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INJECTION LASER DIODES FOR FIBER OPTIC COMMUNICATIONS.(U)
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MANUFACTURING METHODS AND TECHNOLOGY ENGINEERING PROGRAM QUARTERLY TECHNICAL REPORT

Contract Number DAAB07-76-C-0040

INJECTION LASER DIODES FOR FIBER OPTIC COMMUNICATIONS

Prepared by:

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

Second Quarterly Report
for the Period 30 September 1976 to 31 December 1976

Approved for public release; distribution unlimited.

Placed by:

U. S. Army Electronics Command, Production Division
Fort Monmouth, N. J. 07703

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Thomas E. Stockton
Operations Manager

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for the Period 30 September 1976 to 31 December 1976

This project has been accomplished as part of the US Army Manufacturing and Technology Program, which has as its objective the timely establishment of manufacturing processes techniques or equipment to insure the efficient production of current or future programs.

REPORT DOCUMENTATION PAGE

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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 → over

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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	
	ROLE	WT	ROLE	WT	ROLE	WT
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 Communications 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.

The major program objectives for the second quarter of the program included finalization of the semiconductor laser chip configuration with regard to the active region thickness and stripe width, completion of the pill package design, and construction of the burn-in racks for lifetesting. In addition, the first lot of engineering samples was fabricated during the second quarter.

SECTION II

MANUFACTURING METHODS AND TECHNOLOGY ENGINEERING.

2.1 Materials Technology.

2.1.1 Liquid Phase Epitaxial Synthesis of Device Structures.

Primary effort expended during the second quarter of the program involved finalization of the epitaxial structure and optimization of the contact stripe width. Samples were grown during this period to determine the proper melt compositions and growth times required to yield structures compatible with the performance characteristics dictated by specification SCS-516. Of the epitaxial wafers synthesized during this period, DH-A-102 exhibited the most satisfactory performance with regard to output power, stripe width, peak wavelength and beam divergence. Triple stripe geometry injection laser diode chips fabricated from this particular wafer were eventually employed in the units delivered as first engineering samples. The performance characteristics of these units are discussed in detail under paragraph 2.4. Table 1 shows the melt compositions for wafer DH-A-102 as listed on the run sheet. Note that, in addition to melt compositions, growth conditions are listed as well as the layer thicknesses obtained from the photomicrograph of the cleaved and stained cross section of the wafer (Figure 1). GaAs ingot and slice numbers are recorded to maintain complete traceability throughout the entire LPE process. Vacuum readings less than 200 μm indicate system integrity and the absence of leaks. A hydrogen flow rate of 150 cc/min for a

TABLE 1.

Epitaxial Wafer Melt Compositions

Run # DH-A-102 Crystal # 7780 Job # 2043

Date 10-12-76 Slice # 24 Type Tri-Stripe

Bin #	GaAs gm.	Ga gm.	Dopants mg.	Growth Time Min.	Temp. °C	Layer Thickness μm
1	1	5	1 Te	2°C +5	853	1.6
2	1	5	1 Te; 3.5 Al	7	850	1.1
3	1	5	1 Te; 7.0 Al	7	849	1.1
4	1	5	10 Si; 1.0 Al	30 sec.	848	0.4
5	1	5	100 Ge; 7.0 Al	15	848	1.9
6	1	5	500 Ge	15	845	2.9
7	1	5	-	5	842	0.5
8	-	-	-	Wipe	841	-
9	-	-	-	-		
10	-	-	-	-		

acuum: 110 μm Flow Rate: 150cc/min Flush Time: 2 hr

at Ram: 0.8 ppm O_2 at Run : 0.8 ppm Surface Condition: Good

ents:

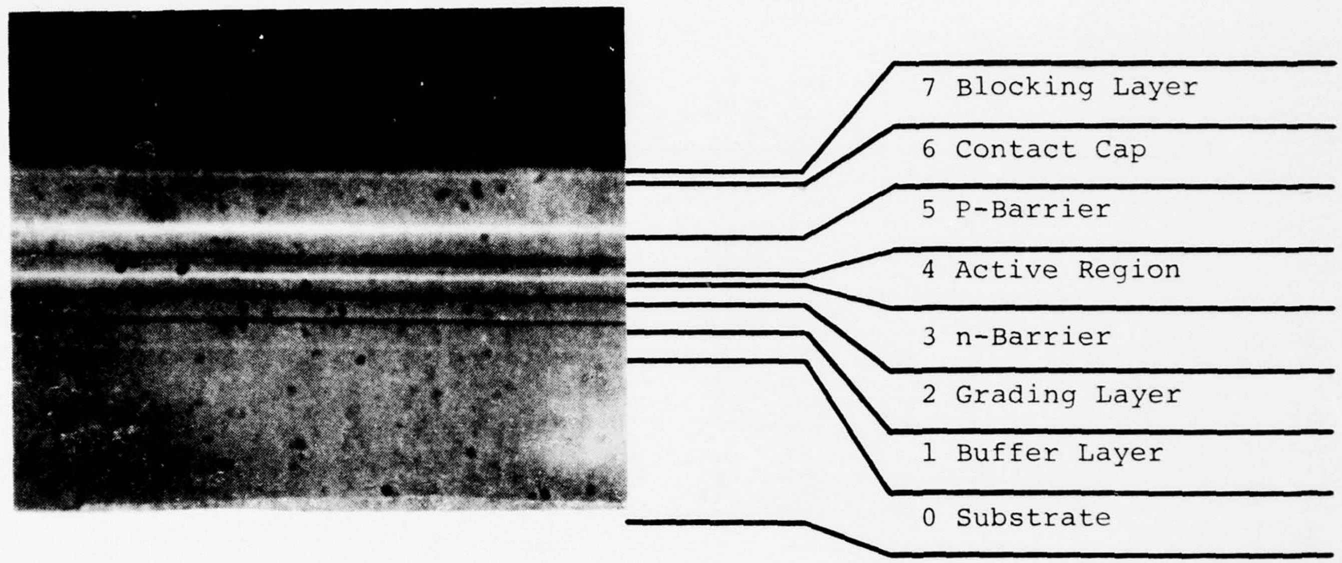


Figure 1. Photomicrograph of Cleaved Cross Section of Epitaxial Wafer DH-A-102.

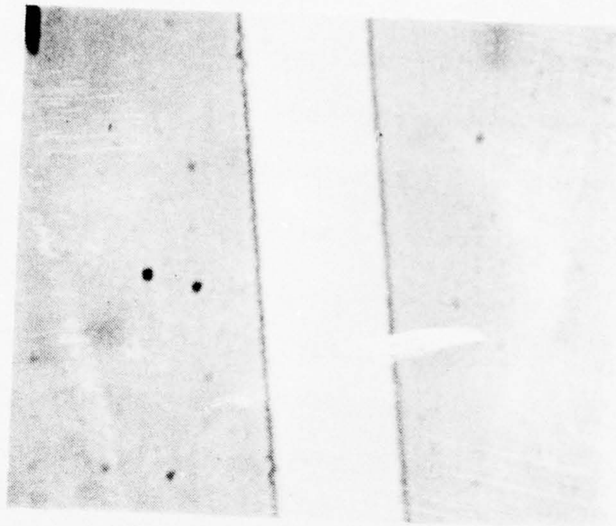
flush period of 2 hours is normally required to reduce the background O_2 level below 1.0 ppm. These conditions have been found to be absolutely essential for obtaining defect free crystal growth having the mirror like surface morphology required for high resolution photolithography.

Several important modifications to the epitaxial structure were carried out as a result of studies performed during the first quarter of the program. In order to obtain reasonably low threshold current densities ($< 2.0 KA/cm^2$), the active region thickness has been reduced to ~0.4 μm. Contact resistance, and hence thermal impedance, has been reduced slightly by eliminating the Aluminum previously used in the cap layer (melt #6) to limit lateral current spreading. Also, a lattice matching layer (melt #2), has been incorporated to reduce stress caused by the excessive mismatch between the n-type barrier (melt #3) and the straight GaAs buffer layer (melt #1). Recent reliability studies with double heterojunction room temperature CW lasers have demonstrated an improvement in lifetime using this technique. Normally, in longer wavelength devices, the lattice matching layer would not be required; but, because the bandgap step must be increased significantly in shorter wavelength lasers to maintain carrier and optical confinement, the discontinuity at the buffer-barrier interface can be reduced by using this intermediate layer. This technique is normally referred to as 'step-grading'.

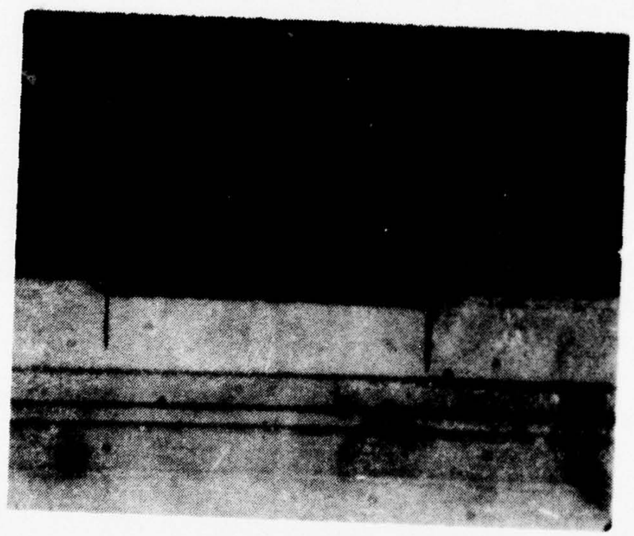
2.1.2 Wafer Processing.

Photolithography and chemical etching techniques for stripe geometry definition have improved considerably during the second quarter. Refinements in the techniques include improved optics for mask alignment, improved dust control in the photoresist facility, and accurate calibration of the etch rates for 3:1:1 H_2PO_3: H_2O:H_2O_2 in GaAs. For 14 μm wide rails, the etch rate is 0.09 μm/sec at 25°C in the blocking layer (~10^{16} n-type GaAs). The etch rate has been observed to depend strongly on the stripe width for exposed GaAs rails less than 10 μm wide. The etch rate increases linearly to approximately 0.25 μm/sec for 5 μm wide rails. This effect is responsible in part for the increased degree of difficulty encountered in channel definition for very narrow etched channel stripes.

The optimum stripe width required to obtain 25 μm optical source size as defined in SCS-516 (Appendix C) has been determined empirically to be between 14 μm and 16 μm. Stripe geometry consisting of 15 μm wide channels etched through the blocking layer of wafer DH-A-102 are shown in the photographs of Figure 2. Views from both the top surface and cleaved cross section of the wafer are indicated. After metallizing the wafer and cleaving into slivers, reflective SiO-Cr-Au optical coatings were applied to the rear facet of each sliver. The slivers were then cut into discreet triple element modules for use in the construction of the laser diodes delivered as first engineering samples.



Top
(X 1.1K)



Front
(X 2.7K)

Figure 2. Etched Contact Channel
(DH-A-102).

Implementation of the Al_2O_3 anti-reflective coatings is anticipated for the next report period. The e-Gun evaporation system required for the deposition of the optical coating is manufactured by Thermionics Laboratory, Inc. and consists of a multiple crucible water cooled source (Model 100-0051) in conjunction with a 3000 watt source control unit (Model 150-0030). The crucible assembly will be installed in a Consolidated Vacuum Corp. CV-18 vacuum system specially modified to accept the e-Gun apparatus.

2.2 Packaging Technology.

2.2.1 Package Design.

Finalization of the package design has been successfully accomplished during this report period. Mechanical and electrical comparison of both the Cu-ceramic and Cu-Mylar pill packages indicate relatively little difference in performance between the two types. Environmental test results for both types as reported under paragraph 2.4 Because of the inherent simplicity of the Cu-Mylar configuration shown in the blow up diagram in Figure 3, this package design has been chosen for use in fabrication of the second set of engineering samples. One important advantage to using this type of construction is the ease with which the window mating face can be lapped flat. Unlike the Cu-ceramic package, which consists of two very dissimilar materials, the Cu-Mylar package consists of materials all having approximately the same hardness. Hence, surface flatness consistent with a 0.001" epoxy inter-

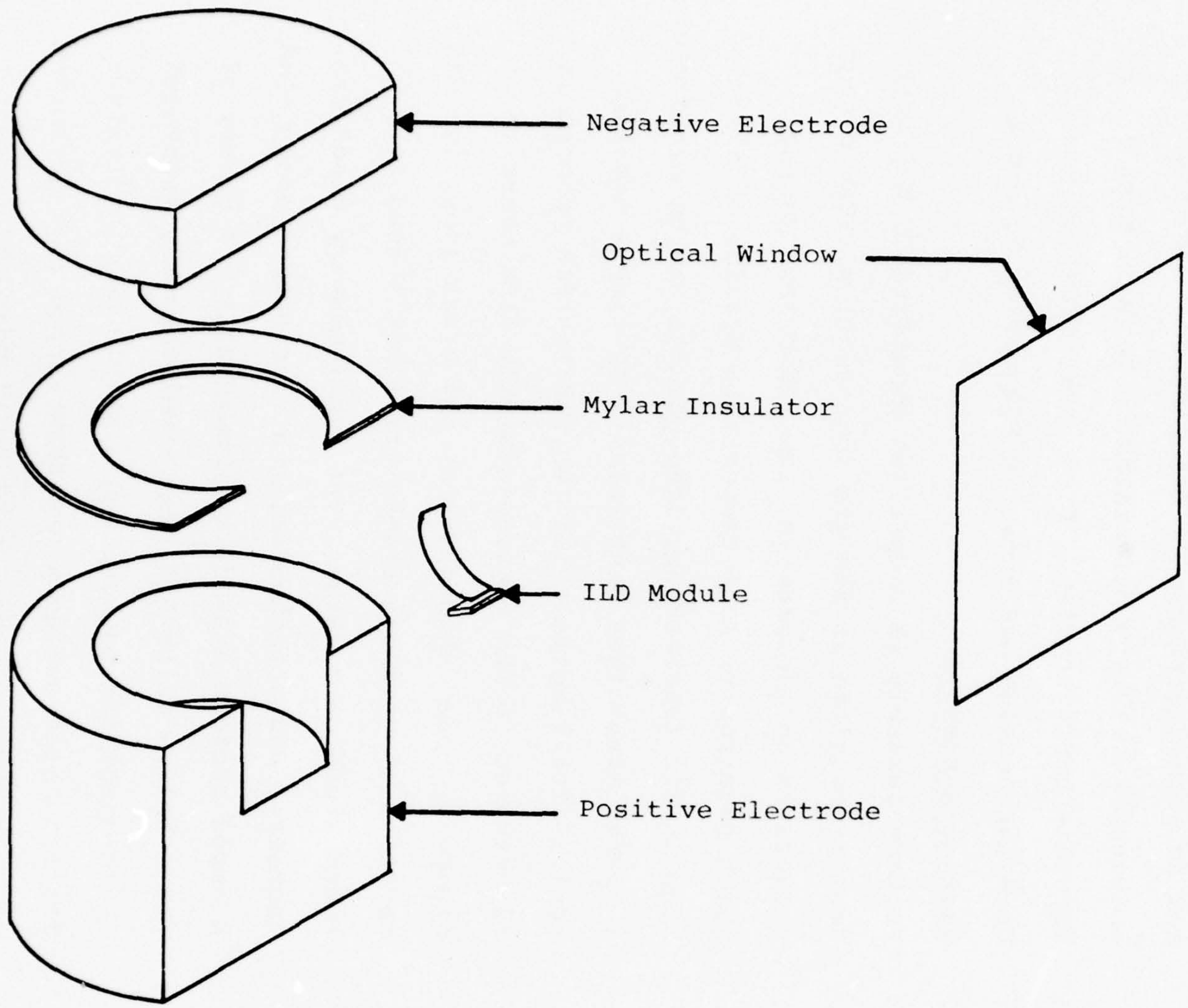
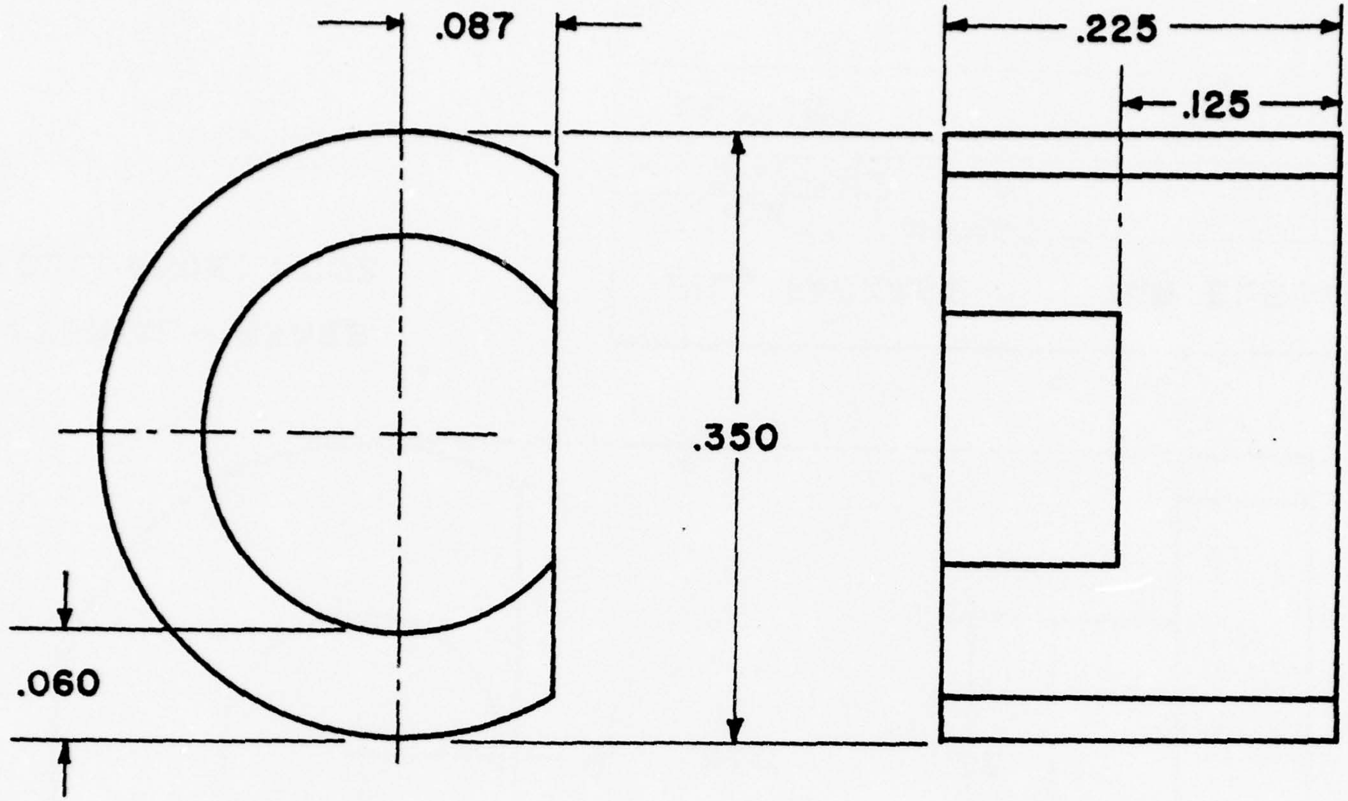


Figure 3. Blow-Up Diagram of Cu-Mylar Pill Package Construction.

face between the package and the optical window can easily be obtained. To reduce the overall capacitance of the package to below 8 pF, a 0.005" thick epoxy clad mylar preform is employed to attach the positive and negative terminals of the package. Package inductance has been calculated to be less than 0.8 nH for this configuration. Piece part drawings for the Cu-Mylar package are shown in Figures 4, 5, and 6.

2.2.2 <u>Package Assembly.</u>

Package assembly is simplified considerably using the design described in the previous section. The design results in an inexpensive, low inductance package which requires no high temperature brazing or alloying step in its fabrication. The package can be manufactured in large quantities with relatively simple machine tools. The simplicity of the fabrication process is illustrated in the package assembly flow chart in Figure 7. Disc shaped copper and brass (positive and negative electrodes) blanks are first turned from round stock on a lathe. The complementary discs are degreased and attached using a ring shaped epoxy clad stamped preform available commercially. A number of these hollow pills are then simultaneously truncated using a milling machine and a simple holding fixture. The truncated surfaces are then lapped flat, deburred, and the parts cleaned prior to standard Ni-Au plating. The packages are then electrically tested to eliminate any failures due to shorts through the mylar film or



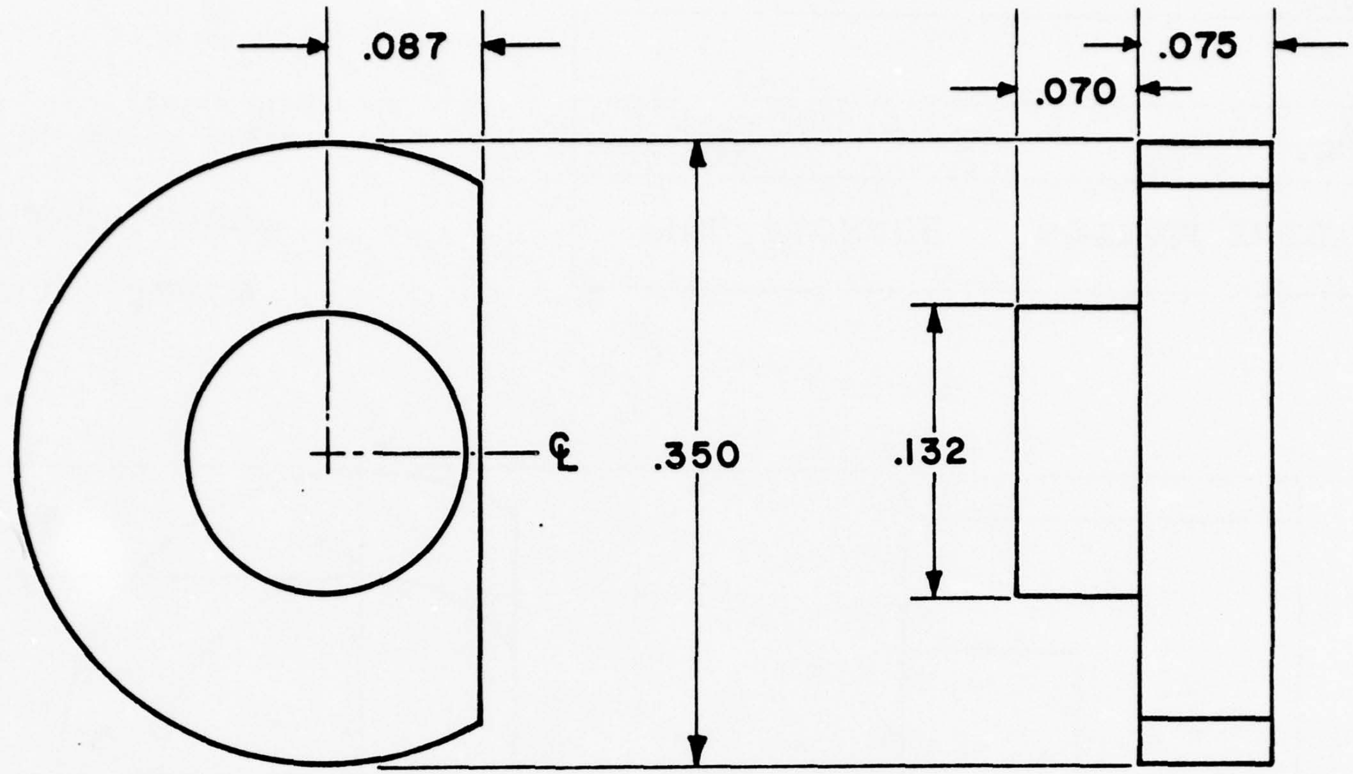
MATERIAL - Te - Cu

TOLERANCE: ±.002

Figure 4. Pill Package - Positive Electrode

PILL PACKAGE BOTTOM ELECTRODE		
SCALE: 10X	APPROVED BY	DRAWN BY
DATE: 11-9-76		M.R.
		DRAWING NUMBER

DIETZGEN NO. 196MF ACEPROOF "MASTER FORM"



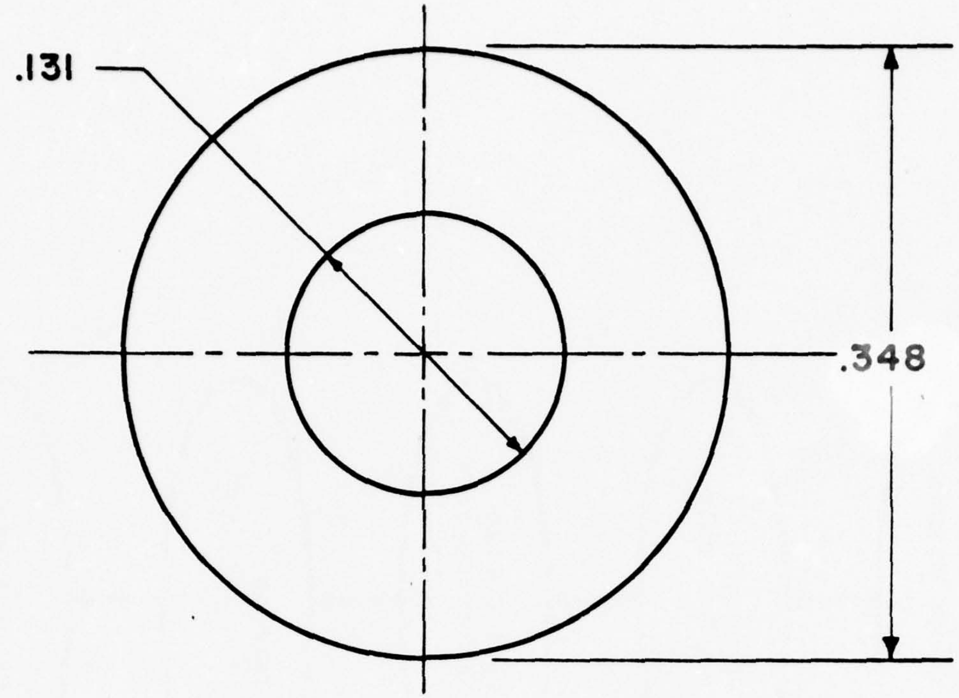
MATERIAL - BRASS

TOLERANCE: ±.002

Figure 5. Pill Package - Negative Electrode

PILL PACKAGE TOP ELECTRODE		
SCALE: 10X / DATE: 9-17-76	APPROVED BY	DRAWN BY M.R.
LDT-180		
		DRAWING NUMBER

"MASTER FORM"



MATERIAL – ABLEFILM 539 TYPE I

TOLERANCE: ±.002

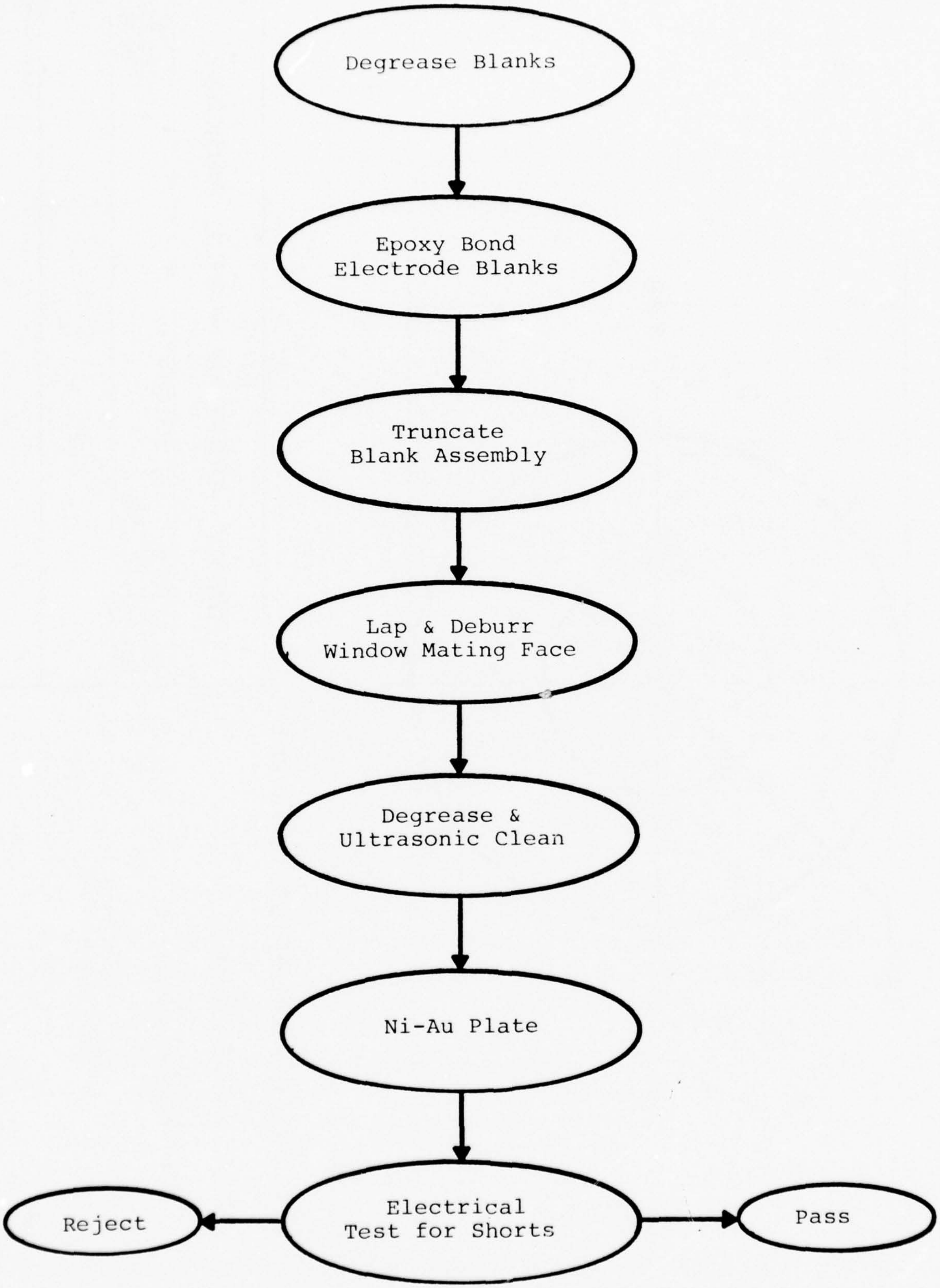
THICKNESS: .005

Fifure 6. Pill Package - Mylar Insulator

EPOXY PREFORM – PILL PACKAGE		
SCALE: 10X	APPROVED BY	DRAWN BY
DATE: 11-10-76		M.R.
		DRAWING NUMBER

DIETZGEN NO 196MF AGEPROOF "MASTER FORM"

Fogure 7. Flow Chart for Cu-Mylar Pill Package Fabrication.



plating bridges between the two electrodes.

2.3.2 Device Assembly.

After having prescreened modules using a low duty cycle pellet test to measure the threshold and output power of each chip, selected modules are mounted on the pill package. Indium is used to bond the module p-side down to the positive electrode and to attach the fly wire interconnect.

A new technique for attaching the optical window to the pill package was developed during this quarter of the program and was used in the fabrication of the first engineering samples. The preform previously used has been eliminated because of the difficulty encountered in obtaining a good seal between the window and the package. Air pockets which formed between the mylar film and the window were the primary cause of this problem. Also, the epoxy could not be fully cured at the recommended 150°C temperature without risking damage to the Indium bonded laser modules. The first attempt to attach optical windows using the temperature cured epoxy preforms resulted in complete destruction of the devices due to Indium migration over the P/N junction of the laser module. This difficult problem was solved by using a new UV curing optical epoxy to attach the windows. This epoxy is not available as a clad preform and must be applied as a liquid. Nevertheless, uniform bond line thickness less than 0.001" has been obtained regularly with this technique.

Norland Optical Adhesive 61 is a clear, colorless, liquid photopolymer that cures when exposed to ultra-violet light. Since it is an all solid materials system, it offers many advantages in bonding of optical elements where the bonding surface can be activated with light. The use of NOA 61 eliminates premixing, drying, or heat curing operations common to other optical adhesive systems.

The epoxy was designed to give the best possible bond to glass surfaces. More specifically it was designed to meet conditions of extreme temperature cycling and humidity for doublets and achromatic lenses such as those put forth by Mil. Spec. A-3920-B. It can be used in any application of glass to glass to metal where an extremely strong bond is needed.

Preliminary environmental tests with this non-hermetic packaging scheme have been extremely encouraging. Packages fabricated using these methods have successfully passed gross and fine leak tests corresponding to leak rates of less than 10^{-8} cc/sec. (MIL-STD-750, Method 1071, Condition H).

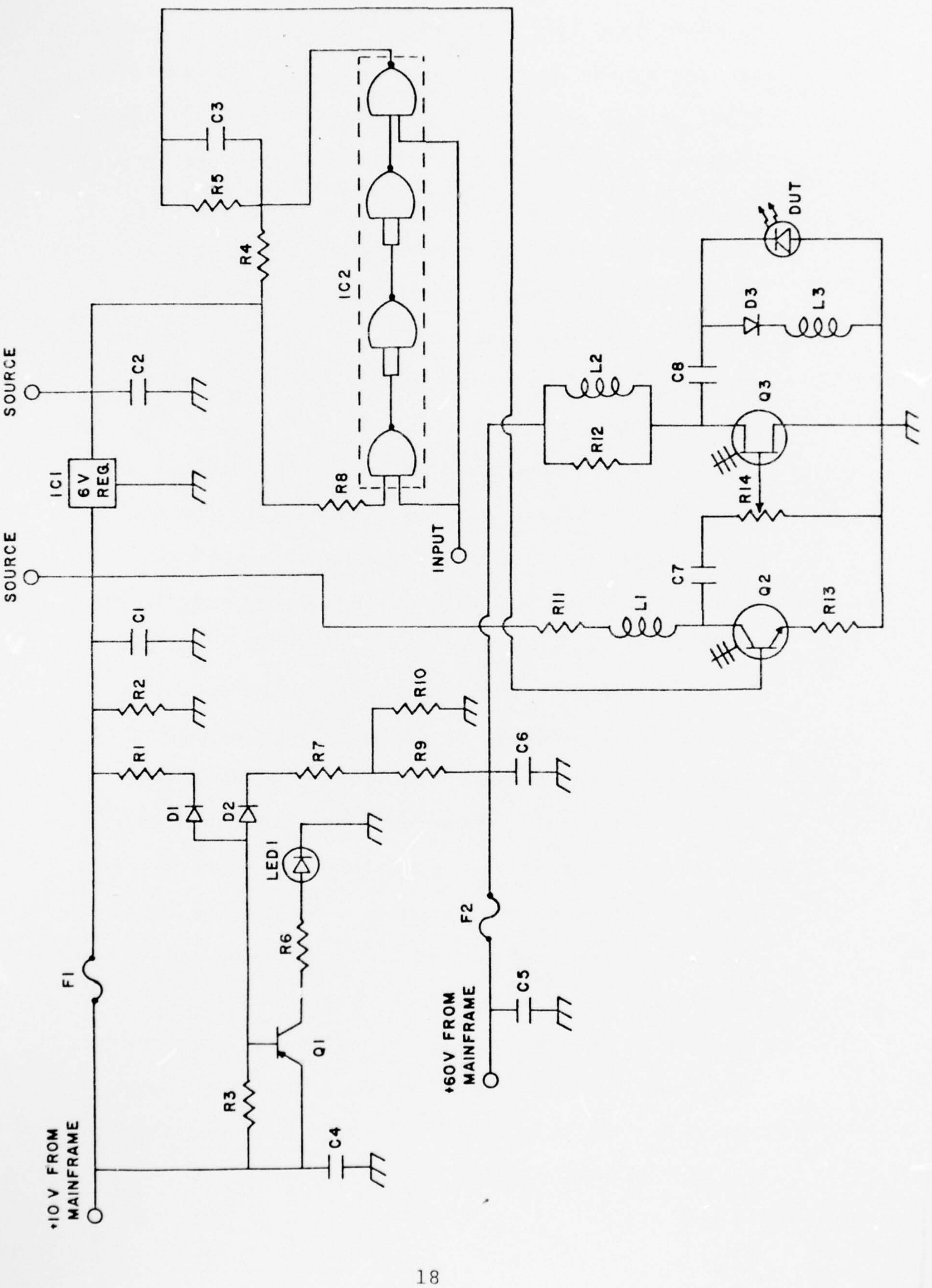
2.3 Test Equipment.

Numerous changes have been made in the design of the life test equipment. These changes have resulted in a simpler and more elegant circuit which is also more reliable and potentially versatile.

Difficulties were encountered with instability and oscillation when several positions of burn-in were operated in tandem. These problems were attributed to board land area size and layout, especially that related to the use of two output FET's in parallel. Also, it was suspected that cross coupling of pulses from one board to another introduced effects such as spurious triggering, probably due in part to the random interaction of the multiple oscillator running at slightly different frequencies. Other matters such as power dissipation and the need for circuit protection of individual boards added to the motivation for redesign.

Design changes have been made in each stage of the burn-in rack pulser circuit resulting in the new design shown in Figure 8. The output stage was changed from two FET's in pulse coupled mode to a single FET in capacitive discharge mode. Further, it was found that the power dissipation could be significantly reduced by changing from simple RC charging of the output capacitor to an inductive storage technique. These changes eliminated the single-board oscillation problems. The driver stage also was changed to an inductive storage arrangement similar to the output stage. In addition to reducing the driver power by a rather dramatic 80%, the new circuit offered the bonus of sufficient extra drive amplitude to allow the addition of a drive level control. The only change in the pulse conditioning circuit was the addition of a pullup resistor on the

Figure 8. Circuit Schematic for 10MHz ILD Life Test Driver (single position).



TTL gate output to improve its drive capability. The drive pulses for the board are now derived from a buffered common clock for the entire burn-in rack, rather than from individual on-board oscillators, partly in the interest of simplicity and partly to reduce potential board interactions. The common clock has its own independent power supply and comprises an improved Schottky TTL 10 MHz crystal controlled oscillator, buffered to drive the individual boards through lengths of coaxial cable. In addition to the changes, each position is individually fused and has a special circuit to detect and display the presence of a blown fuse.

Operation of the circuit is as follows. Two supply voltages, 10 volts @ 360 mA and 60 volts @ 300 mA, furnish all power required by one position. The input signal is a Schottky TTL compatible 10 MHz squarewave. This input signal is conditioned to a 10 NS pulse by IC2, whose output drives Q2 through R5 and C3. R4 is a gate pullup resistor. Current flows in Q2's collector circuit for 90 NS out of the 100 NS cycle, allowing current in L1 to reach a peak valve of 500 mA. When the 10 NS pulse occurs, Q2 switches off. The current cannot change instantly in L1, so it switches into C7 and R14 to generate a positive pulse of about 20 volts across R14. When Q2 turns on again after 10 NS, the pulse is terminated. C7 is sufficiently large to couple this transient without any DC level change over the cycle. R13 acts to limit the current in Q2 and R11 damps out unwanted oscillation in L1 by reducing its "Q". The position of R14 determines the level of drive to the gate of Q3 which in turn determines the peak amplitude of its current pulse. Between drive pulses, Q3 is not conducting and current flows through L2, D3, and L3 to charge C8 to about 60 volts. When Q3 is pulsed on, C8 discharges through the laser under test. The amplitude of this pulse depends on the final voltage on C8 before discharge, the value of C8. and the level of drive selected by R14. L3 serves to time delay the reverse recovery current long enough to prevent it from adding a tail to the laser current pulse. LED 1 will light to indicate if either F1 or F2 is open. When F1 and F2 are good, D1 is reverse biased by the 10 volt supply and D2 is reverse biased by the voltage derived from the voltage divider R9 and R10 connected to the 60 volt supply. Single D1 and D2 are reverse biased, no current flows in R1 or R7 and Q1 is held off by R3 and the LED is not lighted. If fuse F1 opens, D1 will now conduct with a current path through R1 and R2, causing base current to flow in Q1, causing current to flow in R6 and LED 1. If fuse F2 opens, D2 will conduct through R7 and R10, also turning on Q1 and LED 1. Either fuse, then, will cause the LED to light if it is open. IC1 is a monolithic 6 volt regulator which supplies power to IC2. Capacitors C1, C2, C4, C5, and C6 all bypass the power supplies to

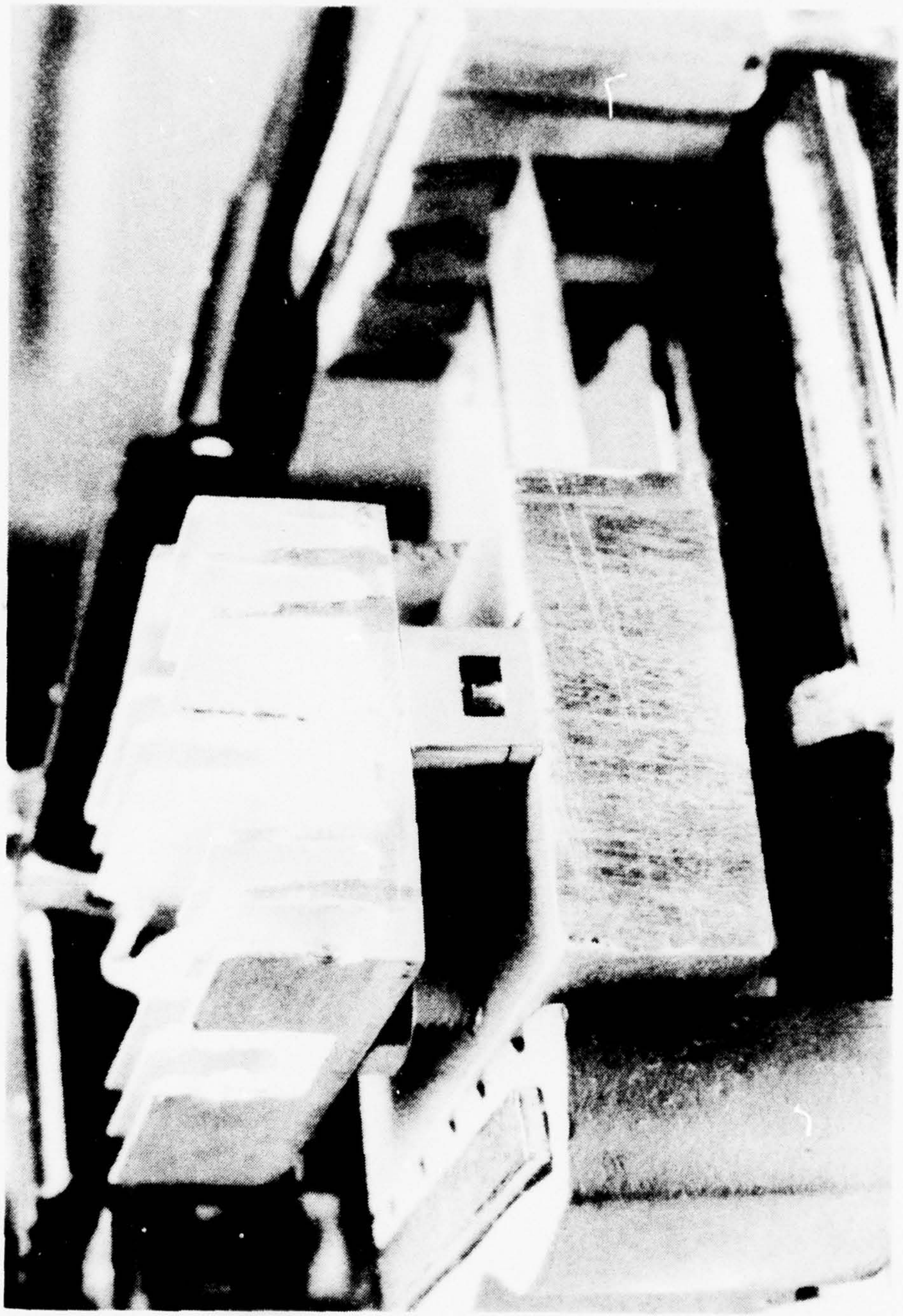
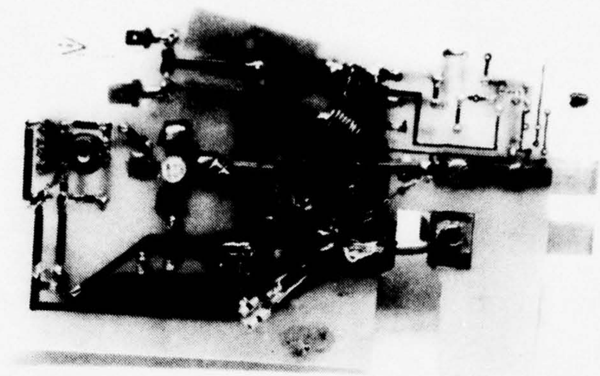
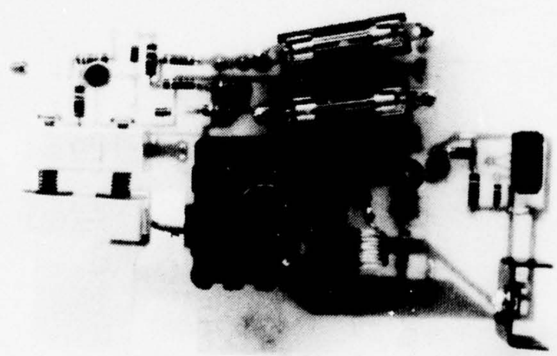


Figure 9. Photograph of Self-Aligning ILD Driver Clamp Assembly.



Front



Back

Figure 10. Photographs of ILD Driver
(single life test position).

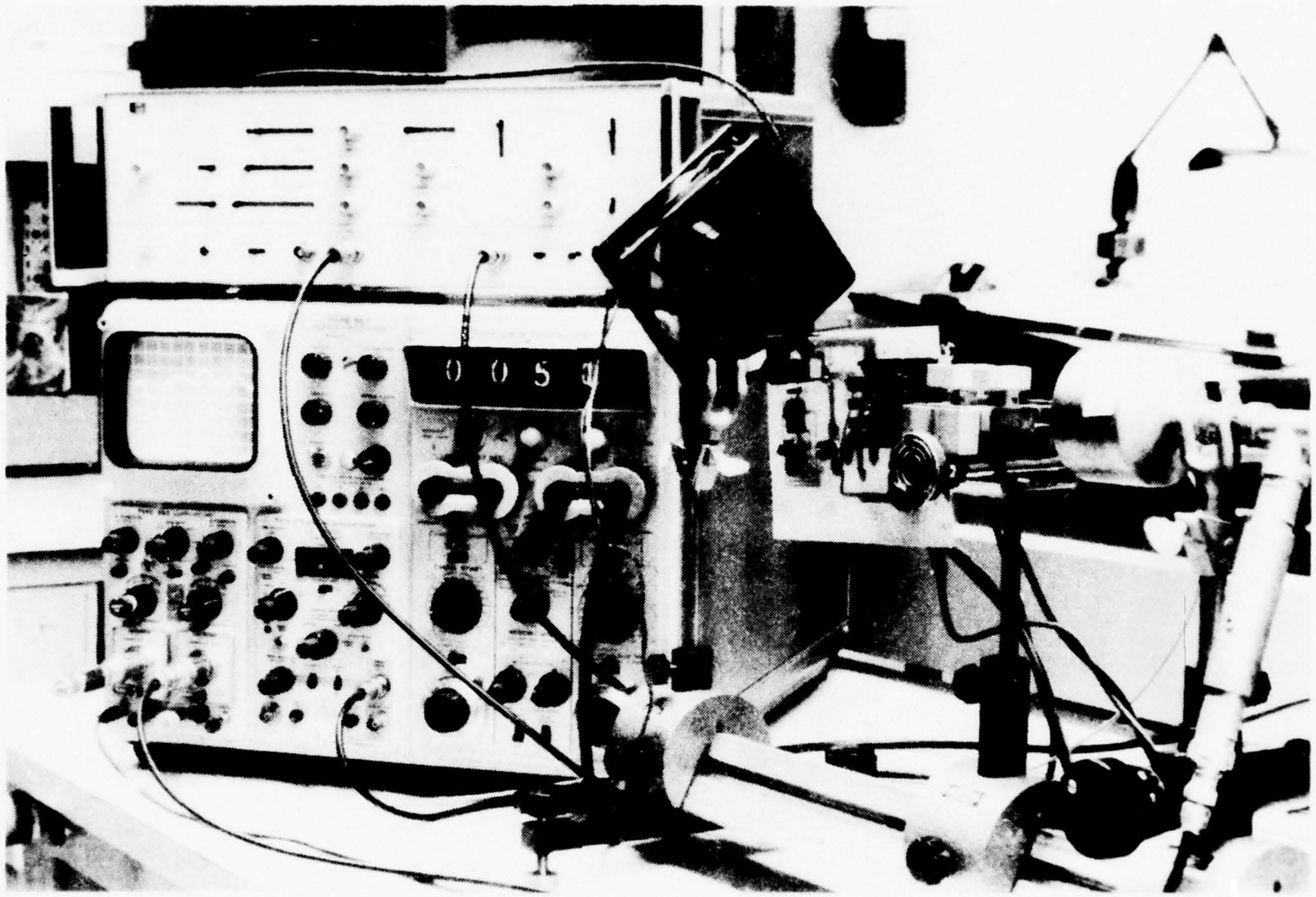


Figure 11. Photograph of Power Measurement Test Set.

TABLE 2

Parts List for 10MHz IL Driver
(Single Burn-In Position)

Item	Description
Q1	Fairchild 2N3906 Transistor
Q2	Communications Transistor Corp. D3-28 Trans.
Q3	Siliconix VMP-1 Mospower Fet
IC1	Fairchild 7806 6V Regulator
IC2	Fairchild 9S00 TTL Quad. Nand
D1,2	1N4004 Silicon Diode
D3	Fairchild FD600 Silicon Diode
LED1	Visible Red Led
C1.2,3,4	0.1μF GMV 50V Epoxy Monolithic Cap
C5	0.1μF GMV 100V Epoxy Monolithic Cap
C6	0.056μF ± 10% 80V Film Cap
C7	0.017μF ± 10% 80V Film Cap
C8	0.001 μF ± 10% 100V Orange Drop Cap
L1	8 Turns on 1/2" Mandrel 18 gA Copper
L2	8 Turns on 1/2" Mandrel 18 gA Copper
L3	2 Turns on 1/2"Mandrel 18 gA Copper
F1,2	AGC 3/4" 0.75A 250V Fuse
R1	10K 1/2W 10% Carbon Resistor
R2	2.2K 1/2W 10% Carbon Resistor
R3	10K 1/2W 10% Carbon Resistor
R4	220Ω 1/2W 10% Carbon Resistor
R5	100Ω 1/2W 10% Carbon Resistor
R6	470Ω 1/2W 10% Carbon Resistor
R7	10K 1/2W 10% Carbon Resistor

TABLE 2. (Continued)

Item	Description
R8	1K 1/4W 10% Carbon Resistor
R9	8.2K 1/2W 10% Carbon Resistor
R10	2.2K 1/2W 10% Carbon Resistor
R11	10Ω 1/2W 10% Carbon Resistor
R12	47Ω 2W 10% Carbon Resistor
R13	10Ω 1/2W 10% Carbon Resistor
R14	500Ω 1/4W 20% Carbon Trimmer Potentiometer

TABLE 3

Parts List for Common Clock Board.

Item	Description
C_9	68 PF ± 10% Silvered Mica Cap
C_{10}	180 PF ± 10% Silvered Mica Cap
C_{11}	500 μF ± 20% Electrolytic Cap
C_{12}	3.3 μF ± 20% Electrolytic Cap
C_{13}	0.1 μF GMV Epoxy Monolithic Cap
R_{15}	220Ω 1/2W 10% Carbon Resistor
XTAL	10 MHZ Crystal
T_1	12.6V AC 2A Transformer
IG_3	Fairchild 9S00 Schottky TTL Quad. Mand
$IC_{4,5}$	Fairchild 9S04 Schottky TTL Hex Inverter
IC_6	Fairchild 7806 6V Regulator
$D_{4,5,6,7}$	1N4004 Silicon Diode

ground.

A new circuit board layout incorporating all of the changes and additions has been designed and is in production. The fixture which holds, connects, and heatsinks the laser under test has been redesigned for improved ease of laser inspection and removal. The new design is also self-aligning to the laser package. Figure 9 shows a photograph of the triple stripe LED mounted in the new spring loaded heat sink. The actual board layout for a single burn-in position is shown in Figure 10. An overall view of the power measurement test set is shown in Figure 11. Parts lists for the modified version of the 10MHz driver and the common clock board are given in Tables 2 and 3 respectively.

The F4000 vacuum photo diode has proven to be somewhat marginal in its ability to resolve power levels much less than 100 mW peak. For this reason, an effort to determine a suitable high speed detector which can be cross calibrated at higher power levels with the F4000 is currently underway.

2.4 Device Performance.

The first set of 10 engineering samples fabricated during this report period was characterized with respect to the more important parameters outlined in specification SCS-516 (Appendix C). Threshold current, output power, peak wavelength, beam divergence, near field uniformity, and environmental tests were carried out in order to obtain a preliminary evaluation of overall device performance. Not all tests required for confirmatory sample acceptance were performed since, at the end of this report period, much of the specialized test equipment, including burn-in racks, is still in the process of being designed and built.

2.4.1 Output Power and Drive Characteristics.

Table 4 outlines output power measurements performed on the first set of engineering samples fabricated from epitaxial wafer DH-A-102. The maximum duty factor which could be obtained using the first generation IL driver as limited to 2.5% (1.0MHz, 25 nsec at the drive currents necessary to obtain reasonable output power levels. This is due in part to the high threshold currents obtained for this first group of samples in conjunction with the limited drive capability of the pulser. As stated in paragraph 2.3, the problems associated with the test pulser are currently being resolved through rather extensive design modifications. It can be seen from the data that higher than expected threshold current densities for this structure are responsible for the marginal performance of these units (~ 5 KA/cm^2). Peak emission wavelength for these units is within specification however. Further reduction in the cavity thickness from 0.4 μm to 0.2 μm will be required to obtain threshold currents below 1.5A. This modification should result in output power levels in excess of 230 mW at 2.5A based on the differential

TABLE 4

TEST DATA

First Engineering Samples

Wafer # DH-A-102

Unit #	Ith A	Po mW	@	Imax. A	λ peak nm
A1	3.4	128		4.0	805
A2	3.5	88		4.0	822
A3	1.8	360		3.0	815
A4	3.2	160		4.0	814
A5	3.2	128		4.0	818
A6	2.8	208		3.5	815
B1	2.6	176		3.5	804
B2	3.2	264		4.0	812
B3	1.8	296		3.0	814
B4	2.6	224		4.0	812

Test Conditions: Repitition Rate - 1.0 MHz
Pulse Width - 25 nsec.

efficiencies obtained from the data in Table 4 (η=230mW/A overdrive).

2.4.2 Far Field Beam Characteristics.

Typical far field intensity distributions parallel and perpendicular to the plane of the junction are shown in Figures 12 and 13 respectively. These measurements were performed using a motor driven goniometer, and X-Y plotter in conjunction with the ITT F4000 vacuum photodiode. A new manually driven goniometer specifically designed for use with the triple stripe geometry IL device is planned for completion during the next report period. Multiple parallel transverse modes can be distinguished clearly in Figure 12.

2.4.3 Near Field Uniformity.

Qualitative measurements of the element to element uniformity were performed using a silicon vidicon tube and camera arrangement shown here in the photograph of Figure 14. In general, most of the units did not exhibit uniform element to element intensity in the triple stripe array. Small variations in I_{th} of as little as 50 mA between elements was sufficient to cause severe nonuniformity in the near field. In at least one instance, only one element of the parallel array lased. Reducing the cavity width is expected to eliminate this problem also since the slight differences in threshold current among the elements are thought to be due to differences in lateral current leakage for each element. Reducing the cavity thickness to .2 μm

Figure 12. Far Field Intensity Distribution
Parallel to Junction Plane.

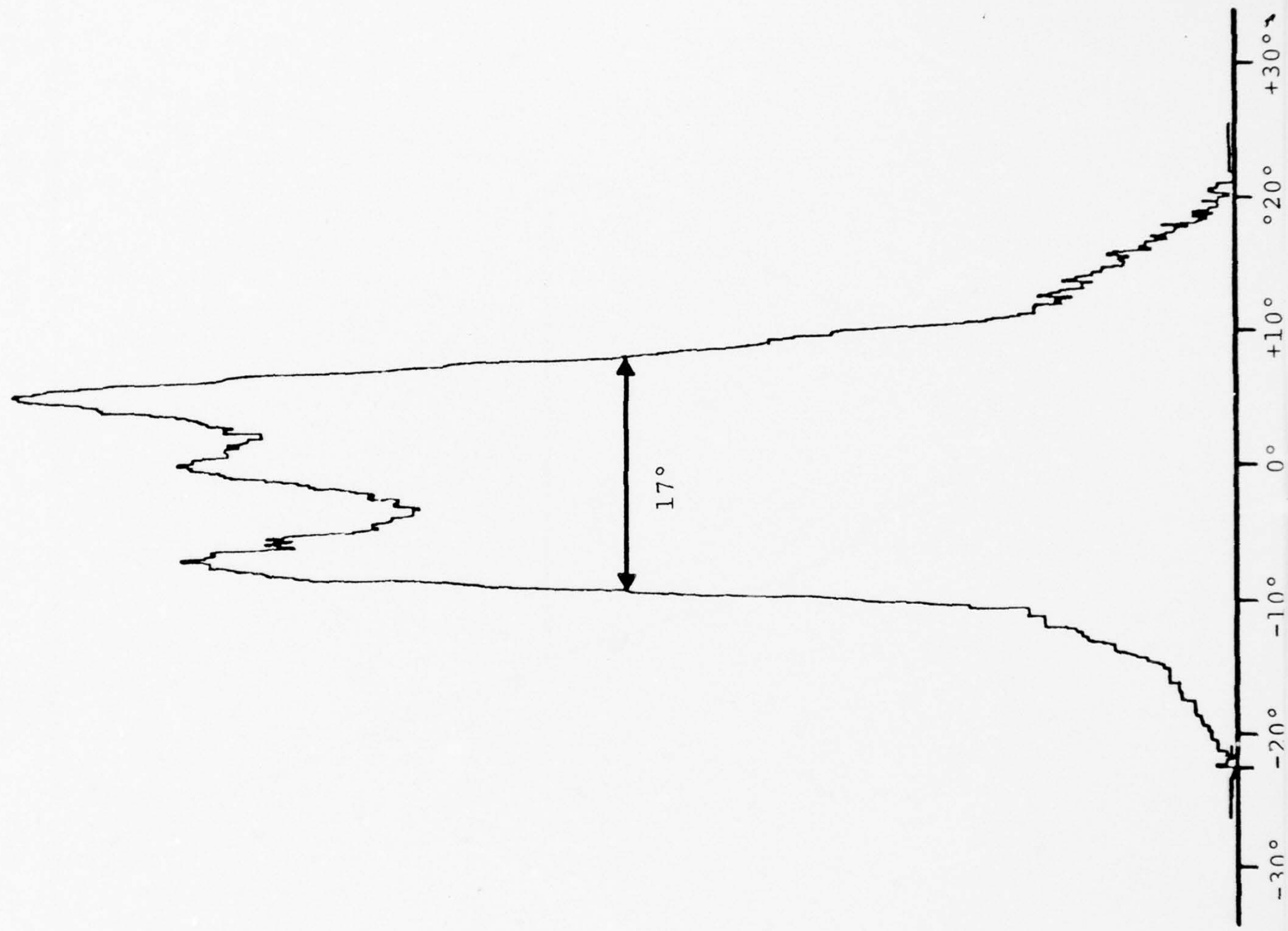
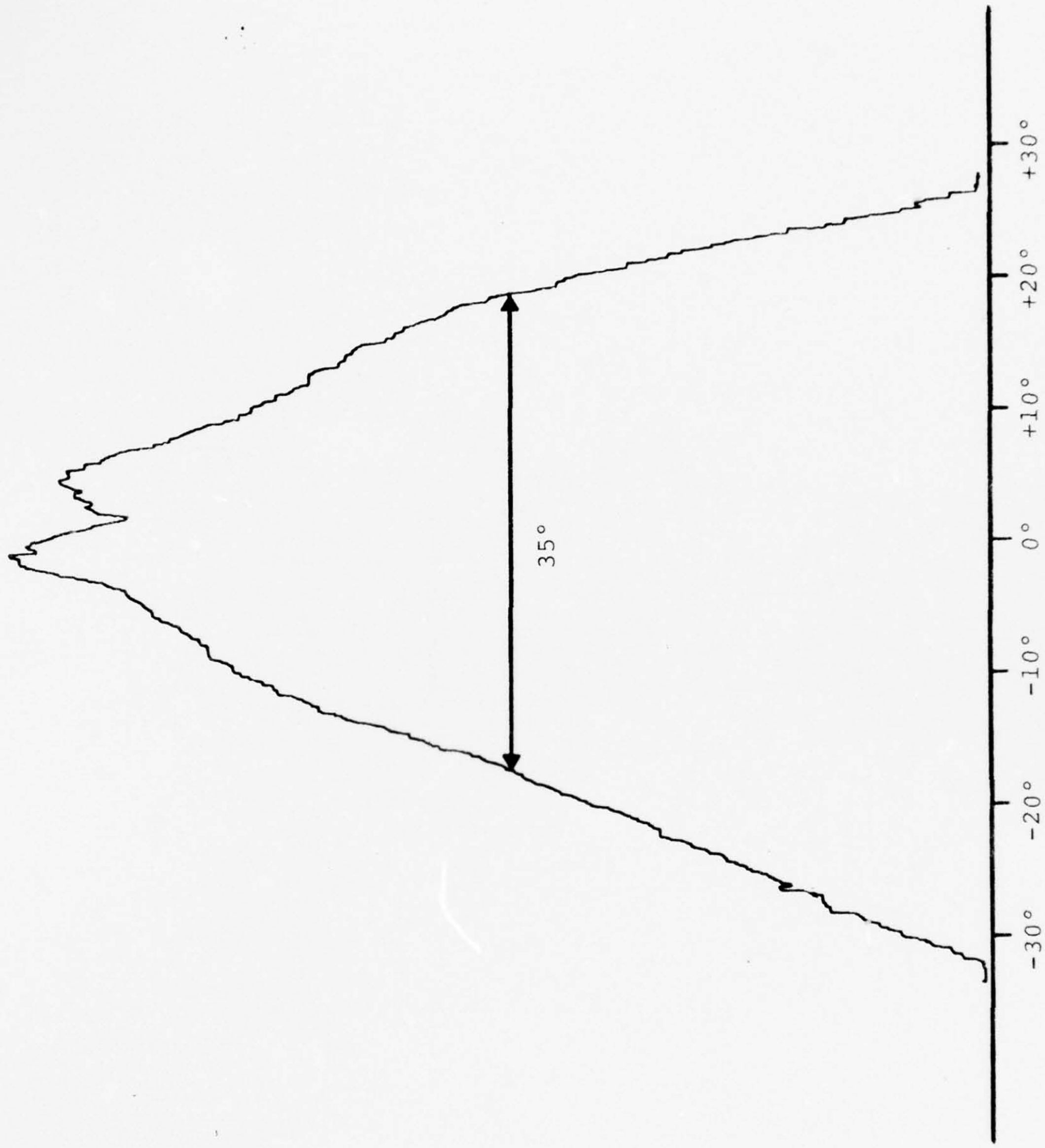


Figure 13. Far Field Intensity Distribution Perpendicular to Junction Plane.



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2.2 Other publications.- The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation

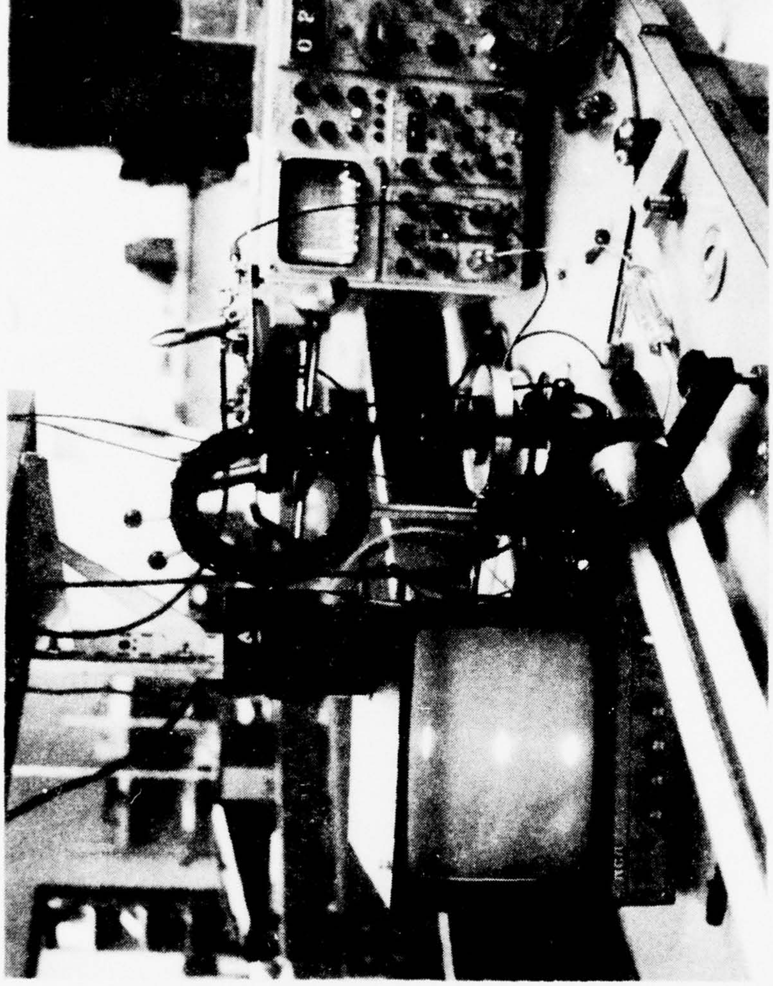

Figure 14. Near Field Element Uniformity Display Set Up.

3.5 Marking.- Marking shall be in accordance with MIL-S-19500 except the following information shall be marked on each unit.

TABLE 5.

ENVIRONMENTAL TEST REPORT

TO:	Laser Diode Laboratories, Inc.	DATE:	January 5, 1977
	205 Forrest Street	P.O. NO.	5286
	Metuchen, New Jersey 08840	ATL JOB NO.	T-4616
ATTENTION:	Mr. Steve Lerner	ITEMS TESTED	10 - Special Lasers

Associated Testing Laboratories, Inc. certifies that the above referenced devices have been subjected to Environmental Tests as set forth in the referenced purchase order.

TEST	SPECIFICATION	TEST METHOD	QUANTITY ACCEPTED	QUANTITY REJECTED
Thermal Shock	MIL-STD-202	107, Con. A	10	0
Acceleration	MIL-STD-750B	2006, 1,000g	10*	0
Vibration	MIL-STD-750B	2056	10*	0
Shock	MIL-STD-750B	2016.2	10*	0

*Following these tests some parts were noted to have small cracks in various corners. Parts are to be evaluated by Laser Diodes Laboratories, Inc.

Approved by:

Edwin C. Barlow - Project Engineer

will tend to lessen current spreading considerably.

2.4.4 Environmental Testing.

Both types of pill package construction were built and tested as part of the first engineering sample submission. 'A' units in Table 4 were of the Cu-Mylar variety while 'B' units were Cu-ceramic types. Both types faired extremely well in thermal shock, acceleration, vibration, and mechanical shock as shown in the test report submitted by ATL, the independent testing facility selected for use in this program. As stated previously in paragraph 2.3.2, samples of the Cu-Mylar pill package has also successfully passed MIL-STD-750, Method 1071 for hermiticity. (See Table 5.)

SECTION III

SUMMARY AND CONCLUSIONS

The second quarter of the program has witnessed finalization of the semiconductor laser chip configuration required to yield performance characteristics satisfying the requirements of specification SCS-516. The chip design is a monolithic triple stripe geometry double heterojunction structure having an active region thickness between 0.2 μm and 0.3 μm and individual stripe widths of 14 μm to 16 μm each. The cavity length is nominally 250 μm with HR rear facet coatings applied to the chip.

Also during this report period, the optimum package configuration has been determined for use in the second engineering sample submission. The Cu-Mylar pill package incorporating an optical window attached via UV cured epoxy has proven to be the design most compatible with specification requirements and manufactureability.

Preliminary evaluation of the first set of engineering samples fabricated and tested during this report period has demonstrated manufactureability of the triple stripe geometry ILD in accordance with the requirements set forth in specification SCS-516. Although device performance was marginal in some respects, the appropriate modifications to the device design required for conformance can be implemented in a straightforward manner.

Difficulties encountered in the design and construction of the life test racks have been clearly identified and appropriate steps to rectify these problem areas are currently underway.

Plans for the third quarter of the program include fabrication and testing of the second set of engineering samples. Completion of a sufficient number of burn-in and life test positions for the 2000 hour life test of these samples is also scheduled. Installation of the e-Gun apparatus and construction of specification test apparatus will also be undertaken during the next quarter.

APPENDIX A

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

T. E. Stockton	96 Hrs.
A. Gennaro	109 Hrs.
S. Klunk	70 Hrs.
R. Albano	170 Hrs.
Manufacturing Personnel	627 Hrs.

APPENDIX B

BIOGRAPHIES OF KEY PERSONNEL.

Robert B. Gill

Robert Gill received the B. S. degree in physics from Fairleigh Dickinson University in 1963 and the M. S. degree in physics from Stevens Institute of Technology in 1967.

Mr. Gill was employed at RCA Laboratories in 1963, where he was primarily engaged in the development of semiconductor devices, including lead-salt infrared photoconductive and photovoltaic detectors and thin-film gallium arsenide solar cells. His responsibilities included the preparation and characterization of materials, device design and evaluation, and process development.

In 1968, Mr. Gill transferred to the Optoelectronic Products Department of the RCA Solidstate Division where he was assigned to Semiconductor Engineering. His primary responsibilities were the solution of problems associated with GaAs, (GaAl)As, and GaP single and multiple epitaxy and the design of electroluminescent devices including injection lasers and visible and infrared emitters utilizing these materials. His work in these areas contributed to the design and development of the first commercial GaAs and (GaAl)As single heterojunction and LOC injection laser and laser arrays.

In 1971, Mr. Gill joined the staff of Laser Diode Laboratories, Inc., as Operations Manager, Devices, and became the President in 1973. In this position he is in charge of R & D as well as production engineering on materials, designs and processes for the injection lasers and laser arrays.

Under his direction Laser Diode Laboratories, Inc., developed and was the first to introduce into commercial sale:

(a) a continuous wave room temperature GaAlAs laser diode

(b) a radiation resistant, heterojunction light emitting diode

(c) a high power, high duty cycle, triple heterojunction, stacked laser array

(d) a fiber optic coupled version of the preceding device, and

(e) a 820 nm light emitting diode which was qualified for use as an infrared source in the Goggle Program.

Mr. Gill is author or co-author of 19 technical and scientific papers.

Thomas E. Stockton

Thomas Stockton was graduated with high distinction in Physics from Rutgers University where he received his Bachelor's Degree in 1971.

Mr. Stockton was employed at RCA Laboratories in 1972 where he was primarily engaged in Optoelectronic device research, design, fabrication and testing. Primarily responsible for the development of multi-heterojunction injection lasers, his assignments included crystal growth, liquid phase epitaxy, contact development, diffusion technology and all aspects of device processing and assembly. His significant achievements included development of a high power LOC laser for optical communications and fuzing, CW operation of AlGaAs multiple heterojunction lasers, degradation studies leading to improved high damage threshold semiconductor lasers, and a cold cathode electron emitter.

Mr. Stockton joined the staff at Laser Diode Laboratories, Inc., in the fall of 1974 as Operations Manager, Devices.

Among the programs concluded under his leadership, were the introduction of the first commercial room temperature continuous wave injection laser and the development of several fiber optic coupled GaAs arrays capable of emitting up to 350 watts from a .040 inch planar aperture.

He has co-authored one paper and holds a patent for a defect free liquid phase epitaxial process. Mr Stockton is a member of Phi Beta Kappa and the IEEE.

Albert Gennaro

Mr. Gennaro received the B. S. degree in physics from Fairleigh Dickinson University in 1958. From 1958 to 1960 he pursued graduate studies in physics at Stevens Institute of Technology.

From 1960 to 1962 Mr. Gennaro was employed by the Solid State Division of Bendix Corporation where he was engaged in the design and development of transistors and diodes. In 1962 he joined the Solid State Division of RCA where he worked as a product development engineer in the development of designs and processes for the fabrication of transistors and integrated circuits. In 1972 Mr. Gennaro joined Laser Diode Laboratories as Manufacturing Manager GaAs Crystal Production. He later transferred to the device operation at Laser Diode Laboratories.

He currently is Manager, Product Development within the device operation. In his current capacity, Mr. Gennaro is responsible for device design and the development of processes required for the fabrication of heterojunction LED's suitable for use as sources in high speed communication applications.

In addition, Mr. Gennaro is responsible for the design and fabrication of all fiber optic coupled light emitting diodes, laser diodes and laser array package assemblies.

Steven Klunk

Steven Klunk received the A.A. Diploma in Engineering Technology from Cleveland Institute of Electronics in 1969 and has attended the University of Maryland.

From 1961-1967, Mr. Klunk was with the U.S.A.F. where he was engaged in photographic systems repair and maintainance.

In 1967, he joined Perkin Elmer Corp where he worked as a field engineer on HF systems. From 1969 to 1972 Mr. Klunk was with the Applications Group of RCA's Optoelectronic Products Activity. At RCA his primary responsibilities included the design and fabrication of laser modulators, and burn-in and life test equipment for support of that activity's injection laser product development effort.

Mr. Klunk joined Laser Diode Laboratories, in 1972 as an applications engineer. In this capacity he has been responsible for the design and fabrication of special laser diode modulators, test equipment and laser illuminator systems. He is currently engaged in the development of LDL products intended for use in the modulation of room temperature CW laser diode at rate ranging from 10 to 500 Megahertz.

Mr. Klunk has co-authored two technical papers on modulators and modulator design for pulsed operation of laser diodes.

Robin Adair

Mr. Adair earned his B.S. EE degree at New Jersey Institute of Technology, graduating Cum Laude in 1975. His senior project won awards from both NJIT and the IEEE, and was published by the IEEE.

He joined Laser Diode Laboratories in 1976 as an Applications Engineer and is responsible for design and fabrication of electronic support and test equipment for semiconductor diode lasers. He is currently developing burn-in, test, and modulator circuits for both high duty cycle lasers and high radiance communications LED's.

INJECTION LASER DIODE FOR USE IN FIBER OPTIC COMMUNICATIONS

1. SCOPE

1.1 Scope.- This specification covers the detail requirements for Gallium Aluminum Arsenide (GaAlAs) injection laser diodes having a wavelength of 820 nanometers (nm). The injection laser (IL) devices shall incorporate the physical and electrical characteristics compatible with fiber optic cables and systems employing the use of fiber optics.

1.2 Recommended operating conditions: $I_P = 3A$

$T_a = 20°C$

$V_F = 2.0\ V$ at $I_P = 3A$

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids or request for proposals, form a part of this specification to the extent specified herein:

SPECIFICATIONS

MILITARY

MIL-C-675	Coating of Glass Optical Elements.
MIL-S-19500	Semiconductor Devices, General Specification for.

STANDARDS

MILITARY

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts.
MIL-STD-750	Test Methods for Semiconductor Devices.

(Copies of documents required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer. Both title and number or symbol should be stipulated when requesting copies.)

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2.2 Other publications.- The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

Laser Parameter Measurements Handbook, by H. G. Heard.

(Application for copies should be addressed to John Wiley & Sons, Inc., New York, N.Y.)

3. REQUIREMENTS

3.1 General description.- The IL devices are double heterojunction (DH) devices used at high data rates at a wavelength of 820 nm and shall be compatible with fiber optic cables. The operating temperature range shall be 20°C to 30°C.

3.2 Performance characteristics.- Performance characteristics shall be as specified in Tables III, IV and V. I_p is the value of the current to obtain peak pulse optical output power equal to 200 mW and shall have a minimum value of 3A. (See 4.6.5). I_p shall be determined for each device. This I_p value shall be the I_p value used for each device throughout the remainder of the document.

3.2.1 Process conditioning.- All units shall be process conditioned. (See 4.5.1).

3.2.2 Burn-In.- All units shall be burned-in. (See 4.5.2).

3.3 Design, construction, and physical dimensions.- The design, construction and physical dimensions shall be as specified in Figures 1, 2, and 3 and herein.

3.3.1 Metals.- External metal surfaces shall be corrosion resistant or shall be plated or treated to resist corrosion.

3.4 Window.- The window shall contain no strain or cracks over the entire diameter and be free from optical distortion and lens effects over the central 0.303 inch diameter. The window shall be anti-reflection coated on both surfaces for a wavelength of λ = 820 nm. The coating shall conform to the abrasion resistance requirement of MIL-C-675.

3.5 Marking.- Marking shall be in accordance with MIL-S-19500 except the following information shall be marked on each unit.

(a) Date code.
(b) Manufacturer's identification.
(c) Part number: SCS-516

3.6 Resistance to solvents.- When the device is subjected to solvents, there shall be no evidence of: (a) mechanical or electrical damage, (b) deterioration of the materials or finishes, and (c) illegibility of case marking.

3.7 Solderability.- Leads shall be solderable.

3.8 Thermal shock.- After being subjected to specified temperature cycling, there shall be no evidence of defects or damage to case, leads, or seals or loss of marking legibility.

3.9 Shock.- After being subjected to a shock of 500g for .5 msec, there shall be no evidence of defects or damage to leads or seals. Also, the device shall be electrically operable (see Subgroup 2 of Table III).

3.10 Vibration fatigue.- After being subjected to a vibration with a constant peak acceleration of 20g minimum and a frequency of 60 ± 20 Hz for at least 32 ± 8 hours, there shall be no evidence of defects or damage to case, leads or seals. Also, the device shall be electrically operable (see Subgroup 2 of Table III).

3.11 Vibration, variable frequency.- After being subjected to a vibration with a constant peak acceleration of 20g minimum and a frequency range between 100 and 2000 Hz, there shall be no evidence of defects or damage to case, leads, or seals. Also, the device shall be electrically operable (see Subgroup 2 of Table III).

3.12 Constant acceleration.- After being subjected to a constant acceleration of 1000g for 1 minute in each of its orientations, there shall be no evidence of defects or damage to case, leads, or seals. Also, the device shall be electrically operable (see Subgroup 2 of Table III).

3.13 High temperature life.- After being stored at 85°C for the specified time there shall be no evidence of defects or damage to case, leads or seals or loss of marking legibility. Also, the device shall be electrically operable (see Subgroup 2 of Table III).

3.14 Steady state operation.- After being subjected to steady state operation (I_F = 100 mA) for the specified temperature and time, the device shall be electrically operable (see Subgroup 2 of Table III).

3.15 Moisture resistance.- After being subjected to the specified humidity and temperature cycling, there shall be no evidence of corrosion of external metal surfaces. Also, the device shall be electrically operable (see Subgroup 2 of Table III).

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4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspection.- Inspection shall be classified as follows:

(a) First article inspection (does not include preparation for delivery). (See 4.4).

(b) Quality conformance inspection. (See 4.5).

4.3 Test plan.- The contractor prepared Government-approved test plan, as cited in the contract, shall contain:

(a) Time schedule and sequence of examinations and tests.

(b) A description of the method of test and procedures.

(c) Identification and brief description of each inspection instrument and date of most recent calibration.

4.4 First article.- Unless otherwise specified in the contract, the first article inspection shall be performed by the contractor.

4.4.1 First article units.- The contractor shall furnish 50 samples for first article inspection.

4.4.2 First article inspection.- The first article inspection shall consist of Table II and all the tests included in the Government-approved test plan (See 4.3), to show compliance with the requirements of section 3. No failures shall be permitted.

4.4.2.1 Order of testing.- Prior to first article inspection, all units shall have been process conditioned followed by burn-in. (See 4.5.1 and 4.5.2).

4.5 Quality conformance inspection.- Quality conformance inspection shall consist of the examinations and tests specified for Group A inspection (Table III), Group B inspection (Table IV), and Group C inspection (Table V). The following shall apply:

(a) Prior to performing Group A inspection, all units shall be subjected to the tests specified in paragraphs 4.5.1 and 4.5.2.

(b) If the manufacturer chooses the following option(s) for testing, the sample units that are to be used in Group C inspection shall be designated as such prior to conducting the referenced Group B tests. Moreover, the number of failed diodes to be counted for lot acceptance or rejection as a result of Group C test shall be equal to all failed diodes of the test in Group B inspection, which were predesignated for use in Group C inspection, plus any additional failures occurring during Group C testing.

(1) For subgroup 3 life test in Group C inspection, the manufacturer has the option of using all or a portion of the sample already subjected to 340 hours of Group B life testing for an additional 660 hours of testing to meet the 1,000 hour requirement.

(2) For the thermal shock (temperature cycling) test of Group C inspection, the manufacturer has the option of using all or a portion of the sample already subjected to 10 cycles of Group B thermal shock (temperature cycling) testing for an additional 15 cycles of testing to meet the 25-cycle requirement.

4.5.1 Process conditioning.- Process conditioning shall be performed on 100 percent of the units. The measurement and sequence shall be as specified in Table I.

4.5.2 Burn-In.- Burn-In shall be performed on 100% of the units for 168 hours minimum under the following conditions:

$I_p =$ (See 3.2)

$T_a = 20°C$

DF = 10%

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4.5.2.1 Pre-burn-in measurements.- Prior to burn-in, measurement of the parameters listed in subgroup 2 of Table III shall be performed on 100% of the units at $T_a = 25°C$.

4.5.2.2 Post burn-in measurements.- Post burn-in measurements, listed in subgroup 2 of Table III, shall be performed within 8 hours of the removal of bias conditions at 25°C. The values observed for each device shall not exceed the following, relative to the pre-burn-in measurements:

$$\Delta \lambda_p = 1\%$$

$$\Delta P_{opt} = 1\%$$

Table I.- Process conditioning

Test	MIL-STD	Method No.	Details
High temperature life (non-operating)	750	1031	Storage temperature = 85°C Storage time = 48 hours minimum
Thermal shock	202	107	Test Condition A except t(high) = 85°C; t(low) = -40°C; time at temperature extremes = 15 minutes maximum
Constant acceleration	750	2006	1,000 g

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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 life	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.

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Table III.- Group A inspection
T_a = 25°C ± 2°C unless otherwise specified

Test	Condition	Test Method	Min	Max	units	LTPD
Subgroup 1						7
Visual and mechanical inspection		Method 2071 of MIL-STD-750	See 3.3			
Window		4.6.1				
Stripe width	I_p = (See 3.2) t_p = 10 ns DF = 10%	4.6.3				
(a) single			25		µm	
(b) triple			75		µm	
Subgroup 2						5
Peak wavelength	I_p = (See 3.2)	4.6.4	800	830	nm	
Peak optical pulse power output	I_p = (See 3.2)	4.6.5	200		mW	
Subgroup 3						5
Thermal impedance	I_p = (See 3.2) t_p = 10 ns	4.6.6	10		°C	
Beam width	I_p = (See 3.2) t_p = 10 ns	4.6.7				
(a) in junction plane			15		angular degrees	
(b) perpendicular to junction				40	angular degrees	

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Table IV.- Group B inspection

Test	Reqt Para	MIL-STD-750 Method	Condition	LTPD
Subgroup 1				15
Physical dimensions	3.3	2071	See Figures 1, 2 & 3	
Subgroup 2				15
Thermal shock (temperature cycling)	3.8	1051	Test Condition A except t(high) = 85°C; t(low) = -40°C; 10 cycles; time at temperature extremes = 15 minutes maximum	
Moisture resistance	3.3.1, 3.15	1021		
End point measurements: Subgroup 2 of Table III				
Subgroup 3				15
Shock	3.9	2016	Non-operating 500 g	
Vibration fatigue	3.10	2046	Non-operating	
Vibration, variable frequency	3.11	2056	Non-operating	
Constant acceleration	3.12	2006	force applied = 1,000 g	
End point measurements: Subgroup 2 of Table III				
Subgroup 4				7
High temperature life (non-operating) (See 4.5(b))	3.13	1032	T_a = 85°C	
End point measurements: Subgroup 2 of Table III				
Subgroup 5				5
Steady state operation life	3.14	1027	I_p = (See 3.2) at 50°C DF = 10% (See 6.2) t_p = 10 ns at R_p = MHz	
End point measurements: Subgroup 2 of Table III				

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Table V.- Group C inspection

Test	Reqt Para	MIL-STD-750 Method	Details	LTPD
Subgroup 1				15
Thermal shock (temperature cycling) (See 4.5(b))	3.8	1051	Test Condition A_1 except t(high) = 85°C; t(low) = -40°C; time at temperature extremes = 15 minutes, min; total test time = 72 hrs, max	
End point measurements: Subgroup 2 of Table III				
Subgroup 2				3 devices no failur
Resistance to solvents (See 4.6.2)	3.6	Method 215 of MIL-STD-202		
End point measurements: Subgroup 2 of Table III				
Subgroup 3				7
High temperature life (non-operating) (See 4.5(b))	3.13	1031	T_a = 85°C for 1000 hrs	
End point measurements: Subgroup 2 of Table III				
Subgroup 4				5
Steady state operation life	3.14	1026	I_p = (See 3.2) T_a = 25°C for 2000 hrs DF = 10% (See 6.2)	
End point measurements: 1/ Subgroup 2 of Table III				

1/ Limits of subgroup 2 Table III same except P_{opt} = 190 mW min.

4.6 Test methods and conditions.- Conditions and methods of examination and test shall be as specified in Tables I, II, III, IV and V and as follows:

4.6.1 Window.- Visual inspection shall be made to insure there are no cracks or optical distortions in the window.

4.6.2 Resistance to solvents.- Resistance to solvents shall be performed in accordance with Method 215 of MIL-STD-202.

4.6.3 Stripe width.- The stripe width size can be determined by using a microscope objective and a normal lens (for projection) combination with a magnification of at least 200X. The image shall be scanned in the junction plane with a calibrated ITT Phototube #F4000 (see 6.3), masked with an 0.5 mm slit. Slit shall be perpendicular to the direction scanned. The relative intensity shall be measured until it falls to 90% of its peak value. These boundaries will define the stripe width. (See Figure 4).

4.6.4 Peak wavelength (λ_p).- Peak wavelength shall be measured using a grating spectrometer with a resolution of at least one angstrom.

4.6.5 Peak optical pulse power (P_{opt}).- P_{opt} is measured using a calibrated ITT Phototube #F4000 terminated into 50 ohms positioned at a distance of 1.5 cm with a rectangular aperture of width .39 cm and length 1.03 cm. (See Figure 6). (See 6.3).

4.6.6 Thermal impedance.- With unit mounted on a heat sink capable of being heated above room temperature, it is driven at 0.1% duty cycle to minimize self-heating effects. Measurements of peak output wavelength (λ_p) versus temperature (T) from 20°C to 40°C are recorded. In order to take into account its own heating effect, unit is then operated at 20°C and at 10% duty cycle. The peak output wavelength is then recorded under these conditions. The voltage drop (V_D) across the output of the unit is then measured. (See 6.2).

4.6.7 Beam width.- A calibrated ITT Phototube #F4000 (see 6.3), shall be mounted on a turntable and masked with a small aperture so that is angular resolution is at least one degree. The distance between the unit and the detector shall be at least 20 cm. The relative intensity shall be measured until its value falls down to 50% of its peak value. This area will define the beam width. The beam width in angular degrees is measured in both the junction plane and in the plane perpendicular to the junction plane. (See Figure 5).

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5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging and packing.- Units shall be prepared for delivery as specified in the contract.

6. NOTES

6.1 Abbreviations, symbols, and definitions.- The abbreviations, symbols, and definitions are as follows:

DF	duty factor
I_p	input pulse current
P_{opt}	peak pulse optical power output
T_a	ambient temperature
t_p	pulse width at 3 db point
R_p	pulse repetition rate
V_F	forward voltage
λp	peak wavelength

6.2 Calculation of thermal impedance (Z_t).- Thermal impedance can be calculated by taking the slope (α) of the curve λ vs temperature measured in 4.6.6 and the following:

$$Z_t = \frac{\Delta T}{\Delta P} \quad \text{where } \Delta P = I_p \times VD \times DF \text{ and } DF = T_p \times t_p$$

$$\Delta T = \frac{\Delta \lambda}{\alpha} \quad \text{where } \Delta T, \text{ and } \Delta\lambda \text{ are taken from graph}$$

6.3 Method for calibration of ITT phototube #F4000.- This information can be found on pages 180 to 190 in "Laser Parameter Measurements Handbook." Manufacturer's calibration is acceptable if traceable to an NBS standard.

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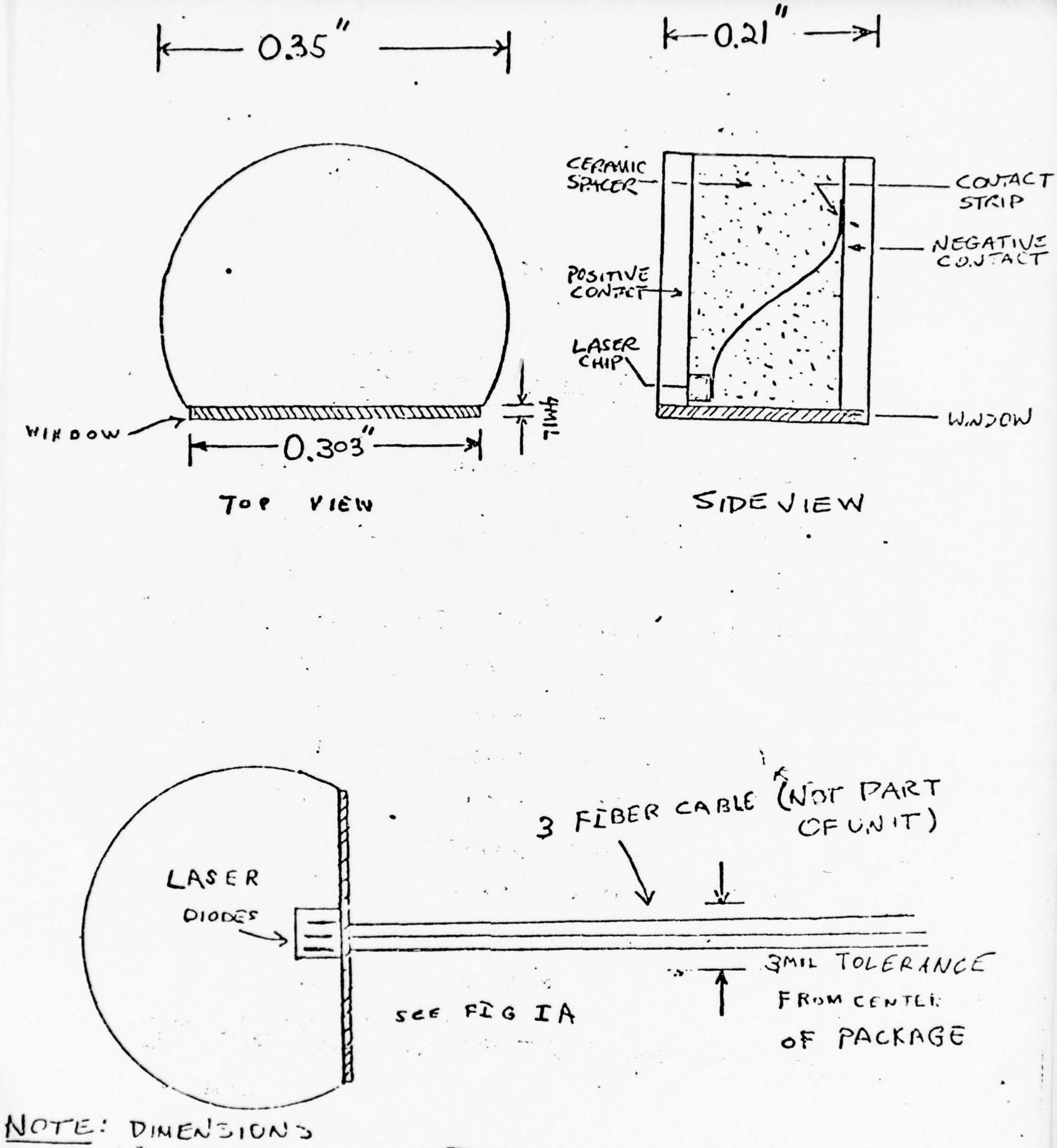

FIG. 1. Laser package

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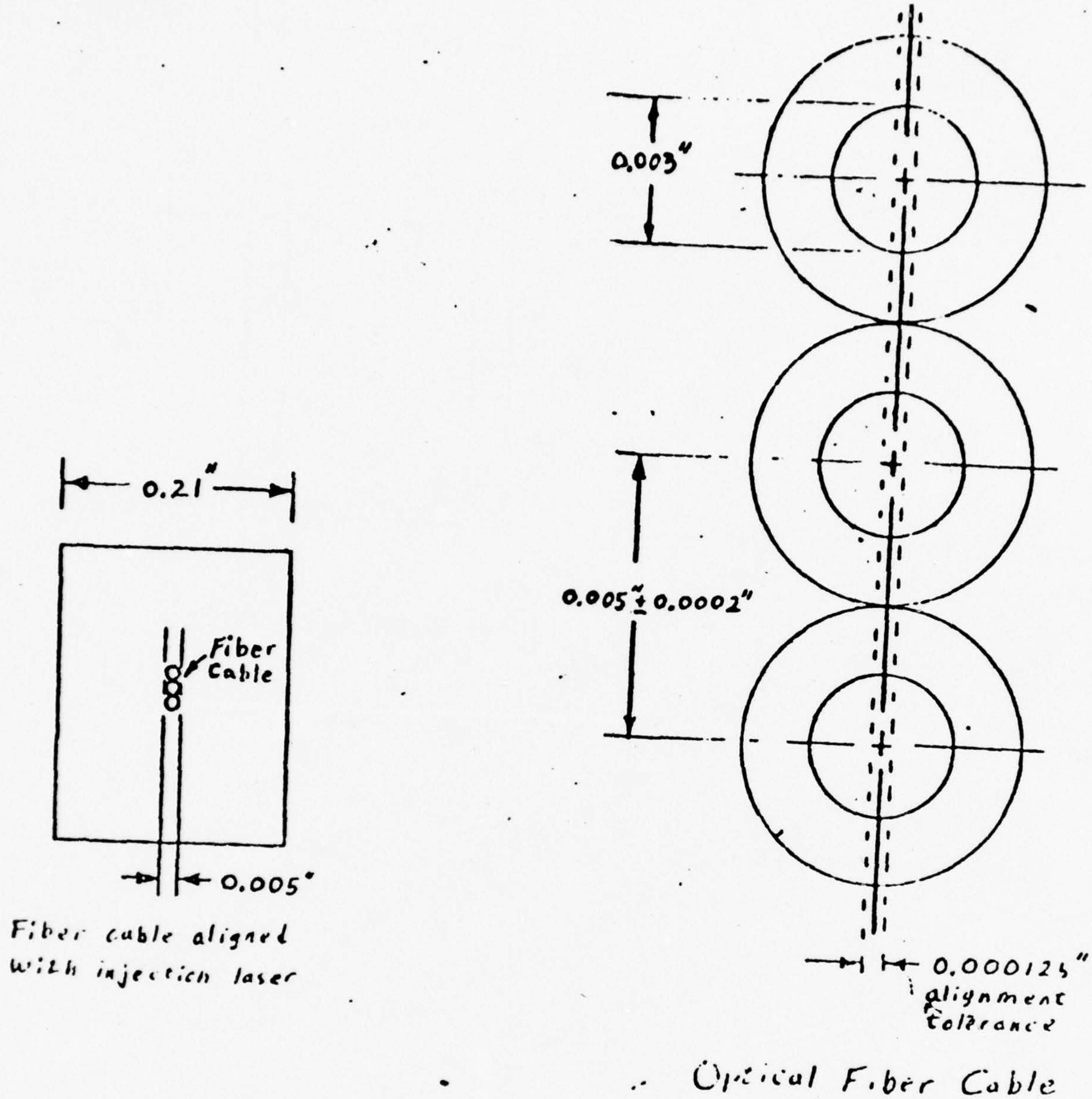

Figure 1A. Fiber cable (NOT PART OF UNIT)

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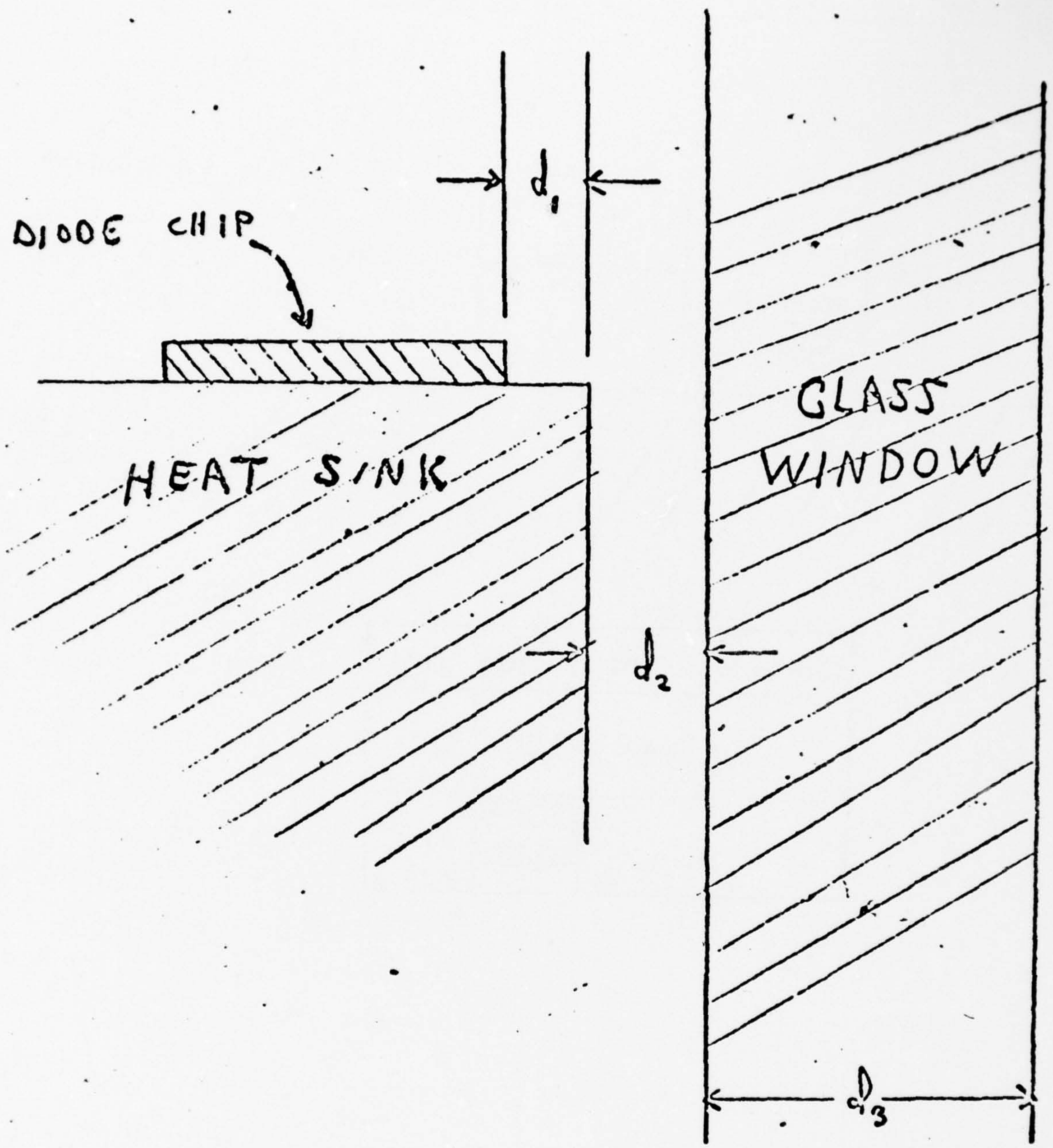

(MAX) d_1 = 1 MIL (0.0254 MM)

d_2 = 1.5 MIL (0.0381 MM) ± .5 MIL

(MIN) d_3 = 3 MIL (0.1016 MM)

(MAX) = 5 MIL

Figure 2. Mounting dimensions

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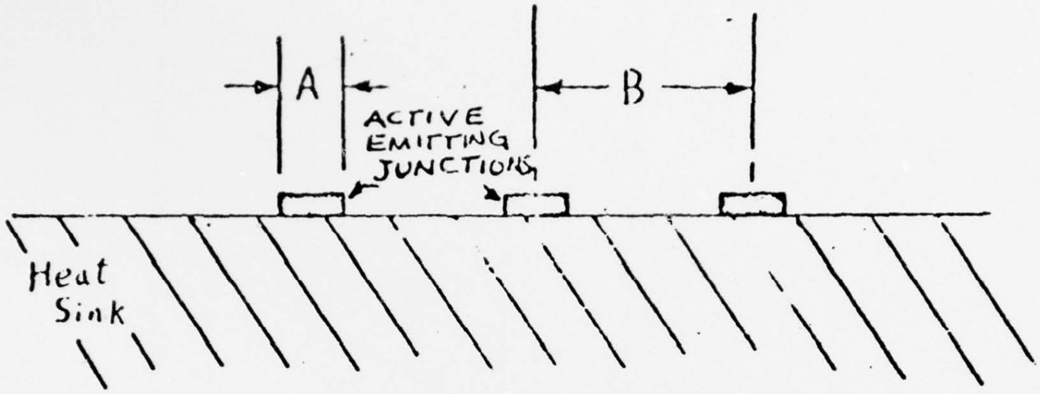
TRIPLE STRIPE GEOMETRY



DIMENSION	INCHES	μM
A(MAX)	0.001	25
B	0.005 ±0.0002	125 ±5

FIG. 3 FRONT VIEW OF DIODE ASSEMBLY

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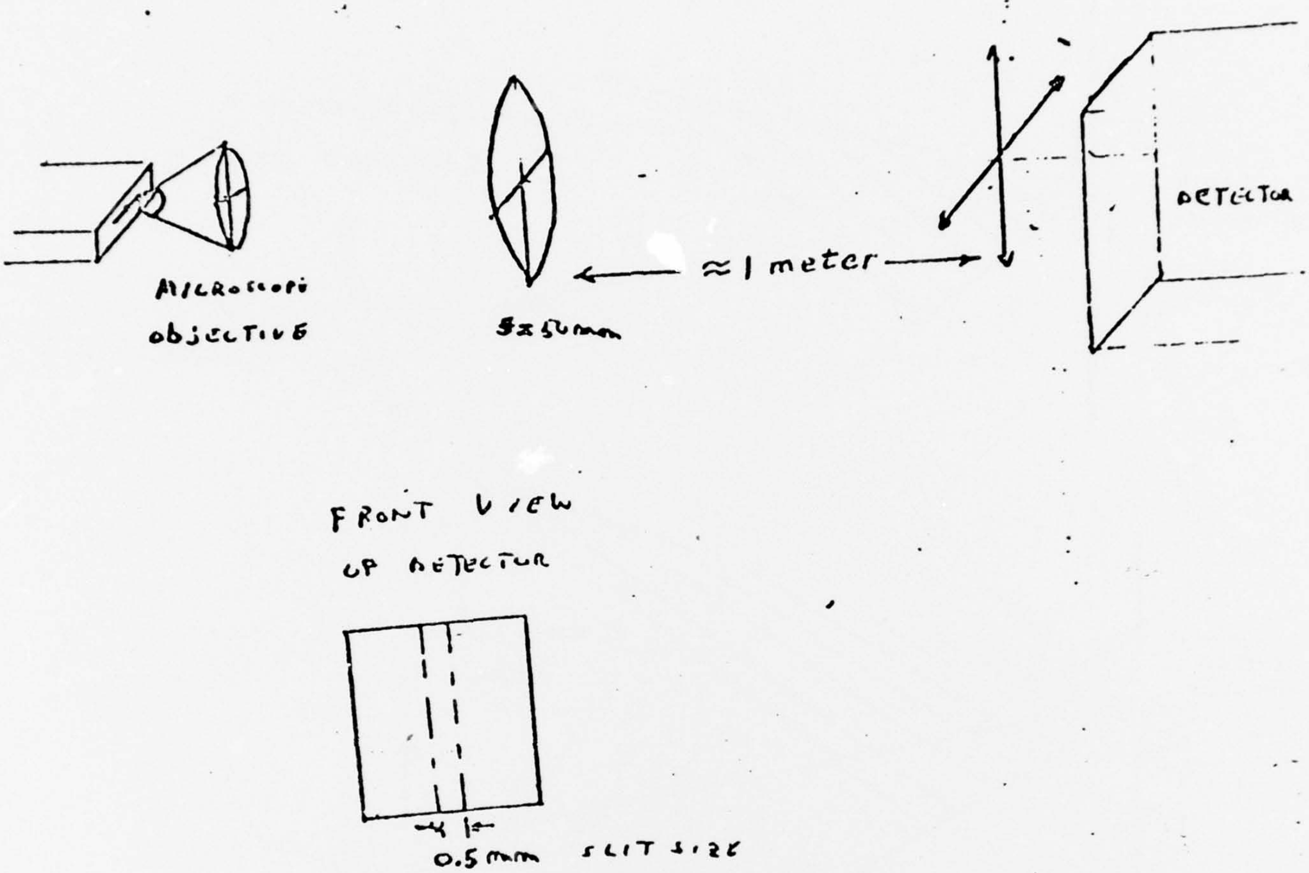

Figure 4. Stripe width

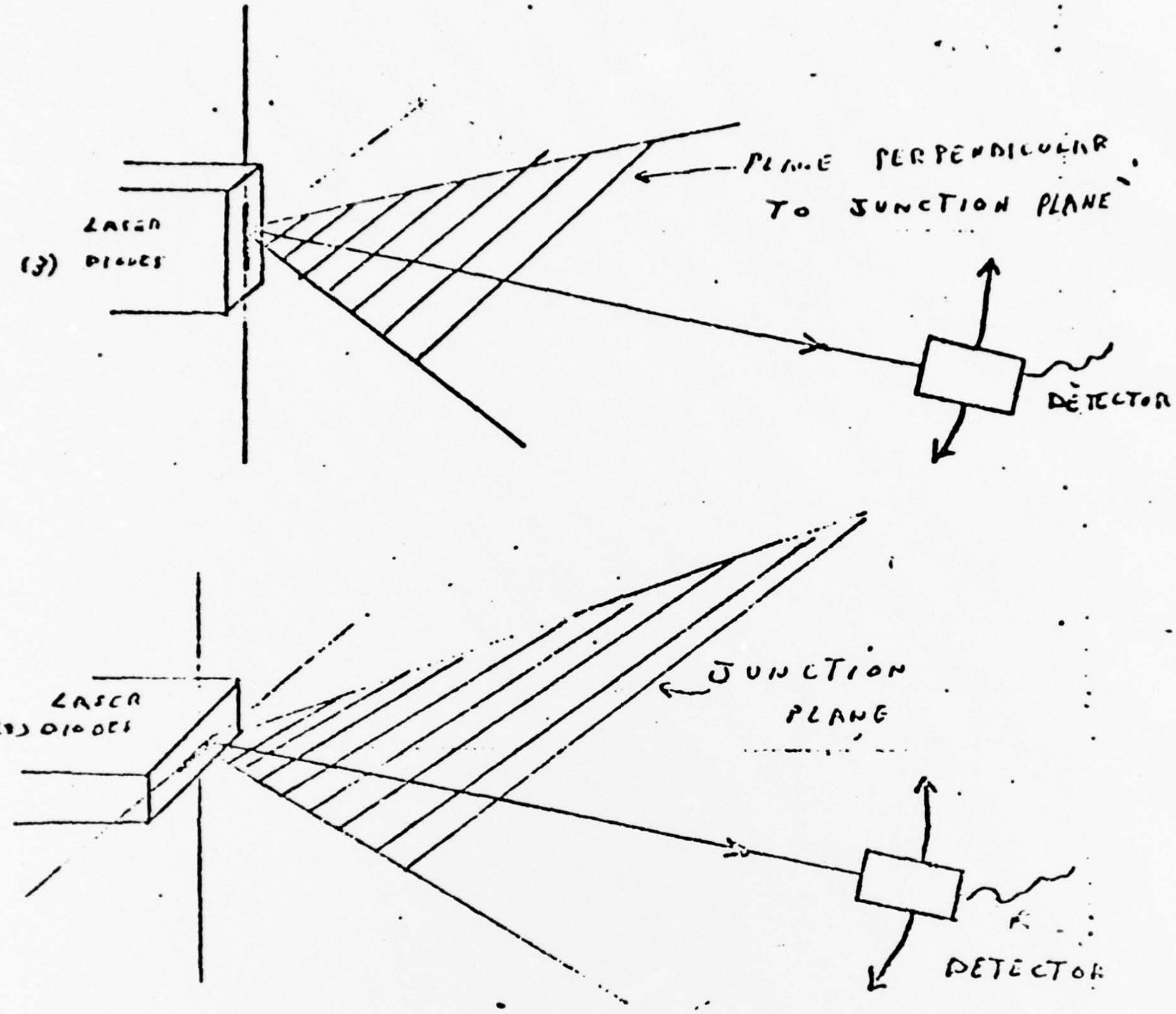

Figure 5. Beam width

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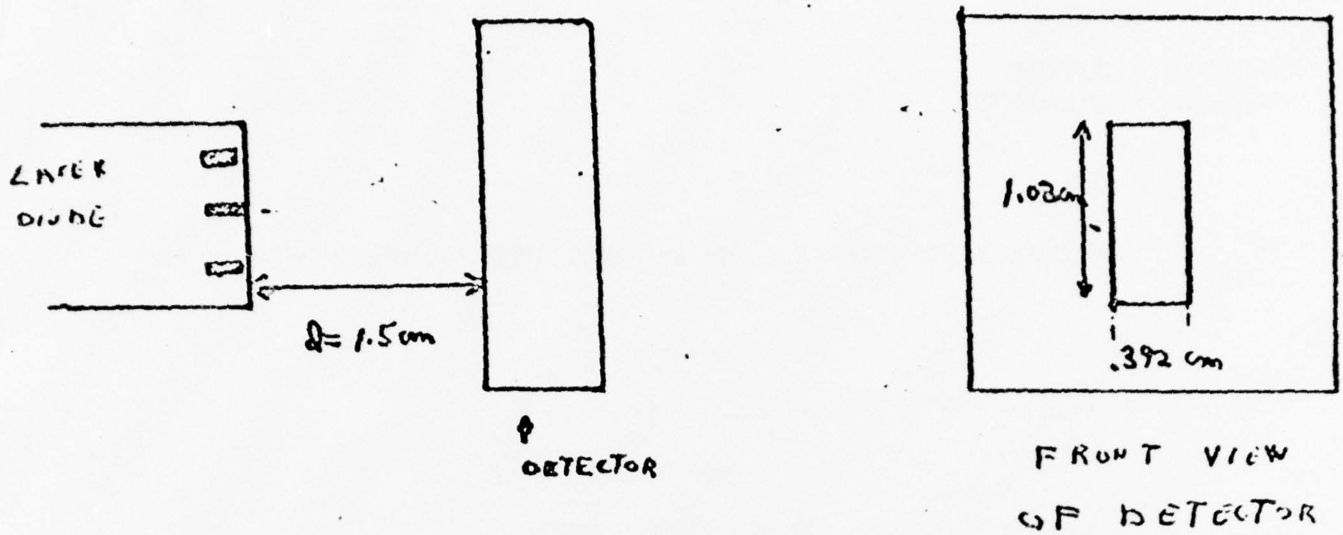

FIG. 6 LASER POWER MEASUREMENTS

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ELECTRONICS COMMAND
TECHNICAL REQUIREMENTS

SCS-516
AMENDMENT-1
29 December 1975

INJECTION LASER DIODE FOR USE IN FIBER OPTIC COMMUNICATIONS

Page 1

1.2 line 2, delete "20°C" and substitute "25°C"

Page 2

3.2 line 3, delete "minimum" and substitute "maximum"

3.4 delete and substitute:

"3.4 Window.- The window shall contain no strain or cracks over that portion which is in the optical path (area of input radiation incident on the injection laser chip). This portion of the window shall also be free from optical distortion and lens effects. The window shall be anti-reflection coated on both surfaces for a wavelength of λ = 820 nm. The coating shall conform to the abrasion resistance requirement of MIL-C-675."

Page 3

3.7 delete in its entirety.

3.14 line 2, delete "(I_F = 100 mA)"

Page 5

4.5.2 line 4, delete "20°C" and substitute "25°C"

Page 8

Table III, Subgroup 3, Thermal impedance, under units column, delete "°C" and substitute "°C/W"

Page 9

Table IV, Subgroup 5, under Condition column, delete "50°C" and substitute "25°C" for I_p

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Page 10

Table V, Subgroup 2, under Details column for Resistance to solvents, add, "except solvents used shall be:

(a) Methyl alcohol, per O-M-232, Grade A.

(b) Ethyl alcohol, per O-E-00760, Type 1, Grade A.

(c) Isopropyl alcohol, per TT-I-735, Grade A.

(d) Three (3) parts by volume of isopropyl alcohol, as specified in (c) above and one (1) part by volume of distilled water."

Page 11

4.6.1 Add, "This test shall be performed prior to attaching the window to the case."

4.6.2 Add, "except solvents used shall be:

(a) Methyl alcohol, per O-M-232, Grade A.

(b) Ethyl alcohol, per O-E-00760, Type 1, Grade A.

(c) Isopropyl alcohol, per TT-I-735, Grade A.

(d) Three (3) parts by volume of isopropyl alcohol, as specified in (c) above and one (1) part by volume of distilled water."

4.6.5 line 3, delete ".39 cm" and substitute ".394 cm"
line 3, delete "1.03 cm" and substitute "1.09 cm"

4.6.6 lines 4 and 5, delete "20°C" and substitute "25°C"

Page 19

Fig 6 Front view of detector, delete "1.03 cm" and substitute "1.09 cm"
Delete ".392 cm" and substitute ".394 cm"

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ELECTRONICS COMMAND
TECHNICAL REQUIREMENTS

SCS-516
AMENDMENT -2
20 April 1976

INJECTION LASER DIODE FOR USE IN FIBER OPTIC COMMUNICATIONS

Page 8

Subgroup 1 - Stripe width (a) single - change "25 mm minimum" to "25 mm maximum."

Stripe width (b) triple - change "75 mm minimum" to "75 mm maximum."

Subgroup 3 - Thermal impedance - change "10° c/w minimum" to "10° c/w maximum."

Beam width (9) in junction plane - change "15 angular degrees minimum" to "15 angular degrees maximum."

INJECTION LASER DIODE FOR USE IN FIBER OPTIC COMMUNICATIONS

Page 8

To Table III - Subgroup 3, add:

Test	Condition	Test Method	Min	Max	Units
Average Optical Power Output Per Stripe	I_p = (see 3.2) t_p = 10 ns	4.6.8 & 6.4	6.3	7.0	mW.

Page 11

4.6.8 Power Uniformity from Stripe to Stripe

Laser stripe must be magnified to 200 x using a lens that has a f number of 1.2. The projected images of each of the three junction faces must be tested for average power using a silicon photodiode.

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6.4 Definition of average optical power

Average optical power = Peak optical power / 10

Average optical power/stripe = 1/3 average optical power.

APPENDIX D

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