Letters

Engineers' Role

Many conditions mentioned in the study of the engineer by Rudoff and Lucken (11 June, p. 1103) existed at the Boeing Company in Seattle from 1967 to 1970 during my employment there as a weights research engineer. R. Hijman, in *Spotlight*, published by the Seattle Professional Engineering Employees Association, described the work environment as: ". . . chronic built-in insecurity, tradesman wages for professional work, the involuntary nomadic life, plus blasting a career in a crowded and not-altogether-clean bullpen working at a fraction of your ability, and chewing your way through layer after layer of frustration . . . noise and distraction during normal working hours, and the system with its insistence on the squarest possible pegs for those awfully square holes, and all kinds of inducements and pressures to whittle yourself down to fit."

The primary problem was the educational gap between the newly hired engineers and the old hands. Since the engineering managers are far removed from the details of engineering and even further removed from the technical theory, they cannot be adequate judges of when obsolesence occurs. As a result of this myopia, many engineers with years of experience, but who never attained the level of management, drift imperceptibly into obsolescence, yet paradoxically are left to directly lead the more recent graduates. An antagonism arises between the two groups, the most appalling aspect of which is a discouraging, perhaps unconsciously, of methods or techniques unknown to the older engineers, but familiar to the newer ones. This is largely because of the exponential growth and dissemination of technical knowledge, which exists to a greater degree in the university than in industry.

While Rudoff and Lucken try to relate the engineer to a sociological definition of professionalism, I am more concerned with an abuse of the concept of professionalism, a concept which the company strongly promotes. The "professional" engineer is reminded that it is unprofessional to strike, belong to a union, or in any way negotiate with the company other than as an individual, in return for which he is allowed a freedom from the time clock and occasionally permitted to indulge in a lengthened lunch hour, so long as the lost time approximately equals the free overtime expected of him; this effortlessly rids the scene of any organized bargaining and means that the company is required to improve its benefits only to remain competitive with the other companies in attracting new employees.

The root cause of all the ailments of aerospace engineers is the specialization required by the industry. The engineer's task becomes narrow, repetitive, and efficient, and leaves him an unimaginative husk, numbed by frustration and boredom, an obsessive advocate of his specialty to the exclusion of inquiry and open-minded problem-solving.

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Rudoff and Lucken seem to assume that the engineer has superhuman prescience, so that he can foresee all of the uses for his discovery or development that may be found by the hundreds of thousands of people who may have access to a new device. This is preposterous. The engineers' role is to make hardware available. Whether the purchaser of a box of matches uses them to start his furnace to warm himself and his family or to commit arson is his decision. This is not within the control of either the manufacturer or the engineer who designed the match. The same argument holds for any more elaborate piece of equipment, such as the internal combustion engine. It is the choice of the owner of the engine to either keep it adjusted for good performance and negligible harmful emission, or to neglect it (recall that the engine with the least amount of harmful emission in a recent test was a well-tuned internal combustion engine). It is no more possible for the engineer to foresee the use of his technological innovations than it is for the physician to foresee what good or evil will be effected by the child he delivers in the maternity ward. After all, the worst crimes and the greatest advances are all caused by people. Should the physician so dread delivering a future murderer that he no longer delivers any children?

Also, the performance criteria (number of patents and publications) used by Rudoff and Lucken appear to be a naive carry-over from their academic, nonengineering milieu. While these criteria may have some merit for engineers in advanced development sections and on university staffs, they are meaningless to production and design engineers, whose value lies in their ability to speed production or to design a part for cheaper manufacture without degrading performance. Even though many of these innovations are not patentable by law, they save money. In other cases, obtaining patents would alert the competition. Often, more money may be made by using the improvement until the competition learns to copy it, at which time the experience gained may be used for another improvement. While major discoveries may give the basic principles for new products, the technology that provides these products is based upon thousands of small innovations, which not only bridge the gap from theory to the actual product, but also keep the manufacturing equipment running in the factory.

The authors conjecture that the unemployed engineers may be hostile to the defense industry as a consequence of their unemployment. Even though I left the defense industry voluntarily while it was still thriving, I did so because I and most of the engineers with whom I worked realized that the welfare of any company heavily committed to defense was dependent upon the whim of a fickle government which could award and cancel contracts at its fancy. This view is reinforced by the findings in Shapley's survey of engineers who were recently released from the defense industry (News and Comment, 11 June, p. 1116).

Rudoff and Lucken correctly observe that most engineers are primarily interested in their fields of specialty and secondarily in financial reward and public image. It is perhaps this order of interest that explains the engineers' languorous attitude toward the professional societies and toward image building. When employment was no problem, the general attitude among engineers in the defense industry was that they were doing recognized engineering jobs, so that they were obviously professional engineers.

As in the case of the medical practitioners during the depression of the 1930's, the present financial hardships thrust upon engineers may be the irritant required to cause them to think seriously about what their profession is, what it should be, and what their societies should do to bring about a correspondence between the two.

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The Space Shuttle

The conflicting analyses of the costs and benefits of the space shuttle that were carried out by Rand and by Mathematica (News and Comment, 11 June, p. 1112) have stimulated controversy over this space transportation system. The costs and benefits of the shuttle constituted a major topic of discussion at the recent Space Systems Meeting of the American Institute of Aeronautics and Astronautics.

The cost of the full operational space transportation system is now put at $12.7 billion, although new cost-cutting efforts may reduce that figure. This cost includes shuttle development, test, and production; establishment of facilities; and a reusable orbit-to-orbit shuttle or "space tug" that would be used to emplace and retrieve satellites in orbits up to the geosynchronous.

According to the Office of Management and Budget (OMB), the shuttle must be wholly justifiable on the basis of economic return, and the system must generate this return at a 10 percent discount rate. Such a conservatively high rate reflects the relatively low priority now afforded to space ventures.

Lindley (*1*) reports that the OMB specifications would be met by a traffic rate of 39 flights per year, much lower than the recent rate of launches by all users (NASA, Department of Defense, Comsat, and so forth). The specifications would also be met by a continuing level of space spending, again by all users combined, of $3 billion per year—much lower than is the case even today. Woodcock (*2*), analyzing shuttle design requirements after the methods applied to new commercial jet transports, also concludes that the current designs are adequate to meet the OMB requirements.

Shuttle benefits include reduced launch costs, elimination of launch losses through an intact-abort capability, on-orbit refurbishment and checkout of satellites with attendant simplification of satellite design, and optimal use of man in spaceborne investigations. Two types of payloads would be carried: those physically separated from the shuttle and those which remain attached, subsequently returning to Earth. These classes are referred to, respectively, as "automated satellites" and "sortie missions."

The automated satellite represents a development of the classic unmanned satellite. Salee (*3*) proposes an analytic method for determining the cost reductions such satellites might achieve. He suggests maintenance of the satellite by routine shuttle revisit, rather than relying upon redundant or high-reliability design. Salee concludes that such satellites should use available hardware, with new development eschewed in favor of proven designs. The resulting payloads would feature low technological risk, high credibility of cost prediction, and lower research and development cost. He reports a saving of 50 percent in a typical case, the High Energy Astronomical Observatory.

The sortie mission represents a fundamentally new mode of space operation. Bader and Farlow (*4*) propose that scientific sortie flights could resemble the experiment-carrying aircraft flights of the NASA program; their conclusions are echoed by Stuhlinger and Downey (*5*). In sortie flights, the scientists themselves would furnish the instruments, which could be of standard laboratory design, and they would accompany them to orbit. The instruments would require little or no space-qualification, and the scientists would require no astronaut training.

This approach contrasts with current methods, in which space experiments require the involvement of hierarchies of designers, managers, review and evaluation boards, contractors, and NASA centers. The time from experiment proposal to flight is 3 to 5 years; the cost, $30,000 per pound and up. Shuttle sortie experiments could be carried out at an equipment cost of $100 to $1000 per pound. Time from proposal to flight would be months or even weeks. Most important, the scientist could spend his time actually preparing