. . . one should not lose sight of the fact that academic research should be relevant, not solely to the needs of industry, but basically to those of society, which supports it through tax dollars. The engineer has a responsibility to consider, therefore, the social consequences of his work, and insofar as he can, to guide it in a direction which will add to, rather than subtract from, the sum total of human happiness.

major companies recently turned up the information that this work had had very little impact, if any, on their current operating or design procedures.

Why has this isolation into separate compartments come about? In Europe academic chemical engineering research is much more practically oriented, and this points to a principal element in the present syndrome. It is as true now as in earlier times that he who pays the piper calls the tune, and less than 10% of current chemical engineering research support in American universities is obtained from industry. Professors have oriented their research proposals towards impressing their peers and their colleagues in the funding agencies, and this, in turn, has led to an emphasis on scientific innovativeness, rather than applied research.

Now all this is not necessarily bad. One of the oldest complaints of the man who cannot understand current research is that it is all impractical, which is invariably accompanied by the assertion that the old problems are still important. Historically, there has always been a lag between academic engineering research and practical application, although of late this has become shorter and shorter. Thus, there was an exponential increase in the number of papers devoted to thin-shell theory in the late forties, until in the early fifties the first monococque airplane wing was introduced. More recently, the development of optimal control theory and the design of space vehicle trajectories have proceeded almost simultaneously. Academic engineering research is seldom of lasting value when it addresses itself directly to industrial development or production problems. On the other hand, it should not lose sight of these problems, and, in some sense, it should be motivated by them. One distinction that has been made between the applied mathematician and the theoretical engineer is that the engineer solves specific theoretical problems of an engineering nature, while the applied mathematician tries to generalize these problems by studying their mathematical structure. In the same way, academic chemical engineering research should rarely deal with specific chemical process developments, but instead should be concerned with basic principles and generalizations of industrial and societal problems. To the extent that this connection is lost, to that extent the research tends to become isolated and sterile.

What can be done to bridge the gap? Clearly, new and more effective means of communication must be set up. One avenue which has not been fully exploited in chemical engineering is the specialist conference, dealing with a particular area of technical interest, and usually lasting several days. These should feature leading contributors, both academic and industrial, to the field, and the program should allow for a thorough review and discussion of current aspects and future goals. The Gordon Research Conferences and the Engineering Foundation Conferences are examples of useful specialist conferences, but the central areas of chemical engineering have rarely been touched. A considerable expansion of these specialized conferences, designed on a regular and periodic basis to attract participants, both academic and industrial, on an international basis, would be most helpful in providing a forum for concerned research and design persons from both sides of the fence to get together in a critical and constructive fashion.

It may also be that a new type of journal or newsletter should be initiated, in order to bring the methods and results of current chemical engineering research to both industrial and academic readers in understandable, uncomplicated language.

Finally, one should not lose sight of the fact that academic research should be relevant, not solely to the needs of industry, but basically to those of society, which supports it through tax dollars. The engineer has a responsibility to consider, therefore, the social consequences of his work, and insofar as he can, to guide it in a direction which will add to, rather than subtract from, the sum total of human happiness.

from our READERS

CORCORAN SPEAKS OUT

Sir: In response to your Editorial (Winter 1971) I must agree with your statement that papers published in *CEE* would not have been published in *CEP*.

The whole rationale of the development of *CEE* was that papers of the type you have been publishing were not being published. Now that you have done this successfully, the obvious conclusion is that these papers should have been published in the past elsewhere. That is not sufficient reason as far as I am personally concerned to discontinue *CEE*.

If everyone agrees that the publishing of the papers of the type you have published is a good idea, either there should be more support from AIChE for the program, or AIChE taking over the program in its present form, or rearrangement of the plans for *CEP* to include papers like the ones you have been presenting. My personal feeling is that *CEP* and *CEE* are complementary and do not interfere with each other.

I hope that there will be an opportunity to continue *CEE* with its present focus. One way to enhance its impact is, like you say, to be sure that all people who are concerned with chemical engineering know that it exists. I do not believe that is the case with many of the industrial engineers at the present time. Those that have seen the magazine, in my opinion, have been very interested in reading it subsequently. We need to get the magazine before those people. That is one of our major problems at the moment.

Wm. H. Corcoran
California Institute of Technology

Editor's note: We appreciate this and similar indications of support that we have received.

MIT SUMMER PROGRAM

Sir: The following is a short announcement of a summer program at Massachusetts Institute of Technology, June 22 through July 1, 1971, on "NEW DEVELOPMENTS IN MODELING, SIMULATION, AND OPTIMIZATION OF CHEMICAL PROCESSES".

This special summer program will present basic principles necessary to understand and apply new techniques for computer-aided design and control of industrial-scale chemical processes. Topics to be covered include steady-state process stimulation, optimization techniques, unsteady-state process simulation, computer-oriented methods for estimation and correlation of physical properties, and comprehensive problem-oriented computing systems for chemical process design. Contact: Director of the Summer Session M. I. T., Room E19-356 Cambridge, Massachusetts 02139.

L. B. Evans
Massachusetts Institute of Technology.

"PRE-BIRDIAN" THROWBACKS

Sir: Since the advent of Transport Phenomena, the chemical engineer has become increasingly aware of the proper use of conservation laws in the lumped and distributed parameter simulation of physical systems. Coupled with the computer revolution, the chemical engineer has, for the first time, really begun to look at the variability in the system parameters as a means of increasing the validity of the simulation. A classic example of this trend is in the use of the temperature variable heat capacity term in the analysis of unsteady-state stirred tank processes. Despite the ready availability of transport-oriented textbooks, we still see some throwbacks to "pre-Birdian" methods of analysis when faced with the problem of what to do with the variable parameter terms. There is hardly a chemical engineering textbook on the market today, with the exception of Aris' new chemical reactor analysis book, which has not in some way erroneously incorporated the variable heat capacity term into the unsteady-state thermal energy balance. Should the variable heat capacity term be inside or outside of the temperature derivative term in the energy balance? We wish to pin-point the origin of the question by referring to an example from Himmelblau and Bischoff, "Process Analysis and Simulation," page 30, Example 2.5-1, 1968. We would like to make it abundantly clear that this example from Himmelblau and Bischoff in no way detracts from their otherwise excellent textbook. Their example 2.5.1, page 30, is only slightly in error. It is the things not said that are of great consequence in the general use of their example problem for variable heat capacity cases. To ease the burden of the presentation, we shall use their nomenclature exclusively and commence our derivation using their equations (a) and (b), page 30, Thus,

$$\frac{dm_t}{dt} = (\rho v S)_{in} \qquad (a)$$

$$\frac{dE_t}{dt} = \left[(\hat{U} + p\hat{V} + \hat{K})\rho v S\right]_{in} \qquad (b)$$

By letting $\hat{K} = 0$, $E_t = U_t$, and $(\rho v S)_{in} = w_i$, equations (a) and (b) become:

$$\frac{dm_t}{dt} = w_i \; ; \; m_t(0) = 0 \qquad (a^1)$$

$$\frac{dU_t}{dt} = (\hat{U}_i + p\hat{V}_i)w_i \; ; \; T_t(0) = T_i \qquad (b^1)$$

The initial condition in equation (b^1) reflects the idea that the walls of the tank are radiating at T_i, initially. The walls have no heat capacity. Basically, the system equations (a^1) and (b^1) describe the unsteady-state filling of an insulated evacuated tank with helium gas. Equation (a^1) represents the unsteady-state mass balance and equation (b^1) describes the unsteady-state thermal energy balance. The thermodynamic system is the mass of helium gas in the tank at any time. The system boundary is the wetted surface of the tank.

The reference temperatures are rarely needed explicitly in a derivation of this kind. At any time,

$$\frac{dm_t\hat{U}_t}{dt} = w_i\hat{U}_i + w_i p\hat{V}_i \qquad (c)$$

Using equation (a^1), we can unfold equation (c) into

$$m_t \frac{d\hat{U}_t}{dt} = w_i(\hat{U}_i - \hat{U}_t) + w_i p\hat{V}_i \qquad (d)$$

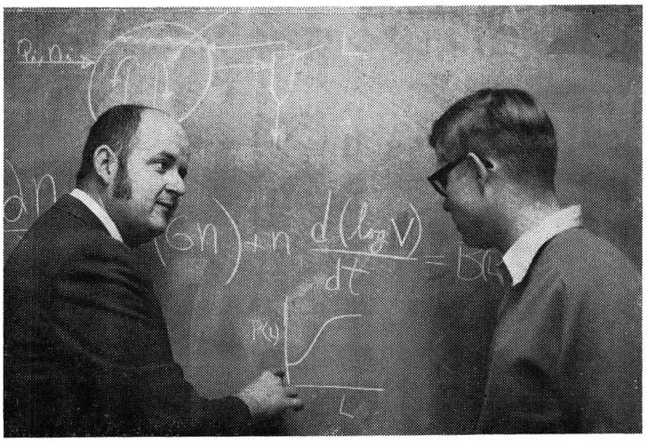
The term $p\hat{V}_i$ is given for an ideal gas by

$$p\hat{V}_i = \frac{RT_i}{(M.W.)} \qquad (e)$$

Therefore, equation (d) becomes

$$m_t \frac{d\hat{U}_t}{dt} = w_i \int_t^i d\hat{U} + w_i \frac{RT_i}{(M.W.)} \qquad (f)$$

(Continued on page 66)



A fine point in particle classification is discussed with graduate student Eric Nuttall.

Florida and after 1968, at the University of Arizona, he has expanded his interests in particle systems to include grinding, biological and dispersed phase populations.

Alan has found that the two elements of research, experimentation and theoretical formulation, reinforce each other. One element for a time will lead the other, and then their relative positions will reverse. For instance, the theory first indicates what particle dynamics phenomena needs to be measured, *e.g.* nucleation and growth rate kinetics, particle breakage, particle classification, etc. Experimental data are then analyzed using the general CSD theory to back-out and correlate these empirical particle dynamics functions. Then, with numerical values and/or reasonable empiricisms representing such particle kinetics, the mathematical theory is utilized in overall computer simulations to predict the behavior of large complicated systems that cannot be studied directly. In this phase, CSD theory leads experimental kinetics and motivates further refinement of experimental measurements.

From the previous discussion, Alan's involvement in the academic world would appear to be totally one of a researcher. Actually, he has equally involved himself in teaching at both the graduate and undergraduate levels. He teaches such courses as transport phenomena, process control, unit operations, process dynamics, and a special topics course in particulate systems. He has been able to bring to these the same balance that he has displayed in his research. In his area of specialization, together with Dr. Larson of Iowa State University, he has written a book that can be used as a graduate text in courses concerned with crystallization in particular and particulate processes in general.

. . . no student should go through to the PhD without the awareness of how theoretical models are tested and their necessary relationship to the real world.

This balance between experiment and theory has amplified a similar balance in the Chemical Engineering Department at the University of Arizona. The department has concentrated on teaching computational theory, methods, and techniques by utilizing transport phenomena, unit operations, process control, thermodynamics, etc. The desired end result is a capability to design chemical engineering processes and equipment, and to analyze chemical engineering data to understand a given process. The effective chemical engineer must have a sound grasp of theory plus an appreciation of the experimental process to gain these ends. In this regard, the faculty at the U of A feels strongly that every PhD candidate should have some experience in the planning or execution of an experimental program at least once during his graduate career. Such experience can come at the MS level or in gathering and organizing experimental data taken by others, *e.g.* data made available by an industrial organization or in a previous experimental study by another student. The U of A faculty's main concern in this area is that no student go through to the PhD without awareness of how theoretical models are tested and their necessary relationship to the real world.

LETTERS (con't from p. 57)

It is a well know thermodynamic principle that for a single component, nonreacting, single phase, ideal gas system in a state of quasi-equilibrium, that

$$d\hat{U} = \hat{C}_v(T)dT \qquad (g)$$

where $\hat{C}_v(T)$ is the heat capacity at constant volume per unit mass. Usually, $\hat{C}_v(T) = a + bT + CT^2 + - - -$.

Combining equations (f) and (g) yields

$$m_t \hat{C}_v(T) \frac{dT_t}{dt} = w_i \int_{T_t}^{T_i} \hat{C}_v(T)dT + w_i \frac{RT_i}{(M.W.)} \qquad (h)$$

At this juncture, it is possible to effect a simplification by letting $\hat{C}_v(T)$ be a constant. Thus,

$$m_t \hat{C}_v \frac{dT_t}{dt} = w_i \hat{C}_v \left[T_i - T_t\right] + \frac{w_i RT_i}{(M.W.)} \qquad (i)$$

which is the same as equation (b) of Himmelblau and Bischoff.

Now the reoccuring error associated with problems of this kind is simply the fact that $C_v(T)$ is and should remain outside, not inside, of the time derivative term

(Continued on page 71)

4. THE STUDENTS MAY ACQUIRE A "PSYCHOLOGICAL SET." By just following the organization and development of a topic rather than being involved in such a formulation, they may get into the habit of saying yes . . . that makes sense . . . of course . . . etc. without really understanding the development. They may say, "Yes, I see," when they don't really "see." This process can lead to a false sense of security in the student—and potential disaster at exam time.

SUMMARY

Like most things, semi-notes turn out to be a mixed blessing. With careful use and an awareness of their shortcomings they can be a very useful tool in teaching. The main advantages stem from the fact that:

- The instructor must organize his presentation.
- The students must become involved with the presentation.
- The students like the notes and appreciate them.

The major disadvantages of semi-notes seems to lie in presenting to the student a well-organized and seemingly simple explanation. If the student accepts the logic unquestioningly, he may learn little. Learning is an intensely personal experience—the result of a struggle of each individual with himself, and a special effort must be made to get the student involved in that struggle, thereby making the notes as effective as possible.

The role of the teacher is often likened to that of a guide. But what person would pay good money to hire a hunting guide who invariably said, "Come and watch me hunt." A person who hires a guide wants that guide to take him to where the game may be found, to give him some pointers on technique, but not to down the game for him.

Here, then, is the challenge of effective use of semi-notes: to lead the student to and through the subject and not cheat him of the fun of bagging the game himself. Semi-notes will work. They will work well within the framework of the existing lecture format. The challenge is to keep them working for the student and not to let them work against the best interests of his education.

LITERATURE CITED

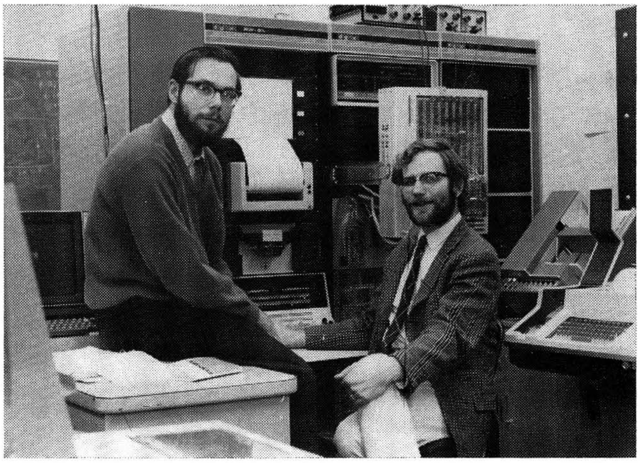
1. Bloom, B. "Taxonomy of Educational Objectives: Cognitive Domain," McKay, New York, 1963.
2. Zumwalt, G. W. "SEMI NOTES: An Aid for the Engineering Lecture," Journal of Engineering Education, 54(5), 182 (1964).

ADDENDUM—WINTER CEE

The following picture and biographies, recently received, are of the authors of "A Facility for Education in Real-Time Computing" CEE, 5, No. 1, p. 30-32 (1971).

James H. Christensen (right) is Assistant Professor of Chemical Engineering, and of Information and Computing Science, at the University of Oklahoma. He received his PhD in Chemical Engineering from the University of Wisconsin in 1967, and was a Ford Foundation Fellow in Engineering Design at Thayer School of Engineering at Dartmouth prior to moving to Oklahoma in July 1968. His main interests are in the application of digital computers to chemical process design, optimization, and control.

Paul M. Vargo (left) received his PhD from Case-Western Reserve University in 1969. During the last 2 years, while a faculty member of the Electrical Engineering School, University of Oklahoma, his activities have included developing a Real-Time Computer System to support education and research activities and initiating a research project exploring Man-Computer Communication.



LETTERS
(Cont'd from p. 66)

in equation (h) even if it is a variable. One usually sees various authors attempt to write, incorrectly, the identity

$$\frac{d\left[m_t \hat{C}_v(t) T_t\right]}{dt} = \frac{d(m_t \hat{U}_t)}{dt} \qquad (j)$$

using reference temperatures and other gimmicks. The right-hand-side of equation (j) correctly accounts for unsteady-state internal energy changes but the left-hand-side is pure nonsense. To the unitiated, the l.h.s. of equation (j) is, indeed, tempting.

The stirred-tank, energy design equations on page 4-23 of *Perry's Handbook,* 4th Ed. are in error.

Burton Davidson
Rutgers University