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MANUFACTURING METHODS AND TECHNOLOGY ENGINEERING PROGRAM QUARTERLY TECHNICAL REPORT

(15) Contract Number DAAB07-76-C-0040

(6) INJECTION LASER DIODES FOR FIBER OPTIC COMMUNICATIONS.

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LASER DIODE LABORATORIES, INC.
205 Forrest Street
Metuchen, New Jersey 08840

(10) Rob /Adair

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Fort Monmouth, N. J. 07703

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Prepared by:

Rob Adair

LASER DIODE LABORATORIES, INC.
205 Forrest Street
Metuchen, New Jersey 08840

Third Quarterly Report
for the Period 1 January 1977 to 31 March 1977

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Gallium Aluminum Arsenide
Double Heterojunction Laser Diode

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

The design and fabrication of injection laser diodes for use in fiber optic communications is discussed with regard to material synthesis, chip configuration, and device assembly in manufacturing environment. The opto-electronic source is based on the GaAs-GaAlAs double heterojunction structure and consists of a parallel array of lasers formed by the application of triple stripe geometry to the surface of the epitaxial wafer. The → next Page

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) monolithic triad of discrete lasing elements is mounted in a high frequency package which incorporates a high quality optical window.

14. KEY WORDS	LINK A		LINK B		LINK C	
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Injection Laser Diodes						
Fiber Optic Communications						
Gallium Aluminum Arsenide						
Double Heterojunction Laser Diode						

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SECTION I

INTRODUCTION

The primary objective of this Manufacturing Method and Technology Engineering Program is threefold. First, the Injection Laser Diode for use in Fiber Optic Commmunications as outlined in Specification SCS-516 must be transferred from a developmental device type to a volume manufactured commercial product without adversely affecting the performance characteristics of the device. Secondly, the manufacturing methods and techniques necessary for the volume production of the laser diode must be developed and implemented to insure the highest degree of device quality and reliability at a reasonable cost. Thirdly, verification of device performance and quality for injection lasers produced in a volume manufacturing environment must be carried out by means of rigorous testing and evaluation to demonstrate the technical adequacy of the manufacturing methods developed under this contract.

Major objectives for the third quarter of the program included fabrication and testing of the second engineering samples, construction of a sufficient number of burn-in and life-test positions for the 2000 hour life test, and installation of the E-gun apparatus. Engineering obstacles prevented some of these goals from being reached completely but the problems have been identified and work is progressing toward their solution.

SECTION II

DEVICE DESIGN REQUIREMENTS AND PERFORMANCE SPECIFICATIONS

2.1 Electro-Optical Characteristics.

Although material production was temporarily slowed by a mechanical failure in the epitaxial wafer gas purifying system, material grown before the failure was available for evaluation and additional wafers were subsequently fabricated based upon the optimum stripe width previously reported. The wavelength of recently fabricated wafers has not had the uniformity generally expected for the laser structure. It is believed that a pull over of the 'n' barrier layer into the active cavity is the probable cause. To control the pull over of aluminum from the 'n' barrier, an intermediate melt containing no aluminum has been used to remove the unwanted aluminum. The composition of this melt is identical to the composition of the active cavity melt except for the aluminum content.

The e-gun still awaits initial operation, due in part to delays in obtaining the power supply and other critical components, and also due to problems encountered following installation. The most serious of these is arcing which occurs when operation is attempted even at relatively low power levels. Evaluation of the system continues and solutions to the problems are actively being sought.

2.2 Test Equipment

Full operation of the burn-in system has been delayed by a number of engineering problems that became apparent after more than twenty-five boards had been assembled. Although a majority of them work as designed, the others exhibit undesirable behavior thought to be related to pulse degradation in the drive circuitry of the common clock. Also, harnessing of the boards has proven more time consuming than anticipated and card-edge connectors will be incorporated in the next run of circuit boards. These and other modifications have not been finally decided, but changing the values of R4, R5, R13, and R14 (Figure 4) strongly affect the problem and it is believed that part of the solution lies in optimization of these parts. The remainder of the problem in the clock drive may be solved by reducing the number of positions driven by each clock line and/or by using special line drivers for the clock lines. The main power supply rack for the burn-in system has been assembled and tested (Figures 2 and 3). It holds a supply capable of ten volts at up to 150 amperes, a supply capable of 60 volts at up to 50 amperes, and an AC power distribution panel which feeds 240 VAC to the main supplies and 120 VAC to the main rack fans and common clock. The AC power distribution panel (Figure 2) has a power failure lockout and provision for a master timer or other external shutdown. A new goniometer (Figure 6) is being designed which will be

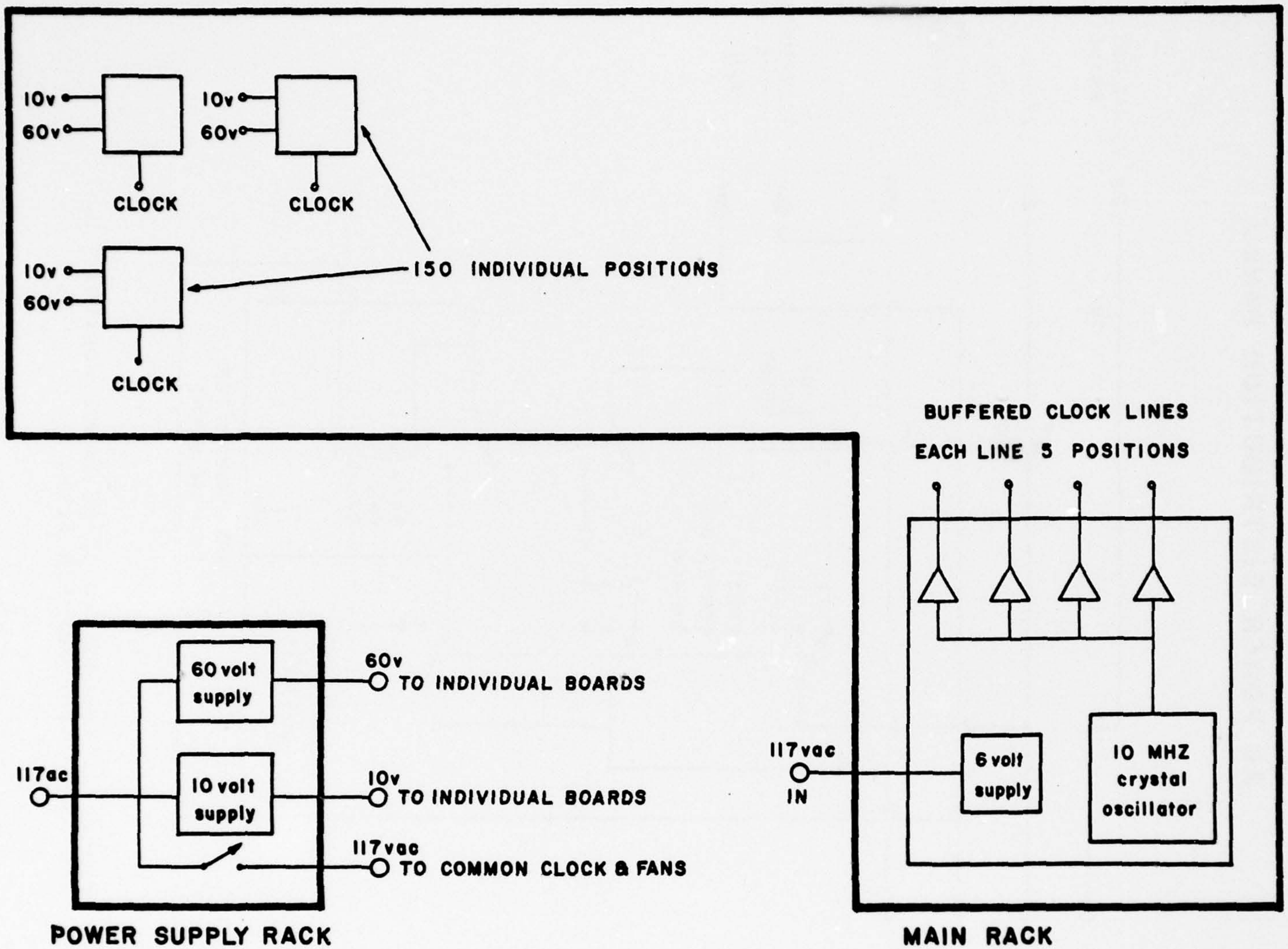


Figure 1. Overall Block Diagram of Burn-In Rack.

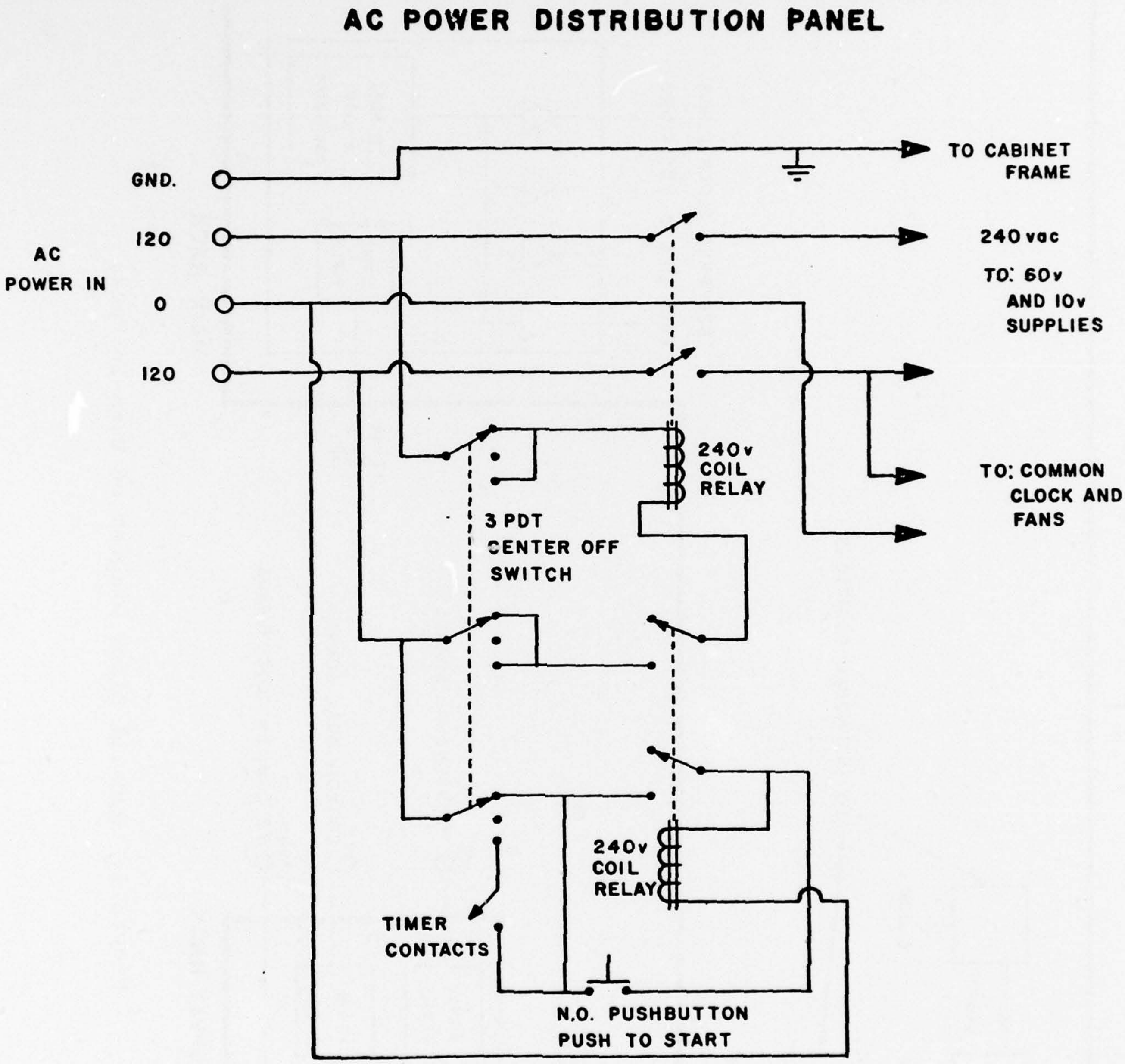


Figure 2. Schematic of AC Power Control Panel for Burn-In Rack.

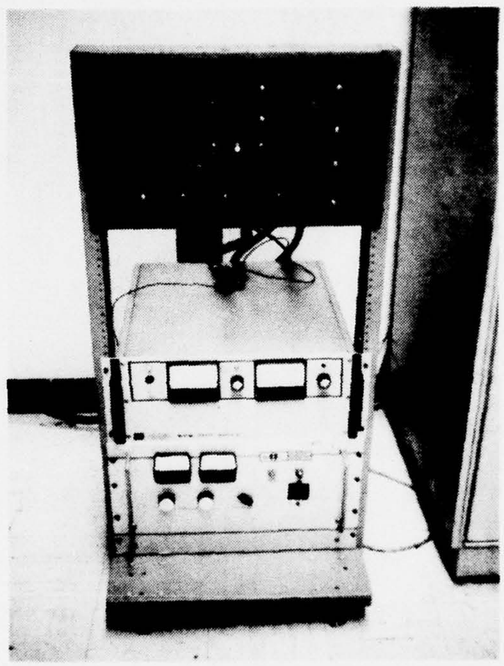
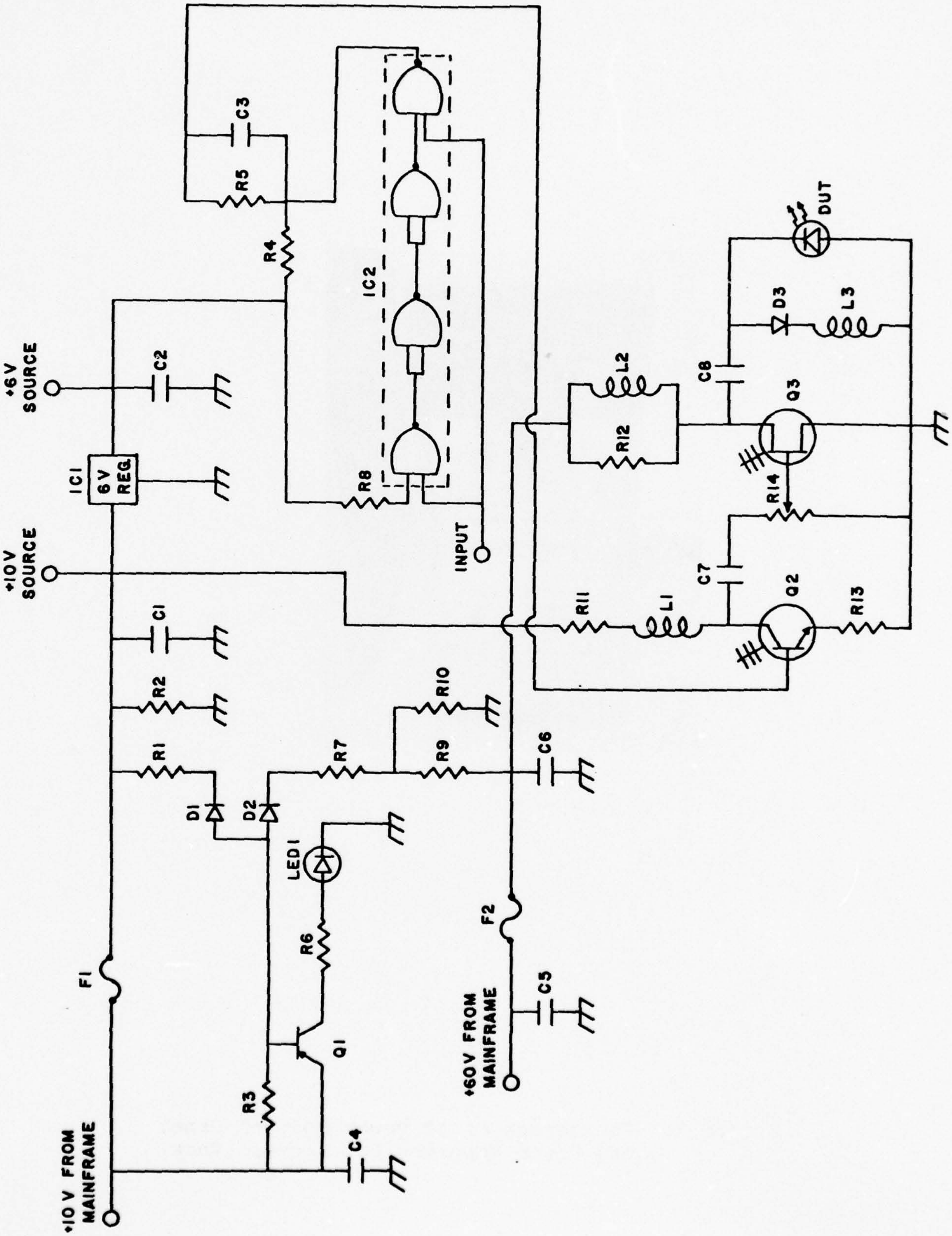


Figure 3. Photograph of AC Power Control Panel and Power Supplies for Burn-in Rack.

Figure 4. Circuit Schematic for 10MHz ILD Life Test Driver (single position).



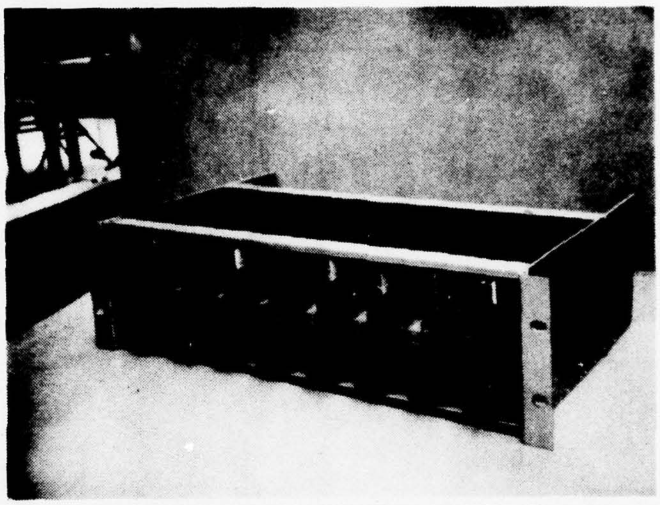


Figure 5. Photograph of One Row of 8 Positions of Burn-In Rack.

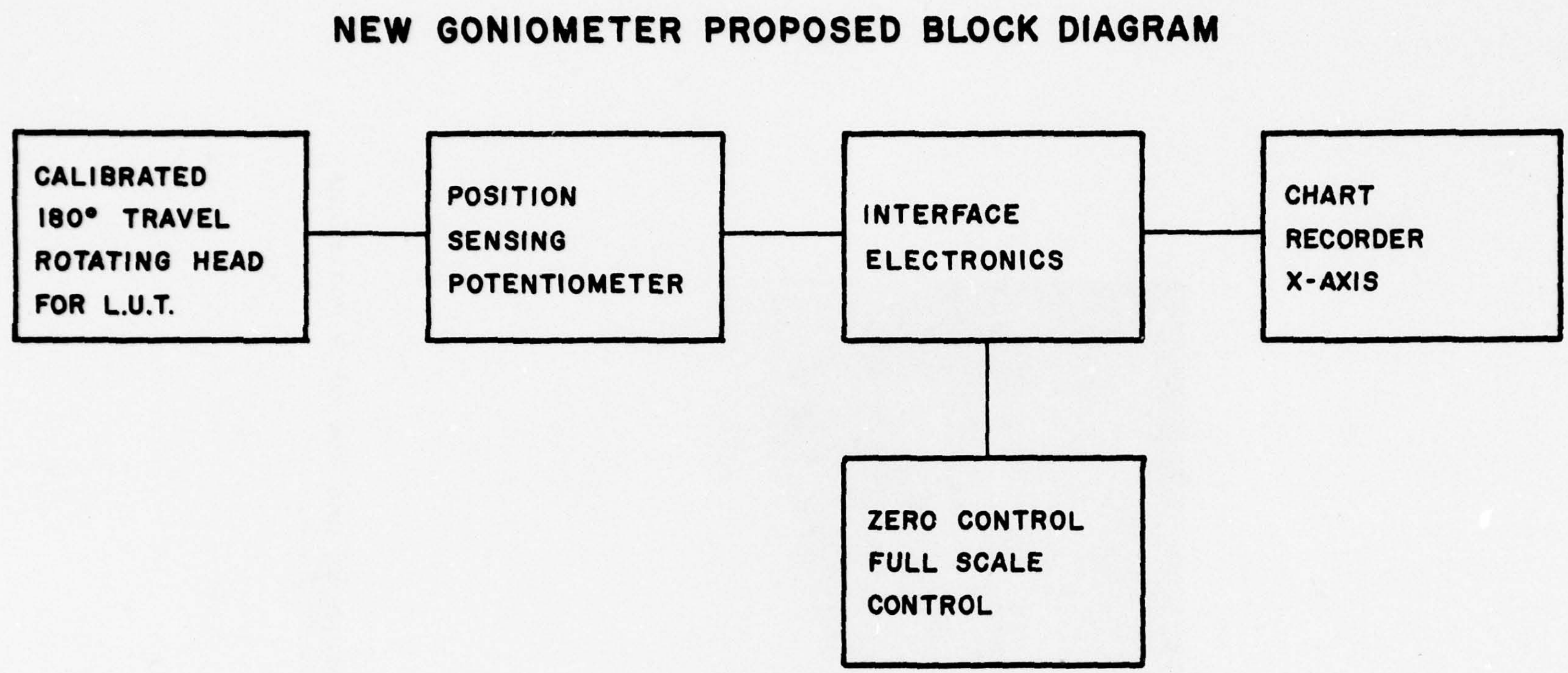


Figure 6. Proposed Block Diagram of New Goniometer (Far Field Measurement Apparatus).

simpler to use yet will afford wider and more versatile beam measurement with no loss in accuracy. The possibility of using a stabilized silicon avalanche photodiode for power measurement is being considered contingent upon how linear and amenable to calibration they are found to be. Goals for the future include full operation of the burn-in system, construction of the new goniometer, construction of a test head for thermal impedance measurement, and investigation into the characteristics of silicon avalanche photodiodes with respect to linearity and calibration against known standards.

2.3 Quality Assurance

Plans for assembly flow and quality assurance have been formulated. The quality assurance flow sheets (Table 1) outline the High-Rel test procedures that will be followed while testing the devices. The flow sheets will also provide a convenient means of tracking each lot through testing. The routing sheet will include procedures and limits for performance testing and, in addition to Table II of SCS-516, will be used for first article inspection as well as production run inspection. The quality assurance flow sheets will accompany the routing sheet through testing and will outline the more detailed test procedures while providing a handy reference for test personnel. An assembly flow block diagram (Figure 7) which will accompany

TABLE 1. QUALITY ASSURANCE FLOW SHEET.

ROUTE SHEET *

Customer ______________________

Device Type SCS-516

Lot No. ______________________

Serial No. Range ______________________

* Use this route sheet and table 2 attached for First Article Ins.

Operation	Date in / out	Quant. in / out	Serial No. of Failures	Test Procedure Paragraph
Process Conditioning (100% of all units)				
1.0 High Temp. Life 85°C, 48 hrs. min.				
2.0 Thermal Shock				
3.0 Constant Acceleration 1000g				
Burn-In 100% of all units				
1.0 Pre-Burn-In Measurement (100%)				
1.1 Peak Wavelength (800-830 nm)				
1.2 Peak Optical Power (200 mw min.)				
2.0 Burn-In: Ta = 25°C DF = 10%				

Operation	Date in / out	Quant. in / out	Serial No. of Failures	Test Procedure Paragraph
3.0 Post Burn-In Measurement				
3.1 Peak Wavelength				
3.2 Peak Optical Power				

Operation	Date in / out	Quant. in / out	Serial No. of Failures	Test Procedure Paragraph
GROUP A INSPECTION (ta=25°C ± 2°C				
Subgroup 1 (32 devices) 1.0 Visual and Mechanical Inspection				
2.0 Window				
3.0 Stripe Width a) Single (25μm max.) b) Triple (75μm max.)				
Subgroup 2 (45 devices) 1.0 Peak Wavelength (800-830nm)				
2.0 Peak Optical Power (200mw min.)				
Subgroup 3 (45 devices) 1.0 Thermal Impedance 10°C/W max.)				
2.0 Beam Width a) in junction plane b) Perpendicular to junc. plane				

Operation	Date in / out	Quant. in / out	Serial No. of Failures	Test Procedur Paragrap
GROUP B INSPECTION				
Subgroup 1 (LTPD=15) 1.0 Physical Dimensions				
Subgroup 2 (LTPD-15)				
1.0 Thermal Shock 10 cycles Cond. A., 85°C High -40°C Low				
2.0 Moisture Measurements				
3.0 End Points Measurements (Subroup 2, Group A Above)				
Subgroup 3 (LTPD-15) 1.0 Shock 500g, 5ms				
2.0 Vibration Fatigue				
3.0 Vibration, Variable Freq.				

Operation	in / out	in / out	Serial No. of Failures	Test Procedure Paragraph
4.0 Constant Acceleration 1000g				
5.0 End Points Measurement (Subgroup 2, Group A Above)				
Subgroup 4 (LTPD=7) 1.0 High Temp. Life T_a = 85°C				
2.0 End Point Measurements (Subgroup 2, Group A Above)				
Subgroup 5 (LTPD = 5) 1.0 Steady State Operating Life T_a = 25°C				
2.0 End Point Measurements Subgroup 2, Group A Above)				
GROUP C INSPECTION Subgroup 1 (LTPD = 15) 1.0 Thermal Shock 25 Cycles (Cond. A, 85°C High -40°C Low)				
2.0 End Point Measurements (Subgroup 2, Group A Above)				
Subgroup 2 (3 devices) 1.0 Resistance to Solvents				

Operation	in / out	in / out	Serial No. of Failures	Test Procedure Paragraph
2.0 End Point Measurements Subgroup 2, Group A Above)				
<u>Subgroup 3 (LTPD = 7)</u> 1.0 High Temp. Life T_a = 86°C, 1000 hrs.				
2.0 End Point Measurements (Subgroup 2, Group A Above)				
Subgroup 4 (25 devices) 1.0 Steady State Operating Life T_a =25°C, 2000 hrs.				
2.0 End Point Measurements (Subgroup 2, Group A Above)				

Table II.- First article inspection

Test	Reqt Para	Method	No of samples 2/ 3	5	7	10	25
Group A inspection	as specified	Table III 1/	To be performed on all units				
Group B inspection Subgroup 1	as specified	Table IV 1/	X				
Subgroup 2				X			
Subgroup 3					X		
Group C inspection Subgroup 1	as specified	Table V 1/	X				
Subgroup 2				X			
High temperature	3.13	Method 1031 of MIL-STD-750 T_a = 85°C for 1000 hrs				X	
Steady state operation life	3.14	Method 1026 of MIL-STD-750 T_a = 25°C for 2000 hrs I_p = (See 3.2) DF = 10%					X

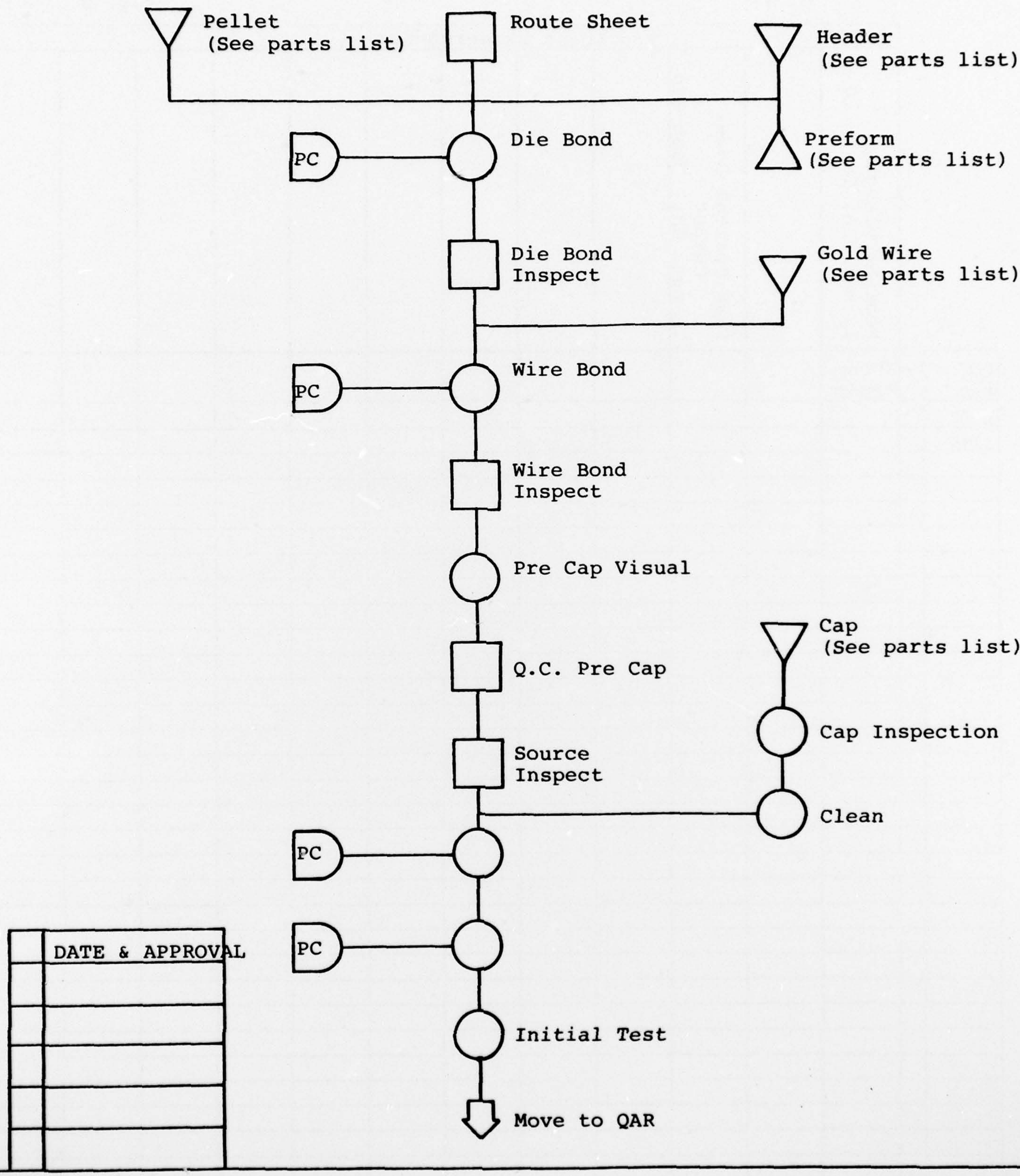
1/ LTPD values do not apply for first article inspection.

2/ No. of samples specified for each column shall be subjected to all the tests of that column.

3/ After 2000 hours, the P_{opt} shall equal 190 mW minimum.

		End Point Measurements											
		Peak Wavelength Ip max. 3A, Test 1.0		Peak Optical Power Output Ip max. 3A. Test 2.0									
Min. Max.		800nm 820nm											
DATE													
TIME													
INSP. BY													

Figure 7. Assembly Flow Block Diagram.



Assembly Flow Diagram
SCS-516

Customer: ______________________
Customer P/N: ______________________
LDL P/N: ______________________

routing documents through assembly will also be included and become a part of the lot history.

2.4 Device Performance

A number of devices fabricated from an earlier wafer were tested for power output and found to be well within specification. The wavelength, however, was found to be both out of tolerance and less uniform than expected. Corrective steps have been taken to remedy these problems as outlined in paragraph 2.1 Units to be fabricated from newly grown material promise to perform well in all respects, reflecting solution of the problems with the epitaxial growth sequence.

SECTION III

SUMMARY

A number of engineering problems have surfaced during the third quarter of this program, but progress toward the important goals has been significant. The epitaxial growth process has been refined further to allow production of material optimized to the specification. The design of the burn-in racks continues to evolve toward a more versatile and reliable system whose performance will meet the requirements of both burn-in and extended life test. Also, during this report period, new apparatus for specification testing has entered various stages of design and construction.

Goals for the next quarter include fabrication of

devices for the second engineering sample which meet specification, completion of the first group of burn-in positions, and commencement of the initial burn-in of these devices. Other goals include completion of the new goniometer, starting construction of the temperature controlled test pulser, and identification of a suitable substitute for the ITT F4000 tube.

APPENDIX A

Engineering Man-Hour Utilization for the Third Quarter of the Program.

	3rd Qrt.	Cumulative
R. B. Gill		138 Hrs.
T. E. Stockton	136 Hrs.	608 Hrs.
A. Gennaro	108 Hrs.	371 Hrs.
R. Albano	196 Hrs.	526 Hrs.
S. Klunk	124 Hrs.	280 Hrs.
Manufacturing Personnel	451 Hrs.	1078 Hrs.

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