WHS-383
30 June 1967

Copy 6 of 6

To: W. H. Brassfield
B. F. Knolle
M. S. Malkin
H. W. Nordyke
S. M. Robinson
J. Sewall
S. S. Strong

Subject: EMC Control Board Meeting, 15 - 16 June 1967

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1) The final EMC Board minutes of 15 - 16 June 1967, are attached to this letter.

2) A preliminary agenda for the next meeting is included in the minutes.

3) Contractors shall direct their responses to action items to their respective SPO's with information copies to the MOL EMC Board, W. W. Shely and W. J. Baldau.

B. F. Knolle
B. F. Knolle

S S Strong
S. S. Strong

MINUTES OF THE MOL EMC CONTROL BOARD MEETING HELD ON

15 - 16 June 1967

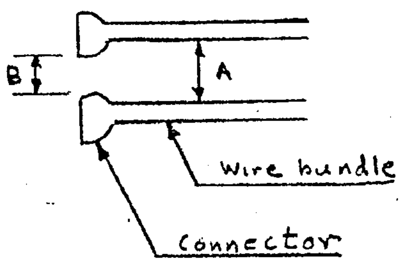
The following summarizes the EMC Board action on the specified items:

(1) Report by EK on the Method of Implementing the Wire Categorization.

A) Since EMC and cabling are handled by the same group, EK does not find it necessary to go through any formal documentation to implement the wire categorization. However, the EMC engineering does not sign-off on the EK cabling drawing. The EMC Control Board recommended that EK institute a procedure where all electrical drawings are signed off for EMC.

B) All major design involving EMC is done in house. EK EMC engineering interprets the wire categories for their subcontractors and will keep the EMC Control Board appraised of any pending problems.

C) The following ruling was made by the EMC Control Board in response to an EK request on the meaning of the separation requirement for wire bundles:



The 64-4 requirement is that A = 4"; the Board recommends a goal of B = 4".

(2) Report on EED's.

A) EK informed the Board that they have no EED applications at this time.

B) DAC informed the Board that they have received the technical information on the MC Thermal Power Meter (TPM) but have not received information on the MAC Low Energy Squib Simulator/High Energy Squib Simulator (LESS/HESS). DAC is not sure whether or not they have received the technical data on the UTC device.

C) GE reported to the Board that they have received technical data on both the TPM and the UTC device. However, they have not received the data on the LESS/HESS.

D) The Board will obtain the technical data on the LESS/HESS, TPM, and the UTC device and forward this information to EK to keep them appraised so they can respond in timely fashion in the event EED applications are levied on them at some future date.

(3) The Loading of Unused Interface Wiring.

A) EK has different cable designs for the two different configurations. Therefore, there are no EK circuits with signals that are not terminated for all flights. EK does have spare wires that are not terminated in any fashion (such as loading or grounding). This procedure has been used in the past without causing any problems.

B) DAC informed the Board that their present design does not allow for any spares (the primary reason for this policy is to save weight). The EMC Control Board notified the SPO/Aerospace representative of the Cable Working Group of this situation.

C) The GE design does allow for spare wires and these spares are left open-circuited.

D) DAC informed the Board that they are presently waiting for the official request from MAC on the loading of the unused circuits on the GBQ flight. In the meantime DAC has informed all the affected groups within their house to anticipate the MAC request so they can respond in a timely manner.

(4) Keeping EK Appraised of Status of White EMC Control Board Meetings.

A) The Board will have information copies of all TWX's and minutes pertaining to white EMC Control Board meeting sent to EK. Two copies of the last EMC Control Board meeting (May 17-18) were given to EK for information.

B) EK requested the right to have any agenda item from the white meeting placed on the agenda of the subsequent black meeting. The Board granted this request. In the event EK has any comments to be made at the white meeting, they will have them made through GE. The Board will investigate the possibility of holding all black EMC Board meetings in order to allow EK to participate directly at all meetings.

C) The present policy is to have an EMC Control Board meeting approximately every eight weeks. The Board will look into scheduling consecutive white-black meeting to cut down the frequency of the meeting and the required traveling. For the time being it is intended that these meetings will be held in Los Angeles unless there are compelling reasons to do otherwise. However, it is expected that in the very near future a meeting will be scheduled for VAFB.

(5) Submittal of Data to the Board.

A) For all future meetings the contractors shall submit copies of briefings that are presented at the meeting. These charts will then be made into an attachment to the minutes. If a contractor wants to submit an analysis or technical position to the other contractors, he may submit this to the Board at the meeting and they will be made attachments to the minutes.

(6) Implementation of EMC Control Plans.

A) EK presented their EMC program status on four briefing charts. Copies of these charts were made by the Board and are in Attachment A of these minutes.

B) GE submitted an outline of the EMC organization and status of their EMC Control program, SAFSL 24005. (Attachment B) GE informed the Board that they do extensive EMC testing on their breadboards. They have approximately 15 subcontractors who have or will be submitting EMC control plans to them. GE does EMI analysis and this is submitted with the PDR package. In response to a Board request GE submitted a copy of the EMC analysis for the CC & I. This analysis becomes Attachment C to the minutes (Attachment C will not be distributed with these minutes; however, it will be in the permanent files of the EMC Control Board).

Kollsman has identified but not confirmed an EMI problem with their star tracker at this time. Kollsman has been appraised of the 64-4 requirements and has obtained the services of an EMC consultant. The Board identified the star tracker as a potential problem area and GE agreed to make the Kollsman EMC control plan available to the Board. GE will appraise the Board of the expected date of submittal.

C) DAC gave the following status on their major subcontractor EMC Control Plans:

Pratt & Whitney	accepted
Hamilton Standard	accepted
IBM	accepted
Honeywell	accepted
AiResearch	not accepted yet but approximately 90% completed
Collins	not submitted yet

The Board identified the ACTS/SCE as a critical item and requested DAC to submit a copy of the Honeywell EMC Control Plan by 7 July. DAC shall report to the Board at the next meeting the date they expect Collins to submit their EMC Control Plan.

The following is the DAC implementation of the Laboratory Vehicle EMC Control Plan:

The EMC Group works with the design engineers.

The EMC Group signs off on all CEI's, IFS's, and TRS's.

The EMC Group does not sign off on engineering production drawings.

DAC has an EMC Working Group.

The Board strongly recommended to DAC that they establish a procedure for signing off all electrical drawings for EMC, as we are in the early stage of the design where they can be most effective in achieving a compatible system.

DAC informed the Board that they have been unable to implement the Composite EMC Control (except for the preliminary frequency management analysis) because they have not received the required documentation from the other associate contractors. The Board directed DAC to submit a list of all documents they need and the date they are needed to implement the Composite Control Plan by the next Board meeting.

DAC informed the Board that they would like to revise the Composite EMC Control Plan and requested the Board to make recommendations for changing the Plan. The Board agreed to review the Composite Control Plan for changes and will continue this discussion with DAC at a separate meeting. At this meeting the progress in implementing both Control Plans will be explored in greater detail.

D) All contractors will present at the next Board Meeting the status of the Subcontractor Control Plans.

All contractors will report at the next Board Meeting the methods being used which insure that EMC requirements are being implemented in equipment and system design. The EMC Board stated that a Company procedure whereby EMC managers sign off on the engineering drawings would be considered as an acceptable control method.

(7) <u>Anticipated Deviation Request by the Associate Contractors.</u>

A) EK gave a presentation of their measurement and analysis of the short duration generated (conducted and radiated) interference caused by 5v (<5 ma) and 2v power switching. These levels are not within the limits of the steady state specification. However, the Board considers this "short duration noise" and a waiver is required only if this noise results in interference. EK will submit this data and the trade off penalties (the weight, power, etc. for adding filtering) to their SPO. In their letter they will officially inform the SPO whether these levels cause interference within their system. EK shall request their SPO to determine whether these levels cause interference with the other segments. EK shall also inform their SPO the latest date they require a reply.

B) GE informed the Board of the following potential problems:

1. GE still anticipates using the PC-30 (Hi Shear) EED. The susceptibility mode of this EED pointed out in the 17 May meeting will not be a factor because only one bridge will be used. However, this EED has not been tested in 400-550 MHz and 1200-1400 MHz ranges and may require a deviation.

2. GE knows that short duration noise (conducted and generated) will be generated when the EED's are fired. The Board informed GE to submit the data with an analysis concerning the effect of this EMI on their segment. GE shall request their SPO to have DAC, in their role of EMC integrator, make an analysis as to the effect of this EMI on the rest of the MOL.

3. GE informed the Board that they also generate short duration noise when they switch primary power. The Board informed GE to follow the same procedure as described for the EEDs.

4. The Board also requested DAC to provide the status of their analysis for determining the non-interference of the noise generated by the power switching transients.

C) DAC informed the Board of the following potential request:

1. They are now preparing a deviation request against the susceptibility levels for conducted interference in the audio frequency range for all Laboratory Vehicle equipment. DAC submitted the preliminary values for this request at the 17 May meeting. DAC submitted preliminary technical justification for these levels (see Attachment D of these minutes) and the minutes on the 19 June TEM on EMC Aspects of Power Quality (Attachment E). DAC could not indicate to the Board at this time when they will have more definitive information concerning this impending request.

2. DAC may need relief from the conducted generation limits for the voltage regulator used with the TWT.

3. DAC anticipates that they will need a deviation on the radiated interference levels for TTCV.

D) The Board directed all contractors to identify any further deviation requests (including AGE) they anticipate at the next EMC Control Board Meeting. The Board stated that the policy is NOT to grant blanket deviations. Exceptions will be made where it can be established by analysis and/or test that the requirements are not needed to insure compatibility. Blanket deviations will not be granted.

(8) Use of Specialists.

The Board stated the policy that for any future meetings the associate contractors may bring specialists for discussion on particular agenda items. (Example: A member of test group for items involving testing.)

(9) Report on Status of EMC Testing.

A) EK gave a presentation of their status. The EMC Board made copies of the EK briefing charts and they are included in these minutes as Attachment F. EK intends to determine the susceptibility threshold limits for all components.

B) The GE presentation on testing is given in Attachment G.

C) DAC had no written material to be included in the minutes at the time of the meeting. The Board requested DAC supply in writing the status of their EMC testing program by 23 June. Their write-up will be made into an attachment of these minutes. (Attachment H.)

D) The EMC Board requests all contractors to present at the next black EMC Board meeting:

1. Their Company's plan for providing support to the integrated EMC program to include:

   (a) Philosophy of test support for EMC tests (factory to pad) on all out of plant EMC tests.

   (b) Test Equipment support for these tests.

   (c) EMC support personnel for these tests.

   (d) Design provisions for accomplishing EMC test.

   (e) A schedule to accomplish (a) - (d) above.

(10) <u>EMC Integration</u>

The EMC Control Board requested DAC to prepare a presentation of their role as EMC Integrator. This presentation, complete with handouts, will cover the DAC definition of their role of the EMC Integrator, the status of their actions to date, and the schedule of actions to be accomplished. This presentation is to be given at the next white and next black EMC Board Meetings.

(11) <u>DAC Interface</u>

DAC presented the status of their interface requirements. Basic EMC requirements on Vehicle interfaces have been negotiated between GE and DAC. These basic requirements appear in all interface specifications in accordance with the complexity or nature of the particular interface. Any deviations are noted (or negotiated) within the particular IFS.

DAC has not negotiated inclusion of EMC susceptibility tables into the IFSs. DAC presently questions the need of these tables in the IFS and if the tables become necessary, they possibly should be placed in Section 6 (noncontractual) of the IFS.

DAC has begun analysis of Induced EMI on GB-TIII cabling in view of action items levied at last EMC Control Board Meeting and of IFS 201001 sign-off meeting. Due dates for action items were noted.

The next white EMC Control Board Meeting has been tentatively set for July 11 and 12. After this meeting it is planned to run consecutive white/black meetings which, it is felt, will be more effective and reduce the amount of traveling.

The following items will be added to the agenda of the white EMC Control Board Meeting scheduled for 11 and 12 July 1967.

(1) DAC shall inform the Board when the Collins EMC Control Plan will be submitted. (6C)

(2) All contractors shall give the status of the subcontractor EMC Control Plans. (6D)

(3) All contractors to identify any anticipated deviation requests (including AGE) not already identified. (7D)

(4) All contractors to present their Company Plan for supporting the integrated EMC program. (9D)

(5) DAC to give a presentation of their EMC integration role. (10)

(6) DAC shall submit a list of all information items they need and the date needed to implement the composite Control Plan. DAC shall also give a brief presentation on what they intend to do with this data. (6C)

The following are preliminary agenda items for the next black EMC Control Board Meeting:

(1) All contractors shall report the methods being used to insure the implementation of the EMC requirements (e.g., the sign off of drawings). (6D)

(2) GE shall submit data with analysis concerning the effect of the EMI generated when they fire their EEDs. (7B2)

(3) GE shall submit data with analysis concerning the effect of the noise generated when they switch power. (7B3)

(4) DAC shall submit data with analysis for determining the non-interference of the noise generated by switching power transients. (7B4)

(5) EK shall report status of submitting short duration analysis to their SPO. (7A)

(6) GE shall inform the Board when the Kollsman EMC Control Plan will be submitted. (6B)

ACTION ITEMS

(1) DAC shall submit a copy of the Honeywell EMC Control Plan by 7 July 1967.
5-246 (6C)

LIST OF ATTENDEES

E. Jacobs
R. Schult
Grady Fox
Dwight Johnson
J. E. Seright
Alan S. Lupfer
Eugene Manfreda
R. H. Dickinson
J. B. Johnston
C. R. White
H. B. Thomas
R. E. Freeman
R. C. Twomey
W. W. Shely
W. J. Baldau
Frank Lewotsky

MOL SPO

Aerospace Corporation

6/14/67
Eastman Kodak Company

General Electric Company

Douglas Aircraft Company

ATTACHMENT A

EMC PROGRAM STATUS

- Parts

  Sprague developing filters which attenuate d.c. motor generated interference to 64-4 levels.

- Component Control Plans

  1. Recorder.
  2. Processor.

- Bonding Diagrams

  1. TM bonding layout (This is a suggested layout which EK interface has discussed with GE who has design responsibility.)
  2. External structure/heater tube assembly.

- Power Returns

  Diagram in preparation.

- Test Equipment

  1. New NF-105 receiver in-house.
  2. EMC-10 receiver in-house.
  3. New Solar transient generator in-house.
  4. Audio and r.f. generators for susceptibility in process of being specified.
  5. Transient detectors, chart recorders, oscilloscopes and recording cameras for EMISM testing in process of being specified.

- Generated Interference

  Extensive breadboard testing as reported by < 5v at < 5ma charts shown in this report.

- Susceptibility

  Breadboarded transient suppression circuitry.

- Breadboard Component Tests

  1. Temperature sensor amplifier (I.P.)
  2. Prototype heater controller.
  3. Record handling equipment breadboard.

- EMI Training Session
- Transients

  Realistic definition - change of requirements.
  Implementation

- Audio Ripple

  Realistic definition - change of requirements.

- Power Distribution Diagram

STATUS

GENERAL ELECTRIC EMC CONTROL PLAN

(SAFSL EXHIBIT 24005)

I. GE's EMC control plan is not on contract. Comments on the plan were submitted to AF on 19 May 1967. No reply has been received to date. Meanwhile GE is proceeding to implement the plan.

II. Status of Implementation

1. EMC Group Organized, Meetings Held.

Members:

R. H. Dickinson	-	Program Management, Chairman
J. B. Johnston	-	Systems Engineering
C. R. White	-	Design Engineering
L. M. Reveron	-	Quality Assurance and Reliability
V. A. Smith	-	System Test and Development
E. T. Birsch	-	Manufacturing

Ex Officio Attendees:

J. R. O'Connell	-	Major Subcontracts
C. M. Garcia	-	Development Testing (Des. Engineering)
W. Orr	-	AGE Engineering (Des. Engineering)
R. A. Spinelli	-	VAFB Testing (ST&D)
C. R. Keller	-	Associate Contractor Testing (ST&D)

2. Subcontractor Surveillance

7 Subcontractor EMC Control Plans Reviewed
3 Approved
4 Plan Review Meetings Held With S/C
Monitored SDS Computer EMI Tests

3. Generated EMI Analysis on CC&I Subsystem
4. Released Design Note on Shielding
5. Prepared Checklist for use in EMC Design Reviews
6. Released Instructions for Wire Categorization
7. Performed Detailed Comparison of DP-1690 and SSD Exhibit 64-4. Updating of DP-1690 in Process.
8. In-House Design Reviews:

   1 Completed
   4 Scheduled in June

9. Preparing Revision to Ground Test Plan

(ATTACHMENT D(a)

M E M O R A N D U M

Date: APR 14 1967
A3-810-EBCO-M-056

TO: M. H. Peairs, A3-810

FROM: R. C. Weaver, A3-810

SUBJECT: PROPOSED REVISION TO STD 0003, STANDARD SPECIFICATION, POWER QUALITY, ELECTRICAL, MOL SYSTEM ORBITING VEHICLE

COPIES TO: E. G. Corcoran, I. B. Friedman, C. W. Gann, W. S. Hayes, J. R. Hill, R. H. Lenke, R. H. McDougle, W. C. Peart, M. W. Ralsten, C. R. Rubenstein, R. C. Twomey, A3-810; C. F. Marvin, A3-816; File

REFERENCE: Memorandum A3-810-EBCO-M-055

This memorandum transmits the proposed revision to Standard Specification STD 0003 as reviewed and coordinated with SPO/Aerospace on 12 and 13 April 1967. The proposed Standard delineates the characteristics of primary electric power to be supplied to the MOL Laboratory (LM) utilization equipment when operating with (a) one or more of the LM fuel cell powerplants, (b) the dc ground power supply or backup battery, or (c) any combination of these sources.

It is intended that the characteristics defined in the proposed Standard will be used as a guideline in redefining the characteristics of primary power for utilization equipments which are a part of the Mission Payload Segment and Gemini B. It should be pointed out that the ripple and transient voltage limits given in the proposed Standard are contingent on Associate Contractor acceptance of the requirements imposed by paragraph 4.2, "Utilization Equipment Turn-On."

The limit curves presented in the proposed Standard reflect conditions seen when operating on ground power. To support redefinition of power quality characteristics in the Associate Contractor Interface Specifications, it was necessary to develop ripple and transient limits for the case of operation on fuel cell power only. These limits are shown on the attachments to this memorandum.

TO: M. H. Peairs, A3-810

A summary of the data used to generate the revised limits for ripple and transient voltages is given in the reference memorandum. It is particularily appropriate to note here that the maximum duration of transient undervoltage (Abnormal Operation, Limit 4 on Figure 3 in the proposed Standard) is based on the time-current characteristics of a 15 ampere magnetic circuit breaker. If any load circuit requires the use of a protective device with time-current characteristics beyond the range of a 15 ampere magnetic circuit breaker, it will be necessary to extend the envelope for Limit 4.

R. C. Weaver

R. C. Weaver, Section Chief
Power Distribution

RCW:pmc

Attachments: 1 - Envelopes of Single Event Transient Voltage Indicating Recovery to Steady-State Limits, System On One Fuel Cell Powerplant

2 - Electric System Ripple Limits, System On One Fuel Cell Powerplant

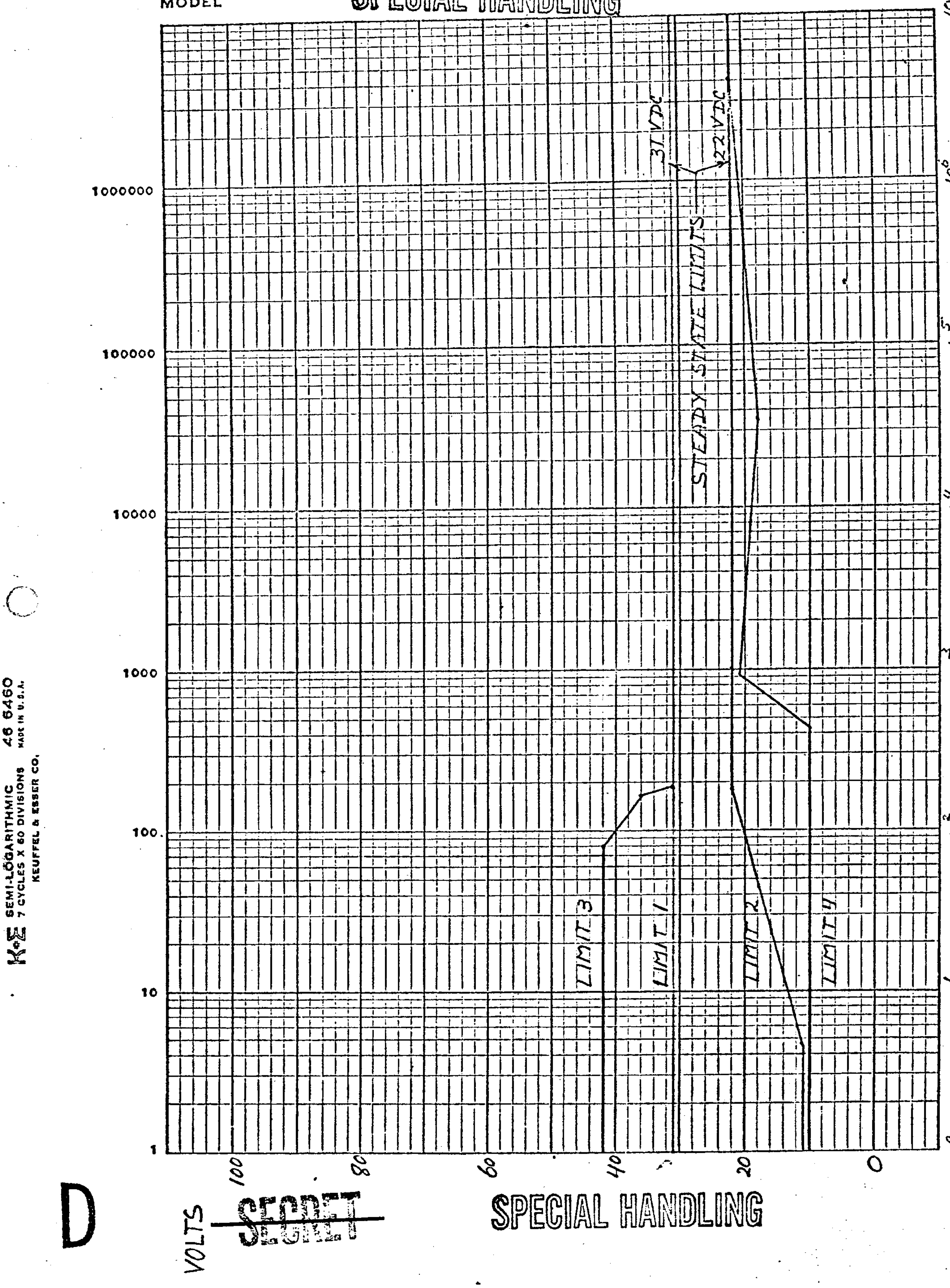
NRO APPROVED FOR RELEASE 1 JULY 2015

~~SECRET~~

PRELIMINARY

SPECIAL HANDLING

MODEL DATE

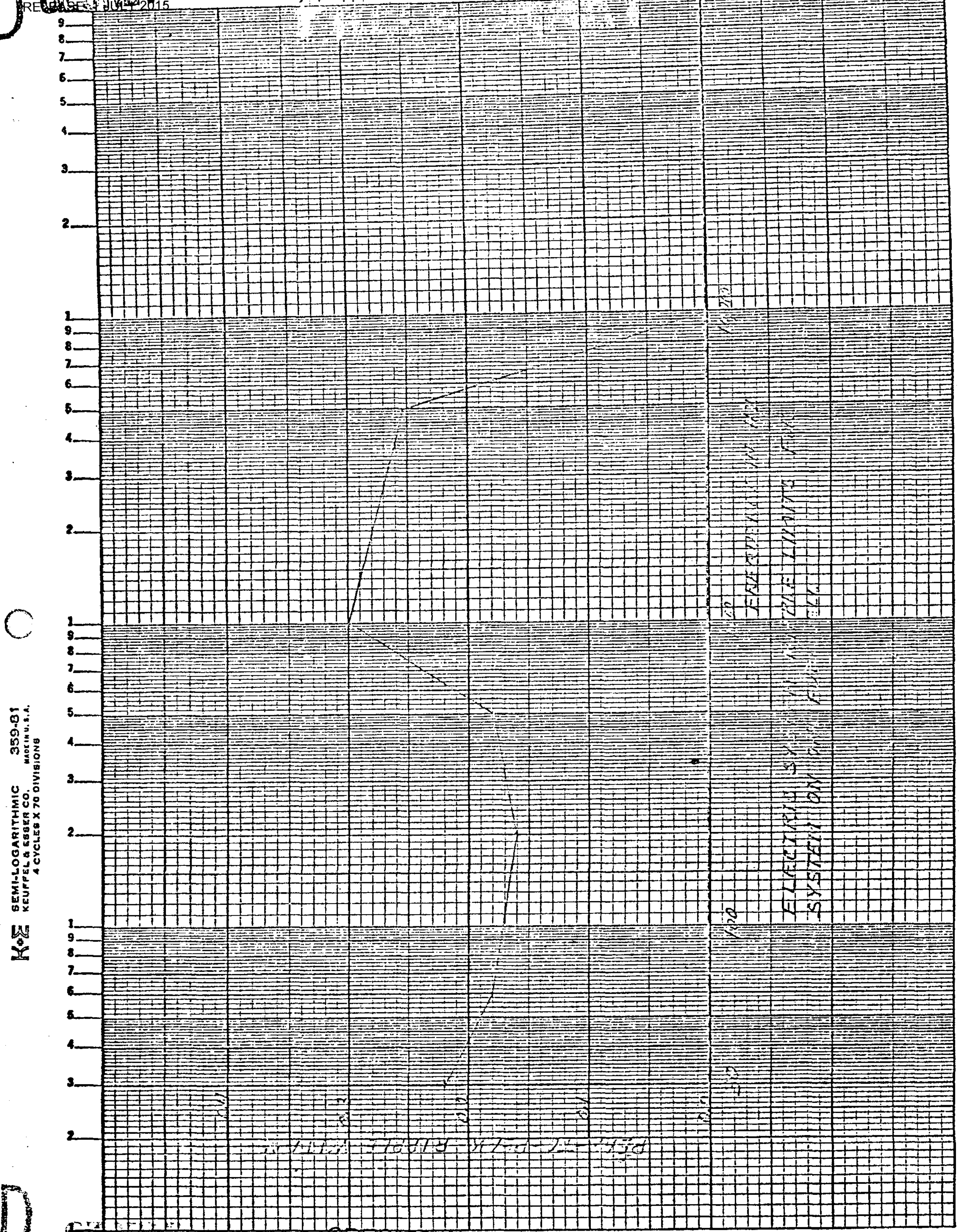


ENVELOPES OF SINGLE EVENT TRANSIENT VOLTAGES INDICATING RECOVERY TO STEADY-STATE LIMITS FOR SYSTEM ON ONE FUEL CELL

D

~~SECRET~~

SPECIAL HANDLING


K+E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
ELECTRICAL
SYSTEM ON

STANDARD SPECIFICATION

POWER QUALITY, ELECTRICAL, MOL LABORATORY MODULE

1. GENERAL

1.1 Scope. This standard delineates the characteristics of the primary electric power to be supplied to the MOL Laboratory Module (LM) utilization equipment when operating as a total system and is predicated on all equipments meeting their individual specification requirements.

1.2 Purpose. The purpose of this standard is to assure compatibility between the LM primary power system and the LM utilization equipment to the extent of confining the LM primary power and utilization equipment characteristics within the limits specified herein. The utilization equipment specification shall specify this standard for power requirements.

The characteristics of primary power defined herein shall be used as a guideline in redefining the characteristics of primary power for utilization equipments which are a part of the Mission Payload Segment and Gemini B.

1.3 Deviations. Requests for deviations to the requirements specified herein are subject to approval by the Douglas Aircraft Company, MOL Vehicle Electronics, Electrical Power Branch.

2. APPLICABLE DOCUMENTS

None

3. DEFINITIONS

3.1 Electric System. The electric system is all equipment necessary for the production, distribution, control, and utilization of primary electric power.

3.2 Normal Electric-System Operation. Normal operation of the electric system encompasses all functional operations required of the electric system in order to meet mission requirements without performance degradation. These functional operations may occur at any time and any number of times during LM assembly and checkout, launch preparation, ascent, and orbiting. Examples of such normal operations are the switching of utilization loads and paralleling and transfer of primary power sources.

3.3 Abnormal Electric-System Operation. Abnormal operation of the electric system is the malfunction of some part of the electric system which could cause the quality of primary power to exceed normal electric-system operating limits. The malfunction is uncontrolled, however recovery from abnormal to normal operation is a controlled action. Abnormal operation may occur at any given instant during LM assembly and checkout, launch preparation, ascent, and orbiting. An example of an abnormal operation is an electric power fault and subsequent clearing by protective devices.

3.4 Primary Power. Primary power is that power provided from (a) one or more of the LM fuel cell powerplants, (b) the dc ground power supply or backup battery, or (c) any combination of these sources.

3.5 Utilization Equipment. Utilization equipment is any equipment which operates from primary power.

NOTE: Devices such as circuit breakers, fuses, relay contacts, cables, etc. which are necessary for the distribution and control of primary power shall not be considered as utilization equipment. Devices such as inverters, converters, filters, etc. which intentionally condition the power obtained from the primary power sources shall be considered as utilization equipment.

3.6 Steady-State Voltage. The steady-state voltage is a dc voltage which is fixed in value for a given set of system operating conditions. The value of steady-state voltage will change as a function of load demand and primary power source capacity.

3.7. Ripple. Ripple is a periodic variation of voltage about the steady-state voltage and may be of any repetitive waveform.

3.8 Transients. A transient is a non-periodic variation of voltage of any waveform. The transient may be a single excursion of either positive or negative polarity, but will usually contain multiple excursions of a damped oscillatory nature.

NOTE: Examples of steady-state, ripple, and transient voltages are shown in Figure 1.

3.9 Power Interruption. A power interruption is (a) a transient undervoltage condition which exceeds the lower limit transient voltage envelope specified for normal electric system operation, or (b) a power outage which is the complete loss of primary power at the input terminals of the utilization equipment.

D ~~SECRET~~ PRELIMINARY

SPECIAL HANDLING

4. DETAIL REQUIREMENTS

4.1 Utilization Equipment Classification. The utilization equipment shall be classified in accordance with its functional requirements during the modes of electric system operation specified herein. Class I equipment shall be supplied power from the auxiliary bus; Class II equipment from the main bus; and Class III equipment from the inhibit bus. The applicable classification shall be specified in the equipment specification.

that equipment

4.2 Utilization Equipment Turn-On. The single event transient voltage limits specified herein are based in part on restricting the maximum charging current surge permitted during utilization equipment turn-on. No utilization equipment shall present a single event charging current surge in excess of the following criteria: That portion of the utilization equipment input impedance which can be represented by an equivalent shunt capacitor, shall not exceed 0.5 microfarad per watt of the steady-state power specified in the equipment specification.

4.3 Utilization Equipment Input Power Quality. When use of power is required having other characteristics or closer tolerances than specified herein, the conversion to such characteristics shall be accomplished as part of the utilization equipment.

4.3.1 Normal Electric System Operation. The following requirements are applicable to all classes of utilization equipment unless otherwise noted. When supplied with primary power having the characteristics specified in this paragraph the utilization equipment:

(a) Shall meet performance requirements specified in the equipment specification for normal electric system operation.

(b) Shall remain safe.

4.3.1.1 Steady-State Voltage. The steady-state voltage at the input terminals of the utilization equipment shall remain within the limits of 22 to 31 volts dc (ripple not included).

4.3.1.2 Ripple. The frequency components of the ripple voltage at the input terminals of the utilization equipment shall not exceed the limits shown in Figure 2.

4.3.1.3 Transient Voltages. As a result of single event switching in other parts of the Electrical Power System, the transient voltages at the input terminal of any given utilization equipment shall not exceed the limits specified below:

4.3.1.3.1 Transient Overvoltages. Single event transient overvoltages shall not exceed Limit 1 of Figure 3.

4.3.1.3.2 Transient Undervoltages. Single event transient undervoltages shall not exceed Limit 2 of Figure 3.

4.3.1.4 Power Outage. (Applicable to Class III utilization equipment only). During normal electric system operation, Class III equipments shall be capable of experiencing power outages (pp 3.9b). These outages will occur on a scheduled basis rather than at random. The duration of any single power outage shall not exceed 25 minutes.

4.3.2 Abnormal Electric System Operation. The following requirements are applicable to all classes of Utilization Equipment unless otherwise noted. When supplied with primary power having the characteristics specified in this paragraph, the utilization equipment:

(a) Shall meet performance requirements specified in the equipment specification for abnormal electric system operation.

(b) Shall remain safe.

(c) Shall, on return of primary power to normal electric system operation:

(1) Recover in accordance with requirements in the detail equipment specification, and

(2) Provide specified performance with no degradation in reliability resulting from the abnormal electric system operation.

4.3.2.1 Steady-State Overvoltage. The steady-state overvoltage at the input terminals of the utilization equipment shall not exceed 33 volts dc (ripple not included).

4.3.2.2 Steady-State Undervoltage. The steady-state undervoltage at the input terminals of the utilization equipments shall not be less than 20 volts dc, (ripple not included).

4.3.2.3 Ripple. The frequency components of the ripple voltage at the input terminals of the utilization equipment shall not exceed the limits shown in Figure 2.

4.3.2.4 Transient Overvoltages. Single event transient overvoltages at the input terminals of the utilization equipment shall not exceed Limit 3 of Figure 3.

4.3.2.5 Power Interruption.

4.3.2.5.1 Transient Undervoltages. Single event transient undervoltages at the input terminals of the utilization equipment shall not exceed Limit 4 of Figure 3.

4.3.2.5.2 Power Outage. In addition to power outages specified for Class III Utilization equipment during Normal Electric System Operation (Paragraph 4.3.1.4), all classes of utilization equipment may experience a contingency mode of power outage under the provisions of Abnormal Electric System Operation. This condition could occur as the result of a combination of component failures, or mismanagement of the primary power system. In the event of such a contingency, the period of power outage will vary for the different classes of utilization equipment as follows.

4.3.2.5.3 Class I Equipment. For Class I utilization equipment the maximum duration of power outage shall be 50 milliseconds.

4.3.2.5.4 Class II Equipment. For Class II utilization equipment the duration of power outage is indeterminate.

4.3.2.5.5 Class III Equipment. For Class III utilization equipment, the duration of power outage is indeterminate.

4.4 Electromagnetic Compatibility. Susceptibility to and generation of electromagnetic interference is controlled by the specific equipment specification. The requirements of this Power Quality standard are contingent on all utilization equipments meeting their specification requirements.

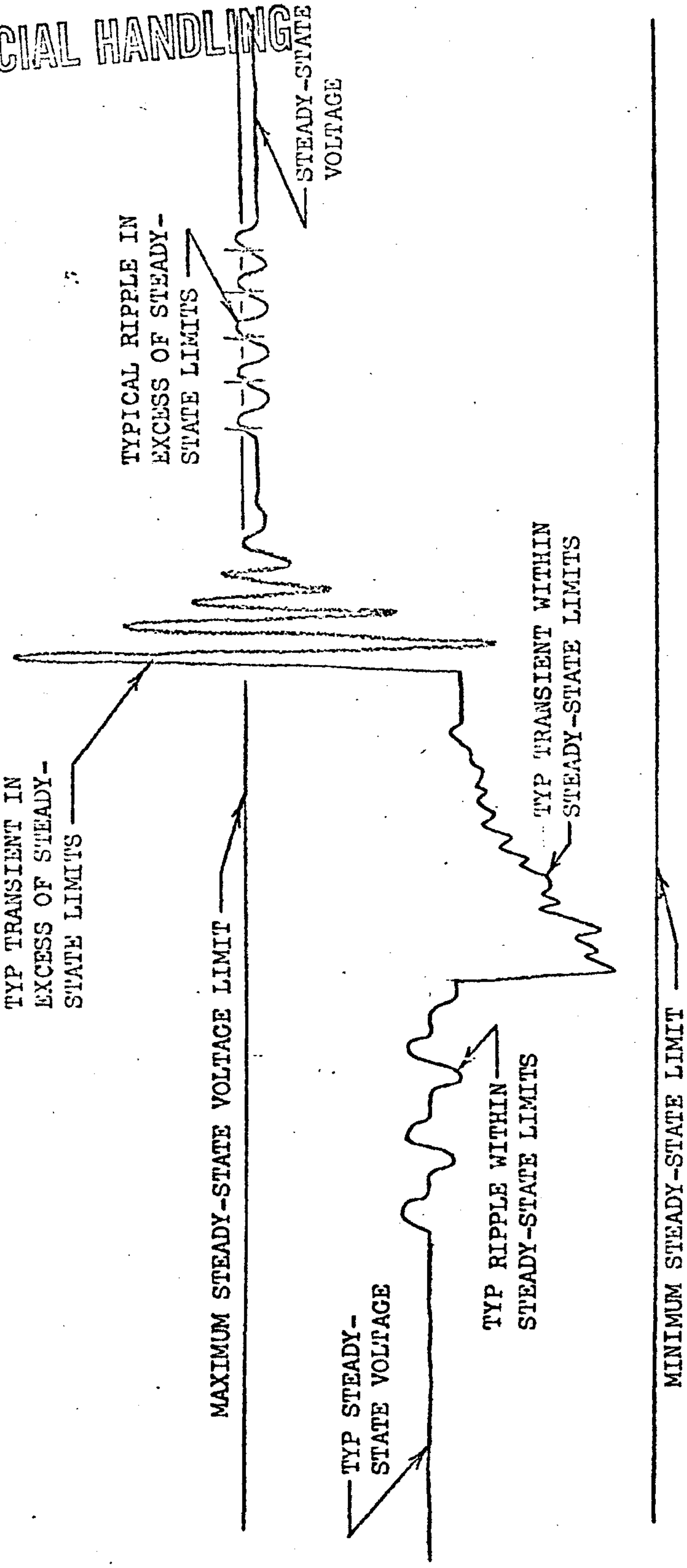
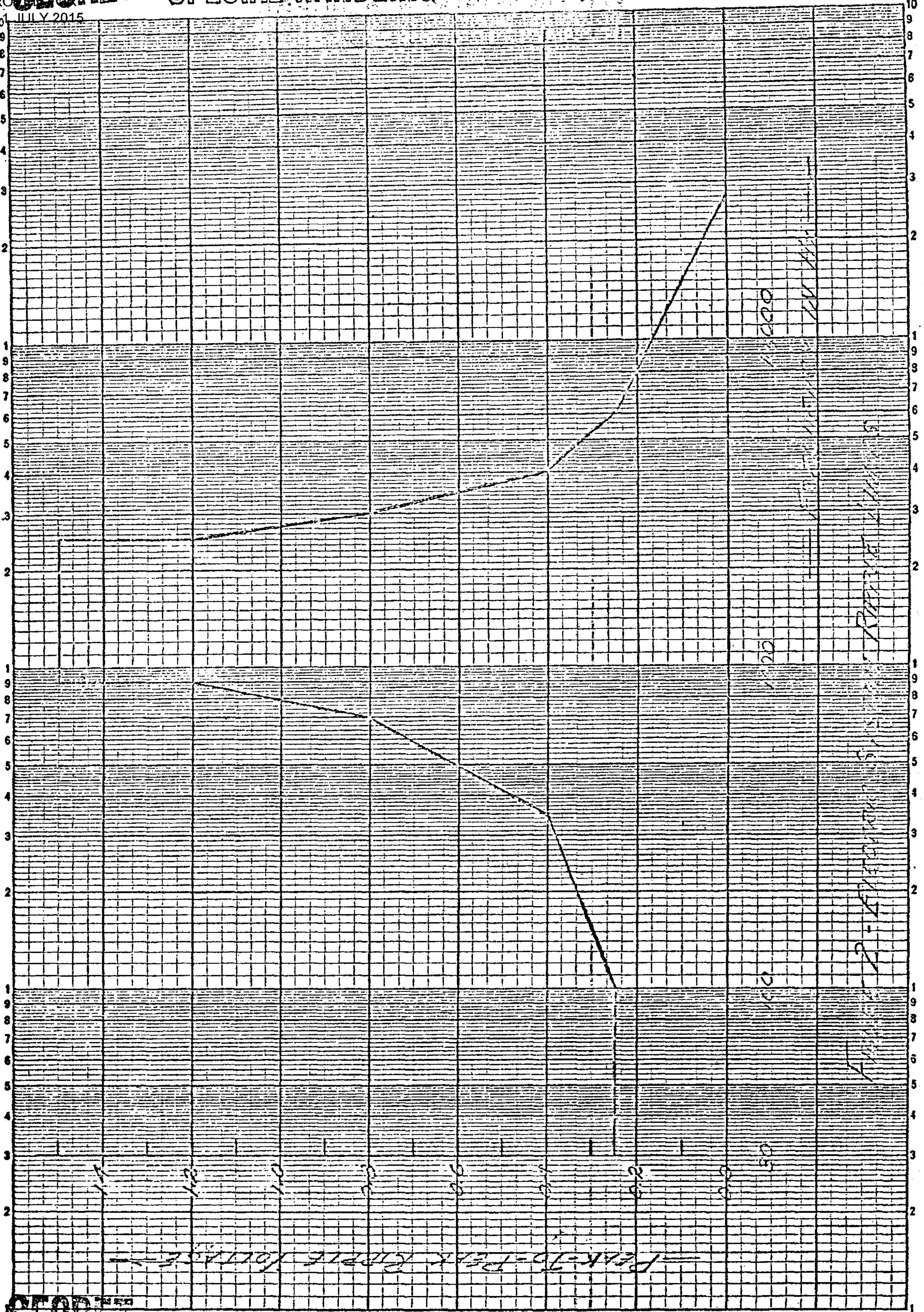


FIGURE 1 - EXAMPLES OF STEADY-STATE, RIPPLE, AND TRANSIENT VOLTAGES



MODEL

DATE

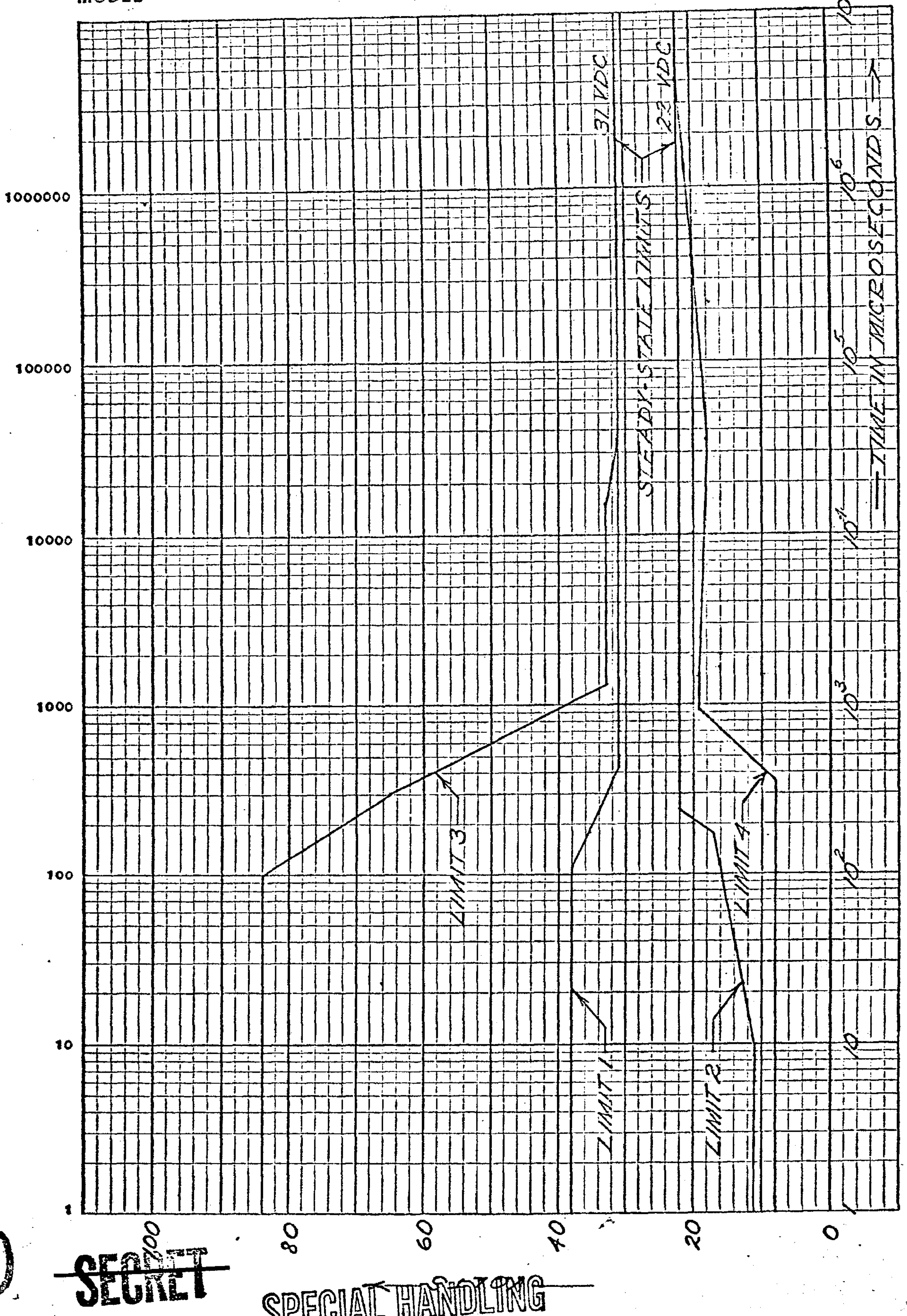


FIGURE 3 - ENVELOPES OF SINGLE EVENT TRANSIENT VOLTAGES INDICATING RECOVERY TO STEADY-STATE LIMITS

D

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SPECIAL HANDLING

MEMORANDUM

Date: APR 19 1967
A3-810-EBCO-M-055

TO: M. H. Peairs, A3-810

FROM: I. B. Friedman, A3-810; Ext. 3004

SUBJECT: SUPPORTING DATA FOR PROPOSED REVISION TO STD 0003

COPIES TO: S. G. Blankenship, M. W. Ralsten, R. C. Weaver, A3-810; File

THIS COPY FOR

The test report transmitted herewith, provides the backup data supporting the proposed revisions to the MOL Power Quality Standard STD 0003. This report, and the proposed revisions to the Standard, were submitted to SPO/Aerospace on 12 April 1967.

I. B. Friedman
Power Distribution Section

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SPECIAL HANDLING

POWER SYSTEM TRANSIENT RESPONSES AND RIPPLE TESTS

SCOPE: This report contains a summary of the data used to define the primary power quality for the MOL Laboratory Module.

PURPOSE: The purpose of this report is to provide backup data to supplement and support the proposed revisions to the MOL Laboratory Module Power Quality Standard (dated 12 April 1967--Preliminary).

TRANSIENT TESTS

The electrical system was simulated using lumped, bilateral, and passive elements. A fuel cell approximation was synthesized from an equivalent circuit provided by Pratt and Whitney Aircraft. Cables and wires were simulated by inductors in series with resistors. All protective devices, relay contacts and connectors were simulated by resistors. Utilization equipment was simulated by resistors and capacitors. Inductors were not included in the simulated utilization equipment as the transient response of the system improves with the addition of inductors. All impedances were scaled up by a factor of 10^5 in order to keep component values within practical limits.

The entire electrical system was reduced to a power source, a distribution network and three simulated loads operating in parallel. These loads served the following purpose:

a. A single composite load representing a large percentage of the utilization equipments, equal to one kw.

b. A single (composite) load representing utilization equipment which when switched "on" or "off" produces an electrical disturbance.

c. A third single load representing a typical utilization equipment at whose terminals the influence of the above electrical disturbance was measured.

For the transient producing loads three types were considered:

a. A 300 watt motor simulated by a resistor in parallel with a comparatively large capacitor and small resistor in series.

b. A typical load of 1000 watts simulated by a resistor in parallel with a comparatively small capacitor.

c. A maximum fault load of 0.1 ohm simulated by a resistor in series with a 15 amp magnetic circuit breaker.

The transient tests consisted of turning "on" or "off" the various transient producing loads, and recording the disturbance. System parameters were varied with each type of load to determine those combinations producing the maximum transient voltages. In determining these effects, the following variations and their combinations were made:

a. Effect when operating from three fuel cell powerplants, located 15 feet from the main bus, one fuel cell powerplant (in assumed high temperature mode) located 20 feet from the main bus, and from the ground power supply located near the J box or 100 feet from the main bus.

b. Effect of varying the load feeder distribution line length from very near to 30 feet from the main bus.

c. Effect of step load changes of 1000 watts, and of 0.1 ohm faults.

d. Effect of varying the one kw load filter capacitors from 10 to 500 microfarads.

e. Effect of adding suppression capacitance of 50 to 150 microfarads across the main bus, and up to 1000 microfarads at the umbilical connector.

In each case the disturbance was recorded on film from an oscilloscope trace.

Transient voltage envelopes were constructed from these pictures.

RIPPLE TESTS

The ripple tests were based on the narrowband conducted interference limits, shown in Figure 2 of SAFSL Exhibit 11005. As an approximation on a system level with one fuel cell operating in the high temperature mode, the allowable current was doubled. The currents were introduced into the circuit from a signal generator simulating ripple producing loads. The voltage ripple produced, as a result of these currents, was measured at the load representing a typical utilization equipment. System parameters were again varied to determine worst case conditions.

Ripple frequency response curves were constructed from the data.

ADDITIONAL NOTES

From its specification the ground power supply has a maximum dynamic transient response of 3 volts for a load change of 250A. From the tests specified herein, a one kw load change corresponds to an approximate 35A current change. The maximum power supply voltage change for a 1 kw load change consequently is 0. 42 volts. The response time of the power supply is 100 milliseconds.

TEST DATA

The attached data and calculations provide a record of the results used to redefine the power quality limits.

4

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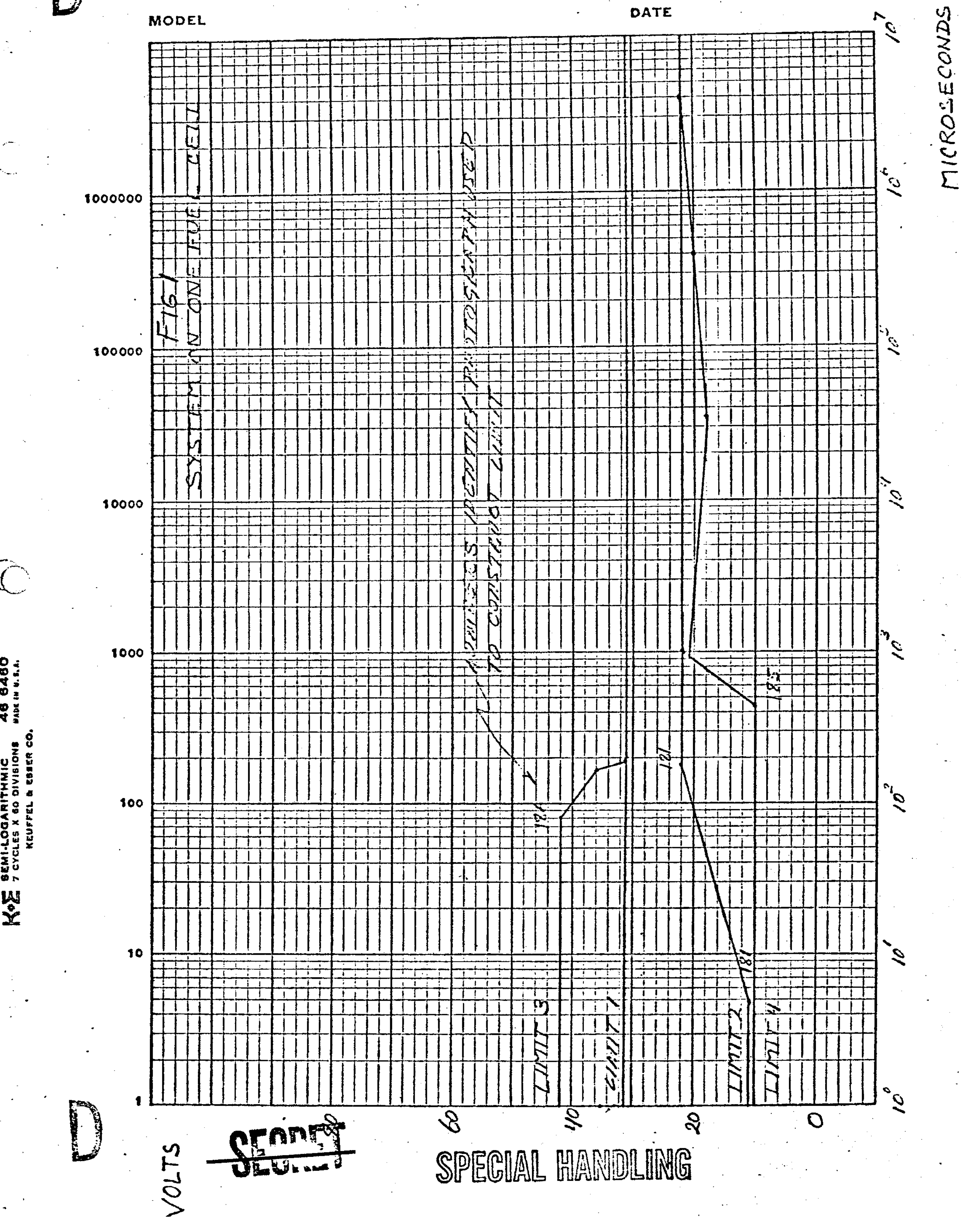

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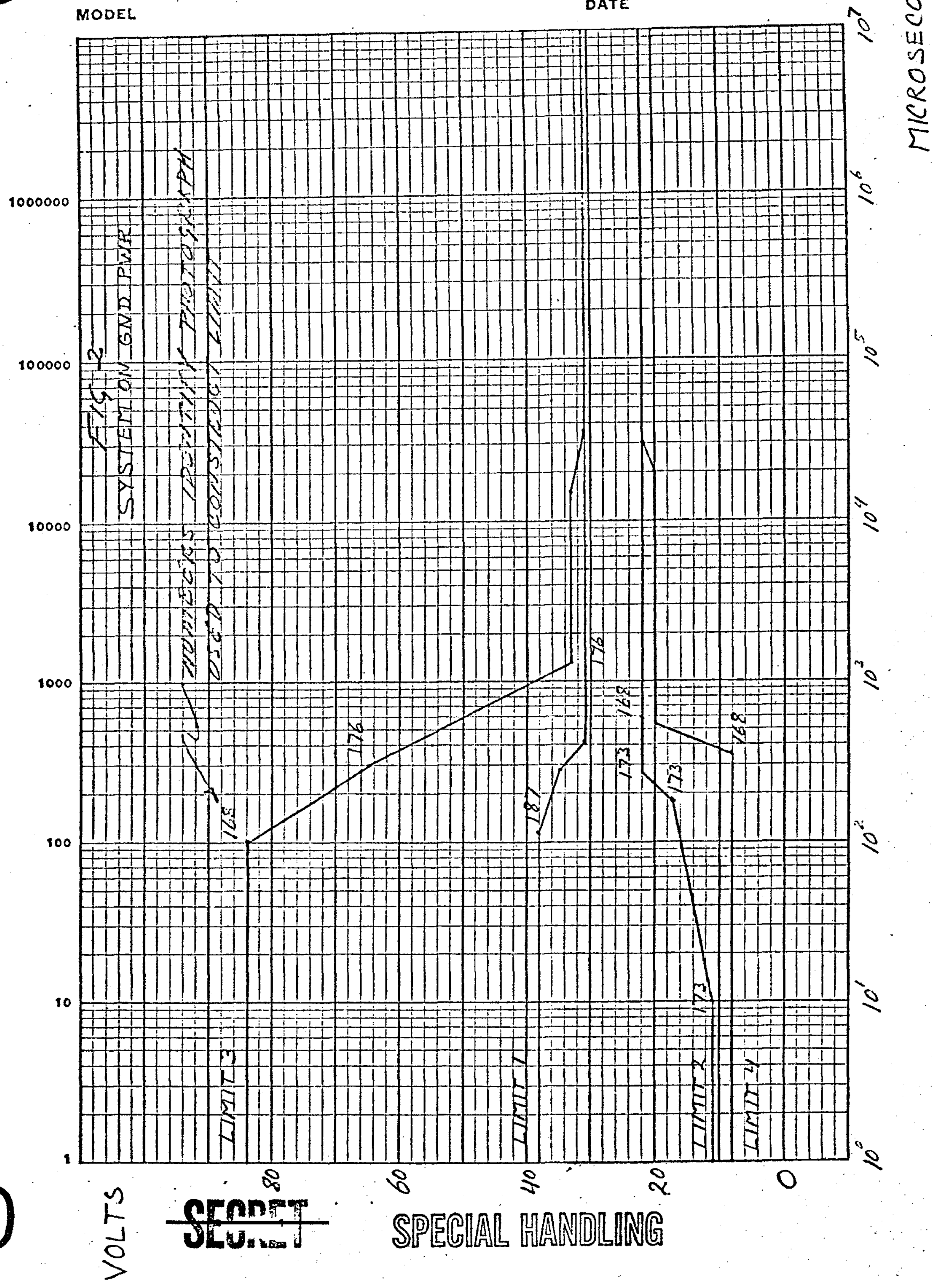
SPECIAL HANDLING

MODEL DATE



K+E SEMI-LOGARITHMIC 46 6460
7 CYCLES X 60 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

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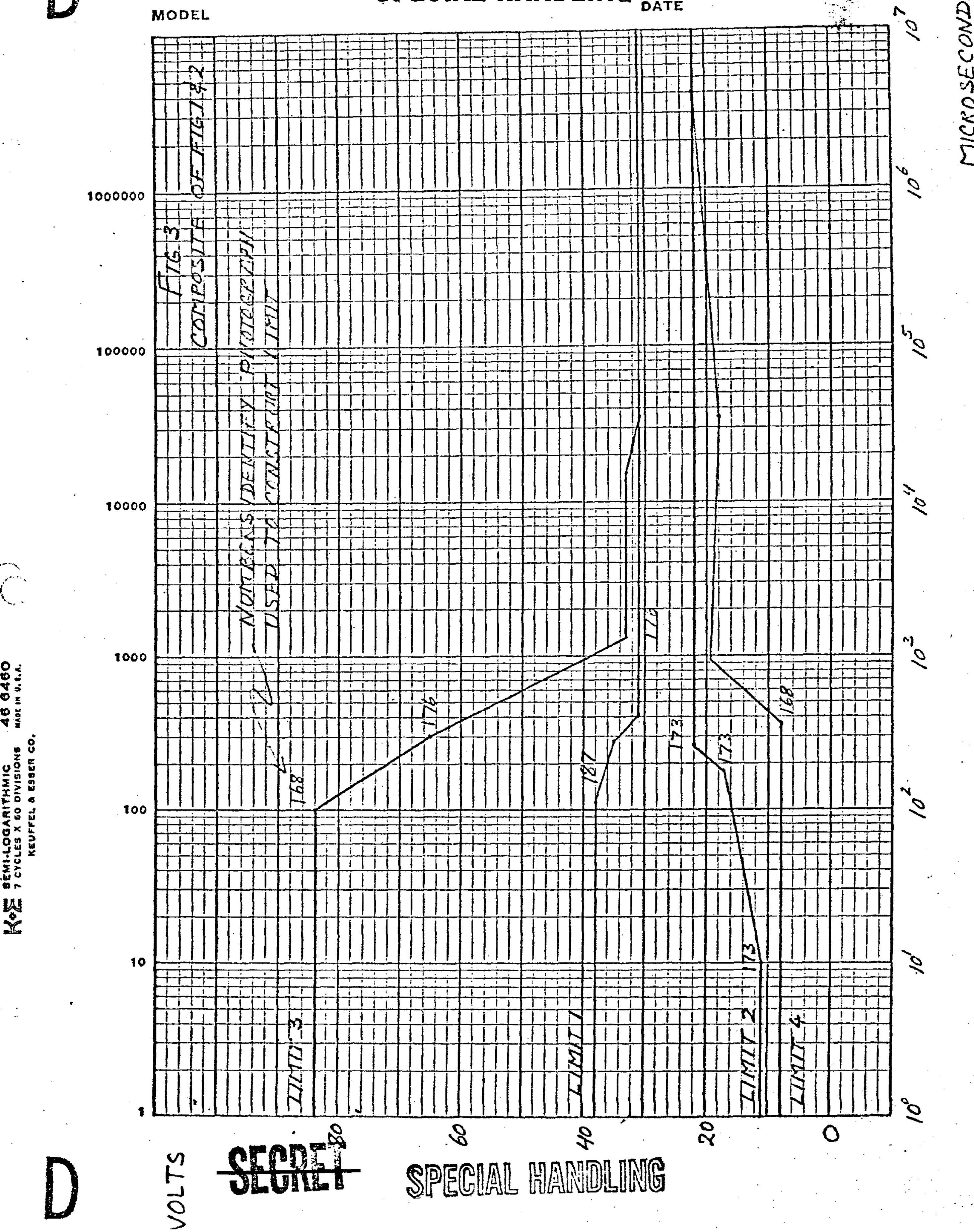
SPECIAL HANDLING



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SPECIAL HANDLING

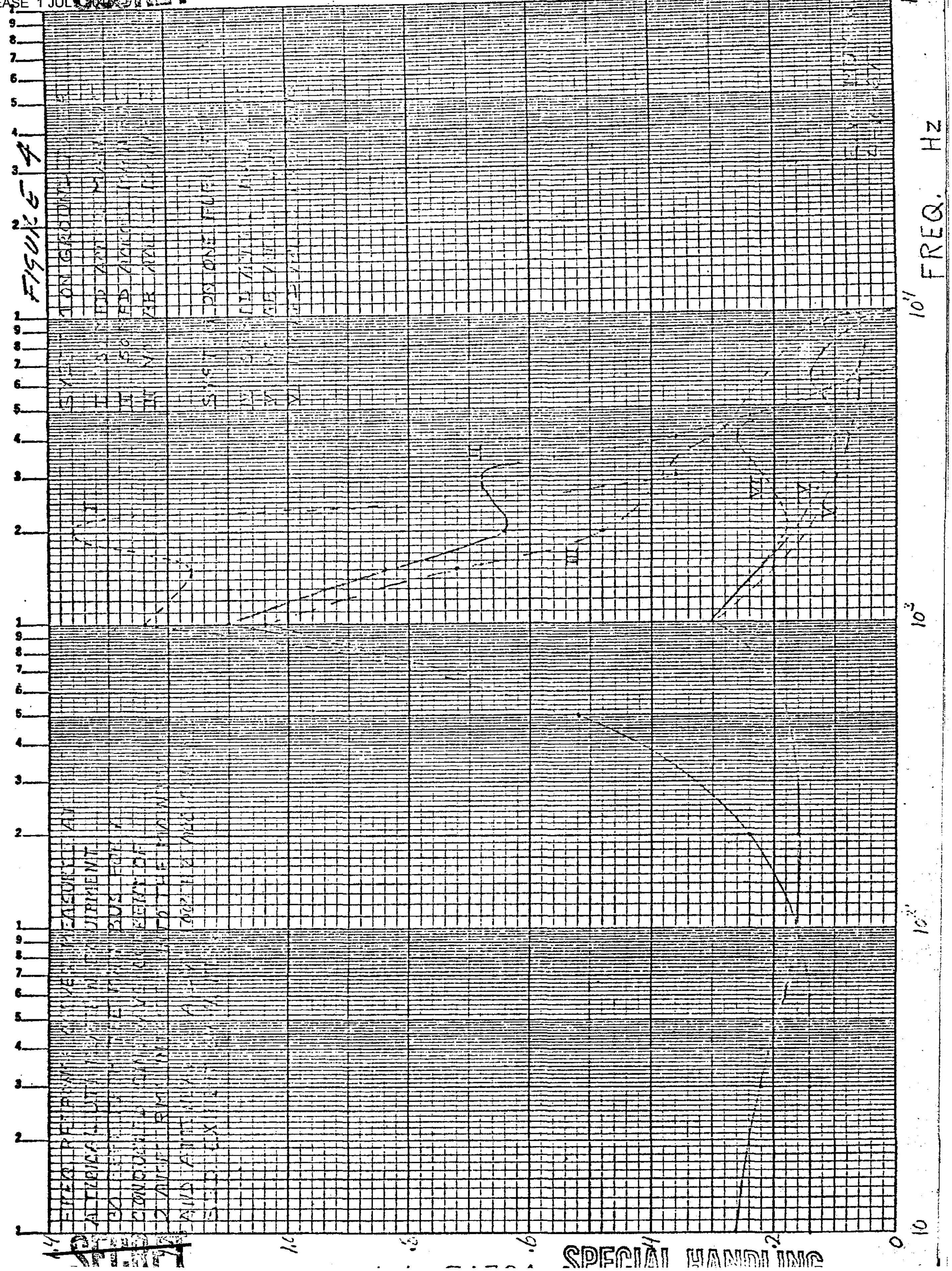


FIGURE E-4
FREQ. Hz
KE SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS

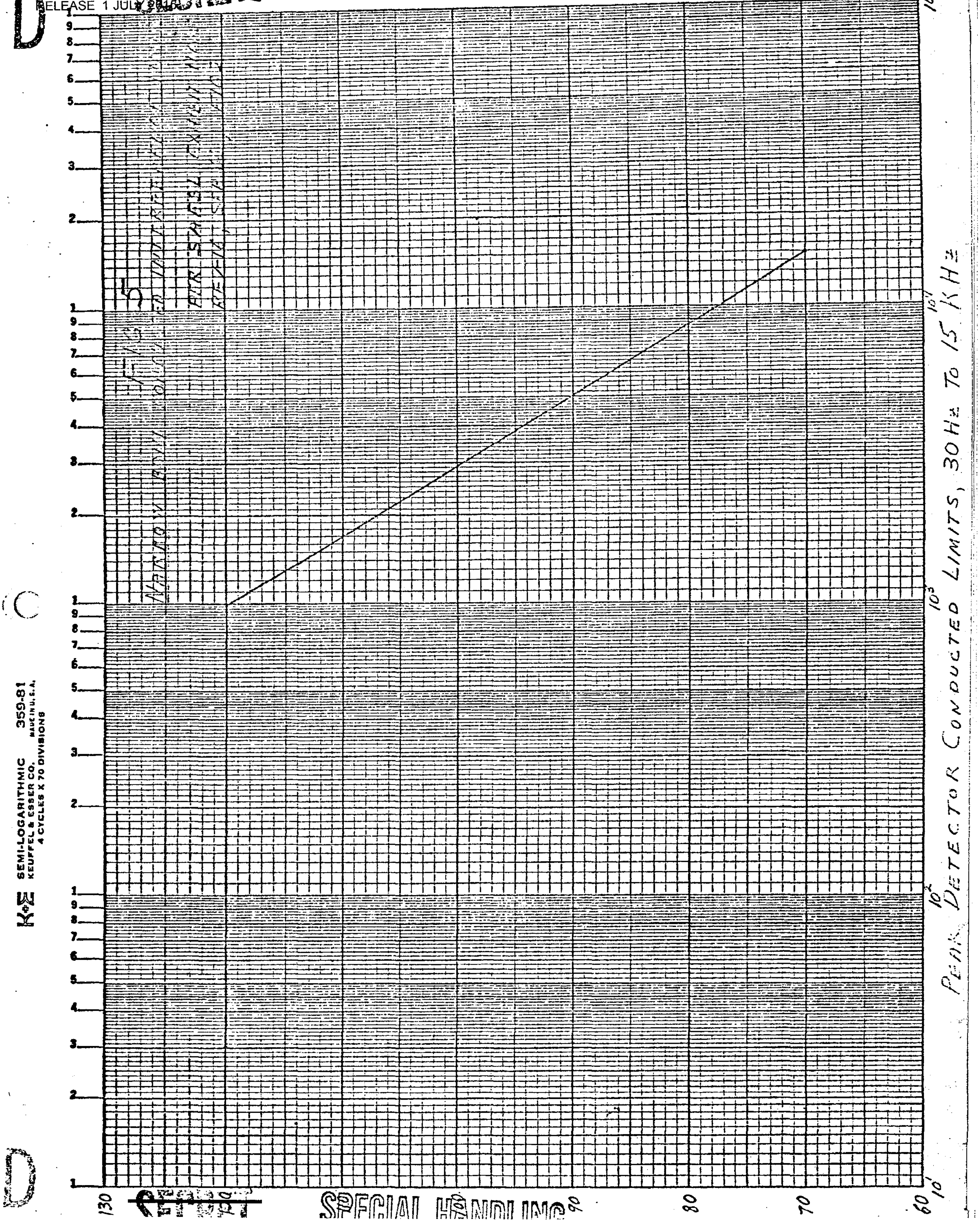

PEAK DETECTOR CONDUCTED LIMITS, 30 Hz TO 15 KHz
FIG 5
SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
130
90
80
70
60

FIG 8

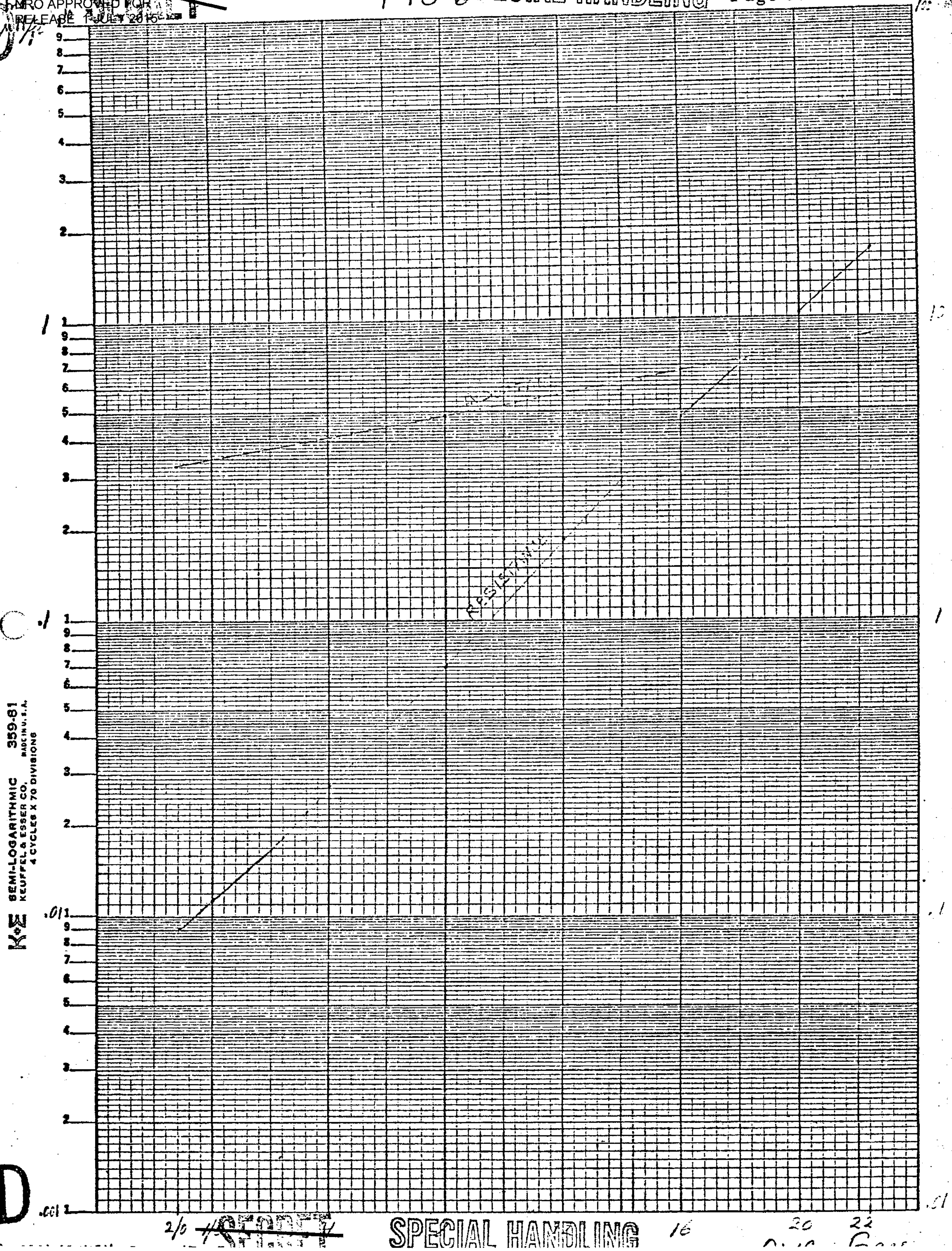

RESISTANCE
SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS

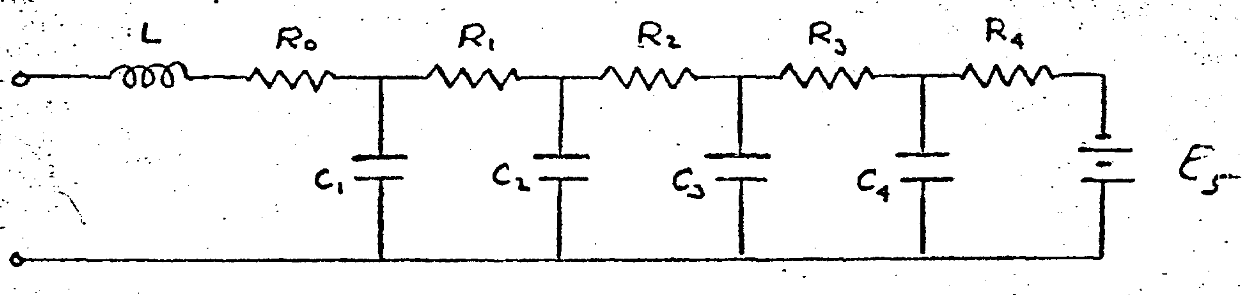
FIGURE 8
~~TABLE~~

MOL POWERCEL EQUIVALENT CIRCUIT

ALTERNATE

		3 POWERPLANTS OPERATING			2 POWERPLANTS OPERATING		
POWER ~ WATTS		600	900	1200	800	1200	1800
TEMPERATURE ~ F		387	387	387	436	436	436
CONCENTRATION ~ % H_2O		28.7	28.7	28.7	24	24	24
R_0	OHMS	0.0162	0.0162	0.0162	0.0154	0.0154	0.0154
R_1	OHMS	0.0177	0.0150	0.0121	0.0150	0.0121	0.0098
R_2	OHMS	0.0321	0.0278	0.0212	0.0278	0.0212	0.0145
R_3	OHMS	0.0500	0.045	0.0285	0.045	0.0285	0.0166
R_4	OHMS	0.0540	0.036	0.021	0.036	0.021	0.0137
C_1	FARADS	0.0445	0.0478	0.055	0.0478	0.055	0.0702
C_2	FARADS	0.144	0.237	0.28	0.237	0.28	0.366
C_3	FARADS	0.50	0.825	1.03	0.825	1.03	1.56
C_4	FARADS	2.78	5.15	9.35	5.15	9.35	9.53
L	HENRYS	1.7×10^{-7}	1.7×10^{-7}	1.7×10^{-7}	1.7×10^{-7}	1.7×10^{-7}	1.7×10^{-7}

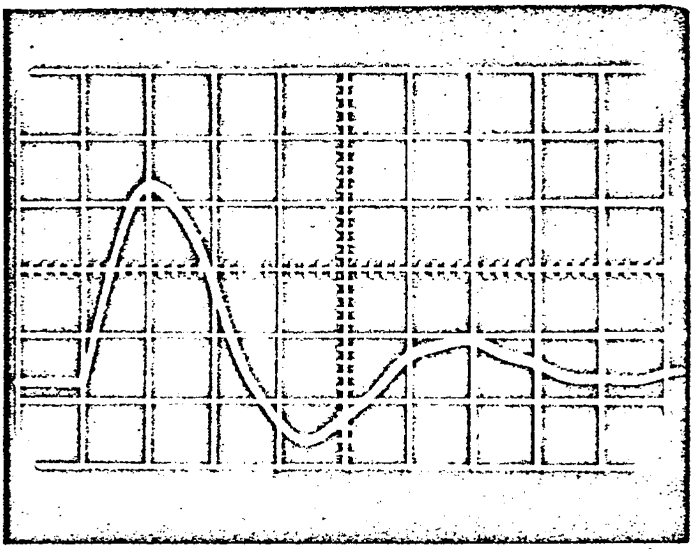
values per F.C.



.0162
.0121
.0212
.0285
.021
.0990 Ω

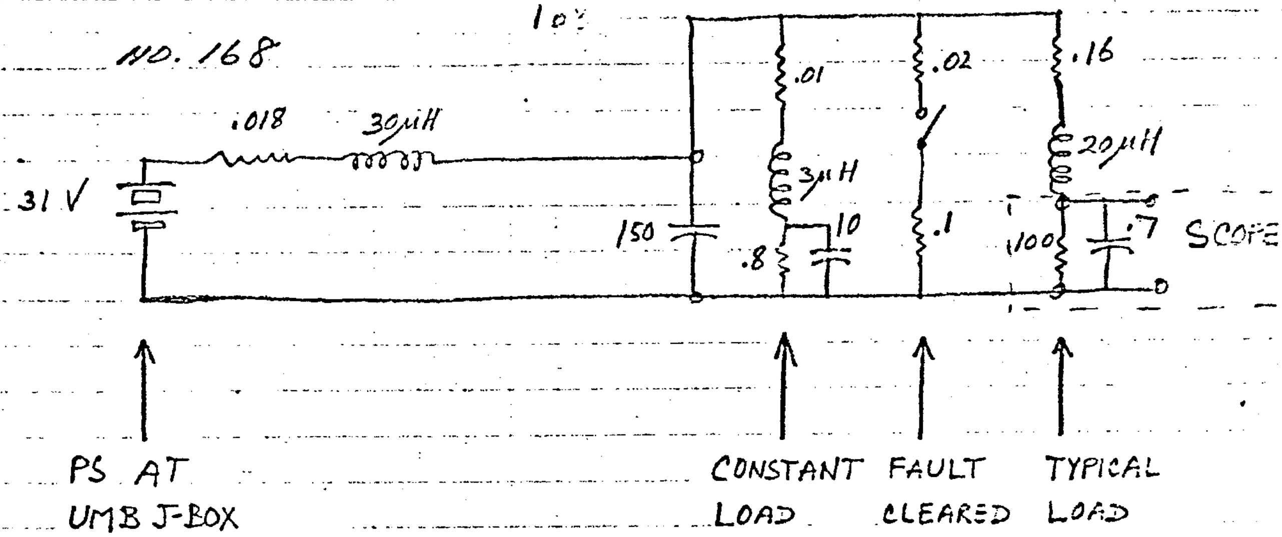
D ~~SECRET~~ SPECIAL HANDLING

Ground power. Power supply near umbilical J-box.
A .1 ohm fault cleared.
Small input capacitors.



Sens:
Vert 20V/cm, centerline = 60
Hor 100 microsec/cm.

Switch opened at t = 50 microsec

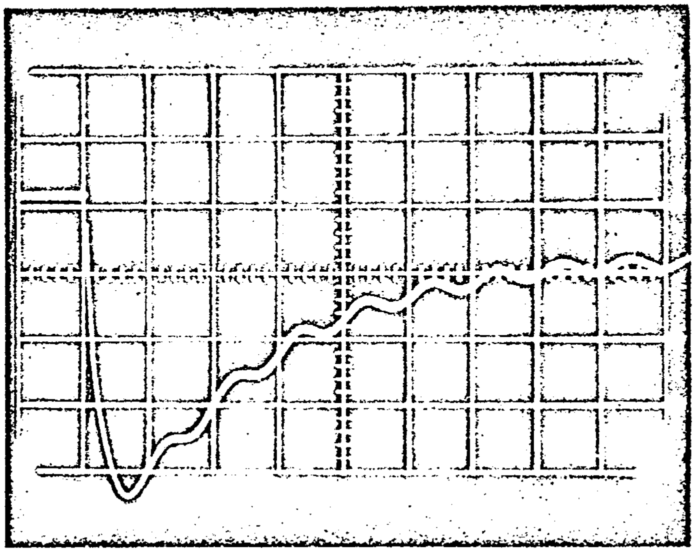


D ~~SECRET~~ SPECIAL HANDLING

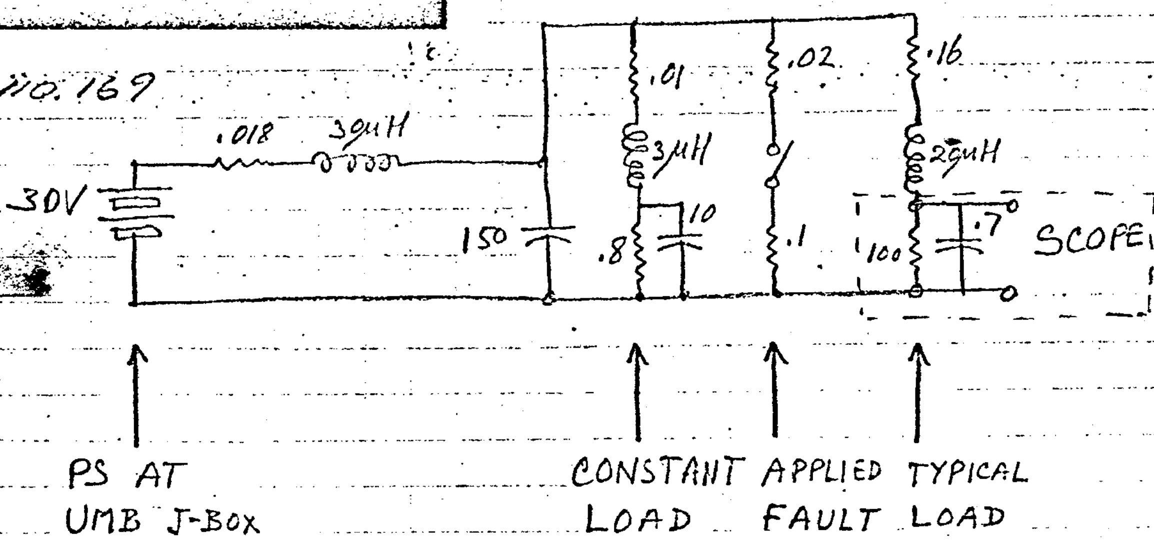
D ~~SECRET~~ SPECIAL HANDLING

Ground power. Power supply near umbilical J-box.
A .1 ohm fault applied.
Small input capacitor.
Sens: Vert 5V/cm, centerline = 25V
Hor 100 microsec /cm

Switch closed at t = 100 microsec



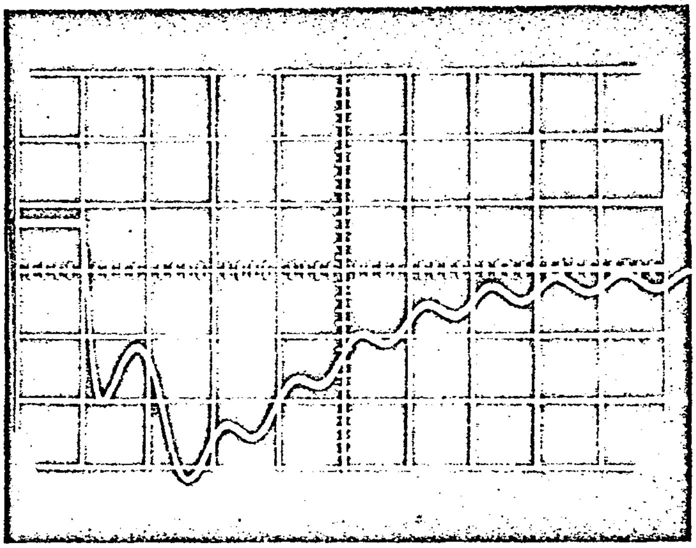
No. 169



D ~~SECRET~~ SPECIAL HANDLING

Ground power. Power supply near umbilical J-box.
A .1 ohm fault applied.
Large input capacitors.
Sens: Vert 5V/cm, centerline = 25V
Hor 100 microsec/cm.

Switch closed at t = 100 microsec



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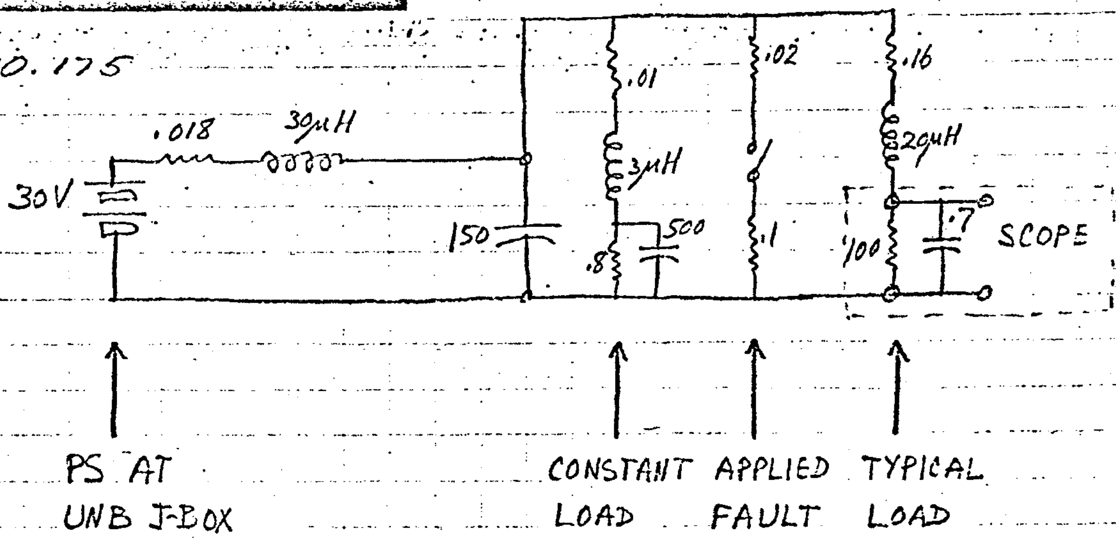
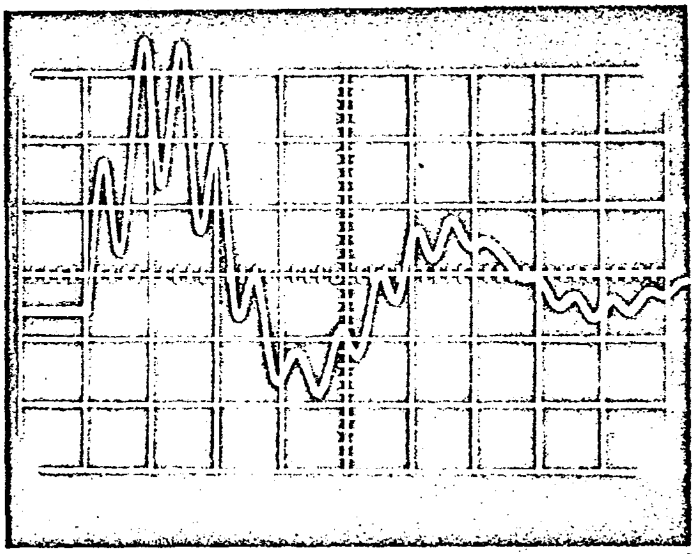
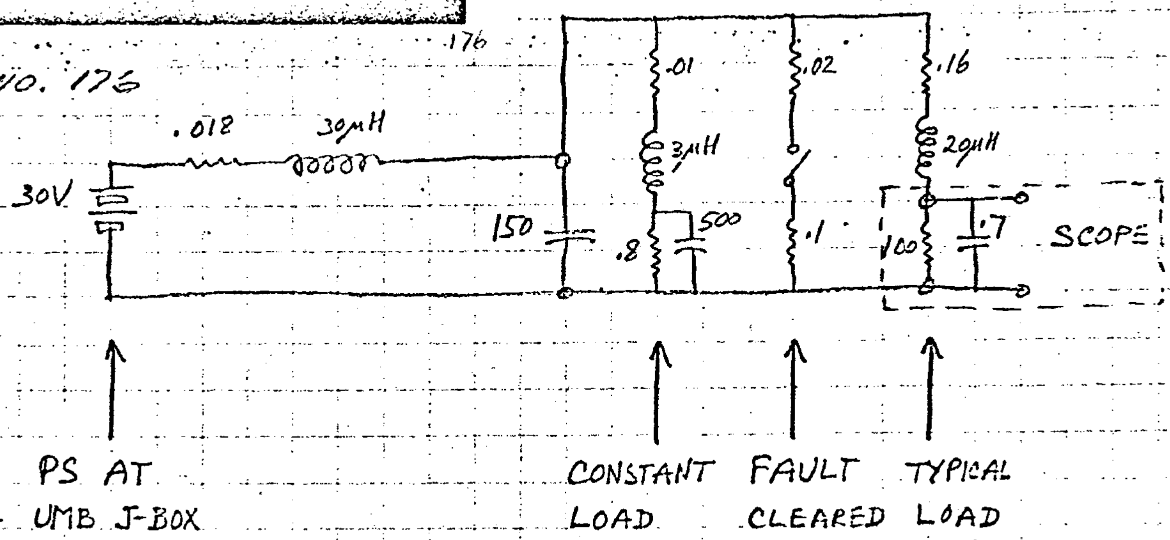


Ground power. Power supply near umbilical J-box.
A .1 ohm fault cleared.
Large input capacitor.
Sens: Vert 10V/cm, center line = 30V
Hor 100 microsec/cm



Switch closed at t = 100 microsec

No. 176



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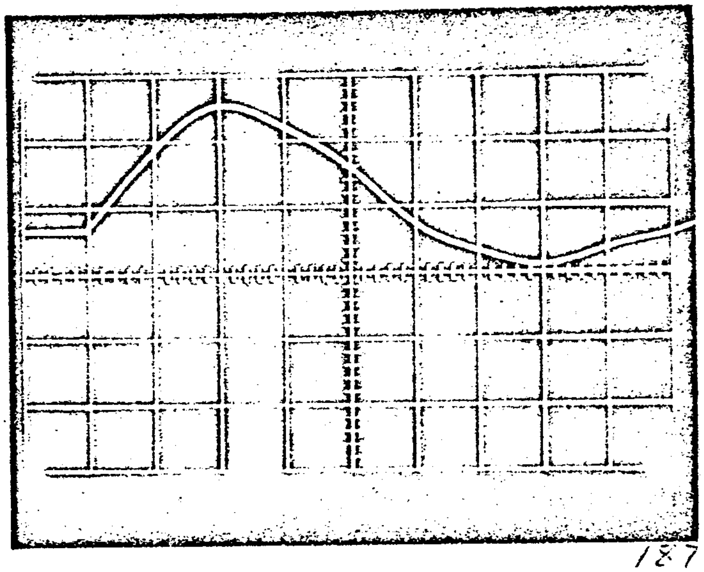
SPECIAL HANDLING

~~SECRET~~ ~~SECRET~~

Ground power. Power supply near umbilical J-box.

A 1KW load turn-off from an original 2KW load!!
Small input capacitors

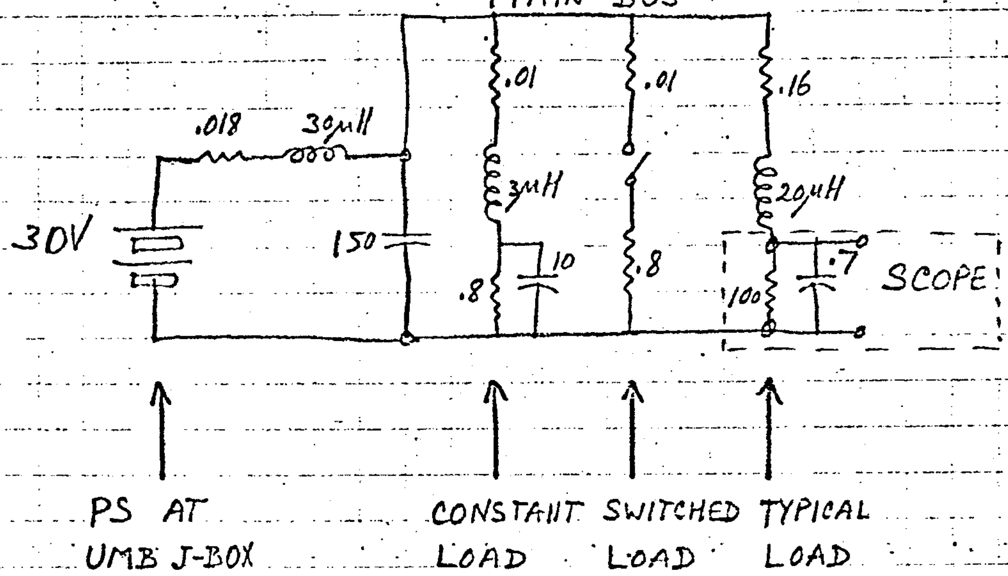


187

Sens: Vert 5V/cm, centerline = 25V
Hor 50 microsec/cm

Switch opened at t = 50 microsec

NO. 187



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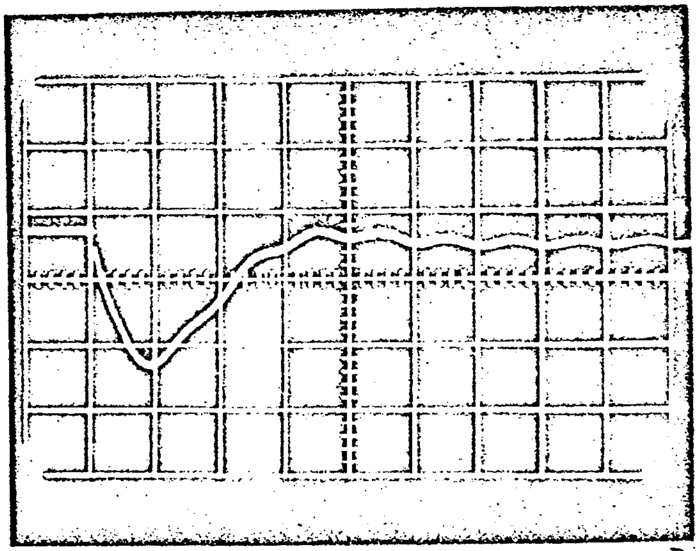
SPECIAL HANDLING

D ~~SECRET~~ SPECIAL HANDLING

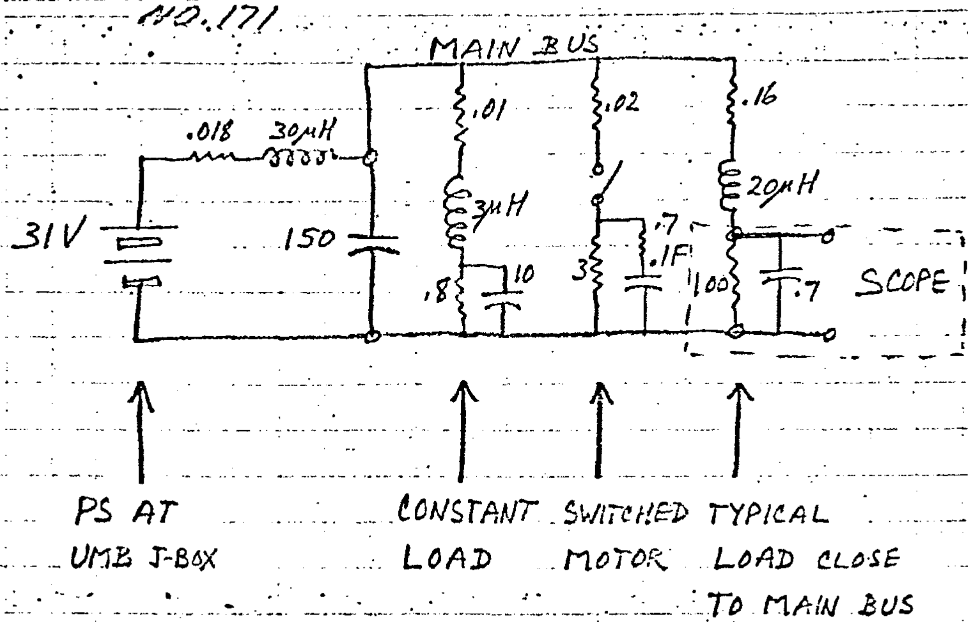
Ground power. Power supply near umbilical J-box.
A 300 W motor turn-on in addition to a 1 KW steady load.



Sens: Vert 5V/cm, centerline = 25V
Hor 100 microsec/cm

Switch closed at t = 100 microsec.

NO. 171

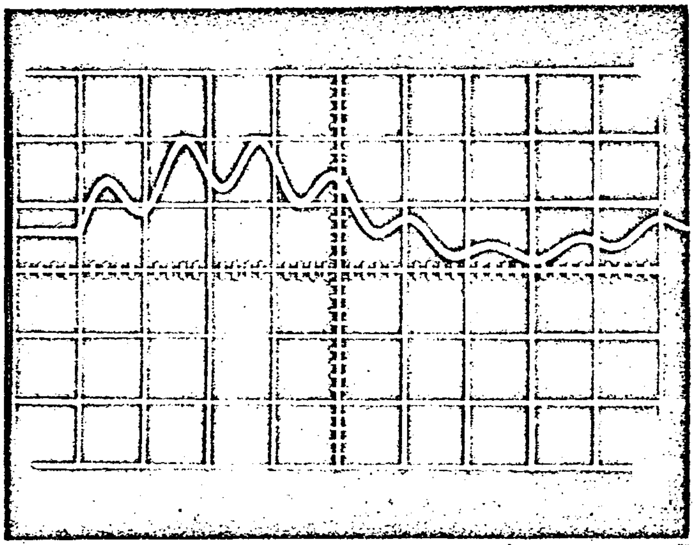


D ~~SECRET~~ SPECIAL HANDLING

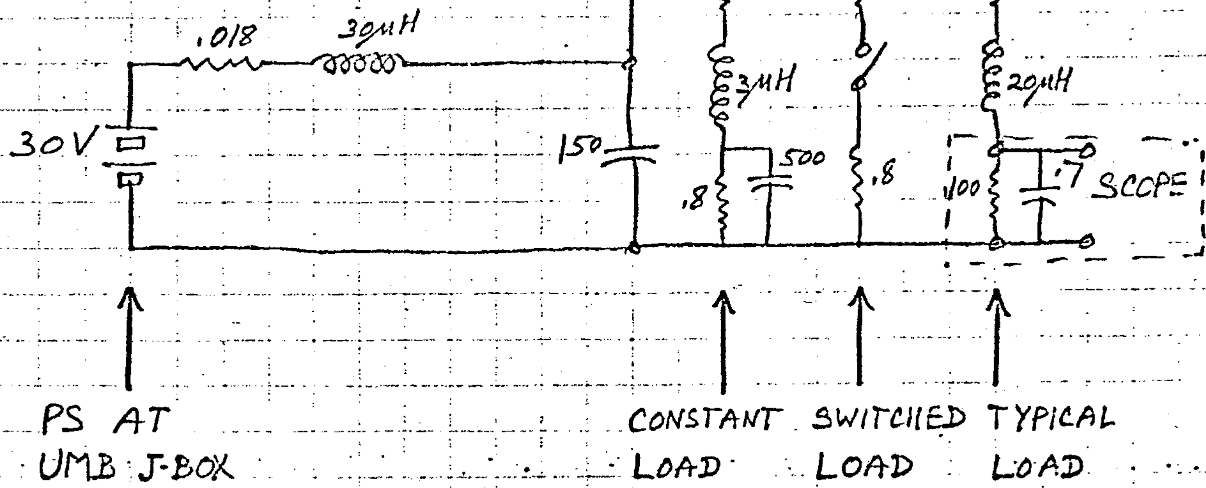
Ground power. Power supply near umbilical J-box.
A 1KW load turn-off from a
2KW initial load.

Sens: Vert 5V/cm, centerline = 25V
Hor 100 microsec/cm

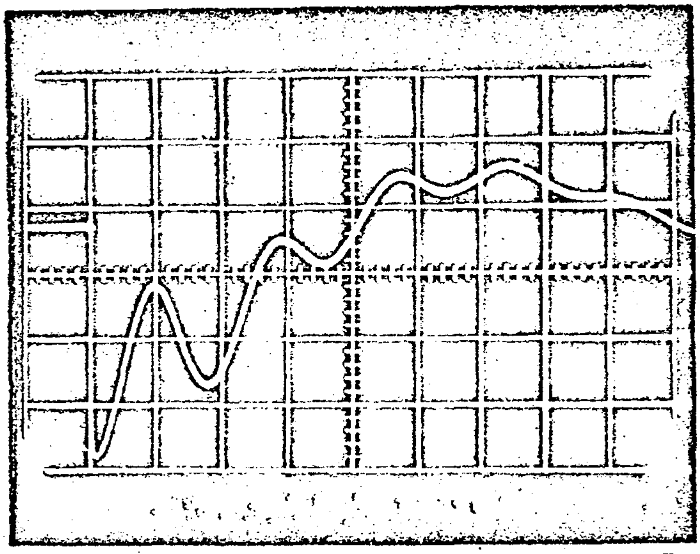
Switch opened at t = 100 microsec



NO. 174



Ground power. Power supply near umbilical J-box.
A 1KW load turn-on in addition to another 1KW load.

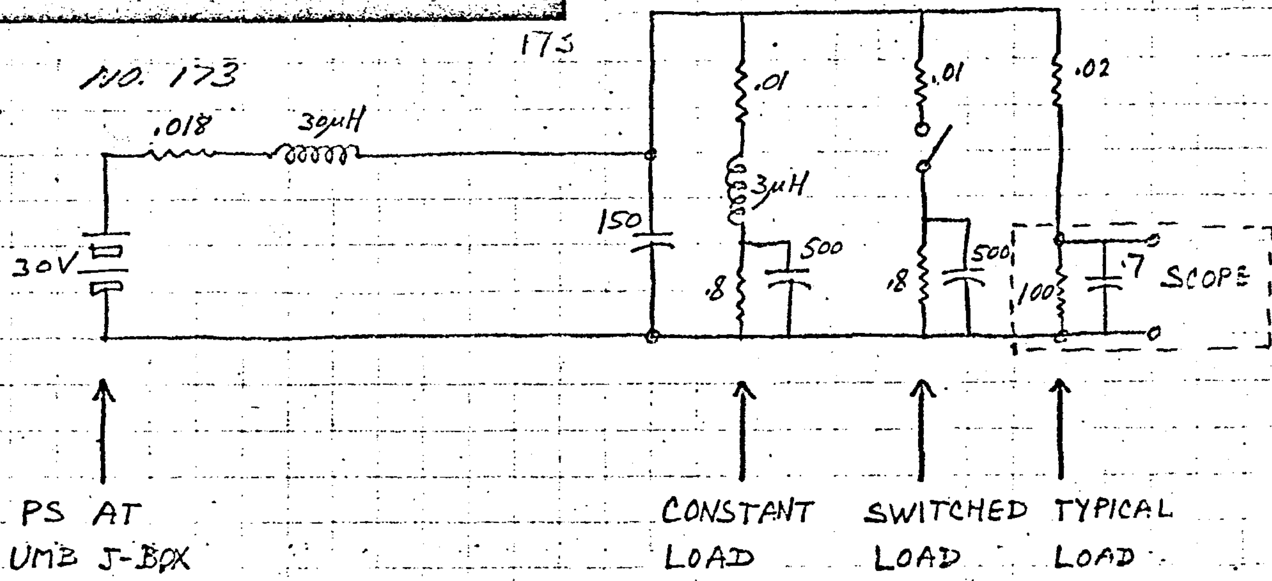


Sens: Vert 5V/cm, centerline = 25V
Hor 100 microsec/cm

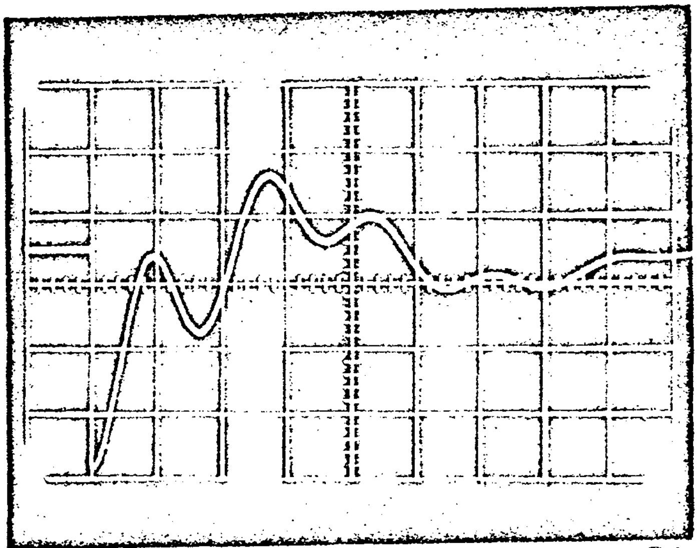
Switch closed at t = 100 microsec

175

NO. 173



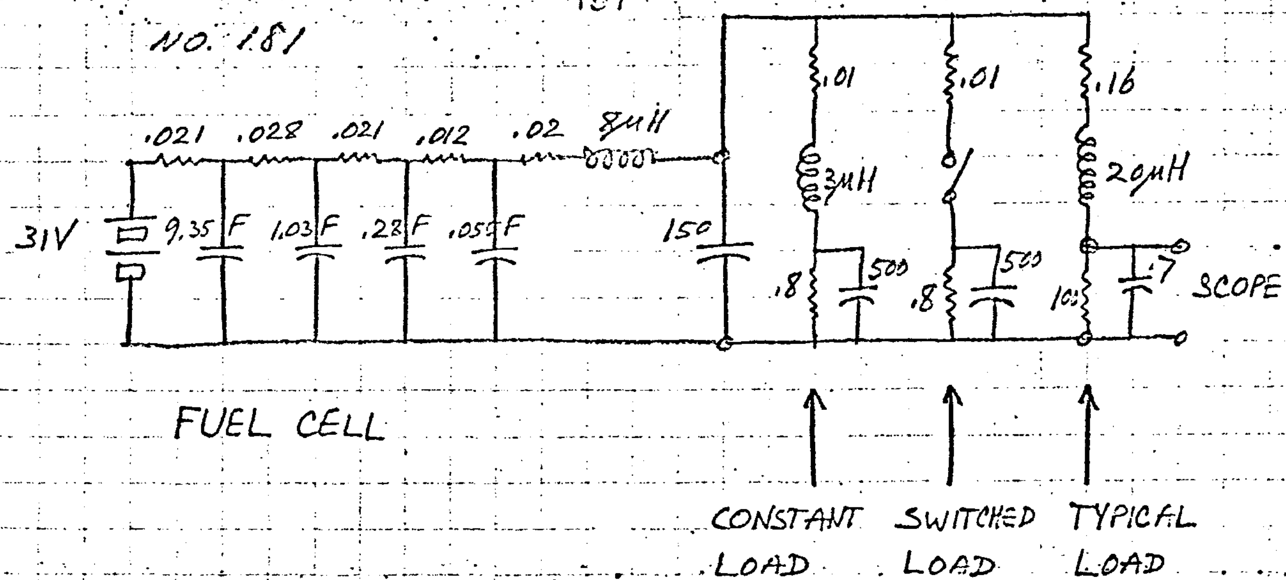
One fuel cell in the hot mode. A 1 KW load turn-on in addition to another 1 KW load.



181

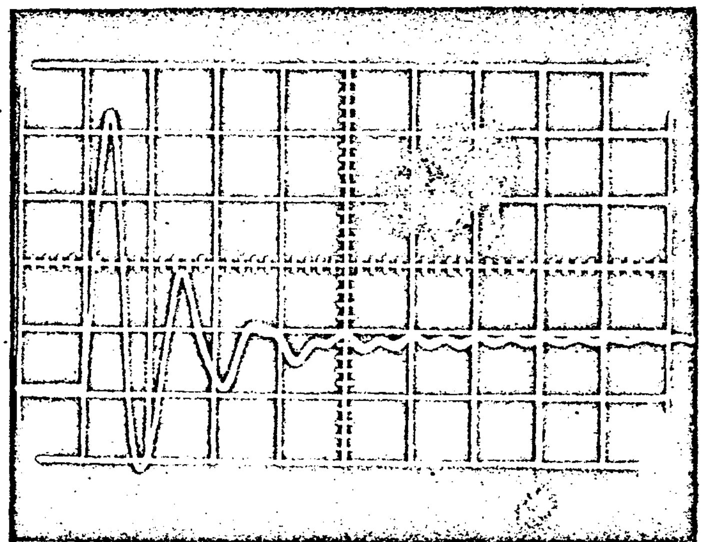
Sens: Vert 5V/cm, centerline = 25V
Hor 100 microsec/cm

Switch closed at t = 100 microsec



D

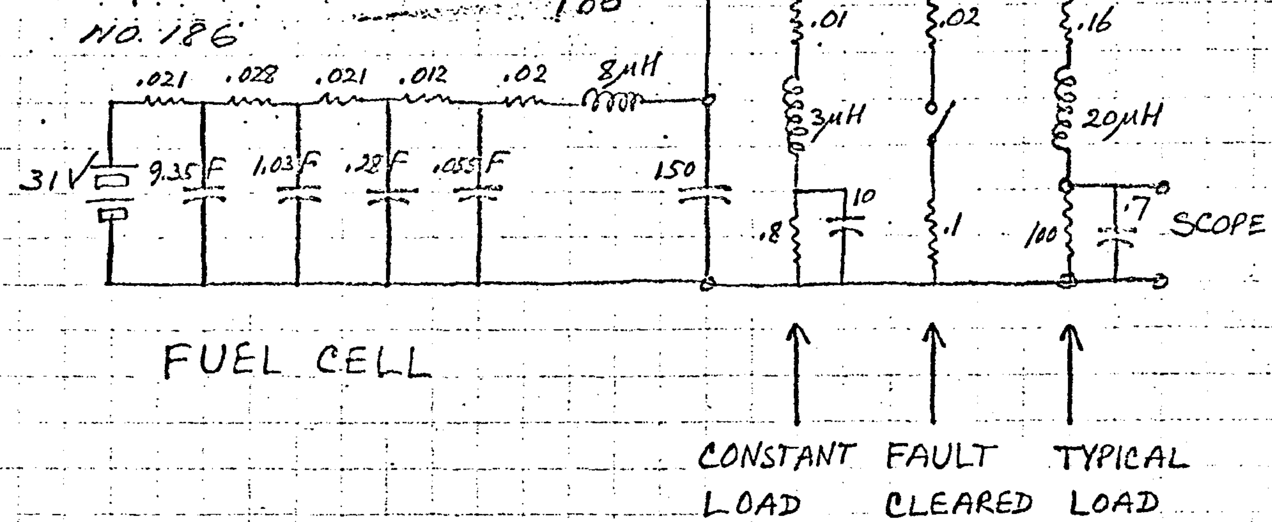
One fuel cell in the hot mode. A .1 ohm fault cleared.
Small input capacitors



Sens: Vert 5V/cm, centerline = 25V
Hor 200 microsec/cm.

Switch opened at t = 200 microsec

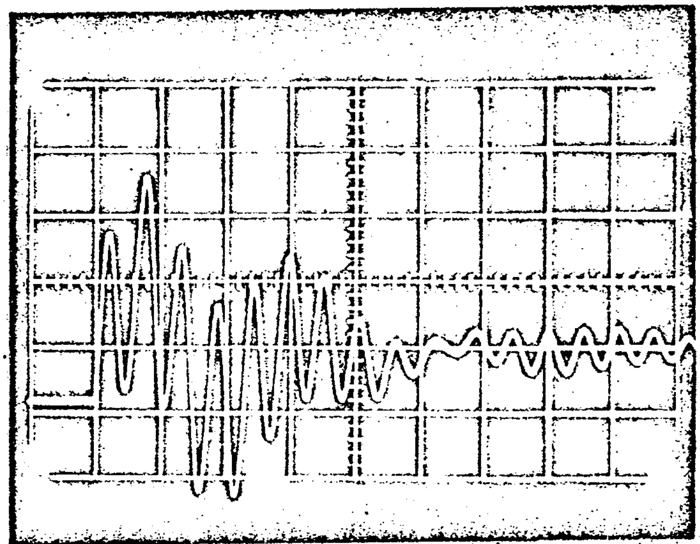
186

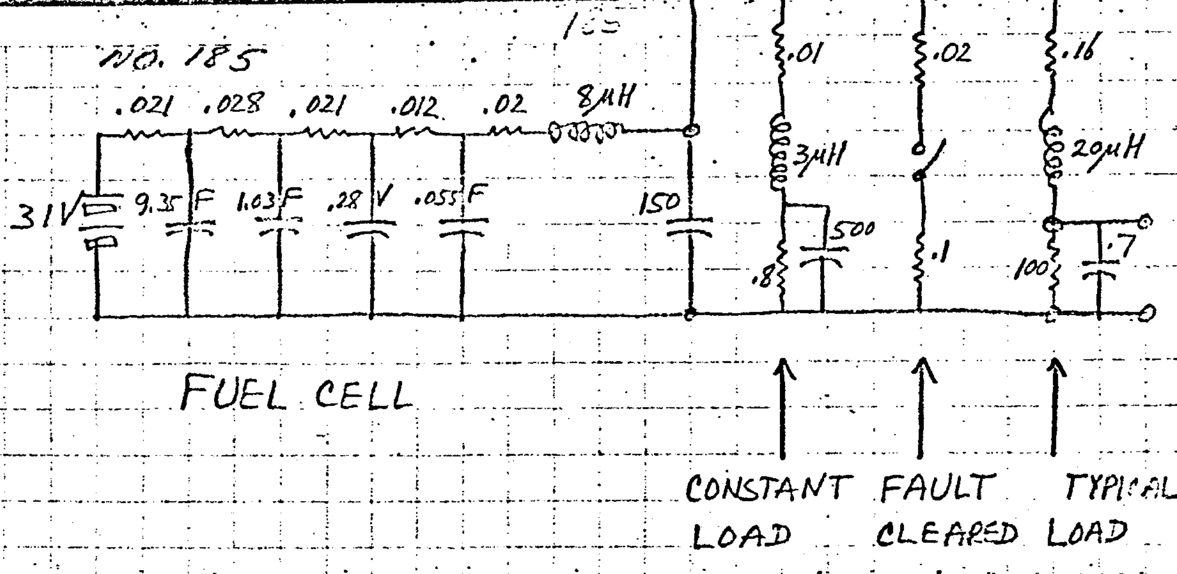


One fuel cell in the hot mode. A .1 ohm fault cleared
Large input capacitors

Sens: Vert 5V/cm, centerline = 25V
Hor 200 microsec/cm

Switch opened at t = 200 microsec

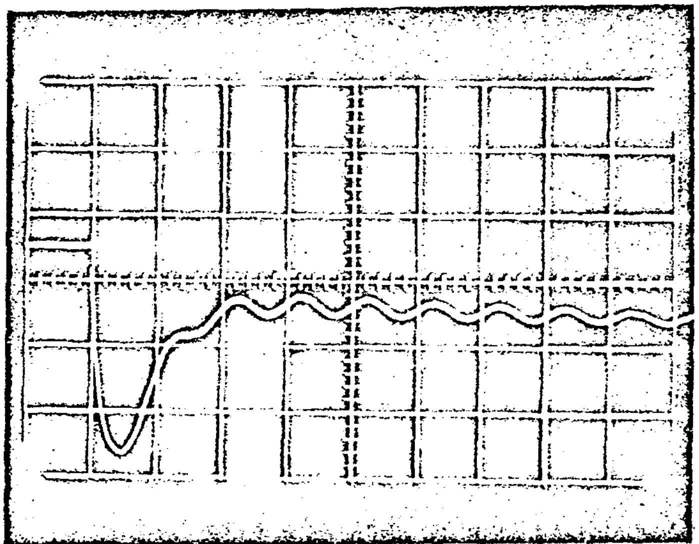




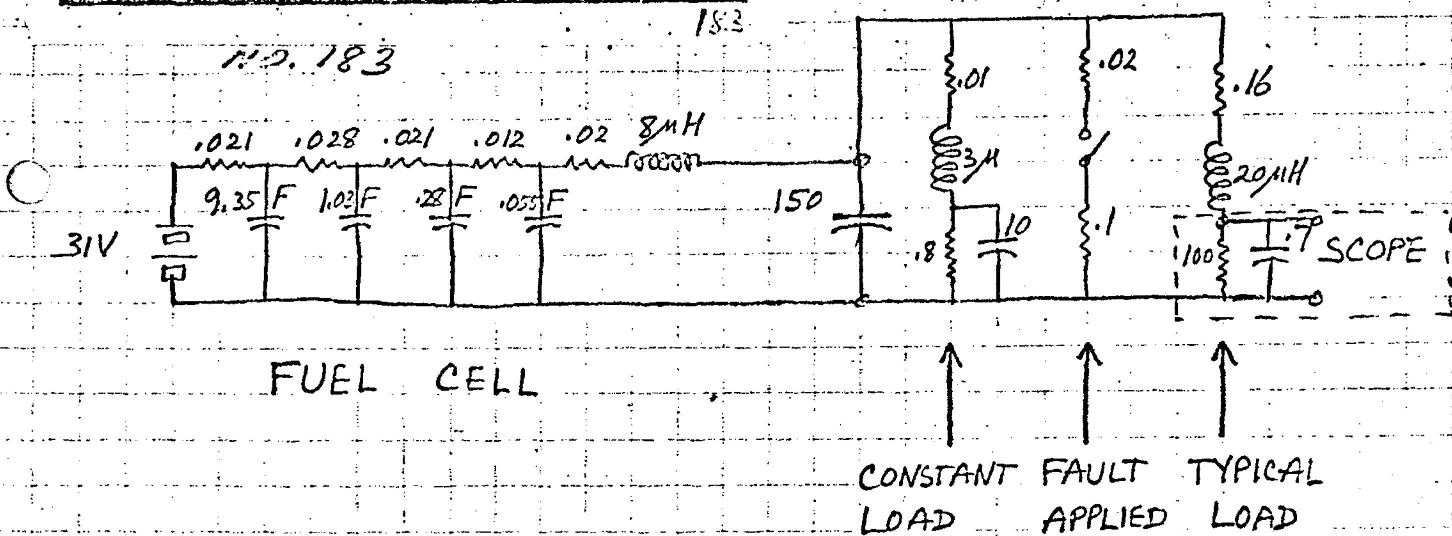
One fuel cell in the hot mode. A .1 ohm fault applied.
Small input capacitors

Sens: Vert 5V/cm, centerline = 25V
Hor 100 microsec /cm

Switch closed at t = 100 microsec

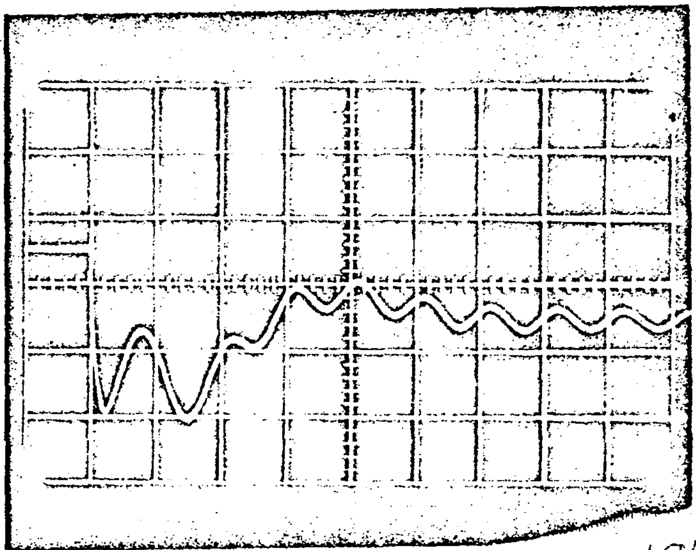


183



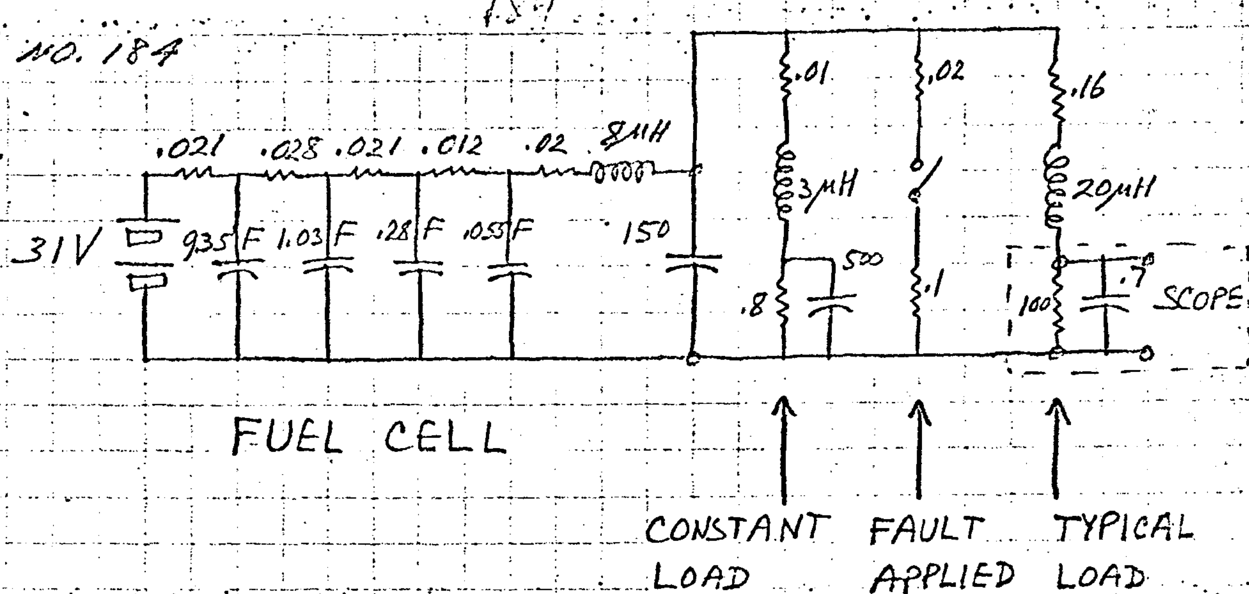
D

One fuel cell in the hot mode. A .1 ohm fault applied.
Large input capacitors.



Sens: Vert 5V/cm, centerline = 25V
Hor 100 microsec/cm

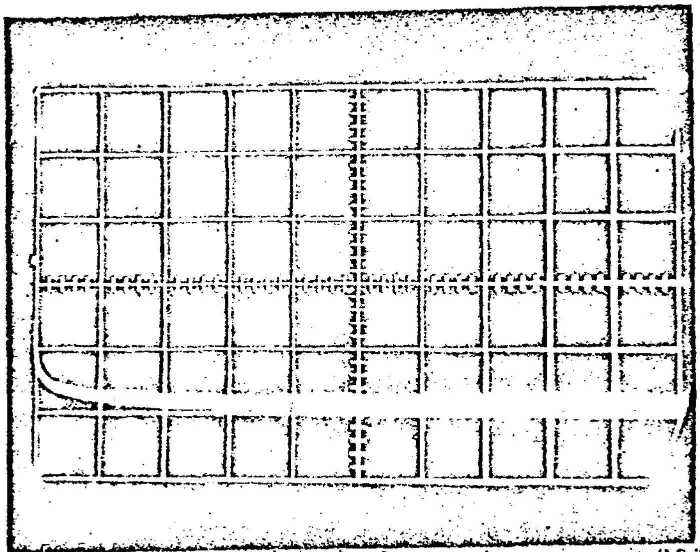
Switch closed at t = 100 microsec



One fuel cell in the hot mode. A .10hm fault applied.

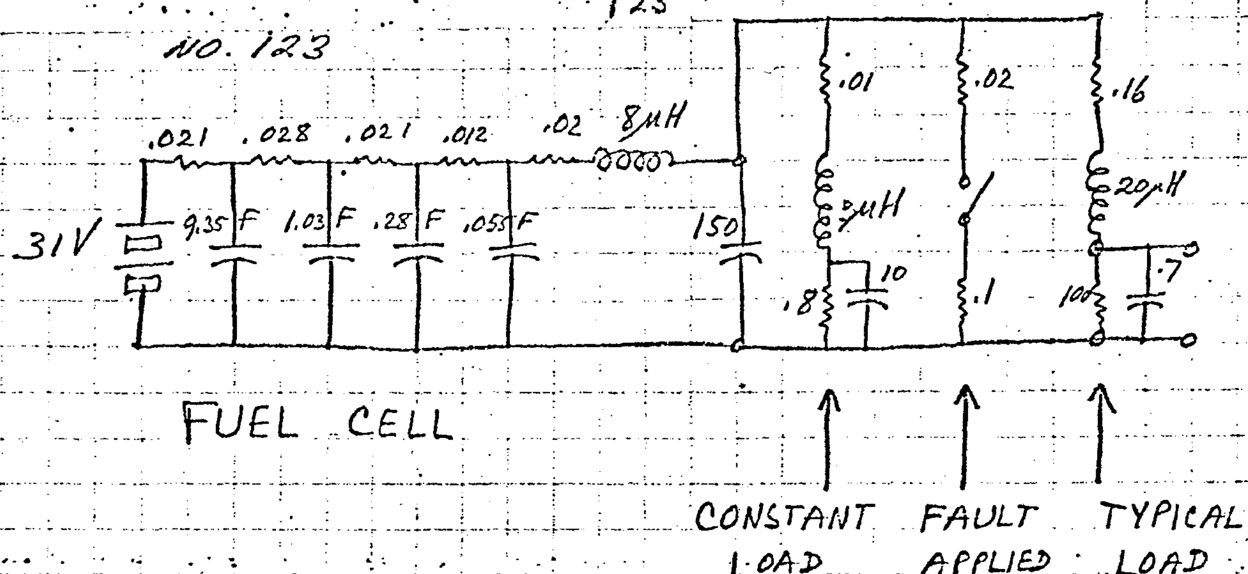
Sens: Vert 5V/cm, centerline = 25V
Hor. 200 millisec/cm

Switch closed at t = 0 millisec



123

NO. 123



ATTACHMENT E

MINUTES

TECHNICAL EXCHANGE MEETING

EMC ASPECTS POWER QUALITY

9 June 1967

McDonnell

Douglas

Attendees:

J. R Cummings, McDonnell
R. J. Schepp , McDonnell
R. Weaver, DAC
R. C Twomey, DAC
R. J. Obleman. DAC
N. K. Weaver, DAC
R. P Toutant. DAC
R. E. Freeman. DAC

DAC handed out a package consisting of data on the ripple characteristics for the power system. The contents of the package were discussed. Bob Weaver, of DAC, briefed the meeting on the technology used on the analysis and laboratory testing to evolve the ripple content of the power line voltage. The handling of this analysis was disucssed. McDonnell presented their method of controlling the reflected noise on the power system as used on the NASA Gemini. This method was discussed thoroughly and its potential application to the DAC subcontractors was discussed. Following agreements were reached on the power ripple problem.

1. McDonnell proposed that the 1.5 volt value in Figure 1 be lowered to 1.2 volts in order to remain within existing equipment specifications. DAC cannot agree to lowering the limit at this time, but will re-evaluate the assumptions used in arriving at the 1.5 volt limit. MAC stated they could technically agree to accepting 1.5 volts, but, since equipment specs are affected, would have to discuss it further, and coordinate with the customer before a firm decision could be made. DAC noted that the total ripple seen on the power distribution system is dependent on the noise fed back on the bus, and any ripple guarantee is dependent on the suppliers (DAC) control of uniform limitations of noise generation by all utilization equip= ment.

2. Margins not to be included in IFS. Technical agreement was reached that no margin of safety should be added to the above susceptibility curve in the interface specification. The 6 dB EMISM safety margin would be applied to any power utilization equipment which is identified as a critical circuit.

3. It was technically agreed that the ripple noise fed back into the power bus by any given load should be apportioned in accordance to the dc current drawn by the load. For the purpose of the interface specification it was technically agreed that the Gemini B will not reflect an rms ripple in excess of 5% of the dc current load.

The transient curves of the power quality specification were discussed. Particularly it was noted the major problem area is in the use of ground power during check-out. The basic problem with transients is the increased duration of expected transient times in relation to transient duration times now on contract. The longer transient duration time during normal operation, as noted on limit 1 of Figure 2, must be further investigated by McDonnell.

Three possible solutions were discussed which could lead to an agreement on transients. These were:

a. (MAC-DAC) Determine if G/B must operate from Lab AGE power during check-out.

b. (DAC) Investigate the possibility of using a sensor and power interrupter circuit to protect from AGE power transients.

c. (MAC) Determine attenuation of transients afforded by MAC sub-bus filter.

If the above investigations do not result in a solution, MAC will determine impact of meeting the transient requirements shown in Figure 2. MAC and DAC will investigate the equipment test method to be used in the event the long duration transient requirements are imposed in the IFS. This would include a review of the acceptability of the McDonnell transient generator for such a test.

MODEL

FIGURE 8 - ENVELOPES OF SINGLE EVENT TRANSIENT VOLTAGES INDICATING RECOVERY TO STEADY-STATE LIMITS

Page 7 of 8

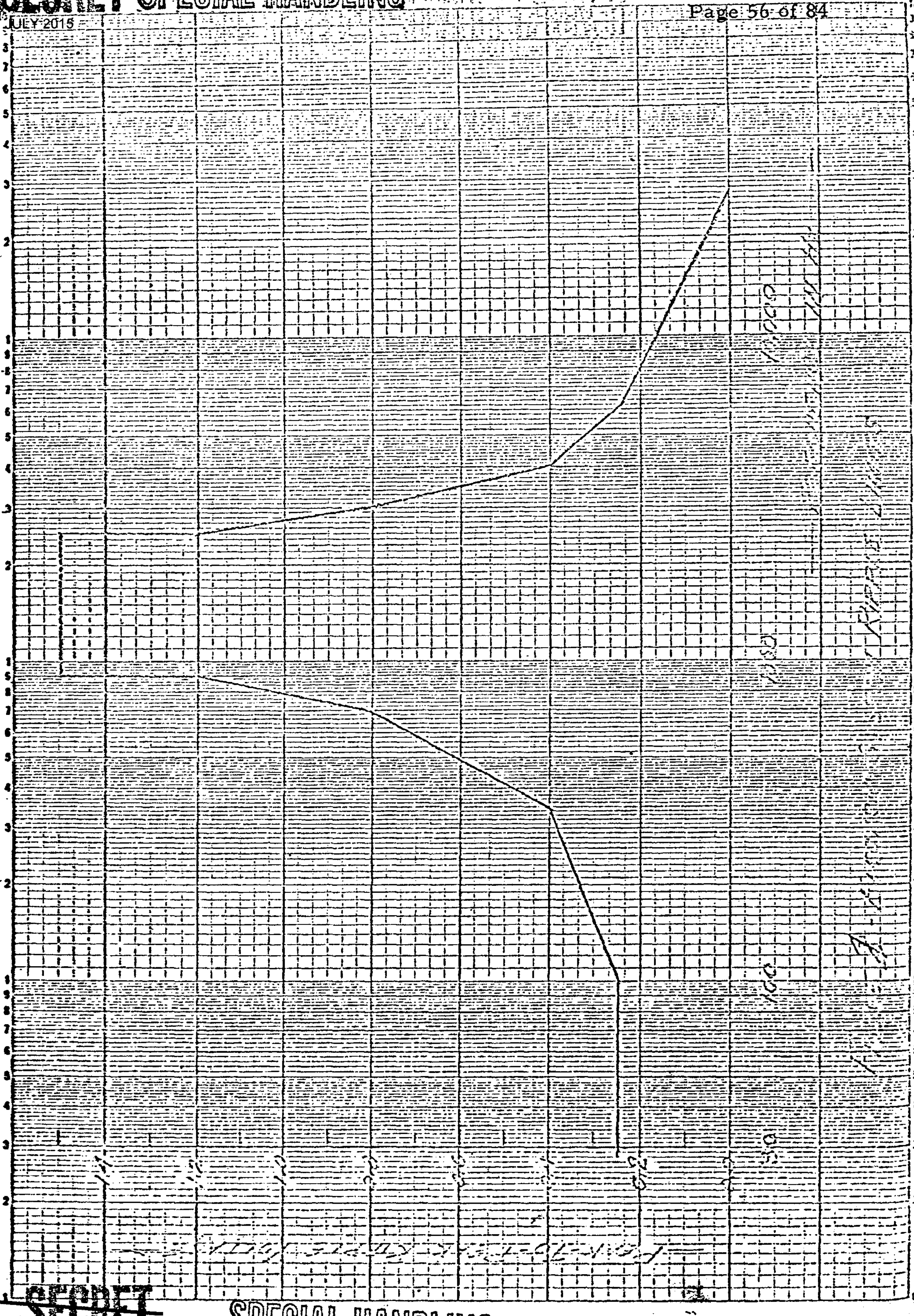


PLATE 80 K+E ALBANENE TRACING PAPER

ATTACHMENT F

6 db SAFETY MARGIN - EMISM DETERMINATION

Susceptibility Threshold (Components)

- Engineering design analysis (verified by laboratory tests as required) will provide susceptibility threshold information.
- Susceptibility threshold will be described by plots showing malfunction amplitude versus frequency (for steady state ac) and malfunction amplitude versus pulse width (for transients).

Test Equipment

- The PS subsystem will be operated by the Sensor Test Console.
- MPSS/PS lines will be operated by the MMTS (GE) through MPSS equipments.
- Interference meters, transient - volt - meters, and oscilloscopes will be used for testing.
- Transient detection will be accomplished using the following set-up.

6 db SAFETY MARGIN TESTS - EMISM DETERMINATION

Test Configuration

- The EMISM shall be determined for critcal input/output lines of the PS subsystem (LM and MM) and for critical MPSS/PS interface lines in the MM.
- EMISM of MPSS/PS interface lines in the LM will be determined only by calculation.
- Critical lines within the PS subsystem (LM and MM) will be verified for proper EMISM on each prime unit.
- Critical MPSS/PS interface lines within the MM will be verified for EMISM.

Philosophy for Determining EMISM

- EMISM will be determined by comparison of measured conducted interference to the susceptibility threshold of each line.

EMC REQUIREMENTS - COMPONENTS

Generated Interference

64-4 with the following exceptions:

1. Broadband interference limits 30 Hz - 15 k Hz changed from 100 db above 1 microampere/MHz to 134 db above 1 microampere/MHz.
2. Broadband interference limits 15 k Hz to 2 MHz changed as follows: 134db above 1 microampere/MHz at 15 k Hz, decreasing linearly on the semilog plot to 105 db above 1 microampere/MHz at 150 k Hz, and decreasing linearly from there on the semilog plot to 50 db above 1 microampere/MHz at 2 MHz.
3. No radiated requirements in 1 GHz to 10 GHz range.

Audio Susceptibility

64-4 for all components using unregulated 28v power:

1. Voltage introduced sequentially in both the primary power and return line, with component chassis and power return line grounded to ground plane.

2. Tests at high, low and nominal line voltage and nominal temperature.
3. Tests at high and low temperature and nominal voltage.

Transient Susceptibility

- Interface components using unregulated 28v power
  Primary power line to return, $\pm$ 100v
- Non-interface components using unregulated 28v power
  Primary power line to return, $\pm$ 30v

RF Conducted Susceptibility

- 64-4 levels

Radiated Susceptibility

- 64-4 levels

AF Induced into Cables

- 64-4 levels

AF Induced into Equipment

- 64-4 levels

EEDs

- Non-applicable

EMC REQUIREMENTS - SYSTEM

Compatibility

- Proper functioning within the EKC system.

6 db Safety Margin

- Internal EKC system
- Interface

EMC REQUIREMENTS - I/F

SSD Exhibit 64-4

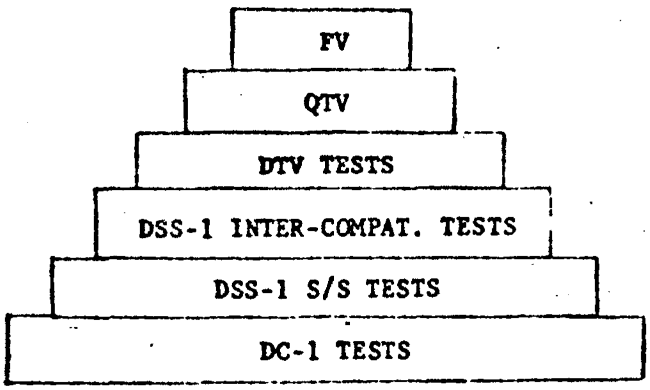
EK or GE Deviations Applicable to the I/F

- 12 db to 6 db for EMISM
- Bonding 5:1; 2.5 mΩ D. C.

ATTACHMENT G
15 June 1967

EMC TEST

SUMMARY



EMC TESTING

- DC-1 COMPONENT SIGNATURES
  - DETERMINE CONDUCTED GENERATION
  - DETERMINE RADIATED GENERATION
  - DETERMINE RIPPLE SUSCEPTIBILITY
  - DETERMINE TRANSIENT SUSCEPTIBILITY
  - PROBE FOR CIRCUIT SENSITIVITY THRESHOLDS

- DSS-1 SUBSYSTEM COMPATIBILITY

  PCM TLM S/S
  COMMAND S/S
  NAVIGATION S/S

  - SIMULATE INTERFACES WITH OTHER SUBSYSTEMS
  - DETERMINE EMISM AT CRITICAL POINTS WITHIN THE SUBSYSTEMS

- DSS-1 INTER-COMPATIBILITY
  - PCM/CMD/EPSD/CD
    - SIMULATE INTERFACES WITH NAVIGATION
    - DETERMINE EMISM AT INTERFACES BETWEEN SUBSYSTEM
    - DETERMINE DEGRADATION, IF ANY, IN EMISM AT CRITICAL POINTS WITHIN SUBSYSTEM
    - INSERT RIPPLE AND TRANSIENTS ON POWER BUS
    - MEASURE CONDUCTED GENERATION ON POWER BUS
  - PCM/CMD/EPSD/CD/NAVIGATION
    - DETERMINE EMISM AT INTERFACES BETWEEN AVE ELECTRONICS/NAV
    - DETERMINE DEGRADATION, IF ANY, IN EMISM AT INTERNAL CRITICAL POINTS
    - INSERT RIPPLE AND TRANSIENTS ON POWER BUS
    - MEASURE CONDUCTED GENERATION ON POWER BUS

- DTV COMPATIBILITY

  - SUPPLEMENT COMPONENT SIGNATURE TESTING
  - DEMONSTRATE CONDUCTED COMPATIBILITY, TIME DOMAIN
  - DEMONSTRATE CONDUCTED COMPATIBILITY, FREQUENCY DOMAIN
  - DETERMINE CONDUCTED GENERATION SIGNATURE OF MPSS POWER BUSES
  - DEMONSTRATE IMMUNITY TO TRANSIENTS AND RIPPLE ON THE POWER BUSES
  - DEMONSTRATE IMMUNITY TO RF FIELDS
  - DEMONSTRATE COMPATIBILITY WITH CITE

MMAS AND LM INTERFACES ARE SIMULATED.

D

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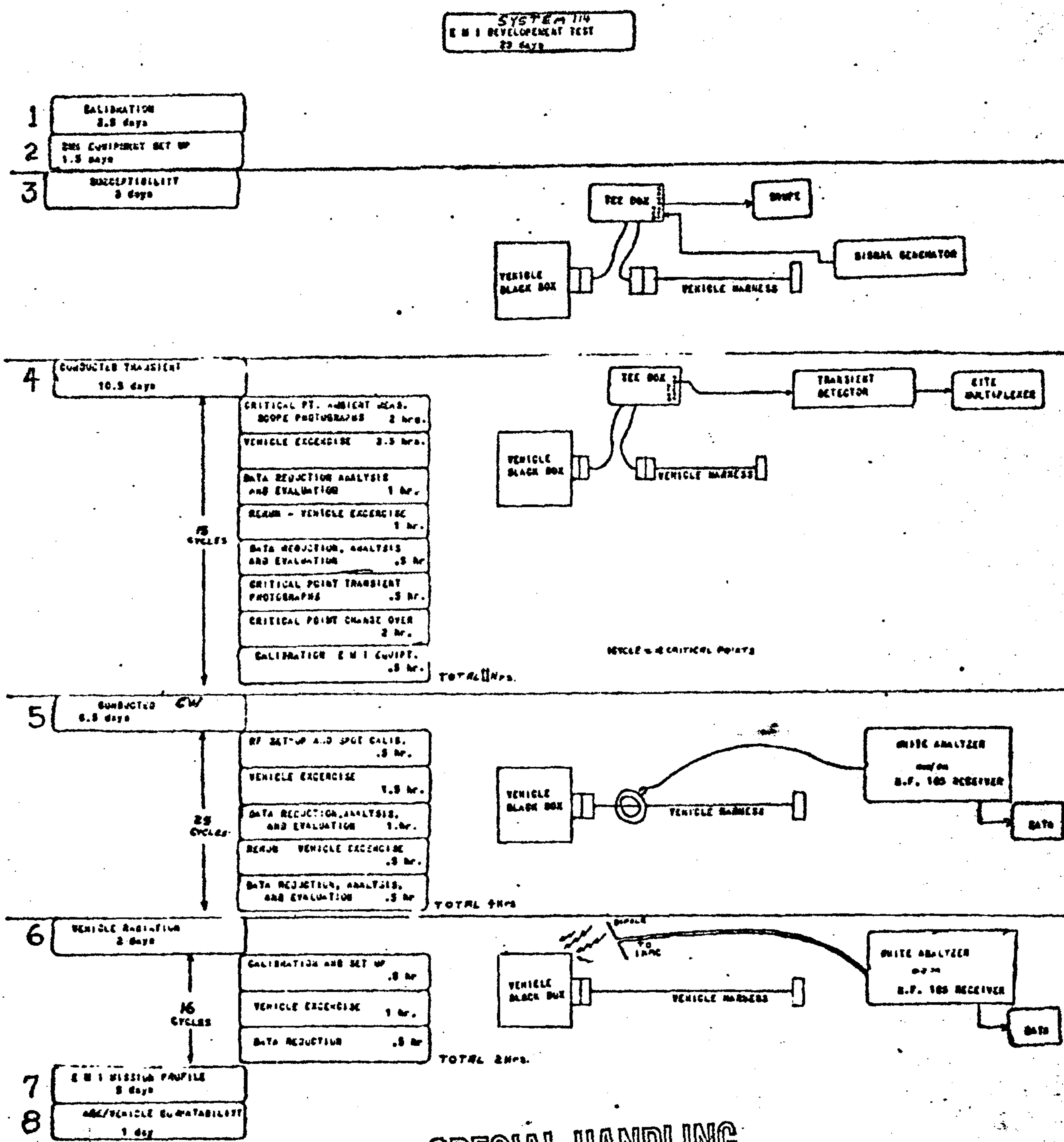
SPECIAL HANDLING



SPECIAL HANDLING

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D

MAJOR EMC TEST EQUIPMENT

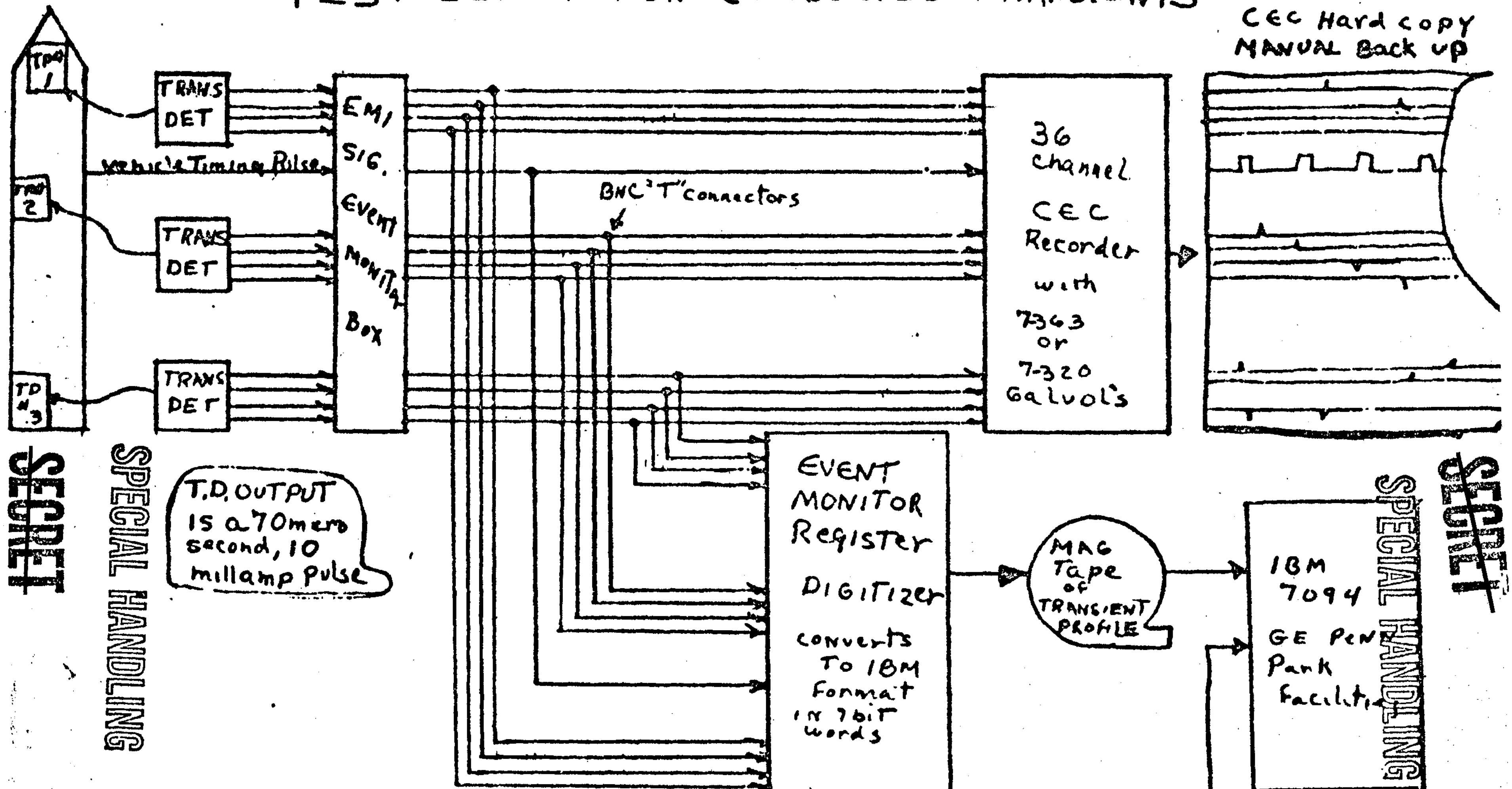
- AUTOMATIC SPECTRUM ANALYZER

  (14 KC TO 1 KMC)
- TRANSIENT DETECTORS
- TRANSIENT ANALYSIS EQUIPMENT
- OSCILLOSCOPES/CAMERA
- RFI RECEIVER

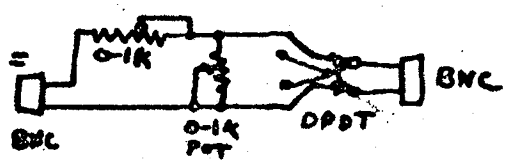
  (1-10 KMC)
- TRANSIENT GENERATOR
- SIGNAL GENERATORS

SECRET
SPECIAL HANDLING

TEST SET UP FOR CONDUCTED TRANSIENTS



TP = Test point or critical point
TRANSIENT Detector - Applied Systems Corp Model 2606
EMI Signal Box = (Floating)

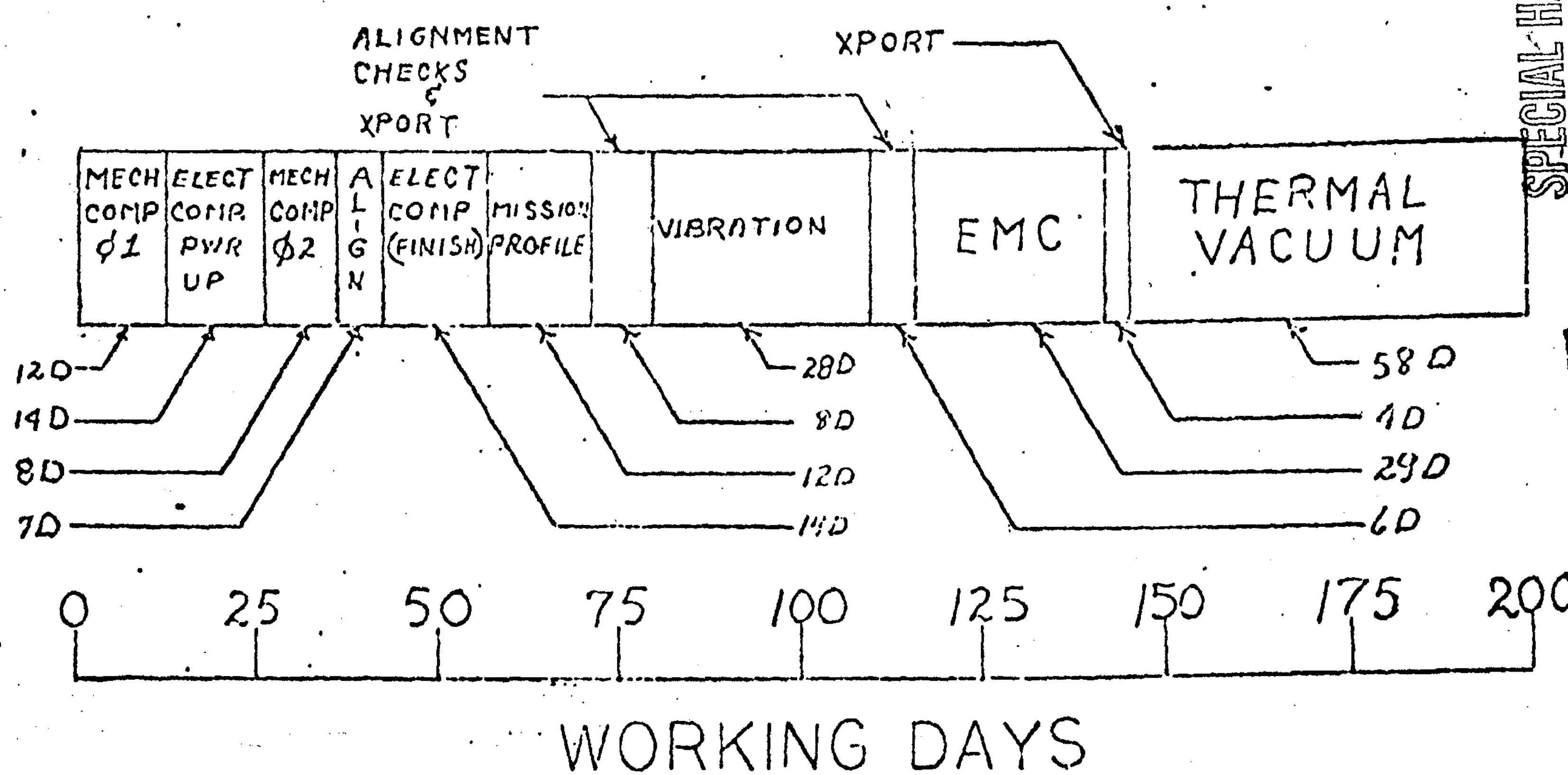


All cabling is RG58

SPECIAL HANDLING
SECRET

D ~~SECRET~~ SPECIAL HANDLING

114 SYSTEM DEVELOPMENT TIME LINE SUMMARY



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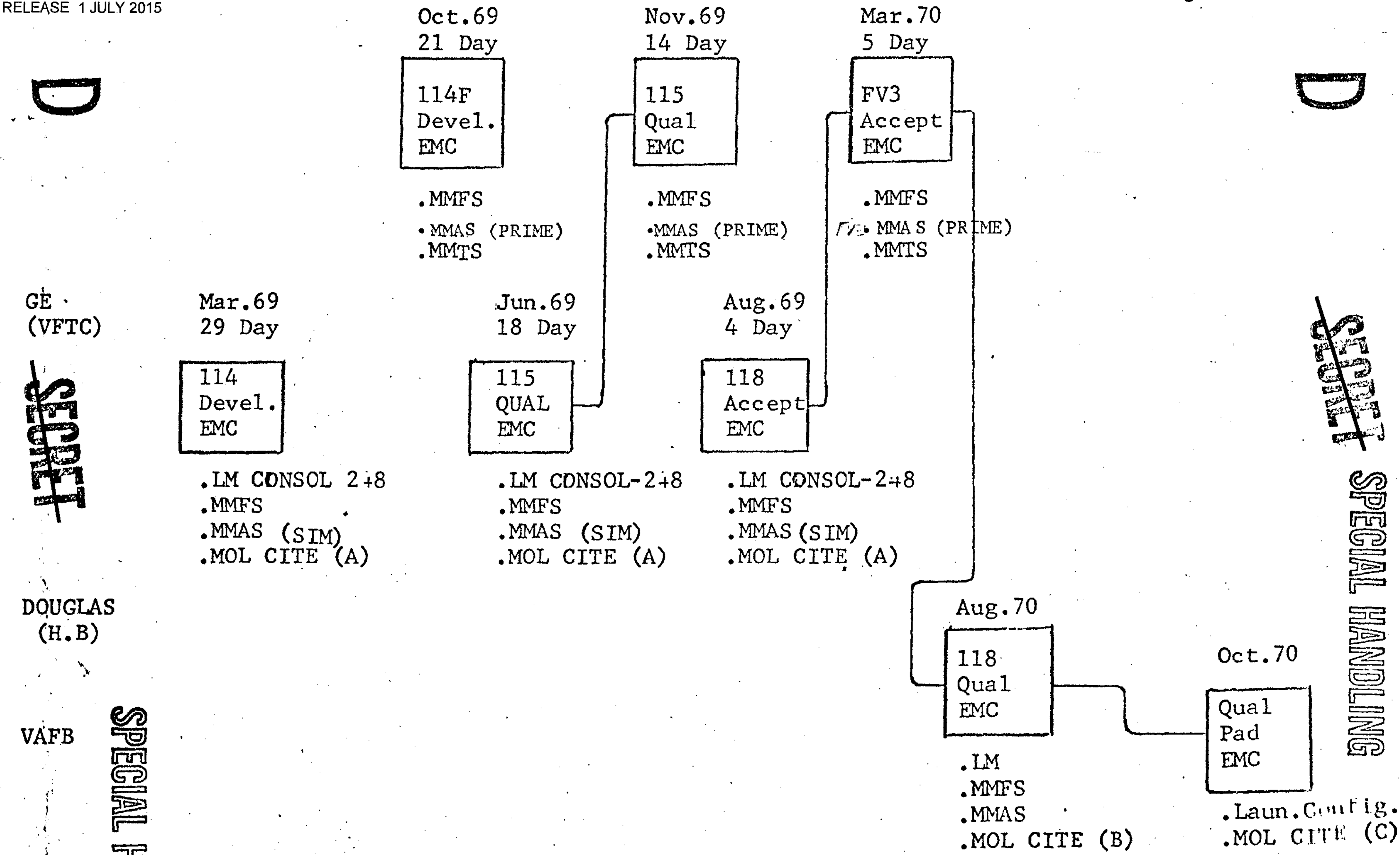

GE (VFTC)
DOUGLAS (H.B)
VAFB
Oct.69 21 Day
114F Devel. EMC
.MMFS
.MMAS (PRIME)
.MMTS
Nov.69 14 Day
115 Qual EMC
.MMFS
.MMAS (PRIME)
.MMTS
Mar.70 5 Day
FV3 Accept EMC
.MMFS
.MMAS (PRIME)
.MMTS
Mar.69 29 Day
114 Devel. EMC
.LM CONSOL 2+8
.MMFS
.MMAS (SIM)
.MOL CITE (A)
Jun.69 18 Day
115 QUAL EMC
.LM CONSOL-2+8
.MMFS
.MMAS (SIM)
.MOL CITE (A)
Aug.69 4 Day
118 Accept EMC
.LM CONSOL-2+8
.MMFS
.MMAS (SIM)
.MOL CITE (A)
Aug.70
118 Qual EMC
.LM
.MMFS
.MMAS
.MOL CITE (B)
Oct.70
Qual Pad EMC
.Laun.Config.
.MOL CITE (C)

AGENDA ITEM #7

D

~~SECRET~~ SPECIAL HANDLING

114 EMC SYSTEM DEVELOPMENT TEST

AT GE (VFTC)

BASELINE:

INPUT -- SUSPECT CRITICAL TEST POINT LIST FROM COMPONENT AND SUBSYSTEM DESIGN ENGINEERING EMC TESTS.

OBJECTIVES:

- PROVE 6 db SAFETY MARGIN
- PROVE NO SYSTEM DEGRADATION DUE TO EMI
  (EXAMPLE TV MICROWAVE LINK)
- MEASURE SYSTEM AMBIENT NOISE
- REVALIDATE CRITICAL POINT MALFUNCTION LEVELS OF INTEGRATED SUBSYSTEMS BY VEHICLE HARNESS.
- VALIDATE VEHICLE/AGE EMC INTERFACE
- PROVE EMI SUBPRESSION OF ENVIRONMENTAL CONTROL
- PROVIDE CRITICAL TEST POINT INPUT FOR SYSTEM QUAL VEHICLE AND VEHICLE 114F DEVELOPMENT TEST AT ____.
- KEEP VEHICLE EMI HISTORICAL LOG

GE (VFTC)

D ~~SECRET~~ SPECIAL HANDLING

TEST POINT	MALFUNCTION LEVEL	SYSTEM NOISE LEVEL	AMBIENT	SAFETY MARGIN db	REASON (COMMAND)
3. +6V Continuous Command Decoder P375 +8, Bat P	A. 1.2V PP audio B. +2.1V, GT or equals .2 micro sec	1.8 V P-P .1 micro sec	1.2 V P-P .1 micro sec	AMB. 7.06db	TT&C (AGE)
	C. -2.1V, GT or equals .2 micro sec D. Bus dip equal to or GT 2V, 1 milli sec	2.1 V P-P .1 micro sec		6db	Man. Int.
4. -6V Continuous Command Decoder P375, +8, Bat P	A. GT 8.4 V P-P audio B. +3.5 V, GT or equal to .2 micro sec	2.1 V P-P .1 micro sec	1.2 V P-P .1 micro sec	12.2db	TT&C (AGE)
	C. -3.5 V, GT or equal to .2 micro sec D. Bus dip equal to or GT 2 V, .1 milli sec	2.1 V P-P .1 micro sec		9.6db	Man. Int.

DISTRIBUTION:

PAGE NO. 1 OF 1

CONT. ON

FORM [illegible] REV. [illegible]

TEST CONFIGURATION:

- COMMAND SEQUENCES -- FOR DEVEL + QUAL.
  1. SELECTED REPETITIVE COMMAND SEQUENCING TO VERIFY NO CHANGE OR VARIATION OF NOISE LEVELS
  2. TEST INTEGRATED MISSION PROFILE COMMAND SEQUENCE TO VERIFY EMC FOR ALL COMMAND FUNCTIONS

- TEE BOX INSTALLATION -- FOR CONDUCTED INTERFERENCE MONITORING

MAJOR EQUIPMENT LIST

1. TRANSIENT DETECTORS

   (a) A THRESHOLD LEVEL DEVICE CAPABLE OF MEASURING POSITIVE AND NEGATIVE GOING TRANSIENTS FROM 5V TO 250V OF DURATIONS AS SHORT AS .1μSEC.

2. AUTOMATIC SPECTRUM SCANNER AND PLOTTER SYSTEM

   (a) AN AUTO SPECTRUM DISPLAY AND SIGNAL RECOGNITION SYSTEM CAPABLE OF PLOTTING PEAK AND AVERAGE FUNCTION SIMULTANEOUSLY FROM 20 H_Z TO $1GH_Z$

   (b) OR NF105 AND ASSOCIATED ACCESSORIES

   (c) NF112 (1 TO $10GH_Z$)

3. CATHO-RAY OSCILLOSCOPES AND SCOPE CAMERAS

   OSCILLOSCOPES UP TO 85 MH_Z WILL BE USED TO OBTAIN NOISE AND TRANSIENT SIGNATURES OF AMBIENT AND DYNAMIC INTERFERENCE

4. TEE BOXES

   THESE ARE SPECIAL TEST BOXES, ADAPTERS AND CABLES WHICH WILL BE DEVELOPED FOR SYSTEM TEST PURPOSES

5. NOISE GENERATORS

115 EMC SYSTEM QUAL TEST

AT GE (VFTC)

BASE LINE:

INPUT -- RESULTS OF EMC DEVELOPMENT TEST

(REDUCED CRITICAL TEST POINT LIST)

OBJECTIVES:

- PROVE 6 db SAFETY MARGINS PER 64-4
- MEASURE SYSTEM AMBIENT NOISE (REDUCED)
- SPOT CHECK ON ENVIRONMENTAL CONTROLLERS
- PROVE EMC OF STAGE ~~3~~ 4 SUBSYSTEMS
- PROVIDE GE CRITICAL TEST POINT LIST FOR FV3 EMC TESTING AT [redacted] AND VEHICLE 118
- COMPLETE AND RECORD EMI HISTORICAL LOG WITH VEHICLE 114

EGINEERING [redacted]

114F EMC TEST (~~DEVELOPMENT~~) @ (NORTH)

BASE LINE:

INPUT --

1. INTERFACE CRITICAL TEST POINTS FROM 114 DEVELOPMENT EMC TEST
2. CRITICAL TEST POINTS FROM COMPONENT AND SYBSYSTEM DESIGN ENGINEERING EMC TESTS

GE - OBJECTIVES: AT (NORTH)

- PROVE 6 db SAFETY MARGIN OF MMFS/AS (PRIME) INTERFACE
- CONFORM OR ELIMINATE CRITICAL TEST POINTS PREVIOUSLY ESTABLISHED DURING THE 114 DEVELOPMENT EMC TEST USINGT THE ACTUAL PRIME BAY IN PLACE OF THE ELECTRICAL SIMULATOR
- MEASURE AMBIENT NOISE LEVEL OF MMFS/AS PRIME INTERFACE
- DETERMINE EMI EFFECT OF MMAS (PRIME)
- PROVIDE UP-DATED CRITICAL TEST POINT LIST FOR 115 EMC TEST AT
- MAINTAIN VEHICLE HISTORICAL EMI LOG

118 EMC SYSTEM ACCEPTANCE TEST

AT GE (VFTC)

BASE LINE:

INPUT -- REVISED CRITICAL TEST POINT LIST FROM VEHICLE 115 QUAL EMC TEST AT GE - VFTC

OBJECTIVES:

- PROVE 6 db SAFETY MARGIN PER 64-4
- REVISE CRITICAL TEST POINT LIST DUE TO BLOCK CHANGES IF ANY
- MINIMUM AMOUNT OF CONNECTOR MATING AND DEMATING
- PROVIDE INPUTS TO PROGRAM EMI HISTORICAL LOG

118 EMC ~~QUAL~~ TEST

AT DOUGLAS (H.B.)

BASE LINE:

INPUTS -- CRITICAL TEST POINT LISTS FROM 118 EMC ACCEPTANCE TEST AT GE (VTC) AND 118 QUAL EMC TEST AT

OBJECTIVES:

- PROVE 6 db SAFETY MARGIN OF FULLY MATED ORBITAL CONFIGURATION
- ELIMINATE THOSE SUSPECT CRITICAL TEST POINTS OF THE LM/MMFS INTERFACE
- MEASURE AMBIENT NOISE LEVELS OF LM/MMFS
- PROVIDE UP-DATED CRITICAL TEST POINT LIST
- PROVIDE INPUTS TO PROGRAM EMI HISTORICAL LOG

12

D SECRET SPECIAL HANDLING

118 EMC ~~QUAL~~ TEST

AT VAFB

BASE LINE:

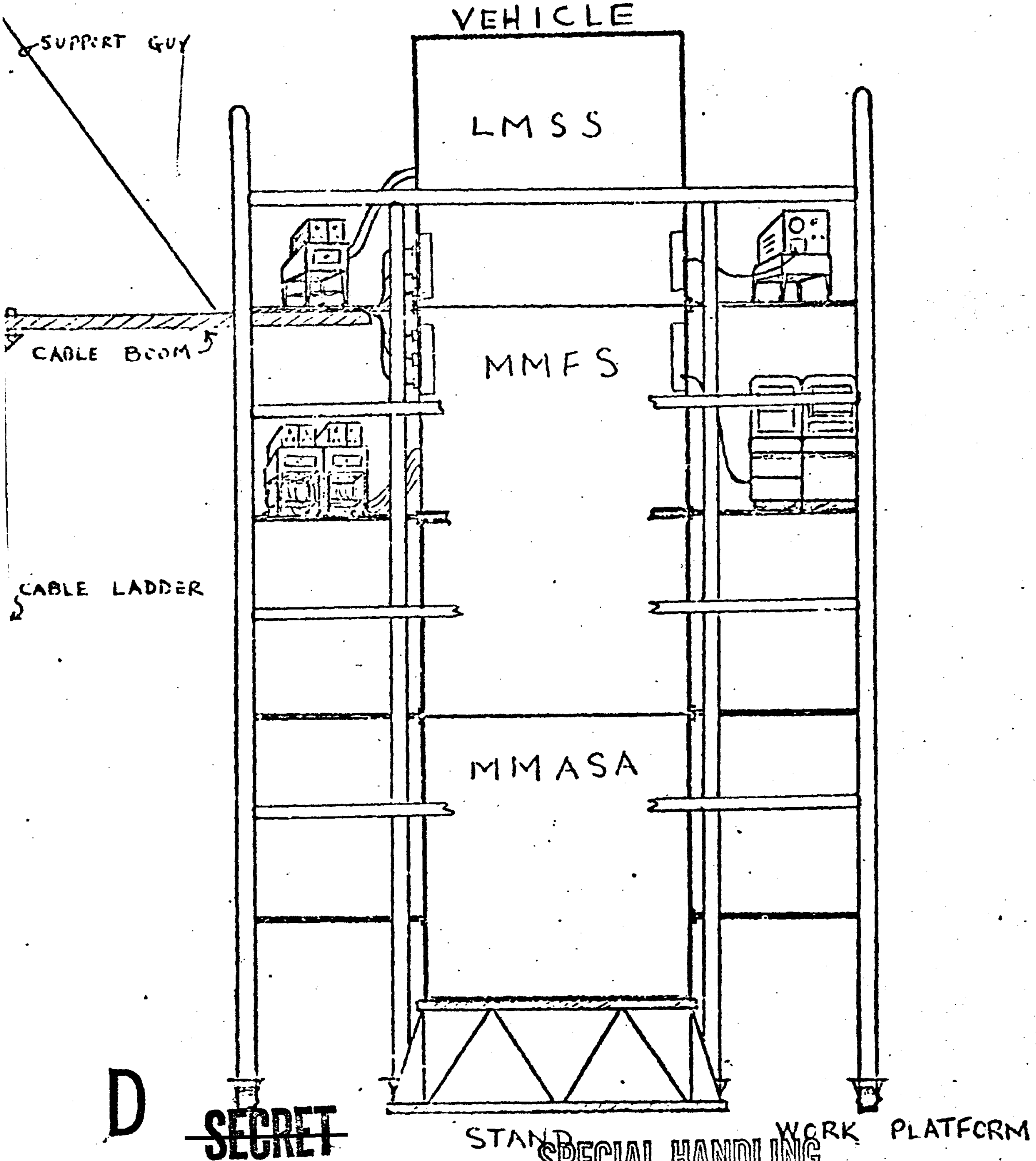
INPUT -- PROVEN 6 db SAFETY MARGIN ON ALL CRITICAL TEST POINTS FROM 118 EMC TEST AT DOUGLAS. (H.B.)

OBJECTIVES:

- PROVE VEHICLE OPERATES WITH NO DEGRADATION IN THE LAUNCH PAD ENVIRONMENT
- NO VEHICLE HARNESS CONNECTOR DEMATING
- PROVE SUCCESSFUL VEHICLE OPERATION BY COMPLETION OF A TIMP IN AN ACTUAL RADIATED FIELD

eg. EED

ST&D VERTICAL TEST SET-UP



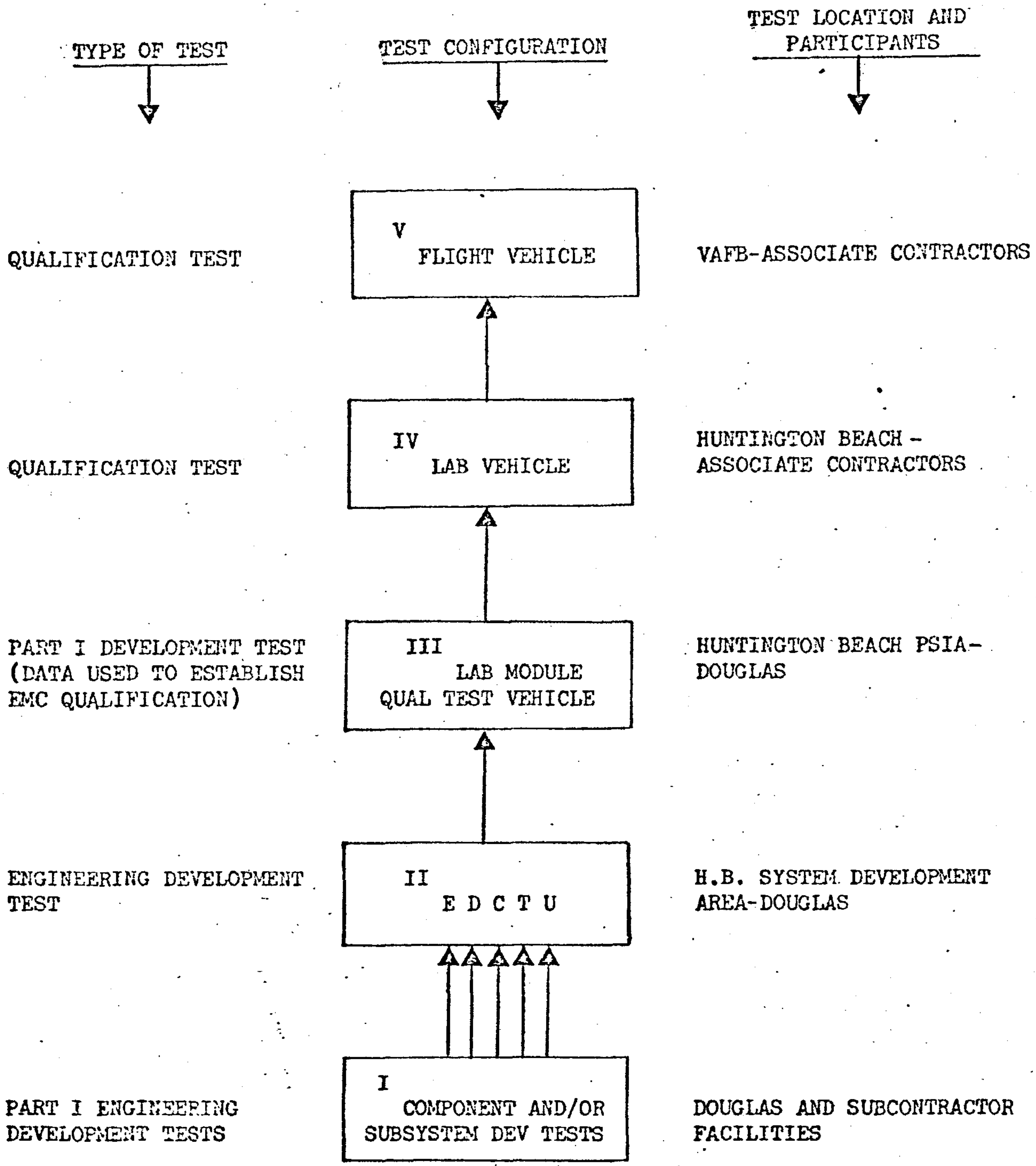
ATTACHMENT H

ELECTROMAGNETIC COMPATIBILITY TEST FLOW

FOR THE

LABORATORY MODULE, LABORATORY VEHICLE, AND FLIGHT VEHICLE

The following pages provide an overview of the subject testing. It is not the intent of this description to provide test plan and test flow details. These are, or will be, the subject of other documents. The EMC testing is representative of Douglas planning and does not necessarily represent a coordinated and agreed to plan where contractors other than Douglas are involved.



EMC TEST FLOW

I EMC TESTING OF DOUGLAS VEHICLE COMPONENTS AND SUBSYSTEMS

Test Objectives and Approach

The ultimate objective of these tests is to ascertain that the components and/or subsystems have met their EMC design requirements.

Within this overall objective are the derivation of malfunction threshold curves and EMISM test point (or test method) identification for subsystems and circuits which are susceptible to the EM environment. These data are used during subsystem and system integration tests to establish the electromagnetic interference safety margins.

Test Specimen Description

The test specimen is the component, where adequate component interfaces are used, or the subsystem or major portion thereof.

The bulk of the tests are classified as development tests, but the test sample configuration and test procedures are controlled to the extent necessary to assure data of a quality which is admissible toward the EMC qualification of the equipment. The "development test" status is retained to assure early identification and correction of EMI problems, and to assure that equipment delivered for use in system integration testing will have had the benefit of the EMC development cycle.

Test Environment and/or Conditions

Most of the component EMC testing is conducted in a screen room environment. Test requirements are defined in the applicable Technical Requirement specification and/or CEI specification. The EMC design requirements and test requirements are essentially the same as those identified in SAFSL Exhibit 11005, which is in turn very similar to SSD Exhibit 64-4.

II EMC VEHICLE SYSTEM DEVELOPMENT TESTING USING THE ELECTRONIC DEVELOPMENT and COMPATIBILITY TEST UNIT (EDCTU)

Test Objective and Approach

The Laboratory Module electrical subsystems are assembled and integrated into an electrically functioning system for the purpose of determining inter-subsystem compatibility, EDCTU/ASTEG (All Systems Test Group) compatibility, and development of the checkout software programs. Each of the EDCTU subsystems is operated independently and then in conjunction with other subsystems to simulate a vehicle configuration. From the standpoint of EMC, the EMISM test points are monitored and the data are compared with data obtained during the component and subsystem development testing. The techniques of EMC measurement using the RFI Test Set (CEI 207417A) and other standard instruments are developed at this time. Any discrepancies between the desired and acquired test data are recorded, with corrective action taken where necessary.

Test Specimen Description

The EDCTU is an operating assembly of vehicle equipment arranged on vertically mounted metal panels. Four panels form a large square with good physical access to both sides. The physical placement of equipment roughly duplicates that of the Laboratory Module, but the ability to accomplish useful system development takes precedence over simulation of the vehicle physical layout. Wire runs are longer and equipment spacing is frequently greater than in an actual vehicle. The resulting electromagnetic simulation is not exact, but the usefulness of the EDCTU as an EMC design tool is still very high.

Wherever practicable, the EDCTU equipment will be EMC qualified prior to use in the EDCTU. Where this is not the case, the equipment will have at least progressed quite far in its EMC develonment cycle prior to use in the EDCTU. The design objective is to use EMC qualified equipment.

Test Environment and/or Conditions

The EM environment is that of the EDCTU test area. This area is located in a new, metal clad building which has been used previously and successfully for the same purpose on another program. No attempt is made to provide shielding equivalent to a screen room as radiated interference and susceptibility tests on the EDCTU are not planned. The facility has been checked and found to be void of harmful interference. The equipment is operated by Douglas personnel with support from subcontractors, where required. EMC testing is conducted throughout the EDCTU development cycle and during EDCTU/ASTEG interface compatibility testing.

III EMC TESTING ON THE LABORATORY MODULE QUALIFICATION TEST VEHICLE (LMQTV)

Test Objective and Approach

The object of this test is to verify that the Electromagnetic Compatibility (EMC) status of the Laboratory Module as determined by the ASTEG (All Systems Equipment Group) is actually indicative of the overall EMC of the LM.

The ASTEG will determine the EMC status of the LM during the checkout of the LM in the PSIA (Production Systems Integration Area). These ASTEG EMC measurements are standard readouts for all production LM's and consist of GO-NO GO measurements to verify that the vehicle electrical bus voltage transients have not exceeded the permissible maximum value, and to verify that the electromagnetic interference safety margins (EMISM) on selected critical susceptible subsystems are within acceptible limits. Actual safety margins are not measured by ASTEG.

Susceptible circuits are identified during subsystem design and development (not a part of this test). The susceptible circuits to be monitored by ASTEG are selected on the basis of their being the most indicative of the overall EMC of the critical subsystem with which they are associated. Generally, these circuits are those which are the most sensitive to an adverse electromagentic (EM) environment.

When the standard PSIA LM checkout has indicated acceptance of the LMQTV, manual EMISM measurements using the EMI test set, CEI 207417A, and standard laboratory instruments will be made on the circuits monitored for EMC status by ASTEG and on certain other susceptible circuits which, during subsystem development, were determined to be less susceptible to the EM environment than those selected for the ASTEG readout. The purpose of these measurements is to verify that the EMC status determined by the ASTEG is based on ASTEG measurements of the most susceptible point or points in each of the critical susceptible subsystems, and that the LM configuration has not altered the validity of the original susceptible circuit selection which was based on a component, subsystem, or EDCTU configuration tests.

LMQTV EMC tests are classified as Part I development testing with the test data used to establish the EMC qualification of the Laboratory Module.

Test Specimen Description

The specimen is the LMQTV after it has successfully passed the standard production PSIA acceptance test. The specimen remains in the LM PSIA test stand with all ASTEG cables connected.

III EMC TESTING ON THE LABORATORY MODULE QUALIFICATION TEST VEHICLE (LMQTV) (Continued)

Test Environment and/or Conditions

The electromagnetic environment is that which exists in the PSIA. Although the final portion of the test will be run on the LMQTV after it has passed the PSIA acceptance tests, as much work as may be possible will be conducted on a non-conflicting basis during the PSIA production acceptance testing. The vehicle subsystems will be operated on ground power and vehicle power. During a short portion of the test the radio frequency subsystems will be operated open-loop to the extent permitted by FCC/Range restrictions.

The tests are conducted by Douglas personnel.

IV EMC TESTING ON THE LABORATORY VEHICLE

Test Objectives and Approach

The purpose of this test is to establish the electromagnetic compatibility qualification of the Laboratory Vehicle by demonstrating that the significant electrical/electronic portions of the vehicle are capable of operating together while maintaining a contractually prescribed margin of safe operation in specific designated critical susceptible subsystems. This test is a continuation of similar tests conducted at lower levels of vehicle assembly wherein the electromagnetic interference safety margins (EMISM) for critical susceptible subsystems were established in the limited system segment environment. The primary difference between this "LV" test and previous EMC system segment tests is that the subsystems of the Laboratory Vehicle are now operated in the electromagnetic environment created by the interconnected subsystems of the Laboratory Vehicle.

Test Specimen Description

These tests are conducted on a flight configuration (vehicle #3) while it is in the Douglas Huntington Beach Production Systems Integration Area. The specimen remains in the test stand during the test. The Laboratory Module and Mission Module (Mission Payload System Segment) have been previously qualified for EMC prior to joining to form the Laboratory Vehicle.

Test Environment and/or Conditions

The ambient EM environment is essentially the same as previously presented to the LMQTV during its EMC testing. The primary difference is the presence of the fully equipped Mission Module. No significant EM environment changes are expected for the Laboratory Module, although this will be a new external environment for the Mission Module.

The EMC tests are conducted after the successful completion of the Laboratory Vehicle checkout and prior to the Laboratory Vehicle vibration testing. The tests are under the overall direction of Douglas with the actual measurements made by the associate contractor who supplies the portion of the vehicle under test. Test equipment and its maintenance are supplied by each associate contractor in support of his portion of the test.

V VANDENBERG EMC TEST

Test Objective and Approach

The objective of this test is to qualify the MOL flight vehicle to the program electromagnetic interference requirements by demonstrating that selected critical test points within the flight vehicle, so chosen that they are indicative of total segment performance, have a minimum 6 db safety margin below the susceptibility levels of the critical test points.

Critical test points are identified by each segment contractor and approved by the SPO. These critical test points are measured either by normal AGE equipment (such as CAGE, CITE or ASTEG), by special test equipment (such as a RFI test set), or by both. It is not anticipated that standard RIFI equipment (such as the NF-105) will be used, except possibly for trouble shooting.

All equipment will be operated wherever practicable. Fuel and cryogenics will not be loaded, inert or substitute gases may be substituted. That equipment which is not capable of operation in the earth's atmosphere (such as some EC&LS components) will be exempt from operation during this test; analysis will be used in lieu of actual tests.

Pertinent elements of the full mission sequence will be simulated from countdown through countup, injection, on-orbit, up to and including Gemini seperation. Repetition of portions of a simulated mission may be required after trouble-shooting and for open-loop radiation tests.

Test Specimen Description

The test specimen will be a standard, fully mission configured MOL flight vehicle consisting of a TIIIM booster, the Mission Payload segment, a Laboratory Module/Mission Module, a Gemini spacecraft, and flight crew equipment (where practicable). Only OGE normally used with flight vehicle equipment will be utilized, except for specialized RFI test sets (where required and approved). Flight vehicle qualified systems only shall be used except where approved simulators are required (such as EED's).

Test Environment and/or Conditions

The test environment will be that of the MOL launch complex at Vandenberg Air Force Base, including the operation of all AGE normally used in countdown and countup operations, and operation of all base support equipment normally used during the launch and injection sequence of a MOL mission.

The tests are under the overall direction of Douglas. The actual testing is conducted by the associate contractor who supplies the system under test.