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WANL-TME-1831

Westinghouse Astronuclear Laboratory

NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING HELD WITH SNPO AT WANL ON JULY 18, 1968
(Title Unclassified)

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Westinghouse Electric Corporation
Astronuclear Laboratory
P. O. Box 10864
Pittsburgh, Pennsylvania 15236

Classification cancelled (~~or changed to~~)
by authority of
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E. A. DeZubay, Manager
Thermo-Flow Laboratory

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J. L. Meuche, Manager
Engineering Mechanics

GROUP I
Excluded From Automatic Downgrading and Declassification

SPECIAL REREVIEW FINAL DETERMINATION
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Reviewers	Class.	Date
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NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING HELD WITH SNPO AT WANL ON JULY 18, 1968

(U)

Attendees:

A. Bournia	WANL	W. L. Jacob	WANL
E. L. Brickman	WANL	G. A. Kalvin, Jr.	SNPO-C
J. Burgess	WANL	J. L. Koetting	WANL
P. Cherish	WANL	C. L. Meuche	WANL
J. DiCristofaro	WANL	R. Muth	WANL
R. N. Eichbauer	WANL	N. A. Norman	AGC
N. J. Ettenson	WANL	R. L. Oelrich	WANL
H. J. Fix	WANL	N. P. Spofford	WANL
R. A. Gualdoni	SNPO-C	B. H. Stahl	WANL
W. J. Havener	WANL	J. A. Swanson	WANL
H. H. Hoffman	SNPO-C	F. G. Tauch	WANL
J. R. Huber	WANL	D. C. Thompson	WANL

The Monthly Development Test Program Review Meeting was held on July 18, 1968.

This report is divided into two discrete sections. The first section covers the activities of the Thermo-Flow Laboratory and the second, those of the Engineering Mechanics Laboratory. Table I of each section lists the tests performed during the reporting period and those planned for the next period. Discussions of the individual tests follow.

SECTION A

MONTHLY REVIEW OF THERMO-FLOW LABORATORY TESTS

TABLE 1

THERMO-FLOW LABORATORY TEST SCHEDULE

PERFORMED THIS PERIOD (June-July 15)	PLANNED NEXT PERIOD (July 15-August)
Tests for NRX-A6 TFL-3. f Reflector Thermal Transient Test - Initiated Testing.	Complete testing.
Tests for PW-1 TFL-1. a Single Cluster Tests Test Configuration TFL-1. a. 23 LASL Exit Gas Thermocouple Tests. TFL-1. a. 24 One Facility Checkout Run Performed. TFL-1. a. 25 PW-1 Test. TFL-1. a. 26 LASL Exit Gas Thermocouple Test. TFL-1. a. 27 PW-1 Test.	Test Configurations to be run. XE-2 Type Elemets for Checkout Cluster for PW-1. Composite Hot End Hardware. LASL Exit Gas Thermocouple (LASL to supply improved elements).
Tests for R-1 TFL-1. e Support Stem Impedance - Design Initiated on Two Fixtures.	Complete design.
TFL-2. a Core Periphery Test - Mock-up of alternate inner core-simulated element (uncoated) assembly for TFL-2. a. 0004 completed. Revised fabricating technique for liners being developed. FS-1 furnace assembled and delivered to test facility.	Start assembly of TFL-2. a. 0004 model.
TFL-6. d Flow Tube Spool Seal Leak Test - Completed fixture - Hold.	Possibly initiate testing.

(This Page is Unclassified)

TABLE 1 (Continued)

PERFORMED THIS PERIOD (June-July 15)	PLANNED NEXT PERIOD (July 15-August)
General Development Tests	
TFL-1.b Single Element Tests (1.2395 to 1.2475) - Total - 81	
4 - A6C Part II	
27 - II-Ga	LASL exchange tests, Phase II-Ga elements, Y-12 high expansion matrix development elements, "Q" coat development tests, flour evaluation tests, and chuck and furnace development tests.
5 - Phase IV-B	
6 - Phase PW-1 PEWEE-1 LASL elements	
6 - Phase E-1 LASL Exchange elements	
6 - Phase E-2 LASL Exchange elements	
16 - Phase YFE	
2 - Phase I-Dc "Q" Coat Development Tests	
1 - Test Phase CTX	
1 - High void element checkout test	
6 - Checkout tests, XE-2 type elements	
1 - Test of high void element with low helium pressure.	
TFL-5.b Interstitial Corrosion Tests - Tests on Pyrofoil.	Continue testing.
Facilities	
WANL Liquid Hydrogen Facility Checkout.	Operation.
WANHES Liquid Hydrogen.	
Water Injection System for Single Element Furnace. Three checkout tests completed.	Conduct additional checkout tests and modify system as required.
CL-1 Facility Checkout Conducted.	
FS-1 Installation 84% Complete.	Continue FS-1 Installation.

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TESTS FOR NRX-A6

TFL-3. f Reflector Thermal Transient Test

Three tests were conducted on the NRX-A6 spare reflector ring, Figure 1. The purpose of this test is to measure the temperature and strain response of the ring during transient heat up. The ring is heated by impressing boiling water temperature on the reflector inside diameter. The thermal and strain gauge data is being analyzed by the responsible analytical engineering groups in order to determine the degree of correlation with the analytical models that are presently being used for the prediction of the response parameters. Indication has been made that more tests will be required to verify the analytical models. Different strain-gauge types and redundant thermocouple instrumentation will be incorporated. Test operations are on a standby basis awaiting final go-ahead from the cracking problem task group leaders. Strain gauge measurement locations remained the same for all three tests. However, thermocouple mounting techniques and mounting locations were varied. The thermocouple locations were identical for Run 1 and Run 2. The difference between the two runs was that the reflector inside diameter and outside diameter thermocouples were pinned under tiny copper bars for Run 1; but were taped under a 3 mil thick aluminum foil-teflon laminated adhesive for Run 2. The change was necessitated since it appeared that the inside diameter thermocouples were reading closer to water temperature than was expected. The data from Run 2 verified the Run 1 condition for the inside diameter thermocouples. The data from Run 2 is considered to be good data. A temperature versus time plot of some of the thermocouple locations is shown on Figure 2. The maximum temperature gradient from inside diameter to outside diameter is shown to be approximately 150°F.

There was some question concerning the uniformity of material properties and temperature response around the ring. Consequently, Run 3 was conducted with 24 thermocouples placed at about mid span height equally spaced azimuthally

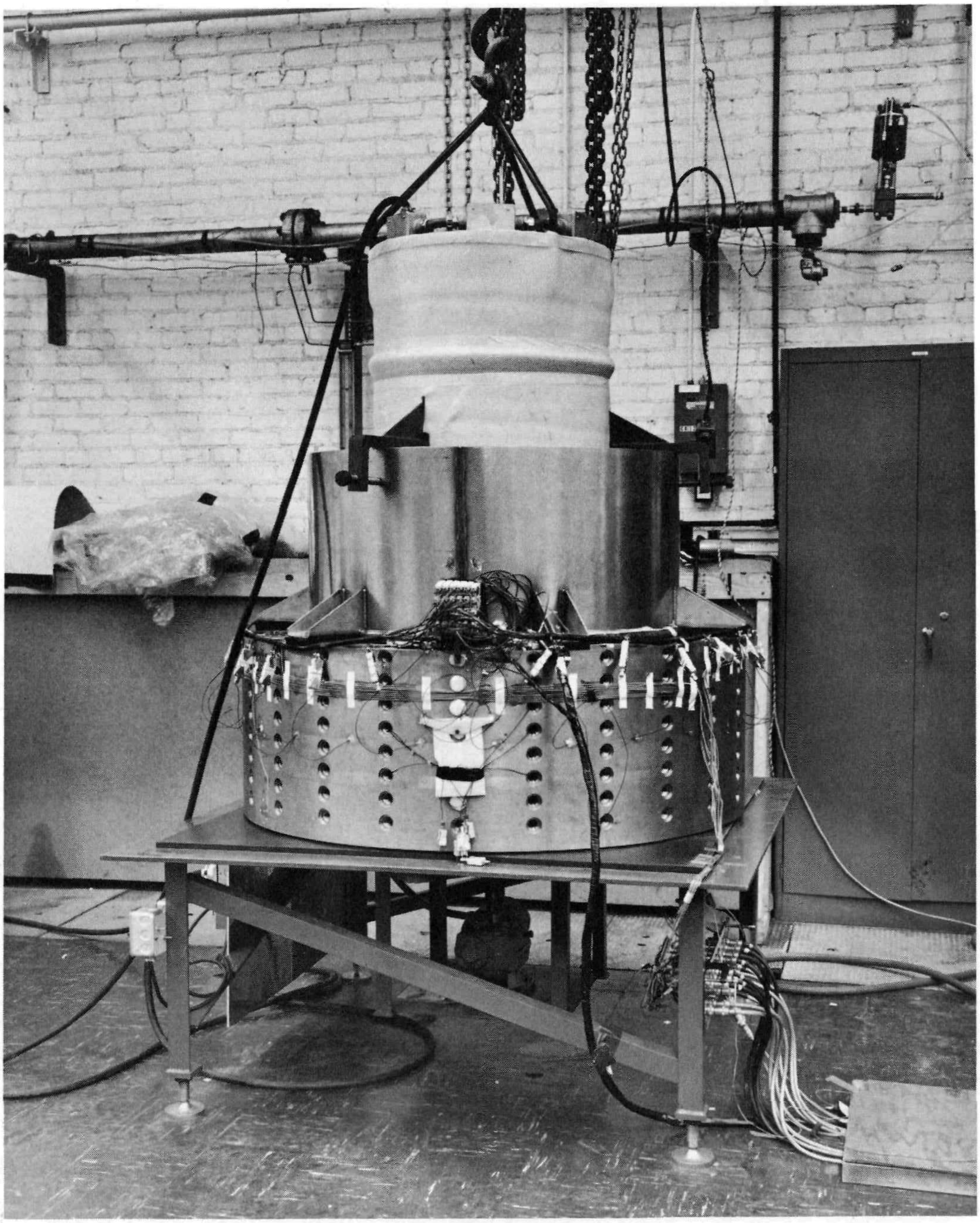

FIGURE 1

REFLECTOR THERMAL TRANSIENT TEST MODEL

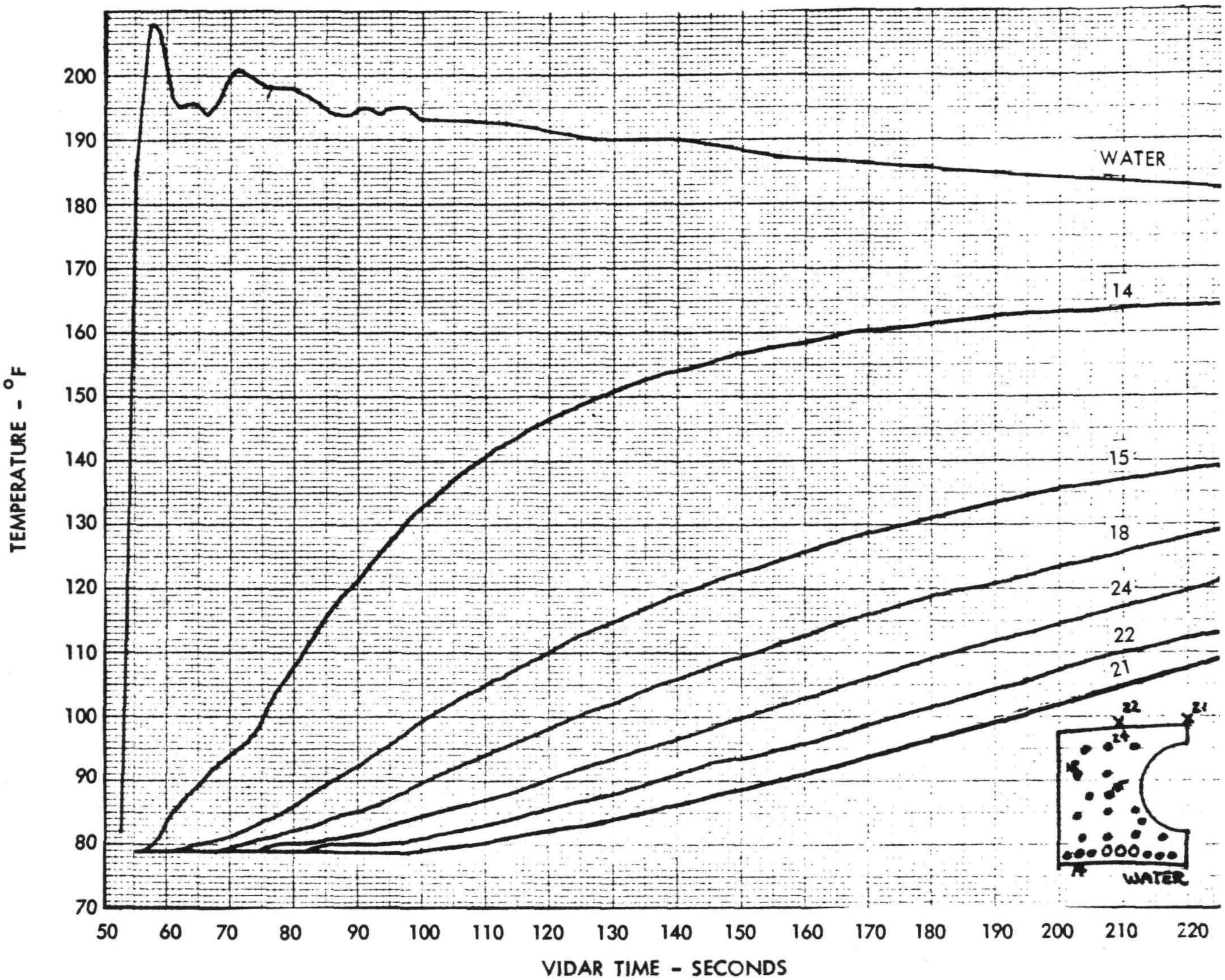

FIGURE 2

TEMPERATURE VS TIME FOR REFLECTOR THERMAL TRANSIENT TEST

TFL-3. f Reflector Thermal Transient Test (Continued)

around the O. D. of the reflector. Twelve were placed on the control drum bore-reflector O. D. web and 12 were placed between the drum bores. The test verified the uniformity of properties since all of the thermocouples on the webs and between the drum bores responded uniformly in their respective areas. The 12 web temperatures lag the 12 temperatures between the drum bores. The maximum difference between the warmest and coolest thermocouple in each of the two areas throughout the test period was less than 1°F. The initial difference between thermocouples before the test was 0.66°F.

TESTS FOR PW-1

TFL-1.a Single Cluster Development Tests

(U) A third facility checkout cluster, Test No. TFL-1.a.0024a, was constructed using standard A6 components. A successful (approximately four minutes) run at full power on June 6 indicated the flow system is acceptable without further work to resume general cluster testing. A gas leak in the heat exchanger terminated the test. The heat exchanger was rebuilt and testing resumed.

(C-RD) Test TFL-1.a.0023a of a LASL exit gas thermocouple was conducted on June 17, with an exit gas temperature of 4500°R. The test ran 2.9 minutes at full power. The exit gas thermocouple did not read properly during the test. Post test analysis revealed it failed in what appeared to be a mechanical or brittle failure. The test was terminated due to breaking of fuel elements.

(C-RD) Post test analysis of this test and TFL-1.a.0025a below, indicated that NRX-A6 cluster orificing that was used in both cluster assemblies should be modified. Thermal and Nuclear Design department performed an analysis of cluster orificing for the high void PEWEE elements and recommended orifice changes, that were incorporated in the tests TFL-1.a.0026a, TFL-1.a.0026b, and TFL-1.a.0027a. Test TFL-1.a.0026a was completed on June 21, 1968. This test model incorporated the second build of the LASL exit gas thermocouple. Three attempts to attain test specifications were unsuccessful and resulted in cracking the cold end chuck requiring replacement. Test TFL-1.a.0026b was a rebuild of the LASL exit gas thermocouple cluster model incorporating the pedestal assembly from TFL-1.a.0026a. This test was terminated at 53 seconds of steady state operation due to large pinholes on the inner element flats at 10 to 11 inches causing center element insulator failure and cold end element breakage.

(U) Due to the difficulties experienced with the first modified center element for use with the PEWEE standoff pedestal design, an alternate approach for model assembly was chosen using a brazed pedestal assembly consisting of a pedestal, sleeve, and tapered washer. The six fueled peripheral elements were set on the

TFL-1.a Single Cluster Development Tests (Continued)

(U) pedestal and carried the tie rod load. With this configuration, test TFL-1.a.0025a was conducted on June 18. Cluster model electrical arcing at the hydrogen inlet plenum occurred before full power was obtained. This was followed by fuel elements breaking and the test was terminated by an abort shut-down. As mentioned above, re-orificing of the fuel elements were performed before the next test.

(C-RD) Test TFL-1.a.0027a was conducted over the period June 23-24, 1968. This PW-1 cluster model used a brazed pedestal assembly consisting of a pedestal sleeve and tapered washer. A successful test of 12 minutes at steady state, with model exit gas temperatures of approximately 4660°R was obtained. The test was terminated due to formation of two pinholes at roughly 24 inches on the inside flats of the fueled elements which caused melting and arcing of the center element insulators. To achieve longer than a 12 minute life of the fuel elements, further thermal analysis of the cluster orificing was performed, and changes made that were incorporated in the next test.

(U) Test TFL-1.a.0027b was conducted on June 28, 1968. The test was aborted after eight minutes in the power up ramp. Post test investigation indicated high thermal gradients and high temperatures between element faces which caused cracking, bore failure, and arcing to the center element.

(C-RD) Due to the above difficulties, the decision was made to: switch from high void to low void XE-2 elements using standard NRX-A6 cluster model orificing, modify the cold end electric current braid-shoe-nut arrangement to permit faster power up ramps, and build a checkout cluster to be tested at the design (4650°R) operating conditions. The goal of this work is to achieve 20 minutes or longer tests on each model build.

TESTS FOR R-1

TFL-1.e Support Stem Impedance Test

The test fixture has been designed for measuring the aft end impedance of the support stem assembly. The detailing of the fixture has begun.

Equipment necessary to adapt five reactor grade support stems for flow testing has been designed and turned over to Drafting for detailing.

TFL-2.a Core Periphery Test

The assembly room was relocated, and the test hardware was moved to the new area. Construction of storage shelves for the test hardware was started and is presently 50% completed.

The technique being developed for fabricating the TFL-2.a.0004 model Z-liners was revised during this period from a pulling method to a bend press method. Tooling for the revised method is now being fabricated. The revised production date was rescheduled to start around August 8, 1968.

Core sub-assembly and wrapper sub-assembly drawings were prepared, checked and released.

Coating requirements which included the second set of simulated elements and four cores were coated at WNCO and are presently awaiting shipment.

Pre-assembly work in preparing the uncoated simulated elements was completed and the elements were assembled to the core for inspection measurements. No further inspection work was attempted at this time because of the storage problem encountered on relocating the assembly room.

Analysis work continued towards determining a model for predicting the seal pressure distribution. Presently the CDC 6600 track computer code is being used to expedite a more rapid turn around time for obtaining computer results. Presently experimental information obtained from WANL-TME-1495, "Experimental Results of the NRX-A5 Single Seal Program" is being exploited to approximate the scarf joint leakage. This information, in addition to the previous flow data published in

TFL-2.a Core Periphery Test (Continued)

WANL-TME-600 is being utilized to provide an iterative converging solution for matching the computer results to the test data.

TFL-6.d Flow Tube Spool Seal Leak Test

The test fixture and related hardware has been fabricated. A hold has been placed on this test until July 24, 1968 pending possible design change.

GENERAL DEVELOPMENT TESTS

TFL-1.b Single Element Process Development and Evaluation Tests

(U) Eighty-one single element corrosion tests were conducted during this period.

(C-RD) Twenty-seven high expansion graphite elements from Phase II-Ga were corrosion tested for multiple 10 minute cycles at R1.07 or D1.01 conditions.

(U) Four tests were conducted as part of A6-C Part II verification using XE-2 elements.

(C-RD) Five Phase IV-B elements were tested at R1.07 conditions for 10 minute cycles.

(U) Six LASL PEWEE-1 elements were tested at A6.04 or P1.02 conditions.

(C-RD) Twelve tests were conducted as part of the LASL exchange program at W-IB4500, R1.07, or A6.04 conditions.

(U) Sixteen Phase YFE, Y-12 flour evaluation, tests were conducted at R1.07 or D1.01 conditions.

(C-RD) Two Phase I-Dc, "Q" coat development, elements were tested. One at R1.07 and the second at D1.01 conditions.

(C-RD) Seven checkout tests were conducted at D1.01 and W-IB4500 test conditions.

(C-RD) One test of a Phase CTX salt qualification element was conducted and a high void element was evaluated at R1.07 conditions for 10 minute cycles employing a low helium atmosphere pressure.

(C-RD) Tests of elements from the LASL exchange program, Phase II-Ga, Y-12 high expansion matrix development, and "Q" coat development are planned for next period. Chuck and furnace development tests will also be conducted.

TFL-5.b Interstitial Corrosion Tests

(U) The third fixture chosen for test contained a 0.002 inch wide x 0.250 inch deep x 2 inch long flow slot opposite a 0.0055 inch thick "Grafoil" wrapper bent at a 120° angle, Figure 3. This fixture was chosen because the side fit between the specimen halves was not considered good. This specimen would provide some

TFL-5.b Interstitial Corrosion Test (Continued)

data and experience if successfully tested and would not have been considered a serious loss if the test was aborted. It also aided in the development of testing techniques.

The parameters set on this specimen, Ser. No. 3-4 are listed as follows:

Test Time (min)	15
Inlet Pressure (psig)	585 Average
Flow Rate (lb/sec)	5.04×10^{-5} Average
Temperature (^{o}R)	3322
Initial Coupon Wt. (gms)	0.171
Final Coupon Wt. (gms)	0.147

The requested flow of 1200 std. cc/min H_2 could not be regulated until delivery of additional valve trims so the standard flow of 14,000 std. cc/min H_2 was established. During initial power ramp to operating temperature a sharp increase in specimen pressure differential was noticed. This increase continued after the 0 to 20 paid specimen pressure differential indicator went off scale. This excessive specimen pressure differential created an unstable condition in the control system which resulted in variations of flow rate and inlet pressure. Maximum flow variation was from 2.38×10^{-5} lb/sec to 7.36×10^{-5} lb/sec maximum pressure variation was from 570 to 600 psig.

Figure 4 shows the specimen and coupon after test. The coupon had corrosion on all edges and along the 120^{o} bend, with a through hole about 0.1 inches from the existing inlet edge. Thickness measurements showed that the coupon increased in thickness by the anticipated 10%.

The flow slot portion of the specimen was sectioned axially to determine coating effectiveness in the flow slot. Examination of the flow slot surfaces shows that the coating extended 0.150 inches into the 0.250 inch deep slot. The last 0.150 inches of the 2 inch long slot shows coating to the full depth, evidence exists that the same condition was true on the inlet end.

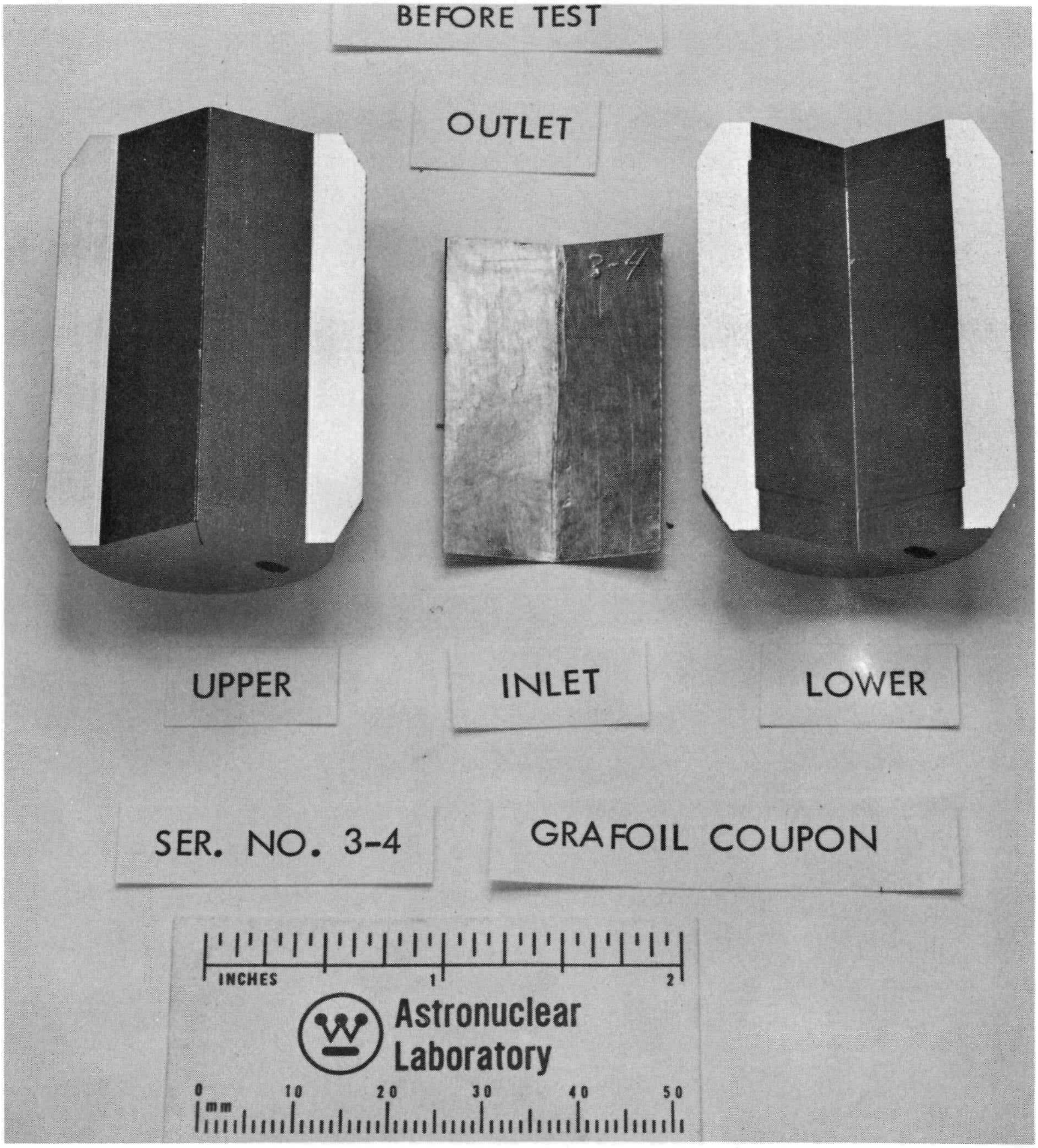

FIGURE 3

INTERSTITIAL CORROSION TEST, PRE-TEST

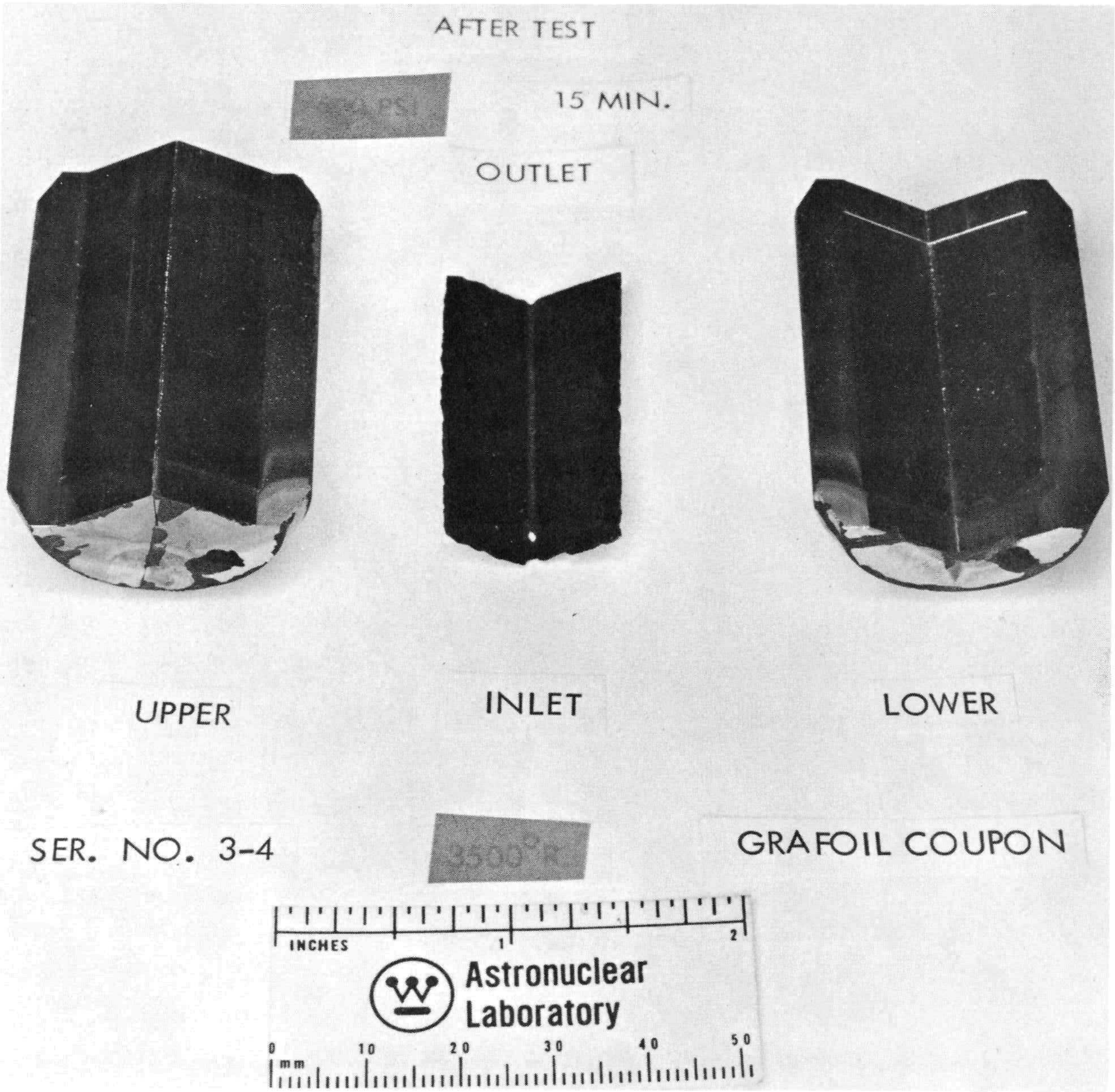

FIGURE 4

INTERSTITIAL CORROSION TEST, POST TEST

TFL-5.b Interstitial Corrosion Test (Continued)

An area of corrosion extends from the coating boundaries to the bottom of the flow slot and varies from 0.008 inch minimum to 0.020 inch maximum in depth. Judging from the outline of this area, it is assumed that the surface had no coating protection at all. Another area under investigation is the possibility that thermal stress pinched the flow gap shut next to the "Grafoil" directing the hydrogen toward the bottom of the slot. The next configuration to be tested will simulate the same thickness "Grafoil" wrapper opposite a 0.005 inch wide filler strip slot.

FACILITIES

WANL Liquid Hydrogen Facility

(U) Installation of the facility and the deluge system was completed. The deluge system was checked out on June 27, 1968, Figures 5 and 6. On July 3, 1968, the dewar was cold shocked with an equivalent weight of liquid nitrogen and passed successfully.

(U) Preparation of procedures for WANL and SNPO safety review is in progress.

WANHES Liquid Hydrogen Facility

(U) The cryogenic piping is out for rebid. The site construction package is being prepared for rebidding without the water supply.

Water Injection System for Single Element Furnace

(C-RD) Three checkout tests were conducted with the water injection system for the Single Element Furnace. Power levels of 750 KW were attained at hydrogen flow rates of 600 scfm and a furnace exit pressure of 435 psig. Reasonably stable water flows were attained at constant power levels. Some instability was encountered on the power up ramps. Graphite part breakage occurred on a number of the tests.

(U) Plans for next period include conducting additional tests after making required modifications to the system.

FS-1 Installation

(U) The FS-1 Core Periphery Facility is about 84% complete. Construction work on the test facility continued on a limited effort-level as technician manpower was reassigned to the PEWEE cluster test program. The FS-1 furnace assembly was completed including the installation of the cold flow checkout model (orificed pressure chamber) and the assembly was moved to the test cell.

CL-1 Facility Checkout

(U) A CL-1 cluster facility checkout run, TFL-1.a.0024a, conducted at full power for 4 minutes on June 6 indicated the flow system was acceptable without further work to resume general cluster testing.

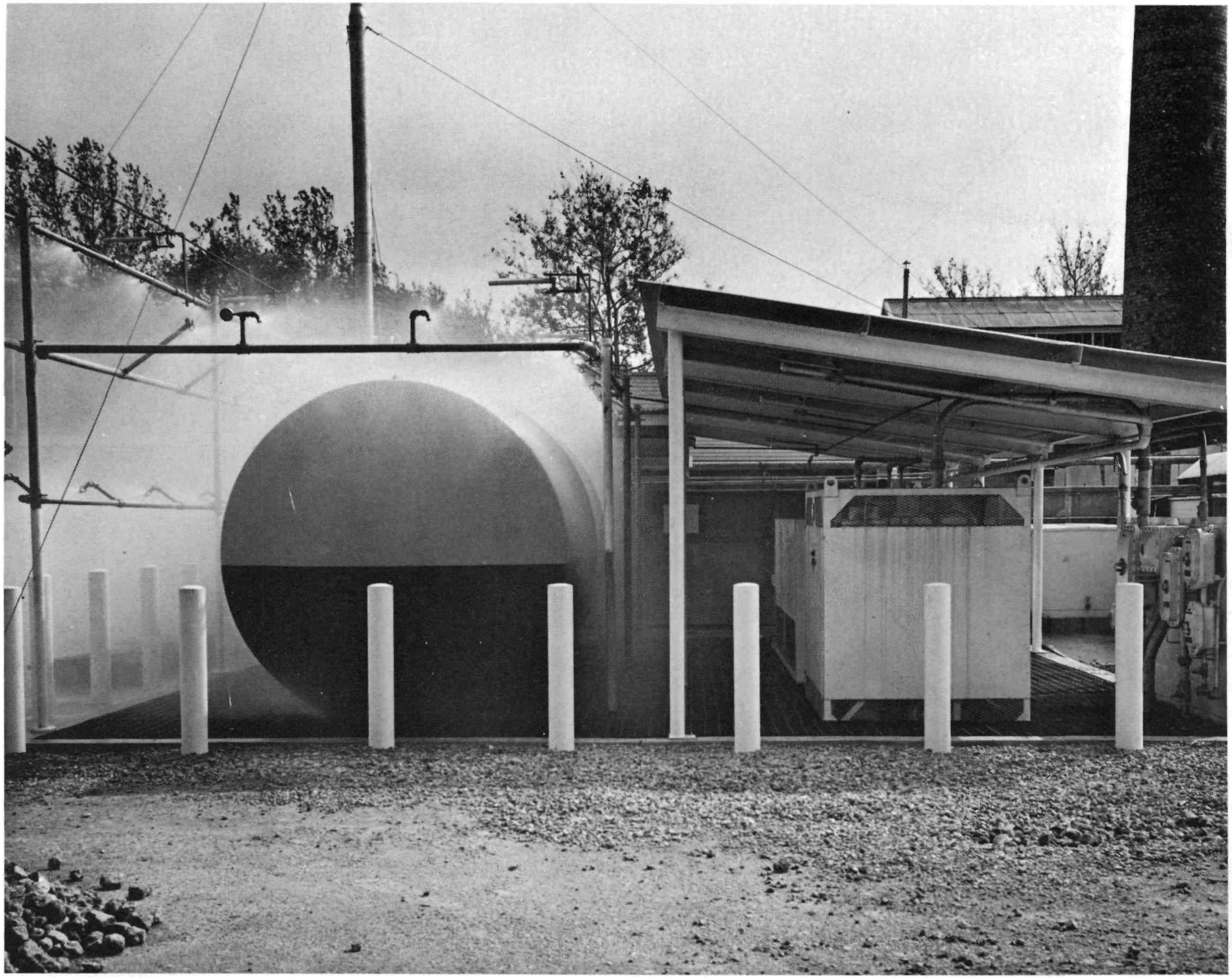

FIGURE 5

WANL LIQUID HYDROGEN FACILITY

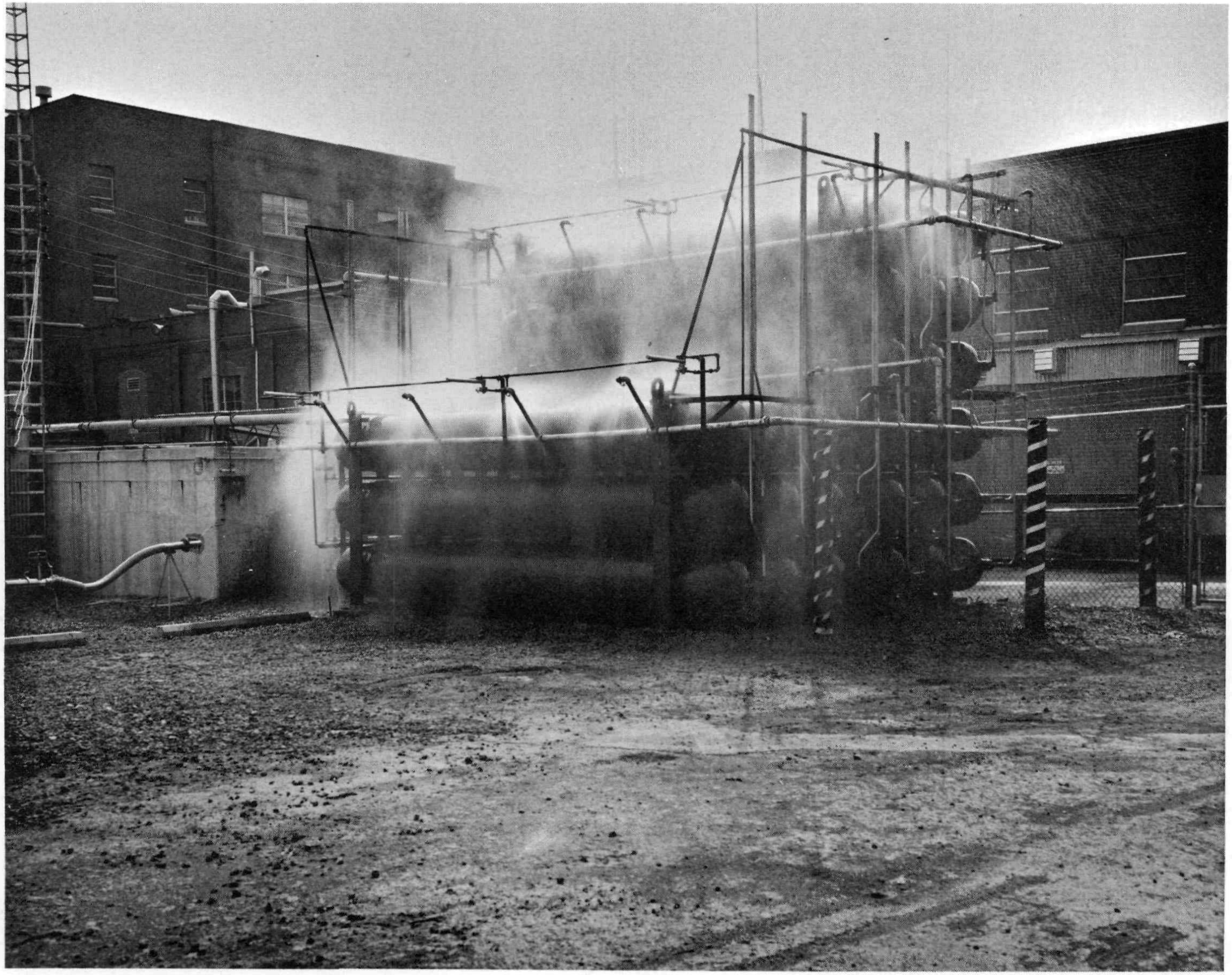

FIGURE 6

WANL LIQUID HYDROGEN FACILITY

SECTION B

MONTHLY REVIEW OF ENGINEERING MECHANICS TESTS

TABLE I

ENGINEERING MECHANICS LABORATORY

PERFORMED THIS PERIOD (June 4, 1968 - July 18, 1968)		PLANNED NEXT PERIOD (July 18, 1968 - August 27, 1968)	
TESTS IN SUPPORT OF R-1			
REFLECTOR SYSTEM TESTS		**REFLECTOR SYSTEM TESTS**	
A.2	Beryllium Properties Test		
A.4	3 Drum Ganged Drive System Test	A.4	Continue
		A.4	Band Fatigue Tests
		A.4	Band Tension
FUEL ELEMENTS		**FUEL ELEMENTS**	
B.1	PEWEE I Fuel Elements		
B.1	LASL GEM Plus GED Process Fuel Elements		
B.1	Fuel Element Transition Tip Flexural Testing		
AXIAL SUPPORT		**AXIAL SUPPORT**	
C.3	Interface Friction Tests	C.3	Continue
C.1	Thermal Cycle Testing		
C.1	Component Creep Testing		
		C.2	Thermal Shock Development Test
CORE PERIPHERY TESTING		**CORE PERIPHERY TESTING**	
		E.1	Wrapper Expansion Test
		E.1	Axial Impedance Test
		E.4	Pyrofoil Thermal Shock
CORE ASSEMBLY TESTING		**CORE ASSEMBLY TESTING**	
D.2	Wear Tests of Carbitex Seal Segments		
G.2	Partial Length Core Dynamic Test (Flat Seals)	G.2	Continue

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PERFORMED THIS PERIOD (June 4, 1968 - July 18, 1968)	PLANNED NEXT PERIOD (July 18, 1968 - August 27, 1968)

TESTS IN SUPPORT OF R-1

ANTICRITICALITY POISON SYSTEM TEST		**ANTICRITICALITY POISON SYSTEM TEST**	
J.1	Poison Wire Withdrawal Test		
J.1	Poison Wire Ocean Water Corrosion Test	J.1	Continue
J.1	Poison Wire Retainer Pull Test		
SUPPORT STEM TESTS		**SUPPORT STEM TESTS**	
L.1	Stem Assembly Tensile and Thread Strength Test	L.1	Continue

TESTS IN SUPPORT OF NRX & XE

XE Calorimeter Support Vibration Test
Scram Tests of Control Drum Assembly for XE-1
Control Drum Shaft Torsion Tests
A-6 Beryllium Ring Thermal Response Test
Calibration of LASL Tie Rods for FFL Tests

(This Page is Unclassified)

REFLECTOR SYSTEM TESTS

EML-A.2 Beryllium Properties Test

Eight DCB (double cantilever beam) specimens were tested at 140°R temperature. Four specimens were from S-200 block pressed material and four were from A-6 ring pressed material, pressing number 4055.

Load to start the initial crack and the number of crack arrests prior to complete fracture is tabulated below.

Specimen Number		Load to Initiate First Crack	No. of Crack Arrests
S-200 No.	1	187.5	8
	2	187.5	5
	3	205	6
	4	220	9
A6 4055 No.	1	170	7
	2	138	9
	3	150	11
	4	160	7

From previous tests of two DCB specimens from A6 ring pressed material, pressing number 4055, the load to initiate the first crack was 202 and 175 pounds and the number of crack arrests in each case was 3.

EML-A.4 3 Drum Ganged Drive System Test

Two test series were conducted on the 3 drum ganged drive fixture. The first series was run without drive bands installed. Each drum was successively locked in 45°, 90°, 135° and 180° positions and released and drum dampening and angular overshoot were recorded. Tests were run with and without a simulated pressure drop load of 600 lb.

The stainless steel bands were installed for the second series and each drum was again successively locked in 45°, 90°, 135° and 180° positions and released. Tests again were run with and without a simulated pressure drop load of 600 lb and band strain was recorded in addition to drum dampening and angular overshoot.

Data tape playback and data reduction is currently in work.

FUEL ELEMENT TESTS

EML-B.1

PEWEE I Fuel Elements

A series of room temperature flexure tests was performed on PEWEE I fuel elements to provide experimental verification of the fuel element strength. The apparatus used, as shown in Figure 1, consists of two supports which are six inches apart, and the loading points which are two inches from both supports. The fixture was mounted in Wiedemann UTM for loading, and the deflection of the mid-span of the specimen was measured by SRD-1 strain gage extensometer.

The specimens for these tests were remnants of the specimens which had previously been tested in direct tension at room temperature. Additional specimens were taken from previously untested elements to provide a comparison. The results of these tests are summarized in Table II.

LASL GEM Plus GED Process Fuel Elements

Several samples of LASL Fuel Elements, coated in the GEM plus GED process were tested at room temperature in the short bundling test

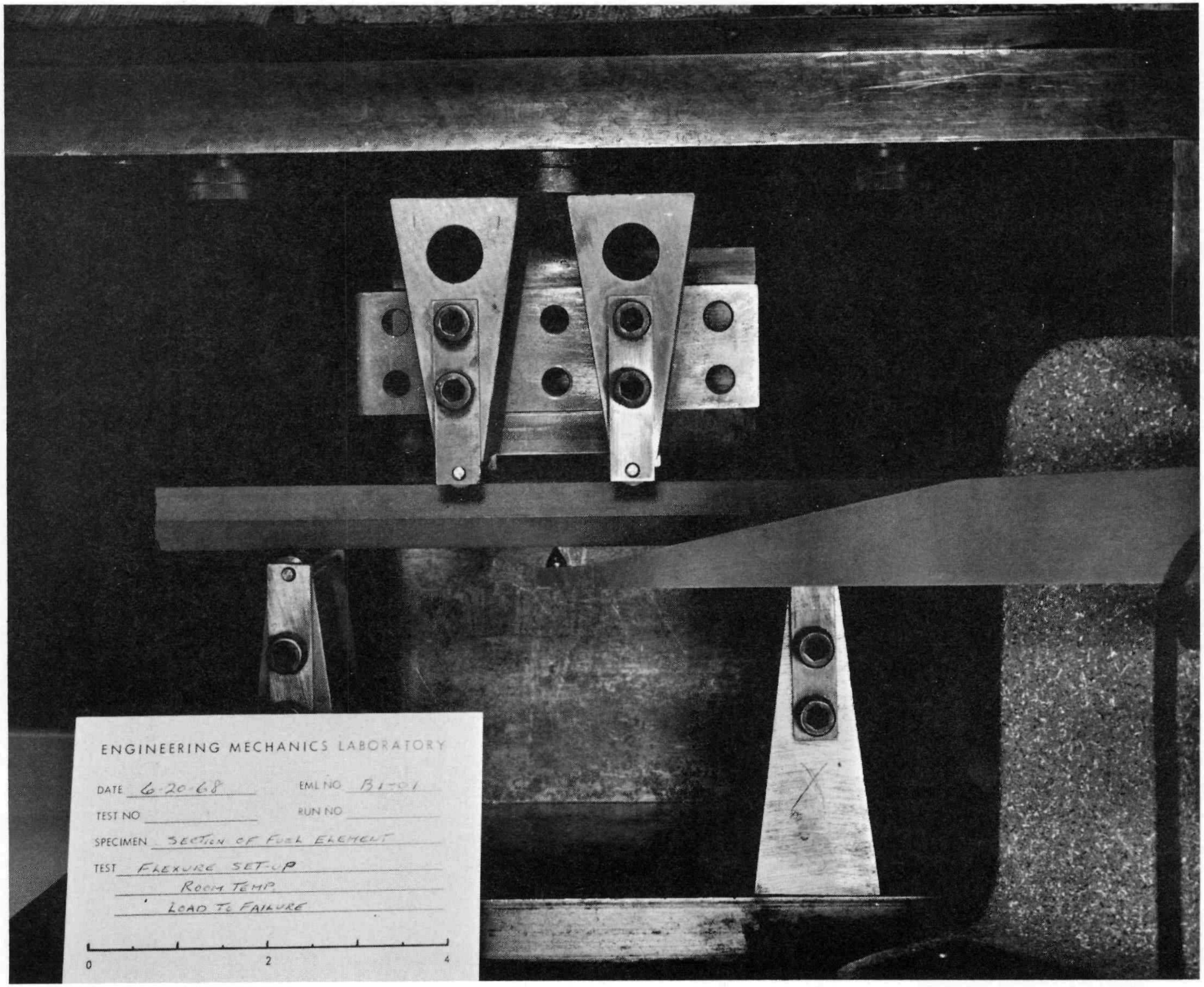


FIGURE 1
FUEL ELEMENT FLEXURE TEST FIXTURE
EML-B.1

TABLE II

FLEXURAL TEST RESULTS - PEWEE I FUEL ELEMENTS

Serial No.	Type (5)	Location	Ultimate Flexure Stress (psi) (1)	Modulus of Elasticity (10^6 psi) (2)	Tensile Stress (psi) (3)
525-57255	G05	13-23	3730	3.71	1680
525-57318	G05	13-23	3650	3.71	1860
525-57319	G05	13-23	3330	3.56	(4)
525-57085	G21	13-23	3090	3.31	1840
525-57122	G21	33-43	3060	3.11	1760
525-57123	G21	13-23	3390	3.62	1890
525-57039	G06	13-23	3620	3.68	2060
525-57159	G06	33-43	4360	3.85	2030
525-57170	G06	13-23	3620	3.87	1990
525-57177	G06	13-23	3620	3.87	(4)
477-58665	G24	13-23	3470	4.71	2590
477-58665	G24	33-43	3260	4.74	2400
477-58667	G24	13-23	3860	4.13	2460
477-58673	G24	13-23	3890	4.16	(4)
525-57287	G25	13-23	3620	3.51	2360
525-57297	G25	13-23	3470	3.53	(4)
477-58642	G04	13-23	3710	4.15	2400
477-58643	G04	13-23	3770	3.83	(4)

NOTE:

1. Based on Flexure Formula Stress: $f_b = \frac{Mc}{I}$
2. Calculated from Deflection Equation: $y = \frac{Pa}{24 E I} (3L^2 - 4a^2)$
3. Based on Direct Tensile Tests (Per Comparison)
4. Specimens not previously tested.
5.

Type	Matrix	Coating	Manufacturer
G04	NbC Additive	GED	WNCO
G05	Standard	GED	WNCO
G06	Nb Resinate	GED	WNCO
G21	Nb Resinate	GEM	WEFF
G24	NbC Additive	GEM	WEFF
G25	Standard	GEM	WEFF

(U) fixture to determine the strain at failure. Four of the specimens were taken from Stations 8 to 18 of four different elements; the remaining four were taken from different stations from the same element. The results of these tests, which are summarized in Table III show that there is no significant difference in the strain at failure for any region along the length of the element. Further, there was no significant difference between the results obtained from previous testing of PEWEE I GEM coated elements and the results of these tests.

EML-B.1 Fuel Element Transition Tip Flexural Testing

(CRD) It had been analytically determined the the transition tips of fuel elements could be flexurally loaded during cooldown and deflected as much as three to four mils if a standoff design were not utilized. The room temperature tip flexure tests were designed to determine whether the tips could withstand such a deflection and the magnitude of the loads necessary to produce that deflection.

(CRD) The test fixture, shown in Figure 2, positioned the test specimen so that the cantilevered length was 0.75 inch. This placed the brazed joint between the fuel element and the unfueled graphite portion of the transition tip inside the clamping portion of the fixture. The fixture was mounted in the Wiedemann UTM for loading, and the tip deflection was measured by a dial gage indicator. All specimens failed at the fuel element/transition tip braze joint and the data is shown in Table IV. The failure was not catastrophic, but there was a marked fall off of load and increase of tip deflection. The specimens are currently undergoing metallographic examination to determine the depth of the separation.

TABLE III

SUMMARY OF TEST RESULTS

LASL GEM PLUS GED COATED FUEL ELEMENTS

Element S/N	Specimen Station	Failure Station	Failure Strain (Micro in/inch)
43748	8-18	13	2160
43652	8-18	12 3/4	2000
43894	8-18	14 1/4	2220
43849	8-18	14 1/4	2120
43984	8 1/2 - 18 1/2	15 1/8	2300
43984	19-29	24 3/8	2180
43984	29 1/2 - 39 1/2	35 1/8	2220
43984	40-50	44	2300

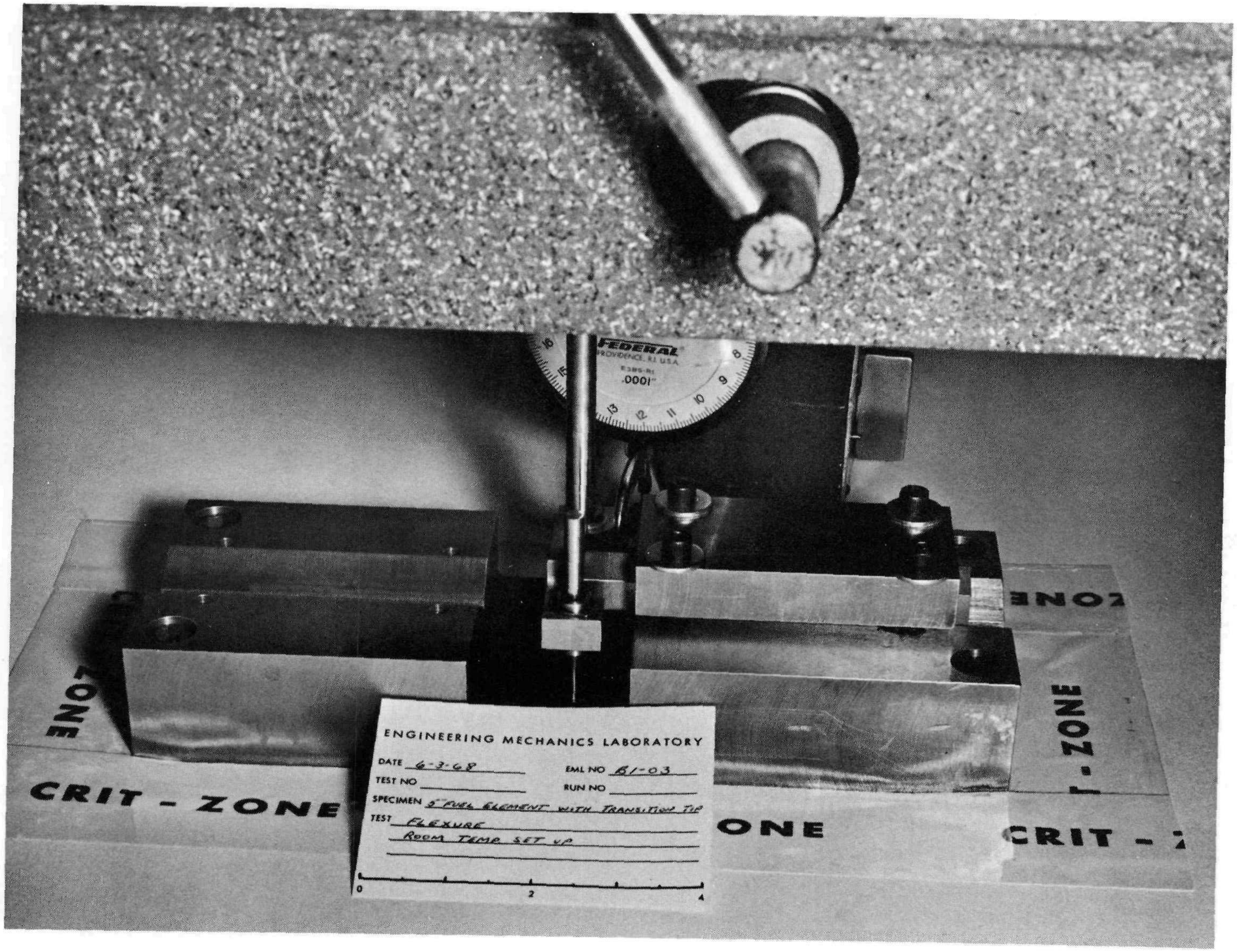


FIGURE 2
TIP DEFLECTION FLEXURE TEST FIXTURE
EML-B.1

CONFIDENTIAL
RESTRICTED DATA
Atomic Energy Act - 1954

TABLE 4
TRANSITION TIP FLEXURE TESTS
SUMMARY OF TEST RESULTS

Element S/N	(1) Type	Failure Load (lb)	Failure Deflection (in)
525-57135	GO5	165	.0032
525-57039	G06	210	.0039
525-57085	G21	143	.0026
477-58665	G24	150	.0028
525-57287	G25	113	.0016
477-58642	G04	155	.0018

NOTE:

1.

Type	Matrix	Coating	Manufacturer
G04	NbC Additive	GED	WNCO
G05	Standard	GED	WNCO
G06	Nb Resinate	GED	WNCO
G21	Nb Resinate	GEM	WEFF
G24	NbC Additive	GEM	WEFF
G25	Standard	GEM	WEFF

AXIAL SUPPORT SYSTEM TESTS

EML-C.3 Interface Friction Tests

(U) A preliminary investigation is being made to establish the relationship between surface condition and friction values for composite friction test specimens made from PEWEE reactor grade material. Traces of the surface conditions of specimens that were used for friction tests at 4400°R temperature and contact pressure of 300 psi were made by a profilometer which gave a measure of surface waviness and surface roughness.

(U) Comparison of the surface conditions of the test specimens revealed that a specimen that had the coating scuffed during test had approximately the same waviness (400 microinches peak to peak) as the unscuffed specimen. However the combination of roughness and waviness of the scuffed specimen surface was approximately 800 microinches peak to peak while the unscuffed specimen surface was approximately 600 microinches peak to peak.

(U) Surface finish traces will be made on the remaining specimens prior to running friction tests in an attempt to correlate surface condition with friction.

EML-C.1 Thermal Cycle Testing

(CRD) A thermal cycle test consisting of five separate cycles simulating startup, cooldown and full power operation was performed on a short cluster of PEWEE I hardware. The load was supported by two fuel elements six mils longer than the other elements and 180° apart. Examination of the cluster after the first two test cycles revealed that the six mil length extension was eliminated by creep and the load for the final 3 cycles was carried equally by all seven elements in the cluster. The total length change of the elements due to creep varied from 5 to 11 mils at the end of the fifth test cycle.

(CRD)

No loss of structural load carrying ability was noted and no welding was observed. Axial cracks were seen in the tips of four of the six elements tested. Generally, the root tip of the cracks occurred in the braze joint. The number of cracks increased as the test continued, and existing cracks enlarged slightly with each additional test cycle. In a followup test currently in progress, three non-load bearing elements have shown cracking similar to that observed for the load carrying elements. These results imply that loading of the elements does not affect crack initiation, but may influence the rate of propagation of cracks once they are formed.

(CRD)

The fuel elements used for these tests were prevously rejected by Quality Control for dimensional or physical appearance, but were certified reactor grade in every other respect. Since some tips crack while others in the same test do not, difference in material properties or processing is suspected. An investigation is underway to verify the history of material and manufacturing processing to which these element tips were subjected. Also, since cracks have not been observed as a result of Materials or Thermal Fluid Flow testing, the test process itself is being examined to see if there are significant parameters which could affect the carbide material.

(U)

EML-C.1 Component Creep Testing

(U) During the past month, a thermal cycle test and a high temperature creep test were conducted on PEWEE I hot end support components as a sequel to the Development Tests conducted in February and March, 1968.

(CRD) The high temperature creep test utilized a center element 60 mils longer than the fueled elements which caused the center element to carry the total axial load during the one hour test duration. The surrounding fuel elements were bundled with a 500 lb load applied to each element of the cluster. Dimensional measurements were made on the central element before and after testing, and gas flow leakage was measured in the welded joint regions between the center element and pedestal and between the pedestal and tapered washer. This welding occurs during the test period.

(CRD) Center element creep measured on each of the faces was observed to range from 2.8 to 4.9 mils over the six inch length and the distribution of the creep was rather even over the six inch length. The change in profile of the center element following testing was quite similar to profiles obtained on previous tests in that some tip spreading and slight bowing of the tips occurred. Across flats dimensions and inside diameter changes ranged from 0 to 0.3 mil. Leakage measurement through the welded joint was approximately 1.2 cc per minute at 10 psig and 2.2 cc per minute at 15 psig, at room temperature. These quantities are insignificant, and it is believed that further reduction in leakage would occur at high temperatures.

CORE ASSEMBLY TESTING

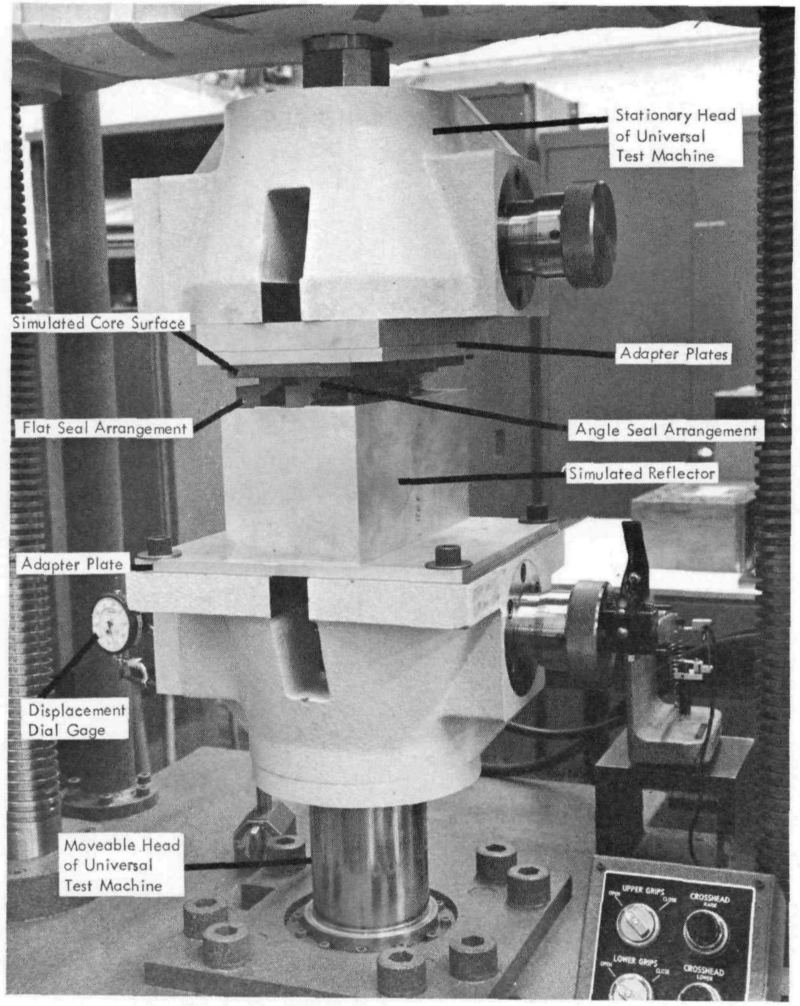
EML-D.2 Wear Tests of Carbitex Seal Segments

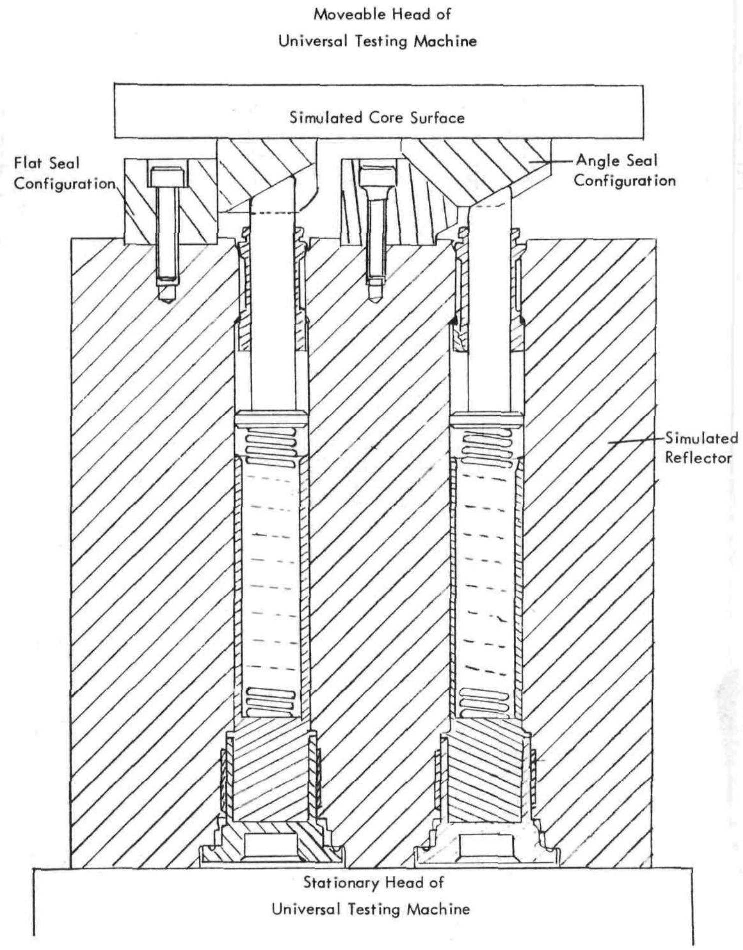
A test was performed to determine the wear characteristics of seal segments machined from Carbitex 700 material. Flat and angle seal configurations were mocked up in straight sections and tested in the setup shown in Figure 3. The simulated inner seal segment was moved 0.3 inch relative to the outer seal 102 times. Normal burnishing occurred at the seal interfaces and where the plunger pin contacts the inner seal and no delamination, excessive wear, breakage or other abnormalities were found as a result of the test.

EML-G.2 Partial Length Core Dynamic Test (Flat Seals)

The undamped natural frequency of the flat seal type design is calculated to be 10.3 cps. Data at resonance at input g levels above the design requirement is needed to evaluate the flat seal design for the lateral support system. Of particular interest is data on the dynamic integrity and response characteristics at large relative displacements and at inpact. A 1 inch relative motion limitation of the thruster system limits the input g level that can be applied at low frequencies near 10 cps.

Seals at 90° and 270° were removed from each row of the partial core test setup to reduce lateral support friction and thereby reduce the g level required to break friction and cause relative motion. The removal of these seals (shown in Figure 4) reduced friction but did not significantly change the effective spring rate of the lateral support. The breakaway g level was reduced from 2.4 g to 1.6 g by this method and frequencies could be investigated at 8 and 9 cps. Data is presently being evaluated.





TEST SETUP IN
UNIVERSAL TEST MACHINE

SCHEMATIC SKETCH OF
WEAR TEST FIXTURE

FIGURE 3
EML-D.2

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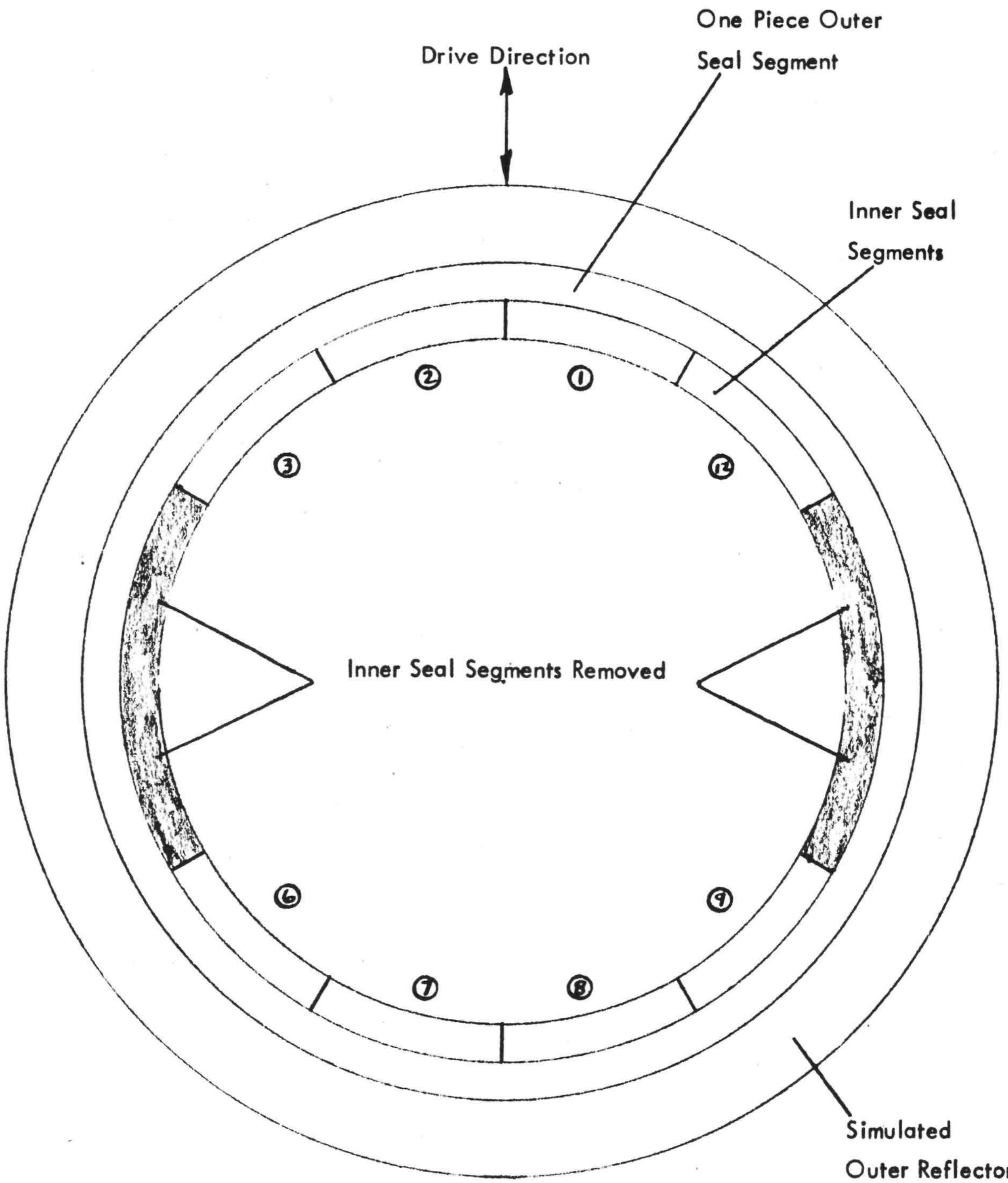

FIGURE 4
SCHEMATIC SKETCH OF CARBITEX INNER AND OUTER SEAL SEGMENT ARRANGMENT FOR VIBRATION TEST IN PARTIAL LENGTH CORE
EML-G.2

ANTICRITICALITY SYSTEM TESTS

EML-J.1 Poison Wire Withdrawal Tests

(CRD) Four tests were conducted at ambient temperature to determine the withdrawal force necessary to remove the candidate R-1 poison wires from coated fuel elements. Figure 5 shows the poison wire exiting from the elements.

(U) Two types of R-1 candidate poison wires tested: Type I consisted of a 16 mil 304 SS wire on which boron carbide beads were strung and then encased with teflon type "TFE-R" shrinkable tubing; Type II consisted of the same central wire and beads but the encasement was a sprayed on coating of 5 mil thick Dupont Type "S" teflon coating. A section of each of these wires is shown in Figure 6. The poison wire types used for each of the tests are shown below.

(U)

Test 1	6 Type I poison wires
Test 2	2 Type I and 4 Type II poison wires
Test 3	4 Type 1 at 30° and 1.8 ips only - repeated 10 times
Test 4	4 Type II at 30° and 1.8 ips only - repeated 10 times

(U) Tests 1 and 2 consisted of withdrawing six poison wires from an R-1 cluster at angles from 0° to 45° in 5° increments. The forces and displacements were recorded for withdrawal speeds of .9, 1.8 and 3.6 inches per second.

(U) Results of Test I are shown in Figure 7a. These maximum withdrawal load values remain approximately constant for withdraw angles between 0° to 35°. For lower angles, the frictional forces developed at the edge of the fuel element hole are increased as the shrinkable tubing is scraped

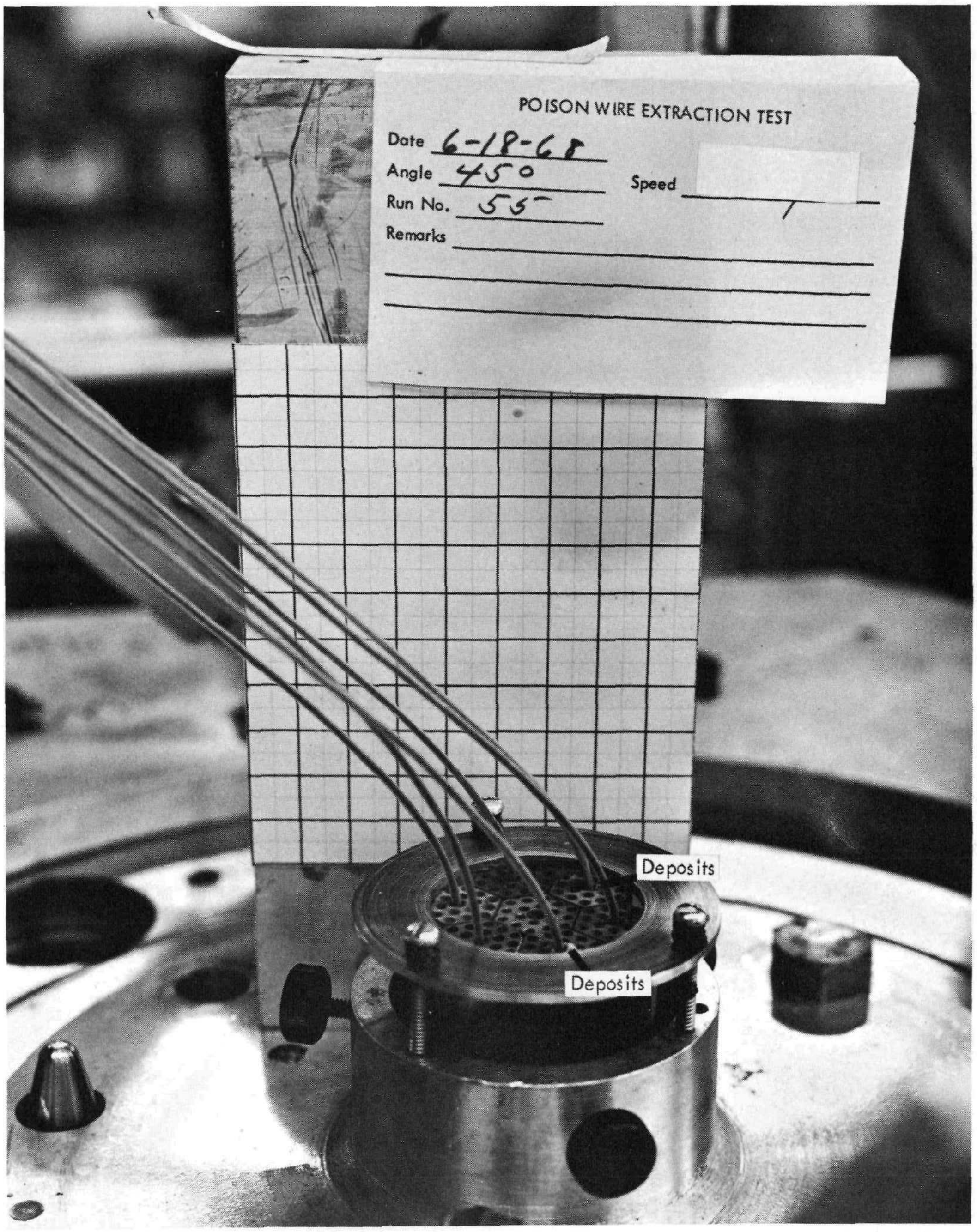

FIGURE 5
TYPE I R-1 POISON WIRE WITHDRAWAL 45° ANGLE
EML-J.1

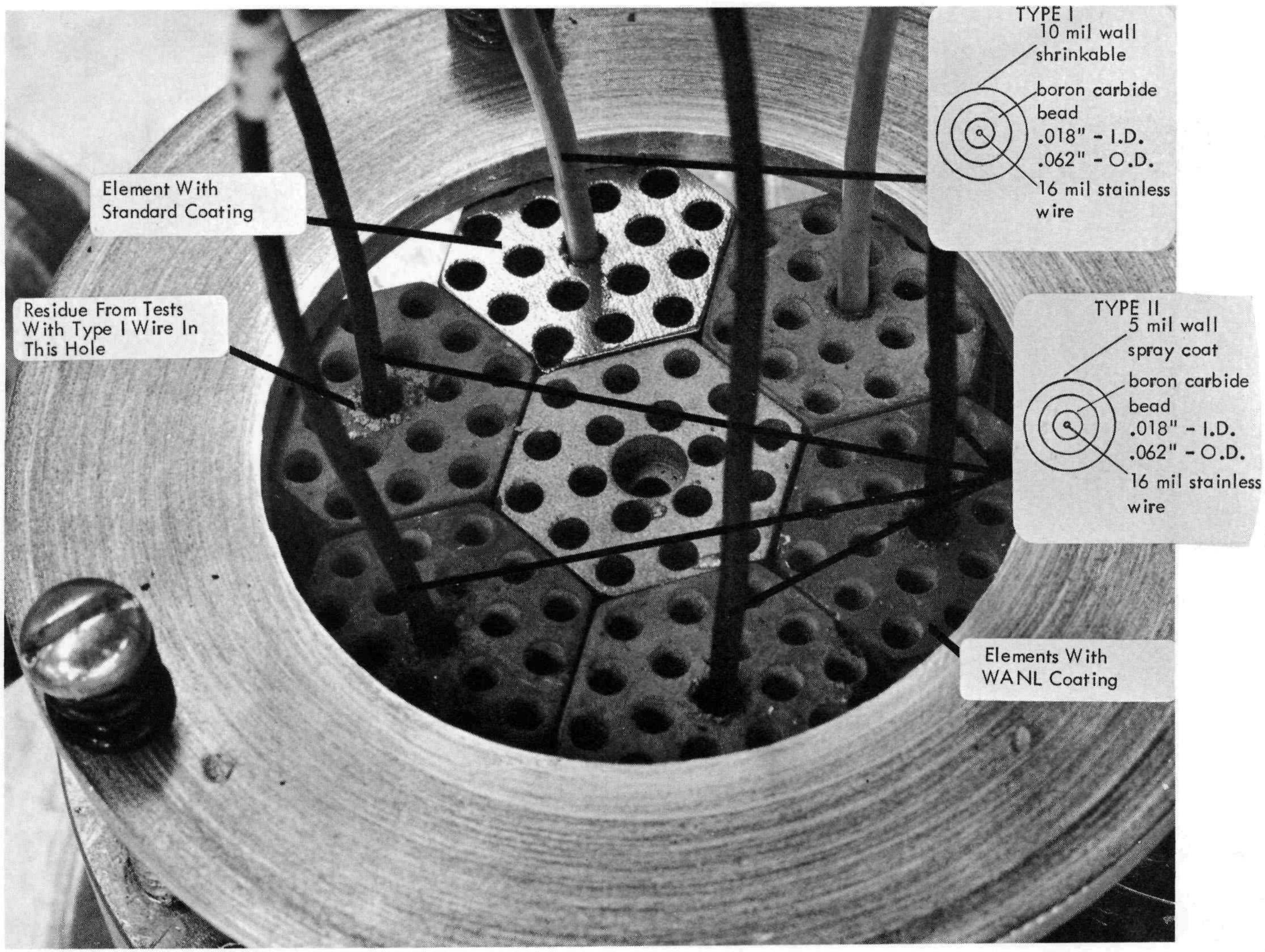

FIGURE 6
VIEW OF EXIT HOLES AFTER
COMPLETING WITHDRAWAL TESTS
EML-J.1

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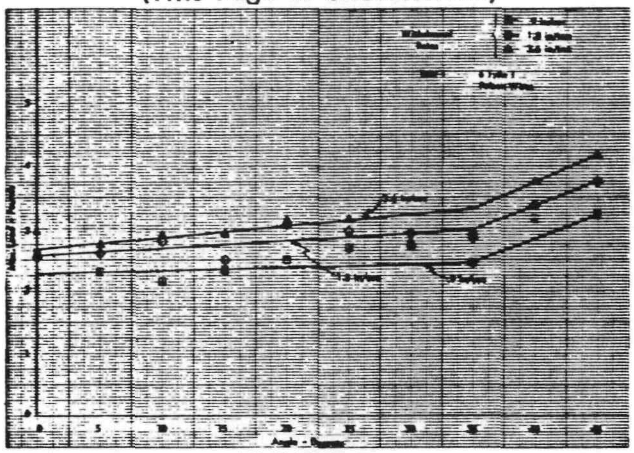

FIGURE 7a

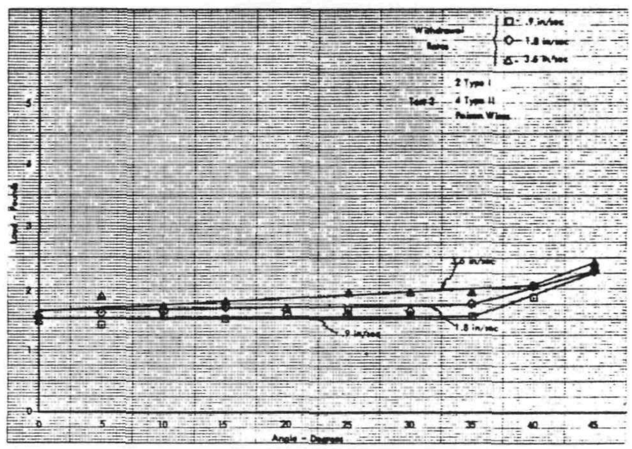

FIGURE 7b

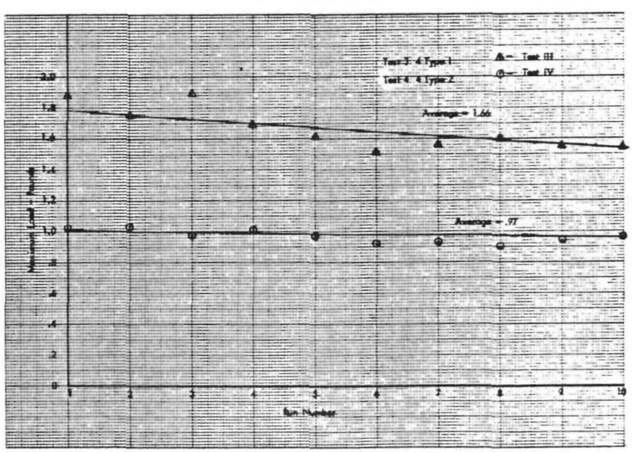

FIGURE 7c
FORCES REQUIRED TO WITHDRAW POISON WIRES
EML-J.1

by the hole edge. As the angle increased, more material was deposited. Figure 6 shows the deposits created.

(U) These deposits of the shrinkable tubing left at the exit will not seriously affect the structural integrity of the poison wire since the 16 mil diameter 304 stainless wire and not the shrinkable tube reacts the load.

(U) Results of Test 2 are shown in Figure 7b. Again the maximum values remain approximately constant for the withdrawal angles from 0° to 35° and increase at greater angles. The forces are less than those recorded in Test I since the wire diameters are .072 for the Type II wires and .082 inches for the Type I wires. The results of tests 3 and 4 are shown in Figure 7c and it can be seen that little change occurs in the withdrawal force under repeated cycle conditions.

EML-J.1 Poison Wire Ocean Water Corrosion Test

(U) A development test program has been initiated to determine whether the corrosive effect of ocean water can be detrimental to the performance of poison wires.

(U) Two poison wires each consisting of a 304A stainless steel central wire, boron beads and a shrinkable teflon sheath have been immersed for 32 days in a substitute of ocean water mixture. The test was performed at room temperature with slight agitations being periodically applied to the water mixture. The substitute ocean water mixture was prepared in accordance with ASTM Specification D1141-52, Section 4. This water mixture consists, therefore, of concentrations of organic salts, as listed in Table 5, but none of the heavy metals. The regent water used in the preparation of the mixture was determined to have a total matter content and electrical conductivity meeting the requirements of ASTM Specification D1193-66.

(U) The corrosive effect of the substitute ocean water will be evaluated from weights, diameter measurements, photographs and tension tests performed on the poison wires before and after the immersion period. Samples of the water mixture taken at 10, 15 and 20 days were checked for electrical conductivity and solid matter content. The sample drawn after 20 days showed no change in electrical conductivity from that of the original mixture. The solid matter content increased from 35,196 ppm to 36,028 ppm.

TABLE 5

CHEMICAL COMPOSITION OF
SUBSTITUTE OCEAN WATER*

(U)

Compound	Concentration grams/liter
NaCl	24.53
$MgCl_2$	5.20
Na_2SO_4	4.09
$CaCl_2$	1.16
KCl	00.695
$NaHCO_3$	0.201
KBr	0.101
H_3BO_3	0.027
$SrCl_2$	0.025
NaF	0.003
$Ba(NO_3)_2$	0.0000994
$Mn(NO)_2$	0.0000340
$Cu(NO_3)_2$	0.0000308
$Zn(NO_3)_2$	0.0000096
$Pb(NO_3)_2$	0.0000066
$AgNO_3$	0.00000049

* From ASTM Specification D1141-52

EML-J.1 Poison Wire Retainer Pull Test

(U) Two series of tension tests were performed on a poison wire retainer mechanism. A photograph of the test setup is shown in Figures 8a and 8b. In the first arrangement, the forces required to detach the retainer from the cluster hardware were determined. This scheme is one of the primary candidate designs being considered. Forces between 2.10 and 2.15 lb were required to disengage the coupling. A cross section sketch of the design is seen in Figure 8c.

(U) Forces on the plunger, compress the spring, which in turn releases the ball detent, separating the retainer from the end fitting on the stem protective cap.

(U) The second series of tests were performed to determine the forces required to separate the retainer body from the end fitting without operating the detent mechanism in the normal manner. In this case the detaching forces which were required varied from 5.12 to 5.6 lbs.

SUPPORT STEM TESTS

EML-L.1 Stem Assembly Tensile and Thread Strength Test

(U) Cyclic and static tensile load tests were performed on simulated stem ends. Short length specimen of the aft and forward ends with ground threads were subjected to cyclic loading over a range of 0 lbs to 850 lbs for 100 cycles.

(U) Ultimate static tensile tests were performed on four aft end stems and three forward end stems with ground threads. The test specimens included stems both with and without Silastic RTV 891 sealant on the threaded joints.

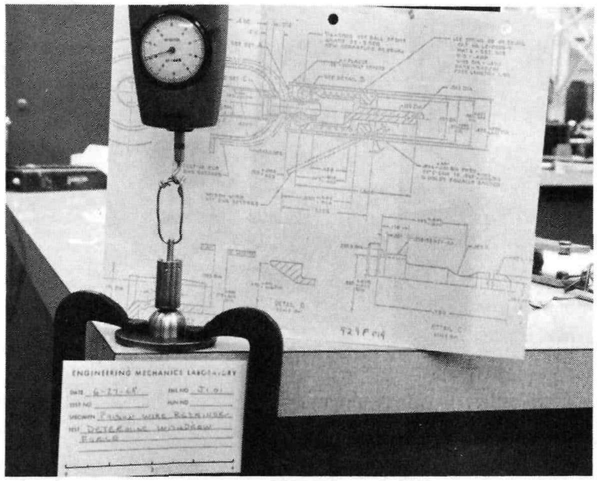

FIGURE 8a
NORMAL OPERATION FOR WITHDRAWING WIRES

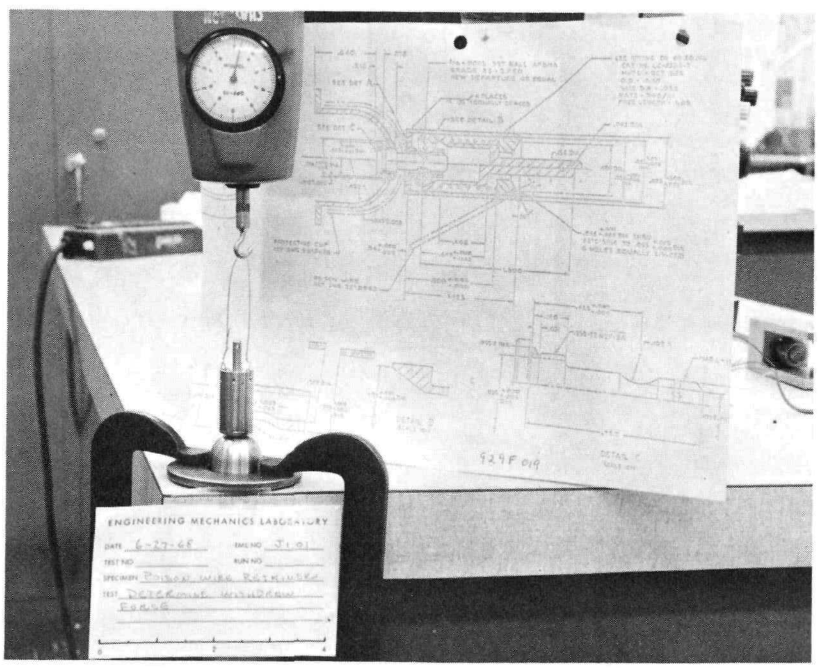

FIGURE 8b
SIMULATING EXTERNAL FORCES ON RETAINER BODY
EML-J.1

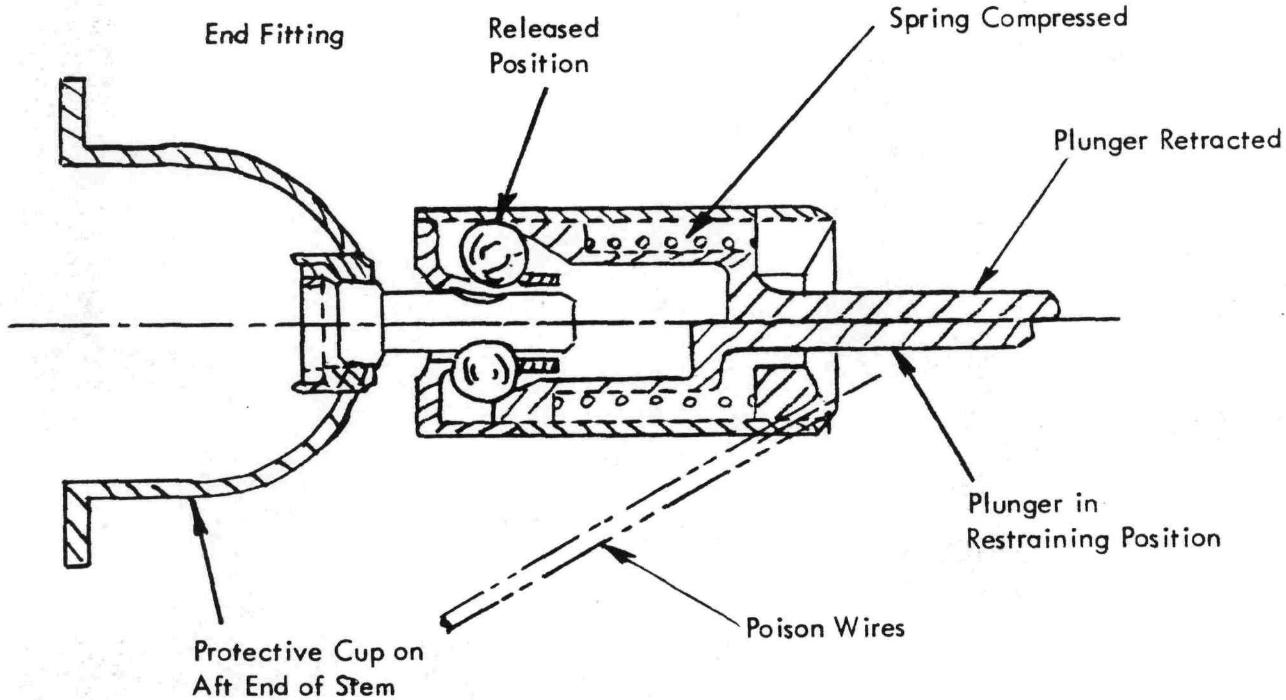

FIGURE 8c
SCHEMATIC OF MECHANISM
EML-J.1

The results of the testing are summarized in the following table.

(U)

Description	Use of Silastic RTV-891	Failure Location	Area at Failure (in^2)	Elongation (in)	Ultimate Load (lbs)	Ultimate Strength (ksi)
Aft End	No	In the neck	2.25×10^{-2}	0.104	3,350	149
	No	In the neck	2.25×10^{-2}	0.1272	3,275	145
	Yes	In the thread	2.55×10^{-2}	0.1224	3,315	130
	Yes	In the neck	2.25×10^{-2}	0.1284	3,290	146
Cycled 50 to 850 lb	No	No failure after 178,186 cycles	--	--	--	37.8
Forward End	No	In the thread	1.72×10^{-2}	0.041	2,535	147
	Yes	In the thread	1.72×10^{-2}	0.038	2,600	151
	Yes	In the thread	1.72×10^{-2}	--	2,550	148
Cycled 25 to 825 lbs	No	Failure in first thread 65,427 cycles	--	--	--	39.3

(U) The same series of tests will be repeated for simulated support stems with rolled threads.

EML-G.4 XE Calorimeter Support Vibration Test

(U) Tests at ambient conditions were performed to determine the ability of the calorimeter support to survive vibration loading. The support bracket with a calorimeter attached was bolted to a base plate and vibrated in three mutually perpendicular axes. The test arrangements for the most critical direction is shown in Figure 9. Six strain gages were used to monitor strains at the critical locations on the calorimeter and support bracket.

(U) Exploratory investigative and resonance dwell tests were conducted for a total elapsed time of 60 minutes. Vibration tests in the least rigid direction was performed last.

(U) The vibration tests were conducted in the following sequence:

Direction X - Test A & Test B
Direction Y - Test A & Test B
Direction Z - Test A & Test B
Direction X - Test C
Direction Y - Test C
Direction Z - Test C

where

Test A - Exploratory Test

(U) 5 cps to 10 cps at .10 in double amplitude
10 cps to 1000 cps at $\pm$ 1 g input

Test B - 7 Minute Investigative Sweep Test

5 cps to 20 cps at .10 in double amplitude
20 cps to 180 cps at $\pm$ 2 g's input
180 cps to 400 cps at .00122 in. double amplitude
400 cps to 1000 cps at $\pm$ 10 g's input

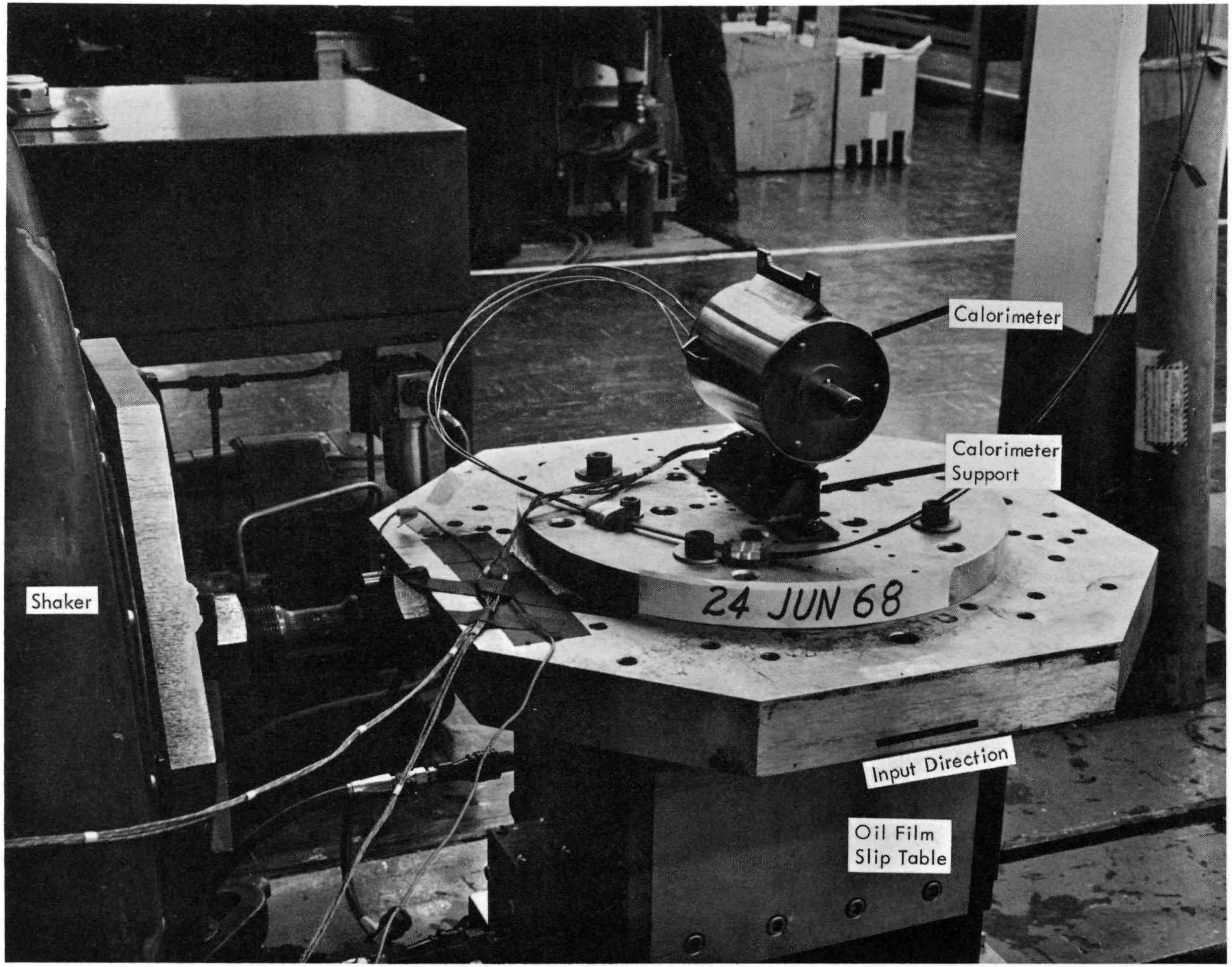

FIGURE 9
TEST SETUP IN MOST CRITICAL DIRECTION
EML-G.4

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Test C - 10 Minute Resonant Dwell Test

Each resonance at the output level

Defined from the 7- minute sweep test

(U) The output signals from the strain gages, control accelerometer and frequency of vibration were recorded on an oscillograph.

The test data summarizing resonant frequencies is shown in Table 6.

TABLE 6

(U)

Direction	Test	Resonant Frequency	Strain (μ in/in)	Gage
X	A	513	200	3
X	B	525	200	3
X	C	509	750	3
Y	A	509	250	4
Y	B	508	500	4
Y	C	488	360	4
Z	A	55	2600	1
Z	B	55	2600	1
Z	C	48	3800	1

(U) The major resonances occurred at 48, 488, and 509 cps. The largest amplification in strain (38) was recorded at 48 cps. The entire 10 minute resonant dwell test was run at this frequency and although cracks developed at two places on the calorimeter flange, the support bracket revealed no damage and the complete assembly remained intact.

Scram Tests of Control Drum Assembly for XE-1

(U) The purpose of this test was to determine the failure mode of the control drum assembly as a result of scrams performed at ambient and cryogenic temperatures. The test arrangement consisted of control drum, hard stop and simulated soft stop.

(U) A cantilever beam was used as a soft stop to reduce the angular velocity of the drum at 15 degrees prior to impact against the hard stop. The spring rate of the cantilever beam was 2650 in-lb per radian, compared to the actual soft stop value of 2580 in-lb per radian. The scram spring torque at 15 degrees was 5.4 ft. lbs.

(U) A transducer attached to the aft end of the control drum was used to record angular displacements as the system was scrammed from various angles. The test setup did not consider the effects of the actuator system during scram, but the results are an indication of the structural adequacy of the hardware.

(U) The series of tests at ambient temperature were performed using a dome end bearing shaft which had been yielded seven degrees during previous scrams into a hard stop. The scram angle was varied from 65° in 5 degree increments. The transducer signal showed an additional 9 degrees yielding before failure at the 180 degree scram. Figure 10 is a photograph of the failed dome end bearing shaft showing the failure mode. The stop arm distortions before and after testing are shown in Figure 11.

(U) Similar scram tests were performed at liquid nitrogen temperature (-320°F). The control drum with an unused dome end bearing shaft was scrammed at each position from the 65 degree to the 180 degrees in 5 degree increments. Twenty-six additional scrams were performed from what was

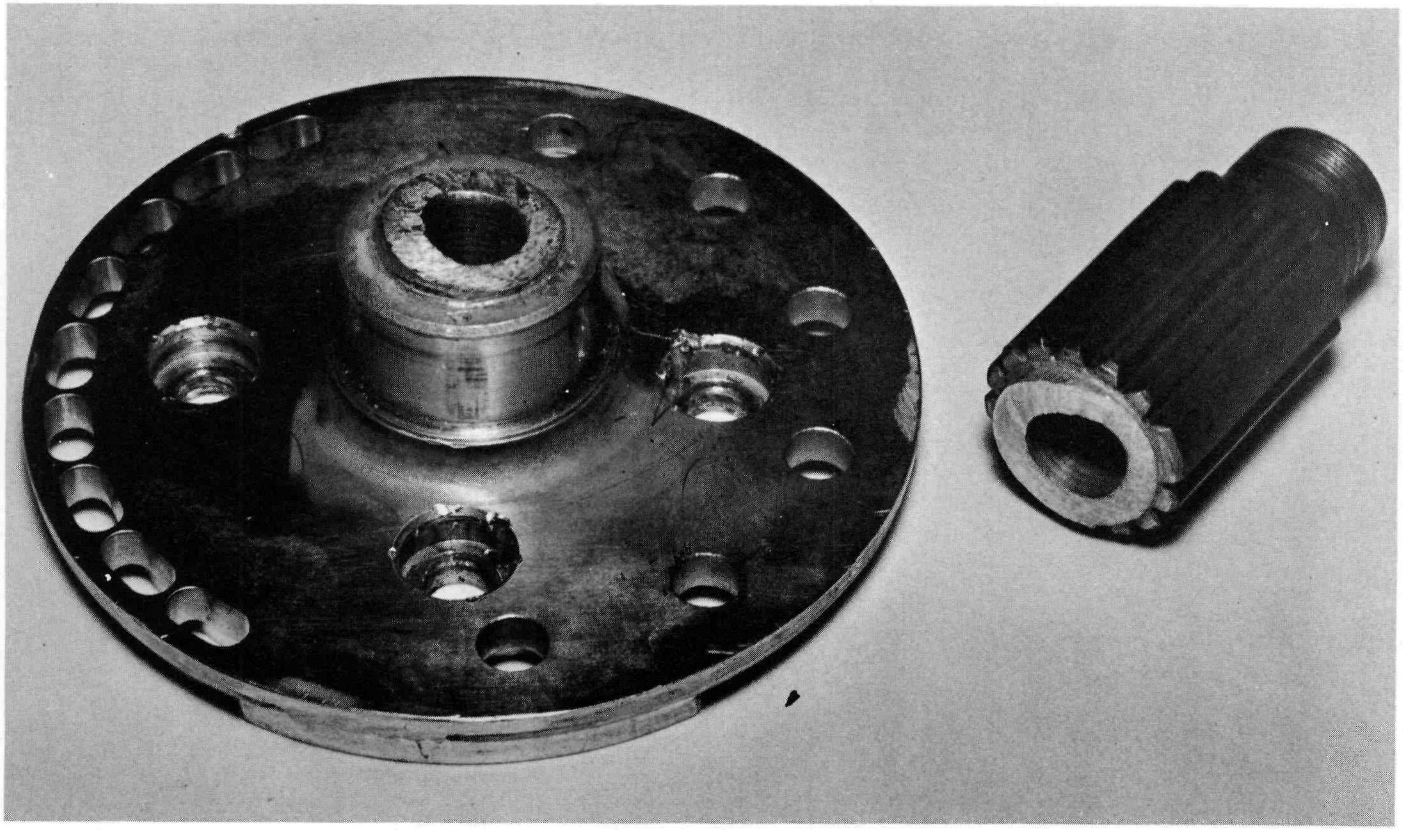
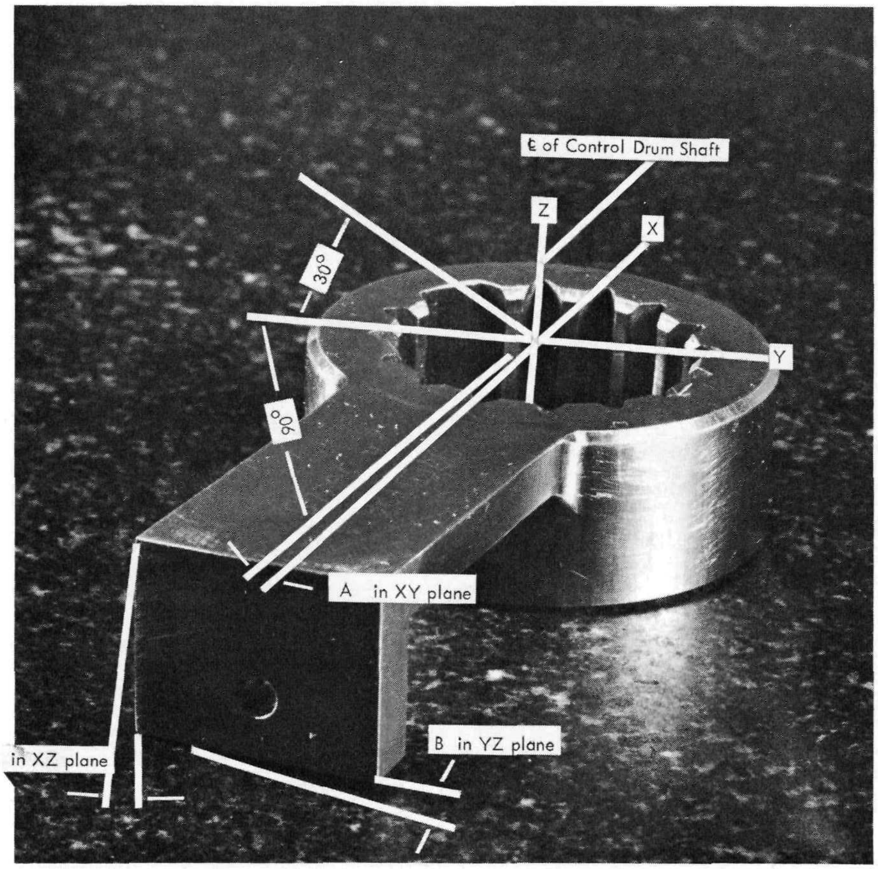


FIGURE 10
FAILURE MODE OF DOME END BEARING SHAFT
(AMBIENT CONDITIONS)



Dimension (See Figure for Location	Normal	PART NUMBER 976D126A			
		Test at Ambient Temp.		Test at -320°F	
		Before Test	After Test	1st Series	2nd Series
A Between Center Hole on Arm	120°	120.866°	120.966°	122.250°	122.0°
B Parallelism or Twist	0°	1.45°	1.68°	2.44°	2.67°
C Perpendicularity Arm to Teeth	0°	.690°	.690°	.92°	1.05°

FIGURE
DISTORTIONS OF STOP ARMS

FIGURE 11
DISTORTIONS OF STOP ARMS

thought to be the 180 degree position. Disassembly of the test assembly revealed a slippage of the transducer shaft which resulted in erroneous angular measurement. Actual positions were as high as 246°. An inspection of the stop arm showed a yielding of 2 degrees 15 minutes, a twist of 2.44 degrees and bend .92 degrees. See Figure 11.

After inspection, the control drum assembly was reassembled in the fixture, the temperature was lowered to -320°F and the test was repeated. After scramming, from 65 to 180 degrees in 5 degree increments, twenty additional scrams were performed from the 180 degree position. The recorded shaft yielding at the end of this series was one additional degree without breaking. An inspection showed a decrease in angular yielding of the stop arm by 15 minutes; but twist and bending increased to 2.67 and 1.05 degrees respectively, as shown in Figure 11.

Concluded from the tests are:

Ambient Temperature Test

1) The previously yielded dome end bearing shaft continued to yield after the 165 degree scram.

2) Failure occurred after the shaft had twisted nine degrees at a scram from 180 degrees.

Cryogenic Temperature Test (-320°F)

1) An unused dome end bearing shaft was subjected to 98 scrams. Forty-eight of tests were from positions of 180° and higher. An inspection after testing showed the total twist of the shaft was 7° twenty-five minutes. Therefore, the shaft can absorb energy at cryogenic temperatures without fracture.

Control Drum Shaft Torsion Tests

(U) Torsion tests were continued on simulated control drum shafts on a Baldwin-Lima Hamilton 5000 lb. in. torsion testing machine at Westinghouse Research. The torque was read from a Baldwin SR-4 torque pickup with a strain indicator as shown in Figure 12. Shaft twist was measured by a scale on the driven chuck and by dial gages attached to wires which wrapped around the specimens during test.

The following table gives the results of the tests. Test 1 and 2 have been previously reported and are given here for reader convenience.

(U)

Test No.	Specimen	Temp.	Torque to Fail	Shaft Twist
1	937J394H01C Actual Shaft	Ambient	3875(lb.in)	32.6°
2	Simulated Shaft	Ambient	3975	40°*
3	Simulated Shaft	-300°F	4250	**
4	Simulated Shaft	-300°F	4525	13°
5	Simulated Shaft	Ambient	3400	10°

* Slipping in grips occurred.

** Wires froze on dial indicators giving erroneous reading.

A-6 Beryllium Ring Thermal Response Test

(U) The NRX-A6 spare reflector ring, pressing number 4055, was subjected to 3 thermal tests. Test facility and description is covered in the Fluid Flow Laboratory portion of this report.

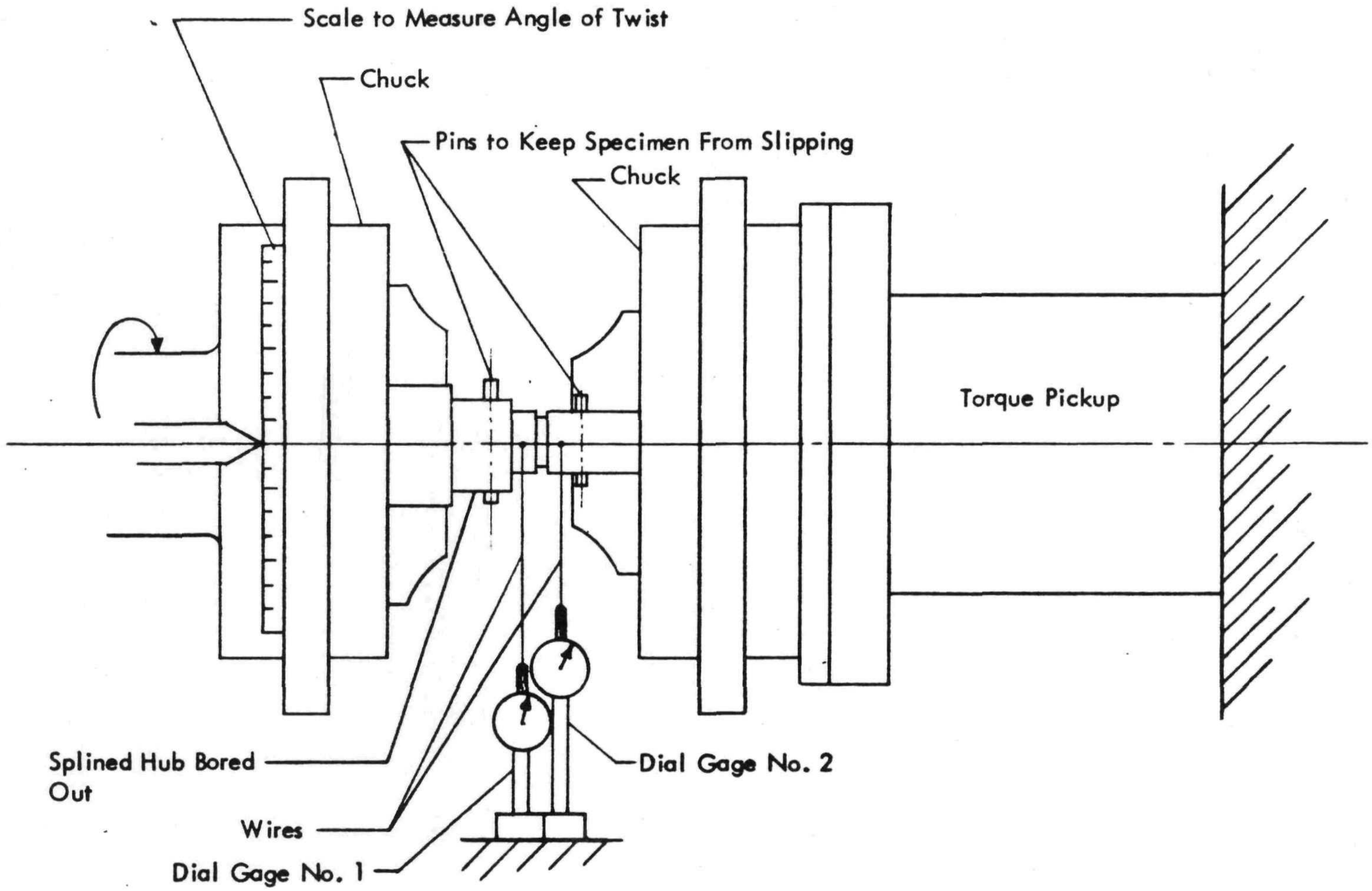


FIGURE 12
TORQUE TEST OF SIMULATED CONTROL DRUM SHAFTS

(U) Strain and temperature data were recorded on the Vidar data acquisition system in the Engineering Mechanics Laboratory.

(U) Maximum thermal gradient across the ring cross section was 90° and occurred 138 seconds after hot water release. Maximum strain of 1800 microinches/inch also occurred at this time and was located in the thin web section of the ring between the drum bore and ring outer diameter.

All data have been transmitted to the Structural Analysis group.

Calibration of LASL Tie Rods for FFL Tests

(CRD) Three LASL support rods were instrumented and calibrated for the Thermal Flow Laboratory. The components will be used to monitor tie rod loads in the hydrogen corrosion tests of the hot end hardware including exit gas thermocouples. Axial tensile loads from zero to 600 lbs were applied to each specimen and the resulting strains recorded. Calibration factors and resistance substitution values were supplied.