**SECRET CONFESSIONS OF A DESIGNER**

 I have a guilty secret: I do design. I don't mean that I study how people do design or that I set problems for my students to work. I actually sit down with a CAD system and a pile of catalogs and design things. An even dirtier secret is that I enjoy it. Some will say that I’m an academic and that I'm supposed to be a scientist, but I have

This craving to be an engineer.

 I enjoy designing because it is challenging. I have done my share of mathematical theorem proving and of sitting in a lab gazing at the gyrations of an oscilloscope trace. I've also put in time working at a drawing board, or more recently a CAD system. I'm here to tell you that, for me, the most satisfying experience as an engineer is doing design.

Why is that? Because it is the most demanding pursuit.

 When you address a design problem, the knowledge base is governed by the problem, not by whatever theory you developed for your last paper.

You have to face a design problem on its terms, not yours. Usually this means researching unfamiliar fields. Even more important, when you do design you have to make decisions based on partial information. There is never enough time or money to analyze everything to the point that all the decisions are easy. That's why we use safety factors, to allow for what we don’t know. Nothing is more intellectually demanding than making decisions when you do not have complete information. On an expensive project, this can require considerable insight and courage.

Those who think theoretical work is the height of intellectual achievement are blinded by their own egos. One can, perhaps, forgive this attitude in pure scientists who have never been exposed to the challenges of doing design. However, I suspect that some of you have been put down, as I have, by colleagues who make no secret of their View that design is for those who lack the talent to be scientists. They should know better, and maybe they do, but they don't admit it.

 My remarks are primarily addressed to faculty members in American universities. They are not intended for engineers working in industry nor are they addressed to our colleagues from other countries, who probably find the situation I am addressing rather curious.

 Those of us in academia are becoming increasingly irrelevant. There is a huge and widening gulf between us and our peers and former students in industry. This is not news. It has been said many times. It has been going on for a very long time, at least since the early 1960s.

 The immediate cause of this phenomenon is not hard to identify. We spend our careers trying very hard to be what we are not. We were trained to be engineers, and presumably we were at one time strongly motivated to be engineers, but we try to become scientists. You will say that the pressures force us in that direction. The pressures we \_perceive\_ are, indeed, intense. I will examine those perceptions more carefully in a moment. However, let us first think about what distinguishes an engineer from a scientist.

 I like to use an aphorism that is actually a distillation of something written by Herbert Simon in his book, The Sciences of the Artificial. "Science is the study of what is. Engineering is the creation of what is to be."

 Notice the critical role of the word "creation" in making this distinction. The parts of engineering practice devoted to synthesis, or creation, are design and manufacture. Design is planning for manufacture.

 You cannot be an engineer and participate in the creation of tomorrow’s technologies without participating in design. Engineers study the world as it is in order to obtain knowledge that can be used in design. However, we must always remember that this knowledge is a tool. To an engineer, science is a means to an end, not the end in

Itself.

 Think about the Apollo project. It is always mentioned as a \_scientific\_ achievement. Actually, the science did not start until the astronauts landed on the moon and started deploying instruments and making observations. It was engineers who got them there and brought them back, anonymous engineers. If you are ever in Houston, go to

NASA's Johnson Space Center and have a look at the Saturn V rocket.

Look at the F-l engines on the first stage. Look at the turbo-pumps that delivered I5 tons of propellant into the engine every second while running on bearings lubricated only by the propellant itself. They were designed by engineers with training generally similar to our own.

 We don't appreciate our own importance, nor do we appreciate how mechanical engineers have been a major influence in shaping our world. We do not publicize our activities effectively. In the popular terminology of the 1990s, we have low self-esteem.

 I would encourage you all to get involved in real design projects. If you do, many of you will be hooked, like me, by the challenge that design presents. It is not hard to find problems that are sufficiently challenging. We are surrounded by them. Most manufacturing companies have lots of problems that they lack the resources to address.

 I had a lot of trouble a couple of years ago with the flap over "design for manufacturability." I mean, whoever designs anything without intending it to be manufactured? Certainly there is good design and bad design. Good design has always been design for manufacturability and always will be. Actually, this whole problem was brought to us by the managers of some of our more visible corporations. These people had no understanding of engineering, although they were responsible for companies that were dependent on mechanical engineers to maintain their competitiveness. They thought it was a fine idea to enhance productivity by making all departments, even the design and manufacturing departments, compete against each other as "profit centers." These are the same guys who take home six- or seven-figure salaries while their companies are losing billions and closing plants and laying off thousands of employees. Or course, they didn't take the blame. Where did they place the blame? On us, the design engineers: and we let them do it.

 A common response to the question of why engineers are not visible to the general public is that what we do does not impact large numbers of people. This is quite untrue. Think about the millions of people who have flown in Boeing 747s. Does anyone know who led the design of that aircraft? The lives of hundreds of thousands of people every day depend on the design of the suspension linkages in the automobiles we drive. Does anyone know who was responsible for the suspension design of, say, the Ford Taurus? Of course, relatively few engineers have the

opportunity to be responsible for major projects that will affect very large numbers of people, but then, not every bio-medical researcher is Jonas Salk or Alexander Fleming either.

 Look at what the physicists have done. They've talked the government into putting $8 billion or more of taxpayers' money into the Superconducting Super Collider. What is the objective? To beat the Europeans to the next couple of subatomic resonances to be discovered. Is there any application? None in the foreseeable future; and, if ever

it does lead to applications it will be engineers who have the job of developing them. This, my friends, is \_chutzpah\_. Good luck to them.

I hope they pull it off because it will keep lots of our fellow mechanical engineers in challenging employment. [Well, we know what happened to the SCSC.

 Think about the job of keeping the entire 54 miles of the accelerator loop cooled to liquid-helium temperatures. There is a company in Columbus, Ohio, in the business of manufacturing cryogenic expansion engine refrigerators that may have a shot at the job. The technology is sophisticated but will need to be improved by at least an order of magnitude to handle the capacities required. Again, it is mechanical engineers who will do it. The result will be that a couple of physicists will win Nobel prizes and have their names become household terms, while the mechanical engineers who made is possible will remain anonymous.

 It's no wonder we wind up identifying with science when science has such a positive image and the image of engineering is, at best, neutral. Many of us academics have colleagues who want to make sure that we only engage in "scholarly" pursuits, with scholarly usually defined as scientific. This attitude is very strange, since creative synthesis is regarded as scholarly in many other disciplines, but synthesis is somehow suspect in engineering.

 Why is the design of a strangely shaped object that sits in the town square and collects pigeon droppings considered to be scholarship applicable to promotion and tenure of a fine arts professor, while the much more demanding design of an elegantly functional mechanism for extracting glass bottles from blow molds at high production rates, without distortion of the soft glass, is not similarly applicable for a mechanical engineer?

 Most of you will argue that these incongruities are imposed on us from outside, but is this really so? I think that those of you who have sat on promotion and tenure committees will agree with me that it is really the faculty of the department who define what is and is not acceptable scholarship in any given field. It has to be so, since only the professionals in a field can set appropriate standards. Could it be that we are doing this to ourselves?

 The usual definition of research suitable for a doctoral dissertation is that it should be a fundamental contribution to knowledge in the field of the research. Is not the creation of a new technology, something that did not previously exist, a fundamental contribution to knowledge? I’m not talking about routine design, such as redesigning a mounting bracket to accommodate a different model motor. That is not our business, as engineering researchers, any more that it is the business of a research chemist to perform routine water-quality analyses. I am talking about the design of a machine or system that creates a fundamentally new technology or extends an existing technology to domains in which it has never before been applied.

 The pressure to obtain research funding is often cited as a reason why we gravitate to science rather than function as real engineers. It is true that the National Science Foundation is a highly visible source of research funds in engineering departments. The NSF was established to fund basic scientific research and correctly regards this as its primary mission. It is not surprising that it approaches engineering research from the same point of view. However, did you know that, according to a recent survey by an intersociety working group sponsored by the American Association for the Advancement of Science, the NSF is a conduit for only 1.5% of the federal funds allocated for mechanical engineering research, not counting the Department of Defense? If defense spending is included, the NSF budget vanishes into the noise level. We have cut ourselves off from much of this research funding by

Years of disinterest, since that funding is directed at synthesis projects. These projects have come to be viewed as the exclusive province of industry. We have elected not to pursue those projects, unlike our colleagues in some other countries, where universities provide real technical leadership to industry.

 If we are to change our current direction and focus on being real engineers 'and proud of it' the initiative is going to have to come from us. Nobody else is going to do it for us. Certainly not the deans and provosts of our universities. Not even our colleagues in industry.

 I really don't want to get into the debate over the virtues of studying design scientifically and using that knowledge to enhance instruction in design engineering versus teaching design by practice. It think it is of value to study how people do design. Since the NSF is culturally incapable of funding us to do design projects, I think we should definitely encourage them to fund us to study design.

 However, I do not think that trying to make design respectable by studying it scientifically will ever solve our dilemma. The only real solution is to recognize that doing design is intrinsic to being an engineer and to emphasize that an engineer is not just a variety of scientist. The value of pure scientific research is finally being questioned. It is a good time to stop emphasizing our similarities to scientists and to start emphasizing our differences.

 Let us start by taking a more positive view of what we do, particularly of the creative part of our profession. Let us push on our colleagues to get scholarship defined in a manner that is appropriate for engineering, emphasizing the importance of creative design as well as scientific study. In my view, this is not, by any means, creating an easy option. It adds a different, challenging element to the professional activities of a faculty member and requires some different approaches to the evaluation and documentation of scholarship. Might it not be that identifying scholarship with science is the easy option, and this is why we have continued to live with it?

 I hope you will join me in saying: "I am not a scientist. I am not a passive observer of the world. I am something that is both more challenging and more important. I am someone who creates new technology to make the world of the future. I am an engineer."

 Let us be proud to be what we are and resist the pressures that try to turn us into something different. If we do that, we will have embarked on the road back to relevance. If we choose to continue to drift further and further into irrelevance, by becoming more and more closely identified with scientists, then let us at least admit that

This is by our own choice and is not imposed upon us by anyone else.

**Kenneth J. Waldron**

**John B. Nordholt Professor**

**Department of Mechanical Engineering**

**Ohio State University**

**Columbus, Ohio**