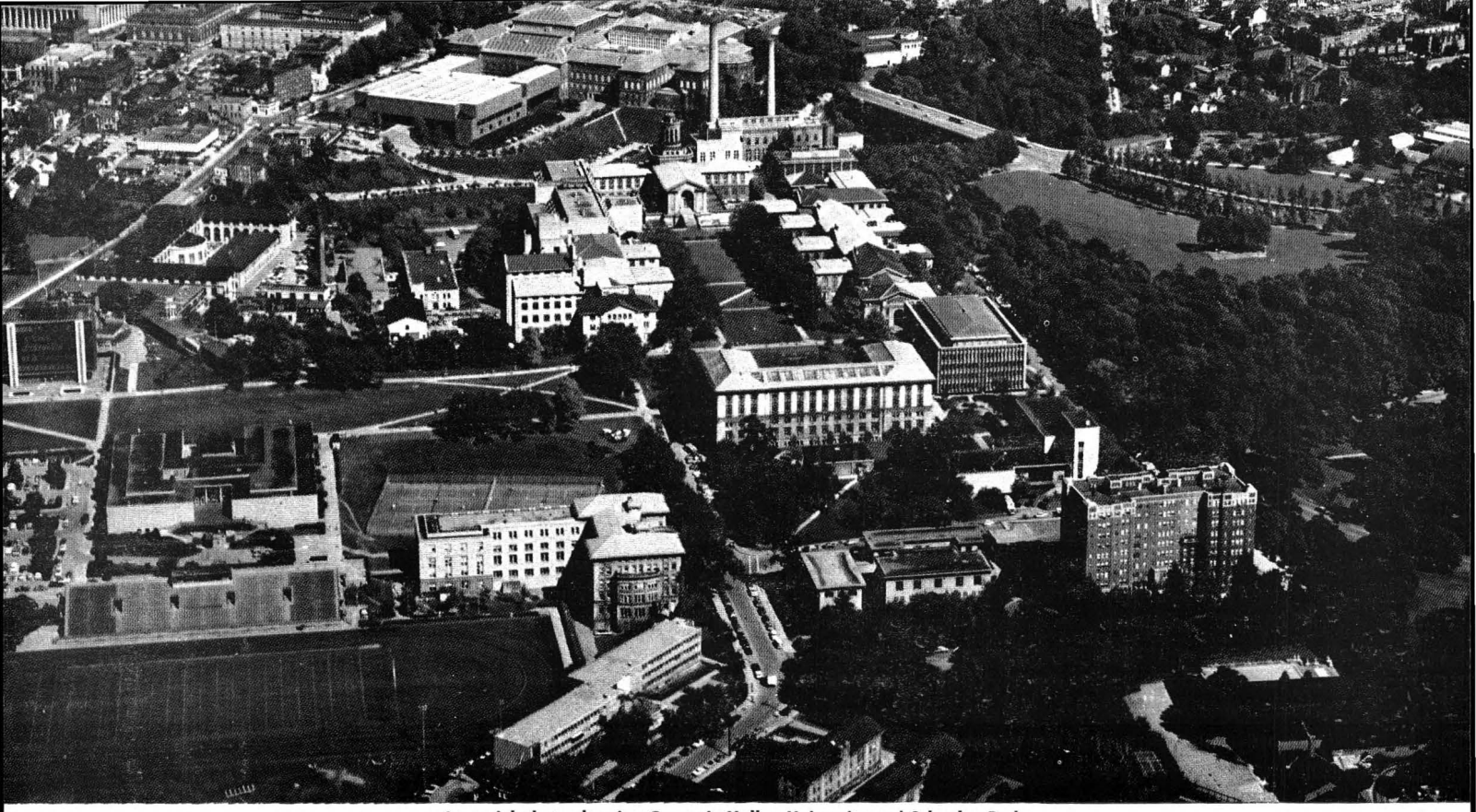

An aerial photo showing Carnegie-Mellon University and Schenley Park.

ChE department

CARNEGIE - MELLON

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IN JUNE OF 1974, I was headed for Pittsburgh to attend a national AIChE meeting. On my only previous trip, I flew to Pittsburgh at night to interview for a position as Assistant Professor with the Department of Chemical Engineering at Carnegie-Mellon University (CMU). But this was my first trip by car and I did some exploring. I found that the absence of any regular pattern of streets and the scarcity of signs made driving in Pittsburgh an adventure. The hills of the city create such a turmoil in the network of roads that Fifth Avenue intersects Sixth Avenue.

Once I found it, Carnegie-Mellon's 100-acre campus turned out to be remarkably spacious for an urban university with only 4500 students and 450 faculty. That commodious feeling is enhanced by neighboring Schenley Park whose 500 acres include hiking trails, a golf course, tennis courts and a skating rink. On the academic side, I was pleasantly surprised to discover an outstanding College of Fine Arts here. Drama has been quite successful, with two student productions—"Godspell" and "Pippin"—becoming well known on Broadway. Other major strengths of Carnegie-Mellon University are the Graduate School of Industrial Administration (GSIA), the Computer Science Program, and the Engineering College. All are nationally recognized. Herb Toor, a former Head of Chemical Engineering, ably leads the Engineering College as its current Dean.

GSIA gained its reputation by emphasizing the use of modern mathematics, behavior sciences, and orderly analytical problem-solving in managerial decision-making. President Richard M. Cyert, a former dean of GSIA, has successfully applied these concepts to transform the University's financial state into one of fiscal health: the University is run without deficits. In this era of a nation-

wide decline in college enrollments, it is important for a university to have good fiscal management.

GENERAL ATMOSPHERE

BUT I BECAME MOST enthusiastic about that segment of the university with which I am most familiar: the Department of Chemical Engineering. It is a dynamic place, with continuous and productive activity. Such activity is possible both because of superior people, and because of good relations among the faculty and between faculty and students.

Tom Fort, as Head of the Department, deserves much of the credit for generating and maintaining that atmosphere. In spite of many time-consuming administrative chores, he maintains an open-door policy in his relations with both faculty and students: he will listen to any and all problems. Knowing the talents of each of the faculty, Tom applies his administrative influence to help each of us to make the most of our talent. Finally, the Department is run in a democratic manner: each of the faculty is polled before a decision is made on a matter of substance. Such policies permit good relations among faculty and promote productivity.

Good relations are also enhanced by the Friday happy-hours organized by the graduate students. The proceeds from a soft-drink machine operated by the students are used to buy beer which is then made available, free, to all. These well-attended weekly events are held in the department's graduate student lounge (ignored by the University) which contains a pool table, a fooze-ball table, a TV-Pong game, and the daily *New York Times*, all obtained from vending machine proceeds.

Prof. Cussler answered a knock at the door of his office only to be greeted by a shaving cream pie in the face, which was prepared by a group of students to celebrate his birthday.

Besides the formal weekly departmental seminars at which researchers from outside the University are invited to speak, several internal seminar programs have been organized. One of these is the biweekly "zoo meeting," in which graduate students and postdoctoral researchers in the programs directed by Ed Cussler or Fennell Evans get together to discuss recent findings. On alternate weeks, another informal seminar meets. The latter program, organized by John Anderson, involves more than half the faculty in the Department and their graduate students as well as a few from other departments. Topics generally pertain to interfacial phenomena or preparation and behavior of hydrosols. Some of the talks are reviews or tutorials, but the main purpose of these seminars is to convey freshly obtained information and to gather criticism regarding the proposed interpretation. A third group, organized by Art Westerberg and Gary Powers, meets regularly to discuss problems related to computer-aided design. These informal seminars provide a means for broadening perspectives on problems which are incompletely solved. The resulting interplay of ideas has a synergistic effect, causing the total research output of the Department to be greater than the sum of contributions possible from isolated individuals.

Simultaneous collisions in many-body systems are possible. This photo records one such event in which all the faculty of the ChE Department were recently found in the same place at the same time. Seated (left to right): Kun Li, Bob Rothfus, Tom Fort, Steve Rosen, and Ed Cussler. Standing are Gary Powers, Rosemary Frollini, Clarence Miller, Ethel Casassa, John Zondlo, Dennis Prieve, Fennell Evans, Eric Suuberg, Tony Dent, Mike Massey, John Anderson, Howard Gerhart, and Art Westerberg.

It is, sir, as I have said,

a small college, and yet
there are those who love it.

——Daniel Webster
(1818)

All Souls College, Oxford, planned better than it knew when it limited the number of its undergraduates to four; four is exacly the right number for any college which is really intent on getting results.

——Albert Jay Nock
(1943)

While these words were written about other schools, they echo a sentiment which has always been held at Carnegie-Mellon University. Although a university must be large enough to accommodate the diversity of its students' interests, it should remain small enough to be personal. Close personal relations between faculty and students have existed since the beginning, as illustrated in the following recollections by Mr. Frederick L. Koethen, who enrolled in the first class at (then) Carnegie Tech in 1905:

After things at Tech had become organized, Director and Mrs. Hamerschlag took a trip to Europe. We knew about this trip and, when we learned they were due back in Pittsburgh, some of the boys went to the station, removed the two horses from an open passenger rig, and attached two ropes to the vehicle. A crowd of students provided ample motor power for a triumphal tour of Oakland. It was a sincere expression of the respect and admiration they had for their leader. They did not have a mass meeting to build up enthusiasm for the stunt. It was not necessary.

Dr. Herbert F. Sills was frequently late to give his chemistry lectures at one o'clock. We finally told him that the next time he was late, we were going to the baseball game. It was a temptation to us because Forbes Field was very close. It was new and the Pirates in the National League were playing championship ball. The next time he was late came very soon. We were walking over the Panther Hollow bridge toward Forbes Field when we met Dr. Sills. We told him to turn around, which he did, then bought his own ticket and enjoyed the game with us. That was not the approved way to "run a railroad" or any other organization but the later lectures of Dr. Sills did seem to come across better, being given by a friend.

Since that first class of 200 students in 1905, enrollment at CMU has climbed to the current 4500. Now the Department of Chemical Engineering alone has more undergraduates (a total of about 300) than the entire school had in Mr. Koethen's time. There are also 80 full-time and 45 part-time graduate students, together with seven postdoctoral fellows.

PERSONAL TOUCH CONTINUES

YET THE PERSONAL touch has not been forgotten. Episodes like those quoted above still occur. For example, last year Kun Li and Steve Rosen each taught one section of a course entitled "Analysis, Synthesis, and Evaluation," which is required of all engineering sophomores and emphasizes creative engineering. One part of the course involved a project on how to make use of the rubber in worn-out automobile tires. One morning, near the end of that part of the course, Profs. Li and Rosen each found awards for their efforts outside their office doors. They were halves of a worn-out tire, cut diagonally, each of which bore an inscription. Kun's read

Good year, Dr. Li,
We're tired of your course,
We shed a tear* for the souls next year.

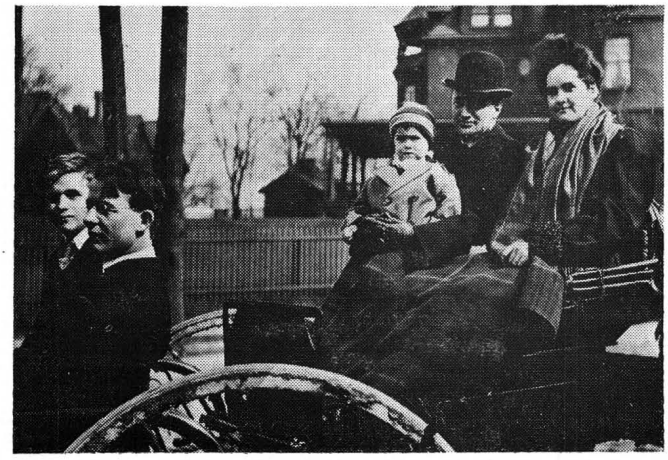
while Steve's said

Don't tread on us, Dr. Rosen,
We never promised you a Rosen garden,
Spare us.

The students had come up with a solution to the problem that had never occurred to their teachers.

On another occasion, Ed Cussler returned to his office to find a large part of it occupied by a fully inflated weather balloon. Then there was the time when Prof. Cussler answered a knock at the door of his office only to be greeted by a shaving-cream pie in the face, which was prepared by a group of graduate students to celebrate his birthday. Considerable speculation followed about what would have happened if a visiting professor, who was in the office at the time, had answered the door instead.

To cope with the increasing numbers of stu-



Director and Mrs. Hamerschlag are welcomed back from an European trip (1905) by students who pulled their carriage on a tour through Oakland as a stunt.

Another recent educational development in the Department is the New Alternatives Program, which was designed to give master's-level training in ChE to technically oriented students whose bachelor's degree is not in ChE

*An allusion to University Professor Dick Teare, who also taught part of the course.

dents, we have increased the number of faculty members by three since I arrived, and have broken core courses into multiple sections. However, none of the lecture or recitation sections is taught by a graduate student. One of the new faculty members is John Zondlo, who is a full-time instructor in charge of the three undergraduate lab courses. Prof. Zondlo takes care of the daily operation of the lab, including a total refurbishment of the facilities during last summer, daily maintenance of the equipment, and setting up the schedule of experiments. The rest of the faculty equally share the responsibility of explaining experiments to students, deciding on any modifications to existing apparatus, and grading the lab reports, with about two or three experiments assigned to each faculty member.

An educational development, which occurred here several years ago, was the organization of the Colloids, Polymers, and Surfaces Program (CPS). It grew out of an expression of need by local industries for graduate-level training of some of their employees in these specialized areas. Since there were several faculty members here who had research interests in these subjects, Fennell Evans took on the task of organizing a joint program with the Chemistry Department which leads to a nonthesis Master's degree in CPS. Besides a core of lecture courses, students are required to complete eight credits of a special laboratory course taught by Ethel Casassa. Students get individual instruction on a variety of research-oriented instruments. All these instruments are also available to other students in chemistry or chemical engineering who may need them for their thesis research. While the CPS program was designed for students who hold full-time jobs in local industry, a number of regular graduate students have elected either some of the lecture courses or a joint ChE-CPS Master's degree, which requires a thesis

An educational development, which occurred here several years ago, was the organization of the Colloids, Polymers, and Surfaces Program (CPS).

Because of the interest and favorable reaction from industry, plans are underway to teach some of the material in the CPS program to undergraduates in ChE. Fundamentals of colloids, polymers and surfaces will be taught in new lecture courses with applications to conventional unit operations such as polymer processing and solid/liquid separations. Again, a laboratory course will be included in the curriculum to illustrate the principles.

Another recent educational development in the Department is the New Alternatives Program, which was designed to give master's-level training in ChE to technically oriented students whose bachelor's degree is not in ChE. Students in the program are given an intensive course during the summer, complete with laboratory experiments, which covers undergraduate ChE principles. Upon successful completion of the summer program, they are admitted to the regular master's degree program, where they compete with other ChE students in both courses and the comprehensive written exam given to all graduate students. Details of this program have been previously published (CEE *11*, 176 (1977)).

DEPARTMENTAL RESEARCH

ALL FACULTY IN the Department are actively involved in research. Topics are generally related to energy, biochemical engineering, colloids, polymers, surfaces, or computer-aided design. Some of the projects involve the development of large-scale equipment, such as the coal-gasification work by Mike Massey or the development of heat exchangers for the ocean-thermal energy conversion (OTEC) plant by Bob Rothfus. Both of these industrial-scale projects involve a number of

Ethel Casassa, giving instructions to students in the CPS lab on the technique for operating a pressure-filter to remove dust from solutions used in light-scattering experiments.

These informal seminars provide a means for broadening perspectives on problems which are incompletely solved. The resulting interplay of ideas has a synerqistic effect, causing the total research output of the department to be greater than the sum of contributions possible from isolated individuals.

faculty from several departments. Eric Suuberg also conducts energy-related research in coal pyrolysis.

Clarence Miller and Tom Fort are currently studying systems where surfactants lower interfacial tensions between oil and water. One major application is in tertiary oil-recovery, where surfactant flooding is used to increase the amount of oil obtained from wells. Prof. Miller is also interested in spreading of liquids on rough surfaces and other interfacial phenomena. Gas adsorption and surface chemistry are also of interest to Prof. Miller and, separately, to Tony Dent, whose research focuses on heterogeneous catalysis. Other studies of kinetics of gas-solid reactions are preformed by Kun Li, who worked for a local steel manufacturer before joining CMU. As a result, his particular subject is iron-ore reduction, where he has some fascinating electronmicrographs showing reduced-iron whiskers growing out of the oxide. Why, he asks, does reduction occur in this manner?

Kun Li and Bob Rothfus also have an interest in fine particle technology. Their most recent joint venture was to study the coagulation of iron-oxide particles in water by the addition of alum. Thus, Prof. Li provides a link between the gas/solid interface people and the liquid/solid interface people.

John Anderson's research concerns hindered diffusion of hydrosols and macromolecules in pores, together with electrokinetic effects which result from the charge on all solid/aqueous interfaces. Examples of hydrosols (a phase which is finely dispersed in water) include latex paints, waste-water sludge, milk and most other foodstuffs, as well as blood cells and globular proteins. Prof. Anderson's work overlaps with mine, which is the transport of hydrosols. Because of their finite size and electrostatic charge, colloidal particles behave differently from molecular solutes. I am currently applying my approach to the deposition of latex films on steel surfaces. On the other hand, Prof. Anderson's work is applicable to the transport of large solutes through porous membranes as well as the catalyzed reaction of macromolecules in liquid-filled pores.

Additional studies on transport of molecular or ionic solutes through biological membranes are conducted by Ed Cussler and Fennell Evans. They attempt to explain such anamolous behavior as transport of a solute in the direction of increasing concentration, or transport at a rate which is nonlinearily related to the difference in concontration across the membrane. Prof. Cussler is also concerned with solubilization kinetics and the psychophysics of texture—that is, relating what people perceive as the feel of foods to chemical and physical properties. He likes to introduce the latter subject as the "Funny Feelies" (maybe that's why some people jokingly call him Crazy Ed).

Fennell Evans is also involved with surfactants, with applications to detergency. He recently developed a surfactant-selective electrode for measuring the concentration of free surfactant molecules in the presence of aggregates of surfactant molecules known as micelles. This and other work on the behavior of electrolytes complements much of the research here on aqueous systems.

Both John Anderson and I use latex polymers as sols in our work. The mechanism for synthesizing these sols by emulsion polymerization is one of the topics of Steve Rosen's research. He is also developing an *in situ* polymerization process for stabilizing soil on which emergency shelters could be built and is studying ways to separate polymer mixtures in order to recycle the huge masses of petroleum-based polymers which are discarded as solid municipal wastes. A third project, in cooperation with Tom Fort, focuses on improved interfacial bonding in polymer-based composites.

As a Vice President of PPG Industries, Howard Gerhart was instrumental in the inception of the CPS program. After retiring from PPG in 1974, Dr. Gerhart joined CMU and organized the National Coatings Center (NCC). As a branch of Carnegie-Mellon Institute of Research (CMIR), NCC provides a national focus for both fundamental and applied research related to coatings and corrosion. Besides a full-time staff of postdoctoral researchers, who cooperate with faculty in chemistry and ChE, the NCC has access to the analystical-instrument resources of CMIR, the present counterpart of the pre-merger Mellon Institute. Dr. Gerhart and I have cooperated in several projects, including the electrophoretic and chemiphoretic (electroless) deposition of latex films on metal surfaces, and the sacrificial protection of steel against corrosion. At the NCC, Dr. Gerhart has also succeeded in developing a new polymeric material with a high refractive index for optical use.

Much of the research described above lies on an interface between ChE and some other discipline (often chemistry). However, Gary Powers and Art Westerberg are studying the use of the computer in the very traditional area of chemical process design. They cooperate, through the Design Research Center (DRC), with people in all the other engineering departments on campus, as

Continued on page 135.

significant upward trend in grade point average, which has recently been in the region of 2.8/4.0 compared with about 2.0/4.0 before the inception of the laboratory. This is not of course a true A-B comparison, but it is generally felt that the average ability of our students has not changed noticeably in recent years. Moreover, ten out of fourteen classes were taught by the author over a period of seven years, which included the transition from a lecture course to the combined lecture-laboratory course. Consistency in standards and grading were thus maintained.

From a qualitative standpoint, there has been a most definite improvement in the students' motivation and interest. The only complaint of substance concerns the lack of multiple set-ups, which results in students performing some of the experiments before the corresponding topics have been covered in the lectures. This situation is dictated by lack of facilities rather than pedagogical philosophy. Whereas students are obliged to study unfamiliar material by themselves, which is salutary to some extent, it would be more effective from the point of view of reinforcement, if multiple set-ups were available to permit parallel operation of the lectures and experiments.

Despite these shortcomings, however, the concept of reinforcing the classroom experience with short experiments has proved successful, and should be extended to other suitable courses in the curriculum, such as transport phenomena, and chemical kinetics and reactor design. □

ACKNOWLEDGMENTS

The author is grateful to many of his colleagues for helpful discussions and suggestions, and in particular to Professor Bernard D. Wood of Syracuse University, who designed the Vortex Tube and Triple Point experiments, and Professor C. William Savery of Drexel University, who designed the P-V-T experiment.

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well as with people in computer science, applied mathematics and operations research. Art is the Director of the DRC which currently has 17 members. As one cooperative project, they are developing the nonnumeric processing capability of computers to do design.

Prof. Powers is actively studying the use of fault trees, a technology growing out of the aerospace industry, to evaluate process safety and reliability. He is developing methods to synthesize and then analyze fault trees, given the process components and their interconnection. He and Prof. Westerberg are also developing process synthesis techniques. They work on such problems as total process flowsheet synthesis, reaction path synthesis (getting the computer to do chemistry), separation system synthesis, energy recovery network synthesis, and control system synthesis—in each case the idea is to get the computer into the act of suggesting alternative flowsheets. Prof. Westerberg is also working on advanced approaches for performing computer-aided process analysis coupled with optimization.

OVERALL IMPRESSIONS

WHILE CARNEGIE-MELLON University may not be all things to all people, the programs in the areas of Industrial Administration, Drama, Computer Science and Engineering are strong with an unusual emphasis on professionalism. The urban surroundings of Oakland—an area filled with parks, a wide selection of ethnic restaurants, the Carnegie Library and Museum, and Scaife Art Gallery—provide a pleasant setting in which to live and work. Within the Department of Chemical Engineering, the research interests of faculty are diverse, from the abstract to the practical. Although our size is expanding, personal contacts among faculty members, and between the faculty and students, are frequent and continuous. From those first impressions of 1974, as well as from my experience of living here for three years, I conclude that Carnegie-Mellon University, as well as Pittsburgh, is "someplace special." □

ChE news

Dr. Billy L. Crynes, professor of ChE at Oklahoma State University, has been approved to head OSU's School of Chemical Engineering. Crynes received his B.S. from Rose-Hulman Institute. His M.S. and his Ph.D. are from Purdue University.