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TO: W. E. JORDAN

FROM: R. L. MENEGUS

PROCEDURE FOR IMPROVING TEMPERATURE DISTRIBUTION VIA RODS AND COLUMNS - B PILE

INTRODUCTION

The relationships relating poison distribution and consequent temperature distribution are described in memorandum dated September 27, 1945-subject "Procedure for Improving Temperature Distribution via Rods and Columns", by J. A. Wheeler and R. L. Menegus.

Since the development of relationships between rod changes and temperature shifts, the temperature distribution of the B Pile has been improved as much as possible by shifting the rods. Certain unbalances have been found which can only be removed by improvement of the poison pattern. At present the maximum imperfection in the B Pile is 5% diagonal quadrupole unbalance. An estimate of the poison pattern needed to correct these imperfections is given herein. This poison pattern has been calculated as an example of application of the principles and is not intended as a recommendation.

SUMMARY

A test was made on September 24, 1945 to check the magnitude of the temperature shift due to control rods which has been given in Wheeler and Menegus to Jordan, September 27, 1945, "Procedure for Improving Temperature Distribution via Rods and Columns". By combining these observations with the principles of flattening, a pattern was arrived at which should prove satisfactory as regards reactivity and balance of the temperature distribution. It is postulated that the optimum control rod configuration holding about 50 ih is to have A and 9 rods at 120 inches out, because at this setting a given small change in the reactivity held by the rods results in the smallest change in temperature distribution. The problem then is to pick a poison column pattern which will balance A and 9 at 120 inches out. This pattern holding a total of 408 ih (actually 301 ih effective) is given under "Details".

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DETAILS

The test of the temperature shift due to rod displacement was made two days after the pile attained xenon equilibrium following the startup of September 19, 1945. It was established that 9 rod be set at 250 inches out and A be set to keep the unit steady at 225 MW. By inserting 9 rod to 200 inches out and withdrawing A to compensate, the unit was unbalanced sufficiently to allow measurement of the changes in temperature moments over a period of 24 hours after the rod change. The results are shown in the attached diagram. It will be noted that about 6 hours after the rod change, the dipole moments reached a maximum falling off to the equilibrium values which for our purposes can be measured after about 36 hours. It is seen that the change in horizontal dipole moment is about 4.6%, and the change in vertical dipole moment is about 2.8%, whereas the curves* predict 6.3% and 4.1% respectively. The quadrupole moments did not change enough to make the results suitable for further use.

On withdrawing 9 to 270 inches out and inserting A to balance, the observed change in the horizontal dipole moment is 8.6%, and in the vertical dipole moment is 5.7%, whereas the curves* predict 8.7% and 5.4% respectively. On the basis of this test for the present, we will use the curves as given as being a good estimate of the temperature shift due to control rods.

Since we now have the absolute value of the unbalancing effect of the control rods by actual test, we are in a position to determine what the moments of the temperature distribution would be if the rods were completely withdrawn from the balanced pile. These moments are then the moments induced by the poison pattern. Thus the pattern required to balance both A and 9 at 120 inches can be computed.

After the pile was balanced by withdrawing 9 to 270 inches and inserting A to compensate, the observed moments were:

$D_x = 0.3\%$

$D_y = -1.9$

$q_1 = 2.8$

$q_2 = 5.2$

By Figure 1 of Wheeler and Menegus to Jordan September 27, 1945, we find that the moments due to the control rods are: $d_x = 10.7\%$ and $d_y = -17.3\%$. The quadrupole effect of the control rods is not known, therefore we will assume that moving A from 43 inches out to 120 inches out and 9 from 270 inches out to 120 inches out will cause no change in q_1. Also we will assume that A at 120 inches out and 9 at 120 inches out induce no diagonal quadrupole moment, q_2. The value of $q_1 = 2.8\%$ above we will attempt to reduce to zero by giving the new pattern an increase in Q_1 of (520*)(2.8) = 1500 (Lattice-Unit) ^{2}-inhours above that of the present pattern, thereby we eliminate from subsequent calculations any reference to the quadrupole moments - until the very end.

* Wheeler and Menegus to Jordan "Procedure for Improving Temperature Distribution via Rods and Columns", 9/27/45.

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The effects of the present poison pattern are then:

$d_x = -10.7 + 0.3 = -10.4\%$ and $d_y = 17.3 + (-1.9) = +15.4\%$. The poison moments for the present pattern are calculated to be:

$D_x = 418$
$D_y = -332$
$Q_1 = -5548$
$Q_2 = -355$

With A and 9 at 120 inches out, the effect of the control rods should be exactly compensated by the poison pattern. The calculation of the new pattern is then as follows:

Moments of Rods A at 120", 9 at 120"	Moment to be Induced by Poison Pattern	Moment Induced by Present Poison Pattern
$d_x = 24.3$	$d_x = -24.3$	$d_x = -10.4$
$d_y = -3.3$	$d_y = 3.3$	$d_y = 15.4$

Change in Moment Which Should be Caused by Change in Pattern	Change in Poison Moment Required	Required Moments of New Pattern
$\Delta d_x = -13.9$	$\Delta D_x = 417$	$D_x = 835$
$\Delta d_y = -12.1$	$\Delta D_y = 363$	$D_y = 31$
		$Q_1 = 7050$
		$Q_2 = 0$

A pattern which has the required moments is:

2682	42.2 ih	1569	24.3 ih
3179	49.1 ih	1474	38.7 ih
3274	49.1 ih	1579	41.9 ih
3169	31.5 ih	2082	39.0 ih
2666	13.6 ih	2374	68.0 ih
2066	10.4 ih		

CONCLUSION

The pattern as computed above is the result of observations and calculations made on the 105-B pile. This pile has been unbalanced, notably to the right, for a large fraction of its period of operation, and it may have other asymmetries which are difficult to observe. The observations have a rather low accuracy since there are many disturbing influences, and consequently the predictions

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presumably have the same low accuracy. The procedure in arriving at a pattern which will balance both A and 9 at 120" is to approach the pattern given above in steps. Perhaps after the first step or two, a revised estimate on the basis of observations made on these changes would be in order.

Finally, it must be remembered that any pattern can give the best results only when its total inhour value can remain constant. If increases in the strength of the pattern need to be made periodically, practical considerations limit the number of columns which may be altered, and the efficiency of flattening is lowered.

R. L. Menegus

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