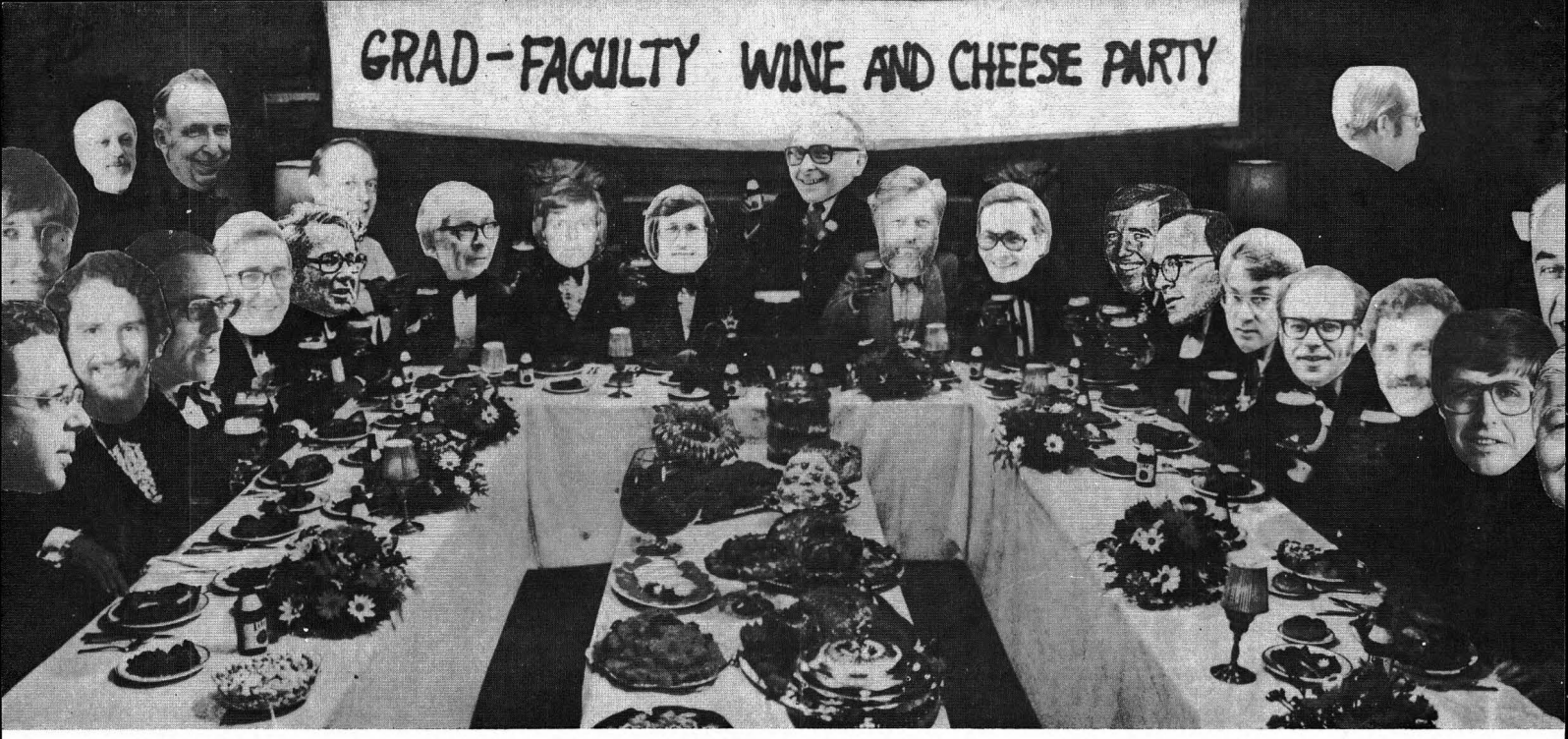

The older students provided a clue-sheet for the new students at the Fall faculty-graduate student party.

ChE department

UNIVERSITY OF MINNESOTA

RUTHERFORD ARIS
U. Minnesota
Minneapolis, MN 55455

AS EARLY AS 1902, G. B. Frankforter of the Department of Chemistry wrote to Cyrus Northrop the President of the University of Minnesota to point out

> **"the importance of offering . . . . a course of study in which both chemistry and engineering are represented. Such a source is now offered in all of the larger institutions of Germany and in nearly all of the larger Universities and technical institutions of this country.**
>
> **"What I would respectfully recommend then is, that a course of study be offered which will meet the urgent demands of the present time. I will state that I have consulted the various members of the engineering faculty concerned and the plan meets with their most hearty approval. I will also say that in offering this new course, there need not be a single dollar of additional expense to the University.**
>
> **I would also recommend that the School of Chemistry be separated from the College of Science, Literature and the Arts, in as much as the work is entirely foreign to that College. We graduate four men this year and there are some twenty members of the present Freshman class. With this new course which is sure to be popular although it is an exceedingly difficult one, we shall be quite on a par with the School of Mines.**
>
> **Very respectfully submitted,**
> **(Signed) G. B. Frankforter."**

The School of Mines has since passed away but the "new course" continues to be both "popular" and "exceedingly difficult", and what president could fail to approve a program urged with such enthusiasm and costing "not a single dollar of additional expense."!

It was not until 1919 however that the curriculum was formalized as the "Chemical Engineering Course" and what was effectively a department arose as a division of the School of Chemistry. Charles A. Mann was promoted to the rank of professor with the title of acting head of the Division of Chemical Engineering. For the time being very inadequate quarters had to be used, and no satisfactory development of the experimental phases of chemical engineering could be put into operation until the completion of the fourth wing of the Chemistry Building. In the meantime, however, every effort was made to develop a satisfactory course in chemical engineering.

Twenty years later the department was still in the bowels of the chemistry building. Montillon and Montonna had joined Mann and were the three professors, with Rogers and Stoppel as assistant professors, Grove and Piret as instructors, and Armstrong, Chamberlain, Clegg, Eldredge among the teaching assistants. B. F. Ruth had been on the faculty; Amundson, Piercy and a host of others had graduated and the curriculum now contained Unit Operations, ChE Thermodynamics, Plant Design and Economics as well as courses on Explosives, Dyestuffs, Cellulose, Gas Manufacture and Sanitary Chemistry.

Thirty years later, just after Mann's death, Ceaglske and Piret were professors, Amundson and Stoppel associate professors and Stevenson, Preckshot and Madden assistant professors. The search outside the department for a new head was unsuccessful and Amundson, who had been made Acting Head in 1949, became the Head in 1951 and the big move from the basement of Chemistry to a new building was about to begin. It was a building of some 65,000 sq. ft. designed to handle 80 seniors and 100 graduate students. Apart from some dissatisfaction with certain of the materials (walls somewhat permeable to sound, for example) the building proved satisfactory but is once again stretched at its seams with the numbers of students. Many of the details of the transfer to the new building fell to some of the new faculty who had joined the department in the late 40's, notably to George Preckshot. There have been several episodes of remodeling, including the latest one to meet OSHA's requirements but in the fiscal climate of the moment there seems little prospect of the radical reorganization that is really necessary.

In the early 50's there were about eight members of the department, Ceaglske and Piret being the professors until joined by Amundson in '51 and Stoppel in '52. Isbin had come in 1950 and soon became an associate professor, being joined in that rank by Madden and Preckshot around the middle of the decade. Tsuchiya came in 1956 to bring the total number, including Hap Earle, to nine.

The pace of research increased in the 1950's also with such outstanding graduate students as Acrivos and Lapidus. Piret attracted a number of French students. Outstanding among them was Olegh Bilous who did his Ph.D. work with Piret but also, on the side, wrote with Amundson some of the first papers on chemical reactors as dynamical systems.

During his sabbatical at Cambridge in 1954-5, Amundson not only wrote up much of this research but saw something of what could be done in a department when colleagues of diverse backgrounds are brought together and realized the potential of team teaching for developing really good cooperation. Toward the end of the decade he was able to put these ideas into effect as both numbers and research activity took off again. With Stoppel's death, but Isbin's promotion and Ranz's appointment, the tale of professors stood

. . . the department used to have a reputation for being dominantly theoretical. This was never really accurate, for there has always been a predominance of experimental programs.

at five, with three associate professors and an increasing number of assistants. Dahler, Fredrickson and Aris came in 1958 and were joined by Scriven in 1959. Edgar Piret left to be the Scientific Attaché in Paris. Davis came in 1963 and Keller in 1964 being followed in 1965, by Schmidt and Carr. These years also saw some of our outstanding graduates, such as Ramkrishna and Luss (and later Rhee and Varma), remaining for a short while as assistant professors. In 1969 there were nine professors (we avoid the neologism "full professors" as having too dyspeptic an image), three associates and three on the tenure track among a total of seven assistant professors. Of course it is not only the faculty that matter and graduates of the department probably remember best the outstanding figures of the staff: Ruth Nelson, who had everything at her finger tips or in a little 3x5 file box; Verne Nelsen, to whom the mysteries of stock and budget were as plain as day, and John Antolak without whom no experimental project got off the ground and but for whom the lab would have given up the ghost long before OSHA boxed it about with regulations.

In 1970 the Dean, disbanding the School of Mines and Metallurgy, allowed some of the more scientific types to come to chemical engineering and it became a department of Chemical Engineering and Materials Science, almost half as large again as before. The development of the department in the 1970's was governed by two considerations; namely, the need to integrate into it

the newly acquired aspect of materials science and to maintain and strengthen the standing that, by this time, the department had acquired. The area of polymers was a natural bridge between the chemical and the material ends of the operation and Macosko came in 1970, starting a very active program in polymer processing and rheology. Thomas was with us from '73 to '77 when he returned to Massachusetts, changing places with Tirrell, whose powerful progress has been recognized both internally and externally, by a Dreyfus Award and a Sloan Fellowship. Then Wellinghoff, a polymer morphologist, came to strengthen the bridge from the materials science side in 1978. Meanwhile, Gerberich had come in as a metallurgical materials scientist and Hutchinson, an electron microscopist (who had been part of the transfer of 1970) had left for the University of Washington. George Stephanopoulos came from the University of Florida to bring a great strength in the theory of design and control and was with us from 1974 to 1980, when, to our regret, he returned to Greece.

When, in 1974 (after 25 years of headship) Amundson asked to be relieved, his colleagues, much as they deplored the suggestion, could scarcely refuse. Aris was Head for four years and was succeeded by Keller in 1978. The department's magnanimity was further tested in 1980 when Keller was appointed the Academic Vice-President of the University of Minnesota and, bowing to the greater good of the greater number, we forged ahead under Davis' dynamic leadership. This brought in, in 1980, four new faculty members; two, Cussler and Evans, at a senior level and two, Jensen and Griffin, at the junior.

THE PRESENT

The continuing strength and harmony of the faculty is the final tribute to Amundson's years of building, for it survived his departure in 1976. On May 17, 1979, a date not inappropriate to one of Norweigan descent, we were able to incorporate Amundson's achievement into the permanent fabric of the University by renaming the chemical engineering building after him. As was commented at the time, there is no one in the engineering profession who should be in any doubt as to the subject taught in an Amundson Hall.

The strength of the department lies not merely in the achievement of its individual members, which has attracted the usual round of awards, but in the easy spirit of cooperation which marks it. At

This building has been named

AMUNDSON HALL

in honor of

NEAL RUSSELL AMUNDSON

for twenty-five years Head of the Department of Chemical Engineering and Materials Science and Regents' Professor of Chemical Engineering who, by his example and insistence on the highest academic standards, has built, not merely a building, but a department and has left his mark both on the University of Minnesota and on the whole profession of chemical engineering.

No one in the engineering profession would have any doubt as to the discipline taught in an Amundson Hall.

---

the graduate level this is manifested in the cooperative supervision of students, not in any regimented or organized fashion, but as the opportunity evolves naturally. We have been fortunate over the years in attracting some excellent students and this, of course, makes such cooperation easy. This team spirit is fostered at the undergraduate level by the system of team teaching. Graduate students spend the first quarter getting acquainted with the work of the different members of the department and organizing their preferences. This results in the assignment to an advisor at the beginning of the second quarter of their graduate experience and allows them to get moving on their research during the first summer. Though course work continues into the second year, the student presents a dossier showing the beginning of his or her research by the seventh quarter and faces, at this time, an oral preliminary examination on graduate course work. Beyond this the student is free to spend full time on research. The different groups of graduate students jointly or severally supervised by the faculty have different modes of operation; some meet regularly for group seminars but others work rather more individually. The general attitude is that it is the subject matter that counts and the way in which it can be developed in the intellectual context of the university.

Over the years the department has been

fortunate in its visitors and has entertained for sabbatical or other visits such persons as K. G. Denbigh, H. Kramer, E. Wicke, L. Waldmann, W. Schowalter, H. Brenner, W. Resnick, E. Rotstein, R. W. Fahien, J. Sinfelt and R. Rosensweig to name but a few. We also benefit from the adjunct professorships of not a few engineers in the Twin Cities area who come in and teach a course or take a lab with great enthusiasm and devotion, and who immensely enrich the student's experience by their industrial experience. K. J. Valentas, now the Vice-President for Engineering at Pillsbury, has taught a food engineering course for years: H. Kramer of General Mills, before his sudden death last year, had made a major contribution to the design course. Among the others, W. C. Johnson of 3M and B. Koepke of Honeywell have taught regularly as have J. Johnson, R. Minday, L. White and many more.

To summarize the scope and interests of the faculty is a difficult task and it is best to proceed alphabetically, letting the grouping and overlapping of research areas become evident as we go.

ARIS is interested in any problem that yields a significant mathematical structure and more generally in the whole question of how physical systems may be modeled intelligently. With CARR he shares an interest in continuous chromatographic reactors of rotating or counter-current design. Of course, Carr's interests in kinetics go far beyond this area of joint investigation reaching to the kinetics of reactions among species having nonequilibrium energy distributions and to multiphoton infrared photochemical reaction engineering. Atomic and radical reactions, particularly those occurring in the atmosphere and in combustion, are also one of Carr's interests and he has investigated large kinetic systems using sensitivity analysis.

CUSSLER brings an interest in the mass transfer processes of biological systems and this includes work on corrosion of ionic materials as well as problems in membrane diffusion. With EVANS he explores the kinetics of detergency, especially of the bile which is the human body's detergent. His interests even extend into the psychology of perception, for, in food development, the understanding of the impact of food texture can only be understood by a combination of engineering and psychology. Cussler is one of the keenest runners in the University and has actually participated in the Boston marathon; with Evans and Griffin, Tirrell and Macosko we can field a formidable team.

DAHLER, who also has an appointment in Chemistry, has research interests that encompass a broad spectrum of problems in nonequilibrium statistical mechanics and in the theory of atomic and molecular collisions. DAVIS also comes from a background in chemical physics and has applied this in several engineering contexts as well as having continued his work in the theory of liquids. Thus, with Scriven and others he has looked into some questions of interfaces, micelles, thin films, microdispersions and emulsions and their applications to enhanced oil recovery. Percolation theory has been one of his tools and this has recently led to an analysis of some problems in surface diffusion connected with catalysis. With Evans and Tirrell he has an interest in the study of transport processes and the statistical mechanics of diffusion relaxation and flow. Evans studies micelle formation under unusual conditions ranging from those that form in low melting fused salts to those in aqueous solutions up to 200°C. Using a Taylor dispersion technique he has also done much work in determining the diffusion coefficients of small solutes and works with Davis to link these determinations up with the basic theory. In collaboration with Cussler he is trying to understand why organosilicon films are so effective in inhibiting corrosion.

FREDRICKSON has the reputation of being of that select band of teachers who can make thermodynamics both interesting and understandable. It is to be hoped that he will have time to get his text out soon but as Director of Undergraduate Studies and Editor of Chemical Engineering Science he has his hands more than full. Besides all this he has a very active research program in the dynamics of bacterial populations and, in particular, of mixed cultures and the dynamics of competition and predation.

GERBERICH is an expert in the fields of flow and fracture, studying hydrogen embrittlement, polymer fracture, elastic-plastic fracture mechanics and fatigue crack growth. GRIFFIN joined the department in 1980 after a post-doctoral stay at the Surface Science Division of NBS and his doctorate at Princeton. His research interests are in the fields of heterogeneous catalysis and surface chemistry with particular emphasis on the reactions that involve oxide catalysts. He uses in-situ measurement techniques such as infrared spectroscopy to examine the catalyst under reaction conditions. His interests link most closely with Schmidt's and he is one of a group, with Jensen and Aris, which, under Schmidt's leadership, looks at various aspects of catalysis and its applications in chemical engineering.

ISBIN, the doyen of the department in virtue of his more than 30 years of service, is a well-known nuclear and chemical engineer and, for many years, a member of the Advisory Committee on Reactor Safeguards. His expertise on two-phase flow and transport has spread now to the problems involved in the design of solar boilers while his experience in reactor safeguards had led him to a more general concern with risk analysis. When JENSEN came from Wisconsin in 1980 he brought with him an interest both in chemical reaction engineering and in process control. In the first area his projects concern the fundamental reaction and transport phenomena of catalytic coal gasification and the chemical deposition of microelectronic materials. He is also investigating the problem of multiple steady states, oscillations and pattern formation in combustion and heterogeneous catalysis. In the control area, he is our expert on development of algorithms and real time experiments with the department's PDP 11/60 minicomputer.

Before his elevation to the academic vice-presidency, KELLER, besides heading the department, conducted a research program in various biomedical areas, particularly those involving blood flow and its relation to artificial organ design, thrombogenesis and arteriosclerosis. MACOSKO, the first monomeric unit of the polymer bridge, is interested in all aspects of polymer processing. This includes models for processes that involve network polymerization and relating the reaction kinetics to the development of network structures and to the physical properties that result from these. He is also bringing his rheological interests to bear on one of Scriven's main concerns, that of coating flows with non-Newtonian fluids. In ORIANI we are fortunate in having a man of extensive industrial background who took early retirement from U.S. Steel to become the first Director of the Corrosion Research Center. RANZ has applied his understanding of fluid mechanics and his great skill and feeling for the order of magnitude of different physical effects to a number of rather difficult fluid mechanical and mass transfer problems. His particular emphasis is now concentrated on new models of laminar and turbulent mixing with chemical reaction in one and two phase systems, but aerosol technology continues to be an active subject for him. As one of the leaders, with Amundson, in the development of team teaching 20 years ago his influence and example are still most valuable.

SCHMIDT, one of the five members of the department whose primary training was in chemistry, came from the University of Chicago in 1965. He leads a very active group of students in research on many aspects of surface science and catalysis. He uses techniques, such as Auger and photoelectron spectroscopy, to characterize reactions on single and polycrystalline surfaces of transition metals. The dynamics of both natural and forced oscillations of catalytic reactions is another of the things he has looked into both experimentally and theoretically and on which a natural collaboration with Aris has developed. Schmidt's is the initiative behind an informal center for catalysis that has grown up to use the mutually interlocking interests of Griffin, Jensen and Aris with his own.

Of SCRIVEN's interests a complete article could be written in itself. His work on porous media has covered both the application to enhanced recovery and to the properties of catalysts pellets, packed beds and foodstuffs; some of this is being done in conjunction with Davis. A second area covers micro-structured fluids either in thin films or at interfaces or in dispersions. The need for computational results has led him to pioneer the application of finite element methods and to develop a range of computer-aided analytical techniques which allow the generation of numbers to assist, rather than obscure or dominate, the insight that can be obtained through mathematical analysis. SIVERTSEN's current research interest has centered on the relationship between the structure and various physical properties of bulk and magnetic thin film solids, especially the oxide analogs of the alkali halides.

TIRRELL, who also serves as the Director of Graduate Studies in the Department, is very active in many areas of polymer science. These include the control and design of polymerization reactors where experimental studies are coupled with appropriate mathematical models. Of particular interest is the copolymerization of many components where temperature and mass transfer, reaction kinetics and reactor design all influence the composition and molecular weight distributions and properties of the product. He also studies high conversion free radical polymerization both theoretically and experimentally and is using dynamic scattering techniques to develop and apply modern theories of polymer diffusion in concentrated systems. Another area of interest is the influence of hydrodynamics on the kinetics processes involving macromolecules. These influences are exerted through induced conformational changes which in turn affect some of kinetic processes. TSUCHIYA came to the department in 1956 as the forefront of the development of interest in biological and bacteriological matters. He still is very interested in the role of metabolic products in the growth of microorganisms and in the development of continuous processes. On the materials science side, WALLACE uses positron probing to investigate the microstructures and substrates of metals and alloys. He has a considerable knowledge of the history of metallurgy and has taught an Honors Seminar in that area. WELLINGHOFF is interested, amongst other things, in polymers which normally crystallize very slowly in solution by chainfolding but can exhibit a fine spinodal phase separation along with rapid formation of fringed micelle crystals to provide the crosslinks for an extended elastic network. The interaction of flowfields upon polymer solvents is another part of his research, as is the kinetics and morphology of polymer phase separation in blends of polymers and the exciting new area of conducting polymers.

It would be futile to try and indicate the range of the papers published by members of the department for at the last count that the Dean required of us there were over a hundred papers published last year and almost as many the year before. It may, however, be germane to point out that several earlier contributions to this journal have reflected the approach of the department to the enjoyment of chemical engineering and have discussed various aspects of its program.* For some strange reason the department used to have a reputation for being dominantly theoretical. This was never really accurate, for there has always been a predominance of experimental programs. What we have tried to cultivate is the lively interaction of theory and experiment that is the hallmark of fruitful research. How well we have attained this balance is for others to judge.

*See II, 36-39; III, 48-52; VII, 19-40; X, 2-5; X, 114-124; XI, 68-73; XII, 148-151; Profiles of faculty are at V, 104-106 1971; XI, 50-52 177; XIII, 8-12 1979. Lighthearted ephemera appear at IX, 118-119 1975 and XV, 12 1981.