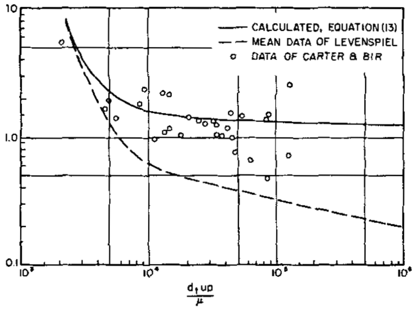

Fig. 2. Comparison of measured axial dispersion coefficients with those from the combined model.

and Bir that the effective dispersion coefficient was independent of the total length of test section.

In order to check the combined model quantitatively with the results of Carter and Bir, the sizes of the various components of the model must be estimated. The total length of each pass of the reactor was approximately $L_i = 115$ in. and the tube diameter was $d_t = 5/16 = 0.312$ in. Between the injection and measurement points there were essentially twelve passes, each of which had two 90 deg. bends.

Values of the group D/ud_t for straight pipe have been correlated as a function of Reynolds number by Levenspiel (*6*) and are shown as the dashed line in Figure 2. As mentioned above, there is no information available on mixing in 90 deg. bends, and so $L_{b\ eq}$ cannot be determined a priori. It was found that a value of

$$\frac{L_{b\ eq}}{L} = \frac{L_{b\ eqi}}{L_i} = 0.07$$

which when substituted into Equation (12) yields

$$\frac{D_e}{ud_t} = 0.93 \frac{D}{ud_t} + 0.9 \qquad (13)$$

gave results of the correct order of magnitude as shown by a comparison of the solid line with the data points in Figure 2. This value in terms of pipe diameters is

$$\frac{L_{b\ eqi}}{d_t} = 26$$

or

$$L_{b\ eqi} = 8 \text{ in.}$$

This figure seems to be of an acceptable order of magnitude, since reference *1* states that systems with very roughly comparable degrees of flow disruption require about 20 to 30 pipe diameters before attempting to use an orifice flow measurement device. This length of pipe is necessary if the disturbed flow is not to cause errors in the orifice measurement. The measurement case is not directly equivalent to the mixing and dispersion problem, but it does indicate something about the order of magnitude of flow disruptions.

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Chemical Engineering—Volume I, J. M. Coulson and J. F. Richardson. (Second Revised Edition). Macmillan, New York (1964). 492 pages.

This is the first major revision of the well-known text which was first published in 1954. The total number of chapters has remained unchanged although the text has been expanded by over one hundred pages. The chapter headings are the same and cover the unit operations of fluid flow, heat and mass transfer, and combined heat mass and momentum transfer in boundary-layer and pipe flow. A final chapter on humidification operations is included.

The authors have responded to the increased emphasis of the past ten years upon fundamentals of transport processes with expanded material in these areas. There is now a more obvious recognition that fluids in motion possess momentum as well as energy, and some material on rotational flow and other fluid dynamical concepts has been included; however, there is relatively little on fluid dynamics as such, and not enough to satisfy the instructor who would like to introduce fluid dynamics in a systematic way. Increased emphasis is given to unsteady state heat transfer as well as other unsteady state processes. The material in the chapter on design applications has been expanded considerably.

The first part of the present mass transfer chapter is almost identical to that of the first edition. For those who are used to the Bird, Stewart, and Lightfoot approach to defining diffusivity, the approach here will be unsatisfactory. For example, how one would apply the relative velocity convection correction in the case of an arbitrary catalytic surface reaction is unclear. The only cases discussed are those of equal-molal counter diffusion and diffusion through a stagnant gas. For these reasons this chapter is still weak. New material on mass transfer in turbulent fluids, unsteady state mass transfer, and various mass transfer models has been added. The two-film model, penetration theory, and random surface renewal theory are discussed to some extent.

The chapter entitled, "Momentum, Heat and Mass Transfer," contains additional material on transport fundamentals and analogies; it lacks material and illustrative problems concerning simultaneous heat, mass, and momentum transfer.

The chapter on boundary layers is still good as far as it goes. By taking the integral approach exclusively, it gives no real indication of the extent of applicability of boundary-layer theory. There is no indication as to how boundary-layer theory would be used on surfaces with pressure gradients. Boundary-layer mass transfer is given short shrift; there *is* no discussion of boundary-layer transfer with chemical reaction or interaction of heat and mass transfer, as in transpiration cooling, which has become an important area for chemical engineers.

The problems are given at the end of the book rather than after individual chapters. They have been expanded to about 150 problems. Their utility has been increased by keying the problem numbers to the particular chapter involved. One of the strong points of this book has been the illustrative problems that are worked out in the text; these are as good as ever and better in some cases. This book will continue to be a valuable text for those who want an introduction to chemical engineering from the viewpoint of the unit operations, for it now includes more material on the fundamentals of the physical processes involved. Those who need a text for a course which combines both the unit operations and applications to design as well as some fundamentals of transport processes will find this book useful and valuable.

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Cryogenics, M. McClintock, Reinhold Publishing Corporation, New York (1964). 270 pages. $10.75.

This book is mainly for the nonspecialist who wishes to obtain a broad view of this important and rapidly developing field. It is descriptive in its treatment, with a minimum of mathematical equations. It is concerned largely with the physics of low-temperature phenomena and touches very briefly on the engineering aspects.

The first chapter reviews the general principles of the various methods of producing refrigeration at temperatures below −150°C. The second chapter treats the principles of thermal insulation and illustrates them by showing how various vessels, both large and small, for the storage of cryogenic liquids are insulated against heat leak from surroundings. Chapter 3 considers the various methods that are available for the measurement of low temperatures.

The next five chapters deal with the properties of materials at cryogenic temperatures. Chapter 4 describes the unusual and interesting properties of liquid helium 3 and helium 4 and discusses the theories proposed to explain these phenomena. Chapter 4 is concerned with the mechanical properties

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$$N_{Fr} = \frac{V^2}{g\,m} \qquad (6)$$

Equations for the viscous flow of liquid films down a vertical plate have been established by Nusselt (*20*). Using his expressions for the mean velocity of the film, *V*, and the average film thickness, *m*, one obtains

$$N_{Fr} = \frac{\rho^2 g\,m^3}{9\,\mu^2} = \frac{1}{3}\frac{Q}{\nu} \qquad (7)$$

There are two definitions of Reynolds number in common use:

$$N_{Re}' = \frac{Q}{\nu} \qquad (8a)$$

and

$$N_{Re} = \frac{4Q}{\nu} \qquad (8b)$$

When Equations (7) and (8*b*) are combined, the Reynolds number may be expressed in terms of the Froude number as

$$N_{Re} = 12\,N_{Fr} \qquad (9)$$

The above expression gives a very simple relationship between the Reynolds and Froude numbers. It has been derived by combining Equations (7) and (8*b*) and is therefore valid when these expressions are applicable. Equa-

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of solids-ductility, flexibility, strength, stress-strain relationships, and related subjects. Chapter 6 treats the various magnetic properties which are exhibited by materials at low temperatures. Chapter 7 is concerned with thermal and transport properties, such as, heat capacity, coefficient of expansion, and thermal and electrical conductivity. Chapter 8 deals with superconductivity, first describing the phenomenon and then presenting the BCS (after authors Bardun, Cooper, and Schrieffer) theory, which appears to offer the best explanation of this amazing phenomenon. The final chapter considers briefly some of the practical applications of cryogenics. The applications discussed cover the fields of rocketry, the life sciences, the use of bubble chambers in high-energy particle physics, the production of high-strength magnetic fields, and the use of low temperatures in infrared detectors, masers, lasers, and cryotrons.

The book is well written, authoritative, and readable and might be recommended to anyone interested in gaining a broad, descriptive picture of the field of cryogenics as it exists today.

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ERRATA

In Equation (14) of the article, "The Application of Boundary-Layer Theory to Power-Law Pseudoplastic Fluids: Similar Solutions" by W. R. Schowalter, which appeared on page 24 of the March, 1960, issue of the *A.I.Ch.E. Journal,* the second term should read

$$\frac{g^{n+1}\,W^o}{(U^o)^n}\,\frac{\partial U^o}{\partial z^o}\,[F'\,G' - 1]$$

The subsequent analysis for three-dimensional boundary layers which possess similar solutions is affected. One is led to the conclusion that if W^o and U^o are proportional, similar solutions are possible for those classes of potential flows which yield similar solutions in two-dimensional flow.

The author is grateful to Professor J. N. Kapur, who brought this error to his attention.

The article, "Behavior of Non-Newtonian Fluids in the Inlet Region of a Channel" by Morton Collins and W. R. Schowalter, which appeared on page 98 of the January, 1963, issue of the *A.I.Ch.E. Journal* contains an error on page 102. The eleventh line of the first column of that page should read, "found to be 0.069 and 0.68 . . . ."