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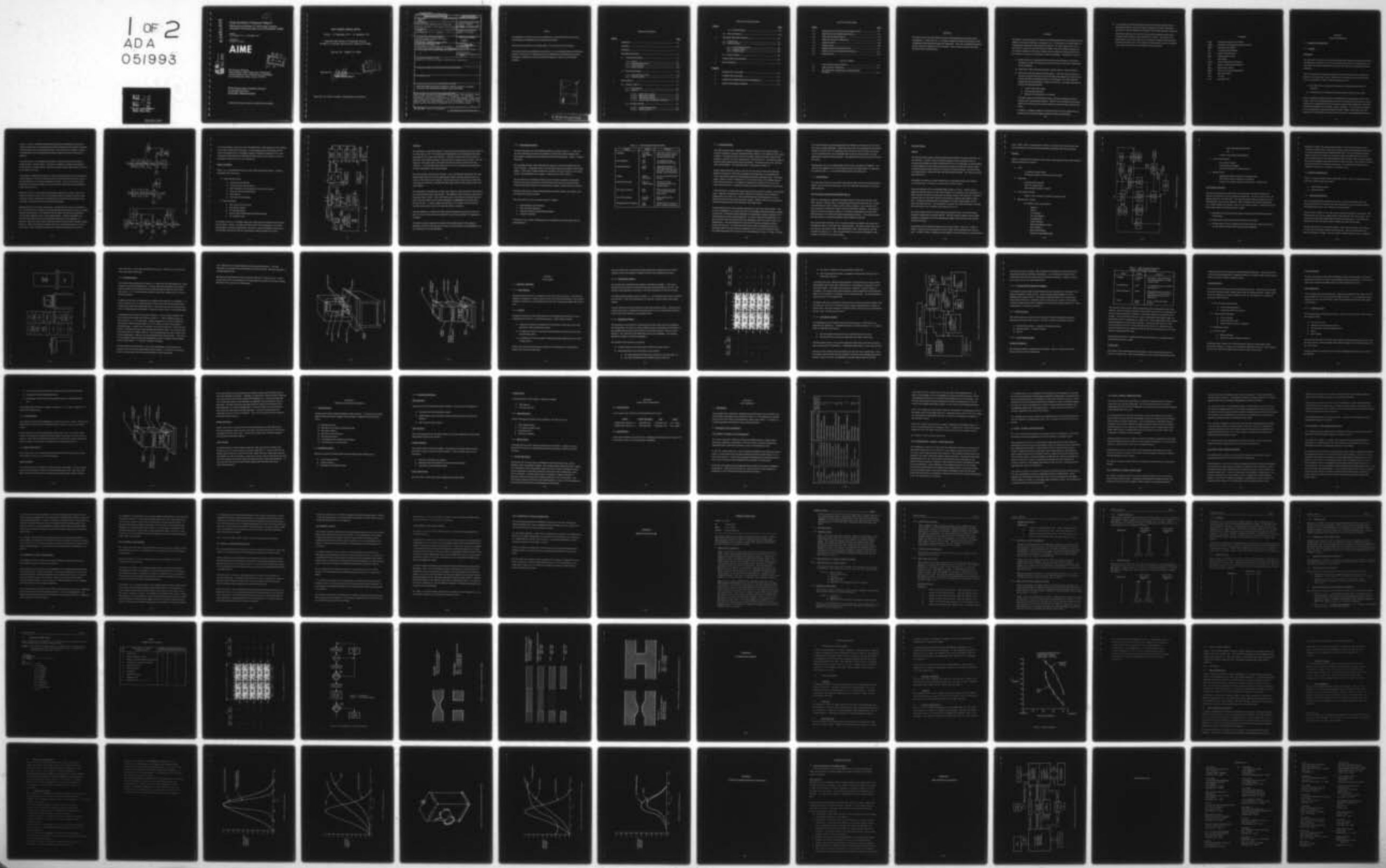

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First Quarterly Progress Report

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

PERIOD:
22 SEPTEMBER 1977 - 31 DECEMBER 1977

CONTRACT:
DAAB07-77-C-0585

AIME

Production Division
Procurement and Production Directorate
United States Army Electronics Command
Fort Monmouth, New Jersey 07703

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Burlington, Massachusetts

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Approved by: J. M. Laskey

J. M. Laskey
AIME Program Manager

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This report covers the work performed on the AIME equipment task during the period 22 September - 31 December. 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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ABSTRACT

This report covers the work performed on the AIME equipment task during the period 22 September - 31 December 1977. 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 Method 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 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
LDLS	Lasar Differential Line Scanner
MAP	Memory Allocation and Protection
RBV	Return Beam Vidicon
RDOS	Real-Time Disc Operating System
SOS	Silicon On Saphire
TVL	TV Line
UUT	Unit Under Test

SECTION 1

SYSTEM DESCRIPTION

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% 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% 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 among 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.

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 bands to the substrate metalization. As previously mentioned, this is a 100% 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.

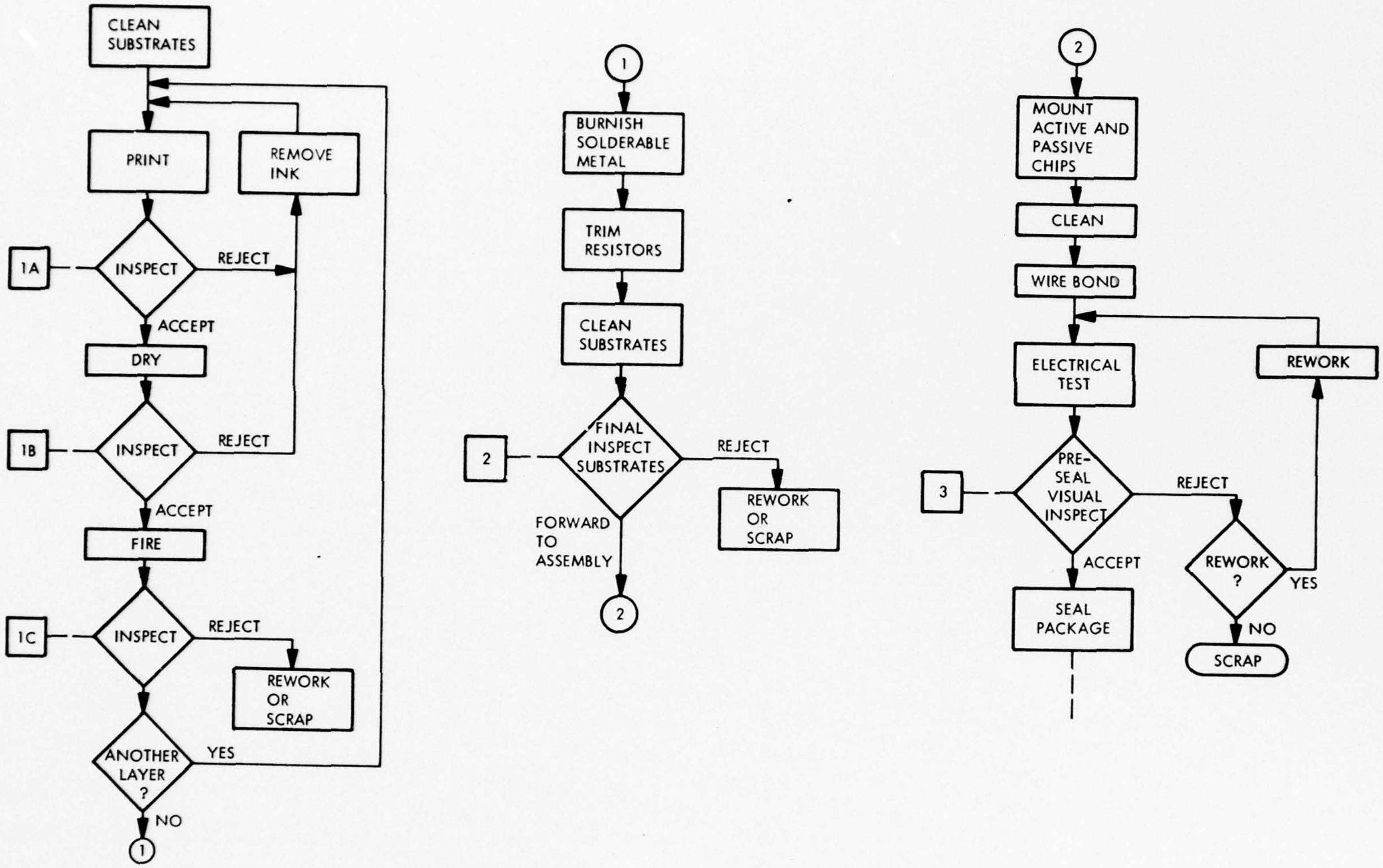


Figure 1-1. Manufacturing Process Flow with Inspection Points

At process inspection point 3 (pre-cap visual inspection) a 100% 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 and Time-Base Corrector
- Video-Disc Recorder/Reproducer
- Video Monitor
- Illumination Power Supplies

(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).

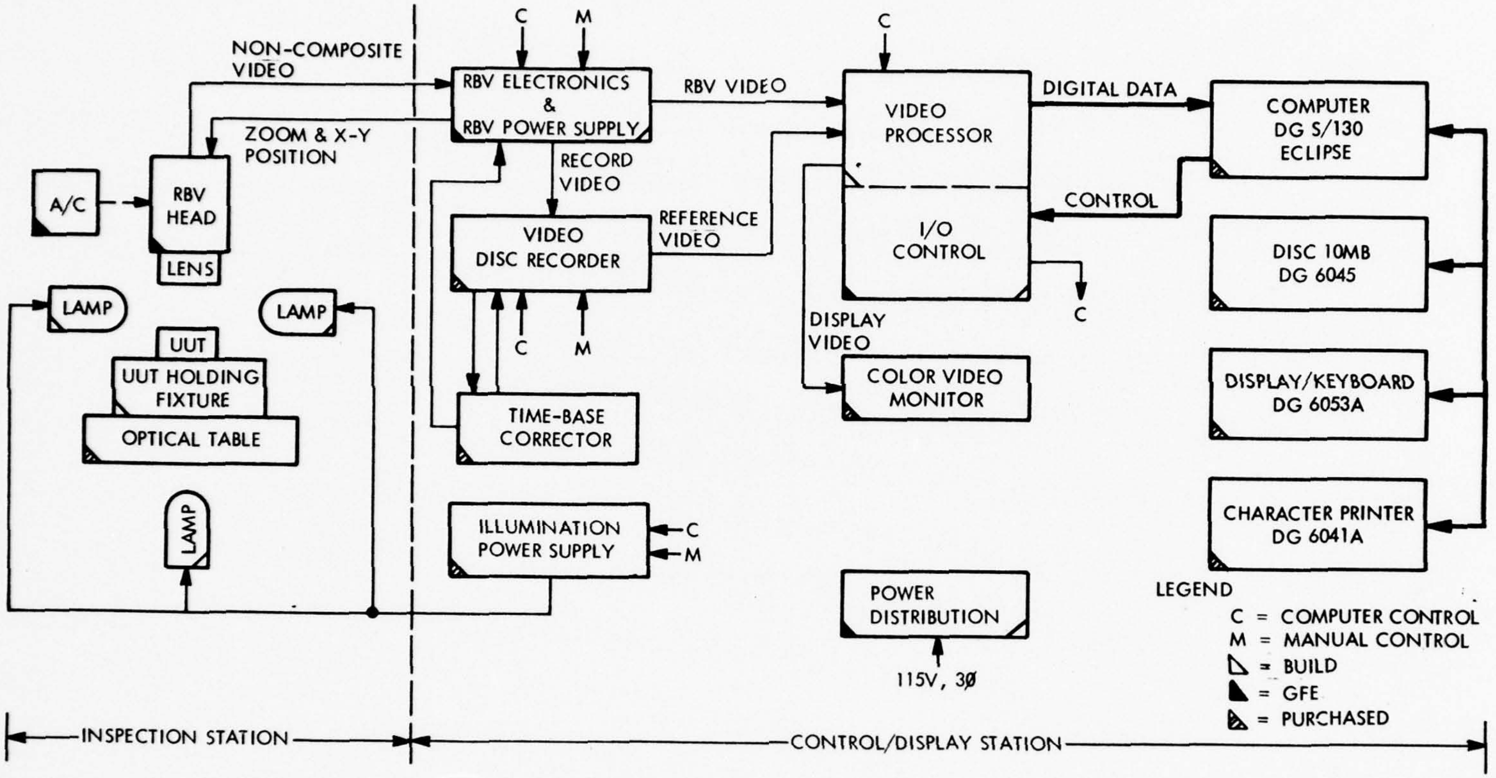


Figure 1-2. AIME Demonstration Model - Block Diagram

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 1-1. 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 contains 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, 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 (LOCAL Control) with controls located on the front panels of the RBV electronics chassis, the video processor chassis, and the video-disc recorder.

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

With CPU control four basic operating modes are possible:

- Manual Sequence and Evaluation
- Semi-Automatic Inspection
- Automatic Inspection (Demonstration System)
- Program Generation.

All aspects of each of these operating modes are controlled via operator inputs from the display/keyboard.

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, removable 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	EFS-1A ARVIN-ECHO	400 frame storage, variable frame step-rate, remote control
Time Base Corrector	5020 CVS	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

1.1.3 Inspection Station

The AIME project proposal contained a preliminary concept for the Inspection Station. 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 1-5.

Further analysis indicated, however, that the structure/shroud would have insufficient rigidity to maintain the 0.0005 inch orthogolity 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° 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° apart and the slightly defocused filament is imaged on the hybrid. Illumination angle established by the Illumination Analysis (Appendix 2) for both illuminators remains approximately 20°. 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 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. 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 AIDE air conditioner 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.

Modifications to the vacuum holding fixture will be made to facilitate back lighting. And, 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, same, 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.

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 disk 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. Use will be made of existing software modules from the AIDE System when applicable. The ARTS will operate under RDOS Rev 6.

The highest level software module will function as an interpreter which can be utilized in an on-line mode, or execute a previously generated test sequence.

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 typed on the terminal.

Structure

Figure 1-3 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
- Software driver modules
    - one module for each major function
        - DISPLAY
        - PRINT
        - XY POSITION
        - UUT ALIGNMENT
        - ILLUMINATION
        - ZOOM CONTROL
        - VIDEO RECORDER ACCESS
        - RBV CONTROL
        - IMAGE PROCESSING
        - PASS/FAIL DETERMINATION

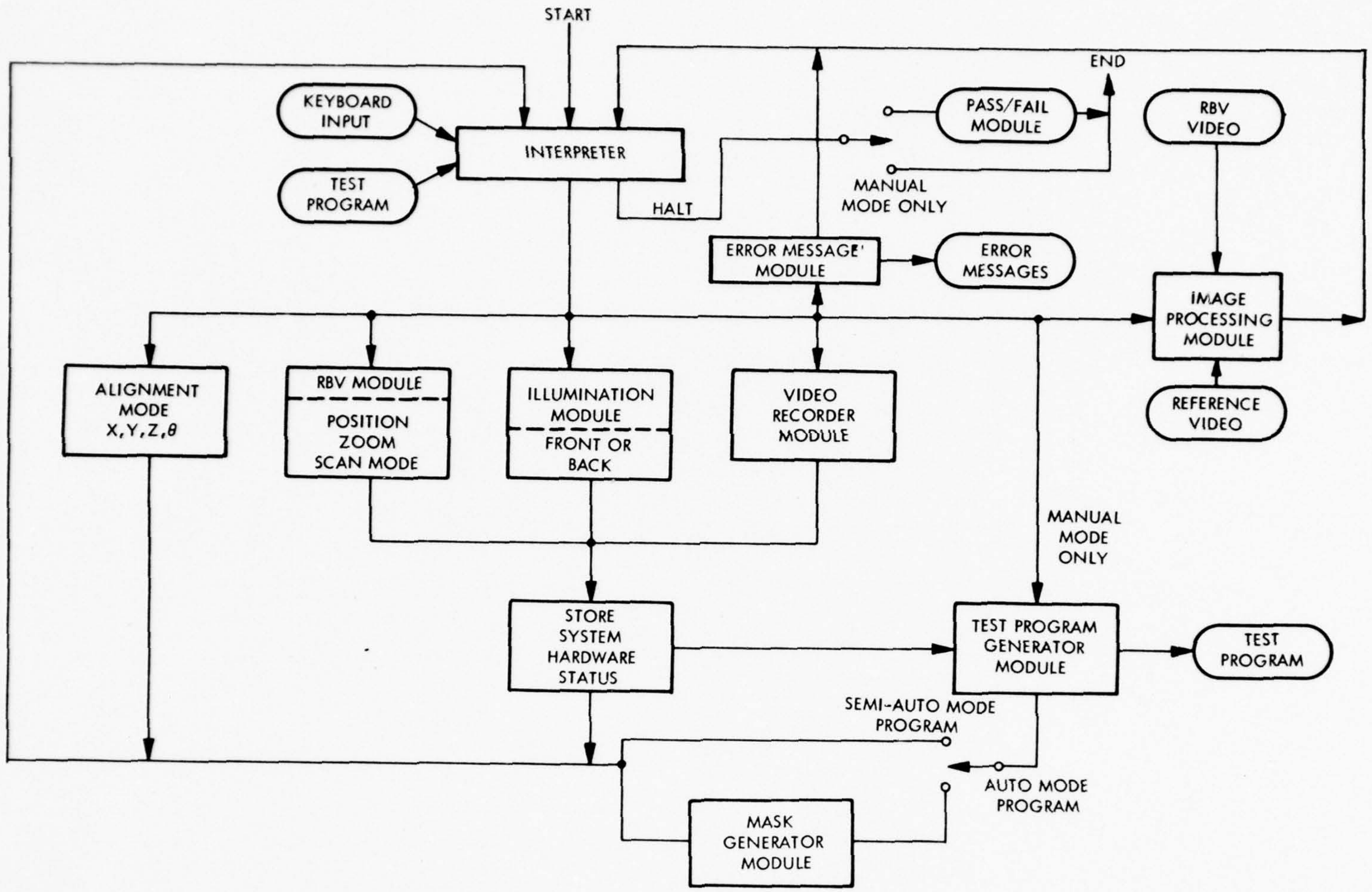


Figure 1-3. AIME Software Block Diagram

        - TEST PROGRAM GENERATION
        - ETC
    - 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 programs 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. When a suitable image is seen on the monitor (i.e., proper illumination, position, zoom, etc.) the operator pushes a '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) Indexing and storage of the image on the video disc-recorder,

(3) 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.

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.

1.2 PHYSICAL DESCRIPTION

Figure 1-4 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, 25-1/2" 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 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 and time-base corrector, as well as the I/O-Interface/Video Processor chassis. Both racks contain their own blower assemblies for cooling. The racks will be connected together to form a single unit.

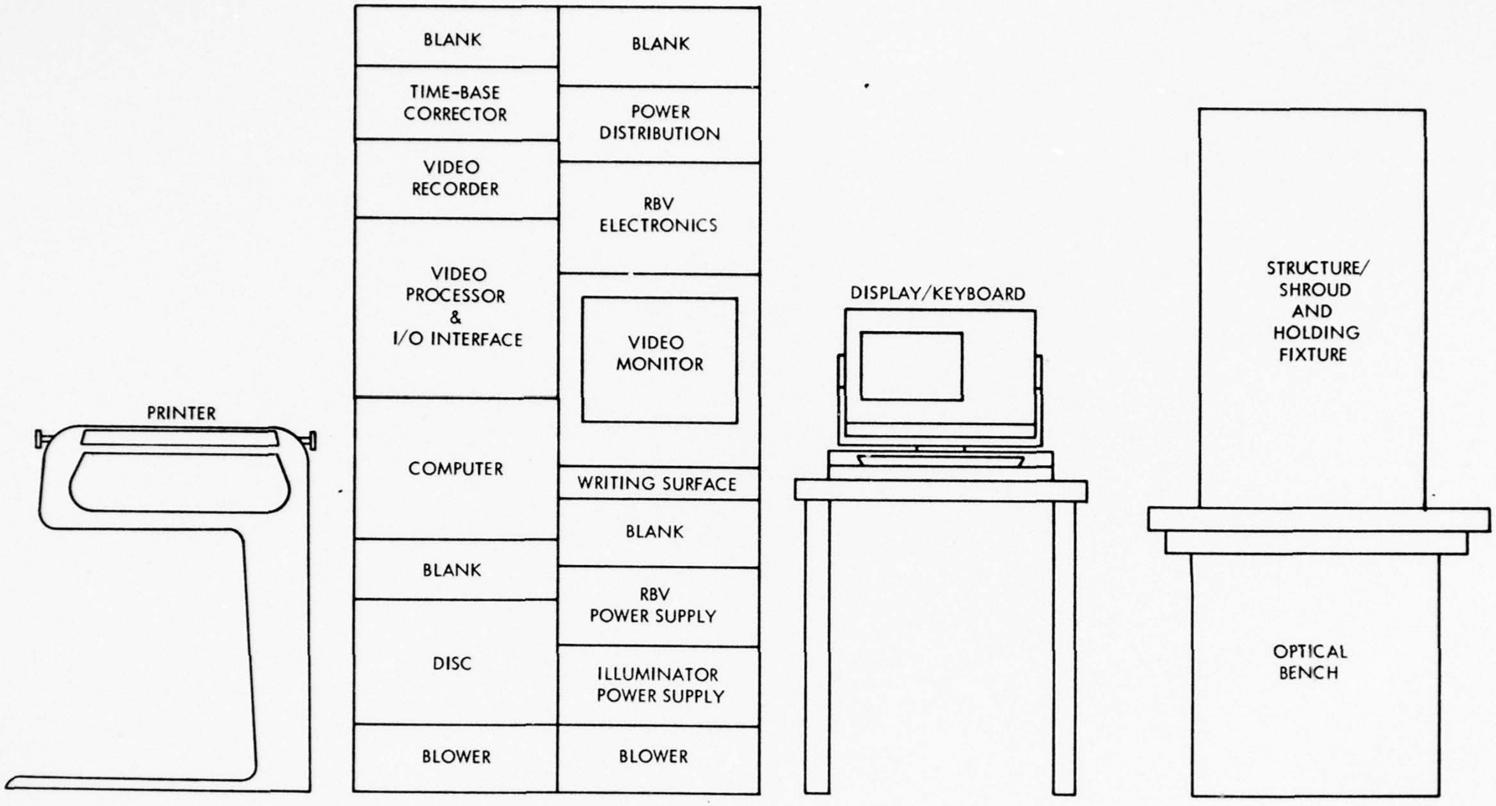


Figure 1-4. AIME Demonstration Configuration

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 1-5, 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 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 AIDE GFE air conditioner. 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 1-6. 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.

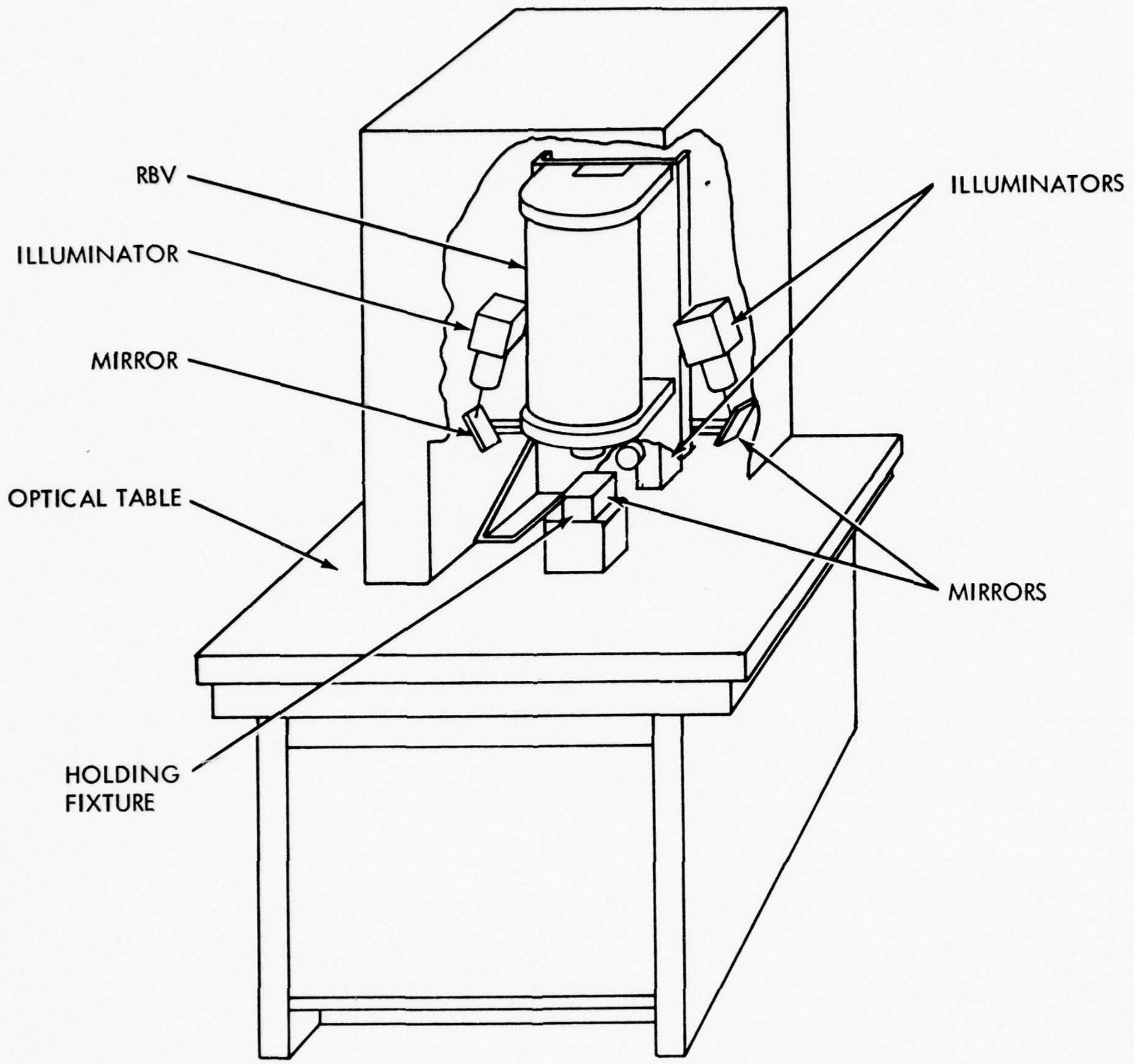


Figure 1-5. Inspection Station

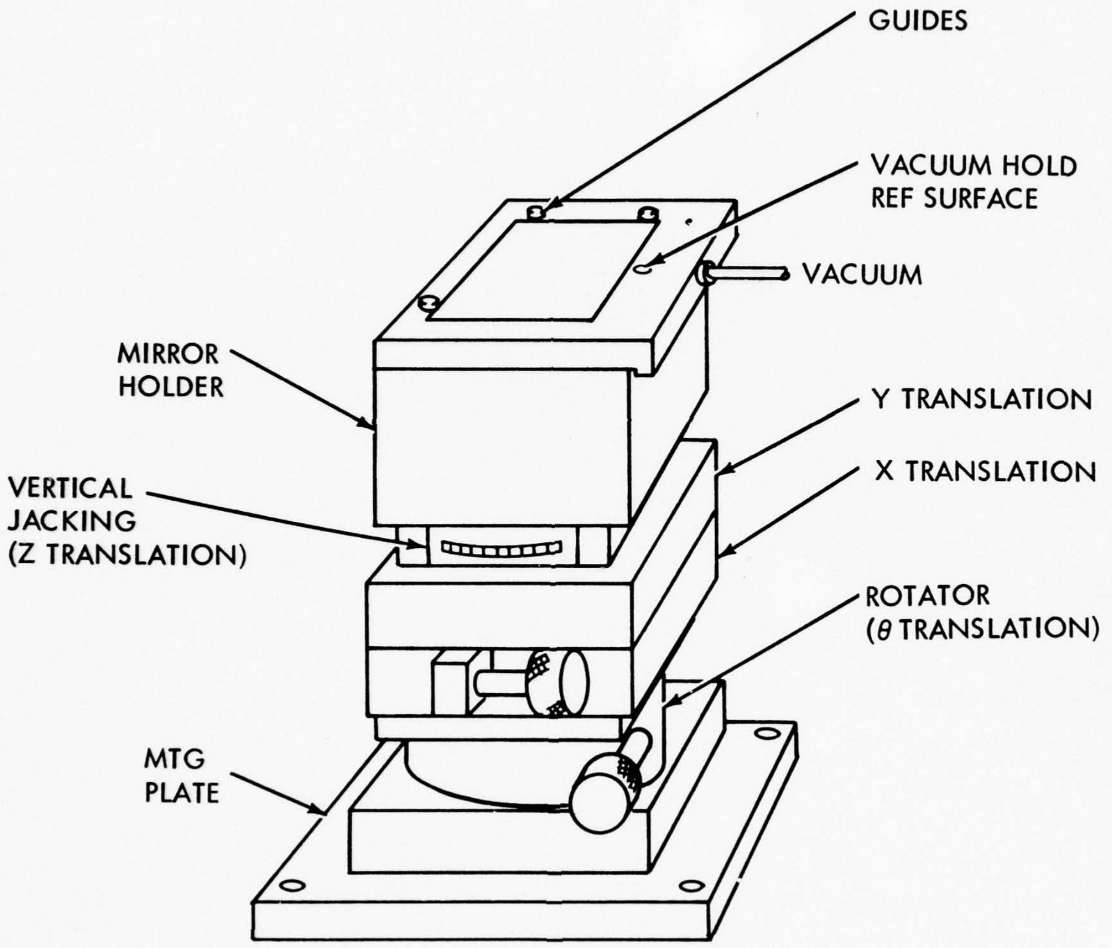


Figure 1-6. Holding Fixture

SECTION 2

CONCLUSIONS

2.1 PROGRAM PROGRESS

2.1.1 GFE Inspection

During the month of November an inspection of the AIDE system took place. All AIDE components were identified. Further, the RBV camera and associated electronics were powered. Satisfactory performance was demonstrated by observing a detail image with the RBV camera chain.

2.1.2 Analyses

During the first quarter of the AIME program several analyses were performed to aid in establishing the baseline for a demonstration system. These analyses include:

(1) A hybrid fault analysis to establish the characteristics of the faults to be investigated by the AIME demonstration system.

(2) An illumination analysis to determine the illumination requirements for the AIME demonstration system.

(3) An investigation into other possible inspection techniques using other than an RBV scanning system.

Finally, the AIME demonstration system baseline was established and a detailed block diagram of the system was generated.

This part of the AIME First Quarterly Report presents the conclusions of each of these analyses as well as providing the original narratives in the Appendix of this report.

2.1.2.1 Hybrid Fault Analysis

The complete text of the hybrid fault analysis is provided in Appendix 1. This report discusses each of the faults to be generated and the controlling methods to be used. The method of fault generation is discussed as well as the distribution of each class of fault.

The AIME substrate pattern is shown in Figure 2-1. One substrate pattern will be generated for each fault. Faults will be generated by two methods: printing screens and manually induced.

Cracks in substrates will not be generated on the AIME substrate pattern. Substrates with cracks from the RCA, Burlington hybrid facility will be used to investigate the detection of cracks in the manual hybrid pre-cap inspection mode.

2.1.2.2 Illumination Analysis

The illumination requirements for the demonstration AIME system have been established. The requirements were based on a study of different types of illumination and the effects on the resulting contrast between gold conductor lines and film resistors, and the ceramic substrate. The positioning of the illumination sources was established. The complete Illumination Analysis is included in Appendix 2.

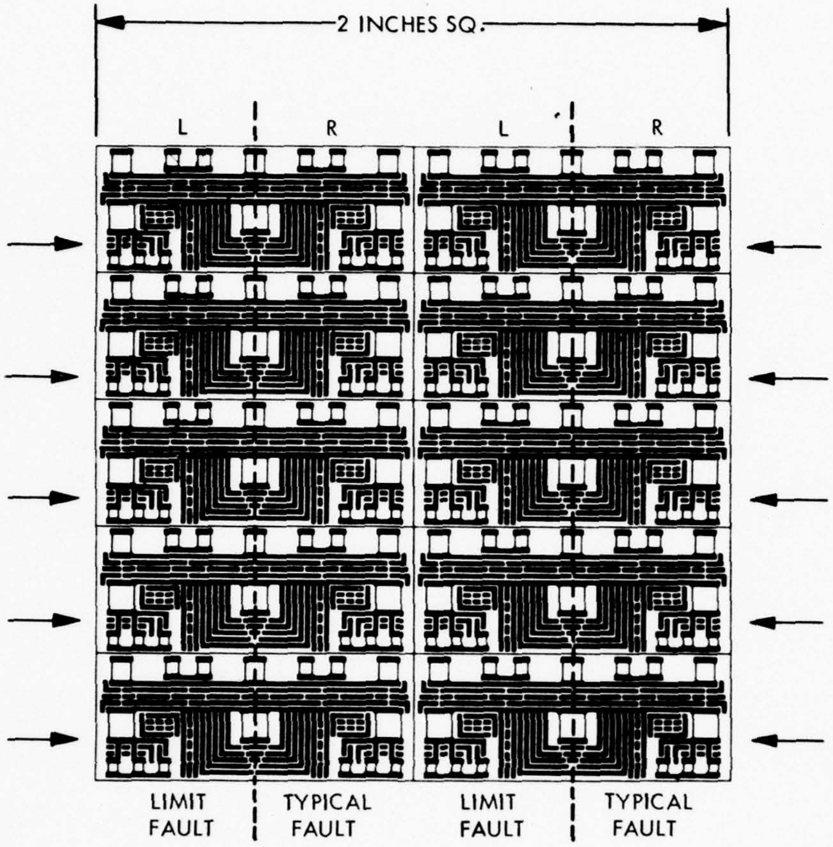
The conclusion of the analysis is as follows:

(1) A Quartz-Halogen (color temperature of 3000° K) has been selected

(2) Three illumination source units will be used as follows:

- Two units positioned to illuminate the conductor or top side of the UUT
- One unit to illuminate the non-conductor or back of the UUT

PATTERN NO.	LINE WIDTH (Mils)	LINE SPACING (Mils)
1*	4	4
2*	4	6
3*	5	4
4*	5	5
5	8	5



PATTERN NO.	LINE WIDTH (Mils)	LINE SPACING (Mils)
6	8	8
7	10	5
8	10	10
9*	4 & 6	4
10*	4 & 6	6

* FINE LINE PATTERNS

Figure 2-1. Multiple-Image Demonstration Pattern

(3) The angle of incidence of the top illuminators will be 20°

(4) The lamp housing will provide a mounting for spectral filters if necessary to obtain better contrast.

It should be noted that, although a back illuminator is being provided, its usage could be constrained by the fact that some substrates have a gold-platinum metalization over the entire back surface. The pattern over the back is, typically, a series of squares or rectangles. This pattern along with the substrate, greatly attenuate the total transmitted light as well as introduce a "modulation" on the transmitted light. The back illuminator is being provided as an investigative tool.

In addition to the above conclusions, the report also compares the spectral response of the RBV (the same RBV used on the AIDE program) with the standard photopic response for human vision. Both these responses correspond closely, such that it can be concluded that the RBV "sees" what the human eye sees.

2.1.2.3 AIME System Baseline

In establishing the AIME baseline of the demonstration system, a block diagram was generated (see Appendix 4). A simplified diagram is provided in Figure 2-2. Two signal paths are illustrated in this figure:

- The video signals from the RBV camera and the video disc recorder
- The horizontal and vertical sync signal lines and system control lines

The block diagram shows a local control panel with control lines to the RBV electronics, video processor and I/O electronics. A centralized control panel, as such, does not exist.

The Local Control Panel is shown to illustrate the use of the Local Control Mode. When the system is placed in this mode the computer is removed as the controlling element and instead, a series of controls are substituted to provide manual control of the AIME

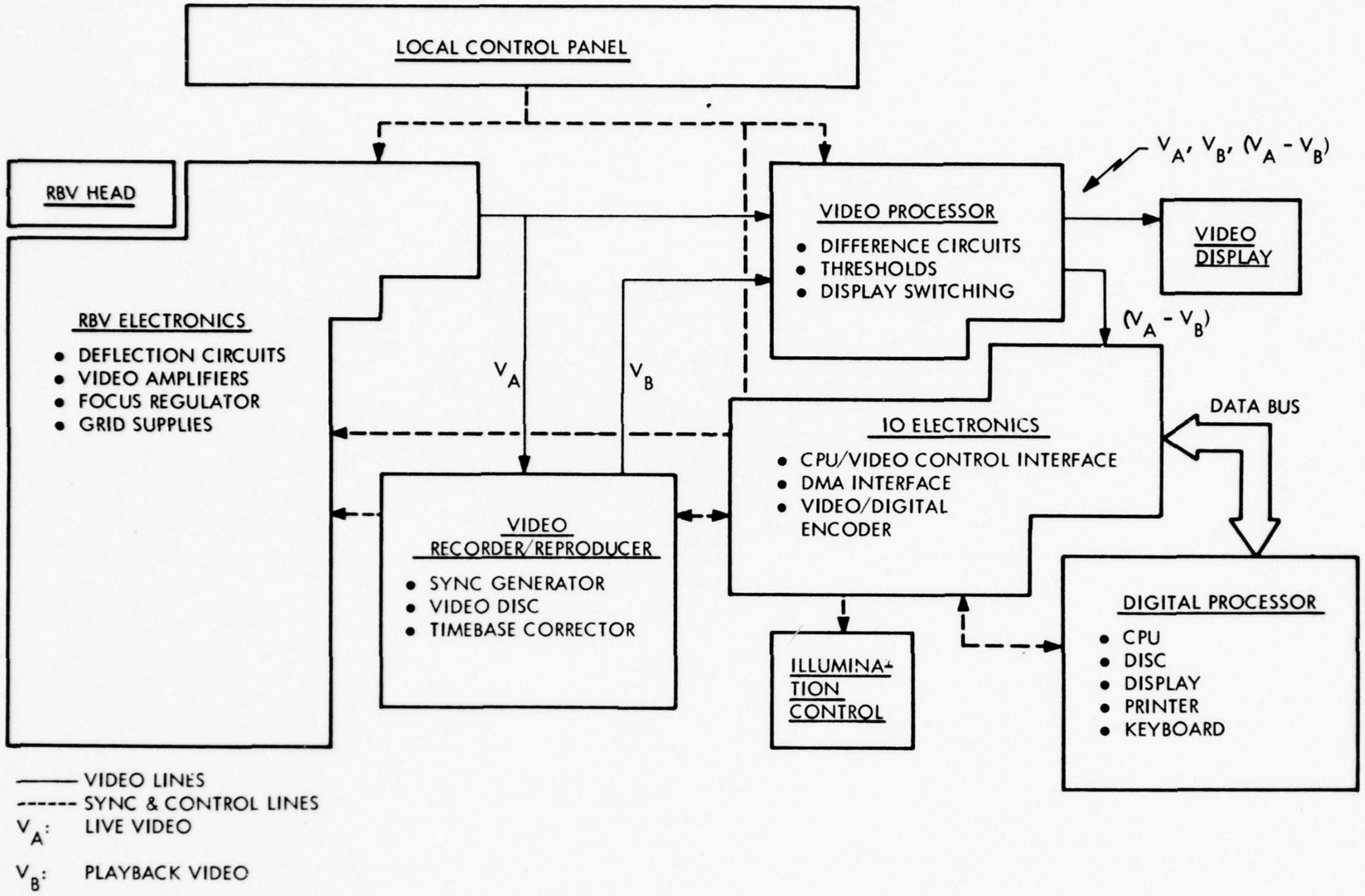


Figure 2-2. AIME Demonstration System Simplified Block Diagram

demonstration system elements. This control mode is intended to be used during system integration and periodic calibration/maintenance. Local controls are provided on the front panels of the RBV electronics and video processor assemblies. Further, the video disc recorder has its own front panel controls.

2.1.2.4 Alternate Hybrid Inspection Techniques

An investigation into possible alternate hybrid inspection techniques was undertaken and is included in Appendix 3 of this report. The one possible method suggested is a lasar differential line scanner (LDLS). This method is presently being used to inspect transparent objects which have a repetitive matrix of patterns (such as masks or SOS wafers). A reflective light system could be configured, but several disadvantages would exist. These disadvantages are contained in the report.

2.1.3 Hardware Design

This section reports on progress with the design of the AIME demonstration hardware, during the first quarter of the contract. The areas reported on include the following:

(1) Control/Display Station - electrical and mechanical design
(2) Inspection Station - mechanical design
(3) Software

2.1.3.1 Control/Display Station

Computer/Peripherals

The computer/peripheral configuration was finalized. Table 2-1 contains the selected devices and some of their main features.

Table 2-1. AIME Computer/Peripherals
Vendor: Data General Corporation

Device	Model	Features
Computer	ECLIPSE S/130	64K words, memory allocation and protection (MAP), 700 nsec memory cycle
Disc Subsystem	6045	10 megabyte storage, removable disc-pack unit
Display/Keyboard	6053A	Detachable keyboard, 96 ASCII character set, 5 x 7 dot matrix, 1920 character storage, user-defined keys
Printer	Dasher 6041A	60 cps, 40 character buffer memory

The computer selected for the AIME demonstration system is different from that in the proposal. The two computers considered were the Data General Nova 3/D (proposed) and the Data General Eclipse S/130 (selected). The Eclipse computer was selected for two reasons. First, the Eclipse S/130 has a class of instructions which enable simpler and faster BYTE and BIT manipulations of a digital word. These manipulations will be required by the algorithms used in the image processing. Second, the S/130 also has a faster memory cycle time (700 nsec versus 1000 nsec for the NOVA 3/D). The faster cycle time will minimize the time required to manipulate the data file (256K bits or 16K words) needed to represent the RBV image.

The peripherals selected are standard Data General units which are compatible with the selected run-time system, RDOS.

Control Panel

The proposed AIME demonstration system included a control panel used to operate the system in a manual mode. This was eliminated in favor of a stored utility program which would execute operator commands via the display/keyboard interface. This approach will eliminate the design/integration of additional hardware to implement AIME control functions, which are already available as software drivers.

Computer Interface

The computer interface design was started during this quarter. This interface will provide the primary link between the computer and the other test system elements. Digital control words are outputted to the system element to be set up. The following are examples of the type of control required:

(1) RBV and associated electronics
    - Beam centering and focus
    - Target and control grid voltages

(2) Video Recorder/Reproducer
    - Frame selection
    - Record/playback modes
    - Monitor selector (camera or playback)

(3) Illumination Control

(4) Video Processor
    - Display selection
    - High-speed memory transfer controller

In addition to these controls, the I/O electronics has circuitry to input digitized video data into the computer core memory via a high speed DMA (Direct Memory Access) channel. The data rate of the DMA channel will be in excess of 750K words/second.

Power Distribution

The power distribution for the AIME demonstration system has been started. The power distribution encompasses both the Control/Display and Inspection Stations. The AIDE power panel will be modified and implemented in the AIME demonstration system.

Rack Configuration

The rack configuration has been finalized. Instead of reworking the AIDE system rack and buying another rack, two new racks will be bought and wired. A cost tradeoff showed this approach to be the most cost effective, while also preserving the bulk of the AIDE system Control Station.

2.1.3.2 Inspection Station

The Inspection Station design has been started. There are five major items which comprise the Inspection Station:

- RBV camera mount
- Mounting for the illumination sources
- UUT (substrate and hybrid) holding fixture
- Shroud
- Optical Bench

The layouts for these items have been started and 60% of all the optical and mechanical items have been ordered. These include the optical bench, holding-fixture translation stages, and the vacuum pump.

Particular attention is being paid to several aspects influencing the final layout. These are the following:

(1) The orthogonality of the RBV camera mount with respect to the optical table

(2) The placement of the illumination sources

(3) Establishing a holding-fixture concept which results in a simple but flexible unit.

The holding-fixture will allow four degrees of freedom: X, Y, Z and θ. Figure 2-3 is a sketch of the holding fixture.

2.1.4 Software Design

This quarter has been spent on defining the overall system software concept. The Run-Time system software modules have been defined to obtain a minimal, modular, and efficient system.

Software design was limited to the initializer module of the ARTS. The function of this module is to open the data channels to the video display, line printer, keyboard, and UUT program. This module also displays the AIME format on the video terminal, attaches the system interrupts, and provides a real-time task for control of the keyboard.

2.2 OTHER CONCLUSIONS

Several other tasks were completed during the first quarter of the AIME program which will contribute to the success of the AIME program.

Image Processing

Two methods of image processing are envisioned for the AIME system. The first method involves a detailed analysis of the UUT, determining the type of fault. This is the same type of image processing which was envisioned in the original AIME Program Proposal.

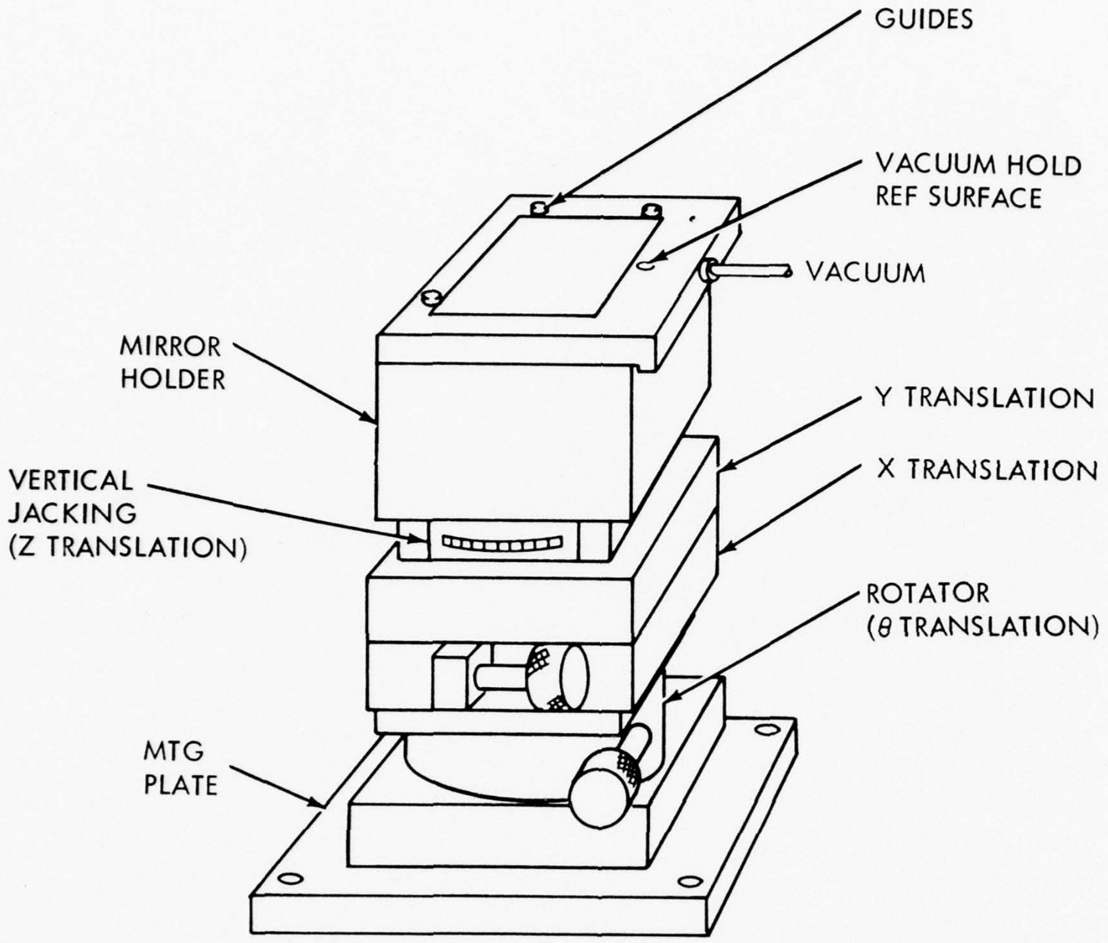


Figure 2-3. Holding Fixture

The second method of image processing is an attempt to speed up the evaluation process and is thus called the "quick look". Basically, the "quick look" analysis involves comparing a previously stored mask with the digitized RBV difference data. The mask is generated from a known good substrate and represents an acceptable or normal tolerance range for that image. The video image data, generated by the test system of the substrate (UUT) under inspection, is compared with this mask. If the UUT is good, all the incoming data will be ignored by the image processing algorithm. If any of the incoming data falls outside the mask area, the UUT is defective. The UUT may be taken aside for analysis by the detailed image processor.

System Cycle Time

System Cycle Time was analyzed for the various operating modes of the AIME system. Data processing time, video-recorder access time, and RBV operation time are the major components of the total time cycle. This cycle time study will be completed during the second quarter of the AIME program.

Video Recorder

An investigation into available standard video-disc units was made and resulted in the selection of a 525 TVL unit made by Arvin-Echo, model EFS-1A. Because of the critical timing required between the video-disc recorder and the RBV video output when comparing video signals on a line-by-line basis, a time-base corrector must be used with the video-disc recorder to stablize the recorder output with respect to some common timing element. As such, the time-base corrector will be used to generate the horizontal and vertical synchronization signals.

SECTION 3

PROGRAM FOR THE NEXT INTERVAL

3.1 DESIGN REVIEW

A design review will be conducted during the month of January. At that time the complete AIME Demonstration System baseline will be presented. Included in this presentation will be:

1. The physical layout
2. Definition of the control and operating modes
3. The system software
4. The electro-optical elements
5. The inspection station
6. A presentation of the substrate fault analysis
7. A demonstration of an RBV system.

3.2 HARDWARE DESIGN

During the next quarter designs will have been completed in the following areas:

- Control/Display Station
- Inspection Station
- Substrates with "Standard" Faults

3.2.1 Control/Display Station

RBV Electronics

All designs of the RBV electronics will be completed. The major areas of design are:

- Horizontal and vertical deflection circuits
- Implementation of the time-base corrector as the horizontal and vertical sync generator
- RBV electrode control circuits

Video Processor

The major design efforts for the video processor are the video difference circuits and the video-monitor input selector circuits.

Computer Interface

The computer interface will be completed. This interface involves the digital circuitry between the computer and the test system elements. There are three major areas of this design:

- General I/O computer data transfers
- High-speed DMA (Direct Memory Access) input data transfers
- Video Disc recorder interface design.

Power Control Panel

The AIDE Power Control Panel will be modified for the AIME system.

Purchase Items

All long lead items will be ordered. These items include:

- Video Monitor
- Video Disc Recorder

3.2.2 Inspection Station

Design of the Inspection Station will be completed. The major items are:

- RBV Holding-Fixture
- UUT Sample Holding-Fixture
- Structure/Shroud
- Illuminator Mounting

3.2.3 Hybrid Samples

The design and layout of the substrate samples will be completed. Appendix 1 contains the Hybrid Fault Analysis, which illustrates the substrate patterns and the faults to be simulated.

3.3 SOFTWARE DESIGN

Next quarter, the run-time system, excluding the image processing module, will be designed, coded, and partially validated. The run-time system contains the driver modules for controlling the AIME demonstration system hardware as well as providing the overall control and sequence of operations required to perform the AIME demonstration system modes of operation. Included in these modes of operation is a special sequence of operations, which will result in the automatic generation of a UUT test program. The Test Program Generator will allow a test-station operator to create a UUT test-program by simple interactive operations on the Display/Keyboard interface.

SECTION 4
PUBLICATION AND REPORTS

4.1 PUBLICATIONS

Two (2) reports were prepared and submitted during this period.

Report	Contract Reference	Date	Author
Monthly Status Report No. 1	CLIN 0004/C001	1 November 1977	J.M. Laskey
Monthly Status Report No. 2	CLIN 0004/C001	8 December 1977	J.M. Laskey

4.2 CONFERENCES

A Post-Award Conference was held at RCA, Burlington, Massachusetts on 25 October 1977 with ECOM, DCASMA, and RCA personnel in attendance.

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.

5.2 RESUMES OF KEY PERSONNEL

J.M. LASKEY - Manager, Project Management

Mr. Laskey received his BS degree in Electrical Engineering from Carnegie-Mellon University, Pittsburgh, Pennsylvania in 1955 and a Master of Science in Engineering Management from Northeastern University, Boston, Massachusetts in 1968.

In 1955, Mr. Laskey joined RCA, and was initially responsible for the design and development of a variety of electronic test systems utilized for depot and field test of U.S. Air Force radar systems. Automatic test equipment technology matured during this period, and he was part of the team that established RCA's present ATE product line.

In 1962 this ATE organization was transferred from Camden, New Jersey to Burlington, Massachusetts. Between 1962 and 1965, Mr. Laskey served as Project Engineer at Burlington, for the USAMICOM Automatic Missile Test System.

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	140
R. J. Wildenberger	Manager, AT&MS Engineering	AIME Program Design Manager	114
L. Arlan	Manager, Engineering Design	TV System Design	59
J. J. Klein	Manager, Engineering Design	TV System Design	27
K. E. Ghostlaw	Manager, Project Design	Mechanical Design	8
R. B. Mark	Senior Engineering Scientist	Optical/Mechanical System Design	281
M. J. Cantella	Senior Engineering Scientist	Electro/Optical System Design	44
P. F. Minghella	Senior Project Member	Mechanical Design	216
M. W. Stewich	Senior Project Member	RBV System Design	3
B. T. Joyce	Senior Engineering Scientist	Manufacturing Hybrid Design and Fabrication	12
T. J. Dudziak	Member	Electrical Design	292
E. W. Ketler	Senior Project Member	Electrical Design	125
M. F. Krayewsky	Member	Software Design	34

From 1965 to 1971 Mr. Laskey had a major role in the LCSS management team. As Senior Project Engineer, he was responsible for the initial production program, and the establishment and operation of a world-wide field support team for LCSS systems. Key elements of this program involved production and world-wide deployment of LCSS, the Army's first automatic field support system, to meet critical missile deployment dates.

In 1971, Mr. Laskey was a key member of the team responsible for developing the EQUATE test system, the first third-generation ATE. During the period of 1972 to 1976, Mr. Laskey was responsible for managing the extension of automatic test technology into support of non-electronic systems.

In 1976, Mr. Laskey was the program manager responsible for development of the U.S. Army's ATE standard high-order language, OPAL. Currently, Mr. Laskey is the program manager for the ECOM MM&T Automatic In-Process Microcircuit Evaluation Program.

Mr. Laskey is a senior member of the IEEE.

R. J. WILDENBERGER - Manager, AT&MS Engineering

Mr. Wildenberger joined RCA in June 1959, and attended the University of Pennsylvania on the graduate study program. He worked as a junior engineer on Data Link Test sets for two years, and was then transferred to the Automatic Test Equipment Section where he was assigned to the design of high speed analog to digital converters. He assisted in the design and integration of AC, DC, and resistance measurements section of the Signal Corps Digital Evaluation Equipment, Automatic Programming and Test Set, and Ordinance Digital Evaluation Equipment. On the Multisystem Test Equipment program, he was assigned overall design responsibility for the analog measurements section. He was then assigned to the Lunar Module program with overall design responsibility for the Descent Engine Control Assembly Special Test Equipment, followed by overall hardware design responsibility for the LM Communications Test Station.

As a design leader, he was responsible for the design of the VHF Ranging Test Assembly for the LM Communications Ground Support Equipment, Developmental Test Equipment for the IGLOO WHITE program, the Reliability Test Set on the AN/TSW-93 program, and the development of special testing instrumentation techniques for Internal Combustion Engines. For four years he was responsible for AN/TSM-93 weapon systems test design for TOW and Shillelagh systems plus LCSS R&D programs. He has also served as the electrical manager responsible for the AEGIS ORTS system.

Mr. Wildenberger received his BSEE from Bucknell University in 1959 and his MSE (EE) from the University of Pennsylvania in 1966. He is a member of Tau Beta Pi and Pi Mu Epsilon.

L. ARLAN - Manager, Engineering Design

Mr. Arlan received his BEE degree from Clarkson College of Technology in 1954 and his MS degree in Electrical Engineering from Drexel Institute of Technology in 1961.

Since joining RCA in 1954, Mr. Arlan has been continuously involved in the design and development of television cameras and display systems for military and space applications. His assignments have included: missile-borne television, cooled IR vidicon camera systems, design of key sections of the Ranger lunar landing television, development of electro-optical test systems for IR guided missiles, design activity on the classified Red Flame II sensor system, and project engineer assignments on a number of low light level television cameras for passive or passive/active operation with CaAs illuminators. Further, in 1972 Mr. Arlan designed and delivered to the Air Force a special camera for high sensitivity, point source detection.

Mr. Arlan is a member of Tau Beta Pi, Eta Kappa Nu, RESA and he has received several RCA team and individual awards for outstanding technical accomplishments. He has published an article entitled "Infrared Fiber Optics" and has presented two IRIS papers, "The IR Vidicon as a Sensor for Long Range High Temperature Targets" and "Evaluation of a Vidicon Airborne Reconnaissance System".

J. J. KLEIN - Manager, Engineering Design

Mr. Klein received his BS and MS degrees in Electrical Engineering from Northeastern University in 1949 and 1955 respectively. He was assistant professor in Electrical Engineering from 1949 to 1956 at Northeastern University and has been lecturing continually in the Evening School since 1955.

Mr. Klein joined RCA in June 1956 and became a leader of an advanced circuit design group, which concentrated heavily in lightweight, solid-state, integrated and conventional type circuits for aerospace applications. Past assignments have included the design of multisensor scan-converter displays for high performance tactical aircraft, surveillance television systems, Laser Altimeter for Moon Mapping Camera, and the design of lightweight, highly reliable, and highly efficient power supplies for the Lunar Module radar, transponder, and attitude control equipments.

During the past few years, Mr. Klein has been project engineer responsible for the design and build of High Resolution Airborne TV Camera Systems utilizing the 4-1/2" Return Beam Vidicon as a sensor for two major Air Force funded programs.

During the past year, he has managed a group specializing in the design of Low Light Level TV Cameras, Precision E/O Trackers, Space Surveillance and Detection Systems, and High Resolution Camera Systems.

Mr. Klein is a member of the Tau Beta Pi, Eta Kappa Nu, and the Society for Information Display.

K. E. GHOSTLAW - Manager, Project Design

Mr. Ghostlaw joined RCA in 1965 as a senior mechanical engineer on the Land Combat Support System (LCSS) program. Engineering responsibilities included the design, documentation, and factory follow of shelter mounted automatic test equipments including electro-optics, power distribution, and UUT test accessories. Project responsibilities included interface with U. S. Army Missile Command for drawing acceptance, coordinating equipment sell off and monitoring implementation of technical directives.

Mr. Ghostlaw has been a Project Design Manager for ATE programs at RCA since 1973. His mechanical engineering efforts on ATE systems include design, follow and sell off of AN/TSM-93 LCSS, PDR AGE, EQUATE and NAFI (AN/USM-410 and AN/USM-407) hardware. Mr. Ghostlaw was responsible for the AN/USM-410 van installation, including design of equipment mountings and the environmental control system.

He is currently responsible for design of AEGIS ORTS ship mounted equipment including a test and monitor console, and data terminal. From 1958 to 1965, Mr. Ghostlaw was associated with Sylvania Electronic Systems where he had experience in production and design engineering activities. He was also assigned to configuration management for Minuteman ground electronics system.

Mr. Ghostlaw received his BSME degree from Tufts University in 1958 and has taken advanced mechanical engineering courses at Northeastern University.

R. B. MARK - Senior Engineering Scientist

Mr. Mark received a BS degree in Aeronautical Engineering and BSEE and an MS in Instrumentation from MIT in 1946, 1954 and 1960 respectively.

Since joining RCA in 1956, Mr. Mark has been engaged in dynamic analysis and simulation of interceptor fire control systems, synthesis of equations for ECM simulation, analysis of ballistic missile range determination from angle measurements, system design of an ultrasonic height sensor, a study of a short range missile guidance autopilot system, and analysis of instrumentation and computer errors in "strapped down" inertial guidance systems. He has been responsible for design of a redundant gyro and servo system for a spaceborne radar antenna, for a developmental inertial navigation system, and for gimballed camera stabilization systems for helicopter fire control, night surveillance, high resolution daylight surveillance, and classified applications.

On the ECHPA AN/UXD-1 program, he was responsible for analysis of the photometric and MTF performance of the system, including focal plane shutter, image motion, lens, focus, and aerodynamic effects, and for performance specification of the vibration isolation and image motion compensation subsystems.

He has published papers on keyed demodulators, a shipboard wave height sensor and an optical filter temperature controller.

M. J. CANTELLA - Senior Engineering Scientist

Mr. Cantella received his BSEE from the Rensselaer Polytechnic Institute in 1954 and his MSEE from the Massachusetts Institute of Technology in 1959.

At present, Mr. Cantella is a member of the Radiation Programs Management Office, responsible for developing new electro-optics systems for surveillance and real-time information acquisition, transmission, retrieval, and recording.

His experience since joining RCA in 1959, includes system analysis, technique development, and equipment design for various radar and electro-optical systems. He made major contributions to the conception and design of an Optical Surveillance Subsystem for use in the detection of space objects. He developed special modes of operating image tubes and was Project Engineer in RCA's development of an ultra high resolution return beam vidicon and storage tube. He was responsible for the development and feasibility demonstration of the first Laser Target Designation System. As the Advanced Sensors Group Leader, he applied imaging and laser devices to systems for high resolution reconnaissance, low light level viewing, optical surveillance, electro-optics counter-measures, target tracking, and weapon control.

From 1954 to 1957 he served with the U. S. Navy as Electronics Officer aboard aircraft carriers and was responsible for all on-board radar, communications, display, and aircraft landing control equipments. From 1957 to 1959 he was employed by MIT Lincoln Laboratory and worked on the MIT Research Staff. His experience here included the design of transistorized circuits for a high-speed digital computer, and the design and instrumentation of high vacuum apparatus for display, storage, level selector, high power, and television pick-up tubes.

Mr. Cantella is the author of several technical papers, has contributed to text books on electro-optics, has lectured at the University of Rhode Island and the University of Arizona, and is a member of Tau Beta Pi, Eta Kappa Nu, Sigma Xi, and the Society of Photo-Optical Instrumentation Engineers. He has made several patent disclosures and holds three U. S. patents.

P. R. MINGHELLA - Senior Project Member

Mr. Minghella received his BSME from Lowell Technological Institute in 1960 and has taken graduate courses at Northeastern University.

Since joining RCA in March 1965, his responsibilities have included the mechanical design of the Maverick electro-optical seeker head. This camera is unique in that it mates with fiber optics and lens, a deflection intensifier, photo multiplier and vidicon. He designed the off axis detector and mirror assembly. This unit is a precision, motor driven mechanism which positions a mirror, relative to a vidicon and detector array, repeatedly and with extreme accuracies within 0.000030 inch.

He was responsible for design of the LCSS optical alignment fixtures for the TOW, Shillelagh, Dragon and Lance electro-optical guidance systems. A major accomplishment was the design of the positioning table which provided motor driven angular offsets from a collimated source with four arc second accuracy.

Mr. Minghella was responsible for the mechanical design and development of the Automated Image Device Evaluator. Using a high resolution RBV camera, this electro-optical system measures a number of performance characteristics of image intensifier tubes. All focusing and positioning of optical components is done remotely or automatically inside a light tight, air suspension optical bench structure. He is presently responsible for the mechanical design of the AZ-EL head, a tripod mounted goniometer, for the U.S. Army. It consists of a laser rangefinder having the capability of measuring azimuth and elevation angles within one milliradian.

M.W. STEWICH - Senior Member

Mr. Stewich received his BS in Engineering Physics from the University of Maine in 1960. He joined RCA in that year, and participated in an investigation of missile infrared plume characteristics.

From 1961 to 1963, he served as maintenance officer and shop officer with an Army Ordnance forward support unit.

Since 1963, he has been active in applying imaging sensors and television techniques to special purpose detection, surveillance, and information handling systems. His experience includes the analytic and laboratory evaluation of imaging devices, the development of techniques for special imaging sensor functions, the system application of these techniques, and system performance evaluation and analysis.

In particular, he was associated with the Laser Target Designator System (LTDS) program from concept through the flight testing of experimental hardware. His contribution to Project Nightlife included electro-optical design, human factors measurements, and system analysis, integration, and test. On PAVEFIRE, he provided system analysis, design, and evaluation. He has participated in several study and measurements programs, including HAVEDAGGER, Advanced Sensors Support and the E/O Parametric Study in which he served as project engineer during the latter phases of the program. He has been involved in the application of ultra high resolution camera tubes to aerial reconnaissance, and the application of television equipment and techniques to non-digital information storage and retrieval on the Tactical Information Processing and Interpretation (TIPI) study program. Mr. Stewich has been active as a principal investigator in IR and D and company-sponsored programs, and has prepared several RCA technical reports on image tube analysis, evaluation, and applications. His recent work in this area has been with silicon pickup and silicon storage tube technology.

He is a member of RESA, Sigma Pi Sigma, and has one patent currently pending.

B.T. JOYCE - Senior Engineering Scientist

Mr. Joyce graduated from the University of Maine in 1948 with a BS degree in Engineering Physics. He received his MS from the Massachusetts Institute of Technology 1950.

Initial employment was with the Electronics Corporation of America where until 1955 he designed and developed specialized test equipment for infrared photoconductors and other photosensitive devices used in military systems. He also designed and developed aircraft fire and explosion detection and suppression equipment using lead-sulphide photoconductors as sensing elements.

Upon joining RCA in 1955, Mr. Joyce specialized in a transistor circuit design for a variety of applications. Appointed manager in 1959, he became responsible for supervising design and development activities on a series of government and RCA sponsored program involving computer equipment and automatic test systems.

Since January 1971, given responsibility for the engineering of thick-film, hybrid microelectronic circuits, he has been directly involved in the product design, process development, manufacture, and evaluation of hybrid microcircuits for the Navy AEGIS program, Army automatic test equipment programs, NASA space programs, and special company product development programs for hybrid microcircuits.

In 1976 he presented a paper at ECOM's Symposium on Hybrid Microelectronics, entitled "Trade-off Considerations in Contrasting Hybrid Applications", directly addressed toward six different hybrids used in Army equipment.

T. J. DUDZIAK - Member

Mr. Dudziak received his BSEE from Lowell Technological Institute in June 1973, and his MSEE in June 1976 from the University of Lowell. As an undergraduate, Mr. Dudziak designed pulse position demodulator circuits for the purposes of recovering electrocardiogram information from remote VHF transmitters. He was Chief Engineer of the Institution's FM Stereo Broadcast Facility, and participated in its original design and construction.

Mr. Dudziak joined RCA in June 1973 as an Associate Member of an Automatic test enginering group participating in research on engine exhaust gas analysis. He later was assigned to the ATE/ICE program where he participated in the redesign of signal conditioning hardware, specified and implemented programmable diagnostic unit improvements, and provided hardware support to the design and development of diagnostic software.

He was responsible for the design of a data-bus receiver/driver card on the AEGIS program. His responsibilities also included supporting the testing of an analog buffer hybrid.

As a member of a redesign team for the EQUATE, AN/USM-410, PIU (Programmable Interface Unit) he was responsible for the PIU Programming and Buffer assemblies. He also designed a high-speed Analog buffer and a hybrid assembly used for high impedance measurements.

Mr. Dudziak has designed several diagnostic test programs utilizing the ATLAS programming language on the AN/USM-410. These programs supported the TACFIRE system and the AN/ARN-89A Automatic Direction Finder.

Mr. Dudziak is a member of the IEEE. He holds a first-class radio-telephone license, and has an Engineer-in-Training (EIT) certification.

E.W. KETLER - Senior Project Member

Mr. Ketler received his BSEE and MSEE degrees in 1965 and 1966 respectively from Cornell University.

He joined RCA in 1966 and was assigned to the circuit design group on the LCSS program. Subsequently, he was assigned to the Lunar Module Program where he conducted several studies on stabilization and control of the LM radar. From 1967 to 1969, he was engaged in Low Light Level Television (LLLTV) design which included the design of the Project Red Flame TV electronics, and systems studies on Image Motion Stabilization for LLLTV. In 1969, he joined the TRIM program where he developed video circuits, synchronization electronics, and other TV circuits. Mr. Ketler was also responsible for TRIM factory follow and qualification testing.

In 1971 Mr. Ketler transferred to the Automatic Testing and Monitoring System group at Burlington, where he was responsible for product improvement of LCSS Automatic Test Equipment. Next he pursued several assignments in electrical-optical Test Equipment Design. From 1972 to 1974 Mr. Ketler was the project engineer for the design, development and integration of the Automated Image Device Evaluator (AIDE) which is a computer based electro-optics tester utilizing a Return Beam Vidicon (RBV) sensor. Mr. Ketler's most recent assignment has been AN/USM-410 Automatic Test Equipment integration and acceptance test responsibilities.

Mr. Ketler is a member of IEEE, Eta Kappa Nu, Tau Beta Pi, and Phi Kappa Phi. He is also nearing completion of an MS degree in Computer Science.

M.F. KRAYEWSKY - Member, Technical Staff

Mr. Krayewsky graduated from Northeastern University in 1974 with a BS degree in Electrical Engineering. He has completed numerous graduate courses at Lowell University and Northeastern University in computer science.

Mr. Krayewsky joined RCA in 1974 and was assigned to the Automatic Test and Monitoring Systems. His initial responsibilities were to design two test programs for an audio and I.F. module from the AN/ARC-115 Transceiver. He was then involved in the system integration of EQUATE's (AN/USM) 2, 3 and 4.

In 1975 he designed and validated the system software for the Automated Image Device Evaluator (AIDE), an electrical-optical test equipment design utilizing a return beam vidicon.

Mr. Krayewsky again designed several test programs for support of equipment from the CEFLY, CANCER, TACFIRE and MULTEWS systems. He was then involved in a six month study to explore the use of infrared scanning for the purpose of fault isolation testing on printed circuit boards.

APPENDIX 1

HYBRID FAULT ANALYSIS

INTERNAL CORRESPONDENCE

January 18, 1978

TO: Distribution

FROM: B. T. Joyce

SUBJECT: Defects Analysis

This report results from a review of typical conductor faults in hybrid thick-film substrates that result from normal printing, probing and work-in-process handling in general. The report specifically addresses the requirements of the contract to demonstrate automatic inspection of good and deliberately faulted substrates.

1. Demonstration Substrates

Table 1 delineates the substrates that will be fabricated for use in AIME. Each of the 10-image substrates that will be produced for this purpose will take the general form shown in Figure 1. The pattern shown is not the final design but represents the basic plan for a design containing one conductor layer and one resistor layer. In the final design, each of the 10 images on the 2 inch x 2 inch substrate will contain lines with the different widths and different spacing designated around the border in the figure. The basic types of patterns will be similar to one another, differing only as the conductor densities differ. There will be right-hand and left-hand symmetry to each of the ten patterns. This approach will allow a fault to be placed in each half of the same substrate at topographically similar locations. One fault will be designed to simulate a "spec-limit" condition and the other fault, to simulate a more typical condition.

There are two groups of demonstration substrates necessary to show AIME equipment performance at two critical in-process substrate inspection points: 1) after printing and drying of the gold conductor layer and 2) after firing the gold layer and printing, drying and firing the resistor layer that uses 100K ohm/square ink. The demonstration points in the processing are depicted in Figure 2 by the inspection triangles with double lines. Note that no automatic inspection is planned when the inks are wet even though such an inspection will be very desirable for production versions of AIME type equipment. After all, this is the inspection point that can be most effective in identifying an out-of-control process and for initiating immediate corrective action. But "wet" ink inspection demonstrations are impractical on this program simply because of the logistics of handling in conjunction with on-going hardware/software debugging.

The two inspection points that will be demonstrated are meaningful points in a real production flow. Corrective action can be taken on printed substrates rejected after drying before firing: and the final substrate inspection is routinely performed normally on a 100% basis before moving the substrates on to the next level of assembly where chip parts are added.

2. Substrate Faults

2.1 Substrate Cracks

Table 1 identifies all faults and fault combinations delineated in the Statement of Work except for substrate cracks. In general substrate crack widths fall below the 0.5 mil resolution of the demonstration system. To develop the hardware necessary to automatically detect cracks would expend time and money beyond the scope of this effort. In addition substrates rarely stay cracked during substrate printing, drying and firing. They break! The potential for cracking during assembly is less rare, therefore although no automatic inspection will be attempted on cracked substrates, manual inspection in the pre-cap hybrid mode will be assessed using specimens of AS products known to have substrate cracks.

2.2 Basic Methods for Simulating Substrate Faults

2.2.1 Designed Faults in Screens (Masks)

The following faults identified in Table 1 can reasonably be simulated by appropriate modification of the basic layout of the 10-image pattern:

Lot No.	2	Opens (Voids)
	3	Shorts and Whiskers
	4	No Print
	5	Narrow Conductor
	6	Wide Conductor
	10	Combination (as applicable for above faults)

2.2.2 Manually Induced Faults

The following faults identified in Table 1 can be simulated realistically only by manual faulting of printed substrates:

Lot No.	7	Scratches
	9	Smeared Lines
	10	Combination (as applicable for manually induced faults)

Lot No. 8 for mislocated lines is a special case in which the faults will be produced by deliberately misaligning the substrate by known amounts during the printing operations.

2.2.3 Distribution of Faults

The 10 different images defined by Figure 1 can be divided into two basic groups: a fine-line group and a medium-line group. For some of the fault types it will be useful to take advantage of similarities between the two groups to derive more information from the test samples. For example, all patterns with 4-mil lines can have identical void patterns introduced on the conductors, but the designed fault can be located differently on each of the patterns. Thus the local region around the fault will present a different video picture to the system even though the faults are the same. Similarly, all patterns with 4-mil spaces between conductors can have identical short circuits introduced at different locations on the patterns.

2.3 Detailed Fault Descriptions

The following paragraphs describe the faults that are planned for the demonstration substrates.

2.3.1 Open Conductors (Voids)

Open conductors (or voids) typically occur during the printing process because of a plugged screen caused by lint or drying ink. Voids will be designed into the layout itself so that faults of lot no. 2 can be produced in a controlled manner. Figure 3 illustrates the design of conductor voids. Note that in addition to a limit type fault, three sizes of typical faults are planned, one of which is illustrated. The other two faults will close the gap between conductors to 1/2 and 1/3 the separation shown. Tentatively the designed faults will be distributed as follows among the 10 patterns in accordance with the general thinking outlined in para. 2.2.3.

Fine Line Patterns:

Pattern No.	
1	Faults on long horizontal line: Limit and typical size 1
2	Faults on long vertical lines: Limit and typical size 1
3	Faults on short horizontal line: Limit and typical size 2
4	Faults on short vertical lines: Limit and typical size 2
9	Faults on vertical lines: Typical size 2 and typical size 3
10	Faults on horizontal lines: Typical size 2 and typical size 3

Medium Line Patterns

Pattern No.	
5	Faults on long horizontal line: Limit and typical size 1
6	Faults on long vertical line: Limit and typical size 1
7	Faults on short horizontal line: Limit and typical size 3
8	Faults on long vertical line: Limit and typical size 3

2.3.2 No-Print of Selected Conductors

"No-print" conditions make open conductors as deadly to a hybrid circuit as the voids discussed in 2.3.1. But the causes of no-print conditions are different. If the printer has not been set up properly or gets out of adjustment, defective printing occurs. But even with proper adjustment of equipment, a line or lines can misprint because of a poor substrate - one with excessive camber. A "no-print", in fact, quite often leaves behind some line indication with mesh marks.

Figure 4 shows the planned design for faults due to missing printed conductor in varying degrees. At the top of the figure is drawn a "Limit fault" that in effect simulates a condition where continuity still remains in the conductor at the two edges of the designed line. But then less and less material is left behind in the typical faults simulated below the limit fault.

Following an approach similar to that described for voids in 2.3.1, the different degrees of fault conditions would be appropriately distributed at different relative locations among the 10 patterns.

2.3.3 Shorts and Whiskers between Conductors

Shorts and whiskers are formed during the printing process primarily due to printer adjustment problems with poor screen breakaway from the substrate. A low viscosity ink can cause the problem as well as excessive camber. The fault conditions are more likely in large-area screen printing that challenges the printer to its limit.

Figure 5 shows the planned fault designs to simulate printed defects by means of the layout. Note that these faults are essentially the opposite of voids. The faults would be distributed among the Fine Line Patterns and Medium Line Patterns in accordance with the same plan as shown for voids (para. 2.3.1); e.g., pattern No. 1 would contain faults on a long horizontal line with the left-hand side of the pattern containing the limit fault and the right-hand side of the pattern containing the typical size-1 fault.

2.3.4 Narrow Conductors

Conductors will be made narrower than their design widths to 0.5-mil granularity by deliberate layout designs. All lines of a given pattern will be reduced by the same amount. Taking advantage of the right-hand and left-hand symmetry of each pattern to increase the number of combinations, the distribution of the various narrow lines is planned as follows:

Pattern No.	Fault Design Line Width (mils) LEFT	Fault Design Line Width (mils) RIGHT	Normal Design Line Width (mils)
1	3.5	3.0	4
2	2.5	2.0	4
3	4.0	3.5	5
4	3.0	2.5	5
5	7.0	6.0	8
6	5.0	4.0	8
7	8.0	6.0	10
8	5.0	4.0	10
9	3.0 & 4.0	2.5 & 3.5	4 & 6
10	2.0 & 3.0	1.5 & 2.5	4 & 6

2.3.5 Wide Conductors

Conductors will be made wider than their design widths to 0.5-mil granularity by deliberate layout design. All lines of a given pattern will be increased by the same amount. Taking advantage of right-hand and left-hand symmetry to increase the number of combinations, the distribution of various wide lines is planned as follows:

Pattern No.	Fault Design Line Width (mils) LEFT	Fault Design Line Width (mils) RIGHT	Normal Design Line Width (mils)
1	4.5	5.0	4
2	5.5	6.0	4
3	6.0	6.5	5
4	7.0	7.5	5
5	9.0	10.0	8
6	11.0	12.0	8
7	12.0	14.0	10
8	15.0	16.0	10
9	5.0 & 7.0	4.5 & 9.0	4 & 6
10	6.0 & 8.0	6.5 & 10.0	4 & 6

2.3.6 Scratches

Scratches occur in practice from careless handling. Use of sharp probes for continuity tests and resistor-value measurements is common. If the probe slips, it can gouge the material. Scratches caused by probes would be on fired (not dried) material. Scratching of dried material would be caused more typically by someone's use of metal tweezers in handling a thick-film substrate in the dried or fired state. Normally, substrates are handled manually by personnel using finger cots or plastic tweezers, so damage by tweezers is uncommon in a controlled production environment. Another possible source for scratches of film, either dried or fired, is the dragging of one substrate (especially its corner) over another.

Scratches of conductors on the demonstration substrates will be simulated manually with real tools and even the corner of another substrate. To the extent practicable, these faults will be "expertly" made by hand and the results will be documented in a quantitative fashion. "Limit" faults and "typical" faults will be located and distributed in a manner similar to that outlined for opens (para. 2.3.1) and shorts.

2.3.7 Mislocated Lines

Once a design is confirmed, the only way lines can get mislocated is when they are printed; and then all lines of the pattern are mislocated together with respect to the substrate reference axis. Demonstration substrates will be made by deliberately misaligning plates using the adjustable vernier controls of the printer. Thus all ten patterns will be displaced by the same amount in the same direction as follows during the conductor printing:

	Displacement (mils)	
Sample No.	X	Y
1	2	0
2	4	0
3	6	0
4	0	2
5	0	4
6	0	6
7	1	1
8	2	2
9	4	4
10	6	6

2.3.8 Smeared Lines

Smearing is a defect occurring during printing when the inks are still wet because of accidents in handling. Much like the case for scratches, these faults will be introduced manually on wet conductor ink to simulate varying degrees of smears and the results will be documented quantitatively. These different degrees of smearing faults will be distributed among the 10 patterns without any special concern relative to the line widths and spacings.

2.3.9 Combinations of Conductor Faults

Different practical faults will be designed by layout or manually produced to simulate opens (voids), shorts and whiskers, no-print, scratches and smears. No meaningful new information appeared to be realizable by including combinations of narrow and wide conductors and mislocated conductors with the other faults. Therefore, these gross-type faults are not included for the so-called "combination"-fault substrates. Combination faults will be distributed randomly among all 10 different patterns.

3. Substrate Alignment Considerations

This paragraph is included in the defects analysis because it provides a basis for considering "real-world" printing alignment capabilities and practice in relation to alignment allowances of MIL-STD-883.

3.1 Practical Production Printing

Limited data taken on RCA-AS printed substrates revealed the following:

a. Maximum deviation of the average location of a given line in a production lot with respect to its location as designed, 1 to 2 mils.

b. Standard deviation for the location of a given line in each specific lot with respect to its average location in that lot, 0.5 to 1 mil.

3.2 Specific Requirements in MIL-STD-883, Method 2017

This specification gives very little guidance relative to thick-film alignment.

a. Para. 3.1.3.1(h) - Reject "substrate that does not have 50% of the original design separation between operating metalization and the edge of the substrate". AS hybrids usually are designed to have a 10 mil separation between a conductor and substrate edge; therefore, misalignment of the conductor up to 5 mils would be acceptable.

b. Para. 3.1.3.2.8 - Metallization alignment. This paragraph is applicable to thin film, but not thick film hybrids.

3.3 Practical Alignment Rules

Reject substrates for misalignment of conductor metalization by more than 50% of the minimum spacing between conductor layers.

Example: For 10-mil line spacing, reject if metallization is misaligned by more than 5 mils; for 5-mil line spacing, reject if metalization is misaligned by more than 2.5 mils.

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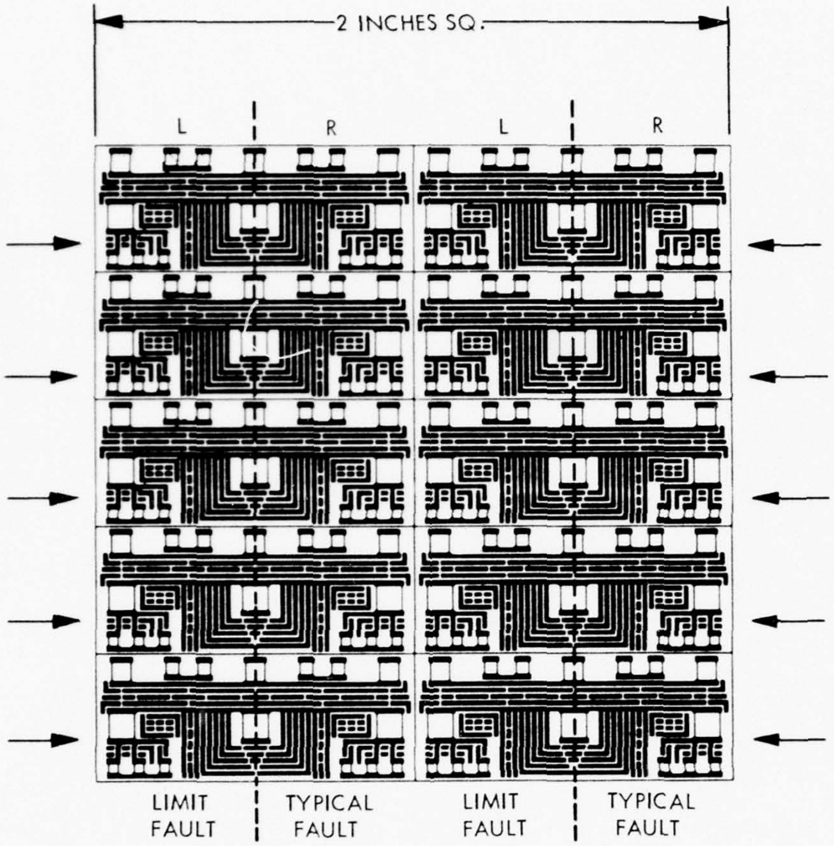
TABLE 1

DEMONSTRATION SUBSTRATES

LOT NO.	DESCRIPTION OF 10-IMAGE SUBSTRATE PLATES	NUMBER OF SUBSTRATE PLATES	
		DRIED GOLD	FIRED GOLD/RESISTORS
1	FAULT FREE	10	10
2	OPEN CONDUCTORS (VOIDS)	2	2
3	SHORTS & WHISKERS BETWEEN CONDUCTORS	2	2
4	NO PRINT OF SELECTED CONDUCTORS	2	2
5	NARROW CONDUCTOR	2	2
6	WIDE CONDUCTOR	2	2
7	SCRATCHES	2	2
8	MISLOCATED LINES	10	10
9	SMEARED LINES	2	2
10	COMBINATION OF 2, 3, 4, 7 & 9	2	2

PATTERN NO.	LINE WIDTH (Mils)	LINE SPACING (Mils)
1*	4	4
2*	4	6
3*	5	4
4*	5	5
5	8	5



PATTERN NO.	LINE WIDTH (Mils)	LINE SPACING (Mils)
6	8	8
7	10	5
8	10	10
9*	4 & 6	4
10*	4 & 6	6

* FINE LINE PATTERNS

Figure 1. Multiple-Image Demonstration Pattern

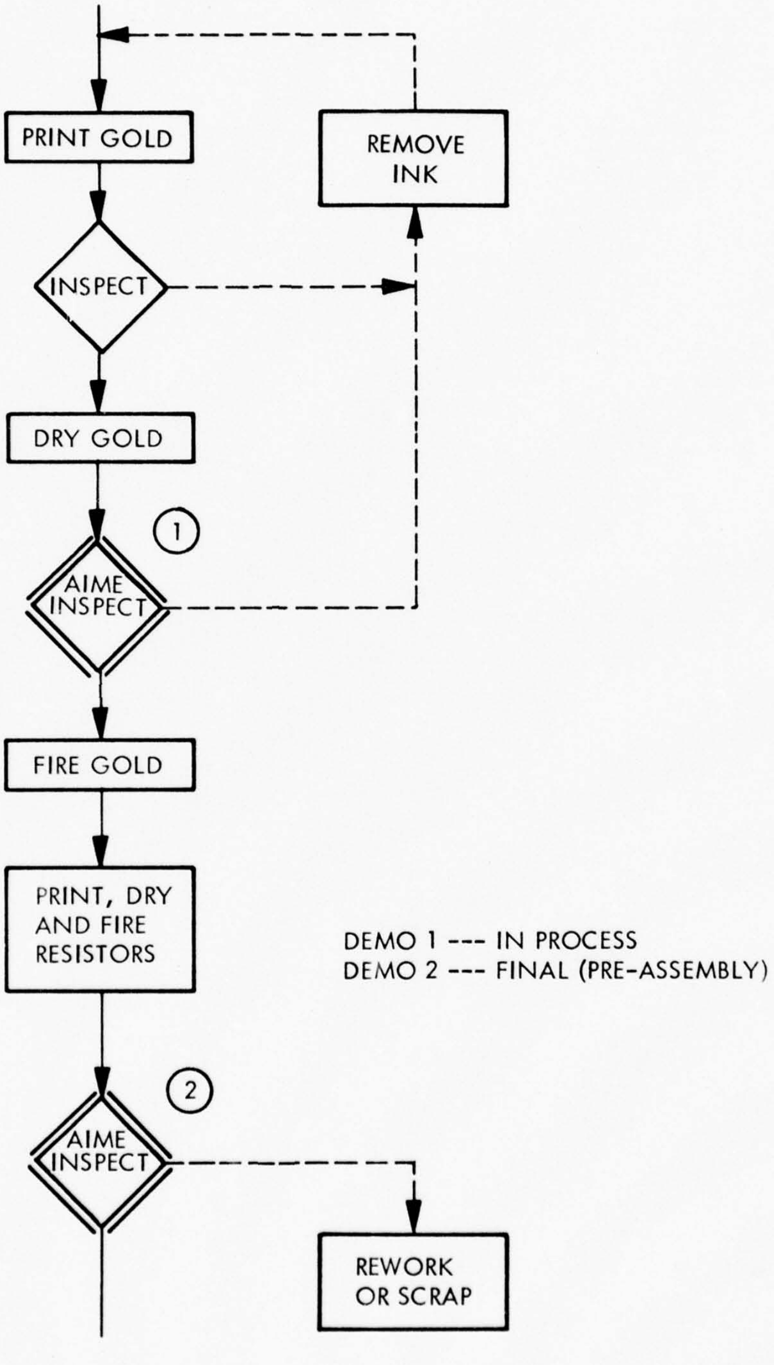


Figure 2. Demonstrations of Substrate Inspection

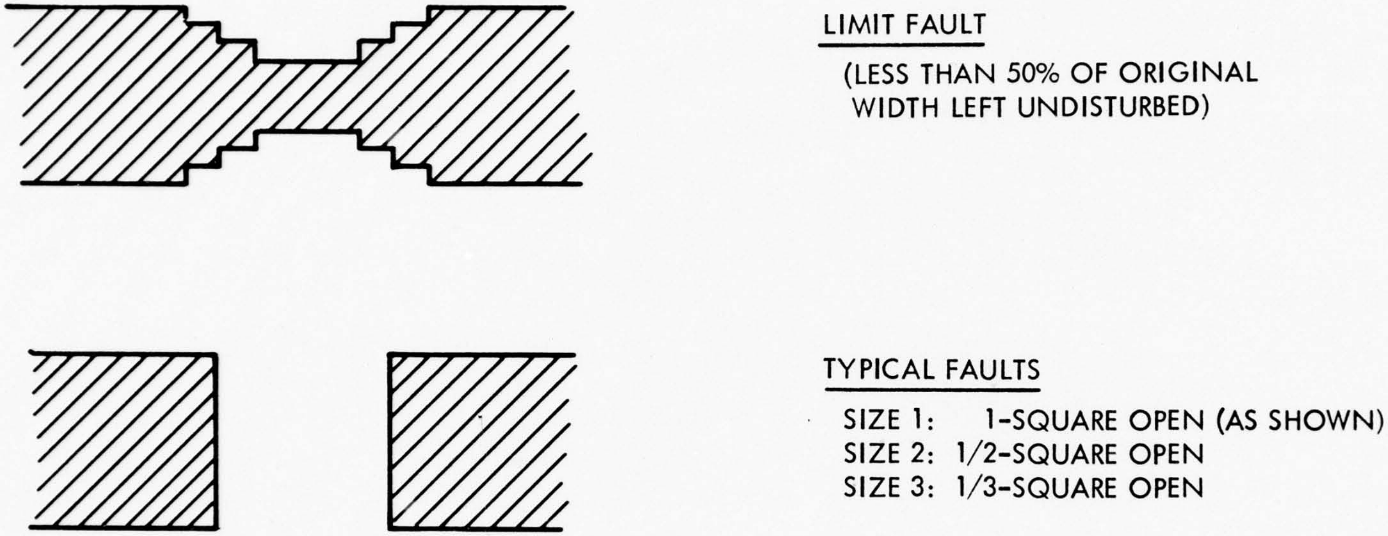


Figure 3. Fault Designs: Open Conductors (Voids)

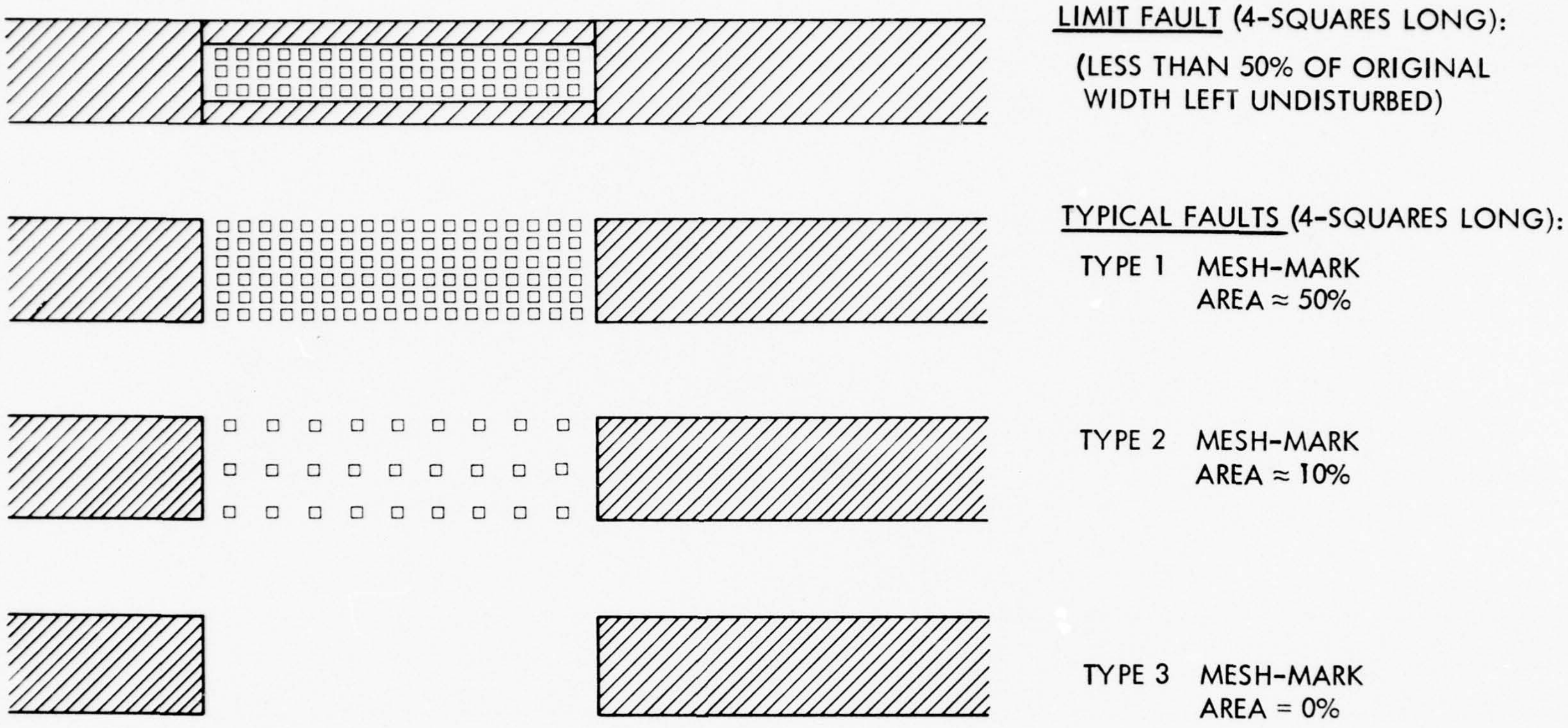
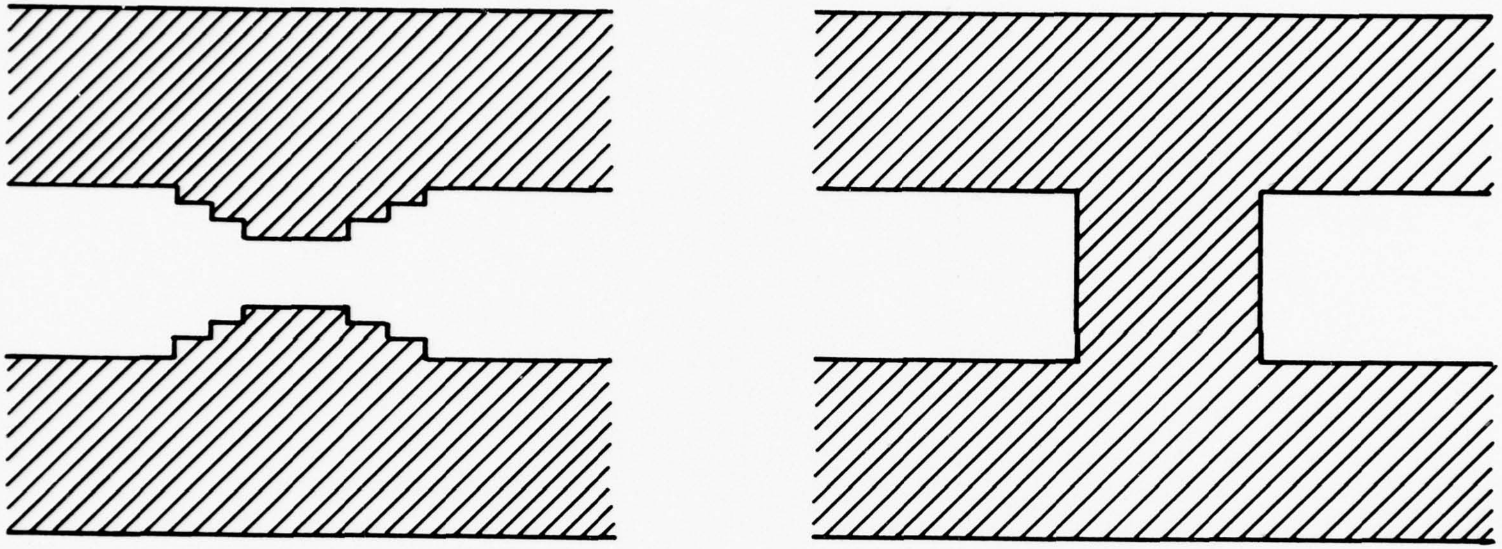


Figure 4. Fault Designs No Print of Conductor



LIMIT FAULT

LESS THAN 50% OF ORIGINAL
DESIGN SPACING LEFT
BETWEEN CONDUCTORS

TYPICAL FAULTS

SIZE 1: 1-SQUARE (AS SHOWN)
SIZE 2: 1/2-SQUARE
SIZE 3: 1/3-SQUARE

Figure 5. Fault Designs: Shorts and Whiskers between Conductors

APPENDIX 2

ILLUMINATION ANALYSIS

Illumination Analysis

1.0 DESCRIPTION OF HYBRID CIRCUITS

A hybrid circuit assembly or "hybrid" comprises a ceramic substrate (alumina) on which are deposited various combinations of gold conductors, gold/platinum conductive pads, dielectric layers and film resistors. The various elements are applied in successive layers by screening processes and are relatively rugged and durable when fired. The substrate is hard, abrasive and durable. Thickness generally ranges from 20 to 30 mils. Maximum size of substrates required to be accomodated by the AIME system, without repositioning, is two inches by two inches.

2.0 OPTICAL PROPERTIES

2.1 Substrate

The alumina substrate is white and translucent with a substantial amount of internal scattering. Effective reflectivity is approximately 70% if the supporting surface is aluminum and 50% of it is non-reflective. Substrate reflection is approximately Lambertian with no evidence of sheen or other directional properties.

2.2 Dielectric

The dielectric layers are white translucent and barely distinguishable from the substrate. The mesh of the screen commonly used to deposit the dielectric is 200 per inch, resulting in a distinguishable (with magnification) but low contrast pattern. Some sheen is present at grazing illumination angles.

2.3 Gold Conductors

The gold conductors are screened with a mesh of 325 per inch and the granularity is clearly visible. Despite the graininess of the surface, a strong specular component of reflection is apparent, even at near perpendicular illumination and observation angles.

For perpendicular observation and near perpendicular illumination, the reflectivity exceeds that of the substrate. As the illumination direction departs from the normal, the reflection from the gold decreases until, at 45° the gold reflectivity is substantially less than that of the substrate (See Figure 1).

Where covered by dielectric, the gold, although dimmer is still clearly visible, but the dielectric scattering eliminates the directional properties of the gold reflectivity.

2.4 Platinum - Gold Pads

Like the gold, these conductors are screened at 325 per inch. However, they show little if any directional reflectivity. The color is gray, indicating uniform spectral response in the visible (and RBV) range.

2.5 Resistors

The resistors are very low in reflectivity with a slight sheen which makes the screening pattern, a mesh of 200 per inch, visible. Even the highlights are much lower in reflectivity than any of the other materials.

2.6 Backside Metallization

About 50% of the hybrids are metallized with gold-platinum, over the entire rear surface, in a pattern of squares and rectangles. Typically the squares are spaced twenty to the inch and the rectangles are slightly longer in one dimension. The blank lines between the squares are about .007 inch in width.

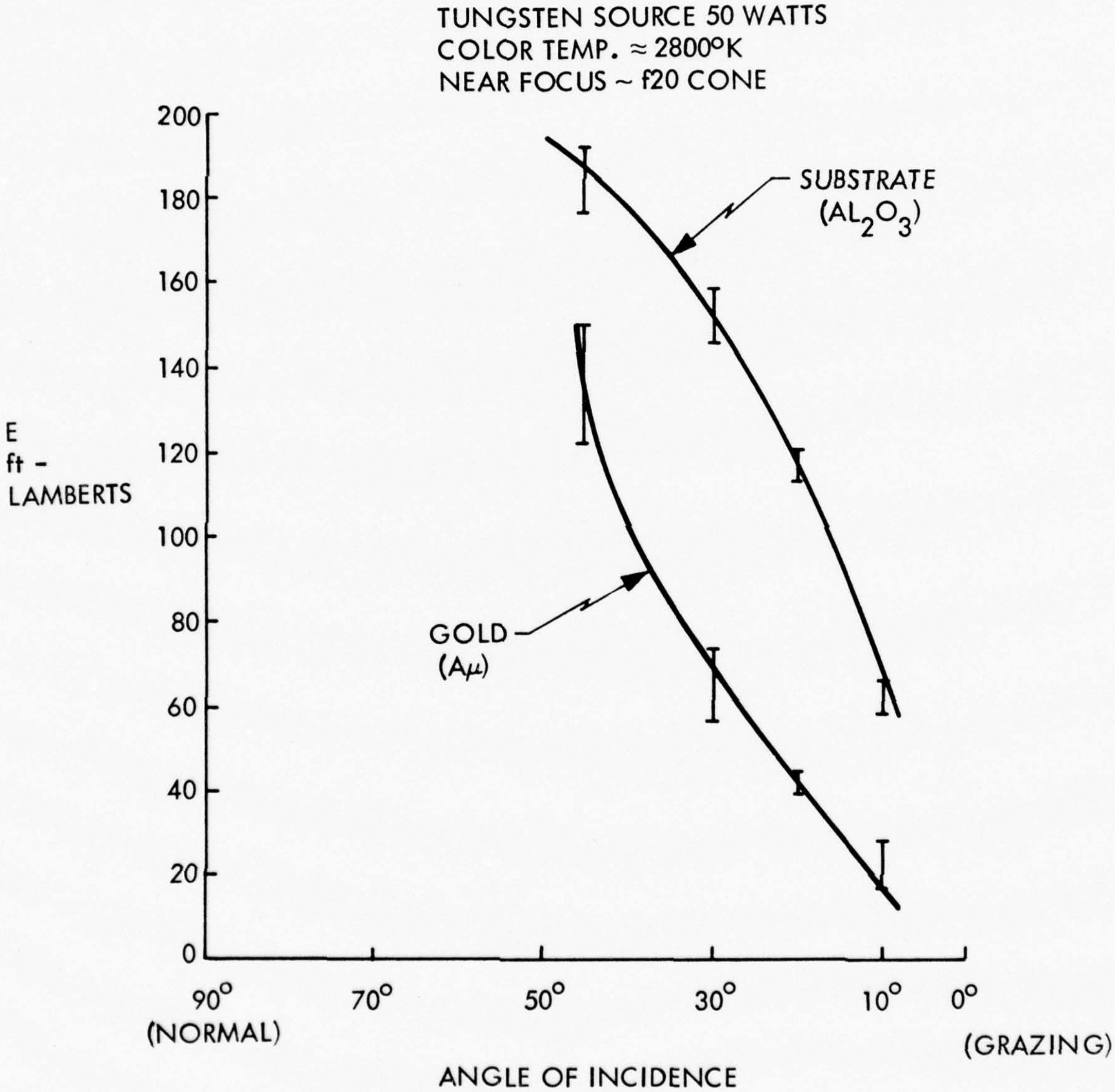


Figure 1. Hybrid Luminance

With the substrate back-illuminated, there is considerable blurring of the pattern, caused by scattering in the substrate. The attenuation of light caused by the reduction of area is approxinately 4:1. Transmission of the subatrate alone, for 30 mil thickness with diffuse illumination is 36%. Tests have shown that high contrast between gold conductors and film resistors, and that of the substrate can be achieved with back-illumination in spite of the backside metalization.

3.0 SENSOR SPECTRAL RESPONSE

Figure 2 shows a representative relative spectral response for the ASOS surface employed in the 4.5 inch RBV tube. Also shown for comparison is the standard photopic response for human vision. From the curves it can be seen that visual observations of hybrid photometric properties will correspond reasonably well with the RBV responses.

4.0 ILLUMINATOR

4.1 Spectral Properties

Figure 3 shows the approximate spectral properties of tungsten halide incandescent lamps at color temperatures of $3000^{\circ}K$ and $2350^{\circ}K$ respectively. The former represents the normal operating condition for maximum output and rated lifetime of 50 hours, while the latter represents a reduction of luminous output by a factor of ten to one. This would be accomplished by lowering the lamp voltage to 50% of rated value (a current of 70% of rated value). It results in a pronounced red shift in the peak response and a sharp reduction of the green-blue regions of the spectrum.

In addition to altering the spectral content of the lamp, reducing the voltage may cause the halogen cycle to cease functioning thereby permitting evaporated tungsten to be deposited on the lamp envelope. For these reasons, other means of varying the illuminator output have been explored and will be discussed below.

4.2 Use of Iris for Attenuation

To improve illumination efficiency and eliminate the annoyance of scattered light,a housing, shown in Figure 4, and a condensing lens are required. The lens tube also provides a convenient mounting for an adjustable iris, which, placed close to the lens aperture, will attenuate the illuminator output without vignetting the illuminated area. By this means attenuation ratios of greater than 100:1 can be obtained without any change in the lamp spectral properties.

The tube also provides a mounting for a "hot mirror" and for spectral filters if necessary. The former can reduce the heat output of the illuminator by at least

60% and the latter may be used for contrast enhancement.

Other means of verying the illuminance on the RBV tube face are neutral density filters, RBV lens iris adjustment (subject to depth of field requirements), and exposure time control, if the snapshot mode is utilized.

4.3 Spectral Filtering

As shown in Figure 1, there is good contrast between the gold and the aluminum oxide substrate for tungsten illumination at obtainable angles of incidence*. Figure 5 shows the relative spectral responses of the ASOS (RBV) photo-surface ,the 3000^{o}K tungsten source and the reflectivity of gold. Figure 6 shows the resulting system response to the gold conductors and to flat spectrum surfaces such as the alumina substrate.

4.4 Back Illumination

Although back illumination would increase the contrast, relative to the substrate, of all deposited materials except the dielectric layer, there would be no contrast of gold versus the resistors. The front contrast of gold, and carbon relative to the substrate is good, but further tests are required to determine adequacy of S/N for automatic processing. At this time it appears that back illumination is the preferred approach for deposition inspection.

---

*Note that angles above 30 degrees are precluded because of interference with the RBV and lens assemblies. If a shutter is used, to implement the "snapshot" mode, angles above 20 degrees are precluded.

4.5 Reduction of "Graininess"

Owing to the screens used in depositing the layers, the surfaces appear rough under magnification and the local reflectivity varies, as shown in figure 1 (for a single illuminator). Examination shows that some or most of this variation is caused by shadowing in local depressions having dimensions corresponding to the mesh spacing. To minimize these shadows for frontal illumination, two illuminators will be symmetrically located relative to the center of the hybrid mounting surface. This arrangement will also mininize shading due to variation of distance from the illuminator over the surface of the substrate.

4.6 Illumination Geometry

The hybrid can be illuminated by focussed, collimated or divergent light but the substrate size, 2 inches by 2 inches, would necessitate an unusually large illuminator aperture (about 3 inches diameter) if collimated light were to be used.

Of the two remaining methods focussing is the more efficient in that the lamp filament area is directly imaged onto the hybrid.

To avoid local variations due to the image of the filament wires, a defocussing distance of about 0.5 inch is required.

The lamp of Figure 4 is designed for focussed or imaging illumination in that the filament is closely coiled so as to produce a nearly solid source area.

Since the source is rectangular, there is only one angle of incidence at which the source image matches the square substrate, about 33° for the lamp dimensions.

Figure 1 indicates that maximum reflictivity ratios are obtained for incidence angles between 10 and 30 degrees, with luminance decreasing steeply as incidence decreases.

Accordingly an angle of 20 degrees, representing the limit due to shadowing by the RBV camera shutter housing, is chosen.

Allowing for variation of the **illuminator** condensing lens focal length and for nonuniformity in the edges of the defocussed beam, a distance of 20 inches from the condensing lens to the center of the substrate will assure that the filiament image plane approaches no closer than 0.5 inch from any point on the substrate,and the substrate lies within the region of the beam.

With these dimensions, the illuminance on the substrate can be estimated for two illuminators of Figure 4, to be 4800 lumens/square foot. Reflectivity is at least 50% so the resulting luminance is 2400 ft. lamberts. The nominal requirement is 114 ft. lamberts with the RBV lens set at f8 and operating in the continuous mode. A margin of 21:1 is therefore left for any spectral filtering which may be employed.

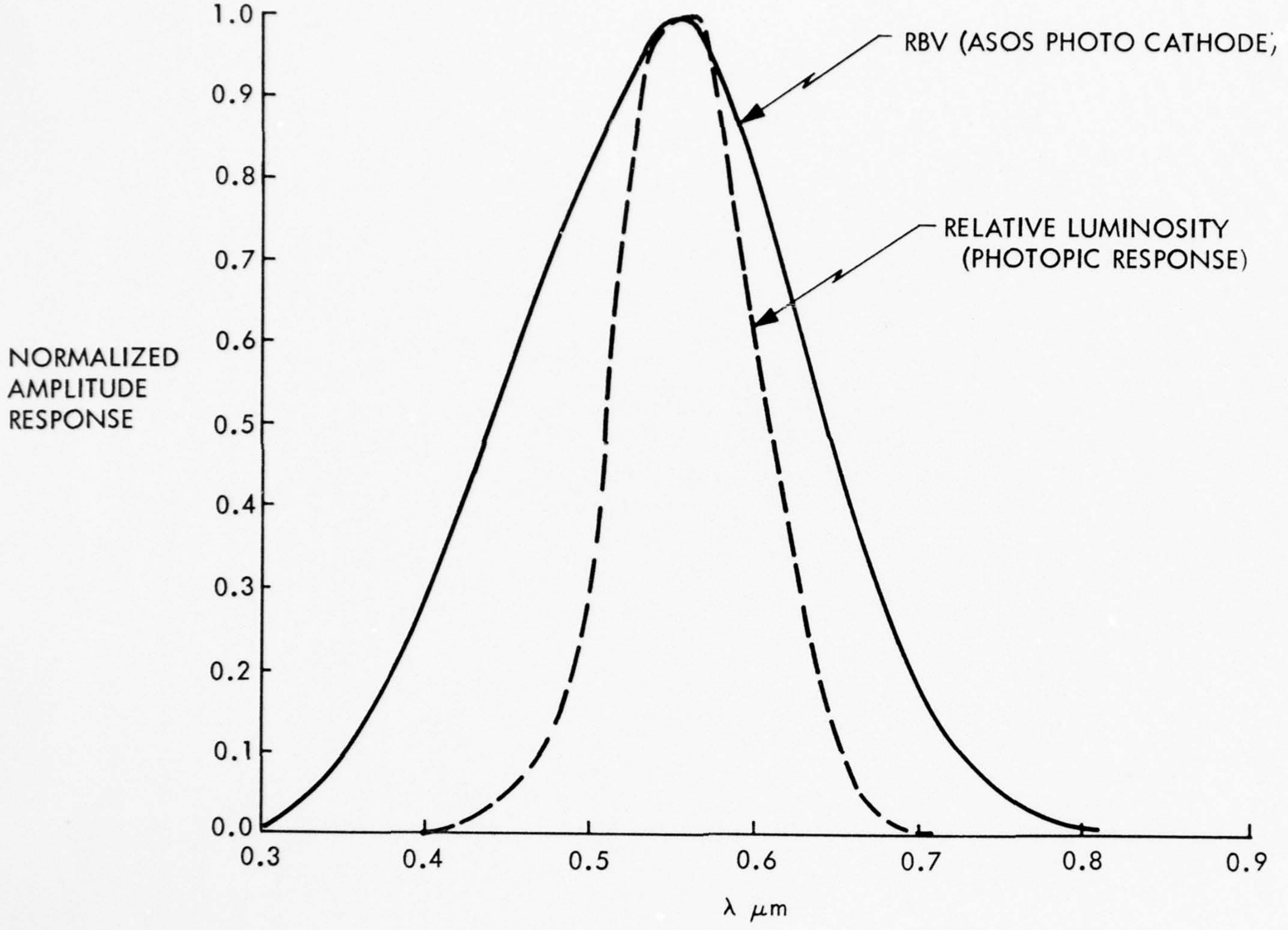


Figure 2. RBV Spectral Response

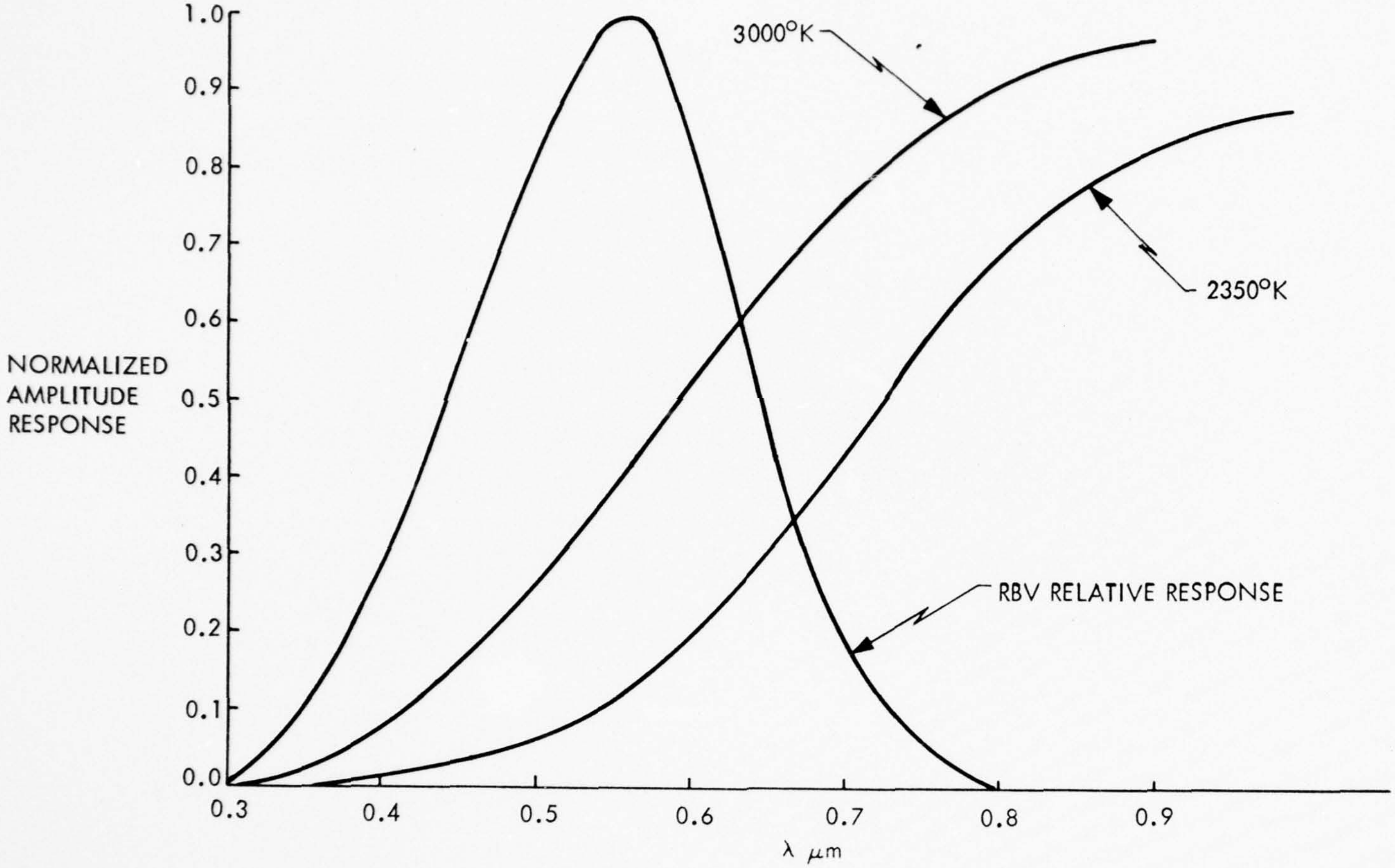


Figure 3. Illuminator Spectral Content

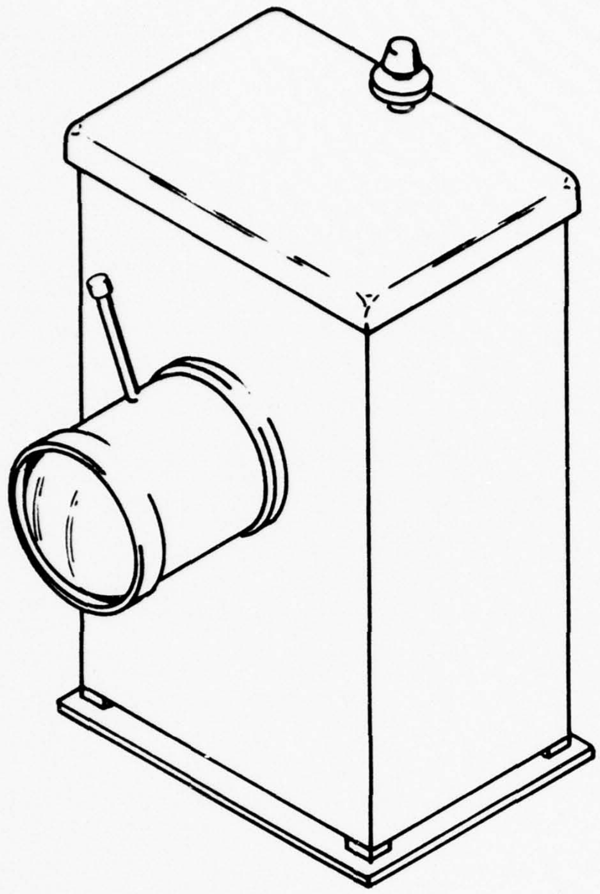


Figure 4. Lamp Housing with Condensing Optics Assembly

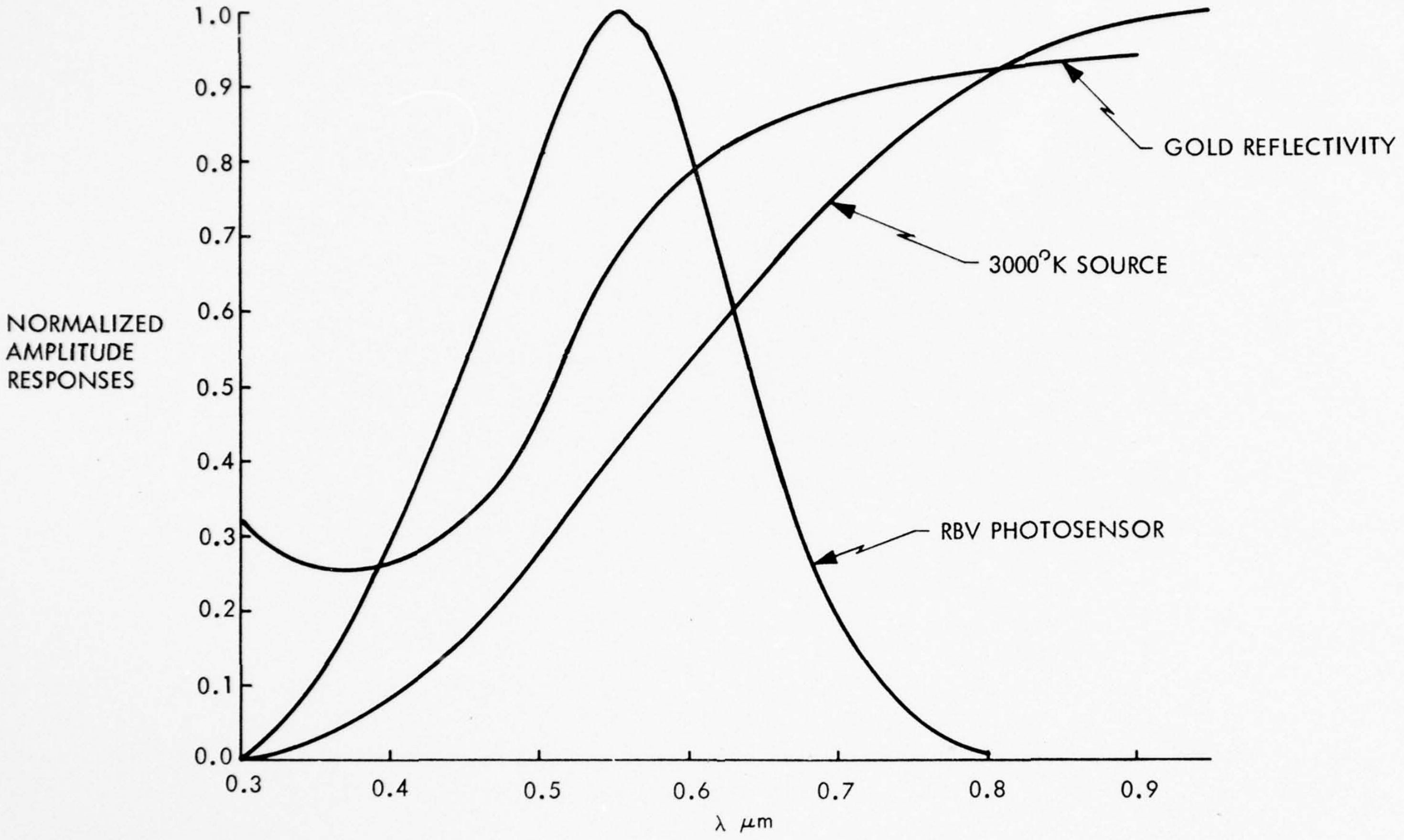


Figure 5. System Spectral Characteristics for Gold Conductors

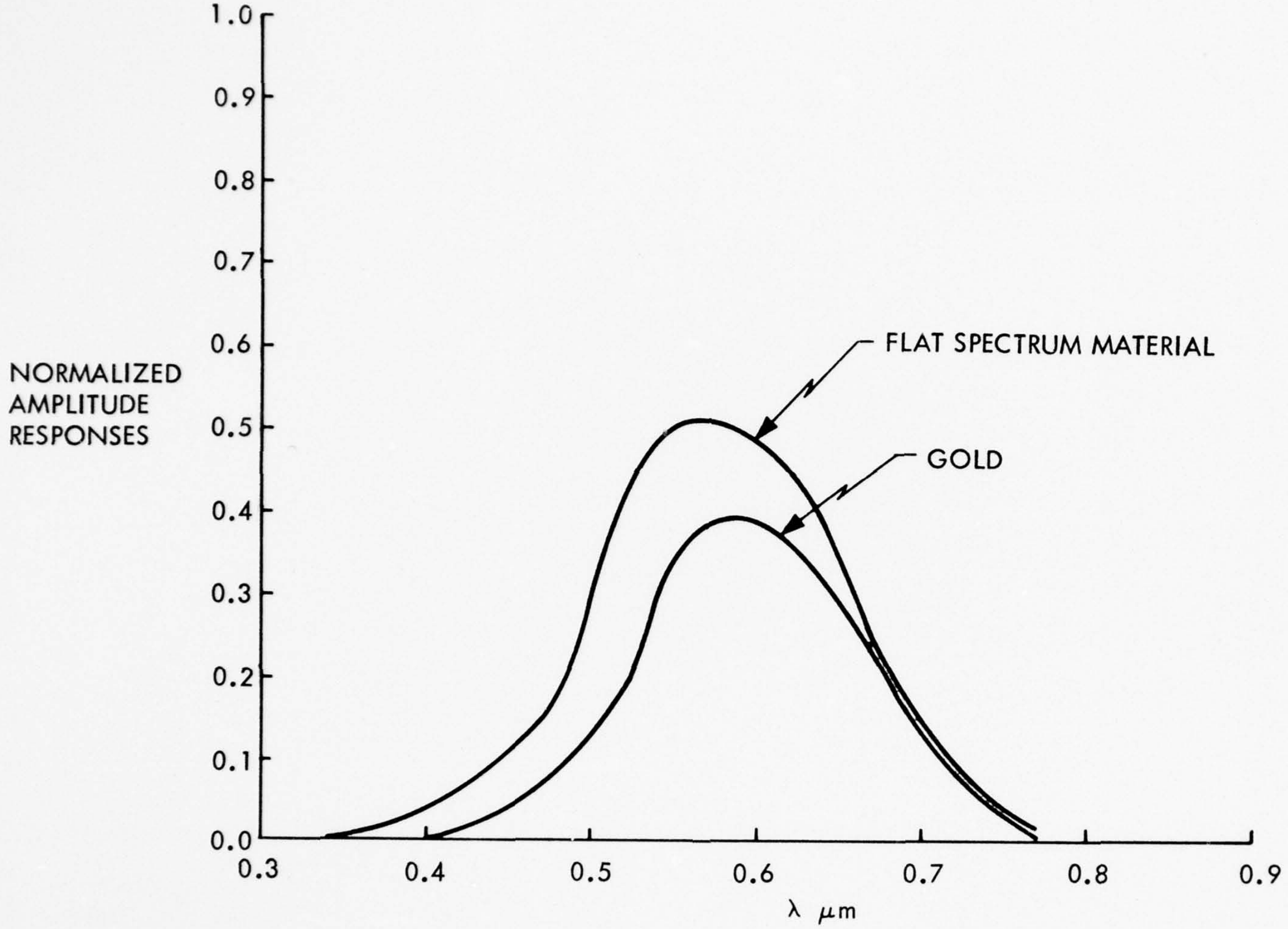


Figure 6. System Relative Responses

APPENDIX 3

ALTERNATE HYBRID INSPECTION TECHNIQUES

ALTERNATE APPROACHES

1) LASER DIFFERENTIAL LINE SCANNER (LDLS)

A laser differential line scanner (LDLS) which is used to examine LSI masks was evaluated to determine whether it could be adapted to do hybrid circuit inspection.

LDLS Operation:

The LDLS can test transparent objects (such as masks or SOS wafers) which have a repetitive matrix of patterns. The incident laser beam is split and aligned to scan identical areas of adjacent patterns on the glass mask with a 525/60 TV raster of 24 mils width. The detectors are placed on the opposite side of the mask. The mask holding fixture is translated in X and Y to scan the full mask.

Disadvantages of the presently configured LDLS are that it cannot inspect non-transparent objects like hybrid circuits. However, a laser scanner could be configured to utilize a reflected light detector but the system would have certain disadvantages as follows:

a) Monochromatic laser light could not be color filtered to take advantage of spectral information in the hybrid.

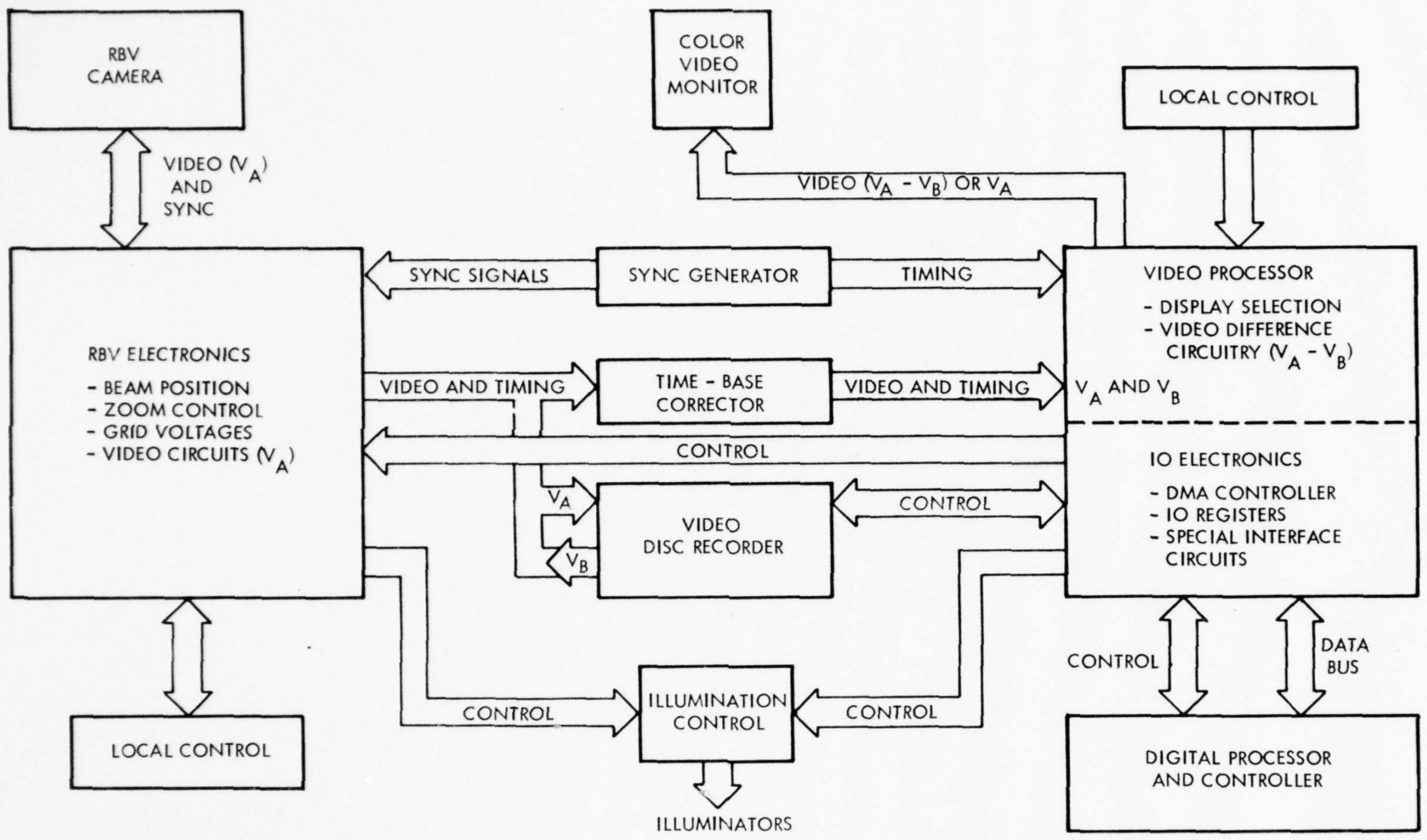
b) It would be difficult to zoom the laser scanner as is done in the RBV electronics. Wide angle laser deflection for overall hybrid viewing can be accomplished with an acousto-optic crystal (horizontal) and galvonometer driven mirror (vertical) in conjunction with optics to increase the deflection angle. But narrow angle (zoom) viewing would require an optics focal length change.

c) Steering the laser beam to different parts of the hybrid would require accurate UUT fixture translation instead of the stationary hybrid fixture used by the RBV system which has electronic zoom and steering.

d) Image non-uniformity (shading) may result from certain types of mechanical laser beam deflection because the scan velocity is not constant. The RBV has linear (constant velocity) scanning in horizontal and vertical.

APPENDIX 4

AIME SYSTEM BLOCK DIAGRAM



AIME Demonstration System Functional Block Diagram

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Rome Air Development Center
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