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A REACTOR CALCULATION

Based on Two Group, Three Region Theory

Problem: - Given the nuclear constants, for fast and slow neutrons, of the concentric materials composing a cylindrical reactor and the dimensions of the cylindrical system, it is required to calculate the core, multiplication constant, k, the radial buckling constant, ℓ^2, and the values of the fast and slow fluxes and currents ϕ_f, ϕ_s, J_f and J_s respectively, at the two cylindrical interfaces dividing the reactor into 3 regions. The required values are to be calculated to six significant figures. The given quantities are to be considered to have a precision of 1 in six significant figures.

Sheets are attached that indicate how this problem may be solved. This solution is based on Matrix theory. At the start sheet 3 is filled out and the Q matrix found for the outer or end region. Then sheet 2 is completed and the Y matrix for the intermediate region is found. The (QY) matrix is found by the matrix multiplication of the Q matrix into the Y matrix. Sheet one is for the core.

Both of the constants, for fast neutrons, τ and D_f, are given for the core. Only the diffusion constant, D_s, for the slow neutrons is given. The other slow neutron constant, L^2, is determined when that value of Σ_{as} is found for which the reactor is critical. This value of Σ_{as} is found by an iterative process.

First a reasonable value of Σ_{as} is assumed. The core multiplication, k, is calculated from equation (2) on sheet 4 and the block at the top of the sheet 1 is filled in. The quadratic in X may now be

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solved and values for M^2 and M obtained. The values for ℓ^2 are to be used for checking purposes. The core matrix is then filled out with $\ell \frac{J_1(\ell r)}{J_0(\ell r)}$ considered as an unknown. At this point the (QYY_c) matrix is found by the matrix multiplication of the (QY) matrix into the core matrix (Y_c). The resulting two by two matrix is to be considered to be of rank one, hence its determinant is set equal to zero and a value of the unknown is found. If this value of $\ell \frac{J_1(\ell r)}{J_0(\ell r)}$ is multiplied by the radius r of the core, a transcendental equation whose argument is ℓr is obtained, the solution of which yeilds a value of ℓ since r is known. The first approximation to the desired value of the radial buckling constant ℓ_1^2 is thus obtained. By using this value of ℓ^2 in equation (1) on sheet 4 a second trial value of Σ'_{as} is obtained from which a second approximation to ℓ^2 is found by the prosess just described for sheet 1. After the third approximation to ℓ^2 has been calculated it can be seen that the first differences of the consecutive values of ^{2} are the first two members of an alternating sequence whose limit is zero. After the third or fourth approximation to ℓ^2 has been calculated it is possible to estimate an ℓ^2 that will give a k and a Σ_{as} for which the value of the determinant of the (QYY_c) matrix will be sufficiently close to zero that the core matrix, Y_c, may be filled out.

Sheet 5 is for calculating the V matrix elements which are the values of the fast and slow fluxes and currents at the core edge (radius). On this sheet only A' needs to be calculated. It is taken as the average of the two values obtained for it from the ratios $\frac{\alpha}{\beta}$ and $\frac{\gamma}{\delta}$. Sheet 6

is to be used for the calculation of the V_1 matrix, the elements of which are the fast and slow fluxes and currents at the intermediate region edge (radius). This matrix found by multiplying the Y matrix on sheet 2 into the V matrix on sheet 5.

A sample calculation is also attached. The given quantities in the blocks at the tops of the first three sheets are underscored.

The given quantities for four different reactors are as follows. The core values are the same for all of this group of reactors.

Reactor 1

$\tau = 64$ $\quad$ $r = 20$ cm

$D_f = 1.243$, $\quad$ $D_s = 0.264$, $\quad$ $H_z = 79$ cm (same for all regions)

A suggested trial value of $\Sigma_{as} = 0.05$

Intermediate region

$\tau = 33.0$, $\quad$ $L^2 = 8.29$, $\quad$ $r = 20$ cm

$D_f = 1.143$, $\quad$ $D_s = 0.167$, $\quad$ $R = 28$ cm

End region (outer cylinder)

$\tau = 2139$, $\quad$ $L^2 = 1879$, $\quad$ $r = 28$ cm

$D_f = 1.48$ $\quad$ $D_s = 1.52$ $\quad$ $R = \infty$

Intermediate region

		Reactor 2	Reactor 3	Reactor 4
$\tau = 87.8$,	$D_f = 0.644$	$r = 20$	$r = 20$	$r = 20$
$L^2 = 320$.	$D_s = 0.530$	$R = 32.5$	$R = 40$	$R = 45$

end Region

$\tau = 2139$.	$D_f = 1.48$	$r = 32.5$	$r = 40$	$r = 45$
$L^2 = 1879$,	$D_s = 1.52$	$R = \infty$	$R = \infty$	$R = \infty$

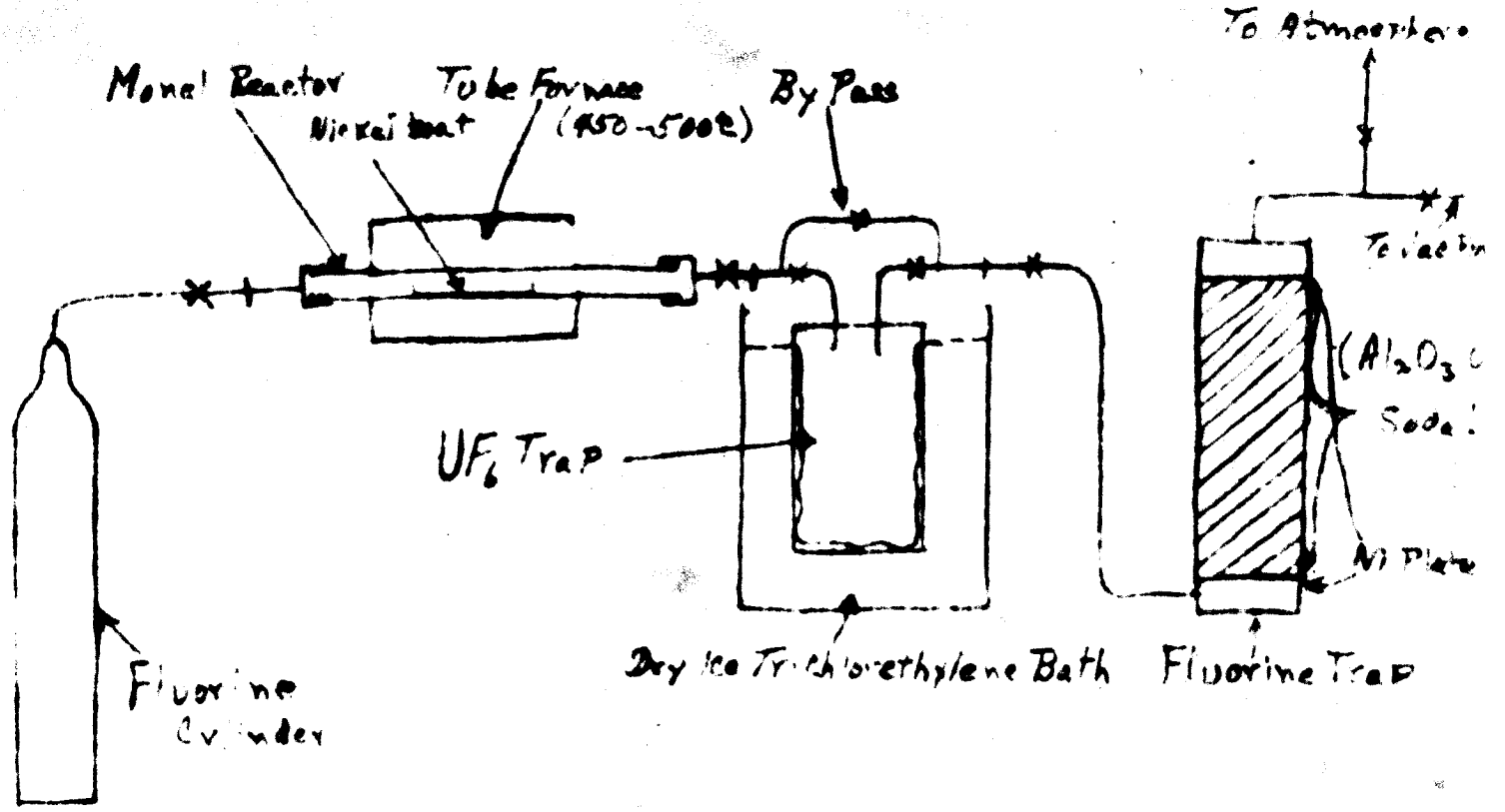
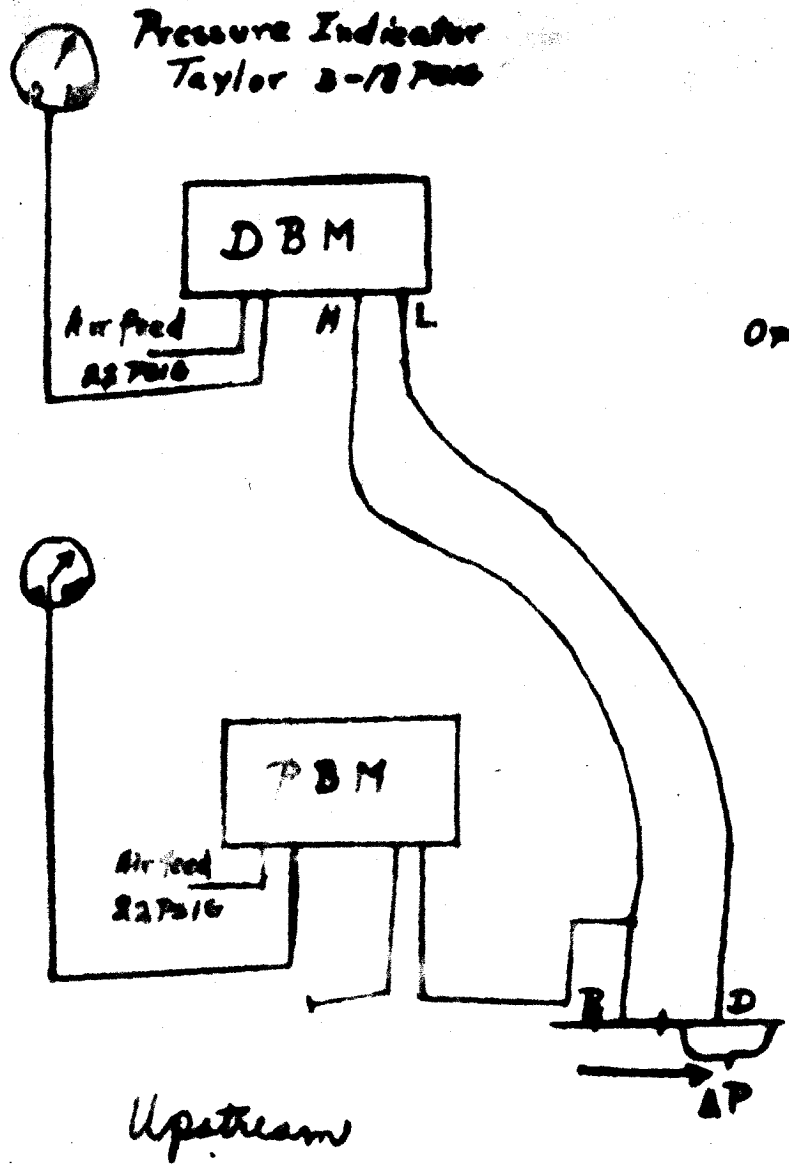


Fig 1a Lab Scale UF_6 Production from UF_4



Operates in Ranges 0-100 cm absolute

DBM = Differential Blind Multiplier

PBM = Pressure Blind Multiplier

Fig. 2. Sketch of Pressure Transmitter