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DISC LASER AMPLIFIER

Jack F. Moffat, Jr.

ILC Technology, Incorporated

Prepared for:

Naval Research Laboratory
Advanced Research Projects Agency

10 April 1973

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10 April 1973

DISC LASER AMPLIFIER

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by: Jack Moffat, Jr.

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13. ABSTRACT

Twenty four 10 mm bore flashlamps ranging from 6 inch arc length to 56 inch arc length were life tested at high fractions of explosion energy. These tests indicate that previously established lamp life prediction rules (developed for smaller lamps) can be applied to large lamps without serious error. A magnetic force analysis was made for linear flashlamps in a close packed cylindrical array. It was established that the magnetically induced tensile stress in the lamp envelope is reduced by as much as a factor of 15 if the currents in adjacent lamps flow in opposite directions rather than in the same direction. A variety of lamp mount and high voltage insulation systems were designed and tested. The design finally chosen for full scale multiple lamp tests was successful with regard to high voltage insulation and mounting stress, but less than satisfactory in terms of production yield. A ten lamp test fixture was designed, constructed, and tested with ten lamps and a total stored energy of 45 kilojoules for 500 pulses without failure.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Disc Laser						
Arc Discharge						
Flashlamp						
High Voltage Insulation						

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LIST OF FIGURES

1.0 SUMMARY

Attachment Number 1 to Contract N00014-73-C-0142 states that "the Contractor shall conduct research and development on design aspects of large disc lasers with emphasis on determination of failure modes of large xenon flash pump lamps; lamp length, diameter and life tradeoffs; effects of asymmetric magnetic forces and their minimization; and the design and development of low mechanical stress high voltage terminations and mounts for such lamps. The design shall be supported by life testing of prototype lamps, both individually and in the finally determined close configuration including the chosen mounting, high voltage termination and at least one fourth of a reflector assembly."

A total of 24 individual 10 mm bore flashlamps ranging from 6 inch arc length to 56 inch arc length were life tested at high fractions of explosion energy. These tests indicate that previously established lamp life prediction rules (developed for smaller lamps) can be applied to large lamps without serious error. There is some evidence that the lamp life vs. fraction of explosion energy relationship may be slightly different for long lamps than for short lamps, but many more tests would be required at low fractions of explosion energy to establish the trend.

A magnetic force analysis was made for linear flashlamps in a close packed cylindrical array. It was established that the magnetically induced tensile stress in the lamp envelope is reduced by as much as a factor of 15 if the currents in adjacent lamps flow in opposite directions rather than in the same direction. For the particular case of twenty 32 inch arc,10 mm bore lamps mounted on a 5.5 cm radius cylinder, the magnetically induced stress from 3500 amp pulses is 165 psi if the current flow is opposite in adjacent lamps, and 3140 psi if all currents are in the same direction. The stresses that would result from two adjacent lamps failing to fire is 535 psi.

A variety of lamp mount and high voltage insulation systems were designed and tested. The design finally chosen for full scale multiple tests was found to be successful with regard to high voltage insulation and mounting stress, but less than satisfactory in terms of production yield. An improved design to reduce production problems was fabricated and is recommended for future programs.

A ten lamp test fixture was designed, constructed, and tested with ten lamps and a total stored energy of 45 kilojoules for 500 pulses without failure. During the performance of the tests, the following significant observations were made:

1. Future disc laser amplifier structures should be designed to provide a complete nitrogen purge in order to minimize generation of acoustical noise and the possibility of damage resulting from acoustic shock waves.
2. A cylindrical pyrex shield separating the flashlamp region from the laser disc region is helpful in reducing shock waves.
3. A disc laser structure based on the design concepts tested in this program should operate reliably for 1000 to 5000 pulses at full energy.
4. The failure of one pair of lamps to fire does not result in destructive magnetic forces in adjacent lamps.
5. Resilient lamp supports can be provided to reduce the stress in lamp envelopes (although intermediate supports were not needed on this program).

2.0 EXPLOSION LIMIT AND LIFE TESTS

Xenon flashlamp explosion limit and life tests were conducted on 10 mm bore, 2 mm wall, xenon flashlamps with arc lengths varying from 6 inches to 56 inches. The purpose of the tests was to determine experimentally if there were any length dependent factors which affect the explosion limit of xenon flashlamps constructed with abnormally high length to diameter ratios.

Xenon flashlamps constructed for these tests were all fabricated from fully annealed 2 mm wall, 10 mm bore quartz tubing. The seal construction consists of a single grade tungsten rod to quartz reentrant seal, with electrical connections made by means of flexible leads. The basic lamp design is illustrated in Figure 1.

Approximately 10 lamps of each 3 different arc lengths were constructed for the purposes of these tests. The arc lengths chosen were 6 inches, 18 inches and 30 inches.

2.1 Description of Test Methods

The purpose of this test was to compare the performance of large diameter long flashlamps with the previously established model,[1,2] which provides a means of predicting the explosion limit of flashlamps and the expected life of a flashlamp when operated at a specified fraction of its explosion limit. The basic test method employed was to calculate an expected life based on the previous model and then determine the actual life when the test lamps were operated at high fractions of explosion energy.

During the tests the lamps were carefully mounted in a strain free manner with the electrical current return path separated from the lamp by a large distance to insure that magnetic forces were minimized. All tests were conducted in a large test enclosure without reflectors so that optical loading of the lamp was also minimized. The tests were conducted in an air environment, so that acoustical shock loading of the lamp envelope due to absorption of UV radiation in air was a possible factor in the tests.

2.2 Test Results

The test results of the program are presented in Figures 2 through 5. In all cases the termination of a test sequence occurred when the lamp envelope fractured. In all cases except one, lamp fracture was violent and resulted in virtually total destruction of the lamp envelope.

2.3 Conclusions

2.3.1 Lamp Life Slope

The most extensive lamp life data was collected on 6, 18 and 30 inch arc length lamps. Examination of Figures 3 and 4 suggests that the best fit lamp life vs. energy line appears to vary somewhat from previously established data (referenced in reference 1). The effect of this possible slope change appears to have the effect of slightly depressing the single shot explosion energy for long lamps, but substantially increasing expected lamp life when these lamps are operated at less than 50 or 60% of explosion energy. It also suggests that for 18 and 30 inch lamps, million pulse life expectancy might be achieved at 0.3 of explosion energy rather than at 0.2 of explosion energy as was previously thought. Many more lamp tests would be required to ascertain whether or not these apparent changes are really significant.

It is also interesting to note that for the 6 inch lamp data (Figure 2) the best fit lamp life slope and the previously established lamp life slope are essentially the same.

Energy storage capacity limitations prevented the testing of 56 inch arc length lamps at high fractions of explosion energy.

2.3.2 Abnormal Early Failures

Out of a total of 24 tests performed at more than 0.4 of explosion energy, only one abnormal early failure was noted. One of the 56 inch arc length lamps suffered a cracked seal but the lamp envelope was not destroyed. In spite of this early failure, the data point (shown on Figure 5) still results in reasonably good grouping of the data.

In order to firmly establish the new indicated lamp life slopes, it would be necessary to perform substantial additional tests at energies which would yield expected lamp life between 10^5 and 10^6 pulses.

3.0 MAGNETIC FORCES BETWEEN FLASHLAMPS IN A CYLINDRICAL CONFIGURATION

The magnetic force analysis studies performed under this contract provide a means of quantitatively estimating the magnetic forces acting on flashlamps in a large scale Nd:glass disc laser amplifier.

It can be shown that the magnetic force between two parallel cylindrical conductors, per unit length, is equal to

$$F = 2i_1 i_2/d \qquad (1)$$

where F is the force per unit length, i_1 and i_2 are the currents in the conductors, and d is the distance between the axes of the conductors. If the currents are expressed in emu (1 emu = 10 A) and the distance in cm, Equation (1) gives the force in dynes per cm length. Equation (1) is exactly valid for any cylindrically symmetrical distribution of current in the individual conductors. The force is attractive if the currents flow in the same direction and repulsive if they flow in opposite directions.

The force between any two cylindrical conductors with their axes lying on the surface of a larger cylinder of radius R, as shown in Figure 7 and carrying equal currents, is then

$$F = 2i^2/(2R \sin \theta/2) \qquad (2)$$

per unit length, where θ is the angular separation of the axes of the two conductors on the surface of the large cylinder. The radial component of this force is $F \sin \theta/2$, which is equal to

$$F_r = i^2/R \qquad (3)$$

per unit length. Thus the radial component of the force between the two conductors is independent of their relative positions on the large cylinder.

The tangential component of the force between the two conductors is

$$F_t = F \cos \theta/2 = (i^2/R) \cot \theta/2 \qquad (4)$$

We can now calculate the components of the force on a given conductor when there are n conductors uniformly spaced on the surface of the large cylinder, each carrying the same current i. If the currents are all in the same direction, the radial component is

$$F_r = (n - 1)i^2/R \tag{5}$$

directed inward.

If n is even and the current flows in opposite directions in alternate conductors,

$$F_r = i^2/R \tag{6}$$

directed outward, since the number of outward contributions is one greater than the number of inward contributions. In either case, the tangential component of the force on the given conductor vanishes because of symmetry, as can be seen from consideration of Figure 7.

If one conductor is removed from the array (one flashlamp fails to fire), the radial component of force on each of the remaining conductors changes by i^2/R, the direction of the change depending on whether the currents in the missing conductor and the one under consideration are in the same or opposite directions. The tangential component of force on each of the remaining lamps changes from zero to the amount given by Equation (4).

As an example, we calculate the magnetic forces for the case of 20 lamps, each carrying a current of 3500 A, with their axes on a reference cylinder of 5.5 cm radius. If all of the currents are in the same direction, the radial component of force on each lamp is 29.1 pounds force per foot of length. If the currents are in opposite directions in alternate lamps, the force per foot of length is only 1.53 pounds. If one lamp fails to fire, a tangential component of 9.66 pounds force per foot of length is exerted on the lamps on either side of it, and smaller tangential forces are exerted on its more remote neighbors.

If, in the arrangement of 20 lamps with currents in opposite directions in adjacent lamps, one adjacent pair fails to fire, the radial force on the remaining lamps remains unchanged and the tangential force on a lamp next to the pair not firing becomes 4.96 pounds force per foot of length. The resultant force on this lamp is then 5.18 pounds per foot.

If the lamp is supported at points spaced L feet apart, we can calculate the maximum safe load approximately by considering the portion between two adjacent supports to be auniformly loaded beam of span L feet. Kent (Mechanical Engineers' Handbook, 12th edition, p. 8-15) gives the equation

$$W = 2\ \sigma S/ (3L) \tag{7}$$

as the maximum safe load of such a beam, where W is the total load in pounds, σ is the maximum allowable tensile stress in psi, and S is the section modulus, which is equal to the moment of inertia divided by half the beam thickness in the direction of the load. For a flashlamp with inside and outside diameters of 10 and 14 mm, as an example, S is equal to 0.125 in^3, as calculated from the equation

$$S = 0.0982(d^4 - d_i^{\,4})/d \tag{8}$$

given on p. 8-10 of the reference just cited.

If the distance between supports is three feet, the maximum tensile stress in the quartz due to the magnetic forces is 165 psi if all lamps fire. If one adjacent pair fails to fire, the maximum stress in the lamps on either side of this pair is 536 psi. If the external connections were such that a single lamp could fail to fire, the maximum stress in its closest neighbors would be 1042 psi. Finally, if the lamps were connected so that current flowed in the same direction in all of them, the maximum tensile stress in each lamp, due to the radial magnetic force, would be 3140 psi.

4.0 HIGH VOLTAGE INSULATION SYSTEMS

The objective of this task was to devise a high voltage insulation system for linear xenon flashlamps that would insulate the electrical conductors from the lamp support structure and simultaneously provide a mounting surface that would insure strain free mounting of the lamp in the disc laser structure.

The various designs investigated are illustrated in Figure 8. Design A was discarded because of difficulty in manufacturing. Designs B and C were discarded because high voltage tests of sample structures showed that these designs would not provide adequate voltage isolation between the current carrying conductor and the metal support sleeve.

Design D was adopted for the tests under this contract. A sample lamp end was constructed as shown in Figure 8D, and was hi-potted to 50 kV dc for two minutes without breakdown. The same sample was then subjected to a pulse test in which the center conductor was pulsed to 40 kV with a pulse duration of approximately 2 μs at a pulse repetition rate of 10 PPS for approximately 50 hours. After this test there was no visible or electrical sign of degradation of the insulation system.

During construction of the test lamps used on this program it was found that while the Design 8D is adequate from the standpoint of high voltage breakdown, it is mechanically weak and results in a high attrition of lamps during installation of the insulating system. Design 8E, incorporating a thicker quartz extension, is recommended for future lamp construction.

5.0 LAMP ASSEMBLY DESIGN AND PROOF TESTING

5.1 Test Fixture Construction Details

A multiple lamp test fixture was designed and constructed. This test fixture, capable of holding ten 32 inch arc length, 10 mm OD lamps, is illustrated in Appendix I. This test fixture was designed to interface with the lamp insulation design shown in Figure 8D, and provides for optional intermediate lamp supports at 3 points along the lamp arc length.

5.2 Lamp Construction

Thirty-two inch arc length, 10 mm bore lamps were constructed in accordance with the insulation system design shown in Figure 8D. A total of 26 lamps were fabricated for this program. Six lamps were broken during potting and high pot tests while installing the high voltage insulation on the lamp ends. Ten lamps were broken during the test program described in 5.3 below. Ten lamps remain intact and are installed in the lamp test fixture.

5.3 Test Program Summary

A complete test program log is included as Appendix II of this report.

Initially, all test lamps were tested in pairs in the lamp test fixture with the lamps located as far apart as possible. This test constituted an acceptance test of the lamp structures.

Lamps were then progressively moved closer and closer together until two lamps were operated in adjacent positions in the test fixture. These tests confirmed that the lamps were capable of withstanding magnetic forces associated with two lamps operating in close proximity.

The test plan then provided for gradually increasing the number of lamps in the test fixture. Difficulties first arose with six lamps in the fixture when two lamp pairs were located at either side of the fixture and one lamp pair was located at the top of the fixture. Repeated tests under these conditions resulted in breakage of the lamps at the top of the fixture. In some cases, fragments of the two top lamps also fractured other lamps.

It was postulated that a shock wave emanating from the two pairs at either side of the cavity might be propagated upward in a manner that could damage the lamps in the top fixture. At this point, the test fixture was modified and a pyrex glass shield was added to reduce the possibility of this type of shock induced failure. When tests were continued, it was determined that the addition of the pyrex cylinder did in fact, remove this difficulty.

As the number of lamps in the fixture was increased, the acoustic shock noise generated by ultraviolet radiation inside the cavity became excessive. The fixture was further modified to provide more complete purging of the fixture with gaseous nitrogen. It appears necessary to have a reasonably well sealed disc laser cavity purged with gaseous nitrogen to reduce the acoustic shock and acoustic noise.

During the course of the test, one high voltage arc-over to ground was experienced at one high voltage termination. For the remainder of the tests, this problem was solved by adding mylar sheet under the terminal block. On future assemblies, this terminal block would be made of solid insulating material. This is not considered to be a basic difficulty with the system.

After the test fixture had been successfully operated with 10 lamps operated from 5 pulse forming networks, each storing 9 kJ at 20 kV, experimental center support mechanisms were tried. These are illustrated in Appendix I. The experimental support material withstood repeated operation at full energy without damage. A data sheet for this material is included as part of Appendix I.

5.4 Conclusions and Recommendations

During the course of this program, it has been shown that 32inch arc length, 10 x 14 mm linear flashlamps can be operated successfully in a half cylinder array consistent with the design requirements for the Naval Research Laboratory disc laser system. The lamp mounting and insulation system that was developed provides for strain-free mounting of the lamps at the ends, adequate high voltage insulation properties and very little increase in overall lamp diameter. A multiple lamp array fabricated in accordance with this design can be expected to operate reliably for an estimated 1,000 to 5 000 pulses without catastrophic lamp failure. Over 600 pulses at full energy were actually demonstrated during the course of this test.

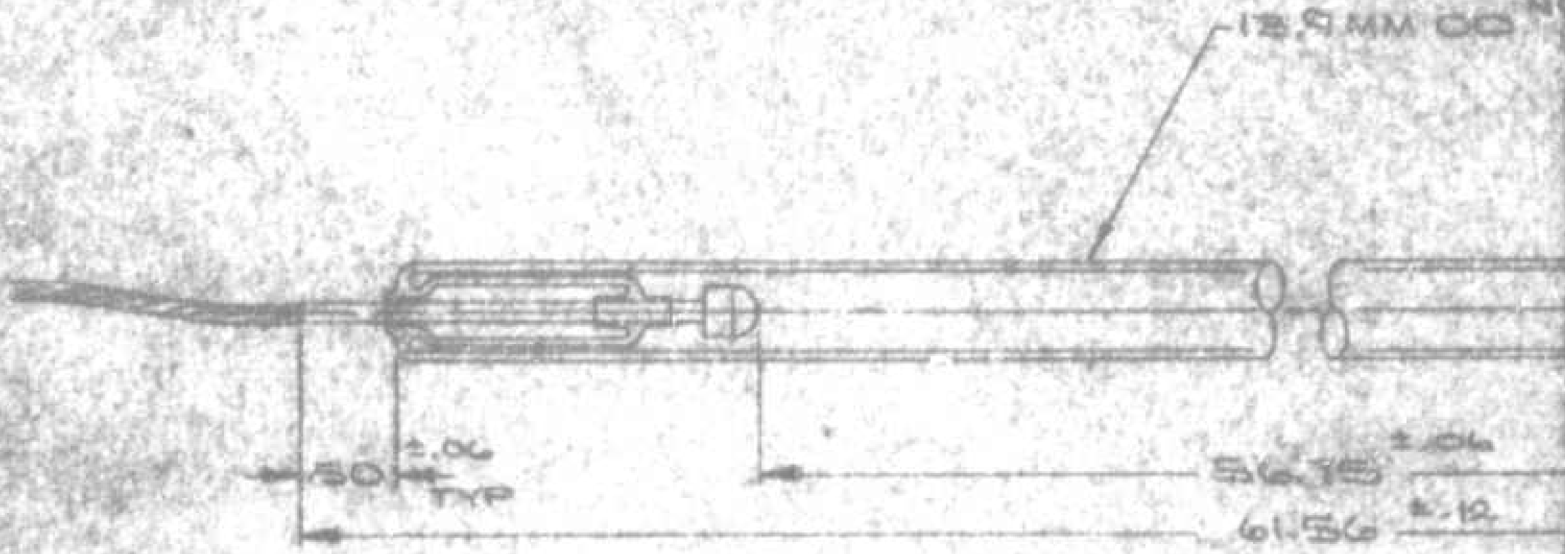
Complete gaseous nitrogen purge of the interior of the disc laser system is highly recommended. It results in minimum acoustical noise from the assembly and greatly reduces the possibility of destructive shock waves being developed inside the disc system.

Addition of a circular pyrex shatter shield between the lamps and the laser disc region is highly recommended. It is an easy way to reduce acoustic shock effects and should provide adequate protection for the laser discs.

6.0 REFERENCES

1. Edgerton, H.E., J. H. Goncz and P. W. Jameson, "Xenon Flash Lamp Limits of Operation" in J.G.A. DeGraaf and P. Tegelaar (eds) Proceedings of the Sixth International Congress on High Speed Photography, H. O. Tjeek Willink and Zoon, N.V. Haarlem, 1963, p. 143

2. ILC Technical Bulletin No. 1, "An Introduction to Flash Lamps".



Notes:

1. TIP-OFF HEIGHT .06 MAX
2. ENVELOPE MATL: 2MM WALL CLEAR FUSED QUARTZ
3. MAX NON FLEXIBLE LENGTH 62.3"

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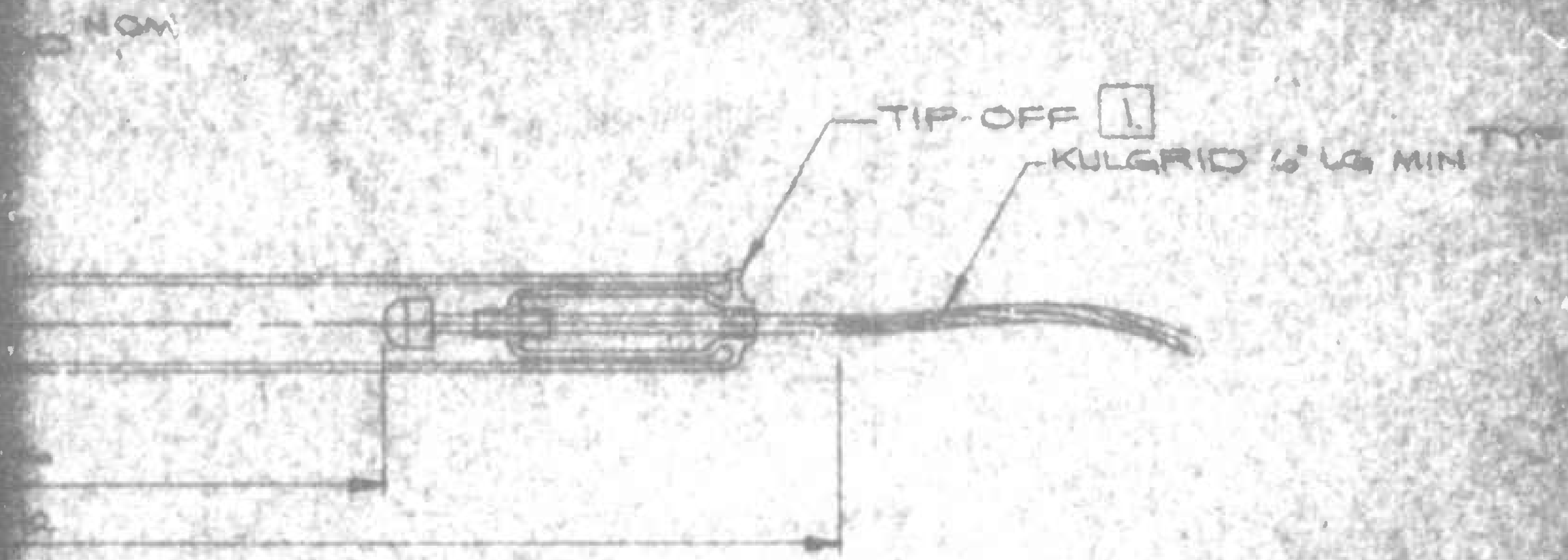

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APPD

DESIGN ACTIVITY APPD

ILC INC.

399 COMMERCIAL STREET SUNNYVALE, CALIFORNIA

TITLE LAMP, XENON FLASH ILC MODEL L-100

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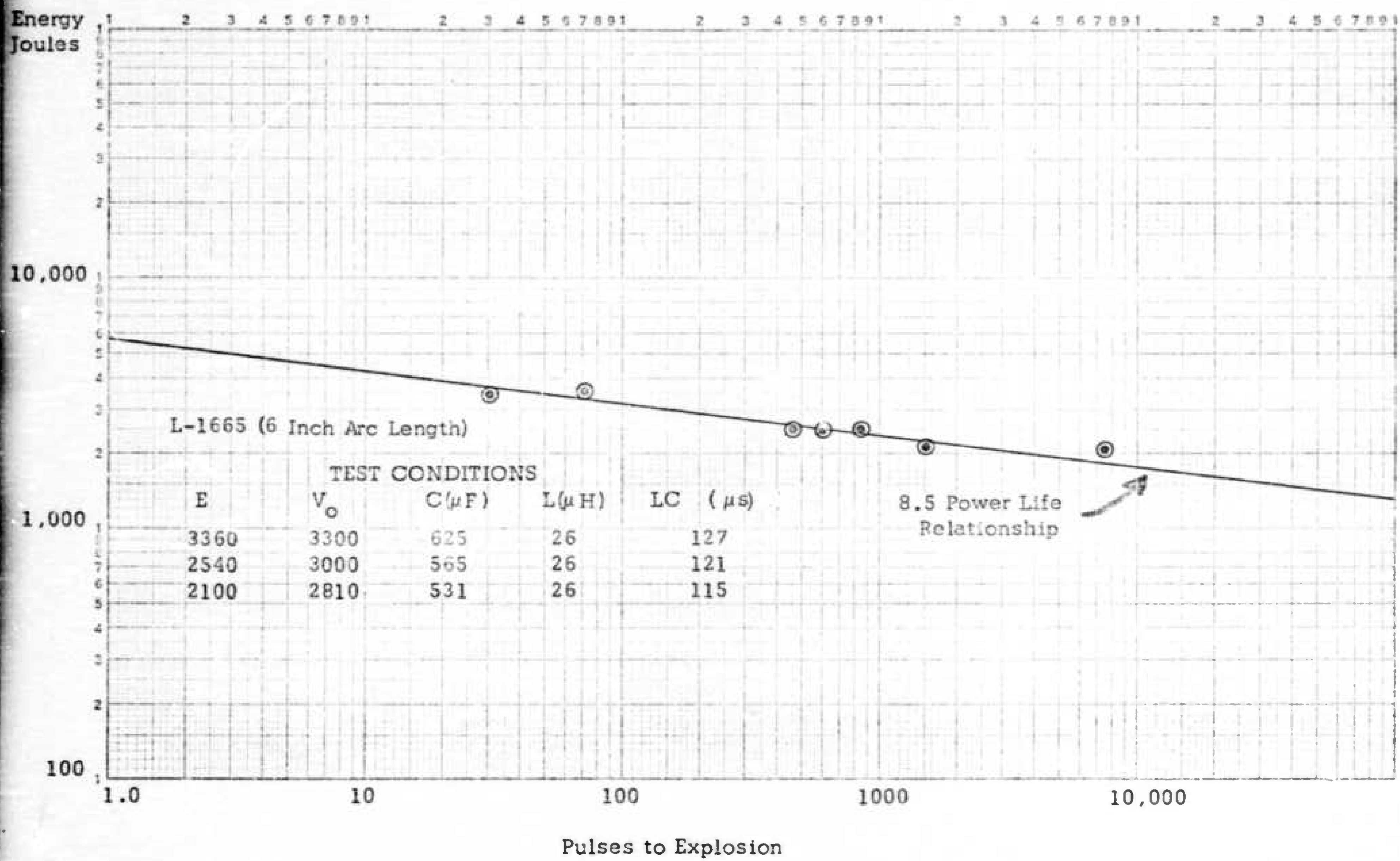
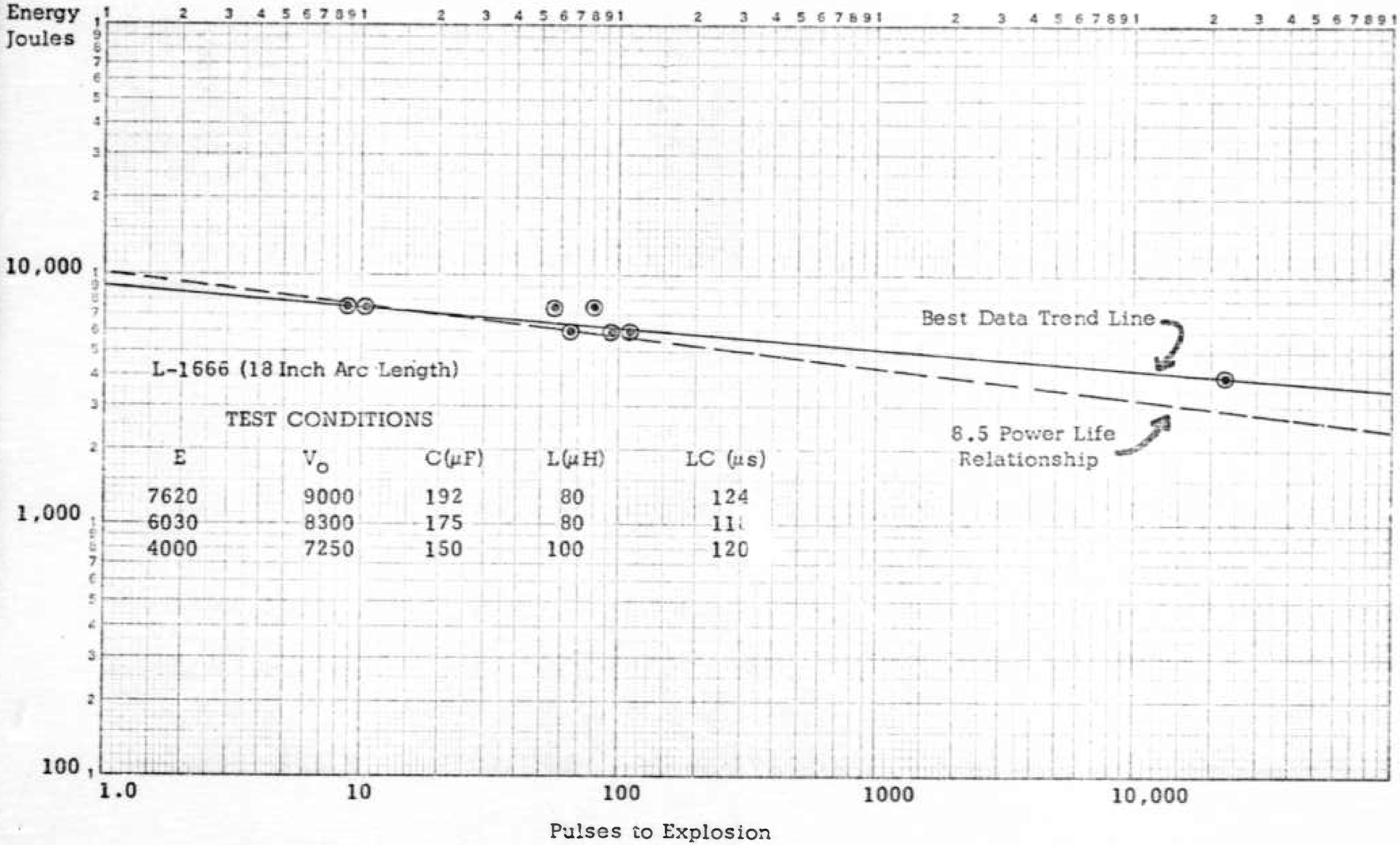


FIGURE 2. HIGH ENERGY LIFE TESTS



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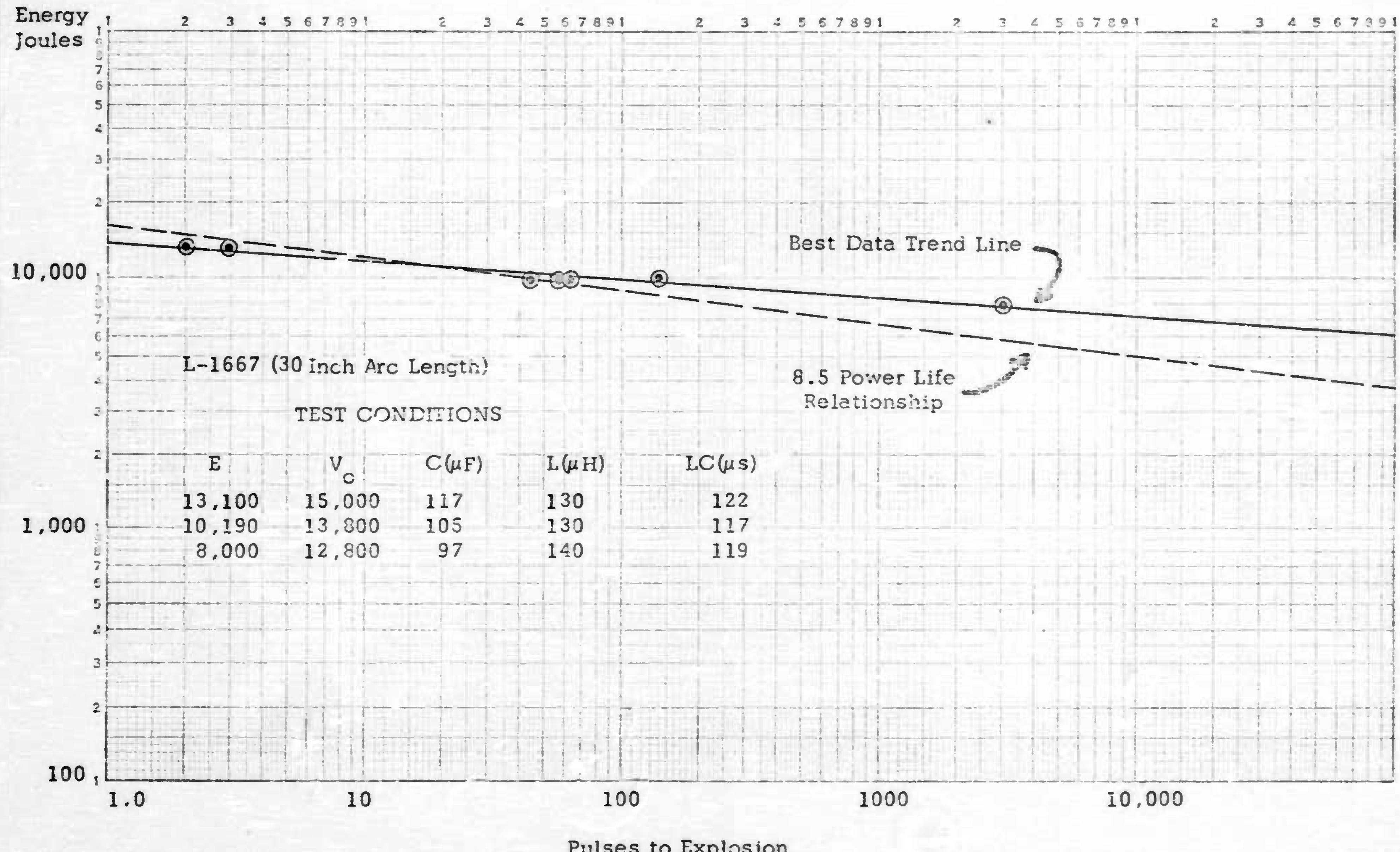

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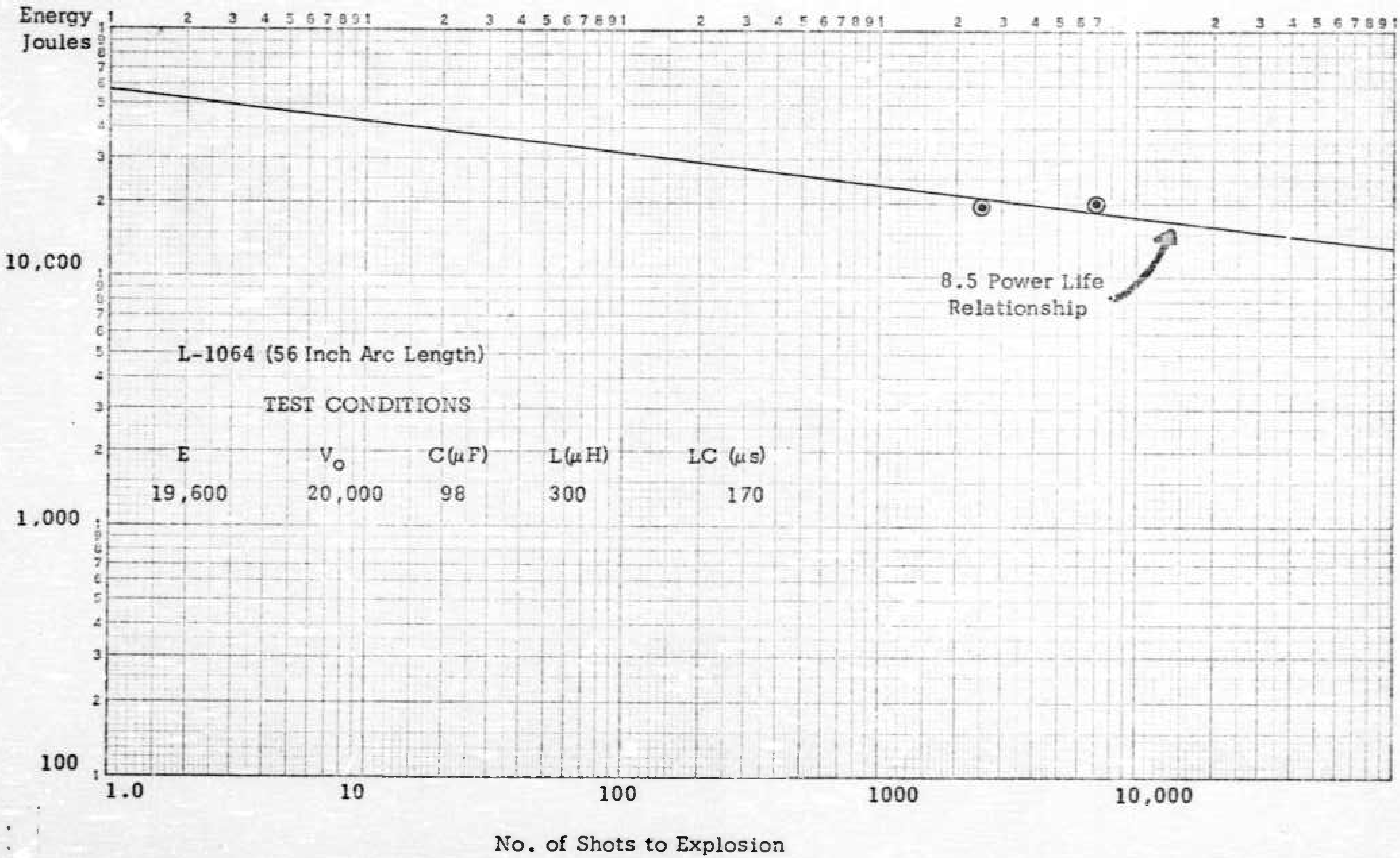

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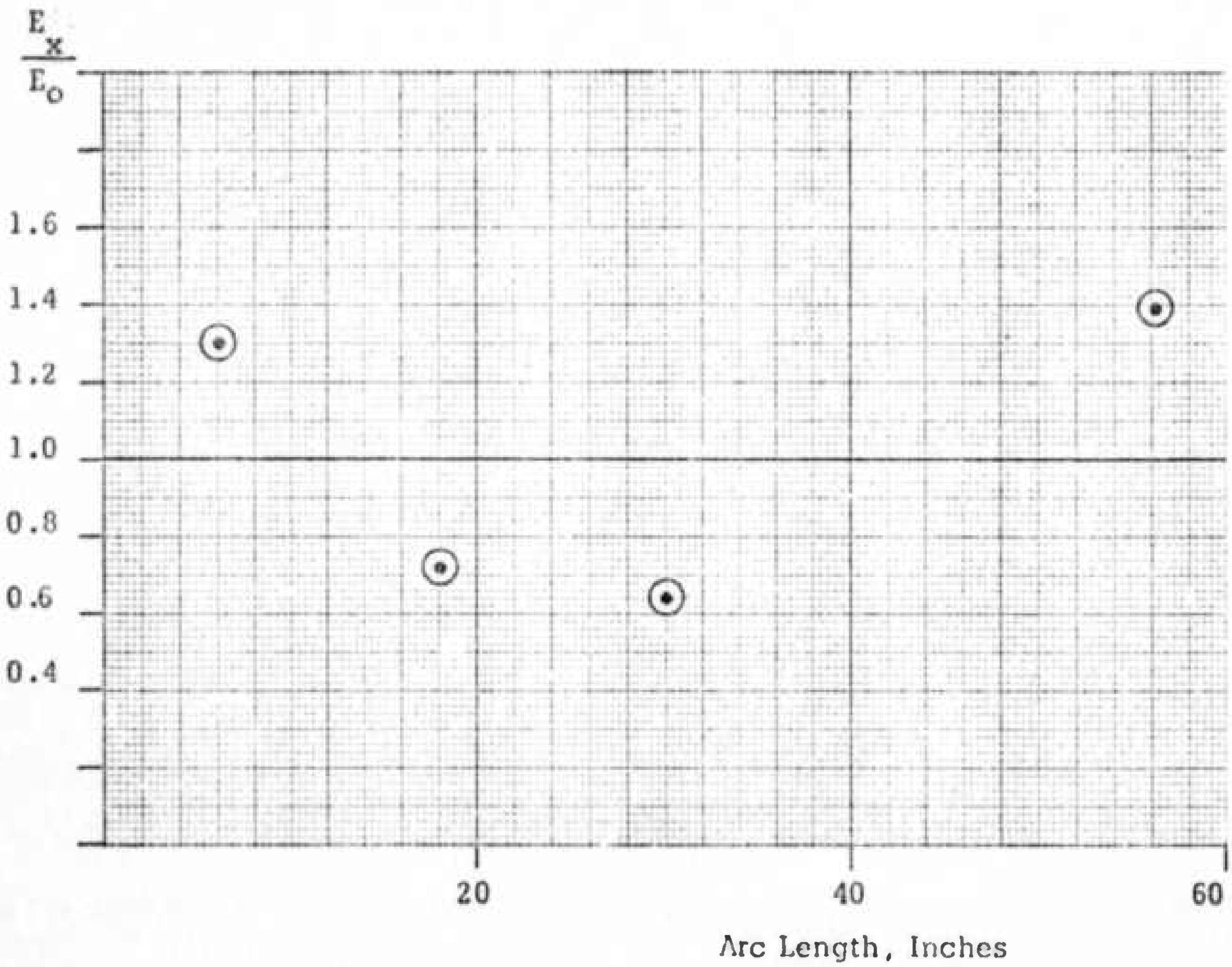


Lamp Bore Diameter - 10 mm

Lamp Wall Thickness - 2 mm

Circuit Time Constant - $(\sqrt{LC}) = 120\ \mu s$

E_x is derived from Figures 2, 3, 4 and 5.

E_o is 700 joules per inch.

FIGURE 6

EXPLOSION LIMIT (Ex) AS A FUNCTION OF ARC LENGTH

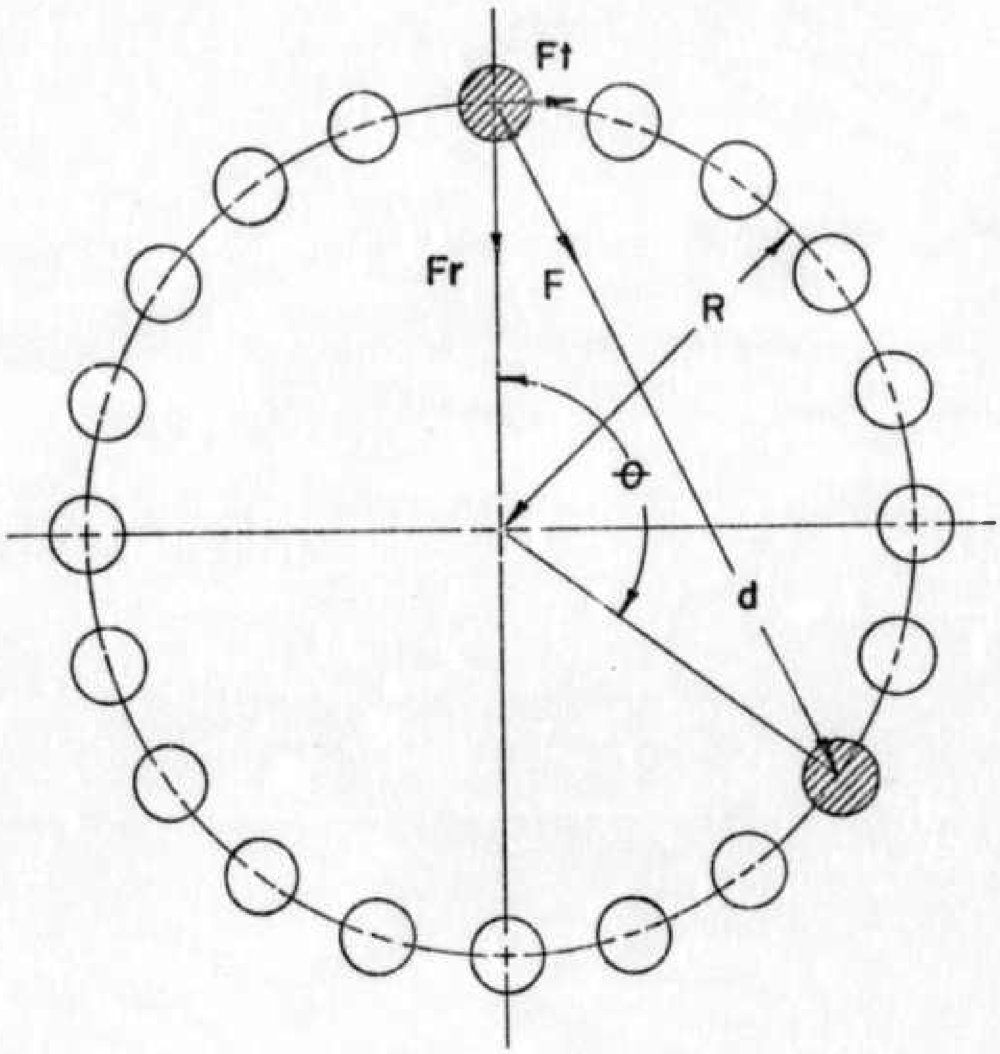
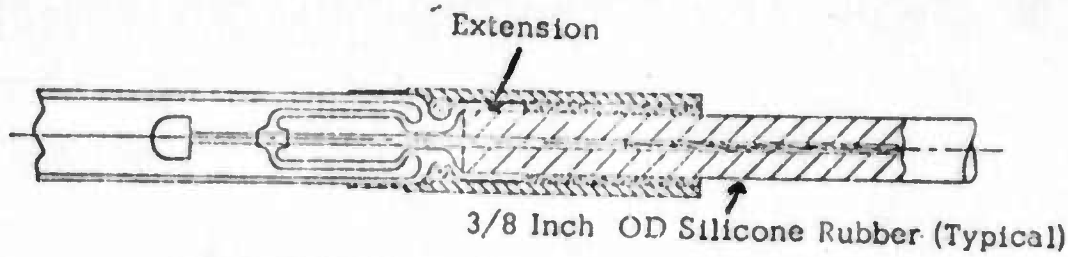


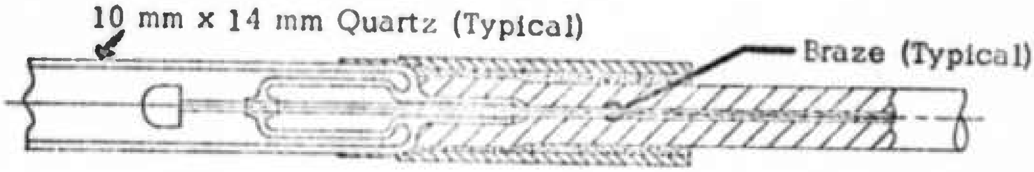
FIGURE 7. Magnetic Forces on Conductors in Cylindrical Configuration

(a)



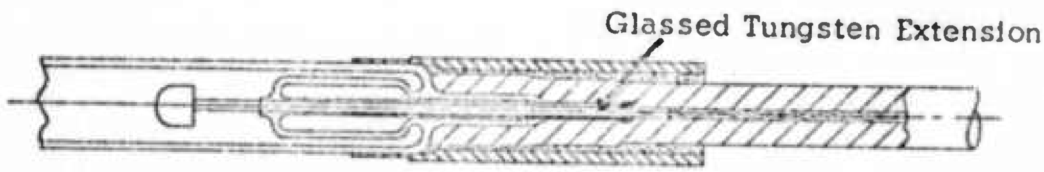
3/8 Inch ID Quartz Tube Extension

(b)



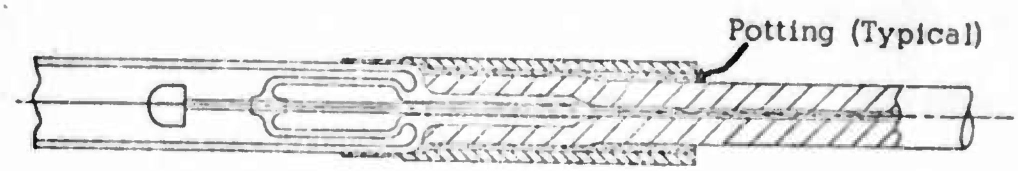
0.200 x 1 Inch Extension

(c)



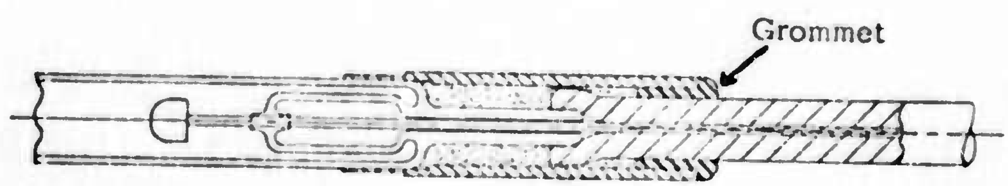
0.200 x 1 Inch Extension Plus Glassed Tungsten

(d)



.200 x 1-1/4 Inch Extension

(e)



.350 x 1-1/4 Inch Extension Plus Grommet (Proposed)

FIGURE 8. INSULATION SYSTEM DESIGNS

APPENDIX I

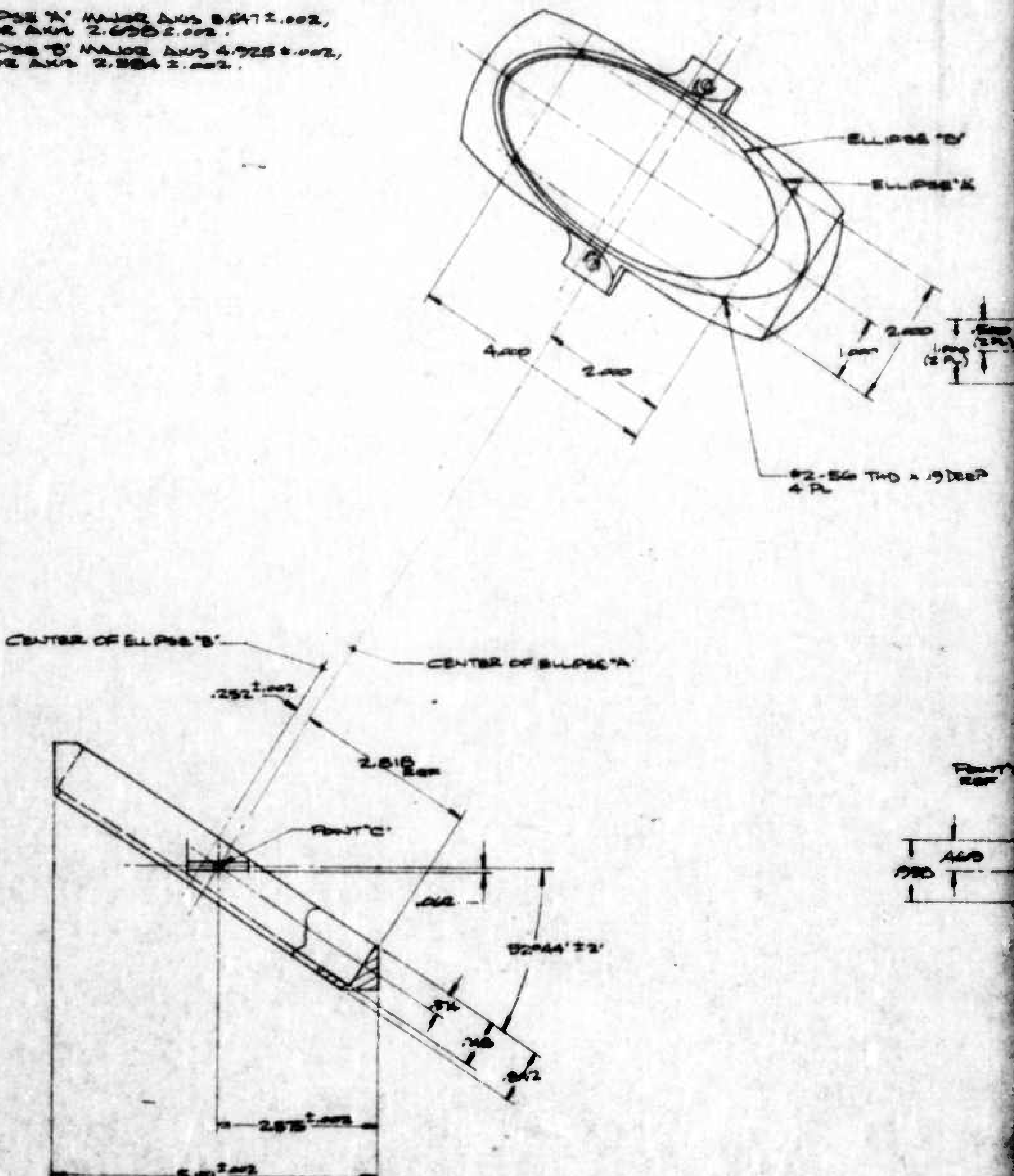
MULTIPLE LAMP TEST FIXTURE DESIGN DETAILS

DRAWING LIST
NRL LAMP TEST FIXTURE

41901A	Disc Holder
41902B	Lamp Base 14 mm
41903A	Lamp Test Fixture
41904 N/C	Channel Base
41905 N/C	Lamp End Support (Inner)
41906 N/C	Lamp End Support (Outer)
41907 N/C	Lamp Support Middle (Inner)
41908 N/C	Lamp Support Middle (Outer)
41909 N/C	Reflector Quadrant
41910 N/C	Ground Ring
41911 N/C	Barrier Insulation (L. H.)
41912 N/C	Insulated Standoff
41914 A	Terminal Lamp Lead
41915 N/C	Fitting Thd Fitting
41916 N/C	Extrusion
41917 N/C	Barrier Insulator (R. H.)
41920 A	Lamp Mount Experimental
41921 N/C	Lamp Mount Experimental
-----	Metex Mesh Strips Data Sheet

NOTES:

1. ELLIPSE "A" MAJOR AXIS 5.547 ±.002, MINOR AXIS 2.630 ±.002.
2. ELLIPSE "B" MAJOR AXIS 4.725 ±.002, MINOR AXIS 2.384 ±.002.



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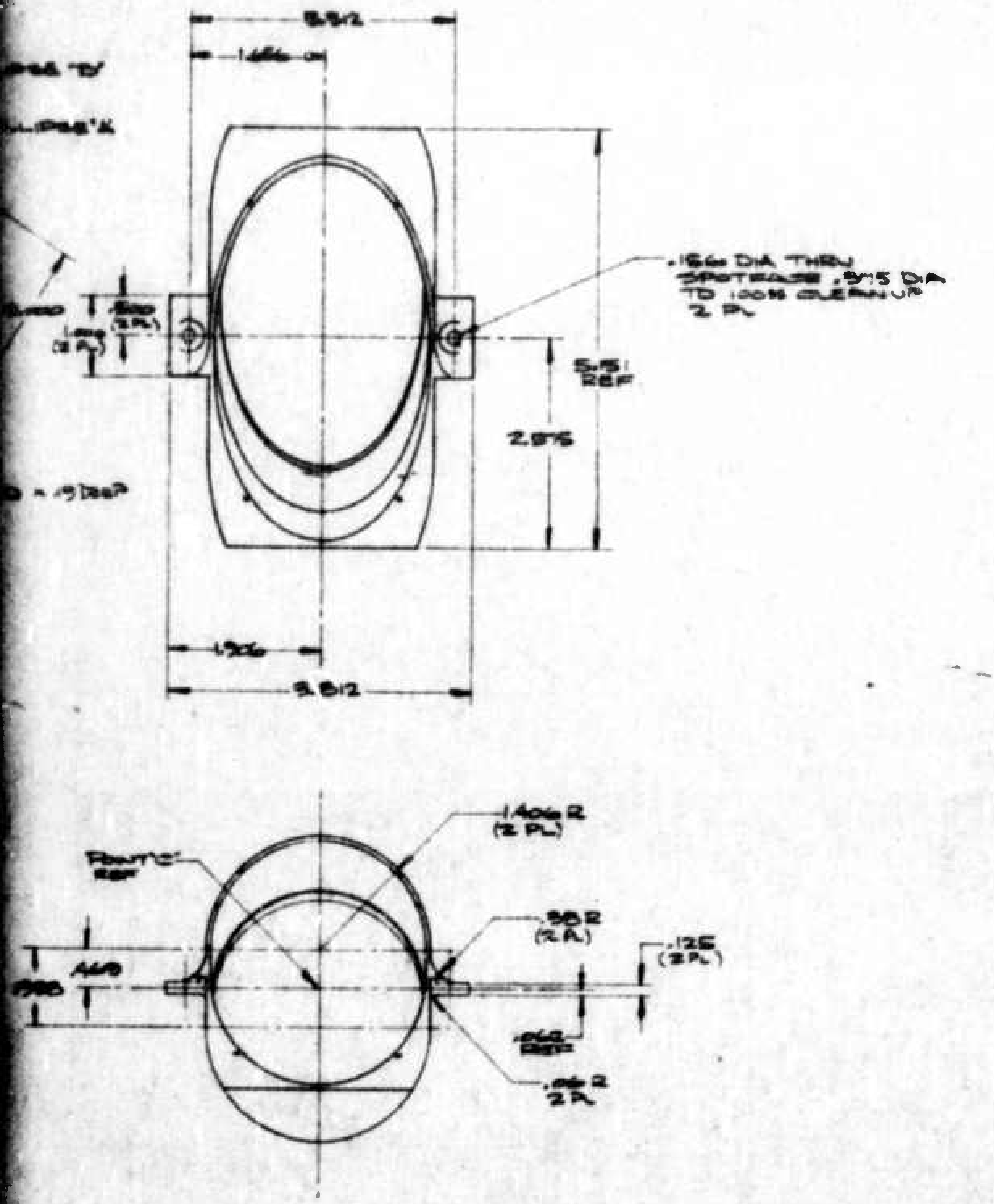

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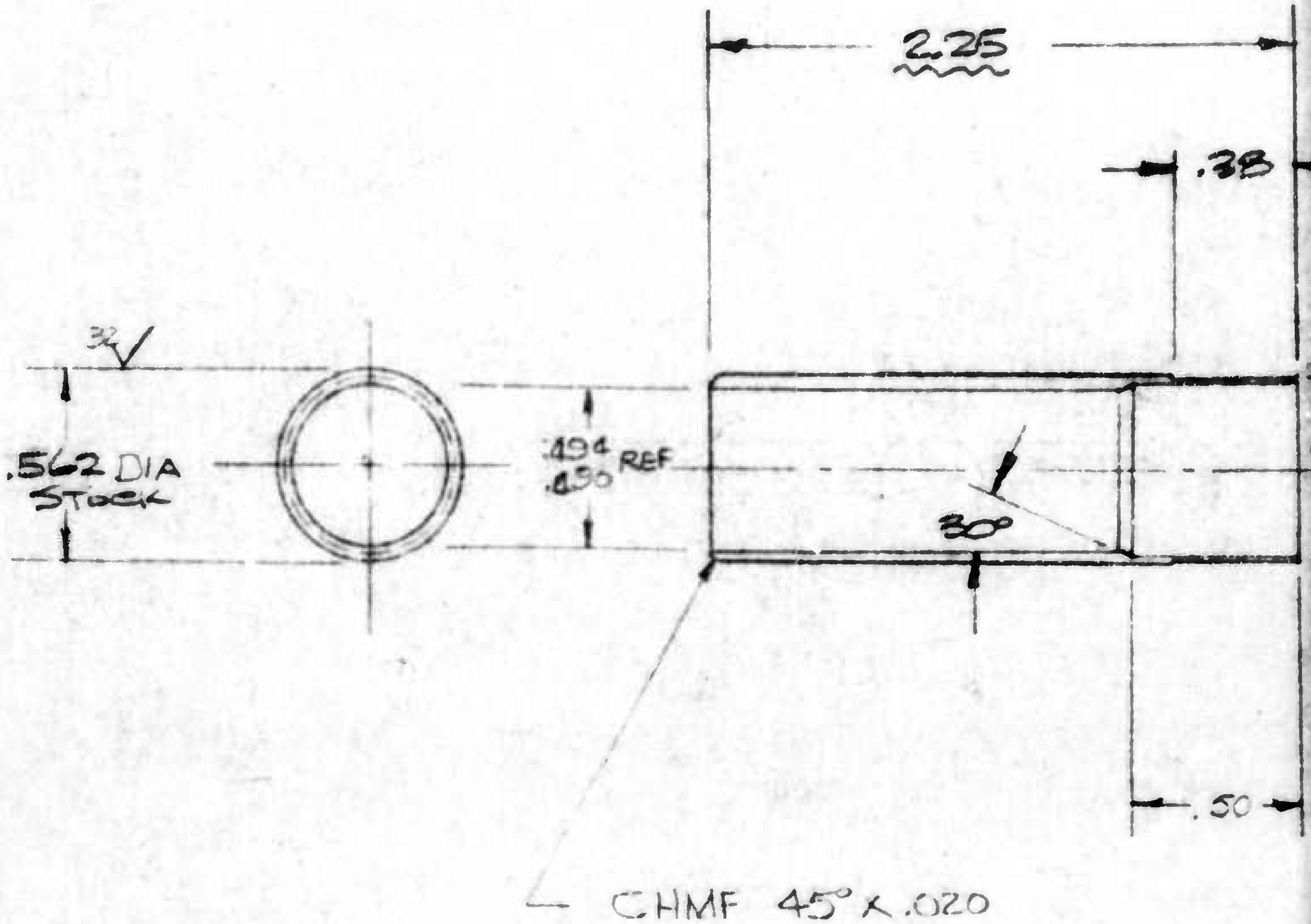
41901 A



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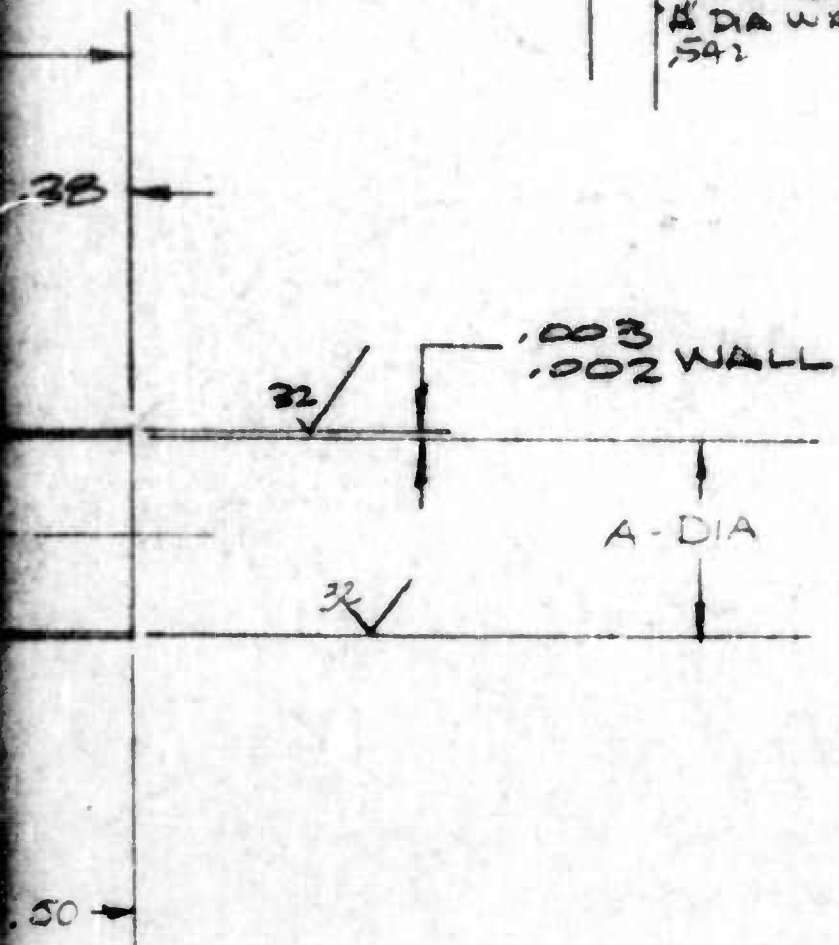

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CONTRACT NO.

		DATE
DRAWN		
CHECK	[illegible]	[illegible]
APPD		

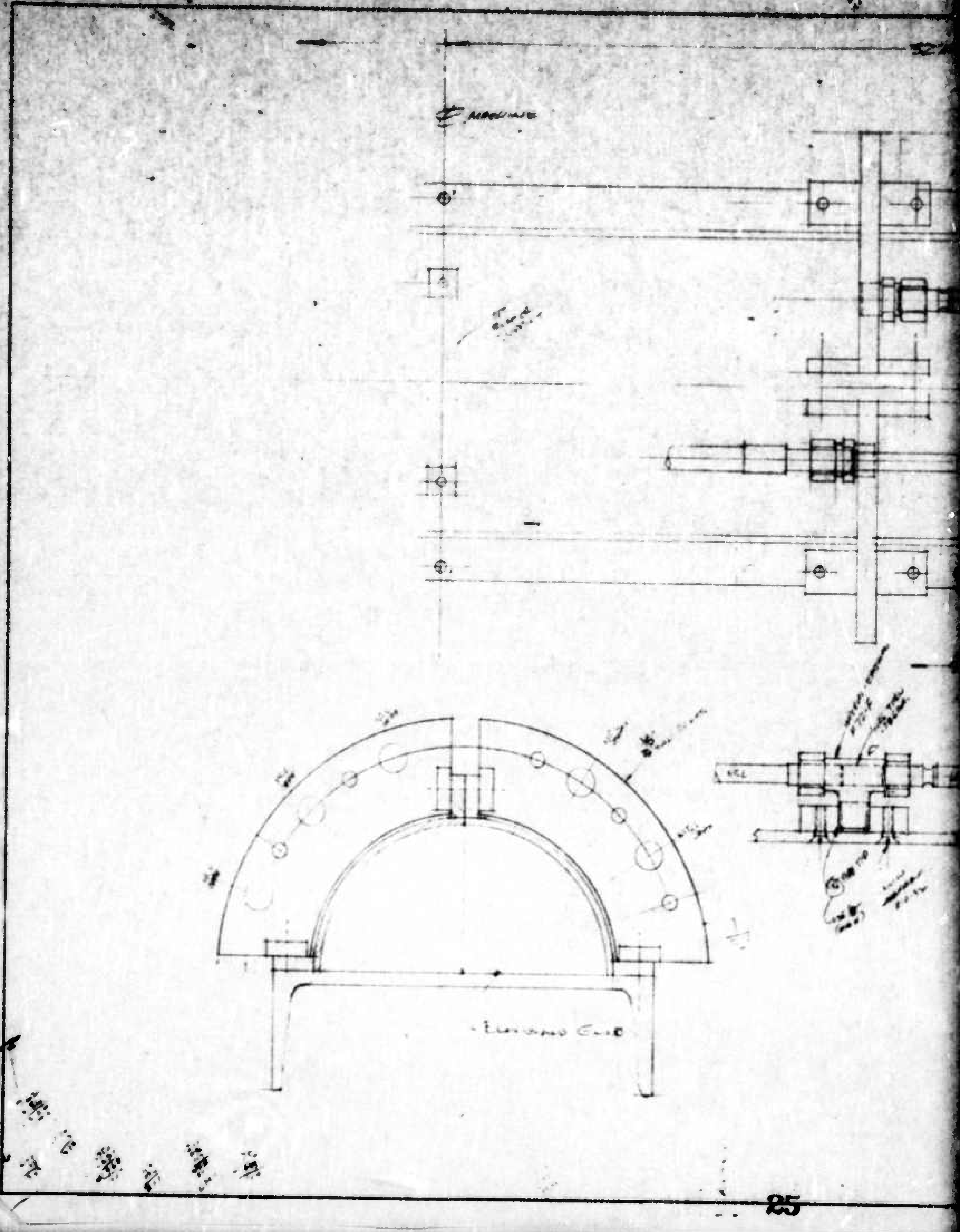
DESIGN ACTIVITY APPD

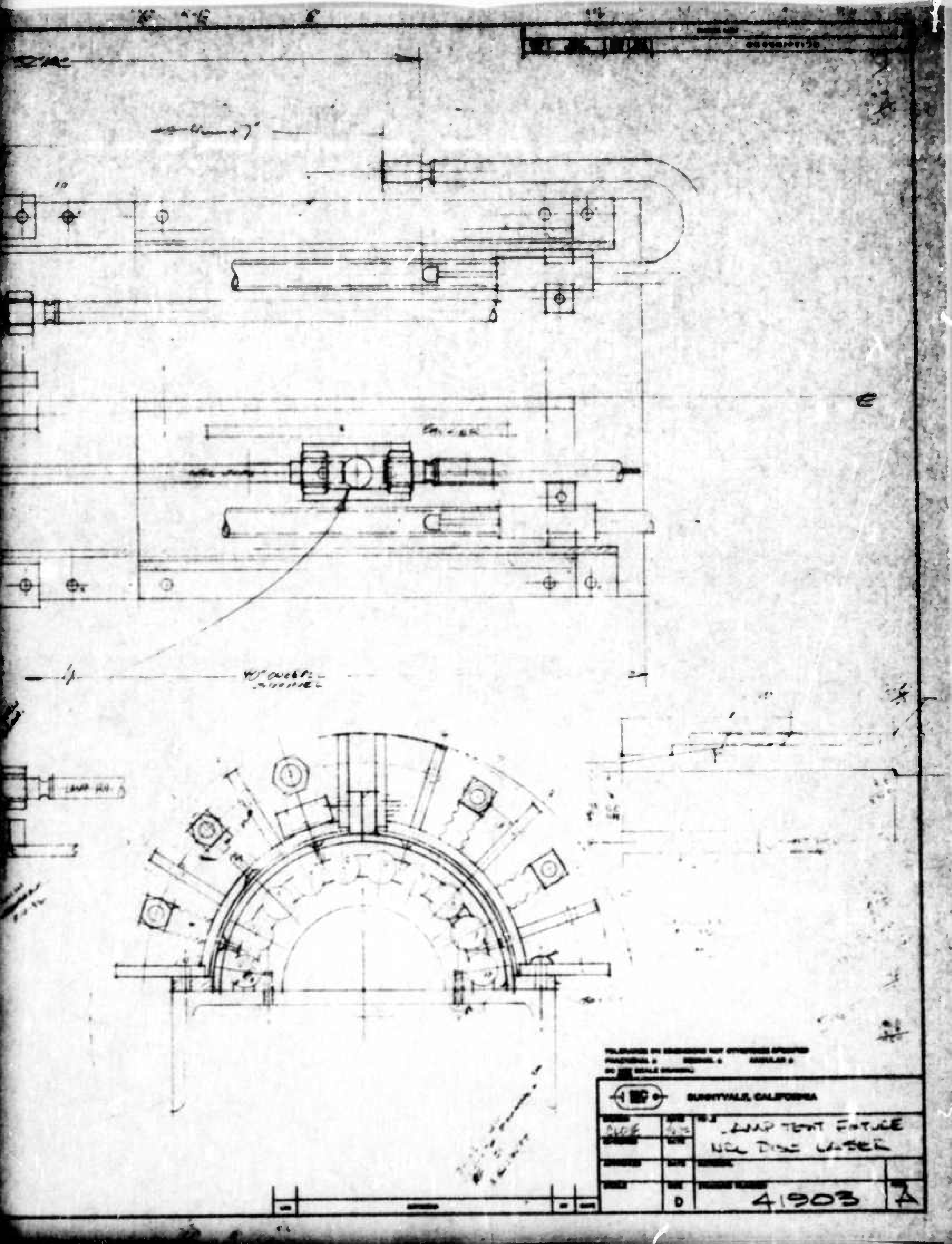
ILC INC.
164 COMMERCIAL STREET SUNNYVALE, CALIFORNIA [illegible]

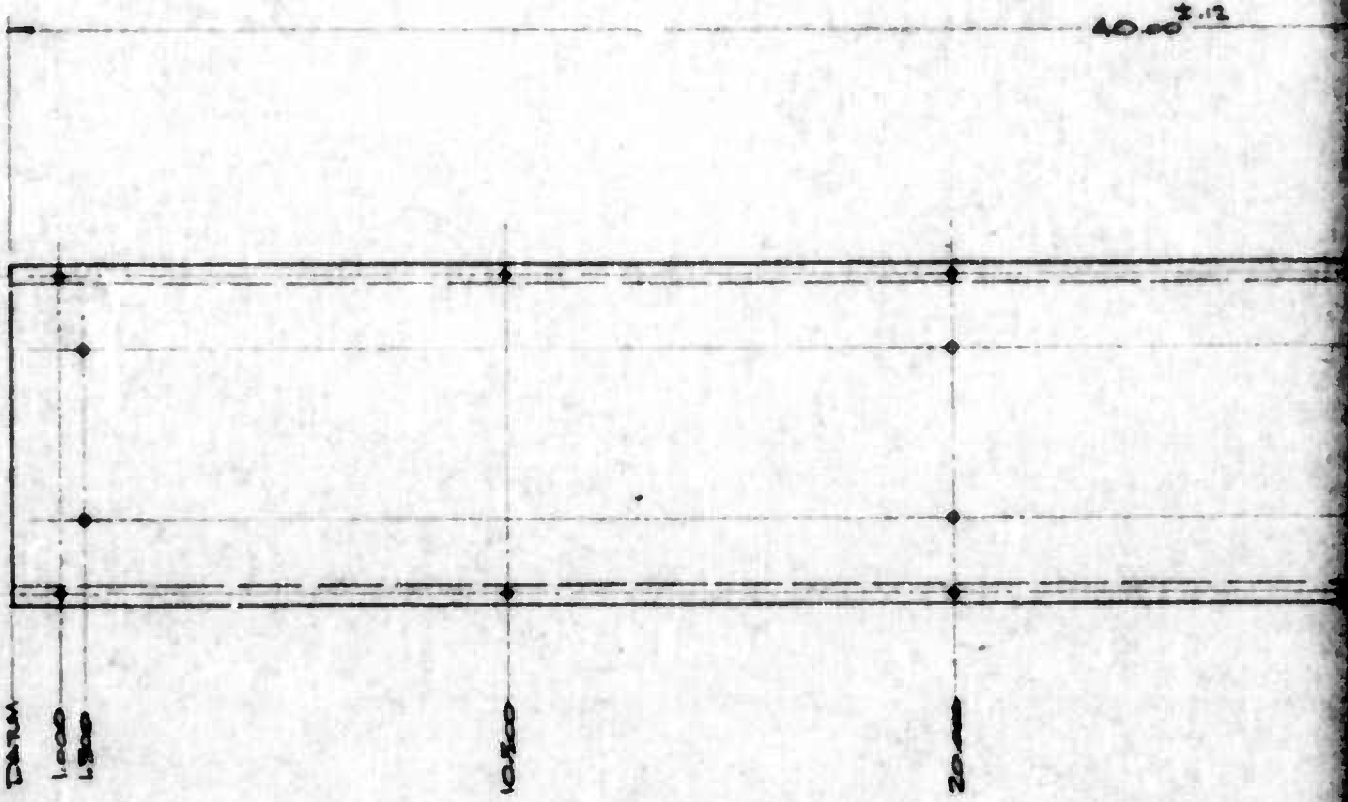
TITLE: LAMP BASE -14MM

SIZE	CODE IDENT. NO.	DWG. NO.
B	31573	41902

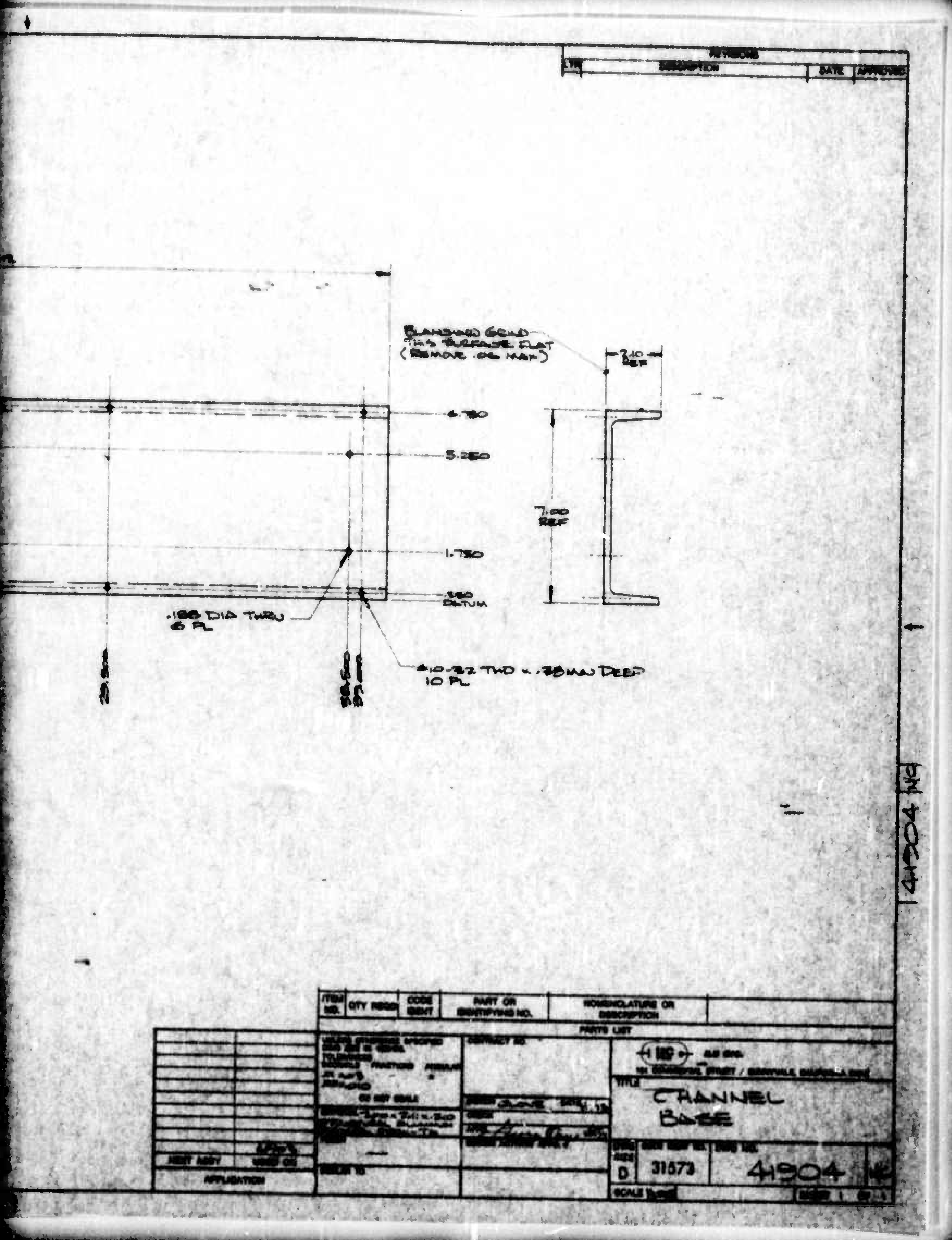
SCALE 2:1 | SHEET 1 OF 1




SUNNYVALE, CALIFORNIA
LAMP TEST FIXTURE
D
41903
A

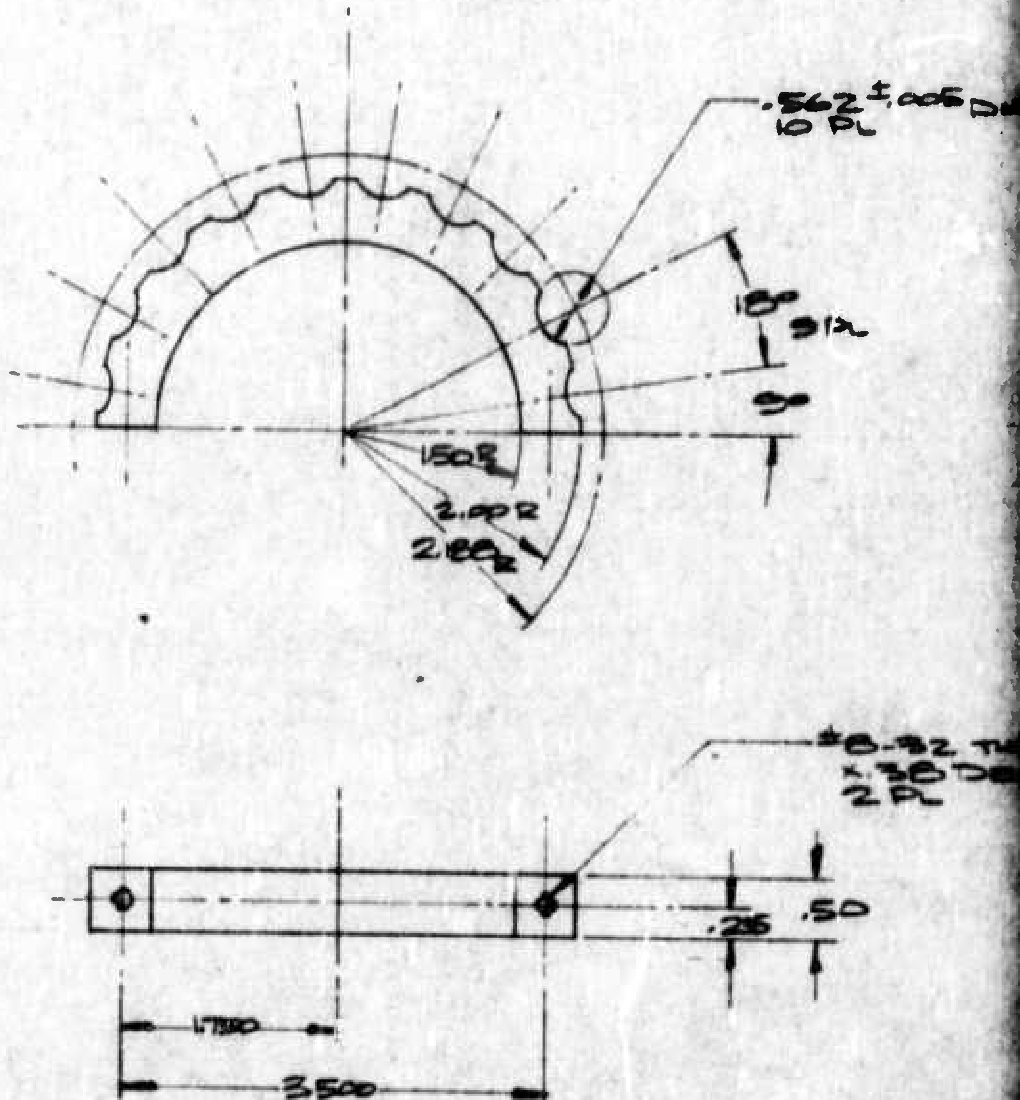


40.00 ±.12
DATUM
1.000
1.300
10.500
20.000


REVISIONS
DESCRIPTION
DATE
APPROVED
BLANCHARD GRIND
THIS SURFACE FLAT
(REMOVE .06 MAX)
2.10
REF
6.750
5.250
7.00
REF
1.750
.250
DATUM
.188 DIA THRU
6 PL
#10-32 THD x .38 MIN DEEP
10 PL
ITEM NO.
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
PARTS LIST
CONTRACT NO.
DO NOT SCALE
TITLE
CHANNEL
BASE
NEXT ASSY
USED ON
APPLICATION
D
31573
41904
41904

NOTES:

1. BREAK ALL SHARP EDGES & BRIGHT POLISH USING TYCRO WHEEL. .030 R MAX



ITEM NO.	QTY REQD	CODE IDENT	IDE

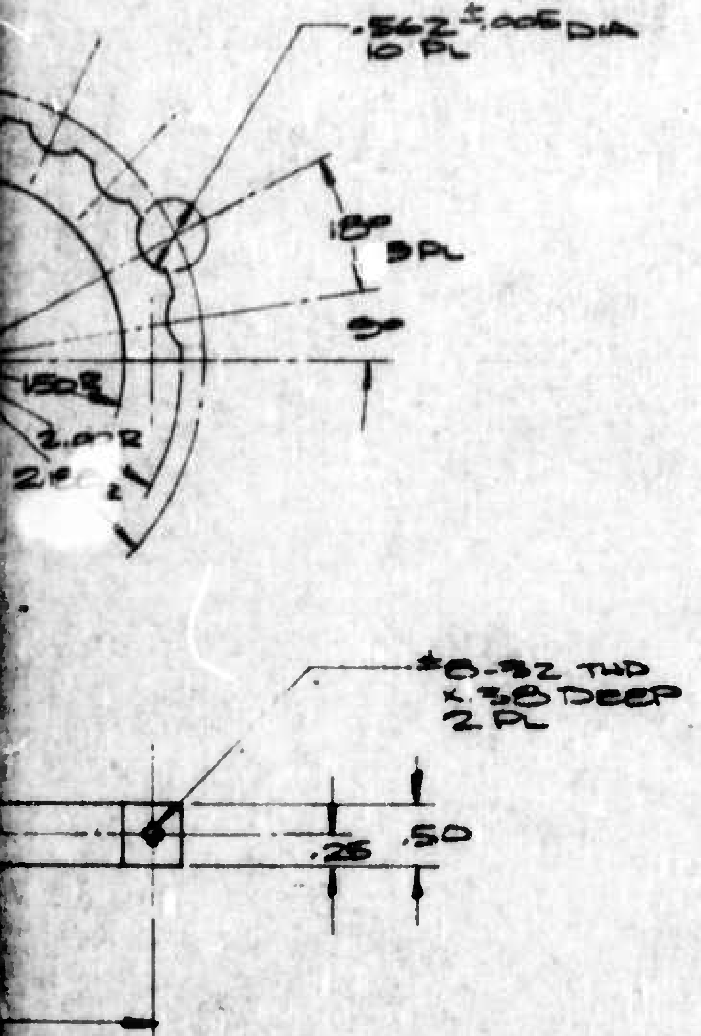
UNLESS OTHERWISE SPECIFIED DIMS ARE IN INCHES.
TOLERANCES
DECIMALS .XX ±.03, .XXX ±.010 FRACTIONS - ANGULAR ±1°
DO NOT SCALE

MATERIAL 4.00 OD X .500 W ALUM TUBING 6061-T6

FINISH

SIMILAR TO

NEXT ASSY	USED ON
APPLICATION	



REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

41905 N/C

ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMS ARE IN INCHES.
TOLERANCES
DECIMALS FRACTIONS ANGULAR
.XX ±.015 - ±1/0'
.XXX ±.010

DO NOT SCALE

MATERIAL 4.00 OD x .500W ALUM TUBING 6061-T6

FINISH —

SIMILAR TO

USED ON

APPLICATION

CONTRACT NO.

DRAWN C. BLOUE DATE

CHECK

APPD.

DESIGN ACTIVITY APPD.

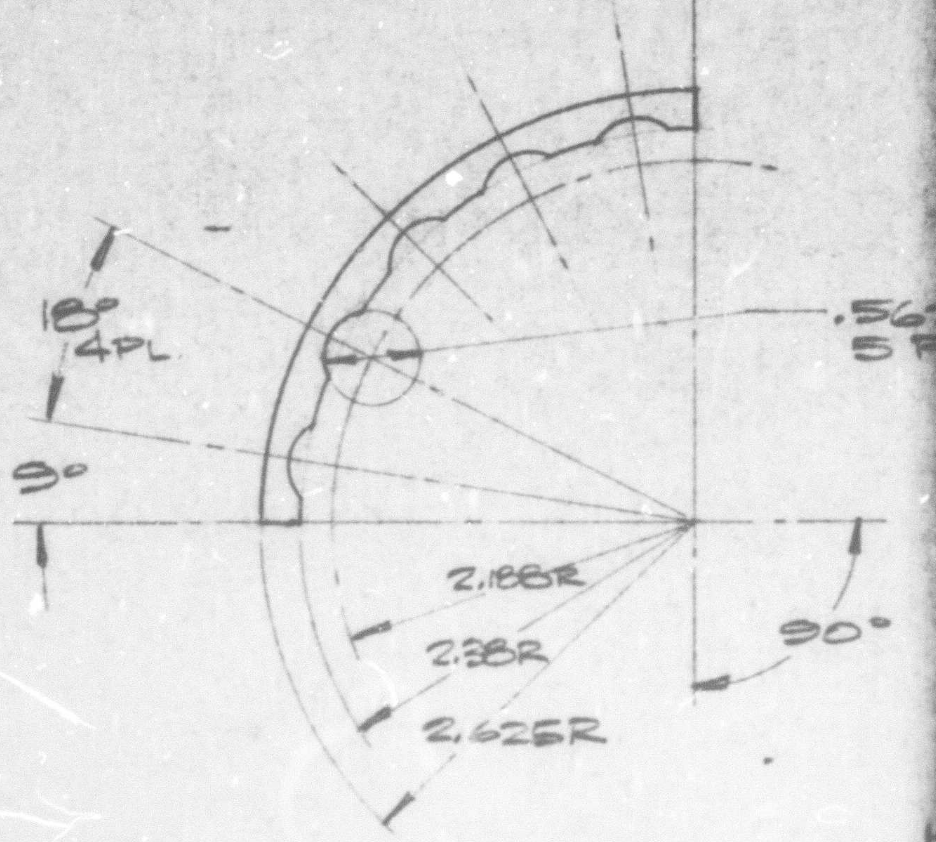
ILC INC.
164 COMMERCIAL STREET / SUNNYVALE, CALIFORNIA 94086

TITLE
LAMP END SUPPORT - INNER

DWG SIZE	CODE IDENT NO.	DWG NO.	
C	31573	41905	N/C

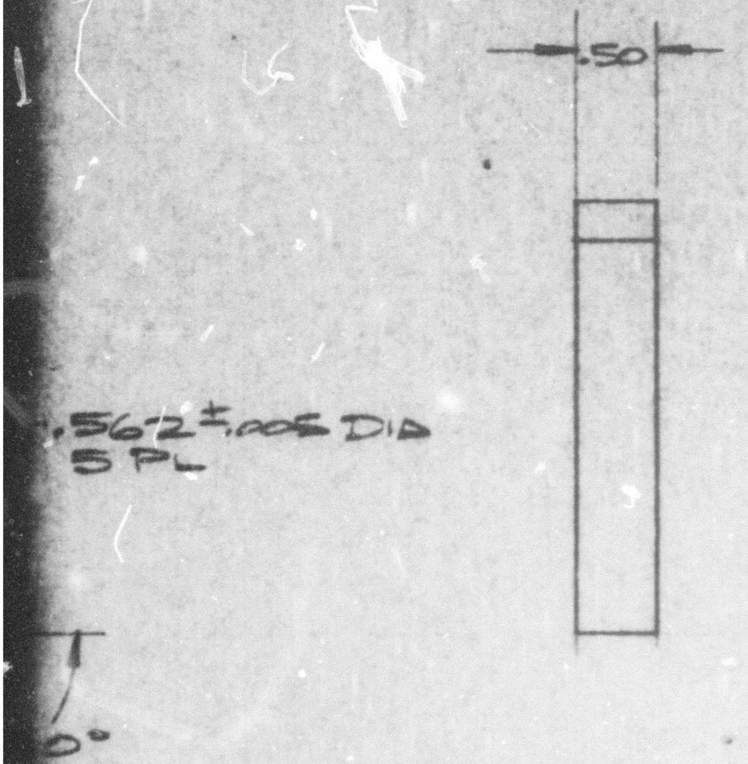
SCALE 1/1 SHEET 1 OF 1

NOTES:
1. BREAK ALL SHARP EDGES &
BRIGHT POLISH USING TYCRO WHEEL.
.030 R MAX



NEXT ASSY	USED ON
APPLICATION	

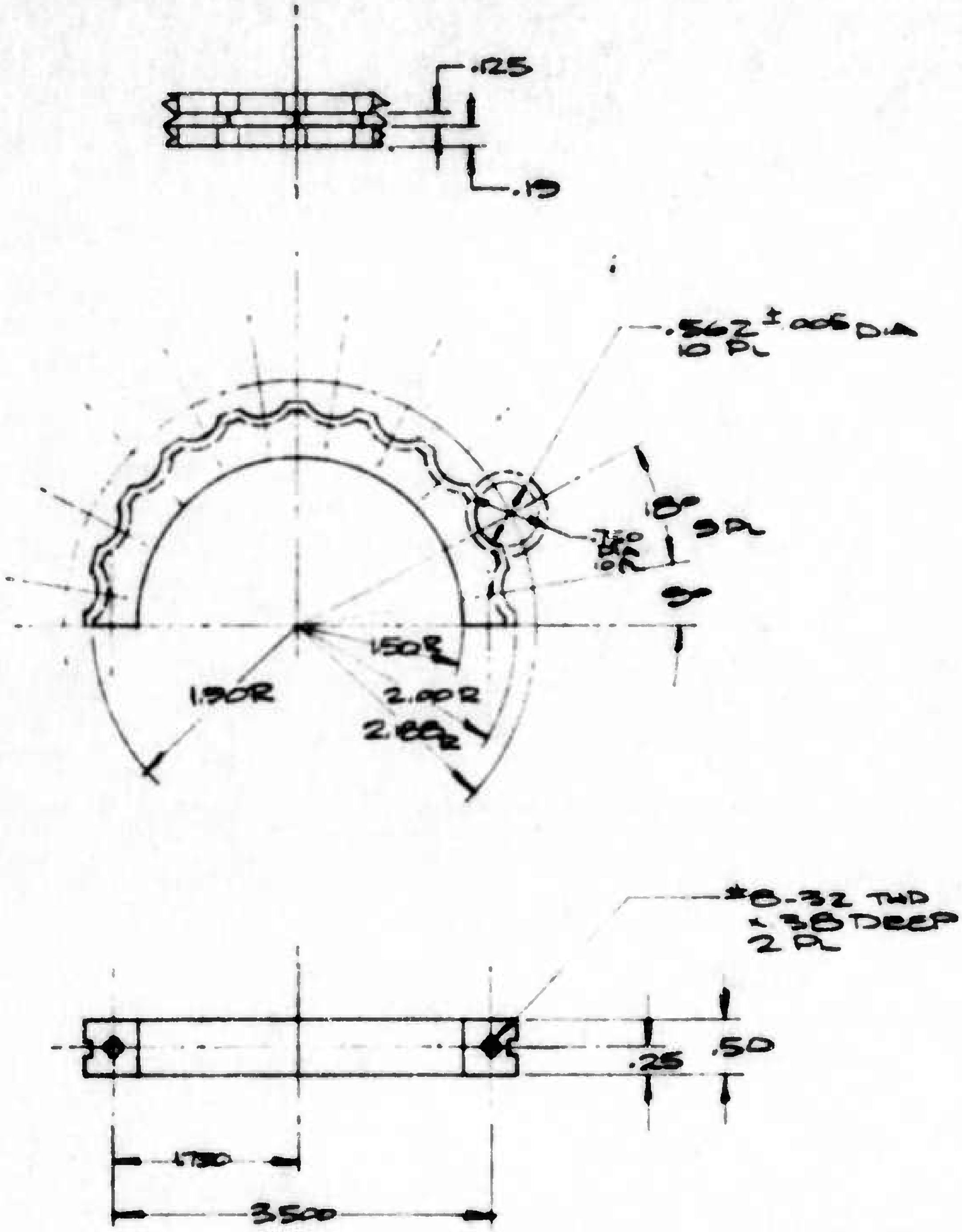
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

UNLESS OTHERWISE SPEC. DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS ± 1/32 ANGLES ± 10' .XX DEC ± .03 .XXX DEC ± .010	CONTRACT NO.	ILC INC. 164 COMMERCIAL STREET SUNNYVALE, CALIFORNIA 94086	
	DRAWN C LOVE · DATE 1/18/73	TITLE LAMP END SUPPORT-OUTER	
MATERIAL: ALUMINUM 6061-T6	CHECK		
	APPD [signature] 1/24/73 DESIGN ACTIVITY APPD	SIZE B · CODE IDENT. NO. 31573	DWG. NO. 41906 N/C
FINISH: —		SCALE 1/1	SHEET 1 OF 1

...D ON



ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMS ARE IN INCHES.
TOLERANCES
DECIMALS FRACTIONS ANGULAR
XX ±.03 - ±1/2°
XXX ±.010
DO NOT SCALE

MATERIAL 4.00 OD x .500W ALUM TUBING 6061-T6

FINISH —

SIMILAR TO

CONTRACT NO.

DRAWN GLOVE DATE

CHECK

APPD

DESIGN ACTIVITY APPD

TITLE

DWG SIZE C

CODE

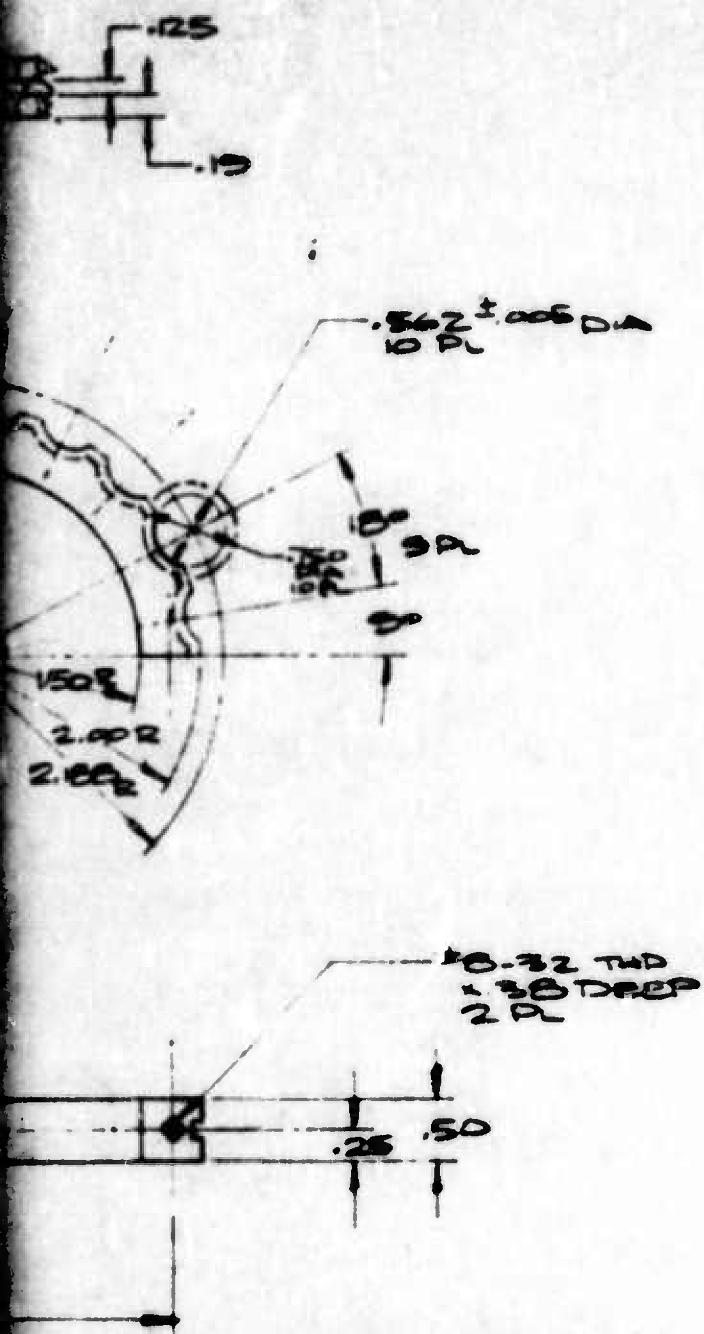
SCALE 1/1

NEXT ASSY | USED ON

APPLICATION

LTR

LTR	REVISIONS DESCRIPTION	DATE	APPROVED



41907 NC

ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMS ARE IN INCHES.
TOLERANCES
DECIMALS FRACTIONS ANGULAR
.XX ±.03 - ±1°
.XXX ±.010
DO NOT SCALE

MATERIAL 4.00 OD x .500W ALUM TUBING 6061-T6

FINISH —

SIMILAR TO

CONTRACT NO.

DRAWN GLOVE DATE

CHECK

APPD.

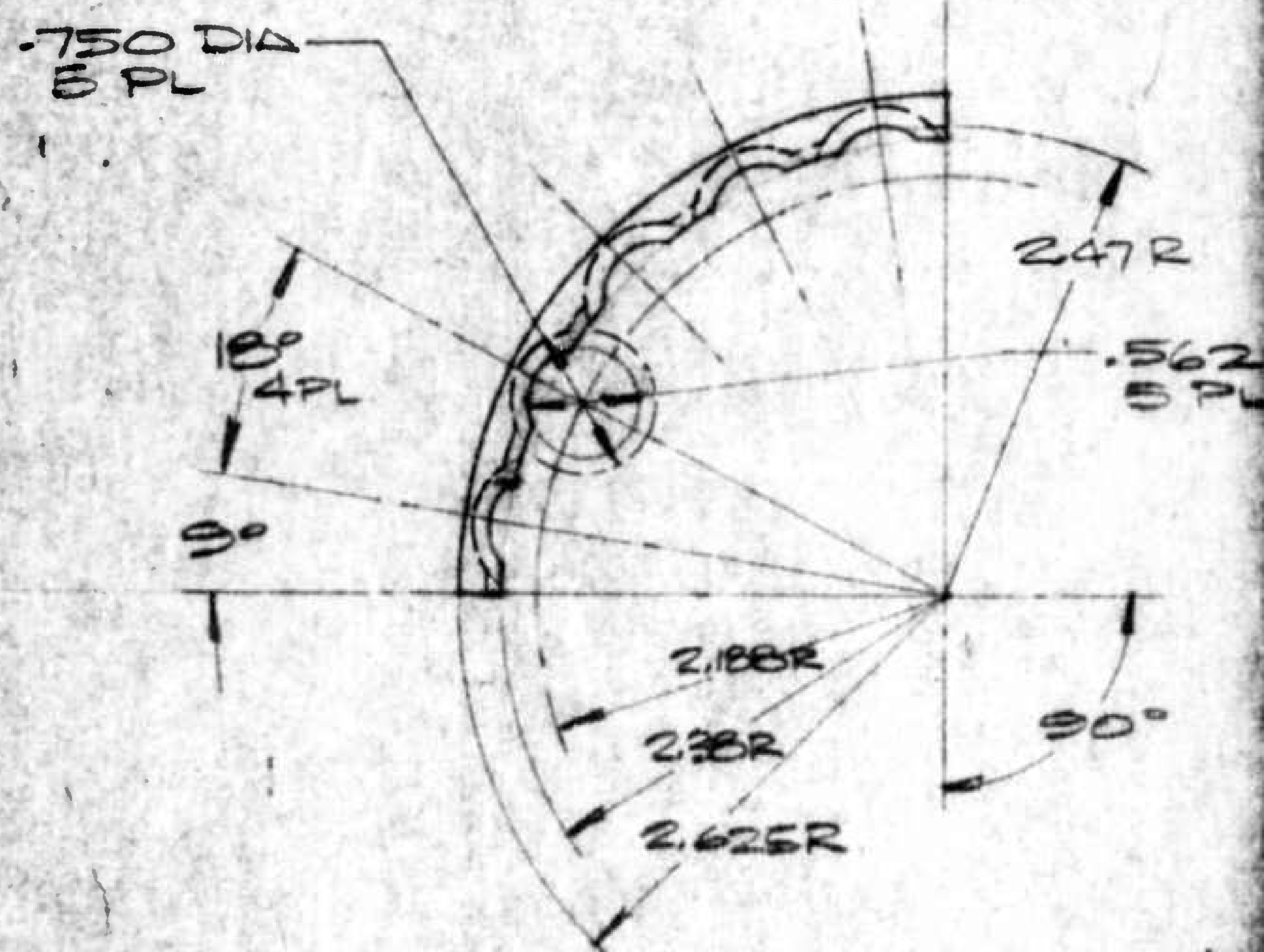
DESIGN ACTIVITY APPD.

ALC INC.
184 COMMERCIAL STREET SUNNYVALE CALIFORNIA

TITLE LAMP SUPPORT-MIDDLE, INNER

DWG SIZE	CODE IDENT NO.	DWG NO.
C	31573	41907 NC

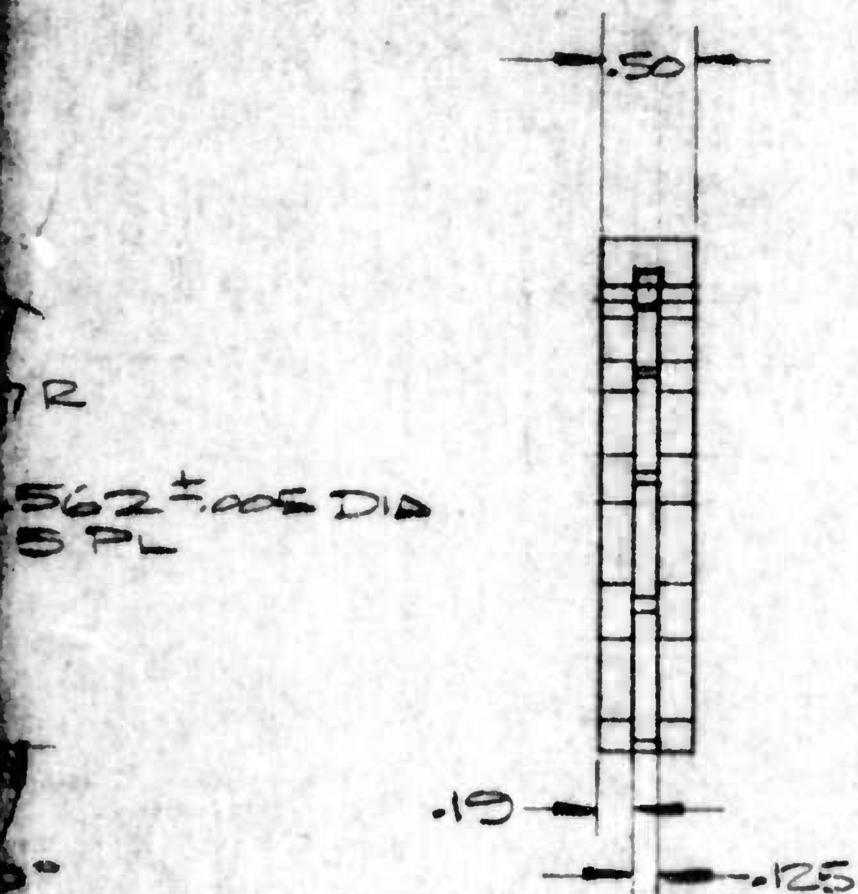
SCALE 1/1 SHEET



NEXT ASSY	USED ON
APPLICATION	

1900617

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

UNLESS OTHERWISE SPEC.
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
ANGLES ± 10'
.XX DEC ± .03
.XXX DEC ± .010

MATERIAL: ALUMINUM

FINISH: —

CONTRACT NO.

DRAWN C LOVE DATE

CHECK

APPD

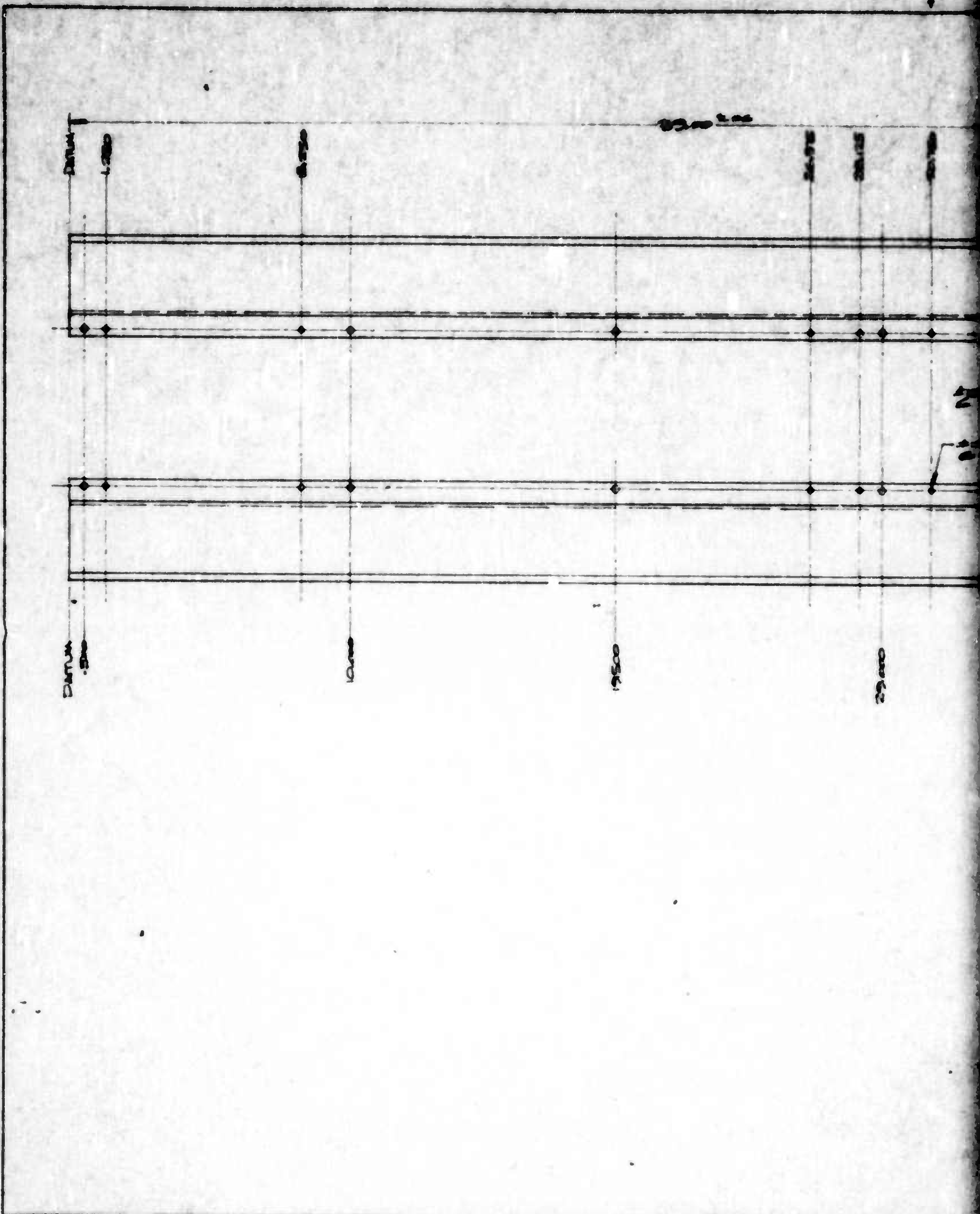
DESIGN ACTIVITY APPD

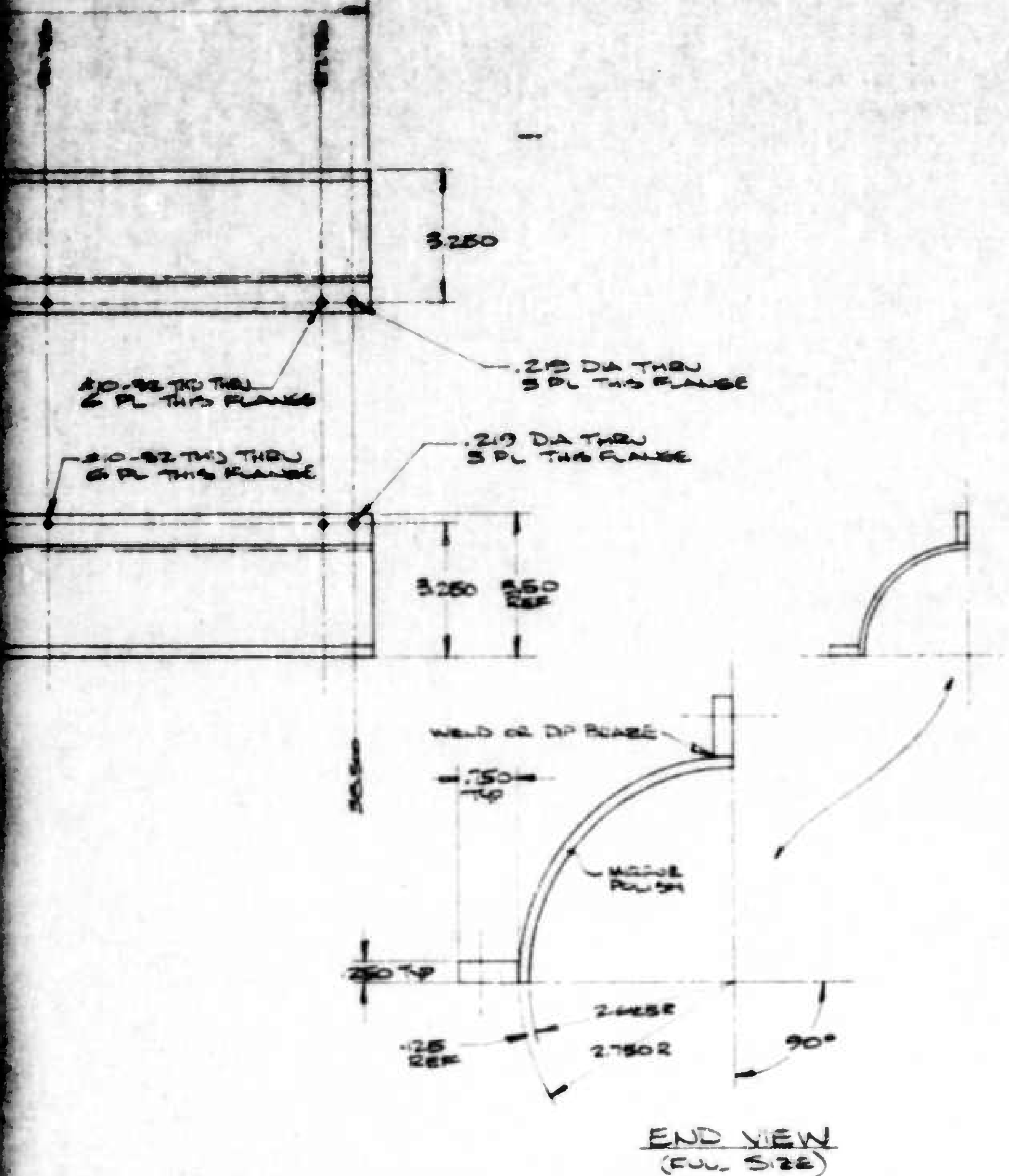
ILC INC.
164 COMMERCIAL STREET SUNNYVALE, CALIFORNIA 94086

TITLE LAMP SUPPORT — MIDDLE, OUTER

SIZE	CODE IDENT. NO.	DWG. NO.
B	31573	41908 N/C

SCALE 1/1 SHEET 1 OF 1


DATUM
DATUM



END VIEW
(FULL SIZE)

ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

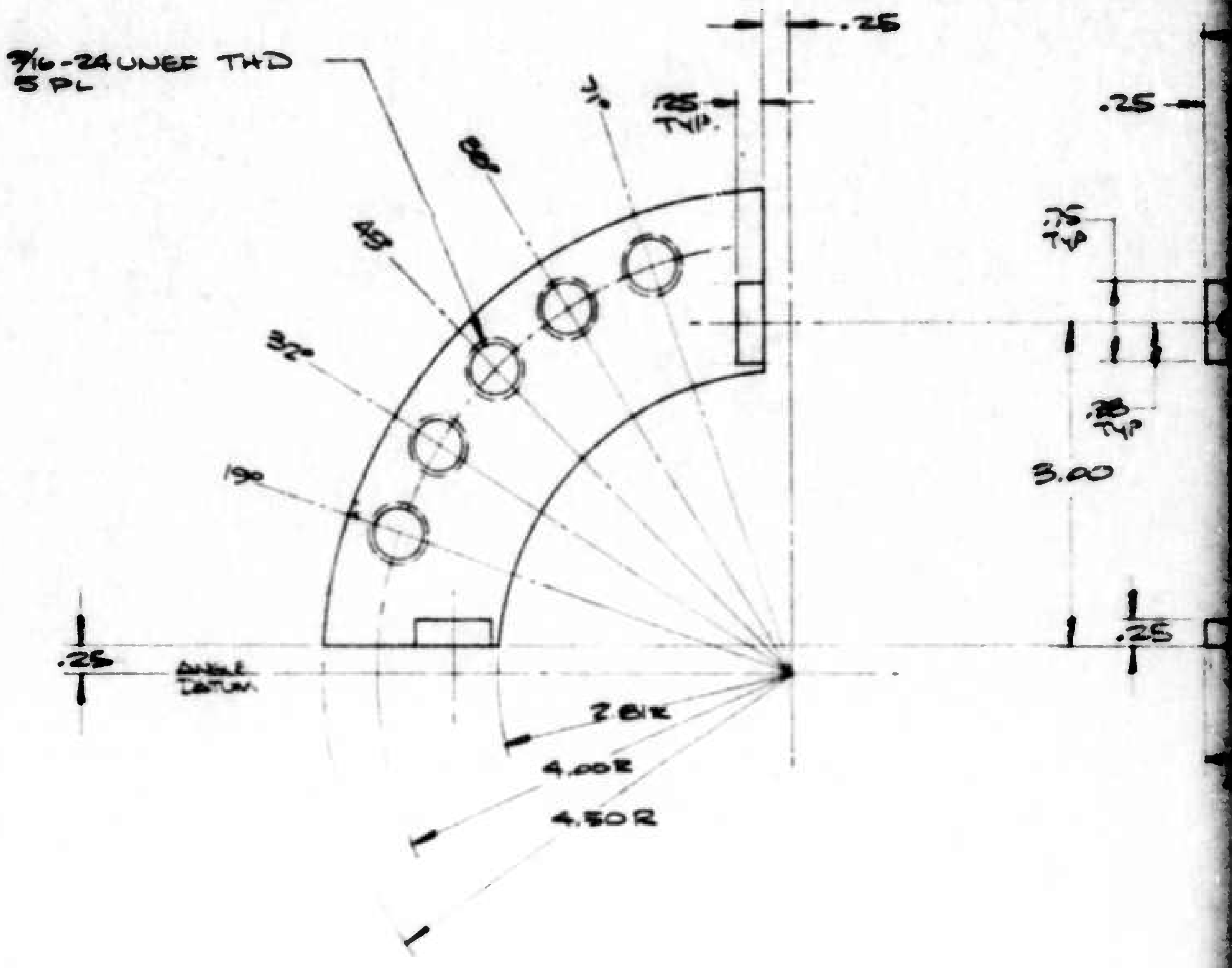
UNLESS OTHERWISE SPECIFIED DIMS ARE IN INCHES TOLERANCES DECIMALS FRACTIONS ANGULAR	CONTRACT NO.
DO NOT SCALE	DRAWN GLOVE
MATERIAL 6061-T6 ALUMINUM	CHECK
FINISH —	APPD.
SIMILAR TO	

NEXT ASSY	USED ON
	41903
APPLICATION	

TITLE: REFLECTOR QUADRANT

DWG SIZE	CODE IDENT NO.	DWG NO.	
D	31573	41909	NK

SCALE | SHEET 1 OF 1



ITEM NO.	QTY REQD	CODE IDENT	ID[illegible]

UNLESS OTHERWISE SPECIFIED
DIMS ARE IN INCHES
TOLERANCES
DECIMALS FRACTIONS ANGULAR
XX ±.03 ±1/2°
XXX±.010
DO NOT SCALE

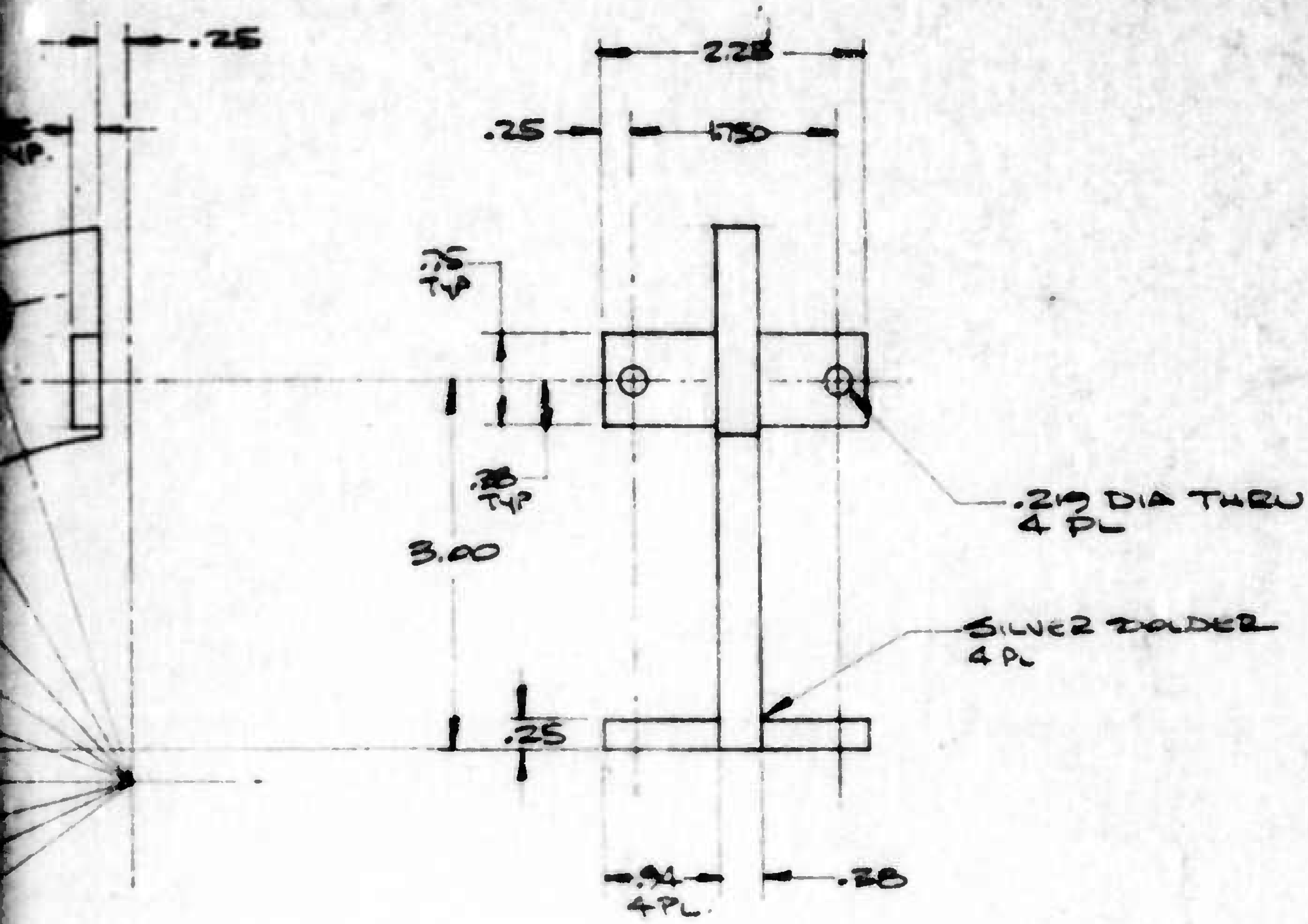
MATERIAL HALF HARD BRASS
ALLOY 260 ASTM-B-36

FINISH —

SIMILAR TO

	41905
NEXT ASSY	USED ON
APPLICATION	

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



41910 NC

ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMS ARE IN INCHES
TOLERANCES
DECIMALS FRACTIONS ANGULAR
XX ±.03 ±1/2°
XXX±.010
DO NOT SCALE

CONTRACT NO.

ILC INC.
164 COMMERCIAL STREET / SUNNYVALE, CALIFORNIA

DRAWN CLOVE DATE 1/1/78
CHECK
APPD.

TITLE
GROUND RING

MATERIAL HALF HARD BRASS ALLOY 260 ASTM-B-36

FINISH ——

DESIGN ACTIVITY APPD.

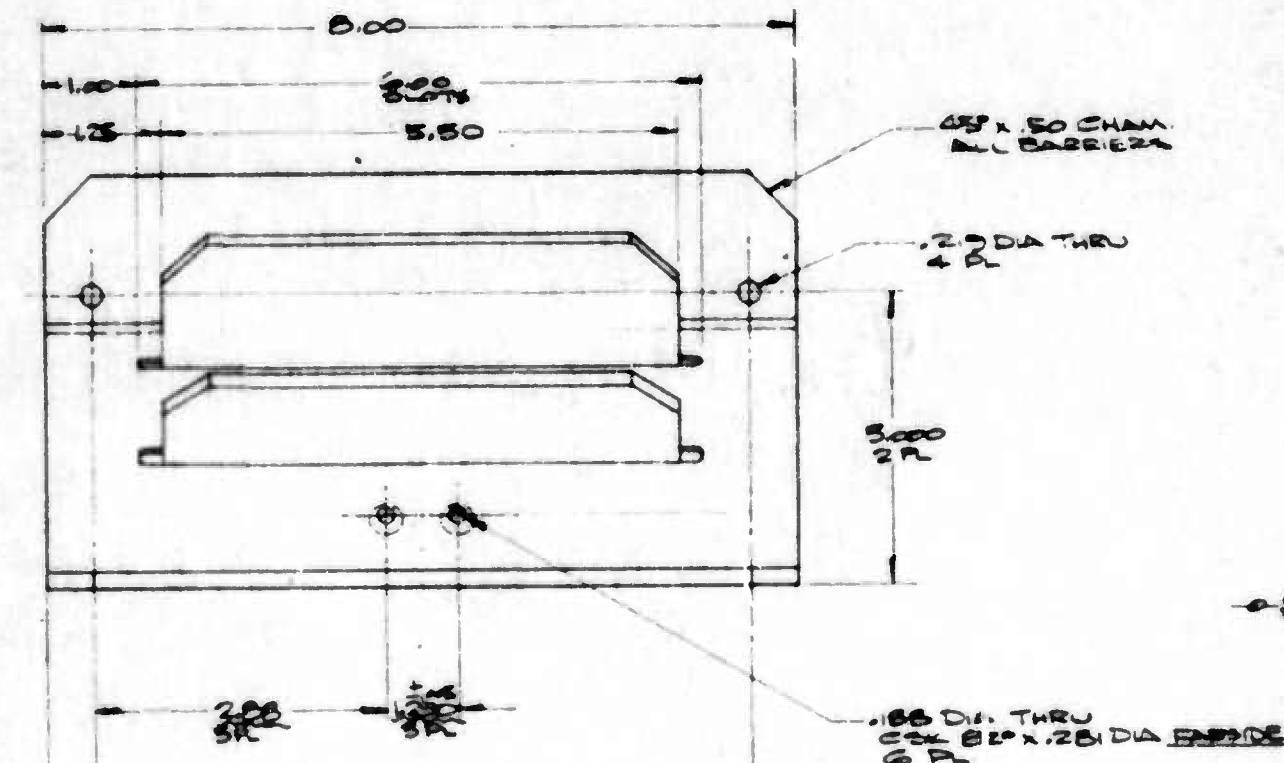
41908
NEXT ASSY USED ON
APPLICATION

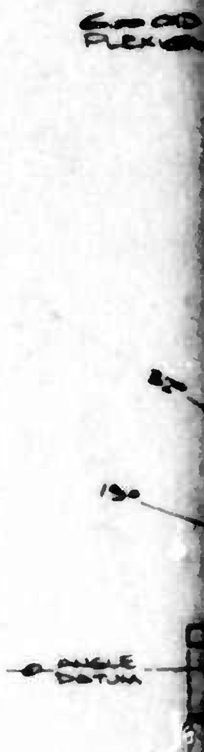
SIMILAR TO

DWG SIZE	CODE IDENT NO.	DWG NO.	
C	31573	41910	NC

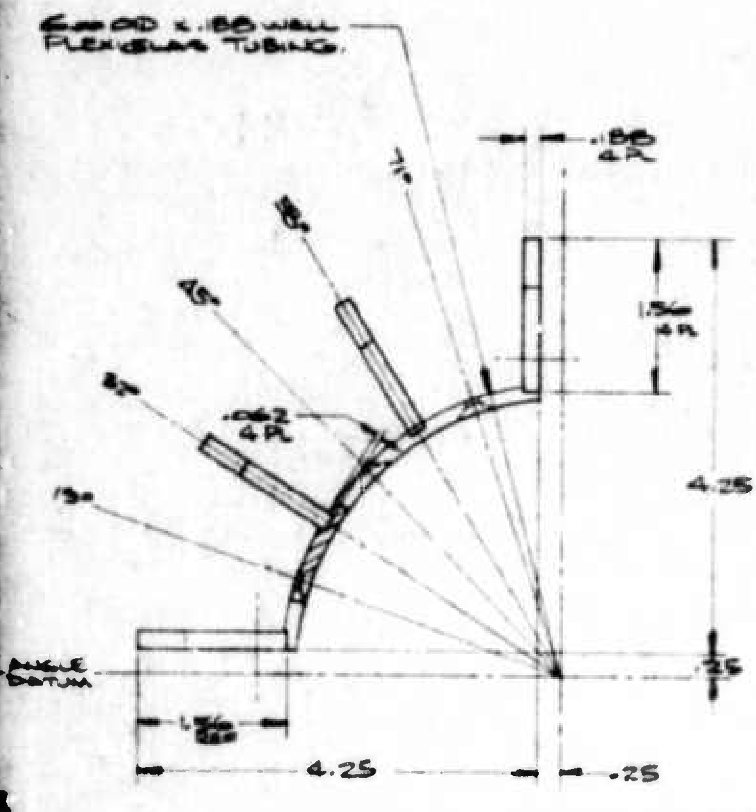
SCALE FULL SHEET 1 OF 1

NOTES:
1. CEMENT ALL JOINTS.
2. FIRE POLISH ALL MACHINED EDGES.





REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

41903	
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMS ARE IN INCHES
TOLERANCES
DECIMALS FRACTIONS ANGULAR
.XX ± .03 ± 1°
.XXX ± .010
DO NOT SCALE

MATERIAL PLEXIGLAS

FINISH —

SIMILAR TO

CONTRACT NO.

DRAWN OLIVE DATE

CHECK

APPD

DESIGN ACTIVITY APPD

ILC

ILC AMG.

164 COMMERCIAL STREET / SUNNYVALE, CALIFORNIA

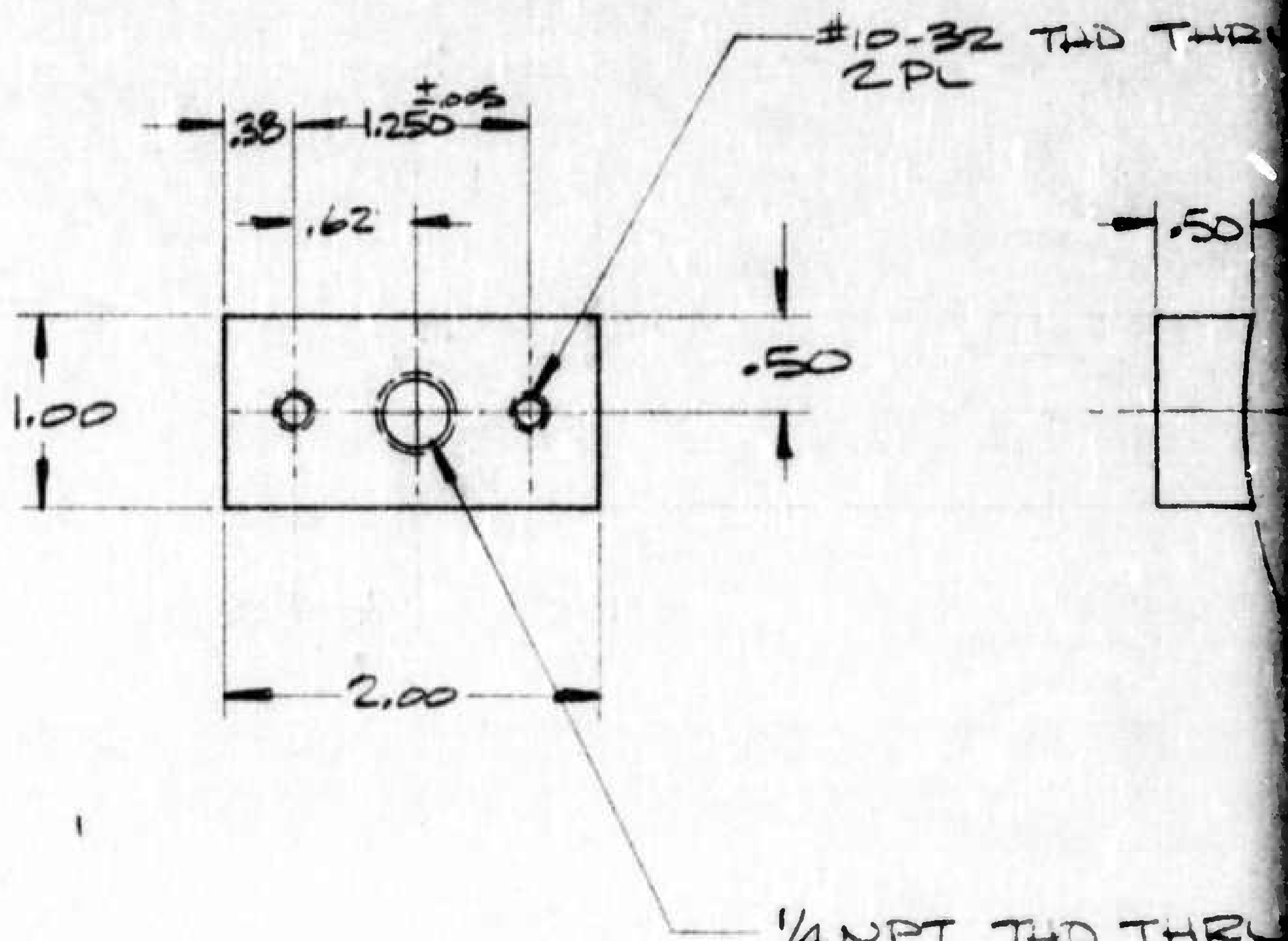
TITLE BARRIER INSULATOR (L.A.)

DWG SIZE	CODE IDENT NO.	DWG NO.	
D	31573	41911	NC

SCALE FULL — SHEET 1 OF 1

41911 NC

NOTES:
1. FIRE POLISH



	41903
NEXT ASSY	USED ON
APPLICATION	

41912 N/C

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

THRU

THRU

ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

UNLESS OTHERWISE SPEC.
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 63√
ANGLES ±
.XX DEC ±.03
.XXX DEC ±.010

MATERIAL: PLEXIGLAS

FINISH: —

CONTRACT NO.

DRAWN CLOVE DATE 1-23-03

CHECK

APPD Geo Ciupka

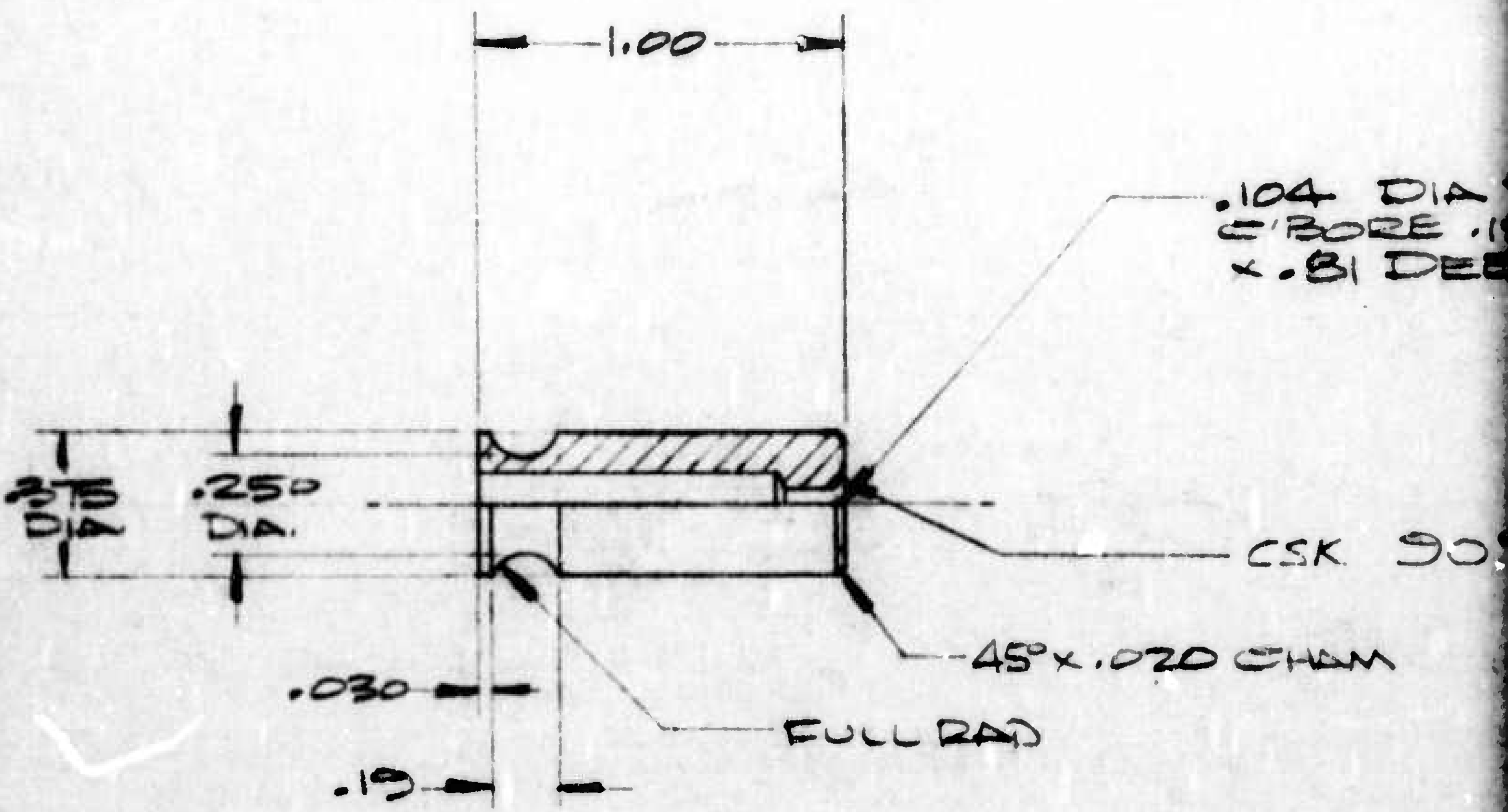
DESIGN ACTIVITY APPD

ILC INC.
164 COMMERCIAL STREET SUNNYVALE, CALIFORNIA 94086

TITLE: INSULATED STANDOFF

SIZE	CODE IDENT. NO.	DWG. NO.
B	31573	41912 N/C

SCALE FULL SHEET 1 OF 1



	4190З
NEXT ASSY	USED ON
APPLICATION	

4914

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	ADD 90° x .20 DIA CSK	3-7-73	GO

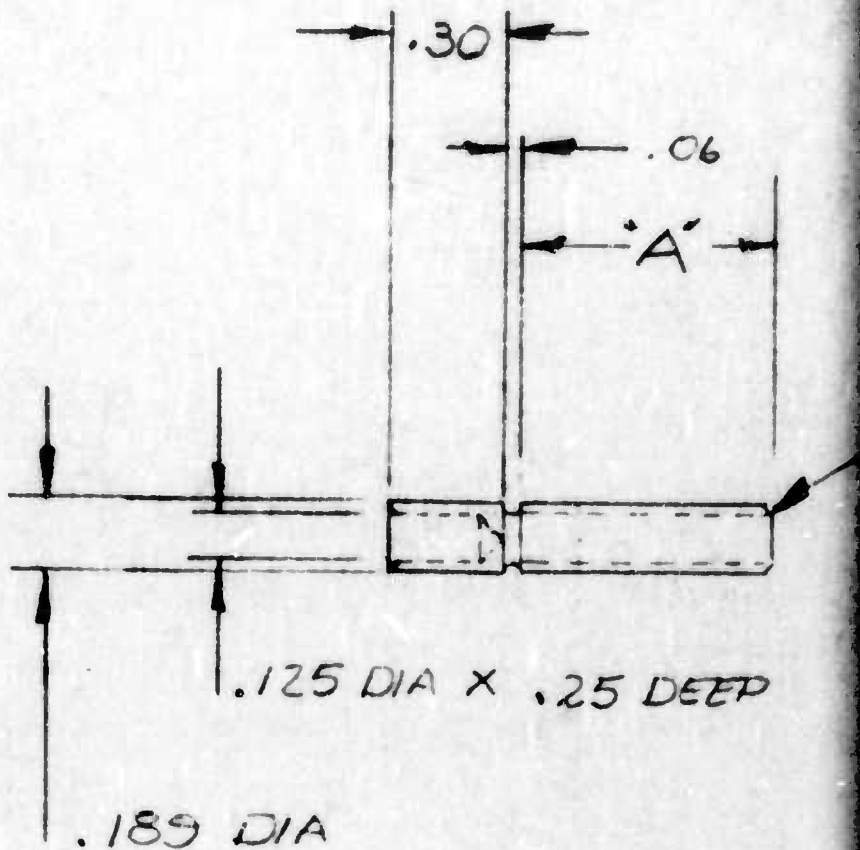
DIA THRU
RE .188 DIA
DEEP

90° X .20 DIA

ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

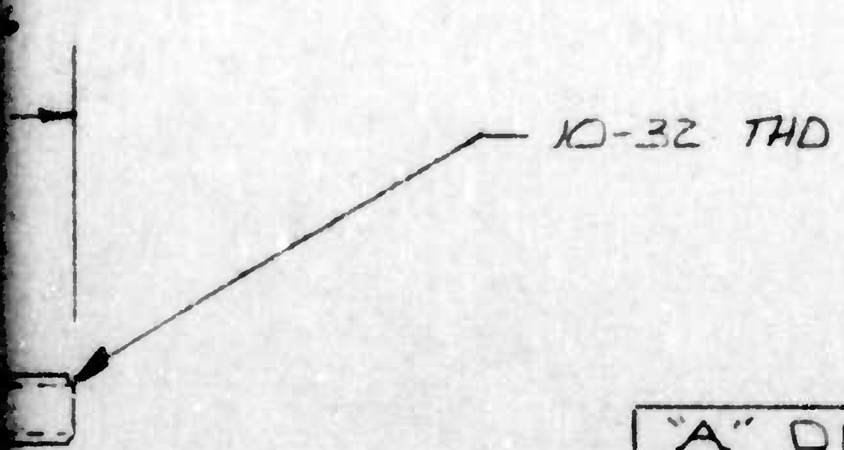
UNLESS OTHERWISE SPEC. DIMENSIONS ARE IN INCHES TOLERANCES: 63 FRACTIONS ± ANGLES ± .XX DEC ±.03 .XXX DEC ±.010	CONTRACT NO.	ILC INC. 164 COMMERCIAL STREET SUNNYVALE, CALIFORNIA 94086
MATERIAL: HALF HARD BRASS QQ-B-637	DRAWN CLONIE DATE	TITLE TERMINAL - LAMP LEAD
	CHECK	
	APPD Geo Origi	
FINISH: —	DESIGN ACTIVITY APPD	SIZE B · CODE IDENT. NO. 31573 · DWG. NO. 4914 A
		SCALE 2x · SHEET 1 OF 1

ON



NEXT ASSY	USED ON
APPLICATION	

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



EP

"A" DIM.	
-1	.50
-3	1.00

ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

UNLESS OTHERWISE SPEC.
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
ANGLES ±
XX. DEC ±
XXX DEC ±

MATERIAL: COPPER OR BRASS

FINISH: STOCK

CONTRACT NO.

DRAWN	G OIYE	DATE
CHECK		
APPD		
DESIGN ACTIVITY APPD		

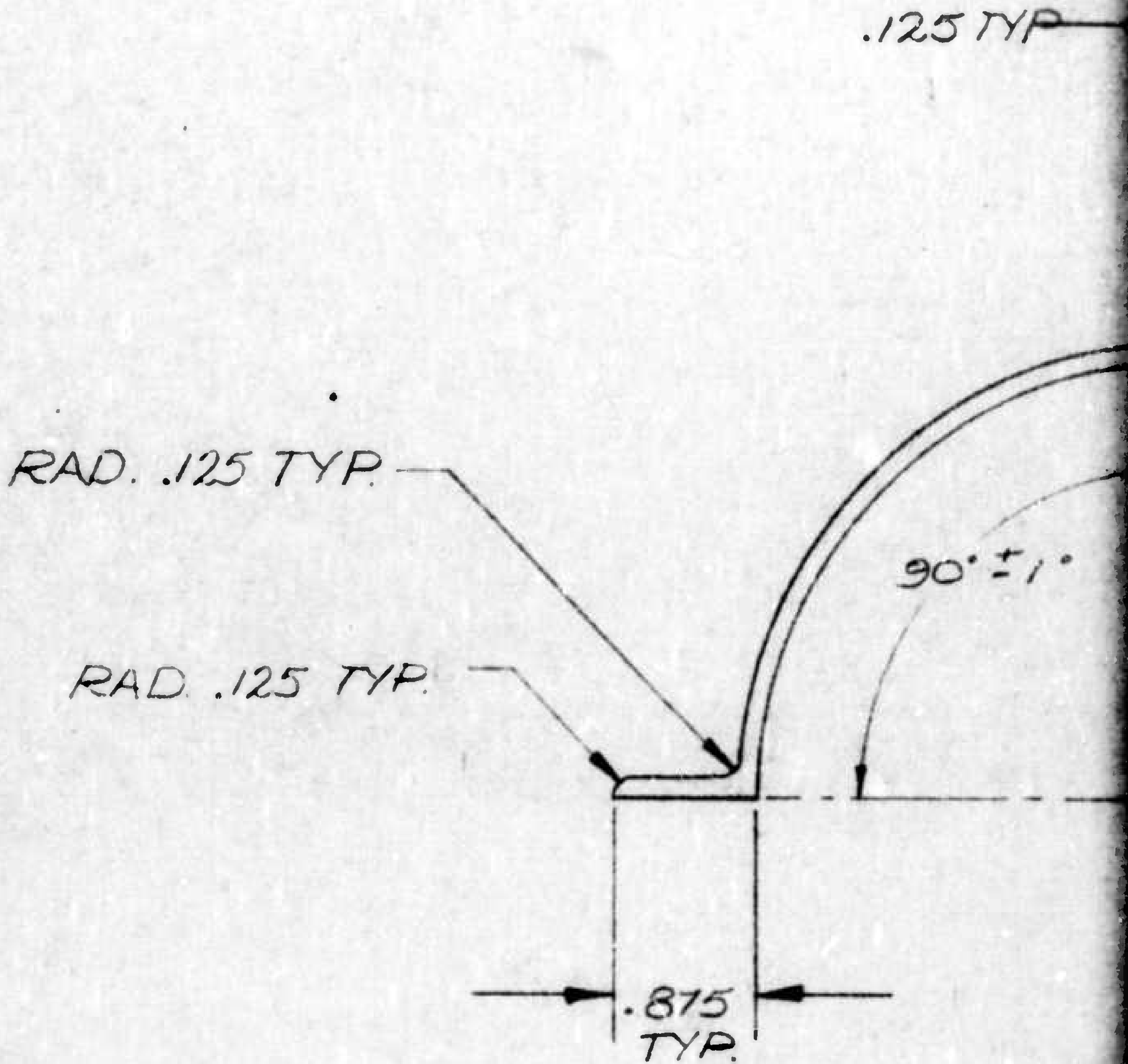
ILC INC.
164 COMMERCIAL STREET SUNNYVALE, CALIFORNIA 94086

TITLE FITTING, THD'D METER

SIZE	CODE IDENT. NO.	DWG. NO.
B	31573	41915

SCALE 2:1 | SHEET 1 OF 1

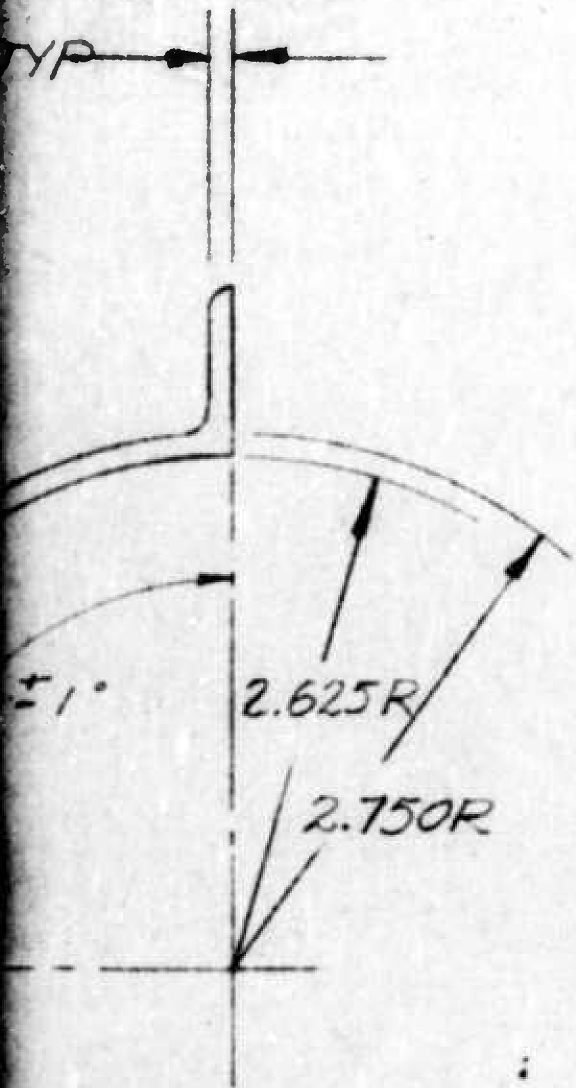
... ON



NEXT ASSY	USED ON
APPLICATION	

41916 NC

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



41916 NC

ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

UNLESS OTHERWISE SPEC.
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
ANGLES ± NOTED
.XX DEC ±
.XXX DEC ± .01

MATERIAL: 6463-T5

FINISH:

CONTRACT NO. NRL

DRAWN GO DATE 3-25-7?

CHECK

APPD

DESIGN ACTIVITY APPD

ILC INC.
164 COMMERCIAL STREET SUNNYVALE, CALIFORNIA 94086

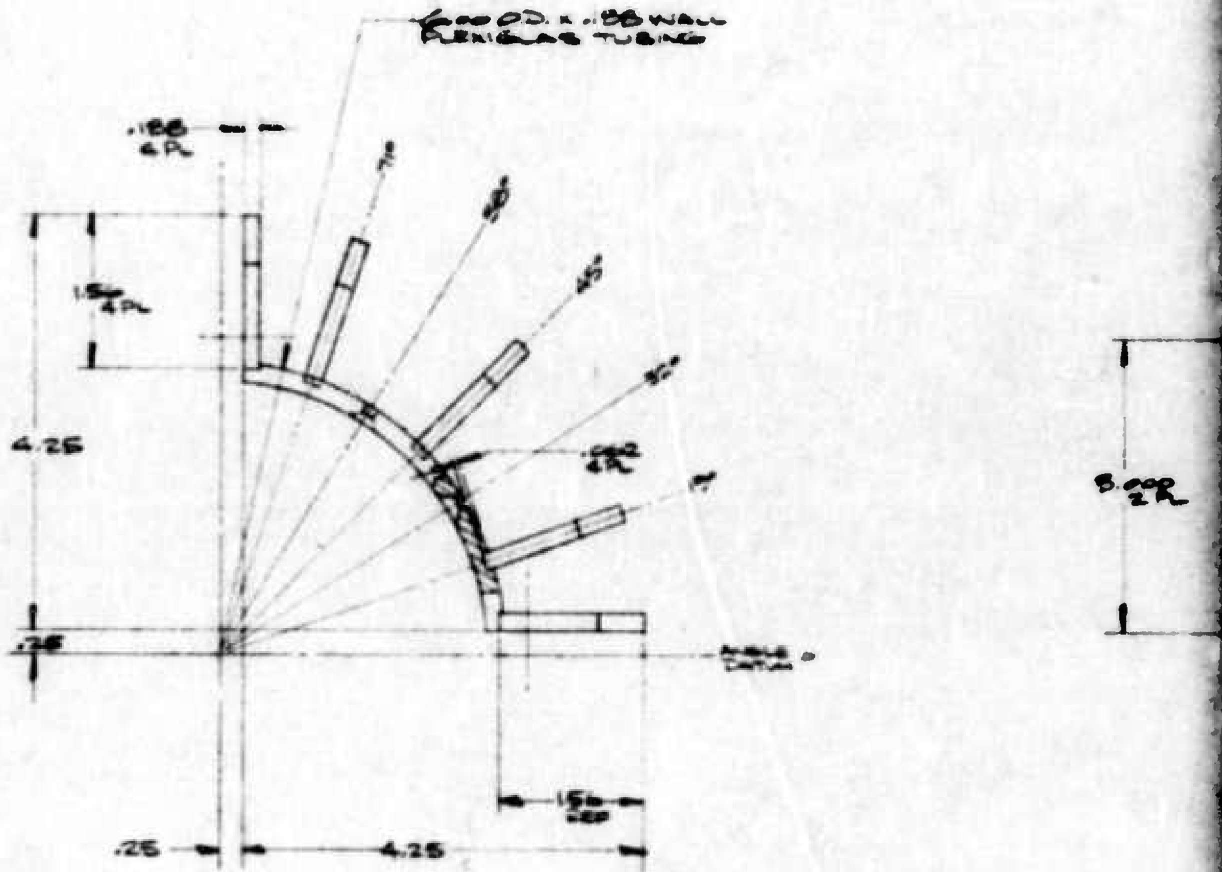
TITLE EXTRUSION

SIZE	CODE IDENT. NO.	DWG. NO.
B	31573	41916 N/C

SCALE 1:1 SHEET 1 OF 1

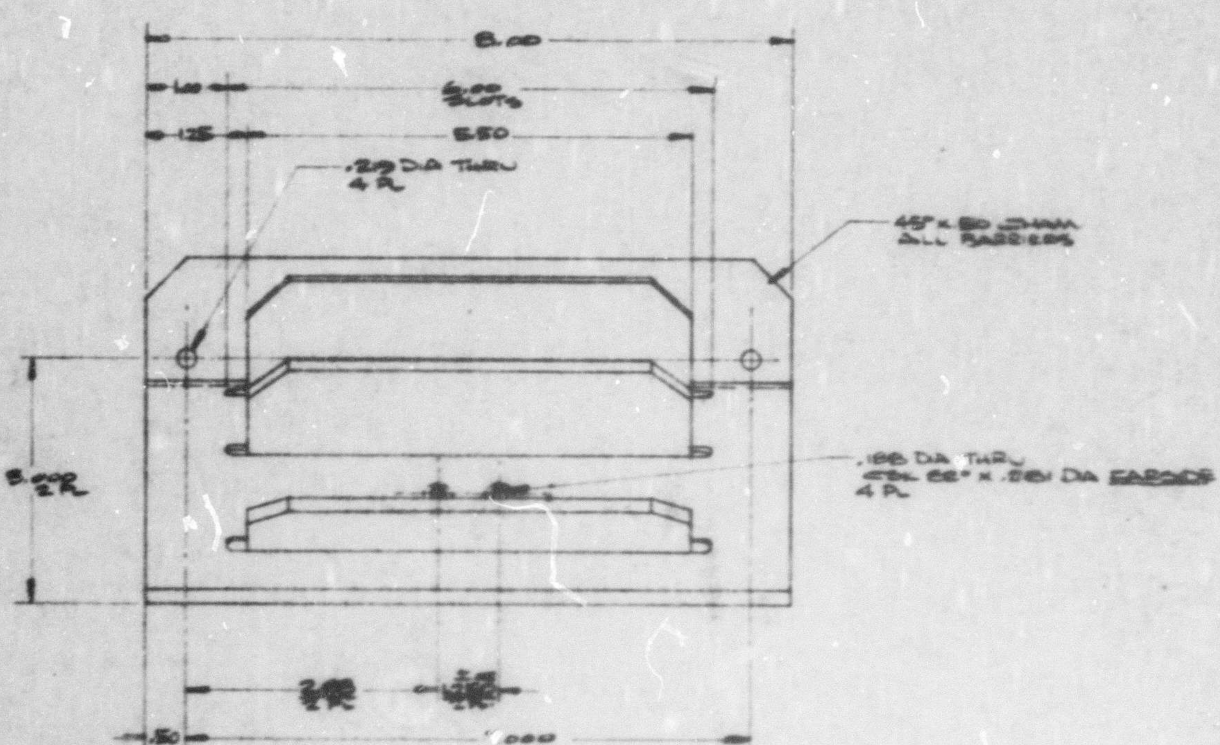
ON

OTES:
1. CEMENT ALL JOINTS.
2. ... POLISH ALL MACHINED EDGES



REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	[illegible]	[illegible]	[illegible]



41917 A

ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	

PARTS LIST

NEXT ASSY	USED ON
	41923

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMS ARE IN INCHES
TOLERANCES
DECIMALS FRACTIONS ANGULAR
DO NOT SCALE

MATERIAL: PLEXIGLAS

FINISH: —

SIMILAR TO

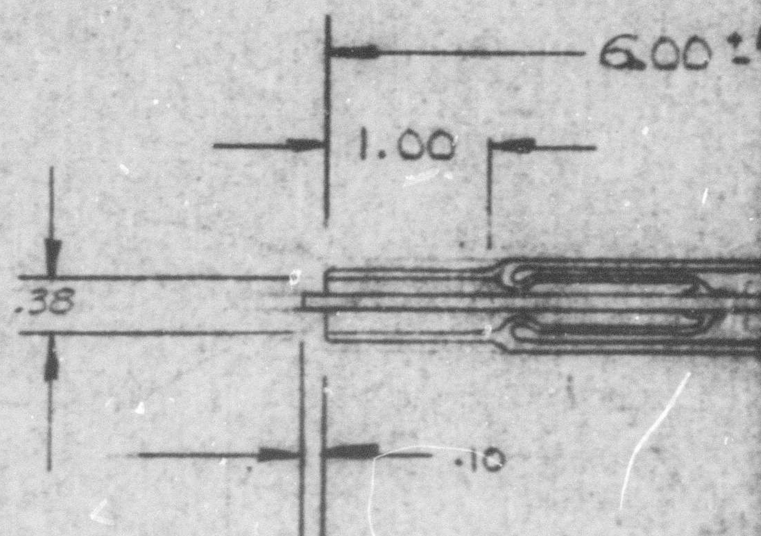
CONTRACT NO.

DRAWN | DATE
CHECK
APPD
DESIGN ACTIVITY APPD

TITLE: BARRIER INSULATOR (2 PL)

DWG SIZE	CODE IDENT NO.	DWG NO.	
D	31573	41917	A

SCALE FULL SHEET 1 OF 1



ITEM NO.	QTY

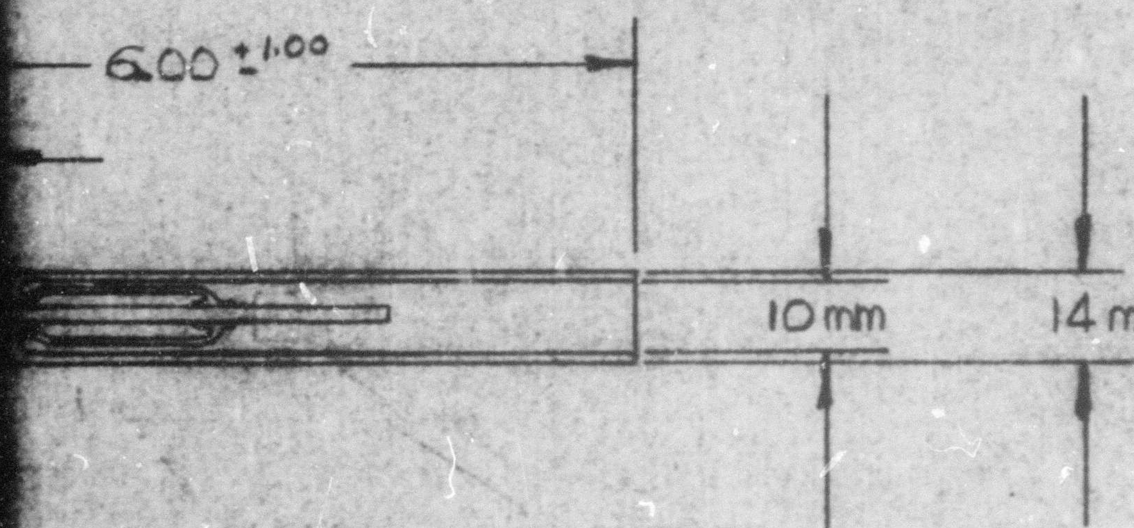
UNLESS OTHE
DIMENSIONS A
TOLERANCES:
FRACTIONS ±
ANGLES ±
.XX DEC ±
.XXX DEC ±

MATERIAL:
QUAR
TUNG

FINISH:

NEXT ASSY	USED ON
APPLICATION	

REVISIONS			
LTR	DESCRIPTION	DATE	APPR
A	.38 WAS 14mm, .10 WAS .500, ANODE REMOVED	1-16-73	



ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

UNLESS OTHERWISE SPEC. DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
ANGLES ±
.XX DEC ±
.XXX DEC ±

MATERIAL: QUARTZ TUNGSTEN

FINISH:

... D ON

CONTRACT NO.

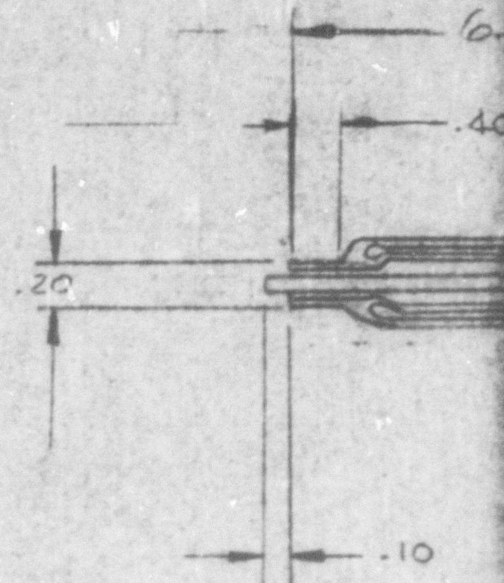
DRAWN G Oive DATE [illegible]
CHECK
APPD
DESIGN ACTIVITY APPD

ILC INC.
164 COMMERCIAL STREET SUNNYVALE, CALIFORNIA 94086

TITLE LAMP MOUNT, EXPERIMENTAL - NRL

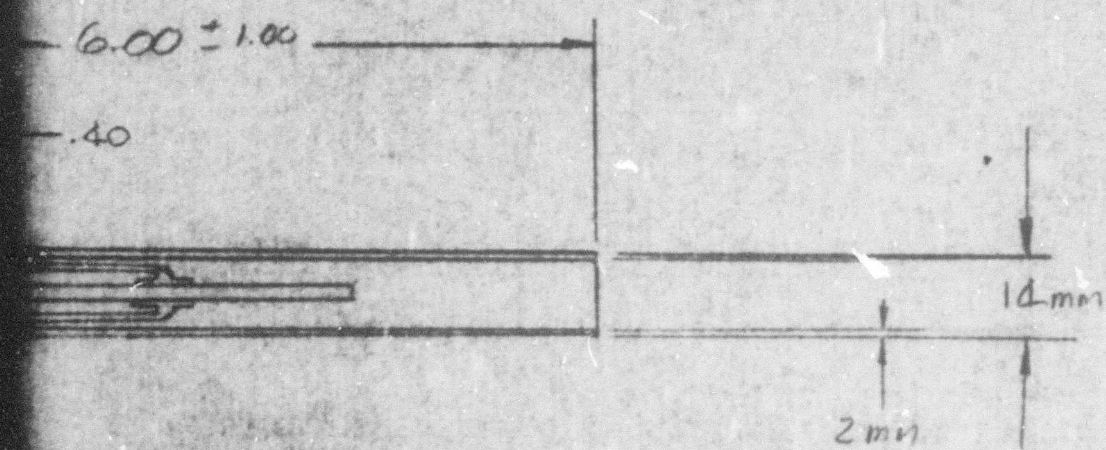
SIZE	CODE IDENT. NO.	DWG. NO.
B	31573	41920 A

SCALE 1:1 SHEET 1 OF



NEXT ASSY	USED ON
APPLICATION	

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



ITEM NO.	QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

UNLESS OTHERWISE SPEC. DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
ANGLES ±
.XX DEC ± .03
.XXX DEC ±

MATERIAL:

FINISH:

CONTRACT NO.

DRAWN	DATE
CHECK	
APPD	

DESIGN ACTIVITY APPD

ILC INC.
164 COMMERCIAL STREET SUNNYVALE, CALIFORNIA 940[illegible]

TITLE LAMP MOUNT EXPERIMENTAL

SIZE	CODE IDENT. NO.	DWG. NO.
B	31573	41921

SCALE | SHEET 1 OF 1

METEX

EMI Mesh Strips ™

(all metal)

EMI gasketing

Product Summary For Quick Reference	ME-42
Name	Metex EMI Mesh Strips (all metal)
Function	EMI Gasketing
Forms	Round and rectangular cross section strips, also with attachment fins
Construction	All resilient knitted wire mesh
Gasket Height	.062 to .500 inches
Joint Unevenness	.020 to .100 inches
Gasket Compressing Force	5 to 100 p.s.i.
EMI Rating	14kHz(H) >25-30dB; 18MHz(E) >102dB; 1.0GHz(P) 83 >93dB (See "EMI Characteristics")

FIGURE 4

Compression vs. Pressure
Monel Round EMI Mesh Strips
Test Method MT-405

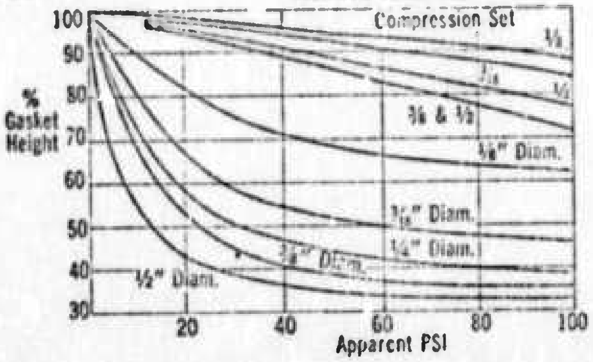
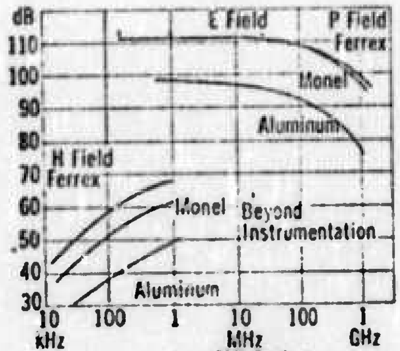


FIGURE 5



EMI Rating
1/4 x 1/8 Samples, 12 x 12 Gaskets
Test Method MT-102

AVAILABLE FORMS

Strips: METEX EMI Strips are continuous gasketing material made from resilient knitted wire mesh. Standard cross sections are round, rectangular, round with attachment fin, and double round with attachment fin (see sketches with tables). Standard materials are Monel, aluminum and Ferrex.™(1) Other sizes, cross sections and materials are also available.

Fabricated Gaskets: All of the listed METEX EMI strips can be formed and joined into ready-to-use one piece fabricated gaskets.

(1) Metex Trademark for tin plated, copper clad steel gasketing.

SPECIFICATIONS

Monel	QQ-N-281B or AMS-4730-A	
Aluminum	Alloy 5056	
Ferrex (Tin plated, copper clad, steel)		% By Weight
Tin Plate	ASTM B-33 MIL-W-3861	2-3%
Copper Cladding	ASTM B-227	30-40%
Steel Wire	SAE 1010	Balance

HOW TO ORDER

Strip Materials: Are ordered by part number from tables 1, 2, 3 or 4. Strips are usually supplied on spools in continuous lengths.

Fabricated Gaskets: Since such details as corner radii, corner and joint construction vary with type and size of EMI strip, it is not possible to show a simple drawing standard. Please supply sketch or verbal description based on this outline.

For variations of part numbers and designs shown on this page use METEX DESIGN ASSISTANCE SERVICE. Call Metex, Cal-Metex, or your local representative.

HOW TO ORDER (Cont'd)

1. Choose strip by part number.
2. Specify inside dimensions or diameter for these cross sections:

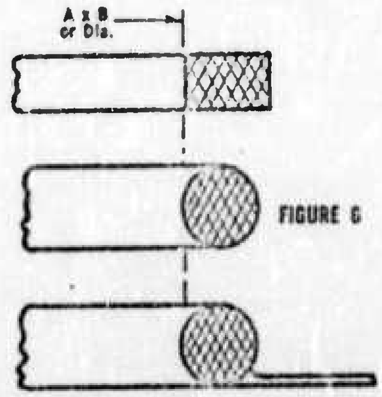


FIGURE 6

Or outside dimensions or diameter for this cross section:

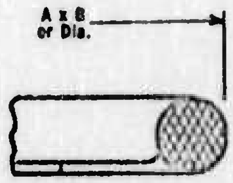


FIGURE 7

Note: A new Metex part number will have to be assigned for your fabricated gasket.

3. Tolerances: A x B or dia. are:
   0-5"; ±.03
   5-10"; ±.06
   Over 10"; ±.06 for every 10".
4. On request METEX will supply a detailed drawing conforming with your description.

TOLERANCES (for Tables 1 thru 4)

Rectangular Strips		Round Strips	
.062 to .188,	+.015 −.000	.062 to .125,	+.015 −.000
over .188 to .375,	+.032 −.000	over .125 to .188,	+.032 −.000
over .375 to .500,	+.047 −.000	over .188 to .375,	+.047 −.000
over .500 to 1.000,	+.062 −.000	over .375 to .750,	+.062 −.000

Measured under 4 ounce load with 1/2" anvils on a Federal Product Model 22P hand snap gauge or equivalent.

Single Round with Fin and Double Round with Fin, overall width.
up to 1.00, ±.06
Over 1.00, ±.12

APPENDIX II

TEST PROGRAM LOG

TEST DATA

10 LAMP ARRAY TESTS FOR DISC LASER
INSULATION SYSTEM AND LAMP MOUNT CONFIGURATION

ILC Technology

TEST DATA SHEET

Name of Test: System checkout of one capacitor bank and discharge system using two (2) lamps.

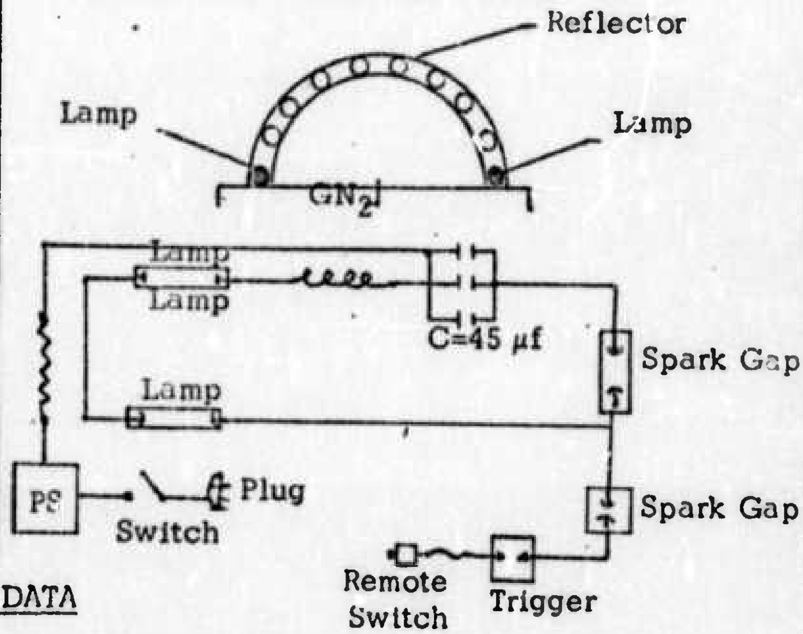
Objective(s): a. Check out single energy storage system

b. Test two lamps to full energy when located in extreme positions.

Test Item Description:

1. 3 ILC 14 μF capacitors
2. 1 NRL 300 μH inductor
3. 1 NRL spark gap
4. 1 NRL primary spark gap
5. 1 NRL trigger
6. 1 40 ft. RG 8 Coax
7. 1 ILC 41900 test fixture
8. 2 ILC L-1858 Lamps
9. 1 ILC PG 10 Pulse Generator
10. 1 ILC 41903 test fixture

Test Set Up



TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
1. a.	2/26/73	2	-12.0	0	No fire
b.	" "		-12.5	0	No fire
c.	" "		-14.0	3	No fire
d.	" "		-14.0	0	Add scope - voltage at lamps OK. Reverse polarity of power supply.
e.	" "		+14.0	2	OK
f.	" "		+14.0	5	No evidence of burning of insulation - all good.
g.	" "		+16.0	5	Still no burning or discoloration all good.
h.	" "		+18.0	5	Reset gap for higher voltage. Still good.
	" "		+20.0	5	Still good. Stop testing.
		TOTAL		22	

ILC Technology

TEST DATA SHEET

Name of Test: Acceptance Test

Objective(s): (a) Establish integrity of all lamps at 20 kV in opposite sides of test fixture.

Test Item Description:	Test Set Up
Same as Test 1 except 6 new lamps were tested.	Same as Test 1.

TEST DATA

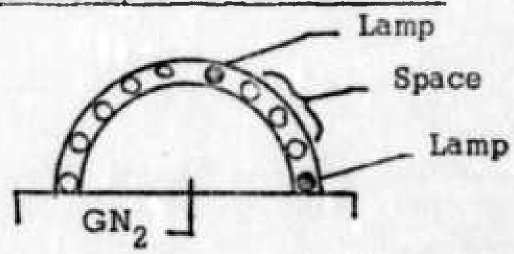
Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
2. a.	2/27/73	2	+20	11	OK. Change lamps.
b.	" "	2	+20	10	OK. Carbon on top reflector weld area, clean change lamps.
c.	" "	2	+20	10	Lamps OK, still some carbon but no evidence of electrical arcing.
		TOTAL		31	

ILC Technology

TEST DATA SHEET

Name of Test: Magnetic Force Effect on Two Lamps

Objective(s): (a) Determine ability of two unsupported lamps to withstand magnetic force effects at a spacing of 3 lamps between them.

Test Item Description:	Test Set Up
Same as Tests 1 and 2 except last lamp pair used.	 No. 1 Bank Electrical System

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
3. a.	2/27/73	2	+16	2	OK
b.		2	+18	2	OK
c.		2	+20	5	Looks good. No more carbon or mechanical failures.
		TOTAL		9	

ILC Technology

TEST DATA SHEET

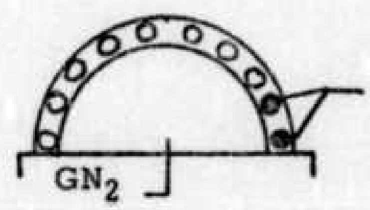
Name of Test: Magnetic Force Effects on two Side by Side Lamps

Objective(s): (a) Determine integrity of 2 lamps operating in a normal position.

Test Item Description:

Same as Test 3 except lamps moved side by side.

Test Set Up



No. 1 Bank Electrical System

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
4. a.	2/27/73	2	+16	2	OK
b.	" "	2	+18	2	OK
c.	" "	2	+20	10	OK
		TOTAL		14	

ILC Technology

TEST DATA SHEET

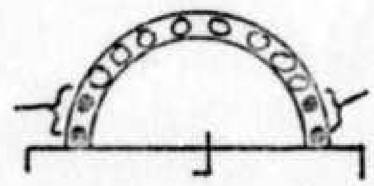
Name of Test: Magnetic Force Effects on Two Pairs of Lamps

Objective(s): (a) Determine integrity of 2 pairs of lamps in extreme quadrants.

Test Item Description:

Same as Test 4 except 2 more lamps added in 9 o'clock position and no. 2 bank added.

Test Set Up



No. 1 and No. 2 Bank Electrical System

TEST DATA

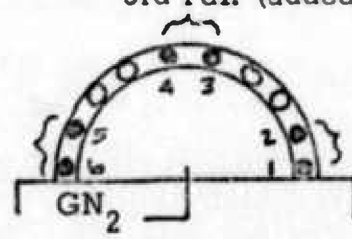
Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
5. a.	2/27/73	4	+16	3	OK
b.	2/27/73	4	+18	3	OK
c.	2/27/73	4	+20	5	OK
d.	2/27/73		+20	5	OK
		TOTAL		16	

ILC Technology

TEST DATA SHEET

Name of Test: Magnetic Force Effects on three pairs of lamps

Objective(s): (a) Determine integrity of three pairs of lamps.

Test Item Description:	Test Set Up
Same as Test 5 except: Two more lamps added at 12 o'clock position. No. 3 bank added.	3rd Pair (added) 2nd Pair  1st Pair No. 1, No. 2 & No. 3 Banks

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
6. a.	2/28/73	6	+16	3	No. 3 lamp broke.

This lamp broke a cathode end probably on the 1st shot. 3" of envelope was gone. Bob Burns saw a fire check at one end of one of the lamps during installation. Examination of the remaining ends shows no fire checking.

Conclusion: Fire check was at broken end.

Action: Inspect all remaining lamps for fire checks.

Results:
1. Very little if any at anode - slight strain at cathode.
2. Cathode end is good - slight strain at anode.
3. Anode moderate strain - cathode broken.
4. Slight strain at anode - very little at cathode.
5. Very little strain both ends.
6. Light strain at anode - very little at anode - substantial wick at anode. Replace with no. 7.
7. Moderate strain at anode - none at cathode.
8. Moderate at anode - little at cathode - replaces no. 3.

ILC Technology

TEST DATA SHEET

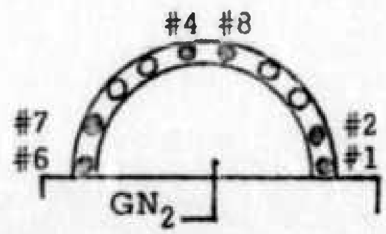
Name of Test: Magnetic Force Effects on three Pairs of Lamps

Objective(s): (a) Repeat Test No. 6

Test Item Description:

#3 Lamp reaplced by #8.
#6 Lamp replaced by #7.
Everything else the same as Test #6.

Test Set Up



Same Electrical.

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
7. a.	2/28/73	6	+16	1	OK
b.	" "	6	+16	1	OK
c.	" "	6	+16	1	OK
d.	" "	6	+18	1	OK
e.	" "	6	+18	1	OK
f.	" "	6	+18	1	OK
g.	" "	6	+18	2	OK Total 5 shots at 18 kV
h.	" "	6	+20	3	Broke lamps #8 and #4 (This is the same physical position as Test No. 6)
		TOTAL		11	

No. 4 has a crack at cathode end and leaked.

Action: Will try lossening up the mounting holes of lamp clamps to stop possibility of stressing lamps. Also will leave clamp at the junction of the two lamps quite loose.

ILC Technology

TEST DATA SHEET

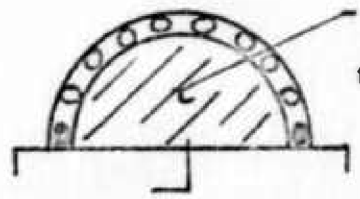
Name of Test: Acceptance Test New Lamps

Objective(s): (a) Check out 3 new lamps for operational integrity.

Test Item Description:

Three new lamps.

Test Set Up



Added end barrier to test fixture.

. Use No. 1 bank of capacitors.

. Leave one end of lamp mount very loose.

TEST DATA

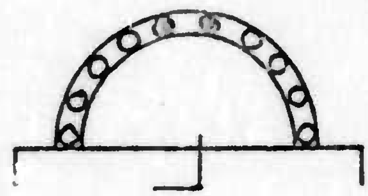
Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
8. a.	3/1/73	2	+16	2	OK
b.	" "	2	+18	2	OK
c.	" "	2	+20	1	OK
d.	" "	2	+20	5	OK . Change left hand lamp to new lamp.
e.	" "	2	+18	2	OK
f.	" "		+20	5	OK
		TOTAL		17	

ILC Technology

TEST DATA SHEET

Name of Test: Lamp Position Evaluation.

Objective(s): (a) Determine if a pair of lamps in the 12 o'clock position will operate successfully.

Test Item Description:	Test Set Up
Lamp No.'s 5 and 6 first, then No's 1 and 2 second. All other equipment same as Test 8.	 No. 1 Bank of Capacitors

TEST DATA

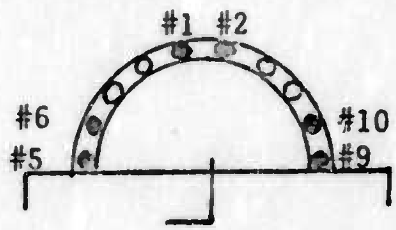
Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
9. a.	3/1/73	2	+16	3	OK
b.	" "		+18	2	OK
c.	" "		+20	5	OK
d.	" "		+20	5	OK. Change lamps
e.	" "		+18		OK
f.			+20	5	OK
g.	" "		+20	5	OK
		TOTAL		28	

ILC Technology

TEST DATA SHEET

Name of Test: Repeat Test No.'s 6 and 7 with 3 pairs of Lamps

Objective(s): (a) Verify that excessive forces exist in this configuration.

Test Item Description:	Test Set Up
Lamp No.'s 1 and 2, 5 and 6, and 9 and 10.	 Capacitor Banks 1, 2 and 3.

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
10. a.	3/1/73	6	+18	1	OK
b.	" "	6	+18.	0	Lamps 1, 2, 6 and 10 broke

Observations:

No obvious failure modes observed.
Acoustical noise quite loud.

Conclusions & Action

(a) Re-evaluate magnetic force analysis.
(b) Evaluate the acoustic affects of test fixture.
(c) Fabricate new lamps.
(d) Modify test fixture to include pyrex shatter shield

ILC Technology

TEST DATA SHEET

Name of Test: Acceptance Test 4 New Lamps in Modified Test Fixture

Objective(s): (a) Establish lamp performance integrity.

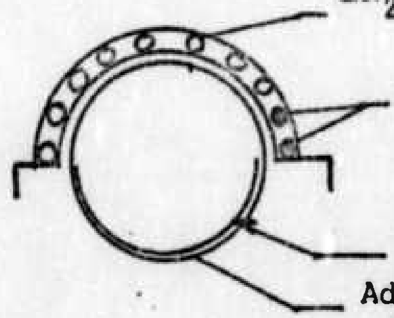
(b) Preliminary performance evaluation of modif. test fixture.

Test Item Description:

Lamp No.'s(12 and 13) (11 and 15).

Retest No.'s 9 and 5. Both lamps had chips.

Test Set Up



Capacitor Bank No. 1

TEST DATA

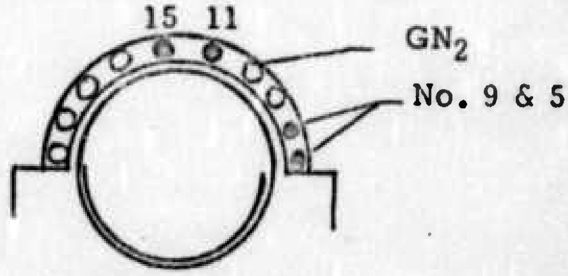
Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
11. a.	3/9/73	2	+14	-	Didn't fire - go to 18 kV
b.	" "	2	+18	2	OK
c.	" "	2	+20	10	OK - Change Lamps to #11 and #15
d.	" "	2	+18	3	OK
e.	" "	2	+20	10	OK - change lamps #9 and #5
f.	" "	2	+18	3	OK
g.	" "	2	+20	10	OK - add 2 lamps for next test.
		TOTAL		38	

ILC Technology

TEST DATA SHEET

Name of Test: Magnetic Force and Acoustic Force Evaluation with 2 pairs of Lamps

Objective(s): (a) Evaluate performance of 2 pairs of lamps located at the 12 o'clock and 3 o'clock positions.

Test Item Description:	Test Set Up
Lamp No.'s 5 and 9 and 11 and 15. Modified test fixture with Pyrex tube.	 Capacitor Banks No.'s 1 and 2.

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
12. a.	3/9/73	4	+16	1	OK
b.	" "	4	+18	3	OK
c.	" "	4	+20	10	OK - Add lamps 12 and 13 for next test.
		TOTAL		14	

ILC Technology

TEST DATA SHEET

Name of Test: Magnetic Force/Acoustic Force Evaluation with 3 Pairs of Lamps.

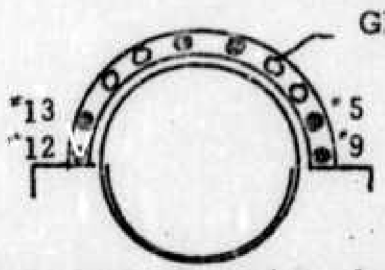
Objective(s): (a) Evaluate the effectiveness of the pyrex tube as an acoustic damper.

Test Item Description:

Lamp No.'s (5 and 9) (11 and 15) and (12 and 13).

Modified test fixture with Pyrex tube.

Test Set Up



Capacitor Banks 1, 2, and 3. Same as tests 6, 7, and 10 except for pyrex tube.

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
13. a.	3/9/73	6	+16	3	OK
b.	" "	6	+18	5	OK
c.	" "	6	+20	10	OK
		TOTAL		18	

Conclusions:

(a) Addition of the pyrex tube reduced. Lamp loads sufficient to prevent breakage of the lamps.

(b) Go on to 10 lamp test after reacceptance test of used lamps.

ILC Technology

TEST DATA SHEET

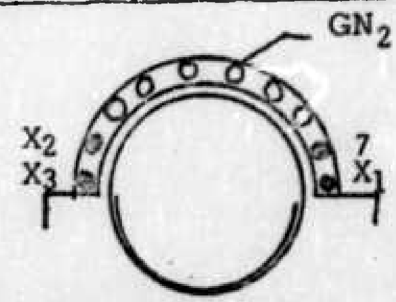
Name of Test: Reacceptance Test of All Used Lamps.

Objective(s): (a) Select 4 more lamps for 10 lamp test.

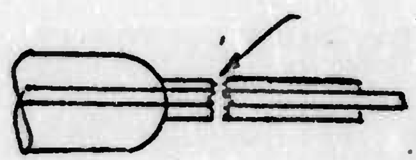
Test Item Description:

Larmp No.'s 7, X, X_2, X_3.

Test Set Up



Capacitor Bank No.'s 1 and 2.



TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
14. a.	3/9/73	4	+16	3	Very noisy - doesn't sound right. Test 1 bank at a time.
b.	" "	2	+20	10	No. 7 and X, OK
c.	" "	2	+20	1	Noisy - examination showed that the tungsten broke on one lamp and shorted to the reflector. The other lamp had a large nick.
		TOTAL		14	Decision: Test 8 lamps.

ILC Technology

TEST DATA SHEET

Name of Test: Eight Lamp 10 Shot Test

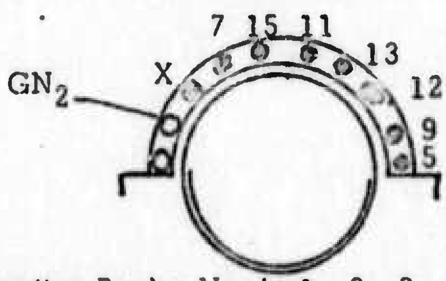
Objective(s): (a) Evaluate lamp and test fixture performance.

Test Item Description:

Lamp No.'s (5 and 9) (12 and 13), (11 and 15) and (7 and X).

Modified test fixture with Pyrex tube.

Test Set Up



Capacitor Banks No.'s 1, 2, 3, 4.

No center supports.

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
15. a.	3/9/73	8	+16	9	No. 4 spark gap needed adjusting.
b.	" "	8	+18	1	Plexiglass insulator shorted to reflector - added mylar and polyethelene sheet.
c.	" "	8	+16	1	OK
d.	" "	8	+18	7	Had to adjust spark gap.
e.	" "	8	+20	10	OK after spark gap was adjusted.
		TOTAL		28	Decision: Make 2 more lamps and complete 100 shot test.

ILC Technology

TEST DATA SHEET

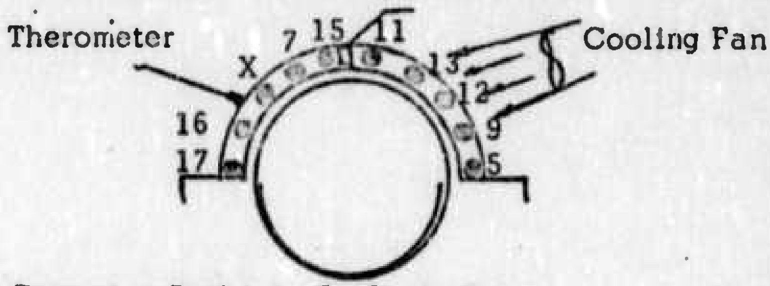
Name of Test: 10 Lamp 100 Shot Endurance Test.

Objective(s): (a) Determine lamp and test fixture performance for 100 shots.

Test Item Description:

Lamps (5 and 9) (12 and 13) (11 and 15) (7 and X) and (16 and 17).

Test Set Up



Capacitor Banks 1, 2, 3, 4, 5.

GN_2 applied between lamps 11 and 15.

Rep rate 2-1/2 shots/min.

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
16. a.	3/12/73	10	+18	2	OK
b.	3/12/73	10	+20	5	OK - shut down 5 min.
c.	3/12/73	10	+20	5	OK - shut down 2 min.
d.	3/12/73	10	+20	5	OK - shut down 2 min.
e.	3/12/73	10	+20	5	OK - shut down 2 min.
f.	" "	10	+20	5	Test continued in 5 shot increments to a total of 102 shots at 20 kV. Successfully completed.
	2023 hours	TOTAL		102	
					Decision: Try for 500 shot endurance test.

ILC Technology

TEST DATA SHEET

Name of Test: Post Test Inspection of Test No. 16

Objective(s): (a) Disassemble 10 lamp test.

(b) Inspect

(c) Re-identify all lamps.

Test Item Description: | Test Set Up

a. Reassembly Remarks:

No visual signs of arcing, darkening or degradation. Pyrex tube etched from acetone deposits. Looks good throughout.

b. Inspection (Spark Test Lamps):

No. ten lamp is dead. Appears that potting primer got into seal cavity and damaged the seal. All other nine remaining lamps are good.

c. Lamps have been reidentified counterclockwise from 1 thru 10 starting at 3 o'clock position.

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
Coil Test	3/14/73	No. 1	Spark Coil	NA	OK
"	"	No.2	" "	"	OK
"	"	No.3	" "	"	OK
"	"	No.4	" "	"	OK
"	"	No.5	" "	"	OK
"	"	No.6	" "	"	OK
"	"	No.7	" "	"	OK
"	"	No.8	" "	"	OK
"	"	No.9	" "	"	OK
"	"	No.10	" "	"	Dead

ILC Technology

TEST DATA SHEET

Name of Test: Metex Center Supports Evaluation

Objective(s): (a) Evaluate performance of ferrex metex bridle and alum. metex pad.

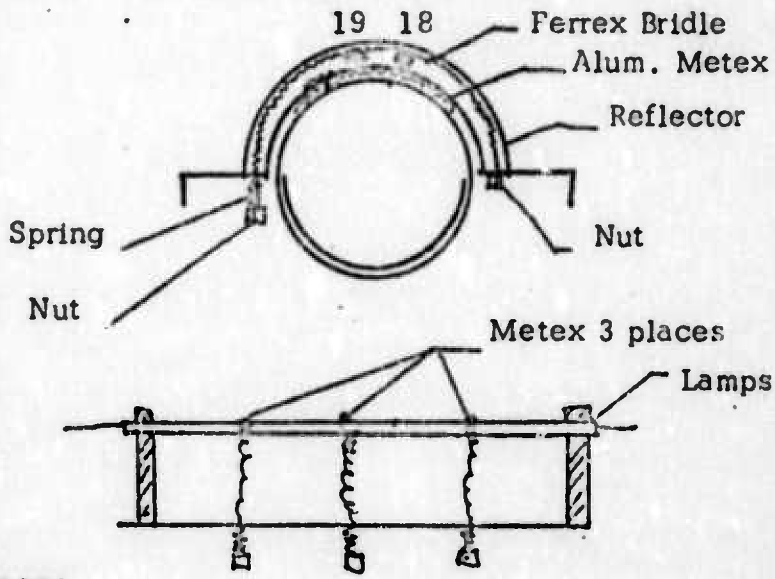
Test Item Description:

Lamp No.'s 18 and 19.

1/8 Ferrex Metex bridle spring loaded over the lamps.

1/8 aluminum metex pad between the lamps and the Pyrex tube.

Test Set Up



TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
18. a.	3/14/73	2	+16	2	OK
b.	" "	2	+16	5	OK
c.	" "	2	+18	3	OK
d.	" "	2	+20	10	OK
					Add metex 3 places.
e.	" "	2	+16	1	Looks good.
f.	" "	2	+20	1	Looks good.
g.	" "	2	+20	11	Looks good. Go on to 100 shots.
		TOTAL		33	

ILC Technology

TEST DATA SHEET

Name of Test: 100 Shot Metex Evaluation Test

Objective(s): (a) Evaluate performance of ferrex and aluminum metex with 2 lamps.

Test Item Description:	Test Set Up
Same as Test No. 18g.	Same as 18g.

TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
19. a.	3/15/73				
	0945 hours	2	+20	22	Looks good, change resistor.
	0955 hours	2	+20	20	Looks good, change resistor add fan.
	1012 hours	2	+20	20	Looks good, change resistor.
	1018 hours	2	+20	15	Looks good, change resistor.
	1022 hours	2	+20	11	Stop test. 1. Ferrex darkened on one side away from cooling. 2. Spring force good.
		TOTAL		88	3. Alum metex looks good.

ILC Technology

TEST DATA SHEET

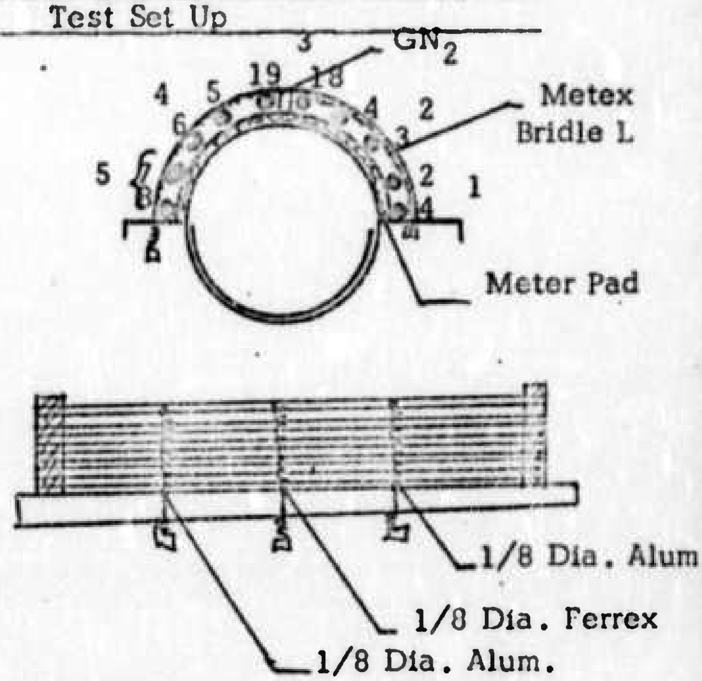
Name of Test: 10 Lamp Endurance Test with Center Supports

Objective(s): (a) Determine weaknesses in the entire system and the limiting components.

Test Item Description:

Lamps (1 and 2) (3 and 4) (18 and 19) (5 and 6) and (7 and 8).

Test Set Up



TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
20. a.	3/15/73 1343 hours	10	+16	1	Not all lamps fired.
b.	1347 hours	10	+18	3	All lamps fired.
c.	1415 hours	10	+20	5	Everything OK except inner alum. metex failed. Badly shredded. Remove inner metex pad.
d.	1603 hours	10	+20	5	Looks good.
e.	1607 hours	10	+20	5	Alum. meter bridle starting to shred. Remove 2 alum. bridles
f.	1630 hours	10	+20	10	Looks good but seems noisy.
		TOTAL		29	Decision: Shut dowr and add more GN_2.

ILC Technology

TEST DATA SHEET

Name of Test: 10 Lamp Endurance Test Continuation with Added GN_2.

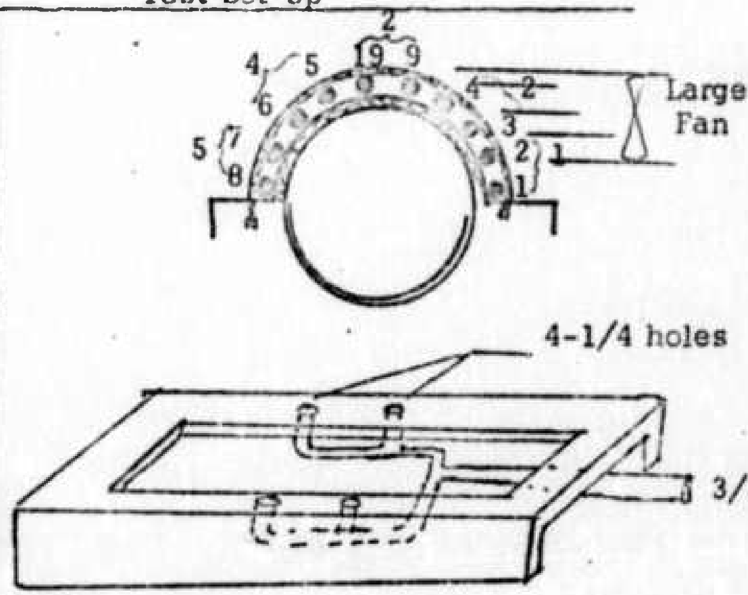
Objective(s): (a) Evaluate component performance.

(b) Determine component units.

Test Item Description:

Replace lamp #18 with lamp #9. All others same as Test 20.

Test Set Up



TEST DATA

Test/Point	Date/Time	No. of Lamps	Voltage KV	No. of Shots	REMARKS
21.	3/16/73				
a.	1033 hours	10	+16	1	OK
b.			+18	2	OK
c.			+20	5	OK but very noisy. Stop and tape up all cracks around edges of fixture.
d.	1112 hours	10	+20	5	Very quiet.
e.	1225 hours	10	+20	45	Looks good. Metex dark but still OK. All lamps still good.
f.	1330 hours	10	+20	25	Add large fan
g.	1610 hours	10	+20	22	Still OK. Total 329 shots at 20 kV
h.	1805 hours	10	+20	171	Completed 500 shots at 20 kV. Everything looks good. All lamps are still good.
		TOTAL		276	

Post Test Activities

1. Disassembled all electrical equipment and returned components to NRL.

2. Test fixture and lamps kept intact at ILC (all 10 lamps are still good).

Summary:

Lamps

Number of 32 inch lamps fabricated:	26
Number of 32 inch lamps broken during potting and hypot:	6
Number of 32 inch lamps broken during tests:	10
Number of good lamps remaining:	10

Shots

Number at 16kV or less:	57
Number at 18kV	61
Number at 20kV	676
TOTAL	794

Insulation System

Number of designs tried: 5

(a) 3/8" ID quartz tube extension (hard to make)

(b) .200" OD x 1" long quartz extension (too short)

(c) .200" OD x 1" long extension plus glassed tungsten (would not stand 20kV hypot)

(d) .200" OD x 1-1/4" long extension (weak mechanically).

(e) .350" OD x 1-1/4" long extension (very strong. No lamps made, only test seals).

SUMMARY OF PROBLEMS AND SOLUTIONS

Problems	Solutions
1. Insulation system would not withstand hypot to 60kV or 45kV pulsing hypot at 10 PPS.	1. Added 1-1/4" x .200" dia. quartz extension on lamp and slipped 3/8 OD x 1/8 ID silicone sleeve over the extension with Dow Corning Silgard 184 as a sealant. Potted entire system in an 9/16" dia. OD aluminum sleeve.
2. Solution to Problem No. 1, although successful, has a mechanical weakness at the .200 dia.to 14mm OD transition.	2. This section has been thickened to .350" OD and is very strong. No lam were made this way in this phase.
3. Three pairs of lamps in alternate pairs of spaces would not survive a 27 kJ test due to acoustic shockwave concentrations.	3. Addition of a pyrex cylinder in the center of the array with 1/8" clearance from cylinder to lamps.
4. Excessive noise and acoustic shock within the test fixture.	4. Addition of four 1/4" dia. GN_2 ports and sealing of all cracks and air leaks reduced noise.
5. Lamps break during handling and potting.	5. See No. 2.
6. Arc over to ground at plexiglass terminal block.	6. Added mylar sheet under terminal block. This terminal will be solid in future models.
7. Center supports to restrain magnetic forces.	7. Used Ferrex Metex with a spring and bridle design.

CONCLUSIONS

1. A successful lamp insulation system design was developed and demonstrated with all objectives met.

2. A successful lamp end support was developed and demonstrated with all objectives met.

3. 32 in. arc length lamps, reverse series connected in pairs, can be successfully operated in a ten lamp semi-cylindrical array.

4. A pyrex shatter shield design was successfully demonstrated.

5. The aluminum potting shell and lamp support is difficult to fit and needs to be re-sized in future designs.

6. The lamp end quartz extension needs to be beefed up to .350" dia. x 1-1/4" long for future lamps to prevent handling losses.

7. The 32 in. arc length lamp operated in reversed series pairs do not require center supports but can be supported by a spring loaded metex bridle if desired.

8. Ferrex metex can be used in intimate contact with the lamps without harmful affects.

9. Aluminum Metex is not a good material in a flashlamp environment.

10. GN_2 purge is a must for low noise operation.

11. Addition of a pyrex shatter shield is a good way to reduce acoustic shock affects.

12. Acoustic forces must be considered when designing a laser lamp array to prevent lamp breakage.

13. Electro magnetic forces can be reduced by operating the lamps in reversed series pairs.