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Westinghouse Astronuclear Laboratory

NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING
HELD WITH SNPO AT WANL ON MAY 4, 1967
(Title Unclassified)

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(Title Unclassified)

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Classification cancelled (or changed to) by authority of DOC by TIC, date SEP 10 1973

E. A. DeZubay, Manager
Thermo-Flow Laboratory

C. L. Meuche, Manager
Engineering Mechanics Laboratory

INFORMATION CATEGORY

CONFIDENTIAL R.D.

Authorized Classifier 5/16/67 Date

GROUP I - Excluded From Automatic Downgrading and Declassification.

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NOTES OF MONTHLY DEVELOPMENT TEST PROGRAM REVIEW MEETING HELD WITH SNPO ON MAY 4, 1967

Attendees:

H. J. Fix	WANL	R. L. Oelrich	WANL
R. Gagne	SNPO-C	J. S. Olinger	WANL
W. J. Havener	WANL	D. E. Plummer	WANL
H. H. Hoffman	SNPO-C	M. Rieb	AGC
G. Kalvin	SNPO-C	W. J. Rowan	WANL
I. E. Kanter	WANL	L. A. Salvador	WANL
C. L. Meuche	WANL	P. A. Stancampiano	WANL
H. Murphy	SNPO-C		

The Monthly Development Test Program Review Meeting was held on May 4, 1967.

Lists of the tests performed and planned next period by the Engineering Mechanics and Thermo-Flow Laboratories were distributed to those in attendance. These schedules are shown in Tables I and II.

The individual tests were then discussed in the order shown.

TABLE I

THERMO-FLOW LABORATORY TEST SCHEDULE

PERFORMED THIS PERIOD (April)	PLANNED NEXT PERIOD (May)
Tests for NRX-A6	
TFL-1.a Single Cluster Tests -	Continue Testing.
Test / Configuration	
11a NRX-A6 Exit Gas Thermocouple, T. C. Assembly from 8b, Cups & Blocks from 10a.	
12a NRX-A6 Exit Gas Thermocouple	
12b NRX-A6 Exit Gas Thermocouple	
12c NRX-A6 Exit Gas Thermocouple, Non-Fuel, Match Fit on Check, Splice on Thermocouple	
13a NRX-A6 Exit Gas Thermocouple	
TFL-2.a Filler Strip Model	
Test Model TFL-2.a.0002 - Design Established and in Final Assembly.	Test to be Conducted.
Test Model TFL-2.a.0003 - Design Established. Tile Being Machined and Filler Strip Awaiting Coating.	Model Fabrication to Continue.
TFL-2.c Plunger Pin Capsule Seal Tests - Completed Thermal Expansion Tests.	No Activity.
TFL-3.e Nozzle Interface Seal Tests - Received Fixture.	Conduct Tests.
General Development	
TFL-1.b Single Element Tests -	
Nine Tests at High Power Levels for Furnace Engineering Evaluation Using High Void Elements.	Additional Tests to Establish the Capability of the Corrosion Furnace System at High Power and Flow Levels.
Five Tests for Hot End Chuck Development Using Pyrofoil.	Initial Testing of the Water Injection System.

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THERMO-FLOW LABORATORY TEST SCHEDULE (Continued)

PERFORMED THIS PERIOD (April)	PLANNED NEXT PERIOD (May)
General Development (Continued)	
TFL-1. b Single Element Tests -	
Four Tests to Evaluate the Hydrogen Flow System and Larger Flow Orifice.	Hot End and Cold End Chuck Development Testing.
TFL-5. b Interstitial Corrosion - Temperature Effect	Continue Testing.
TFL-5. c Permeability -	
18 Inch Furnace Checkout	Continue Testing.
High Temperature Instrumentation Qualification Furnace Tests	Continue Testing.

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TABLE II

ENGINEERING MECHANICS TESTING

PERFORMED THIS PERIOD (April 1967)	PLANNED NEXT PERIOD (May 1967)
Tests for NRX-A6	
EML-C.1 Carbide Composition Cup Development Test	EML-C.1 A6 Cup Proof Tests
NbC Billet Thermal Gradient Test	LASL Pedestal Proof Tests
EML-D.1 Lateral Support Spring Temperature Load Test	
EML-D.5 Lateral Support System Tests	EML-D.5 Lateral Support System Dynamic Tests
	EML-E.2 Conduct Friction Tests
Tests for NR-1	
EML-A.4 Ganged Drum Decoupler Fixture	EML-A.4 Ganged Drum Drive Band Tensile Tests
General Development	
EML-A.2 Beryllium Properties	EML-A.2 Conduct Low Temperature Tests
EML-C.1 Regular Support Block Thermal Gradient Tests	EML-C.1 Thermal Gradient Tests on Regular Support Blocks
EML-C.1 Core Periphery Pyrofoil Wrapper High Temperature Strain Proof Tests	
Facilities	
EML-A.1 Reflector Thermal Gradient Facility	

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TFL-1.a Single Cluster Development Tests

A report on the last nine exit gas thermocouple tests was given during the meeting. The first four of these tests; however, have been previously described in WANL-TME-1607 and will not be included here. Test TFL-1.a.0011a was conducted using the NRX-A6 exit gas thermocouple and tie rod assembly which had been previously evaluated for a period of 16.5 minutes in test TFL-1.a.0008a. The tungsten protection cups were those previously employed in test TFL-1.a. 0010a for a period of 21 minutes. The test was held at steady-state for 10.9 minutes when a short circuit in the electrical control console caused the test to be terminated. The tie rod and tube liner melted from an over-temperature caused by the loss of hydrogen coolant.

Tests TFL-1.a.0012a and TFL-1.a.0012b were conducted using the same thermocouple, support hardware, and protection cups. The tests operated for periods of 11.5 and 1.5 minutes, respectively. In both cases the thermocouple, support hardware, and protection cups were undamaged by the effects of time, flow, or temperature. Although the tests were planned to operate for 20 minutes, they were terminated early because of fuel element failure in the cluster. Test TFL-1.a.0012c was conducted for a period of 25 minutes. Although there was no output from the thermocouple, because of a splice breaking during start-up, the test was still considered successful because of the condition of the thermocouple, support hardware, and protection cups after the test, Figure 1 . There is now approximately 39 minutes of operating time on all hardware including the thermocouple. It is planned to make a new splice on the thermocouple in a location where it will not be bothered by expansion of the test assembly. The configuration will then be reassembled and tested for another 20 minutes.

Test TFL-1.a.0013a was conducted using a new thermocouple and all new support hardware. It operated for a period of 25 minutes and was terminated by a

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TESTS FOR NRX-A6

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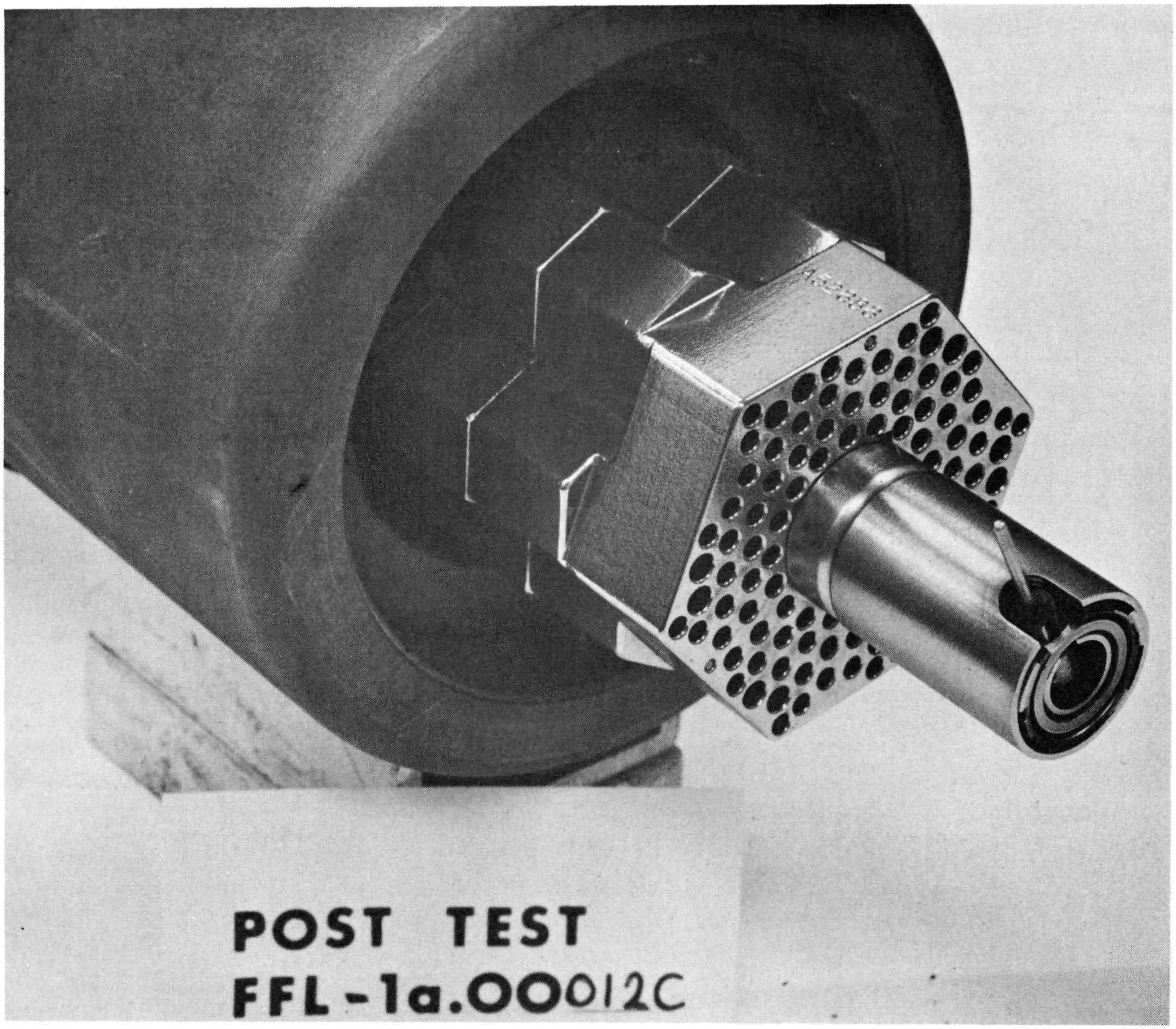

FIGURE 1

VIEW OF TEST ASSEMBLY AFTER APPROXIMATELY 39 MINUTES OF TESTING normal shutdown. The thermocouple and support hardware performed adequately and will be retested in the near future.

TFL-2.a Filler Strip Corrosion Tests

The configuration design for TFL-2.a.0002, filler strip test model of the multi-layer wrapped periphery for NRX-A6, was specified in final form on April 24, 1967. The present design incorporates an eight layer wrapper of grafoil sandwiched between the coated hot buffer type filler strips and the hot buffer tile. Each layer of the wrapper contains two circumferential split liners, with each layer stacked in such a manner, that radial alignment between the gaps formed by any two circumferential liners is eliminated. The main test objective is to evaluate the wrapper periphery at reactor temperature levels.

To expedite an early test, available hardware from pervious tests was modified for use. This hardware, not considered suitable for fulfilling all of the test objectives of the final design, was acceptable for the alternate model. The test is presently scheduled for the week of May 22, 1967.

Concurrence between Thermo-Flow Laboratory and Reactor Design on TFL-2.a.0003, the prime filler strip test model of the multi-layer wrapped periphery for NRX-A6, has been tentatively obtained. Most of the hardware has been procured, tiles are being machined, and the filler strips are ready for coating. Fabrication of the model is proceeding on schedule.

TFL-2.c Plunger Pin Capsule Seal Tests

A test was conducted to determine if the differential expansion of the seal assembly with thermal changes would reduce the sealing effectiveness. A seal assembly with the L-shaped new design seals was torqued to 150 in.-lbs. squeezing the assembly 2.8 mils from hand tight. This assembly had zero leak rate at 100 psid pressure with ambient temperature helium gas. The torquing nut was then backed off 0.7 mils to simulate the expected differential expansion between the materials. This expansion had been previously calculated by Reactor Design. The assembly was again leak-tested and found to be leak free. It was concluded that the seal assembly can compensate for the expected differential expansion. This concludes the activity in this area.

TFL-3.e Nozzle Interface Seal Tests

The NRX-A6 reflector simulator has been received and is being prepared for tests.

EML-C.1 Carbide Composition Cup Development Tests

Early development tests of carbide composition cups (H cross section) showed that some cracks developed in the seat of the cups at loads of 900 lb at $4500^{\circ}R$. When cracks formed, post test observation showed that the seat was permanently deflected towards the support washer. Measurements showed this deformation to be approximately 4 mils for the cup and 2 mils for the washer. Figure 2 shows a typical example of the load pattern after testing at temperature. The diameter of the loaded area, indicated by the frosty finish, approximates that of the molybdenum cone.

These observations led to design of a 2 mil tapered washer (2 mils thicker at the center hole) and an alternate which used pyrofoil washers to simulate the taper of a flat washer. The foils were each 3.5 mils thick and one of these was cut to the outer diameter of the support washer (0.745 inch) while the other was cut to 0.550 inch diameter.

During the last period a series of seven uncoated and three coated carbide cups were run to evaluate these designs. The cups were all made of LASL material (75% NbC, 25% C) but did not meet the X-ray specifications called out on WANL drawings. The cups were furnace tested at 1100 lb and $4300^{\circ}R$ and confirmed that:

1) Flat washers deformed and cracked the cups
2) Tapered washers prevented cracking of the cups
3) Pyrofoil washers prevented cracking of cups

The pyrofoil test was repeated on two additional coated carbide cups but at ascending loads all at $4300^{\circ}R$. The first thermal cycle

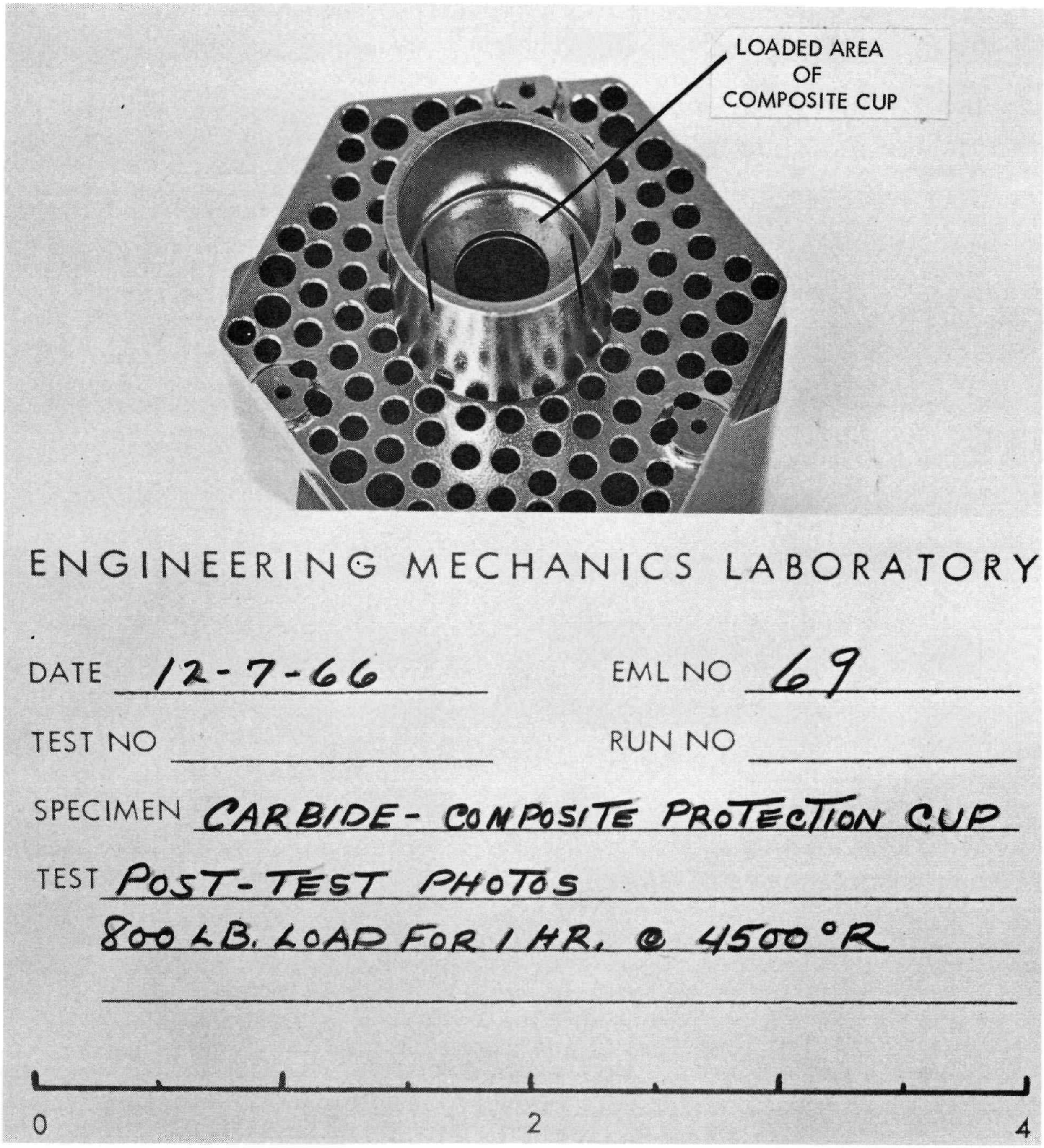

FIGURE 2

EML-C.1

began at 900 lb then 1100, 1300, 1500, 1800 and 2100 lb. A complete microscopic examination was used after each cycle to determine if cracks had developed. Small cracks occurred only after testing to 2100 lb.

By comparison the ATJ cups originally intended for the A6 reactor, tested under identical test conditions, developed cracks at loadings of 1600 lb when uncoated and 1500 lb coated.

Niobium Carbide Cylindrical Billet Thermal Gradient

A test to obtain a radial thermal gradient in a one-inch diameter niobium carbide cylindrical billet was completed with a thermal differential of approximately 200° attained at a furnace temperature of 3850°R. The test fixtures used, previously provided gradients in excess of 1500°R on two-inch diameter cylinders of graphitite "G" and the target gradient for this test was "the maximum obtainable". This test was conducted as a basis for comparison with similar tests that will be used to evaluate LASL pedestals made of similar 75% NbC, 25% C material. The three W-W 26 Re thermocouples used to measure gradient began operating erratically after 50 minutes at temperature, and post-test inspection showed them to be burned out because they were exposed to thermal radiation at the specimen and upper hearth interface. Modifications will be made to provide improved insulation for the thermocouples in this area.

EML-D.1 Lateral Support Spring Temperature - Load Test

A temperature-load test on five A-6 reactor grade lateral support springs (P/N 978D831 HO4E) from Lot. No. LB2426 (free length of 4.370

REF.) was conducted to determine set versus temperature. The entire spring was heated and test conditions and results are summarized in Table III . Figure 3 shows the springs after testing.

Thermal calculations indicate that 1200°R is the maximum temperature the spring will experience in operation and this occurs over several turns only. Based on these test results, the springs are adequate for A6 reactor testing.

EML-D.5 Static Test of the Lateral Support System (EML-86)

A static test was conducted to verify static calculations and to furnish an imput for subsequent dynamic test conditions. The load-deflection loop previously presented is repeated for convenience in Figure 4 . Figure 5 presents the data between A to C in a different form to show the apparent spring rate variation as the core was translated from the center position. The initial relatively stiff system was probably due to the loading of pins at 90 and 270°. After the sliding had started at these points, the lateral support springs became active as seen by the decreasing apparent spring rate to approximately 4500 lb/in.

This complex spring-friction system indicates that a careful evaluation of the system at low g levels should be made during the future dynamic tests. Investigations will be made at 1/2, 1 and 1-1/2 g's prior to the sweep at 2 g's.

A-6 LATERAL SUPPORT SPRING (INCONEL 718)
DATA ON P/N 978D831 HO4E LOT NO. LB2426

Sprg. Sample No.	Free Lgth. (in)	Load @ compr. Lgth. of 3.810" (lbs)	Load @ compr. Lgth. of 3.375" (lbs)	Temp/1 hr. @ compr. lgth. 3.375" (°R)	Load @ compr. Lgth. of 3.810" (lbs)	Lost Load (lbs)	Load @ compr. Lgth. of 3.375" (lbs)	Lost Load (lbs)	Free Lgth. (in)	Final Set (in)	Visual Observation After Test
1	4.373	22	38.5	1110	22	0	38.5	0	4.373	0	Light yellow color No deformation
1A	4.373	22	38.5	1300	20.2	1.8	36	2.5	4.356	.017	Light yellow color Marginal set Light green scale on coils
2	4.365	20	37.1	1450	16.5	3.5	34	3.1	4.262	.101	Dark yellow color Light green scale on coils
3	4.376	20.5	38.1	1590	9.9	10.6	26.8	11.3	4.107	.269	Dark blue color No scale on coils
4	4.376	20.5	36.9	1730	0	20.5	13.2	23.7	3.743	.633	Cherry red for few secs. after heat Dark grey color
5	4.351	19.6	35.8	1960	0	19.6	.8	35	3.404	.947	Dark red for few secs. after heat Dark grey color Coils deformed and spring twisted
Rerun 1A 6	4.356	20.2	36	1450*	16.9	3.3	33.5	2.5	4.279	.077	Dark yellow color

* Compressed to 3.490 inches

TABLE III

EML-D.1

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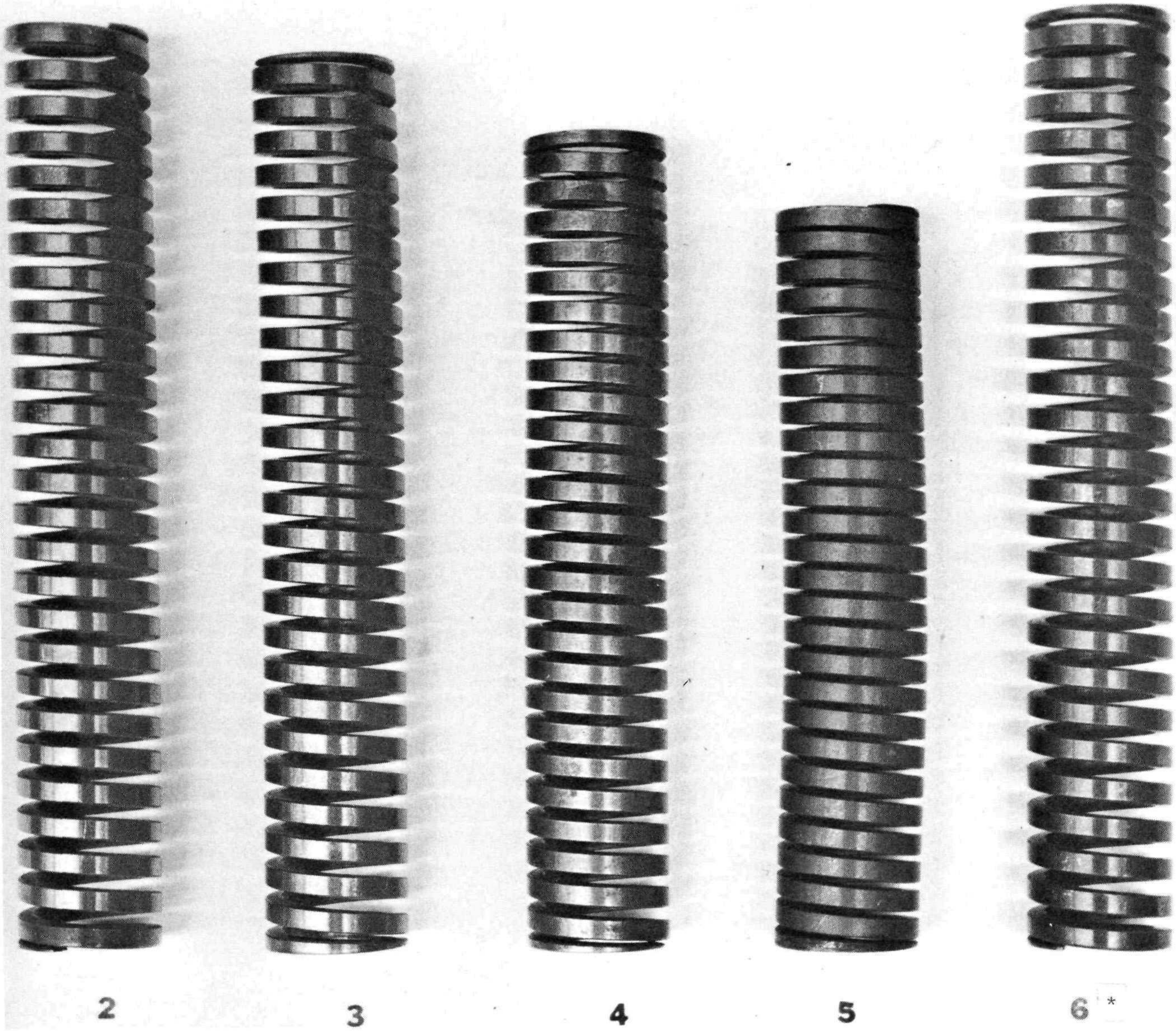

* Spring No. 6 used in Runs 1, 1A and 6

FIGURE 3
SPRINGS AFTER TEST
EML-D.1

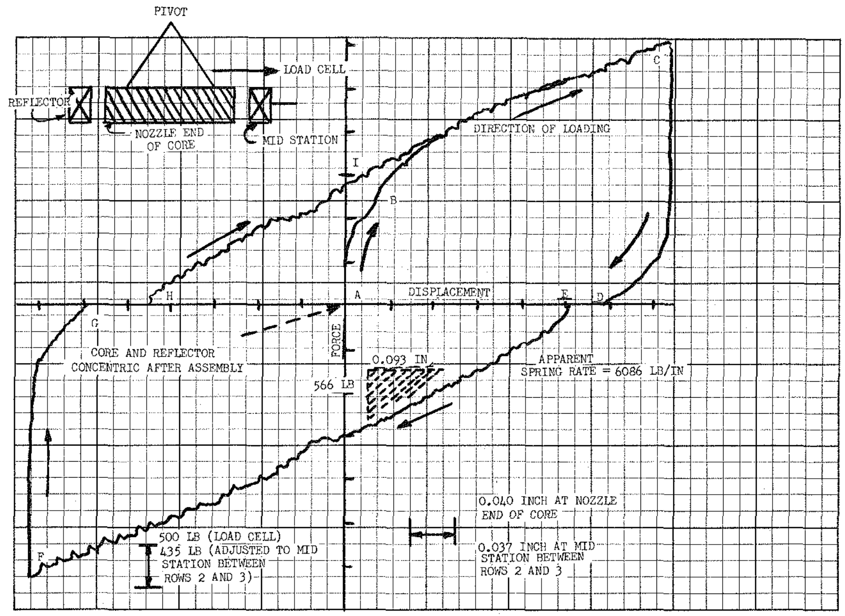

FIGURE 4
TYPICAL LOAD-DEFLECTION CURVE FOR
STATIC TEST OF LATERAL SUPPORT SYSTEM
EML-D.5

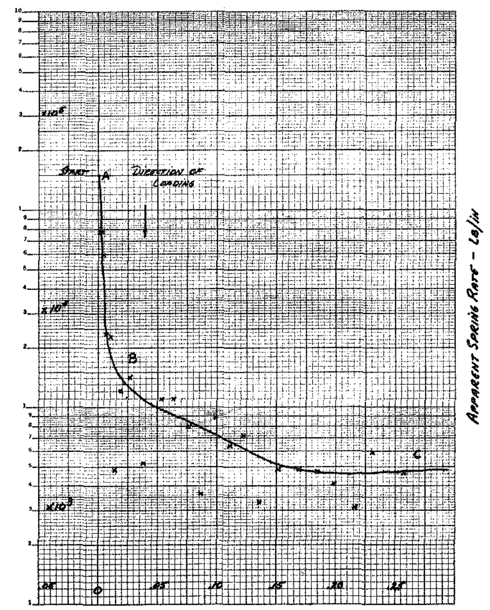

FIGURE 5
APPARENT SPRING RATE VARIATION
EML-D.5

TESTS FOR NR-1

EML-A.4 Drum Decoupler Test Fixture

Detailed drawings defining the components of the drum decoupler test fixture were completed. Procurement of the fixture will be initiated during the next period.

GENERAL DEVELOPMENT

TFL-1.b Single Element Process and Evaluation Tests

Testing continues at WANHES on Phase III and Phase IV of the Fuel Assessment Program. Tests have been conducted on some of the PAX fuel elements and testing has also started on the NRX-A6 elements.

There were eighteen single element experiments conducted at WANL during this period. Nine tests were furnace engineering evaluations at high power and flow levels using high void elements. Power levels of 1345 KW with hydrogen flows of 850 scfm were attained for short periods of time before element failures occurred without apparent damage to furnace and heat exchanger equipment or excessive exit gas temperatures.

Five tests were conducted as part of a hot end chuck development program using pyrofoil in the chuck in an attempt to reduce arcing in the chuck area and hot end damage. This approach shows some promise and further tests are planned.

Four tests were conducted to evaluate the hydrogen flow control and larger flow orifice. The system checked out satisfactorily.

The calibration rig and orifices for the methane inhibition studies were completed and calibration of the orifice was started.

The installation of the water injection system to reduce heat exchanger gas temperatures is 80% complete. It is planned to install water injection systems in all furnaces.

Studies were started on the suspension of carbon containing corrosion inhibitors in liquid hydrogen for possible use in future reactors.

TFL-5.b Interstitial Corrosion Tests

Three tests studying the effects of temperature change on the corrosion reaction in narrow slots were conducted. These conditions and results are given as follows:

Test Number (TFL-5.b.)	038	039	040
Test Time (min.)	15	15	15
Inlet Pressure (psig)	200	200	200
Inlet Gas Temperature (°R)	533	519	521
Average Material Temperature (°R)	Not Available	3114	3296
Flow Rate (lb/sec-H_2)	4.25×10^{-5}	4.27×10^{-5}	4.30×10^{-5}
Weight Loss (gms)	0.398	0.166	0.254
Weight Loss Rate (gms/min)	0.0265	0.01105	0.01694
Corrosion Rate (gms/in^2-sec)	1.105×10^{-5}	4.61×10^{-5}	7.05×10^{-5}

These tests complete the corrosion data over the temperature range of 2900°R, 3100°R, 3300°R, and 3500°R. Test TFL-5.b.039 is a repeat of TFL-5.b.038 which was discarded due to a faulty thermocouple.

Prior to test TFL-5.b.040, enough data was available to predict the specimen weight loss for the specified test conditions. The experimental value was very close to that predicted, verifying correlation between experimental and analytic approaches.

The data obtained to date is presented in a straight line plot of the log of weight loss rate as a function of the reciprocal of the material temperature level (Figure 6).

TFL-5.c <u>Reactor Graphite Component Permeability Tests (18 Inch Furnace)</u>

A preliminary checkout of the new 18 inch furnace was conducted. The power input was 21.5 KW. The heater achieved a local temperature of approximately 2900°F. The test was non-isothermal. Additional checkout tests will be conducted on May 2, 1967, at higher power levels, and peripheral flows will be adjusted so that isothermal conditions exist along the test specimen.

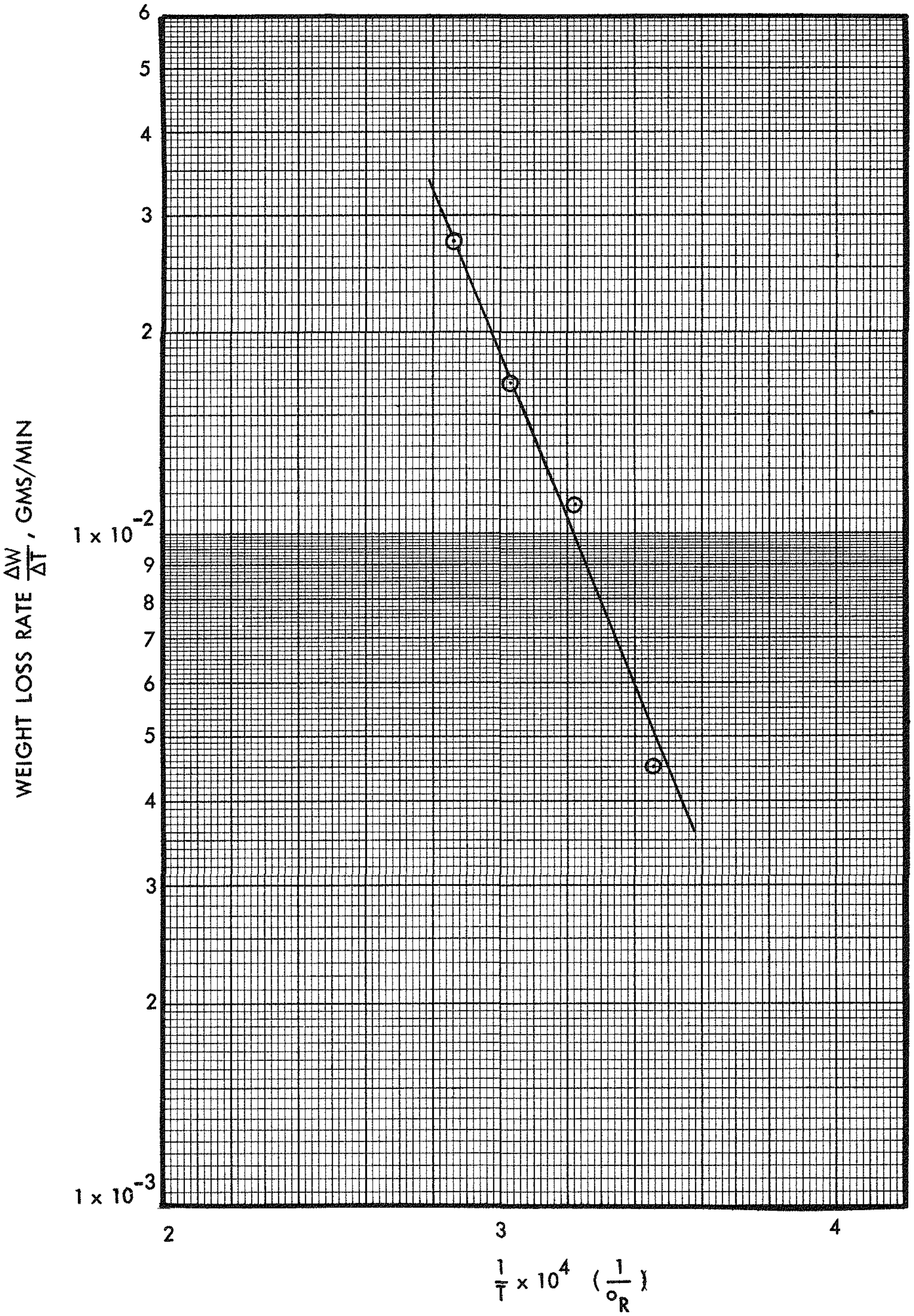

FIGURE 6

LOG OF WEIGHT LOSS RATE AS A FUNCTION OF THE RECIPROCAL OF MATERIAL TEMPERATURE

There were two tests conducted in the high temperature instrumentation qualification furnace. Two elements were capped by filling the flow holes with tapered pins coated with carbonaceous cement. One element had a graphite cap placed over the pin end seals. Each element was pressurized at various differential pressures to 90 psid and the flow measured using ambient temperature helium, ambient hydrogen, and hot helium. The hot helium peak temperatures were 2600°F, 3200°F, 3700°F, and 4200°F with temperature profiles similar to that specified for the reactor. The results are being evaluated.

EML-A.2 Beryllium Properties Test

A 3/4 inch diameter beryllium specimen from pressing 3824 was strain cycled to failure at room temperature.

The specimen withstood cycles at ± 1700, 20 cycles at ± 2000, 20 cycles at ± 2500 and 10 cycles at ± 3000 micro-strain. On the first cycle at ± 4000 micro-strain failure occurred.

Figure 7 shows the stable hysteresis loop for each strain cycle superimposed on the X-Y plot of the final cycle. Figure 8 shows the specimen set up in the Wiedemann with the strain cycle plot for 2500 micro-strain.

Although the room temperature results indicate no serious damage imposed by the initial strain cycling, this does not reflect the behavior at cryogenic temperature. A specimen is currently being set up for strain cycling at LN_2 temperature.

EML-C.1 Thermal Gradient in Regular Support Blocks

The first checkout run to establish lateral thermal gradients in regular and irregular support blocks that will duplicate thermal stress cracking experienced during A5 reactor tests was completed during the last period. This test involved a regular support block cooled on one side by a stainless steel water jacket and exposed to thermal radiation on the opposite side. The gradient was monitored by six W-W 26 Re thermocouples radially spaced across the block and cemented in the flow holes. The test arrangement is shown in Figure 9 and 10.

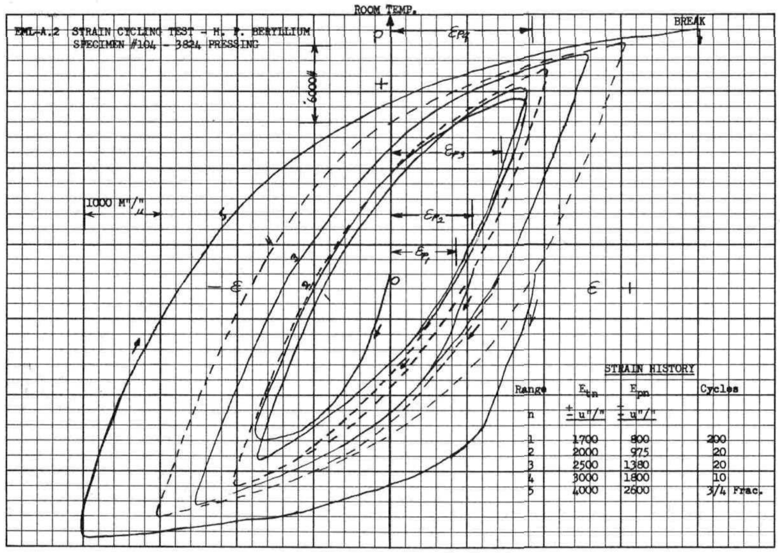

FIGURE 7
STRAIN CYCLING TEST
EML-A.2

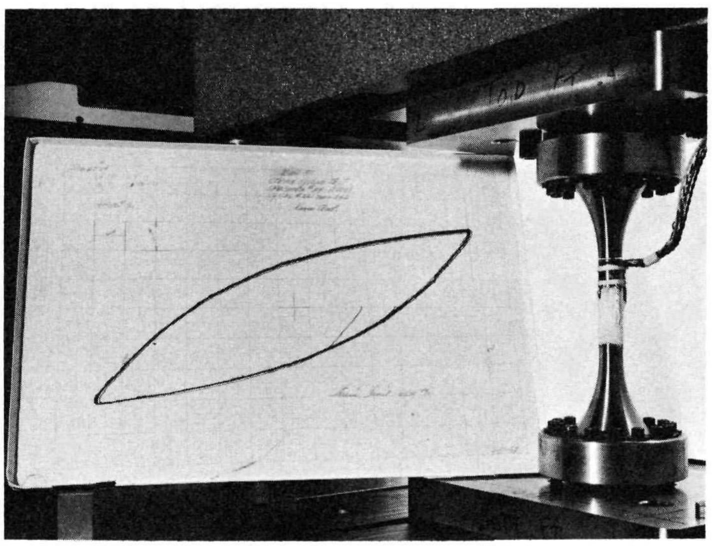

FIGURE 8
BERYLLIUM SPECIMEN SET UP
IN WIEDEMANN MACHINE
EML-A.2

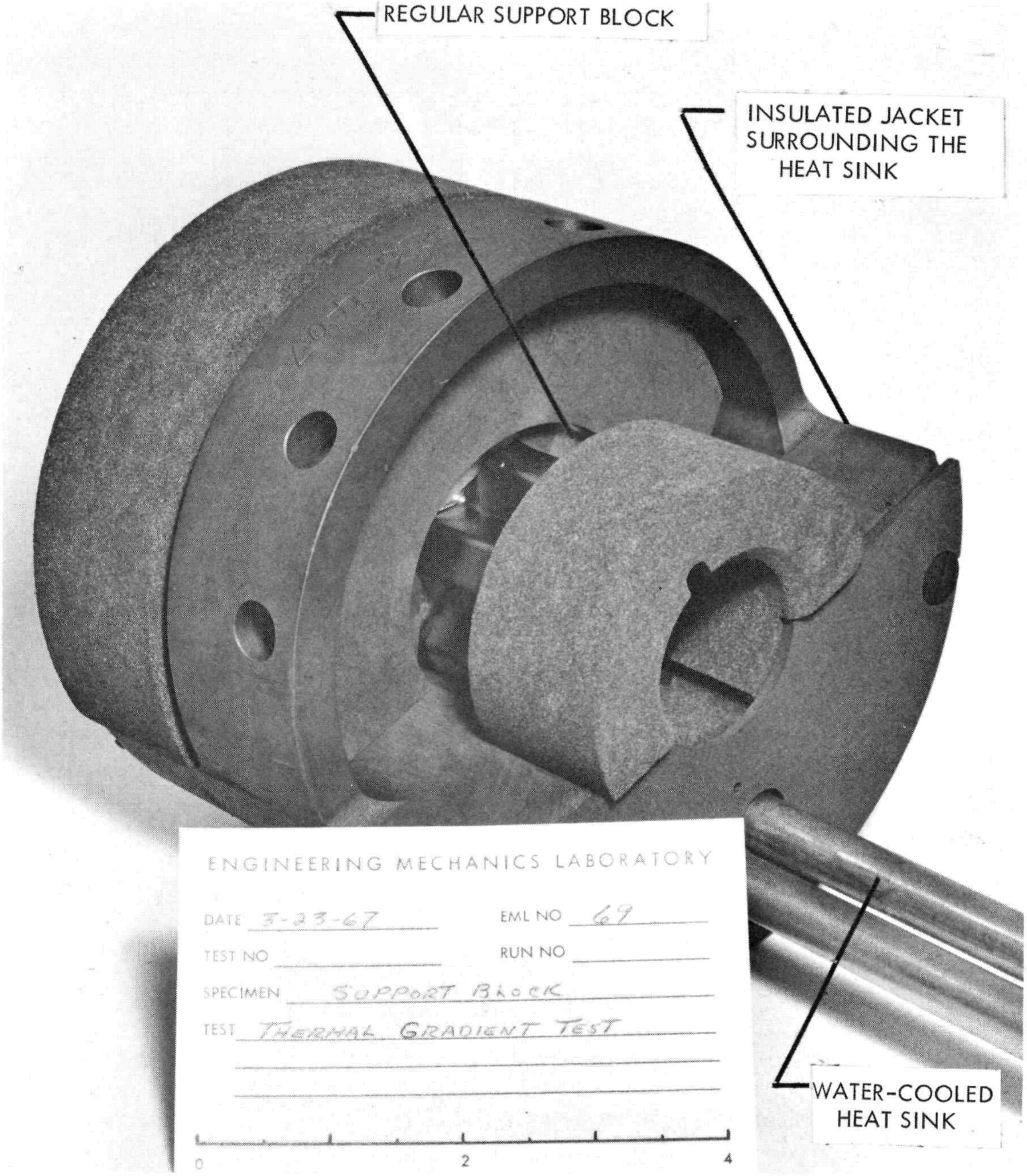

FIGURE 9
TEST ARRANGEMENT USED IN THERMAL GRADIENT TEST OF REGULAR SUPPORT BLOCK

EML-C.1

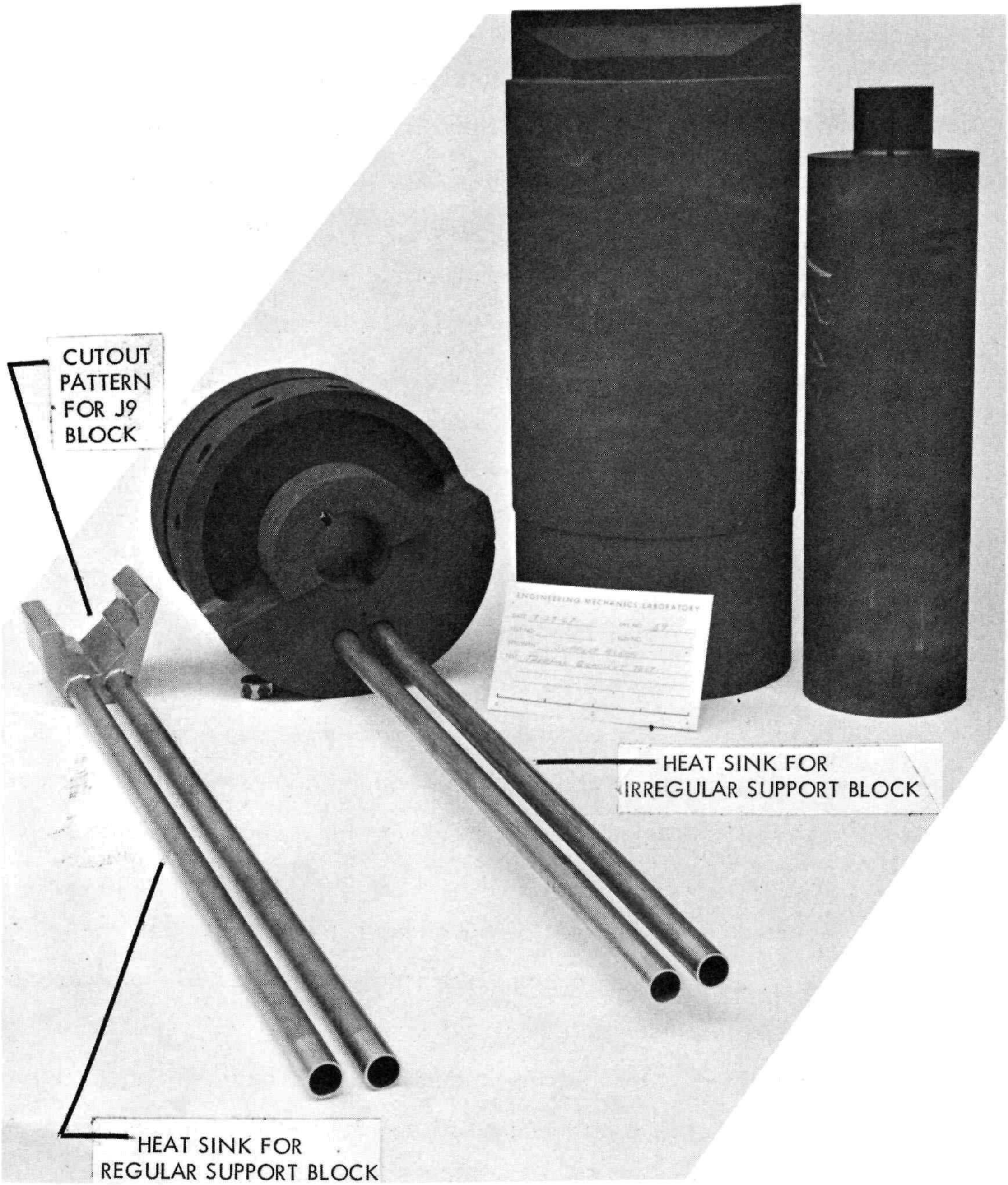

FIGURE 10
THERMAL GRADIENT TEST FIXTURING
SHOWING AN ALTERNATE HEAT SINK
FOR USE ON THE J9 PERIPHERAL SUPPORT BLOCK

EML-C.1

At 3950°R a temperature differential of 525° was achieved between thermocouples on opposite ends of the support block. Microscopic inspection of the sectioned block revealed no cracks in the critical area.

Additional tests are planned after modifications are made to provide larger temperature differentials at higher total temperatures.

This test was the first of a series that will be used to support stress analysis of peripheral support blocks. The test results will be compared to an analytical curve that is used to predict cracking of blocks for combinations of temperature and gradient across the block.

Test fixtures for similar tests of J8 irregular blocks will be procured if this technique proves to be successful.

Pyrofoil Wrapper High Temperature Strain Proof Tests

Proof tests on the NRX-A6 reactor grade foil (P.O. 88432, ECO 14289) were carried out under conditions of maximum strain using a 1.6 relative expansion log. The test log and support with 2 layers of pyrofoil assembled is shown in Figure 11. Two separate tests were performed with 2 layers of pyrofoil wrapped around the log as shown. Each test included one foil specimen cut lengthwise and one crosswise to the direction of rolling. The second test reversed the order in which they were placed on the log. A constant load of 300 ± 20 pounds was maintained on the locking wedge during the heating cycles. The test consisted of heating the log/foil assembly to 4500°R and subsequently cycled three times between 2000°R and 4500°R.

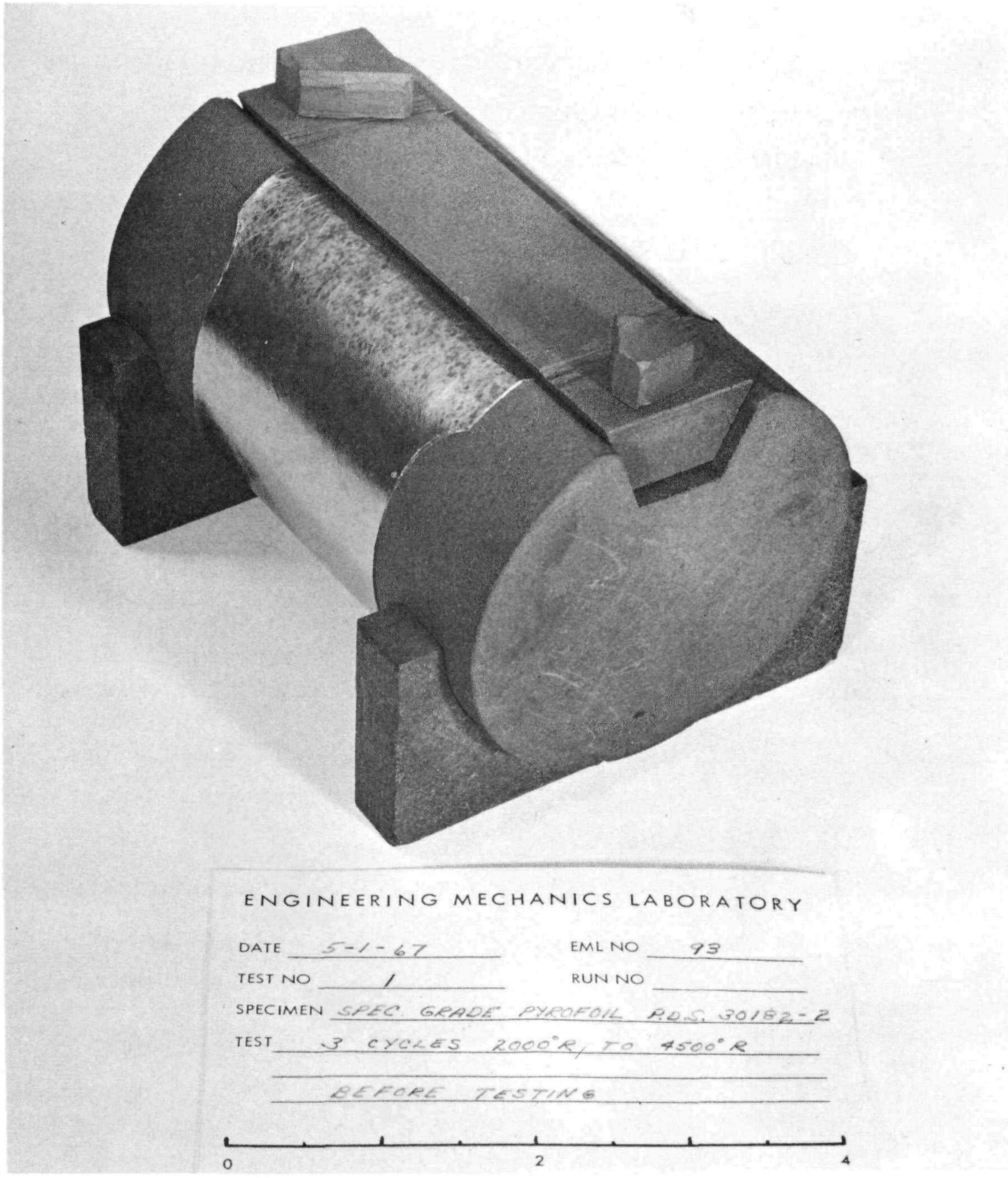

FIGURE 11
EXPANSION LOG TEST FIXTURE FOR
EVALUATION OF NRX-A6 PYROFOIL WRAPPER MATERIAL
EML-C.1

The estimated total strain induced in the pyrofoil wrap at the maximum temperature is 1.0 to 1.4 percent depending on the slack in the wrapper. Results of the two tests' runs are given in Table IV

TABLE IV

Effect of Three High Strain Heating Cycles On NRX-A6 Pyrofoil Wrapper Material

Test No.	Pyrofoil Orientation		Integrity	Plastic Deformation%		Total Def.at Temp.*%	
	Inner Layer	Outer Layer		Inner Layer	Outer Layer	Inner Layer	Outer Layer
1	CW	LW	No break	0.7	0.9	0.9	1.1
2	LW	CW	No break	1.0	1.2	1.2	1.4

* Estimated elastic deformation 0.2%

The condition of the pyrofoil wrap and permanent deformation is depicted in Figure 12.

The NRX-A6 pyrofoil wrapper material (PDS 30182-2) successfully sustained the strain imposed by the expansion of the maximum straining log with no evidence of tears or fracture. The strain levels are beyond those anticipated in the wrapper of the NRX-A6 core.

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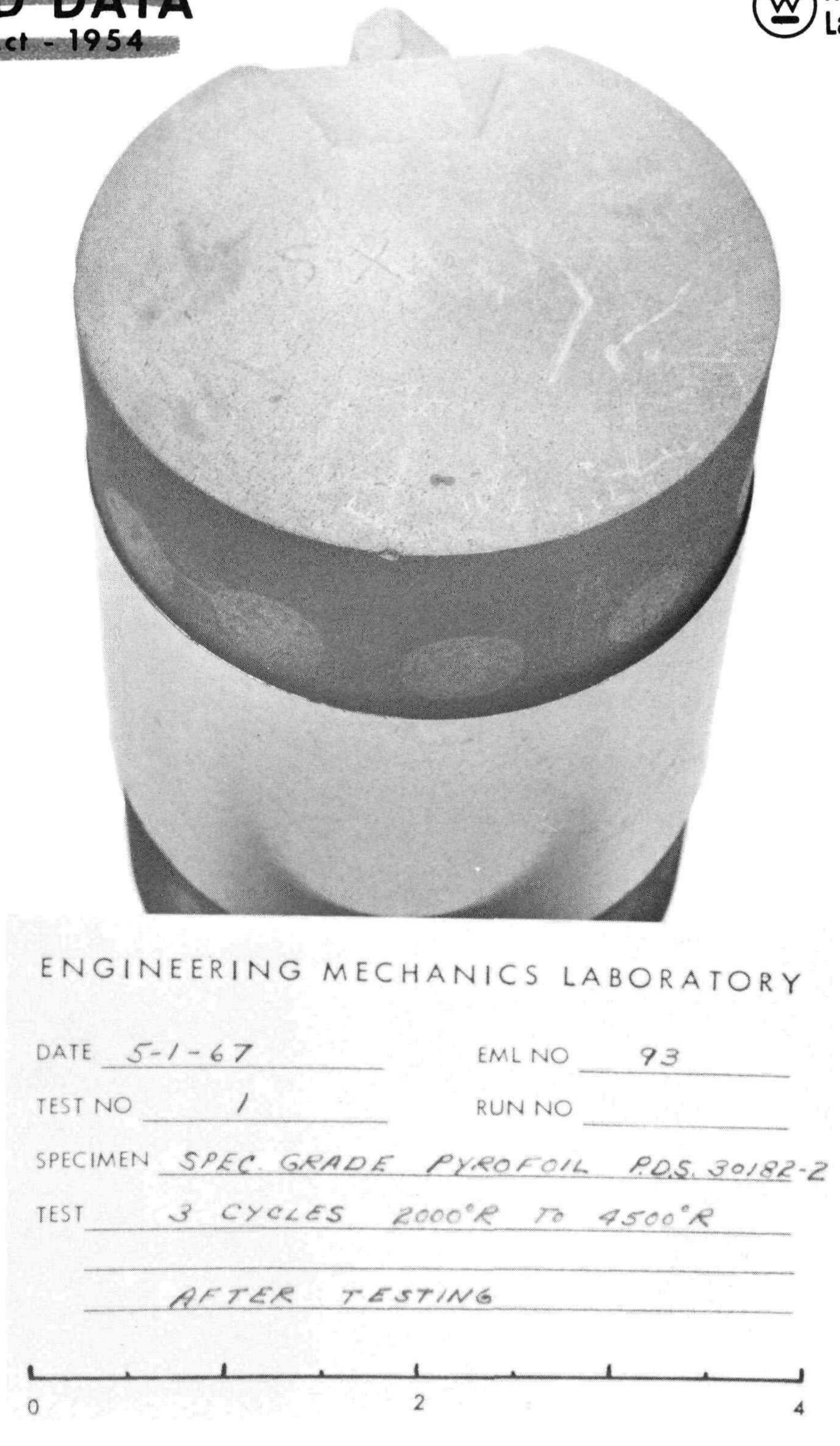

FIGURE 12
PYROFOIL WRAPPER AFTER HIGH TEMPERATURE STRAIN CYCLING

EML-C.1

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FACILITIES

Engineering Mechanics Laboratory Facilities

EML-A.1 Reflector Thermal Gradient Facility

Checkout run no. 2 was completed. Maximum heater temperature achieved was about 5000°R which resulted in a temperature gradient between the I.D. of the reflector and the O.D. of the core of about 1850°R. At this condition the temperature of the heater started to decrease and the test was terminated. Disassembly revealed that the heaters came in contact with the graphite thermal insulator causing a short circuit resulting in the temperature decrease. This problem will be resolved by providing a larger clearance in the thermal insulators. All run data are currently being evaluated.