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A COST AND UTILITY ANALYSIS OF NIM/CAMAC STANDARDS AND EQUIPMENT FOR SHUTTLE PAYLOAD DATA ACQUISITION AND CONTROL SYSTEMS

VOLUME II. TASKS 1 & 2

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FOREWORD

A Cost and Utility Analysis of NIM/CAMAC Standards and Equipment for Shuttle Payload Data Acquisition and Control Systems was performed by the Defense and Space Systems Group of TRW, Inc. under Contract NAS9-14693 for the Lyndon B. Johnson Space Center of the National Aeronautics and Space Administration. The work was managed by Dr. Richard J. Kurz (Telephone (213) 535-2936) of the Instrument Systems Department, TRW Defense and Space Systems Group. The study was administered under the technical direction of Dr. Richard D. Eandi (Telephone (713) 483-5176) of the Space Physics Branch, Johnson Space Center.

The results of the study are presented in three volumes:

VOLUME I. SUMMARY

Overall summary of the analyses and conclusions

VOLUME II. TASKS 1 AND 2

Identification and selection of representative payloads for analysis and functional analysis of the selected paylaods for NIM/CAMAC equipment applicability and commonality.

VOLUME III. TASKS 3 AND 4

Analysis of the modifications to NIM/CAMAC equipment required for compatibility with the Spacelab environment and their estimated cost, development of a management plan for the utilization of NIM/CAMAC equipment and programmatic cost estimates, and assessment of the implementation and impact of CAMAC software.

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1. INTRODUCTION

1.1 STUDY BACKGROUND

The use of Space Shuttle and Spacelab as a low-cost transportation system to support space research and applications programs will change payload implementation and operation significantly. Payload changes from current practices that can be expected with the advent of the Shuttle include:

- Weight, volume, power and environmental constraints will be considerably relaxed.
- Repair, refurbishment and reuse of payload equipment will become routine.
- Hardware development time will be considerably shortened.
- Reuse, modification, and quick turn-around will demand equipment flexibility, interchangeability, and interface simplicity.
- Payloads will require versatile and flexible data management and control systems.

All of these considerations point to the use of standard, modular electronic equipment for Shuttle payloads. This equipment must lend itself to flexible integration into a computer-controlled data management and control system. The commonalities achieved in both hardware and software required for various payloads would result in the cost benefits of reduced development effort and multiple use of such equipment and software.

The NIM (Nuclear Instrument Modules) and CAMAC (Computer Automated Measurement and Control) standards for modular electronic equipment are existing, successful implementations of solutions to similar requirements in ground-based research that have the benefit of extensive user acceptance and experience. They are therefore natural choices to consider for application to Shuttle payloads.

1.1.1 Description of NIM and CAMAC Systems

A very brief description of the NIM and CAMAC standards and equipment is given in the following sections. For complete details, the reader is referred to the publications listed in Table 1-1.

Table 1-1. Selected Publications Regarding NIM and CAMAC

Standard Nuclear Instrument Modules	ERDA Report TID-20893
CAMAC - A Modular Instrumentation System for Data Handling - Description and Specifications	ERDA Report TID-25875
CAMAC - Organization of Multicrate Systems	ERDA Report TID-25876
Supplementary Information on CAMAC Instrumentation System	ERDA Report TID-25877
CAMAC Serial System Organization - A Description	ERDA Report TID-26488
CAMAC - Specification of Amplitude Analog Signals within a Fifty-Ohm System	ERDA Report TID-26614
CAMAC - The Definition of IML, A Language for Use in CAMAC Systems	ERDA Report TID-26615
Block Transfers in CAMAC Systems	ERDA Report TID-26616
IEEE Standard Modular Instrumentation and Digital Interface System (CAMAC)	IEEE Std 583-1975
CAMAC Bulletin	A publication of the ESONE Committee issued three times yearly by EURATOM
Proceedings of 1975 Meeting of IEEE Insdustry Applications Society	IEEE Conference Record 74CHO 833-41A (Part 1)
CAMAC Tutorial Issue	IEEE Transactions on Nuclear Science, NS-20, No. 2, April 1973
Proceedings of 1973 Nuclear Science Symposium	IEEE Transactions on Nuclear Science NS-21 No. 1, February 1974
Proceedings of 1974 Nuclear Science Symposium	IEEE Transactions on Nuclear Science NS-22 No. 1, February 1975
Proceedings of 1975 Nuclear Science Symposium	IEEE Transactions on Nuclear Science NS-23 No. 1, February 1976

1.1.1.1 NIM Standards

The NIM standards were developed by a committee of equipment users under the auspices of the Atomic Energy Commission (now the Energy Research and Development Agency) and the National Bureau of Standards to provide maximum compatibility between instruments produced by various manufacturers. These standards define the equipment characteristics required for mechanical and electrical compatibility.

NIM standards must be met in the design of all the equipment intended for NIM-compatible use. Module and bin dimensions and power connector location and pin assignments have been standardized as have the supply voltages and the allowable current for each supply voltage. Each equipment bin accepts twelve unit module widths and is designed for mounting in a standard 19-inch relay rack.

NIM preferred practices are characteristics added to the basic NIM standards which are recommended by the NIM committee to define linear signals, logic signals, and preamplifier connections.

NIM standards do not prescribe standard circuits, functional instrument specifications, or required fabrication methods. The NIM committee limits itself to matters that affect compatibility and does not judge equipment as to conformity or nonconformity with the standards. Voluntary cooperation of manufacturers and users with the committee has been adequate to standardize for interunit compatibility.

NIM equipment lends itself to analog signal processing and other applications where only a limited amount of digital data is involved.

1.1.1.2 CAMAC Standards

CAMAC is an instrumentation system that has been developed specifically for accommodating digital functions. The system definition that has become the standard for digital data acquisition and control systems was prepared by the European Standards on Nuclear Electronics committee of EURATOM and has been adopted by the ERDA/NBS NIM committee and the IEEE of the U. S. As in the NIM system, the CAMAC standard specifies the requirements for mechanical compatibility and electrical power supply compatibility. The important additional feature of CAMAC is that it uses a multiwire printed circuit board mounted on the rear of the power crate (the CAMAC equivalent of the

NIM bin) to provide a large number of interconnections between modular hardware without external cabling. Called the CAMAC Dataway, it provides for bidirectional communications between modules and the external world or between modules themselves, thus allowing digital control of modules in addition to the more common data acquisition function.

The CAMAC crate is designed to accept up to 25 modules via 86-pin card-edge connectors mounted on the printed Dataway. Operationally, 23 of these connectors or stations are used for modules like ADC's, scalers, registers, etc., and the remaining two are utilized by a crate controller. Local control of modules within a crate is provided by the crate controller which accepts external commands from the branch highway. The branch highway is a separate cable data bus that interconnects controllers in several crates with a branch driver interface to the central processor in use. With the exception of the computer interface, all components of a system are computer-independent and interchangeable.

In addition to defining mechanical and electrical power supply characteristics, the CAMAC standards define the protocols for digital communications within the system. The CAMAC standards provide for a number of system configurations and are sufficiently flexible to accommodate new developments in electronic technology.

The standardization of the digital data and control functions also introduces the possibility of standardized software and the development and use of standard CAMAC software is, in fact, rapidly expanding. The merits of the CAMAC system are best demonstrated by its increasing usage for situations outside of the field of nuclear electronics. These applications range from instrument systems for other scientific disciplines to industrial process control.

1.1.2 Related Studies

In recognition of the possible benefits of using NIM and CAMAC equipment in Shuttle payload instrumentation, NASA and ESA have sponsored a number of studies on various aspects of this topic in addition to the present study. Table 1-2 lists both those activities dealing specifically with the use of NIM and CAMAC equipment for space applications and some closely related studies.

Table 1-2. Related Studies

Feasibility Study of Common Electronic Equipment for Shuttle Sortie Experiment Payloads	Bendix	NAS9-13784 NASA/JSC
Shuttle Environmental Compatibility Test Program	In-house	NASA/JSC
NIM and CAMAC Systems in the Space Program	In-house	NASA/GSFC
Feasibility Study of the Design of BiRa Systems, Inc. Model 5301, 5101, and 3222 CAMAC Modules for Space Use	BiRa Systems	NAS5-22856 NASA/GSFC
NIM (Model 451 and 455) and CAMAC (Model S812 and IR026) Module Studies	Ortec	NAS5-22812 NASA/GSFC
Study of Kinetic Systems, Inc., Model 3110, 3610, and 3640 CAMAC Modules for Space Use	Kinetic Systems	NAS5-22898 NASA/GSFC
Study of SPAMAC/CAMAC Interface for the Spacelab Programme	SGAE	2508/75 JS ESA/ESTEC
Analysis of Commercial Equipment Instrumentation for Spacelab Payloads	Rockwell	NAS8-30541 NASA/MSFC
Cost Reduction Alternatives Study (Task 1) On-Board Computer Utilization and Software Integration	Rockwell	NAS1-12933 NASA/LARC
Pressure Vessel Spacecraft - A Shuttle Era Approach to Low Cost	General Electric	NAS5-24021 NASA/GSFC
Low-Cost Approaches to Scientific Experiment Implementation for Shuttle-Launched and Serviced Automated Spacecraft	TRW	NAS W-2717 NASA/Hdq
Low-Cost Instrument Electronics for Solar Maximum Mission	TRW	NAS5-23478 NASA/GSFC

The Bendix study was the forerunner of the present work and investigated the application of NIM and CAMAC equipment to a group of six Shuttle Sortie research and applications payloads. The Shuttle Environmental Compatibility Test (SECT) program is being carried out at JSC in parallel with the present study and involves actual environmental testing of commercial NIM and CAMAC equipment. The GSFC in-house activity has investigated the applicability of NIM and CAMAC equipment to several payloads in the high-energy astrophysics discipline. In the next three studies, sponsored by GSFC, manufacturers of commercial NIM and CAMAC equipment have investigated possible power reductions for several of their commercial products and the cost impact of using NASA preferred parts and approved manufacturing techniques. The ESA-sponsored study by SGAE (Austria) has addressed possible methods of interfacing CAMAC systems to the Spacelab CDMS. The remaining studies listed, while not directed specifically to the use of NIM and CAMAC equipment, all include work that is relevant to the topic.

A basic guideline for this study was that the data and conclusions contained in Bendix Report BSR4142 (Feasibility Study of Common Electronic Equipment for Shuttle Sortie Experiment Payloads) and Rockwell Report SD74-SA-0047-1 (Analysis of Commercial Equipment and Instrumentation for Spacelab Payloads) should be used as a point of departure, extended where necessary to meet the objectives of this study, and used to support or statistically strengthen the data compiled and conclusions in this investigation.

In addition, it was intended that there be a close coordination between this study and the parallel SECT program at JSC. The test program results were also expected to be available for incorporation into our overall results and conclusions. As it turned out, the test planning has been coordinated with the study, but it has been possible to obtain only a limited amount of actual test data during the period of performance of the study.

1.2 STUDY SCOPE

The major objective of this study was to determine the cost effectiveness of utilizing NIM and CAMAC equipment for Shuttle sortie payload instrumentation. The original statement of work called for the performance of four tasks to accomplish this objective.

Task 1 - Identification and Selection of Potential Shuttle Sortie Payloads for Data Acquisition and Experiment Control Analysis

Task 2 - Functional Analysis of Selected Shuttle Payloads

Task 3 - Modification Analysis of Identified NIM/CAMAC Units

Task 4 - Management Plan for Implementing NIM/CAMAC Standards on Shuttle

Because of its importance to overall experiment costs, Task 4 was supplemented during the course of the study to include the following task:

Task 4B - Implementation and Impact of CAMAC Software

The interrelationship of the study tasks is shown in Figure 1-1.

The objective of Task 1 was to select a representative set of payloads for both science and applications disciplines that would ensure a realistic and statistically significant estimate of equipment utilization.

In Tasks 2A and 2B, the selected payloads were analyzed to determine the applicability of NIM/CAMAC equipment in satisfying their data acquisition and control requirements. In Tasks 2C and 2D the results of these analyses were combined with the comparable results from related studies to arrive at an overall assessment of the applicability and commonality of NIM/CAMAC equipment usage across the spectrum of payloads.

Task 3 dealt with determining the modifications to existing commercial NIM/CAMAC equipment that would be required for its reliable operation in the Spacelab environment as well as the estimated cost of these modifications. This task could be performed in parallel with the rest of the work because of the standardized nature of NIM/CAMAC equipment.

In Task 4A, the results from Task 2, on the applicability of NIM and CAMAC equipment to the representative payloads, were combined with an overall payload mission model for the period 1980 to 1991 to project the total

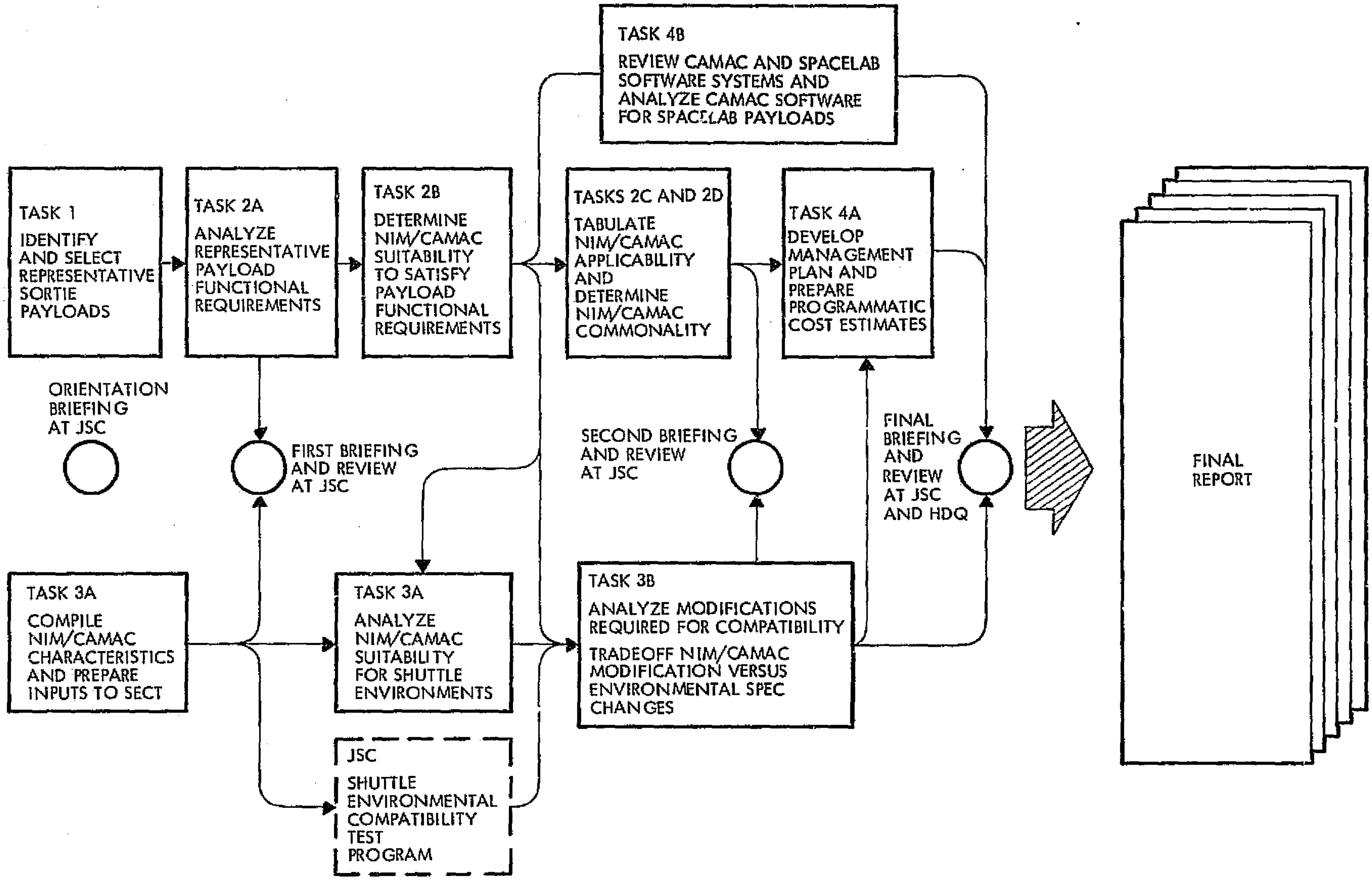

Figure 1-1. Overall Study Task Flow

expected equipment usage. Various approaches to providing the equipment were investigated and a management plan for pooled usage was developed. The cost estimates from Task 3 were then used to prepare programmatic cost estimates.

Finally, in Task 4B, the impact of standardized CAMAC software (made possible by the use of CAMAC hardware) on the overall Spacelab experiment software situation was analyzed and a recommended approach to software implementation was developed. It was possible to independently proceed on the software task with the exception of the final portion in which the specific software requirements for two of the representative payloads were analyzed.

The results of the work under Tasks 1 and 2 are contained in the following two sections, which make up the balance of this volume. Volume III contains the description of Tasks 3, 4A, and 4B.

2. IDENTIFICATION AND SELECTION OF POTENTIAL SHUTTLE SORTIE PAYLOADS FOR DATA ACQUISITION AND EXPERIMENT CONTROL ANALYSIS (TASK 1)

2.1 INTRODUCTION

Our approach to identifying and selecting Shuttle sortie payloads for analysis involved the following three elements:

- select science and applications disciplines to be considered,
- review payload definition documentation,
- identify and select representative payloads/experiments.

The primary sources used in performing this task are listed in Table 2-1, and a list of the disciplines from which representative payloads were selected is given in Table 2-2. The science disciplines to be considered were selected in accordance with the SUSS document except for the discipline of planetary exploration, which was not included here because it does not involve the sortie mode of operation. Although the primary emphasis was placed on the science disciplines, several applications disciplines, taken from the SSPDA documents, were included since these are also scheduled for frequent Shuttle sortie missions. The disciplines of earth observations and earth and ocean physics were combined because of the high degree of similarity found in the instrumentation used for investigations in these disciplines. Space technology was not treated as a separate discipline for payload selection because for the most part it requires instrumentation covered under the other disciplines. Finally, communications/navigation payloads were not considered because of the very limited applicability expected for NIM or CAMAC equipment.

The available payload documentation does not define the term "payload" in a very specific way. A collection of instrumentation that is required to perform a particular type of science or applications investigation tends to be termed a payload. The equipment so defined may or may not utilize all of the resources (e.g., weight, volume, power, etc.) available on a Shuttle sortie mission. In order to tabulate and compare requirements in a reasonably consistent way, we will use the term "payload" in this study to mean a collection of equipment or instruments that can be expected to require approximately the full resources available in one sortie mission.

Table 2-1. Payload Identification and Selection References

Scientific Uses of the Space Shuttle (SUSS), National Academy of Sciences, 1974.

Summarized NASA Payload Descriptions - Sortie Payloads (SSPDA), NASA/MSFC, 1974 and 1975 editions.

Final Report of the Space Shuttle Payload Planning Working Groups, NASA/GSFC, 1973.

Interim Report of the Astronomy Spacelab Payloads Study, NASA/GSFC, 1975.

Table 2-2. Payload Identification and Selection Disciplines

Science Disciplines

Atmospheric and Space Physics - Atmospheric Science
- Magnetospheric Dynamics
- Plasma Physics in Space

High-Energy Astrophysics - X-Ray
- Gamma Ray
- Cosmic Ray

Astronomy - Infrared
- Optical and Ultraviolet

Solar Physics

Life Sciences

Applications Disciplines

Earth Observations and Earth and Ocean Physics

Space Processing Applications

The following criteria and guidelines were used in selecting the representative payloads for analysis in this study:

- The sample should be representative in both the range of data acquisition and control requirements and the range of accommodation and operational modes to be encountered in sortie mode science and applications experiments.

- Emphasis should be placed on scientific investigations recommended in the SUSS document.

- Preference should be given to those payloads that have the most complete available documentation.

- Existing NIM/CAMAC study results should not be duplicated.

One representative payload was selected from each of the seven disciplines listed in Table 2-2. A summary of the selected payloads is given in Table 2-3. As can be seen, each of these payloads includes a number of instruments or groups of equipment. We believe that the composite collection of instrumentation included in these payloads, especially when combined with the results from previous studies, truly represents the range of requirements that can be expected. It should be noted that a large number of the payloads listed in the SSPDA documents simply amount to different grouping of this, or nearly equivalent, instrumentation.

Each of the seven disciplines considered for payload selection will be treated sucessively in the following sections. The selection rationale will be discussed, the payload will be briefly described, and the available definition documentation will be identified. A more detailed description of each payload will be given in Section 2 as part of the functional analysis.

Table 2-3. Payloads Selected for Analysis

Discipline	Payload	Instrumentation
Atmospheric and Space Physics	AMPS	Instrumentation for particle accelerator, wake, chemical release, wave, magnetic confinement, and passive optical experiments.
High-Energy Astrophysics	X-Ray/Gamma-Ray Pallet	Proportional counter array, Bragg crystal spectrometer, high-resolution gamma-ray spectrometer.
Astronomy	One-Meter Cooled Telescope	Filter photometer, spectrophotometer, detector array, Fourier and grating spectrometers.
Solar Physics	ATM	Coronagraph, X-ray telescopes, UV spectroheliometer, XUV spectroheliograph, and chromospheric XUV spectrograph.
Life Sciences	Life Sciences Dedicated Laboratory	Equipment units for biochemical/biophysical analysis, biomedical studies, data management, and laboratory support, holding units, and research support.
Earth Observations Earth and Ocean Physics	Earth Observations Facility	Scanning microwave radiometer, IR radiometer, Lidar, cameras and Bendix results for multispectral scanner and microwave scatterometer.
Space Processing	Space Processing	Furnace, levitation, biological, general purpose, and core equipment groups.

2.2 SCIENCE DISCIPLINES

2.2.1 Atmospheric and Space Physics

The SUSS document defines a number of core instruments that will be required for experiments in both atmospheric sciences as well as space plasma and magnetospheric physics. As indicated in the SSPDA tabulations, current payload definition and planning combines all of this instrumentation into a single Atmospheric, Magnetospheric, and Plasmas in Space (AMPS) payload. The major types of instrumentation identified in the SUSS document as well as the documentation available on the AMPS payload is shown in Table 2-4. AMPS is the obvious choice for analysis to represent this discipline.

Table 2-4. Atmospheric and Space Physics Instrumentation and Selected Payload Documentation

Instruments Identified in SUSS for Sortie Missions

- Atmospheric Sciences

  High-Power Laser and Receiver (Lidar)

  Passive Optical Remote Sensing Instruments

  - High-resolution photometers and interferometers
  - Infrared sounding interferometers

- Space Plasma and Magnetospheric Physics

  Electron and Ion Accelerators

  Plasma Gun

  Chemical and Gaseous Release Devices

  Transmitters and Antennas

  Pallet and Boom-Mounted Diagnostic Instruments

AMPS Definition Documentation

Phase A Conceptual Design Study of the AMPS Payload, TM X-64895, NASA/MSFC, 1974

AMPS Particle Definition Study, NAS8-31375, TRW, 1975

AMPS Data Management Requirements Study, NAS8-31208, TRW, 1975

We have selected a version of the AMPS payload that emphasizes space plasma and magnetospheric physics. The atmospheric science instrumentation was covered in the Bendix work with the exception of the Lidar system which will be treated in this study as part of the earth observations payload. It is generally true that the optical instrumentation for AMPS is very similar to instruments that will be covered in the astronomy, solar physics, and earth observations payloads.

The version of AMPS we have selected includes the instrumentation required to perform six types of experiments. This instrumentation includes the core instruments defined in the SUSS document and is also similar in many respects to the Auroral and Magnetospherics Observatory studied by Bendix. Our analysis will re-examine the control and data acquisition requirements in light of the more complete payload definition available from AMPS studies carried out since the Bendix work.

2.2.2 High-Energy Astrophysics

High-Energy Astrophysics is commonly divided into three subdisciplines - X-ray, gamma ray, and cosmic ray astronomy. The types of instruments identified in the SUSS document for sortie missions are listed in Table 2-5. The SSPDA tabulations include sixteen payloads that use these instruments individually or in various combinations.

The cosmic ray instruments have already received considerable attention in previous studies. The Cosmic Ray Physics Laboratory analyzed by Bendix consisted of a superconducting magnetic spectrometer with associated proportional counters , Cerenkov detectors and a small ionization calorimeter. The High Energy Cosmic Ray Experiment studied by GSFC consisted of a large ionization calorimeter, again with associated proportional counters.

Table 2-5. High-Energy Astrophysics Instrumentation and Selected Payload Documentation

Instruments Identified in SUSS for Sortie Missions

- X-Ray Astronomy

  Large-Area X-Ray Detector with Concentrator

  Large-Area Proportional Counter Array

  High-Energy X-Ray Scintillation Counters

  X-Ray Telescopes

  - low-energy (0.6 m)
  - high-resolution imaging (0.6 m)

  Hard X-Ray Imaging Detector

  Bragg Crystal Spectrometers and Polarimeters

  Broadband Si(Li) Spectrometer

- Gamma-Ray Astronomy

  High-Resolution Gamma-Ray Ge(Li) Spectrometer

  Liquid Xe Proportional Counters

  Double Compton Telescope

  Large-Area, High-Energy, Gamma-Ray Telescope

  High-Resolution, High-Energy, Gamma-Ray Telescope

  Large-Area, Actively-Shielded Scintillation Counters

- Cosmic-Ray Astronomy

  Ionization Calorimeter

  Magnetic Spectrometer

  Large-Area Cerenkov Detectors

  Large-Area Proportional Counters

  Transistion Radiation Detector

Selected Payload Documentation

A Program for High-Energy Astrophysics (1977-1988), NASA/Headquarters, 1974

Design and Performance Specifications for HEAO Experiments A-1, A-3, and C-1

Phase B Definition Study for HEAO Experiment BXR-2

GSFC has also analyzed one of the gamma-ray instruments -- the large-area, high-energy, gamma-ray telescope. The results of these previous analyses will be included in this study in the form of one payload which includes all three instruments. In order to complete the coverage of high-energy astrophysics requirements, we have selected a payload that is made up of the following two X-ray instruments and one gamma-ray instrument:

- Large-Area Proportional Counter Array
- Bragg Crystal Spectrometers and Polarimeters
- High-Resolution Gamma-Ray Ge(Li) Spectrometer

Selected available documentation on these specific types of instruments is listed in Table 2-5. These two payloads, made up of six major instruments, provide a good representation of the requirements in this discipline.

2.2.3 Astronomy

The SUSS document divides the astronomy discipline into infrared astronomy and optical and visible astronomy. Naturally, the principal instruments identified are telescopes. Table 2-6 lists the various telescopes and other instruments discussed in the SUSS document. The SSPDA tabulations list thirty-three astronomy payloads that include these telescopes plus some other astronomical instruments. A number of the payloads are combinations of smaller telescopes and instruments. The focal plane instrumentation for the telescopes that is of primary interest so far as NIM/CAMAC equipment is concerned, is similar for the various telescopes.

A 1.0-meter, optical and ultraviolet telescope facility was analyzed in the Bendix study. We have therefore selected the 1.0-meter Shuttle IR Telescope Facility (SIRTF) for analysis here. The five IR instruments listed in Table 2-3 have been chosen as a typical complement of focal plane instrumentation for SIRTF. The documentation that defines the SIRTF payload is indicated in Table 2-6.

2.2.4 Solar Physics

The SUSS document identifies the instruments listed in Table 2-7 as required for solar physics investigations in the sortie mode of Shuttle operations. The focal plane instrumentation for the telescopes constituting the solar telescope cluster is very similar to that found in the astronomy

Table 2-6. Astronomy Instrumentation and Selected Payload Documentation

<u>Instruments Identified in SUSS for Sortie Missions</u>

- Infrared Astronomy

    1.0-Meter Cooled Telescope
    2.5-Meter Cooled Telescope
    1.0-Meter Ambient Temperature Telescope
    3.0-Meter Ambient Temperature Telescope
    10-Meter Baseline Interferometer (Two 1.0-Meter Telescopes)
    1-Kilometer Baseline Interferometer

- Optical and Ultraviolet Astronomy

    1.0-Meter Diffraction-Limited Telescope
    0.5-Meter General Purpose Telescope
    0.75-Meter UV Survey Telescope
    1.0-Meter Deep-Sky Survey Telescope
    1.0-Meter Wide-Field Telescope
    Very-Wide-Field Camera
    Solar Variation Monitor

<u>Selected Payload Documentation</u>

SIRTF Review Presentation, Hughes Aircraft, 1975

Design Study for Shuttle Infrared Telescope Facility, Report No. 11888, Perkin-Elmer, 1974

Table 2-7. Solar Physics Instrumentation and Selected Payload Documentation

Instruments Identified in SUSS for Sortie Missions

- Solar Telescope Cluster

  1.0-Meter Optical Telescope
  EUV Telescope
  X-Ray Telescopes

- High-Energy Instrumentation

  Proportional Counters
  Scintillation Counters
  Solid-State Detectors
  Bragg Spectrometer/Polarimeter

Selected Payload Documentation

Design and Performance Specifications for ATM Experiments

S-052, CP22876, Ball Brothers Research Corporation
S-054, ASE-1600-C, American Science and Engineering
S-055A, CP29540, Ball Brothers Research Corporation
S-056, 50M16609, NASA/MSFC
S-082A, CP25905, Ball Brothers Research Corporation
S-082B, CP25100, Ball Brothers Research Corporation

telescopes. The high-energy instrumentation is essentially identical to the X-ray and gamma-ray instruments used in high-energy astrophysics. The SSPDA tabulations list fourteen solar physics payloads which again amount to various combinations of the SUSS instruments for the most part.

One of the SSPDA payloads is a Spacelab version of the Skylab ATM instrument cluster. Since these instruments are a very representative sample of solar physics instrumentation and very complete documentation is available for them, it was recommended by JSC at the orientation briefing for this study that this payload be analyzed as the representative of the solar physics discipline. The six ATM instruments are listed in Table 2-3 and the documentation describing them is listed in Table 2-7.

2.2.5 Life Sciences

The discussion of the life sciences discipline in the SUSS document emphasizes the importance of a flexible, laboratory-like facility for Shuttle sortie missions. General requirements and characteristics are specified for the life sciences laboratory, but very little specific instrumentation is defined or identified. The SSPDA tabulations list five life sciences sortie payloads. One of these, the Life Sciences Shuttle Laboratory, is clearly the facility that corresponds to the concepts presented in the SUSS document. This payload, as well as the so-called minilabs and carry-on labs, has been defined in a series of studies performed by Convair/General Dynamics for NASA/MSFC. These studies are documented in a series of reports all entitled, "Life Sciences Payload Definition and Integration Study," GDC-DBD72-002, 1972; CASD-NAS-73-003, 1973; and CASD-NAS-74-046, 1974. We have selected the 30-Day Dedicated Laboratory as the most all-inclusive version for analysis in this study.

2.3 APPLICATIONS DISCIPLINES

2.3.1 Earth Observations and Earth and Ocean Physics

The SSPDA tabulations list a total of twenty-six payloads in these disciplines. Most of these payloads are composed of a variety of remote sensing instruments operating in the microwave, infrared and visible portions of the electromagnetic spectrum. The types of instruments identified are given in Table 2-8. The one exception to the general classification of these instruments as remote sensing instruments is the Zero-G Cloud Physics Laboratory, which is unique as a manned-laboratory-type facility among the payloads defined for these disciplines. As previously mentioned, Skylab versions of two of these instruments were analyzed in the Bendix study -- a thirteen-band multispectral scanner and a microwave scatterometer.

As a representative payload for these disciplines, we have selected a combination of remote sensing instruments listed in Table 2-3. Three different types of remote sensing instruments are included in addition to the two instruments studied by Bendix. In addition, a complement of typical camera systems is included. The documentation used in this study consists of the reports from a series of TRW studies performed of NASA/MSFC under contract NAS8-28013. They are identified in Table 2-8.

2.3.2 Space Processing

The SSPDA tabulation lists sixteen payloads in this discipline. These payloads consist of different combinations of the five equipment groups listed in Table 2-3. We have selected the dedicated, manned version of this payload for analysis. It includes all five equipment groups used in the various payloads. The space processing payloads are described in two reports from a series of studies performed for NASA/MSFC by TRW under contract NAS8-28938. These are: "Requirements and Concepts for Materials Science and Manufacturing in Space Payload Equipment Study," TRW, 1973; and "Space Processing Applications Payload Equipment Study," TRW, 1974.

Table 2-8. Earth Observations and Earth and Ocean Physics Instrumentation and Selected Payload Documentation

Instruments Identified in SSPDA for Sortie Missions

- Multispectral Scanners
- Scanning Microwave Radiometers
- Microwave Scatterometer
- Synthetic Aperture Radar
- Laser Radar (Lidar)
- Infrared Radiometers and Sounders
- Film Cameras
- Zero-G Cloud Physics Laboratory

Selected Payload Documentation

- Mission Requirements for a Manned Earth Observatory, TRW, 1973
- Sensor Development on Shuttle Sortie Missions, TRW, 1974
- Atmospheric Research Using Space-Borne Lasers, ESRO, 1974

3. FUNCTIONAL ANALYSIS OF THE SELECTED SHUTTLE PAYLOADS (TASK 2)

3.1 GENERAL DESCRIPTION

The purpose of Task 2 was to perform a functional analysis of the representative Shuttle payloads selected in Task 1 to determine the applicability of NIM and CAMAC equipment to the control and data management system (CDMS) functions of the instruments in these payloads.

The functional analysis of the data acquisition and experiment control requirements for the selected payloads/experiments is subdivided into four tasks:

Task 2A - Analyze Experiment Functional Requirements

- Establish experiment instrumentation requirements.
- Compile instrumentation details.
- Analyze functional requirements.
- Develop a system design that partitions data acquisition and control system functions for NIM/CAMAC implementation.

Task 2B - Analyze NIM/CAMAC Suitability

- Review manufacturers' functional specifications.
- Determine suitability of available NIM/CAMAC equipment to meet the experiment functional requirements.
- Identify modified and custom-designed NIM/CAMAC modules required.

Task 2C - Tabulate NIM/CAMAC Applicability

Task 2D - Analyze NIM/CAMAC Commonality

The results of Tasks 2A and 2B will be reported on first in Sections 3.2 through 3.8 in which each of the seven representative payloads is discussed individually. Section 3.9 contains the results of Tasks 2C and 2D for the entire set of payloads.

In reviewing the payloads selected for analysis in Task 1, two categories are apparent. Most of the payloads were really clusters of individual instruments, each of which performs an essentially separate scientific inquiry. It is only the commonality of their scientific regions of interest which associates them into a payload. The CDMS requirements for each of these instruments are generally independent of the requirements for the other instruments within the payload. Two of the payloads, on the other hand, were found to be what might be termed laboratories. All of the instruments in these play an interrelated role in pursuing a common piece of scientific research. This affects the CDMS requirements for these payloads in that the signals being processed for one instrument in the laboratory frequently feed back and determine the mode of operation of another instrument.

Those payloads which were considered to be instrument clusters are:

- ATM experiments
- IR telescope
- X-ray/gamma-ray pallet
- AMPS
- Earth observations.

Actually, some of the AMPS experiments, particularly the electron accelerator, verge on being laboratories in their own right.

The two payloads considered to be laboratories are:

- Space processing applications
- Life sciences.

These are discussed at the end of this section.

3.1.1 NIM and CAMAC in Spacelab

As each of the payloads is analyzed in the sections of the report which follow, a common overall configuration for the CDMS will be assumed in each case. This configuration is shown in a simplified form in Figure 3-1. The actual payload instruments are indicated on the right side of the diagram. The signals from these are interfaced either directly into CAMAC modules or first through NIM equipment for initial processing and then into CAMAC. Control signals and some power supply voltages for the instruments are fed back to them from the NIM and CAMAC modules. Each of the modules in the CAMAC crates talks to the controller for that crate via the crate data bus, known as the dataway in CAMAC systems. The crate controllers, in turn, are connected to a bidirectional data bus that is called

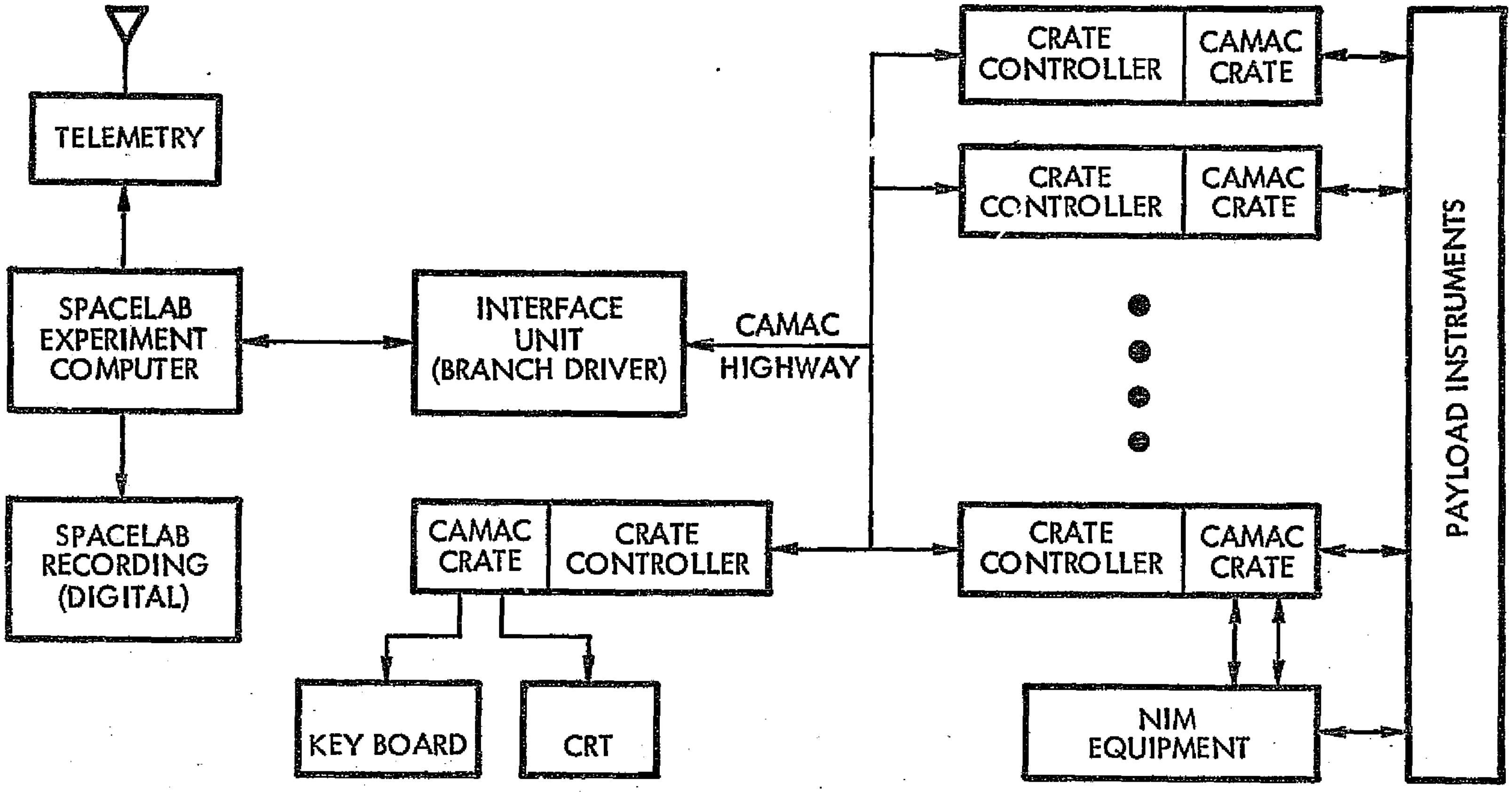

Figure 3-1. General Spacelab CDMS Configuration Using NIM/CAMAC Equipment

a branch highway in CAMAC systems. This branch highway connects to the computer controlling the system via an interface unit that is known as a branch driver in most CAMAC systems. The CAMAC standards define the communication protocol throughout the system up to the branch driver. Both parallel and serial branch highways are defined by the standards. The detailed characteristics of the branch driver depend upon the computer to which it is interfaced.

In the case of Spacelab, a number of options are possible for the interconnection between the CAMAC equipment and the Spacelab CDMS. The CAMAC system could be interfaced at an experiment remote acquisition unit, at an experiment data bus interconnecting station or at the experiment computer input/output unit. It is also perfectly feasible to control the CAMAC system with its own minicomputer, which in turn communicates with the Spacelab experiment computer. In first order, these alternatives do not affect our analysis of the applicability of NIM and CAMAC equipment since they are only reflected in the details of the CAMAC branch driver. The adaptibility of CAMAC systems to a wide variety of interfaces and overall system configurations has been well demonstrated in a diversity of ground-based applications.

The determination of the optimum interface between the Spacelab CDMS and CAMAC systems is not within the scope of this study since it does not significantly affect the applicability of NIM and CAMAC equipment to shuttle payloads. Consequently, as each of the payloads is analyzed in the sections that follow, the block diagrams will only show the systems up to the crate controller and an appropriate overall CDMS structure, such as that shown in Figure 3-1, will be assumed.

In Figure 3-1 we also show a keyboard and display scope (CRT) coupled to the CDMS via CAMAC. The Spacelab CDMS provides keyboard and display capability, which we assumed would normally be used. Should supplemental capability be required, CAMAC is ideally suited to implement this function. There are a wide variety of commercial modules available that are designed specifically for the control of cathode ray tubes and the operation of keyboards. Some of the functions provided in the CRT modules are:

- Sweep synchronization and timing
- Character and vector (graphic) generators
- X-Y-Z display modules
- Light pen modules.

A complete list of the modules available for these functions is given under Product Codes 143 and 144 of the CAMAC Product Guide in Appendix I.

In all of the payload analyses in the sections that follow, the capability to input instructions to the computer from a keyboard and dispay computer-processed data on a CRT is assumed.

While CAMAC can be used to generate alphanumeric and graphic displays, it is not suitable for handling conventional video (i.e., television) displays. Some of the instruments that were analyzed do require video displays. We have assumed that the closed-circuit television capability provided by Spacelab will be used to satisfy those requirements.

Finally, some general comments are in order regarding low-voltage power supplies. In both NIM and CAMAC equipment, the individual modules in each crate are powered by a common power supply that provides standard voltages (i.e., $\pm$ 24 volts, $\pm$ 12 volts, and $\pm$ 6 volts) via the back plane connectors. The crate or bin power supply is normally attached to the back of the crate or bin and operates from conventional AC input power. Two input power options are available in Spacelab (28-V DC or 115/200-V AC, 400 Hz, 3 phase). Since the power supply requirements for all NIM and CAMAC modules are standardized, the power supplies will have the highest commonality of any NIM and CAMAC equipment. Therefore, it is generally conceded that the development of a standard power supply for NIM and CAMAC equipment, which is optimized for Spacelab applications and constraints, is the most reasonable approach. In this study, we have assumed that such an approach would be taken and do not specifically address this area any further in the analysis of NIM and CAMAC equipment applicability.

3.1.2 Format of the Instrument Analyses

The analyses of individual instruments and categories of instruments in Sections 3.2 through 3.8 all follow the same general outline. The functions of the instrument are first explained followed by a description of its CDMS requirements. Next, a functional block diagram showing the implementation of the CDMS with NIM and CAMAC is presented. The analysis of each instrument concludes with a table of the types of NIM and CAMAC equipment required in the CDMS for that instrument. A tabulation of the numbers of each type of NIM and CAMAC modules required for each instrument in a given payload, as well as the totalized requirements for the payload, is given at the end of each section.

Several comments about the NIM and CAMAC equipment summary tables for each instrument should be made. The left-most column of each table lists the various elements in the control and data management system together with the specific functional types of modules required for implementation.

In the case of CAMAC equipment, the second column lists the product code for each type of CAMAC module. The CAMAC product codes are defined in the CAMAC Product Guide, which appears in each issue of the CAMAC Bulletin published by the European Standards on Nuclear Electronics (ESONE) Committee. The most recent edition of the CAMAC Product Guide, reproduced from Issue No. 14 of the CAMAC Bulletin (December 1975), is contained in Appendix I of this report. The CAMAC Product Guide organizes all of the available CAMAC products into functional groups, each of which is designated by a three-digit product code.

As can be seen from the CAMAC Product Guide, many versions of each type of module (i.e., each product code) are available from a number of suppliers. The detailed specifications for each particular module naturally vary. The same thing is true for NIM equipment, but, unfortunately no corresponding tabulation of NIM equipment exists so the designation "NIM" is all that is used in the product code column. Our own classification of NIM modules by functional type will be used in the summary tabulations. A list of NIM equipment manufacturers is distributed by the U.S. NIM Committee and the most recent issue (September 1973) is reproduced in Appendix II.

By specifying the product code for the CAMAC modules, the equipment of many different manufacturers is implied. However, the third column of each of the tables is used to give a specific example of the module required by listing actual model numbers and their manufacturers. These examples are noted very cryptically but a more complete description is given in the CAMAC Product Guide. No particular effort was made to spread the choice of specific modules evenly over the many manufacturers of NIM and CAMAC equipment. To keep the effort of specifying modules to a minimum the same modules and manufacturers were used frequently.

Finally, it should be noted that many NIM modules and almost all CAMAC modules are multichannel devices. Specific cases are noted in the comment column of the tables. This has been taken in account in the summary tabulations of NIM and CAMAC equipment at the end of each section.

3.2 SKYLAB ATM EXPERIMENTS

During the Skylab mission a collection of instruments for solar observations were mounted in the Apollo Telescope Mount (ATM). The ATM provided rough solar pointing for the instruments and a stable platform from which to make observations. Since the ATM instruments represent a good cross section of the instruments that will be used for solar studies aboard the Space Shuttle, an analysis of how their control and data management functions might have been implemented with NIM and CAMAC equipment is very relevant to potential Spacelab use of such standards. For this reason, six of the ATM experiments were selected for analysis in this study.

Table 3-1 lists the six instruments to be analyzed in the study. In addition to showing the "S" designator by which each experiment was known in Skylab, the figure also delineates some of the essential aspects of each experiment.

Figure 3-2 shows the sun end of the ATM canister and the relative mounting positions of the ATM experiments within the canister.

3.2.1 White Light Coronagraph

3.2.1.1 Experiment Description

The purpose of the white light coronagraph experiment (WLCE) aboard Skylab is described in Specification CP22876 of the Ball Brothers Research Corporation. The material in this section is excerpted from that document.

The WLCE was designed to perform K corona measurements of the Sun to support studies of the intermediate and outer corona ($2R_\odot < R < 6R_\odot$). This is the region where coronal streamers are defined and the coronal gas is accelerated to become the solar wind.

Figures 3-3 and 3-4 show the basic structure of the instrument. The primary sensor is the film camera which records the coronal images on 35 mm photographic film. A TV camera is supplied for visual monitoring of the system but the experiment CDMS is not responsible for processing the video data.

The camera system operates in four distinct modes as summarized below. The choice of operating mode is made by manual inputs from the astronaut.

Table 3-1. ATM Instruments

S-052 White Light Coronograph

- Looks at solar corona 4900 Å to 5900 Å
- Film camera and diode matrix
- Pointing error sensor
- Rotating polaroid
- Occulting disk

S-054 X-Ray Spectrographic Telescope

- Soft X-ray solar spectrum
- Camera with diode array
    - Grating
    - Filters
- Image dissector tube and visual display
- Photomultiplier flare detector

S-055A UV Spectroheliometer

- 296 Å to 1342 Å
- Seven photoelectric detectors
- Grating scan
- Quad zero-order detector
- Primary mirror raster scan

S-056 X-Ray Telescope

- 2 Å to 33 Å
- Camera with diode matrix
- X-ray event monitor
    - Al proportional counter
    - Be proportional counter

S-082A XUV Spectroheliograph

- Coronal images 150 Å to 650 Å
- Camera with diode matrix
- Two-position grating

S-082B XUV Spectrograph

- Solar line spectrograms 970 Å to 3940 Å
- Camera with diode matrix
- Primary mirror controlled
- Two-position predisperser grating
- X-ray and visual monitor cameras

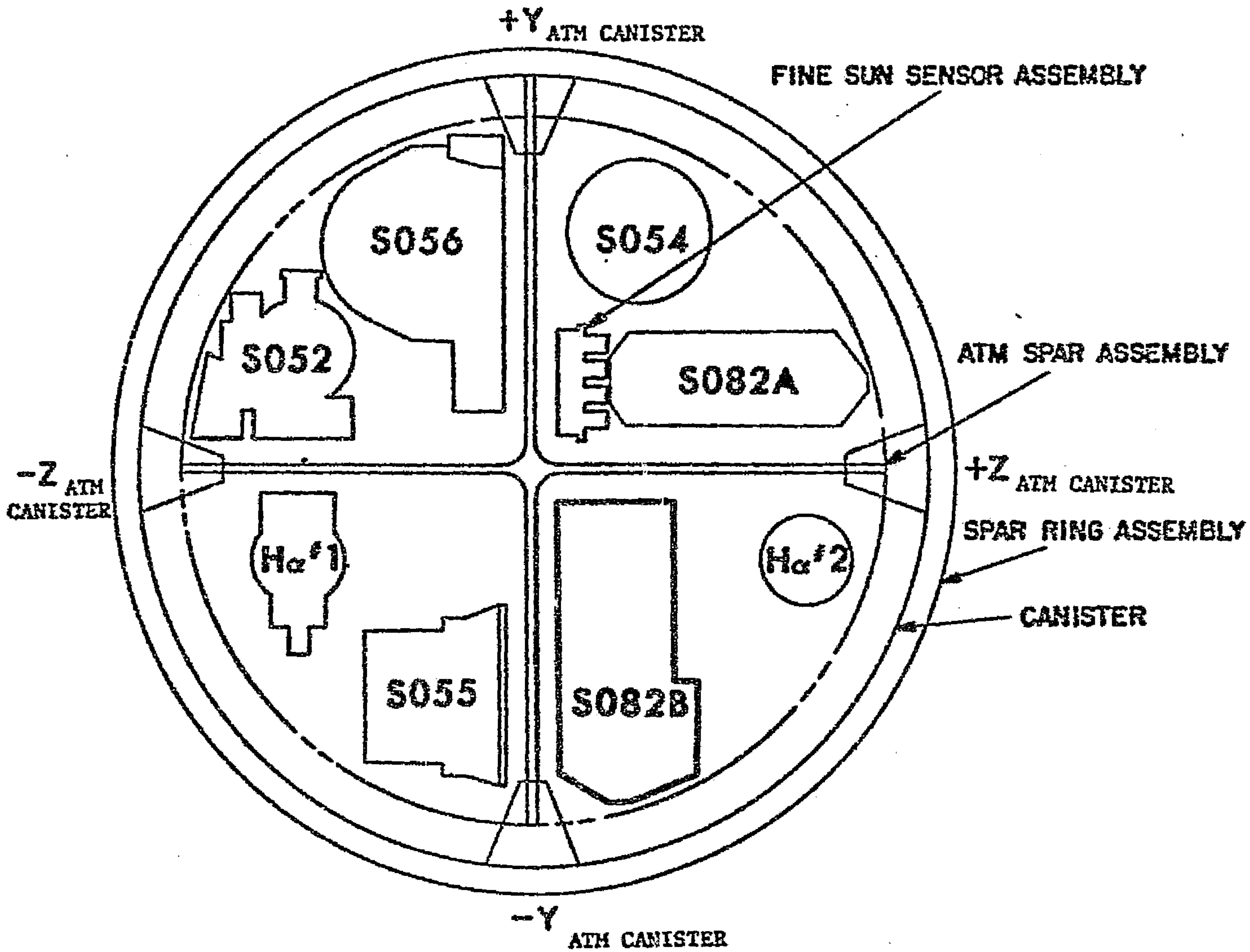

Figure 3-2. ATM Instrument Layout

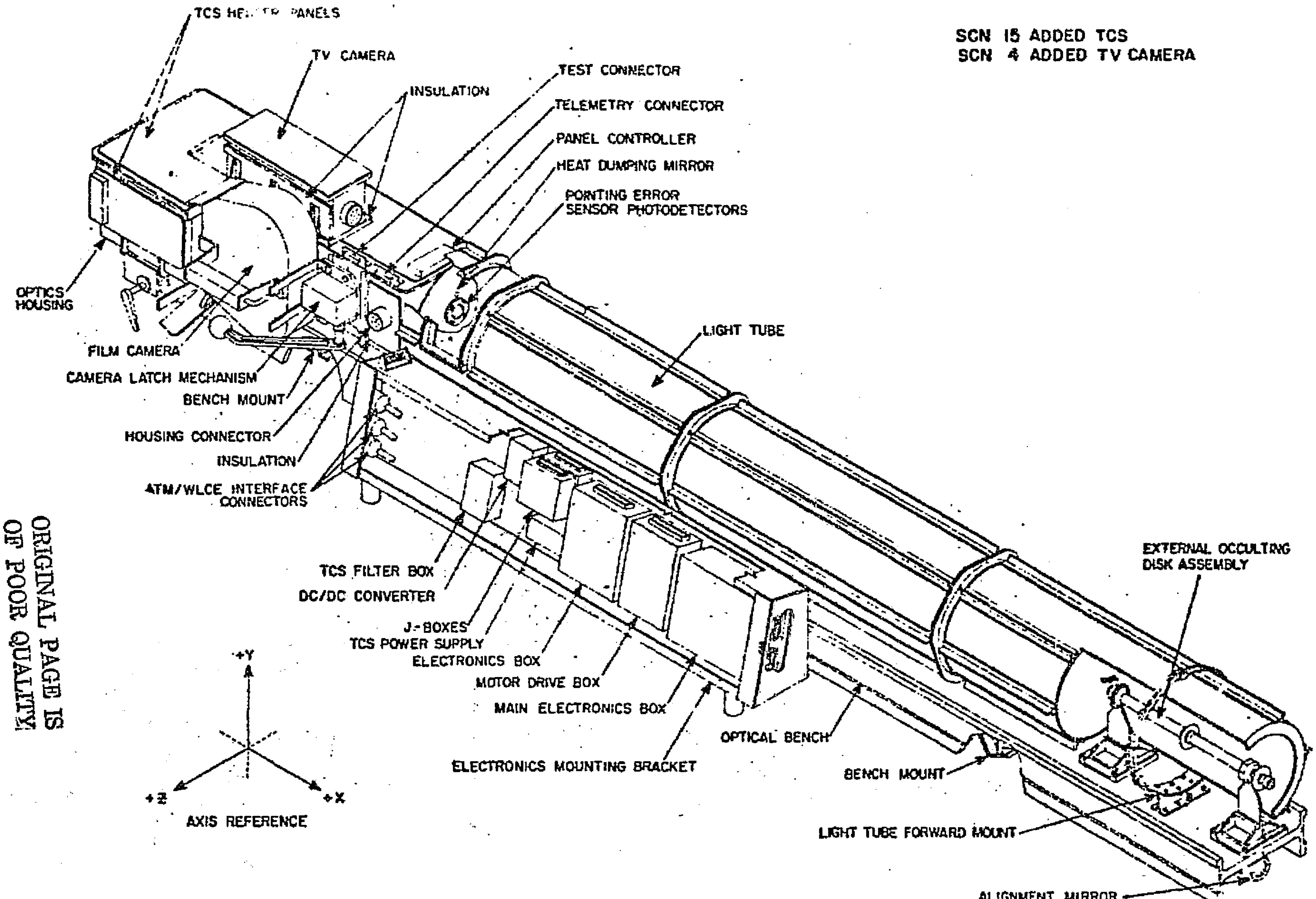

Figure 3-3. ATM Experiment S-052 Configuration

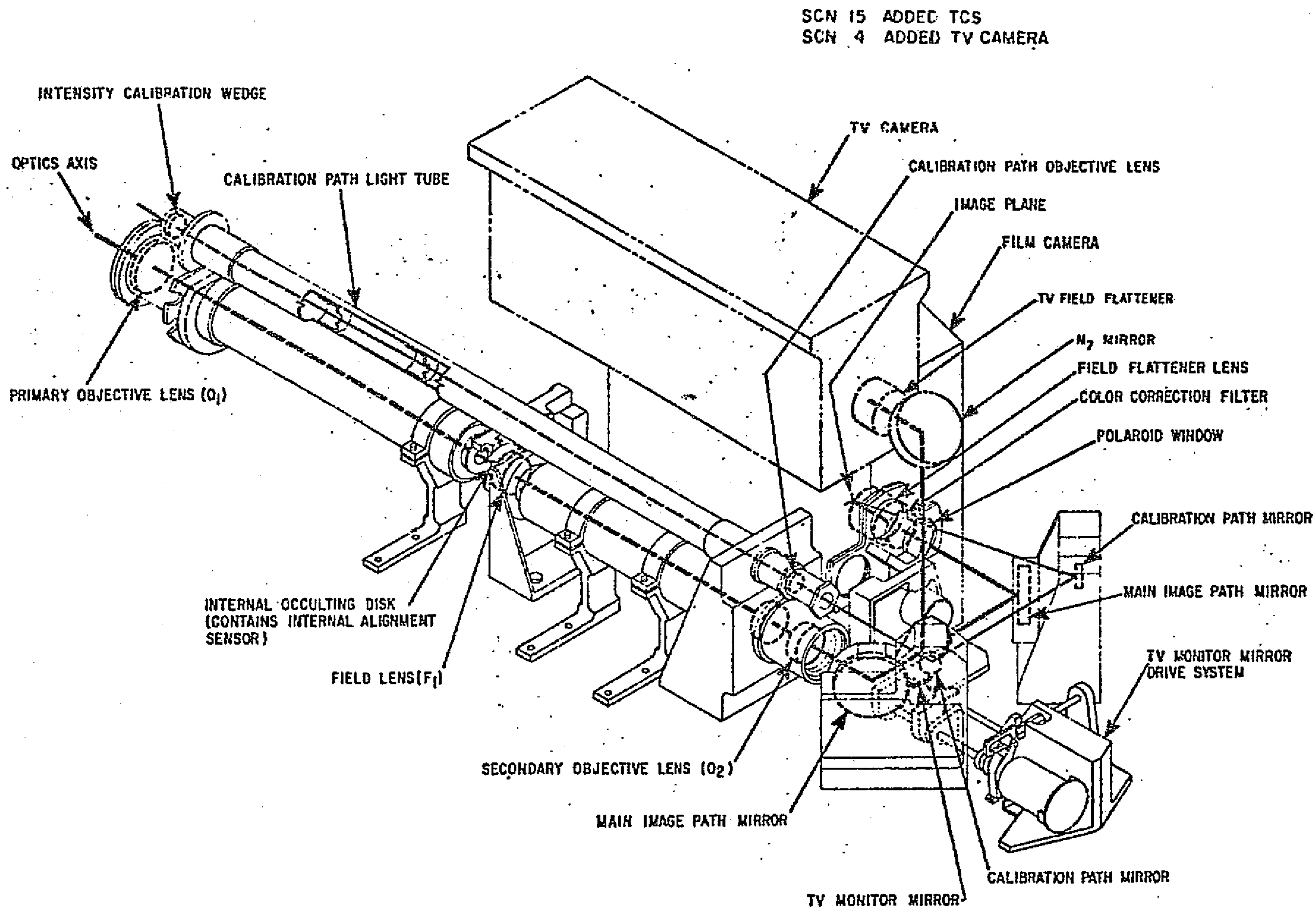

Figure 3-4. ATM Experiment S-052 Optics Housing Detail

Standard Patrol Mode. A camera shutter operate pulse shall occur every five seconds. The duration of the pulses which control exposure time shall sequentially vary from 9 seconds to 27 seconds to 3 seconds. After the complete sequence of three different shutter control pulses, the polarization wheel mechanism shall be automatically commanded to advance one position. The sequence of pulses shall repeat until all combinations of three shutter exposure times and four polarization wheel positions have been utilized for 12 exposures. The camera programmer shall then stop automatically.

Extended Standard Patrol Mode. This shall be the same as the standard patrol mode described above, except the sequence shall continue for 36 exposures.

Fast Scan Mode. In this mode the shutter operate pulse duration will be approximately 27 seconds, 3 seconds and 9 seconds, and shall repeat cyclically in that order. 1/2 second pause time shall occur between each pulse during the duration of the complete scan. The polarization wheel shall be driven to the clear position at the start of the fast scan mode and shall remain in this position during the nominal sequence of 72 exposures. The camera programmer shall automatically stop at the end of the sequence.

Continuous Patrol Mode. In this mode the shutter operate pulse durations will be approximately 9 seconds, 27 seconds, and 3 seconds. Each shutter operation shall occur every 27.5 seconds, including shutter operation time, and shall repeat cyclically in that order throughout the duration of the complete scan. The polarization wheel shall be driven to the clear position while in the continuous patrol mode. The camera shall stay in the continuous patrol mode indefinitely or until a manual stop pulse is given.

3.2.1.2 CDMS Implementation with NIM/CAMAC

Almost all of the data that must be handled by the CDMS for this experiment is housekeeping in nature. There is a digital data requirement to control the camera diode matrix and several stepper motors. Also analog data from the alignment error sensors must be processed. The control system must allow for the choice of operational mode and for closing up the system in the event of extreme pointing error. The status of the experiment including the current operational mode must be displayed for the astronaut.

This CDMS is implemented with ten functional system elements described below:

Camera Programmer. Controls the operation of the film camera including implementing the four operational modes as requested.

Camera Diode Matrix Drive. Supplies 73 bits of information to the camera diodes for recording on the film frames. This information consists of:

- One bit, matrix position identification
- Twenty-five bits, ATM time of exposure
- Nine bits, ATM roll attitude
- Sixteen bits, internal alignment error angle
- Sixteen bits, pointing error angle
- Two bits, polarization wheel position
- Two bits, camera exposure time
- Two bits, mode identification

Internal Occulting Disk Drive. Controls the two motors which position the internal occulting disk of the coronagraph.

Polarization Wheel Drive. Controls the motor positioning the polaroid.

Pointing Error and Internal Error Discriminator and Digitizer. The purpose of this system is to process the analog error signals coming from the instrument in order to control the occulting disk and the aperture door.

Thermal Shield Aperture Door Drive. This system generates a signal to close the aperture door in the event of gross pointing errors.

Control and Display System. This system must provide the capability to select any of the modes of operation of the system and displays signals such as "Experiment Ready" and "Mode Complete".

TV Mirror Drive. This system moves the TV mirror into and out of the light path.

Thermal Control System. This system actively controls the absolute temperature of critical parts of the instrument to 21 ± 3°C.

Power Supply. This system supplies all power required to operate the instrument including ± 10VDC regulated to 0.1 percent for the temperature control system.

This section shows two functional block diagrams for the control and data management system (Figures 3-5 and 3-6). The first is the system diagram from the specification document for the actual Skylab instrument (CP22876, BBRC). Boxes have been drawn in and numbered to indicate the ten system elements identified in the previous section. The second block diagram shows the implementation of the same system using CAMAC hardware. The details of the CAMAC implementation are covered in the table of the following section.

As can be seen from the block diagram no use was found in this experiment for NIM equipment. This is consistent with the fact that most of the CDMS requirements are of a housekeeping nature for which NIM is not particularly suited.

Another detail to note in the block diagram is that, for all the motors that are controlled, a "zero" position is sensed via an input register and the position of the motor is thereafter tracked by the computer memory of how many pulses have been sent to the motor driver.

Table 3-2 shows the detailed equipment requirements to implement the WLCE/CDMS with a NIM/CAMAC interface system. The system elements in the table correspond to the CDMS requirements previously listed.

By including a computer in the control loop many of the functions which had to be implemented by discrete circuits in the Skylab instrument are handled by computer software in the NIM/CAMAC system. Thus, the logic circuitry is generally replaced by computer software.

It should also be noted that any control (i.e., input commands) and display functions required by the instrument are implemented with equipment provided as part of the computer system (as would be the case if this instrument were to be flown on Spacelab). The comments of Section 3.1.1 address the implementation of these functions with CAMAC interface equipment.

3.2.2 X-Ray Spectroscopic Telescope

3.2.2.1 Experiment Description

This instrument was built for Skylab by American Science and Engineering. The material in this section describing the purpose and operation

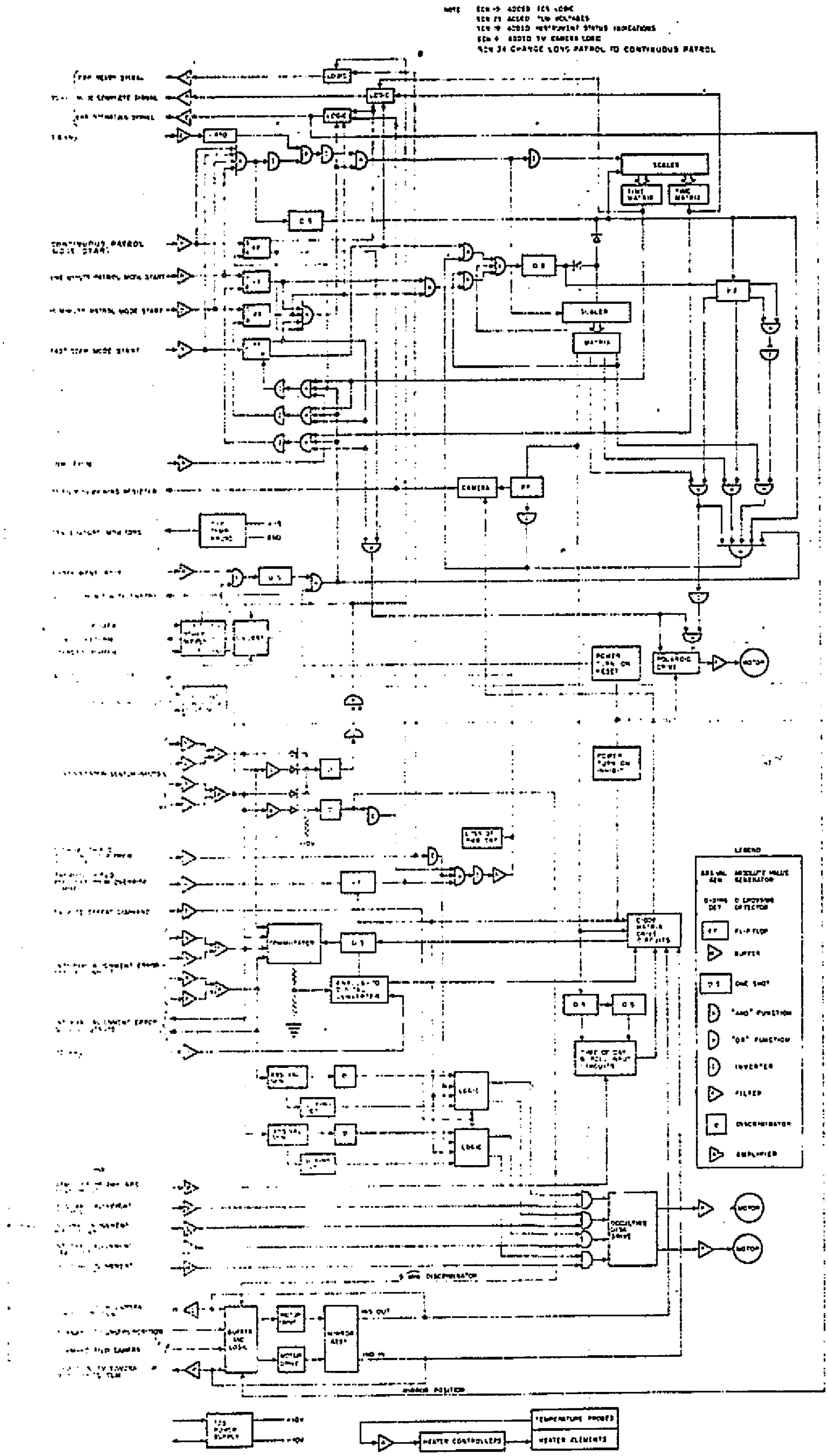

Figure 3-5. ATM Experiment S-052 Electronic Subsystem Block Diagram

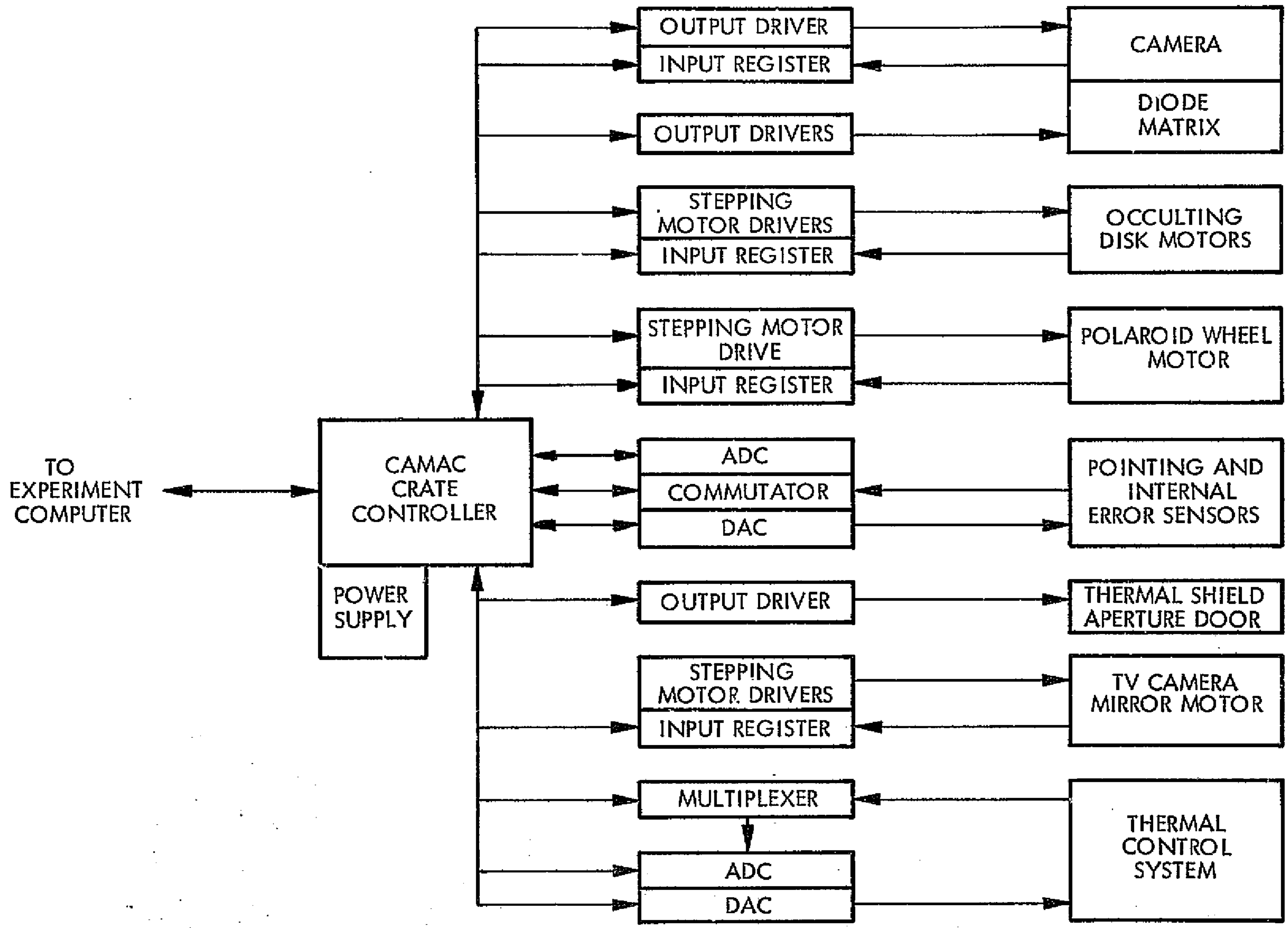

Figure 3-6. ATM Experiment S-052 NIM/CAMAC Implementation

Table 3-2. NIM/CAMAC Implementation of WLCE

System Element	CAMAC Product Code	Specific Example	Comments
<u>Camera Programmer</u>			
Output Driver	133	OD1614	All camera programming would be handled by computer.
Input Register	121	NE7059-1	
<u>Camera Matrix Driver</u>			
Output Driver	133	OD1614	Three units required.
<u>Internal Occulting Disk Drive</u>			
Stepping Motor Drive	145	KS3360	Two motors to be driven.
Input Register	121	NE7059-1	Share register above.
<u>Polarization Wheel Drive</u>			
Stepping Motor Drive	145	KS3361	
<u>Pointing & Internal Error</u>			
Analog Signal Commutator	164	NE9026	
ADC (8 bit)	161	NE7028	
DAC (8 bit)	162	D0200-1512	
<u>Thermal Shield Aperture Door</u>			
Output Driver	133	OD1614	Use same register as Camera Programmer.
<u>TV Camera Mirror Drive</u>			
Stepping Motor Drivers	145	C-ST-4WE	(two required)
Input Register	121	NE7059-1	Share register above.
<u>Thermal Control System</u>			
Multiplexer	164	KS3510	Proportional heater control loop is closed in the computer.
ADC (8 bit)	161	KS3510	
DAC	162	KS3110	

of the experiment is excerpted from their Design and Performance Specification Document, ASE-1600-C.

The primary purpose of the experiment was to study solar emission in the soft X-ray spectrum with a spectral resolution of a fraction of an Angstrom, a spatial resolution of two arc seconds, and a temporal resolution of one second.

The measurements were performed with a telescope assembly consisting of a soft X-ray transmission grating, an image forming soft X-ray telescope and a film camera. The transmission grating was positioned in the optical path to disperse a portion of the incident radiation. Both the undispersed image and the dispersed X-ray spectra were recorded on the 70 mm film of the camera. In order to also gather data during non-flare periods the instrument was equipped with appropriate filters in a filter wheel assembly. These were substituted for the grating upon command and allowed the production of broad-band X-ray photographs of the sun in selected regions of the X-ray spectrum. Finally, the experiment included an electronic imaging system to provide positional information on solar flare activity allowing boresighting of the optical axis of the telescope to the region of activity on the solar disc.

The camera in the system operated with shutter speeds of 1/64 to 256 seconds and a luminescent matrix of diodes recorded information about the time and duration of the exposures, the grating position and the filter position.

A temperature control system was also included in the instrument to maintain constant temperature throughout and thereby preclude thermal misalignment of any of the optical elements in the system.

3.2.2.2 CDMS Implementation with NIM/CAMAC

There are four types of data that must be handled by the CDMS for experiment S-054. The sources of this data can be seen in the overall system diagram (Figure 3-7). The first type is the 10^{-10} to 10^{-5} ampere analog signal coming from the photomultiplier tube used to detect X-ray flares. The second is the 3 to 5 volt pulses from the image dissecting photomultiplier tube, and the third is the housekeeping data associated with operating the camera system. The fourth type of data is that

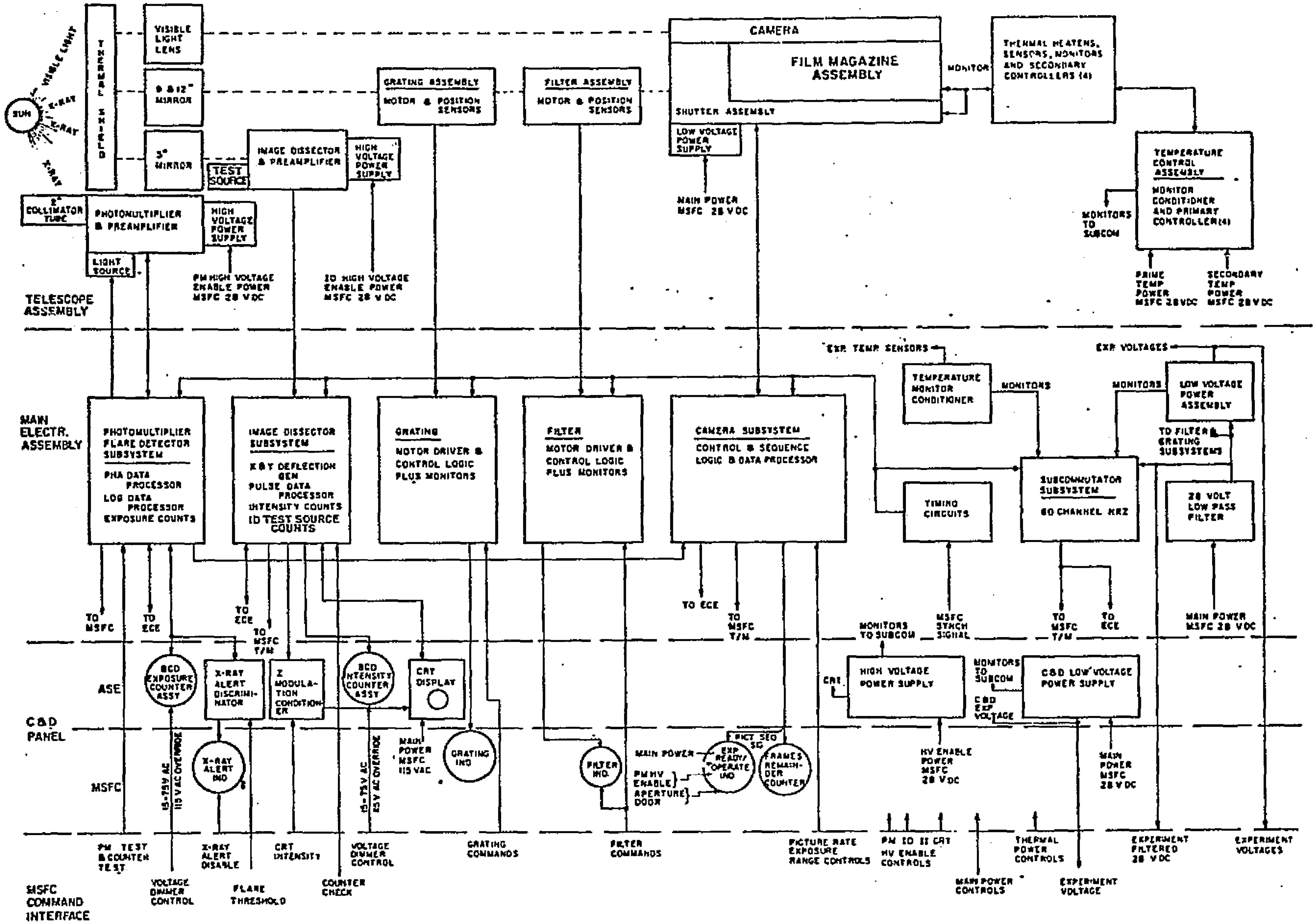

Figure 3-7. ATM Experiment S-054 Overall Blcok Diagram

necessary to control the thermal environment of the X-ray telescope and detector system.

The CDMS to handle this data is made up of the following system elements:

Photomuliplier System. (Figure 3-8) This system element is made up of sub-elements for flare detection and pulse height analysis. Flares are detected by soft X-ray monitoring which is also used for automatic control of the camera and exposure. The pulse height analyzer monitors and processes data on solar activity in the energy range of 10 to 100 Kev.

Imaging System. (Figure 3-9) This system is used to locate flare activity and provide a display to the astronaut so he may align the telescope on the flare. The system must provide control signals to the image dissector tube and process the data for display on the CRT.

Camera System. (Figure 3-10) The CDMS must provide shutter and film advance control signals to the camera. It must also provide the signals necessary to activate the diode array which records such information as grating and filter position on the photographic film. Additionally the CDMS must convey information on camera operation to the telemetry system.

Temperature Control System. This system senses and regulates temperatures within the telescope assembly and monitors Telescope, Camera and Temperature Control Assembly temperatures for telemetry.

Experiment Checkout Equipment. Several pulse generators and a voltage generator are provided in order to periodically verify the correct operation of the other electronic systems.

Other Systems. The instrument requires several additional small system elements to perform such functions as multiplexing analog signals, controlling the grating position and placing the correct filter in front of the camera. The instrument also requires both low and high voltage power supplies.

Control and Display System. The CDMS must provide for manual selection of the various operational modes of the instrument and other required manual inputs. It must also provide for display of various types of instrument status information such as grating status, camera film remaining and filter position.

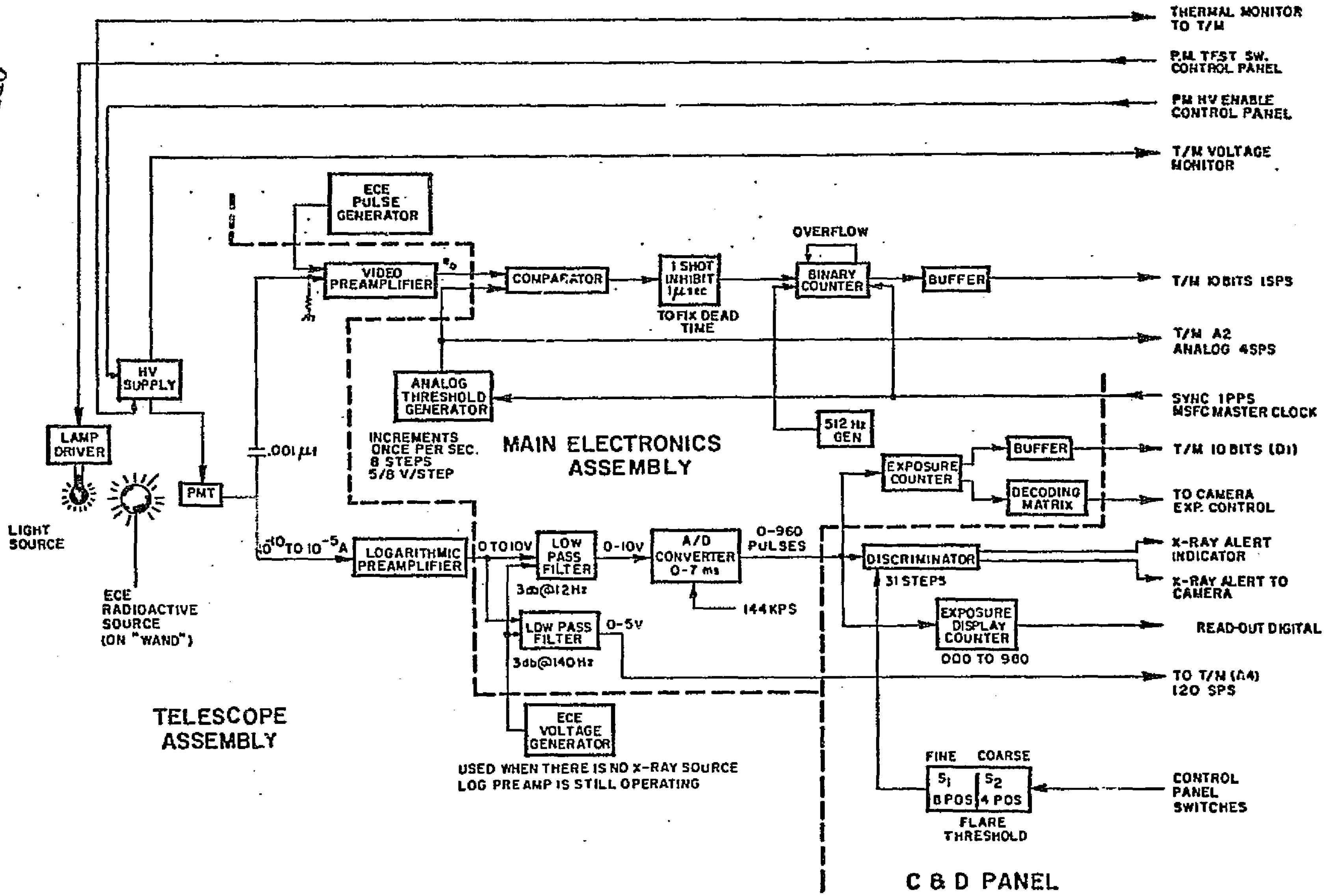

Figure 3-8. ATM Experiment S-054 Photomultiplier Subsystem

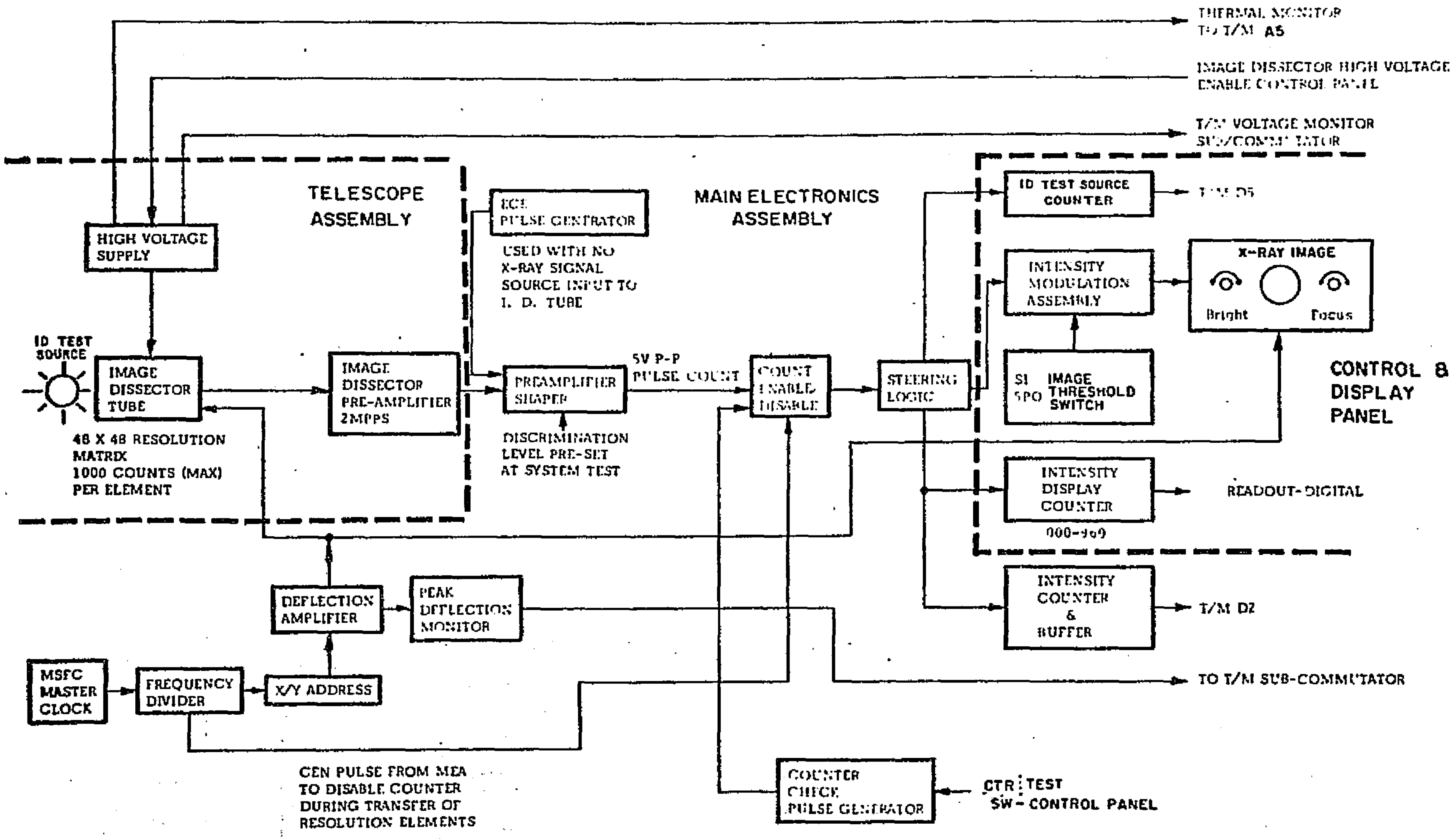

Figure 3-9. ATM Experiment S-054 Imaging Subsystem

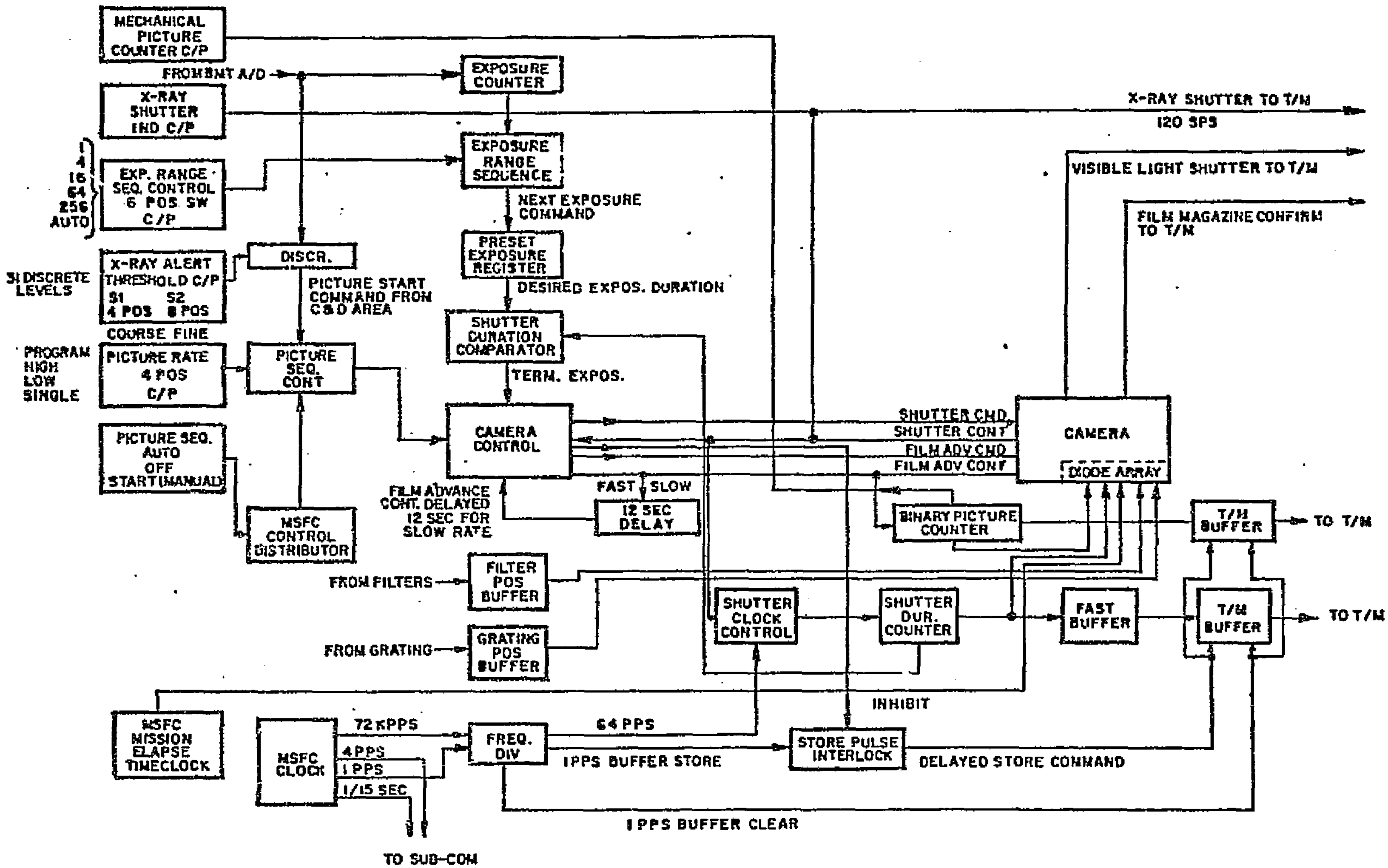

Figure 3-10. ATM Experiment S-054 Camera Control Function

The following pages include the block diagram for the overall S-054 experiment and more detailed block diagrams for the photomultiplier, imaging and camera subsystems. These detailed block diagrams show the system as it was built for Skylab. The camera subsystem in particular would be handled much differently if the system were to be implemented with a computer-controlled CAMAC system. The last block diagram in the section (Figure 3-11) shows the camera control function as it would appear in a CAMAC implementation of the CDMS. A comparison of this diagram with the preceding Figure 3-10 showing the Skylab implementation of camera control with discrete circuits demonstrates the extreme simplification possible in the CDMS using a computer controlled CAMAC system. The primary reason for this simplication is that in the CAMAC system the computer software performs the majority of the control functions that had to be hardwired into the Skylab system.

Because the implementation of the other subsystems with NIM and CAMAC hardware is fairly straightforward, separate block diagrams for these are not shown. The details of the equipment required for this implementation are presented in Table 3-3. However, as mentioned in the previous section, there are many cases, in particular the camera control subsystem, where the entire function can be implemented with CAMAC hardware but the details of the implementation are considerably different from Skylab because of the addition of the computer to the control loop. Several of these cases are commented on in the table. Where there is no CAMAC equivalent of a required hardware element this is indicated in the product code column by a "NONE".

3.2.3 Ultraviolet Scanning Spectroheliometer

3.2.3.1 Experiment Description

The purpose of this instrument is to photoelectrically measure the intensity of a portion of the solar spectrum from a near earth orbit. The instrument consists of a telescope subsystem to collect the solar radiation and a spectrometer subsystem to analyze the wavelength composition of the radiation. Also included is an electronic subsystem for functional and thermal control of the instrument. Seven photoelectric detectors are arranged on the Rowland circle of the spectrometer grating which can be rotated to provide a wavelength scan of the spectral regions

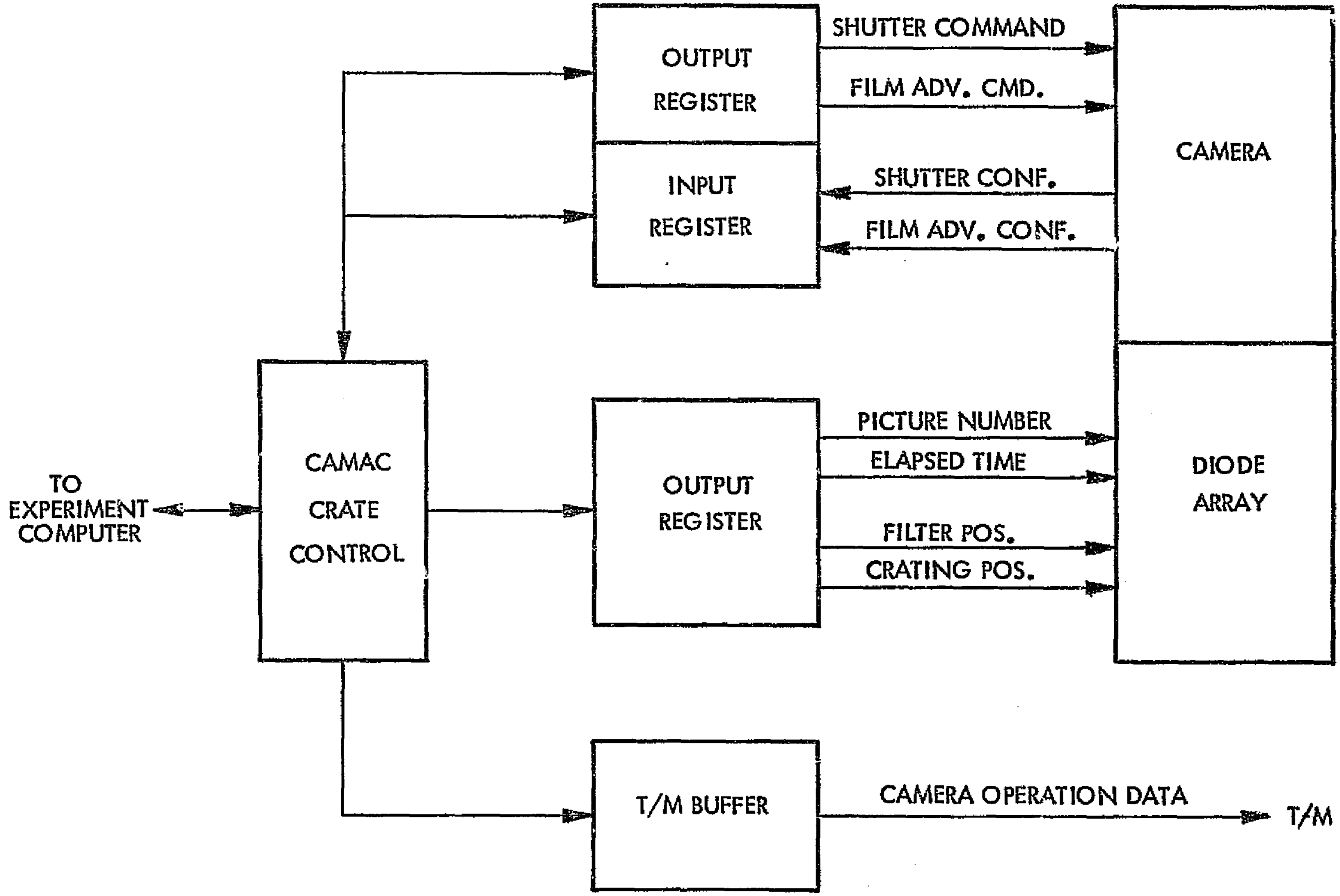

Figure 3-11. ATM Experiment S-054 Camera Control Function NIM/CAMAC Implementation

Table 3-3. NIM/CAMAC Implementation of X-Ray Telescope

System Element	CAMAC Product Code	Specific Example	Comments
Photomultiplier System			
Flare Detection System ADC (10 bits)	161	B01243A	Requires ≤ 7-msec conversion.
Exposure Counter (10 bit)	111	B01002	Use other one-half for intensity counter below.
Buffer (10 bit)	133	OD1614	
Discriminator			
Logarithmic Preamplifier	None		(10^{-10} - 10^{-5} A input)
Low-Pass Filter	None		12-Hz cutoff
Low-Pass Filter	None		140-Hz cutoff
Pulse Height Analyzer			
Comparator			In a CAMAC system, the PHA would not be implemented with these discrete components but with an ADC as shown below
One-shot Inhibit			
Analog Threshold Generator			
512-Hz Generator			
Binary Counter (10 bit)	111	B01002	
Buffer (10 bit)	133	OD1614	
Video Preamplifier	None		
ADC	161	NE7028-1	Use computer to do pulse height accumulation.
Linear Gate	NIM		
Imaging System			
Frequency Divider (72 kHz)	111	SR1605	One-fourth of Quad unit.
X/Y Address (6 bit)	111	SR1605	One-fourth of Quad unit.
D/A Converter (6 bit)	162	D0200-1513	
ID Test Source Counter (6 bit)	111	SR1605	One-fourth of Quad unit.
Intensity Counter (10 bit)	111	B01002	Other one-half of exposure counter above.
Buffer (10 bit)	133	OD1614	
CRT Electronics	144	FDD2012	An XYZ scope display driver system
Intensity Modulation Assembly	144		
Preamplifier Shaper	None		
Deflection Amplifier	None		
Peak Deflection Monitor	None		

Table 3-3. NIM/CAMAC Implementation of X-Ray Telescope (continued)

System Element	CAMAC Product Code	Specific Example	Comment
<u>Camera System</u>			
Mechanical Picture Counter			Because of the computer available in the CAMAC implementation of the CDMS, the Camera System would be handled quite differently from the original experiment. As shown in the block diagram, the CAMAC system would have extensive computer control of all camera functions.
X-Ray Shutter I Indicator			
Exposure Range Sequence Control			
X-Ray Alert Threshold			
Picture Rate Control			
Picture Sequence Control			
Preset Exposure Register			
Shuttle Duration Comparator			
Camera Control			Output Driver for Camera Commands.
Twelve-Second Delay	133	NE9002	
Filter Position Buffer	121	NE7059-1	Input Register for Camera Signals.
Grating Position Buffer	133	OD1614	Driver for Diode Array.
Shutter Clock Control			
Shutter Duration Counter			
Store Pulse Interlock			
Binary Picture Counter			
Fast Buffer			
T/M Buffers (2)			
<u>Temperature Control System</u>			
Multiplexer	164	KS3510	Use Computer to close the control.
ADC (8 bit)	161	KS3510	Loop on proportionally controlled heaters.
DAC's	162	KS3110	
<u>Experiment Checkout Equipment</u>			
ECE Pulse Generators (2)	131	NE7019	
Counter Check Pulse Generator	131	NE7019	
ECE Voltage Generator	162	DO 200-1513	

Table 3-3. NIM/CAMAC Implementation of X-Ray Telescope (continued)

System Element	CAMAC Product Code	Specific Example	Comment
Other Systems			
Timing Circuits	Computer		Computer handles all timing.
Subcommutator Subsystem	164	DO 200-1061	60-channel analog MUX.
Grating System	145	KS3361	Stepper motor control.
Filter System	145	KS3361	Stepper motor control.
Input Register	121	NE7059-1	Share Register in Camera System

of interest. Additionally, there is a zero order detector made of a quadrant of solar cells which will look at the zero order image of the grating and aid in centering the instrument on the solar disk. The detectors are guarded by an ion trap designed to prevent positive or negative charged particles with energies equivalent to 40 electron volts or less from entering the detectors.

In addition to the wavelength scans implemented with the spectrometer grating, the instrument also performs spatial scans of the solar disk by moving the main telescope mirror to generate a raster pattern. Options available include the complete 60 line raster pattern, a 3 line raster and a repeated scan of a single raster line. The choice of option is made via command to the instrument.

3.2.3 2 CDMS Implementation with NIM/CAMAC

The control and data management system for this instrument must control the grating and mirror drives, provide thermal control of the instrument and process the instrument data. These functions are accomplished with eight system elements:

Primary Mirror Drive. This circuit controls the motion of the paraboloidal telescope mirror about two axes to implement the raster scan patterns. It must be capable of implementing a 60 line, 3 line or 1 line raster pattern via command.

Grating Drive. This system element must control the stepping motor which rotates the spectrometer grating .2 Å/step over the range 296 to 1342 Å.

It must include the ability to continuously scan the range, stop the grating at a reference position and perform one step at a time on command.

Primary Data Handling. The primary data handling electronics count the pulses from the seven detectors during the 41 msec or greater integration periods. Between integration periods these data are presented to the ATM telemetry system in real time and in a parallel form at a sample rate of 24 times/second. Additionally, data from one of two detectors (#1 or #3) selectable by command, are presented to the ATM control panel in BCD form for display and updated 1 to 4 times per second.

Analog Monitoring. The instrument temperatures are monitored and presented to the ATM telemetry system as analog voltages. The system also contains a 15 position subcommutator to provide additional system analog monitoring capability. This subcommutator is advanced once per second.

Low Voltage Power Supplies. As designed for Skylab the CDMS contained two redundant low voltage power supplies which produced the following voltages:

- ±15 VDC ±5% regulation
- ±15 VDC ±0.1% regulation
- ±10 VDC ± 1% regulation
- ±5 VDC 2% regulation
- +5 VDC ±5% regulation
- ±28 VDC ±5% regulation

High Voltage Power Supplies. Each of the seven photomultiplier detectors requires its own high voltage power supply. These turn off automatically if excessive detector current is detected or if the ATM door is closed.

Test Pulse Generator. This system element allows in-flight checkout of the pulse electronics. It provides a choice of two frequencies (1.07 MHz and .53 MHz) for exercising the digital data system.

Thermal Control Subsystem (TCS). The TCS provides active thermal control of the instrument to maintain the temperature distribution in the instrument adequate for alignment stability and the temperature level adequate for focus stability.

Control and Display System. Required control functions include an auto raster command, line scan command, line select up/down command and others.

Displays must be provided to show the state of the instrument, monitor the output of the zero order detector and alert the astronaut to any instrument failures.

Figure 3-12 shows the CDMS as it was implemented for the Skylab ATM experiment (this is taken from Ball Brothers Research Corporation, Report #29540). Figure 3-13 shows the same system as it would be implemented using NIM and CAMAC hardware. The only major functional change in the NIM/CAMAC implementation is the addition of the control capability of the computer and the assumed capability of the computer system (see Section 3.1.1) to provide keyboard control inputs and CRT display capability.

Table 3-4 summarizes the detailed list of equipment required to implement the CDMS for the UV Scanning Spectroheliometer with NIM and CAMAC equipment. All three stepping motor assemblies share an input register which identifies a zero position for the motor. Further definition of the motor position depends on computer counting of the steps through which the motor has been turned. As can be seen from the table, the computer in the NIM/CAMAC system supplies the control logic for all of data processing, temperature control and instrument command functions. The NIM power supplies used for the channel multipliers are ideal in that their output voltage is totally controlled by a ± 11 volt input voltage. This control voltage is readily generated in the computer/CAMAC system with a DAC thus putting the channel multiplier voltages directly under software control.

3.2.4 X-Ray Telescope

3.2.4.1 Experiment Description

This experiment was designed to gather data to enable a better understanding of the physical processes occurring in the solar atmosphere, primarily in solar flares. The experiment utilizes two separate and independent instruments to obtain complementary data. One of these instruments is an X-Ray Event Analyzer (X-REA) to provide spectral data (photon intensity as a function of wavelength) in 10 bands from 2 to 20 Å using proportional counters and pulse height analyzers. The other instrument is an X-Ray Telescope (X-RT), employing grazing-incidence optics to provide images of the solar target area in the form of X-ray filtergrams (images

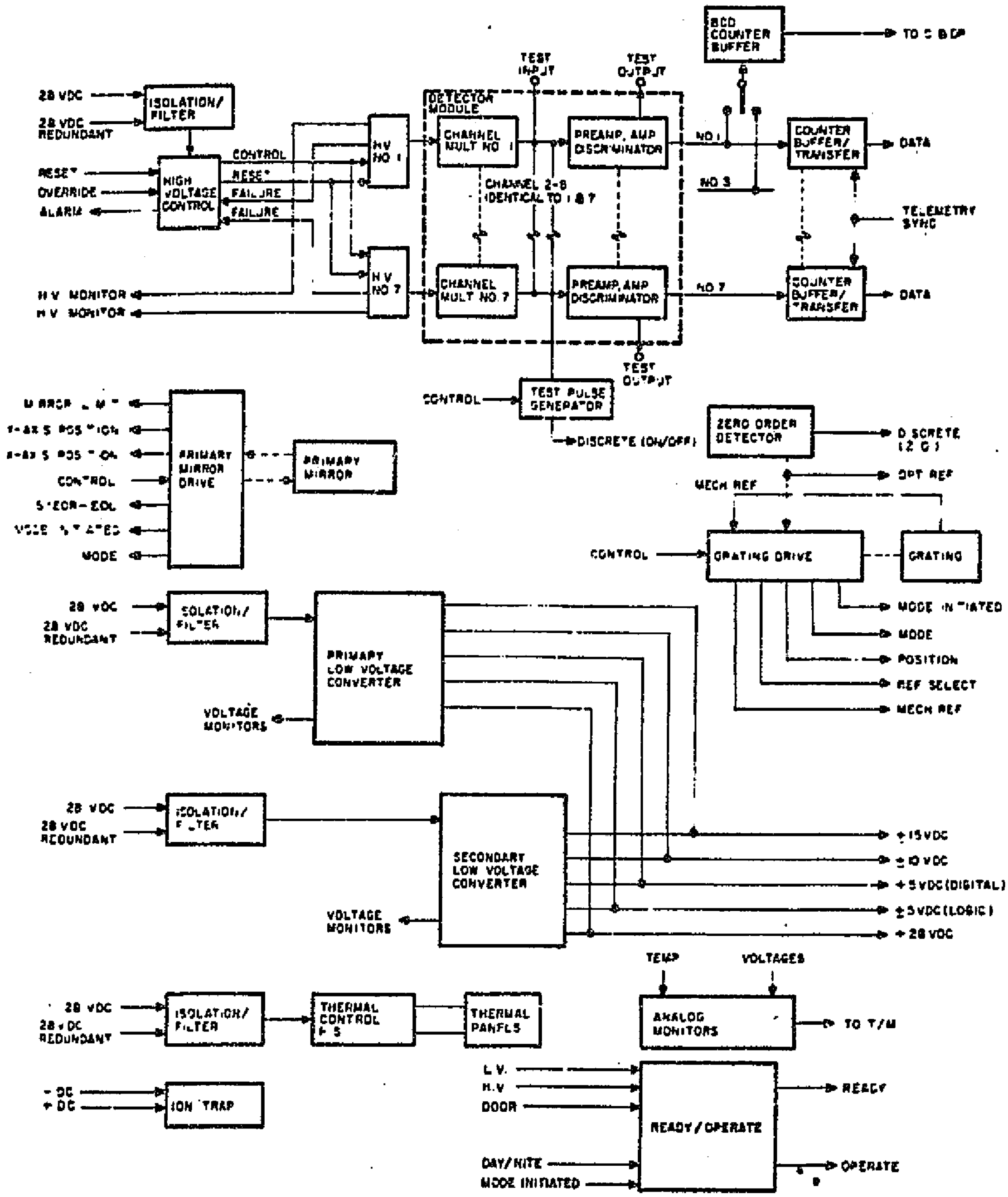

Figure 3-12. ATM Experiment S-055A Electronic Subsystem Block Diagram

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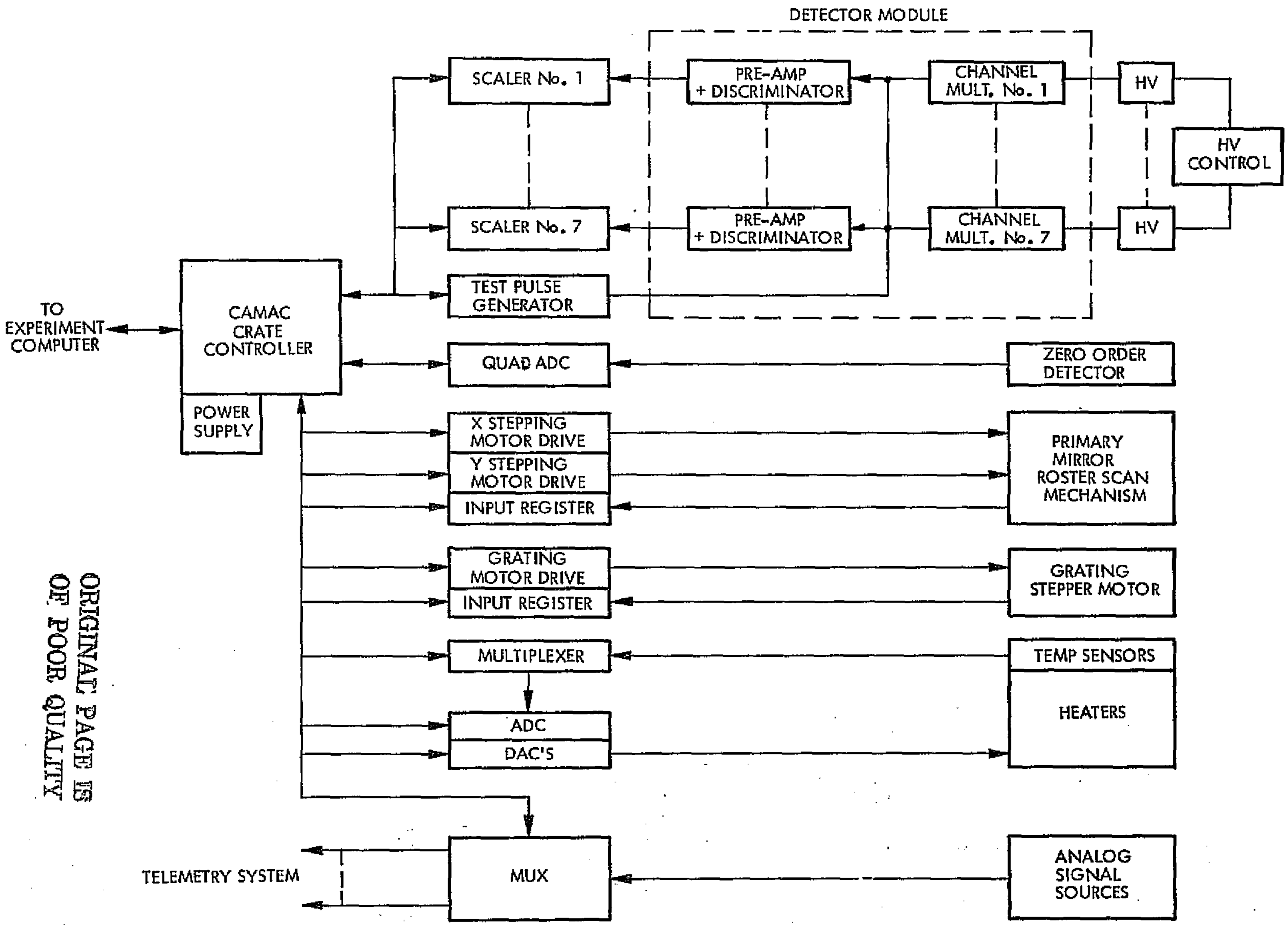

Figure 3-13. ATM Experiment S-055A NIM/CAMAC Implementation

Table 3-4. NIM/CAMAC Implementation of Spectroheliometer

System Element	CAMAC Product Code	Specific Example	Comment
<u>Primary Mirror Drive</u>			
Stepping Motor Drivers (2)	145	KS3360	Two motors to be driven.
Input Register	121	NE7059-1	
<u>Grating Drive</u>			
Stepping Motor Driver	145	WE C-ST-4	
Input Register	121	NE7059-1	Share register above.
<u>Primary Data Handling</u>			
16-bit Scaler (7)	111	NE9054	12-channel 16-bit scaler.
16-bit Output Buffer	133	OD1614	
Quad ADC (zero order)	161	KS3515	
<u>Analog Monitoring</u>			
15-channel MUX	164	KS3530	
<u>High-Voltage Power Supplies</u>			
Power Supplies (7)	NIM	ORTEC 456	Controlled by $\pm$11-V input.
Power Supply Control (DAC)	162	JO D/A-12	
<u>Test Pulse Generator</u>	131	JW217	
<u>Thermal Control System</u>			
Multiplexer	164	KS3510	
ADC (8 bit)	161	KS3510	
DAC's	162	KS3110	Computer does proportional control loop for heaters.

viewed in narrow wavelength intervals) in five bandwiths from 5 to 33 Å. A visible light filtergram is also obtained.

The experiment operates in six modes which cover the expected range of variation in solar activity. There are two quiet sun modes and four active sun modes. Because the time scale of events during a flare varies greatly, active mode observations require additional latitude. This latitude is provided by three active modes and one automatic mode. These modes are specified below in material taken from the MSFC specification document for the experiment (50M16609).

Quiet Sun Modes.

Patrol. In a patrol mode, six exposures will be made in sequence, one in each of the six filter positions. Each filter position will have a programmed exposure time. The filter bandpasses and exposure durations will be selected to correspond with flux levels expected from the "quiescent" sun.

Single Frame. A single frame mode will provide the capability to make single exposures, with a selection of any one of the six filter positions. Exposure time will be that associated with the filter position, or as selected by manual capability to shorten or lengthen all exposure times.

Active Sun Modes.

Active I. An Active I mode will be used during initial stages of flare development which is characterized by a fast rise time (less than one minute) in flux level to flare maximum. To allow short-time-constant event recording, exposures will be made in rapid sequence for five minutes. Three filters (numbers 1, 3, and 5) will be used, with exposure times selected to match the flux levels expected during flares.

Active II. An Active II mode will use the same filters and exposure times as the Active I mode; however, the rate of exposures will be reduced to one set of three exposures (one at each filter position) per minute. This rate is compatible with the flare event time constants expected during flare maximum and initial stages of decay. A total of 60 exposures will be scheduled over 20 minutes.

Active III. An Active III mode will also utilize the same filters and exposure times as the Active I mode. The exposure rate will be further reduced to one set of three exposures (one at each filter position) per 10 minutes, for 18 exposures over 60 minutes.

Automatic. An auto mode will sequentially combine the three active modes for a total exposure time of 85 minutes.

3.2.4.2 CDMS Implementation with NIM/CAMAC

The block diagram of the instrument is shown in Figure 3-14 and Figure 3-15 shows a cutaway view of the X-ray telescope. The CDMS for this instrument must provide control of the camera, thermal control of the instrument and the signal conditioning and buffering between various subsystem sensors and indicators for control and display purposes. It also must provide the pulse height analyzers, digital channel counters, signal conditions and power supplies required to detect, sort, count and record the pulses from the X-REA proportional counters. The CDMS can be broken into three major systems: the camera control system, the thermal control system and the data processing system for the X-REA. These systems and the elements that compose them are discussed below.

Camera Control Electronics.

Filter Motor Drive. This element controls the filter wheel position and transfers filter wheel status information to the rest of the system.

Shutter Motor Drive. This element controls the shutter including frequency and duration of operation.

Film Advance Motor Drive. This motor drive controls the advancement of camera film between frames.

Data Exposure Block. The data exposure block circuitry provides drive signals to mark the data on film (via a diode matrix). There are 44 data inputs to the data block; a 25-bit shutter-open time code, 3-bit camera mode, 3-bit filter code, 2-bit multiplier code, and an 11-bit shutter-closed code.

Mode and Sequencing Logic. The mode and sequencer logic circuitry provides command signals for exposure time, filter sequence and filter/shutter motor open-close signals. This circuitry also counts the number of frames in the various modes to stop the sequence and return to a ready condition for the next sequence.

X-REA Electronics. The X-REA has two coaxial type proportional counters using xenon/methane and argon/methane gas mixtures, respectively, for beryllium and aluminum counters. The maximum count rate is 6000 counts/second

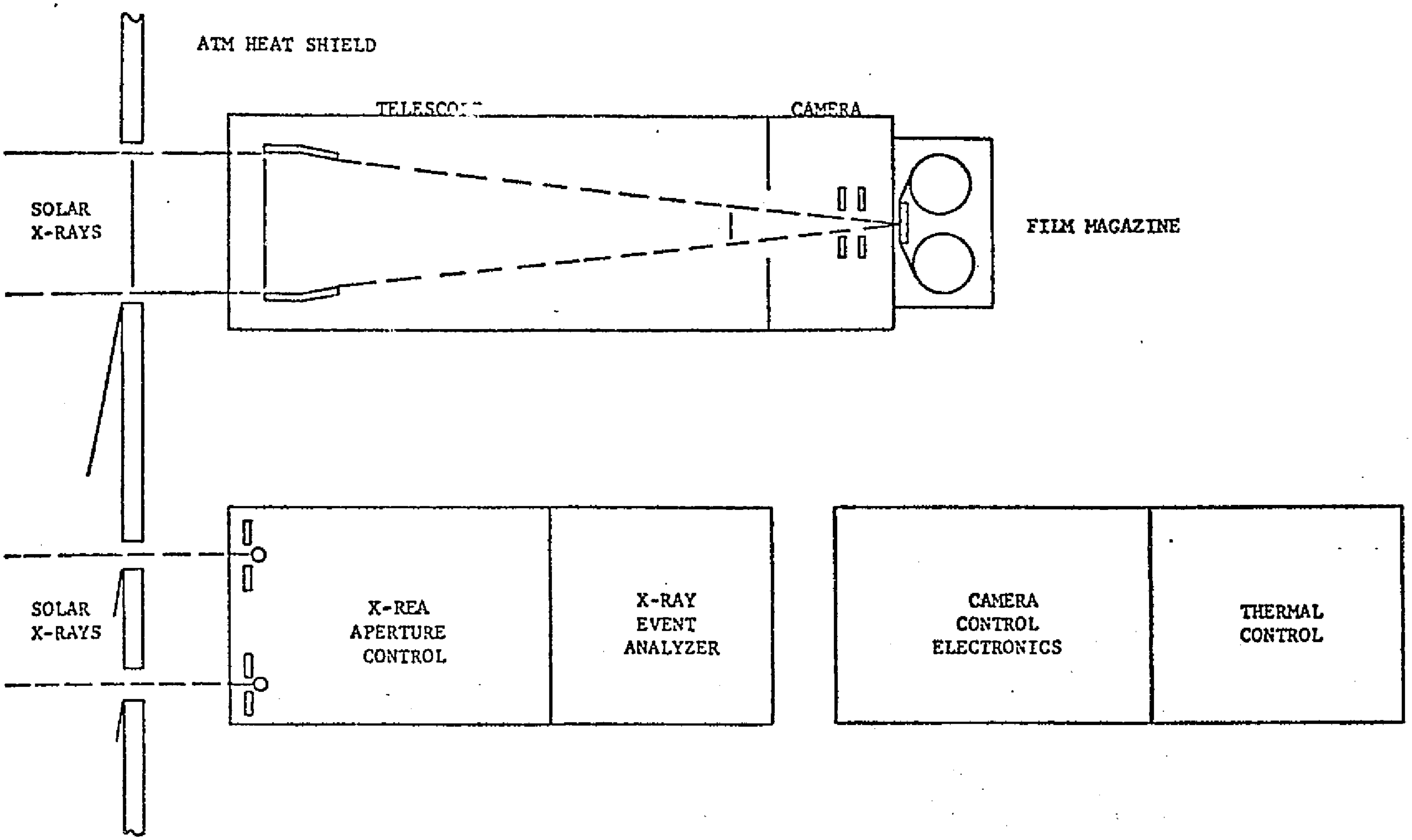

Figure 3-14. ATM Experiment S-056 Block Diagram

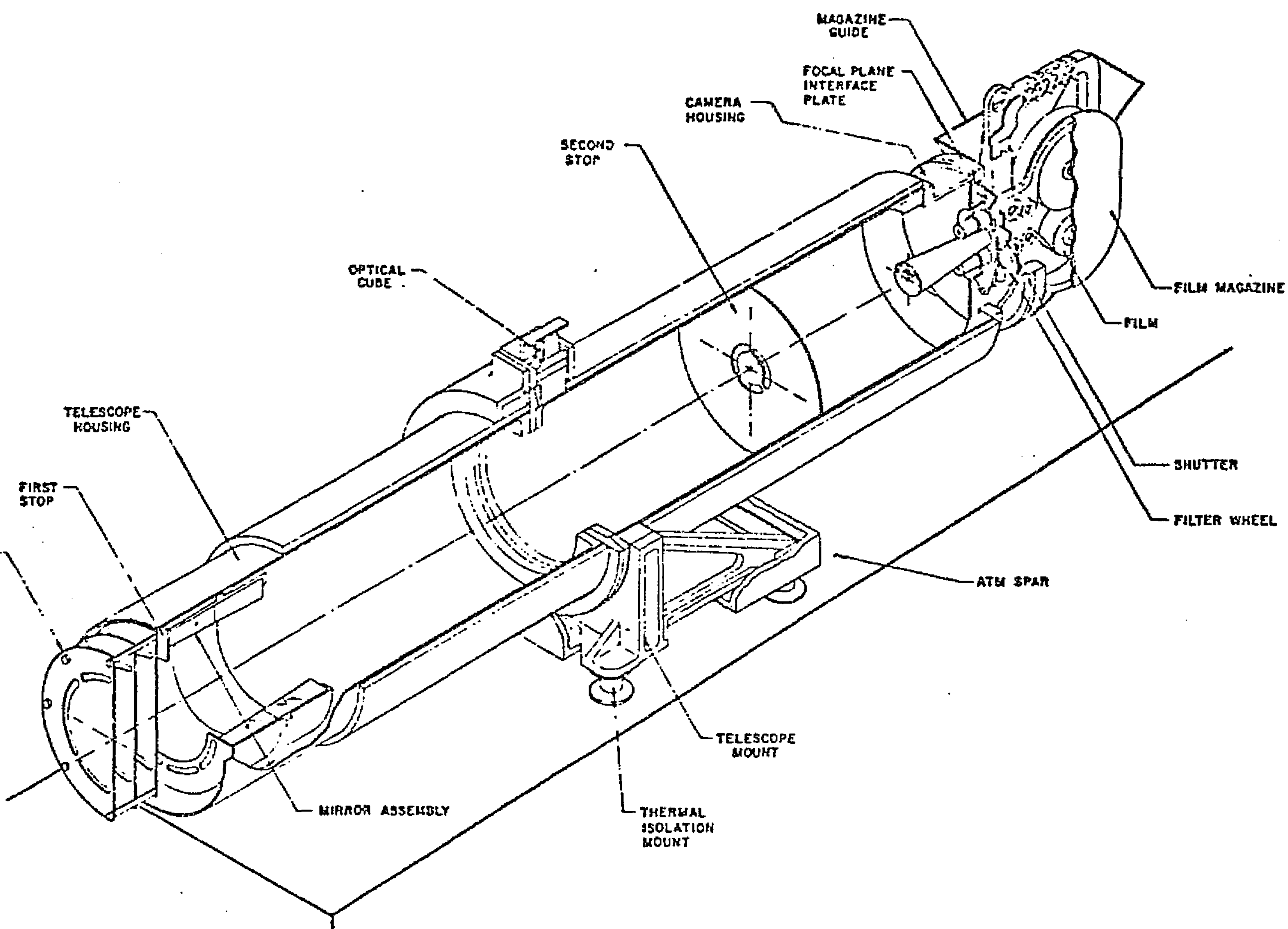

Figure 3-15. ATM Experiment S-056 X-Ray Telescope Cutaway View

but an aperture control places a larger or smaller aperture over the window, thus keeping the count within limits of 32 to 2048 counts/second. The output of the counters feeds into charge sensitive preamplifiers which have an output proportional to the photon energy. It is the output of these preamplifiers that must be processed and interpreted by the CDMS. The elements necessary to do this are:

Pulse Height Analyzers (PHA). There is one PHA for each proportional counter. The Al PHA has four channels covering the 8 to 20 Å wavelength spectrum and the Be PHA has six channels for 2 to 8 Å spectrum.

Digital Signal Processor. This system element records the pulse height spectrum from the two proportional counters and makes this information available for telemetry and display purposes. Event frequency data is also used to supply control information to the aperture control systems of the two counters.

Aperture Control. This element controls the apertures of the proportional counter based on the frequency information from the digital signal processor although manual choice of aperture is also provided for. The aperture value is provided as data to the rest of the system.

Calibrators. Two calibrators provide a pulse generator for each PHA, producing four and six-pulse levels, at a rate of 500 or 900 pulses/second (per channel), to functionally check operation of the amplifiers, all channels of both PHA's and the counters of the digital signal processor.

Ratemeter. This system determines the overall photon flux to the X-REA by summing the PHA channels and normalizing for the aperture size. It provides a logarithmic analog output voltage to the activity history plotter in order to record the count rate.

Activity History Plotter. This produces a hard copy record of the count rate over the range 10 Hz to 250 Hz.

High Voltage Power Supplies. In addition to the low voltages required to energize the circuits of the X-REA electronics, the proportional counters in this system must have high voltage power supplies. These will operate in the range of 1000 to 2300 VDC and are adjustable to a resolution of one percent at one microampere.

Thermal Control System. The thermal control system is designed to maintain the telescope focal length within $\pm$ .05 mm and the pointing alignment stability within 2.5 arc-seconds for a 320-second exposure time. To do this it must maintain a constant temperature of 21°C $\pm$ .3°C along the X-RT. This requirement is met by a system of temperature sensors and proportionally controlled heaters along the X-RT assembly.

Control and Display System. The instrument requires several different commands to determine its mode of operation and must display several signals assessing the status of the instrument in addition to the output of the ratemeter recorded on the activity history plotter.

The CDMS system with its extensive sequencing and decision making requirements is ideally suited to implementation with CAMAC hardware. The functional block diagram in this section (Figure 3-16) shows how the system would be configured to implement all of the experiment functions.

As in the previous experiments input registers are used to determine the motor positions. The two proportional counters used in this instrument are ideally suited for instrumentation with NIM equipment since it is for detectors such as these that much NIM equipment is designed. The amplifiers and single channel analyzers usually come as a single package and their output is appropriate to the CAMAC scalers that are shown. There are several high voltage NIM power supplies appropriate for the proportional counters. The one shown is controllable with a small analog input voltage thereby allowing it to be under software control via a CAMAC DAC.

A DAC is also used to allow the computer to write a strip chart record of the X-ray activity history.

As shown in Table 3-5, the CDMS for the X-ray telescope can be implemented with just a few different types of NIM and CAMAC modules. This and the fact that all control functions for the telescope, including programmed operation, are easily implemented with computer software make the CDMS design very easy conceptually.

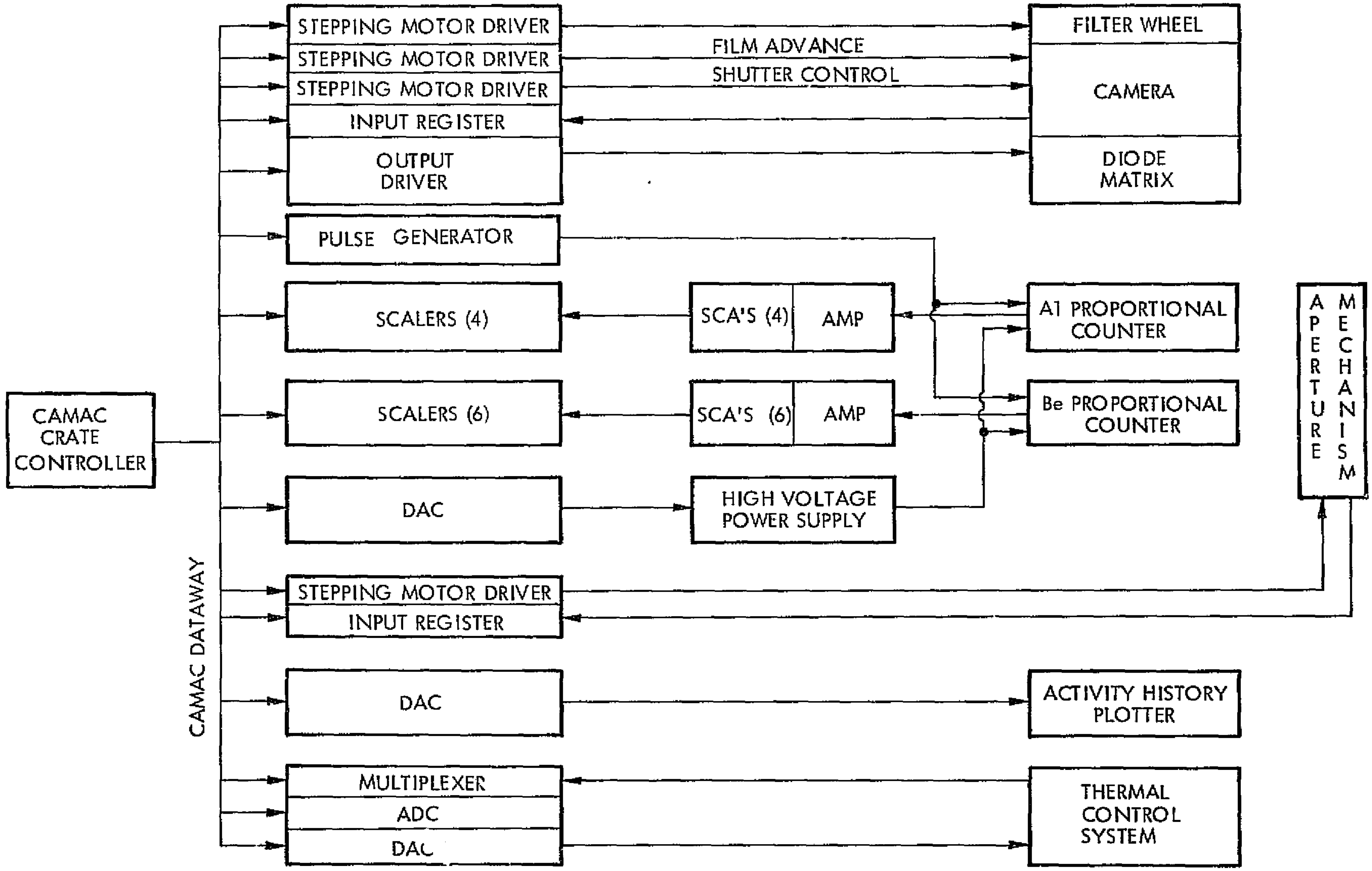

Figure 3-16. ATM Experiment S-056 NIM/CAMAC Implementation

Table 3-5. NIM/CAMAC Implementation of X-Ray Telescope

System Element	CAMAC Product Code	Specific Example	Comments
Camera Control Electronics			
Stepping Motor Driver (Filter)	145	KS3361	
Stepping Motor Driver (Shutter)	145	KS3361	
Stepping Motor Driver (Film Advance)	145	KS3361	
Input Register	121	NE7059-1	One-half of X-Ray
Output Driver	133	KS3080	input register.
X-Ray Electronics			
Pulse Height Analyzer			
Proportional Counter Amplifier	NIM	ORTEC 490A	Preamplifier and SCA in
SCA's (10)	NIM	ORTEC 490A	one package designed
Scalers (10)	111	B01002	specifically for use
Stepping Motor Driver (Aperture)	145	KS3361	with X-ray proportional counters.
Input Register	121	NE7059-1	One-half of Camera con-
Calibration Pulse Generator	131	ORTEC 448	trol input register.
DAC (Activity Plotter)	162	DO 200-1528	
DAC (HV control)	161	DO 200-152B	
High-Voltage Power Supply (2)	NIM	ORTEC 456	
Thermal Control System			
Multiplexer	164	KS3510	
ADC	161	KS3510	
DAC's (3)	162	DO 200-1528	$\pm$10 V, 12-bit - Dornier

3.2.5 Extreme Ultraviolet Spectroheliograph

3.2.5.1 Experiment Description

The XUV Coronal Spectroheliograph Instrument studies the solar corona in the extreme ultraviolet region of the spectrum. In operation it photographically records coronal images of the sun in the various wavelengths between 150 and 650 Å.

The instrument is shown in Figure 3-17. The principal elements are:

- Concave grating
- Heat rejection mirrors
- Film strip camera
- Instrument aperture mechanism
- Grating positioning mechanism
- Short wavelength mirror mechanism
- Alignment reference mirror.

The grating has a four-meter radius and is ruled 3600 lines/millimeter over a four-inch square area. The grating receives light directly from the sun and forms a spectrum of solar images on the film. The wavelength range is covered in two sections, each photographed separately, with the grating turned between exposures to register each section properly on the film strip. A thin aluminum filter is positioned ahead of the film to limit the wavelength bandpass and prevent fogging of the film from stray light.

Two zero order rejection mirrors are mounted internally to the housing to reject heat and white light from the zero order of the concave grating as shown in Figure 3-17. Rejected light is reflected to a third mirror at the aperture of the instrument where it is reflected overboard. When the grating is in the long wavelength position, the short wavelength mirror is folded down so as not to interfere with the light path.

The instrument operates in one of three automatic modes or in the normal mode. The automatic modes are:

- Time sequence
- Spectral sequence
- Flare mode sequence.

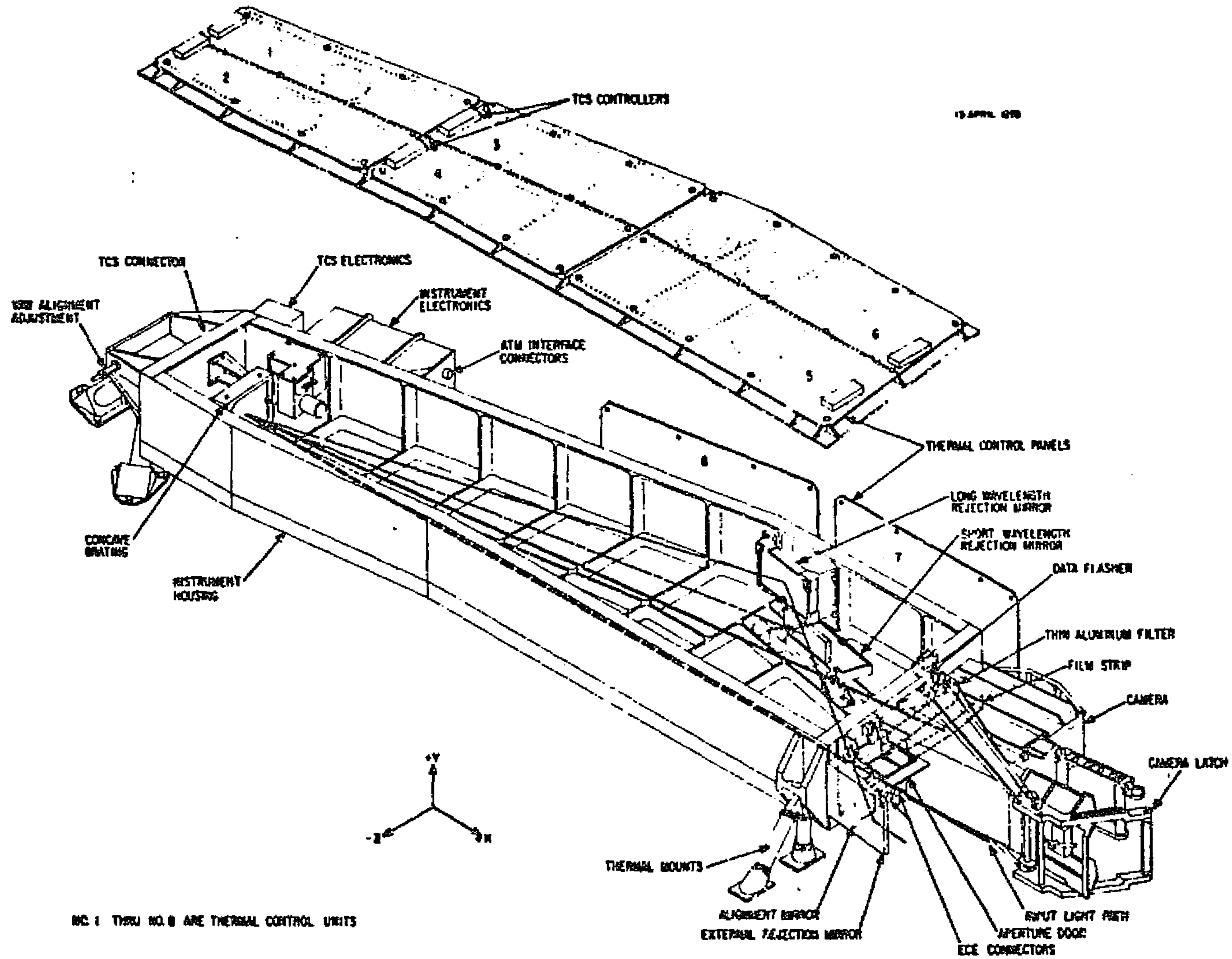

Figure 3-17. ATM Experiment S-082A Instrument Configuration

These are described more fully below in material abstracted from Ball Brothers Research Corporation Specification CP25905.

Time Sequence. This sequence shall provide three automatic exposures at the selected wavelength band. The wavelength band at which the exposures are taken is to be selected manually as the program requirements may dictate. The automatic exposures shall be preprogrammed as a function of the wavelength band selected. The exposure times for normal, short and long shall be as follows:

Normal Exposure

Short Wavelength Grating Position		or	Long Wavelength Grating Position	
10	seconds		20	seconds
40	seconds		80	seconds
160	seconds		320	seconds

Short Exposures. The exposure shall be shortened by a common factor by commanding SHORT EXPOSURE IN prior to actuating the automatic sequence.

Short Wavelength Grating Position		or	Long Wavelength Grating Position	
2.5	seconds		5	seconds
10	seconds		20	seconds
40	seconds		80	seconds

Long Exposures. The exposures shall be lengthened by a common factor by commanding LONG EXPOSURE IN prior to actuating the automatic sequence.

Short Wavelength Grating Position		or	Long Wavelength Grating Position	
40	seconds		80	seconds
160	seconds		320	seconds
640	seconds		1280	seconds

Spectral Sequence. This sequence shall provide six automatic exposures. The sequence shall begin with a picture at the selected wavelenth band; the grating shall change, and a picture taken at the second wavelength band. The grating shall then return to the first position and the cycle repeated until six pictures have been taken. The sequence may begin at either grating position. The exposure time for normal, short, and long shall be the same as for the Time Sequence.

Flare Mode Sequence. This sequence shall provide 24 automatic exposures. The wavelengths and corresponding exposure times shall be as listed in Table 3-6.

Table 3-6. Flare Mode Sequence Exposure Times

Set	Wavelength	Exposure Duration (Seconds)		
1	Short	2.5	10	40
2	Long	5.0	20	80
3	Short	2.5	10	40
4	Short	10	40	160
5	Long	10	40	160
6	Short	2.5	10	40
7	Short	10	40	160
8	Long	10	40	160

3.2.5.2 CDMS Implementation with NIM/CAMAC

Since the primary data for this experiment is recorded on photographic film, the CDMS is uncomplicated. It can be thought of as consisting of four elements as described below:

Camera Control System. This element controls the camera shutter exposure times and the film advance and provides the required signals to the diode matrix (data flasher) in the camera for recording the individual exposure data.

Optical Control System. The function of this system element is to control the positioning of the grating, the short wavelength rejection mirror and the aperture door. Since both the grating and the short wavelength rejection mirror are solenoid-driven their control only requires switching the solenoid.

Command and Display. This functional element must provide command capability to the astronaut to determine the exposure times, wavelength and operational mode of the instrument. It also must display over a dozen signals describing the status of the instrument.

Thermal Control System. The TCS provides active thermal control of the instrument to maintain the absolute temperature of the case within $\pm$ 7°C of the alignment temperature. The TCS limits temperature gradients across the instrument to maintain the focus to the equivalent of 2 arc-seconds of resolution and to limit amplitude lateral movement of the image in the film plane to less than 5 arc-seconds during a five-minute period.

Figure 3-18 shows how the XUV Spectroheliograph CDMS would be implemented using CAMAC hardware. In this implementation all instrument commands are entered via the experiment computer keyboard input and all data is displayed on the experiment CRT. Because the grating and camera systems are fairly self contained units the primary interface to them is via switching signals sent through output registers. This makes the CDMS functions very straightforward and easily implemented.

Because of the simplicity of the CDMS interface requirements for the XUV Spectroheliograph only the five CAMAC modules shown in Table 3-7 are required to implement the system. These, along with the computer and its command and display capabilities, allow the experiment to perform all of the experiment functions that it did aboard Skylab with a discrete CDMS.

3.2.6 Extreme Ultraviolet Spectrograph

3.2.6.1 Experiment Description

The XUV Spectrograph Instrument is used to photographically record line spectrograms of solar radiation between 970 and 1970 and between 1940 and 3950 Å from various small areas on the solar disk and at different levels across the limb. The primary instrument sensor is a film strip camera for recording the XUV spectra but the instrument also includes a TV camera for monitoring the instrument field of view in white light and another detector for XUV monitoring.

By controlling the primary mirror of the instrument the area the instrument is pointed at can be controlled. There are three different pointing modes of operation:

- Boresight mode
- Limb-scanning mode
- Limb-pointing mode

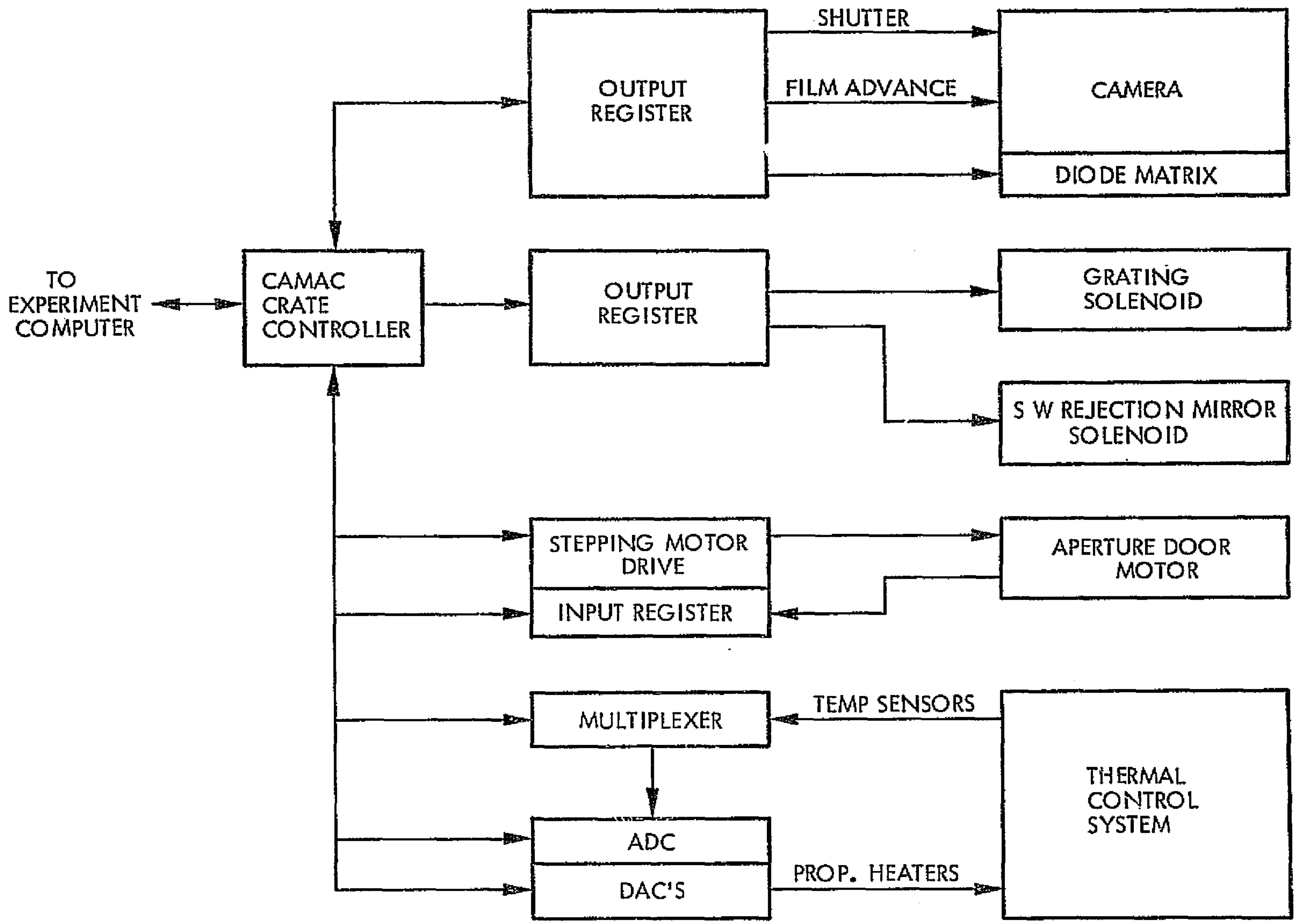

Figure 3-18. ATM Experiment S-082A NIM/CAMAC Implementation

Table 3-7. CAMAC Implementation of ATM/XUV Spectroheliograph

System Element	CAMAC Product Code	Specific Example	Comments
<u>Camera Control System</u>			
Output Driver (42 bit)	133	OD2403	Dual 24-bit - 40 mA
<u>Optical Control System</u>			
Output Driver (4 bits)	133	OD2403	Use unused portions of camera control register.
Stepping Motor Driver	145	KS3361	
Input Register	121	NE7059-1	
<u>Thermal Control System</u>			
Multiplexer	164	KS3510	16-channel ADC - self-scanning
ADC (8 bit)	161		
DAC	162	KS3110	Close thermal control loop within the computer.

<u>Boresight Mode</u>. The boresight mode is used when spectrograms of the central disk are desired or for spectrograms of features or flares. The mode shows the astronaut what the instrument is seeing in white light. It is also used by him to acquire fine pointing on or near the limb prior to activating the limb-scanning mode.

<u>Limb-Scanning Mode</u>. This mode is used when spectrograms near the limb are desired. Before this mode is activated, the instrument is pointed, via the boresight mode, to within 45 arc seconds of the solar limb. As the instrument is scanned by moving the primary mirror a digital readout displays the distance from the limb to the center of the instrument slit in arc seconds. In the limb scanning mode the spectral sequence exposure times are automatically increased for pointing positions of the limb in accordance with a preprogrammed sequence.

<u>Limb-Pointing Mode</u>. This mode is also used to obtain spectrograms near the limb. In this mode the position of the solar image with respect to the instrument slit is actively maintained to within one arc second of the desired pointing direction. This precise pointing is achieved by active control of the primary mirror.

The instrument contains both a predisperser and a main grating. The predisperser grating is moved to either of two orientations to choose between the short or long wavelength range of the instrument. In each of the instrument pointing modes spectra in both wavelength regions are measured. Each pointing mode has associated with it a preprogrammed series of exposure times in both spectral ranges. The instrument may also be operated completely under manual control.

3.2.6.2 CDMS Implementation with NIM/CAMAC

The control and data management system for this instrument must provide signals to operate the film strip camera, position the predisperser grating, choose the instrument aperture, operate the XUV monitor, control the instrument pointing with the primary mirror and provide thermal control of the instrument. These functions are accomplished with the following system elements:

Camera Control Electronics. This subsystem provides exposure control to the camera shutter and controls the film advance between exposures. This system element must also provide 192 bits of time, pointing and exposure information to a diode matrix in the camera. This information is recorded on each exposure.

X-Ray Monitor System. For this system the CDMS is required only to furnish control of a calibration source and the system aperture door. The video camera and its control circuits are not handled by the CDMS.

Predisperser Grating. Control signals must be provided to the predisperser grating positioning mechanism to move the grating between the short and long wavelength orientations.

Primary Mirror Control. This system element must control the instrument pointing during the limb-point mode to one second of arc. It does this by controlling the orientation of the primary mirror.

Instrument Aperture Control. Signals are needed to control the mechanism which selects the instrument aperture.

Thermal Control Subsystem (TCS). The TCS is an integral part of the instrument employing standoff heaters attached to the instrument case and cover.

These are actively controlled to maintain the absolute temperature of the case within ± 1.4°C of the alignment temperature. The TCS also controls temperature gradients along the instrument such that image smear due to case bending during an exposure remains within acceptable limits.

Control and Display System. Controls must be provided to select operational mode, open the shutter, move the predisperser grating and actuate other experiment functions. Data that must be displayed includes aperture status, predisperser grating position, instrument operating mode and other information.

The functional block diagram in Figure 3-19 showing the CAMAC implementation of the CDMS for the XUV spectrograph is deceptively simple. The instrument is relatively complicated and the CDMS should reflect this. However, both of the video systems (XUV Monitor and Pointing Viewer) are supplied to the experiment along with their control electronics and so do not have to be included in the instrument CDMS. It should be noted that had the experiment been required to control and process video signals it would have been necessary to build experiment unique hardware to do this since there is no CAMAC equipment for this purpose.

Table 3-8 summarizes the equipment that would be necessary to implement the XUV Spectrograph with CAMAC aboard Spacelab. As in many of the other ATM experiments, the complexities of the various operating modes do not need to be implemented in the hardware system when a CAMAC approach is used. Instead, any program of instrument operation is straightforwardly achieved in the software of the controlling computer.

3.2.7 Skylab/ATM Payload Summary

From the discussions of the preceding sections it is evident that significant portions of the control and data management functions for the Skylab ATM experiments could have been implemented with NIM and CAMAC hardware. In fact, a lot of the complexity of the experiments resulted from their need to execute programmed observations automatically without the benefit of a computer to control the instrument operation. When a computer is added to the control loop much of this CDMS complexity goes away. And CAMAC greatly helps the situation by performing the interface between the instruments and the computer with a minimum of equipment and

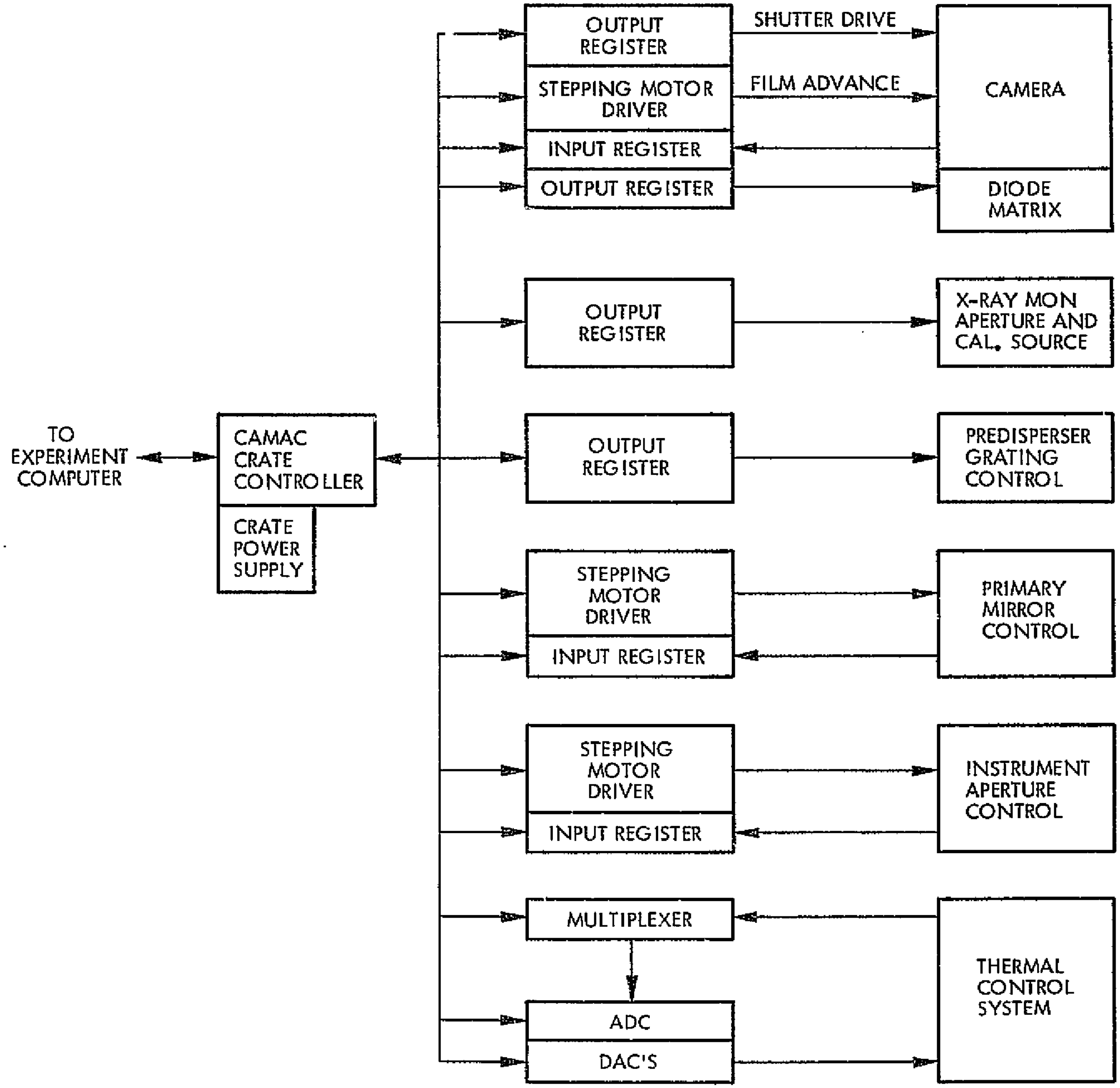

Figure 3-19. ATM Experiment S-082A NIM/CAMAC Implementation

Table 3-8. CAMAC Implementation of ATM/XUV Spectrograph CDMS

System Element	CAMAC Product Code	Specific Example	Comments
Camera Contro'ler			
Output Registers (200 bits)	133	BR3212	3212 is 48 bits (dual 24 bit).
Stepping Motor Driver	145	KS3361	Driver film advance
Input Register	121	NE7059-1	motor.
X-Ray Monitor			
Output Register	133	OR2027	Use also for grating control below.
Predisperser Grating Control			
Output Register	133	OR2027	Use part of X-ray non-register above.
Primary Minor Control			
Stepping Motor Driver	145	WE C-ST-4	
Input Register	121	NE7059-1	Share register above.
Instrument Aperture Control			
Stepping Motor Driver	145	KS3361	
Input Register	121	NE7059-1	Share register above.
Thermal Control System			
Multiplexer	164	KS3510	16-channel ADC - self-scanning.
ADC (8 bit)	161		
DAC	162	KS3110	

minimal requirements for instrument specific electronic designs.

Table 3-9 summarizes all of the NIM and CAMAC equipment that would be required to implement the CDMS functions for the six ATM experiments that were studied. The table lists the various equipment items on the left together with their CAMAC product code. On the right it specifies the number of each type of module required by each of the six experiments. The total requirements are summarized in the last column. The numbers are in all cases the number of NIM or CAMAC modules. This is particularly evident in the case of the DAC's where two octal modules satisfy the requirements for all six experiments.

As seen in the table, the two items most heavily used are output drivers and stepping motor drivers. The first reflects the frequent use of diode arrays in the many ATM experiment cameras. These are all interfaced with output drivers. The high incidence of stepping motor drivers is due to the multitude of mechanical motions required in the ATM instruments.

Table 3-9: ATM Use of NIM and CAMAC Equipment

		Instruments						
		White Light Choronograph	X-Ray Spectrographic Telescope	UV Spectroheliometer	X-Ray Telescope	XUV Spectroheliograph	XUV Spectrograph	
CAMAC Equipment	CAMAC Product Code	S-052	S-054	S-055A	S-056	S-082A	S-082B	Totals
Scaler	111		1		3			4
Input Register	121	1	1	1	1	1	1	6
Pulse Generator	131		2	1	1			4
Output Driver	133	4	5	1	1	2	5	18
Stepping Motor Controller	145	5	2	3	4	1	3	18
ADC	161							
Single Unit - Fast		1	2	4				7
Multichannel - Slow		1	1	1	1	1	1	6
DAC	162	Share 1				Share 1		2
Multiplexer	164	1	1	1				3
Branch Driver	211			Share 1				1
Crate Controller	231			Share 4				4
Crate	411			Share 4				4
NIM Equipment								
High Voltage Power Supply				7	2			9
Linear Gate			1					1
Amplifier/SCA					10			10
Bin				Share 2				2

3.3 SIRTF INFRARED INSTRUMENTS

The Shuttle Infrared Telescope Facility (SIRTF) will provide a cryogenically cooled ($\leq$20°K) telescope for infrared observations in the 1 μm to 1 mm range. It will have a usable aperture of one meter or more. It is intended for infrared studies of astronomical objects such as stars, dust clouds and other galaxies. By being cooled and operating above the earth's atmosphere it will perform observations with 10^3 more sensitivity than is currently available with ground-based instruments. It will also not be limited by atmospheric transmission windows but will be able to make observations at all infrared wavelengths.

Hughes Aircraft Company is currently engaged in a study of the construction of the telescope facility. They have concluded that a doubly folded Gregorian configuration for the instrument will best meet the requirements of the Space Shuttle environment. Their design for the instrument is shown in Figure 3-20.

A key feature in the design is the Multiple Instrument Chamber (MIC) located behind the secondary mirror. This chamber is cooled like the telescope and will house up to six infrared instruments at one time. The infrared beam from the telescope will be alternately switched to the various instruments as they come on line. It is primarily the output of the various instruments of the MIC which must be processed into the Spacelab CDMS for interpretation and display. The feasibility of performing this interface function with NIM and CAMAC equipment is what will be addressed here.

Table 3-10 lists five instruments that are typical candidates for SIRTF flights. A summary description of each is presented. The implementation of the control and data management systems for each with NIM and CAMAC equipment will be addressed in the sections that follow. Section 3.3.6 will consider the processing of the SIRTF housekeeping and fine pointing signals with CAMAC equipment.

3.3.1 Filter Photometer

3.3.1.1 Experiment Description

This instrument will be used for a wide variety of infrared astronomical measurements including studies of the galactic center, analyses of stellar systems just forming in galactic dust clouds and studies of the

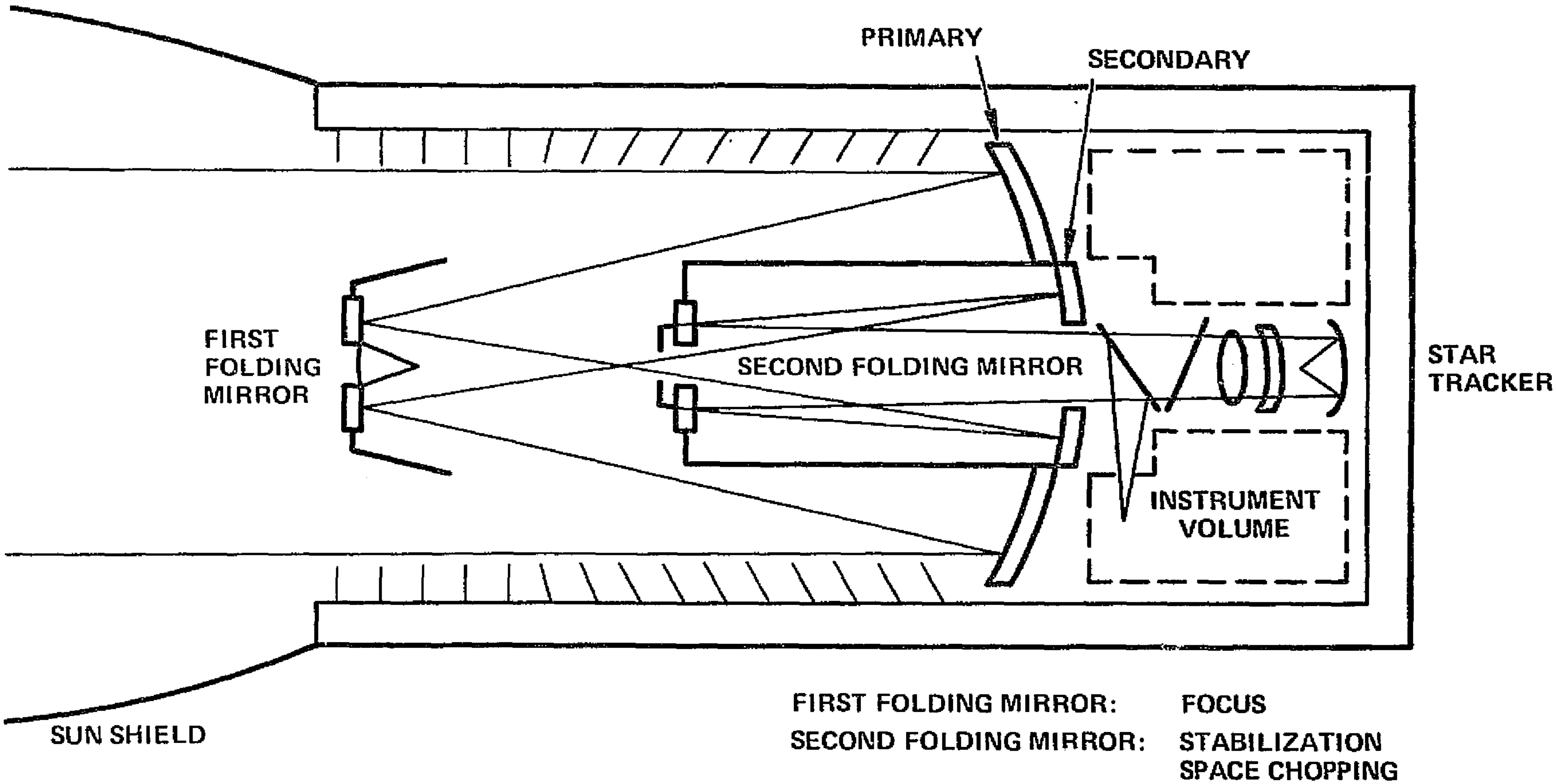

Figure 3-20. SIRTF Telescope Schematic Diagram

Table 3-10. SIRTF Instruments

<u>Filter Photometer</u>

- Multiple Wavelength Photometry
  - Interference Filters
  - Many-position Filter Wheel
- Multiple Apertures
- Blackbody Calibration Source

<u>Filter Wedge Spectrometer</u>

- Similar to Filter Photometer
- Uses Wedge Interference Filter
  - Continuous Variation in λ
  - Narrow λ Band
  - Typically $\lambda/\Delta\lambda = 100$
- Selectable Apertures

<u>Detector Array</u>

- 16 x 16 Element Array
- Probably Charge-Coupled Device
- Shift into 16 ADC's
- Selectable Filters
- Selectable Apertures

<u>Fourier Spectrometer</u>

- Coarse λ selected with Interference Filter
- Michelson Interferometer
  - Stepping Motor Mirror Drive
  - Position and Velocity Sensors

<u>Grating Spectrometer</u>

- Standard Reflection Grating
  - Stepping Motor Driver
  - Programmed λ Scans
- Coarse λ selected with Interference Filter

<u>Housekeeping and Fine Pointing</u>

- 80 + Channels Analog Housekeeping Data
- Control Telescope Fine Pointing
  - Digitize Quadrant Sensor Signals
  - Send Control Signals to Second Flat

energy distribution in such extra-galactic objects as Seyfert galaxies and quasars. The wavelength regions measured would potentially extend over the entire range of 1 micron to 1 mm.

The system consists of the basic elements shown in Figure 3-21. As the beam enters the instrument from the telescope it passes through one of many interference filters selectable by positioning the filter wheel. An aperture is located at the beam focus and this also is selectable to allow a choice of the field size to be seen by the detector. The beam then passes through a field lens to the detector which is cooled to liquid helium temperature. The infrared detector produces small analog signals in response to the incident radiation. These pass directly into a high gain preamplifier mounted physically close to the detector to obtain minimum noise. By the time the signals pass out of the MIC they are on the order of volts.

The signal into the filter photometer is spatially chopped by motion of the second folding mirror of the telescope. This allows subtraction of the infrared background. Additionally, during observations the telescope is regularly moved to an empty region of the sky in order to be able to subtract any instrument background. Since photometric measurements are desired it is also necessary to periodically measure a standard or reference star (whose photometric magnitude is known) during the course of an observing run.

Because the telescope can be rotated about its own pointing axis, polarization measurements can also be made with the filter photometer by simply mounting a transmission polaroid in the filter wheel and performing photometric measurements at several orientations of the telescope about its axis.

3.3.1.2 <u>CDMS Implementation with NIM/CAMAC</u>

The primary signal to be processed by the CDMS is the analog signal on the order of volts mentioned in the previous section. The beam incident on the detector is chopped at a rate between 5 and 200 Hz and it is necessary to take this into account in processing the data from the detector. The resulting signal when integrated is then proportional to brightness of the object being measured.

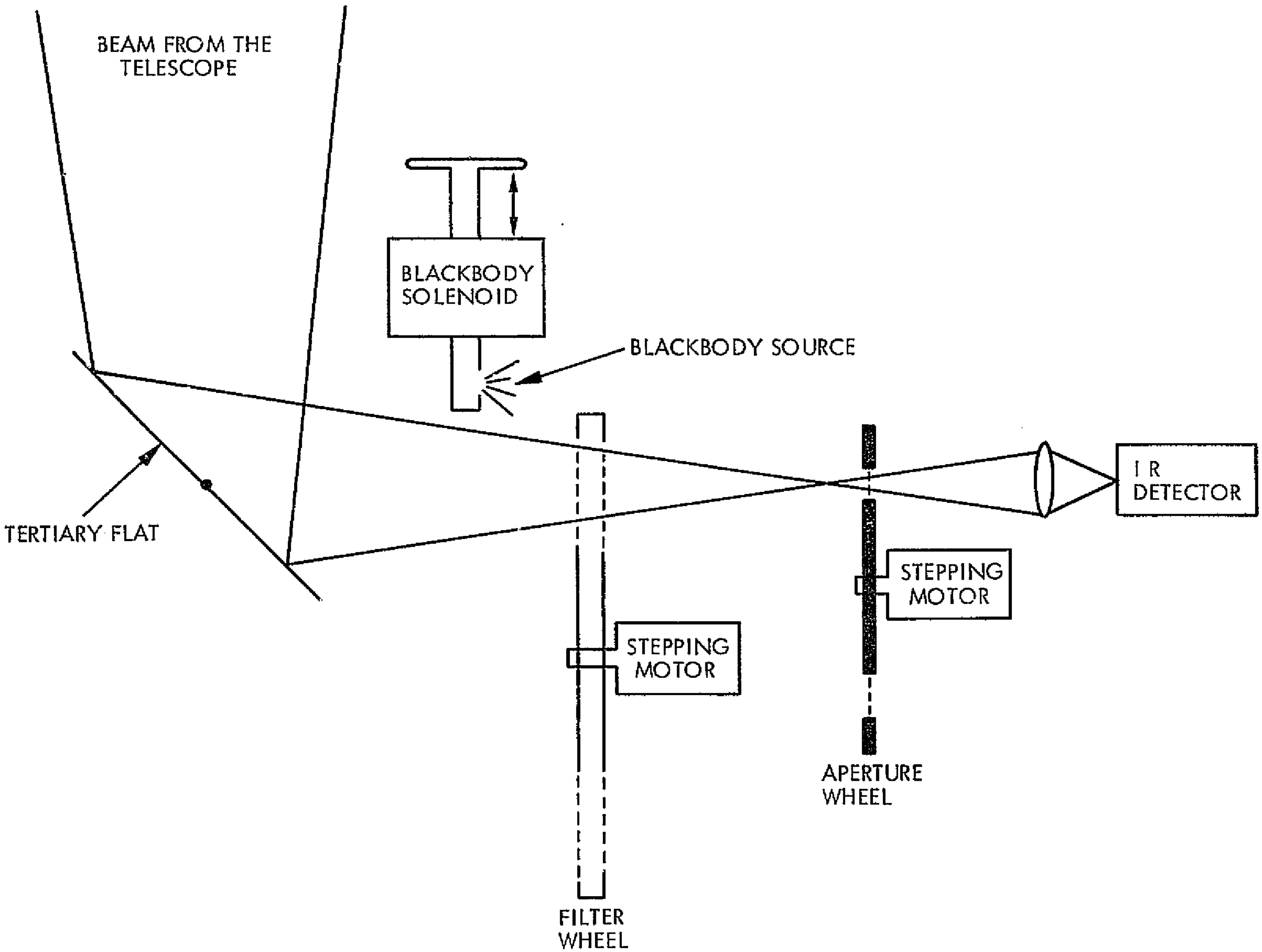

Figure 3-21. SIRTF Filter Photometer Schematic Diagram

The CDMS for this instrument would consist of the following elements:

Signal Processor. This includes an ADC to digitize the signal from the detector and the logic necessary to demodulate this signal with that from the space chopping mirror.

Mechanical Control System. The CDMS must provide control signals to the stepping motors that drive the filter and aperture selection mechanisms. This system must maintain a knowledge of the positions of these two elements for inclusion as part of the data. The mechanical control system would also provide signals to a solenoid that moves a blackbody source into and out of the beam if that is included in the instrument.

Power Supplies. Electrical power must be supplied to the detector and low level electronics and also to the CDMS.

Temperature Monitoring System. There will be an assortment of temperature sensors about the instrument whose signals must be multiplexed into an ADC and provided as data to the rest of the system.

Control and Display. A means must be provided to input commands to the instrument (e.g., to move the filter wheel) and also to display relevant instrument data such as temperatures and the signal to noise ratio attained in the measurement being made.

The functional block diagram in Figure 3-22 shows how the CDMS for the filter photometer would be implemented with CAMAC hardware. Except for the power supply for the detector and the preamplifier electronics, CAMAC hardware in combination with the experiment computer can implement all aspects of the CDMS. All required display functions are performed by the CRT and all manual commands to the instrument are entered via the experiment keyboard. It is assumed that the data from the spatial chopping mirror is available for use in processing the detector data.

Table 3-11 lists the detailed NIM and CAMAC modules required to implement the CDMS for the SIRTF filter photometer. The detector preamplifier and its power supply cannot be implemented with NIM equipment because of the requirement that they reside in close proximity to the detector itself and must therefore operate at cryogenic temperatures. These must be specially built to match the detector system. However, the detector bias voltage can be supplied with a NIM module since that can easily be fed in

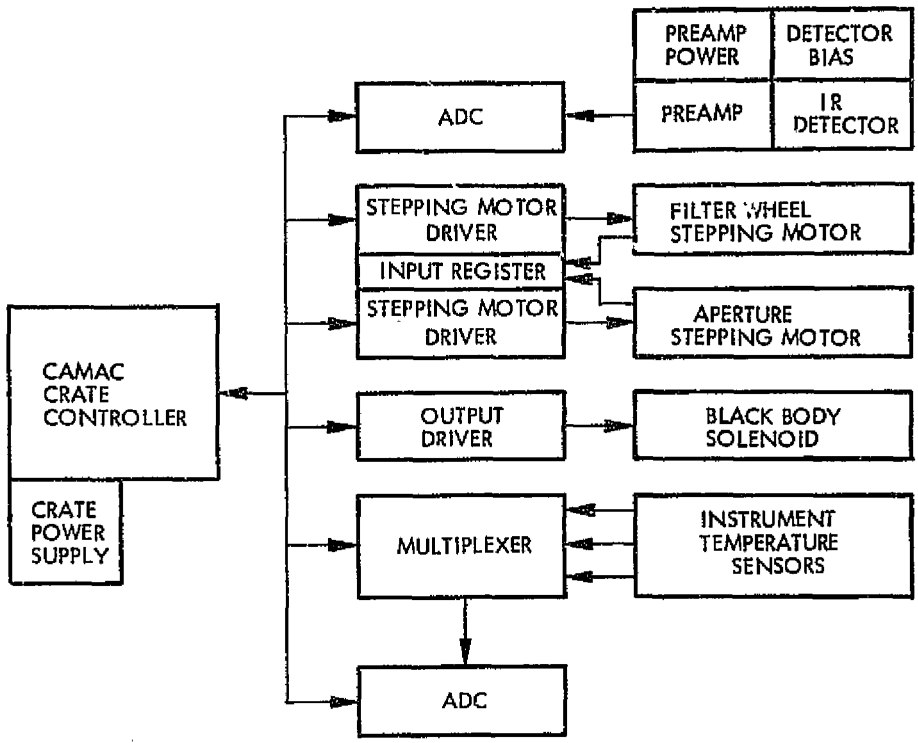

Figure 3-22. SIRTF Filter Photometer NIM/CAMAC Implementation

Table 3-11. NIM/CAMAC Implementation of SIRIF Filter Photometer

System Element	CAMAC Product Code	Specific Example	Comment
<u>Signal Processor</u>			
ADC	161	B01244A	
Preamplifier	None		Closely associated with detector in MIC.
<u>Mechanical Control System</u>			
Stepping Motor Driver	145	KS3361	
Stepping Motor Driver	145	KS3361	
Output Driver	133	OD2403	
Input Register	121	NE7059-1	
<u>Power Supplies</u>			
Detector Bias	NIM	ORTEC 428	
<u>Temperature Monitors</u>			
Multiplexer	164	KS3510	16-channel ADC - self-scanning.
ADC (8 bit)	161	KS3510	

through the wall of the MIC.

3.3.2 Filter Wedge Spectrometer

For moderate resolution spectroscopic measurements in the infrared a device commonly used is the filter wedge spectrometer. This device is conceptually identical to the filter wheel photometer except that the filter wheel element is replaced by a circularly wedged interference filter. The spectral transmission of this element varies continuously as it is rotated spanning a range up to $\pm \lambda/2$. Spectral resolving power is typically $\lambda/\Delta\lambda = 100$.

The CDMS required to support the filter wedge spectrometer is identical to that for the filter photometer except that the positioning of the wedge and determination of this position must be more stringently controlled than the corresponding position of the filter wheel. This is accomplished by finer control of the stepping motor operation. Because of this almost complete identiy, the CDMS for the filter wedge spectrometer need not be discussed further. The corresponding analysis of the filter photometer CDMS applies.

3.3.3 Grating Spectrometer

3.3.3.1 Experiment Description

There are many new types of information to be obtained from infrared spectroscopy. Since many molecular transitions occur in the infrared the study of planetary atmospheres in particular benefits from such measurements. IR spectroscopy is also invaluable in determining the composition of many galactic and extra-galactic objects of interest.

Figure 3-23 shows a typical on-axis grating spectrograph for use in the infrared. The incident IR radiation is focused by the telescope through a filter onto the entrance slit and passes through the center of mirror M1 to the paraboloidal mirror P1. This mirror collimates the beam which is then reflected off M1 and onto the grating. The grating is accurately located on a turntable, which may be rotated in order to scan the spectrum. After reflecting from M2 the now diffracted beam is refocused on the instrument exit slit by P2. Finally, the ellipsoidal mirror M3 focuses the radiation from the exit slit onto the detector.

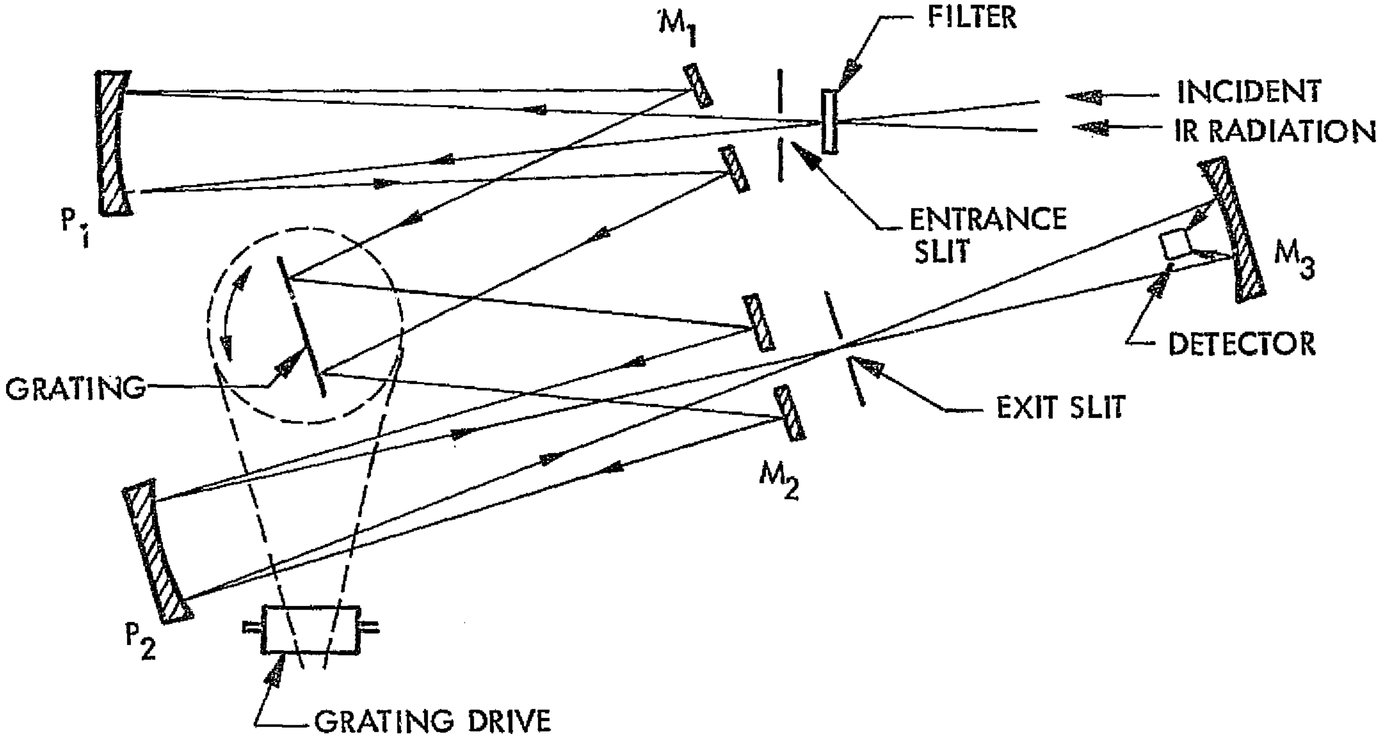

Figure 3-23. SIRTF Grating Spectrometer Schematic Diagram

Operationally, this instrument will be similar to the filter photometer with the additional complexity then each object will be measured at many grating positions. As in the case of the photometer, the second folding flat of the telescope will be used to spatially chop the radiation incident upon the entrance slit of the instrument. Since spectral data can be meaningfully compared to itself, it will not always be necessary when using the grating spectrometer to measure reference objects also. This will only be done when absolute spectral intensities are desired.

3.3.3.2 CDMS Implementation with NIM/CAMAC

The primary data from this instrument (that from the infrared detector) is exactly the same as that from the filter wheel photometer and need not be discussed further. The only additional element that needs to be added to the CDMS for this system is the circuitry necessary to control the positioning of the diffraction grating.

The major functions of the CDMS may be broken down as follows:

Signal Processor. This element is identical to that required for the filter photometer. It must digitize the analog data from the low level electronics (LLE) and must integrate the signal in synchronization with the spatial chopping.

Mechanical Control System. Here three stepping motor drivers are required to control the position of the input filter wheel, the size of the entrance slit and the orientation of the diffraction grating. The mechanical control system must also drive a solenoid to bring a spectral calibration source into and out of the beam if necessary.

Power Supply. As in the other IR systems power is required both for the detector and its LLE and for the CDMS itself.

Temperature Monitoring System. Here again a system to multiplex the signals from several temperature sensors into an ADC is required.

Control and Display. In addition to being able to display the instrument data (both temperatures and spectra) there should be a control function provided to implement automatic scans with the grating. This could be tied into a detector signal-to-noise level.

Figure 3-24 shows how the SIRTF Grating Spectrometer CDMS would be implemented using NIM and CAMAC equipment. Once the mechanical subsystem has been interfaced into the experiment computer through the stepping motor drivers and the crate controller, any program of spectral scans, slit sizes and entrance filters can be implemented automatically in the computer software. This assures accurate and efficient use of the instrument during observations and requires less attention of the payload specialist overseeing the instrument operations.

Table 3-12 lists the NIM and CAMAC modules required to implement the Grating Spectrometer CDMS. The required modules are very similar to those for the other infrared instruments. As in the case of the others the preamplifier for the signal processor must operate in close physical proximity to the cooled detector and cannot therefore be implemented with NIM equipment. The interface into the mechanical subsystem is accomplished with three stepper motor drivers and a single input register to record the zero positions of the motors.

3.3.4 Fourier Spectrometer

3.3.4.1 Experiment Description

As long as a single infrared detector is being used, the IR grating spectrometer has the inherent disadvantage of being able to observe only a single spectral element at a time. The entire spectrum can be observed only by scanning the spectrum past the exit slit. This weakness can be partially alleviated by using a linear array of IR detectors spread out over the spectral image but this makes fine spectral resolution difficult and significantly increases the cost of the CDMS.

Another approach to improving IR spectrometry that is commonly used is the interferometer spectrograph. A schematic diagram of such an instrument is shown in Figure 3-25. As seen from the figure the basic element of the instrument is a Michelson interferometer. By moving one of the mirrors of the interferometer a patter of interference fringes is generated and detected as an intensity modulation. The resulting interferogram, which is a plot of fringe intensity versus mirror position, is the Fourier transform of the infrared spectrum. The spectrum is recovered by calculating the inverse Fourier transform with a computer.

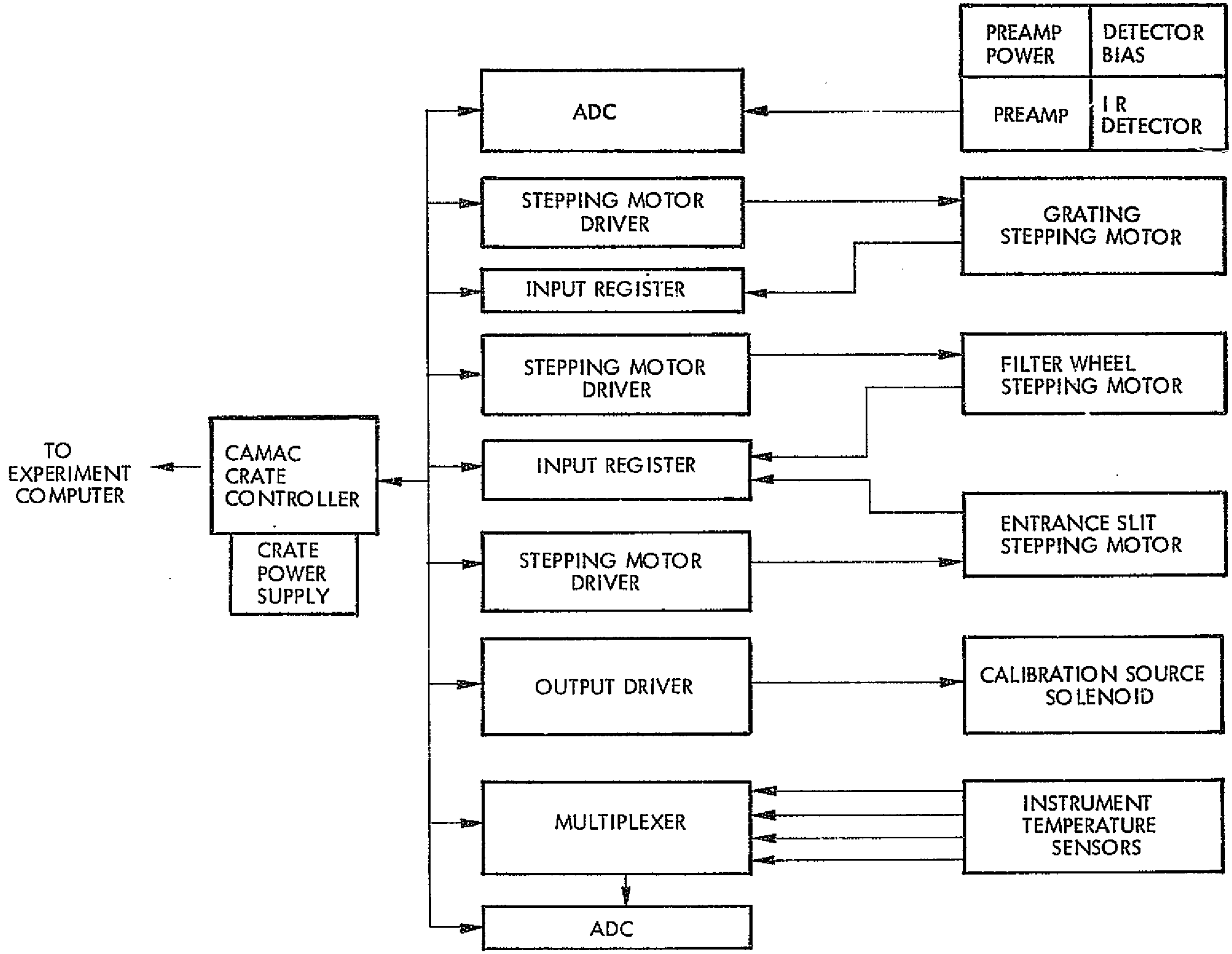

Figure 3-24. SIRTF Grating Spectrometer NIM/CAMAC Implementation

Table 3-12. NIM/CAMAC Implementation of SIRIF Grating Spectrometer

System Element	CAMAC Product Code	Specific Example	Comments
Signal Processor			
ADC	161	B01244A	
Preamplifier	None		Closely associated with detector in MIC.
Mechanical Control System			
Stepping Motor Driver (Grating)	145	KS3361	
Stepping Motor Driver (Filter Wheel)	145	KS3361	
Stepping Motor Driver (Entrance Slit)	145	KS3361	
Output Driver	133	OD2403	Shared among all three stepper motors.
Power Supply			
Detector Bias	NIM	ORTEC 428	
Temperature Monitors			
Multiplexer	164	KS3510	
ADC (8 bit)	161		

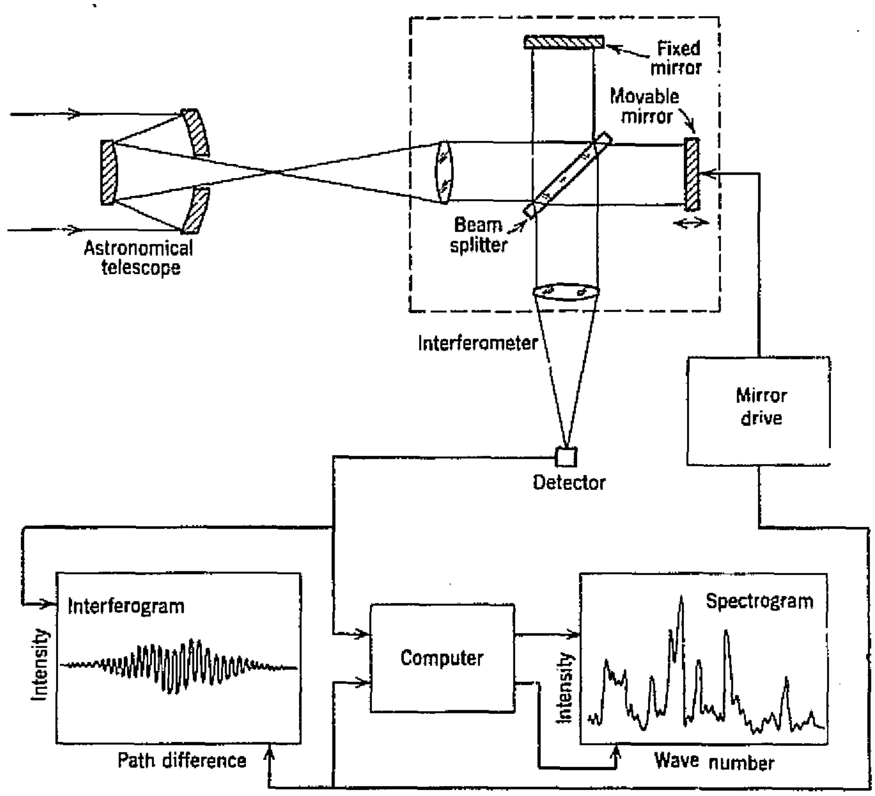

Figure 3-25. SIRTF Fourier Spectrometer Schematic Diagram

It is possible to obtain much higher resolution spectra with interferometric techniques than with a grating spectrograph. In fact, the ultimate limit on resolution is determined only by the noise of the detector.

In IR astrophysical studies the Fourier spectrometer is especially useful for studies of the detailed characteristics of absorption or emission lines where high spectral resolution is required. Used in this fashion it aids in determining line broadening mechanisms, gas densities, and thermal structure of astronomical objects.

3.3.4.2 Implementation with NIM/CAMAC

The CDMS for the Fourier spectrometer contains the same basic elements as that for the grating spectrometer. The difference in this system is the much finer degree of control that must be exercised by the mirror drive network compared to the grating drive of the other system.

Signal Processor. As in the previous IR instruments, the detector consists of a photo-resistive device producing a small analog signal which is preamplified by a circuit located physically close to the detector. The digitization of the signal that then occurs must be done in phase with the movement of the Fourier scanning mirror.

Mechanical Control System. This system must provide for control of three stepping motors, one to select the instrument aperture, a second to choose a broad band interference filter to establish the general spectral range of the measurement to be made, and a third to move the Michelson mirror in a precise fashion to achieve the interferometric spectral scan. The operation of this last motor is adjusted by control loop sensors that record the position and velocity of the mirror and feed that information back to the stepping motor control circuits. Also required is a signal to control the position of a calibration source.

Power Supply. Power is required to operate the detector and its preamplifier circuit and also to supply the CDMS itself. Additionally, depending on the exact nature of the mirror control circuit, special power may have to be supplied to drive the mirror.

Temperature Monitoring System. A multiplexer is required to selectively connect the outputs of various temperature sensors into an ADC.

Control and Display. This system must provide for command input to the instrument to choose filters, initiate scans and select scan rates. It must provide for the display of instrument temperatures and status information. If it is to display the spectra as they are taken it must be able to store the accumulated data and Fourier transform it for display.

Figure 3-26 shows a CDMS functional block diagram for the Fourier spectrometer which is very similar to those for the other infrared instruments. The outstanding difference in this system is the addition of the feedback control signals from the position and velocity sensors on the Michelson mirror. In the CAMAC system these are processed into the experiment computer via a multiplexer and an ADC. There they are used as control parameters to modify the stepping motor signals that are moving the mirror. This greatly enhances the precision of the Fourier scan.

As is shown in Table 3-13, NIM and CAMAC can implement virtually all of the CDMS requirements for the Fourier spectrometer. The computer in the CAMAC implementation of the system is particularly useful for this instrument because it can perform a fast Fourier transform algorithm on the data as it is taken. This allows almost real time analysis of the data quality. Because the mirror drive in this system is implemented with a stepping motor rather than a speaker-coil type of drive the high power requirements for precision control of position and velocity do not exist.

3.3.5 Detector Array

3.3.5.1 Experiment Description

There are many regions in the sky that could be much better understood by mapping the area with a two-dimensional array of infrared sensors. Two such areas are the galactic center and the region of star formation in the Orion nebula. In both of these the spatial extent and distribution of the IR sources is of interest.

The exact details of how such an infrared detector array would be structured are uncertain because most arrays of this sort are still in the development stage. However, for purposes of discussing the CDMS requirements, it is reasonable to assume a 16 X 16 element detector array covering about 4 arc minutes (10 mm X 10 mm) in the focal plane of the telescope. The specific process for coupling out the signals from these detectors

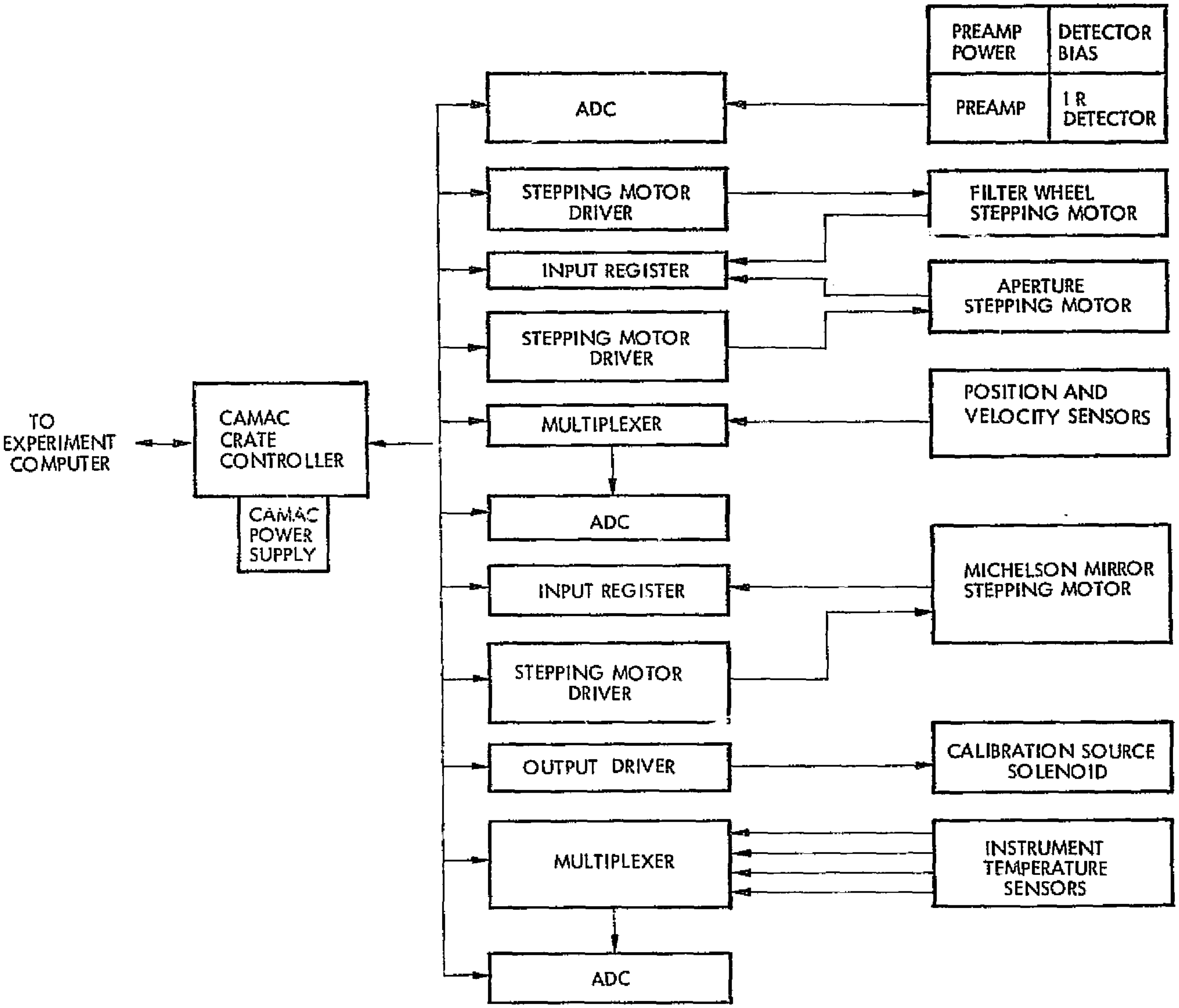

Figure 3-26. SIRTF Fourier Spectrometer NIM/CAMAC Implementation

Table 3-13. NIM/CAMAC Implementation of SIRIF Fourier Spectrometer

System Element	CAMAC Product Code	Specific Example	Comments
<u>Signal Processor</u>			
ADC	161	B01244A	
Preamplifier	None		Closely associated witth the detector in the MIC.
<u>Mechanical Control System</u>			
Stepping Motor Driver (Filter Wheel)	145	KS3361	
Stepping Motor Driver (Aperture)	145	KS3361	
Multiplexer	164	B01704	
ADC	161	B01244A	
Stepping Motor Driver (Mirror Motor)	145	KS3361	
Output Driver	133	NE9002	
Input Register	121	KS3420	Shared among three stepping motors.
<u>Power Supply</u>			
Detector Bias	NIM	ORTEC 428	
<u>Temperature Monitors</u>			
Multiplexer	164	KS3510	
ADC (8 bit)	161		

depends on the exact nature of the detector but it can be assumed that there will be 256 small analog signals to be processed, all of the same type as that from a single IR photoresistive device.

Operationally, the instrument will be used in a manner similar to the filter photometer, but it will generate 256 simultaneous photometric measurements rather than one. The instrument will include a filter wheel for selecting narrow portions of the spectrum in which to observe and will also include a mechanism for selecting apertures of varying sizes. The telescope will be spatially chopped while operating the detector array instrument.

3.3.5.2 CDMS Implementation with NIM/CAMAC

The CDMS for the experiment is similar to that for the filter photometer but with the added complexity of having to process 256 channels of data. Each of these channels forms a separate photometric measurement that must be digitized and have the background value removed. The following system elements are required to implement this CDMS.

Signal Processor. For digitization the array is broken up into 16 groups of 16 detectors with one ADC allotted to each group. Within the group the 16 elements are successively shifted into the ADC for sampling. With 200 Hz chopping and a 30 μsecond conversion time this still allows each detector element to be sampled 10 times per cycle of the chopper. The individual samples from the ADC are then summed as necessary to achieve time integration of the signal.

Mechanical Control System. Control signals must be provided to the stepping motors which position the filter wheel and the aperture selector wheel of the instrument. Additionally, a signal must be provided to move a calibration source into and out of the beam on command if such a source is to be used by the instrument.

Power Supplies. Power is required for the detectors and their associated LLE and also for the circuits that make up the CDMS.

Temperature Monitoring System. The various temperature sensors of the instrument must be multiplexed into an ADC and made available to the system as data.

C.2

Control and Display. Command capability is required to select filters and apertures and perform similar functions. In addition to the requirement to display instrument status information, it may be desirable to provide for an intensity modulated CRT display of the detector array data as it accumulates.

In Figure 3-27, the NIM and CAMAC implementation of the detector array CDMS is illustrated. Since the detectors will probably be charge-coupled devices a special readout clock generator is shown which will generate the appropriate pulses to shift out the signals from each row of detectors into 16 ADC's. The clock generator will be driven by a programmable pulser operating under direct control of the computer. The other aspects of the CDMS are very similar to the CDMS for the filter photometer.

Table 3-14 lists the NIM and CAMAC equipment required to implement this CDMS. Because the readout clock generator depends on the exact nature of the detector system used it cannot be implemented with NIM or CAMAC equipment and must be considered as being supplied as part of the detector system just as the preamplifiers are. The involvement of the experiment computer in this CDMS makes the handling of 256 "pixels" (picture elements) of data feasible. Without the computer the task would be much more difficult.

3.3.6 Housekeeping and Fine Pointing

In addition to performing the interface of the SIRTF experiment data into the Spacelab CDMS, CAMAC equipment can also be used in processing the various housekeeping signals from the telescope facility and in closing the control loop for the fine pointing of the telescope.

It is estimated that there will be over 70 temperature sensors provided to monitor the thermal status of the telescope. The analog signals from these sensors will need to be processed into the experiment computer for conversion and automatic monitoring and display of the values. Additionally there will be flow, pressure, contamination and optical status sensors all producing analog voltages requiring digitization so that they may be interpreted by the computer. None of these above measurements requires rapid (i.e., $\leq$ 1 msec) sampling so multichannel scanning ADC's will be adequate. Ninety or more channels will be required.

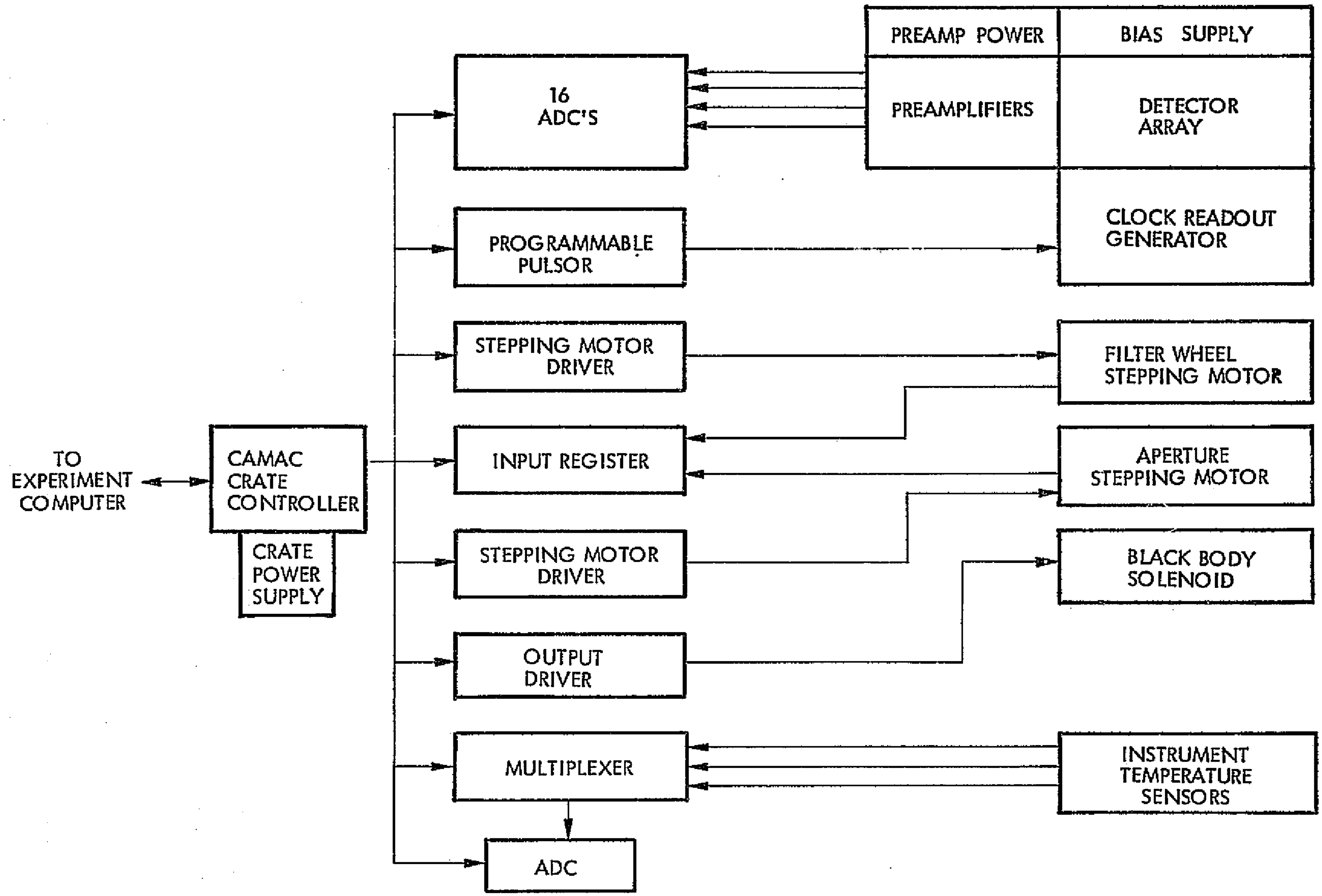

Figure 3-27. SIRTF Detector Array NIM/CAMAC Implementation

Table 3-14. NIM/CAMAC Implementation of SIRIF Detector Array

System Element	CAMAC Product Code	Specific Example	Comments
Signal Processor			
Multiplexers	164	B01704	
ADC's (16)	161	B01244A	
Detector Preamplifiers	None		Closely associated with detector in MIC.
Readout Clock Generator	None		Peculiar to detector system used.
Programmable Pulser	131	SEN2PPG 2016	
Mechanical Control System			
Stepping Motor Driver	145	KS3361	
Stepping Motor Driver	145	KS3361	
Output Driver	133	NE9002	
Input Register	121	KS3420	
Power Supply			
Detector Bias Supply	NIM	ORTEC 428	Low current and low noise required.
Temperature Monitors			
Multiplexer	164	KS3510	
ADC (8 bit)	161		

There will also be some digital data originated by the facility, mostly that from contact switches recording the state of various mechanical structures (i.e., sun shield deployed/retracted). These can be processed into the CDMS with CAMAC input registers. Forty to fifty bits of this type of data will be generated.

One final function of the housekeeping system will be to supply several analog control voltages to the telescope for controlling heater systems. About four of these will be required.

CAMAC equipment will also be suitable in the fine pointing control loop of the telescope. Here the quadrant sensor signals need to be digitized and processed by the computer. Four DAC's will be required to send control signals back to the telescope. Since the entire control loop operates in the 5 Hz region all of these functions can be handled by CAMAC modules.

Table 3-15 summarizes the CAMAC modules required to interface the SIRTF housekeeping and fine pointing function into the Spacelab CDMS. Since a total of eight DAC functions were required, the example shown is a single module containing eight of the devices.

3.3.7 SIRTF Payload Summary

Table 3-16 summarizes the results of the preceding six sections. Shown are the various types of NIM and CAMAC equipment required for SIRTF CDMS interface functions. The number of modules of each type required by each of the five instruments and for housekeeping are indicated. It is to be emphasized that it is the number of modules that are indicated and that in many cases multiple unit modules have been assumed (i.e., DAC's, where an octal module is used).

As seen in the table, the only NIM equipment used is the detector bias supply which is required by each of the five experiments. Other than this NIM equipment was not designed for the small signal, high gain applications required for the signals from infrared detectors. All of the front end, LLE must be considered as part of the detector system and cannot be implemented with NIM equipment.

The most heavily used CAMAC modules are seen to be the analog-to-digital converters. The heavy usage of the fast type is caused primarily because 16 modules are required to digitize the 256 analog signals coming out of the detector array. The requirements for multichannel-slow ADC's are driven up by their heavy usage in processing housekeeping signals from the telescope.

Table 3-15. CAMAC Interface of Housekeeping and Fine Pointing Functions

System Element	CAMAC Product Code	Specific Example	Comments
<u>Housekeeping System</u>			
Multichannel ADC's	161 164	KS3510	16 channels each - six required.
DAC	162	KS3510	Octal Unit - share with fine pointing.
Input Register	121	NE7059-1	Two required.
<u>Fine Pointing System</u>			
Fast ADC	161	B01244	
Multiplexer	164	B01704	[illegible] channel - spares available.
DAC	162	KS3110	Share module above.
Output Register	133	NE9017	

Table 3-16: SIRTF Use of NIM and CAMAC Equipment

		Instruments						
<u>CAMAC Equipment</u>	CAMAC Product Code	Filter Photometer	Filter Wedge Spectrometer	Detector Array	Fourier Spectrometer	Grating Spectrometer	Housekeeping and Fine Pointing	Totals
Input Register	121	1	1	1	1	1	2	7
Pulse Generator	131			1				1
Output Register	133	1	1	1	1	1	1	6
Stepping Motor Driver	145	2	2	1	3	3		11
Analog-to-Digital Converter	161							
Single Unit - Fast		1	1	16	2		1	21
Multichannel - Slow		1	1	1	1	1	6	11
Multiplexer	164				1	1	1	3
Digital-to-Analog Converter	162						1	1
Branch Driver	211			Share 1				1
Crate Controller	231			Share 4				4
Crate	411			Share 4				4
<u>NIM Equipment</u>								
Detector Bias Supply		1	1	1	1	1		5
Bin				Share 1				1

3.4 X-RAY/GAMMA RAY PALLET INSTRUMENTS

The three instruments that comprise the X-ray/gamma ray pallet are listed in Table 3-17. Collectively, these instruments will detect photons with energies ranging from a few tenths of a KeV to ten MeV, a dynamic range of nearly five orders of magnitude. They will provide a wide variety of data on high energy astrophysics phenomena, encompassing discrete sources, diffuse background and earth albedo.

This pallet configuration will be used to search for new discrete sources of radiation and to measure the spectrum, intensity and temporal characteristics of discrete sources. In addition, the position and angular size and structure of discrete X-ray sources will be measured with a resolution better than an arc minute. The spectrum, intensity and isotropy of the diffuse background will be measured along with the spectrum and intensity of the earth's albedo.

3.4.1 Large Proportional Counter Array

3.4.1.1 Instrument Description

This instrument consists of ten multi-wire proportional chamber (MWPC) modules, each with 0.5 m^2 sensitive area. Modulation collimators of two types, for raster scan and for rotating scans, will be available for optional use with any number of the MWPC modules. In addition to the primary sensor modules, two ultraviolet stellar transit detectors will be used to supplement the Orbiter aspect data.

The modules without collimators can be used to search large areas of the sky for new X-ray sources with emissions in the energy range from a few tenths of a KeV to about 100 KeV. The celestial coordinates, spectrum, intensity and temporal characteristics of both discrete and diffuse sources can be measured. With the optional collimators attached to the modules, this instrument can be used to determine the position, angular size and structure of discrete sources to better than an arc minute.

In order to observe photons with energies as low as a few tenths of a KeV, very thin windows (less than a micron thickness of Parylene, for example) must be used to seal the MWPC's. Because the gas used to fill the chamber will diffuse through the windows, a flowing gas system must be provided to maintain the proper operating pressure range.

Table 3-17. X-Ray/Gamma-Ray Pallet Instruments

Large Area Proportional Counter Array

- Modulation Collimators Optional
- Ten Counter Modules, 0.5 m^2 each
- Two UV Stellar Transit Detectors
- Gas Supply for Maintaining Counter Pressure
- Positionable Radioactive Sources for Calibration

Bragg Crystal Spectrometer

- 0.3 m^2 Effective Area
- Sixteen proportional Counter Modules
    - Eight Low Energy (approximately 0.4 to 1.25 KeV)
    - Eight High Energy (approximately 1.25 to 12 KeV)
- Gas Supply for Maintaining Counter Pressure
- X-Ray Tubes and Positionable Radioactive Sources for Calibration

High-Resolution Gamma-Ray Ge(Li) Spectrometer

- Sixteen Ge(Li) Detectors, 16 cm^2 each
- CsI(Na) Active Collimator and Shields
- Plastic Scintillator Charged-Particle Detector
- Heater to Control Temperature of Cryogenically-Cooled Detectors

Energy calibration of the MWPC's will be accomplished with a radioactive source. The need for periodic calibration checks will be satisfied with a remotely positionable source holder attached to each module.

3.4.1.2 Electronics Implementation with NIM/CAMAC

All except a small portion of the electronics requirements can be appropriately satisfied with NIM and CAMAC modules. The amplifiers used to process the very low level signals produced by the MWPC anode wires must be located in close proximity to the chambers and cannot be conveniently packaged in NIM or CAMAC form. The high voltage supplies needed for the aspect sensor photomultiplier tubes are also not available in NIM or CAMAC form. The block diagram in Figure 3-28 shows the NIM/CAMAC implementation that fulfills the complete instrument requirements with the exception of the above mentioned items.

The types of NIM/CAMAC modules used are identified in Table 3-18. The number in parentheses following the name of the system element is the number of times this element is required. The number of identical functional elements provided by each example module is given in the remarks column.

Signal Processor. The signal processor includes all of the NIM and CAMAC modules required to process the MWPC amplifier outputs, identify the occurrence of valid events according to pre-established criteria, and convey the event data to the central computer. The modules shown in the block diagram are required for each of the ten MWPC's; the complete instrument requires ten such NIM/CAMAC signal processor sets.

Four discriminators provide logic pulses for use in the event determination. Coincidence modules are used to identify two different types of events depending on the depth at which the photon energy was deposited in the chamber (near the front anodes or near the middle anodes). The edge anode and back anode signals are used in anti-coincidence to reject charged particles and events not arriving from the front of the chamber. Pulse shape discrimination is used to identify the characteristic shape of a MWPC pulse produced by X-ray energy deposition as distinguished from pulses produced by charged particle energy deposition. The rise times of the pulses are determined by differentiating the pulses with a shaping

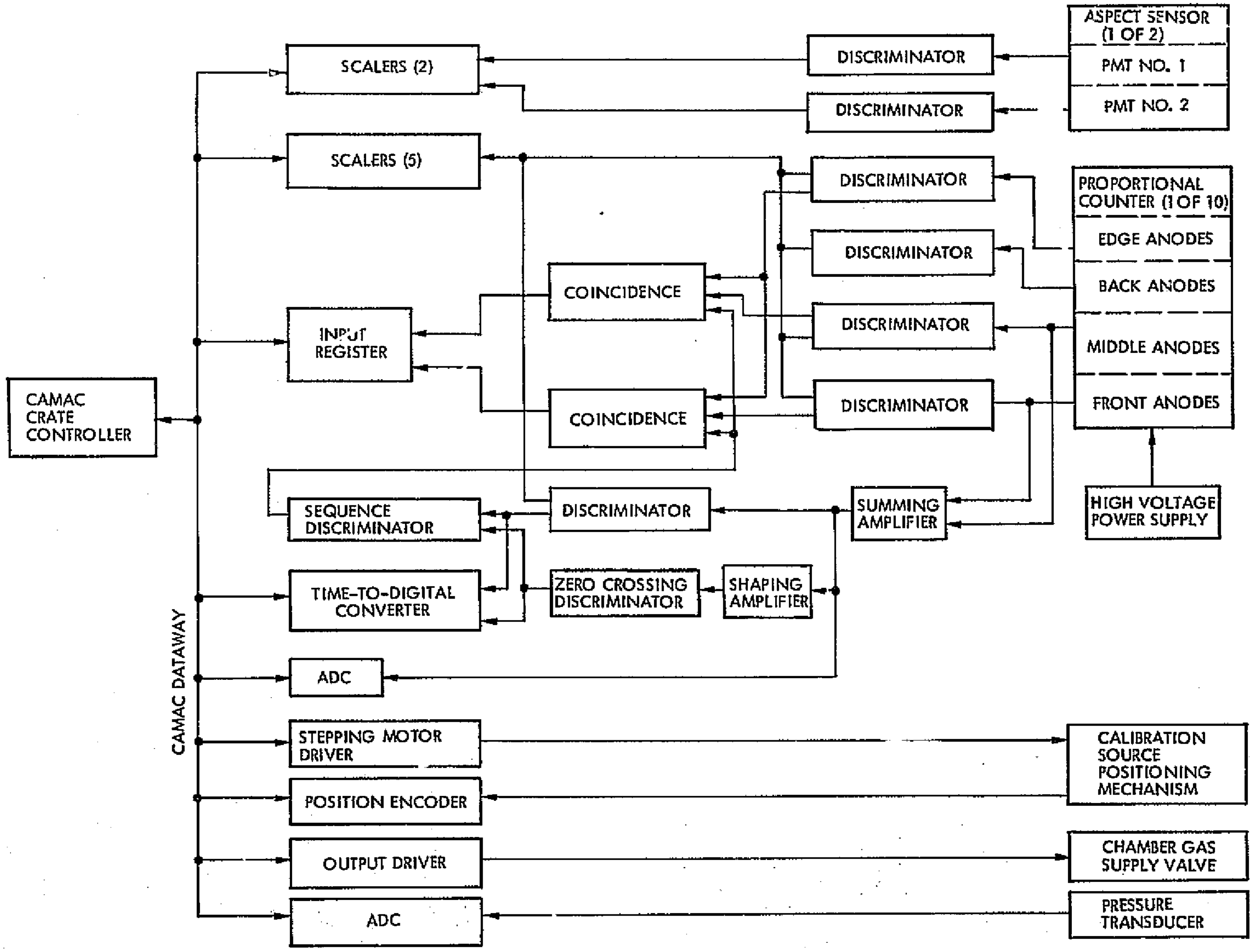

Figure 3-28. Large Area Proportional Counter Array NIM/CAMAC Implementation

Table 3-18. NIM/CAMAC Implementation of Large-Area Proportional Counter Array

System Element	CAMAC Product Code	Specific Example	Comments
<u>Signal Processor</u>			
Discriminator (50)	NIM	EG&G T308	8 elements
Summing Amplifier (10)	NIM	ORTEC 433A	2 elements
Shaping Amplifier (10)	NIM	ORTEC 451	
Zero Crossing Discriminator (10)	NIM	EG&G T140	4 elements
Sequence Discriminator (10)	Custom NIM	not available	4 elements
Coincidence (20)	NIM	EG&G C315	2 elements
Scaler (50)	111	LRS2551	12 elements
Time-to-Digital Converter (10)	161	LRS2228	
ADC (10)	161	LRS2259	12 elements, pulse type
Input Register (20)	123	EG&G C124	24 elements
<u>Aspect Sensor</u>			
Discriminator (4)	NIM	EG&G T308	8 elements
Scaler (4)	111	LRS2551	12 elements
<u>Power Supplies</u>			
Detector High Voltage (10)	NIM	ORTEC 459	
<u>Calibration</u>			
Stepping Motor Driver (10)	145	JO SMC	
Position Encoder (10)	117	SEN 2IPE2019	2 elements
<u>Gas Supply</u>			
ADC (10)	161	KS3510	16 elements, DC level type.
Output Driver (10)	133	KS3040	8 elements

amplifier and measuring the elapsed time between the leading edge (determined by a discriminator) and the zero derivative point on the differentiated pulse (determine by by a zero crossing discriminator). A preliminary rise-time selection is applied in real-time by a custom-built NIM sequence discriminator that produces an output logic pulse only if two input logic pulses appear in the proper sequence. The rise time requirement is included in the event identification logic by applying the sequence discriminator output to the coincidence modules. In addition, the rise time is measured by a time-to-digital converter that measures the time between the leading edge and zero crossing discriminator outputs. This time is recorded as part of the event data and can be used during off-line data analysis as a more precise X-ray pulse shape identi er.

An input register is used to record flags from the coincidence modules to identify the type of event. By having the CAMAC system inspect the contents of this register at a rate significantly higher than the event rate, the need for a separate event interrupt to the computer can be eliminated. If an event interrupt is available, it can be driven by an OR'ed output from the two coincidence units.

Event energy determination is provided by an ADC that measures the amplitude of the MWPC signals. A set of five scalers is used to record the event rates from each group of MWPC wires and also the rate of events that are pulse shape analyzed.

Aspect Sensor. A single aspect sensor assembly is used in conjunction with all ten MWPC modules. It includes two ultraviolet sensitive photomultiplier tubes with Z-shaped slits. Two discriminators and two scalers are used to record star transit information from the aspect sensor.

Power Supplies. An individual NIM high voltage detector bias type supply is used to provide the high potential electric field required for proper operation of each MWPC.

Calibration. The Fe^{55} source used for energy calibration of each MWPC is positioned by a mechanism operated by a stepping motor. A CAMAC stepping motor driver module and a position encoder module are used to control the source position. One such set of calibration equipment is required for use with each of the ten MWPC modules.

Gas Supply. The gas pressure in each MWPC module is measured with a pressure transducer connected to a CAMAC dc level type ADC. Makeup gas is supplied as needed by pulsing a supply valve operated by a CAMAC output driver. One such gas supply system is required for used with each of the ten MWPC modules.

3.4.2 Bragg Crystal Spectrometer

3.4.2.1 Instrument Description

This instrument consists of 16 MWPC modules, eight each of two types. The MWPC's in the low-energy spectrometer (LES) cover the X-ray energy range of 0.4 to 1.25 KeV while the MWPC's in the high-energy spectrometer (HES) cover 1.25 to 12 KeV. X-ray energy dispersion is provided by diffraction from positionable crystals located in front of the chambers.

The instrument is designed to provide very-high-energy resolution in order to observe recombination and absorption edges in the X-ray continuum and line structure of specific X-ray sources. The LES crystal might be KAP, for example, and the MWPC windows would be some very thin material such as the less than one-micron thick Parylene suggested for the large area proportional counter array. The HES crystal might be graphite or calcite, and the MWPC windows could be beryllium on the order of ten microns thick.

3.4.2.2 Electronics Implementation with NIM/CAMAC

All except a small portion of the electronics requirements can be appropriately satisfied with NIM and CAMAC modules. The amplifiers used to process the very low signals produced by the MWPC elements are very similar to those used for the large area proportional counter array MWPC modules. These specialized amplifiers must be located near the MWPC's and, in general, cannot be suitably packaged in NIM or CAMAC form. The block diagram in Figure 3-29 shows the NIM/CAMAC implementation for one of the eight identical low-energy spectrometer modules. Similarly, Figure 3-30 shows the implementation for one of the eight identical high-energy spectrometer modules. In each case, the NIM/CAMAC implementation fulfills the complete instrument requirements with the exception of the above mentioned amplifiers.

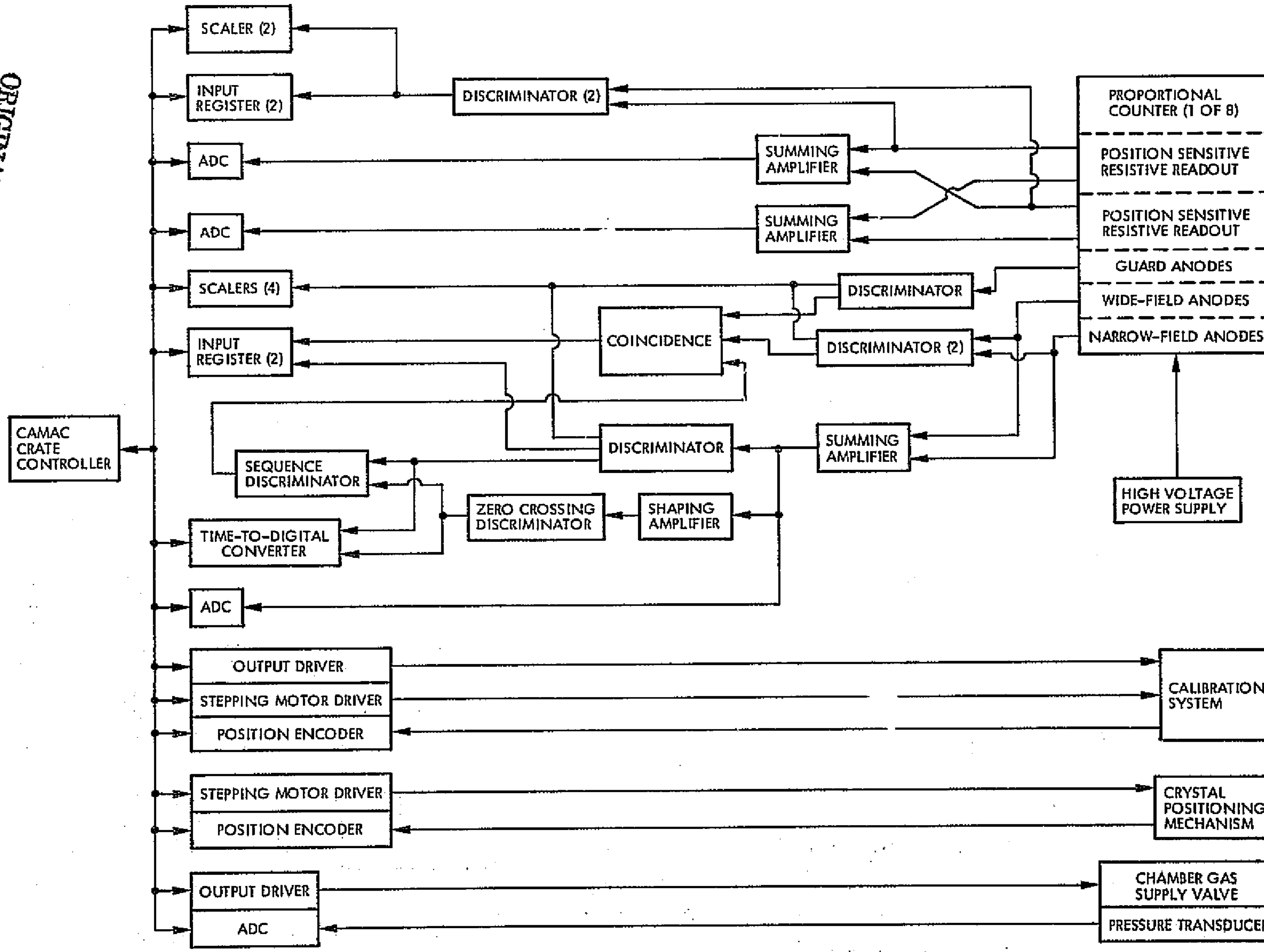

Figure 3-29. Bragg Crystal Low Energy Spectrometer NIM/CAMAC Implementation

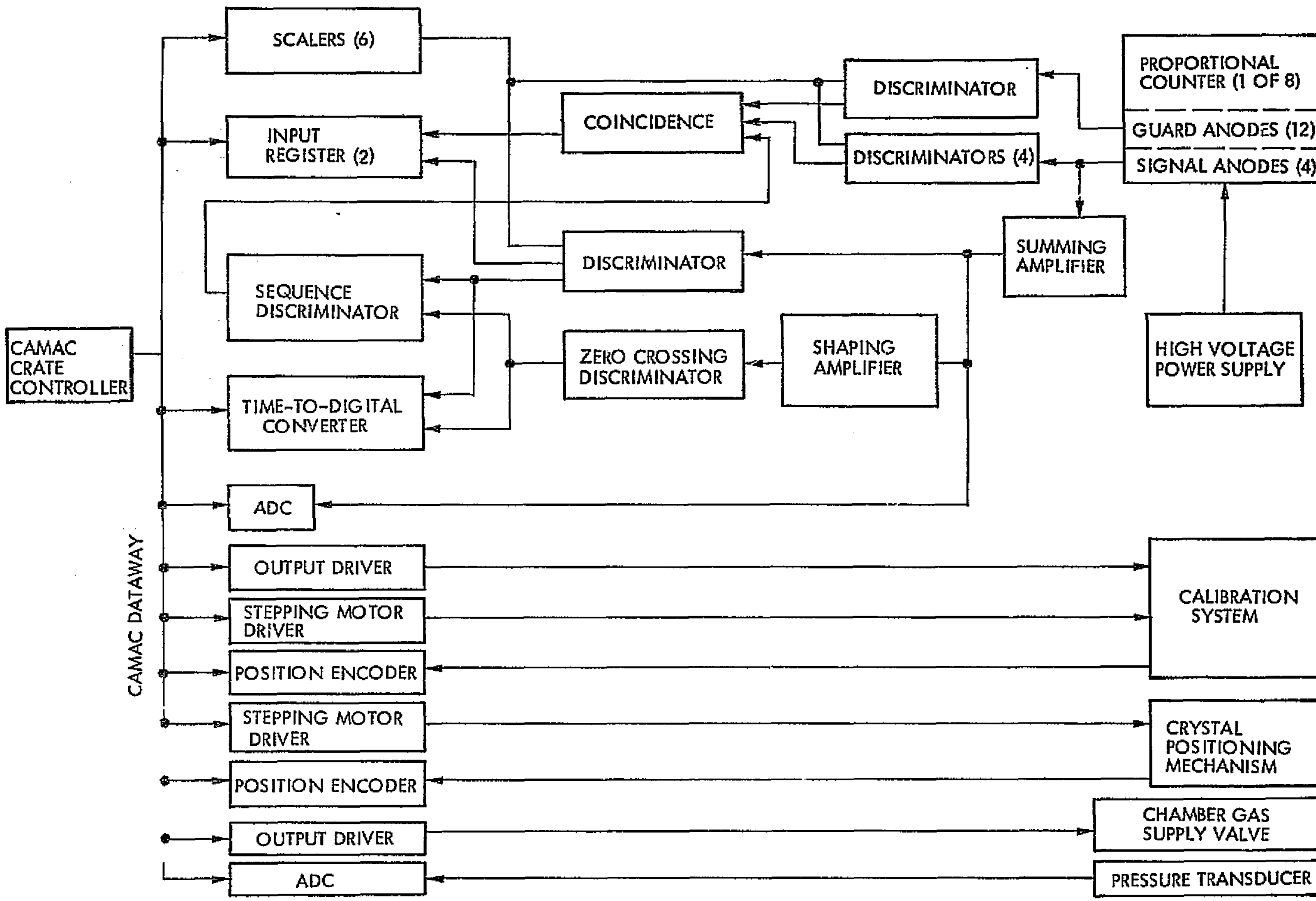

Figure 3-30. Bragg Crystal High Energy Spectrometer NIM/CAMAC Implementation

The types of NIM/CAMAC modules used are identified in Table 3-19. The number in parentheses following the name of the system element is the number of elements required. The number of identical functional elements provided by each example module is given in the remarks column.

Signal Processors. The signal processors include all of the NIM and CAMAC modules required to process the MWPC amplifier outputs, identify the occurrence of valid events according to pre-established criteria, and convey the event data to the central computer. The complete instrument requires eight sets of the LES modules shown in Figure 3-29 and eight sets of HES modules shown in Figure 3-30.

In the LES, five discriminators provide logic pulses for use in event determination. A coincidence module is used to identify the occurrence of an event associated with either the wide field-of-view or narrow field-of-view anodes. The guard anodes are used in anti-coincidence to reject charged particles and events not arriving from the front of the chamber. Pulse shape discrimination is used to identify the characteristic shape of an MWPC pulse produced by X-ray energy deposition as distinguished from pulses produced by charged-particle energy deposition. The implementation of the pulse shape analysis function with NIM/CAMAC modules is the same as that discussed for the large area proportional counter array.

Summing amplifiers are used to provide an analog OR of the outputs of the MWPC resistive readouts since only one of the readouts will be active for a single event. The readout provides position information by acting as a voltage divider with the fraction of the signal appearing at one end proportional to the location at which the input was applied to the resistive element. The signal from the end of the resistive element is digitized by an ADC, and the position information is recovered during off-line data analysis. An input register is used to record flag bits indicating which of the readouts participated in a given event. A separate ADC is used to measure the energy deposited in the MWPC and six scalers record the event rates for various parts of the LES.

In the HES, five discriminators provide logic pulses for use in event determination. A coincidence module is used to identify the occurrences of an event associated with any of the four signal anodes. The twelve guard anodes are used in anti-coincidence to reject charged particles and

Table 3-19. NIM/CAMAC Implementation of Bragg Crystal Spectrometer

System Element	CAMAC Product Code	Specific Example	Comments
<u>Signal Processors</u>			
Discriminator (96)	NIM	EG&G T308	8 elements
Summing Amplifier (32)	NIM	ORTEC 433A	2 elements
Shaping Amplifier (16)	NIM	ORTEC 451	
Zero Crossing Discriminator (16)	NIM	EG&G T140	4 elements
Sequence Discriminator (16)	Custom NIM	not available	4 elements
Coincidence (16)	NIM	EG&G C315	2 elements
Scaler (96)	111	KS3610	6 elements
Time-to-Digital Converter (16)	161	LRS2228	
ADC (32)	161	LRS2259	12 elements, pulse type
Input Register (48)	123	EG&G C124	24 elements
<u>Power Supplies</u>			
Detector High Voltage (16)	NIM	ORTEC 459	
<u>Crystal Positioning</u>			
Stepping Motor Driver (2)	145	JO SMC	
Position Encoder (2)	117	SEN 2IPE2019	2 elements
<u>Calibration</u>			
Output Driver (2)	133	KS3040	8 elements
Stepping Motor Driver (2)	145	JO SMC	
Position Encoder (2)	117	SEN 2IPE2019	2 elements
<u>Gas Supply</u>			
ADC (16)	161	KS3510	16 elements, DC level type
Output Driver (16)	133	KS3040	8 elements

events not arriving from the front of the MWPC's. Pulse shape discrimination is used in the same way and with the same implementation as in LES. An ADC is used to measure the energy deposited in the chamber and six scalers record the event rates for various parts of the HES.

Power Supplies. An individual NIM high-voltage detector bias-type usually is used to provide the high-potential electric field required for proper operation of each MWPC. A total of 16 supplies are required for the complete instrument.

Calibration. The calibration system uses both radioactive sources and X-ray tubes. A CAMAC output driver is used to operate the tube and a stepping motor driver-position encoder combination is used to position the source. One such set of modules is required for use with each of the 16 MWPC's.

Gas Supply. The gas pressure in each MWPC module is measured with a pressure transducer connected to a CAMAC dc-level-type ADC. Makeup gas is supplied as needed by pulsing a supply valve operated by a CAMAC output driver. One such gas supply system is required for use with each of the 16 MWPC's.

Crystal Positioning. Each of the spectrometer assemblies has a crystal that must be scanned by changing the angle of its front surface with respect to the MWPC's. This angular control is provided by a stepping motion driver-position encoder combination. Two such assemblies are required for the complete instrument.

3.4.3 High-Resolution Gamma-Ray Ge(Li) Spectrometer

3.4.3.1 Instrument Description

This instrument consists of 16 Ge(Li) detectors, each with 16-cm^2 useful area. These detectors are encased in a CsI (Na) scintillator assembly that provides active collimation and shielding. A plastic scintillator sheet covers the front of the instrument and is used to reject events due to charged particles entering the collimated aperture of the instrument. The Ge(Li) detectors are attached to a cold plate that provides the correct thermal environment for these solid state devices. The basic cooling capability is provided by a stored solid cryogen, and precise temperature control is achieved with the use of an active heater.

The instrument will be used to search for discrete sources of gamma-ray line emissions in the 0.06 to 10 MeV energy range. It will also be used to measure the gamma-ray spectrum and intensity of discrete sources, the diffuse background, and the earth's albedo.

3.4.3.2 Electronics Implementation with NIM/CAMAC

The electronics requirements for the entire gamma-ray spectrometer can be appropriately satisfied with NIM and CAMAC modules except for the high-voltage power supplies needed for the photomultiplier tubes (PMT) used with the scintillation detectors. The block diagram in Figure 3-31 shows the NIM/CAMAC implementation that fulfills the complete instrument requirements with the exception of the PMT high-voltage supplies.

The types of NIM/CAMAC modules used are identified in Table 3-20. The number in parentheses following the name of the system element is the number of elements required. The number of identical functional elements provided by each example module is given in the remarks column.

Signal Processor. The signal processor includes all of the NIM and CAMAC modules required to process the Ge(Li) and scintillator detector outputs, identify the occurrence of valid events according to pre-established criteria, and convey the event data to the central computer. The modules shown in the block diagram are sufficient to implement the complete instrument.

A total of 24 discriminators are needed to provide logic pulses for use in event determination. Twenty of these are used with a single coincidence function to identify valid Ge(Li) events. Signals from the active collimator and shield assembly are used in anti-coincidence to define the field-of-view of the instrument. A signal from the charged-particle detector covering the aperture is used in anti-coincidence to identify gamma-ray events. The active shield is divided into two parts to identify positron annihilation events. A pair of discriminators is used with each shield half as a single-channel energy analyzer. A coincidence element is used to identify events resulting in the characteristic photon energy (.511 MeV) from an electron-positron annihilation being deposited in each shield half.

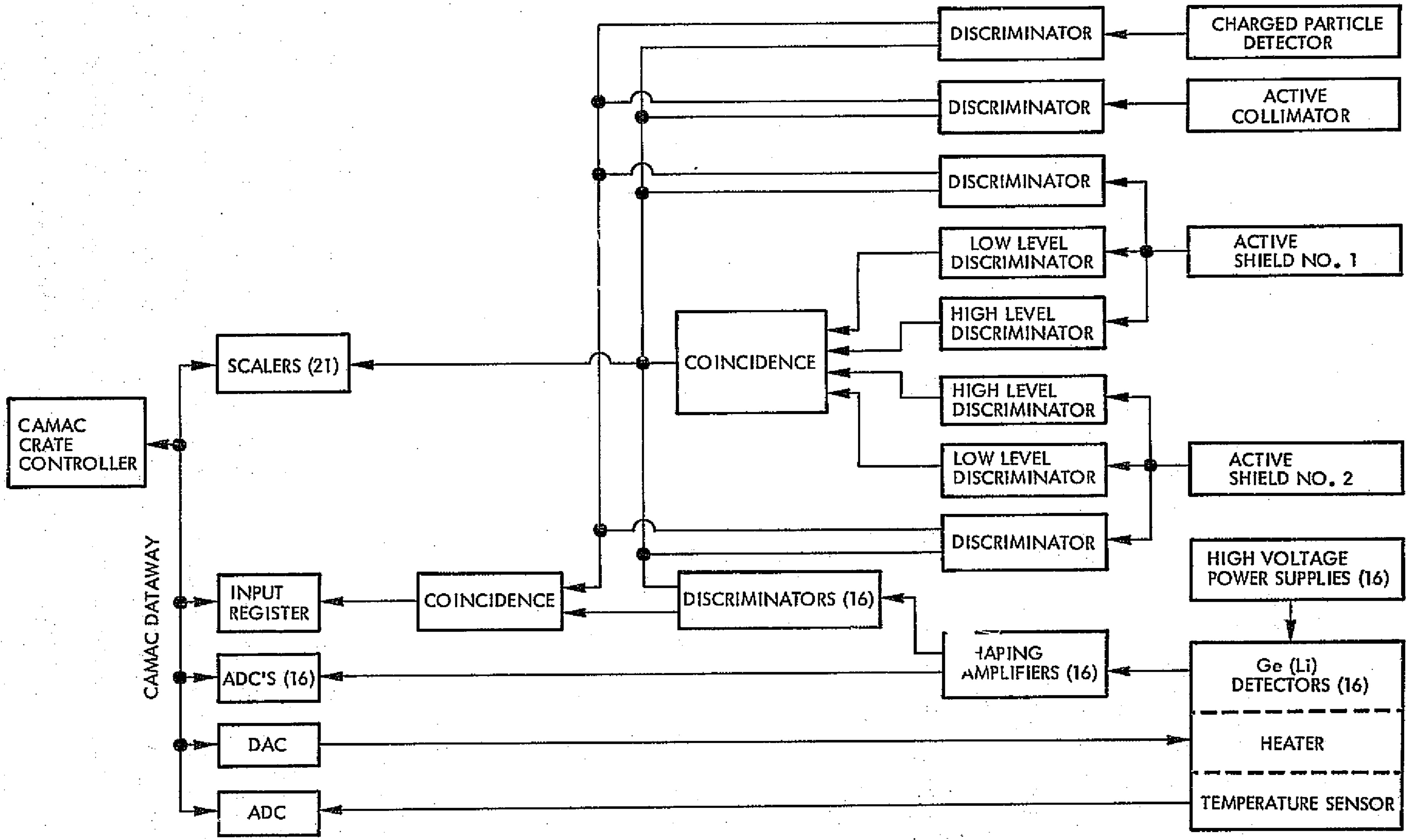

Figure 3-31. High-Resolution Gamma Ray Spectrometer NIM/CAMAC Implementation

Table 3-20. NIM/CAMAC Implementation of High-Resolution Gamma-Ray Ge(Li) Spectrometer

System Element	CAMAC Product Code	Specific Example	Comments
Signal Processor			
Discriminator (24)	NIM	EG&G T308	8 elements
Shaping Amplifier (16)	NIM	ORTEC 451	
Coincidence (2)	NIM	EG&G C315	2 elements
Scaler (21)	111	LRS2551	12 elements
Input Register (1)	123	EG&G C124	24 elements
ADC (16)	161	STD ENG114	pulse type (14 bit)
Power Supplies			
Detector Bias (16)	NIM	ORTEC 459	
Detector Thermal Control			
ADC (1)	161	KS3510	16 elements, DC level type
DAC (1)	162	JO D/A-10	2 elements

A shaping amplifier and a high-resolution 14-bit ADC are used to condition and digitize the signal from each Ge(Li) detector. A set of 21 scalers record the event rates occurring in various parts of the instrument. An input register is used to flag the occurrence of an event for computer readout.

Power Supplies. Individual NIM power supplies are used to establish the correct operating bias for each of the 16 Ge(Li) detectors.

Detector Thermal Control. A dc-level-type ADC is used to determine the detector operating temperature by means of a sensor mounted on the cold plate. A digital-to-analog converter provides control of the heaters used to adjust the plate temperature. A single assembly establishes the same temperature for all 16 detectors.

3.4.4 X-Ray/Gamma-Ray Pallet Summary

Tables 3-21 and 3-22 summarize the results of the NIM/CAMAC implementation for the X-ray/gamma-ray pallet. In each case, the table entry reflects the number of modules required. As noted in the comments column of the tables for the individual instruments, many of these modules provide a number of identical functions. Thus, the number of NIM/CAMAC modules listed in Tables 3-21 and 3-22 provide a significantly larger number of functions for the instruments.

Because NIM equipment is widely used in ground-based laboratories to implement similar instrumentation, it is not surprising that Table 3-21 indicates a requirement for a large number of NIM modules. CAMAC is also widely used in this type of ground-based instrumentation and, hence, Table 3-22 also shows a requirement for a large number of CAMAC modules.

Table 3-21: X-Ray/Gamma Ray Use of NIM Equipment

	Instruments			
	Proportional Counter Array	Bragg Crystal Spectrometer	Gamma Ray Telescope	Totals
Amplifiers				
Shaping	10	16	16	42
Sum/Invert	5	44		49
Discriminators				
Fast - Integral	7	12	3	22
Zero - Crossing	3	4		7
Logic Units	10	8	1	19
High Voltage Power Supplies	10	16	16	42
Bins	5	9	3	17
Special Modules				
Sequence Discriminator	3	4		7

Table 3-22: X-Ray/Gamma Ray Use of CAMAC Equipment

	CAMAC Product Code	Proportional Counter Array	Bragg Crystal Spectrometer	Gamma Ray Telescope	Totals
Scalers	111	5	16	2	23
Position Encoders	117	5	3		8
Coincidence Latch	123	1	3		4
Timed Triac Output	133	2	3		5
ADC's	161				
High Resolution				16	16
Peak (10 bit)		1	4		5
Scanning		1	1		2
Time Digitizer		10	16		26
DAC's	162			1	1
Branch Driver	211		Share 1		1
Crate Controllers	231	2	3	1	6
Crates	411	2	3	1	6

3.5 ATMOSPHERIC, MAGNETOSPHERIC PLASMAS IN SPACE

The Atmospheric, Magnetospheric Plasmas in Space (AMPS) payload was formed by the amalgamation of the Plasma Physics and Environmental Perturbation Laboratory and the Atmospheric Science Facility. The extensive experimental capability provided by this composite AMPS Laboratory is shown diagrammatically in Figure 3-32. The proposed Laboratory is capable of conducting both active and passive experiments in space. In addition, it has the capability of performing laboratory-type plasma physics experiments in space, in cases where the space environment provides the experiments with special advantages.

The active experiments involve the injection of particles, waves, gas, or physical bodies into the magnetospheric plasma. The amount of material introduced will determine the type of active experiment to be performed. If the injected material is either of a lower density than the local plasma or, in the case of physical bodies, is much smaller dimensionally than the Orbiter, then the injected material will be used to perform tracer-type experiments. However, if the material is of a higher concentration than the local environment, or the body is large compared with the Orbiter (which is really a large perturbation experiment in itself), then the space environment has been radically changed and perturbation-type investigations can be performed. This latter type of experimental technique will allow phenomena, that have been observed only randomly in the past, to be produced in a controlled fashion for detailed study with an extensive array of diagnostics.

In addition to the active experiments, the laboratory will perform experiments more in keeping with the type of experiment that has been flown on satellites. These measurements are of a passive nature where temporal measurements of the prevailing space condition can be performed. Simultaneous measurements of many of the magnetospheric parameters in this passive mode will allow an extensive analysis of correlated phenomena. This type of data will help untangle the vast number of phenomena that have been observed in the past but not fully understood. In addition, the passive instrumentation can be used to monitor the effect that the active experiments have on the magnetospheric plasma.

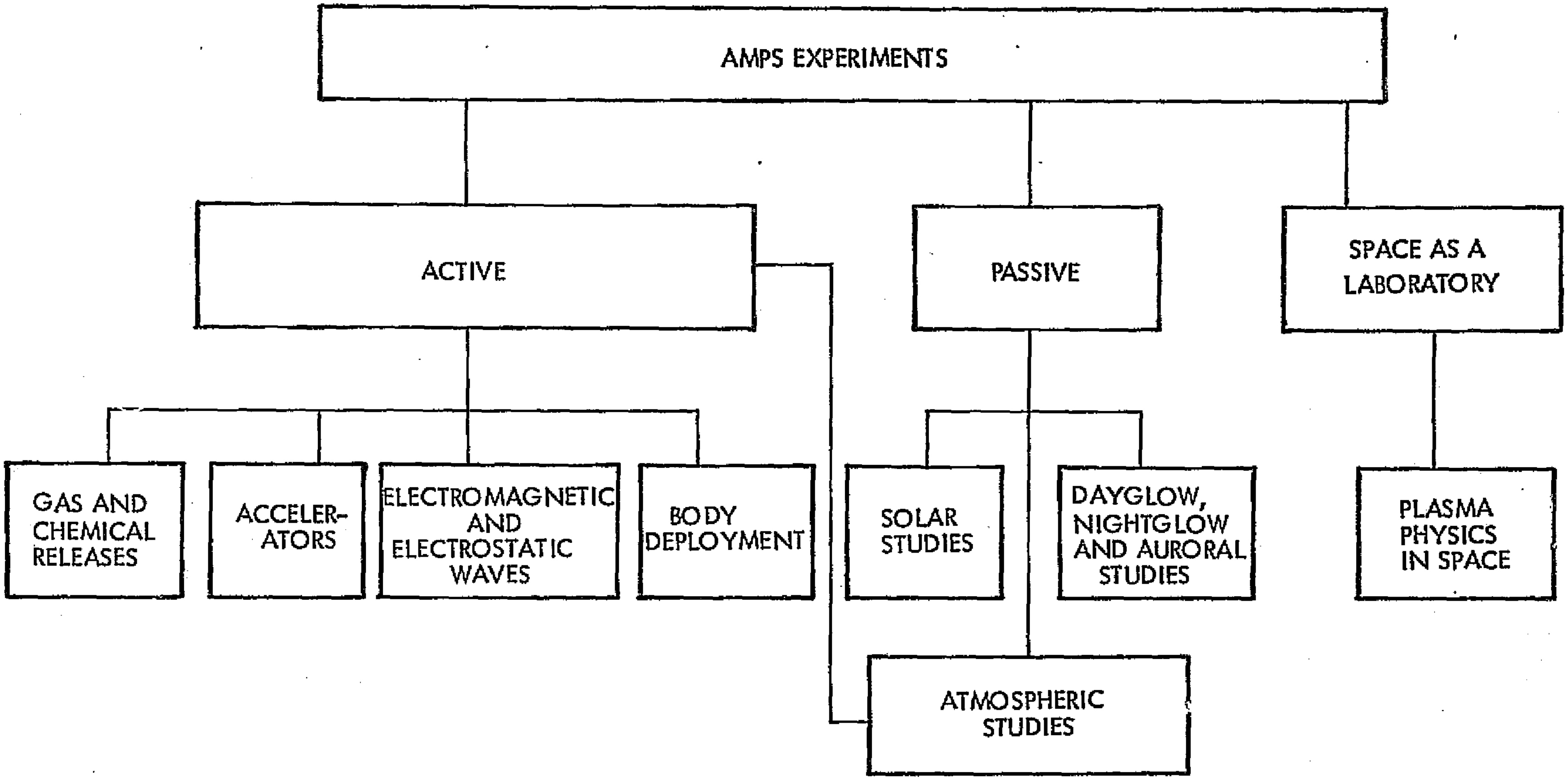

Figure 3-32. AMPS Experiment Categories

The final category of plasma physics in space is obviously a new concept. There are many experiments carried out in ground laboratories where the vacuum chambers in which they are performed are a serious handicap. These include low-frequency wave propagation experiments, containment of dense energetic plasmas, wave-particle interaction studies, etc. The utilization of the space environment will enhance the ability of the experimenter to obtain pertinent data on these effects.

The experiments that are proposed for the AMPS facility require extensive data management capability. The complexity of the experiments requires an extensive control and monitoring capability of the actual perturbing system together with the capability to handle the data coming in from the associated experimental diagnostics. It appears that there is a need for on-board data processing with a substantial data storage capability and a telemetry link with ground control. In order to obtain a reasonable estimate of the suitability of NIM/CAMAC system for implementation of the control and data management systems (CDMS), one experiment from each of the areas shown in Figure 3-32 was selected as a typical example and analyzed.

The six experiments selected for analysis are summarized in Table 3-23. The instrumentation required to perform each of these experiments along with the implementation of the data acquisition and experiment control functions with NIM and CAMAC equipment will be described in the following sections. The composite requirements for an AMPS payload capable of performing this group of representative experiments will be tabulated in the last section.

3.5.1 Accelerator Experiment

3.5.1.1 Experiment Description

The accelerator systems that have been proposed for AMPS include four types of accelerators: electron accelerators, ion accelerators, plasma guns, and MPD arcs. The example we will consider is a typical tracer-type experiment to determine magnetic field line configuration. In this experiment, a beam of 30-KeV electrons is fired from the Space Shuttle and is directed along a magnetic fieldline to the other hemisphere. Here, a portion of the electrons in the beam are reflected back along the fieldline

Table 3-23. AMPS Experiment

Accelerator Experiment

- Active Experiment - Injecting one amp of 30-keV electrons into magnetosphere
- Electrons "bounce" between hemispheres along magnetic field lines
- Measures magnetic field line length, electric fields along field lines, and whether field lines are open or closed

Perturbing Body Experiment

- Active Experiment - Placing a moving body of known geometery into the space plasma
- Body causes changes in local particle populations
- Measures dependence of disturbed region on body shape, size, material, etc.

Chemical and Gas Release Experiment

- Active Experiment - Injecting a large quantity of barium ions into magnetosphere
- Optically visible ions move along magnetic field line but cross field drift occurs due to electric fields
- Measures large-scale, greater than 1 km, electric field strength and gradients

Electromagnetic and Electrostatic Wave Experiment

- Active Experiment - Injecting waves into the magnetosphere
- Waves propagated from one antenna to a receiving antenna in range of one to ten kHz
- Measures wave propagation near the lower hybrid frequency

Passive Studies

- Observation of naturally occurring atmospheric emissions
- Range of optical instrumentation over the spectral range of 300 to 10,000 Å

Magnetic Confinement Studies in Space

- Laboratory Type Experiments - Including studies of plasma containment in the absence of wall effects
- Magnetic field for plasma containment
- Study of particle confinement by magnetic fields and wave growth

by the processes of collision with atmospheric particles and magnetic mirroring. These returning electrons interact with the atmosphere behind and below the Space Shuttle. The resultant excitation of the atmospheric neutral atoms produces a large quantity of photons that can be observed from the Shuttle with optical diagnostics.

The combination of instrumentation required to perform this experiment consists of the electron accelerator and its associated control system, used to generate the electron beam, and diagnostic equipment of several types. A group of particle analyzers (three Faraday cups and an electrostatic analyzer) are used to measure the ejected beam characteristics such as intensity, energy, and spatial distribution. Magnetic and electric field probes determine the local field characteristics. Together, these diagnostic measurements determine the initial conditions of the experiment. An optical diagnostic package consisting of six filter photometers is used to observe the intensity and spectral characteristics of the emissions generated by the impact of the return electron beam on the atmosphere. A low-light-level TV system would also be used to monitor the optical emissions, but as discussed in Section 3.1.1, video systems are assumed to be handled with the existing Spacelab facilities.

3.5.1.2 CDMS Implementation with NIM/CAMAC

The accelerator experiment will require extensive support from the Spacelab CDMS to implement the accelerator operation and process the data generated by the diagnostic instrumentation. The experimenter will program the computer through the keyboard unit to determine the accelerator operating conditions that are required for the next beam ejection. Examples of this operation are initiating, monitoring and controlling the rate at which the energy storage capacitor bank on the pallet is charged by a low-voltage power processor. The predetermined settings for electron source operation will be programmed to produce the required electron current, and the pitch angle of the beam is controlled by programming the strength of the magnetic field in the beam deflection system. Once the electron beam conditions have been determined, the appropriate experimental conditions for the diagnostic equipment will be programmed. At the correct moment, the capacitor bank is discharged through a high-voltage power processor and the high-voltage switch is closed to allow the resultant high voltage to reach the accelerator. The emitted beam is examined for electron energy, wave production, and cross-sectional density variations. The returning beam's interaction with the atmosphere will be monitored by the optical equipment on the pallet.

Figure 3-33 is a block diagram of the system implementation using NIM/CAMAC. NIM and CAMAC modules located in the Spacelab module are used to provide the interface between the pallet-mounted primary experiment instrumentation and the Spacelab CDMS. The electronics directly associated with the accelerator involve high-power circuitry that cannot be implemented with NIM or CAMAC modules. Also, as we have seen in many of the instruments, the diagnostic equipment requires low-level signal processing circuits located in close proximity to the sensors where it is also not reasonable to use NIM or CAMAC modules. The NIM and CAMAC modules used for the accelerator experiment are listed in Table 3-24.

Accelerator Control - CAMAC modules are used to provide the various functions required to control and monitor the electron accelerator. Five analog control signals are provided by a portion of an eight-channel DAC and twelve discrete digital control signals are provided by an optically-isolated output driver. The capability to monitor and process both analog and discrete digital outputs from the accelerator control unit is provided by a portion of a 16-channel slow ADC and a 24-channel, optically-isolated, input register. Although the detailed number of input and output signals required for accelerator control has not been established, the capability provided is conservatively believed to be adequate.

Beam and Field Diagnostics - The conditioned output signals from the three Faraday cups are processed by three channels of the multichannel ADC used in the accelerator control system. High voltage for the Faraday cups is provided by NIM-packaged, analog-voltage-controllable, high-voltage power supplies. The control signals for these supplies is provided by three channels of the DAC used for accelerator control.

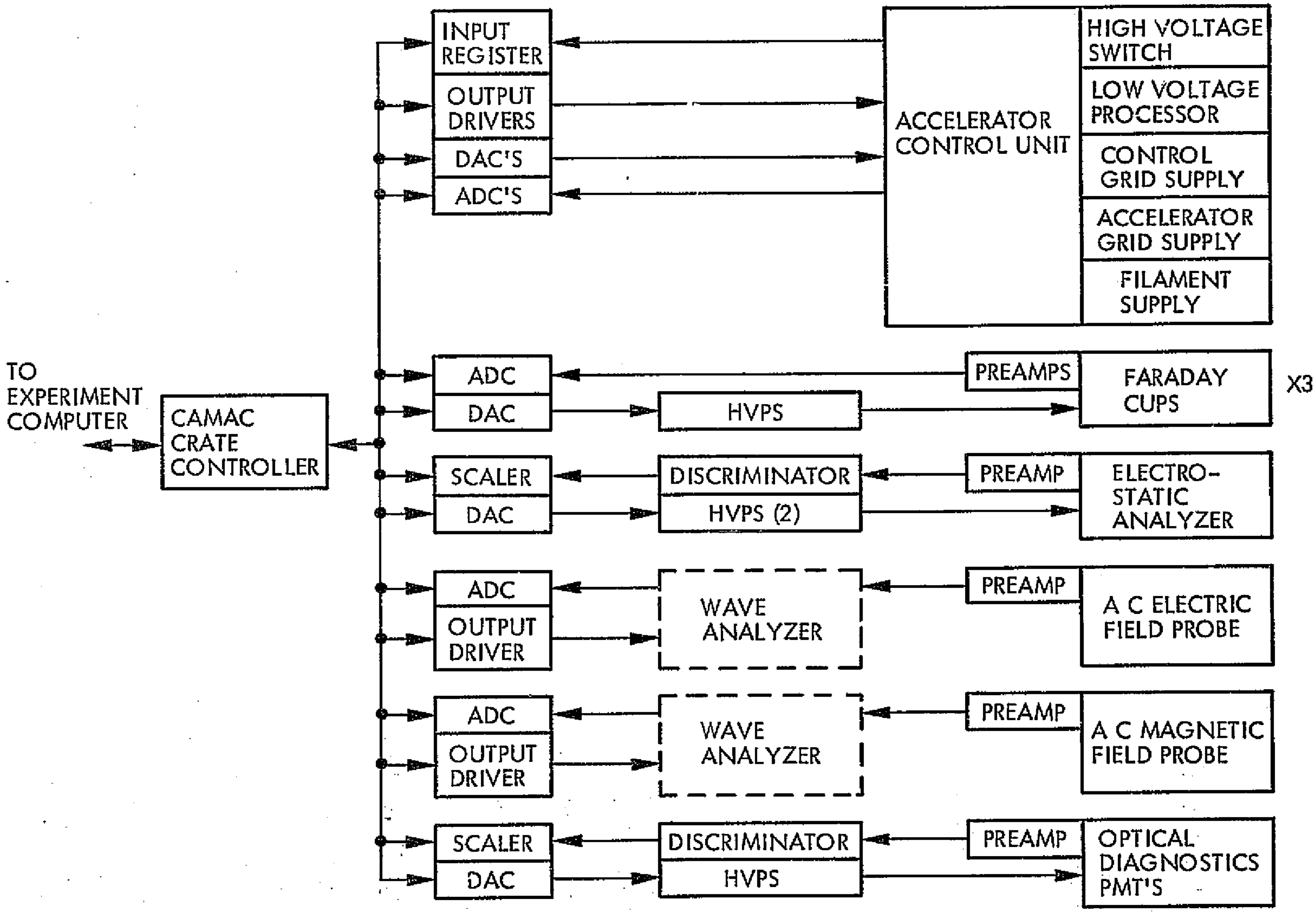

Figure 3-33. AMPS Accelerator Experiment NIM/CAMAC Implementation

Table 3-24. NIM/CAMAC Equipment for Accelerator Experiments

System Element	CAMAC Product Code	Specific Example	Comments
Accelerator Control			
DAC's	162	KS3110	Octal Unit - share with elements below.
Output Driver	133	KS3028	12-bit, optically isolated.
Input Register	121	KS3471	24-bit, optically isolated.
ADC's	161	KS3510	16 channel - share with Faraday cups.
Faraday Cup (X3)			
ADC	161	KS3510	Share with accelerator control.
DAC	162	KS3110	Share accelerator unit.
HV Power Supply	NIM	ORTEC 456	
Electrostatic Analyzer			
Scaler	111	B01004A	Quad Unit - share with photomultipliers.
DAC	162	KS3110	Octal Unit - share with photomultipliers.
Discriminator	NIM	LRS620AL	Octal Unit - share with
HV Power Supply (2)	NIM	ORTEC 456	photomultipliers.
Electric Field Probe			
ADC	161	B01244A	
Output Driver	133	B01082	Dual Unit - share below.
Wave Analyzer	NIM		Custom unit, could be NIM-packaged.
Magnetic Field Probe			
ADC	161	B01244A	
Output Driver	133	B01082	Share with Electric Field Probe.
Wave Analyzer	NIM		Custom unit, could be NIM-packaged.
Photomultiplier (X6)			
Scaler	111	B01004A	Quad units, share one with ESA.
DAC	162	KS3110	Octal Unit, share with ESA.
Discriminator	NIM	LRS620AL	Octal Unit, share with ESA.
HV Power Supply	NIM	ORTEC 456	

The electrostatic analyzer (ESA) requires two programmable high voltages to scan particle energy distributions. These high voltages are provided by the same DAC/programmable power supply combination used for the Faraday cups. The ESA output signals are fast voltage pulses which are converted to standard NIM fast logic pulses by one channel of a fast, octal NIM discriminator. The discriminator outputs in turn are counted with one channel of a four-channel CAMAC scaler.

After signal conditioning at the probe, the output signals of both the magnetic and electric field probes have essentially the same processing requirement. The frequency spectrum of the output analog signal is analyzed by a NIM-packaged wave analyzer. There is no such module on the market today, but the device could be implemented in NIM form. We have assumed an analog output from the wave analyzer which is digitized by a fast, high-resolution CAMAC ADC. The frequency scanning program and data transfer of each wave analyzer are controlled by one-half of a dual 16-channel output driver.

Optical Diagnostics - The optical diagnostic instrumentation consists of six single-channel, fixed-wavelength, filter photometers using photomultiplier sensors. The control and data handling for each unit is identical. The conditioned output signal consists of fast voltage pulses that are standardized by a fast NIM discriminator. The discriminator output pulses are counted with a CAMAC scaler. Controllable high-voltage power for each unit is provided by the same DAC/HVPS combination used in the particle diagnostic equipment.

3.5.2 Perturbing Body Experiment

3.5.2.1 Experiment Description

This experiment involves the interaction between a body, vehicle, or structure moving through space and the local space plasma. The overall objective of the experimental program is to study the axial and transverse dimensions of the perturbed zone created by the moving body due to its rapid motion through the space environment.

The experiment selected is one in which a large insulated inflatable body is deployed with the aid of a boom to a distance of approximately fifty meters in front of the Orbiter. The body is inflated and the region around the body is explored with two diagnostic packages also mounted on booms.

One diagnostic package will remain stationary while the other package is moved around the perturbing body taking measurements. In this way, the stationary package acts as a reference point for the moving system. A third diagnostic package is located on a pallet in the payload bay. The quantities to be measured will be the electron and ion currents, densities, temperatures; and plasma wave production as a function of distance and direction from the wave-producing body.

3.5.5.2 CDMS Implementation with NIM/CAMAC

In general, it appears that this experiment requires only moderate CDMS support. A block diagram of the CDMS that is required for this experiment is shown in Figure 3-34. The major control functions are the positioning of each of the booms and control of the level of inflation of the perturbing body. CAMAC modules are used as the interface between the Spacelab CDMS and the actual boom drive motors.

Each of the three identical diagnostic packages will include low-level signal conditioning electronics as part of the various sensors. Only the final stages of signal processing and data acquisition will be implemented with NIM and CAMAC equipment located in the Spacelab module. Control for the diagnostic instrumentation is provided in the form of programmable high-voltage power. A list of the NIM and CAMAC modules required to implement the perturbing body experiment is given in Table 3-25.

Boom and Deployable Body Control - Digital input control signals for the boom drive motor control electronics are provided with CAMAC stepping motor control units that generate serial pulse trains for both clockwise and counterclockwise movement. Control of two motors for each boom is provided. CAMAC input registers are used to accept parallel digital data from the position encoders on each boom. A portion of an eight-channel CAMAC DAC is used to provide input analog signals to control the body inflation system.

Diagnostic Packages - The electron and ion density and temperature probes have identical control and data acquisition requirements. The electrometer associated with each probe produces a differential analog voltage output that is proportional to the probe current. No NIM-packaged differential amplifiers suitable for processing this signal are currently available, so a custom-built NIM-packaged unit has been assumed. The analog output from

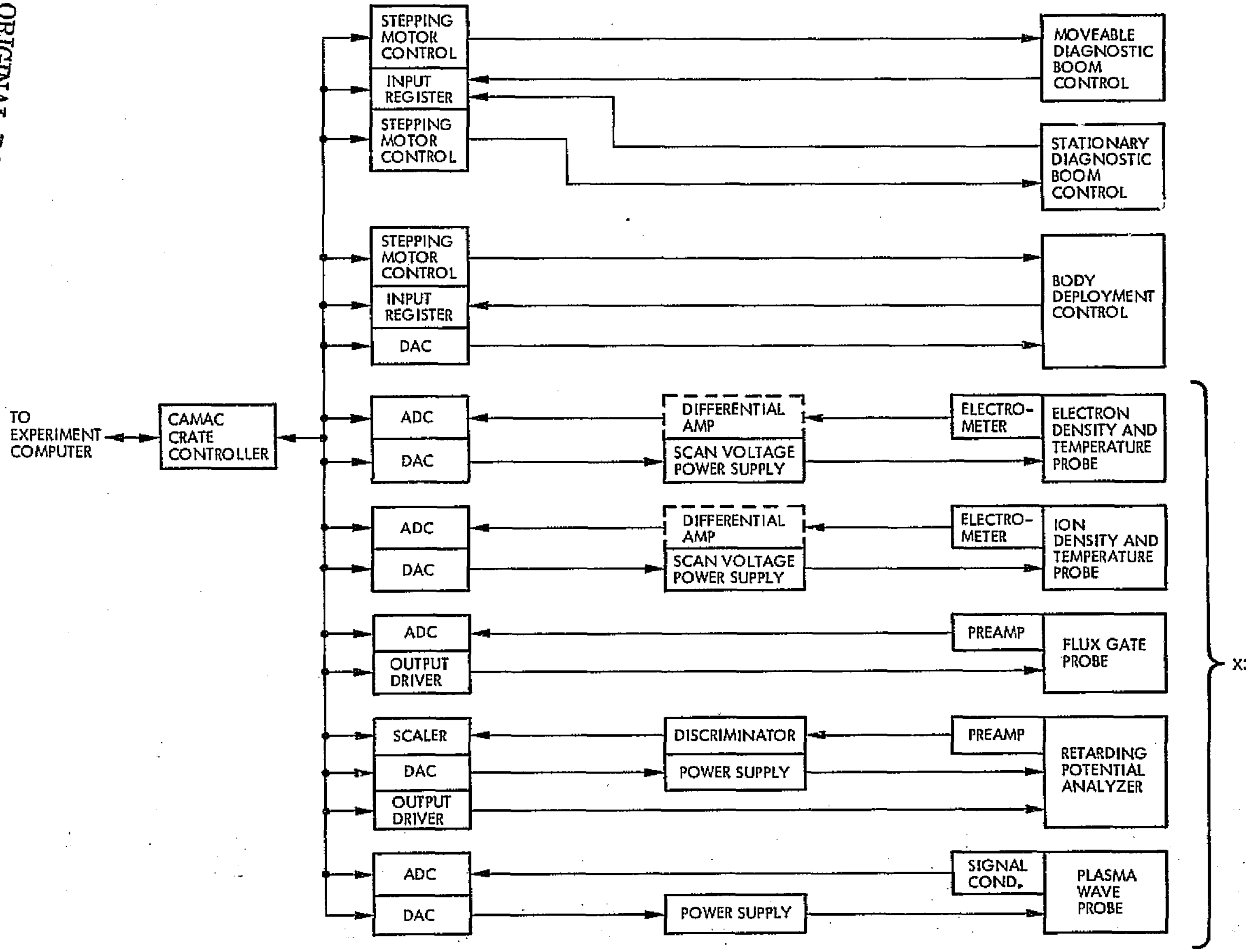

Figure 3-34. AMPS Perturbing Body Experiment NIM/CAMAC Implementation

Table 3-25. NIM/CAMAC Equipment for Perturbing Body Experiments

System Element	CAMAC Product Code	Specific Example	Comments
Boom and Body Control			
Stepping Motor Controllers (3)	145	KS3360	Dual units
Input Register (2)	121	NE7059-1	Used to record boom positions.
DAC	162	KS3110	Octal Unit - share below.
Electron Density/ Temperature Probe (X3)			
ADC	161	KS3510	16 channel, share with below.
DAC	162	KS3110	Share with Boom Instruments.
Differential Amplifier	NIM		Custom unit, could be NIM-packaged.
Scan Voltage Power	NIM	ORTEC 456	
Ion Density/Temperature Probe (X3)			
ADC	161	KS3510	Share with Electron Probe.
DAC	162	KS3110	Share with Boom Instruments.
Differential Amplifier	NIM		Custom unit, could be NIM-
Scan Voltage Power	NIM	ORTEC 456	packaged.
Flux Gate Probe (X3)			
ADC	161	KS3510	Share with Electron Probe.
Output Driver	131	B01082	Turn power supplies on/off.
Retarding Potential Analyzer (X3)			
Scaler	111	B01004A	Quad unit
DAC	162	KS3110	Share with Plasma Wave Probe.
Output Driver	133	B01082	Turn power supplies on/off.
Discriminator	NIM	LRS621AL	Quad unit
Power Supply	NIM	ORTEC 456	
Plasma Wave Probe (X3)			
ADC	161	KS3510	Share with Electron Probe.
DAC	162	KS3110	Share unit above.
Power Supply	NIM	ORTEC 456	

this amplifier is sampled and digitized by a multichannel slow CAMAC ADC. The sampling of the ADC is done in synchronism with the scanning of the probe high voltage. The high voltage is provided by the frequently-used combination of a NIM analog voltage controllable high-voltage power supply and a CAMAC DAC.

The magnetic flux gate probes provide conditioned analog output voltages that are directly suitable for digitization by a multichannel slow CAMAC ADC. Only discrete digital control signals are required for turning probe low-voltage power supplies on and off. A CAMAC output driver is used to provide these signals with a large number of spare channels available.

The control and data handling electronics required for the retarding potential analyzer is essentially identical to that required for the electrostatic analyzer previously discussed. Additional control in the form of discrete digital signals to turn low voltages on and off is provided.

Finally, the plasma wave probe must contain a reasonable amount of signal conditioning circuitry at the sensor to generate an analog output signal that is directly compatible with a slow, multichannel CAMAC ADC. Again, programmable high voltage is provided by a DAC/HVPS combination.

3.5.3 Gas and Chemical Release Experiment

3.5.3.1 Experiment Description

The technique of injecting gases and chemicals into the local plasma can provide information on a variety of topics from auroral precipitation to excitation chemistry. The particular experiment selected in this category is the technique of using chemical releases as tracer diagnostics. The aim of the experiment is to investigate electric fields in the magnetosphere below 400 kilometers. A canister containing barium metal and copper oxide is ejected from the Shuttle and ignited. About five percent of the barium is converted into atoms with a kinetic energy of several tens of electron volts obtained from the Shuttle's orbital velocity. A large percentage of these atoms are converted to ions by sunlight within several minutes. The cloud then moves downward along the magnetic field line under the influence of gravity. The ions also drift across the magnetic field. Above 200 kilometers, where the effect of neutral wind is small, this cross field drift is due to an $\overline{E} \times \overline{B}$ force. From this drift, the magnitude and direction of the electric field can be calculated. The ions are detected and tracked by their optical emissions.

Several types of diagnostic instrumentation are required for this experiment. Complete local magnetic and electric field measurements are desirable. A diagnostic package of three-axis, electric and magnetic AC and DC field probes is deployed on a boom. Energetic particle analyzers are also included in the boom diagnostic package to determine the local conditions. Optical diagnostics consist of a filter photometer mounted on the pallet. Since the phenomena being observed are relatively slow varying, a single instrument with a variety of interchangeable filters can be employed. The low-light-level TV system would also be used, but is not explicitly included here since it does not utilize NIM or CAMAC equipment as previously discussed. The otpical observations would ideally also be complemented by ground-based observations of the barium cloud.

3.5.3.2 CDMS Implementation with NIM/CAMAC

The NIM/CAMAC implementation of the CDMS for the experiment is shown in Figure 3-35. Since most of the instrumentation required to perform the experiment has already been treated in the discussion of the previous two experiments, only a brief discussion of the new elements will be given. The NIM and CAMAC modules used for this experiment are identified in Table 3-26.

Cannister Control - Discrete digital signals are provided by a CAMAC output driver to initiate cannister ejection and ignition. A CAMAC input register (shared with the boom control function) is used to monitor the status of the cannister ejection mechanisms.

Particle and Field Diagnostics - The only new item included is provision for DC field measurements. The field probe signal conditioning electronics outputs an analog voltage that is digitized with a slow CAMAC ADC. All of these signals are processed with an eight-channel module.

Optical Diagnostics - The only difference between the optical diagnostics for the experiment and the accelerator experiment is requirement to control the movable filter wheel. This is handled by a CAMAC stepping motor driver.

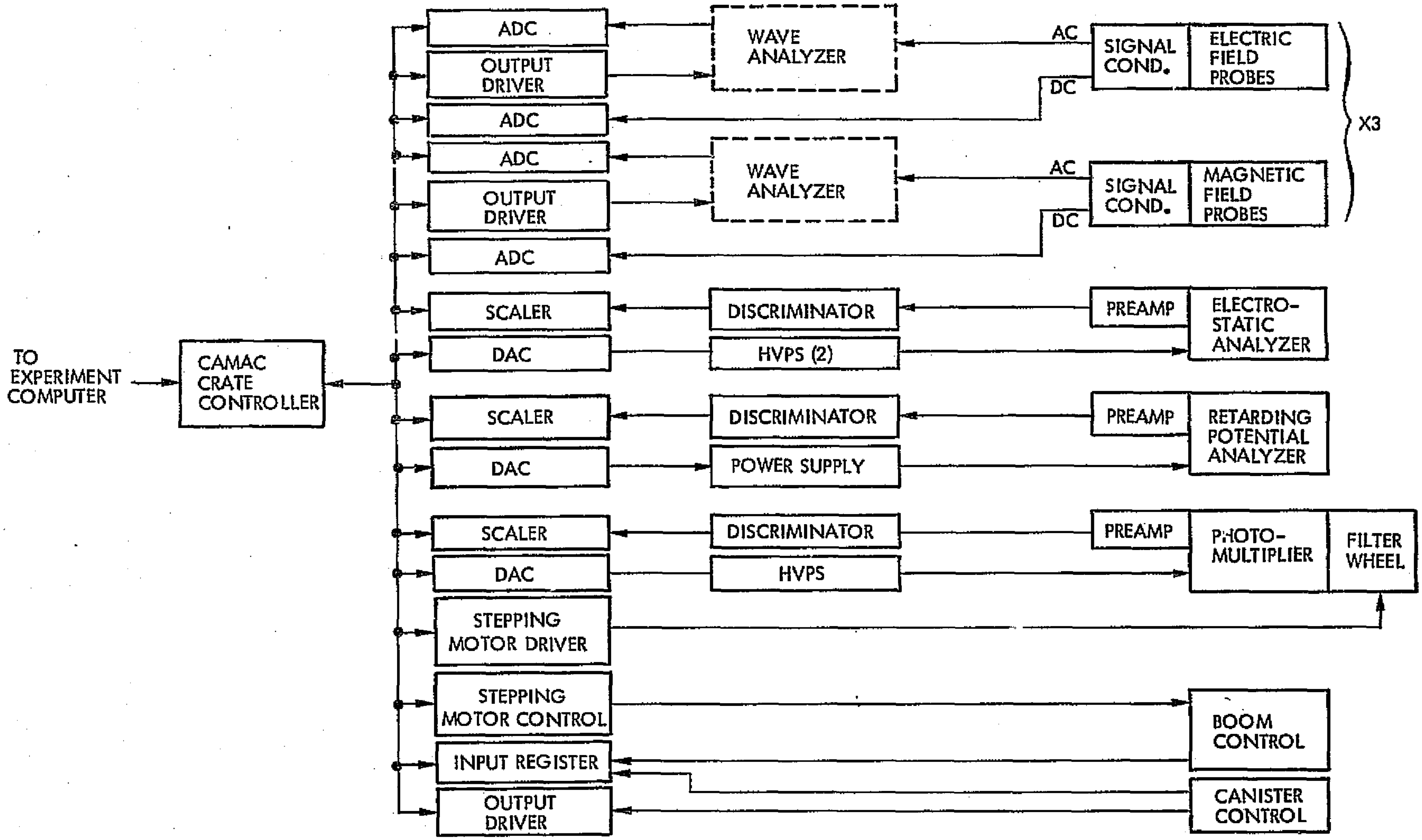

Figure 3-35. AMPS Chemical Release Experiment NIM/CAMAC Implementation

Table 3-26. NIM/CAMAC Equipment for Chemical and Gas Release Experiment

System Element	CAMAC Product Code	Specific Example	Comments
Electric and Magnetic Field Measurements (X3)			
ADC - Fast (2)	161	B01244A	
ADC - Slow	161	EGG AD811	Octal Unit
Output Driver	133	B01082	Dual, 16-bit unit.
Wave Analyzer (2)	NIM		Custom unit, could be NIM-packaged.
Electro-Static Probe			
Scaler	111	B01004A	Quad Unit, share below.
DAC	162	KS3110	Octal Unit - share below.
Discriminator	NIM	LRS621AL	Quad Unit, share below.
HV Power Supplies (2)	NIM	ORTEC 456	
Retarding Potential Probe			
Scaler	111	B01004A	Quad Unit, share with ESA.
DAC	162	KS3110	Share octal unit above.
Discriminator	NIM	LRS621AL	Quad Unit, share with ESA.
Power Supply	NIM	ORTEC 456	
Photomultiplier Tube			
Scaler	111	B01004A	Quad Unit, share with ESA.
DAC	162	KS3110	Share with octal unit above.
Stepping Motor Driver	145	KS3361	
HV Power Supply	NIM	ORTEC 456	
Boom and Cannister Control			
Stepping Motor Control	145	KS3360	
Input Register	121	NE7059-1	
Output Driver	133	B01082	

3.5.4 Electrostatic and Electromagnetic Wave Experiment

3.5.4.1 Experiment Description

The main aim of this experimental area is to study the effect of modifying the environment of the magnetosphere by the injection of electromagnetic and electrostatic waves. The experiment that was chosen as a typical example of one of the early wave propagation studies on Shuttle is the study of electrostatic wave propagation near the lower hybrid resonance (LHR) frequency.

The apparatus required to perform this experiment consists of an antenna system that is mounted on an extendable boom. The antenna is composed of four spherical electrodes about two cms in diameter that are mounted at the four corners of a square with sides of four meters in length. The boom needs to be long enough to remove the system to a position where the magnetic perturbations at the sensor should be less than one percent of the local field. This may be fifty meters or so from the Shuttle. The electrodes are connected so as to form two parallel dipoles, one of which is used for transmitting and the other for receiving. Therefore, this can be carried out in four possible ways. The plane of the probe square is orientated so that it is perpendicular to the direction of the earth's magnetic field. The boom-mounted instrumentation comprised of a stepped-frequency transmitter and a superheterodyne receiver, measures the transfer impedance between the two dipoles as a function of frequency. The predictions are that the impedance should peak at the LHR frequency and above this value should indicate electrostatic propagation.

Instrumentation to measure the local plasma characteristics is also located on the boom. It consists of an AC and DC magnetic field probe as well as electron and ion density and temperature probes.

3.5.4.2 CDMS Implementation with NIM/CAMAC

This experiment requires only a modest amount of CDMS support. Most of the types of instrumentation used to perform the experiment have already been encountered in the previously discussed experiments. The block diagram of the CDMS is shown in Figure 3-36 and the usual tabulation of NIM and CAMAC modules used is given in Table 3-27.

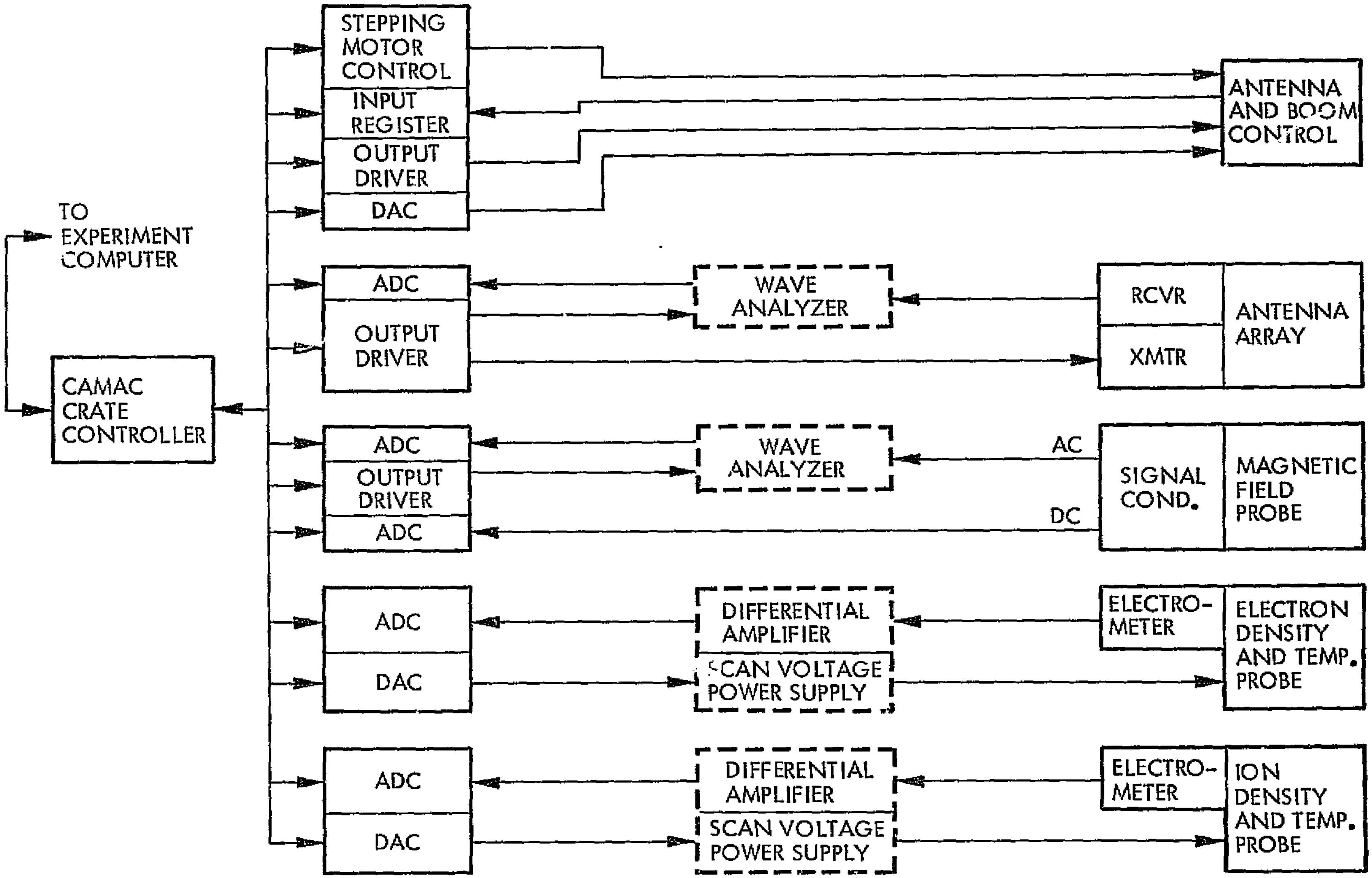

Figure 3-36. AMPS Lower Hydrid Frequency Experiment NIM/CAMAC Implementation

Table 3-27. NIM/CAMAC Equipment for Lower Hybrid Frequency Experiments

System Element	CAMAC Product Code	Specific Example	Comments
<u>Antenna and Boom Control</u>			
Stepping Motor Controllers (2)	145	KS3360	Dual units
Input Register	121	NE7059-1	Used to record positions.
Output Driver	133	B01082	Share below.
DAC	162	KS3110	Octal Unit, share below.
<u>Antenna Array</u>			
ADC - Fast	161	B01244A	
Output Driver	133	B01082	Share with Antenna Control.
Wave Analyzer	NIM		Custom unit, could be NIM-packaged.
<u>Magnetic Field Probe</u>			
ADC - Fast	161	B01244A	
ADC - Slow	161	KS3510	16 channel, share below.
Output Driver	133	B01082	Share with Antenna Control.
Wave Analyzer	NIM		Custom unit, could be NIM-packaged.
<u>Electron Probe</u>			
ADC - Slow	161	KS3510	Share with Magnetic Field Probe.
DAC	162	KS3110	Share with Antenna Control.
Differential Amplifier	NIM		Custom unit, could be NIM-packaged.
Scan Voltage Power Supply	NIM	ORTEC 456	
<u>Ion Probe</u>			
ADC - Slow	161	KS3510	Share with Magnetic Field Probe.
DAC	162	KS3110	Share with Antenna Control.
Differential Amplifier	NIM		Custom unit, could be NIM-packaged.
Scan Voltage Power Supply	NIM	ORTEC 456	

The antenna array instrumentation is unique to this experiment. The boom-mounted transmitter and receiver are not themselves suitable for NIM or CAMAC implementation. The same special NIM-packaged wave analyzer previously used with field probes is for spectrum analysis of the receiver output signal. The CAMAC output driver used to control the wave analyzer is also used to provide discrete digital signals for transmitter control and array switching control signals.

3.5.5 Laboratory Plasma Physics in Space

3.5.5.1 Experiment Description

The performance of laboratory-type plasma physics experiments in space is perhaps the most speculative and least defined of the studies proposed for AMPS. The experiment selected as an example for CDMS analysis is intended to investigate magnetic confinement of plasmas. The experiment requires the deployment of a large electromagnet in the vicinity of the Shuttle to confine plasmas. This will allow studies of basic plasma properties unhampered by the normal restrictions of impurities resulting from interactions of the plasma with the walls of the confinement vessel. Under these conditions plasma wave instabilities, at the low density of the ionospheric plasma close to the Shuttle, would have growth and decay rates many orders of magnitude faster than typical laboratory plasmas. This would allow detailed examination of these phenomena to be carried out.

The main apparatus would be mounted on a boom and consists of two magnet coils in a mirror configuration as well as a plasma gun to enhance the trapped plasma. Diagnostic instrumentation includes a laser source with associated photomultiplier detectors to monitor the trapped plasma density, an AC magnetic field probe, and a triaxial energetic particle analyzer to determine particle energy distributions.

3.5.5.2 CDMS Implementation with NIM/CAMAC

As has been the case for most of the AMPS experiments, CAMAC equipment will be used as interface between the Spacelab CDMS and the experiment mounted on the pallets or deployed on booms. The control requirements of this experiment include magnet control, plasma gun control, laser control, and boom control. The diagnostic instrumentation presents only one new requirement so far as the CDMS is concerned -- the energetic particle analyzers. A block diagram of the CDMS is shown in Figure 3-37, and the NIM and CAMAC modules used in this implementation are listed in Table 3-28.

Control Functions - The magnet control system includes the power supplies necessary to generate the current for the magnet coils and the housekeeping necessary to monitor the status of the magnets. Sixteen channels of ADC are provided to sample and digitize the housekeeping instrumentation analog outputs. Analog and discrete digital signals to control the magnet power supplies are provided by one-half of an eight-channel CAMAC DAC and one-half of a 2 x 16-bit output driver. The balance of the available output signals from these two modules are more than adequate to control the plasma gun power supplies and the laser power supplies. Boom control is implemented in the same manner as before.

Energetic Particle Analyzer - The output of the energetic particle analyzer is an analog pulse whose amplitude is proportional to the particle energy after preamplification at the detector. These pulses are further processed with a NIM spectroscopy amplifier. Because of the high counting rate expected in these analyzers, a NIM-packaged pulse height analyzer (PHA) is used to accumulate the particle energy distribution. The same function could, in principal, be accomplished with a CAMAC fast ADC and accumulation of the data in the computer memory, but the CAMAC dataway would be extremely busy. With the implementation selected, data are stored in the PHA memory (256 channels of the 1024-channel memory are used for each particle analyzer) and periodically transferred to the computer via the CAMAC dataway. The combination of a CAMAC parallel input register and output driver is used to control and transfer data from the PHA to the CAMAC dataway. The detector high voltage is supplied by the conventional arrangement of a NIM HVPS controlled by a CAMAC DAC.

3.5.6 Passive Studies

3.5.6.1 Experiment Description

The passive studies that are proposed as part of the AMPS facility will continue the observation of the natural physical, chemical, and electromagnetic phenomena that have been monitored as part of the space program for over ten years. This type of monitoring program utilizes a variety of instruments to investigate phenomena related to particles, fields, and

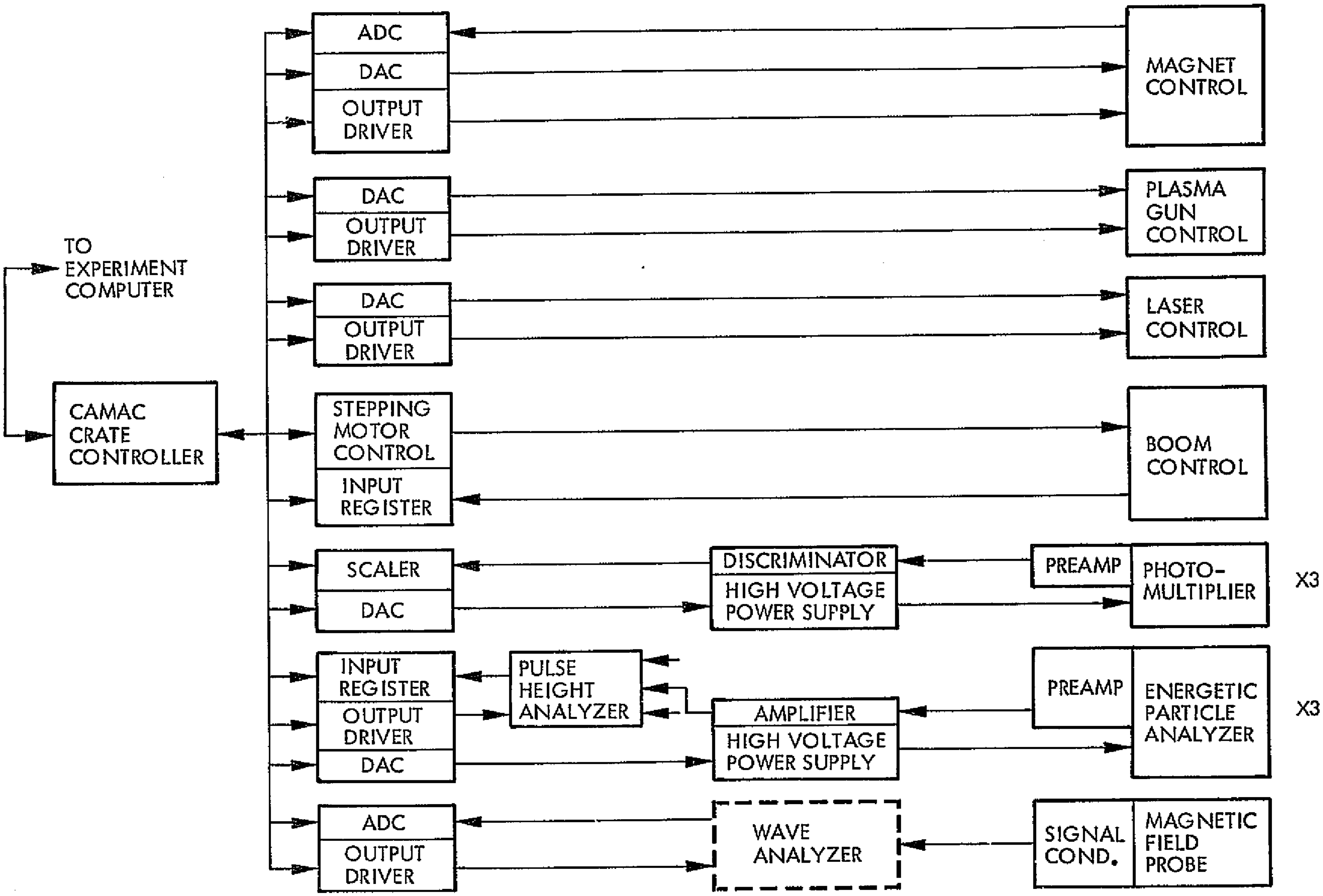

Figure 3-37. AMPS Magnetic Confinement Experiment NIM/CAMAC Implementation

Table 3-28. NIM/CAMAC Equipment for Magnetic Confinement Experiment

System Element	CAMAC Product Code	Specific Example	Comments
Magnet Control			
ADC - Slow	161	KS3510	16-channel unit
DAC	162	KS3110	Octal unit, share below
Output Driver	133	B01082	Share below
Plasma Gun and Laser Control			
DAC	162	KS3110	Share with Magnet Control
Output Driver	133	B01082	Share with Magnet Control
Boom Control			
Stepping Motor Control (2)	145	KS3360	Dual units
Input Register	121	NE7059-1	Used to record positions
Photomultipliers (X3)			
Scaler	111	B01004A	Quad unit
DAC	162	KS3110	Octal unit, share below
Discriminator	NIM	LRS621AL	Quad unit
High-Voltage Power Supply	NIM	ORTEC 456	
Energetic Particle Analyzer (X3)			
Input Register	121	NE7059-1	
Output Driver	133	B01082	Share with Magnetic Field Probe.
DAC	162	KS3110	Share with PMT's
Amplifier	NIM	ORTEC 485	
Pulse Height Analyzer	NIM	LRS3001	Four-quandrant mode
High-Voltage Power Supply	NIM	ORTEC 456	
Magnetic Field Probe			
ADC - Fast	161	B01244A	
Output Driver	133	B01082	Share with EPA

optical effects. The particles and fields instruments are essentially the same instruments that are used to monitor the experiments covered in the sections concerned with the active experiments and plasma physics in space. However, the optical instrumentation is more complex than simple optical diagnostics considered thus far, so the major emphasis in the passive experimental area has been placed on optical instrumentation. The equipment is similar in many respects to that found in the solar physics and astronomy payloads.

The detection and measurement of naturally-occurring and artificially-produced atmospheric emissions is the experiment that has been chosen as a representative example. The optical diagnostic equipment that is required for this experiment covers the spectral range from 40 nm to one μm. The main instrument consists of a cluster of six co-aligned independent spectrometers with each spectrometer optimized for a different spectral region. The spectral range above 110 nm is covered by four Ebert-Fastie spectrometers, and the region below 110 nm is covered by two concave grating spectrometers using a Rowland circle-type mounting. The extreme ultraviolet (EUV) spectrometers are identical except for their detectors. A variety of detectors will be utilized with the six spectrometer instruments.

The Ebert-Fastie spectrometers all use photomultiplier detectors with window/photocathode combinations appropriate to the particular spectral region being analyzed. Single-photon-counting data processing is used for maximum sensitivity. These instruments are scanning spectrometers and consequently grating movement control is required. Control is also required for the spectrometer slits to set the spectral resolution.

One of the EUV spectrometers uses photographic film for data acquisition and, hence, only requires camera and grating control. The other EUV spectrometer uses a position-sensitive microchannel plate detector to provide the electronic equivalent of the photographic film with single-photon-counting sensitivity.

The spectrometer cluster is mounted on a small instrument pointing system (SIPS) that provides pointing for the group of instruments. Since the SIPS is a Spacelab-furnished facility, the associated control electronics are not considered here for NIM/CAMAC implementation.

3.5.6.2 CDMS Implementation with NIM/CAMAC

The block diagram of the CDMS required for the passive optical experiment is shown in Figure 3-38. The four Ebert-Fastie spectrometers are identical so far as the CDMS is concerned. Similarly, the grating control function and slit width control are handled in the same way in all of the spectrometers. For both of these functions, the mechanism can be driven by a stepping motor. A CAMAC dual stepping motor controller is provided for each spectrometer to control the grating and slit drive motors. The position of each mechanism is monitored with CAMAC dual 16-bit parallel input registers.

The photomultiplier pulse analog output signals are processed with fast NIM amplifiers and discriminators and accumulated in a CAMAC scaler. The scaler contents are read out to the computer in synchronism with the grating scanning program. High voltage for the photomultipliers is provided with the conventional CAMAC DAC/NIM HVPS combination.

The EUV spectrometer with electronic data acquisition uses a continuous resistive anode technique to provide a one-dimensional position-sensitive readout. A NIM dual sum/invert amplifier is used to generate the sum and the difference of the signals at each end of the resistive anode. Each resultant signal is digitized with a fast CAMAC ADC. The high voltage needed by the microchannel plate detector is provided in the usual fashion.

Finally, a CAMAC output driver is used to provide film advance signals to the camera and sixteen channels of general housekeeping data acquisition are provided with a slow multichannel CAMAC ADC. The NIM and CAMAC modules used for the entire system are listed in Table 3-29.

3.5.7 AMPS Payload Summary

Table 3-30 summarizes the NIM and CAMAC equipment required for the CDMS implementation of the AMPS payload. The number of modules required is tabulated and, as previously noted, many of the modules provide a number of identical channels or functions.

A reasonably large number of NIM modules are required for this payload, but over one-half of them are high-voltage power supplies. Also, the next most frequently used modules (wave analyzers and differential amplifiers)

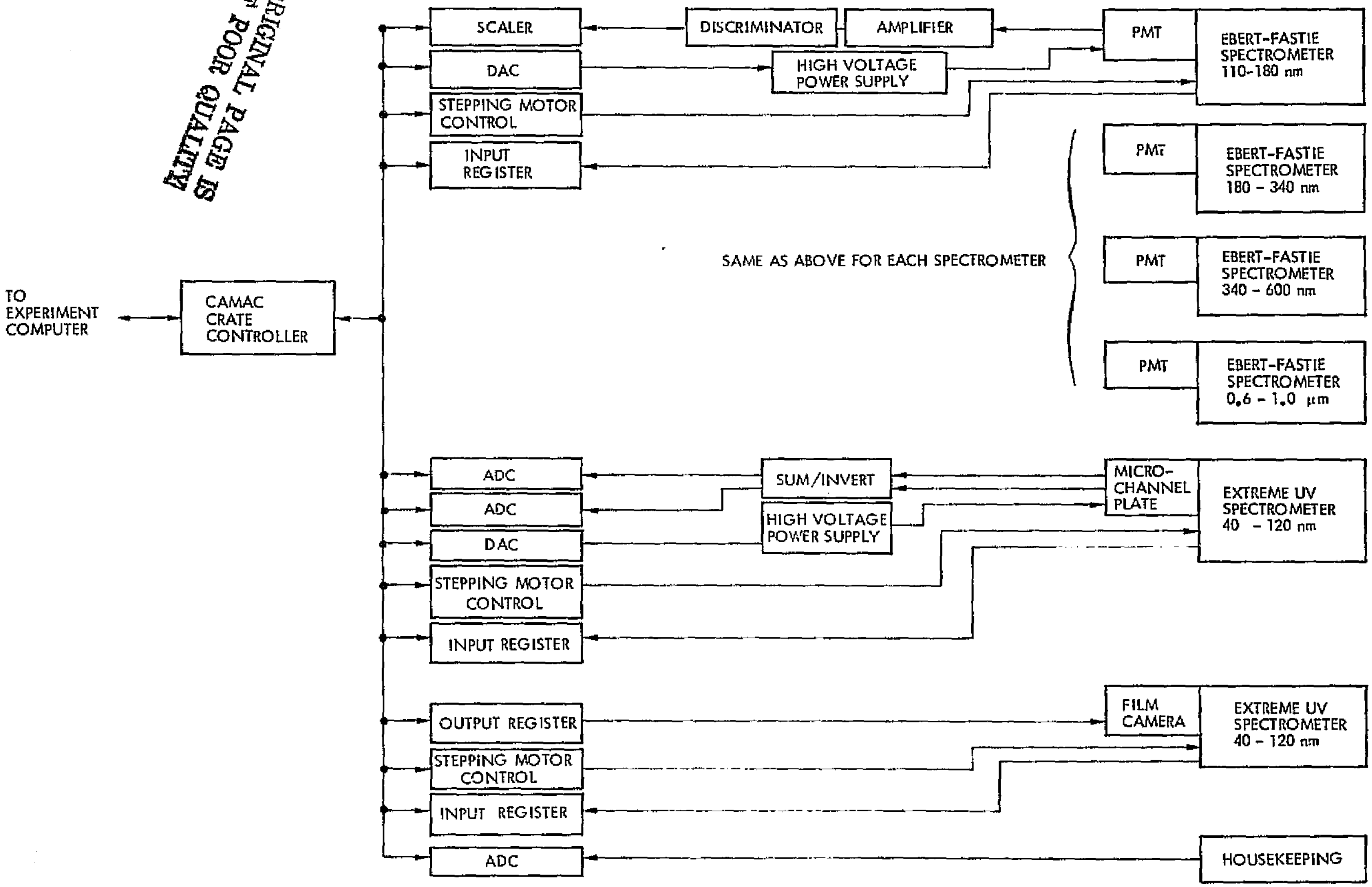

Figure 3-38. AMPS Passive Optical Experiment NIM/CAMAC Implementation

Table 3-29. NIM/CAMAC Equipment for Passive Optical Experiment

System Element	CAMAC Product Code	Specific Example	Comments
Ebert-Fastie Spectrometer			
Scaler	111	B01004A	Quad unit
DAC	162	KS3110	Octal unit, share below
Stepping Motor Controllers (4)	145	KS3360	Dual units
Input Register (2)	121	SE PG601	Dual units
Amplifier	NIM	LRS335	Quad unit
Discriminator	NIM	LRS621AL	Quad unit
High-Voltage Power Supplies (4)	NIM	ORTEC 456	
Extreme UV Spectrometer			
ADC - Fast (2)	161	B01244A	Bipolar input
DAC	162	KS3110	Share with E-F Spectrometer
Stepping Motor Controller	145	KS3360	Dual unit
Input Register	121	NE7059-1	Share below
Sum/Invert Amplifier	NIM	ORTEC 433A	Dual unit
EUV Spectrometer-Film			
Output Driver	133	B01082	Dual unit
Stepping Motor Controller	145	KS3360	Dual unit
Input Register	121	NE7059-1	Share with EUV Spectrometer
Housekeeping			
ADC - Slow	161	KS3510	Sixteen-channel

Table 3-30: AMPS Use of NIM and CAMAC Equipment

CAMAC Equipment	CAMAC Product Code	Accelerator	Pertubing Body	Gas Release	LHR Frequency	Magnetic Confinement	Passive Optical	Totals
		Experiment						
Scaler	111	2	1	1		1	1	6
Input Register	121	1	2	1	1	2	3	10
Output Driver	133	2	2	2	1	2	1	10
Stepping Motor Driver	145		3	2	2	2	6	15
Analog-to-Digital Converter	161							
Single Unit - Fast		2		6	2	1	2	13
Multichannel - Slow		1	1	1	1	1	1	6
Digital-to-Analog Converter	162	2	2	1	1	2	1	9
Branch Driver	211				Share 1			1
Crate Controller	231				Share 4			4
Crate	411				Share 4			4
NIM Equipment								
Shaping Amplifier						3	1	4
Discriminator		1	1	1		1	1	5
High Voltage Power Supply		11	12	4	2	6	5	40
Pulse Height Analyzer						1		1
Sum/Invert							1	1
Bin					Share 8			8
Special Modules								
Differential Amplifier			6		2			8
Wave Analyzer		2		6	2	1		11

are special or custom-built modules, which are not currently manufactured in NIM form, but could be NIM-packaged. Therefore, in spite of the significant number of NIM modules identified, the AMPS payload should not necessarily be considered to be a heavy user of NIM equipment.

In contrast to the situation for NIM, the AMPS requirements for CAMAC modules spread rather uniformly over the module types. Hence, a significant use of CAMAC equipment is possible in the AMPS payload.

3.6 EARTH OBSERVATIONS INSTRUMENTS

The Space Shuttle will be invaluable as a platform from which to make astronomical observations of planets, stars, and galaxies but it will also be heavily used for remote sensing observations of the earth. From its 300 to 400 km altitude, it has an ideal vantage for detailed observations of both atmospheric and surface phenomena. Included in the studies will be measurements related to agriculture, energy minerals, forestry, land use and marine statistics.

There is a multitude of instruments that will be used aboard the Shuttle for the study of the earth and its resources. Of these, six have been selected in this study to analyze the applicability of NIM and CAMAC hardware to their command and data management systems. These six instruments are described in Table 3-31. The signal inputs to these instruments cover large regions of the spectrum and, because of this, the instruments represent a fairly complete cross section of the types of earth-observing sensors that will be used.

The following sections analyze the usefulness of NIM and CAMAC equipment for interfacing these instruments into the Spacelab provided CDMS. Two of the instruments, the 13-band Multispectral Scanner and the Microwave Scatterometer, have previously been analyzed in terms of NIM and CAMAC by the Bendix Corporation. Their results were reviewed and incorporated.

3.6.1 Lidar

3.6.1.1 Experiment Description

The purpose of the Lidar experiment is to study the structure, composition and dynamics of the earth's atmosphere at altitudes below 120 km. The experiment operates by firing a laser into the atmosphere from the Space Shuttle and monitoring the time distribution of the back-scattered radiation. An analysis of the time structure of the back-scattered pulse leads to conclusions about the structure and composition of the scattering medium.

Another parameter that needs to be varied in the experiment to better characterize the scattering medium is the wavelength of the laser radiation. It is expected that lasers operating in the ultraviolet, visible and infrared out to 10 μm (CO_2) will be used. Since some of the scattering processes change the wavelength of the scattered radiation, it is also informative

Table 3-31. Earth Resources Instruments

Lidar

- Three types of detectors
  - Photomultipliers (2000 Å to 8000 Å)
  - Fast Photodiodes (.8 μ to 8 μ)
  - Cd Hg Te (10 μ)
- Monitor time distribution backscattered photons
- Analyze spectral distribution

Infrared Radiometer

- Wavelength one to twenty microns
- Perform vertical temperature soundings
- Fine spectral resolution
  - Interference Filters
  - Fourier Spectrometer
- Related to IRIS and VTPR

Microwave Radiometer

- Wavelength 30 cm to 3 mm
- Planar antenna array
  - Scanned with phase variations
  - 78 discrete steps in ± 50 degrees of nadir
- Similar to ESMR on nimbus

Camera Systems

- Pointable ID camera
- Panoramic camera
- Wide-angle framing camera
- Multispectral camera system
- High-resolution multispectral camera
- Multiresolution framing camera

S-192 Thirteen-band Multispectral Scanner (Bendix)

- .52 μ to 12.5 μ
- Scanning via mirror rotation
- Multiple data sampling modes
- 28-k data buffer

S-103 Microwave Scatterometer (Bendix)

- Three instruments in one
  - Radiometer
  - Scatterometer
  - Radar Altimeter
- Wavelength 2.16 cm (13.9 GHz)
- Mechanically-scanned parabolic antenna

to measure the spectral distribution of the back-scattered light. This will be accomplished with multilayer interference filters for coarse resolution and with a spherical Fabry-Perot interferometer for fine resolution.

In addition to the measurement of back-scattered radiation, laser transmission measurements are planned using a slave satellite to reflect the beam back on itself. These measurements would be performed with the Shuttle and a slave (or sub) satellite. This technique is particularly suited to determining the integrated concentration of a given constituent along the beam path by making two transmission measurements at wavelengths within and just outside an absorption line of the molecule.

For both the back-scattering and transmission-types of measurement, a 1-m^2 telescope accurately aligned to the beam direction will serve to collect the returning radiation. One of three types of detectors will be located at the focus of the telescope. The choice will depend on the wavelength region:

- for .2 μm to .8 μm, photomultipliers will be used;
- for .8 μm to 8 μm, fast photodiodes will be used;
- at 10 μ (CO_2 laser), CdHgTe detectors will be used.

Initially, these detectors will operate without cryogenic cooling but that capability may be added as the system is improved. Since the total duration of the back-scattered pulse is only on the order of a millisecond, it is desirable to operate the detectors in the photon counting mode and avoid the use of an ADC. Unfortunately, this can only be done with the photomultipliers.

3.6.1.1 CDMS Implementation with NIM/CAMAC

Fairly extensive CDMS support is required for the Lidar experiment. In order to analyze the time distribution of returning photons, a multichannel analyzer of at least 100 channels with eight to ten bits per channel is required. At visible wavelengths, each channel of the analyzer will store the photomultiplier counts for one of the short time intervals after the laser is fired; thus forming a hundred-element histogram of the time dependence of the back-scattered radiation. At infrared wavelengths, the CDMS must also provide for the fast (10 to 12 μsec) digitization of the analog signals output from the detectors. The data from each firing of the laser will be displayed in the Spacelab and will also be sent immediately to earth-based laboratories for analysis and interpretation.

The CDMS must provide control signals to the laser to select the power and wavelength at which to operate. It must provide for automatic sequential firings of the laser at frequencies as high as 2 Hz. Additionally, the CDMS must process and interpret an assortment of analog and digital housekeeping data from the instrument.

The CAMAC implementation of the Lidar CDMS, shown in Figure 3-39, makes heavy use of the Spacelab experiment computer to implement the multichannel analyzer function. The returning photon counts are integrated over 10 to 20 μsec with a single scaler and transferred as separate data words to the computer. There they are processed as necessary and stored in an array to be recalled as needed for displaying the histogram or telemetering the data to earth.

The exact details of the laser control electronics are uncertain. The direct functions will certainly be peculiar to the lasers that are used and cannot be implemented with standardized electronics. An output register is provided to supply digital control signals as required.

As indicated in Table 3-32, many of the CDMS requirements for Lidar can be implemented with NIM and CAMAC modules. However, neither the nonphoton-counting amplifiers nor the electronics for direct control of the lasers lend themselves to the NIM and CAMAC systems. These would have to be specially constructed with the instruments.

3.6.2 Infrared Radiometer

3.6.2.1 Experiment Description

This instrument is designed to perform temperature sounding measurements of the earth's atmosphere to aid in weather prediction. An infrared radiometer is required for the measurements because the CO_2 bands of interest lie in the infrared region of the spectrum. Of particular usefulness are the molecular vibration absorption/emission bands at 4.3 μm and 15 μm. Because these must be measured with a spectral resolution of at least five wave numbers, it is necessary that the infrared radiometer be able to isolate small spectral regions. This can be done with interferometric techniques as in the IRIS (Infrared Interferometeric Spectrometer) but adequate resolution can also be achieved with filters. It is the instrumentation of such a filter radiometer that will be considered here.

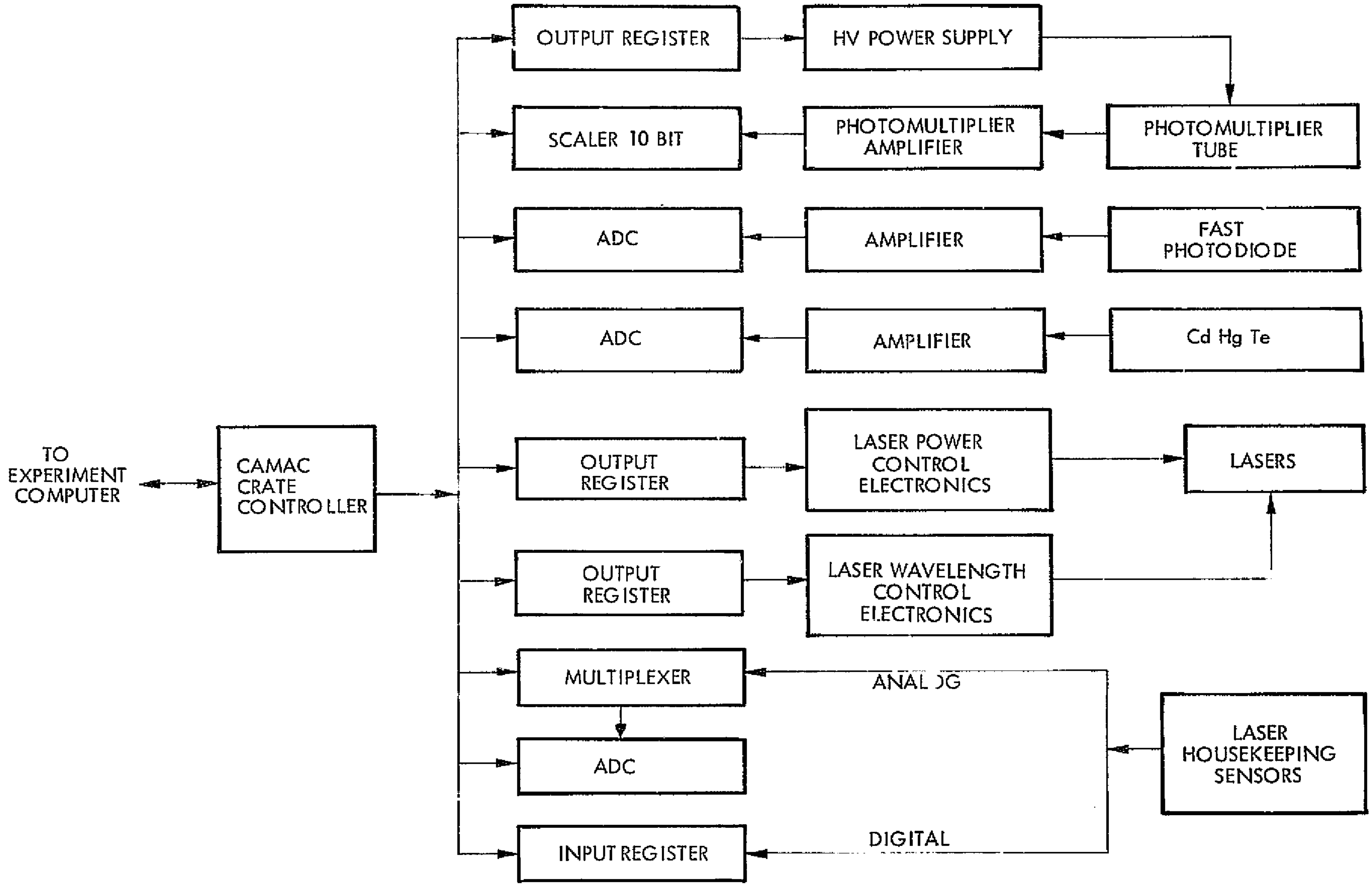

Figure 3-39. Lidar NIM/CAMAC Implementation

Table 3-32. NIM/CAMAC Implementation of Lidar

System Element	CAMAC Product Code	Specific Example	Comments
Detector System			
Photomultiplier Amplifier	NIM	ORTEC 276	
Amplifiers (2)	None		
Scaler (10 bit)	111	B01002	
ADC (2)	161	B01243A	11-μsec conversion time
HV Power Supply	NIM	ORTEC 456	
Output Register	133		Use one bit of register below
Laser Control			
Power Control Electronics	None		
Wavelength Control Electronics	None		
Output Register (2)	133	KS3080	
Housekeeping Signals			
ADC	161	KS3510	
Multiplexer	164		
Input Register	121	NE7059-1	

An example of a filter radiometer is the Vertical Temperature Profiling Radiometer (VTPR) shown in Figure 3-40. This instrument operates in either a measurement or calibration mode. In the measurement mode, the scan mirror sweeps across the earth in 23 discrete steps. There is an eight-segment, narrow-band filter wheel located directly in front of the detector. This is rotated at 16 Hz in synchronization with a chopper wheel directly in front of the detector. The rotations are such that the detector first views the target for 31.25 msec through a filter and then views the 308° K reference of the chopper blade while the filter wheel is changing to the next filter. In the calibration mode, the view of the target is replaced by a view of a calibration source within the instrument. Figure 3-41 shows the optical configuration of the VTPR.

3.6.2.2 CDMS Implementation with NIM/CAMAC

The CDMS requirements to support this instrument are quite straightforward. The primary requirement is to provide for the digitization of the analog signals from the infrared detector. It is presumed that an integral

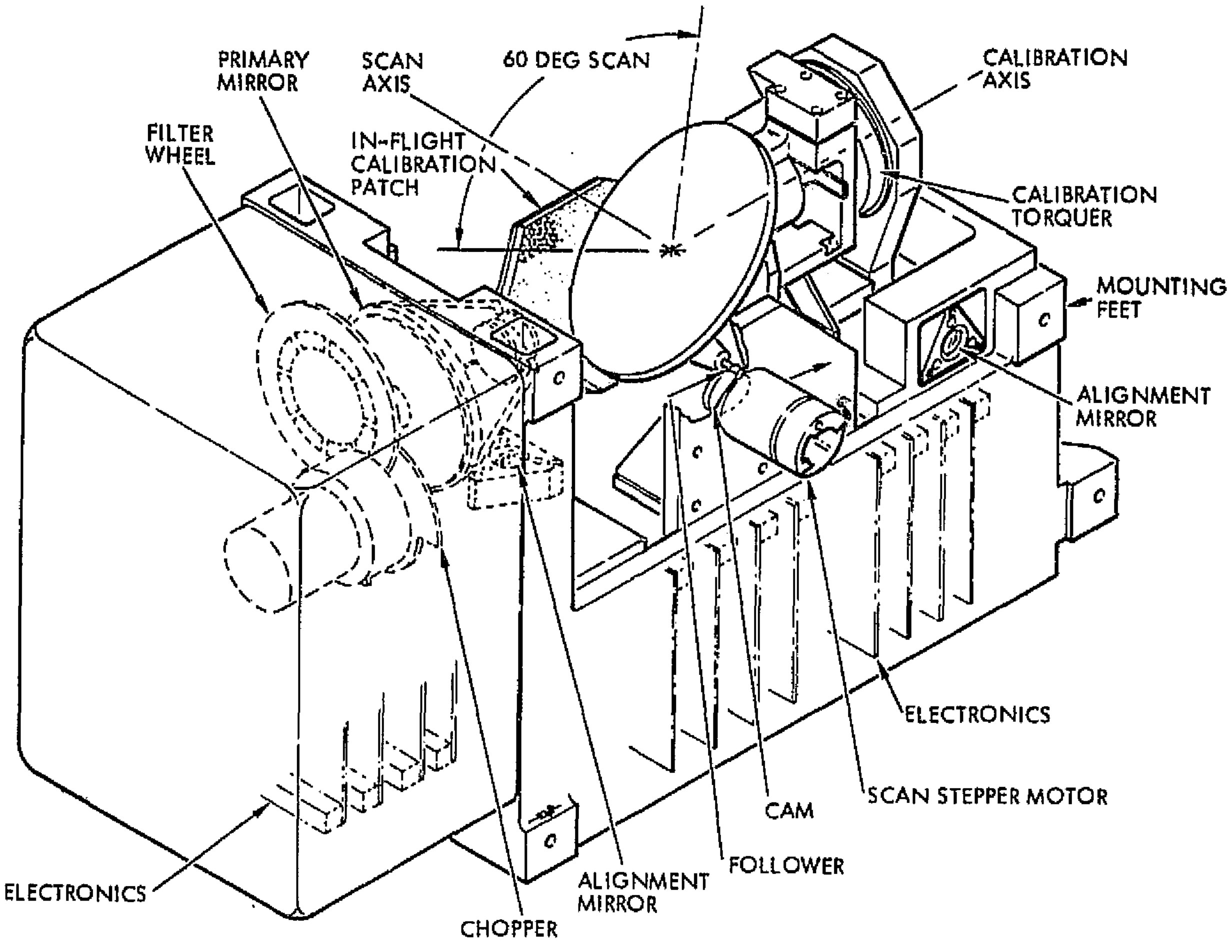

Figure 3-40. Isometric View of VTPR

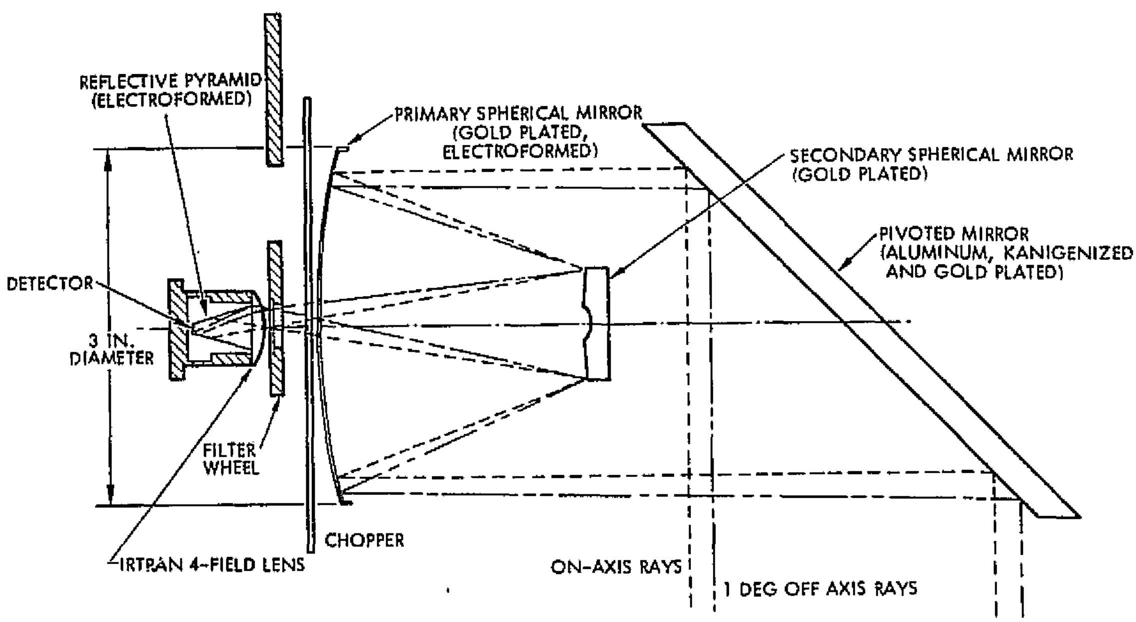

Figure 3-41. VTPR Optical Configuration

part of the detector system will be the low-level electronics that perform the preamplification of the signal and that the CDMS need only worry about processing the signal after this initial amplification stage. The digitization of the detector signal must be performed in synchronization with the chopping of the signal. This is easily managed since the CDMS also provides the control signals to the stepper motor which rotates both the chopper and the filter wheel.

The CDMS also must control the operation of the stepper motor which moves the scanning mirror. Also, several temperature measurements will be made regularly throughout the instrument and will be used to send back an analog signal to a heater in the instrument to maintain it at a constant operating temperature.

Figure 3-42 shows that the implementation of the CDMS functions for the infrared Rodiometer are quite straighforward and easily handled by NIM and CAMAC equipment. This instrument is implemented in a manner very similar to the SIRTF Filter Photometer.

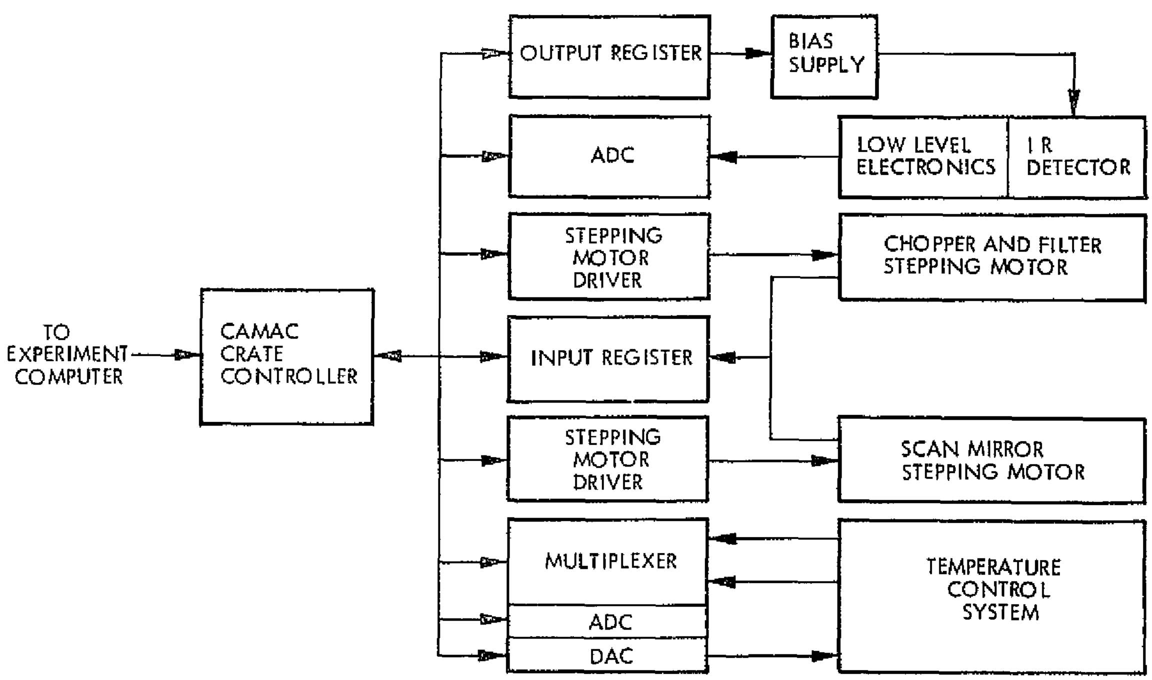

Figure 3-42. VTPR NIM/CAMAC Implementation

Table 3-33 summarizes the NIM and CAMAC modules that would be required to build the CDMS for the Infrared Radiometer. The only element in the system that cannot be handled by either NIM or CAMAC equipment is the low-level electronic function associated with the detector. These would have to be specially designed for that purpose.

3.6.3 Scanning Microwave Radiometer

3.6.3.1 Experiment Description

The microwave region of the spectrum is generally considered to be from about one GHZ to 100 GHz (or λ = 30 cm to λ = 3 mm). Earth observations at these wavelengths primarily observe thermal emission from the earth's surface and from atmospheric constituents such as clouds rain drops, and dust. Compared to optical and infrared wavelengths, the atmosphere is generally much more transparent at microwave wavelengths with the exception of a few significant absorption bands due to water vapor and oxygen. Because of this penetration property, microwave observations, in conjunction with simultaneous visible and infrared cloud maps, can be used to differentiate water clouds from cirrus and ice clouds.

The microwave scattering effects from atmospheric constituents are in the transition region between Rayleigh and Mie scattering and show marked frequency variations in effective emissivities and extinction coefficients. This results in a very complicated inversion process to determine from the observed microwave radiance the temperature and physical nature of the emitting material. As a result, single measurements are frequently ambiguous and multiple measurements under varying conditions are required to evaluate all of the characteristics of the emitting medium.

The scanning function of the microwave radiometer is achieved by phase variations across a planar array antenna. This electrical scanning, rather than mechanical movement of the antenna, avoids problems of attitude perturbations of the spacecraft and also results in a more compact antenna than a corresponding parabolic reflector and feed combination. The signal-to-noise ratio is maximized by operating the radiometer in the Dicke-switched mode using a 340° K reference load. The operational wavelength of the radiometer is chosen to avoid the emission lines of O_2 and H_2O at 0.5 cm and 1.35 cm, respectively, and the operating regions of earth-based radar.

Table 3-33. NIM/CAMAC Implementation of Infrared Radiometer

System Element	CAMAC Product Code	Specific Example	Comments
<u>Detector System</u>			
ADC	161	B01244A	
Output Driver	133	OD1614	
Bias Supply	NIM	ORTEC 456	
Low-Level Electronics	None		
<u>Chopper and Filter Motor</u>			
Stepping Motor Driver	145	KS3361	
Input Register	121	NE7059-1	
<u>Scan Mirror Motor</u>			
Stepping Motor Driver	145	KS3361	
Input Register	121	NE7059-1	Share register above
<u>Temperature Control System</u>			
Multiplexer	164	KS3510	
ADC	161		
DAC	162	D0200-1518	

3.6.3.2 CDMS Implementation with NIM/CAMAC

Extensive CDMS support is required to operate the microwave scanning radiometer. Figure 3-43 shows the block diagram for an Electrically Scanning Microwave Radiometer (ESMR) designed for the Nimbus program. This instrument consists of four major components:

- a phased-array microwave antenna (83.3 cm x 85.5 cm) consisting of 103 waveguide elements each associated with an electrical phase shifter;
- a microwave receiver with a center frequency of 19.35 GHz and an IF bandpass that extends from 50 to 150 MHz;
- a beam steering computer that determines the coil current for each of the phase shifters;
- timing, control, and power circuits.

When such an instrument is flown aboard Spacelab, the functions of the last two components will be fulfilled by the Spacelab CDMS. In particular, the experiment computer will be used to compute the series of signals to each of the 103 phase shifters in order to scan the beam in 78 discrete steps through the nadir to ± 50-degree cross track.

The functional block diagram in Figure 3-44 shows the implementation of the CDMS functions of the experiment using CAMAC equipment and the facilities provided by Spacelab. It is important to note that all of the electronics associated with processing the microwave and IF signals are outside the scope of CAMAC or NIM and must be specially constructed as an intrinsic part of the experiment. Also intrinsic to the experiment is the circuit matrix that generates the actual beam steering signals to the phase shifters although the CAMAC system with the experiment computer performs all of the beam steering calculations and provides digitized control information to the steering circuits.

The CAMAC equipment required for this experiment is summarized in Table 3-34. The most noteworthy item is the beam steering control unit. CAMAC makes extensive use of the experiment computer to calculate the beam steering parameters, but it also requires four CAMAC modules to output all of this information to the actual steering circuits. The four output drivers specified each can handle 128 bits of information, so a total of 512 bits of steering information can be transferred from the computer at one time.

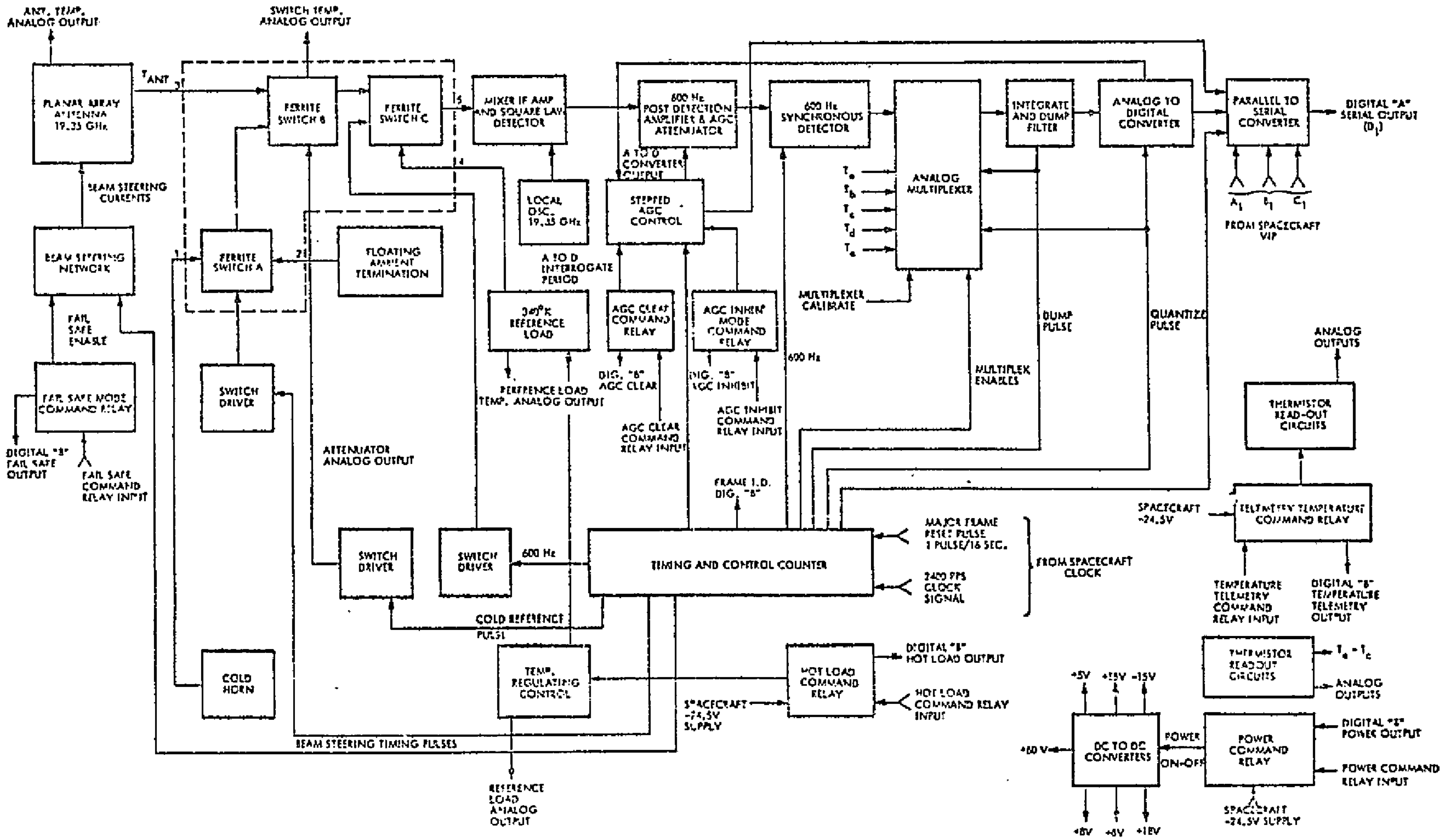

Figure 3-43. ESMR Block Diagram

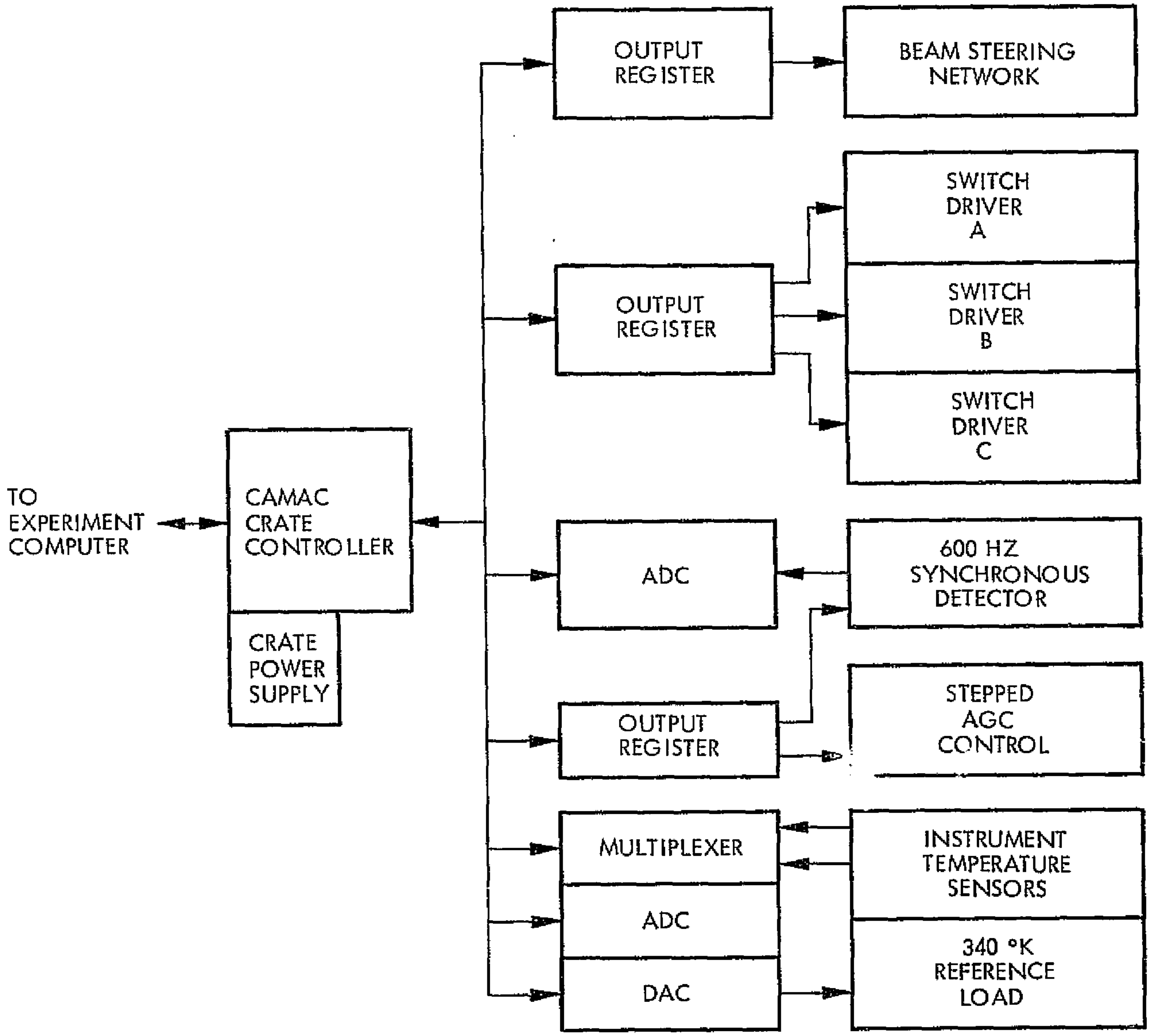

Figure 3-44. ESMR NIM/CAMAC Implementation

Table 3-34. CAMAC Implementation of Microwave Radiometer

System Element	CAMAC Product Code	Specific Example	Comments
Beam Steering Control			
Output Driver (4)	133	BR3212	3212 BiRa (128 bits) Computer handles beam steering calculations.
Switch Driver Control			
Output Driver (1/2)	133	OD1613	Share driver with AGC control
Signal Digitization			
ADC	161	BO1244	
AGC Control			
Output Driver (1/2)	133	OD1613	Share driver with switch driver control.
Temperature Control System			
Multiplexer	164	KS3510	
ADC (8 bit)	161		
DAC	162	NE7015	

3.6.4 Cameras

3.6.4.1 Experiment Description

Most earth observation payloads for Shuttle will use one or more film camera systems for purposes of target area identification, cartographic and topographic mapping, and obtaining multiband monochrome, color, and false color images with various degrees of spatial resolution. The primary characteristics of these various camera systems have been summarized in Volume III of the TRW study, "Mission Requirements for a Manned Earth Observatory," NAS 8-28013, 1973. This information is summarized below.

Six potential film camera systems have been identified for the earth observation payloads.

Pointable Identification Camera - This will use panchromatic color film with a 70-mm format for general identification photography of broad target areas. Two-axis gimballing will be required for pointing of the camera.

Panoramic Camera - This camera uses 13- x 14-cm film to obtain either high-resolution-vertical or stereopanoramic photography. The cross-track field of view is 120 degress and stereophotography is obtained by nodding the camera about the pitch axis through an angle of ± 12.5 degrees.

Wide-Angle Framing - This uses 24- x 48-cm film and has been recommended by the U. S. Department of Interior for use with the Panoramic Camera for mapping. The primary feature of this camera is the high geometric fidelity of the image, enabling cartographic mapping to be performed.

Multispectral Camera System - This uses a group of six metric cameras and 24- x 24-cm film to obtain multiband images on black and white film in four spectral bands in addition to color and false color photography with the other two cameras.

High-Resolution Multispectral Camera System - This uses telephoto optics with a field of view of 1.75 degrees to obtain multiband monochrome, color, and false color images of specific areas of interest.

Multiresolution Framing Camera System - This uses three bore-sighted 24- x 24-cm format cameras with lenses of 46.92- and 184-cm focal length for simultaneous observations of the same target area with three different values of ground resolution. Using false color film in all three cameras, this will enable experimentation to determine resolution requirements for future observations in the experimental areas of lake eutrophication, coastal and geomorphic processes, urban surveys, wildlife ecosystem studies, and geologic mapping.

3.6.4.2 CDMS Implementation with NIM/CAMAC

The CDMS requirements for the earth-observation cameras are very similar to those for the ATM/Skylab cameras. It is assumed that each of the cameras will have a diode array of 48 bits for recording information about time of exposure, length of exposure, shuttle orientation, and other exposure data. Additionally, it is assumed that each of the cameras is equipped with its own intrinsic motor drive and shutter control system which needs only a few digital commands to advance the film and choose the exposure time. By interfacing the cameras with the experiment computer, manual operation can be achieved using the keyboard input to the computer and automatic operation implemented under computer control.

The actual pointing of the cameras and control of their gimbal mounts is not discussed since these functions are assumed to be supplied as support functions by the Spacelab.

As seen in Figure 3-45, the primary elements required to interface the camera CDMS are output drivers. Except for stepper motor control of the filter wheel in the High-Resolution Multispectral Camera, all control signals for these experiments are ones and zeros transferred from the computer to the cameras via the output drivers.

Table 3-35 enumerates the output driver modules required to handle the interface to the camera experiments. Some savings in required hardware is obtained by sharing modules between camera systems. However, because of the 48 bits required to drive the diode matrix in each camera, the system still requires 17 output driver modules.

3.6.5 Thirteen-Band Multispectral Scanner

This instrument was part of the Skylab Earth Resources Experiment Package (EREP) where it was labeled S-192. It was a line-scanning radiometer used to scan lines across the Skylab flight path. It obtained data in thirteen spectral regions from 0.52 μ to 12.5 μ about energy reflected and emitted by the earth's features.

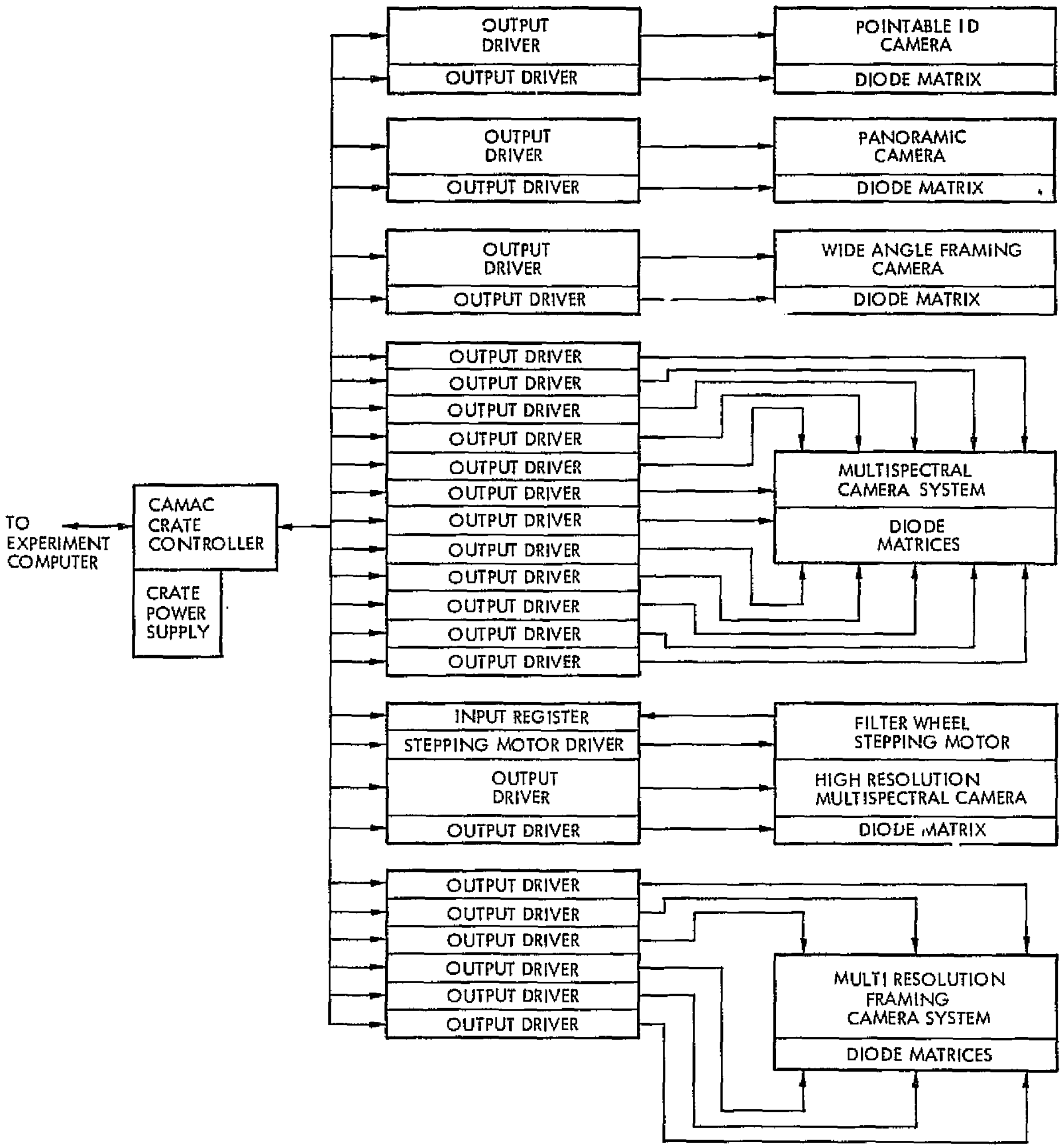

Figure 3-45. Earth Observation Facility Camera System NIM/CAMAC Implementation

Table 3-35. CAMAC Implementation for Earth Resources Camera Systems

System Element	CAMAC Product Code	Specific Example	Comments
<u>Pointable ID Camera</u>			
Output Register (1/4)	133	NE9017	Allow 12 bits for camera control.
Output Driver	133	OD2407	
<u>Panoramic Camera</u>			
Output Register (1/4)	133	NE9017	Share one NE9017
Output Driver	133	OD2407	
<u>Wide-Angle Framing Camera</u>			
Output Register (1/4)	133	NE9017	
Output Driver	133	OD2407	
<u>Multispectral Camera System</u>			
Output Registers (6/4)	133	NE9017	Two required
Output Drivers (6)	133	OD2407	
<u>High-Resolution Multispectral Camera</u>			
Stepping Motor Driver	145	KS3361	
Input Register	121	NE7059-1	
Output Register (1/4)	133	NE9017	Share one NE9017
Output Driver	133	OD2407	
<u>Multispectral Resolution Framing Camera</u>			
Output Register (3/4)	133	NE9017	
Output Drivers (3)	133	OD2407	

This was one of two earth resources experiments which was studied by Bendix to analyze the applicability of NIM and CAMAC instrumentation to the implementation of the data processing system. Their results, including a detailed discussion of the operation of the instrument, are reported in their final report, BSR4142, June 1974. These results were reviewed and found quite reasonable. Their conclusions about NIM and CAMAC applicability to the multispectral scanner are shown in Table 3-36, adapted from BSR4142, page 3-75, Table 3.5.4.

3.6.6 Microwave Scatterometer - Like the Multispectral Scanner, this instrument was flown on Skylab as part of the Earth Resources Experiment Package and was included as part of the Bendix Study, BSR4142. In Skylab it was known as the Orbital Microwave Radar System (S-193) and was operated alternately as a radiometer, a scatterometer, and a radar altimeter. It operated in the 500-MHz to 14-GHz region.

Bendix has analyzed the control and data management system required to support this instrument and has developed a NIM and CAMAC implementation of this system. They concluded that NIM and CAMAC are totally unsuitable standards for handling the RF portions of an experiment like this. However, they did find application for NIM and CAMAC modules in the areas of higher order data processing to be done on the signals. Their analysis of the instrument is contained in Section 3.6 of BSR4142. This has been reviewed and their conclusions are incorporated here as Table 3-37 which is adapted from their report.

3.6.7 Earth Observations Payload Summary

The uses for NIM and CAMAC equipment developed in the preceding sections are summarized in Table 3-38. The results for the two experiments studied by Bendix are included.

One thing that stands out in the table is the very sparse use of NIM equipment. This is due to the fact that many of the signals from the sensors studied, especially those in the microwave region of the spectrum, cannot be suitably handled by NIM equipment. In addition, data from the cameras are recorded directly on film and require no processing at all.

Table 3-36. CAMAC Implementation for Thirteen-Band Multispectral Scanner (Bendix)

System Element	CAMAC Product Code	Specific Example	Comments
Position Encoder	117	EG&G PE019	
Input Gate	121	KS3420	24-channel
Intercept Register	123	EG&G IR026	12-channel/NIM input
Output Register	132	KS3072	Dual, 24-bit
Stepping Motor Controller	145	KS3361	
ADC-Multiplexer	161	BR5301	32-channel

Table 3-37. CAMAC Implementation of Microwave Scatterometer (Bendix)

System Element	CAMAC Product Code	Specific Example	Comments
Position Encoder	117	EG&G PE019	
Input Gate	121	KS3420	24-channel, 2 required
Interrupt Register	123	EG&G IR026	12-channel, NIM input
Output Register	132	KS3072	Dual, 24-bit, 2 required
ADC-Multiplexer	161	BR5301	32-channel plus two
Multiplexer	164		32-channel expanders

Table 3-38: Earth Observations Use of NIM and CAMAC Equipment

CAMAC Equipment	CAMAC Product Code	LIDAR	Infrared Radiometer	Microwave Radiometer	Camera Systems	MSS (Bendix)	Microwave Scatterometer (Bendix)	Totals
		Instruments						
Scaler	111	1						1
Position Encoder	117					1	1	2
Input Register	121	1	1		1	1	2	6
Interrupt Register	123					1	1	2
Output Register	132					1	1	2
Output Driver	133	2	1	5	17			25
Stepping Motor Driver	145		2		1	1	2	6
Analog-to-Digital Converter	161							
Single Unit - Fast		1	1	1				3
Multichannel - Slow		1	1	1		1	1	5
Digital-to-Analog Converter	162		1					1
Multiplexer	164						2	2
Branch Driver	211				Share 1			1
Crate Controller	231				Share 3			3
Crate	411				Share 3			3
NIM Equipment								
High Voltage Power Supply		1						1
Amplifier/SCA		1						1
Bias Supply			1					1
Bin		1						1

The other noteworthy item in the table is the requirement for 25 output drivers. This number reflects the large demand for these modules by the camera systems where they are used to drive the many arrays of light-emitting diodes that identify each image frame.

3.7 LIFE SCIENCES LABORATORY

In order to assess the CDMS requirements for the Spacelab Life Sciences experiments the representative payload selected was the 30-Day Dedicated Laboratory described in the General Dynamics/Convair study report number CASD-NAS-74-046. This is the largest laboratory that might be flown in the Spacelab. As such it represents the maximum requirements for the CDMS.

The Convair study of this laboratory treats the various experiments in terms of equipment units and summarizes the data processing requirments for each of these units. For the purpose of this study the Convair equipment units will be grouped together into five functional categories. These are:

- Biochemical/Biophysical Analysis
- Biomedical Studies
- Data Management and Laboratory Support
- Holding Units and Research Support
- Other Equipment Units

This functional grouping breaks the CDMS requirements for the 30-Day Dedicated Laboratory into categories of manageable size for analysis.

The Convair study summarizes all of the Life Sciences equipment that must be interfaced with the data management system and tabulates the data sampling rates required of each piece of equipment. This summary is reproduced here as Table 3-39.

Table 3-39. Life Sciences Dedicated Laboratory Data Handling Requirements

EQUIPMENT UNIT (EU NO.) & EQUIPMENT ITEM (E.I. NO.)	MEASUREMENT DESCRIPTION OR COMMENT	SAMPLED DATA REQUIREMENTS: Sampling Rate bps	Sampling Duration min/day	Total kbits per day	DOWNLINK REQMTS.: %	kbits/day	DISPLAY REQUIRED	PROCESSING REQUIRED BY CONTROL COMPUTER OR LOCAL ELECTRONICS
Data Management Unit (EU2)								
Display/Keyboard, Portable (63B)	Provides crew guidance at the experiment site. Includes alphanumeric & CRT displays and control keyboard. This device was assumed to be hard wired to the DMS.	0	0	0	0	0	None	The portable display keyboard will require considerable software specific to the experiments being supported.
Couplers, ECG (64), EEG (65), and EMG (66)	Conditions electrophysiological signals from organisms or man. Assumed 6 continuous and 16 intermittent signals.	21,000 56,000	cont. 10 (typical)	1,814,000 33,600	0.1 5	1814 1680	Numeric, CRT, & Warning	Wave form analysis and comparison.
Oscilloscope (132)	Portable unit for display at the experiment site - hard wired to couplers (above) or other sensors which provide the interface to the DMS.	0	0	0	0	0	None	None other than that provided internal to the oscilloscope.
Photocell Couplers (138B)	Monitors light levels in various cages and cage modules including those for plants.	84	cont.	7,260	0	0	Numeric & Warning	Out-of-tolerance comparison.
Pressure Sensor Couplers (143G)	For blood pressure measurements.	2,800	17	2,856	1	28	Numeric & CRT	None.
Signal Conditioners (156)	For miscellaneous physical and physiological measurements.	2,450	21	3,087	1	31	Numeric & CRT	Out-of-tolerance comparison.
	TOTALS	21,084 61,250	cont. intermitt.	1,860,803		3553		
Life Sciences Support Unit (EU 3)								
Accelerometer Coupler (1A)	Measures crew body accelerations.	10,500	60	37,800	1	378	Numeric & CRT	Simple wave form analysis.
Gas Supplies (93A)	Monitors gas vessel pressures.	1	cont.	60	0	0	Numeric & Warning	Rate-of-change analysis.
Power Conditioning Equipment (143)	Includes 6 voltage and amperage monitors.	1	cont.	60	0	0	Numeric & Warning	Out-of-tolerance comparison.
Water Conditioning Equipment (188)	Includes water tank expulsion bladder pressure monitors.	negl.	cont.	40	0	0	Numeric & Warning	Out-of-tolerance comparison.
	TOTALS	2 10,500	cont. intermitt.	37,960		378		
Preparation & Preservation Unit (EU4)								
Freezer, Cryogenic (77B)	Monitor freezer temp. and pressure.	negl.	cont.	14	0	0	Numeric & Warning	Out-of-tolerance comparison.
Freezer, Low Temp. (81)	Monitor temperature.	negl.	cont.	1	0	0	Numeric & Warning	Out-of-tolerance comparison.
Frig. (Refrigerator) (83)	Monitor temperature.	negl.	cont.	1	0	0	Numeric & Warning	Out-of-tolerance comparison.
	TOTALS	0		16		0		
Biochemical/Biophysics Analysis Unit (EU 5)								
Autoanalyzer (7)	Data entered includes specimen I.D., type of analysis, and measured value.	negl.	33	5	5	negl	Numeric	Processing assumed to be done internal to the autoanalyzer.
Commutator, Gas Manifold (50A)	Monitor commutation valve position to determine source of gas being analyzed.	negl.	cont.	6	0	0	Numeric	None.
Fibrometer, Blood Clot (76L)	Data entered includes specimen I.D. and clotting time.	1	4	negl.	5	negl.	Numeric	Processing is performed internal to the automatic fibrometer.
Blood Gas Analyzer (85)	Based on use of NASA's Automated Potentiometric Electrolyte Analyzer, measurements could include pH, CO_2, O_2, K, Ca, Na, Cl, and glucose.	6	15	5	30	2	Numeric	Linear interpolation program required.
Gas Chromatograph (89)	Monitor GC parameters during operation and measure gas concentration values.	37	240	532	1	5	Numeric, CRT, Warning	Wave form analysis.
Mass Spectrometer (91)	Monitors digital output for matter/buffer containing information on mass number and peak heights of gases found during mass scans to detect trace constituents as well as major atmospheric components.	600	cont.	51,840	1	518	Numeric, CRT, Warning	Complex computer processing involving matrix manipulations may be required depending upon experiment requirements.
Sound Level Meter	Monitor laboratory sound levels.	14	cont.	1,210	0	0	Numeric	None.
	TOTALS	614 44	cont. intermitt.	53,598		525		

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Table 3-39. Life Sciences Dedicated Laboratory Data Handling Requirements (Continued)

EQUIPMENT UNIT (EU NO.) & EQUIPMENT ITEM (E.I. NO.)	MEASUREMENT DESCRIPTION OR COMMENT	SAMPLED DATA REQUIREMENTS: Sampling Rate bps	Sampling Duration min/day	Total kbits per day	DOWNLINK REQMTS: %	kbits/day	DISPLAY REQUIRED	PROCESSING REQUIRED BY CONTROL COMPUTER OR LOCAL ELECTRONICS
Biomedical/Behavioral Research Support Unit (EU 12)								
Electrophysiological Receiver (65C)	Monitors electrophysiological signals from man and vertebrates.	14,000	53	44,520	1	445	CRT	Wave form analysis.
Rotating Litter Chair (153A)	Measure experimental data such as subject responses, and monitor operational parameters such as rpm and acceleration.	2753	158	26,100	1	261	Numeric & Warning	Out-of-tolerance comparison.
	TOTALS	0 16,753	cont. intermitt.	70,620		706		
Biomedical Research Support Unit (EU 31)								
Exercise Equipment (bicycle ergometer used as a basis of data reqm'ts (18C)	Monitor ergometer parameters such as energy output.	13	37	29	5	1	Numeric	To be determined.
Flowmeter, Doppler (76K)	Measures instantaneous blood velocity in peripheral vessels.	700	31	1,302	1	13	CRT	To be determined.
Ultrasonoscope (76M)	Displays cross-sectional view of the heart on an oscilloscope which is included as part of the E.I. Video camera will be used to document the image.	0	N.A. (not application)	0	N.A.	N.A.	None	None.
Metabolic Analyzer (125D)	Data readouts include O_2 consumed, CO_2/O_2 ratio, respiratory minute volume, vital capacity, % CO_2, % H_2O, and % O_2. Processing to yield this data is performed internal to the E.I.	25	77	116	1	1	Numeric	Processing, if required, will depend upon specific experiments.
Coupler, Vectorcardiogram (182J)	Converts VCG signals to a format usable by the DMS interface units.	21,000	5	20,951	1	209	CRT	Probable processing will include matrix manipulation & wave form analysis.
	TOTALS	0 21,738	cont. intermitt.	22,398		224		
Small Vertebrate Holding Unit (EU 40) 2 Cage Modules (103)	Monitor temp., air flow, humidity, pressure & feeder.	7	cont.	605	1	6	Numeric & Warning	Out-of-tolerance comparison & simple computations.
Primate Holding Unit (EU 41) 2 Cages, Primate (28A)	Monitor temp., air flow, humidity, pressure & feeder.	7	cont.	605	1	6	Numeric & Warning	Out-of-tolerance comparison & simple computations.
Vertebrate Research Support Unit (EU 42)								
Couplers, Flowmeter (76H)	Monitors water flow at various points in the laboratory.	28	cont.	2,419	0	0	Numeric	Possible integration.
Transducer, Blood Pressure (181C)	Measure vertebrate blood pressure wave contour.	50	27	567	5	28	CRT	Possible wave form analysis.
	TOTALS	28 50	cont. intermitt.	2,986		28		

Table 3-39. Life Sciences Dedicated Laboratory Data Handling Requirements (Continued)

EQUIPMENT UNIT (EU NO.) & EQUIPMENT ITEM (E.I. NO.)	MEASUREMENT DESCRIPTION OR COMMENT	SAMPLED DATA REQUIREMENTS			DOWNLINK REQMTS.		DISPLAY REQUIRED	PROCESSING REQUIRED BY CONTROL COMPUTER OR LOCAL ELECTRONICS
		Sampling Rate bps	Sampling Duration min/day	Total kbits per day	%	kbits/day		
Plant Holding Unit (EU 50) Holding Unit, Plants (101)	Monitor temp., air flow, humidity, and pressure.	2	cont.	173	1	2	Numeric & Warning	Out-of-tolerance comparison.
Plant Research Support Unit (EU 51) Clinostat (50)	Monitor rotation rate.	negl.	cont.	10	0	0	Numeric	None.
Cells & Tissues Holding Unit (EU 60) 2 Holding Units, C/T (98A)	Monitor temperature, air flow, and humidity.	3	cont.	259	1	3	Numeric	Out-of-tolerance comparison.
Invertebrate Holding Unit (EU 70) Holding Unit, Invertebrates (98C)	Monitor temperature, air flow, humidity.	1	cont.	86	1	1	Numeric	Out-of-tolerance comparison.
Life Support Subsystem Test Unit (EU 80) LSS Test Bench (115F)	Monitor data from a typical test item such as Bosch reactor t, p, flow, etc.	24	cont.	2,074	1	21	Numeric	Out-of-tolerance comparison. Various performance calculations.
MSI Measurements Unit (EU 91) Psychomotor Performance Console (144)	Monitor sensor outputs which measure crews ability to perform various psychomotor tasks such as tracking, steadiness, pattern recognition, etc.	20	12	1,728	5	86	Numeric	Unknown but could be substantial.
Bioresearch Centrifuge (EU 23) Bioresearch Centrifuge (43)	Monitor vertebrate environmental parameters and centrifuge operational parameters.	14	cont.	1,210	0	0	Numeric	Out-of-tolerance comparison.
	TOTALS (FOR ALL EU'S)	21,786	cont.	[illegible]		5,539		

3.7.1 Biochemical/Biophysics Analysis

3.7.1.1 Instrument Functions and CDMS Requirements

This category of laboratory equipment (Equipment Unit 5 in the Convair study) performs the biochemical and biophysical analyses of experiment specimens and parameters. These analyses generally require more than simple instrumentation. Among the instruments in this category which must be interfaced to the CDMS are an autoanalyzer, a gas manifold commutator, a blood clot fibrometer, a blood gas analyzer, a gas chromatograph, a mass spectrometer and a sound level meter. Other instruments used for biochemical and biophysical analyses will operate with no dependence on the Spacelab CDMS. The major functions of the CDMS-dependent instruments are summarized below.

Autoanalyzer - The autoanalyzer measures blood, urine and spinal fluid properties by means of specific enzymatic reactions together with light absorbance measurements. Because a commercial unit will be adapted for Spacelab, most of the analysis operations will be performed automatically under control internal to the instrument. The data to be transferred to the Spacelab CDMS will consist only of the digitally encoded sample ID, analysis type and measured value for that analysis.

Gas Manifold Commutator - The commutator monitors valve positions to identify to the CDMS which of several test gases is currently being used. Here only an occasional sampling of the gas valve status is necessary.

Blood Clot Fibrometer - The function of this instrument is to measure the coagulation time of blood plasma to $\pm$ 0.1 second accuracy. It also will be commercial equipment adapted for space use and will supply the Spacelab CDMS with digital values of sample ID and clotting time. These must be passed to the computer for processing and then to the recording and telemetry systems.

Blood Gas Analyzer - This analyzer processes a 1 ml blood sample to measure pH and the concentrations of CO_2, Na, K, Cl, ionized Ca and total Ca. It also measures gases from urine samples. If a non-commercial unit is used the CDMS will have to provide both analog and digital control signals to the instrument and digitize the analog data produced by the instrument.

Gas Chromatograph - This instrument measures the concentration of individual gases in gas mixtures. In particular it monitors such gases as O_2, N_2, H_2, CO_2, H_4, H_2O, and NH_3 down to the parts per million range. When the instrument is operated (~6 hrs/day) the CDMS is used close to the thermal control loop on the chromatographic columns and to digitize the analog data from the detectors. The CDMS computer also performs waveform analyses of the data to determine the gas concentrations present.

Mass Spectrometer - This instrument performs measurements of gas concentrations much the same as the gas chromatograph but can achieve higher sensitivity in some circumstances. Although a self-contained commercial unit requiring very little CDMS interface might be adapted it will be assumed here that a more Spacelab-specific unit is used requiring fairly complete control by the CDMS. This device will require control signals to modulate the peak scanning fields, stepping motor signals to actuate sample admission valves and ADC channels for monitoring temperatures and digitizing the detected signal. Extensive computer processing of the data may be required to determine gas compositions.

Sound Level Meter - The sound level meter monitors ambient acoustical levels producing an analog signal which must be digitized for processing, recording and telemetry.

3.7.1.2 CDMS Implementation with NIM/CAMAC

The block diagram of Figure 3-46 details the CAMAC implementation of the biochemical/biophysics instrumentation interface to the Spacelab CDMS. Because most of the instruments are adapted commercial units and quite self-contained the bulk of the interfacing is done with input registers and ADC's. However, considerable use is made of CAMAC capability in providing detailed control to the mass spectrometer instrument. Here both a fast ADC for the main signal and a multichannel ADC for thermal control are used. Additionally, the mass spectrometer uses an input register and three stepping motor drivers to control the movement of samples through the instrument.

None of the instruments in the biochemical/biophysical analysis group are of a sort requiring NIM equipment. This reflects the fact that all of the low level signals are processed by the commercial instrumentation.

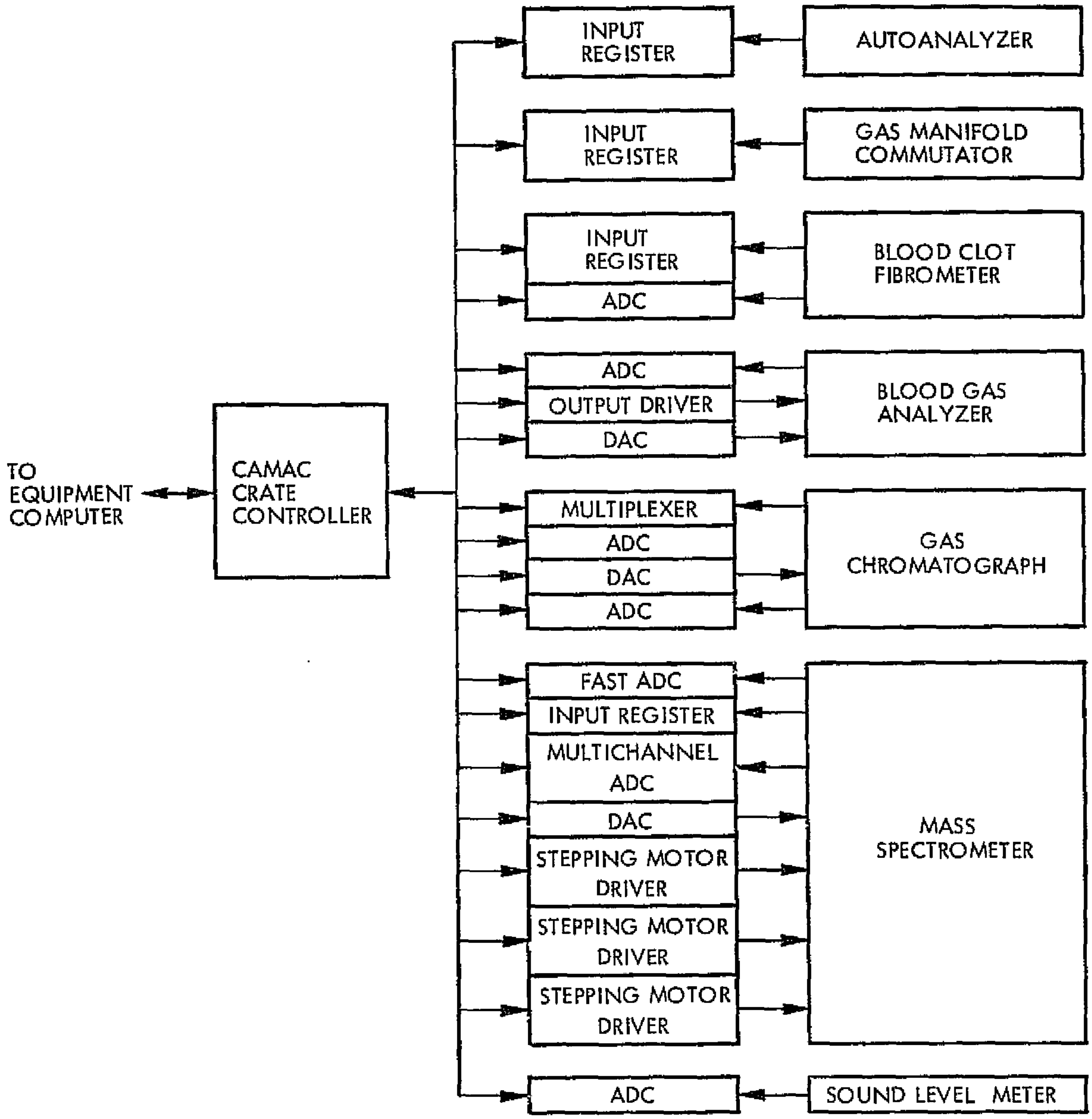


Figure 3-46. Life Sciences Biomedical/Biophysical Analysis NIM/CAMAC Implementation

Table 3-40 lists some specific examples of the CAMAC equipment that could be used to interface this group of instruments to the Spacelab CDMS. While separate input registers are shown for each of the first three instruments it might turn out in practice that fewer would be necessary if they are shared between instruments. This depends on the exact details of the commercial unit used.

3.7.2 Biomedical Analysis

3.7.2.1 Instrument Functions and CDMS Requirements

This category of equipment (Equipment Units 12 and 31 in the Convair study) is intended to provide behavioral and biomedical research functions to the laboratory. The instruments which must be interfaced to the Spacelab CDMS are described briefly below.

Electrophysiological Receiver - This device receives signals transmitted by an electrophysiological backpack worn by the test subject. The data includes electrocardiograms, vectorcardiograms and other cardiographic data. The instrument itself will probably be a commercial unit designed to complement the transmitter contained in the backpack. However, it will be necessary to digitize the analog output signals from the receiver to interface them into the CDMS for processing and interpretation.

Rotating Litter Chair - The litter chair apparatus studies subject response to rotational accelerations. The instrumentation on the subject will produce several analog signals to be multiplexed into an ADC for processing in the CDMS. Additionally, the rotation rate and rotational acceleration of the chair must be digitized.

Exercise Equipment - The bicycle ergometer is used to monitor a subject's energy output during exercise. It produces analog signals which must be digitized.

Doppler Flowmeter - This instrument measures blood pulse velocity and contour and is generally used in conjunction with an ECG. It also produces an analog signal that needs to be digitized in order to be interpreted by the CDMS. Within the CDMS it may also be necessary to provide for a waveform analysis of the blood pulse contour.

Table 3-40. CAMAC Implementation of Biochemical/Biophysical Analysis

System Element	CAMAC Product Code	Specific Example	Comments
Autoanalyzer			
Input Register	121	NE7059-1	
Gas Manifold Commutator			
Input Register	121	NE7059-1	
Blood Clot Fibrometer			
Input Register	121	NE7059-1	
ADC	161	B01244	
Blood Gas Analyzer			
ADC	161	B01244	
Output Driver	133	NE9024	
DAC	162	D0200-1518	
Gas Chromatograph			
Multiplexer	164	KS3510	Sixteen-channel, self-scanning
ADC	161		
DAC	162	D0200-1518	
ADC	161	B01244	Use separate ADC for data since other ADC devoted to thermal control
Mass Spectrometer			
ADC - Fast	161	B01244	
Input Register	121	NE7059-1	Share one of registers above
DAC	162	D0200-1518	
Multichannel ADC	161	KS3510	Sixteen-channel, self-scanning
Stepping Motor Drivers (3)	145	KS3361	
Sound Level Meter			
ADC	161	B01244	

Metabolic Analyzer - This instrument measures such respiration parameters as O_2 consumed, CO_2/O_2 ratio, vital capacity, and respiratory volume. This data is used to determine the metabolic rate of the subject. The bulk of the data processing for the metabolic analyzer is performed internal to the device and the interface to the Spacelab CDMS has merely to accept already digitized data for any further processing.

Vectorcardiogram Coupler - The signals received either directly from a vectorcardiogram device or through the electrophysiological receiver discussed earlier in this section are converted to a more usable form by the vectorcardiogram coupler. It amplifies the signal from the detector and outputs an analog voltage suitable for digitization by the CDMS.

3.7.2.2 CDMS Implementation with NIM/CAMAC

Figure 3-47 outlines the primary elements required in the Biomedical CDMS. The position encoder information from the rotating litter chair is passed to the computer where it can be time differentiated once or twice as required to obtain the rotational velocity and acceleration of the chair. As seen in the diagrm, all other signals in this category of equipment require simple digitization or are input directly as digital signals.

Table 3-41 lists all of the CAMAC modules required to interface the biomedical equipment to the experiment computer. Fast (23 μsec) ADC's are used in most cases so that the sampling rate of the signal is high enough to be able to reproduce and interpret any subtleties in the waveform.

3.7.3 Data Management and Life Sciences Support

3.7.3.1 Instrument Functions and CDMS Requirements

The equipment in this category (Equipment Units 2 and 3 of the Convair study) supplements the Spacelab data management system in order to provide a fuller capability to perform Life Sciences research. This category also provides centralized supporting and interface equipment for the Life Sciences payloads. The equipment elements of this category which require an interface to the CDMS are summarized below.

Portable Display/Keyboard - These two pieces of equipment allow the crew to interface to the CDMS at the experiment site. Relevant experiment data

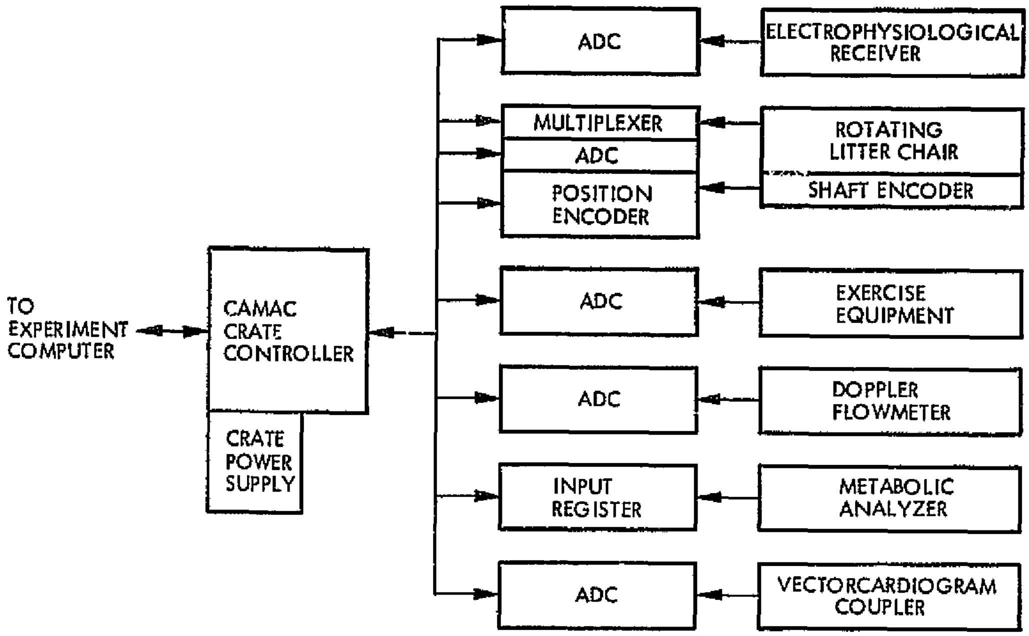


Figure 3-47. Life Sciences Biomedical Studies NIM/CAMAC Implementation

Table 3-41. CAMAC Implementation of Biomedical

System Element	CAMAC Product Code	Specific Example	Comments
Electrophysiological Receiver			
ADC	161	B01244	23-μsec conversion
Rotating Litter Chair			
Multiplexer	164	KS3510	Sixteen-channel ADC - self-scanning.
ADC	161	KS3510	
Position Encoder	117	EG&E PE019	
Exercise Equipment			
ADC	161	B01244	
Doppler Flowmeter			
ADC	161	B01244	
Metabolic Analyzer			
Input Register	121	NE7059-1	
Vectorcardiogram Coupler			
ADC	161	B01244	Fast ADC

is provided to them as required on the CRT display. This equipment is assumed to be supplied by the Spacelab and includes alphanumeric and graphic displays and a control keyboard. No special equipment need be provided by the dedicated 30-day laboratory in order to implement this function. A discussion of a CAMAC implementation of this function for the overall Spacelab is included in Section 3.1.1 of this report.

ECG, EEG and EMG Couplers - The ECG, EEG and EMG instruments are all central to the research program of the Life Sciences Laboratory. In order to take full advantage of these instruments they must be electrically coupled into the CDMS for purposes of real time data reduction. It is estimated that the dedicated 30-day laboratory will require 12 ECG couplers, 4 EEG couplers and 6 EMG couplers. These couplers will be peculiar to the individual detectors and will supply an amplified analog signal to the CDMS that must be digitized for processing.

Oscilloscope - For the immediate interpretation of experiment data as it is gathered, it is necessary to provide an oscilloscope for display of some of the data. This is hardware interfaced to the data sources under CDMS control. This function is assumed to be provided by Spacelab as discussed in Section 3.1.1.

Coupling and Conditioning Equipment - There are a variety of couplers and signal conditioners required to handle the many small analog signals generated by the various detectors within the laboratory. The output of all of these requires digitization for processing in the CDMS. They are summarized briefly below.

- Photo Cell Couplers - Photocells and phototransistors are used in the holding units (cages) and other places in the laboratory to measure ambient light levels. These must be coupled into the CDMS for monitoring of out of tolerance conditions. Up to 24 such sensors may be used.

- Pressure Sensor Couplers - As blood pressure and other pressure measurements are made, they are coupled into the CDMS for real-time processing and interpretation. It is expected that 4 couplers will be required.

- Signal Conditioners - A variety (35) of signal conditioners other than those mentioned above is provided to interface miscellaneous physical and physiological measurements into the CDMS.
- Accelerometer Coupler - The accelerometer is used to measure crew body accelerations and this device prepares the signals from the sensor for interfacing into the CDMS.
- Gas Supplies - In addition to the general pressure measurements mentioned above, the pressures of several gas supplies within the laboratory are regularly sampled and recorded.
- Power Conditioning Equipment - About half a dozen voltages and currents are monitored at various places about the laboratory.
- Water Conditioning Equipment - An occasional measurement of the water tank expulsion bladder pressure is required.

The particular type of signal conditioning involved in these devices is not currently available in NIM or CAMAC form. However, a large number of them could be packaged as NIM modules.

3.7.3.2 CDMS Implementation with NIM/CAMAC

The block diagram of Figure 3-48 shows repeated use of analog-to-digital convertors to interface the signals from this category of equipment into the CDMS. In many cases the sampling rate required is low enough that several signals can share an ADC through a multiplexer. The repetitive usage of ADC's for this equipment is due to the multiplicity of analog signals output by all of these devices.

Absent from the block diagram is the equipment necessary to interface the CRT Display and Keyboard into the experiment computer. This was discussed in Section 3.1.1.

Table 3-42 sums up the equipment required for this interface function. Some economy of module usage is attained by sharing modules as described in the comments column of the table. The 1244 Borer ADC is shown as an example in situations where somewhat greater accuracy in signal digitization is required. Otherwise the Kinetic Systems 3510 is used.

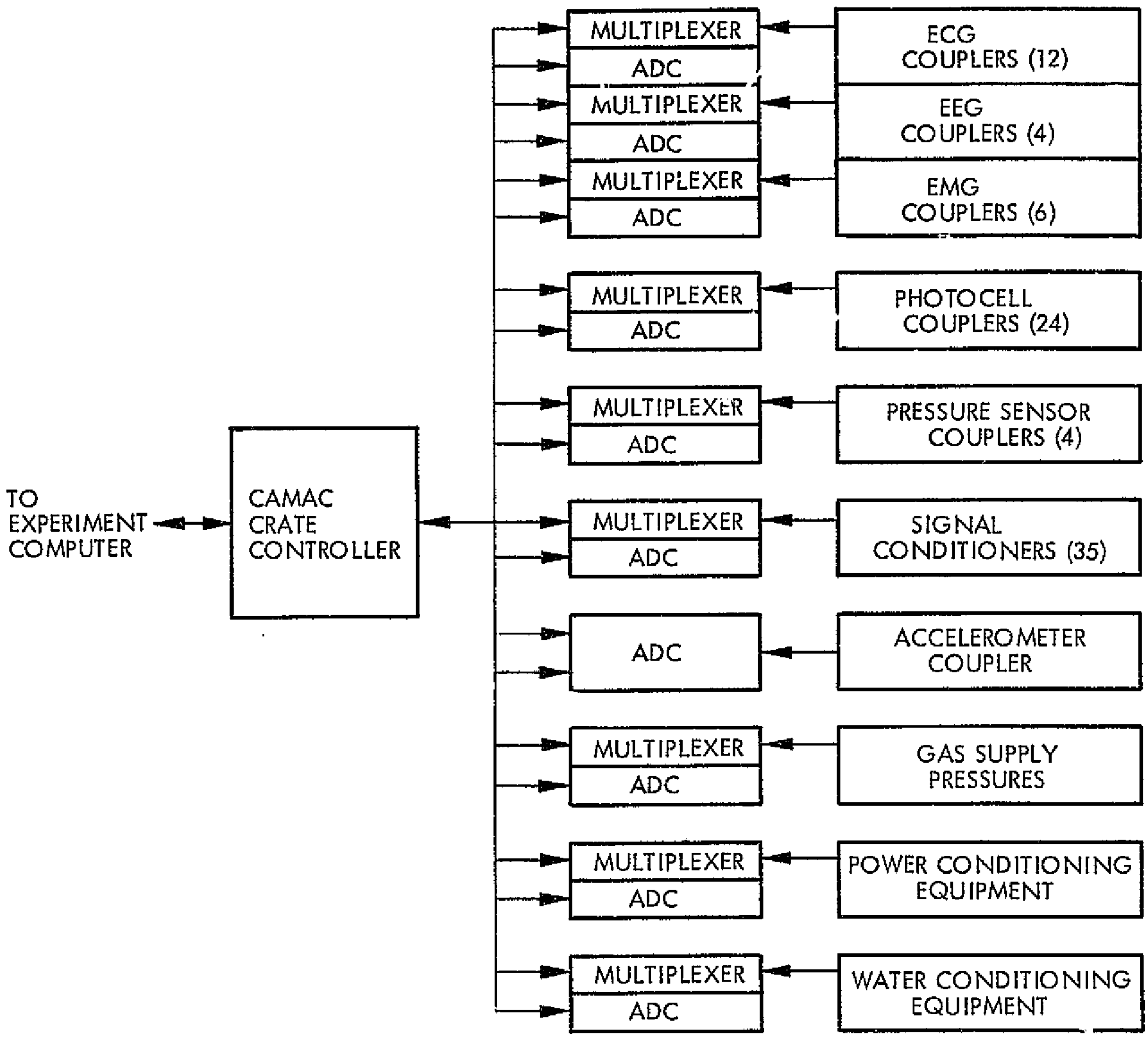


Figure 3-48. Life Sciences Data Management and Laboratory Support NIM/CAMAC Implementation

Table 3-42. CAMAC Interface Modules for Data Management and Life Sciences Support Equipment

System Element	CAMAC Product Code	Specific Example	Comments
ECG, EEG, and EMG Couplers			
Multiplexers (2)	164	B01704	EEG and EMG couplers share a multiplexer and an ADC
ADC's (2)	161	B01244	
Photocell Couplers			
Multiplexer	164	B01704	
ADC	161	B01244	
Pressure Sensor Couplers			
Multiplexer	164	B01704	Eight of the photocell and three of the signal conditioner signals also handled here.
ADC	161	B01244	
Signal Conditioners			
Multiplexer (2)	164	B01704	
ADC's (2)	161	B01244	
Accelerometer Coupler			
ADC	161	B01244	
Gas Supply Pressures			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning
ADC	161	KS3510	
Power Conditioning Equipment			
Multiplexer (1/2)	164	KS3510	Share 1/2 of ADC with water conditioning sensors.
ADC (1/2)	161	KS3510	
Water Conditioning Equipment			
Multiplexer (1/2)	164	KS3510	Share 1/2 of ADC with power conditioning sensors.
ADC (1/2)	161	KS3510	

3.7.4 Holding Units and Research Support

3.7.4.1 Instrument Functions and CDMS Requirements

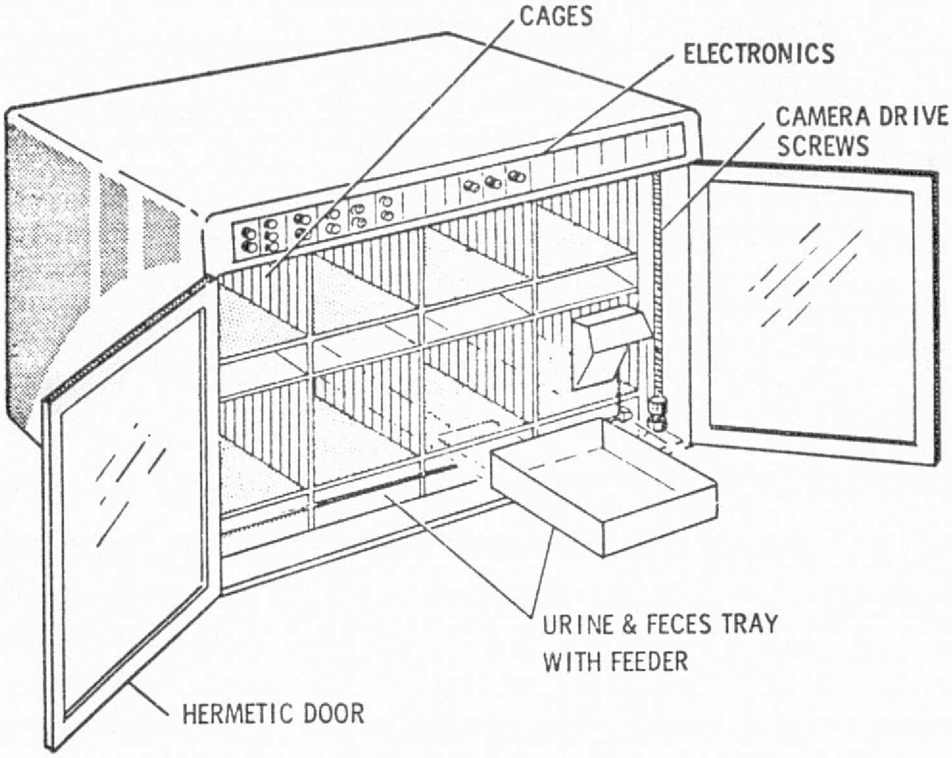
This category of equipment provides for holding (caging) vertebrates as well as for research supporting functions specific to the vertebrate organisms. Also in this category are equipment units which provide environmental enclosures for the growth of plant organisms, invertebrate organisms, and the equipment to support plant research. A final type of equipment is that for housing cells and tissue and supporting research in these areas.

Most of the equipment in this category is still in the conceptual design phase. However, the major characteristics of all of the holding units except that for primates are summarized in the common holding unit shown in Figure 3-49 (from the Convair report CASD-NAS-74-046). The common holding unit forms a basic housing for a variety of organisms and is internally modified as required to suit individual organisms. The unit is sealable in order to minimize air leakage into or out of the organism compartment and is designed to mate with a debris contaminant shroud. An essential feature of the holding unit is a system for controlling its internal temperature within the range 10 to 40°C (possibly using liquid coils integral with the walls of the unit).

When used for plants, the common holding unit must be modified to include a lighting system. When used for small vertebrates the integral temperature control system will probably not be needed since the cage temperature will be controlled by the temperature of the system ventilation air.

The holding unit for primates, because of their larger size, will be custom designed and considerably different from the common holding unit. It will, however, still provide a controlled environment for the animals.

Each of the holding chambers requires regular monitoring of temperature, air flow, humidity and pressure. The sensors for all of these measurements produce analog signals which can be multiplexed into an ADC and then into the Spacelab computer. In the case of temperature and air flow it is assumed that analog control signals will be returned from the CDMS to the holding units. Additionally, the vertebrate and primate holding units will require



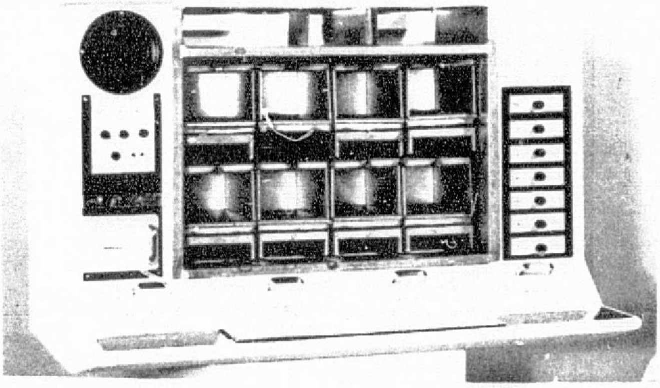


Figure 3-49. Life Sciences Common Holding Unit

stepping motor control signals for positioning of a TV monitoring camera.

Several additional instruments are required to support the vertebrate and plant research functions. These are listed and described briefly below.

Flowmeter Couplers & Blood Pressure Transducer - These devices supply signals proportional to water flow rate at various places in the laboratory.

Also included in this category of equipment is a separate blood pressure transducer to be used on the vertebrates being studied.

The flowmeter coupler and blood pressure transducer both produce analog signals that must be digitized for monitoring and interpretation by the CDMS. In the case of the blood pressure transducer a waveform analysis of the blood pressure wave may be performed by the CDMS computer.

Clinostat - The purpose of the clinostat is to slowly rotate plant organisms relative to the laboratory. It is used on earth to neutralize the effects of gravity through slow rotation of the organism. Its use on Spacelab is to determine if it produces only artifacts relative to a true zero-G environment. The clinostat will be driven by a stepper motor to which the CDMS must supply the control signals.

3.7.4.2 CDMS Implementation with NIM/CAMAC

Figure 3-50 shows the interface of the holding units to the Spacelab CDMS using CAMAC equipment. All of the units are instrumented basically the same with multiplexers and ADC's to sample temperatures and other analog voltages for the control of heaters.

The CAMAC modules required for this interface are listed in Table 3-43. The Kinetic Systems dual stepping motor driver units for the Vertebrate and Primate Holding Units were chosen so as to be able to control the positions of the TV camera for those units in two orthogonal axes.

3.7.5 Other Life Sciences Experiment Units

3.7.5.1 Instrument Functions and CDMS Requirements

This category of equipment consists of several equipment units not covered in the other equipment categories. One of these is the Life Support Subsystem Test Unit. It provides the capability to perform tests on LSS

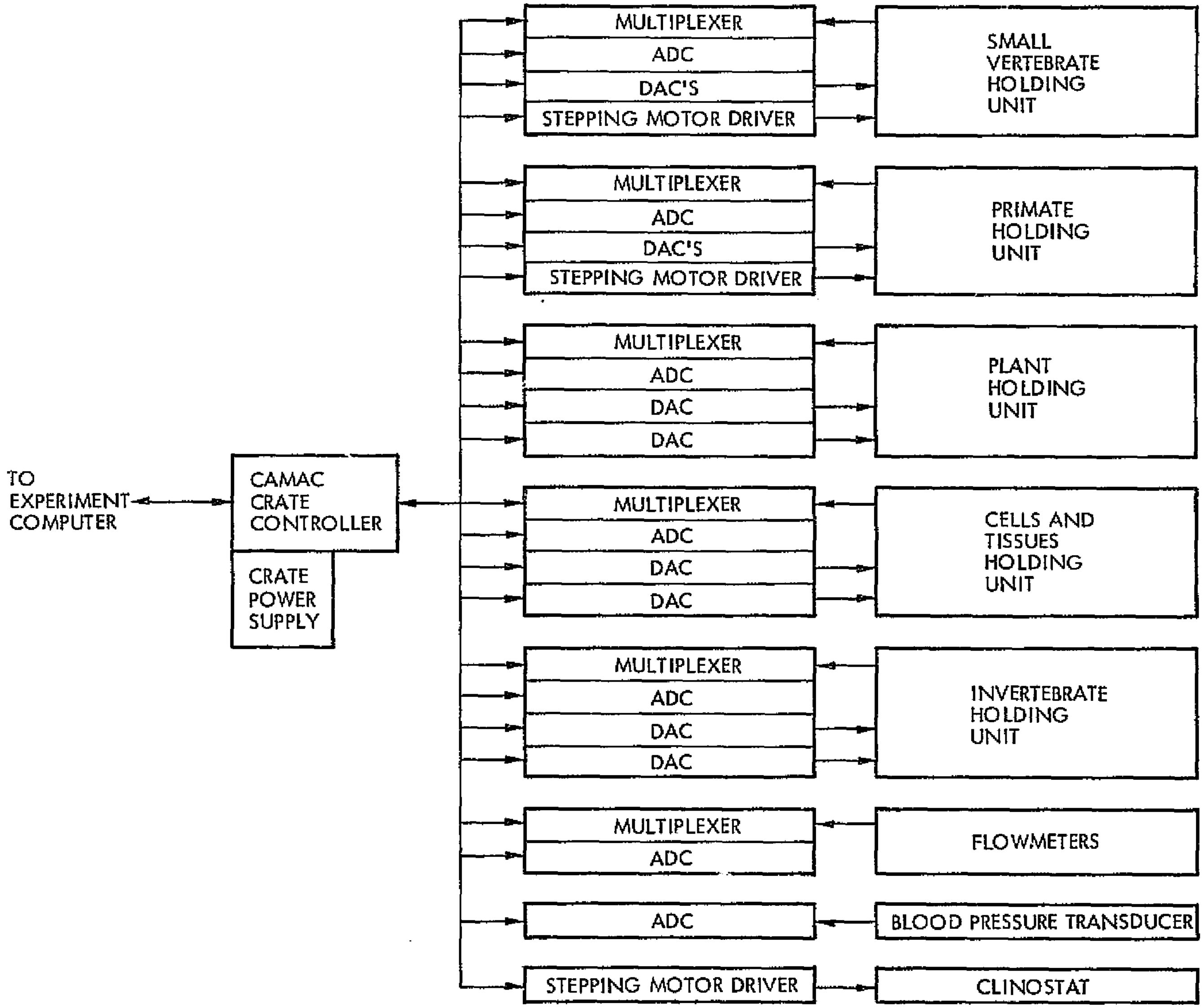


Figure 3-50. Life Sciences Holding Units and Research Support, NIM/CAMAC Implementation

Table 3-43. CAMAC Interface of Holding Units and Research Support Equipment

System Element	CAMAC Product Code	Specific Example	Comments
Small Vertebrate Holding Unit			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning
ADC	161	KS3510	
DAC's (2)	162	D0200-1518	
Stepping Motor Drivers (2)	145	KS3360	Two units in one module
Primate Holding Unit			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning
ADC	161	KS3510	
DAC's (2)	162	D0200-1518	
Stepping Motor Drivers (2)	145	KS3360	Two units in one module
Plant Holding Unit			
Multiplexer	164	KS3510	
ADC	161	KS3510	
DAC's (2)	162	D0200-1518	
Cell and Tissue Holding Unit			
Multiplexer	164	KS3510	
ADC	161	KS3510	
DAC's (2)	162	D0200-1518	
Invertebrate Holding Unit			
Multiplexer	164	KS3510	
ADC	161	KS3510	
DAC's (2)	162	D0200-1518	
Flowmeters			
Multiplexer	164	KS3510	
ADC	161	KS3510	
Blood Pressure Transducer			
ADC	161	B01244	
Clinostat			
Stepping Motor Driver	145	KS3361	

prototype equipment. Its equipment roster includes portable life support systems for EVA and an LSS test bench. The intent of the latter is to support a variety of experiment test apparatus. It supplies electrical power connections, coolant fluid connections, structural support, vacuum connections and general purpose instrumentation. The requirements on the CDMS to support this equipment are fairly minimal. The portable life support systems for EVA require no interface to the CDMS. The only specific requirements are that several analog voltages from measurements of temperature, pressure and flow on the LSS test bench be digitized and monitored for out-of-tolerance by the CDMS.

A second equipment unit in this category is one for the measurement of man/systems integration (MSI) parameters including man's behavior and performance in space and his interaction with various types of equipment. The equipment in this category includes a psychomotor performance console, force/torque measurement taskboard, vision tester and MSI task simulator. Many of the experiments performed with the MSI equipment will also be done independent of the CDMS. Additionally, much of the data gathered in MSI experiments uses equipment from other categories such as ECG's, EEG's and accelerometers. The only additional equipment which requires interfacing to the CDMS is that associated with the psychomotor performance console. Analog data from this console will require digitization for processing in the Spacelab computer and display on the portable CRT.

The third unit of equipment in this category is the bioresearch centrifuge. This device has a total diameter almost equal to that of the Spacelab and includes 8 cage modules for holding vertebrate specimens. The major function of the centrifuge is to simulate a gravitational field for various small vertebrates in order to compare their behavior with that in the zero-G environment of the Spacelab. Various biomedical parameters will be monitored on the vertebrates that get spun in the centrifuge. A transmitter and receiver system will be required to convey these signals from the centrifuge to the rest frame of the Spacelab. At that point they will be digitized and processed to the CDMS in the same fashion as the signals from the electrophysiological receiver in the Biomedical equipment category. Additionally, the centrifuge position will be detected and sampled regularly. This data will be time differentiated to obtain the rotational velocity and acceleration of the centrifuge.

3.7.5.2 CDMS Implementation with NIM/CAMAC

The block diagram of Figure 3-51 shows the straightforward interface of these equipment units into the CDMS with CAMAC equipment. The exact number of signals to be multiplexed into each of the three ACD's is uncertain and is only indicated schematically.

The seven CAMAC modules envisioned for this interface task are shown in Table 3-44. The necessity of three separate sets of multiplexers and ADC's will vary depending on which specific equipment items are being used in the three experiment units.

3.7.6 Life Sciences Payload Summary

The premise in the analysis of the Life Sciences 30-day dedicated laboratory was that most of the equipment to be used in the laboratory would be commercial units modified as required for the Spacelab environment. Since virtually all commercial units perform at least elementary processing of the data signals that they generate, the CDMS requirements for the Life Sciences laboratory are different from that of many of the other instrument groups studied. In the case of the Life Sciences instruments there are no low level signals to be processed and very little digital data. The great majority of the instruments produce analog signals of the type that would normally drive meters or strip chart recorders in the laboratory. In order to efficiently use the computational and analytical capabilities provided by the Spacelab these signals must be regularly sampled, digitized and fed to the experiment computer.

The adapted commercial nature of the Life Sciences instruments is reflected in the summary of required NIM and CAMAC equipment in Table 3-45. First of all, there is no NIM equipment required since all of the signals that might normally be processed in NIM modules are handled by discrete electronics intrinsic of each of the individual instruments.

The other outstanding feature of the table is the heavy usage of analog-to-digital converters. These convert all of the strip chart type of signals from the instruments to a form comprehensible by the computer system.

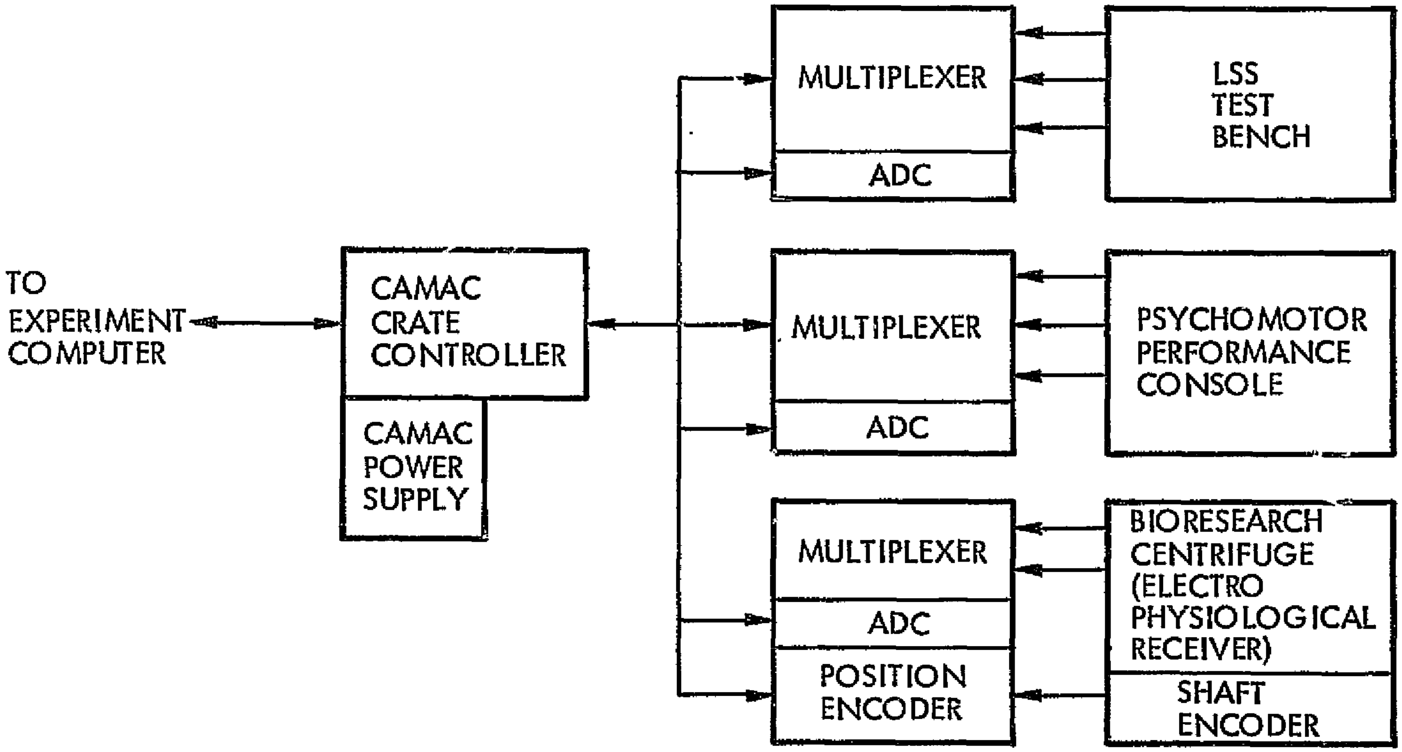


Figure 3-51. Life Sciences Other Equipment Units, NIM/CAMAC Implementation

Table 3-44. CAMAC Implementation for Other Experiment Units

System Element	CAMAC Product Code	Specific Example	Comments
<u>LSS Test Bench</u>			
Multiplexer	164	B01704	
ADC	161	B01244	
<u>Psychomotor Performance Console</u>			
Multiplexer	164	B01704	
ADC	161	B01244	
<u>Bioresearch Centrifuge</u>			
Multiplexer	164	B01704	These signals are transferred from the centrifuge via an electrophysiological transmitter and receiver.
ADC	161	B01244	
Position Encoder	117	EG&G PE019	

Table 3-45: Life Sciences Use of CAMAC Equipment

		Equipment Category					
<u>CAMAC Equipment</u>	CAMAC Product Code	Biochemical/Biophysical Analysis Equipment	Biomedical Analysis Equipment	Data Management and Life Sciences Support	Holding Units and Research Support	Other Experiment Units	Totals
Position Encoder	117		1			1	2
Input Register	121	3	1				4
Output Register	133	1					1
Stepping Motor Driver	145	1			5		6
Analog-to-Digital Converter	161						
Single Unit - Fast		5	4	7	1	3	20
Multichannel - Slow		2	1	3	6		12
Digital-to-Analog Converter	162	1			2		3
Multiplexer	164			6		3	9
Branch Driver	211			Share 1			1
Crate Controller	231	1	1	1	1	Share with Biomedical	4
Crate w/Power Supply	411	1	1	1	1		4

3.8 SPACE PROCESSING APPLICATION PAYLOADS

Six objectives for the Space Processing Applications (SPA) program aboard Space Shuttle have been defined by NASA.

- Make space easily accessible to the international scientific and industrial community for research and development work in materials science and technology.
- Develop techniques that take full advantage of the characteristics of space flight to achieve experimental and process conditions that are not attainable at competitive costs on earth.
- Employ the novel materials research and development techniques that are possible in space to acquire new knowledge in technologically important areas of materials science and technology.
- Apply R&D results obtained in space to advance materials technology generally and in particular, to invent processes to manufacture products in space for use on earth.
- When appropriate, reduce selected space manufacturing processes to practice and conduct pilot production operations to demonstrate their practicality.
- When capabilities to manufacture economically viable products are achieved, initiate commercial production operations in space.

TRW has been involved in several studies of how best to use the Space Shuttle to accomplish these objectives. One result of these studies has been the definition of five payload equipment groupings required to perform the space processing experiments.

Furnace - A grouping of furnaces and associated apparatus for performing activities in which physical contact with the specimen is permissible.

Levitation - Apparatus providing contactless positioning and heating of specimens with associated process control and characterization.

Biological - Equipment which produces separation of biological samples with associated preservation and storage capacity.

General Purpose - Provides services with associated characterization equipment supporting the accommodation of a variety of moderate temperature research areas, including physical or chemical fluid studies.

Core - Consists of centralized data acquisition, processing and equipment control functions.

The primary purpose of this study is to analyze the requirements of the core subelement to support the other four groups of equipment.

Table 3-46 lists all of the equipment items in the SPA payload which require interfacing to the CDMS. The various equipment groupings which use each piece of equipment are indicated. For purposes of discussion these equipment items have been divided into four categories as shown. These will be treated individually in the following sections. It is to be emphasized that this division into categories is primarily for convenience of discussion. Although there is some correlation between the equipment groups and the equipment categories defined in Table 3-46, it is not intended to necessarily reflect a functional grouping.

3.8.1 SPA Equipment Category I

3.8.1.1 Instrument Functions and CDMS Requirements

The seven items of equipment in this category are discussed briefly below.

Flowmeter - This device will be used to measure gas or liquid flow to and from various pieces of test equipment in the biological experiments. Its analog output signal must be digitized for processing in the CDMS.

pH Monitor - Several of the SPA experiments require a continuous monitor of the pH of a test solution. The analog signal from this measurement device is digitized so it can be monitored by the CDMS computer.

UV/Visible Spectrometer - In order to better chart the changes occurring in experiment samples as they are processed this instrument will be used to record the time dependent UV and visible spectra of the samples. The detector for this instrument is a photomultiplier tube operated in the pulse counting mode. Control must also be provided to the stepping motor which moves the grating for spectral scans.

C-3

Table 3-46. Equipment Requiring Interface to CDMS for SPA

Equipment Category	Biological	Furnace	General Purpose	Levitation
Category I				
Flowmeter	●			
pH Monitor	●		●	
UV/Visual Spectrometer	●		●	
Fluid Cooling/Refrigeration Unit	●			
Temperature Measurement System	●	●	●	
Laser Optical Scattering Monitor	●		●	●
Electro-Optical Imaging System		●	●	●
Category II				
Gas Chromatograph			●	●
IR Spectrometer			●	
Vacuum/Pressure Measurement and Control		●	●	●
Nuclear Particle Counting Unit			●	
Mixing and Dispersal Units		●		●
Manipulation and Displacement Units		●		●
Category III				
Liquid Syringe Dispenser			●	●
Inertial Injector				●
Residual Gas Analyzer		●		●
Directional Calorimeter				●
Time Lapse/High-Speed Camera			●	●
Dye Laser/Flash Lamp	●		●	●
Category IV				
Zone Refiner		●		
Directional Solidification Unit		●		
Low-Volt/High-Amp Supply		●	●	●
RF Induction Supply (2 kHz to 2 MHz)		●		●
RF Induction Supply (Mixing and Dispersal)		●		●
High Voltage (17 kV)		●	●	●

Fluid Cooling/Refrigeration Unit - This device will be used to preserve biological samples and will require the processing of analog temperature signals.

Temperature Measurement System - Several devices will be used for temperature measurements in the various SPA experiments. These will include electrical resistance sensors, thermocouples and pyrometers to measure incandescent light intensity. All of these devices produce analog voltages that must be digitized for processing.

Laser Optical Scattering Monitor - Another method of quantizing the changes in materials as they are processed is to measure the light backscattered when a sample is irradiated with a laser. This light is detected by a photomultiplier tube operated in the pulse counting mode.

Electro-Optical Imaging System - The EOIS is a closed circuit TV system used to monitor and record the time evolution of various laboratory processes such as crystal growth, furnace operation and material interactions. The device includes its own recording and playback facilities.

3.8.1.2 CDMS Implementation with NIM/CAMAC

Figure 3-52 illustrates the NIM and CAMAC equipment required to interface the Category I SPA equipment into the Spacelab experiment computer. NIM equipment is particularly well adapted to handling the photomultiplier signals from the Spectrometer and Laser Scattering equipment items since this is the most common type of detector used in ground based accelerator laboratories. It is only because of its self-contained recording and playback capability that the EOIS can be handled with CAMAC modules as shown. After a picture has been taken and stored by the EOIS the individual picture elements are clocked out to a fast ADC under computer control (via the output register). After digitization the computer processes them as required and sends them to the appropriate display unit.

The equipment listed in Table 3-47 implements all of the NIM and CAMAC functions shown in the block diagram. The Ortec 456 high voltage power supplies chosen as an example have a variable output voltage

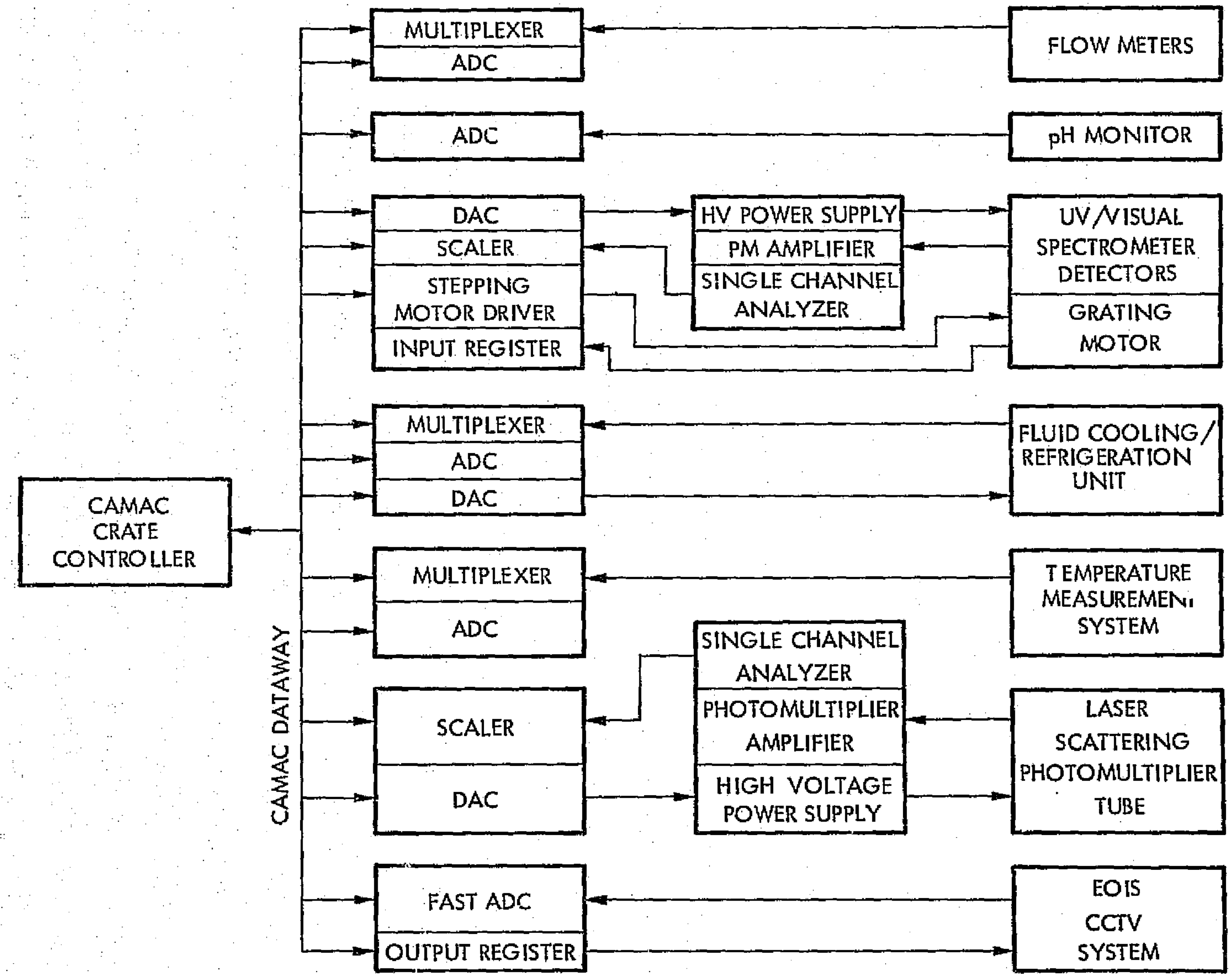


Figure 3-52. SPA Category I Equipment NIM/CAMAC Implementation

Table 3-47. NIM/CAMAC Implementation of Category I SPA Equipment

System Element	CAMAC Product Code	Specific Example	Comments
Flowmeters			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning
ADC	161	KS3510	
pH Monitor			
ADC	161	KS3510	Use one channel of flowmeter ADC
UV/Visual Spectrometer			
Scaler	111	B01002	
Stepping Motor Driver	145	KS3361	
High-Voltage Supply	NIM	ORTEC 456	
Photomultiplier Amplifier	NIM	ORTEC 276	
Single-Channel Analyzer	NIM	ORTEC 406A	
DAC	162	D0200-1528	±10-V, 12-bit, Dornier
Input Register	121	NE7059-1	
Fluid Cooling/Refrigeration Unit			
Multiplexer	164	KS3510	
ADC	161	KS3510	
DAC	162	D0200-1528	
Temperature Measurement System			
Multiplexer	164	KS3510	
ADC	161	KS3510	
Laser Scattering			
Scaler	111	B01002	
High-Voltage Power Supply	NIM	ORTEC 456	
Photomultiplier Amplifier	NIM	ORTEC 276	
	162	D0200-1528	
EOIS/CCTV			
ADC - Fast	161	B01244A	±10-V, 12-bit, 23-μsec conversion time
Output Register	133	KS3080	

controlled by a 0-11 volt input voltage. This input is provided by the DAC's operated under direct software control in the computer. This makes the total operation of the photon detection systems subject to automatic programmed operation. The Borer ADC shown for the EOIS is fast enough to handle the playback signals from the EOIS recorder.

3.8.2 SPA Equipment Category II

3.8.2.1 Instrument Functions and CDMS Requirements

This section contains brief descriptions of the six equipment items in this category.

Gas Chromatograph - This is assumed to be an adaptation of a commercial unit containing its own thermal control and gas sampling subsystems. The analog output of the instrument is digitized so that the CDMS computer can perform waveform analyses of the data to determine the gas concentration present.

IR Spectrometer - Another data point required to understand the physical and chemical changes undergone by some materials during processing is the nature of the infrared spectra of the material. The infrared spectrometer produces analog signals and like the UV/Visual photometer requires control signals to the stepping motor that positions the grating.

Vacuum/Pressure Measurement and Control - Analog signals from pressure sensors must be processed and integrated by the CDMS in order to provide control signals for maintaining test containers at specified pressures.

Nuclear Particle Counting Unit - Some of the materials to be processed in the laboratory will be radioactive and radioactive tracer elements will be used to monitor other processes. The nuclear particle counting unit provides for the recording and analysis of radioactive counting data.

Mixing and Dispersal Units - These instruments will be acoustic, electromagnetic and mechanical devices designed to assure thorough mixing of liquified samples. Analog instrumentation signals will be output by the devices and analog control signals must be input to operate them.

Manipulation and Displacement Units - Three different devices for manipulation samples are envisioned. One will be a standard three axis mechanical manipulator. A second will be a holder for crystals during growth (including a feed mechanism). And a third will be a piezoelectric drive to accomplish small displacements of samples. All three of these devices require the processing of position sensor signals and the input of analog control signals.

3.8.2.2 CDMS Implementation with NIM/CAMAC

Figure 3-53 outlines the CDMS system to support category II instruments using NIM and CAMAC equipment. A stepping motor driver is used to control valve operation in the vacuum/pressure system. The nuclear particle counting unit is readily implemented with NIM modules since this is one of the major functions for which they were designed. Analog signals from the mixing, dispersal, manipulation and displacement units are multiplexed into ADC's for computer processing in order that analog control signals may be returned to these units via DAC's.

Table 3-48 gives specific examples of all of the NIM and CAMAC modules required to handle the CDMS interface for Category II equipment. Fairly extensive use is made of the Kinetic Systems 3510 unit with 16 ADC channels to process the multitude of analog signals produced by the various instruments in this category. The Kinetic Systems 3110 was chosen as an example of the DAC's to be used by this equipment category because it is an 8-channel unit and several channels may be required for each of the two applications shown in the table.

3.8.3 Category III SPA Equipment

3.8.3.1 Instrument Functions and CDMS Requirements

There are six major pieces of equipment in this category.

Liquid Syringe Dispenser - This device is used to inject precise quantities of liquids into a processing volume. It operates on the same principle as a hypodermic syringe. When used for the SPA experiments aboard Spacelab the plunger will be driven by a stepper motor under direct control of the CDMS.

Inertial Injector - This piece of equipment uses the same principal as a pinball machine to impart momentum to a sample to be injected into the processing volume. It is instrumented with a stepping motor to cock

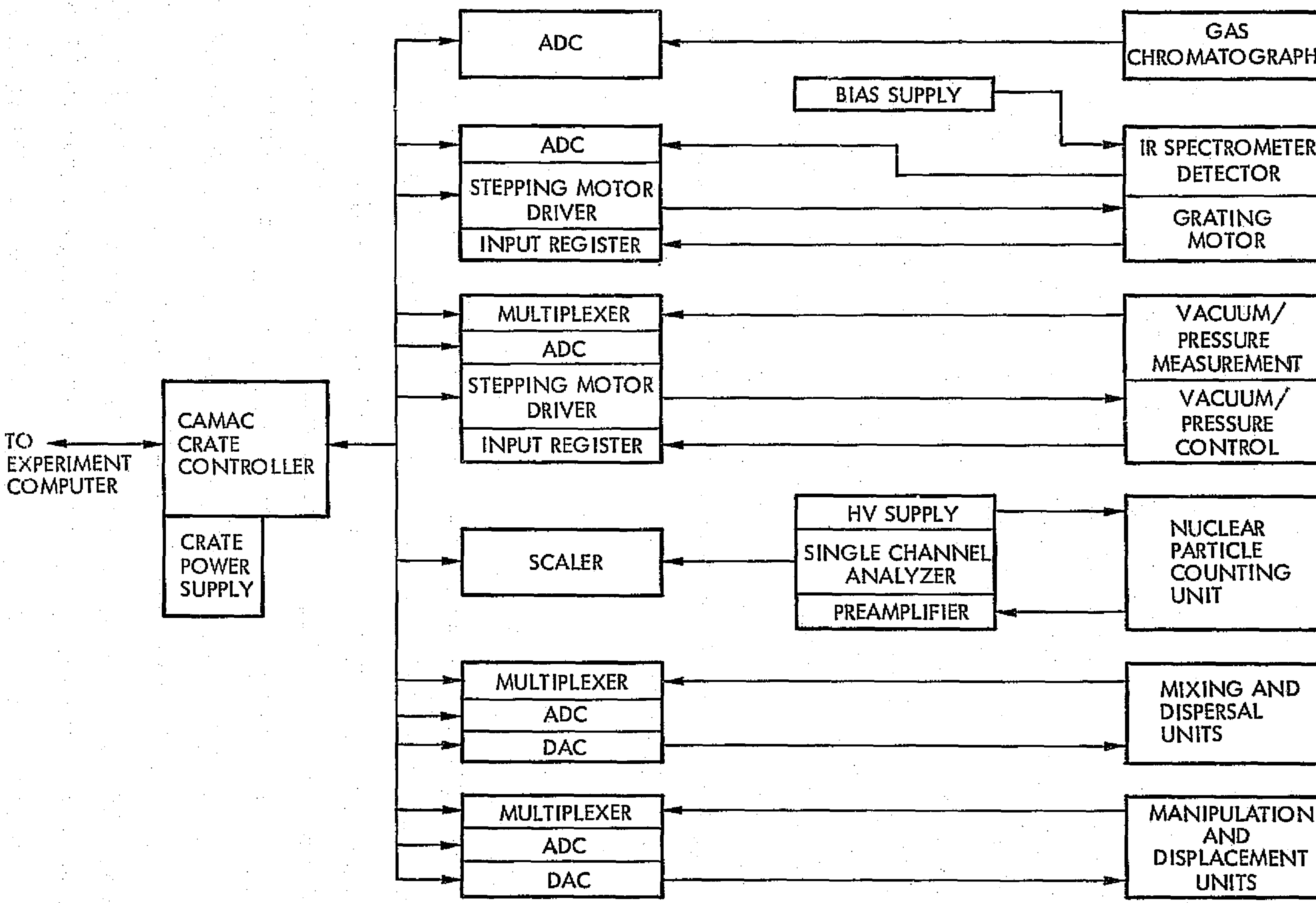


Figure 3-53. SPA Category II Equipment NIM/CAMAC Implementation

Table 3-48. CAMAC Implementation of Category II SPA Equipment

System Element	CAMAC Product Code	Specific Example	Comments
Gas chromatograph			
ADC	161	B01244A	
IR Spectrometer			
ADC	161	B01244A	
Stepping Motor Driver	145	KS3361	
Bias Supply	NIM	ORTEC 459	Five-kV Detector bias supply
Input Register	121	NE7059-1	
Vacuum Pressure System			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning
ADC	161		
Stepping Motor Driver	145	KS3361	
Input Register	121	NE7059-1	Share register above
Nuclear Particle Counting Unit			
HV Supply	NIM	ORTEC 456	
Preamplifier	NIM	ORTEC 276	
Analyzer	NIM	ORTEC 406A	
Scaler	111	B01002	
Mixing and Dispersal Units			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning
ADC	161		
DAC	162	KS3110	Eight-channel, ten-bit
Manipulation and Displacement Units			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning
ADC	161		
DAC	162	KS3110	Eight-channel, ten-bit, share the one above

it and a solenoid-driven release latch to fire it.

Residual Gas Analyzer - The residual gas analyzer is used to measure small quantities of gas remaining in an evacuated region. It is especially useful for detecting and separating traces of organic molecules. It operates on principles similar to that of a mass spectrometer leak detector using an electrostatic analyzer with an impressed voltage swing to scan molecular weights. An analog signal is required to control the voltage scan and the system produces several analog signals (both science and engineering data) which must be digitized for processing by the Spacelab CDMS.

Directional Calorimeter - This instrument is analogous to a radiative flux meter and is used to make temperature measurements of samples being processed. The analog output must be digitized for interpretation by the CDMS.

Time Lapse/High Speed Camera - This device will be used to record the time evolution of several of the SPA processes. It is controlled by an output register that sets the aperture and exposure time and releases the shutter. A stepping motor driver is also required to control the motorized film advance mechanism.

Dye-Laser/Flash Lamp - Dye Laser and Flash Lamp units are provided for controlled illumination of several of the processes to be monitored by the laboratory. They will basically be operated in an ON/OFF mode.

3.8.3.2 CDMS Implementation with NIM/CAMAC

Figure 3-54 blocks out the primary elements of the CDMS to support this category of equipment. Most of the equipment in this category consists of adapted commercial instruments that are mostly self-containted. This means that only the simplest interfaces to the experiment computer are required and results in the fairly simple CDMS shown.

The various CAMAC modules required to implement the CDMS for this category of SPA equipment are described in Table 3-49. No NIM equipment is required in this CDMS because all of the instruments perform their own low level processing of signals. There are no photon or particle counting requirements of the type for which NIM is designed. As indicated

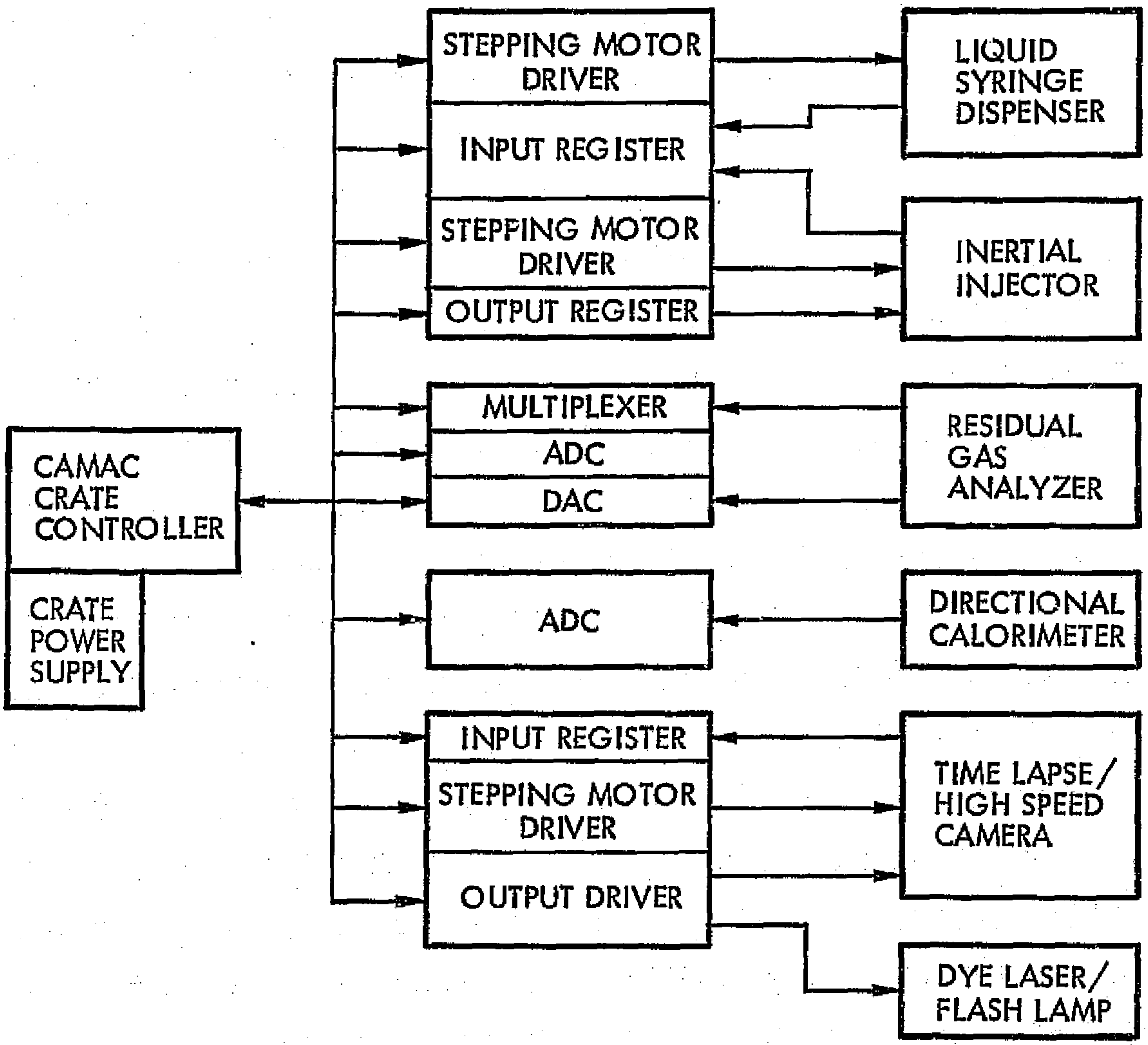


Figure 3-54. SPA Category III Equipment NIM/CAMAC Implementation

Table 3-49. CAMAC Implementation of Category III SPA Equipment

System Element	CAMAC Product Code	Specific Example	Comments
Liquid Syringe Dispenser			
Stepping Motor Driver	145	KS3361	
Input Register	121	NE7059-1	
Inertial Injector			
Stepping Motor Driver	145	KS3361	
Output Register	133	KS3080	Share 1/2 below
Input Register	121	NE7059-1	
Residual Gas Analyzer			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning
ADC	161		
DAC	162	D0200-1528	±10-V, 12-bit, Dornier
Directional Calorimeter			
ADC	161	B01244A	
Time Lapse/High-Speed Camera			
Stepping Motor Driver	145	KS3361	
Output Register	133	KS3080	
Input Register	121	NE7059-1	Share register above
Dye Laser/Flash Lamp			
Output Driver	133	KS3080	Share 1/2 with inertial injector

in the table some economy of CAMAC modules is obtained by sharing input and output registers among several of the instruments.

3.8.4 Category IV SPA Equipment

3.8.4.1 Instrument Functions and CDMS Requirements

This equipment category has only two major instruments, the zone refiner and directional solidification unit, but also includes four power conditioning and conversion units which support many of the other pieces of equipment in the laboratory.

Zone Refiner - This instrument is used in metallic purification processes. A cylinder of metal is passed slowly through the device with the central section being heated to a high temperature. Impurities in the metal are pushed ahead of the hot region to the end of the sample as it moves through. The instrumentation for the zone refiner is used to establish thermal control of the system.

Directional Solidification Unit - This experiment studies solidification processes in cylindrical metal samples by subjecting the sample to a linear temperature gradient along its length. Instrumentation for monitoring and control of the temperature profile is required.

Power Conditioners and Converters - The other four pieces of equipment in this category perform power conditioning on the Spacelab supplied power to support the various SPA instruments. The Low Voltage/High Amperage unit and RF Induction (2KHz to 2MHz) unit are designed primarily to support the General Purpose Furnace and the Directional Solidification Unit. The High Voltage Power Converter is used for the Zone Refiner and Directional Solidification Units. There is also a second RF Induction Unit for powering the Mixing and Dispersal Units and other equipment throughout the laboratory.

3.8.4.2 CDMS Implementation with NIM/CAMAC

Figure 3-55 shows the straightforward design of the CDMS for Category IV equipment with CAMAC modules. The Zone Refiner and Directional Solidification Units are controlled by sampling temperatures with a multiplexer and ADC, closing the control loop in the computer software and feeding back an analog heater control signal through a DAC. Control

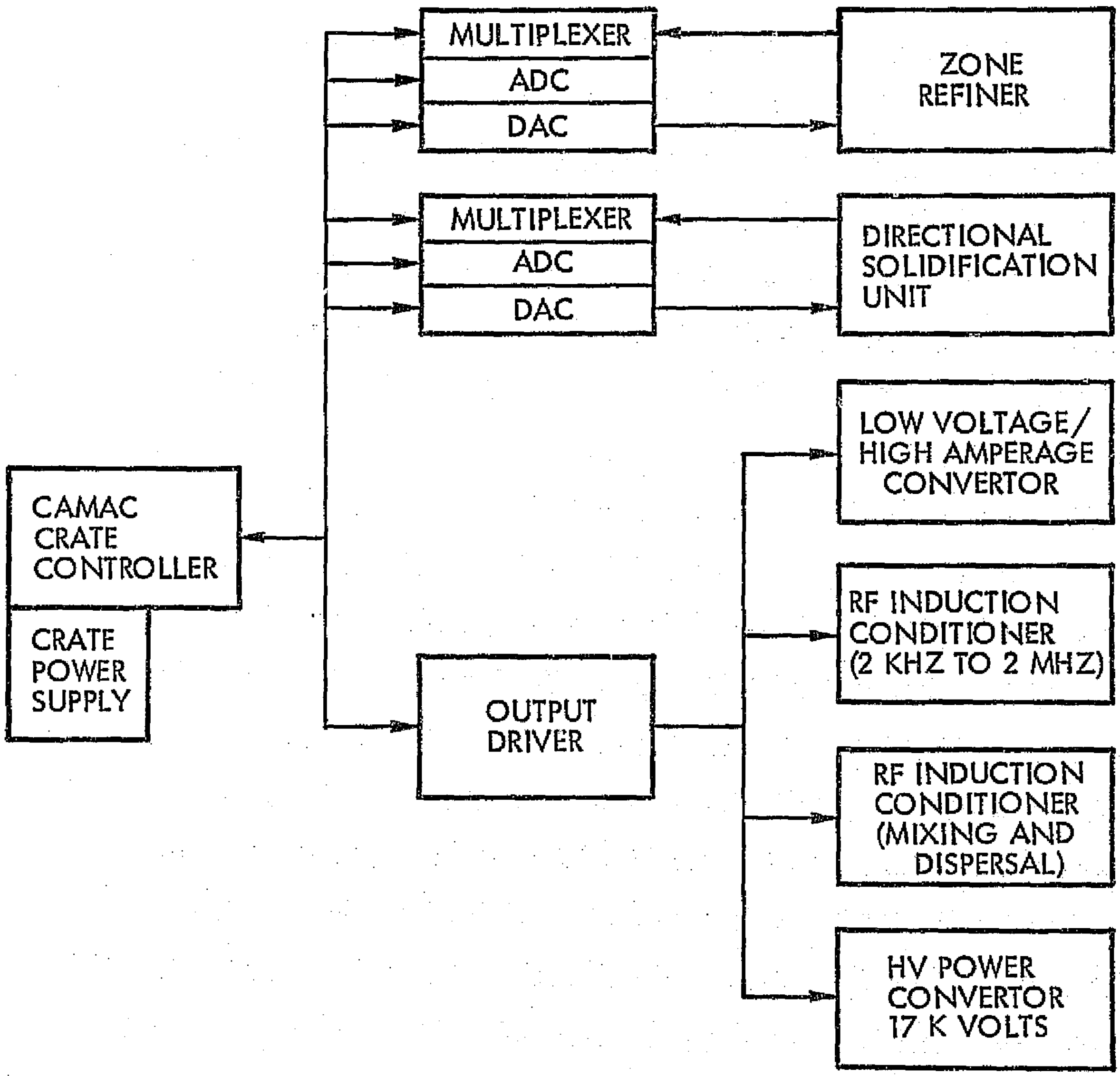


Figure 3-55. SPA Category IV Equipment NIM/CAMAC Implementation

of the power conditioning and conversion units consists solely in switching the units on and off with an output driver module.

The five modules described in Table 3-50 accomplish all of the computer interface functions for the category IV equipment. Since many DAC's are packaged in quad or octal units the total number of modules could be reduced to four by sharing a single DAC module. The simplicity of the CDMS requirement for this category reflects the fact that the items of equipment are mostly self-contained and controlled and require very little external interface.

3.8.5 SPA Payload Summary

The NIM and CAMAC requirements for the SPA data processing and control functions are summarized in Table 3-51.

The fairly heavy use of multichannel ADC's for these instruments is due to the multitude of analog signals they produce. In particular, sensors for measurement of temperature, flow and pressure contribute heavily to the requirements in this category.

Sixteen digital-to-analog converters are specified but these are contained within two octal modules. Each of these modules is shared between two equipment categories.

All of the requirements for NIM equipment are in the first two equipment categories since these contain the photomultiplier tube and infrared sensors. None of the sensors used in the other two categories produce signals of a type suitable for processing by NIM modules.

Table 3-50. CAMAC Implementation of Category IV SPA CDMS

System Element	CAMAC Product Code	Specific Example	Comments
Zone Refiner			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning
ADC	161		
DAC	162	D0200-1528	±10-V, 12-bit
Directional Solidification Unit			
Multiplexer	164	KS3510	Sixteen-channel ADC, self-scanning. Share unit above
ADC	161		
DAC	162	D0200-1528	
Low-Voltage/High-Amp Converter			
Output Register	133	KS3080	Share with other power conditioners
RF Induction Conditioners			
Output Register	133	KS3080	Share with other power conditioners
RF Induction Conditioners			
Output Register	133	KS3080	Share with other power conditioners
HV Power Converter			
Output Register	133	KS3080	Share with other power conditioners

Table 3-51: SPA Use of NIM and CAMAC EQUIPMENT

CAMAC Equipment	CAMAC Product Code	Equipment Category: Category I	Category II	Category III	Category IV	Totals
Scaler	111	1	1			2
Input Register	121	1	1	1		3
Output Register	133	1		2	1	4
Stepping Motor Driver	145	1	2	3		6
Analot-to-Digital Converter	161					
Single Unit - Fast		1	2	1		4
Multichannel - Slow		3	3	1	2	9
Digital to Analog Converter	162		Share 1		Share 1	2
Branch Driver	211			Share 1		1
Crate Controller	231			Share 2		2
Crate	411			Share 2		2
NIM Equipment						
High Voltage Power Supply		2	1			3
Photomultiplier Amplifier		2	1			3
Single Channel Analyzer		2	1			3
Bias Voltage Supply			1			1
Bin				Share 1		1

3.9 NIM/CAMAC APPLICABILITY AND COMMONALITY

3.9.1 Applicability Tabulation

The results of the analyses of the seven representative payloads described in the preceding sections plus the results of the previous work by Bendix and NASA/GSFC were combined to generate a summary tabulation of NIM and CAMAC usage. Before discussing the overall results for NIM and CAMAC equipment applicability, a brief discussion of the four payloads made up of instruments analyzed in other studies will be given.

3.9.1.1 Bendix and NASA/GSFC Payloads

The Bendix study investigated the feasibility of implementing six Shuttle sortie payloads with NIM and CAMAC equipment. The instrumentation required for the two earth observations experiments analyzed by Bendix (13-Band Multispectral Scanner and Microwave Radar System) would actually constitute considerably less than an entire payload in the sense we are using the term here (i.e., a complement of instruments that approximately uses the full payload capability of Spacelab). Consequently, these two instruments were included in the earth observations payload analyzed in Section 3.6, and their results have already been incorporated in Table 3-38.

A somewhat similar case applies for the high-energy astrophysics instruments analyzed by Bendix and NASA/GSFC. The Shuttle Sortie Cosmic Ray Laboratory treated by Bendix consists of a cosmic-ray instrument that is based on a NASA/JSC balloon flight payload. Major components of the system are a superconducting magnet spectrometer and a small ionization calorimeter primarily designed for electron detection.

The two instruments analyzed by NASA/GSFC were designed to fly on automated spacecraft and were also based on experiments that have been flown on balloons. The Explorer Gamma-Ray Experiment Telescope (EGRET) consists of a multiplane, wire spark chamber pictorial gamma-ray detector coupled with a total absorption shower crystal detector. The High-Energy Cosmic-Ray Experiment (HECRE) consists of a large area charge detection system and a large ionization calorimeter primarily designed for nuclear cosmic-ray detection.

We have combined these three instruments into one high-energy astrophysics payload designated as the Cosmic-Ray/Gamma-Ray Payload in our tabulations. The NIM and CAMAC modules required to implement this payload were taken from the Bendix and NASA/GSFC work and are shown in Table 3-52 in the format we have used in the preceding sections.

The remaining three payloads studied by Bendix are payloads in the sense used here. The Astronomical Observatory for Shuttle includes a one-meter telescope designed to operate in the ultraviolet and visible regions of the spectrum with a variety of focal plane instruments. From the standpoint of CDMS requirements, it is similar to the IR telescope discussed in Section 3.3. The Atmospheric Science Facility is composed of large numbers of optical instruments operated in a coordinated fashion to carry out remote sensing measurements on the atmosphere. Finally, the Auroral and Magnetospheric Observatory is very similar to the AMPS payload treated in Section 3.5 and contains many of the same instruments. The NIM and CAMAC equipment requirements for these three payloads that we will use in our overall tabulation have been taken directly from the Bendix study.

3.9.1.2 CAMAC Applicability

The overall summary of CAMAC equipment requirements for the eleven representative Spacelab payloads is presented in Table 3-53. The numbers of modules needed in each payload are tabulated by CAMAC product code. The largest numbers of any particular type of module required in one payload are circled. This information will be used in the commonality analysis (Section 3.9.2). It can immediately be seen that a significant number of modules is required by each payload. The total number of CAMAC modules required to implement the eleven payloads is 648 (not counting crates) yielding an average of 59 modules per payload. From the table, it can be seen that the applicability of CAMAC equipment is relatively uniform over the various disciplines with a factor of two maximum variations up or down from the average. As expected, high-energy astrophysics is the heaviest user of CAMAC equipment. The distribution of applicability amongst the various functional types of CAMAC modules is also seen to be relatively uniform. As would be expected, analog-to-digital converters are the most frequently used type of module.

Table 3-52: Cosmic Ray/Gamma Ray Use of NIM and CAMAC Equipment

	CAMAC Product Code	Cosmic Ray Lab (Bendix)	EGRET (GSFC)	HECRE (GSFC)	Totals
<u>CAMAC Equipment</u>					
Scalers	111	3	10	1	14
Input Gates	121	1	1	1	3
Interrupt Registers	123	1	1	1	3
Clocks & Pulse Generators	131	1	1	1	3
Output Registers	132	2	2	1	5
Analog-to-Digital Converters	161				
High Resolution- Fast			3		3
Multichannel - Slow		3	1	4	8
Time Digitizers		2			2
Digital-to-Analog Converters	162	1		2	3
Multiplexers			1		1
Branch Drivers	211		Share 1		1
Crate Controllers	231	1	1	1	3
Crates	411	1	1	1	3
<u>NIM Equipment</u>					
Amplifiers					
Shaping			1	7	8
Fast		2			2
Delay			3		3
Discriminators					
Fast Integral		1	3	5	9
Slow Integral			6		6
Constant Fraction		8	2	2	12
Linear Fan-Ins		1	4	7	12
Linear Fan-Outs		2	1		3
Logic Units		1	1	1	3
High Voltage Power Supplies		8			8
Bins		3	2	2	7

Table 3-53: CAMAC Equipment Applicability Tabulation

CAMAC Equipment	CAMAC Product Code	Astronomy			High Energy Astrophysics		Space Physics						
		IR Telescope	UV Telescope (Bendix)	ATM - Solar	X-Ray/ Gamma Ray	Cosmic Ray/ Gamma Ray	AMPS	Atmospheric (Bendix)	Auroral (Bendix)	Life Sciences	Earth Observations	Space Processing	Totals
Scalers	111			4	23	14	6		1		1	2	51
Preset Scalers	113		5						3				8
Position Encoders	117		8		8			8	3	2	2		31
Input Gates	121	7	2	6		3	10		1	4	6	3	42
Input Registers	122							7					7
Interrupt Registers	123		3		4	3		4	2		2		18
Clocks & Pulse Generators	131	1	3	4		3		2	4				17
Output Registers	132		5			5		18	5		2		35
Output Drivers	133	6		18	5		10			1	25	4	69
Stepping Motor Controllers	145	11		18	15		15	9		6	6	6	86
Analog-to-Digital Converters	161												
High Resolution/Fast		21		7	16	3	13			20	3	4	87
Multichannel/Slow		11		6	7	8	6	1	2	12	5	9	67
Time Digitizers					26	2							28
Digital-to-Analog Converters	162	1	2	2	1	3	9		6	3	1	2	30
Multiplexers	164	3		3		1			2	9	2		20
Branch Drivers	211	1	1	1	1	1	1	2	2	1	1	1	13
Crate Controllers	231	4	2	4	6	3	4	4	3	4	3	2	39
Crates w/Power Supply	411	4	2	4	6	3	4	4	3	4	3	2	39
Totals		70	33	77	118	52	78	59	37	66	62	35	687

No payload CDMS requirements, for which CAMAC-type equipment was in general applicable, were found that could not be satisfied with available CAMAC modules. Hence, no requirements for functionally-modified or special-purpose modules were identified. In fact, in most cases a number of different modules were available to fulfill any particular functional requirement.

In summary, our conclusion is clear -- from a functional standpoint, CAMAC equipment has been found to have a high degree of applicability for Shuttle payload data acquisition and control requirements.

3.9.1.3 NIM Applicability

The overall summary of NIM equipment requirements for the eleven representative payloads is presented in Table 3-54. For the purposes of this tabulation, we have generated a functional classification for NIM modules that serves the same function as the CAMAC product code. Although the total number of units required is considerable, the applicability of currently available NIM equipment is concentrated in the high-energy astrophysics area. About 70 percent of the total usage occurs in this single discipline. While the distribution of usage among the various functional types of modules is reasonably uniform in this discipline, the usage elsewhere is limited almost entirely to amplifier and high-voltage power supplies with a few discriminators required in addition.

The limited applicability found for NIM equipment makes an approach to implementing Shuttle payloads that is based directly on existing commercial NIM equipment questionable. This conclusion is further strengthened by the fact that the available NIM equipment tends to be not very compactly packaged.

This situation often arises in the case of analog signal processing modules because of the provision of convenient front-panel-mounted switches for manual circuit control and the use of numerous coaxial signal connectors in existing modules. We believe that consideration should be given to developing a more compactly packaged version of NIM-type functions for use in Shuttle experiment instrumentation. Such an approach would be quite feasible because of the reduced need for easily accessible control switches, etc. in spaceflight applications. Some of the functions normally implemented

Table 3-54: NIM Equipment Applicability Tabulation

NIM Equipment	Astronomy: IR Telescope	Astronomy: UV Telescope (Bendix)	Astronomy: ATM - Solar	High-Energy Astrophysics: X-Ray/ Gamma Ray	High-Energy Astrophysics: Cosmic Ray/ Gamma Ray	Space Physics: AMPS	Space Physics: Atmospheric (Bendix)	Space Physics: Auroral (Bendix)	Life Sciences	Earth Observations	Space Processing	Totals
Pulse Amplifiers												
Shaping			10	(42)	8	4		11		1	3	79
Fast					(2)							2
Delay					(3)							3
Sum/Invert				(49)		1						50
Discriminators												
Fast Integral				(22)	9							31
Slow Integral			(10)		6	5						21
Window										1	3	4
Zero-Crossing				(7)								7
Constant-Fraction					(12)							12
Linear Gates			(1)									1
Linear Fan-Ins					(12)							12
Linear Fan-Outs					(3)							3
Logic Units				(19)	3							22
Pulse Height Analyzers						1						
High Voltage Power Supplies	5	2	9	(42)	8	40		7			3	116
Bins w/Power Supply	1	1	2	(17)	7	8		4		1	1	42
Totals	6	3	32	198	73	59	—	22	—	3	10	406
Special Modules												
Sequence Discriminators				7								
Wave Analyzers						8						
Differential Amplifier						6						

in NIM form are available in a more compact CAMAC form (see product code 165 in the CAMAC Product Guide). We have not used these modules in the present analysis because almost all of them are manufactured by a Polish and a Hungarian firm.

Finally, almost one-third of the applicable NIM modules are high-voltage power supplies (HVPS's). For many reasons, the use of NIM-packaged HVPS's is not attractive for Spacelab applications. For instance, since the NIM units must be located in a pressurized environment, extensive high-voltage cabling would be required between the Spacelab Module or Igloo and pallet-mounted instruments. A much more reasonable approach would be to develop a family of standard programmable HVPS's suitable for operation in normal spaceflight environments. The frequent, relatively common requirements for HVPS's found in our work here and in previous analyses leads to the conclusion that such an approach would be cost effective.

In summary, we conclude that the limited applicability found for existing NIM equipment, coupled with the unattractive packaging features found in the NIM versions of the potentially most applicable types of functions, makes the development of standard modules specifically designed for spaceflight applications more reasonable than attempting a general standardization based on existing NIM equipment.

3.9.2 Commonality Analysis

A more quantitative measure of the commonality of the requirements found for any particular NIM or CAMAC unit can be obtained by comparing the number of units required when they can be shared among payloads as opposed to being dedicated to each payload. A simplified version of this comparison is presented in this section. A more detailed and realistic treatment of the comparison is given in Section 2, Volume III, as part of the discussion of Task 4A.

The simplified commonality analysis involved comparing the number of units that would be required if the eleven payloads were flown in a serial sequence as opposed to in parallel. The assumption implicit in this exercise is that for the serial case, any particular unit would be available to all payloads as required. Hence, for the serial case, only the number of units required by the largest user of that particular piece of equipment would be required to carry out all the flights. For the parallel case, the total number of units needed by all users would be required. As previously noted, the largest user of each type of module is designated by the circled entries in Tables 3-53 and 3-54. The commonality analysis amounts to comparing the circled numbers with the numbers in the right-hand column of the tables.

A summary of this comparison is presented in Table 3-55. For CAMAC equipment, the serial case requires a total of 217 units versus 687 units in the parallel case. For NIM equipment, the corresponding numbers are 245 versus 406. In other words, because of the increased commonality of the requirements for CAMAC equipment, allowing the units to be shared by users results in a reduction of almost 70 percent in the number of units needed compared with a reduction of 40 percent for NIM equipment.

So far as the various types of equipment are concerned, the equipment that is common to every CAMAC system, such as crates, crate controllers, and branch drivers, obviously has the highest commonality. The numbers here merely substantiate the discussion in Section 3.1.1 regarding low-voltage power supplies for NIM and CAMAC equipment. If use of the overall standard is adopted, it would be well worth the investment to develop special versions of the system-common equipment for spaceflight application if required. At the level of breakdown given in Table 3-55, the degree of commonality found for CAMAC module applications is quite uniform. So far as individual types of functional modules are concerned (see Table 3-53), there is considerable variation and the most commonly used units are the two types of ADC's and stepper motor controllers.

Therefore, regarding CAMAC equipment, we conclude that the high degree of both applicability and commonality found warrants its serious consideration for use in Spacelab payload instrumentation. We further believe that there is enough common application for this conclusion to hold true independent of the question of the amount of modification required for the Spacelab environment. In other words, the degree of applicability and commonality is sufficient to justify the development of special spaceflight versions of the equipment, if required.

Table 3-55: Unit Quantities Required to Implement the Representative Payloads

Equipment Item	Parallel Flight Sequence (Dedicated Usage)	Serial Flight Sequence (Shared Usage)
CAMAC		
Serial Input Registers (111, 113 & 117)	90	36
Parallel Input Registers (121, 122, 123 & 127)	67	25
Output Registers (131, 132, 133)	121	47
Motor Controllers (145)	86	18
A-D & D-A Converters (161, 162 & 164)	232	77
System-Common Equipment (211, 231, 411)	91	14
Total	687	217
NIM		
Pulse Amplifiers	134	96
Discriminators	75	54
Linear Gates, Fan-Ins, Fan-Outs, Logic Units, PHA	39	36
High Voltage Power Supplies	116	42
Bins	42	17
Total	406	245

For NIM equipment, the only type of module reaching a commonality comparable to that found for CAMAC is high-voltage power supplies; and, as discussed in Section3.9.1.3,NIM is not an efficient form of implementation for this function in the Shuttle environment. Therefore, the commonality analysis only confirms the conclusion reached in Section 3.9.1.3.

APPENDIX I

CAMAC PRODUCT GUIDE

CAMAC PRODUCT GUIDE

HARDWARE

This guide consists of a list of CAMAC equipment which is believed to be offered for sale by manufacturers in Europe and the USA. The information has been compiled by CERN-NP-Electronics and is mainly based on information communicated by manufacturers and available up to the 20th September 1975.

Every effort has been made to ensure the completeness and accuracy of the list, and it is hoped that most products and manufacturers have been included. Inclusion in this list does not necessarily indicate that products are fully compatible with the CAMAC specifications nor that they are recommended or approved by the ESONE Committee. Similarly, omission from this list does not indicate disapproval by the ESONE Committee.

Reader service

Readers are advised to use the Reader service enquiry card, inserted in this Bulletin, if you wish to obtain more information on CAMAC Products, and to be on the manufacturers mailing list.

Remarks on some columns in the Index of Products

Column

NC – N is new, C is corrected entry.

WIDTH – 1 to 25, indicates module width or—for crates—the number of stations available.
– 0 indicates unknown width or format.
– Blank, the width has no meaning.
– NA indicates other format, normally a 19 inch rack mounted chassis.

NPR – Number in brackets is issue number of the Bulletin in which the item was or is described in the New Products section.

DELIV – Date on which item became or will become available.

REF No – Reader service reference number.

CLASSIFICATION GROUPS

code		page
1	DATA MODULES (I/O Transfers and Processing)	
11	Digital Serial Input Modules (Scalers, Time Interval and Bi-directional Counters, Serial Coded etc.)	III
12	Digital Parallel Input Modules (Storing and Non-Storing Registers, Coinc. Latch, LAM, Status etc.)	V
13	Digital Output Modules (Serial: Clocks, Timers, Pulse Generators, Parallel: TTL Output, Drivers)	VIII
14	Digital I/O, Peripheral and Instrumentation Interfacing Modules (Serial and Parallel I/O Regs, Printer-, Tape-, DVM-, Plotter- and Analyser Interfaces, Step-Motor Drivers, Supply CTR, Displays)	XI
15	Digital Handling and Processing Modules (and/or/not Gates, Fan-Outs, Digital Level and Code Converters, Buffers, Delays, Arithm. Processors etc.)	XIV
16	Analogue Modules (ADC, DAC, Multiplexers, Amplifiers, Linear Gates, Discriminators etc.)	XVI
17	Other Digital and/or Analogue Modules (Mixed Analogue and Digital, Not Dataway Connected etc.)	XX
2	SYSTEM CONTROL (Computer Couplers, Controllers and Related Equipment)	
21	Interfaces/Drivers and Controllers (Parallel Mode for 4600 Branch and Other Multi-Crate Bus, Single-Crate Systems, Autonomous Systems)	XXI
22	Interfaces/Controllers/Drivers for Serial Highway	XXIV
23	Units Related to 4600 Branch or Other Parallel Mode Control/Data Highway (Crate Controllers, Terminations, LAM Graders, Branch/Bus extenders)	XXIV
3	TEST EQUIPMENT	
31	System Related Test Gear	XXVI
32	Branch Related Testers/Controllers and Displays	XXVI
33	Dataway Related Testers and Displays	XXVI
34	Module Related Test Gear (Module Extenders)	XXVII
37	Other Test Gear for CAMAC Equipment	XXVII
4	CRATES, SUPPLIES, COMPONENTS, ACCESSORIES	
41	Crates and Related Components/Accessories (Crates with/without Dataway and Supply, Blank Crates, Crate Ventilation Gear)	XXVIII
42	Supplies and Related Components/Accessories (Single- and Multi-Crate Supplies, Blank Supply Chassis, Control Panels, Supply Ventilation)	XXX
43	Recommended or Standard Components/Accessories (Branch Cables, Connectors etc., Dataway Connectors, Boards etc., Blank Modules, Other Stnd Components)	XXXI

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.

1 DATA MODULES — I/O TRANSFERS AND PROCESSING

11 Digital Serial Input Modules — Scalers, Time Interval and Bi-directional Counters, Serial Coded etc.

111 Simple Serial Binary Registers

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
N	24 BIT SCALER (15MHZ)	CAM 2,01	METRIMPEX	1	/72		14,1001
	1X24 BIT BINARY BLIND SCALER (20MHZ NIM OR 10MHZ TTL I/P,EXT INHIBIT IN,OVF O/P)	J EB 10	SCHLUMBERGER	1	/71		14,1002
	MINISCALER (2X16BIT,30MHZ,SEPARATE GATES AND EXTERNAL RESET,NIM LEVELS)	1002	BORER	1	/69		14,1003
	MINISCALER (2X16BIT,30MHZ,SEPARATE GATES AND EXTERNAL RESET,NIM LEVELS)	002	NUCL. ENTERPRISES	1			14,1004
	MINISCALER(2X16BIT,30MHZ,SEPARATE GATES AND EXT RESET,NIM LEVELS)	C 104	RDT	1	/71		14,1005
	DUAL SCALER (2X16BIT, 50MHZ)	DS 050	STND ENGINEERING	1	/73		14,1006
	DUAL 150 MHZ 16 BIT SCALER (ONE 50 OHMS, ONE UNTERMINATED NIM INPUT PER SCALER)	2S 2024/16	SEN	1	/70		14,1007
	DUAL SCALER (2X16BIT, 100MHZ)	DS 100	STND ENGINEERING	1	/73		14,1008
	DUAL SCALER (2X16BIT, 150MHZ)	DS 150	STND ENGINEERING	1	/74		14,1009
	DUAL SCALER (2X16BIT, 200MHZ)	DS 200	STND ENGINEERING	1	/74		14,1010
	DUAL 24 BIT BINARY SCALER (15MHZ, NIM OR TTL INPUTS'	FHC 1313	FRIESEKE	1	/72		14,1011
N	QUAD SCALER (4X12 OR 2X24 BIT, 15MHZ)	CAM 2,02	METRIMPEX	1	/72		14,1012
	DOUBLE SCALER (24/16BIT,50MHZ,2 I/P & 3 GATE MODES,INHIBIT, P1=OVERFLOW) SELECTABLE,50MHZ,COMMON GAT*,NIM LEVELS)	C-DS-24	WENZEL ELEKTRONIK	1	/72		14,1013
	FOUR-FOLD CAMAC SCALER (4X16BIT,40MHZ, ONE 50 OHMS,ONE HI-Z NIM I/P PER SCALER)	4 S 2004	SEN	1	/70		14,1022
	TIME DIGITIZER(4X16BIT,CLOCK RATE 70/85MHZ, WITH CENTER FINDING LOGIC)	TD 2031	SEN	1	/72		14,1023
	TIME DIGITIZER (4X16BIT,CLOCK RATE 70/85MHZ,NIM LEVELS)	TD 2041	SEN	1	/72	(4)	14,1024
	QUAD SCALER (4X16BIT, 50MHZ)	QS 050	STND ENGINEERING	1	/73		14,1025
	SERIAL REGISTER (4X16BIT,2X32BIT SELECT-ABLE,100MHZ,COMMON GATE,NIM LEVELS)	SR 1608	GEC-ELLIOTT	1	/71		14,1026
	FOUR-FOLD SCALER(4X16BIT,2X32BIT SELECT-ABLE,100MHZ,COMMON GATE,NIM LEVELS)	4 S 2003/100	SEN	1	/70		14,1027
	QUAD SCALER (4X16BIT, 150MHZ)	QS 150	STND ENGINEERING	1	/74		14,1028
	QUAD SCALER (4X16BIT, 200MHZ)	QS 200	STND ENGINEERING	1	/74		14,1029
	QUAD SCALER (4X24BIT, 50MHZ, DATAWAY AND/OR EXT FAST INHIBIT, NIM LEVELS)	S4245	EG&G/ORTEC	1		(7)	14,1030
N	SCALER-TIMER (4X24BIT, INT. 1MHZ CRYSTAL OSCILLATOR, RESOLUTION 10MHZ)	CAM 5,02	METRIMPEX	1	/73		14,1031
	QUAD COUNTING REGISTER(4X24BIT,NIM INPUT TTL INHIBIT IN,TTL CARRY AND OVF OUT)	709-2	NUCL. ENTERPRISES	1	/71		14,1032

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NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	DIGITAL INPUT REGISTER (5X8BIT PARALL INPUT GATES,5TH BYTE SETS L,TTL,1=H)	DD 200-2001	DORNIER	1	/71		14,1098
	(WITH FRONT PANEL CONNECTOR)	DD 200-2201		1	/72		
	(MODULE WITH ONLY LOGIC BOARD)	DD 200-2000		1	/73		
	DIGITAL INPUT REGISTER (5X8BIT PARALL INPUT GATES,5TH BYTE SETS L,HLL,1=H)	DD 200-2002	DORNIER	1	/72		14,1099
	(WITH FRONT PANEL CONNECTOR)	DD 200-2202		1	/72		
	PARALLEL INPUT GATE(16X16BIT,TTL, 1=LOW)	IG 25601	GEC-ELLIOTT	2	/72		14,1100
	128 BIT RECEIVER (ADDRESSABLE AS 8 16BIT WORDS OR 128 1-BIT WORDS)	C 341	INFORMATEK	1	/73		14,1101

122 Storing Registers

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	OPTICAL ISOLATED INPUT REGISTER	2601	BI RA SYSTEMS	1	/74		14,1102
	PARALLEL INPUT REGISTER (16BIT,CONTINU-OUS OR STROBED MODES CONTROLLED BY REG)	2014-1	NUCL. ENTERPRISES	1	/70		14,1103
	DYN. DIG. INPUT (16BIT, TTL, LAM IF INPUT 0-1 OR 1-0 OR BOTH)	C 76451-A1/-A4	SIEMENS	1	/73	(6)	14,1104
	INPUT REGISTER (16BIT)	PR 301	STND ENGINEERING	1	/73		14,1105
	DYNAMIC DIGITAL INPUT 16BIT FLOATING I/P	C 76451-A17-A3	SIEMENS	1	/73	(6)	14,1106
	ISOLATED INPUT REGISTER(16BIT,AR302D FOR 12,24 OR 48VDC, AR302A FOR 115VAC)	AR 302*	STND ENGINEERING	1	/74		14,1107
	INPUT REGISTER (16BIT,CONTACT CLOSURE)	AR 302C	STND ENGINEERING	1	/74		14,1108
	PARALLEL-INPUT-REGISTER (SINGLE 16/24BIT OPT,READY SIGNALS,I/O TTL,CONTROL BUS)	RS PI 2 1230/1	AEG-TELEFUNKEN	1	/70	(1)	14,1109
	INPUT REGISTER (24BIT, SPEC CONN, 8 BIT ALSO VIA LEMO,LAM ON NON-ZERO OR STROBE)	FHC 1308	FRIESEKE	1	/71		14,1110
N	CONTACT SENSE (24BIT ISOLATED INPUT REG, SENSES 12,24,48VDC OR 120VAC INPUTS)	CS	JOERGER	1	09/75		14,1111
N	CONTACT SENSE (24BIT ISOLATED INPUT REG, SENSES STATE OF SERIES SWITCHES)	CS-1		1	08/75		
	INPUT REGISTER 24-BIT	3470	KINETIC SYSTEMS	1	/71	(4)	14,1112
	INPUT REGISTER (24BIT)	PR 304	STND ENGINEERING	1	/73		14,1113
	INPUT REGISTER (24 INPUTS, + STROBE, OPTICALLY ISOLATED)	IR-2	JOERGER	1	/74	(11)	14,1114
	BALANCED INPUT REGISTER WITH ADDRESSING	3430	KINETIC SYSTEMS	1	/72	(8)	14,1115
	PARALLEL INPUT REGISTER (2X16BIT, TTL)	2312	BI RA SYSTEMS	1	/73		14,1116
	DUAL INPUT REGISTER(2X16BIT,LAM & STROBE I/P & DATA-READ-STROBE O/P PER CHANNEL)	PR 1610 SERIES	GEC-ELLIOTT	1	/73		14,1117
	CANAL UNTERM, I/P'S VIA SCHMITT TRIGGERS I/P FILTER RESPONSE 1USEC TO 10MS	PR 1611		1			
	DUAL 16 BIT INPUT REGISTER (TTL LEVELS, CERN SPECS 072)	2IR 2002	SEN	1	/72		14,1118
	DUAL 16 BIT INPUT REGISTER(EXT STROBE OR DATAWAY COMMAND STORES DATA,TTL LEVELS)	2IR 2010	SEN	1	/70		14,1119
	DUAL INPUT REGISTER (16BIT)	PR 601	STND ENGINEERING	1	/73		14,1120
	DIGITAL INPUT (2X16BIT FLOATING INPUT)	C 76451-A8-A3	SIEMENS	1	/73	(6)	14,1121
	DUAL 24 BIT PARALLEL INPUT REGISTER(TTL)	2322	BI RA SYSTEMS	1	/73		14,1122
	DUAL 24 BIT INPUT REGISTER (TTL, HANDSHAKE)	RI-224	EG&G/ORTEC	1	/72		14,1123
	DUAL INPUT REGISTER(2X24BIT,LAM & STROBE I/P & DATA-READ-STROBE O/P PER CHANNEL)	PR 2400 SERIES	GEC-ELLIOTT	1	/73		14,1124
	CANAL UNTERM, I/P'S VIA SCHMITT TRIGGERS I/P FILTER RESPONSE 1USEC TO 10MS	PR 2401		1	/73		
	(SAME BUT WITH TWISTED PAIR INPUTS)	PR 2402		1	/73		
	(SAME BUT WITH OPTICAL ISOLATION INPUT, LOGIC 1 = 5V OR 12MA)	PR 2403		1	/73		
	DUAL INPUT REGISTER (2X24BIT,I/P INTEGR TTL, FULL LAM, OUTPUT STROBES)	220	HYTEC	1	/73		14,1125
	INPUT REGISTER (2X24BIT, 3 MODES OF DATA ENTRY, LED DISPLAY)	IR	JOERGER	1	/72	(7)	14,1126
	DUAL PARALLEL INPUT REGISTER(2X24BIT,EXT LOAD REQUEST,4 OPER MODES,TTL LEVELS)	60A	JORWAY	1	/70		14,1127
	24-BIT DUAL PARALLEL INPUT REGISTER (A HAS LO-Z, B HAS UNTERMINATED INPUT)	9041A/9041B	NUCL. ENTERPRISES	1	/72	(7)	14,1128
	PARALLEL INPUT REGISTER (2X24 BITS)	J RE 10	SCHLUMBERGER	1	/73	(7)	14,1129
	DUAL 24 BIT PARALLEL INPUT REGISTER (WITH LED DISPLAY OPTION)	PR-604	STND ENGINEERING	1	/72		14,1130

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
C	DUAL INPUT REG.(2X24BIT,SEP,TIMING,LOGIC BIT+ISE POS/NEG,4TIMINGS 3DATA IN MODES)	C-IL-48	WENZEL ELEKTRONIK	1	/75	(14)	14,1131
N	QUAD 24 BIT INPUT REGISTER (4X24, HAND-SHAKE DATA TRANSFER, 3 DATA ENTRY MODES)	QIR	JUERGEN	1	09/75	(14)	14,1132
	DORNIER MODULES ALSO MARKETED BY SIEMENS		SIEMENS				14,1133
	DIGITAL INPUT REGISTER, EXTERNAL STROBE (4X8BIT INPUT LATCHES, 1X8BIT SET LAM)	DU 200-2004	DORNIER	1	/73		14,1134
	(SAME WITH FRONT PANEL CONNECTOR)	DU 200-2204		1	/73		

123 Terminated Signal Input Registers (Coinc. Latch, Pattern etc.)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	12 BIT PARALLEL INPUT REGISTER (NIM)	2351	BI RA SYSTEMS	1	/73		14,1135
	STROBED INPUT REGISTER (12BIT COINC AND LATCH,NIM LEVELS,PATTERN AND L-REQ APPL)	SIR 2026	SEN	1	/70		14,1136
	16BIT DISCRIMINATOR-COINCIDENCE REGISTER	2352	BI RA SYSTEMS	2	01/75		14,1137
	FAST COINCIDENCE LATCH(16BIT,DISCR I/P, MIN 2 NSEC STROBE-SIGNAL OVERLAP)	64	JORWAY	1	/71	(1)	14,1138
	16 FOLD DCR (16 DISCR, COMMON STROBE, -70MV THRESHOLD, FAST SUMMING OUTPUTS)	2340B	LRS-LECROY	2	/71	(6)	14,1139
	16-CH COINCIDENCE REGISTER (STROBE I/P, 2NS OVERLAP,FAST SUM O/P AND CLEAR,NIM)	2341S	LRS-LECROY	1	/71	(4)	14,1140
N	16 CHANNEL STROBED COINCIDENCE (16 COINC INPUTS, COINC & LAM OUTPUT, 10NS RESOL.)	CAM 8,05	METRIMPEX	2	/74		14,1141
	PATTERN UNIT (16 INDIV NIM INPUTS,COMMON NIM GATE)	021	NUCL. ENTERPRISES	2	/71	(6)	14,1142
	FAST INPUT REGISTER (ASSEMBLES 16BIT WORDS FROM IL2 INPUTS)	9053	NUCL. ENTERPRISES	1	/74		14,1143
	PATTERN UNIT(16BIT,I/P STROBED WITH COMMON GATE,10 NSEC OVERLAP,NIM LEVELS)	C 101	RDT	2	/71		14,1144
	16 BIT PATTERN UNIT (NIM I/P AND GATE)	J PU 10	SCHLUMBERGER	1	/72		14,1145
	PATTERN UNIT 16 BIT (16 INDIVIDUAL NIM INPUTS,COMMON NIM GATE, CERN SPECS 021)	16P 2007	SEN	2	/70		14,1146
	16 BIT PATTERN UNIT (CERN 071, 16 INDIV NIM INPUTS,COMMON NIM GATE,LED DISPLAY)	16P 2047	SEN	1	/72	(11)	14,1147
	COINCIDENCE REGISTER/LATCH (16 CHANNEL)	CR 116	STND ENGINEERING	1	/74		14,1148
	COINCIDENCE REGISTER/LATCH (16 CHANNEL)	CR 216	STND ENGINEERING	1	/74		14,1149
	COINCIDENCE REGISTER (16 CH,COMMON GATE, MIN OVERLAP 2NS,DOUBLE PULSE RESOL 10NS)	CR-6001	STND ENGINEERING	1	/74	(12)	14,1150
	COINCIDENCE LATCH (24 NIM INPUTS WITH COMMON STROBE, EXT RESET, 2NSEC OVERLAP)	C124	EG&G/ORTEC	2			14,1151
N	PARALLEL INPUT REGISTER (24BIT)	CAM 2,05	METRIMPEX	1	/74		14,1152
	COINCIDENCE REGISTER/LATCH (24 CHANNEL)	CR 224	STND ENGINEERING	1	/74		14,1153
	COINCIDENCE BUFFER (2X12BIT,ONE STROBE PER 12BITS,MIN 2NS OVERLAP,NIM INPUTS)	C212	EG&G/ORTEC	2	/71		14,1154

124 Manual Input Modules (Word Generators, Parameter Units)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	PARAMETER UNIT 12 BIT (PROVIDES 12 BIT COMMUNICATION,PUSH BUTTON L-REQUEST)	P 2005	SEN	1	/70		14,1155
	MANUAL INPUT REGISTER (INPUTS A HAND-SET 16-BIT WORD, MANUAL AND ELECTR LAM I/P)	1041	BORER	1	/73	(8)	14,1156
	24 BIT PARAMETER UNIT	2501	BI RA SYSTEMS	1	/73		14,1157
	WORD GENERATOR (24BIT WORD MANUALLY SET BY SWITCHES)	WG 2401	GEC-ELLIOTT	1	/71		14,1158
	DATA SWITCHES (16/24 BITS,READABLE + CONTENT ADDR)	C 322	INFORMATEK	1	/72		14,1159
N	MANUAL INPUT/OUTPUT (TEST UNIT PROVIDES MANUAL DATA INPUT & VISUAL DATA OUTPUT)	MI/O	JUERGEN	1	08/75		14,1160
	MANUAL INPUT/OUTPUT REGISTER (24 BITS, SWITCH I/P + LAM, 24 LED O/P REGISTER)	201	JORWAY	1	/74	(11)	14,1161
C	24-BIT MANUAL INPUT	3460	KINETIC SYSTEMS	2	/73		14,1162
N	24-BIT MANUAL INPUT	3461		1	/75		
	WORD GENERATOR (24 BITS OF BINARY DATA, SWITCH SELECTED)	9020	NUCL. ENTERPRISES	1	/71	(2)	14,1163
	24 BIT WORD GENERATOR WITH LAM	WGR-241	STND ENGINEERING	1	/73		14,1164

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NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	MANUAL REGISTER (FOUR 16 BIT WORDS)	231	POLON	3	/74		14,1165
	PARAMETER UNIT (QUAD 4-DECADE BCD PARAMETERS MANUALLY SET)	022	NUCL, ENTERPRISES	4	/71	(2)	14,1166
	PARAMETER UNIT (QUAD 4 DECADE BCD PARAMETERS MANUALLY SET)	C 105	ROT	4	/71		14,1167

127 Other Parallel Input Modules (Incl. Lam and Status Registers, see 232 for Lam Grader)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	24-BIT INTERRUPT REGISTER (STATUS COMPARED,CHANGE GIVES LAM)	1051	BORER	1	/72	(3)	14,1168
	PRIORITY INPUT REGISTER(12BITS ORED TO LAM,FAST COINC LATCH APPL,MASK REGISTER)	63	JORWAY	2	/70		14,1169
	INPUT REGISTER (12 BIT, ORED TO LAM, COINCIDENCE LATCH APPL, NIM INPUTS)	65	JORWAY	1	/74		14,1170
N	INTERRUPT REQUEST REGISTER (16 INPUTS, ANY INPUT GIVES LAM)	CAM 2,09	METRIMPEX	1	/72		14,1171
N	INTERRUPT REQUEST REGISTER (8 CHANNELS)	9608	NUCL, ENTERPRISES	6		(14)	14,1172
	INTERRUPT REQUEST REGISTER	EC 218	NUCL, ENTERPRISES	1			14,1173
	LAM REQUEST REGISTER (16 BIT)	300	POLON	1	/74		14,1174
	INTERRUPT ALARM REGISTER (16 BITS, INDIVIDUALLY MASKABLE)	J IR 10	SCHLUMBERGER	1	/74	(11)	14,1175
	64 LINE SURVEYOR (SINGLE OR CONTINUOUS SURVEY CYCLES, 3 SURVEY MODES)	64LS 2052	SEN	1		(9)	14,1176
	ISOLATED INTERRUPT GATE(16BIT,*=D FOR 12,24 OR 48V,*=A FOR 115VAC VERSION)	AIG 302*	STND ENGINEERING	1	/74		14,1177
	INTERRUPT GATE (16BIT,CONTACT CLOSURE)	AIG 302C	STND ENGINEERING	1	/74		14,1178
	ISOLATED INTERRUPT REGISTER(16BIT,*=D FOR 12,24 OR 48VDC,*=A FOR 115VAC)	AIR 302*	STND ENGINEERING	1	/74		14,1179
	INTERRUPT REGISTER(16BIT,COTACT CLOSURE)	AIR 302C	STND ENGINEERING	1	/74		14,1180
	INTERRUPT GATE (24BIT)	IG 304	STND ENGINEERING	1	/74		14,1181
	DUAL INTERRUPT GATE (24BIT)	IG 604	STND ENGINEERING	1	/74		14,1182
	INTERRUPT REGISTER (12BIT) INTERRUPT REGISTER (16BIT) INTERRUPT REGISTER (24BIT)	IR 012 IR 016 IR 024	STND ENGINEERING	1 1 1	/74 /74 /74		14,1183
	INTERRUPT REGISTER (24BIT)	IR 304	STND ENGINEERING	1	/74		14,1184
	STATUS INTERRUPT (24BIT,I/P&LATCH&LAM& MASK,GROUP&SEL-LAM-TEST,VAR,LOGIC&LEVEL)	C-SI-24	WENZEL ELEKTRONIK	1	/74	(12)	14,1185

13 Digital Output Modules — Serial: Clocks, Timers, Pulse Generators, Parallel: TTL Output, Drivers

131 Serial Output Modules (Clocks, Timers, Pulse GEN)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	PRESET SCALER (LEVEL OR PULSE TRAIN O/P, DURATION SET BY COMMAND,SINGLE & REPEAT)	PSR 0801	GEC-ELLIOTT	1	/73		14,1186
N	CLOCK PULSE GENERATOR (10 FIX & 1 PRO-GRAMMABLE O/P, INT, 1MHZ, EXT, MAX 5MHZ)	CAM 5,01	METRIMPEX	1	/73		14,1187
N	SCALER-TIMER (4X24BIT, INT, 1MHZ CRYSTAL OSCILLATOR, RESOLUTION 10MHZ)	CAM 5,02	METRIMPEX	2	/73		14,1188
	CRYSTAL CLOCK GENERATOR (7 TTL OUTPUTS FOR 1HZ TO 1MHZ FREQUENCY DECADES)	FMC 1303	FRIESEKE	1	/71	(1)	14,1189
	CRYSTAL CONTROLLED PULSE GENERATOR(7 DE-CADES-1HZ TO 1MHZ-500NS PULSES OUT,TTL)	PG 0001	GEC-ELLIOTT	1	/71		14,1190
	REAL TIME CLOCK (4SEC CLOCK/5MSEC STOP WATCH)	C 320	INFORMATEK	1	/72		14,1191
	CLOCK GENERATOR (INT 10MHZ, EXT 50MHZ, 8 DECADE STEPS,PLUS PROGRAMMABLE OUTPUT)	CG	JOERGER	1	/72	(7)	14,1192
	GATED CLOCK (10MHZ TO 1HZ, INT-EXT CLOCK, SYNCHRONOUS GATING)	217	JORWAY	1	/74	(11)	14,1193
	CLOCK PULSE GENERATOR (7 OUTPUTS-1HZ TO 1MHZ-IN DECADE STEPS,10MHZ EXT IN,TTL)	7019-1	NUCL, ENTERPRISES	1	/70		14,1194
	CLOCK GENERATOR(INTERN 1MHZ, EXT 10MHZ, 7 DECADES 1HZ-1MHZ TTL O/P,50SEC WIDTH)	730A	POLON	1	/74		14,1195
	CLOCK PULSE GENERATOR(7 DECADES-1HZ TO 1MHZ-500 NSEC PULSES OUT,TTL AND NIM)	C 109	ROT	1	/71		14,1196
	1 HZ - 1 MHZ QUARTZ CLOCK (7 O/P - 1HZ TO 1MHZ-200 TO 800 NSEC WIDTH,TTL LEVEL)	J HG 10	SCHLUMBERGER	1	/71		14,1197

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	QUARZ-CLOCK WITH 2 TIMER FUNCTIONS	C 76451-A14-A2	SIEMENS	1	/72		14,1198
	CAMAC-CLOCK-GENERATOR(7 DECADES-10MHZ TO 1HZ,50/500 NSEC O/P PULSES,2,8V/50 OHMS)	C-CG-10	WENZEL ELEKTRONIK	1	/71		14,1199
	CLOCK/TIMER (0,0018 TO 10 HRS TIME INTERVAL,TIME-OF-DAY OUTPUT)	1411	HOMER	1	/72	(3)	14,1200
	REAL TIME CLOCK, LIVE TIME INTEGRATOR, PRESET TIMER	RC014	EG&G/ORTEC	1	/73		14,1201
	REAL TIME CLOCK (COUNTS ,1 SEC TO 999 DAYS, DISPLAYS HRS/MIN/SEC, 50/60HZ GEN)	RTC	JOERGER	2	/73	(7)	14,1202
N	WATCHDOG TIMER (MONITORS SYSTEM ACTIVITY GENERATES AUDIO ALARM & CONTACT CLOSURE)	WT	JOERGER	1	08/75	(14)	14,1203
	REAL TIME CLOCK	9064	NUCL, ENTERPRISES	1		(10)	14,1204
	REAL TIME CLOCK (3,8 USEC TO 18,2 HRS, PRESET-TIME AND PRESET-COUNT MODES)	RTC 2014	SEN	1	/71		14,1205
	INTERVAL TIMER/WATCHDOG (100USEC-300SEC INTERVAL, 1 SEC--100 SEC TIMEOUT)	EC 384	SENSION	1	/74	(13)	14,1206
	REAL TIME CLOCK (PRESET COUNTER, PRESET TIMER 3,8USEC TO 18,2 HRS, ELAPSE TIME)	RTC 018	STND ENGINEERING	1	/74	(12)	14,1207
	DEAD TIME COUNTER	2203	BI RA SYSTEMS	1	/74		14,1208
	TIMER MODULE	3655	KINETIC SYSTEMS	1	/73		14,1209
	TIME BASE (10 TO 100MHZ IN INCREMENTS OF 10MHZ, USED WITH TD 2031/TD 2041)	TB 2032	SEN	1	/71		14,1210
	TIMER (MIN 1USEC,OVF FROM COUNTER-PP1)	C 76451-A12-A1	SIEMENS	2	/73	(6)	14,1211
	TEST PULSE GENERATOR (5 TO 50 NSEC NIM O/P PULSE DERIVED FROM S1,F(25) OR EXT)	TPG 0202	GEC-ELLIOTT	1	/71		14,1212
	TEST PULSE GENERATOR (NIM PULSE PAIR)	215	JORWAY	1	/75		14,1213
	8 CHANNEL DELAY GENERATOR (DELAY 0 TO 99 TIMES CLOCK, DELAYS CASCADABLE)	220	JORWAY	1	/74	(11)	14,1214
N	SERIAL OUTPUT REGISTER (12/16/24 BIT, SCALER OR SHIFT REG, INT, 100HZ & 1MHZ)	CAM 2,11	METRIMPEX	1	/73		14,1215
	DUAL PROGRAMMED PULSE GENERATOR(50HZ/ 2KHZ/5KHZ PULSE TRAIN,LENGTH BY COMMAND)	2PPG 2016	SEN	1	/71		14,1216

132 Parallel Output Registers (TTL, HTL, NIM etc.)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	OPTICAL ISOLATED OUTPUT REGISTER	3601	BI RA SYSTEMS	1	/74		14,1217
	12 BIT PARALLEL OUTPUT REGISTER (NIM)	3251	BI RA SYSTEMS	1	/73		14,1218
	15 BIT PARALLEL OUTPUT REGISTER (BIT ADDRESSABLE, NIM LEVELS OR PULSES)	C 343	INFORMATEK	1	/73		14,1219
	12 BIT OUTPUT REGISTER(DC OR PULSE O/P, UPDATING STROBE OUTPUT,NIM LEVELS)	41	JORWAY	1	/71	(2)	14,1220
	OUTPUT REGISTER (12BIT, NIM PULSES OR LEVELS OUT)	OR 2027	SEN	1	/70		14,1221
	OUTPUT REGISTER (12BIT)	PR 312	STND ENGINEERING	1	/73		14,1222
	DIFFERENTIAL OUTPUT REGISTER	3030	KINETIC SYSTEMS	1	/72	(8)	14,1223
	OUTPUT REGISTER (12 CHANNEL)	OR 612	STND ENGINEERING	1	/73		14,1224
	OUTPUT REGISTER (24BIT TTL VIA SPEC CONN 8BIT ALSO VIA FRONT PANEL LEMO)	FHC 1109	FRIESEKE	1	/72		14,1225
N	PARALLEL OUTPUT REGISTER (24BIT, OUTPUT WITH CAMAC STANDARD)	CAM 2,12-3	METRIMPEX	1	/73		14,1226
	OUTPUT REGISTER (24 BIT, 16 MA 5V OUT)	9600A	NUCL, ENTERPRISES	0		(13)	14,1227
	OUTPUT REGISTER (24BIT,OPTO-COUPLER,7MA)	9603	NUCL, ENTERPRISES	0		(13)	14,1228
	OUTPUT REGISTER (24BIT WORD, TTL O/P VIA 37-WAY CONN)	351	POLON	1	/73		14,1229
	OUTPUT REGISTER (24BIT)	PR 314	STND ENGINEERING	1	/73		14,1230
	PARALLEL OUTPUT REG, (24BIT,NEG/OPT POS TTL,ADJ, DURATION&LEVEL,4 TIMING MODES)	C-OC-24	WENZEL ELEKTRONIK	1	/73	(10)	14,1231
	DUAL 16BIT PARALLEL OUTPUT REGISTER(TTL)	3212	BI RA SYSTEMS	1	/73		14,1232
	DUAL 16 BIT OUTPUT REGISTER (SELECTABLE O/P STAGES ON PLUGABLE PC, FP CONNECTOR)	2OR 2051	SEN	1		(9)	14,1233
	DUAL 24 BIT PARALLEL OUTPUT REGISTER	3222	BI RA SYSTEMS	1	/73		14,1234
	OUTPUT REGISTER (2X24BIT DATA OUT,DATA-READY + BUSY FORM HANDSHAKE, TTL)	RO-224	EG&G/ORTEC	1	/72		14,1235

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	OUTPUT REGISTER (2X24BIT OR 6XBUIT, LED DISPLAY)	OR	JOERGER	1	/72	(7)	14,1236
	24-BIT DUAL OUTPUT REGISTER	9042	NUCL, ENTERPRISES	1	/72	(7)	14,1237
	DUAL OUTPUT REGISTER (2X24BIT, DATAWAY READ AND WRITE, HANDSHAKE CONTROL, LO=Z)	9043A	NUCL, ENTERPRISES	1		(7)	14,1238
	(SAME BUT HI=Z)	9043B		1		(7)	
	PARALLEL OUTPUT REGISTER (2X24 BITS)	J RS 10	SCHLUMBERGER	1	/73	(7)	14,1239
	DUAL 24 BIT PARALLEL OUTPUT REGISTER (WITH LED DISPLAY OPTION)	PR-612	STAD ENGINEERING	1	/71	(6)	14,1240
	DIGITAL OUTPUT REGISTER (4X8BIT PARALL OUTPUT REGISTER,NO L,TTL,1=H)	DU 200-2501	DORNIER	1	/71		14,1241
	(WITH FRONT PANEL CONNECTOR)	DU 200-2701		1	/72		
	(MODULE WITH ONLY LOGIC BOARD)	DU 200-2500		1	/73		
	DIGITAL OUTPUT REGISTER (4X8BIT PARALLEL OUPTPUT REGISTER, HLL 12V)	DU 200-2505	DORNIER	1	/73		14,1242
	(SAME WITH FRONT PANEL CONNECTOR)	DU 200-2705		1	/73		
	(SAME, NO F.P. CONNECTOR, INVERTING)	DU 200-2506		1	/73		
	(SAME WITH FRONT PANEL CONNECTOR)	DU 200-2706		1	/73		
	DIGITAL OUTPUT REGISTER (4X8BIT PARALLEL OUPTPUT REGISTER, HLL 24V)	DU 200-2507	DORNIER	1	/73		14,1243
	(SAME WITH FRONT PANEL CONNECTOR)	DU 200-2707		1	/73		
	(SAME, NO F.P. CONNECTOR, INVERTING)	DU 200-2508		1	/73		
	(SAME WITH FRONT PANEL CONNECTOR)	DU 200-2708		1	/73		
	DORNIER MODULES ALSO MARKETED BY SIEMENS		SIEMENS				14,1244
N	QUAD 24 BIT OUTPUT REGISTER (4X24, HAND-SHAKE DATA TRANSFER, PROG. O/P POLARITY)	QOR	JOERGER	1	09/75	(14)	14,1245
	128 BIT OUTPUT REGISTER (ADDRESSABLE AS 8 16BIT OR 128 1-BIT WORDS)	C 342	INFORMATEK	* 1	/73		14,1246

133 Parallel Output Drivers (Open Coll., Relay etc.)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	TRIAC OUTPUT REGISTER (8 BITS, 2 AMPS, ZERO VOLTAGE SWITCHING)	LT	JOERGER	1	/74	(13)	14,1247
N	12 BIT OUTPUT REGISTER (RELAY CONTACTS, SELECTIVE SET/CLEAR LAM GENERATION)	240	JORWAY	1	/75		14,1248
	8 CHANNEL TIMED TRIAC OUTPUT	3040	KINETIC SYSTEMS	2	/74	(13)	14,1249
	8 BIT TRIAC OUTPUT REGISTER	3080	KINETIC SYSTEMS	1	/73		14,1250
	12-BIT OUTPUT REGISTER (WITH OPTICAL ISOLATION,OPEN COLL O/P, MAX 30V/100MA)	3082	KINETIC SYSTEMS	1			14,1251
~	12-BIT OUTPUT REGISTER WITH ISOLATED RELAY	3087	KINETIC SYSTEMS	1	/71	(4)	14,1252
	DRIVER (16BIT,OPEN COLLECTOR OUTPUT VIA MULTIWAY CONNECTOR,MAX 150MA/LINE)	9002	NUCL, ENTERPRISES	1	/71		14,1253
	OUTPUT REGISTER (16BIT, 48V/.05A MAX, 2X37-WAY O/P CONN)	360	POLON	1	/73		14,1254
	OUTPUT REGISTER (16BIT,250V/.1A MAX, 2X37-WAY O/P CONN)	360A		1	/73		
	(SAME, 25V/1A MAX)	360B		1	/73		
N	16-BIT OUTPUT REGISTER (ISOLATED RELAY CONTACTS & LATCHBACK INPUT)	3094	KINETIC SYSTEMS	1	/74		14,1255
	RELAY DRIVER (16 WAY RELAY OUTPUT)	J RD 10	SCHLUMBERGER	1	/73	(8)	14,1256
	PARALLEL OUTPUT REGISTER (16BIT REED RE-LAY,MAX SWITCHED PWR 10W,4 TIMING MODES)	C-OR-16	WENZEL ELEKTRONIK	1	/72	(10)	14,1257
N	PARALLEL OUTPUT REGISTER (24BIT, OUTPUT WITH OPEN COLLECTOR, EXT. 30V/100MA)	CAM 2.12-1	METRIMPEX	1	/73		14,1258
N	PARALLEL OUTPUT REGISTER (24BIT, OUTPUT WITH OPEN COLLECTOR, TTL)	CAM 2.12-2	METRIMPEX	1	/73		14,1259
	DRIVER (24BIT OUTPUT REGISTER,SET AND READ BY COMMAND,24BIT I/P DATA ACCEPTED)	9017	NUCL, ENTERPRISES	1	/71	(1)	14,1260
	OUTPUT REGISTER (24 BIT, 40 MA 30V OUT)	9600B	NUCL, ENTERPRISES	0		(13)	14,1261
	(SAME INVERTED OUTPUTS)	9600C		0		(13)	
	OUTPUT REGISTER (24 BIT, 1 AMP 60V OUT)	9601	NUCL, ENTERPRISES	0		(13)	14,1262
	(SAME WITH RELAY CONTACTS, MUX CONCEPT)	9602A		0		(13)	
	(SAME WITH RELAY CONTACTS,FREE CONTACTS)	9602B		0		(13)	
	OUTPUT REGISTER (2X16BIT,OPEN COLLECTOR)	1084	BORER	1	/74		14,1263
	OUTPUT DRIVER(2X16BIT,40MA SINKING,1=LO, DATAWAY READ & WRITE,LAM I/P,STROBE O/P)	OD 1613	GEC-ELLIOTT	1	/72		14,1264
	(SAME, 1=HI)	OD 1614		1	/72		
	OUTPUT DRIVER(2X16BIT,125MA SINKING,1=LO DATAWAY READ & WRITE,LAM I/P,STROBE O/P)	OD 1617	GEC-ELLIOTT	1	/72		14,1265
	(SAME, 1=HI)	OD 1618		1	/72		

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	OUTPUT DRIVER(2X16BIT,TOTEMPOLE,30 LOADS DATAWAY READ & WRITE,LAM I/P,STROBE O/P)	OD 1620	GEC-ELLIOTT	1	/72		14.1266
	2X16 OR 4X8 BIT OUTPUT REGISTER	J RS 30	SCHLUMBERGER	1	/74	(11)	14.1267
	DUAL 16 BIT OUTPUT REGISTER (TTL LEVELS, OPEN COLL OUTPUTS VIA CABLE)	20R 2008	SEN	1	/70		14.1268
	DUAL OUTPUT DRIVER (200MA SINKING,24V)	2OR 2051HC	SEN	1		(9)	14.1269
	DUAL OUTPUT DRIVER (HI VOLTAGE DRIVER)	2OR 2051HV	SEN	1		(9)	14.1270
	DIGITAL OUTPUT (2X16BIT, MAX 30V)	C 76451-A9-A4	SIEMENS	1	/73	(6)	14.1271
	OUTPUT REGISTER (2X16BIT VIA ISOLATING CONTACTS)	1082	BORER	1	/72	(4)	14.1272
	DIGITAL OUTPUT (2X16BIT RELAYS)	C 76451-A9-A3	SIEMENS	1	/73	(6)	14.1273
	PARALLEL-OUTPUT-REGISTER (DUAL 24BIT, OR QUAD 12BIT,OPEN COLLECTOR OUTPUT)	MS PU 1 1230/1	AEG-TELEFUNKEN	1	/70	(1)	14.1274
	PARALLEL-OUTPUT REGISTER (24BIT, OPEN COLLECTOR OUTPUT, HANDSHAKE FACILITY)	MS PU 2 1230/1	AEG-TELEFUNKEN	1	/72	(4)	14.1275
	OUTPUT DRIVER(2X24BIT,40MA SINKING,1=LO, DATAWAY READ & WRITE,LAM I/P,STROBE O/P)	OD 2403	GEC-ELLIOTT	1	/72		14.1276
	(SAME, 1=HI)	OD 2404		1	/72		
	OUTPUT DRIVER(2X24BIT,125MA SINKING,1=LO DATAWAY READ & WRITE,LAM I/P,STROBE O/P)	OD 2407	GEC-ELLIOTT	1	/72		14.1277
	(SAME, 1=HI)	OD 2408		1	/72		
	OUTPUT DRIVER(2X24BIT,TOTEMPOLE,30 LOADS DATAWAY READ & WRITE,LAM I/P,STROBE O/P)	OD 2410	GEC-ELLIOTT	1	/72		14.1278
	DUAL OUTPUT REGISTER (2X24BIT, OPEN COLL O/P, FULL LAM, OUTPUT STROBES)	200-2	HYTEC	1	/73		14.1279
	OUTPUT REGISTER (2X24BIT OR 6X8BIT, 250MA SINKING, DIODE CLAMPED)	OR-1	JOERGER	1	/73		14.1280
	DUAL 24 BIT OUTPUT REGISTER(DC OR PULSE O/P,UPDATING O/P STROBE,TTL OPEN COLL)	40	JORWAY	1	/71	(2)	14.1281
	DUAL 24 BIT OUTPUT REGISTER (DC OR PULSE O/P UPDATING, 300MA SINK, DIODE CLAMPED)	40-2	JORWAY	1	/74		14.1282
	DUAL 24-BIT OUTPUT REGISTER (OPEN COLL DRIVERS, MAX 24V OR 250MA, REAR OUTPUTS)	3072	KINETIC SYSTEMS	1			14.1283
	DIGITAL OUTPUT REGISTER (4X8BIT PARALLEL OUTPUT REGISTER,NO L,OPEN COLL O/P,1=HI)	OU 200-2502	DORNIER	1	/72		14.1284
	(SAME WITH FRONT PANEL CONNECTOR, 1=HI)	OU 200-2702		1	/72		
	(SAME, NO F.P. CONNECTOR, 1=LO)	OU 200-2503			/72		
	(SAME WITH F.P. CONNECTOR, 1=LO)	OU 200-2703			/72		
	DIGITAL OUTPUT REGISTER WITH REED RELAYS (4X8BIT OUTPUT REG,OPEN CONTACT=0)	OU 200-2504	DORNIER	1	/71		14.1285
	(WITH FRONT PANEL CONNECTOR)	OU 200-2704		1	/71		
	DORNIER MODULES ALSO MARKETED BY SIEMENS		SIEMENS				14.1286

14 Digital I/O, Peripheral and Instrumentation Interfacing modules — Serial and Parallel I/O Regs, Printer-, Tape-, DVM-, Plotter- and Analyser Interfaces, Step-Motor Drivers, Supply CTR, Displays

141 Serial Input/Output Modules (General Purpose)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	SERIAL INPUT/OUTPUT REGISTER 16BIT CODED	9063	NUCL. ENTERPRISES	1	/74	(13)	14.1287

142 Parallel I/O Registers (General Purpose)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
N	UNIVERSAL INPUT/OUTPUT REGISTER (2X16BIT INPUT, 1X16BIT OUTPUT, RELAYS OPTIONAL)	1031A	BORER	1	07/75		14.1288
N	INPUT RELAY ADAPTER (24BIT I/P RELAY COILS, O/P TO CAM 2.05/CAM 2.09)	CAM 8.02-1	METRIMPEX	2	/75		14.1289
N	OUTPUT RELAY ADAPTER (24BIT, I/P RELAY COILS TO CAM 2.12-1, RELAY CONTACTS O/P)	CAM 8.02-2	METRIMPEX	2	/75		14.1290
N	OPTOISOLATOR (24 INPUTS, OUTPUTS MAY BE CONNECTED TO CAM 2.05/CAM 2.09	CAM 8.09-1	METRIMPEX	2	/74		14.1291
C	UNIVERSAL INPUT/OUTPUT REGISTER	9066	NUCL. ENTERPRISES	1	01/75		14.1292
	16 BIT INPUT/OUTPUT REGISTER (O/P STAGES ON PLUGABLE PC, FP CONNECTOR)	IOR 2053	SEN	1	/74	(11)	14.1293
	INPUT/OUTPUT REGISTER (24 BITS IN, 12 BITS OUT, OPTICALLY COUPLED)	IOR-1	JOERGER	1	/74	(11)	14.1294
	INPUT/OUTPUT REGISTER (24BIT)	IO 302	STND ENGINEERING	1	02/75		14.1295
	INPUT/OUTPUT REGISTER (24BIT, INTEGRATED INPUT, OUTPUT STROBES, FULL LAM)	210	HYTEC	1	07/75		14.1296

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	INPUT/OUTPUT REGISTER (24 BIT, POS & NEG LOGIC O/P SINKING 450 MA)	9048	NUCL, ENTERPRISES	1			14,1297
	DUAL INPUT DUAL OUTPUT REGISYER (16BIT, TTL IN, OPEN COLL TTL OUT, MAX 40MA,30V)	C110	MDT	1	/72		14,1298
	INPUT/OUTPUT REGISTER(2X24BIT IN,2X12BIT OUT, 3 ENTRY MODES, LED DISPLAY)	IM-1	JOERGER	1	/72	(7)	14,1299
	BUFFER STORE/REGISTER (32X24BIT,WITH EXTERNAL ADDRESSING FACILITY)	104	HYTEC	1			14,1300
	(SAME, 32X24BIT, WITHOUT EXT ADDR)	100		1			
	(SAME, 32X16BIT, WITHOUT EXT ADDR)	101		1	/72		
	BUFFER STORE/REGISTER (32X16BIT, WITH EXTERNAL ADDRESSING FACILITY)	105	HYTEC	1			14,1301
	(SAME, 16X24BIT, WITHOUT EXT ADDR)	102		1	/72		
	(SAME, 16X16BIT, WITHOUT EXT ADDR)	103		1	/73		

143 Peripheral Interfacing Modules (For TTY, Tape etc.)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	DESK CALCULATOR CTRL (DIEHL INTERFACE TO FMC 1301/02/11 AND FMC 1309)	FMC 1312	FRIESEKE	1	/72		14,1302
	INTERFACE FOR ASR33 TTY,SERIAL DATA LINK	6711	BI RA SYSTEMS	1	/74		14,1303
	TELETYPE O/P CTRL (10 FMC 1301/02/11 AND FMC 1309 VIA SPEC CONN,TTY MOTOR ON/OFF)	FMC 1307	FRIESEKE	1	/71		14,1304
	TELETYPE INTERFACE	90	JORWAY	2	/71		14,1305
N	SERIAL DRIVER/RECEIVER (TTY, TTX & MODEM INTERFACE, V24 CCITT STANDARD)	CAM 3,04	METRIMPEX	1	/75		14,1306
	TELETYPEWRITER INTERFACE(I/O DATA TRANSF AND CONTROL,LAM USED AS TWO-WAY FLAG)	7061-1	NUCL, ENTERPRISES	1	/70	(1)	14,1307
	TELETYPE INTERFACE (FOR ASR 33, SER I/O)	500	POLON	1	/74		14,1308
	TERMINAL DRIVER	J TY 20	SCHLUMBERGER	1	/73	(11)	14,1309
	TELETYPE OR CRT INTERFACE	TCU 100	STND ENGINEERING	1	/74		14,1310
	VERSATEC LINE PRINTER INTERFACE	3320	KINETIC SYSTEMS	1	/72		14,1311
	INTERFACING OUTPUT UNIT(8BIT DATA, CONTR & STATUS REGS, FOR FACIT SP1 INTERFACE)	SP1/ACCEPTOR	ARSYCOM	1	/74	(12)	14,1312
	PAPER TAPE PUNCH INTERFACE, COUPLES TO FACIT 4070,DATA DYNAMICS,RACAL DIGISTORE	TP 0801	GEC-ELLIOTT	1	01/75	(1)	14,1313
	INTERFACING INPUT UNIT (8BIT DATA/STATUS & CONTR REGS, FOR FACIT SP1 INTERFACE)	SP1/SOURCE	ARSYCOM	1	/74	(12)	14,1314
	PAPER TAPE READER INTERFACE (COUPLES TO LINWOOD, TREND, & RACAL DIGISTORE)	TR 0801	GEC-ELLIOTT	1	01/75	(1)	14,1315
	MAGNETIC TAPE INTERFACE (TAPE DECKS OR CASSETTES)	CS 0042	NUCL, ENTERPRISES	1	/73	(8)	14,1316
	CASSETTE INTERFACE (READS & WRITES BY 8 OR 16BIT WORDS, 8BIT LAM REG) CONTROLS--	J CK 10	SCHLUMBERGER	1	/75	(12)	14,1317
	CASSETTE DRIVER FOR 1 CASSETTE	C CK 10			/75	(12)	
	CASSETTE DRIVER FOR 2 CASSETTES	C CK 11			/75	(12)	
	PORTABLE CASSETTE DRIVER(FOR 1 CASSETTE)	P CK 10	SCHLUMBERGER		/75		14,1318
	DISK DRIVE FOR COS-110	9370	NUCL, ENTERPRISES	NA		(13)	14,1319
	INTERFACE FOR DISK DRIVE	9370		0		(13)	
	UNIVERSAL ASYNCHRONOUS TRANSMITTER/RECEIVER (129 CHAR,BUFFER)	C 317	INFORMATEK	1	/73		14,1320
	PERIPHERAL READER(8BIT PARALLEL DATA IN, NEG OR POS TTL,HANDSHAKE CONTROLS)	7064-1	NUCL, ENTERPRISES	1	/71	(1)	14,1321
	PERIPHERAL DRIVER (8BIT DATA OUT,NEG OR POS TTL,HANDSHAKE CONTROLS)	7065-1	NUCL, ENTERPRISES	1	/71	(1)	14,1322

144 Display Modules, Display and Plotter Interfacing

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	24 BIT LED BCD DISPLAY (ONE FMC 1301/02/11 VIA SPEC CONNECTOR)	FMC 1305	FRIESEKE	1	/71	(1)	14,1323
	24 BIT NIXIE BCD DISPLAY (SELECTS ONE OF 10 FMC 1301/02/11 VIA SPEC CONNECTION)	FMC 1306	FRIESEKE	2	/71	(1)	14,1324
	24 BIT LED BINARY DISPLAY (ONE FMC 1313 OR FMC 1309 VIA SPECIAL CONNECTION)	FMC 1315	FRIESEKE	1	/72		14,1325
N	DISPLAY UNIT (8CMX10CM CRT, INPUTS- X,Y- +&-5V, Z- 5V)	CAM 3,01	METRIMPEX	12	/73		14,1326
N	DISPLAY DRIVER (FOR CAM 3,01)	CAM 3,02	METRIMPEX	3	/73		14,1327
N	24 BIT DECIMAL DISPLAY (6 SYMBOLS 0,1, ...,9,A,B, ...,F)	CAM 3,08	METRIMPEX	1	/74		14,1328

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	DECIMAL DISPLAY UNIT (ADDRESS AND 5 DATA DECADES + MULTIPLIER DISPLAYED)	9007	NUCL. ENTERPRISES	NA	/71		14,1329
	DISPLAY CONTROLLER (FOR 9007, INCLUDES BIN TO DECIMAL CONVERTER)	9006		2	/71		
	COLOUR DISPLAY INTERFACE	9062	NUCL. ENTERPRISES	NA	04/75	(12)	14,1330
	EXTERNAL DISPLAY FOR J EA 10 SCALER	C AE 10	SCHLUMBERGER	NA	/73		14,1331
	SCALER DISPLAY THROUGH COMPUTER (DISPLAY OF 24BIT WORD, 30MHZ)	J AF 15	SCHLUMBERGER	2	/71		14,1332
	MANUAL BINARY DISPLAY (CONTENT OF A REGISTER DISPLAYED, EXT MULTIWAY CONN)	J AF 20	SCHLUMBERGER	1	/71		14,1333
	GRAPHIC DISPLAY DRIVER FOR HP1311/TEK604	4301	BI RA SYSTEMS	1	/74		14,1334
	GRAPHIC DISPLAY DRIVER FOR STORAGE DISPLAY TEK 602	4301A	BI RA SYSTEMS	2	/74		14,1335
	INTERACTIVE GRAPHICS DISPLAY PROCESSOR	DP 1603	GEC-ELLIOTT	4	09/75		14,1336
	128 CHARACTERS, 9X7 DOT MATRIX, 4 SIZES, VECTORS, ARCS, CIRCLES IN THREE LINE TYPES	DP 1603A		2			
	LIGHT PEN & TRACKER BALL INPUTS, 32 CONTROL INSTRUCTIONS, BUILT IN 4K STORE.	DP 1603B		2			
	CRT DECIMAL DISPLAY SYSTEM (INCLUDING)	72A	JORWAY	NA	/71	(2)	14,1337
	DISPLAY DRIVER	72A		5			
	DISPLAY SYSTEM COMPRISING		KINETIC SYSTEMS		/71	(4)	14,1338
	DISPLAY SYNCHRONIZING (COMPATIBLE WITH 60HZ 525 LINE MONITORS)	3200		1	/71		
	DISPLAY SYNCHRONIZING (COMPATIBLE WITH 50HZ 625 LINE MONITORS)	3200E		1	/74	(12)	
	DISPLAY TIMING	3205		1	/71		
	DISPLAY CONTROL	3210		1	/71		
	DISPLAY REFRESH (ALPHANUMERIC + GRAPHS)	3212		1	/71		
	DUAL LIGHT PEN INTERFACE	3225		1	/72		
N	PROGRAMMABLE DISPLAY SYSTEM	3232		4	10/75		
	COLOR MONITOR	RGB 5200 M			/71		
	STORAGE DISPLAY DRIVER	3260		1	/72		
	DISPLAY DRIVER (TWO 10BIT DAC, OUTPUT RANGE +5V TO -5V, TWO OPERATION MODES)	7011-2	NUCL. ENTERPRISES	2	/70	(1)	14,1339
	STORAGE OSCILLOSCOPE (DRIVER FOR TEKTRONIX 611 OR 601, USED WITH 7011)	9028	NUCL. ENTERPRISES	1	/71	(2)	14,1340
	SCOPE DISPLAY DRIVER	J DD 10	SCHLUMBERGER	2	/73	(7)	14,1341
	MANUAL CONTROL OF J DD 10	MC 10		NA			
	SCOPE DISPLAY DRIVER X-Y-Z (SYSTEM)	FDD 2012	SEN	1	/71	(1)	14,1342
	STORAGE DISPLAY DRIVER FOR TEKTRONIX 611 OR 601	SDD 2015		1	/71	(1)	
	CHARACTER GENERATOR	CG 2018		1	/71	(1)	
	VECTOR GENERATOR	VG 2028		1	/71	(1)	
	LIGHT PEN FOR FDD 2012 OR CG 2018	LP 2435			/71		
N	LIGHT PEN (INCLUDES TRIGGER SWITCH)	EC397	SENSION				14,1343
N	LIGHT PEN PROCESSOR	EC396		1	/75		
N	PLOTTER DRIVER (2X10BIT, X,Y OUT +&- 2,5MV)	CAM 3,03	METRIMPEX	3	/73		14,1344
	PLOTTER DRIVER	J XY 10	SCHLUMBERGER	1	/73	(8)	14,1345
N	X-Y RECORDER DRIVER	XY 2074	SEN	1		(14)	14,1346

145 Instrumentation Interfacing Modules (DVM, Supply CTR, Stepping Motor Drivers, Pulse Analyser CTR)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
[illegible]	DUAL 15 CHANNEL SERIAL OUTPUT MODULE (STEPPER MOTOR CONTROLLER, TTL)	3101	BI RA SYSTEMS	2	/73		14,1347
	STEP MOTOR DRIVER (MAX 32768 STEPS, RATE, ROTATION AND START/STOP FULLY COMMANDED)	1161	BORER	1	/72	(3)	14,1348
	STEPPING MOTOR CONTROLLER & DRIVER (ADJUSTABLE ACCEL/DECEL, TIME & MAX FREQ)	SMC	JOERGER	1	/74	(13)	14,1349
	STEPPING MOTOR CONTROLLER, DUAL	3360	KINETIC SYSTEMS	1	/72	(4)	14,1350
	STEPPING MOTOR CONTROLLER, ACCELERATING	3361	KINETIC SYSTEMS	1	/73		14,1351
	STEPPING MOTOR DRIVER	J CP 20	SCHLUMBERGER	1	/74	(9)	14,1352
	SUPPLY FOR J CP 20	C APP 10			/74		
	[illegible]NTINUOUS STEPPER CONTROL (65536 STEPS, [illegible]ITION/DIRECT./SPEED/ACCELER. CONTROL)	C-ST-4	WENZEL ELEKTRONIK	2	/72		14,1353
	[illegible]REMENTAL STEPPER CONTROL (65536 STEPS, POSITION/DIRECT./SPEED/ACCELER. CONTROL)	C-ST-4-1	WENZEL ELEKTRONIK	2	/72		14,1354
	VARIABLE PULSE DURATION TRIAC OUTPUT MODULE	3701	BI RA SYSTEMS	2	/74		14,1355
	TRIAC OUTPUT REGISTER (8 BITS, 2 AMPS, ZERO VOLTAGE SWITCHING)	LT	JOERGER	1	/74	(13)	14,1356

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	POWER SUPPLY CONTROLLER 12-B.5	3158	KINETIC SYSTEMS	1	/73		14,1357
	CAMAC-TO-SCIPP PHA INTERFACE	2323	BI RA SYSTEMS	2	/73		14,1358
	INTERFACE CAMAC - O-LABEN 8000SERIES MULTICHANNEL ANALYZERS	5380	LABEN	3		(12)	14,1359
	ADC-CAMAC INTERFACE (FOR PULSE ADC 8215, 8210,8211,8212,8112 & T-O-F CONV 8270)	5910	LABEN	1		(12)	14,1360
	MULTICHANNEL ANALYZER - CAMAC INTERFACE (FOR PACKARD 9000 AND 900 SERIES MCA)	9701	PACKARD	3		(4)	14,1361
	SYNCHRO TO DIGITAL CONVERTER (SINGLE AND MULTI-TURN CAPABILITIES)	SDC	JOERGER	2	/73	(13)	14,1362
	DUAL SYNCHRO-DIGITAL CONVERTER (14BIT)	CS 0047	NUCL. ENTERPRISES	2	/73		14,1363
	DUAL INCREMENTAL POSITION ENCODER (2X20 BIT X-Y DIGITIZATION BY UP-DOWN COUNTER)	21PL 2019	SEN	1	/71		14,1364
	INTERFACE FOR MEASURING DEVICES (DUAL INPUT FOR 2 INSTRUMENTS)	DO 200-1412	DORNIER	1	/74	(10)	14,1365
	OUTPUT REGISTER (16 OR 24 BIT TTL DRIVER FOR FAST-ROUTING MULTIPLEXER SYSTEM)	CM 665	J AND P	1	/71		14,1366
	PULSE DURATION DEMODULATOR	3720	KINETIC SYSTEMS	1	/73		14,1367
	PLUMBICON READ OUT TERMINAL	J PO 10/PUDDING	SCHLUMBERGER	1	/71	(6)	14,1368
	PLUMBICON READ OUT (5 SCALERS RECORD DIGITIZED OUTPUTS FROM PLUMBICON CAMERA)	J PM 10/PLUM	SCHLUMBERGER	1	/71	(6)	14,1369
	SPARK CHAMBER READ OUT	J SC 10		2	/72		
N	INTERFACE FOR DIGITAL PROCESSING SCOPES #P1051, #P2051 & #P2052		TEKTRONIX	0			14,1370
	ADC/CAMAC INTERFACE (FOR ANY ADC,2X16BIT O/P BUFFER,STATUS,LAM HANDL,CLOCK TIME)	C-AI-2	WENZEL ELEKTRONIK	1	/73	(10)	14,1371
N	ISOLATED ON-OFF CONTROLLER FOR 16DEVICES 5 CONTROL-LINES/DEV.,1-SEC-FAILURE-TEST)	C-PC-16	WENZEL ELEKTRONIK	1	08/75	(14)	14,1372

147 Other Digital I/O Modules (Incl. Data Links)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CAMAC DATA LINK MODULE (16 BIT PARALLEL,ASYNCHRONOUS DATA LINK)	6701	BI RA SYSTEMS	2	/73		14,1373
	BIT-SYNCHRONIZER - HARDWARE PROGRAMABLE 0 TO 10V INPUT, PCM-SIGNAL IN SERIES	DO 200-2251	DORNIER	3	/73		14,1374
	FORMAT-SYNCHRONIZER (IDENT & S/P OF DATA WORDS, SOFT- & HARDWARE PROGRAMMABLE)	DO 200-2260	DORNIER	4	/73		14,1375
	COMMUNICATION INTERFACE (V24/V23/V21 MODEM INTERFACE WITH AUTO-DIAL OPTION)	DO 200-2911	DORNIER	1	/73	(10)	14,1376
	START-STOP CONTROLLER(START,STOP,RESET, MANUAL OR DATAWAY CONTROL, 100HZ CLOCK)	FMC 1304	FRILSEKE	1	/71	(1)	14,1377
N	COMMUNICATION INTERFACE	3340	KINETIC SYSTEMS	1	/75		14,1378
N	COMMUNICATION INTERFACE W/ BUFFER	3340B		1	/75		
N	SERIAL DRIVER/RECEIVER (TTY, TTX & MODEM INTERFACE, V24 CCITT STANDARD)	CAM 5.04	METRIMPEX	1	/75		14,1379
	SERIAL INTERFACE (V24 SPEC, QUAD VERSION VARIABLE TRANSMISSION RATES)	9045	NUCL. ENTERPRISES	1	/73	(13)	14,1380
N	SERIAL INTERFACE (VARIABLE TRANSMISSION RATE)	9046	NUCL. ENTERPRISES	1	09/75		14,1381
	START-STOP UNIT (START, STOP CLOCK AND GATE OUTPUTS)	J AH 10	SCHLUMBERGER	1	/71		14,1382
	FOUR FOLD BUSY DONE (START SIGNAL INITIATED BY COMMAND,DEVICE RETURNS LAM)	48D 2021	SEN	1	/71		14,1383
N	DATA TRANSMISSSION MODULE (50BD TO 9,6KB SYNC/ASYNC, V24, USE WITH 0326)	0350	SENSION	1	/75		14,1384

15 Digital Handling and Processing Modules — and/or/nor Gates, Fan-Outs, Digital Level and Code Converters, Buffers, Delays, Arithm. Processors etc.

151 Fan-Outs, and/or/not-Gates

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	FAN-OUT UNIT (2 ORED INPUTS PROVIDE 8 TRUE,2 COMPLEM OUTPUTS,NIM SIGNALS)	FO 0001	GEC-ELLIOTT	1	/71		14,1385
	NIM FANOUT (DUAL FOUR FOLD & COMPLEMENT, NIM DRIVER, -14MA INTO 50OHMS)	FON	JOERGER	1	/73		14,1386
C	TTL FANOUT (DUAL FOUR FOLD & COMPLEMENT, TTL DRIVER, 53MA CURRENT SINK)	FOT	JOERGER	1	/73	(14)	14,1387

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	NIM FANOUT (7-ORED INPUTS, 8 O/P+2 COMPL O/P GATED FROM DATAWAY)	216	JORWAY	1	/75		14,1388
	FAN OUT MODULE (IL2 I/P, 16 IL2 O/P)	9060	NUCL, ENTERPRISES	1	/73		14,1389
	SIX-FOLD CONTROLLED GATE (INDIV GATING, FAN-IN AND FAN-OUT CONTROLLED BY 3 REGS)	6CG 2017	SEN	1	/71	(4)	14,1390
	FAST LOGIC UNIT (4X4 NIM INPUTS)	FLU 2062	SEN	1		(12)	14,1391

152 Digital Level Converters

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	6 CHANNEL TTL/NIM CONVERTER	5601	BI RA SYSTEMS	1	/73		14,1392
	6 CHANNEL NIM/TTL CONVERTER	5602	BI RA SYSTEMS	1	/73		14,1393
C	HEX CONVERTER (NIM TO TTL LEVELS PLUS TWO COMPLEMENT OUTPUTS)	CNT	JOERGER	1	/73	(14)	14,1394
C	HEX CONVERTER (TTL TO NIM LEVELS PLUS TWO COMPLEMENT OUTPUTS)	CTN	JOERGER	1	/73	(14)	14,1395
	HEX IL1 TO IL2 CONVERTER (6 TTL SIGNALS IN,6 NIM SIGNALS OUT)	7052-1	NUCL, ENTERPRISES	1	/70		14,1396

153 Code Converters

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	DECIMAL INPUT 6 NUMBERS 3 DIGITS CODE CONVERTER	DD 200-2005	DORNIER	2	/74		14,1397
	(SAME BUT 3 NUMBERS)	DD 200-2006		2	/74		
	CAMAC BCD-TO-BINARY CONVERTER	LEM-52/5,7	EISENMANN	1			14,1398
	CAMAC BINARY-TO-BCD CONVERTER WITH DECIMAL DISPLAY	LEM-52/5,8	EISENMANN	1			14,1399
	GRAY CODE TO BCD CONVERTER (DUAL CHANNEL INPUT WITH MEMORY)	EIM	JOERGER	1	/74		14,1400
	BINARY CODE CONVERTER(BIN-BCD OR BCD-BIN CONVERSION, DATA FROM DATAWAY OR FRONT)	9044	NUCL, ENTERPRISES	1		(7)	14,1401
	BINARY TO DECIMAL CODE CONVERTER (24 BIT BINARY TO 8 DECADE)	610	POLON	1	/74		14,1402
	BCD TO BINARY CONVERTER (29BIT BCD TO 24BIT BINARY, CONV TIME 325 NSEC)	CD 001	STND ENGINEERING	1	/73	(12)	14,1403
	BINARY TO BCD CONVERTER (CONV TIME 325 NSEC,24BITS TO MAX 16777216-1 BCD CODED)	CD 002	STND ENGINEERING	1	/73	(12)	14,1404
	BINARY TO BCD-CONVERTER(24BIT TO 8 DECA-DE,DISPLAY,CONV 4USEC,TTL LEVEL OUT,1MH)	C-BBC-24	WENZEL ELEKTRONIK	2	/71		14,1405

154 Buffer Memories, Storage Units

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	PROGRAM STORE/REGISTER (256X24BIT RAM + 64X24BIT ROM, EXT ADDR, USE WITH 7025-2)	110A	HYTEC	1			14,1406
	(SAME BUT WITHOUT EDIT ROM)	110		1			
	(SAME BUT NO BUFFER AND NO EXT ADDR)	112		1	/73		
	1024 WORD 24 BIT STATIC-STORE (NORMAL & BYTE MODES, CLEAR, INCR, DECR, READ, & OVER-WRITE ON ADDRESS REG ARE PERFORMED)	130	HYTEC	1	07/75		14,1407
	(SAME WITH MEMORY ACCESS ALSO FROM FRONT PANEL, MASTER/SLAVE OPERATION)	131		2	08/75		
	3-DECADE ADC & 16-WAY MUX (PRESET X1-X10 AMPL, 16X24 STORE, 100USEC/CH UPDATE)	500-1	HYTEC	1	/73		14,1408
	(SAME AS 500-1 BUT WITH 8-WAY MUX)	502		1	/74		
	(SAME BUT BINARY ADC)	501		1	/74		
	(SAME AS 501 BUT WITH 8-WAY MUX)	503		1	/74		
	(SAME, BUT AMPL GAIN CAN BE SET AND STORED INDIVIDUALLY/CHANNEL, BCD/BIN)	510		2	/74		
	256 WORD FIFO BUFFER (24 BITS PER WORD)	3841	KINETIC SYSTEMS	1	05/75	(13)	14,1409
	2048-WORD 16 BIT STORE	9061	NUCL, ENTERPRISES	2		(10)	14,1410
N	4096 WORD 16 BIT STORE	9061B	NUCL, ENTERPRISES	2	06/75		14,1411
	256 WORDS OF 24 BIT STORE MODULE	CS 0015	NUCL, ENTERPRISES	1	/72	(7)	14,1412
	PROGRAMMABLE READ ONLY MEMORY (32 WORDS, 16 BITS, LOADED BY SOLDER CONNECTIONS)	221	POLON	1	03/75		14,1413
	BUFFER MEMORY (256 16BIT WORDS, USE WITH J CAN 21/C/M)	J MT 20	SCHLUMBERGER	1	/72		14,1414
	CAMAC CORE MEMORY MODULE (2K X 16 BIT)	MM 216C	STND ENGINEERING	3	/74	(12)	14,1415
	(4K X 16 BIT)	MM 416C		3	/74	(12)	
	(8K X 16 BIT)	MM 816C		3	/74	(12)	
	(2K X 24 BIT)	MM 224C		3	/74	(12)	
	(4K X 24 BIT)	MM 424C		3	/74	(12)	
N	SPECTRUM MEMORY	F51-4653/CD	WENHMANN	1	/75		14,1416

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NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF, No.

155 Logic and Arithmetic Processing Modules

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF, No.
	FLOATING POINT ARITHMETIC INTERFACE (FOR USE WITH M 128 HARD, FLOAT, POINT)	C 327	INFORMATEK	1	/73		14,1417
N	MICROPROCESSOR MODULE (FOR FAST ASSY, OF SPECIAL INTERFACES ETC, 8080 BASED)	0326	SENSION	1	/75		14,1418
C	96 CHAN, DRIFT CHAMBER TDC (,5US/1US F,S,, 8 BIT, 40 DEEP BUFFER, DIFF I/P)	2770	LRS-LECROY	2	05/75	(13)	14,1419
	128 CHAN, MWPC ENCODER (RECEIVER, DELAY, LATCH, ENCODER, 80 HIT BUFFER, DIFF I/P)	2720		2	05/75	(13)	

16 Analogue Modoles — ADC, DAC, Multiplexers, Amplifiers, Linear Gates, Discriminators etc.

161 Analogue Input Modules (DC and Pulse ADC, TDC)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF, No.
	32 CHANNEL ANALOG DATA SYSTEM (EXPANDABLE WITH ADDITIONAL MUX MODULES)	5301	BI RA SYSTEMS	2	/74		14,1420
N	A/F CONVERTER	CAM 4,13	METRIMPEX	1	/73		14,1421
	ANALOG INPUT (DUAL SLOPE ADC, +/-16V RANGE,14BITS/16V+SIGN,0,2SEC CONVERSION)	DO 200-1021	DORNIER	1	/72		14,1422
	ANALOGUE TO DIGITAL INTEFACE (WITH PLUG-IN CONVERTER CARDS ADC/80, ADC/100 AND ADC/120 FOR 8, 10 AND 12 BIT CONVERSION)	ADC 1201	GEC-ELLIOTT	1	/71	(1)	14,1423
	16 CHANNEL, SCANNING A/D CONVERTER	3510	KINETIC SYSTEMS	1	/74		14,1424
N	INTEGRATING A/D CONVERTER (ISOLATED I/P INTEGR TIME 1S/,1S/,02S, RANGE ,03 - 5V)	CAM 4,06-2	METRIMPEX	3	/74		14,1425
	INTEGRATING ADC (12BIT, RANGES 0 TO +5V, 0 TO -5V, 40MSEC CONVERSION TIME)	700	POLON	1	/73		14,1426
	VOLTAGE - FREQUENCY CONVERTER (USED WITH MULTIPLEXERS J MX 10/20)	J CTF 10	SCHLUMBERGER	2	/73		14,1427
	UP-DOWN SCALER/FREQUENCY METER	J EF 10		1	/73		
	DUAL DIGITAL VOLTMETER (+AND- 0,1V, 10 BIT, DIFFERENTIAL INPUT)	2DVM 2013	SEN	1	/71		14,1428
	DIG, VOLTMETER (12BIT + SIGN, POT-FREE RANGES--AC/DC ,02V - 20V,DC 5-100MA)	C 76451-A13-A1	SIEMENS	2	/73		14,1429
	DIGITAL VOLTMETER (SAME AS TYPE C 76451-A13-A1 WITH DISPLAY)	C 76451-A13-A2	SIEMENS	2	/73		14,1430
	ANALOG INPUTS (MULTIPLEXER-ADC, 8 DIFF I/P,+/-10V RANGE,7BITS/10V+SIGN)	DO 200-1013	DORNIER	2	/72		14,1431
	(SAME FOR +/-5V RANGE, 7BITS/5V+SIGN)	DO 200-1016		2	/72		
	(SAME FOR +10V RANGE, 8BITS/10V)	DO 200-1019		2	/72		
	DORNIER MODULES ALSO MARKETED BY SIEMENS		SIEMENS				14,1432
	ANALOG INPUT (ADC, +/-10V RANGE, 7BITS/10V+SIGN)	DO 200-1027	DORNIER	2	/72		14,1433
	(SAME FOR +/-5V RANGE, 7BITS/5V +SIGN)	DO 200-1028		2	/72		
	(SAME FOR +10V RANGE, 8BITS/10V)	DO 200-1029		2	/72		
	ANALOGUE TO DIGITAL CONVERTER(8BIT, I/P RANGE 0 TO +5V OR 0 TO -5V,25 USEC CONV)	7028-1	NUCL, ENTERPRISES	1	/70		14,1434
	HIGH SPEED DIGITIZER (8BIT, 100NSEC, RESOLUTION, WITH 256 WORD BUFFER)	SA/D 01	STND ENGINEERING	1	/74	(12)	14,1435
	DUAL 10 BIT ANALOG TO DIGITAL CONVERTER	3515	KINETIC SYSTEMS	1	/73		14,1436
	SINGLE 10BIT ANALOG TO DIGITAL CONVERTER	3515S	KINETIC SYSTEMS	1	/74		14,1437
	DUAL ADC (10BIT, 10USEC CONV TIME)	A/D 210	STND ENGINEERING	2	03/75		14,1438
	DUAL SLOPE ADC (+AND- 0,01/1/10V RANGES, 11BIT RESOLUTION,20MS CONV TIME)	1241	BORER	2	/72	(3)	14,1439
	SUCCESS, APPROX, ADC (WITH S+H, +/-5V OR 0 TO +/-10V, 10-BIT,20/11 USEC ACCESS)	1243/1243A	BORER	2	/72	(9)	14,1440
	SUCCESS, APPROX, ADC (WITH S+H, +/-5V OR 0 TO +/-10V, 12-BIT,23/13 USEC ACCESS)	1244/1244A	BORER	2	/73	(9)	14,1441
	ANALOG INPUTS (MULTIPLEXER-ADC, 8 DIFF I/P,+/-10V RANGE,11BITS/10V+SIGN)	DO 200-1003	DORNIER	2	/72		14,1442
	(SAME FOR +/-5V RANGE, 11BITS/5V+SIGN)	DO 200-1006		2	/72		
	(SAME FOR +10V RANGE, 12BITS/10V)	DO 200-1009		2	/72		
	ANALOG INPUT (ADC, +/-10V RANGE, 11BITS/10V+SIGN)	DO 200-1024	DORNIER	2	/72		14,1443
	(SAME FOR +/-5V RANGE,11BITS/ 5V+SIGN)	DO 200-1025		2	/72		
	(SAME FOR +10V RANGE,12BITS/10V)	DO 200-1026		2	/72		
	OCTAL ADC (8X11BIT + OVF, POS INPUT, 1 MV RESOL, COMMON STROBE, FAST CLEAR)	AD811	LRS/ORTEC	1	03/75	(13)	14,1444

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	3-DECADE ADC & 16-WAY MUX (PRESET X1-X10 AMPL, 16X24 STORE, 100USEC/CH UPDATE)	500-1	HYTEC	1	/73		14,1445
	(SAME AS 500-1 BUT WITH 8-WAY MUX)	502		1	/74		
	(SAME BUT BINARY ADC)	501		1	/74		
	(SAME AS 501 BUT WITH 8-WAY MUX)	503		1	/74		
	(SAME, BUT AMPL GAIN CAN BE SET AND STORED INDIVIDUALLY/CHANNEL, BCD/BIN)	510		2	/74		
	16-CHANNEL A/D CONVERTER (DIFFERENTIAL INPUTS, 11 BITS + SIGN)	AM-I	JUENGER	2	/74	(11)	14,1446
N	16-CHANNEL A/D CONVERTER (ACCEPTS 4-20MA CURRENT INPUTS, 11 BITS)	AM/I	JUENGER	2	09/75		14,1447
C	A/D CONVERTER (12BIT,MAX 40 USEC CONVERSION, +AND-5V, +AND-10V, +10V RANGES)	30	JORWAY	2	/71	(2)	14,1448
	16 CHANNEL A/D CONVERTER (FET MUX DIFF INPUTS, 12BIT AUTO CYCLING, DUAL SLOPE)	34	JORWAY	2	/74		14,1449
	DUAL 12 BIT ANALOG TO DIGITAL CONVERTER	3520	KINETIC SYSTEMS	1	/73		14,1450
	SINGLE 12BIT ANALOG TO DIGITAL CONVERTER	3520S	KINETIC SYSTEMS	1	/74		14,1451
C	INSULATED ADC (12BITS, 100 USEC, 10MV, FULL SCALE, 300V COMMON MODE)	IADC 2069	SEN	2		(14)	14,1452
	DUAL ADC (12BIT, 25USEC CONV TIME)	A/D 212	STND ENGINEERING	2	03/75		14,1453
C	DIGITAL VOLTMETER (19,999MV TO 1999,9V)	9068	NUCL, ENTERPRISES	2		(13)	14,1454
	DUAL ADC (14BIT, 50USEC CONV TIME)	A/D 114	STND ENGINEERING	1	03/75		14,1455
N	SUCCES, APPROX, 16 BIT ADC (+&-10V, 5MS CONVERSION TIME, INPUT PROTECTION)	0324	SENSION	2	/75		14,1456
	OCTAL CHARGE DIGITIZER (8X8BIT CHARGE SENSITIVE ADC, READOUT IN 4X16BIT WORDS)	QD808	EG&G/ORTEC	1		(7)	14,1457
	QUAD FAST GATED INTEGRATOR (CHARGE DIGITIZER, 4X10 BIT)	QD410	EG&G/ORTEC	1	/74	(10)	14,1458
	OCTAL ADC (8 FAST I/P,8BIT/CH, COMMON GATE, NIM LEVELS, BILINEAR MODE)	2248	LRS-LECROY	1	/71		14,1459
	12-CHANNEL ADC (12 FAST I/P, 10BIT/CH, ,25PC SENSITIVITY, FAST CLEAR)	2249A	LRS-LECROY	1	/74	(9)	14,1460
C	12-CHAN, FAST CONV, ADC(4,9US/8,9BIT,32-DEEP BUFFERS, 1/8PS SENSITIVITY,0-256PS)	2250	LRS-LECROY	1	04/75	(13)	14,1461
	12-CHANNEL PEAK ADC (10BIT/CH, -2V FULL SCALE, FAST CLEAR, COMMON GATE)	2259	LRS-LECROY	1	02/75	(13)	14,1462
	OCTAL ADC (MIN 5 NSEC PULSES, POS OR NEG 8BIT/100 PC RESOLUTION, 250 USEC CONV)	9040	NUCL, ENTERPRISES	1	/72	(4)	14,1463
	ANALOGUE TO DIGITAL CONVERTER (80MHZ, 12 BITS)	9060	NUCL, ENTERPRISES	[illegible]	/74	(10)	14,1464
	16,000 CHANNEL PULSE ADC (200MHZ CLOCK)	J CAN 21 C/H	SCHLUMBERGER	6	/72	(6)	14,1465
	1024 CHANNEL PULSE ADC (100MHZ CLOCK)	J CAN 40	SCHLUMBERGER	2	/72	(6)	14,1466
	FAST ADC(10 & 12BIT VERSIONS,WITH SAMPLE AND HOLD, CONV TIME 2USEC/4,5USEC)	FADC 2067	SEN	2		(12)	14,1467
	FAST DUAL ADC (DATA AS FOR 2067)	2 FADC 2068		2		(12)	
	EVENT TIMER(4-CHANNEL TIME DIGITIZER, 8B 100MHZ INT, CLOCK, LAM WHEN DONE)	2206	DI RA SYSTEMS	1	/74		14,1468
	QUAD CAMAC SCALER (4X16BIT OR 2X32BIT, 100MHZ)	1004A	BORER	1	01/75		14,1469
	TIME DIGITIZER (4X16BIT,50MHZ CLOCK,WITH CENTRE FINDER, USABLE WITH PRE-AMP 511)	1005	BORER	1	/72		14,1470
	TIME DIGITIZER (4 NIM STOP CHANNELS, COMMON START, 200 PSECS RESOLUTION)	TD104	EG&G/ORTEC	1		(7)	14,1471
	OCTAL TDC (8X11BIT+OVF, COMMON START, 100PSEC RESOLUTION, FAST CLEAR)	TD811	EG&G/ORTEC	1	03/76	(13)	14,1472
	TIME DIGITIZER (6 CHANNELS,16 BITS, 100 MHZ CLOCK RATE)	TD	JUENGER	1	/74	(11)	14,1473
	QUAD TIME-TO-DIGITAL CONVERTER(9BIT/CH, 102/510NSEC RANGES,130USEC CONVERS,NIM)	2226A	LRS-LECROY	1	/70	(2)	14,1474
	OCTAL TIME-TO-DIGITAL CONVERTER(10BIT/CH 102/204/510 NSEC RANGES, FAST CLEAR)	2228	LRS-LECROY	1	/74	(9)	14,1475
C	96 CHAN, DRIFT CHAMBER TDC (,5US/1US F,S,, 8 BIT, 40 DEEP BUFFER, DIFF I/P)	2770	LRS-LECROY	2	05/75	(13)	14,1476
	128 CHAN, MWPC ENCODER (RECEIVER, DELAY, LATCH, ENCODER, 80 HIT BUFFER, DIFF I/P)	2720		2	06/75	(13)	
N	A/D CONVERTER (11BIT + SIGN OR 12, CONV TIME 30USEC, RANGE +&-5V, INTERNAL SEM)	CAM 4,05	METRIMPEX	2	/72		14,1477

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	SIXTEEN FOLD TIME-TO-DIGITAL-CONVERTER (100MHZ EXT CLOCK, 4BIT SCALERS USED)	TDC-16	NUCLETRON	1	/74		14,1478
	TIME DIGITIZER(4X16BIT,CLOCK RATE 70/85MHZ, WITH CENTER FINDING LOGIC)	TD 2031	SEN	1	/72		14,1479
	TIME DIGITIZER (4X16BIT,CLOCK RATE 70/85MHZ,NIM LEVELS)	TD 2041	SEN	1	/72	(4)	14,1480
	SERIAL TIME DIGITIZER (6-8BIT 100MHZ, SER + SEQUENT COUNT MODE,SHIFT-REG GATE)	STD 2050	SEN	1	/72		14,1481
	OCTAL TIME TO DIGITAL CONVERTER	TD 008	STVO ENGINEERING	1	04/75		14,1482

162 Analogue Output Modules (DAC)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	8 CHANNEL 8 BIT D/A CONVERTER (CURRENT OR VOLTAGE O/P,SLOW ANALOG METER DRIVER)	5405	BI RA SYSTEMS	1	/73		14,1483
	ANALOG OUTPUT (DAC, +10V O/P RANGE, 5MA, 8BIT RESOLUTION, SINGLE O/P)	DO 200-1511	DORNIER	1	/73		14,1484
	(SAME WITH 12BIT RESOLUTION, SINGLE O/P)	DO 200-1521		1	/73		
	(SAME WITH 8BIT RESOLUTION, DUAL O/P)	DO 200-1512		1	/73		
	(SAME WITH 12BIT RESOLUTION, DUAL O/P)	DO 200-1522		1	/73		
	(SAME WITH 8BIT RESOLUTION, QUAD O/P)	DO 200-1517		1	/73		
	(SAME WITH 12BIT RESOLUTION, QUAD O/P)	DO 200-1527		1	/73		
	ANALOG OUTPUT (DAC,+&-10V O/P RANGE,5MA, 8BIT RESOLUTION, SINGLE O/P)	DO 200-1513	DORNIER	1	/73		14,1485
	(SAME WITH 12BIT RESOLUTION, SINGLE O/P)	DO 200-1523		1	/73		
	(SAME WITH 8BIT RESOLUTION, DUAL O/P)	DO 200-1514		1	/73		
	(SAME WITH 12BIT RESOLUTION, DUAL O/P;	DO 200-1524		1	/73		
	(SAME WITH 8BIT RESOLUTION, QUAD O/P)	DO 200-1518		1	/73		
	(SAME WITH 12BIT RESOLUTION, QUAD O/P)	DO 200-1528		1	/73		
	ANALOG OUTPUT (DAC, +&-5V O/P RANGE,5MA, 8BIT RESOLUTION, SINGLE O/P)	DO 200-1515	DORNIER	1	/73		14,1486
	(SAME WITH 12BIT RESOLUTION, SINGLE O/P)	DO 200-1525		1	/73		
	(SAME WITH 8BIT RESOLUTION, DUAL O/P)	DO 200-1516		1	/73		
	(SAME WITH 12BIT RESOLUTION, DUAL O/P)	DO 200-1526		1	/73		
	(SAME WITH 8BIT RESOLUTION, QUAD O/P)	DO 200-1519		1	/73		
	(SAME WITH 12BIT RESOLUTION, QUAD O/P)	DO 200-1529		1	/73		
	DORNIER MODULES ALSO MARKETED BY SIEMENS		SIEMENS				14,1487
	OCTAL DAC (10BIT,0-5V,50OHMS,10USECS)	DAC 1082	GEC-ELLIOTT	1	/73		14,1488
	(SAME BUT WITH 2'S COMPLEMENT 9BIT+SIGN, +AND- 5V, 50OHMS)	DAC 1082(B)		1	/73		
	QUAD DAC (4 CHANNEL VERSION OF DAC 1082)	DAC 1042	GEC-ELLIOTT	1	/74		14,1489
	(SAME, 4 CHANNEL VERSION OF DAC 1082(B)	DAC 1042(B)		1	/74		
	DUAL 12 BIT DAC (+/- 10V OR +/- 5V O/P, FOR X-Y DISPLAY DRIVE)	550	HYTEC	1	10/75		14,1490
	DUAL D/A CONVERTER (10 BIT, 10USEC CONV TIME, +10V, +AND-10V, +AND-5V RANGES)	D/A-10	JOERGER	1	/73	(13)	14,1491
	DUAL D/A CONVERTER (12 BIT, 30USEC CONV TIME, +10V, +AND-10V, +AND-5V RANGES)	D/A-12	JOERGER	1	/73	(13)	14,1492
	OCTAL D/A CONVERTER (8BIT RESOLUTION, 0 TO 2MA OR 0 TO +10V OUT)	8 D/A	JOERGER	1	/73	(13)	14,1493
	D/A CONVERTER (12BIT,5 USEC CONVERSION, O/P RANGES +AND-2,5V/5V/10V AND +5V/10V)	31	JORWAY	1	/71	(2)	14,1494
	8 CHANNEL 10 BIT D-A CONVERTER	3110	KINETIC SYSTEMS	1	/72		14,1495
N	DIGITAL TO ANALOG CONVERTER (12BIT, CONV TIME 10USEC, O/P RANGE 0 TO 5V, MAX 5MA)	CAM 4,10	METRIMPEX	1	/72		14,1496
N	DIGITAL TO ANALOG CONVERTER (4X10BIT, TIME 10USEC, O/P RANGE +&-5V, MAX 5MA)	CAM 4,11	METRIMPEX	2	/74		14,1497
	DUAL DIGITAL-TO-ANALOG CONVERTER (10BIT, OUTPUT 0 TO +10V OR -5 TO +5V)	2DAC 2011	SEN	1	/71		14,1498
	DUAL DAC (12BIT, +AND-10V OR +AND-20MA)	C 76451-A15-A4	SIEMENS	1	/73		14,1499
	ISOLATED DUAL DAC (10BIT,30USEC,10V/5MA, OPTOCOUPLER,4 TIMING MODES,RANGE-MODIF)	C-DA-210	WENZEL ELEKTRONIK	1	/74		14,1500
	QUAD DAC (8BIT,10USEC,5V/50MA,4TIMING-M, +,- &RANGE MODIF,OPT,GROUND-REJ&,5USEC)	C-DA-408	WENZEL ELEKTRONIK	1	/74	(11)	14,1501
	QUAD DAC(10BIT,10USEC,5V/50MA,4TIMING-M, +,- &RANGE MODIF,OPT,GROUND-REJ&,5USEC)	C-DA-410	WENZEL ELEKTRONIK	1	/74	(11)	14,1502

164 Analogue Handling and Processing Modules I (MX)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	SEE ALSO DORNIER ADC TYPES		DORNIER				14,1503
N	MULTIPLEXER CONTROL UNIT (UP TO 7 CAM 4,06-21 /R CAM 4,08-22)	CAM 4,08-1	METRIMPEX	1	/74		14,1504
	12 INPUT ANALOGUE MULTIPLEXER (RANDOM OR SCAN ACCESS CONTROLLED BY SKIP REGISTER)	MX 2025	SEN	1	/72	(8)	14,1505

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	12-CHANNEL ANALOGUE MULTIPLEXER (FET, 5 USEC SWITCHING TIME, +/-10V)	MX 2070	SEN	1		(13)	14,1506
	WIDE-BAND ROUTER (12-CHANNEL 50 OHMS ANALOGUE MULTIPLEXER)	WBR 2073	SEN	1		(13)	14,1507
	15 CHANNEL MULTIPLEXER (ANALOGUE SIGNALS ROUTED TO ADC/DVM,DIRECT + SCAN MODES)	1701	BORER	1	/72	(3)	14,1508
	DORNIER MODULES ALSO MARKETED BY SIEMENS		SIEMENS				14,1509
	RELAY MULTIPLEXER(16 CHANNELS, MAX 200V/500MA OR 10VA, DATAWAY SET+INCR ADDRESS)	DU 200-1036	DORNIER	1	/72		14,1510
	(WITH FRONT PANEL CONNECTOR)	DU 200-1236		1	/72		
	(SAME WITH LOW THERMO VOLTAGE CONTACTS)	DU 200-1035		2	/71		
	(WITH FRONT PANEL CONNECTOR)	DU 200-1235		2	/71		
	ANALOG MULTIPLEXER (15 CHANNELS,REED RELAYS,MAN AND DATAWAY SEL, EXPANDABLE)	AM	JUERGEN	2	/72	(6)	14,1511
	16-CHANNEL A/D CONVERTER (DIFFERENTIAL INPUTS, 11 BITS + SIGN)	AM-1	JUERGEN	2	/74	(11)	14,1512
N	16-CHANNEL A/D CONVERTER (ACCEPTS 4-20MA CURRENT INPUTS, 11 BITS)	AM/I	JUERGEN	2	09/75		14,1513
C	15 CHANNEL RELAY MULTIPLEXER	3530	KINETIC SYSTEMS	1	/73		14,1514
N	15 CHANNEL RELAY MULTIPLEXER	3530L		2	/75		
	MASTER MULTIPLEXER (16 CH, 4 POLE REED)	601	NUCL, ENTERPRISES		/70		14,1515
	SLAVE MULTIPLEXER (16 CH, 4 POLE REED)	603			/70		
	16 CHANNEL RELAY MULTIPLEXER STANDARD LEVEL)	J MX 10	SCHLUMBERGER	1	/73		14,1516
	(SAME FOR LOW LEVEL)	J MX 20		1	/73		
	MULTIPLEXER MANUAL CONTROL	J AX 10		1	/73		
	MULTIPLEXER 16X4 CONTACTS		SIEMENS	1	/74		14,1517
	16-CHANNEL FAST MULTIPLEXER (FET SWITCHES FOR ADC 1243 AND 1244)	1704	BORER	1	/72	(4)	14,1518
	FET MULTIPLEXER (16 CHANNELS, MAX +OR-10V, DATAWAY SET + INCR ADDRESS)	DU 200-1031	DORNIER	1	/72		14,1519
	(SAME WITH FRONT PANEL CONNECTOR)	DU 200-1231		1	/72		
	FET MULTIPLEXER (16 DIFF I/P, MAX +OR-10V, DATAWAY SET+INCR ADDRESS)	DU 200-1034	DORNIER	1	/72		14,1520
	(WITH FRONT PANEL CONNECTOR)	DU 200-1234		1	/72		
	16 CHANNEL A/D CONVERTER (FET MUX DIFF INPUTS, 12BIT AUTO CYCLING, DUAL SLOPE)	34	[illegible]		/74		14,1521
N	16 CHANNEL FAST DIGITAL MULTIPLEXER (PULSE WIDTH MIN 7 NSEC)	CAM 6,03	METRIMPEX	2	/74		14,1522
N	16 CHANNEL MULTIPLEXER (SWITCHING OF 3 WIRES, MAX 500HZ, MAX 100V)	CAM 4,08-21	METRIMPEX	2	/74		14,1523
N	16 CHANNEL MULTIPLEXER (SWITCHING OF 4 WIRES, MAX 500HZ, MAX 100V)	CAM 4,08-22	METRIMPEX	2	/74		14,1524
	MULTIPLEXER-SOLID STATE (16 SINGLE-ENDED OR 8 DIFF CHAN,RANDOM OR SEQUENT ACCESS)	9026	NUCL, ENTERPRISES	1	/71		14,1525
	SOLID STATE MULTIPLEXER (16 CH, RANDOM, & SEQUENT ACCESS, MULTI-MUX SCAN MODE)	MX 016	STND ENGINEERING	1	/74	(12)	14,1526
	32 CHANNEL ANALOG MULTIPLEXER (SERVE AS CHANNEL EXPANDER FOR 5301 DATA SYSTEM)	5101	HI RA SYSTEMS	1	/74		14,1527
N	32 CHANNEL ANALOG MULTIPLEXER (MAX 100KHZ, MAX +&-5V IN)	CAM 4,07	METRIMPEX	1	/73		14,1528
	RELAY MULTIPLEXER (32 CHANNELS)	750	POLON	2	03/75		14,1529
	MULTIPLEXER (32 CHANNEL, 2 CONTACTS)	C 76451-A4-A1	SIEMENS	2	/73		14,1530
	MULTIPLEXER (32 CHANNEL, 4 CONTACTS)	C 75451-A4-A2	SIEMENS	2	/73		14,1531
	MULTIPLEXER 32X2 CONTACTS	C 72458-A0625-AC01	SIEMENS	1	/74		14,1532
	FET MULTIPLEXER (32 CHANNELS, MAX +OR-10V, DATAWAY SET+INCR ADDRESS)	DU 200-1032	DORNIER	1	/72		14,1533
	(WITH FRONT PANEL CONNECTOR)	DU 200-1232		1	/72		
	FET MULTIPLEXER (32 DIFF I/P, MAX +OR-10V, DATAWAY SET+INCR ADDRESS)	DU 200-1037	DORNIER	2	/72		14,1534
	(SAME WITH FRONT PANEL CONNECTORS)	DU 200-1237		2	/72		
	FET MULTIPLEXER (64 CHANNELS MAX +OR-10V, DATAWAY SET+INCR ADDRESS)	DU 200-1061	DORNIER	2	/73		14,1535
	(WITH FRONT PANEL CONNECTOR)	[illegible]0-1261		2	/73		

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OF POOR QUALITY

165 Analogue Handling and Processing Modules II (LIN. Gates, Ampl., Discriminators etc.)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
N	PREAMPLIFIER (GAIN RANGES-- X10, X30, X100, X300)	CAM 4,15	METRIMPEX	3	/72		14,1536
N	FILTER AMPLIFIER (GAIN RANGE-- OFF, X1, X10)	CAM 4,16	METRIMPEX	3	/72		14,1537
	ACTIVE FILTER AMPLIFIER(10 - 1000 GAIN, ,25-4USEC GAUSS, PULSE SHAPING,0-10V OUT	1101	POLON	3	/74		14,1538
	BASELINE RESTORER(,1% COUNT RATE STABIL UP TO 50KHZ,0-10 I/O SIGNALS,1V/V GAIN)	1102	POLON	2	/74		14,1539
	DELAY AMPLIFIER(,25 - 4,75USEC DELAY, 0 TO 10V IN/OUT SIGNALS, 1V/V GAIN)	1103	POLON	2	03/75		14,1540
	SUM-INVERT AMPLIFIER(,2% NON-LINEARITY, 1V/V GAIN, 0 TO 10V IN/OUT SIGNALS)	1104	POLON	1	/74		14,1541
	LINEAR GATE (,2% NON-LINEARITY, +/- 1V/V GAIN, 0 TO 10V IN/OUT SIGNALS)	1105	POLON	1	/73		14,1542
	PULSE STRETCHER(,06-,9USEC I/P WIDTH, 1USEC O/P WIDTH OF PULSES, ,9 V/V GAIN)	1106	POLON	1	/74		14,1543
	SINGLE CHANNEL ANALYSER (,2-10V LO/HI LEVEL, ,2-2V WINDOW, ,5-2,5USEC DELAY)	1201	POLON	3	/74		14,1544
	LINEAR RATEMETER (10 TO 100K CPS RANGE, 1S TO 30S TIME CONSTANTS)	1301	POLON	3	/74		14,1545
	LOGIC SHAPER AND DELAY (,2 TO 110USEC DELAY, ,2 TO 11USEC O/P PULSE WIDTH)	1401	POLON	2	/74		14,1546
	UNIVERSAL COINCIDENCE (,1 TO 2USEC RESOLVING TIME)	1402	POLON	2	/74		14,1547
N	FAST AMPLIFIER (200V/V GAIN, 10NS RISE TIME, 200NS TC DIFF, 200NS TC INTEGR)	1501	POLON	3	/75		14,1548
	FAN OUT (1 NIM IN, 2 NIM & 1 COMPL TTL OUT)	1504	POLON	1	/73		14,1549
	CAMAC CONTROLLED PULSE SHAPER (4 PM I/P, 4 NIM I/P & 8 NIM O/P)	CPS 2065	SEN	1		(12)	14,1550
	DUAL PULSE DELAY UNIT	PD 002	STND ENGINEERING	5	/73		14,1551
	SAMPLE-AND-HOLD AMPLIFIER (DUAL DIFF AMPL,+/-10V RANGE,20MA OUT,5USEC SETTL)	DO 200-1040	DORNIER	2	/72		14,1552
	(SINGLE AMPL VERSION, BOTH TYPES HAVE HOLD AND TRACK MODES)	DO 200-1041		2	/72		
	PROGRAMABLE AMPLIFIER/ATTENUATOR (GAIN 0DB TO 60DB IN 10 STEPS, ATTENUATION ,5)	DO 200-1052	DORNIER	2	/73		14,1553
	(SAME BUT DUAL CHANNEL VERSION)	DO 200-1053		1	/73		
	PROGRAMMABLE AMPLIFIER (GAIN 1, 10, 100, 1000)	DO 200-1054	DORNIER	1	05/75		14,1554
	(SAME BUT DUAL CHANNEL VERSION)	DO 200-1055		1	05/75		
	PROGRAMMABLE PRESISION ATTENUATOR (1/1 TO 1/2048, 20V MAX I/P RANGE)	PPA 2071	SEN	1		(13)	14,1555
	DIGITAL WINDOW DISCRIMINATOR (WITH 128X16BIT BUFFER, PARALLEL + SERIAL I/P)	DWD 2046	SEN	1	/72	(8)	14,1556
N	TIME TO PULSE HEIGHT CONVERTER (START-STOP I/P, MAX 256NSEC, RESOL 100PSEC)	CAM 4,17	METRIMPEX	2	/74		14,1557

17 Other Digital and/or Analogue Modules — Mixed Analogue and Digital, Not Dataway Connected etc.

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
N	PROM PROGRAMMER	3090	KINETIC SYSTEMS	2	11/75		14,1558
N	DUAL BRIDGE POWER SUPPLY (FLOATING OUTPUTS EACH MAX 24V/200MA)	CAM 4,08-3	METRIMPEX	2	/74		14,1559
N	OCTAL FLOATING POWERED BRIDGE (PT-THERMO-R APPL, USE WITH CAM 4,08-21)	CAM 4,08-41	METRIMPEX	2	/74		14,1560
N	OCTAL FLOATING POWERED BRIDGE (PT-THERMO-R APPL, USE WITH CAM 4,08-22)	CAM 4,08-42	METRIMPEX	2	/74		14,1561
N	COLD POINT POWER SUPPLY (FOR COLD POINT REFERENCE BRIDGES)	CAM 4,08-5	METRIMPEX	2	/74		14,1562
	DETECTOR BIAS SUPPLY (0 TO +/-2000V, 1MOHM AND 10MOHM OUTPUT RESISTANCE)	1901	POLON	4	/74		14,1563
	NUMERICAL CONTROL SYSTEM, COMPRISING --	C 500	NOT				14,1564
	DATA WRITER AND DISPLAY	C 504		4A			
	SERIAL CONTROLLER	C 502		0			
	DATA RECEIVER FOR MECHANICAL OPERATIONS (5 DECADE DATA,3 DECADE INSTRUCTION REG)	C 501		0		(7)	

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CAMAC PROM PROGRAMMER		SENSION	2		(13)	14,1565
	CURRENT SOURCE (1MA TO 10MA AND FOR PT 100 ADAPTION)	C 76451-A5-A1	SIEMENS	2	/73		14,1566

2 SYSTEM CONTROL EQUIPMENT — COMPUTER COUPLERS, CONTROLLERS AND RELATED EQUIPMENT

21 Interfaces/Drivers and Controllers — Parallel Mode for 4600 Branch and Other Multi-Crate Bus, Single-Crate Systems, Autonomous Systems

211 Interfaces/Drivers for Multicrate Systems I (4600 Branch Compatible)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	EXECUTIVE SUITE ASSEMBLY OF MODULAR CONTROLLERS IN CAMAC CRATE, COVERS SYSTEM COMPLEXITY FROM SINGLE SOURCE-SINGLE CRATE TO MULTI SOURCE-MULTI CRATE SYSTEMS, COMPRISING		GEC-ELLIOTT				14,2001
	EXECUTIVE CONTROLLER (TRANSFORMS STANDARD CRATE INTO SYSTEM CRATE)	MX-CTN-2		2	/72		
	BRANCH COUPLER (ONE PER BRANCH, MAX 7)	BR-CPR-2		2	/72		
	AND SYSTEM INTERFACE SOURCE UNITS, ALSO OPTIONALLY AUTONOMOUS CONTROLLER SOURCE UNITS (ALL INSERTED INTO SYSTEM CRATE)		GEC-ELLIOTT				14,2002
	PDP-11 SYSTEM INTERFACE, COMPRISING		GEC-ELLIOTT				14,2003
	PROGRAM TRANSFER INTERFACE	PTI-11 C/D		3	/72		
	UNIBUS TERMINATION UNIT	TRM-11-1		1	/74		
	INTER UNIT BUS (LINKS UNIBUS TO ALL SI SOURCE UNITS FORMING INTERFACE)	IUB-X			/74		
	INTERRUPT VECTOR GENERATOR (ADDS AUTONOMOUS ENTRY OF GL-DERIVED INTERRUPTS)	IVG-11		1	/72		
	AUTONOMOUS MEMORY ACCESS CONTROLLER (2 USEC/WORD TRANSFER TO PDP-11 STORE)	AMC-11		2	06/75		
	NOVA/SUPERNOVA SYSTEM INTERFACE, COMPR		GEC-ELLIOTT				14,2004
	PROGRAM TRANSFER INTERFACE	PTI-N C/D		3	/72		
	I/O BUS TERMINATION UNIT	TRM-N		1	/72		
	INTER UNIT BUS	IUB-X			/74		
	INTERRUPT VECTOR GENERATOR (256 BIT TRAP STORE, BRANCH OR GL PRIORITY MODES)	IVG-2402		1	/74		
	INTERDATA 70-SERIES SYSTEM INTERFACE COMPRISING		GEC-ELLIOTT				14,2005
	PROGRAM TRANSFER INTERFACE	PTI-70 C/D		3	/73		
	I/O BUS TERMINATION UNIT	TRM-70		1			
	INTER UNIT BUS	IUB-X			/74		
	INTERRUPT VECTOR GENERATOR (256 BIT TRAP STORE, BRANCH OR GL PRIORITY MODES)	IVG-2402		1	/74		
	HONEYWELL 316/516 SYSTEM INTERFACE, COMPR		GEC-ELLIOTT				14,2006
	PROGRAM TRANSFER INTERFACE	PTI-H16 C/D		3	/73		
	I/O BUS TERMINATION UNIT	TRM-H16		1			
	SYSTEM INTERFACE BUS	SI-BUS-XH16			/73		
	GEC 4080 SYSTEM INTERFACE, COMPRISING		GEC-ELLIOTT				14,2007
	DIRECT TRANSFERS INTERFACE	PTI-2050 C/D		3	/73		
	INTERRUPT VECTOR GENERATOR	IVG-2402		1	/74		
	BLOCK TRANSFER CHANNEL CONTROLLER	PTI-2050 D		3	/73		
	INTER UNIT BUS	IUB-X			/74		
	AUTONOMOUS MEMORY ACCESS CONTROLLER (2,5 US/WORD TRANSFER TO GEC-4080 STORE)	AMC-4080		2	06/75		
	GEC 2050 SYSTEM INTERFACE (SAME ITEMS AS FOR GEC 4080 INTERFACE)		GEC-ELLIOTT		/74		14,2008
	SYSTEM CRATE TEST UNIT (TWO-COMMAND TEST UNIT FOR CHECKING SYSTEM CRATE SYSTEMS)	SC-TST-1	GEC-ELLIOTT	3	/72		14,2009
	BRANCH HIGHWAY DRIVER	3991	KINETIC SYSTEMS	2	/75		14,2010
	MICROPROGRAMMED BRANCH DRIVER FOR PDP-11 (FROM 256 UP TO 4K WORDS MEMORY)	1201	BI RA SYSTEMS	NA	/72	(5)	14,2011
	UNIBUS CABLE ASSEMBLY	8101			/72		
	PDP-11 CAMAC CONTROLLER (SEQUENTIAL READ/WRITE, 24 GRADED-L INTERRUPT DIRECTLY)	CA 11-A	D E C	NA	/71	(2)	14,2012
	PDP-15 CAMAC INTERFACE (18/24BIT, PROGR, SEQUENT ADDR AND BLOCK TRANSFER MODES)	CA 15 A	D E C	NA	/71	(1)	14,2013
	PDP-11 INTERFACE/BRANCH DRIVER (24 VECTOR ADDRESSES, PROGRAMMED AND MULTIPLE DMA-TRANSFER, ADDRESS SCAN AND -LIST MODE, REPEAT-, LAM- AND STOP MODE)	CA 11-C	D E C	NA	/72	(4)	14,2014
	PDP-11 BRANCH DRIVER (FOR 4600 COMPATIBLE, PROGRAMMED AND SEQUENT ADDR MODES)	BD-011	EG&G/ORTEC	NA	/71		14,2015
N	PDP-11 INTERFACE (BRANCH AND/OR SERIAL HIGHWAY, DMA, 80011 REG, ASSIGNMENTS)	211	JORWAY	NA	12/75		14,2016
	PDP-11 BRANCH DRIVER	KS 0011	KINETIC SYSTEMS	NA	/71	(4)	14,2017

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	INTERFACE AND DRIVER FOR PDP 11 OR PDP 8 MULTI-CRATE SYSTEM, COMPRISING		NUCL. ENTERPRISES				14,2018
	BRANCH INTERFACE	9031		2	/72	(7)	
	16-BIT CONTROLLER (WITH EITHER OF THE FOLLOWING INTERFACE CARDS)	9030		3	/72	(7)	
	PDP 11 INTERFACE CARD	9032			/72		
	INTERFACE CARD FOR DEC PDP 8 SERIES	9034			/73	(7)	
	INTERFACE CAMAC-PDP 11 (PROGRAMMED,BLOCK TRANSFER AND SEQUENTIAL ADDR MODES)	ICP 11/ICP 11 A	SCHLUMBERGER	NA	/71	(4)	14,2019
	NOVA BRANCH DRIVER	1251-1	BI RA SYSTEMS	NA	/73	(5)	14,2020
	NOVA BRANCH DRIVER WITH DATA CHANNEL	1251-2	BI RA SYSTEMS	NA	/74	(5)	14,2021
	NOVA BRANCH DRIVER	NBD 100	STND ENGINEERING	2	/74		14,2022
	INTERFACE/SYSTEM CONTROLLER TO HP2100, 2114, 2115, 2116	2201	BORER	NA	/71	(4)	14,2023
	PRIME COMPUTER BRANCH DRIVER (WITH DTM, PRIME COMPUTER BRANCH CABLE TYPE 8103)	1260	BI RA SYSTEMS	NA	/74		14,2024
	INTERFACE FOR VARIAN 620I/L/F COMPUTER (PROGR,SEQUENT AND BLOCK TRANSFERS)	2204	BORER	NA	/72		14,2025
N	CTL MODULAR ONE AUTONOMOUS BRANCH HIGHWAY CONTROLLER	20368	C T L	NA	/75	(14)	14,2026
	SYSTEM CONTROLLER FOR SIEMENS 404/3 (TRANSFER OF 16 OR 24 BIT DATAWORDS PARALLEL BRANCH COMMAND CHAINING)	DO 200-2921	DORNIER	6	/73		14,2027
	(SAME BUT WITHOUT COMMAND CHAINING)	DO 200-2922		6	/73		
	SYSTEM CONTROLLER FOR SIEMENS 404/3 (TRANSFER OF 16 OR 24 BIT DATAWORDS PARALLEL BRANCH BUT NO COMMAND CHAINING)	DO 200-2923	DORNIER *	6	/73		14,2028
	MICRODATA 800/CIP 2000 BRANCH DRIVER	91	JORWAY	NA	/73	(7)	14,2029
	BRANCH DRIVER (24BIT, PROGR, SEQUENT AND BLOCK TRANSFER MODES, MAX 7 CRATES)	5400	LABEN	4		(8)	14,2030
N	BRANCH DRIVER - INTERFACE FOR 1001 TPA-1	CAM 1,04	METRIMPEX	NA	/73		14,2031
N	AUTONOM ADAPTER (INTERFACES CAMAC TO AUTONOMOUS CHANNEL)	CAM 1,18		1	/74		
	INTERFACE-DRIVER FOR VARIAN 73/620I/620L MULTI-CRATE SYSTEM, COMPRISING		NUCL. ENTERPRISES			(8)	14,2032
	BRANCH INTERFACE	9031		2	/72	(7)	
	16-BIT CONTROLLER	9030		3	/72	(7)	
	AND						
	INTERFACE CARD FOR VARIAN 73/620I/620L SERIES COMPUTERS	CS 0044				(8)	
	SYSTEM CONTROLLER FOR SIEMENS 320/330 (AUTO-DL, 24 VECTOR ADDR, PROGRAMMED & DMA TRANSF, ADDR-SCAN,INCREM,RANDOM LIST REPEAT,LAM & STOP MODES)	C 72451 A1002	SIEMENS	8	/74		14,2033

212 Interfaces/Drivers for Multicrate Systems II (for other Parallel Mode Control/Data Highway)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	DEDICATED CRATE CONTROLLER FOR NOVA	NC023	EG&G/ORTEC	2	/73		14,2034
	TERMINATOR FOR NOVA I/O BUS	NT022		1	/73		
	BIDIRECTIONAL DATA BREAK MODULE FOR PDP8 COMPUTERS (FOR USE WITH 7048-2)	1000	HYTEC	2	/74		14,2035
	PROGRAMMED DATAWAY CONTROLLER (PART OF 7000-SER SYSTEM WITH EXT CONTR HIGHWAY)	.125-2	NUCL. ENTERPRISES	2	/70		14,2036
	COMMAND GENERATOR	.062-1		2	/71		
	TRANSFER REGISTER	.063-1		1	/70.		
	PROGRAM CONTROL UNIT	0362-2		NA	/70		
	WIRED STORE	7044-1		1	/70		
	CONTROLLER/INTERFACE FOR T1630 COMPUTER (MAX 8 CRATES, PROG/ADDR,SCAN/STOP MODE)	JCT 16-10		2			
	DMA MODULE	JDM 16,10		2			
	CRATE CONTROLLER FOR NOVA COMPUTER	CC 2023A/B	SEN	2	/70		14,2037
	CRATE CONTROLLER BUS TERMINATOR FOR CC 2023A/B (ONE PER SYSTEM)	BT 2022		1	/71		

213 Interfaces/Drivers for Single-Crate Systems (4100 Dataway Compatible)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	SINGLE CRATE SYSTEM CONTROLLERS(SEE EXECUTIVE SUITE, CLASS .211)		GEC-ELLIOTT				14,2038
	PDP-11-SERIES CRATE CONTROLLER	1304	BI RA SYSTEMS	2	/73		14,2039
	CRATE CONTROLLER/PDP11 UNIBUS INTERFACE	1533A	BORER	2	/72	(4)	14,2040
	NPR CONTROLLER FOR DMA TO PDP11 E.G. VIA 1533A CRATE CONTROLLER/INTERFACE	1542	BORER	NA	/73	(6)	14,2041
	SINGLE CRATE CONTROLLER/PDP-11 INTERFACE (MULTIPLE BUS ADDRESS VERSION)	CA-11-E	D E C	2	/74	(9)	14,2042

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
C	SINGLE CRATE CONTROLLER/PDP-11 INTERFACE (PROGRAMMED TRANSFERS, WITH NAF REG & CONNECTOR TO DMA OPTION CA-11-FN)	CA-11-FP	D E C	2	06/75	(14)	14,2043
C	PDP-11 DMA INTERFACE FOR CA-11-FP (8 DMA CHANNELS, MI OR LIST MODE, 16BIT WC, CA, OFFSET FOR EACH CHANNEL, LIMIT REGISTER)	CA-11-FN		2	06/75 06/75	(14)	
N	POWER SUPPLY FOR CA-11-F CONTROLLER (GENERATES AC LO & DC LO)	CA-11-PS		NA	06/75	(14)	
	DEDICATED CRATE CONTROLLER FOR PDP-11 (MULTIPLE TRANSFER OR AUTO ADDRESS SCAN)	DC011	EONG/ORTEC	2		(7)	14,2044
	SINGLE CRATE CONTROLLER FOR PDP-8/E ADDR.-SCAN MODE, DMA I/O, MAX 22 LAMS)	LEM-52/32.1	EISENMANN	3		(13)	14,2045
C	UNIBUS CRATE CONTROLLER PDP-11	3911A	KINETIC SYSTEMS	2	/72		14,2046
	INTERFACE AND DRIVER FOR PDP 11 OR PDP 8 SINGLE CRATE SYSTEM, COMPRISING		NUCL. ENTERPRISES				14,2047
	16-BIT CONTROLLER (WITH EITHER OF THE FOLLOWING INTERFACE CARDS)	9030		3	/72	(7)	
	PDP 11 INTERFACE CARD	9032			/72		
	INTERFACE CARD FOR DEC PDP 8 SERIES	9034			/73	(7)	
	AUTONOMOUS CONTROLLER FOR PDP 11	9033	NUCL. ENTERPRISES	2	/73	(8)	14,2048
	CAMAC CRATE-PDP 11 INTERFACE	J CC 11	SCHLUMBERGER	2		(7)	14,2049
	UNIBUS TERMINATOR	J UT 11		1	/74		
	UNIBUS EXTENDER	C BEX 11			/74		
	CRATE-SYSTEM CONTROLLER FOR PDP-11 (24 BIT READ & WRITE CAPABILITIES)	C-CSC-11	WENZEL ELEKTRONIK	2	/72		14,2050
	NOVA-SERIES CRATE CONTROLLER	1303	BI RA SYSTEMS	2	/73		14,2051
	SINGLE CRATE CONTROLLER TO HP COMPUTERS WITH EXT SYNCHRONISATION FACILITIES	1531A	BORER	2	02/75		14,2052
	INTERFACE FOR HP 2114-2115 COMPUTERS, COMPRISING--		NUCL. ENTERPRISES				14,2053
	16-BIT CONTROLLER	9030		3	/72	(7)	
	AND INTERFACE CARD FOR HP 2114-2115	CS 0058			/74		
N	CTL MODULAR ONE PROGRAMMED DATAWAY CONTROLLER	1.75	C T L	3	/75	(14)	14,2054
	VARIAN-CAMAC INTERFACE CRATE CONTROLLER (16BIT SEQUENT+BLOCK TRANSF. 1 CC/CRATE)	C 300	INFORMATEK	2	/72		14,2055
N	CRATE CONTROLLER-INTERFACE FOR 1001TPA-1	CAM 1.02	METRIMPEX	3	/73		14,2056
	INTERFACE-DRIVER FOR VARIAN 73/620I/620L SINGLE CRATE SYSTEM,COMPRISING		NUCL. ENTERPRISES			(8)	14,2057
	16-BIT CONTROLLER	9030		3	/72	(7)	
	AND INTERFACE CARD FOR VARIAN 73/620I/620L SERIES COMPUTERS	CS 0044				(8)	
	INTERFACE FOR HONEYWELL 316-516 COMPUTERS, COMPRISING--		NUCL. ENTERPRISES				14,2058
	16-BIT CONTROLLER	9030		3	/72	(7)	
C	AND INTERFACE CARD FOR HONEYWELL 316-516	9038			/74		
	INTERFACE FOR K202 COMPUTER (24BIT,AUTONOMOUS BLOCK TRANSFERS TO/FROM MEMORY, L-NUMBER INTERRUPT ENCODER)	100	POLON	3	/73		14,2059
	SINGLE CRATE CONTROLLER FOR MICRAL N/G/S	JC MIC 10	R 2 E	2	02/75	(13)	14,2060
	CRATE INTERFACE FOR MULTI 20 OR MULTI 8	J CM 8/20	SCHLUMBERGER	3	/74		14,2061
	CRATE CONTROLLER 320	C 72451-A1446-A6	SIEMENS	3	/72		14,2062
	CRATE CONTROLLER 404	C 76451-A1446-A7	SIEMENS	2	/73		14,2063

214 Controllers for Autonomously Operated Systems (and Related Units)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	DATA PROCESSOR (AUTONOMOUS PROGRAMABLE SINGLE DATAWAY CONTROLLER 16 REGISTERS	DU 200-2951	DORNIER	3	/73		14,2064
	DATA PROCESSOR (AUTONOMOUS PROGRAMABLE SINGLE DATAWAY CONTROLLER 16 REGISTERS, REGISTERS AND MEMORY EXPANDABLE)	DU 200-2951		3	/73		
N	MICROCOMPUTER	3880	KINETIC SYSTEMS	2	11/75		14,2065
N	CRATE CONTROLLER FOR 3880	3908		2	11/75		
	CADET (SINGLE-CRATE CONTROLLER FOR READ-ONLY SYSTEM, INCL MODULE TEST & DISPLAY)	CT 2058	SEN	4		(12)	14,2066
	PRINT BUFFER (ALLOWS A PARALLEL PRINTER TO BE USED WITH THE CT 2058)	PR 2059		4		(12)	
	PROGRAMMABLE CRATE CONTROLLER	S 800	SENSION	22		(13)	14,2067
	PROGRAMMABLE CRATE CONTROLLER	S 804	SENSION	22		(13)	14,2068

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CAMAC MICROPROCESSOR CRATE CONTROLLER	MIK XA	STAD ENGINEERING	0	/74		14,2069

217 Other Parallel Mode Interfaces/Drivers/Controllers

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	SYSTEM CRATE CONTROLLER	3960	KINETIC SYSTEMS	2	/73		14,2070
	MODCOMP I,MODCOMP II & MODCOMP III SYSTEM DRIVER(USE WITH 3960)	3970		2	/73		
	CONTROL DATA 6000 SERIES SYSTEM DRIVER (USE WITH 3960)	3973		3	/75		
	MANUAL SYSTEM DRIVER(USE WITH 3960)	3980	KINETIC SYSTEMS	2	/73		14,2071

22 Interfaces/Controllers/Drivers for Serial Highway

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	SERIAL CRATE CONTROLLER TYPE L-1 (CONFORMING TO ESONE/SH/01 AND ERRATA)	SCC 2401	GEC-ELLIOTT	2	06/75		14,2072
	SERIAL EXTENSION UNIT, 8 BIT BYTE SERIAL LINK, BRANCH COMPATIBLE, CONSISTING OF		JOERGER		/73	(8)	14,2073
	SERIAL CRATE CONTROLLER *L-1* (CONFORMS TO ESONE/SH/01 & TID-26488 + ERRATA)	74		2	/74	(11)	
	MANUAL SERIAL DRIVER (BIT/BYTE MODE, MULTIPLE MESSAGES, ERROR GENERATION)	78	JORWAY	4	/74		14,2074
N	PDP-11 INTERFACE (BRANCH AND/OR SERIAL HIGHWAY, DMA, 80011 REG, ASSIGNMENTS)	211	JORWAY	NA	12/75		14,2075
N	MASTER LOOP CONTROL UNIT	3930	KINETIC SYSTEMS	2	/75		14,2076
C	SERIAL HIGHWAY LOOP CONTROL UNIT	3931	KINETIC SYSTEMS	2	/75	(13)	14,2077
	TRANSF, ISOLATED SERIAL D-PORT ADAPTER	3932	KINETIC SYSTEMS	1	/75	(13)	14,2078
N	CRATE CONTROLLER EXPANDER	3940	KINETIC SYSTEMS	1	/75		14,2079
N	SERIAL CRATE CONTROLLER TYPE L-1	3950	KINETIC SYSTEMS	3	/75		14,2080
	TYPE L-1 CRATE CONTROLLER FOR THE "STANDARD" SERIAL HIGHWAY	3952	KINETIC SYSTEMS	2	/75	(13)	14,2081
	DRIVER FOR SERIAL HIGHWAY	3992	KINETIC SYSTEMS	3	/74	(11)	14,2082
	DRIVER FOR SERIAL HIGHWAY (WITH 256 WORD FIFO BUFFER)	3994	KINETIC SYSTEMS	4	/75	(13)	14,2083
N	SERIAL HIGHWAY CONTROLLER	9080	NUCL, ENTERPRISES		09/75		14,2084
	SERIAL CRATE CONTROLLER SPECIFICATION L1	CH 6001	ROVSING	2	11/75	(13)	14,2085

23 Units Related to 4600 Branch or Other Parallel Mode Control/Data Highway — Crate Controllers, Terminations, Lam Graders, Branch/Bus Extenders

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	DISPLAY DRIVER(CONTROLS 72A DISPLAY, ALSO CRATE CTR AND BRANCH DRIVER)	72A	JORWAY	5	/71		14,2086

231 Crate Controllers (Type A-1, Other CC Types)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	TYPE A-1 CRATE CONTROLLER	1301	HI RA SYSTEMS	2	/73		14,2087
	CRATE CONTROLLER /ESONE TYPE A1/ (CONFORMS TO EUR4600 SPECS)	1502	BORER	2	/72		14,2088
	CRATE CONTROLLER TYPE CCA-1 ACCORDING TO EUR4600 SPECS WITH CERN OPTIONS	DO 200-2905	DORNIER	2	/74		14,2089
	CAMAC CRATE CONTROLLER TYPE A-1 (CONFORMS TO EUR4600 SPECIFICATIONS)	CC101	EG&G/ORTEC	2	/72		14,2090
	ESONE TYPE A-1 CRATE CONTROLLER(CONFORMS TO EUR4600 SPECS, INCL CERN HOLD OPTION)	CC 2405	GEC-ELLIOTT	2	/73		14,2091
	CRATE CONTROLLER TYPE A-1 (CONFORMS TO EUR4600 SPECS)	CCA-1	JOERGER	2	/72	(5)	14,2092
	BRANCH CRATE CONTROLLER/TYPE A-1 (CONFORMS TO EUR 4600 SPECS, 1972)	70A	JORWAY	2	/73	(7)	14,2093
	TYPE A-1 CRATE CONTROLLER	3900	KINETIC SYSTEMS	2	/73		14,2094
N	TYPE A-1 CRATE CONTROLLER (CONFORMS TO EUR4600 SPECS)	CAM 1,01	METRIMPEX	2	/73		14,2095
	CRATE A-1 CONTROLLER (CONFORMS TO EUR 4600 SPECS)	9016	NUCL, ENTERPRISES	2		(4)	14,2096
	CRATE CONTROLLER TYPE A (CONFORMS TO EUR4600 SPECS)	C 106	RDT	2	/71		14,2097
	CRATE CONTROLLER TYPE A-1 (CONFORMS TO EUR4600 SPECS)	J CRC 51	SCHLUMBERGER	2	/72	(1)	14,2098
	A-1 CRATE CONTROLLER (CONFORMS TO EUR4600 SPECS, INCL CERN SPEC HOLD LINE)	ACC 2034	SEN	2	/72		14,2099

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CRATE CONTROLLER A1 (EUR 4600 SPECS AND CERN NOTE 38-00)	C 72451-A1446-A2	SIEMENS	2	/70	(1)	14,2100
	TYPE A-1 (ESONE) CRATE CONTROLLER	CC-A1	STND ENGINEERING	2	/ .	(6)	14,2101
	TYPE A1 CONTROLLER WITH TERMINATOR (MEETS 4600 SPECS OF JAN 1972)	CCT-A1	STND ENGINEERING	2	/73		14,2102

232 Lam Graders

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	LAM GRADER (24 BIT MASK REGISTER, PLUG-IN PATCH BOARD, CERN 064)	LG 2401	GEC-ELLIOTT	1	/72		14,2103
	LAM GRADER (INTERNALLY PATCHABLE, SWITCH SELECTABLE MULTI-CRATE BG-RESPONSE)	LG	JOERGER	1	/73	(8)	14,2104
C	LAM GRADER-SORTER	75	JORWAY	1	/73	(7)	14,2105
N	LAM GRADER (24 BIT)	CAM 1,10	METRIMPEX	1	/74		14,2106
	LAM GRADER (DESIGNED TO EUR 4600 SPECS)	064	NUCL. ENTERPRISES	1	/72	(4)	14,2107
	PRIORITY GRADER	9037	N CL. ENTERPRISES	1		(10)	14,2108
	LAM GRADER (CERN SPECS 064)	C 107	RDT	1	/71		14,2109
	LAM GRADER (CERN SPECS 064)	LG 2001	SEN	1	/72	(6)	14,2110
	LAM GRADER (24BIT MASK REG, WITH CABLE, PATCHABLE C-ADDR-REG FOR MULTI-CRATE BG)	C 76451-A18-A1	SIEMENS	0	/74		14,2111
N	LAM GRADER(241/P-&24MASKED-&SUM-LAM-LEDS 24G,X24M,LAM+SUM-TOG,LAM1-7-PATCHPANEL)	C-LG-24	WENZEL ELEKTRONIK	1	06/75	(14)	14,2112

233 Terminations (Simple, with Indicators)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	BRANCH HIGHWAY TERMINATOR	6601	BI RA SYSTEMS	1	/73		14,2113
	BRANCH TERMINATION UNIT (WITH BUILT-IN CABLE)	1592	BORER	1	/73		14,2114
	BRANCH TERMINATION UNIT (NON INDICATING)	BT 6503	GEC-ELLIOTT	2	/72		14,2115
	BRANCH TERMINATION UNIT	BT 6601	GEC-ELLIOTT	2	/71		14,2116
	BRANCH TERMINATOR	BT	JOERGER	2	/72		14,2117
	BRANCH TERMINATION WITH INTEGRAL CABLE	50C	JORWAY	2	/72		14,2118
	BRANCH TERMINATOR IN A CONNECTOR	BT-01	KINETIC SYSTEMS	NA	/73		14,2119
N	BRANCH TERMINATOR	CAM 1,11-1	METRIMPEX	2	/72		14,2120
	BRANCH TERMINATOR	J BT 20	SCHLUMBERGER	2	/71		14,2121
	BRANCH TERMINATOR (NON-INDICATING, 40 CM FLYING CABLE WITH BRANCH CONNECTOR)	BT 231	SEMRA-BENNEY	1	/74		14,2122
	(DITTO, XXX= CABLE LENGTH IN CM)	BT 231XXX		1	/74		
	CRATE CONTROLLER BUS TERMINATOR FOR A-1 CRATE CONTROLLER	BT 2042	SEN	1	/72		14,2123
	BRANCH HIGHWAY TERMINATOR	BHT 2055	SEN	1	/74	(11)	14,2124
	BRANCH HIGHWAY TERMINATOR	BHT-001	STND ENGINEERING	1	/73		14,2125
	BRANCH HIGHWAY TERMINATOR, WITH DISPLAY	BHT-002/D	STND ENGINEERING	2	/73		14,2126
	BRANCH TERMINATOR (FULL BRANCH MONITOR WITH INTERNAL STORAGE AND LED DISPLAY)	BT 6502	GEC-ELLIOTT	2	/72		14,2127
	VISUAL BRANCH TERMINATOR (STORES AND DISPLAYS ON LEDS BRANCH SIGNALS)	VBT	JOERGER	2	/72	(6)	14,2128
	BRANCH TERMINATION WITH BRANCH DISPLAY	51	JORWAY	2	/72		14,2129
N	BRANCH TERMINATOR (WITH INDICATORS)	CAM 1,11-2	METRIMPEX	2	/72		14,2130
	BRANCH TERMINATION UNIT (WITH INDICATOR AND POWER SUPPLY)	C 72451-A10-A1	SIEMENS	NA	/73	(3)	14,2131

234 Branch Extenders, Bus Extenders

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	DIFFERENTIAL BRANCH EXTENDER (FOR EXTENDING BRANCHES UP TO 3 KM)	DBE 6501	GEC-ELLIOTT	2	/71		14,2132
	BRANCH HIGHWAY TRANSCEIVER FOR LONG DISTANCE TRANSMISSION	J BHT 10	SCHLUMBERGER	2		(4)	14,2133
	SERIAL DRIVER (TERMINATES BRANCH HIGHWAY AND RETRANSMITS COMMAND SERIALLY)	SD	JOERGER	2			14,2134
	SERIAL RECEIVER (RECEIVES SERIAL DATA, DRIVES TYPE A-1 SYSTEM, OPTICAL ISOL)	SR		2			

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	UNIBUS EXTENDER, TRANSMITTER RECEIVER (FOR DISTANCES UP TO 200 METRE OR MORE)	1594 1595	BORER	2 2	/72 /72		14,2135

3 TEST EQUIPMENT

31 System Related test Gear

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	SYSTEM CHECK OUT UNIT, STORES DATA & COMMAND IN READABLE REGS, PROGRAMMABLE C	DTM 4	GEC-ELLIOTT	1	/74		14,3001
	SYSTEM TEST UNIT (FOR EXECUTIVE SUIT SYSTEM CONFIGURATION, SEE MX-CTR-2)	SC-TST-1	GEC-ELLIOTT	3	/72		14,3002

311 Computer Simulators

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	PDP-11 SIMULATOR	6101	BI RA SYSTEMS	NA	/72	(5)	14,3003
	TEST MODULE (USED IN SYSTEM TEST OF READ/WRITE CAPABILITY)	TMU24	EG&G/ORTEC	2	/71		14,3004
	TEST CONTROLLER WITH PROGRAM PLUGBOARD	SPS 2048	NUCL. ENTERPRISES	2	01/75	(12)	14,3005
	CAMAC SYSTEM SIMULATOR/TESTER	CSS/T	STND ENGINEERING	6	/73		14,3006

32 Branch Related Testers/Controllers and Displays

321 Branch Testers/Controllers (Manual, Programmed)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	MANUAL BRANCH TESTER (TYPE A SYSTEM TEST SET WITH MX-CTR-2 & BR-CPR-2)	SC-TST-1	GEC-ELLIOTT	/			14,3007
N	MANUAL CONTROLLER (SWITCHES FOR N,A,F,C, I,Z, OP-MODES- REPEAT,SINGLE & STEPPING)	110	POLON	4	/75		14,3008
	BRANCH HIGHWAY TEST POINT MODULE(24 DIR-ECT,22 INDIRECT ACCESS POINTS FOR TEST)	CD 18104	HUGHES	NA	/71	(3)	14,3009
	BRANCH HIGHWAY REMOVE INHIBIT MODULE (REMOVES INHIBIT FROM BCH/BA/BF/BN/BTA)	CD 18105	HUGHES	NA	/71	(3)	14,3010
	MANUAL BRANCH DRIVER (FOR TESTING TYPE A SYSTEMS)	MBD	JOERGER	5	/72	(6)	14,3011
	MANUAL BRANCH CONTROL SET (COMPRISING TYPES C COB 10 AND T CMB 10)	C CMB 10	SCHLUMBERGER	NA	/71	(1)	14,3012

33 Dataway Related Testers and Displays

331 Dataway Controllers/Testers Manual, Programmed)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
N	MC WORD GENERATOR FOR USE WITH TYPE 110 (25 BITS WORD TO W BUS LINES)	232	POLON	1	/75		14,3013
N	WORD DISPLAY FOR USE WITH TYPE 110	260		1	/75		
N	TEST CONTROLLER24	744006/D	WEHRMANN	1	/75		14,3014
N	TEST CONTROLLER25	744006/E	WEHRMANN	1	/75		14,3015
	MANUAL CRATE CONTROLLER	GFK-LEM	EISENMANN	6	/71		14,3016
	MANUAL CRATE CONTROLLER	MCC	JOERGER	5	/72		14,3017
N	MANUAL DATAWAY TEST CONTROLLER	CAM 7.01	METRIMPEX	3	/73		14,3018
	MANUAL DATAWAY CONTROLLER/DISPLAY SYSTEM INTERFACE TO DATAWAY CONTROL AND DISPLAY CRATE	D AI 10 J DA 10 C AI 10	SCHLUMBERGER	 1 NA	/71		14,3019
	MANUAL CRATE CONTROLLER	J CMC 10	SCHLUMBERGER	6	/71	(1)	14,3020
	TEST MODULE FOR CRATE CONTROLLER AND DATAWAY	DTM 2040	SEN	1	/72		14,3021
	MANUAL 24 BIT CRATE CONTROLLER	MCC-240	STND ENGINEERING	2	/72	(5)	14,3022
	DYNAMIC TEST CONTROLLER (GENERATES ALL POSSIBLE CAMAC COMMANDS IN SINGLE CRATE)	TC 2403	GEC-ELLIOTT	3	/71		14,3023
	DYNAMIC TEST CONTROLLER (2 SIMULT TRANSF SINGLE,STEP-BY-STEP AND CONTINUOUS MODE)	C 108	RDT	6	/71	(4)	14,3024
	DATAWAY SERVICE MODULE	J DS 10	SCHLUMBERGER	1	/74	(12)	14,3025
N	MANUAL INPUT/OUTPUT (TEST UNIT PROVIDES MANUAL DATA INPUT & VISUAL DATA OUTPUT)	MI/O	JOERGER	1	08/75		14,3026
	CONTROLEUR SORTIE DATAWAY (DATAWAY TEST MODULE)	21403	TRANSRACK	1	/70		14,3027

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.

332 Dataway Displays

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
N	DATAWAY DISPLAY	734053/A	HERRMANN	2	/75		14,3028
	CAMAC TEST MODULE/DATAWAY DISPLAY	6102	BI RA SYSTEMS	2	/73		14,3029
	CAMAC DATAWAY DISPLAY (DATAWAY SIGNAL PATTERN STORED/DISPLAYED,2 TEST MODES)	1801	BORER	1	/71	(1)	14,3030
	CAMAC DATAWAY TEST AND DISPLAY MODULE	LEM-52/16,2	EISENMANN	1			14,3031
	DATAWAY MEMORY (DISPLAY + READABLE REGISTER)	C 340	INFORMATEK	1	/72		14,3032
	DATAWAY DISPLAY (STORES AND DISPLAYS DATAWAY SIGNALS; FAR=DXC175132BP1P2)	DD	JOERGER	1	/72	(6)	14,3033
	DATAWAY DISPLAY (SEPARATE R & W DISPLAY, TRACKS OR STORES, MANUAL CLEAR)	202	JORWAY	1	/74	(11)	14,3034
	DATAWAY DISPLAY	3290	KINETIC SYSTEMS	1	/72		14,3035
	DATAWAY DISPLAY (WITH MEMORY, FOLLOW, ON-LINE & TRIGGER MODES)	9554	NUCL. ENTERPRISES	1		(13)	14,3036
	DATAWAY DISPLAY	C 76451-A16-A1	SIEMENS	1	/73	(6)	14,3037
	DATAWAY DISPLAY MODULE	DD-002	STND ENGINEERING	1	/72	(5)	14,3038
	DATAWAY DISPLAY (DISPLAYS AND STORES DATAWAY SIGNAL PATTERN)	C-D1-24	WENZEL ELEKTRONIK	1	/72		14,3039

34 Module Related Test Gear (Module Extenders)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CAMAC MANUAL MODULE TESTER	6103	BI RA SYSTEMS	NA	/74		14,3040

341 Module Extenders

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CAMAC EXTENDER MODULE	8201	BI RA SYSTEMS	1	/73		14,3041
	EXTENSION FRAME (MODULE EXTENDER)	EF 1-1	GEC-ELLIOTT	1	/71		14,3042
	MODULE EXTENDER (+AND-6V,+AND-24V FUSED, RETRACTABLE LOCKING DEVICE)	ME	JOERGER	1	/72		14,3043
	EXTENDER MODULE (FUSED +&-6V AND +&-24V, SUPPORT ARM)	11A	JORWAY	1	/74		14,3044
C	EXTENDER MODULE (W/36 POS PC EDGE CONN)	1100	KINETIC SYSTEMS	1	/71	(4)	14,3045
N	EXTENDER CARD	1150F	KINETIC SYSTEMS	1			14,3046
N	DATAWAY EXTENDER MODULE	9073	NUCL. ENTERPRISES	1	01/75		14,3047
	BUFFERED EXTENDER (25NSEC PROPAGATION DELAY, 60 CM FLEXIBLE CABLE)	060	POLON	1	03/75		14,3048
	EXTENDER MODULE	061	POLON	1	/73		14,3049
	EXTENDER	CEX	SDT	1	/72		14,3050
	MODULE EXTENDER	ME 2030	SEN	1	/70		14,3051
	DATAWAY EXTENDER MODULE	EB 01	STND ENGINEERING	1	/72		14,3052
	EXTENDER (XXX=LENGTH OF CABLE IN MM BEYOND RACK, SINGLE WIDTH)	577/XXX	TEKDATA	1	/72	(5)	14,3053
	(DITO, DOUBLE WIDTH, FIXED SIDES)	5813/XXX		2	/73		
	(DITO, DOUBLE WIDTH, HINGED SIDES)	5824/XXX		2	/75		
	PROLONGATEUR POUR TIROIRS CAMAC CABLE (WIRED EXTENDER)	41401	TRANSRACK	1	/70		14,3054
	PROLONGATEUR POUR TIROIRS CAMAC NON CABLE (UNWIRED EXTENDER)	41402	TRANSRACK	1	/70		14,3055

37 Other Test Gear for CAMAC Equipment

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	TRANSIENT GENERATOR(MODULE NOISE SUSCEPT IBILITY TESTED BY TRANSIENTS ON DC LINES	TG	JOERGER	1	/73		14,3056

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.

4 CRATES, SUPPLIES, COMPONENTS, ACCESSORIES

41 Crates and Related Components/Accessories — Crates with/without Dataway and Supply, Blank Crates, Crate Ventilation Gear

411 Crates with Dataway and Supply

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CRATE (270VA,COOLED,MODULAR POWERED BY MAX 8X1922 OR 1X1923/1925 + MAX 4X1922)	1902A	BORER	25	/69		14,4001
	VOLTAGE REGULATOR (FOR +OR-24V/6A, +/-12V/7A,+/-6V/8A/16A/24A)	1922			/69		
	VOLTAGE REGULATOR (+&-6V 25A MAX, OR 40A MAX WITH EXTERNAL +6V SUPPLY)	1923			/74		
	VOLTAGE REGULATOR (+AND-6V, 25A MAX, 270W RATING, USABLE WITH 4X1922)	1925			/73		
	CAMAC MINICRATE (19 INCH RACK MOUNTING) (+6V/15A,-6V/5A, +24V/2A,-24V/2A,200W)	307,100CC	EDS SYSTEMTECHNIK	17	/73	(10)	14,4002
	POWERED CRATE	MC200	EG&G/ORTEC	25	/74		14,4003
	POWERED CRATE (INCL. CRATE AND POWER SUPPLY COOLING TO SUPPL CP 1 SPEC)	PS 004/PA1/VC 0040	GEC-ELLIOTT	25	05/75		14,4004
	POWERED CRATE (+&-6V/40A, +&-24V/8A, 200V/.1A, 117V AC, MAX 300W)	CPC/14	GRENSON		/73		14,4005
N	POWERED CRATE (+&-6V/20A, +&-24V/5A, 200V/0,03A, 117VAC/0,5A, MAX 200W)	CPC/15			10/75		
C	POWERED CRATE	1500/28	KINETIC SYSTEMS	NA	/73		14,4006
N	POWERED CRATE (42A CAPABILITY ON +6V)	1500/42	KINETIC SYSTEMS	NA			14,4007
N	POWERED CRATE (MAX 400W, +&-24V/3A, +&-12V/3A,+&-6V/24A,-6V/6A,+200V/.1A,AC)	CAM 9,01	METRIMPEX	24	/72		14,4008
	POWER CRATE (9070 CRATE WITH 9022 POWER SUPPLY)	9071	NUCL. ENTERPRISES	24	/74	(12)	14,4009
	POWERED CRATE (+AND-6V/25A, +AND-24V/6A, (INCL POWER DESIGN TYPE AEC432 SUPPLY)	NSI-875CC100AEC432	NUCL. SPECIALTIES	25	/72		14,4010
C	POWERED CRATE (6U,VENTILATED,NO FAN,130W +6V/15A,-6V/4A,+AND-24V/2A,+200V/50MA)	2000	POLON	25	/71		14,4011
	POWERED CRATE	CCMW-CSAN	RDT	25	/71		14,4012
	POWERED CRATE(SEE P7 ALJ 13)	C7 ALJ 13 OW	SAPHYMO-STEL	25		(1)	14,4013
	POWER SUPPLY (CAMAC CRATE)	CM5125/53/OW/BLOCS	SAPHYMO-STEL	25	/72		14,4014
	POWERED VENTILATED CRATE (+6V/24A, -6V/16A, +AND-24V/3A, MAX 400W)	C JAL-41	SCHLUMBERGER	25	/73	(8)	14,4015
	POWER CRATE (200W MAX,+6V/25A,-6V/10A, +AND-12V/3A,+AND-24V/3A,200V/0,05A)	PC 2006/B	SEN	25	/70		14,4016
	POWER CRATE (200W MAX,+6V/25A,-6V/10A, +AND-24V/3A,200V/0,05A)	PC 2006/C		25	/71		
	COMPLETE POWER CRATE	CPC 2057	SEN	25	/74	(11)	14,4017
N	POWERED CRATE (500W, +6V/65A OR 25A, -6V/25A OR 65A, MAX TOT CURRENT IS 80A)	HPC 2075	SEN	25		(14)	14,4018
N	POWERED CRATE (200W, +&-6V/10A, +&-12V/2A, +&-24V/3A)	SPC 2077	SEN	25		(14)	14,4019
	POWERED CRATE (7U,VENT,+AND-6V/26A,+AND-12V/6,5A,+AND-24V/6,5A,200V/0,1A,200W)	C 76455-A2	SIEMENS	25	/71	(3)	14,1020
	POWERED CRATE (SAME BUT WITH 117V AC)	C 76455-A1		25	/71		
	POWERED CAMAC CRATE	PCS/12	SIND ENGINEERING	25	/72		14,4021
	POWERED CAMAC CRATE	PCS/42	SIND ENGINEERING	25	/72		14,4022
	POWERED CRATE (SEE CRATE C-CF AND SUPPLY P-156 FOR RATINGS)	C-CF + P-156	WENZEL ELEKTRONIK	25	05/75		14,4023
	POWERED CRATE (SEE C-CF & SUPPLY P-264)	C-CF + P-264		25	03/75		
C	POWERED CRATE (SEE C-CF & SUPPLY P-300F)	C-CF + P-300F		25	04/75	(14)	

412 Crates with Dataway, without Supply

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	VENTILATED CRATE (HEAVY DUTY 25 STATION FASTON CONNECTORS, 6U HIGH)	VC 0022	GEC-ELLIOTT	25	/74		14,4024
	(SAME BUT WITH ALL PATCH LINES BUSSED AS PER LOGELAB REQUIREMENTS)	VC 0030		25	/74		
	5U CRATE 25 STATION HEAVY DUTY, FITS TO PS 0004 USING ADAPTOR PA 1.	VC 0040	GEC-ELLIOTT	25	05/75		14,4025
	CONVERTS FASTON CONNECTORS TO RECOMMENDED FIXED POWER CONNECTOR ON CHOSEN CRATE	7AMP	GEC-ELLIOTT		/73		14,4026
	CAMAC CRATE VERDRAHTET (EMPTY CRATE WITH WIRED DATAWAY)	2,064,000,6	KNUERR	25	/73	(2)	14,4027

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CRATE	9070	NUCL. ENTERPRISES	24	//4		14,4028
	CAMAC COMPATIBLE CRATE (WIRED)	NSI-875 DD-WV	NUCL. SPECIALTIES	25	//1		14,4029
	CAMAC CRATE (WIRED)	NSI-875 CC 100	NUCL. SPECIALTIES	25	//2		14,4030
N	UNPOWERED CRATE WITH DATAWAY (5U, VENTILATED, NO FAN, 25 STATIONS)	002	POLON	25	//5		14,4031
	UNPOWERED CRATE WITH DATAWAY (6U, EMPTY, VENTILATED, NO FAN)	012	POLON	25	//1		14,4032
	UNPOWERED CRATE WITH DATAWAY (360 MM)	CM 5125/33/DW	SAPHYMO-STEL	25			14,4033
	(525 MM)	CM 5125/53/DW		25			
	UNPOWERED CRATE WITH DATAWAY AND CONNECTORS	UPC 2029	SEN	25	//0		14,4034
	CRATE (WIRED CRATE)	WCS	STND ENGINEERING	25	//2	(5)	14,4035
C	WIRED CRATE (HEAVY DUTY, 3 FAN & MONIT. UNIT, 6U, USE WITH P-156, P-264, P-300F)	C-CF	WENZEL ELEKTRONIK	25	03/75	(14)	14,4036
	CRATE (WITH DATAWAY AND VENTILATION)	C 76455-A3	SIEMENS	25	//2		14,4037

413 Crates without Dataway, with Supply

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CAMAC CRATE (+6V/25A,-6V/12,5A,+&-24V/6A,+&-12V/4A)	DO 200-3001	DORNIER	NA	//4		14,4038
	(SAME WITHOUT +&-12V SUPPLY)	DO 200-3002		NA	//4		

417 Blank Crates and Other Components and Accessories

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
N	RACK BLOWER (1 U HIGH, MAY BE USED WITH AIR SCOOP NSI-12109-AS FOR HI EFFIC.)	NSI-05235-HB	NUCL. SPECIALTIES	NA	07/75		14,4039
	CRATE (5U,EMPTY, 25 STATIONS)	HCF/5CAM/5/25	IMHOF-BEDCO	25	//1		14,4040
	(SAME BUT WITH 24 STATIONS)	HCF/5CAM/5/24		24	//2		
	CRATE (6U,EMPTY,WITH VENTILATION BAFFLE, 25 STATIONS, HARWELL TYPE 7000)	HCF/6CAM/5V/25		25	//1		
	(SAME BUT WITH 24 STATIONS)	HCF/6CAM/5V/24		24	//2		
	CRATE (6U,EMPTY,WITH VENTILATION BAFFLE, REMOVABLE PANEL, 25 STNS, HARWELL 7000)	HCF/6CAM/5VR/25		25	//1		
	(SAME BUT WITH 24 STATIONS)	HCF/6CAM/5VR/24		24	//2		
	CAMAC CRATE (EMPTY)	2,080,000,6	KNUERR	25	//0	(2)	14,4041
	CAMAC CRATE (EMPTY,INCL HARDWARE SUPPLY CHASSIS AND VENTILATION PANEL)	2,086,000,6		25		(2)	
	CAMAC COMPATIBLE CRATE	NSI 875 DD/WV	NUCL. SPECIALTIES	25	//0		14,4042
	CAMAC CRATE (UNWIRED)	NSI 875 CC 100	NUCL. SPECIALTIES	25	//2	(5)	14,4043
	CHASSIS CAMAC (6 UNITES AVEC FENTE DE VENTILATION, 525 MM PROFONDEUR)	9905-1-05	OSL	25	//1		14,4044
	(360 MM PROFONDEUR)	9905-2-05		25	//1		
	CAMAC CRATE WITH VENTILATION BAFFLE (6U, 525MM DEPTH)	9905HVD3/98/525	OSL	25			14,4045
	(SAME BUT WITH 460MM DEPTH)	99055HV3AVD/98/460		25			
	(SAME BUT WITH 360MM DEPTH)	99055HV3AVD/98/360		25			
	CRATE (6U, EMPTY, VENTILATED, NO FAN)	010	POLON	25	//1		14,4046
	VENTILATED CRATE NO POWER NO DATAWAY (TWO FANS)	CCMN	RDT	25	//1		14,4047
	(SAME WITH 3 FANS)	CCMNA		25	//2		
	UNPOWERED CRATE	UC 2057	SEN	25	//4	(11)	14,4048
	CAMAC CRATE (EMPTY CRATE)	C	STND ENGINEERING	25	//2		14,4049
	CHASSIS CAMAC NORMALISE 5U (EMPTY CRATE,360 MM DEEP)	40206	TRANSRACK	25	//4		14,4050
	(*=7 FOR 460MM & *=8 FOR 525MM DEEP)	4020*		25			
	CHASSIS CAMAC 5U UTILES (EMPTY CRATE,6U TOTAL,360MM DEEP,VENTILATION HARDWARE)	40203	TRANSRACK	25	//4		14,4051
	(*=4 FOR 460MM & *=5 FOR 525MM DEEP)	4020*		25			
	CHASSIS CAMAC 5U UTILES (EMPTY CRATE,6U TOTAL,360MM DEEP,WITH TWO FANS)	40200	TRANSRACK	25	//4		14,4052
	(*=1 FOR 460MM & *=2 FOR 525MM DEEP)	4020*		25			
	CAMAC CRATE (EMPTY) HEAVY DUTY		OSL/WILLSHERBQUICK		//3		14,4053
	6U WITH VENTILATION BAFFLE	9905-5HV		25	//3		
	5U NON VENTILATED	9905-5H		25	//3		
	DEPTH OPTIONS 360MM, 460MM, 525MM						
	CAMAC CRATE WITH VENTILATION BAFFLE (6U, 525MM DEPTH)	99055HV3AVD/98/525	OSL/WILLSHERBQUICK	25	//3		14,4054
	(SAME BUT WITH 460 MM DEPTH)	99055HV3AVD/98/460		25	//3		
	(SAME BUT WITH 360 MM DEPTH)	99055HV3AVD/98/360		25	//3		
	VENTILATION UNIT	CAM/FV	IMHOF-BEDCO		//3		14,4055

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NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	LUFTEREINHEIT (VENTILATION UNIT,COMPLETE WITH 3 FANS AND FILTER)	2,081,000,6	KNUERR		7/0		14,4056
	(VENTILATION UNIT,NO FAN,NO FILTER)	2,065,000,0					
	AIR SCOOP (STOPS CHIMNEY EFFECT BETWEEN UN-VENTILATED CRATES IN RACK, 1U HIGH)	NSI-12109-AS	NUCL, SPECIALITIES	NA	7/1		14,4057
	VENTILATION MODULE	VM 2057	SEN		7/4	(11)	14,4058
	1U VENTILATION GRILL	1 UG	GSC/WILLSHER&QUICK		7/2		14,4059
	CARD EXTENDER (FOR SUPPLY OF 2057)	CE 2061	SEN				14,4060

42 Supplies and Related Components/Accessories — Single- and Multi-Crate Supplies, Blank Supply Chassis, Control Panels, Supply Ventilation

421 Multi-Crate Supplies

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	POWER SUPPLY FLEXIBLE SYSTEM (TO SPECS CERN-ISM-CU/72-43), COMPRISING	CPU/10	GRENSON		7/1		14,4061
	BASIC CRATE(FOR SUPPLY MODULES,INCLUDES REFERENCE,CONTROL AND 200V/0,1A)	CFC					
	SUPPLY MODULE(* IN TYPE = P FOR POS AND N FOR NEG OUTPUT VOLTAGE 6V/ 6A)	CF*/6					
	(12V/ 3A)	CF*/12					
C	(24V/ 3A)	CF*/24					
	POWER SUPPLY SYSTEM (CRATE) (MODULE OPTIONS AS FOLLOWS)	C4BMT204/L6BM1306	SAPHYMO-STEL		7/2		14,4062
	POWER SUPPLY MODULE 6 V/10 A (6V/20A & 6V/40A OPTIONS ALSO AVAILABLE)	BP 75 6,10					
	12 V/ 2 A (ALSO 12V/4A, 7A, 15A & 25A OPTIONS)	BSN					
	24 V/ 1,2A (ALSO 24V/2,5A, 3,5A, 9A & 15A OPTIONS)	BSN					

422 Single-Crate Supplies

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	POWER SUPPLY AND COOLING UNIT (+6V/42A, -6V/25A,+&-24V/6A, 375W, 2U FAN UNIT)	PS 0004	GEC-ELLIOTT		05/75		14,4063
	CAMAC POWER UNIT (+6V/15A,-6V/3A,+24V/2A -24V/2A,200V/0,05A,117VAC)	CPU/4	GRENSON				14,4064
	CAMAC POWER SUPPLY - RACK MOUNTING (+6V/20A,-6V/5A,+AND-24V/5A,200V/0,05A)	CPU/2	GRENSON		7/1		14,4065
	CAMAC POWER SUPPLY - RACK MOUNTING (+6V/20A,-6V/5A, +&-12V/2A, +&-24V/3A)	CPU/5	GRENSON		7/1		14,4066
	POWER SUPPLY (RACK MOUNTING,+6V/25A, -6V/15A,+AND-24V/5A,200V/0,1A)	CPU/6	GRENSON		7/1		14,4067
	POWER SUPPLY (RACK MOUNTING,+6V/25A, -6V/15A,+AND-24V/5A,+AND-12V)	CPU/7	GRENSON		7/1		14,4068
	POWER SUPPLY (+6V/20A,-6V/5A, +AND-24V/5A,200V/0,05A)	9001	NUCL, ENTERPRISES		7/1		14,4069
	POWER UNIT (+6V/15A,-6V/3A, +AND-24V/2A,200V/0,05A)	9022	NUCL, ENTERPRISES		7/1	(2)	14,4070
	POWER SUPPLY (BACK MOUNTING,+6V/15A, -6V/4A,+AND-24V/2A,+200V/50MA,130W)	CZC-10	POLON		7/3		14,4071
	POWER UNIT (+6V/20A, -6V/15A,+24V/2A, -24V/2A,200V/0,1A)	SP 426	POWER ELECTRONICS		7/4		14,4072
	POWER UNIT (+6V/25A, -6V/25A, +24V/5A, -24V/5A, 200V/100MA)	SP 558	POWER ELECTRONICS		7/5		14,4073
	POWER SUPPLY (+6V/25A,-6V/5A, +AND-12V/2A,+AND-24V/3A,200V/0,1A)	C 303	RDT		7/1		14,4074
	POWER SUPPLY UNIT -MAINTENANCE ONLY- (+6V/10A,-6V/2A,+AND-24V/1,5A)	P4 ALJ 13	SAPHYMO-STEL		7/1		14,4075
	(+6V/5A,-6V/1,5A,+AND-12V/1,5A, +AND-24V/1,5A) -MAINTENANCE ONLY-	P6 ALJ 13					
	(+6V/25A,-6V/10A,+AND-12V/3A, +AND-24V/3A,+200V/0,1A,MAX 200W)	P7 ALJ 13	SAPHYMO-STEL				14,4076
	POWER SUPPLY (+6V/32A,-6V/32A,+24V/6A, -24V/6A,+200V/,1A,300W, POWER FAIL LAM)	PS 2057	SEN		7/4	(11)	14,4077
	SUPPLY (+AND-6V/26A,+AND-12V/6,5A,+AND-24V/6,5A,200V/0,1A,117V AC, 200W MAX)	C 76455-A4	SIEMENS		7/2		14,4078
	SUPPLY (SAME BUT WITHOUT 117V AC)	C 76455-A5			7/2		
	POWER SUPPLY (+AND-6V/6A SHARED AND +AND-24V/2A SHARED, METERING OF V AND I)	825	STND ENGINEERING		7/2		14,4079
	POWER SUPPLY AND BLOWER UNIT	1410	STND ENGINEERING		7/2	(5)	14,4080
	CAMAC POWER SUPPLY	1510/12	STND ENGINEERING	NA	7/2		14,4081

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CAMAC POWER SUPPLY	1510/42	STND ENGINEERING	NA	/72		14,4082
C	PLUG-IN POWER SUPPLY 156W (+-6V/6A, +-12V/2A,+-24V/1A,117VAC)	P-156-1	WENZEL ELEKTRONIK		05/75		14,4083
C	PLUG-IN POWER SUPPLY 264W (+-6V/10A, +-12V/2A,+-24V/2A,117VAC,OPT,+200V/40MA)	P-264			03/75		
	PLUG-IN POWER SUPPLY 300-&FAN(+-6V/32A, +-12V/3A,+-24V/6A,+200V/100MA,117VAC)	P-300F			04/75		

427 Blank Supply Chassis, Other Components/Accessories

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	POWER SUPPLY CRATE (STANDARD)	MCF/4/PPC	IMMUF-BEDLO	NA	/71		14,4084
	POWER SUPPLY CRATE (WIRED)	MCF/PPC/WY		NA	/71		
	NETZTEILCHASSIS (EMPTY SUPPLY CHASSIS)	2,082,000,5	KNUERR		/70		14,4085
	POWER SUPPLY CRATE(FOR SEPARATE SUPPLY)	C5AN	RDT		/71		14,4086
	MAINS SWITCH ASSEMBLY	MS 3	GEC-ELLIOTT	NA	/71		14,4087
	POWER INDICATOR	0704	NULL, ENTERPRISES	NA	/70		14,4088

43 Recommended or Standard Components/Accessories — Branch Cables, Connectors etc., Dataway Connectors, Boards etc., Blank Modules, Other Stnd Components

431 Branch Related (Cables, Connectors etc.)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	BRANCH HIGHWAY CABLE	B102	BI RA SYSTEMS		/73		14,4089
	BRANCH HIGHWAY CABLE	BH001	EG&G/ORTEC		/71		14,4090
	BRANCH HIGHWAY CABLE (WITH CONNECTORS, 27 CM LONG)	BHC 027	GEC-ELLIOTT		/72		14,4091
	SAME,***=067,107 & 207 FOR CORRESP LENGTH IN CM,OTHER LENGHTS TO SPEC ORDER	BHC ***			/72		
	BRANCH HIGHWAY CABLE ASSEMBLY (WITH CONNECTORS,27 CM LONG)	CC 66 PUL PB-27	HUGHES		/71		14,4092
	(XX CM LONG,PVC JACKET)	CC 66 PUL PB-XX					
	BRANCH HIGHWAY CABLE (COMPLETE PTFE CABLE ASSEMBLY,27CM LONG)	CO 18067-27	HUGHES		/70		14,4093
	(*** 107, 207 - OR CUSTOMER SPECIFIED - FOR CORRESPONDING LENGTH IN CM)	CO 18067/***			/71		
	BRANCH HIGHWAY CABLE		JOERGER				14,4094
	BRANCH CABLE WITH CONNECTOR (1,5 FT TO 75 FT LONG)		JORWAY		/71		14,4095
	BRANCH HIGHWAY CABLE (66 TWISTED PAIRS)	CL 90	SCHLUMBERGER		/71		14,4096
	BRANCH HIGHWAY CABLE ASSEMBLY (COMPLETE WITH CONNECTORS, LENGTH 27 CM)	BHC 27	SEMRA-BENNEY		/72		14,4097
	(SAME, XXX=LENGTH IN CM, 040,100 ETC)	BHC XXX			/72		
	BRANCH HIGHWAY CABLES(COMPLETE WITH CONNECTOR,XXX = LENGTH IN METERS)	2000/132/XXX	TENDATA		/71	(4)	14,4098
	BRANCH HIGHWAY CONNECTOR (FREE MEMBER, PIN MOULDING WITH METAL PIN PROTECTOR)	WS50132P00BN527-H	HUGHES		/73		14,4099
	BRANCH HIGHWAY CONNECTOR (FIXED MEMBER,SOCKET MOULDING)	WS50132S00BN000	HUGHES		/70		14,4100
	(FREE MEMBER,PIN MOULDING, PXX YYY SELECTS JACKSCREW)	WS50132PXXBNYYY					
	HOOD (FOR FREE MEMBER)	WAC 0132 H055					
	EXTENDED BRANCH CABLE (LOW COST TELE-PHONE CABLE FOR LONG BRANCH RUNS)	EBC XXXX	GEC-ELLIOTT		/72		14,4101
	BRANCH HIGHWAY CABLE ONLY (PLAIN PVC JACKET)	66 PUL PB	HUGHES		/71		14,4102
	BRANCH HIGHWAY CABLE (132-WAY)	LIY-Y72x2x0,08M	LEONISCHE		/72		14,4103
	BRANCH HIGHWAY CABLE (TRUE 132-WAY WITH METALISED POLYESTER SCREEN, PVC JACKET)	LI2Y(ST)Y66x2x0,18	LEONISCHE				14,4104
C	CABLE FOR BRANCH HIGHWAY (PVC JACKET)	132 PE 189	PRECICABLE		/71		14,4105
C	(BRAIDED RILSAN JACKET)	132 PE 210					
C	(MEPLAT 20MMX10,8MM,GAINE PVC NOIR)	132 PE 291			/72		
	CABLE EXTENSION MODULE (JOINS TWO BRANCH HIGHWAY CABLES)	CU 18106	HUGHES		/72		14,4106
	BRANCH HIGHWAY TO PDP-11 (COMPLETE WITH CONNECTORS, XXXX LENGTH IN METERS)	5805/P/132/XXX	TENDATA		/73	(6)	14,4107
	BRANCH HIGHWAY JUNCTION BOX	5849	TENDATA		/75		14,4108

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432 Dataway Related (Connectors, Boards, Assemblies)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	ADDRESS & FUNCTION DECODING PC	AFD 2066	SEN				14,4100
	DATAWAY MOTHERBOARD (MULTILAYER PWM)	DM-1	SINO ENGINEERING		7/2		14,4110
	DATAWAY MOTHERBOARD (WITH CONNECTORS)	1166	WEMHMANN		7/4	(10)	14,4111
	DATAWAY SOCKET (MOTHERBOARD COMPLETE WITH 25 CONNECTORS)	CIM	MDI		7/0		14,4112
	DATAWAY MINI WRAPPING (MOTHERBOARD WITH 25 DATAWAY CONNECTORS)	J/DW	SAPHYMO-STEL		7/1		14,4113
	DATAWAY MOTHERBOARD ASSEMBLY	DM 2	SINO ENGINEERING		7/2		14,4114
	DATAWAY CONNECTOR, EDGE TYPE II (WIRE WRAP) (TERMI-POINT/WIRE WRAP) (MOTHERBOARD SOLDER) (WIRE SOLDER)	1-163633-0 1-163634-0 1-163635-0 1-163636-0	AMP AG		7/0 7/0 7/0 7/0		14,4115
C	DATAWAY CONNECTOR WITH CARD GUIDES (HAND SOLDER, DIP SOLDER & MINI-WRAP)	PCB043N/7-1E00	BURNDY	NA	7/4		14,4116
	DATAWAY CONNECTOR (MINI-WRAP)	EAA 043 0301	HUGHES		7/1	(2)	14,4117
	CAMAC DATAWAY CONNECTOR (A INSERT A FOR SOLDER TAG, B SOLDER PIN, C MINI WRAP)	6030 086P 26 * BL	ITT CANNON		7/3	(6)	14,4118
	CAMAC-LEISTE(DATAWAY CONNECTOR,WIREWRAP)	4,000,060,0	KNUERR		7/0		14,4119
	DATAWAY FEMALE CONNECTOR, MINI-WRAP *=1 FOR WIRE SOLDER, 5 FOR BOARD SOLDER	2422 061 04334 2422 061 043*4	PHILIPS		7/1	(5) (5)	14,4120
	DATAWAY MALE CONNECTOR (MATING THE CRATE MOUNTED 86-WAY CONNECTOR SOCKET)	2422 060 14314	PHILIPS		7/2	(5)	14,4121
	CONNECTEUR 254 DOUBLE FACE (DATAWAY CONNECTOR,WIRE WRAP) (MOTHERBOARD SOLDER) (WIRE SOLDER)	254 DF 43 BWV 254 DF 43 AYV 254 DF 43 AZV	SOCAPEX		7/0 7/0 7/0		14,4122
	DATAWAY CONNECTOR (MINI-WRAP) (WIRE-SOLDER) (FLOW SOLDER)	8606-86 21 15 000 8606 86 21 10 000 8606 86 21 14 000	SOURIAU		7/1		14,4123
	DATAWAY CONNECTOR (*=2 FLOW SOLDER,*=3 SOLDER LUGS,*=4 MINIWRAP,AU PLATING) (FLOW SOLDER,NI + AU PLATING) (13 MINIWRAP CONTACTS,OTHER ARE FLOW SOLDER,NI + AU PLATING) (*=7 MINIWRAP,*=8 SOLDER LUGS, NI + AU PLATING) MOUNTING BRACKETS FOR ABOVE	C 288* CSP 221 C 2885 CSP 221 C 2586 CSP 221 C 288* CSP 221 C A523	UECL		7/1		14,4124
	DATAWAY CONNECTOR HOOD (43-WAY DOUBLE SIDED, 2,54 MM PITCH CONTACTS)	S 4051	TEKDATA	1	7/5		14,4125

433 Module Related (Blank Modules, Patchboars etc.)

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CAMAC CARRYING CASE (TAKES 8 MODULES)	C/NCC8-4	HENESA		7/3		14,4126
	CAMAC CARRYING CASE (TAKES 12 MODULES	C/NCC12-6	HENESA		7/3		14,4127
	BLANK MODULE KIT (SINGLE WIDTH) (SAME,*=2,3 & 4 FOR CORRESP WIDTH)	BM 1 BM *	GEC-ELLIOTT	1	7/3		14,4128
	SINGLE CARD MOUNTING KIT (EMPTY MODULE,SHORT SCREEN PLATE) (SAME,*=2,3 & 4 FOR CORRESP WIDTH) GLE CARD MOUNTING KIT (EMPTY MODULE, (EMPTY MODULE,LONGT SCREEN PLATE) (SAME,*=2,3 & 4 FOR CORRESP WIDTH)	CAM/M1/A CAM/M*/A CAM/M1/B CAM/M*/B	IMHOF-BEDCO	1 1	7/2 7/3 7/2 7/3		14,4129
	CAMAC HARDWARE	CM-001	KINETIC SYSTEMS	1	7/1	(4)	14,4130
	CAMAC-KASSETTE (EMPTY MODULE,WIDTH 1/25) (*=2,3,4,5,6 FOR CORRESPONDING WIDTHS)	2,090,001,8 2,090,00*,8	KNUERR	1	7/0 7/0	(2)	14,4131
	CAMAC COMPATIBLE MODULE (EMPTY, WIDTH=1, ALSO IN 2 & 3 UNIT WIDTHS)	NSI 875 DM	NUCL. SPECIALTIES	1	7/0		14,4132
	CAMAC MODULE (EMPTY MODULE HARDWARE) (SAME, *= 2, 3, & 4 FOR CORRESP WIDTH)	NSI 875 CM-100-1 NSI 875 CM-100-*	NUCL. SPECIALTIES	1	7/2 7/2	(5) (5)	14,4133
	CAMAC MODULE,SHIELDED (EMPTY, 1 WIDTH) (SAME, *=2, 3, AND 4 FOR CORRESP WIDTH)	NSI-875-DM/SPH-1 NSI-875-DM/SPH-*	NUCL. SPECIALTIES	1	7/1 7/1		14,4134
	CAMAC MODULE (EMPTY,W=1/25) (*=2,3,4,6 & 8 FOR CORRESP WIDTH) (*=C&2 FOR WIDTH 10 & 12 RESPECTIVELY)	021 02* 03*	POLON	1	7/1 7/1 7/1		14,4135
	EMPTY MODULE 1 UNIT (SAME,*=2,3 & 4 FOR CORRESP WIDTH)	CCA 1 CCA *	RDT	1	7/0		14,4136

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	EMPTY MODULE SCREENED (1 WIDE, ADD TYPE SUFFIX A FOR SHORT, B FOR LONG SCREENS)	CM1	SEMRA-BENNEY	1	//3		14,4137
	(DITO, *=2,3,4 OR 6 FOR CORRESP WIDTH)	CM*					
	MODULE HARDWARE (EMPTY MODULE, W=1/25, ALSO AVAILABLE W=2/25,3/25 & UP TO 8/25)		STND ENGINEERING	1	//2		14,4138
	TIROIRE MODULAIRE POUR CARTE BASCULANTE (EMTY MODULE FOR HINGED CARD)	41405	TRANSRACK	2	//2		14,4139
	TIROIRE MODULAIRE POUR 2 CARTES BASCUL. (EMTY MODULE FOR 2 HINGED CARDS)	41406		3	//2		
	TIROIR MODULAIRE (EMPTY MODULE,W=1/25)	TM 50125	TRANSRACK	1	//0		14,4140
	(*=2,3,4 & 5 FOR CORRESPONDING WIDTH))	TM 50*25					
	(**=06,08,10 AND 12 FOR CORRESP WIDTH)	TM 5**25					
	CAMAC MODULE (EMPTY,1/25 CARD MODULE)	CAMCAS 1	WILLSHER & QUICK	1	//1	(2)	14,4141
	(*=2,3 & 4 FOR CORRESPONDING WIDTH)	CAMCAS *				(2)	
	CAMAC MODULE (EMPTY,1/25 CARD MODULE)	CAMCAS 1-6	WILLSHER & QUICK	1	//2		14,4142
	(*=2,3 & 4 FOR CORRESPONDING WIDTH)	CAMCAS *-6			//2		
	CAMAC MODULE(EMPTY,1/25 SCREENED MODULE)	CAMMOD 1-6	WILLSHER & QUICK	1	//2		14,4143
	(*=2,3 & 4 FOR CORRESPONDING WIDTH)	CAMMOD *-6			//2		
	CAMAC MODULE(EMPTY,2/25 SCREENED MODULE)	CAMMOD 2	WILLSHER & QUICK	2	//1	(2)	14,4144
	(*=3 & 4 FOR CORRESPONDING WIDTH)	CAMMOD *				(2)	
	EMTY MODULE WITH HINGED CARDS (2/25)	9905-CB2	OSL/WILLSHER&QUICK	2	//3		14,4145
	(3/25)	9905-CB3		3	//3		
	EMPTY MODULE (1/25)	9905-ST1	OSL/WILLSHER&QUICK	1	//3		14,4146
	(**= T2, T3, T4, T5, T6, T8, T10, AND T12 FOR CORRESPONDING WIDTH)	9905-S**			//3		
	TIROIR MODULAIRE POUR COMMANDE	9905-TC-1	OSL	1	//1		14,4147
	TIROIR MODULAIRE DE COMMANDE (SUPPLY CONTROL MODULE)	41703	TRANSRACK	1	//0		14,4148
	BLANK CAMAC MODULE PC BOARD (GOLD PLATED & ETCHED FINGERS BOTH SIDES)	NSI-04071-PC	NUCL. SPECIALTIES		//1		14,4149
	GENERAL-PURPOSE IC PATCH BOARD	18605	VERO ELECTRONICS		//4		14,4150
	MK-1 KLUGE MODULE (131 MIXED 14, 16, 24 PIN SOCKETS)	8301	HI RA SYSTEMS	2	//3		14,4151
	MK-5 KLUGE MODULE (HAS 70 14 PIN, 13 AND 2 24 PIN WIRE WRAP SOCKETS)	8305		2	//3		
	MK-6 KLUGE MODULE (HAS 34 14 PIN, 18 16 PIN & 3 24 PIN WIRE WRAP SOCKETS)	8306		1	//3		
	CAMAC-UNIVERSAL-BOARD(PRINTED CARD MODU-LE WITH 28 14-PIN + 28 16-PIN SOCKETS)	DU 200-2900	DORNIER	2	//1		14,4152
	CAMAC PROTOTYPE ASSEMBLY BOARDS (MX B1 HAS 68 SITES, MX B2 HAS 80 SITES)	MX B1/MX B2	GEC-ELLIOTT	NA	//1		14,4153
	(MX B3 HAS 68 SITES,MX B4 HAS 80 SITES, MX B3/MX B4 INCLUDE 5V CIRCUIT)	MX B3/MX B4		NA	//1		
	PRINTED CIRCUIT TEST BOARD	10	JORWAY	1	//1		14,4154
	KLUGE BOARD FOR WIRE WRAP	15	JORWAY	3	//4		14,4155
	KLUGE CARD (FOR CREATING YOUR OWN CAMAC MODULES)	2000-36	KINETIC SYSTEMS	1	//1	(4)	14,4156
C	KLUGE WITH 52 POSITION 2D CONNECTOR	2000-52		1	//3		
N	KLUGE WITH 25 POSITION D CONNECTOR	2000-25		1			
	EXPERIMENTIERPLATTE (PRINTED CIRCUIT BOARD)	4,000,087,0	KNUERR	NA	//0		14,4157
	EXPERIMENTIERPLATTE (P,C,B,)	4,000,088,0		NA	//3		
	DECODED MATRIX BOARD (FOR PROTOTYPE WIRING OF 64 14-PIN SITES, A&F DECODED)	D 21 521	NUCL. ENTERPRISES	0	//4		14,4158
	MODULE PRINTED CIRCUIT BOARDS(TAKE 24,16 OR 14 PIN, ON THE WHOLE 1092 PINS)	CBP 1	RUT	NA	//2		14,4159
	(SAME, WITH MINI-WRAP TO OV AND +6V)	CBP 2		NA	//2		
	BLANK MODULE(COMPLETE WITH PRINTED BOARD FOR 69 INTEGRATED CIRCUITS,1 U WIDTH)	BM 2020/10	SEN	1	//0		14,4160
	(SAME,2U WIDTH)	BM 2020/20		2	//0		
	EXPERIMENT PLATE	C 72468-A453-A1	SIEMENS	1	//2		14,4161

437 Other Recommended or Standard Components/Access.

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
N	RIBBON CABLE FOR LAM GRADER (XXX DENOTES LENGTH IN METERS)	S 4003/XXX	TEKDATA			(14)	14,4162
	NIM/CAMAC ADAPTOR	NCA-1	GEC-ELLIOTT		//4		14,4163
	NIM ADAPTOR	9072	NUCL. ENTERPRISES		//4		14,4164
	NIM-CAMAC ADAPTOR	CAN	RUT	NA	//1		14,4165
	NIM/CAMAC ADAPTOR	ANC 10	SCHLUMBERGER		//2		14,4166

NC	DESIGNATION & SHORT DATA	TYPE	MANUFACTURER	WIDTH	DELIV.	NPR	REF. No.
	CAMAC NIM ADAPTOR	CNA 2033	SEN	2	7/1		14,4167
	CAM GRADER CABLE (20CM, WITH CONNECTORS) (40CM, WITH CONNECTORS)	CGC 20 CGC 40	GEC-ELLIOTT		7/2 7/2		14,4168
	CAM GRADER CABLE		JOERGER				14,4169
	52 WAY CANNON 200525 HARNESSES CAM GRADER CABLE, XXX= LENGTH IN METERS)	580975/52/XXX	TEKDATA		7/3		14,4170
	CAM GRADER CONNECTOR (52-PIN FIXED MEMBER, TAKES PIN TYPE 031-9540-000)	2 DD 52 P	ITT CANNON		7/0		14,4171
	COAXIAL CONNECTOR (PANEL MOUNTING, CABLE CONNECTOR HAS TYPE F 00,250 & FS 00,250) T- & L-ADAPTERS, FREE DOUBLE SOCKET, AND ARE ALSO AVAILABLE	NA 00,250	LEMO		7/0	(4)	14,4172

INDEX OF MANUFACTURERS

AEG-Telefunken
Elisabethenstrasse 3, Postfach 830
D-7900 Ulm, Germany

AMP AG
Haldenstrasse 11
CH-6000 Luzern, Switzerland

Applied Computer Systems Ltd.
2 Charlton Street,
Manchester M1 3JL, England

Arsycom B.V.
Kabelweg 43-47,
Amsterdam 1016, Netherland

BF Vertrieb GmbH
(Sales of F & H Products in Germany)
Bergwaldstrasse 30, Postfach 76
D-7500 Karlsruhe 41, Germany

BI RA Systems, Inc.
3520 D Pan American Freeway, N.E.
Albuquerque, New Mexico 87107,
USA

Borer Electronics AG
Postfach
CH-4500 Solothurn 2, Switzerland

N Borer Electronics
Box 17-126
West Hartford, CT 06117, USA

Burndy Electra AG
Hertistrasse 23,
CH-8304 Wallisellen, Switzerland

Cannon Electric GmbH
Bureau Schweiz
Friedenstrasse 15,
CH-8304 Wallisellen, Switzerland

Christian Rovsing A/S
Marielundvej 46B
DK-2730 Herlev, Denmark

N Computer Technology Limited
Eaton Road, Hemel Hempstead
Hertfordshire HP2 7EQ, England

Digital Equipment Corporation (DEC)
146 Main Street, Maynard
Massachusetts 01754, USA

Digital Equipment GmbH
Wallensteinplatz 2,
D-8000 München 40, Germany

Dornier System
Vertrieb Elektronik, Abt. VCE
Postfach 648
D-799 Friedrichshafen, Germany

EDS Systemtechnik GmbH
Trierer Strasse 281
D-5100 Aachen, Germany

EG & G/ORTEC, Inc.
High Energy Physics Department
500 Midland Road, Oak Ridge,
Tennessee 37830, USA

J. Eisenmann, Elektronik für
Prozessautomatisierung
Vogesenstrasse 6
D-7513 Stutensee-Buechig, Germany

Emihus — See Hughes

Frieseke & Hoepfner GmbH
Export Dept. & Production
Tennenloher Strasse
D-8520 Erlangen-Brück, Germany

Frieseke & Hoepfner
See also BF Vertrieb
(Sales of F & H Products in Germany)

GEC-Elliott Process Automation Ltd.
Camac Group, New Parks
Leicester LE3 1UF, England

Granson Electronics Limited
Long March Industrial Estate
High March Road, Daventry
Northants NN11 4HQ, England

Hans Knuerr KG
Ampfingstrasse 27
D-8000 München 8, Germany

High Energy & Nuclear Equipment SA
2, Chemin de Tavernay,
CH-1218 Grand-Saconnex,
Switzerland

Hughes Microcomponents Limited
Clive House
12-18 Queens Road, Weybridge,
Surrey, England

Hytec Electronics
Court Road, Maidenhead
Berkshire SL6 8LQ, England

IDAS (Informations-, Daten -und
Automationssysteme) GmbH
Kornmarkt 9
D-6250 Limburg/Lahn, Germany

Imhof-Bedco Standard Products Ltd
Colne Way Trading Estate, By-Pass,
Watford, Herts, England

Informatek
Z.A. de Courtabœuf, B.P. 81
F-91401 - Orsay, France

ITT Cannon — See Cannon

J and P Engineering (Reading) Ltd.
Portman House
Cardiff Road, Reading
Berkshire RG1-8JF, England

C Joerger Enterprises, Inc
32 New York Avenue
Westbury, N.Y. 11590, USA

Jorway Corporation
27 Bond Street, Westbury,
New York 11590, USA

Kinetic Systems Corporation
Maryknoll Drive,
Lockport, Ill. 60441, USA

C Kinetic Systems International S.A.
6, Chemin de Tavernay,
CH-1218 Grand Saconnex (Geneva)
Switzerland

Knuerr — See Hans Knuerr

Laben (Division of Montedel)
Via Edoardo Bassini, 15
I-20133 Milano, Italy

Le Croy Research Systems Corp.
126 North Route 303, West Nyack,
New York 10994, USA

Le Croy Research Systems SA
81, Avenue Casai
CH-1216 Cointrin, Geneva
Switzerland

Lemo SA
CH-1110 Morges, Switzerland

Leonische Drahtwerke AG
Abholfach
D-8500 Nürnberg 1, Germany

LRS-LeCroy — See LeCroy

N Metrimpex
P.O. Box 202
H-1391 Budapest 62, Hungary

Nuclear Enterprises Limited
Bath Road, Beenham
Reading RG7 5PR, England

Nuclear Enterprises Inc.
935 Terminal Way
San Carlos, California 94070, USA

Nuclear Specialties Inc.
6341 Scarlett Court, Dublin,
California 94566, USA

Nucletron SA
11, Chemin G. de Prangins
CH-1004 Lausanne, Switzerland

Numelec S.A.
Division Electronique Nucléaire
2, Petite Place,
F-78000 Versailles, France

ORTEC Incorporated
Software Dev, Digital Data Systems
100, Midland Road, Oak Ridge,
Tennessee 37830, USA

ORTEC GmbH
Frankfurterring 81
D-8000 München 40, Germany

O.S.L.
18bis, Avenue du Général de Gaulle
F-06340 La Trinité, France

OSL/Willsher and Quick — See OSL
respectively Willsher and Quick

Packard Instrument Company, Inc.
Subsidiary of AMBAC Industries, Inc.
2200 Warrenville Rd.,
Downers Grove, Illinois 60515, USA

Polon
Nuclear Equipment Establishment
00-086 Warsaw, Bielanska 1, Poland

Power Electronics (London) Limited
Kingston Road Commerce Estate
Leatherhead, Surrey, England

C Precicable
151, Rue Michel-Carré
F-95101 Argenteuil, France

RDT, Ing. Rosselli Del Turco
Rossello S.R.L.
Via di Tor Cervara, 261
Casella postale 7207
Roma Nomentano
I-00155 Rome, Italy

Réalisations Études Électroniques
(R 2 E)

Zone d'Activités de Courtabœuf
F-91, 403 Orsay, France

Rovsing — See Christian Rovsing

Saphymo-Stel
51, rue de l'Amiral-Mouchez
F-75013 Paris, France

Schlumberger Instruments &
Systèmes
Dépt. Instrumentation Nucléaire
B.P. 47 (57, rue de Paris)
F-92222 Bagneux, France

Semra-Benney (Electronics) Limited
Industrial Estate,
Chandler's Ford, Eastleigh,
Hampshire SO5 3DP, England

SEN Electronique
31, Avenue Ernest-Pictet, C.P. 57
CH-1211 Genève 13, Switzerland

C Sension Limited
Manor Lane, Holmes Chapel, Crewe
Cheshire CW4 8AB, England

Siemens AG
Bereich Mess- und Prozesstechnik
Postfach 21 1080
D-7500 Karlsruhe 21, Germany

SOCAPEX (Thomson-CSF)
9, Rue Edouard Nieuport
F-92153 Suresnes, France

Software Partners
Grossgerauer Weg 2
D-61 Darmstadt, Germany

Souriau et Cie
13, Rue Gallieni, B.P. 410
F-92 Boulogne-Billancourt,
Hauts-de-Seine, France

Standard Engineering Corporation
44800 Industrial Drive,
Fremont, California 94538, USA

Tekdata Limited
Westport Lake, Canal Lane,
Tunstall, Stoke-on-Trent,
Staffs ST6 4PA, England

N Tektronix, Inc.
P.O. Box 500, Beaverton,
Oregon 97005, USA

Telefunken — See AEG-Telefunken

Transrack
B.P. 12
22, Avenue Raspail
F-94100 Saint-Maur, France

Ultra Electronics (Components) Ltd
Fassetts Road, Loudwater,
Bucks. HP10 9UT, England

Vero Electronics Ltd.
Industrial Estate, Chandler's Ford,
Eastleigh, Hants SO5 3ZR, England

Karl Wehrmann, Industrievertr.
Spaldingstrasse 74
D-2000 Hamburg 1, Germany

Wenzel Elektronik
Wardeinstrasse 3
D-8000 München 82, Germany

Willsher and Quick Ltd.
Walrow, Highbridge
Somerset, England

APPENDIX II

NIM EQUIPMENT SUPPLIERS

September 4, 1973

Procurement-N21

NIM SYSTEM INSTRUMENTS & COMPONENTS

I. SUPPLIERS OF UNWIRED NIM BINS & MODULES

Bull Run Machine & Welding, Inc.
Route 2
Clinton, Tennessee 37716

Nuclear Specialties, Inc.
540 Lewelling Boulevard
San Leandro, California 94579
Attn: Mr. John Timm

Mech-Tronics
1723 North Twenty-Fifth Avenue
Melrose Park, Illinois 60160

Vector Electronic Company
12460 Gladstone Avenue
Sylmar, California 91342
Attn: Mr. Floyd L. Hill

Semra Benney (Electronics) Ltd.
Ind. Est. Chandlers Ford
Eastleigh
Hampshire S05 3ZU
ENGLAND

A. Imhof Ltd.
Ashley Wks
Cowley Mill Road
Wx Bridge
Middlesex
ENGLAND

L-Electronique Appliquee
98 rue Maurice Arnouy
92 MonTrouge
FRANCE

SEFAMO (Baudet Donon Roussel)
74-78 Boul. du General-Leclerc
Les Lilas (Seine)
FRANCE

Transrack
22 Avenue Raspail
F-94 St-Maur
FRANCE

Nuclear Enterprises, Inc.
935 Terminal Way
San Carlos, California 94070

ORTEC, Inc.
100 Midland Road
Oak Ridge, Tennessee 37830

Tennelec, Inc.
Drawer D
Oak Ridge, Tennessee 37830

Industrial Fabricating
820 Woodend Road
Stratford, Conn. 06497

Perini & Scott (Australasia) Pty. Ltd.
126A Pacific Highway
Waitara, N.S.W. 2077
P. O. Box 163
North Sydney 2060
AUSTRALIA

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II. SUPPLIERS OF NIM INSTRUMENTS & WIRED BINS

Acquidata
910 Justin Lane
Austin, Texas 78757

Applied Nuclear Corporation
4101 South Congress
Austin, Texas 78745

Berkeley Nucleonics Corporation
1198 Tenth Street
Berkeley, California 94702

Canberra Industries, Inc.
Sturrup Nuclear Division
45 Gracey Avenue
Meriden, Connecticut 06450

Chronetics, Inc.
500 Nuber Avenue
Mt. Vernon, New York 10550

Cosmic Radiation Laboratories, Inc.
1645 Montauk Highway
Bellport, Long Island, New York 11713

Darcy Industries
Behlman Division
1723 Cloverfield Blvd.
Santa Monica, California 90404

EG&G, Inc.
500 Midland Road
Oak Ridge, Tenn 37830

✓ Elscint, Inc.
P. O. Box 297
Palisades, New Jersey 07650

John Fluke Mfg. Company, Inc.
P. O. Box 7428
Seattle, Washington 98133

Gearhart-Owen Industries, Inc.
P. O. Box 1936
Fort Worth, Texas 76101

Bertan Associates, Inc.
180 Miller Place
Hicksville, New York 11801

ETEC Corporation
Attn: Mr. H. Graves
3392 Investment Blvd.
Hayward, California 94545

II. SUPPLIERS OF NIM INSTRUMENTS & WIRED BINS (CONTINUED)

Geoscience Inc.
Hamden
Connecticut 06014

Harshaw Chemical Company
Crystal & Electronic Products Department
6801 Cochran Road
Salon, Ohio 44139

✓ Hewlett Packard Company
1501 Page Mill Road
Palo Alto, California 94304

Industrial Fabricators
820 Woodland Road
Stratford, Conn. 06497

Jorway Company
550 Old Country Road
Hicksville, New York 11801

Kicksort, Inc.
Attn: Mr. J. P. McMahon
4200 West 124th Place
Alsip, Illinois 60658

LeCroy Research Systems Corp.
126 N. Route 303
West Nyack, New York 10994

✓ Mech-Tronics
1723 North Twenty-Fifth Avenue
Melrose Park, Illinois 60160

Nanosecond Systems, Inc.
176 Linwood Avenue
Fairfield, Connecticut 06431

Northern Scientific Company
303 Price Place
P. O. Box 4247
Madison, Wisconsin 53711

Nuclear Chicago Corporation
Radiation Instrument Development Lab.
333 East Howard Avenue
Des Plaines, Illinois 60018

II. SUPPLIERS OF NIM INSTRUMENTS & WIRED BINS (CONTINUED)

Nuclear Data, Inc.
100 West Golf Road
P. O. Box 451
Palatine, Illinois 60067

Nuclear Diodes, Inc.
P. O. Box 135
Prairie View, Illinois 60069

Nuclear Enterprises, Inc.
935 Terminal Way
San Carlos, California 94070

ORTEC, Inc.
P. O. Box C
Oak Ridge, Tennessee 37830

Packard Instrument Company
2200 Warrenville Road
Downers Grove, Illinois 60515

Princeton Applied Research Corp.
P. O. Box 565
Princeton, New Jersey 08540

Science Accessories Corporation
65 Station Street
Southport, Connecticut 06490

Scientific Engineering Company
6901 N. Lamar Boulevard
Austin, Texas 78752

Technical Instruments, Inc.
441 Washington Avenue
North Haven, Connecticut 06473

Tennelec, Inc.
Drawer D
Oak Ridge, Tennessee 37830

Transistor Specialties, Inc.
120 Terminal Drive
Plainview, Long Island, New York 11803

Victoreen Instrument Division
10101 Woodland Avenue
Cleveland, Ohio 44104

Nuclear Equipment Corp.
931 Terminal Way
San Carlos, California 94070

Nuclear Specialties, Inc.
540 Lewelling Blvd.
San Leandro, California 94579

Power Designs, Inc.
1700 Shames Drive
Westbury, New York 11590

Tomlinson Research Instruments Corp.
1690 Capital Circle S.W.
Post Office Box 1049
Tallahassee, Florida 32301

Velonex
560 Robert Avenue
Santa Clara, California 95050

II. SUPPLIERS OF NIM INSTRUMENTS & WIRED BINS (CONTINUED)

Conuclear Limited
551 Ferry Road
Winnipeg 21, Manitoba
CANADA

Simtec Ltd.
3400 Metropolitan Blvd. East
Montreal 38, Quebec
CANADA

Sperry Gyroscope (Ottawa) Limited
3 Hamilton Avenue
Ottawa 3, Ontario
CANADA

C&N Electrical
The Green Gosport
Hampshire
ENGLAND

Ekco Instruments
St. Peters Road
Maidenhead Berkshire
ENGLAND

Willsher & Quick Ltd.
Wallrow
Highbridge
Somerset
ENGLAND

H.V.L.
Leuvensesteenweg 1026/1048
Brussels 14
BELGIUM

Perini & Scott (A'Asia) Pty. Ltd.
P.O. Box 163
North Sydney 2060
AUSTRALIA

II. SUPPLIERS OF NIM INSTRUMENTS & WIRED BINS (CONTINUED)

J&P Engineering (Reading) Ltd.
Portman House, Cardiff Road
Reading, Berks
ENGLAND

Panax Equipment Ltd.
Holmethorpe Industrial Estate
Redhill, Surrey
ENGLAND

C.R.C. "Service Export"
77 rue Gabriel Peri
92-Montrouge
FRANCE

C.R.C. "Usine"
5 rue Doguerre
42 Saint-Etienne
FRANCE

Intertechnique
B.P. No. 1
78 - Plaisir
FRANCE

Societe D'Applications Industrielles
De La Physique
38, Rue Gabriel-Crie
92-Malakoff
FRANCE

Gesellschaft fur Nucleonic und
Electronic MBH
8 Munchen 54
Gartnerstrasse 60
Munich
GERMANY

Knurr AG
Ampfingstrasse 27
D-8 Munchen 80
GERMANY

Nucletron Ver. GMBH
Gartnerstrasse 60
D-8 Munchen - 50
GERMANY

Nuclear Measurement Laboratories
Dalroad Industrial Estate
Dallow Road
Luton, Bedfordshire
ENGLAND

Semra Benney (Electronics) Ltd.
Ind. Est. Chandlers Ford
Eastleigh, Hampshire S05 3ZU
ENGLAND

ORTEC, GmbH
8 Munich 13
Frankfurter Ring
GERMANY

Roland Zeissler
D-521 Troisdorf Bez. Koln
Postfach 93
GERMANY

II. SUPPLIERS OF NIM INSTRUMENTS & WIRED BINS (CONTINUED)

Wiener KG
106 Nevenhaus
D-5675 Hilgen
Postfach 31
GERMANY

ELSCINT Ltd.
An ELRON Subsidiary
P. O. Box 5258
Haifa, ISRAEL

Nippon Atomic Industry Group Co., Ltd.
3-2-5 Kasnmigaseki Chiyodaku
Tokyo 100
JAPAN

OSAKA DENPA Co., Ltd.
4-14 Honjyo-Nishidori, Oyodo-Ku
Osaka 531
JAPAN

Jokyo Genshi Kogyo K.K.
2-12-8 Higashi-Gotanda, Shinagawa-Ku
Tokyo
JAPAN

Mr. Tore Seem
Kirkevn-71
1344 Haslum
NORWAY

Nuclear Enterprises Ltd.
Sighthill, Edinburgh EH11-4EY
SCOTLAND

Oltronix
Jamtlandsgatan 125
Vallingby
Stockholm
SWEDEN

Borer Electronics Company
P. O. Box 4500
Solothurn 2
SWITZERLAND

SEN Electronique
31 Avenue Ernest Pictet
1211 Geneve 13
SWITZERLAND

Ing Rosselli Del Turco Rossello
Via Di Tor Cervara, 261
00155 Rome
ITALY

MONTEDEL S.p.A.
Divisione Laben
Via E. Bassini, 15
20133 Milano
ITALY

APEX Co.
5-24, 2-Chome
Sukarayama, Zushi-Shi,
Kanagawa-Ken
JAPAN

Clear Pulse Engineering Company
1-26, 6-Chome
Chuo, Ohta-Ku, Tokyo
JAPAN

IKEGAMI Tsoshinki Co. Ltd.
21, Motogi,
Kawashaki-Shi, Kanagawa-Ken
JAPAN

III. POWER SUPPLIES FOR NIM SYSTEM BINS

B. L. Packer Company, Inc.
5-05 Burns Avenue
Hicksville, New York 11801
Attn: Mr. Leroy Packer, Pres.

Power Designs, Inc.
1700 Shames Drive
Westbury, New York 11590
Attn: Mr. Herbert Roth

Ratheon Company-Sorensen Operation
Richards Avenue
South Norwalk, Connecticut 06854
Attn: Mr. P. J. Greaney

Perini & Scott (A'Asia) Pty. Ltd.
P. O. Box 163
North Sydney 2060
AUSTRALIA
Attn: Mr. R. Scott Simpson

Nuclear Enterprises, Inc.
935 Terminal Way
San Carlos, California 94070

ORTEC, Inc.
100 Midland Road
Oak Ridge, Tennessee 37830

Tenelec, Inc.
P. O. Box D
Oak Ridge, Tennessee 37830

Elscint Inc.
P. O. Box 297
Palisades Park, New Jersey 07650

J&P Engineering (Reading) Ltd.
Portman House, Cardiff Road
Reading, Berks
ENGLAND

C.R.C. "Service Export"
77 rue Gabriel Peri
92 - Montrouge
FRANCE

C.R.C. "Usine"
5 rue Daguerre
42 Saint-Etienne
FRANCE

Intertechnique
B.P. No. 1
78-Plaisir
FRANCE

S.A.I.P.
38 rue Gabriel-Crie
92-Malakoff
FRANCE

H.V.L.
Leuvensesteenweg 1026/1048
Brussels 14
BELGIUM

Nuclear Measurements Laboratories
Dalroad Industrial Estate
Dallow Road
Luton Bedfordshire
ENGLAND

PANAX Equipment Ltd.
Holmethorpe Industrial Estate
Redhill, Surrey
ENGLAND

Grenson Electronics Ltd.
High March Road
Long March Industrial Estate
Daventry, Northants NN11 4HQ
ENGLAND

Semra Benney (Electronics) Ltd.
Ind. Est. Chandlers Ford
Eastleigh, Hampshire S05 3ZU
ENGLAND

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III. POWER SUPPLIES FOR NIM SYSTEM BINS

SAPHYMO-S.R.A.T.
14 rue Rene Coche
92-Vanves
FRANCE

Sefamo (Baudet Donon Roussel)
74-78 Boul du General-Leclerc
Les Lilas (Seine)
FRANCE

Nucletron Ver. GMBH
Gartnerstrasse 60
D-8 Munchen-50
GERMANY

ORTEC, GmbH
8 Munich 13
Frankfurter Ring 81
GERMANY

Wiener AG
106 Nevenhaus
D-5675 Hilgen
Postfach 31
GERMANY

ELSCINT LTD
An ELRON Subsidiary
P. O. Box 5258
Haifa
ISRAEL
Attn: Mr. M. Opher

ELIND - Elettronica Industriale
Via Monte Suello 19
20133 Milano
ITALIA
Attn: Mr. F. Bonini

MONTEDEL S.P.A.
Divisione LABEN
Via E. Bassini, 15
20133 Milano
ITALY

OSAKA DENPA CO., Ltd.
4-14 Honjyo-Nishidori, Oyodo-Ku
Osaka 531
JAPAN

APEX Co.
5-24, 6-Chome, Sakura yama,
Zushi-Shi, Kanagawa-Ken
JAPAN

Tokyo Genshi Kogyo K.K.
2-12-8 Higashi-Gotanda, Shinagawa-Ku
Tokyo
JAPAN

Nippon Atomic Industry Group Co.,Ltd.
2-5, 3-Chome, Kasumigaseki,
Chiyoda-Ky Tokyo
JAPAN

Mr. Tore Seem
Kirkevn. 71
1344 Haslum
NORWAY

III. POWER SUPPLIES FOR NIM SYSTEM BINS

Oltronix AG
Jamtlandsgatan 125
Vallingby
Stockholm
SWEDEN

Nuclear Enterprises Ltd.
Sighthill, Edinburgh EH11 4EY
SCOTLAND

Borer AG
P. O. Box 4500
Solothurn
SWITZERLAND

SEN Electronique
31 Av. Ernest-Pictet
1211 Genève 13
SWITZERLAND

IV. MISCELLANEOUS COMPONENTS

(a) Connector blocks, contacts, guides, hoods, and polarizing pins (See ND-519, ND-514, ND-522, ND-541) are available from:

AMP, Inc.
P. O. Box 3608
Harrisburg, Pa. 17105
Attn: Mr. Tony Stewart

Winchester Electronics
Main Street & Hillside Avenue
Oakville, Connecticut 06779
Attn: Mr. T. R. Farcas

NOTE: See Notes on ND-519 regarding contacts and tools.
See also ND-514, ND-522, and ND-541.

(b) Handles (optional) - (See ND-512) can be obtained from Cambridge Thermionic Corporation, 445 Concord Avenue, Cambridge, Mass. 02138. Identification of a typical handle is as follows:

Handle, semi-frost aluminum, CTC No. 1230-2 Ferrules (for above handle), semi-frost aluminum, CTC No. 1953-2.

(c) Fasteners (see ND-512) are obtainable from the companies listed below. However, it should be noted that suppliers of blank modules frequently include the fasteners.

Amaton Electronic Hardware Company, Inc.
432 Main Street
New Rochelle, New York 10801

IV. MISCELLANEOUS COMPONENTS (CONTINUED)

(c) Fasteners (Continued)

Southco Inc.
South Chester Corporation
Lester, Pa. 19113

Nuclear Specialties, Inc.
540 Lewelling Blvd.
San Leandro, California 94579

(d) Laminated Busses

Eldre Components, Inc.
1239 University Avenue
Rochester, New York 14607

Methode Manufacturing Company
1700 Hicks Road
Rolling Meadow, Illinois 60004
Attn: Mr. George C. Wright

Nuclear Specialties, Inc.
540 Lewelling Blvd.
San Leandro, California 94579

ORTEC, Inc.
100 Midland Road
Oak Ridge, Tennessee 37830

ORTEC, GmbH
8 Munich 13
Frankfurter Ring 81
GERMANY

(e) High Voltage Connectors (see ND-545)

AMP, Inc.
P. O. Box 3608
Harrisburg, Pa. 17105
Attn: Mr. Tony Stewart

Kings Electronics Company, Inc.
40 Marbledale Road
Tuckahoe, New York 10717
Attn: Mr. S. H. Jackson

STARTRONICS, Inc.
Moulton Street
Georgetown, Mass. 01830
Attn: Mr. W. E. Jackson

Winchester Electronics
Main Street & Hillside Avenue
Oakville, Conn. 06779
Attn: Mr. Tore Anderson

Coaxial Connectors Type 50CM (see ND-549)

KINGS Electronics Co., Inc.
40 Marbledale Road
Tuckahoe, N. Y. 10717

LEMO SA
CH-1110 Morges, SWITZERLAND

LEMO U.S.A., Inc.
2015 Second Street
Berkeley, CA 94109

Quick Loc Connectors Ltd.
P. O. Box 306, Shoreham-by-Sea
Sussex BN4 5ET
ENGLAND

The above compilation is undoubtedly incomplete. Information regarding corrections, additions, or deletions is solicited and should be addressed to:

Louis Costrell, Chairman
AEC Committee on Nuclear
Instrument Modules
Radiation Physics Building
National Bureau of Standards
Washington, D. C. 20234

USCOMM-NBS-DC