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FINAL REPORT FOR SKYLAB INDICATORS

ENGINEERING TECHNICAL REPORT

(EVENT TIMER)

(SECONDARY DISPLAY)

(FOUR-DIGIT METABOLIC DISPLAY)

CONTRACT: NAS 8-26120

prepared for:

NASA

GEORGE C. MARSHALL SPACE FLIGHT CENTER

MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

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THE SINGER COMPANY • KEARFOTT DIVISION

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

ABCD	Decimal No.
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 = 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

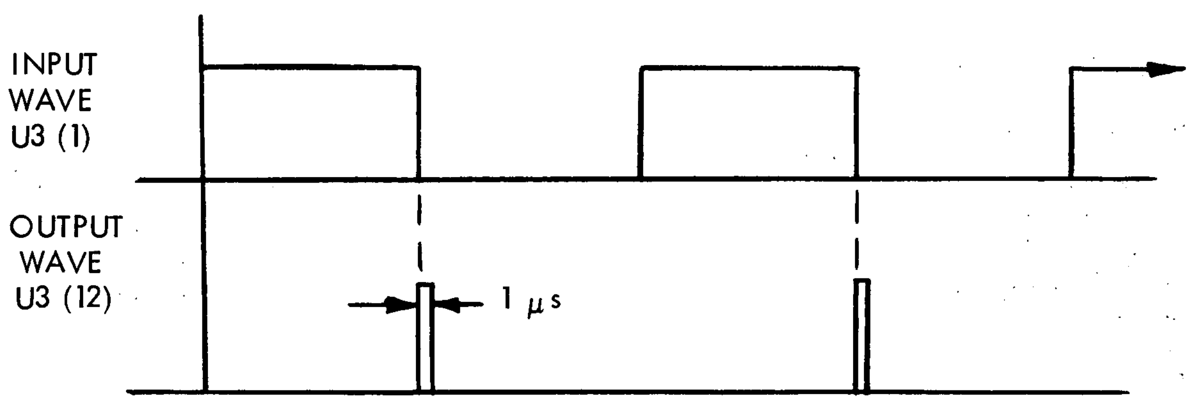
2.4.1 Oscillator (Cards A5, A6, and A7)

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 us 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 μs 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.

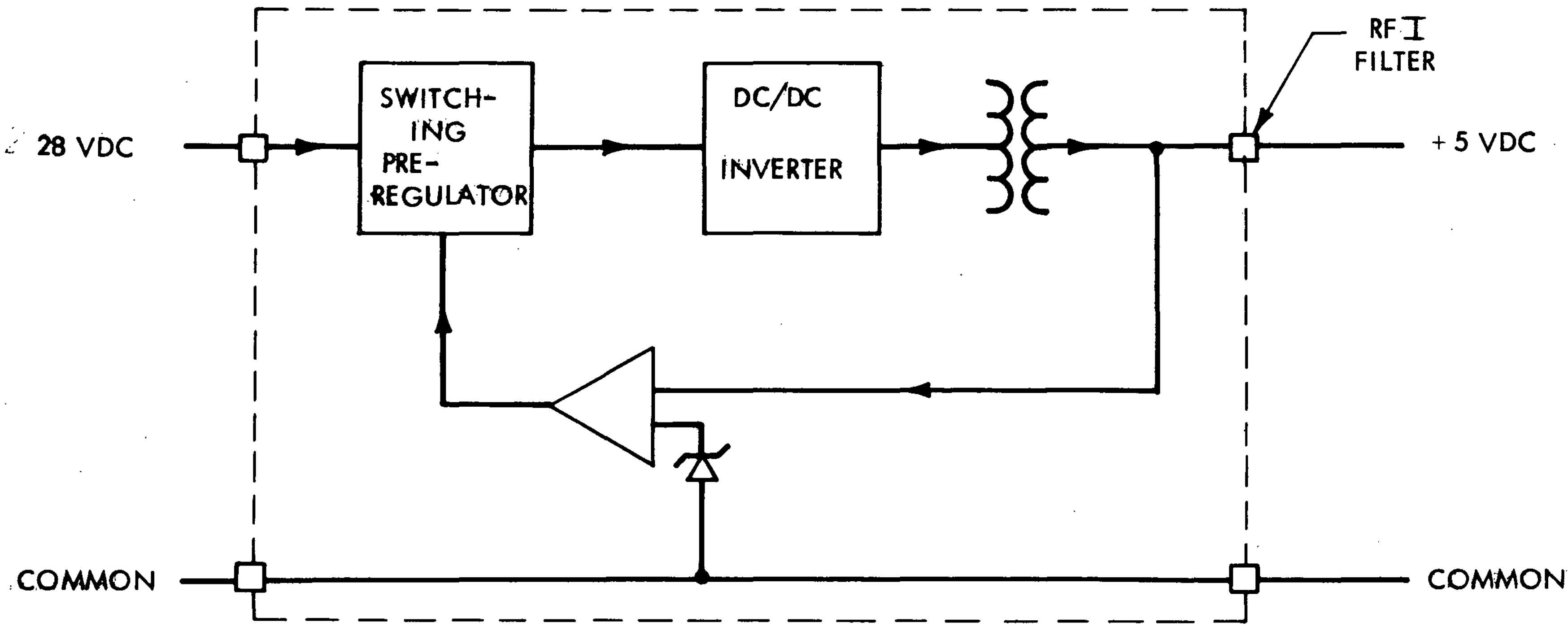


FIGURE 1
BLOCK DIAGRAM
LEM POWER SUPPLY

2.4.5.2 Switching Pre-regulator

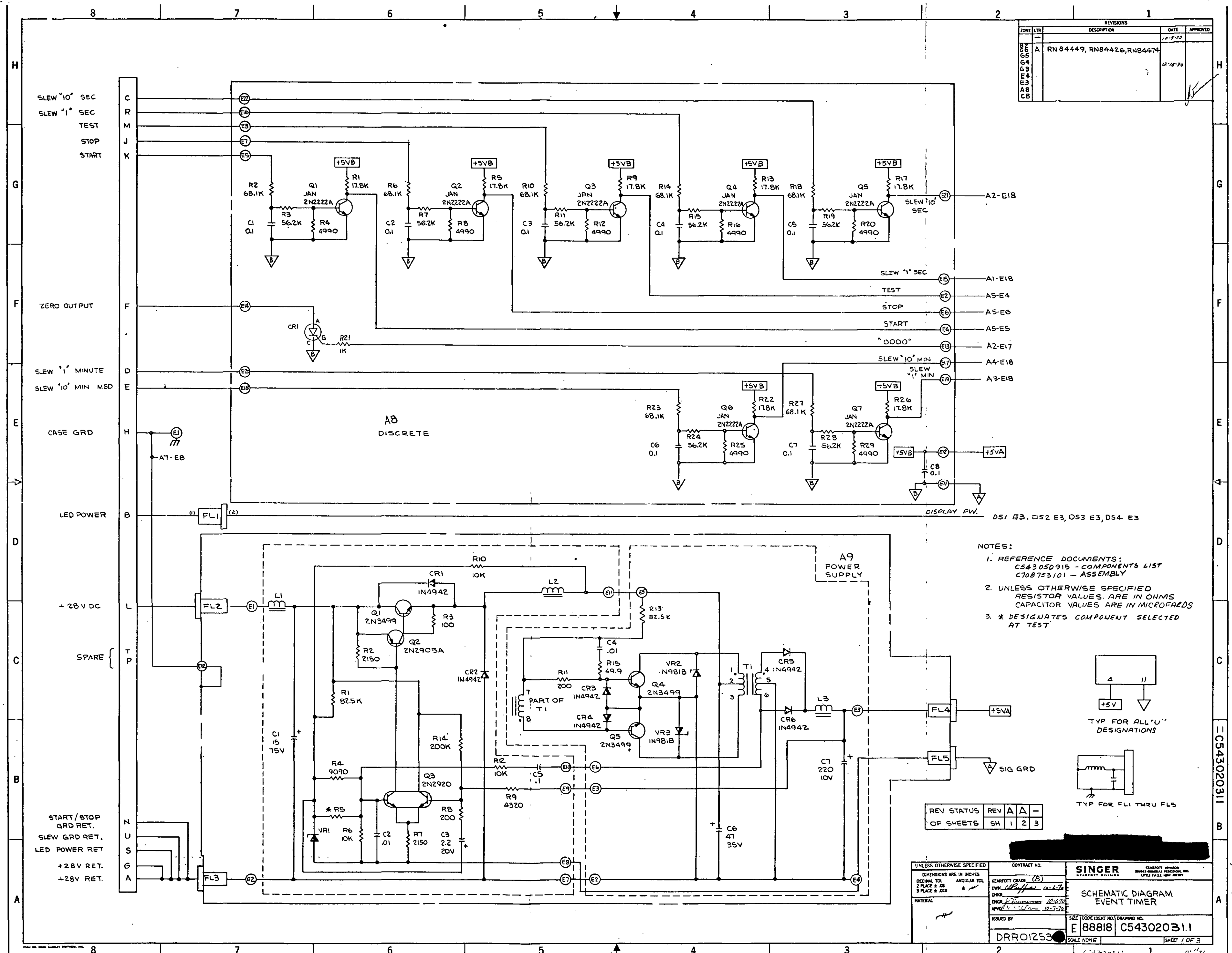
The pre-regulator consists primarily of a power switch (Q1) and driver (Q2) followed by an LC filter (L2, C6). To follow the operation of the switching regulator, assume Q1 is conducting and further that this voltage is inverted in the square wave inverter (Q4, Q5) and transformed to 6 volts by means 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.

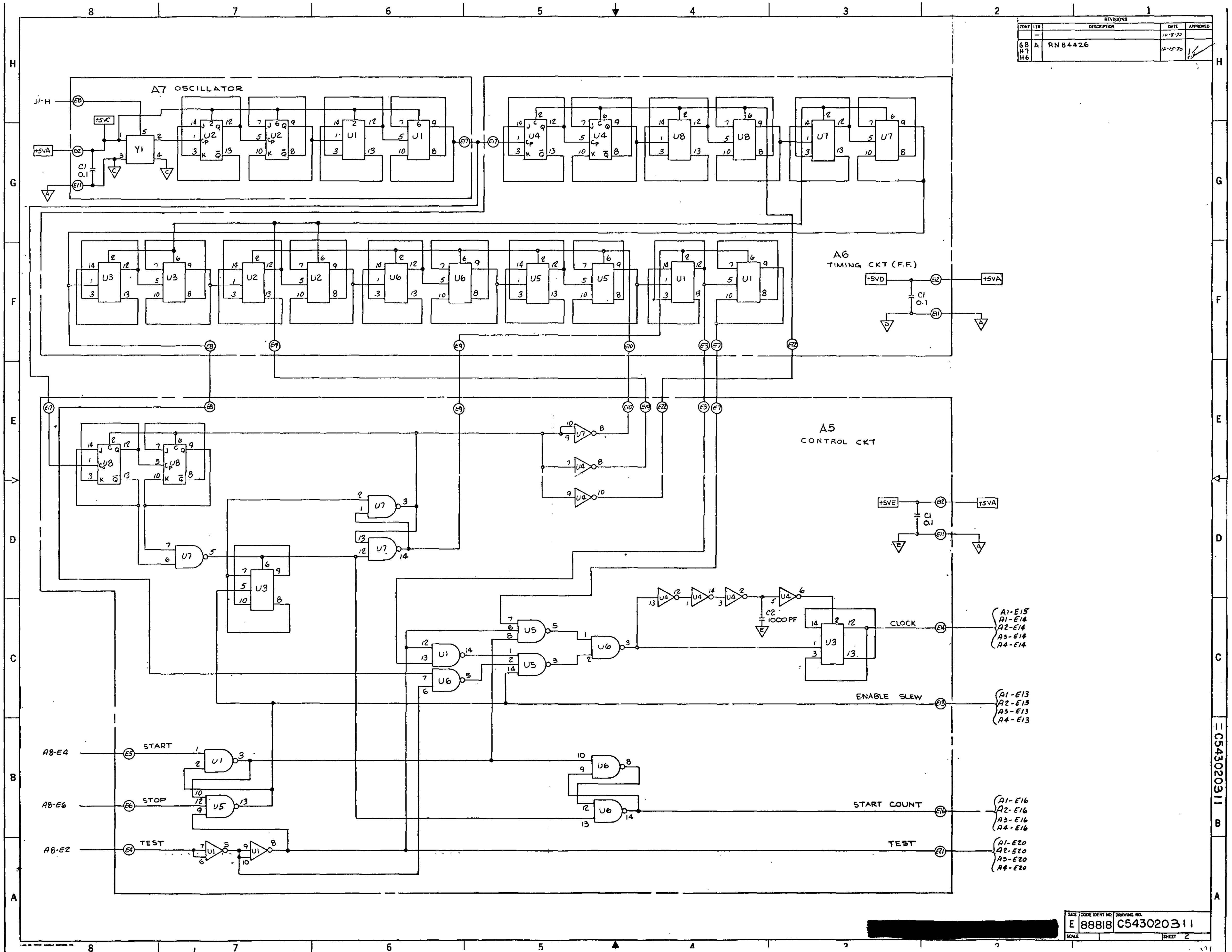

REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
A | RN 84449, RN84426, RN84474
SLEW "10" SEC
SLEW "1" SEC
TEST
STOP
START
ZERO OUTPUT
SLEW "1" MINUTE
SLEW "10" MIN MSD
CASE GRD
LED POWER
+28V DC
SPARE
START/STOP GRD RET.
SLEW GRD RET.
LED POWER RET
+28V RET.
+28V RET.
A8
DISCRETE
A9
POWER SUPPLY
A2-E18
A1-E18
A5-E4
A5-E6
A5-E5
A2-E17
A4-E18
A3-E18
DISPLAY PW.
DS1 E3, DS2 E3, DS3 E3, DS4 E3
NOTES:
1. REFERENCE DOCUMENTS:
C543050915 - COMPONENTS LIST
C708753101 - ASSEMBLY
2. UNLESS OTHERWISE SPECIFIED
RESISTOR VALUES ARE IN OHMS
CAPACITOR VALUES ARE IN MICROFARDS
3. ✱ DESIGNATES COMPONENT SELECTED AT TEST
TYP FOR ALL "U" DESIGNATIONS
TYP FOR FL1 THRU FL5
SIG GRD
REV STATUS | REV | A | A | —
OF SHEETS | SH | 1 | 2 | 3
[redacted]
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
SINGER
SCHEMATIC DIAGRAM
EVENT TIMER
E 88818 C543020311
DRR01253
SCALE NONE
SHEET 1 OF 3
C543020311

11/12

11/12

FOLDOUT FRAME 1

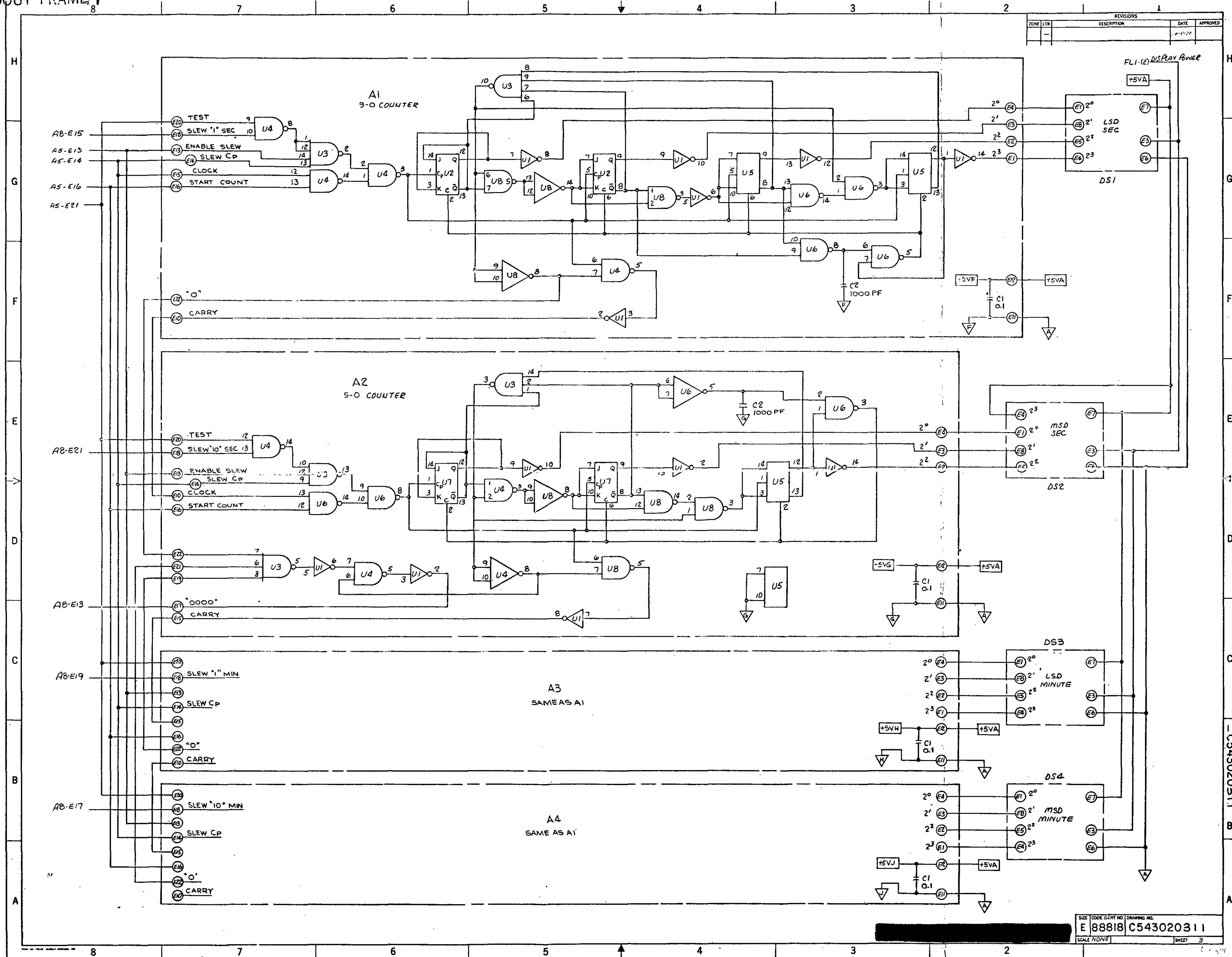
FOLDOUT FRAME 2



13/14

FOLDOUT FRAME 1

FOLDOUT FRAME 2



15/16

15/16

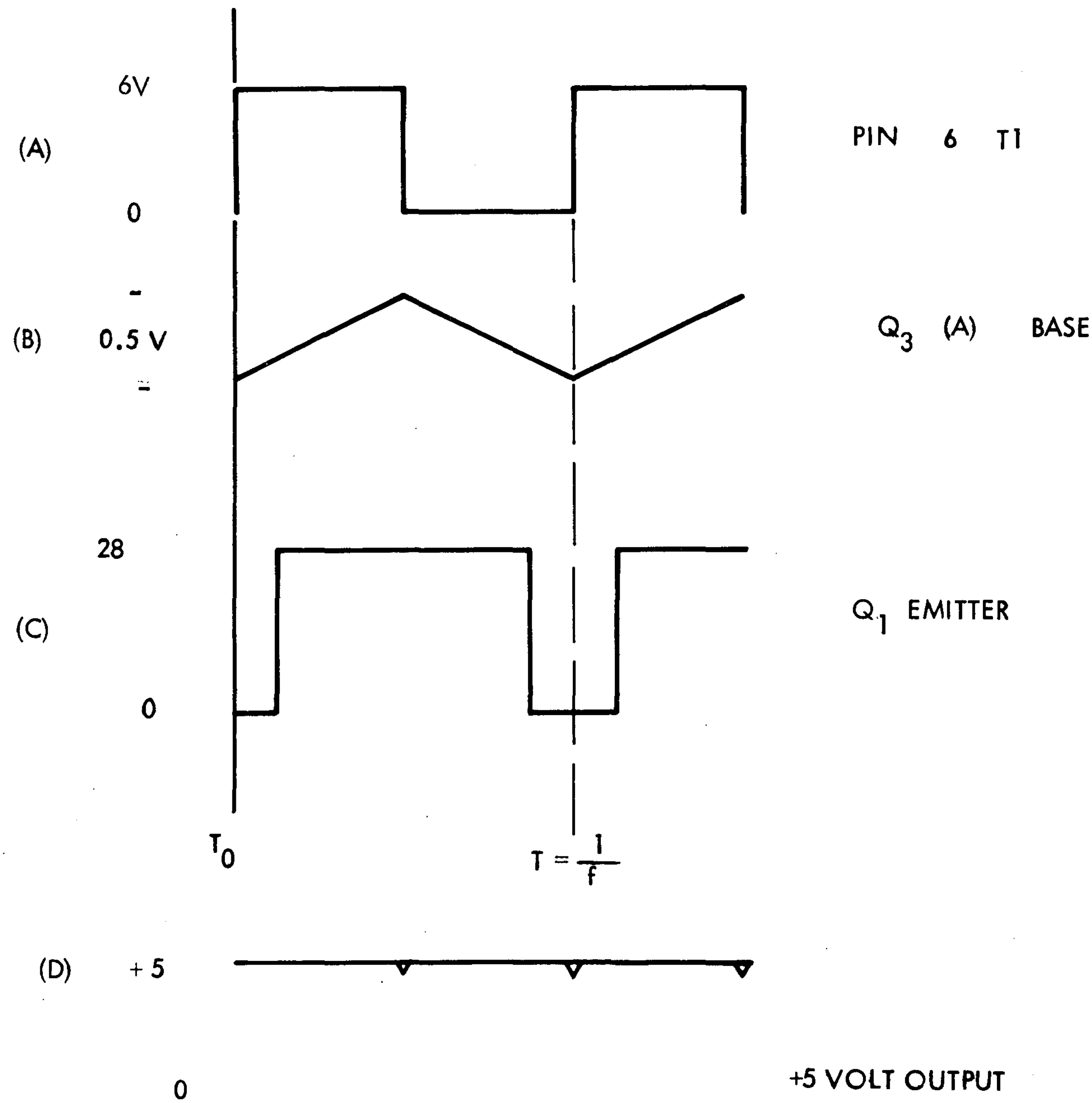


FIGURE 2

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

Measurement	Command No.	Analog Input Range	Digital Range	Parameter Range
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 O2 Comsumed	5	0 to 5 vdc	0000 to 4000	0.000 to 4.000 liters/min
MA CO2 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.

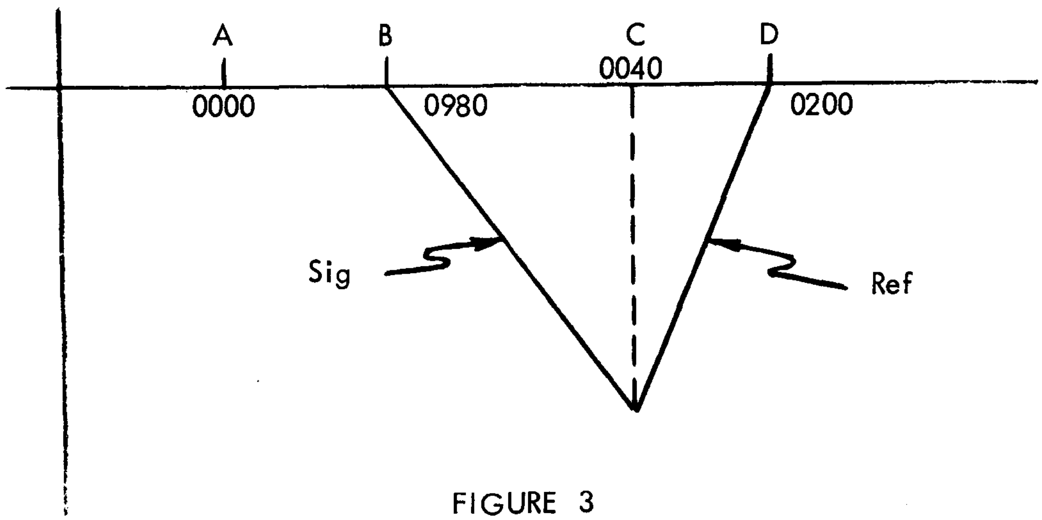


FIGURE 3

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 flipflop 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 ± 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, ±6V 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.

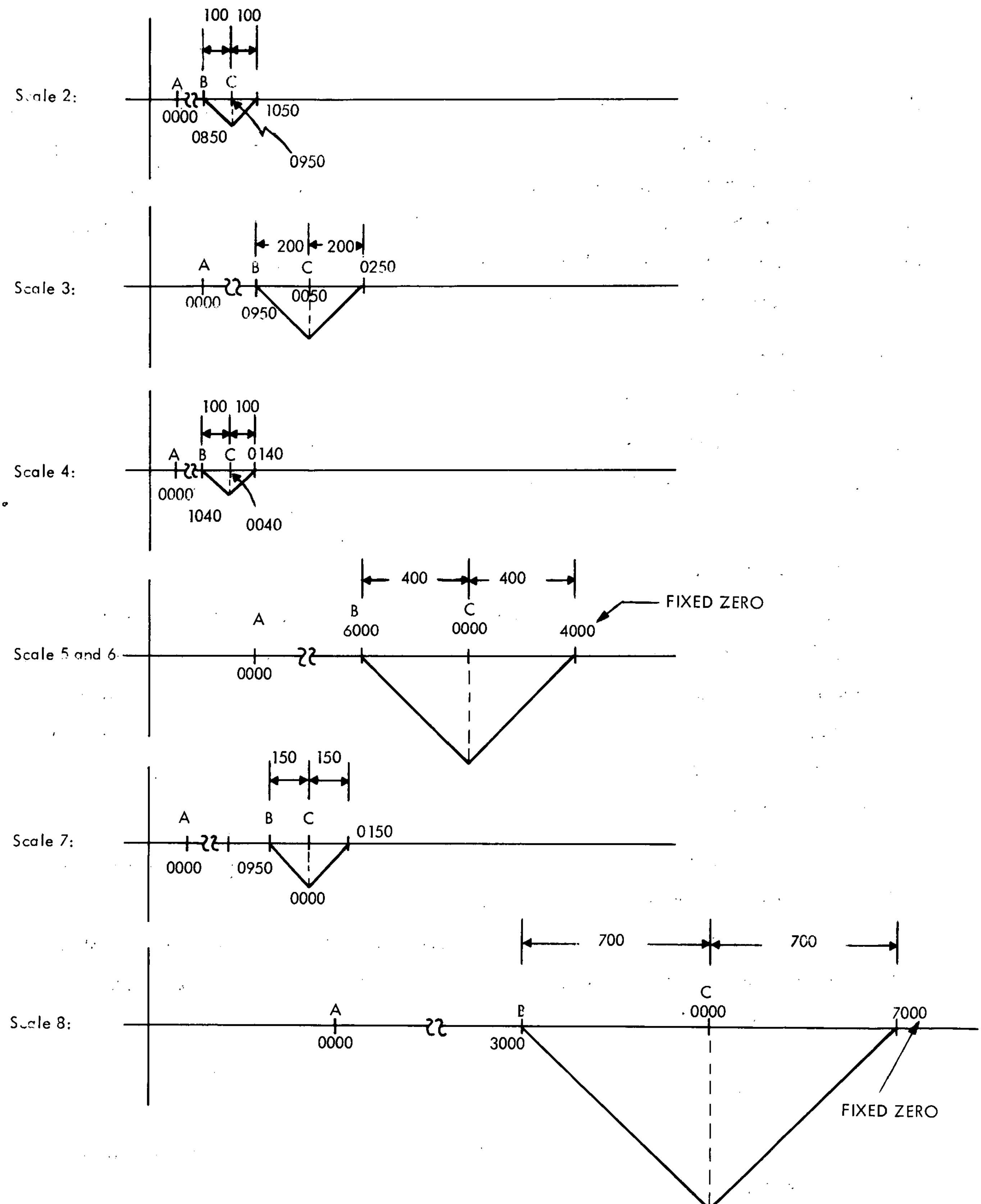
3.2.2 Description of the A3 Card

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 LED's. 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.

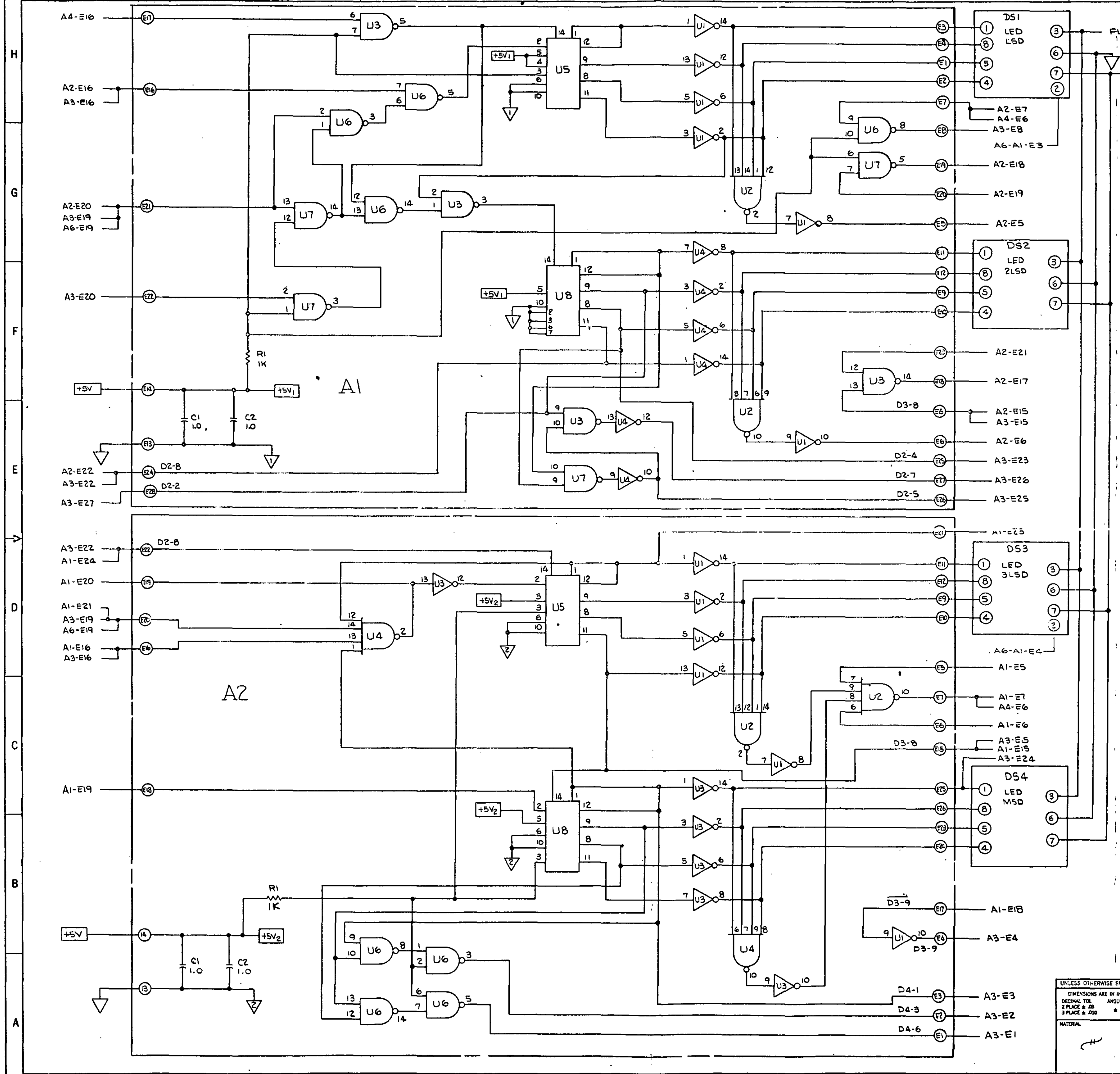
3.2.5 Power Supply

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

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±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.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	–		12-9-70	
2B	A	RN83719, RN84448 REVISION STATUS CHANGED	11/21/70	
2B	B	RN94830 REVISION STATUS CHANGED	12/22/70	
2B	C	RN98521	3.12.71	



NOTES:

1. REF DOCUMENTS:
   C708753091 – ASSEMBLY
   C543053916 – 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 Y32.16
7. COMMON CONNECTION SYMBOL IDENTIFICATION ARE AS FOLLOWS:

+5V, +5V1, +5V2, +5V3, +5V4, +5V5: +5VDC — SIG GRD (1–5): SIG GRD — CASE GRD
+12V: +12V DC
-12V: -12V DC
12 (triangle): ± 12V RET.

REV STATUS	REV	C	–	C	–	–
OF SHEETS	SH	1	2	3	4	5

[redacted]

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
DECIMAL TOL / ANGULAR TOL
2 PLACE ± .03
3 PLACE ± .010
MATERIAL

CONTRACT NO.
KEARFOTT GRADE (B)
DWN 11-6-70
CHKR
ENGR
APVD
ISSUED BY

SINGER
KEARFOTT DIVISION

SCHEMATIC DIAGRAM
SECONDARY DISPLAY

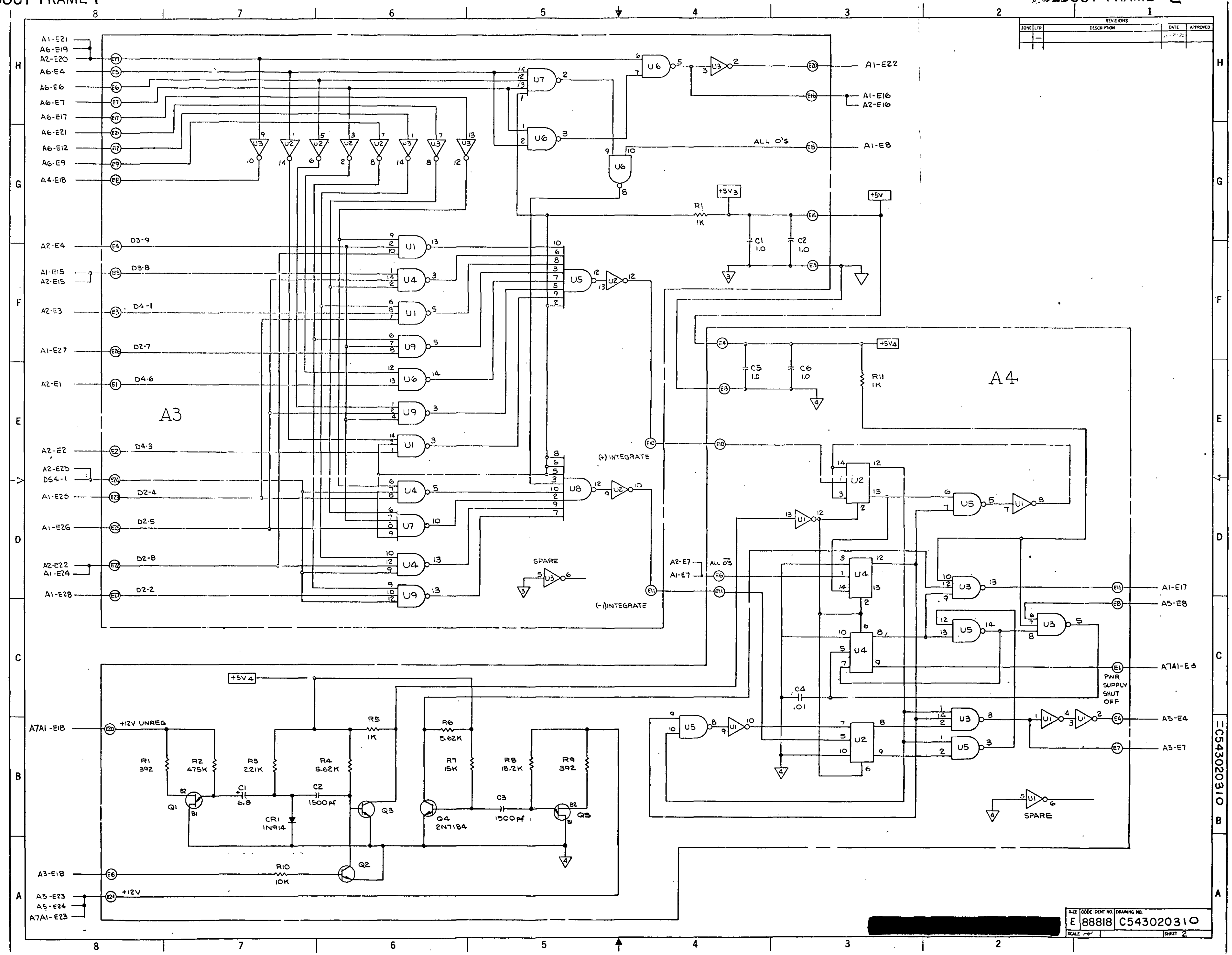
SIZE E | CODE IDENT NO. 88818 | DRAWING NO. C543020310
SCALE | SHEET 1 OF 5

DRR01253

=C543020310

FOLDOUT FRAME 1

FOLDOUT FRAME 2



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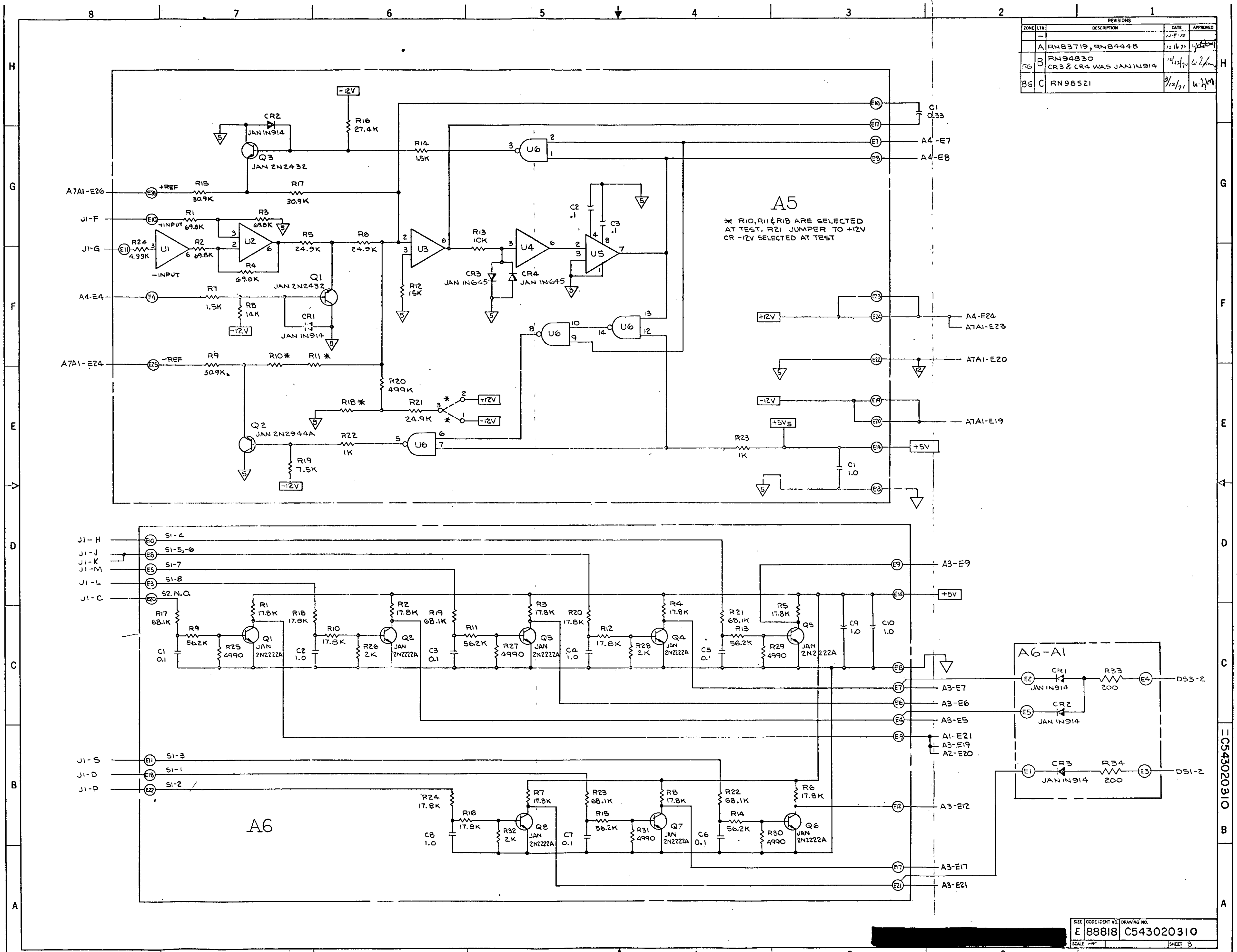
FOLDOUT FRAME 1

FOLDOUT FRAME 2



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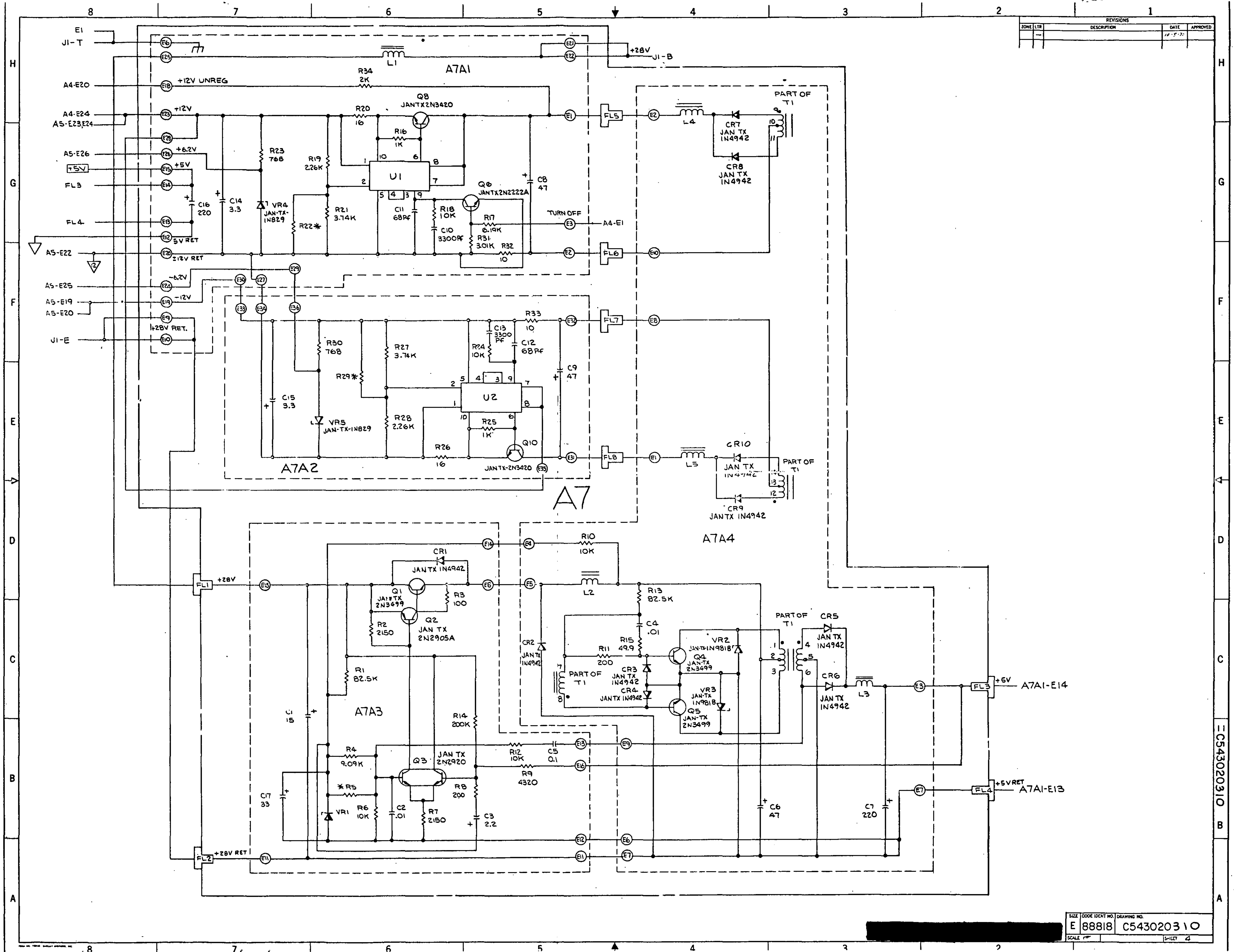
FOLDOUT FRAME 1 FOLDOUT FRAME 2



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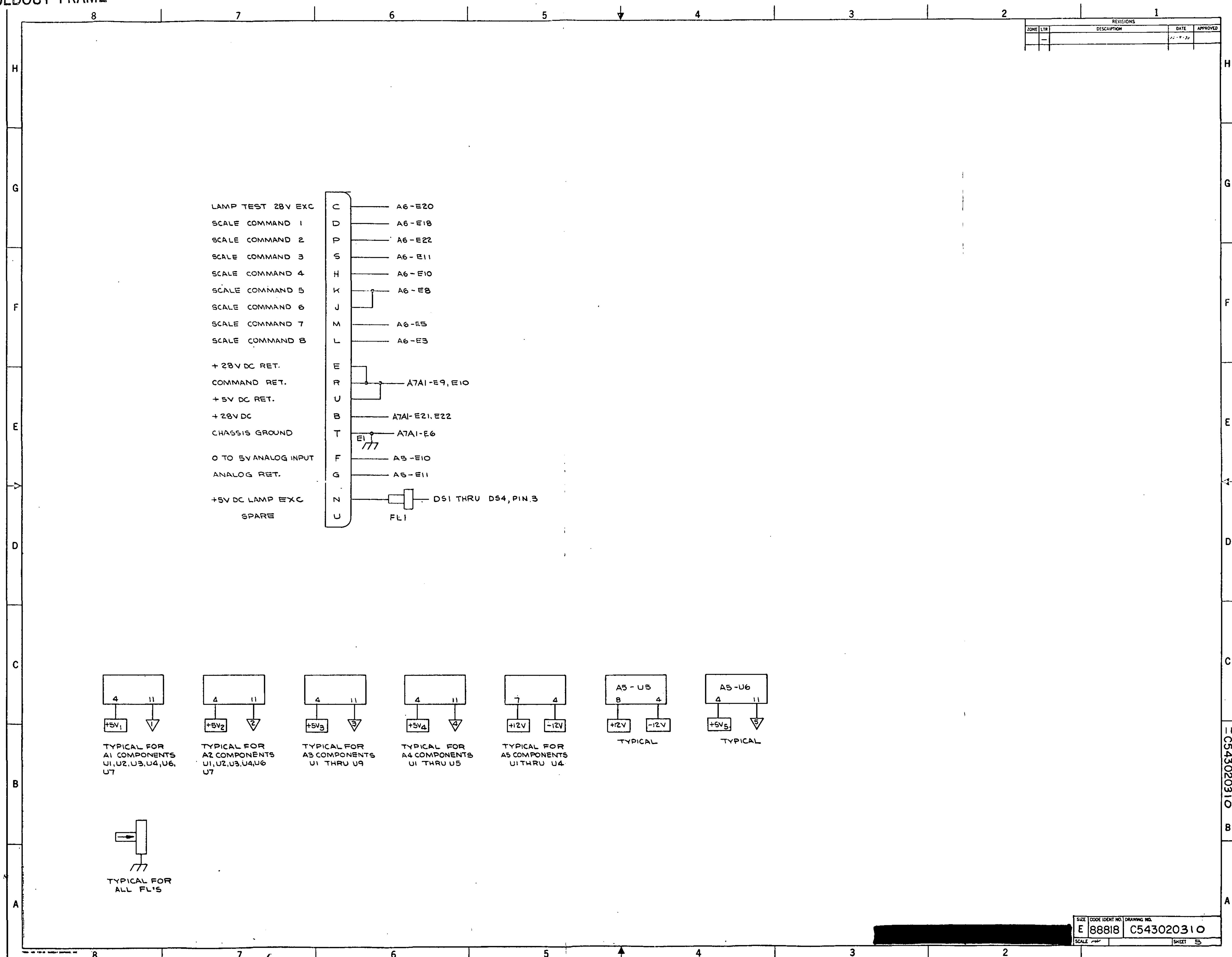
FOLDOUT FRAME 1

FOLDOUT FRAME 2



[redacted]

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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.

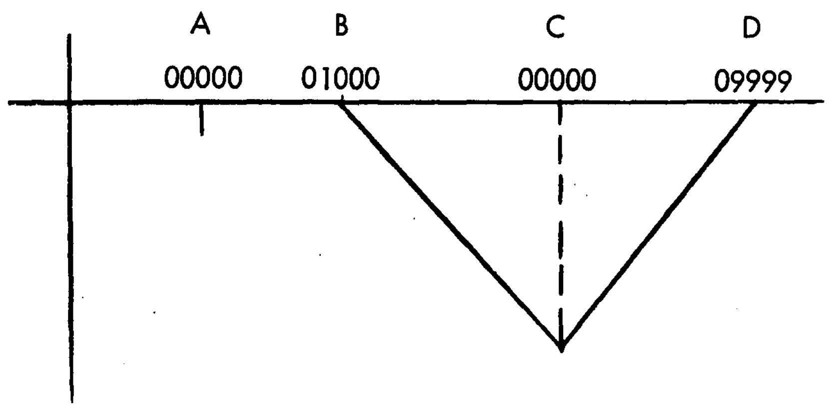
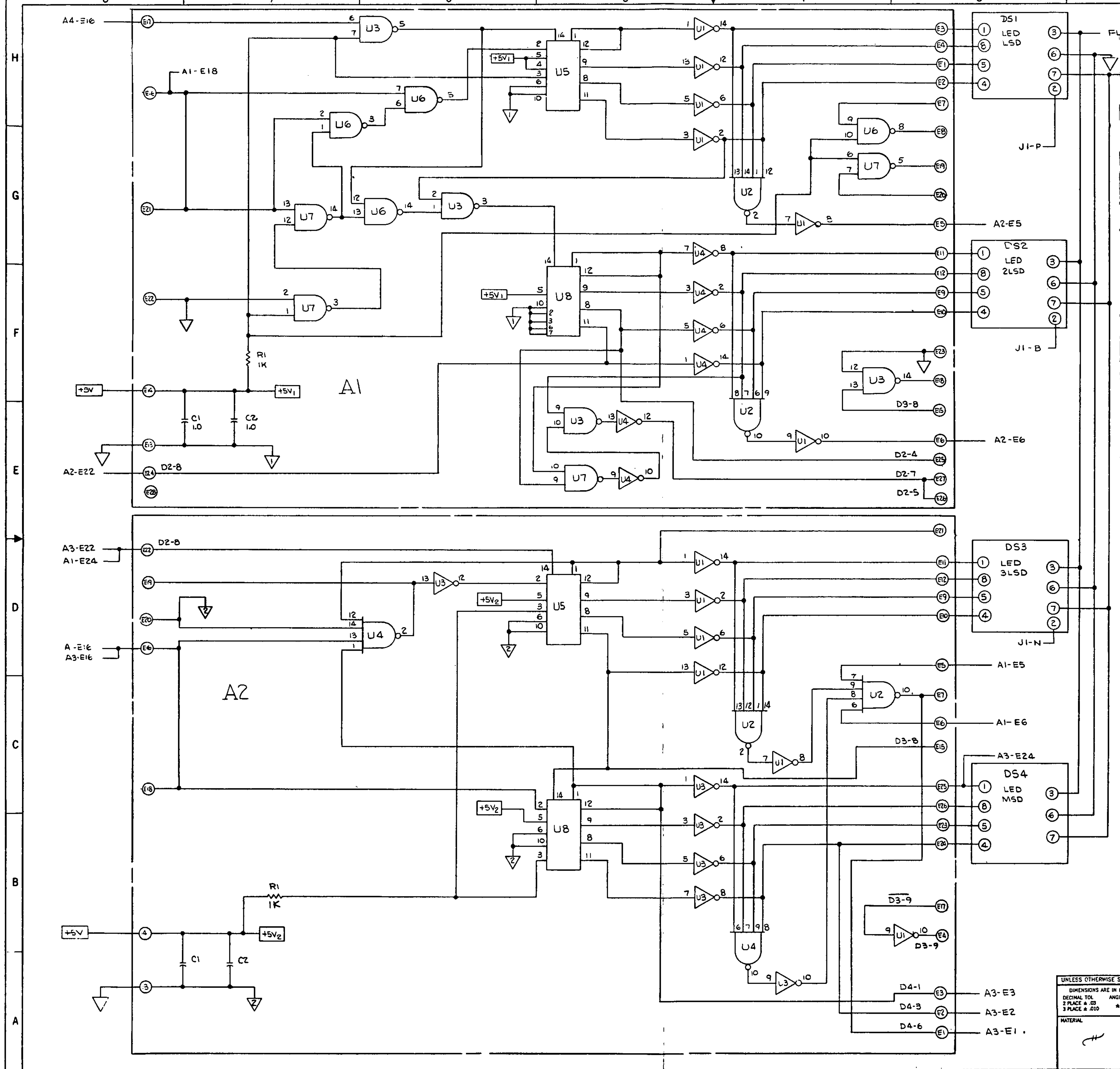


FIGURE 5

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 1

FOLDOUT FRAME 2



NOTES:

1. REF DOCUMENTS:
   C708753110 - ASSEMBLY
   C543053971 - 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 VALES ARE IN OHMS
   CAPACITANCE VALES 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 Y32.16
7. COMMON CONNECTION SYMBOL IDENTIFICATION ARE AS FOLLOWS:

+5V +5VDC — SIG GRD — CASE GRD

+5V1, +5V2, +5V3, +5V4, +5V5 +5VDC — 1, 2, 3, 4, 5 SIG GRD

+12V +12 V DC

-12V -12V DC

12 ± 12V RET.

REV STATUS	REV	–	–	–	–
OF SHEETS	SH	1	2	3	4	5

[redacted]

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DECIMAL TOL ANGULAR TOL 2 PLACE ± .03 3 PLACE ± .010 ±

MATERIAL

CONTRACT NO. NAS8-26120

KEARFOTT GRADE (B)

DWN 1-12-71

CHKD 2-5-71

ENGR 2/5/71

APVD 2-5-71

ISSUED BY DRR01253

SINGER KEARFOTT DIVISION

SCHEMATIC DIAGRAM INDICATOR FOUR DIGIT DISPLAY

SIZE E CODE IDENT NO. 88818 DRAWING NO. C543020341

SCALE — SHEET 1 OF 5

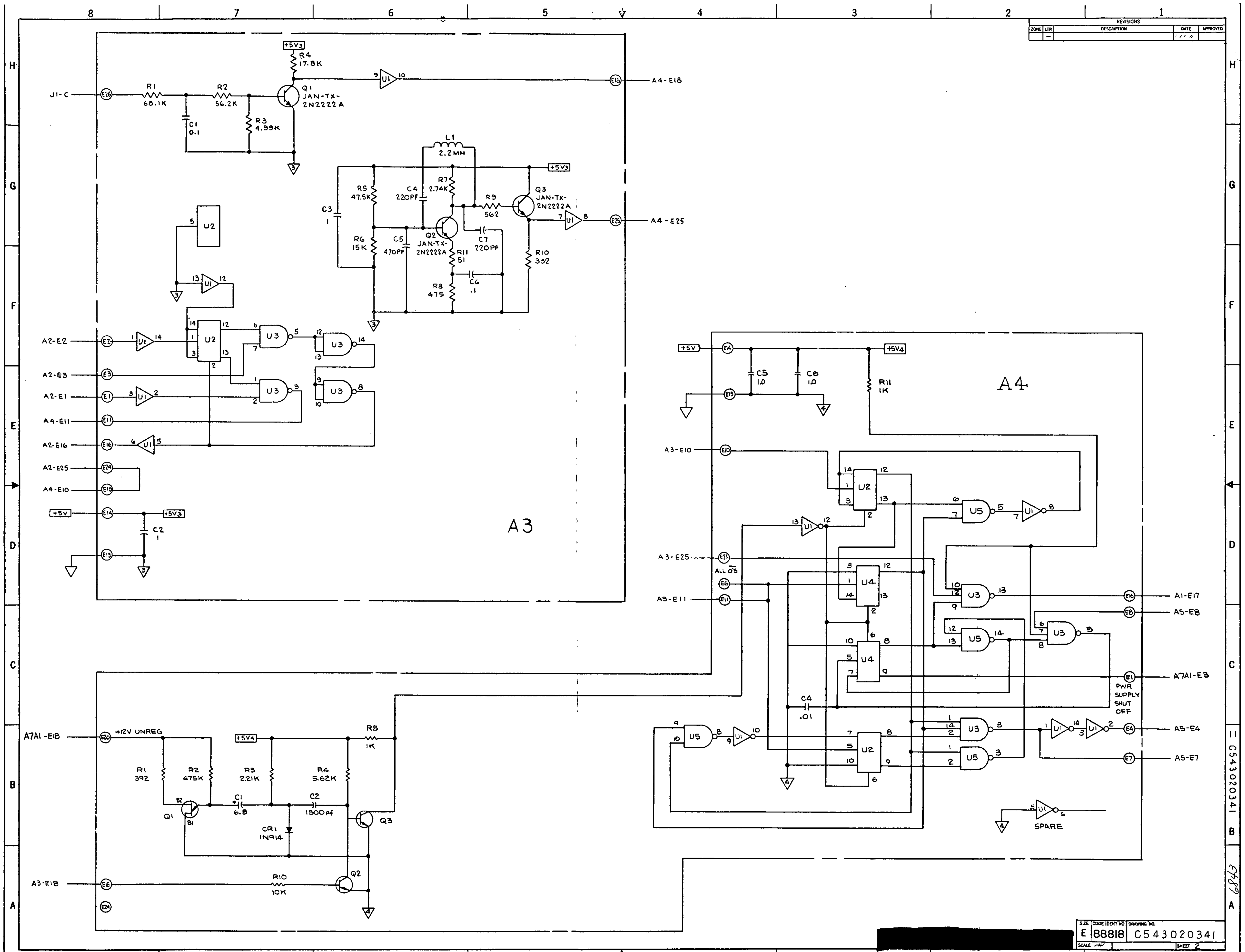
C543020341 B

6843

39/40

FOLDOUT FRAME 1

FOLDOUT FRAME 2



[redacted]

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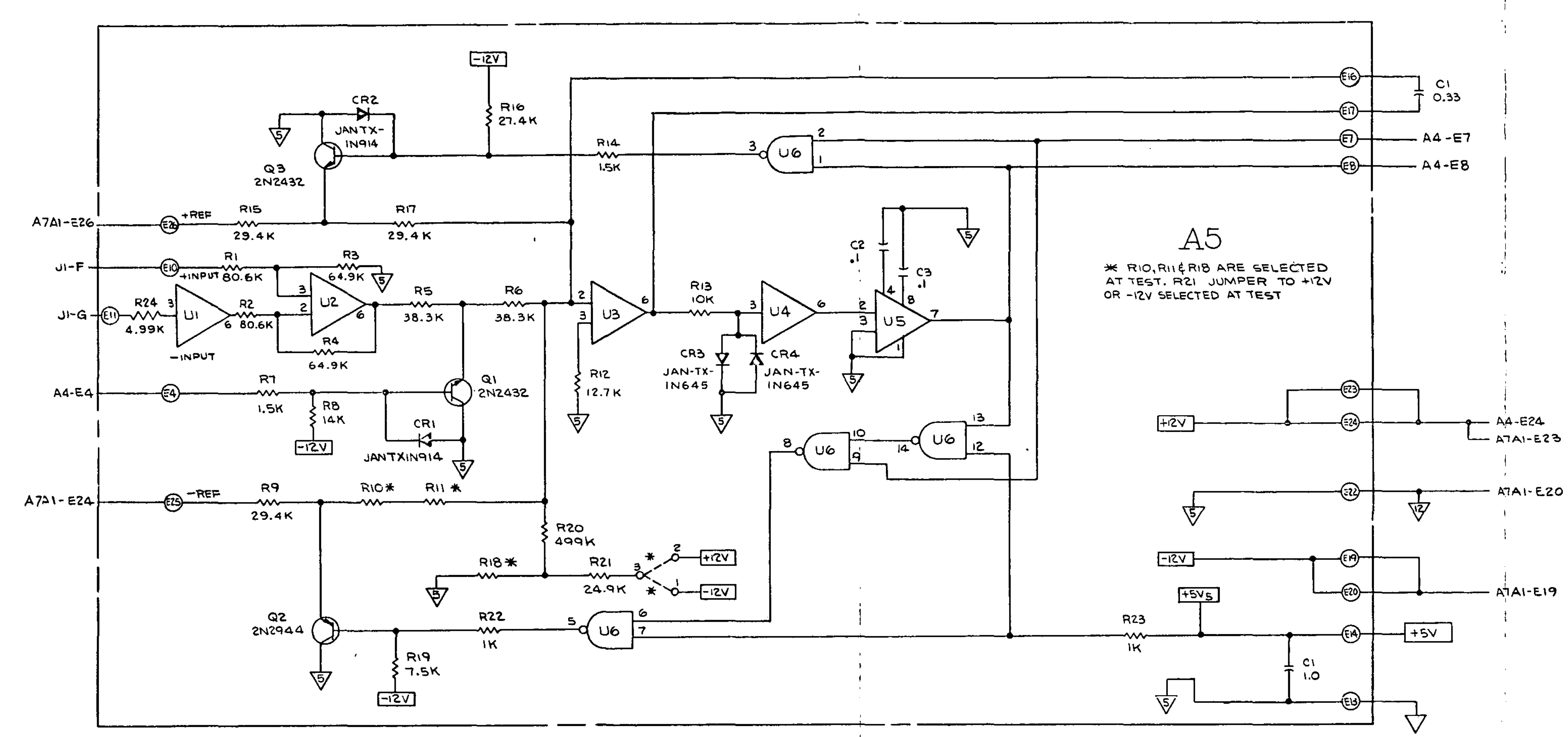
FOLDOUT FRAME 1

FOLDOUT FRAME 2



[redacted]

SIZE	CODE IDENT NO.	DRAWING NO.
E	88818	C543020341

SHEET 3

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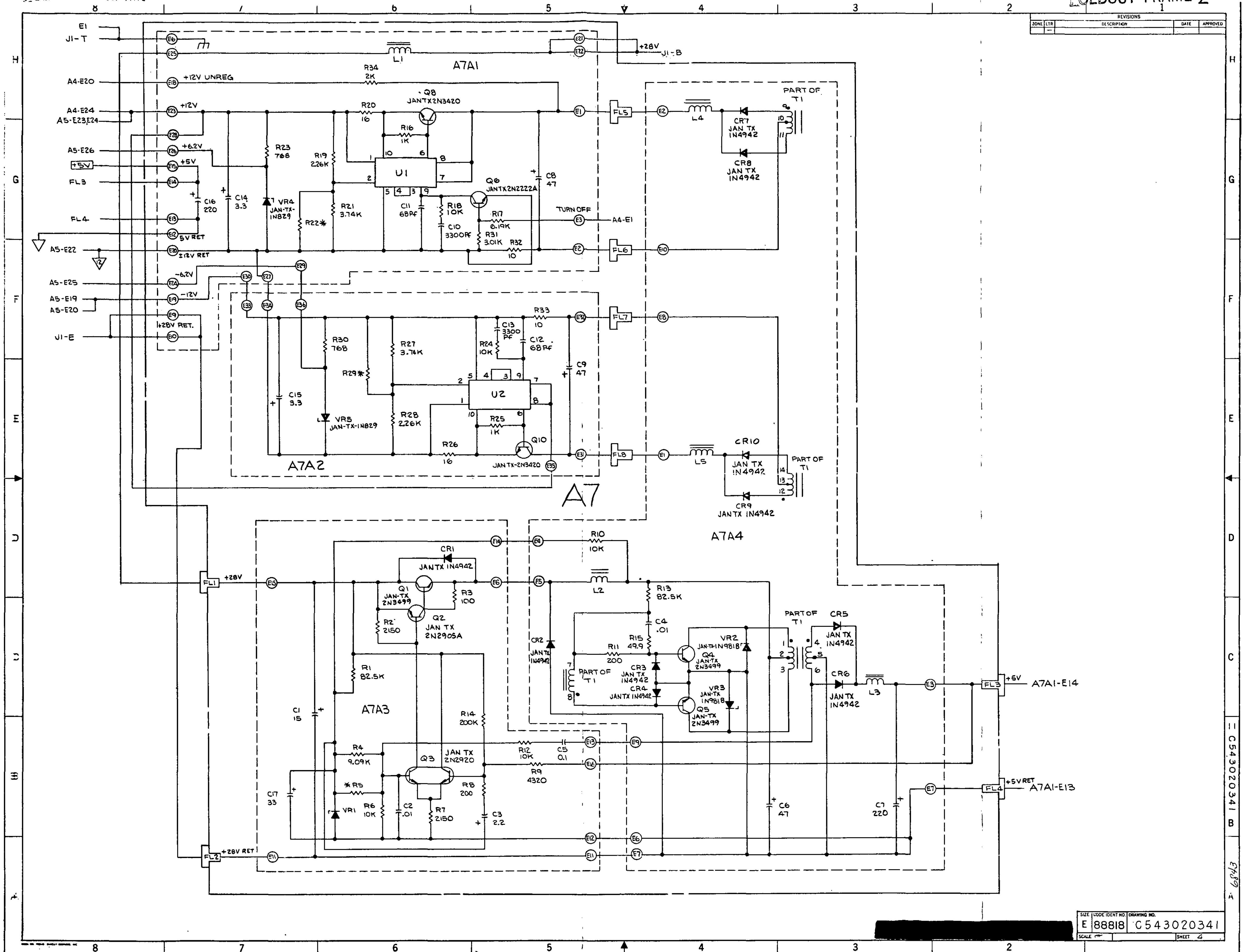
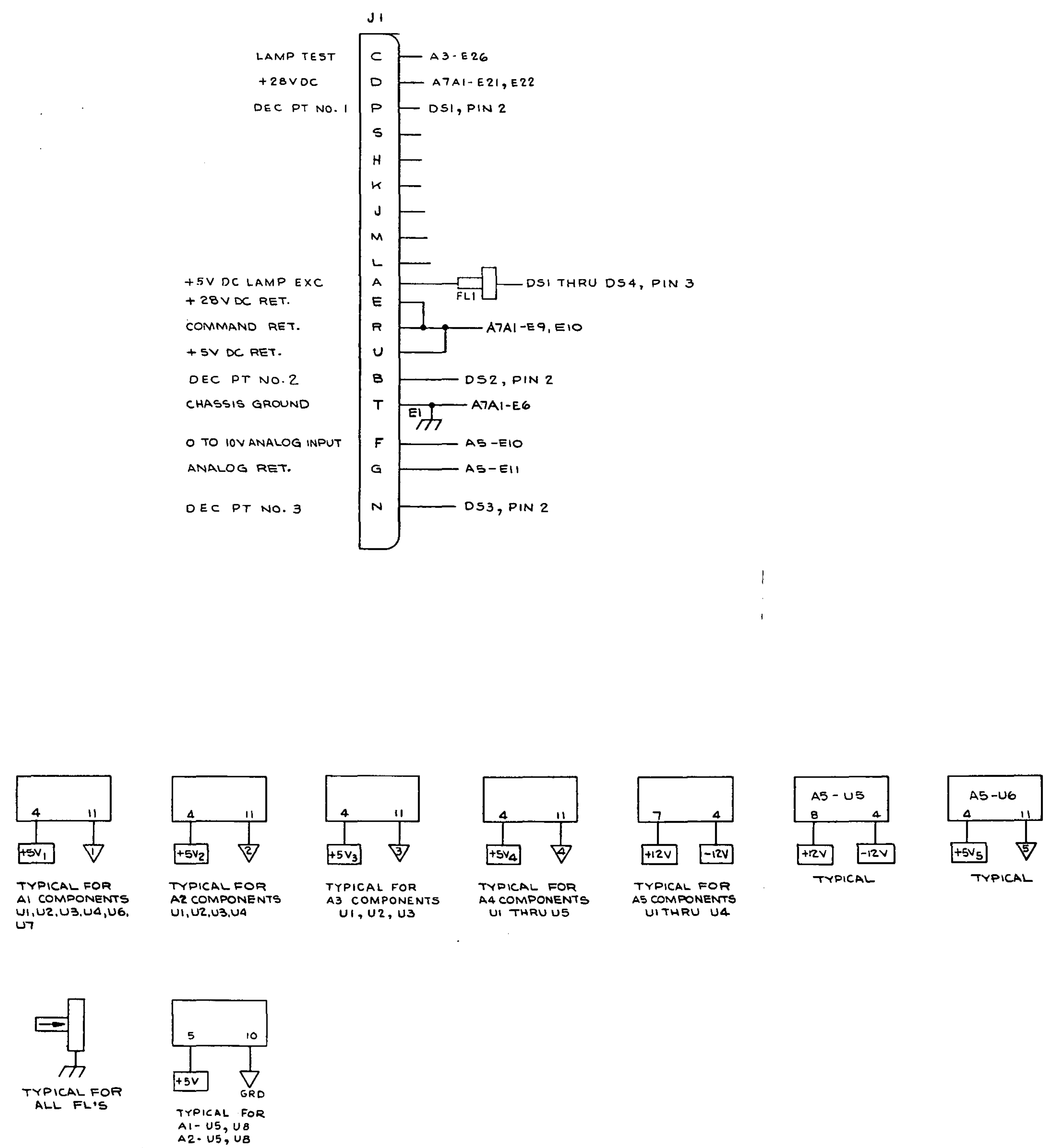
FOLDOUT FRAME 1

FOLDOUT FRAME 2



45/46



[redacted]

E 88818 C543020341
SHEET 5

1 C543020341

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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

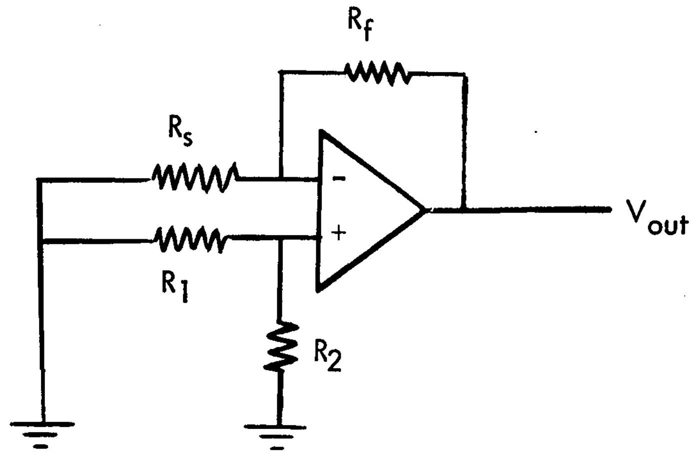
The effect of voltage and current offset can best be seen from the general differential amplifier configuration. Here an ideal amplifier is used in conjunction with a voltage offset source V_{os} and current offset source Ios; see Figure 6.

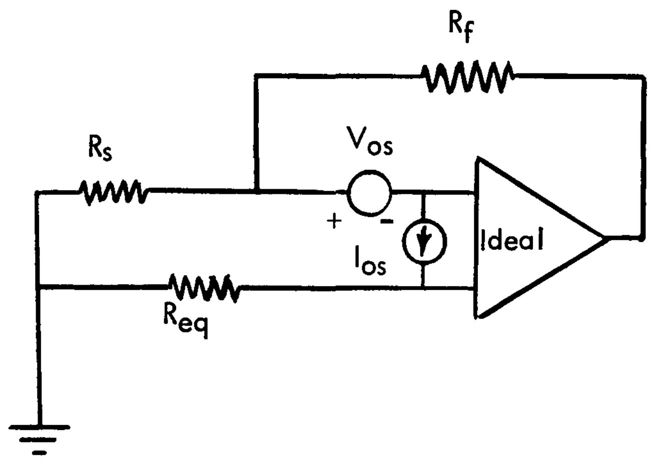
If R_{eq} is made equal to $\frac{R_s \; R_f}{R_s + R_f}$ then,

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

This means that V_{out}/I_{os} is soley a function of Rf.

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:

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

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

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

FIGURE 6

5.1 VOLTAGE OFFSET DUE TO TEMPERATURE

Listed below are the temperature coefficients of the operational amplifiers:

LM102:

V_{os} = 6μv/°C

I_{os} = 30na at -20°C, 4na at 60°C, 10na at 25°C

LM107:

V_{os} = 15μv/°C

I_{os} = 0.2na/°C

Offset error due to U1 (LM102):

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

Temp.	Δ (from Rm. Temp)	ΔV_{os}
-20°C	-45°C	-45 X 6 = -270μv
+60°C	+35°C	+35 X 6 = 210μv

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

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

Temp.	ΔI_{os} (from Rm. Temp)	ΔV_{out}
-20°C	+20na	$20\times10^{-9} \times 5\times10^{3}$ = 100μv
+60°C	-6na	$-6\times10^{-9} \times 5 \times 10^{3}$ = -30μv

In parts per thousand of full scale. $\frac{0.1\times10^{-3}}{5}$ = 0.02 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	$2 \times 15 \times 10^{-6} \times (-45)$ = -1350μv = -0.27ppk (max) (C)
+60°C	$2 \times 15 \times 10^{-6} \times (35)$ = 1050μv

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

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

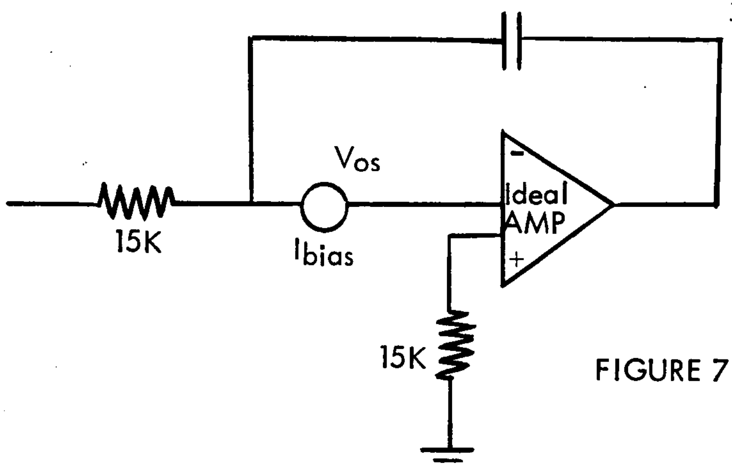


FIGURE 7

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

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

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

Temp.	ΔIb offset
-20°C	-9na
+60°C	7na

Drift current due to V_{os}

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

Temp.	I_{drift} from Room Temp
-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:

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

In parts per thousand this is

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

Similarily for drift due to ΔV_{os}:

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

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) $\Delta V_{offset} \approx 1\mu v/{}^{\circ}C$

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

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.

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

For Q1 and Q2 ΔV_{offset} = +35μv at 60°C
= −45μv at −20°C

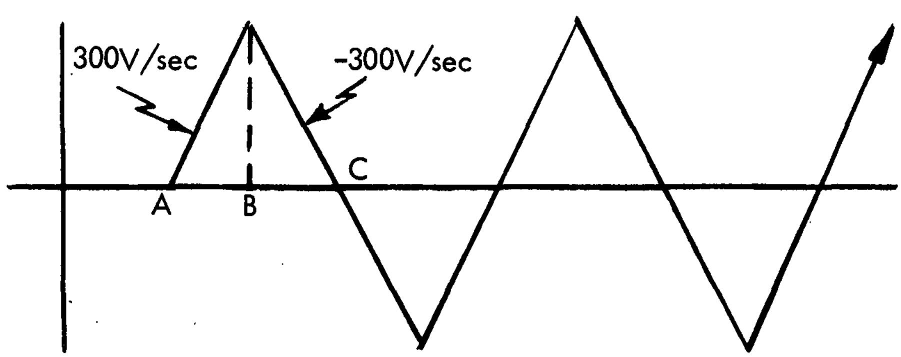
These values will be considered negligible.

Zener references IN829A

V_Z = 6.2 v
Max. T_C = .0005%/°C = 30μv/°C
For ΔT of +35°C, ΔVz = 1mv = .16ppk
For ΔT of −45°C, ΔVz = 1.4mV - .23ppk (max) (G)

U4 Buffer (LM102) <u>Zeroing Error</u>
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 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 μs

Therefore - f (zeroing) = 600KHz

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

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

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

Σ error^2 $\approx$ .374

error .61 ppk = .061% 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 ±12v/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.)

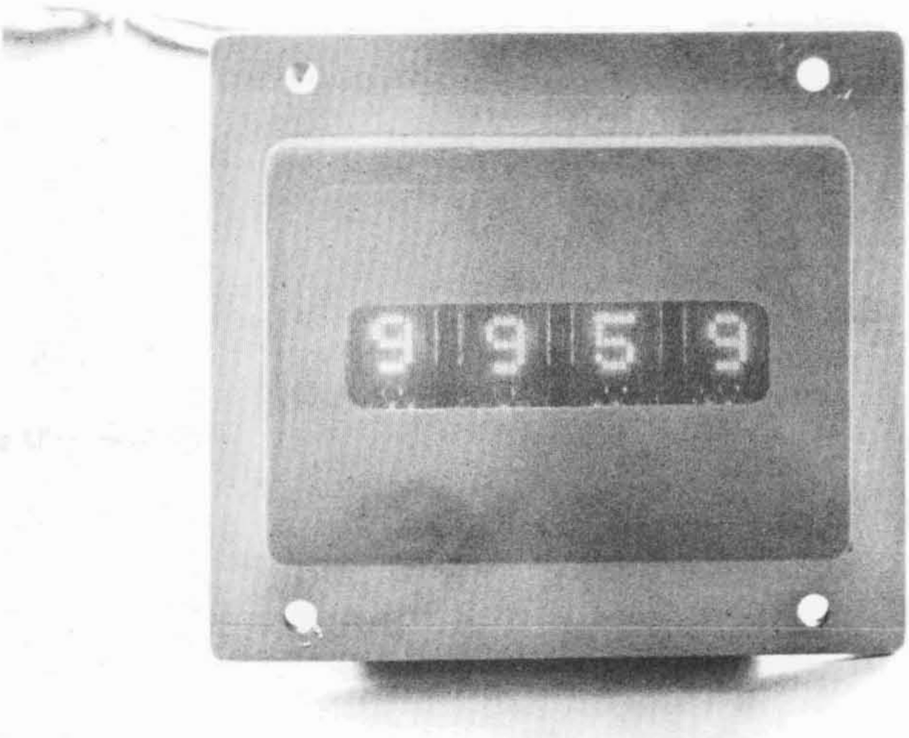
APPENDIX A

MECHANICAL ASPECTS

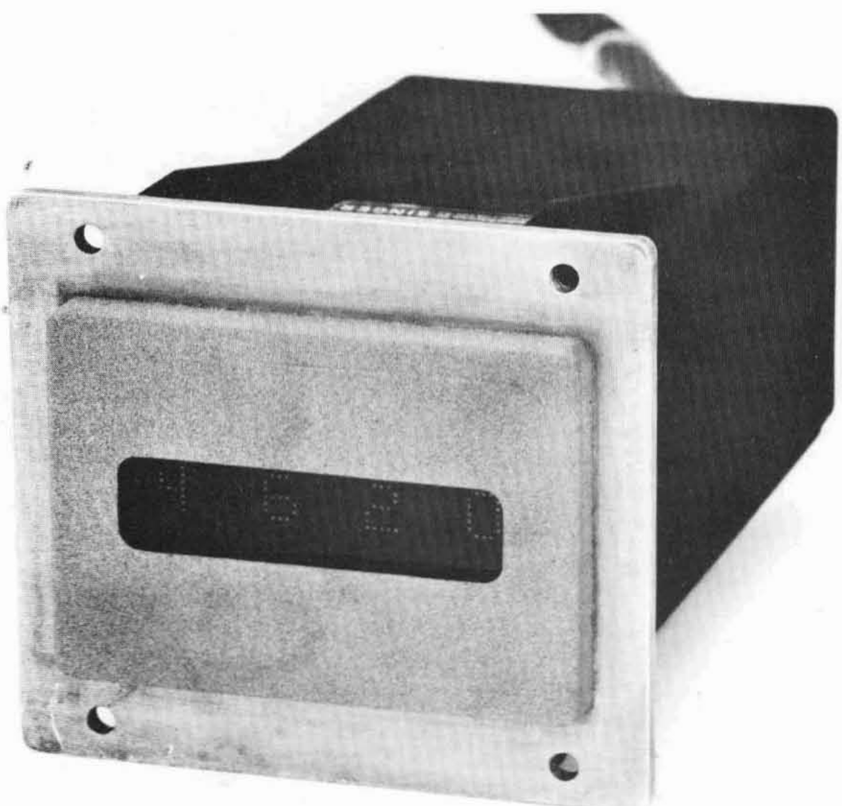
PHOTOGRAPHS OF SKYLAB DISPLAYS

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

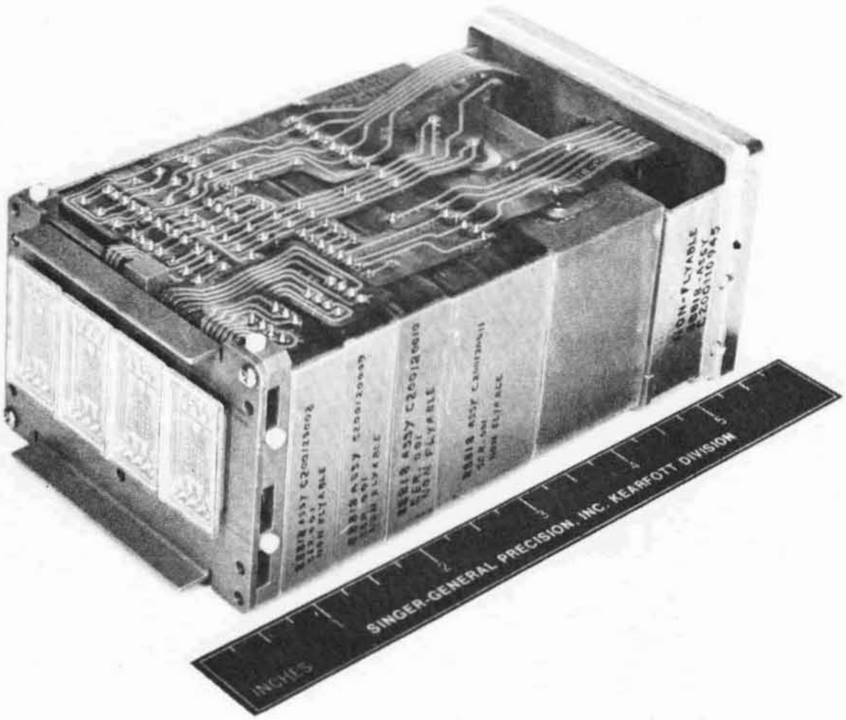
2 (9)



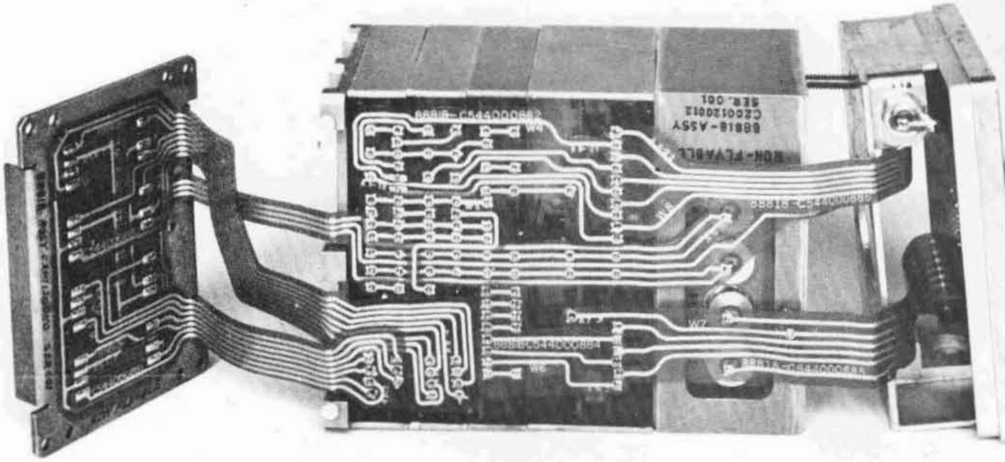
EVENT TIMER



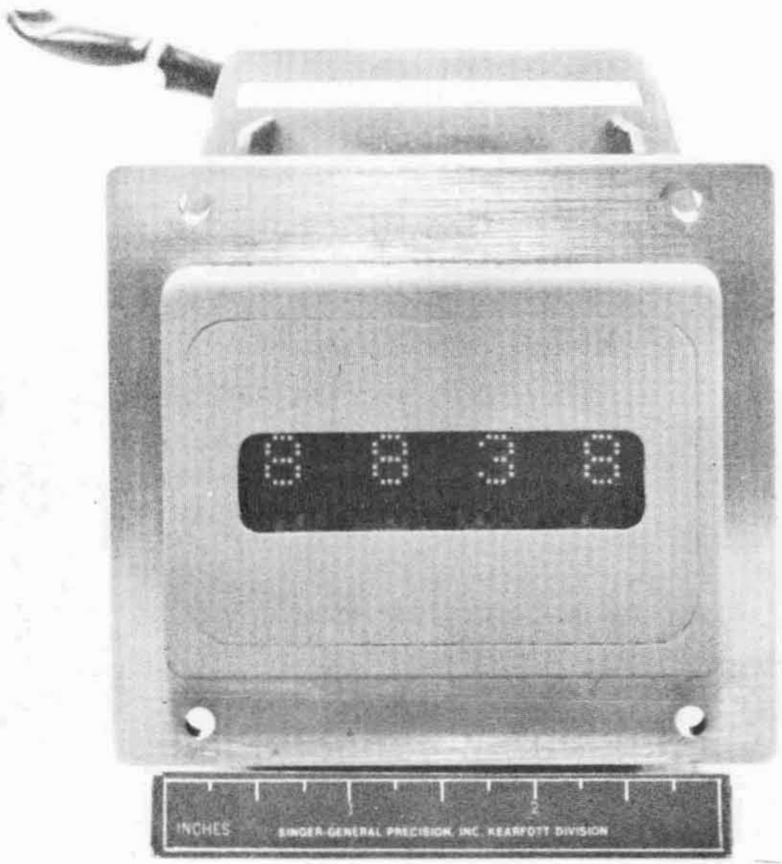
EVENT TIMER



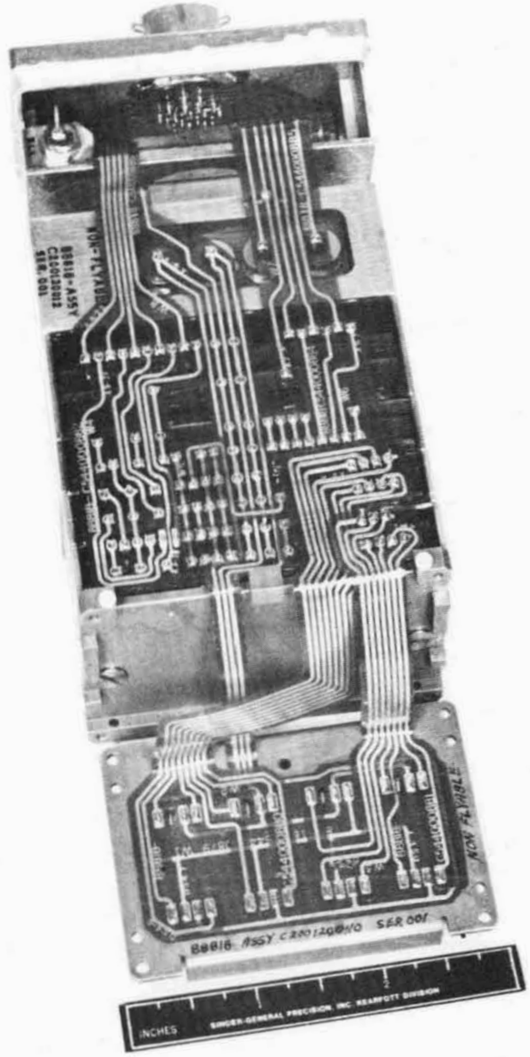
EVENT TIMER



EVENT TIMER



EVENT TIMER



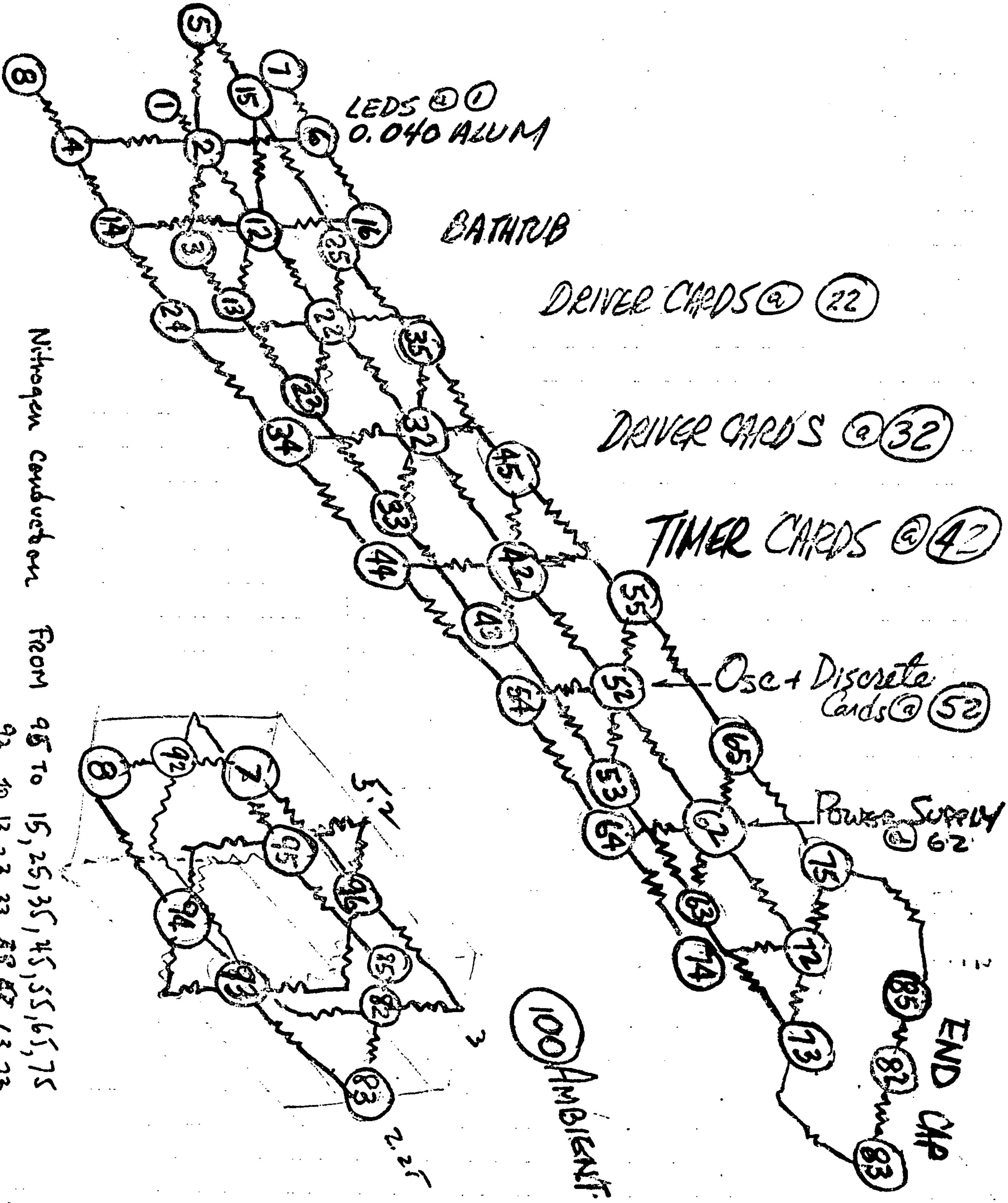
EVENT TIMER

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


LEDS @ 1
0.040 ALUM
BATHTUB
DRIVER CARDS @ 22
DRIVER CARDS @ 32
TIMER CARDS @ 42
Osc + Discrete Cards @ 52
Power Supply @ 62
END CAP
100 AMBIENT
Nitrogen conduction FROM 95 TO 15, 25, 35, 45, 55, 65, 75
93 to 13, 23, 33, 43, 53, 63, 73
94 to 14, 24, 34, 44, 54, 64, 74

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	.16640938 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

$K_{potting}$ = .0001486
K_{alum} = .161
$K_{nitrogen}$ = .000025 Gap ~ .032"

Res. of pressure contact Assume $\frac{IN^2 \cdot 5°C}{W}$ or $15.81 \frac{°F\text{-}IN^2}{BTU/MIN}$

Res. of thermal clip $(5.125)(2) \frac{W \cdot °C}{W}$ = $10.25 \frac{°C \cdot IN}{W}$ or $324.25 \frac{°F\text{-}IN}{BTU/MIN}$

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

07/23/70

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)	NØDE/NØDE		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	.18900665 E+03	.18150000 E+03	4	8		
7	.17579295 E+03	.18150000 E+03	6	7		
8	.17644472 E+03	.12880000 E+03	6	16		
11		.12880000 E+03	4	14		
12	.18973665 E+03	.35800000 E+02	12	16		
13	.18964172 E+03	.37200000 E+02	3	13		
14	.18872709 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		.46480000 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		.46400000 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	.17372044 E+03	.35030000 E+04	33	43		
44	.17814611 E+03	.35030000 E+04	35	45		
45	.1737[illegible] 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		.46470000 E+04	42	44		
50		.97200000 E+04	42	45		
51		.[illegible]6840000 E+03	44	54		
52	.19652539 E+03	.1881[illegible] E+04	42	52		.70000000 E-01
53	.1735[illegible]731 E+03	.30670000 E+03	43	53		
54	[illegible]	.30670000 E+03	45	55		
55	.1735[illegible]731 E+03	.654[illegible] E+03	54	94		
56		.94[illegible]1000 E+03	53	93		
57		.94[illegible]1000 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	.16951179 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		

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 [signature] DATE 2/24/71

TEST PERFORMED BY [signature] DATE 2/24/71

APPROVALS: [signature] DATE 2/24/71

[signature] DATE 2/24/71

F2462G 8/70

SINGER
KEARFOTT DIVISION

C194010241 REV —

CODE IDENT NO. 88818

CONTROL ______

REVISION RECORD

REV	DESCRIPTION	APPROVAL AND DATE
—	RELEASE	~~[illegible]~~ 2-24-71

REV	—																				—
PAGE	1 & 2																				OTHER PAGES
REVISION SYMBOL OF REVISED PAGES																					

ASTERISKS (*) SHOWN LOCATE CHANGES FROM PREVIOUS ISSUE FOR CONVENIENCE ONLY - NO LIABILITY ASSUMED

F2464F 8/70

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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.

NOMENCLATURE	PART NUMBER	SERIAL NUMBER
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.

4.4 Test Data. The test data sheets are attached.

4.5 Test Equipment.

NOMENCLATURE	MANUFACTURER	MODEL, TYPE, OR PART NO.	S/N
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

SINGER
KEARFOTT DIVISION

[illegible] REV –

CODE IDENT NO. 88818

DATE 2-1-71 INSP. F.8

P/N C708753100 S/N 002

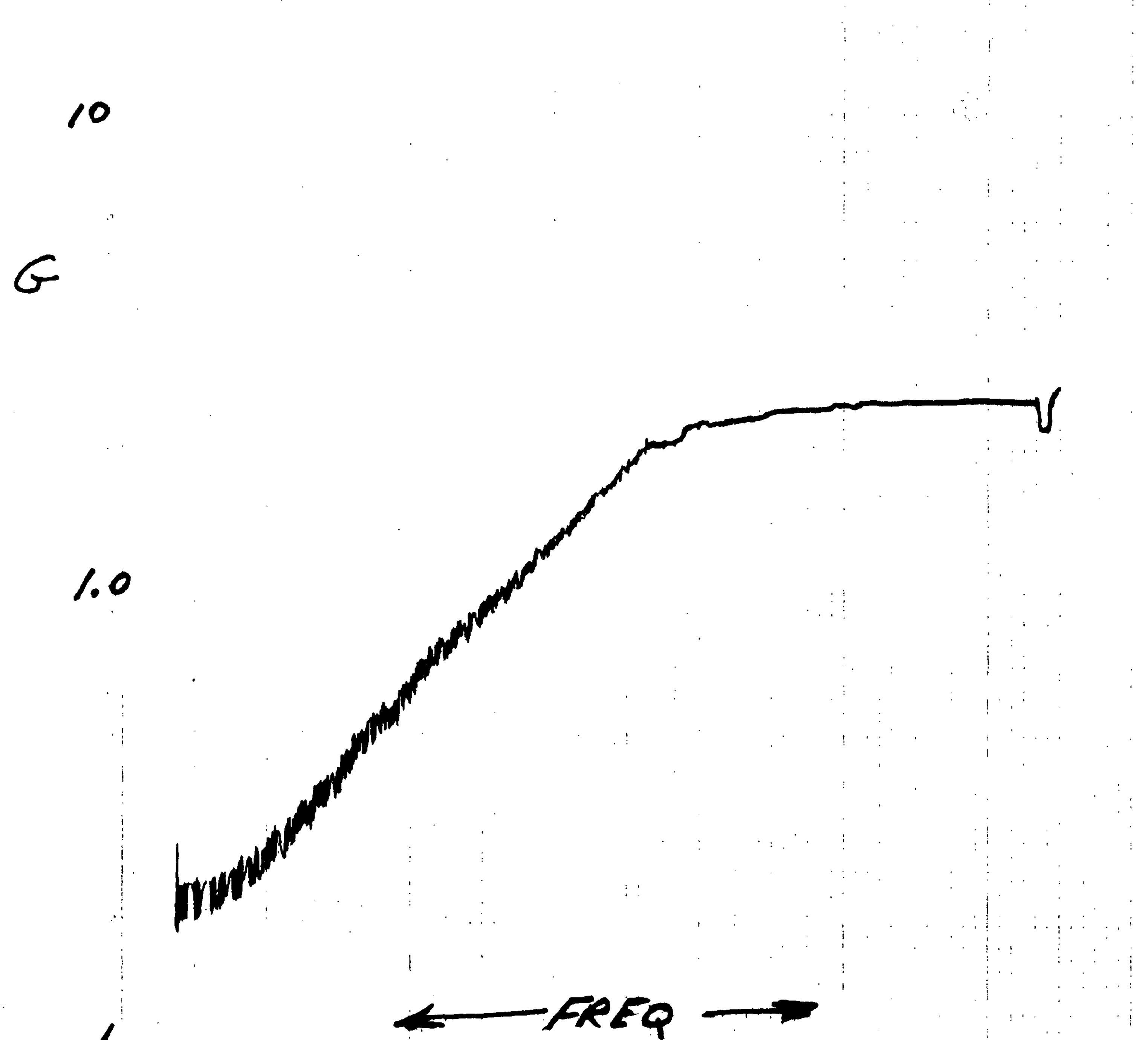
G ... FREQ

5 ... 30 Hz

.1 ... 100G

ANALYZER ... – FILTER BW –

FLIGHT AXIS



SINGER
KEARFOTT DIVISION

C194010241 REV. –

CODE IDENT NO. 38313

2-1-71 F.S

C708753100 002

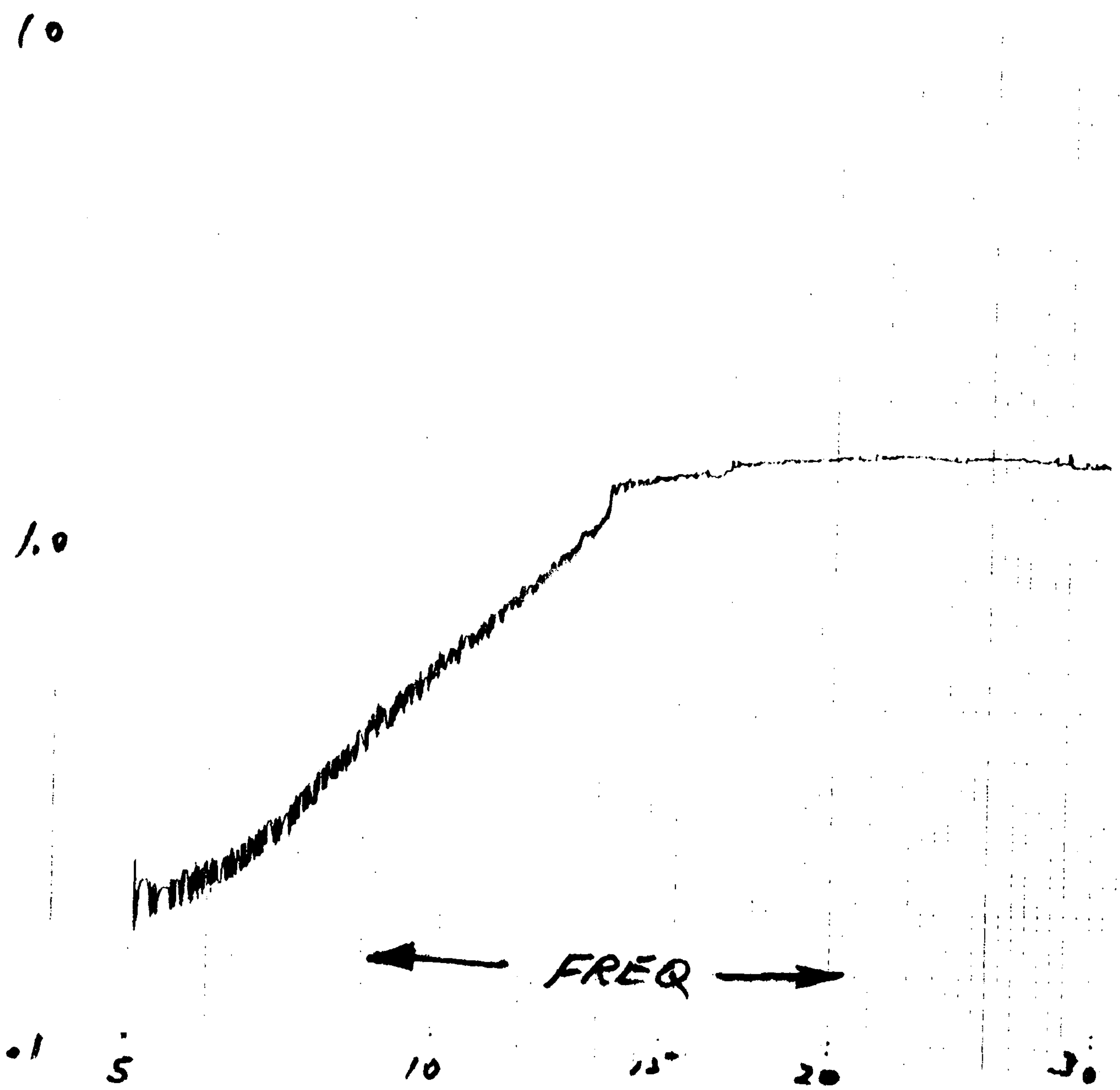
G FREQ

5 30

.1 100G

FILTER BW

LATERAL AXIS



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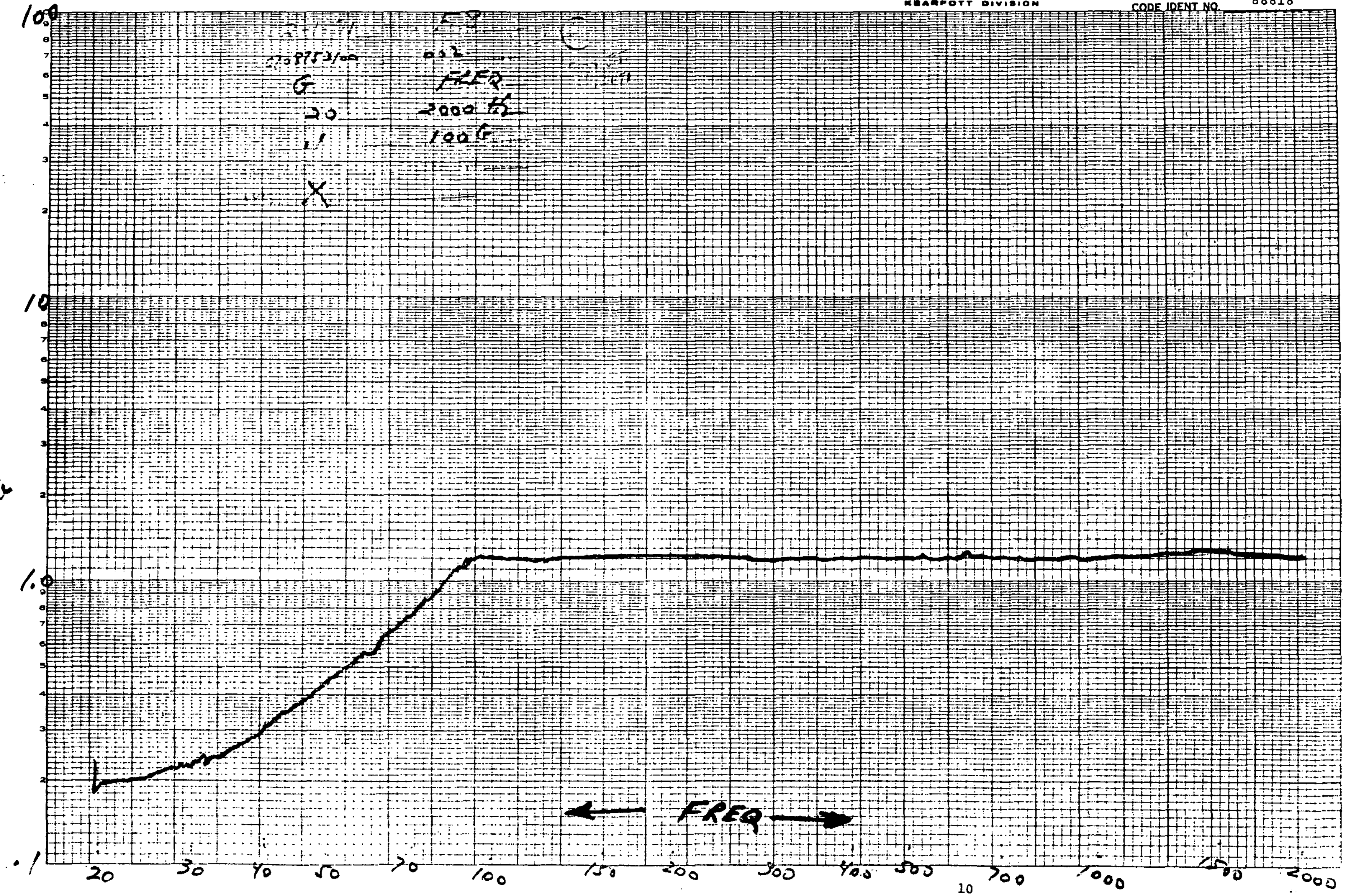
KEARFOTT DIVISION

C194010241 REV. —
CODE IDENT NO. 88818



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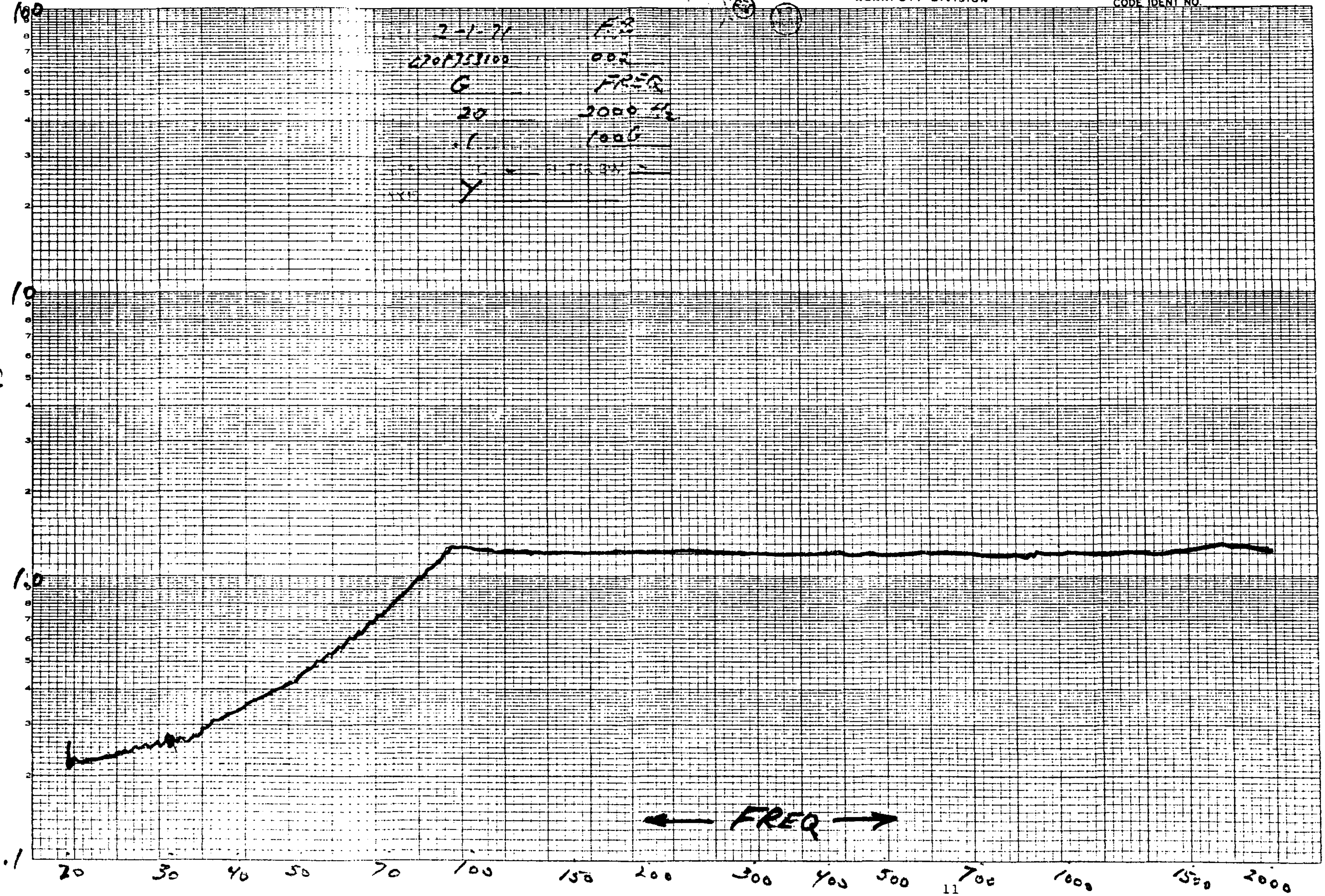
B-10

SINGER
KEARFOTT DIVISION

C194010241 REV. —
CODE IDENT NO. 88818



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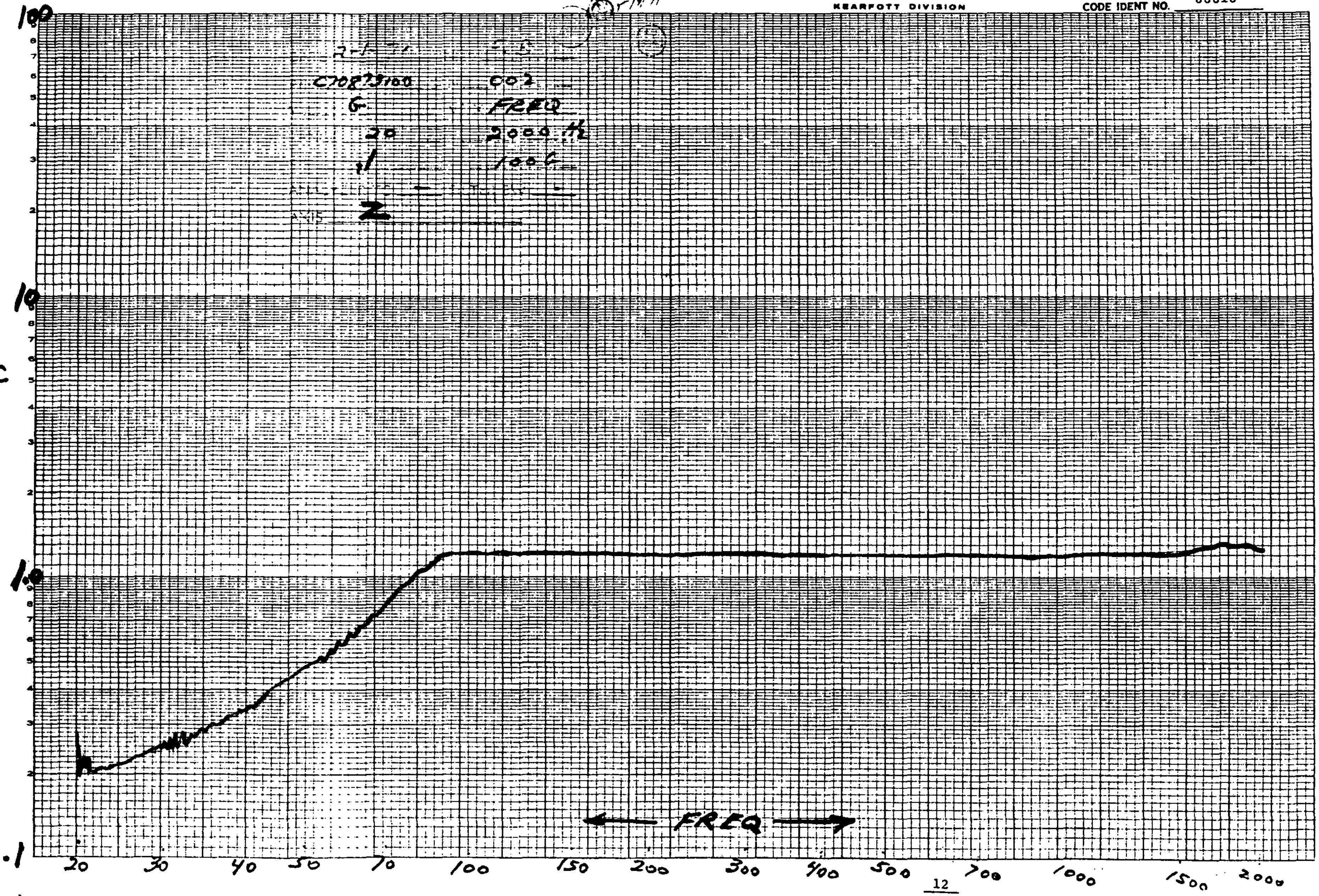
C70873100
002
G
FREQ
20
2000 Hz
.1
100 G
Z
100
10
1.0
.1
G
20
30
40
50
70
100
150
200
300
400
500
700
1000
1500
2000
← FREQ →

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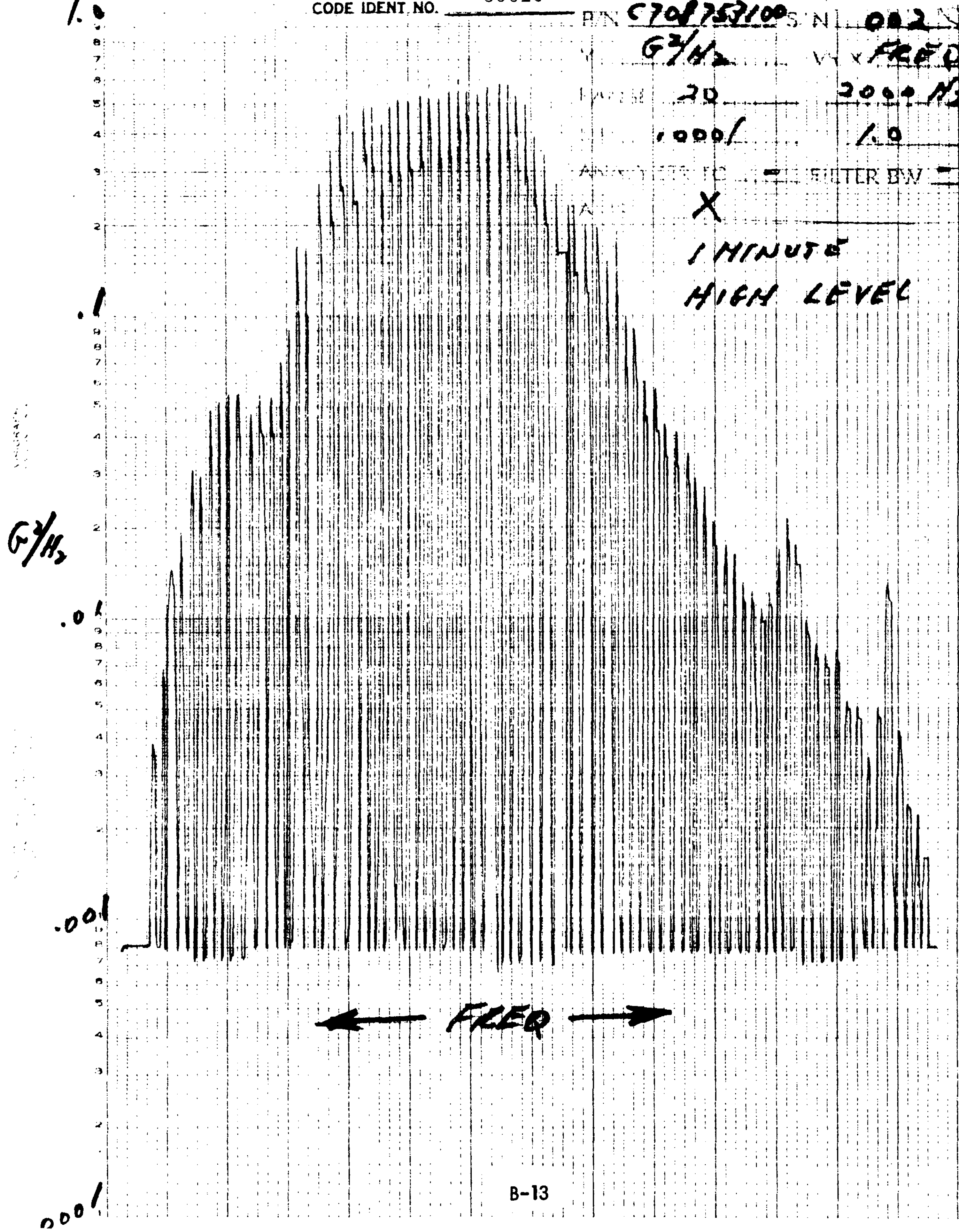
KEARFOTT DIVISION

C194010241 REV. –

CODE IDENT NO. 88818

DATE 1-29-71 INSP. F.B

P/N C7087S3100 S/N 002



SINGER
KEARFOTT DIVISION

C194010241 REV. –

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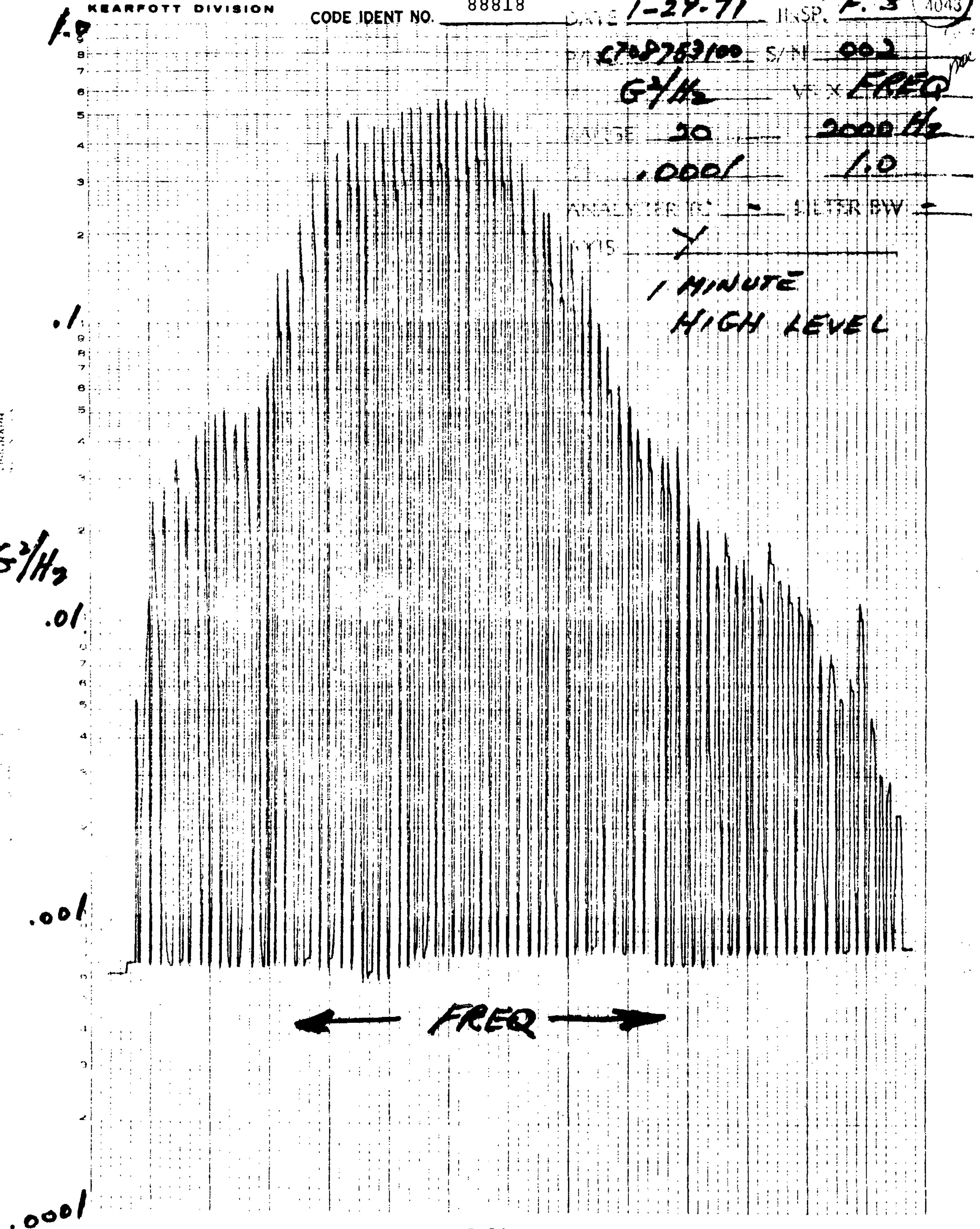

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KEARFOTT DIVISION

C194010241 REV. —

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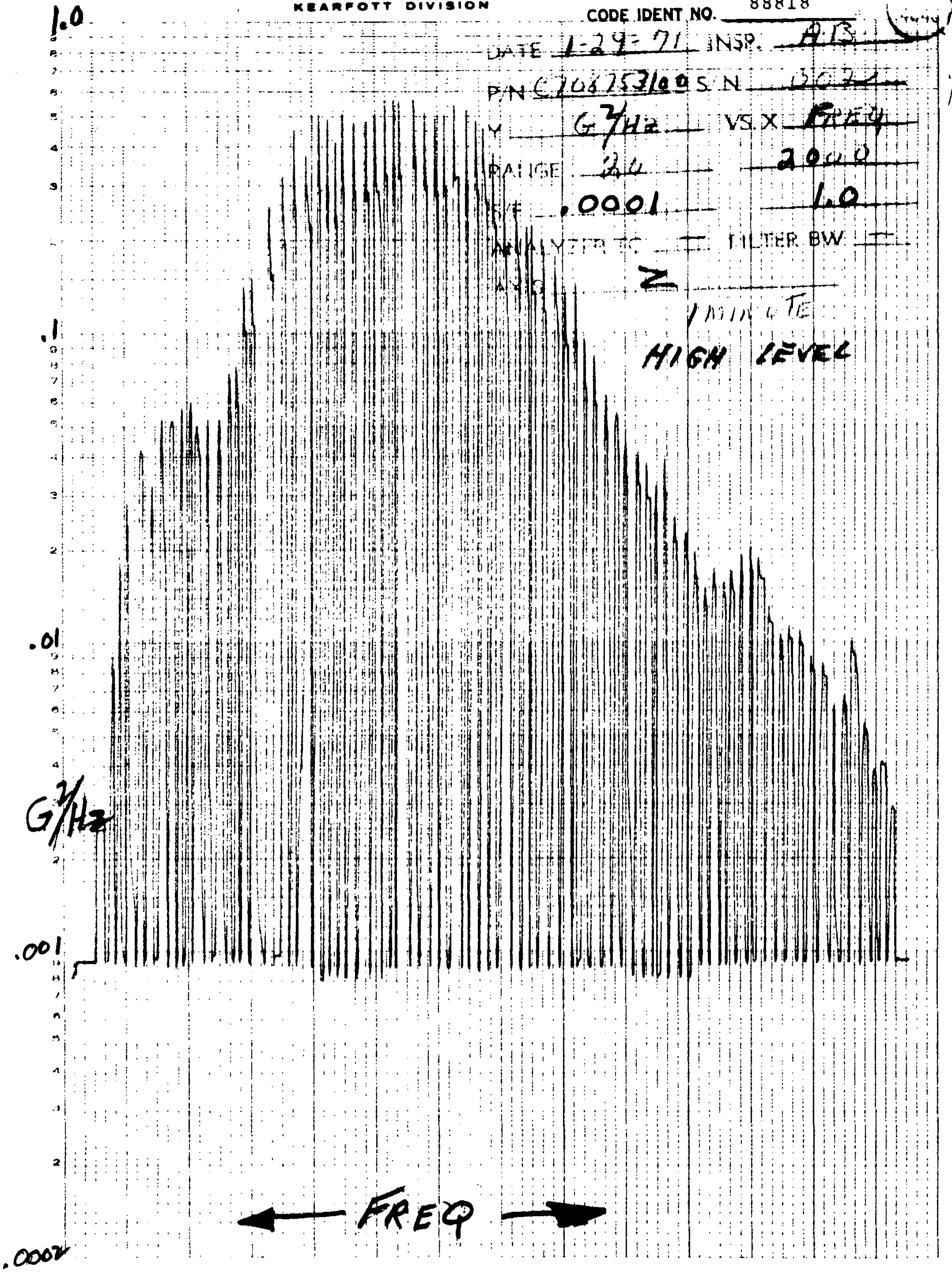

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C194010241 REV. –

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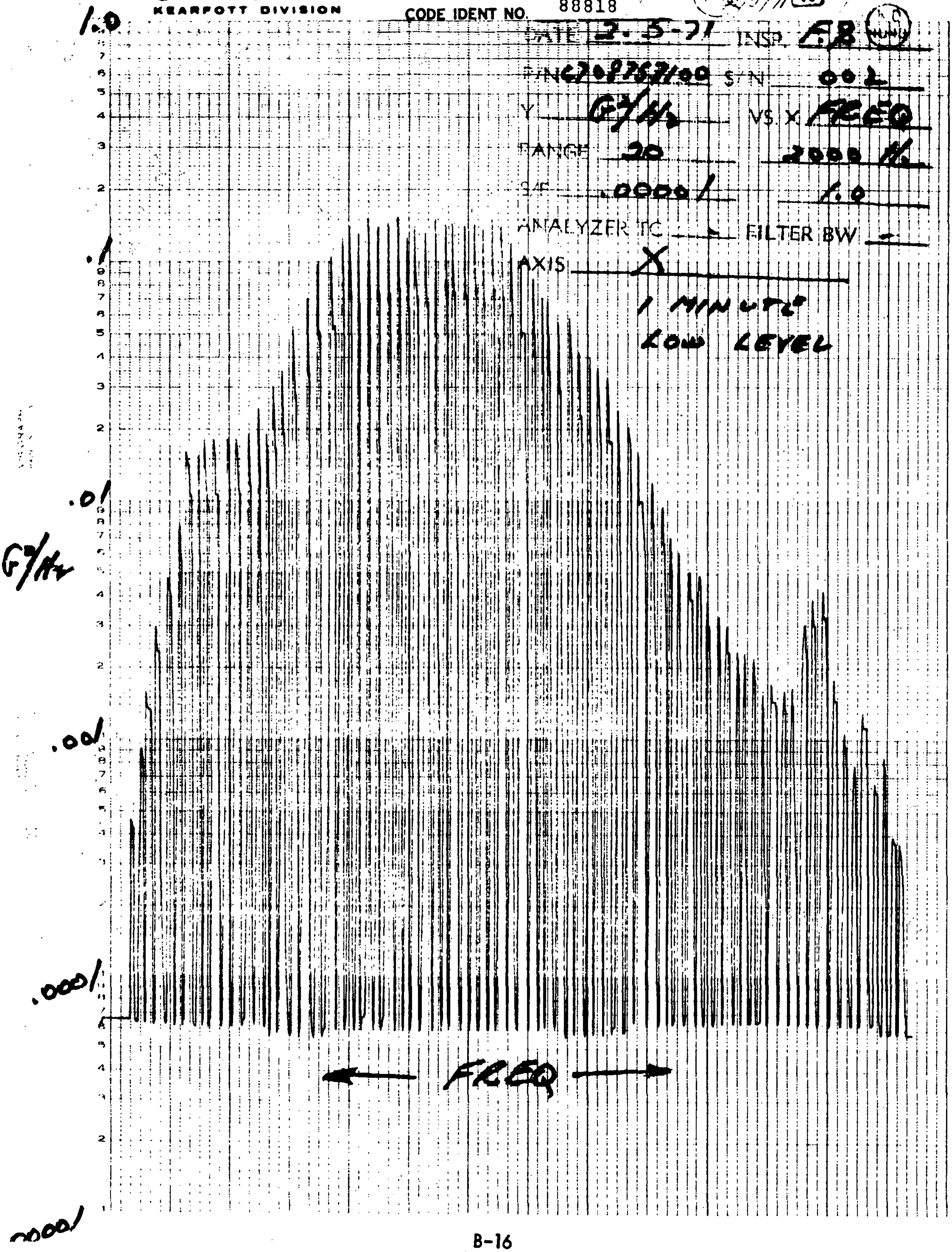

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C194010241 REV. -

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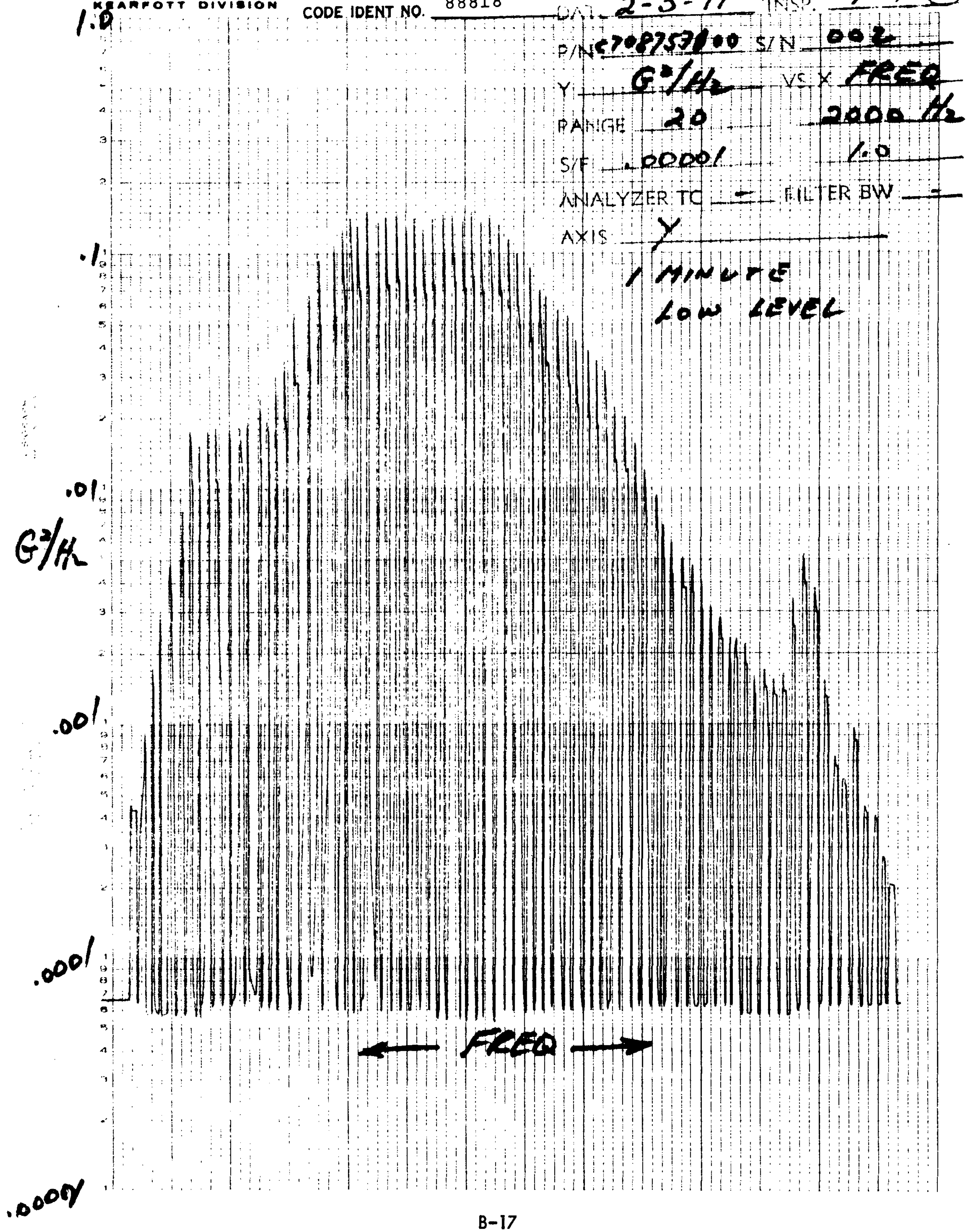

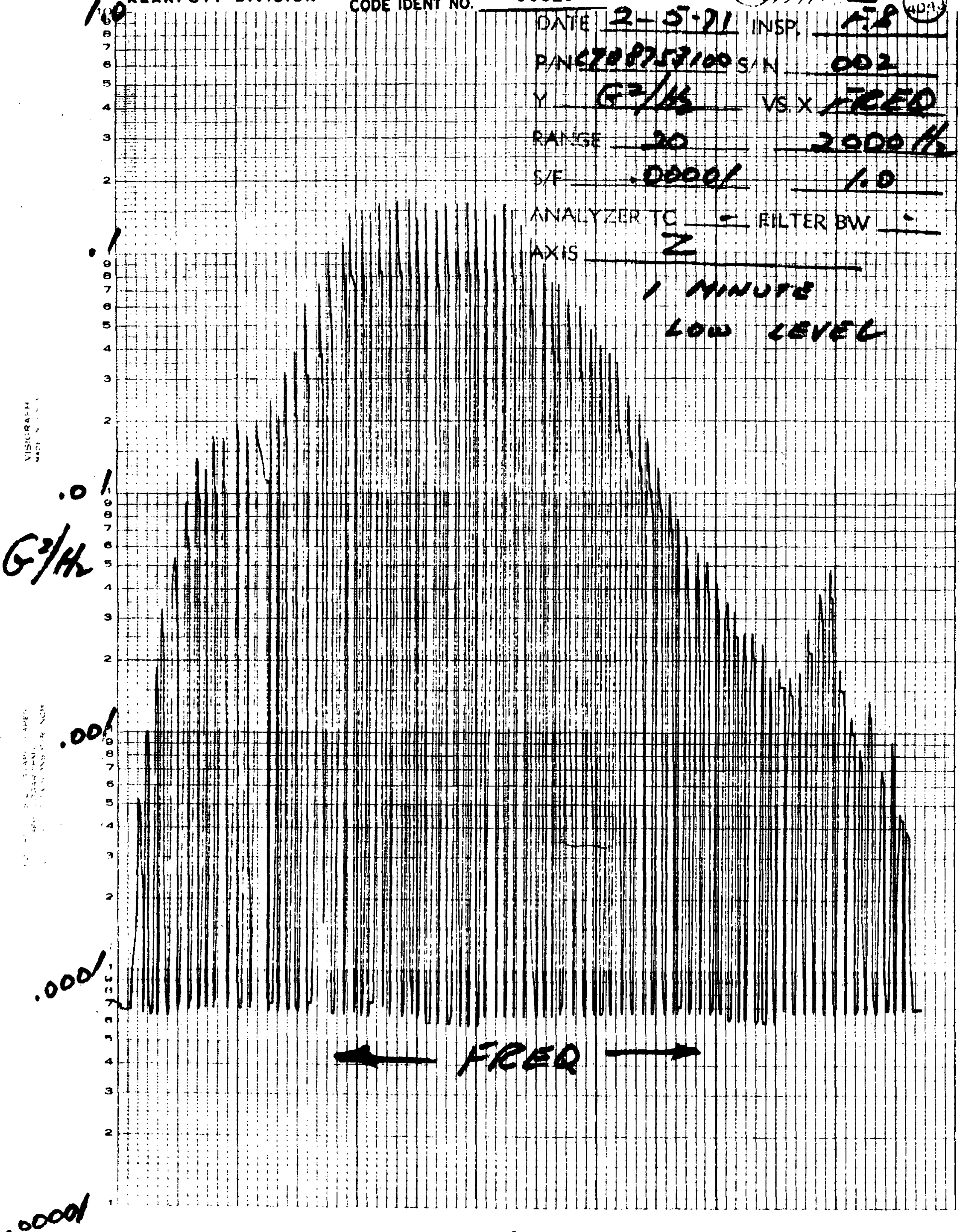
DATE 2-5-71
INSP.
P/N
S/N 002
Y G²/Hz
VS. X FREQ
RANGE 20 2000 Hz
S/F .0001 1.0
ANALYZER TC —
FILTER BW —
AXIS Z
1 MINUTE
LOW LEVEL
1.0
.1
.01
G²/Hz
.001
.0001
.00001
FREQ

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

W. Tyberg

Approved by: J. Attwoll

J. Attwoll

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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:

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

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

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

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

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

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 indentured parts list.

4. Both the Event Timer and the Secondary Display are certified to meet the electromagnetic 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 g^2/Hz

    20-90 Hz at 9 dB/oct

    90-150 Hz at 0.012 g^2/Hz

    150-285 Hz at + 9 dB/oct

    285-500 Hz at 31 g^2/hz

    500-2000 Hz at -12 dB/oct

    2000 Hz at 0.0012 g^2/Hz

    Composite = 11.8 grms

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

    20 Hz at 0.00013 g^2/Hz

    20-90 Hz at +9 dB/oct

    90-150 Hz at 0.012 g^2/Hz

    150-285 Hz at + 9 dB/oct

    285-500 Hz at 0.077 g^2/Hz

500-2000 Hz at - 12 dB/oct

2000 Hz at 0.00028 g^2/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 consulation 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.

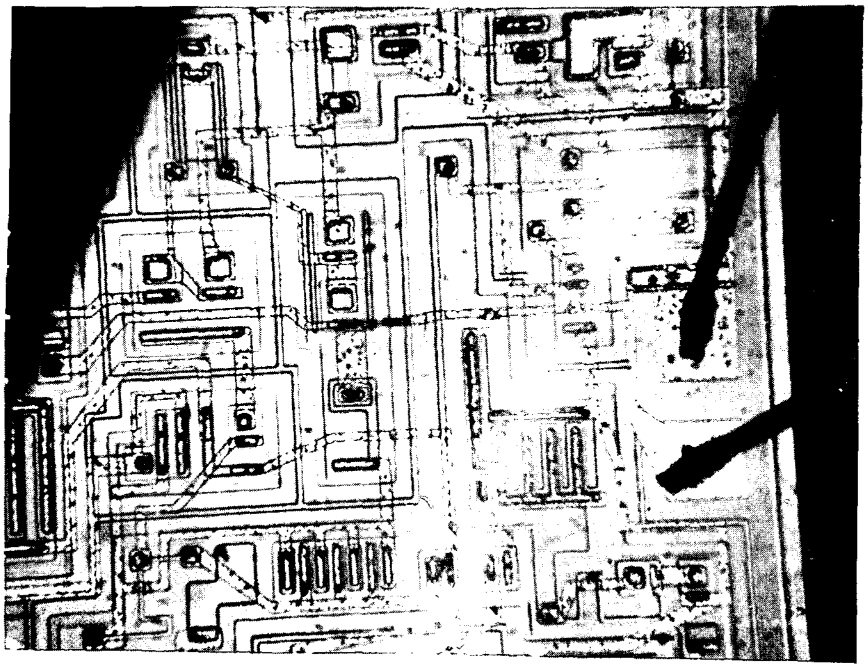
Tests were conducted on five (5) LM 102 flatpacks in accordance with the schedule Attachment 2. Cumulative total time of operational testing was in excess of 96 hours. Various power cycling tests, changing the on/off sequence of the B+ and B- supplies with various input signal levels were conducted with 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.

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.

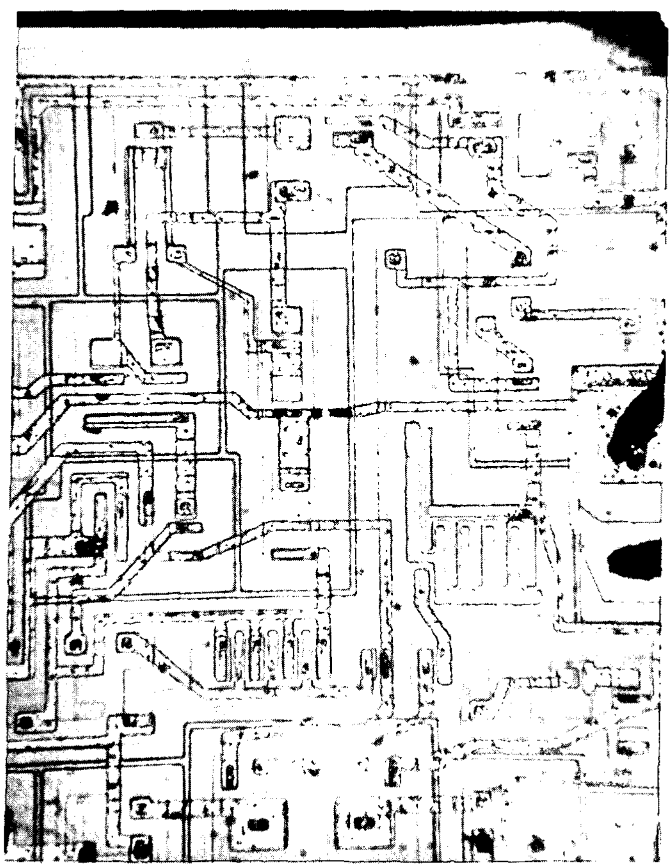
Currently only Secondary Display SN/201 and SN/102 do not contain this resistor. Both are in process of retrofit.



LAB SAMPLE

LM102

8 VOLTS 600 MA



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

2900 Semiconductor Drive, Santa Clara, California 95051 (408) 732-5000/TWX (910) 339-9240 CABLE: NATSEMICON TELEX: 346353

FAILURE ANALYSIS REPORT

RELIABILITY ENGINEERING DEPARTMENT

MICROCIRCUITS DIVISION

stomer / dress	Singer Kearfott	File No. 701
		Date April 19, 1971
quester	Dept/Company	Analysis By M. Parker
erences/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.

4/23/71

To: J. Kornowski
From: V. Ciliberto / W. Tyberg

Subject: Summary Of Reliability-Engineering Evaluation on Five Sample Voltage Followers - National Semi Type LM102

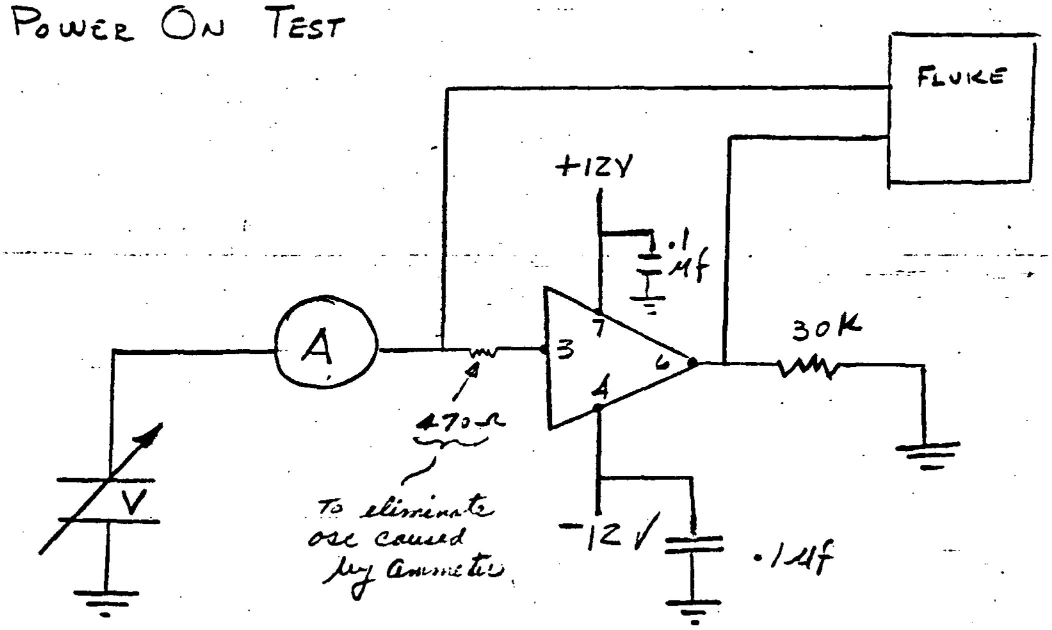
Reference —— Nat. Semi. Letter dated 4/19/71 - Attached.

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
[signature]

POWER ON TEST 4/2/71



a) Increase V from approx 12 volts - current will be read at saturation. Keep on increasing 1 ma at a time. For retest return to approx 6.0V to see if unit still tracks.

b) Repeat (a) with negative input

---

a) + TEST Unit #1) +12V read no current
13V " .6 ma
13.5V " 1.5 ma
14.0V " 2.5 ma
15.0V " 4.0 ma
15.5V " 5.0 ma
16.0V " 6.0 ma

Retest at 6.0V = -6.0V out no current drawn
16.0V " 6.0 ma
17.0V " 6.8 ma
18.0V " 6.8 ma
19.0V " 8.0 ma
20.0V " 10.0 ma

Retest ① at 6.0V — read - no current - no failure -

Remarks:
Unit #1 did not experience any fail 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

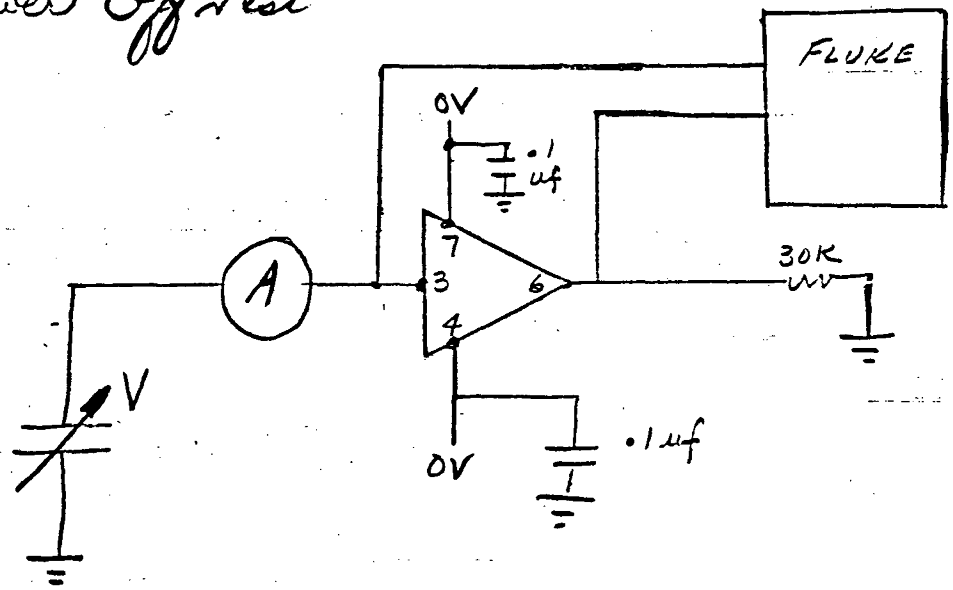
Input	read	
0V		no current drawn
1V		" " "
2V		2.5 ma
3V		2.5
4V		2.5
5V		2.5
6V		2.5
7V		2.5
9V		2.5
10V		2.5
11V		0 current
12V		6 ma
14V		7 ma
15V		7.5 ma
16V		25 ma
17V		48 ma
18V		65 ma
19V		72 ma
20V		80 ma
28V		>100 ma

no failure detected

Test b) Unit #2 with 4.7K-Ω resistor in circuit instead of 470Ω

	Input	read	
	6V		no current drawn = 6 volts out
	10V		" " "
	11V		.100 ma
	12V		.2 ma
	13V		.4 ma
	14V		.6 ma
	15V		.9 ma
	16V		1.0 ma
	17		1.3 ma
	18		1.5 ma
	19		1.8 ma
	20		2.0 ma
Retest	6.0V		6.0V out—no failure

2) Power Off Test 4/2/71



a) Increase V from 0 volts 1ma at a time
Turn power supply ± 12V on after every
increase and confirm unit still operates.

b) Repeat with negative input.

---

a) Unit #1

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

Test a) Unit #2 Repeated above test with no apparent difference
Test b) Unit #2 at -24 volts input - showed appr. 500ma
☆ drawn for 5 seconds - no failure noted. Heat[illegible]

3) Overstress Test 4/5/71
Unit #3

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 +12 V with pin 4 (neg) varying from 0 V to -12 V (at 50 Hertz rate) pin 3 grounded.

2) 24 hrs at: pin 7 held at -12 V with pin 4 (pos.) varying from 0 V. to +12 V (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.

(5)

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

4428 1/69

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

EQUIPMENT *EVENT TIMER* SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC *C543020271* PART NO. *C708755100*

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. (oC)		STRESS		STRESS RATIO
								RATED	AMB	RATED	OPERATING	COL. 10 / COL. 11
1	A1, A3, A4	Counter Board	C53L000756	C536000756	SINGER-KEARFOTT	3	100%	As	Shown	on Sheet	2 of 11	
2	A2	Counter Board	C536000757	C536000757	"	1	"	As	Shown	on Sheet	3 of 11	
3	A5	Control Logic	C536000758	C536000758	"	1	"	As	Shown	on Sheet	4 of 11	
4	A6	Timer Board	C536000759	C536000759	"	1	"	As	Shown	on Sheet	5 of 11	
5	A7	Oscillator Board	C536000760	C536000760	"	1	"	As	Shown	on Sheet	6 of 11	
6	A8	Discrete Board	C536000761	C536000761	"	1	"	As	Shown	on Sheet	7 of 11	
7	A9	Power Supply	C200110760	C200110760	"	1	"	As	Shown	on Sheet	9 of 11	
8	DS1-DS4	LED Indicator	C406000025	C406000025	Hewlett-Packard	4	"	95	85	800 mw	300 mw.	.375
9	FL1	Filter, RFI	C517009224	C517009224	Gulton	1	"	125	"	100V	5V	.02
10	J1	Connector, 18 pin	C520013000	C520013000	Deutsch	1	"	200	"	1500 V / 7.5A	100V / .5A	.066 / .066

SIGNATURE	DATE
[illegible]	12/1/70
[illegible]	7/13/71

REV. A

PAGE 1

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EQUIPMENT EVENT TIMER SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020271 PART NO. C708753100

Ref: Counter Boards A1, A3, A4

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 COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1	Capacitor, ceramic	CKF05BX 104KR	MIL-C-39014/2	Aerovox	1	100%	125	85	100V	5V	.05
2	C2	Capacitor, ceramic	CKF05BX 102KR	MIL-C-39014/1	"	1	"	"	"	200V	5V	.025
3	U1	Hex Inverter, TTL SNR5404	SN13572	C528000461	T.I	1	"	"	"	8V	5V	.625
4	U2, U5	Low Power, Dual J-KFF, SNR54L73	SN13570	C528000458	"	2	"	"	"	8V	5V	.625
5	U3	Low Power, Dual 4-in, TTL SNR54L20	SN13569	C528000457	"	1	"	"	"	8V	5V	.625
6	U4, U6, U8	Low Power, Quad 2-in, TTL SNR54L00	SN13567	C528000455	"	3	"	"	"	8V	5V	.625
7	A1 OR A3 OR A4	Circuit Board	C535005219	C535005219	Precision Circuits	1	"	140	"	—	—	—

SIGNATURE [signature] DATE 7/15/71

REV. A

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EQUIPMENT EVENT TIMER — SKYLAB — RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020271 — PART NO. C708753100

Ref: Counter Board A2

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
1	C1	Capacitor, ceramic	CKR06BX 104KR	MIL-C-39014/2	Aerovox	1	100%	125	85	100V	5V	.05
2	C2	Capacitor, ceramic	CKR05BX 102KR	MIL-C-39014/1	"	1	"	"	"	200V	5V	.025
3	U1	Hex Inverter, TTL SNR5404	SN13682	C528000461	T.I.	1	"	"	"	8V	5V	.625
4	U3	Low Power, Triple 3-in, TTL SNR54L10	SN13568	C528000456	"	1	"	"	"	8V	5V	.625
5	U4, U6, U8	Low Power, Quad 2-in, TTL SNR54L00	SN13567	C528000455	"	3	"	"	"	8V	5V	.625
6	U5, U7	Low Power, Dual J-K FF SNR54L73	SN13570	C528000458	"	2	"	"	"	8V	5V	.625
7	A2	Circuit Board	C535005220	C535005220	Precision Circuits	1	"	140	"	—	—	—

SIGNATURE [signature] VAC — DATE 7/13/71

REV. A

PAGE 3

REMARKS:

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EQUIPMENT Event Timer SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020271 PART NO. C708753100

Ref: Control Logic Board A5

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 COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1	Capacitor, ceramic	CKR06BX104KR	MIL-C-39014/2	Aerovox	1	100%	125	85	100V	5V	.05
2	C2	Capacitor, ceramic	CKR05BX102KR	MIL-C-39014/1	"	1	"	"	"	200V	5V	.025
3	U1, U6, U7	Low Power Quad 2-in, TTL SNR54L00	SN13567	C528000455	T.I.	3	"	"	"	8V	5V	.625
4	U3, U8	Low Power, Dual J-K FF SNR54L73	SN13570	C528000458	"	2	"	"	"	8V	5V	.625
5	U4	Hex Inverter, TTL SNR5404	SN13579	C528000462	"	1	"	"	"	8V	5V	.625
6	U5	Low Power, Triple 3-in, TTL SNR54L10	SN13568	C528000456	"	1	"	"	"	8V	5V	.625
7	A5	Circuit Board	C535005221	C535005221	Precision Circuits	1	"	140	"	—	—	—

SIGNATURE [signature] DATE
VHC 7/15/71

REV. A

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LITTLE FALLS, NEW JERSEY

EQUIPMENT EVENT TIMER

REFERENCE SCHEMATIC C5430202??

Ref: Timer Board A6

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
1	C1	Capacitor, ceramic	CKR06BX 104KR	MIL-C-39014/2	Aerovox	1	100%	125	85	100V	5V	.05
2	U1-U8	Low Power Dual J-K F.F. SNR54L73	SN13570	C528000458	T.I.	8	"	"	"	8V	5V	.625
3	A6	Circuit Board	C535005222	C535005222	Precision Circuits	1	"	140	"	—	—	—

SIGNATURE [signature] DATE
VJC 7/15/71

REV. A

PAGE 5

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Event Timer SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020271 PART NO. C708753100

Ref: Oscillator 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. (oC)		STRESS		STRESS RATIO COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1	Capacitor, ceramic	CKR05BX 104KR	MIL-C-39014/2	Aerovox	1	100%	125	85	100V	5V	.05
2	U1, U2	Low Power, Dual J-K FF SNR54L73	SN13570	C528000458	T.I.	2	"	"	"	8V	5V	.625
3	Y1	Oscillator	MC266X1-001H	C567000024	McCoy	1	"	"	"	—	—	—
4	A7	Circuit Board	C535005223	C535005223	Precision Circuits	1	"	140	"	—	—	—

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

EQUIPMENT EVENT TIMER

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020271

PART NO. C708753100

Ref: Discrete Board A8

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
1	C1-C8	Capacitor, ceramic	CKR06BX 104KR	MIL-C-39014/2	Aerovox	8	100%	125	85	100V	28V	.28
2	CR1	SCR	W976A	C531000385	TI	1	"	"	"	275MA	168MA	.611
3	Q1-Q7	Transistor, silicon NPN	JANTX 2N2222A	MIL-S-19500/	"	7	"	200	"	500MW	3MW	<.01
4	R1, R5, R9, R13, R17	Resistor, Film	RNR50H 1782FR	MIL-R-55182/7	MEPCO	5	"	125	"	50MW	2MW	.04
5	R22, R26	Resistor, Film	RNR50H 1782FR	MIL-R-55182/7	"	2	"	"	"	50MW	2MW	.04
6	R2, 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

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Event Timer

REFERENCE SCHEMATIC C5433202271

Ref: Discrete Board A8

SKYLAB RELIABILITY DATA LIST

PART NO. C7087153100

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 COL. 10 COL. 11
								RATED	AMB	RATED	OPERATING	
13	A8	Circuit Board	C535005224	C535005224	Precision Circuits	1	100%	140	85	—	—	—

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LITTLE FALLS, NEW JERSEY

EQUIPMENT *EVENT TIMER* SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC *C543020271* 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)		STRESS		STRESS RATIO COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1	Capacitor, tantalum	C655006100	C665003100	Union Carbide	1	100%	125	85	75V	28V	.373
2	C2,C4	Capacitor, ceramic	CKR06BX 103KR	MIL-C-39014/2	Aerovox	2	"	"	"	200V	5V	.025
3	C3	Capacitor, tantalum	CSR13E 225KR	MIL-C-39003/1	Union Carbide	1	"	"	"	20V	5V	.25
4	C5	Capacitor, ceramic	CKR06BX 104KR	MIL-C-39014/2	Aerovox	1	"	"	"	100V	10V	.10
5	C6	Capacitor, tantalum	CSR13F 476KR	MIL-C-39003/1	Union Carbide	1	"	"	"	35V	10V	.286
6	C7	Capacitor, tantalum	CSR13C 227KR	MIL-C-39003/1	"	1	"	"	"	10V	5V	.50
7	CR1	Diode, silicon	JANTX 1N4942	MIL-S-19500/359	Unitrode	1	"	175	"	200V/.8A	32.5V/Neg.	<.01
8	CR2-CR4	Diode, silicon	JANTX 1N4942	MIL-S-19500/359	"	3	"	"	"	200V/.8A	31V/0.11A	.138
9	CR5,CR6	Diode, silicon	JANTX 1N4942	MIL-S-19500/359	"	2	"	"	"	200V/.8A	11V/.17A	.212
10	FL2-FL5	Filter, RFI	D-347	C517009994	Gulton	4	"	125	"	100V	FL2 = 32V FL3, FL5 = NEG. FL4 = 5.5V	.32 <.01 .035
11	L1	Choke	C702870211	C702870211	Electro Winding	1	"	130	"	.336A	.15A	.44
12	L2	Choke	C702870210	C702870210	"	1	"	"	"	.551A	.15A	.27

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EQUIPMENT EVENT TIMER SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020271 PART NO. C708753100

Ref: Power Supply Board A9

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
13	L3	Choke	C702866234	C702866234	Electro Winding	1	100%	130	85	2.30A	.44A	.19
14	Q1	Transistor, silicon, NPN	2N3499	1532002546	Motorola	1	"	175	"	.65W	.26W	.40
15	Q2	Transistor, silicon, PNP	JANTX 2N2905A	MIL-S-19500/290	National	1	"	"	"	.394W	20MW	.051
16	Q3	Transistor, silicon, NPN	JANTX 2N2920	MIL-S-19500/355	"	1	"	"	"	.32W	59MW	.184
17	Q4, Q5	Transistor, silicon, NPN	1532002546	1532002546	Motorola	2	"	"	"	.65W	80MW	.123
18	R1, R13	Resistor, film	RNR55C 8252FR	MIL-R-55182/1	Mepco	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	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	"	2	"	"	"	100MW	R8 = <1MW R11 = 48MW	<.01 .48

* Selected part: Select from RNR55C1212FR thru RNR55C1742FR

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EQUIPMENT Event Timer

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C5430202Z71

PART NO. C708753100

Ref: Power Supply Board A9

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
25	R9	Resistor, film	RNR55C 4321FR	MIL-R-55182/1	MEPCO	1	100%	125	85	100 mW	0.6 mW	<.01
26	R14	Resistor, film	RNR57C 2003FR	MIL-R-55182/2	"	1	"	"	"	125 mW	3 mW	.024
27	R15	Resistor, film	RNR50H 49R9FR	MIL-R-55182/7	"	1	"	"	"	50 mW	6.6 mW	.132
28	T1	Transformer	C702866121	C702866121	Electro Winding	1	"	130	"	.55A	.44A	.79
29	VR1	Diode, zener	1N4780A-TX	C531000768	General Semiconductor	1	"	175	"	400mW	9 mW	.023
30	VR2, VR3	Diode, zener	JANTX 1N981B	MIL-S-19500/117	Dickson	2	"	"	"	400mW	NEG.	<.01
31	A9A1	Circuit Board	C535005225	C535005225	Precision Circuits	1	"	140	"	—	—	—
32	A9A2	"	C535005226	C535005226	"	1	"	140	"	—	—	—

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

EQUIPMENT Secondary Display — SKYLAB — RELIABILITY DATA LIST

REFERENCE SCHEMATIC C5430202?6 — PART NO. C708753090

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. (oC)		STRESS		STRESS RATIO COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
1	A1	Counter Board	C536000764	C536000764	SINGER KEARFOTT	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	Discrete 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	Deutsch	1	"	200	"	1500V/7.5A	100V/.5A	.066/.066

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

EQUIPMENT Secondary Display SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020276 PART NO. C708753090

Ref: Counter Board A1

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	AMB	STRESS RATED	STRESS OPERATING	STRESS RATIO COL. 10 / COL. 11
1	C1,C2	Capacitor, Ceramic	C605006092	C605006092	Republic (MUCON)	2	100%	125	75	50V	5V	.10
2	R1	Resistor Film	RNR50H 1001FR	MIL-R-55182/7	MEPCO	1	"	"	"	50 mW	1 mW	.02
3	U1,U4	Hex Inverter, TTL SNR5404	SN13682	C528000461	T.I.	2	"	"	"	8V	5V	.625
4	U2	Low Power, Dual 4-in, TTL SNR54L20	SN13569	C528000457	"	1	"	"	"	8V	5V	.625
5	U3	Med Power, Quad 2-in SNR5400	SN13580	C528000463	"	1	"	"	"	8V	5V	.625
6	U5,U8	Decade Counter, TTL SNH5490506	SN21146 / SN22226A	C574000073	"	2	"	"	"	8V	5V	.625
7	U6,U7	Low Power, Quad 2-in TTL SNR54L00	SN13567	C528000455	"	2	"	"	"	8V	5V	.625
8	A1	Circuit Board	C535005228	C535005228	Precision Circuits	1	"	140	"	—	—	—

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

EQUIPMENT Secondary Display

REFERENCE SCHEMATIC [illegible]

Pc Counter Board A2

SKYLAB RELIABILITY DATA LIST

PART NO. C708753090

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
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	MEPCO	1	"	"	"	50mW	1mW	.02
3	U1, U3	Hex Inverter, TTL SNR5404	SN13682	C528000461	T.I.	2	"	"	"	8V	5V	.625
4	U2, U4	Low Power, Dual 4-in SNR54L20	SN13569	C528000457	"	2	"	"	"	8V	5V	.625
5	U5, U8	Decade Counter, TTL SNH5490506	~~SN21146~~ SN22226A	C574000073	"	2	"	"	"	8V	5V	.625
6	U6	Low Power Quad 2-in, TTL SNR54L00	SN13567	C528000455	"	1	"	"	"	8V	5V	.625
7	A2	Circuit Board	C535005229	C535005229	Precision Circuits	1	"	140	"	—	—	—

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LITTLE FALLS, NEW JERSEY

EQUIPMENT [illegible]

REFERENCE SCHEMATIC C5430220776

SKYLAB RELIABILITY DATA LIST

PART NO. C708753090

Ref: Control Logic Board A3

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 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, [illegible]	PMR50H 1001FR	MIL-R-55182/[illegible]	MEPCO	1	"	"	"	50 mW	1 mW	.02
3	U1, U4, U9	Low Power, Triple 3-in TTL SNR54L10	SN13568	C528000456	T.I.	3	"	"	"	8V	5V	.625
4	U2, U3	Low Power, Hex Inverter, TTL SNR54L04	SN13579	C528000462	"	2	"	"	"	8V	5V	.625
5	U5, U8	Low Power, 8-in. TTL SNH54L30506	SN21150	C574000065	"	2	"	"	"	8V	5V	.625
6	U6	Low Power Quad 2-in, TTL SNR54L00	SN13567	C528000455	"	1	"	"	"	8V	5V	.625
7	U7	Low Power Dual 4-in TTL SNR54L20	SN13569	C528000457	"	1	"	"	"	8V	5V	.625
8	A3	Circuit Board	C535005230	C535005230	Precision Circuits	1	"	140	"	—	—	—

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Stationary Display SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C5430202276 PART NO. C7087530?0

Ref: Oscillator Board A4

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO 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,C3	Capacitor, ceramic	CKR06BX 152KR	MIL-C-39014/2	Aerovox	2	"	"	"	200V	5V	.025
3	C4	Capacitor, ceramic	CKR06BX 103KR	MIL-C-39014/2	Aerovox	1	"	"	"	100V	5V	.05
4	C5,C6	Capacitor, ceramic	C605006092	C605006092	Republic (MUCON)	2	"	"	"	50V	5V	.10
5	CR1	Diode, silicon	JANTX 1N914	MIL-S-19500/116	T.I	1	"	175	"	160 mw	5 mw	.031
6	Q1,Q5	Transistor, unijunction	S2N2419B	C5380?0579	G.E.	2	"	200	"	300 mw	25 mw	.083
7	Q2	Transistor, silicon NPN	JANTX 2N2222A	MIL-S-19500/255	T.I	1	"	"	"	300 mw	25mw	.083
8	Q3,Q4	Transistor silicon NPN	JANTX 2N718A	MIL-S-19500/181	T.I.	2	"	"	"	328 mw	25mw	.076
9	R1,R9	Resistor, film	RNR50H 3920FR	MIL-R-55182/7	MEPCO	2	"	125	"	50mw	5mw	.10
10	R2	Resistor, film	RNR60H 4753FR	MIL-R-55182/3	"	1	"	"	"	125mw	5mw	.04
11	R3	Resistor, film	RNR50H 2211FR	MIL-R-55182/7	"	1	"	"	"	50 mw	5mw	.10
12	R4,R6	Resistor, film	RNR50H 5621FR	MIL-R-55182/7	"	2	"	"	"	50 mw	5mw	.10

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Secondary Display SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C5430202 76 PART NO. C708753090

Ref. Oscillator Board A4

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. (oC) RATED	9 APPLICATION TEMP. (oC) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
13	R5, R11	Resistor, Film	PNR50H 1001FR	MIL-R-55182/7	MEPCO	2	100%	125	85	50mw	5mw	.10
14	R7	Resistor, Film	PNR50H 1502FR	MIL-R-55182/7	"	1	"	"	"	50mw	5mw	.10
15	R8	Resistor, Film	PNR50H 1822FR	MIL-R-55182/7	"	1	"	"	"	50mw	5mw	.10
16	R10	Resistor, Film	PNR50H 1002FR	MIL-R-55182/7	"	1	"	"	"	50mw	5mw	.10
17	U1	Low Power, Hex Inverter, TTL SNR54L04	SN13579	C528000462	T.I.	1	"	"	"	8V	5V	.625
18	U2, U4	Low Power, Dual J-K FF SNR54L73	SN13570	C528000458	"	2	"	"	"	8V	5V	.625
19	U3	Low Power, Triple 3-in, TTL SNR54L10	SN13568	C528000456	"	1	"	"	"	8V	5V	.625
20	U5	Low Power, Quad 2-in, TTL SNR54L00	SN13567	C528000455	"	1	"	"	"	8V	5V	.625
21	A4	Circuit Board	C535005231	C535005231	Precision Circuits	1	"	140	"	—	—	—

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

EQUIPMENT Secondary Display SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020276 PART NO. C7087153090

Ref: Discrete Board A5

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
1	C1	Capacitor, ceramic	C605006092	C605006092	Republic (MUCON)	1	100%	125	85	50V	5V	.10
2	C2,C3	Capacitor, ceramic	CKR05BX 104KR	MIL-C-39014/2	Aerovox	2	"	"	"	100V	5V	.05
3	CR1-CR4	Diode, silicon	JANTX 1N914	MIL-S-19500/116	T.I.	4	"	175	"	160mW	1mW	<.01
4	Q1,Q3	Transistor, silicon NPN	JANTX 2N2432	MIL-S-19500/313	Crystalonics	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	MEPCO	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 RNR50H49R9FR thru RNR50H9530FR

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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 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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
13	R12	Resistor, Film	RNR50H 1502FR	MIL-R-55182/7	AIEPCO	1	100%	125	85	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 7502FR	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	RNR50N 1001FR	MIL-R-55182/7	"	2	"	"	"	50 mw	1mw	.02
20	R24	Resistor, Film	RNR50H4991FR	MIL-R-55182/7	"	1	"	"	"	50mw	1mw	.02
21	U1, U4	Voltage Follower, LM102	SL11573	C574000078	National Semiconductor	2	"	"	"	8V	5V	.625
22	U2, U3	Operational Amplifier LM107	SL11572	C574000077	"	2	"	"	"	8V	5V	.625
23	U5	Voltage Comparator /Buffer LM106	SL11574	C574000079	"	1	"	"	"	8V	5V	.625
24	U6	Low Power, Quad 2-in, TTL SNR54L00	SN13567	C528000455	"	1	"	"	"	8V	5V	.625
25	A5	Circuit Board	C535005232	C535005232	Precision Circuits	1	"	140	"	—	—	—

*Selected Resistor: Select from: RNR55H4989FR thru RNR55H9530FR

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Secondary Display

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C5453[illegible]0276

PART NO. C7087153090

Ref. Integrator Board A6

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 COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1-C8	Capacitor, ceramic	CKR06BX 104KR	MIL-C-39014/2	Aerovox	8	100%	125	85	100V	5V	.05
2	C9, C10	Capacitor, ceramic	C605006092	C605006092	Republic (Mucon)	2	"	"	"	50V	5V	.10
3	Q1-Q8	Transistor, silicon NPN	JANTX 2N2222A	MIL-S-19500/255	T.I.	8	"	200	"	300mw	5mw	<.01
4	R1-R8	Resistor, film	RNR50H 1782FR	MIL-R-55182/7	MEPCO	8	"	125	"	50mw	5mw	.10
5	R9-R16	Resistor, film	RNR50H 5622FR	MIL-R-55182/7	"	8	"	"	"	50mw	5mw	.10
6	R17-R24	Resistor film	RNR50H 6812FR	MIL-R-55182/7	"	8	"	"	"	50mw	5mw	.10
7	R25-R32	Resistor, film	RNR50H 4991FR	MIL-R-55182/7	"	8	"	"	"	50mw	5mw	.10
8	A6	Circuit Board	C535000233	C535000233	Precision Circuits	1	"	140	"	—	—	—

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Secondary Display SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C5150020776 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)		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-39014/2	Aerovox	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	CKR05BX 332KR	MIL-C-39014/2	Aerovox	2	"	"	"	200V	16V	.08
8	C11,C12	Capacitor, ceramic	CKR05BX, 680KR	MIL-C-39014/1	"	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	"	1	"	"	"	15V	9V	.60
11	CR1-CR10	Diode; silicon	JANTX 1N4942	MIL-S-19500/359	Unitrode	10	"	175	"	.75A	.015A	.02
12	FL1-FL8	Filter, RFI	D-347	C517009294	Gulton	8	"	125	"	100V	FL1 = 32V FL2, FL4, FL6 = NEG FL3, FL8 = 5V FL5 = 16V / FL7 = 12V	.32 <.01 .05 .16 / .12

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EQUIPMENT Secondary Display SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C5430020276 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)		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	"	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	National	1	"	"	"	1.99W	.22W	.111
18	Q3	Transistor silicon NPN	JANTX 2N2920	MIL-S-19500/355	National	1	"	"	"	.49W	60mW	.124
19	Q6	Transistor, silicon NPN	JANTX 2N2222A	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	1.0mW	.10
24	R4	Resistor, film	RNR55C 9091FR	MIL-R-55182/1	"	1	"	"	"	100mW	2mW	[illegible]

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Secondary Display SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C5430202?6 PART NO. C7087530?0

Ref: Power Supply Board A7

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
25	R5	Resistor, film	RNR55C *	MIL-R-55182/1	MEPCO	1	100%	125	85	100 mw	1 mw	.01
26	R6, R10, R12, R18, R24	Resistor, film	RNR55C 1002FR	MIL-R-55182/1	"	5	"	"	"	100 mw	R6 = 3 mw R10 = 17 mw R12 = 13 mw R18, R24 = 1 mw	.03 .17 .13 .01
27	R8, R11	Resistor, film	RNR55C 2000FR	MIL-R-55182/1	"	2	"	"	"	100 mw	R8 = 1 mw R11 = 45 mw	.01 .45
28	R9	Resistor, film	RNR55C 4321FR	MIL-R-55182/1	"	1	"	"	"	100 mw	1 mw	.01
29	R14	Resistor, film	RNR57C 2003FR	MIL-R-55182/2	"	1	"	"	"	125 mw	9 mw	.072
30	R15	Resistor, film	RNR50H 49R9FR	MIL-R-55182/7	"	1	"	"	"	50 mw	20 mw	.40
31	R16, R25	Resistor, film	RNR55C 1001FR	MIL-R-55182/1	"	2	"	"	"	100 mw	1 mw	.01
32	R17	Resistor, film	RNR55C 6191FR	MIL-R-55182/1	"	1	"	"	"	100 mw	5 mw	.05
33	R19, R28	Resistor, film	RNR55C 2261FR	MIL-R-55182/1	"	2	"	"	"	100 mw	10 mw	.10
34	R20, R26	Resistor, carbon	RCR07G 160JR	MIL-R-39008/1	Allen-Bradley	2	"	100	"	125 mw	30 mw	.24
35	R21, R27	Resistor, film	RNR55C 3741FR	MIL-R-55182/1	MEPCO	2	"	125	"	100 mw	14 mw	.14
36	R22, R29	Resistor, film	RNR55C **	MIL-R-55182/1	"	2	"	125	"	100 mw	4 mw	.04

* Selected Resistor: Select from RNR55C1212FR thru RNR55C1742FR

** Selected Resistor: Select from RNR55C1872FR thru RNR55C1003FR

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

EQUIPMENT Secondary Display

REFERENCE SCHEMATIC C543020276

SKYLAB RELIABILITY DATA LIST

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)		STRESS		STRESS RATIO COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
37	R23, R30	Resistor, wirewound	RWR81S 7620FR	MIL-R-39007/9	Dale	2	100%	125	85	600 mW	44 mW	.07
38	R31	Resistor, film	RNR55C 3011FR	MIL-R-55182/1	MEPCO	1	"	"	"	100 mW	.12 mW	<.01
39	R32, R33	Resistor, carbon	RCR07G 160JR	MIL-R-39008/1	Allen-Bradley	2	"	100	"	125 mW	16 mW	.13
40	R34	Resistor, film	RNR55C 2001FR	MIL-R-55182/1	MEPCO	1	"	125	"	100 mW	8 mW	.08
41	T1	Transformer	C702866121	C702866121	Electro Winding	1	"	130	"	.55A	.44A	.79
42	U1, U2	Voltage Regulator µA723	SL7723000	C574000081	Fairchild	2	"	125	"	8V	5V	.625
43	VR1	Diode, zener	1N4780-TX	C531000768	General Semiconductor	1	"	175	"	180 mW	9 mW	.05
44	VR2, VR3	Diode, zener	JANTX 1N981B	MIL-S-19500/117	Dickson	2	"	"	"	320 mW	10 mW	.031
45	VR4, VR5	Diode, zener	JANTX 1N829	MIL-S-19500/159	Motorola	2	"	"	"	400 mW	46.5 mW	.116
46	A7A1	Circuit Board	C535005234	C535005234	[illegible] Circuits	1	"	140	"	—	—	—
47	A7A2	"	C535005235	C535005235	"	1	"	140	"	—	—	—
48	A7A3	"	C535005236	C535005236	"	1	"	140	"	—	—	—
49	A7A4	"	C535005237	C535005237	"	1	"	140	"	—	—	—

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

EQUIPMENT *Four Digit Indicator* SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC *C543020341* PART NO. *C708753110*

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
1	A1	COUNTER BOARD ASSY	C536000815	C536000815	SINGER KEARFOTT	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	FL1	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

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Four Digit Display

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020341

PART NO. C708753110

REF: Counter Board A1

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 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	Mepco	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-in, TTL SNR54L20	SN13569	C528000457	"	1	"	"	"	8V	5V	.625
5	U3	Med. Power, Quad 2-in SNR5400	SN13580	C528000463	"	1	"	"	"	8V	5V	.625
6	U5, U8	Decade Counter, TTL SNH5490506	SN21146	C574000073	"	2	"	"	"	8V	5V	.625
7	U6, U7	Low Power, Quad 2-in TTL SNR54L00	SN13567	C528000455	"	2	"	"	"	8V	5V	.625
8	A1	Circuit Board	C535005228	C535005228	Precision Circuits	1	"	140	"	—	—	—

SIGNATURE	DATE
V. Ciliberto	7/6/71

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Four Digit Display

REFERENCE SCHEMATIC C543020341

REF: Counter Board A2

SKYLAB RELIABILITY DATA LIST

PART NO. C708753110

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 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	MEPCO	1	"	"	"	50 mw	1 mw	.02
3	U1, U3	HEX INVERTER, TTL SNR5404	SN13682	C528000461	T.I.	2	"	"	"	8V	5V	.625
4	U2, U4	LOW POWER, DUAL 4-in SNR54L20	SN13569	C528000457	"	2	"	"	"	8V	5V	.625
5	U5, U8	DECADE COUNTER, TTL SNH5490506	SN2114L	C574000073	"	2	"	"	"	8V	5V	.625
6	A2	CIRCUIT BOARD	C535005229	C535005229	PRECISION CIRCUITS	1	"	140	"	—	—	—

SIGNATURE: V. Ciliberto DATE: 7/6/71

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EQUIPMENT Four Digit Display

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543 020 341

PART NO. C708753110

REF: Oscillator Board Assy-A3

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 COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
1	U1	Low Power, Hex Inverter TTL SNR54L04	SN13579	C528000462	T.I	1	100%	125	85	8V	5V	.625
2	U2	Low Power, Dual J-K, FF SNR54L73	SN13570	C528000458	"	1	"	"	"	8V	5V	.625
3	U3	Low Power, Quad 2-in TTL SNR54L00	SN13567	C528000455	"	1	"	"	"	8V	5V	.625
4	C1	Capacitor, Ceramic	CKR06 BX104KR	MIL-C-39014/2	Aerovox	1	"	"	"	100V	15V	.15
5	C2,C3	Capacitor, Ceramic	C605006092	C605006092	Republic (Hucon)	2	"	"	"	50V	6V	.12
6	C5	Capacitor, Ceramic	CKR05 BX471KR	MIL-C-39014/1	Aerovox	1	"	"	"	200V	6V	.03
7	C6	Capacitor, Ceramic	CKR06 BX104KR	MIL-C-39014/2	Aerovox	1	"	"	"	100V	6V	.06
8	C4,C7	Capacitor, Ceramic	CKR05 BX221KR	MIL-C-39014/1	Aerovox	2	"	"	"	200V	6V	.03
9	Q1, Q2, Q3	Transistor, Silicon, NPN	JAN-TX 2222A	MIL-S-19500/255	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 [signature] DATE 7/6/71

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LITTLE FALLS, NEW JERSEY

EQUIPMENT Four Digit Indicator

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020341

PART NO. C708753110

REF: Oscillator Board Assy-A3

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 COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
12	R3	Resistor, Film	RNR50H 4991FR	Mil-R-55182/7	Mepco	1	100%	125	85	50 mw	<5 mw	<.10
13	R4	Resistor, Film	RNR50H 1782FR	Mil-R-55182/7	Mepco	1	"	"	"	"	"	"
14	R5	Resistor, Film	RNR50H 4752FR	Mil-R-55182/7	Mepco	1	"	"	"	"	"	"
15	R6	Resistor, Film	RNR50H 1502FR	Mil-R-55182/7	Mepco	1	"	"	"	"	"	"
16	R7	Resistor, Film	RNR50H 2741FR	Mil-R-55182/7	Mepco	1	"	"	"	"	"	"
17	R8	Resistor, Film	RNR50H 4750FR	Mil-R-55182/7	Mepco	1	"	"	"	"	"	"
18	R9	Resistor, Film	RNR50H 5620FR	Mil-R-55182/7	Mepco	1	"	"	"	"	"	"
19	R10	Resistor, Film	RNR50H 3320FR	Mil-R-55182/7	Mepco	1	"	"	"	"	"	"
20	R11	Resistor, Film	RNR50H 51R1FR	Mil-R-55182/7	Mepco	1	"	"	"	"	"	"
21	L1	Choke	C506009057	C506009057	Vanguard Electric	1	"	130	"	99 ma	5 ma	.051
22	A3	Circuit Board	C535005265	C535005265	Precision Circuits	1	"	140	"	-	-	-

SIGNATURE: V. Ciliberto DATE: 7/6/71

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EQUIPMENT FOUR DIGIT DISPLAY — SKYLAB — RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543 020 341 — PART NO. C708753110

REF: CONTROL BOARD ASSY-A4

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	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	C605006092	C605006092	REPUBLIC (MUCON)	2	"	"	"	50V	5V	.10
5	CR1	DIODE, SILICON	JAN-TX 1N914	MIL-S-19500/116	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

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EQUIPMENT Four Digit Indicator — SKYLAB — RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020341 — PART NO. C708753110

REF: Control Board Assy - A4

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
13	R5, R11	Resistor, Film	RNR 50H 1001FR	MIL-R-55182/7	MEPCO	2	100%	125	85	50mw	5mw	.10
14	R10	Resistor, Film	RNR50H 1002FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	5mw	.10
15	U1	Low Power, Hex Inverter, TTL SNR54L04	SN13579	C528000462	T.I.	1	"	"	"	8V	5V	.625
16	U2, U4	Low Power, Dual J-K FF SNR54L73	SN13570	C528000458	T.I.	2	"	"	"	8V	5V	.625
17	U3	Low Power, Triple 3-IN, TTL SNR54L10	SN13568	C528000456	T.I.	1	"	"	"	8V	5V.	.625
18	U5	Low Power, Quad 2-IN, TTL SNR54L00	SN13567	C528000455	T.I	1	"	"	"	8V	5V	.625
19	A4	Circuit Board	C535005231	C535005231	Precision Circuits	1	"	140	"	—	—	—

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EQUIPMENT FOUR DIGIT DISPLAY — SKYLAB — RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543 020 341 — PART NO. C708753110

REF: INTEGRATOR BOARD ASSY-A5

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. (OC)		STRESS		STRESS RATIO COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
1	C1	CAPACITOR, CERAMIC	C605006092	C605006092	REPUBLIC (MUCON)	1	100%	125	85	50V	5V	.10
2	C2,C3	CAPACITOR, CERAMIC	CKR06BX 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

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EQUIPMENT Four Digit Display

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020341

PART NO. C708753110

REF: Integrator Board Assy -A5

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
13	R10	Resistor, Film	RNR 50 H *	MIL-R-55182/7	MEPCO	1	100%	125	85	50mw	1mw	.02
14	R11	Resistor, Film	RNR50H **	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw	.02
15	R12	Resistor, Film	RNR50H 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 50 H 2742FR	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw	.02
18	R18	Resistor, Film	RNR50H **	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw	.02
19	R19	Resistor, Film	RNR50H 7501H	MIL-R-55182/7	MEPCO	1	"	"	"	50mw	1mw	.02
20	R20	Resistor, Film	RNR60H 4993FR	MIL-R-55182/3	MEPCO	1	"	"	"	50mw	1mw	.02
21	R22,R23	Resistor, Film	RNR50H 1001FR	MIL-R 55182/7	MEPCO	1	"	"	"	50mw	1mw	.02
22	R24	Resistor, Film	RNR50H 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 RNR50H2802FR thru RNR50H3242FR

** Selected Resistor: Select from RNR50H49R9FR thru RNR50H1001FR

SIGNATURE: [signature] DATE: 7/6/71

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EQUIPMENT FOUR DIGIT DISPLAY

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543 020 341

PART NO. C708753110

REF: INTEGRATOR BOARD ASSY -5

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
25	U5	VOLTAGE COMPENSATOR/BUFFER LM106	SL11574	C574000079	NAT. SEMI.	1	100%	125	85	8V	5V	.625
26	U6	LOW POWER, QUAD 2-IN, TTL SNR54L00	SN13567	C528000455	T.I	1	"	"	"	8V	5V	.625
27	A5	CIRCUIT BOARD	C535005232	C535005232	PRECISION CIRCUITS	1	"	"	"	—	—	—

SIGNATURE V. Citiberto DATE 7/6/71

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

EQUIPMENT Four Digit Display

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C5430020341 PART NO. C708753110

REF: Power Supply Board Assy-A7

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) RATED	APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
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 1N4942	MIL-S-19500/359	Unitrode	10	"	175	"	.75A	.015A	.02
12	FL1-FL8	Filter, RFI	D-347	C517009294	Gulton	8	"	125	"	100V	FL1=32V FL2, FL4, FL6=NEG. FL3, FL8=5V FL5=16V/FL7=12V	.32 <.01 .05 .16/.12

SIGNATURE	DATE
V. Calabrese	7/6/71
VLC	8/5/71

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LITTLE FALLS, NEW JERSEY

EQUIPMENT *Four Digit Display* SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC *C543020341* PART NO. *C708753110*

REF: Power Supply Board Assy - 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)		STRESS		STRESS RATIO
								RATED	AMB	RATED	OPERATING	COL. 10 / COL. 11
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	TRANSITOR, 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 mw	10mw	.10
22	R2,R7	RESISTOR, FILM	RNR55C 2151FR	MIL-R-55182/1	MEPCO	2	"	"	"	100 mw	9mw	.09
23	R3	RESISTOR, FILM	RNR55C 1000FR	MIL-R-55182/1	MEPCO	1	"	"	"	100 mw	10mw	.10
24	R4	RESISTOR, FILM	RNR55C 9091FR	MIL-R 55182/1	MEPCO	1	"	"	"	100 mw	2mw	.02

SIGNATURE *V. Celebuto* DATE *7/6/71*

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EQUIPMENT FOUR DIGIT DISPLAY

SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020341

PART NO. C708753110

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)		STRESS		STRESS RATIO COL. 10 / COL. 11
								RATED	AMB	RATED	OPERATING	
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	"	"	"	100 mw	3mw	.03
27	R10	RESISTOR, FILM	RNR55C 1002FR	MIL-R 55182/1	MEPCO	1	"	"	"	100 mw	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	"	"	"	100 mw	1mw	.01
30	R8, R11	RESISTOR, FILM	RNR55C 2000FR	MIL-R 55182/1	MEPCO	1	"	"	"	100 mw	R8 = 1mw R11 = 45mw	.01 .45
31	R9	RESISTOR, FILM	RNR55C 4321FR	MIL-R 55182/1	MEPCO	1	"	"	"	100 mw	1mw	.01
32	R14	RESISTOR, FILM	RNR57C 2003FR	MIL-R 55182/2	MEPCO	1	"	"	"	125mw	9mw	.072
33	R15	RESISTOR, FILM	RNR50H 49R9FR	MIL-R 55182/7	MEPCO	1	"	"	"	50mw	20mw	.40
34	R16, R25	RESISTOR, FILM	RNR55C 1001FR	MIL-R 55182/1	MEPCO	2	"	"	"	100 mw	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

SIGNATURE: J. Cilibertо DATE: 7/6/71

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EQUIPMENT Four Digit Display SKYLAB RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020341 PART NO. C708753110

REF: Power Supply Board A7

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
37	R20, R26	Resistor, Carbon	RCR07G 160JR	MIL-R-39008/1	Allen Bradley	2	100%	100	85	125mw	30mw	.24
38	R21, R27	Resistor, Film	RNR55C 3741FR	MIL-R 55182/1	Mepco	2	"	125	"	100mw	14mw	.14
39	R22, R29	Resistor, Film	RNR55C *	MIL-R 55182/1	Mepco	2	"	125	"	100mw	4mw	.04
40	R23, R30	Resistor, Wirewound	RWR81S 7680FR	MIL-R 39007/9	Dale	2	"	125	"	600mw	44mw	.07
41	R31	Resistor, Film	RNR55C 3011FR	MIL-R 55182/1	Mepco	1	"	125	"	100mw	.12mw	<.01
42	R32, R33	Resistor, Carbon	RCR07G 100JR	MIL-R 39008/1	Allen Bradley	2	"	100	"	125mw	16mw	.13
43	R34	Resistor, Film	RNR55C 2001FR	MIL-R 55182/1	Mepco	1	"	125	"	100mw	8mw	.08
44	T1	Transformer	C702866121	C702866121	Electro Winding	1	"	130	"	.55A	.44A	.79
45	U1, U2	Voltage Regulator µa 723	QL7723000	C574000081	Fairchild	2	"	125	"	8V	5V	.625
46	VR1	Diode, Zener	1N4780-TX	C531000768	General Semiconductor	1	"	175	"	180mw	9mw	.05
47	VR2, VR3	Diode, Zener	JAN-TX 1N981B	MIL-S 19500/117	Dickson	2	"	175	"	320mw	10mw	.031
48	VR4, VR5	Diode, Zener	JAN-TX 1N829	MIL-S 19500/159	Motorola	2	"	175	"	400mw	46.5mw	.116

* SELECTED RESISTOR: SELECT FROM RNR55C1872FR THRU RNR55C1003FR

SIGNATURE	DATE
V. Ciliberto	7/6/71
VC	8/5/71

REV. A

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EQUIPMENT Four Digit Display

SKYLAB

RELIABILITY DATA LIST

REFERENCE SCHEMATIC C543020341

PART NO. C708753:10

REF: Power Supply Board A7

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) RATED	9 APPLICATION TEMP. (°C) AMB	10 STRESS RATED	11 STRESS OPERATING	12 STRESS RATIO COL. 10 / COL. 11
49	A7A1	CIRCUIT BOARD	C535005234	C535005234	PRECISION CIRCUITS	1	100%	140	85	—	—	—
50	A7A2	CIRCUIT BOARD	C535005235	C535005235	PRECISION CIRCUITS	1	"	"	"	—	—	—
51	A7A3	CIRCUIT BOARD	C535005236	C535005236	PRECISION CIRCUITS	1	"	"	"	—	—	—
52	A7A4	CIRCUIT BOARD	C535005237	C535005237	PRECISION CIRCUITS	1	"	"	"	—	—	—

SIGNATURE V.C. White DATE 7/6/71

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CODE IDENT NO. 88818

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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

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

PREPARED BY:		APPROVED BY:		
V. Alibato		Leon Vlourgasian	L. Grazziano	J. Kapranski
ENGINEER				

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NO. C200095116
DOCUMENT ISSUE A
CODE IDENT NO. 88818
DOCUMENT GRADE ______

REVISION STATUS CHART

DOCUMENT ISSUE	DESCRIPTION	APPROVAL AND DATE
—	RELEASE	12/1/70
A	REVISED ALL PAGES EXCEPT PAGES 3 AND 4, ADDED PAGES 31 THROUGH 39.	5/21/71 [illegible]

ISSUE	A																	
PAGE	COVER	REV. CHART																ISSUE SYMBOL OTHER PAGES

ISSUE SYMBOL OF REVISED PAGES

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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 willbe assessed to determine their effect on the reliability of the systems and will result in an updated prediction.

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RELIABILITY 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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FUNCTIONAL DESCRIPTION

Event 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 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.

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)

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

where

λ = mean failure rate in failures per million hours, 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:

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

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

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

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

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

or

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

where t = Mission Time

m = MTBF

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

* 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 λ = 14.7478 failures per million hours of operation (Event Timer); λ = 17.2461 failures per million hours of operation (Secondary Display), and λ = 15.6240 failures per million hours of operation (Four Digit Display).

Event Timer

Part.	Qty	F lab/ea	F lab/total
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

Part	Qty	F lab/ea	F lab/total
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

Part	Qty	F lab/ea	F lab/total
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 derived 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

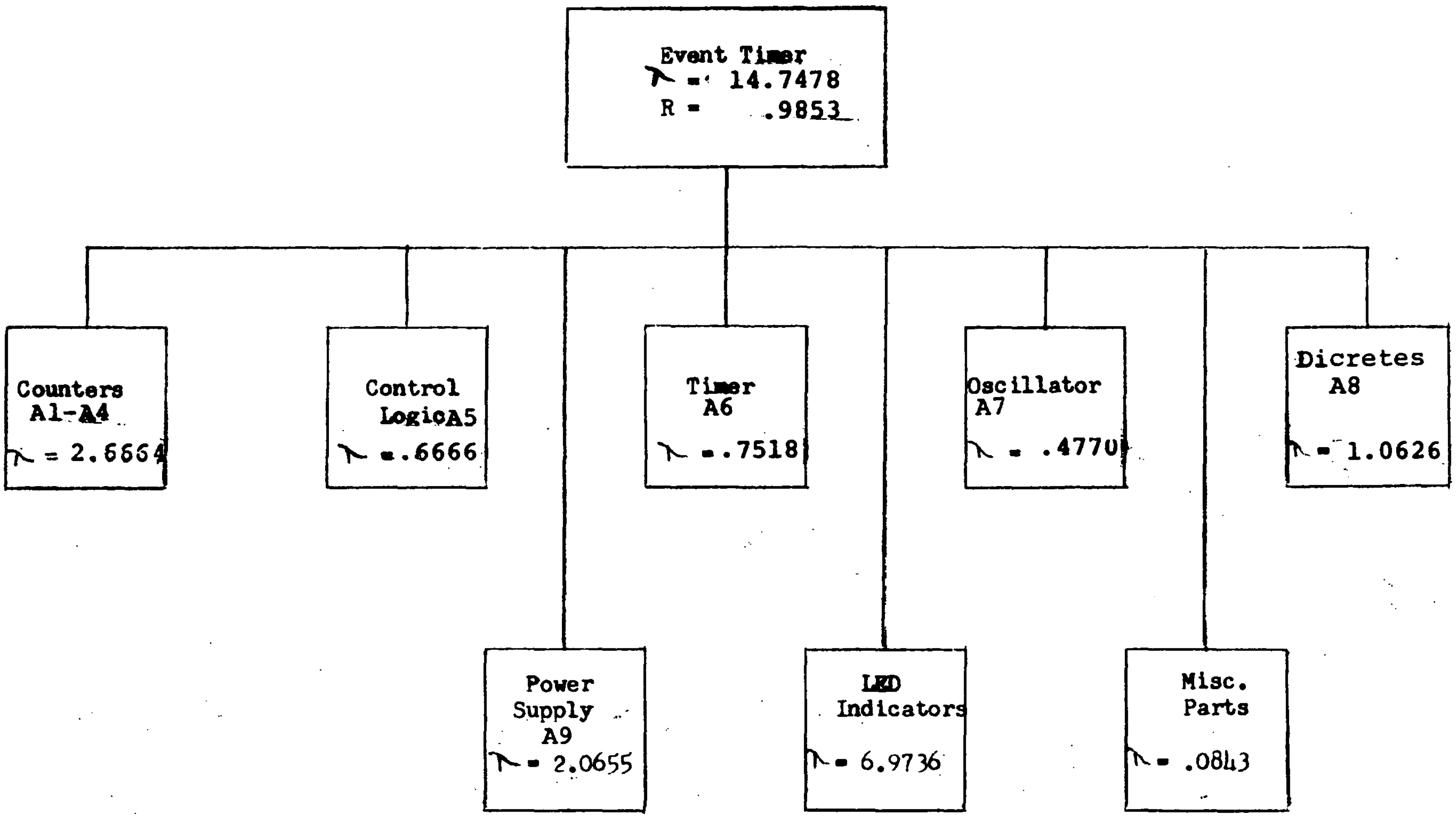
$R = e^{-(15.6240 \times 10^{-6}(1000)}$

$R = e^{-.0156240}$

$R = .9844$

$e^{-\frac{t}{m}}$

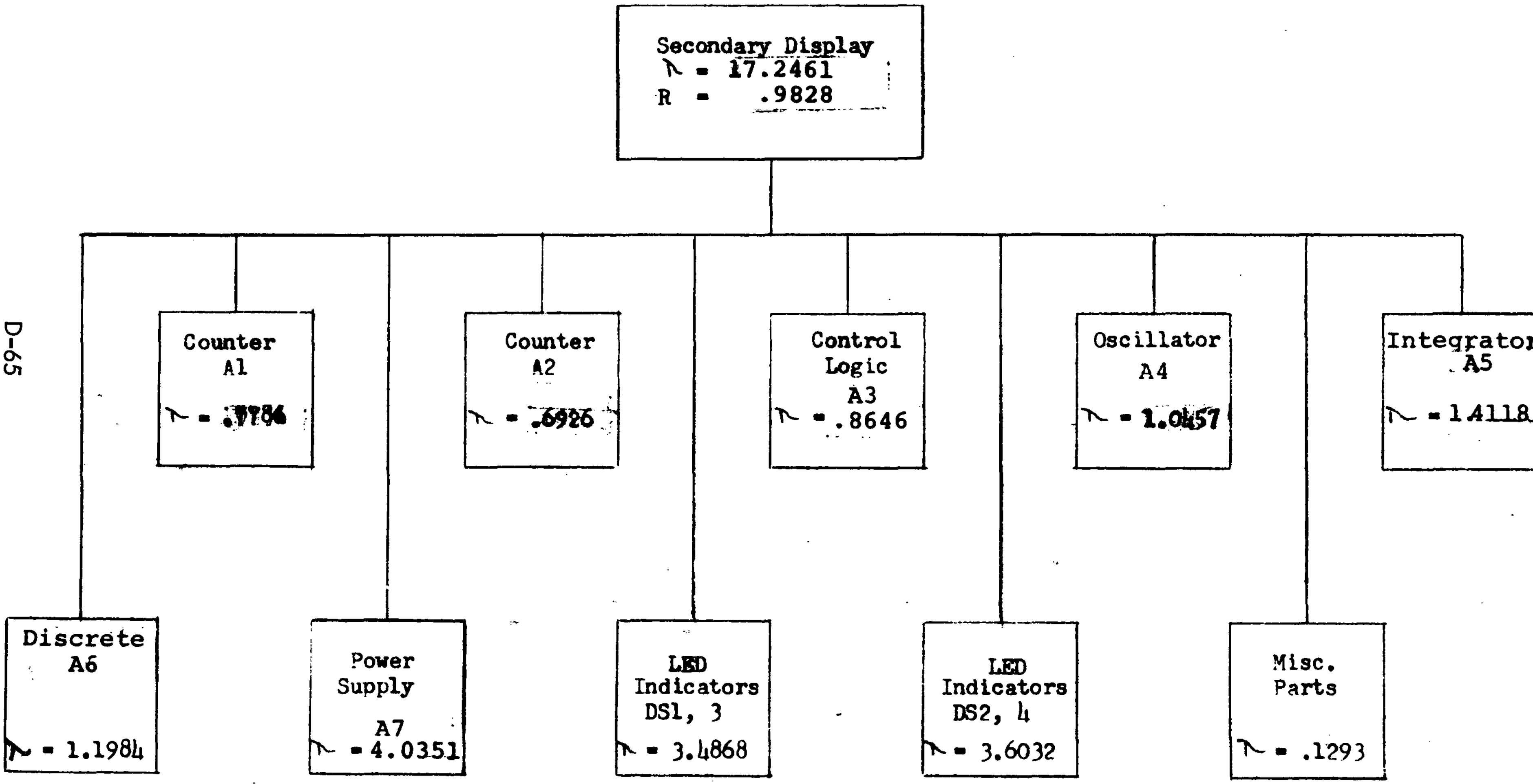
RELIABILITY MODEL FOR
EVENT TIMER IN
OPERATIONAL ENVIRONMENT



* Failure Rate Per Million Hours

FIGURE 1

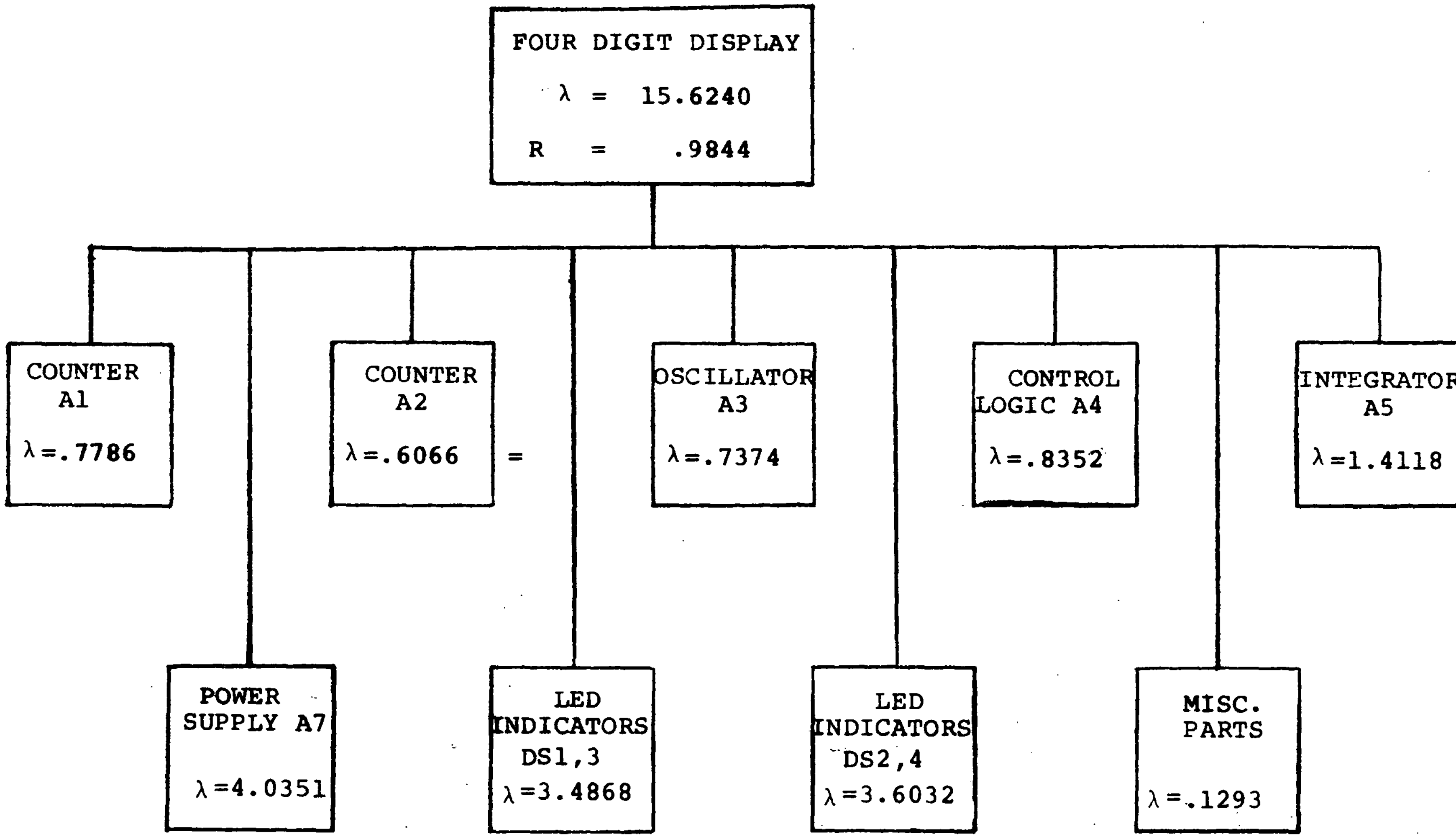
RELIABILITY MODEL FOR
SECONDARY DISPLAY IN
OPERATIONAL ENVIRONMENT



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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EVENT TIMER
RELIABILITY ENGINEERING
RELIABILITY PREDICTION
@ 85°C

$e^{-\frac{t}{m}}$
RELIABILITY ENGINEERING

DATA SUMMARY	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT}$	SOURCE
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	

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EVENT TIMER

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85°C

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	FAILURE RATE $f_{LAB./TOT}$	FAILURE RATE $K_{APPL} \times f_{LAB./TOT.}$	SOURCE
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

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EVENT TIMER

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85°C

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	FAILURE RATE $f_{LAB./TOT}$	FAILURE RATE K_{APPL} x $f_{LAB./TOT.}$	SOURCE
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

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

EVENT TIMER
RELIABILITY ENGINEERING
RELIABILITY PREDICTION
@ 85°C

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT.}$	SOURCE
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

C083 9/69 * Stress values supplied by McCoy

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SINGER-GENERAL PRECISION, INC.
LITTLE FALLS NEW JERSEY

EVENT TIMER
RELIABILITY ENGINEERING

RELIABILITY PREDICTION
@ 85°C

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			fLAB./EA.	fLAB./TOT	KAPPL x fLAB./TOT.	
A8 Board (cont'd)						
C7 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox
C8 Capacitor CKR	.28	1.0	.0017	-	.0017	Aerovox
CR1 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

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

EVENT TIMER
RELIABILITY ENGINEERING
RELIABILITY PREDICTION
@ 85°C

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE			SOURCE
			$f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT.}$	
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

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SINGER KEARFOTT DIVISION KEARFOTT DIVISION SINGER-GENERAL PRECISION, INC. LITTLE FALLS NEW JERSEY	EVENT TIMER **RELIABILITY ENGINEERING** **RELIABILITY PREDICTION** @ 85°C	$e^{-\frac{t}{m}}$ RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE			SOURCE
			$f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT.}$	
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	

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

SECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION
@ 85°C

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

DATA SUMMARY	QTY	K_{APPL}	FAILURE RATE @85°C $\lambda_{LAB/EA.}$	$\lambda_{LAB/TOT}$	$K_{APPL} \times \lambda_{LAB/TOT.}$	NOTES
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	

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LITTLE FALLS NEW JERSEY

SECONDARY DISPLAY

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85°C

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT.}$	SOURCE
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

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

SECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION
@85°C

$e^{-\frac{t}{m}}$
RELIABILITY ENGINEERING

PART NAME A3 Board (cont'd)	STRESS RATIO	KAPPL	FAILURE RATE f LAB./EA.	f LAB./TOT	KAPPL x f LAB./TOT.	SOURCE
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

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

SECONDARY DISPLAY
RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@85°C

RELIABILITY ENGINEERING

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

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SINGER
KEARFOTT DIVISION

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

SECONDARY DISPLAY

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85°C

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE			SOURCE
			$f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT.}$	
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

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

SECONDARY DISPLAY

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85°C

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT.}$	SOURCE
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

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

SECONDARY DISPLAY
RELIABILITY ENGINEERING
RELIABILITY PREDICTION
@ 85°C

$e^{-\frac{t}{m}}$
RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	FAILURE RATE $f_{LAB./TOT}$	FAILURE RATE $K_{APPL} \times f_{LAB./TOT.}$	SOURCE
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

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SINGER-GENERAL PRECISION, INC.
LITTLE FALLS NEW JERSEY

SECONDARY DISPLAY
RELIABILITY ENGINEERING

RELIABILITY PREDICTION
@ 85°C

$e^{-\frac{t}{m}}$
RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			fLAB./EA.	fLAB./TOT	KAPPL x fLAB./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

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

SECONDARY 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

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

SECONDARY DISPLAY

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85°C

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

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)						
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	

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SINGER-GENERAL PRECISION, INC.
LITTLE FALLS NEW JERSEY

FOUR DIGIT DISPLAY

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@85°C

$e^{-\frac{t}{m}}$

RELIABILITY ENGINEERING

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT}$	SOURCE
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	

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SINGER-GENERAL PRECISION, INC.
LITTLE FALLS NEW JERSEY

FOUR DIGIT DISPLAY

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85°C

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE			SOURCE
			$f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT.}$	
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

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SINGER-GENERAL PRECISION, INC.
LITTLE FALLS NEW JERSEY

FOUR DIGIT DISPLAY

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85°C

RELIABILITY ENGINEERING

PART NAME A3 Board (Cont'd)	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	FAILURE RATE $f_{LAB./TOT}$	FAILURE RATE $K_{APPL} \times f_{LAB./TOT.}$	SOURCE
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
					.7374	
A4						
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

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FOUR DIGIT DISPLAY

RELIABILITY ENGINEERING

RELIABILITY PREDICTION

@ 85° C

PART NAME A4 BOARD (Cont'd)	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	FAILURE RATE $f_{LAB./TOT}$	FAILURE RATE $K_{APPL} \times f_{LAB./TOT.}$	SOURCE
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	Aerovoc
CR1 Diode	<.10	1.0	.0294	-	.0294	TRW Elect.
CR2 Diode	<.10	1.0	.0294	-	.0294	TRW Elec.

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RELIABILITY PREDICTION
@ 85°C

PART NAME	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	FAILURE RATE $f_{LAB./TOT}$	FAILURE RATE $K_{APPL} \times f_{LAB./TOT.}$	SOURCE
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

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FOUR DIGIT DISPLAY
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RELIABILITY PREDICTION
@ 85°C

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RELIABILITY ENGINEERING

PART NAME A5 Board (Cont'd)	STRESS RATIO	K_{APPL}	FAILURE RATE $f_{LAB./EA.}$	$f_{LAB./TOT}$	$K_{APPL} \times f_{LAB./TOT.}$	SOURCE
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	Spragure
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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FOUR DIDIT DISPLAY
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PART NAME	STRESS RATIO	KAPPL	FAILURE RATE			SOURCE
			fLAB./EA.	fLAB./TOT.	KAPPL x fLAB./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

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FORU DIGIT DISPLAY
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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)						
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

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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.	
A7 Board (Cont'd)						
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 Siode 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	

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