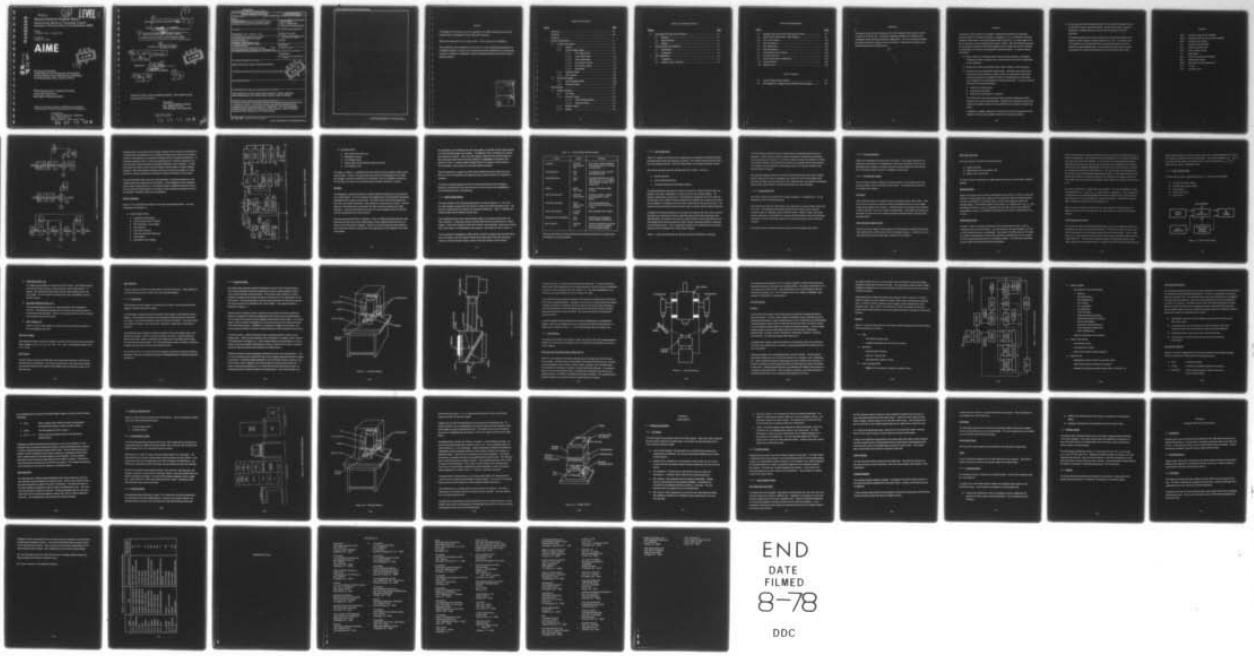
AD-A056 589 RCA GOVERNMENT AND COMMERCIAL SYSTEMS BURLINGTON MA A--ETC F/G 14/2
MANUFACTURING METHODS AND TECHNOLOGY PROGRAM. AUTOMATIC IN-PROC--ETC(U)
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LEVEL II

Second Quarterly Progress Report

Manufacturing Method & Technology Program
Automatic In-Process Microcircuit Evaluation (AIME)

PERIOD:
1 JANUARY 1978 - 31 MARCH 1978

CONTRACT:
DAAB07-77-C-0585

AIME

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78 07 17 084

(1)

(9) SECOND QUARTERLY PROGRESS REPORT. no. 2,

Period: 1 Jan[redacted] - 31 Mar[redacted]78,

(2nd)

(6) Manufacturing Methods & Technology Program .
Automatic In-Process Microcircuit Evaluation (AIME) .

(15) Contract No.: DAAB07-77-C-0585

(10) R. J. Wildenberger
L. Arlan

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Approved by: J. M. Laskey

J. M. Laskey
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(11) May 78

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 0585-2	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Manufacturing Methods and Technology Program Automatic In-Process Microcircuit Evaluation		5. TYPE OF REPORT & PERIOD COVERED Progress Report 1 Jan - 31 March 1978
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Wildenberger, R.J., Arlan L., et al		8. CONTRACT OR GRANT NUMBER(s) DAAB07-77-C-0585
9. PERFORMING ORGANIZATION NAME AND ADDRESS RCA/Government Systems Division Automated Systems Burlington, Massachusetts 01803		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2779808
11. CONTROLLING OFFICE NAME AND ADDRESS Production Division Procurement and Production Directorate 07703 US Army Electronics Command, Ft. Monmouth, N.J.		12. REPORT DATE May 1978
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

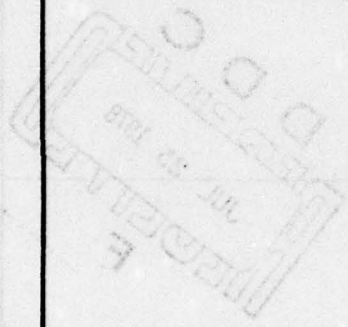
AIME (Automatic In-Process Microcircuit Evaluation), Hybrid, Inspection, Automated Inspection, RBV (Return-Beam-Vidicon), Image Processing.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report covers the work performed on the AIME equipment task during the period 1 January to 31 March. It presents a technical and physical description of the Development Model equipment design and configuration. The work accomplished during the quarter and the task schedule are also presented. Plans for the next quarter have been developed and are outlined herein.

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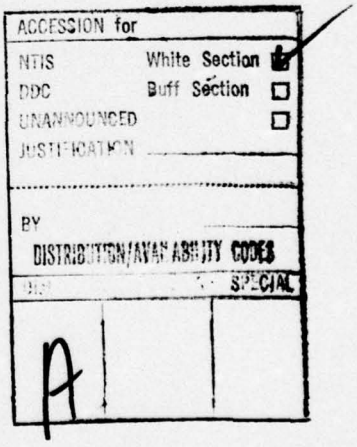


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ABSTRACT

This report covers the work performed on the AIME equipment task during the period 1 January to 31 March 1978. It presents a technical and physical description of the Development Model equipment design and configuration. The work accomplished during the quarter and the task schedule are also presented. Plans for the next quarter have been developed and are outlined herein.

PURPOSE

The purpose of this program is to establish a Manufacturing Methods and Technology Program (MM&T) in accordance with Step 1, paragraph 1.2.2.1, of Electronics Command Industrial Preparedness Procurement Requirements (ECIPPR) No. 15, dated August 1976, for an Automatic In-Process Microcircuit Evaluator (AIME), which will establish techniques for the automatic inspection of thick-film conductor lines on substrates and the elimination of microscopes for visual pre-cap inspection of hybrid assemblies. The MM&T program will include:

(1) System analysis to investigate hybrid image extraction techniques, illumination techniques, and RBV operating modes so that the basis for the AIME configuration can be established.

(2) Design of the AIME Demonstration Model, system software, and test program.

(3) Fabrication of the Demonstration Model Design. The system will contain all the necessary elements required to acquire test data on the inspection of substrate and hybrid assemblies to establish the basis for development of an AIME Equipment configuration and specifications for future procurement. The system elements will perform the following functions:

- Control of the AIME system
- Test program generation
- Stimulus and measurement, as required.

The AIME system will be demonstrated using a specially designed test pattern substrate and a typical hybrid assembly. Software will be developed to provide the control and evaluation required for the inspection of the test pattern substrate and hybrid.

In addition, an English Language Test Document (ELTD) will be generated for the inspection of the specially designed substrate and the hybrid assembly.

(4) A data package for the Demonstration Model will be provided including Test and Demonstration Report, Instruction Manual, Engineering Drawings, equipment specification, program listings, and ELTDs for the substrate and hybrid inspections.

This MM&T program is the result of work done on the Automated Image Device Evaluator (AIDE) Program, Contract DAAB05-74-C-2524. The purpose of the AIDE program was to provide the basis for automated inspection of second generation image intensifier tubes. This program will utilize AIDE hardware components in the design and fabrication of the AIME Demonstration Model.

GLOSSARY

AIDE	Automated Image Device Evaluator
AIME	Automatic In-Process Microcircuit Evaluator
ARTS	AIME Run-Time System
CLI	Command Line Interpreter
CPU	Central Processing Unit
DMA	Direct Memory Access
I/O	Input/Output
MAP	Memory Allocation and Protection
RBV	Return Beam Vidicon
RDOS	Real-Time Disc Operating System
TVL	TV Line
UUT	Unit Under Test

SECTION 1

SYSTEM DESCRIPTION

This section is an update of the System Description contained in the First Quarterly Report and includes system design changes incorporated in the AIME Demonstration Model during the second quarter.

1.1 TECHNICAL DESCRIPTION

1.1.1 General

Background

The Automated In-Process Microcircuit Evaluation (AIME) System will provide the basis for establishing test techniques for the automatic inspection of thick-film conductor-lines on substrates, and eliminate the need of microscopes for visual pre-cap inspection of hybrid assemblies.

There are many points, during the manufacture of hybrid microcircuits, at which some degree of visual inspection is made. However, there are specific major points at which 100 percent visual inspection is made. These inspection points are:

(1) After thick-film processing of the substrate is complete (before the start of assembly).

(2) Immediately before sealing the assembled hybrid package (pre-cap visual).

There are additional significant points, during the thick-film processing of ceramic substrates, where 100 percent continuous inspection would be very desirable, but the costs of manual inspection are prohibitively high and the inspection process itself impedes the achievement of desired throughput rates for printing, drying, and firing. A viable system of automatic in-process inspection amoung the operations involved in adding a thick-film layer to the substrate lot, would greatly improve the yields and assure a more dependable end product.

Figure 1-1 shows a simplified process flow drawing for the manufacture of thick-film hybrids from the point of cleaning the black-alumina substrates to the point after assembly where the hybrid circuit is hermetically sealed. This process flow drawing is arranged to highlight those visual inspection points located in three major areas of the process sequence.

At process point 1A, immediately after printing, a rejected substrate can readily be washed off with a suitable solvent. If the flaw was caused by a problem in the printing process (such as a clogged screen), corrective measures could be taken before too many of the bad prints were made.

At the drying or baking process point, 1B, certain trapped particles, such as lint and dust, could be detected. If flaws are detected at this point, the dried material can be removed from the substrate (more vigorous cleaning is required). Again, as in the case of the substrates with set ink, the plates are recovered and the value added to the substrates in earlier steps is not lost.

Inspection at point 1C occurs after each successive printed layer is fired. The value of picking up faults at this point is to avoid any further labor on a defective substrate, take corrective action as appropriate on any possible out of control process and perform any acceptable, cost-effective rework to the rejected substrates.

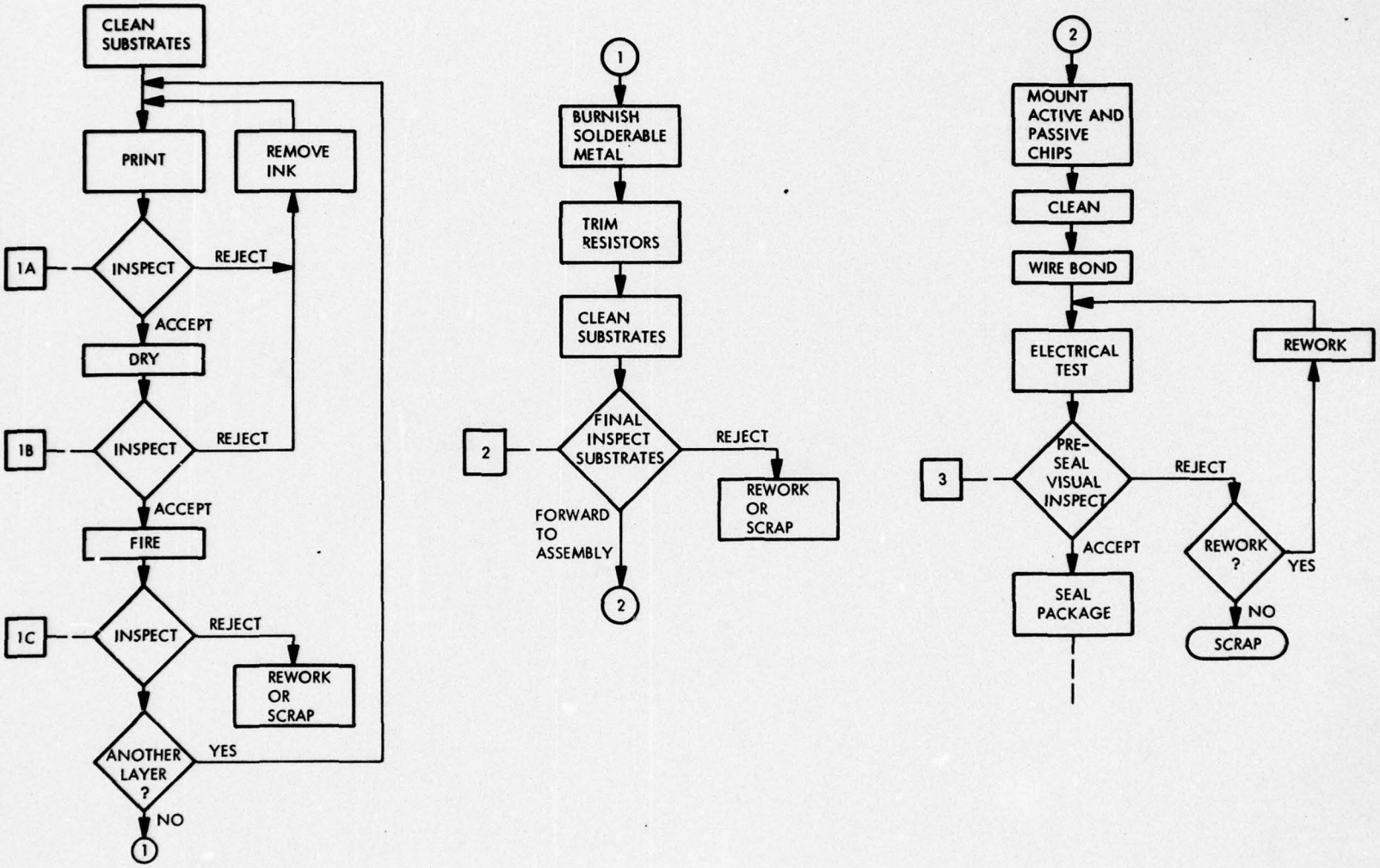


Figure 1-1. Manufacturing Process Flow with Inspection Points

Inspection point 2 on the process flow drawing, identifies the last action to be performed on a substrate before forwarding it to the assembly operations where chip parts are attached and where semiconductors are connected by wiring bonds to the substrate metalization. As previously mentioned, this is a 100 percent inspection point. Automatic inspection on an in-process basis should make this pre-assembly inspection far less important. An interactive inspection system would provide the operator with the ability to identify marginal situations. After electronically zooming in on the area of interest the display on a large screen video monitor would allow the operator to inspect the suspicious area in detail.

At process inspection point 3 (pre-cap visual inspection) a 100 percent inspection is also routinely made of the completed hybrid assembly. At this inspection point the inspection system could be preprogrammed to a disciplined sequence of displayed substrate areas to make sure that the visual inspection is thorough and looks closely at any specific area that is particularly vulnerable to flaws in the manufacture.

System Components

Figure 1-2 is a simplified block diagram of the AIME Demonstration Model. The basic components of the system are:

(1) Control/Display Station

- Computer and Peripherals
- Video Processor and I/O Control
- RBV Electronics, Power Supply
- Sync Generator
- Time-Base Corrector
- Video-Disc Recorder/Reproducer
- Video Monitor
- Illumination Power Supplies

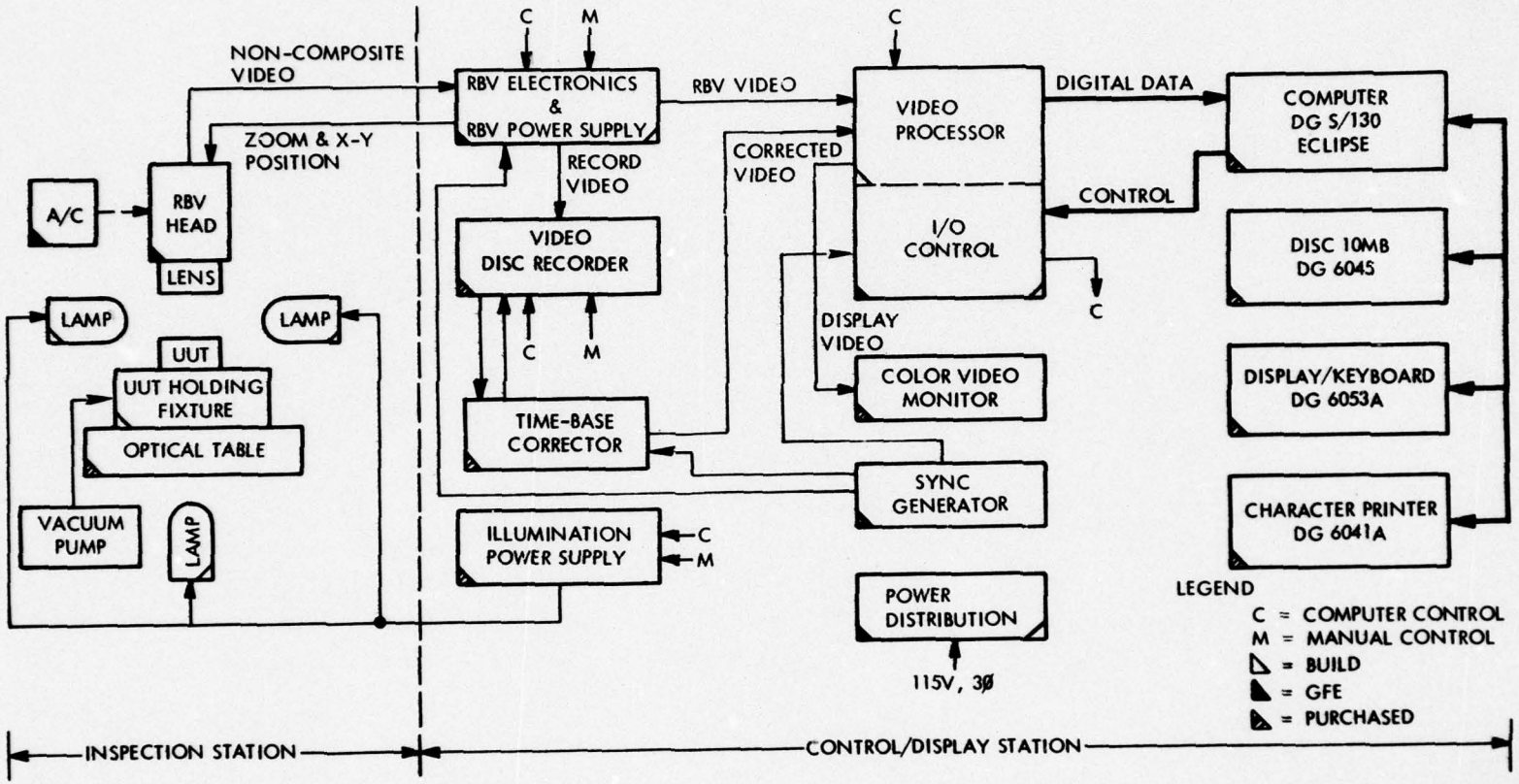


Figure 1-2. AIME Demonstration Model - Block Diagram

(2) Inspection Station

- RBV Camera Head with Lens
- Illuminators (Lamps)
- UUT Holding Fixture
- Optical Table with the Structure/Shroud Assembly
- Air Conditioner Unit

The legend, in Figure 1-2, identifies those items which are under computer control and/or manual control. Further, the legend also shows which of the components are to be built (new designs), purchased (modifications as necessary), and GFE (modified as necessary). All GFE items are removed from the AIDE system (Contract DAAB05-74-C-2524).

Operation

The following is a general description of a typical substrate inspection process performed by the AIME system. The UUT is placed in the holding fixture and subsequently illuminated, projecting the UUT image on the RBV face. The AIME Control selects and positions the RBV scan, via the RBV electronics, to the desired UUT image area to be viewed. The RBV output is a video signal which is directed to the RBV electronics and then to the video processor. A pre-recorded image of the same UUT area is obtained from the video disc-recorder and directed to the video processor.

The video processor performs two functions. First, the difference between the RBV video signal and the video disc-recorder signal output is taken, digitized and fed into the core memory of the AIME system computer. Second, the processor takes the same difference video signal and combines it with the RBV video signal which is then displayed on the color video monitor.

The combination of the difference and RBV video signals is such that the RBV output appears as a black and white image on the monitor. The difference video is directed to the red and green gun-driver circuits. Thus, if the RBV image is wider than the recorded image the green color-gun output will be increased resulting in a highlighting of the greater than normal UUT area. A similar result is obtained if the UUT image is narrower than the recorded image, except now the red color-gun output is increased.

When the inspection is complete the AIME control repositions the RBV beam scan to the next UUT area to be inspected, and repeats the above process until the UUT inspection is completed.

The hybrid-assembly inspection is similar to that described above for the substrate inspection, except that the video disc-recorder is not used and the color highlighting of an out-of-tolerance area is not generated.

1.1.2 Control/Display Station

The major elements of the Control/Display Station are shown in Figure 1-2. One of the two major functions performed by this station is control of the AIME operating modes. This control is maintained by the computer and associated peripherals. Table 1-1 identifies the selected models and key features of these items.

The remaining elements of the Control/Display station are associated with the RBV and Video Processor. Among these items are certain units which are purchased from selected vendors. These items include the video disc-recorder, sync-generator, time-base corrector, color video monitor, and illumination power supplies. These items are also in Table 1-1.

The two methods of controlling the AIME system are with the computer and associated interface (CPU control), and with controls located on the front panels of the RBV electronics chassis, the video processor chassis, and the video-disc recorder (Local Control).

Table 1-1. Control/Display Station Elements

Device	Model	Features
Computer	ECLIPSE Data General (DG)	64K words, memory allocation and protection (MAP), 700 nsec memory cycle
Disc Subsystem	6045 (DG)	10 megabyte storage, removeable disc-pack unit
Display/Keyboard	6053A (DG)	Detachable keyboard, 96 ASCII character set, 5 x 7 dot matrix, 1920 character storage, user-defined keys
Printer	Dasher 6041A (DG)	60 cps, 40 character buffer memory
Video Disc Recorder	VDR-1RA ARVIN-ECHO	400 frame storage, variable frame step-rate, remote control
Time Base Corrector	DPS-1 Digital Video Systems	Will correct greater than 2 μsec of jitter to better than 10 nsec
Color Video Monitor	5411RS19 Conrac	High resolution color monitor
Illumination Power Supplies	6329 Oriel	Stabilized power supply for Quartz Halogen Illuminators
Sync Generator	Tektronix 1410	Provides horizontal and vertical drives as well as Composite Sync and Blanking signals

When the AIME system is being operated by the front panel controls, the computer does not influence the system operation.

1.1.2.1 CPU Control Mode

Under CPU Control, all elements of the AIME System are operated by computer generated commands with operator interventions as required. The primary computer/operator interface is the display/keyboard. The color video monitor is a secondary interface element.

Three basic operating modes are possible under CPU Control. These are:

- Manual Inspection
- Semi-Automatic Inspection
- Automatic Inspection (Demonstration System).

The Manual Inspection operating mode allows the operator to select the desired RBV scan position, zoom-ratio, illumination, as well as the color video monitor display. The operator controls these parameters by 1) depressing the appropriate key on the keyboard, 2) observing on the computer interface display that his selection was accepted and executed by the computer, 3) verifying on the video color monitor that he has the correct view. The operator may then modify the present monitor image or continue with the Manual Inspection.

In addition to the Manual Inspection just described, the operator may also create an inspection program by entering the Program Generation option of the Manual Inspection Mode. With this option, the operator may select the desired monitor view and then depress a keyboard button which will then generate the AIME computer commands required to duplicate the view being observed. Thus, an Inspection Program may be generated by the operator, without any prior knowledge of the AIME System language.

Figure 1-7 shows the keyboard layout with the associated AIME System commands.

The Semi-Automatic Inspection mode is utilized after an inspection program has been generated. In this mode the computer sequences through the pre-determined inspection steps, presenting on the monitor a view for the operator to inspect the substrate or hybrid. The operator evaluates each substrate and presses the appropriate button on the keyboard. The computer does not evaluate the video signal except as the operator indicates by his keyboard entered response.

The Automatic Inspection Mode for the AIME Demonstration System will, under computer control, setup the RBV camera operating mode, select the correct stored image on the video disc recorder, input and evaluate the video difference data, and continue the inspection process until a fault is found or the substrate inspection has been completed.

1.1.2.2 Local Control Mode

The LOCAL control mode is intended as a setup, diagnostic, or evaluation aid. It is not intended for use by an unskilled operator.

This control mode allows the AIME system to be operated in a manner similar to that of the CPU mode. The distinguishing difference between the two control modes is that the computer control is completely removed from the system. Instead, control of the AIME system components is accomplished by controls on the front panels of each of the following components: the RBV electronics chassis, the IO processor chassis, and the video disc recorder.

The details of these front panel controls are given in the descriptions which follow.

1.1.2.3 Power Distribution

AIME power distribution is centralized in one chassis. This chassis contains all the required circuit breakers for controlling the main power to the RBV electronics, the illumination power supplies, computer and the associated peripherals, video devices, the I/O processor chassis and the air conditioner/vacuum pump.

1.1.2.4 IO Processor Chassis

The IO processor chassis contains three main elements: the IO circuitry, the Video processor digital, and the associated analog circuits. This chassis also has its own low-voltage power supplies.

IO Circuits

These circuits provide the main link between the computer and the AIME system. Data-bus receivers and drivers provide the actual communications link as well as sending system timing signals to the computer. Address decoders and storage cards provide the means by which the CPU Mode of control is implemented. The storage card selected by the address decoder stores the computer generated commands used to setup the AIME operating modes.

Video Processor Digital Circuits

The video processor digital circuits generate all the functions to provide the high-speed data transfers from the AIME system into the Computer Memory. In addition, these circuits generate the system timing signals required by the computer.

AIME Video Processor

The video processor provides the following functions:

(1) Display switching
(2) Differencing of live and playback video
(3) Display color enhancement

The video processor, fabricated in a single copper clad board, is housed within a separate package.

Display Switching

Relays on the video processor board, which function either under CPU control or under the control of a rotary display select switch on the IO/Processor front panel when the system is in the Local Operate or Local Setup Modes, route the video signals to provide the selected display. The selectable options are live video (V_A), playback video (V_B), V_A with the difference between V_A and V_B superimposed in color and a special video processor setup display in which V_A is differenced with itself and any residue is superimposed on V_A in color.

Differencing Circuits

Nominal 1.0 volt p-p composite video/sync is fed to the processor via the V_A and V_B connectors on the rear of the chassis. V_B is fed directly to an input attenuator; V_A is fed to a filter network and then to an attenuator. The purpose of the filter network is to adjust the transfer characteristics of the line video channel to compensate for the disc recorder and TBC characteristics introduced in the playback channel. The final form of this filter network cannot be determined until system integration.

The two input attenuators enable setting identical video peak white to video black (not sync) levels in both channels. Once these levels have been equalized, it is possible that different sync levels may exist in two channels. To correct this, each channel passes through a threshold network where the sync tips are self-clamped to an adjustable level by diodes. These levels can be adjusted independently to cause the sync in each channel to be clipped by an equal amount below the video black level. This same network also established the DC input level for the following video differential amplifier. At the output of this network, the two video signals are identical (except for valid differences) between the master and UUT images, the sync tips have been clipped, and the signals are clamped to the same DC level.

The video is differenced in a dual output video amplifier. The two raw difference outputs corresponding to $V_A - V_B$ and $V_B - V_A$ are then fed to comparators. In the comparators, the differences are compared to adjustable thresholds and bilevel video outputs are generated whenever the raw video difference exceeds the threshold. Both bilevel outputs are high for differences greater than the threshold levels.

These two bilevel outputs are routed out of the video processor analog circuits to the digital circuits and are also routed within the video processor to the color enhancement network.

Color Enhancement Circuits

The two bilevel outputs are routed through AND gates (which are enabled only when valid differences can exist) to the video driver network. This network consists of three amplifiers for driving the red, blue and green guns of the color video monitor. The live video input (V_A) is passed directly to the three drivers; this allows generating a black and white image of the UUT. The two bilevel difference outputs are summed into the live video signal ahead of the red and green drivers. Whenever these two levels are high (differences

greater than thresholds, the black and white image will be superimposed with red or green color splashes showing the location of differences. Green will correspond to $V_A - V_B$ (UUT less dense than the master, back lighted mode); red will correspond to $V_B - V_A$ (UUT denser than the master, backlighted mode).

1.1.2.5 RBV Camera System

The RBV camera system, diagramed in Figure 1-3, consists of the following:

- The RBV electronics chassis.
- The RBV power supply chassis.
- Sync generator.
- Lamps and controls.
- RBV camera.

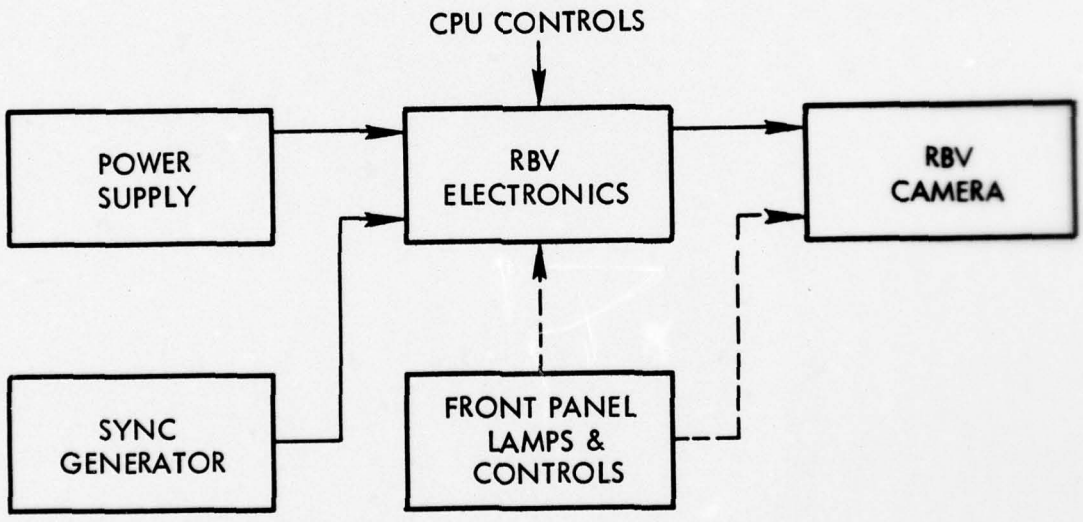


Figure 1-3. RBV Camera System

Camera Electronics

The camera electronics is located in the RBV electronics chassis. Its purose is to provide sweep signals and video signal conditioning for the RBV camera. This assembly contains twelve plug-in circuit boards (A1 through A12), two power supplies, front panel controls/ indicators, and a horizontal deflection driver.

- Horizontal Deflection Waveform Generator, A1

  This board contains a ramp generator used to provide linearity correction to the horizontal yoke driver. The ramp generator operates at the horizontal scan rate.

- Protection Circuits, A2

  These circuits detect the loss of horizontal and vertical deflection. Loss of either signal shuts down the high-voltage power supplies and lights the fault light on the RBV control panel.'

- Vertical Deflection, A3

  This board contains an oscillator, buffer, and yoke driver circuits. The buffer also sums the vertical steering voltage which provides vertical position control.

- Sync Buffers, A4

  Optical isolators are used to buffer and level shift the horizontal drive, vertical drive, and composite blanking signals from the sync generator.

- Target/Focus, A5

  This board generates a stable voltage reference as well as generate the focus coil and target drive signals.

- Beam/Alignment, A6

  The horizontal and vertical alignment coil drive signals are generated on this board. The bias voltage for the RBV tube grid, G1, is also obtained from this card. There is also a circuit which produces a delayed clamp pulse which is supplied to A12.

- Electrode Regulator, A7

  This board provides regulated bias voltages for the RBV tube grids, G2, G3, G4, G5, and G6.

- Beam and G4 Focus Control, A8

  This assembly controls the beam and G4-focus voltages in accordance with the zoom ratio. A two bit binary word is used to specify the zoom ratio (1:1, 1.67:1, 3.60:1, and 10:1). The binary word is decoded to select a preset potentiometer for control of the beam and G4-focus voltages.

- Vertical and Horizontal Digital-to-Analog Converters, A9, A10

  A9 and A10 are identical circuits used to control the vertical and horizontal position of the RBV beam. The beam position can be selected by the computer under CPU control or by the front panel switches under local control. The output of these boards (A9 and A10) provide the beam steering voltages to assemblies A1 and A3 respectively.

- Target, Horizontal Size, and Dynode Gain Control, A11

  This assembly controls the target, horizontal size, and dynode gain signals based on the selected zoom ratio. Control of these signals is similar to that for the A8 board, i.e., a preset potentiometer is selected. In addition, drivers are provided for the front panel lamps which indicate the selected zoom ratio.

- Video Driver/AGC, A12

  A12 buffers and amplifies the video from the RBV camera. The buffered outputs drive the time-base-corrector, video processor, and the video monitor. In addition, this assembles the black burst and horizontal blanking levels to the video signal. On AGC circuit is provided for the video preamplifier located in the RBV camera.

- Horizontal Deflection Driver, A14

  The horizontal deflection driver is a resonant flyback circuit operating at 15750 Hz. This board also provides linear correction and a summing point for the horizontal steering signals. Relays on the board provide the proper operation in accordance with each zoom ratio.

- 1500 V Supply, A18

  A 900 V to 1200 V power supply is provided to drive the dynode as required by the corresponding zoom ratio.

RBV Power Supply

This assembly provides several DC voltages to the RBV electronics and camera assemblies. These voltages are $\pm$6, -6.3, $\pm$15, $\pm$25, -400, +700, +2500. The assembly operates from 115 V, 60 Hz.

RBV Camera

The RBV camera consists of an RBV tube, the camera head electronics, and the focus and deflection coil assemblies. The camera receives sweep, and control grid voltages from the RBV electronics and returns a video signal which represents the image on the RBV tube face.

Sync Generator

The sync generator provides the sweep signals to the RBV electronics. These signals are vertical and horizontal drive, black burst, and composite blanking.

1.1.2.6 Illumination

The illumination system consists of an illumination controller, three illumination power-supplies, and three illuminator housings.

The illumination controller provides an intensity control signal to the illumination power-supplies. This provides for variation of the illumination intensity based on the selected zoom ratio. Zoom ratio information comes from the RBV electronics. Time delay relays are included to provide a lower than normal "cold-start" voltage when an illuminator is turned on.

The illumination power-supplies provide the voltages for the quartz-halogen lamps in the illuminator housings. There is one power-supply for each lamp. Remote sensing was added to each power-supply to compensate for voltage drops in the cables which connect the lamps with the power supplies. The remote sensing also helps to maintain a consistent voltage across the lamp for each preset illumination level.

The main power (115 V, 60 Hz) for the power-supplies is derived from the power distribution panel. There are two switches in the power distribution panel to manually operate the illuminators.

1.1.3 Inspection Station

The AIME project proposal contained a preliminary concept for the Inspection Station. This concept envisioned a structure consisting of aluminum framing material would be used to support the RBV camera assembly. The aluminum frame material is readily available in standard sizes and thus provides an economic as well as rigid support for the RBV camera. The shroud consists of aluminum plates attached to the structure assembly. The shroud material will contribute to the overall rigidity. The inspection Station is illustrated in Figure 1-4.

Further analysis indicated, however, that the structure/shroud would have insufficient rigidity to maintain the 0.0005 inch orthogonality between the camera and holding fixture. A more rigid camera support has been designed using bolted aluminum plates. The camera support, which is similar in appearance to a microscope mount, will be fastened directly to the optical table surface. In addition to providing more rigidity for the camera, the camera support provides a convenient mounting structure for both illuminators and mirrors.

A third illuminator, located on the optical table, has been provided to produce a back lighting mode. Light from this illuminator will be folded 90^{o} by locating a mirror beneath the holding fixture (see Figure 1-5). Since scattered light from the illuminator or mirror incident on the front surface would decrease contrast, a bellows will be used to completely enclose the light path between the illuminator and holding fixture.

Incident illumination remains essentially unchanged from that in the AIME proposal. That is, the two illuminators are located 180^{o} apart and the slightly defocused filament is imaged on the hybrid. Illumination angle established by the Illumination Analysis (reported in the first quarterly report, Appendix 2) for both illuminators remains approximately 20^{o}. In order to uniformly illuminate the 2" x 2" hybrid with the defocused filament image, the illuminators must be located 20 inches from holding fixture. Since the illuminators are

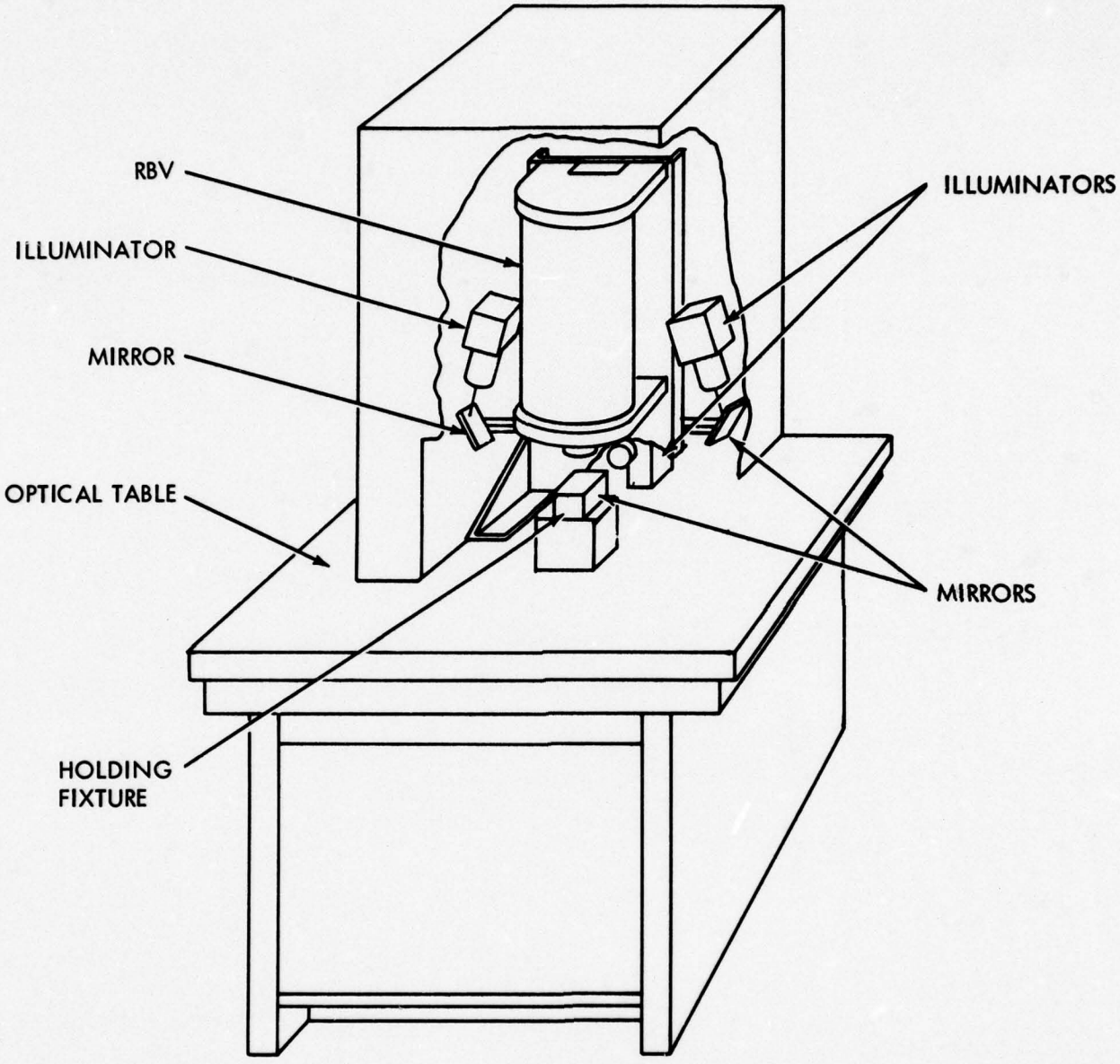


Figure 1-4. Inspection Station

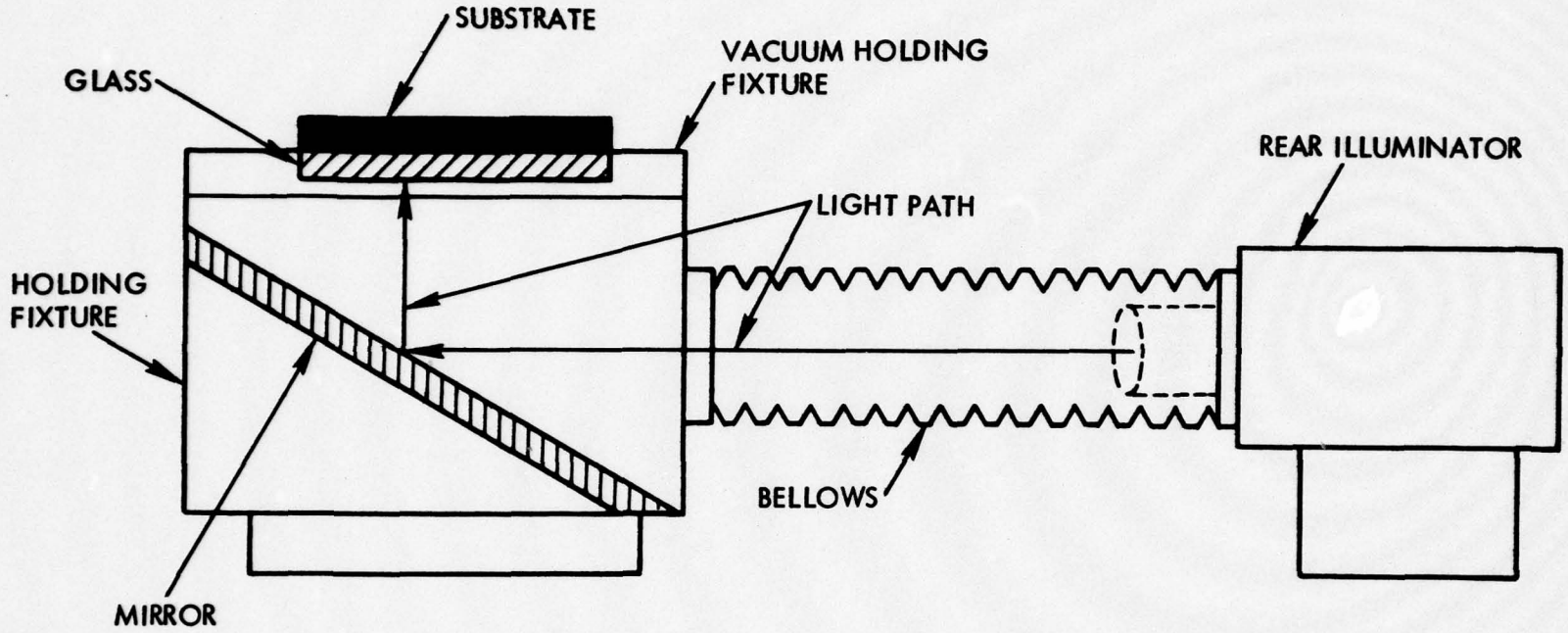


Figure 1-5. Rear Illumination

located 180° apart, the inspection station became four feet wide. To reduce the overall station width, both illuminators are now mounted parallel to the RBV camera and adjustable mirrors are used to fold their beams (see Figure 1-6). The outside dimensions for the shroud are now approximately 26" wide x 28" deep x 36" high.

It was determined that vibrations generated by the illuminator cooling motors would cause RBV camera imaging difficulties. Therefore, the motors will be disconnected and external cooling air from the air conditioner unit will be ducted to each of the three illuminators. Air from the illuminators will be exhausted directly into the shroud, thereby creating a slight positive pressure inside the shroud. This positive pressure will preclude dust inside the shroud.

A mirror housing is located just below to the vacuum holding fixture to facilitate back lighting. Since the back lighting mirror is located directly under the holding fixture, no change will be required for the x, y, z and θ hybrid holding fixture positioning units.

1.1.4 AIME Software

The AIME System Software will consist of Data General Real-Time-Disc-Operating System (RDOS), the Command-Line-Interpreter (CLI), the AIME-Run-Time System, and various utility programs.

Real-Time-Disc-Operating System (RDOS) and CLI

RDOS is a comprehensive and flexible operating system normally used with disc-based NOVA systems. RDOS provides a comprehensive file system that gives the user a simple command language to edit, compile, execute, debug, assemble, save, and delete files. File protection is provided by a number of system-defined file attributes. All peripheral devices are names and treated as files, providing device independence by device name. RDOS provides an I/O facility with buffered and spooled operations. The operating system allocates unused core storage for dynamic system buffers and overlays.

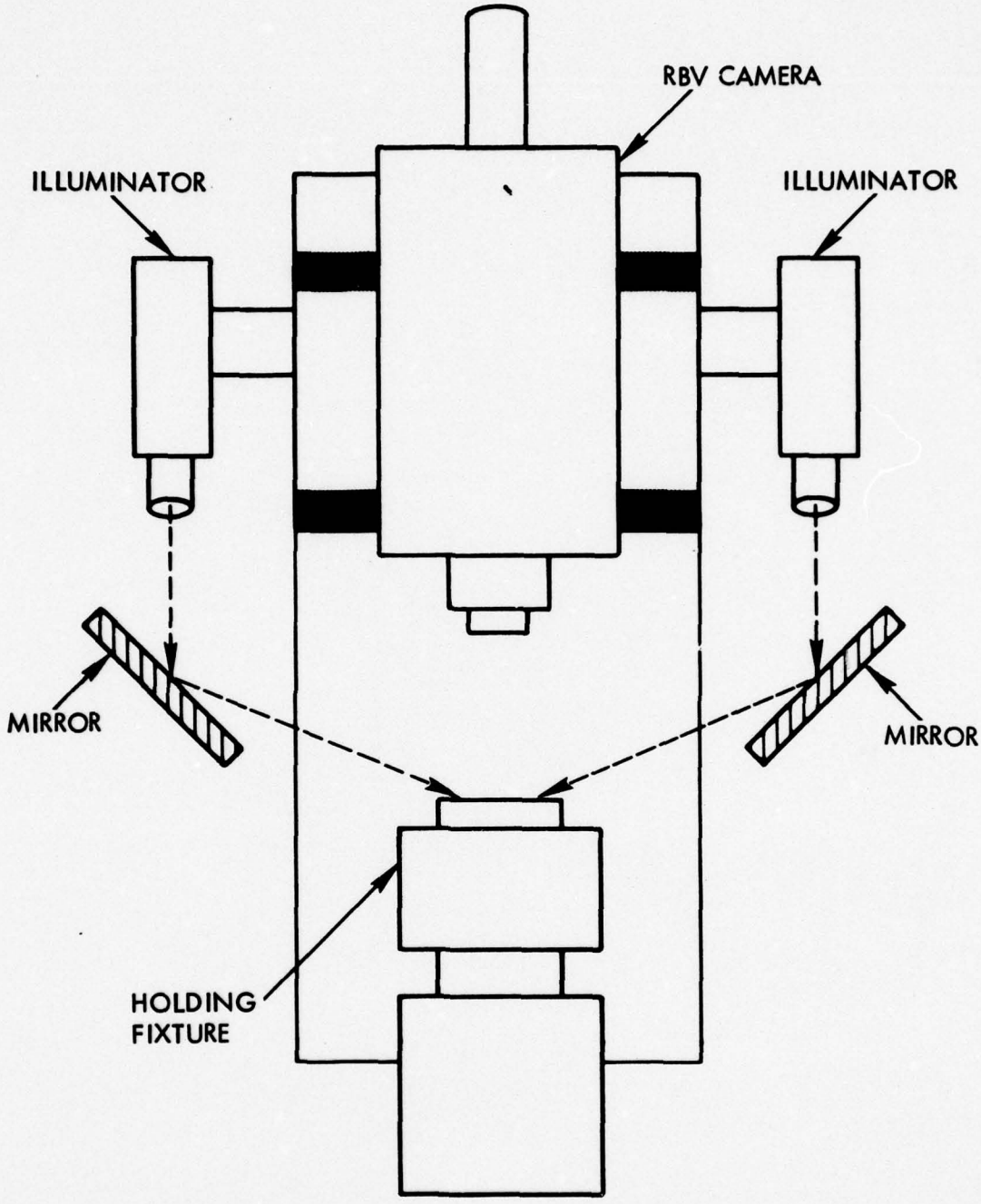


Figure 1-6. Front Illumination

The Command Line Interpreter (CLI) is a dynamic interface to RDOS via the console and translates the input as commands to the operating system. The system restores the CLI to core whenever the system is idle - after initialization, after a disc bootstrap, after the execution of a program, etc. The CLI indicates that it is in control by inputting a ready message "R" followed by a carriage return.

Run-Time System

General

The AIME Run-Time System (ARTS) will perform the functions of program generation, and test execution. It will be written in high level language (ALGOL) utilizing structured programming techniques to obtain modularization for ease of maintenance and understanding. Assembly language modules shall be minimized and used only where necessary for speed or special purpose programming such as required in image processing. Certain existing software modules from the AIDE System have been used with minor modifications: AIMERTS INIT, GETLINE, LIGHT, READINPUT, READMEAS, RTSEXT, RTSTERM, and WAITFOR. The ARTS will operate under RDOS Rev 6.

The highest level software module will function an an interpreter which can be utilized in an on-line mode (manual mode), or execute a previously generated test sequence (auto or semi-auto modes).

Program generation will be accomplished either on-line or off-line. On-line program generation will allow the user to try various setups for X-Y position, zoom, illumination, etc. When a specific test setup is decided upon, the system software will remember, on operator command, the exact setup and will place the test setup in sequence with respect to other tests. Off-line programming will be accomplished by writing a legal sequence of interpreter commands and data. Upon execution of a program, any illegal commands or missing data will result in error messages being displayed to the user.

The result of either off-line or on-line program generation will be a source file listing, comprised of interpreter commands and data. This test program sequence will be readily modifiable, through the use of a text edit program similar to the one used on the EQUATE AN/USM-410 system.

Actual testing will be initiated by typing in the command 'TEST' on the CLI. If TEST/A 'NAME' is entered, the test sequence in the file 'NAME' will be executed in the automatic mode. If TEST/S 'NAME' is entered, the test sequence will be executed in the semi-automatic mode. Where 'TEST' is not followed by 'NAME', the system will be in the manual mode and will respond to and execute specific interpreter commands on the keyboard terminal.

Structure

Figure 1-7 shows the basic structure of the system control elements of the system software. The key elements are as follows:

- Input
  - via keyboard (manual mode)
  - existing test program (auto and semi-auto modes)
- Interpreter
  - interprets input command
  - checks for required data
  - calls appropriate software module
- Error Message Module
  - displays error message for improper command or data

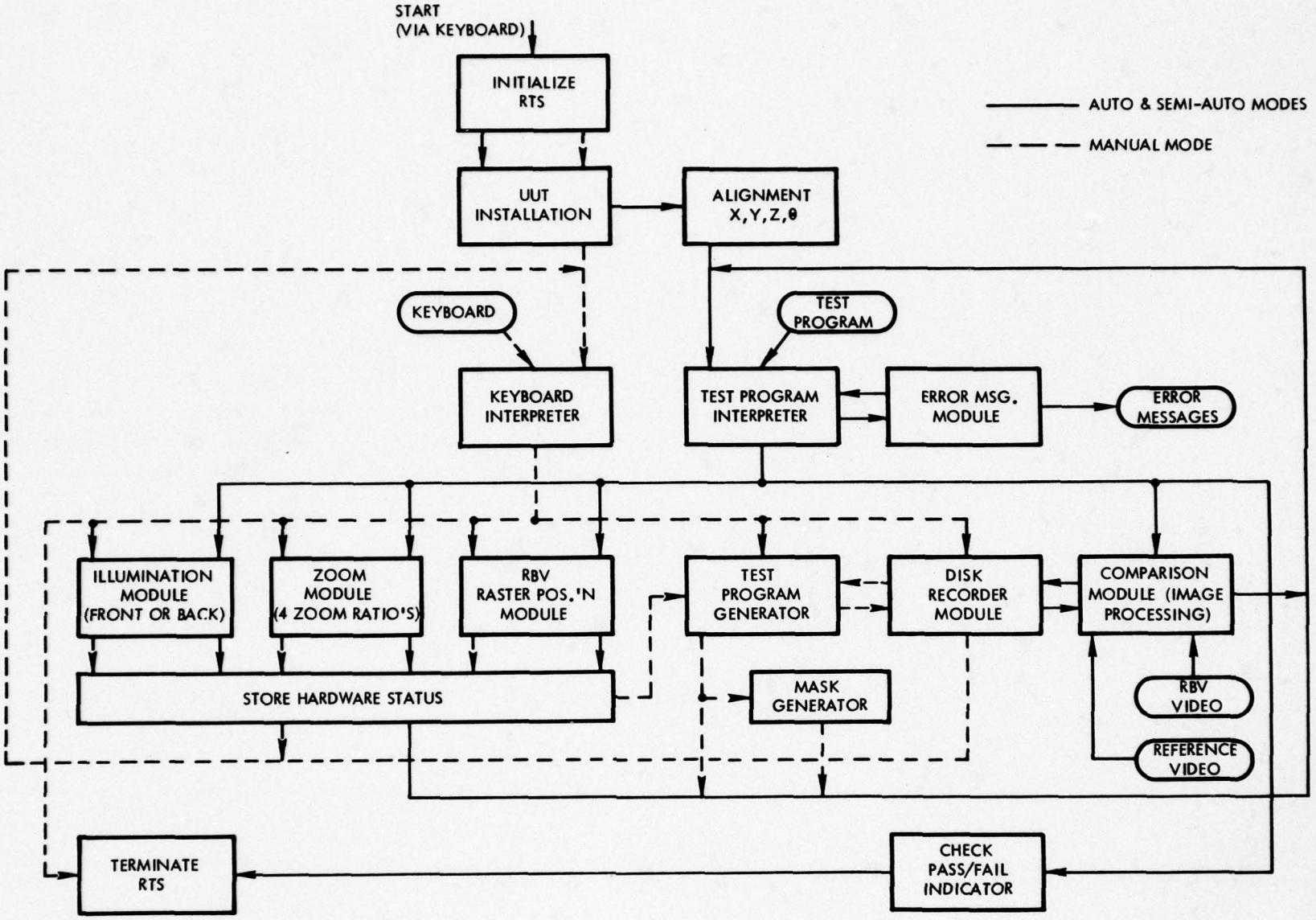


Figure 1-7. AIME Software Block Diagram

- Software Modules
  - one module for each major function
    - DISPLAY
    - RTS INITIALIZER
    - RTS TERMINATOR
    - XY POSITION
    - UUT ALIGNMENT
    - ILLUMINATION
    - ZOOM CONTROL
    - VIDEO RECORDER CONTROL
    - HARDWARE REGISTER CONTROL
    - IMAGE PROCESSING
    - PASS/FAIL DETERMINATION
    - TEST PROGRAM GENERATION
    - MASK GENERATION
  - returns to interpreter upon completion
- Common Data Storage
  - one 'external' module
  - accessible by all modules
  - stores current status of system hardware
- Keyboard Task
  - distinguishes between control keys and other inputs
  - allows direct control of hardware via keyboard
  - activates test program generation module with a 'TESTGEN' key

Test Program Generation

The test program generator will be used to create automatic and semi-automatic test program for substrates and pre-cap hybrids respectively. To create a test program, the operator enters the command TEST. This will activate the system and enable the user to manipulate the system from the keyboard. Sectors have been designated for the user in positioning the image or the monitor. The higher the zoom ratio, the greater the number of sectors. Sectors are square in shape and are numbered from left to right and from the top down. When a suitable image is seen on the monitor the operator pushes the 'TESTGEN' keyboard button which results in the following system actions:

(1) Interrogation of all system status registers and storage of the current setup data for the image,

(2) The generation of a set of commands and related setup data, which when executed at a later date will result in the exact same setup conditions,

(3) Indexing and storage of the image on the video disc-recorder,

(4) The generation of a MASK for the current image for the automatic test program.

The Operator Keyboard

Figure 1-8 shows the configuration of the keys in the keyboard on the display terminal. The keys pertinent to the AIME system are summarized below:

- HALT — to terminate testing.
- PAUSE — to temporarily postpone execution of a program.
- PROCEED — when an operator action is required, this key is used to resume testing.

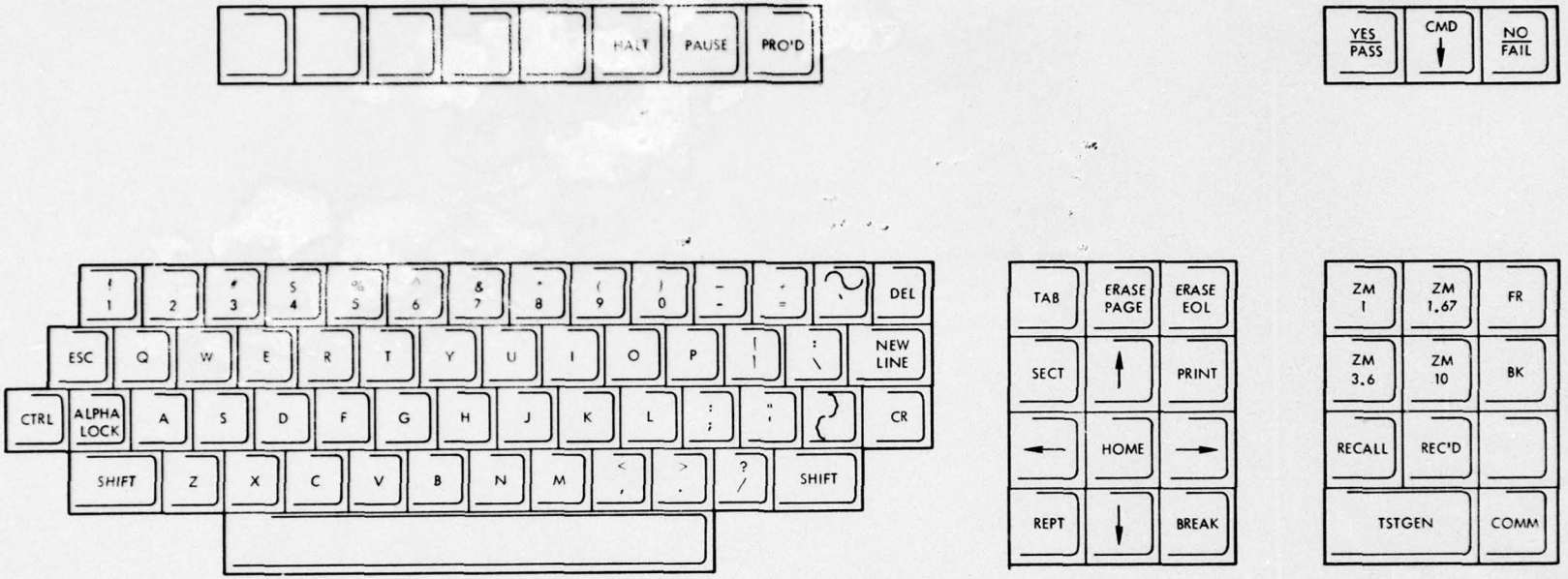


Figure 1-8. Operator Keyboard

- YES/PASS
  NO/FAIL — these dual purpose keys are used when responding to a YES/NO or PASS/FAIL decision.
- CMD — the 11 keys below the CMD button are recognized as test control commands only when the command is preceeded by the depression of the CMD key.

The 11 lower keys are primarily used while operating in the manual mode.

- ZM 1
  ZM 1.67
  ZM 3.6
  ZM 10 — to select one of four zoom ratios for the RBV.
- FR
  BK — to select either front or back illumination for the UUT.
- RECALL — to recall a video image of the disc recorder for displaying purposes on the color monitor.
- REC'D — to record a video image onto the disc recorder.
- TESTGEN — to automatically generate a test program using the current setup conditions.
- COMM — this key is used in the semi-automatic mode as a means for the operator to store any applicable comments he may make.

The remaining keys are located on the middle keypad (Figure 1-8) and are used for image positioning:

- SECT — When a specific sector wants to be seen, depressing this key will ask the operator to input any sector number.
- HOME — This will position the RBV to sector 1.
- ↑, ↓, →, ← — These 4 keys will position the RBV to the appropriate adjacent sector.

Depending on whether the generated test program is to run in the automatic or semi-automatic mode, the proper command for computer image processing/computer decision or operator inspection/operator decision will be added. The user will then proceed by using the various commands to set up further images and repeating the process above, until a suitable number of reference images have been obtained. The test program generation process will then be ended when the HALT button is pressed. This will add a pass/fail decision command to the end of the test program. The resultant test program can be printed out at any time for reference or permanent record.

Mask Generation

The mask generator (software module MASKGEN) will be used to generate a mask for each reference image operating in the automatic mode. Where an etch boundary exists, the mask will consist of a block of '0's with '1's elsewhere. The width of the block of '0's will be sufficient magnitude to maks out offset and registration errors. The resultant mask will then be stored as a disc file. During an automatic mode run, the appropriate mask will be read into the computer memory and "AND ed" with the difference video data. The resultant data is then ready for the image processing.

1.2 PHYSICAL DESCRIPTION

Figure 1-9 shows the physical layout of the AIME system. There are basically two major units of the AIME demonstration system:

- Control/Display Station
- Inspection Station

1.2.1 Control/Display Station

The Control/Display Station consists of two racks, which contain all the control and processing electronics in addition to the video monitor unit, a separate table on which is the display/keyboard unit, and a stand alone character printer.

Both racks are 78" high, 30" deep, and accommodate standard 19" wide panels. The right hand unit has a pull-out writing surface located just below the video monitor. Also, in this rack are the power supply units for the RBV electronics and illuminators. The AIME power distribution and RBV electronics chassis complete the right rack assembly.

The left rack consists of the computer and disc, video recorder, sync generator, and timebase corrector, as well as the I/O Processor chassis. Both racks contain their own blower assemblies for cooling. The racks will be connected together to form a single unit. There will not be a center panel separating the two racks. Elimination of this panel will allow easier inter-rack wiring.

1.2.2 Inspection Station

The Inspection Station illustrated in Figure 1-10, contains the vertically mounted RBV, three illuminators and hybrid holding fixture. Because of the rigidity required, the Inspection Station structure will be fabricated from extruded aluminum sections and

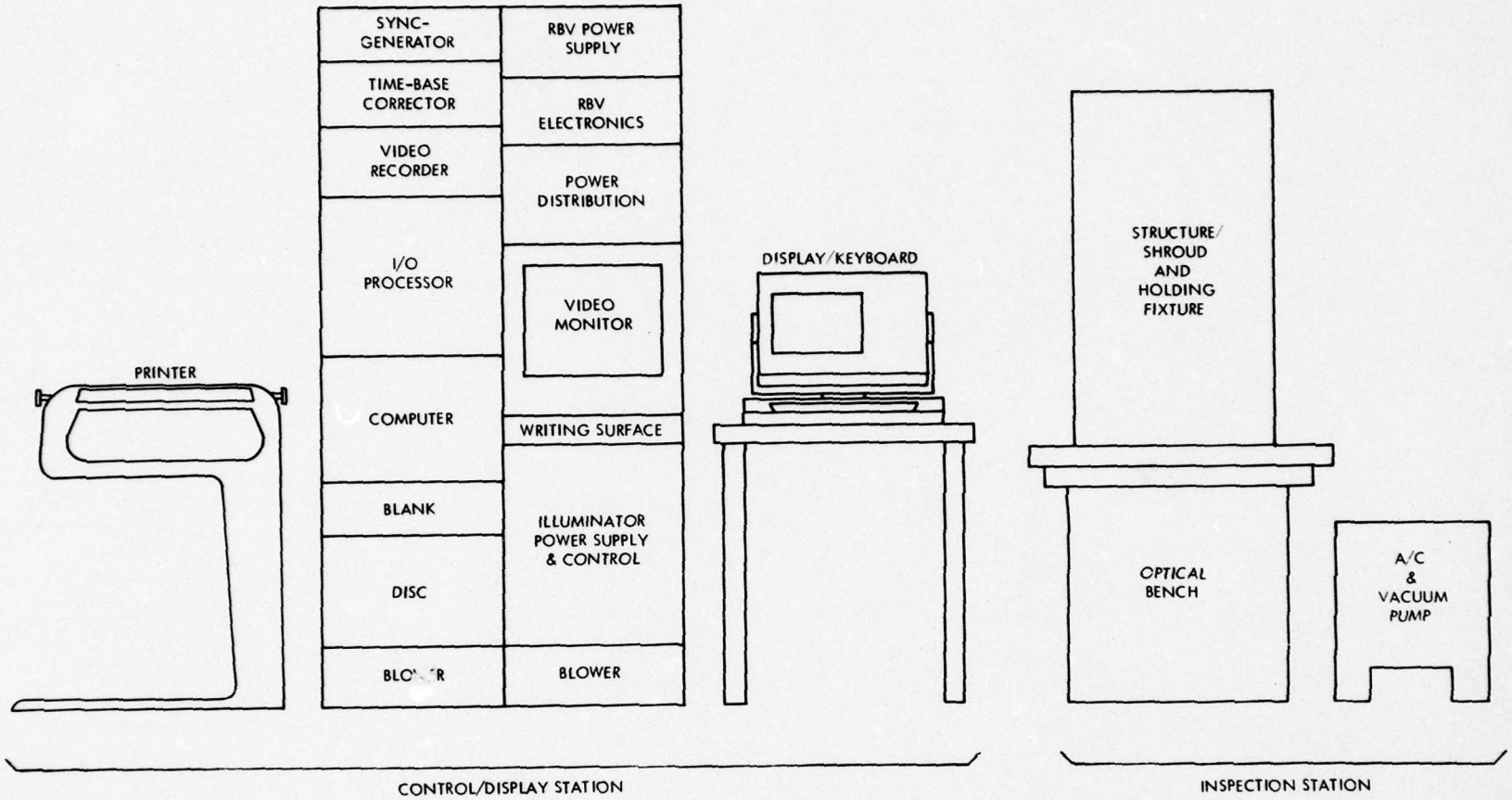


Figure 1-9. AIME Demonstration Configuration

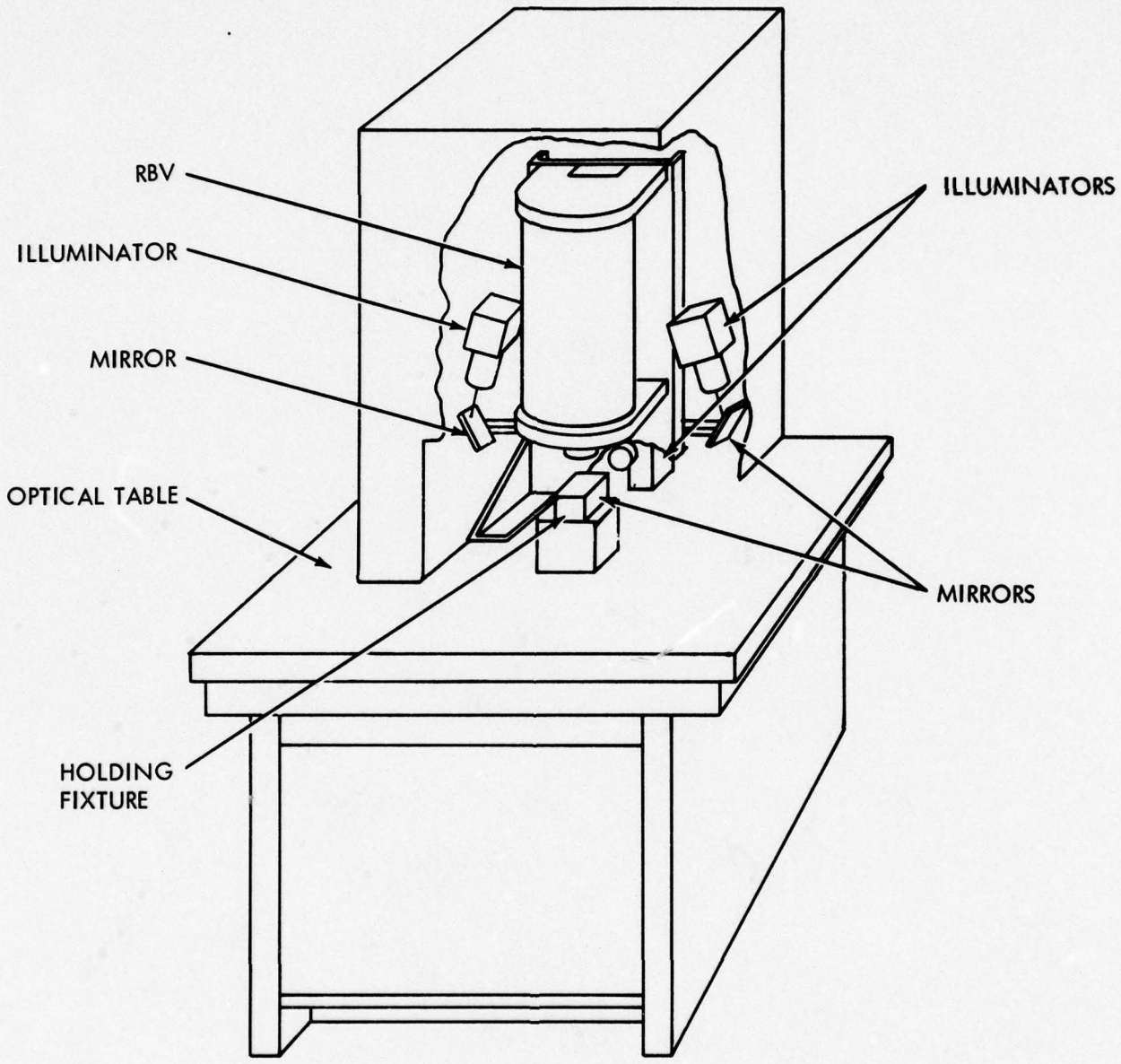


Figure 1-10. Inspection Station

covered with sheet metal. A 3' x 4' honeycomb optical table is used as the working surface or base for the RBV and shroud.

Cooling air for the RBV and illuminators is provided by the air conditioner unit. To reduce vibrations, the air conditioning unit is located remote from the inspection station and its output is ducted through flexible hoses. The small vacuum pump is mounted on top of the air conditioning unit and provides a 25 liter per minute vacuum for the holding fixture.

The holding fixture provides four degrees of freedom, a vacuum holding capability, and precise three point locating pins as shown in Figure 1-11. Three translation stages are used to produce x, y, and z positioning. Angular positioning is obtained by fastening the orthogonally mounted translation stages on a plate, which is attached to the angular, θ, adjustment stage. A thumb screw is provided to secure this adjustment. Three guide pins provide a repeatable reference on the stainless steel reference plate. The reference plate is located on the mirror holder assembly. This assembly houses the mirror which is used for back-illumination. There is also a cut-out section in the reference plate. This cut-out is large enough to implement the back-illumination as well as accepting a special holding unit for smaller than 2" x 2" hybrid or substrate assemblies.

The optical table is fabricated from a very strong, light weight, all metal honeycomb structure with a precision ground stainless steel top surface. An array of 1/4-20 tapped holes on two inch centers allows the stable mounting of bolted accessories.

Three illuminators are mounted inside the shroud and on the structure. Two of the illuminators are mounted to the left and right of the RBV assembly. The third illuminator is mounted behind the RBV.

The light from the illuminators will be projected on the UUT via three mirrors. By this method, there will be two illuminators for illuminating the top of the UUT and the remaining illuminator will be used for back-illumination.

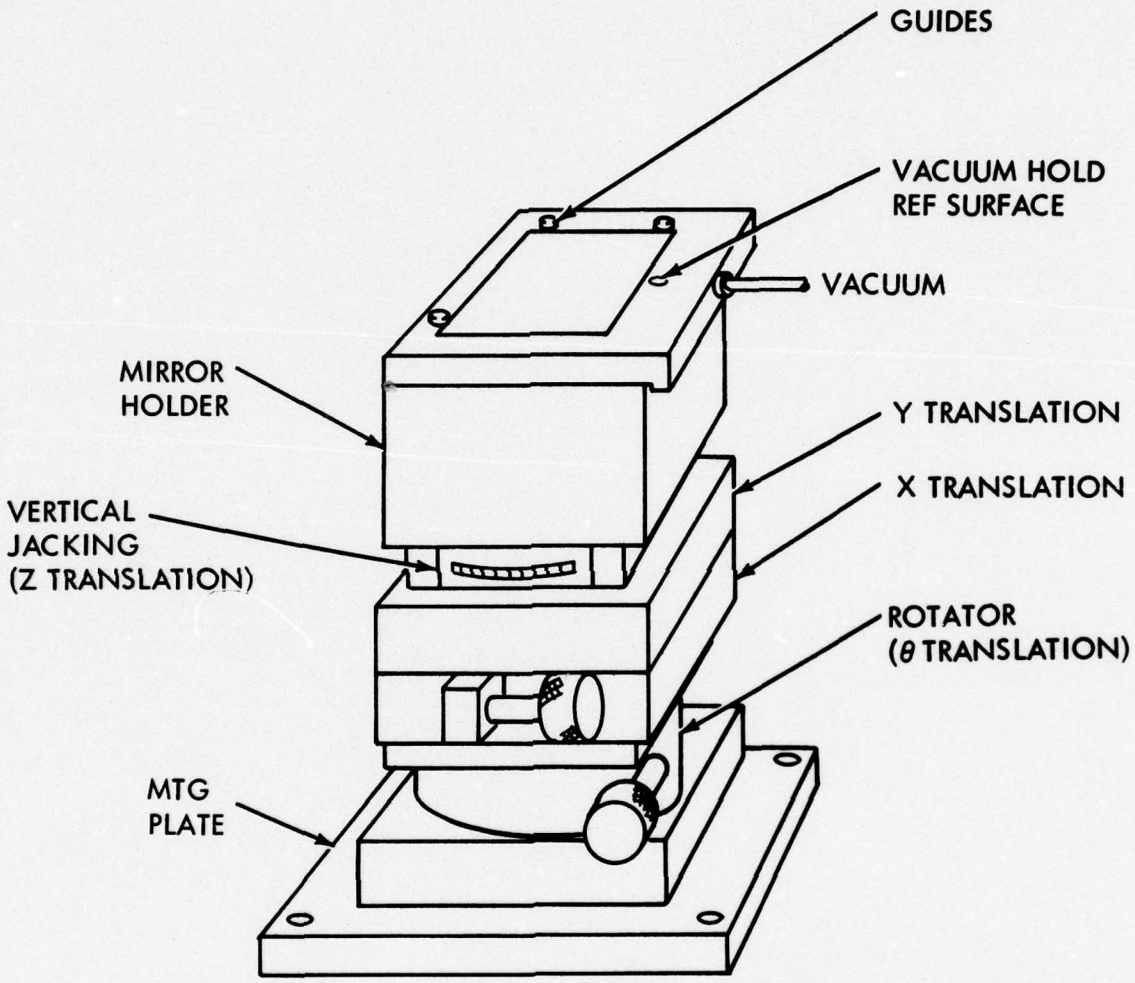


Figure 1-11. Holding Fixture

SECTION 2
CONCLUSIONS

2.1 PROGRAM PROGRESS

2.1.1 GFE Status

The AIDE system was provided as GFE to the AIME program. Many of the AIDE components have been used to fabricate the AIME system. This section will report the status of the AIDE components utilized in AIME.

- Power Control Chassis: The front panel was removed from the chassis and a replacement was fabricated. The new panel implements additional power control circuit-breakers.
- Isolation Power Transformer: The transformer will be used as it was in AIDE, to isolate the RBV electronics and the Processor electronics from the rest of the system.
- Air Conditioner: It will be used to cool the RBV camera as well as the illuminators. A connector will be added for the vacuum pump power.
- RBV Chassis: This component has been modified considerably. Nothing from the AIDE system has been retained unmodified. In particular the 8-bit DAC's were replaced by stable, precision, 12-bit units. The sync generator board was replaced by a rack mountable unit.
- RBV Camera: This component was removed from the AIDE Inspection Station and modified as required for the additional AIME requirements of zoom and beam steering.

- Processor Chassis: This component has also been modified considerably. The digital I/O basket and the chassis connectors have been completely rewired. The front panel connector has been removed. The analog processor basket has been removed along with its resident boards and is being stored.
- Cables: The Control Station power cable will be utilized unmodified. Wires will be added to the air conditioner power cable for the vacuum pump. The RBV Electronics-to-Video Processor control cable will be modified changing one of the connectors and adding wires. The AIDE Inspection Station RBV Camera harness will be used in the AIME Inspection station. Portions of the AIDE Control Station power wiring will be used.

2.1.2 Hardware Design

During the second quarter most of the hardware design has taken place. The AIME system is comprised of two major elements: The Control/Display station and the Inspection station. Further, the Control/Display station consists of a video subsystem and a control subsystem. The Inspection Station was mainly a mechanical design which was completed during the first quarter. The layout was completed during the first quarter. Also included in the Inspection Station are the RBV camera and the illuminators. These designs are reported as part of the Control station.

2.1.2.1 Control/Display Station

RBV Electronics and Camera

All designs have been completed. This includes converting from the AIDE scan rates to the 525 line/30 frame per second/2:1 interlace scan. Originally it was planned to use the sync generator outputs from the time-base connector (TBC). However, during the design phase it was found not possible to use these and have the TBC perform its function. A sync generator was purchased which provides the horizontal and vertical drive signals required by the RBV sweep circuits.

The RBV electrode control circuits have been modified to implement the zoom and the beam positioning requirements of the AIME system. Another HV power supply has been added to supply a separate source to one of the RBV control grids. Also associated with the zoom circuits is a low-voltage programmable power supply used to control the zoom.

As a result of the illumination study, reported in the First Quarterly Report, decoding from the zoom control circuits is used to control the amount of illumination.

A study of the registration requirements of the AIME system (this study is being completed and will be reported in the Third Quarterly Report) revealed that the positioning DACONs must have better short term stability than the units in the AIDE system. Two Phoenix Data 12 bit DACONs were selected to replace the AIDE units.

Video Processor

The video processor analog circuits have been fabricated. The video disc recorder and time-base corrector are the Arvin/Echo, VDR-1RA, and the Digital Video Systems, DPS-1 respectively.

Computer Interface

The computer interface design is complete. The general I/O control circuitry consists of the same circuit board complement as that used on AIDE. However, the boards have been reconfigured.

A video processor logic board has been designed to implement the high-speed DMA transfers required to input the video data into the computer memory.

Included in the I/O control is a board resident within the computer. Special circuits have been designed and wired on this board.

Illumination

The illuminators (three total) are located in the Inspection Station and the power supplies (one for each illuminator) are in the Control Station. The power supplies have been modified to provide remote programming and sensing.

Power Control Panel

The AIDE power control panel has been modified for the AIME power requirements.

Cables

A power-wiring/cable diagram for the Control Station has been completed. This diagram depicts all the power cables for the internal wiring of the Control Station.

2.1.2.2 Inspection Station

The mechanical design is complete and is being fabricated. All the major purchased items have been delivered.

A concept review of the AIME Inspection Station was conducted during January on the mechanical aspects. Improvements were suggested in the following areas:

(1) Cooling of the illuminators will be accomplished by the air conditioning unit instead of the fans provided with the illuminators. This is intended to reduce vibrations.

(2) Folding of the illumination path will reduce the overall size of the Inspection Station.

(3) Additional reinforcing was recommended for the RBV camera mount.

2.1.3 Software Design

The software effort during this quarter was on the design, coding and partial validation of the control program. The manual mode provides the capability for selecting one of four zoom ratios, front or back illumination, RBV XY position, video recorder, play-record control, and test generation.

The video image is divided into sectors (1 X 1 for zooms of 1 and 1.67, 4 X 4 for zoom of 3.6, and 7 X 7 for zoom of 10). Through the keyboard controls, the operator can easily attain the sector desired. Keys are also provided as a means for the operator to record and/or play back an image to/from the video recorder. The test generation control provides the means for an operator to automatically generate a UUT test program.

2.1.4 Hybrids

The layout of the hybrid substrate test patterns has been started. These patterns will include printed lines which are oriented 45° with respect to the substrate edges.

SECTION 3

PROGRAM FOR THE NEXT INTERVAL

3.1 HARDWARE

During the next interval, fabrication and integration of the AIME System hardware components will take place. The goal is for a completely operational system by the last week of June. At this time both LOCAL and CPU control Modes will be operational. Further, performance evaluation of the RBV camera system will have begun.

3.2 HYBRID SAMPLES

Design, layout, fabrication, and delivery of the hybrid sample substrates will take place. Delivery of the substrates is scheduled for the last week of June. Delivery of the pre-capped hybrids took place during the first quarter.

3.3 SOFTWARE

The design and coding of the Image Analysis Program will take place during April and May. This task is scheduled for completion the end of May. Included in this task is the mask generation for the "quick look" substrate inspection.

Validation of the Control Program will take place concurrently with hardware integration during May and June. This is part of the goal to have the AIME System standing by the last week of June.

SECTION 4

PUBLICATION AND REPORTS

4.1 PUBLICATIONS

Four (4) reports were prepared and submitted during this period.

Report	Contract Reference	Date	Author
Monthly Status Report No. 3	CLIN 0004/C001	6 January 1978	J. M. Laskey
Monthly Status Report No. 4	CLIN 0004/C001	16 February 1978	J. M. Laskey
Monthly Status Report No. 5	CLIN 0004/C001	6 March 1978	J. M. Laskey
Final Quarterly Report	CLIN 0004/C001	23 March 1978	R. J. Wildenberger L. Arlan

4.2 CONFERENCES

On 31 January 1978 an AIME Preliminary Design Review was held at RCA, Burlington, Massachusetts with Mr. J. Kelly and Mr. I. H. Pratt, ECOM and RCA personnel in attendance.

- AIME Program Overview
- Control/Display Station
- System Software
- Inspection Station
- Substrate/Hybrid Defect Analysis
- RBV Demonstrations

SECTION 5

KEY PERSONNEL

5.1 ASSIGNMENT

Key personnel from management, engineering and manufacturing, who contributed to the AIME program during this period are listed in Table 5-1. Each individual was selected because of the proven skills and background he brings to this program. Paragraph 5.2 provides biographical information on each assigned individual whose resume was not included in the prior Quarterly Reports.

5.2 RESUMES OF KEY PERSONNEL

E. C. LEA, Senior Member, Circuit Design

Mr. Lea received his BSEE degree from the University of Kentucky in 1959 and MSEE degree from the University of Pennsylvania in 1968.

Upon graduation, Mr. Lea joined the RCA Communications Systems Division where his responsibilities were logic design and power circuit design for the Autoden and Minuteman systems.

In 1964 Mr. Lea joined the Advanced Technology Laboratories where he was responsible for the design of video processing circuits for magnetic tape video recorders. A significant design was the electronics for the first miniaturized video recorder for the Apollo space program. Later he designed the circuits for a brushless dc motor and a 400,000 rpm air turbine.

Recently he has been responsible for the complete electronics design for several Gallium Arsenide laser illuminator systems. The circuits included both logic and pulse drivers for the solid state laser diodes. Other recent tasks have included responsibility for the circuit design of laser scanners, laser rangefinders and an aircraft cockpit display.

Mr. Lea has taught several RCA after hours courses, including Feedback Theory and System Design, and Practical Transistor Course.

Mr. Lea is a member of Eta Kappa Nu and RESA.

Table 5-1. Key Management, Engineering and Manufacturing Personnel

Name	Title	AIME Program Primary Function	AIME Man-Hours During Period
J. M. Laskey	Manager, Project Management	AIME Program Manager	121
R. J. Wildenberger	Manager, AT&MS Engineering	AIME Program Design Manager	43
L. Arlan	Manager, Engineering Design	TV System Design	69
J. J. Klein	Manager, Engineering Design	TV System Design	-
K. E. Ghostlaw	Manager, Project Design	Mechanical Design	24
R. B. Mark	Senior Engineering Scientist	Optical/Mechanical System Design	374
M. J. Cantella	Senior Engineering Scientist	Electro/Optical System Design	125
P. F. Minghella	Senior Project Member	Mechanical Design	464
M. W. Stewich	Senior Project Member	RBV System Design	338
B. T. Joyce	Senior Engineering Scientist	Manufacturing Hybrid Design and Fabrication	63
T. J. Dudziak	Member	Electrical Design	485
E. W. Ketler	Senior Project Member	Electrical Design	3
M. F. Krayewsky	Member	Software Design	443
E. C. Lea	Senior Member	Electro/Optical System Design	389

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US Army Missile Command
Attn: DRSMI-RGP (Mr. Victor Ruwe)
Redstone Arsenal, AL 35805
1

Commander
Harry Diamond Laboratories
Attn: Mr. Horst Gerlach (DRXDO-RAA)
2800 Powder Mill Road
Adelphia, MD 20783
1

Director
Electronic Components Laboratory
Attn: DRSEL-TL-IC
Fort Monmouth, NJ 07703
2

Commander
Naval Electronics Laboratory Center
Attn: Library
San Diego, CA 92152
1

Commander
Department of the Navy, Elex 05143A
Attn: A.H. Young
Electronics System Command
Washington, DC 20360
1

Chief
Naval Ship Systems Command
Department of the Navy
Attn: Code 681A2b, Mr. L. Gumina
Room 3329
Washington, DC
1

Commander
US Naval Air Development Center
Attn: Library
Johnsville, Warminster, PA 18974
2

Commander
Naval Ocean Systems Command
Attn: Mr. Richard Gamble
San Diego, CA 92152
1

Commander
Air Research & Development Command
Attn: RDTCT
Andrews Air Force Base
Washington, DC
1

Commander
Rome Air Development Center
Griffiss Air Force Base
Attn: (EMERR) Mr. L. Gubbins
Rome, NY 13440
1

Commander
Air Force Materials Laboratory
Attn: MATE (Ms. E. Torrance)
Electronic Branch
Wright-Patterson Air Force Base
Dayton, Ohio 45433
1

Commander
Rome Air Development Center
Griffiss Air Force Base
Attn: (EMERR) Mr. Regis C. Hilow
Rome, NY 13440
1

Philco Ford
Attn: Mr. D. Heiden
Landsdale, PA
1

AFAL (AVTA)
Electronic Technology Division
Attn: Mr. Robert D. Larson, Chief
Advanced Electronics Devices Branch
Wright-Patterson Air Force Base
Dayton, Ohio 45433
1

NASA Scientific & Tech
Information Facility
PO Box 8757
Baltimore/Washington Int'l Airport
2

National Aeronautics & Space
Administration
George C. Marshall Space
Flight Center
Attn: R-QUAL-FP
(Mr. Leon C. Hamiter)
Huntsville, AL 35812
1

NSSA-Manned Space Craft Center
Reliability and Flight Safety
Division
Attn: Library
Houston, TX
1

Alpha Industries, Inc.
20 Sylvan Road
Woburn, MA 08101
1

AVANTEK
Attn: Mr. Thielan
3001 Copper Road
Santa Clara, CA 95051
1

Amelco Semiconductor
PO Box 1030
Mountain View, CA 94042
1

Bell Laboratories
Whippany Road
Attn: Tech Reports Center
WH5E-227
Whippany, NJ 07981
1

General Instrument Corp.
Semiconductor Products Group
600 West John Street
Hicksville, Long Island, NY 11802 — 1

Hughes Aircraft Corporation
Attn: Dr. Bruce Crammer
3100 West Alimita Boulevard
Torrance, CA 90509 — 1

Hughes Aircraft Corporation
Attn: Mr. D. Hartman
Bldg. 100 MSA788
PO Box 90515
Los Angeles, CA 90009 — 1

Hughes Aircraft Company
Microelectronics Laboratory
500 Superior Avenue
Newport Beach, CA 92663 — 1

Honeywell Inc.
Semiconductor Products
2747 Fourth Avenue
Minneapolis, MN 55408 — 1

Honeywell Inc.
Hybrid Microelectronics
Components Dept.
Attn: Dr. R.G. Oswald
13350 US19
St. Petersburg, FL 33733 — 1

Harris Semiconductor
PO Box 883
Melbourne, FL 32901 — 1

IBM
Components Division
Attn: Mr. Al Kran
East Fishkill, Rt. 52
Hopewell Junction, NY 12533 — 1

KSC Semiconductor Corp.
Attn: Mr. S. Cudletz, President
KSC Way (Katrina Road)
Chelmsford, MA 01824 — 1

Arthur D. Little
Acorn Park
Attn: Dr. H. Rudenburg 15/206
Cambridge, MA 02140 — 1

Motorola, Inc.
Attn: Mr. J. LaRue
5005 East McDowell Road
Phoenix, AZ 85008 — 1

Dr. Robert H. Rediker
Massachusetts Institute of
Technology
Building 13-3050
Cambridge, MA 02139 — 1

Microwave Associates
Attn: Dr. F. Brand
Burlington, MA 01803 — 1

Rockwell International
Collins Radio Group
Attn: Dr. Cheng Wen
MS 406-246
Dallas, TX 75207 — 1

Northrop Corporation Laboratories
Attn: Library 320-61
3401 West Broadway
Hawthorne, CA 90250 — 1

Rockwell International
Corporation Science Center
Thousand Oaks, CA — 1

Ratheon Company
Semiconductor Operation
Attn: Mr. S. Weinsner
350 Ellis Street
Mountain View, CA 94040 — 1

Raytheon Company
Attn: Dr. S.F. Paik
130 Second Avenue
Waltham, MA 02154 — 1

Sanders Associates, Inc. 1
Attn: Microwave Department
95 Canal Street
Nashua, NH 03060

TRW Semiconductor Inc. 1
Attn: Mr. B. Lindgren
14520 Aviation Blvd.
Lawndale, CA 90260

Texas Instruments 1
Attn: Technical Reports Service
PO Box 5936, MS 105
Dallas, TX 75222