Should technology be scorned?

Science and technology are parts of a seamless spectrum, but there is a good reason to believe that the literature of engineering does a disservice to the professional community it purports to serve.

TECHNOLOGY is largely, but not wholly, the product of scientific enquiry, so why is the first so isolated from the second? The question is not as academic as it may seem. In Britain, for example, governments talk as if the gulf is the cause of Britain's poor economic performance. Engineers also often have a sense of being poor cousins, sharpened by the familiar observation that successful projects (space launches, for example) are called "scientific" triumphs, but failures, "engineering" disasters.

Historically (and recently), the formation of societies such as the National Academy of Engineering in the United States and the Fellowship of Engineering in Britain is partly a response to grumbling of this kind. It may be a more serious, but misguided, matter that grant-making agencies seem bent on blessing university engineering departments with research funds on the pattern familiar in science departments when there is no knowing whether this is how academic engineering would be best enlivened,in teaching, discovery or by means of more direct contributions to economic propsperity.

Part of the difficulty is that engineers are their own worst enemies when, as some do, they seek to endow their profession with a mystique that is essentially divisive. The argument is that engineers differ from scientists in their ambition to get things done, not just to think about them. This, for example, was one of the themes of the Finnistion report on British engineering education which, seven years ago, set the foundations for the pattern of univeristy engineering now emerging. It may be more relevant that the mystique is externally imposed by the usual requirement that engineering courses at universities must be validated by professional organizations. (The same applies to medicine, the oldest form of applied biology.)

That many successful engineers (from the two Stephensons and Brunel to Remington and Edison) were impatient of abstraction goes without saying. It is also usually the case that practising engineers must deal with problems of a practical nature that do not often arise in research laboratories — labour relations, economics and the law, for example. (A sufficient recognition of that would make people as respectful as engineers could wish.) But some kinds of engineering are indistinguishable from applied mathematics, while many research laboratories contain pieces of home-built equipment which, by their function, precision and complexity, would not shame a professional engineer. The mere sight of, say, a high-energy physics particle detector should make that plain.

What this implies is that engineering and the practice of science are a seamless spectrum. If technology is the hard substance of engineering (labour relations and the law excluded), there should be no recognizable boundary between that and research proper. But may not people's objectives, and thus the nature of the intellectual work they do, differ profoundly? Although both engineers and, say, physicists may build similar pieces of equipment, are not their motives very different? Superficially, one might say that scientists' equipment exists so as the better to understand natural phenomena while that built by engineers is directed at some useful task external to itself.

That argument would be the more convincing if it were not that engineers, having built a new machine, find themselves impelled towards better explanations of its functions. The machine becomes the phenomenon, turning engineers into scientists. Those who built the first steam-engines found it necessary quickly to construct steam tables, essentially empirical substitutes for a full thermodynamic understanding of the dependence of pressure on temperature and density (but any other pair of independent variables will suffice) for two-phase water. Modern engineers, software engineers for example, are impelled in similar directions by the need to generalize their experience of a first machine (which may be a program) to the design of its successors.

Naturally, people in this state of mind are not so foolish as to pretend that everything they need to know can be deduced from first principles. Like other scientists, biologists for example, engineers are used to working with empirical generalizations. Modestly, perhaps because they have a good sense of the high cost of empirical measurement, they rarely dignify their generalizations as "laws" in the sense of Newton. Sadly, but not necessarily out of a sense of modesty, they tend to hug to themselves whatever generalizations they may have formed in their own minds. One passing result is that the professional literature of engineering is a disgrace: an outside innocent cannot hope by any amount of diligent reading to know what is in its authors' minds.

The best-known of the civil engineering journals, for example, contain descriptions of the largest earthwork dams; lesser journals describe smaller structures. Other people wishing to build dams on rivers of arbitrary size will have to make their own interpolations betwen contrasting circumstances. Much the same is true of the rest of applied science, even of medicine: readers are supposed to be able to accumulate case-records in their heads until they arrive at their own understanding.

The pity of this state of affairs is that the reality is much more interesting. Engineers in the real world grapple with two problems, of which the chief might be called that of optimization; what is the best (cheapest, most energy-efficient, fastest) machine to do some job. Extrapolating from known machines can yield great benefits, but the big prizes go to those who sense when it is time to change the mould. (*Canard* (wings at the front) aircraft will one day make sense, but it will be a clever person who knows how and when.) Might it not help us all if these questions were taken up directly in the literature of engineering?

The other absorbing question is that of complexity, or of how one comes to terms with one's use of a machine for which there is no *ab initio* explanation. Real life is amply full of demonstrations that one can survive: many of those who do not understand why lead-free gasoline tends to knock have trouble-free driving licences. The fact that mathematicians have so far failed to provide a finite solution of the general travelling-salesman problem, that of how most economically to travel some path between an arbitrary number of destinations, may be a sign that the need to survive without full understanding is perpetual.

Under both these heads, not to mention that of the mutual prosperity, engineering bursts with interest. Why is the literature of engineering so arid? To fear that many people have been restrained from writing what they might have written by the knowledge that their patent applications have not yet been approved would be venal, but it is a constant disappointment that even the accounts of novel semiconductor devices tumbling from the pages of *Applied Physics Letters* are as laconic as appears to be the rule. Could it be that engineers are their own worst enemy in this more serious sense?

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