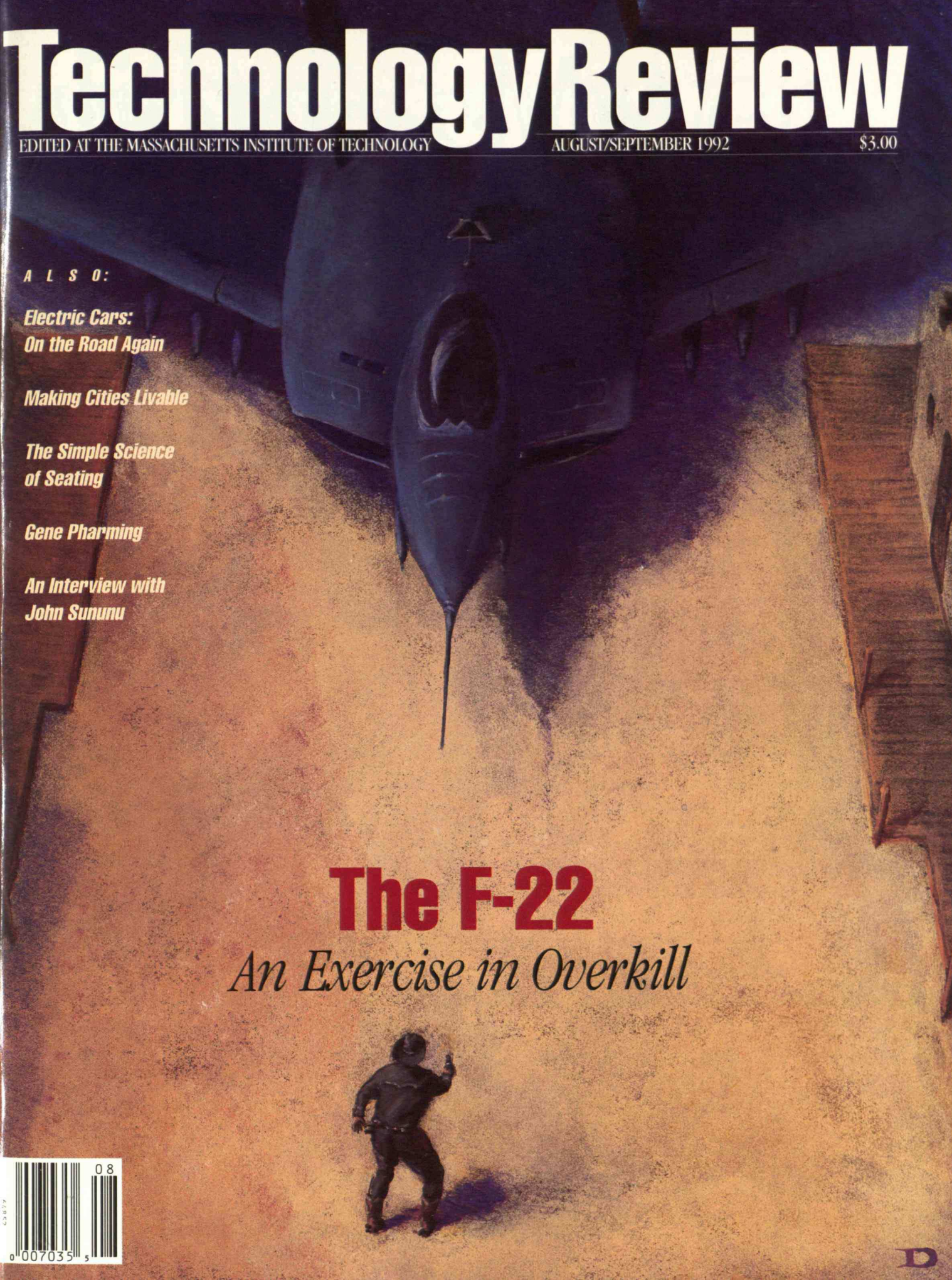
Technology Review

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY AUGUST/SEPTEMBER 1992 $3.00



A L S O:

Electric Cars: On the Road Again

Making Cities Livable

The Simple Science of Seating

Gene Pharming

An Interview with John Sununu

The F-22

An Exercise in Overkill

08
0 007035 5

A Macintosh to start a

Imagine you could design your own personal computer. What would it be? It would be fast, of course. Faster than your basic 486 machine. Fast

The Apple Macintosh Quadra.

enough to handle the rendering, animating, design and analysis jobs that often require a workstation.

It would have immense storage and memory capacity. And it would have features like high-performance networking and accelerated video support built in.

Macintosh Quadra runs all the most powerful engineering software.

You would make it flexible enough to run any kind of application. Affordable enough to put on every engineer's desk. And as long as you're fantasizing here, you'd make it as easy to set up, easy to learn and easy to use as an Apple® Macintosh® personal computer.

But it's not a fantasy. It's a Macintosh Quadra.™

By any measure, the Macintosh Quadra 700 and 950 are two of the most powerful personal computers ever built. Both are based on the Motorola 68040 (rated at 20 and 25 MIPS, running at 25 and 33 MHz), which integrates the processor, math coprocessor and RAM cache all onto one chip.

They're up to twice as fast as any of their forebears. Fast enough to beat the chips off comparably priced 486 computers from IBM, Compaq and Dell.* And fast enough to make programs like AutoCAD, MicroStation Mac,® MacBRAVO! and VersaCAD perform at a level once seen only in dauntingly complex workstations.

Built-in 24-bit video lets you create photo-realistic images without the expense of an extra card.

High-performance subsystems provide built-in support across the board: Ethernet networking, accelerated 24-bit video** support and faster SCSI and NuBus™ slots.

You can add a 400MB hard disk to both

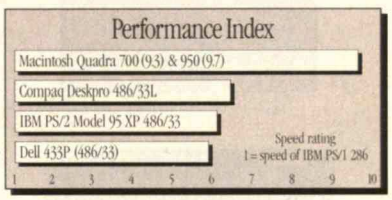
*Comparisons are based on a 1991 independent research study conducted by Ingram Laboratories that tested a variety of personal computers running applications available for both the Macintosh and Microsoft Windows 3.0 environments. **24-bit video support for up to a [illegible] product specifications 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[illegible] 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[illegible]*

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.

There are two Macintosh Quadra models. The 950 sits next to your desk; the 700 fits on top of it.

And Macintosh Quadra fits in with the PCs you already own. The built-in Apple SuperDrive,™ used with Apple's new Macintosh PC Exchange software, allows you to share files easily with MS-DOS PCs via floppy disk or over a network. And with Apple's fully compliant version of UNIX®—A/UX®—you can even run UNIX, X Window, MS-DOS and Macintosh programs all at the same time.



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.†

the 700 and the 950 to accommodate the largest CAD files. And the 950 even lets you add a CD-ROM drive or a removable cartridge drive, and a disk array or more than a gigabyte of internal hard disk storage.

You can increase the memory of the 950 to up to 64MB of RAM for handling compute-intensive applications like three-dimensional modeling and stress analysis.

Over your network, the unique Apple interapplication

Your authorized Apple reseller would be glad to show you all this and more. For the name and location of the one nearest you, call 800-538-9696, extension 200.

And soon you'll discover the latest power of Macintosh personal computers. The power to start a revolution. The power to be your best.®

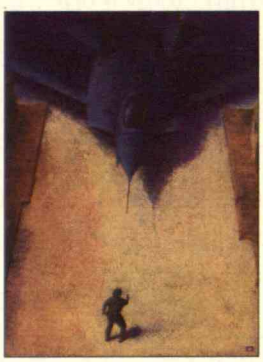
...lso available for 21" monitors with optional third-party video card. †PC Week, December 23/30, 1991. ©1991 Ziff Communications Company. Mention of third-party products is for informational purposes only and constitutes neither an endorsement nor a recommendation. All product ...demarks of Apple Computer, Inc. AutoCAD is a registered trademark of Autodesk, Inc. BackBurner is a trademark of Specular International. MacBRAVO! is a trademark of Schlumberger Technologies, Inc. MacTOPAS is a registered trademark of AT&T Graphics Software Labs. Mathematica is a ...derPro is a trademark of Strata, Inc. Vellum is a registered trademark of Ashlar Incorporated. VersaCAD is a registered trademark of Versacad Corp. X Window System is a trademark of MIT. UNIX is a registered trademark of AT&T. This ad was created using Macintosh computers.

TECHNOLOGY REVIEW
AUGUST/SEPTEMBER 1992

Contents

29

34



42

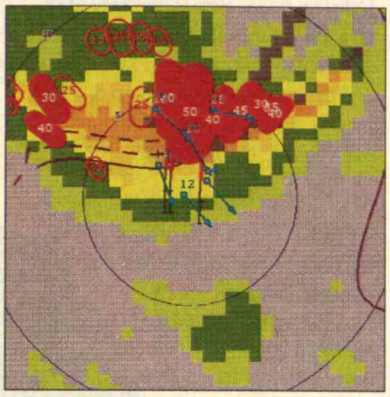
50

60

FEATURES

COVER ILLUSTRATION: BOB DAHM

TECHNOLOGY REVIEW
VOL. 95/NO. 6



8

14

74

DEPARTMENTS

Technology Review (ISSN 0040-1692), Reg. U.S. Patent Office, is published eight times each year (January, February/March, April, May/June, July, August/September, October, and November/December) by the Association of Alumni and Alumnae of the Massachusetts Institute of Technology. The editors seek diverse views, and authors' opinions do not represent official MIT policy. We welcome letters to the editor. Please address them to Letters Editor.

Editorial, circulation, and advertising offices: *Technology Review*, Building W59, MIT, Cambridge, MA 02139, (617) 253-8250; FAX (617) 258-7264. Printed by Lane Press, S. Burlington, VT. Second-class postage paid at Boston, MA and additional mailing offices. Postmaster: send address changes to *Technology Review*, MIT, Building W59, Cambridge, MA 02139.

Subscriptions: $24 per year, libraries and organizations $27. Canada add $6, other foreign countries add $12. Contact *Technology Review*, P.O. Box 489, Mount Morris, IL 61054, (800) 877-5230 or (815)734-6309; FAX (815) 734-4205.

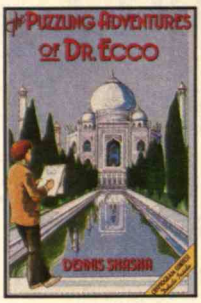
Advertising representatives: Mark E. Lynch, Eastern Sales Manager, 9 Salem Drive, Saratoga Springs, NY, (518) 583-6086; The Leadership Network: SalesConcepts, Inc., 72 Spring Street, New York, NY 10012, (212) 941-8172; Detroit: Keith Olsen/Media, Birmingham, MI, (313) 642-2885.

Thoughtful gifts for thinking people

THE PUZZLING ADVENTURES OF DR. ECCO
by Dennis Shasha

An intriguing book of puzzles and problems presented as the fictional tale of Dr. Jacob Ecco, legendary mathematical detective. Try to solve nearly 40 puzzles found in math and computer science — some of which have stumped physicists and computer scientists. You don't need background in either subject, "only a clear head and imagination." Solutions in back of book.

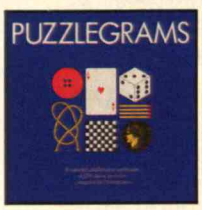
Paperback, 183 pages, $11.95.



PUZZLEGRAMS
by Pentagram

A collection of 178 classic puzzles recreated by one of the world's leading design firms. The book is a stunning, 4-color combination of design and conundrum.

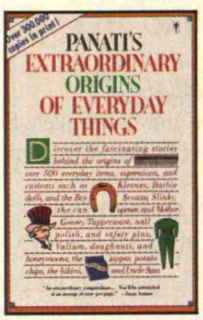
Paperback, 187 pages, $15.95



PANATI'S EXTRAORDINARY ORIGINS OF EVERYDAY THINGS
by Charles Panati

This book unveils the roots, meaning and superstitions behind the objects and vocabulary of our daily lives. A must for anyone fascinated by curious facts, trifles and trivia.

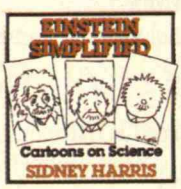
Paperback, 463 pages, $13.00.

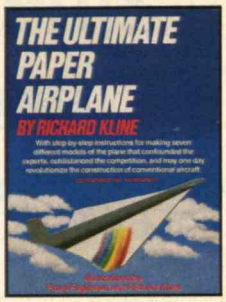


EINSTEIN SIMPLIFIED
Cartoons on Science
by Sydney Harris

No area of science escapes the sharp wit and wayward pen of cartoonist Sidney Harris. A delightful collection of more than 150 cartoons to tickle your funny bone.

Paperback, 160 pages, $9.95

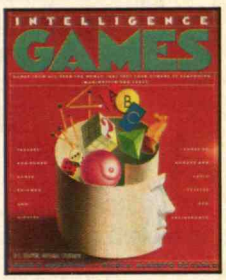




THE ULTIMATE PAPER AIRPLANE
by Richard Kline

More than just a toy, the Kline-Fogleman airfoil earned its inventors two patents and was tested by NASA. Here is the story of its creation, along with the secrets behind its unmatched performance. Plus, instructions and patterns for making seven different models of this incredible plane.

Paperback, 126 pages, $8.95.



INTELLIGENCE GAMES
by Franco Agostini & Nicola Alberto Decarlo

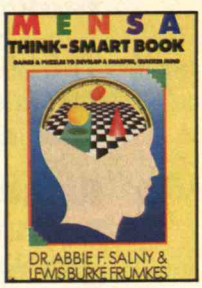
A collection of riddles, logic, boardgames, and enigmas from all over the world to "test your powers of reasoning and savvy."

Paperback, 184 pages, $15.95

WORKING PAPER CLOCK
by James Smith Rudolph

Make your own working clock, entirely from paper. Cut this book into 160 pieces, add a few odds and ends and glue them together, and you'll have a piece that keeps perfect time.

Paperback, $10.95.



MENSA THINK-SMART BOOK
by Dr. Abbie F. Salny & Lewis Burke Frumkes

A book of games and puzzles to develop a quicker mind. Give yourself or a friend a Mensa workout with math, logic, memory problems, and more.

Paperback, 124 pages, $7.95.

Ordered by:

Name _____

Address _____

City _____ State _____ Zip _____

Ship to:

Name _____

Address _____

City _____ State _____ Zip _____

Prepayment, in U.S. funds only, is required

Check or money order enclosed for $ _____ Charge my: _____Mastercard _____Visa

Card # _____ Expires _____

Signature _____

Send order with payment to:
Technology Review Books, MIT-W59, Cambridge, MA 02139

To order by phone with Visa or Mastercard, call (617) 253-8292, 9-5, EST, Mon.-Fri.

Qty	Title	Price	Total

# of Items	U.S.	Outside U.S. Surface Mail
1	$2.00	$3.25
2	$2.75	$5.00
3 - 4	$3.50	$6.75
5+	$4.25	$8.50

For 3 or 4 items subtract $1.00

For 5 or more items subtract $2.00

Add shipping (see chart)

Grand Total

First Line

America's Change of Life

THE American public has lately been educated on menopause—an experience that inevitably visits half the human race yet one that has long been taboo for discussion, even among women. Things change: now it's featured on the evening news, in the daily paper, as cover stories in news weeklies, and in bestselling books such as Gail Sheehy's *The Silent Passage*.

A ready explanation is that members of the baby-boom generation, having reexamined, in turn, other basic aspects of life such as adolescence, education, work, sexuality, and babies, now bring similar passion and resolve to the milestones they are beginning to encounter in their 40s.

At least that's the endeavor of the female half. But as with this cohort's previous innovations—the women's liberation movement, for example—the results will also be instructive to men, the country, and the world. Menopause has particular meaning for, of all things, the U.S. economic engine and its role in the global marketplace.

Men can continue to procreate, should they wish to, virtually to the end of their lives, but menopause poignantly reminds women that their childbearing years are over. They see it as a sign of "getting old," and in our youth-oriented culture that usually means moving on, whether voluntarily or not, and especially when one's influence is already tenuous. Thus it has long been common for menopausal women to engage in denial, become depressed, lose self-esteem, and consequently remain uninformed and ill-equipped to deal with the transition and its aftermath.

But as Sheehy points out, menopause is not a disease. It's "a passage," she says, "that is not cause for remorse but for celebration." *Newsweek* notes that in traditional cultures, "women are revered in aging" and actually look forward to menopause. It is less a signal of inexorable decay than of the beginning of a new, more mature, and even more productive phase of personal development. Having passed (or bypassed) the remorseful stage, the path is cleared for what Margaret Mead called "postmenopausal zest"—quite the opposite of what may have earlier seemed to be the end of the line.

In many ways, the economy of the United States has also been going through a "change of life." And although the transition has not gone unanticipated or unnoticed, we seem to have been dealing with it not unlike the way American women traditionally greeted menopause.

The nation is "getting old," but its ultimate greatness may well lie ahead.

Some of *Technology Review*'s authors have been discussing this phenomenon, though not literally from the above perspective. In the February/March 1992 issue, for example, economist Gar Alperovitz argued that although rapid growth certainly characterized the nation during times past, trying to jump-start the economic engine so that it will perform as it did in earlier days is futile and counterproductive.

The authors of two different articles in this issue—Langdon Winner and Donella H. Meadows—offer comparable perspectives. In "Farewell to Progress," Winner suggests that the evolution of society—true progress—is not secured by relentless exploitation of natural resources, or by scientific breakthroughs and technological innovations alone. Instead, a more mature and strategic approach, one that consolidates assets in a long-term and equitable way, is warranted at our present stage of national life.

Similarly, Meadows differentiates between "dumb growth" and "smart development." Growth means bigger—quantitatively more; development means better—qualitative improvement. Just as individuals cannot remain youthful and grow forever, neither can societies, but all can continue to develop. Instead of desperately trying to "do something, anything, to prime the pump of growth," says Meadows, we must concentrate our unique skills on what is sustainable and durable.

Such analysis may at first seem like gloom and doom, but it is actually optimistic, suggesting the possibility, even the likelihood, of a "postmenopausal zest" for the nation. Beyond the search for simple answers and desperate panaceas lies a more productive phase—"a new plateau of contentment and self acceptance," as Sheehy puts it, and a "new perspective on life and humankind."

The "development" approach is not without precedent in the United States. Witness the ultimately successful Cold War strategy of countering the Soviet Union's numerical superiority in military forces with sophisticated command and control systems and "smart" weapons. In another sphere—one that is more benign and commercial—knowledge-based approaches can be put to work protecting the environment while stimulating the economy. The Bush administration has not figured it out yet, but the public increasingly understands that controlling pollution doesn't necessarily mean high costs or premature industrial retirement.

The United States is technologically mature enough to design products, production processes, and patterns of use and reuse so that pollution isn't produced in the first place— for example, with byproducts that are not "wastes" but inputs to other processes—and with the whole hullabaloo being downright profitable. To do so requires taking the concept of smart development—operation in a "sustained yield" mode rather than one of "harvest to depletion"—more seriously. At its present stage of life, the country is quite capable of some zestfulness along those lines. ■

—STEVEN J. MARCUS

Letters

WOMEN'S SCIENTIFIC LEGACY

In "A World Without Women" (*TR May/June 1992*), David F. Noble observes that the women scientists of our own era face the same ill will that dogged our medieval predecessors. I certainly wouldn't argue with that. But harsh discriminatory treatment began long before the Middle Ages, and in spite of the hostility and barriers, women have worked in science and engineering throughout history.

In ancient Greece, for example, there were numerous women in Plato's academy, the site of the most important mathematical work of the fourth century B.C. However, they had to defy a law forbidding women to attend public meetings. Another example: the last great scientist of antiquity was a woman, Hypatia of Alexandria, but she died as a martyr to science at the hands of a mob—which could not have encouraged other women to follow her independent way.

In the medieval world, the church was indeed dominated by men, but there were large numbers of women in convents, which were centers of learning. Some of these women had positions of significant influence in the church hierarchy, and some were important scholars as well. In fact, Hildegard of Bingen, a German abbess who lived during the twelfth century, authored what have been called the greatest scientific works of the Middle Ages. Hildegard, an authority in the medical sciences, was the most distinguished naturalist of her century. She traveled throughout Germany and France to teach about science, medicine, and theology in monasteries and other church institutions.

Herrad of Landsberg, another abbess, was noted as a teacher of all medieval academic subjects, including medicine and the sciences, and she built a large hospital and served as chief physician. Herrad wrote one of the earliest encyclopedias, portions of which have survived in copied form to provide us with much of our knowledge of the technology of the Middle Ages. Finally, Heloise, better known as the heroine of one of the most famous love stories of all time, was the most learned female physician in France during the twelfth century.

Noble's remarks about the execution of women as witches are on the mark. One of the prominent early European women in engineering suffered this fate: France's first mining engineer was a woman, Martine de Beausoleil, and she was imprisoned for witchcraft and died in prison in 1642, the year Galileo died and Newton was born.

CAROLINE L. HERZENBERG
Argonne National Laboratory
Argonne, Ill.

DISPOSAL BY INJECTION

"Unwelcome Exports" by Frank Popper (*TR April 1992*) is inaccurate and misleading. While it is a fact that American Cyanamid's Fortier plant in Westwego, La., does release the largest amount of hazardous materials in the state, 99 percent of the waste is disposed of by deep well injection, which is regulated and permitted by the Environmental Protection Agency (EPA) and state agencies. This method safely and effectively disposes of waste several thousand feet into subsurface geological formations. EPA's Office of Solid Waste and Emergency Response recently determined that deep well injection is among the safest waste-management methods available.

It is also worth noting that in October

1990, the EPA granted the Fortier plant's application for an exemption to the land disposal restrictions imposed by the 1984 Resource Conservation and Recovery Act. We proved that we met the requirements of federal codes, and we demonstrated that there would be no migration of materials from the waste disposal area for 10,000 years. There is no way that the waste could ever "drift to Florida, degrading the environment," as Prof. Popper suggests.

PAUL D. MOGOLESKO
Manager of Manufacturing Services
American Cyanamid Co.
Wayne, N.J.

The author responds:
When I wrote of toxic chemicals that would drift to Florida, I was clearly referring to the collective air pollution, water pollution, and hazardous waste from four plants, two apiece in Louisiana and Texas. The Westwego plant is but one of the four.

Also, I am happy to hear that the Westwego plant received the EPA exemption in 1990. But my article explicitly stated that I was using EPA's 1989 data, which were then the latest available.

HIGHER PRIORITY FOR TEACHING

In "Reforming Freshman Science" (*TR Forum, May/June 1992*), Sheila Tobias correctly points out that teaching in introductory college science courses is generally so uninspired that it discourages students from majoring in the subject. She stops short of suggesting why science teaching is so bad, but it does not seem too hard to understand: most undergraduates attend universities that give a much higher priority to research than to teaching. Even when universities pay lip service to teaching, the academic reward system gives little weight to it, and this is especially true in science and engineering, where outside research grants provide significant returns to the university.

However, the worst result of this situation may be the general decline in scientific literacy rather than the proclaimed shortage of scientists. After all, the future of the American economy depends on the ability of the work force to deal with technology. Thus, it might be more worthwhile to analyze college survey courses in science rather than the introductory courses aimed at prospective science majors.

MARK GOODMAN
Center for Science and
International Affairs
Harvard University

BLUE IN '92

Unlike Edwin Diamond and Jane Newman (*"The Candidates and the Issues," TR May/June 1992*), I have seen very little "genuine public-policy dialogue" in this year's presidential race. The situation is so pathetic that Ross Perot has offered like a modern Don Quixote to save the country.

MOSES CAMMER
Waban, Mass.

MULTIMEDIA COLLABORATION

In "Being There: The Promise of Multimedia Communications" (*TR May/June 1992*), David Brittan succinctly presents some of the key commercial and research systems aimed at facilitating collaborative activities. But the article focuses on technologies that support synchronous collaboration—for example, face-to-face meetings or shared drawing surfaces—though in fact much collaboration occurs asynchronously, as when authors review one another's papers. Interestingly, too, asynchronous tools have not been adopted widely in the workplace, despite the fact that they demand less technological infrastructure.

Why is this so? Perhaps developers need to be more in tune with individual work patterns, group dynamics, and social networks. These types of issues have not been major factors for software applications designed for individual users performing individual tasks.

GEORGE FITZMAURICE
University of Toronto

FUNDS FOR FLYING

In "Building a New Economic Order" (*TR April 1992*), Ann Markusen and Joel Yudken show that they simply do not understand the commercial aircraft industry.

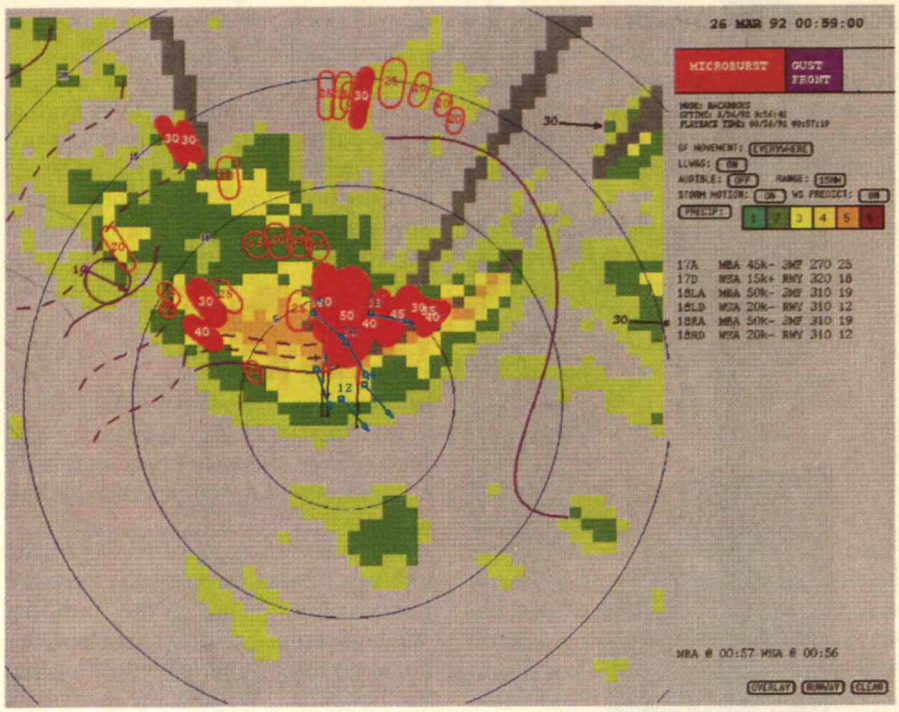
For one thing, the success of the industry is not a "direct result of massive public commitment," as they indicate. While government R&D has helped, it is not solely responsible for everything that has happened. Witness the many U.S. industries that have had considerably more federal help and are nevertheless fading from the scene.

Also, citing 3,652 Defense Department "rescue operations" of companies hardly proves a point. Only one of these supposed bail-outs had anything to do with aerospace anyway. And as for Lockheed's $350 million loan guarantee, it came not from the Pentagon but from the Treasury. Finally, the United States did indeed build many planes during World War I, but they were only 6 percent of the total; France and England built 60 percent. What does that prove—that countries at war defend themselves?

R.J. WALDMANN
Director of Government Affairs
Boeing Commercial Airplane Group
Seattle, Wash.

Correction:
In "A World Without Women" by David Noble (*May/June 1992*), the illustrations on pages 55, 56, 58, and 60 were incorrectly credited. The correct sources are: pages 55 and 58, Bibliothèque Nationale, Paris; page 56, Oslo/London, The Schøyen Collection, MS.27; page 60, Giraudon/Art Resource, N.Y.

MIT Reporter



Air-traffic controllers in Orlando have been using an expert computer system to alert approaching aircraft to dangerous local patterns called microbursts (solid red).

Detecting Ill Winds

Later this year, 47 airports around the country will begin installing new computerized radar systems developed by MIT-affiliated Lincoln Laboratory and the National Center for Atmospheric Research. Called terminal Doppler weather radar, the systems are designed to detect small-scale, short-duration meteorological events called microbursts—wind patterns believed to have caused at least 30 airliner crashes and more than 500 deaths since the 1960s.

The key to detecting microbursts as they form is an expert computer system that analyzes data from doppler radar, which can accurately detect wind speeds at different distances from the runway. It uses the same principle as police radar guns—analyzing the change in frequency of a radio echo from moving objects, in this case particles carried by the wind. The system can give 10 to 20 minutes of warning about potentially lethal downdrafts, enough to divert aircraft on final approach to an airport.

A microburst, which typically is less than two miles wide, resembles a spout of water from a garden hose pointed straight down: a stream of cold air falls rapidly toward the ground, where it spreads outward and bounces back up.

An airliner flying through a microburst encounters a stiff headwind from the outward airflow, then a severe downdraft, and finally a tailwind. Unless a pilot knows what to expect, the initial headwind prompts exactly the wrong response: the pilot tilts the plane's nose downward to cancel the heightened lift. That reaction amplifies the downdraft's effect; if the plane is close to the ground, the result can be a collision.

That is exactly what happened to a Delta jet that crashed at Dallas-Fort Worth airport in 1985, killing 137 people in probably the best-known case of an accident caused by a microburst.

The power of the new doppler radar system was dramatically demonstrated the first week after a prototype was installed at Denver's Stapleton airport in 1988. As five United jets approached the runway in a row, the system revealed an 85-knot microburst forming in their path. The alerted planes veered off and circled until the wind—one of the strongest microbursts ever detected—had dissipated. "We got off with a big bang," says James Evans, head of the weather sensing group at Lincoln Lab.

Prototypes installed in Kansas City and Orlando have helped hone the systems to be installed this year. For example, because of central Florida's stormy weather, the Orlando setup initially provided many overly conservative warnings that "pilots started to ignore," says Evans.

The first test systems relied on an expert meteorologist monitoring the doppler radar screen for conditions that might produce a microburst. What has made full-scale implementation possible is a computerized expert system that can automatically analyze the weather and provide readily understood displays for air-traffic controllers to relay to pilots.

Obstacles near some airports may produce spurious radar echoes that can cause confusion in the system, says John Mazor, spokesperson for the Air Line Pilots' Association. The group maintains that a combination of technologies, including an onboard detector under development, could be the best strategy to avoid microburst accidents. Still, he says, the doppler system is "going to be a very significant improvement" over today's detection abilities.

—David L. Chandler (The author is a science reporter for the Boston Globe.*)*

Designing Better Tankers

The oil spilled from the *Exxon Valdez* may have mostly faded from sight along the Alaskan coastline, but it has left a still-visible mark on the shipbuilding industry that could lead to safer ships.

The outcry that followed the supertanker's 1988 grounding prompted Congress to pass the Oil Pollution Act of

PHOTO: MIT LINCOLN LABORATORY