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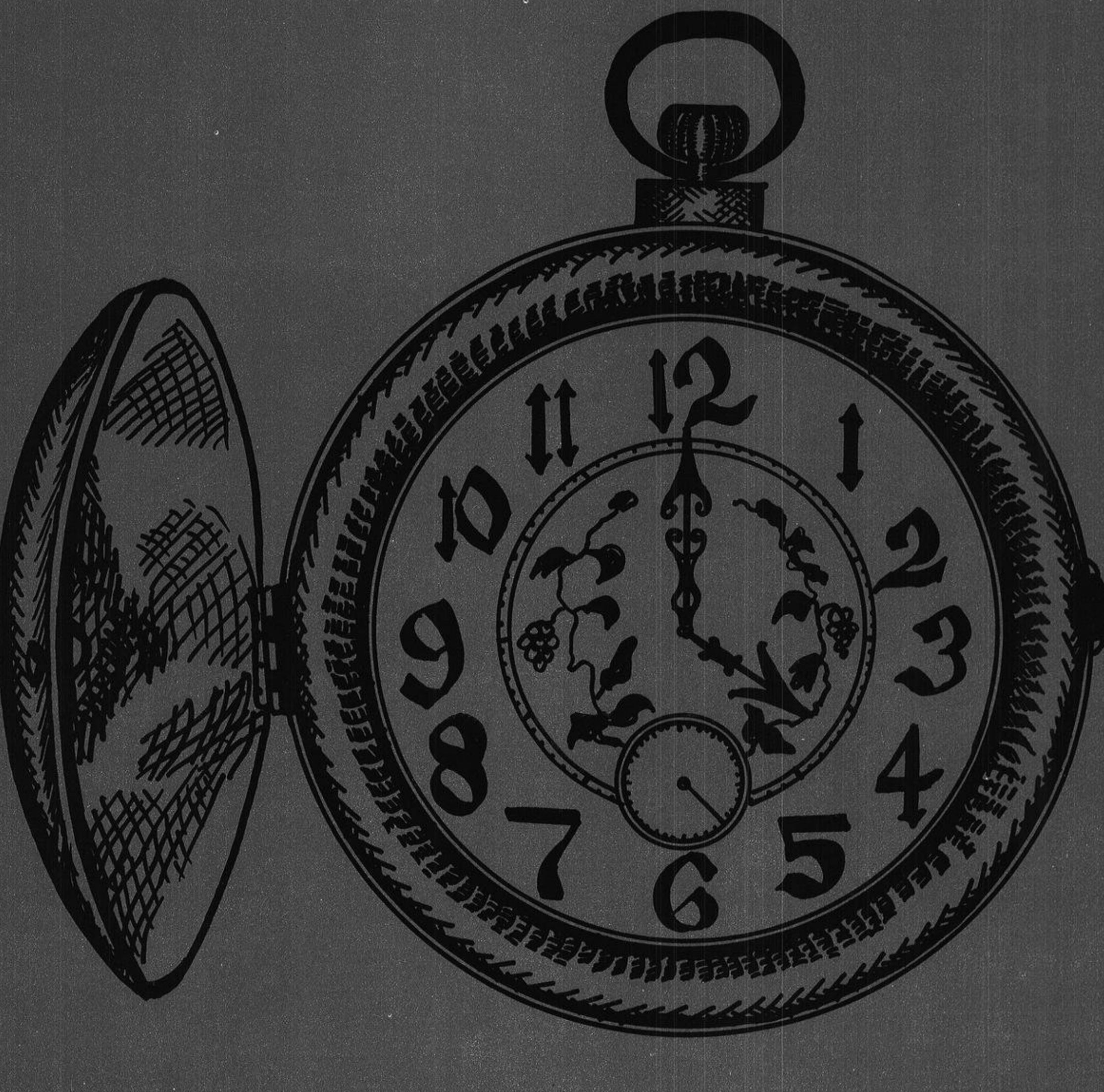
wisconsin engineer



"The crux of the matter is not only whether the human species will survive, but even more whether it can survive without falling into a state of worthless existence."

The Limits to Growth

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MEMBER OF ENGINEERING COLLEGE MAGAZINES ASSOCIATION

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Editorial

Good Teaching Means Never Having to Say You're Sorry

by Jim Guenther

Classroom teaching of undergraduates at the University of Wisconsin has not been given the attention it requires. The College of Engineering is one of the finest in the country, and yet even there, many factors lead to less than optimum use of educational resources.

The central purpose of the College of Engineering is the dissemination of information. This can only be accomplished with a balanced program of research, course development and classroom instruction. Research forms the future basis of the profession, course development forms the foundation of the curriculum and classroom teaching handles the extremely important task of dissemination of information to students. Any distortion of this balance results in a lower quality of education.

I have chosen to deal with one of these factors, an important deterrent to good teaching and one which can be dealt with by the college. This is the overemphasis on research by the faculty.

To put my criticism in perspective, I must first point out that research in the engineering college is a very important component of engineering education. There can be no questioning the value to students of a professor who does research and then relates his results in the classroom. The important point here is that the emphasis on research is leading to a deterioration in classroom teaching.

The reason for this bold statement stems from a comparison of the incentives for research versus those for teaching. Some of the incentives for good research include: ease in gaining tenure and promotions, acceptance by the faculty and by engineers in practice, the possibility of consulting work (which carries with it substantial financial rewards), and the satisfaction of contribution to scientific knowledge.

On the other side of the ledger are the "rewards" for good teaching: difficulty in gaining tenure and promotions, professional acceptance gained much later than for research of equal level and invitations to speak at engineering education meetings (without payment) instead of lucrative consulting work. There are also the positive incentives of student recognition, possible local teaching awards, and the satisfaction of doing a service for the students and for engineering education.

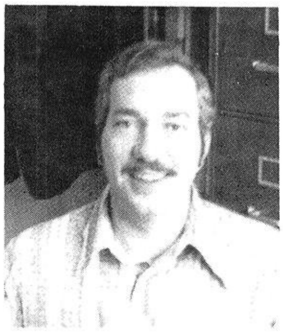
This is not to imply that there are not a lot of very good teachers in spite of the system and not because of it.

There are many ways that a balance can be achieved. Teaching awards can be increased both in number and in amount of stipend. Promotions and granting of tenure can be liberalized to allow faculty to concertrate on teaching methods and development of new courses without fear of denial when promotion comes up. And finally, a sabbatical should be recommended for faculty members to update their education, to gain experience in industry, or to improve themselves in any other way which will make for a better teaching atmosphere and a better qualified faculty. These are by no means inclusive of all that can be done to give students a better education, but rather they should serve as examples of what can be done to improve the college.

Let's see some action on these matters! Let's create an institution renowned for its progressive and innovative teaching atmosphere as well as its world ranking research.

Some Social Consequences of Technological Success

Robert A. Richardson
Visiting Assistant Professor
General Engineering Department



The author received his PhD from Yale in the Philosophy of Art and of Science. He then taught at Cornell College in Iowa before coming to UW. Presently, his interests are centered on the social impact of science and technology.

I want to talk about technology from the perspective of someone whose academic background is in Philosophy, because not everyone has a clear idea of what Philosophy is about, I feel that I ought to begin with a brief discussion of the field.

There are a variety of subjects such as law, art, science or politics which have a philosophical side, and around this aspect of such disciplines philosophical specialties have grown. As a result, there are philosophers of art who are not artists, philosophers of science who are not scientists, philosophers of history who are not historians, political philosophers who are not politicans, and legal philosophers who are not lawyers. We might therefore say that a philosopher is someone who knows exactly how a thing is done without being able to do it himself — or to put it another way, he is someone who claims to know your business better than you do. Since there is always something presumptuous about such a claim, it is not too surprising that philosophers have, from time to time, been subjected to a certain amount of derision and rough handling from those they set themselves up in business to help.

But perhaps this is enough background to give you some assurance that in considering some of the social consequences of technology, I am standing in the best philosophical tradition: being neither a social scientist nor a technologist, I am able to address myself simultaneously to two areas about which I know practically nothing. I call this philosophy; others might wish to call it knowledge a la mode, or interdisciplinary ignorance, or even something impolite.

Basically, I wish to make three points:

1) In our culture, technology is all-pervasive. Merely stating this should prove that I have a firm grip on the obvious, but I will go further and say it plainer still. **Technology is everywhere.**

2) This all-pervasive technology inspires ambivalent attitudes in each of us. In plain language, **everybody loves it and hates it.**

3) The role of technology in our society has suddenly become the subject of so much discussion and scrutiny because in fundamental ways the society is coming apart at the seams and this collapse of the social fabric is due in no small part to the successes of technology. Thus it can be said of technology that in certain respects **the more it succeeds, the more it fails.**

In order to illustrate my first point about the pervasiveness of technology, I want to discuss briefly what is probably the fundamental machine of the modern world. By this I do not mean the steam engine, the automobile, the electric dynamo or the nuclear accelerator. I mean a machine so domesticated and familiar that we use it countless times a day without thinking of it as a sophisticated technological device — in fact, we most often use it without thinking about it at all. I mean the clock.

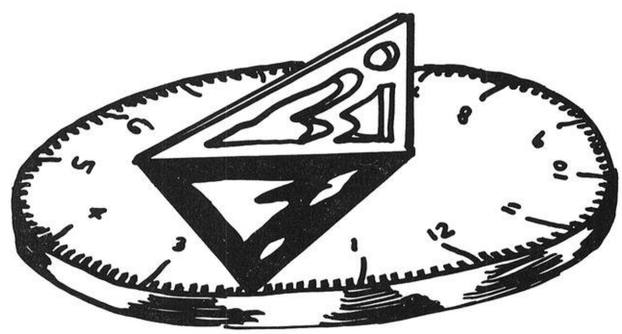
Lewis Mumford, on whose discussion of the clock *Technics and Civilization* I am drawing here, has said:

> The clock . . . is the key machine of the modern industrial age.
> For every phase of its development the clock is both the outstanding fact and the typical symbol of the machine: Even today no other machine is so ubiquitous . . .
> In its relationship to determinable quantities of energy, to standardization, to automatic action, and finally to its own special product, accurate timing, the clock has been the foremost machine in modern technics. And at each period it has remained in the lead; it marks a perfection toward which other machines aspire . . .
> (*Technics and Civilization,* p. 15, Harbinger edition, 1963.)

JUST LIKE CLOCKWORK

But the impact of the clock has by no means been restricted to the technical sphere, for in many important respects, contemporary western civilization is a creature of the clock. The clock regulates every aspect of our lives from the time we awaken in the morning until we go to bed at night. I can remove my watch from my wrist but time's shackles remain unshakeable. Not only are we bound to the clock forever, but we can scarcely imagine a way of life that would be free from it, or really believe that there was ever a point in history when men were not deeply imbued with the consciousness of time. But of course there was.

There is no precise date to mark the invention of the mechanical clock. Legend attributes its invention to a monk named Gerbert who lived in the tenth century, but it probably did not occur until much later. We do have definite records to show the existence of mechanical clocks by the thirteenth century. By the middle of that same century also, bell towers had come into existence in public places to toll the passing of the hours; and the division of hours into sixty minutes and of minutes into sixty seconds had become common. By the end of the sixteenth century, both watches and small domestic clocks had been introduced and the wealthier classes took over these new mechanisms and popularized them.



It is hard for us to understand the alteration in human affairs which the introduction of the clock must have occasioned. We are so used to dividing our days into a series of units each exactly like the other that we take it for granted that this is inevitable and natural and that there is in fact some pure medium called time somehow flowing past us at a speed measured by the clock. Yet this conception is by no means necessary, and in fact, there is very little basis for it in human psychology or physiology — or for that matter, in the rhythms of nature generally. Felt time (psychological time, if you prefer) is full of swirls and eddies, and the "rate of its passage" varies depending on what is happening. There is an old saw about how fast time flies when you are enjoying yourself, and all of us know, if only from remembering our days in school, how slow it can sometimes go. However, it is unlikely that any two of us feel the duration of time identically. It is also the case that physiological rhythms, such as beating of the heart and the breathing of the lungs, are far from metronomic varying as they do with mood, activities and circumstances. The rhythms of nature are variable also. Throughout the year, the days are of uneven duration and the relation between day and night steadily changes. Things that grow have their own regularities but they are nothing like the beat of the clock. Thus before the modern era and the invention of the mechanical clock, time for most people tended to be measured more by the events that occupied it than by the calendar: when the ewes lambed; when the crop was sown; when the leaves fell; when the snow came; these have been the measures of time for most men throughout history. In fact, many eastern civilizations have had, from our standpoint, a very loose time sense; and the Hindus, it is said, have been so indifferent to time that they lack even an accurate chronology of the years.

ORGANIC VERSUS MECHANICAL TIME

We can, then, talk about two different kinds of time. The first is organic time: variable, developmental, and cumulative. Here a given time is significant or insignificant, fruitful or barren, exciting or dull, and other events are kept track of (roughly) by their relative proximity to some time that marks itself out for special attention because of some especially memorable character that it has. The second is mechanical time. Mechanical time is a series of perfectly identical units. It is a neutral medium flowing past at a uniform rate. One time is the same as another time, though the events in the two times may differ. Time is not a sequence of experiences, but a collection of hours, minutes and seconds.

It is perfectly clear which of these two kinds of time is more natural just as it is perfectly clear which one has been imposed upon the other and which one we live by. We regulate our natural functions by mechanical time. We eat, sleep, work and play when the clock tells us it is proper to do so.

One consequence of this conception of time is the tremendous gain in human efficiency that it makes possible. Every psychological or physiological or organic "clock" may have a tempo of its own, but the shift to mechanical time, just because it dissociates time from human events and human variability, makes possible the synchronization of human affairs. Try to imagine an airline or a factory or a school which operated without such synchronization and think of the consequences.

Another consequence of the abstract conceptualization of time is that it takes on the character of an enclosed space. Thus it can be divided, or filled up, or expanded, or saved — if we are clever enough. Indeed, once time is viewed as a quantity it seems to be impossible to get enough of it. We spend great amounts of time figuring out how to save time, make more time, use time more efficiently. One thing we can never seem to do with time is enjoy it — for it is always passing by too fast for us to keep pace with it. Indeed, even our recreation is likely to be done by the clock. We are always conscious of time and of needing to know the time. I expect that if we had some way of measuring time consciousness and temporal anxiety and then graphed them against each other, we would find that the anxiety curve rises steadily from the invention of the faceless bell clock (which tolled only the hours) through the large public clock with face and hands, through the domestic clock, the pocket watch and the wristwatch. The more aware of time we are the more we need to know what time it is, and the more we know what time it is the more aware of time we are. Perhaps the face of the clock is the vicious circle **par excellence.** It is obvious that all of this subjection of our biological rhythms to the mechanical beat of the clock must exact a high psychic cost, but we have paid it so long that we would no longer even know how to count it.

Daily habits are not the only things that have been affected by the clock and our conception of mechanical time. The clock has exercised a powerful hold on the human imagination. For one thing, its dissociation of time from events helped to create the belief in an independent world of mathematically measurable sequences and thus to create the world of science. Mechanical, abstract, or clock time is enshrined in Newton's physics and his mechanics would be inconceivable without it. Not only this but Newton, like many of his contemporaries, viewed the universe as the analogue of a great clock, set in perfecting working order and wound up once and for all by a clockmaker god who was forever after unnecessary and could therefore be ignored. The notion of the universe as a clock is with us more than dimly still, and if we were to analyze our conception of causality, we would find at the bottom of it an image of gears upon gears and mechanical pushes and pulls like the workings of a clock.

The clockwork image has also been extended to the social sphere. Our vaunted system of governmental "checks and balances" is described by means of a phrase applicable to the workings of a mechanical clock, and it was devised by men who by and large believed in a clockwork universe. Moreover, every time someone refers to the pendulum of history or says that "the pendulum has swung too far," he is unwittingly reducing a complex social process to the simple workings of a machine. Indeed, it has been a more or less explicit goal over a long span of years to make not only our machines but our social institutions and our personal relations function "like clockwork."

In sum, then, the clock has been an instrument for regularizing, regulating and synchronizing human conduct. It has promoted order, efficiency, and productivity. In doing so, it has required that organic rhythms be sacrificed or at least adapted to its measure, and it has tended to be antithetical to spontaneity, novelty and uniqueness while promoting uniformity, regularity and deliberation in human activities.

This, of course, is why everybody loves it **and** hates it. Now I would not have spent so much time on the clock if I did not believe that in important respects it typified technology generally, and in fact, I think much of the previous discussion is applicable to other technologies as well: the tendencies implicit in the technology of time-telling are implicit in others also. And if this is so there are several points to be made.

For one thing, it is often said that technology is neither good nor bad in itself; it is how it is used that matters. I am prepared to accept that as true. But I hasten to add that it is an exceedingly trivial truth. It simply doesn't get us very far to ask whether the clock has been put to good uses or bad uses; the important questions about it simply don't arise at this level. The importance of the clock and its profound impact on human values and human choices is far more than simply a matter of the particular purposes for which clocks have been employed. We could allow, for the sake of argument, that every use to which every clock was ever put was perfectly benign and even morally laudatory. That would not in any way make us less the servants of time, nor alter our fundamental ambivalence toward the clock. The same thing can be said equally well of the automobile, of the computer or of television. (This incidentally is part of what Marshall McLuhan meant when he said of T.V. that the medium is the message; it is not program content that profoundly changes us, but rather the effects of the medium on our habits, our expectations, and our modes of perception.)

It is important to note also that nobody planned or anticipated the revolution which the adoption of the clock would cause. Indeed it is an irony of history that the first real need for clocks, and the place where they developed, appears to have been in the monasteries of western Europe. Here the highly routinized life and the requirement of offering regular prayers made it essential to develop an accurate means of marking the hours. Thus Christian monks with their "eyes fixed on eternity" developed a machine which fostered the consciousness of earthly time, and so by seeking to order their little world better they succeeded in undermining it utterly. This situation is by no means unique. Just because they are new, new technologies tend to have consequences no one can foresee — consequences which might, in fact, appall their creators if they could foresee them.

Sometimes the consequences of technological innovation ramify because one new technology calls another into being either by inspiring it or actually requiring it. As Sigmund Freud once put it, in a different context: **"If there were no railway to make light of distances, my child would never have left home and I should not need the telephone to hear his voice."** And each new technology in turn may call yet another into being, and the network of complications multiplies. Each strand of the network is likely to cause some alteration in human habits, perceptions and beliefs. But just what this alteration will consist in is virtually impossible to say in advance.

It is probably most often the case that machines are invented and technologies are developed to widen the range of choices open to men. And there can be no doubt that by synchronizing human behavior, productivity has greatly increased and certain possibilities have been enhanced so that the choice of goods and services and the range of options for action open to most men have been widened. Yet at the same time that these new avenues have opened up, one option has been closing. It has become harder and harder to live except by the clock, until you and I have no choice in the matter at all. It is not open to us to lose track of the time for very long. Thus we are freed for some things only at the cost of dependence on the instruments of our liberation, and when we would like to put them down for just awhile, we find we no longer can. This is as true of the clock as it is of the automobile or the telephone. I have known people who thought they could live without any or all of these only to find that they could not. It is very hard to escape the conviction that in the end every technological solution carries with it this price — that we will be owned in some measure by the thing that frees us.

But technology is not unique in this respect. Each of us is born into a society with settled habits, conventions, convictions and institutions. All of these profoundly limit the range of choices open to us. At the same time, they make it possible to achieve certain goods which would otherwise be unobtainable. Moreover, we are dependent upon them in very much the same way that we are dependent on technology. this should remind us that our ambivalence toward technology is part of an ambivalence toward techniques and ordered processes in general. We like them because they aid us in getting something we want; but we feel their pinch, too, and would like at least occasionally to escape their confines. This holds for laws, for organizations, for social conventions as much as for technological systems. The person who is perfectly adapted to all of these at all times simply does not exist.

But even if in the best of circumstances there is reason for us to feel hemmed in by our established social, political, or productive techniques, why is it that just now there seems to be more than a mere ambivalence about these things? Why is there, in so many quarters, such deep animosity toward them? Obviously, the complete answer to this question — even if I knew it — could not be elaborated here. But let me suggest some possible reasons for this state of affairs. This will bring me to my third and final point: the more technology succeeds, the more it fails.

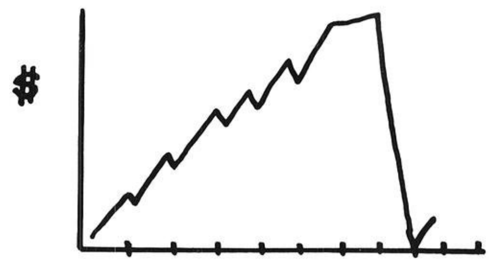
"The more technology succeeds, the more it fails."

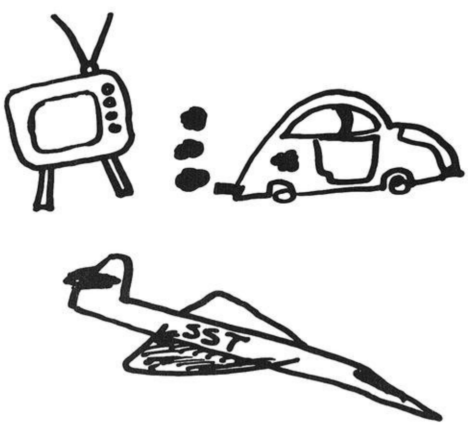
We have achieved such material abundance as a result of technology that considerable time is now spent dreaming up new things to need. Yet much of what we consume turns out to be dust and ashes in our mouths; it just doesn't bring the anticipated satisfaction. For a very long time, it was possible to believe that if we were not wholly satisfied with the life we had, then more possessions and things would surely satisfy us. Well, now we have more, but still the satisfaction has not come. So, ironically, the success of technology has led us to apprehend the fact the desire for more material satisfaction is likely to remain forever unconsummated. If things are our goal, we can never get enough of them. That desire has made our society go for quite sometime. But now, it seems to many people that this path to progress was in fact a treadmill. They suggest that we ought to try to learn how to get off.

In addition, the success of technology has created social, economic and political pressures which strain all of our existing institutions. At every level of government, for example, technology poses problems which the system is ill-equipped to handle; the knowledge, and often the will, to handle them simply is not there. And whether it is a matter of financing Lockheed, or dealing with the stresses on family life, or overcoming the plight of the migrant worker, or solving the problems of urban congestion, one can see how technological achievements have pressed against the existing framework of things and threatened them with collapse. Some degree of social disruption is inherent in every new technology, and the more widely it is adopted and the more potent it is, the greater the potential for social rupture.

At the same time that we have come to depend more heavily upon technology, the complexity of technological systems has steadily increased. Few of us know how anything works, or how to fix it, or even who is responsible if it fails or to whom to be grateful if it does its job. Thus, we are the passive subjects of technological expertise throughout an ever-widening portion of our lives. Since the power to direct our own lives is important to each of us, whatever makes us feel less capable of doing this is bound to be threatening. And again, the more successful technology becomes, the larger this threat looms.

Another of the factors which has called both technology and many of our social institutions into question is that so many of our institutions have tended to take on what might be called the "technological style." Technical efficiency requires a high degree of deliberation and planning. All the components of a technical system must be carefully interrelated; the materials that enter the system must be carefully charted, and, to the greatest possible extent, all contingencies should be accounted for in advance. Planning, coordination and control are essential to the efficient production of goods. Not surprisingly, the evident success of this sort of operation in the material sphere has inspired imitation and led to efforts to adapt it to social processes; economic, governmental, social and educational institutions — even the supermarket and the shoe store — can all be seen to have aped to some degree the processes of technology. Unfortunately, the variability, spontaneity and plain cantankerousness that makes the human adventure adventurous ill accords with the social or institutional planner's notions of efficiency. Efficiency is not the only, or even the deepest, impulse of the human spirit. There is something (something of great value I might add) in all of us that resists being managed even if this is being done by the experts for our own good. And this vital insistence on not being reduced to a cogwheel, even in the most perfectly functioning of clocks, is threatened everywhere that institutional managers aspire to inappropriate notions of efficiency and planners dream of perfect systems of human management and control. Thus one of the reasons that the role of technology in our society is increasingly a matter of contention is because of resistance to the extension of certain technological assumptions and processes deeper and deeper into the fabric of our lives.





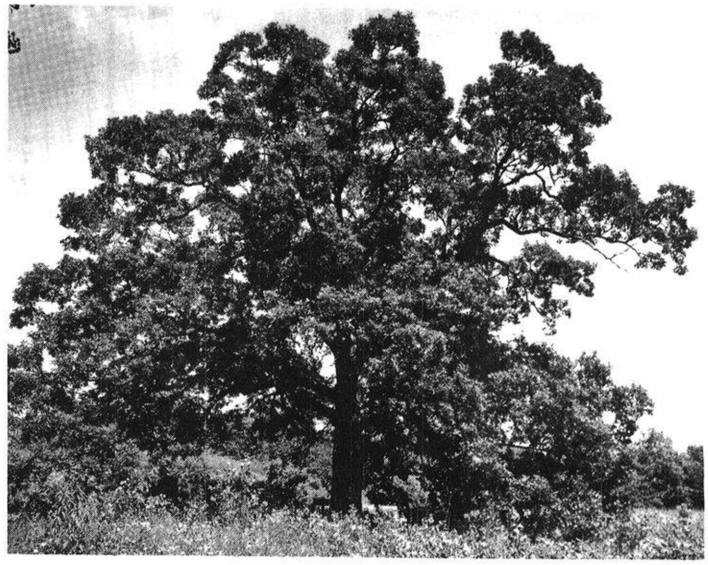
These factors, although they are by no means exhaustive, go some distance toward accounting for the fact that technology is presently a subject of widespread public concern — and this concern does not simply exist in spite of the successes of technology but in considerable measure because of them. This concern makes many of those whose lives and means of livelihood are bound up with technology profoundly uncomfortable, and this is thoroughly understandable. But if they will permit a meddling philosopher to offer advice, I recommend that they listen to the voices of that concern as patiently and as openly as they possibly can, and I hope that is sound and healthy in the examination underway. It might seem easier, and certainly it must often be tempting, to write every critic off as having fallen victim to a rabidly antitechnological spirit believed to be abroad in the land. But I am as sure as I am of anything that such a response would be extremely unfortunate for us all. Obviously, the role that technology plays in our society will remain large, but equally obviously it cannot continue to play the unexamined role that it has. The age of technology is not over, but the age of technological innocence is. This fact is going to complicate engineering and the life of the engineer, but where after all is the injustice in that?

The University's Living Laboratory

ENJOYING NATURE

You must not know too much, or be too precise or scientific about birds and trees and flowers and watercraft; a certain free margin, and even vagueness — perhaps ignorance, credulity — helps your enjoyment of these things.

—Walt Whitman

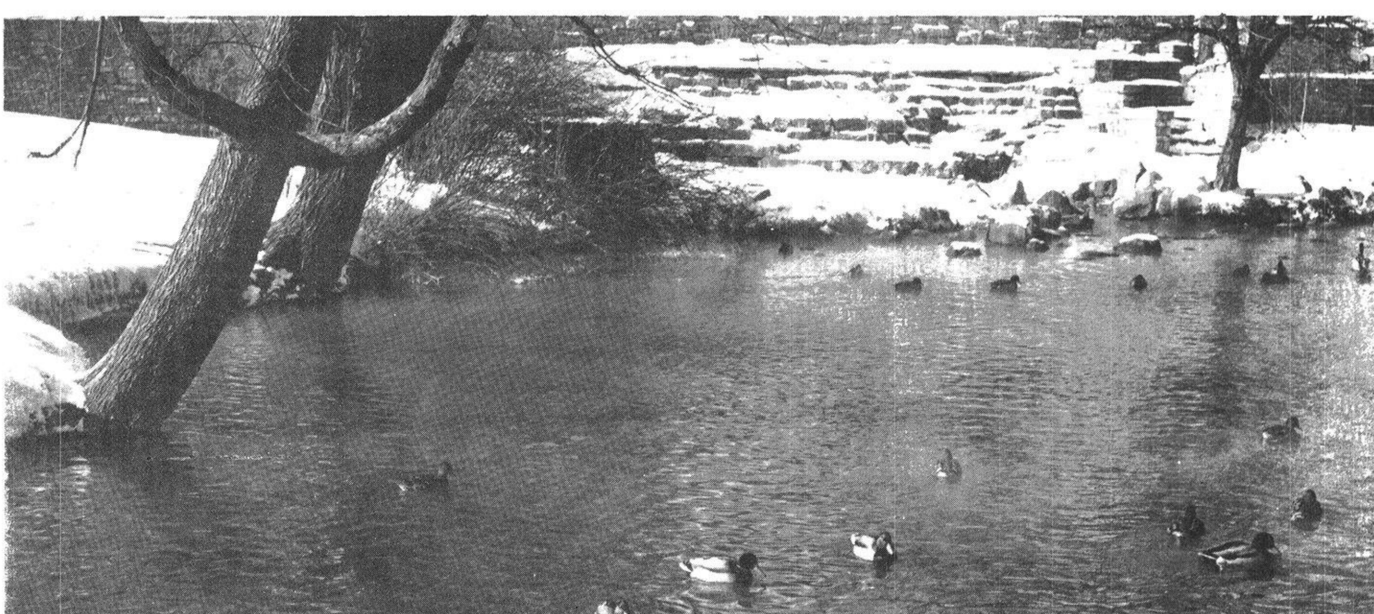


WHEN I HEARD THE LEARN'D ASTRONOMER

When I heard the learn'd astronomer,
When the proofs, the figures were ranged in columns before me,
When I was shown the charts and diagrams, to add, divide, and measure them,
When I sitting heard the astronomer where he lectured with much applause in the lecture room,

How soon unaccountable I became tired and sick.
Till rising and gliding out I wander'd off by myself,
In the mystical moist night-air, and from time to time,
Look'd up in perfect silence at the stars.

—Walt Whitman



Effect of Oil on Aquatic Ecosystems

by Kevin Bright

Kevin Bright is a junior majoring in zoology. She transfered to Wisconsin after attending McHenry Junior College for two years. Her home is Crystal Lake, Illinois.

Technology has become the mode of this era. Productivity, the basis of technology, promotes consumption, ignoring the fact that the earth's resources are finite. There is a limit which can be exceeded. The succession of this limit, witnessed in the accumulation of wastes, brings with it, contamination.

Waste, the final link in the technology-production-consumption chain, is the grossest violater of the resources. Its domination has been perpetuated by our consumptive lifestyle.

Demand brings on more demand, and this singleness in purpose overshadows all other considerations. They will not be noticed until consequences occur and build to the point where they hamper, or completely prevent the normal functioning of other spheres. The prevailing policy becomes a death sentence. Concentration of undesirable materials results with no outlets to get rid of them.

In the aquatic ecosystem, dilution and dispersion of waste products occurs through complex and interdependent processes. To upset such a delicately balanced and capable system as this, is to ruin its self-sustaining ability. The quantities of pollutants it has taken to destroy these workings cannot be comprehended.

The amazing amount of carelessness and unknowledgeable activity adds to the already serious situation. Oil pollution is an embarrassing example, of which, there have been numerous instances.

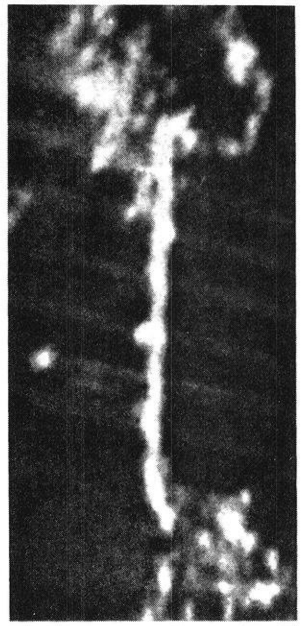
"Within the past ten years, over 550 tanker collisions have occurred, 45 of which have involved ships entering or leaving ports. The routine discharge by tankers and other ships, of oil and wastes is also a major contributor." (Department of State Bulletin)

Essentially oil, like any other pollutant changes energy availability, altering normal conditions. Aquatic species are affected as the regular channels of energy are diverted by the pollutant,either through its prevention of absorption, or through its production of toxic materials. Suffocation occurs both within the organism and its environment as absorption decreases and toxic materials accumulate.

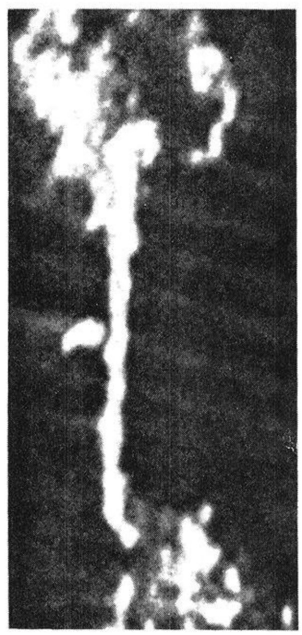
Because of the perfection of the aquatic ecosystem and the remarkable amount of work it accomplishes, it seems especially tragic when its balance is upset by misguided action.

The collision of the Arizona and Oregon Standard near the Golden Gate Bridge on January 18, 1971 was one such instance. Eight hundred and forty thousand gallons of oil were dumped into the ocean. The unbelievable quantity of pollutant makes it impossible to completely correct the damage.

"The oil spilled was the heavy type called Bunker-C used as a ship fuel which must be kept above 130°F., if it is flow freely. In the cold water, it congealed but some volatile components mixed with water; the full effect on shellfish may not become apparent for years." (White, 1972)



U.S. COAST GUARD



Radar enabled the U.S. Coast Guard to record a collision of two oil tankers near the Golden Gate Bridge. The thick vertical line represents the bridge. Two dots to the left of the bridge are the oil tankers, before and after the accident.

The impairments that oil will cause to the normal functioning of marine life are both immediate and latent. The immediate effects were harmful to fish, birds, mollusks, and algae. The gummy tides coated and choked the algae, mollusks, and fish. The birds' feathers were saturated, reducing buoyancy and water resistance, finally killing them. (White, 1971)

"Half were western Grebs, a fifth were Scoters and the rest included 27 species—loons, scaups and common murres. They all sit on the sea and dive for their food. Diving into the water, they come up into black oil." (White, 1971)

The nature of the oil's coating ability was great for the species of birds but it is even of a greater magnitude for water. Its saturation coefficient is something of the order of four acres to the gallon. (Hynes, 1966) Eight hundred and forty thousand gallons of oil multiplied by four, produces a figure so staggering, that it is difficult to perceive on any basis. Restriction of oxygen and light along 3/4 of the San Francisco Bay Coast reduced photosynthesis as the algae species were enveloped.

From this information it can be concluded that the effects of oil on the water are similar to the evidences of eutrophication. Photosynthesis is conducted through the chlorophyll in algae. As the chlorophyll is literally covered with oil, this process is blocked.

> *"Changes in the chlorophyll concentration in the epilimnion, correspond with the trend of phosphate accumulation, reduced transparency and an increase in the O^2 deficit." (Hasler, 1969)*

The removal of oil from water is neither difficult nor costly. Straw will absorb up to 40 times its weight in oil. This precipitate mixture can then be carried away. If action could be prompted when an accident occurs, at least some of the effects mentioned above, could be lessened.

In addition to enhancing prevailing trends, such as eutrophication, oil pollution creates new problems. The immediate ones have already been mentioned. It is the latent and the subtle biochemical effects which are more serious. These implications can only be postulated in a general manner from theories that are already known.

For example, the work of Dr. Max Blumer explains the general effects of oil on marine life.

Oil contains aromatic hydrocarbons: benzene, toulene, and xylene; saturated hydrocarbons: paraffins; and unsaturated hydrocarbons: olefins. All three types behave differently in water.

Benzene, toulene and xylene do not naturally occur in aquatic environments. They are soluble in water and enter organisms which have not evolved the bacteria necessary for breakdown. These materials concentrate generally in the fatty tissues where they remain intact. By transfer from the fat of one organism to another, they become more concentrated as they move up the food chain. They have been implicated as carcinogens, capable of inducing cancer within the cell.

The paraffins which have a straight-chain formation are unexpectedly non-biodegradable in the sediments. Their specific effect is in the reduction of cellular metabolism (Narcosis) in the larvae of shrimp hatched on the sediments.

The toxicity of the olefins has not been proven, but this group of hydrocarbons interferes with ecologic processes. Various chemicals are used for such purposes as attracting predators to their prey and somehow, the olefins prevent the normal action of these chemicals.

As it is evidenced in other forms of pollution, oil pollution also changes a diverse system to a non-diverse system. Resistant species develop to reproduce and their survival is dependent upon specific conditions.

Natural fauna sometimes remain, depending upon the extent of the pollution. In the oceans, which are far too large to be completely affected, survival in the oil covered areas depends upon three factors: 1) The organism's position in the intertidal zone (as the water cleanses life forms in lower zones). 2) Tidal levels at the time of the spill, and 3) the extent of the offshore kelp bed which serves as a refuge — no oil was found beneath the kelp canopy paralleling the coast. (Science Digest)

Replacement of one species by another under abnormal conditions is too high a price to pay for our present lifestyle. Technology creates at the expense of destruction. All processes create but the difference in technology lies in the fact that the destruction greatly outweighs the creation.

Accidents and careless behavior are pathetic actions. As pointed out above, removal of oil is neither difficult, nor costly. However, it has become so, at nature's expense. Careless behavior increases the costs and the price becomes an ugly tax upon nature, preventing its normal functioning.

On the Rational Approach to Modern Problems

by A.C. Scott

The author is a professor of Electrical Engineering at UW. He received his BS, MS, and ScD degrees from MIT; the last being in 1962. His work experience includes time with the Pentagon and Sylvania Electric. Presently, he is researching non-linear wave theorx with applications in Biophysics.

THE RATIONAL AGE

Most people nowadays have great faith in the rational approach to knowledge, a faith which derives from the spectacular achievements of modern science and technology. In our living rooms, surrounded by the wonders of electronics and applied chemistry, we have watched our young men shoot golf balls on the moon. And although general nuclear warfare is a troublesome thought, the fission reactor can supply vastly increased amounts of energy and the fusion reactor may become, for all practical purposes, an infinite source of energy. The digital computer appears to offer many new possibilities for scientific management of complex social problems.

It is the spirit of our age to quantify, theorize and predict. As such diverse and incredibly intricate problems as long range weather forecasting, managing New York City, winning the Vietnam war, and understanding the structure of poetry are "broken down" and analyzed, a few begin to suggest that a more direct mode of perception may sometimes be in order. Harvey Broovks finds this a disturbing development (2);

"Eastern religions are enjoying a great vogue, and everywhere there is rising preoccupation with the emotional, the sensual, the affective aspects of human experience at the expense of the cognitive, systematic, and analytical aspects. Emotion-centered personality types are emerging as heroes to be emulated, again especially among the younger generation."

. . ."to the extent that (this development) implies that feeling and sympathy can substitute for reason and evidence in the management of human affairs, it is retrogressive and threatening."

while Eugene Rabinowitch points out (3);

"All that man has achieved in advancing beyond the animal stage — his tools, his edifices, his scientific explorations, technological achievements and philosophical systems — has been due to his capacity for abstract thinking: counting, measuring, logical inference, abstraction, generalization and mathematical informulation."

Those elements of the human experience which are difficult to quantify. . .joy, sadness, devotion, wonder, love, understanding, a sense of purpose, a sense of beauty. . .are not intentionally left out of consideration in this rational age, but often quietly forgotten.

HOW RATIONAL IS SCIENCE

In considering the nature of current scientific practice it is important to distinguish between leaders and followers. To paraphrase a suggestion by William James in his penetrating analysis of religious psychology (4), we should emphasize the study of those for whom science "exists not as a dull habit, but as an acute fever." From this vista much of science is not nearly as rational or dedicated to "linear thinking" as its critics would have us believe. The outstanding scientist often proceeds by a "quantum leap"of the imagination directly to the solution; a process which at present defies explanation.

Oliver Heaviside is an interesting example in my own field of electrical engineering. In the late 19th century he developed an operational calculus for linear dynamical systems which is now of fundamental importance for much of modern electronics. When pressed by university mathematicians for a logical justification of his techniques, he replied that he did not need to understand the process of digestion in order to enjoy his dinner.

Albert Einstein's criticism of the statistical interpretation of quantum dynamics on the grounds that "God does not throw dice!" is more an emotional than a rational position although recently it has received rational support.

John von Neuman greatly appreciated the importance of the **key idea** in unraveling possible solutions to complex nonlinear dynamical systems. His interest in the development of the digital computer after World War II was motivated in part by the belief that the "synergetic" approach of "playing" with complex systems of equations on a computer could make one aware of qualitatively new effects. This belief has been brilliantly confirmed in the recent concept of the "soliton" as a partial basis for the solution of a wide class of non-linear wave problems (5).

To buttress his case for the importance of basic science in making decisions about technological policy, Harvey Brooks states (2):

It is no accident that Rachel Carson, who wrote *The Sea Around Us*, was also one of the first people to popularize the ecological side effects of the use of pesticides in her more famous book *The Silent Spring*. Miss Carson was in close contact with oceanographers, and much of the earliest evidence for the occurrence of pesticides in the environment and their concentration in the food chain came, rather accidentally, from basic research in oceanography."

But those who have read *The Sea Around Us* and appreciated Miss Carson's deep sense of wonder for the beauty of the natural world must ask whether this emotional attitude might not have contributed to the creative urge which led her to *The Silent Spring*.

Who can consider Aldo Leopold's request that we learn to "think like a mountain" in order to understand the ecological interdependence of wolves, deer and plants; and tell us where emotional perception leaves off and rational perception begins? Read what he says of workaday science (6).

> "Science contributes moral as well as material blessings to the world. Its great moral contribution is objectivity, or the scientific point of view. This means doubting everything except facts; it means hewing to the facts, let the chips fall where they may. One of the facts hewn to by science is that every river needs more people, and all people need more inventions, and hence more science; the good life depends on the infinite extension of this logic. That the good life on any river may likewise depend on the perception of its music, and the preservation of some music to perceive, is a form of doubt not yet entertained by science."

In a provocative recent article, Thomas Blackburn has suggested that both sensuous and intellectual perceptions of nature can be included in a common frame of reference through a notion of **complementarity** similar to that which is employed by physicists to deal with dual "wave-particle" nature of matter. He points out that (7)

> "Our understanding of really complex systems (organisms, societies, ecosystems, the mind) is rudimentary and our ways of investigating such systems and communicating about them primative." . . ."To 'see' a complex system as an organic whole requires an act of trained intuition, just as seeing order in a welter of numerical data does."

To the vast majority of us for whom science exists "as a dull habit" Blackburn suggests that

> ". . .the intuitive knowledge essential to a full understanding of complex systems can be encouraged and prepared for by (i) training scientists to be aware of sensuous clues about their surroundings; (ii) insisting on sensuous knowledge as part of the intellectual structure of science, not as an afterthought; and (iii) approaching complex systems opening, respecting their organic complexity before choosing an abstract quantification space into which to project them."

How rational is science? If we consider the advice of many scientific leaders, the answer must certainly be: not entirely.

THE ANTIRATIONAL MOVEMENT

The antirational movement should be viewed in perspective as one component of a rather extensive shift in attitudes of young people since the mid 1960's. Although it is an incredibly difficult task to untangle the twisted casual web of social change, the maturing of post World War II technologies and their effect upon the physical and social environment, the availability of consciousness expanding drugs which have made certain emotions (such as joy, and a sense of understanding) generally available, and the nearly catastrophic bureaucratic incompetence and insensitivity demonstrated during the Indo-China war, have certainly been contributing factors. This change has been discussed in detail by Charles Reich in terms of the growth of a new **consciousness** or complex of social attitudes (8). He calls this new set of attitudes "Consciousness III" and that sublime faith in bureaucratic expertise dominant in the 1950's "Consciousness II." When a person shifts away from Consciousness II to Consciousness III, his attitudes toward conventional science and the rational and quantitative approach to knowledge necessarily change. Users of mind expanding drugs report a totally new awareness of time and spatial relations between geometrical objects and an "understanding" of such relations which often continues to influence subsequent perception. This tendency toward total understanding of complex situations makes him impatient with the typical scientist's narrow concentration upon quantification and isolated "cause and effect" situations. Science is also seen as essential to modern technology which in turn has brought us the environmental degradation associated with the "plastic society" (9) and the practice of "electronic warfare" against underdeveloped countries. Finally the Consciousness III person favors cooperation over competitionbetween individuals. As Harvey Brooks rather glumly puts it "some very able and talented people seem to be rejecting the 'rat race'."

But is the Consciousness III attitude toward science really so different from that of the best scientists? Charles Reich says (8)

> "It is of the essence of the thinking of the new generation that man should be constantly open to new experience, constantly ready to have his old ways of thinking changed, constantly hoping that he will be sensitive enough and receptive enough to let the wonders of nature and mankind come to him. Consciousness II regards it as a weakness to be surprised or awed; III cultivates the experience. Consciousness III says 'the full moon blew my mind' and is proud of it; II has seen the moon before and takes it in stride."

IS THERE A RATIONAL BASIS FOR THE RATIONAL APPROACH?

The previous discussion has been primarily to set the stage for a critical examination of the claims of rational science. I wish to consider whether there is a rational basis for the above mentioned assertion by Rabinowitch that "counting, measuring, logical inference, abstraction, generalization and mathematical formulation" provide the only sure approach to human knowledge. Only a rational argument is appropriate; an intuitive discussion might be satisfying to some, but it would be open to the charge of circularity.

Let us consider man as a component in a vast information processing machine (i.p.m.) consisting of all humanity throughout history. Let us ask whether such an i.p.m. can understand its own dynamics. To begin, we must consider whether any i.p.m. can understand its own dynamics. Simple systems obviously cannot. For example, the thermostat which controls the temperature in the room by switching the furnace on when it is too cold and off when it is too hot clearly has no possibility of understanding even the simple Boolean logic of its activity; it has only two states. On a higher level we don't expect the television set to comprehend the design of its video amplifiers or the electron dynamics of its picture tube. And although the dog in front of the TV may exhibit the "fine sensitivity for the moods of his master" suggested by Rabinowitch, we don't expect him to be able to understand how he is so motivated. But with human society, so workaday science tells us, rational perception can lead us to understanding. On the surface the proposition sounds **fishy**. . .rather like the medieval assertion that the earth is at the center of the universe.

But there is a **rational** basis for suspicion. In an epoch-making paper published in 1931, Kurt Godel, a young mathematician at the University of Vienna, shattered preconceived notions about the power of the axiomatic method in mathematics (10). He showed that **any** consistent arithmatical logic is **incomplete.** More simply this means that there exist **true statements** about the integers which **cannot be proved** within a consistent logic. (A simple example may be the statement that any even number can be expressed as the sum of two prime numbers.) Nagel and Newman have stated that Godel's proof limits the mathematical power of computers:

> "Godel's conclusions bear on the question whether a calculating machine can be constructed that would match the human brain in mathematical intelligence. Today's calculating machines have a fixed set of directives built into them; these directives correspond to the fixed rules of inference of formalized axiomatic procedure. The machines thus supply answers to problems by operating in a step-by-step manner, each step being controlled by the built-in directives. But, as Godel showed in his incompleteness theorem, there are innumerable problems in elementary number theory that fall outside the scope of a fixed axiomatic method, and that such engines are incapable of answering, however intricate and ingenious their built-in mechanisms may be, and however rapid their operations. The human brain may, to be sure, have built-in limitations of its own. . .(but Godel's) theory does indicate that the structure and power of the human mind are far more complex and subtle than any non-living machine yet envisaged.

Others have argued that there is no reason why machines cannot be designed to do the same things brains do. . .what ever that might be (11).

Our interest here, however, is not with this "brain-machine" controversy because any computing machine can be considered as a component of the vast i.p.m. we call human society. But it is clear that "the fixed rules of inference" assumed by Nagel and Newman do limit the performance of an i.p.m. And in the intellectual activity of human society it is just such fixed rules that are provided by rational science.

It is an amusing situation. The **rationalist** assertion that "counting, measuring, logical inference, abstraction, generalization and mathematical formulation" provide the only sure approach to human knowledge rests on the **intuition** of workaday scientists; while the **humanist** view that other modes of perception are important is supported by a **rational argument.** Rationalism, which rejects emotional phenomena, should never be confused with naturalism, which only rejects the supernatural. Perhaps the next great task for the human intellect is to learn what it is that it cannot understand.

THE ROLE OF THE RATIONAL SCIENTIST

To question the naive assumption that rational science is the source of all knowledge is not to suggest that it is useless. Clearly there are many important human problems which require expert assistance for their solution. But we scientists and engineers must approach such problems with an appropriate measure of **humility.** We must recognize the many palpable realities of human experience about which rational science can tell us **absolutely nothing.** This point has been emphasized by Barry Commoner in connection with environmental problems (12):

> "With the determination of benefits and risk and the development of techniques which improve the balance between them, the applicability of scientific procedures to the problems of environmental contamination come to an abrupt end. What then remains is a judgment which balances the stated risks against the corresponding benefits." . . ."No scientific principle can tell us how to make the choice, which may sometimes be forced upon us by the insecticide problem, between the shade of the elm tree and the song of the robin."

If the rational scientist could be persuaded to retire upstage and assume an appropriate supporting role in the unfolding human drama, we might expect a gradual return of **man** to the footlights. We might expect a "new renaissance" from the vantage point of which today's technological world (with its polluted air and plastic clutter, its ravenous consumption of raw materials and spiritual emptiness, its needless greed and mindless violence) would seem a dark age indeed.

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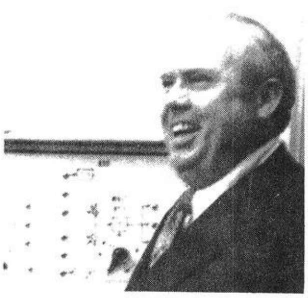
Man Made World

by

Carolyn Graff

"Increasing technical literacy" among non-engineers is one of the goals of a new program in engineering — Man Made World.

Man Made World is a book, a course, and a humanistic approach to society and technology. It was started five years ago as a summer program preparing high school teachers to teach the course on the junior level. Today there are 26



James J. McNeary of the General Engineering Department uses a large logic circuit board to demonstrate to teacher and students part of the logic section in Man Made World. He taught high school for 18 years before getting involved with the program.

high schools in the state who offer the course. James J. McNeary of the General Engineering Department has been active in the program. He has taught the course to teachers and this semester is teaching a one credit mini-course to university students.

Bridges must be built between science and reality. Man Made World defines what science can or cannot do for man and gives insight into potential solutions. Contemporary problems on pollution, traffic control, health services and communications are presented, the instructor then gives the method of solution and finally the theory behind the solution. This is the opposite of conventional science courses which present theory first.

Some of the concepts taught are decision making, computer operations, systems and modeling. Advanced mathmetical and technical language is avoided to give the non-technical student an understanding of science today. The types of problems solved give the student exposure to reality that exists.

Next fall the course will be offered in three parts to students at the university. It is hoped that many students will take the course so that the gap existing between society and technology will not be widened.