ARRAY E

LMS HIGH VOLTAGE POWER SUPPLY

CAPACITOR PROBLEM ANALYSIS AND CORRECTIVE ACTION

Prepared by: D. Cook
D. Cook

Approved by: L. C. Duesterberg
L. C. Duesterberg

1.0 INTRODUCTION

The purpose of this report is to document a capacitor problem discovered in the high voltage power supplies being built for LMS and to describe the plan to correct the problem.

2.0 DEFINITION OF PROBLEM

During the in-process test, on the flight ion pump power supply (2347566 SN 21) at Bendix EOD, the output voltage registered 500 volts in lieu of the expected 3500V and the input current read 18ma in lieu of the expected 10ma. The problem was isolated to the multiplier subassembly (potted unit). The Bendix Reliability Group conducted a failure analysis of the multiplier unit as follows:

2.1 A series of electrical tests on the potted unit indicated the problem was probably a short on one of 3 capacitors (2340399-2) in the unit.

2.2 The potting was removed and capacitors were examined under a microscope. Several showed evidence of pits on the surface. One pit showed evidence that the silver had burned thru. It was concluded this was the shorted area. A microsection of the capacitor (see photomicrograph #1) shows a pit in the dielectric material. Photomicrograph #2 shows another pit in the same capacitor.

2.3 A total of eighteen capacitors out of the same lot of Aerovox (Olean Division) units were inspected and 12 had evidence of pits. Photomicrographs 3 and 4 show some of the pits in another capacitor.

2.4 The above evidence was presented to the Aerovox, Olean Division, and they confirmed that the lot was a bad lot of capacitors.

It was concluded that the total lot of Olean capacitors were suspected and that the multiplier and filter sections for both Qual and Flight hardware would have to be rebuilt.

3.0 PLAN FOR CORRECTIVE ACTION

The following plan for correcting the problem is currently being followed on an expedited basis:

3.1 New electron multiplier (EM) and ion pump (IP) multipliers and EM filter are being fabricated and tested as shown in the attached schedule using the following parts:

3.1.1	Qual Unit	Qty	Diodes	Qty	Capacitors
	IP Multiplier	16	S1N4948	9	3544389-2
	EM Multiplier	12	2340384-1	6	2340399-6
	Filter		N/A	4	2340399-7

3.1.2	Flight Unit	Qty	Diodes	Qty	Capacitors
	IP Multiplier	16	S1N4948	9	2340399-6
	EM Multiplier	12	S1N4948	6	2340399-6
	Filter		N/A	4	2340399-7

3.1.3 Beacuse of the lead time in obtaining new capacitors for rebuilding the units was 6 weeks, an investigation was made to determine if a lot of EOD 3544389-2 and -3 capacitors on hand at EOD could be qualified. These capacitors were made at Aerovox, Myrtle Beach and units out of the lot were used to build Engineering Model and Prototype LMS HVPS's. Several Myrtle Beach capacitors were examined under a microscope and were X-rayed and no evidence of pits were found. Several 3544389-2 capacitors were also tested at 2000 volts and above for several hours by Bendix engineers and no arcing thru the dielectric material was observed. Messrs D. Cook and P. Sondeen visited the Myrtle Beach facility and obtained sufficient data to indicate the lot of capacitors could be qualified. See attached Trip Report 9721-2579 for details.

3.1.4 The testing to be done on the capacitors and diodes to upgrade them to the PN's shown are defined in AER's 420 and 422 attached. The Qual unit IP multiplier was already built with the 3544389-2 capacitors before the screening requirements of AER 420 were generated. Since there was a shortage of diodes and the schedule would not permit waiting for a new order, the decision was made to proceed with the IP multiplier as is. It did receive a 240 hour burn-in test with 1500V applied to the capacitors.

3.2 The new multiplier and filter units will be installed on the qual and flight power supply PCB's as shown in the attached schedule.

ALSEP ENGINEERING REQUIREMENT

Short Title: DIODE TESTING	Date: Nov. 4, 1971
Originator: D. W. COOK	Principal Group Responsible for Action: LMS ENGINEERING
Effectivity: LMS Qual. Unit	Groups Affected: ☐ Mfg ☐ Sys. Support ☒ QA ☐ Others ☐ Test ☒ Reliability ☐ NASA Test Mgr.

Requirement:

I. The purpose of this AER is to detail those tests to be conducted on Diode P/N SS 4948 and to upgrade them to BxA P/N 2340384-1.

II. Tests to be conducted on 34 pieces purchased on BxA PO M 9174.

1. Visual inspection of the body of the diode will be conducted using a 5 to 10 power magnifier. Visible cracks in the body shall be cause for rejection.

2. Dimensional measurements shall be made in accordance with figure 1 of this document.

3. Measure Forward Voltage of the diodes. Measured values shall be in accordance with the following:

Parameter	Min	Max	Nominal
Forward Voltage V_f	0.6 Vdc	1.2 Vdc	
Forward Current I_f			1.0 Adc

Signature R. C. Johnston

Action by Responsible Group:

QC as Suggested

W. L. O'Mara

Signature J. J. Ellison

Distribution:

Master to AER File

O'Mara	R. Kovac	J. Hendrickson
Ellison	L. Duesterberg	W. Morsfield
T. Fenske	D. Cook	E. Frank
H. Reinhold	R. Johnston	

4. Measure the Reverse Current of the diodes. The measured values shall be in accordance with the following table.

Parameter	Max	Nominal
Reverse Voltage V_r		1,000 Vdc
Reverse Current I_r	0.1μ Adc	

III. The groups responsible for this work are as follows

1. Tests 1, 2, 3, and 4 are to be conducted by receiving inspection under supervision of LMS Engineering.

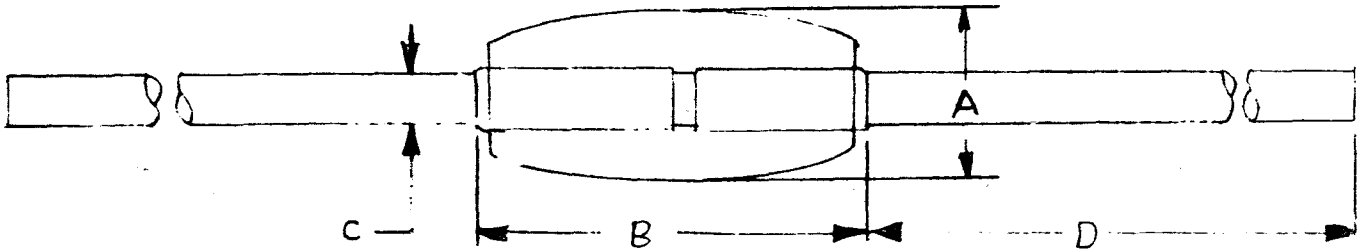
2. All diodes shall be serialized at the time of inspection and all tests are to be documented by serial number on reproducible data sheets. These sheets then become a part of the formal ADP for the power supplies.

3. When tests 1-4 are completed, the diodes shall be individually packaged in sealable plastic bags and identified with a label calling out the new part number (ie 2340384-1) and the serial number.

IV Special Handling

1. All test fixtures, tools, table surfaces, etc. which are brought in contact with the diodes must be free from grease, oil, water or dirt. It is recommended that these items be cleaned with alcohol or trichloroethylene prior to use.

2. Diodes should be kept in this plastic bags whenever they are not being tested.



Dimensions	Min	Max	Units
A	------	0.150	Inch
B	------	0.180	Inch
C	------	0.035	Inch
D	0.900	1.250	Inch

Figure 1. Diode Package Outline

TEST DATA ON DIODE P/N 2340384-1

Date ____________________

QC ____________________

Serial No.	Visual	Dimen-sional	V_F		I_R			Serial No.	Visual	Dimen-sional	V_F		I_R	
			0.6-1.2Vdc		0.1 μAdc max						0.6-1.2Vdc		0.1 μAdc max	

AER- 420

ALSEP ENGINEERING REQUIREMENT

Short Title: Capacitor Testing	Date: 11/3/71
Originator: D. W. Cook	Principal Group Responsible for Action: LMS Engineering
Effectivity: LSM Qual & Flight Hardware	Groups Affected: ☐ Mfg ☐ Sys. Support ☒ QA ☐ Others ☐ Test ☒ Reliability ☐ NASA Test Mgr.

Requirement:

I. The purpose of this AER is to detail those tests to be conducted on capacitors Bx EOD P/N 3544389-2 and -3 to upgrade them to BxA P/N 2340399-6 and -7.

II Tests to be conducted on 100 pieces of the -6 and 60 pieces of the -7.

1. Visually inspect the capacitors per paragraph 4.2.1 of SCD 2340399C.

2. Measure thickness "T" of the capacitors. Limits are per Figure 1 of 2340399. Except the minimum thickness "T" shall be .022 for the -6 and .073 for the -7.

3. Measure dielectric withstanding voltage on the 2340399-6 capacitor only per paragraph 3.4.6 of SCD 2340399C.

4. X-Ray and inspect the negatives per paragraph 4.1.1.4 of SCD 2340399C. Except X-Ray to be done on disks that have the silver electrodes..

(See Attached Sheet for continuation)

Signature [signature]

Action by Responsible Group:

GC will support - use LMS Change # [signature]

Signature [signature]

Distribution:

ster to AER File
O'Mara
S. Ellison
J. Abston
J. McNaughton
T. Fenske
H. Reinhold
R. Kovac
D. Fithian
D. Douthat
L. Duesterberg
D. Cook
R. Johnston
J. Hendrickson

4a. Delete dye inspection of paragraph 4.1.1.2 of 2340399C.

Send 25 pieces each of the -6 and -7 capacitor back to Aerovox, Myrtle Beach for Group B and C testing per SCD 2340399 except the number of capacitors tested for Group C shall be 20 of each dash number.

III. The groups responsible for this work are as follows:

1. Tests 1, 2 and 3 to be done by incoming inspection under supervision of LMS Engineering.

2. Test 4 to be done by the Bendix X-Ray group Dept. and the negatives reviewed by incoming inspection, ALSEP reliability and LMS engineering.

3. Test 5 will be done by Aerovox Corp., Myrtle Beach, S.C. Facility

IV. All test results must be documented by capacitor serial number on reproducible forms because they will be part of the formal document.

V. After completion of tests II-1 thru II-5 the capacitors must be individually packaged in sealable plastic bags with the new part number (ie 2340399-6 or -7) and their serial number.

VI. The capacitors are not encapsulated and therefore need special handling requirements, which are:

1. White nylon gloves must be worn whenever the capacitors are handled outside of their plastic bag.

2. All test fixtures, micrometers, calipers, table surfaces, etc. which are brought in contact with the capacitors must be free from grease, oil, water, or dirt. It is recommended that these items be cleaned with alcohol or trichloroethylene.

3. Keep the capacitors in their individual plastic bags whenever they arn't being tested and keep the bags closed.

TEST DATA ON CAPACITOR P/N 2340399-6 Date ____________

Test Run In Accordance with AER-420 QC ____________

Serial No.	Visual	Thick-ness	Dielec. With-Standing	X-Ray			Serial No.	Visual	Thick-ness	Dielec. With-Standing	X-Ray			
		.022-.026	@ 2250V						.022-.026	@ 2250V				

TEST DATA ON CAPACITOR P/N 2340399-7 Date _____

Test Run In Accordance with AER-420 QC _____

Serial No.	Visual	Thick-ness	X-Ray		Serial No.	Visual	Thick-ness	X-Ray		Serial No.	Visual	Thick-ness	X-Ray	
		.073-.080					.073-.080					.073-.080		

Internal
Memorandum

Bendix Aerospace Systems Division
Ann Arbor, Michigan

Date Nov. 1, 1971 Letter No. 9721-2579

To S. Ellison/L. Duesterberg

From P. Sondeen/D. Cook

Subject Trip Report Visit to Aerovox Corp. Hi-Q Div.
Myrtle Beach S. C. October 28, 1971

Ref (1) BxA Electro Optics Spec Control Dwg 3544389
Ref (2) BxA Spec Control Dwg 2340399
Ref (3) Aerovox QCC Material Qualification Reports
Lots 71-0551 and 71-0627

1. Purpose of the trip was to obtain information from Aerovox regarding lot test data on the capacitors identified as 3544389-2 and -3 which were ordered by EOD on PO # EO 9998. Additionally, since Ref (1) did not contain a rated continuous working voltage, data was needed to establish the rated value.

2. Personnel

Bendix
P. Sondeen Reliability-Parts & Materials
D. Cook Engineering-LMS

Aerovox
G. Woody Spec. Engr.
P. Bobich QC Manager

3. Lot test data and control

Aerovox standard Q. C. practice is to sample and qualify each lot of capacitors produced. Ref (3) includes such data as lot number, body material, mix batch, press used, kiln used for firing, firing temperature, date and Aerovox part number.

Each sample is tested mechanically, electrically and visually to establish conformance with the part number requirements.

Aerovox QC practice has been audited to NPC 200-3 and the Division has furnished parts for use in Apollo and Surveyor. Also the Division is qualified for the Established Reliability capacitors types CKRO5 and CKRO6, and has been approved by DESC for compliance with MIL-STD-790.

4. Capacitors ordered per ref (1) were handled as hi-rel products in the Division and were 100% tested electrically with each disk and data referenced to individual serial number. A residual inventory from the production lot at the Division is 380 of the (-2) part and 230 of the (-3) part. Ref (1) did not include a requirement for Group B and C testing as is required by Ref (2). The Group B Test consists of a voltage-temperature curve performed on two samples and Group C test is a 2000 hr life test at 85°C and 1.5x rated voltage. Sufficient samples are on hand to perform Group B and C tests on the received lot.

5. The dielectric strength test voltages specified in Ref (1) for the -2 and -3 part are 2000V and 6000V respectively. Corresponding approximately to twice the voltage in the LMS power supply application. Aerovox was asked if this value was ordinarily 1.5x or 2.0 x the rated continuous working voltage. Aerovox replied that the use of 1.5 x is an industry standard for capacitors rated above 1000V and that 2.0 x is ordinarily used for capacitors with a lower rated voltage. For ceramic capacitors with different formulations, the .020" thickness usually carries a 1000V continuous rating however the 836 body has consistently shown outstanding dielectric strength. Lot test data in Ref 3 indicates an average breakdown of 218 VPM for the -3 part and 307 VPM for the -2 part. Also there were no dielectric failures in the entire lot. Aerovox stated that they could assign a rating of 1500V for the -2 part and 4000V for -3 corresponding to 75VPM and 56VPM respectively or 25% of the average breakdown value.

This rating will be verified by performing a life test of 2000 hours at 85°C and 1.5x rated voltage (2250V for -2 and 6KV for -3). An LTPD of 10% requires a sample size of 38 pieces with 1 reject allowed.

Bendix agreed to perform a visual and X-ray inspection on the lot to select the thicker disks and to eliminate any units which may have voids in the dielectric. This provides additional confidence in the application of the capacitors.

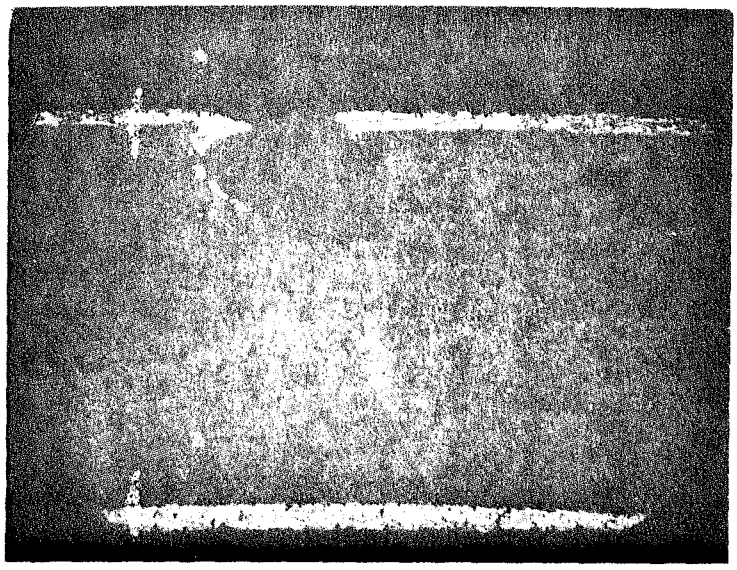
6. Bendix personnel were conducted on a tour of the plant to observe the manufacturing processes and controls used in the production of 30 to 40 million units per month. The process is highly mechanized which results in a very high level of product uniformity and provides a very impressive product history over a wide range of ceramic formulations, disk diameters and thickness.

7. For application in the LMS qual and flight power supplies, Ref (2) will be revised to add a -6 and -7 part defining the requirements which can be met by reinspection and added testing of the 3544389-2 and -3 parts.

P. Sondeen

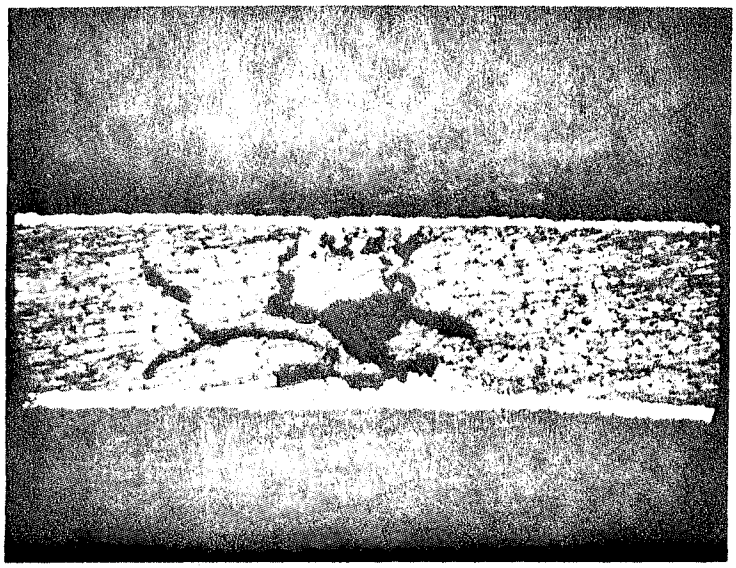
D. Cook

copies: J. Hendrickson
R. Hiebert
R. Roukas
W. Moresfield
D. Sullivan
M. O Mara
E. Frank

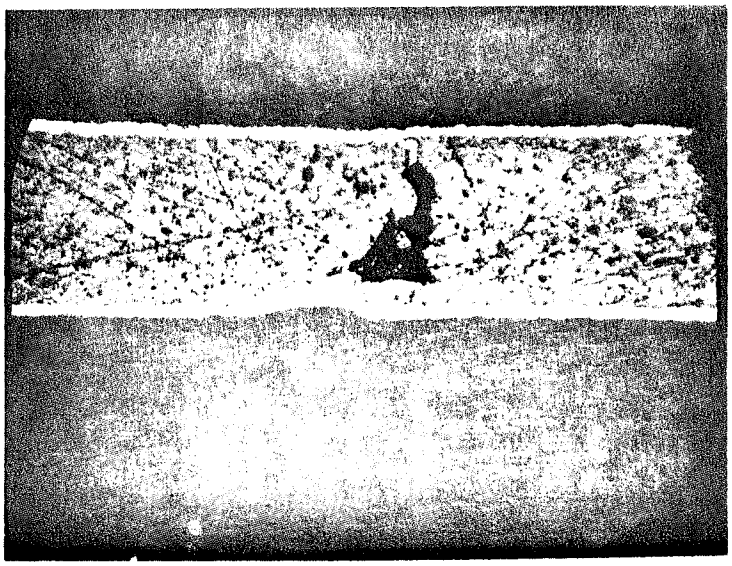


PHOTOMICROGRAPH # 1
ION PUMP HVPS MULTIPLIER ASSY. SECTIONED CAPACITOR SHOWING PIT WHICH ARCED. X100 MICROGRAPH.

PHOTOMICROGRAPH # 2
SAME CAPACITOR AS ABOVE SHOWING ANOTHER PIT. X100 MICROGRAPH.



PHOTOMICROGRAPH # 3
EOD REJECTED CAPACITOR SECTIONED PART
SHOWING VOID WHICH DID NOT CAUSE 40Ω SHORT.
X50 MICROGRAPH.



PHOTOMICROGRAPH # 4
SAME CAPACITOR AS IN # 3 SHOWING
40Ω PATH. X50 MICROGRAPH

Bendix Aerospace Systems Division

MASTER SCHEDULE

Title: HVPS REWORK SCHEDULE

No:

Revision No:

Issued On: 11/15/71

Updated On:

Line	Item
1	QUAL UNIT
2	Screen Capacitors/Diodes
3	Assy EM Multiplier
4	Encapsulate Multiplier
5	Cond Coat Multiplier
6	Install Shield on Multiplier
7	Burn-in 60 hours
8	Assemble Filter
9	Encapsulate Filter
10	Cond Coat Filter
11	Install Shield Filter
12	Burn in 32 hrs
13	Remove Multiplier and Filter from PCB
14	Install New Mult/Filters on PCB
15	RTV Coat and Cure
16	Test Select Resistors
17	Conformal Coat and Cure
18	In-Process Test
19	Install IP Multiplier on PCB
20	Test and Select Resistors
21	Epoxy Coat andCure
22	RTV Coat and Cure
23	Conformal Coat and Cure
24	In-Process Test
25	HVPS Final Assy and Inspect
26	
27	FLIGHT UNIT
28	Assy EM Multiplier
29	Encapsulate
30	Cond Coat and Cure
31	Install Shield
32	Burn-in
33	Assemble Filter
34	Encapsulate
35	Cond Coat and Cure
36	Install Shield
37	Burn-in
38	Complete Assy of EM HVPS
39	RTV Coat and Cure
40	Test and Select Resistors
41	Conformal Coat and Cure
42	In-Process Test
43	Receive SIN Diodes (16)
44	Assemble IP Multiplier
45	Encapsulate
46	Cond Coat
47	Install Shield
48	Burn-in
49	Complete Assy of IP HVPS
50	Test and Select Resistors
51	Epoxy Coat and Cure
52	RTV and Cure
53	Conformal Coat and Cure
54	In-Process Test
55	HVPS Final Assy and Inspection
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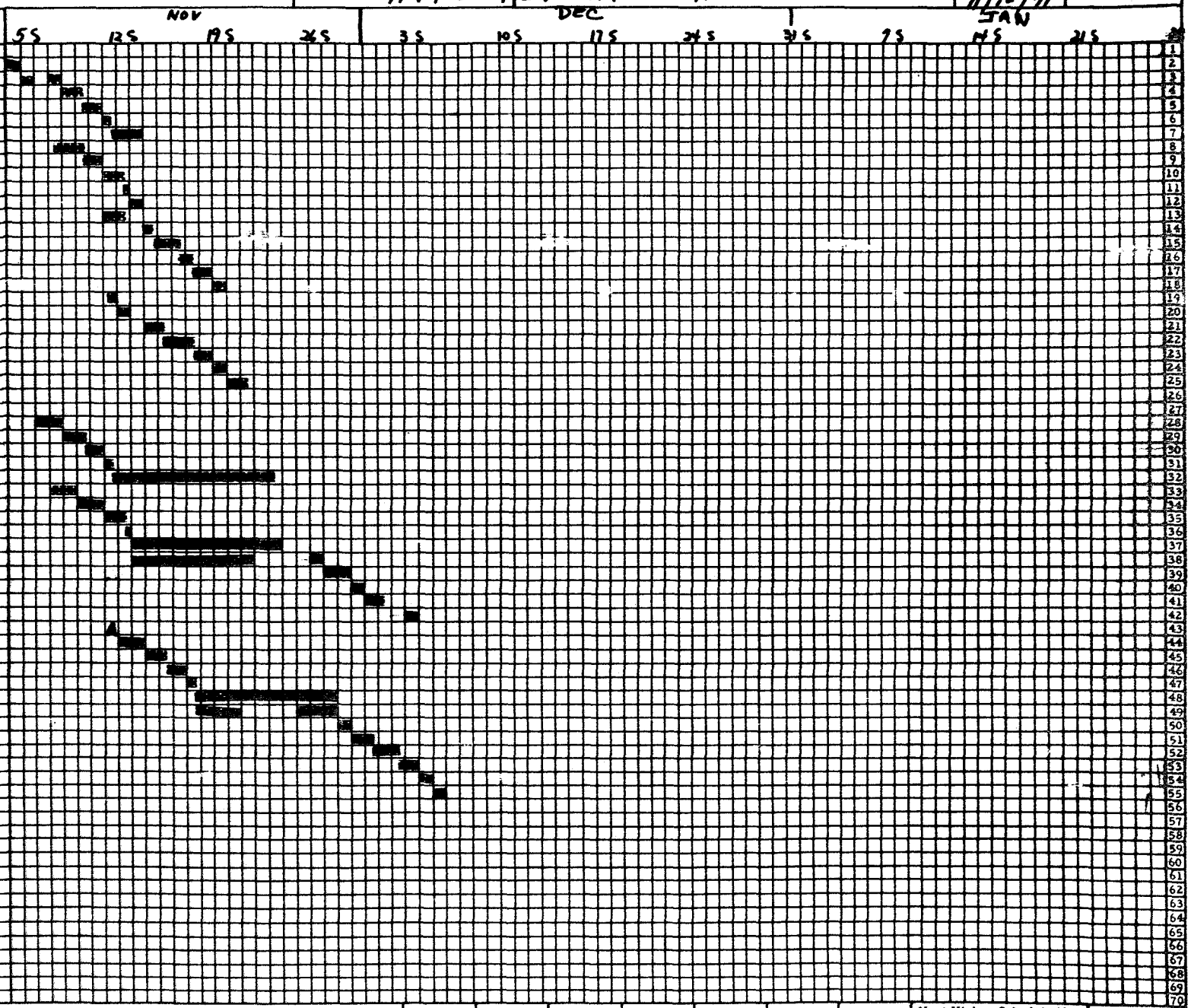

Remarks

							Next Higher Schedule No	Page
		Test	Mfg Dept	Mfg Prog	Engr	Prog Cont		___ of ___

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