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Exporting Hydroelectric Energy

Carlos M. Varsavsky

While today most countries face energy shortages, hundreds of thousands of megawatts of hydroelectric power remain undeveloped in Africa, Asia, and Latin America mainly because of small local demand. Unlike fossil fuels, such energy if not used today is lost forever. At the same time, no scheme has yet been found "to containerize" it for export.

For example, in Zaire between 30,000 and 35,000 MW can be generated at a cost well under one cent per kilowatt hour. This energy, however, cannot be used in Zaire or in regions that could be reached from Zaire by means of conventional transmission lines for decades to come. If a way were found to deliver this energy to any of the industrialized nations, it would be an enormous boom to the economy of Zaire, and it would save the world a significant amount of nonrenewable fuels. There are other developing countries with similar potential.

For more than a decade, considerable effort has been spent in developing the concept of the Solar Power Satellite (SPS) [1]. In essence, the scheme consists of a very large array of photovoltaic cells (about 100 square kilometers in area), placed in geosynchronous orbit, which produces dc electricity; this is converted into microwaves and beamed to earth from an antenna about 1 kilometer in radius. The microwaves are received on earth and transformed back into dc electricity that can be delivered to the existing grid after alternation. A system of the above dimensions would make about 5000 MW available to the public utilities. It will take over 20 years to make such a scheme operational on a commercial basis, and by far the largest technological and cost uncertainties reside in the collecting array of cells, antenna, and associated electronics, to be placed in space. What I suggest is a modification to the SPS scheme, in which a hydroelectric station substitutes for the solar energy collector. The electric energy generated at the station is transformed into microwaves and beamed toward a reflector in geosynchronous orbit, that would send the microwave beam back to earth where the energy is needed. The main advantage of this proposal over SPS is the elimination of, first, the construction and, next, the maintainence of a structure of 100 square kilometers with a substantial amount of complicated electronics about 35,000 km above the earth's surface. Instead, my proposed system would have in space only a reflecting antenna which would be large but an order of magnitude smaller than the array, and passive, which means no maintenance and very long life. Other advantages are the elimination of blackouts when the earth eclipses the solar collector, the positive economic impact

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on the developing country, and the likelihood of a shorter lead time for implementation. The main disadvantages are the larger investments on earth and some additional losses.

A superconducting line from Zaire to Europe or the production of hydrogen, or some other high-energy density material, by electrolysis may also be viable alternatives for exporting hydroelectric energy. I am surprised that practically no attention has been given to these possiblities.

References

[1] Glaser, Peter, E., "Solar Power from Satellites," *Physics Today*, February 1977, p. 30.

[2] AIAA Position Paper, "Solar Power Satellites," *Astronautics and Aeronautics*, January 1979, p. 14.

CSIT Forms Working Group on Three Mile Island

The March 28 nuclear accident at Three Mile Island raises serious questions about the regulation, design, construction, operation, maintenance, safety management, emergency management, etc. of nuclear power plants. In response to these concerns, CSIT has established a Working Group on Three Mile Island. The Purpose of WG-TMI is to work toward correcting any safety problems that may exist in nuclear power plants or that are likely to occur in future plants. The tentative tasks are to evaluate and comment on the major published reports on TMI, identify outstanding technical and institutional problems of nuclear safety, and monitor progress in correcting these problems. The group will rely on the exhaustive use of published reports and on our own independent investigation and analysis. We expect that the output of this effort will be a series of reports and proposed position papers to be published in TECHNOLOGY AND SOCIETY and/or circulated within IEEE in other ways consistent with IEEE procedures. The intent is to stimulate action to correct the nuclear safety problems. We will coordinate our efforts with other cognizant IEEE entities. WG-TMI will avoid making any judgment as to whether the benefits of nuclear power outweigh the risks. We believe that all responsible citizens have a common interest in correcting any safety problems that may exist in nuclear power plants, and we invite all concerned IEEE members to join in this effort. If you would like to participate or would like more information on WG-TMI, please contact:

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Even if you don't wish to participate, we would welcome your comments on the accident at, TMI—in particular, what you regard to be the most useful role of WG-TMI and of IEEE as a whole in this area.

Report from Working Group

The Working Group on National Security (WG-NS) is pursuing several subject areas at this time. Of particular interest and concern to the WG-NS is national security and the U.S. energy situation. Also, recent developments in information theory, in data and communication systems, "the cryptography affair" (IEEE IT Group Newsletter, Dec. 1977); the International Traffic in Arms Regulation (ITAR); and weapons development and the arms race are being studied.

A number of avenues are being studied in the area of energy: the global context of the energy problem; energy and defense; and the ultimate limits in energy supply. Coal, sythetic fuels, oil shale, nuclear energy, hydrogen, solar, tidal power, and geothermal energy are considered together with the U.S. reserves of oil and natural gas.

In "the cryptography affair," at issue are relatively new (1977) cryptographic techniques available for secure communications. Would disclosure of these new techniques threaten our national security, or would suppression of the techniques threaten free research and the right to privacy?

In a letter dated 7 July 1977 to Mr. E. K. Gannett, Staff Secretary of the IEEE Publications Board, Mr. J. A. Meyer of Bethesda, MD noted that the International Traffic in Arms Regulations (ITAR) existed as a method for controlling the effects of new technology on national security, and that scientists and engineers should submit papers on any technological topic that is covered by ITAR to the U.S. State Department for approval prior to dissemination. A brief article on cryptography by Richard Harris appeared in the June issue of TECHNOLOGY AND SOCIETY.

The WG-NS would appreciate receiving your comments. Suggestions from IEEE members for additional subject areas to pursue are welcome. You are invited to actively participate and to share your thoughts with the us. Please send your comments, suggestions, etc. to:

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To the Editor:

I have read with interest Frank Turner's article that appeared in the March issue of Technology and Society. I agree with most of the points made by Mr. Turner. Indeed, he has brought out the state of the present technoculture and the value basis succinctly. But I would like to add that the problem is deeper and the whole position of science and technology in relation to "development" needs reevaluation from a paradigmatic position.

At present, technology is producer-driven rather than consumer-responsive. This is the main reason why several products with trivial social purpose are being put on the market. Many people are uneasy about this situation and they would very much like technology to be essentially consumer-responsive. The inexorable law of diminishing returns (a la Ricardo) is operating here, and society must find ways of expressing what it wants more clearly.

Technology's main contribution has been a rise in productivity and efficiency over the last 100 years. But now, the productivity and efficiency are themselves being questioned—"productivity for whom," "efficient for whom," to the producer or to the society?

This again is a difficult position to reconcile. A total holistic view has to be taken so that the overall benefits are optimized without externalizing a major portion of costs. This calls for a change in the axis of economics, which at present aims at maximization of private benefits.

At a more fundamental plane, the question of "means" and "ends" in relation to sciece and technology has become crucial and can no longer be evaded. Science and technology provide us with the means to create almost anything we want, but worthwhile ends have to be developed to direct these means. The blind acceptance of science and technology (warts and all) is no longer possible because of the mounting dysfunctional secondary and tertiary effects of technology. It is not enough to have only rigorous analysis of markets to prove the potential beneficial attributes of new technology, but a rigorous analysis of the underlying paradigms to unravel the deeply embedded assumptions is necessary.

Another characteristic of science and technology has been that it has created a large array of hardware of global interdependence through the globe-girdling technologies of communication, transportation, military, and space. But a package of software to support this hardware—monetary agreements, international conflict resolution methodologies, peacekeeping mechanisms, property laws governing humankind's common heritage of air, water, and other resources, etc., are lacking. Unless this is remedied, the global technology system will become more dysfunctional and susceptible to disruption.

Historical and contemporary societies tend to emphasize only one of the three benefit sets—spiritual, social, and material—at the expense of the others. One of the major deficiencies of the present technoculture has been the restriction of benefits to one of these corridors only, thus making a large number of people who do not belong to that corridor "dissatisfied." For example, the market economy countries stress the "material" aspect, the centrally planned economies stress the "social" aspect, and many preindustrial societies stress the "religious" aspect.

It may be speculated that the resurgence of interest in several religious cults, including reversion to fundamentalism as in Islam, by several groups in different societies may be due to such "dissatisfaction" arising out of overstressing only the "material" aspect in the metaphor of "development." A new philosophy of "progress" which harmonizes all three benefit sets is the prime need at present.

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Bombay, India

August 25, 1979

To the Editor:

I was shocked by the indictment of research in the article of Frank T. Turner in the March issue of Technology and Society. As a person who would have died without the emergency use of a new and semi-experimental "wonder drug," I have a personal stake in research and development. Admittedly, most people are more comfortable with the past—they have spent most of their lives there! And as one who neither died of disease, accident, nor starvation because of inferior technology, Mr. Turner can look back in nostalgic pleasure. I can assure him that many others do not—but most of us didn't make it here!

Igor Alexeff
University of Tennessee

To the Editor:

In giving recognition to the notable services rendered by Virginia Edgerton, along with the strong encouragement and support she received from Prof. Stephen Unger, our Editor, Norman Balabanian, has demonstrated some journalistic perception which is all too rare in our profession.

The story of Virginia Edgerton's sense of responsibility and her personalized initiative deserves to be on the record to serve as an incentive for other and younger engineers. Unfortunately, however, too many other stories of similar conscientious initiative remain untold. And some of the untold stories relate to the subversion of engineering disciplines on a tremendous scale. (Fortunately, some examples are now appearing on the record in a new book, *Ethical Problems in Engineering*, published by Rensselaer Polytechnic Institute.)

It is difficult to understand why the arrangers of the program felt the need for introducing the rambling philosophies of Samuel Florman, who makes it quite clear that he has little comprehension of what is involved in the practice of professional disciplines. Fortunately the Editor has accurately pointed out that "Samuel Florman is an accomplished speaker (and writer) with a good ability to turn a phrase...Florman has contributed nothing to a meaningful debate."

Let's hope that the Editor will enlarge on the theme of "personalized professional responsibility" and on the experiences of other engineers who have demonstrated their integrity and courage to uphold their ethical commitments in defense of the public interest, even when the odds were very much against them.

ADOLPH J. ACKERMAN
Consulting Engineer

1979 September 4

TO THE EDITOR:

From time to time, the matter of the IEEE being an international versus a U.S. national organization arises. The position of the IEE is that it is international, and yet the "IEEE Energy Committee Position Statement on Solar Energy" on p. 5 of the March issue of TECHNOLOGY AND SOCIETY is clearly a statement relating only to the U.S. This is a serious error. Would an IEEE committee take a position on energy, for, say, Japan or India?

The IEEE can have a position on U.S. matters only through USAB, and such positions must be identified as being only for the U.S. and by U.S. members on a committee for the U.S. We insult the rest of the world by a pretense of being international. This duplicity must stop. If TECHNOLOGY AND SOCIETY is a U.S. document, the mast head should say so. At least TECHNOLOGY AND SOCIETY should not participate in confusion caused by items it prints from other parts of IEEE. The editor could add clarifying notes.

Minor insult is added to major insult of our non-U.S. members with the use of quad as a unit instead of the nearly equivalent SI unit exajoule, EJ.

As the new editor, you must have several problems. I hope my comments on these problems are useful to you.

ROBERT H. BUSHNELL
Boulder, CO

TO THE EDITOR:

In the light of my position paper published in the March issue of TECHNOLOGY AND SOCIETY, I was very pleased to read Prof. Melman's IEEE/AIAA talk.

Not only does he urge the redirection of our technology toward the solution of some of our real problems, but he calls attention to some of the weaknesses of our military-dominated R & D. As this orientation has spread through the rest of the profession to some degree, I believe it is at least partly responsible for the deteriorating status of our consumer-goods industry and technology.

FRANK T. TURNER
Nova Scotia, Canada

TO THE EDITOR:

May I add yet one more comment to the continuing Nuclear Power debate? Mr. Fellenzer's Letter to the Editor. (Vol. 7, No. 27, Sept. '79) and many similar arguments from the industry sound very convincing. Un fortunately, they are not sufficiently convincing to convince the authors and the industry, of their own position. I, for one, would be far more sympathetic to the industry position if the industry's actions reflected their arguments.

To be specific: if nuclear power is so very safe, why the limits on liability protection (the Price Anderson act)? If, indeed, experience has given the industry confidence in the safety of reactors, isn't it time to repeal the Price-Anderson act? In the meanwhile, as long as someone tells me that reactors are perfectly safe, but isn't willing to stand behind this safety claim, I am very, very skeptical.

Or, in the common vernacular: put your money where your mouth is.

ERWIN VOGEL
Gaithersburg, MD

Ethical Trilemmas

L. B. Cebik

The Institute of Electrical and Electronics Engineers is one of the oldest and largest professional engineering societies. Like its sister engineering organizations, it is caught up in the swirling forces of modern times. The old values seem to be falling away one by one. The respect we once took as our automatic due for belonging to a profession no longer comes to us. A hundred pressures from a hundred sides pull our minds from the performance of our duties and convert our once challenging work to a tangle of anxieties.

IEEE has been in the forefront of attempts to cope with these anxieties. Perhaps only the civil engineers have been as active. 1974 saw a new 19-point code of ethics adopted by the Board of Directors. 1977 saw the development of procedures for IEEE support of ethical engineers and for

The author is Professor of Philosophy and Assistant Dean for Research, University of Tennessee, Knoxville. This is the text of a talk presented before the East Tennessee Section of the IEEE, September 12, 1979.

handling alleged infractions of the IEEE code by members. 1979 sees the rise of a new mature beast: the formal academic course in engineering ethics. From inside and out, the pressures of ethics—whatever it is—squeeze from us our last drop of patience.

Let us pause to look at some of the sources of pressure. In fact, we do not have to look if we do not wish to. We can, instead, bury ourselves in the work of the day and ignore the squeeze. Such an attitude was most graphically expressed recently by an engineer (not a member of IEEE) who said, "My priorities are simple. First, to stay out of jail. Second, to put food in the table. Last, to advance my profession."

We can all take this stance. However, I give this warning: when you look up one day, even if only from curiosity, your profession may be unrecognizable. Whether you like its new form may be largely a function of the role you play in shaping it.

Traditionally, we are inured to living with dilemmas, the insoluble conflict of opposing duties. The demand for technical solutions which meet the highest standards of current knowledge, processes, materials, and cost effectiveness is a challenge which places every electrical and electronic engineer in continual conflict.

For example: your engineering analysis of an automatic control system for a railway network shows it to be unreliable and inadequately tested. Your employer rejects your report with threats that any additional action on your part may result in dismissal. He assures you that the system is in fact safe, when viewed from an overall perspective beyond your specialty. Delays to rework subsystems in accord with your report will kill all profit. Do you trust your skills and violate your role as an employee? This is the dilemma you face by being both a professional engineer and an employee.

For example, you determine that an automatic control system is unreliable and may permit accidents on a railway network. Your employer silences your protests, arguing that your first loyalty is to him. Your desire to protect the public which rides the system leads you to search for other outlets of warning. You can send you report to the city board governing the system and its public use. Should you? Should your interest in the public good override your commitment to act as a faithful agent or trustee for your employer? Here is a dilemma between your roles as a public citizen and an employee.

For example: after due process before the governing board of a railway network, you are dismissed from employ. No longer do you have assigned duties to analyze the automatic control system. Nonetheless, you stand by your original findings that the system is unreliable. As an engineer, your professional judgment demands hearing. As a citizen, you have received the benefits of current standards of due process. In this dilemma, do you console yourself in the knowledge that you have done all you can? Or do you take extraordinary action, such as "whistle-blowing?"

In dozens of forms, we all have confronted dilemmas between two aspects of our roles. We either resolved them or learned to live with them. In the examples, we recognize elements of the now infamous BART case. It was even more complex than the examples suggest.

What is most unusual about the BART case is this. In the most graphic way—one involving ultimately a train crash, three firings, and a court suits—all three elements of our professional lives came together. Events vindicated Hjortsvang, Bruder, and Blankenzee, but when each initially faced the problem, matters were far from certain. Each man faced a three-cornered conflict among his role as an engineer, as an employee, and as a concerned member of the public. Each faced the confusion of a trilemma.

With this multi-faceted problem IEEE as a professional society has had to grapple. From these events emerged the 1974 code of ethics of IEEE and the attempt to develop procedures to deal with future cases wherein questions of ethics arose. Twin procedures are emerging: one to handle violations of the code and the other to protect engineers who try to live up to it.

The IEEE code of ethics (with a 1979 revision of its Preable) contains 19 provisions and fits neatly on one page. The procedures occupy nine columns of small print. How can a code of ethics have come to this state?

Let us back up to watch history introduce further pressures upon us. Codes of ethics in their simplest form record a set of ideals to which their adherents aspire. The shortest code in my possession contains five or six sentences. Its wording begins typically thus: "A member should strive to act...." Such wording and generality are not designed to be enforced.

Second-level codes contain more stringent language. "Engineers shall accept responsibility for their actions." This is simple and plain and enforceable. The irresponsible member may be expelled. If licensing is a function of a given society, a professional may be stripped of permission to practice.

First- and second-level codes are ordinarily written in the language of human interactions. They specify the parameters of relationships. IEEE's basic code follows this pattern. Article I specifies the relationship of the engineer to his profession. Article II relates the engineer to his peers, Article III to his employers and clients, Article IV to his community and the public.

As we graduate from first to second-level codes, we evolve enforcement procedures. Usually these are informal and *ad hoc* procedures, developed as needs arise. In the history of professional societies, codes have at the second level been used to protect members economically and socially, enhancing their image and income. Entry standards and exams, licensure, and other such acts typify the prime work of societies with second level codes.

The famous Goldfarb case has changed all this. The court held, in effect, that a mimimum fee schedule for lawyers enforced through bar associations, is not exempt from antitrust provisions [Goldfarb v. Virginia State Bar (1975)]. In a case involving the National Society of Professional Engineers, the court reaffirmed this position by challenging the Society's ethical prohibition of competitive bidding [National Society of Professional Engineers v. United State (1978)]. The immediate effect of these cases is to deny professions and professional organizations immunity to provisions of antitrust statutes. By extension, immunity from all other generally applicable laws is also denied. Thus, the farther reaching effect of such rulings is to reduce the protections which societies can offer professionals.

The self-governance of the professions is being put to a stiff test. In fact, there appears to be a race between professional codes of ethics and the law for domination. The law seems content to let the professions regulate themselves so long as their mechanisms are open to all relevant parties and so long as the rights of all parties are preserved. Nonetheless, if professional societies do not work out rational solutions to their real and potential trilemmas, the law may well impose irrational solutions.

Even before Goldfarb, however, two strategies were emerging in the effort to preserve self-regulation for the professions. Third-level codes of ethics take one of two forms (which are not logically exclusive).

Level three-A consists of codes with have changed their substance. Instead of addressing human relationships, they prescribe and proscribe specific forms and activities. Typical are the codes of the American Psychological Association and the American Dental Association. The dentists, for example, forbid the use of secret agents and exclusive methods; set standards for cards, letterheads, and announcements, prescribe rules for office-door lettering and signs; and designate proper means of being listed in directories.

Now here are easily and clearly enforceable principles. A violation consisting, say, of an oversized door sign, is mechanically detectable. It is clear. And it is law-like. In fact, many find codes expressed as prescribed and proscribed actions and practices to be *too* law-like. For such critics, the only thing missing from these codes of ethics is the ethics. Gone are the human ideals and relationships. Gone are the guides to making hard decisions. What is left is little more than a quasi-criminal code enforced by a professional society rather than a constitutional government.

Level three-B codes take a different tack. To their second-level codes, they append long procedural statements to establish due process for cases of conflict and violation. This is the route IEEE has taken. It establishes a committee, an administrator, and an appeals board. Over fifty steps or procedures are spelled out for handling cases. The traditional content of the ethical code is preserved at the cost of a system of due process which emulates and rivals the courts of the law.

Whichever direction we turn, professional codes of ethics become more like the law. And the law is not cheap. Mediation or arbitration of disputes, substantive input to policy formation bodies, and self-disciplining of the memberships for violation of ethics all require investment of time, money and personnel. IEEE must surely grow, either withdrawing engineers from engineering or adding non-engineers to run an engineering society. Either way, destiny moves farther from the hands of the individuals professional. As Kafka painfuly showed in *The Trial*, well-established systems of law drag people along, oblivious to their needs or wants.

The picture is even bleaker, owing to pressures from the real law. In its efforts to support engineers, IEEE has discovered that it dare not act in behalf of only its members, lest it be guilty of collective bargaining. Other concessions must surely follow.

Is there a way out of this pressure-packed arena? One perennial suggestion, since Rousseau invented the noble savage, is simplification. William Wisely, formerly director of ASCE, has suggested that a one-sentence Professional Ethic might suffice as the "sole basis for the judgment of questions or allegations of unprofessional conduct, and for enforcement action when violations occur." The Ethic is this: "The engineer shall apply specialized knowledge and skill at all times in the public interest, with honesty, integrity and honor." ["Public Obligation and the Ethics System," *Proceedings of A.S.C.E.,* 105 (July, 1979) 133.]

While we might sympathize with Professor Wisely's sentiment, his suggestion is too late. Imagine an engineer deprived of his good standing on grounds that he had violated "honor." Given the intermixing of the law with the ethical proceedings of a society, I can imagine him bringing suit against the society for all manner of damages. The concept in question lacks sufficient precedent and definition to be legal or quasi-legal grounds for public action. No, it will take more than dreams of bygone golden ages to overcome the legalization of professional ethics.

What, then, may be done? In one sense, the answer is nothing. Our trilemmas have pushed professional ethical codes into the arena of quasi-law from whence they shall never return. The problems which brought the trilemmas to our attention are real. They demand the sort of treatment which only quasi-law, time, money, and effort can give them.

We can get used to the change. We can make use of this new and emerging system to aid the profession and its members. We can learn to expect of the system only what it can do. So, in another sense, there is something we can do.

And one thing more. When all professional codes are fully laden with particularistic proscriptions and procedures, we can refuse to forget that there are other important ideas. There are human relationships and ideals of endeavor to preserve and make real. As in all ethical adventures of mankind, not the printed page, but only the hearts and minds of dedicated professionals can preserve them.

Technology in Society: An International Journal, Vol. 1, No. 1, Spring 1979. Elmsford, NY: Pergamon Press. Reviewed by Terry L. Hweitt, Tektronics.

This past summer saw the introduction of a new publication related to technology and society. Titled *Technology in Society: An International Journal,* it is published quarterly by Pergamon Press. Editors are George Bugliarello and A. George Shillinger, both of the Polytechnic Institute of New York where the editorial offices are maintained. The Advisory Board listing of 26 individuals includes many who should be familiar to IEEE members including Edward E. David, Jr., Patrick E. Haggerty, Edward Teller, and Ernst Weber.

The stated aims of the journal are:

> In establishing this journal the editors are striving to create a single forum for a variety of related disciplines and concerns that, until now, have been widely dispersed in the literature: technology assessment; science, technology and society; management of technology; technology and policy; the economics of technology; technology transfer; appropriate technology and economic development; ethical and value implications of science and technology; science and public policy; technology forecasting.

The editors further state:

> ... *Technology In Society* has three objectives. The first is to explore how technology affects our society in its many aspects.... The second is to study the ways in which social processes and attitudes lead to technological decisions.... The third objective is to identify combinations of technological or social choices open to us, and their effects on society.

The first issue of 86 pages contains eight articles in addition to the Introduction and a small amount of advertising. A brief review of each article will be given.

Harvey Brooks opens with "Technology: Hope or Catastrophe?" in which he first surveys the wide range of current opinions on the world-wide social problems which are so interconnected with science and technology. He aptly points out that the current intellectual revolt against science and technology is not new but is more sigificant today since the well-educated are a significant fraction of the total population. Brooks admits to being an optimist while stating that the barriers to solving today's problems are more political and institutional than due to material or technical limits. In the end he presents a statement of hope and faith which most of us would echo:

> In the long run I would find it difficult to believe that the frailty of human institions will deny us the realization of the opportunities which lie within our intellectual capabilities, if not our moral ones. So I end with the proposition that science is more hope than catastrophe, though, admittedly, it is nip and tuck."

The global complications of today are next evaluated by Harlan Cleveland in the article "Do Global Technologies Require Global Policies?" Although acknowledging the changing and increasing impact of science and technology on the international order, he indicates that both science and technology are somewhat more constrained today since "science is now widely regarded as too important to be left to the scientists" and that we are also rid of the popular assumption which states that "if we could invent something, we had better manufacture it." (I doubt whether many would agree that these are indeed settled questions.)

Cleveland believes that the internationalization of internal affairs is already far advanced because of the global demands currently placed upon all nations, and that global bargaining by all nations "will be done in a spirit of mutuality or not at all."

Edward Wenk, in "Political Limits in Steering Technology: Pathologies of the Short Run," states that we need to better understand the various processes by which science and engineering are translated to social purpose. He also believes that the structure and procession of human affairs have a greater influence on the application of technology toward social uses than does any lack of technical innovation. The primary decisions in guiding technology are made by government, with the President as systems manager. Yet, the decision-making system of government is heavily biased by political expediency, and Wenk then lists a number of other "pathologies of the short run," including the reward structure in industry, the complexity of modern life, an inability to relate cause and effect, shortage of time and media pressure for the quick fix. He concludes with a resounding call for new attitudes:

> People are part of the decision apparatus. Unless they are willing to trade off instant gratification for some vision of the future benefits of humankind generally, and for their own progeny specifically, we will be in difficulty. Unless the public embeds the future in its decision calculus, the political leadership will remain in the vise of the short run. The hazard then exists of action or inaction which could debase individual integrity or extinguish humanity altogether. Even before that may happen, the benign neglect of the future may undermine even the future capacity to decide.

In "Nuclear Energy and the Interdependence of Nations," Edward Teller states that the most critical effect of the energy shortage will be in the Third World where increasing population will be met with decreasing supplies of oil. He believes that oil is the only material deliverable in small individual quantities suitable to the needs of primitive people. It should therefore be the objective of industrialized countries such as ours to concentrate on the use of advanced technologies for our energy sources. Teller naturally focuses on nuclear energy though giving a recognition of alternate forms of energy sources.

A brief review of the history of space exploration concludes with an optimistic appraisal of the space shuttle program in "The Impact of Our Enterprise in Space," by Hans Mark. The article is thinly veiled propaganda for a full-speed ahead in space exploration. The enticement presented is that the space shuttle will allow "many people (to) fly in space without much training." However, we are then left with:

> In trying to imagine what will happen once we have the shuttle, it may be better to look toward the poets and dreamers rather than the engineers.... The fact is that engineers and technical people generally tend to be too optimistic in the short term. We tend to

> really are and therefore overestimate what we can do in the span of the next twelve months. However, in looking at the long-term future, we tend to be timid, and it is here that the poets and the dreamers can help.

Mark then concludes with:

> ...There is no doubt we are faced with limits; every generation has been in the past. What is important is to recognize that the human imagination is not limited and that it is the use of that imagination which allows man to grow, to transend his limits, and to fulfill his dreams.

In the following article Peter Glaser discusses in considerable detail "The Potential for Solar Energy Development." Starting with the statistic that the sun contributes to the earth 5,000 times the total energy input from all other sources combined, Glaser proceeds to present an impressive quantity of figures related to the various forms of energy conversion which use the sun as the primary source. Among these conversion methods are solar water heaters, solar thermal conversion power plants, photovoltaic systems, wind power, ocean thermal energy, bioconversion, and solar power satellites.

Glaser concludes that it is too early to tell which solar conversion methods will prove to be beneficial and believes it necessary to develop all promising solar energy possiblities. He states that "...it is conceivable that the inevitable transition to renewable energy resources could be well underway by the first quarter of the 21st century and be completed by the middle of that century."

"The Five Buds of Technophilosophy" is the inviting title of an article by Mario Bunge. He first defines technophilosophy as, obviously, the philosopy of technology. Bunge calls this a budding field since

> Technophilosophy is...an underdeveloped branch of philosophy that has suffered from an excess of romantic mistrust of technology, as well as from a number of misunderstandings—such as the equation of technology with science (which dates back to Bacon) and the confusion of technology with its products, particularly the bad ones.

His five "buds" are

technoepistemology	the philosophical study of technical knowledge
technometaphysics	the philosophical study of the nature of artificial systems
technoaxiology	the branch of philosophy dealing with the nature of values and their impact on humans
technoethics	the branch of ethics that investigates the moral issues encountered by technologists
technopraxiology	the philosophical study of human action guided by technology

Finally, Bunge throws out a bit of a challenge to technologists:

> "...the technologist may not realize that he is a part-time technophilosopher...The moment he realizes this he may decide to take philosophy, or some of it, more seriously, and perphaps even to advance it. This would be a bonanza for philosophy, which is always in need of the cooperation of those who know something about the object of their musings."

Langdon Winner concludes the series of articles with another philosophical undertaking, "The Polititcal and Present Prospects." Winner welcomes the 20th century reemergence of "thinking about technology" which has been essentially avoided since a "technical orthodoxy" presented by Francis Bacon. Included in the list of standard tenets of this technical orthodoxy are:

> —that the things men make are under their firm control
> —that technologies are neutral
> —that what technicians or engineers do is simply a matter of problem solving

Winner then discusses the uses of technology by both capitalism and Marxism and the absence in both economic systems of the development of a valid philosophy of technology. He then leads to the development of alternative technology where "...the significance of alternative technology...is the possibility of a fundamental reevaluation of the place and meaning of technology in human activity." Winner finally asks:

> Is it not clear today that a society based on energy conservation and decentralized technologies using renewable resources would, in all likelihood, look very much different from a society based upon massive deployment of nuclear reactors?

In summary, *Technology In Society* appears to be primarly a forum for academic papers. As such, it serves a very useful purpose in providing a source of reference material for those who are already fairly knowledgeable in the area of science, technology, and society. The articles are well-written, and at a level that should be quite understandable to any professional. Unfortunately this journal is not likely to be found among the standard reading materials of many practical engineers.

As stated in the Introduction, "Papers will be invited, but the editors will also consider unsolicited manuscripts. The principal function of the Advisory Board will be to seek out new and/or unpublished talent and, in general, to encourage thoughtful articles that will contribute to better understanding and more creative and prudent social use of technology." Letters to the editor are also invited.

The general tone of the journal is one of cautious optimism regarding the future. Technological and social problems are to be studied and written about—but not to be hit over the head with. The activist is likely to be disappointed with the journal since it somewhat buries the criticality of most problems faced today in the area of science, technology, and society.

Technology In Society is a welcome addition to the list of publications related to the area of science, technology, and society and it is hoped that it becomes a useful voice in the definition and solution of our critical problems.

CSIT Meeting

January 19, 1980

The next meeting of CSIT will be held on Saturday, January 19, 1980, 10:15 AM to 3 PM, in Room 1306A of the Mudd Engineering Building, Columbia University, New York City. CSIT meetings are open to all IEEE members, and we hope you will take this opportunity to become better acquainted with us and with our activities. Light lunch will be provided. If you plan to attend, please notify Dr. Stephen Unger, (201) 567-5923.

Excerpts from the Kemeny Commission Report on Three Mile Island

[Editor's note: The following excerpts are from the Report of the President's Commission on the Accident at Three Mile Island, *which was released on October 30. The commission, chaired by Dartmouth College president John G. Kemeny, was established by President Carter on April 11 to investigate the accident that occurred at the Three Mile Island Unit-2 nuclear power plant on March 28, 1979.]*

Overview

...After a 6-month investigation of all factors surrounding the accident and contributing to it, the Commission has concluded that:

> *To prevent nuclear accidents as serious as Three Mile Island, fundamental changes will be necessary in the organization, procedures, and practices—and above all—in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions we investigated are typical, of the nuclear industry.*

This conclusion speaks of *necessary* fundamental changes. We do not claim that our proposed recommendations are sufficient to assure the safety of nuclear power.

Our findings do not, standing alone, require the conclusion that nuclear power is inherently too dangerous to permit it to continue and expand as a form of power generation. Neither do they suggest that the nation should move forward aggressively to develop additional commercial nuclear power. They simply state that if the country wishes, for larger reasons, to confront the risks that are inherently associated with nuclear power, fundamental changes are necessary if those risks are to be kept within tolerable limits.

In the testimony we received, one word occurred over and over again. That word is "mindset."...After many years of operation of nuclear power plants, with no evidence that any member of the general public has been hurt, the belief that nuclear power plants are sufficiently safe grew into a conviction. One must recognize this to understand why many key steps that could have prevented the accident at Three Mile Island were not taken. The Commission is convinced that this attitude must be changed to one that says nuclear power is by its very nature potentially dangerous, and, therefore, one must continually question whether the safeguards already in place are sufficient to prevent major accidents. A comprehensive system is required in which equipment and human beings are treated with equal importance...we are convinced that regulations alone cannot assure safety...it is an absorbing concern with safety that will bring about safety.....

We find a fundamental fault even with the existing body of regulations. While scientists and engineers have worried for decades about the safety of nuclear equipment, we find that the approach to nuclear safety had a major flaw. It was natural for the regulators and the industry to ask: "What is the worst kind of equipment failure that can occur?" Some potentially serious scenarios, such as the break of a huge pipe that carries the water cooling the nuclear reactor, were studied extensively and diligently, and were used as a basis for the design of plants. A preoccupation developed with such large-break accidents as did the attitude that if they could be controlled, we need not worry about the analysis of "less important" accidents.

Large-break accidents require extremely fast reaction, which therefore must be automatically performed by the equipment. Lesser accidents may develop much more slowly and their control may be dependent on the appropriate actions of human beings. This was the tragedy of Three Mile Island, where the equipment failures in the accident were significantly less dramatic than those that had been thoroughly analyzed, but where the result confused those who managed the accident....Since such combinations of minor equipment failures are likely to occur much more often than the huge accidents, they deserve extensive and thorough study. In addition, they require operators and supervisors who have a thorough understanding of the functioning of the plant and who can respond to combinations of small equipment failures.

Just how serious was the accident? Based on our investigation of the health effects of the accident, we conclude that in spite of serious damage to the plant, most of the radiation was contained and the actual release will have a negligible effect on the physical health of individuals. The major health effect of the accident was found to be mental stress.

...The ongoing cleanup operation at TMI demonstrates that the plant was inadequately designed to cope with the cleanup of a damaged plant.

...When NRC was split off from the old Atomic Energy Commission, the purpose of the split was to separate the regulators from those who were promoting the peaceful uses of atomic energy....But, we have seen evidence that some of the old promotional philosophy still influences the regulatory practices of the NRC. While some compromises between the needs of safety and the needs of an industry are inevitable, the evidence suggests that the NRC has sometimes erred on the side of the industry's convenience rather than carrying out its primary mission of assuring safety.

...In the licensing process, applications are only *required* to analyze "single-failure" accidents. They are not required to analyze what happens when two systems fail independently of each other, such as the event that took place at TMI.

....the utility that operates a nuclear plant must be held legally responsible for the fundamental design and procedures that assure nuclear safety. However, the analysis of this particular accident raises the serious question of whether all electric utilities automatically have the necessary technical expertise and managerial capabilities for administering such a dangerous high-technology plant. We, therefore, recommend the development of higher standards of organization and management that a company must meet before it is granted a license to operate a nuclear power plant.

...we fell that our findings and recommendations are of vital importance for the future of nuclear power. We are convinced that, unless portions of the industry and its regulatory agency undergo fundamental changes, they will over time totally destroy public confidence and, hence, *they* will be responsible for the elimination of nuclear power as a viable source of energy.

Commission Findings

A. Assessment of Significant Events

3. The pilot-operated relief valve (PORV) at the top of the pressurizer opened as expected when pressure rose but failed to close when pressure decreased, thereby creating an opening in the primary coolant system—a small-break loss-of-coolant accident (LOCA). The PORV indicator light in the control room showed only that the signal had been sent to close the PORV rather than the fact that the PORV remained open. The operators, relying on the indicator light and believing that the PORV had closed, did not heed other indications and were unaware of the PORV failure; the LOCA continued for over 2 hours. The TMI-2 emergency procedure for a stuck-open PORV did not state that unless the PORV block valve was closed, a LOCA would exist. Prior to TMI, the NRC had paid insufficient attention to LOCA's of this size and the probability of their occurrence in licensing reviews. Instead, the NRC focused most of its attention on large-break LOCA's.

4. The high pressure injection system (HPI)—a major design safety system—came on automatically. However, the operators were conditioned to maintain the specified water level in the pressurizer and were concerned that the [reactor cooling system] was "going solid," that is, filled with water. Therefore, they cut back HPI from 1,000 gallons per minute to less than 100 gallons per minute. For extended periods on March 28, HPI was either not operating or operating at an insufficient rate. This led to much of the core being uncovered for extended periods on March 28 and resulted in severe damage to the core. If the HPI had not been throttled, core damage would have been prevented in spite of a stuck-open PORV.

5. TMI management and engineering personnel also had difficulty in analyzing events. Even after supervisory personnel took charge, significant delays occurred before core damage was fully recognized, and stable cooling of the core was achieved.

6. Some of the key TMI-2 operating and emergency procedures in use on March 28 were inadequate, including the procedures for a LOCA and for pressurizer operation. Deficiencies in these procedures could cause operator confusion or incorrect action.

7. Several earlier warnings that operators needed clear instructions for dealing with events like those during the TMI accident had been disregarded by Babcock & Wilcox (B&W) and the Nuclear Regulatory Commission (NRC).

a. In September 1977, an incident occurred at the Davis-Besse plant, also equipped with a B&W reactor. During that incident, a PORV stuck open and pressurizer level increased, while pressure fell. Although there were no serious consequences of that incident, operators had improperly interfered with the HPI, apparently relying on rising pressurizer level. The David-Besse plant had been operating at only 9 percent power and the PORV block valve was closed approximately 20 minutes after the PORV stuck open. That incident was investigated by both B&W and the NRC, but no information calling attention to the correct operator actions was provided to utilities prior to the TMI accident. A B&W engineer had stated in an internal B&W memorandum written more than a year before the TMI accident that if the Davis-Besse event had occurred in a reactor operating at full power, "it is quite possible, perhaps probable, that core uncovery and possible fuel damage would have occurred."

b. An NRC official in January 1978 pointed out the likelihood for erroneous operator action in a TMI-type incident. The NRC did not notify utilities prior to the accident.

c. A Tennessee Valley Authority (TVA) engineer analyzed the problem of rising pressurizer level and falling pressure more than a year before the accident. His analysis was provided to B&W, NRC, and the Advisory Committee on Reactor Safeguards. Again no notification was given to utilities prior to the accident.

8. The control room was not adequately designed with the management of an accident in mind. (See also finding G.8.e.) For example:

a. Burns and Roe, the TMI architect-engineer, had never systematically evaluated control room design in the context of a serious accident to see how well it would serve in emergency conditions.

b. The information was presented in a manner which could confuse operators:

(i) Over 100 alarms went off in the early stages of the accident with no way of suppressing the unimportant ones and identifying the important ones. The danger of having too many alarms was recognized by Burns and Roe during the design stage, but the problem was never resolved.

(ii) The arrangement of controls and indicators was not well thought out. Some key indicators relevant to the accident were on the back of the control panel.

(iii) Several instruments went off-scale during the course of the accident, depriving operators of highly significant diagnostic information. These instruments were not designed to follow the course of an accident.

(iv) The computer printer registering alarms was running more than 2½ hours behind the events and at one point jammed, thereby losing valuable information.

E. THE UTILITY AND ITS SUPPLIERS

1.b. Nine times before the TMI accident, PORVs stuck open at B&W plants. B&W did not inform its customers of these failures, nor did it highlight them in its own training program so that operators would be aware that such a failure causes a small-break LOCA.

1.f. After an incident at TMI-2 a year earlier during which the PORV stuck open, an indicator light was installed in the control room. That light showed only that a signal had been sent to close the valve—it did not show whether the valve was actually closed—and this contributed to the confusion during the accident.

5. Utility management did not require attention to detail as a way of life at Three Mile Island. For example:

a. Management permitted operation of the plant with a number of poor control room practices:

(i) A shift supervisor testified that there had never been less than 52 alarms lit in the control room.

(ii) TMI Commission staff and NRC inspections noted a large number of control room instruments out of calibration and tags hanging on the instrument panel indicating equipment out of service. Operators testified that one of these tags obscured one of the emergency feedwater block control valve indicator lights.

(iii) When shifts changed in the control room, there was no systematic check on the status of the plant and the line-up of valves.

b. There were deficiencies in the review, approval, and implementation of TMI-2 plant procedures.

(vi) Performance of surveillance tests was not adequately verified to be sure that the procedures were followed correctly. On the day of the accident, emergency feedwater block valves which should have been open were closed. They may have been left closed during a surveillance test 2 days earlier.

h. Management did not assure adequate indentification of piping and valves throughout the plant. The Commission staff noted that pipe and valve identification practices were significantly below standard industrial practices. Eight hours into the accident, Met Ed personnel spent 10 minutes trying unsuccessfully to locate three decay heat valves in a high radiation field in the auxiliary building.

k. On November 3, 1978, a mechanic caused a complete shutdown of the plant, including exercising of emergency systems, when he tripped a switch on the polisher panel, thinking he was turning on a light. The only corrective actions was to put a guard on the switch.

l. Sensitive areas of the plant were accessible to large numbers of people. On the day before the accident, as many as 750 people had access to the auxiliary building.

F. TRAINING OF OPERATING PERSONNEL

2. The TMI training program conformed to the NRC standard for training. Moreover, TMI operator license candidates had higher scores than the national average on NRC licensing examinations and operating tests. Nevertheless, the training of the operators proved to be inadequate for responding to the accident.

G. THE NUCLEAR REGULATORY COMMISSION

2. NRC labels safety problems that apply to a number of plants as "generic." Once a problem is labeled "generic," the licensing of an individual plant can be completed without resolving the problem. NRC has a history of leaving generic safety problems unresolved for periods of many years—for example, the problem of anticipated transients without scram.

8. There are serious inadequacies in the NRC licensing process.

e. ...despite recognition within NRC and various industrial groups that outdated technology in the control room could seriously handicap operators during an accident, NRC continues to licence new plants with similarly deficient control rooms. As noted before, problems with the control room contributed to the confusion during the TMI accident. (See also finding A.8)

f. The requirement of additional instrumentation to aid in accident diagnosis and control was considered by NRC as early as 1975, but its implementation was delayed by industry opposition as expressed by the Atomic Industrial Forum (AIF)....The lack of instrumentation to display in the control room the full range of temperatures from the core thermocouples contributed to the confusion involved in the attempt to rapidly depressurize the primary system on March 28.

9. The Office of Inspection and Enforcement (I&E) is charged with determining whether licensees are complying with NRC regulations, rules, and licensing conditions. Some serious deficiencies in this office are:

a. A 1978 General Accounting Office report found that I&E inspectors did little independent testing of construction work, relied heavily on the utility's self-evaluation, spent little time observing ongoing construction work, and did not communicate routinely with people who did the actual construction work. Similar problems exist in I&E inspections of operating plants. For example, the principal I&E inspector for TMI-2 completed an inspection shortly before the accident by examining utility records and interviewing plant personnel, but without physically examining any equipment.

d. I&E inspectors at various time have had difficulties having safety issues that thay have raised seriously considered within the office. For example, in 1978 one I&E inspector raised the issue of operater termination of HPI during the September 1977 incident at Davis-Besse. For some 5 months, none of his efforts produced any action. He then took advantage of the "open door policy" of NRC and went directly to two of the commissioners. These commissioners considered his complaint serious enough to merit further exploration. Unfortunately, this meeting with the commissioners did not take place until one week before the TMI-2 accident.

Acceptance Statement

Delivered by V. Edgerton, CSIT Award Recipient, April 24, 1979.

I am indeed honored to receive this award. I dedicate it to all 190,000 IEEE members, some of whom, I am certain, are going through the same thing that I went through—but without getting an award.

This award is a pledge to our fellowman, to protect them from equipment malfunction and from technological damage. In the fifties, Albert Einstein warned us that for the first time since the dawn of history we were facing total annihilation through nuclear war. By the sixties nuclear war was unthinkable; we won't have nuclear war, we said. But the thought gradually emerged that maybe equipment malfuctions, as depicted in the movie *Dr. Strangelove*, would trigger a nuclear explosion and still cause total annihilation. Now, in 1979, we have experienced Three Mile Island. It would be alarmist to imply that TMI could lead to total annihilation, but we cannot close our eyes to the reality of the situation, either.

We can no longer continue to be the docile technicians that are optimum for the modern bureaucratic organization and also, at the same time, protect our fellowman. We had better make a choice. As the second recipient of this very proud award, I would like to state the first three ground rules of engineering ethics. I address them to all employers of engineers, whether they be for profit or not-for-profit organizations: First, an engineer will not do a job just because you tell him to. Second, deliberate design of malfunctioning equipment such that it kills or harms is a crime, and ordering an engineer to do so is also a crime. And third, the person who commits this crime can be jailed.

So my message to all the nontechnical people of the world and those of you who are here and who are not in our field is: I want you to notice that the IEEE is on this now. This is the second year in a row the award has been made. I am getting this award because maybe—we don't know for sure, but maybe—some people are walking around the streets of New York today who might have died, and they are walking around directly because of the IEEE. And I want to address all IEEE members everywhere, and especially the three men in San Francisco who received this award last year, with my message. And that is: *Be proud.*