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MANUFACTURING METHODS AND TECHNOLOGY (MM AND T) MEASURE FOR FAB--ETC(U)
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SEVENTH QUARTERLY PROGRESS REPORT

FOR

MANUFACTURING METHODS AND TECHNOLOGY (MM&T)

MEASURE FOR FABRICATION OF LOW VOLTAGE

START SEALED BEAM ARC LAMPS

1 Jan. 1978 to 31 March 1978

CONTRACT NO. DAAB07-76-C-0034

U.S. Army Electronics Command
Production Division
Production Integration Branch
Ft. Monmouth, NJ 07703

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301 Industrial Way
San Carlos, CA 94070

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7th Quarterly Progress Report
1 Jan. 1978 to 31 March 1978

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A program is in progress to establish a production capability for the purpose of meeting estimated military needs for the X6335, a 1kW sealed beam xenon arc lamp with low voltage starting mechanism.

In accordance with the requirements of the contract, the third engineering sample is still undergoing fabrication to meet specification.

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2.0 Abstract

The following items required attention during this report period.

1. a. Front end of lamp was strengthened to increase the pressure safety margin.

   b. A pressure test was performed to determine the lamps rupture strength.

2. a. The body seal, metal to ceramic junction was re-evaluated for stress and strain.

   b. The main body Kovar seals and ceramic seal were fabricated to reduce stress with the ceramic insulation.

3. a. A damper spring was incorporated into the design of the stinger mechanism to dampen the return shock of the armature mass.

   b. Damper springs were incorporated into the MM&T lamp design after cycle testing to 2000 on off cycles of 5 second durations at the 1kW power level.

   c. A test vehicle to long term test the stinger mechanism was designed and built.

4. a. De-mountable electrode lamps financed by EIMAC were built to optimize cathode and anode geometry versus lamp life. (See Figure 3 and 4)

5. a. An oil trap was installed in the vacuum deposition coater to reduce any problems of oil backstreaming. This action was initiated as a result of surface analysis taken from a silver coated reflector.

   b. A test stand was set-up to optically determine the focal point of each production reflector.

6. a. Tooling design is complete for the MM&T lamps.

   b. Leak checking tooling was fabricated to check brazed assemblies for leak tightness. The leak test check is made on a helium leak detector to provide for a vacuum or pressure integral assembly.

   c. Major lamp sub-assemblies were jigged for position and alignment prior to brazing.

   d. EIMAC production personnel are gaining familiarity with the assembly methods required to fabricate sub-assemblies.

Continued from DD 1473; Block 20. Abstract

7. a. All detail drawings for MM&T parts were completed.

   b. Detail part tolerances and dimensions were reviewed. All braze washers and wire sizes were reviewed and finalized.

   c. Cleaning specifications for lamp parts were reviewed and documented.

8. a. The 3rd engineering sample was evaluated after testing for reliability.

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MANUFACTURING METHODS AND TECHNOLOGY (MM&T)
MEASURE FOR FABRICATION OF LOW VOLTAGE
START SEALED BEAM ARC LAMPS.

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SEVENTH QUARTERLY PROGRESS REP~~ORT~~, no. 7,

1 Jan~~. 1978 to~~ 31 Mar~~ch 19~~78,

"The objective of this manufacturing methods and technology project is to establish the technology and capability to fabricate Low Voltage Start Sealed Beam Arc Lamps".

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CONTRACT NO. DAAB07-76-C-0034

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By

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Roy Roberts
Tim Bell

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ABSTRACT

A program is in progress to establish a production capability for the purpose of meeting estimated military needs for the X6335, 1kW sealed beam xenon arc lamp with low voltage starting mechanism.

In accordance with the requirements of the contract, the third engineering sample is still undergoing fabrication to meet specifications.

Table of Contents

LIST OF FIGURES

1.0 PURPOSE

The objective of this program is to establish a production capability for the purpose of meeting estimated military needs for a period of two (2) years after completion of the contract, and to establish plans which may be used to meet expanded requirements.

The program is intended to demonstrate and to "prove-out" the manufacturing processes, methods and techniques that are utilized in the production of 1kW sealed beam xenon arc lamps with a low voltage starting mechanism.

The lamp initially chosen for the program was the X6257. This lamp was developed for military searchlight applications. The high voltage version of this lamp was developed initially under Contract Number DAAK02-68-C-0215. The 1kW lamp was further refined on a PEM Contract Number DAAB05-71-C-2609. The low voltage starting X6257 was not developed with government funds, but was developed with Varian funds.

This contract is divided into three phases:

1. Engineering Samples, wherein modifications are being made to designs arrived at under previous development in order to improve their optical performance, safety and utility in the field and to reduce their cost. Production drawings, procedures, and tooling will also be developed. These parameters will be based on delivery of three (3) samples.
2. Confirmatory Samples, wherein the delivery of three

(3) units will be made to demonstrate that lamps can be made with production techniques and procedures to meet the specification.

3. Pilot run, wherein the delivery of thirty (30) units will be made to demonstrate the capability of meeting the planned production rate.

The engineering sample phase is needed to incorporate features which will make the lamp start more reliably, be easier to fabricate, be safer to operate, have a highly accurate mounting surface for optical reference and afford cost reduction.

During this quarter the 3rd engineering sample underwent additional changes to improve reliability in the following areas:

a) stinger mechanism
b) ceramic to metal body seal
c) stiffened window flange
d) tooling evaluated for effectiveness

2.0 GLOSSARY

LVS	Low voltage starting.
Stinger	Moveable electrode used for lamp ignition.
Mandrel	A stainless steel tool which is polished to a mirrored surface with a special elliptical contour upon which the reflector is electroformed.
EI (Characteristic)	The voltage (E) across the lamp for a given current (I) passing through the lamp.
PBC	Peak beam candlepower
EMI	Electromagnetic interference
De-mountable lamp	A lamp designed for electrode removal.

3.0 NARRATIVE AND DATA

The lamp is comprised of conventional tungsten electrodes positioned in a ceramic/metal structure with a reflector and sapphire window. The arc is located at the focal point of the reflector so that a directed beam is obtained coaxial with the electrodes. The low voltage starting mechanism includes a moveable electrode called the "stinger" which is coaxial with the anode.

The lamp is filled with up to 20 atmospheres of high purity xenon at room temperature. The lamp's spectral output is a typical high pressure xenon arc spectrum as reflected from a silver mirror and transmitted through a sapphire window. The wavelength range is about 130 nm to 6500 nm. The silver reflector coating was selected for maximum output in the visible and near IR bands.

The lamp operating voltage is 19.5 D.C. $\pm .5$v. The lamp voltage is determined primarily by the inter-electrode gap and the lamp pressure. The lamp acts much like a constant voltage device, that is, large changes in current result in small changes in operating voltage. Ignition is accomplished by use of the stinger. To commence the start cycle, the solenoid voltage is applied causing the stinger to move forward. The moment the stinger contacts the cathode tip, the electrical circuit is completed and current begins to flow through the choke. After approximately .5 seconds, the solenoid voltage is removed and the stinger starts to return to its deenergized position, thus breaking the circuit.

At this time, the stored energy in the choke is dumped into the arc. The stinger then draws this arc back and transfers the arc to the anode.

3.1 DESIGN AND ANALYSIS

1. The front window flange was strengthened to increase the lamp's safety factor to a four times safety over and above the lamps operating pressure of approximately 500 pounds per square inch.

   The following equation was employed to determine the proper window flange thickness to obtain the desired safety factor. The manner of loading assumes that the edges are simply supported with a uniform load distributed over the entire surface.

   $$\text{Maximum stress} = \frac{3w}{8\P m t^2}(3m+1)$$

   w=total applied load
   m=reciprocal of Poisson's ratio
   t=thickness of flange

   It was determined by calculation that a thirty percent stress reduction in the body to metal ceramic seals was theoretically possible. This degree of improvement could significantly reduce the potential problem of lamp leakers during the production runs. A new design was developed that incorporated changes to achieve this improvement. The basic change involved a reduced seal thickness with a longer kovar seal, in addition the ceramic ring was made shorter.
2. A spring was designed to dampen the movement of the stinger's armature on its return. This becomes an additional lamp part and will reduce shock and vibration loading of the bearings and thereby improve stinger reliability. The stinger housing design has adequate room with the existing design to accomodate the damper spring which is mounted off the stinger end seal.

3. Tooling design was reviewed thoroughly by EIMAC production engineers. The review consisted of evaluating fit and function for the new brazing tooling, determining materials and establishing quantities.

From initial conception, the lamp design incorporated as much self-jigging between parts and sub-assemblies as possible so that a minimum of special tooling would be required.

4. The brazing technique for the anode fin coolers was improved to maximize heat conduction. The improvement involved changes in plating parts prior to brazing and also some changes occurred in the materials and dimensions of the tooling. As a result of these improvements, large even fillets resulted on each of the cooling fin attachment points.

5. The third engineering sample was tested in accordance with the MM&T contract specifications. The lamp was evaluated after the 1500 on-off cycles of 2 minutes on, eight minutes off for a total of 250 hours cycle time. The recorded peak beam intensity of the lamp after cyclic testing dropped to seven million candelas using an illumination meter to record the output. When the lamp was re-tested for candlepower a two volt drop-off in voltage was observed at 51 amps. This lower voltage condition indicated that the lamp had developed a leak and was responsible for the low peak beam intensity. The next step taken was to suspend further testing and locate the leak. This required opening the lamp and leak checking on a leak detector at EIMAC's expense. The leak detector recorded a small leak present at the body metal to ceramic seal interface. This leakage

is attributed to cyclic thermal stress that occurred during the reliability testing. To alleviate this problem in the future a material thickness modification to both the metal seal and ceramic insulator will be incorporated to lower the metal to ceramic interface stress.

Other findings observed with the lamp as follows:

a. The cathode burn-back was measured to be .005 inches.

b. The anode revealed signs of degradation around the central through-hole, although a .080 diameter rod was able to easily pass without obstruction.

c. The anode to heatsink braze resulted in an inadequate braze flow, consequently a brazing void was present around the anode which reduces heat conduction resulting in a thermally overloaded anode during lamp operation.

d. The stinger rod did not reveal any signs of melting when viewed under the microscope.

e. The sapphire bearings in the stinger mechanism did not indicate any signs of sapphire chips or cracks.

3.2 FABRICATION AND TOOLING

1. Sub-assemblies were fabricated and leak checked without evidence of leaks. These assemblies are being made by EIMAC production personnel in order to gain familiarity with the tooling used to accomplish manufacturing the sub-assemblies.
2. Figure 1 illustrates tooling used for brazing the following assemblies; cathode to reflector support; the stinger rod; and final body braze assembly. The cathode to reflector support braze is made with carbon tooling and ceramic standoffs to correctly position the cathode sleeve during brazing. The differential expansion rates are calculated very closely to obtain the clearance required at the brazing temperature in order to assure part accuracy. The body braze tooling utilizes carbon tooling to hold the stinger housing and position the cathode cooling fins. In addition, stainless steel tooling assures concentricity between the anode and large body cup. This concentricity is achieved by calculating differential expansion rates for the mating parts.

   Figure 2 is a photograph which also shows some of the braze tooling used in assembling lamp parts. The following identifies various tooling and assemblies.

   a) Cathode to strut assemblies.
   b) Reflector support ring assembly.
   c) Cathode to reflector support tooling.
   d) Window flange assembly.
   e) Window assembly tooling.
   f) Body braze tooling.
   g) Anode cooling fin tooling.
   h) Stinger and blow out plug tooling.
   i) Stinger tube to anode base assembly.
   j) Stinger rod assembly.
   k) Stinger rod tooling.

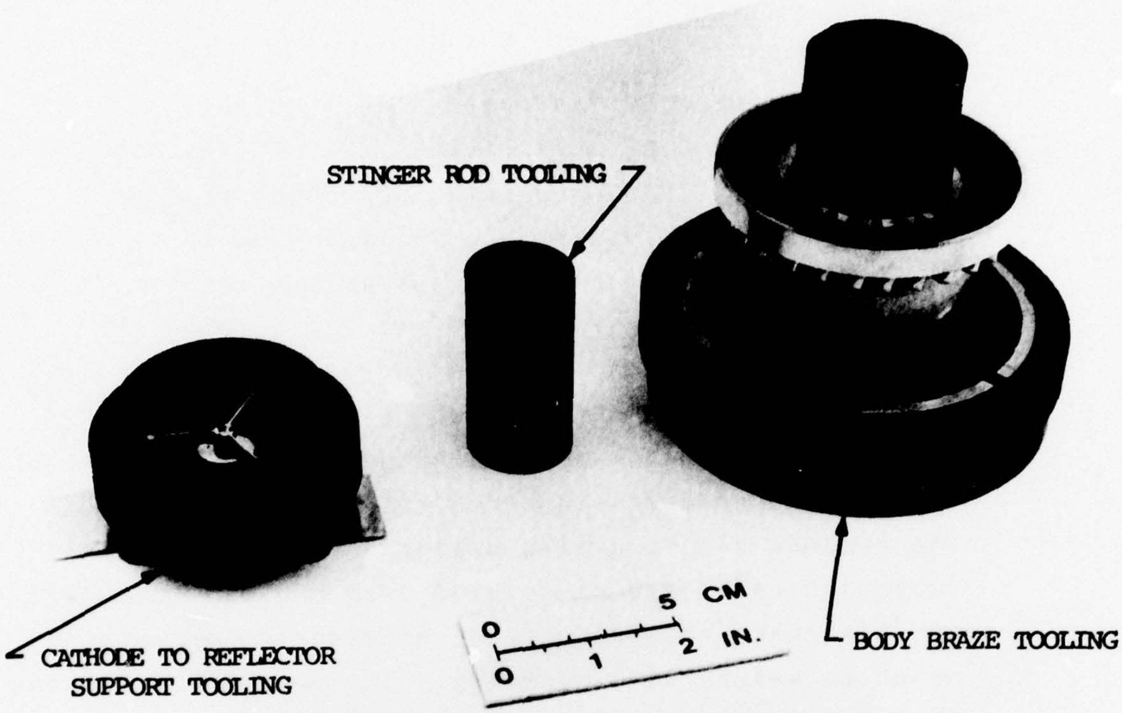


Figure 1.
Brazing Tooling

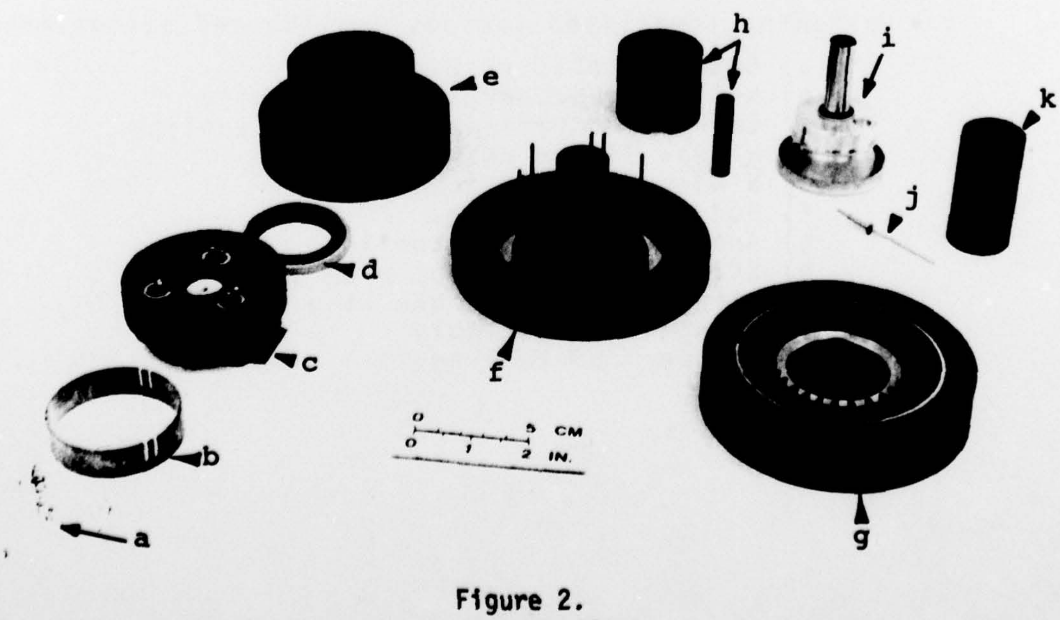


Figure 2.
Brazing Tooling

3. Additional sets of cathode and strut tooling were made in order to adequately satisfy increased usage of future brazed assembly requirements. Production personnel have become very familiar with methods of assembling the lamps. These personnel are ready to fabricate additional lamps for the confirmatory and pilot runs, once an acceptable 3rd engineering sample meets specifications.

3.3 TESTING

3.3.1 REFLECTORS FOCAL POINT

A test stand arrangement was constructed to optically determine the reflector's focal point location and to verify the reflector's contour by recording relative reflector output readings. The readings were recorded by a microammeter connected to a detector. An adjustable quartz bulb was attached to a depth gauge to determine the reflector's focal point. The microammeter then records the reflector's peak output thus enabling an accurate adjustment of the quartz bulb along the reflector optical axis.

3.3.2 LAMP PRESSURE TEST

A test was set-up to determine the rupture point for the MM&T lamp body. A completed lamp was hooked up to a nitrogen supply bottle containing 2500 psi pressure. The lamp was evaluated at 700, 1000 and 1400 pounds per square inch of pressure to determine if any noticeable deformation had occurred. The front window flange showed slight deformation occurring at 1400 psi. The lamp was then taken up in pressure to its bursting pressure of 2000 psi.

3.3.3 STINGER MECHANISM

A stinger test vehicle was designed to facilitate long term testing of the stinger mechanism for reliability. The main purpose of the test is to determine the effects of shock and vibration loading on the stinger housing when the armature returns. The following test results were obtained:

a) Test performed with no damping devices to reduce shock and vibration. The test lasted approximately 20,000 cycles and both sapphire bearings were chipped.

b) Wave washers were inserted as a spring damper, the stinger failed at 23,000 cycles and fractured the washer in two places. Stinger bearings showed no evidence of failure.

c) A compression spring damper was inserted having a spring constant of 25 lb/in. After 80,000 cycles no evidence of sapphire bearing failure or stinger binding was noted.

3.3.4 LAMP PERFORMANCE TEST

Below is electrical and photometric information obtained during life cycling the 3rd engineering sample.

Burn-in : The lamp was operated at 1kw ± 50 watts for 2 hours.

Voltage and current: After reaching thermal stability for 5 minutes and at 40 CFM ±5 CFM airflow the voltage at 51 amps was 19.3 volts and at 25 amps was 17.2 volts.

Beam intensity: The lamp when operated with 28 volt input and with 5 inch diameter F/1.3 optics equipped with a .300 inch aperture projected a 2.2 degree beam angle. The peak intensity of the beam was 25 million candelas as measured with an illumination meter.

Beam stability: The beam stability as recorded on a chart recorder was ten percent. The recording was made after the lamp operated for a period of 1 minute at 51 amps.

Reliability: The test was operated for 10 minutes duration of 2 minutes on time and 8 minutes off time for 1500 cycles. The input voltage to the driving circuit was 28 volts.

The following data was recorded for voltage and current values at the lamp.

Number Starts	E Volts	I Amps
90	18.5	62.6
155	18.6	65.6
300	17.9	64.5
590	17.6	64.5
735	18.9	62.5
850	17.6	63.3
1000	18.1	62.0
1130	18.2	62.1
1400	17.9	64.2
1500	17.5	67

3.4 CONCLUSION

At the end of this reporting period the third engineering sample was fabricated and tested. The lamp was fully operational without any interruptions during the 1500 cycles, the lamp leaked at the body ceramic to metal seal area. This leak prompted a design change to reduce the interface stress at the seal joint. The change will be incorporated into the next engineering sample and life tested in accordance with specifications.

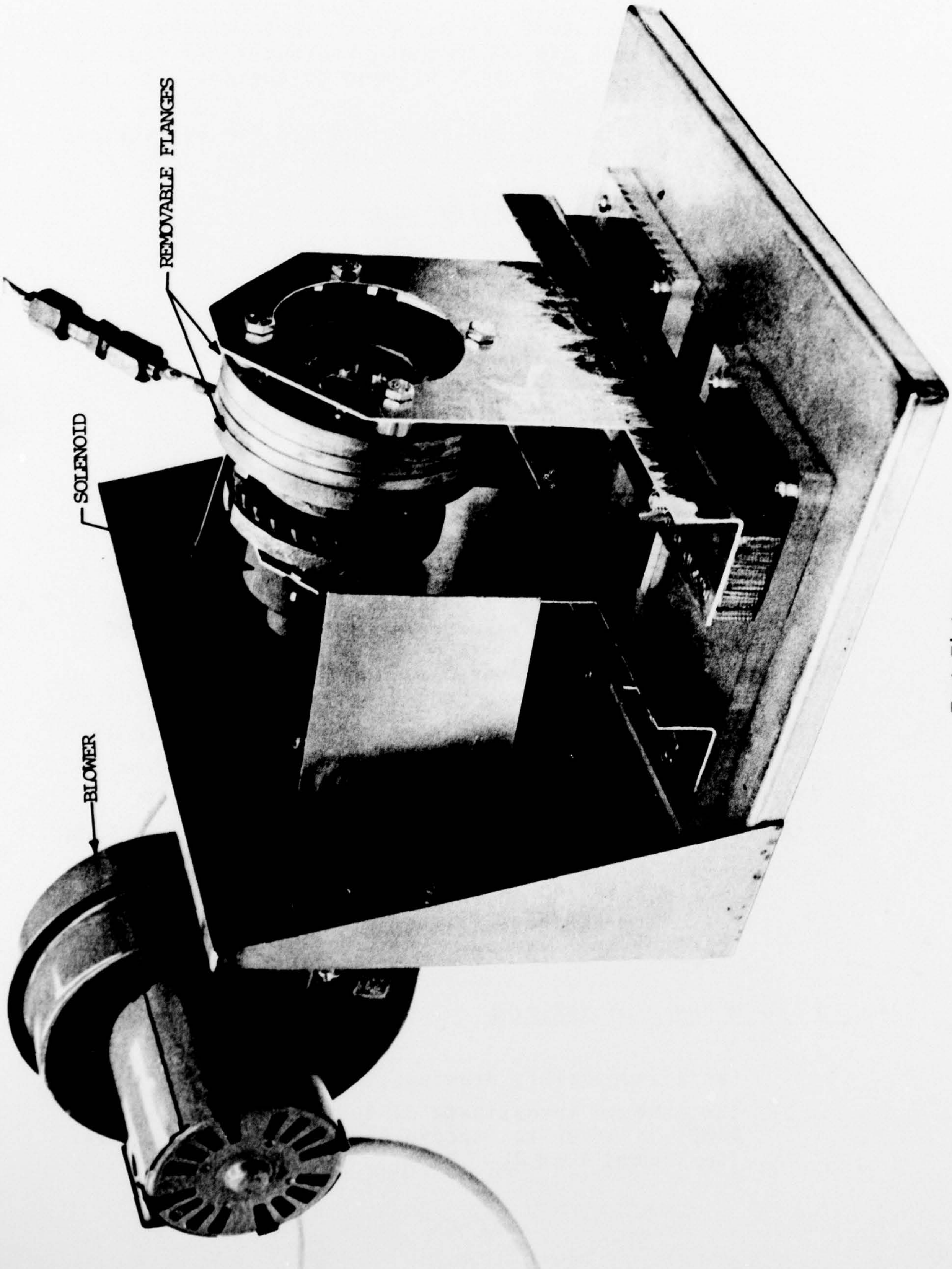
Other areas in which design problems were solved include:

a) Stinger mechanism was equipped with an armature return spring to dampen the stinger return.

b) A thicker window flange was incorporated into future MM&T lamps.

4.0 PROGRAM FOR NEXT INTERVAL

1. Finalize assembly drawings.
2. Continue to investigate EIMAC funded de-mountable lamps in order to improve overall output and life. (See Figures 3 and 4)



Test Fixture
De-Mountable MM&T Style Lamp

Figure 3.


Con-Flat Removable Flange (Anode)
Con-Flat Removable (Cathode)
De-Mountable " T " Style Lamp

Figure 4.

3. Test 3rd engineering sample in accordance with MM&T specification and equipped with the new body seal design to reduce stress levels during reliability tests.

5.0 PUBLICATIONS AND REPORTS

None

6.0 IDENTIFICATION OF PERSONNEL

The following is a list of key personnel who worked on this contract during the period January 1978 through March 1978.

Roy Roberts	108.0 Hours	
Nick Picoulin	47.3 Hours	
Welton Jones	68.5 Hours	
Nick Cortese	.5 Hours	
Alice Estrada	13.5 Hours	
Vic Kristen	18.0 Hours	
Tim Bell	27.5 Hours	
Craig Smith	12.5 Hours	
Bud Stuart	20.0 Hours	
Cheryl Handley	1.5 Hours	(Draftperson)
Greg Guild	101.0 Hours	
Paul Wierenga	16.7 Hours	

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