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CLINCH RIVER BREEDER REACTOR PLANT

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Effect of Sodium Pool Temperature on Grapple Drive Stem Temperatures at Seals in CRBRP IVTM

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ABSTRACT

The effect of sodium pool temperature on the grapple drive stem temperatures at the seals of the CRBRP (Clinch River Breeder Reactor Plant) IVTM (In-Vessel Transfer Machine) has been calculated.

Reducing the sodium pool temperature from 500F to 400F reduces the maximum grapple drive stem temperature at the seals from 510F to 472F on the initial up-stroke, and from 285F to 225F when system is at dynamic thermal equilibrium. The time the stem can remain in lowered position without stem temperature exceeding 300F at seals when stem is raised, increases from 4 minutes to 20 minutes, (the system being initially at dynamic thermal equilibrium).

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FIGURES

I. INTRODUCTION

The results of an analysis of the grapple drive stem temperatures at the grapple drive stem reciprocating seals during fuel transfer operation of the IVTM (In-Vessel Transfer Machine) for the CRBRP (Clinch River Breeder Reactor Plant) are presented. The system analyzed is the same as the system analyzed in Ref. 1, with the following exceptions:

1. Sodium pool temperature of 400F as well as 500F, is analyzed.
2. The calculated temperature distributions in the top shield 48 hours after reactor shutdown (Ref. 2) are used. These temperature distributions are shown in Fig. 1.
3. The grapple drive stem stroke is 214.62 inches (Ref. 3).
4. The elevation of the lower end of the seals is 141 inches (Ref. 4).
5. The elevation of the sodium pool surface is minus (-) 87 inches (Ref. 4).

II. RESULTS

Figure 2 shows the maximum temperature of the grapple drive stem in the raised position and Fig. 1 shows the temperature distribution in the structure surrounding the grapple drive stem, during fuel transfer operation, after enough fuel transfer cycles have been completed for the system to have reached dynamic thermal equilibrium. Dynamic thermal equilibrium is defined as that state when system temperatures at any particular point in the fuel transfer cycle remain the same in each succeeding fuel transfer cycle. The maximum temperature of the grapple drive stem in the raised position, shown in Fig. 2, occurs at 1337 seconds from the start of each fuel transfer cycle (see Fig. 3), i.e., when the stem just reaches the raised position for the last time in the fuel transfer cycle. It is seen in Fig. 2 that the maximum stem temperature seen by the seals is 225F if the sodium pool temperature is 400F, and 285F if the sodium pool temperature is 500F.

It can be deduced from the temperature distributions shown in Fig. 1, that the temperature of the seal housings in the upper end of the nozzle will be somewhat less than 200F if the sodium pool temperature is 400F and somewhat greater than 200F if the sodium pool temperature is 500F. It can also be deduced from the temperature distributions shown in Fig. 1 that the temperature of the hold-down actuating shafts, which have a

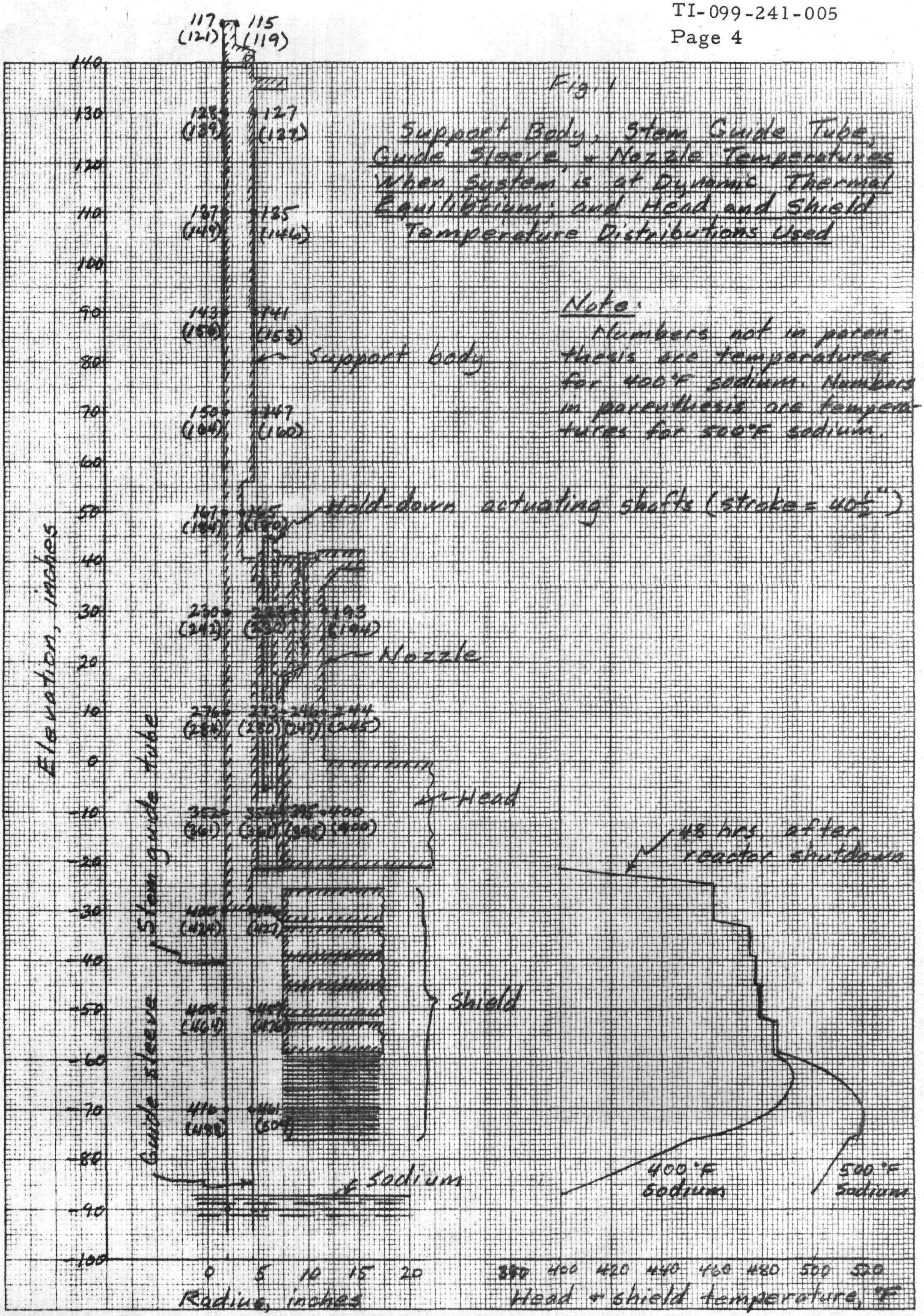


Fig. 1
Support Body, Stem Guide Tube, Guide Sleeve, + Nozzle Temperatures When System is at Dynamic Thermal Equilibrium; and Head and Shield Temperature Distributions Used
Note:
Numbers not in parenthesis are temperatures for 400°F sodium. Numbers in parenthesis are temperatures for 500°F sodium.
Support body
Hold-down actuating shafts (stroke = 40½")
Nozzle
Head
Shield
Sodium
Stem guide tube
Guide sleeve
48 hrs. after reactor shutdown
400°F sodium
500°F sodium
Elevation, inches
Radius, inches
Head + shield temperature, °F
117 (121) 115 (119)
128 (129) 127 (127)
137 (149) 135 (146)
143 (156) 141 (153)
150 (164) 147 (160)
147 (184)
230 (242) 193 (194)
276 (284) 233 (280) 246 (247) 244 (245)
352 (361) 354 (360) 395 (395) 400 (400)
400 (424) (427)
400 (464) (426)
416 (488) 441 (504)
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100
0 5 10 15 20
380 400 420 440 460 480 500 520

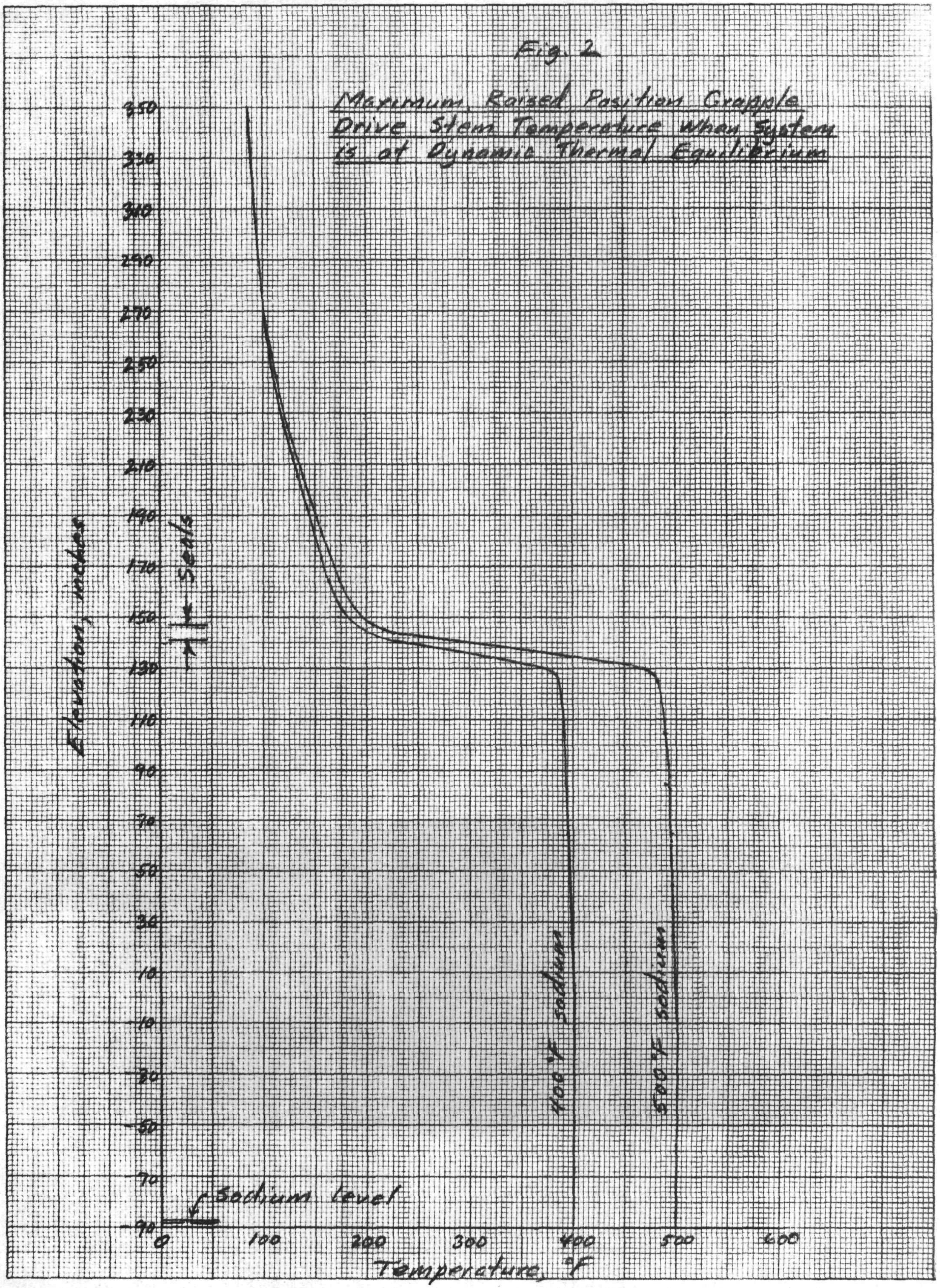
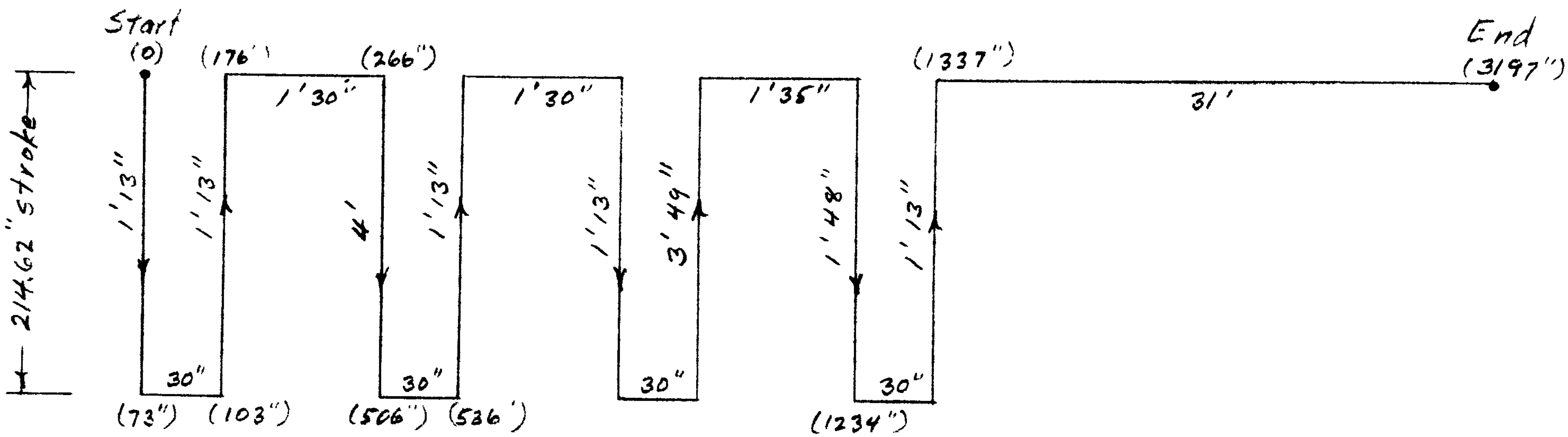


Fig. 2

Maximum Raised Position Grapple Drive Stem Temperature When System is at Dynamic Thermal Equilibrium

Fig. 3

Fuel Transfer Cycle for IVTM



stroke of 40-1/2 inches, could exceed 300F at the seals when these shafts approach or reach the raised position whether the sodium pool temperature is 400 or 500F.

Figures 4 and 5 show for sodium pool temperatures of 400F and 500F, respectively, the change in temperature with time of the grapple stem if the stem is held in the lowered position for a prolonged period, the system having been initially at dynamic thermal equilibrium. Two ordinate scales are shown. The ordinate scale on the right side gives the correct elevation for the temperatures shown. The ordinate scale on the left side shows what the stem temperatures would be in the raised position if the stem is raised instantaneously. Inasmuch as it takes a finite amount of time for the stem to be raised, and since the stem cools during this time, the actual stem temperature, when in the raised position, would be lower than the temperatures shown. However, the difference, i.e., the amount of cooling, is not significant if the stem moves up at a speed of 15 ft/min.

The stem temperature distribution, labelled zero (0) minutes, is that computed at 1234 seconds from the start of the fuel transfer cycle (see Fig. 3), i.e., when the stem just reaches the lowered position for the last time in the fuel transfer cycle. Stem temperature distributions at times 10, 20, 30, and 60 minutes later, and when the system reaches thermal equilibrium, are also shown. The dip in stem temperature, at the lowered position elevation of around minus (-) 50 inches, in the 30 and 40 minute curves is due to the low heat capacity of the guide sleeve and stem guide tube (see Fig. 1) as compared with the heat capacity of the support body. It is seen that if the drive stem is held in the lowered position for 20 minutes or longer in the case of sodium pool temperature = 400F (Fig. 4), and for about 4 minutes or longer in the case of sodium pool temperature = 500F (Fig. 5), the seals will see a stem temperature of 300F or higher when the stem is raised.

If the stem is held in the lowered position until thermal equilibrium is reached (which, on the basis of the plots shown in Figures 4 and 5, would probably take at least a couple of hours), and the stem is then raised at a speed of 15 ft/min, it is seen from Figures 4 and 5 respectively, that, during this up-stroke, the temperature of the grapple drive stem sliding past the seals will range up to 472F if the sodium pool temperature is 400F, and up to 510F if the sodium pool temperature is 500F. This is expected to be the condition for the initial up-stroke.

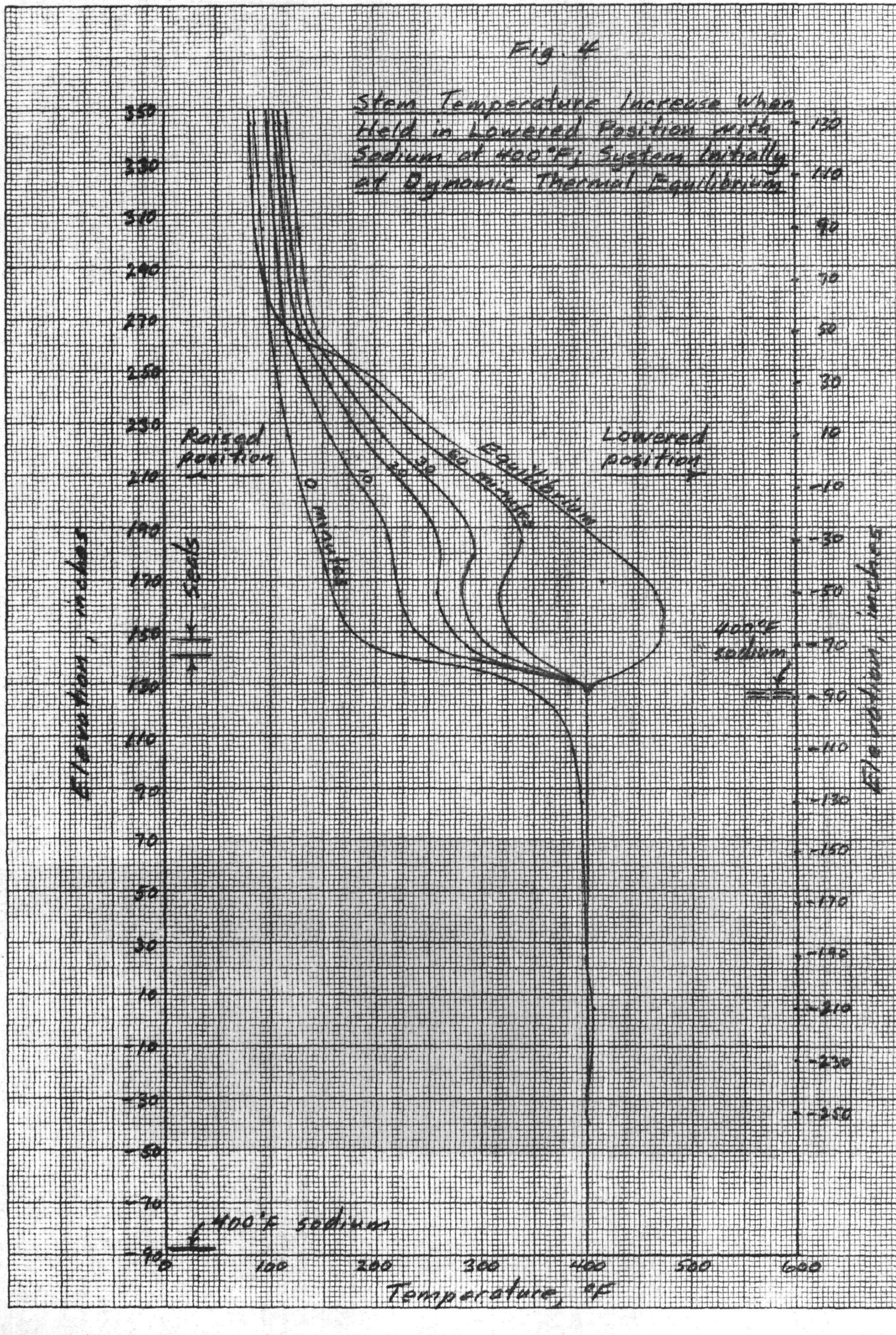


Fig. 4

Stem Temperature Increase When Held in Lowered Position with Sodium at 400°F; System Initially at Dynamic Thermal Equilibrium

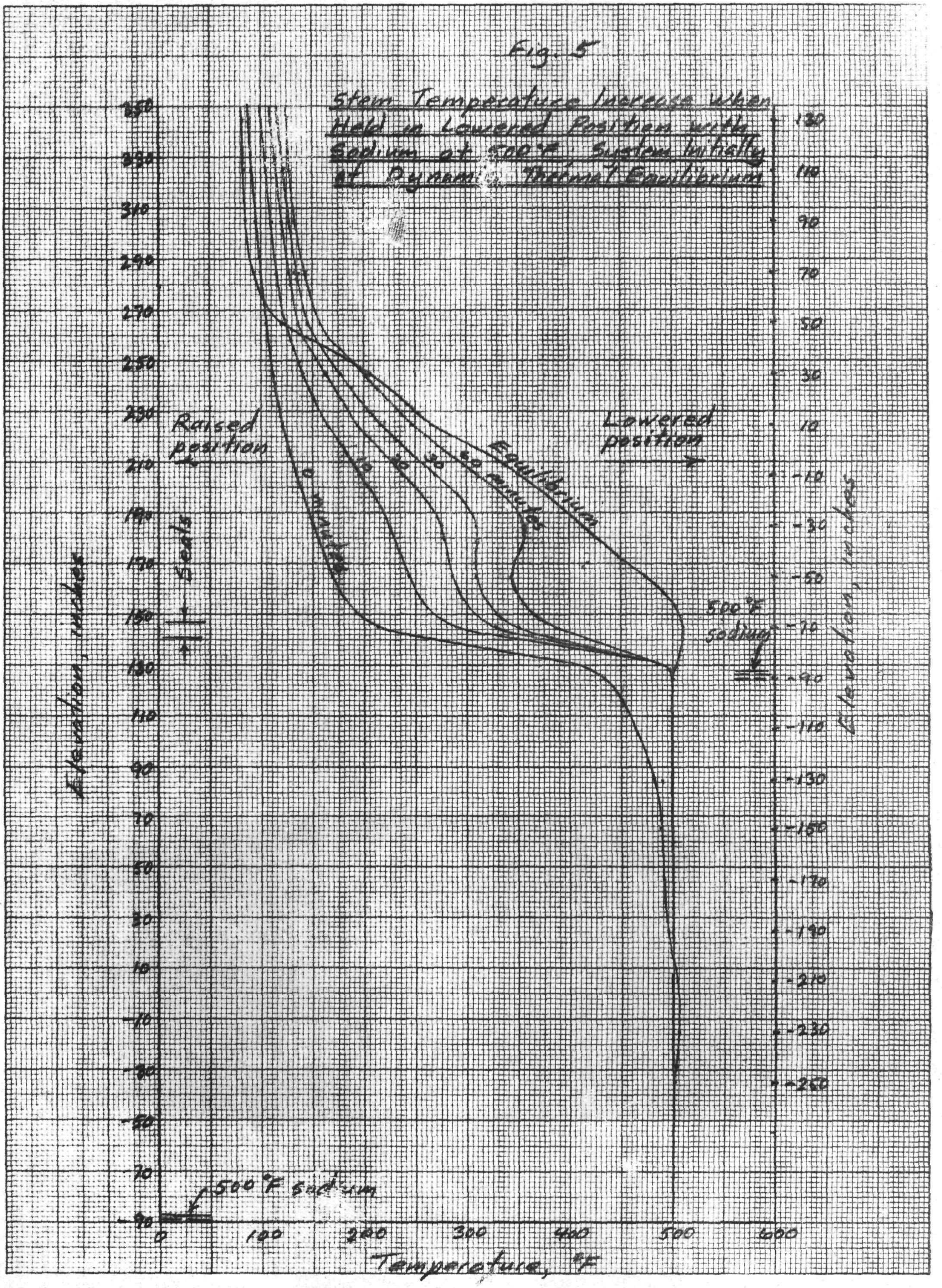


Fig. 5
Stem Temperature Increase when Held in Lowered Position with Sodium at 500°F, System Initially at Dynamic Thermal Equilibrium
Raised position
Lowered position
Seals
0 minutes
10
20
30
50 minutes
Equilibrium
500°F sodium
500°F sodium
Elevation, inches
Elevation, inches
Temperature, °F
0
100
200
300
400
500
600

if it is desired to limit the maximum temperature of the grapple drive stem at the seals to 300F, it can be accomplished by stopping the up-stroke when the temperature of the grapple drive stem at the seals reaches 300F, and holding the stem at this position long enough for it to cool sufficiently before completing the up-stroke. It can be determined from Figs. 4 and 5 that the temperature of the grapple drive stem at the seals will reach 300F when the stem is raised to 75 inches below the raised position. On the basis of calculations made in Ref. 5 for an IVTM and support body having slightly different dimensions, the stem will have to be held in this position for about an hour in the case of sodium pool temperature = 500F (and somewhat less time in the case of sodium pool temperature = 400F)for it to cool enough to permit completion of the up-stroke without the temperature of the grapple drive stem exceeding 300F at the seals. The stem cools by virtue of heat transfer by conduction and radiation to the colder support body surrounding it. From this point on, the fuel transfer cycle shown in Fig. 3, can be followed without the temperature of the grapple drive stem exceeding 300F at the seals.

III. CONCLUSIONS

Reducing the sodium pool temperature from 500F to 400F reduces the maximum grapple drive stem temperatures at the seals and increases the time the stem can remain in the lowered position without the stem temperature exceeding 300F at the seals when the stem is raised, to the following extent:

		Sodium Pool Temperature	
		400F	500F
1.	Maximum stem temperature seen by seals during initial up-stroke.	472F	510F
2.	Maximum stem temperature at seals when system is operating at dynamic thermal equilibrium.	225F	285F
3.	Length of time stem can remain in lowered position without stem temperature exceeding 300F at seals when stem is raised (at 15 ft/min.); system initially at dynamic thermal equilibrium.	20 min.	4 min.

IV. REFERENCES

1. TI-099-241-002, "Thermal Analysis of Seals in CRBRP In-Vessel Transfer Machine", T. Shimazaki, 2-12-74.

2. ARD Letter WA40082, April 9, 1974

3. IL, Kellogg to Steele, "Phase IV, IVTM Seal and Bushing Test", May 10, 1974.

4. K. Bilibin, Personal communication, June 7, 1974.

5. TI-097-241-010, "In-Vessel Transfer Machine Seal Thermal Analysis", T. Shimazaki, 12-15-73.