ENERGETIC PARTICLE FLUX
EXPERIMENT (IMP-F & G)
January 28, 1965 - June 30, 1971

Final Technical Report On
NASA Grant NAS 5-9091

Principal Investigator:
Kinsey A. Anderson

Series 13, Issue 105
December 12, 1972

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For:
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Principal Investigator:
Kinsey A. Anderson

December 12, 1972
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Abstract

This report summarizes the technical aspects of the University of California IMP-F experiment aboard the Explorer-34 and the University of California IMP-G (S1) and IMP-G' (S2) experiments aboard the Explorer-41. The experiment detectors and electronics are discussed for each experiment as well as the fabrication, pre-flight and post-flight history. A description of the Ground Support Equipment is also given for each experiment.

Since these three experiments were essentially all different, this report is made up of three basic sections accordingly. The IMP-G experiment was essentially the IMP-F experiment with the addition of four Geiger-Mueller detectors and only the differences and additions from the IMP-F are discussed. Whereas, the IMP-G' was a supplementary experiment and differed completely from the IMP-F and IMP-G experiments.

It is concluded that the ground support equipment approach used for the IMP-F and IMP-G experiments where emphasis was placed on a thorough exercise and monitoring of the experiment operation during various testing phases provided a high degree of confidence and reliability in these experiments. (No known electronic failures have occurred during the spacecraft lifetime although some detector problems were experienced.)

The IMP-G ground support system with its greater emphasis on computer software proved to be a valuable experience in that it pointed out the difficulties in coordinating the writing and debugging efforts with a spacecraft prime contractor. As a result of this experience, in later projects, much of the test functions were incorporated into the experiment in order to reduce some of this software effort.
It is felt that the management approach used for the supplementary experiments, where the combined replacement experiments from two organizations were looked upon as a single experiment by the GSFC personnel, caused a great deal of difficulty throughout the program.
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I. THE IMP-F EXPERIMENT ABOARD EXPLORER-34

Description of Detectors

The University of California IMP-F experiment aboard Explorer-34 contains two geiger-Mueller tubes, one of which looks directly at particle fluxes while the other observes the particle flux backscattered off an 8 mil gold foil. Protons lose energy in the gold foil without backscattering while electrons backscatter with high efficiency and little energy loss. With this arrangement, proton and electron fluxes can be identified and separated.

The open counter, GM2, and the scatter detector, GM1, are both pointing along the spin axis. GM1 is a Lionel 205 HT Geiger-Mueller tube with a standard thickness mica window while GM2 is a thin-window version of the same tube with an energy threshold of about one-half as high as for GM1. Thus for electrons it is possible to derive some energy spectrum information about the fluxes. A 4-inch ionization chamber completes the detector complement which is shown in Figure 1. Table 1 summarizes the characteristics of the detectors.

Geiger-Mueller Detectors

The Lionel 205 HT Geiger-Mueller detector has a cylindrical cathode of \( \frac{1}{4} '' \) inside diameter, and it is sensitive to radiation over the entire \( \frac{1}{8} '' \) diameter window. This tube has a 1.2-1.4 mg/cm\(^2\) mica window, and a typical electron detection efficiency versus electron energy curve is shown in Figure 2. The threshold, arbitrarily defined as the 1/e efficiency point, is about 40 keV for these tubes. GM2 is a special thin-window (0.7 mg/cm\(^2\) mica) modified Lionel
Figure 1 The IMP-F Experiment
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<th>Type of Detector</th>
<th>Window</th>
<th>Directional Sensitivity</th>
<th>Omnidirectional Sensitivity</th>
<th>Geometry Factor</th>
<th>Look Angle FWHM</th>
<th>Angle to Spin Axis</th>
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<td>GM1</td>
<td>Lionel 205 HT GM tube in scatter configuration</td>
<td>1.4 mg/cm²</td>
<td>&gt;45 keV</td>
<td>None</td>
<td>&gt;4 MeV</td>
<td>&gt;40 MeV</td>
<td>3.6 x 10⁻²</td>
</tr>
<tr>
<td>GM2</td>
<td>Lionel 205 HT thin window GM tube</td>
<td>0.7 mg/cm²</td>
<td>&gt;22 keV</td>
<td>&gt;0.3 MeV</td>
<td>&gt;4 MeV</td>
<td>&gt;40 MeV</td>
<td>0.29</td>
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<td>Ion Chamber</td>
<td>4&quot; diameter spherical Neher-type integrating ion chamber</td>
<td>210 mg/cm²</td>
<td>---</td>
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<td>&gt;0.7 MeV</td>
<td>&gt;12 MeV</td>
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Figure 2: Typical GM Electron Detection Efficiency
205 HT. The window diameter has been necked down to 0.17" in order to support the mica window against pressure. Its response to electrons is also shown in Figure 2. As can be seen, its threshold is about 22 keV for electrons.

The proton response of these tubes is calculated from range energy curves given by Trower after the tube window thicknesses are calibrated with an alpha-particle source.

The 8 mil gold scatter foil used in GM1 provides effective discrimination against protons. All particles seen by the counter must backscatter off the foil. Protons lose energy before they are scattered through large angles, as can be illustrated by calculating the rms scattering of a 10 MeV proton in a length equal to its range. From Fermi:

\[
\sigma^2 \approx \frac{8\pi N D z^2 Z^2 e^4}{V^2 p^2} \ln \left(\frac{a_0 V p}{2Z^{4/3} z e^2}\right)
\]

where \( N \) = number of atoms per \( \text{cm}^3 \), \( D \) = length of travel (placed equal to the range), \( z \) = charge of particle = 1 for proton, \( Z \) = charge of scatter = 79 for gold, \( e \) = electron charge, \( V \) = velocity of particle, \( p \) = momentum of particle, and \( a_0 \) = Bohr radius. We obtain

\[
\sqrt{\sigma^2} \approx 0.2 \text{ radians} \approx 10^\circ
\]

Tests on the efficiency of the scatter foil for proton rejection were conducted using a cyclotron beam of 4 MeV protons. An upper limit of 0.1% was obtained for the proton detection efficiency. Furthermore the observation of solar proton events in space has confirmed that the count rate of the scatter counter due to backscattered protons is negligible.
Electrons backscatter off the gold foil with high efficiency. A well referenced treatment of electron scattering is contained in Siegbahn, and only the pertinent results will be mentioned here. The 8 mil gold foil is thick enough to insure saturation backscattering of electrons of a few MeV or lower energies. Fifty per cent of a normally incident beam of electrons and 70% of a diffuse beam will be backscattered from the gold foil. The angular distribution of the backscattered electrons will be approximately $\cos^2 \theta$ in angular dependence. Neither the backscatter efficiency nor the angular distribution of the backscattered electrons is dependent on the energy of the incident electron. However, energy loss occurs in the scattering foil. Measurements indicate that for a heavy element such as gold the probable energy loss is about 5-10%, with about two-thirds of the particles losing less than 20% of their energy. The effect of this energy loss is two-fold:

1. The energy threshold of the scatter counters are about 5 keV higher than the bare GM tube, and

2. the counting efficiency versus electron energy curve is not quite as sharply falling.

Thus the scatter counter's (GM1) threshold is about 45 keV for electrons. From the above considerations the scattering efficiency would be expected to stay fairly constant over a wide range of electron energy above the threshold for the scatter counter. Figure 3 shows the measured efficiency versus energy for the IMP-3 scatter counter configuration, which is similar to the GM1 detectors flown here.

The GM tubes are shielded with 1.5 g/cm$^2$ of brass. This shielding is in addition to the spacecraft packaging and outer skin so that the total shielding is about 2.0 g/cm$^2$. Range-energy curves were used to determine the threshold energies for penetrating particles.
Figure 3 GM Scatter Counter Efficiency
The Geiger-Mueller tubes have dead times following a pulse. These dead times change at very high count rates since the voltage across the tube never recovers completely after a pulse before a new pulse starts. The variation of the count rate with flux is shown in Figure 4 for GM1 of the Explorer-34. The assumption of a constant dead time fits the curve well over the tube's useful dynamic range, and individually fitted dead times are used to correct the count rates of the detectors. These are entered as constants in the data processing format and are typically $\sim 10^{-4}$ seconds.

The GM detectors have a FWHM opening angle of $\sim 70^\circ$. In most applications, the GM data is treated as an omnidirectional average.

**Ionization Chamber**

A schematic of the ion chamber carried aboard Explorer-34 is shown in Figure 5. This is an integrating Neher-type ionization chamber. The operation of the chamber is straightforward. Before the ion chamber is energized, the tungsten whisker is not touching the collector (anode) and it is uncharged. When the +700 volts is applied, the whisker is charged to this potential. The electrostatic force existing between the collector and the whisker attracts the whisker and charges the collector to +700 volts which then repels the tungsten whisker. As the anode collects electrons from ionization in the chamber, the anode voltage drops until it reaches a critical voltage (about 500 V) which creates a powerful enough electrostatic force on the whisker to cause it to flick over and recharge the anode. The pulse created by
Figure 4: Typical GM Count Rate vs. Flux Calibration Curve
Figure 5

4" IONIZATION CHAMBER
the recharging is recorded and represents a specific amount of ionization in the chamber. The calibration curve of the Explorer-34 chamber is shown in Figure 6.

The response of the chamber to protons and electrons of different energies can be calculated. For very high energy (minimum ionizing) particles which penetrate the spacecraft the calculation is fairly simple. However, for low energy particles both the thickness of material surrounding the chamber, and the varying ionization loss of the particle with energy must be taken into account. The amount of energy lost in the chamber can be calculated from range-energy curves, and the material to be traversed before entering the chamber may be estimated from considerations of the ion chamber location on the spacecraft. Figure 7 gives the results of such calculations.

For the Explorer-34 ion chamber the time span between pulses is measured to milliseconds and read out every 10.24 seconds. Thus the time resolution of the Explorer-34 ion chamber is an inverse function of the radiation level. At galactic cosmic ray background levels the time resolution is about ten minutes.

Experiment Electronics Description

As indicated in the block diagram, Figure 8, each of the Geiger-Mueller detector pulse outputs is shaped and amplified by a pulse shaper (PS) and is then sent to its outputs driven stage (D) which provides the required electronic interface between the experiment and its accumulators. These accumulators are located in the Digital Data Processor (DDP) section of the spacecraft (S/C) encoder. The GM1 detector feeds the #3a accumulator an "S-T" type 16 bit accumulator and, likewise,
RESPONSE TO GAMMA RADIATION
IONIZATION CHAMBER no. 20
AT 700 VOLTS
5.44 X 10^-10 COULOMBS/PULSE
7.0 GMS ARGON

SOURCE CODE
- 1.35 MC Ra
X 901 MC Ra
O 1400 C Co60
• 140 C Co60

EVALUATED BY: L. N. SHAW
DATE: 15 FEBRUARY, 1967

Figure 6   IMP-F Ionization Chamber Calibration
Figure 7  Ionization Chamber Proton-Electron Response
the #3b accumulator is used for the GM2 detector. The accumulation cycle is identical for these two accumulators and both are read-out every 10.24 seconds.

An "S-T" accumulator will count signal pulses or events ("S" mode) up to the capacity of the accumulator ($2^{15}$-1) and will then count clock pulses ("T" mode) for the rest of the accumulation period. This is illustrated in Figure 9. The purpose of the "T" mode is to allow for an immediate interpretation of an overflow condition (i.e., the number of input events during the accumulation time is greater than the accumulation capacity). This technique avoids the multiple foldover problems inherent in a conventional "S" mode accumulator.

From Figure 9a it can be seen that the last bit is used to control selection of either the events input or a 3200 Hz clock input to the accumulator. The accumulator is initially reset to zero and events are selected as the input. Accumulation then proceeds in this "S" mode until either (a) the end of the 9.92 second accumulation interval, or (b) until the accumulator has reached its maximum count of $2^{15}$-1 events. If the maximum count has been reached, the next event will select the clock input and the accumulated results will then represent the time interval, T, indicated in Figure 9b. The clock frequency is chosen such that the accumulator will not overflow if counting clock pulses for 9.92 seconds, the maximum accumulation time. The accumulator input is "frozen" and readout by additional gating not shown during the 0.32 second interval. Thus, the last bit identifies the S or T mode for the 9.92 accumulation cycle. And, the average input event rate, R, is given as either
16.

3200 HZ CLOCK

EVENTS

Figure 9a "S-T" Accumulator

Figure 9b "S-T" Accumulator Timing

Figure 9a  "S-T" Accumulator

Figure 9b  "S-T" Accumulator Timing
where, \( N_s \) represents the accumulated counts (15 bits) in the "S" mode and \( N_t \) is the number of counts in the "T" mode.

Accumulators #3c, #3d, and #3e provide a time interval measurement for the ionization chamber detector. Because of the low count rates and wide dynamic range of the detector, about \( 5 \times 10^{-4} \) to \( 5 \times 10^1 \) Hz, a dual time base technique is used -- the 6400 Hz clock and the 10.24 second periodicity of the synchronization signals F3ab and F3cd. (See also Figure 10). The results presented in these accumulators will represent one of the following:

1. The elapsed time \( T_1 \) or \( T_2 \) between the ion chamber pulse and the start of the F3cd freeze and readout time.
2. The elapsed time \( T_3 \) between the first pair of ion chamber pulses occurring during the accumulation time of #3cd.
3. The presence of an ion chamber pulse that occurred during the freeze time of the #3cd accumulator, a "hidden" pulse.
4. No ion chamber pulse(s) during the last accumulation interval or freeze time of #3cd.

The ion chamber pulses are amplified, shaped and then fire a one shot multivibrator #1. This one shot provides a fixed deadtime to filter out any possible noise pulses from the detector.

One shot #1 drives a special 2 bit accumulator, #3e, a "jammer", via an output driver stage and its accumulation cycle is identical to that for #3c and #3d. It has only three possible states representing that
Figure 10  Ion Chamber Timing
either 0, 1, or 2 or more events occurred during the accumulation cycle and, thus, it serves to identify the results in accumulators #3c and #3d. These two accumulators are connected as a redundant pair, 14 bits only, in order to enhance data reduction.

Flip-Flops #1 and #2 are reset at the beginning (leading edge) of the freeze time F3cd. The synchronization signals F3ab, F3cd and the 6400 Hz clock each passes through an isolation buffer, B, which provides (a) optimum isolation between the experiment and the S/C encoder and (b) noise suppression. Flip-Flop #3 is reset on the trailing edge of F3ab. Gates G1 through G4 are initially closed.

The occurrence of an ion chamber pulse, after the freeze time F3cd, will open the gate G1 and toggle Flip-Flop #1. This will open gate G2 and allow the 6400 Hz clock to be counted by the accumulators. Gate G2 is closed and the measurement cycle stopped by either (a) the beginning of a new F3cd cycle which will reset Flip-Flop #1 or (b) the occurrence of a second ion chamber pulse which will toggle Flip-Flop #1, close G2, set Flip-Flop #2, and close G1.

Since there is a reasonable probability of an ion chamber pulse occurring during the freeze and readout time of the accumulators #3c and #3d, a "hidden pulse," and, since this could be significant for interval measurements at low count rates, a means is provided to identify these pulses. Flip-Flop #3 and gates G3 and G4 are used for this purpose. If an ion chamber pulse occurs during the accumulator freeze time, gate G3 is opened and Flip-Flop #3 is set which enables gate G4. Gate G4 will pass the F3ab signal and produce a single count in the accumulators. For periods less than about 10 seconds this single count is insignificant and will be "covered up" by the 6400 Hz clock.
The general equation for computing the ion chamber period, $T$, when a single event has occurred during the accumulation time which is indicated by the accumulator #3e having a single count and #3c and #3d having $>1$ counts is

$$T = \frac{(N_z + 1) (10.24) + (N_1 - N_2)}{N + 1} \times 6400$$

where

- $T$ = the period in seconds
- $N_2$ = the present #3c readout
- $N_1$ = the last #3c readout $>1$ preceding the present #3c readout
- $N_z$ = the number of #3e readouts which have been 0's or 1's between the $N_1$ and $N_2$ readouts
- $N$ = the number of #3c readouts which have been 1's between the $N_1$ and $N_2$ readouts.

If 2 or more pulses have occurred during a given #3c accumulation cycle, which is identified by accumulator #3e, the ion chamber period is given as

$$T = \frac{N_p}{6400}$$

where $N_p$ = the accumulated count in #3c.

A DC to DC power converter operating at a nominal 4 kHz provides low voltage logic power and the high voltage for the three detectors. A full wave rectifier produces the +3volts DC for the logic circuits. A voltage quadrupler and a gaseous discharge regulator tube provides +700 volts DC for the detectors.

Detailed electrical and mechanical drawings are given in Appendix II.
Specifications

Various mechanical and electrical specifications of the experiment are as indicated below.

MECHANICAL - THERMAL

1. Total experiment weight, potted: 1.33 lbs
2. Overall dimensions: 10"W x 5.1"D x 6.2"H
3. Operating temperature range: -60°C to +70°C

ELECTRICAL

1. Input power
   a. Voltage: 11.5 to 11.7 volts nominal
   ± 1% regulation
   b. Current: 11.6 mA nominal
   c. Power: 135 mW nominal

2. Synchronization signals F3ab and F3cd
   a. True state: ≤ - 2V @ 100kΩ
   b. False state: ≥ + 5.5V @ 200kΩ
   c. Rise and fall times: ≤ 30 μsec between +3v and -1.8v
   d. Period: 10.24 seconds
   e. True state width: 0.32 seconds

3. Clock signal
   a. TRUE state, FALSE state, rise and fall times: same as F3ab and F3cd above
   b. Frequency: 6400 Hz
   c. Symmetry: approx. 50%
4. Accumulator inputs
   a. Amplitude: +3.5V to +7V (6V nominal)
   b. Pulse width: 2 to 3 μsec @ 50% amplitude
   c. Rise and fall times: 0.2 to 2 μsec between 10% to 90% amplitude
   d. Base level: -1.5V to +0.5V
   e. Maximum frequency: 25kHz average
   f. Pulse pair resolution: ≤12.5 μsec

Telemetry

The University of California IMP-F experiment uses two 16 bit "S-T" accumulators, a 16 bit and a 14 bit "S" accumulator and a 2 bit "jammer" accumulator. (See Figures 8, 10, and 11.) The #3d accumulator is used as a redundant accumulator, 14 bits, for #3c. All accumulators are readout and reset twice per S/C sequence of 20.48 seconds. Thus, all three experiment detectors are readout once each 10.24 seconds. The "S-T" accumulators are reset to binary zeros while all others are reset to binary ones. The freeze time and readout of the #3c, #3d, and #3e accumulators lags the freeze time and readout of the #3a and #3b accumulators by 5.12 seconds. The #3a and #3b accumulators are frozen simultaneously and readout as successive 4 big (hexadecimal) bursts, the least significant bits first, into the telemetry stream. This is also true for the #3c, #3d, and #3e accumulators. Accumulator readouts occur in channels 4 through 7 inclusive during frames 2, 6, 10 and 14 as indicated in Figure 11.
Figure 11  UCal IMP-F Telemetry Format
Ground Support Equipment

Ground support equipment for the IMP-F experiment consisted of two classes of equipment--(1) bench checkout equipment and (2) a set of deliverable Ground Support Equipment, GSE, that became part of the S/C GSE system. The bench checkout equipment consisted of a Bench Checkout Box, power supply, counters and other equipment as required. This Bench Checkout Box served as a basic experiment logic exerciser and was used for (a) acceptance testing during the fabrication phases, (b) evaluation and testing during environmental tests and calibration at UCAL and (c) for experiment operational verification and tests in the field as required. The deliverable UCAL GSE was supplied with the experiment to Goddard Space Flight Center, GSFC, and became part of the total S/C GSE system. This GSE generated electrical stimulation and controlled the application of this electrical stimulus and radioactive source stimulus to the experiment. This allowed for a continuous cycling operational test of the experiment during all integration and environmental test phases of the S/C up until launch.

The Bench Checkout Box was housed in a 8" x 6" x 4" box. It was built from discrete components and power was supplied by a set of mercury batteries. A block diagram is given in Figure 12. The Geiger-Mueller, GM, channels could be independently stimulated at a fixed or variable rate via the inputs to experiment pulse shaper test points. Ion chamber channel stimulation was available either from the same signal source divided by 4 or a single event could be inserted from a one shot multivibrator. The clock sync could be driven at the nominal 6400 Hz rate from the 12.8 kHz oscillator and
a divide by 2. Flip-Flop.* On-off operation of the F3ab and F3cd sync signals was provided for with the bistable multivibrators serving as switch noise filters. (Detailed drawings are given in Appendix II, g.v.).

The "deliverable" UCAL IMP-F GSE consisted of a rack mountable set of electronics, Figure 13, a Buffer Box, Figure 14, and appropriate cabling. The Buffer Box was attached and electrically connected to the experiment through the experiment test connector. This GSE was used to provide a complete operational checkout of the experiment and its DDP accumulators during all testing phases after delivery of the experiment to GSFC. All operational modes of the experiment and its DDP accumulators are checked by applying electrical stimulus to the experiment. Detector performance was evaluated by use of a 100 μC Co⁶⁰ radioactive source. This source was held by a jig in the experiment in order to provide repeatable radioactive source stimulation. Both types of stimulus (electrical and source) were under automatic or manual control of the GSE.

The manual mode of operation permitted application of any single stimulus condition to the experiment in order to facilitate debugging when necessary.

*The reader should be aware that the IMP-F experiment and the AIMP-D & E experiments used identical electronics but they had slight differences in the external accumulator configuration, their timing, and their nomenclature. And, the same GSE was used for both projects with only nomenclature changes as required. Thus, many drawings used for IMP-F will have AIMP nomenclature and will include some features that are peculiar to the AIMP. The AIMP accumulators were readout four times slower than IMP-F and used a 1600Hz clock. Simulation of this clock rate is provided for in the Bench Checkout Box. The following items are also equivalent for these projects. #5 sync = F3cd sync, #6 sync - F3ab sync, IC clock = #3c & 3d Acc's, IC count = #3e Acc, SIMP = IMP-F. A description of the AIMP is given in "Final Report for Energetic Particle Flux Experiment AIMP-D&E," NAS5-9077, Space Sciences Laboratory Series 11, Issue 75.
Figure 14  IMP-F GSE Buffer Box
A block diagram of this GSE is given in Figure 15. All electrical stimulus for the experiment is derived from 3 signals received from the Buffer Box--F3ab sync, F3cd sync, and the 6400 Hz clock. The F3ab and F3cd sync signals are delayed about 20μsec behind the 6400 Hz clock in a driver section (see detailed schematics) prior to use in the signal generation section in order to prevent noise spike generation during the transition time of the sync signals. Application of the generated signals at the proper time to the experiment is via the three switch sections which are controlled by the slave counter and matrix section. The slave counters receive S/C GSE signals (A, a₁, a₂, a₃ and a₄) which identify S/C sequences 0 through 15 the maximum number of sequences per cycle in the GSE. These signals and F3ab sync, F3cd sync are used to produce two slaved countdown chains in synchronism with the accumulator cycles in order to keep all stimulus in step with the accumulator cycles. The slaving action occurs within 10.24 seconds or less after turn-on or an interruption of any of the sync lines. The slave counter section also provides the electrical-source stimulus control via the Buffer Box.

On the front panel of the MAIN GSE box, Figure 13, are three switches for control of the operating mode - MANUAL SEQUENCE, MODE, and STIMULATION. With the MODE switch in the AUTO position and the STIMULATION switch in the BOTH position the GSE repeatedly cycles through 16 S/C sequences with 8 sequences of electrical stimulation and 8 sequences of source stimulation. If the STIMULATION switch is in the ELECTR. position, the GSE cycles continuously through the 8 sequences of electrical stimulation and
with this switch in the SOURCE position only source stimulation is allowed. The 8 position MANUAL SEQUENCE switch provides for application of any one of the electrical stimulus conditions when the MODE switch is in MAN and the STIMULATION switch is in ELECTR.

Table 2 lists the stimulus signals, their use and the resultant accumulator readouts. The 3abS and 3abE designations represent a pulse generated at the start and the end respectively of the F3ab freeze time. Since this system is essentially a coherent system it is possible to predict very precise electrical readout limits as indicated in the table. Radioactive source limits were determined prior to delivery of the experiment with an in house source and then predicted and updated as required for the GSFC sources used during testing.

**Fabrication and Qualification**

The experiment electronics was fabricated by the subcontractor, Marshall Laboratories, Torrance, California. Welded, cordwood, 3 volt logic modules mounted on a double sided printed circuit board were housed in a standard GSFC supplied "D" frame. Visual and thermal tests were performed at the subcontractor's site prior to accepting delivery. The GM detectors are commercial items, whereas, the ionization chamber was fabricated at UCAL. The Geiger-Mueller detector housings and other miscellaneous hardware were also built in house. Integration of the detectors and electronics, high voltage potting, etc. was performed at UCAL. And, detector calibration, thermal and vacuum qualification tests were done in house. The experiment was potted (Ecco-foam), vibrated and magnetically qualified at GSFC. The ground support equipment was fabricated at UCAL.
<table>
<thead>
<tr>
<th>SEQ. NO.</th>
<th>#3a GM1</th>
<th>#3b GM2</th>
<th>#3c IC CLOCK</th>
<th>#3e IC COUNT</th>
<th>GM'S</th>
<th>ION CHAMBER</th>
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<tr>
<td>0</td>
<td>15359T*</td>
<td>15359T*</td>
<td>16**</td>
<td>2</td>
<td>6400 Hz</td>
<td>400 Hz</td>
</tr>
<tr>
<td></td>
<td>15359T*</td>
<td>15359T*</td>
<td>16**</td>
<td>2</td>
<td>T MODE</td>
<td>FAST RATE</td>
</tr>
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<td>15359T*</td>
<td>0</td>
<td>32768*</td>
<td>1</td>
<td>6400 Hz and ZERO</td>
<td>3abS</td>
</tr>
<tr>
<td></td>
<td>15359T*</td>
<td>0</td>
<td>32768*</td>
<td>1</td>
<td>T MODE and X TALK</td>
<td>SINGLE PULSE</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>15359T*</td>
<td>30719*</td>
<td>1</td>
<td>ZERO and 6400 Hz</td>
<td>3abE</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>15359T*</td>
<td>30719*</td>
<td>1</td>
<td>T MODE and X TALK</td>
<td>SINGLE PULSE</td>
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<tr>
<td>3</td>
<td>31743*</td>
<td>31743*</td>
<td>2049</td>
<td>2</td>
<td>3200 Hz</td>
<td>3abS + 3abE</td>
</tr>
<tr>
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<td>31743*</td>
<td>31743*</td>
<td>2049</td>
<td>2</td>
<td>S MODE HIGH RATE</td>
<td>PULSE PAIR</td>
</tr>
<tr>
<td>4</td>
<td>3968*</td>
<td>3968*</td>
<td>30719*</td>
<td>1</td>
<td>400 Hz</td>
<td>3abE/2</td>
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<tr>
<td></td>
<td>3968*</td>
<td>3968*</td>
<td>0</td>
<td>0</td>
<td>S MODE LOW RATE</td>
<td>SLOW RATE</td>
</tr>
<tr>
<td>5</td>
<td>2048</td>
<td>2048</td>
<td>30719*</td>
<td>1</td>
<td>6400 (3cd$)</td>
<td>3abE/2</td>
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<tr>
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<td>2048</td>
<td>2048</td>
<td>0</td>
<td>0</td>
<td>BURST</td>
<td>SLOW RATE</td>
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<td>6</td>
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<td>13cd$</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>SINGLE PULSE</td>
<td>HIDDEN PULSE</td>
</tr>
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<td>0</td>
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<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>QUIET</td>
<td>QUIET</td>
</tr>
<tr>
<td>8</td>
<td>RS</td>
<td>RS</td>
<td>RS</td>
<td>RS</td>
<td>RADIOACTIVE SOURCE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RS</td>
<td>RS</td>
<td>RS</td>
<td>RS</td>
<td></td>
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</tr>
<tr>
<td>15</td>
<td>RS</td>
<td>RS</td>
<td>RS</td>
<td>RS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Limits: *+0, **+1, others ±0
-1 -2
History

The experiment electronics was accepted from the subcontractor on February 24, 1966. Detectors were being mated with the electronics and preliminary tests performed from May 5, 1966 to July 19, 1966. During vacuum testing on August 19, 1966, the ionization chamber detector was found to be defective. This detector was replaced on September 13, 1966 and it was subsequently found to be marginal during tests performed between September 19 to November 18, 1966. The ionization chamber was replaced again on November 19, 1966. Thermal and vacuum qualification tests at UCAL were successively completed on November 28, 1966. The experiment was delivered to GSFC on November 29, 1966, potted, vibrated and magnetically qualified, and successively integrated into the S/C on November 30, 1966. During some of the testing phase at GSFC and at the Western Test Range, WTR, it was discovered that the ionization chamber exhibited some occasional double pulsing — the second pulse occurring about 150 to 200 \( \mu \text{sec} \) after the main pulse. This did not affect the basic calibration of the detector. It did produce undesirable, but, recognizable results in the accumulator outputs. This detector was not replaced due to the tight scheduling problems and the unavailability of a more suitable ionization chamber at the time. Final calibrations were performed at WTR on May 10, 1967 and the experiment was launched from WTR on May 24, 1967 at 07:06 hrs PDST.

The experiment functioned normally from launch until September 4, 1967. On that date as the spacecraft exited from the earth's magnetosphere, GM1, the scatter detector, went into a continuous discharge mode, counting \( >10^4 \) cps. By September 14 the pulses from GM1 were
too small to be counted by the electronics. By September 18, 1967 the count rate in GM2, the open counter, was limited to \( \leq 10^2 \) cps by the current drain due to GM1 which had pulled down the power supply voltage. On September 27 the ionization chamber stopped counting; apparently also due to low power supply voltage. Data from GM2, although of limited usefulness, continued to be received through November 8, 1967.
REFERENCES

   Range-Energy and dE/dX Plots of Charged Particles in Matter,
   University of California, Lawrence Radiation Laboratory,
   Berkeley, Publication UCRL-2426, 1966

2. Fermi, E., Notes compiled by J. Orear, A. H. Rosenfeld,
   and R. A. Schluter, *Nuclear Physics,* University of Chicago

   Res.,* 70, 1039, 1965

   Vol. 1, N. Holland Publishing Co., Amsterdam, Netherlands, 1965
II. THE IMP-G (S1) EXPERIMENT ABOARD EXPLORER-41

Description of Detectors

The University of California experiment aboard Explorer-41 contains six Geiger-Mueller detectors, three, P1, P2, P3, pointed along the spin axis and three, E1, E2, E3, pointed perpendicular to the spin axis. Four detectors look directly at the particle fluxes while two, P2 and E2, observe the particle flux backscatter off an 8 mil gold foil. The backscatter detectors are only sensitive to electrons. With these six detectors, electron fluxes are measured in four integral energy intervals, protons in three integral energy intervals, and solar X-rays in two energy intervals.

Additionally, a 4" diameter ionization chamber identical to the one in the Explorer-34 experiment is included. The configuration of these detectors is shown in Figures 16 and 17 and the detector characteristics are given in Table 3.

Geiger-Mueller Detectors

All the Geiger-Mueller detectors are manufactured by LND, Inc. E1, E2, E3, P2, and P3 use the LND Model 7041 which are similar to the Lionel 205HT used in the Explorer-34 experiment. These GM detectors have a cylindrical cathode of $\frac{4}{4}''$ inside diameter with a $\frac{1}{4}''$ diameter mica window and are sensitive to radiation over the entire area of the window. Various thicknesses of mica windows and additional aluminum foils over the windows are used to obtain the energy thresholds desired. P1 is a LND 705 GM detector with cathode of inside diameter $0.093''$ and with an extra thin, $0.5$ mg/cm$^2$ mica window. A discussion of the energy response and scattering technique is given in the previous section on Explorer-34. All these LND detectors are filled with neon and a trace
Figure 16

Ionization Chamber

Test Connectors

P1, P2, P3

E1, E2, E3

CAL-05

DMG-G Experiment, Front View
Table 3

Explorer-41 Detector Characteristics

<table>
<thead>
<tr>
<th>Detector Designation</th>
<th>Type of Detector</th>
<th>Window</th>
<th>Electrons</th>
<th>Protons</th>
<th>X-ray Factor cm² ster</th>
<th>Look Angle FWHM</th>
<th>Angle to Spin Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>LND 705 GM tube</td>
<td>0.5 mg/cm² mica</td>
<td>&gt;18 KeV</td>
<td>&gt;0.25 MeV</td>
<td>None</td>
<td>2.7 × 10⁻²</td>
<td>40°</td>
</tr>
<tr>
<td>P2</td>
<td>LND 7041 GM tube in scatter configuration</td>
<td>1.5 mg/cm² mica</td>
<td>&gt;45 KeV</td>
<td>---</td>
<td>None</td>
<td>6.3 × 10⁻²</td>
<td>70°</td>
</tr>
<tr>
<td>P3</td>
<td>LND 7041 GM tube with Al foil</td>
<td>3.0 mg/cm² mica and 4.5 mg/Al</td>
<td>&gt;80 KeV</td>
<td>&gt;1.5 MeV</td>
<td>None</td>
<td>0.75</td>
<td>70°</td>
</tr>
<tr>
<td>E₁</td>
<td>LND 7041 GM tube, thick window</td>
<td>13 mg/cm² mica</td>
<td>&gt;120 KeV</td>
<td>&gt;2.3 MeV</td>
<td>3-20 KeV*</td>
<td>1.03</td>
<td>70°</td>
</tr>
<tr>
<td>E₂</td>
<td>LND 7041 GM tube in scatter configuration</td>
<td>1.5 mg/cm² mica</td>
<td>&gt;45 KeV</td>
<td>---</td>
<td>None</td>
<td>6.5 × 10⁻²</td>
<td>70°</td>
</tr>
<tr>
<td>E₃</td>
<td>LND 7041 GM tube with Al foil</td>
<td>2.7 mg/cm² mica and 4.5 mg/Al</td>
<td>&gt;80 KeV</td>
<td>&gt;1.5 MeV</td>
<td>1-20 KeV*</td>
<td>0.86</td>
<td>70°</td>
</tr>
<tr>
<td>IC</td>
<td>4&quot; diameter spherical, Neher type integrating ionization chamber</td>
<td>210 mg/cm² Aluminum skin</td>
<td>&gt;0.7 MeV</td>
<td>&gt;12 MeV</td>
<td>≥20 KeV* maximum sensitivity</td>
<td>~80 cm²</td>
<td>omnidirectional</td>
</tr>
</tbody>
</table>

* X-ray range -- 0.1% efficiency points
of bromine quench gas. The use of bromine instead of the more standard chlorine contributes to more stable performance and flatter plateau slopes. The shielding for these detectors is identical to that for the Explorer-34 GM detectors.

The two open detectors which point perpendicular to the spin axis, El and E3, view the sun on every spin since the spin axis is oriented perpendicular to the ecliptic plane. These two detectors respond to solar X-rays in the 1 to 10 keV region, and in particular E3's background is predominantly due to quiet time soft X-rays.

The X-ray response of these counters can be calculated if the composition of the mica window and the fill gas is known. If an X-ray beam of intensity $I_0(\lambda)$ is incident on a material of thickness, $\ell$, then the intensity of the penetrating beam is

$$I(\lambda) = I_0(\lambda) \exp \left[ - \rho \ell \sigma(\lambda) \right]$$

where $\rho = \text{density of the material}$, and $\sigma(\lambda) = \text{cross-section}$.

$$\sigma(\lambda) = \frac{1}{\rho} \sum \rho_i \sigma_i(\lambda)$$

where $\rho_i = \text{density of element } i \text{ in the material}$ and $\sigma_i(\lambda) = \text{cross-section for element } i$.

For an X-ray to be counted by the Geiger-Mueller tube, it must penetrate the window and stop in the gas. Therefore, the counting efficiency is given by

$$\frac{I(\lambda)}{I_0(\lambda)} = \exp \left[ - \rho \ell \sigma(\lambda) \right]_{\text{mica}} \left\{ 1 - \exp \left[ - \rho \ell \sigma(\lambda) \right]_{\text{gas}} \right\}$$

Using the cross-sections kindly supplied by L. Acton (private communication), the calculation has been carried for El and E3. The resulting efficiency curve is shown in Figure 18.
Figure 18  Explorer-41 X-ray Response
The accumulation period of the detectors is several times the
spin period so that E1, E2, E3 essentially average particle fluxes over
a wide cone of directions. However, some pitch-angle information can
be obtained through comparisons of E2 and P2 and E3 with P3.

**Ionization Chamber**

The ionization chamber is essentially identical to that in the
Explorer 34 experiment. The calibration curve for the Explorer-41
chamber is given in Figure 19. The energy response is shown in
Figure 7 of the section on Explorer-34.

**Experiment Electronics Description**

The block diagram of the University of California IMP-G exper-
iment is given in Figure 20. It should be noted that this IMP-G electronics
is very similar to that used for the IMP-F experiment—the principle
difference being those changes necessary to accommodate the four additional
detectors. Therefore, those sections previously discussed that are the
same will not be repeated here (e.g., Ion Chamber logic, S-T accumu-
lators, etc.).

Commutation of the six Geiger-Mueller detectors into the #3a
and #3b accumulators is by means of a 2 pole 4 position electronic switch
controlled by a matrix section which is driven by the CAL COM syn-
chronization signal. The CAL COM signal switches every S/C sequence
(i.e., 2 S/C sequences per cycle). However, the use of this signal was
not sufficient to identify uniquely the GM detector positions in the tele-
metry format. (The CAL COM signal was the only available signal
from the S/C encoder for this commutation—it was originally intended
for use in the IMP-F prior to a reconfiguration of the #3a and #3b
accumulators). A 3200 Hz signal, derived from the 6400 Hz clock, was
Figure 19 Explorer-41 Ionization Chamber Calibration
Figure 20  IMP-G Experiment Block Diagram
used as an additional commutator input signal to provide this identification. The 3200 Hz frequency was chosen rather than the 6400 Hz in order to provide an "S" mode accumulator output which gives a tighter limit for this ID. Since the accumulator ID outputs are redundant, they can also be used in data processing as a "noise" check on the data.

In the Ion Chamber logic section two minor changes were made: (a) a different phase from the One Shot #1 was used to drive the #3e, IC COUNT, output; and (b) the One Shot #3 was added. In addition, there was a change made in the accumulator configuration prior to launch. The #3e accumulator became defective late in the S/C testing phases. Because of the difficulty in making a repair of this accumulator in the S/C flight encoder and the inherent risk to the project as a whole, it was decided to disable the #3e accumulator and use the #3d accumulator in its place. This was easily accomplished by a simple external wiring change. Thus, as flown, the #3e accumulator was inactive, the #3d accumulator is used for the IC COUNT output, and the #3c accumulator was used for the IC CLOCK output.

The output drivers were also changed from a transformer coupled technique to a one shot plus a 6 volt driver combination. This was done in order to reduce some difficulties during the fabrication phases in the setting of the pulse width, rise and fall times for the output driver stages.

The power supply is very similar to that used in the IMP-F. Here, two additional gaseous discharge regulators were used to provide the additional high voltages, one of these being 550 volts which was required for the P1 detector. And a full wave rectifier was added to
provide the +6 volts DC.

Specifications

Several of the mechanical and electrical specifications of the experiment are as indicated below.

MECHANICAL-THERMAL

1. Total experiment weight, potted: 2.52 lbs.
2. Overall dimensions: 10" W x 5.1" D x 6.5" H
3. Operating temperature range: -30°C to +70°C

ELECTRICAL

1. Input power
   a. Voltage: 11.5 to 11.7 volts nominal ±1% regulation
   b. Current: 29 mA nominal
   c. Power: 340 mW nominal

2. Synchronization signals
   a. True state: ≤ -2v @ 100 KΩ
   b. False state: ≥ +5v @ 200 KΩ
   c. Rise and fall times: ≤ 30 µsec between +3v and -1.8v
   d. F3ab and F3cd period: 10.24 seconds
      True state width: 0.32 seconds
      F3cd lags F3ab: 5.12 seconds
e. CLOCK

Frequency: 6400 Hz
Symmetry approx. 50%

f. CAL COM

Period: 20.48 seconds
True state width: 10.24 seconds
False: from Frame 2, Channel 8 through Frame 10, Channel 7

3. Output Pulses

a. Amplitude: +3.5V to +7V (+6V nominal)
b. Pulse width 2.5 μsec ± 0.5 μsec @ 50% amplitude
c. Rise and fall times: 0.2 μsec to 2 μsec @ 10% and 90% amplitude
d. Maximum rates: 25 kHz average
e. Pulse pair resolution 10 μsec or better
f. Base level -1.5V to +0.5V

Telemetry

The University of California IMP-G experiment uses two 16-bit "S-T" accumulators, a 16-bit "S" accumulator, and a 14-bit "S" accumulator (the 2-bit accumulator #3e is inactive). See Figures 20 and 21. All accumulators are readout and reset twice per S/C sequence of 20.48 seconds. The "S-T" accumulators are reset to binary zeroes, while the "S" accumulators are reset to binary ones. A complete experiment cycle requires 40.96 seconds. The beginning of the cycle is identified with a special ID readout (31743 +0) occurring in the #3a and #3b accumulators. The Ion Chamber data are readout four times per experiment cycle. Data from each of the GM detectors are accumulated for 9.92 seconds (10.24-0.32) every 40.96 seconds. Each of the accumulator
Figure 21  UCal IMP-G Telemetry Format
pairs (#3a-#3b and #3c-#3d) inputs are frozen simultaneously for 0.32 seconds every 10.24 seconds during which time the data are readout as successive 4-bit hexadecimal bursts with the least significant bits first. The freeze and readout times of the #3c and #3d accumulators lag the freeze and readout of the #3a and #3b accumulators by 5.12 seconds. The readouts occur in channels 4 through 7 inclusive during frames 2, 6, 10, and 14 as indicated.

**Ground Support Equipment**

The ground support equipment for the UCAL IMP-G experiment consisted of a Bench Checkout Box and a deliverable set of GSE that became part of the S/C GSE system. (Both types of equipment are similar in purpose and function to that which was used for the IMP-F project). Here, the basic Bench Checkout Box features have been expanded to include matrix control of the experiment and additional logic to simplify the Ion Chamber logic testing. A principal departure of the deliverable GSE, however, is the considerable effort that was expended on the UCAL software used in the S/C GSE computer (an SDS 920) in order to automate the UCAL GSE system. The motivation behind this software effort was twofold: (a) a desire by the GSFC personnel to automate the S/C GSE system if possible; and (b) the desire by UCAL to determine if this GSE system approach would be a reasonable one for future projects, namely the IMP-I.

The IMP-G Bench Checkout Box was housed in a 12" W x 7" D x 5" H box as illustrated in Figure 22. Power was supplied internally by a pair of mercury batteries sufficient for at least 125 hours of operation. This equipment used MOSFET integrated circuits, supplied by GSFC, which
were surplus items from the AIMP D and E projects. Only two IC types were used: (a) a triple input gate; and (b) a master slave Flip Flop.

Referring to the block diagram in Figure 23, the matrix control section allowed for complete control of the experiment commutator section. By forcing Y and \( \overline{Y} \) via the experiment test points and driving CAL COM, \( \overline{X} \), it was possible to force the selection of any of the four commutator signal inputs. (The Y signal is the count down by two of CAL COM in the experiment). With the MATRIX CONTROL switch in the MAN position, the CAL COM line was driven (but not Y or \( \overline{Y} \)) which allowed TRUE FALSE control of CAL COM via the MAN switch. Putting the MATRIX CONTROL switch in the AUTO position allowed CAL COM to be driven at either the nominal fixed rate or at a variable rate (Y and \( \overline{Y} \) not driven). The variable rate provided a speed up of 10 to 100 times the nominal commutator switching rate in order to facilitate testing. Manual operation of the F3ab and F3cd sync lines was provided for by means of two switches, Flip-Flops used as switch noise filters and appropriate interface drivers.

The GM channel stimulus control logic provides a means of applying stimulus derived from either the fixed 6.4 KHz oscillator or a variable oscillator to the six GM channels in various combinations. With the GM SELECT switch in the ALL position and the SELECT switch in the ON position, all six GM channels were driven by the selected stimulus. Whereas, placing the SELECT switch in the OFF position removed all GM stimulus. With the GM SELECT switch in any of the single channel positions and the SELECT switch in the ON (OTHERS OFF) position only that particular channel was driven. But putting the SELECT switch in the OFF (OTHERS ON) position provided complementary control--the five remaining channels were simultaneously driven while the single selected channel was not--
Figure 23  IMP-G Bench Checkout Box, Block Diagram
which provided a means of performing crosstalk checks in the GM channels. The fixed 6.4 KHz oscillator was also applied to the CLOCK switch for use as the 6400 Hz CLOCK synchronization signal to the experiment.

The IC channel stimulus logic operated in any of three possible modes. In the MAN mode, a single event was simulated each time the MAN/PP switch was pressed. In the PULSE PAIR mode, a pulse pair with a spacing of ten 6400 KHz CLOCK cycles was produced each time the MAN/PP switch was activated. The AUTO mode produced a continuous series of pulses with a spacing of 16 clock cycles.

Additional features of this Checkout Box included test points to monitor the experiment outputs and all experiment test points. And, the Checkout Box could also be used as a GM channel and IC channel stimulus source while the experiment was operating in the S/C.

The "deliverable" UCAL IMP-G GSE equipment consisted of a rack mountable set of electronics (Figure 24), a Buffer Box (Figure 25), and appropriate cabling. The Buffer Box was attached and electrically connected to the experiment by means of the 15 pin experiment test connector. As with the IMP-F, this GSE was used to provide a complete operational checkout of the experiment and its DDP accumulators during all testing phases after delivery of the experiment to GSFC. All operational modes of the experiment and its DDP accumulators were checked by applying electrical stimulus to the experiment. Detector performance was evaluated by use of a 100 μc Co\(^{60}\) radioactive source. This radioactive source was held by a jig in the experiment in order to provide repeatable stimulation. Both types of stimulus (electrical and source)
were under automatic or manual control of the GSE. The manual mode of operation permitted application of any single stimulus condition to the experiment in order to facilitate debugging when necessary.

An integral part of this GSE system was the software used in the S/C GSE computer (an SDS 920). This software performed a comprehensive set of tests on the experimental data which lead to a GO or NO GO status for the experiment for each GSE stimulus cycle. The type of cycle was determined by the settings of the CYCLE RATE and STIMULATION switches and was approximately 10 or 20 minutes in length. The six possible stimulation cycles are illustrated in Figure 26. The electrical stimulus subcycle of 10 sequences was similar in concept to that used for the IMP-F experiment. It is illustrated in detail in Figure 27. All cycles were terminated by a special end cycle electrical stimulus which the software recognized. This forced a series of summary calculations and limit tests to be performed, the results of which were presented in a data summary printout which included the GO-NO GO status tag. Limit tests were made on the electrical stimulus data and also on the average rates and a statistical goodness of fit test (Chi Squared Test) for the source stimulation data. If a NO GO status was indicated, various pointers and flags were used to identify the nature of the problem.

This software system could also function in the absence of the GSE hardware. (The software included a test for this). In this case, the operating cycle would become a SOURCE cycle. The cycle rate was determined by a computer panel switch, CS16, which selected a 16 sequence or a 40 sequence source cycle. Additionally, a priority switch,
<table>
<thead>
<tr>
<th>STIMULATION</th>
<th>CYCLE RATE</th>
<th>CYCLE</th>
</tr>
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<td>ELECT</td>
<td>10 MIN</td>
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<tr>
<td></td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>10 SEQ</td>
<td>10 SEQ</td>
</tr>
<tr>
<td></td>
<td>6:50</td>
<td>2 SEQ</td>
</tr>
<tr>
<td></td>
<td>8 MIN</td>
<td></td>
</tr>
<tr>
<td>ELECT</td>
<td>20 MIN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>10 SEQ</td>
<td>10 SEQ</td>
</tr>
<tr>
<td></td>
<td>10 SEQ</td>
<td>10 SEQ</td>
</tr>
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<td></td>
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<tr>
<td>SOURCE</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>D.S.</td>
</tr>
<tr>
<td></td>
<td>16 SEQ</td>
<td>2 SEQ</td>
</tr>
<tr>
<td></td>
<td>5:28</td>
<td></td>
</tr>
<tr>
<td>SOURCE</td>
<td>20 MIN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S</td>
<td></td>
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<tr>
<td></td>
<td>40 SEQ</td>
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<td>13:39</td>
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<td>BOTH</td>
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<td></td>
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<td>16 SEQ</td>
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<td></td>
<td>10 MIN</td>
<td></td>
</tr>
<tr>
<td>BOTH</td>
<td>20 MIN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td>10 SEQ</td>
<td>40 SEQ</td>
</tr>
<tr>
<td></td>
<td>18:26</td>
<td>2 SEQ</td>
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Figure 26  Basic IMP-G GSE Cycles
<table>
<thead>
<tr>
<th>ELECT SEQUENCE</th>
<th>GM CHECKS</th>
<th>STIMULATION</th>
<th>OUTPUTS</th>
<th>IC CHECKS</th>
<th>STIMULATION</th>
<th>OUTPUTS</th>
<th>COMPT SENSE CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X-TALK &amp; OUTPUTS + T MODE CHECKS</td>
<td>6400 Hz-E1</td>
<td>0 0 0</td>
<td>3b5/2</td>
<td>0 0</td>
<td>(1P2K), (1P2K)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>X-TALK &amp; OUTPUTS + T MODE CHECKS</td>
<td>6400 Hz-E2</td>
<td>0 0 0</td>
<td>3b5/2</td>
<td>0 0</td>
<td>32768</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>X-TALK &amp; OUTPUTS + T MODE CHECKS</td>
<td>6400 Hz-E2,2E3P3</td>
<td>0 0 0</td>
<td>3b5</td>
<td>0 0</td>
<td>32768</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>X-TALK &amp; INPUTS</td>
<td>6400 Hz-E1,P1,E3P3</td>
<td>0 0 0</td>
<td>3b5+3AE</td>
<td>0 0</td>
<td>2048</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>X-TALK &amp; OUTPUTS + T MODE CHECKS</td>
<td>6300 Hz-P1</td>
<td>0 1535T</td>
<td>S.P.</td>
<td>0 0</td>
<td>32768</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>X-TALK &amp; OUTPUTS + T MODE CHECKS</td>
<td>6300 Hz-P2</td>
<td>0 1535T</td>
<td>B.P.</td>
<td>0 0</td>
<td>2048</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>QUIET</td>
<td>3E6+ E1.P1</td>
<td>0 0 0</td>
<td>FAST</td>
<td>0 0</td>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>QUIET</td>
<td>3E6+ E2,2E3P3</td>
<td>0 0 0</td>
<td>HIDDEN</td>
<td>0 0</td>
<td>0 0</td>
<td>0</td>
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<table>
<thead>
<tr>
<th>A</th>
<th>END CYCLE</th>
<th>6400 Hz-E1.P1</th>
<th>1535T</th>
<th>1535T</th>
<th>END CYCLE</th>
<th>(600 Hz) (32x)</th>
<th>B</th>
<th>2</th>
<th>2</th>
<th>(1E+8T5) + (E+INSERT+K5) (P=INSERT+K5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>(DATA SUMMARY)</td>
<td>__________</td>
<td>0 0 0</td>
<td>0 0</td>
<td>(DATA SUMMARY)</td>
<td>__________</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
<td>-----------------------------------------------</td>
</tr>
</tbody>
</table>

NOTES:

1. TYPICAL CONSTANTS ARE:
   K1 = 1000
   K2 = 10
   K5 = 20
   K4 = 3

2. THESE ARE 64 FOR "MODIFIED" FLIGHT ENCODER (4-17-68), 5U04

3. THESE ARE 224 FOR "MODIFIED" FLIGHT ENCODER (4-17-68), 5U04

Figure 27 IMP-G GSE Electrical Stimulus Format
PSW, was provided on the panel which would force the end of the present cycle and would start a new cycle as determined by the CS16 switch. A further discussion of the GSE software is given in Appendix I.

A block diagram of the IMP-G GSE hardware is given in Figure 28. All electrical stimulus signals are derived from the experiment signals $\bar{X}$ (CAL COM), Y, F3ab, F3cd, and the 6400 Hz clock. These stimulus signals were applied under control of the GM and IC commutators to the Output Drivers (7 ea) and hence to the Buffer Box and then the experiment. A Sync Lost section determined the validity of the GM and IC counter phases with respect to the CAL COM signal. In the event of an internal sync loss, the GSE cycle was automatically stopped and then restarted after regaining internal synchronization. A real time counter display used in conjunction with the F3ab and F3cd (GM and IC) counter displays and the cycle indicators provided a relative indication of the whereabouts of the GSE within a given cycle at any given time.

Rather than the use of counters slaved to the S/C GSE sequences (as was the case for the IMP-F GSE) for overall synchronization of the system, the IMP-G GSE system used four software tests. Three of these, ES1, ES5, and ES9, occurred in the electrical stimulation sequences 1, 5, and 9, respectively. The fourth, DS, occurred during the data summary stimulus.

These test conditions are illustrated in Figure 27.
Figure 28    IMP-G GSE Block Diagram
Fabrication and Qualification

The experiment electronics were fabricated by the subcontractor, Marshall Laboratories, Torrance, California. Welded, cordwood, 3-volt logic modules were mounted on two welded subassemblies (daughter boards) and on the main printed circuit board (mother board). The daughter boards contained the commutator logic and the ion chamber logic, respectively. A GSFC supplied "D" frame housed the experiment and the assembly was potted solid with the Ecco-Foam for structural rigidity. Visual and thermal tests were performed at the subcontractor's site prior to accepting delivery. The GM detectors are commercial items, whereas the ion chamber was fabricated at UCAL. The housings for the Gieger-Mueller detectors and other miscellaneous hardware were also built in house. Integration of the detectors and electronics and final assembly were performed at UCAL.

Detector calibrations, thermal, and vacuum qualification tests were done in house. The experiment was potted, vibrated, and magnetically qualified at GSFC. Ground support equipment was fabricated at UCAL.

History

The experimental electronics were accepted from the subcontractor on September 14, 1967. Final assembly and preliminary testing took place from September 15 to October 8, 1967. Thermal and vacuum qualification tests were performed successively between October 9 to October 15, 1967. The experiment was delivered to GSFC on October 18, 1967. It was subsequently potted, vibrated on October 19 and magnetically qualified on October 20, 1967. While it was being integrated
with the spacecraft on October 23, a malfunction was discovered. A defective electronic module (apparently the result of vibration tests) was replaced and the experiment integration was completed successively on October 24, 1967. Final calibrations were performed on May 20, 1968 at the Western Test Range and the experiment was successively launched from WTR on June 21, 1968 at 01:48 HRS PSDT.

All detectors functioned normally from launch to present (April, 1972) except for the ionization chamber. The chamber occasionally becomes intermittent or even ceases operation for periods of days to weeks. However, during times when pulses are observed from the chamber the response to incident radiation is normal. Apparently, the tungsten whisker occasionally sticks to the anode resulting in intermittent operation of the chamber.
III. The IMP-G' (S2) Experiment Aboard Explorer-41

Introduction

The University of California experiment flown aboard Explorer-41 was one of two experiments flown as replacements for the STL-TRW experiment which was on the IMP-F spacecraft. The other replacement experiment was supplied by the University of Iowa. An illustration of the University of California experiment is given in Figure 29.

Various "ground rules" were established by the GSFC IMP project management as to how this replacement would be made. First, it was necessary that the two replacement experiments, basically, appear as a single experiment to the spacecraft. As a result, the UCal experiment plugged into and interfaced electrically through the UIowa experiment. Additionally, these two experiments were restrained to the size, weight, power and electrical interface requirements that had been established for the STL-TRW experiment.

A number of problems were experienced in producing a flight qualified experiment. Some of this could be traced back to the restrictions imposed by the original ground rules. For example: (1) the severe size restraints placed on the UCal experiment led to many difficulties in the repairability of the experiment; (2) dependency on the UIowa experiment during qualification testing caused several problems.

Another significant factor was a time-management related problem. Originally it was expected that a flight qualified experiment would have to be available within 6 months or less. (A contract go ahead was given in September, 1967, with an anticipated launch of
May, 1968.) Thus, a rather tight schedule was anticipated. However, the spacecraft schedule eventually slipped about 1 year. University of California attempted to take advantage of these spacecraft schedule slips by making several experiment modifications for the purpose of improving the science and engineering of the experiment. Some of these changes proved to be detrimental very late in the program. The experiment was never fully integrated into the spacecraft until a few weeks before launch. And, indeed, there was a serious interference problem from the UIowa to the UCal experiment which was the result of sensitivity modifications to the experiment that had been made several months earlier. These and other problems are pointed out in the Pre-Launch History section.

Description of the Detectors

This experiment consists of a parallel plate electrostatic analyzer with two funnel-mouthed channel multiplier detectors located at different distances along the analyzer plates to provide two energy windows for electrons. Figure 30 gives a schematic of the detector system and Table 4 summarizes the detector characteristics. The entrance aperture is pointed $30^\circ$ above the satellite equatorial plane, and a sun shield is utilized to prevent solar ultraviolet radiation from entering the aperture. In addition the plates are coated with a lamp black coating to prevent scattered UV from entering the channel multipliers. The energy response is shown in Figure 31. The experiment was designed with large geocentric factors to detect low solar electron fluxes. In the magnetosphere the trapped radiation will saturate the channel multipliers and thereby shorten their lifetime. To increase the useful life of the experiment an automatic shutoff circuit was employed which turned off the high voltage to the plates and channel multiplier when the number of counts exceeded eight in 2 msec in channel 1.
### Table 4 IMP-G Detector Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Channel 1</th>
<th>Channel 2</th>
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</thead>
<tbody>
<tr>
<td><strong>Electron Energy Range</strong></td>
<td>4 - 8</td>
<td>9 - 13</td>
</tr>
<tr>
<td>(fwhm) keV</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Geometric Factor</strong></td>
<td>0.05</td>
<td>0.013</td>
</tr>
<tr>
<td>(cm^2 ster)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 31  Energy Response of Electrostatic Analyzer
Experiment Electronics Description

Signals from each of the detectors are amplified and shaped by preamplifiers which feed AND gates as indicated in Figure 32. The AND gates are disabled during the STL freeze time of 0.48 seconds which overlaps the freeze and readout time of the accumulators. The gate outputs are prescaled by 16 and feed the output drivers, OD, which provide the drive to the #2a and #2b accumulators after passing through the UIowa experiment. (The #2a signal is subcomutated by UIowa--see below.) The detector data rates, R, for the accumulators is given as

\[ R = \frac{(N \times 2^4)}{(5.12 - 0.48)} = 3.448 N \]

where N is the accumulated counts.

The output of the D1 detector preamplifier is monitored by an automatic high voltage shut off circuit. This signal feeds a \(2^7\) counter which is reset at a 500 Hz rate. If \(2^6, 64\), pulses are received within the 2 ms period, 32 kHz rate, the control Flip-Flop is set which turns off the high voltage and also resets the \(2^{10}\) counter in the automatic turn on circuit. (It should be noted that as flown, the shutoff circuit actually responded to 8 pulses in 2 ms, 8 kHz rate -- see Pre-Launch History, par. 22.) After \(2^{10}\) counts of the 5.12 second period freeze signal (i.e., 5243 seconds or 1 hr 27 min 23 sec) the control Flip-Flop is toggled to a reset condition which allows the high voltage to turn on.

The +3.5 kv used by the detectors and the -3.5 kv for the electrostatic plates was generated by a chopper driven DC to DC converter feeding two 5 stage voltage doublers. Voltage regulation of
both multipliers was provided by use of a 700 volt corona discharge regulator tube operating in the first stage of the +3.5 kv multiplier. (See detailed schematics in Appendix IV.) High voltage shut off control was provided by blocking the base feedback currents to the chopper transistors.

An additional chopper driven DC to DC converter using two full wave rectifiers produced the +6 volts and the +3 volts. A voltage doubler was used to generate +12 volts for operation of the HV shut off circuit within the power supply itself.

Specifications

MECHANICAL - THERMAL

1. Total experiment weight, potted: 1.18 lbs
2. Overall dimensions (excluding sun shield): 5.0" W x 5.1" D x 1.6" H
3. Operating temperature range: -15°C to +45°C

ELECTRICAL

1. Input power
   a. Voltage: 28 volts ± 5% regulation
   b. Current: 25 mA
   c. Power: 700 mW
   14.2 mA (HV off)
   400 mW (HV off)
2. STL FREEZE sync signal
   a. True state: ≤ -3V @ 20 kΩ
   b. False state: ≥ +6.5V @ 10 kΩ
   c. Rise and fall times: < 5 μsec
   d. Period: 5.12 sec
   e. True state width: 0.480 sec

3. Accumulation inputs
   a. Amplitude: +3.5V to +7V (6V nominal)
   b. Pulse width: > 3 μsec @ 3.5 V
   c. Base level: -5V to +0.5 V
   d. Maximum frequency: 51.2 kHz

Telemetry

The UCal IMP-G supplementary experiment uses two 8 bit "S" type accumulators #2a and #2b. The #2a accumulator is used for the D1 detector data and #2b is used for D2. As indicated in Figure 33, these accumulators are readout 4 times per S/C sequence, each 5.12 seconds, in sequences 0 through 7, only, of the 16 sequences. (In sequences 8 through 15, these telemetry slots are occupied by analog data.) Readouts occur during frames 1, 5, 9 and 13, however, D1 data is only present in frame 13 of sequence 0. (The UIowa experiment uses frames 1, 5, and 9 of sequence 0.) The accumulators are frozen simultaneously and readout as successive hexadecimal, 4 bit, bursts, the least significant bits first, into the telemetry stream. The accumulators are reset to binary ones after readout.

Ground Support Equipment

Ground support equipment for the IMP-G' experiment consisted of a Bench Checkout Box -- there was no deliverable set of GSE.
Figure 33  UCal IMP-G' Telemetry Format

NOTE: Acc's #2a and #2b in Seq's 0 through 7 only (of 16). In Seq 0
D1 in Frame 13 only.
This Bench Checkout Box, Figure 34, provided the basic functions to exercise the experiment. Stimulus to the detector channels was available at a 500 Hz or 1000 Hz rate. By use of the STIMULUS switch, stimulus could be applied to either data channel independently or to both channels at the same time. An additional switch disabled this stimulus and applied a 85 kHz signal to the D1 channel for checking the HV disable function in the experiment. The STL FREEZE signal could be applied at a 20 Hz rate or turned off via the FREEZE switch. Power was derived from a 6.2 volt zener diode.

Fabrication

All mechanical and electrical fabrication for this experiment was done in house at University of California. The channel multiplier detectors were commercial items; however, the electrostatic analyzer was fabricated in house. Electronic packaging included the use of the SN500 series of RTL logic and discrete component cordwood modules. The experiment was housed in a University of California built half "D" frame with top and bottom covers. High voltage potting was done at the University of California, whereas, final potting of the experiment with Eccofoam was done at GSFC. The Bench Checkout Box was fabricated at UCal.

Pre-Launch History and Qualification

The pre-launch history and qualification of the IMP-G' experiment is given in summary form in Table 5. And, further details are given in the referenced paragraphs below. The flight unit was SN#02; however, the history of both the SN#01 and SN#02 units is given since the successful qualification of the SN#02 unit was closely related to the SN#01 unit.
Figure 34
IMP-G' Bench Checkout Box Block Diagram
### TABLE 5 HISTORY SUMMARY OF THE IMP-G' EXPERIMENT

<table>
<thead>
<tr>
<th>DATE</th>
<th>S/N</th>
<th>ITEM</th>
<th>REF. PAR.</th>
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<tbody>
<tr>
<td>9/21-11/10/67</td>
<td>X</td>
<td>Fabrication</td>
<td>---</td>
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<tr>
<td>11/13/67</td>
<td>X</td>
<td>Magnetic tests and potting at GSFC. Magnetic test indicated stray fields from HV disable relay outside of specifications.</td>
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</tr>
<tr>
<td>11/29/67</td>
<td>--</td>
<td>New HV disable circuit designed and approved by GSFC.</td>
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</tr>
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<td>11/10-1/31/68</td>
<td>X</td>
<td>Fabrication</td>
<td>---</td>
</tr>
<tr>
<td>1/31-2/5/68</td>
<td>X</td>
<td>In house testing</td>
<td>---</td>
</tr>
<tr>
<td>2/8/68</td>
<td>X</td>
<td>Magnetic tests. Potting and vibration tests at GSFC.</td>
<td>---</td>
</tr>
<tr>
<td>2/9-9/25/68</td>
<td>X</td>
<td>HV disable circuit modified. Channeltron detectors replaced because of possible mechanical stress mounting problems.</td>
<td>---</td>
</tr>
<tr>
<td>3/22-4/5/68</td>
<td>X</td>
<td>S/C ther-vac tests. Test aborted</td>
<td>1</td>
</tr>
<tr>
<td>4/9-4/11/68</td>
<td>X</td>
<td>Subsystem ther-vac test.</td>
<td>2</td>
</tr>
<tr>
<td>9/25-9/29/68</td>
<td>X</td>
<td>In house testing</td>
<td>---</td>
</tr>
<tr>
<td>10/1/68</td>
<td>X</td>
<td>Magnetic tests and potting at GSFC.</td>
<td>---</td>
</tr>
<tr>
<td>11/13-11/25/68</td>
<td>X</td>
<td>S/C ther-vac tests. Test aborted</td>
<td>3</td>
</tr>
<tr>
<td>12/17-12/20/68</td>
<td>X</td>
<td>Subsystem ther-vac test at UCal. HV enable inoperative below +12°C.</td>
<td>---</td>
</tr>
<tr>
<td>12/27/68</td>
<td>X</td>
<td>In house tests and repairs</td>
<td>4</td>
</tr>
<tr>
<td>2/14/69</td>
<td>X</td>
<td>Potted and vibration tests at GSFC.</td>
<td>---</td>
</tr>
<tr>
<td>2/17-2/20/69</td>
<td>X</td>
<td>Subsystem ther-vac test of UCAl/UIowa.</td>
<td>---</td>
</tr>
<tr>
<td>1/7-11/10/69</td>
<td>X</td>
<td>Subsystem ther-vac test of UCAl/UIowa. Test aborted.</td>
<td>6</td>
</tr>
<tr>
<td>2/20-4/5/69</td>
<td>X</td>
<td>Modifications to pre-amp sensitivity and HV supply</td>
<td>7</td>
</tr>
<tr>
<td>4/8/69</td>
<td>X</td>
<td>Magnetic tests, potting and vibration tests at GSFC.</td>
<td>---</td>
</tr>
<tr>
<td>DATE</td>
<td>S/N 01</td>
<td>S/N 02</td>
<td>ITEM</td>
</tr>
<tr>
<td>------------</td>
<td>--------</td>
<td>--------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>4/9/69</td>
<td>X</td>
<td>X</td>
<td>In house management changed. Both units in ther-vac at GSFC. Unit 01: input current spikes - corona? Unit 02: many HV turn-offs - noise?</td>
</tr>
<tr>
<td>4/9/69</td>
<td></td>
<td>X</td>
<td>Chamber vented and opened. Attempts to reduce noise problems by changes in the set up (cables, grounds, etc)</td>
</tr>
<tr>
<td>4/10/69</td>
<td></td>
<td>X</td>
<td>Ther-vac restart. HV turn-on problem.</td>
</tr>
<tr>
<td>4/11/69</td>
<td>X</td>
<td>X</td>
<td>Removed from ther-vac. Both units returned to UCal for debugging.</td>
</tr>
<tr>
<td>4/11/69</td>
<td></td>
<td>X</td>
<td>Started tests at UCal.</td>
</tr>
<tr>
<td>4/11-12/69</td>
<td></td>
<td>X</td>
<td>1st confirmation of continuous HV turn-off malfunction.</td>
</tr>
<tr>
<td>4/12/69</td>
<td></td>
<td>X</td>
<td>Top cover removed. And, 2 millisecond reset oscillator probed.</td>
</tr>
<tr>
<td>4/12/69</td>
<td></td>
<td>X</td>
<td>1st confirmation of I&lt;sub&gt;n&lt;/sub&gt; spikes.</td>
</tr>
<tr>
<td>4/12/69</td>
<td></td>
<td>X</td>
<td>Mother board electronics released from experiment frame. Malfunction gone!</td>
</tr>
<tr>
<td>4/14-4/15/69</td>
<td></td>
<td>X</td>
<td>Mother board remounted in frame. Further testing.</td>
</tr>
<tr>
<td>4/15/69</td>
<td></td>
<td>X</td>
<td>Excess counts observed in output channel due to corona.</td>
</tr>
<tr>
<td>4/17/69</td>
<td>X</td>
<td>X</td>
<td>GO-NO GO decision being made at UCal and GSFC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>Ready for &quot;transplant.&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>NO-GO</td>
</tr>
<tr>
<td>4/18/69</td>
<td></td>
<td>X</td>
<td>Testing electronics -- FREEZE pulse problem.</td>
</tr>
<tr>
<td>4/18/69</td>
<td></td>
<td>X</td>
<td>Mother board transplant and electrical tests.</td>
</tr>
<tr>
<td>4/19/69</td>
<td></td>
<td>X</td>
<td>Thermal tests (UCal).</td>
</tr>
<tr>
<td>4/19/69</td>
<td></td>
<td>X</td>
<td>Ther-vac tests (UCal).</td>
</tr>
<tr>
<td>4/20/69</td>
<td></td>
<td>X</td>
<td>Returned to GSFC for potting, vibration and ther-vac.</td>
</tr>
<tr>
<td>4/23/69</td>
<td></td>
<td>X</td>
<td>Ther-vac set up -- X-talk problem.</td>
</tr>
<tr>
<td>4/24-5/1/69</td>
<td></td>
<td>X</td>
<td>Vac tests to find exact cause of corona problem.</td>
</tr>
<tr>
<td>4/25/69</td>
<td></td>
<td>X</td>
<td>Operational check in CTA S/C</td>
</tr>
<tr>
<td>4/25-5/6/69</td>
<td></td>
<td>X</td>
<td>Ther-vac tests at GSFC.</td>
</tr>
<tr>
<td>DATE</td>
<td>S/N</td>
<td>ITEM</td>
<td>REF. PAR.</td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
<td>--------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>5/6/69</td>
<td>X</td>
<td>T &amp; E chamber lost vac. HV was on approximately 6 minutes.</td>
<td>28</td>
</tr>
<tr>
<td>5/6/69</td>
<td>X</td>
<td>Ther-vac restarted. (Chamber # 241).</td>
<td>---</td>
</tr>
<tr>
<td>5/6-5/9/69</td>
<td>X</td>
<td>Ther-vac (GSFC).</td>
<td>29</td>
</tr>
<tr>
<td>5/9/69</td>
<td>X</td>
<td>Final deperm, top cover removed and pictures taken for degassing analysis.</td>
<td>---</td>
</tr>
<tr>
<td>5/9/69</td>
<td>X</td>
<td>Experiment returned to UCal, Berk. for further X-talk checks.</td>
<td>---</td>
</tr>
<tr>
<td>5/12/69</td>
<td>X</td>
<td>X-talk checks.</td>
<td>30</td>
</tr>
<tr>
<td>5/15/69</td>
<td>X</td>
<td>Design review meeting at GSFC. Passed.</td>
<td>---</td>
</tr>
<tr>
<td>5/20/69</td>
<td>X</td>
<td>Integration at WTR. Interference pickup problem.</td>
<td>31</td>
</tr>
<tr>
<td>5/22-5/23/69</td>
<td>X</td>
<td>Interference tests and repair at UCal.</td>
<td>32</td>
</tr>
<tr>
<td>5/26/69</td>
<td>X</td>
<td>Integration.</td>
<td>---</td>
</tr>
<tr>
<td>6/21/69</td>
<td>X</td>
<td>Launch</td>
<td>33</td>
</tr>
</tbody>
</table>
1. During the S/C thermal-vacuum tests of 3/22 to 4/5/68, no data output was observed for the SN#02 unit. This was due to a blown fuse in the UIowa power line interface to the UCal experiment. (Malfunction report A-02756.)

2. A separate subsystem thermal vacuum test of UCal SN02 was performed. Six hours at -10°C and 3 hours at +40°C. Operation was satisfactory.

3. Spacecraft thermal-vacuum tests were being performed on the SN01 unit from 11/13 to 11/25/68. On 11/19 no counts were observed on detector #2 at low temperatures apparently due to a faulty Flip-Flop. (Malfunction report A-03360.) On 11/21 the high voltage would not turn on at low temperatures. This was due to a faulty Flip-Flop in the HV enable circuit. (Malfunction report A-03304.)

4. The SN01 experiment was returned to UCal on 12/27/68. Bench checks indicated both channels were operating. High voltage enable failure was diagnosed to be due to faulty Flip-Flops which were replaced. Possible high voltage arcing during accidental high voltage turn on in poor vacuum resulted in several more Flip-Flop failures. (Malfunction report A-03422.) Inspection of the high voltage supply indicated that potting compound (Silgard) was peeling off some areas of the circuit board. These portions of the board were repotted in RTV after the detector coupling capacitor was reoriented to eliminate some of the high voltage circuit board pads.

5. From 3/26 to 4/4/69 spacecraft thermal-vacuum tests were being performed on the SN01 unit. The experiment was operational until 4/1/69 during high temperature turn-on when the experiment drew excess current of ~5 mA and high counts were observed in channel 1.
6. A subsystem thermal-vacuum test of the combined UCal-UIowa experiments was performed from 1/7 to 1/10/69. Twenty-four hours at \(-10^\circ\text{C}\) followed by 24 hours at \(+40^\circ\text{C}\). However, after 22 hours at \(+40^\circ\text{C}\) the UIowa low voltage supply failed and, thus, terminated the test. (See Malfunction report A-003302.) The UCal unit operated satisfactorily throughout the test. No damage to unit was observed. Some anomalies were present in the data which were found to be due to the poor test equipment available and the long unshielded cabling used by UIowa.

7. The SN02 unit was returned to UCal on 2/20/69. More sensitive pre-amps were installed and the logic circuits were completely retested. The high voltage supply was revised to eliminate the air bubble problem found in the prototype supply. Both circuit boards were potted with RTV to eliminate peeling. Leads to detectors were mounted in shielded Kel-F boxes.

8. In house management was changed on 4/9/69 in order to place a high priority on this experiment. Both units were in subsystem thermal-vacuum tests at this time. The general problems being experienced were: Unit 01 -- input current spiking and/or drawing 5 to 10 mA excessive input current. Unit 02 -- various random automatic high voltage (HV) turn-offs.

It was concluded that the 01 unit probably had a corona problem and would require a laboratory analysis. Thus, efforts were concentrated on the 02 unit since this appeared to be an external interference problem. After a few preliminary tests (exchanged GSE, cables, etc.), it was obvious that the chamber would have to be vented and the door opened in order to further investigate the interference problem in this unit.
9. The chamber was vented and the door opened on April 9. It was discovered that the major interference source was the "MVRC" control system near this chamber (#241). The experiment HV would only stay on approximately 1 to 30 seconds with the MVRC on. Several techniques reduced the interference to a near acceptable level: (1) connecting the experiment frame to the signal common; (2) adding a series resistor to the FREEZE signal line; (3) capacitive filtering of the noise spikes on the 28 volt power buss (these were approximately 1 v p-p without filtering); (4) elimination of the ground loops in the set up.

After discussions with the IMP-G project office, it was decided that the MVRC could be left off during further ther-vac testing and preparations were made to restart the test.

10. The chamber door was closed by 1200 hours on 4/10. Power was applied to the experiment at 1800 hours. The HV would not stay on for more than about 0.5 second. Additional testing revealed that these HV turn-offs were not what was experienced before and that the most probable cause was a loss of the reset signal to the 210 counter which would then allow the normal radioactive source rates to cause a HV turn-off in less than 1 second.

11. Preliminary checks were performed on both units on 4/11. Operation was normal. The 02 unit was then put into a cold soak and the 01 unit was put under vacuum conditions.

12. On 4/11 and at -12°C the 02 unit's automatic HV disable circuit malfunctioned. The HV would turn-off with "LO" GSE electrical stimulation. This confirmed the results at GSFC. This malfunction appeared to occur only below ambient temperatures.
13. The top cover was removed on 4/12 and the Eccofoam was removed from the electronics area to allow probing of the suspected 2 ms reset oscillator. While reproducing the failure mode on the bench with Propellon, it was confirmed that two stages of the oscillator were operating properly. The third stage was not accessible without removal of the mother board electronics from the experiment frame.

14. On 4/12, after the experiment had been in vacuum overnight, the door was opened to set up for a hot vacuum test. The door was closed and the temperature raised at 1330 hours. At about 1700 hours while at + 40°C and 1 x 10⁻⁶ mm Hg the first spiking of the input current began to occur.

15. The mother board electronics was released from the experiment frame to allow further testing (probing) of the malfunction. However, from this time on it was not possible to reproduce the previous failure mode after repeated efforts on 4/12, 4/13, and 4/14!

16. On 4/14 the mother board was remounted in the frame and further attempts were made to induce the failure mode throughout the day without success. It was decided by UCal that it would not be necessary to have an automatic HV disable function in this 02 experiment because of the high gain pre amps that were being used. (Laboratory testing of the degradation properties of the channeltrons -- simulated radiation belt passes -- showed that the experiment would operate satisfactorily under these conditions.) On the assumption that this unit could be flown without the automatic HV disable function (by cutting a single wire) a complete thermal test was then performed on this unit.
17. On 4/15 the first evidence of excess counts was observed in the channel outputs due to the corona problem while at \(-3^\circ\text{C}\) and \(6 \times 10^{-7}\) mm Hg. The experiment had been under continuous vacuum for about three days at this time. In addition, the input current displayed the following conditions during these three days: (1) Normal input current (2) Excess input current (3) Random positive spiking from the normal input current level (4) Random negative spiking from the excess input current level (5) A general tendency to drift from the excess current level towards a normal current level (6) Very erratic spiking between these two current levels. It was during (6) that the excess channel counts were observed.

18. Various conversations were being held on 4/17 between the UCal and IMP-G project office personnel to decide whether these two experiments were worth pursuing further under the present conditions. It was decided that a final "all-out" attempt should be made to try and save at least one of these experiments. It would also be necessary to prove to a GSFC design review board that no corona problem could be expected in the flight unit. The plan was as follows:

**The 01 Unit:** This unit would undergo a quick vacuum check in the hopes that the corona problem was reproducible in approximately 1-3 hours. If this was the case, then a quick fix would be made on the assumption that we knew where the corona problem was. Then, the unit would go back into vacuum tests for at least 6 hours and if the corona problem did not reappear it would be assumed that the problem had been corrected.
The 02 Unit: It would be necessary to have an operational automatic HV disable circuit in this unit. It was not reasonable to expect to repair the present mother board electronics. This unit's mother board would be removed in preparation for a "transplant" of the mother board from the 01 unit. The high gain pre amps would be retained in this unit if the transplant were to take place.

The 02 unit was prepared for the transplant and the 01 unit was put back into a vacuum test. After 4-1/2 hours of vacuum testing on the 01 unit, no corona had occurred and a NO-GO decision had to be made on this unit.

19. Operational checks of the 01 mother board electronics were being performed on 4/18 in preparation of the transplant into the 02 unit. During this test a design problem was discovered with the interface of the FREEZE sync signal to the TI 510 Flip-Flop in the 2^10 counter. (This is used for the automatic HV turn-on function.) It was found that the ISO SMP which was driving the 510 Flip-Flop would provide a fall time of only about 1 to 2 μs which is a borderline condition for these Flip-Flops particularly at low temperatures. In order to preclude this problem of proper turn-on, it was determined that an additional 500 series gate would be necessary between the ISO AMP and the 510 Flip-Flop to provide adequate fall time. A 516 gate was added to the circuit by mounting it on a small p. c. board which was in turn mounted to the side of the mother board. This mounting technique was used to prevent any unnecessary disturbance of the integrated circuit logic which was already in place and potted on the mother board. A complete operational check of the mother board was then performed successfully.
20. The 01 mother board was transplanted into the 02 unit on 4/18. During testing of the electronics it was found that 2 adjacent magnet wires had developed an intermittent short. This was corrected by rerouting of these magnet wires. An operational bench check was then performed satisfactorily.

21. A thermal test was performed on the 02 unit with the HV kept in a disabled condition by means of a shorting plug on 4/19. Complete electrical performance was monitored throughout the test which consisted of 2 hours at -15°C and 1-1/2 hours at +45°C. Operation was normal.

22. A thermal-vacuum test was run on 4/19 and 4/20. The experiment was under vacuum conditions for 24 hours during this test. The test consisted of a +40°C hot soak for 13 hours and about 5 hours at -10 to +10°C. (There were equipment problems in holding a cold temperature with this vacuum system.) The input current was continuously monitored during the test and stimulation was provided by a radioactive source and an electron gun.

The significant results observed during the test were: (1) No evidence of corona was observed. (2) The channeltrons characteristically behaved as if they were "dirty" (water vapor or other gases present in the channels) when HV was first applied to them after only a few hours in vacuum. This characteristic produced some erratic and high counts for several minutes and typically would cause about two HV turn-offs before beginning to settle down. (3) The channeltrons continued to display a subdued erratic behavior during the 24 hour test which was particularly noticeable in channel 2. But, there was a general trend of both channeltrons to "clean up" the longer they were under vacuum and the longer they were run.
During this test one "problem" was noted with the automatic HV turn-off circuit. It was found that a turn-off would occur at a 4 KHz rate rather than at the 32 KHz rate as expected. (The turn-off rate is sensed by a 2^6 counter which is reset every 1-1/2 hours.) From discussions with UCal personnel it was discovered that three additional Flip-Flop stages (factor of 8) had been added to the counter some time ago. And, there was reason to believe that this 4 KHz turn-off rate had existed in both units since that time. It, thus, appeared likely that this problem was the result of a layout or wiring problem (e.g., no reset to these 3 stages) rather than a malfunction. It was decided that this condition should be left as is since (1) the turn-off at a lower rate would not harm the science of the experiment; (2) the turn-off at the 4 KHz rate otherwise appeared normal and consistent; (3) it would provide a faster turn-off if a corona problem ever existed; and (4) a major rework of the electronics would be required to correct this condition and sufficient time was not available due to the further extensive testing required at GSFC before the experiment could be considered qualified to fly.

23. The 02 unit was returned to GSFC on 4/20 for potting, vibration, and thermal-vacuum qualification. Potting was performed on the evening of 4/20. Vibration and CG measurements were completed on 4/21. At 1500 hours on 4/21 the thermal-vacuum test was being set up at T & E.

24. At about 1330 hours on 4/13 while performing operational tests of the experiment in the vacuum chamber prior to closing the door it was discovered that a cross-talk problem existed between both data channels. Electrical stimulation was being used from the GSE which
provides a "LO" rate of about 500 Hz and a "HI" rate of about 1 KHz. These signals are inserted at the outputs of the post amps where they enter the $\frac{1}{16}$ prescaler (same in both channels). It was found that with stimulation of a single channel the X-talk rate on the non-stimulated channel was $1/16$ the output rate of the stimulated channel ($1/256$ of the GSE stimulation rate).

After considerable testing to locate the X-talk mechanism, it was found that it was not entering through the cabling system. But, it had to be picked up at the pre amps since normal saturated signals were observed at their outputs during the X-talk conditions. The conclusion reached was that this X-talk was due to the high output pulse currents which induced X-talk internal to the experiment due to the large coax cable capacitive loads being used in the set up. This was confirmed by reducing these pulse currents with a 300 ohm series resistor in series with output leads at the experiment which stopped the X-talk.

Further investigation at the UCal laboratory revealed that the ground returns for the pre amps were in series with the output stage returns on the printed circuit layout. Also, the unloaded output pulse rise and fall times were about 100 ns. A simulated test was performed on the 01 mother board to determine the approximate impedance of this common return line. It was found that driving a 10 mA pulse with 100 ns rise and fall times through this line produced drops of about 3.5 mv and about 5 mv on the return lines of the pre amps. With about 150 pf loading on an output stage producing pulse currents of approximately 4.5 mA and a pre amp sensitivity of about 2 mv/100 ns, it was quite plausible that this was the mechanism being observed at GSFC.
As a result of the above, it was determined that a S/C interface check should be performed before proceeding to determine if this X-talk condition would exist in the S/C. (There was no information available at this time on either the UIowa or the encoder cabling capacitive loading to the UCal experiment.)

25. From 4/24 to 5/1 tests were being performed on the 01 unit to determine the exact cause of the corona problem. After running this unit at vacuum conditions for 24 hours, no corona was observed. It was then decided to disconnect the channeltron HV leads so that the experiment could be run at any pressure in the hopes that the corona could be induced again more quickly. (The channeltron HV lead areas were spot potted.) This technique proved to lead only to a "blind alley."

On 4/26 at 1830 hours the unit was put back under deep vacuum conditions and in a hot soak. At about 1900 hours on 4/27 input current spiking had begun to reappear. By 1100 hours on 4/28 the spiking had become sufficiently regular to make a correlation between the spiking and a visual observation of corona near the channel 1 area of HV stack. The temperature was then lowered slowly and at 1200 hours on 5/29 the input current went into the excess current mode and (a very weak) continuous corona was observed in the high voltage area. (It was very difficult to pinpoint the location of this corona at this time since it appeared to be coming through the Eccofoam.)

On 5/1 the Eccofoam was carefully removed from the corona area and the unit was put back under vacuum conditions. The corona occurred almost immediately and was easily observed at this time.
The HV stack was removed from the experiment frame and inspected. It was found that the Sylgard potting had lifted from the pc board in this area and the corona path was visible on the pc board. It was noted that this ground line did not exist on the 02 unit pc board. (This area was milled off and replaced by shielded boxes for detector decoupling in the 02 unit.) Also, RTV was used for potting the sides of the pc boards on the 02 unit rather than Sylgard. Thus, this potential problem could not exist in the 02 unit.

26. On 4/25 an operational check was performed with the experiment in the CTA S/C and no X-talk problems were observed. It was therefore decided by the IMP-G project office that the thermal-vacuum test could be run with 910 Ω series resistors in the output lines to prevent X-talk in the test set up.

27. From 4/25 to 5/6 the GSFC thermal-vacuum qualification was being performed. The general observations were:

(1) The channeltrons displayed the expected "dirty" condition when first turned on with the resultant HV turn-offs until they settled down.

(2) Channel 2 tended to behave more erratically than channel 1. But, by 4/28 both channels were beginning to behave well based on statistical tests.

(3) Occasional HV turn-offs were experienced due to RF pick up in the T & E environment.

(4) More frequent HV turn-offs were experienced on 5/1 after the 8' x 8' chamber was put into operation. These turn-offs were reduced to an acceptable level by additional shielding of the outside cables to the GSE.
(5) A correlation between HV turn-offs and daytime working hours was observed.
(6) No evidence of a corona problem was observed.
(7) The detector performance improved the longer the experiment ran under vacuum conditions.

28. On 5/6 at about 0500 hours, vacuum was lost in the chamber due to a primary power failure in the T & E building. (The experiment had only about 12 hours to go before finishing these tests at that time.) As a result of the vacuum loss the HV had been on for about 370 seconds under a vacuum of only 150 to 200 microns. It was decided that a short recycle test would be necessary to complete the thermal-vacuum qualification as a result of this failure.

29. The thermal-vacuum recycle test was run from 5/6 to 5/9. The experiment was still operational and general observations were as noted before. The channeltrons recovered from the erratic behavior in about 1 hour.

30. A X-talk test was performed on 5/12 at UCal. It was found that about 210 pf loading on channel 1 would produce X-talk into channel 2. And, about 360 pf loading on channel 2 would produce X-talk into channel 1. This is in good agreement with the impedance measurements made on 4/23 (e.g., \((210/360) \approx 3/5\)).

Further, it was learned from UIowa on 5/7 that the capacitive loading on channel 1 was nearly zero pico farads (looks into a 470 KΩ resistor in Iowa) and the loading on channel 2 was about 25-32 pf in their experiment. Also, from the project office it was found that the encoder cable loading for channel 2 would be about 50 pf. Thus, the
total loading in channel 2 should be no more than about 82 pf and on
channel 1 it is negligible. Therefore, it appeared that there was a
safety factor of about 4 against potential X-talk.

31. During integration tests in the S/C on 5/20/69 high count
rates were observed in both data channels. Further investigation
revealed that this was probably due to UIowa converter spikes on the
28 volt line to the UCal experiment, and, that they were being picked
up by the sensitive pre-amplifiers in the experiment. These spikes
were observed to be approximately 0.4 volts p-p with a periodicity of
240 μsec.

32. The experiment was returned to UCal for simulation of this
interference problem and for a possible solution. Simulation was suc-
cessful and a simple fix consisting of 3 capacitors from the signal
common to the frame ground provided an adequate safety margin.

33. The IMP-G launch took place on 6/21/69, 0148 hrs PDST
from WTR. Plans were made to turn on the UCal-UIowa supplemen-
tary experiments on 6/26 for the first time.

Post-Launch History

From time of first turn on the experiment was observed to
stay on only for short intervals (< several minutes) before being shut
off by the automatic turn off. Below is an analysis of the behavior of
the experiment:

1. First confirmed experimental data on orbit 3, day 181,
0550 UT sequence 65840 (0 sequence). Apparently before this time the
experiment was turning on in UIowa sequences. Last observed turn-on
is in orbit 15, day 222, 1825 UT sequence 241238. This was the end
of the orbit. Orbit 16 and thereafter had no turn on since the UIowa experiment failed in orbit 15.

2. The counting rate in interplanetary medium is fairly steady. However, statistical fluctuations are observed implying that the count rate observed is not due to pickup of a fixed frequency.

Average count rate (interplanetary medium) \( \sim 700 \text{ counts/sec} \) \( \sim 35 \text{ counts/sec} \)

Equivalent flux 

\[ 3.5 \times 10^3 \text{ (cm}^2 \text{ sec ster keV)}^{-1} \]
\[ 6 \times 10^2 \text{ (cm}^2 \text{ sec ster keV)}^{-1} \]

(4 to 8 keV) 

(9 to 13 keV)

3. The count rate in regions of terrestrial particles (as observed by the UCal S-1 experiment at energies above 20 keV) is much higher, indicating that the S-2 instrument is counting particles as designed.

4. Turn off rate was measured to be 4 KHz (average) during pre-flight tests. The observed background rate of \( \sim 700 \) counts per second is compatible with turn-offs within several seconds (on the average) due to statistical fluctuations.

5. The source of the high background counting rate may be either particles or possibly scattered stray solar ultraviolet to which the channeltrons are sensitive. Stray solar UV as an explanation is somewhat incompatible with the steady count rate observed in channel 1 since presumably the count rate should show a strong spin period dependence, ranging from essentially no counts when the detector is pointed away from the sun to a very high count rate when the detector is pointed toward the sun. Particle fluxes of the magnitude reported here may be the source of the background since no observations have been made in this energy range with this sensitivity. Recent measurements by the Apollo 15 Subsatellite (Anderson et al., 1972) show that
the quiet time electron level in the interplanetary medium is
\( \sim 10^2 \text{ (cm}^2 \text{ sec ster keV)}^{-1} \) at 6 keV and \( \sim 50 \) at 13 keV, with variations of an order of magnitude.

Another possibility is a slight misalignment of the sun shield for the detector allowing extraneous indirect scattering (so as to explain the lack of strong spin dependence) of UV into the detector may be the source of the high background.

6. The loss of data after orbit 15 is very unfortunate in that the spacecraft would have been in the earth's magnetotail region within a few months. The magnetotail is free of trapped terrestrial radiation as well as being out of the solar wind. Therefore, if the background rate of the detector had been due to particles then it would have dropped to a low level in the magnetotail.

7. The loss of data for UCal S-2 after orbit 15 is clearly due to the failure of the UIowa low voltage supply. UIowa apparently puts the STL sync-freeze pulse through a gate before sending it to UCal S-2, contrary to our expectations from correspondence and conversations with both UIowa and GSFC. The STL sync-freeze pulse is used to turn on the UCal S-2 high voltage power supply.
REFERENCES

Appendix I

The IMP-G' GSE Software

A flow diagram for the main loop of the software used by the UCal GSE is illustrated in Figure I-1. Three major paths should be noted: (1) the data summary path on the left, (2) the background or source stimulus path in the center, and (3) the electrical stimulus path on the right. A further breakdown of the data summary path is given in Figure I-2.

The program was entered once per S/C sequence and the initial test was to determine which of the two halves of the data was available—the A or B sequence data. A data summary synchronization test was then performed. If DS data was present, the branch was made. Otherwise, the additional synchronization tests ES1, ES5, and ES9 were performed and the ESEQ was updated or set as required. (See Table I-1 for a description of the various mnemonics used and Table I-2 for the test equations.) If ES1, ES5, or ES9 was satisfied, then a test was made for loss of electrical synchronization and IED was set if true.

For sequences (ESEQ) other than 1, 5, 9, 10, and 11, the normal path was to update the EXIT counter, set the tags E and FF, reset SSEQ, and proceed with the electrical limit tests. The electrical limits are given in Table I-3. Additional items required for printout were then found, the appropriate data was printed, and a return was then made to the S/C GSE system software.
Figure I-1  UCal IMP-G GSE System, Main Loop
Figure I-2  UCal IMP-G GSE System, DS, LDS and NDS Logic
# Table I-1

## MNEMONICS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>TYPICAL VALUES</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>O, 1</td>
<td>Background. A &quot;1&quot; indicates background data has occurred since the last DS. Set by BKD test.</td>
</tr>
<tr>
<td>BKD</td>
<td>T, F</td>
<td>Background data test. Test for background data under source conditions.</td>
</tr>
<tr>
<td>C</td>
<td>0, 1</td>
<td>Computer control. A &quot;1&quot; indicates the system source cycle is under computer control (not GSE).</td>
</tr>
<tr>
<td>Cl6</td>
<td>0, 1</td>
<td>A sense switch entry. A &quot;1&quot; indicates 16 seq source cycle request if computer controlled (no GSE) and a &quot;0&quot; indicates a 40 seq source cycle request.</td>
</tr>
<tr>
<td>DS</td>
<td>F, T</td>
<td>Data summary synchronization test. Test for presence of data summary GSE stimulus.</td>
</tr>
<tr>
<td>E</td>
<td>1, 0</td>
<td>Electrical. A &quot;1&quot; indicates at least 1 elect seq has occurred since the last DS.</td>
</tr>
<tr>
<td>ECY</td>
<td>0, ..., 5</td>
<td>Electrical cycle. Indicates number of elapsed elect cycles (10 seq's). Normal values are 1, 2 or 5 at DS time.</td>
</tr>
<tr>
<td>Elect Limits</td>
<td>OFF, ON</td>
<td>&quot;On&quot; indicates the elect limit tests are active in the program. (A sense switch entry).</td>
</tr>
<tr>
<td>EK</td>
<td>0, 1</td>
<td>A &quot;1&quot; indicates elect seq #1 sync achieved (ESI). Used to test for IED and to set ECY.</td>
</tr>
<tr>
<td>ESEQ</td>
<td>0, ..., 11</td>
<td>Electrical sequence. Indicates the presently assumed electrical sequence number.</td>
</tr>
<tr>
<td>ESI</td>
<td>F, T</td>
<td>Electrical sequence #1 synchronization test. A test for the presence of elect seq #1 GSE stimulus.</td>
</tr>
<tr>
<td>ITEM</td>
<td>TYPICAL VALUES</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>ES5</td>
<td>F,T</td>
<td>Same as ESI except for elect seq # 5.</td>
</tr>
<tr>
<td>ES9</td>
<td>F,T</td>
<td>Same as ESI except for elect seq # 9.</td>
</tr>
<tr>
<td>EXIT</td>
<td>0,...5</td>
<td>Exit counter. Used to exit to source branch after elect cycle or after loss of synchronization.</td>
</tr>
<tr>
<td>FE</td>
<td>0,1</td>
<td>First electrical. A &quot;1&quot; indicates at least 1 elect seq has occurred since the last DS.</td>
</tr>
<tr>
<td>IC₁, IC₂</td>
<td>--</td>
<td>The Ion Chamber data in frame # 6 and frame # 14 respectively, channels 4 &amp; 5, sequence A.</td>
</tr>
<tr>
<td>IED</td>
<td>0,1</td>
<td>Insufficient electrical data. A &quot;1&quot; indicates insufficient elect data to perform elect limit tests.</td>
</tr>
<tr>
<td>ISD</td>
<td>0,1</td>
<td>Insufficient source data. A &quot;1&quot; indicates insufficient source data to perform source limit tests.</td>
</tr>
<tr>
<td>K</td>
<td>0,1</td>
<td>Forces a C40 source cycle to take place before the first Cl6 source cycle to insure that the GSE is not present.</td>
</tr>
<tr>
<td>Kl,...K5</td>
<td></td>
<td>Constants used in the synchronization test equations.</td>
</tr>
<tr>
<td>L</td>
<td>0,1</td>
<td>A &quot;1&quot; allows only a Cl6 source cycle when a priority request is made.</td>
</tr>
<tr>
<td>LOS</td>
<td>S/C SEQ</td>
<td>Last data summary. Indicates the S/C sequence where the last data summary occurred.</td>
</tr>
<tr>
<td>NDS</td>
<td>S/C SEQ</td>
<td>Next data summary. Predicts where the next data summary will occur if the cycle is not changed.</td>
</tr>
<tr>
<td>PSW</td>
<td>0,1</td>
<td>Priority switch. A change of the switch position indicates a Cl6 source cycle has been requested.</td>
</tr>
<tr>
<td>R</td>
<td>0,1</td>
<td>Repeat. A &quot;1&quot; forces a redundant printout of the DS data (DS data not re-calculated).</td>
</tr>
<tr>
<td>S</td>
<td>0,1</td>
<td>Source. A &quot;1&quot; indicates at least 1 source seq has occurred since the last DS.</td>
</tr>
<tr>
<td>ITEM</td>
<td>TYPICAL VALUES</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Source Limits</td>
<td>OFF, ON</td>
<td>&quot;On&quot; indicates the source limit tests are active in the program. (A sense switch entry).</td>
</tr>
<tr>
<td>SR</td>
<td>0,1</td>
<td>Source repeat. A &quot;1&quot; allows a single repeat of the DS printout under source conditions for expt seq &quot;B&quot;.</td>
</tr>
<tr>
<td>SSEQ</td>
<td>0,...41</td>
<td>Source sequence. Indicates presently assumed source sequence number.</td>
</tr>
<tr>
<td>STIMULATION</td>
<td>E01,..E50</td>
<td>Identifies the present electrical or source sequence.</td>
</tr>
<tr>
<td></td>
<td>SOL,..S40</td>
<td></td>
</tr>
<tr>
<td>S16</td>
<td>0,1</td>
<td>A &quot;1&quot; indicates 16 source sequences have occurred during the system cycle.</td>
</tr>
<tr>
<td>S40</td>
<td>0,1</td>
<td>A &quot;1&quot; indicates 40 source sequences have occurred during the system cycle.</td>
</tr>
<tr>
<td>X</td>
<td>0,1</td>
<td>Used with the PSW to test for an external priority request.</td>
</tr>
<tr>
<td>XSEQ</td>
<td>A, B</td>
<td>Experiment sequence. An &quot;A&quot; indicates the first seq of expt cycle (ID₁, ID₂, El, and Pl data). A &quot;B&quot; indicates the second seq of expt cycle (E2, P2, E3 and P3 data).</td>
</tr>
</tbody>
</table>
Table I-2
Special Test Equations

ES1 = (E1 > K1) \cdot (P1 < K2)

ES5 = (E1 < K2) \cdot (P1 > K1)

ES9 = \left( IC_1 = K3 \pm K4 \right) \cdot \left( IC_2 = K3 \pm K4 \right)

DS = \left( IC_1 = 8 \pm K4 \right) + \left[ (E1 = 15359T \pm K4) \cdot (P1 = 15359T \pm K4) \right]

BKD = (E1 < K5) \cdot (P1 < K5)

K1 = 1000
K2 = 10
K3 = 32
K4 = 3
K5 = 10
### Table I-3

**UCAL IMP-G GSE**  
**Electrical Limits**

<table>
<thead>
<tr>
<th>Elect Seq</th>
<th>Acc 3a</th>
<th>Acc 3b</th>
<th>Acc 3c</th>
<th>Acc 3d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ID ^15359+0 T^-1</td>
<td>ID 0</td>
<td>0 32768+0</td>
<td>0 1</td>
</tr>
<tr>
<td>2</td>
<td>2048 31743+0</td>
<td>0 0</td>
<td>0 32768+0</td>
<td>0 1</td>
</tr>
<tr>
<td>3</td>
<td>ID 0</td>
<td>ID 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>4</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>5</td>
<td>ID 0 15359T^-1</td>
<td>ID 0 32768+0</td>
<td>32768+0</td>
<td>1 1</td>
</tr>
<tr>
<td>6</td>
<td>0 2048 31743+0</td>
<td>2048 2048</td>
<td>2 2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>ID 0</td>
<td>ID 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>8</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>9</td>
<td>ID 1</td>
<td>ID 1</td>
<td>32 32</td>
<td>64 64</td>
</tr>
<tr>
<td>10</td>
<td>1 1</td>
<td>1 1</td>
<td>1 1</td>
<td>0 0</td>
</tr>
</tbody>
</table>

**NOTE:**

1. ID = 31743+0

2. All limits are +0 except where noted.
If ESEQ was equal to 10, a test was made for the contiguity of the 10 electrical sequences. If the test was not satisfied, the IED tag was set. When ESEQ was equal to 11 (a background or source sequence), the EXIT counter was set to 4 in order to force further B or S sequences through the EXIT ≥ 4 test which, otherwise, functioned as an additional synchronization test path.

The printout format is illustrated in Figure I-3. For an electrical stimulus sequence the rates and IC period were not computed as indicated in the flow diagram. Listed in the A, B sequence printout were expected average rates and the high and low limits for the 7 detectors which were being used for data summary calculations. The type of stimulation was identified (e.g., E14, the fourth sequence in the second subcycle of electrical stimulus; S11, the eleventh sequence of source stimulation). Additional parameters of interest were listed on the right. These included an indication (ON, OFF) of whether the electrical and/or source limit tests were active in the program--these could be deactivated by operator intervention.

Once it was determined that source (or background) data was present, a test was made to determine if the last printout was a data summary printout. If it was, a branch was made which caused the second DS printout to occur. Otherwise, the BKD and priority request tests were made. If the PSW switch had been changed, a branch was made which set L, C and normally would set ISD. The appropriate calculations were then made for the data summary and the printout produced. Additional entries into the source branch would then proceed via the L = 1 branch which would force a 16 sequence source cycle ending with the data summary printout.
Figure I-3  UCal IMP-G GSE Printer Format
If no priority request had been made, the normal path through the source branch was through the SSEQ > 39 test, SSEQ would be updated and the various source calculations were performed. The cycle would then, normally, be ended by the DS test being satisfied. However, if the CSE hardware was not present the SSEQ > 39 branch was taken which set K and produced the data summary. With K set, additional source cycles were then under control of the C16 panel switch.

Entry into the data summary branch was normally via the DS test. SR was then set and the ISD test was made before proceeding with DS calculations. Figure 1-2 gives the logic flow for the DS, LDS and NDS calculations. And, Table 1-4 gives the functions performed versus the cycle conditions and the resulting branches that are required. The Chi Square calculation was computed as follows:

$$X^2 = \frac{\sum_{i=1}^{n} (\bar{N} - N_i)^2}{\bar{N}}.$$ 

where n is 8 or 20 for the S16 and S40 cycles respectively, Ni is the detector counts, and \(\bar{N}\) is the average detector counts from the previous cycle. The use of the previous cycle for \(\bar{N}\) was required because of speed restrictions in the computer. This occasionally caused some \(X^2\) values to be outside the limits used but this was not considered a significant problem. The 2% to 98% limits were used (i.e. 96% of the \(X^2\) should fall inside the limits) and they are

<table>
<thead>
<tr>
<th>Samples</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>1.564 to 16.622</td>
</tr>
<tr>
<td>20</td>
<td>8.567 to 33.687</td>
</tr>
</tbody>
</table>
### Table I-4  Branch Conditions and Equations

<table>
<thead>
<tr>
<th>Conditions</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ES 16</td>
<td>S 16</td>
<td>E 2</td>
<td>ES 16 B</td>
<td>S 16 B</td>
<td>ES 16 IED</td>
<td>ES 16 B IED</td>
<td>E IED</td>
</tr>
<tr>
<td></td>
<td>ES 40</td>
<td>S 40</td>
<td>E 5</td>
<td>ES 40 B</td>
<td>S 40 B</td>
<td>ES 40 IED</td>
<td>ES 40 B IED</td>
<td>S IED</td>
</tr>
<tr>
<td></td>
<td>CS 16</td>
<td>ES ISD</td>
<td></td>
<td>CS 16 B</td>
<td></td>
<td></td>
<td></td>
<td>IED ISD</td>
</tr>
<tr>
<td>F</td>
<td>Compute AV’s</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>U</td>
<td>Compute X^2’s</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>N</td>
<td>Compute IC spread</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>C</td>
<td>Check Limits on AV’s, X^2’s, and IC spread</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>T</td>
<td>Set up their flags</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Compute and set up HIGH-LOW values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Set up the “S” GO-NO GO</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>N</td>
<td>Set up the “E” GO-NO GO</td>
<td>X</td>
<td>--</td>
<td>X</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S</td>
<td>Set up the “GO-NO GO”</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>B</td>
<td>X</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

### Notes:
- X = function is performed
- -- = function is not performed
- B = set to blank since "S" and "E"
- GO-NO GO’s are indeterminable

### Branch Equations:
- B0 = E2 + ES + ISD + S IED
- B1 = B0 + B
- B5 = ES + IED
The calculation of the IC spread was given as

\[ S = (T_{\text{max}} - T_{\text{min}}) \frac{(100)}{\bar{T}} \]

where $T_{\text{max}}$, $T_{\text{min}}$ and $\bar{T}$ are the maximum, minimum and average values respectively for the Ion Chamber periods during the cycle.

The cycle identification word (see printout format) was found as follows:

```
X X X X X X X b X X X
```

1 2 3 4 5 6 7  Field number

Field 1 is set to "E" if the program variable E is 1.

" 2 is the value of the program variable ECY (i.e. 2 or 5).
" 3 is set to "C" if the program variable C is 1.
" 4 is set to "S" if the program variable S is 1.
" 5 is set to "16" if the program variable S16 is 1.
" 5 is set to "40" if the program variable S40 is 1.
" 6 is set to "B" if the program variable B is 1.
" 7 is set to "IES" if the program variables IED and ISD are both 1.
" 7 is set to "IED" if only the variable IED is 1.
" 7 is set to "ISD" if only the variable ISD is 1.

The electrical flags printout identified the first sequence where an error occurred for a given detector and if any additional errors had occurred during the cycle. If any of these were set, this caused the E and the NO-Go to be printed. The S and the NO-GO were set if any of the $X^2$ values, averages, or IC spread were outside their limits.
### Appendix II
**IMP-F Drawings**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMP - 1</td>
<td>IMP-F Block Diagram, rev E</td>
</tr>
<tr>
<td>2</td>
<td>GSE Main Electronics Block Diagram, rev A</td>
</tr>
<tr>
<td>3</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>(AIMP)</strong> - 4</td>
<td>UC AIMP/SIMP Checkout Box</td>
</tr>
<tr>
<td>101</td>
<td>N/A</td>
</tr>
<tr>
<td>102</td>
<td>Detector Location &amp; Look Angles, Ion Chamber Experiment</td>
</tr>
<tr>
<td>103</td>
<td>Frame Details, UCal Experiment IMP-F &amp; G</td>
</tr>
<tr>
<td>104</td>
<td>N/A</td>
</tr>
<tr>
<td>105</td>
<td>N/A</td>
</tr>
<tr>
<td>106</td>
<td>Rear Mount Block, GM2, rev A</td>
</tr>
<tr>
<td>107</td>
<td>Front Mount Block, GM2, rev A</td>
</tr>
<tr>
<td><strong>(AIMP)</strong> - 108</td>
<td>Scattering Unit, rev A</td>
</tr>
<tr>
<td>109</td>
<td>Stand, Ion Chamber</td>
</tr>
<tr>
<td>110</td>
<td>N/A</td>
</tr>
<tr>
<td>111</td>
<td>GM2 Tube Shield, rev A</td>
</tr>
<tr>
<td>112</td>
<td>GM1 Tube Shield, rev A</td>
</tr>
<tr>
<td>113</td>
<td>Front Bracket, GM1, rev A</td>
</tr>
<tr>
<td>114</td>
<td>Rear Bracket, GM1, rev C</td>
</tr>
<tr>
<td>115</td>
<td>Backscatter Cap Plate</td>
</tr>
<tr>
<td><strong>(AIMP)</strong> - 116</td>
<td>Scattering Unit Cap Plate, rev A</td>
</tr>
<tr>
<td>117</td>
<td>Source Mount, rev B</td>
</tr>
<tr>
<td><strong>(AIMP)</strong> - 118</td>
<td>Drill Fixture, rev B</td>
</tr>
<tr>
<td><strong>(AIMP)</strong> - 119</td>
<td>Calibration</td>
</tr>
<tr>
<td>Part Number</td>
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<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
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<tr>
<td>(AIMP) - 120</td>
<td>Ion Chamber Assembly</td>
</tr>
<tr>
<td>(AIMP) - 121</td>
<td>Base, Collector, rev B</td>
</tr>
<tr>
<td>(AIMP) - 122</td>
<td>Collector Assembly, rev C</td>
</tr>
<tr>
<td>(AIMP) - 123</td>
<td>Stem</td>
</tr>
<tr>
<td>(AIMP) - 124</td>
<td>Electrostatic Shield</td>
</tr>
<tr>
<td>(AIMP) - 125</td>
<td>Collector Rod, rev B</td>
</tr>
<tr>
<td>(AIMP) - 126</td>
<td>Shield, Outer, rev A</td>
</tr>
<tr>
<td>(AIMP) - 127</td>
<td>Tube Socket, rev A</td>
</tr>
<tr>
<td>128</td>
<td>N/A</td>
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<tr>
<td>(AIMP) - 129</td>
<td>Space Bushing, T.P. Connector, rev B</td>
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<tr>
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<td>AIMP - 205</td>
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<td>Power Supply, GSE</td>
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<td>214</td>
<td>Wiring Diagram, GSE</td>
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</table>
USE MAGNETICALLY TESTED MAGNESIUM SECURE FROM PAOLI OR PELLINEN

*5/8 DRILL X 3/16 DEEP
TAP #2-56 TO BOTTOM 2 PLACES

*5/8 DRILL X 3/16 DEEP
TAP #2-56 TO BOTTOM 40° CSM TO 3/16 DIA. 2 PLACES

#5/8 DRILL THRU TAP #2-56 2 HOLES

SEC. A-A
USE MAGNETICLY TESTED MAGNESIUM
SECURE FROM PAOLI OR PELLINEN

#51 DRILL
#2-56 TAP X 3/16 DP
110° C5K TO 3/16 DIA.
2 PLACES
NOTE: USE MAGNETICALLY TESTED BRASS, SECURE FROM PAOLI OR PELLININ.
NO. SIMP 109  
JOb SIMP  
APP. E.A.P.  
SPACE SCIENCES LABORATORY  
UNIVERSITY OF CALIFORNIA  
SCALE 2 : 1  
DR.  
DATE  

TITLE STAND, ION CHAMBER  
SE-CUR6 PROM PAOLI OR. DELLINEN  

10° TYP

51 DRILL, 2-56 TAP
2 PCS.
ON 1 1/8 B.C.

51 DRILL, 2-56 TAP
6 HOLES ON 1 1/8 B.C.
EQ SPACED.

1/8" TYP

1/16" TYP

#44 DRILL, 6
HOLES, EQ
SPACED ON
1 1/8 B.C.
NOTES:
1- ROUND CORNERS OF SLOT INSIDE & OUT.
2- LOCATE SLOT WITH FIXTURE #118.
NOTES:

1. Round corners of slot inside and out.

2. Locate slot and bevel cut with fixture #118.
NO. SIMP-113
REV. A
1 FEB. 66
SPACE SCIENCES LABORATORY
UNIVERSITY OF CALIFORNIA
SCALE 2" = 1'
DR. TOY
DATE DEC. 6, 1966
REQD.
MATL. AZ - 31 B
SECURE FROM PAOLI OR PELLINEN

TITLE: FRONT BRACKET, GM1

* 5/16 DRILL x 1/4 DEEP
TAP #2-56 TO BOTTOM
110° C5K. TO 3/16 DIA.
2 PLACES

9/16 DIA.
THRU
+0.002
DIA. THRU

4.37

.875

.50

3/32

.625 + .002

1.065

m10

TAP #2-56 TO BOTTOM
5 PLACES

.687

1.250

1.250

1.250
SEC. A-A

#51 DRILL x 1/4 DEEP
TAP #3-56 TO BOTTOM
110° CSK. TO 3/16 DIA.
2 PLACES

1/32
1/32

.687

#51 DRILL x 1/4 DEEP
TAP #2-56 TO BOTTOM
ON .81 B.C.
3 PLACES

.965

.875

.596

.625

.625

5/62
USE MAGNETICALLY TESTED BRASS
SECURE FROM PAOLI OR PELLINEN

NO. SIMP - 115  JOB SIMP  APP

SPACE SCIENCES LABORATORY

UNIVERSITY OF CALIFORNIA

TITLE  BACKSCATTER CAP PLATE

REQD  BRASS

SCALE  2" = 1"

DR  RON TOY
DATE  DEC. 3, 1965

UNITED STATES OF AMERICA

3/4

30°

3 HOLE ON
.81 B.C.

#41 DRILL

.063
TITLE: SCATTERING UNIT CAP PLATE

USE MAGNETICALLY TESTED BRASS SECURED FROM PAOLI OR PELLINEN
DRILL FIXTURE

1.687

1.345

0.156

0.096

0.066

1.937

1.812

1.0

0.060 DIA. - USE 3/8" DRILL AS 3 PLACES REAMER

STEEL
100 MICRO CURIES C_60 ± 5%

100μC CURIES C_60 CENTER OF ACTIVITY AS INDICATED.

OVERALL LENGTH 2" MAX, 1 7/16" MIN END TO BE ROUNDED

HEAD TO PASS THROUGH 3/8" DIA HOLE. THREADER WHATEVER SIZE IS CONVENIENT

BODY TO BE NON-MAGNETIC STAINLESS STEEL. ACTIVITY TO BE SEALED IN TUBE BY WELDING OR SILVER SOLDERING
BASE - COLLECTOR

NOTE: FOR HEADERS
9/64 DRILL, +.05 CTR BORE, FINISH DRILL TO .159
Screw holes are spaced 16mm apart. Appox. 30 drill hole 1 mm. DRILL LINES 16 3D DRILL LINES. 

INTERFERENCE FIT MATCHES 16 3D DRILL LINES.

TYPICAL SECTION FOR SCREW HOLES

APPROX. 30 DRILL HOLE 1 MM DRILL LINES. DRILL LINES 16 3D DRILL LINES

TYPICAL SECTION FOR SCREW HOLES
ELECTROSTATIC SHIELD

Dimensions:
- Width: 5/32
- Length: 11
- Thickness: 3/16
- Diameter: 878 ±.003
- Radius: 0.010 ±.005
\[ \text{\( \frac{1}{8} \) DIA \( \pm \frac{1}{64} \) BALL} \]

-\( \frac{1}{2} \)This should be held as closely as possible.
NOTE: MACHINE CAPS SUPPLIED TO ABOVE DIMENSIONS.
AIEP-134-A

AIEP

APP

SPACE SCIENCES LABORATORY

UNIVERSITY OF CALIFORNIA

SCALE

REQ.

MATL

HARD BRASS

DATE

11 JUNE 65

15/64 REAM 1D

.020 ±.004

.010 DEEP

1/16

9/32

1/32

2/16
<table>
<thead>
<tr>
<th>NO.</th>
<th>AMP-124</th>
<th>JOB</th>
<th>APP</th>
<th>SPACE SCIENCES LABORATORY</th>
<th>SCALE</th>
<th>DR.</th>
<th>DATE</th>
</tr>
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<tr>
<td>TITLE</td>
<td>CATHODE CLIP LAND TO 0.01 X</td>
<td></td>
<td></td>
<td>UNIVERSITY OF CALIFORNIA</td>
<td>4:1</td>
<td></td>
<td>10-5-66</td>
</tr>
</tbody>
</table>

**NOTE:**
- Turn OD round 1/8 OD x 21 GA
- HARD BRASS TURNING

**BREAK EDGES TO APPROX JOB OF OD**
PROTECTIVE CAP, GM 1

SCRATCH 3 PLACES
APPROX 0.010 DEEP

-20 DRILL 1/8" DEEP
TAP 8-32 TO BOT.
PROTECTIVE CAP, CM 2

*2.8 DRILL 8/64 DEEP
TAP G-32 TO BOLT.

SCRATCH 2 PLACES
APPROX 0.010 DEEP
NOTES:

1. THESE CORNERS SHARP -- ALL OTHERS MAY BE ROUNDED
NO. SIMP-141

JOB

APP.

SPACE SCIENCES LABORATORY

UNIVERSITY OF CALIFORNIA

SCALE 4:1

REQD.

MATL.

DATE

PHOSPHOR - BRONZE

---

TITLE SPRING SOURCE MOUNT

---

#52 DRILL THRU

2 HOLES

ROUND CORNERS

---

3/64

1/4

.011

---

.090 ±.015

.200

30° ± 3°
1. FULL PENETRATION ON ALL WELDS.
   ALL WELDS TO BE LEAK TIGHT.
EDGE TO BE FLAT TO .004

2.000 R. ±.003

1.125 DIA. ±.003

.281 DIA. ±.003

.016 NOM. WALL

.025 +.010 -.005

.015 +.005 -.005
FILL TUBE

4.000 ± .125

.250 DIA.
STOCK SIZE

.219 DIA.
DOSE/PULSE: ~0.2 MR/HR
FILL: 7.0 GMS. ARGON (~ 98 PSIG)
ALL RESISTORS: 1.0 MEG, 1/8 WATT
CHAMBER VOLUME: 525 CM$^3$
SHELL: .022 -.027 IN ALUMINUM
150 - 185 MG/CM$^2$
TEMPERATURE COEFFICIENT: ~ + .015 %/°C
CHARGE/PULSE: ~ 4.5 x 10$^{-10}$ COULOMBS
Q/PULSE = \frac{C_{\text{total}} \Delta V}{\text{No. of Pulses}}

C = 0.001 \mu F WEST-CAP PLASTIC CAPACITOR
V_0 = \text{STARTING POTENTIAL}
\Delta V = \text{TYPICALLY 50 + 100 VOLTS}
TO OUTSIDE OF SPACE CRAFT

CLAMPING RING

PINCH OFFS
POWER SUPPLY, GSE
### Appendix III

**IMP-G (S1) Drawing List**

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<td>3</td>
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<td>4</td>
<td>UCal Telemetry Format and Timing</td>
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<td>Bottom Bracket, P1-P3, rev B</td>
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<td>P3 Shield</td>
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<td>116</td>
<td>E1 Shield</td>
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<td>117</td>
<td>E3 Shield</td>
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<td>P2 Shield</td>
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<td>E2 Shield</td>
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127  Cathode Clip
128  PI Cathode Cushion
129  Cathode Cushion
130  Anode Clip
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132  Anode Insulator, rev A
133  Anode Rod
134  Stand, Ion Chamber
135  Source Holder Assembly
136  PI, P3 Potting Cover
137  PI, P3 Protective Cover
138  PI Aperature
139  E2-P2 Protective Cover
140  E1-E3 Protective Cover
141  Drill Jig, PI Aperature
142  E3, P3 Foil Assembly

IMP G - 201  UCal IMP-G Checkout Box Freeze and Matrix Control Circuit Schematic
202  UCal IMP-G Checkout Box GM-Control Circuit Schematic
203  UCal IMP-G Checkout Box IC Control Circuit Schematic
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<td>UCal IMP-G Checkout Box GM-Control Wiring Diagram</td>
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<td>DAM-15P-NMC-2</td>
<td>DAM-15S-NMC-2</td>
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<td>----------------</td>
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<tr>
<td><strong>P1</strong></td>
<td><strong>J1</strong></td>
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<tr>
<td>1</td>
<td>#3e ACC.</td>
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<tr>
<td>2</td>
<td>COMMON</td>
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<tr>
<td>4</td>
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<tr>
<td>5</td>
<td>F*3cd SYNC.</td>
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<tr>
<td>6</td>
<td>F*3cd SYNC.</td>
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<tr>
<td>7</td>
<td>G400PPS CLOCK</td>
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<td>8</td>
<td>THERMISTOR</td>
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<td>#3e ACC.</td>
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<tr>
<td>12</td>
<td>+11.7 V</td>
</tr>
<tr>
<td>13</td>
<td>RETURN(+11.7V)</td>
</tr>
<tr>
<td>14</td>
<td>+11.7 V</td>
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<tr>
<td>15</td>
<td>CAL COM SYNC.</td>
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</table>

**SPACE CRAFT CONNECTOR**

**TEST CONNECTOR "A"**
(Spare pins are 7, 8, 9, 10, 14, 15, 19, 20, 23, 24)

**TEST CONNECTOR "B"**
A. ID — BEGINNING OF CYCLE IDENTIFICATION (OUTPUT = 51744.5°).
B. E1, E2, E3 — EQUATORIAL DETECTORS 1, 2, AND 3 RESPECTIVELY.
C. P1, P2, P3 — POLAR DETECTORS 1, 2, AND 3 RESPECTIVELY.
D. IC — IC CLOCK, OUTPUT.
E. * THE *3e ACCUMULATOR IS A 2 BIT JAMMER FOR THE IC COUNT OUTPUT.
F. IN THE IMP-4 FLIGHT CONFIGURATION THE *3e ACCUMULATOR WAS DEACTIVATED AND ITS FUNCTION REPLACED BY THE *3d ACCUMULATOR IN THE ENCODER SN*04 ON 4/17/68 DUE TO A MALFUNCTION OF THE *3e ACCUMULATOR PRIOR TO LAUNCH.
### Table: Data Collection

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<thead>
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<th>X-TALK CHECKS</th>
<th>STIMULATION</th>
<th>OUTPUTS</th>
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<tr>
<td>1</td>
<td>X-TALK 8</td>
<td>6400 Hz - E1</td>
<td>1536 E1</td>
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<tr>
<td>2</td>
<td>X-TALK 9</td>
<td>6400 Hz - E1</td>
<td>1536 E1</td>
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<tr>
<td>3</td>
<td>X-TALK 10</td>
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<td>1536 E1</td>
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<table>
<thead>
<tr>
<th>IC CHECKS</th>
<th>STIMULATION</th>
<th>OUTPUTS</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>3 x 50 Hz / E1</td>
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</tr>
<tr>
<td>2</td>
<td>3 x 50 Hz / E1</td>
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<thead>
<tr>
<th>COMP SENSE CONDITIONS</th>
</tr>
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<tbody>
<tr>
<td>3 x 50 Hz / E1</td>
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</table>

### Notes:

- **TYPICAL CONSTANTS ARE**
  - K1 = 1000
  - K2 = 10
  - K3 = 20
  - K4 = 2
- **THese are 40 for "unmodified" flight**
  - ENCODE (4.17-6B), ON FOR
  - **THere are 224 for "modified" flight**
  - ENCODE (4.17-6B), ON FOR
TOP BRACKET, P1 - P3

#51 DRILL x 1/4 DF
TAP #2-56 TO BOTTOM
110° CSK TO 1/4 DIA.

2 PLACES

.625 ± .002 Dia. Thru
2 Places

.125

1.650

4.40

25°

4.40

438

7/8

5/16

.125

1/4

#51 DRILL THRU
TAP #2-56 ~ 2 PLCS.
#51 DRILL THRU TAP #2-56 5 PLCS.

.625 ± .002 DIA. BORE THRU 2 PLCS.

.656 DIA. X .063 DEEP 2 PLCS.

.076 ± .015 TO SLOT TYP.

.063 TYP

3/4

1/2

#51 DRILL X 1/8 DEEP TAP #2-56 TO BOTTOM

SPACE SCIENCES LABORATORY UNIVERSITY OF CALIFORNIA

USE MAGNETICALLY TESTED MAGNESIUM SECURE FROM FAOLI.
TITLE: FRONT BRACKET, E1-E3

1.900

.625 ± .002 DIA. 2 PLCS.

.312

.125

3/32 R.

.716 7/16

.125

.315

.560

.560

.312

.312

.440

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.312

.312

.125

.125

.312

.312
#44 Drill Thru
18 Places

Approx. .030
Typ.

8 Equal Spaces
@ .10 = .80
REAR BRACKET, E1-E3

#51 Drill Thru
#44 Drill x 0.1 DP
Tap #2-56

.288 .288

1/8 Slot

.076 +.015 to Slot
Typ

.063 DP
Typ

.250

.250

.250

.076 +.015 to Slot
Typ

.625 +.002
Dia. thru 2 Plcs.

0.890

1.650

1/4 Drill 1/4 Deep
Tap #2-56 to Bottom

110° CSK to 1/4 Dia.
2 Plcs.

.656 Bore x .063 DP
2 Plcs.

#5 Drill x 3/16 DP
Tap #2-56
4 Plcs.

#5 Drill x 1/4 Deep
Tap #2-56 to Bottom

USE MAGNETICALLY TESTED MAGNESIUM SECURE FROM PROLL.
Use magnetically tested magnesium. Secure from flange.

#51 drill thru
#44 drill x 0.1 DP
Tap *2-56

.125 + .002 .000 Dia.
2 PLCS.

.625 -.002 Dia.
2 PLCS.

#51 drill x 1/4 DP.
Tap *2-56 to bottom
110° sk to 1/4 Dia.
2 PLCS.

#51 drill x 3/16 DP.
Tap *2-56 to bottom
LEFT BRACKET, P2-E2

#51 DRILL THRU
#44 DRILL X 0.1 DP.
TAP #2-56

#51 DRILL X 1/4 DP
TAP #2-56 TO BOTTOM.
10° CSK TO 1/4 DIA.
2 PLCS.

.656 BORE X .063 DP ~ 2 PLCS.

.625 ± .002 DIA.
BORE THRU 2 PLCS.

#51 DRILL
X 1/8 DP.
TAP #2-56 TO BOTTOM.

.063 ± .015
TYP.

.076 ± .000
TYP.

1/8 SLOT
TYP.

1/2 R

1/4

1.25

.560

.576

.274

.125

.890

.900

1.500

.150

.125

.770

.560

5 PLCS.

USE MAGNETICALLY TESTED MAGNESIUM SECURE FROM PAOLI.
25/64 R.

TYP.

#42 DRILL THRU

3 PLCS.

.087

.576

3/4
USE MAGNETICALLY TESTED BRASS SECURE FROM PACL.
NOTES:
1. ROUND INSIDE & OUTSIDE CORNERS OF SLOT.
2. LOCATE DRILLED HOLES & SLOT WITH FIXTURE # IMP G-120.
NOTES:

1. ROUND INSIDE & OUTSIDE CORNERS OF SLOT.
2. LOCATE DRILLED HOLES & SLOT WITH FIXTURE # IMP G-120.
NOTES:

1. ROUND INSIDE & OUTSIDE CORNERS OF SLOT.
2. LOCATE DRILLED HOLES & SLOT WITH FIXTURE #IMP G-120.

USE MAGNETICALLY TESTED BRASS, SECURE FROM PAOLI.
NOTES:
1. ROUND INSIDE & OUTSIDE CORNERS OF SLOT.
2. LOCATE DRILLED HOLES & SLOT WITH FIXTURE #IMP G-120.

USE MAGNETICALLY TESTED BRASS SECURE FROM PAOLI.
NOTES:
1. ROUND INSIDE & OUTSIDE CORNERS OF SLOT.
2. LOCATE DRILLED HOLES & SLOT WITH FIXTURE # IMP G-110.
NOTES:

1. ROUND INSIDE & OUTSIDE CORNERS OF SLOT.

2. LOCATE DRILLED HOLES & SLOT WITH FIXTURE *IMP G-120*.
Fixture Shields

- 0.066 TYP.
- 0.0465 REAM
- USE 56 DRILL (6 PLCS.)
- 38°
NOTE:
1. THESE CORNERS SHARP —
ALL OTHERS MAY BE ROUNDED.
SECTION 1.

1. UNLESS OTHERWISE SPECIFIED:
   REMOVE BURRS & SHARP EDGES .008 R.

   A

   NOTE:

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   CONNECTOR BRACKET, 15 PIN

   K14-20L - IMPG-122
NOTE:
1. UNLESS OTHERWISE SPECIFIED:
   REMOVE BURRS & SHARP EDGES 0.005 R.
   12° ALL OVER.
NOTE:

1. USE MAGNETICALLY TESTED BRASS.
   SECURE FROM PAOLI.
#51 DRILL THRU 2 HOLES TO BE ALIGNED WITH SCATTERING UNIT.

BOTTOM TO MATCH SCATTERING UNIT.

IMP G-124
**Title:** Cathode Clip

**Break Edge to Approx. 0.005 of O.D.**

**Dimensions:**
- 3/16
- 0.050 ± 0.005
- 0.20 ± 0.004
- 0.10 ± 0.004
- 0.277
- 0.320 ± 0.003
- 0.14

**Material:** Hard Brass

**Drawn by:** K.P. Toy

**Scale:** 4" = 1"
TITLE: P1 - CATHODE CUSHION
NOTE:
1. BORE TO BE FITTED TO O.D.
   OF INDIVIDUAL GM TUBE.
BREAK EDGE TO APPROX .005 OF O.D.

.020 ± .004

.050 ± .005

.100 ± .005

.297 ± .003

.340 ± .003
ANODE CUSHION

1/8 DIA. THRU

1.250

.500 ± .002

.245 ± .002
NOTES:
1. REDUCE TO FIT INDIVIDUAL TUBE.
2. $P_1 = 0.792$ NOMINAL.
   OTHERS $= 0.710$ NOMINAL.
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<tr>
<th>DWG. NO.</th>
<th>IMPG - 133</th>
<th>REV.</th>
<th>DATE</th>
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<tr>
<td>MATL.</td>
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<td>UNIVERSITY OF CALIFORNIA</td>
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<tr>
<td>TITLE</td>
<td>ANODE ROD</td>
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| DRAWN   | R.P. TOY   |      |      |                            |
| SCALE   | 4" = 1"    |      |      |                            |
| CHECK   | R.T. Tool  |      |      |                            |
| APP.    | R.T. Tool  |      |      |                            |
| DATE    | 17 Aug. 67 |      |      |                            |

[Diagram of anode rod with dimensions: .347, .025 TYP., .050, .125 01A.]
STAND, ION CHAMBER

#51 DRILL  
#2-56 TAP  
on 13/8 B.C.  
2 Holes

10° TYP.

1.74 ± 0.003

0.096

0.050

1/2 DIA. THRU  
3 PLCS.

#44 DRILL  
equally spaced  
on 13/8 B.C.  
6 Holes

1.023 DIA.

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DRAWN: R.P. TOY
SCALE: 2" = 1"
CHECK: 
APP.
DATE: 25 AUG. 67

USE MAGNETICALLY TESTED MAGNESIUM SECURE FROM FAOLI.
#70 DRILL THRU ON .565 B.C.
2 HOLES

.045±.008

.015±.003

.625±.002

.655±.005

.150

.003

.003
#70 DRILL THRU ON .565 B.C. ~2 HOLES

*29 DRILL x .175 DP TAP *8-32 TO BOTTOM

THESE SURFACES DYED RED
P1 APERTURE

#38 DRILL THRU (0.1015 Dia.)

#52 DRILL THRU C'SINK 82° X 1/32 ON 0.500 B.C. 2 PLACES

0.035

0.625

KNIFE EDGE
*29 DRILL x .225 DEEP
TAP #8-32 TO BOTTOM

THIS SURFACE
DYED RED
THIS SURFACE DYED RED
#56 Drill thru on 0.500 B.C. 2 Places
1 MIL ALUM FOIL

BRASS RETAINER RING

0.375 DIA.

0.014

0.032
TITLICAL IMP G CHECKOUT BOX
CONNECTOR WIRING & POWER SUPPLY

SM-54-20S

GM CONTROL

MATRIX CONTROL AND FREEZE

IC CONTROL

+3V
+6V
HVI-1
HVI-2
HVI-3
TP (BROWN)
TP (RED)
TP (ORANGE)
3a GM
3b GM
IC CLOCK
IC Counter
GND
GND
GND
GND
Y SYNC

B1 = BURGESS H135 R OR EQUIVALENT
B2 = BURGESS H133 R OR EQUIVALENT

DENOTES FRONT PANEL MARKING.

DENOTES FRONT PANEL TEST POINT.
NOTES:
1. ALL MODULES ARE GME TYPE 551170 (OR 55112B)
   OR ANI TYPE 551200S.
2. ALL NPN TRANSISTORS ARE 2N4114.
3. Denotes front panel labeling.
4. Denotes rear panel labeling.
5. Denotes output.
6. Denotes -6.75 VDC.
7. Denotes -6.05 VDC.
8. Denotes selected value.
SHIELDED WIRE = RG 174 U.
OUTSIDE SHIELD = BRAID (ALPHA, BELEDEN).
ALL OTHERS = #21 BAYCHEM.

NOTE:
1. RUN OUTSIDE SHIELD ALL THE WAY TO CONNECTORS.

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G.S.E. CABLE
EQUATION:

$$IC = (3abs/2)(1+2) + (3abs)(5) + ([3abs] + [3abe]) \cdot (6) + [200](3ab)(9) + [3ads](10) + [800](3ab)(15)$$
To UCAL G.S.E.

TO UCAL G.S.E.

DIM-95

DIM-15P

TO UCAL EXPT.

5 EACH F3ab, F3cd, CLK, CAL COM, Y.

MEMSHA (BOTTOM VIEW)

7 EACH E1, E2, E3, P1, P2, P3, IC.
### Appendix IV

**IMP-G' (S2) Drawing List**

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<th>UCal IMP-G Supplementary Experiment Frame Outline, rev A</th>
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<td>UCal IMP-G Supplementary Experiment Top Cover</td>
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<td>103</td>
<td>UCal IMP-G Supplementary Experiment Sun Shield</td>
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<th>UCal IMP-G Supplementary Experiment, S/N 2 Schematic, rev B</th>
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<td>204</td>
<td>S/C and Test Cables</td>
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<th>Checkout Box, S/N 1, rev B</th>
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<td>301</td>
<td>NA</td>
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<tr>
<td>302</td>
<td>S/C Connector Cable and Test Connector Cable, rev A</td>
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</table>
NOTES
1. ALL THIN WALL SECTIONS ARE .035 THICK.
8

£v

m

*'52 DRILL THRU COUNTERSINK 1/16 IN.
12 PLACES

1. UNSPECIFIED RADIUS TO BE 1.56 ± .005R.
2. ALL DECIMAL TOLERANCES TO BE ± .005.
SAME AS ABOVE
NOTES:
1. ALL DIODES IN H.V. STACKS ARE IN32B3.
2. ALL CAPACITORS IN H.V. STACKS ARE "SPAGUE .02uF, I KV CAPS.
3. * DENOTES 28K RETURN.
4. + DENOTES SIGNAL GND.

2N4351