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LARGE RADIOISOTOPE
HEAT SOURCE CAPSULE (LRHSC)
FIFTH QUARTERLY PROGRESS REPORT
JULY-SEPTEMBER 1968

AEC Research and Development Report

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

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JULY-SEPTEMBER 1968

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Contract AT(29-2)-2338 with the
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A DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

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FOREWORD

This is the fifth quarterly progress report, describing the technical status of the Large Radioisotope Heat Source Capsule (LRHSC) Program. It covers the work accomplished by Atomics International during the period from July 1, 1968 through September 30, 1968 under contract AT(29-2)-2338 for the U.S. Atomic Energy Commission.

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I. INTRODUCTION

The LRHSC Program has been established to develop the technology of an isotope fuel capsule capable of operating in a space environment at a surface temperature of about 2000°F for five years or more. The objectives of the present phase are the design, fabrication, test and evaluation of a test capsule whose design takes into account the operating requirements of a typical heat source. The work includes process, fabrication and test activities. The process and fabrication includes the work required to define an acceptable manufacturing specification for the reference design capsule and to manufacture the test items required for the program. The FY 1969 test program involves various coupons and capsules with evaluation of chemical compatibility, capsule creep and capsule impact testing. In addition to indicating the suitability of the reference capsule for ground test, the data generated in this study will be used to validate presently accepted design approaches and define design margins that would actually exist for high temperature capsules intended for flight systems.

The LRHSC Program is being accomplished under the following tasks:

- 1) Program Management
- 2) Capsule Design
- 3) Process Development
- 4) Fabrication and Assembly
- 5) Capsule Creep Testing
- 6) Impact Testing

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II. PROGRAM MANAGEMENT

A. TASK OBJECTIVES

The objectives of this task are to provide management, directions and planning for all aspects of the Large Radioisotope Heat Source Capsule Program. This includes technical direction, reporting, detailed plans and procedures.

B. SUMMARY OF TASK STATUS

The official milestones for GFY 1969 are shown in Table II-1. All milestones planned to date for the fiscal year have been successfully accomplished. Overall reprogramming of manpower and scope has been necessary due to reduction in the GFY 1969 budget. The program continues to document results and issue Topical Reports.

C. ACCOMPLISHMENTS DURING THE QUARTER

Long range planning has been accomplished during the quarter to tailor the FY 1969 effort to the revised funding level. The overall plan, including technical requirements, schedules and manpower, has been completed and submitted to Sandia and AEC management.

One topical report was issued during the quarter (Topical Report # 5, Compatibility Testing, September 15, 1968).

A program review briefing was given at NASA-Lewis Research Center during the reporting period.

The first three milestones for this fiscal year have been met on schedule. As shown in Table II-1, two were creep rig startup events and the third was distribution of Topical Report # 5.

TABLE II-1
OFFICIAL MILESTONE SUMMARY

<u>Official Milestones</u>	<u>Target Date</u>	<u>Status</u>
1. Startup Creep Rig # 2	July 1968	Complete
2. Startup Creep Rig # 3	August 1968	Complete
3. Distribute Topical Report # 5	September 1968	Complete
4. Complete First "A" Capsule	October 1968	October 1968
5. Startup Creep Rig # 4	October 1968	October 1968
6. Complete First "C" Capsule	November 1968	November 1968
7. Conduct Preliminary Impact Tests	November 1968	November 1968
8. Complete First Creep Rupture Test	January 1969	January 1969
9. Distribute Topical Report # 6	March 1969	March 1969
10. Complete "C" Capsule Short Term Tests	May 1969	May 1969
11. Distribute Topical Report # 7	June 1969	June 1969

III. CAPSULE DESIGN

A. TASK OBJECTIVES

The objective of this task is to prepare all the drawings necessary to completely define the engineering, fabrication, and testing requirements of the Large Radioisotope Heat Source Capsule Program. This encompasses capsule piece-part, capsule assembly and test fixture drawings.

B. SUMMARY OF TASK STATUS

The design of the inner liner flanged cap was modified from one piece construction to two piece construction.

The forward fuel closure ring was relocated in order that both impact absorbers will have the same design configuration.

The design of the "TIG" weld fixture T-6001645 was modified to provide positive locating of the weld head to the centerline of the capsule.

C. ACCOMPLISHMENTS DURING THE QUARTER

The integrally fabricated Ta-10W flange caps were fabricated by a sequence of three coining operations with in-process machining and annealing. This method yielded good parts but was found to be too costly.

A design review was conducted with the vendor performing the work and the LRHSC Program Office. It was concluded that even successful development of the blank shaping approach would not meet the part cost reduction goal. Machining and preparation of the blank, forming, and then final machining would still involve excessive man-hours. A revised design consisting of a two piece inner liner flanged cap was adopted. A Ta-10W inner liner stepped cap (available) with a Ta-10W fuel retainer ring (available) is press fit together and TIG welded at five places, leaving paths for He pressure equalization in the

nose section of the capsule. This design requires minimum machining and meets the cost/schedule program milestone established for this part. It also results in the capsule liner being symmetrical from the standpoint of dimensions, piece-part configuration and assembly.

As a result of the design modification of the inner liner flanged cap, a design review of the Ta-10W capsule resulted in relocating the forward fuel retainer ring to provide additional symmetry to the capsule thus allowing both impact absorbers to have the same design configuration. Figure III-1 shows the cross-section of the Ta-10W capsule with the design modifications incorporated.

During the initial stages of "TIG" weld development utilizing T-6001645 a difficulty in locating and maintaining the location of the "TIG" weld head with the centerline of the capsule required a design modification to the weld head holding fixture to provide a positive locating capability. This design modification was completed and is now incorporated in the fixture.

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Figure III-1. Ta-10W Liner Assembly

IV. PROCESS DEVELOPMENT

A. TASK OBJECTIVES

The objectives of the process development task are to provide the necessary technical guidance and control to all phases of the capsule fabrication in applications considered laboratory practice, to quality fabrication, assembly and weld procedures, to perform the required experimental work in processes extending present technology, and to provide material and process specifications for the capsule fabrication program. The processes of interest include raw material and piece part fabrication, cleaning, annealing, joining, and non-destructive testing. Studies of alternate materials fabrication and assembly techniques will be performed as required.

B. SUMMARY OF TASK STATUS

Development of the pressure feed-through tube braze joint was concluded.

The two piece sleeve type of braze joint has been established as the LRHSC Creep Capsule Standard. TDR No. AI-68-TDR-105 has been released describing the preparation and quality control for this process.

Weld parameters for the TIG closure weld of the .020 inch Ta-10W capsule assembly were established along with weld parameters for the .127 inch T-111 structural closure weld with the .020 inch Ta-10W liner inside.

The CVD Al_2O_3 coating scale-up has been discontinued due to reduction in the LRHSC Program scope. Plasma arc spraying of the Al_2O_3 coating required on the four Creep "C" capsules will be accomplished utilizing existing AI procedures.

C. ACCOMPLISHMENTS DURING THE QUARTER

1. Brazing

Development of the pressure feed-through tube braze joint has been concluded. Brazing experiments with the common silver base alloy Easy-Flo 45 have been completed and evaluated. The first evaluation joint used a prefluxed paste mixture. The resulting joint appeared splattered with a black deposit; however, it did hold a vacuum and was leak tight. The ultrasonic C-scan revealed a 50% unbonded region. The second evaluation was with unfluxed 0.020" diameter wire. Upon reaching the melting point of the alloy, a vapor deposit was noted in the vacuum chamber. The resultant poor joint was attributed to the low vapor pressure of the 26% Cd in the alloy.

Two 82T-Ni-18% Au braze alloys have been evaluated. The first, Perma-braze 130, yielded a poor joint due to lack of wetting and flow. The second, produced to Rocketdyne Specification RB0170-064, yielded a joint completely wetted with good flow. Two additional attempts to make a Ta-10W to stainless steel braze joint with 82Au-18Ni (per Rocketdyne Specification RB0170-064) were made. The first failed when the braze alloy melted and fell away from the joint area along the stainless steel. The second braze was leak tight but ultrasonic inspection showed that penetration was less than 1/4 inch. This was attributed to both a tight fit and the greater thermal expansion of the stainless steel inner tube.

The most successful joint to date is the double enclosure joint with the Au-20 Cu braze alloy. This concept uses a stainless steel collar surrounding the conventional joint with an over-abundance of braze alloy and is the type of joint used on the creep capsule currently on test. During the quarter several "B" series creep capsules were brazed with the double enclosure joint. These assemblies were substantially leak tested and pressure tested (10,000 psi) successfully.

It is concluded that the double enclosure joint with the Au-20 Cu braze alloy will adequately meet the requirements of this program and no further braze development activities are planned.

Figure IV-1 shows the design configuration of the double enclosure braze joint.

2. Welding

Weld certification of the LRHS capsule welds continued during the quarter. Figure IV-2 shows the Ta-10W inner liner stepped cap E.B. welded to a 0.020 inch Ta-10W sleeve. This weld procedure is completed and available for test capsule welds. Figure IV-3 shows the Ta-10W outer liner stepped cap E.B. welded to a 0.020 inch Ta-10W outer liner sleeve section. This weld procedure is completed and available for test capsule welds. Figure IV-4 shows the inner liner E.B. stitch weld test sample. This E.B. stitch weld is necessary to allow helium to leak from the fuel region into the central void volume. The weld procedure is complete and available for test capsule welds. The E.B. weld of the outer liner stepped cap to the flange section of the inner liner flanged cap has been developed and is available. The establishment of this weld procedure completes the necessary weld parameters for the capsule up to the point of simulated fueling and the subsequent thermally hot handling of the capsule.

Figure IV-5 shows the half sections of a stainless steel mockup with the welds identified by weld procedure (W.P.). Figure IV-6 shows a prototype Ta-10W liner assembly to the point where it is ready for fuel loading. Figure IV-7 shows the prototype Ta-10W liner assembly with the fuel retainer ring, impact absorber, and outer liner closure cap assembled and ready for the final TIG closure weld.

Figure IV-1. **BRAZE JOINT COMPONENTS**

Figure IV-2. Ta-10W Inner Liner
Stepped Cap E.B. Welded
to Ta-10W Sleeve

Figure IV-3. Ta-10W Outer
Liner Stepped Cap
E.B. Welded to Ta-10W Sleeve

Figure IV-4. Ta-10W Inner Liner
Stitch Weld
Development Part

Figure IV-5. Stainless-Steel Half Section
(Shows capsule up to point of fueling
and weld parameters available.)

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Figure IV-6. Ta-10W Development Capsule
(Assembled to the point of fuel loading.)

Figure IV-7. Ta-10W Capsule
Ready for Final Closure Weld

Rework of TIG weld fixture T-6001645 has been completed and checked out with the Rytek Power Supply and Controller. TIG Weld Procedure 1237 is presently 90% complete. Development of the T-111 structural weld with the .020 inch Ta-10W liner is also being completed for "A" and "C" type capsules.

3. Documentation and Specifications

The T-111 deep drawing specification ST0602NA0003 was updated and released.

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V. FABRICATION AND ASSEMBLY

A. TASK OBJECTIVES

The objectives of this task are to obtain all tantalum and platinum alloy semi-stock required for the LRHSC Development Program, to fabricate all capsule and test piece parts, to develop, fabricate, and check out all capsule piece part and assembly tooling, and to assemble all capsules and compatibility coupon stacks.

B. SUMMARY OF TASK STATUS

Due to the change in program requirements the second heat (Heat "B") of T-111 material which was to be used for GFY 1969 structure shell and end cap fabrication has been cancelled. Structural shells and end caps required for GFY 1969 capsules are being fabricated from Heat "A". The sixty Ta-10W impact absorbers ordered for GFY 1969 impact capsules were also cancelled. Material originally rejected from Heat "A" has been received from National Research Corporation on consignment for reevaluation.

Purchase orders were prepared for the forming and final machining of GFY 1969 test capsule components. The parts will be used to complete the test capsule requirements shown in Figure V-1. Figure V-2 indicates the piece part fabrication requirements and status for GFY 1969 capsules.

Creep capsules B4a, B5a, and B7a have been assembled, inspected and delivered to test.

LARGE RADIOISOTOPE HEAT SOURCE PROGRAM

CAPSULE DESIGN-FABRICATION AND ASSEMBLY

CAPSULE DESIGNATION	CAPSULE CONFIGURATION	GFY 69 FABRICATION		TOTAL
		TEST	SPARES	
CREEP CAPSULE "A"		4	1	5
CREEP CAPSULE "B"		5	-	5
CREEP CAPSULE "C"		4	-	4
IMPACT CAPSULE "A"		6	-	6
TOTAL		19	1	20

Figure V-1.

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PART NO.	PART NAME	MAT'L.	SHAPE	BLANKS CUT	PO's PLACED	QUANTITY REQUIRED (EACH)	FORMING COMP	FINAL MACH. (COMP EST)	DELIVERED TO AI (EST)
N73420018	INNER LINER END CAP	Ta-10W		COMP.	COMP.	40	COMP.	10-25-68	10-30-68
N73420019	INNER LINER SLEEVE	Ta-10W		N/R	COMP.	20	N/R	10-25-68	10-30-68
N73420027	STRUCTURAL SHELL END CAP	T-111		COMP.	COMP.	35	COMP.	10-30-68	11-06-68
N73420026	OUTER LINER END CAP	Ta-10W		COMP.	COMP.	20	COMP.	10-28-68	11-01-68
N73420024	IMPACT ABSORBER	Ta-10W		N/R	N/R	3	N/R	N/R	AVAIL.
N73420012	OUTER LINER SLEEVE	Ta-10W		N/R	COMP.	20	N/R	10-29-68	11-02-68
N73420010	CLOSURE RETAINER RING	Ta-10W		COMP.	COMP.	40	COMP.	10-15-68	10-21-68
N73420009	IMPACT ABSORBER	Ta-10W		N/R	N/R	3	N/R	N/R	AVAIL.
N73420008	OUTER LINER CLOSURE END CAP	Ta-10W		COMP.	COMP.	20	COMP.	10-29-68	11-05-68
N73420036	PRESSURE FEEDTHRU TUBE	Ta-10W		N/R	COMP.	15	N/R	N/R	AVAIL.
N73420005	STRUCTURAL SHELL	T-111		COMP.	COMP.	20	IN WORK	11-07-68	11-12-68
N73420085	PRESSURE FEEDTHRU TUBE CLAD	Pt-Rh		N/R	COMP.	6	N/R	N/R	AVAIL.
N73420020	OXIDATION CLOSURE CAP	Pt-Rh		COMP.	COMP.	7	IN WORK	11-14-68	11-19-68
N73420002	OXIDATION SHELL	Pt-Rh		COMP.	COMP.	7	IN DEV.	11-14-68	11-19-68

N/R = NOT REQUIRED

= COMPLETE

Figure V-2. Piece-Part Fabrication Status

C. ACCOMPLISHMENTS DURING THE QUARTER

1. GFY 1969 Materials

Tantalum Alloys

Fourteen 10 x 10 x .170 T-111 plates from Heat "A" have been received from National Research Corporation and visually and ultrasonically inspected. After reviewing the inspection reports, six plates were accepted for fabrication. Seven plates were returned to National Research Corporation. The six good T-111 plates will be used to form structural shells for impact capsules.

2. Capsule Piece-Part Fabrication

a. T-111 Structure Shell (N73420005)

Development of the deep drawing of the T-111 shell has been completed and the process documented in the form of a released process specification. Large Radioisotope Heat Source Capsule Program Topical Report No. 4, "T-111 Pressure Vessel Development and Fabrication" (AI-AEC-12712), was issued July 25, 1968. This report contains the details of tooling development and checkout, and the history of problems encountered and solutions generated during the development effort. Figure V-3 shows three T-111 shells fabricated with this process. Fabrication development took place on structures S/N 001 through S/N 023. Deep drawing of the remaining T-111 material (18 pieces) for structure shells S/N 024 through S/N 041 has been completed through the fourth draw. Table V-1 tabulates the status of fabrication of all shells to date.

S/N 024 through S/N 039

These shells have been drawn satisfactorily through four draws. No discrepancies exist except for minor surface blemishes which were scarfed out after each draw.

Figure V-3. Structural Shells Formed to AI
Process Specification

TABLE V-1

T-111 STRUCTURAL SHELL FABRICATION HISTORY

S/N	INITIAL BLANK SIZE	DIES USED								ANNEALED AFTER X DRAW	ANNEAL TEMP.	ANNEAL TIME	PART UTILIZA- TION	REMARKS
		1	2	3	4	5	6	7	8					
001	10"		X		X		X			None	None	None	Develop.	
002	8-1/2"		X		X		X	X	X	None	None	None	Develop.	
003	5-3/4"		X		X					None	None	None	Develop.	
004	5-3/4"		X		X					None	None	None	Develop.	
005	5-3/4"		X		X		X			4	2700°F	1 Hr.	Develop.	
006	5-3/4"		X		X		X			4	2700°F	1 Hr.	Develop.	
007	5-3/4"		X		X	X	X	X	X	6	2700°F	1 Hr.	Develop.	
008	5-3/4"		X		X	X	X	X	X	6	2700°F	1 Hr.	Develop.	
009	5-3/4"		X	X	X	X	X	X	X	6	2550°F	1 Hr.	Develop.	
010	5-3/4"		X	X	X	X	X	X	X	6	2550°F	1 Hr.	Develop.	
011	5-3/4"		X	X	X	X	X	X	X	6	2550°F	1 Hr.	Develop.	
012	5-3/4"		X	X	X	X	X	X	X	6	2550°F	1 Hr.	Develop.	
013	6-1/2"	X	X	X	X	X	X	X	X	6	2700°F	1 Hr.	Develop.	
014	6-1/2"	X	X	X	X	X	X	X	X	6	2700°F	1 Hr.	Develop.	Assigned to B-1a
015	6-1/2"	X	X	X	X	X	X	X	X	6	2700°F	1 Hr.	Qual.	Assigned to B-2a
016	6-1/2"	X	X	X	X	X	X	X	X	6	2700°F	1 Hr.	Qual.	Assigned to Weld Qual.
017	6-1/2"	X	X	X	X	X	X	X		None	None		Exp.	To certify annealing cycle
018	6-1/2"	X	X	X	X	X	X	X	X	6	2700°F	1 Hr.	Test	Assigned to B-4a
019	6-1/2"	X	X	X	X	X	X	X	X	6	2700°F	1 Hr.	Test	Assigned to A-2a
020	6-1/2"	X	X	X	X	X	X	X	X	6	2700°F	1 Hr.	Test	Scrap
021	6-1/2"	X	X	X	X	X	X	X		6	2700°F	1 Hr.	Test	Scrap
022	6-1/2"	X	X	X	X	X	X	X	X	6	2700°F	1 Hr.	Test	Assigned to B-7a
023	6-1/2"	X	X	X	X	X	X	X	X	6	2700°F	1 Hr.	Test	Assigned to B-5a
024	6-1/2"	X	X	X	X								Test	
025	6-1/2"	X	X	X	X								Test	
026	6-1/2"	X	X	X	X								Test	
027	6-1/2"	X	X	X	X								Test	

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TABLE V-1 (Continued)
T-111 STRUCTURAL SHELL FABRICATION HISTORY

S/N	INITIAL BLANK SIZE	DIES USED								ANNEALED AFTER X DRAW	ANNEAL TEMP.	ANNEAL TIME	PART UTILIZA- TION	REMARKS
		1	2	3	4	5	6	7	8					
028	6-1/2"	X	X	X	X								Test	
029	6-1/2"	X	X	X	X								Test	
030	6-1/2"	X	X	X	X								Test	
031	6-1/2"	X	X	X	X								Test	
032	6-1/2"	X	X	X	X								Test	
033	6-1/2"	X	X	X	X								Test	
034	6-1/2"	X	X	X	X								Test	
035	6-1/2"	X	X	X	X								Test	
036	6-1/2"	X	X	X	X								Test	
037	6-1/2"	X	X	X	X								Test	
038	6-1/2"	X	X	X	X								Test	
039	6-1/2"	X	X	X	X								Test	
040	6-1/2"	X	X	X	X								Test	
041	6-1/2"	X	X	X	X								Test	

S/N 040

A slippage in the tooling on draw #3 produced this shell off center. In order to face off this shell, more than the normal amount of material was removed. It was drawn through draw #4 without further mishap and will be used for a creep "B" capsule. The only result will be that no "before and after" weld material will be available from the shell itself.

S/N 041

After the fourth draw, circumferential cracks appeared on the upper outside diameter of the shell. These will be removed before the fifth draw. This shell may be slightly short due to the material removed.

S/N 019

This structure shell has been sent to Precision Quality Products for final machining. The electrode is being prepared to elox the I. D. after which the I. D. will be cleaned up by lapping. This structure will be used for the first creep "A" capsule.

b. T-111 Structural End Cap (N73420006)

Production tooling for the end caps has been completed and the first three articles produced are shown in Figure V-4. Blanks for 15 structure caps were prepared and all caps were satisfactorily formed and are ready for inspection.

c. T-111 Structural End Cap with Feed-Through Boss (N73420027)

Tooling for this part has been completed and the first three articles produced are shown in Figure V-5. The process used to produce these parts is also outlined in LRHSC Topical Report No. 4, "T-111 Pressure Vessel Development Fabrication" (AI-AEC-12712). Blanks for twenty caps were prepared and all caps have been formed and are ready for inspection.

Figure V-4. T-111 Structural End Caps

Figure V-5. T-111 Structural End Caps with
Pressure Feed-Through Tube Boss

d. Ta-10W Inner Liner Stepped Cap (N73420018)

The first three stepped caps have been received and used in the weld development of WP 1233 (Ta-10W inner liner stepped cap to the Ta-10W inner liner tube). Figure V-6 shows the Ta-10W stepped cap E.B. welded to a Ta-10W tube section. Blanks were prepared and 40 caps were formed, inspected and sent to final machining.

e. Ta-10W Fuel Retainer Ring (N73420010)

The first three retainer rings were received and have been used in the prototype capsule and for weld development. Figure V-7 shows a Ta-10W fuel retainer ring fabricated from 0.037 inch sheet stock. Twenty-nine blanks were prepared and successfully formed, inspected and sent to final machining.

f. Ta-10W Inner Liner Flanged Cap (N73420016)

The initial Ta-10W flanged caps were fabricated by a sequence of three coining operations with in-process machining and annealing. This method yields the proper parts but is considered too costly.

To reduce the part cost, a new blank design approach was attempted. Three disc shaped blanks 1.425 inch diameter were cut from 0.250 inch Ta-10W sheet stock. Flange cap hemispheres were pressed. The hemispheres were pressed almost to the full depth of the die. They were quite uniform in surface finish in comparison to the parts pressed previously.

In an attempt to cause the Ta-10W material to be pressed to the full depth of the die center machining on the four blanks was performed prior to forming of the caps, the philosophy being that reducing the thickness at the center of the blank would reduce the amount of material to be moved during the forming operation. Two blanks had a center thickness of 0.100 inch, one had 0.050 inch, and one had a 0.030 inch center thickness. The results of the drawing operations on all of the blanks were similar. Although a complete inner spherical impression was obtained, the outer surfaces were incomplete. All of the outer

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Figure V-6. Ta-10W Inner Liner Stepped Cap
Welded to Ta-10W Tube (WP 1233)

Figure V-7. Ta-10W Fuel Retainer Ring Fabri-
cated From 0.037 Sheet Stock

surfaces had flat spots indicating that the parts did not reach the bottom of the die.

A design review was conducted with the vendor performing the work and the LRHSC Program Office. It was concluded that even successful development of the blank shaping approach would not meet the part cost reduction goal. Machining and preparation of the blank, forming, and then final machining would still involve excessive man-hours. A revised design consisting of a two piece inner liner flanged cap was adopted. A Ta-10W inner liner stepped cap with a Ta-10W fuel retainer ring is press fit together and TIG welded at five places, leaving five unwelded paths for He pressure equalization in the nose section of the capsule. This design requires minimum machining and meets the cost/schedule program milestone established for this part. Figure V-8 shows this revised flange cap design.

g. Ta-10W Outer Liner Stepped Cap (N73420014)

The tooling for this part is complete and three parts have been produced. The repeatability of this process to produce good parts has been satisfactorily established.

The success of this coining operation depends upon a combination of hold down pressure, hold down to die match-up, and ram pressure. Of the first five 2.312 inch x 0.027 inch blanks drawn through the process, one good part was attained by having a proper combination of the above mentioned variables. The other four parts failed due to either too much hold down pressures, uneven distribution of hold down pressure, or improper ram pressure.

The tooling was modified to prevent locking of the blank in the die during the forming operation which ultimately fails the nose section in tension. This modification achieves the required repeatability.

Twenty blanks were prepared and successfully formed. They will be sent for final machining after inspection.

h. Ta-10W Outer Liner End Cap (N73420008)

The first three outer liner end caps were received and have been used for weld development. The same tooling used in the forming of the outer liner stepped cap (N73420014) has been utilized to produce the outer liner end cap with only the blank diameter being made smaller. Blanks were prepared and 20 caps were formed. Presently they are awaiting inspection and final machining.

i. Pt-Rh Barrier Shell (N73420002)

The tooling for forming the Pt-Rh oxidation shell has been checked out using a 6 inch diameter x 0.020 inch thick copper blank. After three successful draws a similar size of Pt-Rh was pressed through die # 1. The bottom of the cup had a smooth, uniform surface; however, the rim was moderately wrinkled over one inch depth. Figure V-9 shows the Pt-Rh shell after the first draw. To eliminate the wrinkling problem a special ironing fixture was designed and installed on the second stage die. After several draws were performed on copper development parts the platinum-rhodium shell was successfully drawn through die # 2. Figure V-10 shows the Pt-Rh shell after the second draw. Figure V-11 shows the Pt-Rh shell after the third draw. Two more draws will be required to achieve the design dimensions.

j. Pt-Rh Barrier Cap With Feed-Through (N73420020)

An intermediate forming tool has been fabricated to eliminate the tearing of the cap during forming. The sequence of fabrication is as follows:

- 1) Spin feed-through boss.
- 2) Form cap radius on new intermediate forming tool.
- 3) Form cap weld lip on existing final form tool.

3. Capsule Assembly

Creep Capsules B4a, B5a, and B7a have been assembled, tested, and delivered to creep testing.

Figure V-8. New Design of Inner Liner
Flanged Cap Consisting of a Ta-10W
Fuel Retainer Ring Press Fitted to a Ta-10W
Inner Liner Stepped Cap and TIG Welded 1/4 inch -
Five Places, Evenly Spaced.

Figure V-9. Pt-Rh Barrier Shell After Draw No. 1.

Figure V-10. Platinum-Rhodium Barrier Shell
Drawn Through Second Stage Die

Figure V-11. Pt-Rh Barrier Shell
After Draw No. 3

A weld head holding fixture has been designed, fabricated, and installed on TIG Weld Fixture T-6001645. The assembled fixture is shown in Figure V-12.

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Figure V-12. Weld Head Holding Fixture
for TIG Weld Fixture No. T-6001645

VI. CREEP TESTING

A. TASK OBJECTIVES

The LRHSC Program fuel capsule design utilizes a first generation tantalum alloy (Ta-10W) as primary containment for the fuel, a second generation tantalum alloy (T-111) for the major structural containment, and Pt-10%Rh for oxidation protection of the reactive refractory metal containers. The objective of this task is to provide and test a design approach that accounts for creep deformation at elevated temperatures for a refractory metal capsule containing alpha emitting fuel.

To achieve this end a test series has been designed, utilizing the LRHSC reference design as a test vehicle, to evaluate heat to heat variations on the creep properties of the T-111 (Ta, 8W, 2Hf) structural shell, determine the effects of variable stress on the creep of the shell, relate uniaxial and biaxial stress states to creep of T-111, and finally to determine the interacting effects of capsule components on the creep of that structural member.

B. SUMMARY OF TASK STATUS

The original GFY 1969 program plan called for a series of 23 creep tests in 12 test rigs. Due to the reduction in program funding, it is currently planned to perform 14 creep tests in 4 test rigs this fiscal year. The tests which have been deferred are primarily those of one year or greater duration.

Three creep test rigs have been constructed and are operational and three capsule creep tests have been completed. Two of the test capsules are undergoing limited post-test evaluation and the third is still in the test rig. Two additional creep tests are in progress. Preliminary observations on these first five tests indicate that the creep rate is lower than expected. The capsule tangential stress at the mean diameter necessary to produce a particular creep rate may be as much as 30% greater than the stress required for the same

creep rate in uniaxial constant load tests. Part of the apparent increase in capsule creep strength is due to the biaxial configuration and the rest of the increase is most probably due to effects of the capsule fabrication sequence. A correlation between uniaxial and biaxial creep test results is one of the LRHSC program goals.

C. ACCOMPLISHMENTS DURING THE QUARTER

1. Test Rig Design

Some problems were encountered with the optical strain measuring system during the operation of capsule B2a. The problems effected accuracy and repeatability of the diametral measurements. The inaccuracies were reduced by maintenance of the cathetometer, however, not down to the desired level. Experimentation with a new set of optics in the cathetometer on capsule B5 in the second rig indicated that significant improvement in the accuracy and repeatability (almost an order of magnitude) was possible. A new cathetometer stand design was required for this new set of optics. The stand was designed and installed on all four rigs. The stand, shown on Rig No. 1 in Figure VI-1, is a 1/4 inch thick steel plate supported by angle iron. Dogs are bonded to the surface of the plate for the feet of the cathetometer. The bond is relatively brittle so that if bumped it comes off rather than moves. With the new stand and optics in place, the accuracy of the diametral measurements are now to within 0.0001 inch using two different operators.

Figure VI-1. Cathetometer Stand Attached to
Creep Rig No. 1

The second creep rig was completed early in the quarter. The test of capsule B5a was conducted in the rig and it proved to work quite satisfactorily. That test has been terminated and a second capsule is now on test. The third creep rig was completed and checked out during the quarter. Capsule B7 is operating in the rig. Its performance is good.

The test chamber and pumping station for the fourth rig were constructed and are shown in Figure VI-2. The chamber and pump are now undergoing cold evacuation tests. The tests indicate that the system is operating well in the 10^{-8} torr range. The furnace and power controller for this rig are under construction. The expected completion is early in October. It is planned to install a long term test (>10,000 hours) in this rig.

All of the very short term tests will be run in Rig No. 1. Because of the relatively high pressure rates, the pressure in these capsules will be controlled automatically. The tests to be run in the remaining three or four rigs are longer term and will not require a pressure adjustment more often than every couple of days. In order to reduce the cost of maintaining these rigs they will be controlled manually. Since they are to be operated manually, they will be controlled from a single pressure gauging console. This type of arrangement has been used quite successfully on another program at AI where as many as 150 biaxial stress rupture tests have been controlled from a single manifold. The design of the pressure manifold is shown in Figure VI-3. It is built into the superstructure of the test facility. The system is completely closed. Any requirement for a reduction of pressure in the manifold is taken care of by bleed tanks. Non-hydrocarbon evacuation of the system is accomplished by a bank of sorption pumps. These are blanked out of the system by a high pressure valve when the system is in normal operation. The evacuation is required on the startup of tests when a capsule containing air is installed into the system. The operation is relatively simple. To adjust the stress on the capsule, the required pressure is fed into the manifold. The isolation valve to the desired

Figure VI-2. Test Stand for Rig No. 4

Figure VI-3. Creep Capsule Pressure Manifold

capsule is then opened and that pressure fed into the capsule. The valve is then sealed and the pressure in the manifold for the next capsule is established until all of the changes required are made.

2. Test Operations

a. Creep Capsule B2a

Capsule B2a was terminated at 1% diametral strain after 2500 hours of total test operation. The test results are shown in Figure VI-4. This test was intended to achieve 0.1% strain in 480 hours under a constant stress, thereafter in a stress rate mode to achieve 1% total strain in the following 1000 hours. As reported previously the original model used to select the pressure for the capsules resulted in a pressure in the first test which was low by as much as 30%. To be on the conservative side the second test, B2a, was started with only a 15% increase in hoop stress over the baseline case. After the target 480 hours, the capsule had strained less than 0.05%. At that time the pressure in the capsule was increased at a pressure rate 30% over the baseline calculated ramp. After about 1700 total hours of operation the capsule achieved the target 0.1%. As can be seen from Figure VI-7, the final 1% strain was achieved after 2450 hours of test time.

b. Creep Capsule B5*

Creep Capsule B5* is designed to have the same strain schedule as B2a, with the exception that the test is not to be terminated until the total apparent strain is 5%. The test has been started and the initial stress is 30% above the baseline calculations. The stress is 16,500 psi, and the test is operating at 2000°F. The capsule has been on test for 450 hours and has achieved 0.07% strain. This compares favorably with the desired 0.1% strain at 480 hours.

CREEP TEST RESULTS - CAPSULE B-2a

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Figure VI-4.

c. Creep Capsule B7

Creep Capsule test B7 is designed to have the same strain schedule as B2a and B5*; however, the test will not be terminated until rupture. After 316 hours at 2000°F, with a hoop stress of 16,500 psi, the apparent strain is 0.05%. Again it appears that the 30% increase in hoop stress will provide the desired strain-time characteristic.

d. Creep Capsule B5a

Creep Capsule B5a is the same design as the other "B" capsules with the exception that this one was not fully recrystallized prior to testing. It was pressurized at 2000°F to produce a hoop stress of 16,500 psi, the same as B5* and B7. The creep rate of this capsule was about an order of magnitude greater than for either of the two similar capsules. The apparent strength was about that of the baseline calculations, or possibly lower by about 10%. After 290 hours at this constant stress the strain was 0.5%. The capsule was then pressurized at a rate intended to induce 1% strain in the following 100 hours. It was to continue on this rate until 5% total strain had been achieved. This rate was based on the apparent strength shown in the early constant stress portion of the test. After 425 hours of accumulated test operation the capsule achieved 1% strain. This was 135 hours after the ramp had begun. It continued on as shown in Figure VI-5 until 5% total strain had been reached after 680 hours of test.

The test was terminated and is now undergoing destructive examination. A photograph of the capsule after testing is shown in Figure VI-6. As can be seen from the photograph the plane of maximum strain at the end of life was not at the mid plane. This is different than the other capsules examined to date, in that the maximum strain did not occur at the mid plane. The destructive examination indicates a variation in structure in this plane as compared to the remainder of the capsule. This evaluation continues.

CREEP TEST RESULTS—CAPSULE B-5a

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Figure VI- 5.

Figure VI-6. Creep Capsule After Test

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VII. IMPACT TESTING

A. TASK OBJECTIVE

The objective of this task is to determine, by testing, the capability of the reference capsule design to survive impact. The developmental impact tests will also allow insight into the actual capsule deformation phenomena, determine the capsule failure modes and ascertain the relative influence of various capsule impact parameters on capsule failure. A total of 6 capsules will be impacted hot ($\sim 1200^{\circ}\text{F}$) on a granite target at various velocities and impact angles during GFY 1969.

B. SUMMARY OF TASK STATUS

The impact testing will be accomplished in November 1969. The initial impact test plan called for testing a matrix of 18 capsules at various angles, velocities, temperatures, with and without impact absorbers, and with general structural wall thicknesses. It is planned to complete this test plan. However, because of limited funding only 6 will be tested this year. The six will be impacted at 1200°F , with and without impact absorbers, at two velocities and in the end on mode of impact. Two will be with reduced wall thickness structures.

C. ACCOMPLISHMENTS DURING THE QUARTER

The activity during the quarter was entirely related to preparing the facility. Certain modifications to the impact tester were analyzed, designed and actual hardware modifications were initiated.