

**FINAL REPORT
FOR
SKYLAB INDICATORS****ENGINEERING
TECHNICAL
REPORT**

(EVENT TIMER)

(SECONDARY DISPLAY)

(FOUR-DIGIT METABOLIC DISPLAY)

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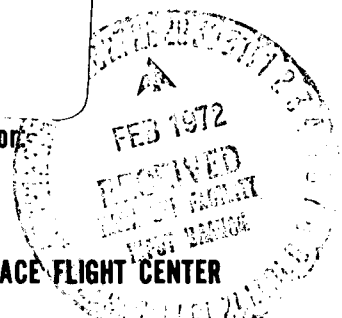
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GEORGE C. MARSHALL SPACE FLIGHT CENTER

MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812



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AEROSPACE & MARINE SYSTEMS

FINAL REPORT
FOR
SKYLAB INDICATORS

(EVENT TIMER)
(SECONDARY DISPLAY)
(FOUR-DIGIT METABOLIC DISPLAY)

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1. GENERAL

This report summarizes the effort in developing the following indicators:

- Event Timer
- Secondary Display
- 4 Digit Display (Metabolic)

The electrical design of the latter two displays are very similar and therefore comments made will pertain to both, and their major differences will be outlined in the description.

The mechanical design, vibration analysis, and thermal analysis of all these units are identical. Therefore, these descriptions will pertain to all three (3) units. All problems incurred during the program are discussed along with the recommendations, conclusions and actions taken to rectify the situations.

2. TECHNICAL DESCRIPTION EVENT TIMER

2.1 GENERAL OPERATIONAL REQUIREMENTS

The Event Timer was designed according to the specifications provided by NASA/MSFC to perform the following functions:

- a) Count backwards at a 1 count/second rate from any preset number of 0000-9959.
- b) Slew to any number from 0000-9959 at a 2 pps rate for each digit.
- c) Capability to stop counting or start counting by switch command.
- d) To resume counting 1 second after the start switch has been thrown.
- e) The capability of illuminating each diode in the LED's to assure that each diode is functional (lamp test).
- f) When the device reaches the number 0000, an SCR turns on with the capability to sink 250 ma and will do so until the load is removed.

The above functions are implemented as discussed in the general technical description below. References to schematics that are found at the end of this section are made.

2.2 A1-A4 COUNTER CARDS

Since all four cards are basically the same, only the A1 card is discussed here. (Refer to Schematic C543020311.)

Flip flops U2 and U5 make up a conventional down BCD counter. The counter is of the synchronous type. Since this counter is BCD, the unwanted binary numbers 10 to 15 must be eliminated. This is accomplished by sensing the following states of the counters

<u>ABCD</u>	<u>Decimal No.</u>
1010	10
1011	11
1100	12
1101	13
1110	14
1111	15

and resetting the counter to "0" when these states are present.

This is easily implemented by the equation:

$$AB + AC = \text{reset}$$

The output of U6 (5) is the reset signal. Additionally, when counting backwards the counter must go from 0---9. If the counter was allowed to go naturally from 0 to 15, the counter would reset to "0" because of the unwanted "15" state, as mentioned above. To accomplish the 0---9 transition, the " $\overline{0}$ " condition is detected by U3 (10). This output is used to set the JK input of U2 (7, 10) to a "0" and to set the JK input of U5 (3, 14) to a "1" so that on the next transition the number appearing is 1001 or "9". Additionally, this "0" condition U3 (10) is also gated with the input clock to be used as a carry for the next card; E10. E22 also generates the "0" condition for the counter card that is used in conjunction with the other counter cards to generate the all 0's condition, i.e., the condition in which the display reads 0000.

The Q outputs of U8 and U5 are fed through inverters U1 to the BCD inputs of the Hewlett-Packard LED's.

In the start mode, a "1" appears at E16 and a "0" at E13; this allows 1 pps to be fed to the counters. This pulse appears on the clock input E15 and E14.

In the stop (slew mode), a "0" appears at E16 which stops any carry pulses from coming through. Also when the slew command E8 is low, 2 pps is fed to each counter that is to be slewed so that any number can be preset.

2.3 LAMP TEST

The input E20, lamp test, allows a high frequency 1024 Hz to be gated into each counter. This rapid frequency makes all the diodes of the LED light up since it is going through all the numbers rapidly.

2.4 OSCILLATOR, COUNTDOWN AND CONTROL LOGIC

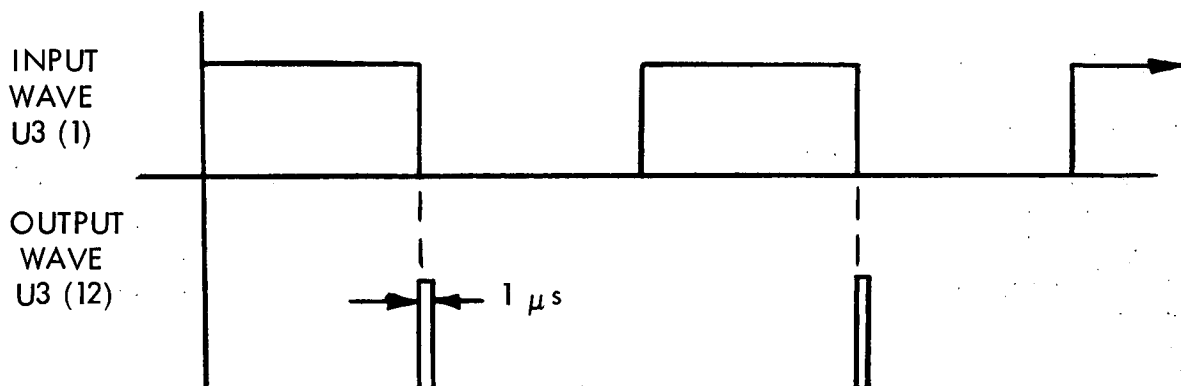
2.4.1 Oscillator (Cards A5, A6, and A7)

The oscillator Y1 is a McCoy Crystal Oscillator operating at the nominal frequency of 1.048576 MHz. This frequency was chosen because 1048576 is equal to 2^{20} and is easily divided to give 1 and 2 pps needed to run the clock. U1 and U2 of A7 and U1-U8 of A6 comprise the 2^{20} divider.

The output of U1 (9) is a 1 pps square wave, while the output of the previous flip flop, U1 (12) is a 2 pps signal. The former signal is used as the input frequency to the clock while the latter is used for slewing.

2.4.2 A5 Control Card

The logic composed of U3 (12) and U4 make up a one shot that generates an approximately 1 μ s pulse whenever U3 (1) sees a 1---0 transition. This circuit therefore shapes the clock pulse to appear as shown below:



In shaping the pulse thusly, a great amount of noise immunity is attainable, since the counter card that the clock pulse is feeding is effectively enabled for only $1\mu s$ and not for a full second.

The 2 pps or 1 pps is selected as the input to the one shot depending on whether the unit is in stop or start mode. In "stop", the 2 pps is available at the output of the one shot, while in the start mode 1 pps is available.

Additionally, 1024 pps are gated into the one shot whenever the "test" line is enabled. This allows 1024 pps to enter the clock and all diodes on the LED are lit.

2.4.3 One Second Start Delay (A5 Card)

When going from "stop" to "start", it is necessary that the next pulse appear 1 second after the "start" switch is thrown; otherwise, as much as 1 second of time can be lost. The logic sequence when going from "stop" to "start" is as follows:

Assume initially that the unit is in the stop mode, i.e., E5 is "1" and E6 "0". The switch is now thrown to start so that E5 is "0" and E6 "1". U5 (13)'s transition to a "0" clocks the JK flip flop's input U3 (5). The outputs of U3 change from the reset condition to U3 (9) = "1" and U3 (8) "0". This sets latch U7 (3) to "1" and U7 (14) to "0". The output of U7 (3) is fed to inverters which resets the whole divide down chain of A6. This output also enables counter U8 to be clocked by the 65536 Hz pulse coming from A7 (E17). Three of these pulses are counted to insure that all the count down flip flops have reset. Once these pulses are counted, U3 resets which enables the count down chain and also latches U6 (14), the "start" line to a "1". Resetting the count down chain results in a 1 second delay.

2.4.4 A8 Card

The A8 card consists of 7 transistor buffers which respond to a signal of 16 volts or greater. Capacitive filtering is used at the inputs to eliminate the possibility of noise actuation.

The input signals that are affected are:

Start
Stop
Test
Slew 1 Second
Slew 10 Seconds
Slew 1 Minute
Slew 10 Minutes.

The A8 card also contains an SCR CR1 which is turned on whenever the display reads "0000" providing a load of approximately 1000 ohms is connected.

2.4.5 Power Supply

In order to attain low power consumption, an efficient 28/5 VDC power supply is used. The complete schematic is shown in C543020311 (A9 card). Additionally, low power flat-packs were used throughout the design to minimize the overall power.

2.4.5.1 General

The power supply, shown in Figure 1, consists of three major sections:

- Switching pre-regulator
- DC/DC Inverter
- Reference and Error Amplitude

These sections are connected in a loop to provide a regulated 5 volt output from the unregulated 28 volt input.

In operation, the error amplifier senses the output voltage, compares this voltage against a reference and gates the unregulated input voltage. The result is a pre-regulated DC voltage (referenced to the 5 volt output) being applied to a DC/DC inverter. By means of a step-down transformer, this pre-regulated voltage is reduced to a 5 volt level thereby completing the loop.

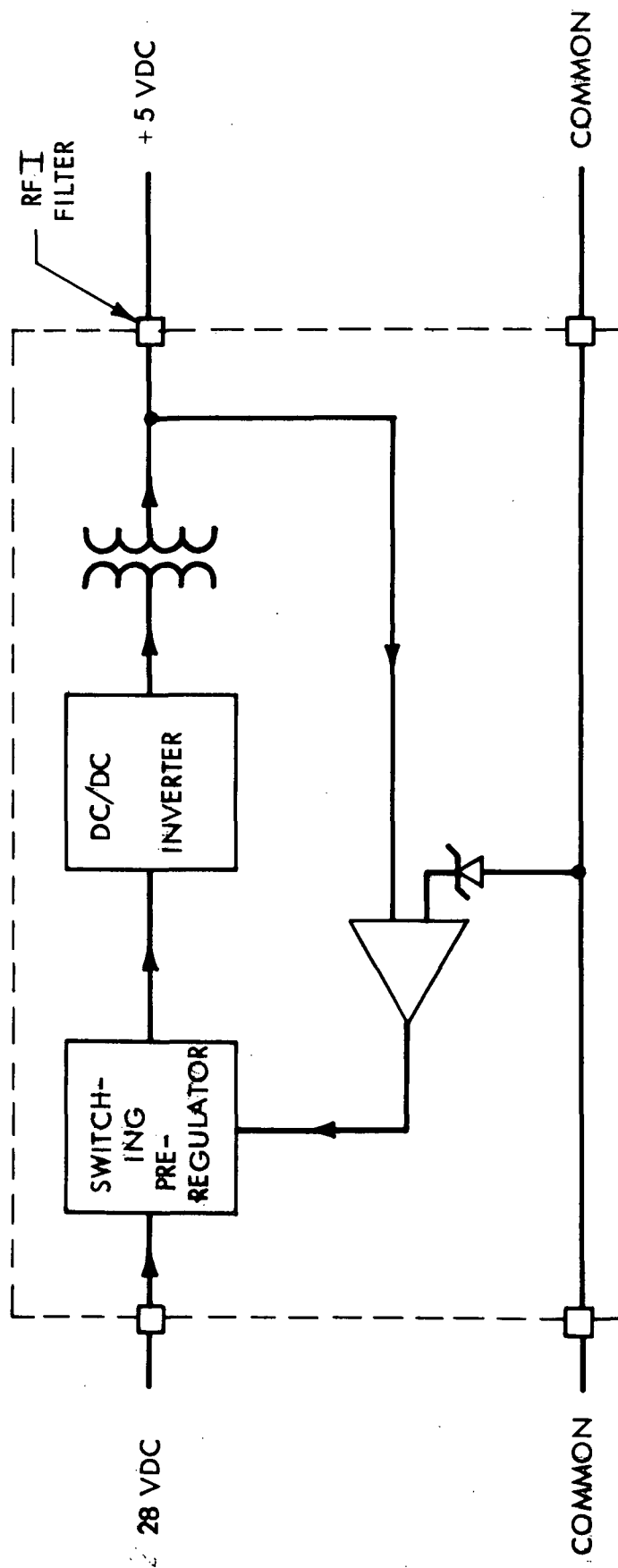


FIGURE 1
BLOCK DIAGRAM
LEM POWER SUPPLY

2.4.5.2 Switching Pre-regulator

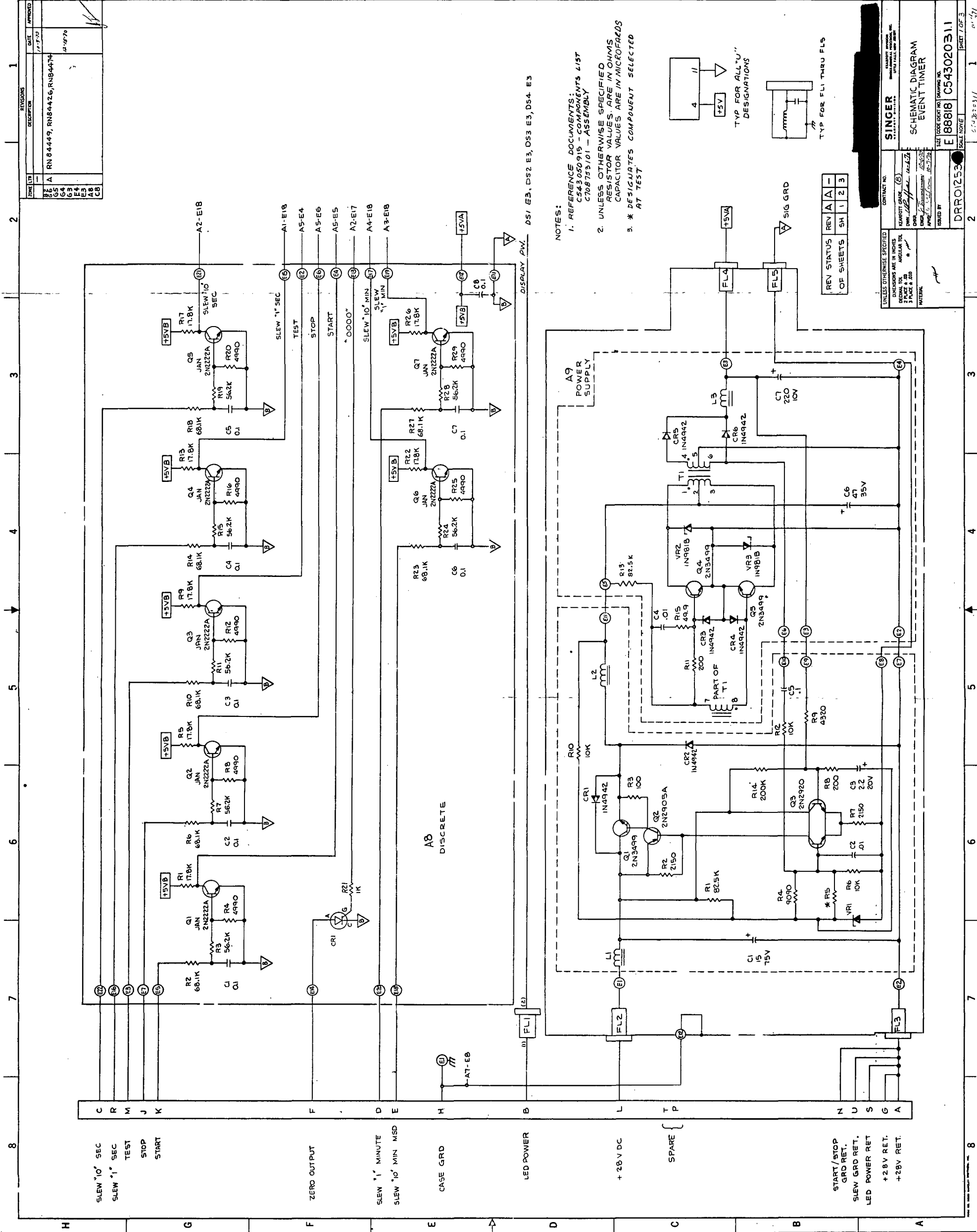
The pre-regulator consists primarily of a power switch (Q1) and driver (Q2) followed by an LC filter (L2, C6). To follow the operation of the switching regulator, assume Q1 is conducting and further that this voltage is inverted in the square wave inverter (Q4, Q5) and transformed to 6 volts by means of T1 where it is rectified (CR5, CR6) and filtered (C3, C7). By means of R9, the base of Q3 (B) senses the output voltage and depending upon whether this voltage is above or below the voltage of Q3 (A) base (clamped by VR1, R4, R5, R6), the power switch Q1 is gated OFF or ON. This regulation loop is made to switch on and off at the same rate as the inverter frequency by impressing a triangular wave upon the reference voltage. Typical wave forms are shown in Figure 2. It will be noted that as the input voltage is increased, the average voltage provided at T1 primary is constant or regulated.

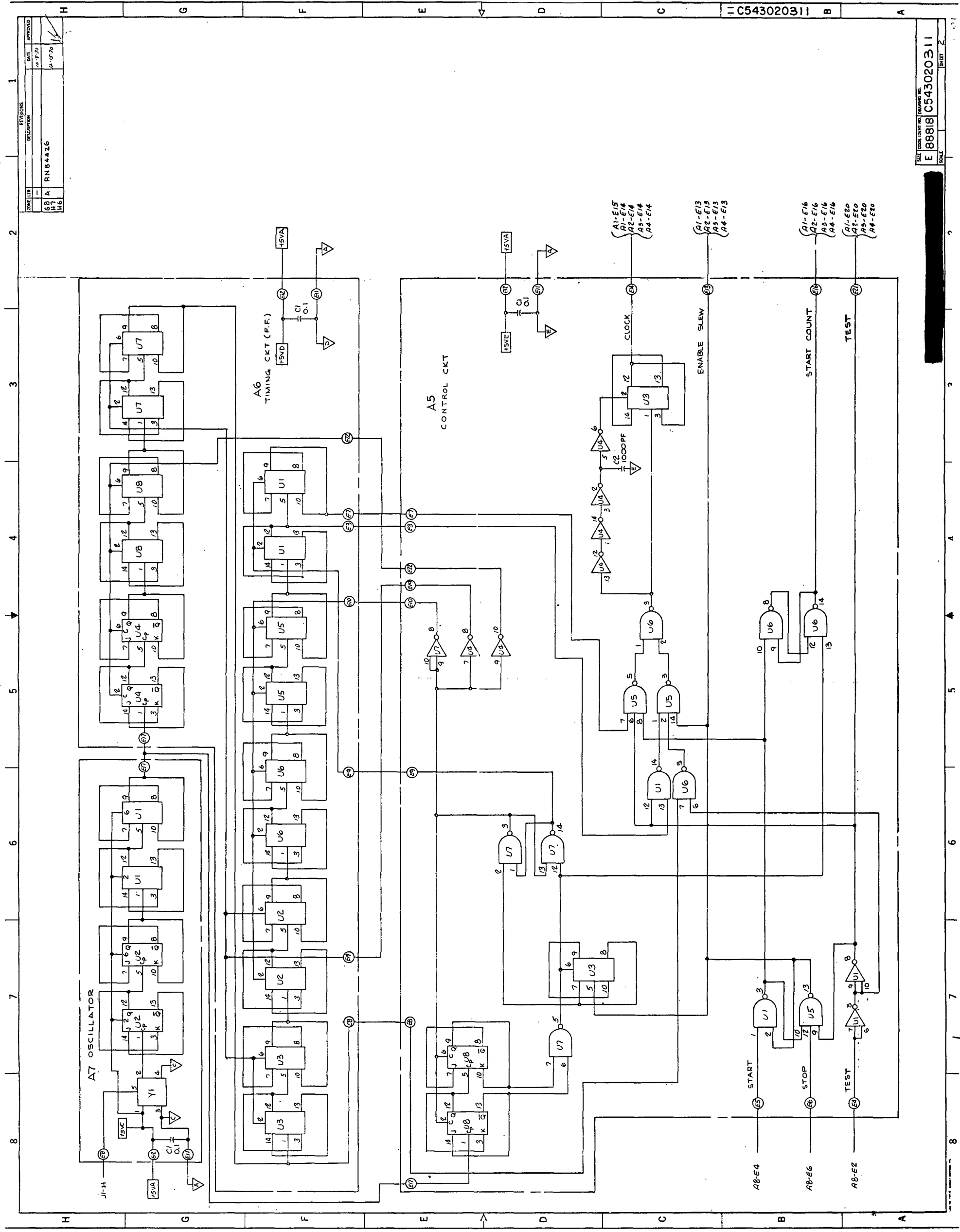
2.4.5.3 Inverter

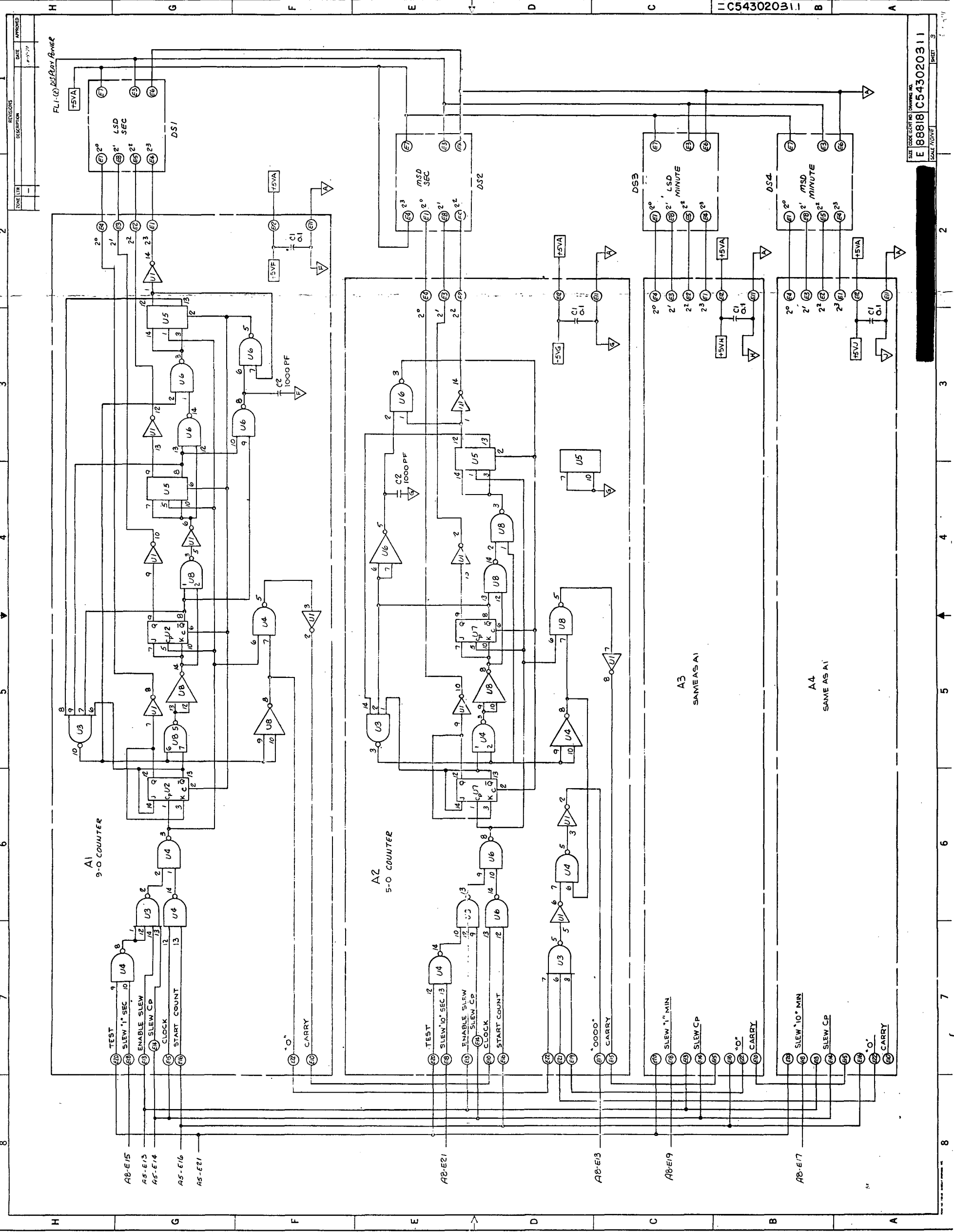
The inverter is of the saturable transformer type in which either Q4 or Q5 conducts for a half cycle. The frequency of this inversion is dependent upon transformer parameters which are relatively constant from transformer to transformer and the applied voltage. Since the applied voltage is regulated, the frequency is fixed from unit to unit at approximately 50 KHz. R13 assures starting of the inverter and once started, the inverter is free running. As can be seen in (D) in Figure 2, the ripple content is found to be a small valley at twice the inverter frequency since full wave rectification (CR5, CR6) produces a dc output of continuous amplitude with very narrow drop-outs occurring at the inverter transition periods. The filter (L3, C7) can then be made small since the ripple components are small.

2.4.3 Transient and EMI Protection

In addition to the normal power supply components, L1C1 and FL1 thru FL4 have been provided to suppress any interference which may exist due to switching. The power supply card is housed in a separate section into which access is made by means of RFI filters. L1C1 provides the additional function of transient filter. This filter is designed to smooth out the +80 - 100 volt transient found on the power input lines as well as normal MIL-STD-704 28V ripple.







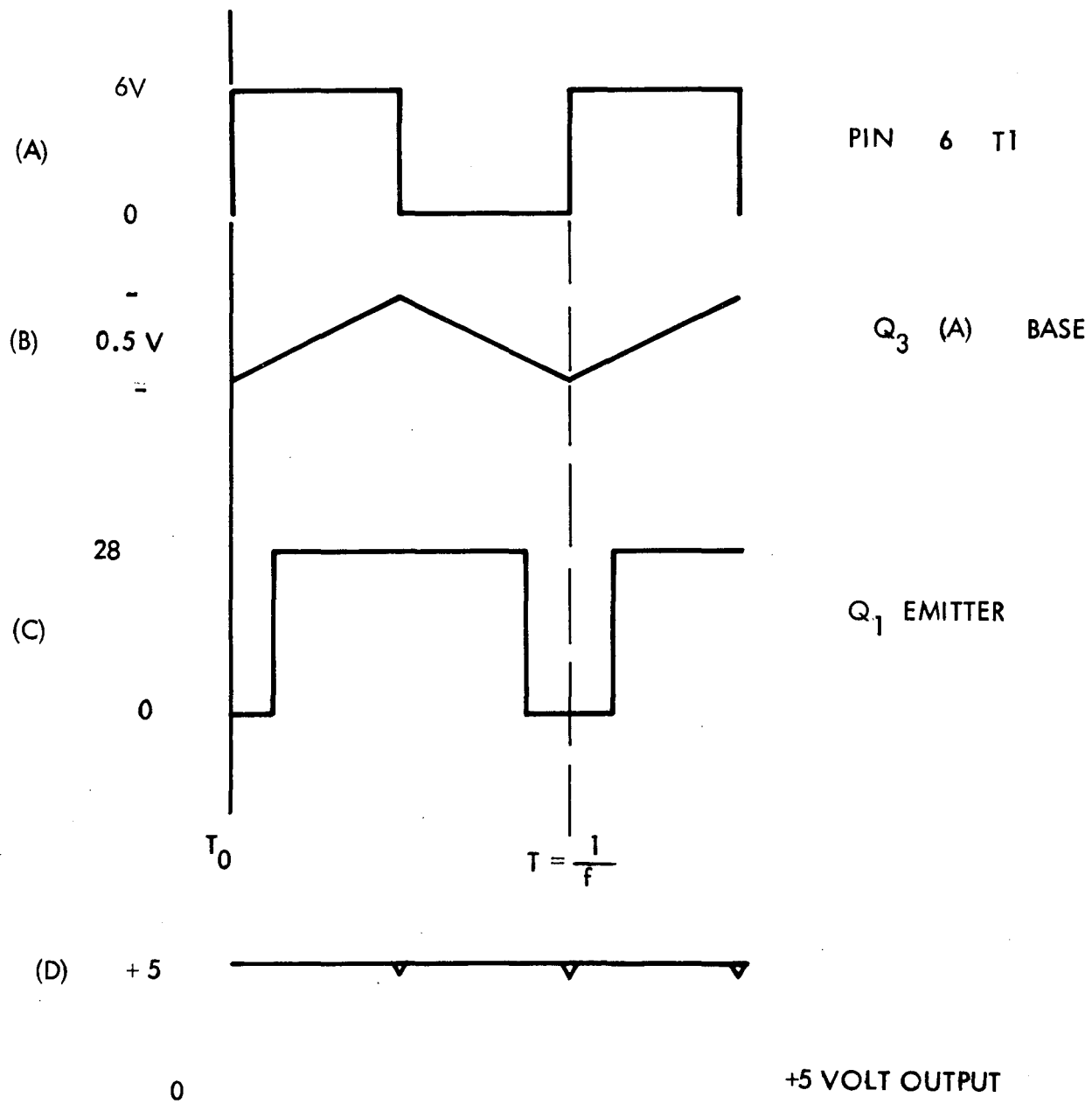


FIGURE 2
TYPICAL SWITCHING WAVEFORMS

3. SECONDARY DISPLAY

3.1 GENERAL OPERATIONAL REQUIREMENTS

The Secondary Display is designed to respond to a 0 – 5 volt dc analog signal input with a BCD 4 digit output. A total of 8 scales is displayed, two of which are identical. The scales are listed below:

COMMAND FUNCTION SECONDARY DISPLAY DIGITAL RANGES

<u>Measurement</u>	<u>Command No.</u>	<u>Analog Input Range</u>	<u>Digital Range</u>	<u>Parameter Range</u>
Heart Rate	1	0 to 5 vdc	0040 to 0200	40 to 200 beats/min
Body Temperature	2	0 to 5 vdc	0950 to 1050	95.0 to 105.0°F
Systolic Pressure	3	0 to 5 vdc	0050 to 0250	50 to 250 mmHg
Diastolic Pressure	4	0 to 5 vdc	0040 to 0140	40 to 140 mmHg
MA O ₂ Consumed	5	0 to 5 vdc	0000 to 4000	0.000 to 4.000 liters/min
MA CO ₂ Produced	6	0 to 5 vdc	0000 to 4000	0.000 to 4.000 liters/min
MA Vol/Min	7	0 to 5 vdc	0000 to 0150	0 to 150 liters/min
MA Vital Capacity	8	0 to 5 vdc	0000 to 7000	0.000 to 7.000 liters/min

Scale changes are performed digitally.

3.2 ANALOG/DIGITAL CONVERSION TECHNIQUE (Refer to Schematic C543020310)

The technique used in converting the analog input voltage 0 to 5 volts into digital BCD form is the well known up/down ramp method. In this method, the input signal is integrated up for a predetermined time after which the signal is integrated down by a reference voltage till 0 crossover. The time required for this down integration is proportional to the input voltage applied. The point at which the up integration of the signal commences and where the down integration starts determines the scale that is used. Scale changing is therefore only a matter

of changing these initial points of integration. During the up and down integration, an approximate 40KHz clock pulse enters 4 BCD decade counters. The counter is programmed to reset at the number 1100 so that numbers from 0000 to 1099 can be displayed.

An example of how the A/D operates in scale 1 is outlined in Figure 3.

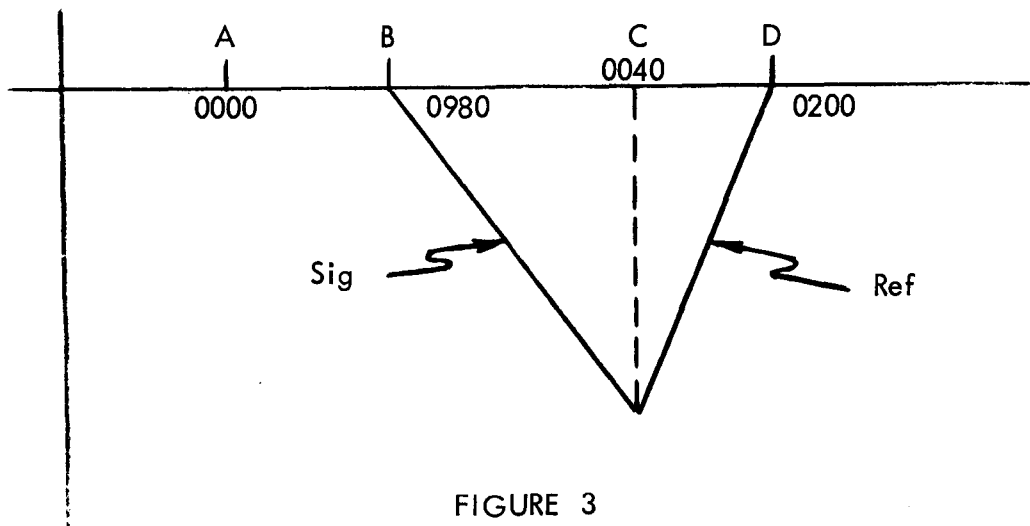


FIGURE 3

The heart of the A/D converter is composed of the A4 and A5 cards. On the A4 card, one will find two unijunction oscillators composed of Q1, Q3 (oscillator A) and Q5, Q4 (oscillator B) respectively. The former's rate is approximately 1 pulse every 2 - 2.25 seconds. This pulse is used to reset the flip flop logic U2 and U4 of the A4 card before an update. The latter oscillator oscillates at approximately 40 KHz and is used as the clocking frequency. The sequence of an update is described below. Assume that the display is sitting at some arbitrary number.

- a. First an update clock pulse is fed to reset U2 and U4 from the "A" oscillator. When the flip flops reset, 40KHz clock pulses are sent out to the counter cards A1 and A2 from A4 (E16).
- b. Now that clock pulses are entering counters A1 and A2, the counters are accumulating at a 40KHz rate.

- c. With the initiating reset pulse the logic is such that the J input of U4 (14) is high so that a transition of the flip flop is made if the CP input U4 (1) is clocked. U4 (1) is connected to the all "0"s. The initiating reset pulse also places A4 (E7) High and A4 (E1) Low. Whenever A4 (E7) is High, the A5 analog card goes into a zeroing mode. This means that the integrator U3 is slewed around zero with 0 crossover determined by the comparator U5. When A4 (E1) is Low, it turns the ± 12 and ± 6 reference signals on.

Turning on these voltages during the update time saves power.

- d. When the display passes through all 0's point (refer to A on Figure 3), the 0's signal clocks U4 (1). This enables U2 (1) to be clocked. U2 (1) is clocked when signal integration is required, (Point B) Figure 3, 0890 for scale No. 1.
- e. The output E7 and E4 of A4 both go Low. This effectively disconnects the $\pm$ ref signal on A5 by saturating Q2 and Q3 of A5 and applies the analog input signal to the integrator U3 by cutting Q1 off. Integrator U3 proceeds to integrate the signal up until the down (-) integration signal appears at A4 E11. For Scale 1, this number is 0040 point C. When this occurs, A4 (E7, E4) return to a "1" and the negative reference only is allowed to be integrated. Since the negative reference is constant, the rate of integration remains the same irrespective of input signal. The integrator continues to integrate the negative reference until 0 crossover is reached at which time U4 (5) on the A4 card receives a pulse which performs two (2) functions. It inhibits the clock pulse from passing through A4 U3 (13) and places A4 (E) at "1" shutting off the ± 12 , ± 6 V power supply. The display now shows a number proportioned to the input voltage for the scale selected. The unit remains inactive until another reset pulse occurs about 2 seconds later. The conversion time takes about 40-50 ms and since the ± 12 , ± 6 volts supplies are off for most of the time, an apparent power saving is obviously made.

3.2.1 Description of the A5 Card

The A5 card is composed of the analog circuitry. The input signal is applied between E10 and E11. U1 acts as a unity gain buffer so that greater than 1 meg input impedance is achieved on the low side. U2 operates as a differential unit gain amplifier. The output of U2 is therefore equal to the input at E10, E11. The high side input impedance is approximately equal to 140K while the low side input has an input impedance much greater than 1 meg when the amplifiers are turned on.

U3 is a differential op. amp. operating as an integrator. The input signal, + ref and - ref, application is controlled by the analog switches Q1, Q3 and Q2 respectively. The output of U3 is fed to another unity gain voltage follower U4 whose input voltage is limited to ± 6 volts by CR3, CR4. They function to limit the voltage excursion at the input to the comparator U5 which is operating as a 0 crossover detector.

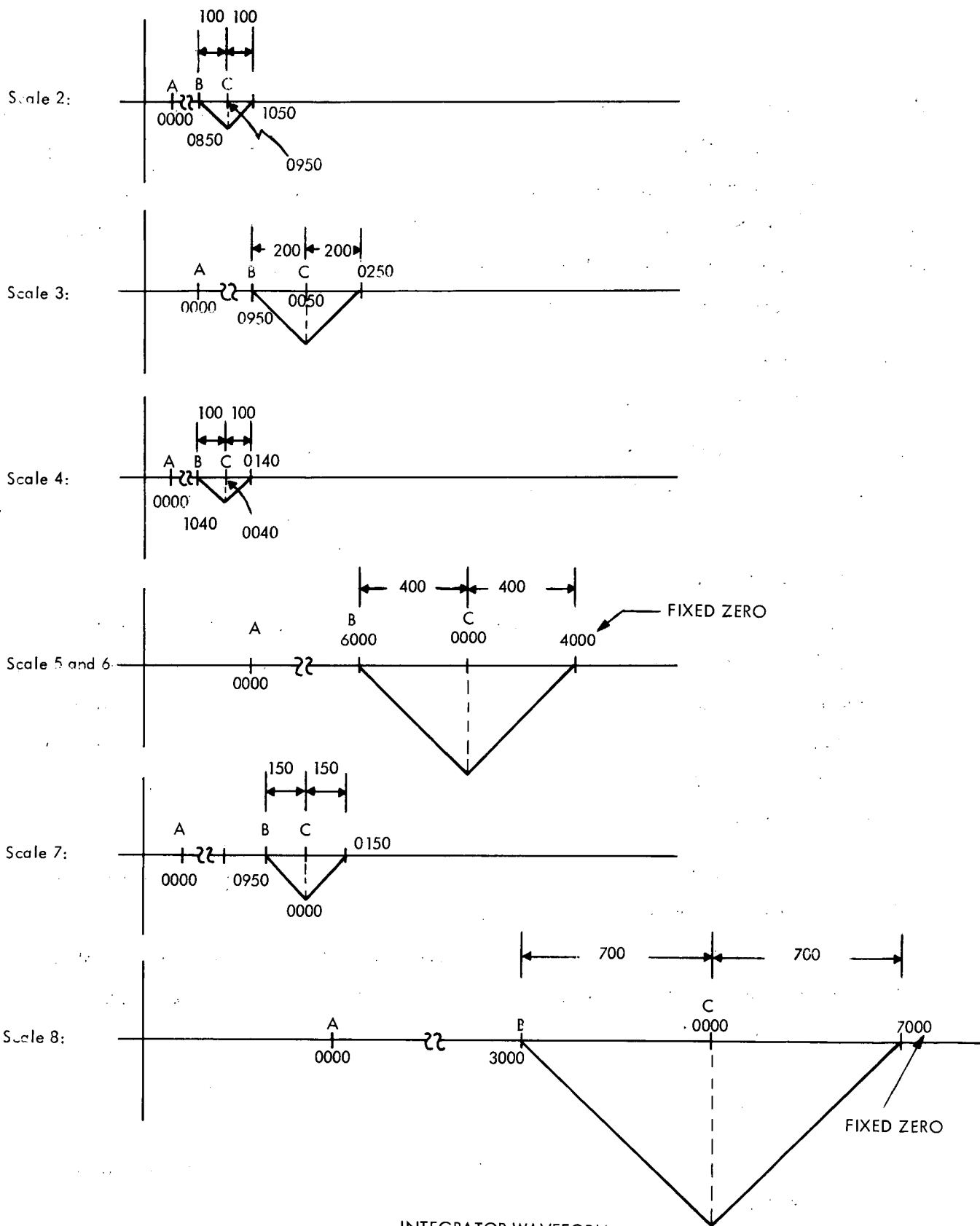
3.2.2 Description of the A3 Card

As discussed earlier, scale changing is done digitally. To accomplish this, the point where (+) integration is made and (-) integration is performed must be controlled.

E10 and E11 of A3 supplies these pulses to the flip flop sequencer U2, U4 of A4. Depending on which scale is commanded, proper pulses appear at different points. The waveform for all eight scales are shown in Figure 4. Note that Scale 5, 6 and 8 have a fixed 0 as the LSD. Clock pulses enter the 2nd LSD digit. In this condition, the last three decade counters count up to their natural maximum of 999. This was so designed because at 40KC rate it would take about 1/2 second for an update if all 4 digits were used.

3.2.3 Description of the A6 Card

The A6 card contains 8 transistors buffers which converts the 28 volts command signals into compatible TTL logic levels. Only seven of these buffers, Q2-Q8 are command signal inputs (i.e. - scale 5 and 6 are identical). Q1 is a buffer for the lamp test command. When



INTEGRATOR WAVEFORM
(SCALE 2-8)

FIGURE 4

this buffer is activated, the update oscillator on the A4 card is disabled through Q2 on that card. that card. This effectively puts U2 and U4 of A4 in a constant reset mode. 40KHz clock pulses are thus fed continuously to the counter cards A1 and A2. The lamp test buffer also controls logic on the A1 and A2 cards so that the 40KHz clock pulses enter the LSD and the 2nd least significant digit. All the counters are cycling through the numbers at a high rate and the display appears as if all diodes are lit.

Additionally, whenever scale 5, 6 or 8 is enabled, the LSD digit is reset to 0 and the 40KHz clock pulses enter the second LSD digit.

The A6-A1 card rides piggy back with the A6 card. Its function is to excite the appropriate decimal points on the display whenever the 2nd, 5th 6th or 8th scale is enabled.

3.2.4 A1 and A2 Card

The A1 and A2 card compose the counter cards. U5 and U8 of both cards are decade counters. The output of the decade counters are fed to inverters which feed the logic input of the LEDs. The peripheral logic performs the number decode function. As an example, scale 1 requires 0980 as a starting point for integration. The "9" is obtained from A2 (E4) and the "8" from A1 (E24). These numbers are Anded in the A3 card and fed to the flip flop sequencer of A4.

The A1 and A2 cards count up to 1099 maximum for scale 1, 2, 3, 4, 7. This is accomplished by resetting U5 and U8 of A2 whenever the number 1100 appears. For scales 5, 6 and 8, the first counter U5 of A1 is reset and clock pulses are gated into the input of U8 (14). The last three decades A1, U8, A2 (U5 and U8) count up to their natural limit (999); the reset logic is disabled.

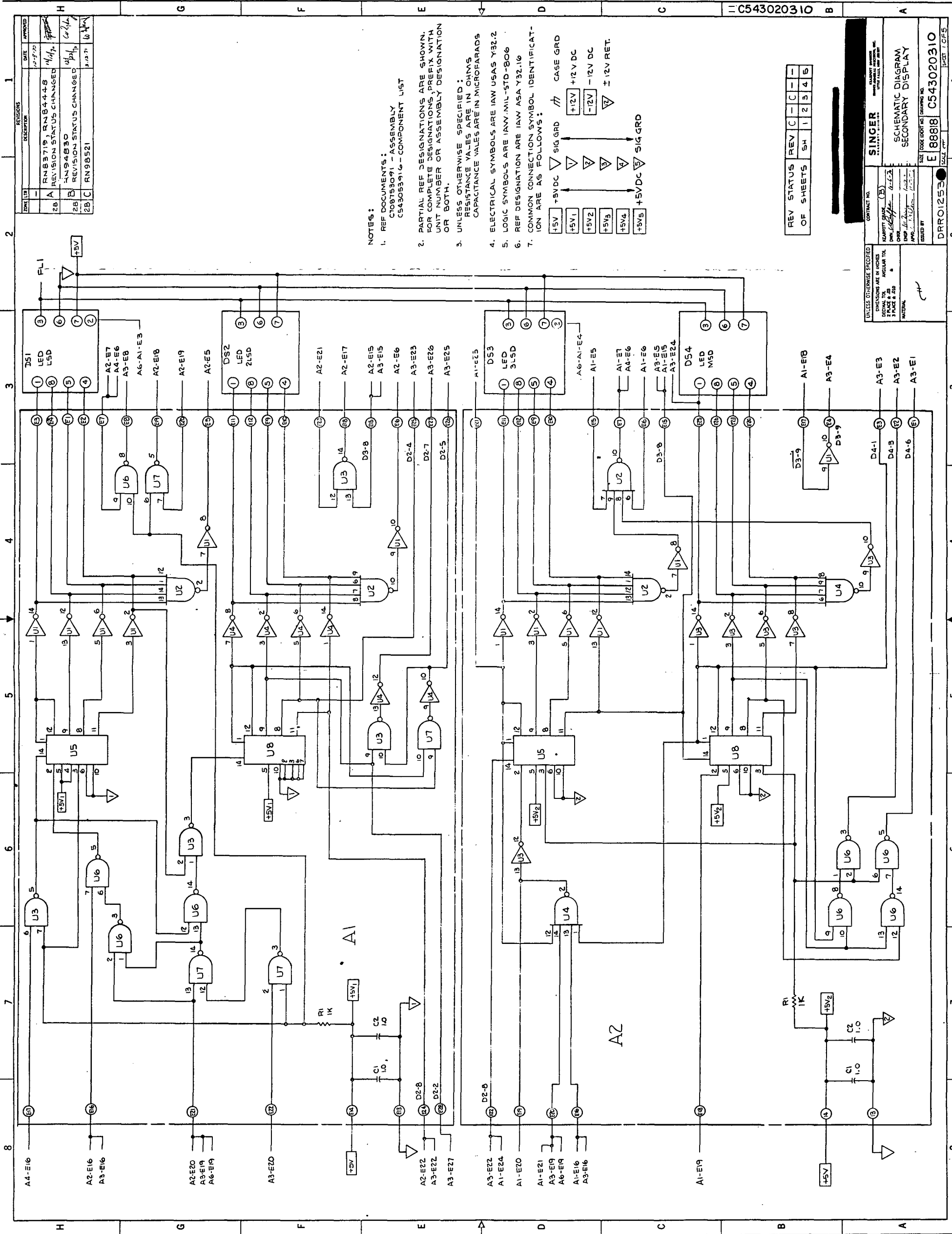
3.2.5 Power Supply

The 5 volt power supply section is essentially identical to the event timer power supply. Refer to Figure 1 .

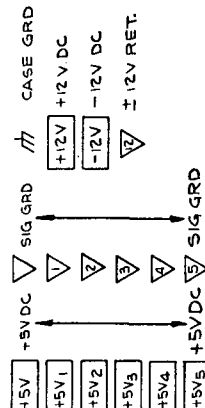
THE SINGER COMPANY • KEARFOTT DIVISION

Additionally, two (2) extra windings are present for T1. These windings are center tapped and the voltage is full wave rectified by CR7, CR8 and CR9, and CR10 respectively giving about $\pm 16V$ of unregulated dc. E18 delivers approximately +12 volts of unregulated dc to the update (A) oscillator of A4.

The unregulated ± 16 volts are passed through regulators U1 and U2, the outputs of which deliver ± 12 volts regulated with about 10 mv ripple. The ± 6 volt ref signals are Zenered from the above ± 12 volt regulated supplies. The ± 12 volts are turned on by applying a low to E3 and off by applying a high to E3. This signal in the display is derived from A4 (E1). Since the ± 12 volts are turned off the ± 6 volt references are also turned off. RFI feed through filters FL 1 - FL 8 reduce any noise that is generated by the power supply.



- NOTES:
1. REF DOCUMENTS:
C08753091 - ASSEMBLY
C543020310 - COMPONENT LIST
 2. PARTIAL REF DESIGNATIONS ARE SHOWN.
FOR COMPLETE DESIGNATIONS, PREFIX WITH
UNIT NUMBER OR ASSEMBLY DESIGNATION
OR BOTH.
 3. UNLESS OTHERWISE SPECIFIED:
RESISTANCE VALUES ARE IN OHMS
CAPACITANCE VALUES ARE IN MICROFARADS
 4. ELECTRICAL SYMBOLS ARE IAW USAS Y32.2
 5. LOGIC SYMBOLS ARE IAW MIL-STD-806
 6. REF DESIGNATION ARE IAW ASA Y32.10
 7. COMMON CONNECTION SYMBOL IDENTIFICATION ARE AS FOLLOWS:



REV	STATUS	REV	C	C	-
1	SH	1	2	3	4

CONTRACT NO. **SINGER**

REVISIONS: **28** **11/17/72**

DESCRIPTION: **REVISION STATUS CHANGED**

DATE: **11/17/72**

APPROVED: **11/17/72**

SCHEMATIC DIAGRAM
SECONDARY DISPLAY

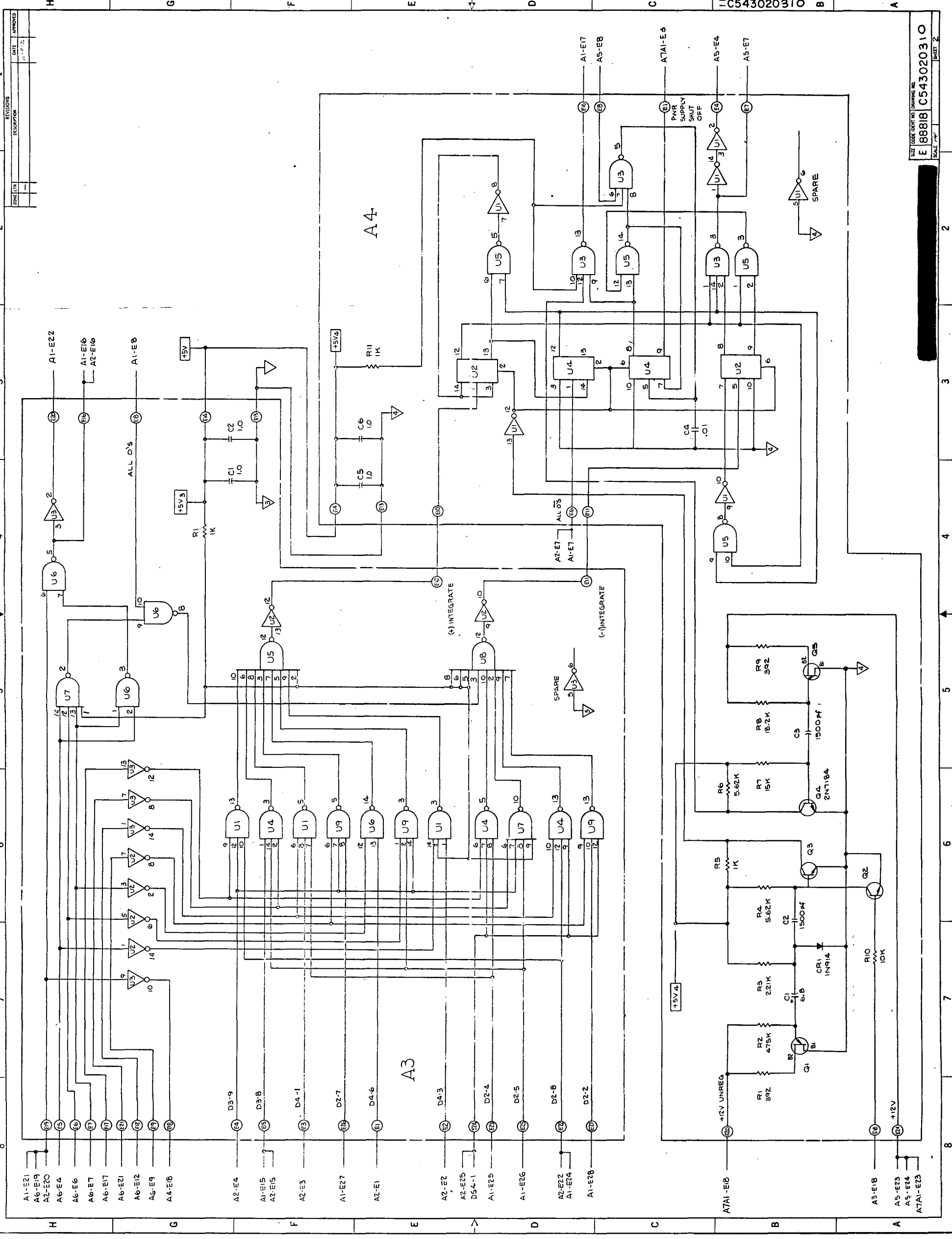
UNIT NO. **88818** **C543020310**

DATE: **11/17/72**

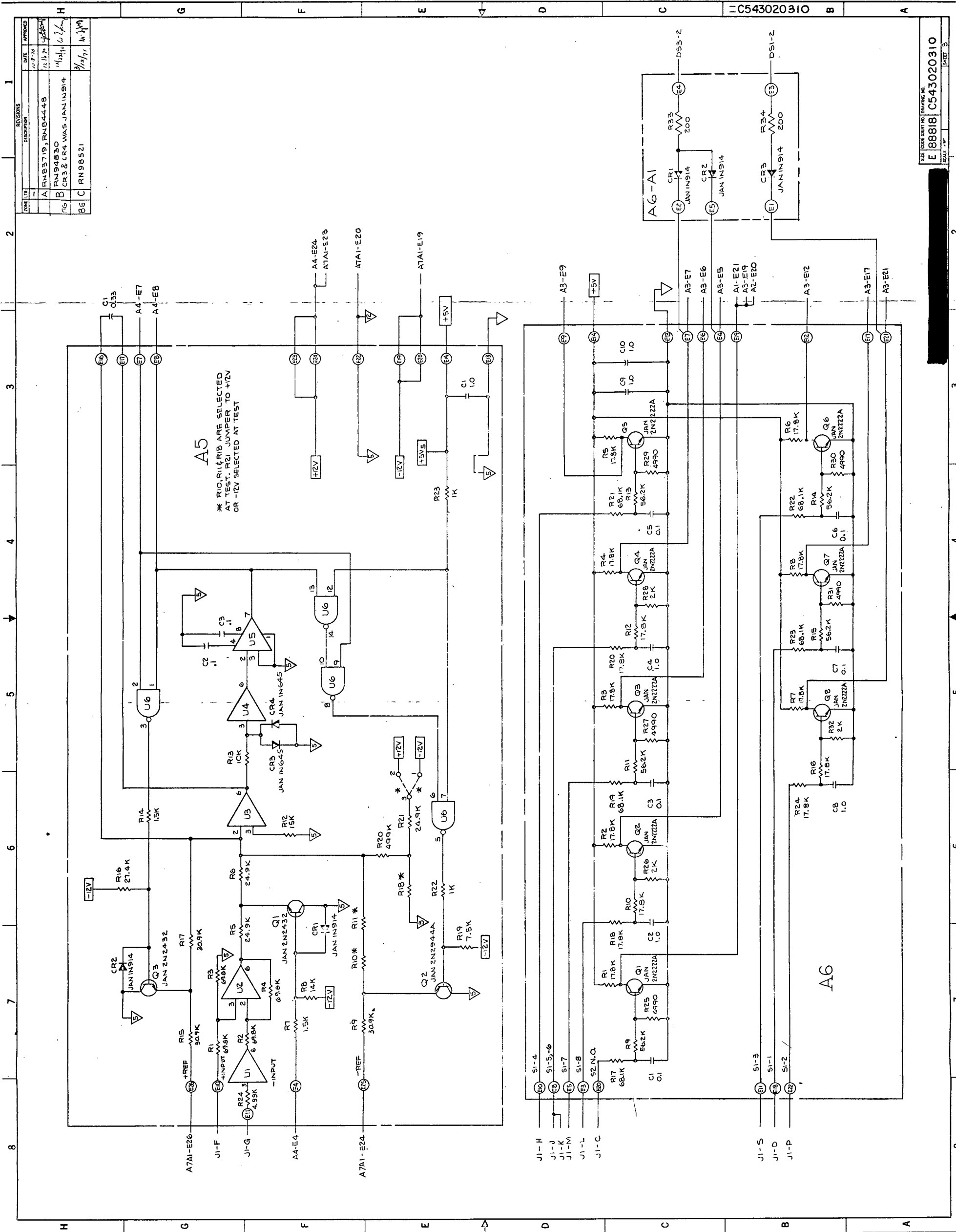
DESIGNED BY: **DRRO1253**

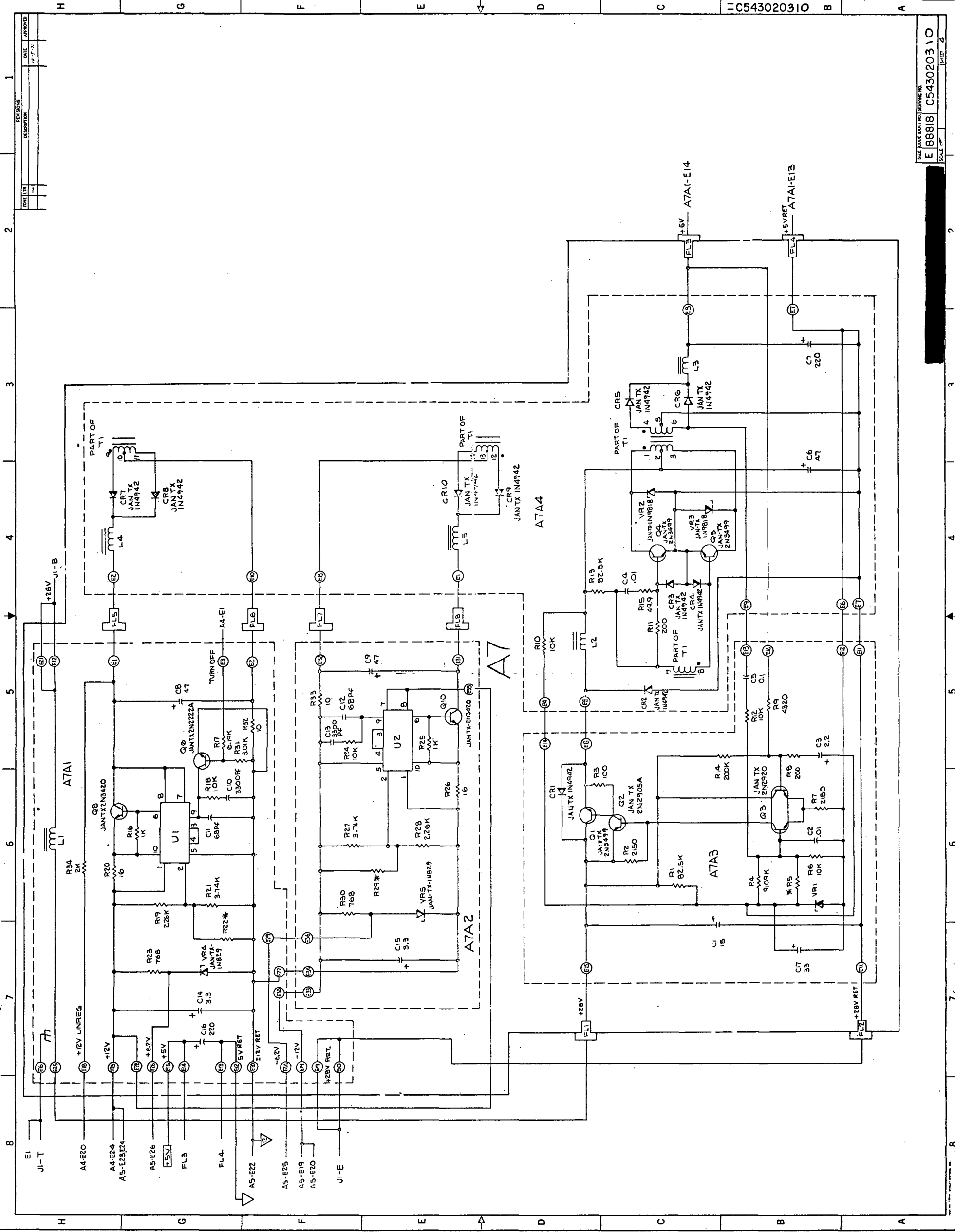
SCALE: **1:1**

SHEET: **1** OF **1**

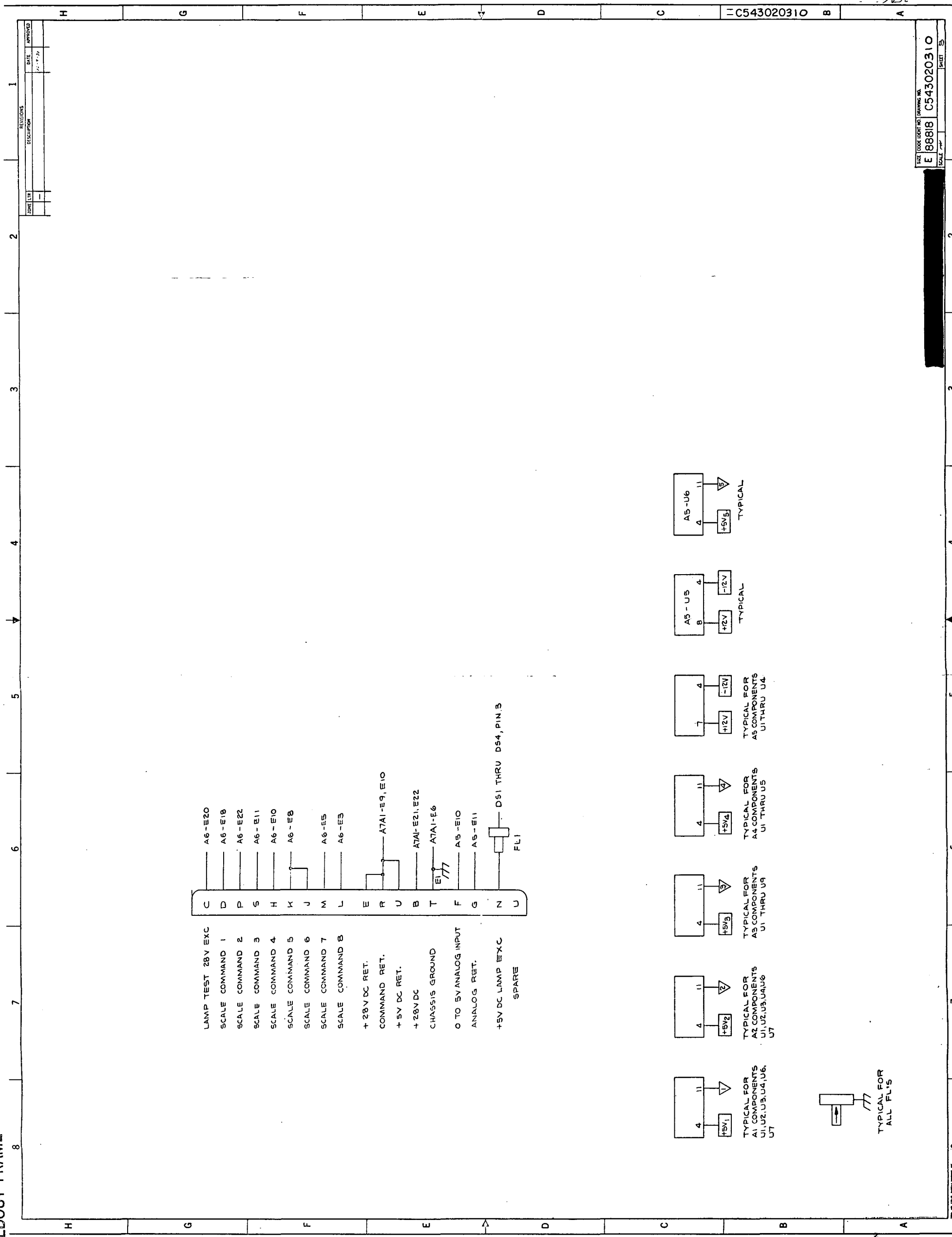


USE FOR LIGHT AND HEAVY WORK
E 88818 C543020310
SCALE 1/4" = 1"





SIZE 100% DATE 10/1/72 DRAWING NO. E 88818 C543020310



4. FOUR-DIGIT DISPLAY

4.1 OPERATIONAL REQUIREMENTS

The 4 digit display responds to a 0-10 volt analog input signal and displays the voltage as BCD 4 digit information. The operation is therefore equivalent to a 0-10 volt DVM. The operation of this unit is completely analogous to the "secondary display." In this case only one scale is available for display, that is 0000-9999. Because of the great similarity between the 4 digit display and "secondary display" the differences will only be outlined.

4.1.1 Differences Between Secondary and Four Digit Display (Refer to Schematic C543020341)

All the circuitry, that is, A1, A2, A4, A5, A7 is similar. The A6 card is eliminated since scale selection is not required. The A3 card is completely changed and its description follows:

4.1.2 A3 Card Description

- a. A 400 KHz oscillator made up of Q2, L1, C4, C5 C7. This oscillator is a typical Hartley Oscillator.
Q3 is an emitter follower which feeds inverter U1 (7). A 400 KC clock pulse is necessary because the indicator has to display a reading of about 10 times the magnitude of the "secondary display". If the 40 KC oscillator of the secondary display were used, an update would take .5 - 1 second which is prohibitive.
- b. Q1 provides a 28/5 volt buffer for the lamp test signal.
- c. U2 provides 1 bit of fifth decade information so that the unit can reset at the number 11000. In the case of the SD, the display was reset at 1100. In this case however, the display is reset at the number 11000 with flip flop U2 performing the function of the dummy fifth number. The waveform of the integration for this display is shown in Figure 5.

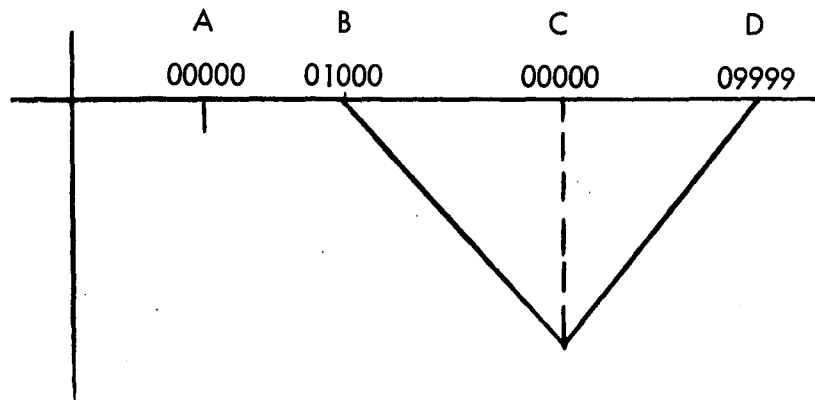
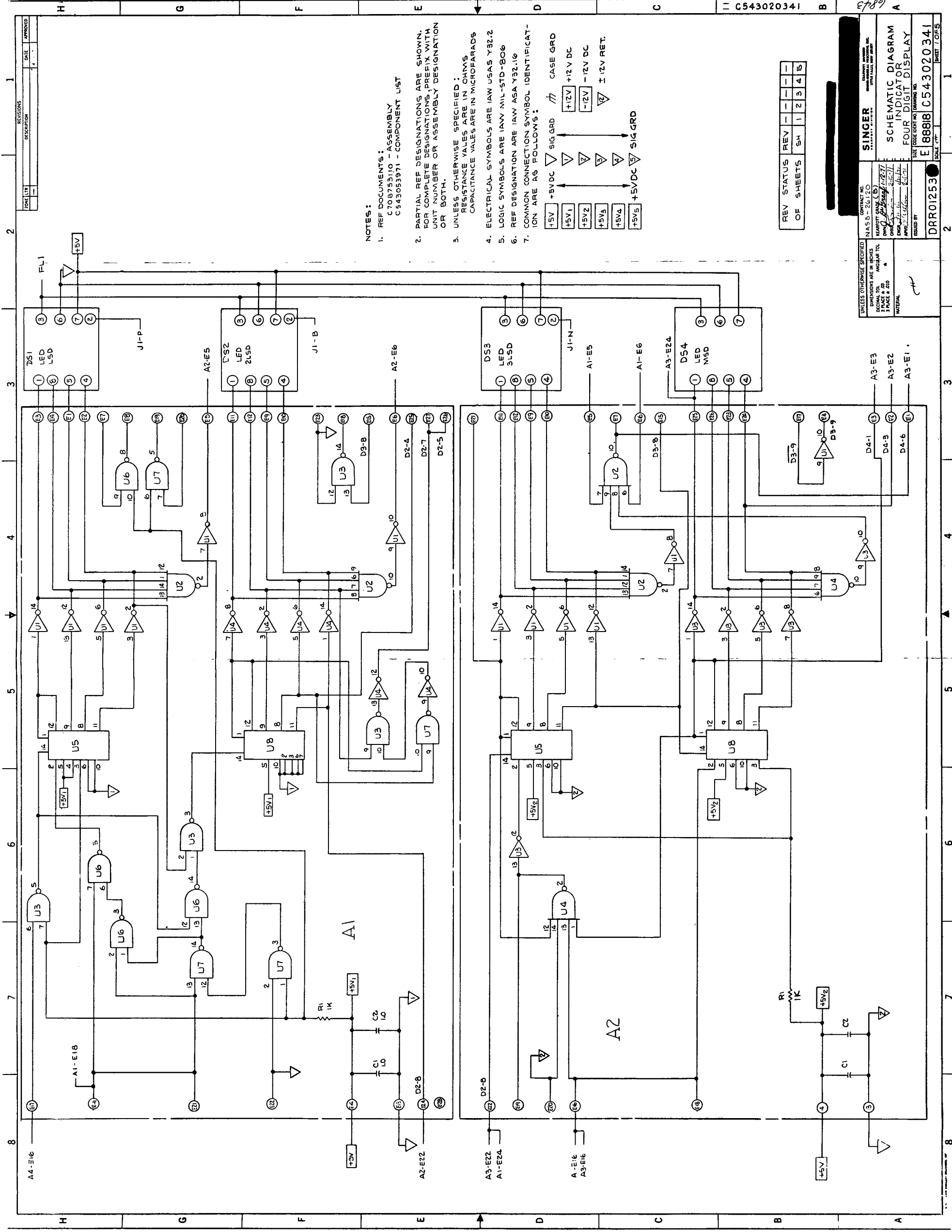
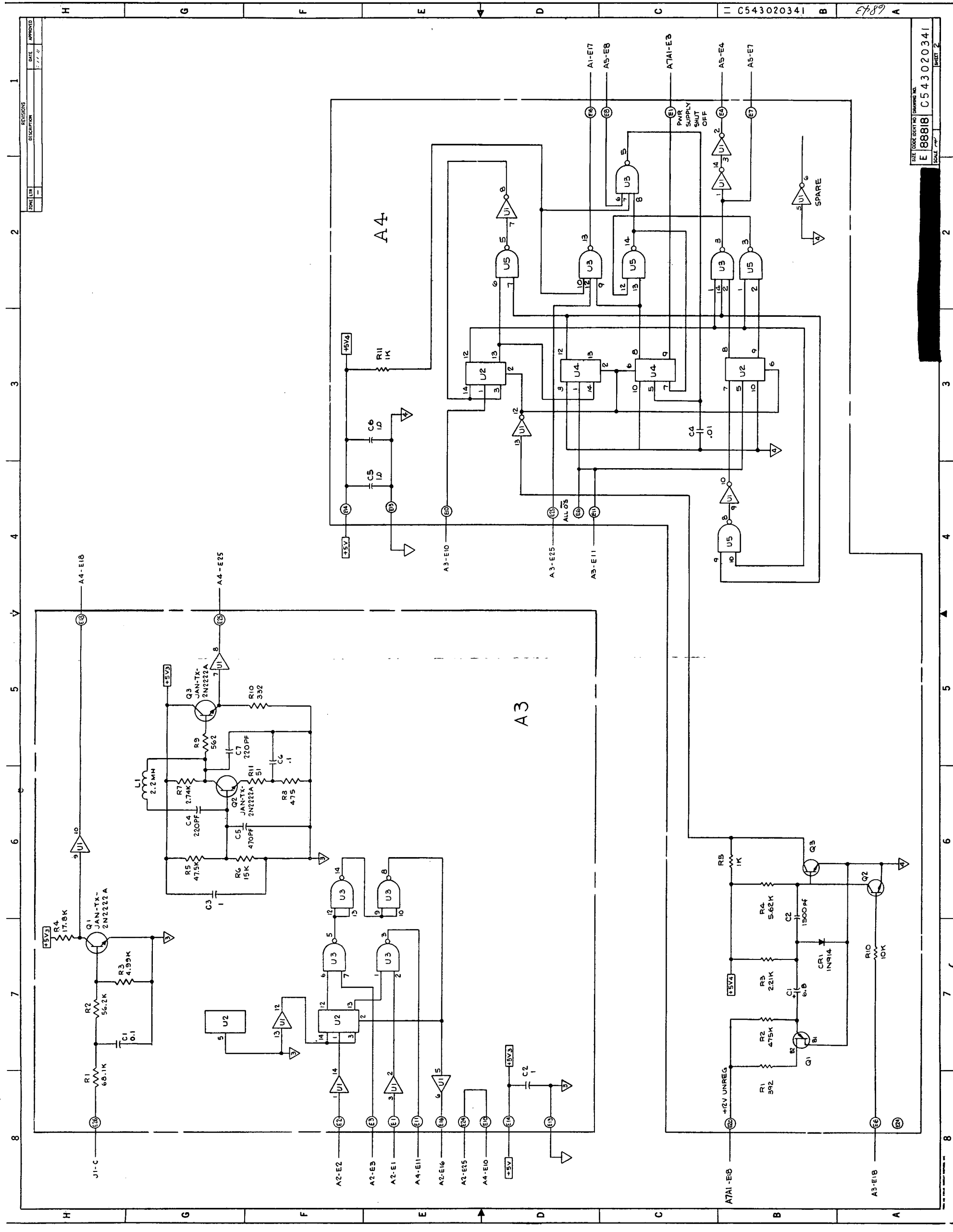
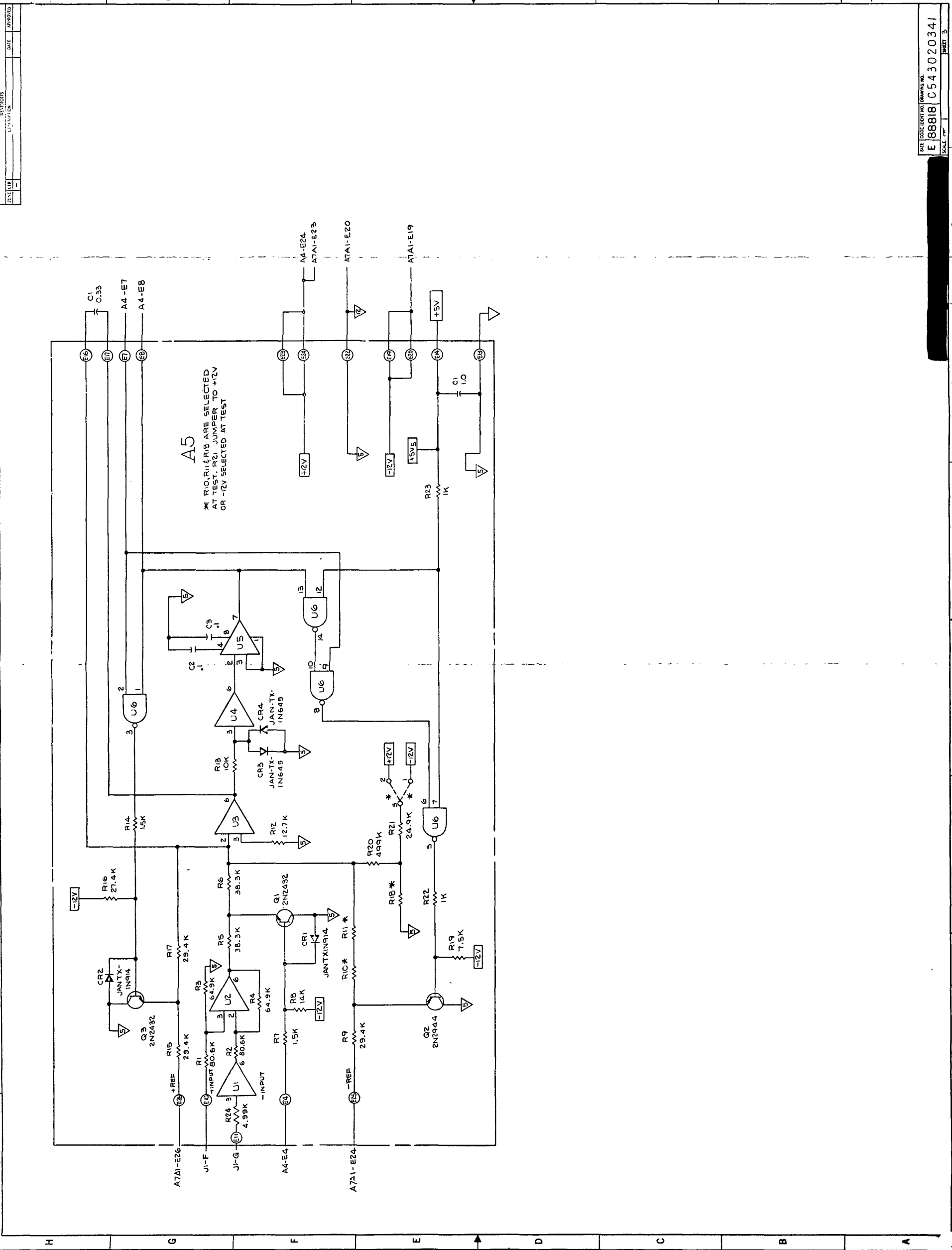


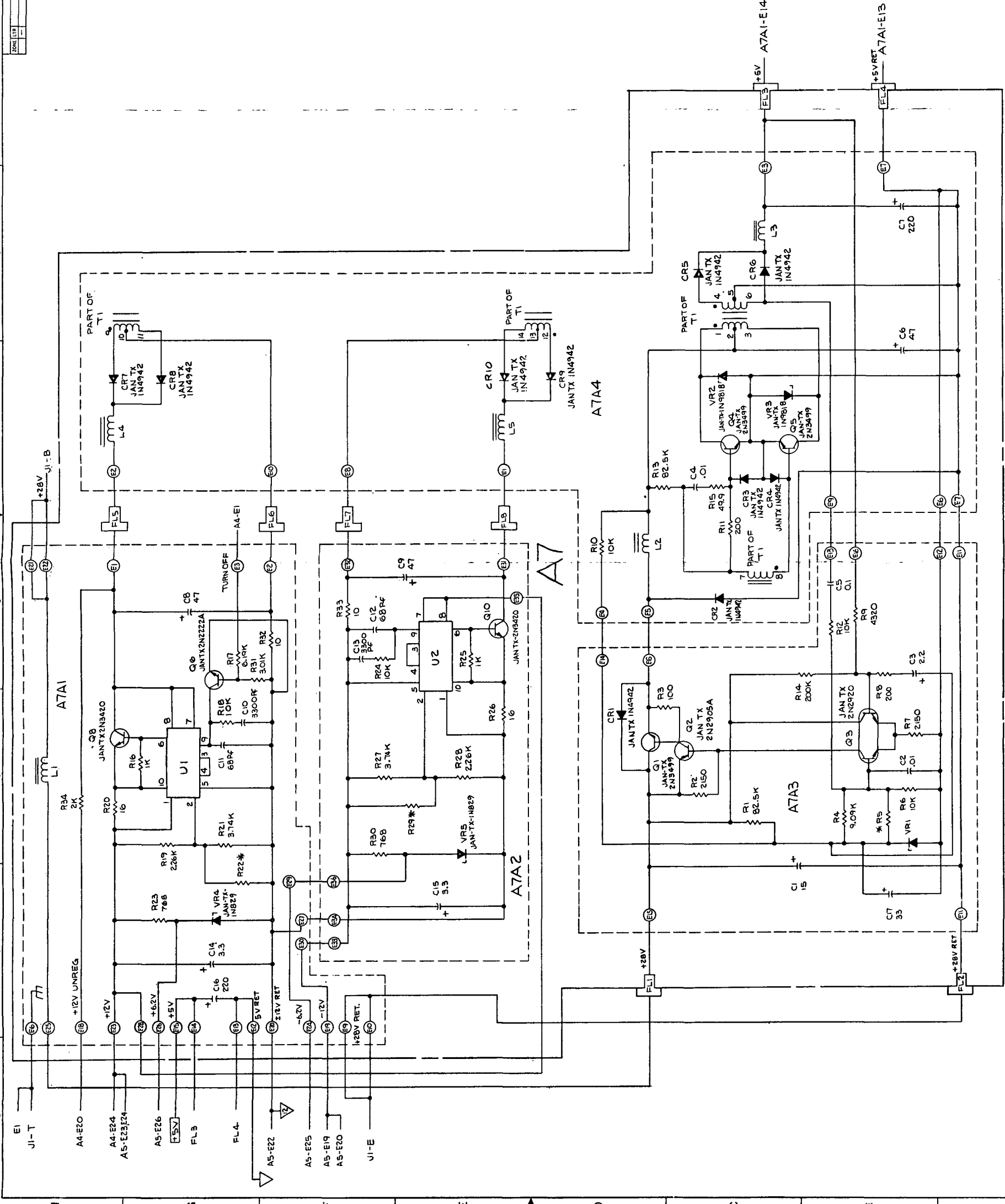
FIGURE 5

Here again the A4 logic sequencer looks for the all 0's condition (A), then for the up integrate signal (B), the down integration signal (C) and finally 0 cross-over (D).



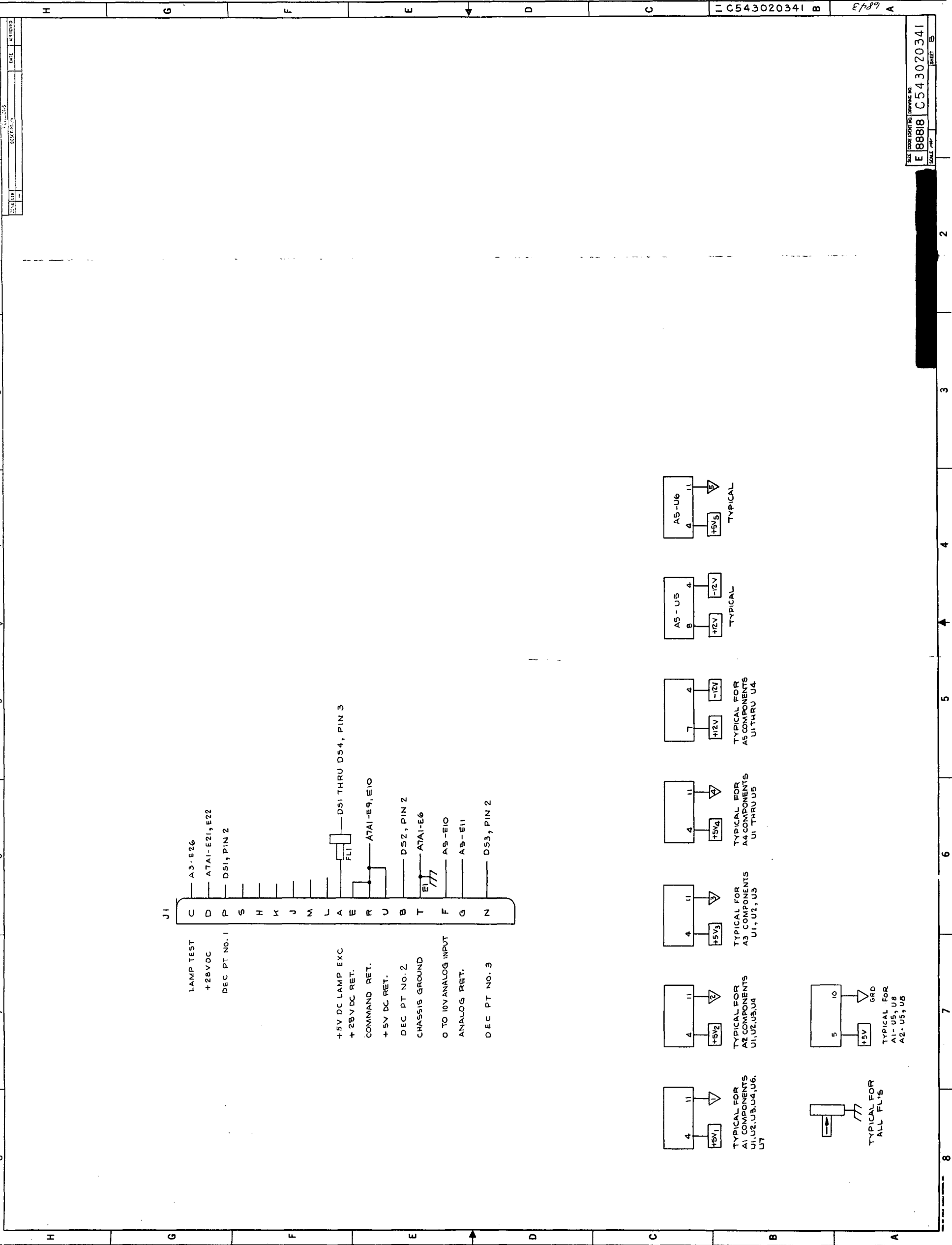






FOLDOUT FRAME 2

FOLDOUT FRAME 1



DATE 10/1/55
E 88818 C 543020341 B
DRAWING NO.
E 88818 C 543020341
SHEET 5

47/48

5. ERROR ANALYSIS (SECONDARY DISPLAY)

The sources of error are basically confined to the analog board A5. These sources are listed as follows:

- a. Scaling resistors
- b. Static amplifier voltage offset
- c. Static current offsets
- d. Static analog switch offsets
- e. Voltage offsets due to temperature variation
- f. Current offsets due to temperature variation
- g. Analog switch offset due to temperature variation
- h. Ref voltage variations due to temperature
- i. Zeroing error

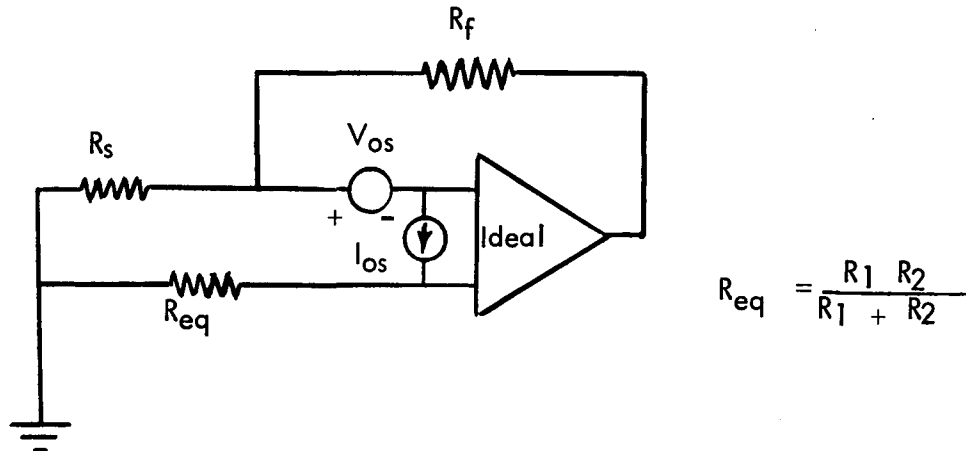
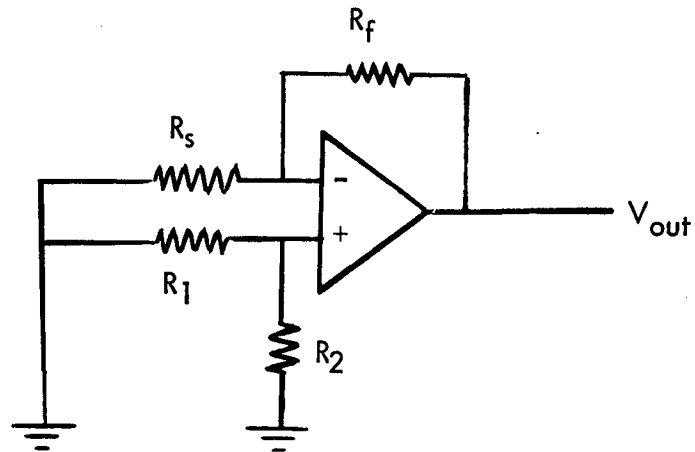
The effect of voltage and current offset can best be seen from the general differential amplifier configuration. Here an ideal amplifier is used in conjunction with a voltage offset source V_{OS} and current offset source I_{OS} ; see Figure 6.

If R_{eq} is made equal to $\frac{R_s R_f}{R_s + R_f}$ then,

$$V_{out} / I_{OS} = I_{OS} R_f.$$

This means that V_{out} / I_{OS} is solely a function of R_f .

It will be assumed that all static voltage current offset errors have been trimmed out using R18 as a trim. Also, the scaling resistor changing with temperature will be ignored since it is assumed that these resistors track each other.



$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

V_{out} due to V_{os} is easily derived to be:

$$V_{out}/V_{os} = \left(1 + \frac{R_f}{R_s} \right) V_{os} \quad (1)$$

V_{out} due to I_{os} can be found similarly to be :

$$V_{out}/I_{os} = I_{os} R_{eq} \left[1 + \frac{R_f}{R_s} \right] \quad (2)$$

FIGURE 6

5.1 VOLTAGE OFFSET DUE TO TEMPERATURE

Listed below are the temperature coefficients of the operational amplifiers:

LM102:

$$V_{os} = 6\mu\text{v}/^{\circ}\text{C}$$

$$I_{os} = \begin{matrix} 30\text{na} & 4\text{na} & 10\text{na} \\ \text{at } -20^{\circ}\text{C} & \text{at } 60^{\circ}\text{C} & \text{at } 25^{\circ}\text{C} \end{matrix}$$

LM107:

$$V_{os} = 15\mu\text{v}/^{\circ}\text{C}$$

$$I_{os} = 0.2\text{na}/^{\circ}\text{C}$$

Offset error due to U1 (LM102):

From eq (1) $\Delta V_{out}/V_{os} = \Delta V_{os}$; Temp. Range $-20^{\circ}\text{C} \longleftrightarrow 60^{\circ}\text{C}$ Rm. Temp. = 25°C

Temp.	Δ (from Rm. Temp)	ΔV_{os}
-20°C	-45°C	$-45 \times 6 = -270\mu\text{v}$
$+60^{\circ}\text{C}$	$+35^{\circ}\text{C}$	$+35 \times 6 = 210\mu\text{v}$

In parts per thousand (ppk) of full scale (5 volts) $= \frac{0.27}{5} \times 10^{-3} = 0.054 \text{ ppk (max) (A)}$

$$\Delta V_{out}/I_{os} = \Delta I_{os} R_{24} = \Delta I_{os} \times 5\text{K}$$

Temp.	ΔI_{os} (from Rm. Temp)	ΔV_{out}
-20°C	$+20\text{na}$	$20 \times 10^{-9} \times 5 \times 10^3 = 100\mu\text{v}$
$+60^{\circ}\text{C}$	-6na	$-6 \times 10^{-9} \times 5 \times 10^3 = -30\mu\text{v}$

In parts per thousand of full scale. $\frac{0.1 \times 10^{-3}}{5} = 0.02 \text{ ppk (max) (B)}$

5.2 OFFSET ERROR DUE TO U2 (LM107)

$$\Delta = V_{out}/V_{os} = (1 + \frac{R_4}{R_2}) \Delta V_{os} = 2 \Delta V_{os} \quad (R_4 = R_2)$$

Temp.	ΔV_{out} (from Rm. Temp)
-20°C	$2 \times 15 \times 10^{-6} \times (-45) = -1350\mu\text{v} = -0.27 \text{ ppk (max) (C)}$
$+60^{\circ}\text{C}$	$2 \times 15 \times 10^{-6} \times (35) = 1050\mu\text{v}$

$$\Delta V_{out}/I_{os} = \Delta I_{os} R_f = 70 \times 10^3 R_f$$

Temp.	ΔV_{out}
-20°C	$-70 \times 10^3 \times 0.2 \times 10^{-9} \times 45 = -630 \mu v = -0.13 \text{ppk (max) (D)}$
+60°C	$70 \times 10^3 \times 0.2 \times 10^{-9} \times 35 = 490 \mu v$

5.3 DRIFT IN THE INTEGRATOR DUE TO OFFSET

When U3 is integrating, current and voltage offsets will cause integrator drift (see Figure 7).

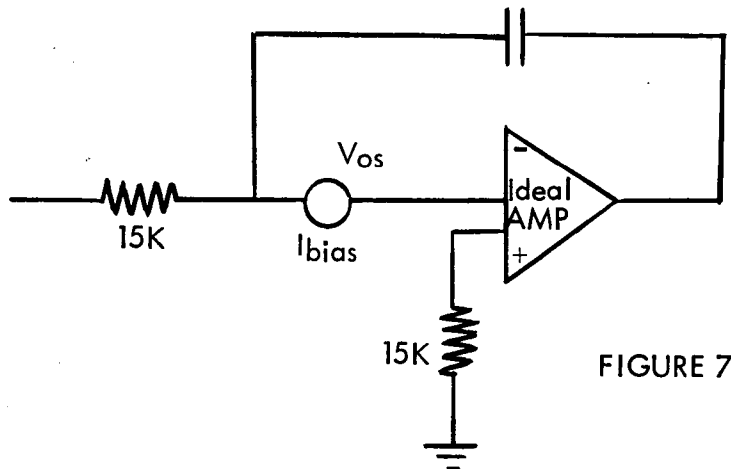


FIGURE 7

$$\text{Integrator drift current due to } V_{os} = \frac{V_{os}}{R}$$

$$\text{Integrator drift current due to bias current} = I_{os}$$

For the LM107: $\Delta I_{os} = 0.2 \text{na}/^\circ\text{C}$

Temp.	$\Delta I_b \text{ offset}$
-20°C	-9na
+60°C	7na

Drift current due to V_{os}

$$I_{\text{drift}} = \frac{15\mu\text{v}}{15\text{k}} / ^\circ\text{C} = 1\text{na}/^\circ\text{C}$$

<u>Temp.</u>	<u>I_{drift} from Room Temp</u>
-20°C	-45 X 1 = -45na
+60°C	+35 X 1 = 35na

The full scale rate of integration is 300v/sec.

The drift rate of integration due to I_{os} is:

$$\frac{dV}{dt} = \frac{\Delta I_{os}}{C} = \frac{-9\text{na}}{.33 \times 10^{-6}} = -27 \times 10^{-3} \text{ v/sec}$$

In parts per thousand this is

$$\frac{27 \times 10^{-3}}{300} = 0.09 \text{ ppk (max) (E)}$$

Similarly for drift due to ΔV_{os} :

$$\frac{dV}{dt} = \frac{45 \times 10^{-9}}{.33 \times 10^{-6}} = .135 \text{ V/second} \rightarrow 0.45 \text{ ppk (F)}$$

Analog switch offset errors; error due to the change in the saturation voltage of Q1, Q2 and Q3 with temperature are taken into account here:

For Q1, Q2 (2N2432) $\Delta V_{\text{offset}} \approx 1\mu\text{v}/^\circ\text{C}$

For Q3 (2N29449) $\Delta V_{\text{offset}} \approx 1\mu\text{v}/^\circ\text{C}$

During the up integration Q1 is off and Q2 and Q3 are on. Since the offset voltages across Q3 and Q2 are opposite in sign, the offsets will essentially cancel each other.

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During the down integration Q1 and Q2 are both on while Q3 is off.

$$\begin{aligned}\text{For Q1 and Q2 } \Delta V_{\text{offset}} &= +35\mu\text{v at } 60^\circ\text{C} \\ &= -45\mu\text{v at } -20^\circ\text{C}\end{aligned}$$

These values will be considered negligible.

Zener references IN829A

$$V_Z = 6.2 \text{ v}$$

$$\text{Max. } T_C = .0005\%/^\circ\text{C} = 30\mu\text{v}/^\circ\text{C}$$

$$\text{For } \Delta T \text{ of } +35^\circ\text{C}, \Delta V_Z = 1\text{mv} = .16\text{ppk}$$

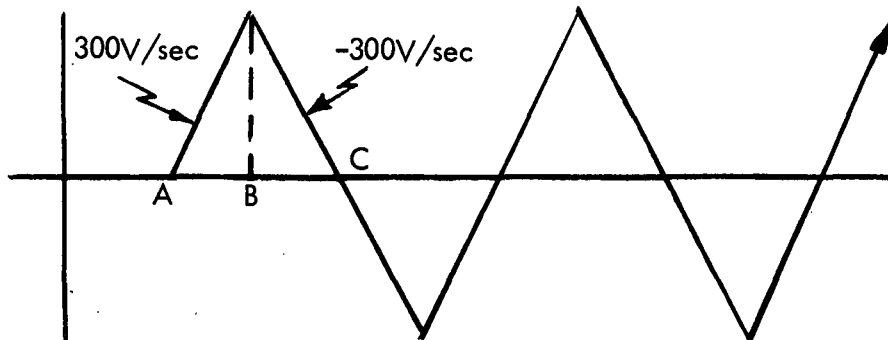
$$\text{For } \Delta T \text{ of } -45^\circ\text{C}, \Delta V_Z = 1.4\text{mV} = .23\text{ppk (max)} \quad (\text{G})$$

U4 Buffer (LM102)

Zeroing Error

U5 (Comparator)

Variations with temperature in the characteristics of these devices will not affect accuracy due to the zeroing process. Conversions will be referenced to the comparator trigger level at the time the conversion takes place.



Shown above is blown up exaggerated view of the zeroing waveform at the output of the

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integrator. The source of this zeroing error is:

- | | |
|----------------------------------|-------|
| 1. Comparator response time | 20ns |
| 2. Gate delay | 33ns |
| 3. Switch storage time | 250ns |
| 4. Switching time (differential) | 100ns |
| 5. Total time from A to B | 400ns |
| 6. Total time from B to C | 400ns |

The time for 1 cycle 1.6 μ s

Therefore - f (zeroing) = 600KHz

Maximum zeroing voltage $V_{max} = 300 \times 400 \times 10^{-9} = .12 \text{ mv}$

Scales 2 and 4 have the lowest full scale excursion of the integrating signal. This voltage is about 0.8 volts.

The effect therefore of the zeroing error is maximum on this scale and is given by

$$\frac{.12 \times 10^{-3}}{.8} = .15 \text{ ppk (H)}$$

All the errors found above will be RSS'd to give an overall accuracy.

	ERROR IN PPK	ERROR 2
A. Voltage offsets U1	.05	.0025
B. Current offsets U1	.02	.0004
C. Voltage offsets U2	.27	.07
D. Current offsets U2	.13	.017
E. Current offsets U3	.09	0.008
F. Voltage offsets U3	.45	0.2

Analog switch offsets

Q1, Q2, Q3 negligible

G. Zener references	.23	.053
H. Zeroing error	.15	.023
		0.374

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$$\Sigma \text{ error}^2 = .374$$

$$\text{error} \quad .61 \text{ ppk} = .061\% \text{ of full scale}$$

With an accuracy requirement for the secondary display of 0.4% of full scale, the indicator is well within specification.

6. ERROR (FOUR-DIGIT DISPLAY)

The error analysis for the 4 digit display is basically the same as that of the secondary display. With an accuracy requirement of 0.2 percent of full scale, the indicator is well within specification.

7. SUMMARY AND CONCLUSIONS

The secondary display as well as the metabolic display exhibited exceptional accuracy during pre ATP tests. The units were run from 0-140°F and reading variations of less than 0.1 percent were typical over this temperature range.

A problem that frequently occurs with a high input impedance differential input is common mode voltages. These voltages occur because the ground of the signal source is different than the power ground of the display. This usually results in 60 Hz (or whatever line frequency the supplies are run from) signal between the grounds. The signal essentially acts as a common mode voltage on the differential input. As long as this voltage remains below the $\pm 12\text{v}/\text{amp}$ supplies, the common mode voltage will be ignored by the amplifier.

Once the common mode voltage together with the input signal exceeds 11-12 volts the op amp will saturate and accuracy will be lost. The solution to this problem is to tie the low analog signal input back to the display power ground. This is eventually done in the system anyway.

It was noted that some LM102 U1 (on A5 board), tended to oscillate whenever the input was tied to ground through a low impedance source. This of course affected accuracy. National Semiconductor (the manufacturer) confirmed this possibility and suggested that a larger than 2K resistor be put in series with the signal (R24). This eliminated the oscillation problem. The accuracy was not affected since the input impedance is greater than 100 megohms. This 5K resistor also serves as a current limiter to any transients or accidental voltages placed on the low input.

It was noted during the program that the input to the LM102 was overstressed due to excessive current input. National Semiconductor states that this input pin (2) can take in excess of

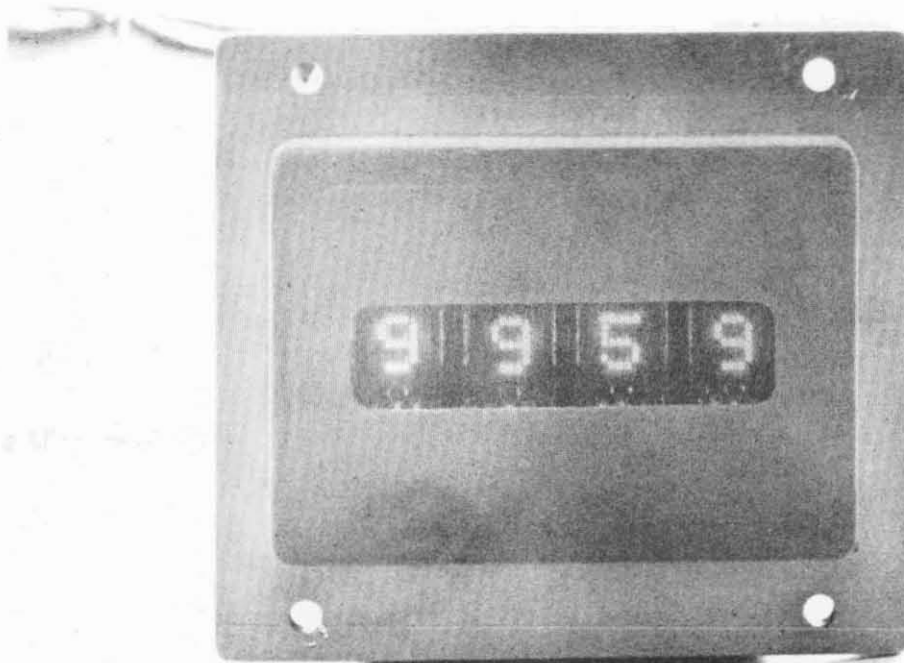
400 ma before the conductor run in the chip metalizes. With 5K input resistance, this kind of current would require voltages that are not normally available. (Refer to reliability failure analysis report in Appendix D.)

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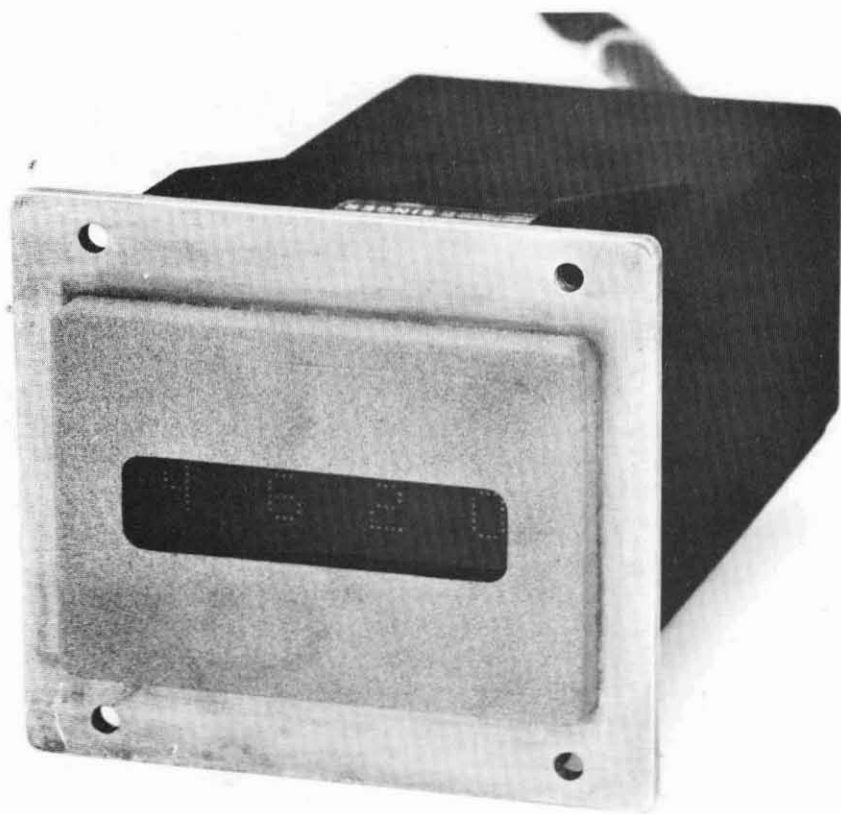
APPENDIX A
MECHANICAL ASPECTS

PHOTOGRAPHS OF SKYLAB DISPLAYS

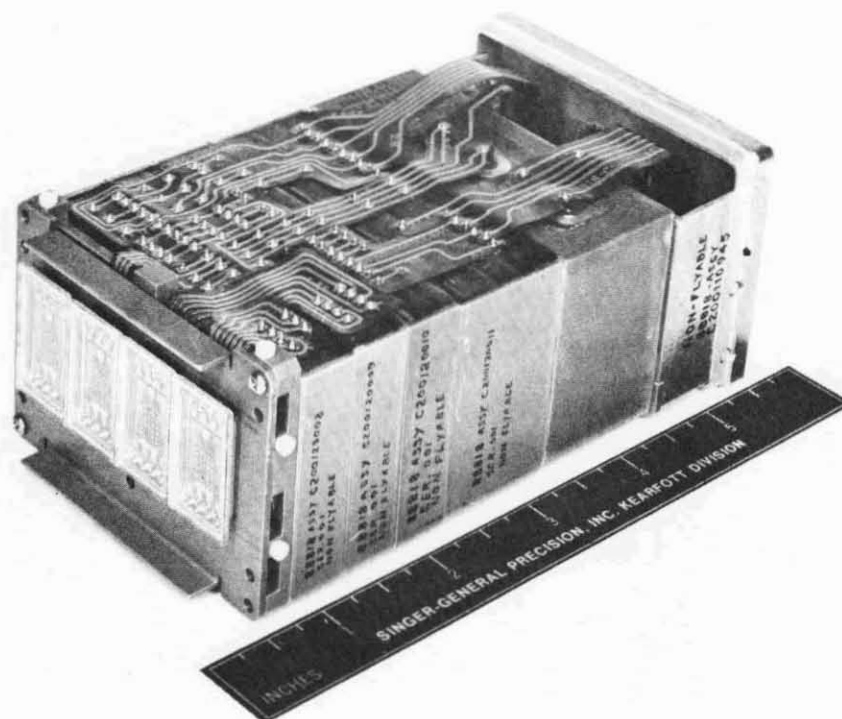
The following photos depict various views of the Event Timer. The Secondary Display and Metabolic Display are identical except for their length.



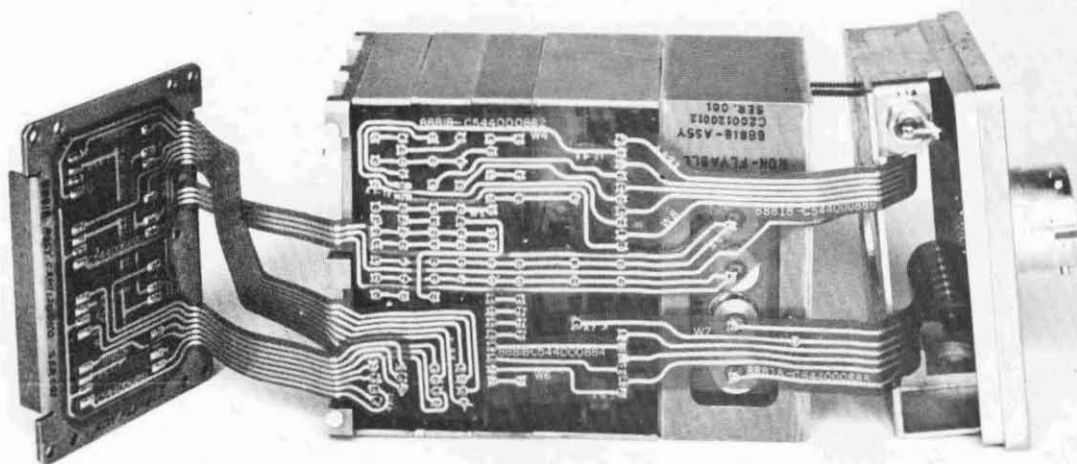
EVENT TIMER



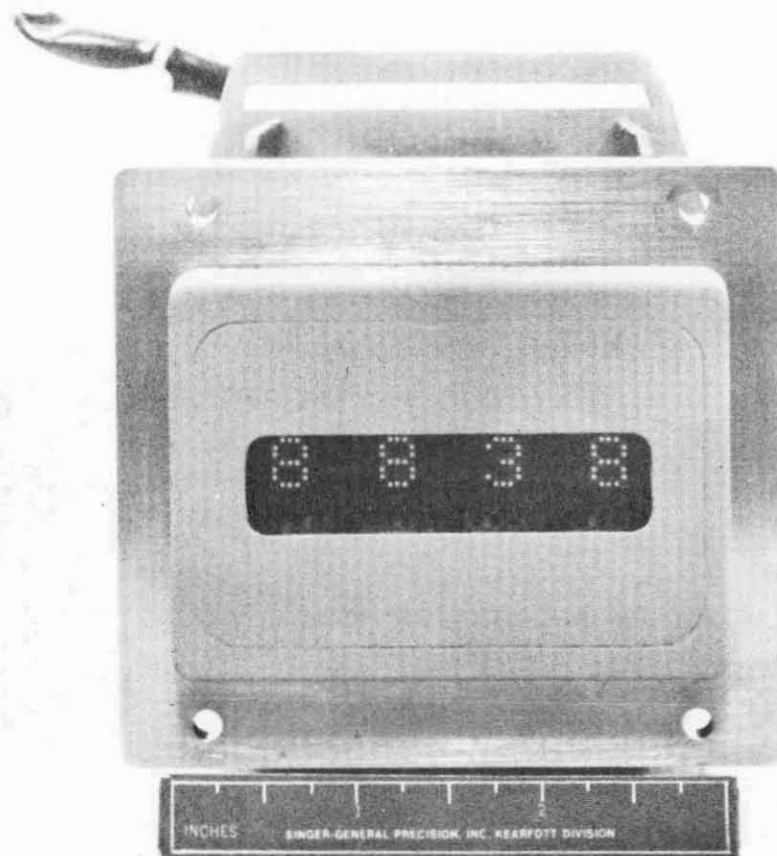
EVENT TIMER



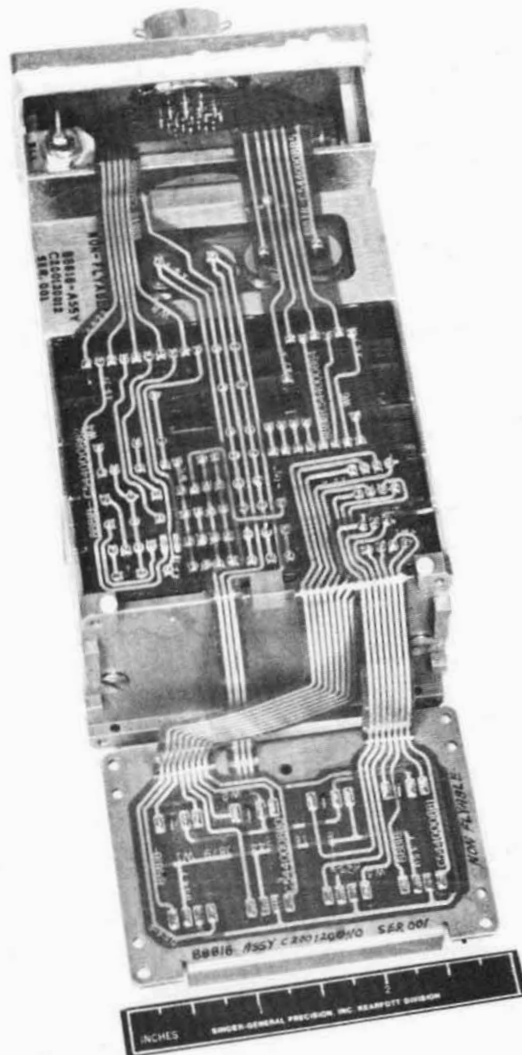
EVENT TIMER



EVENT TIMER



EVENT TIMER



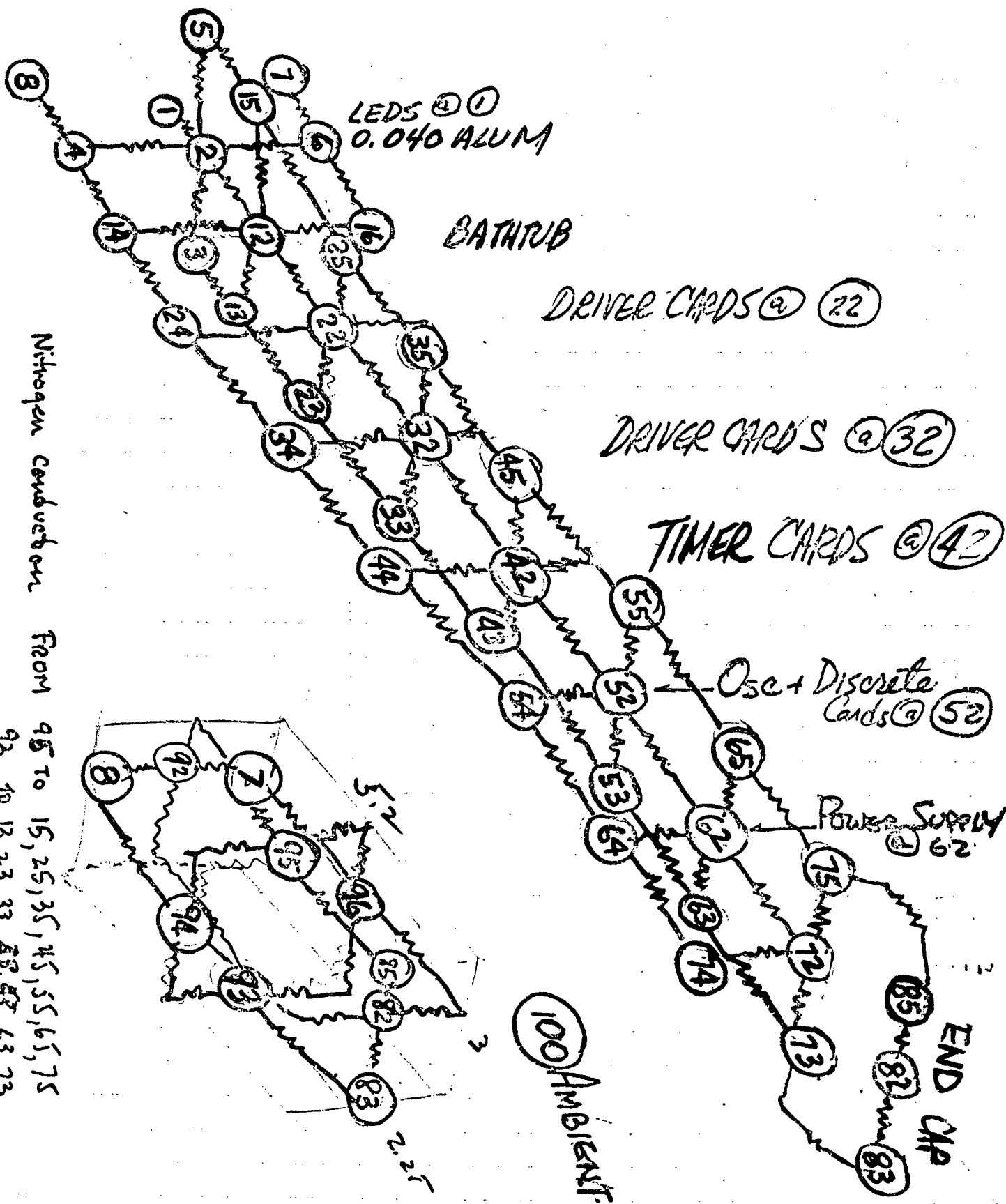
EVENT TIMER

THERMAL ANALYSIS DATA

SKYLAB 140 DEG F VACUUM WITH THERMAL CLIPS&NO CARD HEAT SINKS

2.600 WATT	LED	182.0 DEG F
.129 WATT	DRIVER CARDS	180.7 DEG F
.129 WATT	DRIVER CARDS	183.8 DEG F
.189 WATT	TIMER CARDS	185.9 DEG F
.133 WATT	OSC+DISCRETES CARDS	185.8 DEG F
.928 WATT	POWER SUPPLY CARDS	191.5 DEG F
.005 WATT	FILTERS	167.5 DEG F

07/23/70



I	T(I)	R(I)	NODE/NODE	C(I)	Q(I)
1	.18203809 E+03	.10300000 E+02	1 2		.26000000 E+01
2	.18051431 E+03	.12620000 E+03	2 3		
3	.17842954 E+03	.47800000 E+02	2 4		
4	.17771650 E+03	.12620000 E+03	2 5		
5	.17842954 E+03	.47800000 E+02	2 6		
6	.17778354 E+03	.18150000 E+03	4 8		
7	.16764215 E+03	.18150000 E+03	6 7		
8	.16812931 E+03	.12880000 E+03	6 16		
11		.12880000 E+03	4 14		
12	.17757271 E+03	.35800000 E+02	12 16		
13	.17781008 E+03	.37200000 E+02	3 13		
14	.17697378 E+03	.37200000 E+02	5 15		
15	.17781008 E+03	.25910000 E+04	14 94		
16	.17761960 E+03	.37420000 E+04	13 93		
17		.37420000 E+04	15 95		
18		.74800000 E+02	12 13		
19		.35800000 E+02	12 14		
20		.74800000 E+02	12 15		
21		.22740000 E+03	14 24		
22	.18071444 E+03	.36290000 E+03	12 22		.12900000 E+00
23	.17467372 E+03	.32840000 E+03	13 23		
24	.17301297 E+03	.32840000 E+03	15 25		
25	.17467372 E+03	.98460000 E+03	24 94		
26		.14220000 E+04	23 93		
27		.14220000 E+04	25 95		
28		.97200000 E+04	22 23		
29		.46480000 E+04	22 24		
30		.97200000 E+04	22 25		
31		.24250000 E+03	24 34		
32	.18375359 E+03	.72200000 E+03	22 32		.12900000 E+00
33	.16765132 E+03	.35030000 E+04	23 33		
34	.17066088 E+03	.35030000 E+04	25 35		
35	.16765132 E+03	.98460000 E+03	34 94		
36		.14220000 E+04	33 93		
37		.14220000 E+04	35 95		
38		.97200000 E+04	32 33		
39		.46480000 E+04	32 34		
40		.97200000 E+04	32 35		
41		.24250000 E+03	34 44		
42	.18591407 E+03	.72200000 E+03	32 42		.18900000 E+00
43	.16613654 E+03	.35030000 E+04	33 43		
44	.16932018 E+03	.35030000 E+04	35 45		
45	.16613654 E+03	.98460000 E+03	44 94		
46		.14220000 E+04	43 93		
47		.14220000 E+04	45 95		
48		.97200000 E+04	42 43		
49		.46480000 E+04	42 44		
50		.97200000 E+04	42 45		
51		.26240000 E+03	44 54		
52	.18577674 E+03	.10818000 E+04	42 52		.13300000 E+00
53	.16604059 E+03	.30670000 E+03	43 53		
54	.16840938 E+03	.30670000 E+03	45 55		
55	.16604059 E+03	.65640000 E+03	54 94		
56		.94810000 E+03	53 93		
57		.94810000 E+03	55 95		

58		.64800000 E+04	52	53	
59		.31050000 E+04	52	54	
60		.64800000 E+04	52	55	
61		.28230000 E+03	54	64	
62	.19152133 E+03	.14413000 E+04	52	62	.92800000 E+00
63	.16595050 E+03	.40780000 E+03	63	53	
64	.16784407 E+03	.40780000 E+03	55	65	
65	.16595050 E+03	.49230000 E+03	64	94	
66		.71110000 E+03	63	93	
67		.71110000 E+03	65	95	
68		.64800000 E+04	62	63	
69		.31050000 E+04	62	64	
70		.64800000 E+04	62	65	
71		.24250000 E+03	64	74	
72	.16747418 E+03	.72200000 E+03	62	72	.50000000 E-02
73	.16559636 E+03	.35030000 E+04	63	73	
74	.16751464 E+03	.35030000 E+04	65	75	
75	.16559636 E+03	.16410000 E+05	74	94	
76		.85330000 E+03	73	93	
77		.85330000 E+03	75	95	
78		.12420000 E+03	75	85	
79		.12420000 E+03	73	83	
80		.35800000 E+02	72	74	
81		.84700000 E+02	82	85	
82	.16297772 E+03	.84700000 E+02	82	83	
83	.16378466 E+03	.15400000 E+03	82	96	
84		.15400000 E+03	82	94	
85	.16378466 E+03	.14350000 E+03	83	93	
86		.14350000 E+03	85	95	
87		.62700000 E+02	93	96	
88		.62700000 E+02	93	94	
89		.10760000 E+03	94	8	
90		.62700000 E+02	94	95	
91		.22640000 E+03	95	92	
92	.16305837 E+03	.62700000 E+02	95	96	
93	.16305563 E+03	.10760000 E+03	96	7	
94	.16376330 E+03	.41410000 E+03	7	92	
95	.16305563 E+03	.41410000 E+03	8	92	
96	.16282101 E+03	.22640000 E+03	93	92	
97		.98840544 E+03	82	100	
98		.57012360 E+03	93	100	
99		.42684206 E+03	94	100	
100	.14000000 E+03	.57012360 E+03	95	100	-1
101		.42784189 E+03	96	100	
102		.98820751 E+03	92	100	
103		.10770000 E+03	72	73	
104		.10770000 E+03	72	75	

Conduction k BTU/MIN-IN-°F

$$k_{\text{potting}} = .0001486$$

$$k_{\text{alum}} = .161$$

$$k_{\text{nitrogen}} = .000025$$

$$\text{gap} \sim .032$$

Res. of pressure contact

$$\text{Assume } \frac{1 \text{ in}^2 \cdot 5^\circ\text{C}}{\text{W}} \text{ or } 15.81 \frac{^\circ\text{F} \cdot \text{in}^2}{\text{BTU/MIN}}$$

Res. of thermal clip

$$(5.125)(2) \frac{\text{W} \cdot ^\circ\text{C}}{\text{W}} = 10.25 \frac{^\circ\text{C} \cdot \text{in}}{\text{W}} \text{ or } 324.25 \frac{^\circ\text{F} \cdot \text{in}}{\text{BTU/MIN}}$$

SKYLAB 140 DEG F VACUUM WITHOUT THERMAL CLIPS&NO CARD HEAT SINKS .

2.600 WATT	LED	210.0 DEG F
.129 WATT	DRIVER CARDS	201.4 DEG F
.129 WATT	DRIVER CARDS	197.8 DEG F
.189 WATT	TIMER CARDS	195.3 DEG F
.133 WATT	OSC+DISCRETES CARDS	190.8 DEG F
.928 WATT	POWER SUPPLY CARDS	193.3 DEG F
.005 WATT	FILTERS	168.0 DEG F

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SKYLAB SEC. DISPLAY 140 DEG F VACUUM-THERMAL CLIPS&NO CD SINKS

3.000 WATT LED	194.0 DEG F
.860 WATT TIMING CARD	202.5 DEG F
.040 WATT TIMING CARD	198.1 DEG F
.190 WATT DISCRETE CARD	198.2 DEG F
.070 WATT 12V SUPPLY	196.6 DEG F
1.300 WATT 5V SUPPLY	208.2 DEG F

07/31/70

I	T(I)	R(I)	NODE/NODE	C(I)	C(I)
1	.19403220 E+03	.10300000 E+02	1 2		.30000000 E+01
2	.19227144 E+03	.12620000 E+03	2 3		
3	.19023976 E+03	.47800000 E+02	2 4		
4	.18891781 E+03	.12620000 E+03	2 5		
5	.19023976 E+03	.47800000 E+02	2 6		
6	.18900685 E+03	.18150000 E+03	4 8		
7	.17579295 E+03	.18150000 E+03	6 7		
8	.17644472 E+03	.12630000 E+03	6 16		
11		.12830000 E+03	4 14		
12	.18973665 E+03	.35800000 E+02	12 16		
13	.18964172 E+03	.37200000 E+02	3 13		
14	.18572709 E+03	.37200000 E+02	5 15		
15	.18964172 E+03	.25910000 E+04	14 94		
16	.18957930 E+03	.37420000 E+04	13 93		
17		.37420000 E+04	15 95		
18		.74800000 E+02	12 13		
19		.35800000 E+02	12 14		
20		.74800000 E+02	12 15		
21		.22740000 E+03	14 24		
22	.20253629 E+03	.36290000 E+03	12 22		.86000000 E+00
23	.18565671 E+03	.32840000 E+03	13 23		
24	.18353732 E+03	.32840000 E+03	15 25		
25	.18565671 E+03	.98460000 E+03	24 94		
26		.14220000 E+04	23 93		
27		.14220000 E+04	25 95		
28		.97200000 E+04	22 23		
29		.46460000 E+04	22 24		
30		.97200000 E+04	22 25		
31		.24250000 E+03	24 34		
32	.19812820 E+03	.72200000 E+03	22 32		.40000000 E-01
33	.17603287 E+03	.35030000 E+04	23 33		
34	.18015521 E+03	.35030000 E+04	25 35		
35	.17603287 E+03	.98460000 E+03	34 94		
36		.14220000 E+04	33 93		
37		.14220000 E+04	35 95		
38		.97200000 E+04	32 33		
39		.46460000 E+04	32 34		
40		.97200000 E+04	32 35		
41		.24250000 E+03	34 44		
42	.19815153 E+03	.72200000 E+03	32 42		.19000000 E+00
43	.17372042 E+03	.35030000 E+04	33 43		
44	.17814611 E+03	.35030000 E+04	35 45		
45	.17372042 E+03	.98460000 E+03	44 94		
46		.14220000 E+04	43 93		
47		.14220000 E+04	45 95		
48		.97200000 E+04	42 43		
49		.46460000 E+04	42 44		
50		.97200000 E+04	42 45		
51		.24250000 E+03	44 54		
52	.19857589 E+03	.18817000 E+04	42 52		.70000000 E-01
53	.1735 781 E+03	.35030000 E+03	43 53		
54	.176 0125 E+03	.35030000 E+03	45 55		
55	.1735 781 E+03	.65630000 E+03	54 94		
56		.92310000 E+03	53 93		
57		.92310000 E+03	55 95		

58		.64800000 E+04	52	53	
59		.31050000 E+04	52	54	
60		.64800000 E+04	52	55	
61		.28230000 E+03	54	64	
62	.20817125 E+03	.14413000 E+04	52	62	.13000000 E+01
63	.17357679 E+03	.40780000 E+03	63	53	
64	.17616591 E+03	.40780000 E+03	55	65	
65	.17357679 E+03	.49230000 E+03	64	94	
66		.71110000 E+03	63	93	
67		.71110000 E+03	65	95	
68		.64800000 E+04	62	63	
69		.31050000 E+04	62	64	
70		.64800000 E+04	62	65	
71		.24250000 E+03	64	74	
72	.17572205 E+03	.72200000 E+03	62	72	.50000000 E-02
73	.17321657 E+03	.35030000 E+04	63	73	
74	.17577163 E+03	.35030000 E+04	65	75	
75	.17321657 E+03	.16410000 E+05	74	94	
76		.85330000 E+03	73	93	
77		.85330000 E+03	75	95	
78		.12420000 E+03	75	85	
79		.12420000 E+03	73	83	
80		.35800000 E+02	72	74	
81		.84700000 E+02	82	85	
82	.16973360 E+03	.84700000 E+02	82	83	
83	.17080596 E+03	.15400000 E+03	82	96	
84		.15400000 E+03	82	94	
85	.17080596 E+03	.14350000 E+03	83	93	
86		.14350000 E+03	85	95	
87		.62700000 E+02	93	96	
88		.62700000 E+02	93	94	
89		.10760000 E+03	94	8	
90		.62700000 E+02	94	95	
91		.22640000 E+03	95	92	
92	.16980969 E+03	.62700000 E+02	95	96	
93	.16983395 E+03	.10760000 E+03	96	7	
94	.17077426 E+03	.41410000 E+03	7	92	
95	.16983395 E+03	.41410000 E+03	8	92	
96	.16951175 E+03	.22640000 E+03	93	92	
97		.97197949 E+03	82	100	
98		.56061797 E+03	93	100	
99		.41948513 E+03	94	100	
100	.14000000 E+03	.56061797 E+03	95	100	-1
101		.42079928 E+03	96	100	
102		.97179625 E+03	92	100	
103		.10770000 E+03	72	73	
104		.10770000 E+03	72	75	

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APPENDIX B
VIBRATION TEST REPORT

SINGER

SINGER-GENERAL PRECISION, INC.
KEARFOTT DIVISION
LITTLE FALLS, NEW JERSEY 07424

C194010241

REV —

CODE IDENT NO. 88818

DATE _____

VIBRATION TEST REPORT

ON
EVENT TIMER

PART NO. C708753100

TEST PERFORMED BY:

SINGER-GENERAL PRECISION, INC.
KEARFOTT DIVISION
LITTLE FALLS, NEW JERSEY 07424

CONTRACT NO. NAS 8-26120

TEST INITIATED 1/29/71 DATE COMPLETED 2/5/71

TEST REPORT PREPARED BY F Miller DATE 2/24/71

TEST PERFORMED BY W. Ruppberg DATE 2/24/71

APPROVALS: JR Attwood DATE 2/24/71

C. L. O. DATE 2/24/71

CONTROL: _____

REVISION RECORD

REV	DESCRIPTION	APPROVAL AND DATE
—	RELEASE	~~Hand~~ 2-24-71

REV	—																			—
PAGE	1 & 2																			OTHER
REVISION SYMBOL OF REVISED PAGES																				PAGES
ASTERISKS (*) SHOWN LOCATE CHANGES FROM PREVIOUS ISSUE FOR CONVENIENCE ONLY - NO LIABILITY ASSUMED																				

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2. DESCRIPTION OF EVENT TIMER	4
3. REFERENCES	5
4. FACTUAL DATA	5
4.1 Description of Test Apparatus	5
4.2 Test Procedures	5
4.2.1 Vehicle Dynamics	5
4.2.2 Sine Evaluation	5
4.2.3 High Level Vibration(1 min/axis).	6
4.2.4 Low Level Vibration (4 min/axis).	6
4.3 Test Results	6
4.4 Test Data	7
4.5 Test Equipment	7

1. REASON FOR TEST. The Event Timer was tested to evaluate its compliance to the following specifications:

NASA-MSFC

40M3807

Event Timer,
Specification for

50M02408
Appendix A

Vibration Criteria for
ATM Rack

2. DESCRIPTION OF EVENT TIMER.

2.1 The Event Timer Part No. C708753100 has a four digit display of minutes and seconds. The display counts backwards toward zero-zero-zero-zero. The Timer has an internal 1 megahertz (MHz) clock which it divides down to display time on its light emitting diode numerical displays. An internal power supply generates the dc levels from 28 volts direct current (Vdc). The display can be stopped, started, slewed, and lamp tested with external command signals.

2.2 Item Tested.

<u>NOMENCLATURE</u>	<u>PART NUMBER</u>	<u>SERIAL NUMBER</u>
Event Timer	C708753100	202

2.3 Disposition of Test Sample. Upon completion of tests, a complete acceptance test was performed and the unit shipped.

3. REFERENCES. The following documents are referenced in this Test Report:

Singer-Kearfott Division

TPC198261244

Vibration Qualification Test
Procedure with Integral Log

NASA-MSFC

40M38207

Specification for Event Timer

50M02408
Appendix A

Vibration Criteria for ATM Rack

4. FACTUAL DATA

4.1 Description of Test Apparatus. The tests were made with the Event Timer connected to its Test Set. During each of the vibration tests, the unit was energized and continuously counting along with the electronic counter. At the end of each test, the Event Timer elapsed time count was compared with the Hewlett-Packard counter reading.

4.2 Test Procedures. Performance criteria were as detailed in TPC198261244 Vibration Qualification Test Procedure. The Event Timer display was compared to the instrument counter display to determine performance.

4.2.1 Vehicle Dynamics. The Event Timer was subjected to the following vibration and axes:

Flight Axis (5 to 30 Hz at 3 oct/min)
5 to 13 Hz at 0.29 inches D.A. Disp.
13 to 30 Hz at 2.5 G's peak

Lateral Axis (5 to 30 Hz at 3 oct/min)
5 to 12 Hz at 0.20 inches D.A. Disp.
12 to 30 Hz at 1.5 G's peak

4.2.2 Sine Evaluation. (20 to 2000 Hz at 1 oct/min). The energized unit was subjected to the following levels in each of the three axes:

20 to 90 Hz at 0.0029 inches D.A. Disp.
90 to 2000 Hz at 1.2 G's peak

4.2.3 High Level Vibration (1 min/axis).

20 Hz at 0.00046 g^2/Hz

20 to 90 Hz at +9 db/oct

90 to 150 Hz at 0.046 g^2/Hz

150 to 285 Hz at +9 db/oct

285 to 500 Hz at 0.31 g^2/Hz

500 to 2000 Hz at -12 db/oct

2000 Hz at 0.0012 g^2/Hz

Composite = 11.8 g rms

4.2.4 Low Level Vibration (4 min/axis).

20 Hz at 0.00013 g^2/Hz

20 to 90 Hz at +9 db/oct

90 to 150 Hz at 0.012 g^2/Hz

150 to 285 Hz at +9 db/oct

285 to 500 Hz at 0.077 g^2/Hz

500 to 2000 Hz at -12 db/oct

2000 Hz at 0.00028 g^2/Hz

Composite = 5.9 g rms

4.3 Test Results. The Event Timer passed the following vibration tests:

1. Vehicle Dynamics
2. Sine Evaluation
3. High Level Random Vibration
4. Low Level Random Vibration

It is noted that in all of the tests, the Event Timer met the performance criteria referred to in 4.2.

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CODE IDENT NO. 88818

4.4 Test Data. The test data sheets are attached.

4.5 Test Equipment.

<u>NOMENCLATURE</u>	<u>MANUFACTURER</u>	<u>MODEL, TYPE, OR PART NO.</u>	<u>S/N</u>
Vibration Exciter	Ling	177A or equivalent	1
Vibration Fixture	Kearfott	C056485026	1
Test Set, Skylab Indicator	Kearfott	C053885027	1
Electronic Pulse Counter	Hewlett-Packard	52456/53456 or equivalent	2

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REVISIONS
CODE IDENT NO. 88818

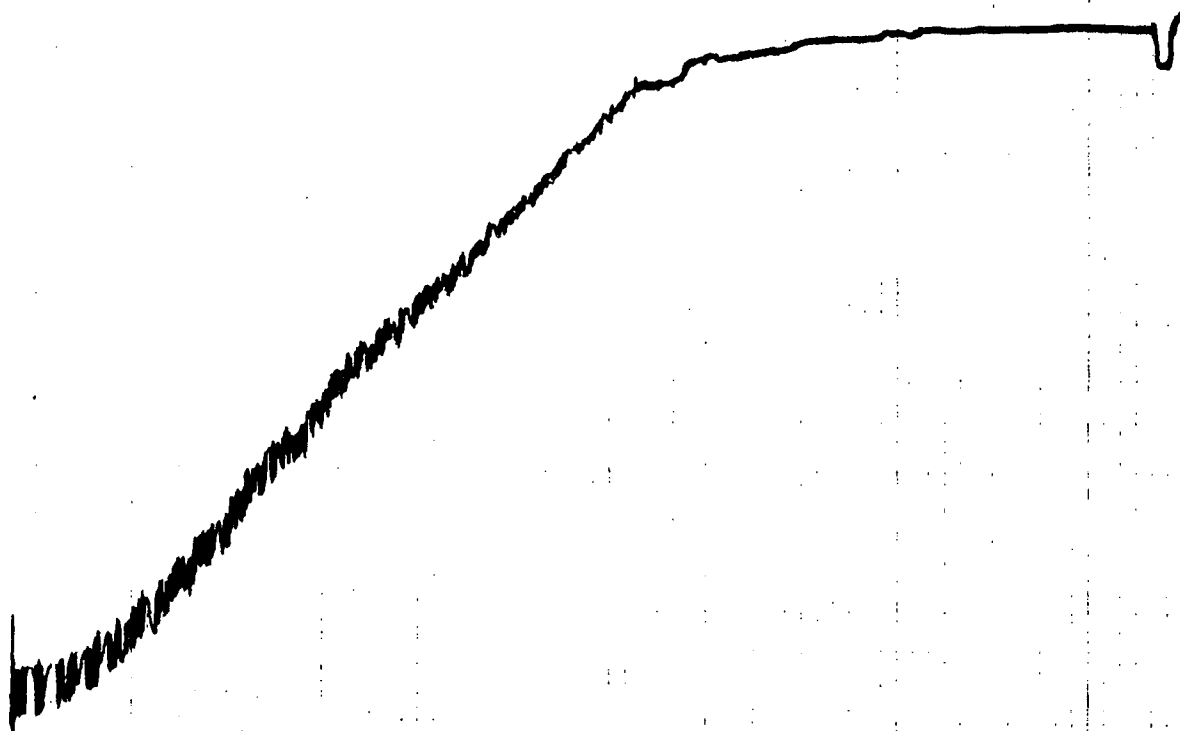
100

DATE 2-1-71 INSP. F.B.
P/N C7087531.0 S.N. 002
V. G V. X FREQ
LAMP 5 30 Hz
ST .1 100 G
ANALYST P.T.C. - ALL THRU BW -
FLIGHT AXIS

10

G

1.0



← FREQ →

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HEARFOTT DIVISION

CL94010241 REV. —

CODE IDENT NO. 38313

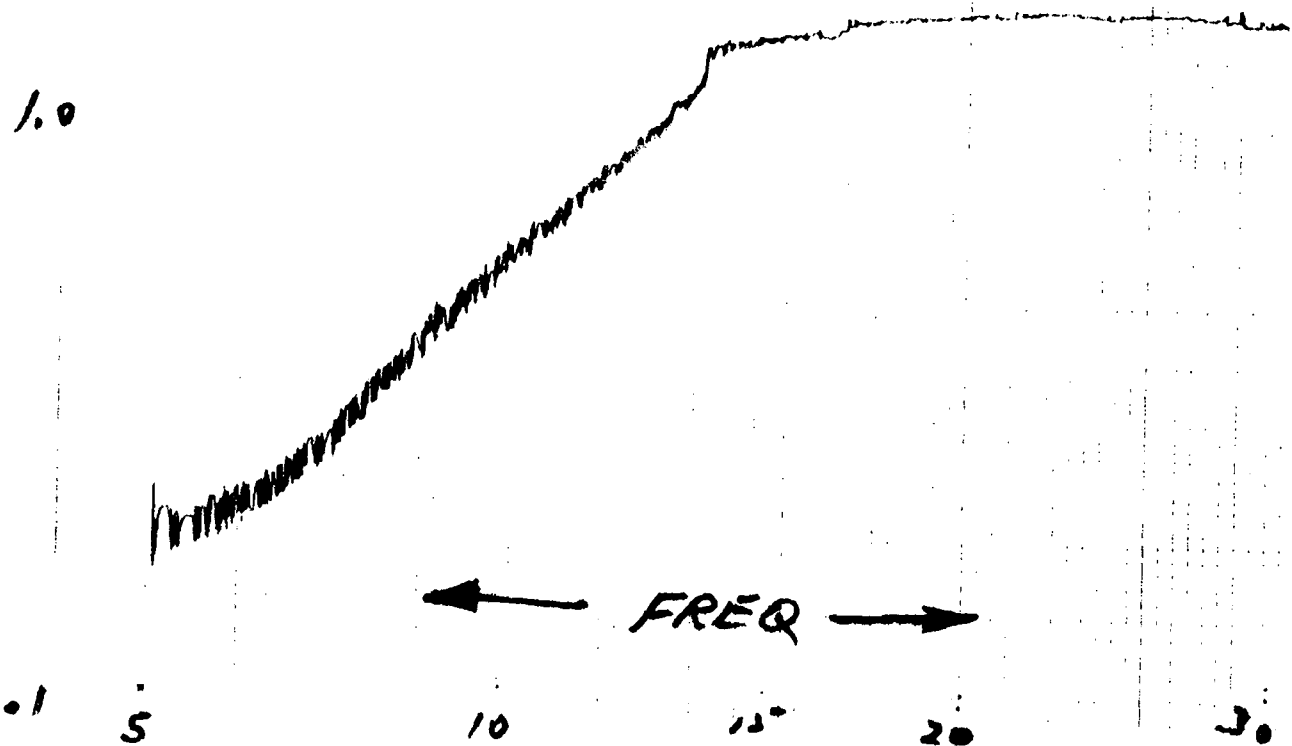
100

2-1-71 F.S.
C708753/00 002
G FREQ
5 30
.1 100 G
LATERAL AXIS



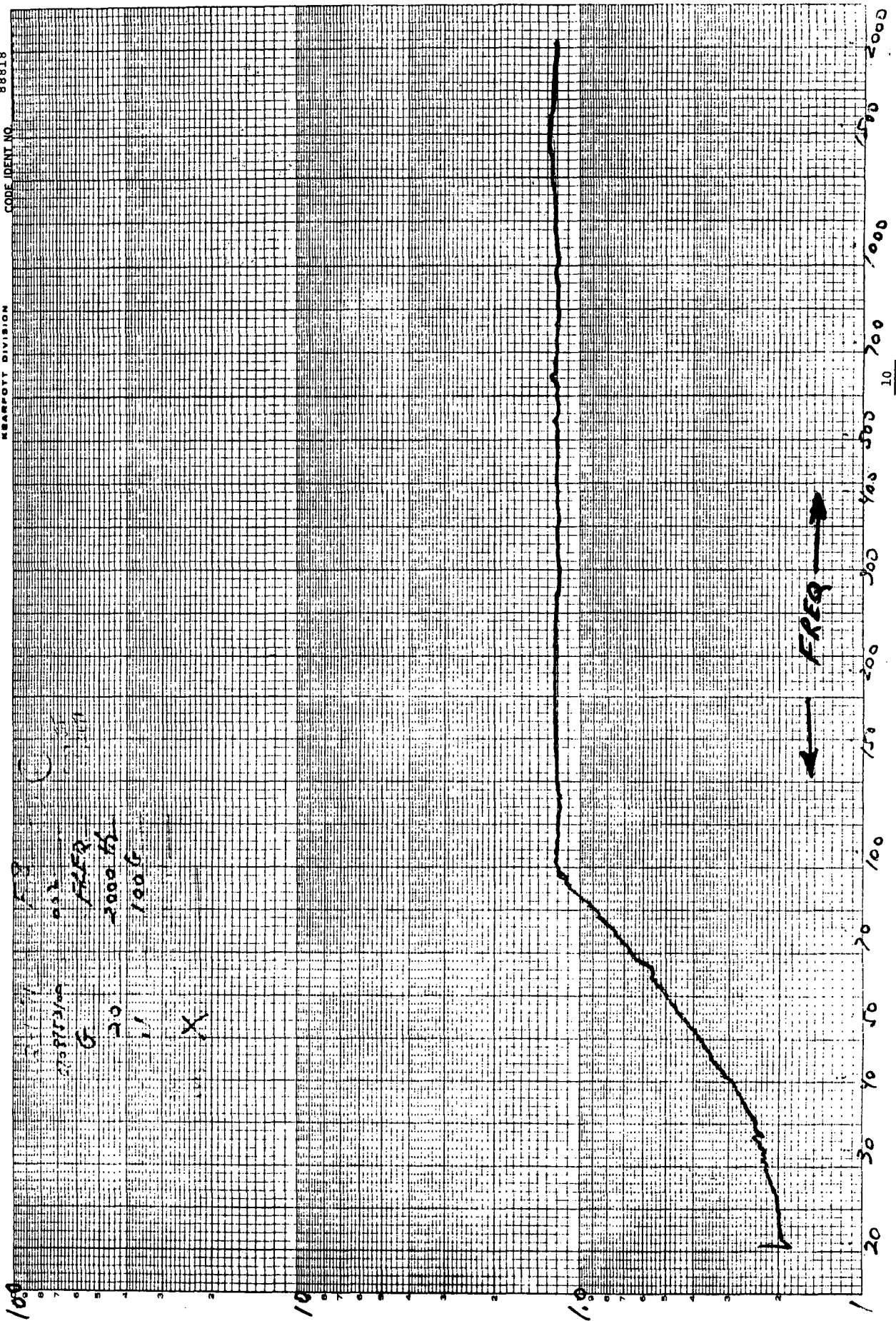
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1.0



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HEARST DIVISION

C194010241 REV. 88818
CODE IDENT NO.

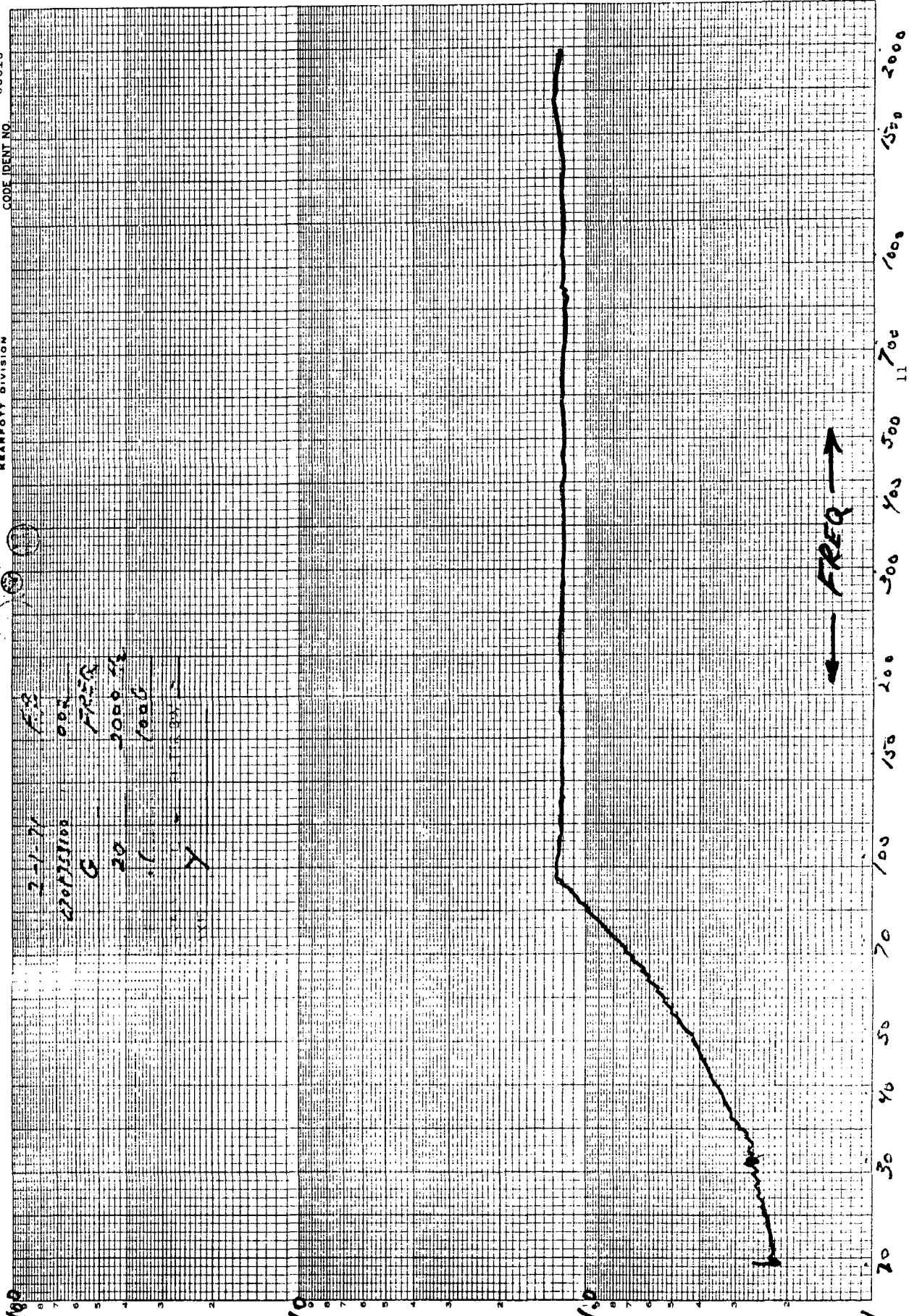


CL94010241 REV 1

CODE IDENT NO 88818

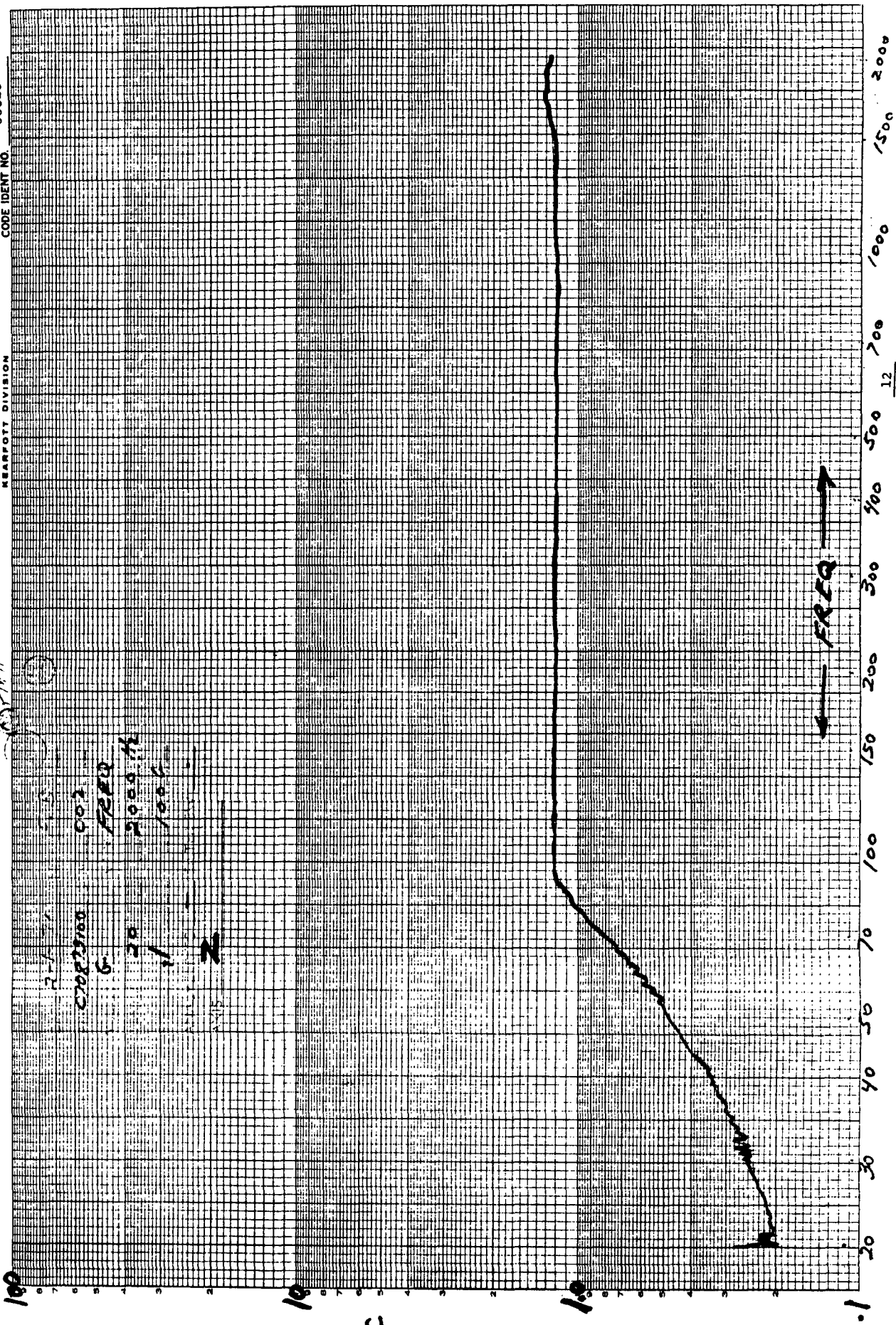
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HEARFOTY DIVISION

2-1-71



SINGER
NEARPOFF DIVISION

100/1
2-11/71



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KEARFOTT DIVISION

C194010241 REV. —

DATE 1-29-71 INSP. F.B.

CODE IDENT. NO. 88818

P/N C708753100 S/N 082

V G³/H₂ VV FREQ

POWER 20 3000 Hz

IMP. 1000/ 1.0

ANALYZER FC — FILTER BW —

AGE X

1 MINUTE
HIGH LEVEL

G³/H₂

← FREQ →

SINGER
KEARFOTT DIVISION

C194010241 REV. —

CODE IDENT NO. 88818

DATE 1-29-71

INSTR. F. 8

KD
4043

PT. C70P783100

S/N 002

G²/H₂

FREQ

RANGE 20

2000 Hz

.0001

1.0

ANALYZER 10

FILTER BW

WYS

1 MINUTE
HIGH LEVEL

GRAPH

G²/H₂

.01

.001

.0001

← FREQ →

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KEARFOOT DIVISION

C194010241 REV. —

CODE IDENT NO. 88818

1.0

DATE 1-29-71 INSP. A.B.

P/N C706753100 S/N 0021

Y $G^{2/Hz}$ VS X FREQ

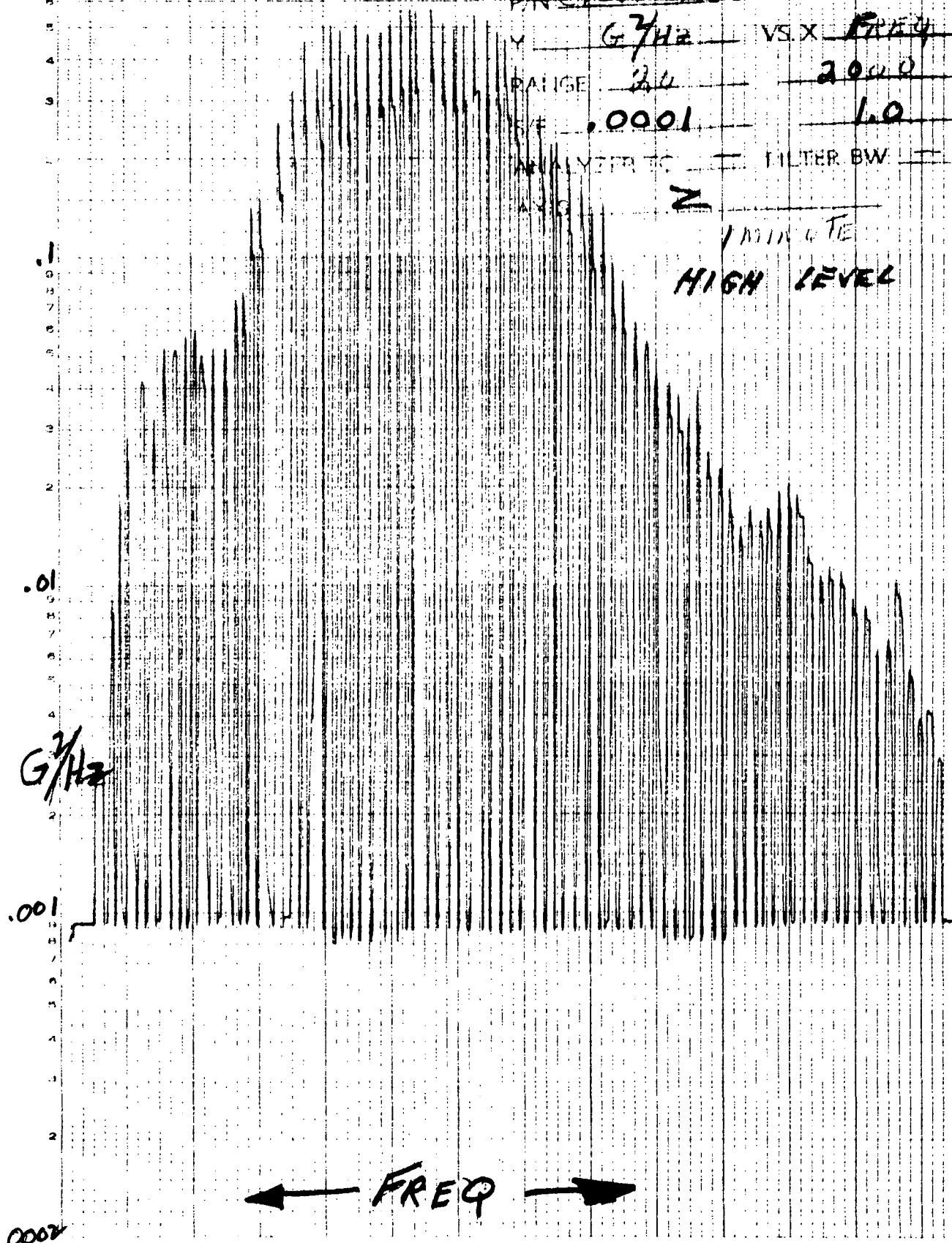
RANGE 20 2000

S/E .0001 1.0

ANALYZER TC — FILTER BW —

W/F 2

1 MINUTE
HIGH LEVEL



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C194010241 REV. —

CODE IDENT NO. 88818

2/5/71  748 

DATE 2-5-71 INSP. FB

SYN 002

Y G/H VS. X FREQ

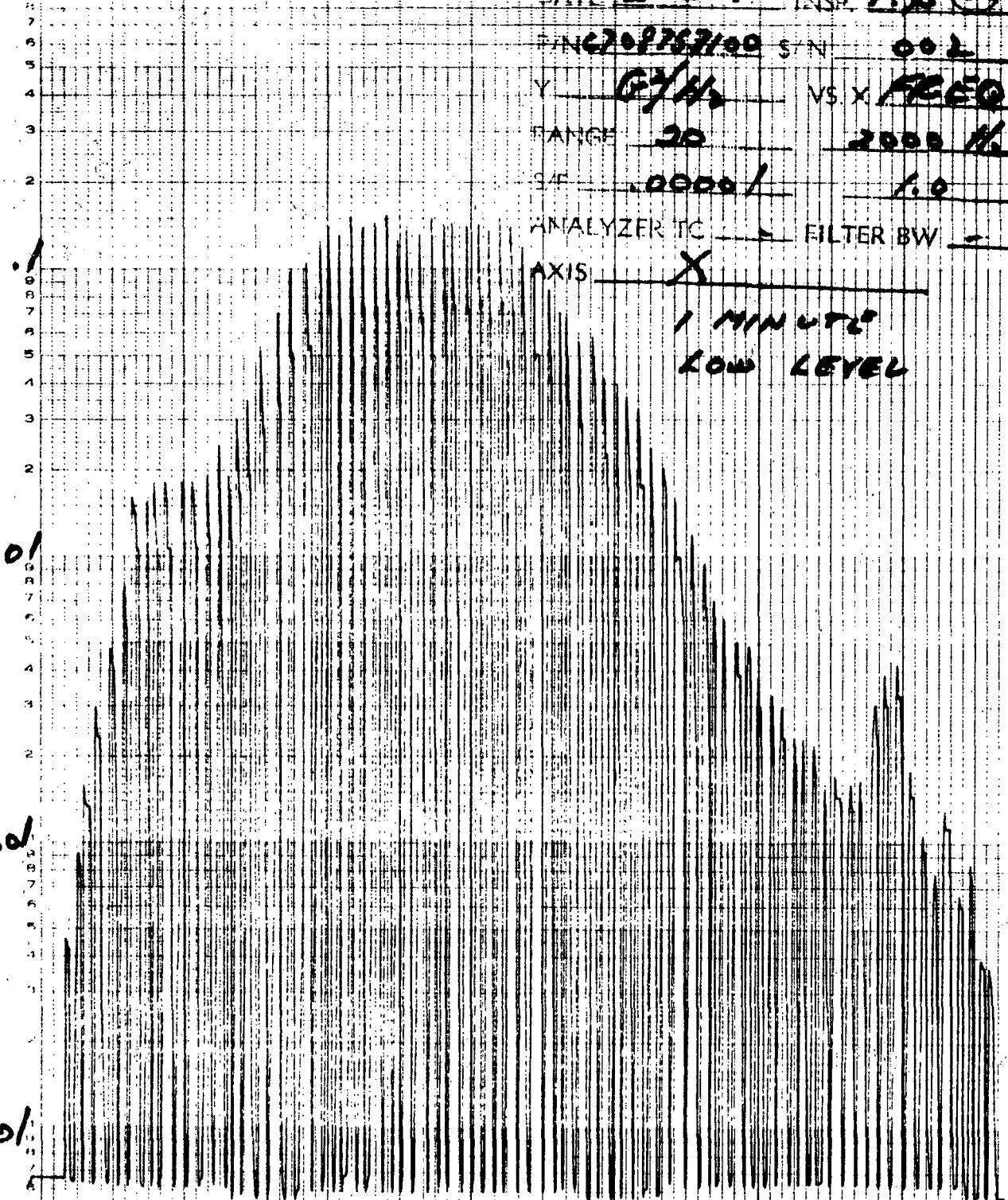
RANGE 20 2000 Hz

SAFE 00001 1.0

ANALYZER TC — FILTER BW —

AXIS X

1 MINUTE
LOW LEVEL



1.0
0.1
0.01
0.001
0.0001

G/H

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C194010241 REV. -

CODE IDENT NO. 88818

DATE 2-5-71 (16 12) 7/18/71 (15 12) F. 8 (15 12)

P/N 6708753800 S/N 002
Y G²/Hz VS X FREQ
RANGE 20 2000 Hz
S/F .00001 1.0
ANALYZER TC - FILTER BW -
AXIS Y

1 MINUTE
LOW LEVEL

.01
G²/Hz

.001

.0001

.00001

← FREQ →

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C194010241

REV. —

CODE IDENT NO.

88818

DATE 2-5-71 INSP. 1.8

P/N C70P753100 S/N 002

Y G²/H VS. X FREQ

RANGE 20 2000 Hz

S/F .00001 1.0

ANALYZER TC — FILTER BW —

AXIS Z

1 MINUTE
LOW LEVEL

G²/H

.00001

← FREQ →

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APPENDIX C
QUALIFICATION REPORT

Document No. C194010242

Doc. Issue -

QUALIFICATION REPORT
SECONDARY DISPLAY AND EVENT TIMER
S-GPI PART NOS. C708753090 AND C708753100

Prepared by:
Singer-General Precision, Inc.
Kearfott Division
Little Falls, New Jersey

Prepared for:
NASA
Huntsville, Alabama
Contract No. NAS 8-26120

26 February 1971

SINGER
KEARFOTT DIVISION

APPROVAL PAGE

Document No. C194010242

Prepared by: 
W. Tyberg

Approved by: 
J. Attwooll

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1. SCOPE

This document shall serve as certification that the Secondary Display and Event Timer meet the design, performance and environmental requirements of Specification 40M 38208 (Secondary Display) and Specification 40M 38207 (Event Timer).

The qualification tests required by the above specifications are tabulated in Section 3 of this document. In accordance with these specs, satisfaction of these test requirements are by test performance, similarity to a previously manufactured item, analysis, inspection, and/or demonstration of validation of records.

This document cross-indexes the requirements and the method of compliance to the requirements and also lists the differences between both the Secondary Display and Event Timer and the item which was previously qualified.

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein:

<u>Number</u>	<u>Title</u>
	<u>Source Control Drawing</u>
C168753090	Secondary Display
C168753100	Event Timer
	<u>Acceptance Test Procedure</u>
TPC 198261229	Secondary Display
TPC 198261230	Event Timer
	<u>Quality Assurance Program Plan</u>
C200095184	Secondary Display and Event Timer
	<u>Reliability Program Plan</u>
C200095115	Secondary Display and Event Timer

3. REQUIREMENTS

The following cross-index tabulates the qualification requirements for the Secondary Display Indicator (Table I) and Event Timer (Table II), respectively.

Where tests are performed, reference to the acceptable test specification is made in the index.

Where qualification is by similarity to a previously manufactured item, a reference is made to the applicable note of this document which substantiates the qualification by similarity.

Where tests are to be satisfied by inspection, reference is made to the inspection plan.

TABLE I

REQUIREMENTS SECONDARY DISPLAY TEST/VERIFICATION CROSS-INDEX

REQUIREMENT		TEST COMMENT	
SUBJECT	PARAGRAPH	TYPE	PARAGRAPH
Exterior Configuration	3.2.1.1	Q and A	Refer To Note 2
Numeric Presentation	3.2.1.2	Q and A	Refer To Note 2
Interface	3.2.1.3	Q and A	Refer To Note 2
Terminal Arrangement	3.2.1.4	Q and A	Refer To Note 2
Terminal Strength	3.2.1.5	Q	Refer To Note 2 and 3
Weight	3.2.1.6	Q and A	Refer To Note 2 and 3
Window	3.2.1.7	Q	Refer To Note 2
Power Consumption	3.2.1.8	Q and A	Refer To Note 2
Display Illumination	3.2.1.9	Q	Refer To Note 2
Power Input	3.2.1.10	Q and A	Refer To Note 2
Power Characteristics	3.2.1.11	Q	Refer To Note 2
Performance	3.2.1.12	Q and A	Refer To Note 2

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REQUIREMENT		TEST COMMENT	
SUBJECT	PARAGRAPH	TYPE	PARAGRAPH
Input Signals	3.2.1.13	Q and A	Refer To Note 2
Accuracy	3.2.1.14	Q and A	Refer To Note 2
Resolution	3.2.1.15	Q and A	Refer To Note 2
Sealing	3.2.1.16	Q and A	Refer To Note 2
Control Signals	3.2.1.17	Q and A	Refer To Note 2
Input Impedance	3.2.1.18	Q and A	Refer To Note 2
Brightness	3.2.1.19.1	Q	Refer To Note 2
Color	3.2.1.19.2	Q	Refer To Note 2
Readability	3.2.1.19.3	Q	Refer To Note 2
Parallax	3.2.1.19.4	Q	Refer To Note 2
Numerals	3.2.1.19.5	Q	Refer To Note 2
Protective Devices	3.2.1.20	Q	Refer To Note 2
Grounds	3.2.1.21	Q	Not applicable
Materials, parts, processes	3.2.2.1	Q	Not applicable
Flammability and outgassing	3.2.2.1.1	Q	Similarity Note 3
Fungus	3.2.2.1.2	Q	Note 2 and 3
Hermetic sealing	3.2.2.2	Q and A	Note 2
Thermal design	3.2.2.3	Q	Note 2
Dielectric strength	3.2.2.4	Q	Note 2
Soldering	3.2.2.5	Q	Note 2 and 3
Potting and molding	3.2.2.6	Q	Note 2 and 3
Finishes	3.2.2.7	Q	Note 2 and 3
Vibration	3.2.2.8	Q	Note 2
Mechanical resonance frequency	3.2.2.9	Q	Similarity Note 2

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REQUIREMENT		TEST COMMENT	
SUBJECT	PARAGRAPH	TYPE	PARAGRAPH
Insulation resistance	3.2.2.10	Q and A	Note 2
Workmanship	3.2.2.11	Q and A	Note 2 and 3
Printed circuits	3.2.2.12	Q	Note 2 and 3
Metals	3.2.2.13	Q	Note 2 and 3
Nonoperative environment	3.3.1	Q	Note 2 and 3
Operative environment	3.3.2	Q	Note 2 and 3
Operating position	3.4.5	Q	Not applicable
Storage life	3.3.6	Q	Note 2
Interchangeability	3.4.7	Q	Note 2 and 3
Product identification	3.4.8	Q and A	Note 2 and 3
Safety	3.4.9	Q	Note 2 and 3
Reliability	3.4.10	Q	Note 2 and 3

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TABLE II
EVENT TIMER

REQUIREMENT		TEST VERIFICATION	
SUBJECT	PARAGRAPH	TYPE	PARAGRAPH
Exterior configuration	3.2.1.1	Q and A	Note 1
Numeric presentation	3.2.1.2	Q and A	Note 1
Interface	3.2.1.3	Q and A	Note 1
Terminal arrangement	3.2.1.4	Q and A	Note 1
Terminal strength	3.2.1.5	Q	Note 1 and 3
Weight	3.2.1.6	Q and A	Note 1 and 3
Window	3.2.1.7	Q	Note 1 and 3
Power consumption	3.2.1.8	Q and A	Note 1
Display illumination	3.2.1.9	Q and A	Note 1
Power Input	3.2.1.10	Q and A	Note 1
Power Characteristics	3.2.1.11	Q	Note 1
Presetting operation	3.2.1.12	Q and A	Note 1
Zero output	3.2.1.13	Q and A	Note 1
Count down	3.2.1.14	Q and A	Note 1
Load generated noise	3.2.1.15	Q and A	Note 1
Brightness	3.2.1.16.1	Q and A	Note 1
Color	3.2.1.16.2	Q	Note 1
Readability	3.2.1.16.3	Q and A	Note 1
Parallax	3.2.1.16.4	Q	Note 1
Numerals	3.2.1.16.5	Q	Note 1
Protective devices	3.2.1.17	Q	Not applicable
Grounds	3.2.1.18	Q and A	Note 1
Materials, parts, and processes	3.2.2.1	Q	Notes 1 and 3

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REQUIREMENT		TEST VERIFICATION	
SUBJECT	PARAGRAPH	TYPE	PARAGRAPH
Flammability and outgassing	3.2.2.1.2	Q	Note 1
Fungus	3.2.2.1.3	Q	Notes 1 and 3
Hermetic sealing	3.2.2.2	Q and A	Note 1
Thermal design	3.2.2.3	Q	Note 1
Dielectric strength	3.2.2.4	Q	Note 1
Soldering	3.2.2.5	Q	Note 1 and 3
Potting and molding	3.2.2.6	Q	Notes 1 and 3
Finishes	3.2.2.7	Q	Notes 1 and 3
Vibration	3.2.2.8	Q	Refer to Appendix
Mechanical resonance	3.2.2.9	Q	Note 1
Insulation resistance	3.2.2.10	Q and A	Note 1
Workmanship	3.2.2.11	Q	Note 1 and 3
Printed circuits	3.2.2.12	Q	Note 1 and 3
Metals	3.2.2.13	Q	Note 1 and 3
Nonoperative environment	3.3.1	Q	Note 1 and 3
Operative environment	3.3.2	Q	Note 1 and 3
Inputs	3.4.1	Q and A	Note 1 and 3
Start operation	3.4.2	Q and A	
Stop operation	3.4.3	Q and A	Note 1
Slow operation	3.4.4	Q and A	
Zero output	3.4.5	Q and A	Note 1
Accuracy	3.4.6	Q	Note 1
Operating position	3.4.7	Q	N/A
Electromagnetic interference	3.4.8	Q	Note 4
Storage life	3.4.9	Q	Note 1
Interchangeability	3.4.10	Q	Note 1
Product identification	3.4.11	Q and A	Note 1

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REQUIREMENTS		TEST VERIFICATION	
SUBJECT	PARAGRAPH	TYPE	PARAGRAPH
Safety	3.4.12	Q	Note 1
Life	3.14.13.2	Q	Note 1

NOTES:

1. In accordance with paragraph 4.5 of 40M 38208/7, qualification of the Event Timer and Secondary Display to NASA/MFC requirements is by similarity of design and construction to the Event Timer (C708753071) and Mission Clock (C708753080) built by Kearfott for GAEC.
2. Qualification of the Secondary Display to NASA/MFC requirements is by similarity of design and construction of the Event Timer (C708753071) and Helium Temperature/Pressure Indicator (C708753013) built by Kearfott for GAEC.
3. Materials, parts and processes which have been used on both the GAC Mission Clock, Event Timer and Helium Temp/Press Indicators shall be automatically approved without submittal. Documentation shall be limited to the indented parts list.
4. Both the Event Timer and the Secondary Display are certified to meet the electro-magnetic compatibility, environmental non-operative and operative and life requirements by similarity of their design to the Kearfott produced Event Timer (C708753071) and Mission Clock (C708753080) of the GAC program.

4. DIFFERENCES BETWEEN EVENT TIMER/SECONDARY DISPLAY
AND THE GAEC EVENT TIMER, MISSION CLOCK,
AND HELIUM TEMP/PRESS INDICATORS

- A. The mechanical design and concept is similar in nature. Differences in outline and mounting configuration may be seen by review of each of the indicators detail specifications.
- B. The circuitry for the counters, logic and power supply are almost identical when the Event Timer is compared to the GAEC Event Timer or Mission Clock. One difference is that LED's are used for the NASA/MFC Event Timer as opposed to electroluminescent lamps. This eliminates the need for SCR switching circuitry. The other difference is that flextapes are used for interconnecting, as opposed to hard wiring.
- C. The circuitry for the Secondary Display uses similar components to those used in the GAEC Mission Clock Event Timer. The A/D converter is the same type as was used in the helium temp/press indicators. The same series of flatpacks as was used in the GAEC Event Timer and Mission Clock is used in the Secondary Display. The differences again are that LED's are used for display purposes and flextape is used for interconnection.
- D. As approved by NASA/MSFC, both the Secondary Display and Event Timer will use soldering of integrated circuits connections. The helium indicator, GAEC Event Timer and Mission Clock used welded integrated circuit connections.

5. QUALIFICATION TEST REPORTS

- A. Final test report for GAEC Mission Clock, K/D P/N's C708753080 thru C708753083, Report Number C200095181.
- B. Final test report for GAEC Event Timer, K/D P/N C708753071, Report Number B194000258.
- C. Final test report for LEM - Helium Temperature Pressure Display, K/D P/N C708753013, Report Number C194010004.

5.1 ADDITIONAL QUALIFICATION TESTING TO BE PERFORMED

As a result of the mounting flange being placed adjacent to the front face, the Event Timer, Part No. C708753100, will be subjected to the vibration tests specified in Appendix A.

APPENDIX A
VIBRATION CRITERIA FOR ATM RACK
STRUCTURE MOUNTED COMPONENTS

Specification 1-A - Input to Components Mounted on ATM Upper or Lower Ring Section.

Total Weight of Components Per Section Less Than 25 Pounds.

1. Vehicle Axis (5-30 Hz at 3 oct/min)

5-13 Hz at 0.29 Inches D.A. Disp.

13-30 Hz at 2.5 G's peak

Lateral Axes (5-30 Hz at 3 oct/min)

5-12 Hz at 0.20 Inches D.A. Disp.

12-30 Hz at 1.5 G's peak

2. Sine Evaluation Criteria (20-2000 Hz at 1 oct/min)

20-90 Hz at 0.0029 Inches D.A. Disp.

90-2000 Hz at 1.2 G's peak

3. High Level Random Vibration Criteria (1 min/axis)

20 Hz at $0.00013 \text{ g}^2/\text{Hz}$

20-90 Hz at 9 dB/oct

90-150 Hz at $0.012 \text{ g}^2/\text{Hz}$

150-285 Hz at + 9 dB/oct

285-500 Hz at $31 \text{ g}^2/\text{Hz}$

500-2000 Hz at -12 dB/oct

2000 Hz at $0.0012 \text{ g}^2/\text{Hz}$

Composite = 11.8 grms

4. Low Level Random Vibration Criteria (4 min/axis)

20 Hz at $0.00013 \text{ g}^2/\text{Hz}$

20-90 Hz at +9 dB/oct

90-150 Hz at $0.012 \text{ g}^2/\text{Hz}$

150-285 Hz at + 9 dB/oct

285-500 Hz at $0.077 \text{ g}^2/\text{Hz}$

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500-2000 Hz at - 12 dB/oct

2000 Hz at $0.00028 \text{ g}^2/\text{Hz}$

Composite = 5.9 grms

5. Shock Criteria

No shock test required

APPENDIX D

RELIABILITY

FAILURE ANALYSIS

No formal failure analysis report is required contractually on Skylab Non Flight units, however, the results of investigations into the cause of the failure of Secondary Display SN/101 are presented herein. Included are the following:

- A. Confirmation of the failure and projected cause
- B. Kearfott tests on similar units
- C. Vendor review of the circuit in which the component failed and failure analysis of their component
- D. Additional circuit protection provided as a result of a product improvement in a different area.

The failure of the Secondary Display indicator SN/101 was attributed to the overstress of an operational amplifier, type LM 102 manufactured by National Semiconductor. This unit was opened at Kearfott and the input conductor path (Pin 3) of the LM 102 was observed to be burned out. After consultation with the manufacturer of the component and considerable testing, the conclusion was reached that a voltage of at least +20 volts magnitude causing a current in the vicinity of 500 ma placed on the input of the LM 102 or the analog low input of the Secondary Display could cause this type of failure. Photographs of this failure are shown in Attachment 1.

Tests were conducted on five (5) LM 102 flatpacks in accordance with the schedule Attachment 2. Cumulative total time of operational testing was in excess of 96 hours. Various power cycling tests, changing the on/off sequence of the B+ and B- supplies with various input signal levels were conducted with no failures. Overstress tests were conducted with 20 volts on the input lead of the LM 102 and another test with -12 volts on the output lead of the LM 102. In both cases, the current through the input conductor (Pin 3) was in the vicinity of 500 ma. The unit with -12 volts on the output lead failed, was opened, and the same type of failure witnessed as occurred in the field failure.

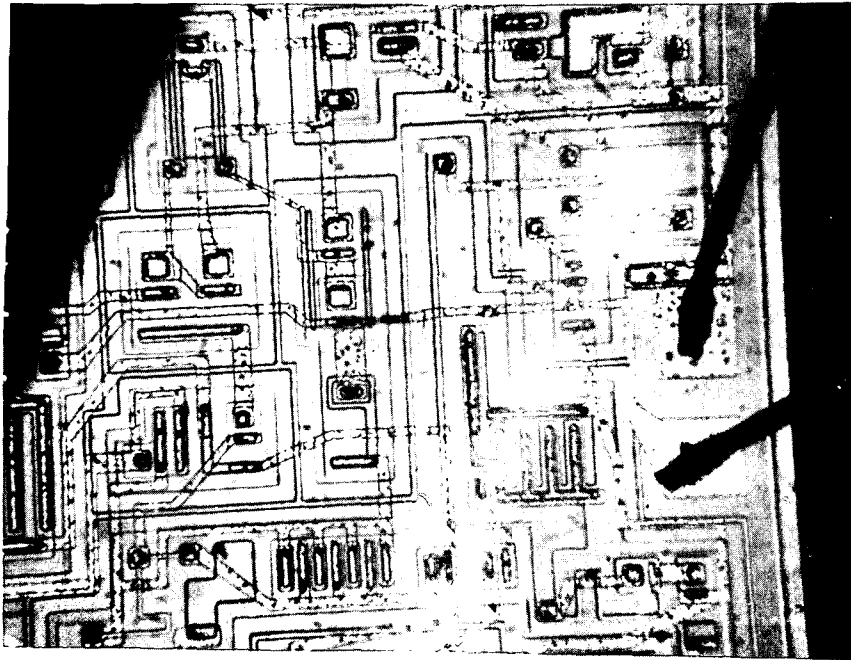
THE SINGER COMPANY • KEARFOTT DIVISION

Both failed LM 102's were sent to National Semiconductor for failure analysis together with a schematic of the circuit in which the LM 102 is used. No fault could be found with the application in which the LM 102's are used. The only explanation for the failure of the LM 102's was an electrical overstress as discussed in the previous paragraph. Attachment 3 contains the documentation from National Semiconductor.

Before failures of the LM 102 occurred in the field, a product improvement consisting of adding a 5 K resistor to the input line of the LM 102 (in series with the analog low input of the Secondary Display) was incorporated. This resistor was added to prevent oscillation of the LM 102 as a result of placing a low impedance or short circuit between the input and power ground of the LM 102. The oscillation resulted in a random updating of the initial sampling of the input analog voltage. Subsequent samplings provided an accurate display of the input analog voltage. However, to prevent this "first time" random display characteristic and to provide a safety factor for any possible degradation of the LM 102 or associated circuitry over a long time period (several years) the resistor was added as suggested by National Semiconductor. Non flight units SN's 103 and up and Flight units 202 and up contained these resistors. Only units without the resistor have failed.

The resistors also provide current limiting on the analog low input to the Secondary Display preventing excessive current transients and eliminating failures caused by direct application of high voltages.

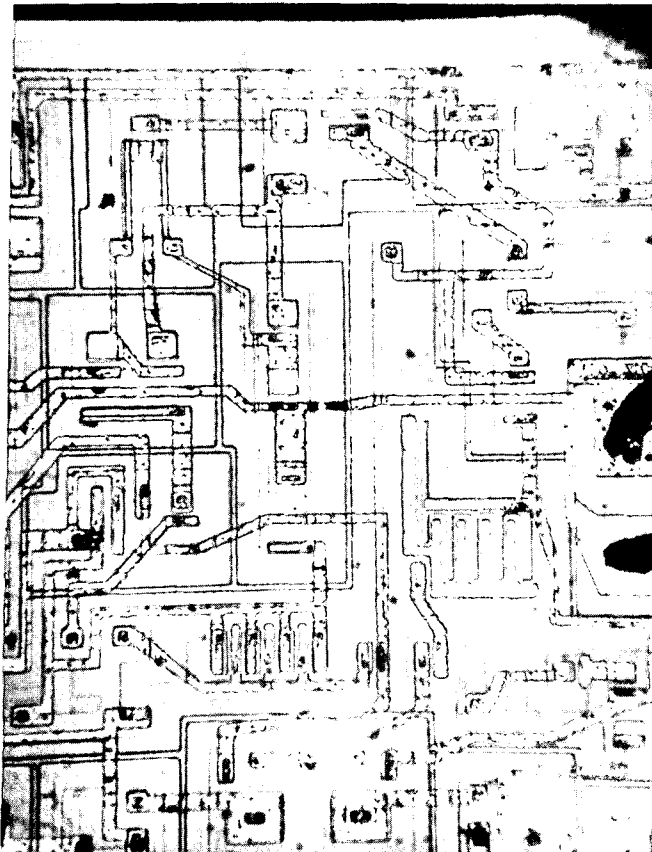
Currently only Secondary Display SN/201 and SN/102 do not contain this resistor. Both are in process of retrofit.



LAB SAMPLE

LM102

8 VOLTS 600 MA



Reproduced from
best available copy.

CUSTOMER SAMPLE

LM102

National Semiconductor Corporation

TO: John Chmiel April 19, 1971
FROM: Dick Kramer
SUBJECT: Singer - Kearfott LM102

John,

Copy of Failure Analysis Report 701 attached. Note that the condition could be duplicated in the lab by driving V minus about 8 volts more positive than the input. The fusing current was on the order of 600 mA. Hopefully, this information, together with Bob Dobkin's, will help the customer resolve his problem.

Regards,

Dick

FAILURE ANALYSIS REPORT
RELIABILITY ENGINEERING DEPARTMENT
MICROCIRCUITS DIVISION

Customer	Singer Kearfott	File No.	701
Address		Date	April 19, 1971
Order No.	Dept/Company	Analysis By	M. Parker
References/Attachments	Hand written letter and electrical schematic	Approved By	
		Distribution:	

BACKGROUND:

Received 2 LM102/883 date code 7013 and 7021.
Both parts had been opened by the customer.

ANALYSIS:

Visual examination showed the metal trace to pin 3 melted open.
Electrical duplication of this condition with a power supply by
grounding pin 3 and applying 8 volts 600mA to V-.

Included is a photo of the failure sent by the customer and a photo
of the same condition duplicated in the lab on a new device.

CONCLUSION:

Customer test and/or application problem.

TO: J. KOPROWSKI
 FROM: V. CILIBERTO / W. TYBERG

4/23/71

Subject: Summary Of Reliability-Engineering Evaluation on Fire
 Sample Voltage Followers - National Semi Type 41102
 Reference ——— Nat. Semi. Letter dated 4/19/71 - Attached:

Test Performed:

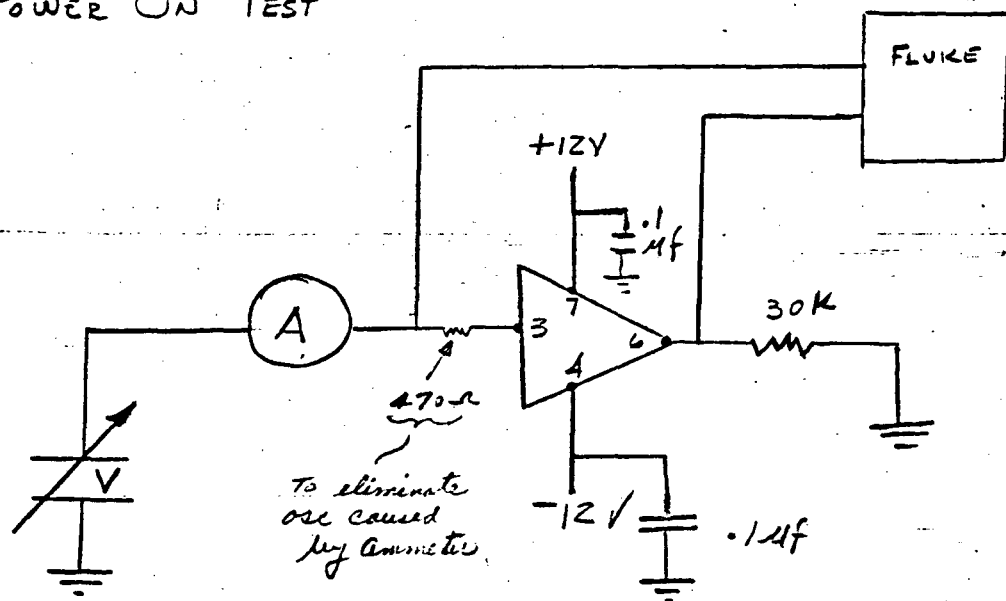
- 1-(a) Power On Test - with positive input
- (b) Power On Test - with negative input
- 2-(a) Power Off Test - with positive input
- (b) Power off Test - with negative input
- 3) Overstress Test
- 4) Power Cycling Test

V. Ciliberto

W. Tyberg

POWER ON TEST

4/2/71



- Increase V from approx 12 volts - current will be read at saturation. Keep on increasing 1ma at a time. For pt test return to approx 6.0V to all if unit still tracks.
- Repeat (2) with negative input

a) + TEST Unit #1) +12V read no current

13V " .6ma

13.5V " 1.5ma

14.0V " 2.5ma

15.0V " 4.0ma

15.5V " 5.0ma

16.0V " 6.0ma

Retest at 6.0V

= -6.0V out ^{no current drawn}

16.0V " 6.0ma

17.0V " 6.8ma

18.0V " 6.8ma

19.0V " 8.0ma

20.0V " 10.0ma

Retest @ 6.0V — read no current
— no failure —

Remarks:

Unit #1 did not experience any failure after test #2
This unit was delidded to look for any apparent signs of stress —

None were detected
— took photo —

1) Power on Test Continued -

4/2/71

Test a) Unit #2 (no resistor) w/oscillation

Input	0V	read	no current drawn
	1V		" " "
	2V		2.5ma
	3V		2.5
	4V		2.5
	5V		2.5
	6V		2.5
	7V		2.5
	9V		2.5
	10V		2.5
	11V		0 current
	12V		6ma
	14V		7ma
	15V		7.5ma
	16V		25ma
	17V		48ma
	18V		65ma
	19V		72ma
	20V		80ma
	28V		>100ma
			no failure detected

Test b) Unit #2 with 4.7K Ω resistor in circuit instead of 47 Ω
 Input 6V read no current drawn = 6v out

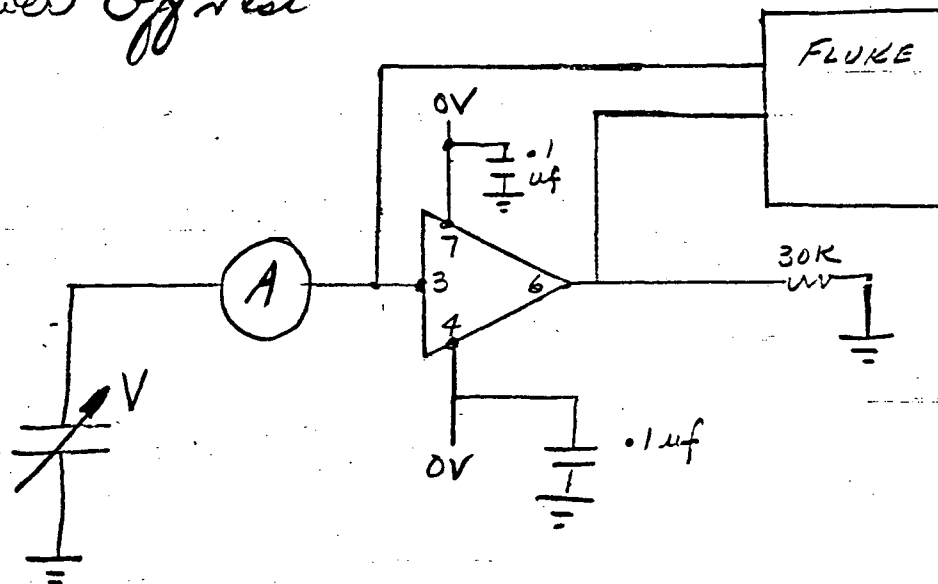
	10V	" " "
	11V	.100ma
	12V	.2ma
	13V	.4ma
	14V	.6ma
	15V	.9ma
	16V	1.0ma
	17	1.3ma
	18	1.5ma
	19	1.8ma
	20	2.0ma
	6.0V	6.0V out - no failure

Relist

D-8

2) Power Off Test

4/2/71



- Increase V from 0 volts 1ma at a time. Turn power supply $\pm 12V$ on after every increase and confirm unit still operates.
- Repeat with negative input.

a) Unit #1	input 2V	read 1ma
	3V	7ma
	4V	10ma
	5V	15ma
	6V	25ma
	7V	36ma
	8V	46ma
	9V	60ma
	10V	70ma
	11V	80ma
	12V	90ma
	15V	120ma
	20V	> 200ma - no failure detected

Test a) Unit #2 Repeated above test with no apparent difference
 Test b) Unit #2 at -2.4 volts input - showed approx 500ma
 drawn for 5 seconds - no failure noted. Re-tested

3) Overstress Test
Unit #3

4/5/71

- 1) Placed +12 volts on output with +12 volts on pin 7 - measure 30 ma on input.
- 2) Placed -12 volts on output with +12 volts on pin 7 - noted appr. 600 ma drawn - and failure of unit was noted - Photo on file -

4) Power Cycling Test 4/6/71 - 4/8/71
Units #4 & #5

- 1) 24 hrs at: pin 7 held at +12V with pin 4 (neg) varying from 0V to -12V (at 50 Hertz rate) pin 3 grounded.
- 2) 24 hrs at: pin 7 held at -12V with pin 4 (pos.) varying from 0V to +12V (at 50 Hertz rate) pin 3 grounded

Total test SN 4 = 48 hours

SN 5 = 48 hrs

96 hrs Total Time

Unit retest at room ambient - no apparent defects.

Memorandum

SINGER

SINGER-GENERAL PRECISION, INC.

KEARFOTT DIVISION

to J. Koprowski

from V. Ciliberto

refer to

subject Skylab - Reliability Data List

date 8/5/71

The attached Reliability Data Lists for the Event Timer, Secondary Display and the Four Digit Indicator are submitted for inclusion in the Final Engineering Report to NASA-MSFC. These documents have been completed in accordance with the Reliability Program Task Requirements and reflect the final design configurations to-date.

V. Ciliberto
V. Ciliberto
Reliability Task Manager
NASA-SKYLAB Program Displays

VC:lb

cc: J. Attwooll
L. Dourgarian
L. Graziano
C. Tiso
W. Tyberg
File

SINGER KEARFOTT DIVISION SINGER-GENERAL PRECISION, INC. LITTLE FALLS, NEW JERSEY			EQUIPMENT <u>EVENT TIMER</u> SKYLAB RELIABILITY DATA LIST REFERENCE SCHEMATIC <u>C51020271</u> PART NO. <u>C702753100</u>									
DATA SUMMARY												
1	2	3	4	5	6	7	8	9		10	11	12
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO
								RATED	AMB	RATED	OPERATING	COL. 10 COL. 11
1	A1A3, A4	Counter Board	2536000756	2536000756	SINGER-KEARFOTT	3	100%	As	Shown on SHEET 2 OF 11			
2	A1A2	Counter Board	2536000757	2536000757	"	1	"	As	Shown on SHEET 3 OF 11			
3	A1A5	Control Logic	2536000758	2536000758	"	1	"	As	Shown on SHEET 4 OF 11			
4	A1A6	Timer Board	2536000759	2536000759	"	1	"	As	Shown on SHEET 5 OF 11			
5	A1A7	Oscillator Board	2536000760	2536000760	"	1	"	As	Shown on SHEET 6 OF 11			
6	A1A8	Discrete Board	2536000761	2536000761	"	1	"	As	Shown on SHEET 7 OF 11			
7	A1A9	Power Supply	2536000762	2536000762	"	1	"	As	Shown on SHEET 8 OF 11			
8	D51-D54	LED Indicator	2406000025	2406000025	Hewlett-Packard	4	"	95	85	800 MW	300 MW	.375
9	FL1	Filament RFI	2570007204	2570007204	General	1	"	125	"	100V	5V	.02
10	J1	Connector, 18 pin	25200013000	25200013000	DeWitt	1	"	200	"	1500V / 7.5A	100V / .5A	.066 / .066
							SIGNATURE		DATE		REV. A	
							J. F. G. G. G.		12/17/70		PAGE 1	
							J. F. G. G. G.		7/13/71			

SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT EVENT TIMER

REFERENCE SCHEMATIC C543020271

Ref: Counter Boards A1, A3, A4

SKYLAB RELIABILITY DATA LIST

PART NO. C708753100

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1	Capacitor, CERAMIC	CRF05BX 104KR	MIL-C-39014/2	Acrovox	1	10%	125	85	100V	5V	.05
2	C2	Capacitor, CERAMIC	CRF05BX 102KR	MIL-C-39014/1	"	1	"	"	"	200V	5V	.025
3	U1	Hex Inverter, TTL	SN13372	C528000461	T.I.	1	"	"	"	8V	5V	.625
4	U2, U5	Low Power, Dual JKFF	SN13570	C528000458	"	2	"	"	"	8V	5V	.625
5	U3	Low Power, Dual 4-10, TTL	SN13569	C528000457	"	1	"	"	"	8V	5V	.625
6	U4, U6, U8	Low Power, Quad 2-10, TTL	SN13567	C528000455	"	3	"	"	"	8V	5V	.625
7	A1 OR A3 OR A4	Circuit Board	C535005219	C535005219	Precision Circuits	1	"	140	"	—	—	—

SIGNATURE W. J. G. J. G. DATE 7/9/71

REV. A

PAGE 2

**NEARFOTT DIVISION
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LITTLE FALLS, NEW JERSEY**

REFERENCE SCHEMATIC C54/320271

Ref: Counter Error A2

PART NO. C-70873-3100

REV. A

2465

NEARFOTT DIVISION
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LITTLE FALLS, NEW JERSEY

REFERENCE SCHEMATIC C54/3020271

Ref: Control Logic Board A5

RELIABILITY DATA LIST

PART NO. C708733100

REV. A

Page 4

**NEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY**

REFERENCE SCHEMATIC C54302027

Ref: Timer Board A6

SKYLAB **RELIABILITY DATA LIST**

PART NO. C708753/00

REV. A

Page 5

**NEARFOTY DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY**

REFERENCE SCHEMATIC C543020271

Ref: Oscillator Basis A7

RELIABILITY DATA LIST

PART NO. C708753100

RELIABILITY DATA LIST

SIGNATURE *Al Zuhairi* DATE 7/15/71

REV. A

9-350

SINGER

REARPORT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT EVENT TIMER

REFERENCE SCHEMATIC C543020271

Ref: Discrete Board A8

SKYLAB RELIABILITY DATA LIST

PART NO. C708753100

1 ITEM NO.	2 REF. DES.	3 PART DESCRIPTION	4 PART NUMBER	5 PROCUREMENT SPECIFICATION	6 MANUFACTURER	7 QTY. PER UNIT	8 DUTY CYCLE	9 APPLICATION TEMP. (°C)		10 STRESS		12 STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1-C8	Capacitor, ceramic	GRK643X 104KR	MIL-C- 39014/2	Aerovox	8	100%	125	85	100✓	28✓	.28
2	C81	SCR	W976A	C531020385	TI	1	"	"	"	275MVA	168MW	.611
3	Q1-Q7	Transistor, silicon NPN	JAN17X 2N1222A	MIL-S- 19501/1	"	7	"	200	"	500MW	3MW	2.01
4	R1,R5,R9, R13,R17	Resistor, film	RNR50H 1782FR	MIL-R- 55182/7	MEICO	5	"	125	"	50MW	2MW	.04
5	R22,R26	Resistor, film	RNR50H 1782FR	MIL-R- 55182/7	"	2	"	"	"	50MW	2MW	.04
6	R3,R6,R10, R14,R18	Resistor, film	RNR50H 6812FR	MIL-R- 55182/7	"	5	"	"	"	50MW	15MW	.30
7	R23,R27	Resistor, film	RNR50H 6812FR	MIL-R- 55182/7	"	2	"	"	"	50MW	15MW	.30
8	R3,R7,R11, R15,R19	Resistor, film	RNR50H 5622FR	MIL-R- 55182/7	"	5	"	"	"	50MW	16MW	.32
9	R24,R28	Resistor, film	RNR50H 5622FR	MIL-R- 55182/7	"	2	"	"	"	50MW	16MW	.32
10	R4,R8,R12, R16,R20	Resistor, film	RNR50H 4991FR	MIL-R- 55182/7	"	5	"	"	"	50MW	5MW	.10
11	R25,R29	Resistor, film	RNR50H 4991FR	MIL-R- 55182/7	"	2	"	"	"	50MW	5MW	.10
12	R21	Resistor, film	RNR50H 1001FR	MIL-R- 55182/7	"	1	"	"	"	50MW	28MW	.56

SIGNATURE TU guth DATE 7/15/71

REV A

PAGE 7

**KEARFOTY DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY**

REFERENCE SCHEMATIC C54320271

Ref: Discrete Bruid A8

PART NO. C704753100

SIGNATURE	DATE
<i>M. Z. G.</i>	7/15/71

$$\frac{R}{V} = A$$

3541

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KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT EVENT TIMER

REFERENCE SCHEMATIC C543020211

SKYLAB RELIABILITY DATA LIST

PART NO. C708753100

Ref. Power Supply Board A9

1	2	3	4	5	6	7	8	9	10	11	12
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)	RATED	STRESS	STRESS RATIO
											COL. 10 COL. 11
1	C1	Capacitor, tantalum	C455006100	C602003100	Union Carbide	1	100%	125	75V	28V	.373
2	C2, C4	Capacitor, ceramic	545006BX 103KR	MIL-C-39014/2	Aerovox	2	"	"	200V	5V	.025
3	C3	Capacitor, tantalum	C5R13E 225KR	MIL-C-59003/1	Union Carbide	1	"	"	20V	5V	.25
4	C5	Capacitor, ceramic	54R06BX 104KR	MIL-C-39014/2	Aerovox	1	"	"	100V	10V	.10
5	C6	Capacitor, tantalum	C5R13F 476KR	MIL-C-39003/1	Union Carbide	1	"	"	35V	10V	.286
6	C7	Capacitor, tantalum	C5R13C 227KR	MIL-C-59003/1	"	1	"	"	10V	5V	.50
7	CR1	Diode, silicon	JAN1TX 1N4942	MIL-S-19500/523	Unitrade	1	"	175	200V	32.5V	6.01
8	CR2-CR4	Diode, silicon	JAN1TX 1N4942	MIL-S-19500/523	"	3	"	"	200V	21V	.138
9	CR5, CR6	Diode, silicon	JAN1TX 1N4942	MIL-S-19500/523	"	2	"	"	200V	11V	.212
10	FL2-FL5	Filter, RFI	D-347	C517009704	Gulfon	4	"	125	100V	FL2 = 33V FL3, FL4 = NEG. FL5 = 5.5V	.32 2.01 1.055
11	L1	Choke	C702870211	C702870211	Electro Whinding	1	"	130	.336A	.15A	.44
12	L2	Choke	C702870210	C702870210	"	1	"	"	.551A	.15A	.27

SIGNATURE M. J. O'S DATE 7/15/77

REV. A

Page 9

SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT EVENT TIMER

REFERENCE SCHEMATIC C543020271

Ref: Power Supply Board A9

SKYLAB RELIABILITY DATA LIST

PART NO. C708753100

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	9 APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 12 COL. 11
								RATED	AMB	RATED	OPERATING	
13	L3	Choke	C702861234	C702861234	Electro Winding	1	100%	130	85	2.30A	.44A	.19
14	Q1	Transistor, silicon, NPN	2N3499	15320002046	Motorola	1	"	175	"	.65W	.26W	.40
15	Q2	Transistor, silicon, PNP	JANTX 2N3905A	MIL-S-19500/220	National	1	"	"	"	.394W	20MW	.051
16	Q3	Transistor, silicon, NPN	JANTX 2N3920	MIL-S-19500/355	"	1	"	"	"	.32W	59MW	.184
17	Q4, Q5	Transistor, silicon, NPN	1532000546	2532000546	Motorola	2	"	"	"	.65W	80MW	.123
18	R1, R13	Resistor, film	RNR55C 8252FR	MIL-R-55182/1	Alenco	2	"	125	"	100MW	6MW	.06
19	R2, R7	Resistor, film	RNR55C 2151FR	MIL-R-55182/1	"	2	"	"	"	100MW	R2 = .5MW R7 = 10MW	.01 .10
20	R3, R1	Resistor, film	RNR55C 1000FR	MIL-R-55182/1	"	1	"	"	"	100MW	10MW	.10
21	R4	Resistor, film	RNR55C 9091FR	MIL-R-55182/1	"	1	"	"	"	100MW	1MW	.01
22	R5	Resistor, film	*	MIL-R-55182/1	"	1	"	"	"	100MW	0.7MW	.01
23	R6, R10, R12	Resistor, film	RNR55C 1002FR	MIL-R-55182/1	"	3	"	"	"	100MW	R6, R12 = 3MW R10 = 17MW	.03 .17
24	R8, R11	Resistor, film	RNR55C 2000FR	MIL-R-55182/1	1	2	"	"	"	100MW	R8 = .1MW R11 = 48MW	.01 .48

SIGNATURE M. J. G. DATE 7/5/77

REV. A

* Selected from RNR55C1212FR thru RNR55C1742FR

**NEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY**

REFERENCE SCHEMATIC C543020271

Ref: Power-Supply Board A9

PART NO. C708753100

SIGNATURE	DATE
<i>M. Z. L.</i>	7/15/71

REV. A

11-25-62

SINGER

KEARFOOT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT SECONDARY DISPLAY

REFERENCE SCHEMATIC C54320276

SKYLAB RELIABILITY DATA LIST

PART NO. C708753090

DATA SUMMARY

1 ITEM NO.	2 REF. DES.	3 PART DESCRIPTION	4 PART NUMBER	5 PROCUREMENT SPECIFICATION	6 MANUFACTURER	7 QTY. PER UNIT	8 DUTY CYCLE	9 APPLICATION TEMP. (°C)		10 STRESS		12 STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
1	A1	Counter Board	C536000764	C536000764	SINGER KEARFOOT	1	100%	As Shown		ON SHEET	2 OF 13	
2	A2	Counter Board	C536000765	C536000765	"	1	"	As Shown		ON SHEET	3 OF 13	
3	A3	Control Logic	C536000766	C536000766	"	1	"	As Shown		ON SHEET	4 OF 13	
4	A4	Oscillator Board	C536000767	C536000767	"	1	"	As Shown		ON SHEET	5 OF 13	
5	A5	Discriminator Board	C536000768	C536000768	"	1	"	As Shown		ON SHEET	7 OF 13	
6	A6	Integrator Board	C536000769	C536000769	"	1	"	As Shown		ON SHEET	9 OF 13	
7	A7	Power Supply	C200110820	C200110820	"	1	"	As Shown		ON SHEET	10 OF 13	
8	C1	Capacitor plastic	C605009305	C605009305	Component Research	1	"	125	85	50V	5V	.10
9	DS1-DS4	LED Indicator	C406000085	C406000085	Hewlett- Packard	4	"	95	"	800 MW	300 MW	.375
10	FL1	Filter, RFI	C517009294	C517009294	Gulton	1	"	125	"	100V	5V	.02
11	J1	Connector, 18 pin	C520013001	C520013001	Deutsche	1	"	200	"	1500V / 7.5A	100V/.5A	.066/ .066
							SIGNATURE <u>W. G. Miller</u>		DATE <u>12/2/70</u>		Rev. A	
											Page 1	

SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT SECONDARY DISPLAY

REFERENCE SCHEMATIC C545020276

Ref. Counter Board A1

SKYLAB RELIABILITY DATA LIST

PART NO. C708753090

1	2	3	4	5	6	7	8	9	10	11	12
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)	RATED	STRESS	STRESS RATIO
								RATED	AMB	OPERATING	COL. 10 COL. 11
1	C402	Capacitor 1000µF	C605006092	C605006092	72 public (MUCON)	2	100%	125	75	5V	.10
2	R1	Resistor 5.1M	R41R50H 1001FR	MIL-R- 55182/7	MEPCO	1	"	"	"	1 MW	.02
3	U1, U4	Hex Inverter TTL	SN13682	C528000461	T.I.	2	"	"	"	5V	.625
4	U2	Low Power Dual 4-14, TTL	SN13569	C528000457	"	1	"	"	"	8V	.625
5	U3	Med Power, Quad 2-14	SN13580	C528000463	"	1	"	"	"	8V	.625
6	U5, U6	Decade Counter, TTL	SN21146	C574000073	"	2	"	"	"	8V	.625
7	U6, U7	Low Power, Quad 2-14, TTL	SN13567	C528000455	"	2	"	"	"	8V	.625
8	A1	Circuit Board	C535005228	C535005228	Precision Circuits	1	"	140	"	—	—

SIGNATURE M. S. S. DATE 8/4/71

REV. A

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SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT Secondary Display

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC 7-1000000000

PART NO. C708753090

Pot Counter Board A2

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1, C2	Transistor	605006092	6605006092	R-public (MILCON)	2	100%	125	85	50V	5V	.10
2	R1	Resistor, 1/2W	1001FR	55122/7	MILPCO	1	"	"	"	50mW	1mW	.02
3	U1, U3	Hex Inverter, TTL	5N13682	6528000457	T.I.	2	"	"	"	8V	5V	.625
4	U2, U4	Low Power, Dual 4-in	5N13569	6528000457	"	2	"	"	"	8V	5V	.625
5	U5, U8	Decoder, TTL Counter, TTL	5N2222A	6528000457	"	2	"	"	"	8V	5V	.625
6	U6	Low Power, Quad 2-in, TTL	5N13567	6528000457	"	1	"	"	"	8V	5V	.625
7	A2	Circuit Board	6535005229	6535005229	Specimen Circuits	1	"	140	"	—	—	—

SIGNATURE W. J. S. DATE 2/14/71

REV. A

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**KEARFOY DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY**

SKYLAB RELIABILITY DATA LIST

PART NO, C708753090

Ref: Control Logic Board A3

SIGNATURE	DATE
WZS	8/4/71

REV: A

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SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT *Computer Display* SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC *C54E020276* PART NO. *C408753090*

Ref: Oscillator Board A14

1	2	3	4	5	6	7	8	9	10	11	12
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)	RATED	STRESS	STRESS RATIO COL. 10 COL. 11
1	C1	Capacitor, tantalum	05R13F	MIL-C-39003/1	Union Carbide	1	100%	125	85	35V	.17
2	C2, C3	Capacitor, ceramic	CR0663X 152KR	MIL-C-39014/2	Hercorex	2	"	"	"	200V	.025
3	C4	Capacitor, ceramic	CR0663X 109KR	MIL-C-39014/2	Alconox	1	"	"	"	100V	.05
4	C5, C6	Capacitor, ceramic	CR05006092	CR05006092	Republic (Mesa)	2	"	"	"	50V	.10
5	CR1	Diode, silicon	JAN V 1N914	MIL-S-19500/116	T.I.	1	"	175	"	160 mW	.031
6	Q1, Q5	Transistor, unipolar	52N24028	CR05000579	G.E.	2	"	200	"	300 mW	.083
7	Q2	Transistor, silicon NPN	JANTX 2N2222A	MIL-S-19500/255	T.I.	1	"	"	"	300 mW	.083
8	Q3, Q4	Transistor, silicon NPN	JANTX 2N1718A	MIL-S-19500/131	T.I.	2	"	"	"	328 mW	.076
9	R1, R9	Resistor, film	RNR504 3920FR	MIL-R-55182/7	MERO	2	"	125	"	50 mW	.10
10	R2	Resistor, film	RNR60H 4753FR	MIL-R-55182/3	"	1	"	"	"	125 mW	.04
11	R3	Resistor, film	RNR50H 2211FR	MIL-R-55182/7	"	1	"	"	"	50 mW	.10
12	R4, R6	Resistor, film	RNR50H 5621FR	MIL-R-55182/7	"	2	"	"	"	50 mW	.10

SIGNATURE *W.C. 0 8/17/71* DATE

REV. A

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SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT SECONDARY DISPLAY

SKYLAB

RELIABILITY DATA LIST

REFERENCE SCHEMATIC CA4020276

PART NO. C708753090

Ref. Oscillator Board A4

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
13	R5, R11	Resistor, film	PNR50H 1001FR	MIL-R-55182/1	MEPCO	2	100%	125	85	50mW	5mW	.10
14	R7	Resistor, film	PNR50H 1502FR	MIL-R-55182/1	"	1	"	"	"	50mW	5mW	.10
15	R8	Resistor, film	PNR50H 1922FR	MIL-R-55182/1	"	1	"	"	"	50mW	5mW	.10
16	R10	Resistor, film	PNR50H 1002FR	MIL-R-55182/1	"	1	"	"	"	50mW	5mW	.10
17	U1	Low Power, Hex Inverter, TTL SNR54104	5N13579	CS28000462	T.I.	1	"	"	"	8V	5V	.625
18	U2, U4	Low Power, Dual JK FF SNR54173	5N13570	CS28000458	"	2	"	"	"	8V	5V	.625
19	U3	Low Power, Triple 5-ml, TTL SNR54110	5N13568	CS28000456	"	1	"	"	"	8V	5V	.625
20	U5	Low Power, Quad 2-10, TTL SNR54100	5N13567	CS28000455	"	1	"	"	"	8V	5V	.625
21	A4	Circuit Board	CS35005231	CS35005231	Precision Circuits	1	"	140	"	—	—	—

SIGNATURE W. J. G. DATE 8/17/71

REV. A

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SINGER KEARFOTT DIVISION SINGER-GENERAL PRECISION, INC. LITTLE FALLS, NEW JERSEY			EQUIPMENT <u>SECONDARY DISPLAY</u> REFERENCE SCHEMATIC <u>CS43020276</u> <u>Ref: Discrete Board 115</u>				SKYLAB PART NO. <u>C701757090</u>				RELIABILITY DATA LIST			
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (OC)		STRESS		STRESS RATIO		
1	2	3	4	5	6	7	8	RATED	AMB	RATED	OPERATING	COL. 10 COL. 11		
1	C1	Capacitor, ceramic	C605006092	C605006092	Republic (MCCON)	1	100"	125	85	50V	5V	.10		
2	C3, C3	Capacitor, ceramic	CRK032X 104MR	MIL-C-39014/2	Aerovox	2	"	"	"	100V	5V	.05		
3	CR1-CR4	Diode, silicon	JANTX 1N914	MIL-S-19500/16	T.I.	4	"	175	"	160mW	1mW	<.01		
4	Q1, Q3	Transistor, silicon NPN	JANTX 2N2432	MIL-S-19500/313	Crystronics	2	"	200	"	180mW	1mW	<.01		
5	Q2	Transistor, silicon PNP	JANTX 2N2944A	MIL-S-19500/382	"	1	"	"	"	262mW	1mW	<.01		
6	R1-R4	Resistor, film	RNR50H 6982FR	MIL-R-55182/7	NEPCO	4	"	125	"	50mW	1mW	.02		
7	R5, R6, R21	Resistor, film	RNR50H 2492FR	MIL-R-55182/7	"	3	"	"	"	50mW	1mW	.02		
8	R7, R14	Resistor, film	RNR50H 1501FR	MIL-R-55182/7	"	2	"	"	"	50mW	1mW	.02		
9	R8	Resistor, film	RNR50H 1402FR	MIL-R-55182/7	"	1	"	"	"	50mW	1mW	.02		
10	R9, R15, R17	Resistor, film	RNR50H 3092FR	MIL-R-55182/7	"	3	"	"	"	50mW	1mW	.02		
11	R10	Resistor, film	RNR50H *	MIL-R-55182/7	"	1	"	"	"	50mW	1mW	.02		
12	R11	Resistor, film	RNR50H **	MIL-R-55182/7	"	1	"	"	"	50mW	1mW	.02		
* Selected Resistor: Select from RNR50H2802FR thru RNR50H3242FR ** Selected Resistor: Select from RNR50H4929FR thru RNR50H9530FR						SIGNATURE <u>W. J. [Signature]</u>		DATE <u>8/24/71</u>		REV. A				
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SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT SECONDARY DISPLAY

REFERENCE SCHEMATIC C543020276

Ref. Discrete Board A5

SKYLAB RELIABILITY DATA LIST

PART NO. C708753090

1	2	3	4	5	6	7	8	9	10	11	12
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)	RATED	STRESS	STRESS RATIO
											COL. 10 COL. 11
13	R12	Resistor, film	RNR50H 1502FR	MIL-R- 55182/7	NIERCO	1	100%	125	50mW	1mW	.02
14	R13	Resistor, film	RNR50H 1002FR	MIL-R- 55182/7	"	1	"	"	50mW	1mW	.02
15	R16	Resistor, film	RNR50H 2742FR	MIL-R- 55182/7	"	1	"	"	50mW	1mW	.02
16	R18	Resistor, film	RNR55H *	MIL-R- 55182/1	"	1	"	"	100mW	1mW	.01
17	R19	Resistor, film	RNR50H 4502FR	MIL-R- 55182/7	"	1	"	"	50mW	1mW	.02
18	R20	Resistor, film	RNR60H 4993FR	MIL-R- 55182/3	"	1	"	"	125mW	1mW	.01
19	R22, R23	Resistor, film	RNR50H 1001FR	MIL-R-55182/7	"	2	"	"	50mW	1mW	.02
20	R24	Resistor, film	RNR50H 4991FR	MIL-R-55182/7	"	1	"	"	50mW	1mW	.02
21	U1, U4	Voltage Follower, LM102	5L11573	C574000078	ANALOG SEMICONDUCTOR	2	"	"	8V	5V	.625
22	U2, U3	Operational Amplifier, LM107	5L11572	C574000077	"	2	"	"	8V	5V	.625
23	U5	Memory Comparator 180Aer LM106	5L11574	C574000079	"	1	"	"	8V	5V	.625
24	U6	Low Power Quad 2-in, TTL SNR54L00	5N13567	C528000455	"	1	"	"	8V	5V	.625
25	A5	Circuit Board	C535005232	C535005232	Precision Circuits	1	"	140	—	—	—

* Selected Resistor: Select from: RNR55H499FR
and RNR55H9530FR

SIGNATURE W. J. S. DATE 3/17/77

REVN

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**KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY**

REFERENCE SCHEMATIC C54330 0276

Ref. Integrator Board A6

RELIABILITY DATA LIST

PART NO. C708753090

SIGNATURE	DATE
<i>[Signature]</i>	8/6/71

REV A

10/9/9

SINGER KEARFOTT DIVISION SINGER-GENERAL PRECISION, INC. LITTLE FALLS, NEW JERSEY			EQUIPMENT <u>SEMI-CONDUCTOR DESIGN</u>			SKYLAB			RELIABILITY DATA LIST			PART NO. <u>C708753090</u>		
REFERENCE SCHEMATIC <u>15-020276</u>			<u>Ref. Power Supply Board A7</u>											
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO	COL. 10	COL. 11
								RATED	AMB	RATED	OPERATING			
1	C1	Capacitor, tantalum	265006100	2605066100	Union Carbide	1	100%	125	85	75V	35V	.467		
2	C2, C4	Capacitor, ceramic	AKR0035X 103KR	MIL-C-39014/2	Aerovox	2	"	"	"	200V	9V	.045		
3	C3	Capacitor, tantalum	25R135 225KR	MIL-C-39003/1	Union Carbide	1	"	"	"	20V	9V	.45		
4	C5	Capacitor, ceramic	AKR0035X 104KR	MIL-C-39014/2	Aerovox	1	"	"	"	100V	6V	.06		
5	C6, C8, C9	Capacitor, tantalum	25R135 476KR	MIL-C-39003/2	Union Carbide	3	"	"	"	35V	22V	.629		
6	C7, C16	Capacitor, tantalum	25R135 227KR	MIL-C-39003/2	Union Carbide	2	"	"	"	10V	5V	.50		
7	C10, C13	Capacitor, ceramic	AKR0035X 332KR	MIL-C-39014/2	Aerovox	2	"	"	"	200V	16V	.08		
8	C11, C12	Capacitor, ceramic	AKR0035X 680KR	MIL-C-39014/1	"	2	"	"	"	200V	16V	.08		
9	C14, C15	Capacitor, tantalum	25R135 335KR	MIL-C-39003/1	Union Carbide	2	"	"	"	50V	12V	.74		
10	C17	Capacitor, tantalum	25R135 335KR	MIL-C-39003/1	"	1	"	"	"	15V	9V	.60		
11	CR1-CR10	Diode, silicon	JANTX 1N4942	MIL-5-19500/357	Unirade	10	"	175	"	.75A	.015A	.02		
12	FL1-FL8	Filter, RFI	D-347	C57009294	Gulton	8	"	125	"	100V				
					SIGNATURE <u>[Signature]</u>		DATE <u>8/28/71</u>		REV. A					
					<u>782</u>				<u>Page 10</u>					

SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT SECONDARY DISPLAY

SKYLAB

RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020276

PART NO. C708753090

Ref: Power Supply Board A7

1	2	3	4	5	6	7	8	9	10	11	12
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)	RATED	STRESS	STRESS RATIO
13	L1	Choke	9702870211	C702870211	Electro Winding	1	100%	130	.336A	.15A	.44
14	L2	Choke	9702870210	C702870210	"	1	"	"	.551A	.15A	.27
15	L3-L5	Choke	C702866234	C702866234	"	3	"	"	2.30A	.44A	.19
16	Q1, Q4, Q5	Transistor Silicon NPN	JANTX 2N3439	MIL-S- 19500/366	Motorola	3	"	175	3.28W	.81W	.247
17	Q2	Transistor Silicon PNP	JANTX 2N2905A	MIL-S- 19500/290	Motorola	1	"	"	1.99W	.22W	.111
18	Q3	Transistor Silicon NPN	JANTX 2N2920	MIL-S- 19500/255	National	1	"	"	.49W	.60mW	.124
19	Q6	Transistor Silicon NPN	JANTX 2N2922A	MIL-S- 19500/255	T.I.	1	"	"	300mW	18mW	.06
20	Q8, Q10	Transistor Silicon NPN	JANTX 2N3420	MIL-S- 19500/393	"	2	"	"	15W	.76W	.05
21	R1, R13	Resistor Film	RNR55C 2252FR	MIL-R- 55182/1	MEPCO	2	"	125	100mW	10mW	.10
22	R2, R7	Resistor Film	RNR55C 2151FR	MIL-R- 55182/1	"	2	"	"	100mW	9mW	.09
23	R3	Resistor Film	RNR55C 1000FR	MIL-R- 55182/1	"	1	"	"	100mW	10mW	.10
24	R4	Resistor Film	RNR55C 9091FR	MIL-R- 55182/1	"	1	"	"	100mW	2mW	.05

SIGNATURE W. Zullo DATE 8/4/71

REV. A

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SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT Secondary Display SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020216

PART NO. C708753070

Ref: Power Supply Board M7

1	2	3	4	5	6	7	8	9	10	11	12
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)	RATED	STRESS	STRESS RATIO
								RATED	AMB	OPERATING	COL. 10 COL. 11
25	R5	Resistor, f.l.m	RNR55C *	MIL-R- 55182/1	MEPCO	1	100%	125	85	1 MW	.01
26	R6, R10, R12, R18, R24	Resistor, f.l.m	RNR55C 1002FR	MIL-R- 55182/1	"	5	"	"	"	100 mW R6 = 3 mW R10 = 17 mW R12 = 13 mW R18, R24 = 1 mW	.03 .13 .13 .01
27	R8, R11	Resistor, f.l.m	RNR55C 2000FR	MIL-R- 55182/1	"	2	"	"	"	100 mW R8 = 1 mW R11 = 45 mW	.01 .45
28	R9	Resistor, f.l.m	RNR55C 4321FR	MIL-R- 55182/1	"	1	"	"	"	100 mW	.01
29	R14	Resistor, f.l.m	RNR57C 2002FR	MIL-R- 55182/2	"	1	"	"	"	125 mW	.072
30	R15	Resistor, f.l.m	RNR550A 49R9FR	MIL-R- 55182/7	"	1	"	"	"	50 mW	.40
31	R16, R25	Resistor, f.l.m	RNR55C 1001FR	MIL-R- 55182/1	"	2	"	"	"	100 mW	.01
32	R17	Resistor, f.l.m	RNR55C 6191FR	MIL-R- 55182/1	"	1	"	"	"	5 mW	.05
33	R19, R28	Resistor, f.l.m	RNR55C 2261FR	MIL-R- 55182/1	"	2	"	"	"	100 mW	.10
34	R20, R26	Resistor, carbon	RCR07G 160JR	MIL-R- 39008/1	Allen- Bradley	2	"	100	"	125 mW	.24
35	R21, R27	Resistor, f.l.m	RNR55C 3741FR	MIL-R- 55182/1	MEPCO	2	"	125	"	100 mW	.14
36	R22, R29	Resistor, f.l.m	RNR55C X *	MIL-R- 55182/1	"	2	"	125	"	100 mW	.04

SIGNATURE W. J. [Signature] DATE 7/17/70

REV. A

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SINGER

KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT Secondary Diodes

REFERENCE SCHEMATIC C543020276

Ref. Power Supply Board A7

SKYLAB RELIABILITY DATA LIST

PART NO. C708753090

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
37	R23, R30	Resistor, wirewound	RWR915 7680FR	MIL-R-39007/9	Dale	2	100%	125	85	600mW	44mW	.07
38	R31	Resistor, film	RNR550 3011FR	MIL-R-55182/1	NIERO	1	"	"	"	100mW	.12mW	.01
39	R32, R33	Resistor, carbon	RCR079 1007R	MIL-R-39008/1	Allen-Brooklyn	2	"	100	"	125mW	16mW	.13
40	R34	Resistor, film	RNR550 2001FR	MIL-R-55182/1	NIERO	1	"	125	"	100mW	8mW	.08
41	T1	Transformer, Voltage Regulator	CTR2266/21	6702866/21	Electro Whidney	1	"	130	"	.55A	.44A	.79
42	U1, U2	Diode, Zener	5177230000	C574000081	Fairchild	2	"	125	"	8V	5V	.625
43	VR1	Diode, Zener	IN4780-TX	C531000768	General Semiconductor	1	"	175	"	180mW	9mW	.05
44	VR2, VR3	Diode, Zener	JANTX IN981B	MIL-S-19500/117	Dickson	2	"	"	"	320mW	10mW	.031
45	VR4, VR5	Diode, Zener	JANTX IN829	MIL-S-19500/159	Motorola	2	"	"	"	400mW	46.5mW	.116
46	A7A1	Current Board	5535005234	C535005234	Currents	1	"	140	"	—	—	—
47	A7A2	"	5535005235	C535005235	"	1	"	140	"	—	—	—
48	A7A3	"	5535005236	C535005236	"	1	"	140	"	—	—	—
49	A7A4	"	5535005237	C535005237	"	1	"	140	"	—	—	—

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W. J. A.

SINGER

KEARFOOT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT Four Digit Indicator

REFERENCE SCHEMATIC C543020341

DATA SUMMARY

SKYLAB RELIABILITY DATA LIST

PART NO. C708753110

ITEM NO.	REP. DES.	3	4	5	6	7	8	9		10	11		12
								APPLICATION TEMP. (°C)	AMB		STRESS	OPERATING	
		PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	RATED	AMB	RATED		COL. 10	COL. 11
1	A1	COUNTER BOARD Assy	C536000815	C536000815	SINGER KEARFOOT	1	100%	As	Shown On Sheet 2 of 15				
2	A2	COUNTER BOARD Assy	C536000816	C536000816	"	1	100%	As	Shown On Sheet 3 of 15				
3	A3	OSCILLATOR BOARD Assy	C536000817	C536000817	"	1	100%	As	Shown On Sheet 4 of 15				
4	A4	CONTROL BOARD Assy	C536000818	C536000818	"	1	100%	As	Shown On Sheet 6 of 15				
5	A5	INTEGRATOR BOARD Assy	C536000819	C536000819	"	1	100%	As	Shown On Sheet 8 of 15				
6	A6	Not Used	-	-	-	-	-	-	-	-	-		
7	A7	POWER SUPPLY Assy	C200110820	C200110820	"	1	100%	As	Shown On Sheet 11 of 15				
8	C1	CAPACITOR PLASTIC	C605009305	C605009305	COMPONENT RESEARCH	1	100%	125	85	50V	5V		.10
9	DS1-DS4	LED INDICATOR	C406000085	C406000085	HEWLETT-PACKARD	4	100%	95	85	800 mw	300 mw		.375
10	F21	FILTER RFI	C517009294	C517009294	GULTON	1	100%	125	85	100V	5V		.02
11	J1	CONNECTOR, 18 PIN	C520013002	C520013002	DEUTSCH	1	100%	200	85	1500V / 7.5A	100V / .5A		.066 / .066

SIGNATURE
W. C. Calkins
DATE
7/2/71
8/5/71

REV. A

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SINGER

HEADQUARTERS DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT Four Digit Display

REFERENCE SCHEMATIC C543020341

REF: COUNTER BOARD A1

SKYLAB RELIABILITY DATA LIST

PART NO. C708753110

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1, C2	CAPACITOR, CERAMIC	C605006092	C605006092	REPUBLIC (MUCON)	2	100%	125	85	50V	5V	.10
2	R1	RESISTOR, FILM	RNR50H 1001FR	MIL-R-55182/7	MEPEO	1	"	"	"	50mw	1mw	.02
3	U1, U4	HEX. INVERTER TTL SNR5404	SN13682	C528000461	T.I.	2	"	"	"	8V	5V	.625
4	U2	LOW POWER DUAL 4-14 TTL SNR54420	SN13569	C528000457	"	1	"	"	"	8V	5V	.625
5	U3	MED. POWER QAO 2-14 SNR54400	SN13580	C528000463	"	1	"	"	"	8V	5V	.625
6	U5, U8	DECADE COUNTER, TTL SNH5490506	SN21146	C574000073	"	2	"	"	"	8V	5V	.625
7	U6, U7	LOW POWER QAO 2-14 TTL SNR54400	SN13567	C528000455	"	2	"	"	"	8V	5V	.625
8	A1	CIRCUIT BOARD	C535005228	C535005228	Precision Circuits	1	"	140	"	-	-	-

SIGNATURE W. G. G. G. DATE 7/6/77

HEADQUARTERS DIVISION
LUNGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

REFERENCE SCHEMATIC C543020341

REF: COUNTER BOARD.A2

SKYLAB RELIABILITY DATA LIST

PART NO. C708753110

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SIGNATURE	DATE
<i>M. C. Liberto</i>	7/6/71

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SINGER CORPORATE DIVISION SINGER-GENERAL PRECISION, INC. LITTLE FALLS, NEW JERSEY		EQUIPMENT <u>Four Digit Display</u> RELIABILITY DATA LIST REFERENCE SCHEMATIC <u>C543 020 341</u> PART NO. <u>C708753 110</u> REF: <u>OSCILLATOR BOARD Assy-A3</u>										
ITEM NO.	REF. DES.	3	4	5	6	7	8	9		10	11	12
		PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO
								RATED	AMB	RATED	OPERATING	COL. 10 COL. 11
1	U1	LOW POWER, HEX INVERTER, TTL SNR 54104	SN13579	C528000462	T.I.	1	100%	125	85	8V	5V	.625
2	U2	LOW POWER, DUAL J-K, FF SNR 54173	SN13570	C528000458	"	1	"	"	"	8V	5V	.625
3	U3	LOW POWER, QUAD 2-IN TTL SNR 54100	SN13567	C528000455	"	1	"	"	"	8V	5V	.625
4	C1	CAPACITOR, CERAMIC	CK206 BX104KR	MIL-C-39014/2	AEROVOX	1	"	"	"	100V	15V	.15
5	C2, C3	CAPACITOR, CERAMIC	CK205 C605006092	C605006 092	REPUBLIC (HUCON)	2	"	"	"	50V	6V	.12
6	C5	CAPACITOR, CERAMIC	CK205 BX471KR	MIL-C-39014/1	AEROVOX	1	"	"	"	200V	6V	.03
7	C6	CAPACITOR, CERAMIC	CK206 BX104KR	MIL-C-39014/2	AEROVOX	1	"	"	"	100V	6V	.06
8	C4, C7	CAPACITOR, CERAMIC	CK205 BX221KR	MIL-C-39014/1	AEROVOX	2	"	"	"	200V	6V	.03
9	Q1, Q2, Q3	TRANSISTOR, SILICON, NPN	JAN-7Y 2222A	MIL-S-19509/255	T.I.	3	"	200	"	300mw	10mw	.033
10	R1	RESISTOR, FILM	RNR50H 6812FR	MIL-R. 55182/7	MEPCO	1	"	125	"	50mw	1mw	.02
11	R2	RESISTOR, FILM	RNR50H 5622FR	MIL-R. 55182/7	MEPCO	1	"	"	"	50mw	<5mw	<10
12	R3	RESISTOR, FILM	RNR50H 4991FR	MIL-R. 55182/7	MEPCO	1	"	"	"	50mw	<5mw	<10

SIGNATURE 2-2-67/1 DATE 7/6/71

REARFOOT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

SKYLAB RELIABILITY DATA LIST

PART NO. C708753110

REF: Oscillator Board Assy-A3

SIGNATURE	DATE
<i>W. E. Liberta</i>	7/6/71

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SINGER

SEAFORT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT Four Digit Display

REFERENCE SCHEMATIC CS43020341

SKYLAB RELIABILITY DATA LIST

PART NO. C708753110

REF: CONTROL BOARD ASSY-A4

1	2	3	4	5	6	7	8	9		10		11	12
								APPLICATION TEMP. (°C)	AMB	RATED	STRESS		
ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	RATED	AMB	RATED	STRESS	COL. 10	COL. 11
1	C1	CAPACITOR, TANTALUM	CSR13F 685KR	MIL-C 39003/1	UNION CARBIDE	1	100%	125	85	35V	6V	.17	
2	C2	CAPACITOR, CERAMIC	CKR06BX 152KR	MIL-C 39014/2	AEROVOX	1	"	"	"	200V	5V	.025	
3	C4	CAPACITOR, CERAMIC	CKR06BX 103KR	MIL-C 39014/2	AEROVOX	1	"	"	"	100V	5V	.05	
4	C5, C6	CAPACITOR, CERAMIC	2605006092	2605006092	REPUBLIC (MUCON)	2	"	"	"	50V	5V	.10	
5	CRI	DIODE, SILICON	JAN-TX IN914	MIL-S 19509/116	T.I.	1	"	175	"	160V	5mw	.031	
6	Q1	TRANSISTOR, UNIJUNCTION	S2N2419B	C532000579	G.E.	2	"	200	"	300mw	25mw	.083	
7	Q2	TRANSISTOR, SILICON, NPN	C532000555	C532000555	T.I.	1	"	"	"	300mw	25mw	.083	
8	Q3	TRANSISTOR, SILICON, NPN	JAN-TX 2N718A	MIL-S 19500/181	T.I.	2	"	"	"	328mw	25mw	.076	
9	R1	RESISTOR, FILM	RNR50H 3920FR	MIL-R 55182/7	MEPCO	2	"	125	"	50mw	5mw	.10	
10	R2	RESISTOR, FILM	RNR60H 4753FR	MIL-R 55182/3	MEPCO	1	"	"	"	125mw	5mw	.04	
11	R3	RESISTOR, FILM	RNR50H 2211FR	MIL-R 55182/7	MEPCO	1	"	"	"	50mw	5mw	.10	
12	R4	RESISTOR, FILM	RNR50H 5621FR	MIL-R 55182/7	MEPCO	2	"	"	"	50mw	5mw	.10	

SIGNATURE W. G. Galt DATE 7/6/71

CLASPOFF DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

SA'Y/LAB RELIABILITY DATA LIST

PART NO. C708753110

REF: CONTROL BOARD ASSY-A4

	SIGNATURE	DATE
	<i>D. C. C. C. C.</i>	<i>7/6/71</i>

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SINGER

REARPORT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT FOUR Digit Display

REFERENCE SCHEMATIC C543 020341

SKYLAB RELIABILITY DATA LIST

PART NO. C708753110

REF: INTEGRATOR BOARD Assy-A5

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1	CAPACITOR, CERAMIC	C605006092	C605006092	REPUBLIC (MUEON)	1	100%	125	85	50V	5V	.10
2	C2, C3	CAPACITOR, CERAMIC	CRK06BX 104KR	MIL-C-39014/2	AEROVOX	2	"	"	"	100V	5V	.05
3	CR1, CR2	DIODE, SILICON	JAN-TX-1N914	MIL-S-19500/116	T.I.	2	"	175	"	160mw	1mw	.022
4	CR3, CR4	DIODE, SILICON	JAN-TX-1N645	MIL-S-19500/240	T.I.	2	"	150	"	408mw	1mw	<.01
5	Q1, Q3	TRANSISTOR, SILICON, NPN	JAN-TX-2N2432	MIL-S-19500/313	CRYSTALONICS	2	"	200	"	180mw	1mw	<.01
6	Q2	TRANSISTOR, SILICON, PNP	JAN-TX-2N2944A	MIL-S-19500/382	CRYSTALONICS	1	"	"	"	262mw	1mw	<.01
7	R1, R2	RESISTOR, FILM	RNR50H 8062FR	MIL-R-55182/7	MEPCO	2	"	125	"	50mw	<5mw	<.01
8	R3, R4	RESISTOR, FILM	RNR50H 6492FR	MIL-R-55182/7	MEPCO	2	"	"	"	50mw	<5mw	<.01
9	R5, R6	RESISTOR, FILM	RNR50H 3832FR	MIL-R-55182/7	MEPCO	2	"	"	"	50mw	<5mw	<.01
10	R7, R14	RESISTOR, FILM	RNR50H 1501FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	<5mw	<.01
11	R8	RESISTOR, FILM	RNR50H 1402FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	<5mw	<.01
12	R9, R15, R17, R21	RESISTOR, FILM	RNR50H 2942FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	<5mw	<.01

SIGNATURE W. G. G. G. DATE 7/6/71

REARFOOT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

REFERENCE SCHEMATIC C543020341

REF: INTEGRATOR BOARD ASSY-A5

PART NO. C708753110

J	ITEM NO.	2	3	4	5	6	7	8	9		10		11	12							
									REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION			MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS	
																		RATED	AMB	RATED	OPERATING
13	R10		RESISTOR, FILM	RNR 50H #	MIL-R-55182/7	MEPCO	1	100%	125	85	50mw	1mw		.02							
14	R11		RESISTOR, FILM	RNR 50H #	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw		.02							
15	R12		RESISTOR, FILM	RNR 50H 1272FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw		.02							
16	R13		RESISTOR, FILM	RNR 50H 1002FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw		.02							
17	R16		RESISTOR, FILM	RNR 50H 2742FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw		.02							
18	R18		RESISTOR, FILM	RNR 50H #	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw		.02							
19	R19		RESISTOR, FILM	RNR 50H 7501H	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw		.02							
20	R20		RESISTOR, FILM	RNR 60H 4993FR	MIL-R-55182/3	MEPCO	1	"	"	"	50mw	1mw		.02							
21	R22,R23		RESISTOR, FILM	RNR 50H 1001FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw		.02							
22	R24		RESISTOR, FILM	RNR 50H 4991FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw		.02							
23	U1,U4		VOLTAGE FOLLOWER LM102	SL11573	C574000078	NAT.SEMI.	2	"	"	"	8V	5V		.625							
24	U2,U3		OPERATIONAL AMPLIFIER, LM102	SL11572	C574000077	NAT.SEMI	2	"	"	"	8V	5V		.625							

* SELECTED RESISTOR: SELECT FROM RNR 50H 2802FR THRU RNR 50H 9242 FR

** SELECTED RESISTOR: SELECT FROM RNR 50H 4993FR THRU RNR 50H 1001FR

SIGNATURE
DATE

7/6/71

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REARFOY DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

REFERENCE SCHEMATIC C543020 341

PART NO. C708753110

REF: INTEGRATOR BOARD Assy -5

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SIGNATURE	DATE
<i>W. C. C. C. C.</i>	7/6/71

SINGER

REARPORT DIVISION
ENGINEER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT Four Digit Display

REFERENCE SCHEMATIC C543020341

REF: Power Supply Board Assy-A7

SKYLAB RELIABILITY DATA LIST

PART NO. C708753110

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1	CAPACITOR, TANTALUM	C605006100	C605006100	UNION CARBIDE	1	100%	125	85	75V	35V	.467
2	C2, C4	CAPACITOR, CERAMIC	CKR06BX 103KR	MIL-C-39014/2	AEROVOX	2	"	"	"	200V	9V	.045
3	C3	CAPACITOR, TANTALUM	CSR13E 225KR	MIL-C-39003/1	UNION CARBIDE	1	"	"	"	20V	9V	.45
4	C5	CAPACITOR, CERAMIC	CKR06BX 104KR	MIL-C-39014/1	UNION CARBIDE	1	"	"	"	100V	6V	.06
5	C6, C8, C9	CAPACITOR, TANTALUM	CSR13F 476KR	MIL-C-39003/2	UNION CARBIDE	3	"	"	"	35V	22V	.629
6	C7, C16	CAPACITOR, TANTALUM	CSR13C 227KR	MIL-C-39003/2	UNION CARBIDE	2	"	"	"	10V	5V	.50
7	C10, C13	CAPACITOR, CERAMIC	CKR06BX 332KR	MIL-C-39014/2	AEROVOX	2	"	"	"	200V	16V	.08
8	C11, C12	CAPACITOR, CERAMIC	CKR05BX 680KR	MIL-C-39014/1	AEROVOX	2	"	"	"	200V	16V	.08
9	C14, C15	CAPACITOR, TANTALUM	CSR13G 335KR	MIL-C-39003/1	UNION CARBIDE	2	"	"	"	50V	12V	.24
10	C17	CAPACITOR, TANTALUM	CSR13D 335KR	MIL-C-39003/1	UNION CARBIDE	1	"	"	"	15V	9V	.60
11	CR1-CR10	DIODE, SILICON	JAN-TX IN4942	MIL-S-19500/359	UNITRODE	10	"	175	"	.75A	.015A	.02
12	FL1-FL8	FILTER, RFI	D-347	C517009294	GULTON	8	"	125	"	100V		

SIGNATURE W. G. Galt DATE 7/6/71
WLC 8/5/71

REV. A

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SINGER

SEARFOT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EQUIPMENT Four Digit Display

SKYLAB

RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020341

PART NO. C7028753110

REF: Power Supply Board Assy-A7

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
13	L1	CHOKE	C702870211	C702870211	ELECTRO WINDING	1	100%	130	85	.336A	.15A	.44
14	L2	CHOKE	C702870210	C702870210	ELECTRO WINDING	1	"	"	"	.551A	.15A	.27
15	L3-L5	CHOKE	C702866234	C702866234	ELECTRO WINDING	3	"	"	"	2.30A	.44A	.19
16	Q1, Q4 Q5	TRANSISTOR, SILICON, NPN	JAN-TX 2N3499	MIL-S-19500/366	MOTOROLA	3	"	175	"	3.28W	.81W	.247
17	Q2	TRANSISTOR, SILICON, PNP	JAN-TX 2N2905A	MIL-S-19500/290	NATIONAL	1	"	"	"	1.99W	.22W	.111
18	Q3	TRANSISTOR, SILICON, NPN	JAN-TX 2N2920	MIL-S-19500/355	NATIONAL	1	"	"	"	.49W	.060W	.124
19	Q6	TRANSISTOR, SILICON, NPN	JAN-TX 2N2222A	MIL-S-19500/255	T.I.	1	"	"	"	.30W	.018W	.060
20	Q8, Q10	TRANSISTOR, SILICON, NPN	JAN-TX 2N3420	MIL-S-19500/393	T.I.	2	"	"	"	15W	.76W	.051
21	R1, R13	RESISTOR, FILM	RNR55C 8252FR	MIL-R-55182/1	MEPCO	2	"	125	"	100 mwr	10 mwr	.10
22	R3, R7	RESISTOR, FILM	RNR55C 2151FR	MIL-R-55182/1	MEPCO	2	"	"	"	100 mwr	9 mwr	.09
23	R3	RESISTOR, FILM	RNR55C 1000FR	MIL-R-55182/1	MEPCO	1	"	"	"	100 mwr	10 mwr	.10
24	R4	RESISTOR, FILM	RNR55C 9091FR	MIL-R-55182/1	MEPCO	1	"	"	"	100 mwr	2 mwr	.02

SIGNATURE R. C. H. H. H. DATE 7/6/71

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EQUIPMENT Four Digit Display

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC CS43020341

PART NO. C708753110

REF. POWER SUPPLY BOARD-A7

ITEM NO.	REF. DES.	3	4	5	6	7	8	9		10	11		12
								APPLICATION TEMP. (°C)	AMB		STRESS	STRESS RATIO	
		PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	RATED		RATED	OPERATING	COL. 10 COL. 11	
25	R5	RESISTOR, FILM	RNR55C *	MIL-R 55182/1	MEPCO	1	100%	125	85	100mw	1mw	.01	
26	R6	RESISTOR, FILM	RNR55C 1002FR	MIL-R 55182/1	MEPCO	1	"	"	"	100mw	3mw	.03	
27	R10	RESISTOR, FILM	RNR55C 1002FR	MIL-R 55182/1	MEPCO	1	"	"	"	100mw	17mw	.17	
28	R12	RESISTOR, FILM	RNR55C 1002FR	MIL-R 55182/1	MEPCO	1	"	"	"	100mw	13mw	.13	
29	R18, R24	RESISTOR, FILM	RNR55C 1002FR	MIL-R 55182/1	MEPCO	1	"	"	"	100mw	1mw	.01	
30	R8, R11	RESISTOR, FILM	RNR55C 2000FR	MIL-R 55182/1	MEPCO	1	"	"	"	100mw	R8 = 1mw R11 = 45mw	.01 .45	
31	R9	RESISTOR, FILM	RNR55C 4321FR	MIL-R 55182/1	MEPCO	1	"	"	"	100mw	1mw	.01	
32	R14	RESISTOR, FILM	RNR57C 2003FR	MIL-R 55182/2	MEPCO	1	"	"	"	125mw	9mw	.072	
33	R15	RESISTOR, FILM	RNR50H 4929FR	MIL-R 55182/7	MEPCO	1	"	"	"	50mw	20mw	.40	
34	R16, R25	RESISTOR, FILM	RNR55C 1001FR	MIL-R 55182/1	MEPCO	2	"	"	"	100mw	1mw	.01	
35	R17	RESISTOR, FILM	RNR55C 6191FR	MIL-R 55182/1	MEPCO	1	"	"	"	100mw	5mw	.05	
36	R19, R28	RESISTOR, FILM	RNR55C 2261FR	MIL-R 55182/1	MEPCO	2	"	"	"	100mw	10mw	.10	

* SELECTED RESISTOR: SELECT FROM RNR55C1212FR
THRU RNR55C1742FR

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EQUIPMENT Four Digit Display

REFERENCE SCHEMATIC CS43 020341

REF: Power Supply Board A7

SKYLAB RELIABILITY DATA LIST

PART NO. 0708753110

ITEM NO.	REF. DES.	PART DESCRIPTION	PART NUMBER	PROCUREMENT SPECIFICATION	MANUFACTURER	QTY. PER UNIT	DUTY CYCLE	APPLICATION TEMP. (°C)		STRESS		STRESS RATIO COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
37	R20, R26	RESISTOR, CARBON	R00076 160JR	MIL-R-39008/1	ALLEN BRADLEY	2	100%	100	85	125 mw	30 mw	.24
38	R21, R27	RESISTOR, FILM	RNR55C 3741FR	MIL-R-55182/1	MEPCO	2	"	125	"	100 mw	14 mw	.14
39	R22, R29	RESISTOR, FILM	RNR55C *	MIL-R-55182/1	MEPCO	2	"	125	"	100 mw	4 mw	.04
40	R23, R30	RESISTOR, WIREWOUND	RWR81S 7680FR	MIL-R-39007/9	DALE	2	"	125	"	600 mw	44 mw	.07
41	R31	RESISTOR, FILM	RNR55C 3011FR	MIL-R-55182/1	MEPCO	1	"	125	"	100 mw	.12 mw	<.01
42	R32, R33	RESISTOR, CARBON	R00076 100JR	MIL-R-39008/1	ALLEN BRADLEY	2	"	100	"	125 mw	16 mw	.13
43	R34	RESISTOR, FILM	RNR55C 2001FR	MIL-R-55182/1	MEPCO	1	"	125	"	100 mw	8 mw	.08
44	T1	TRANSFORMER	0702866121	0702866121	ELECTRO WINDING	1	"	130	"	.55A	.44A	.79
45	U1, U2	VOLTAGE REGULATOR LM723	QLT723000	C574000 081	FAIRCHILD	2	"	125	"	8V	5V	.625
46	VR1	DIODE, ZENER	IN4780-TX	C531000 768	GENERAL SEMICONDUCTOR	1	"	175	"	180 mw	9 mw	.05
47	VR2, VR3	DIODE, ZENER	JAN-TX IN981B	MIL-S-19500/117	DICKSON	2	"	175	"	320 mw	10 mw	.031
48	VR4, VR5	DIODE, ZENER	JAN-TX IN829	MIL-S-19500/159	MOTOROLA	2	"	175	"	400 mw	46.5 mw	.116

* SELECTED RESISTOR: SELECT FROM RNR55C182FR THRU RNR55C1003FR

SIGNATURE
DATE
7/6/71
8/5/71

REV. A

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RELIABILITY DATA LIST

PART NO. C708753110

REF: Power Supply Board A7

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NO. C200095116

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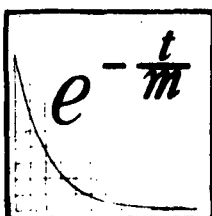
SKYLAB INDICATORS
RELIABILITY PREDICTION
AND
ESTIMATION REPORT
FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
ALABAMA, U.S.A.

AMENDED - JUNE, 1971

CONTRACT NO. NAS8-26120
KEARFOTT SALES ORDER 926-080017

PREPARED BY
RELIABILITY ENGINEERING DEPARTMENT



RELIABILITY ENGINEERING

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ENGINEER				

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DOCUMENT GRADE.

DOCUMENT ISSUE	DESCRIPTION	APPROVAL AND DATE
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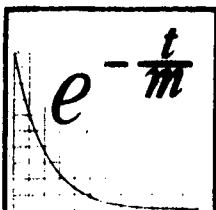
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INTRODUCTION

This document contains the Kearfott Reliability Prediction and Estimation Report for the NASA-MSFC Skylabs Event Timer, Secondary Display and Four Digit Display. This report is written in accordance with the following specifications:

MSFC Specification
(Event Timer)

40M38207

MSFC Specification
(Secondary Display)
(Four Digit Display)

40M38208 and
40M38208-9

Kearfott Division
Reliability Work Statement

Dated June 26, 1970

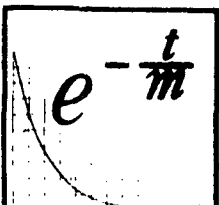
Kearfott Division
Reliability Program Plan

C200095115 Rev. A

NASA Reliability Publication NCP 250-1
(Reference Document)

July 1963

The reliability prediction presented is based on the final design configuration available from the Electrical and Electronic Components Lists C543053900, C543053901 and C543053971 for the Event Timer, the Secondary Display, and Four Digit Display, respectively. Any significant changes to the respective designs will be assessed to determine their effect on the reliability of the systems and will result in an updated prediction.

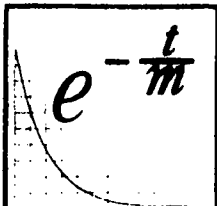


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KEARFOTT DIVISIONKEARFOTT DIVISION
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LITTLE FALLS, NEW JERSEYRELIABILITY DISCUSSION

The Reliability Prediction and Estimation Analysis is a result of reliability studies which were performed to ensure that optimum design for the Event Timer, Secondary Display and Four Digit Display indicators has been achieved.

The analysis included a review of each basic system and the major sections thereof. A thorough study of each of the major sections has resulted in trade-offs and selection of components necessary for maximizing performance and reliability. The choice between utilizing integrated circuits or discrete circuitry for specific applications was based on achieving and maintaining the optimum design when considering state-of-the-art capabilities, reliability, performance, and delivery.

The type of circuitry used in the Event Timer, Secondary Display, and Four Digit Display indicators was thoroughly investigated and is a result of experience and knowledge gained in developing the ATM 4 and 5 digit indicators, ORDEAL, and LEM Apollo Indicators for space application.



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LITTLE FALLS, NEW JERSEYFUNCTIONAL DESCRIPTIONEvent Timer

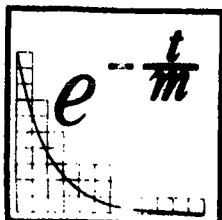
The Event Timer displays four light emitting diode numerics indicating decreasing readouts of time. The readout range is from 99 minutes 59 seconds to 00 minutes 00 seconds with no automatic countdown interruption after 00 minutes 00 seconds. The display is updated once per second and is capable of being preset to any time within the readout range. A zero output circuit is activated at the 00 minutes 00 seconds and remains activated until the circuit is opened by external means. Control of the timer operation and power inputs is from external sources.

The oscillator card A7 contains an oscillator whose output is 1.48576 MHZ and two flatpacks which count down to an output square wave equivalent to 65.536 KHZ.

The timing card A6 contains sixteen flip flops in eight flatpacks and provides divide by 2 to the sixth, 2 to the fifteenth and 2 to the sixteenth outputs. The command rate, clock rate, and clear inputs to the flip flops are brought out. The clear signal presets the circuit at counter start.

The control circuit card A5 provides logic for determining and controlling the mode of operation of the Event Timer. Three command signals, Start, Stop and Test, are inputted to the card which determines the logic levels of the Slew Start Count Test commands and clock repetition rate controlling the indicator. When a Stop command signal is received, the clock repetition rate is set to 2 HZ, the Enable Slew output is set high and the Start command is set low. When a Start command signal is received, the clock repetition rate is set to 1 HZ, a reset signal is generated for setting the flip flops of the timing card to delay the first clock pulse output one second, the Start command is set high and the Slew command is set low. When a Test command signal is received, it overrides the Stop or Start command signals, sets the clock repetition rate to 1024 HZ, and sets the test command low.

The counter logic cards A1-A4 contain seven flatpacks for the selection of a clock which is counted down and encoded as a BCD output. The output is in a 1-2-4-8 code and is capable of driving a Hewlett Packard LED numeric display. A circuit has been provided to reset the BCD output to



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zero when, at power turn-on, the BCD output is greater than nine. A carry output pulse is provided when the BCD output changes from zero to nine.

The discrete card A8 is made up of seven discrete buffer circuits whose input impedance is greater than 100 K ohms. There is also a SCR zero output circuit capable of sinking 200 milliamperes. EMI and random pulse suppression circuits are included in the buffer circuitry.

Secondary Display

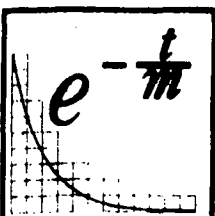
The Secondary Display converts a 0 to 5 VDC analog input signal into BCD digital form and displays this information on four light-emitting diode (LED) numerics. The display is capable of presenting eight (8) different scales, each selected by external scale command. An additional command is used for lamp test in which each of the diodes in the LED display is illuminated by rapidly pulsing the counters, thereby rippling the LED's through all numbers.

The Secondary Display is comprised of six circuit cards, a power supply, and the four LED numerics.

The power supply generates ± 12 VDC, ± 6.2 VDC and $+5$ VDC from a 28 VDC input. The ± 12 VDC and ± 6.2 VDC are used to power the analog section of the display; the 5 VDC is used for logic power. Counter cards A1 and A2 supply the four BCD words of information to the LED's. The LED's contain internal logic which converts the BCD input into numerics. The control logic card A3 provides the necessary logic to assure appearance of the selected scale.

The oscillator card A4 contains two unijunction oscillators: one approx. 40 KHz used as a clock input to the counters, and the other produces a pulse approximately every two seconds to initialize logic prior to an update. The A4 card also informs the A5 integrator to integrate up or down. The operation of the integrator is sequentially controlled by card A4.

The integrator card A5 contains the analog circuitry necessary to implement the analog/BCD conversion and is essentially an integrator and comparator. The technique used for conversion is the Up/Down Ramp method



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comparing the input signal against a known internal reference.

The discrete card A6 serves simply as a buffer card so that 28V command signals are converted to logic levels. This card provides EMI pulse suppression and provides minimum input impedances of 30K ohms.

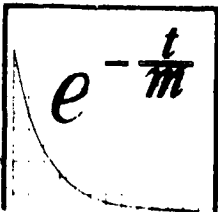
FOUR DIGIT DISPLAY

The Four Digit Display converts a 0 to 10 Vdc analog input signal into BCD digital form (representing the input voltage) and displays this information on four light-emitting diode (LED) numerics. A command is used for lamp test in which each of the diodes in the LED display is illuminated by rapidly pulsing the counters, thereby rippling the LED's through all numbers.

The Four Digit Display is comprised of five circuit cards, a power supply and the four LED numerics.

The power supply generates ± 12 Vdc, ± 6.2 Vdc and $+5$ Vdc from a 28 Vdc input. The ± 12 Vdc and ± 6.2 Vdc are used to power the analog section of the display; the 5 Vdc is used for logic power. Counter cards A1 and A2 supply the four BCD words of information to the LED's. The LED's contain internal logic which converts the BCD input into numerics. Two oscillators are used in the display. The clock oscillator found on the A3 card has a frequency of approximately 400 K hertz. This oscillator is a Hartley, L.C. oscillator. The A4 card contains a unijunction oscillator which delivers a pulse approximately every 2 seconds. This pulse is used to update the display. The A4 card also informs the A5 integrator to integrate up or down. The operation of the integrator is sequentially controlled by card A4.

The integrator card A5 contains the analog circuitry necessary to implement the analog/BCD conversion and is essentially an integrator and comparator. The technique used for conversion is the UP/DOWN Ramp method comparing the input signal against a known internal reference.



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RELIABILITY PREDICTION METHOD

The reliability prediction is an estimate of the inherent reliability of the Event Timer, Secondary Display and Four Digit Display indicators when operating in a space (Earth Orbit) environment. The method and data of Mil Handbook 217A, Reliability Stress and Failure Rate Data for Electronic Equipment, Mil Standard 756A, and Kearfott Secondary Data were used to prepare this prediction.

The method of prediction is to select a criterion in establishing the effects of equipment design. It enables a check upon the initial design to determine compliance to the required reliability. The factors involved in the reliability prediction and analysis are as follows:

- Apportionment of reliability goals and requirements
- Determination of environmental condition and mission profile.
- Development of a reliability mathematical model
- Determination of part population for each functional element
- Design analysis of part application
- Assignment of failure rates, adjusted for stress
- Prediction of reliability
- Feedback of information to appropriate personnel

The approach taken by Reliability Engineering in evaluating and estimating the reliability of the Event Timer and Secondary Display indicators is based on the exponential failure frequency distribution $f(t)$.

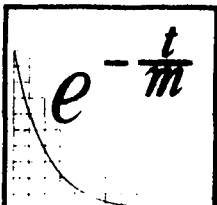
$$f(t) = \lambda e^{-\lambda t}$$

Reliability is a function of Mission Time (t)

$$R(t) = \int_0^t F(t) dt = e^{-\lambda t} = e^{-t/m}$$

where

λ = mean failure rate in failures per million hours,



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 t = mission time in hours,

 $m = 1/\lambda$ = mean time to or between failures in hours (MTBF)

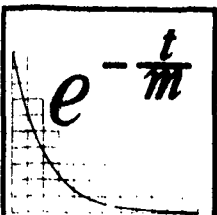
The prediction for the indicators is based on part complexity, design electrical part stress, operation at the maximum allowable temperature of +85°C (including anticipated internal heat rise) and other environmental conditions compatible with those experienced in space environment. Essentially, a worst case Reliability Prediction was made, in that failure rates for continuous operation at the elevated temperature were applied. The predicted reliability for the indicators is shown to be

 Event Timer $R = .9853$

 Secondary Display $R = .9828$

 Four Digit Display $R = .9844$

in an operational environment. This prediction is based on the use of Hi-Rel or Established Reliability parts. The summaries shown in Figures 1, 2 and 3, Reliability Model for the Event Timer (Secondary Display and Four Digit Display), applies to the current FLIGHT-USE production equipment.



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RELIABILITY GOAL

(Ref. Event Timer Spec. 40M382707 para.
3.4.13.2)

Secondary Display and Four Digit Display
Spec- 40M38208 para. 3.4.10.2)

Reliability Design Goal = $R = .998$

*Based on Mission Profile of 1,000 Hrs.

Mathematical Model:

$$R = e^{-t/m}$$

where t = Mission Time

$$.998 = e^{-1000/m}$$

$$m = \text{MTBF}$$

$$\ln .998 = \ln (e^{-1000/m})$$

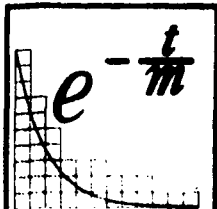
$$\tau = \frac{1}{m} = \text{failure rate per million hours}$$

$$-.002 = -1000/m$$

$$m = \underline{500,000 \text{ Hrs.}}$$

or

$$\tau = 2.00 \text{ per million hours of operation}$$



* Amended per REF. S.O. 926-080017
Dated 6/26/70

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PREDICTED RELIABILITY AND MATHEMATICAL MODEL SUMMARY

Tabulated below are the parts counts and failure rates of present Event Timer, Secondary Display and Four Digit Display system configurations. The total system failure rates for the present configurations are $\lambda = 14.7478$ failures per million hours of operation (Event Timer); $\lambda = 17.2461$ failures per million hours of operation (Secondary Display), and $\lambda = 15.6240$ failures per million hours of operation (Four Digit Display).

Event Timer

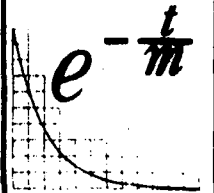
<u>Part.</u>	<u>Qty</u>	<u>F lab/ea</u>	<u>F lab/total</u>
Counters	4	.6666	2.6664
Control Logic	1	.6666	.6666
Timer	1	.7518	.7518
Oscillator	1	.4770	.4770
Discrete	1	1.0626	1.0626
Power Supply	1	2.0655	2.0655
LED Indicators	4	1.7434	6.9736
Misc. Parts	1	.0843	.0843
Total			14.7478

Secondary Display

<u>Part</u>	<u>Qty</u>	<u>F lab/ea</u>	<u>F lab/total</u>
Counters (A1)	1	.7786	.7786
(A2)	1	.6926	.6926
Control Logic	1	.8646	.8646
Oscillator	1	1.0457	1.0457
Integrator	1	1.4118	1.4118
Discrete	1	1.1984	1.1984
Power Supply	1	4.0351	4.0351
LED Indicators (DS1,3)	2	1.7434	3.4868
(DS2,4)	2	1.8016	3.6032
Misc. Parts	1	.1293	.1293
Total			17.2461

Four Digit Display

<u>Part</u>	<u>Qty</u>	<u>F lab/ea</u>	<u>F lab/total</u>
Counters (A1)	1	.7786	.7786
(A2)	1	.6066	.6066
Oscillator	1	.7374	.7374
Control Logic	1	.8352	.8352
Integrator	1	1.4118	1.4118
Power Supply	1	4.0351	4.0351
LED Indicators (DS1,3)	2	1.7434	3.4868
(DS2,4)	2	1.8016	3.6032
Misc. Parts	1	.1293	.1293
Total			15.6240



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The Orbit Environmental "K" Factor from Mil Standard 756A = 1.0
Based on a mission time of 1,000 hours and the respective failure
rates of each indicator, the reliability of the indicators is de-
rived as follows:

$$R = e^{-\lambda t}$$

where: R = probability of success

λ = total failure rate

t = mission time in hours

Event Timer

$$R = e^{-(14.7478 \times 10^{-6}) (1000)}$$

$$R = e^{-.0147478}$$

$$R = .9853$$

Secondary Display

$$R = e^{-(17.2461 \times 10^{-6}) (1000)}$$

$$R = e^{-.0172461}$$

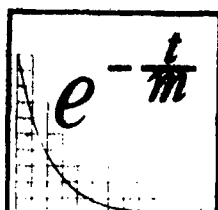
$$R = .9828$$

Four Digit Display

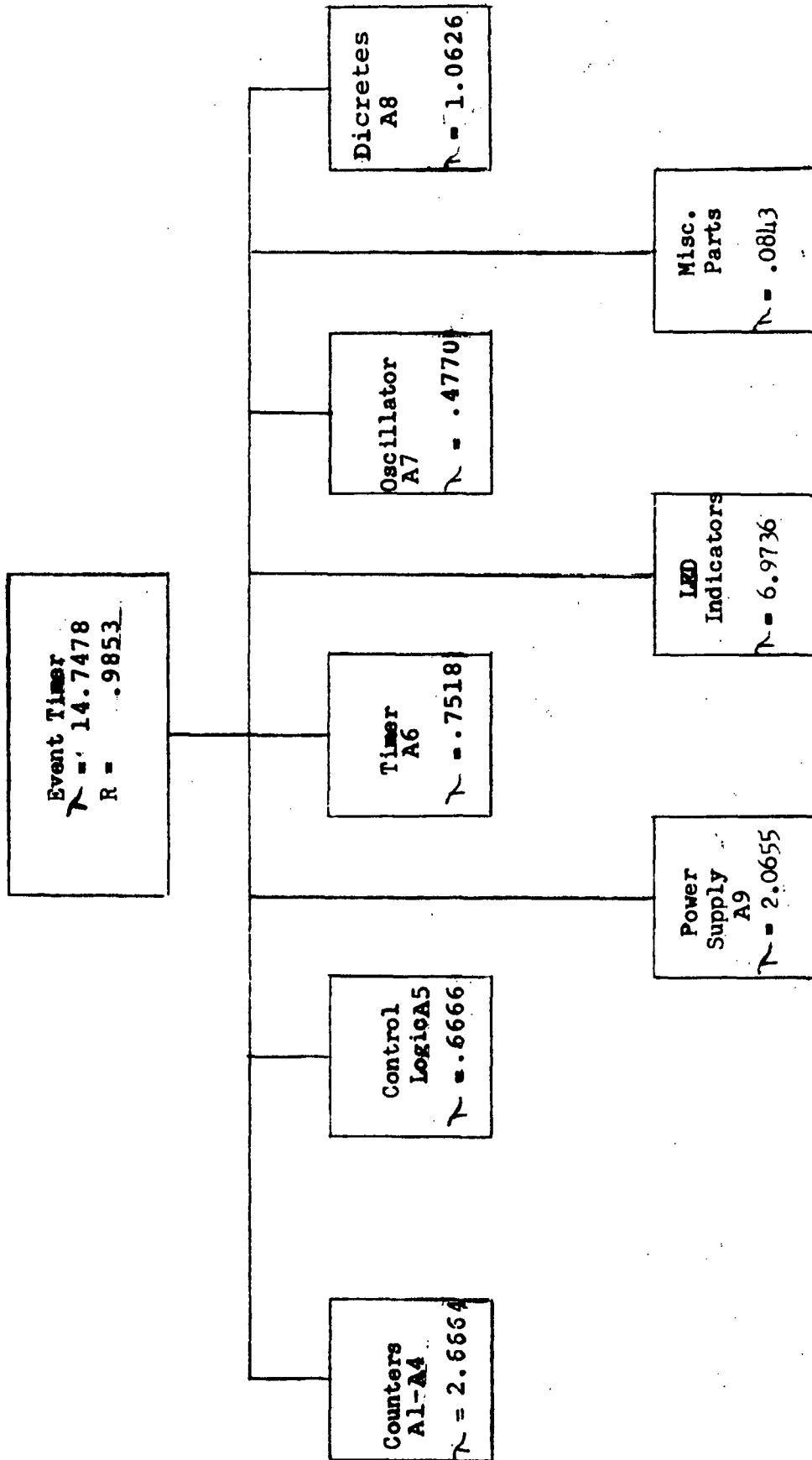
$$R = e^{-(15.6240 \times 10^{-6}) (1000)}$$

$$R = e^{-.0156240}$$

$$R = .9844$$



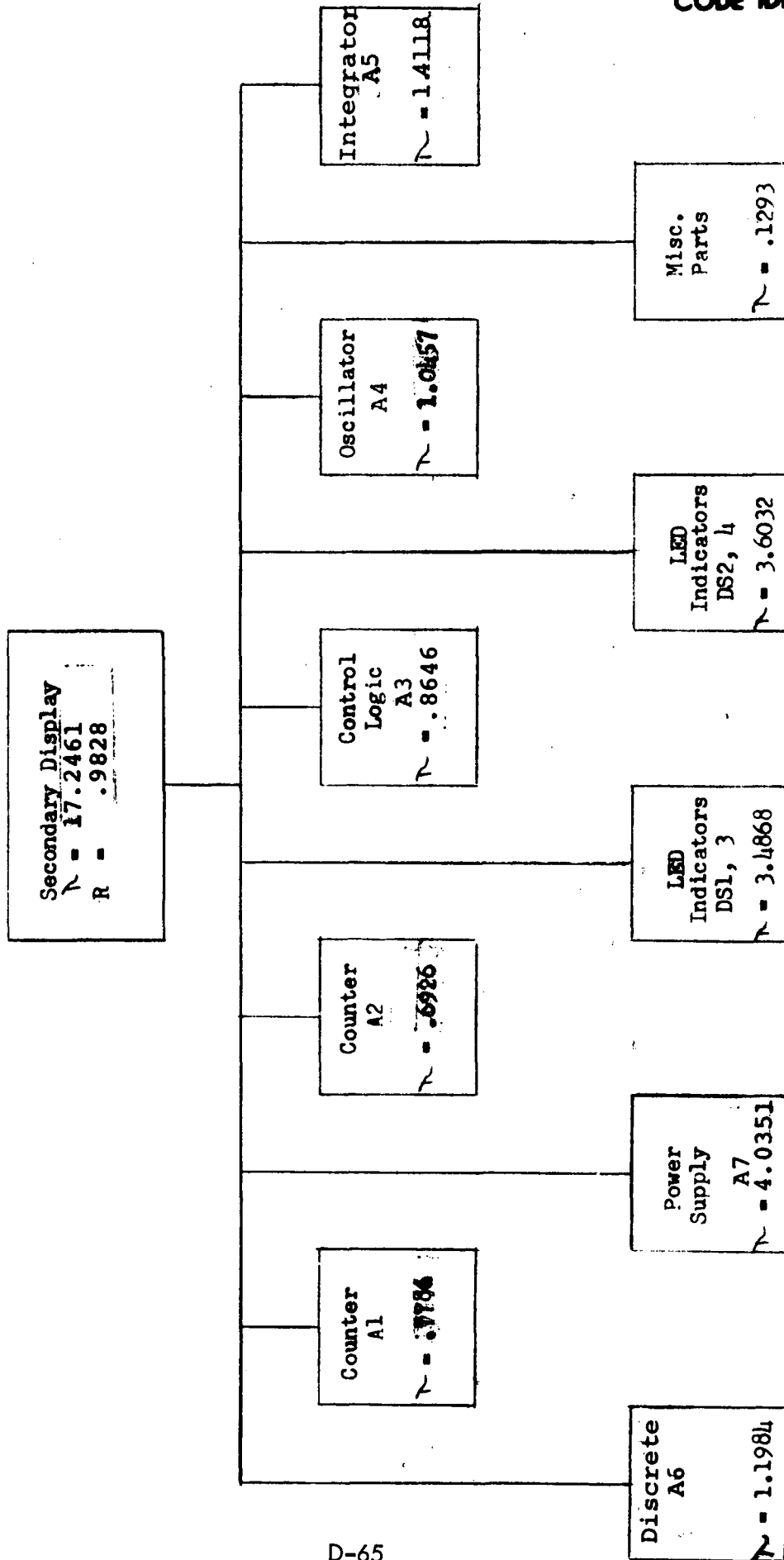
RELIABILITY MODEL FOR
EVENT TIMER IN
OPERATIONAL ENVIRONMENT



- Failure Rate Per Million Hours

FIGURE 1

RELIABILITY MODEL FOR
SECONDARY DISPLAY IN
OPERATIONAL ENVIRONMENT

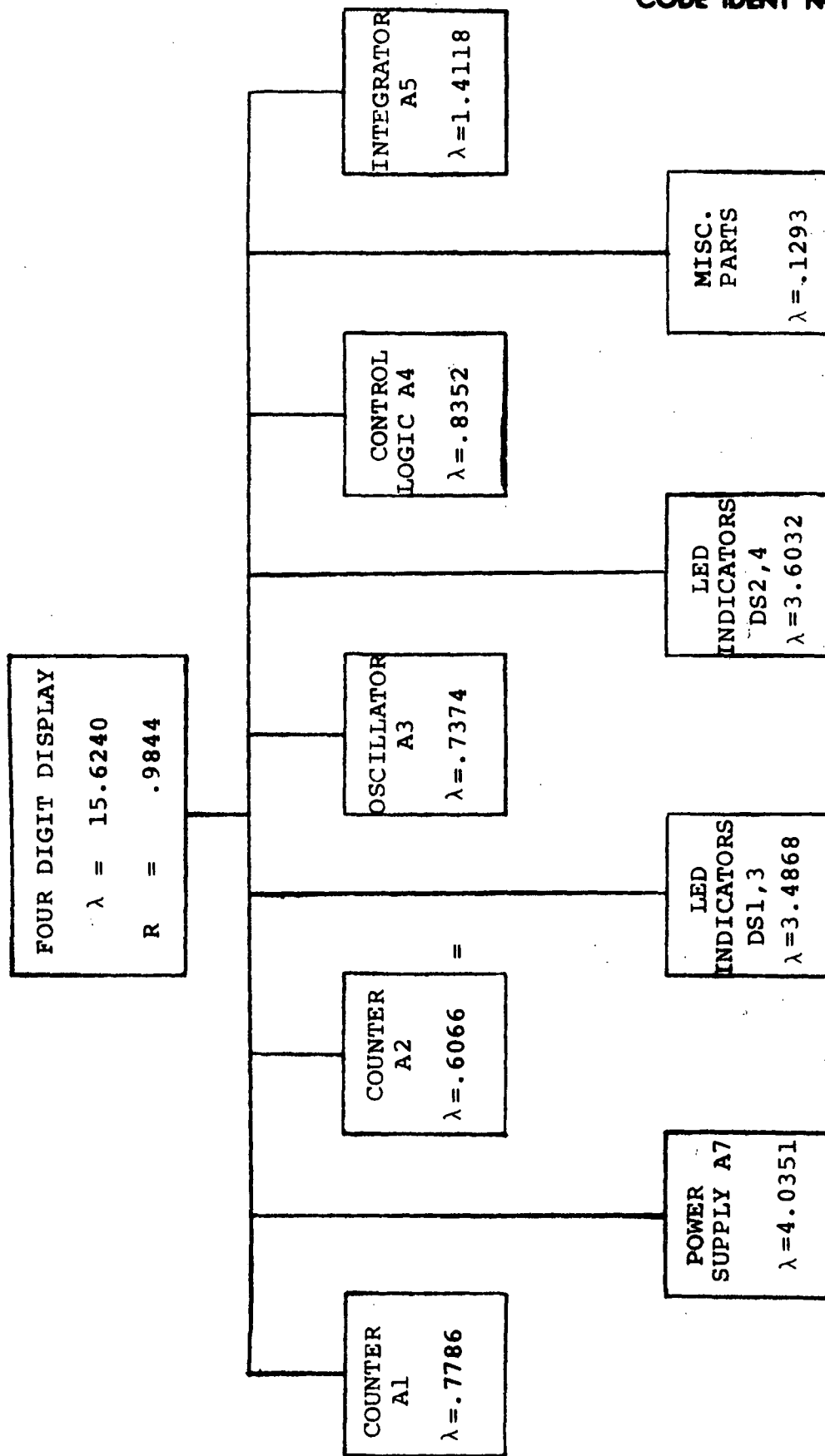


D-65

λ = Failure Rate Per Million Hours

FIGURE 2

RELIABILITY MODEL FOR
FOUR DIGIT DISPLAY IN
OPERATIONAL ENVIRONMENT



λ = FAILURE RATE PER MILLION HOURS.

FIGURE 3

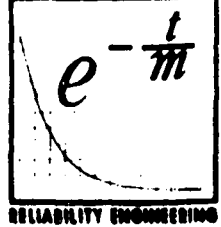
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PAGE ISSUE A

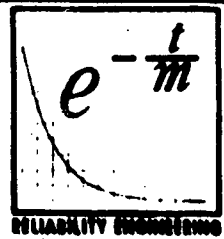
CODE IDENT NO. 88818

SINGERKEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEYEVENT TIMER
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

@ 85°C



DATA SUMMARY	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL X f LAB./TOT	
A1 Board	1	1.0	.6666	-	.6666	From page 15
A2 Board	1	1.0	.6666	-	.6666	From page 15
A3 Board	1	1.0	.6666	-	.6666	From page 16
A4 Board	1	1.0	.6666	-	.6666	From page 16
A5 Board	1	1.0	.6666	-	.6666	From page 17
A6 Board	1	1.0	.7518	-	.7518	From page 17
A7 Board	1	1.0	.4770	-	.4770	From page 17
A8 Board	1	1.0	1.0626	-	1.0626	From page 19
A9 Board	1	1.0	2.0655	-	2.0655	From page 20
DS1 Indicator LED	1	1.0	1.7434	-	1.7434	Kearfott Secondary
DS2 Indicator LED	1	1.0	1.7434	-	1.7434	Kearfott Secondary
DS3 Indicator LED	1	1.0	1.7434	-	1.7434	Kearfott Secondary
DS4 Indicator LED	1	1.0	1.7434	-	1.7434	Kearfott Secondary
FL1 Filter, RFI	1	1.0	.0681	-	.0681	Aerovox
J1 Connector, 18 pin	1	1.0	.0162	-	.0162	Mil Hdbk 217A
Total Failure Rate			-	-	14.7478	
MTBF			-	-	67,807	hrs
R			-	-	.9853	

SINGERKEARFOTT DIVISION
SINGER-GENERAL DIVISION, INC.
LITTLE FALLS NEW JERSEYEVENT TIMER
RELIABILITY ENGINEERING
RELIABILITY PREDICTION
@ 85°C

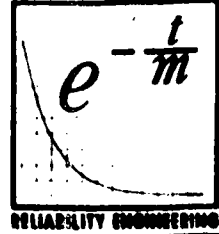
PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL X f LAB./TOT.	
A1 Board						
C1 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U7 Not Used	-	-	-	-	-	-
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A1 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.6666	
A2 Board						
C1 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Not Used	-	-	-	-	-	-
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U7 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A2 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.6666	
A3 Board						
C1 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott

SINGERKEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS, NEW JERSEY

EVENT TIMER

**RELIABILITY ENGINEERING
RELIABILITY PREDICTION**

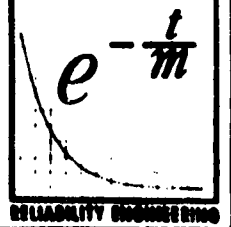
@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f _{LAB./EA.}	f _{LAB./TOT.}	KAPPL X f _{LAB./TOT.}	
A3 Board (cont'd)						
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U7 Not Used	-	-	-	-	-	-
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A3 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.6666	
A4 Board						
C1 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U7 Not Used	-	-	-	-	-	-
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A4 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.6666	
A5 Board						
C1 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Not Used	-	-	-	-	-	-
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott

SINGERKEARFOTT DIVISION
SINGER-GENERAL PRODUCTS, INC.
LITTLE FALLS, NEW JERSEYEVENT TIMER
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT.	KAPPL x f LAB./TOT.	
A5 Board (cont'd)						
U7 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A5 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.6666	
A6 Board						
C1 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U7 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A6 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.7518	
A7 Board						
C1 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
Y1 Oscillator	*	1.0	.2412	-	.2412	McCoy
A7 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.4770	
A8 Board						
C1 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox
C2 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox
C3 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox
C4 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox
C5 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox
C6 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox

* Stress values supplied by McCoy

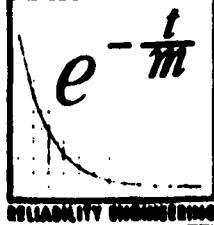
SINGER

KEARFOTT DIVISION

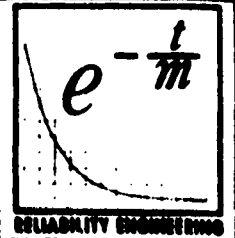
KEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS NEW JERSEYEVENT TIMER
RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85°C



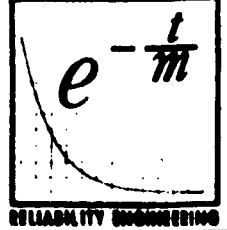
PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL x f LAB./TOT.	
A8 Board (cont'd)						
C7 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox
C8 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox
CRI SCR	<.10	1.0	.0962	-	.0962	Mil Hdbk 217A
Q1 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q2 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q3 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q4 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q5 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q6 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q7 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
R1 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R2 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R3 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R4 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R5 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R6 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R7 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R8 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R9 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R10 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R11 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R12 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R13 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R14 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R15 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R16 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R17 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R18 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R19 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R20 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A

SINGERHEARFOTY DIVISION
SINGER-GENERAL DIVISION, INC.
LITTLE FALLS NEW JERSEYEVENT TIMER
RELIABILITY ENGINEERING
RELIABILITY PREDICTION
@ 85°C

PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL X f LAB./TOT	
A8 Board (cont'd)						
R21 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R22 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R23 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R24 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R25 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R26 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R27 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R28 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R29 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
A8 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					1.0626	
A9 Board						
C1 Capacitor CSR	.37	1.0	.0052	-	.0052	Sprague
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C3 Capacitor CSR	.25	1.0	.0029	-	.0029	Sprague
C4 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C5 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C6 Capacitor CSR	.29	1.0	.0035	-	.0035	Sprague
C7 Capacitor CSR	.50	1.0	.0100	-	.0100	Sprague
CR1 Diode	.25	1.0	.0463	-	.0463	TRW Elect.
CR2 Diode	.25	1.0	.0463	-	.0463	TRW Elect.
CR3 Diode	.25	1.0	.0463	-	.0463	TRW Elect.
CR4 Diode	.25	1.0	.0463	-	.0463	TRW Elect.
CR5 Diode	.25	1.0	.0463	-	.0463	TRW Elect.
CR6 Diode	.25	1.0	.0463	-	.0463	TRW Elect.
FL2 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL3 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL4 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL5 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
L1 Choke	-	1.0	.0666	-	.0666	RADC

SINGERKEANPOTT DIVISION
SINGER-GENERAL PROVISION, INC.
LITTLE FALLS NEW JERSEYEVENT TIMER
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

@ 85°C



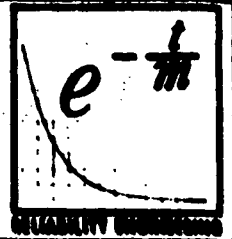
PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL x f LAB./TOT.	
A9 Board (cont'd)						
L2 Choke	-	1.0	.0666	-	.0666	RADC
L3 Choke	-	1.0	.0666	-	.0666	RADC
Q1 Transistor NPN	.74	1.0	.0980	-	.0980	Fairchild
Q2 Transistor PNP	.39	1.0	.0490	-	.0490	Fairchild
Q3 Transistor NPN	.53	1.0	.0660	-	.0660	Fairchild
Q4 Transistor NPN	.47	1.0	.0570	-	.0570	Fairchild
Q5 Transistor NPN	.47	1.0	.0570	-	.0570	Fairchild
R1 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R2 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R3 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R4 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R5 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R6 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R7 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R8 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R9 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R10 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R11 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R12 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R13 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R14 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R15 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
T1 Transformer	-	1.0	.0666	-	.0666	RADC
VR1 Diode Zener	<.10	1.0	.1273	-	.1273	Dickson
VR2 Diode Zener	<.10	1.0	.1273	-	.1273	Dickson
VR3 Diode Zener	<.10	1.0	.1273	-	.1273	Dickson
A9A1 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
A9A2 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					2.0655	

SINGER
KEARFOTT DIVISION

KEARFOTT DIVISION
SINGER-GENERAL PRODUCTS, INC.
LITTLE FALLS, NEW JERSEY

SECONDARY DISPLAY RELIABILITY ENGINEERING RELIABILITY PREDICTION

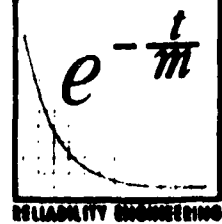
@ 85°C



DATA SUMMARY	QTY	KAPPL	FAILURE RATE @ 85°C			NOTES
			FLAB./EA.	FLAB./TOT	KAPPL X FLAB./TOT	
A1 Board	1	1.0	.7786	-	.7786	From page 22
A2 Board	1	1.0	.6926	-	.6926	From page 22
A3 Board	1	1.0	.8646	-	.8646	From page 23
A4 Board	1	1.0	1.0457	-	1.0457	From page 24
A5 Board	1	1.0	1.4118	-	1.4118	From page 25
A6 Board	1	1.0	1.1984	-	1.1984	From page 27
A7 Board	1	1.0	4.0351	-	4.0351	From page 30
DS1 Indicator LED	1	1.0	1.7434	-	1.7434	Kearfott Secondary
DS2 Indicator LED	1	1.0	1.8016	-	1.8016	Kearfott Secondary
DS3 Indicator LED	1	1.0	1.7434	-	1.7434	Kearfott Secondary
DS4 Indicator LED	1	1.0	1.8016	-	1.8016	Kearfott Secondary
FL1 Filter RFI	1	1.0	.0681	-	.0681	Aerovox
C1 Capacitor CQ	1	1.0	.0450	-	.0450	Mil Hdbk 217A
J1 Connector 18 pin	1	1.0	.0162	-	.0162	Mil Hdbk 217A
					17.2461	
					MTBF = 57,984	hrs.
					R = .9828	

SINGERKEARFOTT DIVISION
SINGER-GENERAL DIVISION, INC.
LITTLE FALLS NEW JERSEYSECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

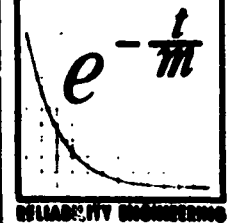
@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL X f LAB./TOT.	
A1 Board						
C1 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
R1 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U7 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A1 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.7786	
A2 Board						
C1 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
R1 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U7 Not Used	-	-	-	-	-	-
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A2 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.6926	
A3 Board						
C1 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox

SINGERKEARFOOT DIVISION
SINGER-GENERAL PREDICTION, INC.
LITTLE FALLS NEW JERSEYSECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

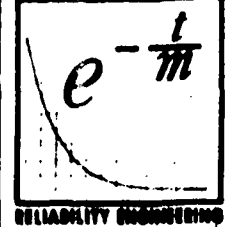
@85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL x f LAB./TOT.	
A3 Board (cont'd)						
R1 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U7 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U9 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A3 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.8646	
A4 Board						
C1 Capacitor CSR	.20	1.0	.0025	-	.0025	Sprague
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C3 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C4 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C5 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C6 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
CR1 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
Q1 Transistor Unijunct.	<.10	1.0	.0863	-	.0863	Mil Hdbk 217A
Q2 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q3 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q4 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q5 Transistor Unijunct.	<.10	1.0	.0863	-	.0863	Mil Hdbk 217A
R1 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R2 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R3 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R4 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R5 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R6 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A

SINGERKEARFOTT DIVISION
SINGER-GENERAL PRODUCTS, INC.
LITTLE FALLS, NEW JERSEYSECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

@85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL x f LAB./TOT	
A4 Board (cont'd)						
R7 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R8 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R9 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R10 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R11 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A4 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					1.0457	
A5 Board						
C1 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C3 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
CR1 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR2 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR3 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR4 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
Q1 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q2 Transistor PNP	<.10	1.0	.0500	-	.0500	Fairchild
Q3 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
R1 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R2 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R3 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R4 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R5 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R6 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R7 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A

SINGER

KEARFOTT DIVISION

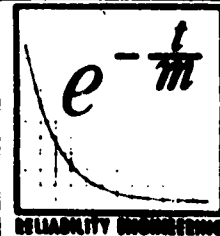
KEARFOTT DIVISION
SINGER-GENERAL PREDICTION, INC.
LITTLE FALLS NEW JERSEY

SECONDARY DISPLAY

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

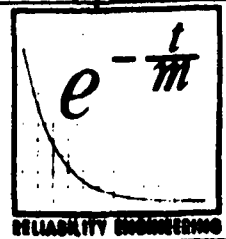
@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL X f LAB./TOT.	
A5 Board (CONT'd)		---				
R8 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R9 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R10 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R11 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R12 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R13 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R14 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R15 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R16 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R17 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R18 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R19 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R20 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R21 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R22 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R23 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
R24 Resistor RNR	< .10	1.0	.0260	-	.0260	Mil Std 199A
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A5 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					1.4118	
A6 Board						
C1 Capacitor CKR	< .10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	< .10	1.0	.0008	-	.0008	Aerovox
C3 Capacitor CKR	< .10	1.0	.0008	-	.0008	Aerovox
C4 Capacitor CKR	< .10	1.0	.0008	-	.0008	Aerovox
C5 Capacitor CKR	< .10	1.0	.0008	-	.0008	Aerovox

SINGERHEARTFOTY DIVISION
SINGER-GENERAL PROVISION, INC.
LITTLE FALLS NEW JERSEYSECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

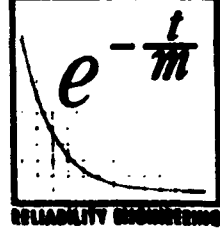
@ 85°C



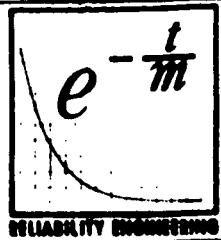
PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL X f LAB./TOT.	
A6 Board (cont'd)						
C6 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C7 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C8 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C9 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C10 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
Q1 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q2 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q3 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q4 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q5 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q6 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q7 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q8 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
R1 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R2 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R3 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R4 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R5 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R6 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R7 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R8 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R9 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R10 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R11 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R12 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R13 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R14 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R15 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R16 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R17 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A

SINGERHEARFOTY DIVISION
SINGER-GENERAL PRODUCTS, INC.
LITTLE FALLS NEW JERSEYSECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL x f LAB./TOT.	
A6 Board (cont'd)						
R18 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R19 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R20 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R21 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R22 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R23 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R24 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R25 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R26 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R27 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R28 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R29 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R30 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R31 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R32 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
CR1 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR2 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR3 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
R33 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R34 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
A6 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					1.1984	
A7 Board						
C1 Capacitor CSR	.47	1.0	.0104	-	.0104	Sprague
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C3 Capacitor CSR	<.45	1.0	.0076	-	.0076	Sprague
C4 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C5 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C6 Capacitor CSR	.63	1.0	.0225	-	.0225	Sprague
C7 Capacitor CSR	.50	1.0	.0105	-	.0105	Sprague

SINGERKEARFOTY DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS NEW JERSEYSECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION
@ 85°C

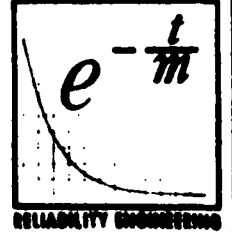
PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f _{LAB./EA.}	f _{LAB./TOT}	KAPPL X f _{LAB./TOT}	
A7 Board (cont'd)						
C8 Capacitor CSR	.63	1.0	.0258	-	.0258	Sprague
C9 Capacitor CSR	.63	1.0	.0258	-	.0258	Sprague
C10 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C11 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C12 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C13 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C14 Capacitor CSR	.24	1.0	.0031	-	.0031	Sprague
C15 Capacitor CSR	.24	1.0	.0031	-	.0031	Sprague
C16 Capacitor CSR	.50	1.0	.0105	-	.0105	Sprague
C17 Capacitor CSR	.60	1.0	.0224	-	.0224	Sprague
CR1 Diode	.10	1.0	.0277	-	.0277	TRW Elect.
CR2 Diode	.10	1.0	.0277	-	.0277	TRW Elect.
CR3 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR4 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR5 Diode	.20	1.0	.0404	-	.0404	TRW Elect.
CR6 Diode	.20	1.0	.0404	-	.0404	TRW Elect.
CR7 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR8 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR9 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR10 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
FL1 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL2 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL3 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL4 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL5 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL6 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL7 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL8 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
L1 Choke	-	1.0	.0666	-	.0666	RADC
L2 Choke	-	1.0	.0666	-	.0666	RADC

SINGER

HEARFOTY DIVISION

HEARFOTY DIVISION
SINGER-GENERAL PRODUCTS, INC.
LITTLE FALLS NEW JERSEYSECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

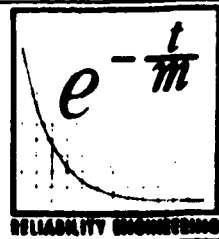
@ 85°C



PART NAME	STRESS RATIO	K _{APPL}	FAILURE RATE			SOURCE
			f _{LAB./EA.}	f _{LAB./TOT}	K _{APPL} x f _{LAB./TOT}	
A7 Board (cont'd)						
L3 Choke	-	1.0	.0666	-	.0666	RADC
L4 Choke	-	1.0	.0666	-	.0666	RADC
L5 Choke	-	1.0	.0666	-	.0666	RADC
Q1 Transistor NPN Pwr.	.25	1.0	.1160	-	.1160	Mil Hdbk 217A
Q2 Transistor PNP	.111	1.0	.1310	-	.1310	Fairchild
Q3 Transistor NPN	.124	1.0	.0505	-	.0505	Fairchild
Q4 Transistor NPN Pwr.	.25	1.0	.0190	-	.0190	Mil Hdbk 217A
Q5 Transistor NPN Pwr.	.25	1.0	.1160	-	.1160	Mil Hdbk 217A
Q6 Transistor NPN	.10	1.0	.0185	-	.0185	Fairchild
Q7 Not Used	-	-	-	-	-	-
Q8 Transistor NPN	.10	1.0	.0185	-	.0185	Fairchild
Q9 Not used	-	-	-	-	-	-
Q10 Transistor NPN	.10	1.0	.0185	-	.0185	Fairchild
R1 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R2 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R3 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R4 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R5 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R6 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R7 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R8 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R9 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R10 Resistor RNR	.17	1.0	.0282	-	.0282	Mil Std 199A
R11 Resistor RNR	.45	1.0	.0355	-	.0355	Mil Std 199A
R12 Resistor RNR	.13	1.0	.0271	-	.0271	Mil Std 199A
R13 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R14 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R15 Resistor RNR	.40	1.0	.0350	-	.0350	Mil Std 199A
R16 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R17 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A

SINGERKEARFOTT DIVISION
SINGER-GENERAL PROVISION, INC.
LITTLE FALLS, NEW JERSEYSECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

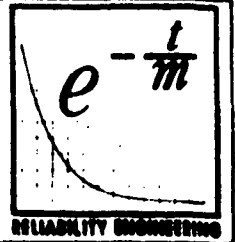
@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f _{LAB./EA.}	f _{LAB./TOT}	KAPPL x f _{LAB./TOT}	
A7 Board (cont'd)						
R18 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R19 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R20 Resistor RCR	.24	1.0	.0106	-	.0106	Mil Std 199A
R21 Resistor RNR	.14	1.0	.0272	-	.0272	Mil Std 199A
R22 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R23 Resistor RWR	<.10	1.0	.0009	-	.0009	Mil Std 199A
R24 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R25 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R26 Resistor RCR	.24	1.0	.0106	-	.0106	Mil Std 199A
R27 Resistor RNR	.14	1.0	.0272	-	.0272	Mil Std 199A
R28 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R29 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R30 Resistor RWR	<.10	1.0	.0009	-	.0009	Mil Std 199A
R31 Resistor RNR	.12	1.0	.0260	-	.0260	Mil Std 199A
R32 Resistor RCR	.13	1.0	.0008	-	.0008	Mil Std 199A
R33 Resistor RCR	.13	1.0	.0008	-	.0008	Mil Std 199A
R34 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
T1 Transformer	-	1.0	.0666	-	.0666	RADC
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
VR1 Diode zener	<.10	1.0	.1273	-	.1273	Dickson
VR2 Diode zener	<.10	1.0	.1273	-	.1273	Dickson
VR3 Diode zener	<.10	1.0	.1273	-	.1273	Dickson
VR4 Diode zener	.30	1.0	.2277	-	.2277	Dickson
VR5 Diode zener	.30	1.0	.2277	-	.2277	Dickson
A7A1 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
A7A2 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
A7A3 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
A7A4 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					4.0351	

SINGERKEARFOTT DIVISION
SINGER-GENERAL PRECISION, INC.
LITTLE FALLS NEW JERSEYFOUR DIGIT DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

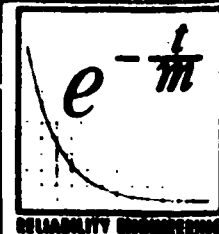
@85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f _{LAB/EA.}	f _{LAB/TOT}	KAPPL x f _{LAB/TOT}	
A1 Board	1	1.0	.7786	-	.7786	From page 32
A2 Board	1	1.0	.6066	-	.6066	From page 32
A3 Board	1	1.0	.7374	-	.7374	From page 34
A4 Board	1	1.0	.8352	-	.8352	From page 34
A5 Board	1	1.0	1.4118	-	1.4118	From page 35
A6 Board not used						
A7 Board	1	1.0	4.0351	-	4.0351	From page 39
DS1 Indicator LED	1	1.0	1.7434	-	1.7434	Kearfott Secondary
DS2 Indicator LED	1	1.0	1.8016	-	1.8016	Kearfott Secondary
DS3 Indicator LED	1	1.0	1.7434	-	1.7434	Kearfott Secondary
DS4 Indicator LED	1	1.0	1.8016	-	1.8016	Kearfott Secondary
FL1 Filter RFI	1	1.0	.0681	-	.0681	Aerovox
C1 Capacitor CQ	1	1.0	.0450	-	.0450	Mil Hdbk 217A
J1 Connector 18 pin	1	1.0	.0162	-	.0162	Mil Hdbk 217 A
					15.6240	
					MTBF = 64,004 hrs.	
					R = .9844	

SINGERKEARFOTT DIVISION
SINGER-GENERAL PRODUCTS, INC.
LITTLE FALLS NEW JERSEYFOUR DIGIT DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

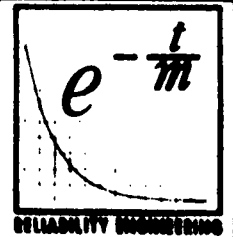
@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f _{LAB./EA.}	f _{LAB./TOT}	KAPPL X f _{LAB./TOT}	
A1 Board						
C1 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
R1 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U7 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A1 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.7786	
A2 Board						
C1 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
R1 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
U1 Int Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 not used	-	-	-	-	-	-
U7 Not used	-	-	-	-	-	-
U8 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A2 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.6066	
A3 Board						
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott

SINGERKEARFOTT DIVISION
SINGER-GENERAL PREDICTION, INC.
LITTLE FALLS NEW JERSEYFOUR DIGIT DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

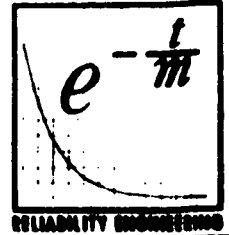
@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL X f LAB./TOT.	
A3 Board (Cont'd)						
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
C1 Capacitor CKR	.15	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	.12	1.0	.0008	-	.0008	Aerovox
C3 Capacitor CKR	.12	1.0	.0008	-	.0008	Aerovox
C4 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C5 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C6 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C7 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
R1 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
R2 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
R3 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
R4 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
R5 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
R6 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
R7 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
R8 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
R9 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
R10 Resistor RNR	.20	1.0	.0260	-	.0260	MIL STD 199A
R11 Resistor RNR	<.10	1.0	.0260	-	.0260	MIL STD 199A
LI Choke	-	1.0	.0666	-	.0666	RADC
Q1 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q2 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q3 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
A3 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
A4					.7374	
C1 Capacitor CSR	.20	1.0	.0025	-	.0025	Sprague
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C3 Not used	-	-	-	-	-	-
C4 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C5 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox

SINGERKEARFOTT DIVISION
SINGER-GENERAL DIVISION, INC.
LITTLE FALLS NEW JERSEYFOUR DIGIT DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

@ 85° C



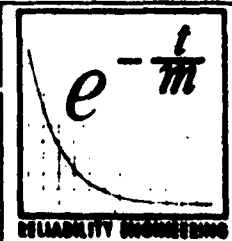
PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f _{LAB./EA.}	f _{LAB./TOT}	KAPPL X f _{LAB./TOT}	
A4 BOARD (Cont'd)						
C6 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
CR1 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
Q1 Transistor Unijunct.	<.10	1.0	.0863	-	.0863	Mil Hdbk 217A
Q2 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q3 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q4 not used	-	-	-	-	-	-
Q5 not used	-	-	-	-	-	-
R1 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R2 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R3 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R4 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R5 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R6 not used	-	-	-	-	-	-
R7 not used	-	-	-	-	-	-
R8 not used	-	-	-	-	-	-
R9 not used	-	-	-	-	-	-
R10 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R11 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
A4 Circuit Board	-	1.0	.0630	-	.0630	9th Symposium
					.8352	
A5 Board						
C1 Capacitor CKR	.10	1.0	.0008	-	.0008	Aerovox
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C3 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
CR1 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR2 Diode	<.10	1.0	.0294	-	.0294	TRW Elec.

SINGER

HEARTFOTY DIVISION

HEARTFOTY DIVISION
SINGER-GENERAL DIVISION, INC.
LITTLE FALLS NEW JERSEYFOUR DIGIT DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

@ 85°C



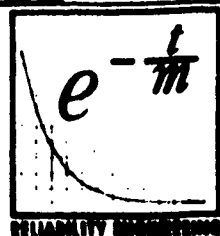
PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL X f LAB./TOT	
A5 Board (Cont'd)						
CR3 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR4 Diode	<.10	1.0	.0294	-	.0294	TRW elect.
Q1 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
Q2 Transistor PNP	<.10	1.0	.0500	-	.0500	Fairchild
Q3 Transistor NPN	<.10	1.0	.0194	-	.0194	Fairchild
R1 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R2 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R3 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R4 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R5 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R6 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R7 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R8 Resistor RND	<.10	1.0	.0260	-	.0260	Mil Std 199A
R9 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R10 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R11 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R12 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R13 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R14 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R15 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R16 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R17 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R18 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R19 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R20 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R21 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R22 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R23 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R24 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A

SINGER
 KEARFOTT DIVISION

 KEARFOTT DIVISION
 SINGER-GENERAL POSITION, INC.
 LITTLE FALLS NEW JERSEY

 FOUR DIGIT DISPLAY
 RELIABILITY ENGINEERING
 RELIABILITY PREDICTION

@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL X f LAB./TOT.	
A5 Board (Cont'd)						
U1 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U2 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U3 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U4 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U5 Int. Circuit	-	1.0	.0860	-	.0860	Kearfott
U6 Int	-	1.0	.0630	-	.0630	9th Symposium
					1.4118	
A6 Board not used	-	-	-	-	-	-
A7 Board						
C1 Capacitor CSR	.47	1.0	.0104	-	.0104	Sprague
C2 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C3 Capacitor CSR	<.45	1.0	.0076	-	.0076	Sprague
C4 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C5 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C6 Capacitor CSR	.63	1.0	.0225	-	.0225	Sprague
C7 Capacitor CSR	.50	1.0	.0105	-	.0105	Sprague
C8 Capacitor CSR	.63	1.0	.0258	-	.0258	Sprague
C9 Capacitor CSR	.63	1.0	.0258	-	.0258	Sprague
C10 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C11 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C12 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C13 Capacitor CKR	<.10	1.0	.0008	-	.0008	Aerovox
C14 Capacitor CSR	.24	1.0	.0031	-	.0031	Sprague
C15 Capacitor CSR	.24	1.0	.0031	-	.0031	Sprague
C16 Capacitor CSR	.50	1.0	.0105	-	.0105	Sprague
C17 Capacitor CSR	.60	1.0	.0224	-	.0224	Sprague
CR1 Diode	.10	1.0	.0277	-	.0277	TRW Elect.
CR2 Diode	.10	1.0	.0277	-	.0277	TRW Elect.
CR3 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR4 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.

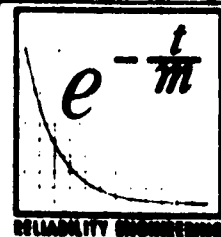
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SINGER

KEARFOTT DIVISION

KEARFOTT DIVISION
SINGER-GENERAL DIVISION, INC.
LITTLE FALLS NEW JERSEYFOUR DITIT DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

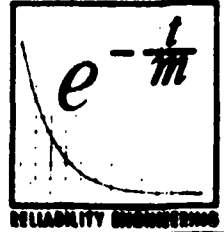
② 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f _{LAB./EA.}	f _{LAB./TOT.}	KAPPL X f _{LAB./TOT.}	
A7 Board (cont'd)						
CR5 Diode	.20	1.0	.0404	-	.0404	TRW Elect
CR6 Diode	.20	1.0	.0404	-	.0404	TRW Elect
CR7 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR8 Diode	<.10	1.0	.0294	-	.0294	TRW Elect
CR9 Diode	<.10	1.0	.0294	-	.0294	TRW Elect
CR10 Diode	<.10	1.0	.0294	-	.0294	TRW Elect
FL1 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL2 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL3 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL4 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL5 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL6 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL7 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
FL8 Filter RFI	-	1.0	.0681	-	.0681	Aerovox
L1 Choke	-	1.0	.0666	-	.0666	RADC
L2 Choke	-	1.0	.0666	-	.0666	RADC.
L3 Choke	-	1.0	.0666	-	.0666	RADC
L4 Choke	-	1.0	.0666	-	.0666	RADC
L5 Choke	-	1.0	.0666	-	.0666	RADC
Q1 Transistor NPN Pwr.	.25	1.0	.1160	-	.1160	Mil Hdbk 217A
Q2 Transistor PNP	.111	1.0	.0505	-	.0505	Fairchild
Q3 Transistor NPN	.124	1.0	.0190	-	.0190	Fairchild
Q4 Transistor NPN Pwr	.25	1.0	.1160	-	.1160	Mil Hdbk 217A
Q5 Transistor NPN Pwr.	.25	1.0	.1160	-	.1160	Mil Hdbk 217A
Q6 Transistor NPN	.10	1.0	.0185	-	.0185	Fairchild
Q7 Not used	-	-	-	-	-	-
Q8 Transistor NPN	.10	1.0	.0185	-	.0185	Fairchild
Q9 Not used	-	-	-	-	-	-
Q10 Transistor NPN	.10	1.0	.0185	-	.0185	Fairchild

SINGERSEARFOTT DIVISION
SINGER-GENERAL PRODUCTS, INC.
LITTLE FALLS NEW JERSEYFORU DIGIT DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION

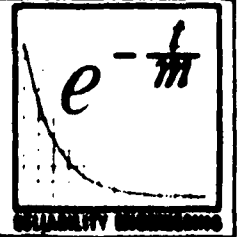
@ 85°C



PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			f LAB./EA.	f LAB./TOT	KAPPL x f LAB./TOT.	
A7 Board (Cont'd)						
R1 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R2 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R3 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R4 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R5 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R6 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R7 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R8 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R9 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R10 Resistor RNR	.17	1.0	.0282	-	.0282	Mil Std 199A
R11 Resistor RNR	.45	1.0	.0355	-	.0355	Mil Std 199A
R12 Resistor RNR	.13	1.0	.0271	-	.0271	Mil Std 199A
R13 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R14 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R15 Resistor RNR	.40	1.0	.0350	-	.0350	Mil Std 199A
R16 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R17 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R18 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R19 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R20 Resistor RCR	.24	1.0	.0106	-	.0106	Mil Std 199A
R21 Resistor RNR	.14	1.0	.0272	-	.0272	Mil Std 199A
R22 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R23 Resistor RWR	<.10	1.0	.0009	-	.0009	Mil Std 199A
R24 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R25 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R26 Resistor RCR	.24	1.0	.0106	-	.0106	Mil Std 199A
R27 Resistor RNR	.14	1.0	.0272	-	.0272	Mil Std 199A
R28 Resistor RNR	.10	1.0	.0260	-	.0260	Mil Std 199A
R29 Resistor RNR	<.10	1.0	.0260	-	.0260	Mil Std 199A
R30 Resistor RWR	<.10	1.0	.0009	-	.0009	Mil Std 199A

SECURITY DIVISION
SINGER-GENERAL PENSION, INC.
LITTLE FALLS NEW JERSEY

@ 85°C

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