Facing Facts about the Engineering Profession

by Samuel C. Florman, P.E., *New York Alpha '44*

"I ACCEPT THE UNIVERSE!" With this fervent cry, Margaret Fuller, an eminent nineteenth century American writer, startled a group of her literary friends. Upon being told of the lady's pronouncement, Thomas Carlyle, the British historian, is reputed to have said: "By God! She'd better."

I've been thinking about this anecdote lately as I ponder developments in the world of engineering. After long and earnest deliberation, I too have decided to accept the universe, more particularly as I see the place within it of the American engineer. Facing facts—and that is what we engineers are taught to do—I conclude that our profession has not evolved the way that I, and many of my colleagues, once assumed it would. The time has come to rethink some of our most cherished assumptions.

More than a half century has passed since I received my degree in civil engineering, and, following a stint in the U.S. Navy Seabees and some time in graduate studies, embarked on my career in the construction industry. I am well pleased with the combination of choice and happenstance that led me to study engineering, and well satisfied with the career that this study enabled me to follow. But I am troubled about the condition of the profession itself, that guild of creative technologists who play such a vital role in the advancement of our civilization.

In the aftermath of World War II, technology stood at the center of human affairs, and I was dazzled by the prospect of an engineering renaissance. As an avocation that verged on becoming a second career, I began to study the history of the profession, considering its role in the general culture and setting forth in writing some of my reflections. First there were articles in professional journals; then I was able to address a wider audience as contributing editor for *Harper's*, columnist for *Technology Review*, and occasional book-reviewer for *The New York Times*. Articles led to authoring books, and books led to speaking engagements, mostly at engineering schools and meetings of professional and industrial groups. I met with many engineers, engineering students, and teachers of engineers and engaged in myriad discussions about our profession, particularly its future, which we invariably agreed would be splendid. Through these contacts I became a prodigious joiner of organizations, including a dozen of the major engineering societies—technical, educational, military, and historical. The somewhat unique combination of writing and lecturing, while continuing to work as an engineer in industry, brought a growing number of invitations and assignments, culminating in service on numerous commissions, committees, and panels dealing with professional issues.

Looking back over the years, I see that some of the assumptions I am now rethinking were ingenuous; others seem reasonable in retrospect but were simply overwhelmed by historical currents that were difficult to predict. As the cold war unfolded, the space race began, the environmental crisis arose, and the computer age came upon us, it appeared certain that the engineering profession would flourish and grow in importance. James Reston, one of the most prominent journalists of the mid-century, observed that "the politicians and even the statesmen, are merely scrambling to deal with the revolutions in weapons, agriculture, and industry created by the scientists and engineers." Since this concern was widely shared, I thought it likely that engineers would be called upon to take leadership positions in the government. At the same time, I believed that individual engineers would emerge from the mists of anonymity and become well-known, indeed celebrated, in the public arena. Also, I dared hope that the profession would become enhanced, shedding all vestiges of its "hired technician" image (to use the terminology of C. Wright Mills in his 1956 book, *The Power Elite*) and developing a culture comparable to law and medicine. This would feature extended professional education, meaningful licensing, binding codes of ethics, and broadly inclusive professional associations. Finally, I was confident that a very large percentage of our most accomplished young people would choose engineering as a career, attracted not only by its importance and inherent appeal, but also by increased financial compensation and job security.

> *"I accept the Universe"*
> –Margaret Fuller / American Writer

Looking out upon the current scene, it appears that none of these prophecies has been realized. Further, it appears that they will not be realized for a long time, if ever. With reluctance and a touch of melancholy, I accept the universe.

However, I hasten to add that disappointments have been offset by unforeseen successes, so what follows is not a message of gloom and doom. In fact, quite the contrary.

Our Presumed "Rightful Place"

My first concession to the universe relates to the presumption that engineers would take their rightful place in the national government. I believed this would happen, not only because the changing times seemed to call for it, but because this development had long since occurred almost everywhere else in the industrialized world. More than 200 years ago the French established professional engineering schools, the most famous of which, the *Ecole Polytechnique*, was conceived under the monarchy, opened in 1794 during the Revolution, and has been supported by every government since. The graduates of this institution, and the other *Grandes Ecoles*, became an elite class, leaders of government, industry, and academia. Germany followed suit, and soon across Europe, Latin America, eventually the entire globe, including Russia and the developing Asian nations, an engineering education become the favored route to positions of authority. The conspicuous exception to this development was Britain—and Britain's most notable offspring, the United States. The historical reasons for this anomaly are worthy of study, but need not detain us here.

"By God! She'd better!"

–Thomas Carlyle / Satirist & Historian

It is a simple fact that, in contrast to a worldwide trend, leaders of the U.S. Government have not studied engineering. In the current 110th Congress, out of 540 members, there is one engineer—one—along with three chemists, two physicists, and a microbiologist. Rounding out the "technical" delegates we find 11 medical doctors, three dentists, three nurses, two veterinarians, one psychologist, an optometrist, and a pharmacist.

It will surprise nobody that 44 percent of the members of Congress hold law degrees and that the vast majority of others list "business" and "public service/politics" as their occupations. Similar profiles are found in past Congresses and in state and municipal governments as well. Not only are engineers absent from governing councils, but the public seems to view the engineering temperament as unsuited to political life, as witness the widespread disapproval, and even ridicule, of Herbert Hoover, our one engineer president, and Jimmy Carter, whose education was grounded in engineering.

Even as advisers—technical counselors—engineers have only grudgingly been accepted into the federal government. There have been a number of eminent so-called science advisors to the President, but the relationship has often been troubled. Most memorably, during the Vietnam War, President Nixon, angered by criticism of his antiballistic missile program, arbitrarily abolished the White House science adviser position altogether. In 1976 President Ford reinstated the post and oversaw the creation of the Office of Science and Technology Policy (OSTP), but problems continued to arise. President George W. Bush waited five months before selecting an adviser, all the while dealing with issues such as global warming and stem-cell research. Also, many in the science and engineering community took offense when Mr. Bush moved the OSTP offices out of the White House and refused to give his adviser the title of "assistant to the president" as had his two predecessors.

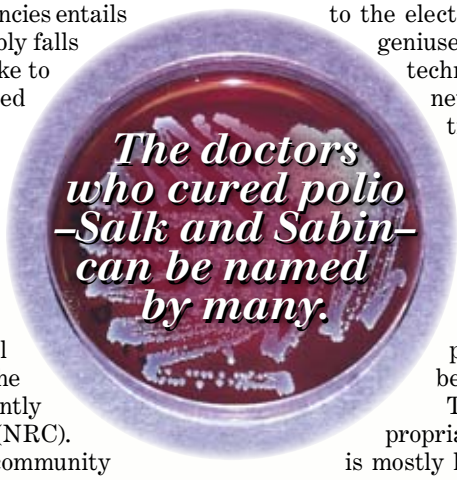
The situation with Congress has been even more contentious. A congressional agency called the Office of Technology Assessment (OTA) was established in 1972 to "provide the legislative branch with adequate and timely information, independently developed, relating to the potential impact of technological applications." OTA opened its doors in 1974 and produced a large number of analytic reports, many of them of the highest quality—according to the agency's many admirers. But, as might have been predicted, the politics was complex, turning especially bitter when Senator Ted Kennedy's office was accused of controlling a majority of the staff. The institution was closed in 1995—not closed exactly, because the law establishing it was never rescinded. OTA simply doesn't get funded, and thus in the real world it doesn't exist. A few members of Congress retain one or two technical experts on their staffs, and there is a science and engineering fellowship program that brings about three dozen scientists and engineers to the Capitol each year. But, in general, engineers are few and far between on Capitol Hill.

Nevertheless, as I noted above, disappointments may be offset by unexpected successes, and that has indeed happened in the relationship between engineering and the federal government. Members of Congress may not have engineers in their midst, nor understand the technical details of many matters that come before them; but the agencies they have created, and fund annually, are administered largely by engineers and are a vital factor in the scientific and technical eminence of the nation.

The origins of this development can be traced to a report written in 1945 by Vannevar Bush, *MA B '16*, who had headed the government's wartime office of Scientific Research and Development. Dr. Bush wrote to President Truman advocating creation of a new federal agency to fund scientific and technological research. After five years of negotiation and compromise, this proposal evolved into Public Law 507, creating the National Science Foundation (NSF). Funding at first was meager, but there was general recognition in both political parties that a strong technology was good for the nation. Today, with a budget approaching $6 billion, the NSF issues about 10,000 grants each year supporting research in science and engineering.

It also subsidizes ancillary projects including science and engineering education. Some authorities had hoped to see NSF become the central command post for all science and technology, but this was not to be. Other agencies evolved somewhat serendipitously, among them the National Aeronautics and Space Administration (NASA) and the Defense Advanced Research Projects Agency (DARPA), both founded in 1958 in response to the 1957 launching of *Sputnik*. Naturally, the funding of these agencies entails much political negotiation and invariably falls short of what most engineers would like to see. But the cause is universally viewed with favor.

In addition, engineers are omnipresent in the think tanks, professional societies, and advocacy groups whose voices are heard in Congressional halls. Probably the most trusted source of technical advice is the national academies complex: the National Academy of Science (NAS), the National Academy of Engineering (NAE), and the Institute of Medicine (IOM), which jointly operate the National Research Council (NRC). Needless to say, a dynamic industrial community and representatives of academia as well play a prominent role in all national debates.



Situated throughout this confusing mélange of organizations are thousands of engineers, applying their erudition, energies, imagination, and standards. Indeed, one can argue that both the engineers and society are better served by this creative chaos than they would be if many of the engineers were elected officials, seated in vaulted chambers, casting votes—while coping with the demands of their constituents and pondering the next election. Come to think of it, although through the years I have met numerous engineers who agreed with my wish to see engineers in elective office, I cannot recall a single one who personally expressed a desire to make a career in politics.

In any event, looking back, and thinking ahead, I conclude that American engineers will not play a significant role as legislators nor as officers in the executive branch of government, and perhaps that is all for the best. It might have been naive to think otherwise. Plato envisioned a society ruled by philosophers; but the Greeks had other ideas and were doubtless the better off for it. Still, I give up the dream with a touch of regret.

The Anonymous Engineer

My next concession can be disposed of more quickly than what we have just reviewed. Even as I once fantasized about engineer-statesmen, I cheerfully assumed that the great engineers of our age would achieve the public recognition to which they were entitled. After all, technologists of a century ago are widely known: Alexander Graham Bell, the Wright Brothers, Eastman, Morse, Westinghouse, and of course Thomas Edison who according to a newspaper survey was at one time "the most admired American." Even the Roeblings, builders of the Brooklyn Bridge, retain a quotient of public recognition. Surely the individuals who create the technical wonders of our time deserve recognition. The electronics revolution has begotten a few familiar names—Bill Gates, Steve Jobs, Hewlett and Packard —but these are associated more with industrial success than they are with engineering brilliance.

Who has heard of Jack Kilby, *IL A '47*, and Robert Noyce, inventors of the monolithic integrated circuit, key to the electronic revolution? Who can name the geniuses behind the turbojet engine, satellite technology, fiber optics, the first practical networked computers, the Global Positioning System, the Internet? These mostly unknown prodigies have been recipients of the Charles Stark Draper, *MA B'22*, prize inaugurated in 1989 by the National Academy of Engineering. This $500,000 award is intended to be the "engineering Nobel prize," since ironically there is no Nobel prize for engineering. (I say ironically, because Nobel was himself an engineer.) The Draper prize is awarded with appropriate care and ceremony, but news of it is mostly lost in the frenzied media world that surrounds us. Why? Perhaps because the great engineers do not have sparkling personalities. Maybe the public relations people who represent the engineering profession feel obliged to be discreet, and discretion doesn't generate much public response. Possibly the newer technological developments are more "black box," inherently less fascinating than earlier innovations, or the public is not as impressionable as generations of the past.

It is encouraging to note that "science writing" has grown as a profession. Of course, that points to another difficulty: the fact that engineering often suffers from comparison with science. Einstein is a name of mythic connotation for which there is no equal in engineering. Dinosaurs, comets, and DNA seem to trump engineering details in the newsworthy department. At the end of World War II the names of scientists who developed the atom bomb became widely known: not only Oppenheimer, but also Bohr, Fermi, Teller, and others. The doctors—Salk and Sabin—who cured the terrible disease polio can be named by many. But engineering remains a profession characterized by anonymity.

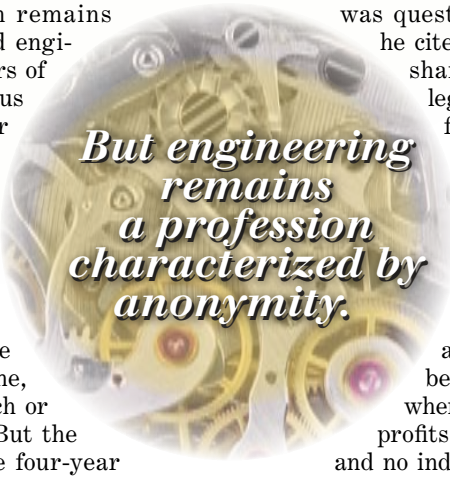
Well, so be it. Engineers are not the only meritorious people who live outside of the spotlight. Indeed, seeking to bask in the spotlight is not the worthiest of goals and might even be an impediment to meaningful accomplishment. Also, if my expectations of glory for the profession were over-exuberant, happily the real achievements of engineers have surpassed any forecasts I might have made.

Fervent Status Quo

This brings me to the nature of the engineering profession itself. Has it flourished as I dreamed it would—as I expected it would—starting in the second half of the 20th century? Well, yes and no.

Yes, because American engineers have been splendidly productive and, in the field of computers particularly, have added an element of entrepreneurial exuberance to their traditional creativity. Yes, because engineering educators have done good work, and American engineering schools are universally deemed the best in the world. There have been imaginative new approaches in curriculum and accreditation, attempting to meet rapidly changing world conditions. (There have also been laudable efforts to bring more women and minorities into the profession. Statistically the results have been disappointing; but this is one area where hope springs eternal.) Yes, because the various engineering societies have nourished professional commitment, sponsored high-quality publications, fostered ethics, and in multiple ways supported the ability of the profession to serve the public interest. (Although it is worrisome that less than half of our engineers belong to a professional society.) Yes, because in 1964 the National Academy of Engineering was founded (under the then 100-year-old charter of the National Academy of Sciences) and has done noble work, to paraphrase its own manifesto, "marshalling the knowledge and insights of eminent members of the engineering profession, sponsoring engineering programs to meet national needs, encouraging education and research, and recognizing the outstanding achievements of engineers." Yes, because Tau Beta Pi, the engineering honor society, more than a century old and with 232 active collegiate chapters, supports service programs that inspire engineering students to do good things in their local communities and in many ways supports its motto, "Integrity and Excellence in Engineering." Yes, because the National Society of Professional Engineers vigorously encourages engineers to pursue the goal of licensure and encourages government officials to protect the public by assigning work to licensed professionals.

But no. In spite of much discussion and zealous crusading, one fundamental condition remains unchanged: The standard accredited engineering degree is earned in four years of undergraduate study. Four years. Thus comparison to law and medicine—or the various Ph.D.-credentialed sciences—cannot be supported. Everyone agrees that a four-year curriculum is not adequate for the ever-expanding scope of engineering knowledge, to say nothing of the element of liberal learning that seems increasingly essential. Many engineers, after graduation, take a one-year master's degree, and some, particularly those who intend to teach or go into research, go on for a Ph.D. But the large majority are satisfied with the four-year bachelor's degree and cite financial pressures as the reason. Many corporations who hire these graduates at modest salaries to perform moderately exacting work are also well satisfied with the existing system. At the same time, there are fervent efforts for change. The American Society of Civil Engineers has formally proposed a five-year requirement, and the National Council of Examiners for Engineering and Surveying has considered recommending the same criterion to the states as a pre-requisite for a Professional Engineer's license. Yet this just points up an additional problem. The licensing of engineers by the individual states is mainly limited to civil engineers, designers of structures that require formal sealed approval by governmental entities. Most engineers have no need for a license, and accordingly most engineers don't bother to obtain one. "Just another silly piece of paper," agreed a group of elite electronics engineers with whom I discussed the topic some years ago. As a side effect of this state of affairs, engineers are not protected by credentialing the way doctors and lawyers are, which in some ways makes them lower on the scale of professionalism. I wish it were otherwise; but I cannot sustain the belief that the four-year degree will be repudiated as the defining accreditation for the profession or that required licensing for engineers will become the norm.



Facing an Emerging Truth

Finally—most bitter to admit—while globalization has made engineering more important than ever, it has made a career in engineering more precarious. We invite students into a proud profession, but then confront many of them with the harsh reality of becoming hirelings, subject to the whims of corporate managers. Even that would be acceptable, according to the author of a 1985 book about engineers entitled *Mechanics of the Middle Class*, to those who become "attached to the industrial corporation by the promise of stable salaries and stable careers." But in these times, when global competition has relentlessly turned corporations lean and mean, the stability that was for many individuals such an attractive feature of an engineering career has largely evaporated.

When the chairman of the board of Intel Corporation was questioned about jobs lost to offshoring, he cited his responsibility to the company's shareholders. "We are expected to and legally required to do the best job we can for them." He then went on to say that he also felt "a responsibility for doing the right thing for the country. . ." by which he presumably meant providing a measure of protection for his American employees. He concluded by saying that he was "looking for public policy to help guide us." In the absence of such public policy he would be obliged to move jobs to other countries whenever that contributed to maximizing profits. Well, there is no such public policy and no indication that there will be one. To the contrary. Corporations receive tax advantages (or at least a delay in required payment) for work performed abroad. As for proposed assistance for engineers hurt by the globalization tidal wave—for example, subsidized mid-career education—there has been little reason to hope for meaningful action.

So job security is sacrificed to the need for short-term profits; offshoring of engineering work is on the rise; and, even as engineers complain of diminishing job security, Congress grants tens of thousands of "emergency" one-year visas allowing additional engineers and technical workers to enter the United States. The rationale for these visas, as proclaimed by industrial lobbyists, is a purported shortage of engineers and other specialists, a shortage that is vehemently disputed in many quarters. Demographer Michael Teitelbaum, vice president of the Sloan Foundation, has noted that a real demand for engineers would manifest itself in low unemployment rates and strong upward pressure on real wages. But such indicators, he finds, are "conspicuously absent from the contemporary marketplace." Talented young people making career choices are sensitive to portents of future developments. In recent decades the percentage of college graduates who opt for engineering has declined from nine percent to less than five.

In the end, I come down on the side of optimism.

Still, I repeat once more that disappointments have been offset by unforeseen successes, and I mean to carry through with this theme of hope.

As we contemplate the new world—the fierce new world of global competition—we see hazards aplenty for engineers. However, as we learn each day in the technical and financial journals, there are bright young people who seem to be energized by challenge and competition, who thrive in the arena of free enterprise. *The Engineer of 2020*, a booklet produced by the National Academy of Engineering, speaks of "dynamism, agility, resilience, and flexibility." Innovation becomes a watchword, the key to our nation's salvation. In places like Silicon Valley we have already seen a generation of dauntless engineers achieving successes both creative and economic. Surely there will be others like them.

Speaking of energy and ambition, there may be engineers moved to fight back against the increased difficulties encountered by the profession because of globalization. Ralph W. Wyndrum, *NY A '36*, past president of IEEE-USA, the nation's largest technical engineering society, has called for his fellow professionals to become "more proactive participants in the public-policy process." Traditionally, engineers have not been confrontational, partly because of natural disposition, partly because of uncertainty about what is appropriate behavior for "professionals." Nevertheless, there is much that engineers might achieve by promoting their legitimate demands *vis-a-vis* government and the corporate community.

Let us agree, then, that the outstanding engineers—brilliant, energetic, ambitious, personable, and let us add the key word of the moment—innovative—these folks will make their way. But what are we to say about the more traditional engineers—the "rank and file" as several studies of the profession refer to them—those who are not given to social networking and competitive struggle, those who are neither entrepreneurial nor politically inclined? For these men and women, whose value often lies in diligence and sober thoughtfulness, the profession, with its new uncertainties, is less obviously attractive than it used to be, certainly less than I once assumed it was going to be. But "obviously" is the operative word here. There are attractions that are not obvious, yet are compelling nevertheless.

I take my clue from the same statistician whom I quoted in connection with the purported shortage of engineers. Dr. Teitelbaum of the Sloan Foundation observes that, in spite of difficulties and disadvantages, some young people pursue careers in engineering because of "significant noneconomic rewards". Among these rewards: "intellectual challenge," "the life of the mind," "the potential to develop exciting and useful new technologies." He characterizes such professional pursuits as "'callings' rather than careers, analogous to those of religious or artistic vocations." Interesting—the word "calling." Although I will not compare engineers to Mother Teresa or Picasso, it is fitting, I believe, to think of engineering as something more than a money-making occupation.

Surely intellectual challenge is part of the picture. There are satisfactions in dealing with numbers, shapes, designs—structural, mechanical, electrical, chemical—satisfactions that animate the spirit in ways that buying and selling do not. Exercising one's wits and technical skills is diverting—existentially pleasurable, to use words that I once incorporated into the title of a book.

There is another gratification traditionally cited by engineers, and that is the knowledge that their actions benefit their fellow humans. We can draw up a list of technical innovations that have enhanced the quality of our lives beyond measure—water supply, sanitation, electricity, mechanical transport, refrigeration, health technologies, electronic communications—the inventory seems endless. Beyond the basics, there are the onward-and-upward projects—such as space exploration—that pique our interest and gladden the heart. And, of course, there is enrichment of the arts. "We have yet sufficiently to realize," wrote Lewis Mumford, "that the symphony orchestra is a triumph of engineering."

Then there are those most critical engineering problems of the moment, many of which are related to—emanate from—past technological achievements. Environmental degradation; global warming; depletion of natural resources; nuclear technology; weaponry and warfare; security of the Internet; and most lately, terrorism—detection and

prevention. And let us not forget energy—production and conservation. The point to be made, in the context of my topic, is that much engineering work today is important. Vitally important. It counts in the scheme of things. It relates to survival, for us and our children's children. Many engineers, in evaluating their careers, prize this aspect of what they do.

In Conclusion

Finally, I see in engineering today the growth of a new force difficult to define with a single word. Some terms that come close to what I discern are: altruism, benevolence, compassion, humanity—manifested largely through an increase in volunteerism. Engineers have traditionally expressed commitment to the public welfare, but usually in general terms, and relating mostly to professsional services that were "advisory in nature." In fact, a review of early codes of ethics reveals misgivings about performing engineering "on a free basis." Times have changed and so have the mores and activities of people in all professions, indeed in all aspects of life. I find the change in engineering, although perhaps a bit slow to develop, inspiring to contemplate. When I first heard about Doctors Without Borders (*Medecins Sans Frontieres*), founded in 1971 to provide emergency humanitarian assistance wherever needed in the world, I wondered why engineers weren't doing the same sort of thing. Individual engineers did serve with the French-based medical organization as well as with the Peace Corps and other volunteer groups, some of them church-sponsored; but *pro bono* work was not widespread. Finally, in the year 2000, Engineers Without Borders was founded. Within five years it was handling over 80 projects in 35 countries, including rebuilding in tsunami-devastated areas, and had established 66 university chapters and 27 regional professional chapters. Other humanitarian groups are evolving, providing engineering assistance to people in need all over the world.

In American engineering schools the concept of "service learning" has taken hold. Engineering Projects in Community Service (EPICS) was established at Purdue University in 1995 and has served as a model for comparable programs in many other institutions. EPICS engages engineering undergraduates in team-based, multi-disciplinary design-and-build projects within their communities. Typical ventures: school playroom facilities for handicapped students; an environmental monitoring system for an art museum; wetland development to mitigate runoff from dairy farms into wilderness areas; and a multi-media learning center for a zoo. Financial support comes from the National Science Foundation, local volunteer organizations, and several technology-based corporations.

Thus I conclude my brief summary of ways in which engineering developed differently from what I envisioned some half century ago. I end on an up note—an inspirational academic program that encourages good citizenship while fostering collaborative engineering skills. (A program, incidentally that won for its faculty founders a prestigious award from the National Academy of Engineering.) This is not to imply that there aren't numerous candidates for a bleak conclusion, such as a collection of letters to the editor of the *Wall Street Journal* arrayed under the heading, "Engineering Becomes a Perilous Career Choice."

But, in the end, I come down on the side of optimism. While I accept the universe, with all its enigmatic frustrations, I also respect that impulse in human nature which seeks to improve the world. This impulse manifests itself in engineering.

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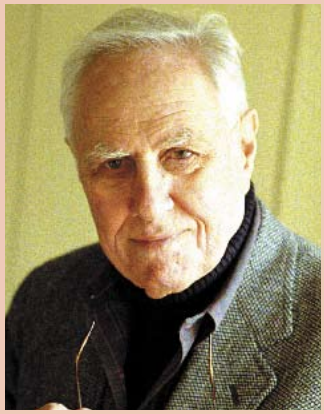

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A featured speaker at Tau Beta Pi's 1984 Convention, he was awarded the Ralph C. Roe medal by the ASME in 1982 in recognition of the individual who has contributed most effectively to a better understanding and appreciation of the engineer's worth to contemporary society. He was recognized with awards from the IEEE (1990), ASEE (1993), and ASCE (2002).

Mr. Florman earned his B.S. in 1944 and his C.E. in 1946 from the Thayer School of Engineering at Dartmouth and a master's degree in English literature from Columbia University in 1947. His more than 250 articles dealing with the relationship of technology to the general culture have appeared in many professional journals and scholarly magazines. He has been a contributing editor to *Harper's* as well as a columnist with *Technology Review*. He is the author of six books, including: *The Civilized Engineer, Blaming Technology,* and *The Existential Pleasures of Engineering*.