identifies the interrelationships between science and technology and the other elements in the socio-cultural system can contribute to understanding the implications of alternative policies. If the understanding born of that research does not produce broader agreement on these critical issues, at least it will serve to illuminate the deeper roots of our disagreement.

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CAN TECHNOLOGY REPLACE SOCIAL ENGINEERING?

ALVIN M. WEINBERG

Alvin M. Weinberg, Director of the Oak Ridge National Laboratory and one of the pioneers of atomic research, presents an argument that in certain respects is a direct rebuttal of Harold Wolff's article. Dr. Weinberg states the technologist may be better able to solve social problems than the social scientist. While he sees a need for a better understanding between social scientist and technologist, the more pressing social problems he feels can be best solved via technological advances. The earth, not space, should be the foci of scientific endeavor.

■ During the war, and immediately afterward, our federal government mobilized its scientific and technical resources, such as the Oak Ridge National Laboratory, around great technological problems. Nuclear reactors, nuclear weapons, radar, and space are some of the miraculous new technologies that have been created by this mobilization of federal effort. In the past few years there has been a major change in focus of much of our federal research. Instead of being preoccupied with technology, our government is now mobilizing around problems that are largely social. We are beginning to ask what can we do about world population, about the deterioration of our environment, about our educational system, our decaying cities, race relations, poverty. President Johnson has dedicated the power of a scientifically oriented federal apparatus to finding solutions for these complex social problems.

Social problems are much more complex than are technological problems. It is much harder to identify a social problem than a technological problem: how do we know when our cities need renewing, or when our population is too big, or when our modes of transportation have broken down? The problems are, in a way, harder to identify just because their are renewed, or our air clean enough, or our transportation solutions are never clear-cut: how do we know when our cities convenient enough? By contrast the availability of a crisp and beautiful technological *solution* often helps focus on the problem to which the new technology is the solution. I doubt that we would have been nearly as concerned with an eventual shortage of energy as we now are if we had not had a neat solution -- nuclear energy -- available to eliminate the shortage.

There is more a basic sense in which social problems are much more difficult than are technological problems. A social problem exists because many people behave, individually, in a socially unacceptable way. To solve a social problem one must induce social change -- one must persuade many people to behave differently than they have behaved in the past. One must persuade many people to have fewer babies, or to drive more carefully, or to refrain from disliking Negroes. By contrast, resolution of a technological problem involves many fewer individual decisions. Once President Roosevelt decided to go after atomic energy, it was by comparison a relatively simple task to mobilize the Manhattan Project.

The resolution of social problems by the traditional methods -- by motivating or forcing people to behave more rationally -- is a frustrating business. People don't behave rationally; it is a long, hard business to persuade individuals to forego immediate personal gain or pleasure (as seen by the individual) in favor of longer term social gain. And indeed, the aim of social engineering is to invent the social devices -- usually legal, but also moral and educational and organizational -- that will change each person's motivation and redirect his activities along ways that are more acceptable to the society.

The technologist is appalled by the difficulties faced by the social engineer; to engineer even a small social change by inducing individuals to behave differently is always hard even when the change is rather neutral or even beneficial. For example, some rice eaters in India are reported to prefer starvation to eating wheat which we send to them. How much harder it is to change motivations where the individual is insecure and feels threatened if he acts differently, as illustrated by the poor

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white's reluctance to accept the Negro as an equal. By contrast, technological engineering is simple: the rocket, the reactor, and the desalination plants are devices that are expensive to develop, to be sure, but their feasibility is relatively easy to assess, and their success relatively easy to achieve once one understands the scientific principles that underlie them. It is, therefore, tempting to raise the following question: In view of the simplicity of technological engineering, and the complexity of social engineering, to what extent can social problems be circumvented by reducing them to technological problems? Can we identify Quick Technological Fixes for profound and almost infinitely complicated social problems, "fixes" that are within the grasp of modern technology, and which would either eliminate the original social problem without requiring a change in the individual's social attitudes, or would so alter the problem as to make its resolution more feasible? To paraphrase Ralph Nader, to what extent can technological *remedies* be found for social problems without first having to remove the *causes* of the problem? It is in this sense that I ask, "Can technology replace social engineering?"

THE MAJOR TECHNOLOGICAL FIXES OF THE PAST

To better explain what I have in mind, I shall describe how two of our profoundest social problems – poverty and war – have in some limited degree been solved by the Technological Fix, rather than by the methods of social engineering. Let me begin with poverty.

The traditional Marxian view of poverty regarded our economic ills as being primarily a question of maldistribution of goods. The Marxist recipe for elimination of poverty, therefore, was to eliminate profit, in the erroneous belief that it was the loss of this relatively small increment from the worker's paycheck that kept him poverty-stricken. The Marxist dogma is typical of the approach of the social engineer: one tries to convince or coerce many people to forego their short-term profits in what is presumed to be the long-term interest of the society as a whole.

The Marxian view seems archaic in this age of mass production and automation not only to us, but apparently to many Eastern bloc economists. For the brilliant advances in the technology of energy, of mass production, and of automation have created the affluent society. Technology has expanded our productive capacity so greatly that even though our distribution is still inefficient, and unfair by Marxian precepts, there is more than enough to go around. Technology has provided a "fix" – greatly expanded production of goods – which enables our capitalistic society to achieve many of the aims of the Marxist social engineer without going through the social revolution Marx viewed as inevitable. Technology has converted the seemingly intractable social problem of *widespread* poverty into a relatively tractable one.

My second example is war. The traditional Christian position views war as primarily a moral issue: if men become good, and model themselves after the Prince of Peace, they will live in peace. This doctrine is so deeply ingrained in the spirit of all civilized men that I suppose it is blasphemy to point out that it has never worked very well – that men have not been good, and that they are not paragons of virtue or even of reasonableness.

Though I realize it is terribly presumptuous to claim, I believe that Edward Teller may have supplied the nearest thing to a Quick Technological Fix to the problem of war. The hydrogen bomb greatly increases the provocation that would precipitate large-scale war – and not because men's motivations have been changed, not because men have become more tolerant and understanding, but rather because the appeal to the primitive instinct of self-preservation has been intensified far beyond anything we could have imagined before the H-bomb was invented. To point out these things today, with the United States involved in a shooting war, must sound hollow and unconvincing; yet the desperate and partial peace we have now is much better than a full-fledged exchange of thermonuclear weapons. One cannot deny that the Soviet leaders now recognize the force of H-bombs, and that this has surely contributed to the less militant attitude of the USSR. One can only hope that the Chinese leadership, as it acquires familiarity with H-bombs, will also become less militant. If I were to be asked who has given the world a more effective means of achieving peace, our great religious leaders who urge men to love their neighbors and, thus, avoid fights, or our weapons technologists who simply present men with no rational alternative to peace, I would vote for the weapons technologist. That the peace we get is at best terribly fragile, I cannot deny; yet, as I shall explain, I think technology can help stabilize our imperfect and precarious peace.

THE TECHNOLOGICAL FIXES OF THE FUTURE

Are there other Technological Fixes on the horizon, other technologies that can reduce immensely complicated social questions to a matter of "engineering"? Are there new technologies that offer society ways of circumventing social problems and at the same time do *not* require individuals to renounce short-term advantage for long-term gain?

Probably the most important new Technological Fix is the Intra-Uterine Device for birth control. Before the IUD was invented, birth control demanded very strong motivation of countless individuals. Even with the pill, the individual's motivation had to be sustained day in and day out; should it flag even temporarily, the strong motivation of the previous month might go for naught. But the IUD, being a one-shot method, greatly reduces the individual motivation required to induce a social change. To be sure, the mother must be sufficiently motivated to accept the IUD in the first place, but, as experience in India already seems to show, it is much easier to persuade the Indian mother to accept the IUD once, than it is to persuade her to take a pill every day. The IUD does not completely replace social engineering by technology; and indeed, in some Spanish American cultures where the husband's manliness is measured by the number of children he has, the IUD attacks only part of the problem. Yet, in many other situations, as in India, the IUD so reduces the social component of the problem as to make an impossibly difficult social problem much less hopeless.

Let me turn now to problems which from the beginning have had both technical and social components – broadly, those concerned with conservation of our resources: our environment, our water, and our raw materials for production of the means of subsistence. The social issue here arises because many people by their individual acts cause shortages and, thus, create economic, and ultimately social, imbalance. For example, people use water wastefully, or they insist on moving to California because of its climate, and so we have water shortages; or too many people drive cars in Los Angeles with its curious meteorology, and so Los Angeles suffocates from smog.

The water resources problem is a particularly good example of a complicated problem with strong social and technological connotations. Our management of water resources in the past has been based largely on the ancient Roman device, the aqueduct: every water shortage was to be relieved by stealing water from someone else who at the moment didn't need the water or was too poor or too weak to prevent the steal. Southern California would steal from Northern California, New York City from upstate New York, the farmer who could afford a cloud-seeder from the farmer who could not

afford a cloud-seeder. The social engineer insists that such shortsighted expedients have got us into serious trouble; we have no water resources policy, we waste water disgracefully, and, perhaps, in denying the ethic of thriftiness in using water, we have generally undermined our moral fiber. The social engineer, therefore, views such technological shenanigans as being shortsighted, if not downright immoral. Instead, he says, we should persuade or force people to use less water, or to stay in the cold Middle West where water is plentiful instead of migrating to California where water is scarce.

The water technologist, on the other hand, views the social engineer's approach as rather impractical. To persuade people to use less water, to get along with expensive water, is difficult, time-consuming, and uncertain in the extreme. Moreover, say the technologists, what right does the water resources expert have to insist that people use water less wastefully? Green lawns and clean cars and swimming pools are part of the good life, American style, 1967, and what right do we have to deny this luxury if there is some alternative to cutting down the water we use?

Here we have a shart confrontation of the two ways of dealing with a complex social issue: the social engineering way which asks people to behave more "reasonably," the technologists' way which tries to avoid changing people's habits or motivation. Even though I am a technologist, I have sympathy for the social engineer. I think we must use our water as efficiently as possible, that we ought to improve people's attitudes toward the use of water, and that everything that can be done to rationalize our water policy will be welcome. Yet as a technologist, I believe I see ways of providing more water more cheaply than the social engineers may concede is possible.

I refer to the possibility of nuclear desalination. The social engineer dismisses the technologist's simpleminded idea of solving a water shortage by transporting more water primarily because, in so doing, the water user steals water from someone else — possibly foreclosing the possibility of ultimately utilizing land now only sparsely settled. But surely water drawn from the sea deprives no one of his share of water. The whole issue is then a technological one; can fresh water be drawn from the sea cheaply enough to have a major impact on our chronically water-short areas like Southern California, Arizona, and the Eastern seaboard?

I believe the answer is yes, though much hard technical work remains to be done. A large program to develop cheap methods of nuclear desalting has been undertaken by the United States, and I have little doubt that within the next ten to twenty years we shall see huge dual-purpose desalting plants springing up on many parched sea coasts of the world. At first these plants will produce water at municipal prices. But I believe, on the basis of research now in progress at ORNL and elsewhere, water from the sea at a cost acceptable for agriculture — less than ten cents per one thousand gallons — is eventually in the cards. In short, for areas close to the sea coasts, technology can provide water without requiring a great and difficult-to-accomplish change in people's attitudes toward the utilization of water.

The Technological Fix for water is based on the availability of extremely cheap energy from very large nuclear reactors. What other social consequences can one foresee flowing from really cheap energy eventually available to every country regardless of its endowment of conventional resources? Though we now see only vaguely the outlines of the possibilities, it does seem likely that from very cheap nuclear energy we shall get hydrogen by electrolysis of water, and, thence, the all important ammonia fertilizer necessary to help feed the hungry of the world; we shall reduce metals without requiring coking coal; we shall even power automobiles with electricity, via fuel cells or storage batteries, thus reducing our world's dependence on crude oil, as well as eliminating our air pollution insofar as it is caused by automobile exhaust or by the burning of fossil fuels. In short, the widespread availability of very cheap energy everywhere in the world ought to lead to an energy autarky in every country of the world; and eventually to an autarky in the many staples of life that should flow from really cheap energy.

WILL TECHNOLOGY REPLACE SOCIAL ENGINEERING?

I hope these examples suggest how social problems can be circumvented or at least reduced to less formidable proportions by the application of the Technological Fix. The examples I have given do not strike me as being fanciful, nor are they at all exhaustive. I have not touched, for example, upon the extent to which really cheap computers and improved technology of communication can help improve elementary teaching without having first to improve our elementary teachers. Nor have I mentioned Ralph Nader's brilliant observation that a safer car, and even its development and adoption by the auto company, is a quicker and probably surer way to reduce traffic deaths than is a campaign to teach people to drive more carefully. Nor have I invoked some really fanciful Technological Fixes: like providing air conditioners and free electricity to operate them for every Negro family in Watts on the assumption (suggested by Huntington) that race rioting is correlated with hot, humid weather; or the ultimate Technological Fix, Aldous Huxley's soma pills that eliminate human unhappiness without improving human relations in the usual sense.

My examples illustrate both the strength and the weakness of the Technological Fix for social problems. The Technological Fix accepts man's intrinsic shortcomings and circumvents them or capitalizes on them for socially useful ends. The Fix is, therefore, eminently practical and, in the short term, relatively effective. One does not wait around trying to change people's minds: if people want more water, one gets them more water rather than requiring them to reduce their use of water; if people insist on driving autos while they are drunk, one provides safer autos that prevent injuries even after a severe accident.

But the technological solutions to social problems tend to be incomplete and metastable, to replace one social problem with another. Perhaps the best example of this instability is the peace imposed upon us by the H-bomb. Evidently the pax hydrogenica is metastable in two senses: in the short term, because the aggressor still enjoys such an advantage; in the long term, because the discrepancy between have and have-not nations must eventually be resolved if we are to have permanent peace. Yet, for these particular shortcomings, technology has something to offer. To the imbalance between offense and defense, technology says let us devise passive defense which redresses the balance. A world with H-bombs and adequate civil defense is less likely to lapse into thermonuclear war than a world with H-bombs alone, at least if one concedes that the danger of the thermonuclear war mainly lies in the acts of irresponsible leaders. Anything that deters the irresponsible leader is a force for peace: a technologically sound civil defense therefore would help stabilize the balance of terror.

To the discrepancy between haves and have-nots, technology offers the nuclear energy revolution, with its possibility of autarky for haves and have-nots alike. How this might work to stabilize our metastable thermonuclear peace is suggested by the possible political effect of the recently proposed Israeli desalting plant. The Arab states I should think would be much less set upon destroying the Jordan River Project if the Israelis had a desalination plant in reserve that would nullify the

effect of such action. In this connection, I think countries like ours can contribute very much. Our country will soon have to decide whether to continue to spend $5.5 x 10^9 per year for space exploration after our lunar landing. Is it too outrageous to suggest that some of this money be devoted to building huge nuclear desalting complexes in the arid ocean rims of the troubled world? If the plants are powered with breeder reactors, the out-of-pocket costs, once the plants are built, should be low enough to make large-scale agriculture feasible in these areas. I estimate that for $4 x 10^9 per year we could build enough desalting capacity to feed more than ten million new mouths per year (provided we use agricultural methods that husband water), and we would, thereby, help stabilize the metastable, bomb-imposed balance of terror.

Yet, I am afraid we technologists shall not satisfy our social engineers, who tell us that our Technological Fixes do not get to the heart of the problem; they are at best temporary expedients; they create new problems as they solve old ones; to put a Technological Fix into effect requires a positive social action. Eventually, social engineering, like the Supreme Court decision on desegregation, must be invoked to solve social problems. And, of course, our social engineers are right. Technology will never *replace* social engineering. But technology has provided and will continue to provide to the social engineer broader options, to make intractable social problems less intractable; perhaps, most of all, technology will buy time – that precious commodity that converts violent social revolution into acceptable social evolution.

Our country now recognizes and is mobilizing around the great social problems that corrupt and disfigure our human existence. It is natural that in this mobilization we should look first to the social engineer. But, unfortunately, the apparatus most readily available to the government, like the great federal laboratories, is technologically oriented, not socially oriented. I believe we have a great opportunity here: for, as I hope I have persuaded you, many of our seemingly social problems do admit of partial technological solutions. Our already deployed technological apparatus can contribute to the resolution of social questions. I plead, therefore, first for our government to deploy its laboratories, its hardware contractors, and its engineering universities around social problems. And I plead, secondly, for understanding and cooperation between technologist and social engineer. Even with all the help he can get from the technologist, the social engineer's problems are never really solved. It is only by cooperation between technologist and social engineer that we can hope to achieve what is the aim of all technologists and social engineers – a better society, and, thereby, a better life, for all of us who are part of society.

POLITICS AND THE COMMUNITY OF SCIENCE

JOSEPH HABERER

Where both of the preceding authors criticize the social scientist for his lack of awareness, Joseph Haberer, Assistant Professor of Political Science at Rutgers University, berates the scientific community in general for a lack of social conscience and cowardice in the face of political pressures.

■ As a problem-solving enterprise, modern science has impressive achievements to its credit. These remarkable successes have enabled some to argue persuasively that science may solve man's political and social problems with equal success. This position implies that scientific skills and knowledge can supplant the political arts and practice; that politics will eventually become superfluous, replaced by the superior practice of science and the scientific expert.

If it was ever possible to think of science as truly divorced from politics, events and developments of the last few decades have made such a view untenable. The rapid growth of its institutions has brought not only heightened internal politicalization – over research priorities, leadership selection, training, setting the future directions of the community, and so on – but also an intensified involvement with the political order itself.

The metamorphosis from a small, individualistically oriented and relatively unorganized endeavor into a large-scale, collectively oriented and highly organized one is, in part, a reflection of the expanding social investment in science. A pattern of exponential growth has taken place within the last few centuries, which is most sharply shown by the rise in the number of scientists and scientific journals over this period.[1]

An indication of the phenomenal growth of the community of science is the size of what may be called the American community of science. One study estimated that this community included approximately 2,617,330 members and suggested that:

> [The American community of science] however ill-defined its boundaries, is in fact a very large, highly interactive and growing community with a self-conscious identity and ideology . . . [and] encompasses not only a hard core of scientists but also a very much larger closely-allied corps of directive and supportive workers essential to the functioning of the community.[2]

Within recent years the concept "community of science" has been frequently encountered in public discourse. Scientists, administrators, legislators, etc., increasingly refer to it, so that the consciousness of the scientific community's existence is almost taken for granted: we all know that it exists; what we do not know so well is the kind of community with which we are dealing and the sense in which it is a community.

In a recently completed study[3] I attempted to come to grips with this kind of problem. The study was conceived as an exploratory investigation in the politics of science. It sought to ascertain significant political characteristics of the community of science through an analysis of the political theories and practices of some influential figures in modern science, particularly as these have had an important bearing on the relationship of science to state and polity. Primary focus was on the community's response to three crises which confronted it and specifically upon the strategy of defense which its acknowledged leaders adopted. The study was confined to