Pure Technology

By "Daedalus of New Scientist"

Reprinted from the First Edition of Albert H. Teich, *Technology and Man's Future* (New York: St. Martin's Press, 1972), pp. 53-61.

In a characteristic passage in Plato's *Republic* we find Glaucon and Socrates discussing the nature of the Good. Glaucon suggests that there are three kinds of good: the simple, inconsequential pleasures; then activities pleasurable both in themselves and their consequences; and finally those tasks and duties not inherently pleasant but undertaken for subsequent advantage. He then asks Socrates to locate "honesty" in one of these categories.

> *Socrates:* I should say, in the best of the three, those which a man must like both for their own sake and for their consequences, if he's going to live the kind of life one wants to have.
>
> *Glaucon:* Well, that's not what most people think; they reckon it belongs to the tedious kind of good, which has to be pursued in order to earn a wage, or, for appearance's sake, to be well thought of.

Glaucon's threefold subdivision remains relevant to this day, and the passage would retain its point if the philosophers had been discussing technology. The usual attitude taken toward technology—certainly by those who put up the money for it-is that its value lies only in its profitable consequences, and research and development in itself is an unavoidable interim expense. Yet to the engineer the chase may be as rewarding as the kill; he may well privately place his activities in the second or even in the first category of good, divorcing it partly or almost wholly from the sordid aftermath of profitable application.

This attitude of mind defines *the Pure Technologist.* Pure technology is the building of machines for their own sake and for the pride or pleasure of accomplishment. It is a creative art form somewhere between art and science. Some examples of pure technology are the record-breaking vehicle, built purely to see if it will behave as intended; the chess-playing computer program, devised for the sheer entertainment of seeing how well it makes out; and that masterpiece in miniature, *Scientific American's* Great International Paper Airplane Competition.

Most other technical projects have some degree of purity, though the assessment of such a subjective quality will rarely be clear-cut. What is the purity status of a cuckoo in a cuckoo clock, for example? Or on a grander scale, is a particle accelerator pure technology? To the physicist it is as applied as any other of his instruments; to the engineer constructing it, it has only to work as intended, and so is pure; an outsider will judge it as pure or as applied according as he judges nuclear physics itself. Yet despite its confusion with (and indeed, latterly, deliberate disguise as) the applied

variety, pure technology is recognizable throughout history as one of the minor muses.

CLASSICAL PIONEERS

The first indubitable instances occur rather late in Classical times. The great Athenian achievements in art and science occurred without any comparable revolution in technology. Nowhere do Glaucon or Socrates express any appreciation of the aesthetically or intellectually stimulating qualities of technology—for them it was firmly in the third, humdrum class of good. Not until Alexandria took over from Athens as the intellectual center of the world did major progress in empirical techniques occur. The "Museum" at Alexandria, founded around 300 B.C. by one of Alexander the Great's generals to be the intellectual showpiece of his regime, was for many centuries a unique library, artistic center, and research institute, and shared so many of the features of modern research establishments that it may fairly be called the MIT of the ancient world.

The Alexandrian pure technologists were the mechanicians, chiefly Ctesibius, Philo, and Hero. That part of their research which directly served the interests of their employers was, as one might expect, military-improving the catapults and ballistas which launched the missiles of the time. But they also carried out much more fundamental and far-reaching research in pure physics.

We know little of Ctesibius except from contemporary references. The Roman engineer Vitruvius tells us that he invented the force-pump, a hydraulic organ, two different forms of catapult, the water-clock, and several types of automata. The stern, practical Roman describes only the pump, the organ, and the clock, and refers us to Ctesibius's own book (now lost) for details of other devices "which serve no useful purpose, but the pleasure of delight."

These delightful inventions are described in one of the surviving treatises of his follower, the famous Hero of Alexandria. Hero probably lived about 100 B.C. and wrote treatises on catapults and missiles, on automata, and on the studies in pneumatics for which he is best known. His books give the first description in recorded history of the works of men who, fascinated by a new science, set out to see what could be done with it for the sheer pleasure of creation. Pure technology was on the march!

Some of the *jeux d'esprit* of the Alexandrian mechanicians is shown in the [treatises'] diagrams. All five "classical machines" (lever, wedge, screw, pulley, and winch) are used in these little contrivances, as well as the float, siphon, water-whistle and other elements discovered or at least first understood at Alexandria. The elasticity of air and the incompressibility of water are recognized and ingeniously exploited; and despite the dry and Euclidean way Hero expounds their working, it is clear what fun he had putting them together.

Some commentators have ridiculed them as "mere scientific toys," but I think this

misses the point. Toys they were indeed for the most part, but they were toys embodying new and important principles which the mechanicians used in more practical equipment, and attempted to explain by theory. Hero never quite explicitly expounds the concept of atmospheric pressure, but he is quite sure that air is a material substance, and gives directions for constructing apparatus to prove the existence of a vacuum. For 100 B.C. this is physics of a high order indeed!

The most famous of all Hero's "toys" is his steam reaction-turbine or Aeolipile, number 50 of the 78 inventions in his *Pneumatics.* This simple machine merely drove itself and illustrated a principle, and there is no reason to suppose that Hero ever envisaged scaling it up. Nowhere in the ancient world was there a more propitious place to make such a revolutionary invention than the Museum at Alexandria; yet nothing came of it. The technical and intellectual and social infrastructure was far too inadequate to handle the application of this piece of pure technology, and the Alexandrian achievement petered out with the general decline of the ancient world in the first few centuries A.D.

The technoscientific reactor did not go critical for over another thousand years, until the European Renaissance. The first really striking piece of pure technology to emerge from the intellectual ferment that followed was the balloon.

THE BALLOON GOES UP

The brothers Montgolfier were papermakers of Annonay in France, and were of an inventive and curious turn of mind. Etienne Montgolfier once tested Leonardo's concept of the parachute by jumping from the top of a building holding a large umbrella! The concept of lighter-than-air flight seems to have matured in their minds from 1767 onwards. They knew of Cavendish's preparation of hydrogen, but a small pilot balloon lost the gas so rapidly by diffusion through the (paper) envelope that they abandoned this notion.

The idea of the fire-balloon is said to have occurred to Etienne on a carriage ride. Immediately on reaching the inn of his destination he called for taffeta and fire, and, to the horror of the proprietor, the world's first lighter than air flying machine, made of badly singed taffeta, rose nobly to the ceiling of one of his bedrooms!

The Montgolfiers organized their first demonstration flight from Annonay market square on June 5, 1783. The craft was made of paper (the material they were most familiar with) and reached a height of 6,000 feet. Garbled reports by the mystified local authorities reached Paris, where Professor Cesar Charles (of Charles' Law fame) deduced that the Montgolfiers must have been using hydrogen. Determined to emulate their feat, he set about the frightening task of filling a 1,000-cubic-foot rubberized silk balloon with hydrogen generated from iron and sulphuric acid. Four days it took, during which time the Professor and his assistants were in constant fear of an explosion: at times the exothermic reaction became so violent that the whole assembly had to have water played over it.

But all went well, and the first hydrogen balloon ascended triumphantly from Paris on August 26, 1783, traveled 15 miles, and was destroyed on landing by horrified peasants. Only when the Montgolfiers exhibited their invention in Paris did Charles realize that he had invented the hydrogen balloon by mistake.

Ballooning soon became a popular activity throughout the Continent. Brave men ascended in both hot-air and hydrogen balloons (Charles reached 10,000 feet on December 1, 1783, and returned safely). The new invention was soon subsidized by the military, who dreamt of balloon transport and aerial observation flights. Indeed, a ballooning corps was formed in the French army after the Revolution; but this near-farcical concept was never a serious threat. The House of Lords dissolved in laughter when Lord St. Vincent, in 1802, speaking of the defense of Britain against Napoleonic invasion, remarked "I do not say they cannot come. I only say they cannot come by sea." Again, a novel extension of human abilities had been developed and exercised for its own sake, and funded by authority on grounds that would not stand up to hostile cost-effectiveness analysis.

MODERN PURE TECHNOLOGY

The massive flowering of invention of the modern era poses for the connoisseur of pure technology the challenge of identifying unambiguous examples of the genre. This is surprisingly difficult. On the face of it, practically every invention made since about 1800 was immediately applied.

But this may not mean that pure technology ceased to exist-only that it was rapidly overtaken by applications. Many of Hero's inventions were never applied at all-the concept of research-based technology scarcely existed in his society. Leonardo da Vinci's beautiful mechanical concepts took centuries to reach fruition (I cannot claim him as a pure technologist because he was essentially a theoretician rather than a practical inventor); Montgolfier's remained pure long enough to recognize as such. But the genius of a technological age lies not in scientific advance or creative imagination, but in seeking applications, in consciously and persistently asking the question, “How can I exploit this?”

Just how automatic and comprehensive this technique of progress has become, with each new piece being fitted into the growing jigsaw puzzle as soon as the development of neighboring fields permits, may be judged by trying to think of inventions in the mainstream of technology which might have been made much before they actually were. (After some cogitation, I can list only seven: gas-phase chromatography, the hovercraft, the standardized goods-container, prestressed concrete, the disc brake, casein glue, and DDT-based insecticides. Perhaps readers can add to-or subtract from the list?) The great majority of inventions appear just as soon as they become feasible.

The clue to discovering pure technology-things made for the sake of making them-in this relentless advance, is to identify developments which. although they occupy

obvious and clearly tillable gaps in the jigsaw, are simply unnecessary: gaps which are not worth filling on any rational basis. This test works best on fairly new inventions, before the patina of age and seeming inevitability has settled on them.

A prime example is the SST [Supersonic Transport], an indubitable masterpiece of thinly disguised pure technology. I need not detail here the ample demonstrations which have been given of the pointlessness and social drawbacks of this project. But given a journey of, say, seven hours at an average of 10 mph and another six at 600 mph (a fair profile of a typical transatlantic air excursion) the expenditure of millions of dollars to clip a few hours off the *high-speed* section seems misguided to say the least, even assuming it is worth shortening the time at all in view of the increased disruption of circadian rhythms. Balancing this insignificant gain and the tiny minority who gain it against the solid debit in expense and noise pollution inflicted on the majority, we can see how unexpectedly powerful is the drive to pure technology in our supposedly cost-conscious society-for the only really compelling reason for building the SST (and of course its rival the Concorde) is the sheer entertainment of overcoming all the technical problems and finally flying such a thrilling machine!

MORE EXAMPLES

The same motivation applies in a practically overt manner to the space rocket. The big rocket is the twentieth-century pure-technological achievement par excellence, but all its pioneers—Oberth, Goddard, von Braun-saw it not as an end in itself but as a means toward the larger pure-technological goal of space flight. Even when the first successful V-2 ballistic rocket was fired in 1942, officially part of German war research, von Braun exclaimed jubilantly that the only trouble was that it landed on the wrong planet!

Again, no scientific or technical considerations can justify on economic grounds the billions of dollars invested in the space program. Even the solid military interest in rocketry and radar and long-distance communication would have been far better served at a fraction of the cost by normal research and development. Yet the splendor of setting foot on our satellite, the sheer poetry of sending our creations out to scan other worlds and report back what they see-these represent pure technology at its best. It seems almost carping and small-souled to query whether the money might not have been better spent on more urgent terrestrial matters.

A quite different instance of modern pure technology, this time not quite rapidly enough overtaken by events to obscure its real appeal, is the laser. The appearance of the first practical prototype in 1960 created such interest that, in the words of the *New York Times*, "almost every corporation and every self-respecting university in the nation obtained a laser of some sort." The appeal of the new device was so widespread, and yet actual commercial applications so elusive, that the laser rapidly acquired the reputation of a solution in search of a problem. In particular, the millions of dollars disbursed by the military to explore its potential as a destructive weapon had so little result that one cynic exclaimed in disgust that the most offensive use you could make

of a laser was to hit someone over the head with it.

The laser is still (judging by the number used in research compared to that in solid commercial applications) a machine with few uses-yet there is no doubt of its powerful hold on the imagination of the technical community. The charm of being able to drill a hole in a razorblade with a beam of light, or bounce photons off the moon, is so great that the actual value of being able to do so is irrelevant.

THE MILITARY TRADITION

These instances of pure technology past and present give an insight into the nature of the discipline. Its central characteristic, like those of art and science, is acceptance of self-imposed challenge and the aggrandizement of the human spirit. It occurs alongside and within applied technology in dynamic and intellectually active societies. It is one of the dramatic arts, and since by and large the human sense of the dramatic is rather direct and unsophisticated, pure technology tends to address itself to naive and, in the fashionable term, charismatic challenges-making large objects go fast, discharging high concentrations of energy, "conquering" space. It is funded on misleading grounds. And behind it, more often than not, lurks the military, like a dim but suspicious creditor, paying up uneasily in the hope of ultimate advantage.

I believe the closeness of the association between militarism and pure technology to be significant. In the convoluted, multidimensional psychospace of all human mental constructs which it is the ultimate goal of psychology to map, the two are very close together. Both are manifestations of aggression, of dynamic material response to a felt challenge, posed in one case by a like-minded group of people and in the other by Nature herself. In both of them the emotive appeal loosely summed up by the word "glory" is as important as the overt goals. This thesis is implicit in the common claim that the space race with Russia is a valuable "sublimation" of political rivalries, but it also explains many other features of military history.

Historians have long debated the motives behind the replacement of the longbow by the musket in European armies around 1600, despite the former's clear superiority in cheapness, accuracy, range, reliability, and rate of fire-advantages it held until the invention of the rifle in the nineteenth century! It has been suggested that expertise in archery declined for some reason after the twelfth century, and that less trainable conscripts had to be used. But the overwhelming melodramatic appeal of the thunderous discharge of gunpowder weapons was probably the key factor.

The same lure of the grandiose is evident in the archmilitarist Prussian tradition. Big Bertha, the enormous gun that shelled Paris from 76 miles away during World War I, was hardly a cost-effective weapon. And the development of the German V-weapons during World War II is an even clearer instance. V-l, a pilotless aircraft, cost about $600 (then) to produce, whereas V-2, the ballistic rocket, cost $25,500; both delivered about the same warhead (around a ton of high explosive) with comparable range and accuracy. Clearly V-l was by far the better weapon, comparing favorably in cost-

effectiveness with manned bombers. Yet V-2, which replaced it, was far more flamboyant.

D. lrving (See Suggested Reading at the end of this article.) supports the conclusion of Dr. R. V. Jones, a British intelligence officer concerned with countermeasures to the V-weapons, that V-2 was supported for "romantic" reasons. He describes the overwhelming, Wagnerian impact repeatedly produced on Nazi officials by the ". . . intoxicating sight of the 13-ton rocket blasting aloft atop a lengthening pillar of fire and condensation, and the roar of its motor echoing back over the sea"-and concludes that such military romanticism probably cost Germany the war. Certainly in the later stages of the struggle von Braun's expensive piece of pure technology, by its wholesale consumption of vital raw materials and labor, inflicted far more damage on Germany than it ever did on Britain. As an inhabitant of old London town at the time, it is clear that my attitude should be one of gratitude.

All approved weapons of war seem to have evolved to meet some minimum level of flashing, banging, shrieking romantic appeal. Subsequent developments have given us the doubly dramatic nuclear ICBM, and promise to deliver a still more expensive, problematically effective, but pure-technologically challenging toy, the ABM. In *Scientific American* (Vol. 221, No. 2, p. 17) H. F. York outlined the grave drawbacks of this strictly technological approach to security. But what fun to make a missile like Sprint, which goes so fast that its outside gets hotter than its inside! Indeed, one must suspect that the universal opprobrium directed at chemical and biological weapons stems not from any deviation from accepted standards of beastliness or efficacy, but simply from their deplorable lack of theatrical impact.

STATIC PURE TECHNOLOGY

But not all fields of pure technology are complicated by military appeal. Architectural pure technology, for example, is concerned with the grandeur of impressive monuments, rather than of wonderful machines. The most outstanding example may also be the very first-the Egyptian pyramids. Kurt Mendelssohn *(Science Journal*, Vol. 4, No. 3, p. 48) has argued persuasively from structural and historical evidence that these were not primarily built as tombs to ensure personal immortality for the Pharaohs (though presumably this suggestion was as attractive to the Pharaohs as any hinted prestigious or military implications in a modern grant application), but as gigantic exercises in pure technology, "built because man had reached the stage at which he was able to build them." Similarly one must acknowledge the considerable pure-technological component in the magnificent cathedrals created in Europe during the ages of faith. But the finest recent example is undoubtedly the Eiffel Tower in Paris. This completely purposeless structure, simply a fine piece of megastatuary, has become a proud symbol and a focal point of the city. One can hardly imagine Paris without it.

Yet, increasingly, modern architectural practice disdains such overt frivolity, and degrades pure-technological aspirations into commercially respectable but inhuman office blocks. The architect W. W. Frischmann believes that it is now technically

possible to build a tower two miles high, so naturally he wants to do it *(Science Journal,* Vol. I , No. 8, p. 62). But in justification he feels impelled to suggest it as a "vertical city" holding half a million people-thus creating about the most obscene human environment of all time.

WHAT TO DO ABOUT IT

It is clear that the malevolent aspect which pure technology is increasingly assuming stems not from its own proud nature but from our obsession with applications. It would take a brave man openly to deny the grey dogma of our time that all human activity must be economically justified, that nothing should ever be done unless it will return 8 percent on capital.

The worst consequences of accepting it can, however, be evaded. And it is here, I believe, that the more flexible and devious European mind has much to teach the innocent technologists of the USA. Consider the noble record of the British aerospace industry. A long series of pure-technological triumphs-among them the Princess Flying Boat, the Brabazon super-airliner, the Blue Streak ICBM and the TSR2 supersonic fighter-bomber-were developed just to the point where the prototype had successfully flown, and were then cancelled (though Blue Streak was kept on in a pure-technological capacity as a space-launcher).

All the satisfaction of dramatic pure technology was gained without inflicting the products on a helpless public or on an already unstable situation. (I like to think that in the case of Blue Streak and TSR2, the engaging British habit of "leaking" information on such machines to the Russians was designed to encourage them to invest heavily in countermeasures tailored to the weak points of weapons that were in fact purely hypothetical. But even the devious European mind rarely attains such an Oriental level of duplicity.)

There is every reason to hope that the pattern will be 'repeated with Concorde. Once the prototype has been exhaustively tested, the program will be cancelled to save money, and peace-loving citizens will be able to breathe freely again. But this civilized technique has only imperfectly crossed the Atlantic. The American counterpart of TSR2, the F-111, was, after prototype testing, procured for the armed forces, to everybody's sorrow. And if the American SST is once successfully flown, what considerations can hope to arrest it?

We are mishandling the forces of pure technology. We dare not suppress it: for the subjective motivation of every dedicated inventor is basically pure-technological-to rise to envisaged challenge and create objects of pride. The nineteenth-century inventors and engineers understood this: that is why their creations had a style and confidence almost unknown today. The economic prudery which forces the once proud art form to don the respectable mantle of application is now actively harmful, and does much to justify the growing and well-founded dislike of juggernautical technomania.

So pure technology must be recognized and fostered. Even in Britain, one of the world's leaders in pure technology, the stifling doctrine of social relevance and immediate profitability is beginning to clip the wings of the more imaginative and high-flying research projects. I would like to see official bodies set up to protect pure technological endeavor, equivalent in function to Britain's Arts Council. In the United States, this might take the form of a National Pure Technology Foundation. Given such a source of funds, it would be possible to devote one's efforts to seeing in the dark, or making machines that play with building-blocks, or constructing mechanical elephants, without having to waste time on the shaky sophistry of practical application at present required.

Allowing pure technology an honest existence will not only leave certain pure-technologically hag-ridden industries free to return to humane and reasonable techniques (I am particularly thinking of the adoption by the airlines of silent, safe, luxurious, city-center to city-center helium-filled airships) but may also restore confidence in technology among a suspicious populace, and introduce a welcome component of aesthetics into the technical scene at large. But most importantly, pure technology promises to be that "moral" equivalent of war" advocated by the great American philosopher William James. Its close psychological affinity to military display may fit it to replace actual combat, just as in the animal kingdom the professional carnivores such as wolves have perfected aggression-rituals which resolve their disputes without bloodshed. Technology has given us the power to exterminate ourselves, and it is fitting that technology should also provide the safe outlet for our overamplified aggression. Let us hope that the space race, that triumph of pure technology, may be an archetype of triumphs yet to come!

Suggested Reading

Plato, *Republic*, Book 2, pp. 357a ff. K. J.Dover trans.

J. Mander, G. Dippel, and H. Gossage, *The Great International Paper Airplane Book,* Simon and Schuster, New York, 1967.

Hero of Alexandria, *A Treatise on Pneumatics*, section 15 ff, Bennett Woodcroft, ed.. Lord, 1851.

K. Lorenz, *On Aggression*, Methuen, 1967.

D. lrving. *The Mare's Nest*, William Kimber, 1964.

SuggestedListening

T. Lehrer, "A Song of Wernher von Braun," *That Was the Year That Was*, Reprise LP Album No. 6179.

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