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INSTRUCTION MANUAL
MODELS 2917A AND 2917S
DIGITAL VOLTMETER

Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR . CALIFORNIA

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CHAPTER I

INTRODUCTION AND SPECIFICATIONS

SCOPE OF MANUAL

This manual specifically pertains to two models of the NLS Series 2900 Digital Voltmeters: Models 2917A and 2917S. The discussion throughout the manual will be directed toward the Model 2917A, the more complex model. Users possessing the Model 2917S may simply disregard the portions of the manual pertaining to measurement functions not included in their instrument. Table 1-1 lists the measurement functions of each instrument and Table 1-2 lists the major subassemblies of each model. Schematic diagrams for each of the two models will be found at the back of the manual.

GENERAL

The Series 2900 Digital Voltmeters are solid state integrating instruments which measure the absolute value of DC voltages or the true integral of varying voltages. In these instruments the unknown input voltage is converted to a pulse train whose repetition rate is directly proportional to the input voltage magnitude. The total number of pulses generated over an accurately clocked one-second interval is counted electronically and displayed as the voltage value.

OPERATING PRINCIPLE

An input of 100 millivolts to the instrument creates 100,000 pulses in one second; this is displayed as 100.000 MV. If the input voltages change during the measuring interval, the pulse repetition rate changes proportionately, and the total number of pulses that occurs during the one-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.

TABLE 1-1. MEASUREMENT FUNCTIONS

FUNCTIONS	2917A	2917S
Volts	X	X
Frequency	X	
Period	X	
Auto Range	X	
Decimal Point Storage	X	X

TABLE 1-2. MAJOR SUBASSEMBLIES OF EACH MODEL

	MODEL 2917A (29-250)	MODEL 2917S (29-292)
Decade Assembly	29-245	29-245
Buffer Assembly	29-240	29-240
Control Assembly	29-253	29-253
Oscillator Assembly	29-329	29-329
Auto Range Assembly	29-139	(None)
Frequency & Period Measuring Assembly	29-256	(None)
Interconnecting Board Assembly	3417	3417
Resetter Assembly	29-152	29-152
Amplifier Assembly	29-259	29-259
Power Supply Assembly	3426	3426
Jumper Board Assembly	(None)	29-263
Storage Assembly	(None)	29-306

NOTE: The Model 2917S may be readily converted into a Model 2917A by removing the printed circuit jumper board (29-263) from P34 and installing in P33-P34 a Frequency-Period board (29-256). Remove the Storage Board (29-306) from P31-P32 and install an Auto-Range Board (29-139) into P31-P32.

Therefore if an integral number of cycles of sine wave noise occurs during the one-second sampling interval, its contribution to the over-all reading is "integrated out." It should be noted that with a 0.01 second sampling rate there is not time for an entire 60-cycle sine wave and some measurement inaccuracy would occur; however at the instrument's slower sampling rates, the error is reduced to negligible value. With sine wave noise of 400 cycles, high reading accuracy can be maintained even with a 0.01 second sampling rate.

THE REVERSIBLE COUNTER

The Series 2900 instruments are uniquely able to provide a higher order of accuracy than that available with other integrating type digital voltmeters because the NLS instruments have a reversible counter. It is only with this type of circuit that an integrating instrument can render a true average reading, for without a reversible counter, any AC component imposed upon the DC input will cause a zero-crossing error which accumulates each time the AC component causes the amplifier output to cross the zero level.

COMMON MODE REJECTION

As shown in the specifications, the common mode rejection capability of a 2900 instrument is extremely high. For the most part, this is due to the use of photoelectric coupling devices which avoid the need for electrical connection at the converter output and at the range command signal connection to the converter.

STABILITY

Long-term stability and reliability are assured in part because no vacuum tubes are used in this instrument. Therefore the problems associated with changing emission levels and with heating are eliminated. The whole instrument dissipates only about 25 watts and no blower is required. In fact, the problem of heat is so minimal that only a few heat sinks are used. Because of this cool operation, the instrument is not likely to require frequent recalibration.

SPECIFICATIONS, MODEL 2917A

FUNCTION: Voltage measurement.

RANGES: As indicated by the RANGE control on the front panel, the instrument has five ranges. However, the manner in which values in each range are displayed is affected by the sampling period selected. Table 1-3 illustrates the several combinations of sampling time with the RANGE control set in each of its positions; in addition, the maximum over-range figures for each setting are given.

ACCURACY: On the 0.1V range.

Accuracy at 25°C: ±0.02% reading ±0.01% full scale ±2 digits. Temperature effects: ±0.002% reading per $^{\circ}$C ±0.003% full scale per $^{\circ}$C.

On the 1, 10, 100, 1000V ranges.

Accuracy at 25°C: ±0.01% reading ±0.005% full scale ±1 digit. Temperature effects: ±0.001% reading per $^{\circ}$C ±0.0005% full scale per $^{\circ}$C.

MEASUREMENT TIME: Sample period may be set at 0.01, or 0.1, or 1 second. As shown under Range, resolution decreases as speed increases. AUTO RANGE selection does not change the sample period; however, up to 50 MSEC per measurement may be added for RANGE selection.

MAXIMUM NUMBER OF MEASUREMENTS: 10 per second.

COMMON MODE REJECTION: 120 DB at 60 CPS; 160 DB with DC.

INPUT RESISTANCE: 100K ohms on 0.1 volt; 1 megohm on 1 volt; 10 megohms on all higher ranges.

SIGNAL MODE INPUT NOISE REJECTION: The integrating characteristic inherently averages out signal noise. Noise rejection varies with noise frequencies and sample period. AC noise attenuation is infinite for 1, 2, 3, etc. CPS noise frequencies for a 1 second sample period; for 10, 20, 30, 40, etc. CPS for 0.1 second period; and for 100, 200, 300, etc. CPS for 0.01 second period. Table 1-4 gives minimum noise rejection ratings at various frequencies for the three sample periods.

NOTE

The values set forth in Table 1-4 apply ONLY if the instantaneous input voltage does not exceed 120% of full scale at any time during the sample period.

TABLE 1-3. SAMPLING TIME

SAMPLE	RANGE CONTROL SETTING	FULL-SCALE READING	MAX. OVER-RANGE READING FOR RATED ACCURACY
1 Second	0.1V	99.999 MV	120.000 MV
	1.0V	.99999V	1.20000V
	10V	9.9999V	12.0000V
	100V	99.999V	120.000V
	1000V	999.99V	1200.00V
0.1 Second	0.1V	.09999V	0.12000V
	1.0V	0.9999V	01.2000V
	10V	09.999V	012.000V
	100V	099.99V	0120.00V
	1000V	0999.9V	01200.0V
0.01 Second	0.1V	0.0999V	00.1200V
	1.0V	00.999V	001.200V
	10V	009.00V	0012.00V
	100V	0099.9V	00120.0V
	1000V	00999.V	001200.V

TABLE 1-4. NOISE REJECTION RATINGS

SAMPLE PERIOD	NOISE FREQUENCY			
	CPS 60-100	CPS 100-200	CPS 200-500	CPS 500-1000
1 Second	42 - 46 DB	46 - 52 DB	52 - 60 DB	60 - 65 DB
0.1 Second	22 - 26 DB	26 - 32 DB	32 - 40 DB	40 - 46 DB
0.01 Second	2 DB	8 DB	15 DB	22 DB

DISPLAY TIME: The readout display duration may be for 1/4, 1/2 or 2 seconds before another scan is started when MODE switch is in RUN position.

DIGITAL READOUT (PRINT): Decimal voltage level. Levels are 0V for logic "1," -27 volt for logic "0," 5 MA, maximum. For output functions and remote functions, see Figures 2-4 and 2-5.

The following table shows full scale reading and connection information for each function.

TABLE 1-5. FUNCTION, FULL SCALE READING AND CONNECTION INFORMATION

FUNCTION	FULL SCALE READING	CONNECTOR	RANGE SWITCH	SAMPLE PERIOD SWITCH	REMOTE CONTROL*	
					FUNCTION	SAM. PER.
VOLTS	99.999 MV	J-3	.1 VOLT		J2-U	
	.99999V		1 VOLT		J2-T	
	9.9999V		10 VOLTS		J2-P	
	99.999V		100 VOLTS		J2-N	
	999.99V		1000 VOLTS		J2-R	
			AUTO RANGE		J2-LL	
	ABOVE ÷ 100			.01 SEC		J2-NN
	ABOVE ÷ 10			.1 SEC		J2-MM
	ABOVE ÷ 1			1 SEC		J2-AA
FREQUENCY		J-6	FREQ		J2-X	
	00300.0 KC			.01 SEC		J2-NN
	0300.00 KC			.1 SEC		J2-MM
	199.999 KC			1 SEC		J2-AA
PERIOD		J-6	PERIOD		J2-Y	
	19999.9 MS			.01 SEC (1 PER.)		J2-NN
	1999.99 MS			.1 SEC (10 PER.)		J2-MM
	199.999 MS			1 SEC (100 PER.)		J2-AA

*FOR REMOTE CONTROL PLACE FRONT PANEL SWITCHES IN THEIR "REMOTE" POSITIONS. CONNECT DESIGNATED PINS TO J2-L.

CHAPTER II

INSTALLATION AND OPERATION

UNPACKING

Instruments are shipped in two-piece polystyrene-bead containers. Cut the tape between container halves and open. If damage is seen, promptly notify the carrier. There is no packing material inside the instrument. It is suggested that the container be saved if future shipment or storage is contemplated.

POWER SOURCE

The instrument is ready for operation from conventional 115-volt, 60-cycle power sources. A 230-volt source may be used if the two primaries of the power transformer are wired in series instead of parallel. Schematic diagram 29-248 identifies the windings.

FUSING

The instrument is protected by a 3AG 0.6-ampere slo-blo fuse which is located in an extractor post on the rear panel. When a 230-volt power source is used (and the power transformer primary rewired as indicated above), it is recommended that a 0.3-ampere fuse be used to provide maximum protection.

POWER GROUNDING

The third pin on the power plug grounds the chassis of the instrument (Figure 2-1). The internal guard area is always isolated from ground. While general electrical practice requires that a chassis ground be provided to avoid shock hazard, the power line ground, as such, is not related to the instrument's ability to provide accurate readings.

CABLES

The instrument is supplied with two input cables (P/N 15004-363). The red pin is input high, black is input low and blue is guard shield (Figure 2-2). There is no connection to the chassis of the instrument. All inputs go directly inside of the guard shield area. When measuring an input that should be shielded, the blue guard shield lead is used; at other times the black and blue leads may be tied together.

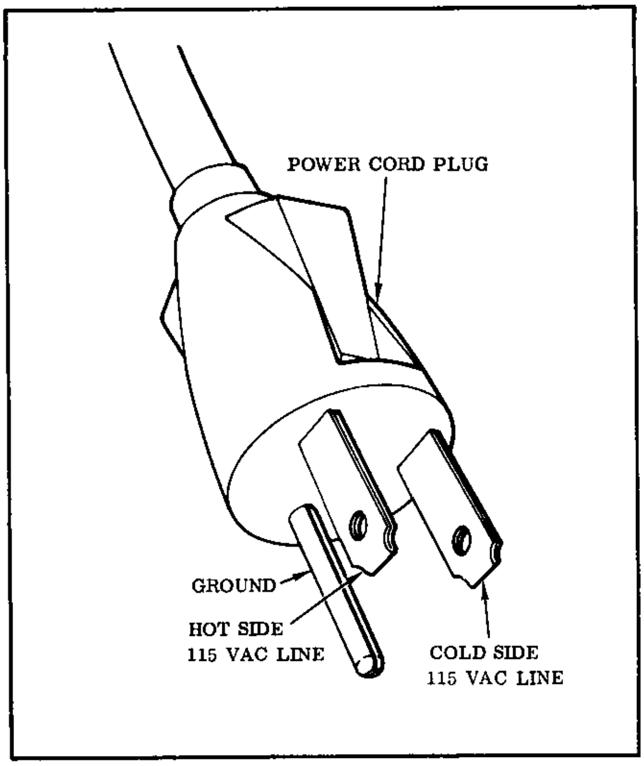


Figure 2-1. Power Plug Pin Coding

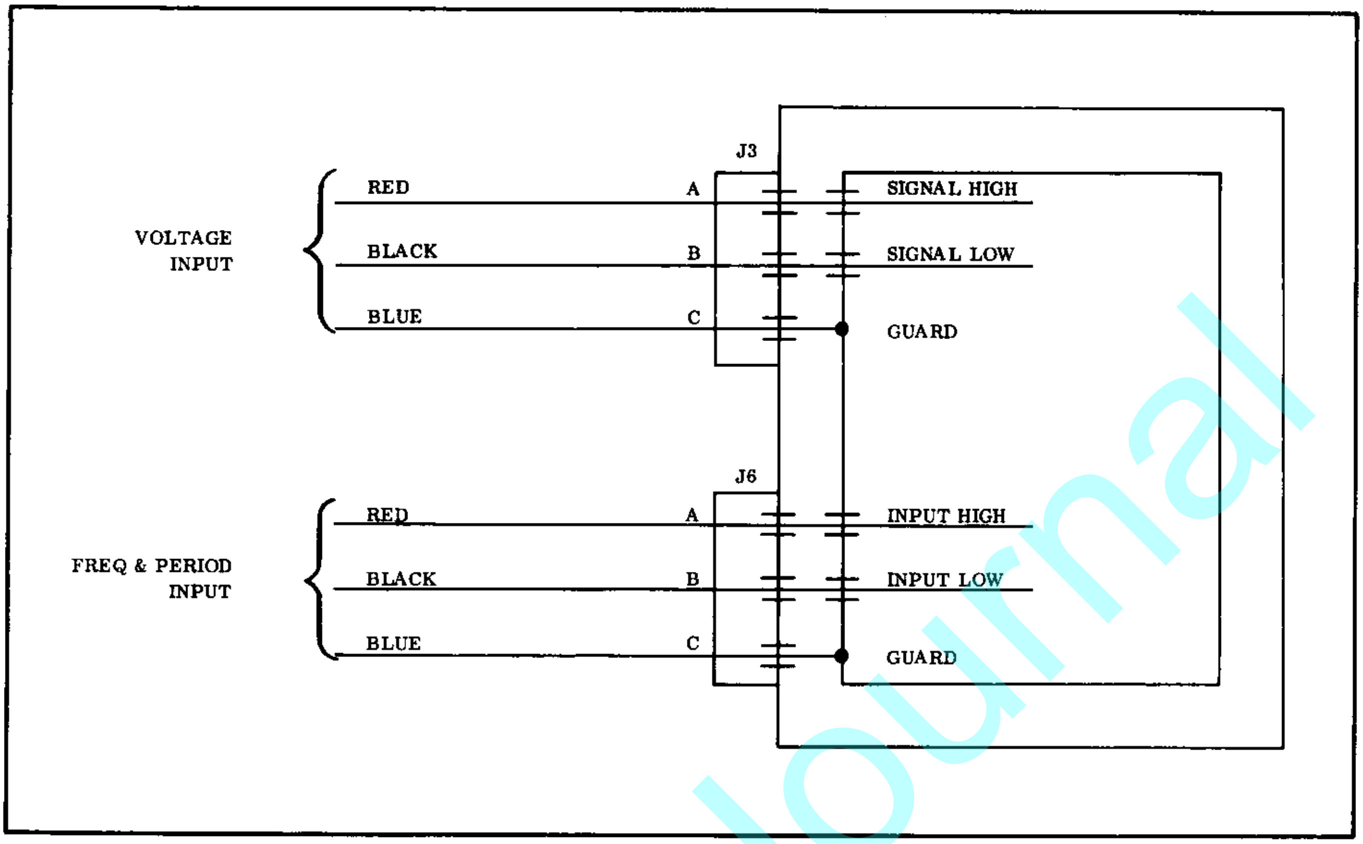


Figure 2-2. Input Connections

The instrument is furnished with mating connectors for printer operation and remote control. Connections to all cables are made at the rear of the instrument (Figures 2-3, 2-4 and 2-5).

CONTROLS

(See Figure 2-6 and Table 2-1.)

POWER SWITCH

The POWER switch has two positions - ON and OFF. Although the instrument is ready to provide fairly accurate readings within 15 minutes, utmost accuracy is ensured if a 30-minute warm-up period is allowed.

SAMPLE PERIOD SWITCH

This control is used to select the measurement time by internally determining the scanning rate of the instrument. When set at the REMOTE position, this function is controlled from a remote operation point connected to the instrument's remote cable See Figure 2-5 for connection information.

RANGE/FUNCTION SWITCH

This control is provided to allow the selection of a specific range of measurement desired. It is also used to select the auto-range, frequency, period and remote modes of operation.

AUTO R - In this position the instrument will automatically select the proper range. Approximately 10 milliseconds is added to the overall scan time for each range change; the sample period time is not affected.

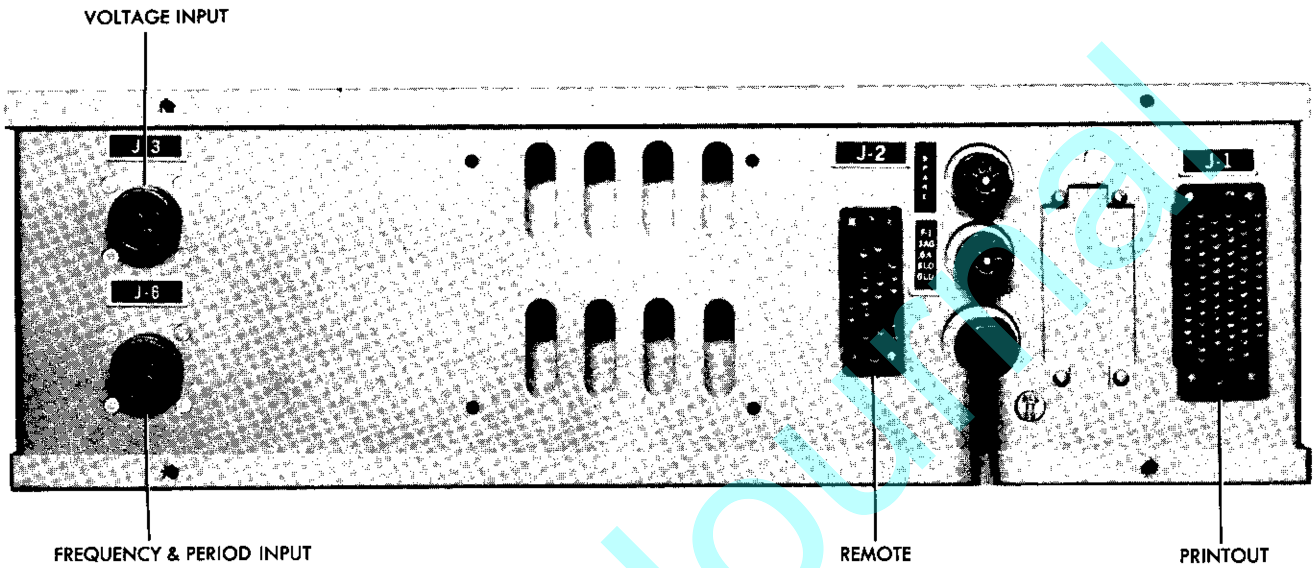


Figure 2-3. Rear View

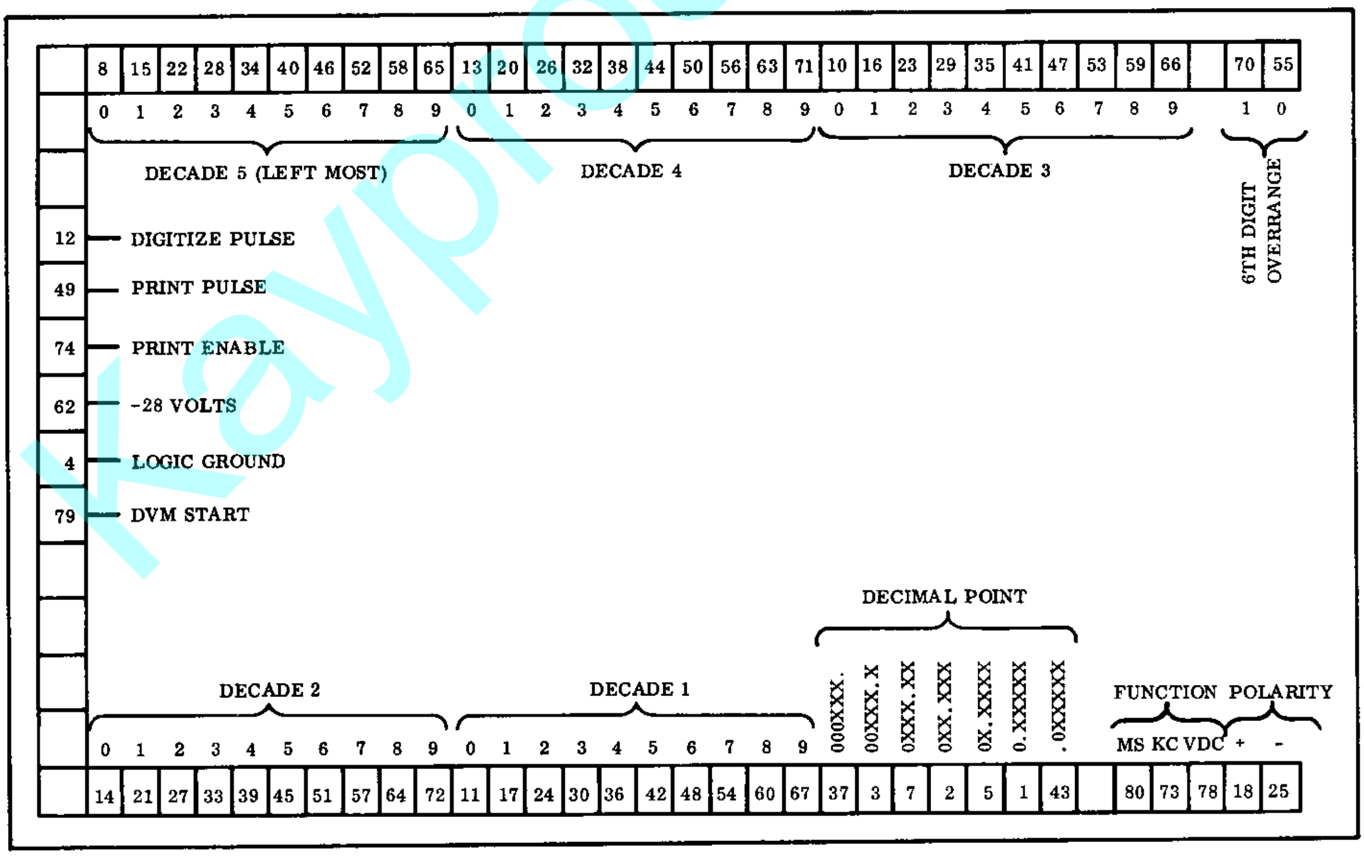


Figure 2-4. Output Connections

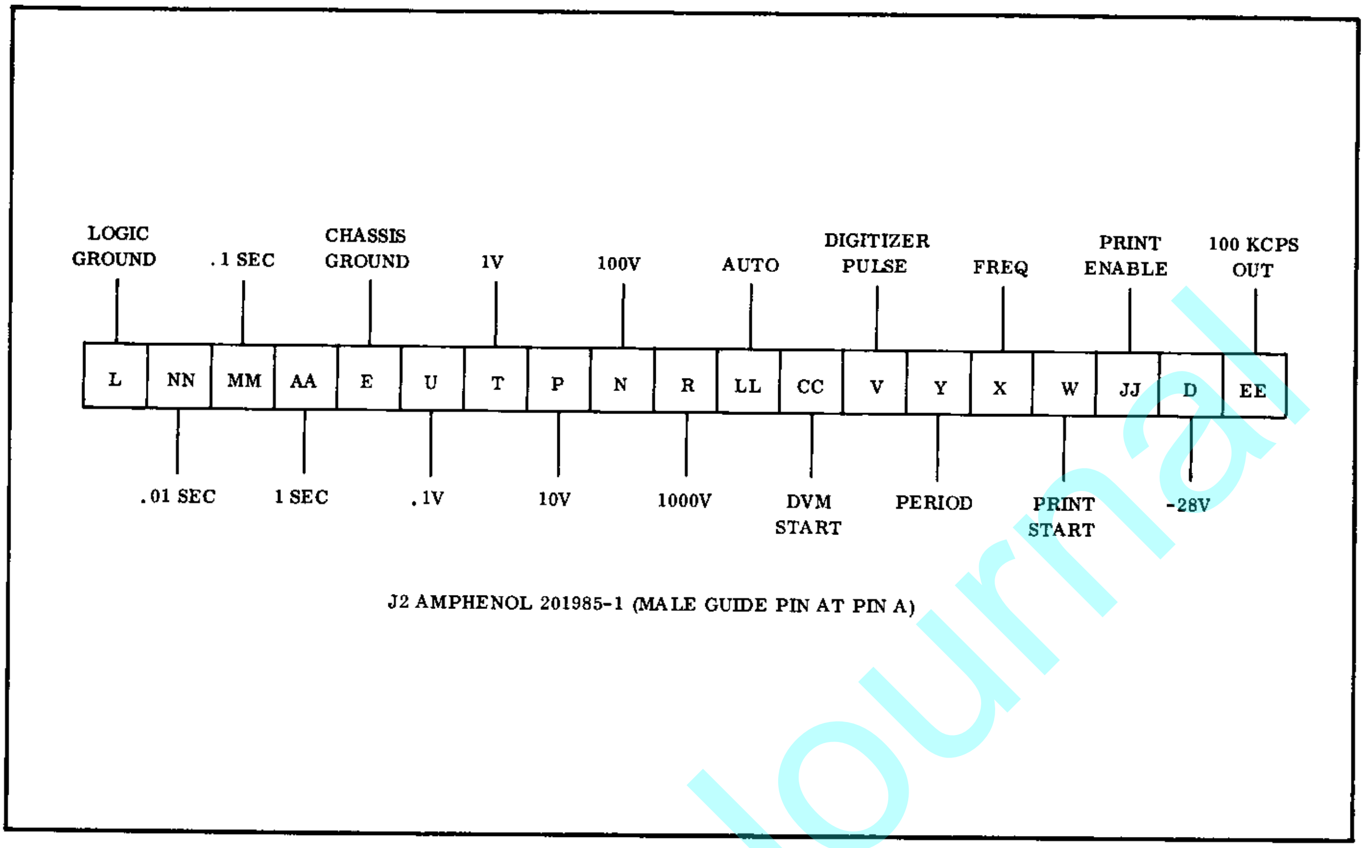


Figure 2-5. Remote Control Connections

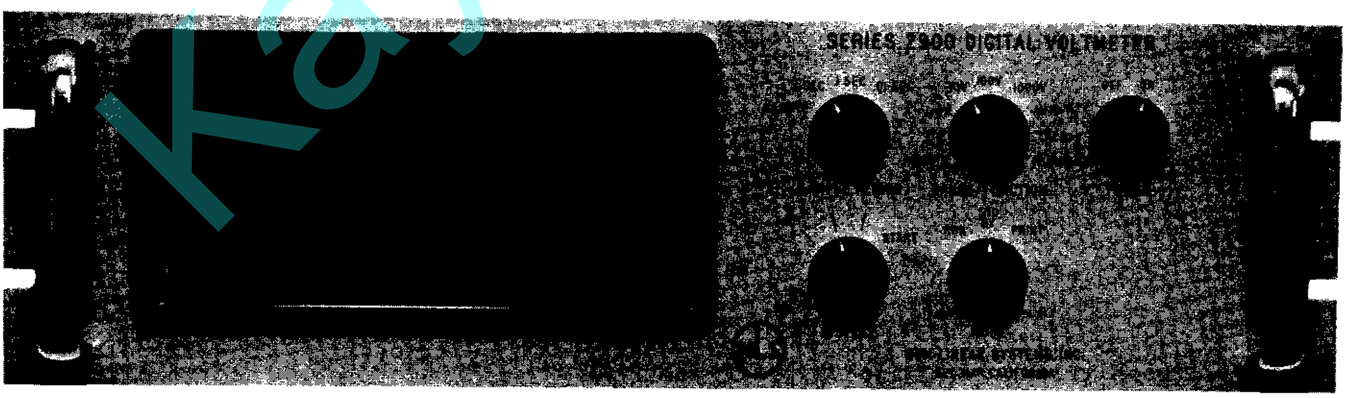


Figure 2-6. Front View

TABLE 2-1. 2917A CONTROLS

SWITCH	POSITION	ACTION
POWER	ON	Supplies power to 2917A
RANGE	.1 VOLT	Locks meter in .1 volt range
	1 VOLT	Locks meter in 1 volt range
	10 VOLTS	Locks meter in 10 volt range
	100 VOLTS	Locks meter in 100 volt range
	1000 VOLTS	Locks meter in 1000 volt range
	AUTO R	Meter selects best range
	FREQ	Selects frequency mode
	PERIOD	Selects period mode
	REMOTE	Use when selecting range externally
SAMPLE PERIOD	REMOTE	Use when selecting sample period externally
	.01 SEC	Locks meter in .01 second sample period
	.1 SEC	Locks meter in .1 second sample period
	1 SEC	Locks meter in 1 second sample period
DISPLAY	FAR CCW	Short readout display (1.4 second)
	MIDDLE LINE	Medium readout display (3/4 second)
	RIGHT LINE	Long readout display (3 seconds)
	START	"Single Scan" - Use when in stand by
MODE	RUN	Auto recycling
	STD BY	Meter completes existing reading and stops
	PRINT	Issues print pulse external "start" required

TOTAL READING TIME

Total time of reading depends on the settings of the RANGE switch, the SAMPLE PERIOD switch, and the DISPLAY switch.

Minimum reading time will occur when a fixed range is chosen, and when in the .01 second sample period and the 1/4 second display time.

Maximum reading time will occur when in AUTO R, and when the 1 second sample period and the 3 second display times are chosen.

FREQ - Pulses exceeding approximately 0.3 volts RMS applied to the frequency input connector (J6-A) are counted over the sample period selected. Maximum countable frequency is 300 KC.

PERIOD - The first pulse applied to J6-A starts the instrument counting at a standard rate. The instrument will stop counting under one of the three following conditions: (1) The second pulse applied at J6-A, if the SAMPLE PERIOD switch is set at .01 SEC; (2) The eleventh pulse applied at J6-A, if the SAMPLE PERIOD switch is set at .1 SEC; or (3) The one hundred and first pulse applied at J6-A, if the SAMPLE PERIOD switch is set at 1 SEC. The period or time between the first and second pulse (SAMPLE PERIOD switch at .01 SEC) is shown in the readout in milliseconds. The average of 10 or 100 periods is shown in milliseconds if the SAMPLE PERIOD switch is set at .1 SEC or 1 SEC respectively.

DISPLAY SWITCH

This switch is used to select the readout display time before a new scan is initiated. The extreme counterclockwise position provides an image persistence of approximately 1/4 to 1/2 second; the next position provides about 1 second; the last position provides about 2 seconds. Added to this switch at the clockwise end of travel is a spring-return START position. This position is used when the instrument is in either STANDBY or in PRINT to initiate a new scan. The switch should be turned to this position for only a moment. The operation provided by this control is not available remotely.

MODE SWITCH

One of the following three modes of operation may be selected:

RUN - At the end of display time, the instrument is internally started on a new scan and the instrument will continue to scan and display indefinitely.

STANDBY - After one scan the instrument will provide a display and stop operation until externally triggered to scan again, or until the display control is momentarily rotated to the START position.

PRINT - At the end of scan, the instrument will generate a negative 10-volt print pulse of 20-millisecond duration to operate a printer. The instrument will only scan again when a print command is issued by the associated printer. See Figure 2-4 for connection information.

CHAPTER III

THEORY OF OPERATION

GENERAL THEORY

In integrating digital voltmeter instruments the unknown input voltage is converted to a pulse train whose repetition rate is directly proportional to the input voltage magnitude. The total number of pulses generated over an accurately clocked 1 second interval is counted electronically and displayed as the voltage value.

In a typical instrument, an input of 100 millivolts would create 100,000 pulses in one second, and this would be displayed as 100.000 volts. If the input voltage changes during the measuring interval, the pulse repetition rate changes proportionately, and the total number of pulses that occur during the one second sample period is a measure of the number of volt-seconds at the input. Therefore, these instruments effectively mathematically integrate the input voltage. Thus, for example, they are useful for obtaining velocity from a voltage which is proportional to acceleration.

Another advantage of these instruments is their inherent ability to reject sinusoidal ripple. This ability stems from the integrating characteristic of the instrument, and the fact that the integrated value of an integral number of sine waves is zero. Therefore, if an integral number of sine wave noise occurs during the one-second sampling interval, their contribution to the over-all readout is "integrated out." (Integrating gives the time - average value of the input voltage in the same way that we obtain average velocity by dividing distance traveled in a given time by the elapsed time.) Sampling times of 1 second, 0.1 second and 0.01 second are usually supplied in integrating DVM's. At the 1 second and 0.1 second intervals, 60 cycle or 400 cycle noise would be virtually completely rejected. On the 0.01 second sampling period, an entire 60 cycle sine wave would not occur, and 60 cycle noise would produce some inaccuracy in measurement; however, 400 CPS noise would be rejected.

The basic functional diagrams of integrating DVM's are shown in Figures 3-1 and 3-2. The unknown input voltage is applied to an integrating circuit whose output is a ramp function whose slope is proportional to input amplitude. This ramp is fed to a voltage comparator which will, at some accurately fixed voltage value, reset the integrator to zero volts instantaneously; whereafter the integrated output will again start climbing toward the voltage comparator's limit value. Thus, a sawtooth function is generated whose frequency is proportional to input voltage. Typically, such an integrator would produce an output which would reach the reset limit at the end of 1 second with a 1 microvolt input, and the lowest range of a digital voltmeter of this type would produce 1 count at the end of 1 second with 1 microvolt input. Full scale on this low range would be 99.999 millivolts, which would produce a frequency of 99.999 cycles per second. Some integrating DVM's use voltage controlled oscillators different than the one described above, but the over-all DVM

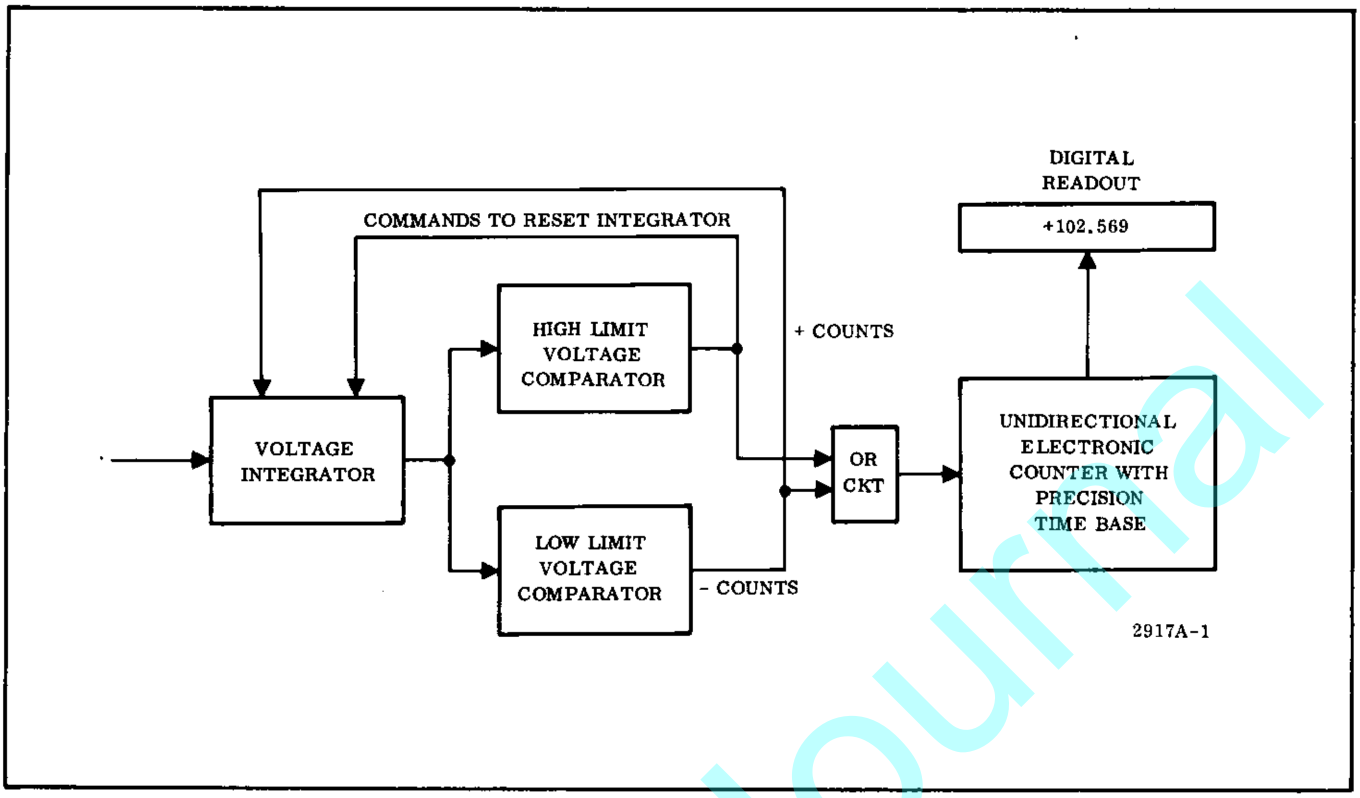


Figure 3-1. An Integrating DVM that will not Properly Evaluate or Integrate Inputs that Change Polarity During the Sample Period

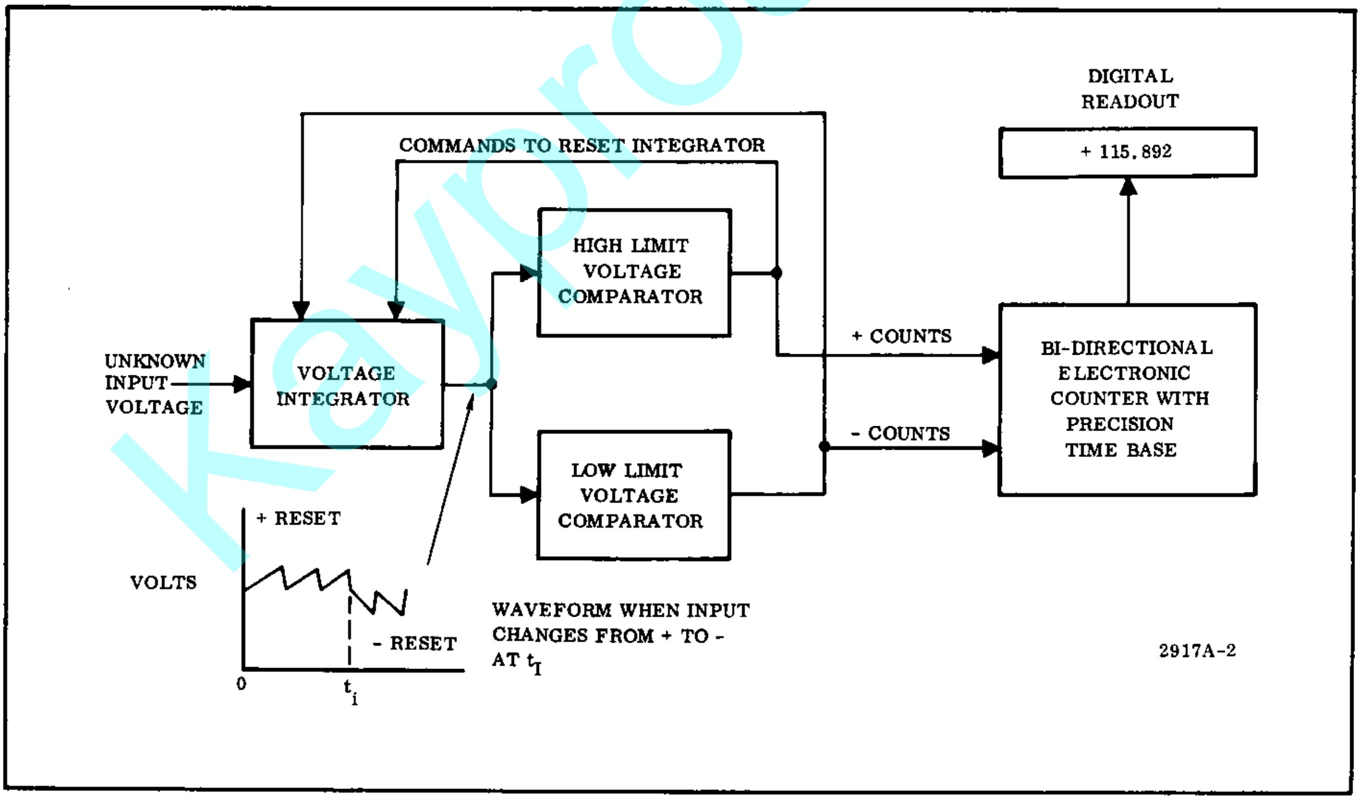


Figure 3-2. A Versatile NLS Integrating DVM with Bi-directional Counter to Properly Average or Integrate Inputs that Change Polarity During the Sample Period

principle is the same. Additional ranges are obtained by attenuating the input voltage in decade steps.

Although most integrating digital voltmeters available today are of the type shown in Figure 3-1, they have serious difficulties which are eliminated by the bi-directional integrating Series 2900 Digital Voltmeters as shown in Figure 3-2. In Figure 3-1 changing the input voltage polarity does not cause the counter to count backwards. Therefore, when using the instrument for mathematical integration, the integral of the absolute value of the input is displayed, without regard to sign. For example, if an AC sine wave is applied, the DVM of Figure 3-1 reads twice the area under one-half the sine wave, whereas the Series 2900 bi-directional integrating DVM of Figure 3-2 reads the true integrated value of the sine wave, which is zero (of course, the DVM of Figure 3-2 could be modified to operate the same as the one in Figure 3-1, if required). Another item to check in integrating DVM's is the necessity for periodic recalibration of the integrator reset circuits of Figures 3-1 and 3-2. In some cases, the blocking oscillators used as resetters must be manually recalibrated from hour to hour against a built-in standard, to obtain full specified accuracy, while NLS integrating DVM's have intrinsically stable resetting circuits that do not require periodic adjustment. Furthermore, the polarity sign of the DVM in Figure 3-1 will be the polarity that the input signal had at the instant the sampling period ended; even if the input signal was predominately positive, a negative sign is likely to be displayed in the readout (Figure 3-3). In the Series 2900 bi-directional DVM of Figure 3-2 however, the bi-direction counter counts forward when the input signal polarity is positive and counts backwards for negative inputs. Thereby, it gives a true mathematical integral, and its polarity sign represents the true polarity of the input average value, even when the input voltage passes through the zero axis during measurement.

Some integrating DVM's have a zero crossing error which can cause several digits error each time the input waveform goes

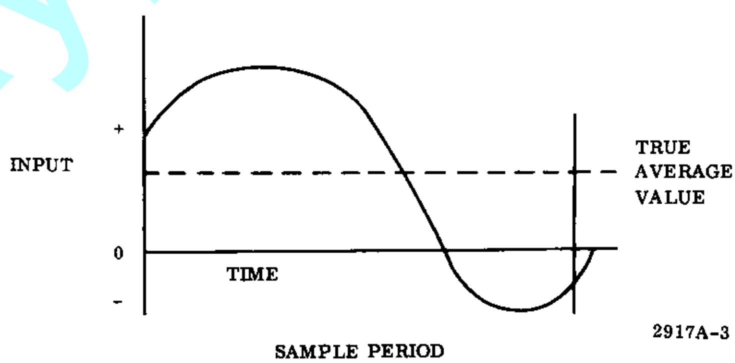


Figure 3-3. Sample Input Waveform

through zero volts. Therefore, if one is attempting to measure a small DC voltage which has enough sinusoidal ripple to cause voltage excursions through zero value (as in Figure 3-3) large errors can occur, and such DVM's are therefore not accurate "null meters." The design of Series 2900 integrating DVM's eliminate this zero crossing error. The DVM of Figure 3-1 displays a minus sign when reading the input shown in Figure 3-3. Also, it adds the average value of the positive portion to the average value of the negative portion, thus giving a high reading. The NLS DVM of Figure 3-2 gives the true average value.

An advantage of the integrating DVM which has heretofore been almost completely ignored is encountered when measuring varying voltages to which statistical analysis must later be applied. If such voltages are measured with a tracking logic or scan logic potentiometric DVM, the numerals obtained will be biased toward 9's (e.g., 1.119, 1.129 or 1.199, 1.299, etc.) when increasing voltages are measured, and toward 0's for decreasing voltages. Integrating DVM's do not have this numerical bias.

SPECIFIC THEORY

Basically, the 2917A instrument consists of two functional units, the converter unit which changes the given input voltage to frequency, and a reversible counter which counts the converter frequency (see Figure 3-4). There is no direct electrical connection between the converter and the counter units.

THE CONVERTER UNIT

The heart of the converter is a highly stable, wide band chopper-stabilized differential amplifier, often called a Miller Integrator. Connected as shown, the amplifier generates an output whose rate of rise is directly and linearly (0.01%) proportional to the input voltage. Two precision Schmitt triggers are connected to the output of the amplifier. One Schmitt trigger will fire at about 1.3 volts if the amplifier swings positively and the other will fire at 0.8 volt if the output voltage swings negatively. When the Schmitt trigger fires through the pulse-shaping network, a fixed amount of charge is delivered to the summing node of the amplifier to neutralize the input current. This action forces the summing node back to ground potential and the output of the amplifier is reset and another pulse is generated again. Since the slope (the rate of rise) of output voltage is linearly proportional to the input voltage for a given time, the frequency at which the Schmitt trigger is fired is also directly proportional (0.01%) to the input voltage. Thus, DC voltage is converted to pulses whose rate of occurrence is an indication of the magnitude of the input voltage. If these pulses are counted, the number of pulses per unit time is an indirect measurement of the input voltage.

The monostables which follow the Schmitt triggers serve as buffer amplifiers. To provide high common mode rejection, the output of the buffer amplifiers is fed into neon bulbs which emit light to activate photo cells (outside the converter box) whose outputs are used to trigger the counter amplifier. The technique is used to actuate the relays in the attenuator; this time, however, the control neon bulbs are located outside the converter and the photo-conductive cells (that control reed relays) are inside the converter box.

THE COUNTER UNIT

The pulses transmitted to the photo cells are used to trigger the converter amplifiers.

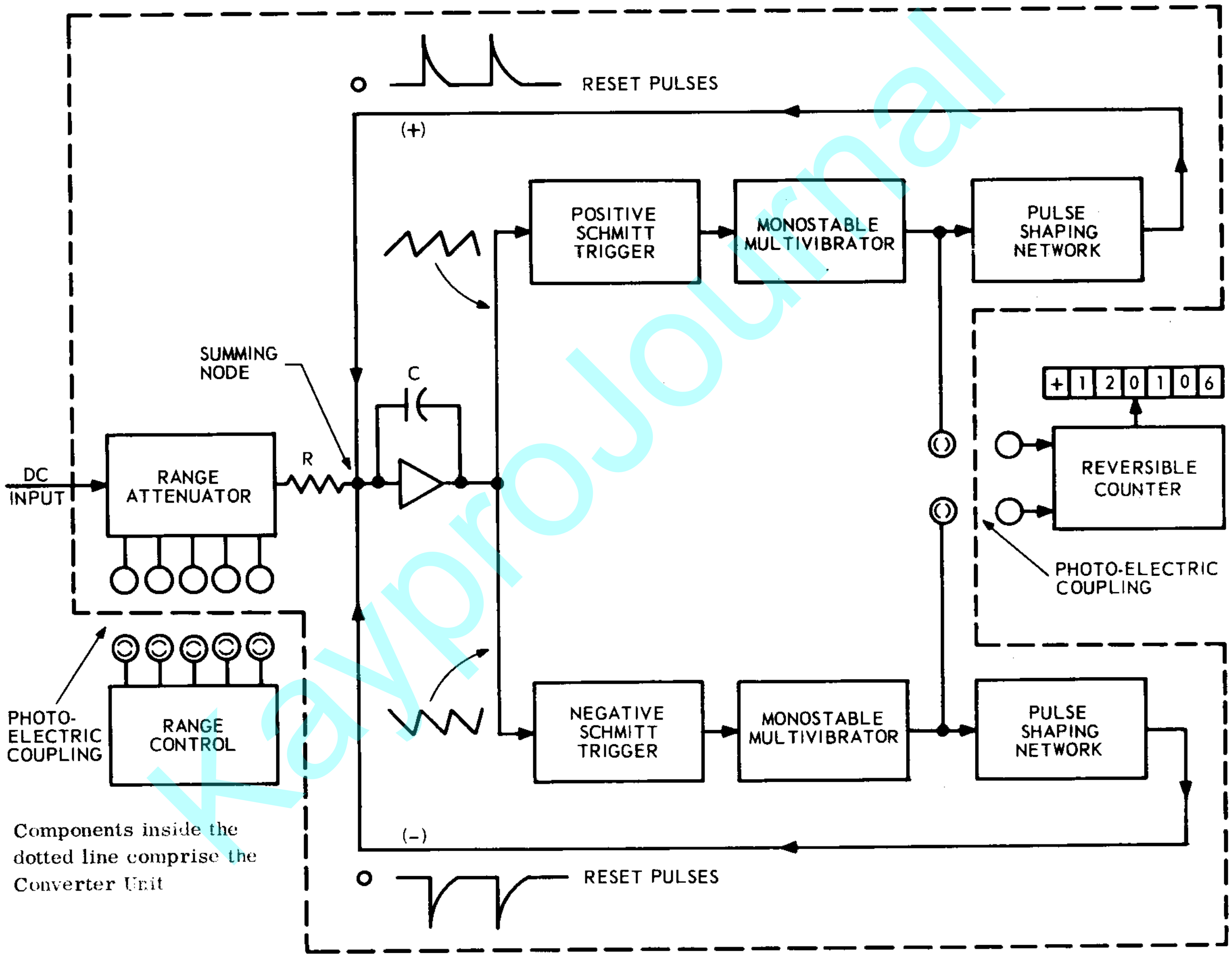


Figure 3-4. Functional Block Diagram

The counter then counts these amplified pulses whose numbers are indicated in the readout. Also, since the counter is reversible, the total count numerically represents the true integral of the input voltage.

From the foregoing description, it can be easily seen that the photoelectric coupling, plus the integrating property of the amplifier, lead to an extremely high common mode level of rejection.

RIPPLE ERROR

One advantage of integrating DVM's is that, without using input filters, they completely reject sinusoidal AC ripple superimposed on the DC voltage being measured, provided that an integral number of noise cycles occur during the DVM's sample period. This is because the integrated value of a sine wave is zero. They will also completely reject any ripple waveforms other than sinusoidal if the area (volt seconds) of the positive polarity section of the ripple waveform is equal to the waveform's negative polarity area. The maximum measurement error caused by ripple occurs when the ripple frequency is such that instead of an integral number of cycles of ripple occurring during the DVM sampling period, an extra half cycle of ripple gets through (see Figure 3-5).

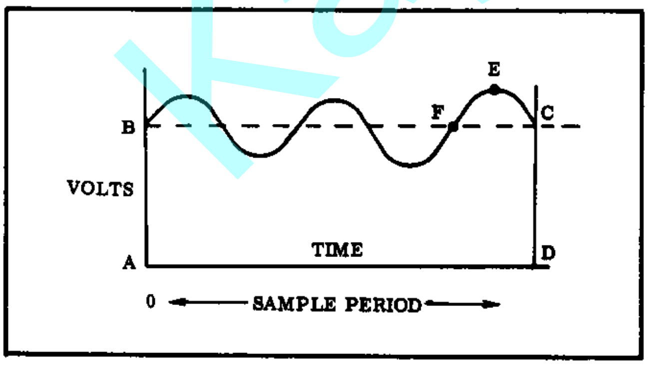


Figure 3-5. DC Signal with Superimposed Noise

This maximum error is calculated by determining how many volt seconds (area FEC in Figure 3-5) the extra half cycle of ripple adds to the volt seconds created by the DC signal (area ABCD in Figure 3-5). The area FEC (in volt seconds) is the average ripple voltage (RMS value ÷ 1.11) multiplied by one-half the ripple waveform period. Area ABCD is found by multiplying the DC amplitude by the DVM sample period. The % error is then 100 times the ratio of area FEC to ABCD or: % error =

$$\frac{\dfrac{\text{RMS ripple amplitude}}{1.11} \times \dfrac{\text{ripple period}}{2}}{\text{DC amplitude} \times \text{DVM sample period}} \times 100$$

Example: What error is caused by 0.3 volts RMS of 100.5 CPS sine wave ripple superimposed on a 20 volt DC signal, using a 1 second DVM sample period?

$$\% \text{ error} = \frac{\dfrac{.3}{1.11} \times \dfrac{1}{100.5 \times 2}}{20 \times 1} \times 100 = 0.00667\%$$

Thus, only 0.00667% error was caused by a ripple voltage whose peak value is 2.1% that of the DC voltage being measured. Note that this is an extreme case since ripple frequencies usually encountered are not odd values like 100.5 CPS, but are whole number values (50, 60, 400, or integral multiples of these), and ripple of such frequencies would be completely rejected.

Ripple-caused error decreases if DVM sampling period is increased, or if ripple frequency increases. For example, the error caused by a 0.3V RMS 10.0005 KC ripple signal on a 20 VDC signal measured with a 1 second DVM sample period would be 0.000065% of reading.

If the ripple is so great as to cross the zero axis (Figure 3-6), some integrating DVM's will add the negative area (area below zero axis) to the positive area, and will display the last polarity encountered (in this case, negative). This results in highly erroneous measurement, and makes the instrument virtually useless for measuring low voltages in the presence of noise. The Series 2900 integrating DVM's are unique in this regard, since they have a bi-directional counter and therefore give the true integral (subtracting the negative area from the positive) and give the correct polarity sign. Furthermore, the Series 2900 Integrating DVM's do not accumulate one digit of zero crossing error each time the input crosses the zero axis.

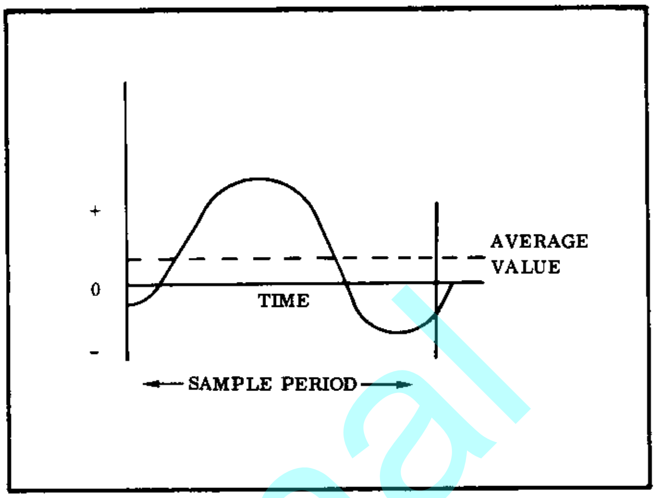


Figure 3-6. AC Noise Crossing the Zero Axis

CHAPTER IV

CALIBRATION

When a 2917A instrument is not providing readings within specifications, it is time for calibration, repair, or both. In the calibration information given in this section, it is assumed that the instrument is in good working order. The physical location of several adjustments is shown in Figure 4-1 and the location of all plug-in board assemblies is shown in Figure 4-2. Follow all steps in the sequence listed.

CALIBRATION EQUIPMENT NEEDED

1. EMF Standard, such as NLS Model 3006. This EMF Standard contains nine unsaturated cadmium standard cells connected in series, and provided with Superior Electric five-way binding posts which are connected to each series junction to make available the voltage from each cell. The available voltages range from approximately 1.019 to 9.172. The Model 3006 is supplied with two calibration tables which indicate voltage values carried to six decimal places and accurate to 0.01%. One table gives the open circuit EMF; the other table gives the output voltage values for a 10 megohm load. In addition, the tables give the cumulative voltage of the cells such as 1.01914, 2.03843, 3.05764, ... 9.17724. These cells have been calibrated at the NLS Standards Laboratory with an NBS certified primary reference.

2. Stable, but not necessarily precisely known DC sources of 0.08-0.1, 0.8-1, 8-10, 80-100, and 800-1000 volts. It is important that the top values for each voltage given not be exceeded; it is also necessary that a correct ratio, ±0.01%, exist among these voltages. These ratios can be readily obtained by the use of a ratio box such as the NLS Model 3020. This NLS ratio box provides rapid and convenient switching facilities for fast, accurate calibration of digital voltmeters.

3. A frequency counter which can count to 100 KC, accurate to ±1 part.

PROCEDURE

NOTE

Before calibrating the instrument, the frequency of the crystal oscillator should be checked and, if necessary, adjusted as follows:

Place board oscillator on an extension board and connect the counter input to P26-6. With a non-metallic screwdriver adjust the clock frequency to provide exactly 100, 000 CPS.

1. Allow the instrument to warm up for 30 minutes with the top and bottom covers in place.

2. Set the RANGE switch at 10V; set the SAMPLE PERIOD at 1 SEC; set the MODE switch at RUN; set the DISPLAY full clockwise (do not engage the spring-return START position).

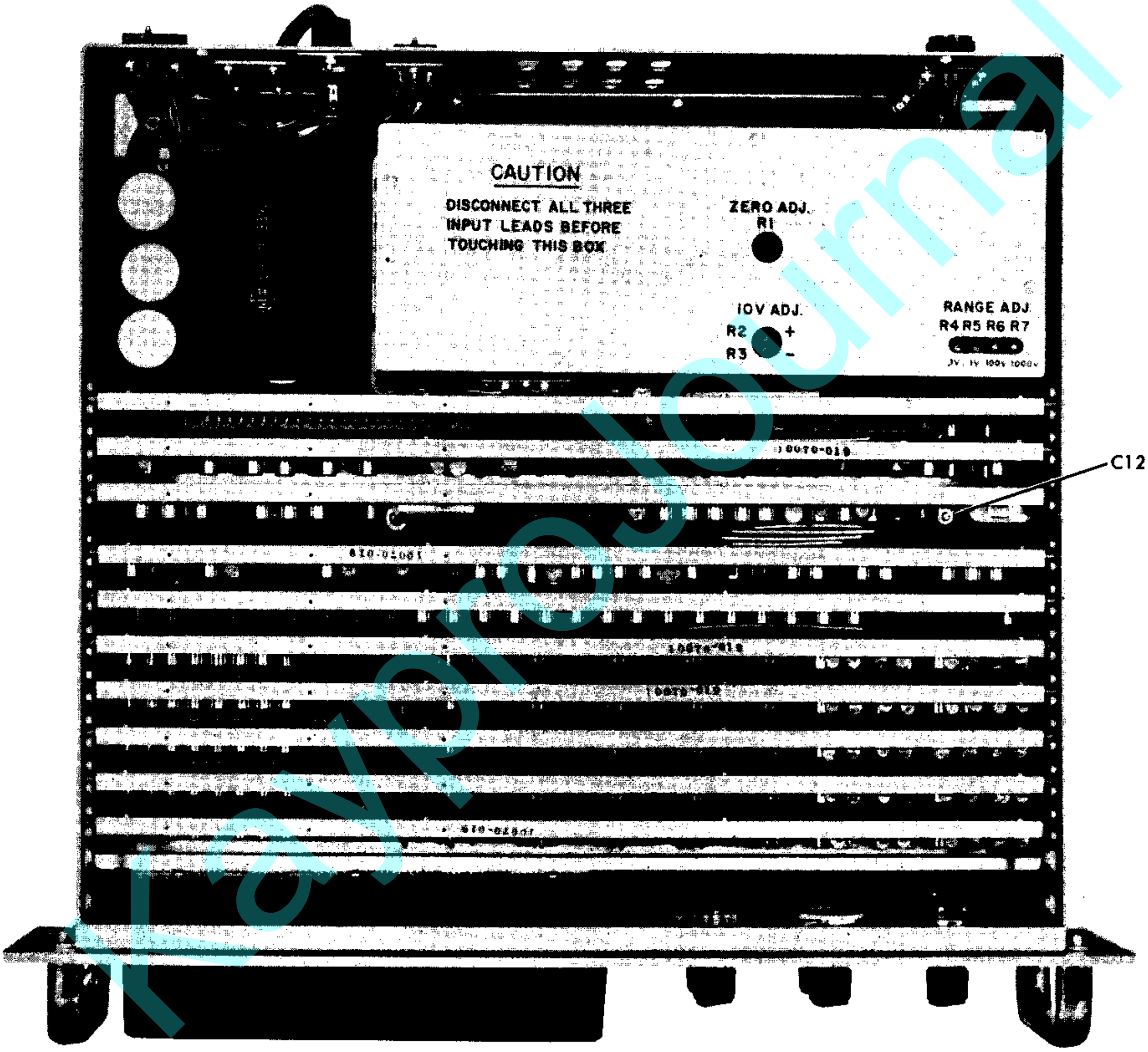


Figure 4-1. Digital Voltmeter Adjustment Points

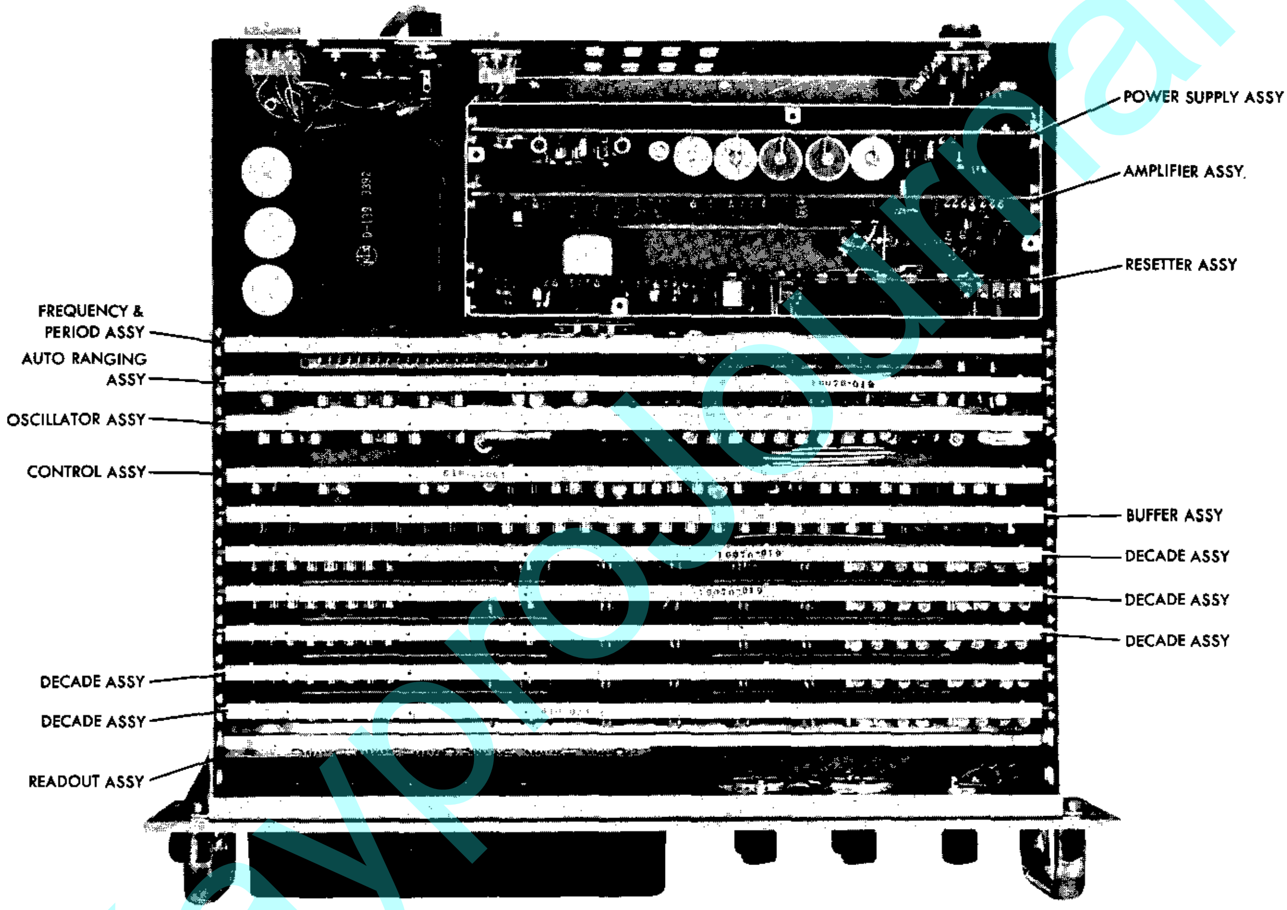


Figure 4-2. Location of Plug-in Board Assemblies

3. Connect the input cable to the instrument and short the three input leads together. Be certain that the leads are not placed near a hot soldering iron or other heat source.

4. Remove the top cover and adjust R-1 until the readout displays all zeroes.

5. Connect the input cable leads to the standard cell bank. The red (signal high) lead is connected to the positive end of the standard cell bank; the black and blue leads are connected to the negative end of the standard cell bank. If electrical noise in the environment keeps the readout display from stabilizing, it will be necessary to connect the standard cell cabinet to the negative polarity along with the blue and black leads.

6. The readout should display the numerical value given for the standard cell bank; if it does not, adjust R-2 for agreement.

7. Reverse the polarity of the leads to the standard cell bank, taking care to avoid placing even a momentary short upon the cells. The read lead connects to negative, black and blue to positive. If necessary (as in Step 5), connect the standard cell case to one leg of the voltage source, but this time to the positive connection.

8. The readout should display the same numerical value obtained in Step 6. If the display is inaccurate, adjust R-3. This step completes the adjustment of the basic range of the instrument. Remove the standare cell bank.

9. Connect the input cable leads to the stable source of 10 (8-10V) volts through the ratio box. Record the reading. Since the instrument has already been calibrated in this range, the reading noted here is the true voltage of the stable source.

10. Using the ratio box, switch the instrument RANGE switch to provide 1 (0.8-1V) volt reading. Ignoring the decimal point, adjust R-5 so that the instrument provides the reading already recorded in Step 9.

11. Follow the procedure in Step 10, but apply 0.1 volt and set the instrument RANGE switch to 0.1V. Adjust R-4.

WARNING

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

12. Follow the procedure given in Step 10, but set the RANGE switch to 100V and apply 100 volts. Adjust R-5.

13. Follow the procedure given in Step 10, but set the RANGE switch to 1000V and apply 100 volts. Adjust R-7. This step completes the normal calibration procedure of the instrument. However, if there is a consistent and uniform error occurring in all ranges, it will be necessary to check the frequency adjustment as given in the Note preceding Step 1.

CHAPTER V

MAINTENANCE

If a 2917A Digital Voltmeter is not working properly, or if it cannot be calibrated according to instructions, service will be required.

EXTENSION BOARDS

During maintenance procedures, two 22-pin extension boards will be required to raise each plug-in module (only one board is required for the resetter, amplifier and power supply boards) so that pin contacts on the bottom of the circuit board become accessible for the measurement of voltages and the observation of wave forms. These boards, NLS part number 1009-22, may be ordered from any NLS Representative or from the NLS Main Office in Del Mar, California.

Before seeking out specific defective components, it is best to establish that the several power supplies are working. Specifically, voltage checks should be made at the voltage output points of the power supplies as indicated on the schematic drawings. A simple 20, 000 ohm-per-volt d'Arsonval type meter may be used for these measurements. The voltage measurements should indicate correct values ±15% when read on a voltmeter with a rated accuracy of ±3%. The outputs of the regulated power supplies cannot be accurately read by this method, but in practice the accuracy of their outputs need not be known; if a regulated power supply fails, it is most likely that the voltage error will be gross (or there will be no output at all) and therefore detectable with simple measuring instruments.

If a measured voltage appears to be at an improper value, the associated power supply components should be checked; if none of these are found to be defective, it will be necessary to proceed along the defective power path, checking wiring, connectors, printed circuitry, and finally components on the boards. An obvious way to make a speedy check is to replace suspected defective boards with known good ones. Since the decade boards are all interchangeable, a malfunction affecting one decade of the readout can be made to affect other decades. For this reason, it is suggested that a trial and error approach be used and the decade boards be interchanged. If the malfunction then manifests itself in a previously unaffected decade, the defective board can be readily isolated. From this point on, a test of components will locate the precise area of failure.

It is suggested that the individual schematics be studied so as to better know what outputs may be expected at each function.

Tables 5-1 and 5-2 list specific types of malfunction. Note that any of dozens of components could fail and yet the symptom would be the same for all, there is no one component which can readily be singled out as a consistent offender. For this reason, the most useful approach to troubleshooting is to provide a list of possible types of failure and identify the plug-in board or circuit area most likely to contain the defective component.

In troubleshooting the instrument, the first step is to find out whether the trouble is in the converter unit or in the counter unit. Once this is known, each unit can be independently repaired.

TABLE 5-1. COUNTER TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
A. In RUN position, meter scans but gives all zero readings with inputs connected to source	No Converter output	A-1. Connect positive voltage input of meter. A-2. Measure output pulses of photo cell at J26-10 with a 1:10 probe. Pulse height should be 50 MV, 5 μSEC wide, minimum at 100 KC. A-3. If pulses are present with prescribed magnitude, converter is working properly. Otherwise, see troubleshooting chart for converter.
	Counter faulty	A-4. If step 3 shows converter is giving the required pulse, proceed to check pulse at P26-8. Pulse should be about 10 volts. If true, proceed to step 5. Otherwise, look for defective parts in the pulse amplifier circuit. A-5. Check for pulses at P24-5. Pulse should be steady, 5 μSEC, 10 volts with no misfirings. If good, proceed to check pulses at P26-20. Good pulses at this point show decade counter board is faulty. Proceed to step B3. Otherwise, look for defective parts in between.

TABLE 5-1. COUNTER TROUBLESHOOTING (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
B. Meter gives erroneous reading	Converter gives false output	B-1. Check the output of converter as in A-1, A-2, and A-3. If good, proceed to B-2.
	Decade boards faulty	B-2. Check pulses at P24-5. Pulse should be 5 μSEC 10 volts. If good, trouble is in decade boards. Proceed to B-3. Otherwise, look for defective parts in gated one-shot. B-3. Change the decade counter boards one by one until trouble is located.
C. Meter does not scan in RUN mode; readout on all the time; input has no effect on readings	Counter faulty	C-1. Replace control board (P23-P24).
D. Readout does not illuminate	Open fuse	D-1. Replace fuse.
E. One or two decades do not illuminate	Burnt out readout lamps	E-1. Interchange the decade board (P11-P12) in which the unlighted lamp is located. If the same lamp still does not light, it is open. Otherwise, proceed to E-2.
	Decade board (readout buffer) faulty	E-2. Replace decade board in question. Trouble is likely to be a defective buffer.
F. Two decimal points light at once	Counter faulty	F-1. Check the buffer section of buffer board (P21-P22).

TABLE 5-1. COUNTER TROUBLESHOOTING (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
G. Meter does not range in one or two ranges	Range neon bulb faulty	G-1. Rotate the RANGE control to see if the correct ranging neon bulb illuminates at each range setting. If the appropriate range light fails to illuminate, it is defective or the associated drive circuit is malfunctioning.
	Range relays faulty or photo-conductive cell faulty	G-2. Use a jumper to short out the photo-conductive cell associated with the malfunctioning range. If jumpering will cause the range to operate, the cell is defective. If the jumper has no effect, the range relay should be suspected of malfunction.

Cover the photo-conductive cells in the attenuator with a strip of black tape. This will prevent external light source from actuating the range. Force the attenuator into the 10-volt range by shorting out the photo-conductive cell for the 10-volt range. Put the particular board to be checked on an extension board.

TABLE 5-2. CONVERTER TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
H. Output of amplifier stays at one voltage level; no reset pulses from resetter board	Resetter board faulty	H-1. Replace resetter board. Check for burned transistor or opened capacitor for the channel concerned
J. Resetter board putting out about 120 KC pulses but amplifier output (P28-18) sits on one voltage level	Amplifier board faulty	J-1. Replace amplifier board

TABLE 5-2. CONVERTER TROUBLESHOOTING (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
K. Amplifier output (P28-18) produces positive and negative pulses at the same time	Amplifier board faulty	K-1. Remove the resetter board (P28). Apply positive voltage to the meter. Amplifier output P28-18 should swing to approximate negative, and swing to about 2 volts when input is negative. If above conditions are true, proceed to K-2. Otherwise, amplifier board is faulty.
	Resetter board faulty	K-2. Replace the resetter board.
L. Amplifier produces only one kind of pulse, either positive or negative on P28-18	Resetter board faulty	L-1. Replace the resetter board. Check the NEGATIVE channel if positive pulses are produced. Check the POSITIVE channel if negative pulses are produced.

CHAPTER VI

RECOMMENDED SPARE PARTS LIST

This chapter lists the spare parts level which is recommended to be stocked for the maintenance of five Model 2917A or 2917S Digital Voltmeters. For up to date price information, check with your NLS Representative or contact the NLS home office.

PART NO.	DESCRIPTION	RECOMMENDED SPARES
29-259	Amplifier Assembly	1
29-139	Auto Range Assembly*	1
29-240	Buffer Assembly	1
29-253	Control Assembly	1
29-245	Decade Assembly	1
29-256	Frequency & Period Measurement Assy*	1
29-329	Oscillator Assembly	1
3426	Power Supply Assembly	1
29-152	Resetter Assembly	1
29-306	Storage Assembly**	1
DD250	Capacitor, 25 PF*	1
SCM476HP035D2	Capacitor, 47 μF, 35V	1
PP22B100C1	Capacitor, 22 μF, 100V	1
1B1582	Capacitor, 150 μF, 50V	5
10B1048	Capacitor, 20 μF, 150V	1
1B1464	Capacitor, 500 μF, 15V	1
10B1065	Capacitor, 10 μF, 100V	1
SCM105FP035C2	Capacitor, 1 μF, 35V	1
PD1A102K	Capacitor, 0.001 μF, 100V	1
VX1X254K	Capacitor, 0.25 μF, 50V	1
TGS20	Capacitor, 0.02 μF, 50V	1
B220	Capacitor, 0.002 μF, 1000V	1
JL470	Capacitor, 470 PF	1
JL330	Capacitor, 330 PF, 100V	5
DD500	Capacitor, 50 PF, 100V	2
BT01	Capacitor, 0.01 μF, 100V	1
MINC68J	Capacitor, 68 PF	1
SCM565BP101D2	Capacitor, 5.6 μF, 35V	1
CM15E201F	Capacitor, 200 PF	1
CM15E680F	Capacitor, 68 PF	1
MINC39J	Capacitor, 39 PF, 75V	1

*DVM P/N 29-250 Only

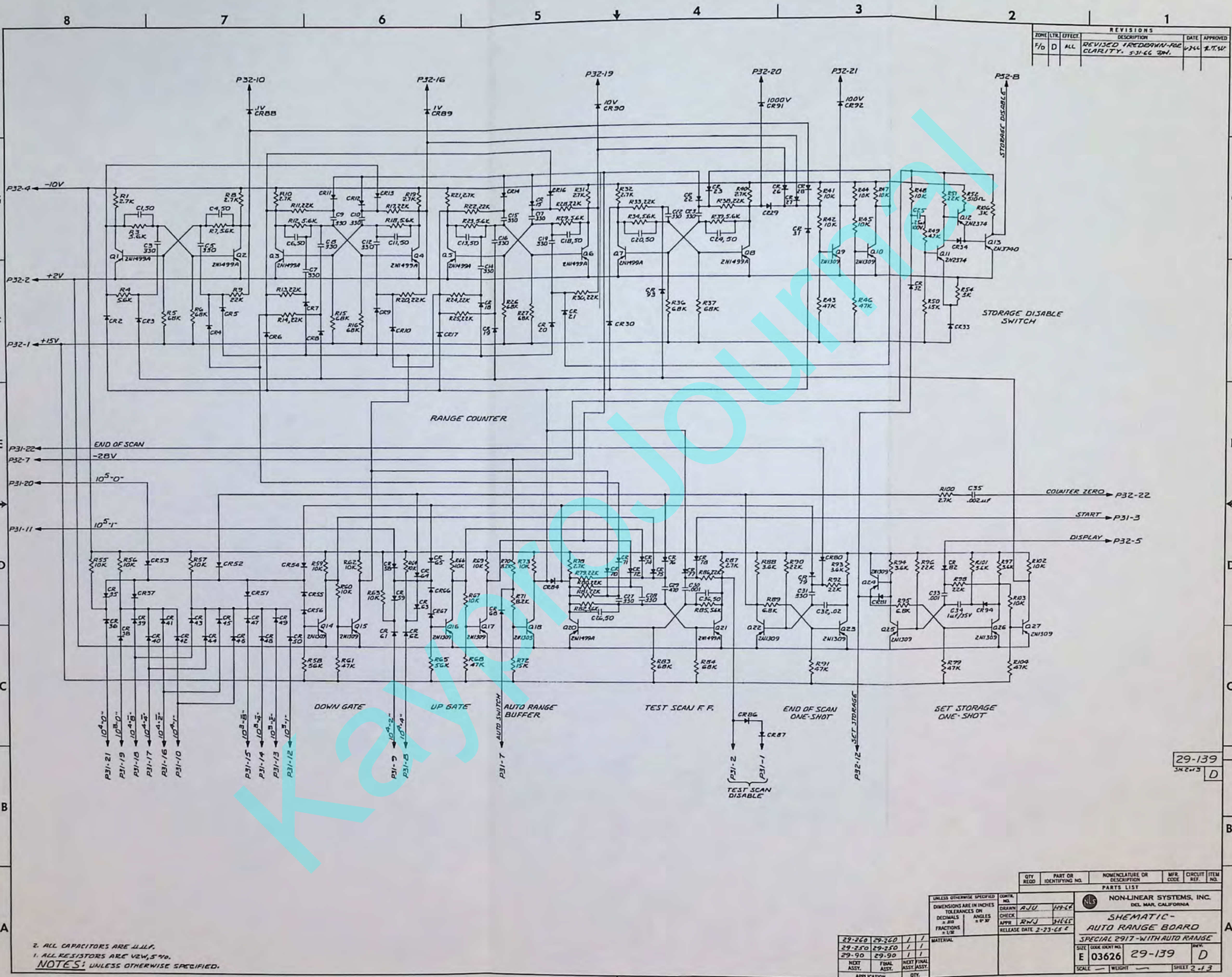
**DVM P/N 29-292 Only

PART NO.	DESCRIPTION	RECOMMENDED SPARES
336-1B1552	Capacitor, 2000 μF, 15V	1
334-1B1553	Capacitor, 1000 μF, 50V	1
VX1J104	Capacitor, 0.1 μF, 100V	1
Z1X224	Capacitor, 0.22 μF, 100V	1
CS13AF270K	Capacitor, 27 μF, 35V	1
SCM185FP010D2	Capacitor, 1.8 μF, 10V	1
SCM33BP010D2	Capacitor, 33 μF, 10V	1
SCM565BP010D2	Capacitor, 5.6 μF, 10V	1
PTT-46E	Capacitor, 100 μF, 10V	1
VX1J332	Capacitor, 0.0033 μF, 100V	1
VC806GWA	Capacitor, 1-18 PF	1
CM20B-501K	Capacitor, 500 PF, 500V	1
CH1417-24	Chopper	1
42975	Contact, Socket	5
3288-100KC	Crystal - X1	1
HR4.4	Diode, Zener	1
29-22	Diode, Zener	1
2-6	Diode	2
SC-4	Diode	2
5003-002	Diode	20
1N4003	Diode	2
1N458	Diode	1
1N774A	Diode	1
31300.6	Fuse, 3AG.6, Slo-Blo	5
4-19-2	Lamp Bulb	(Each Instrument) 20
A083	Lamp, Neon	2
CL703CL	Photo Cell	2
3250L-1-203	Potentiometer, 20K	1
275P-1-102	Potentiometer, 1K	1
275P-1-101	Potentiometer, 100 Ohms	1
4-10-4	Readout Module (0-9 with Decimal)	1
4-10-36	Readout Module (Symbols)	1
6-A1	Relay	2
PW1719	Resistor, 10.05K, 0.02%*	1
PW1719	Resistor, 112.25K, 0.02%*	1
PW1719	Resistor, 55.53K, 0.02%*	1
PW1719	Resistor, 999.5K, 0.02%*	1
PW1719	Resistor, 1 MEGOHM, 0.05%*	1
PW1719	Resistor, 1.5 MEGOHM, 0.05%*	1
PW1719	Resistor, 2.5 MEGOHM, 0.05%*	1
PW1220	Resistor, 500K, 1%*	1

*DVM P/N 29-250 Only

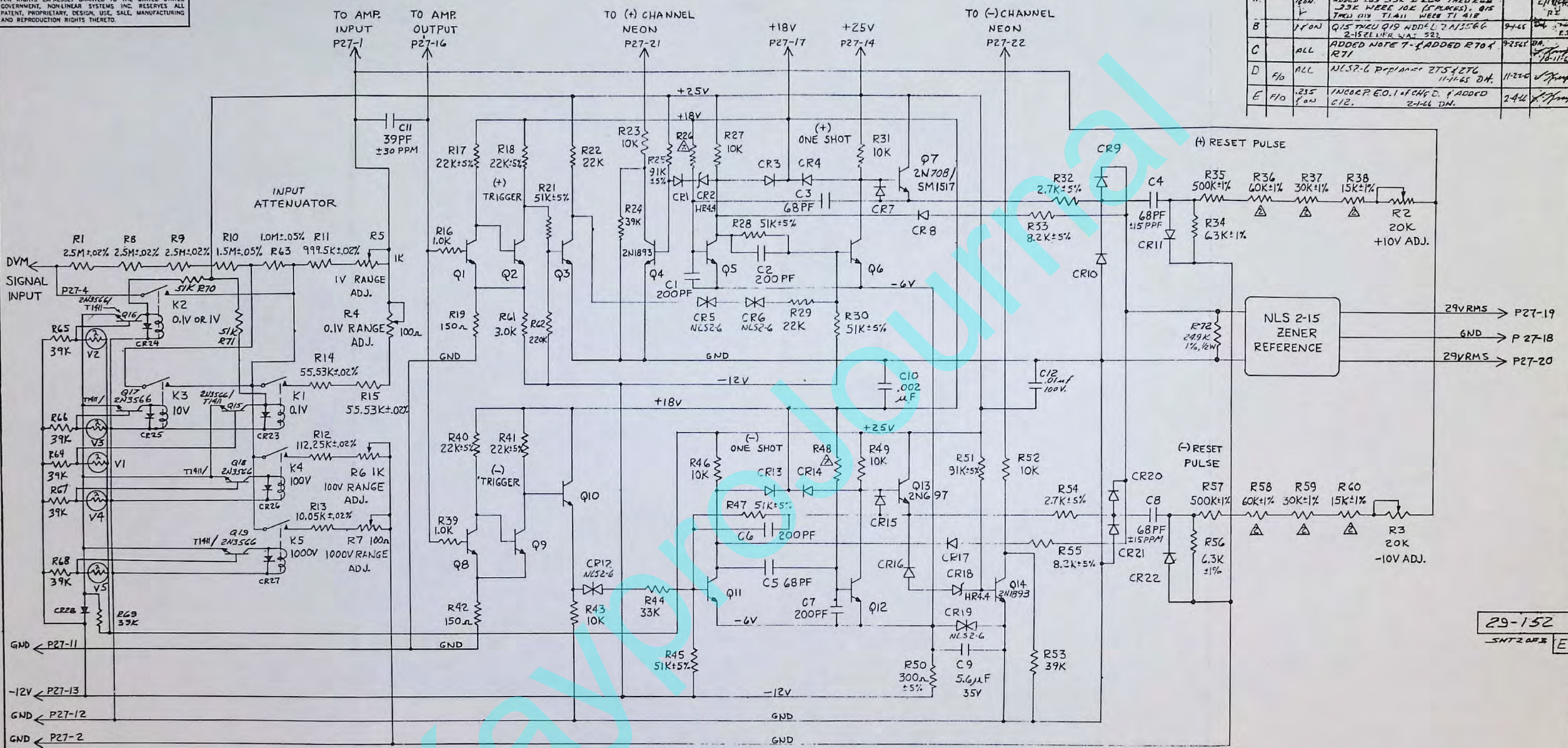
PART NO.	DESCRIPTION	RECOMMENDED SPARES
PW1220	Resistor, 60K, 1%*	1
PW1220	Resistor, 30K, 1%*	1
PW1220	Resistor, 15K, 1%*	1
PW1220	Resistor, 6.3K, 1%*	1
3392	Transformer	1
2N1302	Transistor	1
2N1305	Transistor	1
2N651	Transistor	1
2N697	Transistor	1
2N553	Transistor	1
2N3740	Transistor	1
2N2374	Transistor	5
2N1309	Transistor	8
2N1499	Transistor	5
2N706A	Transistor	2
2N3566	Transistor	1
2N1893	Transistor	1
2N708	Transistor	1
2N274	Transistor	1
3N58	Transistor	5
2N3640	Transistor	1
2N3638A	Transistor*	1
2N3536	Transistor	1
2N2386	Transistor	1
2N2716	Transistor	1
2-15	Zener Reference	1

*DVM P/N 29-250 Only


REVISIONS
ZONE LTR. EFFECT. DESCRIPTION DATE APPROVED
F/0 D ALL REVISED & REDRAWN FOR CLARITY. 5-31-66 RW.
P32-10
P32-16
P32-19
P32-20
P32-21
P52-8
STORAGE DISABLE
P32-4 -10V
P32-2 +2V
P32-1 +15V
RANGE COUNTER
STORAGE DISABLE SWITCH
P31-22 END OF SCAN
P32-7 -28V
P31-20 10^5-0-
P31-11 10^5-1-
COUNTER ZERO P32-22
START P31-3
DISPLAY P32-5
DOWN GATE
UP GATE
AUTO SWITCH
AUTO RANGE BUFFER
TEST SCAN F.F.
END OF SCAN ONE-SHOT
SET STORAGE
SET STORAGE ONE-SHOT
P31-21
P31-19
P31-18
P31-17
P31-16
P31-10
P31-15
P31-14
P31-13
P31-12
P31-9
P31-8
P31-7
P31-2
P31-1
TEST SCAN DISABLE
P32-12
29-139
SH 2 of 3 D
2. ALL CAPACITORS ARE µµF.
1. ALL RESISTORS ARE 1/2W, 5%.
NOTES: UNLESS OTHERWISE SPECIFIED.
PARTS LIST
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA
SHEMATIC-
AUTO RANGE BOARD
SPECIAL 2917-WITH AUTO RANGE
E 03626 29-139 D
SHEET 2 of 3

REVISIONS

SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED
A.		1 & ON	ADDED R69 39K & R64 THRU R68 39K WERE 10K (5 PLACES). Q15 THRU Q19 TI.411 WERE TI 418		6/11/65 R.J.
B		1 & ON	Q15 THRU Q19 ADDED 2N3566 2-15 ZENER WAS 522	9-1-65	E.S.
C		ALL	ADDED NOTE 7-& ADDED R70 & R71	9-25-65	10-11-65
D	F/O	ALL	NLS2-6 Replaces ZT5 & ZT6 11-11-65 DH.	11-22-65	
E	F/O	.235 & ON	INCORP. E.O. 1 of CHG D. & ADDED C12. 2-1-66 DN.	2-4-66	



△ SELECT VALUE FOR MAX FREQ OF 120 Kc TO 135 Kc FOR R26 & R48.
6. ALL DIODES ARE 5003-002
5. CR9,10,11,20,21,22 SELECTED DURING CALIBRATION FOR T.C. CANCELLATION
4. ALL CAPACITORS ARE 100V ±5%.
3. ALL RESISTORS ARE ½W ±10%.
△ RESISTOR MAY BE JUMPERED FOR CALIBRATION.
1. ALL TRANSISTORS 2N706A.
NOTES: UNLESS OTHERWISE SPECIFIED.

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.

PARTS LIST — APPLICATION — QTY.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ± .010, ANGLES ± 0° 30', FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 2-25-65

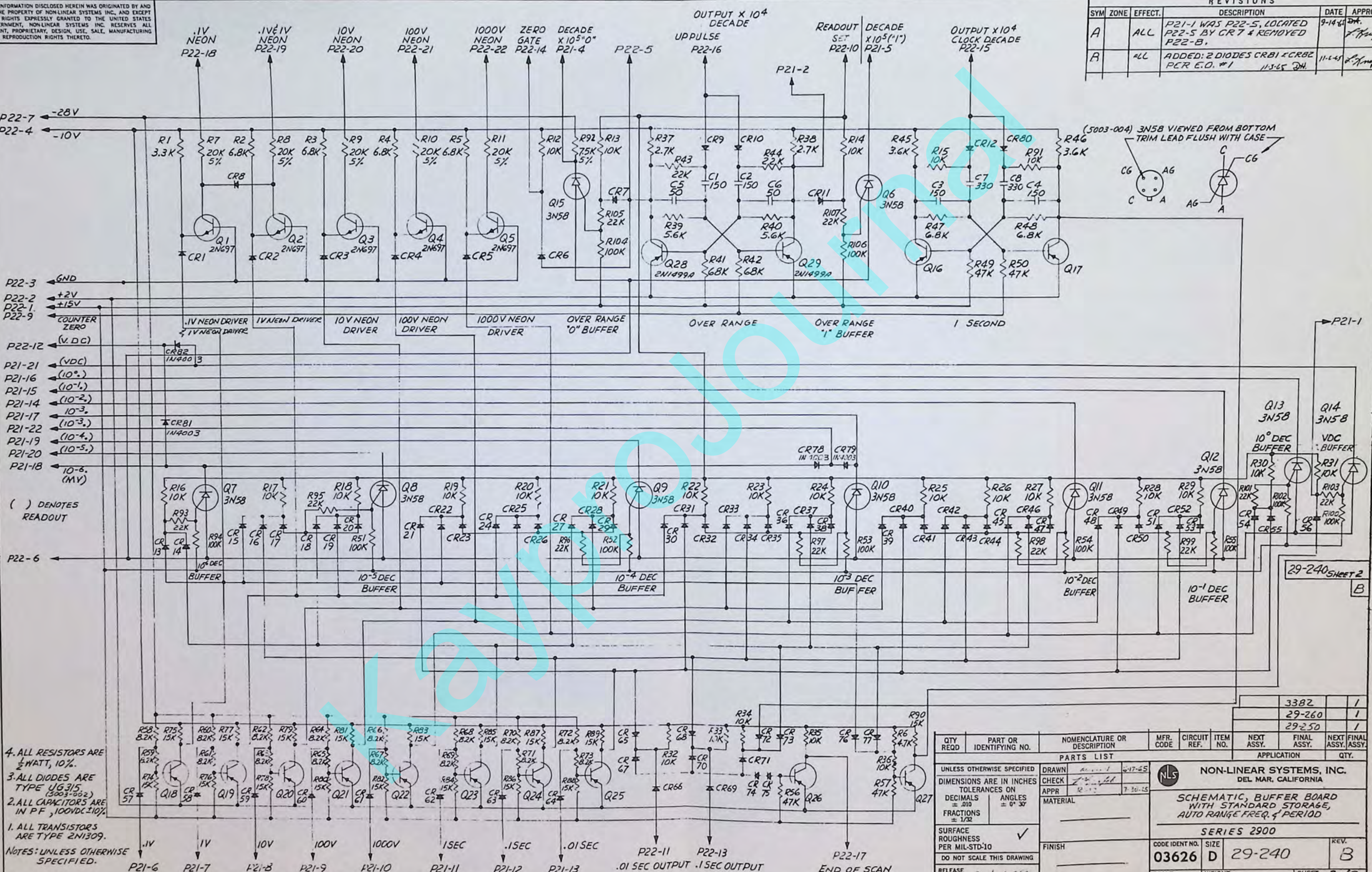
DRAWN R.J.
CHECK
APPR
MATERIAL
FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, RESETTER BOARD
2900

CODE IDENT NO. 03626 | SIZE D | 29-152 | REV E
SCALE | WEIGHT | SHEET 2 of 3

REVISIONS					
SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED
A		ALL	P21-1 WAS P22-5. LOCATED P22-5 BY CR7 & REMOVED P22-8.	9-14-65	
B		ALL	ADDED: 2 DIODES CR81 & CR82 PER E.O. #1 11-3-65	11-6-65	



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL TRANSISTORS ARE TYPE 2N1309.
2. ALL CAPACITORS ARE IN PF, 100VDC ±10%.
3. ALL DIODES ARE TYPE UG315 (5003-002)
4. ALL RESISTORS ARE ½ WATT, 10%.

			3382		1
			29-260		1
			29-250		1
QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.
PARTS LIST					

NEXT ASSY. | FINAL ASSY. | NEXT ASSY. | FINAL ASSY. — APPLICATION — QTY.

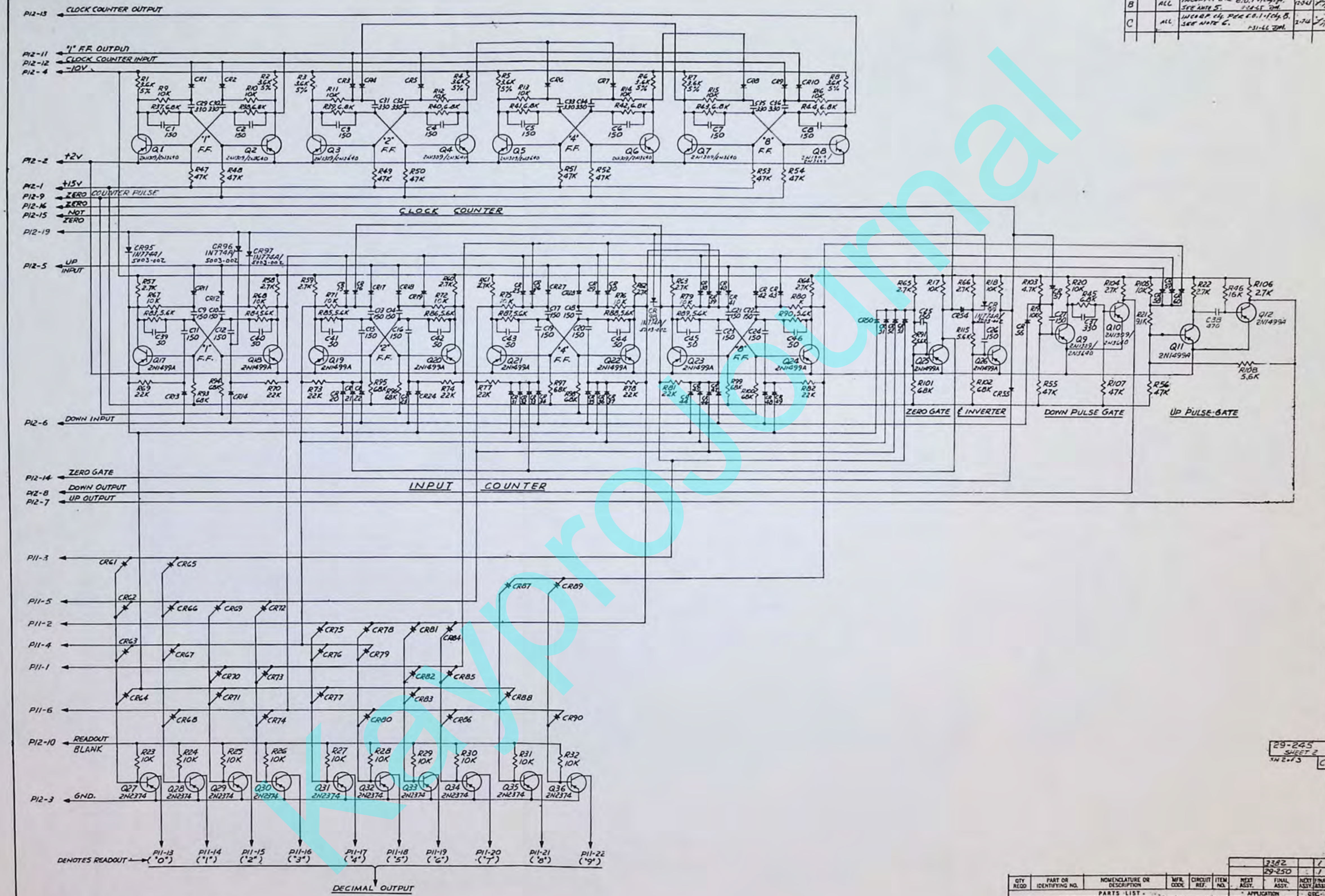
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 — ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 8-4-65

DRAWN 6-17-65
CHECK
APPR 7-30-65
MATERIAL
FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, BUFFER BOARD WITH STANDARD STORAGE, AUTO RANGE FREQ. & PERIOD
SERIES 2900

CODE IDENT NO. 03626 — SIZE D — 29-240 — REV. B
SCALE — WEIGHT — SHEET 2 of 3



6. DIODE 5003-002 MAYBE SUBSTITUTED FOR IN774A (CR95 thru CR99).
5. TRANSISTOR 2N3640 MAY BE USED AS AN ALTERNATE FOR 2N1309 (Q1 thru Q10).
4. ALL CAPACITORS ARE IN PICO FARADS.
3. ALL RESISTORS ARE 1/2 WATT, 10%.
2. ALL DIODES ARE 5003-002 (UG315).
1. ALL TRANSISTORS ARE 2N1309.
NOTES: UNLESS OTHERWISE SPECIFIED

SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED
A		ALL	R67,68,71,72,75,76,79,80 WERE 22K. C38 WAS 150 PF. REMOVED C28.		
B		ALL	INCORP PER E.O. 1-1-6. SEE NOTE 5.		
C		ALL	INCORP PER E.O. 1-1-6. SEE NOTE 6.		

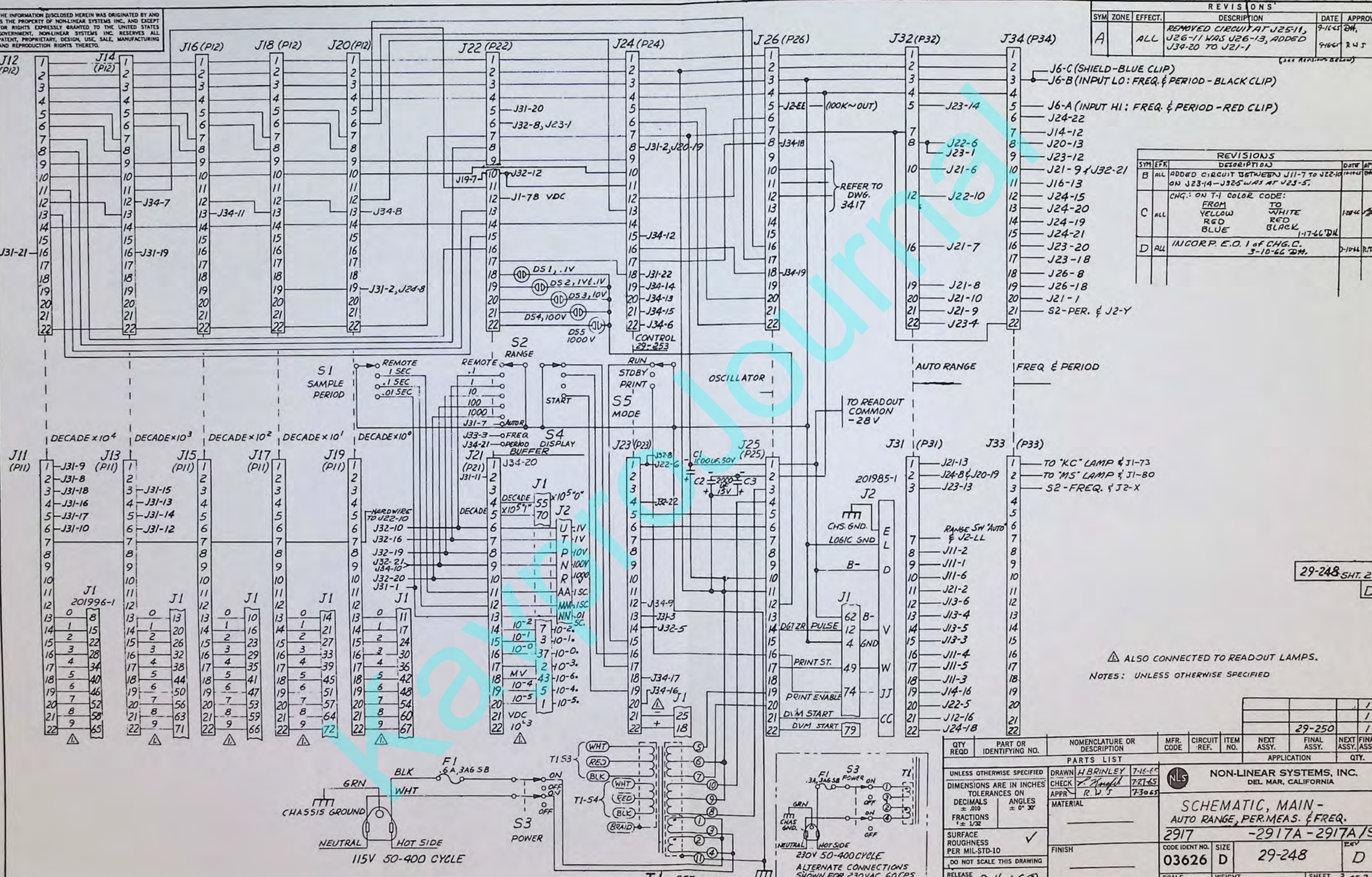
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC — DECADE BOARD, STANDARD
SERIES 2900 MODEL 29174

03626 E 29-245 C

REVISIONS					
SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED
A		ALL	REMOVED CIRCUIT AT J25-11, J26-11 WAS J26-13, ADDED J34-20 TO J21-1	9-16-65 / 9-16-65	D.H. / R.W.S.

REVISIONS				
SYM	EFF.	DESCRIPTION	DATE	APPR.
B	ALL	ADDED CIRCUIT BETWEEN J11-7 TO J22-10 ON J23-14 - J32-5 WAS AT J23-5.		D.H.
C	ALL	CHG.: ON T-1 COLOR CODE: FROM YELLOW, RED, BLUE TO WHITE, RED, BLACK	1-17-66 D.H.	
D	ALL	INCORP. E.O. 1 of CHG. C. 3-10-66 D.H.		



⚠ ALSO CONNECTED TO READOUT LAMPS.

NOTES: UNLESS OTHERWISE SPECIFIED

29-248 SHT. 2 D

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
		PARTS LIST					29-250		1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± .010 ANGLES ± 0° 30' FRACTIONS ± 1/32

SURFACE ROUGHNESS PER MIL-STD-10 ✓

DO NOT SCALE THIS DRAWING

RELEASE DATE 8-4-65

DRAWN H BRINLEY 7-16-65
CHECK 7-27-65
APPR R. W. S. 7-30-65

MATERIAL

FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, MAIN - AUTO RANGE, PER. MEAS. & FREQ.
2917 -2917A - 2917A/S

CODE IDENT NO. 03626 | SIZE D | 29-248 | REV D

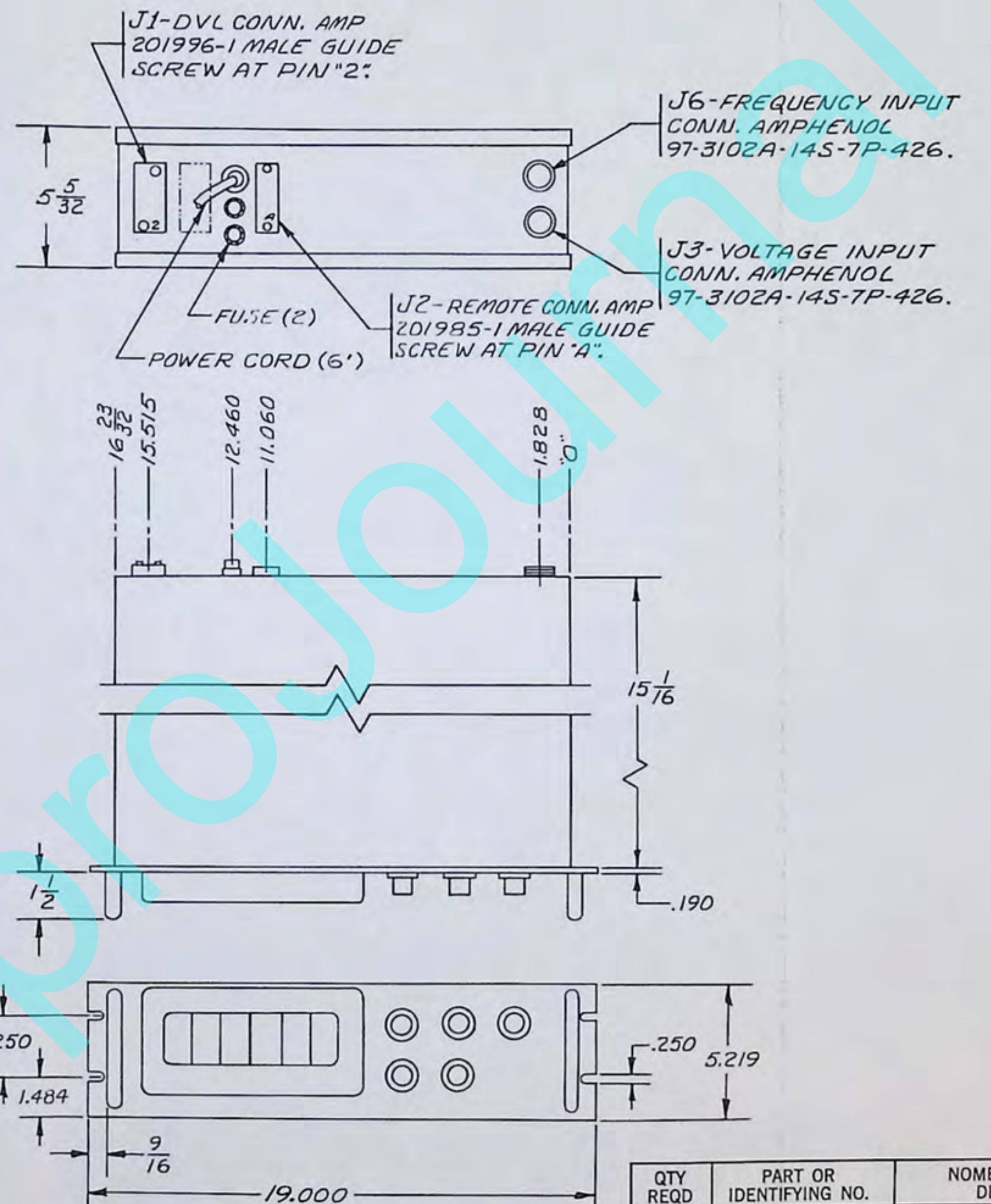
SCALE — WEIGHT — SHEET 2 OF 2

J1 PIN NO.	OUTPUT FUNCTION	
8	0	10^4 DECADE
15	1	
22	2	
28	3	
34	4	
40	5	
46	6	
52	7	
58	8	
65	9	
13	0	10^3 DECADE
20	1	
26	2	
32	3	
38	4	
44	5	
50	6	
56	.7	
63	8	
71	9	
10	0	10^2 DECADE
16	1	
23	2	
29	3	
35	4	
41	5	
47	6	
53	7	
59	8	
66	9	
14	0	10^1 DECADE
21	1	
27	2	
33	3	
39	4	
45	5	
51	6	
57	7	
64	8	
72	9	
11	0	10^0 DECADE
17	1	
24	2	
30	3	
36	4	
42	5	
48	6	
54	7	
60	8	
67	9	
55	0	10^5 DECADE
70	1	10^5 DECADE
7	DECIMAL	10^{-2}
2	↕	10^{-3}
5	↕	10^{-4}
1	↕	10^{-5}
43	DECIMAL	10^{-6}
4	GND	
62	−28V	
49	PRINT START	
12	DGTZR. PULSE	
79	DVM START	
25	−POL	
18	+POL	
78	VDC	
74	PRT. ENABLE	
73	KC	
80	MS	

J2 PIN DESIG.	REMOTE FUNCTION
U	.1V
T	1V
P	10V
N	100V
R	1000V
AA	1 SEC.
MM	.1 SEC.
NN	.01 SEC.
E	CHASSIS GND.
L	LOGIC GND.
D	−28V
V	DGTZR.PULSE
W	PRINT START
JJ	PRT. ENABLE
CC	DVM START
EE	100K~ OUT
LL	AUTO RANGE
X	FREQ.
Y	PERIOD

J3 PIN NO.	DESIGNATION
A	DC IN (HI.)
B	DC IN (LO.)
C	GRD. SHIELD

J6 PIN NO.	DESIGNATION
A	FREQ. IN (HI.)
B	FREQ. IN (LO.)
C	SHIELD



REVISIONS

ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED

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

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32

CONTR. NO.
DRAWN Hanrahan 7-30-65
CHECK [illegible] 8-3-65
APPR [illegible]
RELEASE DATE 8-4-65

MATERIAL

FINISH

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
	29-260		1
	29-250		1
APPLICATION		QTY.	

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

DIGITAL VOLTMETER - OUTLINE DRAWING
2917A 2917A/S

SIZE C CODE IDENT NO. 03626 29-250 REV.

SCALE — WEIGHT — SHEET 3 of 3

29-250 SH 3

NOTES: UNLESS OTHERWISE SPECIFIED.

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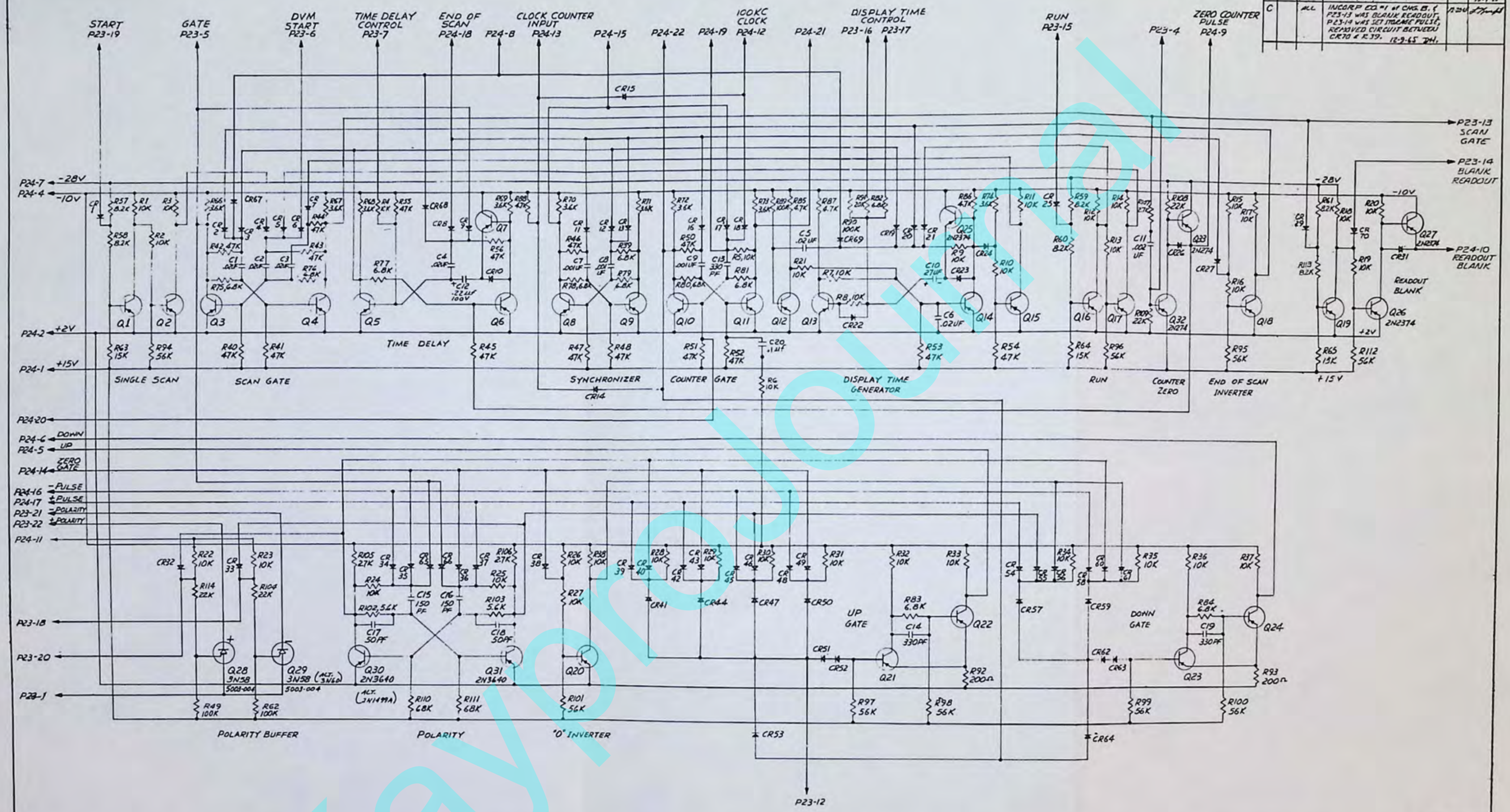
SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPR.
A		ALL	P23-4 WAS P23-1 & P23-1 WAS P23-4.	9-17-65	
B		ALL	ADDED CR70 & CIRCUIT BETWEEN CR70 & R39 - RELOCATED P24-10, P23-13 & P23-14.		10-9-65
C		ALL	INCORP CO. #1 of CHG. B. & P23-13 WAS BLANK READOUT, P23-14 WAS SET STORAGE PULSE, REMOVED CIRCUIT BETWEEN CR70 & R39. 12-9-65 DH.		



5. R16 REF DESIGNATION NOT USED
4. ALL CAPACITORS ARE 100V, 20%.
3. ALL RESISTORS ARE ½W, 10%.
2. ALL DIODES ARE TYPE U6315(5003-002).
1. ALL TRANSISTORS ARE TYPE 2N1309.

NOTES: UNLESS OTHERWISE SPECIFIED

							3382		7
							29-260		1
							29-250		1
QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY	FINAL ASSY
PARTS LIST						APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 8-3-65

DRAWN
CHECK
APPR
MATERIAL
FINISH

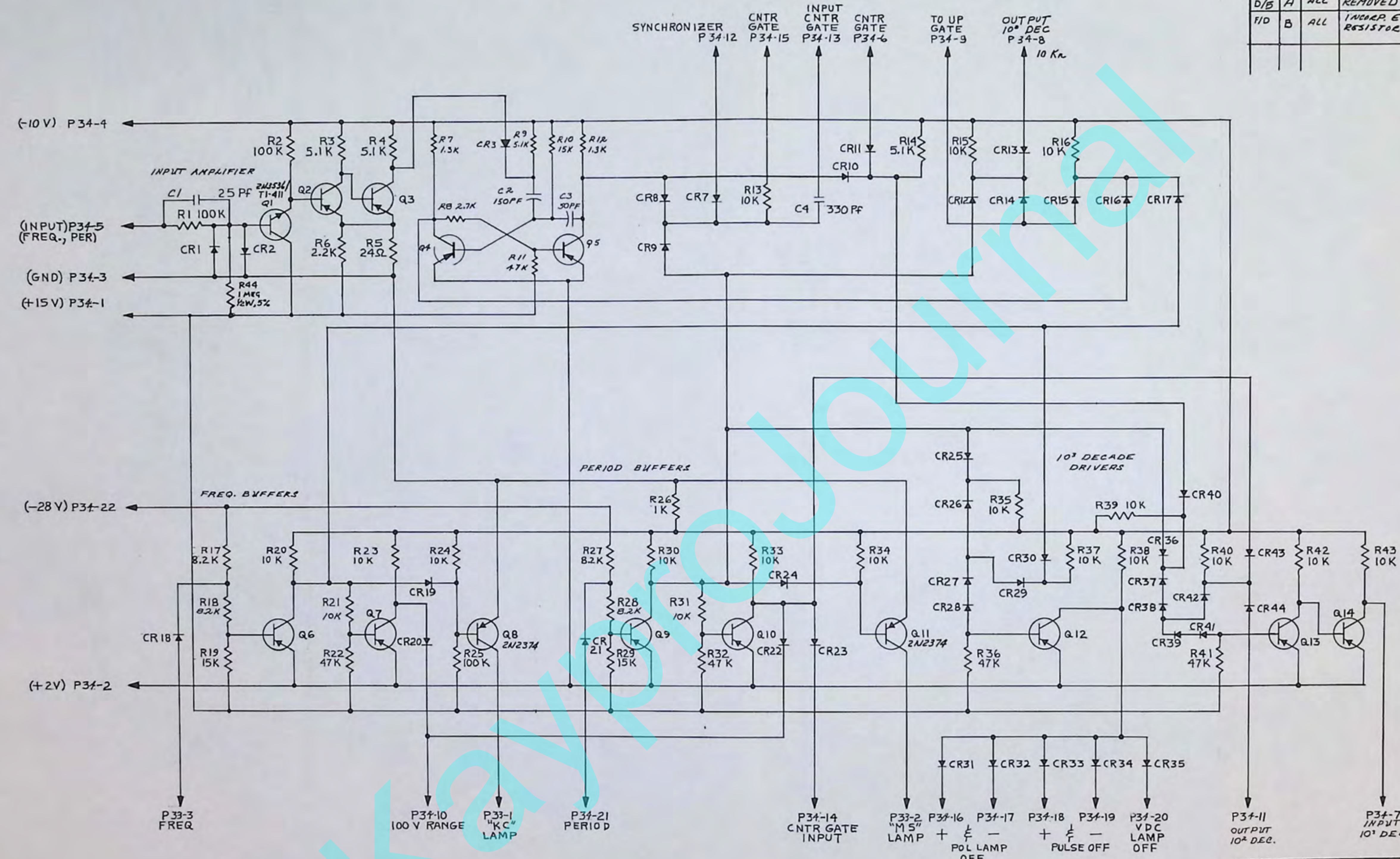
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC-CONTROL BOARD WITH STORAGE, AUTO RANGE FREQ. & PERIOD.

SERIES 2900

CODE IDENT NO. 03626 SIZE E 29-253 C

ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
D/5	A	ALL	REMOVED CR4, CR5 & CR6	9-17-65	DM. / RWJ
F/D	B	ALL	INCORP. E.O.1 of CHG A (ADDED RESISTOR (R44)). 1-31-66 DH.	2-7-66	[illegible]



4. ACCURACY: ± .01% OF READINGS ± 2 DIGITS
3. THE FREQ & PER. INPUT SENS. IS APPROX. .3 VRMS.
NOTE THE AMP. IS DIRECT COUPLED. INSERT 1μf CAP. FOR DC OFFSET SIGNALS
2. ALL TRANSISTORS 2N3638A
1. ALL DIODES 5003-002
NOTES: UNLESS OTHERWISE SPECIFIED

5. RANGE: DC TO 10KC – 1 PERIOD
DC TO 100KC – 10 PERIODS
DC TO 100KC – 100 PERIODS

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
	29-260		1
	29-250		1

APPLICATION | QTY.

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

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ±.010 ANGLES ±0°30'
FRACTIONS ±1/32
MATERIAL

CONTR. NO.
DRAWN Hillard 6-30-65
CHECK L. Knight
APPR RWT 7-30-65
RELEASE DATE 8-4-65

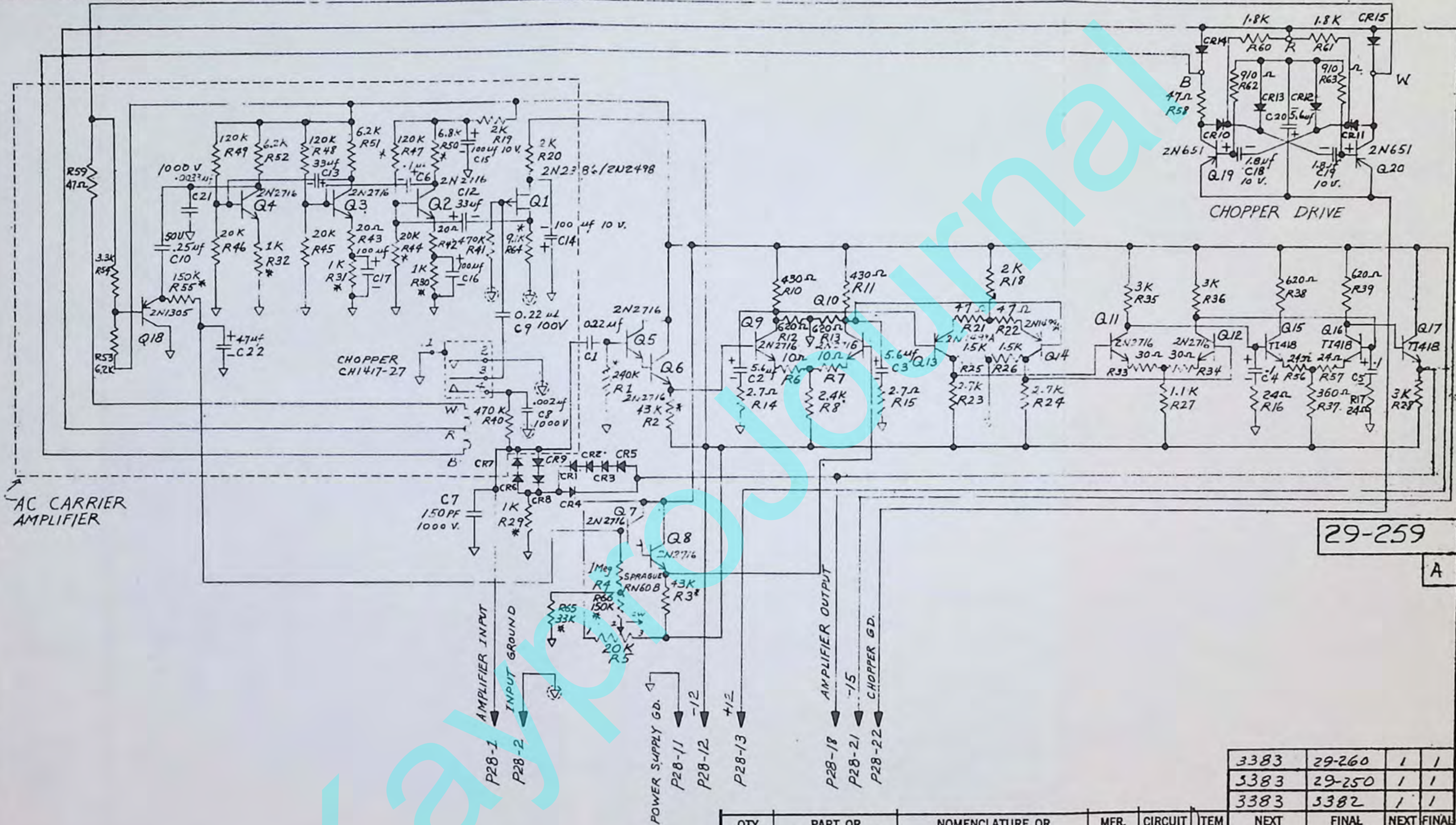
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, FREQUENCY, & PERIOD
2917A

SIZE D | CODE IDENT NO. 03626 | 29-256 | REV. B
SCALE | WEIGHT | SHEET 2 OF 3

B 29-256

REVISIONS					
SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED
A		ALL	CHANGED 2N3635 TO 2N3565. ADDED ALT. FOR Q1, INCORP. EO #1	9-2-65	RJ



QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
						3383	29-260	1	1
						3383	29-250	1	1
						3383	3382	1	1
		PARTS LIST				APPLICATION		QTY.	

4. 2N3565 IS AN ALTERNATE FOR 2N2716 (Q2 THRU Q12), 2N3565 IS AN ALTERNATE FOR TI418 (Q15, 16 & 17).
3. C1, C4 & C5 ARE 100 VOLTS, C2, C3, C12, C13 & C20 ARE 10 VOLTS, C16 & C17 ARE 3 VOLTS.
2. ALL RESISTORS ARE 1/2 WATT, 5%, AB EXCEPT THOSE MARKED WITH ASTERISK (*) ARE CORNING C-20. & R4 IS 2% 1/8 W.
1. DIODES D6 THRU D9 ARE IN458, ALL OTHERS ARE TYPE UG-315 (5003-002).

NOTES: UNLESS OTHERWISE SPECIFIED:

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 8-4-65

DRAWN Hanrahan 7-7-65
CHECK J. Knuft
APPR RJT 8-3-65
MATERIAL
FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, AMPLIFIER BOARD —
SERIES 2900 - MODEL 2917A

CODE IDENT NO. 03626 | SIZE C | 29-259 | REV. A
SCALE ____ WEIGHT ____ SHEET 2 of 3

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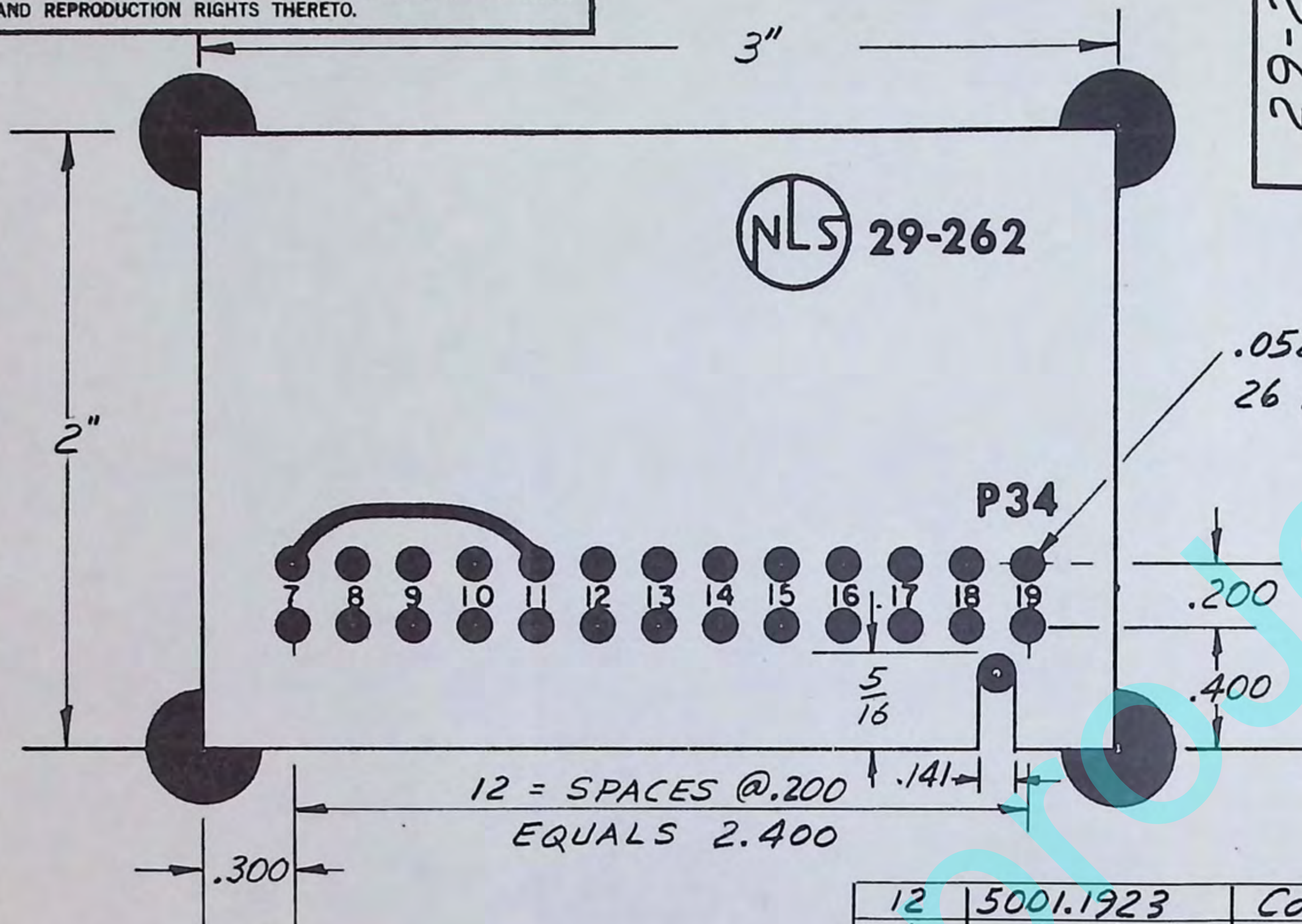
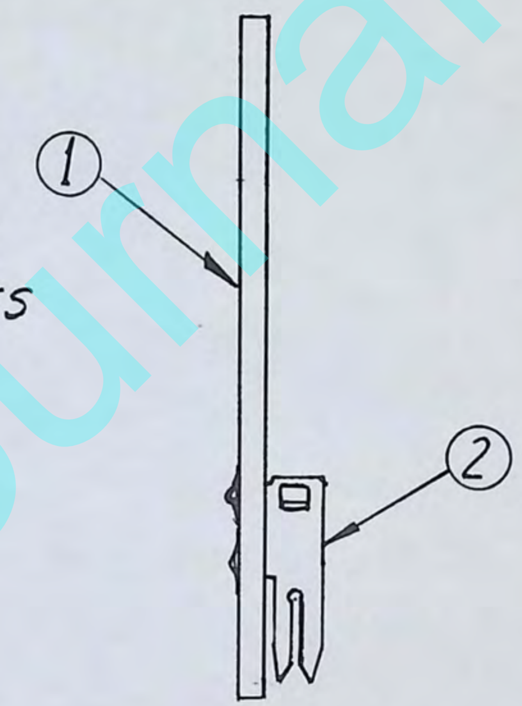
29-263

REVISIONS

SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED
1		ALL	FROM 2917 STANDARD TO 2917 SA	10-28-65	RWJ





PARTS LIST

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.
12	5001.1923	CONTACT - ELCO	91662		2
1	29-262	P.C. BOARD (3/32 THK)			1

APPLICATION / QTY.

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
	29-292		1

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30′
FRACTIONS ± 1/32

SURFACE ROUGHNESS PER MIL-STD-10 ✓

DO NOT SCALE THIS DRAWING

RELEASE DATE 8-6-65 (R)

DRAWN	H. BRINLEY	8-5-65
CHECK	L. Kruphih	8-5-65
APPR	RWJ	8-5-65

MATERIAL

FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

JUMPER BOARD ASSY.-
FREQ. BD. SUBSTITUTE
2917 SA

CODE IDENT NO. 03626 | SIZE B | 29-263

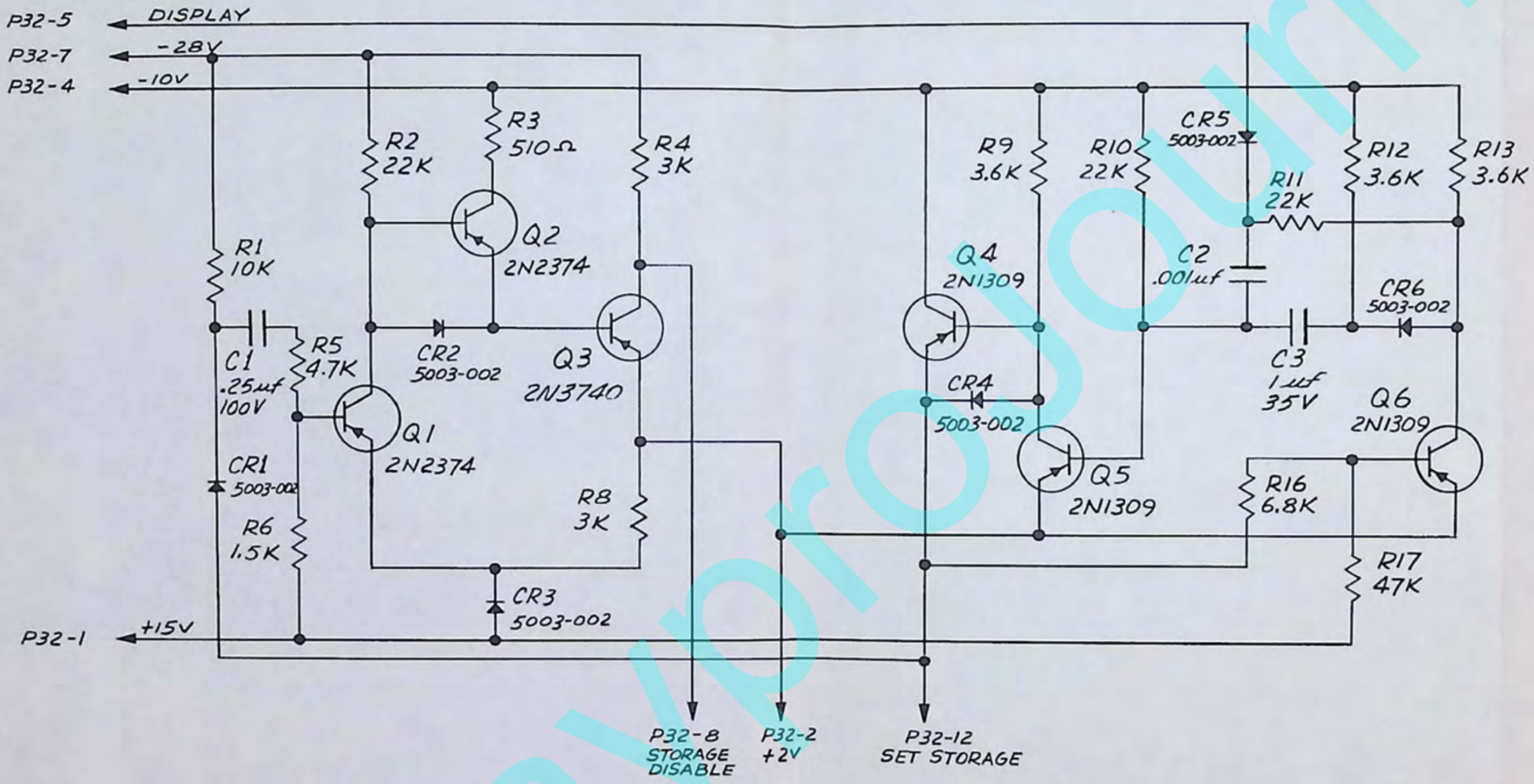
SCALE 2/1 | WEIGHT | SHEET

4 3 2 1

D C B A

ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
F/D	A	.204 & ON	INCORP. E.O. 1 of CHG. "O" 1-20-66 DH.	2-7-66	[signature]
		.244 & ON	INCORP. E.O. 2 of CHG. "O" 2-3-66 DH.		

REVISIONS



29-306 SHT. 2 A

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

PARTS LIST

#504B016

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
	29-292		
	29-288		
APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32

MATERIAL

CONTR. NO.		
DRAWN	H. BRINLEY	9-20-65
CHECK		
APPR	RWJ	9-21-65
RELEASE DATE	11-4-65	

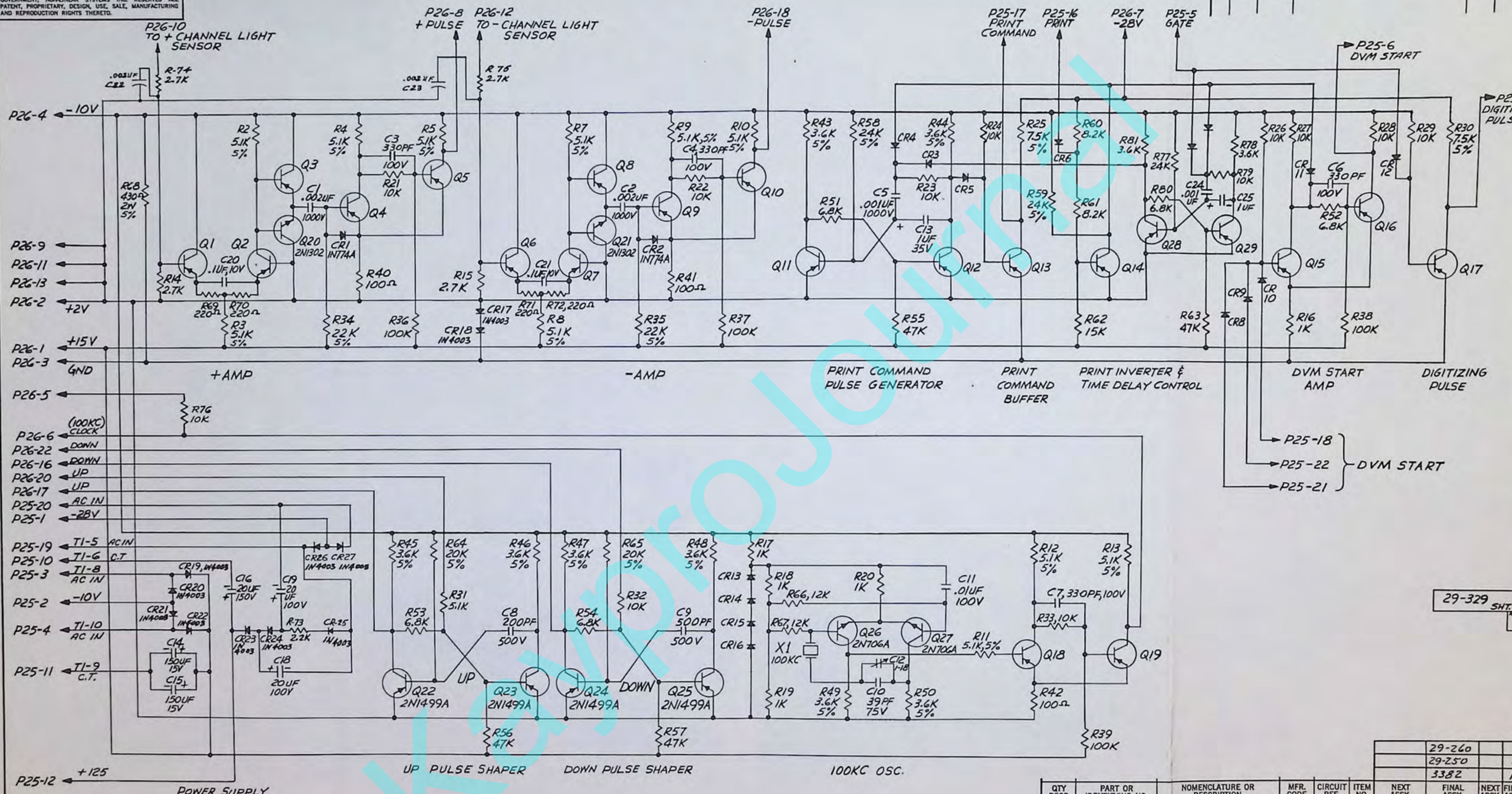
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC,
STORAGE BOARD

2917 SA

SIZE	CODE IDENT NO.		REV.
C	03626	29-306	A
SCALE	WEIGHT		SHEET 2 of 3

REVISIONS					
SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED



3. ALL RESISTORS ARE ½W, 10%.
2. ALL DIODES ARE TYPE UG315(5003-002).
1. ALL TRANSISTORS ARE TYPE 2N1309.
NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
	29-260		1
	29-250		1
	3382		1
APPLICATION		QTY.	

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.
PARTS LIST					

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
FRACTIONS ± 1/32
ANGLES ± 0° 30'
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE 11-16-65

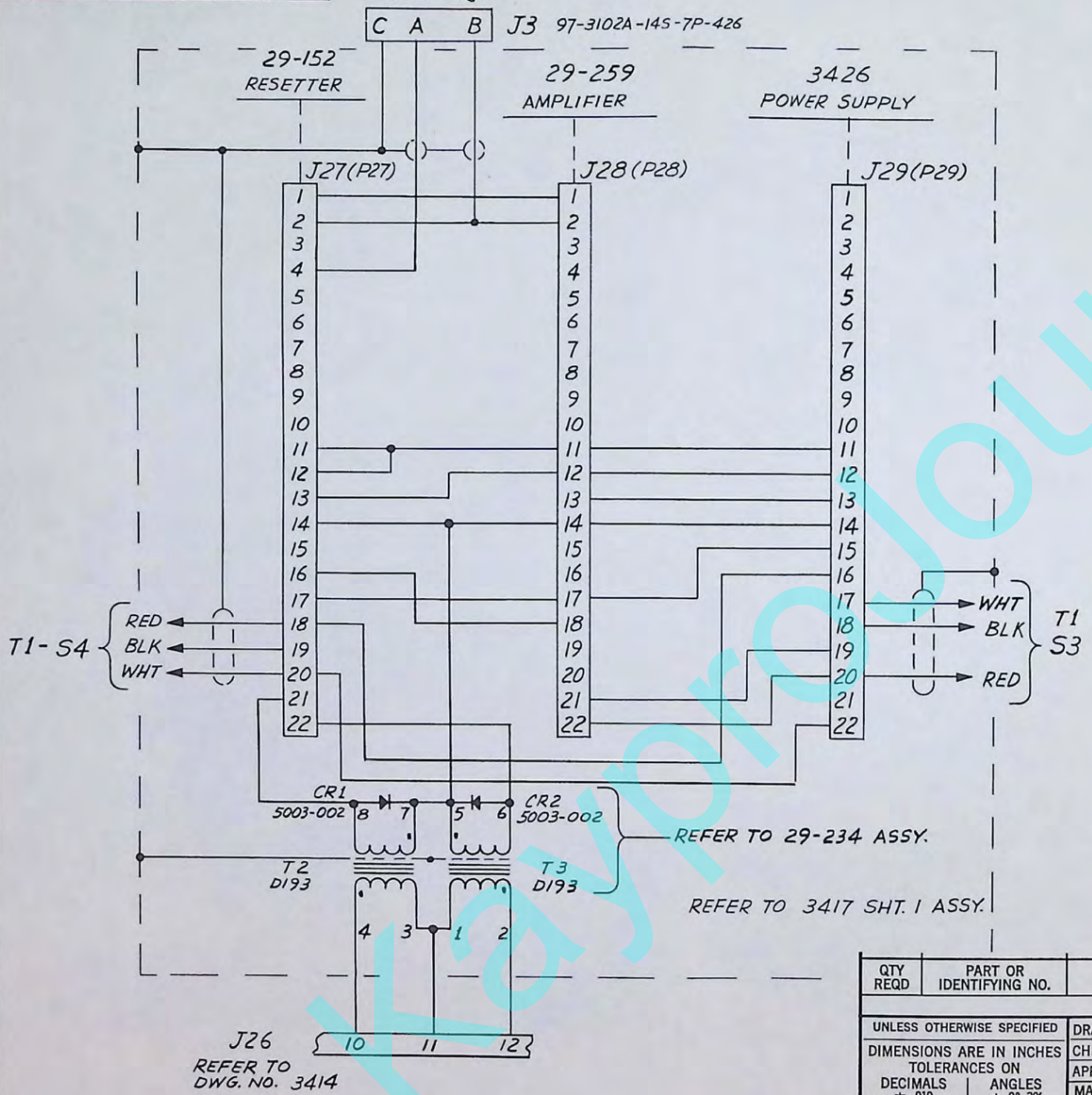
DRAWN H. BRINLEY 10-27-65
CHECK
APPR RWJ 10-29-65
MATERIAL
FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, OSCILLATOR
SERIES 2900

CODE IDENT NO. 03626 | SIZE D | 29-329 | REV
SCALE | WEIGHT | SHEET 2 of 3

REVISIONS					
SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED
A		ALL	J27-1 TO J28-1 WAS J27-3 TO J28-3. J3-B WAS TO J27 & J28-3.	12-29-64	
B			REMOVED DS1 & DS2 LAMPS. ADDED 29-234 ASSY. SCHEMATIC. 29-152 WAS 3420 & 29-259 WAS 3423	7-9-65 HDB	7-30-65 RWJ
C			J26-11 WAS J26-13	9-14-65	9-16-65 RWJ
D			CHANGED T-1 WIRE COLORS: WHITE (WAS YEL) BLACK (WAS BLU)	1-13-66	



3417 SHT. 2

D

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.	NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
						3383	29-77	1	1
						3383	29-260	1	1
						3383	29-250	1	1
						3383	3382	1	1
PARTS LIST						APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30′
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER MIL-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE Rev A 8-4-65

DRAWN	H. BRINLEY	7-10-64
CHECK		
APPR	R. Johnson	7-15-64

MATERIAL

FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, INTERCONNECTING BOARD

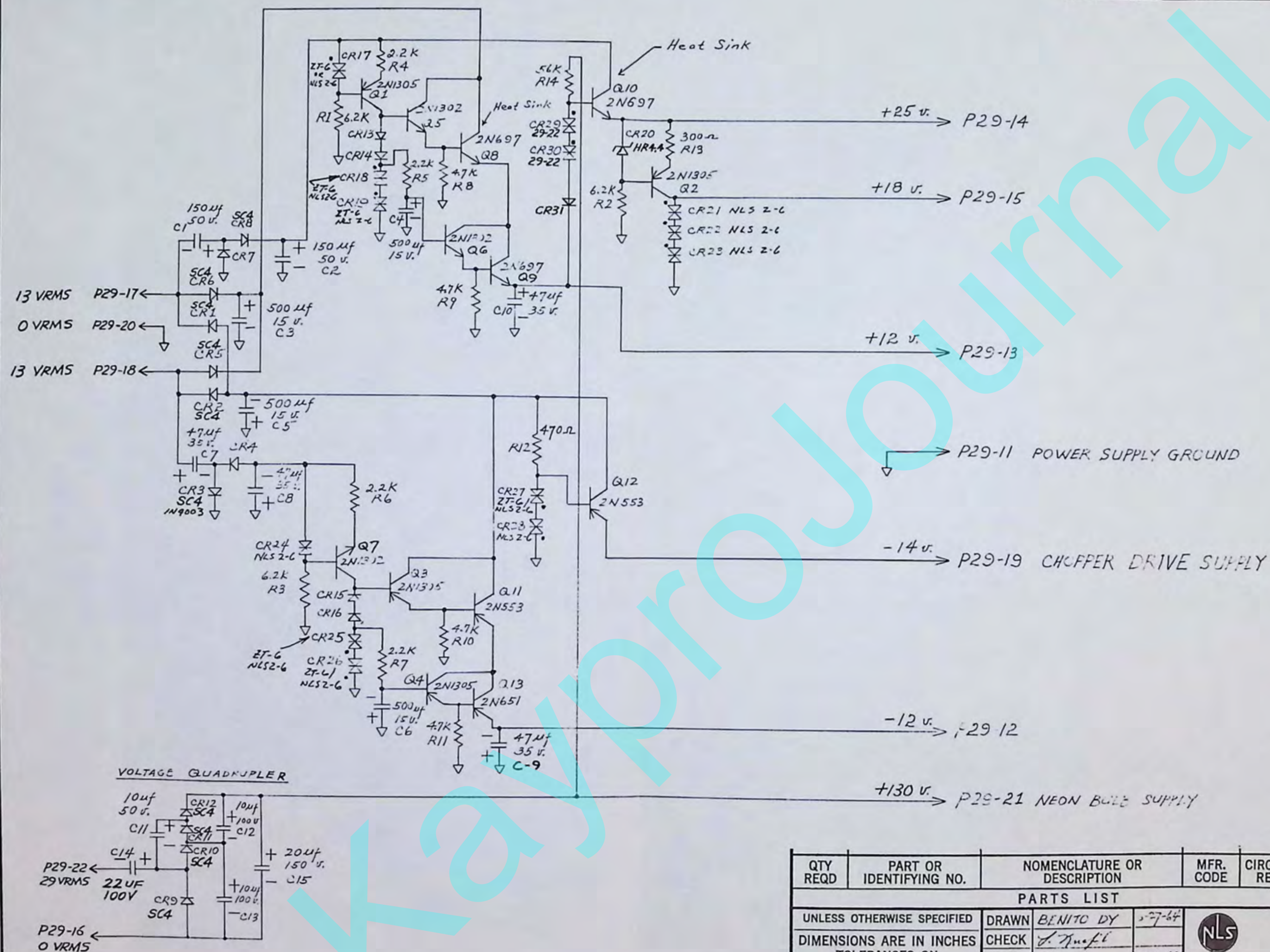
2900

CODE IDENT NO. 03626 | SIZE C | 3417

SCALE | WEIGHT | SHEET 2

REVISIONS

SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED
A	F/0	ALL	ADDED ALTERNATE REF. DES. FOR CR18, CR25, CR26 & CR27	9-27-65 10-11-65	DN. RWJ
B		ALL	INCORP. E.O. (C14 WAS 20UF, 50V.) HOB	9-15-66	



3426 SHEET 2

B

NEXT ASSY.	FINAL ASSY.	NEXT ASSY. QTY.	FINAL ASSY. QTY.
3383	29-260	1	1
3383	29-250	1	1
3383	3382	1	1

APPLICATION

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

PARTS LIST

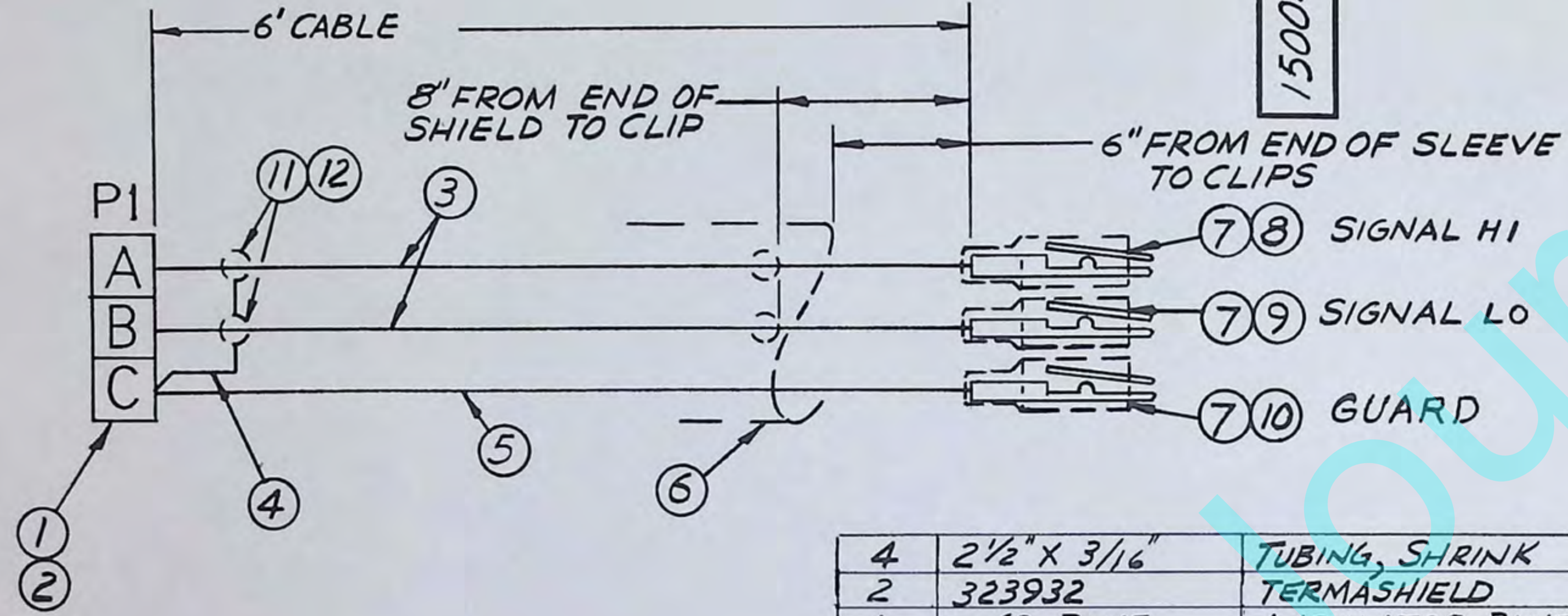
1. ALL RESISTORS ARE ½ WATT, 10%.
2. ALL ZENER DIODES ARE RT-6.
3. ALL DIODES ARE 5002-002 (UG-315).
4. ALTERNATE DIODE FOR SC-4 IS 1N4003.

NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± .010 ANGLES ± 0° 30' FRACTIONS ± 1/32	DRAWN BENITO DY 5-27-64; CHECK; APPR RWJ 7-6-64	NON-LINEAR SYSTEMS, INC. DEL MAR, CALIFORNIA
SURFACE ROUGHNESS PER MIL-STD-10 ✓	MATERIAL	SCHEMATIC POWER SUPPLY BOARD 2900
DO NOT SCALE THIS DRAWING	FINISH	CODE IDENT NO. 03626; SIZE C; 3426
RELEASE DATE 4-5-65		SCALE; WEIGHT; SHEET 2 of 3

15004-363 A

REVISIONS					
SYM	ZONE	EFFECT.	DESCRIPTION	DATE	APPROVED
A		ALL	"HI" WAS "INPUT." "LO" WAS "COMMON." "GUARD" WAS "CHASSIS GND."	9/20/66	[illegible]



QTY.	PART NO.	DESCRIPTION		ITEM NO.
4	2½" X 3/16"	TUBING, SHRINK	THERMOFIT	12
2	323932	TERMASHIELD	AMP	11
1	62-BLUE	INSULATOR, BLUE VINYL - MUELLER		10
1	62-BLK	INSULATOR, BLK VINYL		9
1	62-RED	INSULATOR, RED VINYL		8
3	60-CS	CLIP, COPPER - MUELLER		7
A/R	V105	SLEEVING, VINYL 5/16" I.D. BLK. ILLUMITRONIC		6
A/R	#20 AWG	WIRE, STRANDED - BLK		5
A/R	#22 AWG	WIRE, STRANDED - BLK (#24 PERMISSIBLE)		4
A/R	RG 122/U	COAXIAL		3
1	AN3057-6A	CLAMP		2
1	973106A-14S-7S-426	CONNECTOR - AMPHENOL		1

PARTS LIST

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
APPLICATION		QTY.	

3. STAMP SYMBOL (P1) ON SLEEVING NEAR CONNECTOR.

2. STAMP PART No. (15004-363) ON SLEEVING.

1. INSULATION RESISTANCE TO BE 200,000 MEGOHMS MIN. AT 500V BETWEEN PINS AND BETWEEN EACH PIN AND THE SHELL.

NOTES:

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 — ANGLES ± 0° 30′
FRACTIONS ± 1/32

SURFACE ROUGHNESS PER MIL-STD-10 ✓

DO NOT SCALE THIS DRAWING

RELEASE DATE 12-3-64

DRAWN	H. BRINLEY	11-4-64
CHECK		
APPR	R. W. J.	12-2-64

MATERIAL

FINISH

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

CABLE, INPUT

2900 SERIES

CODE IDENT NO.	SIZE	
03626	B	15004-363
SCALE	WEIGHT	SHEET