ChE classroom

An Interdisciplinary Course

STOICHIOMETRY OF A CITY

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DURING THE FALL terms of 1970 and 1971 we have offered an undergraduate course which is described as follows in the course catalog:

> **E&AS 93a, MATERIAL AND ENERGY BALANCES IN A CITY.**
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> **The city will be considered as a chemical process. A materials flowsheet of input items (water, air, food, fuels, etc.) and output items (water-borne wastes, airborne wastes, solid wastes, etc.) will be developed by the class and used as the basis for calculating the energy balance. The engineering and economic aspects of this view of a city will be discussed and applied to the evaluation of some present and alternative technological practices affecting cities. Open to juniors and seniors with Chemistry 10a and 15b, this course is intended for students whose interests are not primarily technical.**

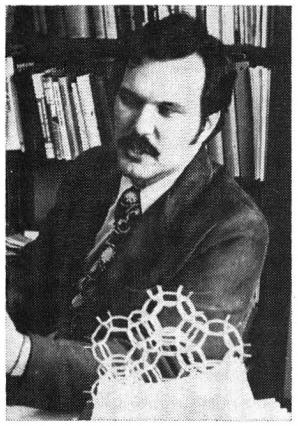
The course met for two 75-minute sessions per week. Class discussions were devoted to the principles of the stoichiometry of combustion processes, basic thermodynamics relating to energy conversion, and some basic principles of the quality control and chemistry of water and air. The American Chemical Society's "Cleaning Our Environment: The Chemical Basis for Action" served as a textbook and was supplemented by various government bulletins and articles from periodicals. Each student in the course was expected to be responsible for acquiring some of the data needed for the flowsheet, to participate in the calculations leading to the flowsheet, and to write a term paper on some topic related to urban environmental quality control.

During the two terms that the course has been offered it attracted a total of about 35 students. Interestingly, nearly half of them were majors in engineering and applied science who apparently wanted a view of engineering in a rather direct and practical problem involving a host of political, social, emotional and economic considerations. The rest of the students came from various majors in Yale College. Most of the students seemed particularly interested in the details of how processes and devices work. Teaching a class of this composition presents some interesting challenges for teachers of engineering. (If such a course were offered in a school where it attracted a larger enrollment it might be advisable to have two instructors, one an engineer and the other an economist or political scientist or sociologist.)

It was interesting indeed to hear students recount their experiences in acquiring data when they presented their results in class for use by other students and for comments and criticism. Their visits to wholesale food markets, the water company, fuel distributors, the power plant, a sewage treatment plant, the refuse incinerator, junk yards, etc., represented new experiences for most of them. The combination of one such site visit, reports of other students, and the calculation of a flowsheet has one very important result. Even the most starry-eyed environmentalists begin to recognize the magnitude of the efforts that will be required for significant improvements in the quality of urban environments. Furthermore, it is to be hoped that they learn that getting the facts in order is a good way to approach any problem.

THERE HAS BEEN another interesting result of the course, one which was not really expected. Various New Haven City agencies and environmental action groups have requested copies of the final report and seem to be finding the flowsheet useful for orientation to urban environmental problems.

There is, however, a significant flaw in a course of this type. It is an interesting course to be involved in the first time it is offered because



Professor Walker received his BS and MS degrees in Chemical Engineering from the University of Texas and his DEng degree from Yale. A member of the Yale faculty for 30 years, he has had continuing responsibilities in chemical engineering and has also served as a residential college master, director of an undergraduate major in combined sciences, and staff member in Yale's Institution for Social and Policy Studies. He is currently Chairman of the American Chemical Society's Petroleum Research Fund Advisory Board. (right)

W. N. Delgass did his doctoral work at Stanford University under Professor Michel Boudart. He joined the Yale Faculty as an Assistant Professor in 1969 after a postdoctoral year at the University of California, Berkeley. His principal research interest is the study of heterogeneous catalysis by Mössbauer and X-ray photoelectron spectroscopy. (left photo)

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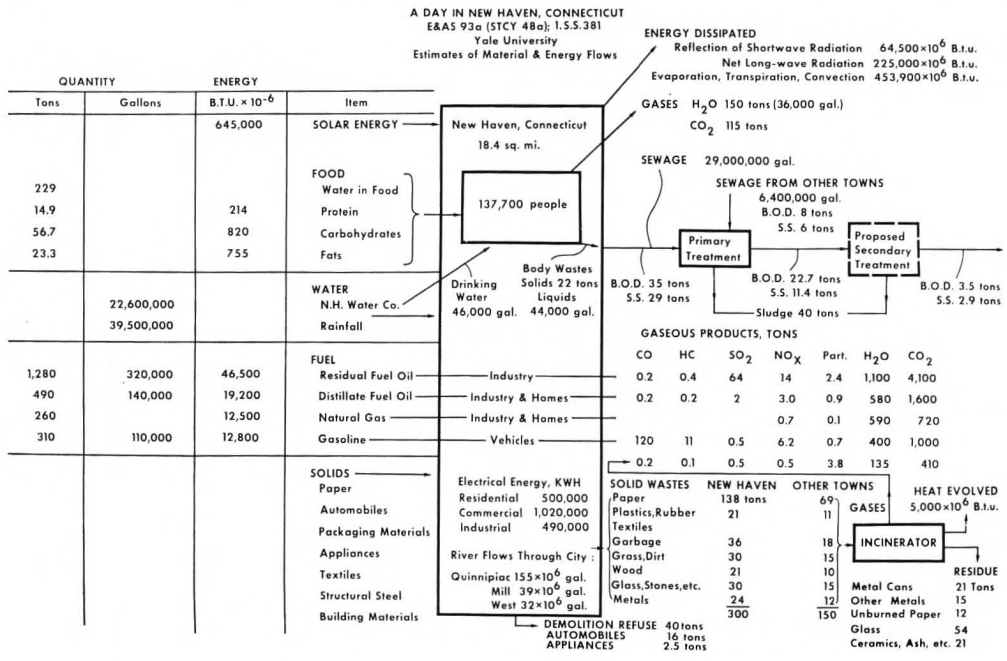
there is a sense of anticipation as to how the flowsheet will look. The second time it is offered there is an opportunity to improve the quality of the data and to include factors not considered by the first group of students. This can continue, of course, by considering variations in time and and space rather than just the steady state and perhaps by using a computer to handle a more detailed model. Such approaches are entirely feasible if a class consists primarily of students in engineering and science, but the course would not then be expected to attract a general audience. Another approach would be simply to use the flowsheet developed by the first groups in the course as a basis for a course and substitute plant visits and problems for the original data collection and calculation activities. Such a course could be readily developed into an interesting Introduction to Chemical Engineering. It is not intended to offer E&AS 93a again at Yale because a new sequence of three term courses in environmental quality control is becoming available in 1972 - 73.

REACTION TO THE course is indicated by the following critique prepared by students on the basis of the 1970 course, when it was taught by C.A.W. A critique of the 1971 course, taught by W.N.D., is not yet available. It is expected by C.A.W. to be kinder; W.N.D. won't commit himself on this matter.

E&AS 93a set out to analyze the city as a chemical process. This new and comprehensive view of a city's energy and material demands tries to tie together a



number of diverse subjects. Although a great deal of interesting material was presented, the goal of an overall perspective was never fully reached.

Much of the course dealt with the waste products of an industrial city and the technology available to remove them. Mr. Walker had to deliver his lectures to a class with backgrounds ranging from a little high school chemistry to a major in science; he handled this problem remarkably well. The lectures were generally informative and frequently very interesting, particularly when he included anecdotes from his personal experience. However, several classes weekly would have been more appropriate than the single two-hour class session.

The readings were a source of added information but did not play a major role in the course. Of greater importance was the gathering of data on inputs and outputs of the city. Small groups were responsible for each area. Toward the end of the term, each group assembled a flow sheet of the data. This was the goal of the course, but its importance seems to have been lost along the way. Ultimately, therefore, the term paper represented most of the work in the course. It gave an opportunity to look deeply at one specific area of a city and its material problems. Despite a knowledgeable and interesting lecturer and an important subject, the course never really pulled the loose ends together.

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It seems clear that creating the flow sheet at the start would have given the class the needed perspective. This would have provided a much better context in which to judge the different economic and technological alternatives open to a city. The course was an ambitious experiment that met with some success. With better structuring and more rigor, it could be outstanding.

Several of the suggestions made by the students were adopted when the course was offered for the second time.

Further details on data and calculations are available from the author.

ACKNOWLEDGMENT

The flowsheet shown here was developed by two graduate students, John Pestle of Yale and Laurence Walker of M.I.T., during the summer of 1971 after some additional information became available. It is quite similar to the flowsheet developed by undergraduates in the fall term of 1970. □

ChE book reviews

Polymer Science and Engineering, D. J. Williams, Prentice-Hall, Englewood Cliffs, N.J. (1972), 401 pp.

One of the peculiar difficulties in writing an introductory textbook on polymers is the diversity of subjects to be covered, each built upon distinctly separate fields of science. Thus, the subject of polymerization has its roots in the reactions and structural analysis of organic chemistry, solution behavior in regular solution theory, rubber elasticity theory in statistical mechanics, polymer morphology and properties in the techniques of solid state physics and rheology in continuum mechanics. Scattered throughout are various applications of probability theory, and superimposed is the need to relate these principles to the practical properties of polymer systems. No single undergraduate curriculum does justice to more than a fraction of these fields. If a book of reasonable length is to be aimed at both chemical engineers and materials scientists, it becomes necessary to compromise, either by including brief introductions to the fields and showing how they apply to polymers, or by leaving out some subjects entirely and concentrating on the relationships between those aspects which are retained. In the former there tends to be oversimplification and a loss of coherence among the parts; in the latter the result is less than a comprehensive coverage.

Dr. Williams has chosen to follow the second course, and has done so rather successfully. The book is intended for seniors and beginning graduate students in chemistry, chemical engineering and materials science. It opens with an extended

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