where here molecular diffusion is replaced with an effective total dissipative effect. Inserting this into Eq. (3), we see that separation factor depends exponentially on length, exactly as predicted by Foo and Rice, 1975.

Furthermore, it has been shown (Gupta and Sweed, 1973) combined dissipation effects under conditions of linear isotherms can be represented by

$$D_T = D + \frac{v^2\bar{\alpha}^2}{h(1+\bar{\alpha})^2} \qquad (5)$$

where h is a mass transfer coefficient, D is axial dispersion coefficient and $\bar{\alpha}$ is an average slope of the linear adsorption isotherm. Taking axial dispersion as being linearly related to velocity (Klinkenberg and Sjenitzer, 1956) and assuming a constant transfer coefficient (slow flow) a combination of Eq. (3), (4), and (5) gives a simple linear connection with fluid velocity:

$$1/\ln \alpha_\infty = av + b$$

the form of which was predicted by Foo and Rice using an entirely different approach.

Clearly, the representation uncovered by Grevillot and Tondeur is a breakthrough, not only because non-linear isotherms can now be easily handled, but because their method is easy to understand and to apply. More work will be needed, however, to uncover a Murphree-type stage efficiency which reflects the unique dispersive force associated with solid or pore diffusion phenomena which so often limit adsorptive based systems (Rice, 1976, p163). In the final analysis, it is column length for a given separation which must be predicted.

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Reply:

We should like to insist on a few points, some of which we thought were clear in the scope and conclusion of our paper.

1. Parametric pumping is not restricted to packed beds, and can *actually* be performed in physically staged cascades, such as, stirred tanks containing an adsorbant, in the way described in our paper.

2. Our staged model was *not* presented for the purpose of representing packed beds, but physically staged configurations. In such, it is the number of stages that is sought, in the final analysis.

3. One reason for this limitation is the restriction to a *single* transfer per half-cycle, which amounts to imposing a value of the "penetration" or "relative displacement," whereas this parameter is free in usual packed bed parapumps.

4. *Only within* this restriction is the ultimate separation factor given by Fenske's equation:

$$\alpha_\infty = (\alpha/\alpha')^N$$

with $\alpha_\infty = x_1/x_{N+1}$ if the isotherms are linear (equation 3 in Rice's letter)

$$\alpha_\infty = \frac{x_1}{1-x_1} \bigg/ \frac{x_{N+1}}{1-x_{N+1}}$$

if the isotherms are mass action type (equation 11b in our paper).

5. In *AIChE J.*, 23, 840 (1977), we extend the staged approach to multiple transfers per half-cycle (thus varying the penetration), a situation more likely to be related to packed bed analysis. If the concentration distribution exiting at each end of the column are conserved before being reinjected, by using a cascade of reservoirs, the separation factor shows an exponential dependence on number of stages N *and* on number of transfers n:

$$\alpha_\infty = \left(\frac{\alpha}{\alpha'}\right)^N \left(\frac{\alpha}{\alpha'}\,\frac{p+\alpha'}{p+\alpha}\right)^{n-1}$$

(for linear isotherms)

In the analogous packed bed situation, one might then expect an exponential increase with bed length and penetration. In the case of mixing and averaging of the exiting solution at each half-cycle (the situation studied by almost all previous workers, including Foo and Rice), no simple relationship is predicted by our model, but separation decreases about exponentially when penetration increases, which agrees with equation 6 of Foo and Rice, originally derived with penetration as a variable, instead of fluid velocity.

6. We do try to obtain usable results on packed bed parapumps from the staged approach, but some unsolved problems stand in the way. In particular the correspondence between staged models and axial dispersion models for such cyclic processes is not as clear cut as for simple tube flow.

To conclude, in the present state of the art, the staged model can be used as a *conceptual and qualitative* model for both packed bed and staged parapumps, but as a *design* model for the latter only.

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ERRATA

In "Simulation of the Dynamic Behavior of Deep Bed Filters" by Chi Tien, Raffi M. Turian and Hemant Pendse [*AIChE J.*, 25, 385 (1979)] the footnote should read "Raffi Turian is presently at the Department of Chemical Engineering, Texas Tech University, Lubbock, Texas 79409".

In "A Sparse Computation System for Process Design and Simulation: Part II. A Performance Evaluation Based on the Simulation of a Natural Gas Liquefaction Process" by R. S. H. Mah and T. D. Lin [*AIChE J.*, 24, 839 (1978)] the sentence beginning l. 39, left column, p. 847 should read:
The iterations were terminated if either the Euclidean norm of the weighted residuals,

$$\left\{ \sum_{i=1}^{n} [w_i f_i(x)]^2 \right\}^{1/2}$$

was less than 10^{-6} or the numerical value of the ratio of the change of a variable to its present value was less than 10^{-8} for every variable. The weights are given in Table 4. Convergence was attained after six, eight, six and nine iterations for the four cases, respectively.

Table 4. Weights in the Residual Norm Evaluation

Equation number	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
w_i	1	x_{ik}	1	$1/F$	$[G\pi(1-\lambda_k)]^{-1}_k$	$[G\pi\lambda_k]^{-1}_k$	$1/G$	$[G\pi(1-\lambda_k)]^{-1}_k$	$[\pi(1-\lambda_k)]^{-1}_k$	1