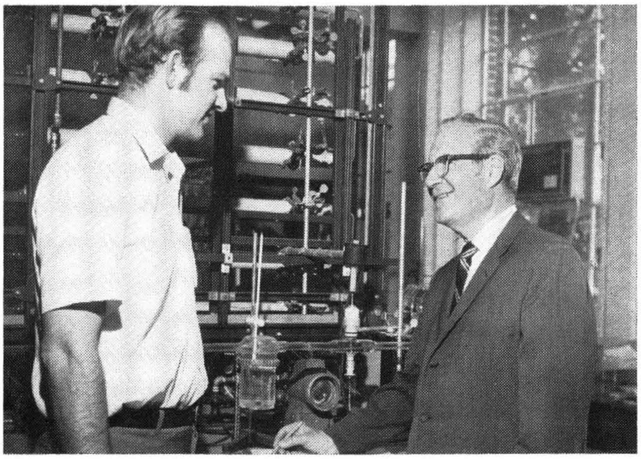

**Dr. McCabe discusses a research problem with Professor R. W. Rousseau.**

is presently undergoing a new, third revision. Chapters on Crystalization in Perry's "Chemical Engineers' Handbook" together with a long list of research publications covering a wide range of topics give evidence of the breadth and depth of Dr. McCabe's interests.

It is only natural and practically inevitable that so talented a person be sought out to help solve problems beyond the confines of the classroom and the laboratory. As a consultant to industry and government, as Vice President and Director of Research for the Flintcoke Company, as an advisor to educational institutions and more recently as Administrative Dean of the Polytechnic Institute of Brooklyn, Dr. McCabe has served his fellow man with great diligence and dedication.

Space does not permit an enumeration of his memberships and offices in numerous scientific and professional societies. That he was the recipient of the William H. Walker Award, the Founder's Award, and of the Tyler Award of the A.I.Ch.E., of the Distinguished Alumnus Award of the University of Michigan, and of the Golden Key Award with Admiral Arleigh Burke (one of his former students) gives some evidence of the high esteem in which he is held by all who have come to know him.

Upon retirement from Brooklyn Poly a few years ago he moved to Chapel Hill, North Carolina with his devoted wife, Lillian. Not content to bask in the light of his past accomplishments, he remains as active and vigorous as ever. Today he holds a Reynolds Professorship in Chemical Engineering at the North Carolina State University at Raleigh. He is teaching again using a new set of notes and supervises graduate research on his early love—crystallization. Indicative of his talent for creative investigation is the fact that he has within the past several years elucidated the phenomenon of contact nucleation, a significant piece of work that other workers in the field have hailed as being of great significance in describing the crystallization process. He is also writing and publishing again and, of course, when he has little else to do, he works on the third edition of his respected "Unit Operations."

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# WHERE DO WE GO FROM HERE?*

*A Founder's View*

WARREN L. McCABE
*North Carolina State University*
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ENGINEERING HAS JUST ended its most romantic era. During the past two decades, good engineering jobs have been available, salaries and working conditions good, money plentiful, public opinion of technology benign. Engineering tasks have been amenable to mathematical modeling of purely physical situations, and all the drudgery taken over by computers.

Suddenly, immediately after the successful completion of the most spectacular engineering effort of all time, this golden age ended with a suddenness that reminds me of the collapse of the euphoric Coolidge era in 1929. Once the human interest of the first moon shots was satisfied, people began to ask: "Just why did we do this, anyway?" It was recognized, paradoxically, that the space effort paralleled the rapid buildup of a set of severe social, racial, environmental, and conservational problems that were not being solved and which, superficially, seem to have originated as a consequence of the very success of our technology and from our ability to improve our material standard of living. The same engineers who were so successful in the space program have

*Remarks given at the Southern Regional Conference of A.I.Ch.E. Student Chapters, North Carolina State University, Raleigh, N.C. April 2, 1971.

**Until now, engineering challenges have been largely solvable by the control of the inanimate forces of nature . . . The big change in the world of the engineer is that the problems now laid on his doorstep do involve emotional factors that must be taken into account.**

had the traumatic experience of being those most severely hurt by the change of mood.

It is reasonable to ask, not just what has happened, but also where do we go from here. What I have to suggest is one chemical engineer's attempt to answer the question.

If I have any business in hazarding an analysis of a question about the future, it is only that by the luck of the draw I happened to be born at the time I was—the last year of the nineteenth century. Actually, the nineteenth century world did not cease to exist on January 1, 1900, but persisted without discontinuity until World War I. It was irrevocably destroyed in Europe in 1914 and here in 1917. I was in the tenth grade in 1914 and I graduated from high school in 1917, so my formative years were essentially vintage Victorian. World War I was followed by a relentless succession of revolutionary changes in science and technology, and in political, economic, and social structures, which influenced all aspects of the interaction of man-with-man and man-with-planet earth. Our worst depression, four wars—two of them the most murderous and destructive in history, and one the stupidest—, the rise of malignant militaristic police states, the opening of South America, Asia, and Africa, the liquidation of colonial empires, the population explosion, the cold war, all have contributed to the production of more social entropy than any other time period of comparable length in history.

In living through such a series of changes and participating in them in a small way, one accumulates memories of events and people, and gets a certain perspective of the past that may be used in evaluating the present.

I am not trying to predict the future. This simply is not possible. The big historical changes come out of the blue, and cannot be foreseen. Some examples are: the discovery of miracle drugs, the discovery and reduction to practice of nuclear reactions, the development of big computers, the perfection of microwave transmission of information and entertainment, the applications of the transistor, and the discovery of the laser. What may be done is to try to sense the kind of challenge that is looming in the immediate future and to establish a frame of reference and an approach that has some promise of helping to meet the challenge.

Meeting challenges is not new to the engineer. The history of our profession consists of challenges encountered and successfully met. The more important of them are:

**1. Ground transportation, first by roads and canals, then by railways, and then by automobiles and superhighways.**

**2. Power generation from fossil fuels and engines and turbines for production of power.**

**3. Generation, transportation, and utilization of electrical energy, and the communication of information by currents and electro-magnetic waves.**

**4. Synthesis of new materials, fuels, chemicals, drugs, and the development of large-scale processes to make them.**

**5. Application of nuclear energy.**

**6. Development of the large computer, and the creation of mathematical models for the analysis of large systems.**

**7. Air and space transportation, from Kitty Hawk to the moon.**

Personal experience illustrates the impact of unexpected discoveries. During World War II, I was involved in work in two of the Divisions of the National Defense Research Committee. One took me to the University of Chicago, and the other to the University of Pennsylvania. At Chicago, I was following work on defense against gas warfare. Right next to our group there was a highly secretive organization called the Metallurgy Laboratory. No one, of course, knew what went on there. In due course, the veil was lifted. It turned out that Fermi and his associates were building and testing the first self-sustaining nuclear pile, and Seaborg and his group were discovering plutonium and investigating its properties.

At Philadelphia, I was engaged in studies on the manufacture and use of liquid oxygen for various applications by the armed services. There was no secret about the fact that across the street a collection of some thousands of vacuum tubes was being assembled to make the first electronic digital computer.

Obviously, nothing in previous experience gave any one an inkling of the development of either the atom bomb or the computer. We would now be living in a far different world if neither of these two events had occurred.

As a starting point for a look ahead, let me state and compare two definitions of engineering. The first is the definition of chemical engineering given in the Constitution of the A.I.Ch.E.

> *Chemical engineering is the application of principles of the sciences, together with the principles of economics and human relations, to fields that pertain to processes and process equipment in which matter is treated to effect a change in state, energy, or composition.*

The second definition is an example of the kind that has been used historically for engineering generally. It is

> *The engineer develops, designs, and builds feasible and operable devices, structures, and systems all of predictable performance, cost, and effectiveness.*

Although the two definitions overlap, they express different point of view. The first emphasizes the method and tools of the engineer; the second states the mission of engineering. In my opinion, the second is the more pertinent to the present. Just as any other calling or profession, engineering serves the body politic and must be prepared to dance to its tune. The public has no interest in how the task is performed. It cares only for the results. Whether the engineer uses advanced mathematics and sophisticated science or relies on experience and common sense is a matter of indifference to those who are supporting us. And this fact is important in plotting a course.

**Just as any other calling or profession, engineering serves the body politic and must be prepared to dance to its tune . . . In the past, the engineer has not exactly been an admirer of the practical politician, but from now on he must learn to respect and work with this important and interesting segment of the human race.**

Considering present issues in the light of the past half-century of experience leads me to one conclusion. It is based on the complicated and highly non-linear makeup of the biological species to which we all belong We call ourselves *homo sapiens* or "man the wise." At times one can feel that the name is flattering. It is true that, when man has applied his hand and head to objective experimentation, careful study and observation of nature, and constructs and uses the great machinery of mathematics and science, he has advanced, over the millenia, from the crude stone axe of the cave man to the moon and back.

Along another dimension, however, the record of the interaction of home sapiens and planet earth is mixed. I refer to his emotional properties and behaviour. Here the spectrum of his accomplishments and failures covers another wide span. Drawing upon his emotions, homo sapiens has fashioned his great religious, moral, and ethical systems; he has shown how benevolent are kindness, love, and consideration for nature and his fellow man; and he has created his masterpieces of literature, art, music and architecture. Antithetical to his wonderful emotional creations, as Mr. Hyde is to Dr. Jeckyll, is man's horrid record in giving way to his other emotions, greed, envy, fear, anger, hatred, and cruelty. These have led him to violence culminating in the hideous history of man's inhumanity to man. His emotions cover the range from the gates of heaven into the depths of hell.

Until now, engineering challenges have been largely solvable by the control of the inanimate forces of nature with little or no involvement in the emotional hangups of man. There were no farmers with shotguns waiting for our astronauts when they landed on the moon, and nobody objected to their litter-bugging while there. Even if possible, Shepard did not have to holler "fore" when he made his 7-iron shot.

The big change in the world of the engineer is that the problems now laid on his doorstep do involve emotional factors that must be taken into account. No longer can his problems be solved by the sole use of mathematical models, computers, and system analysis. Emotional variables are not subject to such objective quantifiable parameters. There are no mathematical models or computer soft-ware for either the creative emotions or for hate, greed, fear, or envy. The facts of life are becoming more obvious daily. No longer can the engineer ram a super-highway through a ghetto; nor plump a jet airport down in a game preserve; nor locate a chemical plant willy-nolly adjacent to a residential area; nor fill the skies with a fleet of SST's. The emotional content of such situations shows in the uncritical rejection by a large and influential section of the body politic of all science and technology. In spite of such scornful

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rejection of rationality, which is itself an emotional act, I am certain that the constructive accomplishments of objective and rational methods have been of tremendous importance in the improvement of the conditions of human life, and I do not agree for one minute that benefits from such rationality have peaked out. It is equally clear that, although sciences and technology still are necessary, they now are far from sufficient.

What corollaries may be deduced from the broadening of the base of engineering into the emotional climate of man? Several seem clear.

1. The second definition of engineering, quoted above, appears more relevant than ever. It is true that the A.I.Ch.E. definition is saved from obsolescence by the phrase "human relations" contained in it, but I have reason to believe that it really refers to the human problems encountered in the management of human organizations, rather than to an expansion in the foundations of all engineering.

2. The engineer is not a specialist in the emotional field. Fortunately, the introduction of a sizable core of curricular time to humanistic and social studies has anticipated the new trend, and emphasis and strengthening in this area are indicated. Nevertheless, the real practical specialist in the emotional field is the politician. Not all emotions are political, of course, but politics is largely emotional. In the past, the engineer has not exactly been an admirer of the practical politician, but from now on he must learn to respect and work with this important and interesting segment of the human race. Not only must the engineer rap with the politician; some engineers will have to become politicians, as in the past some engineers found it necessary to become scientists and applied mathematicians.

3. The portion of man's emotional spectrum that I refer to is, of course, the creative, moral, and constructive end. Herein lies the real challenge. There is no doubt that the alliance of science and technology (which is itself totally amoral) with the cancerous emotions of war has been horribly effective in its own terms, or that it has reached its ultimate limit in giving the the means of obliterating all life on the planet above the level of the cockroach. If only we can do as well at the other end of the emotional spectrum!

I do not wish to suggest in any way that those who were responsible for the initiation and conduct of the program leading to the production and use of nuclear bombs were irresponsible people. In fact they included the most humanistic and brilliant scientists, engineers, political leaders, educational executives, and managerial talent we had. Ironically, the initial stimulus for the development was provided by a blue-ribbon group of phycisists including Albert Einstein, one of the gentlest and kindliest of men. Their motive in urging work in the field of atom bombs was simple: the well-grounded fear that Nazi Germany would make atomic bombs before any one else and reduce the entire world to thralldom. The crowning irony appeared when the war ended and a mission hurried to Europe to see how far the Germans had gone. The mission found that the Nazis had done nothing with atomic energy.

4. Does our present situation mean that our own branch, chemical engineering, is now obsolete? Not at all. Consider one of the major problem complexes in the public eye: conservation and pollution. The chemical engineer, as described in the A.I.Ch.E. definition, converts raw materials into useful products, and he does so in an optimum manner. What is wrong with this? It simply is that processing as now done stops too soon. The criterion of optimization currently used is to maximize rate of return on investment, and to stop when the optimum has been reached. This method probably will have to be modified. I doubt that it will be tolerable in the future to skim the cream from a valuable raw material and literally throw the residue out the window. Both sound conservation and environmental integrity are violated by the oversimplified method now used.

The cure for this is clear; more processing, not less. The materials now discarded must be recycled, reclaimed, or converted to additional useful products not necessarily of maximum profitability as measured by conventional cost accounting. Residues may be discarded only when reduced to a harmless state that will not hurt nature or men.

The emotional input to this problem appears in the allocation of costs. Clearly, the expense of conservation and pollution control is to be great. It could be as much as 50 billion dollars per year,

(Continued on page 164)

guished Lecturer for 1972 has not yet been selected, previous experience suggests that the Lecture will be one of the high points of the week. Dinner Wednesday evening will be a cook-out in the mountains.

**Arrangements:** Participants and their families will be housed in modern University residence halls. There will be an inclusive charge for room and meals. There is also a variety of motels near the campus. Climate in Boulder in August is warm and dry during the day and cool at night.

Although no special program is planned for families, the recreational resources of the University and the nearby mountains offer incomparable opportunities.

An NSF grant is being sought to support the Summer School. Final information and applications will be distributed to Chemical Engineering Departments in January 1972. Questions should be directed to the Director of the Summer School, L. Bryce Andersen, Newark College of Engineering.

Participants may wish to combine the Summer School with Minneapolis Meeting of AIChE (August 27-30).

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### NOMINATIONS FOR LECTURESHIP AWARD

The Chemical Engineering Division Lectureship Award has been bestowed annually upon a distinguished engineering educator since 1963 to recognize and encourage outstanding achievement in an important field of fundamental chemical engineering theory or practice. The recipient delivers the Annual Lecture of the Chemical Division at ASEE's Annual Conference. The award of $1,000 and an engraved certificate is sponsored by the Minnesota Mining and Manufacturing Company. Qualifications for the award include:

- Achievement, through formulation or creative application of fundamental theory and principles of important advances which have been accepted by his colleagues and by others in his field of specialization; promise of making further significant contributions.
- Improvements of lasting influence to chemical engineering education through books, technical articles, or laboratory or other teaching equipment; demonstration of success as a teacher;' as well as ability to inspire students to high level accomplishment.
- Evidence of ability to do original, sound, and productive research personally or through those under his direction and to evaluate and report the significant results obtained.
- Interest in furthering technical progress in chemical engineering through participation in professional and educational societies.

Nominations should be submitted by January 1, 1972 to Professor M. H. Chetrick, Chairman, ChE Division Lectureship Award, Department of Chemical Engineering, Michigan State University, East Lansing, Michigan 48823

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## McCABE:—WHERE . . .

(Continued from page 158)

about five percent of our gross national product. The battle lines to establish who is to foot the bill are now forming.

Two powerful tools are available for solving the pollution-conservation problem. One is our trillion dollar economy and the other our great technological capability. To this must be added the will to pay the necessary price. The worst approach would be to try to solve the difficulties by a purely emotional approach and to start by destroying the means available to do the job.

One other memory comes to mind. In the middle thirties I attended a meeting of the A.I.Ch.E. in Pittsburgh. The principle speaker was a famous editorial writer and commentator. His opening remark was how pleased he was, on passing a steel mill on his way to the banquet, to see smoke issuing from the stacks. He stated how wonderful it was to see the evidence that men at last were going back to work. Such a statement now sounds queer; but at that time it was understandable and everyone there agreed with it. People who had not seen a pay check for three years were eager to trade off absolute air purity for food for their families. Ten years later, during World II, when Pittsburgh was a great engine for producing war material, a small suburban mill town nearly had to be completely evacuated to prevent mass deaths from steel mill pollution. So it is. The triumphs of one period are the menaces of the next.

These are the problems that you, as budding chemical engineers, must face at the outset of your life work. I say outset because of another teaching of history. While current problems are being solved, new and more difficult ones are generated, and often become acute before people have completely met the old challenges. There is no evidence that this effect won't appear, perhaps more than one, during the half-century of your active lives. Then, maybe you will be in my position today; pontificating to your successors on just what they should do with the messes that you probably will be leaving them to clean up.