneously wired. Be certain that the power source is in agreement with the power and grounding requirements of the instrument.

#### CONNECTORS (S/N's X-2.1 thru X-2.156)

Two input connectors (J1 and J2, labeled HI and LO respectively) are located on the front panel of the instrument (Figure 2-2) and are wired in parallel with two connectors (J3 and J4) located on the rear of the instrument (Figure 2-3). Two additional connectors (J5 and J6) are located on the rear of the unit and under normal operating conditions are connected together with a shorting strap. To float the input above chassis ground (up to  $\pm 500$  volts), the shorting strap must be removed.

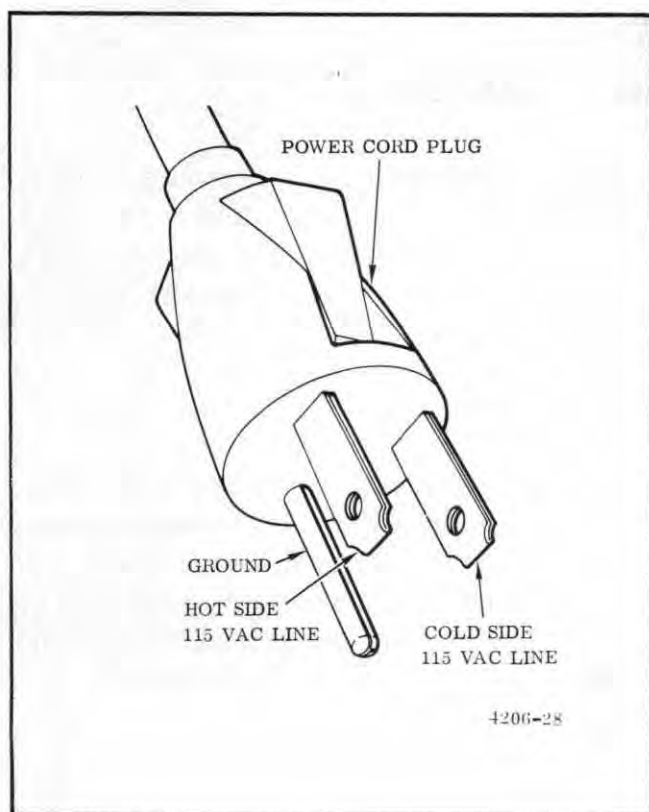


Figure 2-1. Power Plug Pin Coding

#### CONNECTORS (S/N's X-2.157 & subsequent)

These instruments have the same input connectors as those described in the above paragraph and in addition, have three remote triggering connectors (J17, J18 and J19) installed on the rear panel. If the printout option is elected, digital output connector J7 is also installed on the rear panel (see Print Board Assembly Schematic Diagram for connector pin information).

#### CABLE CONNECTIONS

The instrument is supplied with an input cable (P/N 2963-C - 36) for insertion into J1 and J2 on the front panel or J3 and J4 on the rear panel. See Figure 2-4 for connection information. A mating connector is supplied for J7 when the printout capability option is elected.

#### CONTROLS

##### POWER SWITCH (S/NX-2.1 thru X-2.156)

The power switch is located on the front panel of the instrument and has three positions (OFF, STBY. and ON). The STBY. position is used to stop the instrument from taking further readings. The ON position commands the instrument to take readings at its maximum rate (allow 30 minutes for instrument warm-up).

##### POWER SWITCH (S/N's X-2.157 & subseq.)

The STBY. position of the power switch on these instruments has been re-labeled REMOTE. In the REMOTE position, a print/record pulse is issued at the completion of each measurement; in the ON position this pulse is inhibited. In the absence of a remote triggering pulse, the REMOTE position serves as a standby control, i.e., the last reading taken remains stored in the readout.

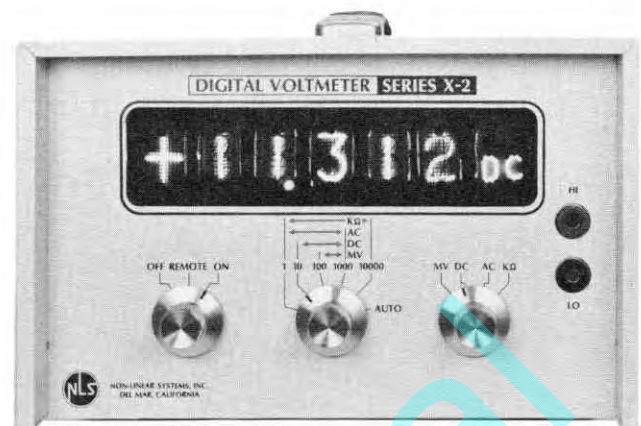
##### REMOTE TRIGGERING (S/N's X-2.157 & subsequent)

To externally trigger the instrument by a recording device through connector J7, the shorting strap between connectors J17 and J18 must be kept in place. Each pulse applied through connector will provide only a single reading. For each pulse applied, a delay of 180 MS will take place in the VDC, MVDC and K ohms functions and a delay of 900 MS will take place in the AC function.

With the shorting strap between connectors J17 and J18 removed, the instrument may also be externally triggered by a contact closure between connectors J18 and J19. For a single reading only, the duration of this



S/N's X-2.1 THRU X-2.156

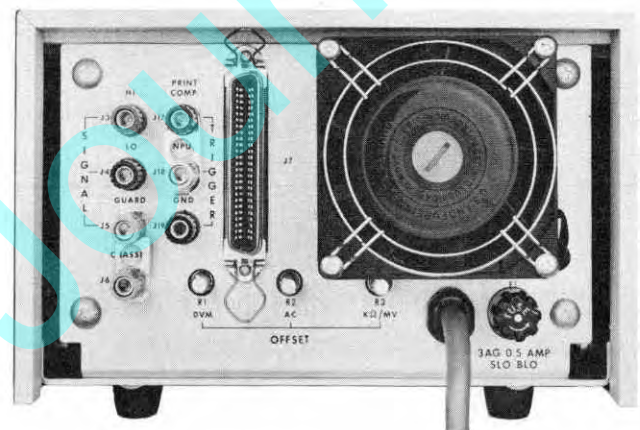


S/N's X-2.157 & SUBSEQUENT

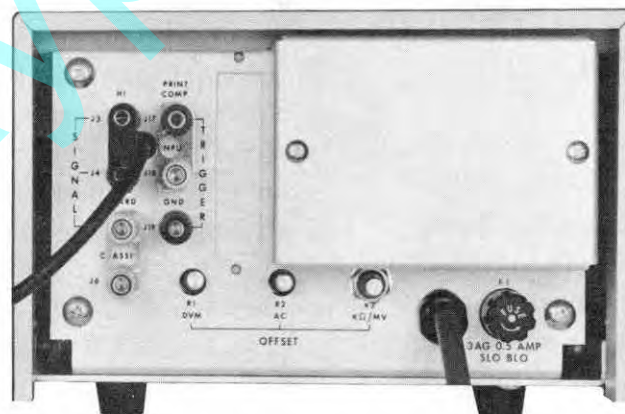
Figure 2-2. Front Views



S/N's X-2.1 THRU X-2.156



S/N's X-2.157 THRU X-2.462



S/N's X-2.463 & SUBSEQUENT

Figure 2-3. Rear Views

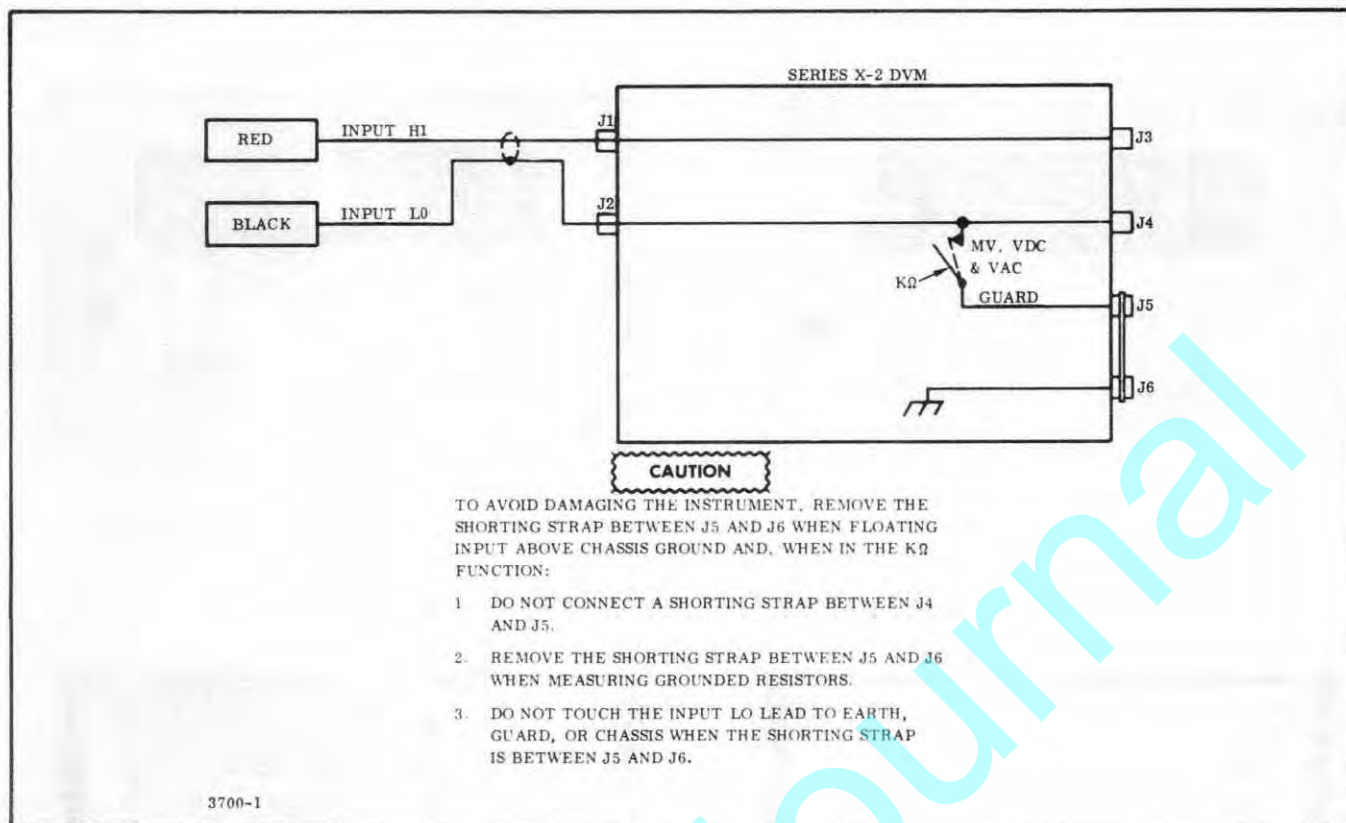


Figure 2-4. Input Connections

closure must be less than 100 MS. Closures in excess of 100 MS (with the exception of range changes) will cause the instrument to continuously scan as long as the closure is applied.

To eliminate first-reading-error with either method of triggering, the input signal to be measured must be applied prior to the application of the triggering pulse.

#### RANGE SWITCH

The range switch is located on the front panel of the instrument and has six positions. (See table I.) When in the 1 position, the instrument is locked in the 1 volt range for the measurement of AC voltages or in the 1K range for the measurement of K ohms. When in the 10 position, the instrument is locked in the 10-volt range for the measurement of AC or DC voltages or in the 10K range for the measurement of K ohms. When in the

100 position, the instrument is locked in the 100-volt range for the measurement of AC and DC voltages, in the 100 MV range for the measurement of millivolts or in the 100K range for the measurement of K ohms. When in the 1000 position, the instrument is locked in the 1000-volt range for the measurement of AC and DC voltages, in the 1000 MV range for the measurement of millivolts or in the 1000K range for the measurement of K ohms. When in the 10,000 position, the instrument is locked in the 10,000K range for the measurement of K ohms. If the instrument has the automatic ranging capability, the proper range is automatically selected when the switch is in the AUTO position. (The 10,000K range can only be selected manually.) With the switch in the AUTO position (if the instrument does not have the auto-ranging capability), the readout will not display decimals and the instrument will be in the lowest range of the particular function selected by the function switch.

## OPERATING CAUTIONS

### GROUND REFERENCE MEASUREMENTS

When measuring an AC power line, or any potential where one side is reference to earth ground, first remove the shorting strap between guard and chassis ground (J5 and J6) on the rear of the instrument. The guard connects to signal low inside the unit. If signal low (J2) is inadvertently connected to the power line "hot" lead, it will be shorted to ground due to internal circuitry and the instrument will be damaged.

### OHMS MEASUREMENT

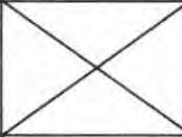
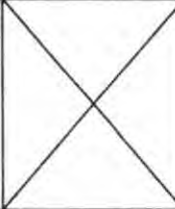
1. Input low is NOT connected to guard (K $\Omega$  mode only). DO NOT therefore connect shorting strap between input low and guard (J4 and J5).
2. If input low lead is allowed to contact earth, guard or chassis with strap between guard and chassis (J5 and J6), fuse on K $\Omega$  Converter will blow.

### EXTERNAL TRIGGERING

When externally triggering the DVM through pin 47 of connector J7, DO NOT apply an input voltage in excess of 5 volts. Failure to observe this precaution may result in damage to the instrument.

Table I. Measurement Capabilities

Table 1: Measurement Capabilities

|                           |            | Range Switch Positions                                                            |                                                                                   |                     |                               |                                                                                     |                                                        |
|---------------------------|------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------|-------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------|
|                           |            | 1                                                                                 | 10                                                                                | 100                 | 1000                          | 10,000                                                                              | AUTO                                                   |
| Function Switch Positions | MV         |  |  | 100 MV RANGE        | 1000 MV RANGE                 |  | 100 MV or 1000 MV RANGES                               |
|                           | DC         |  | 10 VDC RANGE                                                                      | 100 VDC RANGE       | 1000 VDC RANGE                |  | 10 VDC, 100 VDC, or 1000 VDC RANGES                    |
|                           | AC         | 1 VAC RANGE                                                                       | 10 VAC RANGE                                                                      | 100 VAC RANGE       | 1000 VAC RANGE (500 VAC MAX.) |  | 1 VAC, 10 VAC 100 VAC or 1000 VAC RANGES (500 VAC Max) |
|                           | K $\Omega$ | 1K $\Omega$ RANGE                                                                 | 10K $\Omega$ RANGE                                                                | 100K $\Omega$ RANGE | 1000K $\Omega$ RANGE          | 10,000K $\Omega$ RANGE                                                              | ALL EXCEPT 10,000K $\Omega$ RNG.                       |

NOTE: The combined positions of the range and function switches as indicated by  above will produce erroneous readings.

### FUNCTION SWITCH

The function switch is located on the front panel of the instrument and has four positions. (See Table I.) It is used to select the desired measurement function, either MV, DC, AC or K $\Omega$ .

### OFFSET CONTROLS

Three screwdriver-adjust potentiometers are located on the rear of the unit. They are provided to zero the reading of the instrument in each of its measuring functions. The specific use of these controls is described in the calibration instructions.

### DIGITAL READOUT

The instrument is normally supplied with

six readout tubes: polarity display; over-range display; and four 0 thru 9 digital and decimal displays (left to right respectively).

A function tube (displaying MV, DC, AC or K $\Omega$ ) is offered as an optional accessory and when utilized is located on the extreme right of the readout. The polarity display (S/N's X-2,307 and subsequent) also indicates an overload condition, i.e., when the input exceeds the limits of a particular manually selected range, the left-most readout tube will display Q. With the range switch in the AUTO position, the overload display will only illuminate when the extreme limits of the instrument have been reached. Refer to specifications for limits of each measurement function.

#### NOTICE

If at any time it should become necessary to return an NLS instrument to the factory, follow the instructions contained in the Appendix of this manual (page A-1) and utilize NLS Form No. 200-50 (Shipping Notice/Packing Slip), located at the rear of the manual.

## CHAPTER III

### CALIBRATION

In the calibration instructions provided in this chapter, it is assumed, that the instrument is in good working order and only requires calibration. If any components are defective, it may be difficult, if not impossible, to calibrate the instrument.

#### SCOPE

The basic DC calibration procedure is divided into six distinct areas: reference adjustment; zero offset adjustment; 10-volt range calibration for a positive input; 10-volt range calibration for a negative input; 100-volt range calibration; and 1000-volt range calibration.

Since the Series X-2 instruments are capable of millivolts, AC and ohms measurements, calibration procedures for these functions are also included.

#### DC VOLTAGE CALIBRATION

##### EQUIPMENT REQUIRED

1. A voltmeter capable of measuring -20 VDC ( $\pm 1$  MVDC).
2. An extension board, NLS No. 1009-41.
3. A voltage standard between 9.000 volts and 11.998 volts.
4. A voltage standard between 90.00 volts and 119.98 volts.
5. A voltage standard between 900.0 volts and 1000.0 volts.

##### NOTE

It should be noted that the error in making a measurement with the

Series X-2 DVM can be as much as the stated accuracy of the instrument plus the accuracy of the voltage standards used in its calibration.

#### INITIAL PREPARATION

1. Remove the cover of the instrument by removing the four screws (two on each side) attaching the cover to the chassis (Figure 3-1).
2. Plug the power cord into a 115 VAC, 50-60 Hz, single phase power source.
3. Place the power switch in the STBY. position and allow 30 minutes for instrument warm-up.

#### PROCEDURE

##### Reference Adjustment

1. Remove the reference assembly, from instrument (Figure 3-2).
2. Insert extension board into J12 main board assembly.
3. Mount reference assembly on top of extension board by inserting reference board pins into extension board. Use care to ensure proper pin alignment.
4. Connect a voltmeter capable of measuring -20 VDC ( $\pm 1$  MVDC) between ground and -20V output, pin 33 and pin 39 (Figure 3-3).
5. Adjust R1 (Figure 3-3) on reference assembly until test meter reads -20V ( $\pm 1$  MVDC).

Remove reference assembly from extension board and remove extension board from instrument.

7. Insert reference assembly into J12.

#### Zero Offset Adjustment.

1. Place function switch in the DC position.
2. Place power switch in the ON position.
3. Place range switch in the 10 position.
4. Connect the red and black clips of the DVM input cable together.
5. Rotate the DVM OFFSET potentiometer R1, located on the rear of the instrument, to a position which causes the readout to display  $\pm 0.000\text{DC}$ .

#### 10-Volt Range Calibration for a Positive Input Voltage

1. Connect the black lead of the DVM input

cable to the negative terminal of the voltage standard described in paragraph 3 under Equipment Required. Connect the read lead to the positive terminal.

2. Apply approximately 9.5 volts.
3. The numerical value displayed in the readout should be equal to the voltage of the voltage standard. If it is not, adjust potentiometer R30 (Figure 3-2) of the Attenuator Assembly, P/N 37-39, until the readout displays the correct value. Note that input impedance of DVM is 10 Megohms.

#### NOTE

Potentiometers R31 and R38 (Figure 3-2) have been adjusted and sealed at the factory and must not be adjusted in the field. They are temperature coefficient compensators for the  $\pm$  prime calibration.



Figure 3-1. Cover Removal

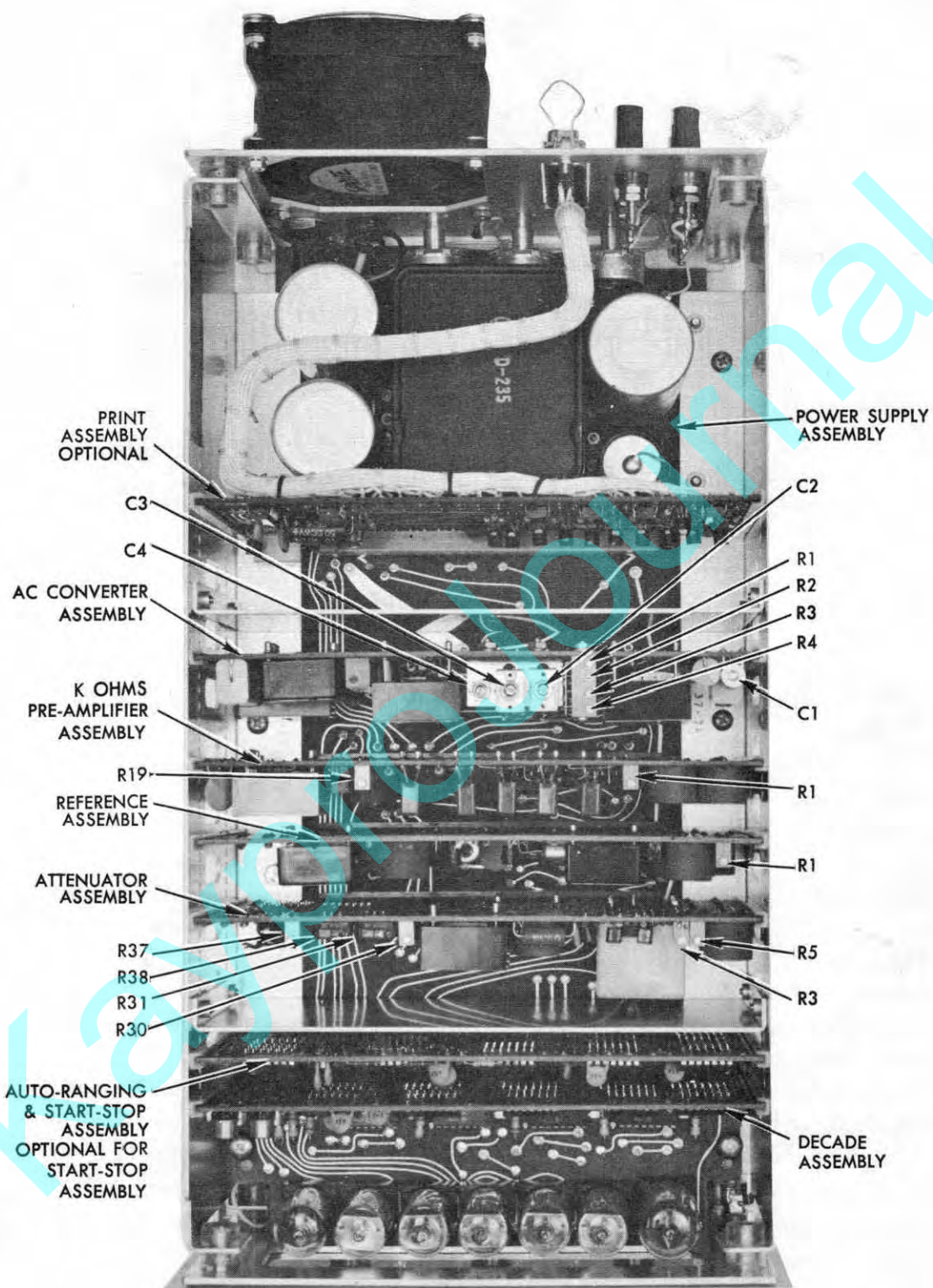


Figure 3-2. Location of Major Subassemblies and Adjustment Points

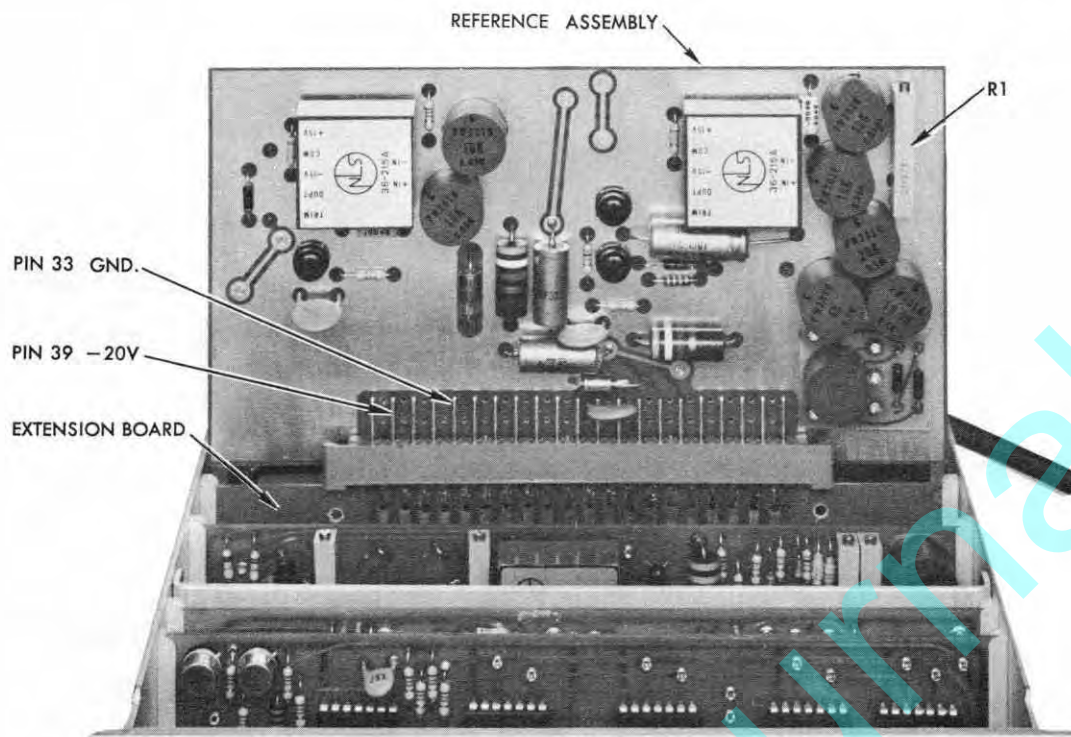


Figure 3-3. Reference Adjustment

#### 10-Volt Range Calibration for a Negative Input Voltage

1. Reverse the connections to the voltage standard.
2. Apply approximately 9.5 volts.
3. The numerical value displayed in the readout should be equal to the voltage of the voltage standard. If it is not, adjust potentiometer R37 (Figure 3-2) of the Attenuator Assembly until the readout displays the correct value.

#### **WARNING**

Use extreme caution in performing the following steps as dangerously high voltages will be employed.

#### 100-Volt Range Calibration

1. Place the range switch in 100 position.
2. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 4 under Equipment Required. Connect the red lead to the positive terminal.
3. Apply approximately 95 volts.
4. The numerical value displayed in the readout should be equal to the voltage of the voltage standard. If it is not, adjust potentiometer R5 (Figure 3-2) of the Attenuator Assembly until the readout displays the correct value.

**WARNING**

Use extreme caution in performing the following steps as dangerously high voltages will be employed.

1000-Volt Range Calibration

1. Place the range switch in the 1000 position.
2. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 5 under Equipment Required. Connect the red lead to the positive terminal.
3. Apply approximately 950 volts.
4. The numerical value displayed in the readout should be equal to the voltage standard. If it is not, adjust potentiometer R3 (Figure 3-2) of the Attenuator Assembly until the readout displays the correct value.

AC CONVERTER CALIBRATION

ADDITIONAL EQUIPMENT REQUIRED

1. An Audio Voltage Standard between 1 volt, 200 Hz - 10K Hz and 500 volts, 200 Hz - 10K Hz.

INITIAL PREPARATION

1. Ensure that the instrument is properly calibrated in the DC voltage measurement function and ensure a 30-minute warm-up period.

PROCEDURE

1. Place the function switch in the AC position.
2. Place the range switch in the 1000 position.

3. Place the power switch in the ON position.
4. Connect the red and black clips of the DVM input cable together.
5. Rotate the AC OFFSET potentiometer, R2, located on the rear of the instrument, to a position which causes the readout to display 0.000 AC.

**WARNING**

Use extreme caution in performing the following steps as dangerously high voltages will be employed.

**CAUTION**

Do not apply more than 500 VAC or damage to the AC Converter Assembly may result.

6. Connect the red lead of the DVM input cable to the AC HI terminal and the black lead to the AC LO terminal of the Audio Voltage Standard
7. Apply approximately 450.00 volts, 200 Hz and adjust R1 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.
8. Apply approximately 450.00 volts, 10K Hz and adjust C1 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

**WARNING**

Use extreme caution in performing the following steps as dangerously high voltage will be employed.

9. Place the range switch in the 100 position. Apply approximately 90.00 volts, 200 Hz and adjust R2 (Figure 3-2) of the AC Converter Assembly until the

numerical value displayed in the readout is equal to the voltage applied.

10. Apply approximately 90.00 volts 10 K Hz and adjust C2 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.
11. Place the range switch in the 10 position. Apply approximately 9.000 volts, 200 Hz and adjust R3 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.
12. Apply approximately 9.000 volts, 10K Hz and adjust C3 of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.
13. Apply approximately 0.9000 volts, 200 Hz and adjust R4 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.
14. Apply approximately 0.9000 volts, 10K Hz and adjust C4 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

#### OHMS CONVERTER AND PRE-AMPLIFIER CALIBRATION

##### ADDITIONAL EQUIPMENT REQUIRED

1. An ohms standard accurate to 0.01%.
2. A voltage standard between 90.00 millivolts and 1199.98 millivolts.

##### INITIAL PREPARATION

1. Ensure that the instrument is properly

calibrated in the DC voltage measurement function and ensure a 30-minute warm-up period.

##### PROCEDURE

1. Place the power switch in the ON position.
2. Place the range switch in the 100 position.
3. Place the function switch in the MV position.
4. Connect the red and black clips of the DVM input cable together.
5. Rotate the K $\Omega$ /MV OFFSET R3 potentiometer, located at the rear of the instrument, to a position which causes the readout to display 00.00 MV.
6. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 2 under Additional Equipment Required. Connect the red lead to the positive terminal.
7. Apply approximately 95.00 millivolts and adjust R19 of the Ohms Converter/Pre-Amplifier Assembly (Figure 3-2) until the numerical value displayed in the readout is equal to the voltage of the voltage standard.
8. Place the range switch in the 1000 position. (S/N's X-2. 189 & subsequent).
9. Apply approximately 950.00 millivolts and adjust R37 (located to the left of R19) of the ohms converter/pre-amplifier assembly until the numerical value displayed in the readout is equal to the voltage of the voltage standard.

10. Place the range switch in the 10000 position.
11. Place the function switch in the K $\Omega$  position.
12. Connect the red and black clips of the DVM input cable together.
13. Rotate the K $\Omega$ /MV OFFSET R3 potentiometer, located on the rear of the instrument, to a position which causes the readout to display 0000 K $\Omega$ .
14. Connect the two leads of the DVM input cable to the output terminals of the ohms standard.
15. Apply approximately 9000 K $\Omega$  and adjust R1 (Figure 3-2) of the ohms converter and pre-amplifier assembly until the numerical value displayed in the readout is equal to the ohmic value applied.
2. Place the range switch in the 100 position.
3. Place the function switch in the MV position.
4. Connect the red and black clips of the DVM input cable together.
5. Rotate the K $\Omega$ /MV OFFSET R3 potentiometer, located on the rear of the instrument, to a position which causes the readout to display 00.00 MV.
6. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 2 under Additional Equipment Required. Connect the red lead to the positive terminal.
7. Apply approximately 95.00 millivolts and adjust R1 of the Ohms Converter/Pre-amplifier assembly (Figure 3-4) until the numerical value displayed in the readout is equal to the voltage of the voltage standard.

## PRECISION PRE-AMPLIFIER CALIBRATION

### INITIAL PREPARATION

1. Ensure that the instrument is properly calibrated in the DC voltage measurement function and ensure a 30-minute warm-up period.

### PROCEDURE

1. Place the power switch in the ON position.
8. Place the range switch in the 1000 position.
9. Apply approximately 950.00 millivolts and adjust R2 of the preamplifier assembly until the numerical value displayed in the readout is equal to the voltage of the voltage standard.

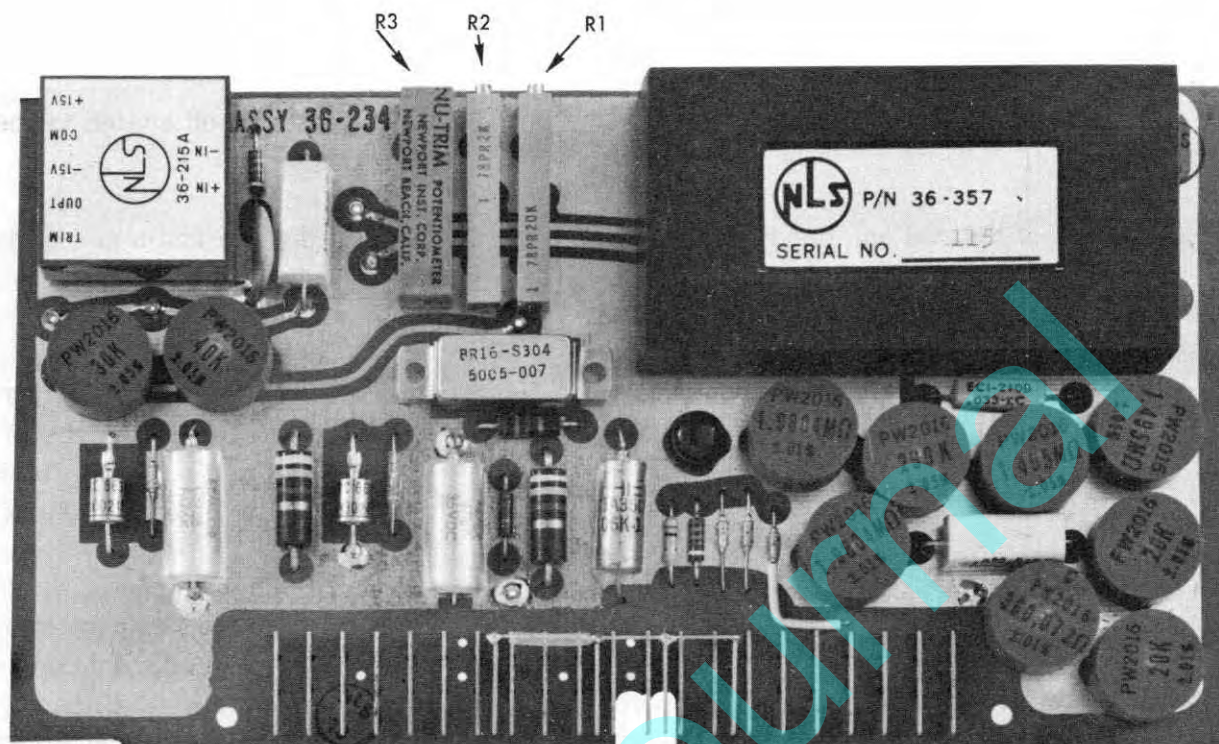


Figure 3-4. Precision Pre-amplifier Assembly Adjustment Points

## CHAPTER IV

### MAINTENANCE

In the Series X-2 Digital Voltmeter, virtually all circuit components are assembled on plug-in modules. Thus maintenance problems are simplified to the point where the instrument can be kept operating without the need for highly trained maintenance personnel. Because of this plug-in design, downtime is held to a minimum; the unit can be kept operating in locations from which it would be impractical or inconvenient to send the instrument to a repair facility or to the manufacturer. Only a very few minutes are needed to replace all the plug-in boards. By using trial-and-error techniques the instrument can be rapidly returned to service, and the defective module repaired at a later date.

For a general understanding of the principles of operation of the Series X-2 DVM, refer to Figures 4-1 through 4-15. For a more detailed analysis, refer to the schematic and wiring diagrams at the end of this manual.

In order to pursue the plug-in philosophy to the fullest, spare modules as listed in Section V, Recommended Spare Parts List, should be kept in stock.

If it is desired to measure voltages and check waveforms on a particular plug-in module, a 41-pin extension board will be required to raise the board so that pin contacts become accessible. These boards, NLS part number 1009-41, may be ordered from any NLS representative or from the NLS Main Office in Del Mar, California.

#### TROUBLESHOOTING

For troubleshooting information, refer to Table 4-1.

#### DIGITAL READOUT REPLACEMENT

The readout tubes providing the digital, polarity and function displays have exceedingly long-life expectancy and rarely require replacement. However, to replace a readout tube in the event of failure, perform the following steps:

1. Remove the cover from the instrument by removing the four screws (two on each side) attaching the cover to the chassis.
2. Remove the decade assembly (front board) from the instrument.
3. Firmly grasp the decade assembly with one hand and the malfunctioning tube with the other.
4. With a rocking motion, carefully pull the tube from its socket.
5. Install new tube, using care to properly align pins into tube socket, and replace decade board and cover in reverse order of removal.

#### FAN LUBRICATION

Under normal operating conditions, the ventilating fan (S/N's X-2.157 thru X-2.462 and those earlier S/N's so modified) should be lubricated every two or three months.

To lubricate the fan, remove the blue slotted plug from rear of fan assembly, and apply two or three drops of Rotron M-21 lubricant.

Figure 4-1. Block Diagram Series X-2 DVM

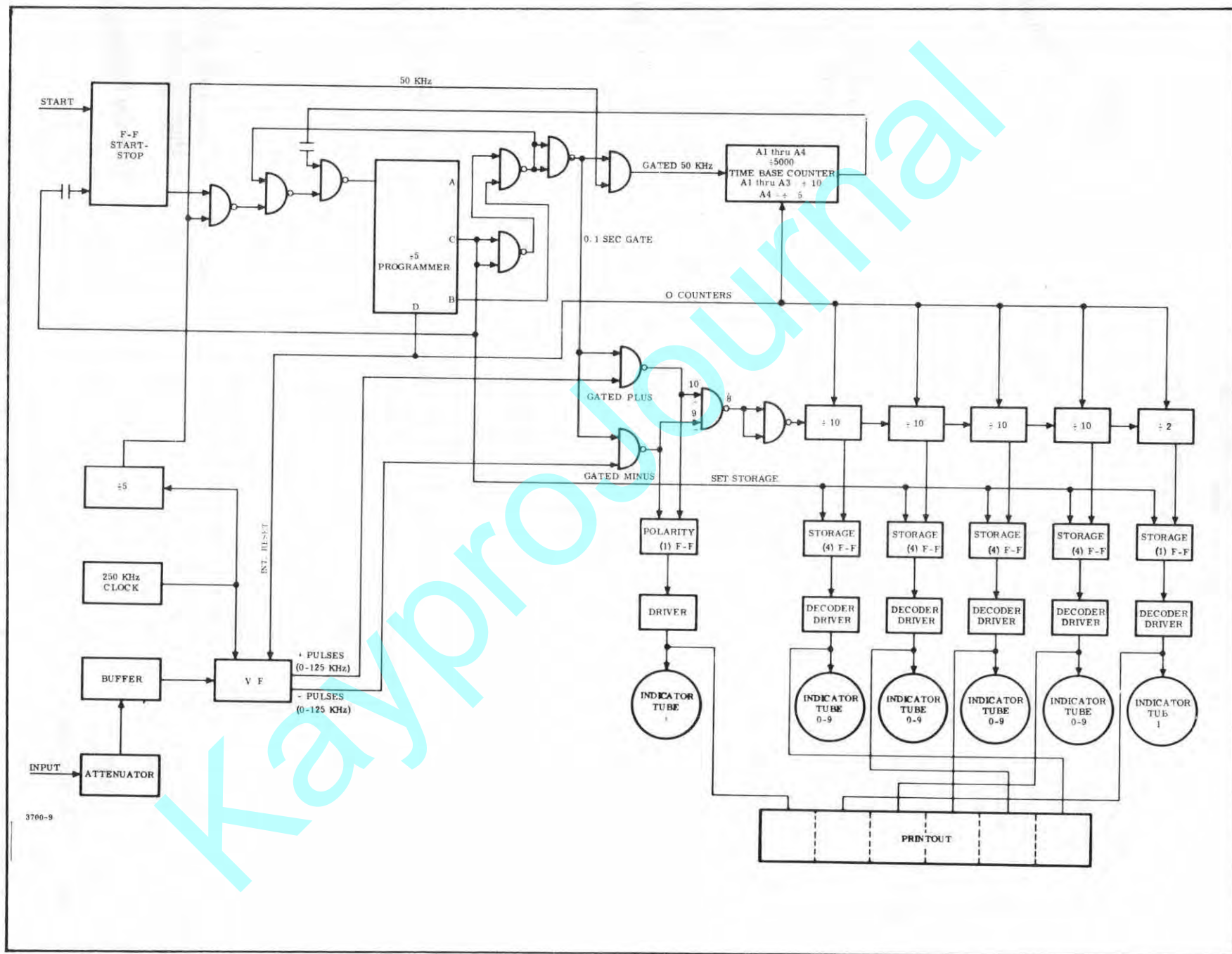


Figure 4-2. Simplified Diagram, Auto-ranging

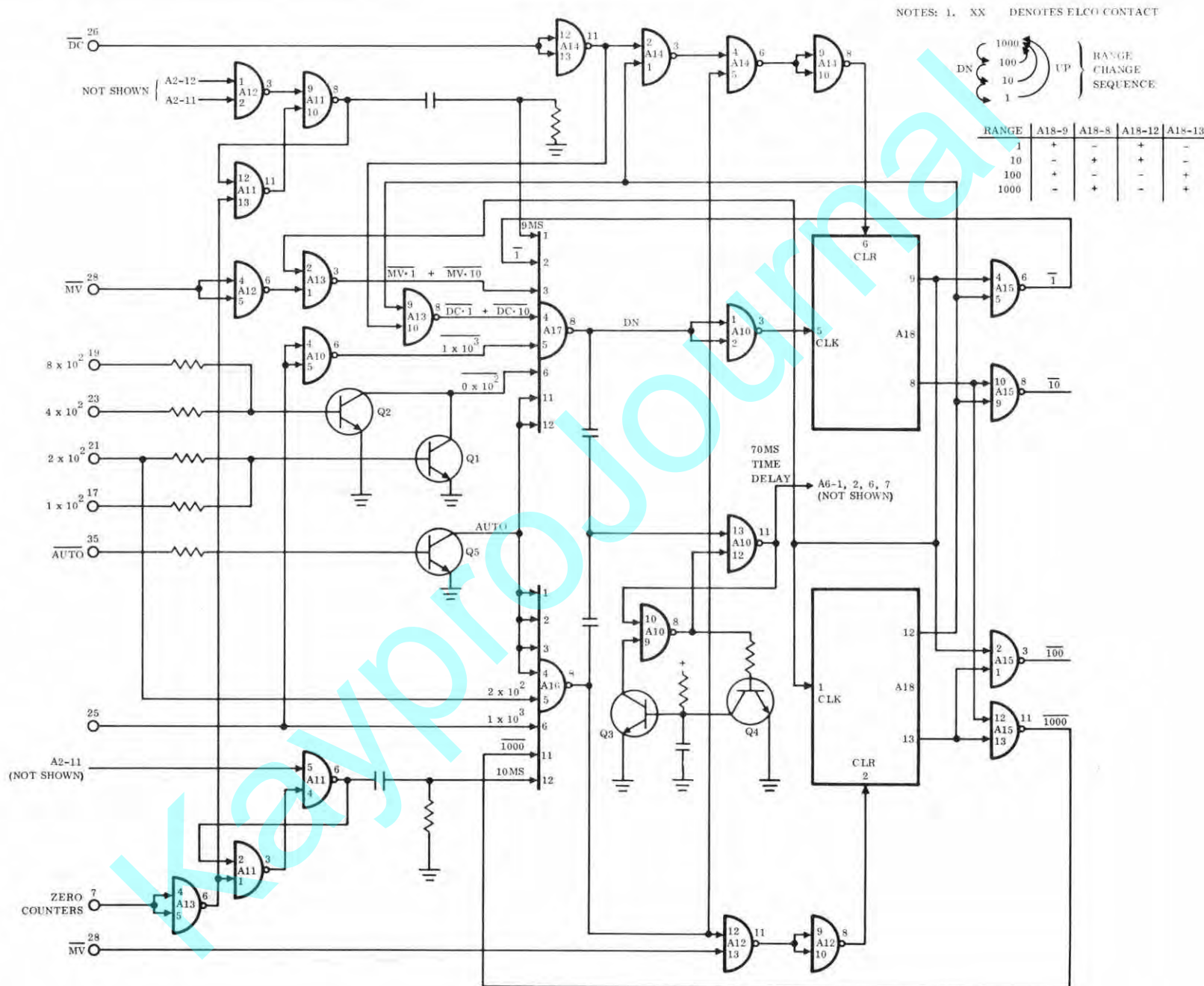


Figure 4-3. Simplified Diagram, Reference Supply

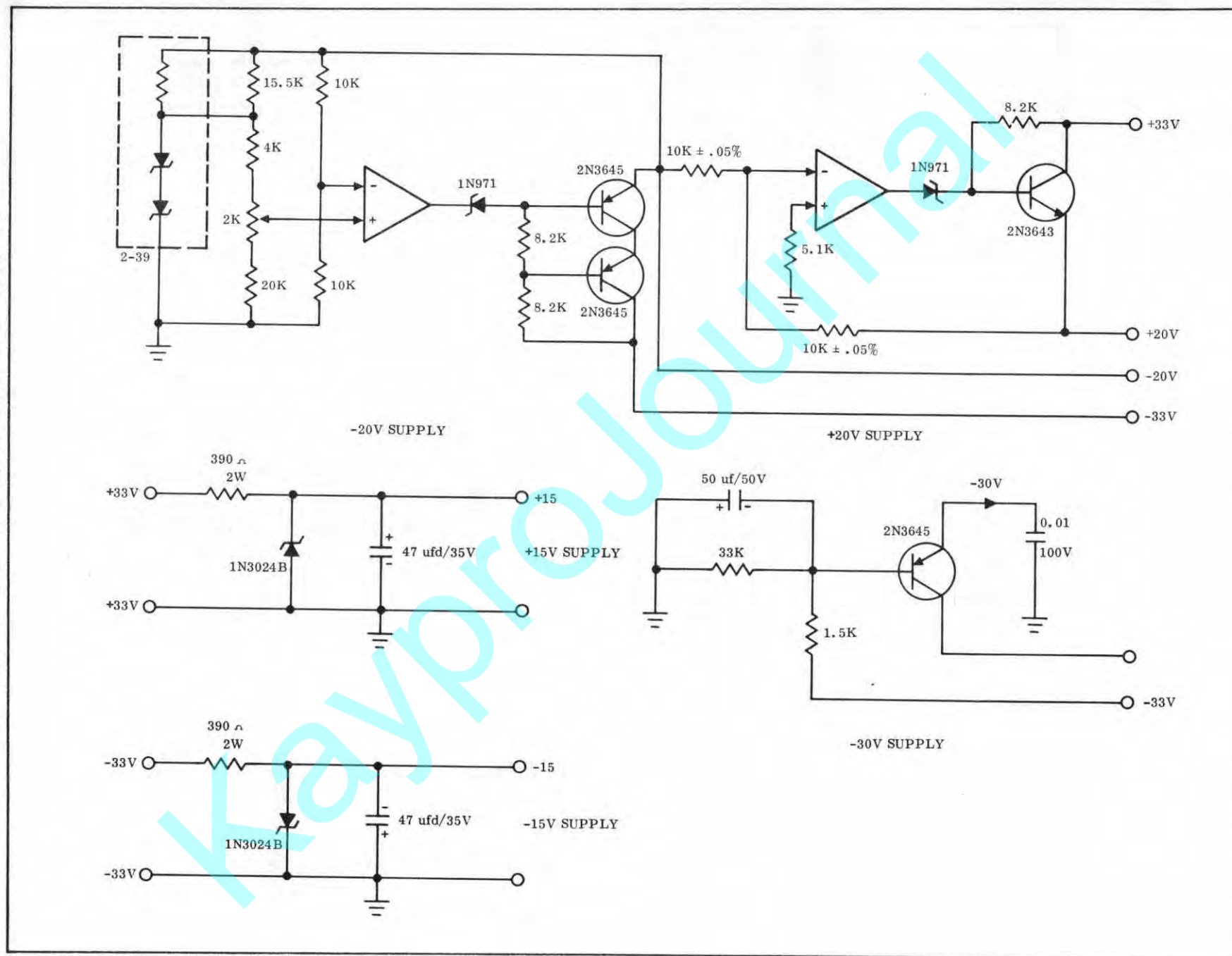


Figure 4-4. Simplified Diagram, Series X-2 Input - Integrator with Resetter  
Circuitry and Temperature Compensation Potentiometers

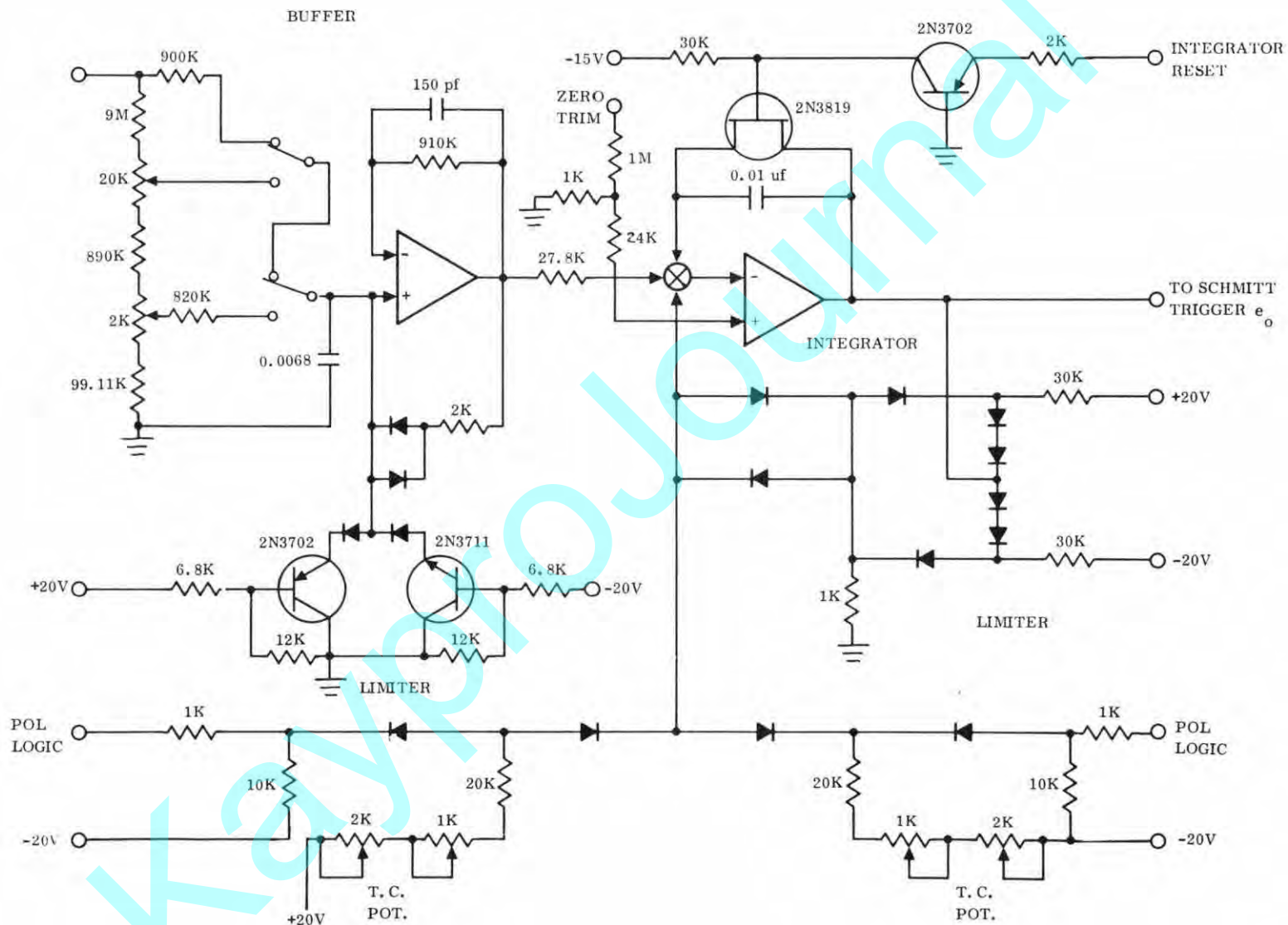
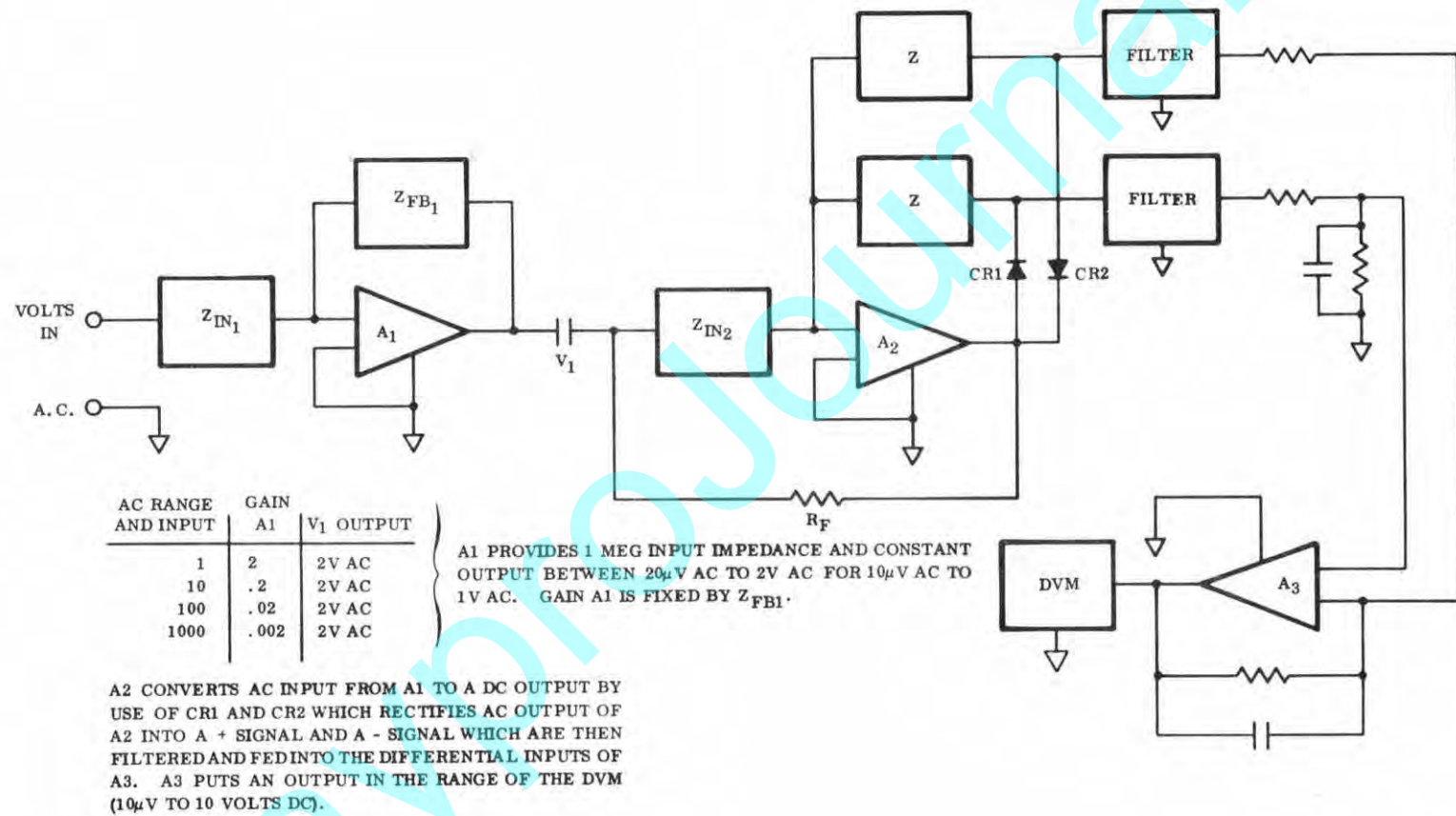


Figure 4-5. Simplified Diagram AC Converter



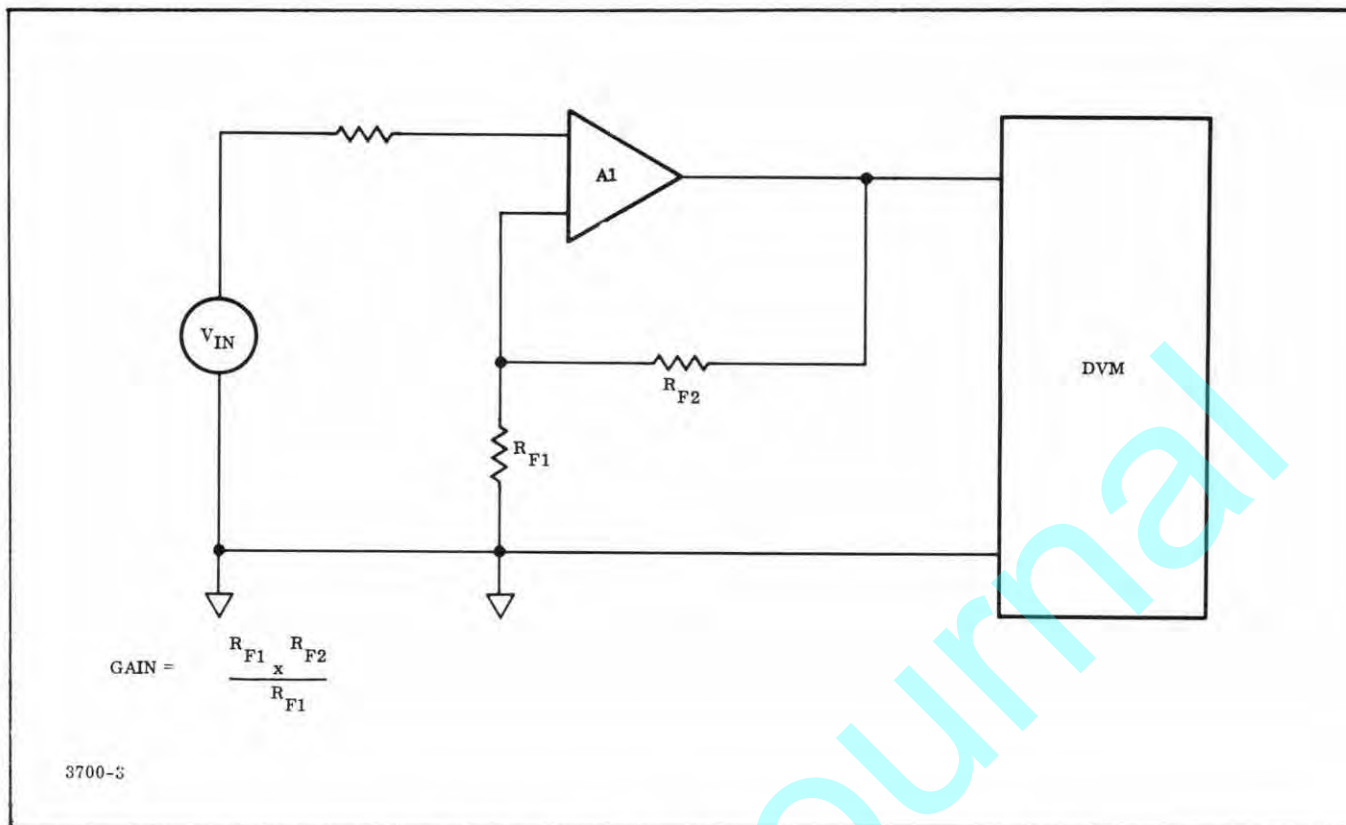


Figure 4-6. Simplified Diagram Pre-amplifier

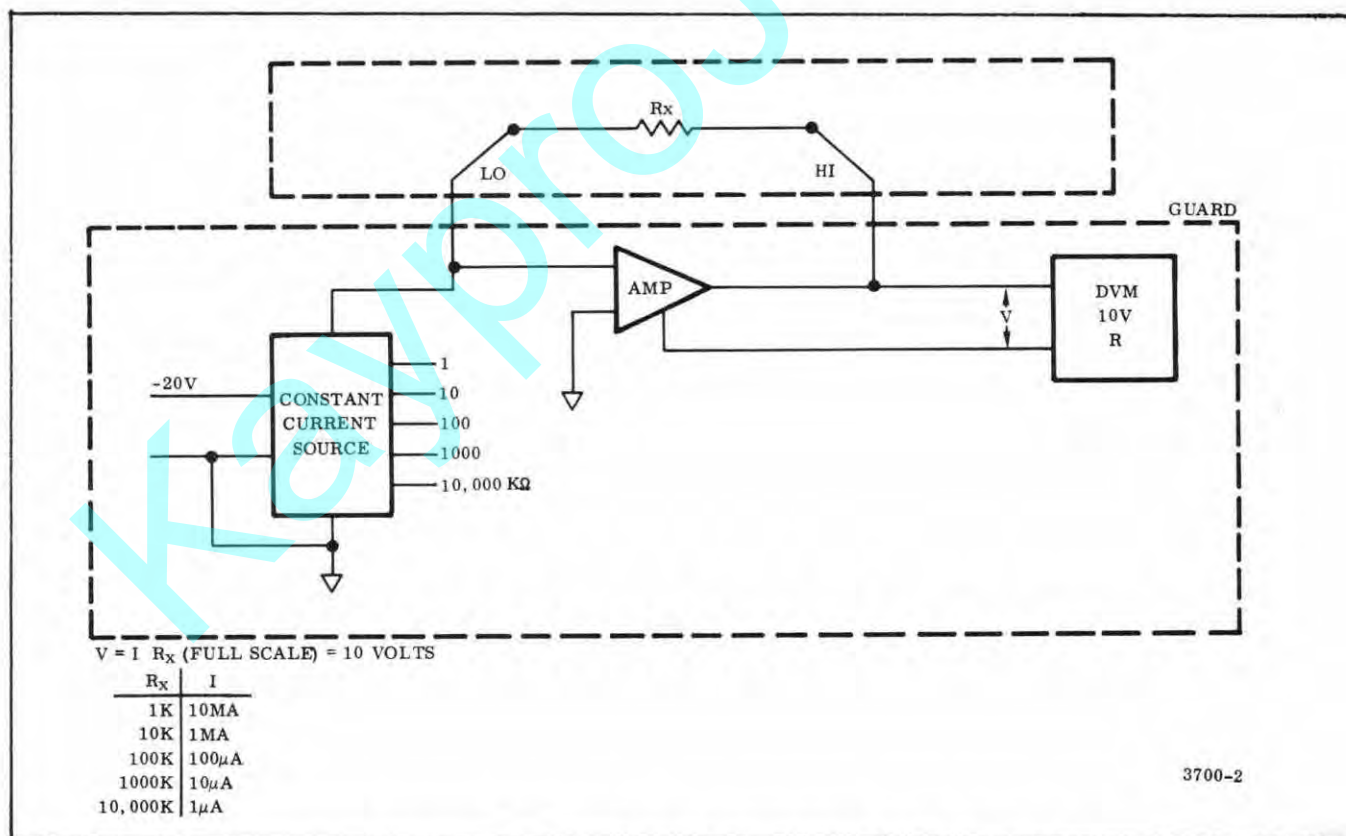


Figure 4-7. Simplified Diagram Ohms Converter

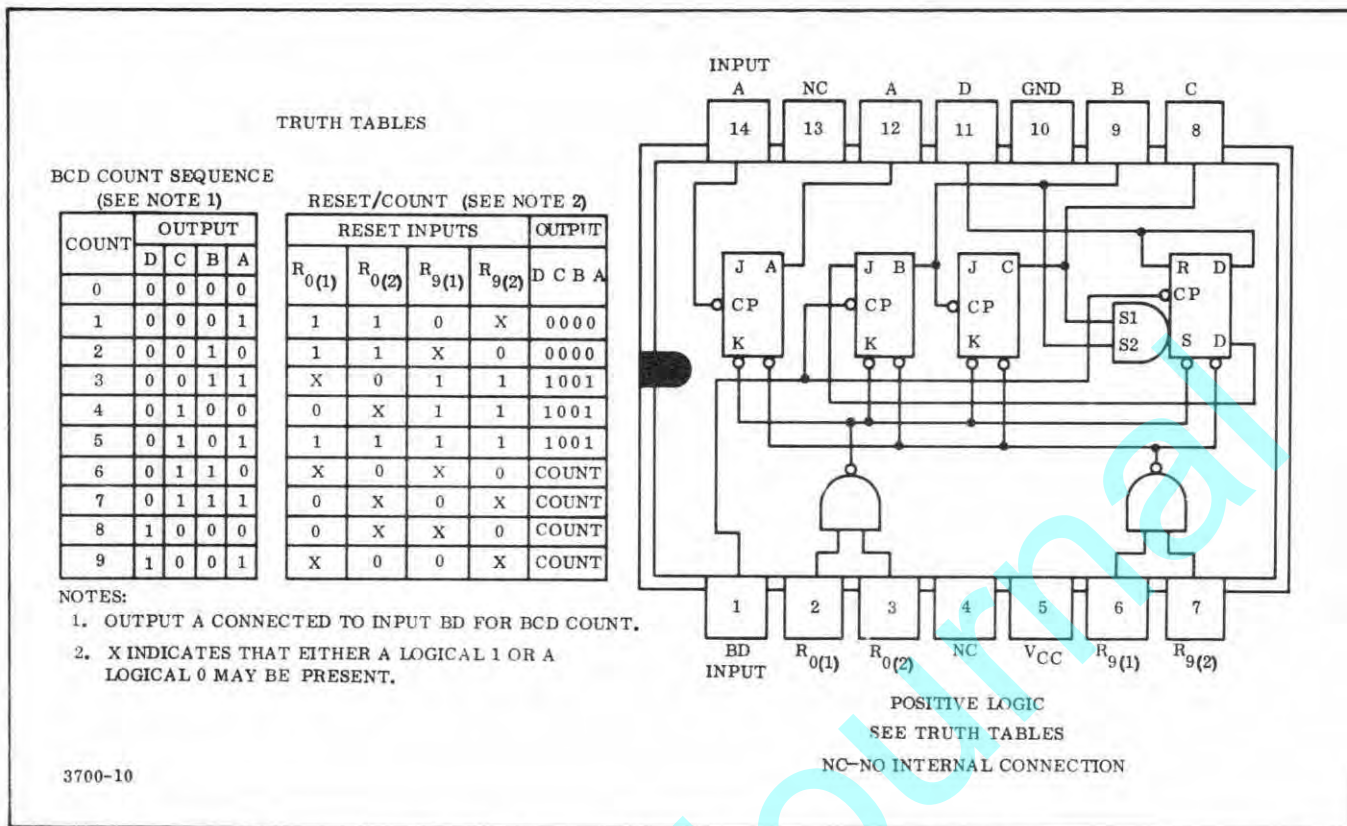


Figure 4-8. Type SN7490N Decade Counter

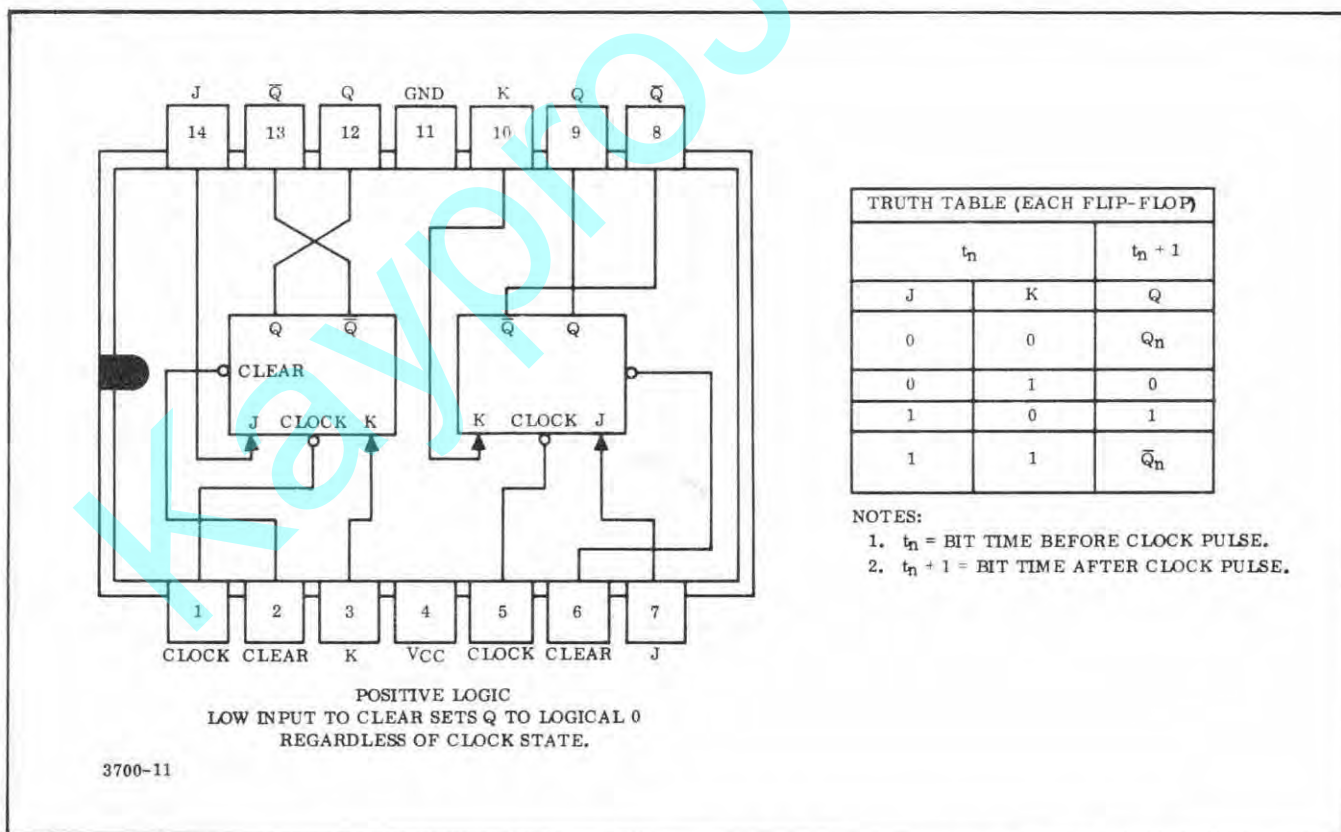
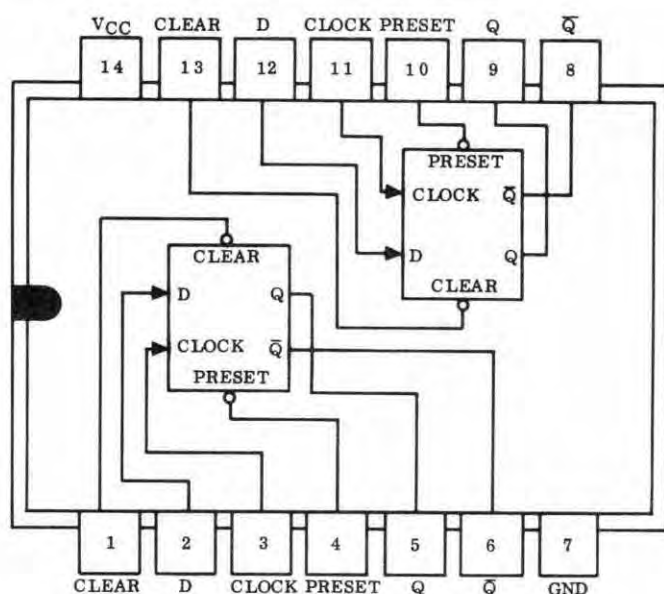


Figure 4-9. Type SN7473N Dual J-K Master-Slave Flip-Flop



TRUTH TABLE (EACH FLIP-FLOP)

| $t_n$   | $t_n + 1$ |                  |
|---------|-----------|------------------|
| INPUT D | OUTPUT Q  | OUTPUT $\bar{Q}$ |
| 0       | 0         | 1                |
| 1       | 1         | 0                |

NOTES:

1.  $t_n$  = BIT TIME BEFORE CLOCK PULSE.
2.  $t_n + 1$  = BIT TIME AFTER CLOCK PULSE.

POSITIVE LOGIC

- a. LOW INPUT TO CLEAR SETS Q TO LOGICAL 0.
- b. LOW INPUT TO PRESET SETS Q TO LOGICAL 1.
- c. CLEAR OR PRESET INPUTS DOMINATE REGARDLESS OF CLOCK AND D INPUTS.

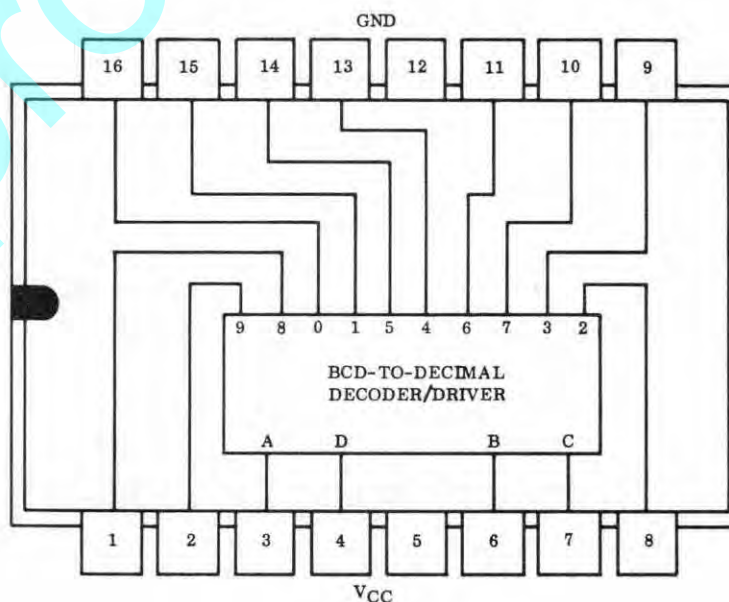
3700-12

Figure 4-10. Type SN7474N Dual D-Type Edge-Triggered Flip-Flop

TRUTH TABLE

| INPUT |   |   |   | OUTPUT ON $\dagger$ |
|-------|---|---|---|---------------------|
| D     | C | B | A |                     |
| 0     | 0 | 0 | 0 | 0                   |
| 0     | 0 | 0 | 1 | 1                   |
| 0     | 0 | 1 | 0 | 2                   |
| 0     | 0 | 1 | 1 | 3                   |
| 0     | 1 | 0 | 0 | 4                   |
| 0     | 1 | 0 | 1 | 5                   |
| 0     | 1 | 1 | 0 | 6                   |
| 0     | 1 | 1 | 1 | 7                   |
| 1     | 0 | 0 | 0 | 8                   |
| 1     | 0 | 0 | 1 | 9                   |

$\dagger$  ALL OTHER OUTPUTS ARE OFF.



POSITIVE LOGIC  
SEE TRUTH TABLE

3700-13

Figure 4-11. Type SNX7441N BCD-to-Decimal Decoder/Driver

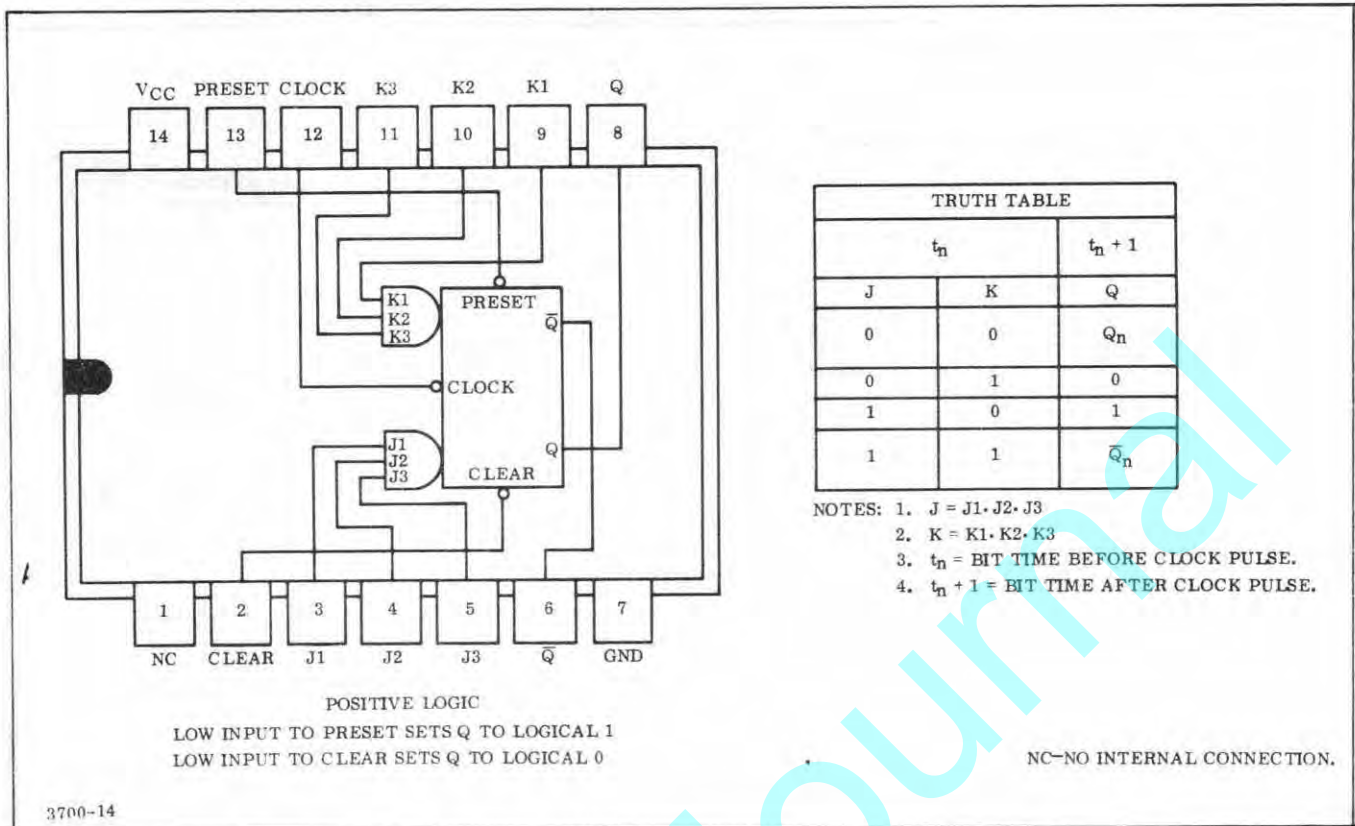


Figure 4-12. Type SN 7472N JK Master-Slave Flip-Flop

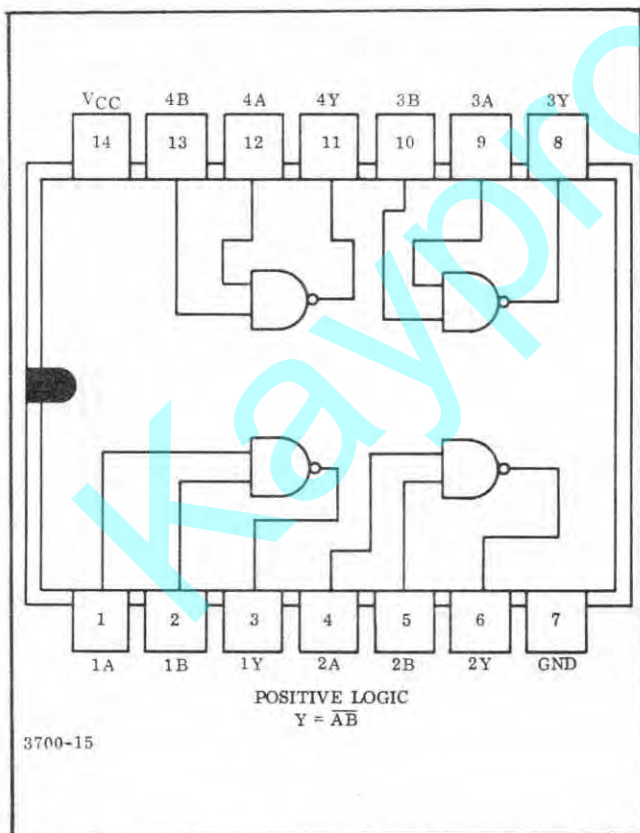


Figure 4-13. Type SN7400N Quadraple 2-Input Positive Nand Gate

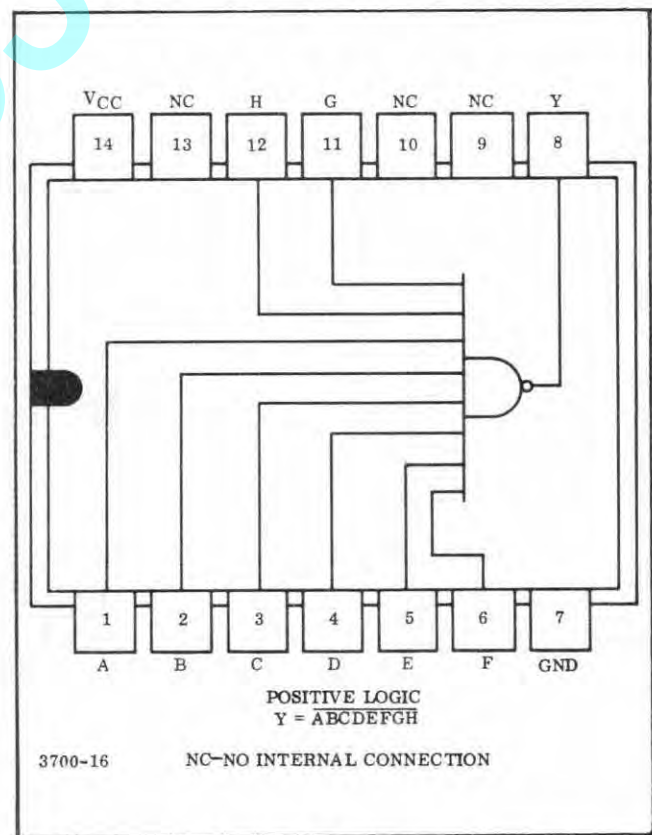
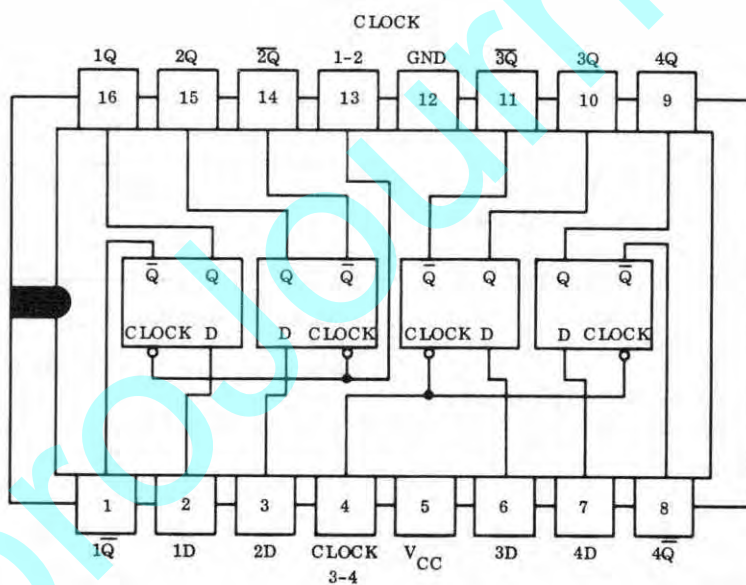


Figure 4-14. Type SN7430N 8-Input Positive Nand Gate

| TRUTH TABLE<br>(EACH LATCH) |           |           |
|-----------------------------|-----------|-----------|
| $t_n$                       | $t_n + 1$ |           |
| D                           | Q         | $\bar{Q}$ |
| 1                           | 1         | 0         |
| 0                           | 0         | 1         |

- NOTES: 1.  $t_n$  = BIT TIME BEFORE  
CLOCK PULSE.
2.  $t_n + 1$  = BIT TIME AFTER  
CLOCK PULSE



3700-17

Figure 4-15. Type SN7475N Quadrate Bistable Latch

TABLE II. Troubleshooting

| SYMPTOM                                                                                   | PROBABLE CAUSE                                         | CORRECTION                                                     |
|-------------------------------------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------------|
| No readout when the POWER switch is positioned to ON                                      | No line-voltage                                        | Check line-voltage                                             |
|                                                                                           |                                                        | Check power cable                                              |
|                                                                                           | 230-volt instrument plugged into 115-volt power outlet | Plug into 230-volt power outlet                                |
|                                                                                           | Open fuse F1 in power supply                           | Replace fuse                                                   |
|                                                                                           | 200V power supply defective                            | Repair 200V power supply<br>C4, R4, R5, R15, CR9, CR12, and Q6 |
| No response to input in K $\Omega$ function                                               | Open fuse F1 in K $\mu$ /MV Converter Assembly         | Replace fuse                                                   |
| Blank indicator in readout                                                                | Defective indicator tube                               | Replace indicator tube                                         |
|                                                                                           | Defective indicator tube driver                        | Replace A11, A12, A13, or A14                                  |
| Samples and measures when POWER switch is in REMOTE position                              | POWER switch defective                                 | Replace switch S1                                              |
| Does not sample continuously when POWER switch is in ON position                          | POWER switch defective                                 | Replace switch S1                                              |
|                                                                                           | Defective Attenuator Assembly                          | Repair or replace                                              |
|                                                                                           | Defective Reference Assembly                           | Repair or replace                                              |
|                                                                                           | Defective Start/Stop and Auto-Range Assembly           | Repair or replace                                              |
| Errors in one polarity but not in other                                                   | 10V range not properly calibrated                      | Check calibration and adjust as necessary                      |
| Samples but does not change readout                                                       | Defective Decade Assembly                              | Repair or replace                                              |
| Function does not control the instrument properly                                         | Function switch defective                              | Replace switch S3                                              |
| Range switch does not control instrument properly, or incorrect decimal point positioning | Defective range switch                                 | Replace switch S2                                              |
|                                                                                           | Defective Start/Stop and Auto-Range Assembly           | Repair or replace                                              |
| All indicators on simultaneously (blur)                                                   | +5V power supply defective                             | Repair +5V power supply                                        |
| Unit does not function in AC mode.                                                        | Defective function switch                              | Replace switch S3                                              |
|                                                                                           | Defective AC/DC Converter Assembly                     | Repair or replace                                              |

TABLE II. Troubleshooting (Con't)

| SYMPTOM                               | PROBABLE CAUSE                                  | CORRECTION                                   |
|---------------------------------------|-------------------------------------------------|----------------------------------------------|
| Readings erratic                      | Defective input cable                           | Replace input cable                          |
|                                       | Defective Reference Assembly                    | Repair or replace                            |
|                                       | Defective Attenuator Assembly                   | Repair or replace                            |
| Some or all decades go to nines       | Defective Decade Assembly                       | Repair or replace                            |
|                                       | Defective Decade Assembly                       | Repair or replace                            |
| Improper polarity                     | Defective Start/Stop and Auto-Range Assembly    | Repair or replace                            |
|                                       | Defective Start/Stop and Auto-Range Assembly    | Replace                                      |
| Improper range changing               | Zero not properly adjusted                      | Adjust zero                                  |
|                                       | 10V range not properly calibrated               | Check calibration and adjust as necessary    |
| Errors in one range but not in others | Range in question not properly calibrated       | Check calibration and adjust as necessary    |
|                                       | Defective range resistor on Attenuator Assembly | Replace range resistor                       |
|                                       | Defective range relay on Attenuator Assembly    | Replace range relay                          |
| Offset in low range but not in others | Group loop on input                             | Check input hookup and eliminate ground loop |
|                                       | Defective Reference Assembly                    | Repair or replace                            |
| Drift                                 | Defective Attenuator Assembly                   | Repair or replace                            |
|                                       | Defective Start/Stop and Auto-Range Assembly    | Repair or replace                            |

#### NOTICE

If at any time it should become necessary to return an NLS instrument to the factory, follow the instructions contained in the Appendix of this manual (page A-1) and utilize NLS Form No. 200-50 (Shipping Notice/Packing Slip), located at the rear of the manual.

## CHAPTER V

### RECOMMENDED SPARE PARTS LIST

| <u>Part No.</u> | <u>Description</u>                                               | <u>Qty.</u> |
|-----------------|------------------------------------------------------------------|-------------|
| 37-30           | Decade Assembly (S/N's X-2 . 1 thru X-2. 301                     | 1           |
| 37-36           | Reference Assembly (S/N's X-2 . 1 thru X-2. 462)                 | 1           |
| 37-39           | Attenuator Assembly (S/N's X-2 . 1 thru X-2, 462)                | 1           |
| 37-69           | Start-Stop Assembly                                              | 1           |
| 37-160          | Decade Assembly (S/N's X-2. 302 & Subsequent)                    | 1           |
| 37-272          | Reference Assembly (S/N's X-2. 463 & Subsequent)                 | 1           |
| 37-275          | Attenuator Assembly (S/N's X-2. 463 & Subsequent)                | 1           |
| 37-360          | Decade Assembly (Replaces 37-160)                                | 1           |
| SP2A2           | Fan Assembly (S/N's X-2. 157 thru X-2. 462 & others so modified) | 1           |
| 1009-41         | Extension Board (Test Equipment)                                 | 1           |
| 31300. 5        | Fuse, 3AGO. 5A Slo-Blo                                           | 6           |
| B5440           | Readout Indicator Tube (0 thru 9)                                | 1           |
| B5441           | Readout Indicator Tube (0 thru 9 & Decimal)                      | 1           |
| B5448           | Readout Indicator Tube (Polarity)                                | 1           |
| 2963-C-36       | Cable Assembly                                                   | 1           |

#### ACCESSORIES

|        |                                                                 |   |
|--------|-----------------------------------------------------------------|---|
| 54361  | Readout Indicator Tube (Function)                               | 1 |
| 37-33  | Start-Stop & Auto Range Assembly                                | 1 |
| 37-42  | Ohms Converter & Pre-Amp Assembly (S/N's X-2. 1 thru X-2. 462)  | 1 |
| 37-45  | AC Converter Assembly, 10K Hz (S/N's X-2. 1 thru X-2. 462)      | 1 |
| 37-77  | AC Converter Assembly, 100 KHz (S/N's X-2. 1 thru X-2. 462)     | 1 |
| 37-89  | Print Board Assembly (S/N's X-2. 1 thru X-2. 462)               | 1 |
| 37-278 | Ohms Converter & Pre-Amp Assembly (S/N's X-2. 463 & Subsequent) | 1 |
| 37-281 | AC Converter Assembly 10KHz (S/N's X-2. 463 & Subsequent)       | 1 |
| 37-315 | AC Converter Assembly 100KHz (S/N's X-2. 463 & Subsequent)      | 1 |
| 37-316 | Print Board Assembly (S/N's X-2. 463 & Subsequent)              | 1 |

## APPENDIX

### 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.

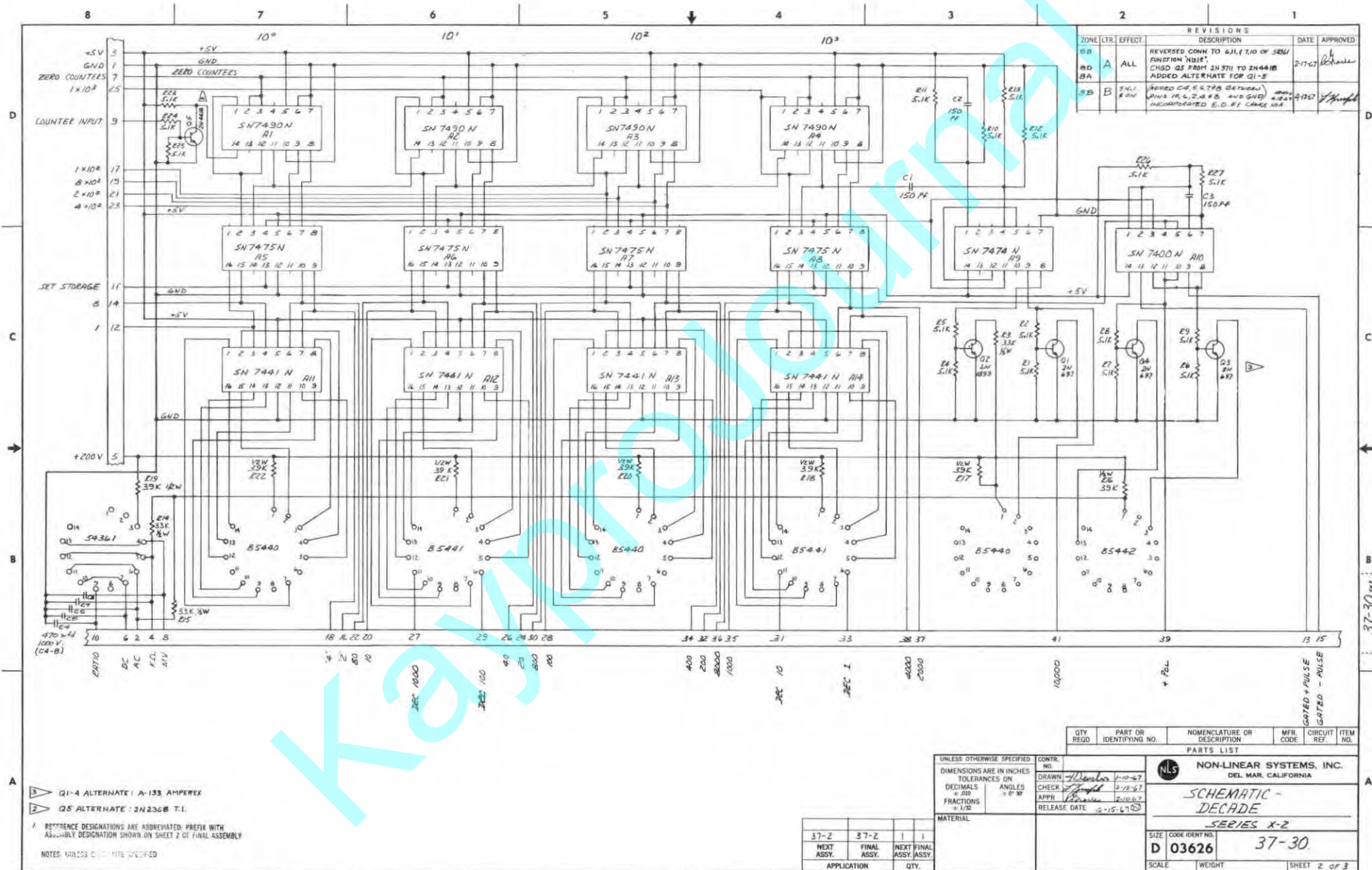
Be certain to pack the instrument carefully; while an outer and inner box, separated by two or three inches of excelsior is desirable, the instrument can be placed into a single container provided it is so packed that it will not shift about. As with the double box method, use two or three inches of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

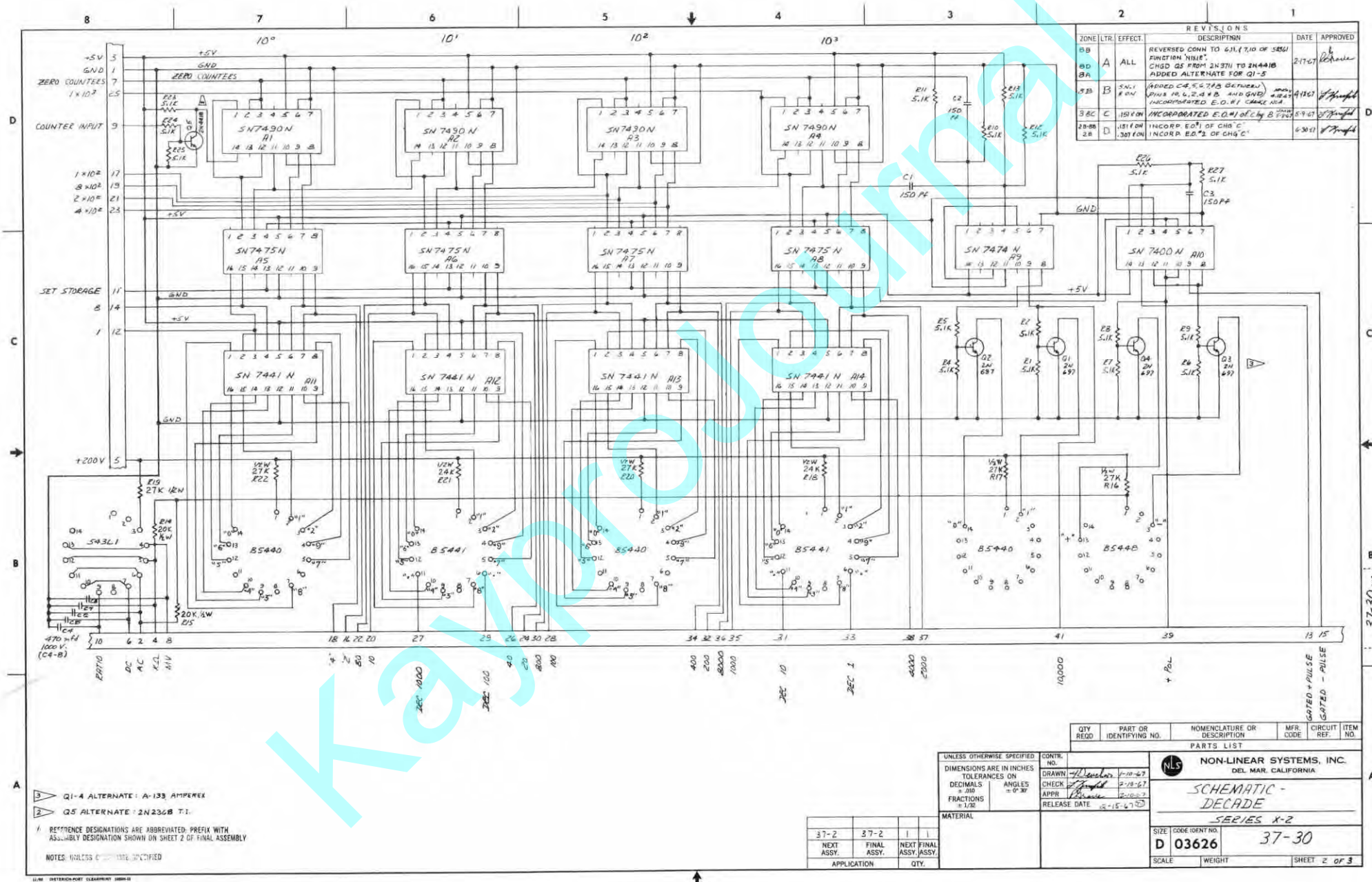
paper so as to keep excelsior or other particles from entering the instrument's louvers. If the original shipping container is in good condition, it may be used.

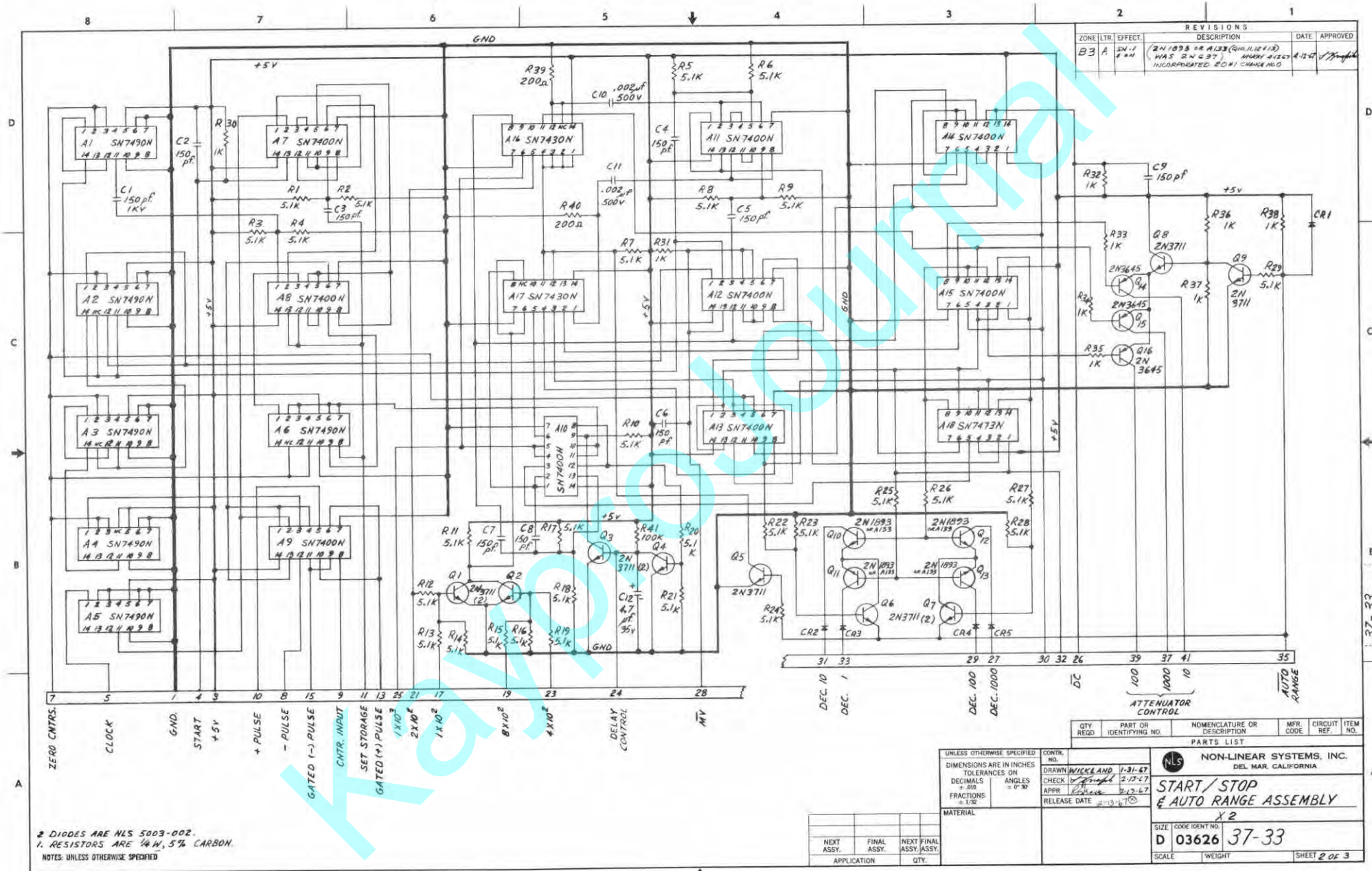
### CLAIM FOR DAMAGE IN SHIPMENT

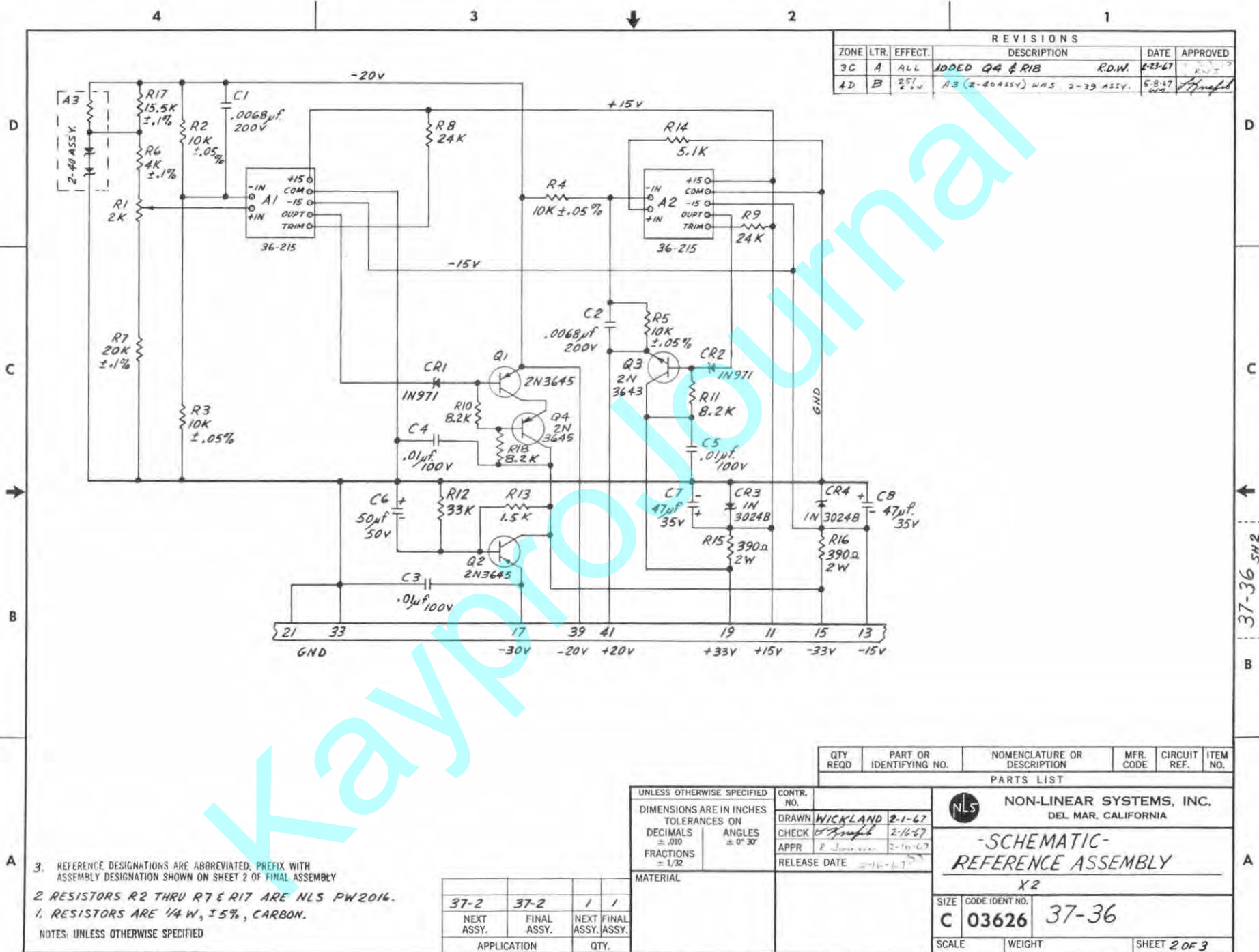
The instrument should be tested as soon as it is received. If it does not operate or is damaged, a claim should be made with the carrier. The claim agent should receive a full report of damage, and this report sent to Non-Linear Systems, Inc. After receiving such a report we will advise you of the disposition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

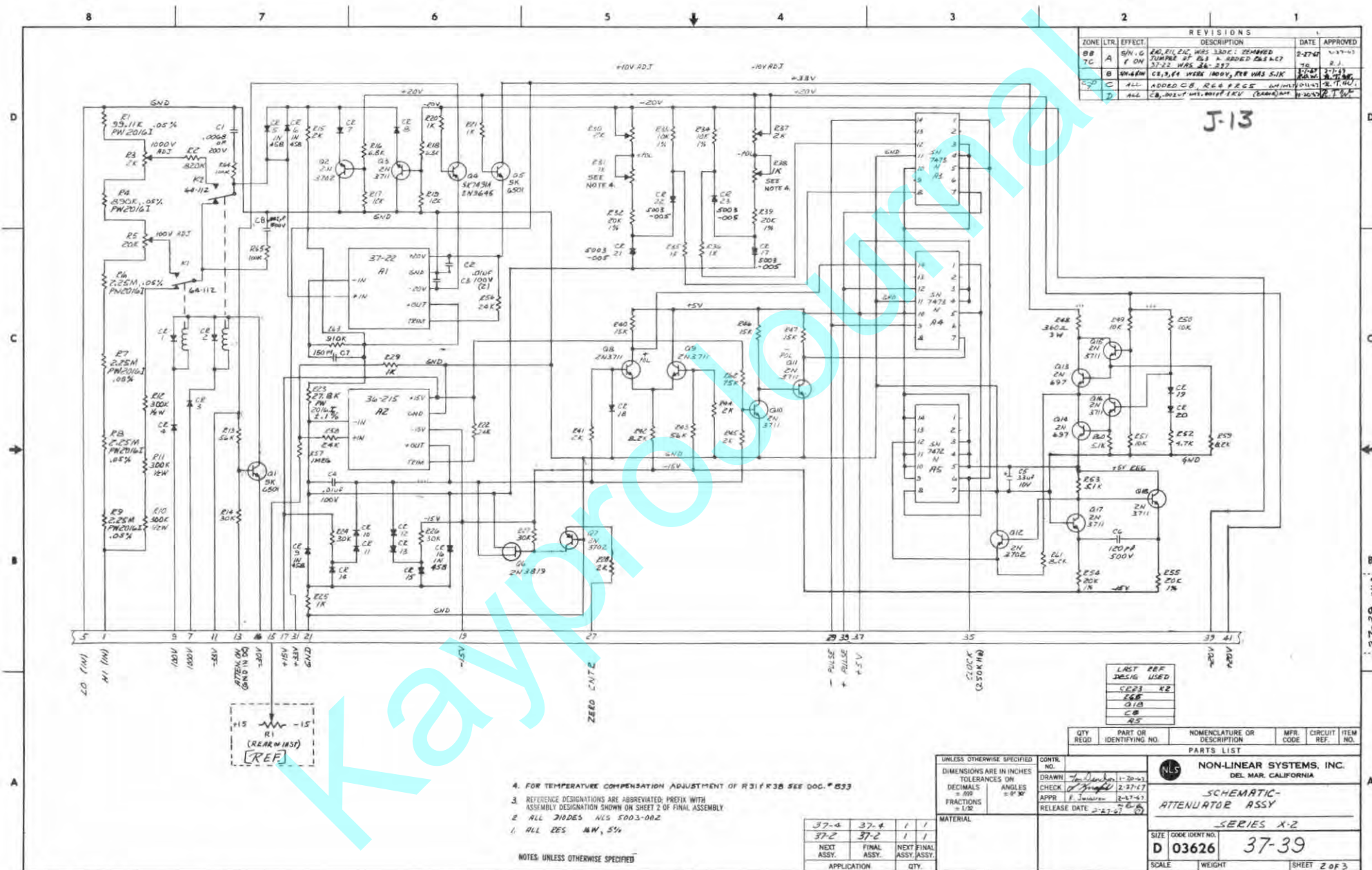


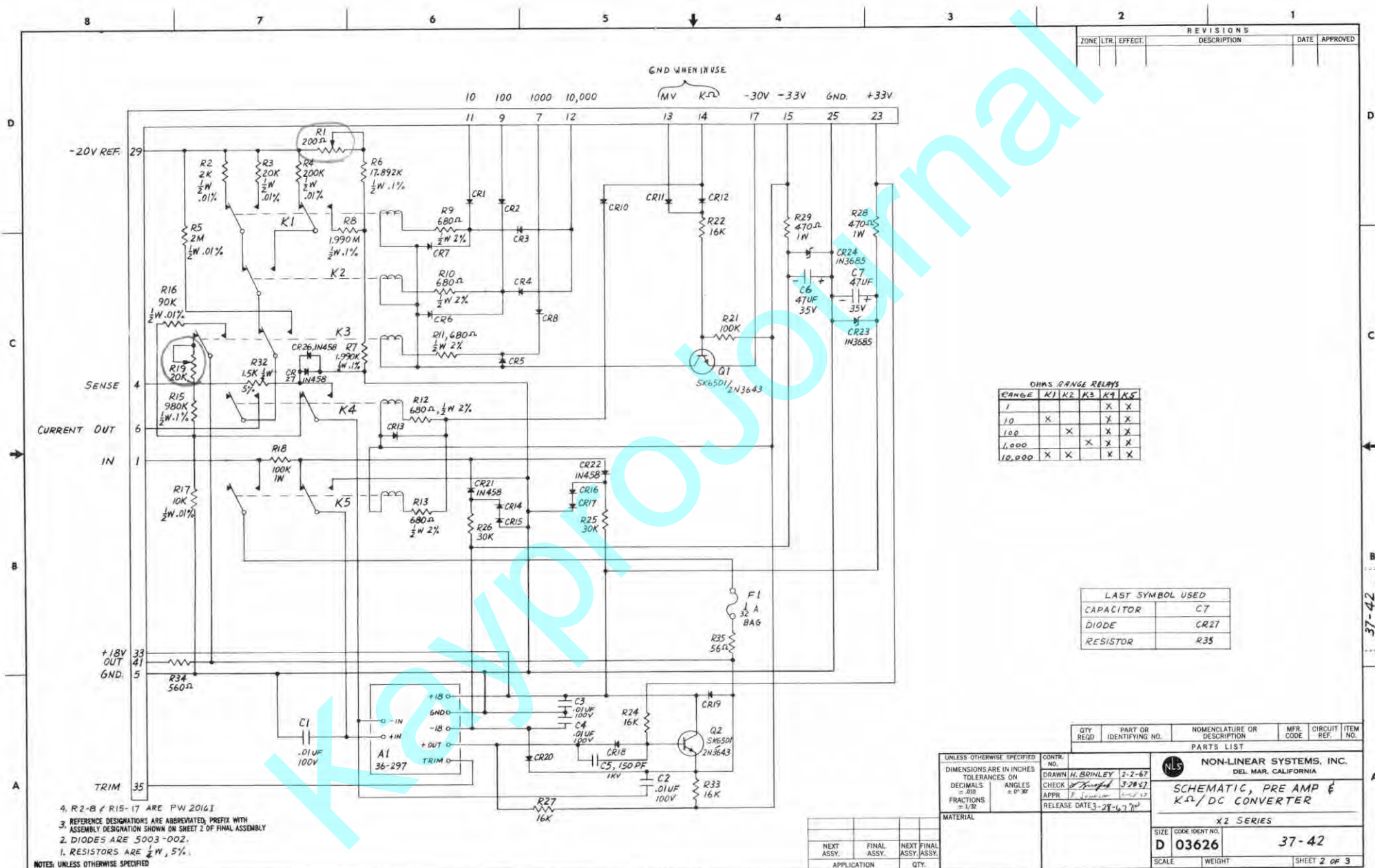


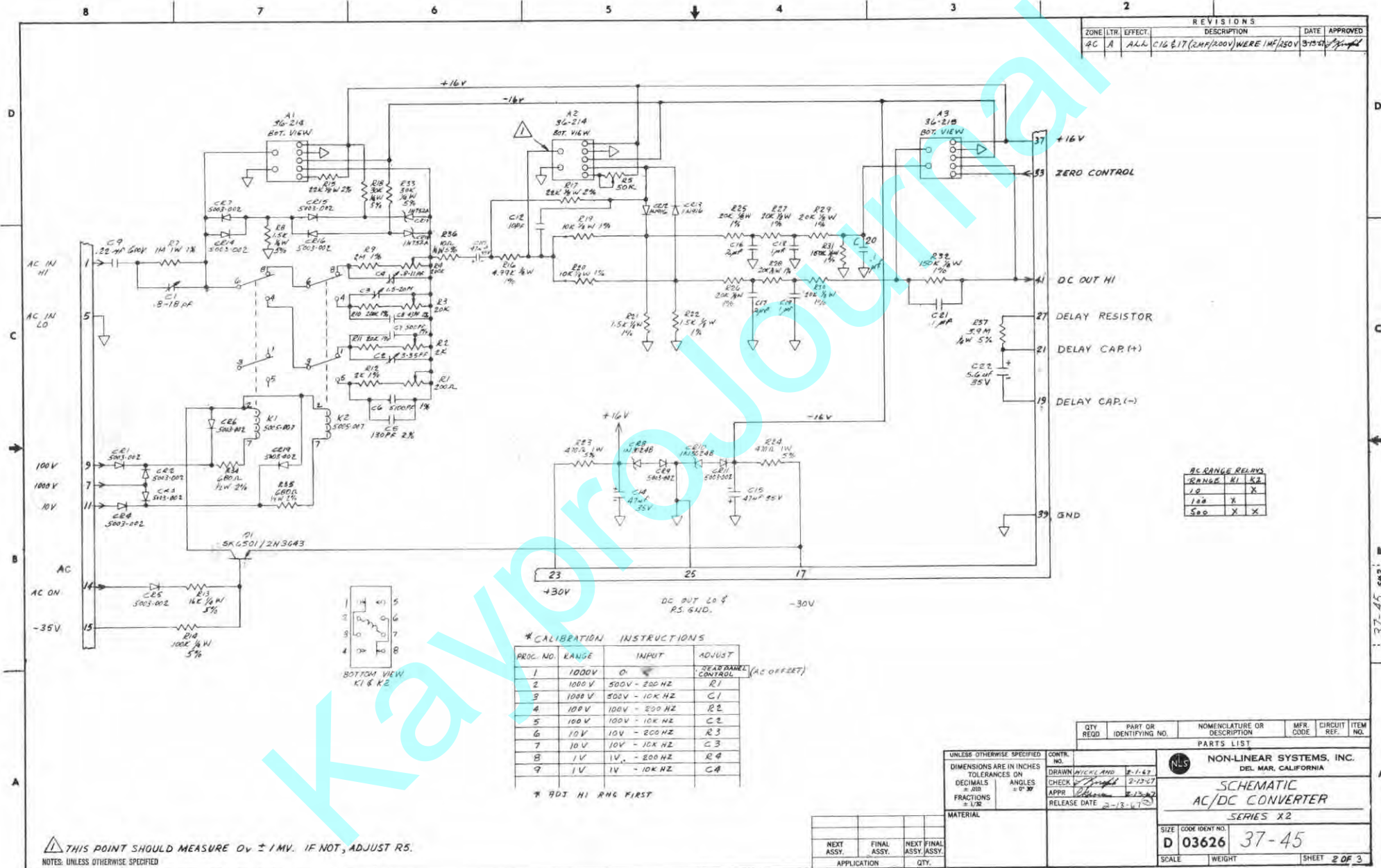












4

3

2

1

| REVISIONS |      |         |                             |         |          |
|-----------|------|---------|-----------------------------|---------|----------|
| ZONE      | LTR. | EFFECT. | DESCRIPTION                 | DATE    | APPROVED |
| 3B        | A    | ALL     | CONNECTED AG-2,3,6,7 TO GND | 2-17-67 | Ph...    |

D

D

C

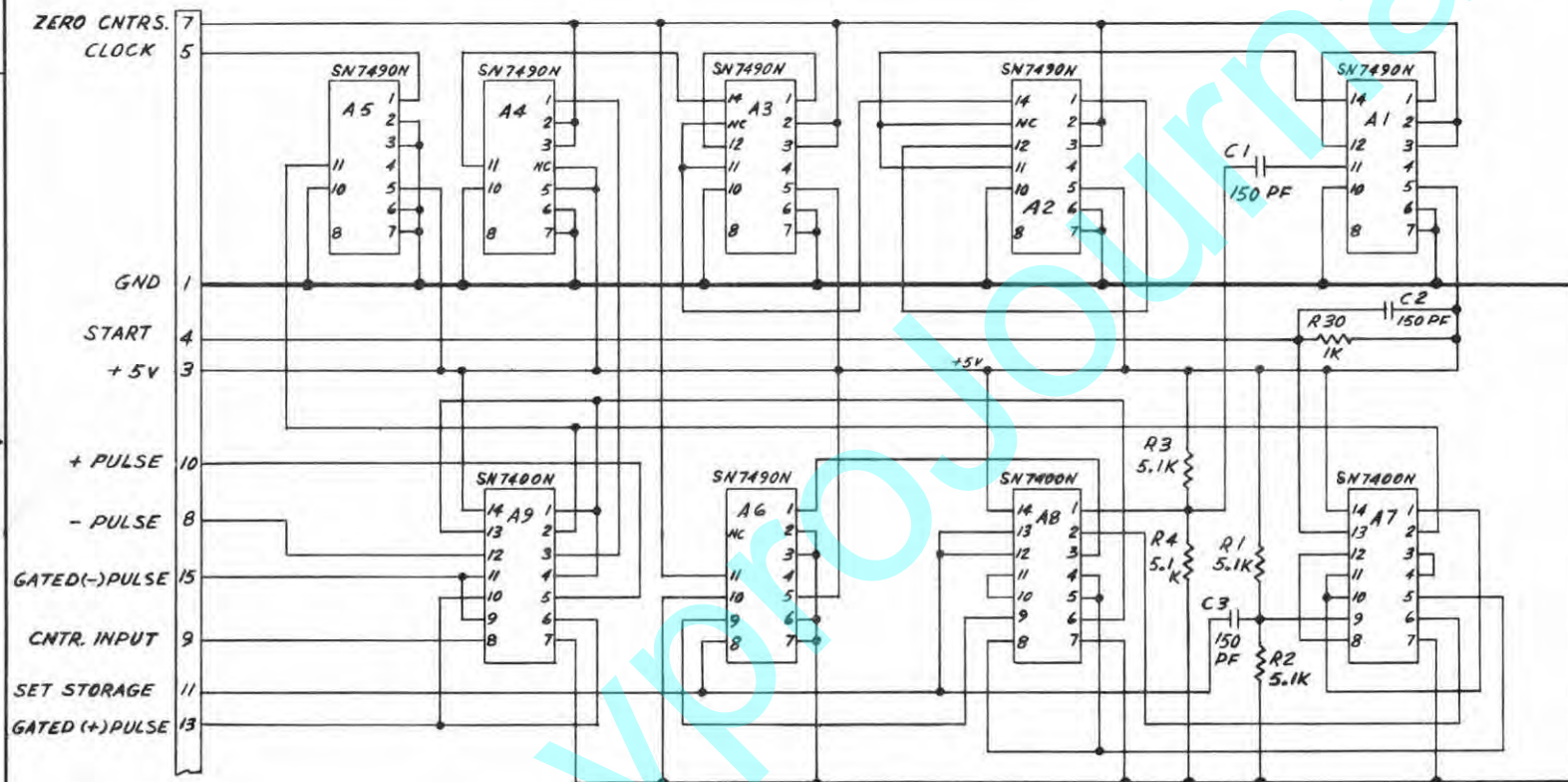
C

B

B

A

A



| QTY REQD | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR. CODE | CIRCUIT REF. | ITEM NO. |
|----------|-------------------------|-----------------------------|-----------|--------------|----------|
|----------|-------------------------|-----------------------------|-----------|--------------|----------|

## PARTS LIST

|                            |                 |              |                 |
|----------------------------|-----------------|--------------|-----------------|
| UNLESS OTHERWISE SPECIFIED |                 | CONTR. NO.   |                 |
| DIMENSIONS ARE IN INCHES   |                 | DRAWN        | WICKLAND 2-3-67 |
| TOLERANCES ON              |                 | CHECK        | 2-13-67         |
| DECIMALS ± .010            | ANGLES ± 0° 30' | APPR         | Ph...           |
| FRACTIONS ± 1/32           |                 | RELEASE DATE | 2-13-67         |

## MATERIAL

|             |             |                  |       |
|-------------|-------------|------------------|-------|
| 37-2        | 37-2        | 1                | 1     |
| NEXT ASSY.  | FINAL ASSY. | NEXT FINAL ASSY. | ASSY. |
| APPLICATION |             | QTY.             |       |

2. REFERENCE DESIGNATIONS ARE ABBREVIATED; PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY

1. RESISTORS ARE 1/4 W, 5%, CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

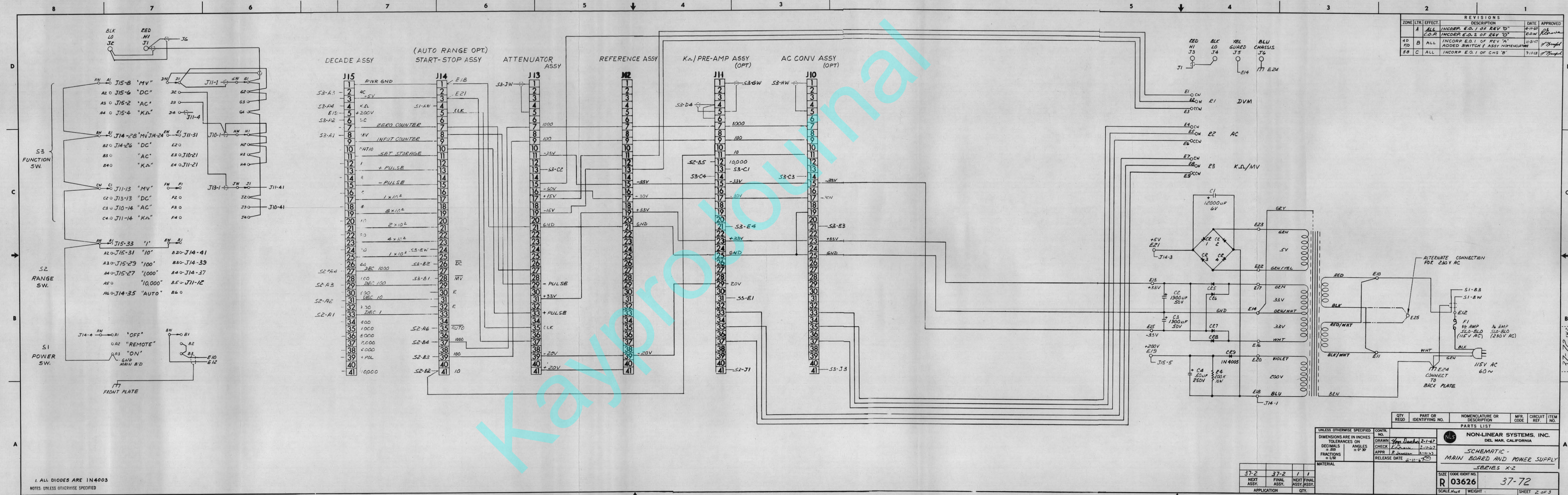
NLS NON-LINEAR SYSTEMS, INC.  
DEL MAR, CALIFORNIA

START STOP  
ASS'Y.

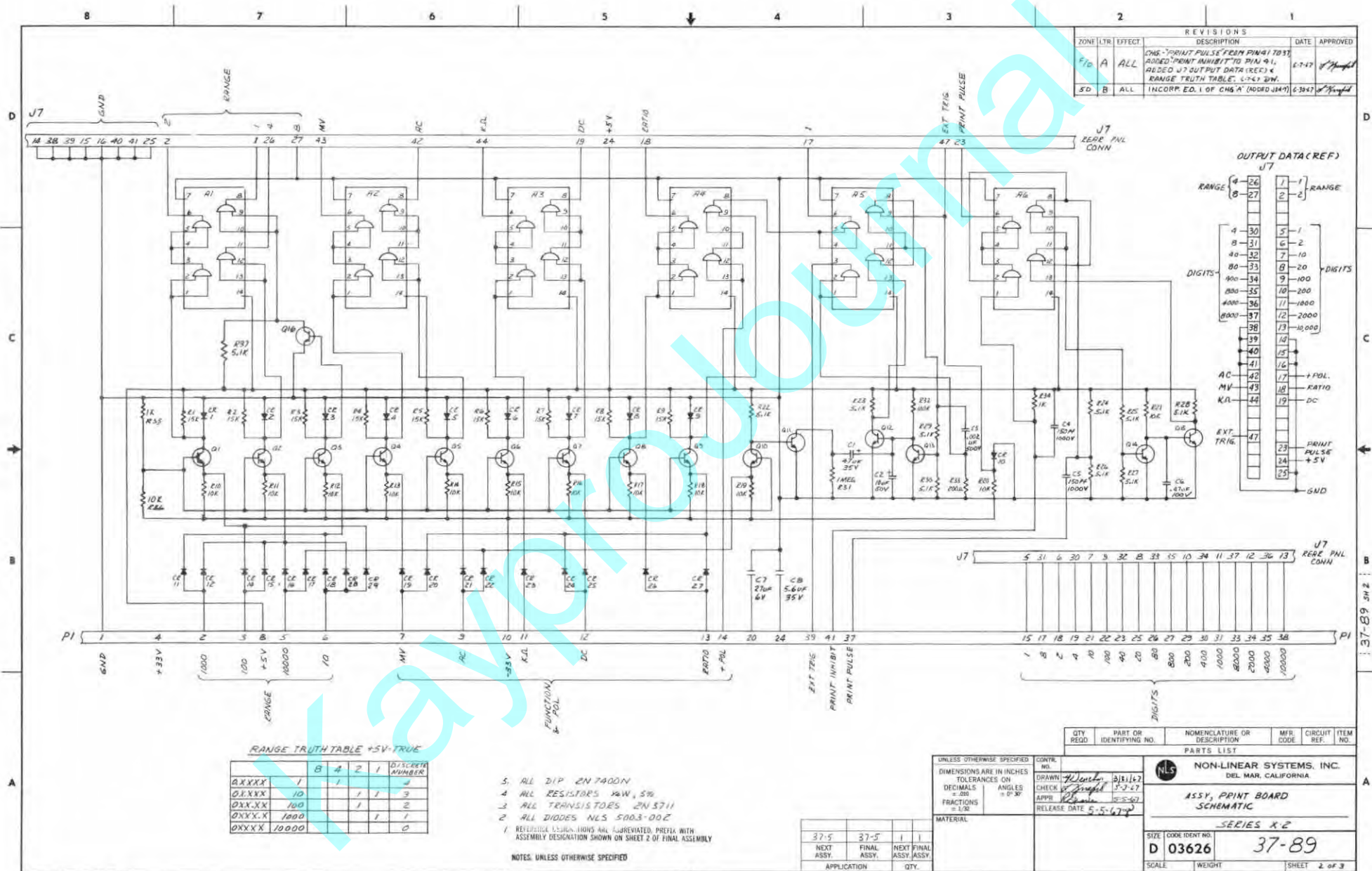
SERIES X2

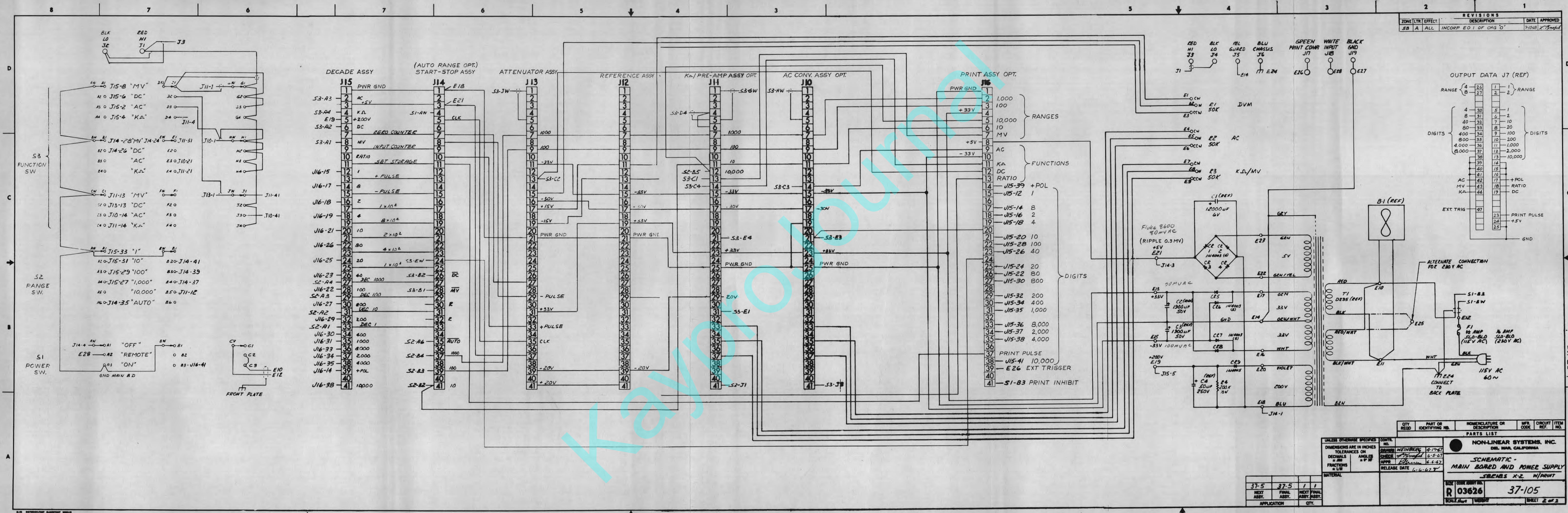
|       |                |
|-------|----------------|
| SIZE  | CODE IDENT NO. |
| C     | 03626 37-69    |
| SCALE | WEIGHT         |

SHEET 2 OF 3





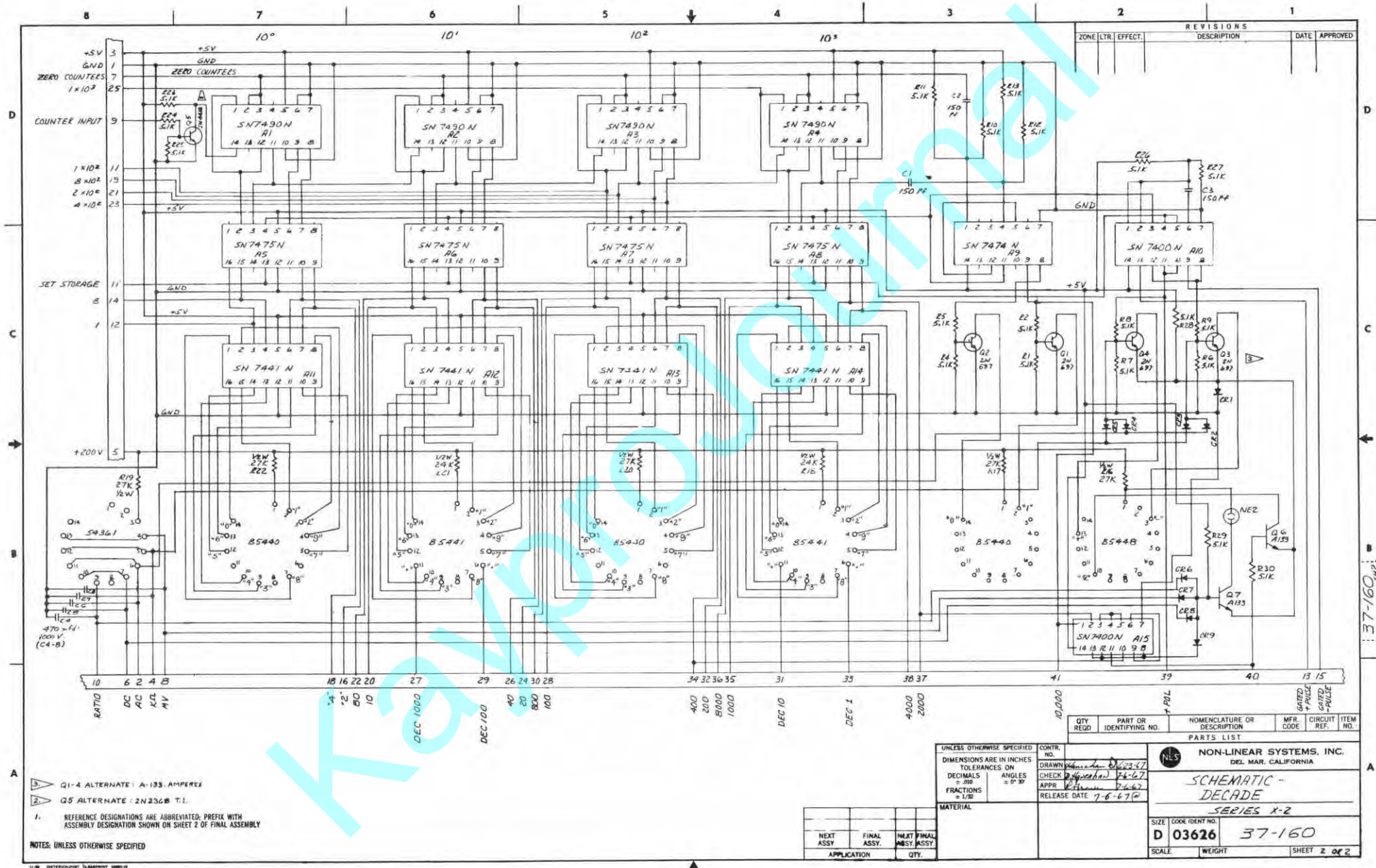




| REVISIONS |    |        |                      |
|-----------|----|--------|----------------------|
| ZONE      | TR | EFFECT | DESCRIPTION          |
| 5B        | A  | ALL    | INCORP EO 1 OF CHG 0 |

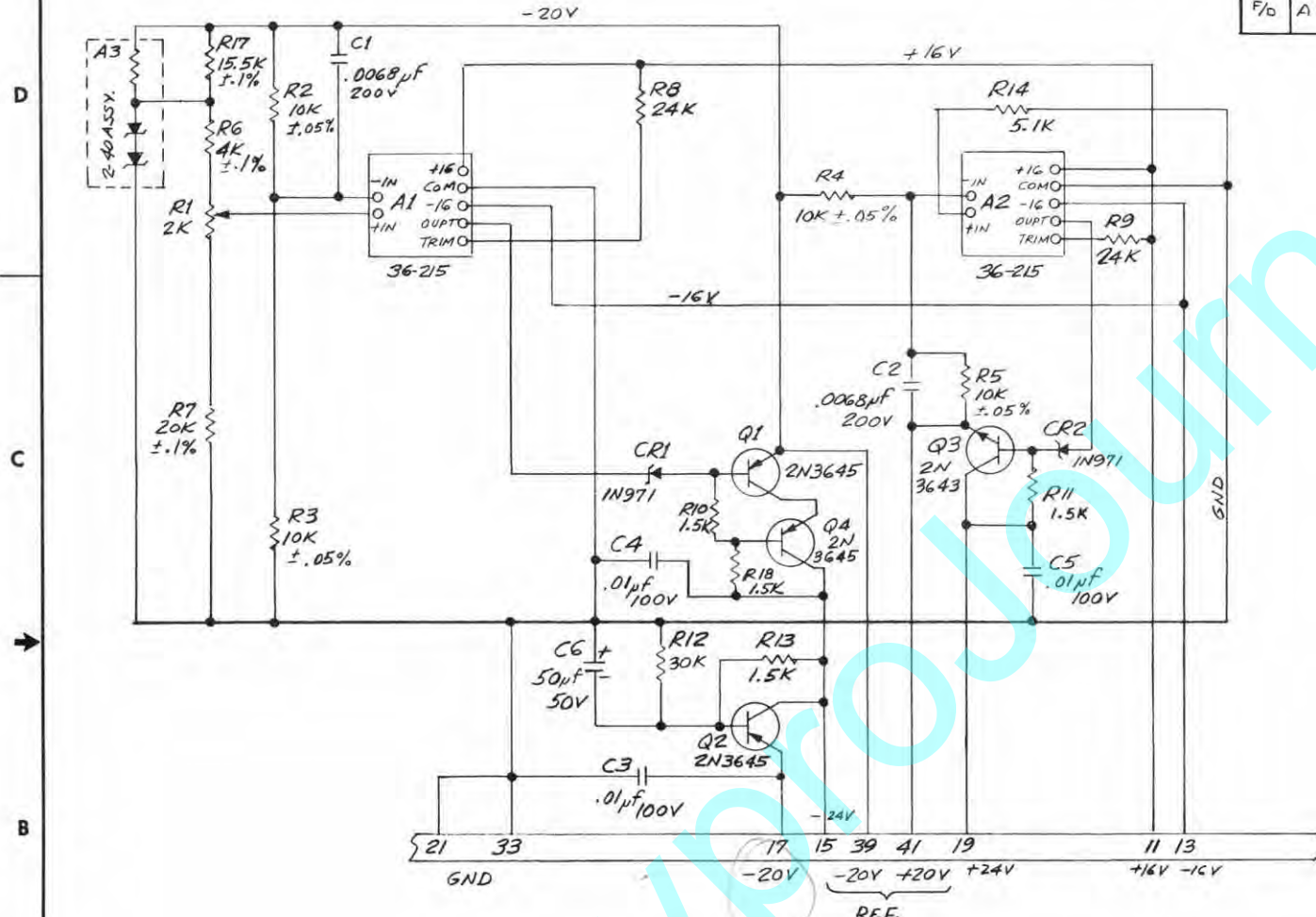
| OUTPUT DATA J7 (REF) |       |    |    |
|----------------------|-------|----|----|
| RANGE                | 4     | 26 | 1  |
|                      | 8     | 31 | 2  |
|                      | 40    | 32 | 7  |
|                      | 80    | 33 | 8  |
|                      | 400   | 34 | 9  |
|                      | 800   | 35 | 10 |
|                      | 4,000 | 36 | 11 |
|                      | 8,000 | 37 | 12 |
|                      | 38    | 13 |    |
|                      | 39    | 14 |    |
|                      | 40    | 15 |    |
|                      | 41    | 16 |    |
|                      | 42    | 17 |    |
|                      | 43    | 18 |    |
|                      | 44    | 19 |    |
|                      | 47    | 23 |    |
|                      | 24    | 24 |    |
|                      | 25    | 25 |    |

| QTY | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR. CODE | CIRCUIT ITEM REF. |
|-----|-------------------------|-----------------------------|-----------|-------------------|
| 1   | WEINBERG 4-19-67        | NON-LINEAR SYSTEMS, INC.    |           |                   |
| 1   | 6-5-67                  | SCHEMATIC -                 |           |                   |
| 1   | 6-6-67                  | MAIN BOARD AND POWER SUPPLY |           |                   |
| 1   | 6-6-67                  | 37-105                      |           |                   |
| 1   | 6-6-67                  | 37-105                      |           |                   |





| REVISIONS |      |                |                                                                  |        |                    |
|-----------|------|----------------|------------------------------------------------------------------|--------|--------------------|
| ZONE      | LTR. | EFFECT.        | DESCRIPTION                                                      | DATE   | APPROVED           |
| F/0       | A    | 4N.543<br>+ 0N | INCOEP. E.O. 1 of CH9 0" & R11<br>WAS SK<br>2-1-68 <del>SK</del> | 2-1-68 | <i>[Signature]</i> |



- REFERENCE DESIGNATIONS ARE ABBREVIATED; PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY
- RESISTORS R2 THRU R7 & R17 ARE NLS PW2016
- RESISTORS ARE 1/4 W, ±5%, CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

|             |             |                  |             |
|-------------|-------------|------------------|-------------|
| 37-14       | 37-14       | 1                | 1           |
| 37-272      | 37-98       | 1                | 1           |
| NEXT ASSY.  | FINAL ASSY. | NEXT FINAL ASSY. | FINAL ASSY. |
| APPLICATION |             | QTY.             |             |

|                            |          |            |
|----------------------------|----------|------------|
| UNLESS OTHERWISE SPECIFIED |          | CONTR. NO. |
| DIMENSIONS ARE IN INCHES   |          |            |
| TOLERANCES ON              |          |            |
| DECIMALS                   | ANGLES   |            |
| ±.010                      | ± 0° 30' |            |
| FRACTIONS                  |          |            |
| ± 1/32                     |          |            |
| MATERIAL                   |          |            |

| QTY REQD | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR. CODE | CIRCUIT REF. | ITEM NO. |
|----------|-------------------------|-----------------------------|-----------|--------------|----------|
|----------|-------------------------|-----------------------------|-----------|--------------|----------|

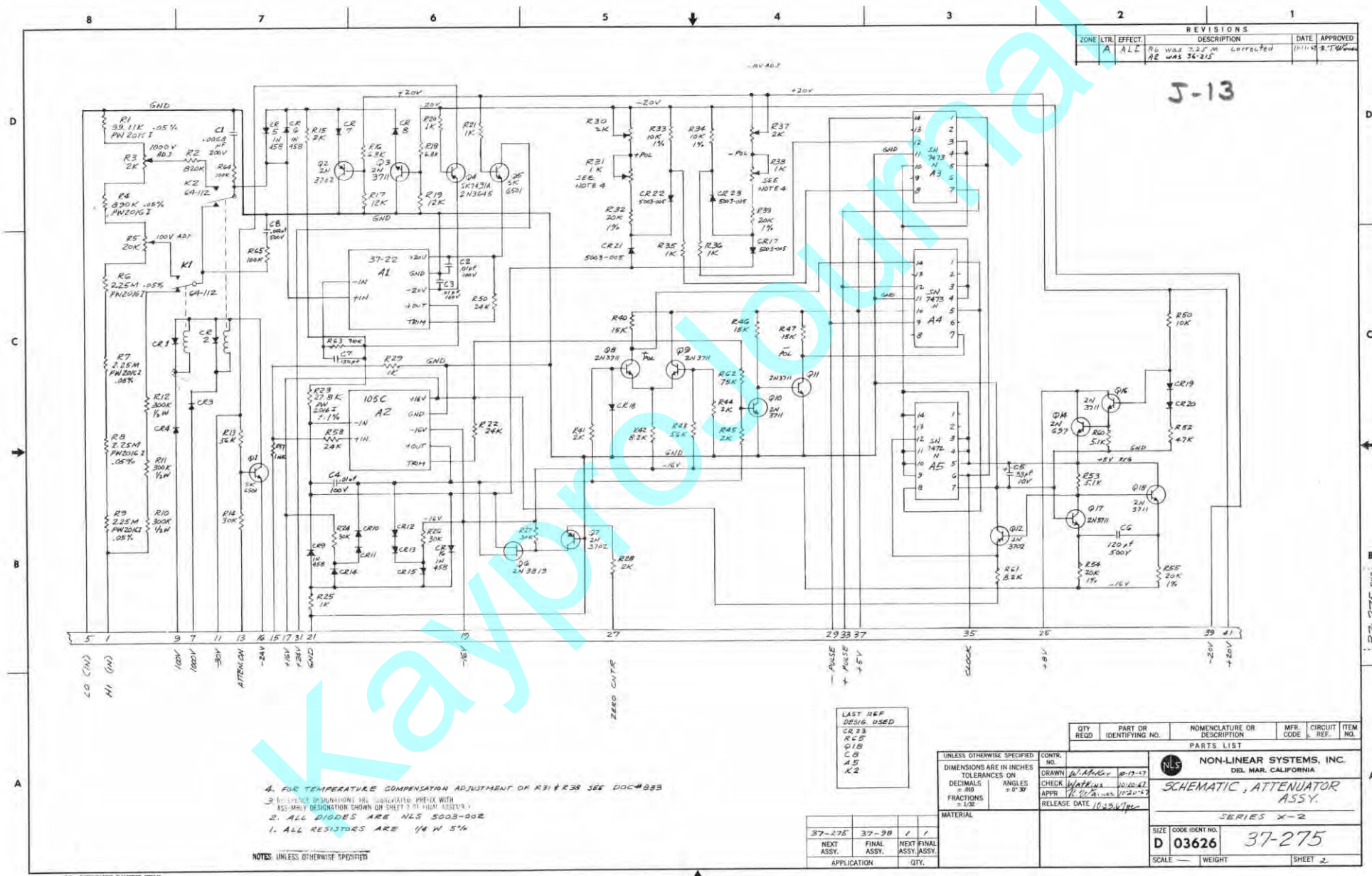
#### PARTS LIST

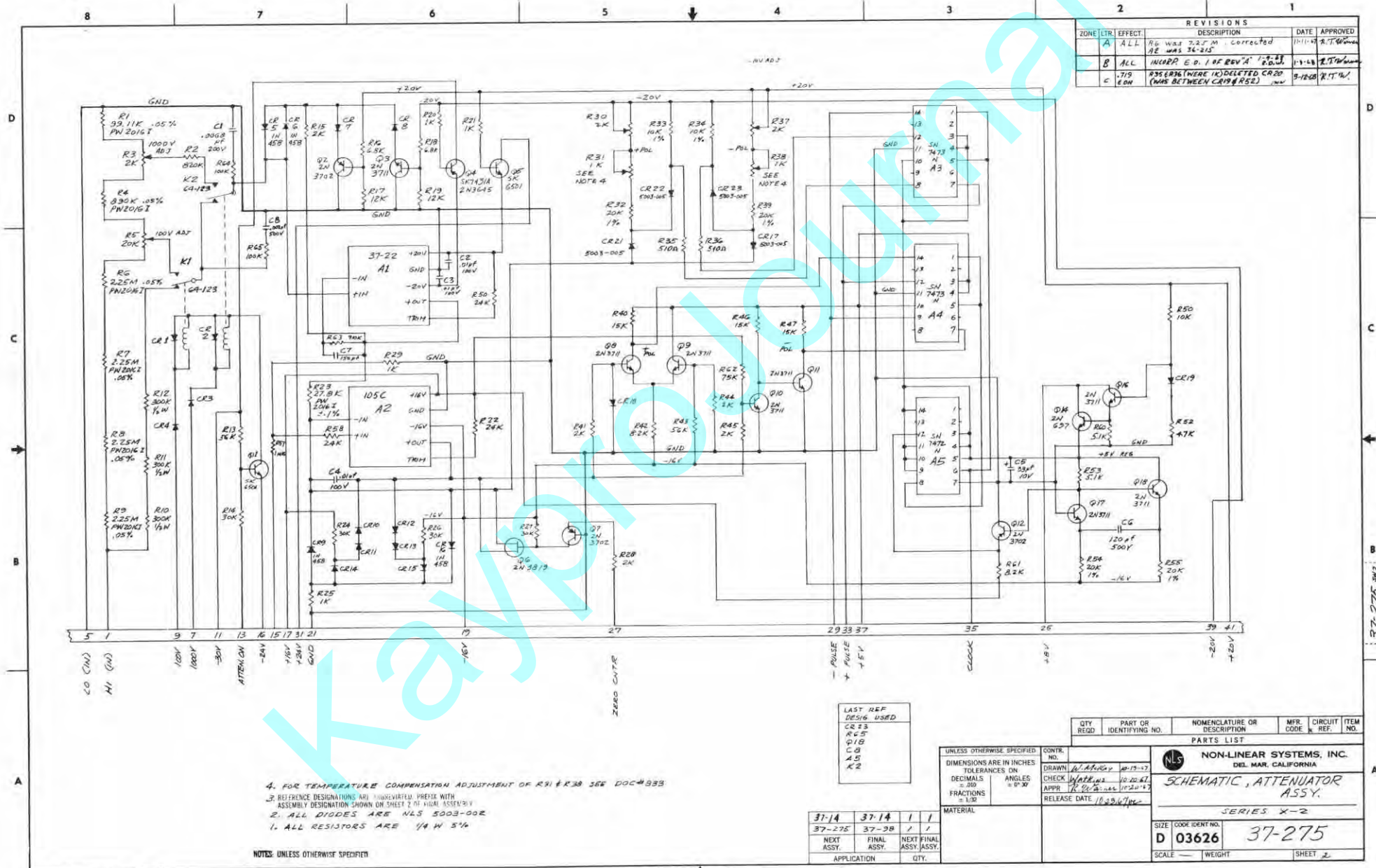
NLS NON-LINEAR SYSTEMS, INC.  
DEL MAR, CALIFORNIA

SCHEMATIC  
REFERENCE ASSEMBLY

X-2

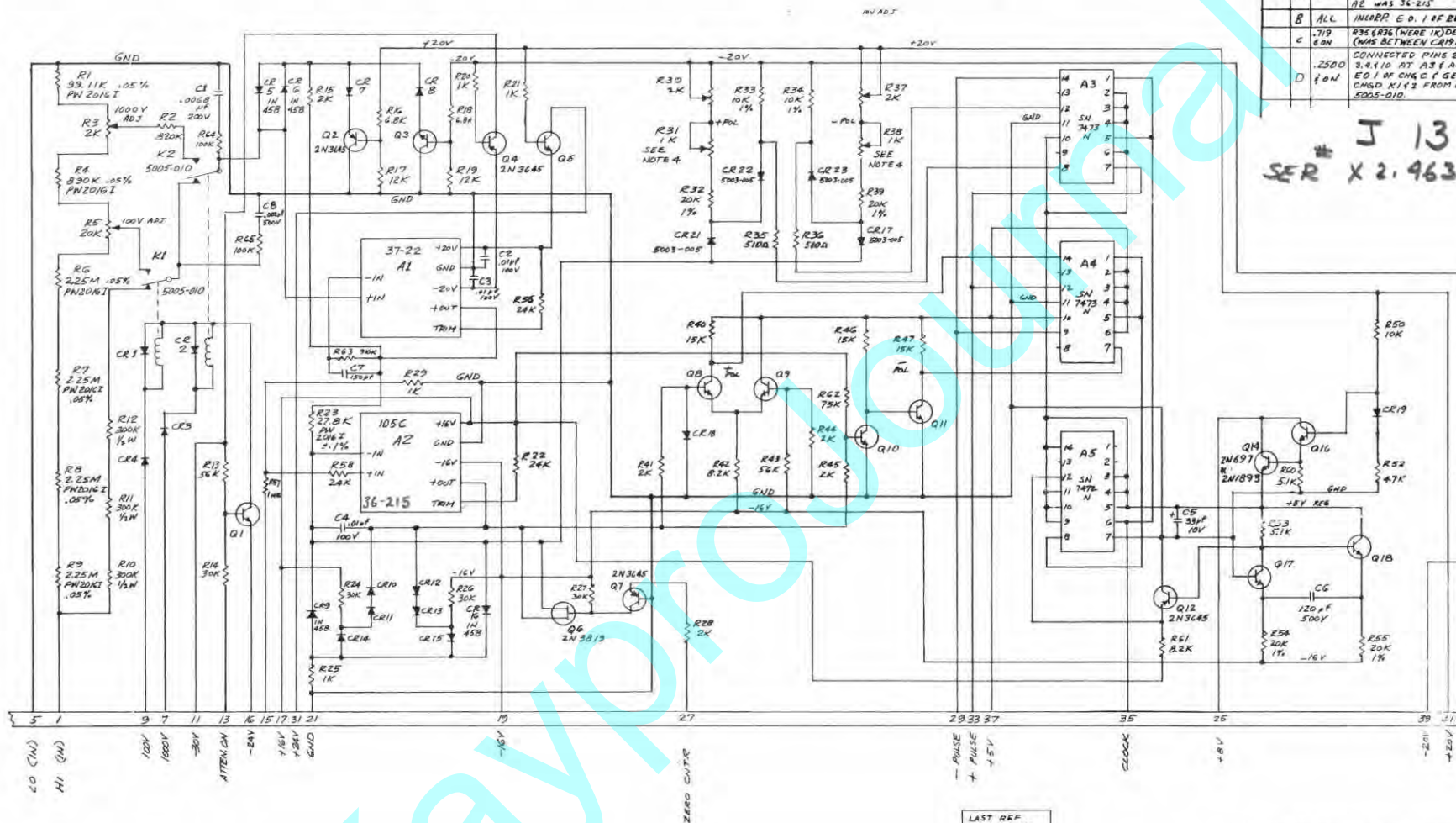
|       |                |              |
|-------|----------------|--------------|
| SIZE  | CODE IDENT NO. |              |
| C     | 03626          | 37-272       |
| SCALE | WEIGHT         | SHEET 2 of 2 |





| REVISIONS |      |        |                                                                                                                                         |                      |
|-----------|------|--------|-----------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| ZONE      | LTR  | EFFECT | DESCRIPTION                                                                                                                             | DATE                 |
| A         | ALL  |        | R6 WAS 3.25M, CORRECTED<br>R8 WAS 3K-20V                                                                                                | 11-11-64 R.T. Wilson |
| B         | ALL  |        | IN CORR. E.D. 1 OF REV. 11-11-64                                                                                                        | 11-11-64 R.T. Wilson |
| C         | 719  |        | 935 (R36) (WIRE IN) DELETED CR20<br>(WAS BETWEEN CR19 & R52)                                                                            | 9-18-68 R.T. Wilson  |
| D         | 2500 |        | CONNECTED PINS 2 & 6 TO PINS<br>3 & 4 AT A3 & A4: INCORR.<br>E.D. 1 OF CHG C. 1 GEN. E.D. 117:<br>CHG. R11/2 FROM 64-123 TO<br>5005-010 | 3-4-69 R.T. Wilson   |

J 13  
SER # X 2.463 & ABOVE



- 5 TRANSISTORS ARE 2N3569
4. FOR TEMPERATURE COMPENSATION ADJUSTMENT OF R31 & R38 SEE DOC#833
- REFERENCE DESIGNATIONS ARE ABBREVIATED. PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY
2. ALL DIODES ARE NLS 5003-002
1. ALL RESISTORS ARE 1/4 W 5%

NOTES: UNLESS OTHERWISE SPECIFIED

| LAST REF. DESIG. USED |      |
|-----------------------|------|
| CR 23                 | R 25 |
| Q 18                  | C 8  |
| A 5                   | K 2  |

#### \* ALTERNATE

UNLESS OTHERWISE SPECIFIED:  
DIMENSIONS ARE IN INCHES  
TOLERANCES ON  
DECIMALS  
FRACTIONS  
MATERIAL

| 37-14       | 37-14       | 1                | 1           |
|-------------|-------------|------------------|-------------|
| 37-275      | 37-98       | 1                | 1           |
| NEXT ASSY.  | FINAL ASSY. | NEXT FINAL ASSY. | FINAL ASSY. |
| APPLICATION | QTY.        |                  |             |

|                                                                                     |                         |                             |           |              |          |
|-------------------------------------------------------------------------------------|-------------------------|-----------------------------|-----------|--------------|----------|
| QTY REQD                                                                            | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR. CODE | CIRCUIT REF. | ITEM NO. |
| PARTS LIST                                                                          |                         |                             |           |              |          |
| <div> <b>NON-LINEAR SYSTEMS, INC.</b><br/>         DEL MAR, CALIFORNIA       </div> |                         |                             |           |              |          |
| <b>SCHEMATIC, ATTENUATOR ASSY.</b>                                                  |                         |                             |           |              |          |
| SERIES X-2                                                                          |                         |                             |           |              |          |
| SIZE CODE IDENT NO.                                                                 |                         |                             |           |              |          |
| <b>D 03626</b>                                                                      |                         |                             |           |              |          |
| SCALE WEIGHT SHEET 2                                                                |                         |                             |           |              |          |

8

7

6

5

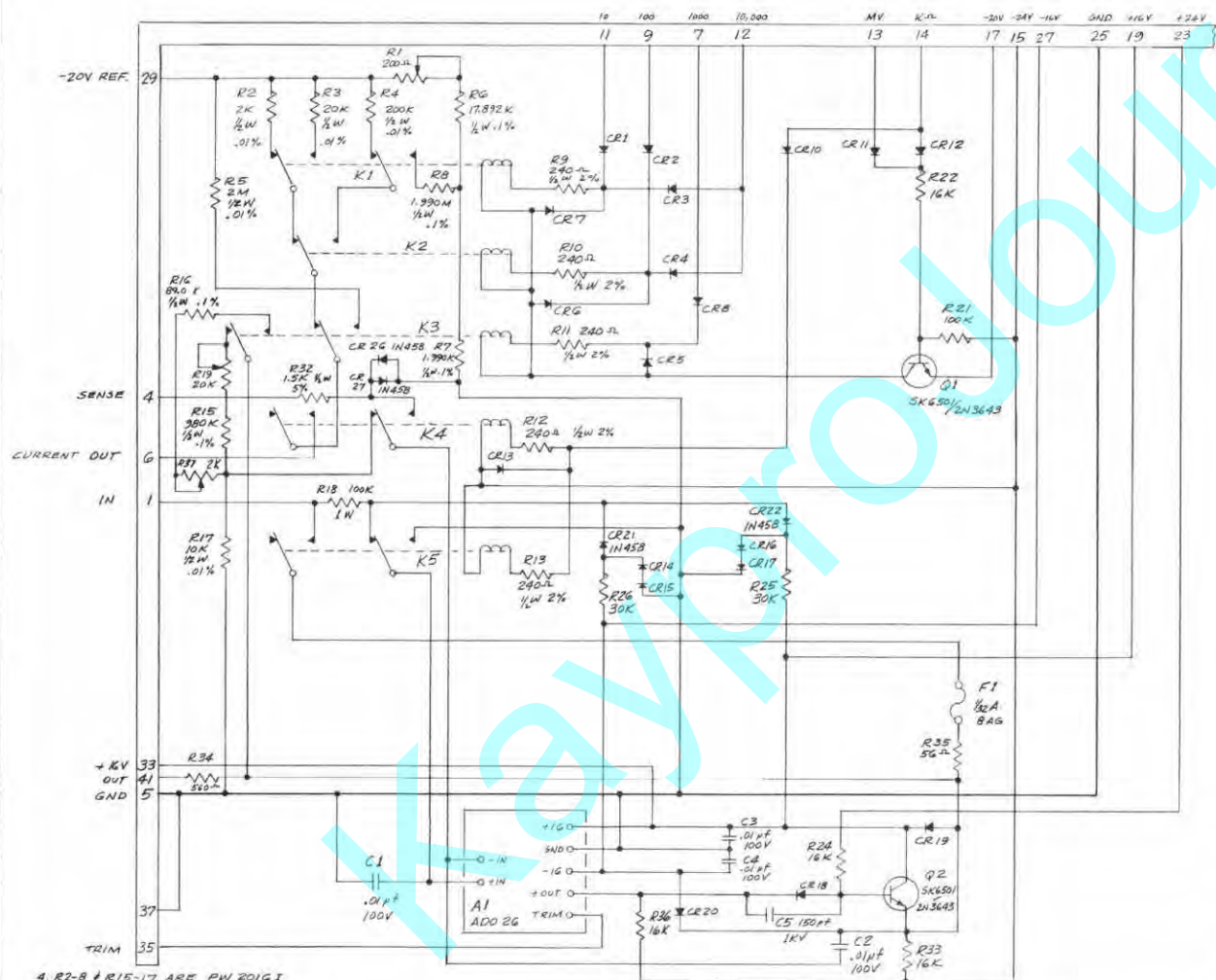
4

3

2

1

| REVISIONS |      |                |                                                                  |  |  |         |             |
|-----------|------|----------------|------------------------------------------------------------------|--|--|---------|-------------|
| ZONE      | LTR. | EFFECT.        | DESCRIPTION                                                      |  |  | DATE    | APPROVED    |
|           | A    | 5/11/67<br>FOR | REMOVED CR28, ADDED R36 & R37<br>R16 WAS 90K .01% 12-1-67 R.G.W. |  |  | 12-1-67 | R.T.W./G.W. |



4. R2-8 & R15-17 ARE PW 201G1

3. REFERENCE DESIGNATIONS ARE ASSEMBLED: PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY

2. DIODES ARE 5003-002 (NLS)

1. RESISTORS ARE 1/4W, 5%.

NOTES: UNLESS OTHERWISE SPECIFIED

| UNLESS OTHERWISE SPECIFIED: |          |
|-----------------------------|----------|
| DIMENSIONS ARE IN INCHES    |          |
| TOLERANCES ON:              |          |
| DECIMALS                    | ± .01    |
| ANGLES                      | ± 0° 30' |
| FRACTIONS                   | ± 1/32   |

CONTR. NO. 37-278

DRAWN BY: M. J. M. 12-1-67

CHECK BY: M. J. M. 12-1-67

APPROVED BY: M. J. M. 12-1-67

RELEASE DATE: 12-1-67

MATERIAL

| QTY REQD | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MPL CODE | CIRCUIT REF. | ITEM NO. |
|----------|-------------------------|-----------------------------|----------|--------------|----------|
|----------|-------------------------|-----------------------------|----------|--------------|----------|

PARTS LIST

NON-LINEAR SYSTEMS, INC.

DEL. MAR, CALIFORNIA

SCHEMATIC, PRE AMP & K-1/DC CONVERTER

X-2 SERIES

SIZE CODE IDENT NO.

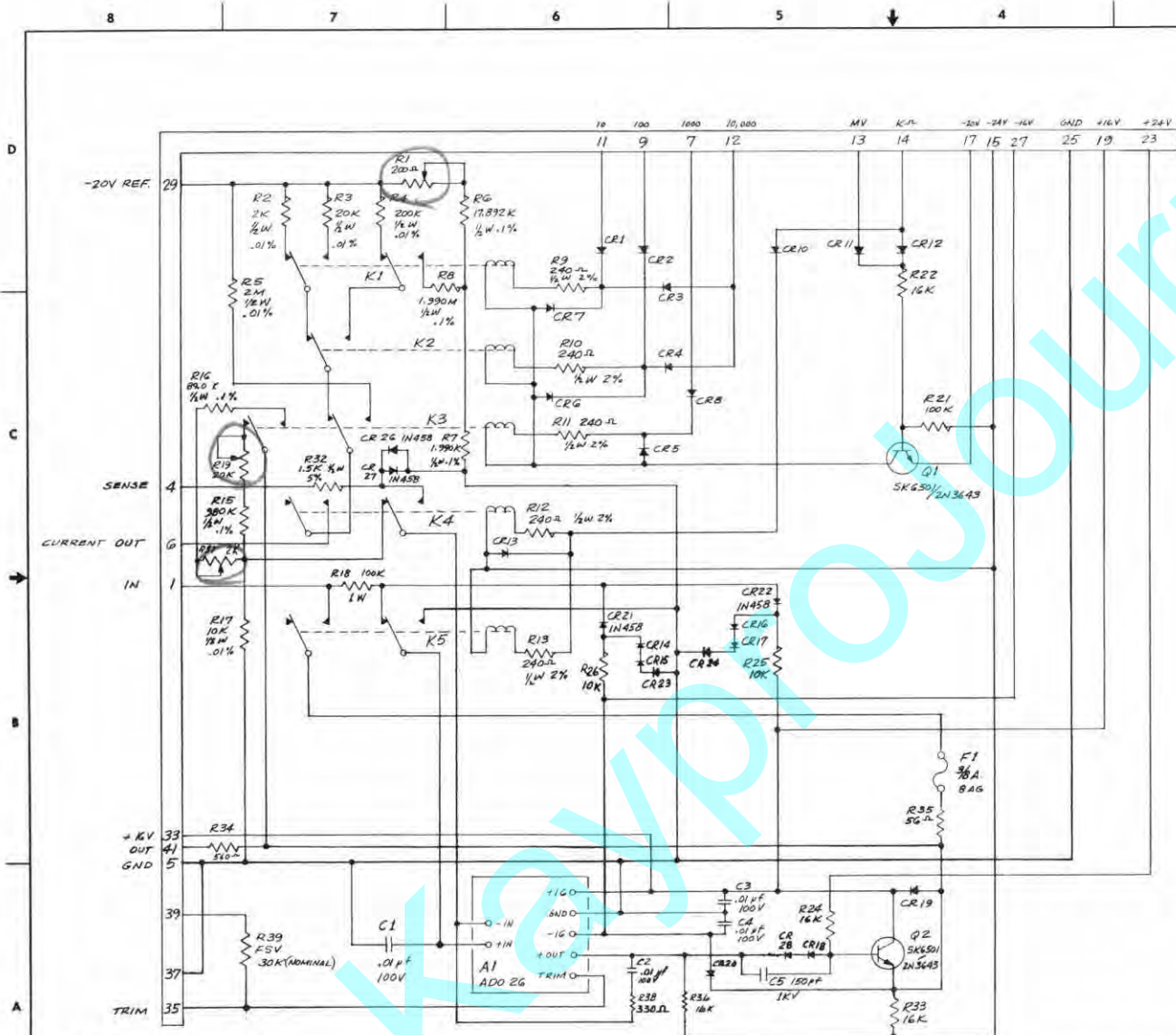
D 03626 37-278

SCALE — WEIGHT

SHEET 2 OF 2

| 37-278      | 37-278      | 1                |
|-------------|-------------|------------------|
| NEXT ASSY.  | FINAL ASSY. | NEXT FINAL ASSY. |
| APPLICATION | QTY.        |                  |

37-278



3. R2-R15-R17 ARE PW 20% I  
 2. DIODES ARE 5003-002 (NLS)  
 1. RESISTORS ARE 1/4W, 5%.

NOTES: UNLESS OTHERWISE SPECIFIED

100 1000 10,000 MV K $\Omega$  -24V -14V GND +16V +24V

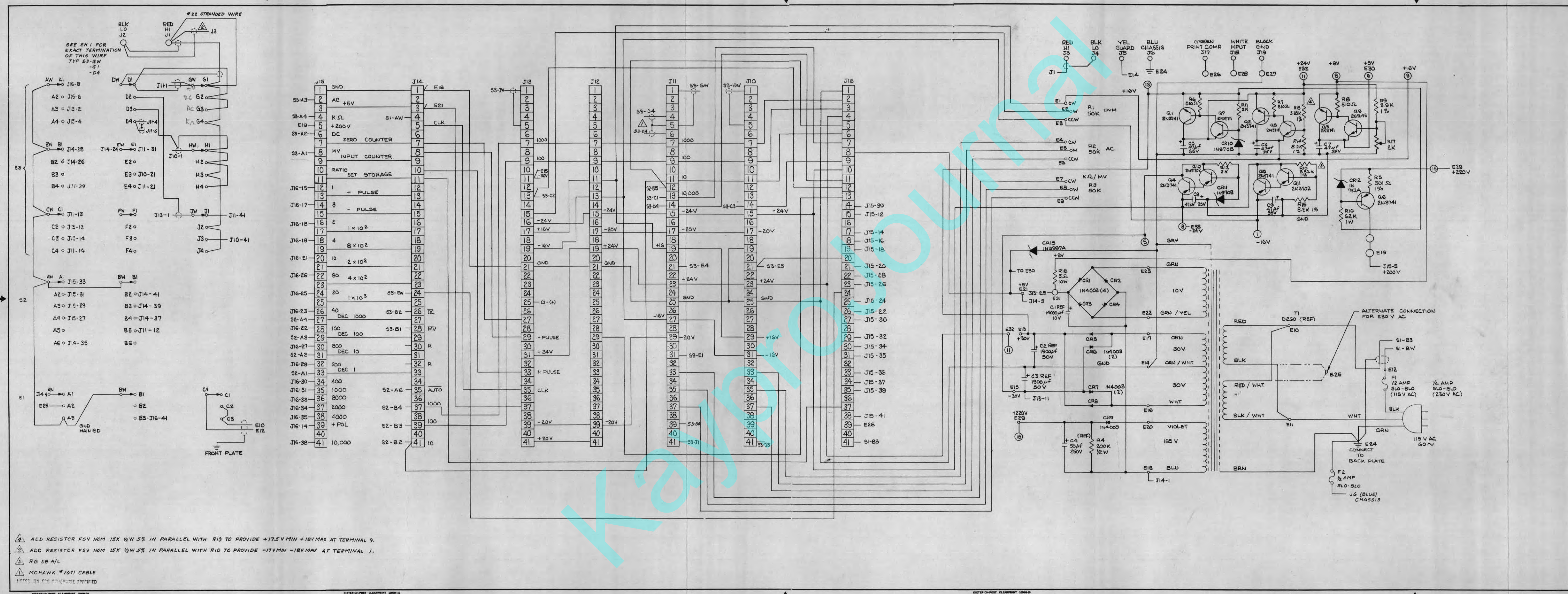
| REVISIONS |         |                                      |                |               |
|-----------|---------|--------------------------------------|----------------|---------------|
| ZONE      | LTR.    | EFFECT                               | DESCRIPTION    | DATE APPROVED |
| A         | 1/1/64  | REMOVED CR18, ADDED R36 & R37 FOR    | 12-1-63 R.T.W. |               |
| B         | 5/1/63  | ADDED CR23 (CR24 R25 62K WARE 30K).  | 4-15-61 R.T.W. |               |
| C         | ALL     | UNREPRESENTED F.O.I. NO. 118 PRV. 2. | 2-15-60 R.T.W. |               |
| D         | 10/1/63 | ADDED CR28                           | 5-15-61 R.T.W. |               |
| E         | 10/1/63 | ADDED R39 (TO PW 354 P33 G.C.)       | 5-15-61 R.T.W. |               |

| QTY REQD                                        | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR. CODE | CIRCUIT REF. | ITEM NO. |
|-------------------------------------------------|-------------------------|-----------------------------|-----------|--------------|----------|
| PARTS LIST                                      |                         |                             |           |              |          |
| NON-LINEAR SYSTEMS, INC.<br>DEL MAR, CALIFORNIA |                         |                             |           |              |          |
| SCHEMATIC, PRE AMP # K-2/DC CONVERTER           |                         |                             |           |              |          |
| X-2 SERIES                                      |                         |                             |           |              |          |
| SIZE CODE IDENT NO.                             |                         |                             |           |              |          |
| D 03626 37-278                                  |                         |                             |           |              |          |
| SCALE — WEIGHT — SHEET 2 OF 2                   |                         |                             |           |              |          |

| CONTR. NO. | DATE      |
|------------|-----------|
| 10-14-67   | 10-14-67  |
| 10-15-67   | 10-15-67  |
| 10-16-67   | 10-16-67  |
| 10-17-67   | 10-17-67  |
| 10-18-67   | 10-18-67  |
| 10-19-67   | 10-19-67  |
| 10-20-67   | 10-20-67  |
| 10-21-67   | 10-21-67  |
| 10-22-67   | 10-22-67  |
| 10-23-67   | 10-23-67  |
| 10-24-67   | 10-24-67  |
| 10-25-67   | 10-25-67  |
| 10-26-67   | 10-26-67  |
| 10-27-67   | 10-27-67  |
| 10-28-67   | 10-28-67  |
| 10-29-67   | 10-29-67  |
| 10-30-67   | 10-30-67  |
| 10-31-67   | 10-31-67  |
| 10-32-67   | 10-32-67  |
| 10-33-67   | 10-33-67  |
| 10-34-67   | 10-34-67  |
| 10-35-67   | 10-35-67  |
| 10-36-67   | 10-36-67  |
| 10-37-67   | 10-37-67  |
| 10-38-67   | 10-38-67  |
| 10-39-67   | 10-39-67  |
| 10-40-67   | 10-40-67  |
| 10-41-67   | 10-41-67  |
| 10-42-67   | 10-42-67  |
| 10-43-67   | 10-43-67  |
| 10-44-67   | 10-44-67  |
| 10-45-67   | 10-45-67  |
| 10-46-67   | 10-46-67  |
| 10-47-67   | 10-47-67  |
| 10-48-67   | 10-48-67  |
| 10-49-67   | 10-49-67  |
| 10-50-67   | 10-50-67  |
| 10-51-67   | 10-51-67  |
| 10-52-67   | 10-52-67  |
| 10-53-67   | 10-53-67  |
| 10-54-67   | 10-54-67  |
| 10-55-67   | 10-55-67  |
| 10-56-67   | 10-56-67  |
| 10-57-67   | 10-57-67  |
| 10-58-67   | 10-58-67  |
| 10-59-67   | 10-59-67  |
| 10-60-67   | 10-60-67  |
| 10-61-67   | 10-61-67  |
| 10-62-67   | 10-62-67  |
| 10-63-67   | 10-63-67  |
| 10-64-67   | 10-64-67  |
| 10-65-67   | 10-65-67  |
| 10-66-67   | 10-66-67  |
| 10-67-67   | 10-67-67  |
| 10-68-67   | 10-68-67  |
| 10-69-67   | 10-69-67  |
| 10-70-67   | 10-70-67  |
| 10-71-67   | 10-71-67  |
| 10-72-67   | 10-72-67  |
| 10-73-67   | 10-73-67  |
| 10-74-67   | 10-74-67  |
| 10-75-67   | 10-75-67  |
| 10-76-67   | 10-76-67  |
| 10-77-67   | 10-77-67  |
| 10-78-67   | 10-78-67  |
| 10-79-67   | 10-79-67  |
| 10-80-67   | 10-80-67  |
| 10-81-67   | 10-81-67  |
| 10-82-67   | 10-82-67  |
| 10-83-67   | 10-83-67  |
| 10-84-67   | 10-84-67  |
| 10-85-67   | 10-85-67  |
| 10-86-67   | 10-86-67  |
| 10-87-67   | 10-87-67  |
| 10-88-67   | 10-88-67  |
| 10-89-67   | 10-89-67  |
| 10-90-67   | 10-90-67  |
| 10-91-67   | 10-91-67  |
| 10-92-67   | 10-92-67  |
| 10-93-67   | 10-93-67  |
| 10-94-67   | 10-94-67  |
| 10-95-67   | 10-95-67  |
| 10-96-67   | 10-96-67  |
| 10-97-67   | 10-97-67  |
| 10-98-67   | 10-98-67  |
| 10-99-67   | 10-99-67  |
| 10-100-67  | 10-100-67 |

37-278





1. ADD RESISTOR FSV NCM 15K 1/2W 5% IN PARALLEL WITH R13 TO PROVIDE +17.5V MIN +18V MAX AT TERMINAL 9.

2. ADD RESISTOR FSV NCM 15K 1/2W 5% IN PARALLEL WITH R10 TO PROVIDE +17V MIN -18V MAX AT TERMINAL 1.

RG 58 A/L

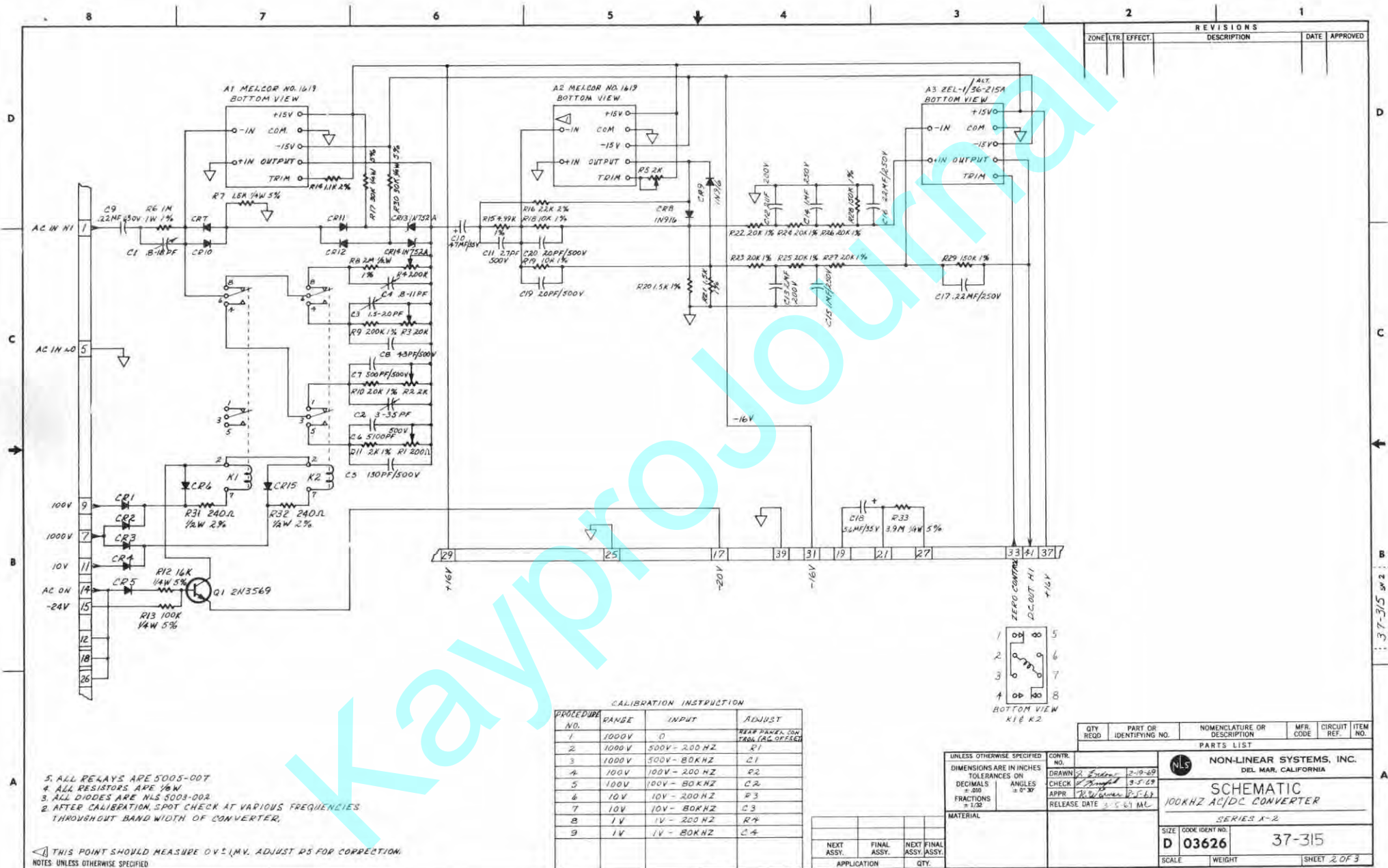
MCHAWK #1671 CABLE

NOTES: UNLESS OTHERWISE SPECIFIED

| REVISIONS |      |         |                                             |                |
|-----------|------|---------|---------------------------------------------|----------------|
| SYM       | ZONE | EFFECT  | DESCRIPTION                                 | DATE           |
| F         | O/A  | SN-1213 | REVISED & REDRAWN INCORP. E.O. 1 OF CHG "E" | 9-10-67 R.T.L. |

| QTY REQD                   | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR. CODE | CIRCUIT REF. | ITEM NO. | NEXT ASSY. | FINAL ASSY. | QTY. |
|----------------------------|-------------------------|-----------------------------|-----------|--------------|----------|------------|-------------|------|
| PARTS LIST                 |                         |                             |           |              |          |            |             |      |
| UNLESS OTHERWISE SPECIFIED |                         |                             |           |              |          |            |             |      |
| DIMENSIONS ARE IN INCHES   |                         |                             |           |              |          |            |             |      |
| TOLERANCES ON              |                         |                             |           |              |          |            |             |      |
| DECIMALS                   |                         |                             |           |              |          |            |             |      |
| FRACTIONS                  |                         |                             |           |              |          |            |             |      |
| SURFACE FINISH             |                         |                             |           |              |          |            |             |      |
| PER MIL-STD-10             |                         |                             |           |              |          |            |             |      |
| DO NOT SCALE THIS DRAWING  |                         |                             |           |              |          |            |             |      |
| RELEASE DATE               |                         |                             |           |              |          |            |             |      |
| 11-10-67 PC                |                         |                             |           |              |          |            |             |      |
| DRAWN WEINBERG 10-22-67    |                         |                             |           |              |          |            |             |      |
| CHECK WATKINS 11-9-67      |                         |                             |           |              |          |            |             |      |
| APPR R.T. WARNER 11-10-67  |                         |                             |           |              |          |            |             |      |
| MATERIAL                   |                         |                             |           |              |          |            |             |      |
| FINISH                     |                         |                             |           |              |          |            |             |      |
| CODE IDENT NO. 03626 R     |                         |                             |           |              |          |            |             |      |
| SIZE 37-298                |                         |                             |           |              |          |            |             |      |
| SCALE WEIGHT               |                         |                             |           |              |          |            |             |      |
| SHEET 2 OF 2               |                         |                             |           |              |          |            |             |      |

37-298 SHEET 2



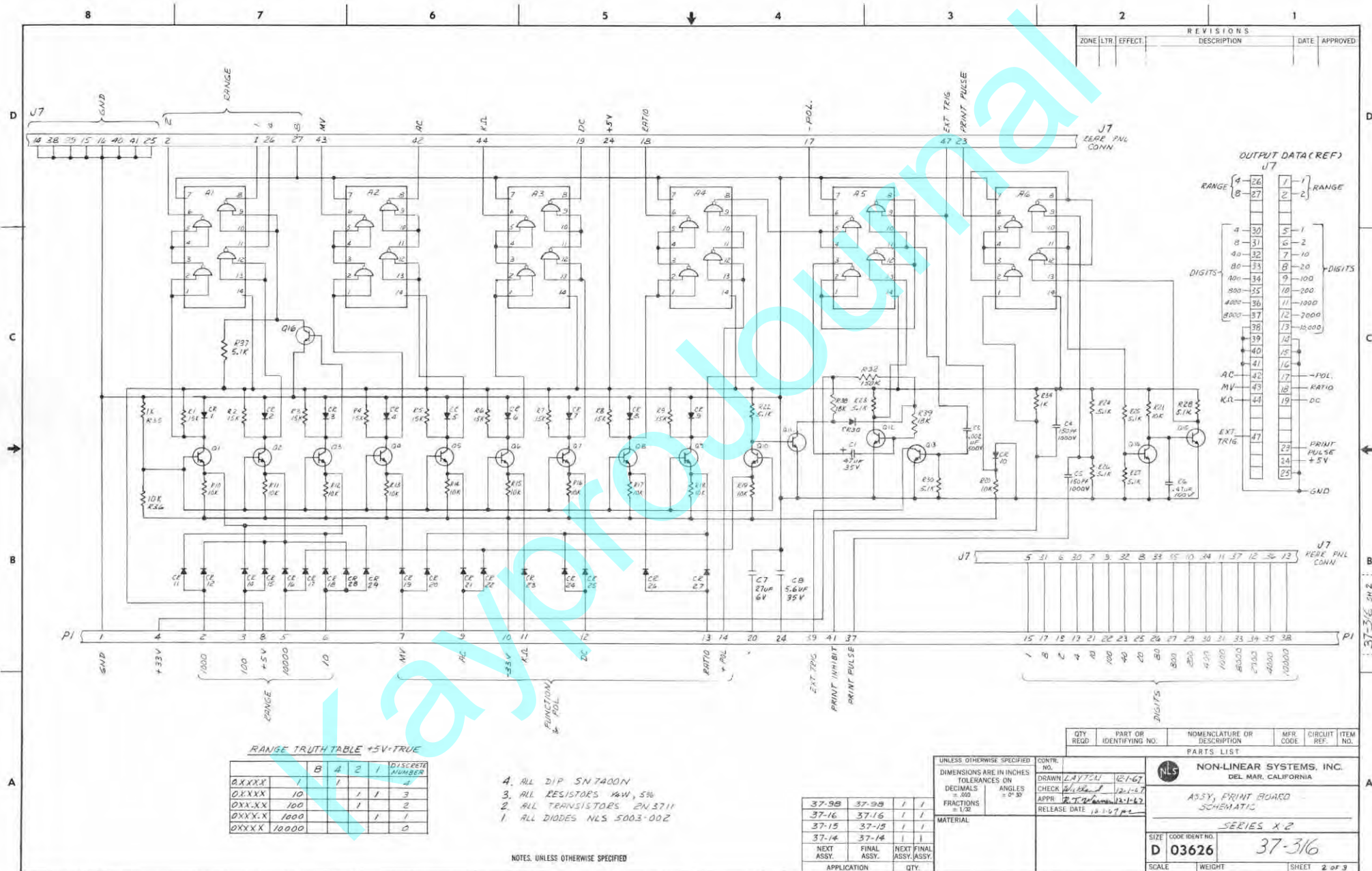
5. ALL RELAYS ARE 5005-007
4. ALL RESISTORS ARE  $\frac{1}{8}W$
3. ALL DIODES ARE NLS 5003-002
2. AFTER CALIBRATION, SPOT CHECK AT VARIOUS FREQUENCIES THROUGHOUT BAND WIDTH OF CONVERTER.

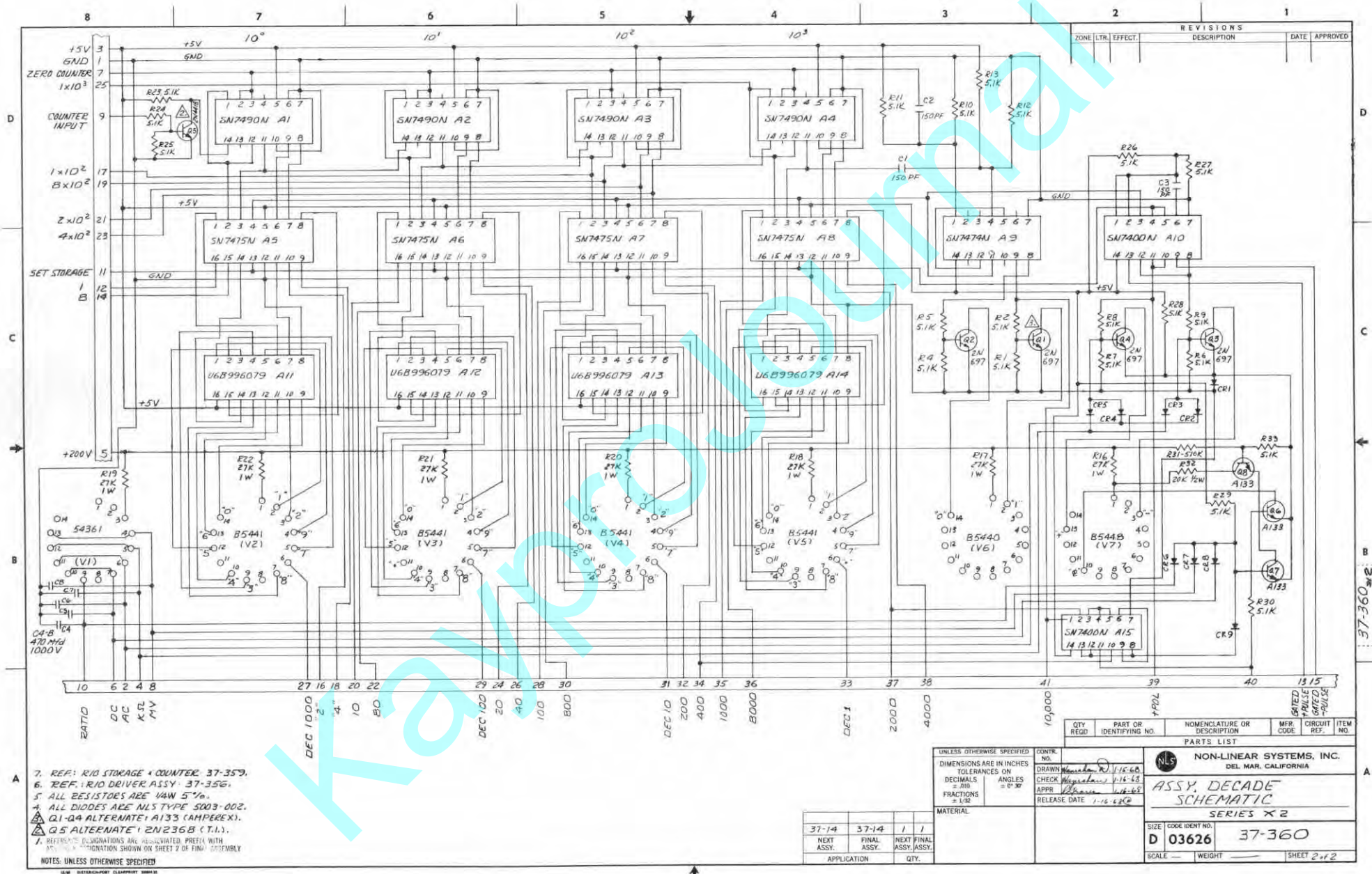
⚠ THIS POINT SHOULD MEASURE  $0V \pm 1mV$ . ADJUST R5 FOR CORRECTION.  
NOTES: UNLESS OTHERWISE SPECIFIED

| CALIBRATION INSTRUCTION |       |               |                                  |
|-------------------------|-------|---------------|----------------------------------|
| PROCEEDING NO.          | RANGE | INPUT         | ADJUST                           |
| 1                       | 1000V | 0             | REAR PANEL, 500<br>TAP, (AL OFF) |
| 2                       | 1000V | 500V - 200 HZ | R1                               |
| 3                       | 1000V | 500V - 80KHZ  | C1                               |
| 4                       | 100V  | 100V - 200 HZ | R2                               |
| 5                       | 100V  | 100V - 80KHZ  | C2                               |
| 6                       | 10V   | 10V - 200 HZ  | R3                               |
| 7                       | 10V   | 10V - 80KHZ   | C3                               |
| 8                       | 1V    | 1V - 200 HZ   | R4                               |
| 9                       | 1V    | 1V - 80KHZ    | C4                               |
|                         |       |               |                                  |

|               |                |               |                |
|---------------|----------------|---------------|----------------|
|               |                |               |                |
|               |                |               |                |
| NEXT<br>ASSY. | FINAL<br>ASSY. | NEXT<br>ASSY. | FINAL<br>ASSY. |
| APPLICATION   |                | QTY.          |                |

|                                                                                                                                                        |  |                            |  |                                                                                                                                            |  |                                                                                                          |  |                 |  |             |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------------------------|--|--------------------------------------------------------------------------------------------------------------------------------------------|--|----------------------------------------------------------------------------------------------------------|--|-----------------|--|-------------|--|
| QTY<br>REQD                                                                                                                                            |  | PART OR<br>IDENTIFYING NO. |  | NOMENCLATURE OR<br>DESCRIPTION                                                                                                             |  | MFR.<br>CODE                                                                                             |  | CIRCUIT<br>REF. |  | ITEM<br>NO. |  |
| PARTS LIST                                                                                                                                             |  |                            |  |                                                                                                                                            |  |                                                                                                          |  |                 |  |             |  |
| UNLESS OTHERWISE SPECIFIED:<br><br>DIMENSIONS ARE IN INCHES<br>TOLERANCES ON<br>DECIMALS      ON ANGLES<br>± .010      ± 0° 30'<br>FRACTIONS<br>± 1/32 |  |                            |  | CONTR.<br>DRAWN <i>R. E. Brown</i> 2-10-69<br>CHECK <i>R. E. Brown</i> 3-5-69<br>APPR <i>R. E. Brown</i> 3-5-69<br>RELEASE DATE 3-5-69 MAL |  | NON-LINEAR SYSTEMS, INC.<br>DEL MAR, CALIFORNIA<br><br>SCHEMATIC<br>100KHZ AC/DC CONVERTER<br>SERIES A-2 |  |                 |  |             |  |
| MATERIAL                                                                                                                                               |  |                            |  | SIZE<br>D 03626                                                                                                                            |  | CODE IDENT NO.<br>37-315                                                                                 |  |                 |  |             |  |
|                                                                                                                                                        |  |                            |  | WEIGHT                                                                                                                                     |  | SHEET 2 OF 3                                                                                             |  |                 |  |             |  |





# warranty

It is the continuous effort of Non-Linear Systems, Inc., to design and manufacture its products in such fashion as to at all times achieve the maximum customer satisfaction. Non-Linear Systems, Inc., issues this warranty in full recognition of its continuing obligation to its customers and its desire to always retain their respect and good will.

Non-Linear Systems, Inc., shall correct, either by repair or replacement, defects in material or workmanship in Non-Linear manufactured units or components where such defect develops within one year after delivery of the equipment to the original customer. In the instance of a defect of Sub-assemblies, Assemblies or Instruments manufactured by others than Non-Linear, every effort will be made to assist the customer in obtaining relief from the original manufacturer.

Any instrument claimed to be defective must be returned to Non-Linear Systems, Inc., Del Mar, California, transportation charges prepaid. The instrument will be repaired and returned to the purchaser, transportation prepaid, unless the instrument is found to be damaged by misuse, in which case the instrument will be returned to the purchaser with repair and transportation billed.

This warranty, being the entire agreement between the parties, is given expressly and in place of all other express or implied warranties including implied warranties for merchantability or fitness for particular use.



**Non-Linear Systems, Inc.**

