hollow rear. When flow is stopped, the radial profile quickly disappears. Estimated from the Einstein relation,* this time of disappearance should be in the order of 20 sec in the present system. After flow is restarted, the radial concentration profile reappears. The student can witness the formation of the axial concentration gradient by noting the presence of a non-uniform (laminar) velocity profile and a small radial variation in concentration both in front of and behind the tracer patch. The fact that the radial concentration gradient has decayed to a fraction of its initial value, while remaining the cause of the axial spreading frequently seems paradoxical to a student who has not seen the dispersion phenomenon. However, actual observation of the dispersing tracer during its journey helps resolve this paradox.

It is a straightforward matter to derive an alternative to Equation (1) to describe a step-input tracer rather than a puse tracer. In practice, however, our experience indicates that step inputs of about 4% $KMnO_4$ solution do not fit the predicted results as well as pulse inputs in a horizontal tube. The discrepancy would appear to result from small density differences between water and $KMnO_4$ solution. The use of pulse tracers obviates this difficulty to a large extent.

Finally, Taylor showed that the characteristic Gaussian pattern did not appear until the following inequality was satisfied:

$$L/u_o << \frac{a^2}{3.8^2 D}$$

An order of magnitude estimate is required for D initially, to estimate how long flow must proceed before the axial concentration profile will become Gaussian. Using the calculated value of the molecular diffusivity, it must finally be verified that the above inequality was, in fact, obeyed.

For the results shown in Fig. 1, the molecular diffusion coefficient was calculated to be 0.7 x 10^{-5} cm^2/sec which compares favourably with Taylor's value of 0.80 x 10^{-5} cm/sec.

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*$D=\overline{x^2}/2\tau$, where $\overline{x^2}$ is mean square displacement and τ the time over which the displacement occurs. We may set $\overline{x^2} \approx a^2$ for present purposes.

ChE problems for teachers

The following problem on transport phenomena were contributed by Professor Ray Fahien, University of Florida.

A nuclear engineer is interested in predicting the temperature buildup in a nuclear reactor in which an annular fuel element is cooled by maintaining the inner and outer walls at a temperature T_0. The fuel element is initially at T_0 also. At time t = 0, the nuclear reaction is permitted to take place and heat is liberated in the annulus at a rate (assume constant) of S_N(Btu/ft^3-hr).

a. Show how his problem is analogous to the momentum transport problem of unsteady state flow in an annulus of radii R_1 and R_2, of an incompressible fluid of density ρ and viscosity μ, with a velocity in the z direction of v_z and under a pressure drop (including gravity) of $(p_o - p_L - \rho g L)/L$.

b. Write expressions for the total heat transport Q Btu/hr from the reactor walls and for the analogous momentum quantity. Repeat for the average velocity V and the analogous energy quantity.

c. Show how a knowledge of V (t) can be used to obtain Q(t).

d. Show that this analogy can also be used in more complicated systems such as those in which several cooling tubes penetrate a cylindrical fuel element even though an analytical solution is not possible. Derive the general relation between V and Q and outline a procedure whereby experimental data on V can be used to obtain Q. State which dimensionless variables should or should not be made the same in each system.

LETTERS (Continued from page 29)

the near-endless font of tax dollars diverting engineering teachers into science research and gradautes into massive science-oriented programs is costing industry so much of the basic engineering talent needed for the expansion and profits to pay the taxes and clean up our environment. If more "scientific engineers" were trained, the outlook for our companies, plants and cities would be healthier.

Rex T. Ellington, Mgr.
Sinclair Oil Corp.

Editor: The article by Dr. Sleicher entitled "Humanities and Social Science In Engineering Curricula" in the Spring, 1968 edition of Chemical Engineering Education was read with interest. Having been exposed to some 18 years of industrial experience with two major United States corporations, the need for development of "values"