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DESIGN AND DEVELOPMENT OF A FAST ION MASS SPECTROMETER

by

J. L. Burch
Principal Investigator

W. C. Gibson
Project Manager

Final Report

SwRI Project 15-5680
NASA Contract NASW 3237

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C. 20546

February 1983

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APPROVED:

John R. Barton, Vice President
Instrumentation Research Division

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I. INTRODUCTION

This project has resulted in the development of two Fast Ion Mass Spectrometers (FIMS A and FIMS B), culminating in their flight on two Project CENTAUR sounding-rocket payloads in December 1981. Analysis of data from these flights is now in progress.

This report summarizes the design, development, construction, calibration, integration, and flight of these new instruments, along with early results from the data analysis efforts. The goal of the program was to develop a medium-energy ion mass spectrometer that could cover mass-velocity space with significantly higher time resolution, improved mass resolution, (particularly for heavier ions) , and wider energy range than existing instruments had achieved. The initial design consisted of a dual-channel cylindrical electrostatic analyzer followed by a dual-channel cylindrical $\bar{E} \times \bar{B}$ velocity filter. As part of the early work on this instrument (FIMS A) investigations into the gain versus count-rate characteristics of the high-current channel electron multipliers (CEM's), which were chosen for ion detection, revealed a systematic behavior that could be used as a criterion for selection of CEM's for long counting lifetimes. This result was published in Review of Scientific Instruments (Hahn and Burch, 1980).

Meanwhile, a computer ray-tracing analysis was used to optimize the FIMS A ion optics, and a prototype instrument was fabricated. Since no suitable calibration facility existed at SwRI at that time, prototype calibration was carried out at Los Alamos National Laboratory. This calibration confirmed the ray-tracing analysis, and work on the FIMS A flight unit began.

Although the FIMS A instrument achieved the expected improvements in time resolution, heavy-ion mass resolution, and energy range, it still was able to sample in only one direction at a time. To improve further the time resolution for sampling in mass-velocity space an angular imaging capability was needed. The FIMS B instrument was designed to meet this goal. In FIMS B the cylindrical energy analyzer was replaced by a spherical sector analyzer that was capable of sampling a 35° x 5° angular fan that is resolved into sixteen 2.2° x 5° sectors by means of a microchannel plate detector at the output of the cylindrical $\bar{E} \times \bar{B}$ velocity filter. The velocity filter was similar in similar in geometry to that of the FIMS A analyzer but with a magnetic field roughly twice as strong to give even better mass resolution for heavy ions. A FIMS B prototype also was calibrated at Los Alamos, and work was begun on a flight unit for Project CENTAUR. The design and early development work on the FIMS A and FIMS B instruments were described in a paper published in Review of Scientific Instruments (Hahn, Burch and Feldman, 1981).

Following the initial FIMS calibrations at Los Alamos, work was begun on a calibration system at SwRI that could test the response of these instruments and their future derivatives over the full range of their capabilities. This calibration system was put into operation in time for calibration of the FIMS A and FIMS B flight units in September 1981.

Integration of these instruments onto two separate Project CENTAUR payloads was accomplished with very few problems at SwRI. A long series of environmental tests of the full-up payloads at GSFC was followed by transport to Cape Parry, NWT, for launch operations. Both payloads were launched into the dayside magnetospheric cleft and operated nominally. Analysis of data from FIMS A and FIMS B, in cooperation with the other Project CENTAUR experimenters, is now underway.

II. DESIGN AND EARLY DEVELOPMENT OF FIMS A AND FIMS B

The design and early development, through prototype calibration, of the FIMS A and FIMS B instruments are documented in the paper entitled "Development of a Fast Ion Mass Spectrometer for Space Research," by S. F. Hahn, J. L. Burch, and W. C. Feldman, which is reproduced in the following pages. Also reproduced in this section is a paper entitled "Exponential Decay and Exponential Recovery of Modal Gains in High Count Rate Channel Electron Multipliers," by S. F. Hahn and J. L. Burch.

Also shown for reference in Figures 1 and 2 at the end of this section are photographs of the FIMS A and FIMS B prototype units.

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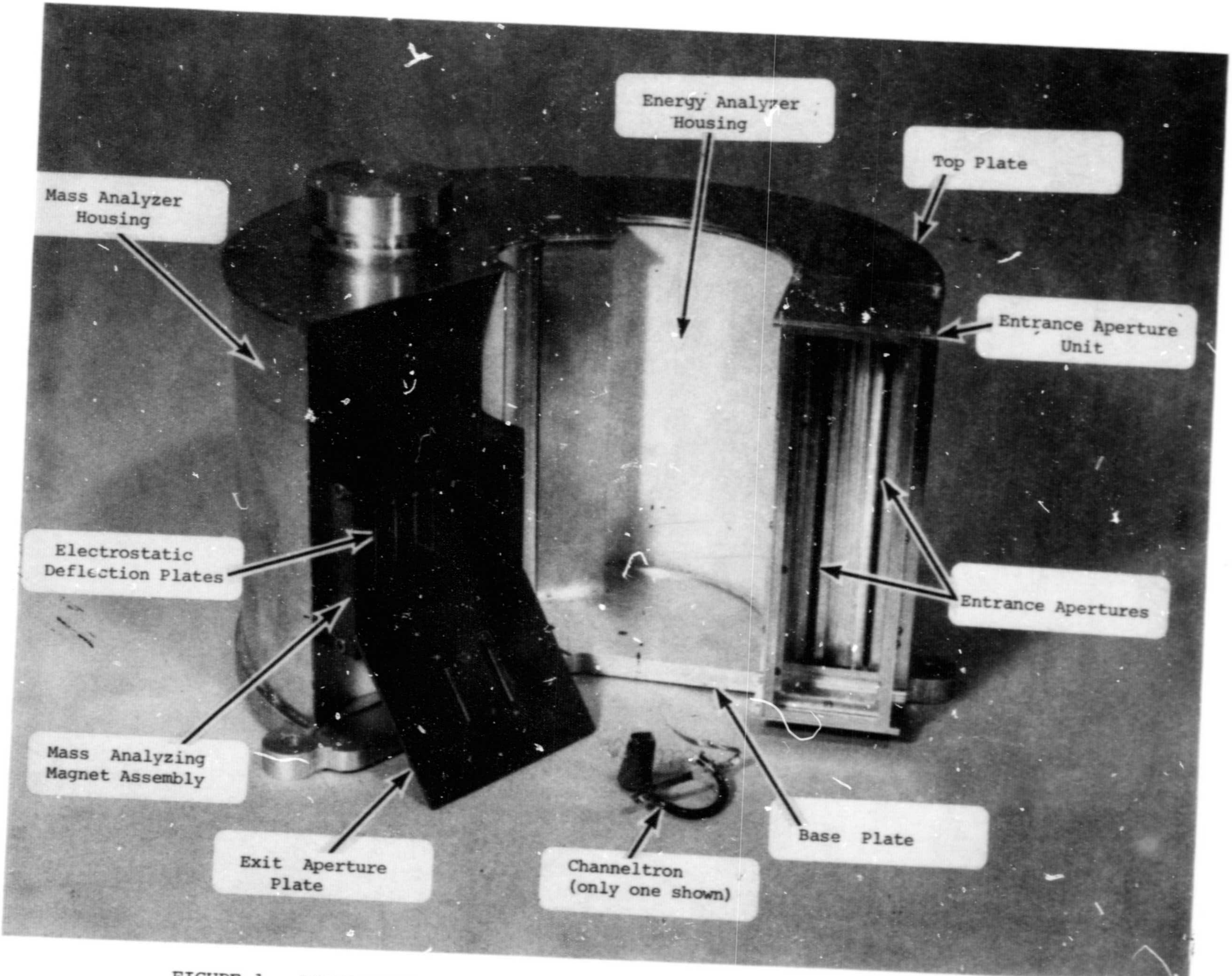

FIGURE 1. PHOTOGRAPH OF FIMS CYLINDRICAL-GEOMETRY PROTOTYPE INSTRUMENT.

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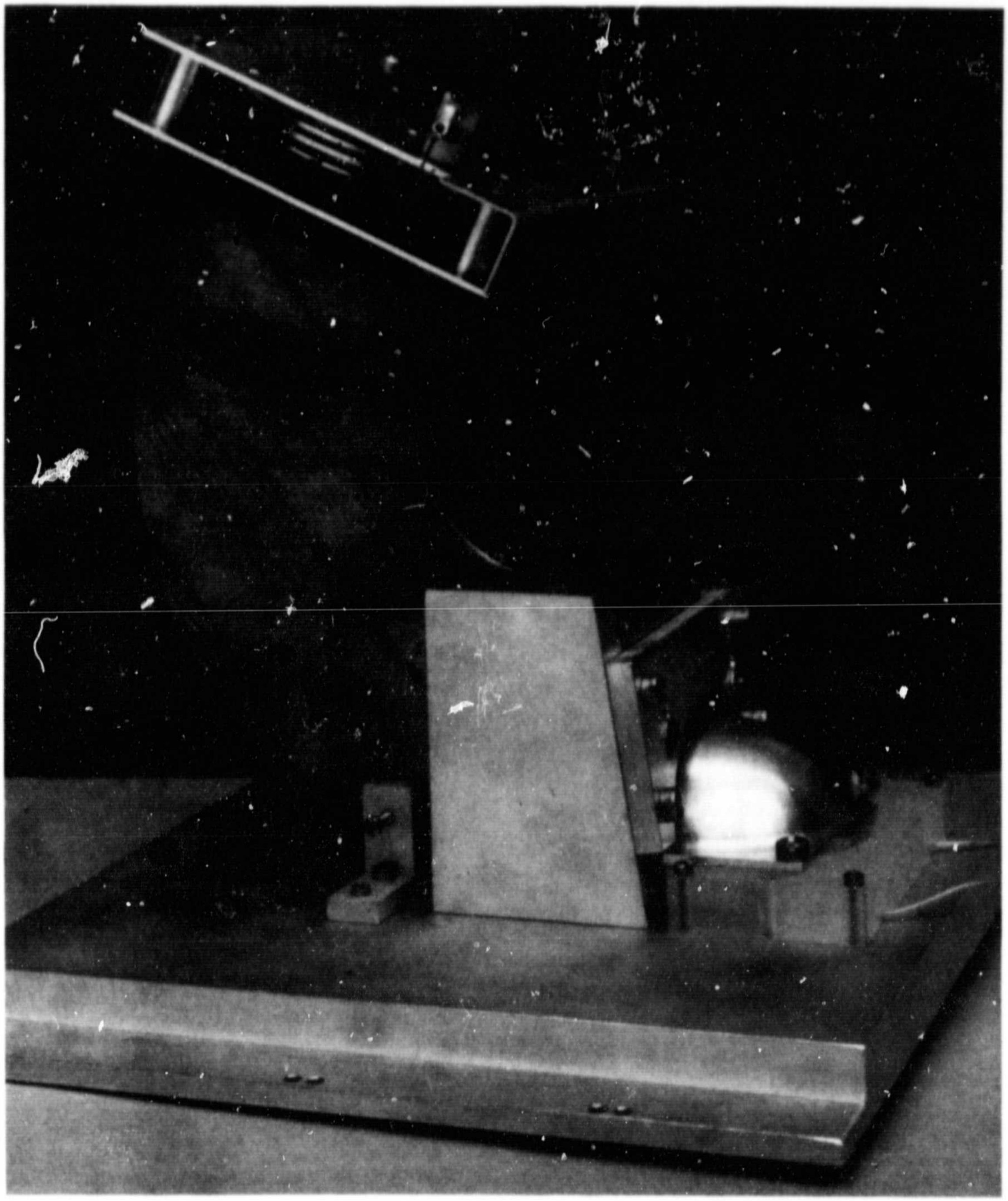

FIGURE 2. PHOTOGRAPH OF FIMS PROTOTYPE INSTRUMENT WITH SPHERICAL ENERGY ANALYZER AND MICRO-CHANNEL PLATE DETECTOR.

Exponential decay and exponential recovery of modal gains in high count rate channel electron multipliers

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(Received 17 July 1979; accepted for publication 5 February 1980)

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A series of data on high count rate channel electron multipliers revealed an initial drop and subsequent recovery of gains in exponential fashion. The FWHM of the pulse height distribution at the initial stage of testing can be used as a good criterion for the selection of operating bias voltage of the channel electron multiplier.

PACS numbers: 84.30.Wp, 29.60.Ef

Recently, high count rate channel electron multipliers (CEM's) developed specifically for the High Altitude Plasma Instrument and the Low Altitude Plasma Instrument for the NASA Dynamics Explorer project were examined in the laboratory to determine their performance characteristics. Although a number of different tests were performed, this note reports only on the results of pulse height analysis (PHA) examined as a function of total accumulated counts. The CEM's (Galileo Electro-Optics Series 4800) have typical channel resistance of $\sim 10^8\ \Omega$, and channel length-to-diameter ratios of 50 (with 1 mm inside diameters). The flat cone aperture has 6 mm × 20 mm rectangular dimensions to accommodate the instrument exit slit.

The CEM's were tested in an extremely clean vacuum chamber with a cryogenic main pump which brings the chamber pressure to typically less than 5×10^{-8} Torr. Extra care was taken to reduce the number of outgassing sources by, for example, using bare solid wire for electrical connections, and adopting only glass, ceramic and vacuum compatible metal for mounting hardware..

Measurements on CEM gain and pulse height distribution were obtained from a conventional charge sensitive preamplifier (ORTEC 142-PC) and wave shaper (ORTEC 460) combination, whose output was connected to either a CAMAC-controlled single channel analyzer or a multichannel analyzer (Nuclear Data 2200). The multichannel analyzer controls were set to match those of the manufacturer so as to achieve continuity in data taking. Data were obtained both at our facility and the manufacturer's.

Figure 1 shows some of the typical data. To emphasize the exponential nature of the gain change as a function of total accumulated counts, a linear scale was used on the x axis. The counts were accumulated at a rate of $\sim 5 \times 10^4\ s^{-1}$ while the CEM modal gain was maintained at $\sim 10^8$ by adjusting bias voltage to ensure no premature fatigue induced by overdriving it. The PHA was performed at a count rate of 5×10^3 counts s^{-1}, which was well within the region where no gain change with count rate was observed.

The data show a characteristic gain history with four distinct phases. The first phase involves an apparently exponential drop in gain. This initial gain reduction is the result of a "clean-up" process, a term used by many.[1] It occurs in a relatively short period of total accumulated counts (TAC's) usually in the range of 3–5 × 10^8. Some units were observed to exceed 10^9 TAC's before reaching the second, minimum gain, phase. At the end of the first phase, the gain is generally one third to one half of the initial gain. For normal CEM's the minimum gain is maintained for a period which is positively correlated to that of the first phase, up to 10^9 TAC's. Those units that were subsequently judged defective had monotonically decreasing gain past 10^{10} TAC's, a test limit we set for convenience.

Even with the positive correlation between the accumulation periods of the first and the second phases, the onset of the third phase, gain recovery, is not very predictable. The third phase is characterized by a strong and fast recovery of gain, again in an exponential fashion. While the overall fluctuation of gain reduction and subsequent recovery has been observed by many, no report is known to us on the exponential nature of the gain recovery. The recovered gain is generally higher or comparable to the initial gain as opposed to the lower recovered gain of regular CEM's. The final gain plateau (the fourth and final phase of the gain history) is consistently close to or higher than the gain observed at the beginning of the test. The gain recovery typically plateaus near 10^9 TAC's, but some units took up to $\sim 4 \times 10^9$ for full recovery. No appreciable change in gain was noticed in subsequent measurements up to 10^{10} counts, the set limit. We believe the gain stays more or less constant past this limit so long as no surface degradation due to contamination takes place, as evidenced in the literature.[2,3]

The gain drop and recovery phenomenon was observed after every exposure of the CEM to air, but the amount of change differed from the very first test values. The physiochemical process behind this gain fluctuation is presently not very well understood.

For statistical reasons it is important to know the FWHM of the CEM. Since the FWHM changes with gain, which is again subject to TAC's, it is better to determine the CEM operational voltage according to the actual FWHM measurements in addition to the usual

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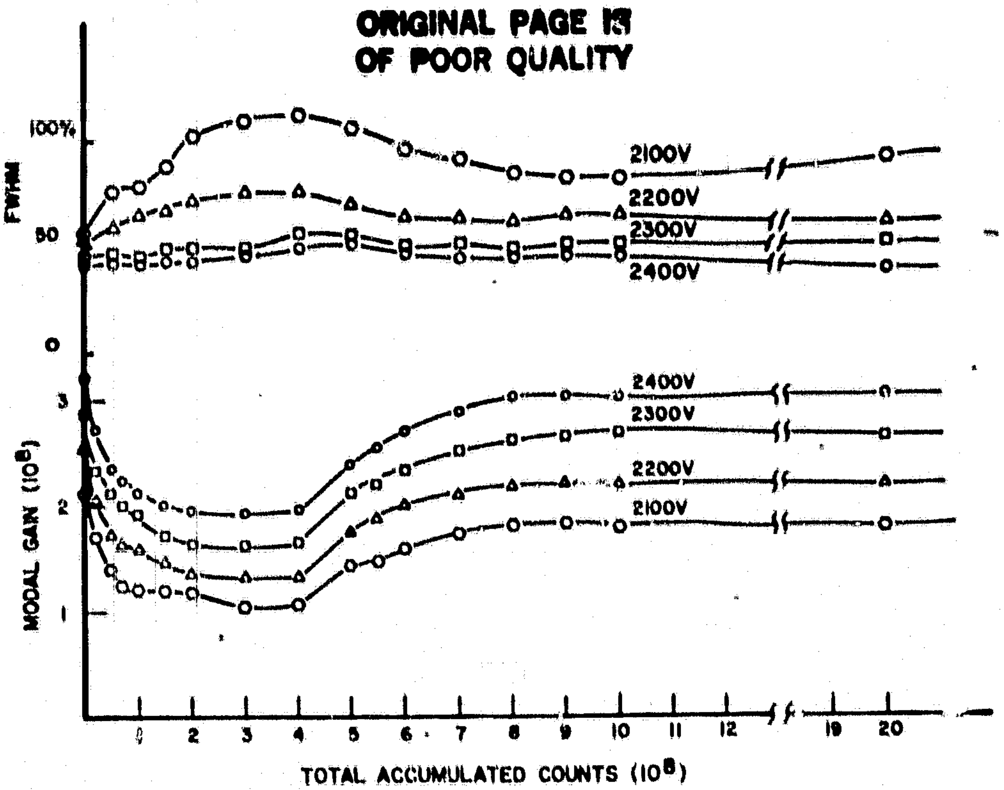

FIG. 1. Changes in modal gain and FWHM as functions of total accumulated counts.

practice of utilizing a gain (or count rate) vs. voltage curve, which does not give a clear-cut bending point. By testing FWHM at different bias voltages as a function of TAC's, one can safely set the operating voltage of a CEM with good statistical confidence. According to the data shown in Fig. 1, a bias voltage of 2300 V is needed if one wants better than 50% FWHM at any time during the operation of the CEM unless *in situ* aging of the CEM beyond the third phase is executed.

This work was supported by NASA Contract Nos. NAS5-24301 and NASW-3237.

[1] E. A. Kurz, "Channel electron multipliers," Am. Lab. **67**, (March 1979).
[2] H. Rosenbauer, Remarks on the qualification of continuous channel electron multipliers (CEM's) for use as detectors in long term space flight missions, unpublished manuscript (May 1978).
[3] J. G. Timothy and R. L. Bybee, Rev. Sci. Instrum. **49**, 1192 (1978).

Development of a fast ion mass spectrometer for space research

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(Received 29 August 1980; accepted for publication 6 October 1980)

An ion mass spectrometer with a cylindrical $\overline{E}\times\overline{B}$ analyzer and either a cylindrical or a spherical electrostatic analyzer is described in this paper. The instrument features two nested channels and a postacceleration between the electrostatic and $\overline{E}\times\overline{B}$ analyzers for wide ranges of energy and mass responses. The dual-channel construction not only doubles the data acquisition rate, but also makes it possible to reverse the electrostatic field orientation in the inner channel (radially outward, as opposed to radially inward in the outer channel) for lighter ions. The outer channel is then optimized for ions of medium to high mass numbers resulting in enhanced mass resolution for such heavy ions. A 90°-deflection angle spherical electrostatic analyzer in combination with a cylindrical $\overline{E}\times\overline{B}$ analyzer provides an extremely wide viewing angle. The angular distribution of ions can be obtained from such geometry if a position-sensitive resistive anode or a detector array is used at the exit aperture. Details on the principles of operation, the instrument design, and calibration are given in this paper.

PACS numbers: 07.75. + h, 95.55.Lb

INTRODUCTION

Low to medium energy (a few eV/e–tens of KeV/e) ion mass spectrometers for ionospheric and magnetospheric research have gained great sophistication during the past two decades. The newer types of instruments have steadily increased the detectable ranges of ion energies and mass numbers, the detection sensitivity, and resolution. Recent progress has been concentrated on $\vec{E}\times\vec{B}$ type filters, in which a permanent magnetic field and a variable electrostatic field are used to form a tunable velocity analyzer. Such an $\vec{E}\times\vec{B}$ filter in combination with an electrostatic energy analyzer provides energy-per-charge (E/q) and mass-per-charge (M/q) measurements of ions.

The geometry of the $\vec{E}\times\vec{B}$ filter has evolved from Cartesian[1,2] to a cylindrical[3,4] configuration, resulting in a more efficient use of volume and ion optics. A typical mass spectrometer[3] utilizes a cylindrical electrostatic energy analyzer followed by a cylindrical $\vec{E}\times\vec{B}$ analyzer which has radial electrostatic and axial magnetic fields formed by a set of coaxial electrostatic deflection plates placed between two magnet pole pieces. Such mass spectrometers are designed to be double focusing at selected mass and energy combinations achieving high sensitivity and good resolution as a whole device.

The energy ranges of such mass spectrometers have been increased by the adoption of a fixed preacceleration voltage applied between the grounded input aperture and the cylindrical electrostatic analyzer plates. The preacceleration increases the minimum energy of ions seen by the $\vec{E}\times\vec{B}$ analyzer to a level where the lightest ion (H^+) can be deflected by the magnetic field alone. So the ion energies which the instrument must handle range only from E_{Acc}/q (energy gained by acceleration) to E_{max}/q (maximum design energy) rather than from 0 to E_{max}/q. The preacceleration, however, results in deterioration of energy and angle resolution of the instrument at the lower ion energies, leads to an energy dependence of the total instrument sensitivity, and requires the use of a retarding potential analyzer (RPA) to obtain energy spectrum information at energies below the preacceleration energy. This approach not only adds to the complexity of the instrument, but also inadvertently decreases the sensitivity of the instrument due to lowered transmittance through a set of RPA grids.

This paper reports on the development of a Fast Ion Mass Spectrometer (FIMS) which is based on the cylindrical $\vec{E}\times\vec{B}$ velocity filter, but which achieves several significant improvements over previous instruments of this type. An isometric view of the calibrated instrument appears in Fig. 1. The energy and angle resolution at low energies has been improved by the use of postacceleration instead of preacceleration. In this approach the postacceleration potential is applied between the exit slit of the electrostatic analyzer and the entrance aperture of the $\vec{E}\times\vec{B}$ analyzer. This arrangement ensures the same wide dynamic operational energy range and still maintains uniform energy and angle resolutions of the basic electrostatic analyzer, eliminating the need of an

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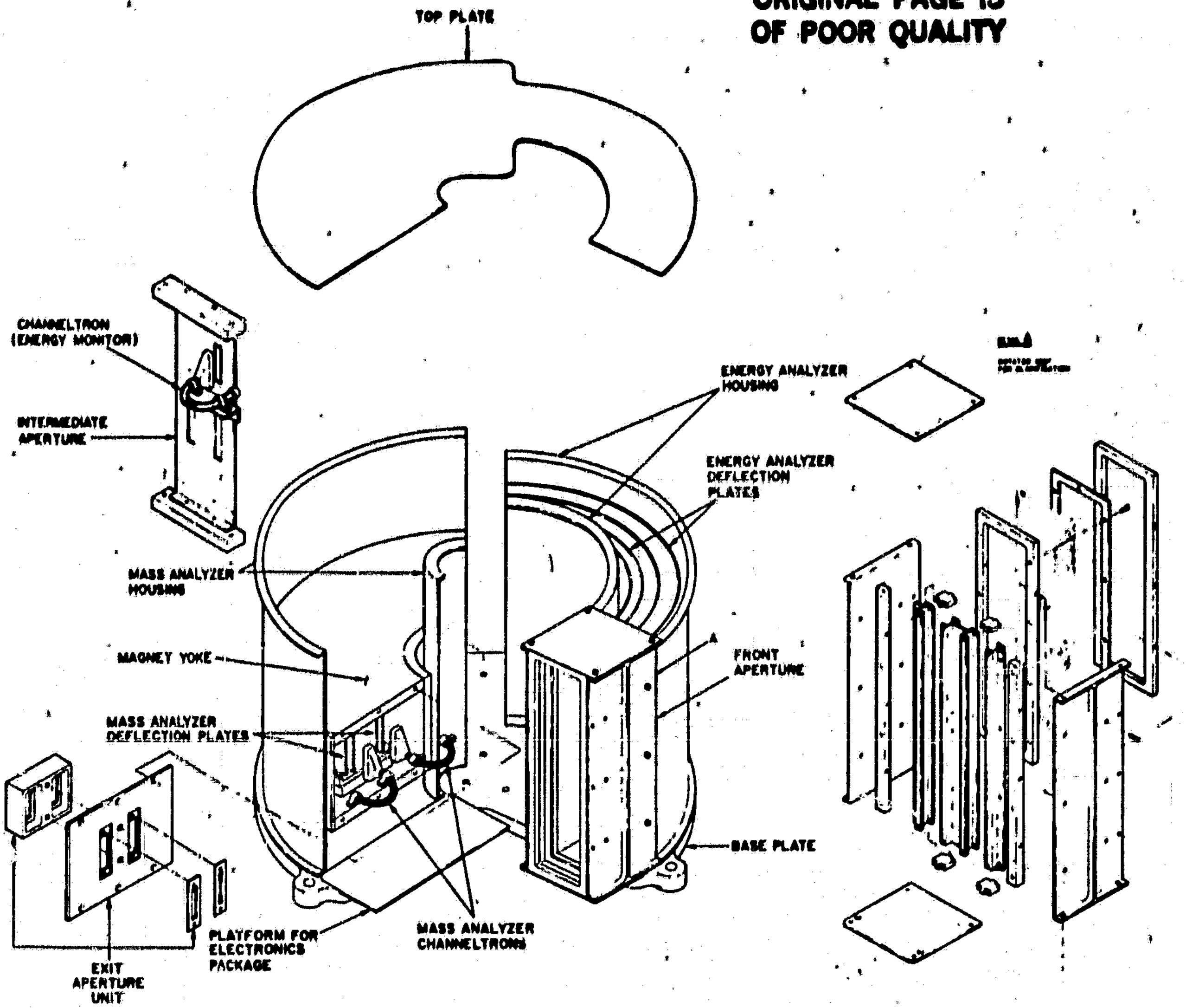

FIG. 1. A dual-channel fast ion mass spectrometer (FIMS) with cylindrical electrostatic and $\bar{E} \times \bar{B}$ analyzers.

RPA of the preacceleration instrument. The sensitivity of the instrument also remains constant for the entire energy range. Postacceleration also enhances the mass resolution of the instrument at low energies since the angle and energy spread past the electrostatic analyzer is reduced by the acceleration potential which precedes the $\bar{E} \times \bar{B}$ analyzer.

A second improvement is the incorporation of dual-channel operation, achieved by placing a second set of deflection plates nested within the radius of the first one. Such a nested geometry allows increase in instrument volume while providing a two-fold increase in data acquisition speed with minimal increases in weight and power consumption over those of the single-channel device. This dual-channel feature also allows the mass resolution of the instrument to be increased at higher mass numbers. As described above, single-channel $\bar{E} \times \bar{B}$ filters of this type have been designed so that low mass–number ions are detected when the radially inward electrostatic deflection force is minimized. An increase of the deflection voltage then allows the detection of higher mass–number ions, but with decreasing mass resolution since as $M/q \rightarrow \infty$, the $\bar{E} \times \bar{B}$ filter becomes essentially an electrostatic analyzer. With two channels, one can use a stronger magnetic field (or a larger radius), thereby optimizing the instrument at an intermediate mass number (e.g., O^+ or C^+). Then, the outer channel can acquire higher mass–number ions in the manner described above using a radially inward electrostatic deflection force, while the inner channel simultaneously covers the lower mass numbers by using a radially outward deflection electric field. This approach has been verified by trajectory computations, and a prototype instrument is now under construction.

An additional improvement has been achieved by the use of spherical electrostatic analyzers instead of the cylindrical units (Fig. 2). This geometry provides an extra large angle of view in at least one dimension (perpendicular to the plane of particle deflection), and, if a 90° deflection angle is used, enables one to measure the angular distribution of particles when a position-sensitive detector is used at the exit aperture.

The principle of device operation and detailed description of the prototype instruments as well as the use of

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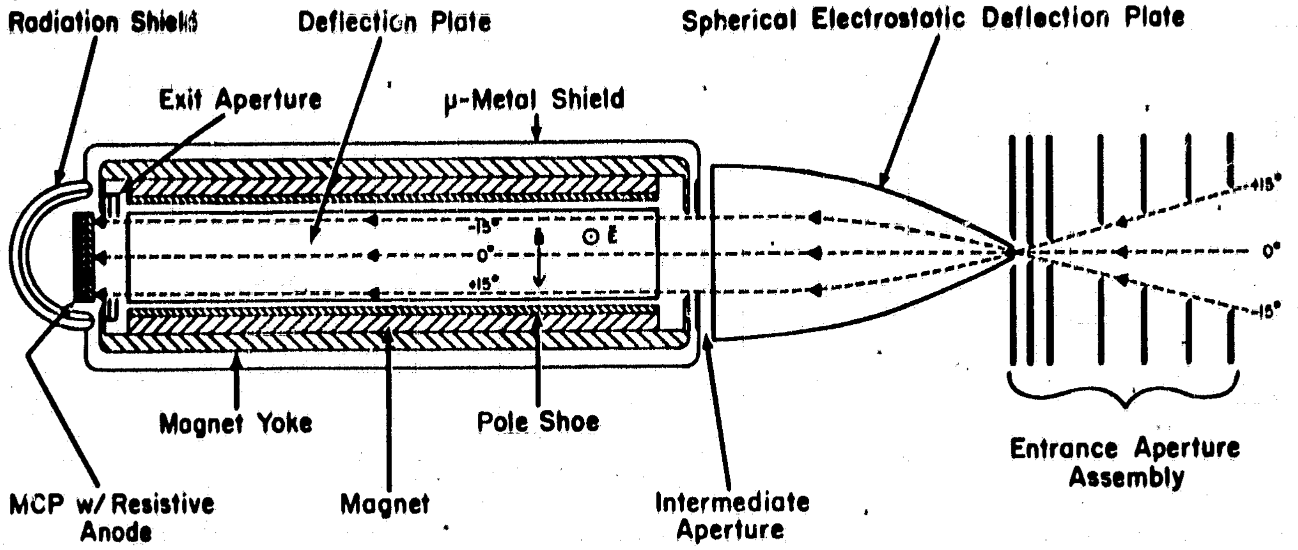

FIG. 2. A developed, cross-sectional side view of a mass spectrometer with dual spherical electrostatic analyzer and cylindrical $\bar{E} \times \bar{B}$ analyzer combinations. Such an instrument has an extra-wide field of view with high angular resolution if position sensitive detectors such as microchannel plates are used at the exit apertures.

spherical electrostatic analyzers are included in the following chapters.

I. OPERATIONAL PRINCIPLES

The analysis of charged particle optics in crossed $\bar{E}$ and $\bar{B}$ fields has been performed by some in cylindrical geometry,[5-7] and a brief review is made in this chapter with the intention of clarifying the meanings of different parameters used in the instrument descriptions. The idealized field sector geometry is shown in Fig. 3 where, for simplicity, no fringing field effect is considered. The magnetic field $\bar{B}$ is uniform within the sector boundary and is directed parallel to the z axis of the cylindrical coordinates of r, ϕ, and z. The radial electric field is generated by the use of a set of coaxial plates. Charged particles introduced into the field region are deflected by the combined effect of both electric and magnetic fields.

Suppose the fields are adjusted so that an ion with mass per unit charge ratio of m_0 and velocity v_0 is deflected along the central trajectory of radius r_0. The ratio of centripetal force by electrostatic field to the total deflection force is defined as

$$f = eE_0/(m_0 v_0^2/r_0^1), \tag{1}$$

where e is the unit positive charge and E_0 is the electric field at $r = r_0$. The quantity f is a measure of the relative deflection forces due to electrostatic and magnetic sources, and is either positive for radially-in or negative for radially-out $\bar{E}$-field orientation. The magnetic field force on the ion is then

$$ev_0'B = (1 - f)(m_0 v_0^2/r_0). \tag{2}$$

The motion of a particle other than those on the central trajectory can be described by an equation of motion in

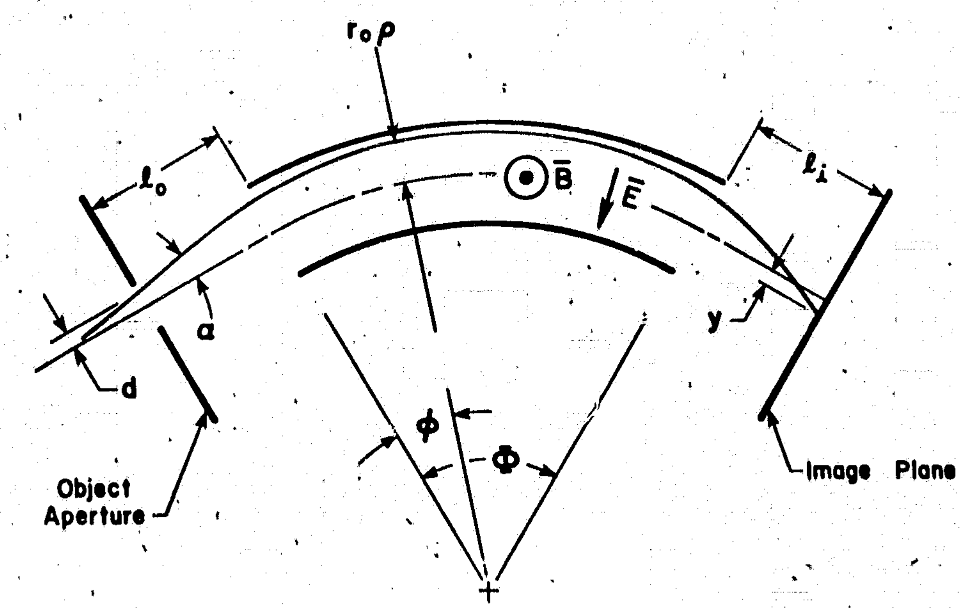

FIG. 3. Basic geometry of a cylindrical $\bar{E} \times \bar{B}$ field sector used for ion trajectory analysis.

cylindrical geometry, which can be solved analytically if first-order approximations are used for certain of the parameters as follows:

$$v = v_0(1 + \beta), \qquad [3(a)]$$

$$m = m_0(1 + \epsilon), \qquad [3(b)]$$

and

$$r = r_0(1 + \rho), \qquad [3(c)]$$

where β, ϵ and ρ are all $\ll 1$.

Using the above approximations and the relationships between r, ϕ, and t, a second-order differential equation of ρ as a function of ϕ is obtained as

$$\frac{d^2\rho}{d\phi^2} + \rho(1 + f^2) = \beta(1 + f) + \epsilon, \qquad (4)$$

where only first-order terms in ρ, β, and ϵ are preserved.

Solving for ρ with boundary conditions given in Fig. 3,

$$\rho(\phi) = A \sin k\phi + B \cos k\phi + [\beta(1 + f) + \epsilon], \qquad (5)$$

where

$$k^2 = 1 + f^2,$$

$$A = \alpha/k,$$

$$B = (d + \alpha l_0)/r_0 - [\beta(1 + f) + \epsilon]/k^2,$$

with α ($\ll 1$) = angle of incidence at the entrance aperture, d = displacement of particle entrance position from the aperture center, and l_0 = object distance.

After leaving the field region the particle follows a straight path to the exit aperture plane, assuming no fringing field effect. The displacement of the intercept point from the point of central ion trajectory at the exit aperture plane is then expressed as

$$D = \left.\frac{d\rho}{d\phi}\right|_{\Phi} [1 - \rho(\Phi)]l_i + \rho(\Phi)r_0, \qquad (6)$$

where l_i is the image distance and Φ is the field sector angle.

Equation (5) is used to evaluate D, and the resultant terms are grouped to represent effects of various sources of dispersions as

$$\begin{aligned} D &= D_\alpha + D_\beta + D_d \\ &= \alpha[r_0/k - l_i l_0 k/r_0) \sin k\Phi + (l_0 + l_i) \cos k\Phi] \\ &\quad + \beta(1 + f + \epsilon/\beta)[(l_i/k) \sin k\Phi + (r_0/k^2)(1 - \cos k\Phi)] \\ &\quad + d[\cos k\Phi - (l_i k/r_0) \sin k\Phi]. \qquad (7) \end{aligned}$$

D_α is the dispersion due to the angular divergence at the entrance aperture, while D_β results from the deviation of ion velocity and mass from those of the central trajectory ion. The last term is the magnification effect of the ion optics. For first order angular focusing ($D_\alpha = 0$), the terms inside the first bracket should reduce to zero, or

$$(l_i + l_0)/(r_0/k + l_i l_0 k/r_0) = -\tan k\Phi. \qquad (8)$$

For example, for a purely electrostatic cylindrical analyzer with $l_i = l_0 = 0$, angular focusing occurs when $k\Phi = \pi$ where $k = (1 + f^2)^{1/2} = 2^{1/2}$. Also, for a purely magnetic analyzer, $k = 1$ and the ions are focused in angle if $\Phi = \pi$. For any value of k between 1–$2^{1/2}$, the focusing should occur between $\pi/2^{1/2}$ and π as both field components contribute in deflecting the ion. In other words, if the field sector angle Φ is set to a value between the two limits, there is a corresponding value of f for which the angular focusing occurs for the ions of given mass-per-charge and energy-per-charge ratios. Since the electrostatic energy analyzer preceding the $\bar{E} \times \bar{B}$ analyzer can be made to be angular focusing at all energies, the complete instrument can be designed for first-order angular focusing at selected ion energy and mass number combinations.

To achieve focusing in energy as well as in angle, the energy dispersion of the electrostatic analyzer should be compensated by the equal but opposite dispersion in the $\bar{E} \times \bar{B}$ analyzer while maintaining the angular focusing conditions. The velocity dispersion of an angularly-focusing electrostatic analyzer is obtained from Eq. (7) by keeping $\epsilon = 0$ (uniform mass-per-charge), $f = 1$ and $k\Phi = \pi$, resulting in $D_{\beta E} = 2\beta r_{0E}$ where the subscript E is used to denote the electrostatic analyzer.

The velocity dispersion D_β in the $\bar{E} \times \bar{B}$ analyzer is given similarly:

$$\begin{aligned} D_\beta &= \beta(1 + f_0)(r_0/k^2)(1 - \cos k\Phi) \\ &= \beta(1 + f_0)[2r_0/(1 + f_0^2)], \qquad (9) \end{aligned}$$

where f_0 is the value of f for which the angular focusing condition is satisfied. For double focusing,

$$D_{\beta E} = D_\beta, \quad \text{or} \quad r_{0E} = r_0(1 + f_0)/(1 + f_0^2). \qquad (10)$$

The mean radius of the electrostatic analyzer, r_{0E}, ranges from $1.0r_0$ for $f_0 = 0$–$1.207r_0$ for $f_0 = 2^{1/2}$. Thus, the mass spectrometer can be made double focusing in energy and angle at a selected combination of ion mass and energy by adjusting the radius of the electrostatic analyzer within the limits with respect to that of the $\bar{E} \times \bar{B}$ analyzer.

Even for an instrument with postacceleration (an acceleration potential is applied between the electrostatic and $\bar{E} \times \bar{B}$ analyzers), the angular focusing condition previously discussed is still applicable as the two component analyzers are operating independently to achieve angular focusing as a complete instrument. The amount of angular dispersion at other than the focusing condition becomes smaller for the instrument with postacceleration, especially for ions whose initial energies prior to acceleration are less than those gained by the postacceleration. As explained in the previous section, the acceleration is required to accomplish a wide dynamic range of operation (from a few eV/e to tens of thousands of eV/e) without the benefit of an electromagnet by raising the minimum energy of the ions to the level required by the permanent magnet. In contrast to postacceleration, a preacceleration scheme (applying acceleration before the ions are introduced into the electrostatic analyzer) required an additional analyzer (a Retarding Potential Analyzer) for low-energy ions,

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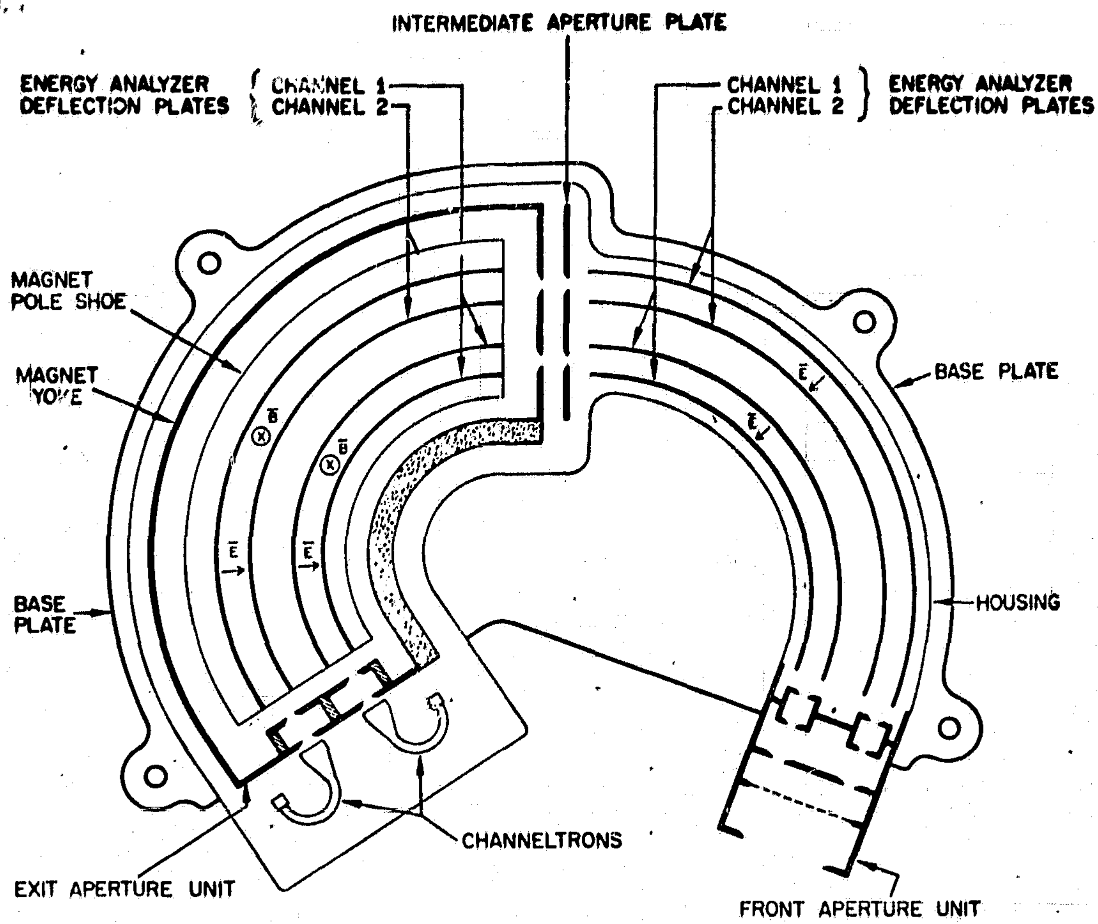

FIG. 4. Schematic presentation of the dual-channel fast ion mass spectrometer (FIMS).

adding to the complexity of the basic instrument. The double-focusing characteristic is also obtained in the instrument with postacceleration, but at a different value of r_{0E} from that of an otherwise identical preacceleration instrument. In the limiting case for which the initial ion energy per charge is much higher than the energy gained by the postacceleration, a similar double-focusing condition applies to both. For low-energy, low-mass ions, the angular focusing occurs near $\phi = \pi/2$ in deflection angle as all the ions are essentially monoenergetic and parallel in motion when introduced into the $\bar{E} \times \bar{B}$ analyzer. This angle is smaller than the minimum possible angle of $\pi/2^{1/2}$ for angular focusing of an $\bar{E} \times \bar{B}$ analyzer. In other words, there is a lower limit in energy for which the double focusing occurs for such an instrument. This limit, however, does not necessarily degrade the mass resolution of the instrument at low energies since the angular dispersion becomes very small for the same low-energy level.

The preceding discussions were verified through ray-tracing calculations on a computer graphics terminal. The design of the instrument was initially based on the results obtained from the simulation. Details of the instrument are given in the following section.

II. INSTRUMENTATION

Figure 4 shows a schematic drawing of the instrument with cross-sectional plane parallel to the base plate. The prototype was built and calibrated in the laboratory. The calibration results are discussed in the next section. The instrument utilizes two ion channels which enable us to collect data at twice the speed of a single-channel device. The two channels are in a nested configuration, so that the additional weight and volume amounts to only a fraction of those for a single channel instrument. Five major functional units make up the physical structure of the instrument excluding the electronics system. These units include the front aperture, the electrostatic analyzer unit, the intermediate aperture, the $\bar{E} \times \bar{B}$ analyzer unit, and the exit aperture/detector unit.

A. Front aperture

The front aperture unit works as a mechanical limiter of the viewing angle of the instrument. The unit consists of a four-stage baffle and a grounded grid which shields ions from the electrostatic leakage field of the deflection plates. The last two baffles are machined to exact opening slit sizes (2.5 × 120 mm) and viewing angles (±10° azimuthal × ±12° polar) and are biased to a slightly positive potential with respect to the instrument body to repel ions of energies lower than the design limit. Particles within the viewing angle and direction are introduced into the two cylindrical electrostatic analyzer channels with little disturbance from the front aperture as there is only one grid of high transparency (≤91%).

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B. Electrostatic analyzer

The two channels of the electrostatic analyzer have mean radii of 6.92 and 8.92 cm each for inner and outer channels, respectively. The ratio of plate separation to mean radius ($\Delta r/r_0$) of a channel is set the same for both of the channels to have the same energy resolution since $\Delta E/E \propto \Delta r/r_0$ in a first-order approximation. The same $\Delta r/r_0$ ratio for both channels also results in ions of the same mean energy being deflected through the central radii of the two channels, thus facilitating direct comparison of data between the two even when a common power supply is used for both.

The sector angles of the two analyzer channels are both 112°. Equation (8) demands that the sum of the image and object distances be different between the two channels if the same sector angle is used for both. For practical reasons, however, the same image and object distance of 1.0 cm is used for the two channels. The top and bottom edges of the deflection plates are machined to have blunt ribs with circular cross sections. This feature helps to maintain the mechanical rigidity of the thin aluminum deflection plates and also to reduce the electrostatic fringing field effect near the edges. The plates are mounted on the base plate and top plate of the housing through Kel-F insulating mounts. The internal area of the deflection plates, which is exposed to the channel, is gold blackened for the effective absorption of energetic photons and the prevention of multiple ion scattering, both of which can cause high background count. The gold black is obtained through carefully controlled evaporation of gold in a vacuum chamber with backfilled gas (98% N_2 and 2% O_2) maintained at a pressure of ~2 Torr. The common practice of serrating the internal surface of the deflection plates is omitted for ease of machining in the prototype instrument.

C. Intermediate aperture

Energy-selected ions from the electrostatic analyzers are angularly focused to a pair of grounded intermediate apertures of widths 3 and 4 mm for inner and outer channels, respectively. The intermediate aperture selects ions within a predefined energy bandwidth and then passes them to the postacceleration region between the grounded plane and another set of matching apertures located on the $\bar{E} \times \bar{B}$ analyzer unit. The postacceleration potential should add enough energy to the ions (−3400 eV/e for the prototype) to guide the lightest ion (H+) through the inner channel at the given radius and flux density of the $\bar{E} \times \bar{B}$ analyzer. The intermediate aperture unit also includes a channel electron multiplier as an ion detector, which is located against the inner channel of the electrostatic analyzer, but vertically offset from the main aperture slit. This detector is used as an energy monitor which measures the energy distributions of the total ion population. All aperture openings have beveled knife edges to reduce any off-angle scattering of particles.

D. $\bar{E} \times \bar{B}$ analyzer unit

The energy-filtered, postaccelerated ions are introduced into the two channels of $\bar{E} \times \bar{B}$ analyzer unit. The unit consists of a magnet assembly and two sets of electrostatic deflection plates. The magnet assembly uses two $SmCo_5$ permanent magnets, pole shoes, and a yoke system which completely encloses the magnetic field region, except for the aperture openings at the inlet and outlet. The entire $\bar{E} \times \bar{B}$ analyzer unit is biased to −3400 V from the instrument body for postacceleration. The initial yoke design was verified by a two-dimensional magnetostatic computer code to achieve uniform flux density inside the field region at minimum weight and low-leakage flux. The complete analyzer unit weighs 2.8 kg in the present design, where elaborate machining was avoided for simplicity. The magnet weight can be reduced, if required, by as much as 25% by further trimming of the yoke. The magnets generate an average flux density of 1330 G in a 3.0 cm gap between pole shoes, and the maximum flux density change within the volume of the channel is approximately 1% of the average value except for the regions near the entrance and exit sides of the channels, where a fringing field effect arises.

The magnetic leakage was measured at not more than 0.75 G at 10 cm from the surface of the magnet yoke in any direction. Further reduction in leakage to less than 1 γ at 1 m seems easily obtainable if a high-μ foil is used for shielding around the yoke. The sector angle defined by the physical boundary of the magnets was selected through computer programming of the beam trajectory calculation, and was set at 123°, which is the same for the electrostatic deflection plates mounted between the magnet pole shoes. This angle is chosen to have angular focusing condition at a value of f near unity, corresponding to essentially electrostatic deflection of ions of heavy mass and/or high energy. Considering that the angular focusing of a purely electrostatic analyzer with cylindrical geometry is achieved at $\Phi = \pi/2^{1/2}$ if the object and image distances are zero, it is clear that the $\bar{E} \times \bar{B}$ analyzer with 123° sector angle and 1.5 cm object and image distances will satisfy focusing conditions when the electrostatic deflection force is perdominant over the magnetic force.

With the same object and image distances for both channels, the angular focusing occurs at $f = 0.75$ and 0.82 for inner and outer channels, respectively, if no fringing field effect is considered. The mean radii of inner and outer channels are 6.0 and 8.0 cm, respectively. The fringing field of the magnet assembly was measured *in situ*, and the effect was calculated for various ion energy and mass combinations. For a 3.0 keV H^+ ion, the magnetic fringing field effect works as if the field boundary is approximately 0.3 cm beyond the pole shoes, and the virtual field sector angle becomes 128.7° in contrast to the physical magnet sector angle of 123°. The electrostatic deflection plates in the $\bar{E} \times \bar{B}$ analyzer unit are machined and gold blackened as described above for the energy analyzer plates.

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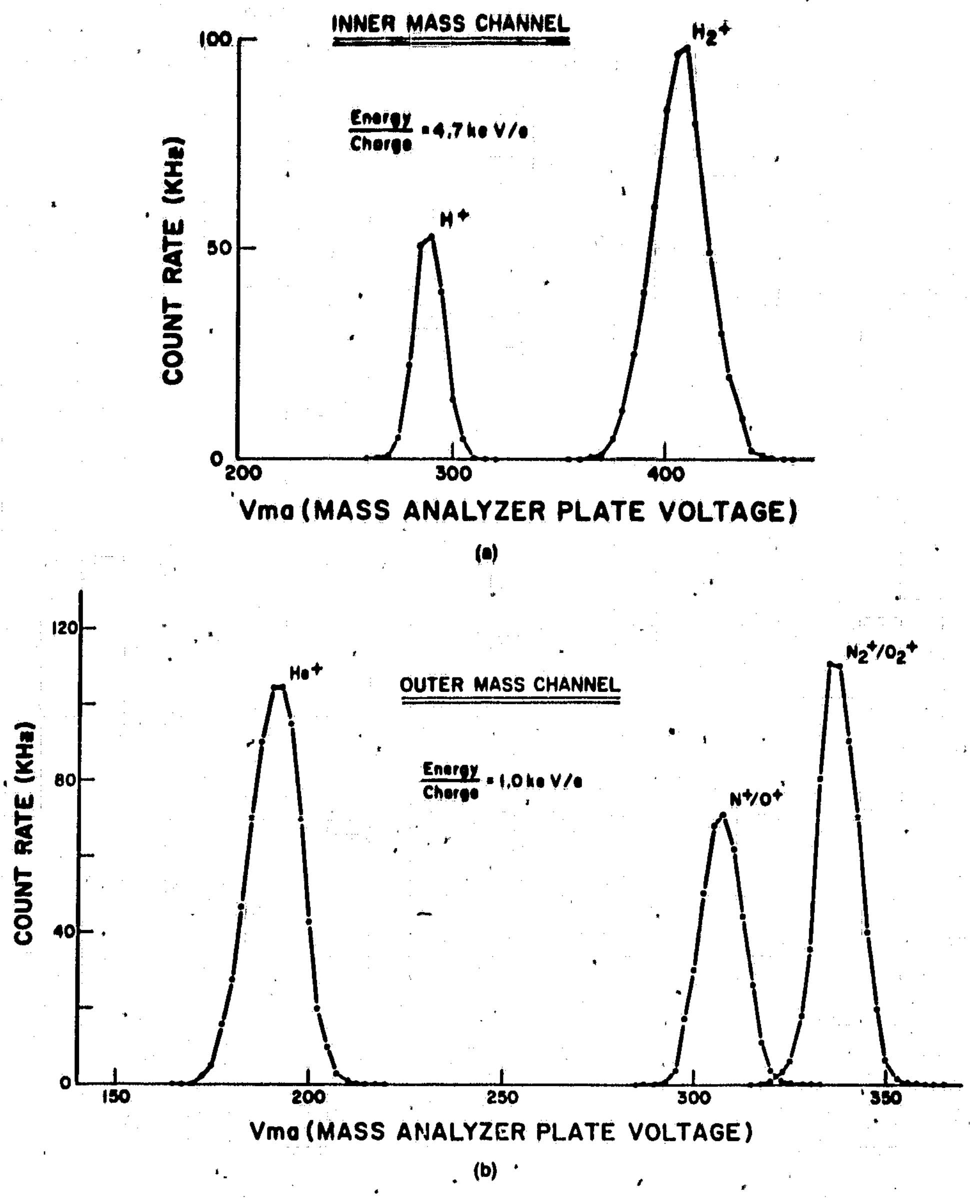

FIG. 5. Calibration data from the dual-channel FIMS of cylindrical geometry. Each set of curves is a composite of separate measurements for different ion species. (a) Inner-channel data for 4.7 keV/e, H^+ and H_2^+ ions. (b) Outer channel data for 1.0 keV/e, He^+, N^+/O^+ and N_2^+/O_2^+ ions. The label N^+/O^+ indicates that the peaks are due to nitrogen.

E. Exit aperture and detector unit

The exit apertures are located at 1.5 cm from the field sector boundary, and are composed of two layers of baffles and a set of two limiting slits on a soft-iron plate. The plate forms part of a magnetic yoke system which completely encloses the magnetic field region, minimizing the leakage flux. Ions with selected mass-per-charge emerge from the apertures and are detected by two high count rate (≥5 MHz) channel electron multipliers (CEM's) set against the apertures. The CEM (Galileo Electro–Optics' 4800 Series) has an input cone of rectangular (6 × 20 mm) opening, which is larger than the exit aperture slit sizes. The bias voltage is individually adjusted to achieve a gain of $\sim 1 \times 10^8$, and ranges from 2200–2700 V. The bias voltage of the CEM's is obtained from the postacceleration potential of the $\bar{E} \times \bar{B}$ analyzer unit, thus eliminating the use of an extra power supply. Different types of material are being considered for the shielding of CEM's against penetrating high-energy radiation, including gold and polyethylene combinations.

III. INSTRUMENT CALIBRATION

The calibration of the instrument has been performed using an ion accelerator facility at Los Alamos Scientific Laboratory. The accelerator main chamber contains a gimballed platform on which the instrument is mounted. Ions are generated by a duo-plasmatron type gun, and are postaccelerated to a desired energy level. A mass-selecting magnet is set between the gun and the flight tube of approximately 3 m in length. The beam intensity and cross sectional distribution are monitored by a set of electron multipliers inside the main chamber next to the beam opening. The chamber is pumped by a combination of ion and turbomolecular pumps to a low 10^{-6} Torr range in pressure. Calibration parameters include the ion species, energy, the orientation of the instruments in two angles, electrostatic analyzer plate voltages, and the $\bar{E} \times \bar{B}$ analyzer plate voltages to determine the energy and mass resolutions, viewing angles, and deflection sensitivity of the electrostatic plates. The instrument response to ions of isotropic distribution is simulated by integrating the data over all angle and energy settings

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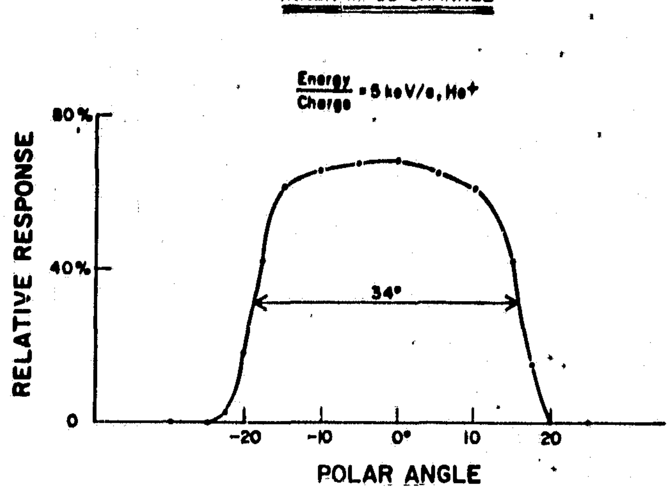

FIG. 6. The response curve in polar viewing angles for a spherical electrostatic and cylindrical $\bar{E} \times \bar{B}$ analyzer combination.

of the instrument. Figure 5 shows some of the data obtained using 4.7 keV/e H^+ and H_2^+ ions on the inner channel. The two mass peaks show resolutions ($\Delta M/M$) of ~0.15 for H^+ and 0.25 for H_2^+ at FWHM. The resolution gets better than 0.1 for H^+ ions of energies below 1.0 keV.

The outer channel calibration data at ion energy of 1.0 keV/e are given in Fig. 5(b). Only He^+ and heavier ions were used in the calibration of the outer channel. The separation of peaks between N^{++}/O^{++} group and N^+/O^+ group ions is large enough for unambiguous identification, which is true for energies up to and above 10 keV/e. The instrument viewing angles vary with the change of ion energies, but generally range between ±5° and ±8° for both polar and azimuthal angles. The energy resolution is quite uniform over entire energy range, and is typically about 7%. The geometric factor, slightly dependent on the ion energies, is estimated at $\sim 1 \times 10^{-3}$ cm²-ster ($\Delta E/E$).

IV. USE OF SPHERICAL ELECTROSTATIC ANALYZER IN COMBINATION WITH CYLINDRICAL $\bar{E} \times \bar{B}$ ANALYZER

On a spin-stabilized satellite, an instrument with its viewing direction perpendicular to the spin axis can scan the whole 4π steradian solid angle per spin if the viewing angle on a plane including the spin axis is 180°. It is thus very advantageous to develop an instrument which has an extra large viewing angle in at least one plane with an ability to resolve the angular response. The mass spectrometer discussed in preceding sections has viewing angles in both polar and azimuthal directions of between ±5° and ±8°, while a wider angular acceptance is often desirable. A modified mass spectrometer has been developed to meet this objective through the use of a spherical electrostatic energy analyzer as shown in Fig. 2. The spherical analyzer has a 90° deflection angle in the plane of trajectory and the apex of the ⅛ of a sphere is used for particle inlet aperture.

The spherical analyzer transforms ion flow such that small area-wide polar angle flux at the inlet aperture converts itself to a large area—parallel flux at the exit aperture after the particles have traced out great circle trajectories of 90° in deflection. As before, the particles emerging from the exit aperture are introduced into the $\bar{E} \times \bar{B}$ analyzer channels for mass analysis. Since the exit positions of parallel particle trajectories correlate uniquely to the particle inlet angles, and the relative positions of particles are conserved in the $\bar{E} \times \bar{B}$ analyzer where there is no force in z-direction, the original particle inlet angle can be recovered at the detector plane if a position sensitive detector is used. A microchannel plate with resistive anode appears the most promising candidate for the detector while an array of channel electron multipliers could also be used. A prototype of the instrument combining 96° spherical electrostatic analyzer with a cylindrical $\bar{E} \times \bar{B}$ analyzer was chosen to verify the feasibility of the novel idea. 96° deflection angle was selected in the prototype device to have focusing in polar angles to a point detector located beyond the exit aperture of $\bar{E} \times \bar{B}$ analyzer. The calibration data shown in Fig. 6 shows the wide (34° at FWHM) angle of acceptance in polar angle.

It was also verified that the mass resolutions of the spectrometer with such configuration was quite comparable to those of cylindrical geometry. The magnetic field sector angle must be changed from that of the cylindrical configuration since the ions incident on $\bar{E} \times \bar{B}$ analyzer are all parallel in the plane of deflection (azimuthal angle). The initial angular focusing (in the deflection plane) occurs at a deflection angle between $\pi/2^{3/2}$ and $\pi/2$ for the parallel ions, which makes the $\int \bar{B} \times d\bar{l}$ factor too small to differentiate high AMU ions. A sample run of trajectory calculations is given in Fig. 7. The previously mentioned postacceleration still applies to the new scheme with the similar effects, raising the minimum energy of ions before being analyzed in the $\bar{E} \times \bar{B}$ unit and also straightening the ion trajectories for less angular spread.

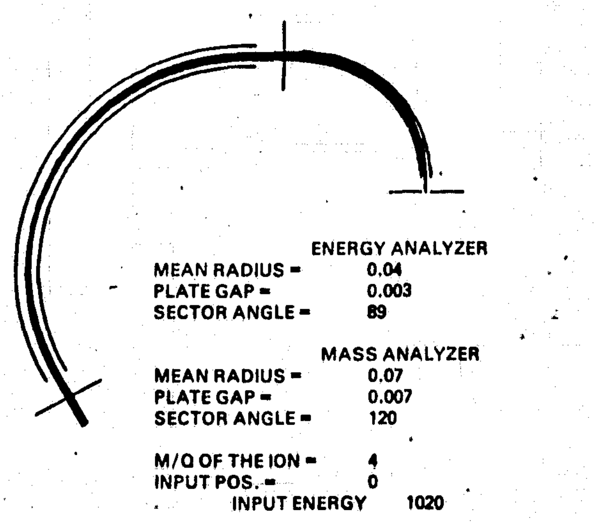

FIG. 7. Ray tracing of ions in a spherical electrostatic and cylindrical $\bar{E} \times \bar{B}$ analyzer combination.

V. DISCUSSIONS

The use of cylindrical electrostatic and $\vec{E} \times \vec{B}$ analyzers in space-borne ion mass spectrometers has led to the achievement of high mass resolutions over wide ion energy ranges. Further improvements have been made possible by the use of more than one channel and the adoption of postacceleration between electrostatic and $\vec{E} \times \vec{B}$ analyzers as established by the calibration data of a laboratory prototype. The use of multiple channels increases the data acquisition speed with little penalty on weight and volume. When a high mass resolution is needed for ions with high mass-to-charge ratios, the magnetic flux density and the postacceleration potential of the $\vec{E} \times \vec{B}$ analyzer can be optimized for such ions on the outer channel. Ions of lower mass-to-charge ratios are then analyzed through the inner channel, which not only provides naturally smaller channel radius, but also work with reversed (radially-outward) electrostatic field to guide the ions through the channel. The postacceleration brings the mass resolution of the instrument to a still higher level, especially when the ion energy per charge is lower than the acceleration voltage. A mass spectrometer of this design has a mass resolution which is high enough to distinguish between O^{++}, O^{+} and NO^{+} up to several keV/*e*.

For a large polar angle response of the mass spectrometer, a spherical electrostatic analyzer was tried in place of the cylindrical unit. A laboratory prototype provides up to 34° FWHM response angle with slightly reduced geometric factor when the same magnet was used in both. It can also provide angular resolutions in polar angles if a position sensitive detector is used on the exit aperture plane.

ACKNOWLEDGMENTS

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[1] E. G. Shelley, R. G. Johnson, and R. D. Sharp, J. Geophys. Res., 77, 6104 (1972).
[2] K. W. Ogilvie, N. McIlwraith, and T. D. Wilkerson, Rev. Sci. Instrum. 39, 441 (1968).
[3] H. Balsiger, P. Eberhardt, J. Geiss, A. Ghillmetti, H. P. Walker, H. Loidl, and H. Rosenbauer, Space Sci. Instrum. 2, 499 (1976).
[4] E. G. Shelley, R. D. Sharp, R. G. Johnson, J. Geiss, P. Eberhardt, H. Balsiger, G. Haerendel, and H. Rosenbauer, IEEE Trans. Geosci. Electron., GE-16, 266 (1978).
[5] R. Herzog, Z. Phys., 89, 447 (1934).
[6] E. G. Johnson and A. O. Nier, Phys. Rev. 91, 10 (1953).
[7] D. Fischer, Z. Phys., 133, 471 (1952).

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III. FLIGHT UNIT CONSTRUCTION

The two FIMS flight instruments were constructed in the laboratories of the Department of Space Sciences at Southwest Research Institute during the period of June through September 1981. A considerable amount of the flight unit construction was performed in clean room facilities owing to the sensitivity of the solid state detectors to contamination from airborne particulate and vapor contaminants. Figures 3 and 4 are photographs of the FIMS A and B flight units.

Appendices A and B of this report contain complete hardware and software reference manuals for the two flight instruments. It will be noticed that the instruments each have an associated Central Electronics Package (CEP) which provides control and data acquisition services for the spectrometers. The CEP associated with the FIMS A instrument was constructed primarily from wide-temperature CMOS digital circuitry. The system consisted of three primary subsystems - the channeltron scalers, parallel-to-serial converters, and the programmable power supply (PPS) controllers. The output of each of the three FIMS A channeltrons was connected to a 16-bit linear accumulator. All three sets of accumulators employed tri-state output buffers so that a single common data bus could be constructed from their commonly connected outputs.

This data bus, in turn, was connected to a single, 16-bit parallel-to-serial converter. The parallel-to-serial converter was used to format channeltron (and PPS command) data for subsequent transmission to the CENTAUR rocket's P.C.M. telemetry encoder. Control of the PPS's was provided by a PROM-stored sequence digital controller. At the P.C.M. system's minor frame rate, a binary counter within the PPS controller was incremented. The counters' output was used to form an effective address into the stored PPS command word table. Two such circuits were utilized, one each for the mass and energy programmable high-voltage power supplies. This rather simple procedure ensured that the power supply step levels were synchronized with the telemetry system's clock.

The CEP for FIMS B was a microprocessor-based system. As shown in the schematic diagrams contained in Appendix B, the FIMS-B controller was constructed from a few LSI microprocessor components. The system used an 8085 microprocessor with software stored in a single 8755 PROM/peripheral interface adaptor chip. The interface to the microchannel plate detector electronics was made through one of the parallel I/O ports on an 8155 RAM/I/O/timer chip. A "ready" flag from the microchannel plate electronics was used to strobe data into the 8155 and to interrupt the 8085.

The function of the FIMS B microprocessor system was similar to that of a conventional laboratory multi-channel analyzer. Two 64-channel data memories were maintained by the system during spectrometer operation. As the detector electronics strobed its 7-bit wide digital data word into the 8155, the interrupted 8085 would read this data word as a pointer into data memory. The data word pointed to would then be incremented by one.

Seperate interrupts were routed to the 8085 from the P.C.M. system's minor and major frame rate clocks. These additional interrupts were used to increment 8085 internal registers which, in turn, were used as pointers into a table of PPS command words. In a manner analogous to that of the FIMS A CEP, the FIMS B CEP was able to use the P.C.M. clock-interrupts just described to synchronize its PPS settings to telemetry timing. Measurements stored in the data memory were sent to the telemetry system through simple 8-bit shift registers.

The two FIMS instruments, each equipped with a pair of programmable high voltage power supplies and a central electronics package, were integrated into their respective rocket payloads in early September, 1981. After a brief series of interface tests with the rockets' systems, both instruments were turned over to the payload integrator on 13 September 1981.

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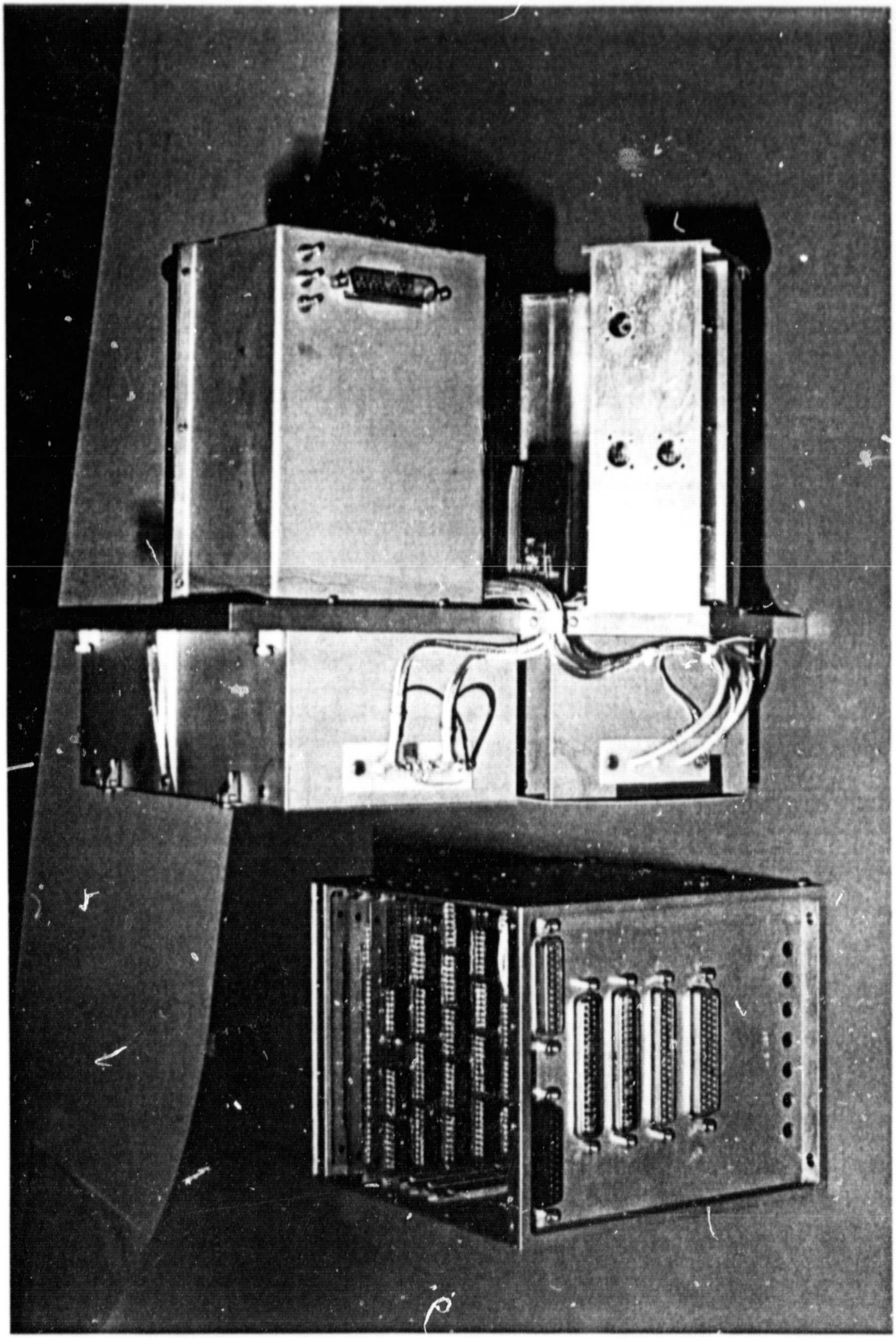

FIGURE 3. FIMS-A FLIGHT INSTRUMENT WITH CEP

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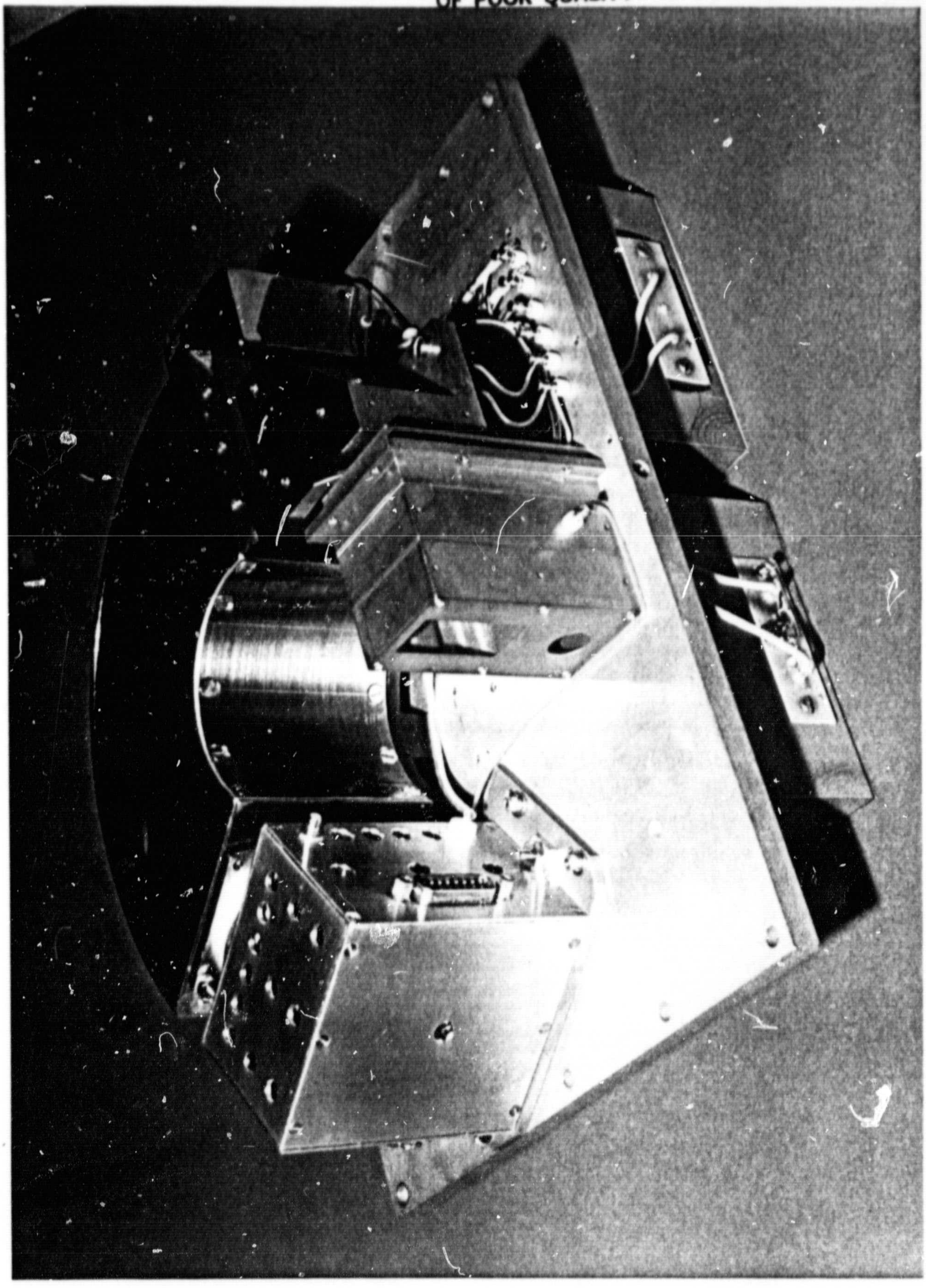

FIGURE 4. FIMS-B FLIGHT INSTRUMENT

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IV. FLIGHT UNIT CALIBRATION

The FIMS A and FIMS B flight units were calibrated in the SwRI RADIAC (Right Angle Deflecting Ion Accelerator) system in September 1981. A photograph of the calibration system appears in Figure 5, and a schematic diagram of its operation is shown in Figure 6. Close-up views of the ion generation system appear in Figure 7. The system is fully computer-automated except for the ion generator, which requires some manual settings. Automation is accomplished with a Hewlett-Packard 2113E minicomputer, which communicates with the calibration system, and the instrument under test, through a CAMAC interface system. This system controls the beam energy, the orientation of the instrument relative to the beam axis, and the various deflection potentials required in the instrument, while acquiring and storing the output data. An example of the excellent mass discrimination obtained with the mass spectrometer that is part of the ion accelerator is shown in Figure 8, in which relative beam current is plotted against the magnetic field produced by the 90° deflection system electromagnet. Purely electrostatic deflection can also be employed when a mixture of beam masses is desired.

An example of the calibration data acquired with the FIMS B instrument in a beam of N_2 ions is shown in Figure 9. Literally hundrsds of such plots were required to characterize the response of the instrument for the full range of parameters over which it operated.

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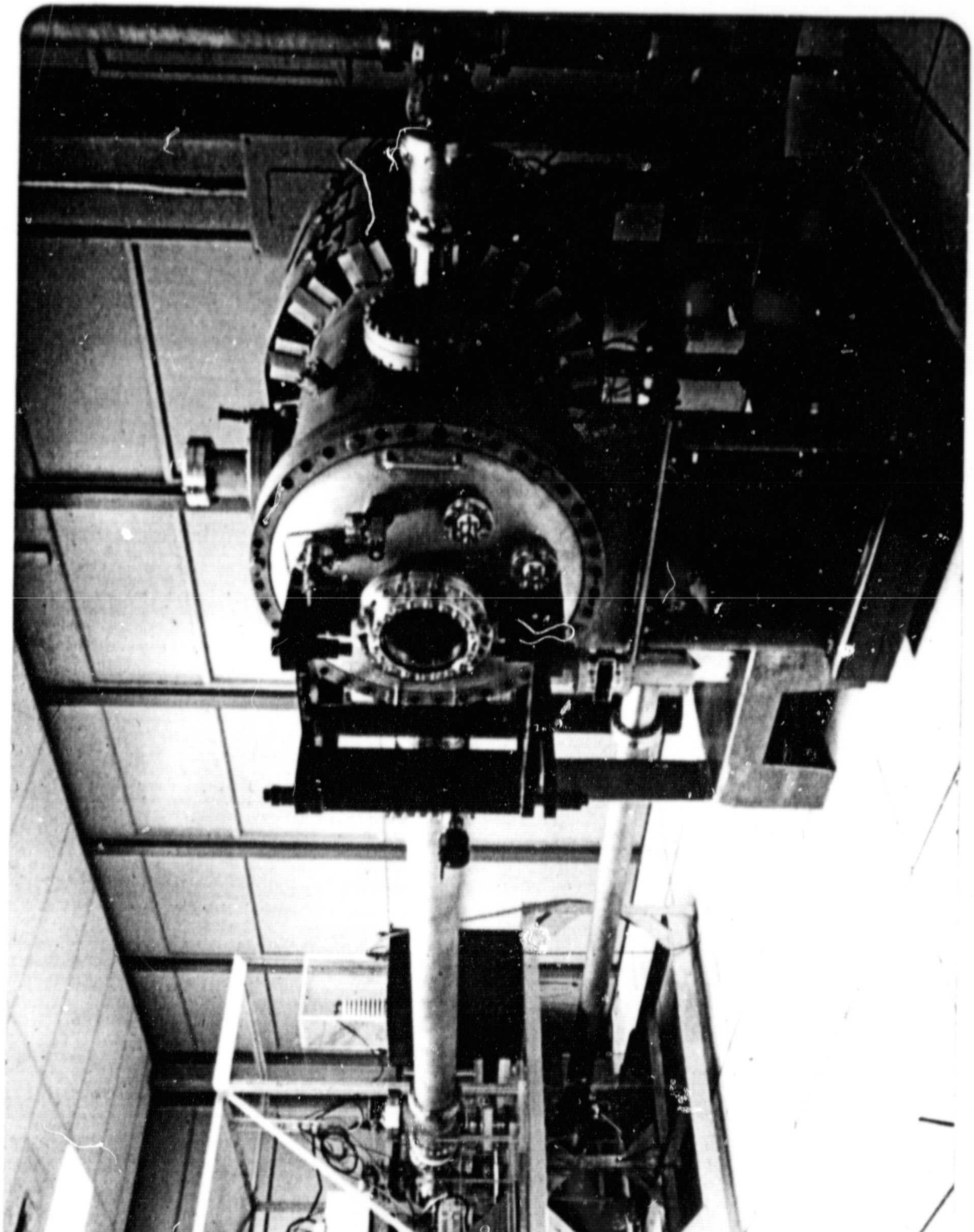

FIGURE 5. PHOTOGRAPH OF THE RADIAC SYSTEM AT SwRI

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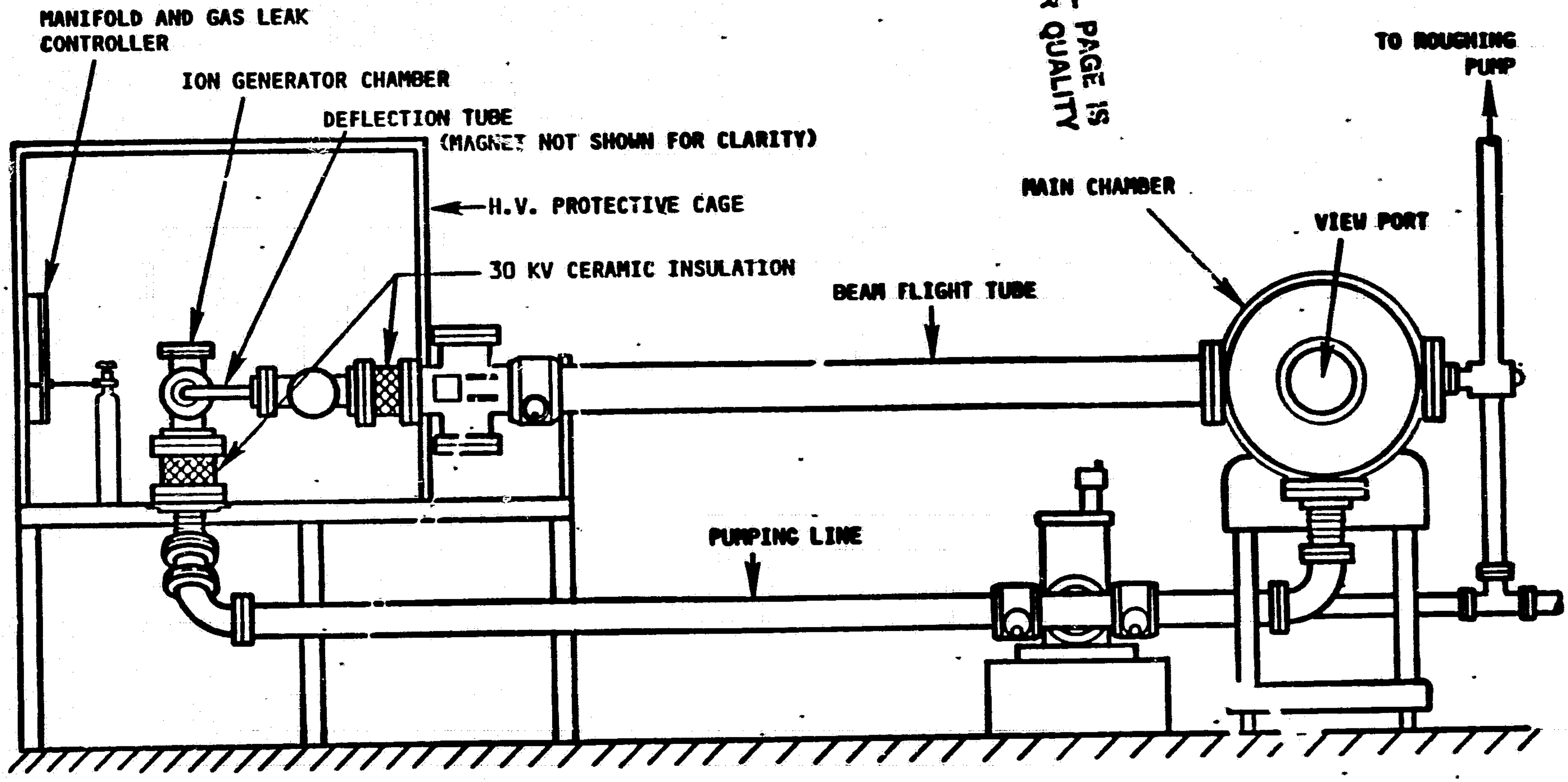

FIGURE 6. ION ACCELERATOR AND CALIBRATION FACILITY

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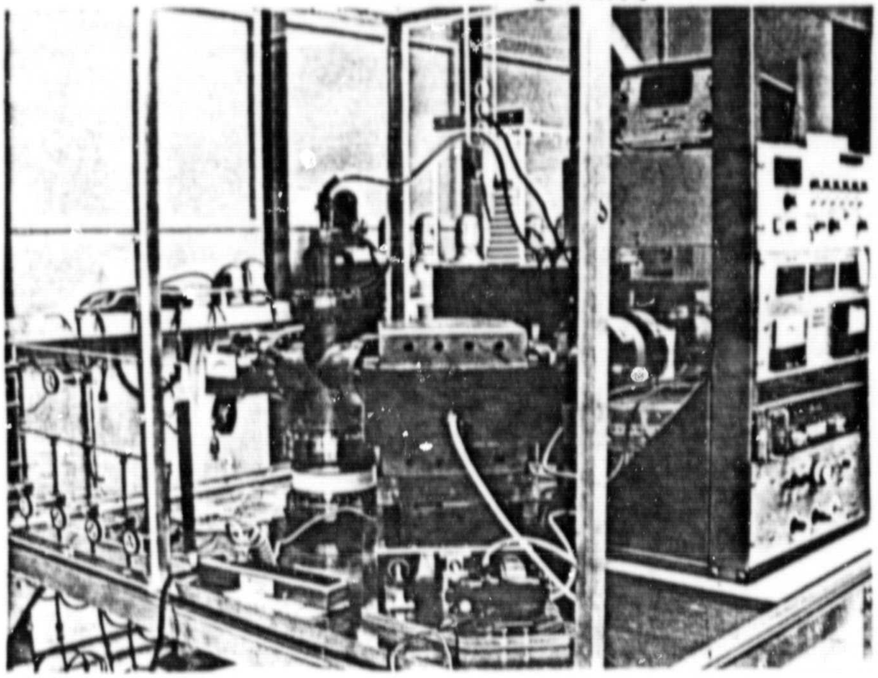

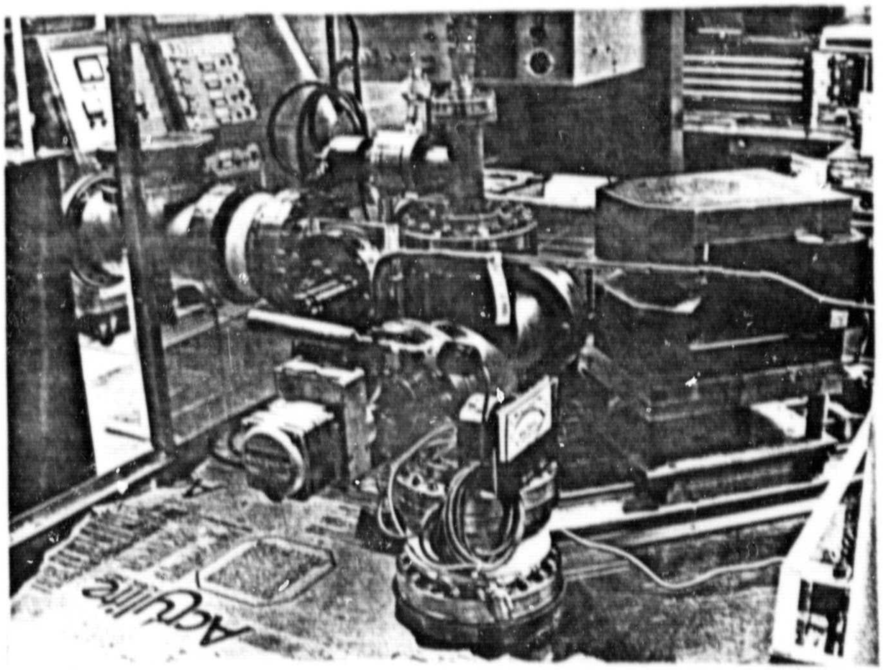

FIGURE 7

ION BEAM GENERATION SYSTEM AND MASS SELECTION SYSTEM FOR THE FIMS ION ACCELERATOR SYSTEM. Top Photograph: View from behind the mass-selection electromagnet. Bottom Photograph: View from ion gun side, showing the electromagnet in its retracted position.

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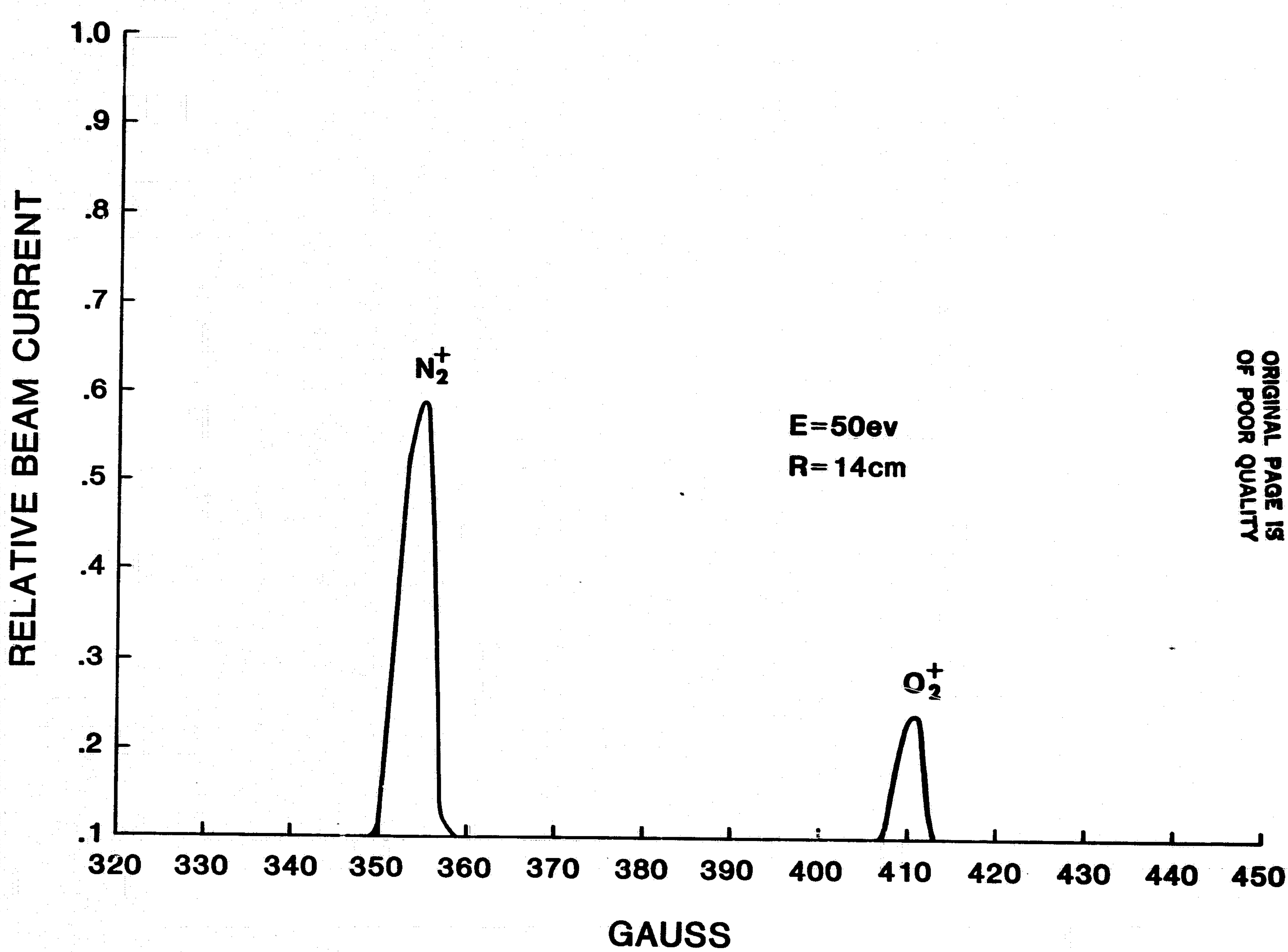

FIGURE 8. PLOT OF BEAM CURRENT vs. FIELD STRENGTH FOR RADIAC.

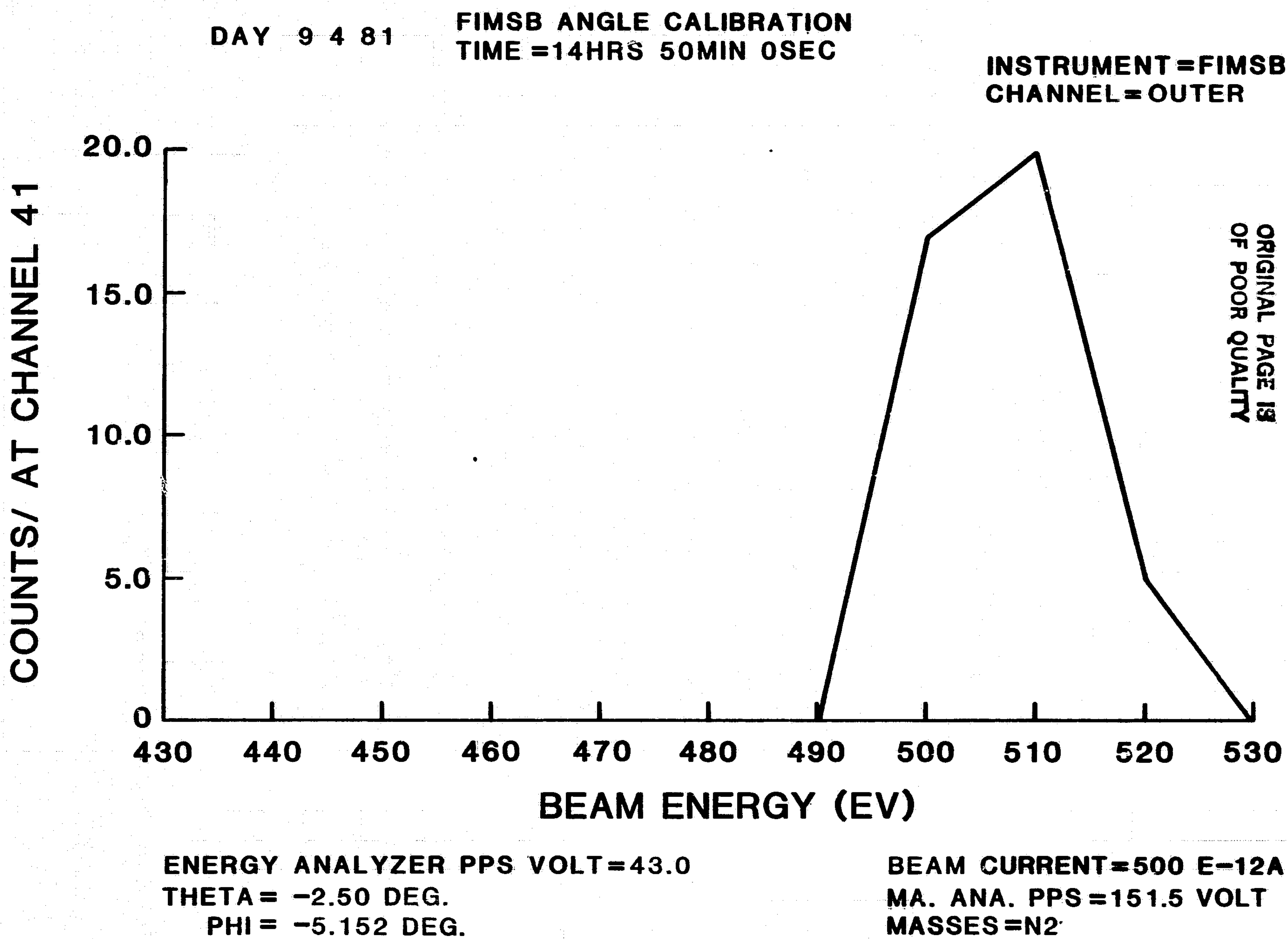

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FIGURE 9. FIMS-B CALIBRATION PLOT.

V. FLIGHT INTEGRATION

The two FIMS instruments were delivered to the payload integrator at SwRI in early September, 1981. Figures 10 and 11 show the locations within each of the two payloads where the instruments were mounted. The entrance apertures of the instruments were oriented 30° up from the X-Y plane as shown in Fig 10.

After a brief "fit check", the instruments underwent a series of interface tests with the rockets' telemetry and power systems. Only one minor change had to be made in the rockets' telemetry format for the FIMS A instrument in order to accommodate a minor design problem with the instrument's controller. Neither instrument seemed to be sensitive to EMI generated by other instruments or by the rockets' systems (i.e. scan platform) during ground testing, although FIMS B did encounter some EMI problems in flight from the scan platform.

Once the two payloads were checked out they were shipped from SwRI to the Goddard Space Flight Center. Arriving at GSFC on 18 September, the payloads were subjected to the usual series of integration and environmental tests. The payloads were later shipped to the NASA Wallops Island Tracking Station where the final assembly of the rockets took place and the integrated systems awaited shipment to Cape Perry, N.W.T., Canada.

The expedition arrived at Cape Perry on 18 November 1981 and began making immediate arrangements for flight. During the preparations for flight no problems were experienced with either of the two FIMS instruments. The rocket carrying FIMS B (X35.001) was launched on 2 December 1981 at 01:38:01 local time. Telemetry records showed nominal performance from the microprocessor-based controller at launch and throughout the remainder of the flight. High voltage was applied to the instrument approximately 122 seconds after launch. Monitor circuits on the outputs of the programmable high-voltage power supplies reported normal performance for both supplies. The rocket was at approximately 600,000 ft. altitude when high voltage was applied. Telemetry records indicate normal behavior of all instrument systems for the remainder of the flight.

The rocket bearing the FIMS A instrument (X35.002) was launched on 13 December 1981 at 22:54:25 local time. Again telemetry records showed normal behavior of all instrument systems throughout the flight. High voltage was applied to the instrument at approximately 121 seconds after launch. No signs of high voltage-breakdown were seen in telemetry data records for the duration of the flight. Neither of the two rockets was recovered following flight.

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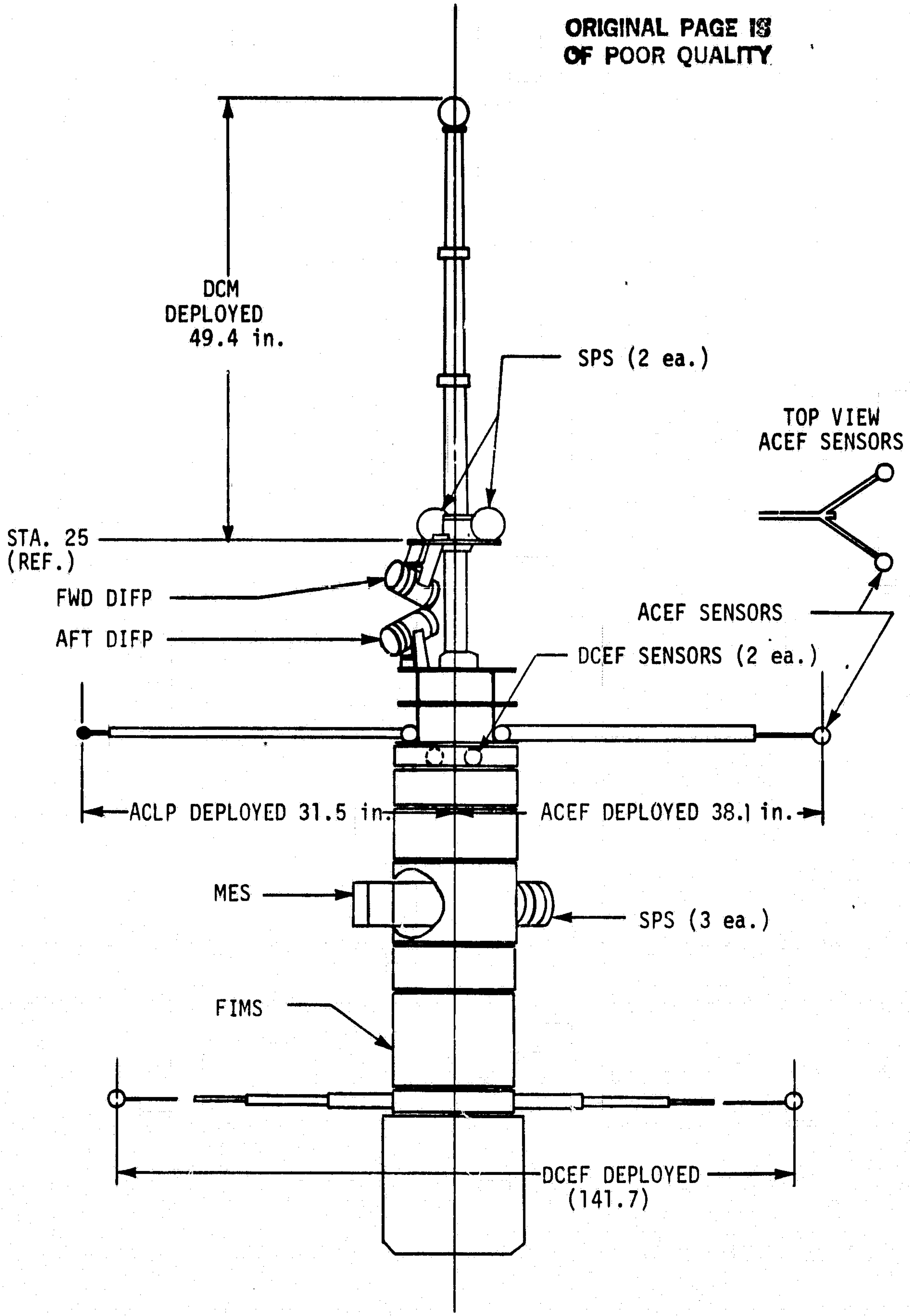

SwRI/NASA PAYLOAD -BBX

FIGURE 10.

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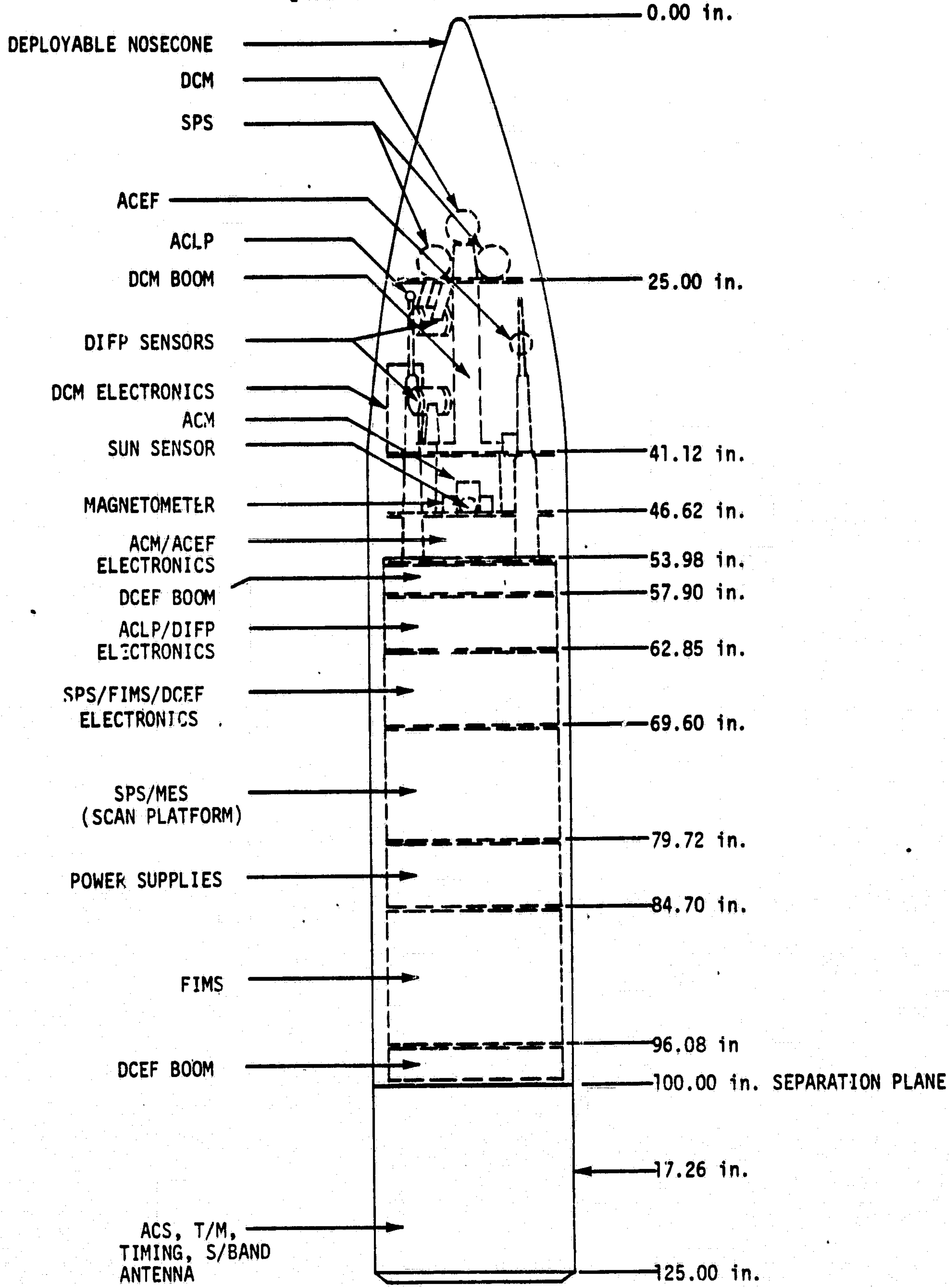

SwRI/NASA PAYLOAD - BBX

FIGURE 11.

VI. DATA ANALYSIS

Analysis of data from the two Project CENTAUR sounding rockets is being performed on the SwRI Space Sciences Data Analysis facility. The primary computational system is the VAX 11/750 CPU with 120 MB disk and tape drive that were partially funded through this contrct. Data display is being performed on our Chromatics CG 7900 color graphics system, which, for this application, is employed as a terminal to the VAX 11/750.

Up to this time only cursory examinations of the data have been performed, since the VAX system has only recently been placed into operation. Detailed data analysis will be performed over the next six months and the results will then be published in appropriate journals. In particular, the Canadian Journal of Physics plans to have a special issue on Project CENTAUR, and one or more papers on the FIMS results will be submitted.

Examples of the FIMS data displays now being generated are shown in Figures 12 and 13. In Figure 12 data from FIMS B for a segment of the flight of the first CENTAUR payload are presented in spectrogram format as follows. In the top panel, count rates are displayed as grey-scale intensi-ties versus angular channel number (vertical scale) and time (horizontal scale). Plotted below the spectrogram are the mass analyzer program power supply (PPS) steps, the energy analyzer PPS steps (both positive and negative), and the payload magnetometer data. Since the payload was oriented nearly along $\bar{B}$, the FIMS B channels sampled nearly constant pitch angles in the range of 30° to 60°. Note in Figure 12 that each of the 16 energy steps are held constant while a mass sweep is made, and that a complete energy-mass cycle requires approximately 20 seconds.

In the spectrogram at the top of Figure 12, where a few of the angular channels for each of the two FIMS B mass channels are plotted as grey-scale intensities, multiple and distinct mass peaks are seen for nearly every mass analyzer PPS sweep. However, one noisy angular channel is apparent in the lower of the two traces, and this particular channel will have to be disregarded in subsequent analyses.

In Figure 13 the FIMS B data are plotted in a different format, but with the same information content as in Figure 12. In these figures each 20-second segment of data is plotted with mass step on the horizontal axis, total count rate for all angular channels on the vertical axis, and energy on the 3rd (or depth) axis. Each energy "plane" is coded in a different color to aid in its identification. The effect of the one noisy angular channel appears as the high baseline or "plateau" that appears on all traces. Although this noisy channel became quiet later in the flight, it does not affect the quality of the data from the other 31 channels. The distinct mass peaks, which we identify as H^+, He^{++}, and at times O^+, are easily seen in the plots of Figure 13. These plots, and similar ones for FIMS A, will be the primary means of initial scanning of the data, which will then be followed by the required detailed analysis and interpretation.

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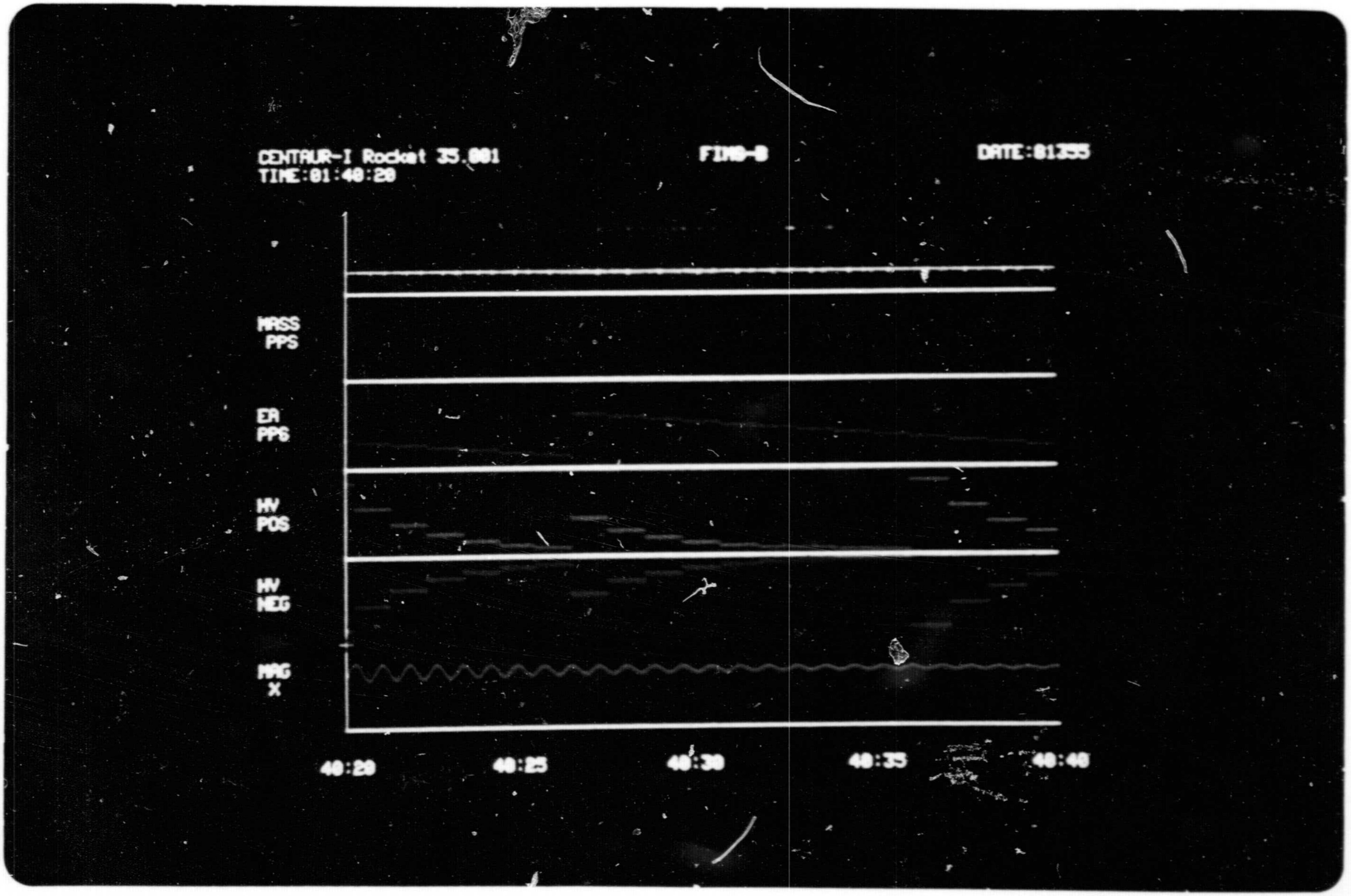

FIGURE 12. FIMS-B SPECTROGRAM

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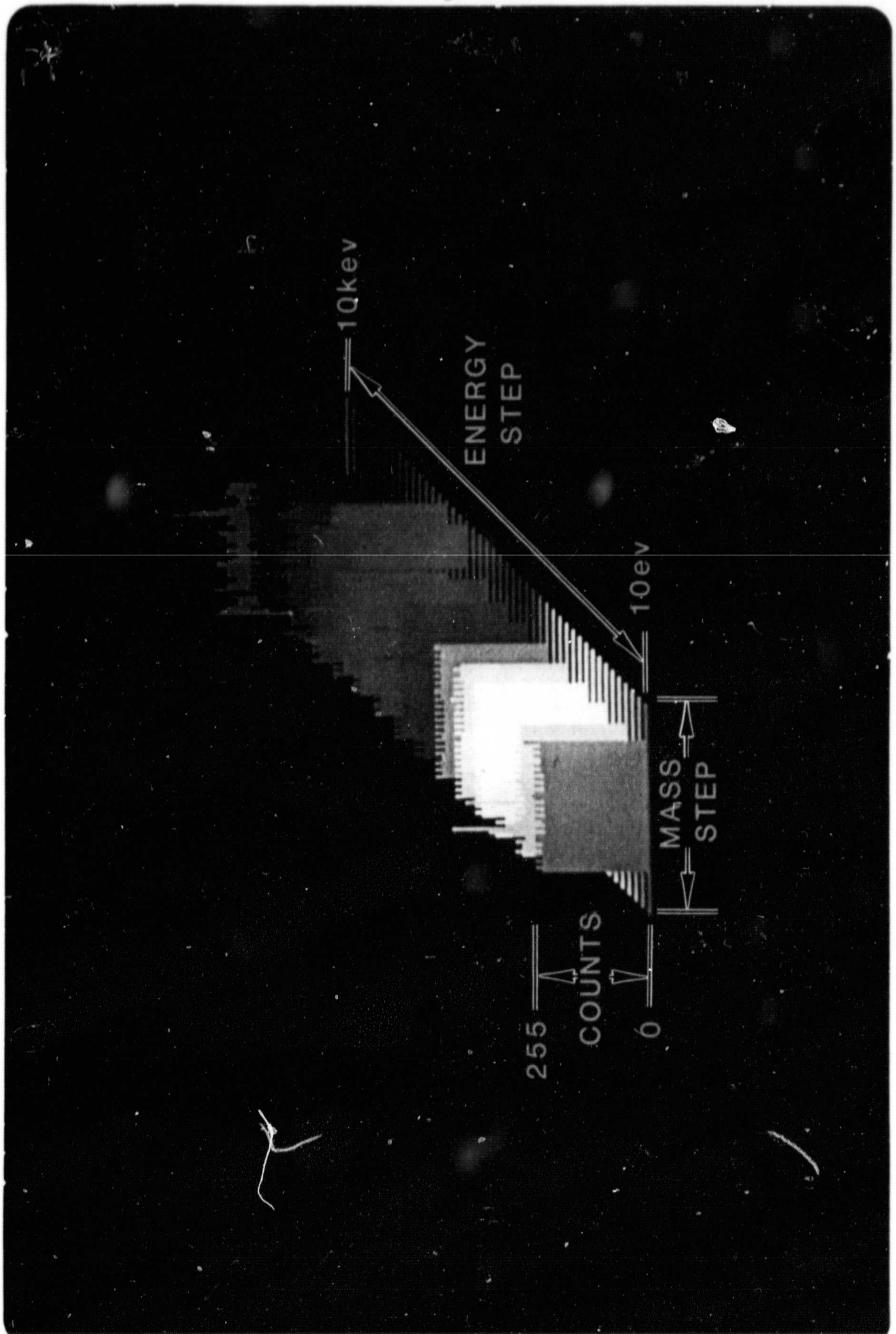

FIGURE 13. FIMS-B DATA ANALYSIS PLOT

APPENDIX A

FIMS MODEL A

HARDWARE/SOFTWARE REFERENCE MANUAL

SOUTHWEST RESEARCH INSTITUTE
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San Antonio, Texas 78284

FAST ION MASS SPECTROMETER MODEL A HARDWARE/SOFTWARE REFERENCE MANUAL

Submitted to

The National Aeronautics and Space Administration
NASA Headquarters
Office of University Affairs

By

The Space Science Department
Instrumentation Research Division
Southwest Research Institute
Project 15-5680

The work performed under NASA Contract NASW-3237,
the Development of a Fast Ion Mass Spectrometer.

September, 1981

Approved:

John R. Barton, Vice President
Instrumentation Research Division

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I. INTRODUCTION

This document provides a single location for all pertinent FIMS operational, calibration and repair information. It is hoped that this document will be of assistance in the field operation of the FIMS instrument should any problems arise with the instrument integrated onto its launch vehicle. Sufficient information is contained herein to troubleshoot the instrument should the occasion arise. All test and calibration records will be kept in this document as well.

The second purpose of this document is to aid in the development of future generations of similar ion mass spectrometers. The experience gained in the laboratory and the field with the FIMS A instrument will be of critical assistance in the development of similar instruments for the OPEN program or for other sounding rocket applications.

The introductory section of this document contains a copy of a paper published in the Review of Scientific Instruments which describes in some detail the geometry of the analyzer sections of the FIMS-A and FIMS-B instruments. As is described in this paper, the primary difference between FIMS-A and FIMS-B is in the area of the electrostatic energy analyzer and in the detectors used. The nomenclature "FIMS-A" refers to that instrument which uses the cylindrical energy analyzer and an array of three channel electron multipliers. The "FIMS-B" instrument uses a spherical energy analyzer and a microchannel plate array with resistive anodes. The Central Electronics Packages for the two instruments are also different. The FIMS-A instrument will be flown for the first time on the A rocket payload of the two payloads produced by the SwRI Department of Space Sciences during the summer of 1981.

This document will serve as a combination Design Specification and Instrument Log Book and should be kept with the FIMS B instrument at all times. Figures I-1 and I-2 are pictures of the fully assembled FIMS A instrument. Figure I-3 is a block diagram of the total instrument system.

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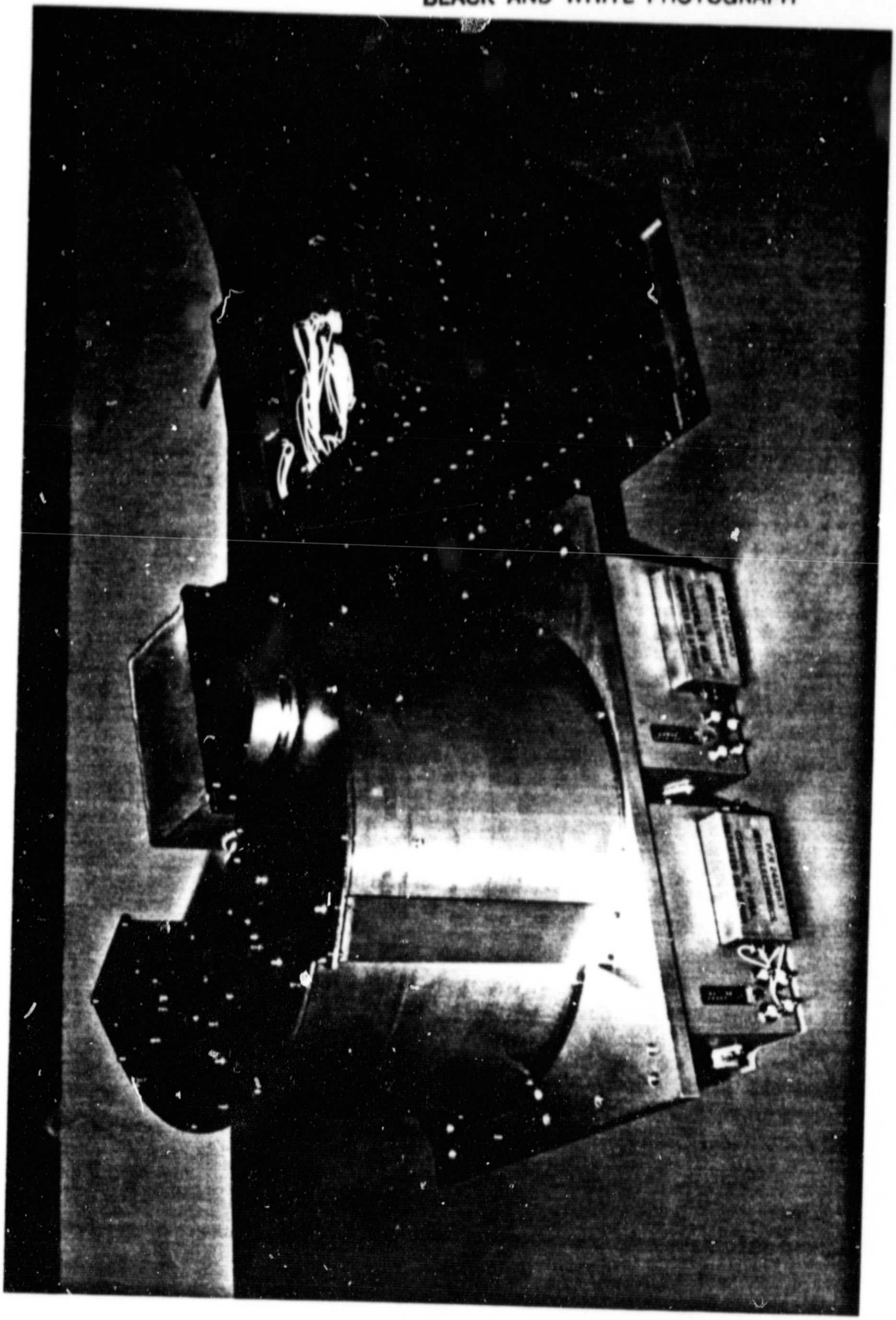

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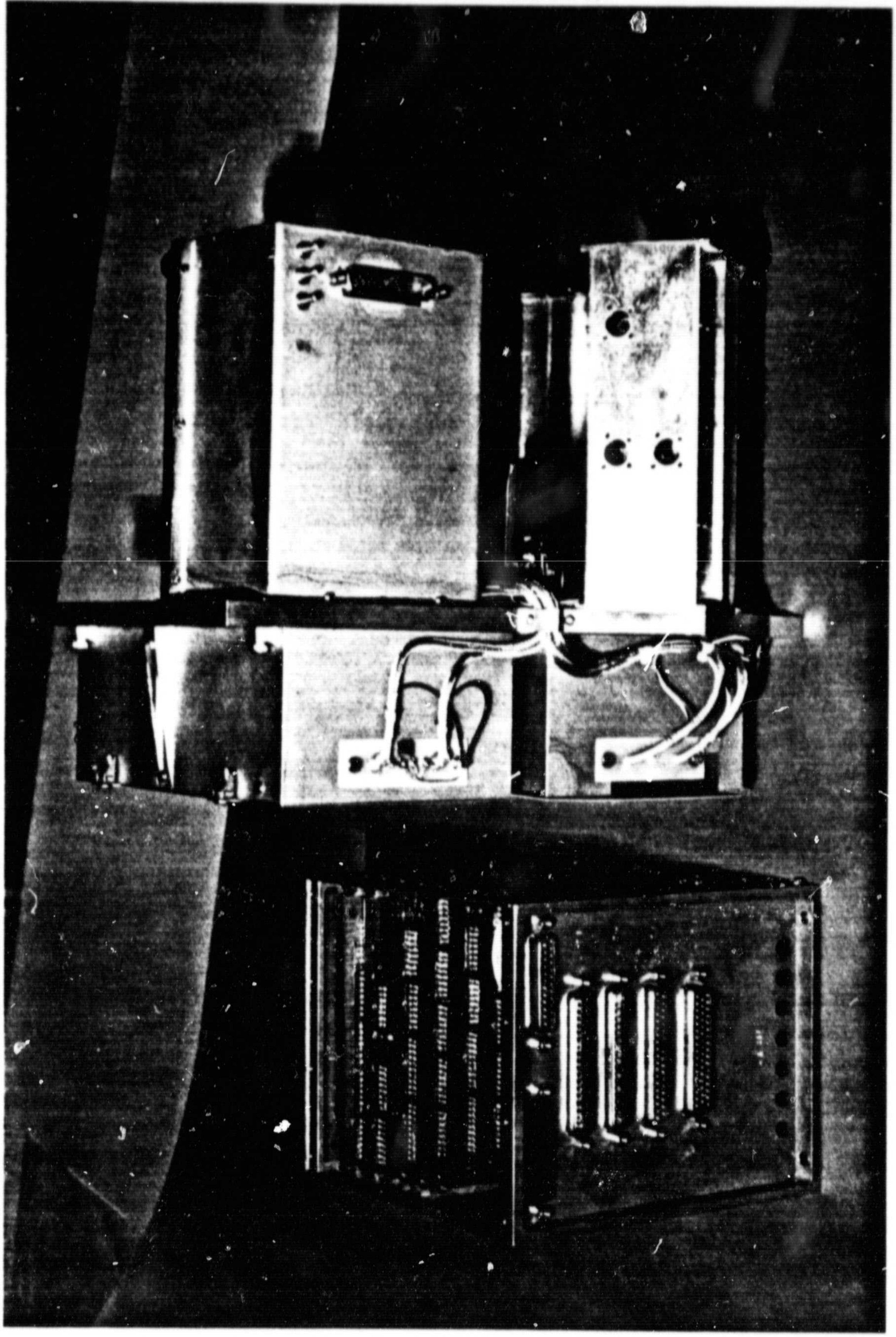

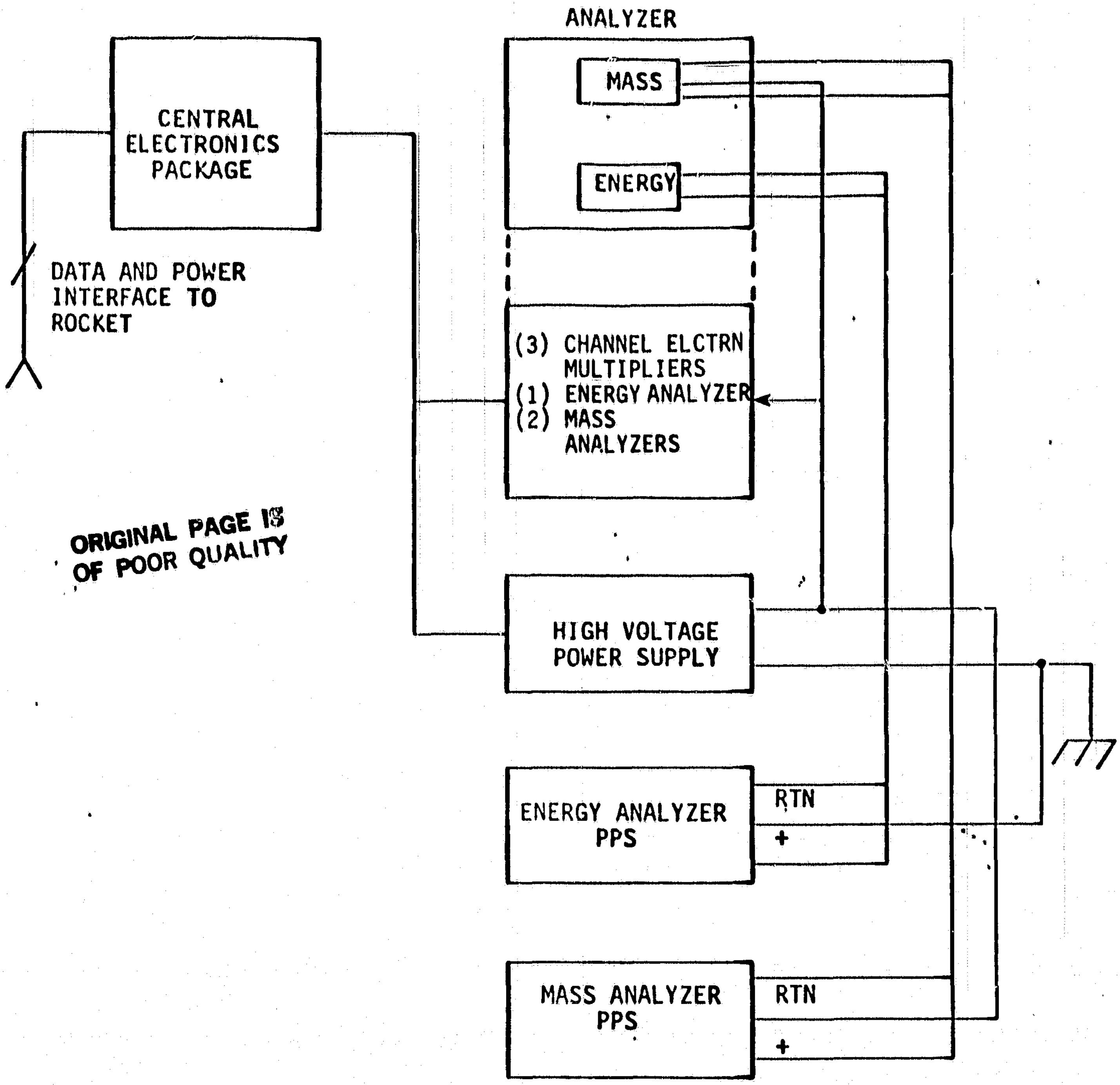

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FIGURE I-3. FIMS INSTRUMENT BLOCK DIAGRAM

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II. QUICK-LOOK TEST INFORMATION

This section presents a short summary of the data produced by the FIMS A instrument, the telemetry locations for these data sources and the procedures to be used to stimulate the various sections of the instrument to obtain responses viewable on PCM telemetry. Table I shows a list of the FIMS A data channels, their respective telemetry word locations and word lengths.

To describe the expected responses, via PCM, of the FIMS A instrument it will be assumed initially that the instrument is operating with only its low voltages and without the externally applied stimulus to its test input connectors. At the onset of power to the FIMS Central Electronics Package, the controllers contained therein will begin to produce stepping counts to the two programmable power supplies. These two 9-bit digital words (S31 and S32) are located in word 8, frame 19 and word 9, frame 20, respectively. Figure 1 is an example strip-chart recording of the output of the S31 data channel. The data contained in this channel is produced by the energy analyzer PPS command words. The stepping rate for this word is approximately 1 step/second. It should be noted that Figure 1 is a strip chart recording made with the deflection calibrated for 10 counts/major division. Since the strip chart recorders used in the PCM ground station are normally calibrated for a deflection of approximately 100 counts/major division, the recorder must be recalibrated using the PCM simulator if an exact correspondence is to be obtained with Figure 1. Such exactness is not necessary for routine operations and a general waveform analysis will be considered adequate.

Telemetry channel S32 corresponds to the mass analyzer program power supply command words. S32 is located in word 9, frame 20 and this 9-bit value range from a minimum of zero counts to a maximum of 63 counts. Figure 2 is an example strip chart recording of the waveforms produced by the Central Electronics Package under normal operation. The mass analyzer commands steps at a rate of 1/major frame, or approximately 1 step every 25 milliseconds. Figure 2 is a copy of a stripchart recording made with the deflection sensitivity again set for 10 counts/division. The stripchart recorder speed was 25 mm/sec.

The FIMS A instrument produces a total of 5 channels of serial/digital data and 3 channels of analog data. At the onset of low voltage power only, only the S31 and S32 channels will show any information. Channels 28, 29, and 30 serial/digital words are derived from the instrument scalers and without high voltage being operated, no counts will appear in these channels. Likewise, analog channels 38, 39 and 40, corresponding to the float potential monitor, energy analyzer program power supply positive monitor and energy analyzer program power supply negative voltage monitor, will show 0 readings initially.

During the execution of a signal input test to the FIMS A instrument, which is described in the next sectionof this document, count values will begin to appear at serial data channels 28, 29 or 30, depending upon which input is being stimulated. It should be noted that all three of these channels are 18 bit words with the second of the two words in each case corresponding to the 9 least significant bits of the count. Serial channel 28 (S28) contains the 18-bit digital count from the energy analyzer. Channel S29 corresponds to the outer mass channel (MA1). The third channel, S30, is used by the inner or second mass analyzer channel. As stated earlier, all three of these serial/digital channels are 18 bits in length. The S31 and S32 channels are 9 bits each. As the test input stimulus is applied to the energy analyzer input, word no. 3 of frame 7 will begin to show counts. Word 2 of frame 7, corresponds to the nine most significant bits of this scaler word. If the setup test procedure for the input signal test is followed properly, it should be possible to see the counts building up as the pulse repetition rate is increased for the energy analyzer input by viewing words 2 and 3 of frame 7. If the test input is applied to mass analyzer channel 1, (S29), counts will begin to appear in words 2 and 3 of frame 23. Again, word 3 of frame 23 is the least significant 9-bits of the 18-bit word. Finally, as counts are applied to the mass analyzer channel 2, (S30), counts will begin to appear in words 8 and 9 of frame 3 with word 9 representing the 9 least significant bits of the 18-bit scaler. The procedure described in the next section of this document should produce a count of approximately 2300 counts in the 18-bit scaler words.

When high voltage is applied to the FIMS instrument by turning the timed 28V switch on, the three analog data channels will respond. Analog channel 38, corresponding to the float potential monitor, is located in word 7, frame 23. This monitor will assume an output of approximately 3.2 volts with the onset of high voltage. There should be no modulation on this channel since it represents the output of the PICO-PAK high voltage power supply and is not programmable. Analog channel 39, word 6, frame 27, corresponds to the positive output of the energy analyzer program power supply and its output can be seen stepping at the same rate as the digital word described earlier in channel S31. The output range for this monitor will be 0 - 2.4 volts. The third analog output from the FIMS A instrument is located in analog channel 40, word 6, frame 19, and it represents the analog output of the negative voltage monitor from the energy analyzer program power supply. It will also step at the same rate as analog channel 39 and its outputs should be of the same magnitude as channel 39 (word 6, frame 27). Only when high voltage is applied and the externally applied stimulus is connected will data be seen on all three analog and three of the five digital channels. Again, with low voltage only applied to the instruments, only channels S31 (word 8, frame 19) and channel S32 (word 9, frame 20) will show any counts. Figures 1 and 2 are examples of the waveforms which should be obtained from these two digital data channels with a stripchart recorder properly calibrated for 10 counts/major division.

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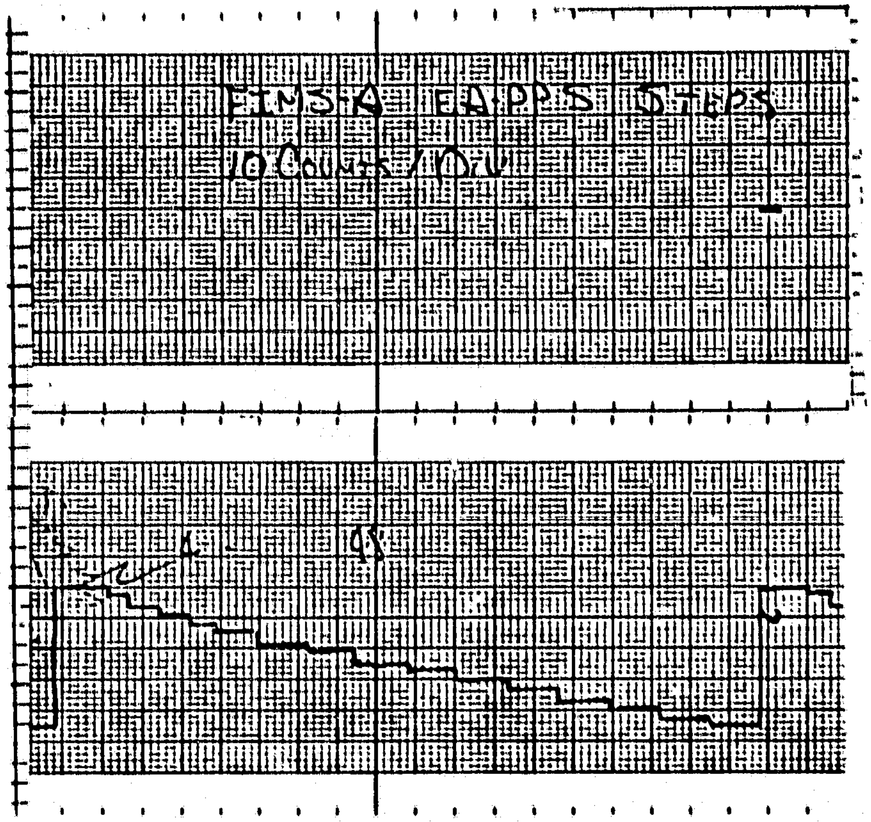

FIGURE II-1

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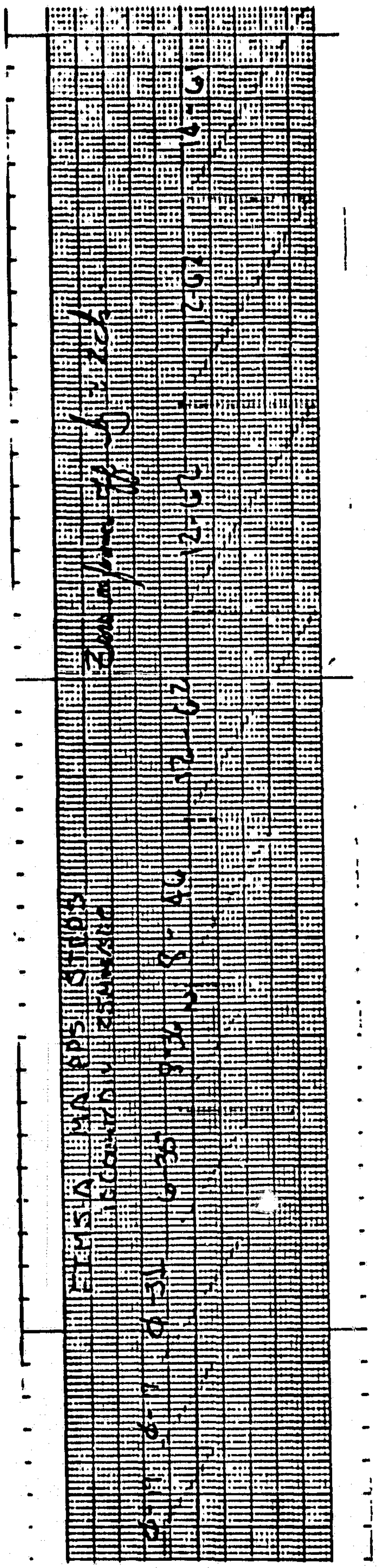

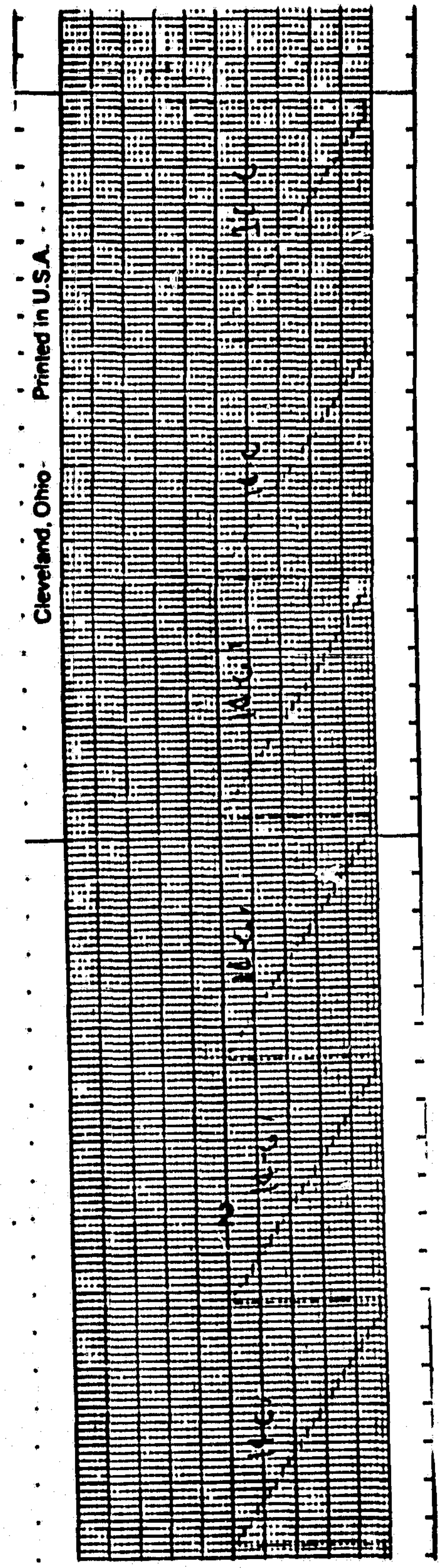

FIGURE II-2

TABLE II-1

FIMS A PCM DATA MATRIX LOCATIONS

Digital Serial Data

Signal Name	Word Length	Matrix No.	Word	Frame
Energy Analyzer Data	18 bit	S28	2 and 3	7
Mass Analyzer Data No. 1 (inner)	18 bit	S29	2 and 3	23
Mass Analyzer Data No. 2 (outer)	18 bit	S30	8 and 9	3
EA PPS Step No.	9 bit	S31	8	19
MA PPS Step No.	9 bit	S32	9	20

Analog Data

Signal Name	Voltage Level	Matrix No.	Word	Frame
Float Potential (-HVPS)	0∿3.2V	A38	7	23
EA PPS + HV Monitor	0∿2.5V	A39	6	27
EA PPS -HV Monitor	0∿2.5V	A40	6	19

VEHICLE NO. 35.001 - 35.002

FIMS A DATA

TABLE II-2 **ORIGINAL PAGE IS OF POOR QUALITY**

MAIN FRAME CHANNEL NO.

Channels 0–1: RESERVED FOR SYNC CODE AND SUBFRAME COUNT

SUB-FRAME NO.'S	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0																
1																
2																
3									S30	S30						
4																
5																
6																
7			S28	S28'												
8																
9																
10																
11																
12																
13																
14										A41						
15										A42						
16																
17																
18																
19							A40		S31							
20										S32						
21																
22																
23			S29	S29												
24																
25																
26																
27							A39									
28																
29																
30																
31																

DATA MATRIX

BIT RATE	200 KBIT/SEC → .5μ SEC/BIT
WORD RATE	20 KWORDS/SEC → 0.05 M SEC/WORD
WORD SIZE	9 BITS + 1 PARITY BIT = 10 BITS
SUB FRAME RATE	1250 SF/SEC → 0.8 MSEC/SUB FRAME
MAIN FRAME RATE	39.0625 MF/SEC [illegible]

III. SIGNAL INPUT TEST PROCEDURE

The following equipment will be needed to perform the signal input test of the FIMS A instrument:

1. A pulser or function generator capable of producing IV negative going pulses, approximately 50 ns wide into a 50 ohm termination.

2. Two variable HP 355 VHF attenautors.

3. An oscilloscope with performance capable of accurately demonstrating the 50 ns negative-going waveform produced by the pulser.

4. Four lengths of coaxial cable, each terminated with a male BNC type connector.

5. A 50 ohm terminator contained in a standard BNC connector shell.

6. A short length of coaxial cable with a BNC on one end and a SELECTRO No. 51-424-3188 connector on the other end.

To perform the signal input tests, perform the following steps:

1. Connect the output of the pulser to the input of the oscilloscope, through a BNC "T", the other side of which is connected to the 50 ohm termination.

2. Adjust the output of the pulser as viewed on the oscilloscope to produce a negative-going pulse approximately 1V in amplitude, 50 ns wide, with a 20 ns fall time, a 20 ns baseline time and a 20 ns rise time. The baseline voltage for this waveform should be 0 V, with the peak amplitude of -1 V.

3. With the pulser adjusted for the proper parameters to produce the waveform described, install the FIMS test cable described earlier and set the pulse repetition rate to approximately 100,000 pulses/second.

4. Set the HP attenuators in such a manner that an attenuation of approximately 29 dB is obtained. If no counts are seen in TM, lower the attenaution in 1 dB steps to a minimum level of 20 dB until counts appear.

5. Apply low voltage to the FIMS Central Electronics Package and observe the corresponding count rates on the telemetry channel assigned to whichever input channel is being used on the instrument. For the energy analyzer, the telemetry assignments are words 2 and 3 of frame 7. For mass analyzer channel 1, the telemetry assignments are words 2 and 3 of frame 23; for the second mass analyzer channel, the telemetry assignments are words 8 and 9 of frame 3. With the pulse repetition rate set

to the value mentioned earlier, it should be possible to observe a count of approximately midscale on both words of the 18-bit word scaler. Since the sample period for each major frame is 23.2 ms, the 18-bit accumulator is capable of count rates of greater than 10 mHz.

Figure III-1 shows the test configuration.

DRAWING NUMBER	

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

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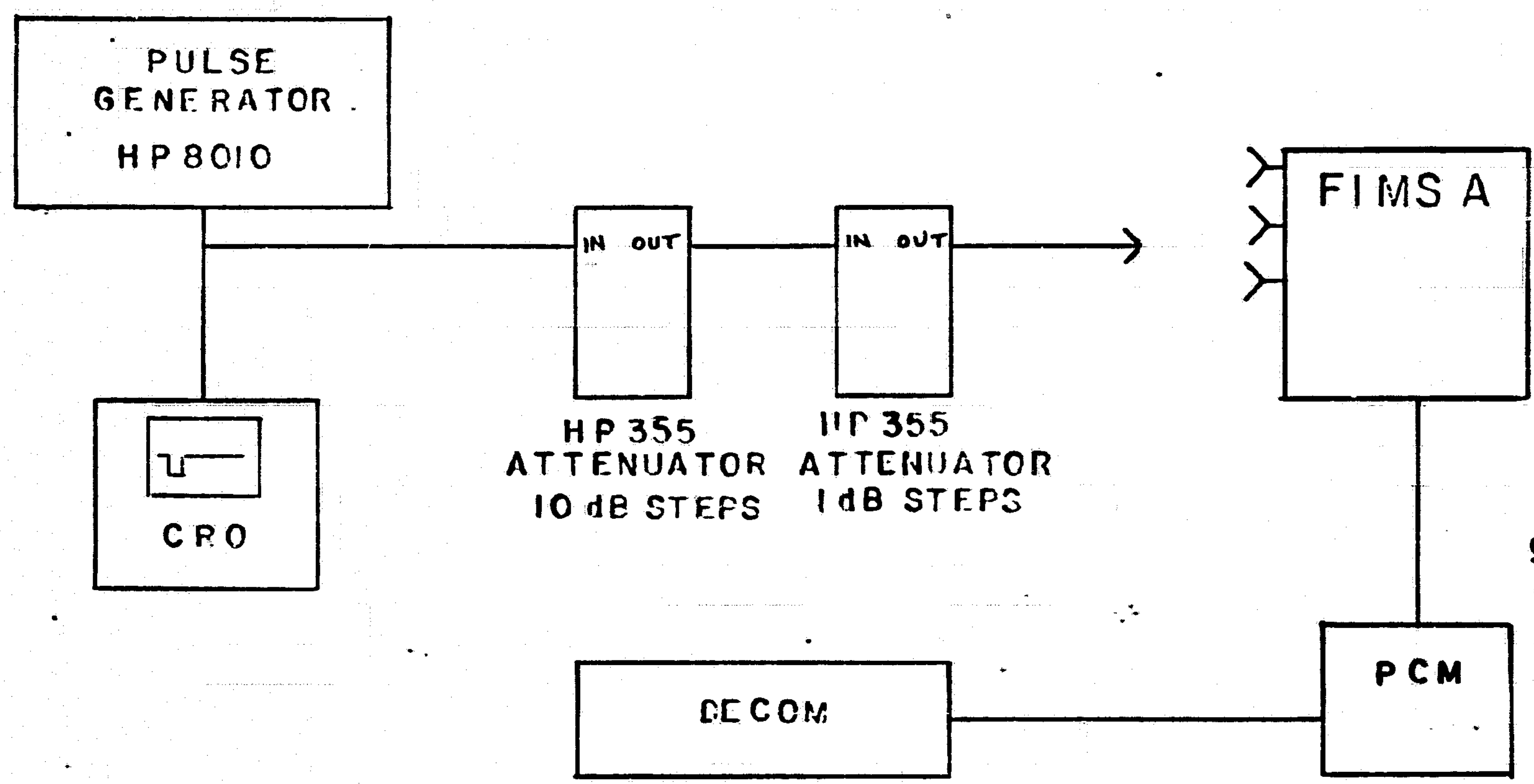

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
TOLERANCES: ANGLES ± 1/2°
2 PLACES ± .02 | UNDER 6 3 PLACES ± .005 | FRACTIONS ± 1/64

MATERIAL

FINISH

QTY REQD

NEXT ASSY | USED ON

APPLICATION

CONTRACT		
DWN	Tomlinson	9/81
CKD		
MECH		
ELECT		
STDS		

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FIMS A TEST CONFIGURATION

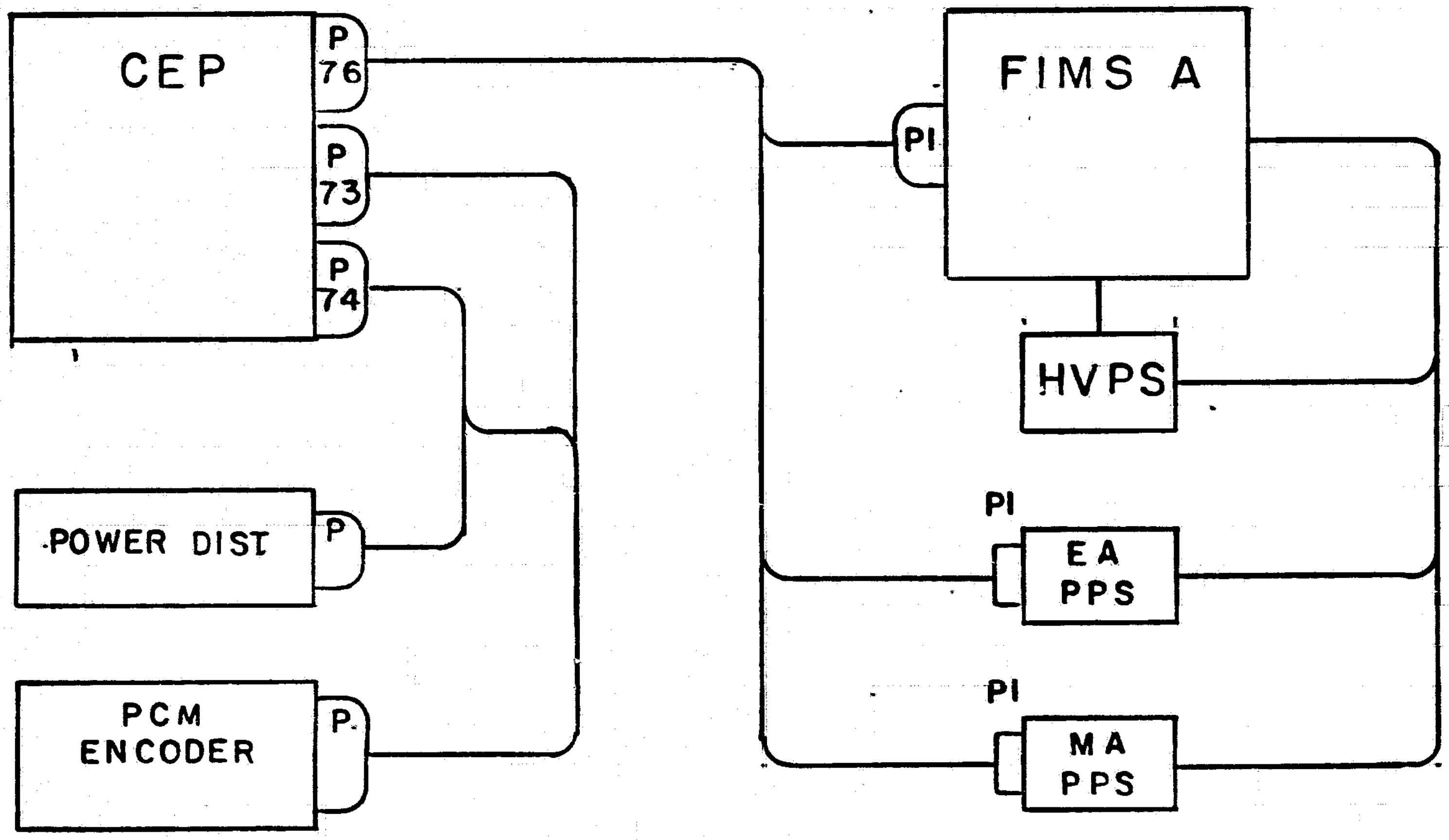
SIZE	CODE IDENT. NO.	DRAWING NO.
A	26401	

SCALE | SHEET

IV. INSTRUMENT CABLING INFORMATION

This section contains the wiring lists and cable pin connections which were used in the construction of the FIMS instrument. Any problems arising from miswiring can be solved by referring to the original wiring lists for the instrument.

FIGURE IV-1



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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
TOLERANCES: ANGLES ± 1/2°
UNDER 6: 2 PLACES ± .01, 3 PLACES ± .005, FRACTIONS ± 1/64

MATERIAL

FINISH

QTY REQD

NEXT ASSY | USED ON

APPLICATION

SIZE

CONTRACT
DWN
CKD
MECH
ELECT
STDS

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FIMS A WIRING DIAGRAM

SIZE: A | CODE IDENT. NO.: 26401 | DRAWING NO.

SCALE | SHEET

SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date

CONNECTOR DD50(P) NMB

TITLE FIMS "A" CEP TO INSTRUMENT & PPS

SHEET 1 OF 2

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
P76	1			EA PPS BIT Ø	W	EA-PPS-P1
"	2			" " 1	T	"
"	3			" " 2	P	"
"	4			" " 3	R	"
"	5			" " 4	X	"
"	6			" " 5	U	"
"	7			RETURN	M	"
"	8			MA PPS ANODE BIT Ø	V	MA-PPS-PI
"	9			MA PPS CATHODE BIT Ø	W	"
"	10			MA PPS ANODE BIT 1	T	"
"	11			MA PPS CATHODE BIT 1	A	"
"	12			MA PPS ANODE BIT 2	S	"
"	13			MA PPS CATHODE BIT 2	P	"
"	14			MA PPS ANODE BIT 3	R	"
"	15			MA PPS CATHODE BIT 3	J	"
"	16			MA PPS ANODE BIT 4	M	"
"	17			MA PPS CATHODE BIT 4	X	"
"	18			MA PPS ANODE BIT 5	U	"
"	19			MA PPS CATHODE BIT 5	N	"
"	20			EA PPS +V MONITOR	F	EA-PPS-P1
"	21			RETURN	N	"
"	22			EA PPS -V MONITOR	V	"
"	23			RETURN	N	"
"	24					
"	25					
P76	26					

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FIGURE IV-2.1

SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date

CONNECTOR
DD50(P) NMB

TITLE
FIMS "A" CEP TO INSTRUMENT & PPS

SHEET 2 OF 2

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
P76	27			TIMED 28V TO EA PPS	B	EA-PPS-P1
"	28			CHASSIS (SHIELD)	C	MA-PPS-P1
"	29			28V RTN TO EA-PPS	E	EA-PPS-P1
"	30			TIMED 28V TO MA-PPS	D	MA-PPS-P1
"	31			28V RTN TO MA-PPS	E	MA-PPS-P1
"	32			MA PAD #1 DATA	1	FIMS P1
"	33			RETURN	2	
"	34			MA PAD #2 DATA	15	
"	35			RETURN	16	
"	36			EA PAD DATA	4	
"	37			RETURN	5	FIMS P1
"	38			SHIELD (CHASSIS)	C	EA-PPS-P1
"	39			FLOAT POT. MON	20	FIMS-P1
"	40			RETURN	8	"
"	41			SHIELD (NO CONNECTION AT CEP)	21	"
"	42			+8V	18	"
"	43			-8V	19	"
"	44			COMMON (8V)	6	"
"	45					"
"	46			+5V	9	"
"	47			5V RETURN	10	"
"	48			TIMED 28V TO INSTRUMENT	13	"
"	49			28V RETURN	25	"
"	50			CHASSIS	21	FIMS-P1

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FIGURE IV-2.2

SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date

CONNECTOR	TITLE	
P73 (37S)	FIMS/SPS CEP	SHEET 1 OF 2

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
P73 (37S)	1			+5v from LVPS #8 (900mA)	8	P97
"	2			COMMON (5 RET)	7	"
"	3			+8 VDC (50mA)	5	"
"	4			-8 VDC	6	"
"	5			COMMON (8V)	12	"
"	6			-6 VDC	10	"
"	7			+6 VDC	9	"
"	8			COMMON (6V)	NC	USE 8V COMMON
"	9			-5 VDC	11	P97
"	10			COMMON	NC	USE 8V COMMON
"	11			TIMED 30 VDC to FIMS HVPS (K8)	6	P93
"	12			30 V RETURN	25	P93
"	13			$MF2^3$	4	P100
"	14			$SF2^4$	5	P100
"	15			SIGNAL RTN (GND)		NC
"	16			GATED CLOCK	9	P100
"	17			$MF\ 2^3$	14	P101
"	18			SIGNAL RTN (GND)		NC
"	19			FIMS "B" DATA S27	1	J107
"	20			" S28	2	J107
"	21			" S29	3	J107
"	22			" S30	4	J107
"	23			" S31	5	J107
"	24			" S32	6	J107
"	25			DIGITAL SIGNAL RTN (GND)	7	J107
"	26			FIMS ENABLE GATE EG27	8	J107

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CONNECTOR P73 (37S) | TITLE FIMS/SPS CEP | SHEET 2 OF 2

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
P73 (37S)	27			ENABLE GATE EG 28	9	J107
"	28			FIMS EG 29	10	"
"	29			" EG 30	11	"
"	30			" EG 31	12	"
"	31			" EG 32	13	"
"	32			FIMS ANALOG DATA A38	38	J109
"	33			FIMS A39	39	J109
"	34			A40	40	J109
"	35			A41	41	J109
"	36			A42	42	J109
"	37			ANALOG RTN (GND)	43	J109

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SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date

CONNECTOR (37S) P74	TITLE FIMS/SPS CEP	SHEET 1 OF 2

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
P74(37S)	1			SPS DIGITAL DATA S12 (SPS)	19	J106
"	2			" S13	20	"
"	3			" S14	21	"
"	4			" S15	22	"
"	5			" S16	23	"
"	6			" S17	24	"
"	7			" S18	25	"
"	8			" S19	26	"
"	9			" S20	27	"
"	10			" S21	28	"
"	11			" S22	29	"
"	12			DIGITAL RTN (GND)	30	"
"	13			ENABLE GATE EG 12	32	"
"	14			" 13	32	"
"	15			" 14	33	"
"	16			" 15	34	"
"	17			" 16	35	"
"	18			" 17	36	"
"	19			" 18	37	"
"	20			" 19	38	"
"	21			" 20	39	"
"	22			" 21	40	"
"	23			" 22	41	"
"	24			CHASSIS	NC	
"	25			200 kHz CLOCK	20	P100
	26			SIGNAL RETURN (GND)	NC	

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SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date

CONNECTOR P74 (37S)

TITLE FIMS/SPS CEP

SHEET 2 OF 2

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
P74(37S)	27			SF 2^4	9	P101
"	28			SIGNAL RETURN	NC	
"	29			ANALOG DATA A12 SPS 3 kv	12	J110
"	30			SPS 3 kv A13 -3 kv	13	"
"	31			SPS PPS A14 PPS	14	"
"	32			ANALOG RTN (GND)		NC
"	33			CHASSIS CONNECTION TO FIMS		NC
"	34			SF 2^3	17	P100
"	35			5 μs GATE	21	P101
"	36					
"	37					

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V. INSTRUMENT TEST RECORDS/HISTORICAL LOG

This section of the system reference manual will be used to store all instrument test records taken during the field test and laboratory calibrations of the instruments. Records of shipment and installation and removal of the instrument will be maintained in this section of the document.

FIMS TEST RECORD/HISTORICAL LOG

DATE	LOCATION	TEST DESCRIPTION

RESULTS:

PROBLEMS/COMMENTS:

FIGURE V-1

VI. INSTRUMENT CALIBRATION RECORDS

This section of the system reference manual contains all of the original calibration information taken for the FIMS A instrument. Any subsequent calibrations or modifications to the instrument will be noted both in this section and in the previous section.

FIMS A ENERGY ANALYZER

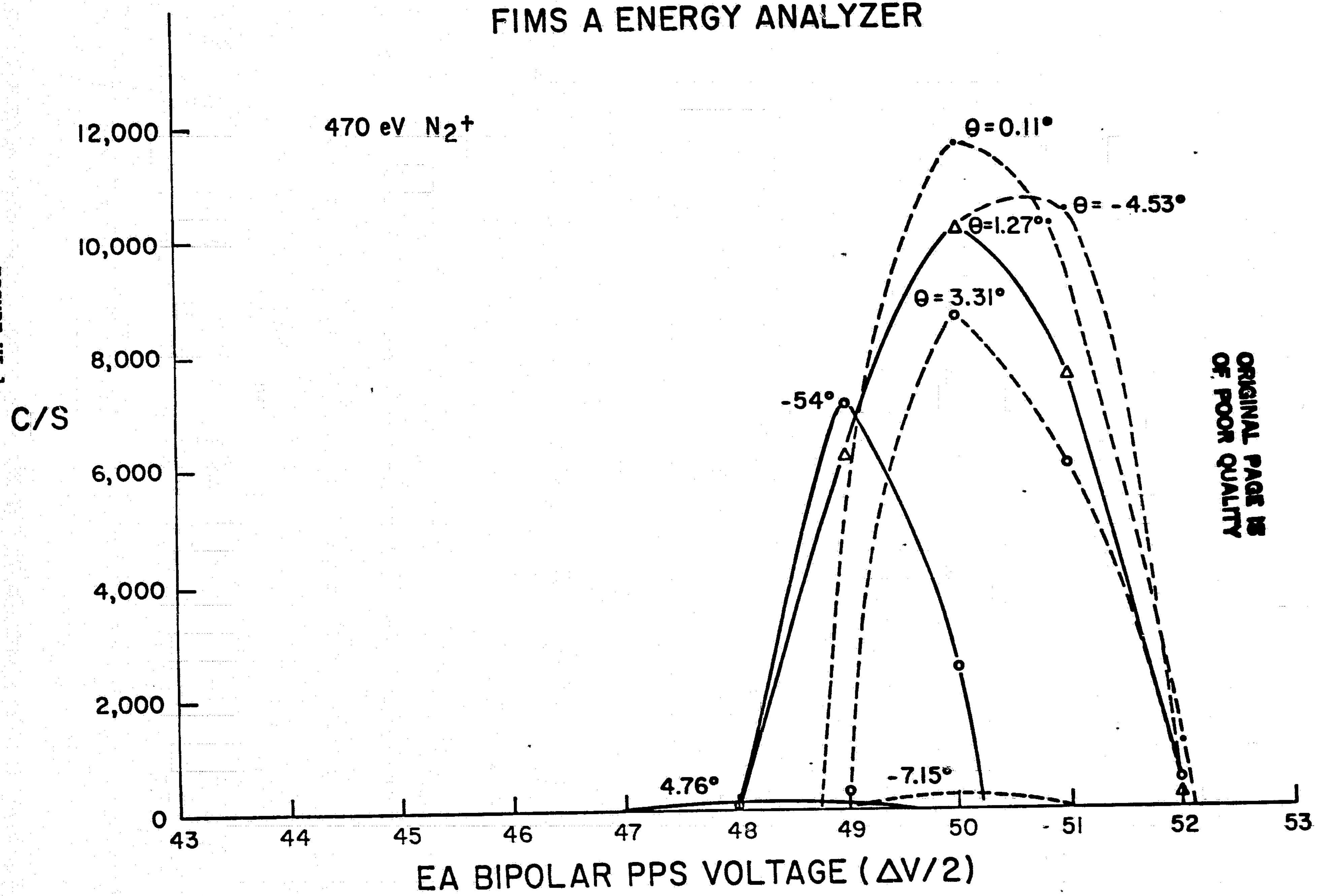

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FIGURE VI-1

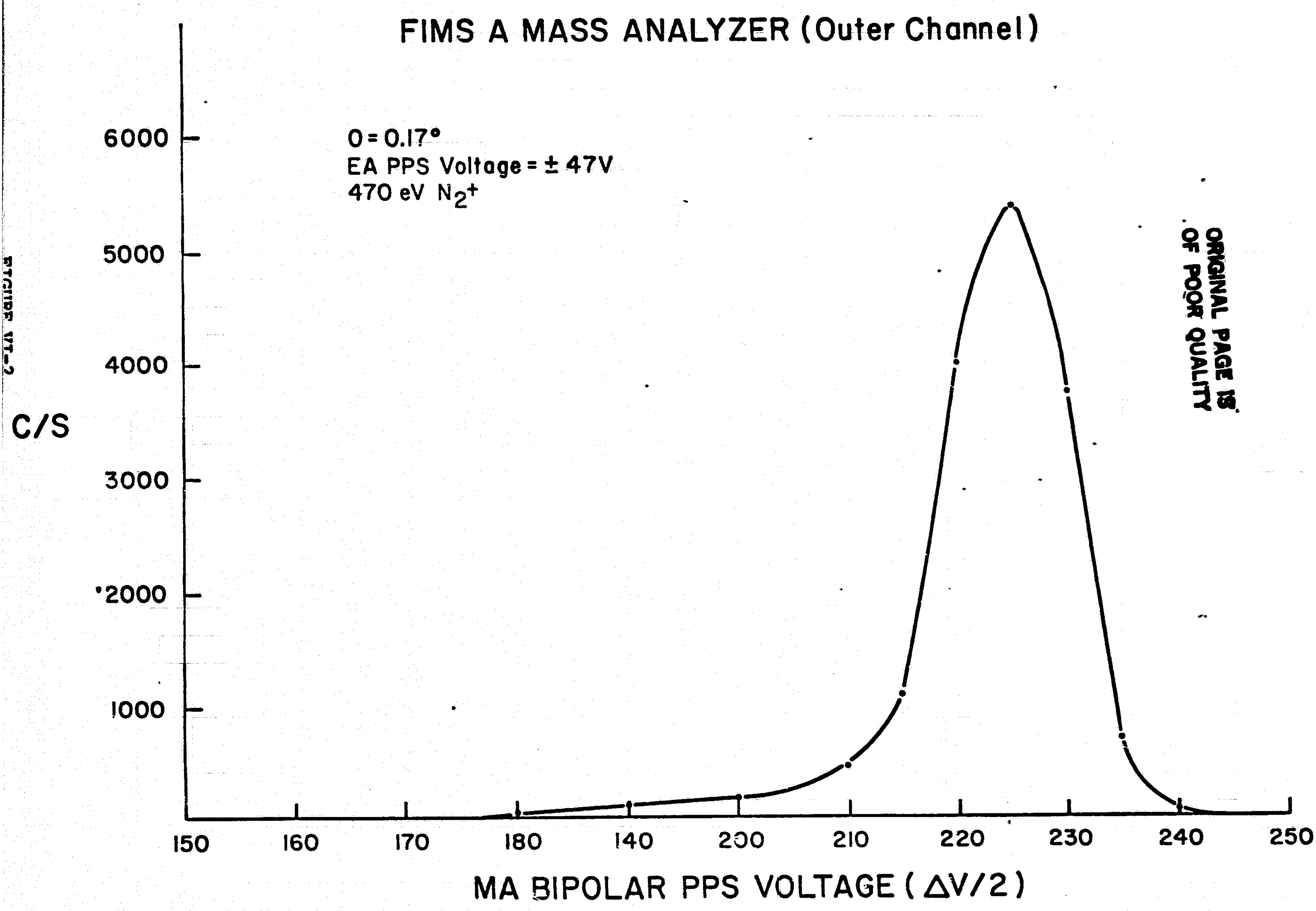

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FIGURE VI-2

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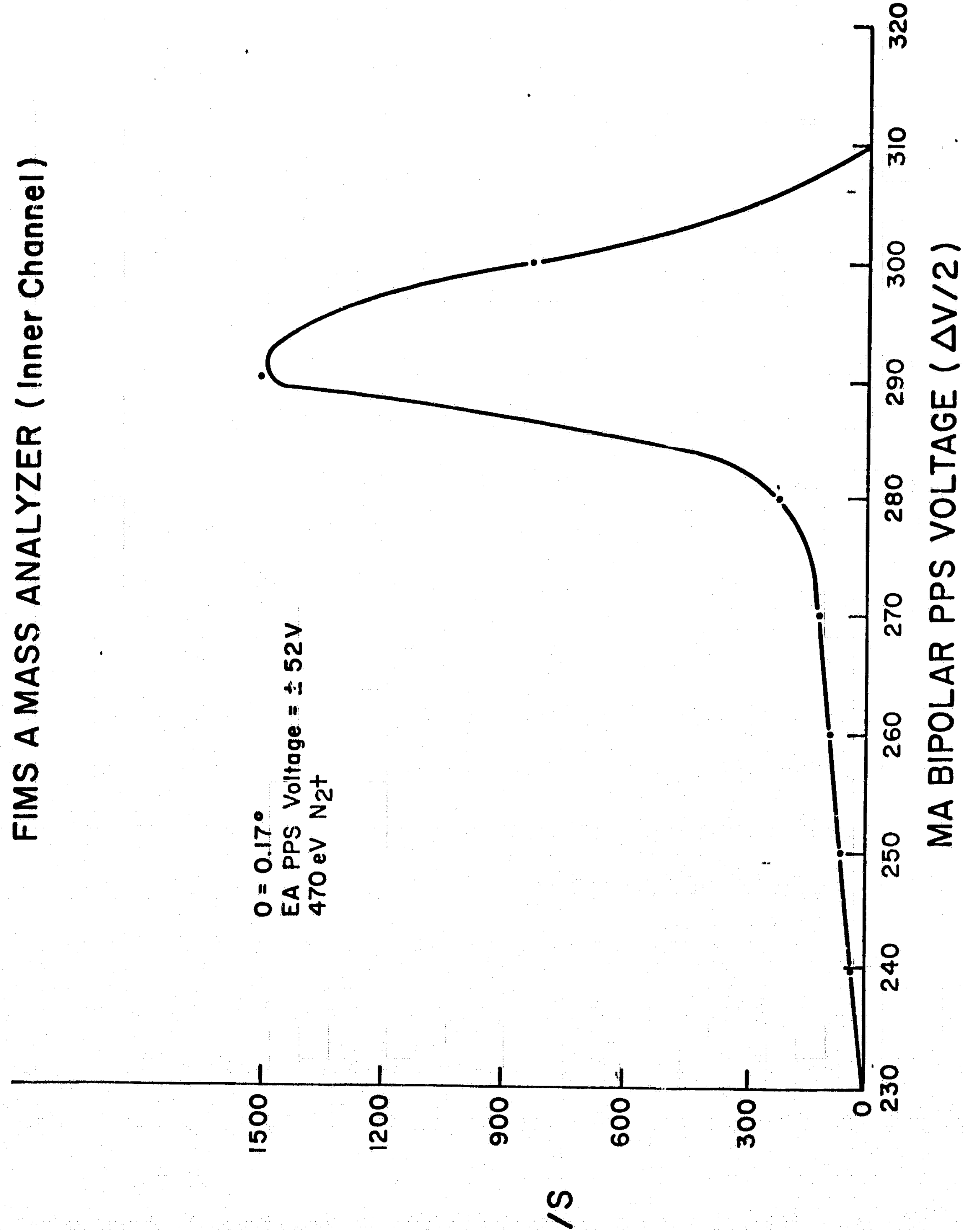

FIGURE VI-3.

VII. INSTRUMENT DESIGN INFORMATION

A. Analyzer Design

The details of the design information pertinent to the energy and mass analyzer sections of the FIMS instrument are described in some detail in Section I of this document. In particular, in the scientific paper published by S. F. Hahn and J. L. Burch in the Review of Scientific Instruments, February 1981. No further comments on the analyzer design will be made in this section of the reference manual.

B. CEP Design

Figures 1, 2 and 3 are the schematic diagrams of the Central Electronics Package used to control the operation of the FIMS A instrument. As can be seen, the system consists of three circuit boards populated almost entirely of CMOS logic with additional help from low-power Schotky prescalers in the area of the high-speed digital accumulators. Board 1 of the three-board set contains all three digital accumulator channels and their respective output buffer latches with tristate drivers. The control lines to support the operation of the accumulators is provided by a decoded state controller located on Board 2. Basically the accumulators are allowed to acquire counts from their respective pulse-amplifier discriminators located within the detector assembly of the instrument for all but 3 minor frames of the telemetry format. With the receipt of an SF 2^4 rising edge, the controller on Board 2 inhibits the accumulation of counts from all three accumulators on the scaler board and transfers those accumulated counts into the buffer-store latchets shown on the Board 1 schematic as 54C 374's. As the time arrives for the transmission of the accumulated count information to the telemetry system, the selected digital data channel is enabled and the tri-state outputs of the octal buffer latches are turned on, thus applying the accumulated count output to the input of the systems one and only shift register assembly. The shift register hardware is located on Board 2 of the set. Each of the three accumulator channels is read out at its respective time in the PCM format. For a period of 3 minor frames, the accumulators are disabled by the controller on Board 2. This dead time is necessary because of the fly-back period of the programmable power supplies used on FIMS. Since the power supply outputs are not stable for a period of 3 minor frames, it is desired that data counts not be accumulated during this period. As seen in the schematic of Board 1, each accumulator channel consists of a 14-bit CMOS synchronous counter string preceded by a 4-bit LS counter. The QA output of the first stage LS counter is brought out as the clock input to the following CMOS counters. This configuration results in the LS counter being used as a high-speed prescaler for the CMOS counters that follow. Since the output of the PAD amplifiers located within the instrument are only 50 ns wide, it is not possible to apply this input directly to the slow CMOS counters, thus the need for the LS prescaler. The board layout for Board 1 is shown as Figure 4 of this document.

Card 2 of the FIMS Central Electronics Package contains all of the instrument controller functions as well as two erasable programmable read-only memory chips in which are stored the PPS commands for both power supplies. As seen on the schematic, the instrument controller is keyed to the rising edge of the SF 2^4 timing signal. Each time a transition is seen on this line, the controller clocked by the 200 kHz clock, goes through 7 states which are used to transfer the accumulated count data in the scalers into their respective buffer latches, to fetch and store the next PPS command from the erasable PROMS into low-power octal latches and to induce the 3 minor frame delay before resumption of count accumulations on the accumulator board. Card 2 thus contains all of the instrument controller functions and it functions basically by keying its activities to the rising edge of the SF 2^4 clock to perform its duty as controller for the two PPS's and the accumulators. (Board 2 layout is Figure 5.)

Card 3 of the FIMS 8-card set contains the interface logic used to receive the incoming signals from the PCM subsystem. As seen in the schematic, the typical electrical interface consists of a 10K ohm pull-up resistor and shunt, with a 100 picofarad capacitor. The line receivers used in this application are 54C of 914's, yielding a high-noise immunity, medium-speed interface circuit. (Fig. 6 is board 3 layout.)

The FIMS A instrument central electronics package is completely hardware controlled; thus, only the PPS commands are stored in PROM and no other software operations are involved. Figure 7 shows component list for the CEP.

The intra-instrument cable details for the FIMS A CEP are shown in Figure 8 of this document. They are provided here should any changes be necessary or construction of any additional cables be required.

C. Programmable Power Supplies

FIMS-A uses two programmable high voltage power supplies. Both power supplies were constructed from the design drawings prepared by the Goddard Space Flight Center for use on the HAPI and LAPI instruments on the Dynamics Explorer Satellite.

A few design changes were made to the power supplies to adapt them to the scientific and operational requirements of the FIMS/Centaur rocket program. The two power supplies used by FIMS are referred to as the energy and mass units, corresponding to the two sections of the instruments analyzer. The energy supply is very similar to the standard D. E. design. Table VII-1 shows the relationship between the 6-bit programming code word and the high voltage output.

The mass analyzer power supply is considerably different from the basic P.P.S. design, the principal difference being that this supply has its high voltage output floated at the -3200 VDC bias used for the mass analyzer float potential. To realize this objective, a considerable effort was invested in insulating the electronics within the supply from the chassis-grounded case of the power supply. The inner surfaces of the case of the power supply are lined with a fiberglass material to prevent high voltage breakdown.

The second major change was the addition of a set of six optical couplers to interface with the 6-bit parallel command interface to the CEP. In summary, the mass P.P.S. has its high voltage return connected to the minus high voltage output of the HVPS, thus floating most of the circuits within the supply at -3200 V. A 50-megohm resistor was placed in series with the high voltage return line to the minus high voltage output of the bias power supply (PICO-PAK).

The third major change was the modification of the input multiplexer circuit and the output voltage range. The resistor network for R_{IN} and R_F was changed to allow the output voltage to step from a maximum of 982 V to a minimum of 25 V in 64 steps.

Table VII-2 shows the relationship between the 6-bit programming code and the high-voltage output of the mass supply.

D. High Voltage Power Supply (HVPS)

The FIMS-A instrument uses a single HVPS to provide the float potential for the mass analyzer deflection plates and the bias for the channel electron multiplier. A standard PICO-PAK Model PP9N provides the bias potential. The pages following contain specification sheets for the unit used on FIMS-A. The high voltage output has been adjusted to -3200 VDC for this application.

E. Fims Instrument Detector Assembly

The detector assembly as shown in the introductory section contains two (2) printed circuit boards containing the charge/preamplifiers for three channel electron multipliers, analog-buffer circuit for monitoring the float or bias potential and the necessary voltage divider resistor networks for the CEMs. The schematic diagram for the instrument is shown in Figure 9 and the component parts list is shown in Figure 10.

I. SPECIFICATIONS

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A. Electrical

1. Input Voltage: 28 ± 4 volts; negative ground.
2. Regulation:
   Line: < ± 0.4%
   Load: (50 to 250 mW output): < ± 1.5%
3. Ripple: <0.007% peak to peak. *
4. Output power: 250 mW maximum.
5. Output voltage: See Table 1 below.
6. Input current: See Figure 3.
7. Temperature drift: < ±1% from -30°C to ±71°C
8. Dynamic load regulation: Equivalent power supply source impedance < 100 KΩ at 1 KHz to < 1 KΩ at 0.5 MHz.

TABLE 1

MODEL	VOLTAGE RANGE	MAX WEIGHT IN GRAMS Without Output Protect'n	With Output Protect'n(L)
PP-5	400-725 volts	110	150
PP-6	725-1300 volts	110	150
PP-7	1150-2000 volts	140	180
PP-8	1500-2600 volts	140	180
PP-9	2300-4000 volts	160	200

A "P" or "N" in the model number indicates positive or negative output polarity.

The letter "L" in the model number indicates current limited to protect against short-circuit or overload damage.

Example: PP-7-N is negative, not output protected; PP-7-PL is positive, and is output short-circuit protected.

* Ripple is measured with input and output returns connected to case.

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A. Electrical (Continued)

9. Stability: After two hours operation, drift less than 0.1% per day.

10. Noise induced into 28 volt power line: less than 25 millivolts across 1 ohm impedance.

11. Impedance between either input and output returns and case is > 10 megohms and < 100 pf.

B. Environmental

Pico-Pacs have been designed and tested to meet or exceed the environmental conditions indicated below:

Altitude: Operational from sea level to 200,000 feet (exposure at reduced pressure > 30 minutes).

Acceleration*: 120 g for 30 seconds - any axis.

Mechanical Shock*: 80 g, 15 milliseconds - any axis.

Thermal Shock*: -55° C to +65° C and +65° C to -55° C, each in less than five minutes.

Sinusoidal Vibration*:

5-28 Hz, 0.55 inch double amplitude } 2 octaves/min.
28 - 3000 Hz, ± 20 g } -any axis

Random Vibration*: 0.1 g 2/Hz, 3 σ, 20-2000 Hz, 90 seconds - any axis.

* Units energized following, but not during, tests.

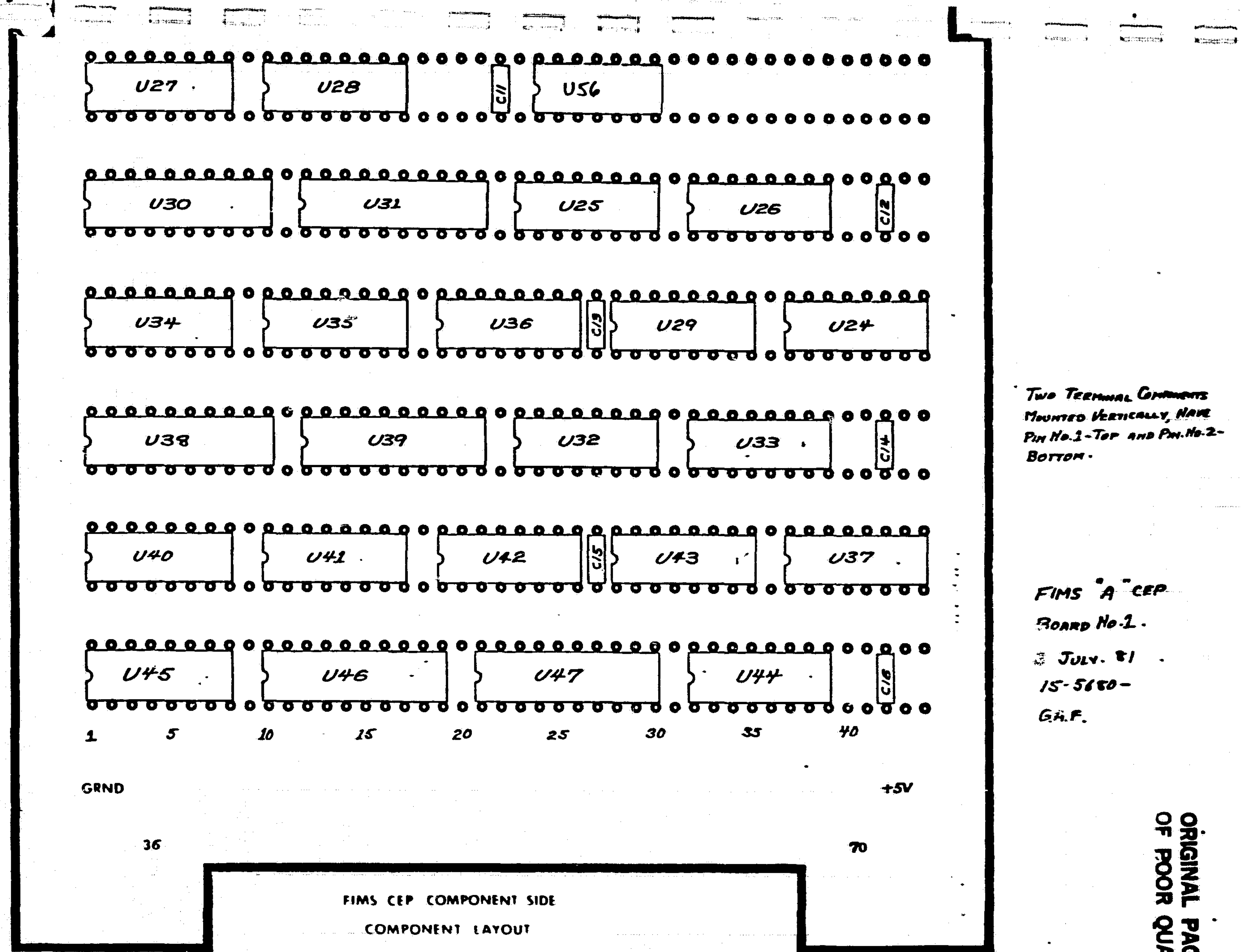

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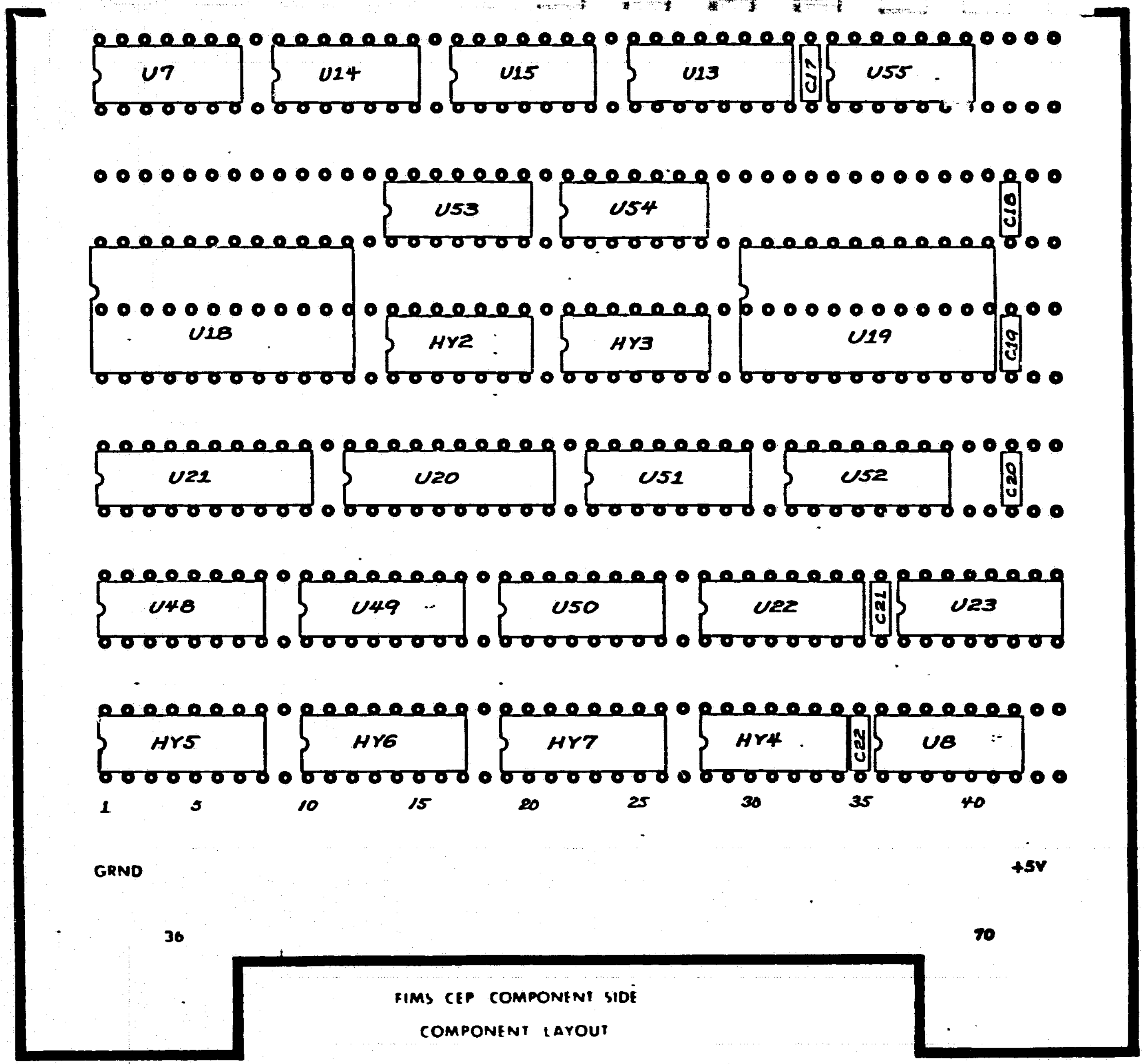
FIGURE VII-4



Two Terminal Components Mounted Vertically, Have Pin No. 1 - Top, And Pin No. 2 - Bottom.

FIMS "A" CEP
Board No. 2
3-July. 81
15-5680-
GAF.

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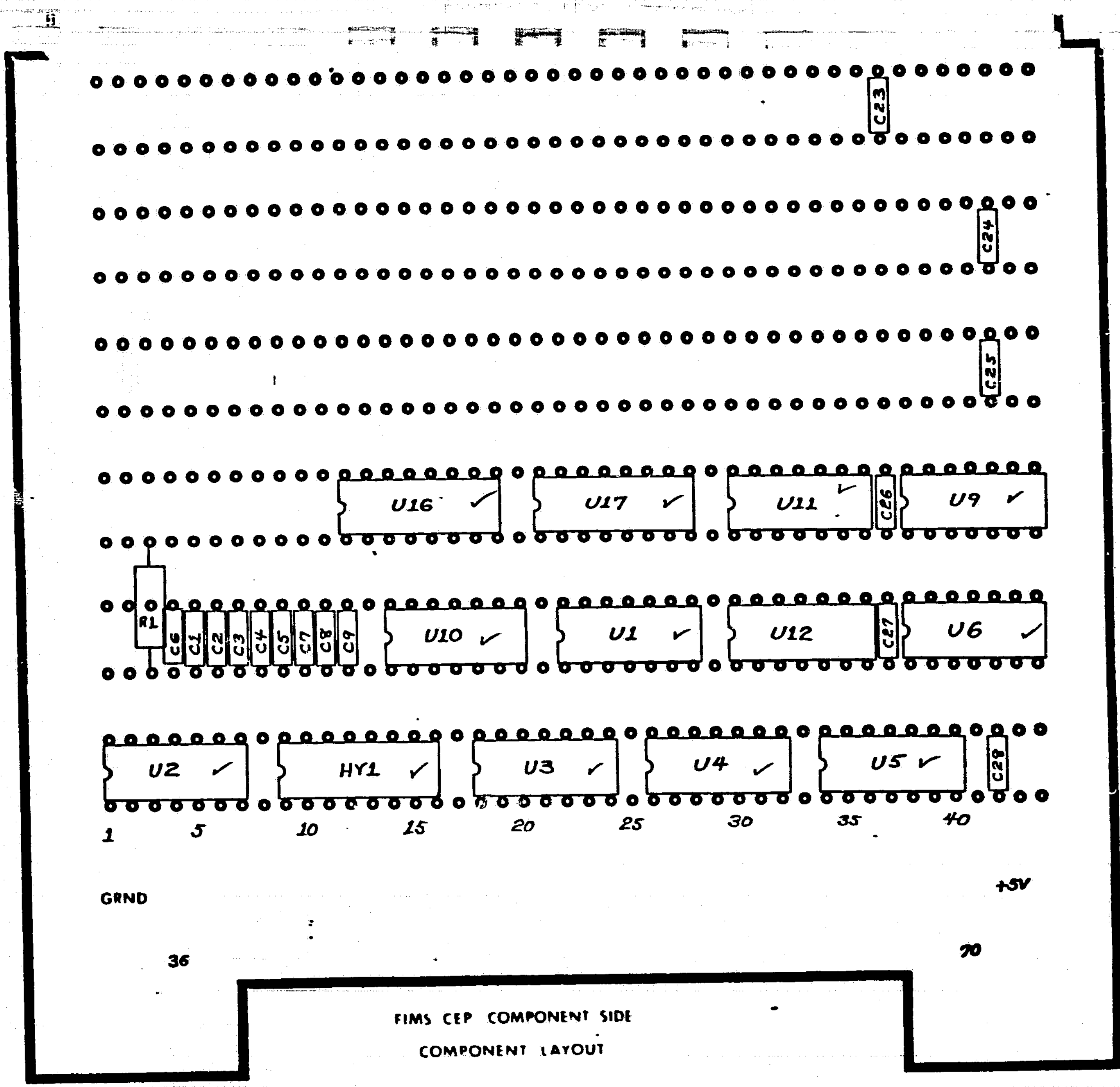
FIGURE VII-5



Two Terminals Components Mounted Vertically. Have Pin No.1 - Top, And Pin No.2 - Bottom.

FIMS "A" CEP
Board No. 3.
3 July. 81
15-5680-
GAF

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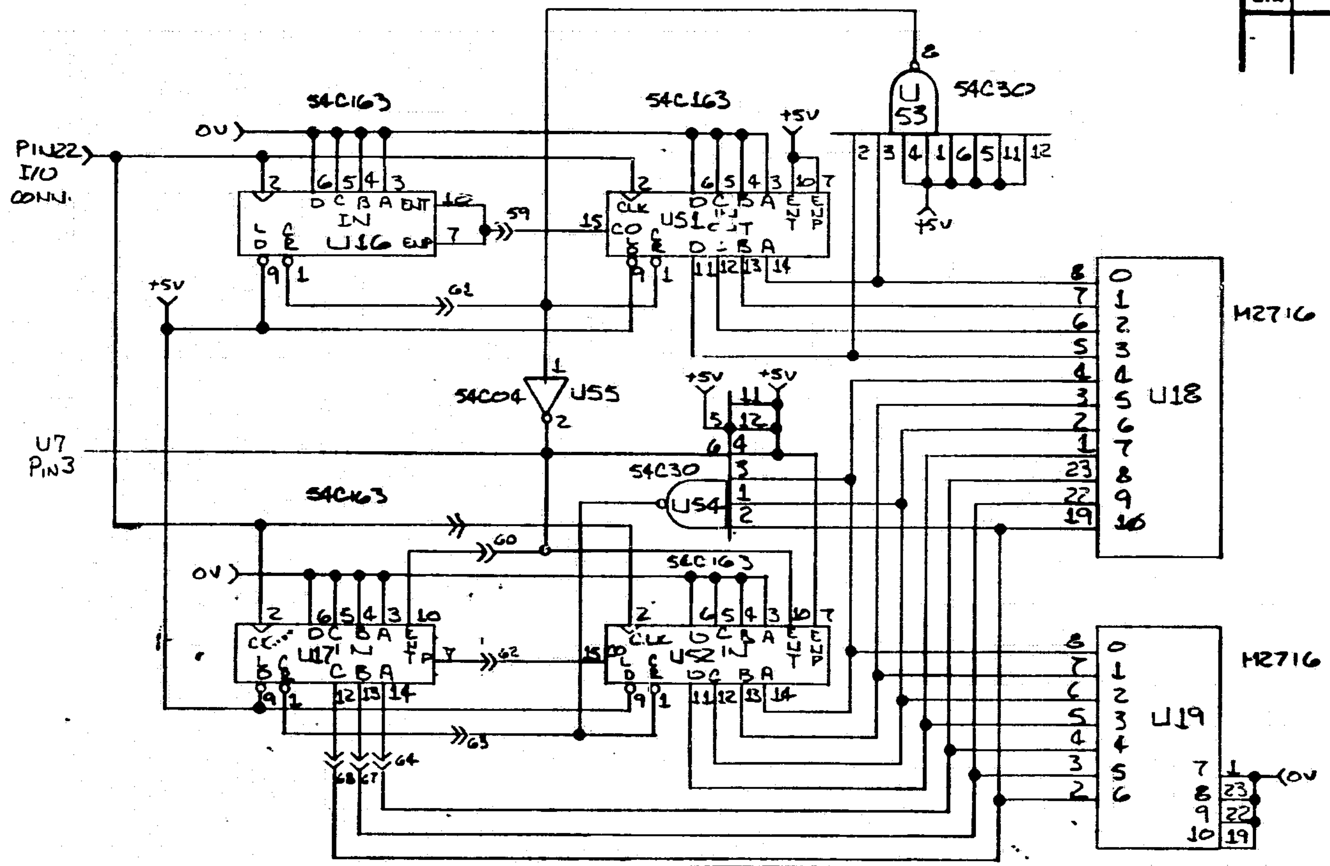
FIGURE VII-6



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REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

FIND NO.	QTY. REQ.	SIZE	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES

TOLERANCES

BASIC DIMENSION	DECIMALS 2 PLACE	DECIMALS 3 PLACE	FRACTIONS
UNDER 6	±.02	±.005	±1/64
6-24 INCL	±.03	±.010	±1/32
OVER 24	±.06	±.015	±1/16
ANGLES±1/2°			

CONTRACT		
DWN		
CKD		
MECH		
ELECT	GIBSON	[illegible]
STDS		

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS

MODIFICATIONS TO FIMS-A CEP

SIZE	CODE IDENT. NO.	DRAWING NO.
B	26401	

SCALE SHEET

MATERIAL

FINISH

COML. TOL. APPLY TO STOCK SIZES

QTY. REQD.

NEXT ASSY	USED ON
APPLICATION	

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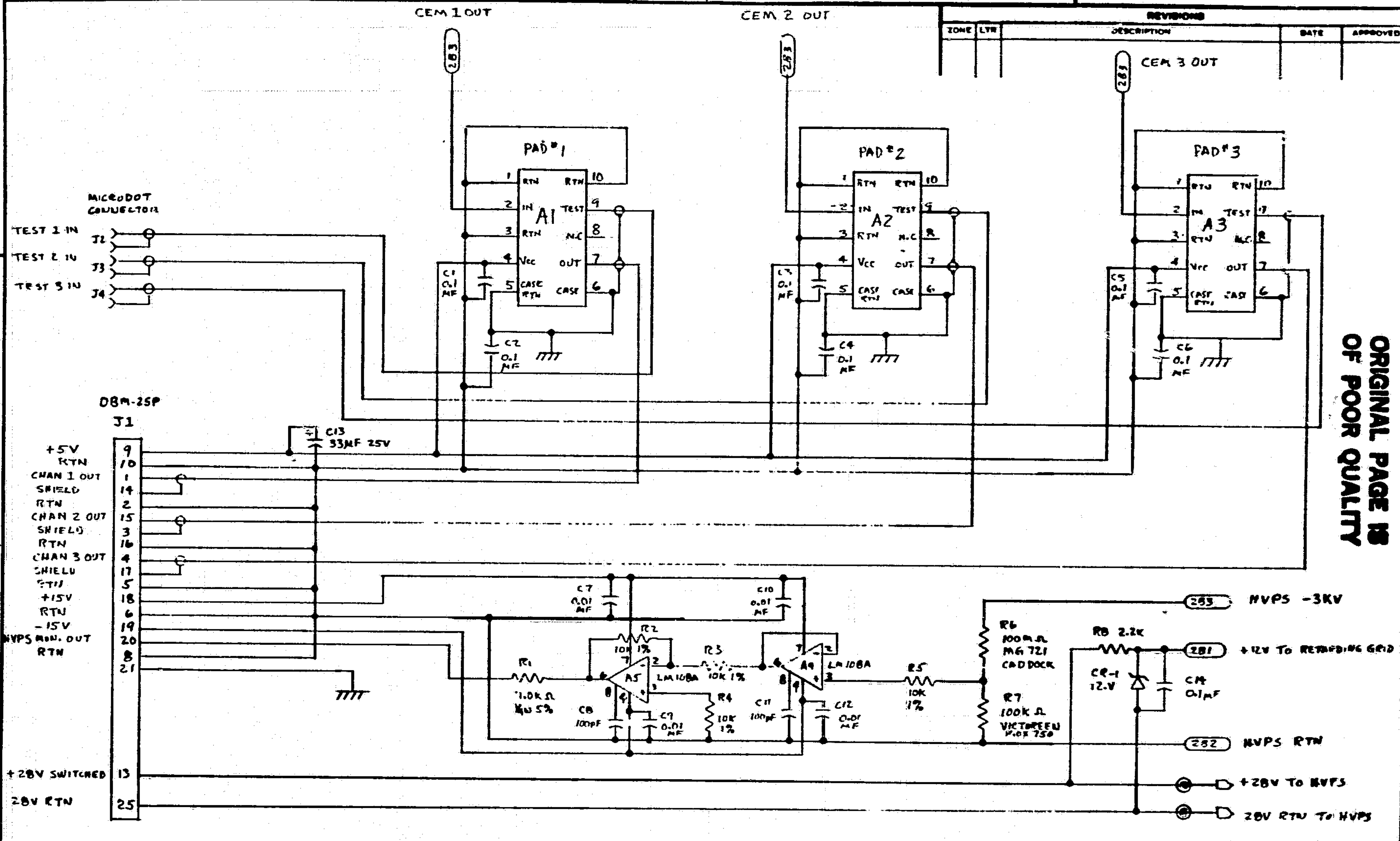

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REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

FIND NO.	QTY. REQ.	SIZE	CODE IDENT. NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES

TOLERANCES

BASIC DIMENSION	DECIMALS 2 PLACE	DECIMALS 3 PLACE	FRACTIONS
UNDER 6	±.02	±.005	±1/64
6-24 INCL	±.03	±.010	±1/32
OVER 24	±.06	±.015	±1/16

ANGLES ±1/2°

COML. TOL. APPLY TO STOCK SIZES

QTY. REQD.

MATERIAL

FINISH

NEXT ASSY | USED ON

APPLICATION

CONTRACT: -5696

APPROVALS SIGNATURE & DATE

DRAWN: Tomlinson 4/23/81

CHECKED

MECH

ELECT

STDS

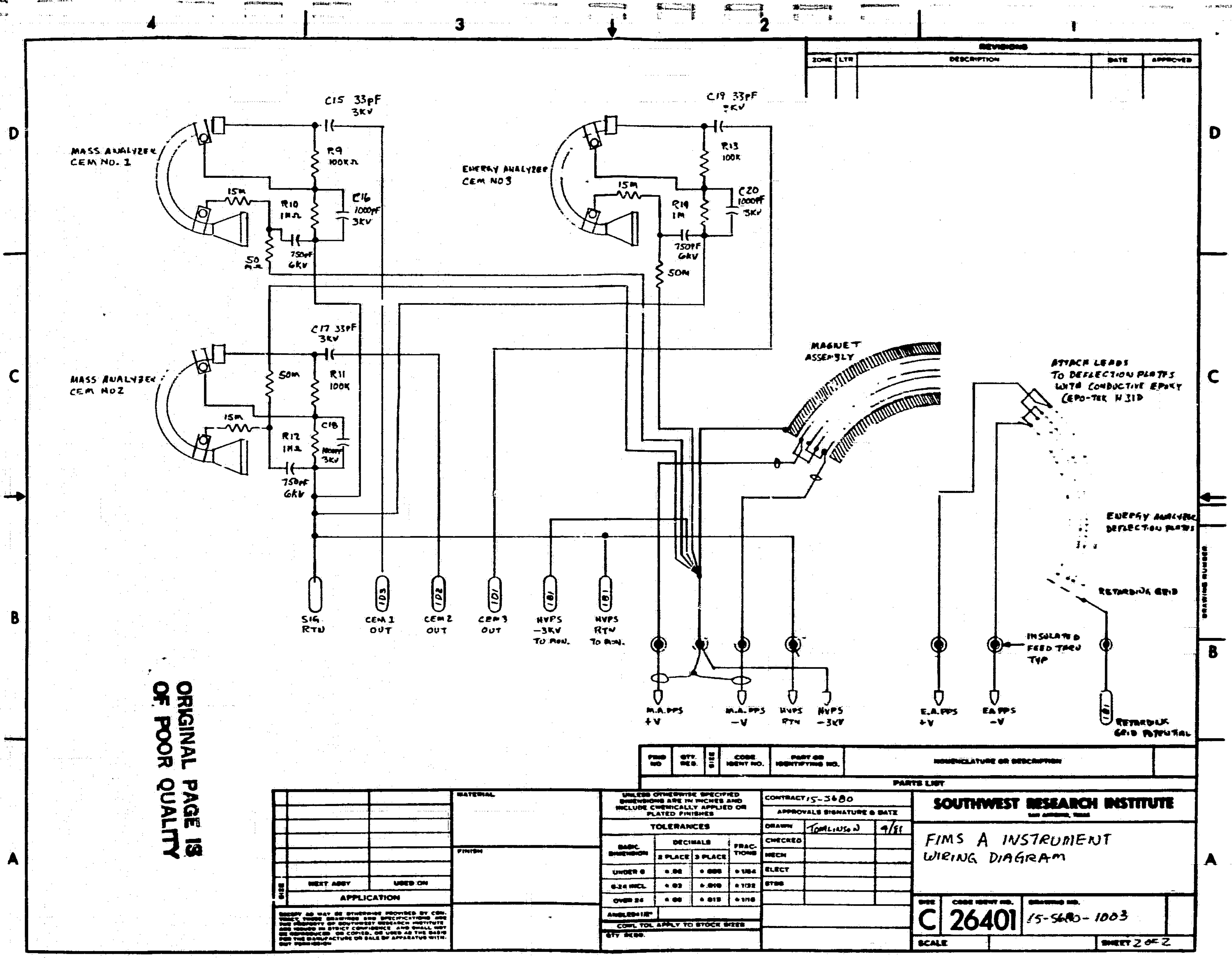
SOUTHWEST RESEARCH INSTITUTE

SAN ANTONIO, TEXAS

FIMS A INSTRUMENT WIRING DIAGRAM

SIZE: C | CODE IDENT NO.: 26401 | DRAWING NO.: 15-5680-1003

SCALE | SHEET 1 OF 2



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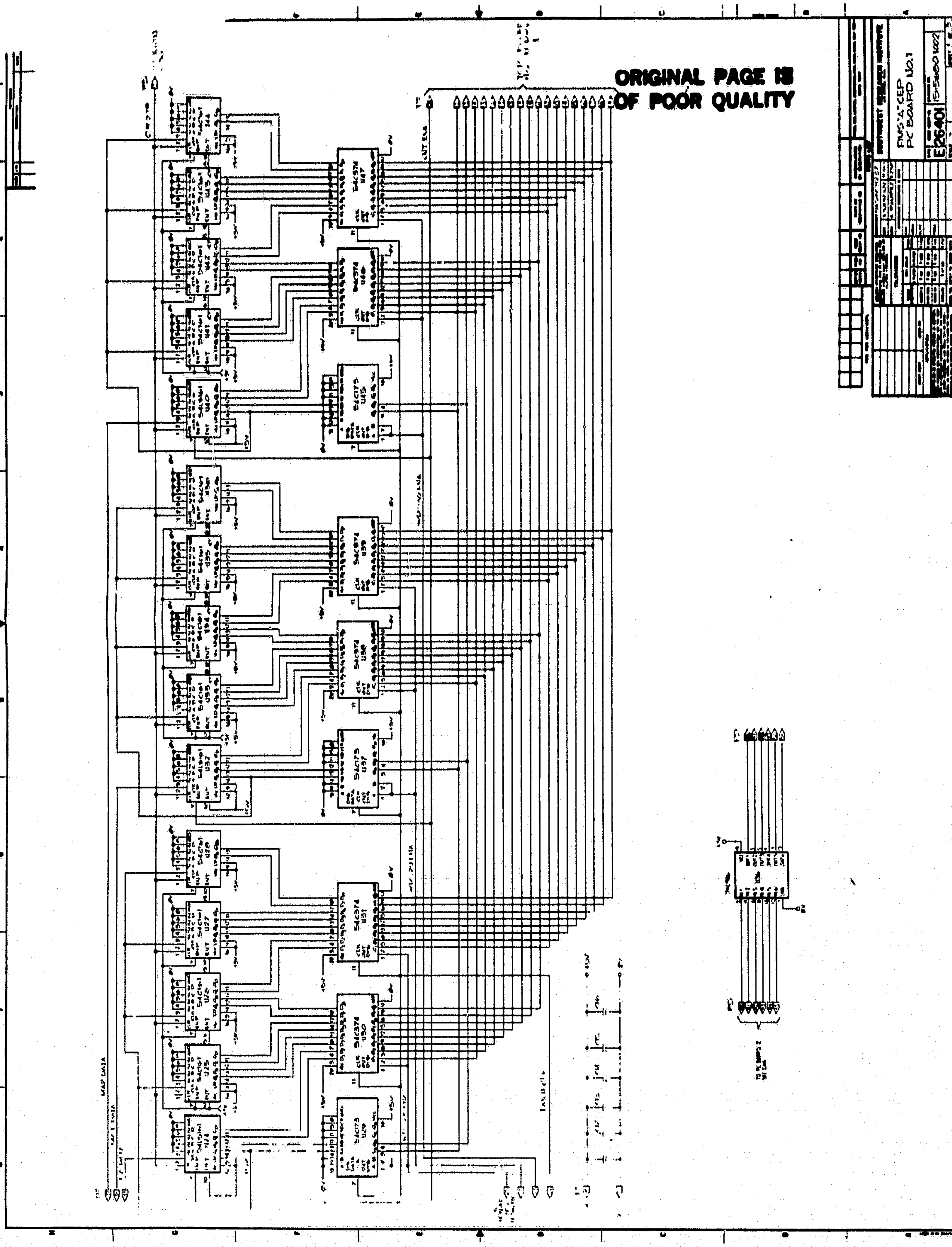

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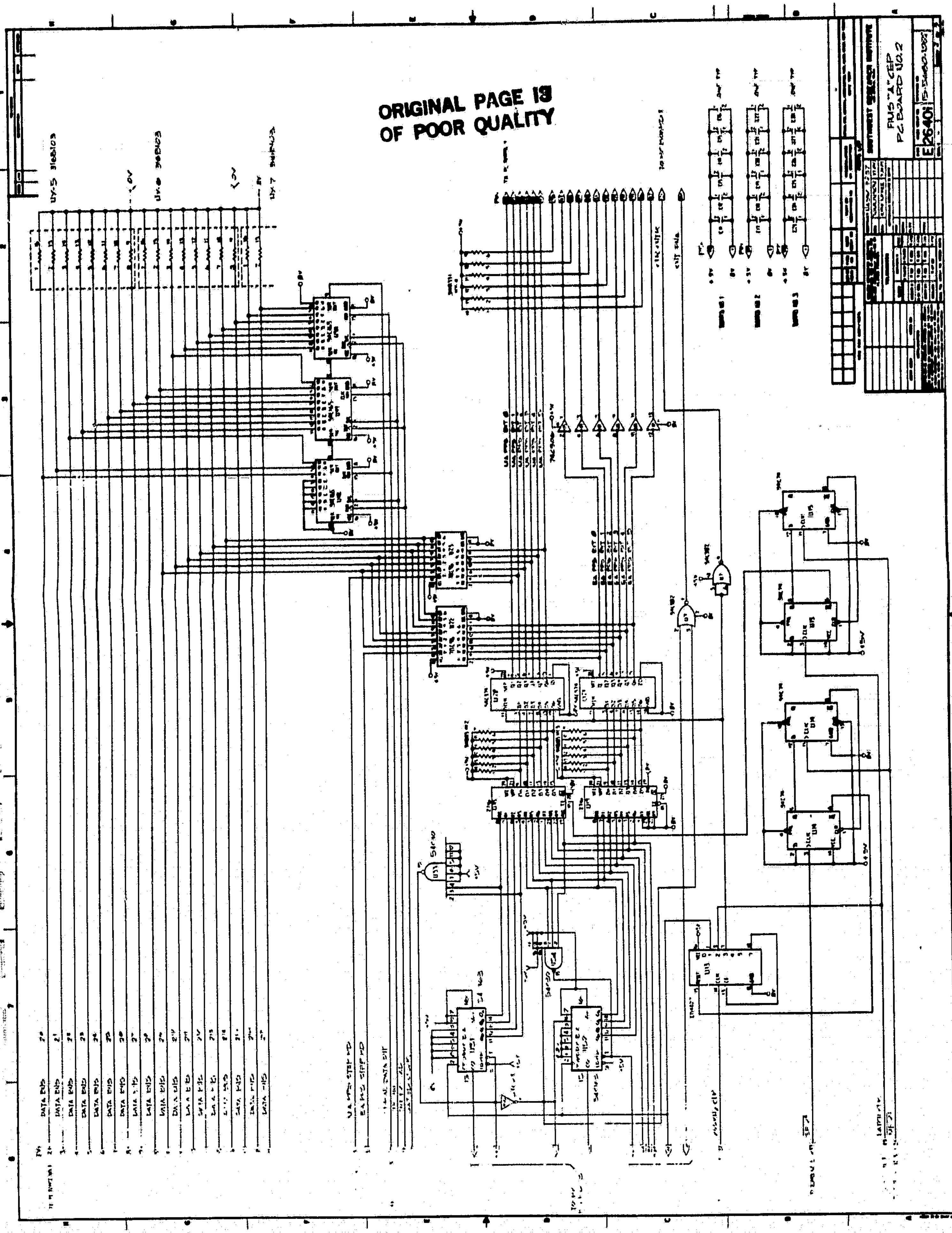

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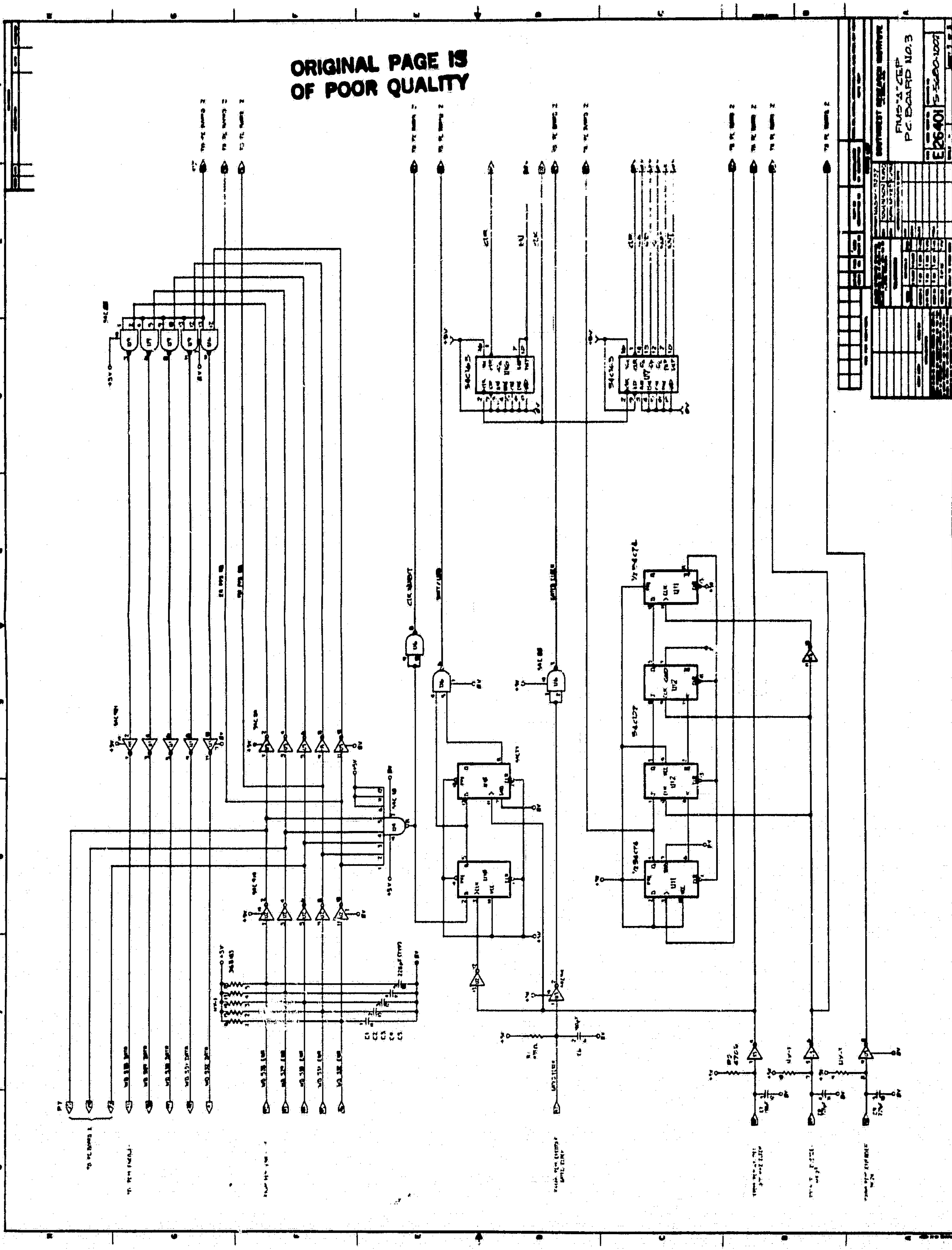

PARTS LIST — SOUTHWEST RESEARCH INSTITUTE — SAN ANTONIO, TEXAS — A — NO. 40 — 5680-1002

DRAWING TITLE: FIMS A CENTRAL ELECTRONICS PACKAGE

SHEET 1 of 2

QTY REQ PER ASSY/INSTALL				UNIT OF MEAS.	FIND NO.	CODE IDENT. NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	NOTES
			2			U6, 9	54C00J		
			2			U5, 55	54C04J	HEX INVERTER	
			3			U4,53,54	54C30J		
			4			U10,11, 14,15	54C74J	DUAL D FLIP FLOP	
			12			U 25-28 U 33-36 U 41-44	54C161J		
			4			U 16,17 51,52	54C163J		
			3			U48,49 50	54C165J		
			3			U29,37 45	54C173J		
			8			U30,31,38 39,46,47	54C374J		
			1			U1	54C901J		
			1			U 56	54C906J		
			2			U2, 3	54C914J		
			1			U7	54LS02J		
			3			U24,32 49	54LS161J		
			1			U 13	CD4022B		
			2			U22,23	70C96		
			2			U18,19	I2716	E-PROM	

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FIG. VII- 7.1

PARTS LIST | SOUTHWEST RESEARCH INSTITUTE | A | NO. 40 | PL 5680-1002

DRAWING TITLE: FIMS A CENTRAL ELECTRONICS PACKAGE

SHEET 2 of 2

QTY REQ PER ASSY/INSTALL			UNIT OF MEAS.	FIND NO.	CODE IDENT. NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	NOTES
			1		U8	DS1630	HEX CMOS TO TTL BUFFER	
			1			CK05101K	100PF 100V CERAMIC CAP	
			7			CK05221K	220 PF 100V	
			18			CK05103K	.01 µF 50V CERAMIC CAP	
			2		Hy2,3	314B 103	14 PIN RESISTOR NETWORK 10 KΩ	
			4		HY1,5,6,7	316B 103	16 PIN RESISTOR NETWORK 10 KΩ	

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FIG. VII -7.2

SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date

CONNECTOR (50S) 50 Pin Sub "D"	TITLE FIMS "A" CEP INTERNAL WIRING	SHEET 1 OF 5

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
J-76	1			E.A. PPS BIT Ø	46	J5
"	2			" 1	47	"
"	3			" 2	48	"
"	4			" 3	49	"
"	5			" 4	50	"
"	6			" 5	51	"
"	7			SIG RETURN	36	J6
"	8			MA PPS ANODE BIT Ø	46	"
"	9			" CATHODE BIT Ø	47	"
"	10			" ANODE BIT 1	48	"
"	11			" CATHODE BIT 1	49	"
"	12			" ANODE BIT 2	50	"
"	13			" CATHODE BIT 2	51	"
"	14			" ANODE BIT 3	52	"
"	15			" CATHODE BIT 3	53	"
"	16			" ANODE BIT 4	54	"
"	17			" CATHODE BIT 4	55	"
"	18			" ANODE BIT 5	56	"
"	19			" CATHODE BIT 5	57	"
"	20			E.A. PPS +V MON (A39)	33	J73
"	21			RETURN	37	"
"	24					
"	25			ORIGINAL PAGE IS OF POOR QUALITY		
J-76	26					

FIGURE VII- .1

SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date
CONNECTOR (50S) 50 PIN Sub "D"	TITLE FIMS "A" CEP INTERNAL WIRING			SHEET 2 OF 5

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
J76	27			TIMED 28V to EA PPS	T1	-
"	28			CHASSIS		GND LUG
"	29			28V return to EA PPS	T2	-
"	30			Timed 28V to MA PPS	T1	-
J76	31			28V return to MA PPS	T2	-
"	32			MA PAD #1 DATA	38	J5
"	33			RETURN	68	"
"	34			MA PAD #2 DATA	37	"
"	35			RETURN	36	"
"	36			EA PAD DATA	39	"
"	37			RETURN	69	"
"	38			CHASSIS		GND LUG
"	39			FLOAT POT. MON. (A38)	32	J73
"	40			RETURN	37	J72
"	41			CHASSIS		GND LUG
"	42			+8V to INSTRUMENT	3	J73
"	43			-8V to INSTRUMENT	4	J73
"	44			COMMON (8V)	5	J73
"	45		-			
"	46			+5V to INSTRUMENT	35	J7
"	47			5V RETURN	1	J7
"	48			TIMED 28V to INSTRUMENT	T1	
"	49			28V RETURN	T2	
J76	50					
J73	11			TIMED 28V from SUPPLY	T1	
J73	12			28V RETURN	T2	

FIGURE VII-' .2

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SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date

CONNECTOR (37P) 37 Pin Sub "D"

TITLE FIMS "A" CEP

SHEET 3 OF 5

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
J73	20			FIMS DATA S28	37	J7
"	21			FIMS DATA S29	38	"
"	22			FIMS DATA S30	39	"
"	23			FIMS DATA S31	40	"
"	24			FIMS DATA S32	41	"
J73	25			SIGNAL RETURN	36	"
J73	27			ENABLE GATE EG28	42	"
"	28			ENABLE GATE EG29	43	"
"	29			ENABLE GATE EG30	44	"
"	30			ENABLE GATE EG31	45	"
"	31			ENABLE GATE EG32	46	"
"	16			GATED CLOCK	47	"
J3	10			200 kHz CLOCK	48	"
J73	17			MF 2^3	49	"
J74	27			SF 2^4	50	"

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FIGURE VII- .3

SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date
CONNECTOR	TITLE FIMA "A" CEP			SHEET 4 OF 5

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
J5	2			BOARD INTERCONNECT	2	J6
"	3			"	3	"
"	4			"	4	"
"	5			"	5	"
"	6			"	6	"
"	7			"	7	"
"	8			"	8	"
"	9			"	9	"
"	10			"	10	"
"	11			"	11	"
"	12			"	12	"
"	13			"	13	"
"	14			"	14	"
"	15			"	15	"
"	16			"	16	"
"	17			"	17	"
"	18			"	18	"
"	19			"	19	"
"	22			"	23	"
"	23			"	23	J7
"	24			"	24	"
"	25			"	25	"
J6	22			"	22	"
"	26			"	26	"
"	27			"	27	"
"	28			"	28	J7

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FIGURE VII- .4

SOUTHWEST RESEARCH INSTITUTE	Code ID.	Number	Rev. Ltr.	Date

CONNECTOR	TITLE FIMS "A" CEP	SHEET 5 OF 5

FROM CONNECTOR	PIN NO.	WIRE ID.	LGTH. FT.	SIGNAL DESCRIPTION	PIN NO.	TO CONNECTOR
J6	29			BOARD INTERCONNECT	29	J7
"	30			"	30	"
"	31			"	31	"
"	32			"	32	"
"	33			"	33	"
"	34			"	34	"
"	59			"	59	"
"	60			"	60	"
"	61			"	61	"
"	62			"	62	"
"	63			"	63	"
"	64			"	64	"
"	65			"	65	"
"	66			"	66	"
"	69			"	69	"
"	40			"	40	J5
"	41			"	41	"
"	42			"	42	"
"	43			"	43	"
"	44			"	44	"
"	45			"	45	"
"	67			"	67	J7
"	68			"	68	"

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FIGURE VII- .5

STEP NO.	VOLTAGE LEVEL	+VO	-VO	+TM	-TM	STEP NO.
0	2500.0 V	2515	2486	5.02	4.95	0
1	2164.9	2179	2154	4.36	4.29	1
2	1874.7	1884	862	3.77	3.71	2
3	1623.4	1630	1611	3.26	3.21	3
4	1405.8	1442	1396	2.83	2.79	4
5	1217.4	1223	1209	2.45	2.41	5
6	1054.2	1061	1049	2.13	2.09	6
7	912.92	918	908	1.84	1.816	7
8	790.55	794	785	1.59	1.57	8
9	684.59	688	681	1.38	1.36	9
10	592.83	595	589	1.19	1.18	10
11	513.37	515	510	1.03	1.02	11
12	444.56	446	442	.894	.884	12
13	384.97	386	383	.774	.766	13
14	333.37	335	332	.672	.664	14
15	288.68	290	287	.581	.575	15
16	249.99	250	247	.500	.496	16
17	216.48	216	214	.434	.430	17
18	187.47	187	186	.375	.372	18
19	162.34	162	161	.324	.322	19
20	140.58	140	139	.280	.279	20
21	121.74	121	121	.243	.242	21
22	105.42	105	105	.210	.210	22
23	91.288	91	90.6	.182	.1820	23
24	79.052	79.2	78.9	.158	.1584	24
25	68.456	68.5	68.4	.137	.1375	25
26	59.281	59.2	59.2	.118	.119	26
27	51.335	51.2	51.3	.102	.103	27
28	44.454	44.3	44.5	.088	.0895	28
29	38.495	38.3	38.5	.0763	.0776	29
30	33.336	33.2	33.4	.0660	.0675	30
31	28.867	28.6	29.0	.0569	.0585	31
32	24.998	25.0	24.92	5.02	4.83	32
33	21.647	21.7	26.61	4.35	4.18	33
34	18.746	18.78	18.7	3.76	3.61	34
35	16.233	16.26	16.2	3.25	3.12	35
36	14.057	14.10	14.04	2.82	2.70	36

TABLE VII-1. ENERGY ANALYZER PPS STEP CODE

ORIGINAL PAGE IS
OF POOR QUALITY

STEP NO.	VOLTAGE LEVEL	+VO	-VO	+TM	-TM	STEP NO.
37	12.173	12.20	12.16	2.44	2.33	37
38	10.541	10.6	10.56	2.12	2.02	38
39	9.1285	9.17	9.13	1.84	1.74	39
40	7.9049	7.94	7.90	1.59	1.50	40
41	6.8454	6.88	6.85	1.38	1.30	41
42	5.9278	5.95	5.93	1.195	1.12	42
43	5.1333	5.15	5.13	1.035	0.96	43
44	4.4452	4.46	4.45	0.898	0.832	44
45	3.8494	3.86	3.85	0.380	0.716	45
46	3.3334	3.36	3.35	0.678	0.618	46
47	2.8866	2.906	2.896	0.588	0.530	47
48	2.4997	2.503	2.498	0.508	0.453	48
49	2.1646	2.169	2.165	0.442	0.389	49
50	1.8745	1.876	1.874	0.384	0.333	50
51	1.6232	1.623	1.620	0.334	0.282	51
52	1.4057	1.407	1.407	0.292	0.243	52
53	1.2173	1.218	1.217	0.255	0.207	53
54	1.0541	1.057	1.056	0.223	0.176	54
55.	0.91281	0.914	0.913	0.195	0.149	55
56	0.79046	0.797	0.801	0.172	0.127	56
57	0.6841	0.691	0.693	0.151	0.1067	57
58	0.59276	0.598	0.600	0.133	0.0890	58
59	0.51331	0.516	0.518	0.1172	0.0734	59
60	0.44450	0.448	0.452	0.1039	0.060	60
61	0.38492	0.388	0.390	0.0921	0.0488	61
62	0.33333	0.331	0.336	0.0820	0.039	62
63	0.289	0.280	0.279	0.075	0.028	63

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE VII-1.2 ENERGY ANALYZER PPS STEP CODE

STEP	RI	RF	V1	-VO	+VO.	-VO	+TM	- TM
1	127K	127K	-7.50	-982.22	982	982	4.91	4.903
2		120K	-7.08	-926.62	934	934	4.67	4.663
3		113K	-6.67	-874.17	874	874	4.37	4.363
4		107K	-6.30	-824.69	829	829	4.145	4.138
5		101K	-5.94	-778.01	774	773	3.87	3.863
6		95K	-5.60	-733.97	739	738	3.69	3.687
7		90K	-5.29	-692.43	700	700	3.501	3.495
8		84K	-4.99	-653.23	655	654	3.27	3.268
9	202K	127K	-4.71	-616.26	619	618	3.09	3.088
10		120K	-4.44	-581.38	588	588	2.94	2.937
11		113K	-4.19	-548.47	550	550	2.75	2.748
12		107K	-3.95	-517.42	522	522	2.610	2.606
13		101K	-3.73	-488.13	487	487	2.436	2.433
14		95K	-3.52	-460.50	465	465	2.325	2.322
15		90K	-3.32	-434.44	441	441	2.204	2.201
16		84K	-3.13	-409.85	412.6	412.1	2.06	2.058
17	323K	127K	-2.95	-386.65	386.1	385.6	7.928	1.926
18		120K	-2.79	-364.76	367.2	366.7	1.834	1.831
19		113K	-2.63	-344.12	343.5	343.0	1.715	1.713
20		107K	-2.48	-324.64	325.9	325.4	1.627	1.625
21		101K	-2.34	-306.26	304.2	303.7	1.519	1.517
22		95K	-2.21	-288.93	290.4	289.9	1.450	1.448
23		90K	-2.08	-272.57	275.3	274.8	1.374	1.373
24		84K	-1.96	-257.14	257.4	256.9	1.285	1.283
25	514K	127K	-1.85	-242.59	243.2	242.8	1.214	1.213
26		120K	-1.75	-228.86	231.4	230.9	1.155	1.153
27		113K	-1.65	-215.90	216.5	216.0	1.080	1.079
28		107K	-1.56	-203.68	205.4	204.9	1.025	1.024
29		101K	-1.47	-192.15	191.7	191.2	.956	.956
30		95K	-1.38	-181.28	183.0	182.5	.913	.912
31		90K	-1.31	-171.02	173.5	173.0	.865	.865
32		84K	-1.23	-161.33	162.2	161.7	.809	.808
33		127K	-1.16	-152.20	152.2	151.7	.759	.758
34	820K	120K	-1.10	-143.59	144.8	144.2	.721	.721
35		113K	-1.03	-135.46	135.5	134.9	.675	.675
36		107K	-.98	-127.79	128.5	128.0	.640	.640

TABLE VII-2.1 MASS ANALYZER PPS STEP CODE

ORIGINAL PAGE IS OF POOR QUALITY

STEP	RI	RF	V1	-VO	+VO	-VO	+TM	-TM
37		101K	-.92	-120.56	120.0	119.4	.597	.597
38		95K	-.87	-113.73	114.5	114.0	.570	.570
39		90K	-.82	-107.30	108.6	108.0	.541	.541
40		84K	-.77	-101.22	101.5	101.0	.505	.505
41	1.306M	127K	-.73	-95.49	95.9	95.4	.478	.477
42		120K	-.69	-90.09	91.3	90.7	.4546	.4547
43		113K	-.65	-84.99	85.4	84.9	.4253	.4255
44		107K	-.61	-80.18	81.0	80.5	.4034	.4036
45		101K	-.58	-75.64	75.7	75.1	.3765	.3768
46		95K	-.54	-71.36	72.2	71.7	.3594	.3597
47		90K	-.51	-67.32	68.5	67.9	.3406	.3410
48		84K	-.48	-63.51	64.0	63.5	.3185	.3189
49	2.082M	127K	-.46	-59.91	60.2	59.6	.2989	.2993
50		120K	-.43	-56.52	57.2	56.7	.2843	.2847
51		113K	-.41	-53.32	53.6	53.0	.2659	.2664
52		107K	-.38	-50.31	50.8	50.3	.2522	.2527
53		101K	-.36	-47.46	47.5	46.9	.2354	.2359
54		95K	-.34	-44.77	45.3	44.8	.2247	.2252
55		90K	-.32	-42.24	43.0	42.4	.2129	.2135
56		84K	-.30	-39.85	40.2	39.6	.1991	.1997
57	3.318M	127K	-.29	-37.59	38.0	37.5	.1882	.1887
58		120K	-.27	-35.46	36.2	35.6	.1789	.1796
59		113K	-.26	-33.56	33.9	33.3	.1674	.1680
60		107K	-.24	-31.56	32.2	31.6	.1587	.1594
61		101K	-.23	-29.78	30.0	29.5	.1481	.1488
62		95K	-.21	-28.09	28.7	28.1	.1414	.1421
63		90K	-.20	-26.50	27.2	26.7	.1340	.1347
64		84K	-.19	-25.00	25.5	24.9	.1253	.1260

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE VII-2.2 MASS ANALYZER PPS STEP CODE

FIMS-A EA-PPS COMMAND

ADDRESS	DATA	ADD	DATA	ADD	DATA
00	06	20	21	40	33
01	06	21	21	41	33
02	09	22	21	42	33
03	09	23	21	43	06
04	0C	24	21	44	06
05	0C	25	24	45	06
06	0C	26	24	46	"
07	0F	27	24	47	"
08	0F	28	24	48	"
09	0F	29	24	49	"
0A	12	2A	27	4A	"
0B	12	2B	27	4B	"
0C	12	2C	27	4C	"
0D	15	2D	27	4D	"
0E	15	2E	27	4E	"
0F	15	2F	2A	4F	"
10	15	30	2A		"
11	18	31	2A		"
12	18	32	2A		"
13	18	33	2A		"
14	18	34	2D		"
15	18	35	2D		"
16	1B	36	2D		"
17	1B	37	2D		"
18	1B	38	2D		"
19	1B	39	30		"
1A	1B	3A	30		"
1B	1E	3B	30		"
1C	1E	3C	30		"
1D	1E	3D	30		"
1E	1E	3E	33		"
1F	1E	3F	33		"

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE VII-3

6 September 1981

FINAL FLIGHT PROMS-FIMS-A

MASS ANALYZER PPS COMMANDS

ORIGINAL PAGE IS
OF POOR QUALITY

Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA
6	00	00	9	33	00	12	66	1B	15	99	33
"	01	01	"	34	0E	"	68	1C	18	A0	08
"	02	02	"	35	0F	"	68	1D	"	A1	09
"	03	03	"	36	10	"	69	1E	"	A2	0A
"	04	04	"	37	11	15	70	06	"	A3	0B
"	05	05	"	38	12	"	71	07	"	A4	0C
"	06	06	"	39	13	"	72	08	"	A5	0D
"	07	07	12	40	01	"	73	09	"	A6	0E
"	08	08	"	41	02	"	74	0A	"	A7	0F
"	09	09	"	42	03	"	75	0B	"	A8	10
"	10	0A	"	43	04	"	76	0C	"	A9	11
"	11	0B	"	44	05	"	77	0D	"	B0	12
"	12	0C	"	45	06	"	78	0E	"	B1	13
"	13	0D	"	46	07	"	79	0F	"	B2	14
"	14	0E	"	47	08	"	80	10	"	B3	15
"	15	0F	"	48	09	"	81	11	"	B4	16
"	16	10	"	49	0A	"	82	12	"	B5	17
"	17	11	"	50	0B	"	83	13	"	B6	18
"	18	12	"	51	0C	"	84	14	"	B7	19
6	19	13	"	52	0D	"	85	15	"	B8	1A
9	20	00	"	53	0E	"	86	16	"	B9	1B
"	21	01	"	54	0F	"	87	17	"	C0	1C
"	22	02	"	55	10	"	88	18	"	C1	1D
"	23	03	"	56	11	"	89	19	"	C2	1E
"	24	04	"	57	12	"	90	1A	"	C3	1F
"	25	05	"	58	13	"	91	1B	"	C4	20
"	26	06	"	59	14	"	92	1C	"	C5	21
"	27	07	"	60	15	"	93	1D	"	C6	22
"	28	08	"	61	16	"	94	1E	"	C7	23
"	29	09	"	62	17	"	95	1F	"	C8	24
"	30	0A	"	63	18	"	96	20	18	C9	25
"	31	0B	"	64	19	"	97	21	18	D0	08
"	32	0C	12	65	1A	15	98	22	21	D1	09

TABLE VII-4.1

FIMS A MA-PPS COMMANDS

ORIGINAL PAGE IS
OF POOR QUALITY

Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA
21D	$D2_H$	$0A_H$	21_D	105_H	$2B_H$	24_D	138_H	29_H	27_D	171_H	18_H
"	D3	0B	"	06	2C	"	39	2A	"	72	19
"	D4	0C	"	07	2D	"	40	2B	"	73	1A
"	D5	0D	"	08	2E	"	41	2C	"	74	1B
"	D6	0E	21	09	2F	"	42	2D	"	75	1C
"	D7	0F	24	110	0D	"	43	3E	"	76	1D
"	D8	10	"	11	0E	"	44	2F	"	77	1E
"	D9	11	"	12	0F	"	45	30	"	78	1F
"	E0	12	"	13	10	"	46	31	"	79	20
"	E1	13	"	14	11	"	47	32	"	80	21
"	E2	14	"	15	12	"	48	33	"	81	22
"	E3	15	"	16	13	"	49	34	"	82	23
"	E4	16	"	17	14	"	50	35	"	83	24
"	E5	17	"	18	15	"	51	36	"	84	25
"	E6	18	"	19	16	"	52	37	"	85	26
"	E7	19	"	120	17	"	53	38	"	86	27
"	E8	1A	"	21	18	"	54	39	"	87	28
"	E9	1B	"	22	19	"	55	3A	"	88	29
"	F0	1C	"	23	1A	"	56	3B	"	89	2A
"	F1	1D	"	24	1B	"	57	3C	"	90	2B
"	F2	1E	"	25	1C	"	58	3D	"	91	2C
"	F3	1F	"	26	1D	24	59	3E	"	92	2D
"	F4	20	"	27	1E	27	60	0D	"	93	2E
"	F5	21	"	28	1F	"	61	0E	"	94	2F
"	F6	22	"	29	20	"	62	0F	"	95	30
"	F7	23	"	30	21	"	63	10	"	96	31
"	F8	24	"	31	22	"	64	11	"	97	32
"	F9	25	"	32	23	"	65	12	"	98	33
"	100	26	"	33	24	"	66	13	"	199	34
"	01	27	"	34	25	"	67	14	"	1A0	35
"	02	28	"	35	26	"	68	15	"	A1	36
"	03	28	"	36	27	"	69	16	"	A2	37
21_D	04	29	24_D	37_H	28_H	27_D	70	17	27_D	A3	38

TABLE VII-4.2

FIMS A MA-PPS COMMANDS

ORIGINAL PAGE IS
OF POOR QUALITY

Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA
27_D	$1A4_H$	39_H	30_D	$1D7_H$	28_H	33_D	210_H	$1A_H$	33_D	243_H	3B
"	A5	3A	"	D8	29	"	11	1B	"	44	3C
"	A6	3B	"	D9	2A	"	12	1C	"	45	3D
"	A7	3C	"	1E0	2B	"	13	1D	"	46	3E
"	A8	3D	"	E1	2C	"	14	1E	"	47	3F
27_D	A9	3E	"	E2	2D	"	15	1F	"	48	3F
30_D	1B0	0D	"	E3	2E	"	16	20	33_D	249	3F
"	B1	0E	"	E4	2F	"	17	21	36_D	250	10
"	B2	0F	"	E5	30	"	18	22	"	51	11
"	B3	10	"	E6	31	"	19	23	"	52	12
"	B4	11	"	E7	32	"	220	24	"	53	13
"	B5	12	"	E8	33	"	21	25	"	54	14
"	B6	13	"	1E9	34	"	22	26	"	55	15
"	B7	14	"	1F0	35	"	23	27	"	56	16
"	B8	15	"	F1	36	"	24	28	"	57	17
"	1B9	16	"	F2	37	"	25	29	"	58	18
"	1C0	17	"	F3	38	"	26	2A	"	259	19
"	C1	18	"	F4	39	"	27	2B	"	260	1A
"	C2	19	"	F5	3A	"	28	2C	"	61	1B
"	C3	1A	"	F6	3B	"	229	2D	"	62	1C
"	C4	1B	"	F7	3C	"	230	2E	"	63	1D
"	C5	1C	"	F8	3D	"	31	2F	"	64	1E
"	C6	1D	30_D	1F9	3E	"	32	30	"	65	1F
"	C7	1E	33_D	200	10	"	33	31	"	66	20
"	C8	1F	"	01	11	"	34	32	"	67	21
"	C9	20	"	02	12	"	35	33	"	68	22
"	1D0	21	"	03	13	"	36	34	"	269	23
"	D1	22	"	04	14	"	37	35	"	70	24
"	D2	23	"	05	15	"	38	36	"	71	25
"	D3	24	"	06	16	"	239	37	"	72	26
"	D4	25	"	07	17	"	240	38	"	73	27
"	D5	26	"	08	18	"	41	39	"	74	28
30_D	D6	27	33_D	09	19	33_D	41	3A	36_D	275	29

TABLE VII-4.3

ORIGINAL PAGE IS
OF POOR QUALITY

Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA
36_D	276_H	$2A_H$	39_D	$2A9_H$	19_H	39_D	$2E2_H$	$3A_H$	42_D	315_H	29_H
"	77	2B	"	2B0	1A	"	E3	3B	"	16	2A
"	78	2C	"	B1	1B	"	E4	3C	"	17	2B
"	79	2D	"	B2	1C	"	E5	3D	"	18	2C
"	280	2E	"	B3	1D	"	E6	3E	"	19	2D
"	81	2F	"	B4	1E	"	E7	3F	"	320	2E
"	82	30	"	B5	1F	"	E8	3E	"	21	2F
"	83	31	"	B6	20	39_D	2E9	3F	"	22	30
"	84	32	"	B7	21	42_D	2F0	10	"	23	31
"	85	33	"	B8	22	"	F1	11	"	24	32
"	86	34	"	2B9	23	"	F2	12	"	25	33
"	87	35	"	2C0	24	"	F3	13	"	26	34
"	88	36	"	C1	25	"	F4	14	"	27	35
"	289	37	"	C2	26	"	F5	15	"	28	36
"	290	38	"	C3	27	"	F6	16	"	329	37
"	91	39	"	C4	28	"	F7	17	"	330	38
"	92	3A	"	C5	29	"	F8	18	"	31	39
"	93	3B	"	C6	2A	"	F9	19	"	32	3A
"	94	3C	"	C7	2B	"	300	1A	"	33	3B
"	95	3D	"	C8	2C	"	01	1B	"	34	3C
"	96	3E	"	2C9	2D	"	02	1C	"	35	3D
"	97	3F	"	2D0	2E	"	03	1D	"	36	3E
"	98	3F	"	D1	2F	"	04	1E	"	37	3F
36_D	299	3F	"	D2	30	"	05	1F	"	38	3F
39_D	2A0	10	"	D3	31	"	06	20	"	339	3F
"	A1	11	"	D4	32	"	07	21	"	340	10
"	A2	12	"	D5	33	"	08	22	"	41	11
"	A3	13	"	D6	34	"	09	23	"	42	12
"	A4	14	"	D7	35	"	310	24	"	43	13
"	A5	15	"	D8	36	"	11	25	"	44	14
"	A6	16	"	2D9	37	"	12	26	"	45	15
"	A7	17	"	2E0	38	"	13	27	"	46	16
39	2A8	18	39_D	E1	39	42	314	28	"	47	17

TABLE VII-4.4

ORIGINAL PAGE IS
OF POOR QUALITY

Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA	Each	ADD	DATA
45_D	348_A	18_H	45_D	380_H	38_H	48_D	$3B2_H$	26_H	51_D	$3E4_H$	14_H
"	49	19	"	81	39	"	B3	27	"	E5	15
"	350	1A	"	82	3A	"	B4	28	"	E6	16
"	51	1B	"	83	3B	"	B5	29	"	E7	17
"	52	1C	"	84	3C	"	B6	2A	"	E8	18
"	53	1D	"	85	3D	"	B7	2B	"	3E9	19
"	54	1E	"	86	3E	"	B8	2C	"	3F0	1A
"	55	1F	"	87	3F	"	3B9	2D	"	F1	1B
"	56	20	"	88	3F	"	3C0	2E	"	F2	1C
"	57	21	45	389	3F	"	C1	2F	"	F3	1D
"	58	22	48	390	10	"	C2	30	"	F4	1E
"	59	23	"	91	11	"	C3	31	"	F5	1F
"	360	24	"	92	12	"	C4	32	"	F6	20
"	61	25	"	93	13	"	C5	33	"	F7	21
"	62	26	"	94	14	"	C6	34	"	F8	22
"	63	27	"	95	15	"	C7	35	"	3F9	23
"	64	28	"	96	16	"	C8	36	"	400	24
"	65	29	"	97	17	"	C9	37	"	01	25
"	66	2A	"	98	18	"	3D0	38	"	02	26
"	67	2B	"	399	19	"	D1	39	"	03	27
"	68	2C	"	3A0	1A	"	D2	3A	"	04	28
"	69	2D	"	A1	1B	"	D3	3B	"	05	29
"	370	2E	"	A2	1C	"	D4	3C	"	06	2A
"	71	2F	"	A3	1D	"	D5	3D	"	07	2B
"	72	30	"	A4	1E	"	D6	3E	"	08	2C
"	73	31	"	A5	1F	"	D7	3F	"	409	2D
"	74	32	"	A6	20	"	D8	3F	"	410	2E
"	75	33	"	A7	21	46_D	3D9	3F	"	11	2F
"	76	34	"	A8	22	51	3E0	10	"	12	30
"	77	35	"	A9	23	"	E1	11	"	13	31
"	78	36	"	3B0	24	"	E2	12	"	14	32
45_D	379_A	37_H	48_D	$B1_H$	25_H	51_D	$3E3_H$	13_H	51_D	15_H	33_H

TABLE VII-4.5

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EA	MA ADD	MA DATA	EA	MA EDD	MA DATA
51	416	34	00	450	0
"	17	35	00	51	0
"	18	36	00	52	0
"	19	37	00	53	0
"	20	38	00	54	0
"	21	39	00	55	0
"	22	3A	00	56	0
"	23	3B	00	57	0
"	24	3C	00	58	0
"	25	3D	00	59	0
"	26	3E	00		
"	27	3F	00		
"	28	3F	00		
"	29	3F	00		
"	430	00			
"	31	00			
"	32	00			
"	33	00			
"	34	00			
"	35	00			
"	36	00			
"	37	00			
"	38	00			
"	39	00			
"	440	00			
"	41	00			
"	42	00			
"	43	00			
"	44	00			
"	45	00			
"	46	00			
"	47	00			
"	48	00			
"	49	00			

C-2

TABLE VII-4.6

PARTS LIST | SOUTHWEST RESEARCH INSTITUTE, SAN ANTONIO, TEXAS | A | NO. [illegible]01 | PL 5680-1003

DRAWING TITLE: FIMS "A" INSTRUMENT WIRING DIAGRAM

SHEET 1

QTY REQ PER ASSY/INSTALL				UNIT OF MEAS.	FIND NO.	CODE IDENT. NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	NOTES
			3			A1, A2 A3	BBRC 52881-1	Hybrid Circuit Pad	CTI
			2			A4, A5	LM108A	OP-AMP	QPL
			1			CR-1	IN963	12.0V 1/4W Zener	QPL
			7			C1,2,3, 4,5,6,14	CK06BX104K	0.1µF 100V Ceramic	QPL
			4			C7,9,10 12	CK05BX103K	0.01µF 100V Ceramic Cap	QPL
			2			C8, C11	CK05BX101K	100pF 100V Ceramic Cap	QPL
			1			C13	CSR13F336K	33µF 35V Tantalum Cap	QPL
			3			X1,2,3	6x20mm Series 4800	Channel Electron Multiplier	Galileo
			1			R1	RCR07G102J	1.0KΩ 1/4W 5% carbon	QPL
			4			R2,3, 4,5	RN55D1002J	10KΩ 1/8W 1% film resistor	QPL
			1			R6	MG721	100MΩ 1% 5kv resistor	CADDOCK
			4			R7,9,11 13	MOX 750	100KΩ 1% 5kv resistor	VICTOREEN
			1			R8	RCR07G222J	2.2kΩ 1/4W 5% carbon	QPL
			3			R10,12, 14	MOX 750	1 megΩ 1% 5FV resistor	VICTOREEN
			4			R15,16, 17,18	MOX 750	10 megΩ 1% 5KV resistor	VICTOREEN
			3			C15,17, 19	X5F	33PF 5KV Ceramic Cap	ERIE
			3			C16,18, 20	X5F	1000PF 5KV Ceramic Cap	ERIE

FIG. VII-

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APPENDIX B

FIMS MODEL B

HARDWARE/SOFTWARE REFERENCE MANUAL

SOUTHWEST RESEARCH INSTITUTE
Post Office Drawer 28510, 6220 Culebra Road
San Antonio, Texas 78284

FAST ION MASS SPECTROMETER MODEL B HARDWARE/SOFTWARE REFERENCE MANUAL

Submitted to

The National Aeronautics and Space Administration
NASA Headquarters
Office of University Affairs

By

The Space Science Department
Instrumentation Research Division
Southwest Research Institute
Project 15-5680

The work performed under NASA Contract NASW-3237,
the Development of a Fast Ion Mass Spectrometer.

September, 1981

Approved:

John R. Barton

John R. Barton, Vice President
Instrumentation Research Division

TABLE OF CONTENTS

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I. INTRODUCTION

This document provides a single source for all FIMS operational, calibration and repair information. It is hoped that this document will be of assistance in the field operation of the FIMS instrument should any problems arise. Sufficient information is contained herein to troubleshoot the instrument in the field. All test and calibration records will be kept in this document as well.

The second purpose of this document is to aid in the development of future generations of similar ion mass spectrometers. The experience gained in the laaboratory and the field with the FIMS B instrument will be of critical assistance in the development of similar instruments for other satellite and rocket-borne instruments.

The introductory section of this document contains a copy of a paper published in the Review of Scientific Instruments which describes in some detail the geometry of the analyzer sections of the FIMS-A and FIMS-B instruments. As is described in this paper, the primary difference between FIMS-A and FIMS-B is in the area of the electrostatic energy analyzer and the detectors. The nomenclature "FIMS-A" refers to that instrument which uses the cylindrical energy analyzer and an array of three channel electron multipliers. The "FIMS-B" instrument uses a spherical energy analyzer and a microchannel plate array with a resistive anode following. The central electronics packages for the two instruments are also different. The FIMS-A instrument will be flown for the first time on the A rocket payload of the two payloads produced by the SwRI Department of Space Sciences during the summer of 1981.

This document will serve as a combination Design Specification and Instrument Log Book and should be kept with the FIMS B instrument at all times. Figure I-1 is a picture of the fully assembled FIMS-B instrument. Not shown in the picture is the instrument's Central Electronics Package. Figure I-2 is a block diagram of the total instrument system.

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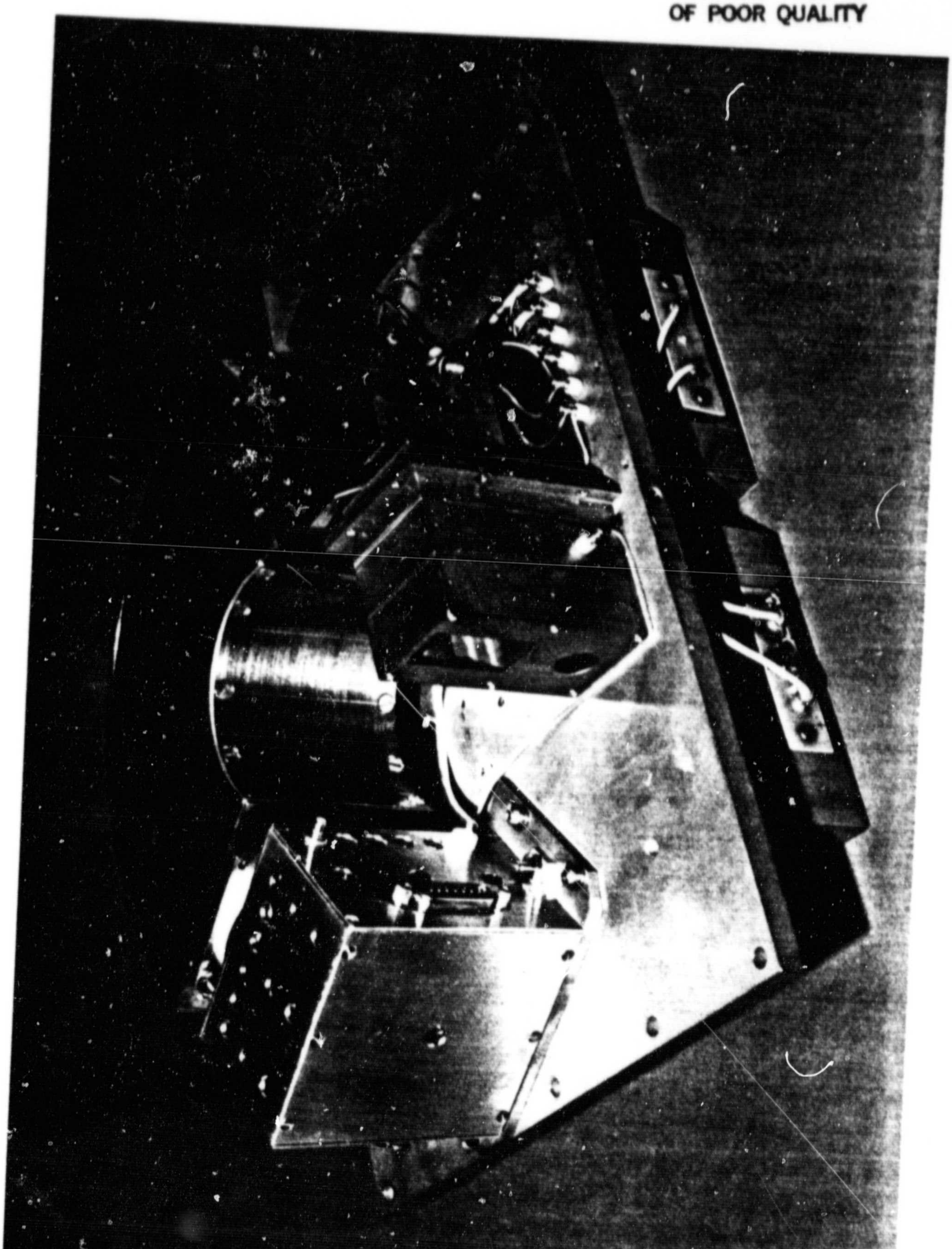

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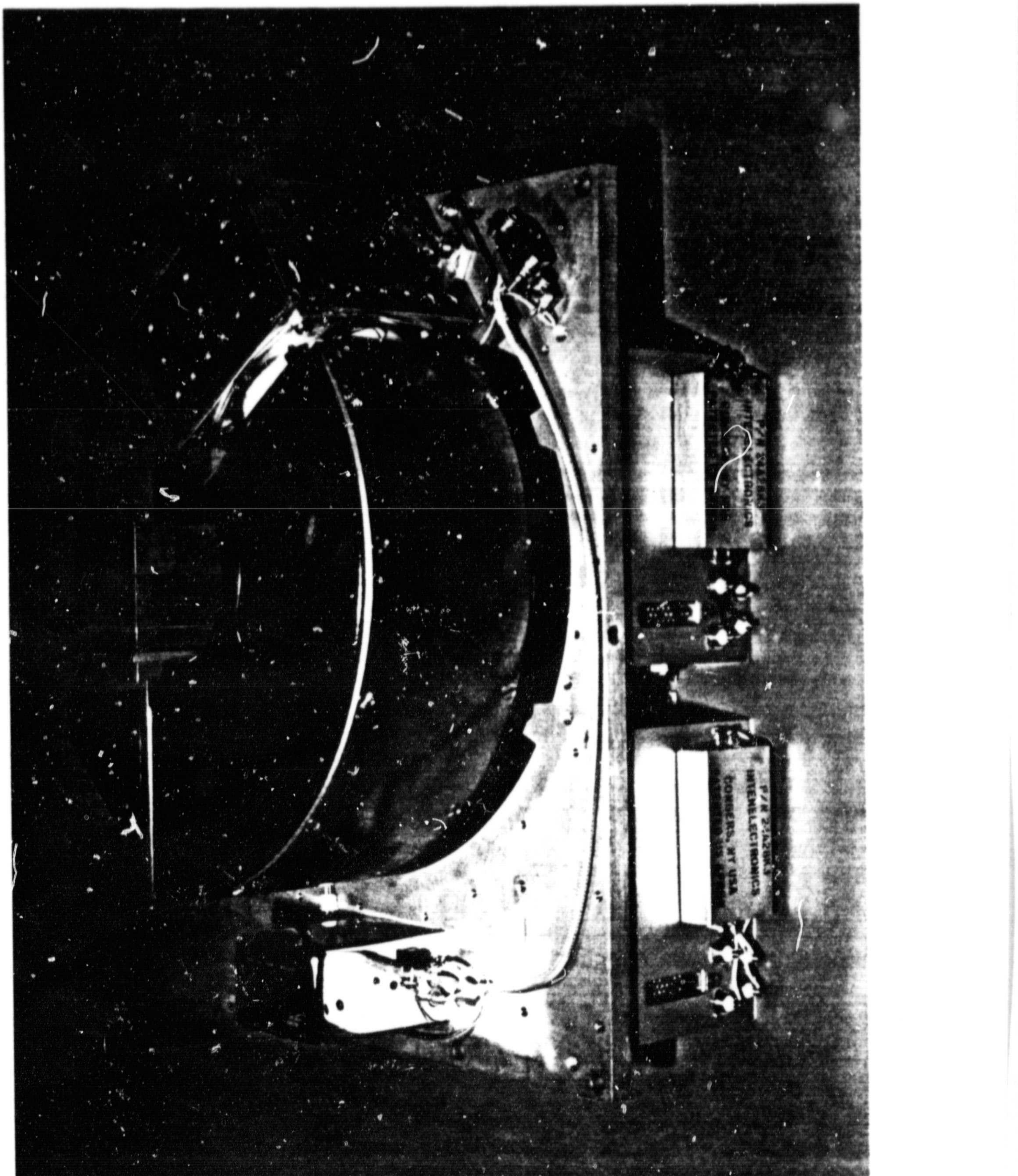

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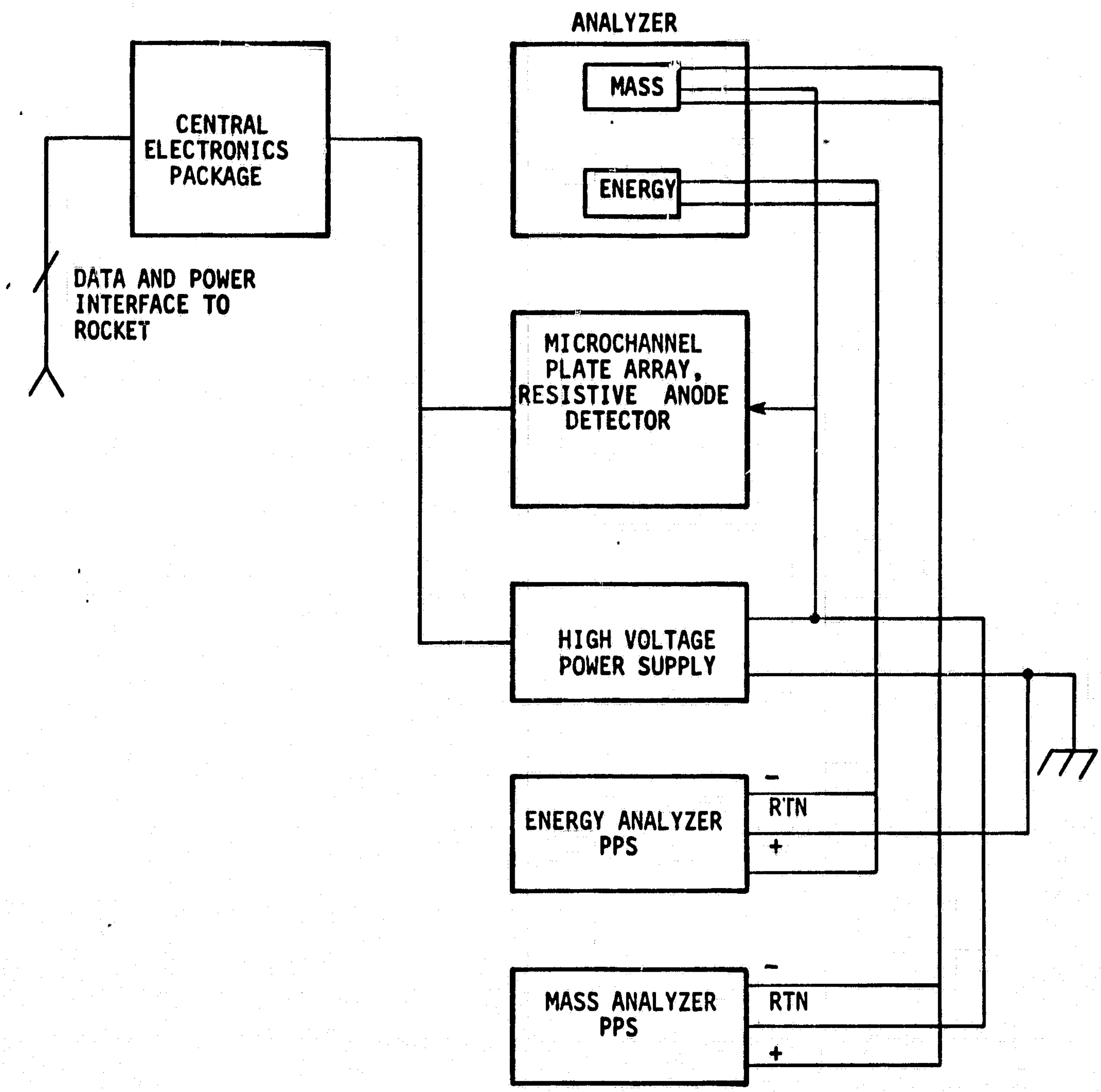

FIGURE I-2. FIMS INSTRUMENT BLOCK DIAGRAM

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II. QUICK-LOOK TEST INFORMATION

The FIMS-B instrument produces three digital data channels, S27, S31 and S32. FIMS-B also produces two analog signals noted as A39 and A40. Digital chanel S27 is located in word 13, all frames, and contains the FIMS B scientific information. It is a 9-bit digital word with all of the information contained in the 8 most significant bits. The least significant bit of the 9-bit word is not used by the instrument.

Channel S31 (word 8, frame 19) is used to transmit the mass analyzer program power supply command word. It is also a 9-bit digital word with the instrument information again contained in the 8 most significant bits of that word. The third digital channel is S32 (word 9, frame 20) and is used to transmit the energy analyzer PPS command words to P.C.M. As is the case with the other two digital channels, channel S32 uses only the 8 most significant bits. The two analog channels, A39 (word 6, frame 27) and A40 (word 6, frame 19) contain the analog monitors from the energy analyzer program power supply. Channel A39 contains the positive output monitor signal and A40 the negative output.

At the onset of low voltage to the FIMS Central Electronics Package, a stepping value will be seen on both S31 and S32. Figures II-1 and II-2 are sample stripchart recordings made of these two channels under normal operating conditions. It should be noted that the strip chart recorder which produced these signals was carefully calibrated for a deflection of 10 counts/major division with the knowledge that the 2' bit of the 9-bit data word is the least significant bit of the word. In other words, when calibrating the stripchart recorder for use in FIMS B testing, use the second least significant bit rather than the least significant bit to represent a count of "1" for the calibration. It is not necessary for routine testing to recalibrate the stripchart recorder just for a FIMS B test. It is possible to observe the general waveform of these two stepping counts to ensure basic function of the Central Electronics Package. Word S27 will not contain any count information unless the signal input test is being conducted. Details for the signal input test for the FIMS B instrument are described in the following section of this manual.

Likewise, analog channels 39 and 40 will not contain any information unless the FIMS B high voltages have been turned on. If the high voltages have been applied, then a stepping signal will be seen on these two channels such as is shown in Figure II-3. Both of these channels should step at the same rate and contain approximately the same signals. It is expected that under normal circumstances these two signals should track each other to within 10%. Again, no data will be obtained from these two data channels unless high voltages are applied to the instrument.

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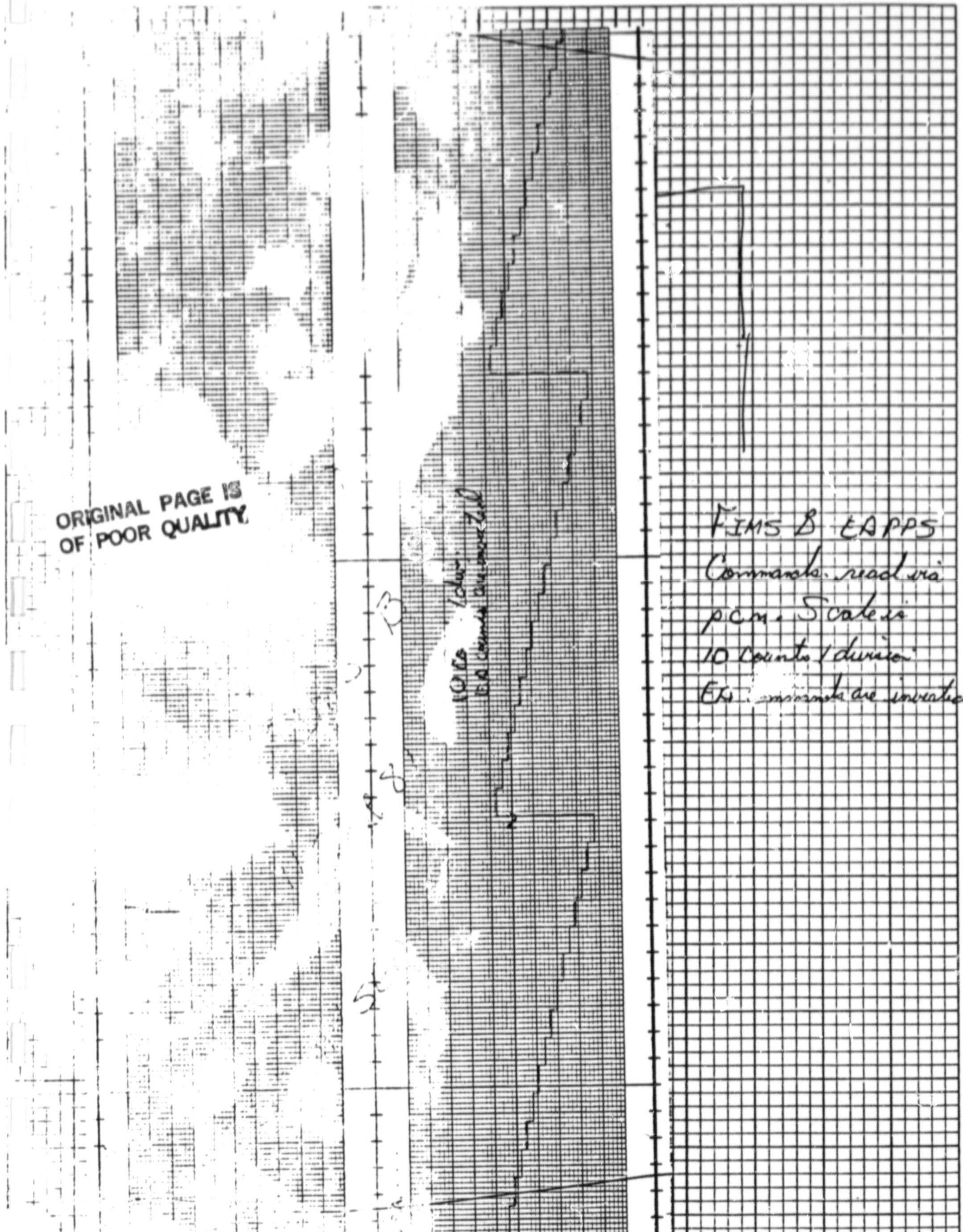

FIGURE II-1
ENERGY ANAL. PPS STEP VALUES

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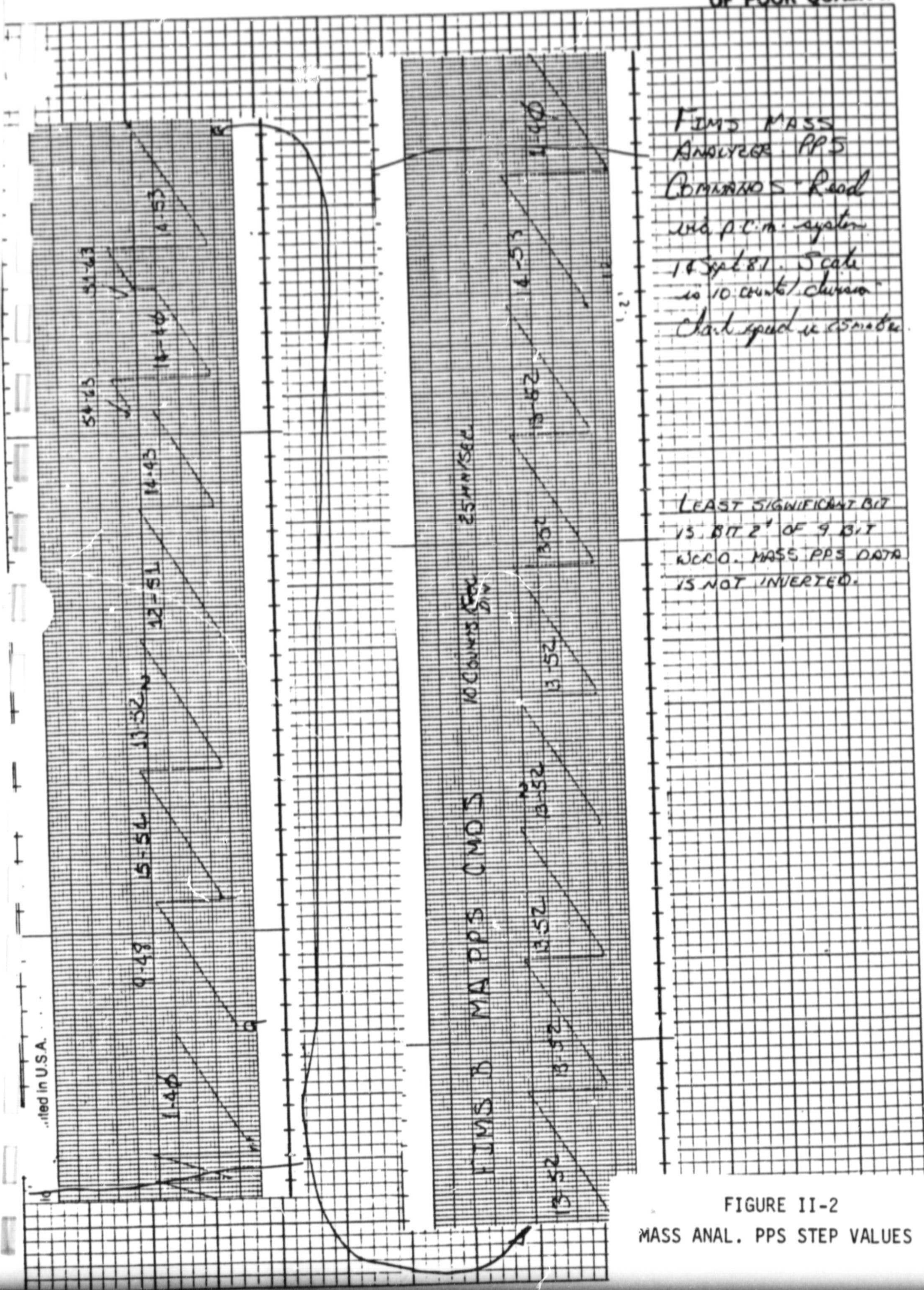

FIGURE II-2
MASS ANAL. PPS STEP VALUES

III. SIGNAL INPUT TEST PROCEDURE

A. Equipment Required

To perform this test the following items will be required:

1. Pulser (i.e. HP8010A) capable of producing a 50ns wide, 100mv pulse at a repetition rate of 8500/sec.

2. Two dial-selectable attenuators. One attenuator should be capable of attenuating in 1 dB steps, while the second should attenuate in 10 dB steps.

3. Single channel oscilloscope, with vertical bandwidth of 100 mHz.

4. One 50 ohm terminator, packaged in a standard BNC-type connector shell.

5. Frequency counter capable of counting 100mv, 50ns wide pulses.

B. Pulser Adjustment

1. Configure the equipment listed above in the manner shown in Figure III-1.

2. With all equipment operating, adjust the output of the pulser to produce a 100mv low-going pulse, 50ns wide. The low-going pulse should drop to 0V, with the high level at +100mv. The leading and trailing edge transition times should be adjusted to approximately 20ns each, although experience has shown that the instrument is not particularly sensitive to transition times. It is assumed that at the time of these adjustments the two dial-selectable attenuators are set to zero and the 50 ohm attenuator is attached to the pulser.

3. Adjust the repetition rate of the pulser to produce an 8500 pulse/second rate.

4. Turn off the pulser, remove the 50 ohm terminator and attach the FIMS-B test cable to the attenuators. Set the dial selectable attenuators for a total of 25 dB.

C. Instrument/Payload Operation

1. With the instrument power off and the pulser off, attach the FIMS-B test cable to the test input connector on the instrument's detector.

2. Apply low voltage only to the FIMS-B instrument, then to the pulser.

3. On the rocket's P.C.M. decommutator dial up word 13, frame 28.

4. With the pulser at 8500 pulses/second, the decommutator should be reading approximately full scale (8 MSB's set). If it is not, adjust the dial slectable attenuators in 1dB steps until counts appear. It should not be necessary to reduce the attenuation below 20dB if the instrument is functioning normally.

5. Select word 13, frame 27, on the decommutator. Under normal operating conditions the instrument will produce a few counts in this channel when frame 28 is near full scale. No other frames for word 13 should have any counts.

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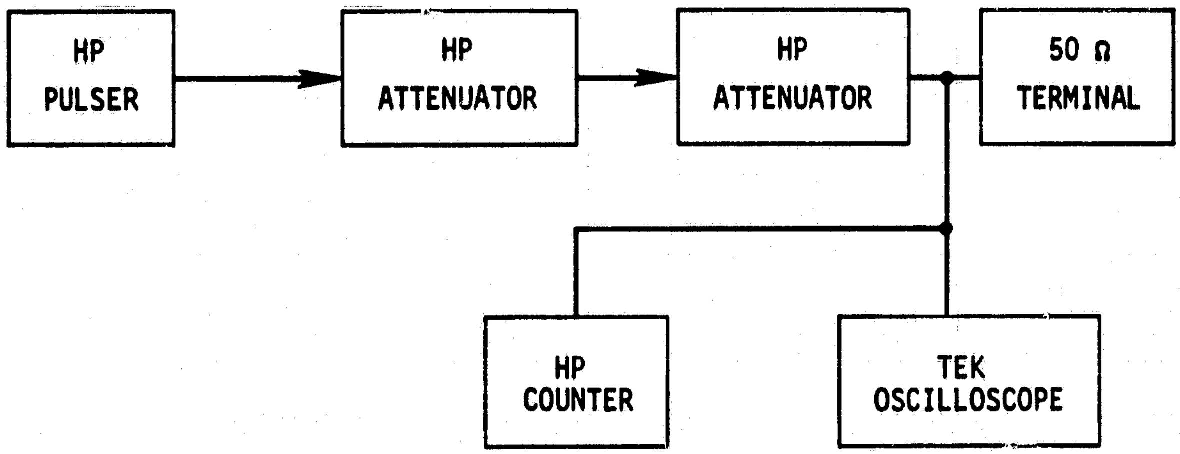

FIGURE III-1. SIGNAL INPUT TEST CONFIGURATION

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```
HEADER
NAME:FIMSB ANGLE CALIBRATE
INNER CHANNEL
THETA
 9  4 81
14 28  0
BEAM MASS:H2
BEAM CURRENT: 500.000
BEAM DEFLECTION VOLTAGE:    0.000
BEAM DEFLECTION CURRENT:    .250
X SWEEP VOLTAGE:     4.000
X SWEEP FREQUENCY:5000.000
Y SWEEP VOLTAGE:     4.000
Y SWEEP FREQUENCY:15000.00
      .049      .049     2.078     2.498     2.300      .005      .116    -5.152 510.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .002      .116    -5.152 500.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .005      .116    -5.152 490.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1223118 5 0 1 0 0 0
  0 0 0 0 0 0 1 1 0 0 0 2 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.297      .002      .116    -5.152 480.000
  0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 011 9 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .002      .116    -5.152 470.000
  0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0194726 5 2 1 0 0 0
  0 0 0 0 0 0 0 1 1 2 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .005      .116    -5.152 460.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3 815 4 0 0 0 0 0
  0 0 0 0 0 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .005      .116    -5.152 450.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .005      .116    -5.152 440.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .005     2.150    -5.152 440.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 41323 4 0 0 1 0 0
  0 0 0 1 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .002     2.150    -5.257 440.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 14131 6 1 2 0 0 0
  0 0 0 0 0 0 1 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .005     2.150    -5.257 430.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0
  0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

      .049      .049     2.078     2.498     2.300      .005     2.150    -5.257 450.000
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3362810 0 1 0 0 0 0
```

```
 .049   .049   2.078   2.498   2.297   .005   2.150  -5.257 460.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.297   .002   3.894  -5.361 460.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.300   .002   3.894  -5.361 450.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.300   .005   3.894  -5.361 440.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0

 .049   .049   2.078   2.498   2.300   .005   3.022  -5.257 440.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 3 03320 3 2 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.297   .002   3.022  -5.257 450.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.297   .005   3.022  -5.361 430.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

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```
 .046   .049   2.078   2.498   2.297   .005  -2.209  -4.943 430.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.297   .002  -2.209  -4.943 440.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.300   .005  -2.209  -4.943 450.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.300   .005  -2.209  -4.943 460.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.300   .005  -2.209  -4.943 470.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 8 2 1 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.075   2.498   2.300   .002  -2.209  -4.943 480.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 51917 0 0 0 0 0 0
0 0 0 0 0 1 2 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.297   .002  -2.209  -4.943 490.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 42416 3 0 0 0 0 0
0 0 0 0 0 0 0 0 1 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0

 .046   .049   2.078   2.498   2.300   .005  -2.209  -4.943 500.000
0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 911 8 2 0 0 0 0 0
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

 .049   .049   2.078   2.498   2.300   .005  -2.209  -4.943 510.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 4 1 0 2 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

```
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0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.300     .002   -3.081   -4.943  520.000
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.297     .005   -3.081   -4.943  530.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.297     .005   -3.081   -4.943  500.000
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0 0 0 0 0 0 0 0 0 0 0 0 0 2 2 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.300     .005   -3.081   -4.943  490.000
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0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.300     .005   -3.081   -4.943  480.000
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0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.300     .002   -3.081   -4.943  470.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.297     .002   -4.825   -4.838  470.000
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.297     .005   -4.825   -4.838  480.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.297     .005   -4.825   -4.838  490.000
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0

    .049     .049    2.078    2.498    2.300     .005   -4.825   -4.838  500.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0
```

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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 1 0 5 9 0 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0

.042 .044 2.136 2.439 2.297 .002 -3.953 -5.047 540.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 2 2 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

.042 .044 2.136 2.439 2.297 .002 -3.953 -5.047 520.000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

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VII. DESIGN INFORMATION

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A. Analyzers

The energy and mass analyzer design aspects of FIMS-B were described earlier in this document, and no furhter information on the analyzers will be presented. The following pages of this section of the document will present a description of the instruments Central Electronics Package.

B. Central Electronics Package

The Central Electronics Package designed for the FIMS B instrument is radically different from that used by the FIMS A instrument. This system is designed around the INTEL 8085 A-2 microprocessor. Figures VII-1 through VII-5 are the detailed schematic diagrams of the FIMS B central electronics package. This system is contained completely on a single printed circuit board. The microprocessor-based controller is a totally interrupt-driven system with interrupting sources being the SF 2^4 timing signal, the MF 2^3 timing signal and the data ready (D.R.) flag from the microchannel plate array detector.

In normal operation the microprocessor is interrupted every 25ms by the SF 2^4 signal to indicate the start of a new major frame of data. Responding to this interrupt, the microprocessor updates the commands to the two program power supplies based on values stored earlier in a look-up table, the values for which were derived from the instrument calibration. After updating the two command words to the PPS line drivers, the microprocessor makes a 1 to 0 to 1 transition on the shift-load line of the two shift registers which are used to send power supply step values to the telemetry system. In other words, the shift load command for the two shift registers used to send PPS values to telemetry is software generated.

Following the update of the two PPS commands, the 8085-based controller disables its science data acquisition for a period of 3 minor frames, or for approximately 2.4ms. This dead time is allowed for PPS settling. However, even during the 2.4ms dead time for scientific data acquisition, the microprocessor still is able to send data acquired during the previous major frame to telemetry based on the arrival of the MF 2^3 timing signal which generates the third processor interrupt. When interrupted by MF 2^3, the microprocessor performs an address pointer manipulation to fetch the next stored value of science data word to telemetry.

Science data information is presented to the Central Electronics Package of the FIMS B instrument in the form of a 6-bit wide address with handshaking flag. The four least significant bits of this 6-bit word represent the binary address of the X-location on the resistive anode detector where a particle event has occured. The two most significant bits of the 6-bit address represent the binary address of the Y location on the resistive anode of the particle event. To the microprocessor, the interface appears to be a simple, 6-bit memory address with a handshaking flag that is used both to latch the data into the 8155 hardware interface

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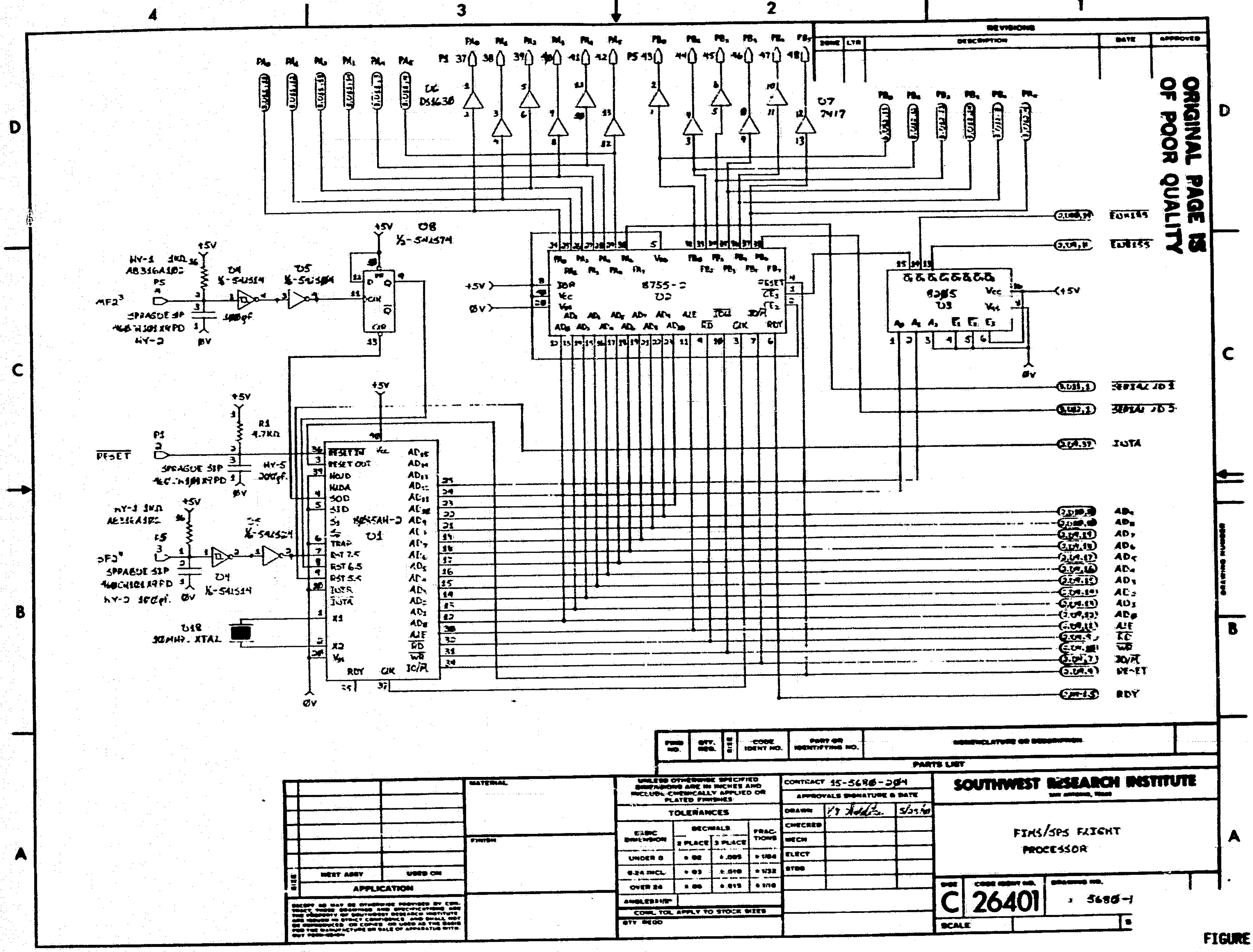
chip and to generate the software interrupt to the 8085. Handshaking with the microchannel plate detector instrument is not completed until the 8085 has had a chance to read the data from the port B interface of the 8155, thus clearing the B buff-full handshaking flag. This ensures that the instrument will not attempt to send new science information to the CEP until the previous information has been properly digested. Stated in its most elemental form, the FIMS B CEP functions as a 64-channel multi-channel analyzer. Each time a 6-bit address is presented to the microprocessor and an interrupt generated, the corresponding memory location in the 64-word science data buffer memory is fetched, incremented by 1 and stored back. This is exactly the same procedure used with any laboratory-style multichannel analyzer.

The flight CEP described here contains a double-buffered memory system whereby two sets of 64 locations are reserved for the science data counts. Two buffers are preserved so that one can be reserved for data incoming from the instrument while the second buffer is used for sending data out to telemetry. At the end of each major frame, signalled by a high-going transition on the SF 2^4 timing signal, the buffer pointers are switched and the buffer previously used for storing incoming science information now becomes the output buffer for data going to telemetry. This technique preserves the integrity of the data as a block thus data that is presented in minor frame 1 has the same staleness as the data presented in minor frame 32.

As mentioned earlier, the microprocessor based controller is totally interrupt driven. The SF 2^4 timing flag initiates the process whereby the microprocessor updates the PPS commands to both program power supplies and also loads these new PPS commands in the telemetry data output shift registers. The SF 2^4 timing flag also initiates a 3-minor frame long blanking period where no new science data interrupts are acquired. Within the three minor frame dead time, however, interrupts are allowed from the MF 2^3 timing flag and are used to initiate the process of sending the next available science data word to telemetry. Stated another way, the first MF 2^3 interrupt which arrives at the microprocessor after the SF 2^4 interrupt is used to flag to the microproprocessor that it should present data from its buffer location 1 to telemetry, likewise the 32nd MF 2^3 interrupt to the microprocessor flags to the software that it should send the 32nd memory location from its science data buffer to telemetry. This results in a very simple mapping technique. The only aspect of this operation which is the least bit involved is the process whereby the numer of data channels sent to telemetry is reduced from the 64 channels produced by the instrument down to the 32 channels forwarded to telemetry. The 32 middle channels of the 64 total are sent to telemetry. This mapping function was arrived at by the simple knowledge of geometry of the instrument, that is channels 0 through 15 are channels which are not struck by particles under normal operation of the analyzer section of the instrument. Likewise, channels 48 through 64 do not contain any scientific information from the instrument.

Contained in the following few pages of this section of the document is a copy of the software listings which are used to control the operation of the FIMS B microprocessor based Central Electronics Package. As seen, the software was written in 8085 assembly language and is now stored in the erasable prom section of the 8755 integrated circuit.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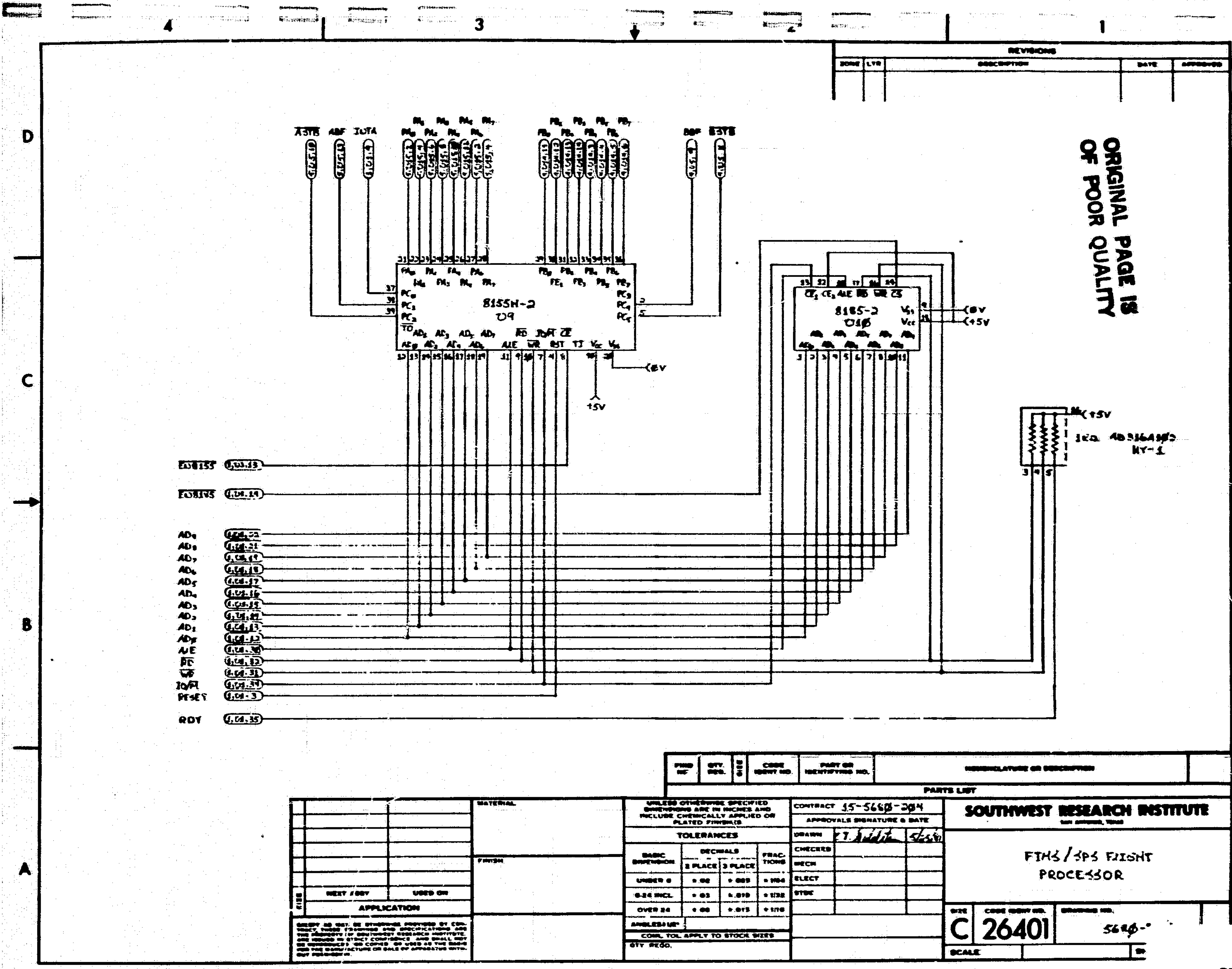
8755-2 U2
8085AH-2 U1
U7 7417
U6 DS1638
U8 ½-54LS74
30MHz. XTAL
SOUTHWEST RESEARCH INSTITUTE
FIMS/SPS FLIGHT PROCESSOR
CONTRACT 15-5686-204
C 26401
5686-1
PARTS LIST
TOLERANCES
APPLICATION
REVISIONS

FIGURE VII-1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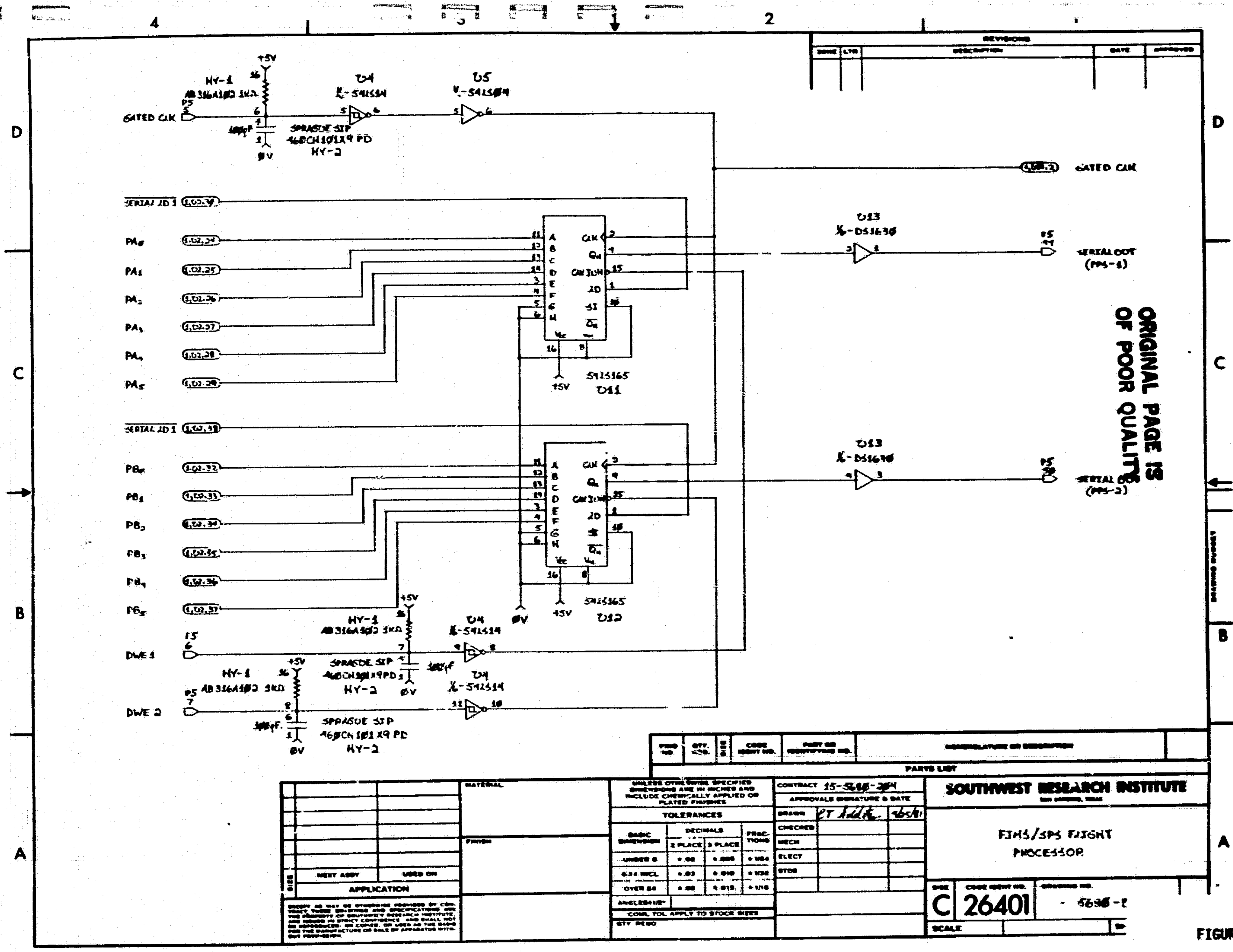
8155H-2
U9
8185-2
U10
+5V
0V
SOUTHWEST RESEARCH INSTITUTE
CONTRACT 15-5660-004
FTHS/SPS FLIGHT PROCESSOR
C
26401
TOLERANCES
PARTS LIST
APPLICATION

FIGURE VII-2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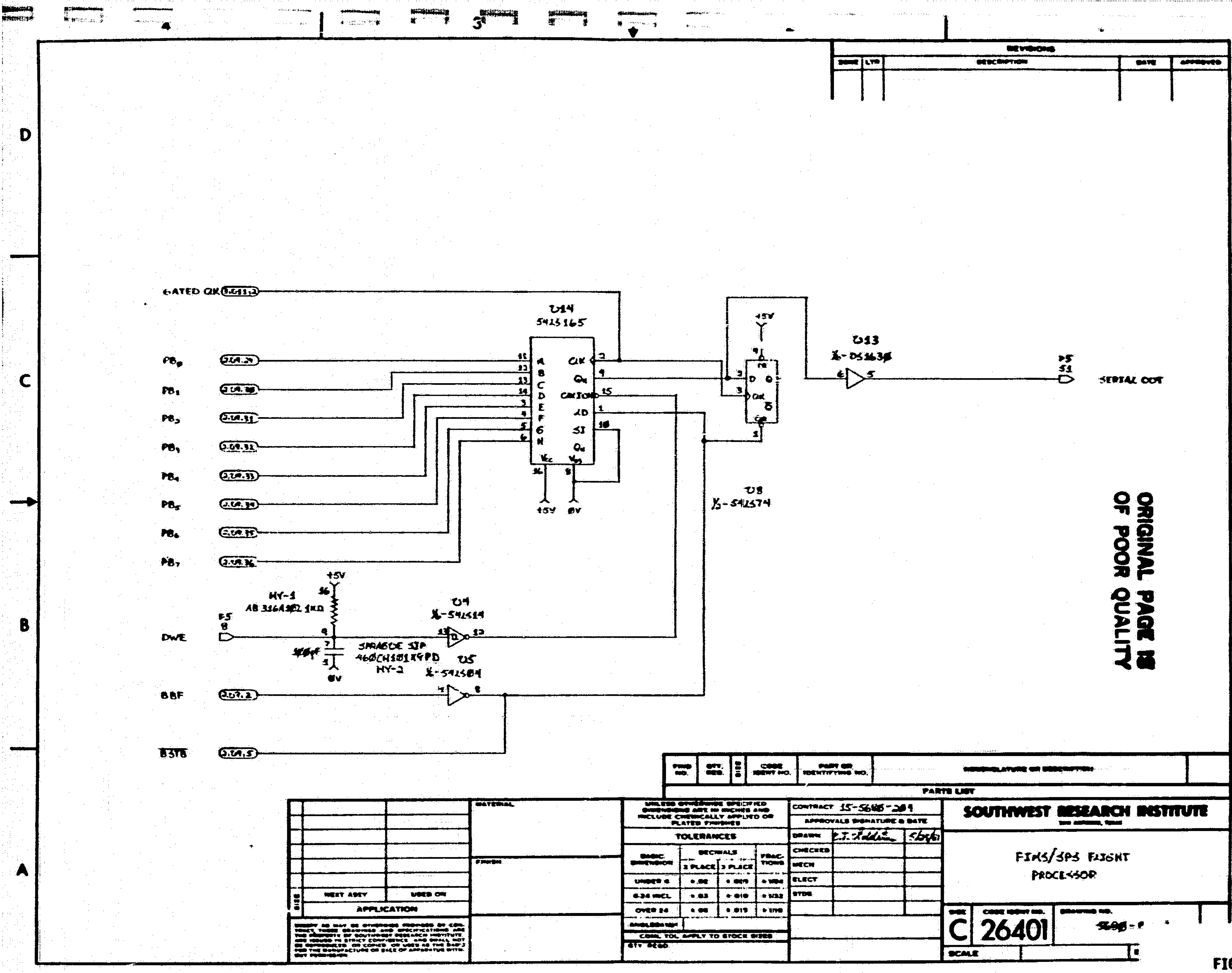
GATED CLK
SERIAL ID 1
PA0
PA1
PA2
PA3
PA4
PA5
PB0
PB1
PB2
PB3
PB4
PB5
DWE 1
DWE 2
SERIAL OUT
(PPS-1)
(PPS-2)
54LS165
U11
U12
U13
U4
U5
HY-1
HY-2
SPRAGUE SIP
+5V
CONTRACT 15-5686-304
APPROVALS SIGNATURE & DATE
TOLERANCES
PARTS LIST
APPLICATION
NEXT ASSY
USED ON
MATERIAL
FINISH
SOUTHWEST RESEARCH INSTITUTE
FIMS/SPS FLIGHT
PROCESSOR
C
26401
SCALE

FIGURE VI



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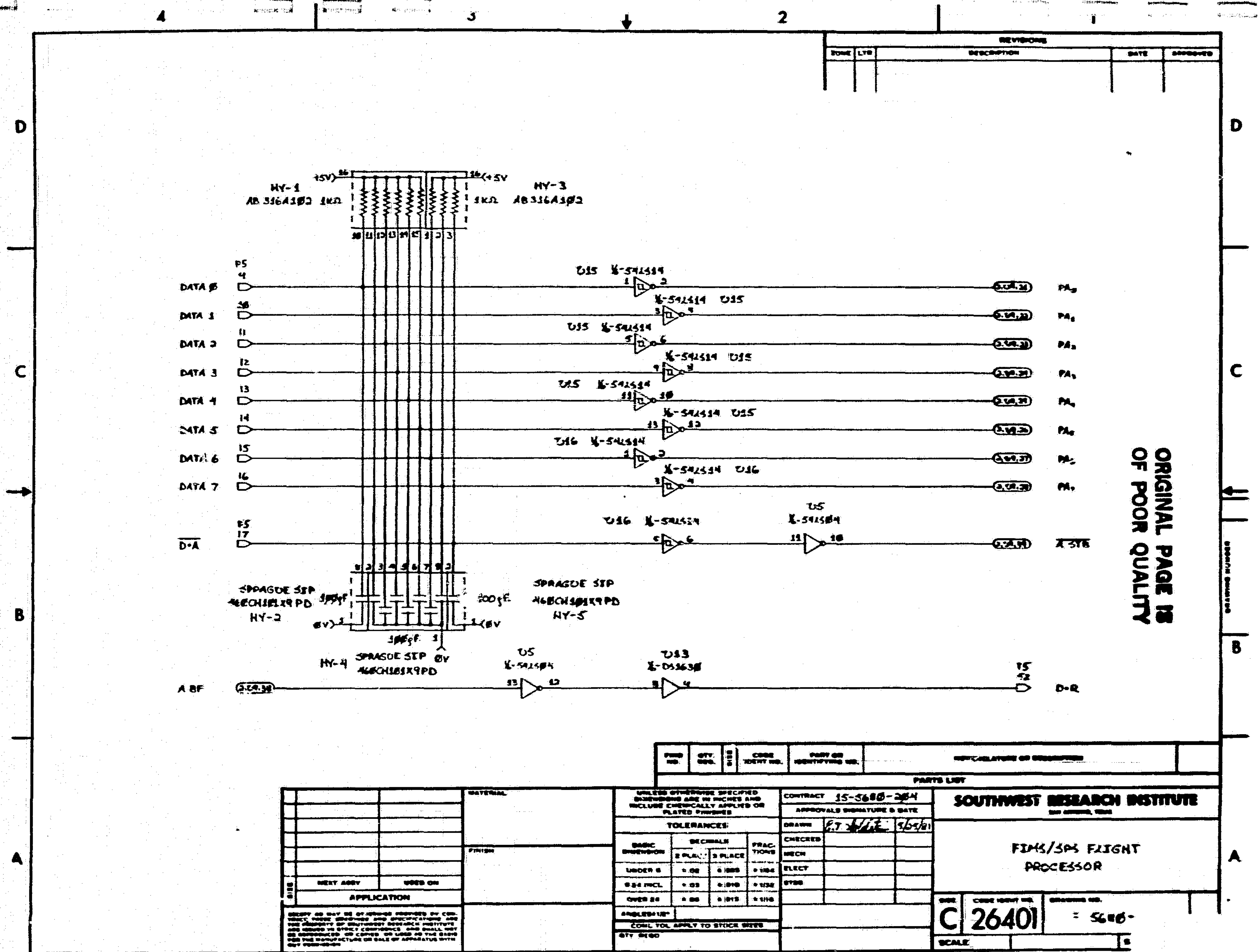
GATED CLK
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
DWE
BBF
BSTB
U14
54LS165
U13
½-DS1630
U8
½-54LS74
U4
⅙-54LS14
U5
⅙-54LS04
SERIAL OUT
+5V
0V
HY-1
HY-2
SPRAGUE SIP
SOUTHWEST RESEARCH INSTITUTE
FIMS/SPS FLIGHT
PROCESSOR
C
26401
CONTRACT 15-5686-204
APPLICATION
TOLERANCES
PARTS LIST
REVISIONS

FIGURE VII-4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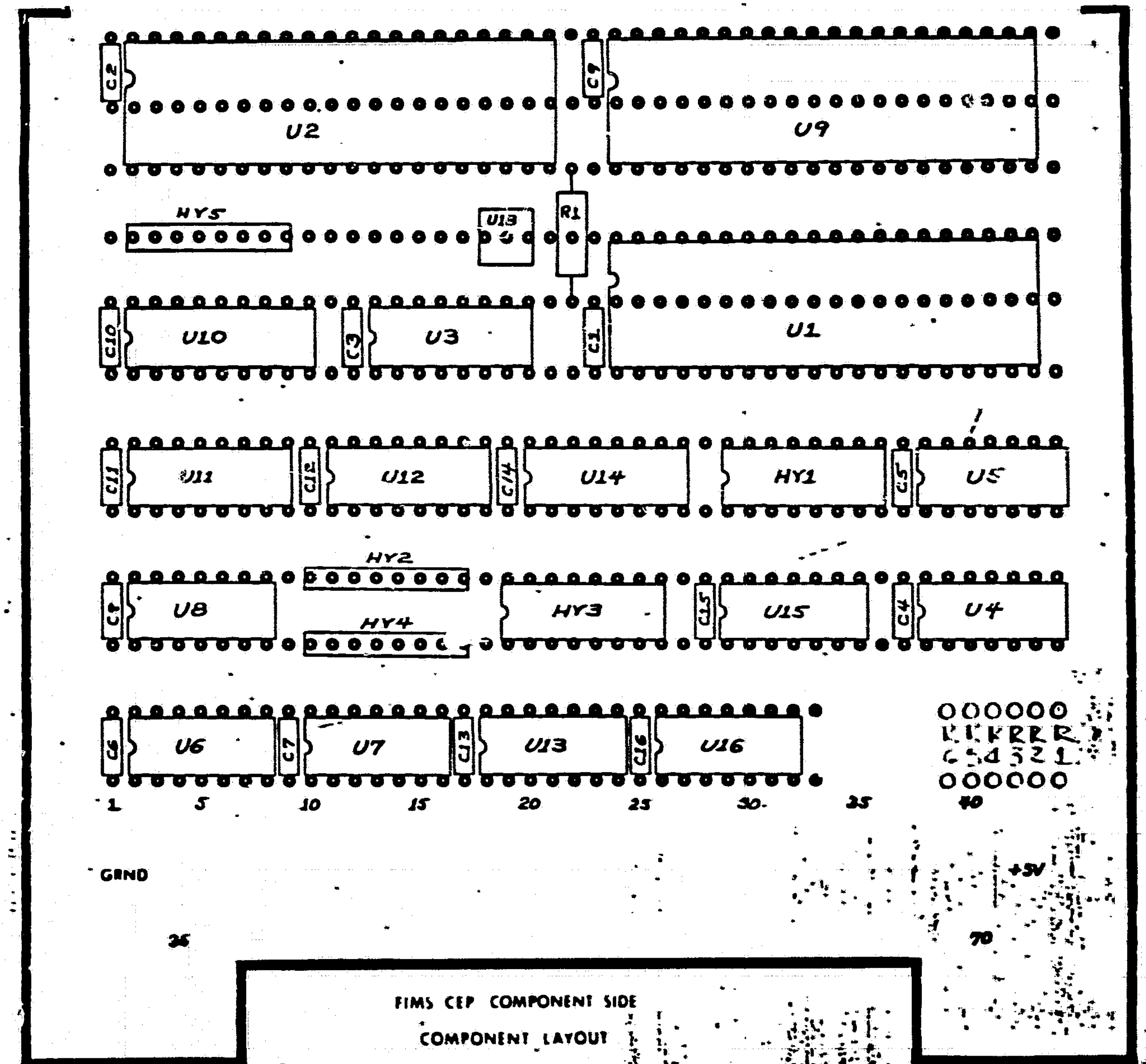
HY-1 AB 316A1Ø2 1KΩ
HY-3 AB 316A1Ø2
+5V
DATA Ø
DATA 1
DATA 2
DATA 3
DATA 4
DATA 5
DATA 6
DATA 7
D·A
A BF
P5
U15
U16
U5
U13
SPRAGUE SIP
HY-2
HY-4
HY-5
200pF
ØV
X STB
D·R
PARTS LIST
SOUTHWEST RESEARCH INSTITUTE
CONTRACT 15-5680-284
FIMS/SPS FLIGHT PROCESSOR
C 26401
TOLERANCES
APPLICATION
NEXT ASSY
USED ON
MATERIAL
FINISH
SCALE

FIGURE VII-

1 REQD

FIMS/SPS
FLIGHT PROCESSOR.
15-5680
3-JULY-81



FIMS CEP COMPONENT SIDE
COMPONENT LAYOUT

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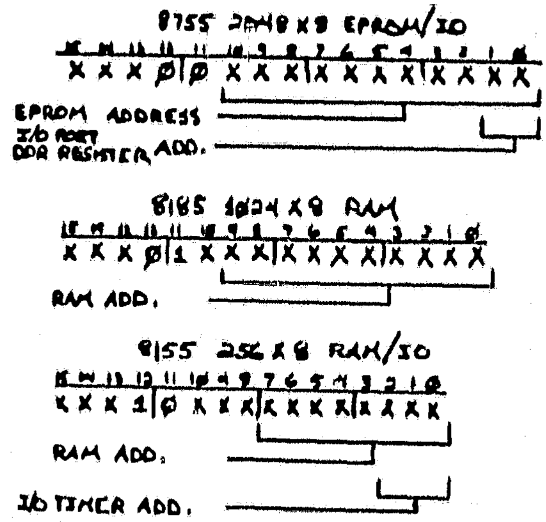

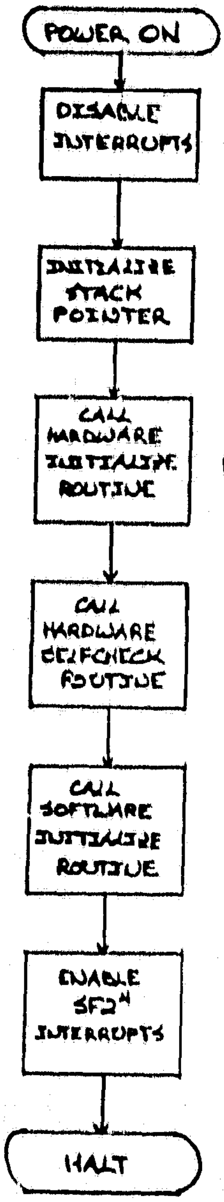

STACK → 10FF - 1000

MA PPS - 8755 PORTA ØØ,Ø2
EA PPS - 8155 PORTB Ø1,Ø3
DATA IN - 8155 PORTA/C 10,11
DATA OUT - 8155 PORTB/C 10,12

EIFLG
1 → ALL MEMORY READ/WRITE O.K.
Ø → 1 OR MORE MEMORY LOCATION READ/WRITE ERROR.

POSSIBLE
HARDWARE CONFIGURATIONS

8755	8185	8155	
ØØØØ - Ø7FF ✓	Ø8ØØ - ØBFF ✓	1ØØØ - 1ØFF ✓	MEMORY
2ØØØ - 27FF	28ØØ - 2BFF	11ØØ - 11FF	
4ØØØ - 47FF	48ØØ - 4BFF	12ØØ - 12FF	
6ØØØ - 67FF	68ØØ - 6BFF	13ØØ - 13FF	
8ØØØ - 87FF	88ØØ - 8BFF	14ØØ - 14FF	
AØØØ - A7FF	A8ØØ - ABFF	15ØØ - 15FF	
CØØØ - C7FF	C8ØØ - CBFF	16ØØ - 16FF	
EØØØ - E7FF	E8ØØ - EBFF	17ØØ - 17FF	
	ØCØØ - ØFFF	3ØØØ - 3ØFF	
	⋮	31ØØ - 31FF	
	ECØØ - EFFF	37ØØ - 37FF	
		FØØØ - FØFF	
		F7ØØ - F7FF	
ØØ - Ø3 ✓	—	ØØ - Ø7	I/O
Ø4 - Ø7		Ø8 - ØF	
Ø8 - ØB		1Ø - 17 ✓	
ØC - ØF		18 - 1F	
⋮		⋮	
FØ - F3		EØ - E7	
F4 - F7		E8 - EF	
F8 - FB		FØ - F7	
FC - FF		F8 - FF	

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8155 256 X 8 RAM 256

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
X	X	X	1	Ø	X	X	X	RAM ADD.							

8185 1024 X 8 RAM

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
X	X	X	0	1	X	RAM ADR.									

8755 2048 X 8 EP ROM

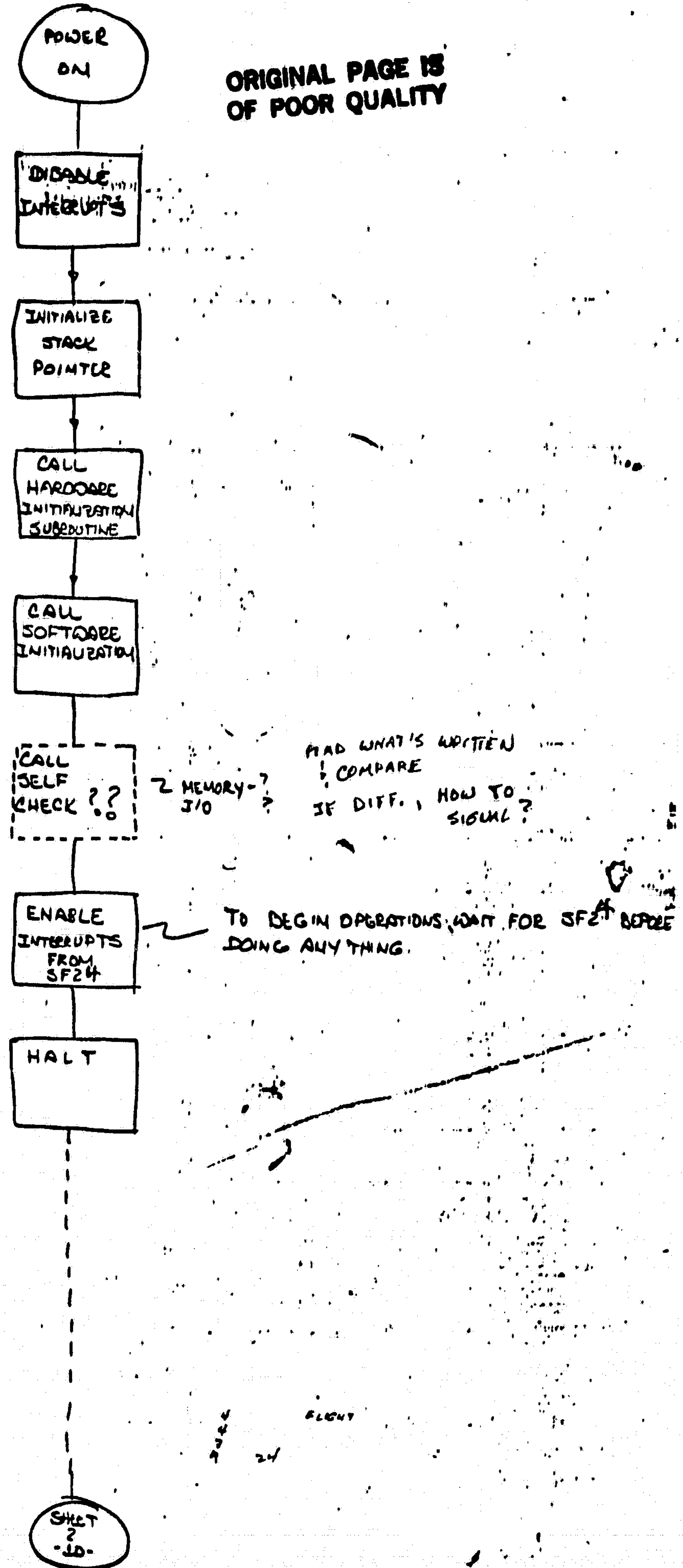
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
X	X	X	0	0	ROM ADD										

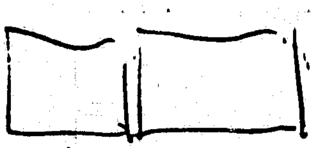
8755 ROM Ø00 - 7FF$_H$
8185 RAM 800 - BFF$_H$ } 800 = C00, 801 = C01
C0Ø - FFF$_H$ } BFF$_H$ = FFF$_H$

8155 RAM 1000 - 10FF$_H$
1100 - 11FF$_H$
1200 - 12FF$_H$
1300 - 13FF$_H$
1400 - 14FF$_H$
1500 - 15FF$_H$
1600 - 16FF$_H$
1700 - 17FF$_H$

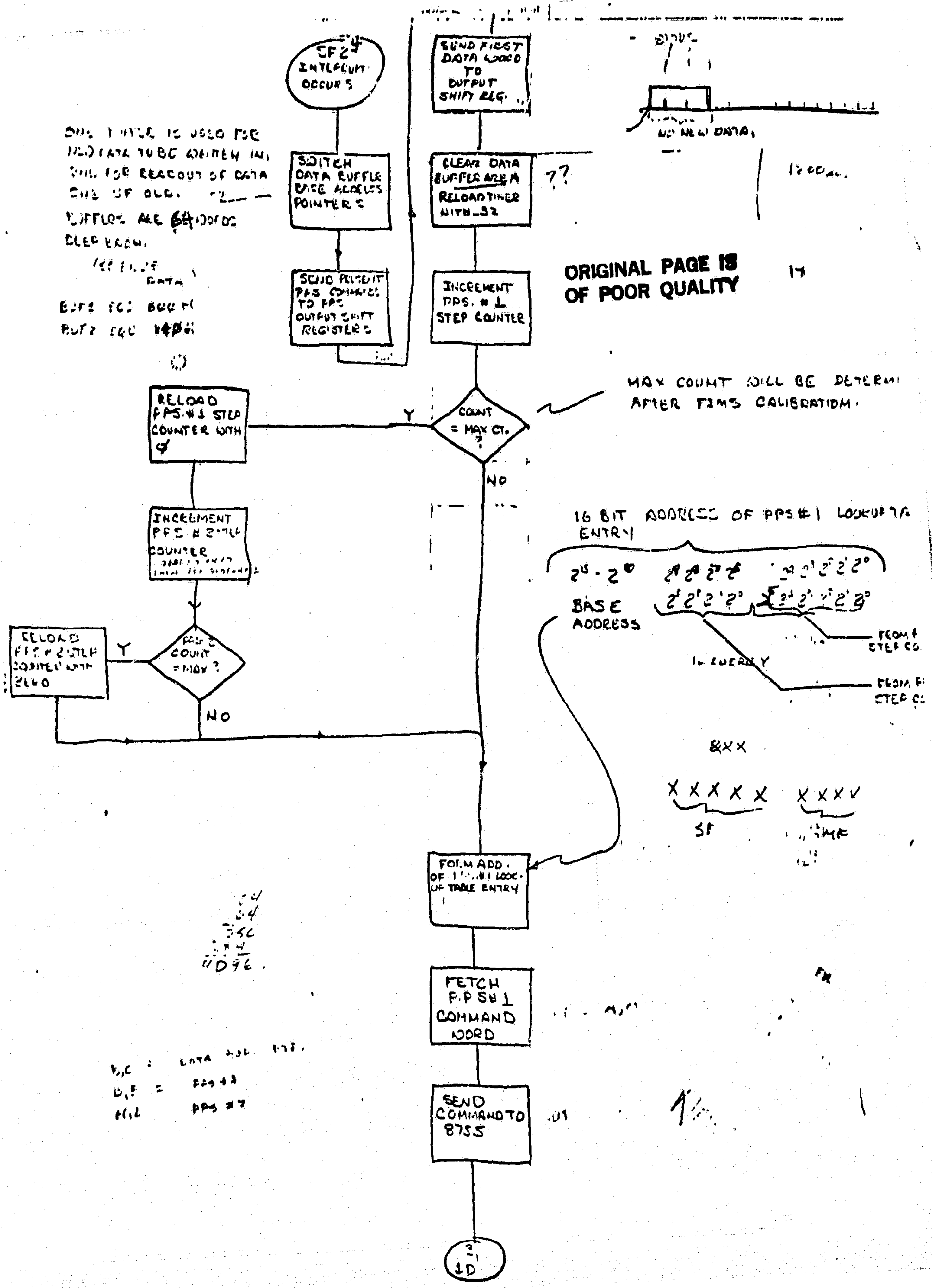
0000 - 07FF$_H$
2000 - 27FF$_H$
4000 - 47FF$_H$
6000 - 67FF$_H$
8000 - 87FF$_H$
A000 - A7FF$_H$
C000 - C7FF$_H$
E000 - E7FF$_H$

```
10  IN
4   CMA
7   MVI  H,08H
7   ANI  1F
4   DCR
4   MOV  L,A
7   MOV  A,M
4   INR  A
7   MOV  M,A
4   EI
10  RET
    ----
    ...  = 17.
```





-10-



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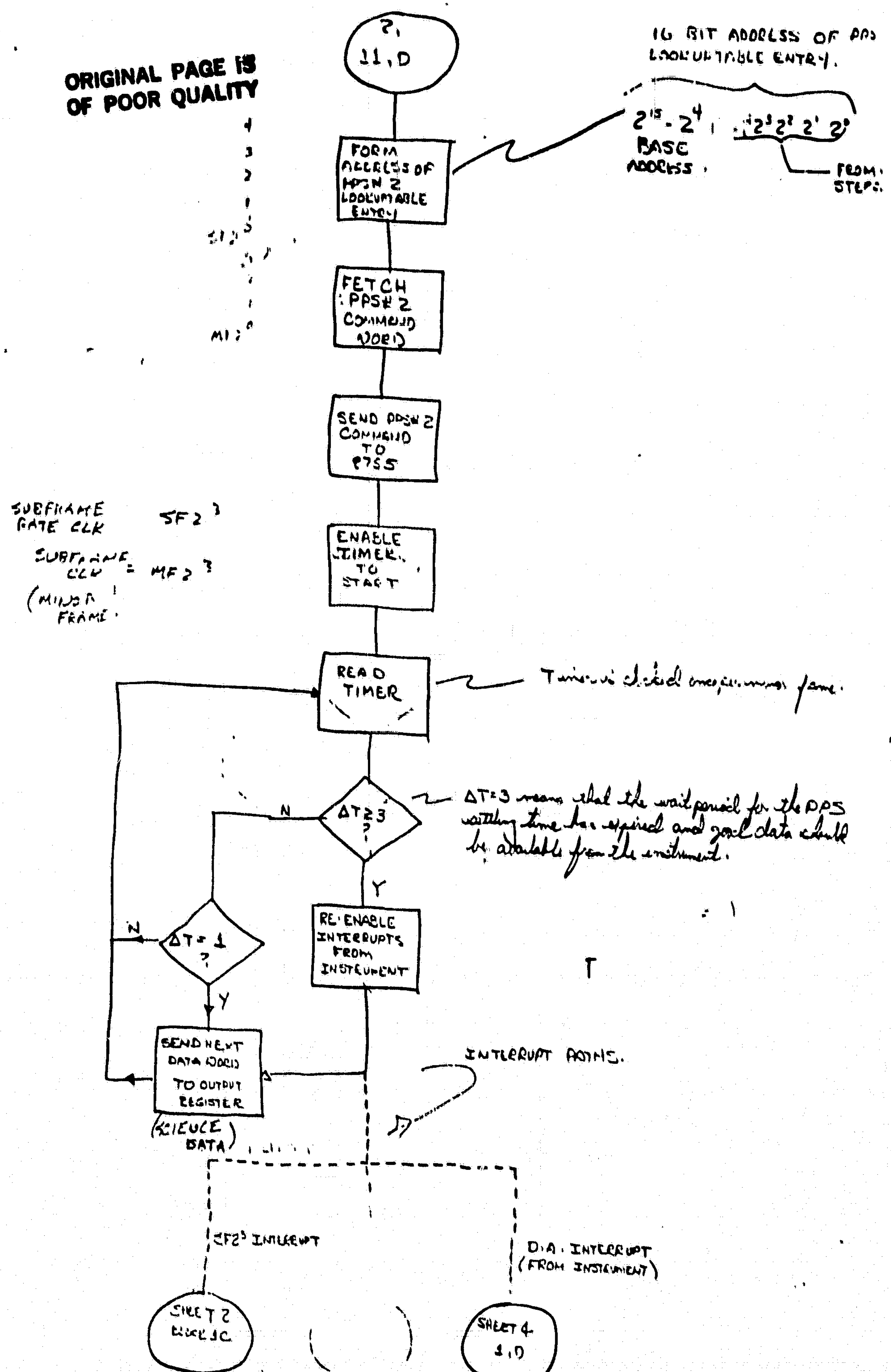

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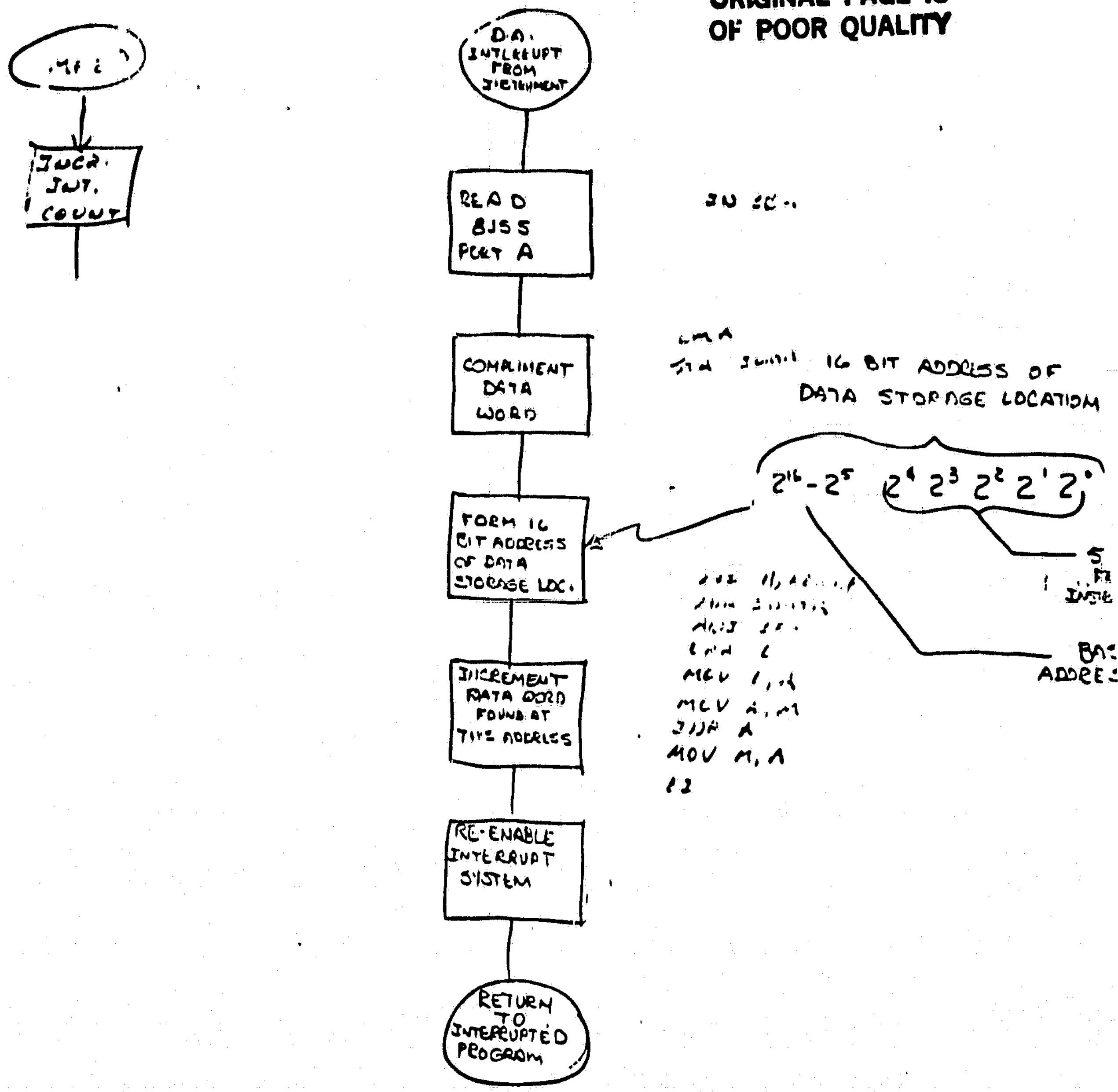

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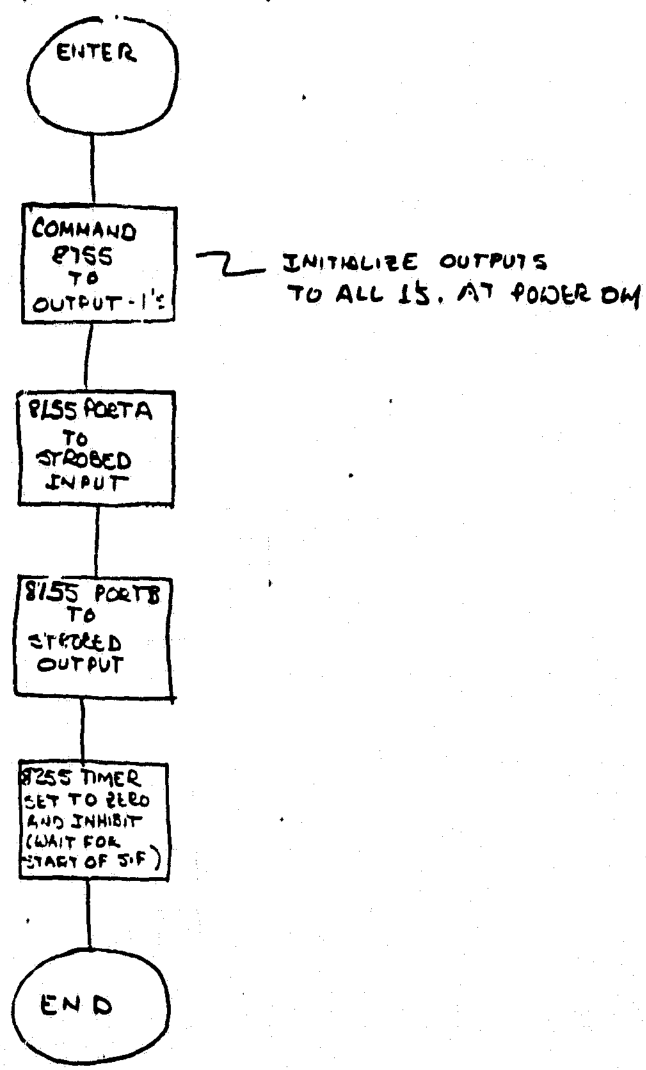

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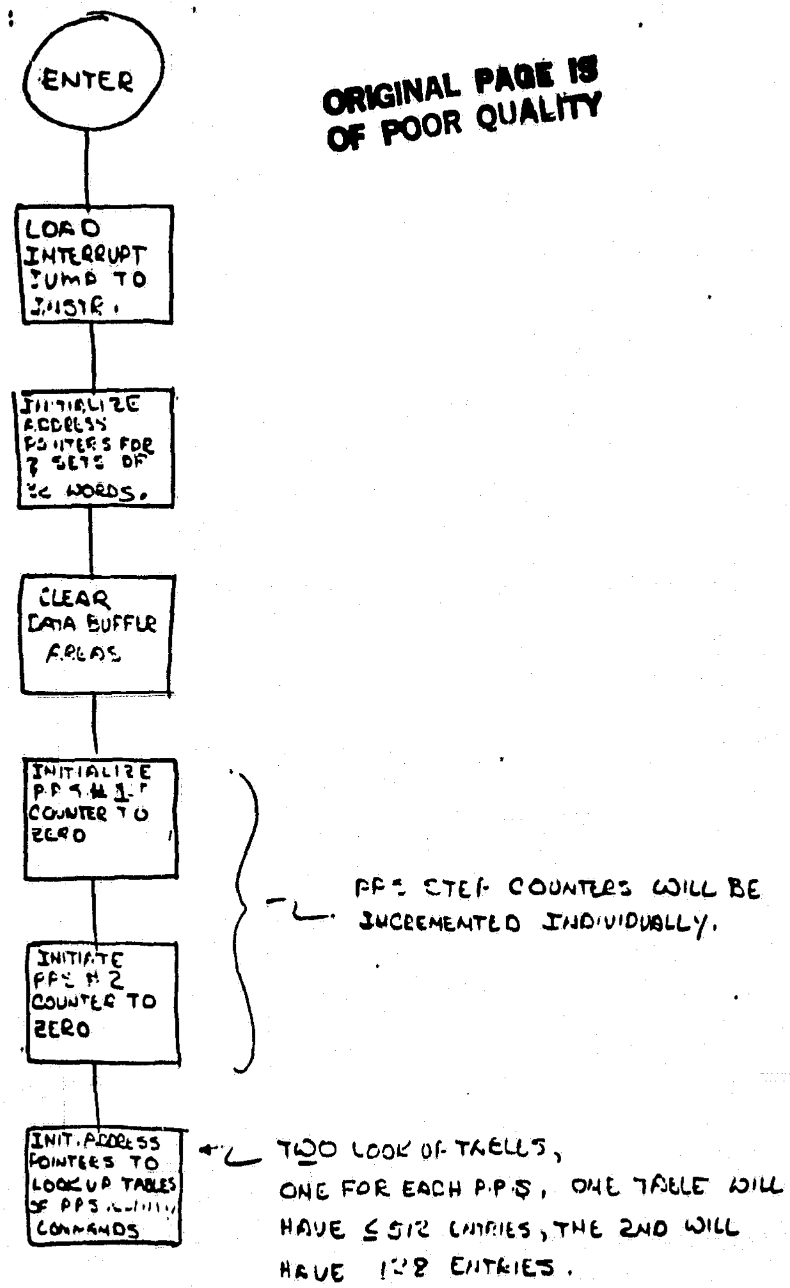

```
0000                  ;**********************************************
0000                  ;**********************************************
0000                  ;*********** FIMS-B CEP FLIGHT SOFTWARE ***********
0000                  ;**********************************************
0000                  ;**********************************************
0000                  ;
0000                  ;EXTERNAL LABEL DEFINITIONS.
0000                  ;
0000                         EXT   MDATA
0000                         EXT   DDATA
0000                         EXT   BUF1
0000                         EXT   BUF2
0000                         EXT   PPS1T
0000                         EXT   PPS2T
0000                         EXT   EIFLG
0000                         EXT   DBASE
0000                         EXT   NEWBF
0000                         EXT   OLDBF
0000                         EXT   PPS1
0000                         EXT   PPS2
0000                         EXT   P1CNT
0000                         EXT   P2CNT
0000                         EXT   P1MAX
0000                         EXT   P2MAX
0000                         EXT   MFCNT
0000                         EXT   DMASK
0000                         EXT   FIRST
0000                         EXT   SDINH
0000                         EXT   PSROM
0000                  ;
0000                  ;HARDWARE INTERRUPT/RESTART BRANCH DEFINITION.
0000                  ;
0000       0000       FIMSB  ORG   0000H          ;CODE STARTS AT 0.
0000 C33F00                  JMP   PWRON          ;GO TO POWER-ON SEQUENCE.
0003       002C              ORG   002CH          ;SCIENCE VECTOR AT 2CH.
002C C31402                  JMP   SCNCE          ;PROCESS SCIENCE INT.
002F       0034              ORG   0034H          ;MF2(3) VECTOR AT 34H.
0034 C3E101                  JMP   MF23           ;PROCESS MF2(3) INT.
0037       003C              ORG   003CH          ;SF2(4) VECTOR AT 3CH.
003C C3FF00                  JMP   SF24           ;PROCESS SF2(4) INT.
003F                  ;
003F                  ;THIS IS THE POWER-ON INITIALIZATION PORTION OF
003F                  ;THE FIMS-B CEP FLIGHT SOFTWARE. THE HARDWARE AND
003F                  ;SOFTWARE WILL BE INITIALIZED, THE MEMORY WILL BE
003F                  ;READ/WRITE CHECKED, AND IF OK, THE INTERRUPT
003F                  ;SYSTEM WILL BE ENABLED.
003F                  ;
003F 31FF10           PWRON  LXI   SP,10FFH       ;INITIALIZE STACK.
0042 CD5300                  CALL  INHW           ;INITIALIZE HARDWARE.
0045 CD9800                  CALL  CHKHW          ;CHECK MEMORY HARDWARE.
0048 CD6400                  CALL  INSW           ;INITIALIZE SOFTWARE.
004B 3EDB                    MVI   A,0DBH         ;FETCH INTERRUPT MASK.
004D 00                      NOP                  ;SET SOD. ENABLE RST 7.5,
004E                  ;                            MASK RST 6.5 AND 5.5
004E FB                      EI                   ;ENABLE INTERRUPT SYSTEM.
```

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```
004F 76                 IDLE   HLT                     ;HALT CPU.
0050 C34F00                    JMP   IDLE              ;DO AGAIN.
0053                    ;
0053                    ;THIS SUBROUTINE WILL INITIALIZE THE 8755 EPROM
0053                    ;I/O PORTS A AND B FOR THE OUTPUT MODE, THE 8155
0053                    ;RAM I/O PORTS A AND B FOR THE STROBED INPUT AND
0053                    ;STROBED OUTPUT MODES, RESPECTIVELY.
0053                    ;
0053 3EFF               INAW   MVI   A,0FFH            ;FETCH 8755 I/O MODE.
0055 D302                      OUT   02H               ;8755 DDR PORT A.
0057 D303                      OUT   03H               ;8755 DDR PORT B.
0059 3E7F                      MVI   A,7FH             ;FETCH I/O DATA.
005B D300                      OUT   00H               ;ZERO PPS #1 VOLTAGE.
005D D301                      OUT   01H               ;ZERO PPS #2 VOLTAGE.
005F 3E1A                      MVI   A,1AH             ;FETCH 8155 I/O MODE.
0061 D310                      OUT   10H               ;SET 8155 COMMAND REG.
0063 C9                        RET                     ;RETURN.
0064                    ;
0064                    ;THIS SUBROUTINE INITIALIZES BUFFER POINTERS,
0064                    ;FLAGS, AND DATA THAT IS USED BY THE FIMS-2
0064                    ;SOFTWARE.
0064                    ;
0064 210500             INSW   LXI   H,PPS2T           ;FETCH PPS #2 TABLE ADD.
0067 011400                    LXI   B,PSROM           ;FETCH ROM ADDRESS.
006A 1600                      MVI   D,00H             ;CLEAR D-REG.
006C 0A                 LDRAM  LDAX  B                 ;FETCH VALUE TO A.
006D 77                        MOV   M,A               ;MOVE TO RAM.
006E 7A                        MOV   A,D               ;FETCH D-REG.
006F FE0F                      CPI   15D               ;Z-BIT SET IF A = 15.
0071 CA7A00                    JZ    SETSW             ;IF Z = 1, SET S/W.
0074 14                        INR   D                 ;BUMP D.
0075 03                        INX   B                 ;BUMP B,C PAIR.
0076 23                        INX   H                 ;BUMP H,L PAIR.
0077 C36C00                    JMP   LDRAM             ;MOVE AGAIN.
007A 3E00               SETSW  MVI   A,00H             ;CLEAR A-REG.
007C 47                        MOV   B,A               ;RESET MF2(3) COUNT.
007D 320C00                    STA   P1CNT             ;RESET PPS #1 STEP COUNT.
0080 320D00                    STA   P2CNT             ;RESET PPS #2 STEP COUNT.
0083 57                        MOV   D,A               ;BUFFER BASE ADD. IN D.
0084 321300                    STA   SDINH             ;RESET DATA INHIBIT FLAG.
0087 3C                        INR   A                 ;BUMP A-REG.
0088 321200                    STA   FIRST             ;SET FIRST TIME THRU FLAG.
008B 0E08                      MVI   C,08H             ;8185 RAM BASE ADD. IN C.
008D 1E3F                      MVI   E,3FH             ;DATA MASK IN E-REG.
008F 3E7F                      MVI   A,7FH             ;FETCH PPS VOLT CODE.
0091 320A00                    STA   PPS1              ;SAVE PPS #1 CODE.
0094 320B00                    STA   PPS2              ;SAVE PPS #2 CODE.
0097 C9                        RET                     ;RETURN.
0098                    ;
0098                    ;THIS SUBROUTINE WILL WRITE TO AND THEN READ FROM
0098                    ;EVERY RAM LOCATION. IF THE DATA READ IS THE SAME
0098                    ;AS THE DATA WRITTEN, PORT A, BIT 7 OF THE 8755
0098                    ;WILL BE SET ALONG WITH THE ENABLE INT. FLAG,
0098                    ;(EIFLG), ALLOWING THE SOFTWARE TO ENABLE THE
0098                    ;INTERRUPT SYSTEM, (EIFLG = 1). IF THE WRITE/READ
```

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```
0098                 ;IS UNSUCCESSFUL AT ANY LOCATION, PORT A, BIT 7 OF
0098                 ;THE 8755 WILL BE CLEARED ALONG WITH EIFLG,
0098                 ;LEAVING THE INTERRUPT SYSTEM DISABLED.
0098                 ;
0098 210008   CHKHW  LXI   H,800H        ;8185 ADDR. IN H,L PAIR.
009B 3600     L8185  MVI   M,00H         ;WRITE 0 TO 8185.
009D 7E              MOV   A,M           ;READ 8185.
009E FE00            CPI   00H           ;Z-BIT SET IF A-REG. = 0.
00A0 C2F000          JNZ   WRTER         ;IF Z-BIT = 0, ERROR.
00A3 36FF            MVI   M,0FFH        ;WRITE FFH TO 8185.
00A5 7E              MOV   A,M           ;READ 8185.
00A6 FEFF            CPI   0FFH          ;Z-BIT SET IF A = FFH.
00A8 C2F000          JNZ   WRTER         ;IF Z-BIT = 0, ERROR.
00AB 7C              MOV   A,H           ;FETCH H-REG. IN A-REG.
00AC FE0B            CPI   0BH           ;Z-BIT SET IF H = 0BH.
00AE CAB500          JZ    LREG          ;IF Z-BIT SET, CHECK L.
00B1 23              INX   H             ;OTHERWISE, BUMP H,L.
00B2 C39B00          JMP   L8185         ;CHECK NEXT LOCATION.
00B5 7D       LREG   MOV   A,L           ;FETCH L-REG. IN A-REG.
00B6 FEFF            CPI   0FFH          ;Z-BIT SET IF L = FFH.
00B8 CABF00          JZ    C8155         ;IF Z-BIT SET, CHECK 8155.
00BB 2C              INR   L             ;OTHERWISE, BUMP L.
00BC C39B00          JMP   L8185         ;CHECK NEXT LOCATION.
00BF C1       C8155  POP   B             ;SAVE RETURN ADD. IN B,C.
00C0 31FF0B          LXI   SP,0BFFH      ;NEW STACK POINTER.
00C3 C5              PUSH  B             ;PUSH RETURN ADD.
00C4 210010          LXI   H,1000H       ;8155 ADDR. IN H,L PAIR.
00C7 3600     L8155  MVI   M,00H         ;WRITE 0 TO 8155.
00C9 7E              MOV   A,M           ;READ 8155.
00CA FE00            CPI   00H           ;Z-BIT SET IF A = 00H.
00CC C2F000          JNZ   WRTER         ;IF Z-BIT = 0, ERROR.
00CF 36FF            MVI   M,0FFH        ;WRITE FFH TO 8155.
00D1 7E              MOV   A,M           ;READ 8155.
00D2 FEFF            CPI   0FFH          ;Z-BIT SET IF A = 0FFH.
00D4 C2F000          JNZ   WRTER         ;IF Z-BIT = 0, ERROR.
00D7 7D              MOV   A,L           ;FETCH L-REG. IN A-REG.
00D8 FEFF            CPI   0FFH          ;Z-BIT SET IF A = 0FFH.
00DA CAE100          JZ    CHKOK         ;IF Z-BIT = 0, CHECK OK.
00DD 2C              INR   L             ;OTHERWISE, BUMP L-REG.
00DE C3C700          JMP   L8155         ;CHECK NEXT LOCATION.
00E1 3EFF     CHKOK  MVI   A,0FFH        ;FETCH I/O DATA.
00E3 D300            OUT   00H           ;SET 8755 PORT A, BIT 7.
00E5 3E01            MVI   A,01H         ;A-REG. = 1.
00E7 320600          STA   EIFLG         ;SET EIFLG.
00EA C1              POP   B             ;FETCH RETURN ADD.
00EB 31FF10          LXI   SP,10FFH      ;RESET STACK POINTER.
00EE C5              PUSH  B             ;RESTORE RETURN ADD.
00EF C9              RET                 ;RETURN.
00F0 3E7F     WRTER  MVI   A,7FH         ;FETCH I/O DATA.
00F2 D300            OUT   00H           ;RESET 8755 PORT A, BIT 7.
00F4 3E00            MVI   A,00H         ;A-REG. = 0.
00F6 320600          STA   EIFLG         ;CLEAR EIFLG.
00F9 C1              POP   B             ;FETCH RETURN ADD.
00FA 31FF10          LXI   SP,10FFH      ;RESET STACK POINTER.
00FD C5              PUSH  B             ;RESTORE RETURN ADD.
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00FE C9                  RET                     ;RETURN.
00FF                     ;*********************************************
00FF                     ;****** SUBFRAME RATE INTERRUPT PROCESSING ******
00FF                     ;*********************************************
00FF 3ED9         SF24   MVI    A,0D9H           ;FETCH INTERRUPT MASK.
0101 00                  NOP                     ;SET SOD. ENABLE RST 7.5,
0102                     ;                        6.5. DISABLE RST 5.5.
0102 3A0A00       LPPS1  LDA    PPS1             ;FETCH PPS #1 VOLTAGE.
0105 E6BF                ANI    0BFH             ;LOAD BY CLEARING BIT 6.
0107 F680                ORI    80H              ;SET BIT 7.
0109 D300                OUT    00H              ;OUTPUT TO 8755, PORT A.
010B F6C0                ORI    0C0H             ;SET BIT 6.
010D D300                OUT    00H              ;OUTPUT TO 8755, PORT A.
010F 3A0B00       LPPS2  LDA    PPS2             ;FETCH PPS #2 VOLTAGE.
0112 E6BF                ANI    0BFH             ;LOAD BY CLEARING BIT 6.
0114 F680                ORI    80H              ;SET BIT 7.
0116 D301                OUT    01H              ;OUTPUT TO 8755, PORT B.
0118 F6C0                ORI    0C0H             ;SET BIT 6.
011A D301                OUT    01H              ;OUTPUT TO 8755, PORT B.
011C 7A           SWTCH  MOV    A,D              ;FETCH BUFFER 1/2 FLAG.
011D FE00                CPI    00H              ;Z-BIT SET IF A-REG. = 0.
011F CA3401              JZ     BUFR2            ;IF Z-BIT = 1, BUFFER #2.
0122 210200       BUFR1  LXI    H,BUF1           ;BUFFER #1 ADD. IN H,L.
0125 220800              SHLD   NEWBF            ;ADD. IN NEWBF,NEWBF + 1.
0128 210300              LXI    H,BUF2           ;BUFFER #2 ADD. IN H,L.
012B 220900              SHLD   OLDBF            ;ADD. IN OLDBF,OLDBF + 1.
012E 3E00                MVI    A,00H            ;CLEAR A-REG.
0130 57                  MOV    D,A              ;D-REG. = BUFFER 1 ADD.
0131 C34301              JMP    CLRNB            ;GO CLEAR NEW BUFFER.
0134 210300       BUFR2  LXI    H,BUF2           ;BUFFER #1 ADD. IN H,L.
0137 220800              SHLD   NEWBF            ;ADD. IN NEWBF,NEWBF + 1.
013A 210200              LXI    H,BUF1           ;BUFFER #2 ADD. IN H,L.
013D 220900              SHLD   OLDBF            ;ADD. IN OLDBF,OLDBF + 1.
0140 3E40                MVI    A,40H            ;A-REG. = 40H.
0142 57                  MOV    D,A              ;D-REG. = BUFFER 2 ADD.
0143 2A0800       CLRNB  LHLD   NEWBF            ;NEW DATA ADD. IN H,L.
0146 3E00                MVI    A,00H            ;CLEAR A-REG.
0148 47                  MOV    B,A              ;CLEAR B-REG.
0149 70           CNBLP  MOV    M,B              ;CLEAR DATA LOCATION.
014A FE1F                CPI    31D              ;Z-BIT SET IF A = 31D.
014C CA5401              JZ     INHSD            ;IF Z = 1, INHIBIT S. D.
014F 23                  INX    H                ;OTHERWISE, BUMP H,L.
0150 3C                  INR    A                ;BUMP A-REG.
0151 C34901              JMP    CNBLP            ;CLEAR NEXT LOCATION.
0154 3A1300       INHSD  LDA    SDINH            ;FETCH DATA INHIBIT FLAG.
0157 FE01                CPI    01H              ;Z-BIT SET IF A-REG. = 1.
0159 CAD901              JZ     ENABD            ;IF Z = 1, ENABLE DATA.
015C 3A0C00       BPPS1  LDA    P1CNT            ;FETCH PPS #1 STEP COUNT.
015F 3C                  INR    A                ;INCREMENT.
0160 320C00              STA    P1CNT            ;SAVE PPS #1 STEP COUNT.
0163 FE28                CPI    40D              ;Z-BIT SET IF MAX. COUNT.
0165 C28201              JNZ    P1ADD            ;IF Z-BIT = 0, FORM ADD.
0168 3E00                MVI    A,00H            ;OTHERWISE, A-REG. = 0.
016A 320C00              STA    P1CNT            ;RESET PPS #1 STEP COUNT.
016D 3C                  INR    A                ;BUMP A-REG.
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016E 321300         STA   SDINH      ;SET DATA INHIBIT FLAG.
0171 3A0D00   BPPS2 LDA   P2CNT      ;FETCH PPS #2 STEP COUNT.
0174 3C             INR   A          ;INCREMENT.
0175 320D00         STA   P2CNT      ;SAVE PPS #2 STEP COUNT.
0178 FE10           CPI   16D        ;Z-BIT SET IF MAX. COUNT.
017A C28201         JNZ   P1ADD      ;IF Z-BIT = 0, FORM ADD.
017D 3E00           MVI   A,00H      ;OTHERWISE, A-REG. = 0.
017F 320D00         STA   P2CNT      ;RESET PPS #2 STEP COUNT.
0182 3A1200   P1ADD LDA   FIRST      ;FETCH FIRST TIME FLAG.
0185 FE00           CPI   00H        ;Z-BIT SET IF A-REG. = 0.
0187 CA9301         JZ    P1TAB      ;IF Z-BIT = 1, FORM ADD.
018A 3E00           MVI   A,00H      ;OTHERWISE, CLEAR A-REG.
018C 321200         STA   FIRST      ;RESET FIRST TIME FLAG.
018F 3C             INR   A          ;BUMP A-REG.
0190 321300         STA   SDINH      ;SET DATA INHIBIT FLAG.
0193 210400   P1TAB LXI   H,PPS1T    ;PPS 1 TABLE ADD. IN H,L.
0196 3A0C00         LDA   P1CNT      ;FETCH PPS #1 STEP COUNT.
0199 E63F           ANI   3FH        ;MASK P1CNT.
019B 47             MOV   B,A        ;SAVE IN B-REG.
019C 3A0D00         LDA   P2CNT      ;FETCH PPS #2 STEP COUNT.
019F E603           ANI   03H        ;MASK BITS 0 AND 1.
01A1 0F             RRC              ;ROTATE RIGHT 2 BITS.
01A2 0F             RRC
01A3 B0             ORA   B          ;OR WITH PPS #1 COUNT.
01A4 6F             MOV   L,A        ;SAVE IN L-REG.
01A5 3A0D00         LDA   P2CNT      ;FETCH PPS #2 STEP COUNT.
01A8 E60C           ANI   0CH        ;MASK BITS 2 AND 3.
01AA 0F             RRC              ;ROTATE RIGHT 2 BITS.
01AB 0F             RRC
01AC B4             ORA   H          ;OR WITH PPS #1 BASE ADD.
01AD 67             MOV   H,A        ;SAVE IN H-REG.
01AE 3EFF           MVI   A,0FFH     ;FETCH 8755 I/O MODE.
01B0 D302           OUT   02H        ;REINITIALIZE PORT A.
01B2 D303           OUT   03H        ;REINITIALIZE PORT B.
01B4 7E             MOV   A,M        ;FETCH PPS #1 VOLTAGE.
01B5 320A00         STA   PPS1       ;SAVE VOLTAGE AT PPS1.
01B8 F6C0           ORI   0C0H       ;SET BITS 6 AND 7.
01BA D300           OUT   00H        ;OUTPUT TO 8755, PORT A.
01BC 210500   P2TAB LXI   H,PPS2T    ;PPS 2 TABLE ADD. IN H,L.
01BF 3A0D00         LDA   P2CNT      ;FETCH PPS #2 STEP COUNT.
01C2 E60F           ANI   0FH        ;MASK P2CNT.
01C4 B5             ORA   L          ;OR WITH PPS #2 BASE ADD.
01C5 6F             MOV   L,A        ;SAVE IN L-REG.
01C6 3EFF           MVI   A,0FFH     ;FETCH 8755 I/O MODE.
01C8 D302           OUT   02H        ;REINITIALIZE PORT A.
01CA D303           OUT   03H        ;REINITIALIZE PORT B.
01CC 7E             MOV   A,M        ;FETCH PPS #2 VOLTAGE.
01CD 320B00         STA   PPS2       ;SAVE VOLTAGE AT PPS2.
01D0 F6C0           ORI   0C0H       ;SET BITS 6 AND 7.
01D2 D301           OUT   01H        ;OUTPUT TO 8755, PORT B.
01D4 3E00     INTEN MVI   A,00H      ;CLEAR A-REG.
01D6 47             MOV   B,A        ;RESET MAIN FRAME COUNT.
01D7 FB             EI               ;ENABLE INTERRUPT SYSTEM.
01D8 C9             RET              ;RETURN.
01D9 3E00     ENABD MVI   A,00H      ;CLEAR A-REG.
```

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01DB 321300        STA SDINH          ;RESET DATA INHIBIT FLAG.
01DE C3D401        JMP  INIEN         ;GO ENABLE INTERRUPT SYSTEM.
01E1               ;♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦
01E1               ;♦♦♦♦♦♦♦ MAINFRAME RATE INTERRUPT PROCESSING ♦♦♦♦♦♦
01E1               ;♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦
01E1 00      MF23  NOP                ;READ INTERRUPT MASK.
01E2 E640          ANI  40H           ;MASK 17.5 BIT.
01E4 FE40          CPI  40H           ;Z-BIT SET IF A = 40H.
01E6 CAFD01        JZ   SFEXT         ;IF Z-BIT SET RETURN.
01E9 2A0900  DDOUT LHLD OLDBF         ;OLD BUFFER ADD. IN H,L.
01EC 7E            MOV  A,M           ;FETCH DATA.
01ED D312          OUT  12H           ;OUTPUT TO 8155, PORT B.
01EF 23            INX  H             ;BUMP H,L PAIR.
01F0 220900        SHLD OLDBF         ;SAVE NEXT ADD. IN OLDBF.
01F3 04            INR  B             ;INCREMENT MAIN FRAME COUNT.
01F4 78            MOV  A,B           ;FETCH MF2(3) COUNT.
01F5 FE03          CPI  03H           ;C-BIT = 1 IF A < 03H.
01F7 D20202        JNC  ENDAT         ;IF C = 0, ENABLE DATA.
01FA 3E40    MFEXT MVI  A,40H         ;FETCH CLEAR SOD COMMAND.
01FC 00            NOP                ;CLEAR SOD.
01FD 3EC9    SFEXT MVI  A,0C9H        ;FETCH SET SOD COMMAND.
01FF 00            NOP                ;SET SOD. LEAVE MASK WITH
0200               ;                   RST 5.5 INHIBITED.
0200 FB            EI                 ;ENABLE INTERRUPT SYSTEM.
0201 C9            RET                ;RETURN.
0202 3A1300  ENDAT LDA  SDINH         ;FETCH DATA INHIBIT FLAG.
0205 FE01          CPI  01H           ;Z-BIT SET IF A-REG. = 1.
0207 CAFA01        JZ   MFEXT         ;IF Z-BIT SET, RETURN.
020A 3E40          MVI  A,40H         ;FETCH CLEAR SOD COMMAND.
020C 00            NOP                ;CLEAR SOD.
020D 3EC8          MVI  A,0C8H        ;FETCH SET SOD COMMAND.
020F 00            NOP                ;SET SOD. ENABLE RST 5.5,
0210               ;                   RST 6.5, RST 7.5.
0210 DB11          IN   11H           ;CLEAR RST 5.5 PENDING.
0212 FB            EI                 ;ENABLE INTERRUPT SYSTEM.
0213 C9            RET                ;RETURN.
0214               ;♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦
0214               ;♦♦♦♦♦♦♦ SCIENCE DATA INTERRUPT PROCESSING ♦♦♦♦♦♦♦
0214               ;♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦
0214 DB11    SCNCE IN   11H           ;INPUT FROM 8155, PORT A.
0216 2F            CMA                ;COMPLIMENT.
0217 61            MOV  H,C           ;DATA BASE ADD. IN H-REG.
0218 A3            ANA  E             ;MASK BITS 0 - 4.
0219 B2            ORA  D             ;OR WITH BUFFER BASE ADD.
021A 6F            MOV  L,A           ;M-REG. POINTS TO DATA.
021B 34            INR  M             ;INCREMENT THAT LOCATION.
021C FB            EI                 ;ENABLE INTERRUPT SYSTEM.
021D C9            RET                ;RETURN.
021E   0000        END  FIMSB
```

TOTAL ERRORS=00

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DM 8080/Z80 RELOC-MACRO ASSEMBLER VER 1.0

```
P  1  L 015C    BPPS2 L 0171    BUF1  X 0002    BUF2  X 0003
F  1  L 0122    BUFF2 L 0134    C8155 L 00BF    CHKHW L 0098
I     L 00E1    CLRNB L 0143    CNBLP L 0149    DBASE X 0007
A     X 0011    EIFLG X 0006    ENABD L 01D9    ENDAT L 0202
IM B  L 0000    FIRST X 0012    IDLE  L 004F    INHSD L 0154
HW    L 0053    INSW  L 0064    INTEN L 01D4    L8155 L 00C7
8185  L 009B    LDRAM L 006C    LPPS1 L 0102    LPPS2 L 010F
RE    L 00B5    MF23  L 01E1    MFCNT X 0010    MFEXT L 01FA
D  A  X 0000    NEWBF X 0008    ODATA X 0001    ODOUT L 01E9
LDBF  X 0009    P1ADD L 0182    P1CNT X 000C    P1MAX X 000E
1 AB  L 0193    P2CNT X 000D    P2MAX X 000F    P2TAB L 01BC
P  1  X 000A    PPS1T X 0004    PPS2  X 000B    PPS2T X 0005
SROM  X 0014    PWRON L 003F    SCNCE L 0214    SDINH X 0013
ETSW  L 007A    SF24  L 00FF    SFEXT L 01FD    SWTCH L 011C
F ER  L 00F0

TOTAL ERRORS=00
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FIMS-B PPS LOOKUP TABLE DATA

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PACNT	PACNT	MA TABLE ADD.	MA TABLE DATA	FA TABLE ADD.	FA TABLE DATA
ØØH	ØØH	4ØØH	Ø1H	8ØØH	Ø6H
Ø1H	ØØH	4Ø1H	Ø2H	8ØØH	Ø6H
Ø2H	ØØH	4Ø2H	Ø3H	8ØØH	Ø6H
Ø3H	ØØH	4Ø3H	Ø4H	8ØØH	Ø6H
Ø4H	ØØH	4Ø4H	Ø5H	8ØØH	Ø6H
Ø5H	ØØH	4Ø5H	Ø6H	8ØØH	Ø6H
Ø6H	ØØH	4Ø6H	Ø7H	8ØØH	Ø6H
Ø7H	ØØH	4Ø7H	Ø8H	8ØØH	Ø6H
Ø8H	ØØH	4Ø8H	Ø9H	8ØØH	Ø6H
Ø9H	ØØH	4Ø9H	ØAH	8ØØH	Ø6H
ØAH	ØØH	4ØAH	ØBH	8ØØH	Ø6H
ØBH	ØØH	4ØBH	ØCH	8ØØH	Ø6H
ØCH	ØØH	4ØCH	ØDH	8ØØH	Ø6H
ØDH	ØØH	4ØDH	ØEH	8ØØH	Ø6H
ØEH	ØØH	4ØEH	ØFH	8ØØH	Ø6H
ØFH	ØØH	4ØFH	1ØH	8ØØH	Ø6H
1ØH	ØØH	41ØH	11H	8ØØH	Ø6H
11H	ØØH	411H	12H	8ØØH	Ø6H
12H	ØØH	412H	13H	8ØØH	Ø6H
13H	ØØH	413H	14H	8ØØH	Ø6H
14H	ØØH	414H	15H	8ØØH	Ø6H
15H	ØØH	415H	16H	8ØØH	Ø6H
16H	ØØH	416H	17H	8ØØH	Ø6H
17H	ØØH	417H	18H	8ØØH	Ø6H
18H	ØØH	418H	19H	8ØØH	Ø6H
19H	ØØH	419H	1AH	8ØØH	Ø6H
1AH	ØØH	41AH	1BH	8ØØH	Ø6H
1BH	ØØH	41BH	1CH	8ØØH	Ø6H
1CH	ØØH	41CH	1DH	8ØØH	Ø6H
1DH	ØØH	41DH	1EH	8ØØH	Ø6H
1EH	ØØH	41EH	1FH	8ØØH	Ø6H
1FH	ØØH	41FH	2ØH	8ØØH	Ø6H
2ØH	ØØH	42ØH	21H	8ØØH	Ø6H
21H	ØØH	421H	22H	8ØØH	Ø6H
22H	ØØH	422H	23H	8ØØH	Ø6H
23H	ØØH	423H	24H	8ØØH	Ø6H
24H	ØØH	424H	25H	8ØØH	Ø6H
25H	ØØH	425H	26H	8ØØH	Ø6H

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FJMS-B PPS LOOKUP TABLE DATA

PICUT	PACUT	MA TABLE ADD.	MA TABLE DATA	EA TABLE ADD.	EA TABLE DATA
26H	ØØH	426H	27H	8ØØH	Ø6H
27H	ØØH	427H	28H	8ØØH	Ø6H
ØØH	Ø1H	44ØH	Ø9H	8Ø1H	Ø9H
Ø1H	Ø1H	441H	ØAH	8Ø1H	Ø9H
Ø2H	Ø1H	442H	ØBH	8Ø1H	Ø9H
Ø3H	Ø1H	443H	ØCH	8Ø1H	Ø9H
Ø4H	Ø1H	444H	ØDH	8Ø1H	Ø9H
Ø5H	Ø1H	445H	ØEH	8Ø1H	Ø9H
Ø6H	Ø1H	446H	ØFH	8Ø1H	Ø9H
Ø7H	Ø1H	447H	1ØH	8Ø1H	Ø9H
Ø8H	Ø1H	448H	11H	8Ø1H	Ø9H
Ø9H	Ø1H	449H	12H	8Ø1H	Ø9H
ØAH	Ø1H	44AH	13H	8Ø1H	Ø9H
ØBH	Ø1H	44BH	14H	8Ø1H	Ø9H
ØCH	Ø1H	44CH	15H	8Ø1H	Ø9H
ØDH	Ø1H	44DH	16H	8Ø1H	Ø9H
ØEH	Ø1H	44EH	17H	8Ø1H	Ø9H
ØFH	Ø1H	44FH	18H	8Ø1H	Ø9H
1ØH	Ø1H	45ØH	19H	8Ø1H	Ø9H
11H	Ø1H	451H	1AH	8Ø1H	Ø9H
12H	Ø1H	452H	1BH	8Ø1H	Ø9H
13H	Ø1H	453H	1CH	8Ø1H	Ø9H
14H	Ø1H	454H	1DH	8Ø1H	Ø9H
15H	Ø1H	455H	1EH	8Ø1H	Ø9H
16H	Ø1H	456H	1FH	8Ø1H	Ø9H
17H	Ø1H	457H	2ØH	8Ø1H	Ø9H
18H	Ø1H	458H	21H	8Ø1H	Ø9H
19H	Ø1H	459H	22H	8Ø1H	Ø9H
1AH	Ø1H	45AH	23H	8Ø1H	Ø9H
1BH	Ø1H	45BH	24H	8Ø1H	Ø9H
1CH	Ø1H	45CH	25H	8Ø1H	Ø9H
1DH	Ø1H	45DH	26H	8Ø1H	Ø9H
1EH	Ø1H	45EH	27H	8Ø1H	Ø9H
1FH	Ø1H	45FH	28H	8Ø1H	Ø9H
2ØH	Ø1H	46ØH	29H	8Ø1H	Ø9H
21H	Ø1H	461H	2AH	8Ø1H	Ø9H
22H	Ø1H	462H	2BH	8Ø1H	Ø9H
23H	Ø1H	463H	2CH	8Ø1H	Ø9H

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FIMS-B PPS LOOKUP TABLE DATA

INPUT	PRINT	MA TABLE ADD.	MA TABLE DATA	EA TABLE ADD.	EA TABLE DATA
24H	01H	464H	2DH	801H	09H
25H	01H	465H	2EH	801H	09H
26H	01H	466H	2FH	801H	09H
27H	01H	467H	30H	801H	09H
00H	02H	480H	0EH	802H	0CH
01H	02H	481H	10H	802H	0CH
02H	02H	482H	11H	802H	0CH
03H	02H	483H	12H	802H	0CH
04H	02H	484H	13H	802H	0CH
05H	02H	485H	14H	802H	0CH
06H	02H	486H	15H	802H	0CH
07H	02H	487H	16H	802H	0CH
08H	02H	488H	17H	802H	0CH
09H	02H	489H	18H	802H	0CH
0AH	02H	48AH	19H	802H	0CH
0BH	02H	48BH	1AH	802H	0CH
0CH	02H	48CH	1BH	802H	0CH
0DH	02H	48DH	1CH	802H	0CH
0EH	02H	48EH	1DH	802H	0CH
0FH	02H	48FH	1EH	802H	0CH
10H	02H	490H	1FH	802H	0CH
11H	02H	491H	20H	802H	0CH
12H	02H	492H	21H	802H	0CH
13H	02H	493H	22H	802H	0CH
14H	02H	494H	23H	802H	0CH
15H	02H	495H	24H	802H	0CH
16H	02H	496H	25H	802H	0CH
17H	02H	497H	26H	802H	0CH
18H	02H	498H	27H	802H	0CH
19H	02H	499H	28H	802H	0CH
1AH	02H	49AH	29H	802H	0CH
1BH	02H	49BH	2AH	802H	0CH
1CH	02H	49CH	2BH	802H	0CH
1DH	02H	49DH	2CH	802H	0CH
1EH	02H	49EH	2DH	802H	0CH
1FH	02H	49FH	2EH	802H	0CH
20H	02H	4A0H	2FH	802H	0CH
21H	02H	4A1H	30H	802H	0CH

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FJMS-B PP3 LOOKUP TABLE DATA

PIVOT	PIVOT	HA TABLE ADD.	HA TABLE DATA	EA TABLE ADD.	EA TABLE DATA
22H	Ø2H	4A2H	31H	8Ø2H	ØCH
23H	Ø2H	4A3H	32H	8Ø2H	ØCH
24H	Ø2H	4A4H	33H	8Ø2H	ØCH
25H	Ø2H	4A5H	34H	8Ø2H	ØCH
26H	Ø2H	4A6H	35H	8Ø2H	ØCH
27H	Ø2H	4A7H	36H	8Ø2H	ØCH
ØØH	Ø3H	4CØH	ØDH	8Ø3H	ØFH
Ø1H	Ø3H	4C1H	ØEH	8Ø3H	ØFH
Ø2H	Ø3H	4C2H	ØFH	8Ø3H	ØFH
Ø3H	Ø3H	4C3H	1ØH	8Ø3H	ØFH
Ø4H	Ø3H	4C4H	11H	8Ø3H	ØFH
Ø5H	Ø3H	4C5H	12H	8Ø3H	ØFH
Ø6H	Ø3H	4C6H	13H	8Ø3H	ØFH
Ø7H	Ø3H	4C7H	14H	8Ø3H	ØFH
Ø8H	Ø3H	4C8H	15H	8Ø3H	ØFH
Ø9H	Ø3H	4C9H	16H	8Ø3H	ØFH
ØAH	Ø3H	4CAH	17H	8Ø3H	ØFH
ØBH	Ø3H	4CBH	18H	8Ø3H	ØFH
ØCH	Ø3H	4CCH	19H	8Ø3H	ØFH
ØDH	Ø3H	4CDH	1AH	8Ø3H	ØFH
ØEH	Ø3H	4CEH	1BH	8Ø3H	ØFH
ØFH	Ø3H	4CFH	1CH	8Ø3H	ØFH
1ØH	Ø3H	4DØH	1DH	8Ø3H	ØFH
11H	Ø3H	4D1H	1EH	8Ø3H	ØFH
12H	Ø3H	4D2H	1FH	8Ø3H	ØFH
13H	Ø3H	4D3H	2ØH	8Ø3H	ØFH
14H	Ø3H	4D4H	21H	8Ø3H	ØFH
15H	Ø3H	4D5H	22H	8Ø3H	ØFH
16H	Ø3H	4D6H	23H	8Ø3H	ØFH
17H	Ø3H	4D7H	24H	8Ø3H	ØFH
18H	Ø3H	4D8H	25H	8Ø3H	ØFH
19H	Ø3H	4D9H	26H	8Ø3H	ØFH
1AH	Ø3H	4DAH	27H	8Ø3H	ØFH
1BH	Ø3H	4DBH	28H	8Ø3H	ØFH
1CH	Ø3H	4DCH	29H	8Ø3H	ØFH
1DH	Ø3H	4DDH	2AH	8Ø3H	ØFH
1EH	Ø3H	4DEH	2BH	8Ø3H	ØFH
1FH	Ø3H	4DFH	2CH	8Ø3H	ØFH

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FIMS-B PPS LOOKUP TABLE DATA

ELECT	PACKET	MA TABLE ADD.	MA TABLE DATA	EA TABLE ADD.	EA TABLE DATA
2ØH	Ø3H	4EØH	2DH	8Ø3H	ØFH
21H	Ø3H	4E1H	2EH	8Ø3H	ØFH
22H	Ø3H	4E2H	2FH	8Ø3H	ØFH
23H	Ø3H	4E3H	3ØH	8Ø3H	ØFH
24H	Ø3H	4E4H	31H	8Ø3H	ØFH
25H	Ø3H	4E5H	32H	8Ø3H	ØFH
26H	Ø3H	4E6H	33H	8Ø3H	ØFH
27H	Ø3H	4E7H	34H	8Ø3H	ØFH
ØØH	Ø4H	5ØØH	ØCH	8Ø4H	12H
Ø1H	Ø4H	5Ø1H	ØDH	8Ø4H	12H
Ø2H	Ø4H	5Ø2H	ØEH	8Ø4H	12H
Ø3H	Ø4H	5Ø3H	ØFH	8Ø4H	12H
Ø4H	Ø4H	5Ø4H	1ØH	8Ø4H	12H
Ø5H	Ø4H	5Ø5H	11H	8Ø4H	12H
Ø6H	Ø4H	5Ø6H	12H	8Ø4H	12H
Ø7H	Ø4H	5Ø7H	13H	8Ø4H	12H
Ø8H	Ø4H	5Ø8H	14H	8Ø4H	12H
?H	Ø4H	5Ø9H	15H	8Ø4H	12H
ØAH	Ø4H	5ØAH	16H	8Ø4H	12H
ØBH	Ø4H	5ØBH	17H	8Ø4H	12H
ØCH	Ø4H	5ØCH	18H	8Ø4H	12H
ØDH	Ø4H	5ØDH	19H	8Ø4H	12H
ØEH	Ø4H	5ØEH	1AH	8Ø4H	12H
ØFH	Ø4H	5ØFH	1BH	8Ø4H	12H
1ØH	Ø4H	51ØH	1CH	8Ø4H	12H
11H	Ø4H	511H	1DH	8Ø4H	12H
12H	Ø4H	512H	1EH	8Ø4H	12H
13H	Ø4H	513H	1FH	8Ø4H	12H
14H	Ø4H	514H	2ØH	8Ø4H	12H
15H	Ø4H	515H	21H	8Ø4H	12H
16H	Ø4H	516H	22H	8Ø4H	12H
17H	Ø4H	517H	23H	8Ø4H	12H
18H	Ø4H	518H	24H	8Ø4H	12H
19H	Ø4H	519H	25H	8Ø4H	12H
1	Ø4H	51AH	26H	8Ø4H	12H
BH	Ø4H	51BH	27H	8Ø4H	12H
1CH	Ø4H	51CH	28H	8Ø4H	12H
DH	Ø4H	51DH	29H	8Ø4H	12H

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FIMS-B PPS LOOKUP TABLE DATA

E/CNT	B/CNT	MA TABLE ADD.	MA TABLE DATA	EA TABLE ADD.	EA TABLE DATA
1EH	04H	51EH	2AH	804H	12H
1FH	04H	51FH	2BH	804H	12H
20H	04H	520H	2CH	804H	12H
21H	04H	521H	2DH	804H	12H
22H	04H	522H	2EH	804H	12H
23H	04H	523H	2FH	804H	12H
24H	04H	524H	30H	804H	12H
25H	04H	525H	31H	804H	12H
26H	04H	526H	32H	804H	12H
27H	04H	527H	33H	804H	12H
00H	05H	540H	0EH	805H	15H
01H	05H	541H	0FH	805H	15H
02H	05H	542H	10H	805H	15H
03H	05H	543H	11H	805H	15H
04H	05H	544H	12H	805H	15H
05H	05H	545H	13H	805H	15H
06H	05H	546H	14H	805H	15H
07H	05H	547H	15H	805H	15H
08H	05H	548H	16H	805H	15H
09H	05H	549H	17H	805H	15H
0AH	05H	54AH	18H	805H	15H
0BH	05H	54BH	19H	805H	15H
0CH	05H	54CH	1AH	805H	15H
0DH	05H	54DH	1BH	805H	15H
0EH	05H	54EH	1CH	805H	15H
0FH	05H	54FH	1DH	805H	15H
10H	05H	550H	1EH	805H	15H
11H	05H	551H	1FH	805H	15H
12H	05H	552H	20H	805H	15H
13H	05H	553H	21H	805H	15H
14H	05H	554H	22H	805H	15H
15H	05H	555H	23H	805H	15H
16H	05H	556H	24H	805H	15H
17H	05H	557H	25H	805H	15H
18H	05H	558H	26H	805H	15H
19H	05H	559H	27H	805H	15H
1AH	05H	55AH	28H	805H	15H
1BH	05H	55BH	29H	805H	15H

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FIHS-B PPS LOOKUP TABLE DATA

PICUT	PSCUT	MA TABLE ADD	MA TABLE DATA	FA TABLE ADD	FA TABLE DATA
1CH	05H	55CH	2AH	805H	15H
1DH	05H	55DH	2BH	805H	15H
1EH	05H	55EH	36H	805H	15H
1FH	05H	55FH	37H	805H	15H
20H	05H	560H	38H	805H	15H
21H	05H	561H	39H	805H	15H
22H	05H	562H	3AH	805H	15H
23H	05H	563H	3BH	805H	15H
24H	05H	564H	3CH	805H	15H
25H	05H	565H	3DH	805H	15H
26H	05H	566H	3EH	805H	15H
27H	05H	567H	3FH	805H	15H
00H	06H	580H	0EH	806H	18H
01H	06H	581H	0FH	806H	18H
02H	06H	582H	10H	806H	18H
03H	06H	583H	11H	806H	18H
04H	06H	584H	12H	806H	18H
05H	06H	585H	13H	806H	18H
06H	06H	586H	14H	806H	18H
07H	06H	587H	15H	806H	18H
[illegible]	06H	588H	16H	806H	18H
[illegible]	06H	589H	17H	806H	18H
[illegible]	06H	58AH	18H	806H	18H
[illegible]	06H	58BH	19H	806H	18H
[illegible]	06H	58CH	1AH	806H	18H
[illegible]	06H	58DH	1BH	806H	18H
[illegible]	06H	58EH	1CH	806H	18H
[illegible]	06H	58FH	1DH	806H	18H
[illegible]	06H	590H	1EH	806H	18H
[illegible]	06H	591H	1FH	806H	18H
[illegible]	06H	592H	20H	806H	18H
[illegible]	06H	593H	21H	806H	18H
[illegible]	06H	594H	22H	806H	18H
[illegible]	06H	595H	23H	806H	18H
[illegible]	06H	596H	24H	806H	18H
[illegible]	06H	597H	25H	806H	18H
18H	06H	598H	26H	806H	18H
19H	06H	599H	27H	806H	18H

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FIMS-B PPS LOOKUP TABLE DATA

IOUT	DINPUT	MA TABLE ADD.	MA TABLE DATA	EA TABLE ADD.	EA TABLE DATA
1AH	Ø6H	59AH	32H	8Ø6H	18H
1BH	Ø6H	59BH	33H	8Ø6H	18H
1CH	Ø6H	59CH	34H	8Ø6H	18H
1DH	Ø6H	59DH	35H	8Ø6H	18H
1EH	Ø6H	59EH	36H	8Ø6H	18H
1FH	Ø6H	59FH	37H	8Ø6H	18H
2ØH	Ø6H	5AØH	38H	8Ø6H	18H
21H	Ø6H	5A1H	39H	8Ø6H	18H
22H	Ø6H	5A2H	3AH	8Ø6H	18H
23H	Ø6H	5A3H	3BH	8Ø6H	18H
24H	Ø6H	5A4H	3CH	8Ø6H	18H
25H	Ø6H	5A5H	3DH	8Ø6H	18H
26H	Ø6H	5A6H	3EH	8Ø6H	18H
27H	Ø6H	5A7H	3FH	8Ø6H	18H
ØØH	Ø7H	5CØH	ØEH	8Ø7H	1BH
Ø1H	Ø7H	5C1H	ØFH	8Ø7H	1BH
Ø2H	Ø7H	5C2H	1ØH	8Ø7H	1BH
Ø3H	Ø7H	5C3H	11H	8Ø7H	1BH
Ø4H	Ø7H	5C4H	12H	8Ø7H	1BH
Ø5H	Ø7H	5C5H	13H	8Ø7H	1BH
Ø6H	Ø7H	5C6H	14H	8Ø7H	1BH
Ø7H	Ø7H	5C7H	15H	8Ø7H	1BH
Ø8H	Ø7H	5C8H	16H	8Ø7H	1BH
Ø9H	Ø7H	5C9H	17H	8Ø7H	1BH
ØAH	Ø7H	5CAH	18H	8Ø7H	1BH
ØBH	Ø7H	5CBH	19H	8Ø7H	1BH
ØCH	Ø7H	5CCH	1AH	8Ø7H	1BH
ØDH	Ø7H	5CDH	1BH	8Ø7H	1BH
ØEH	Ø7H	5CEH	1CH	8Ø7H	1BH
ØFH	Ø7H	5CFH	1DH	8Ø7H	1BH
1ØH	Ø7H	5DØH	1EH	8Ø7H	1BH
11H	Ø7H	5D1H	1FH	8Ø7H	1BH
12H	Ø7H	5D2H	2ØH	8Ø7H	1BH
13H	Ø7H	5D3H	21H	8Ø7H	1BH
14H	Ø7H	5D4H	22H	8Ø7H	1BH
15H	Ø7H	5D5H	23H	8Ø7H	1BH
16H	Ø7H	5D6H	24H	8Ø7H	1BH
17H	Ø7H	5D7H	25H	8Ø7H	1BH

FIMS-B PPS LOOKUP TABLE DATA

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INPUT	FRONT	MA TABLE ADD.	MA TABLE DATA	LA TABLE ADD.	LA TABLE DATA
[illegible]	07H	5D8H	26H	807H	1BH
19H	07H	5D9H	27H	807H	1BH
1AH	07H	5DAH	28H	807H	1BH
1BH	07H	5DBH	29H	807H	1BH
1CH	07H	5DCH	2AH	807H	1BH
1DH	07H	5DDH	2BH	807H	1BH
1EH	07H	5DEH	2CH	807H	1BH
1FH	07H	5DFH	2DH	807H	1BH
20H	07H	5E0H	2EH	807H	1BH
21H	07H	5E1H	2FH	807H	1BH
22H	07H	5E2H	30H	807H	1BH
23H	07H	5E3H	31H	807H	1BH
24H	07H	5E4H	32H	807H	1BH
25H	07H	5E5H	33H	807H	1BH
26H	07H	5E6H	34H	807H	1BH
27H	07H	5E7H	35H	807H	1BH
00H	08H	600H	0DH	808H	1EH
[illegible]H	08H	601H	0EH	808H	1EH
02H	08H	602H	0FH	808H	1EH
03H	08H	603H	10H	808H	1EH
04H	08H	604H	11H	808H	1EH
05H	08H	605H	12H	808H	1EH
06H	08H	606H	13H	808H	1EH
07H	08H	607H	14H	808H	1EH
08H	08H	608H	15H	808H	1EH
09H	08H	609H	16H	808H	1EH
0AH	08H	60AH	17H	808H	1EH
0BH	08H	60BH	18H	808H	1EH
0CH	08H	60CH	19H	808H	1EH
0DH	08H	60DH	1AH	808H	1EH
0EH	08H	60EH	1BH	808H	1EH
0FH	08H	60FH	1CH	808H	1EH
10H	08H	610H	1DH	808H	1EH
[illegible]	08H	611H	1EH	808H	1EH
[illegible]	08H	612H	1FH	808H	1EH
[illegible]	08H	613H	20H	808H	1EH
[illegible]	08H	614H	21H	808H	1EH
[illegible]	08H	615H	22H	808H	1EH

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FTKS-B PPS LOOKUP TABLE DATA

PCUT	P2CUT	MA TABLE ADD.	MA TABLE DATA	FA TABLE ADD.	FA TABLE DATA
16H	08H	616H	23H	808H	1EH
17H	08H	617H	24H	808H	1EH
18H	08H	618H	25H	808H	1EH
19H	08H	619H	26H	808H	1EH
1AH	08H	61AH	27H	808H	1EH
1BH	08H	61BH	28H	808H	1EH
1CH	08H	61CH	29H	808H	1EH
1DH	08H	61DH	2AH	808H	1EH
1EH	08H	61EH	2BH	808H	1EH
1FH	08H	61FH	2CH	808H	1EH
20H	08H	620H	2DH	808H	1EH
21H	08H	621H	2EH	808H	1EH
22H	08H	622H	2FH	808H	1EH
23H	08H	623H	30H	808H	1EH
24H	08H	624H	31H	808H	1EH
25H	08H	625H	32H	808H	1EH
26H	08H	626H	33H	808H	1EH
27H	08H	627H	34H	808H	1EH
00H	09H	640H	0DH	809H	21H
01H	09H	641H	0EH	809H	21H
02H	09H	642H	0FH	809H	21H
03H	09H	643H	10H	809H	21H
04H	09H	644H	11H	809H	21H
05H	09H	645H	12H	809H	21H
06H	09H	646H	13H	809H	21H
07H	09H	647H	14H	809H	21H
08H	09H	648H	15H	809H	21H
09H	09H	649H	16H	809H	21H
0AH	09H	64AH	17H	809H	21H
0BH	09H	64BH	18H	809H	21H
0CH	09H	64CH	19H	809H	21H
0DH	09H	64DH	1AH	809H	21H
0EH	09H	64EH	1BH	809H	21H
0FH	09H	64FH	1CH	809H	21H
10H	09H	650H	1DH	809H	21H
11H	09H	651H	1EH	809H	21H
12H	09H	652H	1FH	809H	21H
13H	09H	653H	20H	809H	21H

FIMS-B PPS LOOKUP TABLE DATA

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PICLST	RACLST	MA TABLE ADD	MA TABLE DATA	EA TABLE ADD.	EA TABLE DATA
14H	09H	654H	21H	809H	21H
15H	09H	655H	22H	809H	21H
16H	09H	656H	23H	809H	21H
17H	09H	657H	24H	809H	21H
18H	09H	658H	25H	809H	21H
19H	09H	659H	26H	809H	21H
1AH	09H	65AH	27H	809H	21H
1BH	09H	65BH	28H	809H	21H
1CH	09H	65CH	29H	809H	21H
1DH	Ø9H	65DH	2AH	809H	21H
1EH	09H	65EH	2BH	809H	21H
1FH	09H	65FH	2CH	809H	21H
2ØH	09H	66ØH	2DH	809H	21H
21H	09H	661H	2EH	809H	21H
22H	09H	662H	2FH	809H	21H
23H	09H	663H	3ØH	809H	21H
24H	Ø9H	664H	31H	809H	21H
25H	Ø9H	665H	32H	809H	21H
26H	Ø9H	666H	33H	809H	21H
27H	Ø9H	667H	34H	8Ø9H	21H
ØØH	ØAH	68ØH	ØDH	8ØAH	24H
Ø1H	ØAH	681H	ØEH	8ØAH	24H
Ø2H	ØAH	682H	ØFH	8ØAH	24H
Ø3H	ØAH	683H	1ØH	8ØAH	24H
Ø4H	ØAH	684H	11H	8ØAH	24H
Ø5H	ØAH	685H	12H	8ØAH	24H
Ø6H	ØAH	686H	13H	8ØAH	24H
Ø7H	ØAH	687H	14H	8ØAH	24H
Ø8H	ØAH	688H	15H	8ØAH	24H
Ø9H	ØAH	689H	16H	8ØAH	24H
ØAH	ØAH	68AH	17H	8ØAH	24H
ØBH	ØAH	68BH	18H	8ØAH	24H
ØCH	ØAH	68CH	19H	8ØAH	24H
ØDH	ØAH	68DH	1AH	8ØAH	24H
ØEH	ØAH	68EH	1BH	8ØAH	24H
ØFH	ØAH	68FH	1CH	8ØAH	24H
1ØH	ØAH	69ØH	1DH	8ØAH	24H
11H	ØAH	69[illegible]H	1EH	8ØAH	24H

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FIMS-B PPS LOOKUP TABLE DATA

L INT	R INT	MA TABLE ADD	MA TABLE DATA	EA TABLE ADD	EA TABLE DATA
12H	0AH	692H	1FH	80AH	24H
13H	0AH	693H	20H	80AH	24H
14H	0AH	694H	21H	80AH	24H
15H	0AH	695H	22H	80AH	24H
16H	0AH	696H	23H	80AH	24H
17H	0AH	697H	24H	80AH	24H
18H	0AH	698H	25H	80AH	24H
19H	0AH	699H	26H	80AH	24H
1AH	0AH	69AH	27H	80AH	24H
1BH	0AH	69BH	28H	80AH	24H
1CH	0AH	69CH	29H	80AH	24H
1DH	0AH	69DH	2AH	80AH	24H
1EH	0AH	69EH	2BH	80AH	24H
1FH	0AH	69FH	2CH	80AH	24H
20H	0AH	6A0H	2DH	80AH	24H
21H	0AH	6A1H	2EH	80AH	24H
22H	0AH	6A2H	2FH	80AH	24H
23H	0AH	6A3H	30H	80AH	24H
24H	0AH	6A4H	31H	80AH	24H
25H	0AH	6A5H	32H	80AH	24H
26H	0AH	6A6H	33H	80AH	24H
27H	0AH	6A7H	34H	80AH	24H
00H	0BH	6C0H	0DH	80BH	27H
01H	0BH	6C1H	0EH	80BH	27H
02H	0BH	6C2H	0FH	80BH	27H
03H	0BH	6C3H	10H	80BH	27H
04H	0BH	6C4H	11H	80BH	27H
05H	0BH	6C5H	12H	80BH	27H
06H	0BH	6C6H	13H	80BH	27H
07H	0BH	6C7H	14H	80BH	27H
08H	0BH	6C8H	15H	80BH	27H
09H	0BH	6C9H	16H	80BH	27H
0AH	0BH	6CAH	17H	80BH	27H
0BH	0BH	6CBH	18H	80BH	27H
0CH	0BH	6CCH	19H	80BH	27H
0DH	0BH	6CDH	1AH	80BH	27H
0EH	0BH	6CEH	1BH	80BH	27H
0FH	0BH	6CFH	1CH	80BH	27H

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[illegible] LOOKUP TABLE DATA

[illegible]	PROM	[illegible] TABLE ADD.	[illegible] TABLE DATA	[illegible] TABLE ADD.	[illegible] TABLE DATA
10H	0E	[illegible]	1DH	80EH	[illegible]
11H	0E	6D1H	1EH	80EH	27H
12H	0E	6D2H	1FH	80EH	[illegible]
13H	0E	6D3H	20H	80[illegible]	[illegible]
14H	0E	6D4H	21H	80EH	27H
15H	0E	6D5H	22H	80BH	27H
16H	0E	6D6H	23H	80EH	27H
17H	0E	6D7H	24H	80FH	27H
18H	0E	6D8H	25H	80EH	27H
19H	0E	6D9H	26H	80EH	27H
1AH	0E	6DAH	27H	80EH	27H
1BH	0E	6DBH	28H	80BH	27H
1CH	0E	6DCH	29H	80FH	27H
1DH	0E	6DDH	2AH	80EH	27H
1EH	0F	6DEH	2BH	80FH	27H
1FH	0E	6DFH	2CH	80FH	27H
20H	0E	6E0H	2DH	80EH	27H
21H	0B	6E1H	2EH	80EH	27H
22H	0B	6E2H	2FH	80EH	27H
23H	0E	6E3H	30H	80BH	27H
24H	0B	6E4H	31H	80BH	27H
25H	0E	6E5H	32H	80BH	27H
26H	0E	6E6H	33H	80BH	27H
27H	0E	6E7H	34H	80EH	27H
00H	0C	700H	0DH	80CH	2AH
01H	0C	701H	0EH	80CH	2AH
02H	0C	702H	0FH	80CH	2AH
03H	0C	703H	10H	80CH	2AH
04H	0C	704H	11H	80CH	2AH
05H	0C	705H	12H	80CH	2AH
06H	0C	706H	13H	80CH	2AH
07H	0C	707H	14H	80CH	2AH
08H	0C	708H	15H	80CH	2AH
09H	0C	709H	16H	80CH	2AH
0AH	0C	70AH	17H	80CH	2AH
0BH	0C	70BH	18H	80CH	2AH
0CH	0C	70CH	19H	80CH	2AH
0DH	0C	70DH	1AH	80CH	2AH

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FIMS-B FPS LOOKUP TABLE DATA

INPUT	PRINT	PA TABLE ADD	PA TABLE DATA	EA TABLE ADD	EA TABLE DATA
0EH	0CH	70FH	1BH	80CH	2AH
0FH	0CH	70EH	1CH	80CH	2AH
10H	0CH	710H	1DH	80CH	2AH
11H	0CH	711H	1EH	80CH	2AH
12H	0CH	712H	1FH	80CH	2AH
13H	0CH	713H	20H	80CH	2AH
14H	0CH	714H	21H	80CH	2AH
15H	0CH	715H	22H	80CH	2AH
16H	0CH	716H	23H	80CH	2AH
17H	0CH	717H	24H	80CH	2AH
18H	0CH	718H	25H	80CH	2AH
19H	0CH	719H	26H	80CH	2AH
1AH	0CH	71AH	27H	80CH	2AH
1BH	0CH	71BH	28H	80CH	2AH
1CH	0CH	71CH	29H	80CH	2AH
1DH	0CH	71DH	2AH	80CH	2AH
1EH	0CH	71EH	2BH	80CH	2AH
1FH	0CH	71FH	2CH	80CH	2AH
20H	0CH	720H	2DH	80CH	2AH
21H	0CH	721H	2EH	80CH	2AH
22H	0CH	722H	2FH	80CH	2AH
23H	0CH	723H	30H	80CH	2AH
24H	0CH	724H	31H	80CH	2AH
25H	0CH	725H	32H	80CH	2AH
26H	0CH	726H	33H	80CH	2AH
27H	0CH	727H	34H	80CH	2AH
00H	0DH	740H	0DH	80DH	2DH
01H	0DH	741H	0EH	80DH	2DH
02H	0DH	742H	0FH	80DH	2DH
03H	0DH	743H	10H	80DH	2DH
04H	0DH	744H	11H	80DH	2DH
05H	0DH	745H	12H	80DH	2DH
06H	0DH	746H	13H	80DH	2DH
07H	0DH	747H	14H	80DH	2DH
08H	0DH	748H	15H	80DH	2DH
09H	0DH	749H	16H	80DH	2DH
0AH	0DH	74AH	17H	80DH	2DH
0BH	0DH	74BH	18H	80DH	2DH

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[illegible] PPS LOOKUP TABLE DATA

POINT	POINT	PA TABLE ADD.	PA TABLE DATA	PA TABLE ADD	PA TABLE DATA
0CH	0DH	74CH	[illegible]	[illegible]	3DH
0DH	0DH	74DH	[illegible]	80DH	[illegible]
0EH	0DH	74EH	[illegible]	80DH	[illegible]
0FH	0DH	74FH	[illegible]	80DH	[illegible]
10H	0DH	750H	[illegible]	80DH	3DH
11H	0DH	751H	[illegible]	80DH	3DH
12H	0DH	752H	[illegible]	80DH	3DH
13H	0DH	753H	[illegible]	80DH	3DH
14H	0DH	754H	[illegible]	80DH	3DH
15H	0DH	755H	[illegible]	80DH	3DH
16H	0DH	756H	[illegible]	80DH	3DH
17H	0DH	757H	[illegible]	80DH	3DH
18H	0DH	758H	25H	80DH	3DH
19H	0DH	759H	26H	80DH	3DH
1AH	0DH	75AH	[illegible]	80DH	3DH
1BH	0DH	75BH	[illegible]	80DH	3DH
1CH	0DH	75CH	[illegible]	80DH	3DH
1DH	0DH	75DH	[illegible]	80DH	3DH
1EH	0DH	75EH	[illegible]	80DH	3DH
1FH	0DH	75FH	[illegible]	80DH	3DH
20H	0DH	760H	[illegible]	80DH	3DH
21H	0DH	761H	[illegible]	80DH	3DH
22H	0DH	762H	[illegible]	80DH	3DH
23H	0DH	763H	[illegible]	80DH	3DH
24H	0DH	764H	[illegible]	80DH	3DH
25H	0DH	765H	32H	80DH	3DH
26H	0DH	766H	33H	80DH	3DH
27H	0DH	767H	[illegible]	80DH	3DH
00H	0EH	780H	0DH	80EH	30H
01H	0EH	781H	0EH	80EH	30H
02H	0EH	782H	0FH	80EH	30H
03H	0EH	783H	10H	80EH	30H
04H	0EH	784H	11H	80EH	30H
05H	0EH	785H	12H	80EH	30H
06H	0EH	786H	13H	80EH	30H
[illegible]	0EH	787H	14H	80EH	30H
08H	0EH	788H	15H	80EH	30H
[illegible]	0EH	789H	16H	80EH	30H

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IIMS-B FPS LOOKUP TABLE DATA

PICUT	PRCUT	MA TABLE ADD.	MA TABLE DATA	EA TABLE ADD.	EA TABLE DATA
ØAH	ØEH	78AH	[illegible]	[illegible]	3ØH
ØBH	ØEH	78BH	[illegible]	8ØFH	3ØH
ØCH	ØFH	78CH	[illegible]	8ØEH	3ØH
ØDH	ØEH	78DH	[illegible]	[illegible]	3ØH
ØEH	ØEH	78EH	[illegible]	8ØFH	3ØH
ØFH	ØFH	78FH	[illegible]	8ØEH	3ØH
1ØH	ØFH	79ØH	[illegible]	8ØEH	[illegible]
11H	ØEH	791H	[illegible]	8ØFH	3ØH
12H	ØEH	792H	[illegible]	8ØFH	3ØH
13H	ØEH	793H	[illegible]	8ØEH	3ØH
14H	ØFH	794H	[illegible]	8ØEH	3ØH
15H	ØEH	795H	[illegible]	8ØEH	3ØH
16H	ØEH	796H	[illegible]	8ØFH	3ØH
17H	ØEH	797H	[illegible]	8ØEH	3ØH
18H	ØFH	798H	[illegible]	8ØFH	3ØH
19H	ØEH	799H	[illegible]	8ØEH	3ØH
1AH	ØEH	79AH	[illegible]	8ØEH	3ØH
1BH	ØEH	79BH	[illegible]	8ØEH	3ØH
1CH	ØFH	79CH	[illegible]	8ØFH	3ØH
1DH	ØEH	79DH	2AH	8ØFH	3ØH
1EH	ØEH	79EH	2BH	8ØEH	3ØH
1FH	ØEH	79FH	2CH	8ØFH	3ØH
2ØH	ØEH	7AØH	2DH	8ØFH	3ØH
21H	ØEH	7A1H	2EH	8ØEH	3ØH
22H	ØEH	7A2H	2FH	8ØEH	3ØH
23H	ØEH	7A3H	3ØH	8ØEH	3ØH
24H	ØEH	7A4H	31H	8ØEH	3ØH
25H	ØEH	7A5H	32H	8ØEH	3ØH
26H	ØEH	7A6H	33H	8ØFH	3ØH
27H	ØFH	7A7H	34H	8ØEH	3ØH
ØØH	ØFH	7CØH	ØEH	8ØFH	33H
Ø1H	ØFH	7C1H	ØFH	8ØFH	33H
Ø2H	ØFH	7C2H	1ØH	8ØFH	33H
Ø3H	ØFH	7C3H	11H	8ØFH	33H
Ø4H	ØFH	7C4H	12H	8ØFH	33H
Ø5H	ØFH	7C5H	13H	8ØFH	33H
Ø6H	ØFH	7C6H	14H	8ØFH	33H
Ø7H	ØFH	7C7H	15H	8ØFH	33H

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FDMS-B MPS LOOKUP TABLE DATA

IDIGT	TE IDIGT	MA TABLE ADD.	MA TABLE DATA	EA TABLE ADD	EA TABLE DATA
08H	0FH	7C8H	16H	80FH	33H
09H	0FH	7C9H	17H	80FH	33H
0AH	0FH	7CAH	18H	80FH	33H
0BH	0FH	7CBH	19H	80FH	33H
0CH	0FH	7CCH	1AH	80FH	33H
0DH	0FH	7CDH	1BH	80FH	33H
0EH	0FH	7CEH	1CH	80FH	33H
0FH	0FH	7CFH	1DH	80FH	33H
10H	0FH	7D0H	1EH	80FH	33H
11H	0FH	7D1H	1FH	80FH	33H
12H	0FH	7D2H	20H	80FH	33H
13H	0FH	7D3H	21H	80FH	33H
14H	0FH	7D4H	22H	80FH	33H
15H	0FH	7D5H	23H	80FH	33H
16H	0FH	7D6H	24H	80FH	33H
17H	0FH	7D7H	25H	80FH	33H
18H	0FH	7D8H	26H	80FH	33H
19H	0FH	7D9H	27H	80FH	33H
1AH	0FH	7DAH	28H	80FH	33H
1BH	0FH	7DBH	29H	80FH	33H
1CH	0FH	7DCH	2AH	80FH	33H
1DH	0FH	7DDH	2BH	80FH	33H
1EH	0FH	7DEH	2CH	80FH	33H
1FH	0FH	7DFH	2DH	80FH	33H
20H	0FH	7E0H	2EH	80FH	33H
21H	0FH	7E1H	2FH	80FH	33H
22H	0FH	7E2H	30H	80FH	33H
23H	0FH	7E3H	31H	80FH	33H
24H	0FH	7E4H	32H	80FH	33H
25H	0FH	7E5H	33H	80FH	33H
26H	0FH	7E6H	34H	80FH	33H
27H	0FH	7E7H	35H	80FH	33H

C. Programmable Power Supplies

FIMS-B uses two programmable high voltage power supplies. Both power supplies were constructed from the design drawings prepared by the Goddard Space Flight Center for use on the HAPI and LAPI instruments on the Dynamics Explorer Satellite.

A few design changes were made to the power supplies to adapt them to the scientific and operational requirements of the FIMS/Centaur rocket program. The two power supplies used by FIMS are referred to as the energy and mass units, corresponding to the two sections of the instruments analyzer. The energy supply is very similar to the standard D.E. design. Table VII-1 shows the relationship between the 6-bit programming code word and the high voltage output.

The mass analyzer power supply is considerably different from the basic P.P.S. design, the principal difference being that this supply has its high voltage output floated at the -2400VDC bias used for the mass analyzer float potential. To realize this objective, a considerable effort was invested in insulating the electronics within the supply from the chassis-grounded case of the power supply. The inner surfaces of the case of the power supply are lined with a fiberglass material to prevent high voltage breakdown.

The second major change was the addition of a set of six optical couplers to interface with the 6-bit parallel command interface to the CEP. In summary, the mass P.P.S. has its high voltage return connected to the minus high voltage output of the HVPS, thus floating most of the circuits within the supply at -2400V. A 50-megohm resistor was placed in series with the high voltage return line to the minus high voltage output of the bias power supply (PICO-PAK). Table VII-2 shows the relationship between the 6-bit programming code and the high-voltage output of the mass supply.

D. High Voltage Power Supply (HVPS)

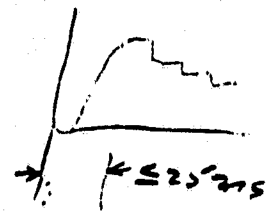
The FIMS-B instrument uses a single HVPS to provide the float potential for the mass analyzer deflection plates and the bias for the microchannel plate detector. A standard PICO-PAK Model PP9N provides the bias potential. The pages following contain specification sheets for the unit used on FIMS-B. The high voltage output has been adjusted to -2400VDC for this application.

8-10-81
GF1394977-7 #2

JTN 23 → 26...

E2 (CARRIER ON) = <5V
E3 (FM mon) = (38-39 KA
E7 (FM mon) = 40-51 KA
E12 (Low Voltage) = (4.5-5.

STEP NO.	VOLTAGE LEVEL	+VO	-VO	E1 +TM	E4 -TM	STEP NO.
0	2500.0 V	2524	2520	5.06	5.03	0
1	2164.9	2174	2170	4.36	4.34	1
2	1874.7	1891	1888	3.80	3.78	2
3	1623.4	1635	1633	3.28	3.27	3
4	1405.8	1417	1415	2.85	2.84	4
5	1217.4	1228	1226	1.23	2.46	5
6	1054.2	1064	1062	2.14	2.13	6
7	912.92	921	920	1.85	1.84	7
8	790.55	789	788	1.59	1.58	8
9	684.59	680	679	1.37	1.36	9
10	592.83	592	591	1.19	1.185	10
11	513.37	512	511	1.03	1.025	11
12	444.56	444	443	.893	.889	12
13	384.97	385	384	.773	.770	13
14	333.37	333.3	333	.670	.667	14
15	288.68	288.7	288.3	.580	.578	15
16	249.99	250.4	250.1	.503	.501	16
17	216.48	215.7	215.5	.4338	.4327	17
18	187.47	187.7	187.5	.3773	.3766	18
19	162.34	162.4	162.2	.3262	.3258	19
20	140.58	140.7	140.6	.2826	.2824	20
21	121.74	121.9	121.8	.2446	.2447	21
22	105.42	105.6	105.5	.2118	.2121	22
23	91.288	91.5	91.4	.1832	.1878	23
24	79.052	79.7	79.6	.1594	.1600	24
25	68.456	68.6	68.6	.1371	.1379	25
26	59.281	59.7	59.7	.1191	.1200	26
27	51.335	51.6	51.6	.1028	.1038	27
28	44.454	44.7	44.7	.0889	.0899	28
29	38.495	38.7	38.7	.0765	.0780	29
30	33.336	33.5	33.5	.0664	.0676	30
31	28.867	29.0	29.0	.0573	.0586	31
32	24.998V	25.12	25.12	5.06	4.900	32
33	21.647	21.66	21.66	4.37	4.220	33
34	18.746	18.86	18.86	3.81	3.67	34
35	16.233	16.33	16.33	3.30	3.18	35
36	14.057	14.17	14.17	2.866	2.75	36
37	12.173	12.29	12.29	2.49	2.38	37
38	10.541	10.65	10.65	2.16	2.06	38
39	9.1285	9.24	9.24	1.876	1.786	39
40	7.9049	7.93	7.93	1.61	1.53	40
41	6.8454	6.83	6.83	1.39[illegible]	1.316	41
42	5.9278	5.95	5.95	1.22	1.14	42
43	5.1333	5.15	5.15	1.06	.998	43
44	4.4452	4.477	4.475	.923	.855	44
45	3.8494	3.881	3.877	.804	.739	45
46	3.3334	3.364	3.360	.702	.639	46
47	2.8866	2.914	2.909	.612	.552	47
48	2.4997	2.525	2.525	.536	.478	48
49	2.1646	2.171	2.174	.467	.410	49
50	1.8745	1.891	1.890	.411	.356	50
51	1.6232	1.631	1.632	.361	.306	51
52	1.4057	1.417	1.416	.318	.264	52
53	1.2173	1.226	1.223	.280	.227	53
54	1.0541	1.062	1.059	.248	.196	54
55	0.91281	.918	.913	.2195	.168	55
56	0.79046	.801	.801	.1965	.1461	56
57	0.68451	.688	.686	.1743	.1242	57
58	0.59276	.598	.596	.1566	.1069	58
59	0.51331	.515	.512	.1403	.0908	59
60	0.44450	.446	.445	.1268	.0777	60
61	0.38492	.385	.382	.1147	.0656	61
62	0.33333	.332	.329	.1044	.0555	62
63	0.289	.292	.287	.0952		



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Data taken with FIXED Supply Voltage = 26.70V

TABLE VII-1

... 3-81 ...

STEP	RI	RF	VI	VO	+VO	+TM	-VO	-TM
1	127K	127K	-7.50	-982.22	977	4.86	979	4.901
2		120K	-7.08	-926.62	924	4.60	927	4.64
3		113K	-6.67	-874.17	865	4.30	867	4.34
4		107K	-6.30	-824.69	818	4.07	820	4.10
5		101K	-5.94	-778.01	770	3.83	772	3.86
6		95K	-5.60	-733.97	728	3.62	730	3.65
7		90K	-5.29	-692.43	694	3.45	695	3.48
8		84K	-4.99	-653.23	645	3.21	647	3.29
9	202K	127K	-4.71	-616.26	617	3.07	618	3.095
10		120K	-4.44	-581.38	584	2.90	58[illegible]	2.93
11		113K	-4.19	-548.47	546	2.716	547	2.74
12		107K	-3.95	-517.42	517	2.57	518	2.59
13		101K	-3.73	-488.13	486	2.42	487	2.44
14		95K	-3.52	-460.50	460	2.285	461	2.306
15		90K	-3.32	-434.44	438	2.18	439	2.177
16		84K	-3.13	-409.85	408	2.026	409	2.04
17	323K	127K	-2.95	-386.65	382	1.898	383	1.915
18		120K	-2.79	-364.76	361.5	1.796	362	1.81
19		113K	-2.63	-344.12	338	1.68	339	1.696
20		107K	-2.48	-324.64	320	1.59	321	1.604
21		101K	-2.34	-306.26	301	1.496	302	1.51
22		95K	-2.21	-288.93	285	1.41	285	1.43
23		90K	-2.08	-272.57	2.71	1.347	272	1.36
24		84K	-1.96	-257.14	252	1.254	253	1.26
25	514K	127K	-1.85	-242.59	241	1.198	242	1.21
26		120K	-1.75	-228.86	228	1.13	229	1.143
27		113K	-1.65	-215.90	213.4	1.06	214	1.07
28		107K	-1.56	-203.68	202	1.00	202	1.01
29		101K	-1.47	-192.15	190	.943	190.	.952
30		95K	-1.38	-181.28	179.6	.891	180	.900
31		90K	-1.31	-171.02	171	.849	171	.857
32		84K	-1.23	-161.33	159	.790	159	.798
33	~~820K~~ 820k	127K	-1.16	-152.20	150	.746	151	.754
34		120K	-1.10	-143.59	142	.706	143	.713
35		113K	-1.03	-135.46	133	.660	133	.667
36		107K	-.98	-127.79	126	.623	~~[illegible]~~	.631
37		101K	-.92	-120.56	118	.587	119	.594
38		95K	-.87	-113.73	112	.554	112	.561
39		90K	-.82	-107.30	107	.528	107	.535
40		84K	-.77	-101.22	99.3	.493	99.6	.498
41	1.306M	127K	-.73	-95.49	94.6		94.6	.474
42		120K	-.69	-90.09	89.5	.444	89.8	.449
43		113K	-.65	-84.99	83.8	.416	84.0	.420
44		107K	-.61	-80.18	79.2	.393	79.5	.397
45		101K	-.58	-75.64	74.6	.370	74.8	.374
46		95K	-.54	-71.36	70.5	.349	70.7	.353
47		90K	-.51	-67.32	67.1	.333	67.3	.336
48		84K	-.48	-63.51	62.4	.309	62.7	.313
49	2.082M	127K	-.46	-59.91	59.5	.295	59.7	.298
50		120K	-.43	-56.52	56.3	.279	56.5	.282
51		113K	-.41	-53.32	52.6	.268	52.9	.264
52		107K	-.38	-50.31	49.8	.246	50.0	.250
53		101K	-.36	-47.46	46.8	.232	47.0	.235
54		95K	-.34	-44.77	44.3	.219	44.4	.222
55		90K	-.32	-42.24	42.2	.2085	42.3	.212
56		84K	-.30	-39.85	39.2	.194	39.4	.197
57	3.318M	127K	-.29	-37.59	37.1	.183	37.2	.186
58		120K	-.27	-35.46	35.1	.173	35.2	.176
59		113K	-.26	-33.56	32.8	.162	33.0	.165
60		107K	-.24	-31.56	31.0	.153	31.2	.156
61		101K	-.23	-29.78	29.2	.144	29.3	.1466
62		95K	-.21	-28.09	27.6	.136	27.	
63		90K	-.20	-26.50	26.2	.129	26.	
64		84K	-.19	-25.00	24.4	.120	24	

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OVERVoltage = 2

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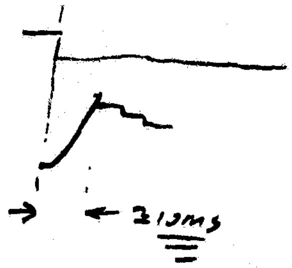

FINAL DATA

.857 × 200 = 171.4 ≈ 171

.849 × 200 = 169.8 ≈ 169.8 ≈ 17

TM·200 = VO
.1227(200) = 24.6
245.4 ≈ ...

TABLE VII-2