TechnologyReview

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY AUGUST/SEPTEMBER 1990 $3.00

"Japan was already defeated....
It wasn't necessary to hit
them with that awful thing"
-Dwight D. Eisenhower

Did we need to drop the bomb?

A HISTORIAN WEIGHS THE EVIDENCE

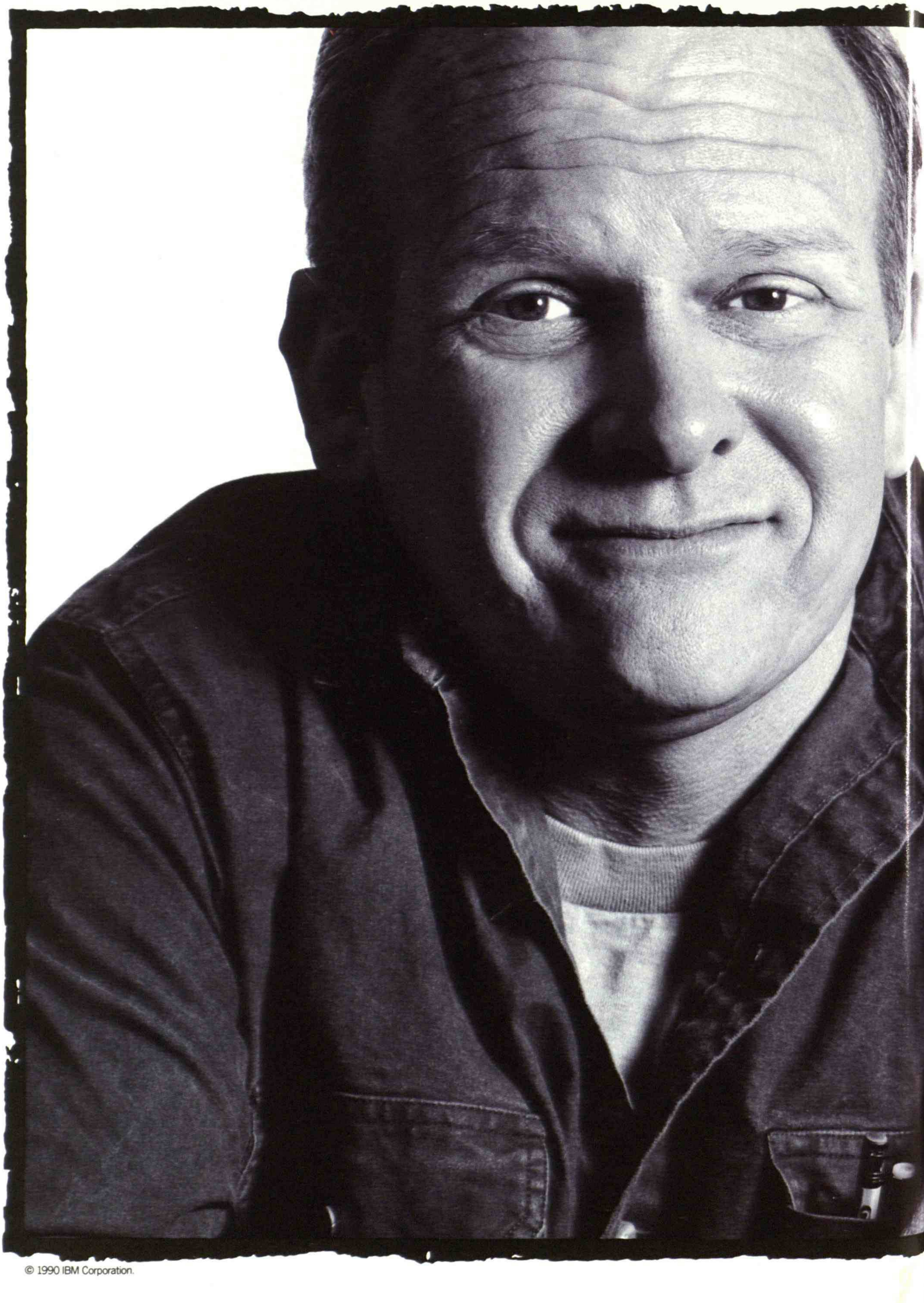
ALSO IN THIS ISSUE:

GETTING TOUGH WITH MEDICAL WASTE

NEURAL NETS GO TO WORK

MINING WITH MICROORGANISMS

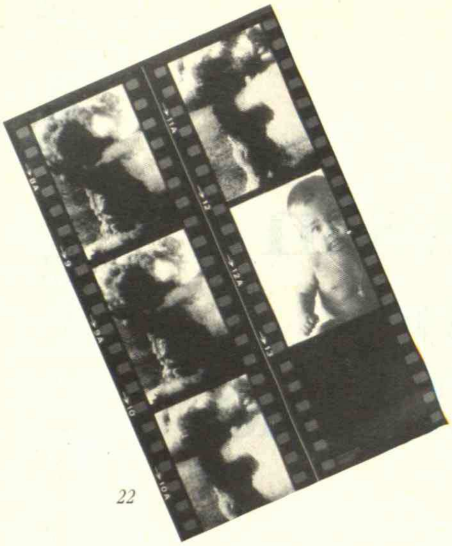
RADICALLY RECYCLED CAMERAS



TECHNOLOGY REVIEW
AUGUST/SEPTEMBER 1990

Contents

FEATURES



22

35

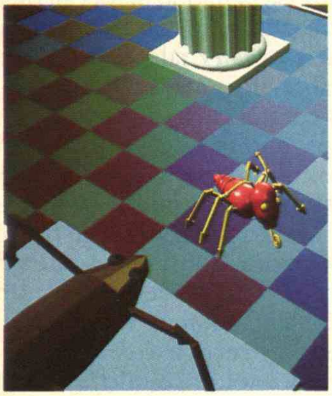
42

58

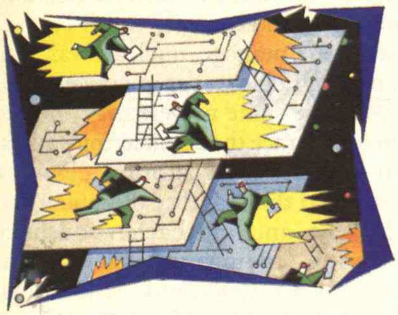
COVER Design: Kathleen Sayre and Nancy Cahners

TECHNOLOGY REVIEW
VOL. 93/NO. 6

DEPARTMENTS



9



14

70

Technology Review (ISSN 0040-1992), 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. Printed by Lane Press, 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. Send inquiries to *Technology Review*, P.O. Box 489, Mount Morris, IL 61054

Advertising representatives: Mark E. Lynch, Eastern Sales Manager, West Ossipee, NH (603) 323-7087; The Leadership Network, 254 Fifth Ave., New York, NY 10001 (212) 684-5500; James G. Elliott Co., Los Angeles, CA (213) 746-8800; Donald Moeller, Dallas, TX 75226 (214) 559-5730; IMI Corp., Tokyo, Japan; Keith Olson/Media, Birmingham, MI (313) 642-2885; Joan Stapleton, Washington, DC (202) 331-7494.

FirstLine

How Star Wars Helped

A couple of years ago, the Strategic Defense Initiative (SDI), President Reagan's call to render nuclear weapons "impotent and obsolete" by building a shield against missiles, was the central arms-control issue. Now Presidents Gorbachev and Bush have agreed to proceed with START, seeking significant reductions of strategic weapons while leaving missile defense as a footnote to be dealt with later. Yet the meteoric career of Star Wars, as it came to be known, produced a legacy worth remembering. By at once promising protection from the terrors of the arms race and seeking to extend that race to the ultimate frontier, Star Wars helped illuminate the insane trap we were in.

Looking back, it is hard to tell when Star Wars was really finished. Was it only recently, when Edward Teller, the physicist who gained Reagan's ear with visions of an x-ray laser that could destroy 100,000 targets in one blast, lost confidence in that technology? Was it last year, when Gorbachev realized he could proceed with START because Congress itself would prevent serious SDI testing? Was it when Reagan left office, or when Gen. James A. Abrahamson, the visionary leader of SDI, was replaced by a bureaucrat? Was it in 1987, when the American Physical Society declared it would be at least a decade before scientists could determine if directed-energy weapons were practical? Was it the day after Reagan's Star Wars speech, when Deputy Secretary of Defense Paul Thayer gathered Pentagon officials and said, "What are we going to do with this mess?"

Dating Star Wars' demise is problematic because it was always the engineering equivalent of a perpetual motion machine. Critics emphasized this from the start. Any shield to protect the public against nuclear weapons must be "leakproof": one explosion could kill a million people. But as Gerold Yonas, the chief scientist of the SDI program, admitted to *Los Angeles Times* reporter Robert Sheer in 1985, "Nobody believes in 100 percent leakproof defense. Nobody believes in 100 percent anything that's ever worked on military systems." Engineers could be reasonably confident of overcoming gravity to reach the moon but could never be certain of outwitting an intelligent human adversary.

If this was obvious, why was the Star Wars debate so protracted? Reporters have no litmus test for truth but do have generally agreed lists of authoritative sources, and one of these is the president of the United States. If he says perpetual motion is possible, reporters may quote members of the American Physical Society who disagree, but cannot ignore the statement. In fact, the statement is so controversial that it will repeatedly make the front page.

> *In promising to stop the arms race by extending it to space, Star Wars illuminated the insane trap we were in.*

Moreover, though the essential problems with Star Wars were simple, the debate grew complex. There was a kind of inevitable logic to this development. In a familiar form of mathematical proof, you posit a statement, use it to deduce something absurd, and thus prove the original statement false. In this case, the assumption that engineers can defend the nation against nuclear weapons led to numerous, intricate contradictions. One was that programmers can be sure that the most complex software ever written will work the first time. (There can be no test of thousands of nuclear warheads streaming toward the U.S.) Even new versions of word-processing programs have bugs that make them "crash," for example, displaying exclamation marks all over the screen and destroying a document.

But as a fairy tale, SDI did yield a valuable insight. Before 1983 the arms-control community had come to accept deterrence—the notion of preventing nuclear war by threatening a retaliation that would destroy civilization. This frightful logic had produced its own chain of absurdities, such as the notion that the United States needs to continually improve technologies of nuclear destruction to deter the Soviets "at every level of conflict." The entire arms-control community agreed on the need to strengthen "communication, command, and control," or "C-cubed," systems to manage nuclear war. But managing nuclear war is nonsensical.

With the same naivete that allowed him to embrace the engineering equivalent of perpetual motion, Reagan challenged the morality of deterrence. When he and Gorbachev outlined sweeping reductions of nuclear weapons in Reykjavik, the arms-controllers shuddered for the stability of deterrence and made it clear that the doctrine requires a minimum of thousands of nuclear warheads. The two heads of state had to pull back, but the arms race never looked quite so sensible again.

Ultimately, Star Wars illuminated the essential illogic of that race. When President Truman and other U.S. leaders knew they had the atomic bomb in 1945, they apparently saw it as a guarantor of peace. With American innocence in control of the ultimate technology—we have long thought of ourselves as untainted by the evil and intrigue of foreign peoples—the world could rest at ease. Of course, events did not and could not work out that way. In the 1980s Star Wars revived the vision of an all-powerful America as global benefactor. This time critics were more swift and merciless about the contradictions of the vision, and that contributed to a somewhat safer world. ■

JONATHAN SCHLEFER

What if there
were
an aerospace
all-star team?

There is—the engineers and scientists just named Technical Fellows of The Boeing Company. They are individuals who have earned reputations for exceptional judgment and competence in their disciplines, and for practical, yet innovative reasoning. (Front Row, L-R) **Richard B. Hall**—precision measurements and laser applications, Boeing Aerospace & Electronics, Seattle; **Wayne E. Woodmansee**—nondestructive testing, Boeing Commercial Airplanes, Seattle; **Coe E. Wescott**—electronic design, Boeing Military Airplanes, Seattle; **Nicholas Albion**—flight control systems, Boeing Helicopters, Philadelphia;

Back Row) **Weightstill William Woods**—sensors, Boeing Aerospace & Electronics, Seattle; **Mervin C. Vincent**—ow observables, Boeing Military Airplanes, Seattle; **Frank C. Fickeisen**—flight controls and systems engineering, Boeing Commercial Airplanes, Seattle; **Albert M. Erisman**—scientific computing and numerical analysis, Boeing Computer Services, Seattle; **Paul E. Rubbert**—aerodynamics and computational fluid dynamics, Boeing Commercial Airplanes, Seattle; **Ulf Goranson**—structures engineering, Boeing Commercial Airplanes, Seattle; **George T. Campbell**—communications and systems engineering, Boeing Aerospace & Electronics, Seattle.

Associate Technical Fellows of The Boeing Company.

Ivan G. Barker
Flight controls, Boeing Commercial Airplanes

Lawrence A. Blakely
Airframe structures design, Boeing Commercial Airplanes

Per A. Bolang
Flight controls and hydraulics, Boeing Commercial Airplanes

Kalman G. Brauner
CAD/CAM, Boeing Commercial Airplanes

Harry H. Burlingame
Laboratory instrumentation, Boeing Commercial Airplanes

Glenn A. Geithman
Non-destructive testing, Boeing Commercial Airplanes

Hans K. Herzog
Electronic systems design, Boeing Commercial Airplanes

Richard D. Hessler
Manufacturing computer systems development, Boeing Aerospace & Electronics

Garth J. Houlihan
Airframe structures engineering, Boeing Commercial Airplanes

Arthur Dean Jacot
Control technology, Boeing Aerospace & Electronics

Forrester T. Johnson
Aerodynamics, computational fluid dynamics, Boeing Commercial Airplanes

Robert E. Jones
Structural mechanics, Boeing Aerospace & Electronics

Bernard J. Lamberty
Antennas and electromagnetics, Boeing Aerospace & Electronics

John G. Lewis
Scientific computing and numerical analysis, Boeing Computer Services

C. David Lunden
Antennas and radomes, Boeing Aerospace & Electronics

Melville D. McIntyre
Avionics and flight systems, Boeing Commercial Airplanes

Bruce L. McManus
Flight control systems, Boeing Helicopters

Glen E. Miller
Fiber-optic sensors, sensor systems, and telemetry, Boeing Aerospace & Electronics

Gerald N. Ostrom
Structure design, Boeing Military Airplanes

Gerald C. Paynter
Propulsion, Boeing Military Airplanes

James M. Peterson
Materials and process technology, aircraft fire safety, Boeing Commercial Airplanes

Robert L. Pinckney
Composite structures, Boeing Helicopters

Bernard F. Ray
Aeronautical engineering, Boeing Military Airplanes

Andrej Martin Savol
Machine vision, Boeing Commercial Airplanes

Kurt Schuppisser
Engine technology and propulsion systems, Boeing Commercial Airplanes

Harold A. Scott
Computer simulation and modeling, Boeing Aerospace & Electronics

Frederick H. Simpson
Ceramic engineering, Boeing Aerospace & Electronics

Jerome Sugamele
Structural dynamics and vibrations, Boeing Commercial Airplanes

Edward N. Tinoco
Aerodynamics, computational fluid dynamics, Boeing Commercial Airplanes

Johannes H. van der Velden
Hydraulics and fluid systems, Boeing Commercial Airplanes

Mark A. Wilhelm
Advanced composites, Boeing Commercial Airplanes

Donald E. Young
Electromagnetic scattering, Boeing Military Airplanes

The Boeing Fellows joined by Associate Technical Fellows.

BOEING