Technology Review

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*Comparisons are based on a 1991 independent research study conducted by Ingram Laboratories that tested a variety of personal computers running applications available for both the Macintosh and Microsoft Windows 3.0 environments. **24-bit video support for up to a product specifications and descriptions were supplied by the respective vendor or supplier. Orbiter images created by Jerry Flynn. ©1992 Apple Computer, Inc. Apple, the Apple logo, A/UX, Mac, Macintosh and "The power to be your best" are registered trademarks and Macintosh Quadra a is a trademark of Wolfram Research, Inc. MicroStation is a registered trademark of Bentley Systems Inc. MS-DOS is a registered trademark and Windows is a trademark of Microsoft Corp. Motorola is a registered trademark of Motorola Corp. NuBus is a trademark of Texas Instrume

with the power revolution.

communications architecture lets you easily take advantage of features like distributed processing, allowing programs like RenderPro and BackBurner to utilize excess CPU cycles on other Mac computers or workstations for faster renderings.

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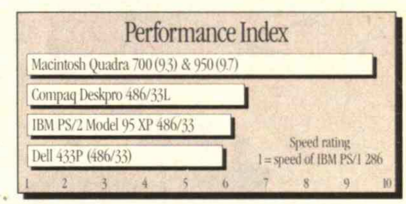

Macintosh Quadra significantly outperforms 486 PCs from IBM, Compaq and Dell running Windows 3.0.

It all adds up to the kind of power that moved *PC Week* to give the Macintosh Quadra its highest satisfaction rating in the categories of overall performance, price relative to performance, expansion capability and ease of installation and configuration.†

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OCTOBER 1992

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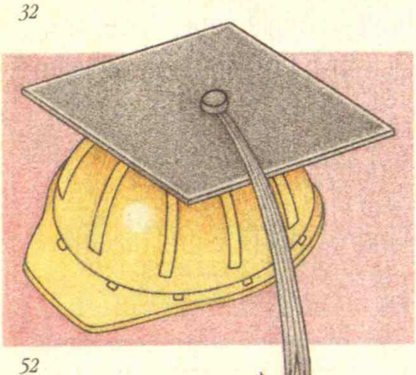
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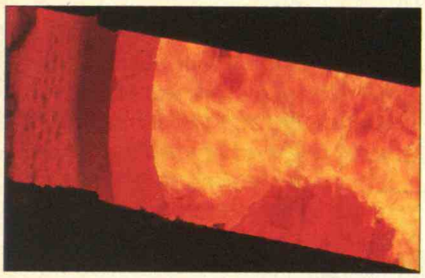
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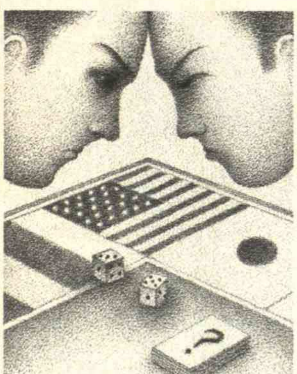
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First Line

Industry's Duty of Care

THE theme of the recent Earth Summit in Rio de Janeiro was "sustainable development." But despite the best intentions of the many governments and public-interest organizations in attendance there, the road to sustainable development has to be paved by industry. Business-as-usual must come to include the widespread use of environmentally sound technologies and practices during all phases of a product's life cycle.

The concept of "duty of care," introduced in the 1990 British Environmental Protection Act, could be of great value in pursuing this goal. Referring to the responsibility of manufacturers to minimize undesirable side effects, duty of care is akin to the U.S. notion of "cradle to grave." Companies must not only provide for the safe disposal of wastes; they must design processes and products to minimize the volume of waste in the first place, and in some cases ensure that the products they make are properly reused or recycled.

Thus, duty of care embodies such goals as preventing pollution ("source reduction"), finding new uses for waste streams, substituting benign materials for those that are toxic, and improving the efficiency and productivity of industrial activities. This is no high-sounding yet hopelessly impractical idea; it in fact reflects a shift in the thinking of leading industrialists. *Changing Course,* for example—a report issued by the Business Council for Sustainable Development in preparation for the Earth Summit—provided examples of a wide variety of actions that companies around the world are taking.

One form of duty of care is manifesting itself in Europe and Japan, where "take-back" or recycling legislation spells out what is expected in responsible industrial practice. Japan's 1991 Law for Promotion of Utilization of Recyclable Resources not only encourages the use of recycled material; it also requires design changes in products—"design for disassembly"—to make them more easily recyclable at the end of their useful lives. This law applies to such products as automobiles, air conditioners, televisions, refrigerators, and washing machines, and it also embraces packaging.

The German automobile industry is grappling with new waste-disposal requirements under which automakers must take responsibility for disposing of cars after consumers are through with them. BMW claims that its new series of smaller cars will have all-plastic parts marked so that they may be easily sorted for recycling. Volkswagen recently announced that it will take back all its 1992 Golf models regardless of how long the cars have been on the road. The German legislation will soon cover electronic products as well.

Companies can be the true agents for making "sustainable development" a worldwide reality.

In the United States, several companies are pioneering responsible environmental stewardship, often using catchy acronyms to identify their programs: 3M has 3P (Pollution Prevention Pays), Dow Chemical has WRAP (Waste Reduction Always Pays), and Chevron has SMART (Save Money and Reduce Toxics). As these names imply, companies often find it profitable to reduce waste, especially through improved economic efficiency.

These companies' experience shows that duty of care can take hold in the United States, and that top-level business managers can make the concept a reality if they commit their organizations not only to the promise but to the actual measures needed to follow through.

First, research and development capabilities should be harnessed toward this end. That is already happening in response to local regulation and public insistence on "green" products. The stringent California standards calling for zero emissions in at least 2 percent of vehicles sold there in 1998 have spurred R&D at U.S. automobile companies. They have pooled resources and expertise for research in areas such as particulate-emissions control and electric-vehicle batteries.

Second and most basic is that companies must now regard the environmental imperative as an integral part of their business goals, and get their suppliers on board as well. Companies should employ a precautionary approach, taking action as soon as they learn that some product or process is environmentally harmful, instead of waiting until forced to do so or until all uncertainties are resolved.

The push to phase out chlorofluorocarbons (CFCs), given their link to the depletion of stratospheric ozone, is a classic precedent. Recognizing the need to reduce the use of CFCs as solvents, electronics companies developed strategies for *eliminating* their use. Independently and through the Industry Cooperative for Ozone Layer Protection, these firms are developing alternative ways of cleaning electronic components that they are passing on to suppliers and spreading to operations abroad. AT&T has led in the development of manufacturing processes that are free of CFCs, and the company is en route to eliminating CFC emissions from all its plants in the United States and abroad.

There is no silver bullet or single approach to realizing the new ethic. Because companies are so diverse, they must all separately address their own particular environmental challenges. Yet when all act individually to reflect duty of care, firms will be able to learn from one another, adopting the "best practices" that emerge in the pursuit of environmental—and economic—excellence. ■

—ROBERT M. WHITE
President of the National Academy of Engineering

—DEANNA J. RICHARDS
Director of the NAE's Technology and the Environment Program

Letters

RELEVANCE AND RIGOR

For those of us teaching introductory science courses, "Reforming Freshman Science" by Sheila Tobias (*TR May/June 1992*) provides an important message. For some years now, we in the Dartmouth Chemistry Department have been doing exactly the sorts of things Tobias recommends: we have integrated exciting demonstrations into classroom lectures, explained the connections between course material and everyday phenomena, and made ourselves accessible to students. One of our professors has recently developed animated Macintosh software that clarifies freshman chemistry concepts by describing the properties of molecules such as AZT, caffeine, Teflon, and aspirin.

However, the effort to retain more students should not mean that we sacrifice scientific rigor. Unfortunately, many freshmen who have been drawn to science through high school courses designed to pique their interest drop out when faced with the demands of college science. In addition to examining the quality of teaching in freshman science, Tobias and others might look at differences in student attention span and self-discipline over the past few decades. After all, "work overload" and "a punishing pace"—reasons Tobias cites for the diminishing numbers of students in science—are relative judgments. What has changed since 1966, when, as Tobias notes, a proportionately larger number of college freshmen planned to major in science or mathematics? The basic principles of science have certainly remained the same.

DEAN E. WILCOX
Associate Professor of Chemistry
Dartmouth College

WHY SHOULD THEY DO IT IN THE ROAD?

The authors of "The Case for Smart Highways" (*TR July 1992*) provide an excellent discussion of how intelligent vehicle/highway systems (IVHS) might help to alleviate urban traffic congestion.

However, the article is silent on the broader potential of IVHS. For example, IVHS could greatly enhance commercial vehicle fleet management, improve driver/operator and public safety, and provide for more effective and efficient regulatory operations.

The broader benefit to safety is briefly mentioned but more in the context of a byproduct of reduced congestion. IVHS technologies are expected to substantially improve motorist safety in both urban and rural locations. Not only radar braking, but vision-enhancement systems and in-vehicle motorist information systems, which provide critical advisory and warning messages, are just some of the many examples of potential future applications.

LYLE SAXTON
Director
IVHS Office of Safety and Traffic Operations R&D
Federal Highway Administration

Before spending billions of dollars refitting the country's highways and vehicles to make them "smart," the American public might want to consider the faulty logic and bogus salesmanship behind the idea.

Smart highways would supposedly unsnarl traffic. But such has been the promise of nearly every urban highway project since the 1940s, and history has shown that these fixes have been quickly overwhelmed by the increased traffic they themselves generate. Highway improvements are not the answer to traffic jams. Mass transportation is. Moreover, it's questionable whether our highway system, which is already collapsing under the weight of age and poor maintenance, could even meet the challenge of so much extra traffic.

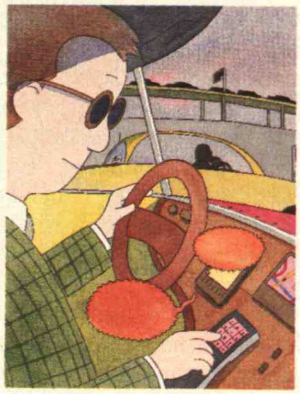
Another problem is that we have little experience with the mass psychology we would invoke by coordinating large-scale traffic flow. Would drivers submit to being herded like sheep by a centralized computer? Or would the game of "outsmarting" the smart highways—by doing the exact opposite of what the computer suggests—thwart the system?

And what if the system failed? Even a single major breakdown during the transition to it could destroy drivers' confidence in the technology. Or if failure occurred after the public had become dependent on the system, chaos could result.

But the most important objections to the smart-highway proposal concern who would pay and who would benefit. It's obvious who would pay: consumers. To justify the enormous public investment in highway refitting, government authorities would have to persuade or force large numbers of people to buy computer-navigated cars. Increased tolls, gas taxes, and extra charges for driving at peak hours could also help, but as the authors admit, these regressive financing solutions have already been rejected by communities like Madison, Wis., Berkeley, Calif., and Honolulu, Hawaii.

As for who would benefit from smart highways, it's clear that the transportation industry would. Carmakers would have the opportunity to sell a whole new fleet of vehicles. Other companies would get lucrative contracts to install sensing, computing, and communications devices in highways. Not surprisingly, GM, Motorola, and the other companies who stand to gain are the ones sponsoring the necessary "R&P"—research and publicity. The whole scheme is reminiscent of the GM pavilion at the 1939 World's Fair, where elaborate dioramas showed GM cars speeding along the 16-lane superhighways of the future, all to be built at taxpayers' expense.

WADE ROUSH
Program in Science, Technology, and Society
MIT



"The Case for Smart Highways" implies that it's a good idea to continue to rely heavily on auto transportation. But this goes against any kind of sound thinking on ecological or economic issues. Rather than investing billions in IVHS, why not improve and expand light and heavy rail?

ANDREW MARK
New York, N.Y.

BRAVE NEW WORKPLACES

In "Post-Industrial Society Defined" (*Letters, TR May/June 1992*), Prof. Daniel Bell takes me to task for questioning the idea of a post-industrial society. In fact, I did not have Bell's justly famous thesis in mind so much as the legion of essays that have since drawn on the idea of post-industrialism to rationalize the decline of U.S. manufacturing excellence.

These essays commonly suggest that there is a kind of zero-sum game between service and manufacturing growth, determined by market forces. But many economists, including myself, have countered that the explosive growth of financial, management, and legal services since the late 1960s is directly related to a qualitative transformation in the nature of manufacturing, not to its demise. Manufacturing and related activities such as distribution now take place among and within companies that span regions, countries, and even continents, and those companies concern themselves with many different economic sectors as well. Coordinating the complex interac-

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MIT Reporter

Spinning Off Heat with Less Pollution

Like a miniature tornado, the tunnel-shaped flame blazing in an experimental burner rotates furiously, spun by precisely aimed jets of air. According to MIT's Janos Beér, professor of chemical engineering, and Majed Toqan, manager of the Institute's Combustion Research Facility, the burner's design could substantially reduce the amount of polluting nitrogen oxides emitted by utilities and industry as they produce power and run manufacturing processes.

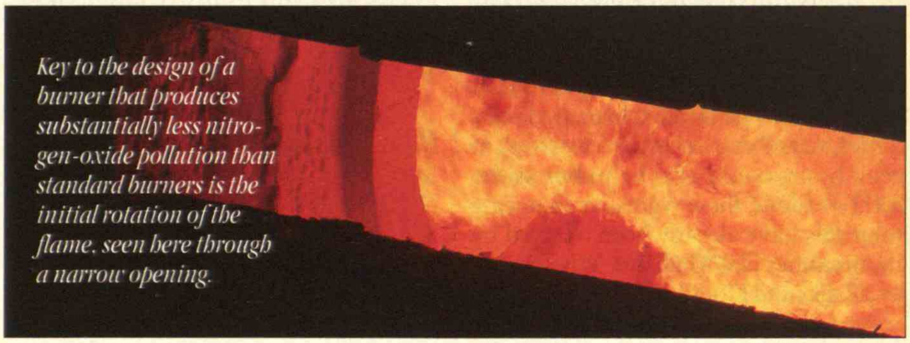
When virtually anything burns, gaseous nitrogen, which makes up 79 percent of the atmosphere, mixes with the oxygen in the burning mixture to generate nitrogen oxides (NO_X). Nitrogen-containing fuel such as coal and oil produce even more NO_X. And in sunlight, the NO_X can mix with hydrocarbons from, say, automobile fuel to form ground-level ozone, which causes respiratory stress and other health problems. Nitrogen oxides are also components of acid rain.

In conventional burners, fuel and air mix vigorously from the start. This makes for efficient combustion but also provides the right conditions—high temperatures and plenty of oxygen—for NO_X formation. The patent-pending "radially stratified flame core burner" invented by Beér and Toqan delays this mixing and thus limits the formation of nitrogen oxides.

"What we are doing is 'staging' the combustion," shouts Beér, peering through a thick piece of dark glass at the roaring, orange flame as it gyres out of the fuel nozzle. In the first stage, the rotation of the cylindrically shaped flame pushes the relatively cool, dense air simultaneously piped into the combustion chamber to the outside of the flame, almost completely separating the fuel from the oxygen. Inside the heat of 1,200-1,500 °C exists a calm zone, much like the eye of a hurricane, where the fuel pyrolyzes, or breaks apart chemical bonds in the absence of oxygen. This creates a waste product of inert nitrogen gas along with heat.

About three feet beyond the fuel nozzle, Beér explains, the flame "blossoms out" and collapses into a doughnut-like shape. In this second stage, air mixes with the pyrolyzed fuel, which ensures that the fuel is burned completely. Carbon dioxide and water are the primary waste products.

The experimental burner can use natural gas, oil, or pulverized coal as a fuel with only minor adjustments. With natural gas, the burner emits as little as 14 to 16 parts per million nitrogen oxides, a significant reduction from the 200 ppm generated in a conventional burner. Burning oil yields about 80 ppm compared with as much as 600 ppm otherwise.



Key to the design of a burner that produces substantially less nitrogen-oxide pollution than standard burners is the initial rotation of the flame, seen here through a narrow opening.

Following laboratory research, the next step is building an industrial-scale burner. ABB Combustion Engineering in Windsor, Conn., plans to scale up the burner from its current 5 million Btu per hour capacity to 80 million Btu per hour. (By comparison, a typical home water heater produces 5,000 to 10,000 Btus per hour, while a small electric-utility boiler might produce the equivalent of 1 billion Btus per hour.) Southern California Edison has agreed to test several of the 80-million-Btu burners on a boiler that generates electric power.

"We're going to be getting more and more calls for low-nitrogen oxide burners," points out Dick Borio, ABB's executive consulting engineer. "It looks like the handwriting is on the wall because of the new Clean Air Act," which imposes regional ozone limits. Meanwhile, state governments in the Northeast and California, where ozone levels are consistently above safety standards, have imposed local regulations. California power plants burning natural gas, for example, are limited to 30 ppm nitrogen oxides in their emissions; oil burners to 100 ppm.

Some burners already on the market reduce industrial NO_X emissions by adding ammonia, which reacts with nitrogen oxides to form nitrogen gas. But, Toqan says, these systems have a disadvantage, since ammonia is an additional and hazardous material. Other low-nitrogen burners use separate chambers for different combustion stages, a technique that the MIT researcher claims requires more space than his system and leads to less efficient burning. Still other burners employ catalysts, much like those in the catalytic converter included in all cars built after 1975, again to form nitrogen gas. Although some of these burners produce, with natural gas fuel, as little as 10 parts per million of NO_X, they can cost 10 to 50 times more than the MIT burner is expected to cost, per ton of avoided NO_X, according to Toqan.

"Combustion-modification techniques like those in the radially stratified burner will most likely give the best bang for the buck," says Angelos Kokkinos, the air-quality control project manager for the Electric Power Research Institute. "If the results we're seeing from MIT follow up in a larger-scale application, we will be very interested in this burner."—*P.J. Skerrett*

PHOTO: PAULA LERNER